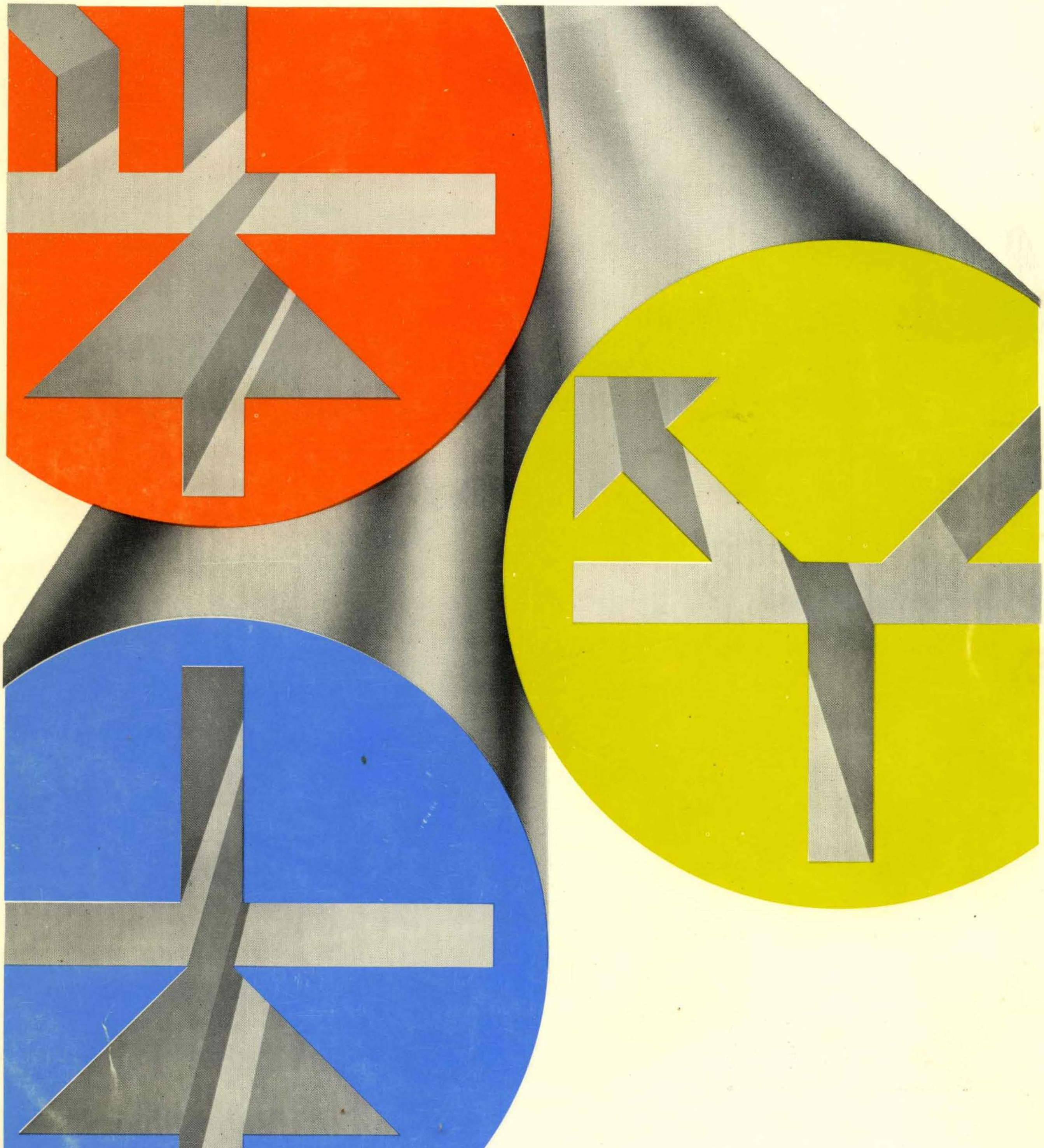
Westinghouse Power Semiconductor User's Manual and Data Book

Assemblies/Rectifiers/Thyristors/Transistors



POWER SEMICONDUCTOR USER'S MANUAL AND DATA BOOK

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# ACKNOWLEDGEMENTS

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It is hoped that the Ⓦ Power Semiconductor User's Manual and Data Book will enable anyone using power semiconductors to do so more effectively. Any suggestions on how future editions of this book can be improved to better serve your needs will be greatly appreciated.

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POWER SEMICONDUCTOR USER'S MANUAL

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Ⓦ POWER SEMICONDUCTOR

USER'S MANUAL

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1 INTRODUCTION

1. PURPOSE

The purpose of this book is to enable persons in any job function (i.e. Purchasing, Design, Production, Engineering, Plant operation and maintenance, Quality Control, Marketing, etc.) to deal with power semiconductors more effectively, regardless of his or her technical background or experience level. Every effort has been made to present this material in a straightforward, easy-to-use format so that the reader can readily apply many of these practical suggestions and ideas directly to his or her job. The reader should note that, although Westinghouse forms and procedures are highlighted in the User's Manual, the information being presented is generally applicable to *any* manufacturer of power semiconductors.

The term "user" in this book refers to both the Original Equipment Manufacturer (OEM) who manufactures equipment utilizing power semiconductors and the End User who purchases, uses, and maintains this equipment.

Engineering terms and other "jargon" perculiar to power semiconductors are used only when needed in the User's Manual and are usually defined within the text or in the appendix. Note: No effort is made in this book to "educate" the reader on how a power semiconductor "operates" in a circuit or how a power semiconductor "works". There are many fine texts on these subjects for those persons interested in these engineering and physics phenomena.

The User's Manual and Data Book is actually two books in one! A brief description of how these two books are organized:

The **User's Manual** is arranged in a somewhat natural sequence of events—Selecting the Proper Power Semiconductor, Semiconductor Procurement, Incoming Inspection, Testing, Device Installation, Equipment Operation, Preventative Maintenance, Troubleshooting, Replacements, Safety, Reliability and Quality Control plus a special section on the manufacture of Ⓦ Power Semiconductors. Sections can be read independently or in any desired sequence depending upon the reader's interest and need.

The **Data Book** offers detailed specifications on the complete line of Westinghouse Power Semiconductors. The General section includes a master cross reference type number index by JEDEC 1N, 2N, and 3N part numbers and industry alpha and numeric part numbers. Using this index, the reader can rapidly locate any power semiconductor part number for which Westinghouse offers an exact or suggested replacement along with the page number of the data sheet for the recommended Westinghouse device. In addition, this section contains the Ⓦ Selling Policy, Warranty Information, Delivery Lead Time Guide Lines, Military/Hi-Rel Product Capabilities, General Application Data Sheets, a Quick Service Directory listing key contacts for special assistance, and a complete listing of Ⓦ Semiconductor Sales Offices and Authorized Ⓦ Semiconductor Distributors. The remaining four product sections—Assemblies, Rectifiers Thyristors (SCR's and RBDT), and Transistors each are subdivided into their respective major product subgroups. Easy-to-use Product Capability Graphs and Product Selector Guides are provided at the beginning of each product section to enable the reader to quickly locate technical data for any given product.

2. POWER SEMICONDUCTOR OVERVIEW

Westinghouse is a world leader in the manufacture of high power semiconductors. In 1952, Westinghouse introduced the first silicon rectifier; in 1957, the first high voltage rectifier stack assemblies were introduced; in 1958, silicon transistors were added, followed by a line of SCR's in 1959. From this infancy, the semiconductor market has mushroomed into virtually every industrial, military, and consumer market. These markets include steel mill drives, space vehicles, and calculators, to name just a few. Even though Westinghouse was a pioneer in many areas of semiconductor development and currently holds basic patents used today by almost every semiconductor manufacturer, the strategic decision was made to concentrate efforts in the power segment (1 ampere and above) of the semiconductor spectrum (see figure 1.1) with primary emphasis on the 40 ampere and above market.

The semiconductor industry's business spectrum is not as homogeneous as one might expect. Each of these power segments represent different technologies, industries, applications, and markets. One popular

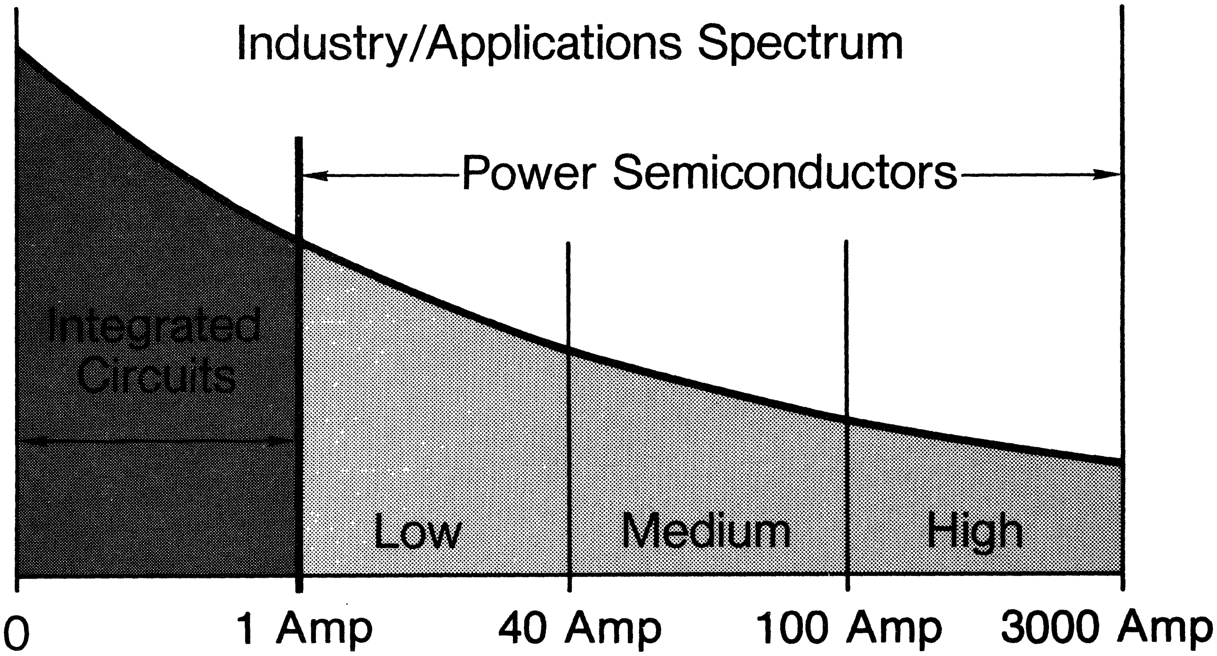


Figure 1.1 Semiconductor Business Spectrum

misconception about the semiconductor industry involves pricing. Integrated circuits, for example, have generally exhibited tremendous price declines—often tenfold or more. People usually assume that since integrated circuits exhibit this type of falling price phenomenon so should all other semiconductors. A little analysis will show why this theory does not hold. Integrated circuit prices, as well as all discrete product prices, fluctuate with *volume*—not with time as many people mistakenly observe. Integrated circuits serve *very* high volume markets and are made and tested with highly automated equipment. The power semiconductor market (especially the higher power areas), by comparison, is a much smaller, lower volume market serving primarily industry and military needs. These products are more custom made and tested to a customer's specification than to common generic type number. Historically, power semiconductor prices did show modest declines as new products were brought on the market initially at premium prices so the semiconductor manufacturers could attempt to recoup the substantial R&D expenses necessary to develop these products. Now, however, many new products—especially higher current and/or voltage extensions of existing products are priced more consistent with prevailing market prices. Today, many power semiconductor types are in the mature stage of their product life cycles. As a result, there are less cost reduction possibilities to offset the ever increasing inflation caused by higher material, labor, and factory expense costs. Therefore, price trends on many power semiconductors now and in the future will be upward instead of downward.

3. Ⓦ POWER SEMICONDUCTOR PRODUCT LINE

Westinghouse offers a comprehensive line of power semiconductors including rectifiers, thyristors—SCR's (silicon controlled rectifiers) and RBDT (reverse blocking diode thyristor), transistors, and assemblies.

• General Purpose Rectifiers	1-2200 Amperes Up to 4KV
• Fast Recovery Rectifiers	6-1400 Amperes Up to 3.2 KV .2-5μs
• Phase Control SCR's	10-1400 Amperes Up to 3 KV

• Fast Switching SCR's	40-900 Amperes Up to 2.2KV 10-80μs
• Reverse Blocking Diode Thyristor (RBDT)	22-80 Amperes Up to 1 KV 2,000-4,000A/μs
• General Purpose Transistors	.5-15 Amperes 30-150V
• High S.O.A. Transistors	1.5-25 Amperes 30-250V
• High Power Switching Transistors	50 Amperes 400-500V

Many of these products are available in a variety of packages including axial lead mount, diamond mount, flat base, studless, stud mount, and disc mount. All of these products are available mounted on air, oil, or water cooled heat sinks in a variety of circuit configurations; these assemblies offer average current ratings from .5 amperes to 10,000 amperes or more with voltage capabilities as high as 688 KV for some high voltage stack designs.

The Ⓦ Data Book covers the vast majority of products and assemblies currently available; however, increased current ratings, voltage ratings, and/or improved turn-off and reverse recovery times will continue to evolve as a result of new product developments and improved production yields. Therefore, the reader is encouraged to contact a Westinghouse sales representative regarding any application(s) that might fall into any of these "fringe" areas.

4. IMPORTANCE OF POWER SEMICONDUCTORS

Power semiconductors have grown from laboratory curiosities to brute-force industrial components which have become competitive necessities in the marketplace. The potential advantages of solid-state power electronics over electromechanical equipment are well known: increased reliability and service life, reduced size and maintenance. In some cases, there is a sizeable cost advantage, while in other cases the performance capabilities can be achieved in no other way. Table 1.1 shows a complete matrix of industrial applications that can use Westinghouse Power Semiconductors (See page 13).

At least three current trends indicate that power semiconductors will become even more important to the user:

1. The growing shortage of oil and gas and the growing environmental concern will stimulate the utilization of clean electrical power in countless new areas now predominantly served by other forms of energy.
2. Efficiency in the manipulation and control of electrical power will have increasing priority as the rising cost of power forces the abandonment of techniques which are "short-term cheap but long-term wasteful."
3. The evolution of present applications and the creation of new applications will cause increasing demands for speed, precision, and reliability in power control that can be satisfied by no other technology.

For these reasons, power semiconductors are penetrating many new application areas and outmoding many traditional design approaches. Product engineering departments accustomed to well established design procedures involving Ward-Leonard drives, relay logic, or selenium rectifiers are faced with extinction overnight if they cannot adapt to the higher levels of complexity and analytical sophistication made possible and made necessary by solid-state electronics. While many technologies evolve over a period of decades—leaving adequate reaction time for business planning—this is not usually the case with power electronics. Solid state technology typically moves from an insignificant share of a market to a dominant share in a period of only 2 to 4 years. The universal S-curve showing the capture of a market by a product which takes advantage of power electronics is shown in Figure 1.2. Thus, a company which does not keep up-to-date in this new technology can easily lose a secure market position because of inadequate reaction time.

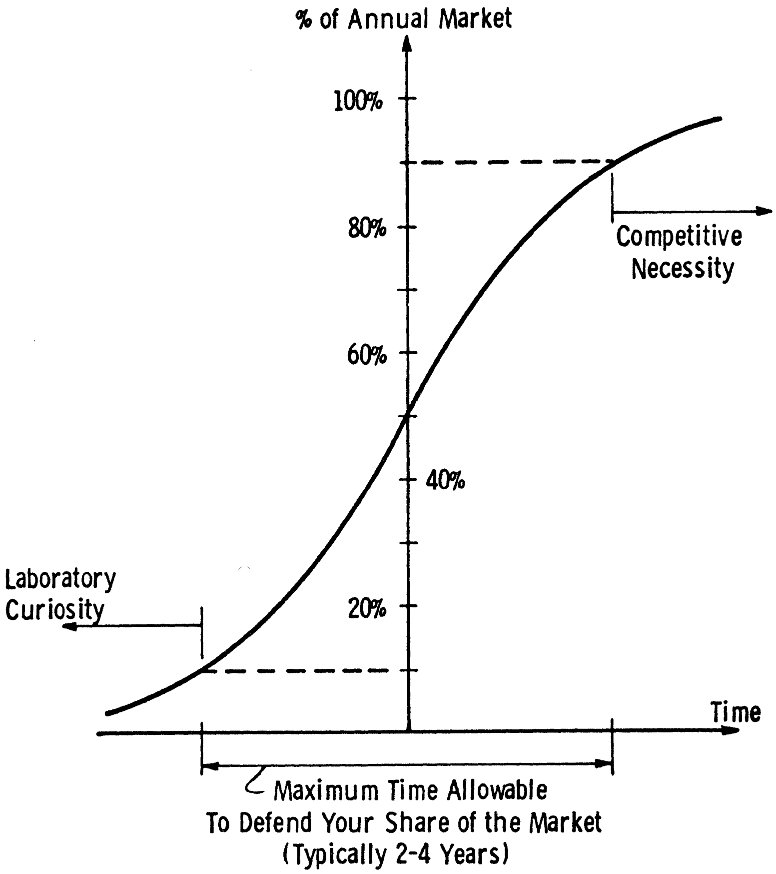


Figure 1.2 Universal s-curve showing market penetration by a product which takes advantage of power electronics.

5. MANUFACTURER /OEM/ END USER RELATIONSHIP

Historically, this relationship has tended to be split into two independent relationships: (1) The semiconductor manufacturer and the customer, the original equipment manufacturer (OEM). (2) The OEM and the customer, the end user.. With the growth and acceptance of power semiconductors into virtually every market segment, as well as the emergence of trends brought on by energy, environmental, and safety considerations,

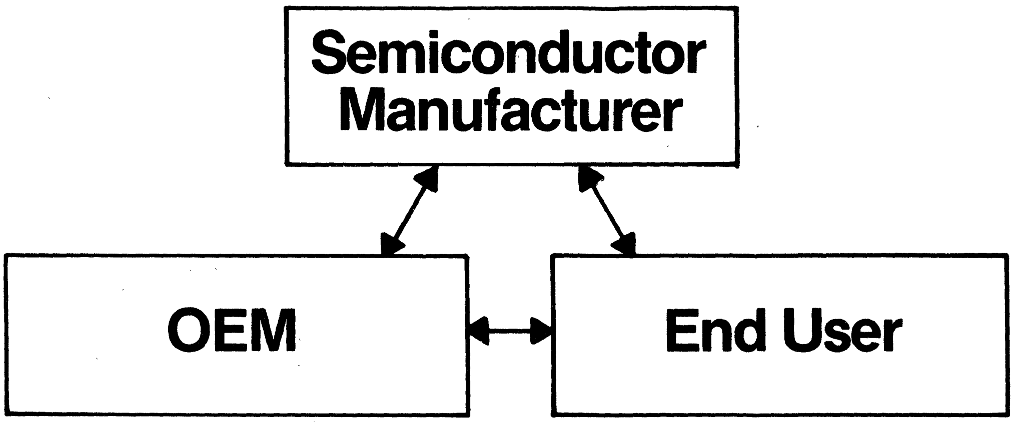
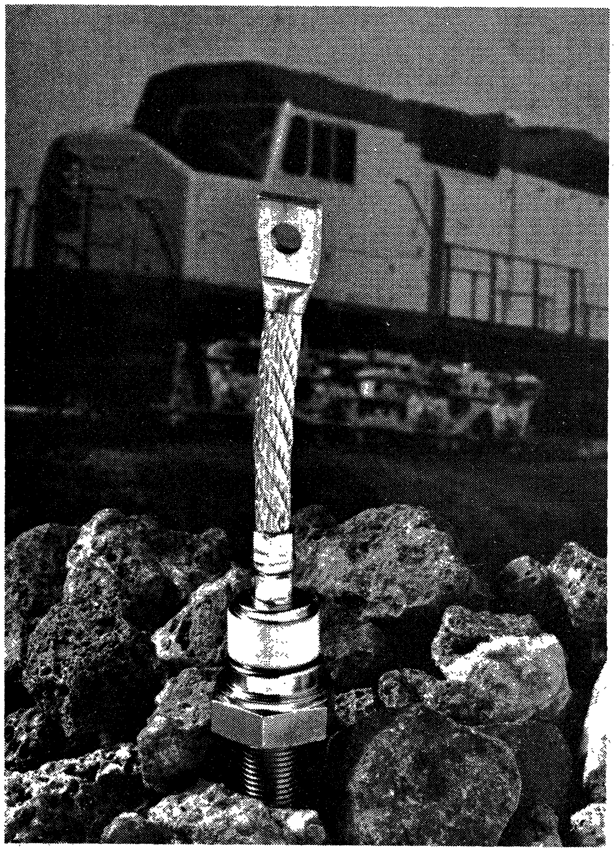


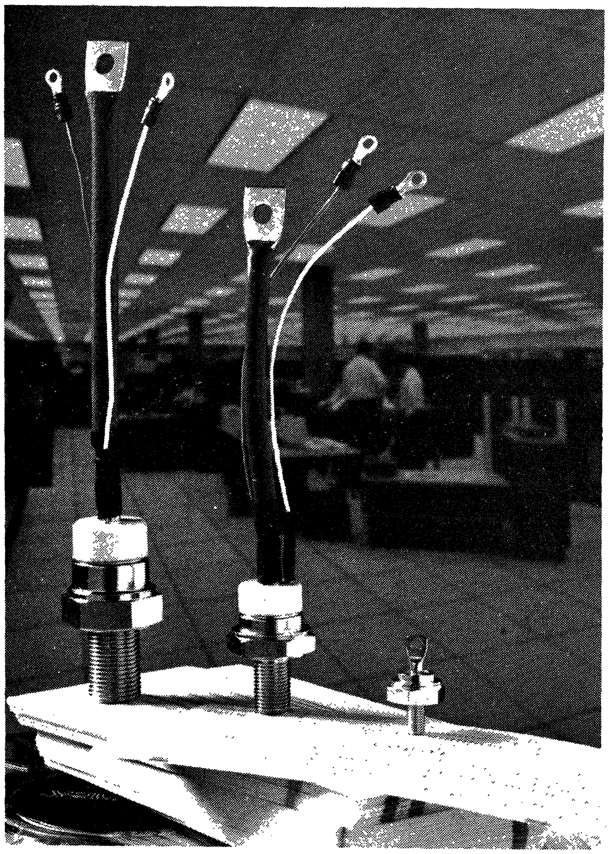
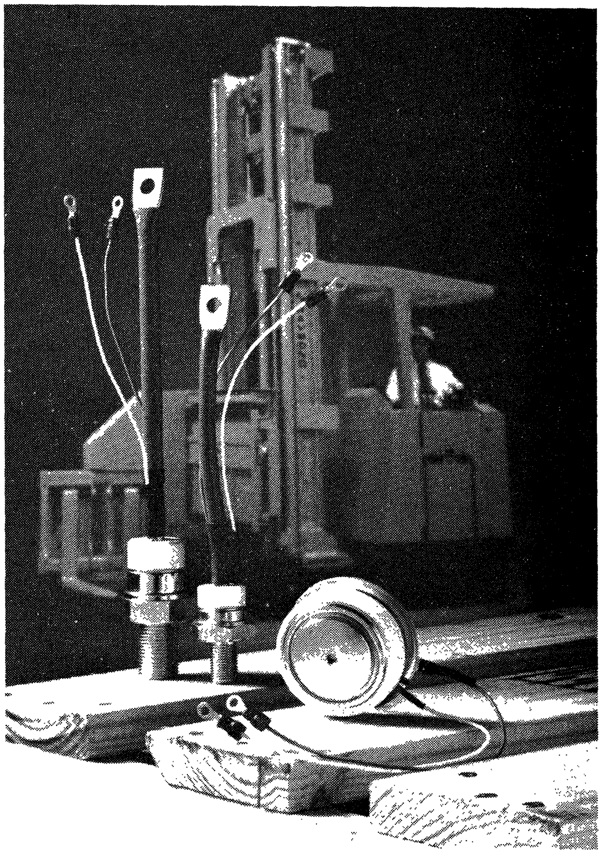
Figure 1.3 Semiconductor Manufacturer, OEM, End User Relationship.

the manufacturer, OEM, and end user relationship has become much more dynamic and comprehensive (shown by the diagram in Figure 1.3). The semiconductor manufacturer has come to recognize that both the OEM and the end user are "Users" of power semiconductors, whether directly or indirectly. The end user is really the ultimate customer—the one who purchases, uses, and maintains the equipment that was built and sold by the OEM who, in turn, purchased power semiconductors from the component manufacturer. The end user wants reliable, efficient, easy-to-maintain equipment that will meet the necessary environmental and safety standards while providing maximum performance at minimum cost. Not until the semiconductor manufacturer, the OEM, and the end user collectively work together can a semiconductor be produced and a piece of equipment be designed that will fulfill all of the end user's needs. This is a shared relationship that, if properly performed, will be mutually rewarding for all concerned.

	RECTIFIERS		THYRISTORS/SCR's			TRANSISTORS			ASSEMBLIES				
	General Purpose	Fast Recovery	Phase Control	Fast Switching	RBDT	General Purpose	High SOA	High Pwr. Switching	Modular	Gold Line Stud Mt.	Air Disc	Liquid Disc	H.V. Stacks
POWER DISTRIBUTION EQUIPMENT													
Fusion Energy Research	•	•	•	•	•						•	•	•
Generator/Exciter	•	•					•	•					
H.V.D.C. Transmission		•	•								•		
Nuclear Fission	•	•	•	•						•	•		
Solar	•	•	•	•				•					
Uninterruptible Power Supplies (UPS)	•	•	•	•		•		•		•	•	•	
Wind Generators	•	•	•	•						•	•		
TRANSPORTATION SYSTEMS													
Electric Vehicle	•	•	•	•		•		•			•		
Elevator/Electric Stairway	•	•	•							•	•		
Locomotives	•	•	•	•						•	•		
Mass Transit	•	•	•	•						•	•		
People Movers	•	•	•	•						•	•		
INDUSTRIAL CONTROLS													
AC Motor Controls	•	•	•	•		•	•	•	•	•	•	•	
AC Motor Starters			•								•		
Air Conditioning	•	•	•	•						•	•	•	
Conveyor	•	•	•							•	•		
Crane & Hoist	•	•	•								•		
DC Motor Control	•	•	•	•		•	•	•	•	•	•	•	
Electric Discharge Machining (EDM)	•		•	•		•		•	•	•			
Electric Space Heating	•		•										
Furnace	•		•							•	•	•	
Heating & Melting	•	•	•	•				•		•	•	•	•
Lift Trucks	•	•	•	•									
Lighting	•	•	•	•					•	•	•		
Machine Tool	•	•	•	•		•		•	•	•			
Off Road Vehicles	•	•	•					•			•		
Off Shore Oil Well Drilling	•	•	•							•	•		
Power Factor Correction			•								•	•	
Pump & Pipeline	•	•	•	•					•	•	•	•	
Solid State Contactors	•		•							•	•	•	
Steel Mill Drives	•	•	•	•						•	•	•	
Welding, Capacitor Discharge	•		•	•						•	•	•	•
Welding, Resistance			•							•	•	•	
POWER SUPPLIES													
Accelerators	•		•								•	•	•
Aircraft	•	•		•		•	•	•					
Aluminum Reduction	•		•								•	•	
Anodizing	•		•							•	•	•	
Arc Heaters	•	•	•								•	•	
Battery Chargers	•		•						•	•	•		
Computer	•	•	•	•		•	•	•	•		•		
Consumer	•	•	•			•			•				
Dielectric Heating	•												•
Electrochemical	•		•								•	•	
Electroplating	•		•							•	•	•	
Electron Beam Welding			•								•		•
Electrostatic Precipitators			•								•		•
Induction Heating	•	•	•	•				•		•	•	•	•
Laser	•	•	•	•	•					•	•		•
Military	•	•	•	•	•		•	•		•	•		•
Mining Power Centers	•		•							•			
Radar/Sonar		•		•	•		•	•					•
Test Equipment	•	•	•	•		•	•	•	•	•	•	•	•
Transmitters, Radio & TV													•
Water Treatment	•		•							•	•	•	
Welding, Arc	•		•							•	•		

Table 1.1 APPLICATIONS FOR Ⓦ POWER SEMICONDUCTORS



2 SELECTING THE PROPER POWER SEMICONDUCTOR FOR YOUR APPLICATION

1. BASIC SEMICONDUCTOR PARAMETERS DEFINED

The primary tool for selecting the proper semiconductor to meet a given requirement is the technical data sheet. In order to use the data sheets effectively, one must first understand the significance of some of the more important parameters used in rating these semiconductors. The following apply to all types of semiconductors:

$T_{J(MAX)}$—Maximum allowable junction temperature. This is a very critical parameter upon which all device ratings are based. Typically, most SCR's have an upper operating junction temperature limit of 125°C(with some high temperature series up to 150°C capability); most transistors have an upper operating junction temperature limit in the range of 150°C to 175°C; and most rectifiers have an upper operating junction temperature limit in the range of 175°C to 200°C. If these respective values are exceeded, the device becomes vulnerable to rapid failure. Of course, proper derating below these maximum limits is necessary in the actual application to assure reliable performance.

$T_{c(MAX)}$—Maximum allowable case temperature. Since the user of semiconductors has no way of actually measuring the junction temperature inside of a device package, the case temperature becomes a practical, useful value which can be measured and monitored. As a result, data sheets usually show the current carrying capability of a device as a function of its case temperature. The case temperature is directly related to the junction temperature by the device characteristic, $R_{\theta JC}$ (thermal impedance).

$R_{\theta JC}$ —Thermal impedance, junction to case. $R_{\theta JC}$ is measured in degrees centigrade per watt and is determined by the device construction and materials used. This parameter indicates the ability of the device to transfer heat away from the junction and out through the device case—the lower the value, the better.

Other basic device parameters by family type that are essential for the semiconductor user to know in the selection effort are as follows:

Family Type	Input/ Control	Output	Losses	Overload	Other Special
RECTIFIERS	NONE	$I_{F(av)}$ (1) V_{RRM} (2)	V_{FM}, (3) I_{RRM} (4)	I_{FSM} (5)	t_{rr} (6)
SCR's	I_{GT} (6)	$I_{T(av)}$, (1) V_{RRM} (2)	V_{TM}, (3) I_{RRM} (4)	I_{TSM} (5)	di/dt, (7) dv/dt, (8) t_{on}, (9) t_q (10)
TRANSISTORS	I_B (6)	I_C, (1) V_{CE} (2)	$V_{CE(SAT)}$, (3) $V_{BE(SAT)}$, (4) I_{CEO} (5)	NONE	SOA, (7) t_{on}, (8) t_{off}, (9) h_{FE} (10)

Table 2.1 BASIC SEMICONDUCTOR DEVICE PARAMETERS

The following expansion of the items in the table explain their importance:

RECTIFIERS

(1) $I_{F(av)}$—Maximum full cycle average forward current (measured with an average reading meter) at a

specified case temperature. This is the maximum amount of current that can be controlled or rectified by any given device.

(2) V_{RRM} —Maximum repetitive peak reverse voltage. This is the maximum allowable voltage that a device will block in the reverse direction. An associated parameter, V_{RSM}, defines the device capability to withstand non-repetitive reverse voltage peaks of less than five millisecond duration. This parameter typically ranges from zero to 25% above the repetitive values.

(3) V_{FM} —Maximum forward voltage drop at a specified forward current and device case temperature. The large majority of the losses in a rectifier are due to the forward voltage drop. Therefore, low forward drops are very desirable in high power devices because less power is dissipated ($P=V_{FM} \times I_{F(av)}$).

(4) I_{RRM} —Maximum reverse leakage current at V_{RRM}. Low reverse leakage currents are desirable for the same reason as a low V_{FM}, less power (watts) to be dissipated ($P=V_{RRM} \times I_{RRM}$).

(5) I_{FSM} —Maximum one-half cycle ($60H_Z$) peak surge current (under load). Ability to withstand current surges in excess of the rated operating current extends the application capability of a rectifier. This characteristic is non-repetitive in nature and, by definition, may occur only 100 times within the life of the device. An associated parameter, I^2t, is used to coordinate sub-cycle fuse clearing time with sub-cycle fault rating of a rectifier.

(6) t_{rr} —Maximum reverse recovery time relates to the time required for the reverse current spike to dissipate after a rectifier stops conducting forward current. This characteristic is especially important on a class of rectifiers called "fast recovery" devices. Because all rectifiers are essentially "self-operated" switches, they have finite switching times. This characteristic becomes important when one wishes to rectify (or switch) at high frequencies.

SCR's

(1) $I_{T(av)}$ —Maximum allowable average forward current at a specified conduction angle and case temperature. If a conduction angle of 180° is specified, this parameter would be the same as $I_{F(av)}$ in a rectifier. However, unlike a rectifier, the conduction angle of an SCR can be controlled from 0 to 180° (typically, a data sheet lists five or six of these angles). The conduction angle defines that part of the sine wave during which the device is conducting current.

(2) V_{RRM} —Maximum repetitive reverse blocking voltage. The same comments apply here as for V_{RRM} of a rectifier. The SCR in addition to having reverse blocking capability will also block voltage in the forward direction. V_{DRM} is the designation for the maximum value of repetitive forward blocking voltage. Most SCR designs are symmetrical in nature—that is, the forward and reverse repetitive blocking voltage capabilities for a given device are equal ($V_{DRM} = V_{RRM}$). Both repetitive voltage ratings (V_{RRM} V_{DRM}) have corresponding non-repetitive voltage ratings, V_{RSM} and V_{DSM}

(3) V_{TM} —Maximum forward voltage drop at a specified forward current and device case temperature. The same comments apply here as for V_{FM} in a rectifier.

(4) I_{RRM} —Maximum reverse leakage current at V_{RRM}. Again, as with a rectifier, low leakage currents, I_{RRM}, are desirable as less power will be dissipated in the blocking (off-state) mode. In addition, as an SCR has repetitive forward voltage capability, V_{DRM}, it also has a forward leakage current, I_{DRM}

(5) I_{TSM} —Maximum peak surge current for a given number of cycles at $60H_Z$. As with a rectifier, this characteristic is by definition non-repetitive and may occur only 100 times within the life of the device. In addition, following this current surge, the repetitive forward blocking voltage, V_{DRM}, is not guaranteed. This subject is treated in more detail in the Ⓦ Thyristor Surge Suppression Ratings Application Data Sheet in the General section of the Data Book. An associated parameter, I^2t, is used for fuse coordination.

(6) I_{GT} —Minimum DC gate current to trigger (turn-on) an SCR at stated conditions of temperature and forward blocking voltage. This characteristic specifies the absolute minimum amount of current that must be provided from a logic source to switch an SCR from blocking voltage (off-state) to conducting current (on-state). For more information, see the SCR Gate Turn-on Characteristics Application Data Sheet in the General section of the Data Book.

(7) di/dt—Maximum rate of rise of peak current allowable with respect to time during SCR turn-on. Because an SCR requires a finite time to turn on, only a very small area of the junction is conducting current at the instant the device is triggered on. If the current is building up very quickly, it must all go through this very small area. When the specified di/dt limit is exceeded, the device can develop a hot spot which can destroy the unit. This is generally not a problem in $60H_Z$ phase control applications but becomes a problem in DC switching applications (e.g. inverters) or in capacitor discharge circuits. When comparing di/dt ratings of different manufacturers be sure the ratings are both repetitive or nonrepetitive and that the ratings are based on the same set of test conditions.

(8) dv/dt—Minimum rate of rise of peak voltage with respect to time which will cause switching from the off-state to the on-state. When the dv/dt limit is exceeded, the potential danger exists of turning the SCR back on when it should remain off. As with di/dt this is generally only a problem in square wave or step function applications. Review all test conditions when comparing dv/dt ratings of different manufacturers—dv/dt can be expressed as either a linear or an exponential function.

(9) t_{on} —Time required for the forward current to reach 90 percent of its final (or maximum) value when switching from the off-state to the on-state under specified conditions. Switching times are important for two reasons—they affect the upper frequency at which the device may be operated and to some degree they determine the system efficiency. When considering frequency of operation (or in pulse applications, the desired pulse width), it becomes simply a matter of whether or not the device can be turned on and off fast enough to satisfy the requirements. Power losses when switching from blocking voltage to conducting current can be a significant consideration for determining system efficiency.

(10) t_q —Turn-off time relates to the time required for an SCR to switch from conducting current to blocking forward voltage. Turn-off time is important for essentially the same reasons as turn-on time. Turn-off time is not critical in most 60 cycle phase control applications; however, a special class of SCR's called "fast switching" devices are used in inverters, choppers, and other high frequency circuits. In these types of applications, the designer must be careful to select a device offering the optimum combination of current handling capability, voltage blocking capability, and turn-off time capability. Due to the wide variety of fast switching applications, data sheet turn-off conditions do not necessarily reflect actual circuit operating conditions. Contact Ⓦ if help is needed in selecting the proper device.

TRANSISTORS

(1) I_C —Collector current. In most applications, this is the current that is manipulated to perform some desired function. In a series regulator, for example, the collector current can be increased or decreased by base current control, depending upon what the load requires.

(2) V_{CE} —Collector-to-emitter voltage. This is similar to V_{RRM} in rectifiers and SCR's in that it represents the device blocking capability in the off-state. There are many related designations: V_{CEO}, V_{CES}, V_{CER}, etc. They differ only in the third subscription letter which indicates the condition of the base: O-open, R-resistor, S-shorted, etc.

(3) $V_{CE(SAT)}$ —Collector-emitter saturation voltage. When driving the base of a transistor, a point is reached where increased base current no longer results in decreased collector-emitter voltage. This is saturation. $V_{CE(SAT)}$ is a measure of the voltage across that junction under saturation and is comparable to forward voltage drop in rectifiers and SCR's. $V_{CE(SAT)}$ and I_C lead to power losses in the transistor during saturated operation and therefore, are important considerations.

(4) $V_{BE(SAT)}$ —Base-emitter saturation voltage. The same general comments apply here as for $V_{CE(SAT)}$ except the comments now refer to a base-emitter rather than a collector-emitter condition. High $V_{BE(SAT)}$ or large variations in $V_{BE(SAT)}$ will cause corresponding changes in $V_{CE(SAT)}$

(5) I_{CEO} —Collector-to-emitter leakage current with the base open. This is usually the primary leakage loss in a transistor. This characteristic is comparable to I_{RRM} in rectifiers or SCR's. While low values of leakage are desirable to minimize power losses, low leakage is not necessarily synonymous with reliability.

(6) I_B —Base current. The function of the base current in a transistor is similar to that of the gate current in an SCR. However, in a transistor, current must be provided into the base as long as the transistor is to be kept on, whereas, the SCR only requires an initial pulse of current to turn it on.

(7) SOA—Safe Operating Area. SOA is a voltage-current plot which describes an area in which the transistor can operate safely. A time limit is given for the collector voltage and collector current that can occur simultaneously in the transistor. Forward bias SOA ratings require the base-emitter to be forward-biased throughout the time that the peak power condition exists and is usually measured in a resistive circuit. A related term is forward current stability, denoted by the symbol I_{SB}. Safe operation of a transistor during inductive switching when a transistor in series with an inductor is turning off necessitates consideration of additional characteristics. The inductance will keep current flowing for some period of time. During this time, the voltage is increasing across the transistor creating a VxI product or power dissipation. Because the base-emitter is reverse-biased, the transistor cannot dissipate as much power. The energy that a transistor can support is denoted by the abbreviation E_{SB}. Inductive switching ratings can be used as a guide to compare transistor capabilities, but actual capabilities must be verified in the actual circuit.

(8) & (9) t_{on} & t_{off} —Turn-on time and turn-off time. These are important parameters in transistors for essentially the same reasons given in the SCR remarks.

(10) h_{FE} —DC current gain under specified conditions of collector current and collector-emitter voltage. This transistor characteristic is the ratio of DC collector current to DC base current. This amplification factor determines the amount of output (I_C) that is generated by a given input (I_B). For example, if h_{FE} is 20 at I_B =1 ampere, then I_C is 20 amperes.

2. CONFUSING TERMINOLOGY—MANUFACTURER VERSUS USER INTERPRETATION

Many users and designers have either been lucky or have learned the hard way how to properly interpret a semiconductor manufacturer's data sheet. Unfortunately, many conventional semiconductor terms and definitions can have double meanings, depending upon whether they are being interpreted from the manufacturer's or the user/designer's point of view. What a semiconductor manufacturer might define as a maximum (minimum) value on a data sheet could well be a minimum (maximum) value for the designer and user. A few examples utilizing SCR terminology will illustrate this dilemma:

Data Sheet Terminology	User or Designer's Interpretation Might Be	Semiconductor Mfgr's Actual Meaning	Remarks
(1) Maximum I_{GT} = 150 ma	Does this mean that no more than 150 ma is needed to turn-on these SCR's?	All SCR's supplied will have gate currents less than or equal to 150 ma. User must supply *more than* 150 ma to assure proper SCR turn-on. In fact, 3 to 5 times as Max. I_{GT} is desirable for SCR turn-on in certain applications.	Here, a value defined as maximum by the manufacturer is for the user or designer, an absolute minimum design limit.
(2) Maximum blocking or off-state voltage V_{DRM}, V_{RRM} =1200 volts.	Does this mean that some devices received will block or support less than 1200 volts?	All devices supplied will support *at least* 1200 volts; however, this limit *cannot* be exceeded in the application.	In this case, the manufacturer's maximum is also, the designer's or user's maximum limit.
(3) Minimum di/dt – 200 A/μs	Does this mean that 200 A/μs can be exceeded in a given application?	All devices supplied will withstand a rate of current rise (di/dt) of *at least* 200 A/μs; however, this limit *cannot* be exceeded in the application.	Here, the manufacturer's minimum value becomes the user's or designer's maximum design limit.
(4) Typical turn off time t_q = 40μs	Can this typical turn-off time be relied on in a given application?	This 40μs turn-off time *only* represents an average value for the product family and is *not* a guaranteed limit.	Typical values should *not* be relied upon by the designer or user as guaranteed values.

Table 2.2 Confusing Data Sheet Terminology

Realistically, data sheets should be written from the user and designer's view point rather than the manufacturer's device-oriented point of view—however, since most users and designers have been "weaned" on this existing terminology, a change in philosophy would create only more confusion. To help those who have yet to conquer data sheet terminology, the following suggestions are offered:

The safest way to interpret a *maximum* or *minimum* data sheet limit is to recognize that (1) they *both* represent *worst case* designer or user conditions, (2) they *both* are *guaranteed* by the semiconductor manufacturer. As for "typical" values, don't rely on them as maximum or minimum design limits in an application. If a "worst case" limit rather than a "typical" value is needed for a particular application, have the semiconductor manufacturer guarantee the design limit needed either by actual testing or written certification. If still in doubt about how to interpret a given data sheet parameter, call the semiconductor manufacturer for clarification.

3. HOW TO USE THE WESTINGHOUSE DATA BOOK

There are four easy ways to locate technical data in the Westinghouse Data Book:

Device Type Number Search

(1) IF ONLY THE PRODUCT TYPE NUMBER IS KNOWN:

Go to the Master Cross Reference Type Number Index in the GENERAL section of the Data Book. Using this JEDEC and alpha/numeric industry index, the reader can rapidly locate any power semiconductor product type number for which Westinghouse offers an exact or suggested replacement along with the page number of the recommended Westinghouse product data.

(2) IF BOTH THE PRODUCT FAMILY AND THE PRODUCT TYPE NUMBER ARE KNOWN:

Go the the alpha/numeric Product Type Number index at the beginning of the approprate generic PRODUCT section (Assemblies, Rectifier, Thyristor-SCR's and RBDT, or Transistors). Using this index, the reader can turn directly to the page location of a given product type number.

General Application Search

(3) IF A SPECIFIC PRODUCT APPLICATION REQUIREMENT IS KNOWN:

Go to the appropriate PRODUCT section (Assemblies, Rectifier, Thyristor-SCR's and RBDT, or Transistors), look under the appropriate product subgroup (i.e. General Purpose or Fast Recovery for Rectifiers), and scan the Product Capability Graphs and Product Selector Guides. These graphs and guides are presented in order of increasing average current so the reader can quickly locate a suitable Westinghouse product type and corresponding page number data location.

(4) IF BOTH A SPECIFIC PRODUCT APPLICATION REQUIREMENT AND THE DESIRED PRODUCT PACKAGE IS KNOWN:

Go to the Ⓦ Data Book Table of Contents for the location of the appropriate PRODUCT section, product subgroup, and package type. The page number shown marks the beginning of the desired data section; the data for a given package type is listed in order of increasing average current rating to simplify the reader's search.

4. KNOW YOUR APPLICATION REQUIREMENTS

Many applications using general purpose rectifiers or transistors and phase control SCR's require the user only to consider such basic parameters as current, voltage, and temperature when developing a new design, working on a conversion or an equipment upgrade, or looking for a replacement device. However, there can be many secondary parameters which can adversely affect desired equipment operation—especially if devices are used in series and/or parallel combinations. Most fast recovery rectifiers, high power switching transistors, and fast switching SCR's require close scrutiny by the user on essentially *all* device parameters to assure proper equipment operation.

To assist the user in selecting the proper power semiconductor for a given application, Westinghouse has developed a series of Application Checklist/Work Sheets in the following areas: (1) General Purpose and Fast Recovery Rectifiers (2) Phase Control SCR's (3) Fast Switching SCR's (4) Power Transistors (5) Assemblies. To use a particular form, simply make a xerox copy and fill it out. With your application requirements down on paper in a logical order, it will be easier to locate a suitable device by self-selection or by calling or writing the semiconductor manufacturer for a device recommendation.

P.S. Even if you have already selected a device yourself, it might be worthwhile getting a confirmation from the manufacturer.

To assist the user in searching for replacement devices, a handy Device Identification Checklist has been developed. A copy of this form is presented on page 54.

GENERAL PURPOSE AND FAST RECOVERY RECTIFIER APPLICATION CHECKLIST

(Make copy for each use)

1. APPLICATION: ______________________

____

2. CIRCUIT:

Sketch circuit (showing all component values including inductances) or attach drawing

3. CIRCUIT VOLTAGE:

- Maximum reverse voltage across rectifier ______ V
- Maximum expected transient voltage ______ V
- Desired voltage safety factor ______
- Preferred rectifier device voltage rating ______ V
- Other ______________ ______

4. CIRCUIT CURRENT: (sketch waveform(s) on back of page)

- Average forward current* ______ A
  - Waveform and frequency ______
  - Duty cycle ______ %
- Overload peak current (waveform) ______ A
  - Duty cycle ______ %
  - Pulse width ______
  - Resume operation following overload □ YES □ NO
- Peak surge current (waveform) ______ A
  - Pulse width ______
  - Number of cycles ______
- Other ______________ ______

*If paralleling is required, state method of current sharing ____

5. THERMAL:

- Cooling Medium (check one) -
  - □ AIR - □ Natural Convection, altitude ____ feet or
    - □ Forced ______ LFM ______ CFM**

**Duct cross-sectional area ____

  - □ WATER - ______ GPM flow rate
  - □ OIL (immersed) - Type ____ Manufacturer ________
  - □ OTHER ______________
- Cooling medium maximum temperature, °C ______
- If heat sink is known, specify $R_{\theta SA}$ ______ °C/W.
- Other thermal considerations

6. MECHANICAL:

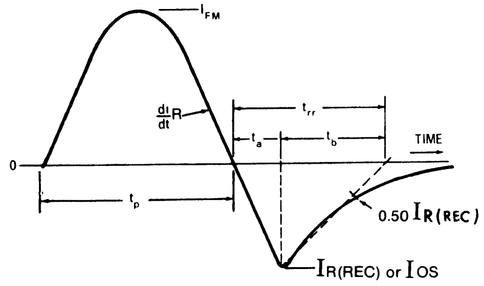
- Desired package type (check one) -
  - □ LEAD MOUNT
  - □ STUD MOUNT - { □ STANDARD POLARITY OR □ REVERSE POLARITY }
  - □ DISC MOUNT
  - □ OTHER
  - □ NO PREFERENCE
- Special size, weight, or other restrictions ______________

____

FOR APPLICATIONS REQUIRING FAST RECOVERY CHARACTERISTICS, COMPLETE THE FOLLOWING SECTION -

7. RECOVERY CHARACTERISTICS: (If required, sketch waveform(s) on back of page)

- Maximum reverse recovery time allowable, t_{rr} ________
- Recovery time, t_a ________
- Recovery time, t_b ________
- Maximum overshoot current, $I_{R(REC)}$ ________ A
- Peak current, I_{FM} ______ A
- Pulse width, t_p ________
- Rate of current fall, di_R/dt ______ A/µs
- Waveform ____________
- Maximum junction temperature ______ °C



8. PROJECT REQUIREMENTS: Quotation Due Date ______

- Quantity Required ______
- Timetable ______
- Long-range Potential ______
- Other Remarks ______

____

____

□ Special screening and/or high reliability test requirements are attached.

□ Also quote on this application using Ⓦ assemblies.

Person Requesting Information

Name ______________

Phone ______________ X ____

Job Function ______________

Company ______________

Address ______________

City ______________ State ____

Bldg. ______________ Zip ____

Please complete a copy of this form for each different application. Forward this form to Westinghouse Electric Corporation, Semiconductor Division, Attention: Sales Department, Youngwood, Pa. 15697 for complete quotation. If you need faster service, please call (412) 925-7272 for a quote.

PHASE CONTROL SCR APPLICATION CHECKLIST

(Make copy for each use)

1. APPLICATION: ____________________

____

2. CIRCUIT:
Sketch circuit (showing all component values including inductances) or attach drawing

3. CIRCUIT VOLTAGE:

- Maximum peak forward and/or reverse voltage across SCR ______ V
- Maximum expected transient voltage ______ V
- Desired voltage safety factor ______
- Preferred SCR voltage rating ______ V
- Other ____________ ______

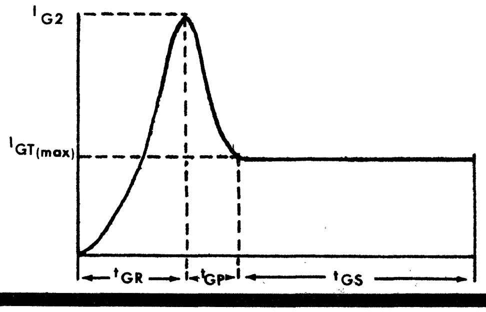
4. CIRCUIT CURRENT: (sketch waveform(s) on back of page)

- Maximum continuous SCR current* - ☐DC, ☐AVERAGE, or ☐RMS ______ A
- Phase - ☐1φ, ☐3φ, ☐6φ, or ☐OTHER ____________
- Conduction angle - ☐Sine or ☐Square, degrees ______
- Current waveform, frequency, and duty cycle ______
- Overload peak current (waveform) ______
  - Duty Cycle ______ %
  - Pulse Width ______
  - Resume Operation Following Overload ☐YES ☐NO
- Peak surge current (waveform) ______ A
  - Pulse Width ______
  - Number of Cycles ______
  - Assymetry (L/R ratio) ______
- Other ____________ ______

*If paralleling is required, state method of current sharing: ______

5. GATE DRIVE AVAILABLE:

- I_{G2} ____________ A
- t_{GP} ____________ μs
- t_{GR} ____________ μs
- t_{GS} ____________ μs
- I_{GT} (max) 25°C ____________ ma
- Forward gate source voltage ____________ V



6. THERMAL:

- Cooling Medium (check one) -
  - ☐ AIR - ☐ Natural Convection, altitude ______ feet or
    - ☐ Forced ______ LFM ______ CFM **

    **Duct cross-sectional area ______
  - ☐ Water - ______ GPM flow rate
  - ☐ OIL (immersed) - Type ______ Manufacturer ______
  - ☐ OTHER - ____________
- Cooling medium maximum temperature, °C ______
- If heat sink is known, specify R_{Θ} SA ______ °C/W.
- Other thermal considerations ____________

____

7. MECHANICAL:

- Desired package type (check one) -
  - ☐ STUD MOUNT
  - ☐ DISC MOUNT
  - ☐ INTEGRAL HEAT SINK
  - ☐ FLAT BASE
  - ☐ OTHER ____________
  - ☐ NO PREFERENCE
- Special size, weight, or other restrictions ____________

____

8. PROJECT REQUIREMENTS: Quotation Due Date ______

- Quantity Required ______
- Timetable ______

Long-range Potential ______

- Other Remarks ______

______

______

☐ Special screening and/or high reliability test requirements are attached.
☐ Also quote on this application using (W) assemblies.

Person Requesting Information

Name ____________

Phone ____________ X ______

Job Function ____________

Company ____________

Address ____________

City ____________ State ______

Bldg. ____________ Zip ______

Please complete a copy of this form for each different application. Forward this form to Westinghouse Electric Corporation, Semiconductor Division, Attention: Sales Department, Youngwood, Pa. 15697 for complete quotation. If you need faster service, please call (412) 925-7272 for a quote.

ⓦ FAST SWITCHING SCR APPLICATION CHECKLIST

(Make copy for each use)

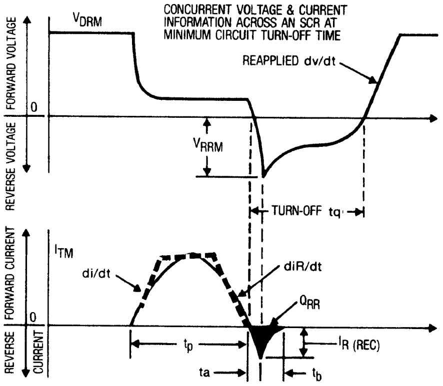
1. APPLICATION: ____________________

____

2. CIRCUIT:
Sketch circuit (showing all component values including inductances) or attach drawing

3. CIRCUIT VOLTAGE:

- Peak forward blocking voltage, V_{DRM} ______ V
- Peak reverse blocking voltage, V_{RRM} ______ V
- Maximum expected transient voltage ______ V
- Desired voltage safety factor ______
- Preferred SCR voltage rating ______ V
- Other ____________________ ______



4. CIRCUIT CURRENT*: (if required, sketch waveform(s) on back of page)

Worst Case Pulsewidth Conditions

- Maximum peak current, I_{TM} ______ A
  - Pulsewidth, t_p ______ μs
  - Waveshape ______
- Initial rate of current rise, di/dt ______ A/μs
- Rate of current fall, di_R/dt ______ A/μs
- Reverse recovered charge, Q_{RR} ______ μcoul.
  - Max, overshoot current $I_{R(REC)}$ ______ A
  - Recovery time, t_a ______ μs
  - Recovery time t_b ______ μs
- Peak surge current (waveform) ______ A
  - Pulsewidth ______
  - Number of cycles ______
  - Assymetry (L/R ratio) ______
- Other ____________________ ______

*If paralleling is required, state method of current sharing: ______

5. SWITCHING:

- □ Soft Commutation or □ Hard Commutation
- Maximum available turn-off time, t_q ____ μs @ T_J ______ °C
- Reapplied dv/dt ______ V/μs
- Maximum operating frequency ______ or duty cycle ______ %

6. GATE DRIVE AVAILABLE:

- I_{G2} ______ A • t_{GP} ______ μS
- t_{GR} ______ μS • t_{GS} ______ μS
- $I_{GT\ (max)}$ @ 25 °C ______ ma
- Forward gate source voltage ______ V

7. THERMAL:

- Cooling Medium (check one) -
  - □ AIR - □ Natural Convection, altitude ____ feet or
    □ Forced ______ LFM ______ CFM **

    ** Duct cross-sectional area ______
  - □ WATER - ______ GPM flow rate
  - □ OIL (immersed) - Type ______ Manufacturer ______
  - □ OTHER - ____________________
- Cooling medium maximum temperature, °C ______
- If heat sink is known, specify $R_{\theta SA}$ ______ °C/W.
- Other thermal considerations ____________________

8. MECHANICAL:

- Desired package type (check one) -
  - □ STUD MOUNT
  - □ DISC MOUNT
  - □ INTEGRAL HEAT SINK
  - □ FLAT BASE
  - □ OTHER ____________________
  - □ NO PREFERENCE
- Special size, weight, or other restrictions ______

9. PROJECT REQUIREMENTS: Quotation Due Date ______

- Quantity Required ______
- Timetable ______

Long-range Potential ______

- Other Remarks ______

______

______

□ Special screening and/or high reliability test requirements are attached.
□ Also quote on this application using ⓦ assemblies.

Person Requesting Information

Name ______

Phone ______ X ____

Job Function ______

Company ______

Address ______

City ______ State ____

Bldg. ______ Zip ____

Please complete a copy of this form for each different application. Forward this form to Westinghouse Electric Corporation, Semiconductor Division, Attention: Sales Department, Youngwood, Pa. 15697 for complete quotation. If you need faster service, please call (412) 925-7272 for a quote.

TRANSISTOR APPLICATION CHECKLIST
(Make copy for each use)

1. APPLICATION: ______________________

____

2. CIRCUIT: Sketch circuit (show all component values including inductances) or attach drawing

3. CIRCUIT VOLTAGE:

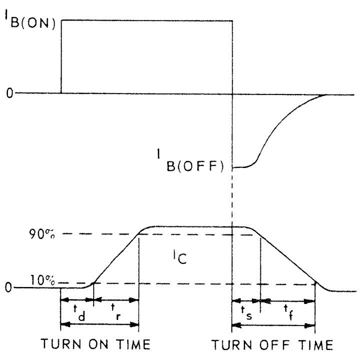
- Source voltage _____ V
- Maximum circuit voltage across transistor _____ V
  ☐ clamped or ☐ unclamped
- Maximum expected transient voltage _____ V
- Maximum emitter base reverse voltage during operation _____ V
- Desired voltage safety factor _____
- Preferred transistor voltage rating _____ V
- Other _____________ _____

4. CIRCUIT CURRENT: (Include load line sketch w/unclamped inductances specified)

- Maximum collector current* _____ A
- Collector current duty cycle ____% and frequency _____ Hz
- Current gain _____
- Other _____________ _____

*If paralleling is required, state method of current sharing ____

5. SWITCHING:



- Maximum base current, $I_{B(ON)}$ _____ A
- Maximum base current, $I_{B(OFF)}$ _____ A
- Turn-off base supply voltage _____ V
- Turn-on delay time, t_d _____ μs
- Turn-on rise time, t_r _____ μs
- Turn-off storage time, t_s _____ μs
- Turn-off fall time, t_f _____ μs
- Maximum junction temperature _____ °C

6. THERMAL:

- Cooling Medium (check one) -
  ☐ AIR - ☐ Natural Convection, altitude _____ feet or
  ☐ Forced _____ LFM _____ CFM**

  ** Duct cross-sectional area _____

  ☐ WATER - _____ GPM flow rate

  ☐ OIL (immersed) - Type _____ Manufacturer _____

  ☐ OTHER - _____________
- Cooling medium maximum temperature, °C _____
- If heat sink is known, specify Rθ SA _____ °C/W.
- Other thermal considerations _____________

  ____

7. MECHANICAL:

- Desired package type (check one) -
  ☐ DIAMOND MOUNT (TO-66/TO-3)
  ☐ STUD MOUNT
  ☐ DISC MOUNT
  ☐ OTHER _____________
  ☐ NO PREFERENCE
- Special size, weight, or other restrictions _____________

  ____

8. PROGRAM REQUIREMENTS: Quotation Due Date _____

- Quantity Required _____
- Timetable _____

Long-range Potential _____

- Other Remarks _____

____

____

☐ Special screening and/or high reliability test requirements are attached.
☐ Also quote on this application using Ⓦ assemblies.

Person Requesting Information

Name _____________

Phone _____________ X ____

Job Function _____________

Company _____________

Address _____________

City _____________ State ____

Bldg. _____________ Zip ____

Please complete a copy of this form for each different application. Forward this form to Westinghouse Electric Corporation, Semiconductor Division, Attention: Sales Department, Youngwood, Pa. 15697 for complete quotation. If you need faster service, please call (412) 925-7272 for a quote.

ASSEMBLY APPLICATION CHECKLIST

(Make copy for each use)

1. APPLICATION: ____________________

____

2. CIRCUIT:
Sketch circuit (showing all component values including inductances) or attach drawing

3. CIRCUIT VOLTAGE:

- Maximum forward and/or reverse voltage across assembly ______ V
- Maximum expected transient voltage ______ V
- Desired voltage safety factor ______
- Preferred assembly voltage rating ______ V
- Other ____________________ ______

4. CIRCUIT CURRENT: (sketch waveform(s) on back of page)

- Maximum output current* — ______ A
  □ AVG., □ RMS, or □ PEAK
  - Waveform and frequency ______
  - Duty cycle ______ %
- Overload peak current (waveform) ______ A
  - Duty cycle ______ %
  - Pulse width ______
  - Resume operation following overload □ YES □ NO
- Peak surge current (waveform) ______ A
  - Pulse width ______
  - Number of cycles ______
- Transformer KVA and percent impedance ___ / ___ %
- Other ____________________ ______

*If paralleling is required, state method of current sharing: ______

5. THERMAL:

- Cooling Medium (check one) -

  □ AIR - □ Natural Convection, altitude ______ feet or
  □ Forced ______ LFM ______ CFM **

  □ WATER - ______ GPM flow rate

  □ OIL (immersed) - Type ______ Manufacturer ______

  □ OTHER - ____________________
- Cooling medium maximum temperature, °C ______
- Other thermal considerations ____________________

  ____

** Duct cross-sectional area ______

6. MECHANICAL:

- Special semiconductor device package requirements □ YES □ NO

  If YES, specify desired package type ____________________
- List any size, weight, mounting, or other requirements ______

  ____

  ____

7. PROJECT REQUIREMENTS: Quotation Due Date ______

- Quantity Required ______
- Timetable ______

Long-range Potential ______

- Other Remarks ______

____

____

□ Special screening and/or high reliability test requirements are attached.

Person Requesting Information

Name ____________________

Phone ______ X ______

Job Function ____________________

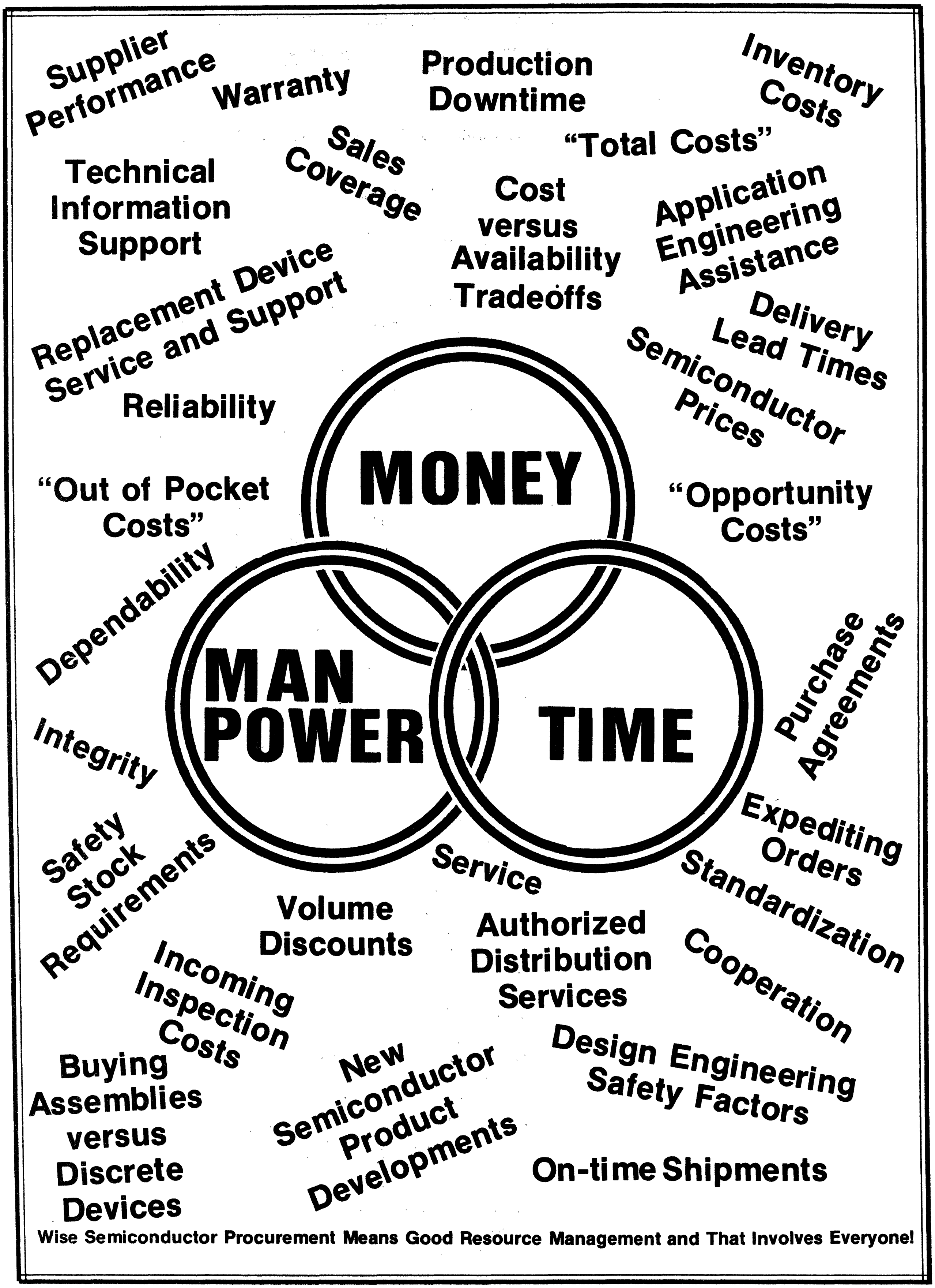
Company ____________________

Address ____________________

City ______ State ______

Bldg. ______ Zip ______

Please complete a copy of this form for each different application. Forward this form to Westinghouse Electric Corporation, Semiconductor Division, Attention: Sales Department, Youngwood, Pa. 15697 for complete quotation. If you need faster service, please call (412) 925-7272 for a quote.


Supplier Performance
Warranty
Production Downtime
Inventory Costs
Sales Coverage
"Total Costs"
Technical Information Support
Cost versus Availability Tradeoffs
Application Engineering Assistance
Replacement Device Service and Support
Delivery Lead Times
Semiconductor Prices
Reliability
MONEY
"Out of Pocket Costs"
"Opportunity Costs"
Dependability
MAN POWER
TIME
Purchase Agreements
Integrity
Expediting Orders
Safety Stock Requirements
Service
Standardization
Volume Discounts
Authorized Distribution Services
Cooperation
Incoming Inspection Costs
Buying Assemblies versus Discrete Devices
New Semiconductor Product Developments
Design Engineering Safety Factors
On-time Shipments
Wise Semiconductor Procurement Means Good Resource Management and That Involves Everyone!

3 SEMICONDUCTOR PROCUREMENT

1. SPEND SEMICONDUCTOR DOLLARS WISELY.

Each user must consider several facets of device and supplier capability in order to make intelligent procurement decisions concerning power semiconductors. Suggestions for evaluation of the "total" value of a power semiconductor supplier are provided in Section 2. Section 1 deals briefly with other suggestions for consideration prior to selecting a device and placing an order: (1) "total" cost, including costs over and above the price of the device and (2) engineering-related financial considerations, such as efficiency, reliability, and device availability versus electrical capability.

Total Cost. The price of a power semiconductor is certainly one of the major items for consideration prior to selection of a device to satisfy the user's needs. However, a user must also consider other costs in order to optimize "total" cost. Packaging, transportation, insurance charges, and hardware requirements associated with a device are easily measurable, although often disregarded. Other total cost considerations are not measured as easily, but can prove to be very significant alternatives. For example, blanket contracts, blanket orders, letters of intent, and other types of purchase agreements are generally vehicles used to obtain lower device prices, however, these agreements help to reduce other cost factors. When a power semiconductor manufacturer has advance knowledge of on-going user requirements, better planning is possible. The net result is improved reproducibility, reduced delivery lead time which helps to minimize user safety stock, and better on-time shipping performance.

Often when a user buys several different semiconductor type numbers in the same product family, a savings can be obtained by ordering only the best rated unit (current, voltage, etc.) for all needs, thus qualifying for a larger volume price discount. Combining purchases for device types of different voltage ratings is usually the most practical way to achieve a higher volume price discount (this is especially true for the lower voltage ratings of a given product type); sometimes combining various current ratings of the same package type will also result in savings. If in doubt, ask the manufacturer to review your semiconductor procurement list and recommend the most economical purchase option. The manufacturer will be glad to help since it is easier to fill one large order for a single device type than many small orders for different part numbers. In addition, the user saves time and money in incoming inspection, inventory costs, improved delivery performance, and standardization of parts.

Another frequently overlooked cost factor relates to special handling. Costly set-up charges can be avoided and better price stability and shorter delivery lead times can be realized if the user limits the number of releases and maximizes release quantities for each device. A decision to enter an order through an authorized distributor to avoid the generally higher minimum release of a manufacturer can often be a reduction in total cost even though the individual device price may be higher; however, beware of counterfeit rebranded devices. Deal only with *authorized* distributors. Trying to save a few dollars on a unit price basis can add significantly to total costs if the devices are determined to be defective at a later date. Extra inspection steps, such as a requirement for government source inspection, also can cause delayed shipments and increased costs because of delays incurred while waiting for arrival of inspectors.

Engineering Related Financial Considerations. Efficiency of equipment, cost of maintenance, reliability, and the cost of auxiliary and protective circuitry are significant items for review in order to obtain a true picture of the cost of a particular power semiconductor. It is often difficult to determine a dollar value for each of these factors, but each item must be considered, nonetheless, if an intelligent procurement decision is to be made.

In a field of rapid technological improvement such as power semiconductors, new devices are introduced at frequent intervals. A single new device often replaces two or more existing device types and/or procurement of new completely tested assemblies of devices on heat sinks (where semiconductor purchase dollars may rise, but total equipment costs decline) is often more economical for the user than handling individual parts. Review of the latest available devices is, therefore, an essential ingredient in wise power semiconductor procurement.

The user must also determine the optimum trade-off between electrical parameters as these parameters relate to the ability of the device manufacturer to reproduce devices consistently. For example, selection of a fast switching SCR often requires trade-offs among blocking voltage, current rating, and turn-off time to assure availability in large quantities.

Adequate safety factors on device ratings are another significant cost-related design consideration. Manufacturers of power semiconductors normally warrant products to meet specific electrical parameters. The designer must apply safety factors to assure the integrity of the application, but application of excessive safety factors can be costly.

Power semiconductor manufacturers spend considerable time and money to develop device families with useful, user-acceptable, ratings. When possible, users should attempt to incorporate these "standard" devices into applications to assure themselves of the best price and product availability. Special electrical test requirements and/or mechanical modifications normally add to cost and delivery lead times.

2. EVALUATING A POWER SEMICONDUCTOR SUPPLIER

The traditional method for evaluating the value of a supplier-price, delivery, service (P,D,S)—is a gross oversimplification of the measurement criteria. The P,D,S rule could cause one to "short change" oneself and prevent the company from realizing the total value of capabilities and services offered by truly good suppliers. Eighteen key items to be used for comparing suppliers have been identified and discussed below under four major categories—General Support, Pre-Order Period, Order Period, and Post-Order Period (see Table 3.1).

Each of the categories (or each of the individual items) must be weighted according to the needs or requirements of each user organization. That user must then evaluate each available supplier for the most important categories (or items). The manufacturer(s) scoring the highest total rating represents the best "total value" supplier to the user.

This method for evalution is presented as a tool to aid in the selection of a supplier. The method is not simply a means of reducing the values of a supplier to a numerical score; the purpose is to identify and quantify the key areas where potential power semiconductor supplier(s) can represent real value to a user.

GENERAL SUPPORT
- —Sales coverage
- —Distributor support
- —Technological leadership
- —Product reproducibility

PRE-ORDER PERIOD
- —Technical information support
- —Application engineering assistance
- —Sample/prototype service
- —Quotation response
- —Competitive price and delivery

ORDER PERIOD
- —Order acknowledgement
- —Customer information service
- —On-time shipments
- —Advance warning of shipping delays
- —Condition of shipments

POST-ORDER PERIOD
- —Reliability
- —Settlement of claims
- —Warranty
- —Replacement of obsolete device types

Table 3.1 Supplier Evaluation Checklist

GENERAL SUPPORT

Sales coverage is the primary link between a power semiconductor manufacturer and the user. A good factory salesperson or manufacturer's representative is a problem solver, not merely an "order taker". A good salesperson is knowledgeable about the total product offering and service capability of the manufacturer and can therefore resolve pre-order, order, or post-order problems or obtain anwers to questions that might arise during these periods.

Distributor support is an important factor in complete service support. Authorized distributors supply local, reliable service for production as well as emergency requirements by providing ample inventories and many value-added features. In addition, these distributors offer a broad spectrum of complimentary products.

Technological leadership assures the user that product which is purchased is manufactured with modern techniques and exhibits state-of-the-art electrical parameters and mechanical configurations. Power semiconductor manufacturers invest millions of dollars annually to keep products and processes up-to-date. New generations of devices or redesigned, upgraded versions of existing products can drastically affect the competitive market position of the user. New power semiconductors can lower or at least maintain equipment costs, offer improved energy utilization, support a cleaner, quieter environment, provide greater system reliability, reduce equipment size and weight, provide increased safety to equipment operators and employees, and can offer new and expanded operating capabilities. Since successful users must incorporate new technologies in equipment in order to remain competitive, they must be extremely conscious of the technological leadership qualities of their power semiconductors suppliers.

Product reproducibility is an often overlooked, but extremely important term for evaluation of power semiconductor manufacturers. Many design engineers have experienced the unfortunate situation of designing a system which incorporates a new state-of-the-art device sample produced under laboratory conditions and then be unable to obtain the device in sufficient volume and/or at a reasonable price. The yield-dependent nature of power semiconductor production dictates the necessity for a manufacturer to maintain a well-controlled production process in order to provide adequate quantities at acceptable price levels. A total value power semiconductor supplier must combine those controls with a full understanding of user requirements—device specifications, required quantities, production timetables.

PRE-ORDER PERIOD

Technical information support includes such items as product data sheets, application data sheets, seminars, technical papers, application handbooks, product newsletters, price lists, cross reference guides, and other semiconductor information. These written communications are the user's most reliable and most comprehensive source of information regarding a given manufacturer's products, services, and capabilities. The completeness and accuracy of the material presented, its pertinence to the user's application, and the rate of response in supplying the requested information are all important factors in providing meaningful, technical information.

Application engineering assistance can be a valuable resource if properly used. While application engineers cannot be expected to design a customer's circuit, they can help a customer avoid misapplication of devices or can assist in solving many different product-related application problems. Frequently, special ratings and other data can be generated for particular customer applications. Failed semiconductors can be examined to determine the cause of failure so that corrective action(s) can be taken. Good application assistance means easy access to engineers who possess a high level of expertise and a willingness to help solve a problem for the customer.

Sample/prototype service relates to the semiconductor manufacturer's willingness to provide samples for qualification for new designs as well as for second source approval. The delivery of the sample(s) must be prompt, with test data when appropriate. Prompt sales follow-up to assure satisfactory performance in the application is required for "total-value" service.

Quotation response refers to such items as speed, accuracy, and completeness of quotation information. Good performance at this phase of a negotiation is essential to prevent serious errors in the order processing and post-order periods.

Competitive price and delivery are treated as a single entity because both items usually must fall within some pre-determined maximum allowable user limit in order to be considered as a valid quotation. The price quoted must fairly reflect the product and services being provided by the semiconductor manufacturer. The delivery time quoted must be realistic; and when a fast delivery is required, the delivery time quoted must truly reflect a best effort from the manufacturer.

ORDER PERIOD

Order acknowledgement must be prompt and accurate to assure timely shipment. Delays at this point are totally unnecessary and are completely avoidable if the items in the General Support and Pre-Order Periods have been treated properly by the power semiconductor manufacturer.

Customer information service reduces user cost when provided promptly in a complete and accurate manner. Little or no effort on the part of the user should be required to determine the status of most orders.

On-time shipments are a true measure of the stated capability of a power semiconductor manufacturer. Historical on-time shipment performance becomes a benchmark for determination of supplier "believability" in all facets of service. Willingness to recognize and discuss reasons for missed delivery promises is another item to consider when evaluating a power semiconductor supplier.

Advance warning of shipping delays is essential if a user is to have time to adjust equipment production schedules to accommodate the delay. Major causes of late semiconductor deliveries are usually the result of shifts in production yields, test correlation problems, production and/or equipment through-put limitations, and/or out-of-spec incoming material component parts. Knowledge of an impending delay must be transmitted to the user immediately.

Condition of shipments when received at the user's plant, to a great extent, depends upon how the product was packaged for shipment and the quality control procedures observed prior to and during shipment. Experienced packers using specially designed cartons and packing material for power semiconductors can make the difference as to whether or not a shipment of product will survive the trip from supplier to user. However, condition of shipments is also a function of the freight carrier employed to move the product and the types of carriers available from the supplier's facility to the user's facility is an important consideration.

POST-ORDER PERIOD

Reliability generally refers to long term product performance - actual field service experience. Reliability is a shared responsibility among the semiconductor manufacturer, the original equipment manufacturer, and the end user and is often regarded as the single most important item by all three groups.

Settlement of claims is often not considered as being very important; however, one only needs to have a single bad experience to really appreciate its value. Settlement of claims includes such things as shipment shortages, incorrect pricing and invoicing, rejected material, transportation charges, customer rework orders, and cancellation charges. There can be a wide discrepancy among various semiconductor manufacturers as to how promptly, efficiently, and fairly such claims are handled.

Warranty is like insurance — no one ever needs it until it is too late. If nothing else, a warranty is at least an indication of the confidence a manufacturer has in the products and services provided. A warranty should define the extent of coverage and the time span of the guarantee. The size of a semiconductor manufacturer and more importantly, the ability to financially handle a large claim must be considered — especially on certain jobs where a high percentage of the equipment cost is due to the power semiconductors.

Replacement of obsolete device types is a continuous problem for the user — both the original equipment manufacturer and the end user of the equipment. Although a fairly high degree of standardization exists within the power semiconductor industry, new designs are evolving constantly, often with slightly different mechanical dimensions and configurations and more often with improved electrical ratings. A "total value" manufacturer provides information and, whenever possible, product as replacement for old or obsolete designs. Since the end user of equipment is usually attempting to procure a few spare parts to get equipment back into operation, it is important for the OEM to maintain a small inventory of replacement semiconductors to support renewal parts business or to support orders for old equipment designs without expensive and lengthy engineering redesign. The ability of the power semiconductor manufacturer to support those needs is another significant criteria for selecting a supplier.

Several precautions must be taken when evaluating suppliers using this or any other method. The person (s) responsible for evaluating suppliers must recognize that within the organization different departmental functions (purchasing, engineering, production, maintenance, general management, research and development, etc.) will place a different degree of importance on each of the items under consideraton. Therefore, an attempt should be made to at least subjectively provide a composite weighting for each of the items that reflects the needs of the total organization. One should also recognize that the type of product or services being sought (commodity-type device versus special device type) as well as the amount of business to be placed (quantity required, lead time, second source requirements) can significantly alter the choice of suppliers. Thus, the best supplier choice under one set of conditions may not be the best choice under a different set of conditions. Finally, nothing is really ever stagnant. User needs change . . . Supplier's products, services, and capabilities also change over time. Therefore, a user must periodically (every 18 months to 2 years) re-evaluate or review the situation to determine whether or not the existing lineup of suppliers is still the best total value.

3. BUYER'S CHECKLIST

PRE-ORDER

Having selected the product required for a given application and having chosen the supplier, the following checklist will help to make the buyer's job easier and to minimize errors and delays:

- If a new customer, establish credit with the supplier prior to placing the purchase order.
- Identify the required device by describing with a single term, either drawing number plus revision, JEDEC number, or manufacturer part number.
- Establish total quantity required.
- Optimize total cost and delivery by considering available purchase agreements, minimum releases, authorized distributors, hardware, packaging and data requirements, standard catalog items versus specials.
- Specify requested shipping date *or* in-plant date.
- Provide complete and accurate "Ship To" and "Bill To" information.
- Specify shipping method (consider cost, transmit time, traceability, insurance cost.)
- Reference negotiation number or quotation number, if applicable.
- Specify tax exemption status.
- Send purchase order directly to manufacturer or authorized distributor.

ORDER

- Proofread acknowledgment.
- Contact supplier directly concerning order status.

POST-ORDER

- Contact the Returned Material Coordinator at the manufacturer concerning administrative errors, such as discrepancies on packing lists or invoices.
- Contact the Returned Material Coordinator at the manufacturer for authorization and specific return instructions prior to returning any material.

4. ENTERING AN ORDER

After selecting a device and a supplier, speed and accuracy are primary factors to consider when placing a purchase order. If a power semiconductor manufacturer can translate the information on the purchase order into factory working language quickly and accurately, the user has a much greater chance to receive the required parts in a timely manner. Chances for production line shutdowns and/or decreased production rates due to parts shortages are greatly reduced.

A concise, but complete, description of the following information on each purchase order will minimize supplier translation time and enhance translation accuracy. Remember that too much information can create as many translation errors as too little information.

1. "Ship To" address. Be sure to include company name, street, plant, department or building number, if applicable, city, state, and zip code.
2. "Charge To" or "Bill To" address. Provide the same information as in (1) above.
3. Purchase order number in a conspicuous location.
4. Note any special marks required on order acknowledgements, packing lists, or invoices.
5. Tax information concerning exemption from state and local taxes. Taxes must be charged if exemption information does not appear on the purchase order or if an exemption certificate, resale certificate, or direct pay permit is not on file with the supplier. Remember that state taxes are based on the "Ship To" address.
6. Description of parts required. In order of preference the best method for part description is (1) user part number or drawing number, specifying most recent revision, (2) JEDEC number, (3) manufacturer part number. Only one of the methods should be used for a single item on a purchase order. Use of more than one method of description (e.g. XYZ Corp. part number 378A94 Revision C or 1N1203) requires order entry personnel to cross check to assure that both descriptions identify exactly the same device. Avoid listing deviations to the device specified on the purchase order. If a JEDEC or supplier part number does not adequately

describe the required part, agree upon the deviations and assign a part number prior to entering the purchase order.

7. Quantity of parts required.
8. Unit price of parts required.
9. Special charges. List charges for environmental testing, special tooling, and/or service charges as separate items if pre-order quotation specified them in that manner.
10. Shipment method preferred. Remember that "best way" or "cheapest way" for the supplier may not be the best or cheapest method for the user.
11. Requested shipping date or in-plant date. Be certain to explain which date is being specified.
12. Negotiation or quotation number. If the supplier has assigned a number to the pre-order discussions, it is always good practice to repeat the number on the purchase order.
13. Special insurance charges, if applicable.

If accurate information is supplied in each of the categories above, entering the order and shipping product will be handled more smoothly. However, the user must consciously make an effort to reduce the time required to transmit an order to the supplier, while minimizing the possibility of interpretation and transmission errors. The best solution is obviously to eliminate extra steps in the order entry process. Time delays and the possibility of errors are automatically inserted when a purchase order is routed through a sales office or through some other intermediate mail stop. Transmission of order information via wire or telephone introduces additional possibilities for interpretation and transmission errors and legally, a manufacturer cannot begin work on an order without the confirming order document. Therefore, for most accurate and efficient order processing, a user should send the purchase order directly to the manufacturer or authorized distributor, when possible.

5. IN-PROCESS ORDER INFORMATION

Significant time intervals occur between the time a user generates a purchase order and the time the user receives the parts against that order. During that period of time it becomes the responsibility of the power semiconductor manufacturer or authorized distributor to keep the user advised of the status of the purchase order. Presentation of order status information by the manufacturer minimizes the time and expense that the user must incur to determine "what's happening."

Order Acknowledgement. The first step the supplier must take is to properly acknowledge receipt of a purchase order and advise the user of a shipping schedule. Although the manufacturer generally checks for accuracy, the user, upon receipt of the acknowledgement, should compare the information to the original order to determine if the order entry process was correct. Many production, shipping, receiving, and incoming inspection problems can be avoided by careful review of documents at this stage of the order.

Order Status. Information to the user does not stop at the order acknowledgement stage. In order to reduce expediting time and expense the manufacturer must continually reconfirm shipping schedules and provide advance warning for shipping delays that may occur.

The manufacturer must also establish a contact point at the factory so that schedule changes and/or questions that do arise can be handled quickly and effectively. The responsible salesperson is a good contact point, however, travel schedules often make that individual difficult to reach and a designated contact at the supplier is most often more convenient for the user.

Invoicing. The invoicing process differs slightly from supplier to supplier, however, a few key items must be presented:

- Invoices must be traceable to the original purchase order of the user. User purchase order number, device type, and unit price are normally considered critical criteria.
- Specific payment terms and address to which payment is to be remitted.
- Delineation of charges not specifically covered by the original purchase order such as transportation charges, insurance charges, special handling fees, etc.
- Date of invoice and date of shipment. These dates normally coincide, however, deviations do occur and must be presented clearly in order to prevent problems with terms of payment.

Test Data. User specifications sometimes specifically require the manufacturer to serialize devices and record test results on a sample basis or for 100% of the devices shipped. Additional requirements, such as a mercury exclusion clause or a certificate of compliance, are often specified. The manufacturer must present such information clearly and include the data with each shipment to reduce receiving and incoming inspection delays at the user's facility.

Ⓦ Order Acknowledgement. After a purchase order has been entered at the factory, a computer-generated order acknowledgement (yellow) for each item is sent to the customer.

(A sample acknowledgement is shown in Figure 3.1). Ⓦ terms and conditions of sale are printed on the reverse side of the form. Orders generally are acknowledged within twenty-four hours after receipt at the factory.

(1) Date that order was entered at the factory by Ⓦ.
(2) Customer purchase order number.
(3) "Charge To" address.
(4) "Ship To" address.
(5) Special remarks required on shipping or invoice documents.
(6) Shipment method if specified on purchase order.
(7) Item number.
(8) Quantity for specified item.
(9) Product type, part number.
(10) Unit price.
(11) Total value of specified item.
(12) Administrative notes.
(13) Requested ship date.
(14) Ⓦ scheduled ship date.
(15) Customer Services Representative responsible for this order.
(16) Ⓦ telephone number.

Any inquiries concerning an open purchase order should be directed to the designated Customer Services Representative at the factory.

Ⓦ Purchase Order Status Report. Ⓦ publishes an open purchase order status report to each customer on a weekly basis. The report has been designed to reduce expediting time and expense by providing timely order information and is mailed each Friday (with an identical copy to the responsible Ⓦ sales representative).

A sample of the order status report appears in Figure 3.2.

(1) Customer purchase order number.
(2) Quantity of parts on open order on the date of the report.
(3) JEDEC number, Ⓦ type, or customer drawing number and revision as specified on the purchase order.
(4) Date that the order was entered at the Ⓦ factory and the requested ship date.
(5) Original Ⓦ scheduled ship date and advance warning for revised schedule date, if required.
(6) Quantity of parts shipped by item since previous report, date of shipment, and shipment method.
(7) Pertinent product and/or planning information.
(8) Name of Customer Services Representative responsible for these orders. Any inquiries concerning an open purchase order should be directed to the designated Customer Services Representative.

In addition to the order status information, this report enables each customer to quickly identify any errors which may have occurred in the order entry process. Early detection of such errors can reduce post-shipment problems.

Each Ⓦ authorized distributor receives a copy of the order status report for purchase orders which they have placed with the factory so that the ultimate customer can receive quick order status information about Ⓦ power semiconductors whether the order is placed directly with Ⓦ or through an authorized Ⓦ distributor.

Westinghouse Electric Corporation

SEMICONDUCTOR DIVISION YOUNGWOOD, PA. 15697

ACKNOWLEDGEMENT

GEN'L ORDER NO	DATE MO.	DAY	YR.	NEG. NO. 03769 / CUSTOMER ORDER NO. ▼	00687 CUST. CODE ▲	COR. NO.	THIS ORDER IS ACCEPTED SUBJECT TO THE CONDITIONS OF SALE NOTED ON THE REVERSE SIDE OF THIS FORM.
23 706143	10	13	6	87-06-143		2	

(5) (1) (2)

MARKS ▶ 98110-P

SHIP TO ▶ XYZ CORP.
1268 MAIN ST.
PLANT 1
CHICAGO, ILLINOIS 60609 (4)

CHARGE TO ▶ XYZ CORP.
1234 MAIN ST.
CHICAGO, ILLINOIS 60609 (3)

(6)

SHIP VIA ▶ UPS

ITEM	QUANTITY	PRODUCT DESCRIPTION	PC	*	UNIT PRICE	MULT.	AMOUNT
(7) 3	(8) 29	[redacted] (9) THYRISTOR T510068007AQ	96		(10) 21 75		(11) 630 75

ADM. NOTES

(12) GOV'T. SOURCE INSPECTION REQ'D.
AT YWD.

WESTINGHOUSE CUSTOMER:

THIS FORM IS ISSUED TO ACKNOWLEDGE RECEIPT OF THE ABOVE LISTED ORDER AND TO PROVIDE YOU WITH A COPY OF OUR WRITEUP WHICH INCLUDES PRICES, SHIPPING PROMISES, PRODUCT DESCRIPTIONS AND OTHER DATA

IF ANY PART OF OUR INTERPRETATION APPEARS TO BE INCORRECT OR QUESTIONABLE, PLEASE OBTAIN IMMEDIATE CLARIFICATION FROM THE PERSON WHOSE NAME IS SHOWN BELOW. (PHONE 412-925-7272) (16)

THANK YOU FOR THIS ORDER.

	(13) REQ'D. SHIP	(14) WILL SHIP	(15) ACKNOWLEDGED BY & DATE
CON'T ON PAGE ____	11116	11116	R. B. BARTHELS

34976H

Figure 3.1 Ⓦ Order Acknowledgement

[illegible]	Item	Order Quantity Balance	Customer Part Number (Drawing Number or Product Ordered)	Order Rec'd at W Mo. Day Y.	Shipment Schedule Requested Mo. Day Y.	Scheduled Mo. Day Y.	Revised Mo. Day Y.	Material Shipped (Since Last Report) Mo. Day	Quantity	[illegible]
80-00-111	1	10	SC6BA31 REV 6	9306	10206	10156	11056			
80-02-123	4	100	2N3055	9306	HREL	HREL				
81-01-155	1	16	1N3294	10016	10296	10296				
81-01-155	1A		1N5406	10016	10296	10296		1028	1000	UPS
87-06-143	3	29	T510068007AO	10136	11116	11116				

(1) (2) (3) (4) (5) (6) (7)

IMPORTANT REMINDER: SEMICONDUCTOR PLANT SHUTDOWN DEC. 23 THRU DEC. 31 PLEASE PLAN ACCORDINGLY

XYZ CORP.
1234 MAIN ST.
CHICAGO, ILLINOIS 60609

CURRENT OPEN PURCHASE ORDER STATUS

Westinghouse Electric Corporation
Semiconductor Division
Youngwood, Pennsylvania 15697

PREPARED BY BOB BARTHELS
CUSTOMER SERVICE REPRESENTATIVE
PHONE 412-295-7272
TWX 510-468-2840
DATE OF REPORT 10/28/76

(8)

FORM 303A

Figure 3.2 Ⓦ Current Open Order Status Report

Ⓦ **Packing List.** The sample packing list in Figure 3.3 accompanies each shipment of Ⓦ power semiconductors. This document serves as the shipping label and provides the following information.

(1) Shipping date.
(2) Customer purchase order number.
(3) "Ship To" address.
(4) "Charge To" address.
(5) Special remarks required on shipping or invoice documents.
(6) Shipment method if specified on purchase order.
(7) Freight charges.
(8) Gross shipping weight.
(9) Carrier.
(10) Item number.
(11) Quantity of specified item in this shipment.
(12) Product type, part number.
(13) Administrative notes.
(14) Certificate of Compliance signed by a Ⓦ Quality Investigator.

Note: A Certificate of Compliance accompanies each shipment. No special request for this information is necessary!

Westinghouse Electric Corporation

SEMICONDUCTOR DIVISION YOUNGWOOD, PA. 15697

(1)

SHIPPING DATE	SHIPMENT NUMBER
28 OCT '76	72198

PACKING LIST

GEN'L ORDER NO	DATE MO.	DAY	YR.	NEG. NO. 04683 / CUSTOMER ORDER NO. ▼	00687 CUST. CODE ▲	COR. NO.
23 101155	10	01	6	81-01-155 (2)		2

MARKS ▶ 98314-P (5)

SHIP TO ▶ XYZ CORP.
1268 MAIN ST. (3)
PLANT 1
CHICAGO, ILLINOIS 60609

CHARGE TO ▶ XYZ CORP. (4)
1234 MAIN ST.
CHICAGO, ILLINOIS 60609

(6)

SHIP VIA ▶ UPS

CARRIER	FREIGHT BILL NO.	TAX %	COLL.	P./CHG.	PPD.
UPS (9)					

FREIGHT CHARGES	GROSS WEIGHT LBS.	OZ.	SHIPPED WITH
(7) 1.05	(8) 3	3	

CERTIFICATE OF COMPLIANCE

THIS IS TO CERTIFY THAT BY ACTUAL INSPECTION AND OR TESTS MATERIALS ARE IN ACCORDANCE WITH THE DRAWINGS AND OR SPECIFICATIONS UNLESS NOTED BELOW. TEST REPORTS WHERE REQUIRED ARE ON FILE AND CAN BE MADE AVAILABLE FOR INSPECTION

(14) SUBMITTED BY N. L. Lowe
QUALITY AND RELIABILITY DEPT.

ITEM	QUANTITY	PRODUCT DESCRIPTION
(10)	(11)	
1A	1000	(12) LEAD MOUNT RECT. 1N5406

ADM. NOTES

(13) GOV'T. SOURCE INSPECTION REQ'D.
AT YWD.

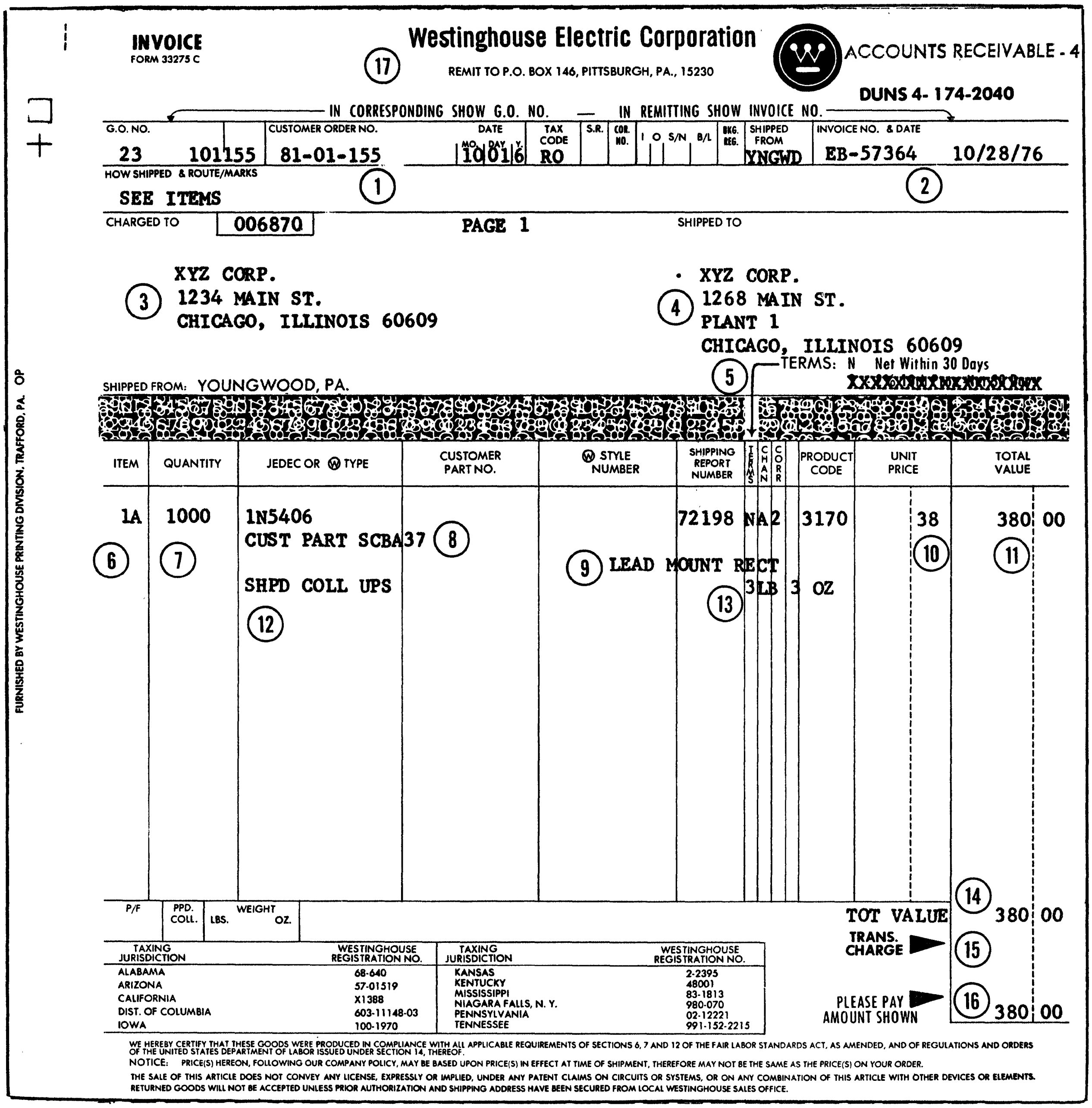
WESTINGHOUSE CUSTOMER RECEIVING NOTE:

PLEASE EXAMINE THIS SHIPMENT IMMEDIATELY TO BE SURE THERE ARE NO DISCREPANCIES. WESTINGHOUSE WILL NOT BE RESPONSIBLE FOR SHORTAGES OR OTHER RECEIVING CLAIMS WHICH ARE ENTERED AFTER 30 DAYS FROM DATE OF SHIPMENT.

IF THIS SHIPMENT SHOWS ANY EVIDENCE OF CARRIER DAMAGE, YOU SHOULD IMMEDIATELY FILE A CLAIM AGAINST THE CARRIER. WESTINGHOUSE DOES NOT ACCEPT RESPONSIBILITY FOR FILING. DAMAGE CLAIMS OF THIS NATURE.

Figure 3.3 Ⓦ Packing List

Ⓦ **Invoice.** Three copies of each invoice are sent to the customer at the time of shipment. A sample invoice is shown in Figure 3.4.


INVOICE
FORM 33275 C

Westinghouse Electric Corporation
REMIT TO P.O. BOX 146, PITTSBURGH, PA., 15230
ACCOUNTS RECEIVABLE - 4
DUNS 4- 174-2040

IN CORRESPONDING SHOW G.O. NO. — IN REMITTING SHOW INVOICE NO.

G.O. NO.	CUSTOMER ORDER NO.	DATE MO. DAY YR.	TAX CODE	S.R.	COR. NO.	I O S/N B/L	BKG. REG.	SHIPPED FROM	INVOICE NO. & DATE
23 101155	81-01-155	10 01 6	RO					YNGWD	EB-57364 10/28/76

HOW SHIPPED & ROUTE/MARKS
SEE ITEMS

CHARGED TO 006870 PAGE 1 SHIPPED TO

XYZ CORP.
1234 MAIN ST.
CHICAGO, ILLINOIS 60609

XYZ CORP.
1268 MAIN ST.
PLANT 1
CHICAGO, ILLINOIS 60609

SHIPPED FROM: YOUNGWOOD, PA.
TERMS: N Net Within 30 Days

ITEM	QUANTITY	JEDEC OR Ⓦ TYPE	CUSTOMER PART NO.	Ⓦ STYLE NUMBER	SHIPPING REPORT NUMBER	TERMS	CHAN	CORR	PRODUCT CODE	UNIT PRICE	TOTAL VALUE
1A	1000	1N5406 CUST PART SCBA37 SHPD COLL UPS		LEAD MOUNT RECT	72198	N	A	2	3170	.38	380 00
					3LB 3 OZ						

P/F	PPD. COLL.	WEIGHT LBS. OZ.

TOT VALUE 380 00
TRANS. CHARGE
PLEASE PAY AMOUNT SHOWN 380 00

TAXING JURISDICTION	WESTINGHOUSE REGISTRATION NO.	TAXING JURISDICTION	WESTINGHOUSE REGISTRATION NO.
ALABAMA	68-640	KANSAS	2-2395
ARIZONA	57-01519	KENTUCKY	48001
CALIFORNIA	X1388	MISSISSIPPI	83-1813
DIST. OF COLUMBIA	603-11148-03	NIAGARA FALLS, N. Y.	980-070
IOWA	100-1970	PENNSYLVANIA	02-12221
		TENNESSEE	991-152-2215

WE HEREBY CERTIFY THAT THESE GOODS WERE PRODUCED IN COMPLIANCE WITH ALL APPLICABLE REQUIREMENTS OF SECTIONS 6, 7 AND 12 OF THE FAIR LABOR STANDARDS ACT, AS AMENDED, AND OF REGULATIONS AND ORDERS OF THE UNITED STATES DEPARTMENT OF LABOR ISSUED UNDER SECTION 14, THEREOF.
NOTICE: PRICE(S) HEREON, FOLLOWING OUR COMPANY POLICY, MAY BE BASED UPON PRICE(S) IN EFFECT AT TIME OF SHIPMENT, THEREFORE MAY NOT BE THE SAME AS THE PRICE(S) ON YOUR ORDER.
THE SALE OF THIS ARTICLE DOES NOT CONVEY ANY LICENSE, EXPRESSLY OR IMPLIED, UNDER ANY PATENT CLAIMS ON CIRCUITS OR SYSTEMS, OR ON ANY COMBINATION OF THIS ARTICLE WITH OTHER DEVICES OR ELEMENTS.
RETURNED GOODS WILL NOT BE ACCEPTED UNLESS PRIOR AUTHORIZATION AND SHIPPING ADDRESS HAVE BEEN SECURED FROM LOCAL WESTINGHOUSE SALES OFFICE.

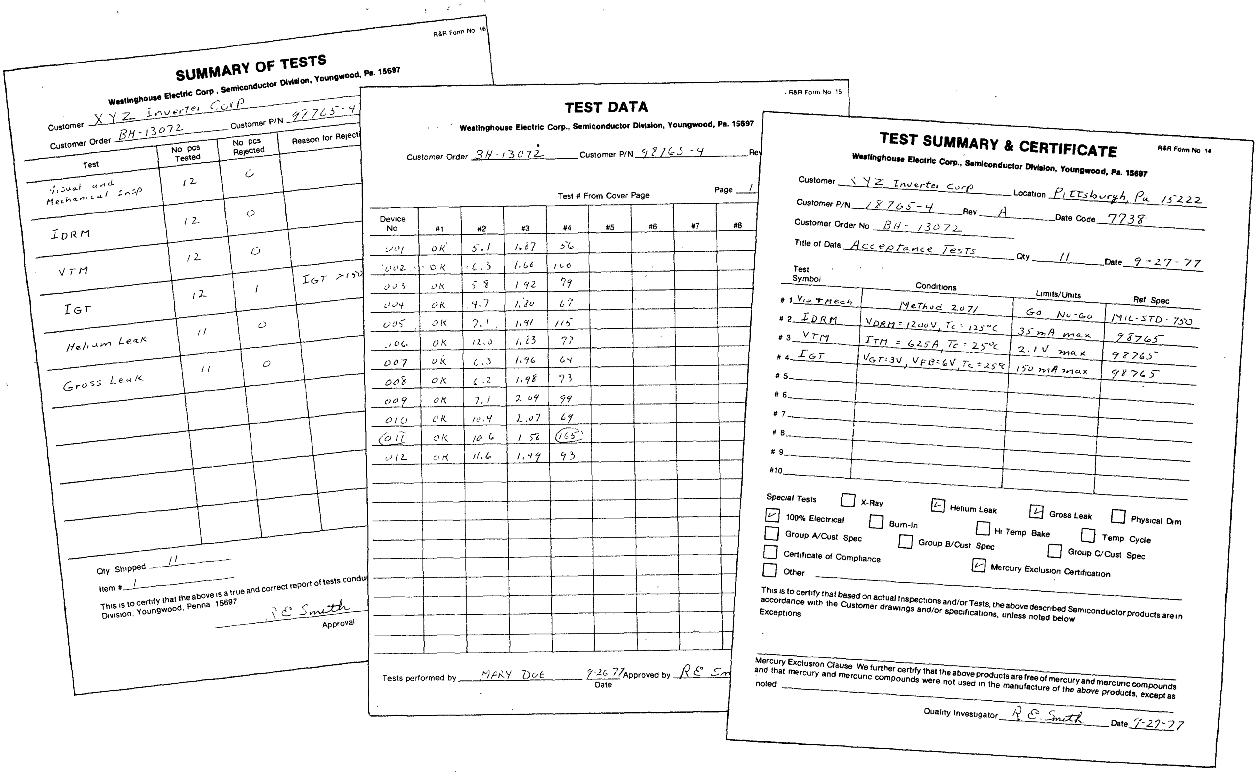
FURNISHED BY WESTINGHOUSE PRINTING DIVISION, TRAFFORD, PA. OP

Figure 3.4 Ⓦ Invoice

(1) Customer purchase order number and date that order was entered at the factory by Ⓦ .
(2) Invoice number and date of shipment.
(3) "Charge To" address.
(4) "Ship To" address.
(5) Terms of sale.
(6) Item(s) included in this shipment.
(7) Quantity shipped against specified item.
(8) Part number.

(9) Product type.
(10) Unit price.
(11) Total value shipped against specified item.
(12) Shipment method.
(13) Gross shipping weight.
(14) Total value of items shipped on this invoice.
(15) Transportation charges, if applicable. (Note: Ⓦ sales policy is freight collect.)
(16) Total value of invoice.
(17) Address to which payment must be sent.

Ⓦ Test Data. The documents in Figure 3.5 illustrate the Ⓦ method used to present test data when requested by the user. It should be noted that a Certificate of Compliance appears on the Ⓦ packing list and accompanies each shipment. Therefore, no special request for this information is necessary.



R&R Form No 16

SUMMARY OF TESTS

Westinghouse Electric Corp., Semiconductor Division, Youngwood, Pa. 15697

Customer XYZ Inverter Corp Customer P/N 97765-4

Customer Order BH-13072

Test	No pcs Tested	No pcs Rejected	Reason for Reject
Visual and Mechanical Insp	12	0	
IDRM	12	0	
VTM	12	0	
IGT	12	1	IGT >150
Helium Leak	11	0	
Gross Leak	11	0	

Qty Shipped 11

Item # 1

This is to certify that the above is a true and correct report of tests conducted ... Division, Youngwood, Penna 15697

R E Smith
Approval

R&R Form No 15

TEST DATA

Westinghouse Electric Corp., Semiconductor Division, Youngwood, Pa. 15697

Customer Order BH-13072 Customer P/N 98765-4 Rev

Test # From Cover Page Page 1

Device No	#1	#2	#3	#4	#5	#6	#7	#8
001	OK	5.1	1.87	56				
002	OK	6.3	1.66	160				
003	OK	5.8	1.92	79				
004	OK	4.7	1.80	67				
005	OK	7.1	1.91	115				
006	OK	12.0	1.83	77				
007	OK	6.3	1.96	64				
008	OK	6.2	1.98	73				
009	OK	7.1	2.09	99				
010	OK	10.4	2.07	69				
011	OK	10.6	1.56	165				
012	OK	11.6	1.99	93				

Tests performed by MARY Doe 9-26-77 Date Approved by R E Smith

TEST SUMMARY & CERTIFICATE R&R Form No 14

Westinghouse Electric Corp., Semiconductor Division, Youngwood, Pa. 15697

Customer XYZ Inverter Corp Location Pittsburgh, Pa 15222

Customer P/N 98765-4 Rev A Date Code 7738

Customer Order No BH-13072

Title of Data Acceptance Tests Qty 11 Date 9-27-77

Test Symbol	Conditions	Limits/Units	Ref Spec
# 1 Vis + Mech	Method 2071	Go No-Go	MIL-STD-750
# 2 IDRM	VDRM = 1200V, Tc = 125°C	35 mA max	98765
# 3 VTM	ITM = 625A, Tc = 25°C	2.1 V max	98765
# 4 IGT	VGT = 3V, VFB = 6V, Tc = 25°C	150 mA max	98765
# 5			
# 6			
# 7			
# 8			
# 9			
#10			

Special Tests
☐ X-Ray ☑ Helium Leak ☑ Gross Leak ☐ Physical Dim
☑ 100% Electrical ☐ Burn-In ☐ Hi Temp Bake ☐ Temp Cycle
☐ Group A/Cust Spec ☐ Group B/Cust Spec ☐ Group C/Cust Spec
☐ Certificate of Compliance ☑ Mercury Exclusion Certification
☐ Other

This is to certify that based on actual Inspections and/or Tests, the above described Semiconductor products are in accordance with the Customer drawings and/or specifications, unless noted below
Exceptions

Mercury Exclusion Clause We further certify that the above products are free of mercury and mercuric compounds and that mercury and mercuric compounds were not used in the manufacture of the above products, except as noted

Quality Investigator R E Smith Date 9-27-77

Figure 3.5 Standard Ⓦ Test Data Documents

6. SHIPPING METHODS AND INSURANCE

Power semiconductors vary in size and weight from a small axial lead rectifier (.1 oz.) to large assemblies of devices on heatsinks (50 lbs.) This wide spectrum of sizes and weights enables the supplier to use several different types of shipping methods to transport the devices. However, these methods differ widely in cost, speed, size and weight limits, geographic coverage, traceability, and available insurance coverage. Since most power semiconductors are shipped on an f.o.b., point of shipment, freight collect basis, the supplier normally honors any specified routing from the user. If the user does not specify a preferred shipping method, the supplier will pick the most economical carrier who provides good service to the shipping facility. Remember, however, that "Best Way" or "Cheapest Way" to the supplier may not be best or cheapest to the user; all services are not available between all points. Therefore, it is a good practice to specify a particular shipment method on all purchase orders.

A brief description of the most common methods for shipping power semiconductors is given below. See Table 3.2 for a comparison of these methods relative to geographic coverage, size and weight limits, insurance, etc.

UPS

This carrier is probably the most popular for small parcel shipments. Transport is handled via truck and/or air (UPS Blue Label), depending upon distance. UPS limits shipments to 50 pounds per carton and 100 pounds per day to a single location.

PARCEL POST

Parcel Post is a branch of the U.S. Postal Service. The service is available to any domestic location with postal service. Packages are transported via truck and/or air. Weight is limited to 50 pounds per carton.

AIR PARCEL POST

Same as Parcel Post except with guaranteed air service. Rates are slightly higher than Parcel Post.

TRUCK

This method is the most economical for shipments over 100 pounds. Trucking firms are licensed to pick up and to deliver to specific states. Care must be taken when routing shipments to assure that the specified carrier can/will deliver to the desired destination. Transfers from one trucking firm to another are common.

AIR FREIGHT

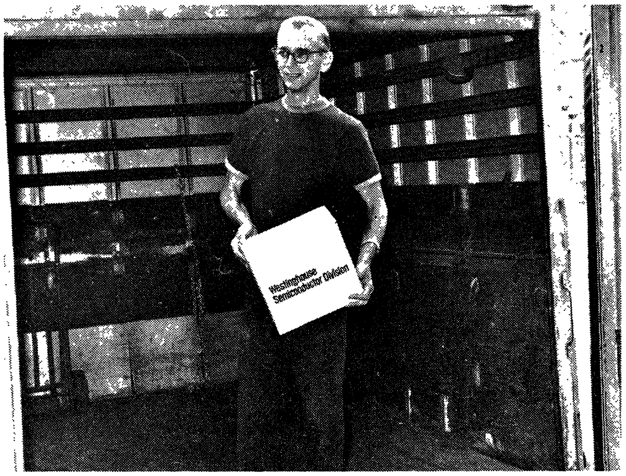
Air shipments can be made via air freight forwarders or via conventional air lines cargo. Air freight forwarders, such as Emery, use any number of airline carriers and, therefore, can route packages quickly to almost any location. Some air forwarders, such as Federal Express, use their own fleet of aircraft to provide the same services. The forwarders are usually more expensive than conventional air lines cargo; however, specific airlines serve limited areas because of federal route restrictions and usually restrict service to scheduled flights of their own airline. Time is the big factor favoring air freight; most carriers offer next-day service to any served location for specific fee.

BUS

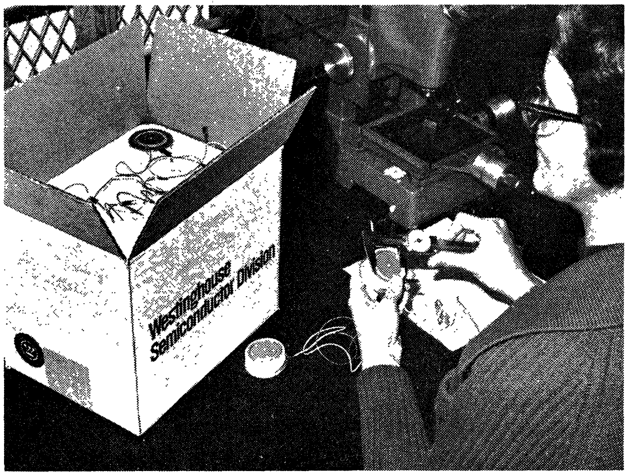
This method is seldom used, but is required when quick deliveries from other carriers is not available to remote areas.

Method	Weight Limits	Geographic Coverage from Youngwood, Pa.	Traceability	Insurance	Frequency of Service From Ⓦ Factory in Youngwood, Pa.
UPS	50 lbs./carton, 100 lbs. to a single location per day.	Continental U.S.	Must be traced from point of shipment. Takes from 1 to 3 weeks.	Automatic $50. Available up to $5,000 maximum.	1 pickup per day.
UPS Blue	50 lbs./carton, 100 lbs. to a single location per day.	California, Oregon, Washington, Georgia, Florida.	Must be traced from point of shipment. Takes from 1 to 3 weeks.	Automatic $50. Available up to $5,000 maximum.	1 pickup per day.
Parcel Post/Air Parcel Post	50 lbs./carton.	Worldwide.	Can only trace insured cartons. Takes from 4 to 8 weeks.	None automatic. Check Postal Service for rates.	2 pickups per day.
Truck	None.	Continental U.S.	Can be traced from either direction. Takes less than 1 week.	Depends on commodity rate. No extra available.	On demand.
Air Freight	None.	Worldwide.	Can be traced from either direction. Takes less than 1 week.	Full value coverage possible.	3 pickups per day.
Bus	50 lbs./carton.	Continental U.S.	Must be traced from point of shipment.	Automatic $50.00. Available up to $250.00 maximum.	Must deliver to terminal.

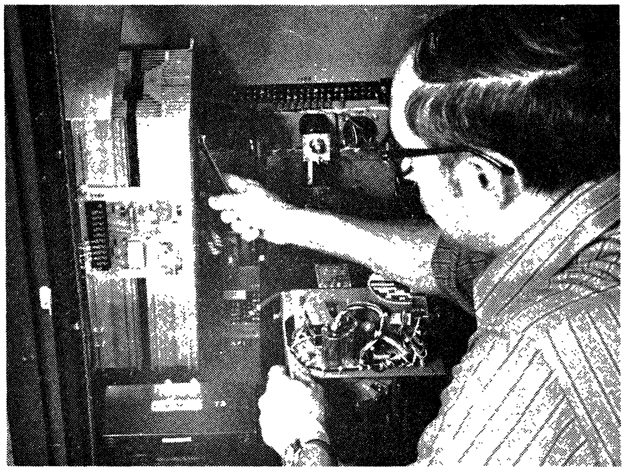
Table 3.2 Comparison of shipping methods for power semiconductors.



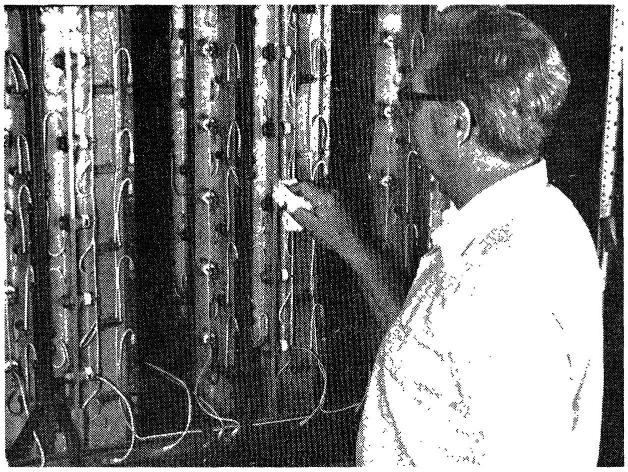
Receiving



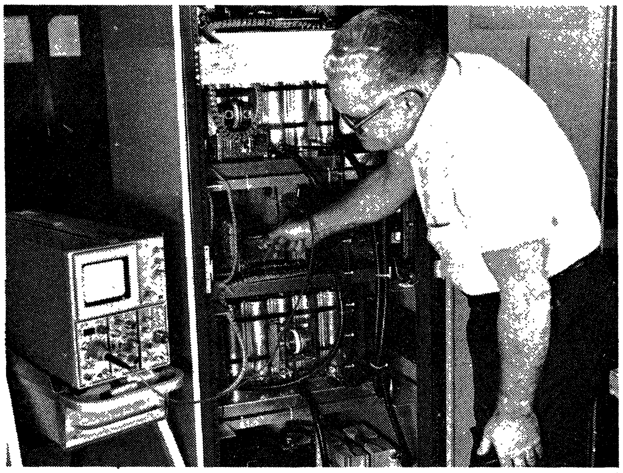
Incoming Inspection



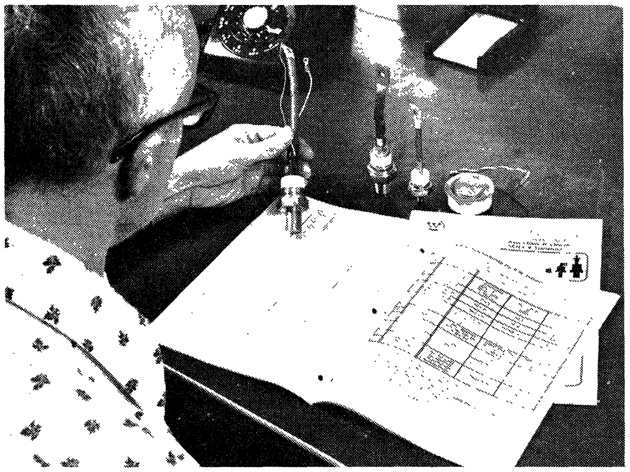
Installation



Cleaning



Trouble Shooting



Identification and Replacement

4 STANDARD OPERATING PROCEDURES FOR THE POWER SEMICONDUCTOR USER

1. RECEIVING

Most users have a fixed procedure for receiving shipments of power semiconductors. If a procedure does not exist, one should be established as quickly as possible to avoid receipt of damaged goods into inventory. An important item to remember is to examine each shipment carefully for evidence of rough handling and container damage. Most power semiconductor manufacturers ship on an f.o.b. point of shipment basis and, therefore, responsibility for the material is transferred at time of shipment. Users must note package damage when signing for a shipment and file a claim against the carrier. Accepting a damaged shipment without noting this fact when signing for the shipment practically eliminates the possibility of a successful claim at a later date.

2. INCOMING INSPECTION

After material has been accepted from the carrier, each shipment normally is examined for administrative, physical, and/or electrical discrepancies. Suggested inspection criteria include:

(1) Match packing list with purchase order to assure compliance.
(2) Validate quantity.
(3) Visually inspect parts for physical damage and proper marking.
(4) Sample check critical mechanical dimensions, if applicable.

Extensive electrical testing normally is not necessary since the manufacturer has fully tested product prior to shipment. If some electrical testing is desired, the tests should be conducted on a sample basis at room temperature (25°C). Caution is advised when testing electrical parameters because devices can be damaged and/or inaccurate data obtained by:

(1) Exceeding maximum operating temperatures with poor test procedures and/or improperly calibrated equipment.
(2) Poor test methods or inexperienced personnel.
(3) Use of different test circuits and/or conditions than used by the manufacturer.

3. CLAIMS

Administrative errors, such as discrepancies on packing lists or invoices, can best be treated by contacting the Returned Material Coordinator at the supplier.

Any decision to return product must be properly authorized in advance. Contact the Returned Material Coordinator at the manufacturer for authorization and specific return instructions. Product should be returned in the original shipping container, when possible. Receipt of *unauthorized* returns at the manufacturer's location often results in delay of resolution of invoices as well as potential loss of material and loss of time required to retest and reship. The minimum information requested prior to authorization includes:

(1) SPECIFIC REASON FOR REJECTION AND RETURN ("does not work" or "failed" is not an adequate explanation).
(2) Quantity and description (part number) of product.

(3) Original order number.
(4) Original ship date.
(5) Original invoice number.
(6) Material and financial disposition requested.
(7) Detailed replacement instructions, if applicable.

4. INSTALLATION, MOUNTING, AND COOLING CONSIDERATIONS

Before installing power semiconductors, it is important to understand why so much emphasis is placed on using proper mounting techniques. In order to obtain maximum efficiency and greater reliability in the use of power semiconductors, it is imperative that the heat developed by power dissipation at the junction be removed as fast as possible. There are usually three distinct obstacles in the path of this heat transfer: (a) interface and material between the semiconductor element and the semiconductor device mounting surface (b) interface between the device mounting surface and the heat sink (c) transfer of heat through the heat sink to the ambient, which might be natural convection air, forced air, oil, or water. These "obstacles" are referred to as thermal resistances: (a) $R_{\theta JC}$ - Junction-to-Case(b) $R_{\theta CS}$ - Case-to-Sink (c) $R_{\theta SA}$ - Sink-to-Ambient. This thermal transfer is depicted using an electrical analog in Figure 4.1.

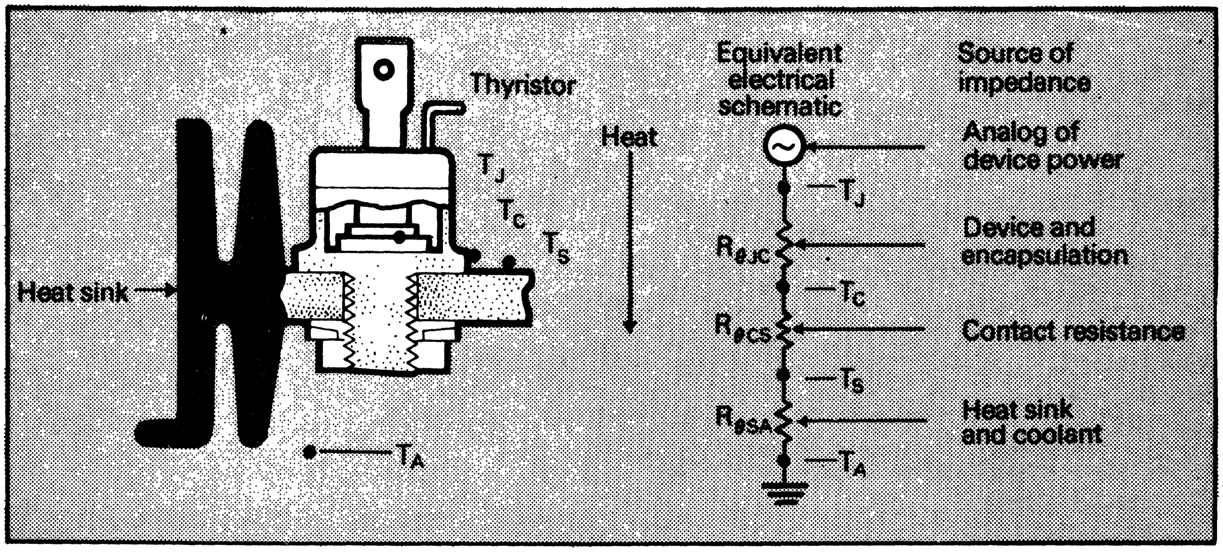


Figure 4.1 Conventional thermal circuit using an electrical analog.

The junction-to-case thermal resistance is generally a function of device construction and design and is determined by the semiconductor manufacturer. Except for disc mount devices which require the user to apply the correct mounting force to assure the proper $R_{\theta JC}$, the user has no control over $R_{\theta JC}$ once a device has been selected. The user's only option then is to select semiconductors that offer low junction-to-case thermal resistances. The other two thermal resistances, however, are quite variable, and the user must carefully consider the various methods and techniques available to insure long life and efficiency.

Primary considerations in obtaining a low case-to-sink thermal resistance are the degree of flatness and surface finish of the device and heat sink mating surfaces, the use of a thermal joint compound, and the proper amount of force (torque) applied. A complete discussion of these considerations and others are presented in the Westinghouse application data sheet "Mounting Power Semiconductors" in the General section of the Data Book. Every user is encouraged to read this application data sheet as it offers many practical suggestions on mounting and remounting all types of power semiconductors — stud mount, disc mount, flat base, etc. A couple of suggestions are worth highlighting: *Use* a torque wrench to insure proper mounting force. *Use* thermal joint compounds sparingly — it only takes a thin film between the device and heat sink mounting interface

— most people apply too much compound! Remember, when using insulating hardware, that the case-to-sink thermal resistances will increase about tenfold!

The final obstacle in the heat removal path is the sink-to-ambient thermal resistance. The semiconductor user can minimize this value by choosing the proper heat sink and most effective cooling method. A semiconductor can be no better than its heat sink! A wide range of heat sink materials, configurations, sizes, and finishes are available that will meet almost any space, cost, and heat dissipation requirement.

The most cost effective and popular air cooled heat sinks are made from aluminum extrusion. For natural convection air, aluminum heat sinks can be black anodized or painted black to optimize their ratings. For example, painting heat sinks black improves natural convection ratings by as much as 25% compared to unpainted heat sinks of equivalent size. For higher output current at less cost, forced convection is the answer. Forced air can frequently allow the user to more than double the output current of a given device/heat sink assembly over natural convection rating capability. Why buy more semiconductors than are really needed to do the job? A few fans and some baffling may provide a substantial savings in system design costs. Use forced air in lieu of natural convection air when possible.

Water cooling is the most efficient type of cooling in general use today. In order to optimize the thermal efficiency of a water-cooled heat sink, pure copper heat sinks should be used. Copper alloys, bronze, aluminum, etc. generally have much lower thermal conductivities and thus are not as efficient. Figure 4.2 shows 1000 ampere SCR's mounted on comparable air cooled and water cooled heat sinks. The water cooled assembly offers from 1.5 to 4 times more output current than the air cooled assembly, weighs only one-third as much, occupies about 40% of the space, and costs about the same. Therefore, when heat sinks are compared, water cooling (if available) is usually the most economical choice; forced convection air is next; and natural convection air is last.

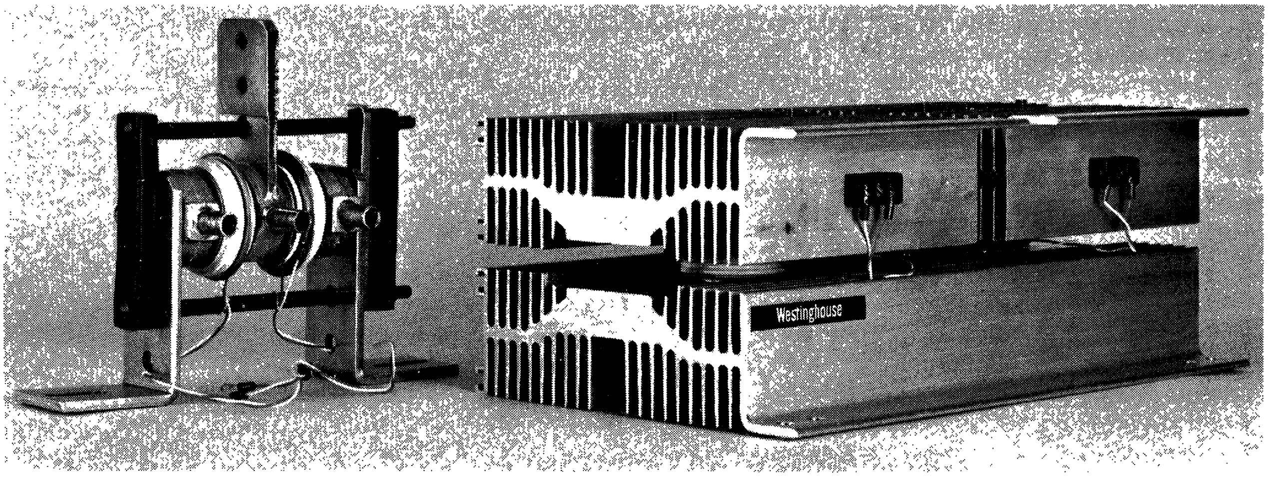


Figure 4.2 1,000A Disc SCR's mounted on comparable water cooled and air cooled heat sinks.

A final consideration when installing power semiconductors is to place them where the surrounding ambient temperature is as low as possible. Do not mount semiconductors near or above transformers or other heat generating components in a cabinet and avoid "dead air" pockets. Mount semiconductors heat sinks vertically so as to take advantage of the natural chimney-effect or up-draft of air flow. When using forced air or water to cool various components in a cabinet, make sure the cooling medium reaches the power semiconductors first. Good installation practices when mounting and cooling power semiconductors will insure good operating performance and long life.

5. OPERATING POWER SEMICONDUCTOR EQUIPMENT

There is still a tendency to consider the "state-of-the-art" in the design, manufacture, and application of power semiconductors as something new, mysterious, and glamorous. Not so! Industry has long been using silicon power semiconductors and a vast knowledge in the use of these devices has evolved. Along with this knowledge has come a new "state-of-the-art" for using and maintaining semiconductor equipment. The emphasis placed on selecting, purchasing, and installing devices is part of it, but of equal importance is the proper use and maintenance of equipment employing power semiconductors.

Protect power semiconductors from excessive heat. Semiconductors are composed of materials having different rates of thermal expansion. Therefore, both short and long term temperature excursions not only impair the electrical characteristics of these devices, but also set up internal mechanical stresses at each of the material interfaces. These combined effects of high temperature excursions can ultimately lead to device malfunction and destruction. The maximum temperature limits of various materials used in semiconductors vary from 150°C for soft solder to 1300°C for silicon. Once these materials are combined into a fabricated device, however, electrical deterioration begins at lower temperatures.

For example, forward and reverse blocking capability of a junction begins to decrease and leakage currents increase when allowable maximum junction temperatures are exceeded. (These temperatures are generally between 125°C and 200°C, far below the maximum temperature limit of silicon itself.)

Periodic monitoring of ambient temperatures, cooling fan operation, cooling water temperatures, and case temperatures of the semiconductors themselves will pinpoint many malfunctions before they cause catastrophic failures. Because of the importance of preventing high temperatures from developing, this monitoring must be emphasized in the operating procedures for the equipment operator.

Avoid overloading equipment. Avoid overloading the semiconductor, which in effect, means protect against overloading the equipment that the semiconductors are feeding and/or controlling. For example, overloading a motor operated with semiconductor controls puts a direct overload on the semiconductors. Even if this overload is only for a short time, the semiconductor's useful life can be shortened. Controls are designed to include motor overloads and the maximum values of overload should never be exceeded. Continued short term overloads above the control specifications can cause undetectable additive damage resulting in random, often unexplainable semiconductor failures.

Operator induced overload conditions that could result in excessive semiconductor currents include high on/off duty cycle or jogging for high production needs, rapid reversing, motor jam, and long acceleration time. Some mechanical problems that can cause motor overloads are high equipment temperature due to lack of cooling, wiring or bearing failure due to improper installation or maintenance, phase failure due to blown fuses or loose connections, phase imbalance, overvoltage, transient overvoltage and contaminants or dirty environment.

Table 4.1 shows various motor stress conditions and the common protection. This table can be used to determine adverse load conditions and the type of protection that should be used. In properly designed system, overload conditions are considered and provisions are made to accommodate the overloads. The user or operator has an obligation to operate the equipment within the design ratings. The table shows the equipment user and designer methods to prevent overloading a motor, and hopefully, to avoid the situation that would cause semiconductor failure or reduce semiconductor life.

Protect power semiconductors from transient overloads. Silicon semiconductors are inherently long life devices if they are adequately protected against surge currents and transient voltage spikes. The protection against failure due to these phenomena are relatively simple and normally this protection is designed into the circuit. In industrial plant environments, most voltage transients in semiconductor circuits arise from three major causes:

Switching is the most common source. Whenever current is switched on or off in an inductive circuit, a transient voltage is generated at the switch terminals. Transformers and motor windings are highly inductive components, and the circuit wiring itself is inductive. Surges caused by lightning contribute to switching transients. These transients can originate in remote circuits and still feed back to the semiconductor circuit through the supply line. Protection of semiconductors from such transients is primarily a matter of attenuating the surge to a level the semiconductor can tolerate.

Commutation transients are associated with the reverse recovery characteristic of a rectifier junction. Since, in normal use, a semiconductor is continually switching from a conducting state to a non-conducting state, there are rapid changes of current (high di/dt). For this reason, and especially where fast switching rectifiers are used, it is imperative to keep circuit inductance at a minimum. Here again, suitable suppression networks should be designed into the circuit.

Regenerative surges in inductive or dynamic loads is the third major source of reverse voltage transients. Such loads include motors, lifting magnets, solenoids, relays, and many other devices involving stored inductive energy in the form of high induced voltage. Suppression of these transient voltages usually requires protective devices with high energy storage capacity.

Problem	Cause	Motor Current Variance	Semiconductor Current or Voltage Variance	Common Semiconductor Protection	Comments
Overload	Operators Choice	Increases three phase current approaching 200%.	Increases semiconductor current, eventual motor burnout can cause surge on semiconductors.	Thermal overload on semiconductors and motors. Design for semiconductor current overload.	Operation at thermal overload conditions can reduce semiconductor life. Depending on the design up to 600% increases in semiconductor currents are possible resulting in reduced life or shorted semiconductors. Surge currents can also reduce semiconductor lifetime and cause semiconductor failures. High ambient temperatures produce the same results as high currents i.e., reduced life and failed semiconductors. Never operate semiconductors without proper cooling.
Motor Jam	Load Blockage	High operating time at locked rotor current to 600%.	Increases semiconductor current, eventual motor burnout can cause surge on semiconductors.	Thermal overload on semiconductors and motors. Design for semiconductor current overload.	
High On/Off Duty Cycle	Jogging for High Production Needs	High operating time at locked rotor current to 600%.	Increases semiconductor current, eventual motor burnout can cause surge on semiconductors.	Thermal overload on semiconductors and motors. Design for semiconductor current overload.	
Rapid Reversing	Production Needs	High operating time at locked rotor current to 600%.	Increases semiconductor current, eventual motor burnout can cause surge on semiconductors.	Thermal overload on semiconductors and motors. Design for semiconductor current overload.	
Long Acceleration Time	High inertia slow starting loads	High operating time at locked rotor current to 600%	Increases semiconductor current, eventual motor burnout can cause surge on semiconductors.	Thermal overload on semiconductors and motors. Design for semiconductor current overload.	
High Equipment Temperature.	High ambient temperatures. Lack of cooling.	No increase but can cause wiring and insulation failure.	Increases semiconductor current, eventual motor burnout can cause surge on semiconductors.	Thermal overload on semiconductors and motors. Design for semiconductor current overload.	
Motor Wiring or Bearing Failure.	Overcurrent, Improper Installation or Maintenance.	Locked rotor current to 600%.	Increases semiconductor current, eventual motor burnout can cause surge on semiconductors.	Thermal overload on semiconductors and motors. Design for semiconductor current overload.	
Phase Failure	Blown Fuse, Loose Connection	Decrease in current until motor core reaches saturation and current increases.	Increases semiconductor current, eventual motor burnout can cause surge on semiconductors.	Thermal overload Phase failure relay.	
Phase Unbalance	Unbalanced single phase loads on same line, poorly regulated service.	Decrease in one phase and increase in the other two phases of current.	Increases semiconductor current, eventual motor burnout can cause surge on semiconductors.	Thermal overload Phase failure relay.	
Overvoltage	High source	Slight voltage increase decreases current. Large increase may saturate core and increase current.	Decrease or increase semiconductor current.	Overvoltage relay.	Increase of currents can cause semiconductor failure and reduced life.
Transient Overvoltage	Lightning, opening inductive switches etc.	Slight average current increases.	High transient voltages across semiconductor when semiconductor is in the off position.	Capacitor-Resistor Networks, Voltraps, MOV, etc.	Short duration high transients can cause semiconductor failure.
Underload	Operators choice	Decrease in motor current.	Decrease in semiconductor current.	None	Light load increases semiconductor life.
Contaminants	Dirty environment	Causes corona	Causes corona	Clean room filters	Clean equipment periodically even with filters. Corona carbonizes dirt and causes eventual semiconductor shorts.

Table 4.1 Motor Overloads and Their Effects on Semiconductors

Some of the common devices used for transient protection are capacitors, zener diodes, free wheeling diodes, ⓦVoltraps, and varistors (MOV/ZNR).

Protect power semiconductor circuits from current overloads. The power semiconductor circuit must be protected from heavy current loads caused by short circuits or other component breakdowns. Several methods are available for this type of protection.

Fuses — Semiconductor fuses protect against overloads and, when properly applied, remove the semiconductor from the power source when an overload occurs. However, the result is downtime and higher operating costs. Therefore, fusing is generally limited to applications where the power source can damage components before slower breakers remove the power.

Mechanical breakers — Magnetically operated breakers provide an inexpensive means of limiting current. This type of breaker operates best under short circuit conditions and offers speedy, low-cost restarting and relatively fast circuit interruption.

Thermal breakers — These employ heating elements to operate bimetallic contact actuators. This type of breaker offers reasonable protection for wires and good protection for components with high thermal capacity. Their ability to protect semiconductors is, however, limited.

Overrated semiconductors — Semiconductors with current ratings high enough to accommodate anticipated current overloads is another method of protection. This approach allows the cost of fuses, wiring, and mounting to be put into the semiconductor. It also allows minimal protection, so safety considerations require a conventional circuit breaker to disable the circuit in extreme malfunctions.

Combinations — Combining circuit breakers with fuses, oversized semiconductors, or current feedback circuits are frequently applied techniques. Another approach is using special branch protection. For example, each leg of a single phase bridge might be separately protected instead of using a single fuse or breaker for the entire converter; a motor armature circuit can be protected by a breaker, while the mains are fused. This arrangement prevents overstressing a motor while the semiconductor devices are operating at high current peaks that are within fuse limits.

Keep power semiconductors clean. Semiconductors and semiconductor equipment must be kept clean. Why? Because on high power semiconductors, the glass or ceramic seal on the semiconductor package can be a source of trouble when dirt accumulates. Even when good engineering practices are followed in the positioning of components and support material to reduce or eliminate excess voltage stress and voltage gradients, these gradients can change with moisture, dirt, pressure, temperature and aging. With a clean system, high transients can initiate corona which will then be extinguished upon return to normal voltage. However, with any accumulation of moisture or dirt on the insulating glass or ceramic surface, the corona will remain when the voltage returns to normal, and can cause extensive damage to the circuit. Even semiconductors without a visible layer of contaminants may be covered with conductive particles that can cause corona. Therefore, periodic cleaning is advisable. The time between cleanings could be lengthened by the proper use of filters, but filters will not eliminate the need for cleaning. A good maintenance program is essential to proper operation of semiconductors.

6. PREVENTATIVE MAINTENANCE

The key to successful and efficient operation of high power semiconductors is a good, well-planned maintenance program. Routine maintenance of semiconductor equipment involves putting into actual practice the good operating procedures listed in section 5 with emphasis placed on (a) temperature build-up, (b) dirt accumulation, and (c) loose mounting and/or connections. A regular schedule should be followed for checking and eliminating these conditions.

(a) Temperature build-up may be caused by excess ambient temperature, poor or blocked air circulation, failure of cooling devices, such as fans or water circulating equipment, dirty heat sinks, and air filters, or equipment overloading. Since temperature build-up is usually gradual, it should be constantly monitored with strategically placed thermocouples. A suggested method of affixing a thermocouple to a semiconductor base or heat sink is to drill a small shallow hole, fit the thermocouple into it, and then peen the surface around the hole to secure it. Equipment designed for forced air cooling or water cooling should never be energized without proper air or water flow.

(b) Dirt accumulation on the glass or ceramic surfaces of semiconductor packages must be periodically and thoroughly removed. When cleaning semiconductors, the safest cleaning method consistent with desired results should be used. Solvents can be hazardous and should be used with care. Even a solvent that is considered non-toxic can kill or injure when used with improper ventilation. One of the safest methods of cleaning is by wiping with clean cloths. Often due to space limitations, the areas that need to be cleaned cannot be properly reached and, therefore, a liquid cleaner must be used. Table 4.2 lists solvents that could be used as cleaners.

Solvent	Fire Hazard	Explosion Hazard	Toxicity Hazard	Electrically Conductive	Attacks Rubber Insulation	Precautions
Water, tap	None	None	None	Yes	None	Rinse with distilled water, dry thoroughly
Water, distilled	None	None	None	No	None	Dry thoroughly
Water/detergent	None	None	None	Yes	None	Rinse with distilled water, dry thoroughly
Methyl alcohol	High	High	High	No	Slight	Avoid skin contact, use ventilation
Ethyl alcohol	High	High	High	No	Slight	Can cause internal damage; ingestion can cause blindness
Isopropyl alcohol	High	High	High	No	Slight	Mix with distilled water to reduce hazards
Paint thinner (mineral spirits)	Low	Low	Low	No	Slight	Use proper ventilation; limit exposure to rubber
Acetone	High	Moderate	Low	No	Slight	Limit exposure to prevent rubber degeneration
Perchloroethylene (dry-cleaning solvent)	Low	Low	Moderate	No	Slight	Use short exposure to prevent rubber damage; irritates eyes and causes headaches; heating causes fumes
Trichloroethylene	Low	Low	Moderate	No	Slight	Use adequate ventilation; limit exposure time to prevent rubber damage
Freon	Low	Low	Low	No	Slight	Use adequate ventilation; limit exposure time
Maltier XL-100	Low	Low	Low	No	Slight	Use adequate ventilation; limit exposure time
Miller Stephenson MS-180	Low	Low	Low	No	Slight	Use adequate ventilation; limit exposure time

Table 4.2 Semiconductor Cleaning Solvent Characteristics

The safest method of cleaning semiconductors, as shown in Table 4.2, is to use a detergent wash and then flush with distilled water. The system must be completely dry before the reapplication of power. Regular tap water can contain many conductive impurities and should not be used as a final rinse.

Methyl, Ethyl, or Isopropyl alcohol could be used for cleaning, but they can attack sleevings and insulations. Before using alcohol or any solvent, its use should be checked on a small sample of sleeving and insulation to determine if they are attacked. Since time of exposure to a solvent determines any adverse effects, the time of exposure during the test should be the same as the time expected during actual cleaning. Any elongation, softening or actual decomposition could eliminate the use of the solvent. A temporary softening may not be detrimental. Remember that alcohol is toxic and should be used with care.

Follow all safety precautions when using any solvents. Read the labels on all the chemicals. Do not mix solvents (or any chemicals) unless recommended. The information regarding solvents, their fire, explosion and toxicity hazards, etc., are believed to be accurate, but it cannot be guaranteed. This information is given as a general recommendation for information only.

(c) Along with scheduled periodic cleaning, a systematic checking of mounting and terminal connection tightness should be specified. If a loosely mounted device is discovered, it should be removed, both mounting surfaces thoroughly cleaned, thermal compound reapplied, and then remounted with the specified torque.

7. TROUBLE SHOOTING AND SERVICING

Properly protected semiconductor devices incorporated in well-designed circuits should last for the life of the equipment. Semiconductors should not be a major problem for the maintenance engineer. However, experience shows that up to a 10-15% failure rate can occur during equipment lifetime, due chiefly to misuse, misapplication, or neglect of the equipment and overloads caused by natural forces, such as lightning. Therefore, to operate efficiently, the maintenance department must have the proper tools and equipment. Most of these essential items are elementary and relatively inexpensive when compared to the wide array of measuring devices and instrumentation available for the study of power semiconductors and associated circuitry. Suggested equipment for moderate service work:

1. Volt-ohmmeter (voltmeter)
2. Clamp-on ammeter
3. Probe-type temperature indicator
4. SCR/Rectifier blocking voltage test circuit (see Figure 4.3)
5. Transistor blocking voltage and gain test circuits (see Figures 4.4 and 4.5)
6. Torque wrench and complete standard tool kit
7. Oscilloscope

An oscilloscope is used for viewing the current and voltage waveshapes within a semiconductor circuit. Eventually, all technicians become familiar with a "scope". It is the most important and useful tool available to the troubleshooter.

Equipment Breakdowns and Malfunctions. What should maintenance personnel look for when equipment breaks down? Are there visual signs to indicate why a semiconductor failed? As with any other type of equipment, there is much that can be learned from one's own senses and experience. With electronics, heat is still the number one symptom of impending failure. So be alert for charred or discolored components—that is a sign that too much current flows or has flowed through the component, and if it has not failed, it soon will. Although the trouble could be limited to the failed component, it is possible that some other component is at fault through failure or misadjustment. A thorough knowledge of the theory of operation of the equipment will be invaluable in tracking down *real* causes of component failure.

Voltage related failures, on the other hand, are a bit more difficult to locate because there is usually no outward sign of failure. However, this type of failure is, more often than not, catastrophic, and shorted devices result. Shorted devices are much easier found than downgrades or control malfunctions. One of the most destructive causes of failed semiconductor components is lightning storms. The electrical forces generated by nature are enormous, so watch for equipment malfunctions during and just after an electrical storm. The maintenance engineer should also monitor closely any equipment that is pushed to its operating limit, thereby increasing the possibility of failures.

As a general procedure for checking out a suspect semiconductor, the following sequence of test checks should be performed:

(1) Look at the suspect device(s) [with the system power *off*] using a volt-ohmmeter—check for shorts.

(2) If no short exists, apply power (reduce power, if possible) and using a voltmeter or scope, check to see if the suspect device is blocking voltage.

(3) If the unit is blocking voltage, the user should then check to see whether or not any current is flowing. This current flow can be measured with a clamp-on ammeter, voltmeter in conjunction with a current shunt or resistor that is in series with the suspect unit, or a scope.

(4) Finally, the suspect unit should be checked along with the other power semiconductor components in the circuit to confirm that the devices are all operating within their maximum allowable case temperature. This maximum allowable case temperature can be determined from the manufacturer's technical data sheet by knowing the device's circuit configuration and actual current magnitude and waveform. A probe-type temperature indicator can be used for making case temperature measurements.

If the suspect device(s) fail any of the above test checks, the system power should be turned off and the suspect devices removed from the circuit for further test and evaluation. In some instances, the devices can be tested without the need of removal, test, reinstallation, and down time. However, the user should make certain that the measurement being taken is that of the device under test by disconnecting one power lead (also gate lead in case of SCR) for circuit isolation. Disc devices, because of their double-sided mounting, may be difficult to isolate and may have to be removed from the circuit. In this case, the disc device must be clamped with sufficient force (approximately 200 lbs.) to get a valid reading.

Rectifier/SCR Testing

Volt-ohmmeter—An ohmmeter can be used to check rectifier polarity or as a quick check to determine whether an SCR or rectifier (diode) has failed *open* or *short*. Note: An ohmmeter is *not* a valid tester for measuring blocking voltage capability. If an SCR anode-cathode measurement shows a short in *either* direction or if the gate-cathode measurement shows a short in *both* directions, then the SCR is a short. For an SCR to be open, the anode-cathode measurement as well as the gate-cathode measurement must show an infinite resistance in *both* directions. Likewise, a rectifier must show zero resistance in both directions for a short and infinite resistance in both directions for an open. A rectifier normally shows low resistance in the forward direction and high resistance when the ohmmeter probes are reversed. Thus, the ohmmeter can be a check for rectifier polarity. An open failure on a Ⓦ high power SCR or rectifier is a rare event due to compression bonded encapsulation (CBE) device construction.

SCR/Rectifier Blocking Voltage Test Circuit—The following test circuit (Figure 4.3) describes a simple blocking voltage tester that is capable of testing devices up to 1800 volts and can be built for about $100.00. The

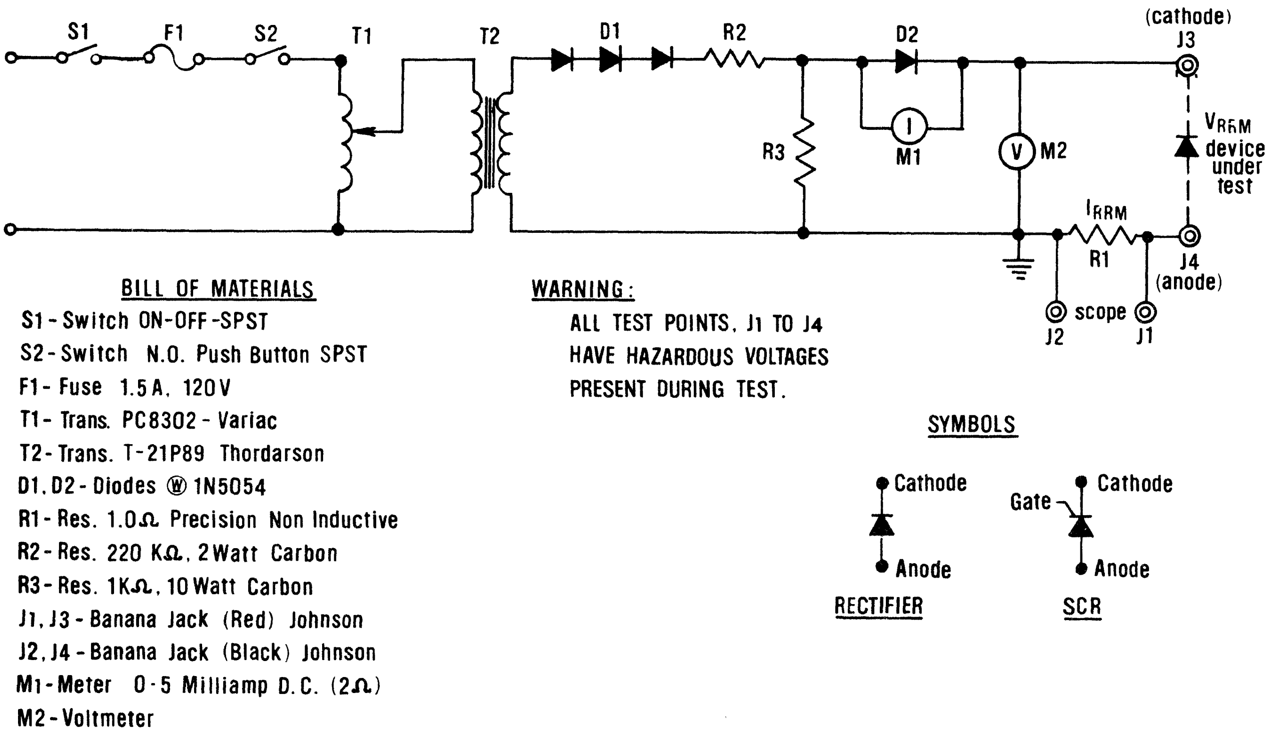


Figure 4.3 SCR/Rectifier Blocking Voltage Test Circuit

safety switch S2 must be depressed to allow voltage application and the variac controls the amount of voltage to the device under test. After each device is tested, the variac setting should be returned to zero so as not to risk damaging a subsequent device under test that might have a lower voltage rating. Never exceed the device's rated voltage when testing. Since this test is conducted at room (ambient) temperature, the measured maximum allowable leakage limit should not exceed one-half the maximum junction temperature leakage current value listed on the manufacturer's technical data sheet. When testing an SCR, the gate lead must be left open (Note: Some non-Westinghouse devices may require a gate bias termination to meet rating). V_{RRM} (reverse voltage) is measured when SCR cathode is connected to J3 and SCR anode is connected to J4; V_{DRM} (forward voltage) is measured when SCR anode and cathode terminals are reversed. The voltage is read indirectly by M2 voltmeter (V_{RRM} = 3.14 X DC meter reading). I_{RRM} or I_{DRM} leakage current is monitored directly with a scope across J2 and J1 or indirectly by M1 milliamp meter across D2 (I_{RRM} or $I_{DRM} \simeq$ 3.14 X average leakage over full cycle meter reading). For rectifiers (diodes), the V_{RRM} (reverse blocking voltage) is tested the same as an SCR. Since most rectifiers are available in standard or reverse polarity, be sure to check the polarity symbol device marking to identify the anode and cathode.

Transistor Testing

The following simple test circuits can be used for a quick check of transistor parameters but are not recommended for classifying devices. Other, more accurate, measuring equipment that has a pulsed duty cycle should be used for incoming inspection. A good curve tracer such as the Tektronix 576 will measure gain, currents, and voltages at a pulsed duty cycle. Other, less accurate, measuring instruments, some in kit form, can be obtained from electronic supply stores for use in troubleshooting a circuit.

Volt-ohmmeter—The only valid ohmmeter measurements on transistors are short or open determinations. A shorted transistor will show a short (resistance approaches zero) in both directions across the base-emitter, collector-emitter or collector-base terminals. This test is accomplished by removing the transistor from the circuit and first measuring the resistance in one direction and then reversing the ohmmeter probes across the terminals. A good transistor will show a low resistance (conduction) in one direction and a high resistance when the probes are reversed. If any of the three tests (i.e., collector-base, collector-emmitter, or base-emmitter) are faulty, then the transistor is faulty. A faulty transistor will have either a low resistance in both directions (shorted) or a high resistance (open).

Note: This ohmmeter test is correct when it indicates a shorted or open transistor, but when it shows a good transistor, it may not be correct because of the low voltages used in the ohmmeter test. Further tests must be made to determine the condition of the transistor.

Transistor Blocking Voltage Test Circuit—The voltage capability of a transistor is measured using the circuit in Figure 4.4. The transistor is connected in one of the three desired modes (i.e., V_{CE}, V_{CB} or V_{EB}). The

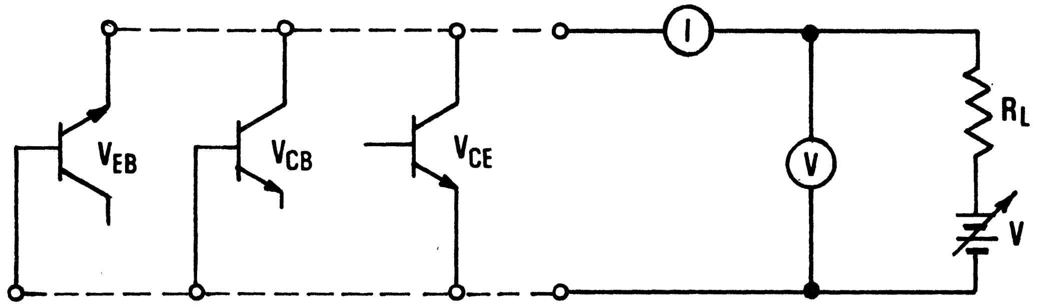


Figure 4.4 Transistor Blocking Voltage Test Circuit

current meter should be capable of 1 ma to 10 ma, the voltmeter and power supply to hundreds of volts and the load resistors should limit the current to about 10 ma if the transistor shorts. The voltage is set to the data sheet limits and the current is read. Any current reading within data sheet limit would indicate a good transistor. If a data sheet is not available then set V_{CE} and V_{CB} to the circuit voltage using 10 ma maximum as an acceptable current. When measuring V_{EB} , if no data sheet is available, set the voltage at 4 volts and use 10 ma as a maximum acceptable current.

Transistor Gain Test Circuit—Gain measurements should be made on a curve tracer or a high current pulsed test set. A D.C. gain measurement can be made if precautions are taken to limit the power dissipation and a heat sink is used. The case temperature should be monitored. A resistor to drop about 2 volts is used in the base as shown in Figure 4.5. The base voltage is slowly increased until the desired collector current is

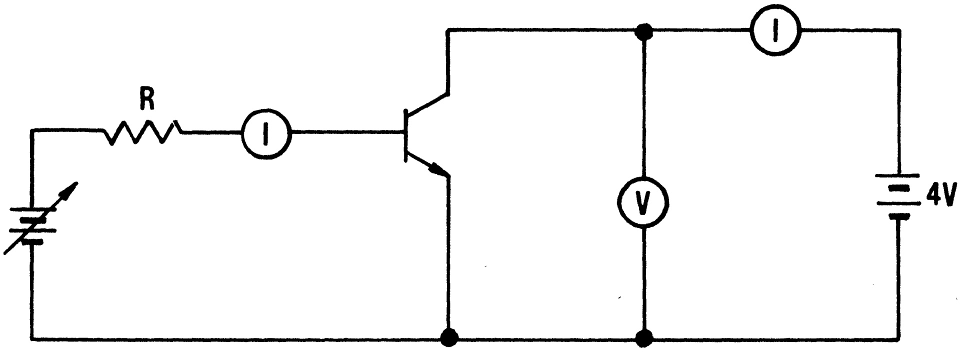


Figure 4.5 Transistor Gain Test Circuit

reached. The collector and base currents are then read. The collector-emitter voltage of 4 volts is usually used. This test is a continuous power test and should be done as quickly as possible to limit internal junction temperature. The gain (h_{FE}) is calculated as follows: $h_{FE} = I_C/I_B$

Common Causes of Power Semiconductor Failure. Most of the advice given thus far deals with the proper installation and operation of power semiconductors. However, in the event all of this advice was not followed or accidentally missed, the knowledgeable maintenance person has a good jump on discovering the reason a particular device has failed by pursuing the following checklists.

Many power semiconductor failures are the result of improper mounting and electrical application. The first step in evaluating any failure should be to assure that good engineering practices have been used in both the mechanical as well as the electrical application of the semiconductor. Faulty mechnical practices often result in eventual electrical failures.

MECHANICAL CHECKLIST

1. Torque—are semiconductors torqued properly?
2. Flatness—are mounting surfaces flat and free of defects?
3. Thermal Compound—is thermal compound used properly?
4. Stress—is there any undue stress placed on the semiconductors?
5. Insulation—are the terminals or case contaminated causing electrical conductive paths?
6. Heat Sink—is it large enough and is it clean and efficient?
7. Other pertinent mechanical details.

Torque—torque wrenches must be used, and the maximum torque rating must not be exceeded. Some semiconductors can be mechanically damaged by too much torque or thermally damaged by too little.

Flatness—heat sink must be flat, free of burrs and ridges, with holes and edges chamfered. These defects could prevent the proper seating of the semiconductor, resulting in thermal or mechanical damage.

Thermal Compound—should always be used according to the manufacturer's instructions. Either too little or too much compound could result in poor thermal impedance. When applying thermal compound, be certain that the threads remain dry. Lubricated torque specs mean that the mating surfaces are lubricated. Apply thermal compound to both sides of insulating washers, when used.

Stress—semiconductor should not be used as a support for heavy electrical leads. Lead stress can cause mechanical seal cracks resulting in hermeticity problems. Mechanical stess can also be transmitted to the junction causing cracks in the element or solders, resulting in failures.

Insulation—insulation between semiconductor terminals or terminals and case is often very small. When operating the semiconductors in moist or contaminated areas where voltage creepage can become a problem, additional protection should be used against such electrical conductive paths.

Heat Sink—should be large enough for proper heat transfer. Undersize heat sinks often cause junction temperature to exceed maximum ratings. All types of corrosion and oils should be removed with solvents or emery cloth to insure the lowest possible thermal impedance between mounting surface and heat sink.

ELECTRICAL CHECKLIST

1. Overcurrent—is current exceeding maximum ratings?
2. Overvoltage—are maximum voltage ratings exceeded?
3. Surge Current—is there a possibility of a fault that could cause a one-time surge?
4. Transient Voltage—are transient suppressors used?
5. Power—is the semiconductor operated within rated power?
6. Testing—is the testing damaging the semiconductor?
7. Specs—is the semiconductor operated within the data sheet?

Overcurrent and overvoltage—absolute maximum ratings should never be exceeded under worst case operating conditions. For reliable operation with a minimum number of failures, current, voltage and temperature should be derated. Usually the greater the derating, the more reliable the semiconductor becomes. The semiconductor manufacturer should be contacted for assistance in derating specific semiconductors. Load, component, and environmental variations (especially temperature) should be investigated as probable causes of voltage or current problems.

Surge—surge current is a fault rating that the semiconductor may see under a fault condition. This fault could happen perhaps only once in the lifetime of the equipment. Surge currents and in-rush currents should be limited to semiconductor capability or, semiconductors with greater capability should be chosen. Since the thermal time constant of the element is small, even a very short surge current can damage a semiconductor. The surge can cause a localized (hot spot) junction temperature to be exceeded even though the case temperature is cool. These localized hot spots can result in degraded or shorted semiconductors.

Transient Voltage—should never exceed maximum rated voltages. These transients can cause a semiconductor to conduct when it should be in a nonconducting period, causing catastrophic failure. Transients that exceed the maximum rated voltage can cause a slow downgrading of the semiconductor spec. Transient protection should be used if occasional or constant transients are suspected.

Power—check power rating for current, voltage and temperature of operation. Power, voltage and current must be derated with an increase in temperature. Never exceed junction temperature even though case temperature is within spec.

Testing—never insert or remove a semiconductor from a test circuit with the power on. Never exceed maximum ratings when testing. Always use proper, calibrated test equipment.

Specification—special characteristics of a semiconductor can be specified to reduce or avoid failures. Burn-in and other hi-rel testing is available to reduce failures.

If after a thorough mechanical and electrical investigation, the user is unable to determine the cause of failure, he should contact the original equipment manufacturer (OEM) for assistance. Any unusual operating or mechanical conditions found in the above investigation, along with a history of use, should be given to the OEM for review.

HISTORY OF USE CHECKLIST

1. When was the semiconductor purchased?
2. What is the date code?
3. How many were purchased?
4. How many failed?
5. How many were installed in equipment?
6. Other history.

The history of the semiconductor's use helps in failure analysis. Was the semiconductor used previously, how much, and with what failure rate? What is the failure rate with the present group? What is the date code? Have other components been changed? What were the operating conditions at the time of failure? These types of questions help isolate a problem and result in an accurate failure analysis.

At this point, if the OEM is unable to determine the probable cause of failure for the user, the OEM can have the semiconductor manufacturer perform a failure analysis. Analysis of the failed semiconductor, along with the information collected above, should aid in a prompt and accurate diagnosis of the cause of the failure.

Semiconductor reliability is a shared responsibility among the semiconductor manufacturer, the circuit and equipment design engineer, and the end user of the equipment. The manufacturer must design and build a reliable semiconductor, the engineer must use good engineering practices when designing the equipment, and *the user must operate the equipment within its ratings and see that it is running properly and that its environment is clean. If these conditions are met, high power semiconductors will be reliable.*

8. IDENTIFICATION AND REPLACEMENT

Many semiconductors are identified by a JEDEC number. JEDEC numbers for rectifiers begin with a "1N" prefix (i.e. 1N4001, 1N1206A, etc.) whereas SCR's and transistors begin with a "2N" prefix (i.e. 2N681, 2N3055, etc.). A JEDEC number is an attempt by the industry (Joint Electronic Device Engineering Council) to standardize electrical and mechanical parameters so that products of one manufacturer will be interchangeable with those of another manufacturer. The user should, however, be careful when making a direct JEDEC substitution of another manufacturer because the JEDEC registered parameters do not always cover all of the critical parameters. As a result, manufacturers using completely different manufacturing processes often sell devices to meet the *same* JEDEC number. While this may not pose a problem in most general purpose and phase control applications, the user must recognize that various manufacturer's devices marked with the *same* JEDEC number can exhibit completely different secondary characteristics and safety margins. An engineer may have unknowingly designed his circuit around a particular JEDEC type number from a manufacturer with process A and a big safety factor (i.e. 6 ampere rated device that really has a 12 ampere actual capability). Everything works fine until the user chooses a replacement JEDEC from another manufacturer . . . then the new devices keep failing in the circuit. Therefore, to be safe, all JEDEC substitutions should be evaluated thoroughly before use.

Most power semiconductors (especially those rated over the 40 to 100 ampere range) are marketed under their respective manufacturer's part number. Even though each manufacturer uses its own device nomenclature, the mechanical packages and electrical ratings are reasonably well-standardized throughout the industry. Therefore, second sourcing and device substitution is not difficult providing the user has a good cross reference guide and the technical data sheets for the devices being evaluated. The Westinghouse Master Cross Reference Type Number Index is located in the General section of this User's Manual and Data Book. Using this JEDEC and alpha/numeric industry index, the user can rapidly locate any power semiconductor product type number for which Westinghouse offers an exact or suggested replacement along with the page number of the corresponding Westinghouse technical data sheets. As with *ANY* cross reference guide, the user *MUST* determine the ultimate substitution acceptability by reviewing the detailed electrical and mechanical characteristic of the devices being considered. This comparison will assure that the manufacturer's suggested replacement will perform properly in the given application.

In the event that the device type number being sought is either unknown (marking is obliterated) or not listed in the Ⓦ Master Cross Reference Type Number Index, a copy of the Replacement Device Identification Checklist should be completed. Chances are Westinghouse can help identify the part and provide a direct or equivalent replacement. Simply call the nearest authorized Ⓦ distributor or local sales representative for a fast response and prompt delivery. See page 54 for checklist.

Replacement. Be sure to order the exact part number—if in doubt, include the *entire* device marking on your order. The most likely place to get "off the shelf" delivery of an exact replacement is directly from the equipment manufacturer. The OEM normally carries an ample supply of renewal parts to service its equipment market. In the event a replacement cannot be obtained from the OEM, the user should contact a local industrial or electronic distributor that handles power semiconductors. A user should only buy a given manufacturer's type number from the manufacturer's authorized distributor outlet or directly from the manufacturer's factory. To do otherwise, the user could receive inferior and/or counterfeit devices from an unknown source. Play it safe . . . deal only with a manufacturer or an authorized distributor.

The maintenance engineer must be thoroughly familiar with equipment service manuals, with the power semiconductors and their technical data sheets, and with the various tools and instruments available for testing and replacing semiconductors. It is wise to carry spare semiconductor components in stock in case of equipment breakdown—especially for critical pieces of equipment.

Many phase control applications—i.e. welding, battery chargers, DC motor controls, and general purpose power supplies can utilize rectifiers, SCR's and/or transistors with fairly broad parameters so long as the device selected has an adequate current and voltage rating and fits mechanically. The user must be *extremely* careful in selecting a replacement semiconductor when general purpose or phase control devices are used in series and/or parallel combination, when fast recovery rectifiers and fast switching SCR's are used in inverters, choppers, etc. or when semiconductor devices are marked with special (non-catalog) part numbers. Specially selected, tested, and/or matched units may be required for the semiconductor to operate properly in the equipment. Failure to use the correct semiconductor device could result in device failures, equipment damage, and plant downtime.

When selecting a device for replacement, the user can always use one with a higher voltage rating provided all other device ratings are equal or better. Likewise, a higher current rated unit can be selected so long as all of the other ratings are equal or better and the mechanical package is the same. By following these guidelines, the user can often locate a suitable replacement faster, reduce spare parts inventory by standardizing on a fewer number of replacement semiconductors, and gain increased reliability with greater voltage and/or current safety factors. Of course, the additional cost for the higher rated semiconductor must be weighed against the savings in inventory reduction, fewer failures, and reduced down time.

In the absence of any other information, a good "rule of thumb" for specifying the proper device voltage rating (based upon the supply voltage to the semiconductor equipment) is as follows: 110V line—use a 300 volt device, 220V line—use a 600 volt device, and a 440V line—use a 1200 volt device. If in doubt about what device to use, call the semiconductor manufacturer and ask for a recommendation.

The user must realize that power semiconductors, like any other component, fail for a reason. It is acceptable to just replace a suspect semiconductor if that is all that is wrong. However, frequently a suspect semiconductor fails as a result of a current or voltage overload elsewhere in the circuit. Simply replacing the suspect semiconductor in these instances will only result in destroying more semiconductors. Therefore, always look for the *cause* of failure before replacing any devices.

Ⓦ Replacement Device Identification Checklist

(make copy for each use)

If you have been unable to locate your power semiconductor part number in the Ⓦ Master cross reference index, simply complete a copy of this form. Chances are Ⓦ can help you identify the part and provide you with a direct or equivalent replacement. Call your nearest authorized distributor or your local sales representative for a fast response and prompt delivery.

PRODUCT CLASSIFICATION

- □ Rectifier
- □ Thyristor (SCR)
- □ Transistor
- □ Other: ________
- □ Do not know.

DEVICE MARKING ________________________

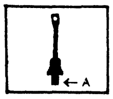
Example:
Ⓦ ⏚ R4041040 7710
1 2 3 4

1. Semiconductor manufacturer's name, symbol or identification:
   □ Ⓦ □ Other: ________
2. Product and/or polarity symbol:
   - □ Rectifier (Standard Polarity)
   - □ Rectifier (Reverse Polarity)
   - □ SCR
   - □ Other: ________ *Sketch*
   - □ No symbol
3. Complete Device part number: ________
4. Manufacturer's date and/or lot code: ________

PHYSICAL DESCRIPTION

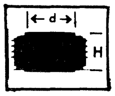
1. **Package Type:** 2. **Approximate Sizes:**

□ STUD MOUNT



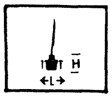
Stud Size (A)
- □ .190"—32
- □ .25"—28
- □ .312"—24
- □ .375"—24
- □ .50"—20
- □ .75"—16
- □ Other ________

□ DISC MOUNT



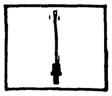
Mounting surface diameter (d): ________
(Smallest diameter)
Package height (H): ________

□ INTEGRAL HEATSINK



Fin size (LxWxH)
- □ 5"x4"x2"
- □ Other: ________

□ STUDLESS

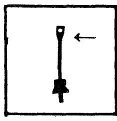


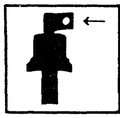
Distance across the flats of the hex:
- □ 1.25"
- □ 1.75"
- □ Other: ________

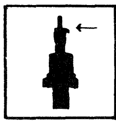
□ OTHER: ________ Sketch

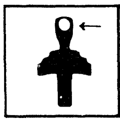
List critical dimensions: ________

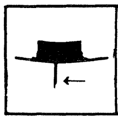
3. **Lead Terminal Description:**

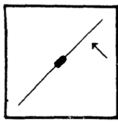
□  FLEX (CABLE) LEAD

□  FLAG LEAD

□  STUD TOP LEAD

□  STANDARD TERMINAL LEAD

□  PIN LEAD

□  AXIAL LEAD

□ Sketch OTHER: ________

Power and/or Control Lead

Lengths: ________

4. **Physical Appearance** (i.e. ceramic or glass-to-metal seal, color of seal or package, nickel plating, etc.): ________

DEVICE ELECTRICAL RATINGS

1. Current: ________ 2. Voltage: ________
3. Other spl. characteristics (surge current, t_{on}, t_{off}, etc.): ________

EQUIPMENT DESCRIPTION

1. Type: ________ 2. Manufacturer: ________
3. **Approximate age:** ________

CURRENT REQUIREMENT

1. Application: □ Replacement □ New Design □ Conversion
2. Quantity required: ____ 3. Required delivery: ________
4. Other considerations: ________

REQUESTED BY

Name: ________ Job Function: ________

Company: ________ Phone No.: (____) ________

Address: ________

City: ________ State: ________ Zip: ________

When removing a defective semiconductor, care must be taken so as not to mar the mounting contact surfaces or damage adjacent components and to preserve all identifying device markings. It is wise to tag the smaller leads (i.e. gate, cathode potential, etc.) for ease of identification. Installing a replacement power semiconductor is discussed in the Westinghouse application data sheet "Mounting Power Semiconductors"—located in the General section of the Westinghouse Data Book. The most important considerations in remounting or replacing devices are to maintain clean mounting and contact surfaces, to continue using a good thermal compound at the mounting interfaces, and to apply the specified torque.

9. SAFETY

Safety in operating and servicing solid state equipment is especially important. Unlike mechanical equipment which has rotating parts, moving contactors, etc., there is nothing to warn one that the equipment is energized. There is also a tendency for the uninitiated to believe that voltage and current levels associated with semiconductor electronics are too low to be dangerous—*don't bet your life on it!* Obvious safety measures must be carefully observed. Most high power equipment includes built in safety interlocks to make certain that the equipment is turned off before anyone can gain access to the circuit areas.

However, maintenance personnel often defeat these interlocks to simplify their service work. This is both careless and stupid. In cases when circuits must be checked while energized there are a few simple rules which could save both personal pain and equipment damage. First, if possible, always work with another person present—one who knows how to shut-down the equipment in a hurry. Second, when working around high voltages, be sure that the floor is covered with a rubber mat, and follow the good practice of working with one hand in your pocket. This sounds simple, but it could prevent one from completing a circuit through the body. Finally, always use insulated tools to avoid short circuits that could further damage electronic components. Some of the common shop practices for safety are too often overlooked or ignored. To name a few:

1. Always wear safety glasses—hot metal from a short or a soldering iron can ruin an eye as quickly as a metal chip.
2. Keep long hair contained with a cap or net.
3. Lock out the disconnect or breaker for the circuit you are about to service.
4. Check with a voltmeter to be sure the circuit is completely dead.
5. Maintain "off limit" areas for high voltage equipment. Access should be allowed only to authorized personnel.

Too many accidents are caused by carelessness or laziness. Bear in mind that it *can* happen, so *be careful.*

5 RELIABILITY

1. UNDERSTANDING SEMICONDUCTOR RELIABILITY

Explanation of reliability. Much has been written about reliability, and it usually ends up in mountains of charts, tables, graphs, curves, and equations which require a mathematical background plus several good courses in statistics to understand. Of course, a great deal of reliability is expressed in statistical terms, such as AQL (Acceptance Quality Level), LTPD (Lot Tolerance Percent Defective), MTBF (Mean Time Between Failures), etc. It will be the object of this section to discuss reliability so that the user, the supplier, the purchasing agent, the salesman and the engineer can understand just what is required and what can be supplied in terms of a reliable product, and to what degree, and at what cost.

The age old requirements of a good newsworthy article are: Who, What, Why, When, and Where. Then, to make this a technical discussion, we add the word, "How".

The *Who* in reliability must refer to the manufacturer. Is the manufacturer dependable? Does back-up data and a good "history" of product usage in the field exist? Can the manufacturer speak knowledgeably in the realm of reliability? These things must be considered when an MTBF figure is discussed or when an LTPD value is specified.

Next, we come to the big question: *What* is Reliability? The dictionary describes it as "worthy of confidence; trustworthy." From the word rely, "to depend on; trust; repose confidence upon". This is all quite graphic and needs no further explanation. However, another parameter enters the picture here and that is the *degree* of reliability. It has become customary in the semiconductor industry to refer to any device which is a cut above the standard as a Hi-Rel device, no matter how reliable (or unreliable) the standard product is or to what degree it has been improved. So now it becomes necessary to define degree or level of reliability required and to do so in a universal language which will put us all in the same ball park. For this reason we turn to the common denominator of statistics.

In the field of semiconductors, the standard for quality has been set by the military, and rightly so, since in many of their applications life itself depends upon the *reliability* of the device being used. The basic document is Specification Mil-S-19500, "Semiconductors, General Specifications For." This specification provides an excellent table for evaluating or planning device reliability. Table 5.1 provides a sampling plan for testing a lot of devices with a reasonable assurance (90% confidence level) that, 9 out of 10 times, the number of defective units that may be found in the lot (regardless of size) will not exceed the percentage indicated by the chosen LTPD number. As an example, let us assume that a certain lot of units has been processed to meet an LTPD of 10. From the table we select a test sample of 38 devices, which allows one failure (a = 1). This would be an actual failure rate for the test sample of 2.63%. The difference between 10% and 2.63% takes into account a statistical probability of picking out defective units in the same proportion as they may appear in a lot, with a small random sample. Note that the larger the sample the greater the percent defective allowed; if we select a sample size of 326 (in the 10% column), the acceptance number is 25. This gives an actual percent defective in the test sample of 7.67%. In other words, if we continue testing the entire lot the acceptance number approaches 10%. This means that if the acceptance number is not exceeded in the first test sample (usually small), one may be sure (90%) that the number of defective units in this particular lot (one manufacturing run) will not exceed the LTPD to which we are testing. Usually, the actual quality of a group of devices is much better than is indicated by the LTPD to which they have been tested, for the simple reason that a manufacturer cannot afford to process devices to the exact degree where each test sample will produce the allowable number of defectives and no more. A rejected lot can be very expensive. Note also that, as data accumulates in "small sample" testing, the better the overall LTPD becomes.

In the example just cited, if a lot is tested to an LTPD of 10 with a sample size of 38, the lot is accepted at this level (10% LTPD) with one reject. If 10 lots in a row are accepted, each with maximum allowable failures, the total sample size becomes 380 and the acceptance number is 10. From the table this would indicate (by extrapolation) an LTPD of 3.7 for the total product. It is evident that a product with a history of lot acceptances must be considered more reliable than a similar new product, even though both are tested to the same specifications and at the same level; hence, there is a definite resistance to change by users of proven semiconductor products, even though the manufacturer has devised numerous tests to show that the product has been improved. Another reason for this "resistance" is the fact that very often changes in product are instituted for

Max. Percent Defective (LTPD) or λ	50	30	20	15	10	7	5	3	2	1.5	1	0.7	0.5	0.3	0.2	0.15	0.1
Acceptance Number (c) (r = c + 1)	Minimum Sample Sizes (For device-hours required for life test, multiply by 1000)																
0	5 (1.03)	8 (0.64)	11 (0.46)	15 (0.34)	22 (0.23)	32 (0.16)	45 (0.11)	76 (0.07)	116 (0.04)	153 (0.03)	231 (0.02)	328 (0.02)	461 (0.01)	767 (0.007)	1152 (0.005)	1534 (0.003)	2303 (0.002)
1	8 (4.4)	13 (2.7)	18 (2.0)	25 (1.4)	38 (0.94)	55 (0.65)	77 (0.46)	129 (0.28)	195 (0.18)	258 (0.14)	390 (0.09)	555 (0.06)	778 (0.045)	1296 (0.027)	1946 (0.018)	2592 (0.013)	3891 (0.009)
2	11 (7.4)	18 (4.5)	25 (3.4)	34 (2.24)	52 (1.6)	75 (1.1)	105 (0.78)	176 (0.47)	266 (0.31)	354 (0.23)	533 (0.15)	759 (0.11)	1065 (0.080)	1773 (0.045)	2662 (0.031)	3547 (0.022)	5323 (0.015)
3	13 (10.5)	22 (6.2)	32 (4.4)	43 (3.2)	65 (2.1)	94 (1.5)	132 (1.0)	221 (0.62)	333 (0.41)	444 (0.31)	668 (0.20)	953 (0.14)	1337 (0.10)	2226 (0.062)	3341 (0.041)	4452 (0.031)	6681 (0.018)
4	16 (12.3)	27 (7.3)	38 (5.3)	52 (3.9)	78 (2.6)	113 (1.8)	158 (1.3)	265 (0.75)	398 (0.50)	531 (0.37)	798 (0.25)	1140 (0.17)	1599 (0.12)	2663 (0.074)	3997 (0.049)	5327 (0.037)	7994 (0.025)
5	19 (13.8)	31 (8.4)	45 (6.0)	60 (4.4)	91 (2.9)	131 (2.0)	184 (1.4)	308 (0.85)	462 (0.57)	617 (0.42)	927 (0.28)	1323 (0.20)	1855 (0.14)	3090 (0.085)	4638 (0.056)	6181 (0.042)	9275 (0.028)
6	21 (15.6)	35 (9.4)	51 (6.6)	68 (4.9)	104 (3.2)	149 (2.2)	209 (1.6)	349 (0.94)	528 (0.62)	700 (0.47)	1054 (0.31)	1503 (0.22)	2107 (0.155)	3509 (0.093)	5267 (0.062)	7019 (0.047)	10533 (0.031)
7	24 (16.6)	39 (10.2)	57 (7.2)	77 (5.3)	116 (3.5)	166 (2.4)	234 (1.7)	390 (1.0)	589 (0.67)	783 (0.51)	1178 (0.34)	1680 (0.24)	2355 (0.17)	3922 (0.101)	5886 (0.067)	7845 (0.051)	11771 (0.034)
8	26 (18.1)	43 (10.9)	63 (7.7)	85 (5.6)	128 (3.7)	184 (2.6)	258 (1.8)	431 (1.1)	648 (0.72)	864 (0.54)	1300 (0.36)	1854 (0.25)	2599 (0.18)	4329 (0.108)	6498 (0.072)	8660 (0.054)	12995 (0.036)
9	28 (19.4)	47 (11.5)	69 (8.1)	93 (6.0)	140 (3.9)	201 (2.7)	282 (1.9)	471 (1.2)	709 (0.77)	945 (0.58)	1421 (0.38)	2027 (0.27)	2842 (0.19)	4733 (0.114)	7103 (0.077)	9468 (0.057)	14206 (0.038)
10	31 (19.9)	51 (12.1)	75 (8.4)	100 (6.3)	152 (4.1)	218 (2.9)	306 (2.0)	511 (1.2)	770 (0.80)	1025 (0.60)	1541 (0.40)	2199 (0.28)	3082 (0.20)	5133 (0.120)	7704 (0.080)	10268 (0.060)	15407 (0.040)
11	33 (21.0)	54 (12.8)	83 (8.3)	111 (6.2)	166 (4.2)	238 (2.9)	332 (2.1)	555 (1.2)	832 (0.83)	1109 (0.62)	1664 (0.42)	2378 (0.29)	3323 (0.21)	5546 (0.12)	8319 (0.083)	11092 (0.062)	16638 (0.042)
12	36 (21.4)	59 (13.0)	89 (8.6)	119 (6.5)	178 (4.3)	254 (3.0)	356 (2.2)	594 (1.3)	890 (0.86)	1187 (0.65)	1781 (0.43)	2544 (0.3)	3562 (0.22)	5936 (0.13)	8904 (0.086)	11872 (0.065)	17808 (0.043)
13	38 (22.3)	63 (13.4)	95 (8.9)	126 (6.7)	190 (4.5)	271 (3.1)	379 (2.26)	632 (1.3)	948 (0.89)	1264 (0.67)	1896 (0.44)	2709 (0.31)	3793 (0.22)	6321 (0.134)	9482 (0.089)	12643 (0.067)	18964 (0.045)
14	40 (23.1)	67 (13.8)	101 (9.2)	134 (6.9)	201 (4.6)	288 (3.2)	403 (2.3)	672 (1.4)	1007 (0.92)	1343 (0.69)	2015 (0.46)	2878 (0.32)	4029 (0.23)	6716 (0.138)	10073 (0.092)	13431 (0.069)	20146 (0.046)
15	43 (23.3)	71 (14.1)	107 (9.4)	142 (7.1)	213 (4.7)	305 (3.3)	426 (2.36)	711 (1.41)	1066 (0.94)	1422 (0.71)	2133 (0.47)	3046 (0.33)	4265 (0.235)	7108 (0.141)	10662 (0.094)	14216 (0.070)	21324 (0.047)
16	45 (24.1)	74 (14.6)	112 (9.7)	150 (7.2)	225 (4.8)	321 (3.37)	450 (2.41)	750 (1.44)	1124 (0.96)	1499 (0.72)	2249 (0.48)	3212 (0.337)	4497 (0.241)	7496 (0.144)	11244 (0.096)	14992 (0.072)	22487 (0.048)
17	47 (24.7)	79 (14.7)	118 (9.86)	158 (7.36)	236 (4.93)	338 (3.44)	473 (2.46)	788 (1.48)	1182 (0.98)	1576 (0.74)	2364 (0.49)	3377 (0.344)	4728 (0.246)	7880 (0.148)	11819 (0.098)	15759 (0.074)	23639 (0.049)
18	50 (24.9)	83 (15.0)	124 (10.0)	165 (7.54)	248 (5.02)	354 (3.51)	496 (2.51)	826 (1.51)	1239 (1.0)	1652 (0.75)	2478 (0.50)	3540 (0.351)	4956 (0.251)	8260 (0.151)	12390 (0.100)	16520 (0.075)	24780 (0.050)
19	52 (25.5)	86 (15.4)	130 (10.2)	173 (7.76)	259 (5.12)	370 (3.58)	518 (2.56)	864 (1.53)	1296 (1.02)	1728 (0.77)	2591 (0.52)	3702 (0.358)	5183 (0.256)	8638 (0.153)	12957 (0.102)	17276 (0.077)	25914 (0.051)
20	54 (26.1)	90 (15.6)	135 (10.4)	180 (7.82)	271 (5.19)	386 (3.65)	541 (2.60)	902 (1.56)	1353 (1.04)	1803 (0.78)	2705 (0.52)	3864 (0.364)	5410 (0.260)	9017 (0.156)	13526 (0.104)	18034 (0.078)	27051 (0.052)
25	65 (27.0)	109 (16.1)	163 (10.8)	217 (8.08)	326 (5.38)	466 (3.76)	652 (2.69)	1086 (1.61)	1629 (1.08)	2173 (0.807)	3259 (0.538)	4656 (0.376)	6518 (0.269)	10863 (0.161)	16295 (0.108)	21726 (0.081)	32589 (0.054)

TABLE 5.1 LTPD sampling plans 1/ 2/

Minimum size of sample to be tested to assure, with a 90 percent confidence, that a lot having percent-defective equal to the specified LTPD will not be accepted (single sample). 1/ Sample sizes are based upon the Poisson exponential binomial limit. 2/ The minimum quality (approximate AQL) required to accept (on the average) 19 of 20 lots is shown in parenthesis for information only.

the sole purpose of cost reduction; then the change is made on an "as good as" basis, and only a similar history of successful usage will convince a user. In this respect, the market is often fickle because it forces many reliable manufacturers to compete with "junk dealers" on price alone, and then it pays a high price to have reliability processed into the device.

In spite of this resistance to changing an established product, it is necessary for a manufacturer to keep abreast of the state-of-the-art and, as is usually the case, an old (and proven) line of devices must be discontinued in favor of the new before enough data has been accumulated to call it equivalent. In these instances, one has to use a "projected" failure rate rather than an actual failure rate. As an example, if we take the factual LTPD of 3.7 as determined above and go back to the Table (by extrapolation), we find that we may expect one failure in 111 units; if the test is a 1000-hour operation life test, we may now say that the product has an established MTBF of 110,000 hours. For the new product, we claim the same MTBF, on the basis of starting with the same test level and including enough processing to give a reasonable assurance that the succeeding lots will pass operating life test. This is considered a projected MTBF. When the LTPD figure is applied to 1000-hour life tests or LTPD per thousand hours, it becomes the life test failure rate, (Lambda), which is expressed as percent defective per 1000-hour operation.

To sum up what is meant by reliability in semiconductors, we find that:

- The degree of reliability must be defined; the term "hi-rel" device is meaningless by itself.
- Degree or level is defined (usually) by a Mean Time Between Failure figure, along with a given confidence level.
- There is a distinction between High Reliability and Established Reliability. A device may be designed for High Reliability, but Established Reliability is achieved only from actual data covering hundreds of thousands of device hours of actual use.
- A good yardstick for estimating a "projected reliability" is the LTPD figure to which the device lot is tested, as set forth in the Table of Mil-S-19500 with a 90% confidence level.

Why is so much emphasis being placed on reliability? As semiconductors are being designed into more complex and sophisticated equipment, it becomes more and more essential to avoid "down" time or malfunctions. Also, in the missile and space program, "expected" failures cannot be tolerated. Although the greatest Hi-Rel requirements are found in such applications as aircraft, military and space projects, the equipment manufacturers and industrial users are beginning to demand more reliability in the semiconductors which they use. Here again, the cost of replacing a component must be weighed against the cost of procuring a sufficiently high reliability device to minimize or eliminate the need for replacement. This becomes our *when* of reliability; when the cost of processing a manufactured lot of semiconductors is attractive when compared to a possible malfunction of a standard device, or when the added reliability of a piece of equipment enhances the manufacturer's reputation for dependability.

Where is reliability introduced into a device—from beginning to end. It starts with the choice of suppliers of component parts and continues with incoming inspection, in-line processes and controls, processing after construction, end of line screening and testing, quality assurance testing, storage and marking methods and controls, and shipping tests and it ends with the user's incoming inspection and application with special emphasis on conformance to the parameters as set forth for the device.

This method of using actual test failures, together with a history of (accumulated data) similar devices, to obtain a projected MTBF is probably an over-simplification, but it does provide a ball park figure which, if anything, would be conservative. No matter what complicated and time consuming system is used, the results will still be an approximation.

How to achieve reliability.

How is this "extra" reliability to be obtained? We have often heard it stated that one cannot test quality into a product. This is very true; however, we can process non-quality out. First, let us consider some of the possible causes of semiconductor failure, not necessarily in order of importance:

- Excessive junction temperature
- Thermal fatigue
- Aging
- Poor construction, misalignment of parts
- Foreign particles
- Mechanical stress
- Lack of hermeticity

- Inconsistencies in crystal, doping, element
- Improper curing of junction coating
- Improper use—nonconformance to limiting parameters assigned to the device

No doubt there are many other causes of failures, but these are the ten most obvious. Many of these "faults" can be greatly minimized by rigid incoming inspections and constant monitoring of fusion furnace temperatures, etching processes, assembly practices, soldering temperature, junction coating and curing, and visual inspection up to encapsulation. This in-line control is essential for good reliability in a product and is a "must" if we are to maintain a reasonable confidence level. However, even the best controls cannot enable one to predict the effect of electrical, mechanical, and environmental stresses upon a device. For this reason, various conditioning procedures have been developed to simulate some of the above listed causes of failure. It is an attempt to prevent and/or weed out devices which may be subject to "infant mortality"-that is, failure in the first week or two of operation. It has been found from experience and many thousands of hours of operation that once a semiconductor survives the first week or two of operation, its chance of reaching the expected lifetime is more than doubled.

Normally, one would believe that with exacting in-line controls, such faults as misalignment, foreign particles, hermeticity, and improper curing would be eliminated, but this is not so. Many things can happen to a device during the encapsulation procedure which usually involves heat stresses from welding and soldering temperatures and mechanical stresses from pressures on the internal lead and pinch-off and crimping operations. Also, the amount of in-line controls must be dictated by the quality and cost required to meet competition in the volume market. Once this criterion is met, we start considering the various procedures for producing a high reliability product. There are three major contributing factors in planning a Hi-Rel program: (a) Level of reliability required; (b) Cost of achieving the required level of reliability and (c) Volume—number of units to be processed. Naturally, the customer wants the most reliability for the least cost and the customer must decide what level can be tolerated. Before going into the various levels of reliability, it would be wise to look into the various tests and procedures that are available to achieve these levels and to consider the good and bad features of each.

1. **Temperature Cycling:** Cycles from minimum to maximum rated junction temperatures and back again in a specified time. This operation is done on a batch basis and is relatively inexpensive. It is designed to weed out those devices that may have a tendency to fail due to expansion and contraction of the various materials in the device package which could crack an element or break a solder connection.

2. **Stabilization Bake:** A bake at the maximum rated temperature. The purpose of this step is to stabilize the device by further curing of the junction coating. This is also an inexpensive procedure. These first two steps are essential before proceeding with further processing. In many instances, especially in the case of military products, it is included in the standard procedure.

3. **X-Ray Examination:** A very expensive operation, made more so because of the elaborate requirements of some semiconductor X-ray specifications which require that all devices be serialized. Film must be processed and examined and careful lot control maintained so that corresponding units and film are shipped together. The equipment is expensive and the operators must be well-trained. This is the only way, however, by which faulty construction or the presence of foreign particles can be detected after encapsulation. The test becomes much more effective if performed after shock and/or vibration tests. Needless to say, the sooner this procedure can be changed from a 100% basis to a sample basis without jeopardizing the confidence level, the happier all concerned will be.

4. **Operating Life:** Perhaps the best single process for improving the reliability of a device. This process consists of actually operating the unit at stated parameters for a specific period of time. Usually, the operating conditons are the maximum rated forward current, reverse voltage, and case temperature. Times vary depending on need. This operation is expensive because every device must be handled separately, it ties up life test equipment for long periods, and scheduling times are often prohibitive. The cost of building special equipment for any particular order is also prohibitive. For this reason, volume and delivery requirements are important considerations in using this procedure.

The reason Operating Life is so highly regarded is graphically illustrated by a Failure Rate versus Operating Time Curve, Figure 5.1. This curve falls very steeply during the initial operating time, then gradually levels out to the inherent value for the device.

5. **Blocking Life:** This process has the rated peak reverse voltage (either full or half wave rectified) applied to the units while in an ambient equal to the maximum rated junction temperature for a determined time period. This is often done in conjunction with Stabilization Bake with a moderate increase in cost because a connec-

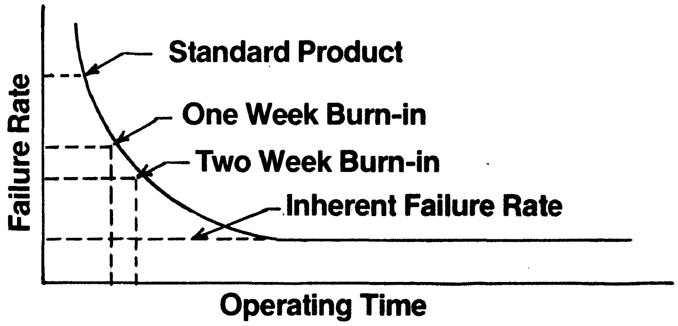


Figure 5.1 Effect of operating life burn-in on semiconductor failure rate over time.

tion must be made to each device, which then limits the number of devices that can be handled at one time. It is no longer a "batch" operation. Blocking Life is a very good alternative for Operating Life.

6. **Power Cycling (Thermal Fatigue):** The Power Cycling test may also be used as a substitute for Operating Life. However, care must be taken as to the number of cycles specified for conditioning because this is a severe test and probably reduces the actual lifetime of the device. The test consists of heating the device up to its operating case temperature by the application of forward current and then force-cooling it back to approximately room temperature. The device under test is subjected to a continuous expansion and contraction of materials which sets up stresses in the soldered and brazed connection within the device package and simulates, in an accelerated manner, the effects of actual usage. Reverse voltage is usually not applied during this test. Here again, a great deal of equipment is involved, depending on the quantities (and size) of units to be conditioned. The equipment is not very complicated and should be relatively inexpensive when compared to operating life test equipment.

7. **Monitored Shock and Vibration:** Used to determine the mechanical stability of the device. The units are subjected to specified vibrations and /or shocks while in an operating state. The current, either forward or reverse, is monitored to detect instantaneous opens or shorts or electrical "noise". This is a slow, therefore expensive, test since only a few units can be processed at a time. When this procedure is called for, it should be done before X-Ray and Hermeticity tests.

8. **Hermeticity Test:** This test is used to determine the effectiveness of the package seal which protects the element. The entranoe of damaging contaminants will reduce the effective life of a semiconductor, hence, a good package seal is imperative in a high reliability device. This is a fairly expensive test when done on a 100% basis. It requires a good commercial tester and is not a batch operation.

Of these procedures, you will note that 1, 2, 4, 5, and 6 are conditioning processes, while 3, 7, and 8 are selection or "weeding out" type of tests. Naturally, any conditioning should be done before the selection tests. The monitored shock and vibration tests can be considered as both conditioning and selecting, and should be performed before hermeticity tests or X-Ray.

All of these procedures become more effective when accompanied by limitations on changes in characteristics, that is, maximum allowable ΔV_F and ΔI_R. This assures a more stable end product but may also eliminate a lot of good devices and prove quite expensive.

After a lot of semiconductors has been stabilized and most of the "weak sisters" removed by some combination of the above mentioned procedures, there is a final process which will enhance reliability tremendously and that is "derating" the device in some (or all) of its parameters. For instance, an 800 volt, 12 amp at $T_C = 150^{\circ}$ C rectifier will be more reliable if rated as a 600 volt device and even more reliable as a 600 volt, 6 amp at $T_C = 125^{\circ}$C device. The intended application of the rectifier would dictate which parameters should be derated for the best results. If the unit may be subjected to high transient voltages, then the voltage should be derated. If the unit is to be used in a circuit with frequent on-off operations or subjected to many temperature excursions, then the current and/or temperature should be derated.

To illustrate to the semiconductor equipment designer and user the value of derating as a reliability tool, graphs of the failure rates per 1000 hours for thyristors, transistors, and rectifiers are shown in figures 5.2, 5.3, and 5.4.

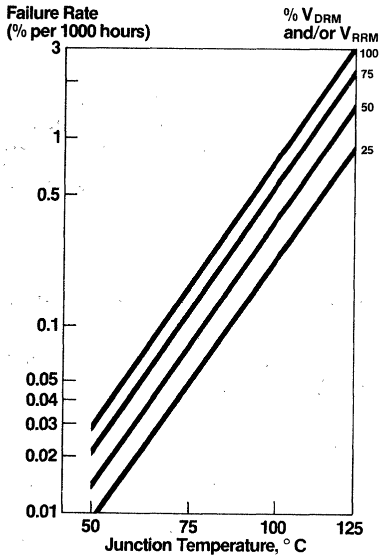


Figure 5.2 Estimated degradation failure rate for thyristors at less than 50 amps per μsec. For catastrophic failures, use 10% of these values.

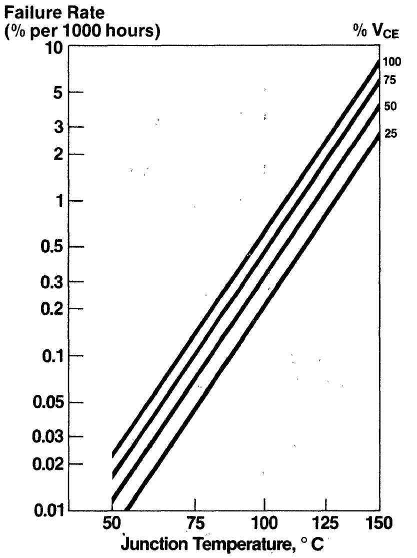


Figure 5.3 Estimated failure rate for transistors. For catastrophic failures, use 10% of these values.

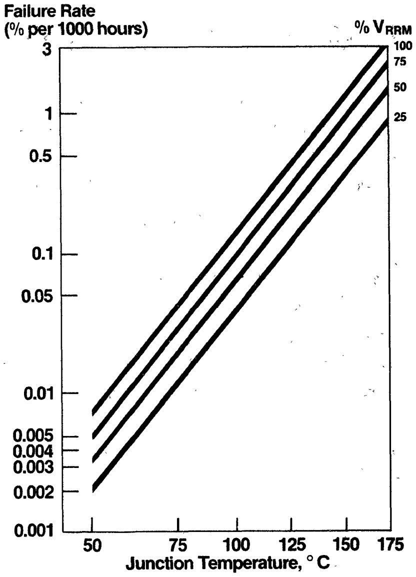


Figure 5.4 Estimated failure rate for rectifiers. For catastrophic failures, use 10% of these values.

These graphs show that one key to enhancing reliability is derating. Derate any of the reliability sensitive parameters, such as the temperature and the voltage to which the semiconductor is subjected, and derate the related parameters of current, power, thermal impedance, and time, and the reliability will be increased. A study of the derating curves shows that a reduction of the junction temperature gives a larger reduction in the failure rate than a similar reduction in applied voltage. Also, a larger percentage of failures is expected at 100% of rated voltage than at a lower (derated) voltage. Using figure 5.2, the failure rate for 125°C and 100% rated voltage is 3%. If the voltage is lowered to 75% of rated value and the junction temperature is decreased to 75°C, the failure rate is 0.15%, or 20 times lower.

This discussion has endeavored to reduce the complicated business of semiconductor reliability, whether achieving, proving, calculating or projecting, to a few undeniable truths, as follows:

- The chief reasons for unreliability must be recognized and dealt with.
- There are only a certain number of processes or procedures that can be applied to a semiconductor device to enhance its quality, once manufacturing is completed.
- There are so many variables in both the manufacture and use of these devices that each type has an inherent degree of reliability which cannot be improved upon with any amount of processing.
- Because of economic and practical considerations, one must sample test to determine and project reliability. Use of Table 5.1 provides a good method for this.
- Expense must be balanced with need in specifying a degree of reliability. Reliability can be a practical thing; it does not have to be a tool for statisticians, nor does it require exotic computer programming.

So let us keep in mind, whether buying or selling reliability, that a Hi-Rel product is a good thing, but the degree of reliability must be handled intelligently. We do not want to waste money, but we do want a device we can depend on—a reliable device.

2. QUALITY CONTROL

To insure reliability, the Westinghouse Semiconductor Division uses a quality control program, a statistical method that monitors the manufacture and testing of semiconductors. The quality of a semiconductor is determined by quality controls, such as incoming materials inspections, control of the silicon processing and chemical purity, electrical tests, environmental tests, packaging and many other controls used in the manufacturing process. These controls are inserted to insure uniform quality.

Testing for reliability

During the design of a semiconductor, and particularly before final manufacturing approval is given, operating, storage, and environmental tests are conducted to determine the integrity and reliability of the semiconductor. The tests can be operated at accelerated stress levels to help determine margins in the device design and to predict the reliability at low application stress levels. A partial list of these tests follows:

- Centrifuge, shock, and thermal shock are evaluated to determine the mechanical features of a design..
- Operating and storage life tests are used to evaluate the physical and chemical stability of the semiconductor design.
- Current surge data is gathered to verify the semiconductor current handling capability and the short, high current capability of the internal connections.
- Thermal fatigue data is used for checking element mounting integrity.
- Thermal impedance measurements are made to insure proper junction temperature during operation.
- Blocking life tests are used to determine if reliability is affected by junction temperature and voltage.
- Step stress testing can be run to show the threshold of failure and the accelerated stress areas such as junction temperature, voltage or environment.

During the manufactured life, a family plan of testing determines if the reliability test results are still valid. The goal of the family plan is to achieve maximum device yield economy consistent with sufficient assurance that end-of-life limits will not be exceeded during the semiconductor equipment lifetime. These results can be used as an interpretation of the reliability of similar device families. Other voltage and current parameters can be extrapolated from similar device characteristics.

Improved reliability is achieved through many corrective actions involving the design, process, fabrication, material, and device assembly inspections. Before any of these are changed, the reliability impact is studied and appropriate testing is instituted. Over the years, there have been improvements in the element surfaces, the element material, and the packaging that have resulted in generally lower failure rates.

Testing to determine the quality of the semiconductors is done on various parameters. This testing is repeated many times as the semiconductor element continues through the manufacturing cycle and is repeated again when the element is assembled in a package. Reliability testing, such as blocking life, is done on a sampling basis in the element state, as well as in the completed package. Surge capability and thermal impedance are used as reliability measurement tools.

Types of failures

Quality is closely related to reliability, which in turn, is dependent on failure rate. There are three types of semiconductor failures: the early or freak failures, the chance failures, and the wearout failures. These failures are shown in Fig. 5.5 in relation to semiconductor lifetime.

Early failures result when semiconductors have some production defect, material defect, or other deficiency. Even with good quality control, semiconductors will always have a small percentage of early failures, but these can be eliminated by doing quality conformance testing on all the units or by sample testing. One or more of the following tests, which could take from 2 hours to 168 hours or more, could be chosen: stabilization bake, operation life, or blocking life. Tests that are not time dependent could include temperature cycling, salt spray and hermeticity.

Wearout failures are practically non-existent in properly applied semiconductors during the normal life of a system. Where they do occur, wearout mechanisms exist both in structural flaws and in internal encapsulated contaminants. Because semiconductors cannot be made completely free of these flaws or contaminants, early failures can happen. But in well-designed, properly applied semiconductors, the wearout should occur long after the useful life of the system itself.

Chance failures occur between the early failures and the much later wearout period. This is the long period of useful life of a semiconductor during which there is small expectation of failures. The failures that do occur are time, temperature, current, and voltage dependent.

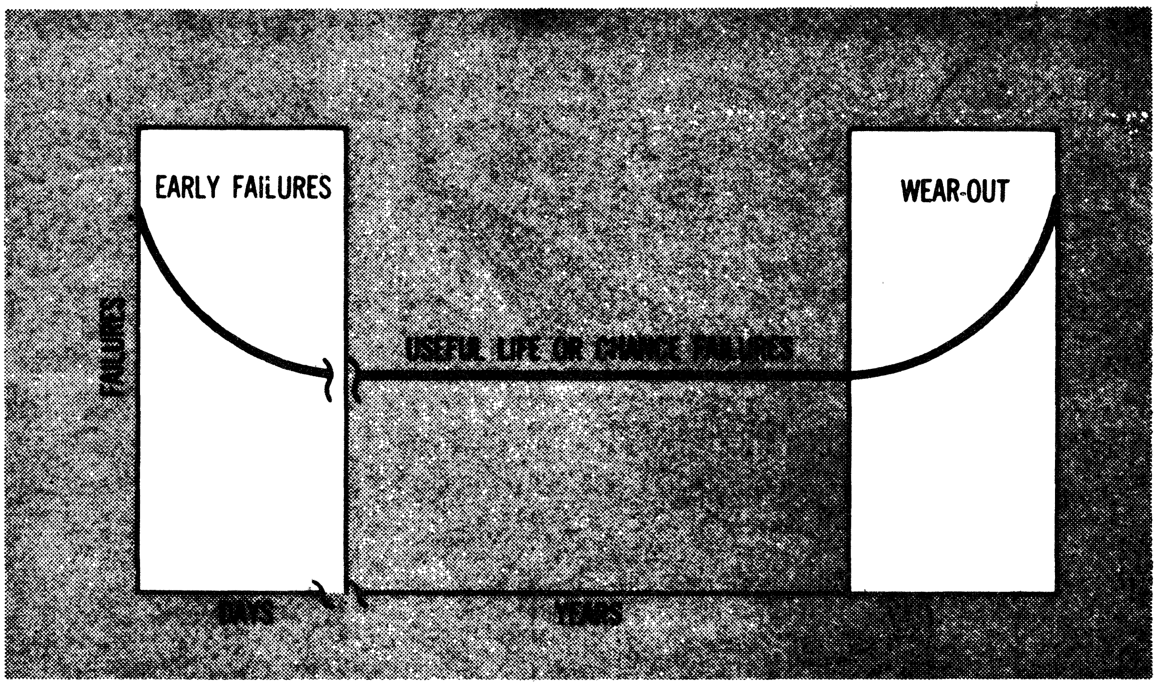


Figure 5.5 The probability of failure as a function of semiconductor lifetime.

Quality and reliability testing defined

Testing for quality and reliability is usually divided into four catagories; Group A, Group B, Group C, and Special.

- **Group A** includes all the standard electrical tests required to assure that a semiconductor meets the voltage, current, switching times, control functions, etc. as stated in the device specification. Group A is performed on every lot.
- **Group B** testing provides assurance that the semiconductor is properly constructed, durable, and will operate under extreme environmental conditions. These tests include operating life tests, stabilization bake, hermeticity tests, humidity, shock and vibration, etc. Once a manufacturer has established a consistent parts supplier and fabrication cycle, group B testing (which is expensive) may be performed on combined lots or alternate lots.
- **Group C** testing, in essence, checks whether or not the semiconductor is properly designed to meet certain special criteria. These tests include such things as high altitude test, salt atmosphere test, and thermal resistance tests. Usually, these tests are necessary only when there is a change of material, design, or process in the manufacturing cycle.
- **Special testing.** In some instances, a customer application puts unique stresses on semiconductors so that extra testing of certain parameters, or even specially designed testing, is required to assure that the semiconductor will perform as required.

  Table 5.2 on page 65 illustrates a typical test plan and preferred order of grouping as recommended in Mil-S-19500.

3. RESPONSIBILITIES

User responsibility: The user has the responsibility of insuring proper operation of the equipment. The maximum rating of the equipment must never be exceeded. The voltage and current must never be raised above maximum ratings to increase production. The cooling system must be monitored periodically to insure proper cooling at all times. The semiconductors and associated equipment must be kept clean. It is imperative to reliable operation that a schedule be set up for cleaning, tightening connections, etc. In short, exercise good operating and maintenance procedures.

Shared responsibility: Semiconductor reliability is a shared responsibility among the semiconductor manufacturer, the original equipment manufacturer (OEM), and the end user of the equipment. The manufacturer must design and build a reliable semiconductor, the OEM must use good engineering practices when designing the equipment, and the user must operate the equipment within its ratings and in a clean environment. If these conditions are met, power semiconductors will be reliable.

Failure analysis as a reliability tool: Failure analysis involves the gathering and analyzing of all possible information about the cause of a failed semiconductor. Knowing the reason for failure, the user can modify the circuit to eliminate any repetitions of this failure mode, or the manufacturer can take corrective action in device fabrication or testing. Proper analysis may determine if a failure is due to voltage, current, over-temperature or surge. However, a failed semiconductor may show more than one mode of failure; a history of the use of the device is then necessary. For instance, if the installation was trouble-free until a certain point in time, when new or different equipment was added or a new operator was being trained, the problem may be easily resolved. Thus, failure analysis can often be specific and give the actual failure mode but, just as often, the actual cause of failure is masked, and help in the form of historical data is needed. A "burn-out" of a semiconductor is often violent enough to mask out much, if not all, of the original cause of failure. So, the more background furnished, the more meaningful the analysis. A good failure analysis will determine the reason for failure and corrective action can then be taken.

- **Group A Inspection**
  Visual & mechanical examination
  Electrical performance tests

- **Group B Inspection**

  Subgroup 1
  Physical dimensions

  Subgroup 2

Solderability	Terminal strength
Temperature cycling	Hermetic Seal
Thermal shock	Misture resistance

  Subgroup 3

Shock	Vibration, variable frequency
Vibration fatigue	Constant acceleration

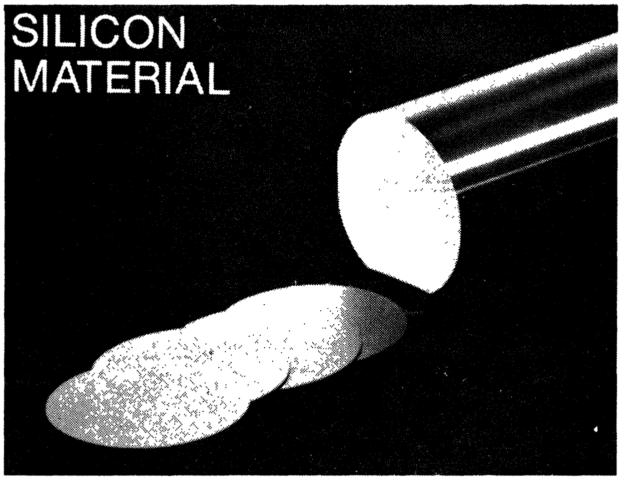
  Subgroup 4
  Terminal strength

  Subgroup 5
  High temperature life, non-operating

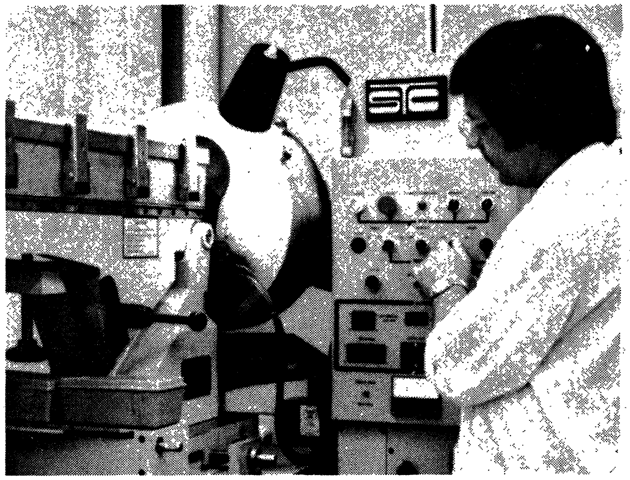
  Subgroup 6
  Operating life

- **Group C Inspection**
  Barometric pressure (altitude)
  Salt atmosphere
  Other periodic tests

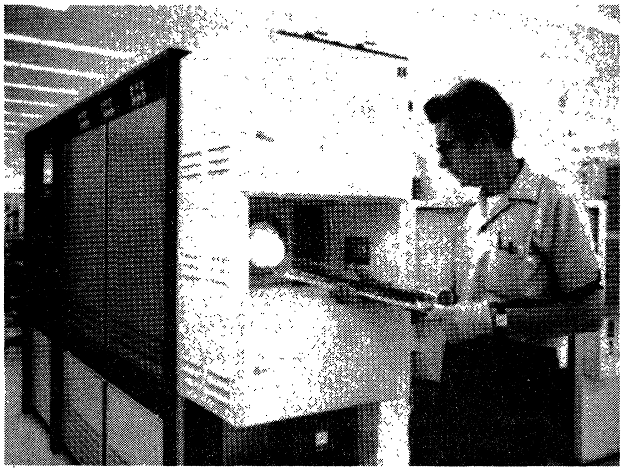
Table 5.2 Typical Test Plan



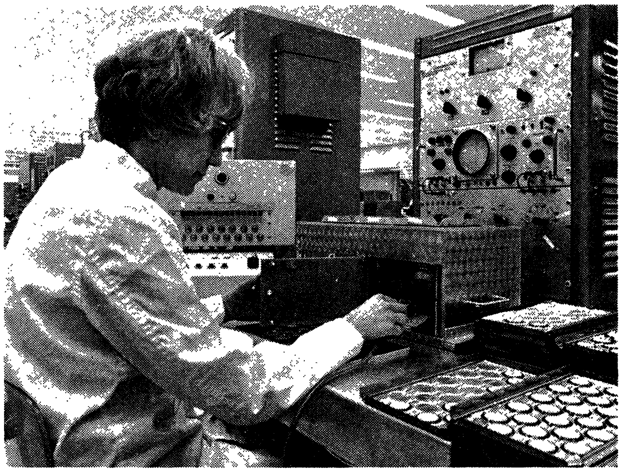
From silicon rod . . .



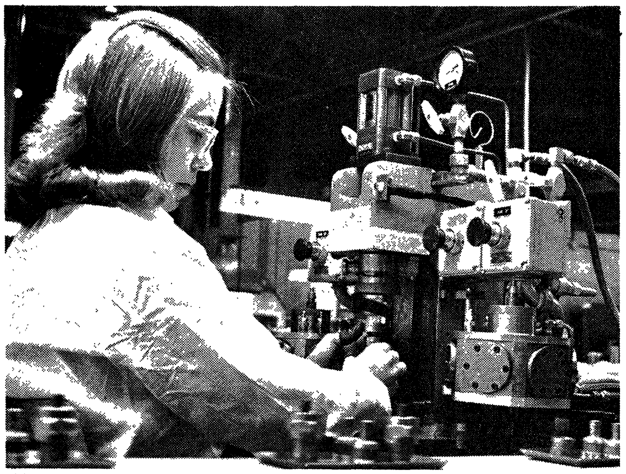
slicing . . .



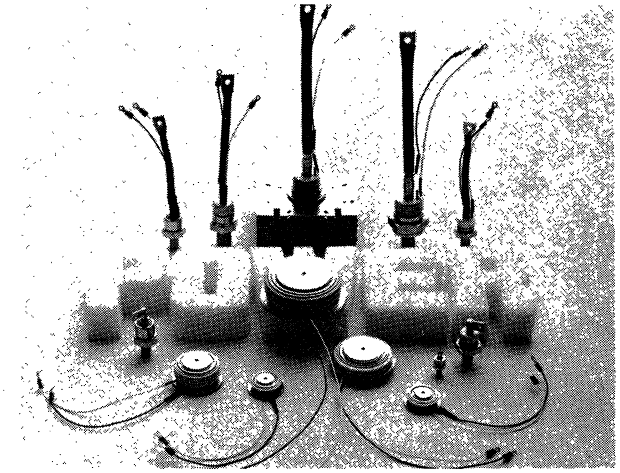
diffusion . . .



element testing . . .



package assembly . . .



to finished devices.

6 MANUFACTURING Ⓦ POWER SEMICONDUCTORS

1. FACILITIES

The Westinghouse Semiconductor Division facility (Figure 6.1) in Youngwood, Pa. is the most modern high power semiconductor manufacturing plant in the world. At the Youngwood facility, nestled in the foothills of the Allegheny Mountains, the silicon elements which house all the electrical characteristics of the power semiconductor component are made. This single location for element production extends its capability for supplying superior high power semiconductor devices to identical assembly facilities in Le Mans, France (Figure 6.2) and San Juan, Puerto Rico (Figure 6.3) with a new facility opening in Brazil to serve the Latin American market.

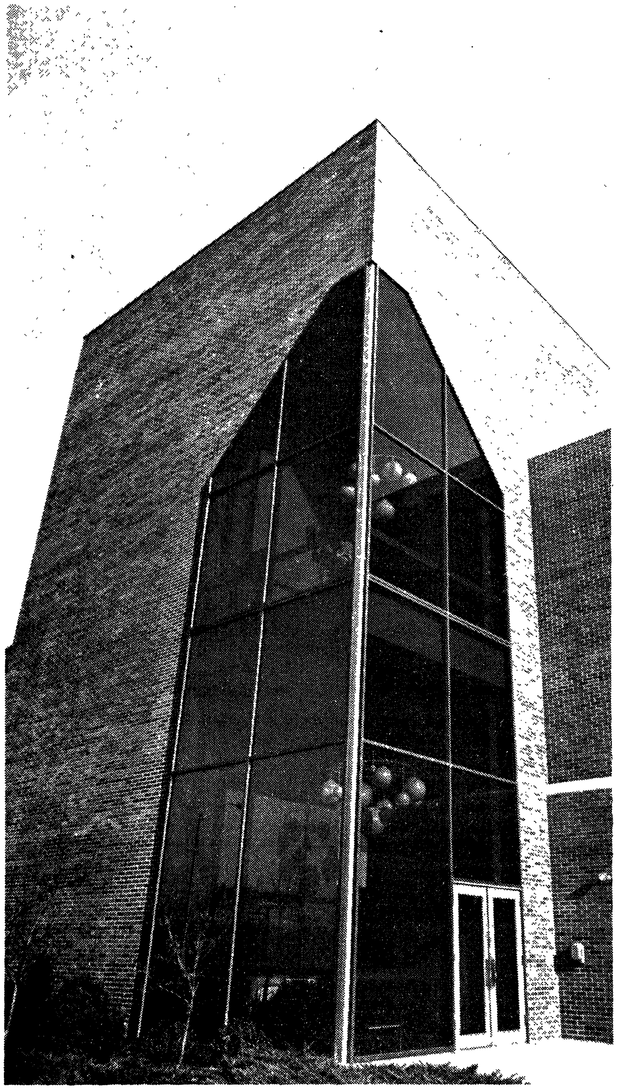


Figure 6.1 Westinghouse-Youngwood, Pa—employing the most modern, up-to-date techniques in high power semiconductor manufacturing.

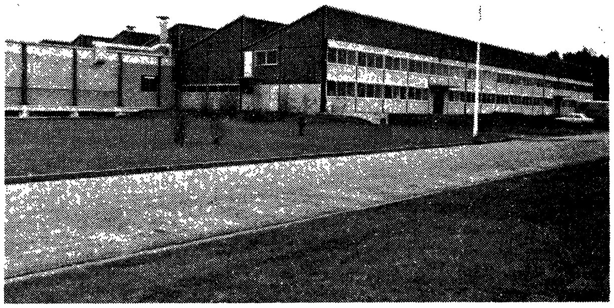
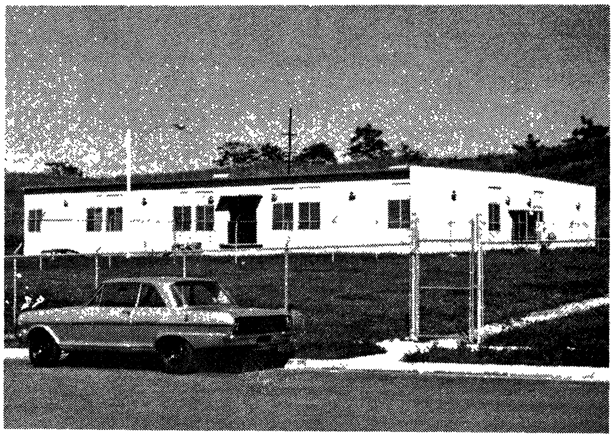


Figure 6.2 Westinghouse, LeMans, France—power semiconductor manufacturing in Europe.

Figure 6.3 Westinghouse, Puerto Rico—power semiconductor assembly in Gurabo (San Juan).



2. PRODUCT BREAKTHROUGHS

Several product breakthroughs have been instrumental in making the Ⓦ manufacturing concept a reality. One key to success is the ability to manufacture, test, and store the semiconductor element independent of the device package. First, element sizes have been standardized for rectifiers, SCR's and transistors. Comparable semiconductor element sizes for Ⓦ high power rectifiers and SCR's are shown in Figure 6.4. The early process-

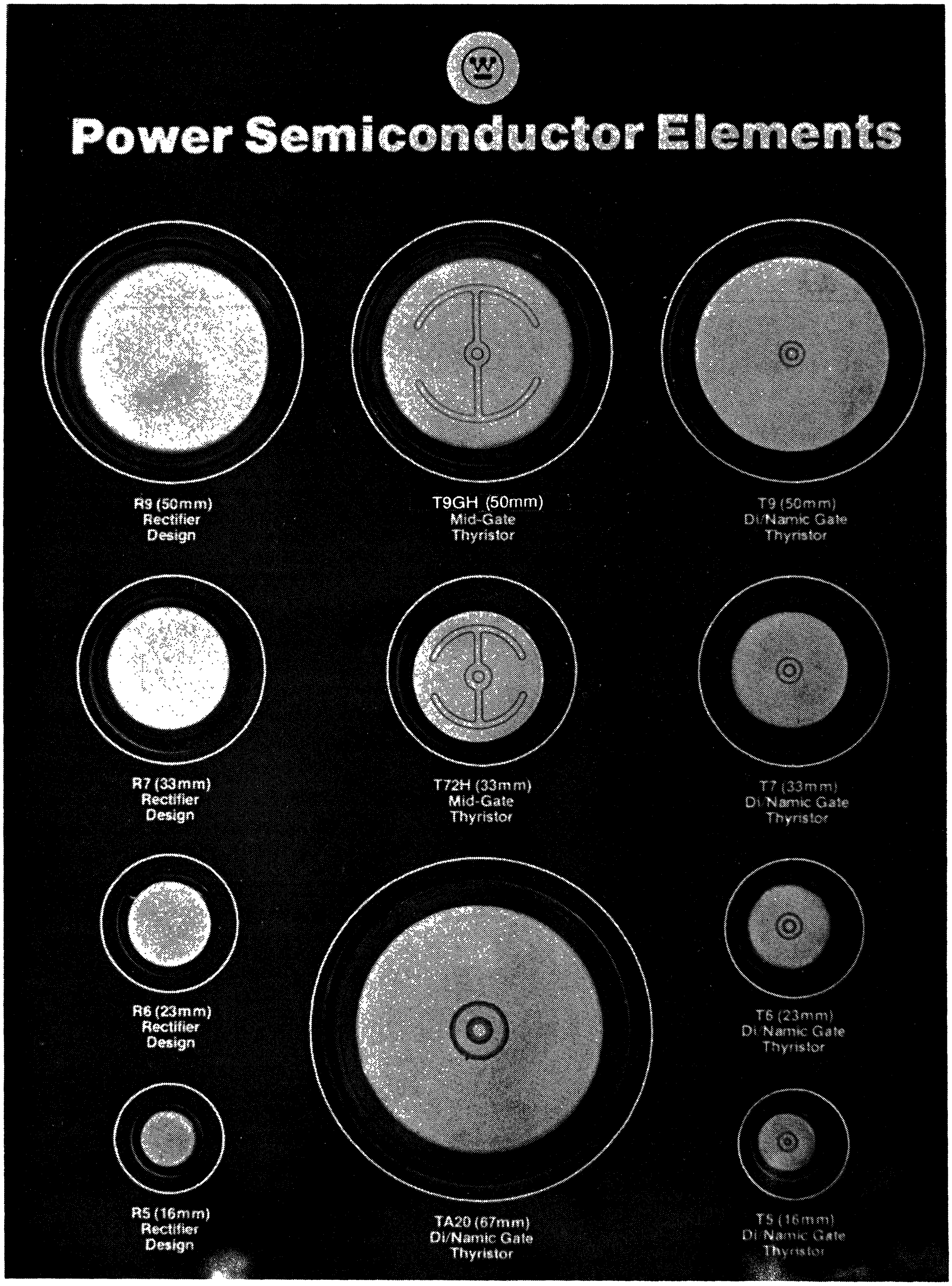


Figure 6.4 Westinghouse Power Semiconductor Elements

ing stages for slicing and diffusing the silicon are identifical for rectifiers and SCR's. An all-diffused process for making rectifiers and SCR's offers good reproducibility and process precision. All Westinghouse high power SCR designs feature center-fired, di/namic gate structures for fast turn-on capability, high repetitive di/dt capability, and low switching losses. This gate structure is comparable to a device built with a pilot SCR to turn on a main SCR (Figure 6.5). Westinghouse developed a special di/namic mid-gate SCR for high peak

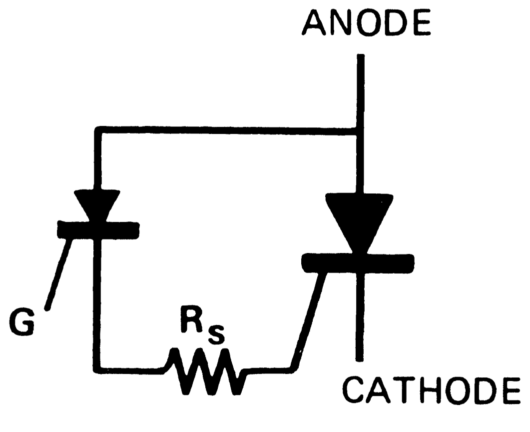


Figure 6.5 Equivalent electrical circuit for the di/namic gate design.

current and narrow pulse width fast switching applications. By using an irradiation process (see Figure 6.6) to produce fast recovery rectifiers and fast switching SCR's, Westinghouse has the advantage of being able to

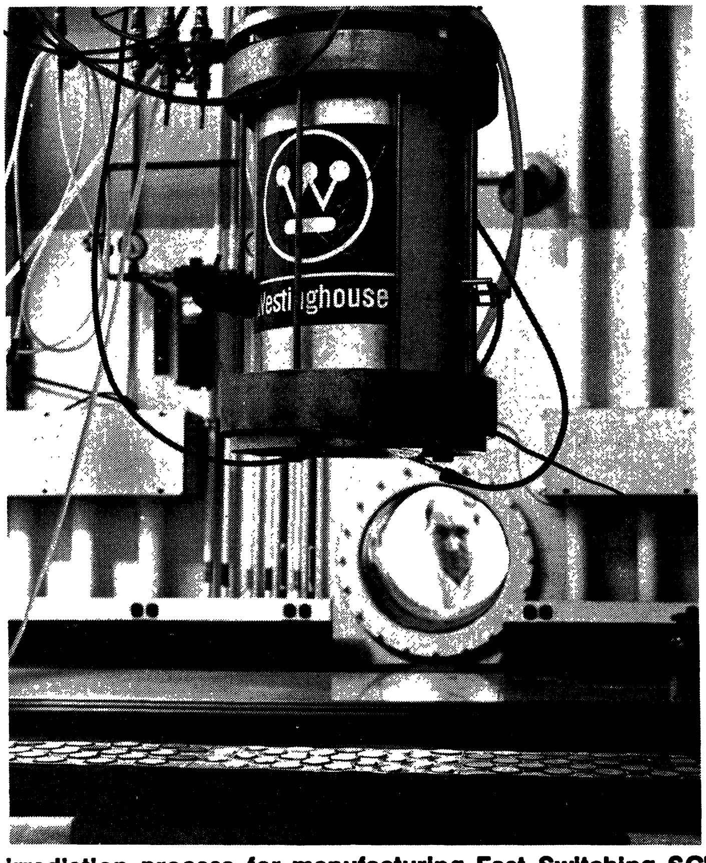


Figure 6.6 Exclusive Ⓦ irradiation process for manufacturing Fast Switching SCR's and Fast Recovery Rectifiers.

apply this technique after the semiconductor element has completed its processing cycle. This process promotes greater manufacturing flexibility and better control in producing fast switching and fast recovery characteristics. Westinghouse's special emitter shunt designs make possible dv/dt capabilities of 300 to 1000 volts per microsecond—the highest available in the industry. Exclusive Ⓦ processes for passivating semiconductor elements, enabling sealing and stabilization of the elements with no danger of degradation, complete the element breakthroughs necessary to establish a World Element Bank (Figure 6.7)—an inventory center for storing completely tested and passivated elements.

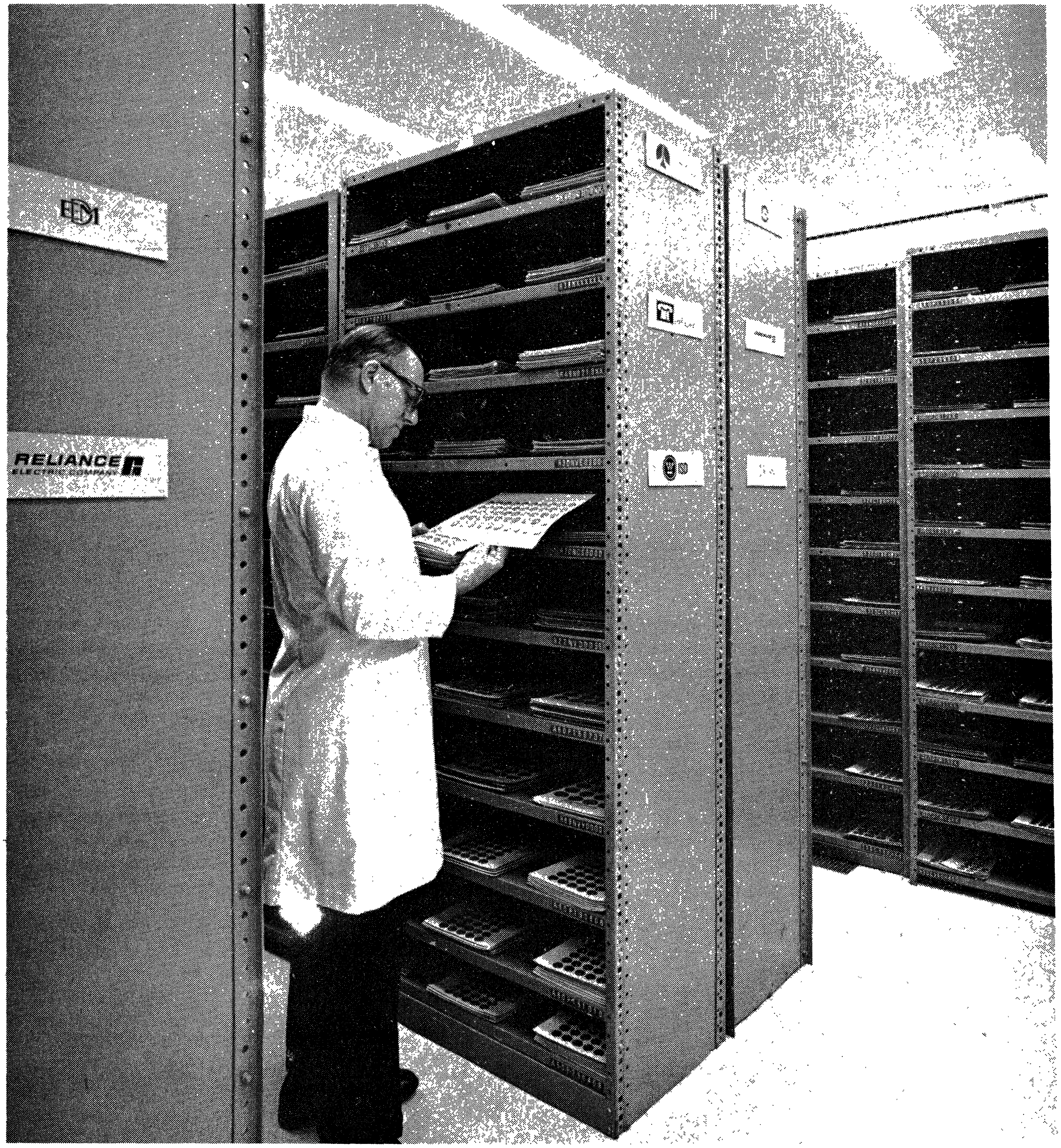


Figure 6.7 The World Element Bank, an inventory center for storing completely tested, passivated semiconductor elements, ready for assembly anywhere in the world.

Originally, power semiconductors were offered only in stud mount packages. Later, by placing the same element in an integral heat sink package, (Figure 6.8), a 40% improvement in current rating was obtained

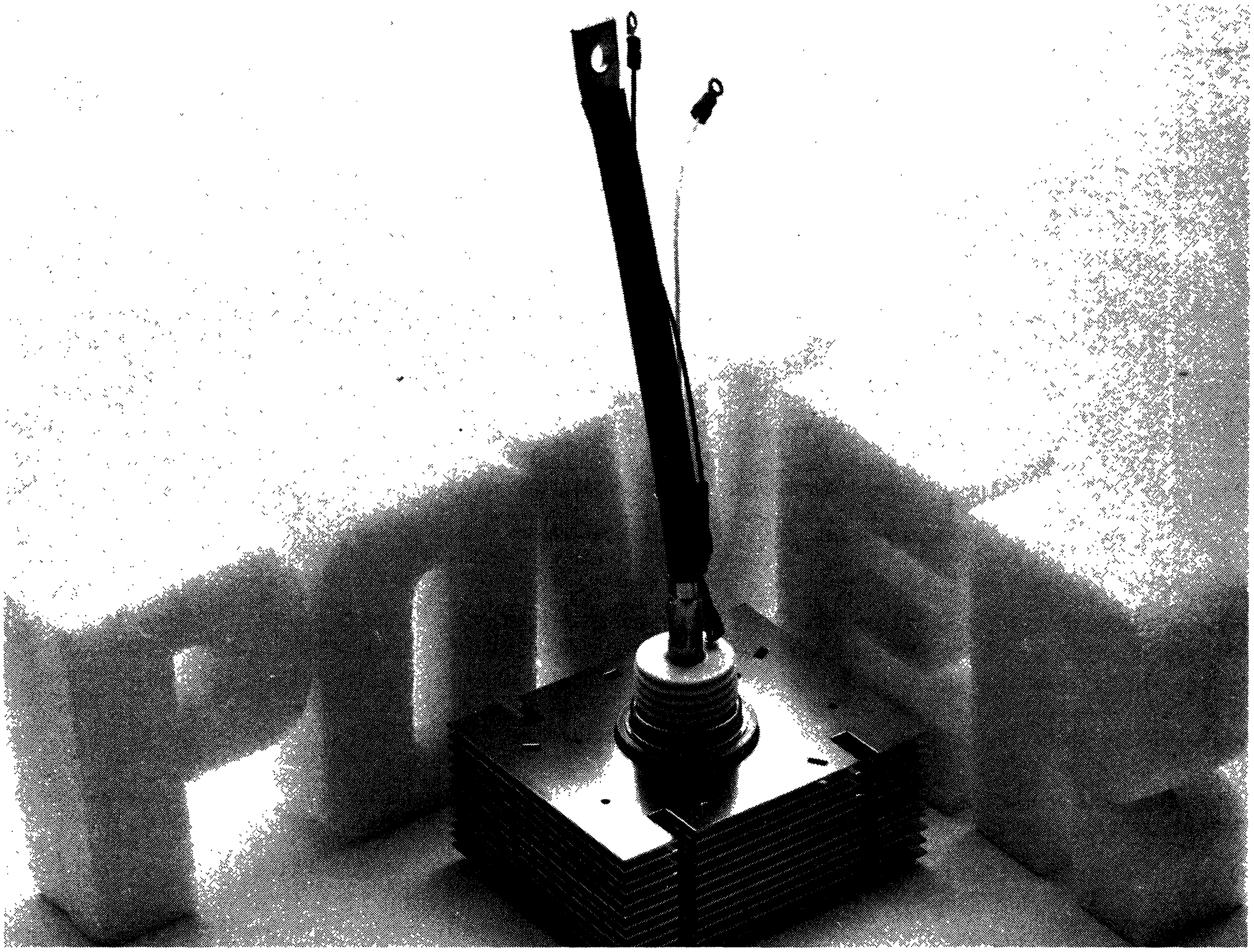


Figure 6.8 An integral heat sink package offers up to a 40% improvement in current rating over the same element size in a stud mount package.

because one thermal interface (case to sink) was eliminated. However, the real innovation in packaging was the disc; with double-sided cooling (Figure 6.9), the same element offers up to an 80% improvement in current rating over the same element in a stud mount package. An additional benefit is that it is easy to stack these disc devices in a series arrangement or a back-to-back arrangement and devices can simply be "flipped over" for reversing polarity. Initially low power semiconductor elements were bonded to the device package with a low temperature or soft solder. Later, hard solder or high temperature soldering techniques were used, and they improved device thermal cycling capabilities by an order of magnitude. However, as element sizes increased and applications became more severe, a more fatigue-free construction was required and compression bonded encapsulation (CBE) was developed. This CBE technique completely eliminates solder connections

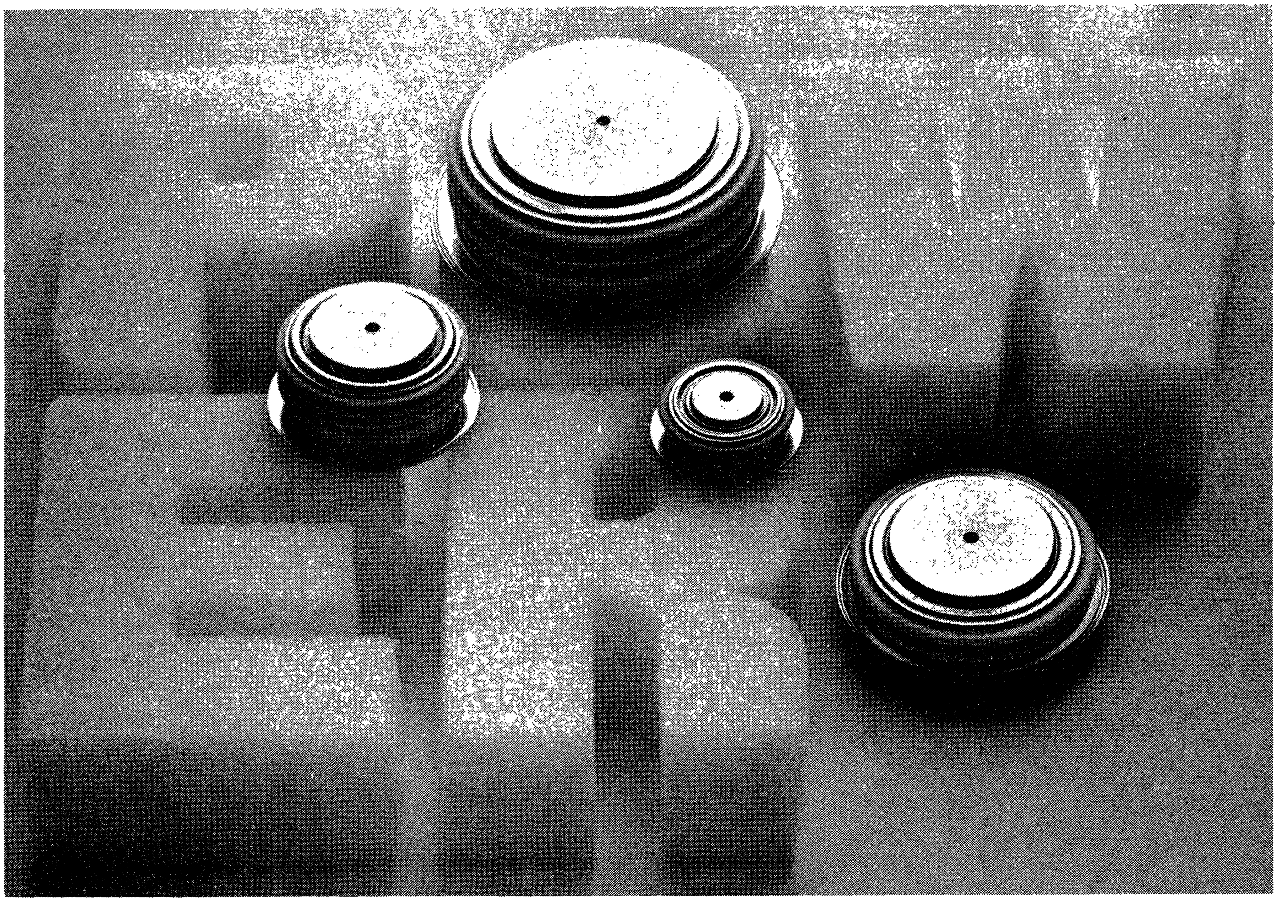


Figure 6.9 Disc packages offer up to 80% improvement in current rating over the same element size in a stud mount package.

between the element and the package. The metallic bond is replaced by a constant-pressure spring washer system (Figure 6.10) which supplies a constant load force to the element. Today, this technique is used to manufacture thermal fatigue free SCR's, rectifiers, and transistors that are magnitudes better than hard solder devices. CBE simplifies the manufacturing process and improves semiconductor reliability. This same design philosophy is employed in the disc package except that the spring clamp system is supplied externally by the user. The Westinghouse worldwide assembly concept owes its success to this patented CBE product breakthrough.

3. KEY MANUFACTURING INNOVATIONS

At the Westinghouse Semiconductor plant, innovative manufacturing procedures are the cornerstone of a large scale manufacturing concept, wherein power semiconductor elements, the heart of the semiconductor device, are the common denominator among worldwide manufacturing plants. This concept is being used to serve the power semiconductor user by guaranteed element availability from an element bank, independent of package requirements. By making package commitment at the last moment, faster delivery, at the required ratings, is made, and an inventory reduction on the part of the user can be realized. Applications, today, require a wide variety of electrical needs. In addition, regional demands require these ratings in an even wider range of

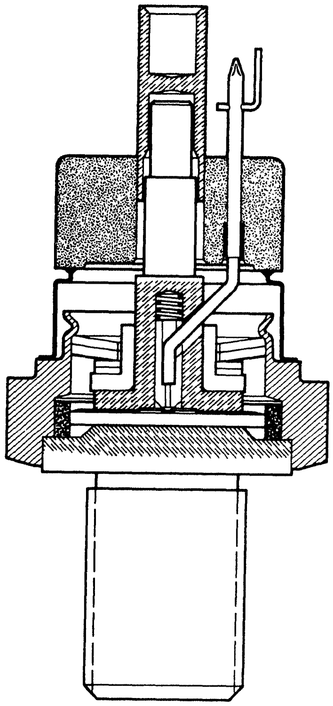


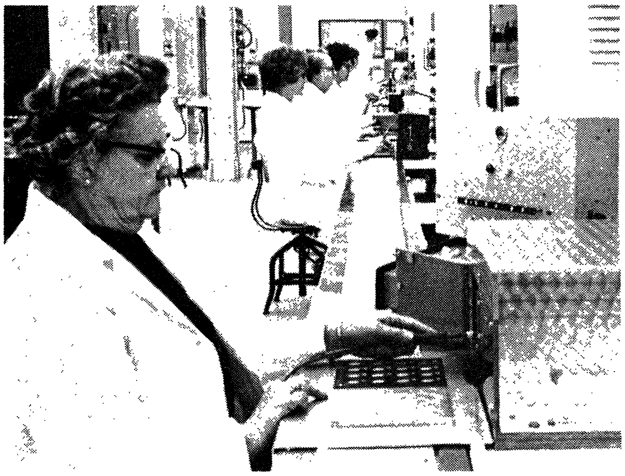
Figure 6.10 Compression Bonded Encapsulation (CBE)

packages or assemblies. This function is well served by the Westinghouse element-oriented manufacturing system wherein the optimum application charcteristics are ensured in processing, test, and package assembly.

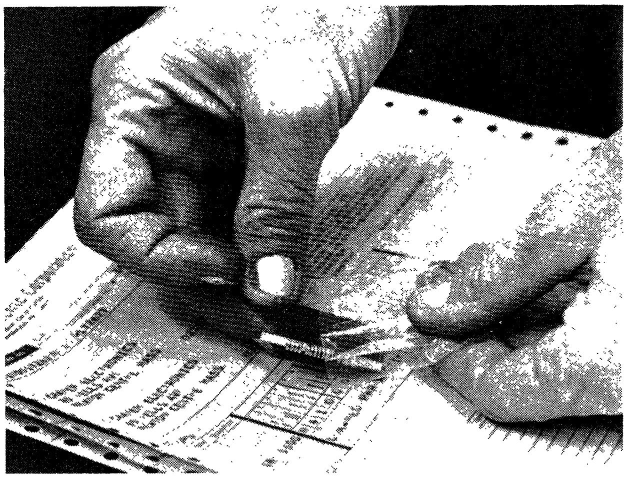
Several basic techniques (Figure 6.11) support this element manufacturing system. The spreading resistance probe, developed to predict a product's characteristics instantly, weeks before the product is completed, means better visibility of design characteristics early in the manufacturing cycle. A Westinghouse 2500 process control computer plays an important role in the diffusion cycle by monitoring furnace temperature cycles and cool-down rate to indicate when a deviation from profile occurs. Through the effective use of the computer, the various process cycles are more controllable and predictable, providing a distribution and yield of products to match requirements. A high volume paced conveyor element test line is used to fully characterize an element before committing it to a device package. All standard and special hot or cold tests can be performed on various size elements simultaneously on this test line. After testing, these passivated elements are quality checked and bubble-packed for storage in the World Element Bank until needed. Fundamental to the element system is Compression Bonded Encapsulation (CBE)—a pressure-mounted contacting means for assembling semiconductor elements into a variety of packages—stud, disc, integral heat sink, or flat base. CBE ensures reliability and flexibility in assembly while eliminating thermal fatigue problems inherent in conventional solder construction designs. Accurate and sophisticated testing have made Westinghouse high power semiconductors among the most reliable to be found anywhere. All this adds up to the advantages of predictable, reproducible element characteristics, World Bank stocking, guaranteed emergency delivery, and reduced inventory and cash flow for users of Westinghouse power semiconductors.

Spreading resistance probe.

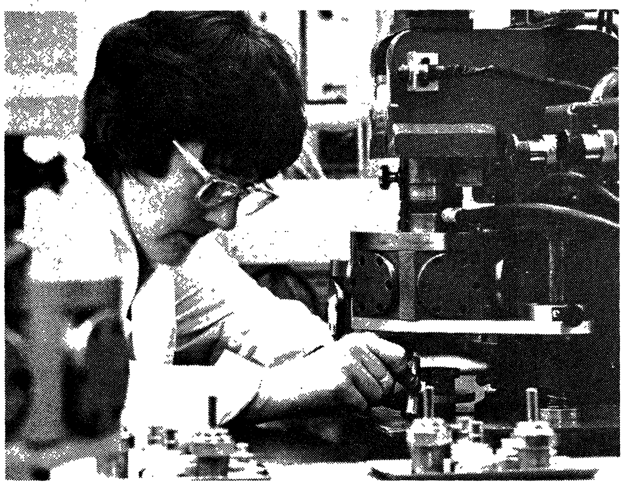
High power conveyor.



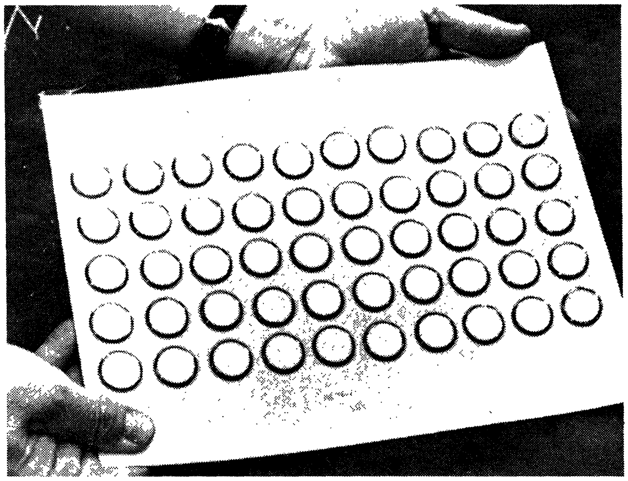
Paced element test line.



In-line product marking.



Patented compression bonded encapsulation.



Bubble-packed elements completely identified, quality checked and ready for World Bank.

Figure 6.11 Key manufacturing innovations.

4. TECHNOLOGY LEADERSHIP

Indicative of Westinghouse's leadership role in manufacturing high power semiconductors, UNITRA of Poland selected Westinghouse from among suppliers worldwide to provide them with semiconductor technology, facilities, and training. This agreement, for Westinghouse the largest sale of technology ever, was the first of its type by a U.S. manufacturer.

The Semiconductor Division also enjoys the support of the Westinghouse Research and Development Center (Figure 6.12) located in Churchill, Pennsylvania, only twenty-five miles from Youngwood. Thus, a continuous program to provide long range product development and the latest technology and manufacturing techniques is carried on from year to year. Westinghouse invests millions of dollars each year to provide the user with products which offer more efficient energy utilization, promote a cleaner environment, result in greater reliability, reduce size and weight, provide for increased safety, and offer new and expanded capabilities at the lowest possible cost.

Figure 6.12 Westinghouse Research and Development Center located in nearby Churchill, Pa.

User's Manual
SEMICONDUCTOR GLOSSARY

AQL—Acceptance Quality Level.

Ambient Temperature—Medium or free air temperature in which device is being operated.

Anode—One of two high current terminals of rectifier or SCR; other terminal is cathode.

Assemblies—Combination of discrete devices on heat sinks connected in various circuit configurations.

Average Current—Current integrated over a full cycle. Current measured on DC ammeter.

Base—Control terminal of a transistor.

Beta—See gain.

Blocking Voltage—Ability of a semiconductor to withstand a specific voltage stress without conducting current.

Breakdown Voltage—Maximum voltage a semiconductor can support in its nonconducting direction.

Bridge—Combination of discrete devices on heat sinks; generally in circuit configurations to change A.C. current to D.C. current.

CBE—Encapsulation technique which replaces conventional solder, metallic bonds with a constant-pressure, spring, washer system. This technique eliminates thermal fatigue due to solder joints.

CFM—Cubic feet per minute - amount of air being moved (CFM = LFM x cross-sectional area of heat sink).

Case Temperature—Temperature of package measured at a specific location. Indirect method for determining junction temperature. For stud devices, proper thermocouple location is center of any hex flat — for disc devices, mount thermocouple on rim (radial edge) of pole face.

Cathode—One of two high current terminals of rectifier or SCR; other terminal is anode. In electronic symbol for rectifier or SCR, arrow points toward cathode.

Chip—Small semiconductor element, usually for one to forty amp discrete device ratings.

Collector—One of high current terminals of a transistor; other terminal is emitter.

Commutation—Transfer of current flow from one circuit element to another.

Conduction Angle—Number of electrical degrees that current flows. A full cycle of A.C. voltage or current is 360 electrical degrees.

Creepage Distance—Shortest distance across surface of an insulator between positive and negative terminals.

Dice—See chip.

Diode—See rectifier.

Disc—Semiconductor package that can be cooled from both sides. Various industry names include Pow-R-Disc, Press Pak, Hockey Puck, etc.

Duty Cycle—Ratio of operating time to total operating plus nonoperating time.

Element—Silicon wafer that has been processed to create a semiconductor junction(s), passivated, tested and ready for assembly into a device package.

Emitter—One of high current terminals of a transistor; other terminal is collector.

Encapsulation—Refers to process of assembling a semiconductor element into device package.

End User—Refers to individuals and/or companies who purchase, use, and maintain equipment utilizing power semiconductors.

Failure—Termination of ability of a device to perform its required function. Also see failure mode.

Failure Mode—Refers to type of failure rather than to cause of failure. Component failures are generally either catastrophic (sudden and complete) failures or degradation (parameter drift) failures. Short- and open-circuit failures are catastrophic and usually occur at random. Degradation failures result in deviations from acceptable limits without complete cessation of the function required.

Fast Recovery Rectifier—Term used to describe rectifiers characterized for fast operating response. This class of devices is used for free wheeling diodes and a variety of high frequency applications.

Fast Switching SCRs—Term used to describe SCRs characterized for turn-off time capability and other speed characteristics. This class of devices is used in choppers, inverters, and other high frequency applications.

Flag Lead—Term used to describe top terminal on some stud mount devices. Terminal is a rigid, metal, flag-shaped connection.

Flat Base—Commonly used to describe a studless (clamp down) or a square base (bolt down) device package.

Flex Lead—Term used to describe top terminal on some stud mount devices. Terminal is made from flexible stranded cable.

Forward Direction—The direction of current flow in a semiconductor.

Forward Polarity—See standard polarity rectifier.

Free Wheeling Rectifier (Diode)—Rectifier that is used to bypass the current due to the stored energy in the inductance.

Full Control—Circuit utilizing all SCR's for controlling both half-cycles in an A.C. circuit.

Fusion—See element.

GPM—Gallons per minute. Water flow rate through liquid cooled heat sink.

Gain—The ratio of output to input. Normally used to characterize amplification properties of a transistor.

Gate—Control terminal of an SCR.

General Purpose Rectifier—Term used to describe rectifiers for conventional power control applications where operating speed is not a prime consideration.

Half Control—An arrangement of rectifiers and SCRs that controls only half the cycle in A.C. circuits.

Hard Solder—A high temperature solder having an expansion coefficient very compatible to the element and package base material.

High Voltage Stack—An assembly of a number of semiconductors connected in series to obtain extra high voltage ratings.

Hi-Rel—Abbreviated version of high reliability. Denotes a device having an established level of reliability above that of standard production line product.

Hockey Puck—See disc.
Integral Heat Sink—Refers to a device package which incorporates its own heat sink. Package is very efficient as the element is mounted directly to the heat sink - eliminating the case to sink thermal resistance.
JAN—Refers to device specifications for military use, with Joint Army and Navy sponsorship.
JEDEC—Joint Electronic Device Engineering Council. Sets parameters and specifications for a standard line of devices throughout the industry.
Junction—A transition region between the positive and negative layers of a semiconductor.
LFM—Linear feet per minute. Rate of air flow moving across a cooling surface.
LTPD—Lot Tolerance Percent Defective.
Leakage Current—The small currents which get through or around the blocking characteristic of a semiconductor device, capacitor, or insulator.
MRO—Term stands for Maintenance, Repair, and Operations of a factory, plant, hospital, etc., and refers to the industrial replacement and retrofit market.
MTBF—Mean Time Between Failures.
OEM—Original Equipment Manufacturers who build and sell equipment utilizing power semiconductors.
OSHA—Occupational Safety and Health Administration. Establish and enforce national standards of safety and health in industry.
Parameter—A value, condition, or characteristic that is a measurable property of a device. It may be electrical, mechanical, or thermal and can be expressed for a given set of operational and environmental conditions.
Passivation—A process by which a semiconductor junction is protected against oxidation and contamination.
Pellet—See element.
Phase Control SCR's—Term used to describe SCRs where fast turn-off time is not a prime requirement.
Pole Face—Mounting surface on a disc device; each disc has two pole faces.
Pow-R-Disc—See disc.
Press-Pak—See disc.
Procurement—Overall process of obtaining a semiconductor. Period between selection of required device and receipt of that device.
Pulse—A flow of electrical energy of short duration which is deliberately generated.
RBDT—Reverse Blocking Diode Thyristor. Two-terminal thyristor, ideal for pulse applications because of its high di/dt and fast switching capabilities.
RMS—Abbreviation stands for root-mean-square and refers to the effective heating value of current.
Rating—The ultimate or limiting condition stated for a given device parameter (either maximum or minimum) beyond which the device will not operate properly and/or is not guaranteed by the manufacturer.
Rectifier—A two-terminal device where current can flow in only one direction — from anode to cathode. Low current rectifiers are frequently called diodes.
Reliability—The probability that a system or device will operate for a given period of time and under given operating conditions.
Reproducibility—The ability to produce a group of semiconductors having the exact characteristics of previously produced groups.
Reverse Direction—Describes the direction in which a semiconductor is nonconducting.
Reverse Polarity Rectifier—Denotes the direction of current flow where stud mount base is the anode and the top terminal is the cathode.
SCR—Silicon Controlled Rectifier—Principal member of the thyristor family — is basically a rectifier with a control feature added. This three-terminal device (anode, cathode, and gate) is a controllable on-off switch.
Soft Solder—Any solder that is not "hard solder". Usually has a melting point of approximately 230°C, as compared to the melting point of hard solder which is in excess of 400°C.
Solid State—An electrical device or circuit using semiconductor devices. (Uses no tubes and has no moving parts.) Mechanical relays, switches, rotaries, m-g sets, thyratrons, ignitrons, and vacuum tubes are replaced by semiconductors.
Spike—An unintended flow of electrical energy of short duration. Graphically displayed on a scope as a very high voltage or current having a very short duration — usually in the microsecond range.
Standard Polarity Rectifier—Denotes direction of current flow where stud mount base is the cathode and the top terminal is the anode.
Strike Distance—The shortest distance in air between points of opposite potential. It is the distance through which arcing might occur.
Stud Top—Term used to describe top terminal on some stud mount devices. Terminal is a threaded stud.
Supplier—Power semiconductor manufacturer or authorized distributor.
Thermal Fatigue—The mechanical stress placed on semiconductor interfaces due to the different expansion rates of the various metals being joined.
Thermal Impedance (Resistance)—The resistance to heat flow through a material or from one material to another. The unit is °C/W, which means the centigrade degrees of temperature rise of the material per each watt of power dissipated at the source.
Thermal Shock—Mechanical stresses placed on material or, more expressly, where two different materials are joined together, due to a sudden large change in temperature. Can be destructive.
Thyristor—One of three primary groups of solid state power devices — rectifiers, transistors, and thyristors. Principal members of the thyristor family includes SCR, triac, RBDT, GATT, GCS, GTO, etc.
Transient (Surge) Suppressor—An electrical device used to absorb the energy of extraneous high peaks of voltage or current. Used to protect semiconductors from ruinous overloads.
Transient Voltages—Extraneous spikes of high voltage which appear across a device due to switching, commutating, interruptions, etc. in associated circuitry or by natural forces such as lightning. Transients are of very short duration, usually in the microsecond range.
Transistor—Three-terminal (base, collector, emitter) device used primarily for switching and amplification applications.
User—Refers to both the original equipment manufacturer (OEM) who manufactures equipment utilizing power semiconductors and the end user who purchases, uses, and maintains this equipment.
Vendor—See supplier.
Wafer—A very thin disc of silicon that has been cut from a silicon rod.

SUBJECT INDEX

How To Use This Book

DEVICE TYPE NUMBER SEARCH

- **If only a JEDEC or Industry Type Number is known:**
  Go to the Master Cross Reference Type Number Index (GENERAL section - Page G3). Using this index, the reader can rapidly locate any power semiconductor JEDEC or industry type number for which Westinghouse offers an exact or suggested replacement along with the page number of the referenced technical data.

or

- **If both the Product Family and the JEDEC or Ⓦ Type Number are known:**
  Go to the Type Number Index at the beginning of the appropriate PRODUCT section. Using this index, the reader can turn directly to the page location for any JEDEC or Ⓦ type number that is listed.

GENERAL APPLICATION SEARCH

- **If a Specific Product Application Requirement is known:**
  Go to the appropriate PRODUCT section and scan the Product Capability Graphs and Product Selector Guides under the appropriate product subgroup. These graphs and guides are presented in order of increasing current rating so the reader can quickly locate a suitable Westinghouse product type along with the page number of the referenced technical data.

or

- **If both a Specific Product Application Requirement and the Desired Device Package are known:**
  Go to the Table of Contents (GENERAL section - Page G2) for the location of the appropriate PRODUCT section, product subgroup, and device package type. The page number reference marks the beginning of the desired data section; the data for a given device package type is presented in order of increasing current rating to simplify the reader's search.

The Ⓦ Power Semiconductor Data Book supersedes all loose-leaf technical data issued prior to January 2, 1978. This technical data is applicable for all Ⓦ power semiconductors manufactured in Youngwood, Pennsylvania.

TABLE OF CONTENTS

MANUFACTURER'S CODES

ATS—Atlantic Semiconductor/Diodes, Inc.
DEL—Delco Electronics
EDI—Electronic Devices, Inc.
EDL—Edal Industries
GE—General Electric
GI—General Instrument
IR—International Rectifier
JAN—JAN (Military)
JED—JEDEC (E.I.A. P/N)
MOT—Motorola
NAT—National Electronics
PPC—Power Physics Corp.
PSI—Power Semiconductors, Inc.
RCA—RCA
SAR—Sarkes Tarzian
SET—Semtech
SOL—Solitron
SSD—Solid State Devices
SYN—Syntron (FMC)
TUN—Tungsol
UNI—Unitrode
VAR—Varo
WCE—Westcode
WES—Westinghouse Electric

The Ⓦ replacements represent what we believe to be equivalents for the products listed. Emphasis has been placed on providing the user with a replacement device of the same current and voltage rating when possible. The user must determine the substitution acceptability by reviewing the electrical, mechanical, and thermal characteristics presented in the referenced technical data sheets. Westinghouse assumes no responsibility for guaranteeing the acceptability of any suggested replacement in this master cross reference type number index.

PRODUCT TYPE NOTES

A—Assembly
D—Drawing (Consult Factory)
R—Rectifier
S—SCR
T—Transistor

REPLACEMENT NOTES

CF—Consult Factory
SO—Special Order—limited availability
XX(5th & 6th digits of Ⓦ Product Description Number)–Replace with appropriate two-digit numeric voltage code.

MASTER CROSS REFERENCE TYPE NUMBER INDEX

JEDEC and Industry Part Numbers

GENERAL

Part Number	Type	Mfgr.	Suggested Ⓦ Replacement	Page
IN248A	R	JED	IN248A	CF
IN248B	R	JED	IN248B	CF
IN248C	R	JED	IN248C	CF
IN249A	R	JED	IN249A	CF
IN249B	R	JED	IN249B	CF
IN249C	R	JED	IN249C	CF
IN250A	R	JED	IN250A	CF
IN250B	R	JED	IN250B	CF
IN250C	R	JED	IN250C	CF
IN1124	R	JED	IN1124	CF
IN1124A	R	JED	IN1124A	CF
IN1125	R	JED	IN1125	CF
IN1125A	R	JED	IN1125A	CF
IN1126	R	JED	IN1126	CF
IN1126A	R	JED	IN1126A	CF
IN1127	R	JED	IN1127	CF
IN1127A	R	JED	IN1127A	CF
IN1128	R	JED	IN1128	CF
IN1128A	R	JED	IN1128A	CF
IN1183	R	JED	IN1183	R15
IN1183A	R	JED	IN1183A	R15
IN1184	R	JED	IN1184	R15
IN1184A	R	JED	IN1184A	R15
IN1185	R	JED	IN1185	R15
IN1185A	R	JED	IN1185A	R15
IN1186	R	JED	IN1186	R15
IN1186A	R	JED	IN1186A	R15
IN1187	R	JED	IN1187	R15
IN1187A	R	JED	IN1187A	R15
IN1188	R	JED	IN1188	R15
IN1188A	R	JED	IN1188A	R15
IN1189	R	JED	IN1189	R15
IN1189A	R	JED	IN1189A	R15
IN1190	R	JED	IN1190	R15
IN1190A	R	JED	IN1190A	R15
IN1191	R	JED	IN1191	R15
IN1191A	R	JED	IN1191A	R15
IN1192	R	JED	IN1192	R15
IN1192A	R	JED	IN1192A	R15
IN1193	R	JED	IN1193	R15
IN1193A	R	JED	IN1193A	R15
IN1194	R	JED	IN1194	R15
IN1194A	R	JED	IN1194A	R15
IN1195	R	JED	IN1195	R15
IN1195A	R	JED	IN1195A	R15
IN1196	R	JED	IN1196	R15
IN1196A	R	JED	IN1196A	R15
IN1197	R	JED	IN1197	R15
IN1197A	R	JED	IN1197A	R15
IN1198	R	JED	IN1198	R15
IN1198A	R	JED	IN1198A	R15
IN1199	R	JED	IN1199	R13
IN1199A	R	JED	IN1199A	R13
IN1199B	R	JED	IN1199B	R13
IN1200	R	JED	IN1200	R13
IN1200A	R	JED	IN1200A	R13
IN1200B	R	JED	IN1200B	R13
IN1201	R	JED	IN1201	R13
IN1201A	R	JED	IN1201A	R13
IN1201B	R	JED	IN1201B	R13
IN1202	R	JED	IN1202	R13
IN1202A	R	JED	IN1202A	R13
IN1202B	R	JED	IN1202B	R13
IN1203	R	JED	IN1203	R13
IN1203A	R	JED	IN1203A	R13
IN1203B	R	JED	IN1203B	R13
IN1204	R	JED	IN1204	R13
IN1204A	R	JED	IN1204A	R13
IN1204B	R	JED	IN1204B	R13
IN1205	R	JED	IN1205	R13
IN1205A	R	JED	IN1205A	R13
IN1205B	R	JED	IN1205B	R13
IN1206	R	JED	IN1206	R13
IN1206A	R	JED	IN1206A	R13
IN1206B	R	JED	IN1206B	R13
IN1271	R	JED	CF	CF
IN1272	R	JED	CF	CF
IN1273	R	JED	CF	CF
IN1274	R	JED	CF	CF
IN1275	R	JED	CF	CF
IN1276	R	JED	CF	CF
IN1277	R	JED	CF	CF

Part Number	Type	Mfgr.	Suggested Ⓦ Replacement	Page
IN1281	R	JED	CF	CF
IN1282	R	JED	CF	CF
IN1283	R	JED	CF	CF
IN1284	R	JED	CF	CF
IN1285	R	JED	CF	CF
IN1286	R	JED	CF	CF
IN1287	R	JED	CF	CF
IN1291	R	JED	CF	CF
IN1292	R	JED	CF	CF
IN1293	R	JED	CF	CF
IN1294	R	JED	CF	CF
IN1295	R	JED	CF	CF
IN1296	R	JED	CF	CF
IN1297	R	JED	CF	CF
IN1330	R	JED	CF	CF
IN1331	R	JED	CF	CF
IN1332	R	JED	CF	CF
IN1333	R	JED	CF	CF
IN1334	R	JED	CF	CF
IN1335	R	JED	CF	CF
IN1336	R	JED	CF	CF
IN1341	R	JED	IN1341	R13
IN1341A	R	JED	IN1341A	R13
IN1341B	R	JED	IN1341B	R13
IN1342	R	JED	IN1342	R13
IN1342A	R	JED	IN1342A	R13
IN1342B	R	JED	IN1342B	R13
IN1343	R	JED	IN1343	R13
IN1343A	R	JED	IN1343A	R13
IN1343B	R	JED	IN1343B	R13
IN1344	R	JED	IN1344	R13
IN1344A	R	JED	IN1344A	R13
IN1344B	R	JED	IN1344B	R13
IN1345	R	JED	IN1345	R13
IN1345A	R	JED	IN1345A	R13
IN1345B	R	JED	IN1345B	R13
IN1346	R	JED	IN1346	R13
IN1346A	R	JED	IN1346A	R13
IN1346B	R	JED	IN1346B	R13
IN1347	R	JED	IN1347	R13
IN1347A	R	JED	IN1347A	R13
IN1347B	R	JEd	IN1347B	R13
IN1348	R	JED	IN1348	R13
IN1348A	R	JED	IN1348A	R13
IN1348B	R	JED	IN1348B	R13
IN1376	R	JED	CF	CF
IN1377	R	JED	CF	CF
IN1378	R	JED	CF	CF
IN1379	R	JED	CF	CF
IN1380	R	JED	CF	CF
IN1381	R	JED	CF	CF
IN1382	R	JED	CF	CF
IN1396	R	JED	R5100010	R23
IN1397	R	JED	R5100110	R23
IN1398	R	JED	R510+110	R23
IN1399	R	JED	R5100210	R23
IN1400	R	JED	R5100310	R23
IN1401	R	JED	R5100410	R23
IN1402	R	JED	R5100510	R23
IN1403	R	JED	R5100610	R23
IN1581	R	JED	IN1581	CF
IN1582	R	JED	IN1582	CF
IN1583	R	JED	IN1583	CF
IN1584	R	JED	IN1584	CF
IN1585	R	JED	IN1585	CF
IN1586	R	JED	IN1586	CF
IN1587	R	JED	IN1587	CF
IN1612	R	JED	IN1612	R13
IN1613	R	JED	IN1613	R13
IN1614	R	JED	IN1614	R13
IN1615	R	JED	IN1615	R13
IN1616	R	JED	IN1616	R13
IN1660	R	JED	IN3260	R27
IN1661	R	JED	IN3261	R27
IN1662	R	JED	IN3262	R27
IN1663	R	JED	IN3263	R27
IN1664	R	JED	IN3265	R27
IN1665	R	JED	IN3267	R27
IN1666	R	JED	IN3268	R27
IN1670	R	JED	IN3161	CF
IN1671	R	JED	IN3162	CF
IN1672	R	JED	IN3163	CF
IN1673	R	JED	IN3164	CF
IN1674	R	JED	IN3166	CF
IN1675	R	JED	IN3168	CF

Part Number	Type	Mfgr.	Suggested Ⓦ Replacement	Page
IN1676	R	JED	IN3169	CF
IN2054	R	JED	IN2054	CF
IN2054R	R	JED	IN2054R	CF
IN2055	R	JED	IN2055	CF
IN2055R	R	JED	IN2055R	CF
IN2056	R	JED	IN2056	CF
IN2056R	R	JED	IN2056R	CF
IN2057	R	JED	IN2057	CF
IN2057R	R	JED	IN2057R	CF
IN2058	R	JED	IN2058	CF
IN2058R	R	JED	IN2058R	CF
IN2059	R	JED	IN2059	CF
IN2059R	R	JED	IN2059R	CF
IN2060	R	JED	IN2060	CF
IN2060R	R	JED	IN2060R	CF
IN2061	R	JED	IN2061	CF
IN2061R	R	JED	IN2061R	CF
IN2063	R	JED	IN2063	CF
IN2063R	R	JED	IN2063R	CF
IN2064	R	JED	IN2064	CF
IN2064R	R	JED	IN2064R	CF
IN2065	R	JED	IN2065	CF
IN2065R	R	JED	IN2065R	CF
IN2066	R	JED	IN2066	CF
IN2066R	R	JED	IN2066R	CF
IN2067	R	JED	IN2067	CF
IN2067R	R	JED	IN2067R	CF
IN2068	R	JED	IN2068	CF
IN2068R	R	JED	IN2068R	CF
IN2128	R	JED	R4040060	R17
IN2129	R	JED	R4040160	R17
IN2130	R	JED	R4040260	R17
IN2131	R	JED	R4040260	R17
IN2132	R	JED	R4040360	R17
IN2133	R	JED	R4040360	R17
IN2135	R	JED	R4040460	R17
IN2137	R	JED	R4040560	R17
IN2138	R	JED	R4040660	R17
IN2154	R	JED	IN2154	R15
IN2155	R	JED	IN2155	R15
IN2156	R	JED	IN2156	R15
IN2157	R	JED	IN2157	R15
IN2158	R	JED	IN2158	R15
IN2159	R	JED	IN2159	R15
IN2160	R	JED	IN2160	R15
IN3085	R	JED	R5D00115	R23
IN3085R	R	JED	R5D10115	R23
IN3086	R	JED	R5D00215	R23
IN3086R	R	JED	R5D10215	R23
IN3087	R	JED	R5D00315	R23
IN3087R	R	JED	R5D10315	R23
IN3088	R	JED	R5D00415	R23
IN3088R	R	JED	R5D10415	R23
IN3089	R	JED	R5D00515	R23
IN3089R	R	JED	R5D10515	R23
IN3090	R	JED	R5D00615	R23
IN3090R	R	JED	R5D10615	R23
IN3091	R	JED	R5D00815	R23
IN3091R	R	JED	R5D10815	R23
IN3092	R	JED	R5D01015	R23
IN3092R	R	JED	R5D11015	R23
IN3111	R	JED	R5D00015	R23
IN3111R	R	JED	R5D10015	R23
IN3161	R	JED	IN3161	CF
IN3161R	R	JED	IN3161R	CF
IN3162	R	JED	IN3162	CF
IN3162R	R	JED	IN3162R	CF
IN3163	R	JED	IN3163	CF
IN3163R	R	JED	IN3163R	CF
IN3164	R	JED	IN3164	CF
IN3164R	R	JED	IN3164R	CF
JAN IN3164	R	JAN	JAN IN3164	G42
JAN IN3164R	R	JAN	JAN IN3164R	G42
IN3165	R	JED	IN3165	CF
IN3165R	R	JED	IN3165R	CF
IN3166	R	JED	IN3166	CF
IN3166R	R	JED	IN3166R	CF
IN3167	R	JED	IN3167	CF
IN3167R	R	JED	IN3167R	CF
IN3168	R	JED	IN3168	CF
IN3168R	R	JED	IN3168R	CF
JAN IN3168	R	JAN	JAN IN3168	G42
JAN IN3168R	R	JAN	JAN IN3168R	G42
IN3169	R	JED	IN3169	CF
IN3169R	R	JED	IN3169R	CF

Note: Manufacturer's Codes, Product Type Notes and Ⓦ Replacement Notes are listed on page G3

Assemblies, Rectifiers, Thyristors, & Transistors
MASTER CROSS REFERENCE TYPE NUMBER INDEX
JEDEC and Industry Part Numbers

Part Number	Type	Mfgr.	Suggested Ⓦ Replacement	Page
IN3170	R	JED	IN3170	CF
IN3170R	R	JED	IN3170R	CF
JAN IN3170	R	JAN	JAN IN3170	G42
JAN IN3170R	R	JAN	JAN IN3170R	G42
IN3171	R	JED	IN3171	CF
IN3171R	R	JED	IN3171R	CF
IN3172	R	JED	IN3172	CF
IN3172R	R	JED	IN3172R	CF
JAN IN3172	R	JAN	JAN IN3172	G42
JAN IN3172R	R	JAN	JAN IN3172R	G42
IN3173	R	JED	IN3173	CF
IN3173R	R	JED	IN3173R	CF
IN3174	R	JED	IN3174	CF
IN3174R	R	JED	IN3174R	CF
JAN IN3174	R	JAN	JAN IN3174	G42
JAN IN3174R	R	JAN	JAN IN3174R	G42
IN3208	R	JED	IN3208	R15
IN3209	R	JED	IN3209	R15
IN3210	R	JED	IN3210	R15
IN3211	R	JED	IN3211	R15
IN3212	R	JED	IN3212	R15
IN3213	R	JED	IN3213	R15
IN3214	R	JED	IN3214	R15
IN3260	R	JED	IN3260	R27
IN3260R	R	JED	IN3260R	R27
IN3261	R	JED	IN3261	R27
IN3261R	R	JED	IN3261R	R27
IN3262	R	JED	IN3262	R27
IN3262R	R	JED	IN3262R	R27
IN3263	R	JED	IN3263	R27
IN3263R	R	JED	IN3263R	R27
JAN IN3263	R	JAN	JAN IN3164	G42
JAN IN3263R	R	JAN	JAN IN3164R	G42
IN3264	R	JED	IN3264	R27
IN3264R	R	JED	IN3264R	R27
IN3265	R	JED	IN3265	R27
IN3265R	R	JED	IN3265R	R27
IN3266	R	JED	IN3266	R27
IN3266R	R	JED	IN3266R	R27
IN3267	R	JED	IN3267	R27
IN3267R	R	JED	IN3267R	R27
JAN IN3267	R	JAN	JAN IN3168	G42
JAN IN3267R	R	JAN	JAN IN3168R	G42
IN3268	R	JED	IN3268	R27
IN3268R	R	JED	IN3268R	R27
IN3269	R	JED	IN3269	R27
IN3269R	R	JED	IN3269R	R27
JAN IN3269	R	JAN	JAN IN3170	G42
JAN IN3269R	R	JAN	JAN IN3170R	G42
IN3270	R	JED	IN3270	R27
IN3270R	R	JED	IN3270R	R27
IN3271	R	JED	IN3271	R27
IN3271R	R	JED	IN3271R	R27
JAN IN3271	R	JAN	JAN IN3172	G42
JAN IN3271R	R	JAN	JAN IN3172R	G42
IN3272	R	JED	IN3272	R27
IN3272R	R	JED	IN3272R	R27
IN3273	R	JED	IN3273	R27
IN3273R	R	JED	IN3273R	R27
JAN IN3273	R	JAN	JAN IN3174	G42
JAN IN3273R	R	JAN	JAN IN3174R	G42
IN3274	R	JED	IN3274	R27
IN3274R	R	JED	IN3274R	R27
IN3275	R	JED	IN3275	R27
IN3275R	R	JED	IN3275R	R27
IN3276	R	JED	IN3276	R27
IN3276R	R	JED	IN3276R	R27
IN3288A	R	JED	IN3288A	R27
IN3288AR	R	JED	IN3288AR	R19
IN3289A	R	JED	IN3289A	R19
IN3289AR	R	JED	IN3289AR	R19
JAN IN3289	R	JAN	JAN IN3289	G42
JAN IN3289R	R	JAN	JAN IN3289R	G42
IN3290A	R	JED	IN3290A	R19
IN3290AR	R	JED	IN3290AR	R19
IN3291A	R	JED	IN3291A	R19
IN3291AR	R	JED	IN3291AR	R19
JAN IN3291	R	JAN	JAN IN3291	G42
JAN IN3291R	R	JAN	JAN IN3291R	G42
IN3292B	R	JED	IN3292B	R19
IN3292BR	R	JED	IN3292BR	R19
IN3293A	R	JED	IN3293A	R19
IN3293AR	R	JED	IN3293AR	R19
JAN IN3293	R	JAN	JAN IN3293	G42
JAN IN3293R	R	JAN	JAN IN3293R	G42
IN3294A	R	JED	IN3294A	R19
IN3294AR	R	JED	IN3294AR	R19
JAN IN3294	R	JAN	JAN IN3294	G42
JAN IN3294R	R	JAN	JAN IN3294R	G42
IN3295A	R	JED	IN3295A	R19
IN3295AR	R	JED	IN3295AR	R19
JAN IN3295	R	JAN	JAN IN3295	G42
JAN IN3295R	R	JAN	JAN IN3295R	G42
IN3296A	R	JED	IN3296A	R19
IN3296AR	R	JED	IN3296AR	R19
IN3297A	R	JED	IN3297A	R19
IN3297AR	R	JED	IN3297AR	R19
IN3615	R	JED	IN3615	R13
IN3616	R	JED	IN3616	R13
IN3617	R	JED	IN3617	R13
IN3618	R	JED	IN3618	R13
IN3619	R	JED	IN3619	R13
IN3620	R	JED	IN3620	R13
IN3621	R	JED	IN3621	R13
IN3622	R	JED	IN3622	R13
IN3623	R	JED	IN3623	R13
IN3624	R	JED	IN3624	R13
IN3670	R	JED	IN3670	R13
IN3670A	R	JED	IN3670A	R13
IN3671	R	JED	IN3671	R13
IN3671A	R	JED	IN3671A	R13
IN3672	R	JED	IN3672	R13
IN3672A	R	JED	IN3672A	R13
IN3673	R	JED	IN3673	R13
IN3673A	R	JED	IN3673A	R13
IN3735	R	JED	IN3735	CF
IN3735A	R	JED	IN3735A	CF
IN3736	R	JED	IN3736	CF
IN3736R	R	JED	IN3736R	CF
IN3737	R	JED	IN3737	CF
IN3737R	R	JED	IN3737R	CF
IN3738	R	JED	IN3738	CF
IN3738R	R	JED	IN3738R	CF
IN3739	R	JED	IN3739	CF
IN3739R	R	JED	IN3739R	CF
IN3740	R	JED	IN3740	CF
IN3740R	R	JED	IN3740R	CF
IN3741	R	JED	IN3741	CF
IN3741R	R	JED	IN3741R	CF
IN3742	R	JED	IN3742	CF
IN3742R	R	JED	IN3742R	CF
IN3743	R	JED	IN3743	CF
IN3743R	R	JED	IN3743R	CF
IN3744	R	JED	IN3744	CF
IN3744R	R	JED	IN3744R	CF
IN3765	R	JED	IN3765	R15
IN3766	R	JED	IN3766	R15
IN3767	R	JED	IN3767	R15
IN3768	R	JED	IN3768	R15
IN3879	R	JED	IN3879	R55
IN3880	R	JED	IN3880	R55
IN3881	R	JED	IN3881	R55
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IN4005	R	JED	IN4005	R9
IN4006	R	JED	IN4006	R9
IN4007	R	JED	IN4007	R29
IN4044	R	JED	IN4044	R29
IN4044R	R	JED	IN4044R	R29
IN4045	R	JED	IN4045	R29
IN4045R	R	JED	IN4045R	R29
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IN4137	R	JED	R4040470	R17
IN4138	R	JED	R4040670	R17
IN4458	R	JED	IN4458	R13
IN4459	R	JED	IN4459	R13
IN4587	R	JED	IN4587	R21
IN4587R	R	JED	IN4587R	R21
IN4588	R	JED	IN4588	R21
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IN5054	R	JED	IN5054	R9
IN5162	R	JED	R5C01215	CF
IN5162R	R	JED	R5C11215	CF
IN5331	R	JED	IN5331	CF
IN5332	R	JED	IN5332	CF
IN5391	R	JED	IN5391	R9
IN5392	R	JED	IN5392	R9
IN5393	R	JED	IN5393	R9
In5394	R	JED	IN5394	R9
IN5395	R	JED	IN5395	R9
IN5396	R	JED	IN5396	R9
IN5397	R	JED	IN5397	R9
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IN5405	R	JED	IN5405	R9
IN5406	R	JED	IN5406	R9
IN5407	R	JED	IN5407	R9
IN5408	R	JED	IN5408	R9
2N681	S	JED	2N681	S11

Note: Manufacturer's Codes, Product Type Notes and Ⓦ Replacement Notes are listed on page G3

Assemblies, Rectifiers, Thyristors, & Transistors
MASTER CROSS REFERENCE TYPE NUMBER INDEX
JEDEC and Industry Part Numbers

Part Number	Type	Mfgr.	Suggested Ⓦ Replacement	Page
2N682	S	JED	2N682	S11
2N683	S	JED	2N683	S11
2N685	S	JED	2N685	S11
2N687	S	JED	2N687	S11
2N688	S	JED	2N688	S11
2N689	S	JED	2N689	S11
2N690	S	JED	2N690	S11
2N691	S	JED	2N691	S11
2N692	S	JED	2N692	S11
2N1015	T	JED	2N1015	T19
2N1015A	T	JED	2N1015A	T19
2N1015B	T	JED	2N1015B	T19
2N1015C	T	JED	2N1015C	T19
2N1015D	T	JED	2N1015D	T19
2N1015E	T	JED	CF	CF
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2N1016A	T	JED	2N1016A	T19
2N1016B	T	JED	2N1016B	T19
2N1016C	T	JED	2N1016C	T19
2N1016D	T	JED	2N1016D	T19
2N1016E	T	JED	CF	CF
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2N3233	T	JED	2N3233	CF
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2N3896	S	JED	2N3896	S31
2N3896	S	JED	T400012208	S13
2N3897	S	JED	T400022208	S13
2N3898	S	JED	T400032208	S13
2N3899	S	JED	T400042208	S13
2N4347	T	JED	2N4347	CF
2N4348	T	JED	2N4348	CF
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2N6263	T	JED	2N3441	T5
2N6371	T	JED	2N6254	T9
3N221	A	JED	3N221	A52
3N222	A	JED	3N222	A52
A28A	R	GE	IN3890	R55
A28B	R	GE	IN3891	R55
A28C	R	GE	IN3892	R55
A28D	R	GE	IN3893	R55
A28F	R	GE	IN3898	R55
A29A	R	GE	IN3890R	R55
A29B	R	GE	IN3891R	R55
A29C	R	GE	IN3892R	R55
A29D	R	GE	IN3893R	R55
A29F	R	GE	IN3889R	R55
A40A	R	GE	IN3209	R15
A40B	R	GE	IN3210	R15
A40C	R	GE	IN3211	R15
A40D	R	GE	IN3212	R15
A40E	R	GE	IN3213	R15
A40F	R	GE	IN3208	R15
A40M	R	GE	IN3214	R15
A41A	R	GE	IN3209R	R15
A41B	R	GE	IN3210R	R15
A41C	R	GE	IN3211R	R15
A41D	R	GE	IN3212R	R15
A41E	R	GE	IN3213R	R15
A41F	R	GE	IN3208R	R15
A41M	R	GE	IN3214R	R15
A50HXX0210	T	WES	A50HXX0210	CF
A50HXX0510	T	WES	A50HXX0510	CF
A51HXX0510	T	WES	A51HXX0510	CF
A60GXX1010	T	WES	A60GXX1010	CF
A60GXX1040	T	WES	A60GXX1040	CF
A60HXX1010	T	WES	CF	CF
A60HXX1510	T	WES	CF	CF

Note: Manufacturer's Codes, Product Type Notes and Ⓦ Replacement Notes are listed on page G3

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JEDEC and Industry Part Numbers

Part Number	Type	Mfgr.	Suggested Ⓦ Replacement	Page
A60HXX2010	T	WES	CF	CF
A61HXX1010	T	WES	CF	CF
A61HXX1510	T	WES	CF	CF
A61HXX2010	T	WES	CF	CF
A61HXX2510	T	WES	CF	CF
A67GXX1010	T	WES	A67GXX1010	CF
A67GXX1040	T	WES	A67GXX1040	CF
A67HXX1010	T	WES	A67HXX1010	CF
A67HXX1510	T	WES	A67HXX1510	CF
A67HXX2010	T	WES	A67HXX2010	CF
A67HXX2510	T	WES	A67HXX2510	CF
A70A	R	GE	R5100110	R23
A70B	R	GE	R5100210	R23
A70C	R	GE	R5100310	R23
A70D	R	GE	R5100410	R23
A70E	R	GE	R5100510	R23
A70M	R	GE	R5100610	R23
A70N	R	GE	R5100810	R23
A70P	R	GE	R5101010	R23
A70PB	R	GE	R5001210	R23
A70S	R	GE	R5100710	R23
A70T	R	GE	R5100910	R23
A71A	R	GE	R5110110	R23
A71B	R	GE	R5110210	R23
A71C	R	GE	R5110310	R23
A71D	R	GE	R5110410	R23
A71E	R	GE	R5110510	R23
A71M	R	GE	R5110610	R23
A71N	R	GE	R5110810	R23
A71P	R	GE	R5111010	
A71PB	R	6GE	R5111210	R23
A71S	R	GE	R5110710	R23
A71T	R	GE	R5110910	R23
A90A	R	GE	R6100125	R31
A90B	R	GE	R6100225	R31
A90C	R	GE	R6100325	R31
A90D	R	GE	R6100425	R31
A90E	R	GE	R6100525	R31
A90M	R	GE	R6100625	R31
A90N	R	GE	R6100825	R31
A90P	R	GE	R6101025	R31
A90PA	R	GE	R6001125	R31
A90PB	R	GE	R6001225	R31
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A91PB	R	GE	R6011225	R31
A91S	R	GE	R6110725	R31
A91T	R	GE	R6110925	R31
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A96E	R	GE	R6020525FJ	R63
A96M	R	GE	R6020625FJ	R63
A96N	R	GE	R6020825FJ	R63
A96P	R	GE	R6021025FJ	R63
A96S	R	GE	R6020725FJ	R63
A96T	R	GE	R6020925FJ	R63
A97A	R	GE	R6030125FJ	R63
A97B	R	GE	R6030225FJ	R63
A97C	R	GE	R6030325FJ	R63
A97D	R	GE	R6030425FJ	R63
A97E	R	GE	R6030525FJ	R63
A97M	R	GE	R6030625FJ	R63
A97N	R	GE	R6030825FJ	R63
A97P	R	GE	R6031025FJ	R63
A97S	R	GE	R6030725FJ	R63
A97T	R	GE	R6030925FJ	R63
A170PC	R	GE	R5001310	R23
A170PD	R	GE	R5001410	R23
A170PE	R	GE	SO	R23
A170RPC	R	GE	R5011310	R23
A170RPD	R	GE	R5011410	R23
A170RPE	R	GE	SO	R23
A180A	R	GE	R5100115	R23
A180B	R	GE	R5100215	R23
A180C	R	GE	R5100315	R23

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A180D	R	GE	R5100415	R23
A180E	R	GE	R5100515	R23
A180M	R	GE	R5100615	R23
A180N	R	GE	R5100815	R23
A180P	R	GE	R5101015	R23
A180PA	R	GE	R5001115	R23
A180PB	R	GE	R5001215	R23
A180PC	R	GE	R5001315	R23
A180PD	R	GE	R5001415	R23
A180PE	R	GE	SO	R23
A180RA	R	GE	R5110115	R23
A180RB	R	GE	R5110215	R23
A180RC	R	GE	R5110315	R23
A180RD	R	GE	R5110415	R23
A180RE	R	GE	R5110515	R23
A180RM	R	GE	R5110615	R23
A180RN	R	GE	R5110815	R23
A180RP	R	GE	R5111015	R23
A180RPA	R	GE	R5011115	R23
A180RPB	R	GE	R5011215	R23
A180RPC	R	GE	R5011315	R23
A180RPD	R	GE	R5011415	R23
A180RPE	R	GE	SO	R23
A180RS	R	GE	R5110715	R23
A180RT	R	GE	R5110915	R23
A180S	R	GE	R5100715	R23
A180T	R	GE	R5100915	R23
A187A	R	GE	R5020110FJ	R59
A187B	R	GE	R5020210FJ	R59
A187C	R	GE	R5020310FJ	R59
A187D	R	GE	R5020410FJ	R59
A187E	R	GE	R5020510FJ	R59
A187M	R	GE	R5020610FJ	R59
A187N	R	GE	R5020810FJ	R59
A187P	R	GE	R5021010FJ	R59
A187PA	R	GE	R5021110FJ	R59
A187PB	R	GE	R5021210FJ	R59
A187PC	R	GE	R5021310FJ	R59
A187PD	R	GE	R5021410FJ	R59
A187PE	R	GE	SO	R59
A187RA	R	GE	R5030110FJ	R59
A187RB	R	GE	R5030210FJ	R59
A187RC	R	GE	R5030310FJ	R59
A187RD	R	GE	R5030410FJ	R59
A187RE	R	GE	R5030510FJ	R59
A187RM	R	GE	R5030610FJ	R59
A187RN	R	GE	R5030810FJ	R59
A187RP	R	GE	R5031010FJ	R59
A187RPA	R	GE	R5031110FJ	R59
A187RPB	R	GE	R5031210FJ	R59
A187RPC	R	GE	R5031310FJ	R59
A187RPD	R	GE	R5031410FJ	R59
A187RPE	R	GE	SO	R59
A187RS	R	GE	R5030710FJ	R59
A187RT	R	GE	R5030910FJ	R59
A187S	R	GE	R5020710FJ	R59
A187T	R	GE	R5020910FJ	R59
A190C	R	GE	R6100325	R31
A190D	R	GE	R6100425	R31
A190E	R	GE	R6100525	R31
A190M	R	GE	R6100625	R31
A190N	R	GE	R6100825	R31
A190P	R	GE	R6101025	R31
A190PA	R	GE	R6001125	R31
A190PB	R	GE	R6001225	R31
A190PC	R	GE	R6001325	R31
A190PD	R	GE	R6001425	R31
A190PE	R	GE	R6001525	R31
A190RC	R	GE	R6110325	R31
A190RD	R	GE	R6110425	R31
A190RE	R	GE	R6110525	R31
A190RM	R	GE	R6110625	R31
A190RN	R	GE	R6110825	R31
A190RP	R	GE	R6111025	R31
A190RPA	R	GE	R6011125	R31
A190RPB	R	GE	R6011225	R31
A190RPC	R	GE	R6011325	R31
A190RPD	R	GE	R6011425	R31
A190RPE	R	GE	R6011525	R31
A190RS	R	GE	R6110725	R31
A190RT	R	GE	R6110925	R31
A190S	R	GE	R6100725	R31
A190T	R	GE	R6100925	R31
A197A	R	GE	R6020125FJ	R63

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A197B	R	GE	R6020225FJ	R63
A197C	R	GE	R6020325FJ	R63
A197D	R	GE	R6020425FJ	R63
A197E	R	GE	R6020525FJ	R63
A197M	R	GE	R6020625FJ	R63
A197N	R	GE	R6020825FJ	R63
A197P	R	GE	R6021025FJ	R63
A197PA	R	GE	R6021125FJ	R63
A197PB	R	GE	R6021225FJ	R63
A197PC	R	GE	R6021325FJ	R63
A197PD	R	GE	R6021425FJ	R63
A197PE	R	GE	R6021525FJ	R63
A197RA	R	GE	R6030125FJ	R63
A197RB	R	GE	R6030225FJ	R63
A197RC	R	GE	R6030325FJ	R63
A197RD	R	GE	R6030425FJ	R63
A197RE	R	GE	R6030525FJ	R63
A197RM	R	GE	R6030625FJ	R63
A197RN	R	GE	R6030825FJ	R63
A197RP	R	GE	R6031025FJ	R63
A197RPA	R	GE	R6031125FJ	R63
A197RPB	R	GE	R6031225FJ	R63
A197RPC	R	GE	R6031325FJ	R63
A197RPD	R	GE	R6031425FJ	R63
A197RPE	R	GE	R6031525FJ	R63
A197RS	R	GE	R6030725FJ	R63
A197RT	R	GE	R6030925FJ	R63
A197S	R	GE	R6020725FJ	R63
A197T	R	GE	R6020925FJ	R63
A291PC	R	GE	R6011325	R31
A291PD	R	GE	R6011425	R31
A291PE	R	GE	R6011525	R31
A291PM	R	GE	R6011625	R31
A291PN	R	GE	R6011825	R31
A291PS	R	GE	R6011725	R31
A295B	R	GE	R7010205	R35
A295C	R	GE	R7010305	R35
A295D	R	GE	R7010405	R35
A295E	R	GE	R7010505	R35
A295M	R	GE	R7010605	R35
A295N	R	GE	R7010805	R35
A295P	R	GE	R7011005	R35
A295PA	R	GE	R7011105	R35
A295PB	R	GE	R7011205	R35
A295PC	R	GE	R7011305	R35
A295PD	R	GE	R7011405	R35
A295PE	R	GE	R7011505	R35
A295PM	R	GE	R7011605	R35
A295PN	R	GE	R7011805	R35
A295PS	R	GE	R7011705	R35
A295S	R	GE	R7010705	R35
A295T	R	GE	R7010905	R35
A296B	R	GE	CF	CF
A296C	R	GE	CF	CF
A296D	R	GE	CF	CF
A296E	R	GE	CF	CF
A296M	R	GE	CF	CF
A296N	R	GE	CF	CF
A296P	R	GE	CF	CF
A296PA	R	GE	CF	CF
A296PB	R	GE	CF	CF
A296PC	R	GE	CF	CF
A296PD	R	GE	CF	CF
A296PE	R	GE	CF	CF
A296PM	R	GE	CF	CF
A296PN	R	GE	CF	CF
A296PS	R	GE	CF	CF
A296S	R	GE	CF	CF
A296T	R	GE	CF	CF
A390A	R	GE	R6200140	R39
A390B	R	GE	R6200240	R39
A390C	R	GE	R6200340	R39
A390D	R	GE	R6200440	R39
A390E	R	GE	R6200540	R39
A390M	R	GE	R6200640	R39
A390N	R	GE	R6200840	R39
A390P	R	GE	R6201040	R39
A390PA	R	GE	R6201140	R39
A390PB	R	GE	R6201240	R39
A390S	R	GE	R6200740	R39
A390T	R	GE	R6200940	R39
A396A	R	GE	R6220140FJ	R67

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A396C	R	GE	R6220340FJ	R67
A396D	R	GE	R6220440FJ	R67
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A396M	R	GE	R6220640FJ	R67
A396N	R	GE	R6220840FJ	R67
A396P	R	GE	R6221040FJ	R67
A396S	R	GE	R6220740FJ	R67
A396T	R	GE	R6220940FJ	R67
A397A	R	GE	R6220140FJ	R67
A397B	R	GE	R6220240FJ	R67
A397C	R	GE	R6220340FJ	R67
A397D	R	GE	R6220440FJ	R67
A397E	R	GE	R6220540FJ	R67
A397M	R	GE	R6220640FJ	R67
A397N	R	GE	R6220840FJ	R67
A397P	R	GE	R6221040FJ	R67
A397PA	R	GE	R6221140FJ	R67
A397PB	R	GE	R6221240FJ	R67
A397PC	R	GE	R6221340FJ	R67
A397PD	R	GE	R6221440FJ	R67
A397PE	R	GE	R6221540FJ	R67
A397S	R	GE	R6220740FJ	R67
A397T	R	GE	R6220940FJ	R67
A430A	R	GE	R7200112	R43
A430B	R	GE	R7200212	R43
A430C	R	GE	R7200312	R43
A430D	R	GE	R7200412	R43
A430E	R	GE	R7200512	R43
A430M	R	GE	R7200612	R43
A430N	R	GE	R7200812	R43
A430P	R	GE	R7201012	R43
A430PA	R	GE	R7201112	R43
A430PB	R	GE	R7201212	R43
A430PC	R	GE	R7201312	R43
A430PD	R	GE	R7201412	R43
A430PE	R	GE	SO	R43
A430S	R	GE	R7200712	R43
A430T	R	GE	R7200912	R43
A437A	R	GE	R7220108EJ	R71
A437B	R	GE	R7220208EJ	R71
A437C	R	GE	R7220308EJ	R71
A437D	R	GE	R7220408EJ	R71
A437E	R	GE	R7220508EJ	R71
A437M	R	GE	R7220608EJ	R71
A437N	R	GE	R7220808EJ	R71
A437P	R	GE	R7221008EJ	R71
A437PA	R	GE	R7221108EJ	R71
A437PB	R	GE	R7221208EJ	R71
A437PC	R	GE	R7221308EJ	R71
A437PD	R	GE	SO	R71
A437PE	R	GE	R7221508EJ	R71
A437S	R	GE	R7220708EJ	R71
A437T	R	GE	R7220908EJ	R71
A500L	R	GE	R7202009	R43
A500LA	R	GE	R7202109	R43
A500LB	R	GE	R7202209	R43
A500LC	R	GE	R7202309	R43
A500LD	R	GE	R7202409	R43
A500LE	R	GE	R7202509	R43
A500LM	R	GE	R7202609	R43
A500LN	R	GE	R7202809	R43
A500LP	R	GE	R7203009	R43
A500LS	R	GE	R7202709	R43
A500LT	R	GE	R7202909	R43
A500P	R	GE	R7201009	R43
A500PA	R	GE	R7201109	R43
A500PB	R	GE	R7201209	R43
A500PC	R	GE	R7201309	R43
A500PD	R	GE	R7201409	R43
A500PE	R	GE	R7201509	R43
A500PM	R	GE	R7201609	R43
A500PN	R	GE	R7201809	R43
A500PS	R	GE	R7201709	R43
A500PT	R	GE	R7201909	R43
A500XX0111	T	WES	A500XX0111	CF
A500XX0118	T	WES	A500XX0118	CF
A510XX0115	T	WES	A510XX0115	CF
A510XX0125	T	WES	A510XX0125	CF
A540A	R	GE	R7200112	R43
A540B	R	GE	R7200212	R43
A540C	R	GE	R7200312	R43
A540D	R	GE	R7200412	R43
A540E	R	GE	R7200512	R43
A540L	R	GE	CF	CF

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A540LA	R	GE	CF	CF
A540LB	R	GE	CF	CF
A540LC	R	GE	CF	CF
A540LD	R	GE	CF	CF
A540M	R	GE	R7200612	R43
A540N	R	GE	R7200812	R43
A540P	R	GE	R7201012	R43
A540PA	R	GE	R7201112	R43
A540PB	R	GE	R7201212	R43
A540PC	R	GE	R7201312	R43
A540PD	R	GE	R7201412	R43
A540PE	R	GE	SO	R43
A540PM	R	GE	SO	R43
A540PN	R	GE	SO	R43
A540PS	R	GE	SO	R43
A540PT	R	GE	SO	R43
A540S	R	GE	R7200712	R43
A540T	R	GE	R7200912	R43
A570A	R	GE	R9200111	R47
A570B	R	GE	R9200211	R47
A570C	R	GE	R9200311	R47
A570D	R	GE	R9200411	R47
A570E	R	GE	R9200511	R47
A570M	R	GE	R9200611	R47
A570N	R	GE	R9200811	R47
A570P	R	GE	R9201011	R47
A570S	R	GE	R9200711	R47
A570T	R	GE	R9200911	R47
A596N	R	GE	R7220808EJ	R71
A596P	R	GE	R7221008EJ	R71
A596PA	R	GE	R7221108EJ	R71
A596PB	R	GE	R7221208EJ	R71
A596T	R	GE	R7220908EJ	R71
A640L	R	GE	R9202016	R47
A640LA	R	GE	R9202116	R47
A640N	R	GE	R9200816	R47
A640P	R	GE	R9201016	R47
A640PA	R	GE	R9201116	R47
A640PB	R	GE	R9201216	R47
A640PC	R	GE	R9201316	R47
A640PD	R	GE	R9201416	R47
A640PE	R	GE	R9201516	R47
A640PM	R	GE	R9201616	R47
A640PN	R	GE	R9201816	R47
A640PS	R	GE	R9201716	R47
A640PT	R	GE	R9201916	R47
A640S	R	GE	R9200716	R47
A640T	R	GE	R9200916	R47
A670XX0515	T	WES	A670XX0515	CF
A670XX0525	T	WES	A670XX0525	CF
AD45-01	R	PSI	IN1184A	R15
AD45-02	R	PSI	IN1186A	R15
AD45-04	R	PSI	IN1188A	R15
AD45-06	R	PSI	IN1190A	R15
AD45-08	R	PSI	R4100840	R15
AD45-10	R	PSI	R4101040	R15
AD45-12	R	PSI	R4101240	R15
AD65-01	R	PSI	R4040170	R17
AD65-02	R	PSI	R4040270	R17
AD65-04	R	PSI	R4040470	R17
AD65-06	R	PSI	R4040670	R17
AD65-08	R	PSI	R4048070	R17
AD65-10	R	PSI	R4041070	R17
AD65-12	R	PSI	R4041270	R17
AL-10-5	A	EDL	MB12A25V05	A3
AL-10-10	A	EDL	MB12A25V10	A3
AL-10-20	A	EDL	MB12A25V20	A3
AL-10-30	A	EDL	MB12A25V30	A3
AL-10-40	A	EDL	MB12A25V40	A3
AL-10-50	A	EDL	MB12A25V50	A3
AL-10-60	A	EDL	MB12A25V60	A3
AL-25-5	A	EDL	MB12A25V05	A3
AL-25-10	A	EDL	MB12A25V10	A3
AL-25-20	A	EDL	MB12A25V20	A3
AL-25-30	A	EDL	MB12A25V30	A3
AL-25-40	A	EDL	MB12A25V40	A3
AL-25-50	A	EDL	MB12A25V50	A3
AL-25-60	A	EDL	MB12A25V60	A3
B10A	A	TUN	MB12A25V10	A3
B10B	A	TUN	MB12A25V20	A3
B10D	A	TUN	MB12A25V40	A3
B10F	A	TUN	MB12A25V60	A3
B10Z	A	TUN	MB12A25V05	A3
B50A	A	TUN	MB12A10V10	A3
B50B	A	TUN	MB12A10V20	A3

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B50D	A	TUN	MB12A10V40	A3
B50F	A	TUN	MB12A10V60	A3
B50Z	A	TUN	MB12A10V05	A3
B55-14	S	PSI	T500144003AQ	S23
B110-14	S	PSI	T500148004AQ	S23
BD125-01	R	PSI	R5100110	R23
BD125-02	R	PSI	R5100210	R23
BD125-04	R	PSI	R5100410	R23
BD125-06	R	PSI	R5100610	R23
BD125-08	R	PSI	R5100810	R23
BD125-10	R	PSI	R5101010	R23
BD125-12	R	PSI	R5001210	R23
BD125-14	R	PSI	R5001410	R23
BD150-01	R	PSI	R5100115	R23
BD150-02	R	PSI	R5100215	R23
BD150-04	R	PSI	R5100415	R23
BD150-06	R	PSI	R5100615	R23
BD150-08	R	PSI	R5100815	R23
BD150-10	R	PSI	R5101015	R23
BD150-12	R	PSI	R5001215	R23
BD150-14	R	PSI	R5001415	R23
C30A	S	GE	T400011608	S13
C30B	S	GE	T400021608	S13
C30C	S	GE	T400031608	S13
C30D	S	GE	T400041608	S13
C30F	S	GE	T400001608	S13
C35A	S	GE	T400012208	S13
C35B	S	GE	T400022208	S13
C35C	S	GE	T400032208	S13
C35D	S	GE	T400042208	S13
C35E	S	GE	T400052208	S13
C35F	S	GE	T400002208	S13
C35M	S	GE	T400062208	S13
C35N	S	GE	T400082208	S13
C35S	S	GE	T400072208	S13
C36A	S	GE	T400011008	S13
C36B	S	GE	T400021008	S13
C36C	S	GE	T400031008	S13
C36D	S	GE	T400041008	S13
C36E	S	GE	T400051008	S13
C36F	S	GE	T400001008	S13
C36M	S	GE	T400061008	S13
C36N	S	GE	T400081008	S13
C36S	S	GE	T400071008	S13
C37A	S	GE	T400011608	S13
C37B	S	GE	T400021608	S13
C37C	S	GE	T400031608	S13
C37D	S	GE	T400041608	S13
C37E	S	GE	T400051608	S13
C37F	S	GE	T400001608	S13
C37M	S	GE	T400061608	S13
C37N	S	GE	T400081608	S13
C37S	S	GE	T400071608	S13
C38A	S	GE	CF	CF
C38B	S	GE	CF	CF
C38C	S	GE	CF	CF
C38D	S	GE	CF	CF
C38E	S	GE	CF	CF
C38M	S	GE	CF	CF
C45A	S	GE	T510015004AB	S27
C45B	S	GE	T510025004AB	S27
C45C	S	GE	T510035004AB	S27
C45D	S	GE	T510045004AB	S27
C45E	S	GE	T510055004AB	S27
C45F	S	GE	T510005004AB	S27
C45G	S	GE	T510025004AB	S27
C45H	S	GE	T510035004AB	S27
C45M	S	GE	T510065004AB	S27
C45N	S	GE	T500084004AA	S23
C45P	S	GE	T500104004AA	S23
C45PA	S	GE	T500114004AA	S23
C45PB	S	Ge	T500124004AA	S23
C45S	S	GE	T500074004AA	S23
C45T	S	GE	T500094004AA	S23
C45U	S	GE	T510005004AB	S27
C46A	S	GE	T510015004AQ	S27
C46B	S	GE	T510025004AQ	S27
C46C	S	GE	T510035004AQ	S27
C46D	S	GE	T510045004AQ	S27
C46E	S	GE	T510055004AQ	S27
C46F	S	GE	T510005004AQ	S27
C46G	S	GE	T510025004AQ	S27
C46H	S	GE	T510035004AQ	S27
C46M	S	GE	T510065004AQ	S27
C46N	S	GE	T500084004AQ	S23

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C46PB	S	GE	T500124004A(	S23
C46S	S	GE	T500074004AQ	S23
C46T	S	GE	T500094004AQ	S23
C46U	S	GE	T510005004A	S27
C50A	S	GE	T510018004AQ	S27
C50B	S	GE	T510028004AQ	S27
C50C	S	GE	T510038004AQ	S27
C50D	S	GE	T510048004AQ	S27
C50E	S	GE	T510058004AQ	S27
C50F	S	GE	T510008004AQ	S27
C50G	S	GE	T510028004AQ	S27
C50H	S	GE	T510038004AQ	S27
C50M	S	GE	T510068004AQ	S27
C50N	S	GE	T500088004AQ	S23
C50P	S	GE	T500108004AQ	S23
C50PA	S	GE	T500118004AQ	S23
C50PB	S	GE	T500128004AQ	S23
C50S	S	GE	T500078004AQ	S23
C50T	S	GE	T500098004AQ	S23
C50U	S	GE	T510008004AQ	S27
C52A	S	GE	T510018004AB	S27
C52B	S	GE	T510028004AB	S27
C52C	S	GE	T510038004AB	S27
C52D	S	GE	T510018004AB	S27
C52E	S	GE	T510058004AB	S27
C52F	S	GE	T510008004AB	S27
C52G	S	GE	T510028004AB	S27
C52H	S	GE	T510038004AB	S27
C52M	S	GE	T510068004AB	S27
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C52P	S	GE	T500108004AA	S23
C52PA	S	GE	T500118004AA	S23
C52PB	S	GE	T500128004AA	S23
C52S	S	GE	T500078004AA	S23
C52T	S	GE	T500098004AA	S23
C52U	S	GE	T510008004AB	S27
C60A	S	GE	T515018004AQ	CF
C60B	S	GE	T515028004AQ	CF
C60C	S	GE	T515038004AQ	CF
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C60U	S	GE	T515008004AQ	CF
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C62F	S	GE	T515008004AB	CF
C62G	S	GE	T515028004AB	CF
C62H	S	GE	T515038004AB	CF
C62U	S	GE	T515008004AB	CF
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C702LD	S	GE	T9G0241003DH	S61
C137E	S	GE	T400062208	S13
C137M	S	GE	T400062208	S13
C137N	S	GE	T400082208	S13
C137P	S	GE	T400102208	S13
C137PB	S	GE	T400122208	S13
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C150T	S	GE	T500098004AQ	S23
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C152M	S	GE	T510068004AB	S27
C152N	S	GE	T500088004AA	S23
C152P	S	GE	T500108004AA	S23
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C152PB	S	GE	T500128004AA	S23
C152PC	S	GE	T500138004AA	S23
C152S	S	GE	T500078004AA	S23
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C153M	S	GE	T507068054AA	S77
C153N	S	GE	T507088054AA	S77
C153P	S	GE	T507108054AA	S77
C153PA	S	GE	T507118054AA	S77
C153S	S	GE	T507078054AA	S77
C153T	S	GE	T507098054AA	S77
C154A	S	GE	T507018084AQ	S77
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C159S	S	GE	T507078054AA	S77
C159T	S	GE	T507098054AA	S77
C160-15	S	PSI	T600151303BT	S33
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C164C	S	GE	T507037084AQ	S77
C164D	S	GE	T507047084AQ	S77
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C165S	S	GE	T507077064AQ	S77
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C180T	S	GE	T600091504BT	S33
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C185E	S	GE	T607051864BT	S79
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C185S	S	GE	T607071864BT	S79
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C186S-30	S	GE	T607071554BT	S79
C186S-40	S	GE	T607071544BT	S79
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C281P	S	GE	T780103504BY	S75
C281PA	S	GE	T780113504BY	S75
C281PB	S	GE	T780123504BY	S75
C281PC	S	GE	T780133504BY	S75
C281PD	S	GE	T780143504BY	S75
C281PE	S	GE	T7801535C4BY	S75
C281PM	S	GE	T780163504BY	S75
C281PN	S	GE	T780183504BY	S75
C281PS	S	GE	T780173504BY	S75
C281S	S	GE	T780073504BY	S75
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C283PB	S	GE	T780123504BY	S75
C283PC	S	GE	T780133504BY	S75
C283PD	S	GE	T780143504BY	S75
C283PE	S	GE	T780153504BY	S75
C283PM	S	GE	T780163504BY	S75

Note: Manufacturer's Codes, Product Type Notes and Ⓦ Replacement Notes are listed on page G3

Assemblies, Rectifiers, Thyristors, & Transistors
MASTER CROSS REFERENCE TYPE NUMBER INDEX
JEDEC and Industry Part Numbers

Part Number	Type	Mfgr.	Suggested Ⓦ Replacement	Page
C283PN	S	GE	T780183504BY	S75
C283PS	S	GE	T780173504BY	S75
C283S	S	GE	T780073504BY	S75
C283T	S	GE	T780093504BY	S75
C286N	S	GE	T7000825C4BY	S37
C286P	S	GE	T700102504BY	S37
C286PA	S	GE	T700112504BY	S37
C286PB	S	GE	T700122504BY	S37
C286PC	S	GE	T700132504BY	S37
C286PD	S	GE	T700142504BY	S37
C286PE	S	GE	T700152504BY	S37
C286PM	S	GE	T700162504BY	S37
C286S	S	GE	T700072504BY	S37
C286T	S	GE	T700092504BY	S37
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C287PE	S	GE	T780153504BY	S75
C287PM	S	GE	T780163504BY	S75
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C291T	S	GE	T780093504BY	S75
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C398M	S	GE	T727064554DN	S91
C398N	S	GE	T727084554DN	S91
C398P	S	GE	T727104554DN	S91
C398PA	S	GE	T727114554DN	S91
C398PB	S	GE	T727124554DN	S91
C398S	S	GE	T727074554DN	S91
C398T	S	GE	T727094554DN	S91
C400	S	GE	CF	CF
C440	S	GE	CF	CF
C441	S	GE	CF	CF
C445	S	GE	CF	CF
C448	S	GE	CF	CF
C501N	S	GE	T720085504DN	S51
C501P	S	GE	T720105504DN	S51
C501PA	S	GE	T720115504DN	S51
C501PB	S	GE	T720125504DN	S51
C501PC	S	GE	T720135504DN	S51
C501PD	S	GE	T720145504DN	S51
C501PE	S	GE	T720155504DN	S51
C501PM	S	GE	T720165504DN	S51
C501S	S	GE	T720075504DN	S51
C501T	S	GE	T720095504DN	S51
C502PE	S	GE	T720155504DN	S51
C502PM	S	GE	T720165504DN	S51
C509	S	GE	CF	CF
C520A	S	GE	T720015504DN	S51
C520B	S	GE	T720025504DN	S51
C520C	S	GE	T720035504DN	S51
C520D	S	GE	T720045504DN	S51
C530A	S	GE	T720015504DN	S51
C530B	S	GE	T720025504DN	S51
C530C	S	GE	T720035504DN	S51
C530D	S	GE	T720045504DN	S51
C530E	S	GE	T720055504ND	S51
C530M	S	GE	T720065504DN	S51
C600	S	GE	CF	CF
C601	S	GE	CF	CF
C602	S	GE	CF	CF
C609	S	GE	CF	CF
C612	S	GE	CF	CF
C701PA	S	GE	T9G0111203DH	S61
C701PB	S	GE	T9G0121203DH	S61
C701PC	S	GE	T9G0131203DH	S61
C701PD	S	GE	T9G0141203DH	S61
C701PE	S	GE	T9G0151203DH	S61
C701PM	S	GE	T9G0161203DH	S61
C702L	S	GE	T9G0201003DH	S61
C702LA	S	GE	T9G0211003DH	S61
C702LB	S	GE	T9G0221003DH	S61
C712L	S	GE	CF	CF
C712PE	S	GE	CF	CF
C712PM	S	GE	CF	CF
C712PN	S	GE	CF	CF
C712PS	S	GE	CF	CF
C712PT	S	GE	CF	CF
CD160-01	R	PSI	IN3261	R27
CD160-02	R	PSI	IN3263	R27
CD160-04	R	PSI	IN3267	R27

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CD160-08	R	PSI	IN3271	R27
CD160-10	R	PSI	IN3273	R27
CD160-12	R	PSI	IN3274	R27
CD160-14	R	PSI	IN3275	R27
CD160-16	R	PSI	IN3276	R27
CD250-01	R	PSI	R6100125	R31
CD250-02	R	PSI	R6100225	R31
CD250-04	R	PSI	R6100425	R31
CD250-06	R	PSI	R6100625	R31
CD250-08	R	PSI	R6100825	R31
CD250-10	R	PSI	R6101025	R31
CD250-12	R	PSI	R6001225	R31
CD250-14	R	PSI	R6001425	R31
CD250-16	R	PSI	R6001625	R31
CD300-01	R	PSI	R6100130	R31
CD300-02	R	PSI	R6100230	R31
CD300-04	R	PSI	R6100430	R31
CD300-06	R	PSI	R6100630	R31
CD300-08	R	PSI	R6100830	R31
CD300-10	R	PSI	R6101030	R31
CD300-12	R	PSI	R6001230	R31
CD300-14	R	PSI	R6001430	R31
CD300-16	R	PSI	R6001630	R31
CH119A	R	TUN	R5100115	R23
CH119AR	R	TUN	R5110115	R23
CH119AZ	R	TUN	R510+115	R23
CH119AZR	R	TUN	R511+115	R23
CH119B	R	TUN	R5100215	R23
CH119BR	R	TUN	R5110215	R23
CH119C	R	TUN	R5100315	R23
CH119CR	R	TUN	R5110315	R23
CH119D	R	TUN	R5100415	R23
CH119DR	R	TUN	R5110415	R23
CH119E	R	TUN	R5100515	R23
CH119ER	R	TUN	R5110515	R23
CH119F	R	TUN	R5100615	R23
CH119FR	R	TUN	R5110615	R23
CH119Z	R	TUN	R5100015	R23
CH119ZR	R	TUN	R5110015	R23
CH10912A	R	TUN	R5100115	R23
CH10912AR	R	TUN	R5110115	R23
CH10912AZ	R	TUN	R510+115	R23
CH10912AZR	R	TUN	R511+115	R23
CH10912B	R	TUN	R5100215	R23
CH10912BR	R	TUN	R5110215	R23
CH10912C	R	TUN	R5100315	R23
CH10912CR	R	TUN	R5110315	R23
CH10912D	R	TUN	R5100415	R23
CH10912DR	R	TUN	R5110415	R23
CH10912E	R	TUN	R5100515	R23
CH10912ER	R	TUN	R5110515	R23
CH10912F	R	TUN	R5100615	R23
CH10912FR	R	TUN	R5110615	R23
CH10912Z	R	TUN	R5100015	R23
CH10912ZR	R	TUN	R5110015	R23
CS131A	R	TUN	IN4045	R29
CS131AR	R	TUN	IN4045R	R29
CS131AZ	R	TUN	IN4046	R29
CS131AZR	R	TUN	IN4046R	R29
CS131B	R	TUN	IN4047	R29
CS131BR	R	TUN	IN4047R	R29
CS131C	R	TUN	IN4049	R29
CS131CR	R	TUN	IN4049R	R29
CS131D	R	TUN	IN4050	R29
CS131DR	R	TUN	IN4050R	R29
CS131E	R	TUN	IN4051	R29
CS131ER	R	TUN	IN4051R	R29
CS131F	R	TUN	IN4052	R29
CS131FR	R	TUN	IN4052R	R29
CS131Z	R	TUN	IN4044	R29
CS131ZR	R	TUN	IN4044R	R29
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D60T455010	T	WES	D60T455010	T33
D60T505010	T	WES	D60T505010	T33
D235	S	PSI	T600—1804BT	S33
D350	S	PSI	T600—1804BT	S33
D390XX0520	T	WES	D390XX0520	CF
D390XX0525	T	WES	D390XX0525	CF
D400	S	PSI	T600—1804BT	S33
D470	S	PSI	T700—3004BT	S37
D480XX0320	T	WES	D480XX0320	CF
D480XX0420	T	WES	D480XX0420	CF
D480XX0520	T	WES	D480XX0520	CF
D480XX0815	T	WES	D480XX0815	CF
D480XX1015	T	WES	D480XX1015	CF
D1197	S	WCE	T9GHXX08-4	S39
D1245	S	WCE	CF	CF
D2406A	R	RCA	IN3880	R55
D2406AR	R	RCA	IN3880R	R55
D2406B	R	RCA	IN3881	R55
D2406BR	R	RCA	IN3881R	R55
D2406C	R	RCA	IN3882	R55
D2406CR	R	RCA	IN3882R	R55
D2406D	R	RCA	IN3883	R55
D2406DR	R	RCA	IN3883R	R55
D2406F	R	RCA	IN3879	R55
D2406FR	R	RCA	IN3879R	R55
D2406M	R	RCA	R3020606	R55
D2406MR	R	RCA	R3030606	R55
D2412A	R	RCA	IN3890	R55
D2412AR	R	RCA	IN3890R	R55
D2412B	R	RCA	IN3891	R55
D2412BR	R	RCA	IN3891R	R55
D2412C	R	RCA	IN3892	R55
D2412CR	R	RCA	IN3892R	R55
D2412D	R	RCA	IN3893	R55
D2412DR	R	RCA	IN3893R	R55
D2412F	R	RCA	IN3889	R55
D2412FR	R	RCA	IN3889R	R55
D2412M	R	RCA	R3020612	R55
D2412MR	R	RCA	R3030612	R55
D2520A	R	RCA	IN3900	R57
D2520AR	R	RCA	IN3900R	R57
D2520B	R	RCA	IN3901	R57
D2520BR	R	RCA	IN3901R	R57
D2520C	R	RCA	IN3902	R57
D2520CR	R	RCA	IN3902R	R57
D2520D	R	RCA	IN3903	R57
D2520DR	R	RCA	IN3903R	R57
D2520F	R	RCA	IN3899	R57
D2520FR	R	RCA	IN3899R	R57
D2520M	R	RCA	R4020620	R57
D2520MR	R	RCA	R4030620	R57
D2540A	R	RCA	IN3910	R57
D2540AR	R	RCA	IN3910R	R57
D2540B	R	RCA	IN3911	R57
D2540BR	R	RCA	IN3911R	R57
D2540D	R	RCA	IN3913	R57
D2540DR	R	RCA	IN3913R	R57
D2540F	R	RCA	IN3909	R57
D2540FR	R	RCA	IN3909R	R57
D2540M	R	RCA	R4020630	R57
D2540MR	R	RCA	R4030630	R57
D3610	R	SYN	R4040160	R17
DRS-250	R	DEL	R6100825	R31
DRS-250R	R	DEL	R6110825	R31
DRS-251	R	DEL	R6101025	R31
DRS-251R	R	DEL	R6111025	R31
DRS-252	R	DEL	R6001225	R31
DRS-252R	R	DEL	R6011225	R31
DRS-253	R	DEL	R6001425	R31
DRS-253R	R	DEL	R6011425	R31
DRS-254	R	DEL	R6001625	R31
DRS-254R	R	DEL	R6011625	R31
E180	S	PSI	CF	CF
E220	S	PSI	CF	CF
E300	S	PSI	CF	CF
E400	S	PSI	CF	CF
E500	S	PSI	CF	CF
EHF1B1	A	SYN	MB12A10V10	A3
EHF2B1	A	SYN	MB12A10V20	A3
EHF3B1	A	SYN	MB12A10V30	A3
EHF4B1	A	SYN	MB12A10V40	A3
EHF5B1	A	SYN	MB12A10V50	A3
EHF6B1	A	SYN	MB12A10V60	A3
EMF1B1	A	SYN	MB12A25V10	A3
EMF2B1	A	SYN	MB12A25V20	A3
EMF4B1	A	SYN	MB12A25V40	A3
EMF6B1	A	SYN	MB12A25V60	A3
ESP05B1	A	SYN	MB11A02V05	A3
ESP1B1	A	SYN	MB11A02V10	A3
ESP2B1	A	SYN	MB11A02V20	A3
ESP4B1	A	SYN	MB11A02V40	A3
ESP6B1	A	SYN	MB11A02V60	A3
ESP8B1	A	SYN	MB11A02V80	A3
ESP10B1	A	SYN	MB11A02W10	A3
F180	S	PSI	CF	CF
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F300	S	PSI	CF	CF
F400	S	PSI	CF	CF
F500	S	PSI	CF	CF
F600	S	PSI	CF	CF
FD600-05	R	PSI	R7200606	R43
FD600-10	R	PSI	R7201006	R43
FD600-12	R	PSI	R7201206	R43
FD600-16	R	PSI	R7201606	R43
FD600-18	R	PSI	R7201806	R43
FD600-20	R	PSI	R7202006	R43
FD600-22	R	PSI	R7202206	R43
FD600-24	R	PSI	R7202406	R43
FD600-30	R	PSI	R7203006	R43
FD900-06	R	PSI	R7200610	R43
FD900-10	R	PSI	R7201010	R43
FD900-12	R	PSI	R7201210	R43
FD900-16	R	PSI	R7201610	R43
FD900-18	R	PSI	R7201810	R43
FD900-20	R	PSI	R7202010	R43
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G300-2	S	PSI	T720023504DN	S51
G300-3	S	PSI	T720033504DN	S51
G300-4	S	PSI	T720043504DN	S51
G300-5	S	PSI	T720053504DN	S51
G300-6	S	PSI	T720063504DN	S51
G300-7	S	PSI	T720073504DN	S51
G300-8	S	PSI	T720083504DN	S51
G300-9	S	PSI	T720093504DN	S51
G300-10	S	PSI	T720103504DN	S51
G300-12	S	PSI	T720123504DN	S51
G300-14	S	PSI	T720143504DN	S51
G300-16	S	PSI	T720163504DN	S51
G300-18	S	PSI	T720183504DN	S51
G300-20	S	PSI	T720203504DN	S51
G300-22	S	PSI	T720223504DN	S51
G400-1	S	PSI	T720013504DN	S51
G400-2	S	PSI	T720023504DN	S51
G400-3	S	PSI	T720033504DN	S51
G400-4	S	PSI	T720043504DN	S51
G400-5	S	PSI	T720053504DN	S51
G400-6	S	PSI	T720063504DN	S51
G400-7	S	PSI	T720073504DN	S51
G400-8	S	PSI	T720083504DN	S51
G400-9	S	PSI	T720093504DN	S51
G400-10	S	PSI	T720103504DN	S51
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G400-16	S	PSI	T720163504DN	S51
G400-18	S	PSI	T720183504DN	S51
G400-20	S	PSI	T720203504DN	S51
G400-22	S	PSI	T720223504DN	S51
G500-1	S	PSI	T720013504DN	S51
G500-2	S	PSI	T720023504DN	S51
G500-3	S	PSI	T720033504DN	S51
G500-4	S	PSI	T720043504DN	S51
G500-5	S	PSI	T720053504DN	S51
G500-6	S	PSI	T720063504DN	S51
G500-7	S	PSI	T720073504DN	S51
G500-8	S	PSI	T720083504DN	S51
G500-9	S	PSI	T720093504DN	S51
G500-10	S	PSI	T720103504DN	S51
G500-12	S	PSI	T720123504DN	S51
G500-14	S	PSI	T720143504DN	S51
G500-16	S	PSI	T720163504DN	S51
G500-18	S	PSI	T720183504DN	S51
G500-20	S	PSI	T720203504DN	S51
G650-1	S	PSI	T720014504DN	S51
G650-2	S	PSI	T720024504DN	S51
G650-3	S	PSI	T720034504DN	S51
G650-4	S	PSI	T720044504DN	S51
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G650-9	S	PSI	T720094504DN	S51
G650-10	S	PSI	T720104504DN	S51
G650-12	S	PSI	T720124504DN	S51
G650-14	S	PSI	T720144504DN	S51
G650-16	S	PSI	T720164504DN	S51
G650-18	S	PSI	T720184504DN	S51
G850-1	S	PSI	T720015504DN	S51
G850-2	S	PSI	T720025504DN	S51
G850-3	S	PSI	T720035504DN	S51
G850-4	S	PSI	T720045504DN	S51
G850-5	S	PSI	T720055504DN	S51
G850-6	S	PSI	T720065504DN	S51
G850-7	S	PSI	T720075504DN	S51
G850-8	S	PSI	T720085504DN	S51
G850-9	S	PSI	T720095504DN	S51
G850-10	S	PSI	T720105504DN	S51
G850-12	S	PSI	T720125504DN	S51
G850-14	S	PSI	T720145504DN	S51
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G950-1	S	PSI	T720015504DN	S51
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G950-8	S	PSI	T720085504DN	S51
G950-9	S	PSI	T720095504DN	S51
G950-10	S	PSI	T720105504DN	S51
G950-12	S	PSI	T720125504DN	S51
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GA2	A	WES	GA2	A19
GA3	A	WES	GA3	A28
GB1	A	WES	GB1	A12
GB2	A	WES	GB2	A20
GB3	A	WES	GB3	A29
GC1	A	WES	GC1	A10
GD1	A	WES	GD1	A9
GD2	A	WES	GD2	A18
GD3	A	WES	GD3	A27
GG800-06	R	PSI	R7200609	R43
GD800-10	R	PSI	R7201009	R43
GD800-12	R	PSI	R7201209	R43
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GD800-20	R	PSI	R7202009	R43
GD800-22	R	PSI	R7202209	R43
GD800-24	R	PSI	R7202409	R43
GD800-30	R	PSI	SO	R43
GD1400-06	R	PSI	R7200612	R43
GD1400-10	R	PSI	R7201012	R43
GD1400-12	R	PSI	R7201212	R43
GD1400-16	R	PSI	SO	R43
GD1400-18	R	PSI	SO	R43
GD1400-20	R	PSI	SO	R43
GE1	A	WES	GE1	A13
GE2	A	WES	GE2	A21
GE3	A	WES	GE3	A30
GEB100	A	GE	MB11A02V05	A3
GEB101	A	GE	MB11A02V10	A3
GEB102	A	GE	MB11A02V20	A3
GEB104	A	GE	MB11A02V40	A3
GEB106	A	GE	MB11A02V60	A3
GEB108	A	GE	MB11A02V80	A3
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H800-24	S	PSI	T920240602DW	S55
H800-26	S	PSI	T920260602DW	S55
H800-28	S	PSI	T920280602DW	S55
H800-30	S	PSI	T920300602DW	S55
H1000-6	S	PSI	T920060702DW	S55
H1000 12	S	PSI	T920120702DW	S55
H1000-18	S	PSI	T920180702DW	S55
H1000 20	S	PSI	T920200702DW	S55
H1000 22	S	PSI	T920220702DW	S55
H1200-6	S	PSI	T920060902DW	S55
H1200-10	S	PSI	T920100902DW	S55
H1200 12	S	PSI	T920120902DW	S55
H1200 14	S	PSI	T920140902DW	S55
H1200 16	S	PSI	T920160902DW	S55
H1400-6	S	PSI	T920061002DW	S55
H1400 8	S	PSI	T920081002DW	S55
H1400 10	S	PSI	T920101002DW	S55
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H1600 6	S	PSI	T920061002DW	S55
H1600-8	S	PSI	T920081002DW	S55
H1600 10	S	PSI	T920101002DW	S55
H1600 12	S	PSI	T920121002DW	S55
H1600 14	S	PSI	T920141002DW	S55
H1800	S	PSI	CF	CF
HD1500 6	R	PSI	R9200611	R47
HD1500 10	R	PSI	R9201011	R47
HD1500 12	R	PSI	R9201211	R47
HD1500-16	R	PSI	R9201611	R47
HD1500-18	R	PSI	R9201811	R47
HD1500-20	R	PSI	R9202011	R47
HD1500-22	R	PSI	R9202211	R47
HD1500-24	R	PSI	R9202411	R47
HD1500-30	R	PSI	R9203011	R47
HD2100-6	R	PSI	R9200620	R47
HD2100-10	R	PSI	R9201020	R47
HD2100-12	R	PSI	R9201220	R47
HD2100-16	R	PSI	R9201620	R47
HD2100-18	R	PSI	R9201820	R47
HD2100-20	R	PSI	R9202020	R47
HD2500-2	R	PSI	R9200220	R47
HD2500-4	R	PSI	R9200420	R47
HD2500-6	R	PSI	R9200620	R47
HD2500-8	R	PSI	R9200820	R47
HD2500-10	R	PSI	R9201020	R47
HD2500-12	R	PSI	R9201220	R47
HD3000-1	R	PSI	CF	CF
HD3000-2	R	PSI	CF	CF
HD3000-4	R	PSI	CF	CF
HD3000-6	R	PSI	CF	CF
HH	A	WES	HH	A76
J3000-2	S	PSI	CF	CF
J3000-4	S	PSI	CF	CF
J3000-6	S	PSI	CF	CF
J3000-8	S	PSI	CF	CF
J3000-10	S	PSI	CF	CF
J3000-12	S	PSI	CF	CF
JD4500-2	R	PSI	CF	CF
JD4500-4	R	PSI	CF	CF
JD4500-6	R	PSI	CF	CF
JD4500-8	R	PSI	CF	CF
JD4500-10	R	PSI	CF	CF
JD4500-12	R	PSI	CF	CF
JD6000-2	R	PSI	CF	CF
JD6000-4	R	PSI	CF	CF
JD6000-6	R	PSI	CF	CF
KBH02	A	GI	MB12A10V20	A3
KBH04	A	GI	MB12A10V40	A3
KBH06	A	GI	MB12A10V60	A3
KBH005	A	GI	MB12A10B05	A3
KBH2502	A	GI	MB12A25V20	A3
KBH2504	A	GI	MB12A25V40	A3
KBH2506	A	GI	MB12A25V60	A3

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KBH25005	A	GI	MB12A25V05	A3
KBPC102	A	GI	MB11A02V20	A3
KBPC104	A	GI	MB11A02V40	A3
KBPC106	A	GI	MB11A02V60	A3
KBPC108	A	GI	MB11A02V80	A3
KBPC110	A	GI	MB11A02W10	A3
KBPC810	A	GI	MB11A06W10	A3
KBPC1005	A	GI	MB11A02V05	A3
KBPC8005	A	GI	MB11A06V05	A3
KBPC8025	A	GI	MB11A06V20	A3
KBPC8045	A	GI	MB11A06V40	A3
KBPC8065	A	GI	MB11A06V60	A3
KBPC8085	A	GI	MB11A06V80	A3
KD6000-2	R	PSI	CF	CF
KD6000-4	R	PSI	CF	CF
KD6000-6	R	PSI	CF	CF
MB11A02VXX	A	WES	MB11A02VXX	A3
MB11A06VXX	A	WES	MB11A06VXX	A3
MB12A10VXX	A	WES	MB12A10VXX	A3
MB12A25VXX	A	WES	MB12A25VXX	A3
MB13A10V05	A	WES	MB12A10V05	A3
MB13A10V10	A	WES	MB12A10V10	A3
MB13A10V20	A	WES	MB12A10V20	A3
MB13A10V30	A	WES	MB12A10V30	A3
MB13A10V40	A	WES	MB12A10V40	A3
MB13A10V50	A	WES	MB12A10V60	A3
MB13A10V60	A	WES	MB12A10V60	A3
MB13A15V10	A	WES	MB12A25V10	A3
MB13A15V20	A	WES	MB12A25V20	A3
MB13A15V30	A	WES	MB12A25V30	A3
MB13A15V40	A	WES	MB12A25V40	A3
MB13A15V50	A	WES	MB12A25V60	A3
MB13A15V60	A	WES	MB12A25V60	A3
MB13A20V10	A	WES	MB12A25V10	A3
MB13A20V20	A	WES	MB12A25V20	A3
MB13A20V30	A	WES	MB12A25V30	A3
MB13A20V40	A	WES	MB12A25V40	A3
MB13A20V50	A	WES	MB12A25V60	A3
MB13A20V60	A	WES	MB12A25V60	A3
MCR39-35	S	MOT	T400002208	S13
MCR45-05	S	MOT	T510005007AB	S27
MCK45-10	S	MOT	T510015007AB	S27
MCR45-15	S	MOT	T510025007AB	S27
MCR45-20	S	MOT	T510025007AB	S27
MCR45-25	S	MOT	T510035007AB	S27
MCR45-30	S	MOT	T510035007AB	S27
MCR45-40	S	MOT	T510045007AB	S27
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MCR45-80	S	MOT	T500084004AA	S23
MCR45-90	S	MOT	T500094004AA	S23
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MCR45-120	S	MOT	T500124004AA	S23
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MCR50-25	S	MOT	T510038007AB	S27
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MCR50-35	S	MOT	T510048007AB	S27
MCR50-40	S	MOT	T510048007AB	S27
MCR50-50	S	MOT	T510058007AB	S27

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MCR50-70	S	MOT	T500078007AA	S23
MCR50-80	S	MOT	T500088007AA	S23
MCR50-90	S	MOT	T500098007AA	S23
MCR52-10	S	MOT	T507017044AA	S77
MCR52-20	S	MOT	T507027044AA	S77
MCR52-30	S	MOT	T507037044AA	S77
MCR52-40	S	MOT	T507047044AA	S77
MCR52-50	S	MOT	T507057044AA	S77
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MCR52-90	S	MOT	T507097044AA	S77
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MCR60-10	S	MOT	T510018007AQ	S27
MCR60-15	S	MOT	T510028007AQ	S27
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MCR235-30	S	MOT	T620032004DN	S43
MCR235-40	S	MOT	T620042004DN	S43
MCR235-50	S	MOT	T620052004DN	S43
MCR235-60	S	MOT	T620062004DN	S43
MCR235-70	S	MOT	T620072004DN	S43
MCR235-80	S	MOT	T620082004DN	S43
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MCR235-120	S	MOT	T620122004DN	S43
MCR235-130	S	MOT	T620132004DN	S43
MCR235-140	S	MOT	T620142004DN	S43
MCR235-150	S	MOT	T620152004DN	S43
MCR235A-10	S	MOT	T627011584DN	S87
MCR235A-20	S	MOT	T627021584DN	S87
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MCR380C-50	S	MOT	T627052564DN	S87
MCR380C-60	S	MOT	T627062564DN	S87
MCR380C-70	S	MOT	T627072564DN	S87

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MCR380C-90	S	MOT	T627092564DN	S87
MCR380C-100	S	MOT	T627102564DN	S87
MCR380D-10	S	MOT	T627012554DN	S87
MCR380D-20	S	MOT	T627022554DN	S87
MCR380D-30	S	MOT	T627032554DN	S87
MCR380D-40	S	MOT	T627042554DN	S87
MCR380D-40	S	MOT	T627052554DN	S87
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MCR380D-110	S	MOT	T627112554DN	S87
MCR380D-120	S	MOT	T627122554DN	S87
MCR420D-50	S	MOT	T627052554DN	S87
MCR420D-60	S	MOT	T627062554DN	S87
MCR420D-70	S	MOT	T627072554DN	S87
MCR4200-80	S	MOT	T627082554DN	S87
MCR420D-90	S	MOT	T627092554DN	S87
MCR420D-100	S	MOT	T627102554DN	S87
MCR470-10	S	MOT	T620013004DN	S43
MCR470-20	S	MOT	T620023004DN	S43
MCR470-30	S	MOT	T620033004DN	S43
MCR470-40	S	MOT	T620043004DN	S43
MCR470-50	S	MOT	T620053004DN	S43
MCR470-60	S	MOT	T620063004DN	S43
MCR470-70	S	MOT	T620073004DN	S43
MCR470-80	S	MOT	T620083004DN	S43
MCR470-90	S	MOT	T620093004DN	S43
MCR470-100	S	MOT	T620103004DN	S43
MCR470-110	S	MOT	T620113004DN	S43
MCR470-120	S	MOT	T620123004DN	S43
MCR470-130	S	MOT	T620133004DN	S43
MCR470-140	S	MOT	T620143004DN	S43
MCR470-150	S	MOT	T620153004DN	S43
MCR470C-10	S	MOT	T627012564DN	S87
MCR470C-20	S	MOT	T627022564DN	S87
MCR470C-30	S	MOT	T627032564DN	S87
MCR470C-40	S	MOT	T627042564DN	S87
MCR470C-50	S	MOT	T627052564DN	S87
MCR470C-60	S	MOT	T627062564DN	S87
MCR470C-70	S	MOT	T627072564DN	S87
MCR470C-80	S	MOT	T627082564DN	S87
MCR470D-10	S	MOT	T627012554DN	S87
MCR470D-20	S	MOT	T627022554DN	S87
MCR470D-30	S	MOT	T627032554DN	S87
MCR470D-40	S	MOT	T627042554DN	S87
MCR470E-10	S	MOT	T627012544DN	S87
MCR470E-20	S	MOT	T627022544DN	S87
MCR470E-30	S	MOT	T627032544DN	S87
MCR470E-40	S	MOT	T627042544DN	S87
MCR470E-50	S	MOT	T627052544DN	S87
MCR470E-60	S	MOT	T627062544DN	S87
MCR470E-70	S	MOT	T627072544DN	S87
MCR470E-80	S	MOT	T627082544DN	S87
MCR470E-90	S	MOT	T627092544DN	S87
MCR470E-100	S	MOT	T627102544DN	S87
MCR470E-110	S	MOT	T627112544DN	S87
MCR470E-120	S	MOT	T627122544DN	S87
MCR550C-10	S	MOT	T727104064DN	S91
MCR550C-20	S	MOT	T727024064DN	S91
MCR550C-30	S	MOT	T727034064DN	S91
MCR550C-40	S	MOT	T727044064DN	S91
MCR550C-50	S	MOT	T727054064DN	S91
MCR550C-60	S	MOT	T727064064DN	S91
MCR550C-70	S	MOT	T727074064DN	S91
MCR550C-80	S	MOT	T727084064DN	S91
MCR550C-90	S	MOT	T727093564DN	S91
MCR550C-100	S	MOT	T727103664DN	S91
MCR550D-10	S	MOT	T727014054DN	S91
MCR550D-20	S	MOT	T727024054DN	S91
MCR550D-30	S	MOT	T727034054DN	S91
MCR550D-40	S	MOT	T727044054DN	S91
MCR550D-50	S	MOT	T727054054DN	S91
MCR550D-60	S	MOT	T727064054DN	S91
MCR550D-70	S	MOT	T727074054DN	S91
MCR550D-80	S	MOT	T727084054DN	S91
MCR550D-90	S	MOT	T727093554DN	S91
MCR550D-100	S	MOT	T727103554DN	S91

Part Number	Type	Mfgr.	Suggested Ⓦ Replacement	Page
MCR550D-110	S	MOT	T727113554DN	S91
MCR550D-120	S	MOT	T727123554DN	S91
MCR800-10	S	MOT	T720015504DN	S51
MCR800-20	S	MOT	T720025504DN	S51
MCR800-30	S	MOT	T720C35504DN	S51
MCR800-40	S	MOT	T720045504DN	S51
MCR800-50	S	MOT	T720055504DN	S51
MCR800-60	S	MOT	T720065504DN	S51
MCR800-70	S	MOT	T720075504DN	S51
MCR800-80	S	MOT	T720085504DN	S51
MCR800-90	S	MOT	T720095504DN	S51
MCR800-100	S	MOT	T720105504DN	S51
MCR800-110	S	MOT	T720115504DN	S51
MCR800-120	S	MOT	T720125504DN	S51
MCR800-130	S	MOT	T720135504DN	S51
MCR800-140	S	MOT	T720145504DN	S51
MCR800-150	S	MOT	T720155504DN	S51
MCR2918-1	S	MOT	T400001608	S13
MCR2918-2	S	MOT	T400001608	S13
MCR2918-3	S	MOT	T400011608	S13
MCR2918-4	S	MOT	T400021608	S13
MCR2918-5	S	MOT	T400031608	S13
MCR2918-6	S	MOT	T400041608	S13
MCR2918-7	S	MOT	T400051608	S13
MCR2918-8	S	MOT	T400061608	S13
MCR3918-1	S	MOT	T400001608	S13
MCR3918-2	S	MOT	T400001608	S13
MCR3918-3	S	MOT	T400011608	S13
MCR3918-4	S	MOT	T400021608	S13
MCR3918-5	S	MOT	T400031608	S13
MCR3918-6	S	MOT	T400041608	S13
MCR3918-7	S	MOT	T400051608	S13
MCR3918-8	S	MOT	T400061608	S13
MCR3935-2	S	MOT	T400002208	S13
MCR3935-3	S	MOT	T400012208	S13
MCR3935-4	S	MOT	T400022208	S13
MCR3935-5	S	MOT	T400032208	S13
MCR3935-6	S	MOT	T400042208	S13
MCR3935-7	S	MOT	T400052208	S13
MCR3935-8	S	MOT	T400062208	S13
MDA922-2	A	MOT	MB11A02V05	A3
MDA922-3	A	MOT	MB11A03V10	A3
MDA922-4	A	MOT	MB11A02V20	A3
MDA922-5	A	MOT	MB11A02V30	A3
MDA922-6	A	MOT	MB11A02V40	A3
MDA922-7	A	MOT	MB11A02V60	A3
MDA922-8	A	MOT	MB11A02V80	A3
MDA922-9	A	MOT	MB11A02W10	A3
MDA952-1	A	MOT	MB11A06V05	A3
MDA952-2	A	MOT	MB11A06V10	A3
MDA952-3	A	MOT	MB11A06V20	A3
MDA952-4	A	MOT	MB11A06V30	A3
MDA952-5	A	MOT	MB11A06V40	A3
MDA980-1	A	MOT	MB12A10V05	A3
MDA980-2	A	MOT	MB12A10V10	A3
MDA980-3	A	MOT	MB12A10V20	A3
MDA980-4	A	MOT	MB12A10V30	A3
MDA980-5	A	MOT	MB12A10V40	A3
MDA980-6	A	MOT	MB12A10V60	A3
MDA990-1	A	MOT	MB12A25V05	A3
MDA990-2	A	MOT	MB12A25V10	A3
MDA990-3	A	MOT	MB12A25V20	A3
MDA990-4	A	MOT	MB12A25V30	A3
MDA990-5	A	MOT	MB12A25V40	A3
MDA990-6	A	MOT	MB12A25V60	A3
MP010ABA	A	WES	MB11A02V05	A3
MP010ABB	A	WES	MB11A02V10	A3
MP010ABD	A	WES	MB11A02V20	A3
MP010ABF	A	WES	MB11A02V30	A3
MP010ABH	A	WES	MB11A02V40	A3
MP010ABK	A	WES	MB11A02V60	A3
MP010ABM	A	WES	MB11A02V60	A3
MP010ABP	A	WES	MB11A02V80	A3
MP010ABS	A	WES	MB11A02V80	A3
MP010ABV	A	WES	MB11A02W10	A3
MP010ABZ	A	WES	MB11A02W10	A3
MP011BBA	A	WES	MB11A02V05	A3
MP011BBB	A	WES	MB11A02V10	A3
MP011BBD	A	WES	MB11A02V20	A3
MP011BBF	A	WES	MB11A02V30	A3

Part Number	Type	Mfgr.	Suggested Ⓦ Replacement	Page
MP011BBH	A	WES	MB11A02V40	A3
MP011BBK	A	WES	MB11A02V60	A3
MP011BBM	A	WES	MB11A02V60	A3
MP011BBP	A	WES	MB11A02V80	A3
MP011BBS	A	WES	MB11A02V80	A3
MP011BBV	A	WES	MB11A02W10	A3
MP011BBZ	A	WES	MB11A02W10	A3
MP012JBA	A	WES	MB12A10V05	A3
MP012JBB	A	WES	MB12A10V10	A3
MP012JBD	A	WES	MB12A10V20	A3
MP012JBF	A	WES	MB12A10V30	A3
MP012JBH	A	WES	MB12A10V40	A3
MP012JBK	A	WES	MB12A10V60	A3
MP012JBM	A	WES	MB12A10V60	A3
MP013MBB	A	WES	MB12A25V10	A3
MP013MBD	A	WES	MB12A25V20	A3
MP013MBF	A	WES	MB12A25V30	A3
MP013MBH	A	WES	MB12A25V40	A3
MP013MBK	A	WES	MB12A25V60	A3
MP013MBM	A	WES	MB12A25V60	A3
MP013RBB	A	WES	MB12A25V10	A3
MP013RBD	A	WES	MB12A25V20	A3
MP013RBF	A	WES	MB12A25V30	A3
MP013RBH	A	WES	MB12A25V40	A3
MP013RBK	A	WES	MB12A25V60	A3
MP013RBM	A	WES	MB12A25V60	A3
MR681	R	MOT	IN3910	R57
MR860	R	MOT	IN3909	R57
MR860R	R	MOT	IN3909R	A57
MR861R	R	MOT	IN3910R	R57
MR862	R	MOT	IN3911	R57
MR862R	R	MOT	IN3911R	R57
MR864	R	MOT	IN3913	R57
MR864R	R	MOT	IN3913R	R57
MR866	R	MOT	R4020630	R57
MR866R	R	MOT	R4030630	R57
MR1120	R	MOT	IN1199A	R13
MR1120R	R	MOT	IN1199AR	R13
MR1121	R	MOT	IN1200A	R13
MR1121R	R	MOT	IN1200AR	R13
MR1122	R	MOT	IN1202A	R13
MR1122R	R	MOT	IN1202AR	R13
MR1124	R	MOT	IN1204A	R13
MR1124R	R	MOT	IN1204AR	R13
MR1126	R	MOT	IN1206A	R13
MR1126R	R	MOT	IN1206AR	R13
MR1128	R	MOT	IN3671A	R13
MR1130	R	MOT	IN3673A	R13
MR1210SB	R	MOT	CF	CF
MR1210SL	R	MOT	CF	CF
MR1210SLR	R	MOT	CF	CF
MR1211SB	R	MOT	CF	CF
MR1211SBR	R	MOT	CF	CF
MR1211SL	R	MOT	CF	CF
MR1211SLR	R	MOT	CF	CF
MR1212SB	R	MOT	CF	CF
MR1212SBR	R	MOT	CF	CF
MR1212SL	R	MOT	CF	CF
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MR1213SB	R	MOT	CF	CF
MR1213SBR	R	MOT	CF	CF
MR1213SL	R	MOT	CF	CF
MR1213SLR	R	MOT	CF	CF
MR1214SB	R	MOT	CF	CF
MR1214SBR	R	MOT	CF	CF
MR1214SL	R	MOT	CF	CF
MR1214SLR	R	MOT	CF	CF
MR1215SB	R	MOT	CF	CF
MR1215SBR	R	MOT	CF	CF
MR1215SL	R	MOT	CF	CF
MR1215SLR	R	MOT	CF	CF
MR1216SB	R	MOT	CF	CF
MR1216SBR	R	MOT	CF	CF
MR1216SL	R	MOT	CF	CF
MR1216SLR	R	MOT	CF	CF
MR1217SB	R	MOT	CF	CF
MR1217SBR	R	MOT	CF	CF
MR1217SL	R	MOT	CF	CF
MR11217SLR	R	MOT	CF	CF
MR1218SB	R	MOT	CF	CF

Note: Manufacturer's Codes, Product Type Notes and Ⓦ Replacement Notes are listed on page G3

Assemblies, Rectifiers, Thyristors, & Transistors
MASTER CROSS REFERENCE TYPE NUMBER INDEX
JEDEC and Industry Part Numbers

GENERAL

Part Number	Type	Mfgr.	Suggested Ⓦ Replacement	Page
MR1218SBR	R	MOT	CF	CF
MR1218SL	R	MOT	CF	CF
MR1218SLR	R	MOT	CF	CF
MR1219SB	R	MOT	CF	CF
MR1219SBR	R	MOT	CF	CF
MR1219SL	R	MOT	CF	CF
MR1319SLR	R	MOT	CF	CF
MR1220FB	R	MOT	CF	CF
MR1220FB	R	MOT	CF	CF
MR1220FBR	R	MOT	CF	CF
MR1220FL	R	MOT	CF	CF
MR1220FLR	R	MOT	CF	CF
MR1220SB	R	MOT	R6100020	R31
MR1220SBR	R	MOT	R6110020	R31
MR1220SL	R	MOT	CF	CF
MR1220SLR	R	MOT	CF	CF
MR1221FB	R	MOT	CF	CF
MR1221FBR	R	MOT	CF	CF
MR1221FL	R	MOT	CF	CF
MR1221FLR	R	MOT	CF	CF
MR1221SB	R	MOT	R6100120	R31
MR1221SBR	R	MOT	R6110120	R31
MR1221SL	R	MOT	CF	CF
MR1221SLR	R	MOT	CF	CF
MR1222FB	R	MOT	CF	CF
MR1222FBR	R	MOT	CF	CF
MR1222FL	R	MOT	CF	CF
MR1222FLR	R	MOT	CF	CF
MR1222SB	R	MOT	R610+120	R31
MR1222SBR	R	MOT	R611+120	R31
MR1222SL	R	MOT	CF	CF
MR1222SLR	R	MOT	CF	CF
MR1223FB	R	MOT	CF	CF
MR1223FBR	R	MOT	CF	CF
MR1223FL	R	MOT	CF	CF
MR1223FLR	R	MOT	CF	CF
MR1223SB	R	MOT	R6100220	R31
MR1223SBR	R	MOT	R6110220	R31
MR1223SL	R	MOT	CF	CF
MR1223SLR	R	MOT	CF	CF
MR1225FB	R	MOT	CF	CF
MR1225FBR	R	MOT	CF	CF
MR1225FL	R	MOT	CF	CF
MR1225FLR	R	MOT	CF	CF
MR1225SB	R	MOT	R6100320	R31
MR1225SBR	R	MOT	R6110320	R31
MR1225SL	R	MOT	CF	CF
MR1225SLR	R	MOT	CF	CF
MR1227FBR	R	MOT	CF	CF
MR1227FL	R	MOT	CF	CF
MR1227FLR	R	MOT	CF	CF
MR1227SB	R	MOT	R6100420	R31
MR1227SBR	R	MOT	R6110420	R31
MR1227SL	R	MOT	CF	CF
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MR1228FB	R	MOT	CF	CF
MR1228FBR	R	MOT	CF	CF
MR1228FL	R	MOT	CF	CF
MR1228FLR	R	MOT	CF	CF
MR1228SB	R	MOT	R6100520	R31
MR1228SBR	R	MOT	R6110520	R31
MR1228SL	R	MOT	CF	CF
MR1228SLR	R	MOT	CF	CF
MR1229FB	R	MOT	CF	CF
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MR1230FL	R	MOT	CF	CF
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MR1231FLR	R	MOT	CF	CF
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MR1231SBR	R	MOT	R6110130	R31
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MR1232FB	R	MOT	CF	CF
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MR1232FL	R	MOT	CF	CF
MR1232FLR	R	MOT	CF	CF
MR1232SB	R	MOT	R610+130	R31
MR1232SBR	R	MOT	R611+130	R31
MR1232SL	R	MOT	CF	CF
MR1232SLR	R	MOT	CF	CF
MR1233FB	R	MOT	CF	CF
MR1233FBR	R	MOT	CF	CF
MR1233FL	R	MOT	CF	CF
MR1233FLR	R	MOT	CF	CF
MR1233SB	R	MOT	R6100230	R31
MR1233SBR	R	MOT	R6110230	R31
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MR1233SLR	R	MOT	CF	CF
MR1235FB	R	MOT	CF	CF
MR1235FBR	R	MOT	CF	CF
MR1235FL	R	MOT	CF	CF
MR1235FLR	R	MOT	CF	CF
MR1235SB	R	MOT	R6100330	R31
MR1235SBR	R	MOT	R6110330	R31
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MR1237FL	R	MOT	CF	CF
MR1237FLR	R	MOT	CF	CF
MR1237SB	R	MOT	R6100430	R31
MR1237SBR	R	MOT	R6110430	R31
MR1237SL	R	MOT	CF	CF
MR1237SLR	R	MOT	CF	CF
MR1238FB	R	MOT	CF	CF
MR1238FBR	R	MOT	CF	CF
MR1238FL	R	MOT	CF	CF
MR1238FLR	R	MOT	CF	CF
MR1238SB	R	MOT	R6100530	R31
MR1238SBR	R	MOT	R6110530	R31
MR1238SL	R	MOT	CF	CF
MR1238SLR	R	MOT	CF	CF
MR1239FB	R	MOT	CF	CF
MR1239FBR	R	MOT	CF	CF
MR1239FL	R	MOT	CF	CF
MR1239FLR	R	MOT	CF	CF
MR1239SB	R	MOT	R6100630	R31
MR1239SBR	R	MOT	R6110630	R31
MR1239SL	R	MOT	CF	CF
MR1239SLR	R	MOT	CF	CF
MR1240FB	R	MOT	CF	CF
MR1240FBR	R	MOT	CF	CF
MR1240FL	R	MOT	CF	CF
MR1240FLR	R	MOT	CF	CF
MR1240SB	R	MOT	R7000004	R35
MR1240SBR	R	MOT	R7010004	R35
MR1240SL	R	MOT	CF	CF
MR1240SLR	R	MOT	CF	CF
MR1241FB	R	MOT	CF	CF
MR1241FBR	R	MOT	CF	CF
MR1241FL	R	MOT	CF	CF
MR1241FLR	R	MOT	CF	CF
MR1241SB	R	MOT	R7000104	R35
MR1241SBR	R	MOT	R7010104	R35
MR1241SL	R	MOT	CF	CF
MR1241SLR	R	MOT	CF	CF
MR1242FB	R	MOT	CF	CF
MR1242FBR	R	MOT	CF	CF
MR1242FL	R	MOT	CF	CF
MR1242FLR	R	MOT	CF	CF
MR1242SB	R	MOT	R700+104	R35
MR1242SBR	R	MOT	R701+104	R35
MR1242SL	R	MOT	CF	CF
MR1242SLR	R	MOT	CF	CF
MR1243FB	R	MOT	CF	CF
MR1243FBR	R	MOT	CF	CF
MR1243FL	R	MOT	CF	CF
MR1243FLR	R	MOT	CF	CF
MR1243SB	R	MOT	R7000204	R35
MR1243SBR	R	MOT	R7010204	R35
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MR1245FL	R	MOT	CF	CF
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MR1245SB	R	MOT	R7000304	R35
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MR1247FB	R	MOT	CF	CF
MR1248FBR	R	MOT	CF	CF
MR1247FL	R	MOT	CF	CF
MR1247FLR	R	MOT	CF	CF
MR1247SB	R	MOT	R7000404	R35
MR1247SBR	R	MOT	R7010404	R35
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MR1248FB	R	MOT	CF	CF
MR1811SBR	R	MOT	CF	CF
MR1248FL	R	MOT	CF	CF
MR1248FLR	R	MOT	CF	CF
MR1248SB	R	MOT	R7000504	R35
MR1248SBR	R	MOT	R7010504	R35
MR1248SL	R	6MOT	CF	CF
MR1248SLR	R	6MOT	CF	CF
MR1249FB	R	6MOT	CF	CF
MR1249FBR	R	MOT	CF	CF
MR1249FL	R	MOT	CF	CF
MR1249FLR	R	MOT	CF	CF
MR1249SB	R	MOT	R7000604	R35
MR1249SBR	R	MOT	R7010604	R35
MR1249SL	R	MOT	CF	CF
MR1249SLR	R	MOT	CF	CF
MR1260FL	R	MOT	CF	CF
MR1260FLR	R	MOT	CF	CF
MR1261FL	R	MOT	CF	CF
MR1261FLR	R	MOT	CF	CF
MR1262FL	R	MOT	CF	CF
MR1262FLR	R	MOT	CF	CF
MR1263FL	R	MOT	CF	CF
MR1263FLR	R	MOT	CF	CF
MR1265FL	R	MOT	CF	CF
MR1265FLR	R	MOT	CF	CF
MR1267FL	R	MOT	CF	CF
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MR1268FL	R	MOT	CF	CF
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MR1269FL	R	MOT	CF	CF
MR1269FLR	R	MOT	CF	CF
MR1810SB	R	MOT	R5100010	R23
MR1810SBR	R	MOT	R5110010	R23
MR1810SL	R	MOT	CF	CF
MR1810SLR	R	MOT	CF	CF
MR1811SB	R	MOT	R5100110	R23
MR1811SBR	R	MOT	R5110110	R23
MR1811SL	R	MOT	CF	CF
MR1811SLR	R	MOT	CF	CF
MR1812SB	R	MOT	R510+110	R23
MR1812SBR	R	MOT	R511+110	R23
MR1812SL	R	MOT	CF	CF
MR1812SLR	R	MOT	CF	CF
MR1813SB	R	MOT	R5100210	R23
MR1813SBR	R	MOT	R5110210	R23
MR1813SL	R	MOT	CF	CF
MR1813SLR	R	MOT	CF	CF
MR1814SB	R	MOT	R510+210	R23
MR1814SBR	R	MOT	R511+210	R23
MR1814SL	R	MOT	CF	CF
MR1814SLR	R	MOT	CF	CF
MR1815SB	R	MOT	R5100310	R23
MR1815SBR	R	MOT	R5110310	R23
MR1815SL	R	MOT	CF	CF
MR1815SLR	R	MOT	CF	CF
MR1816SB	R	MOT	R510+310	R23
MR1816SBR	R	MOT	R511+310	R23
MR1816SL	R	MOT	CF	CF
MR1816SLR	R	MOT	CF	CF
MR1817SB	R	MOT	R5100410	R23-
MR1817SBR	R	MOT	R5110410	R23
MR1817SL	R	MOT	CF	CF
MR1817SLB	R	MOT	CF	CF
MR1818SB	R	MOT	R5100510	R23
MR1818SBR	R	MOT	R5110510	R23
MR1818SL	R	MOT	CF	CF
MR1818SLR	R	MOT	CF	CF
MR1819SB	R	MOT	R5100610	R23
MR1819SBR	R	MOT	R5110610	R23
MR1819SL	R	MOT	CF	CF
MR1819SLR	R	MOT	CF	CF

Note: Manufacturer's Codes, Product Type Notes and Ⓦ Replacement Notes are listed on page G3

Assemblies, Rectifiers, Thyristors, & Transistors
MASTER CROSS REFERENCE TYPE NUMBER INDEX
JEDEC and Industry Part Numbers

Part Number	Type	Mfgr.	Suggested Ⓦ Replacement	Page
MR750	R	MOT	R3400006	R9
MR751	R	MOT	R3400106	R9
MR752	R	MOT	R3400206	R9
MR754	R	MOT	R3400406	R9
MR756	R	MOT	R3400606	R9
N5082A	R	WES	N5082A	CF
N5082B	R	WES	N5082B	CF
N5082C	R	WES	N5082C	CF
N5082D	R	WES	N5082D	CF
N5082E	R	WES	N5082E	CF
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N5082G	R	WES	N5082G	CF
N5082H	R	WES	N5082H	CF
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NL36N	S	NAT	T400082008	S13
NL36S	S	NAT	T400072008	S13
NL511-4	S	NAT	T400102008	S13
NL511-6	S	NAT	T400121008	S13
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NL-C45B	S	NAT	T510025007AB	S27
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NL-C45E	S	NAT	T510055007AB	S27
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NL-C56H	S	NAT	T507038067AA	S77
NL-C56M	S	NAT	T507068067AA	S77
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NL-C178E	S	NAT	T610051302BT	S33
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NL-C181N	S	NAT	T600081502BT	S33
NL-C181P	S	NAT	T600101502BT	S33
NL-C181S	S	NAT	T600071502BT	S33
NL-C181T	S	NAT	T600091502BT	S33
NL-C185A	S	NAT	T607011564BT	S79
NL-C185B	S	NAT	T607021564BT	S79
NL-C185C	S	NAT	T607031564BT	S79
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NL-C185E	S	NAT	T607051564BT	S79
NL-C185M	S	NAT	T607061554BT	S79
NL-C290A	S	NAT	T700013004BY	S37
NL-C290B	S	NAT	T700023004BY	S37
NL-C290C	S	NAT	T700033004BY	S37
NL-C290D	S	NAT	T700043004BY	S37
NL-C290E	S	NAT	T700053004BY	S37
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NL-C291P	S	NAT	T780103504BY	S75
NL-C291PA	S	NAT	T780113504BY	S75
NL-C291PB	S	NAT	T780123504BY	S75
NL-C291S	S	NAT	T780073504BY	S75
NL-C291T	S	NAT	T780093504BY	S75
NL-C295A	S	NAT	T707013364BY	S81
NL-C295B	S	NAT	T707023364BY	S81

Note: Manufacturer's Codes, Product Type Notes and Ⓦ Replacement Notes are listed on page G3

Part Number	Type	Mfgr.	Suggested Ⓦ Replacement	Page
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NL-C295D	S	NAT	T707043364BY	S81
NL-C295E	S	NAT	T707053364BY	S81
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NL-C297B	S	NAT	T787023064BY	CF
NL-C297C	S	NAT	T787033064BY	CF
NL-C297D	S	NAT	T787043064BY	CF
NL-C297E	S	NAT	T787053064BY	CF
NL-C297M	S	NAT	T787063064BY	CF
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NL-C350M	S	NAT	T520061304DN	S41
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NL-C350PA	S	NAT	T520111304DN	S41
NL-C350PB	S	NAT	T520121304DN	S41
NL-C350PC	S	NAT	T520131304DN	S41
NL-C350S	S	NAT	T520071304DN	S41
NL-C350T	S	NAT	T520091304DN	S41
NL-C354A	S	NAT	T527011384DN	S83
NL-C354B	S	NAT	T527021384DN	S83
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NL-C1580PE	S	NAT	T720154504DN	S51
NL-C1580PM	S	NAT	T720164504DN	S51
NL-C1580PS	S	NAT	T720174504DN	S51

Part Number	Type	Mfgr.	Suggested Ⓦ Replacement	Page
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NL-C1580T	S	NAT	T720094504DN	S51
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NL-F150M	S	NAT	T510068004AQ	S27
NL-F150N	S	NAT	T500088004AQ	S23
NL-F150P	S	NAT	T500108004AQ	S23
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NL-F150T	S	NAT	T500098004AQ	S23
NL-F151B	S	NAT	T507028034AQ	S77
NL-F151C	S	NAT	T507038034AQ	S77
NL-F151D	S	NAT	T507048034AQ	S77
NL-F151E	S	NAT	T507058034AQ	S77
NL-F151M	S	NAT	T507068034AQ	S77
NL-F151N	S	NAT	T507088034AQ	S77
NL-F151P	S	NAT	T507108034AQ	S77
NL-F151S	S	NAT	T507078034AQ	S77
NL-F151T	S	NAT	T507098034AQ	S77
NL-F152B	S	NAT	T510028004AB	S27
NL-F152C	S	NAT	T510038004AB	S27
NL-F152E	S	NAT	T510058004AB	S27
NL-F152M	S	NAT	T510068004AB	S27
NL-F152N	S	NAT	T500088004AA	S23
NL-F152P	S	NAT	T500108004AA	S23
NL-F152S	S	NAT	T500078004AA	S23
NL-F152T	S	NAT	T500098004AA	S23
NL-F153B	S	NAT	T507028034AA	S77
NL-F153C	S	NAT	T507038034AA	S77
NL-F153D	S	NAT	T507048034AA	S77
NL-F153E	S	NAT	T507058034AA	S77
NL-F153M	S	NAT	T507068034AA	S77
NL-F153N	S	NAT	T507088034AA	S77
NL-F153P	S	NAT	T507108034AA	S77
NL-F153S	S	NAT	T507078034AA	S77
NL-F153T	S	NAT	T507098034AA	S77
NL-F154A	S	NAT	T507018084AQ	S77
NL-F154B	S	NAT	T507028084AQ	S77
NL-F154C	S	NAT	T507038084AQ	S77
NL-F154D	S	NAT	T507048084AQ	S77
NL-F154E	S	NAT	T507058084AQ	S77
NL-F154M	S	NAT	T507068084AQ	S77
NL-F155A	S	NAT	T507018064AQ	S77
NL-F155B	S	NAT	T507028064AQ	S77
NL-F155C	S	NAT	T507038064AQ	S77
NL-F155D	S	NAT	T507048064AQ	S77
NL-F155E	S	NAT	T507058064AQ	S77
NL-F155M	S	NAT	T507068064AQ	S77
NL-F156A	S	NAT	T507018084AA	S77
NL-F156B	S	NAT	T507028084AA	S77
NL-F156C	S	NAT	T507038084AA	S77
NL-F156D	S	NAT	T507048084AA	S77
NL-F156E	S	NAT	T507058084AA	S77
NL-F156M	S	NAT	T507068084AA	S77
NL-F157A	S	NAT	T507018064AA	S77
NL-F157B	S	NAT	T507028064AA	S77
NL-F157C	S	NAT	T507038064AA	S77
NL-F157D	S	NAT	T507048064AA	S77
NL-F157E	S	NAT	T507058064AA	S77
NL-F157M	S	NAT	T507068064AA	S77
NL-F158A	S	NAT	T507018044AQ	S77
NL-F158B	S	NAT	T507028044AQ	S77
NL-F158C	S	NAT	T507038044AQ	S77
NL-F158D	S	NAT	T507048044AQ	S77
NL-F158E	S	NAT	T507058044AQ	S77
NL-F158M	S	NAT	T507068044AQ	S77
NL-F158N	S	NAT	T507088044AQ	S77
NL-F158P	S	NAT	T507108044AQ	S77
NL-F158S	S	NAT	T507078044AQ	S77
NL-F158T	S	NAT	T507098044AQ	S77
NL-F159A	S	NAT	T507018044AA	S77
NL-F159B	S	NAT	T507028044AA	S77
NL-F159C	S	NAT	T507038044AA	S77
NL-F159D	S	NAT	T507048044AA	S77
NL-F159E	S	NAT	T507058044AA	S77
NL-F159M	S	NAT	T507068044AA	S77
NL-F159N	S	NAT	T507088044AA	S77
NL-F159P	S	NAT	T507108044AA	S77
NL-F159S	S	NAT	T507078044AA	S77
NL-F159T	S	NAT	T507098044AA	S77
NL-F180A	S	NAT	T600011504BT	S33
NL-F180B	S	NAT	T600021504BT	S33
NL-F180C	S	NAT	T600031504BT	S33
NL-F180D	S	NAT	T600041504BT	S33

Part Number	Type	Mfgr.	Suggested Ⓦ Replacement	Page
NL-F180E	S	NAT	T600051504BT	S33
NL-F180M	S	NAT	T600061504BT	S33
NL-F180N	S	NAT	T600081504BT	S33
NL-F180P	S	NAT	T600101504BT	S33
NL-F180S	S	NAT	T600071504BT	S33
NL-F180T	S	NAT	T600091504BT	S33
NL-F185A	S	NAT	T607011564BT	S79
NL-F185B	S	NAT	T607021564BT	S79
NL-F185C	S	NAT	T607031564BT	S79
NL-F185D	S	NAT	T607041564BT	S79
NL-F185E	S	NAT	T607051564BT	S79
NL-F185M	S	NAT	T607061564BT	S79
NL-F290A	S	NAT	T700013004BT	S37
NL-290B	S	NAT	T700023004BY	S37
NL-F290C	S	NAT	T700033004BY	S37
NL-F290D	S	NAT	T700043004BY	S37
NL-F290E	S	NAT	T700053004BY	S37
NL-F290M	S	NAT	T700063004BY	S37
NL-F290N	S	NAT	T700083004BY	S37
NL-F290P	S	NAT	T700103004BY	S37
NL-F290S	S	NAT	T700073004BY	S37
NL-F290T	S	NAT	T700093004BY	S37
NL-F291A	S	NAT	T780013504BY	S75
NL-F291B	S	NAT	T780023504BY	S75
NL-F291C	S	NAT	T780033504BY	S75
NL-F291D	S	NAT	T780043504BY	S75
NL-F291E	S	NAT	T780053504BY	S75
NL-F291M	S	NAT	T780063504BY	S75
NL-F291N	S	NAT	T780083504BY	S75
NL-F291P	S	NAT	T780103504BY	S75
NL-F291S	S	NAT	T780073504BY	S75
NL-F291T	S	NAT	T780093504BY	S75
NL-F295A	S	NAT	T707013364BY	S81
NL-F295B	S	NAT	T707023364BY	S81
NL-F295C	S	NAT	T707033364BY	S81
NL-F295D	S	NAT	T707043364BY	S81
NL-F295E	S	NAT	T707053364BY	S81
NL-F295M	S	NAT	T707063364BY	S81
NL-F297A	S	NAT	T787013064BY	CF
NL-F297B	S	NAT	T787023064BY	CF
NL-F297C	S	NAT	T787033064BY	CF
NL-F297D	S	NAT	T787043064BY	CF
NL-F297E	S	NAT	T787053064BY	CF
NL-F297M	S	NAT	T787063064BY	CF
NL-F350A	S	NAT	T520011304DN	S41
NL-F350B	S	NAT	T520021304DN	S41
NL-F350C	S	NAT	T520031304DN	S41
NL-F350D	S	NAT	T520041304DN	S41
NL-F350E	S	NAT	T520051304DN	S41
NL-F350M	S	NAT	T520061304DN	S41
NL-F350N	S	NAT	T520081304DN	S41
NL-F350P	S	NAT	T520101304DN	S41
NL-F350S	S	NAT	T520071304DN	S41
NL-F350T	S	NAT	T520091304DN	S41
NL-F354A	S	NAT	T527011384DN	S83
NL-F354B	S	NAT	T527021384DN	S83
NL-F354C	S	NAT	T527031384DN	S83
NL-F354D	S	NAT	T527041384DN	S83
NL-F354E	S	NAT	T527051384DN	S83
NL-F354M	S	NAT	T527061384DN	S83
NL-F355A	S	NAT	T527011364DN	S83
NL-F355B	S	NAT	T527021364DN	S83
NL-F355C	S	NAT	T527031364DN	S83
NL-F355D	S	NAT	T527041364DN	S83
NL-F355E	S	NAT	T527051364DN	S83
NL-F355M	S	NAT	T527061364DN	S83
NL-F355N	S	NAT	T527081364DN	S83
NL-F355P	S	NAT	T527101364DN	S83
NL-F355S	S	NAT	T527071364DN	S83
NL-F355T	S	NAT	T527091364DN	S83
NL-F358A	S	NAT	T527011344DN	S83
NL-F358B	S	NAT	T527021344DN	S83
NL-F358C	S	NAT	T527031344DN	S83
NL-F358D	S	NAT	T527041344DN	S83
NL-F358E	S	NAT	T527051344DN	S83
NL-F358M	S	NAT	T527061344DN	S83
NL-F358N	S	NAT	T527081344DN	S83
NL-F358P	S	NAT	T527101344DN	S83
NL-F358S	S	NAT	T527071344DN	S83
NL-F358T	S	NAT	T527091344DN	S83
NL-F380A	S	NAT	T620013004DN	S43
NL-F380B	S	NAT	T630023004DN	S43
NL-F380C	S	NAT	T620033004DN	S43
NL-F380D	S	NAT	T620043004DN	S43
NL-F380E	S	NAT	T620053004DN	S43

Note: Manufacturer's Codes, Product Type Notes and Ⓦ Replacement Notes are listed on page G3

Assemblies, Rectifiers, Thyristors, & Transistors
MASTER CROSS REFERENCE TYPE NUMBER INDEX
JEDEC and Industry Part Numbers

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NL-F380M	S	NAT	T620063004DN	S43
NL-F380N	S	NAT	T620083004DN	S43
NL-F380P	S	NAT	T620103004DN	S43
NL-F380S	S	NAT	T620073004DN	S43
NL-F380T	S	NAT	T620093004DN	S43
NL-F390E	S	NAT	T720055504DN	S51
NL-F390M	S	NAT	T720065504DN	S51
NL-F390N	S	NAT	T720085504DN	S51
NL-F390P	S	NAT	T720105504DN	S51
NL-F390PA	S	NAT	T720115504DN	S51
NL-F390PB	S	NAT	T720125504DN	S51
NL-F390PC	S	NAT	T720135504DN	S51
NL-F390S	S	NAT	T720075504DN	S51
NL-F390T	S	NAT	T720095504DN	S51
NL-F394A	S	NAT	T727014873DN	S91
NL-F394B	S	NAT	T727024873DN	S91
NL-F394C	S	NAT	T727034873DN	S91
NL-F394D	S	NAT	T727044873DN	S91
NL-F394E	S	NAT	T727054873DN	S91
NL-F394M	S	NAT	T727064873DN	S91
NL-F395A	S	NAT	T727014863DN	S91
NL-F395B	S	NAT	T727024863DN	S91
NL-F395C	S	NAT	T727034863DN	S91
NL-F395D	S	NAT	T727044863DN	S91
NL-F395E	S	NAT	T727054863DN	S91
NL-F395M	S	NAT	T727064863DN	S91
NL-F397A	S	NAT	T727014544DN	S91
NL-F397B	S	NAT	T727024544DN	S91
NL-F397C	S	NAT	T727034544DN	S91
NL-F397D	S	NAT	T727044544DN	S91
NL-F397E	S	NAT	T727054544DN	S91
NL-F397M	S	NAT	T727064544DN	S91
NL-F397N	S	NAT	T727084544DN	S91
NL-F397P	S	NAT	T727104544DN	S91
NL-F397PA	S	NAT	T727114544DN	S91
R303XX06	R	WES	R303XX06	R55
R303XX12	R	WES	R303XX12	R55
R310XX03	R	WES	R310XX03	CF
R310XX05	R	WES	R310XX05	CF
R310XX06	R	WES	R310XX06	CF
R310XX12	R	WES	R310XX12	CF
R310XX16	R	WES	R310XX16	CF
R311XX03	R	WES	R311XX03	CF
R311XX05	R	WES	R311XX05	CF
R311XX06	R	WES	R311XX06	CF
R311XX12	R	WES	R311XX12	CF
R311XX16	R	WES	R311XX16	CF
R340XX06	R	WES	R340XX06	R9
R402XX20	R	WES	R402XX20	R57
R402XX30	R	WES	R402XX30	R57
R403XX20	R	WES	R403XX20	R57
R403XX30	R	WES	R403XX30	R57
R404XX60	R	WES	R404XX60	R17
R404XX70	R	WES	R404XX70	R17
R405XX60	R	WES	R405XX60	R17
R405XX70	R	WES	R405XX70	R17
R410XX15	R	WES	R410XX15	CF
R410XX18	R	WES	R410XX18	CF
R410XX20	R	WES	R410XX20	CF
R410XX22	R	WES	R410XX22	CF
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R410XX35	R	WES	R410XX35	CF
R410XX40	R	WES	R410XX40	R15
R411XX15	R	WES	R411XX15	CF
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R411XX22	R	WES	R411XX22	CF
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R411XX35	R	WES	R411XX35	CF
R411XX40	R	WES	R411XX40	R15
R500XX10	R	WES	R500XX10	R23
R500XX15	R	WES	R500XX15	R23
R501XX10	R	WES	R501XX10	R23
R501XX15	R	WES	R501XX15	R23
R502XX08	R	WES	R502XX08	R59
R502XX10	R	WES	R502XX10	R59
R503XX08	R	WES	R503XX08	R59
R503XX10	R	WES	R503XX10	R59
R510XX10	R	WES	R510XX10	R23
R510XX15	R	WES	R510XX15	R23
R511XX10	R	WES	R511XX10	R23
R511XX15	R	WES	R511XX15	R23
R600XX16	R	WES	R600XX16	CF
R600XX20	R	WES	R600XX20	R31
R600XX24	R	WES	R600XX24	CF

Part Number	Type	Mfgr.	Suggested Ⓦ Replacement	Page
R600XX25	R	WES	R600XX25	R31
R600XX28	R	WES	R600XX28	CF
R600XX30	R	WES	R600XX30	R31
R601XX16	R	WES	R601XX16	CF
R601XX20	R	WES	R601XX20	R31
R601XX24	R	WES	R601XX24	CF
R601XX25	R	WES	R601XX25	R31
R601XX28	R	WES	R601XX28	CF
R601XX30	R	WES	R601XX30	R31
R602XX20	R	WES	R602XX20	R63
R602XX25	r	WES	R602XX25	R63
R603XX20	R	WES	R603XX20	R63
R603XX25	R	WES	R603XX25	R63
R610XX16	R	WES	R610XX16	CF
R610XX20	R	WES	R610XX20	R31
R610XX24	R	WES	R610XX24	CF
R610XX25	R	WES	R610XX25	R31
R610XX28	R	WES	R610XX28	CF
R610XX30	R	WES	R610XX30	R31
R611XX16	R	WES	R611XX16	CF
R611XX20	R	WES	R611XX20	R31
R611XX24	R	WES	R611XX24	CF
R611XX25	R	WES	R611XX25	R31
R611XX28	R	WES	R611XX28	CF
R611XX30	R	WES	R611XX30	R31
R620XX30	R	WES	R620XX30	R39
R620XX40	R	WES	R620XX40	R39
R620XX50	R	WES	R620XX50	R39
R622XX35	R	WES	R622XX35	R67
R622XX40	R	WES	R622XX40	R67
R700XX03	R	WES	R700XX03	R35
R700XX04	R	WES	R700XX04	R35
R700XX05	R	WES	R700XX05	R35
R701XX03	R	WES	R701XX03	R35
R701XX04	R	WES	R701XX04	R35
R701XX05	R	WES	R701XX05	R35
R720XX06	R	WES	R720XX06	R43
R720XX09	R	WES	R720XX09	R43
R720XX12	R	WES	R720XX12	R43
R722XX05	R	WES	R722XX05	R17
R722XX06	R	WES	R722XX06	R71
R722XX08	R	WES	R722XX08	R71
R780XX03	R	WES	CF	CF
R780XX04	R	WES	CF	CF
R780XX05	R	WES	CF	CF
R781XX03	R	WES	CF	CF
R781XX04	R	WES	CF	CF
R781XX05	R	WES	CF	CF
R920XX11	R	WES	R920XX11	R47
R920XX16	R	WES	R920XX16	R47
R920XX20	R	WES	R920XX20	R47
R2005	R	SYN	IN1199AR	R13
R2010	R	SYN	IN1200AR	R13
R2015	R	SYN	IN1202AR	R13
R2030	R	SYN	IN1203AR	R13
R2060	R	SYN	IN1206AR	R13
R2070	R	SYN	IN3670AR	R13
R2080	R	SYN	IN3671AR	R13
R2090	R	SYN	IN3672AR	R13
R2100	R	SYN	IN3673AR	R13
R2105	R	SYN	IN3615R	R13
R2110	R	SYN	IN3616R	R13
R2115	R	SYN	IN3618R	R13
R2120	R	SYN	IN3618R	R13
R2125	R	SYN	IN3619R	R13
R2130	R	WES	IN3619R	R13
R2140	R	SYN	IN3620R	R13
R2150	R	SYN	IN3621R	R13
R2160	R	SYN	IN3622R	R13
R2170	R	SYN	R3110716	CF
R2180	R	SYN	IN3632R	R13
R2190	R	SYN	R3110916	CF
R3105	R	SYN	IN1191AR	R15
R3110	R	SYN	IN1192AR	R15
R3115	R	SYN	IN1194AR	R15
R3120	R	SYN	IN1194AR	R15
R3125	R	SYN	IN1195AR	R15
R3130	R	SYN	IN1195AR	R15
R3140	R	SYN	IN1196AR	R15
R3145	R	SYN	IN1197AR	R15
R3150	R	SYN	IN1197AR	R15
R3160	R	SYN	IN1198A	R15
R3170	R	SYN	R4110722	CF
R3180	R	SYN	R4110822	CF
R3190	R	SYN	R4110922	CF

Part Number	Type	Mfgr.	Suggested Ⓦ Replacement	Page
R3205	R	SYN	IN1184R	R14
R3210	R	SYN	IN1184R	R15
R3215	R	SYN	IN1186R	R15
R3220	R	SYN	IN1186R	R15
R3225	R	SYN	IN1187R	R15
R3230	R	SYN	IN1187R	R15
R3240	R	SYN	IN1188AR	R15
R3245	R	SYN	IN1189AR	R15
R3250	R	SYN	IN1189R	R15
R3260	R	SYN	IN1190R	R15
R3270	R	SYN	IN3765R	R15
R3280	R	SYN	IN3766R	R15
R3290	R	SYN	IN3767	R15
R3405	R	SYN	IN1184AR	R15
R3410	R	SYN	IN1184AR	R15
NL-F397PB	S	NAT	T727124544DN	S91
NL-F397S	S	NAT	T727074544DN	S91
NL-F397T	S	NAT	T727094544DN	S91
NL-F398A	S	NAT	T727014554DN	S91
NL-F398B	S	NAT	T727024554DN	S91
NL-F398C	S	NAT	T727034554DN	S91
NL-F398D	S	NAT	T727044554DN	S91
NL-F398E	S	NAT	T727054554DN	S91
NL-F398M	S	NAT	T727064554DN	S91
NL-F398N	S	NAT	T727084554DN	S91
NL-F398P	S	NAT	T727104554DN	S91
NL-F398PA	S	NAT	T727114554DN	S91
NL-F398PB	S	NAT	T727124554DN	S91
NL-F398S	S	NAT	T727074554DN	S91
NL-F398T	S	NAT	T727094554DN	S91
NL-F701E	S	NAT	T9G0051203DH	S61
NL-F701M	S	NAT	T9G0061203DH	S61
NL-F701N	S	NAT	T9G0081203DH	S61
NL-F701P	S	NAT	T9G0101203DH	S61
NL-F701PA	S	NAT	T9G0111203DH	S61
NL-F701PB	S	NAT	T9G0121203DH	S61
NL-F701PC	S	NAT	T9G0131203DH	S61
NL-F701PD	S	NAT	T9G0141203DH	S61
NL-F701PE	S	NAT	T9G0151203DH	S61
NL-F701PM	S	NAT	T9G0161203DH	S61
NL-F701S	S	NAT	T9G0071203DH	S61
NL-F701T	S	NAT	T9G0091203DH	S61
PA..........	A	WES	PA..........	A37
PB..........	A	WES	PB..........	CF
PB05	A	EDI	MB12A25V05	A3
PB10	A	EDI	MB12A25V10	A3
PB20	A	EDI	MB12A25V20	A3
PB40	A	EDI	MB12A25V40	A3
PB60	A	EDI	MB12A25V60	A3
PC..........	A	WES	PC..........	CF
PD..........	A	WES	PD..........	A37
PD05	A	EDI	MB11A02V05	A3
PD10	A	EDI	MB11A02V10	A3
PD20	A	EDI	MB11A01V20	A3
PD40	A	EDI	MB11A02V40	A3
PD60	A	EDI	MB11A02V60	A3
PD80	A	EDI	MB11A02V80	A3
PD100	A	EDI	MB11A02V10	A3
PE..........	A	WES	PE..........	CF
PE05	A	EDI	MB11A06V05	A3
PE10	A	EDI	MB11A06V10	A3
PE20	A	EDI	MB11A06V20	A3
PE40	A	EDI	MB11A06V40	A3
PE60	A	EDI	MB11A06V60	A3
PF..........	A	WES	PF..........	CF
PH..........	A	WES	PH..........	CF
PM..........	A	WES	PM..........	CF
PN..........	A	WES	PN..........	CF
PP..........	A	WES	PP..........	Cf
PQ..........	A	WES	PQ..........	CF
PR..........	A	WES	PR..........	A37
PS..........	A	WES	PS..........	A37
PT..........	A	WES	PT..........	A37
PW..........	A	WES	PW..........	CF
Q220A	S	WCE	CF	CF
R5C0XX10	R	WES	R5C0XX10	R23
R5C0XX15	R	WES	R5C0XX15	R23
R5C1XX10	R	WES	R5C1XX10	R23
R5C1XX15	R	WES	R5C1XX15	R23
R5D0XX10	R	WES	R5D0XX10	R23
R5D0XX15	R	WES	R5D0XX15	R23
R5D1XX10	R	WES	R5D1XX10	R23
R5D1XX15	R	WES	R5D1XX15	R23
R9G0XX13	R	WES	R9G0XX13	R15
R9G0XX18	R	WES	R9G0XX18	R51

Note: Manufacturer's Codes, Product Type Notes and Ⓦ Replacement Notes are listed on page G3

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MASTER CROSS REFERENCE TYPE NUMBER INDEX
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Part Number	Type	Mfgr.	Suggested Ⓦ Replacement	Page
R9G0XX22	R	WES	R9G0XX22	R51
R9G2XX09	R	WES	R9G2XX09	R75
R9G2XX11	R	WES	R9G2XX11	R75
R9G2XX14	R	WES	R9G2XX14	R75
R9H0XX15	R	WES	R9H0XX15	CF
R9H0XX24	R	WES	R9H0XX24	CF
R040XX10	R	WES	R040XX10	CF
R050B	A	WES	CF	CF
R050C	A	WES	CF	CF
R050E	A	WES	CF	CF
R050N	A	WES	CF	CF
R051B	A	WES	CF	CF
R051C	A	WES	CF	CF
R051E	A	WES	CF	CF
R051N	A	WES	CF	CF
R052B	A	WES	CF	CF
R052C	A	WES	CF	CF
R052E	A	WES	CF	CF
R052N	A	WES	CF	CF
R052S	A	WES	CF	CF
R052Y	A	WES	CF	CF
R053B	A	WES	CF	CF
R053C	A	WES	CF	CF
R053E	A	WES	CF	CF
R053N	A	WES	CF	CF
R053S	A	WES	CF	CF
R053Y	A	WES	CF	CF
R054B	A	WES	CF	CF
R054C	A	WES	CF	CF
R054E	A	WES	CF	CF
R054N	A	WES	CF	CF
R054S	A	WES	CF	CF
R054Y	A	WES	CF	CF
R055E	A	WES	CF	CF
R055S	A	WES	CF	CF
R055Y	A	WES	CF	CF
R061B	A	WES	CF	CF
R061C	A	WES	CF	CF
R061E	A	WES	CF	CF
R061N	A	WES	CF	CF
R061S	A	WES	CF	CF
R061Y	A	WES	CF	CF
R062E	A	WES	CF	CF
R062Y	A	WES	CF	CF
R063B	A	WES	CF	CF
R063C	A	WES	CF	CF
R063E	A	WES	CF	CF
R063N	A	WES	CF	CF
R063S	A	WES	CF	CF
R063Y	A	WES	CF	CF
R140XX15	R	WES	R140XX15	CF
R150XX15	R	WES	R150XX15	CF
R240XX30	R	WES	R240XX30	CF
R302XX06	R	WES	R302XX06	R55
R302XX12	R	WES	R302XX12	R55
R3420	R	SYN	IN1186AR	R15
R3425	R	SYN	IN1187AR	R15
R3430	R	SYN	IN1187AR	R15
R3440	R	SYN	IN1188AR	R15
R3445	R	SYN	IN1189AR	R15
R3450	R	SYN	IN1189AR	R15
R3460	R	SYN	IN1190AR	R15
R3470	R	SYN	R4110740	CF
R3480	R	SYN	R4110840	R15
R3490	R	SYN	R4110940	CF
R3605	R	SYN	R4050060	R17
R3615	R	SYN	R4050260	R17
R3620	R	SYN	R4050260	R17
R3625	R	SYN	R4050360	R17
R3630	R	SYN	R4050360	R17
R3635	R	SYN	R4050460	R17
R3640	R	SYN	R4050460	R17
R3645	R	SYN	R4050560	R17
R3650	R	SYN	R4050560	R17
R3660	R	SYN	R4050660	R17
R3670	R	SYN	R4050760	R17
R3680	R	SYN	R4050860	R17
R3690	R	SYN	R4050960	R17
R4205	R	SYN	R5110015	R23
R4210	R	SYN	R5110115	R23
R4220	R	SYN	R5110215	R23
R4230	R	SYN	R5110315	R23
R4240	R	SYN	R5110415	R23
R4250	R	SYN	R5110515	R23
R4260	R	SYN	R5110615	R23

Part Number	Type	Mfgr.	Suggested Ⓦ Replacement	Page
R4270	R	SYN	R5110715	R23
R4280	R	SYN	R5110815	R23
R4290	R	SYN	R5110915	R23
R4305	R	SYN	R5110015	R23
R4310	R	SYN	R5110115	R23
R4320	R	SYN	R5110215	R23
R4330	R	SYN	R5110315	R23
R4340	R	SYN	R5110415	R23
R4350	R	SYN	R5110515	R23
R4360	R	SYN	R5110615	R23
R4370	R	SYN	R5110715	R23
R4380	R	SYN	R5110815	R23
R4390	R	SYN	R5110915	R23
R5110	R	SYN	IN3261R	R27
R5120	R	SYN	IN3263R	R27
R5130	R	SYN	IN3265R	R27
R5140	R	SYN	IN3267R	R27
R5150	R	SYN	IN3268R	R27
R5160	R	SYN	IN3269R	R27
R5170	R	SYN	IN3270R	R27
R5180	R	SYN	IN3271R	R27
R5190	R	SYN	IN3272R	R27
R5305	R	SYN	R6110025	R31
R5310	R	SYN	R6110125	R31
R5320	R	SYN	R6110225	R31
R5330	R	SYN	R6110325	R31
R5340	R	SYN	R6110425	R31
R5350	R	SYN	R6110525	R31
R5360	R	SYN	R6110625	R31
R5370	R	SYN	R6110725	R31
R5380	R	SYN	R6110825	R31
R5390	R	SYN	R6110925	R31
R5410	R	SYN	R6110130	R31
R5420	R	SYN	R6110230	R31
R5430	R	SYN	R6110330	R31
R5440	R	SYN	R6110430	R31
R5450	R	SYN	R6110530	R31
R5460	R	SYN	R6110630	R31
R5470	R	SYN	R6110730	R31
R5480	R	SYN	R6110830	R31
R5490	R	SYN	R6110930	R31
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R20025	R	SYN	IN1203AR	R13
R20040	R	SYN	IN1204AR	R13
R20050	R	SYN	IN1205AR	R13
R21100	R	SYN	IN3624R	R13
R23130	R	SYN	R6011325	R31
R23140	R	SYN	R6011425	R31
R23150	R	SYN	R6011525	R31
R23160	R	SYN	R6011625	R31
R31100	R	SYN	R4111022	R15
R32100	R	SYN	R4111030	CF
R34100	R	SYN	R4111040	R15
R36100	R	SYN	R4051060	R17
R42100	R	SYN	R5111015	R23
R42110	R	SYN	R5011115	R23
R42120	R	SYN	R5011215	R23
R42130	R	SYN	R5011315	R23
R42140	R	SYN	R5011415	R23
R42150	R	SYN	SO	R23
R42160	R	SYN	SO	R23
R43100	R	SYN	R5111015	R23
R43110	R	SYN	R5011115	R23
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R43130	R	SYN	R5011315	R23
R43140	R	SYN	R5011415	R23
R43150	R	SYN	SO	R23
R43160	R	SYN	SO	R23
R50305	R	SYN	R6110025	R31
R50310	R	SYN	R6110125	R31
R50315	R	SYN	R611+125	R31
R50320	R	SYN	R6110225	R31
R50325	R	SYN	R611+225	R31
R50330	R	SYN	R6110325	R31
R50335	R	SYN	R611+325	R31
R50340	R	SYN	R6110425	R31
R50345	R	SYN	R611+425	R31
R50350	R	SYN	R6110525	R31
R50360	R	SYN	R6110625	R31
R50370	R	SYN	R6110725	R31
R50380	R	SYN	R6110825	R31
R50390	R	SYN	R6110925	R31
R50405	R	SYN	R6110030	R31
R50410	R	SYN	R6110130	R31
R50415	R	SYN	R611+130	R31

Part Number	Type	Mfgr.	Suggested Ⓦ Replacement	Page
R50420	R	SYN	R6110230	R31
R50425	R	SYN	R611+230	R31
R50430	R	SYN	R6110330	R31
R50435	R	SYN	R611+330	R31
R50440	R	SYN	R6110430	R31
R50445	R	SYN	R611+430	R31
R50450	R	SYN	R6110530	R31
R50460	R	SYN	R6110630	R31
R50470	R	SYN	R6110730	R31
R50480	R	SYN	R6110830	R31
R50490	R	SYN	R6110930	R31
R51100	R	SYN	R6111016	CF
R53100	R	SYN	R6111025	R31
R53120	R	SYN	R6011225	R31
R54100	R	SYN	R6111030	R31
R503100	R	SYN	R6111025	R31
R503110	R	SYN	R6011125	R31
R503120	R	SYN	R6011225	R31
R504100	R	SYN	R6111030	R31
R504110	R	SYN	R6011130	R31
R504120	R	SYN	R6011230	R31
S612-3	A	SAR	MB11A06V40	A3
S612-5	A	SAR	MB11A06V60	A3
S622-4	A	SAR	MB11A02W10	A3
S2005	R	SYN	IN1199A	R13
S2010	R	SYN	IN1200A	R13
S2015	R	SYN	IN11201A	R13
S2030	R	SYN	IN1203A	R13
S2060	R	SYN	IN1206A	R13
S2070	R	SYN	IN3670A	R13
S2080	R	SYN	IN3671A	R13
S2090	R	SYN	IN3672A	R13
S2100	R	SYN	IN3673A	R13
S2105	R	SYN	IN3615	R13
S2110	R	SYN	IN3616	R13
S2115	R	SYN	IN3617	R13
S2120	R	SYN	IN3618	R13
S2125	R	SYN	R310+216	CF
S2130	R	SYN	IN3619	R13
S2140	R	SYN	IN3620	R13
S2150	R	SYN	IN3621	R13
S2160	R	SYN	IN3622	R13
S2170	R	SYN	R3100716	CF
S2180	R	SYN	IN3623	R13
S2190	R	SYN	R3100916	CF
S3105	R	SYN	IN1191A	R15
S3110	R	SYN	IN1192A	R15
S3115	R	SYN	IN1193A	R15
S3130	R	SYN	IN1194A	R15
S3125	R	SYN	R410+222	CF
S3130	R	SYN	IN1195A	R15
S3135	R	SYN	R410+322	CF
S3140	R	SYN	IN1196A	R15
S3145	R	SYN	R410+422	CF
S3150	R	SYN	IN1197A	R15
S3160	R	SYN	1N1198A	R15
S3170	R	SYN	R4100722	CF
S3180	R	SYN	R4100822	CF
S3190	R	SYN	R4100922	CF
S3205	R	SYN	R4100030	CF
S3210	R	SYN	R4100130	CF
S3215	R	SYN	R410+130	CF
S3220	R	SYN	R4100230	CF
S3225	R	SYN	R410+230	CF
S3230	R	SYN	R4100330	CF
S3235	R	SYN	R410+330	CF
S3240	R	SYN	R4100430	CF
S3245	R	SYN	R410+430	CF
S3250	R	SYN	R4100530	CF
S3260	R	SYN	R4100630	CF
S3270	R	SYN	R4100730	CF
S3280	R	SYN	R4100830	CF
S3290	R	SYN	R4100930	CF
S3410	R	SYN	IN1184A	R15
S3415	R	SYN	IN1185A	R15
S3420	R	SYN	IN1186A	R15
S3425	R	SYN	R410+240	CF
S3430	R	SYN	IN1187A	R15
S3435	R	SYN	R410+340	CF
S3440	R	SYN	IN1188A	R15
S3445	R	SYN	R410+440	CF
S3450	R	SYN	IN1189A	R15
S3460	R	SYN	IN1190A	R15
S3470	R	SYN	R4100740	CF
S3480	R	SYN	R4100840	R15

Note: Manufacturer's Codes, Product Type Notes and Ⓦ Replacement Notes are listed on page G3

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Part Number	Type	Mfgr.	Suggested Ⓦ Replacement	Page
S3490	R	SYN	R4100940	CF
S3605	R	SYN	R4040060	R17
S3615	R	SYN	R404+160	R17
S3620	R	SYN	R4040260	R17
S3625	R	SYN	R404+260	R17
S3630	R	SYN	R4040360	R17
S3635	R	SYN	R404+360	R17
S3640	R	SYN	R4040460	R17
S3645	R	SYN	R404+460	R17
S3650	R	SYN	R4040560	R17
S3660	R	SYN	R4040660	R17
S3670	R	SYN	R4040760	R17
S3680	R	SYN	R4040860	R17
S3690	R	SYN	R4040960	R17
S4205	R	SYN	R5100015	R23
S4210	R	SYN	R5100115	R23
S4220	R	SYN	R5100215	R23
S4230	R	SYN	R5100315	S23
S4240	R	SYN	R5100415	R23
S4250	R	SYN	R5100515	R23
S4260	R	SYN	R5100615	R23
S4270	R	SYN	R5100715	R23
S4280	R	SYN	R5100815	R23
S4290	R	SYN	R5100915	R23
S4305	R	SYN	R5100015	R23
S4310	R	SYN	R5100115	R23
S4320	R	SYN	R5100215	R23
S4330	R	SYN	R5100315	R23
S4340	R	SYN	R5100415	R23
S4350	R	SYN	R5100515	R23
S4360	R	SYN	R5100615	E12
S4370	R	SYN	R5100715	R23
S4380	R	SYN	R5100815	R23
S4390	R	SYN	R5100915	R23
S5110	R	SYN	IN3261	R27
S5120	R	SYN	IN3263	R27
S5130	R	SYN	IN3265	R27
S5140	R	SYN	IN3267	R27
S5150	R	SYN	IN3268	R27
S5160	R	SYN	IN3269	R27
S5170	R	SYN	IN3270	R27
S5180	R	SYN	IN3271	R27
S5190	R	SYN	IN3272	R27
S5305	R	SYN	R6100025	R31
S5310	R	SYN	R6100125	R31
S5320	R	SYN	R6100225	R31
S5330	R	SYN	R6100325	R31
S5340	R	SYN	R6100425	R31
S5350	R	SYN	R6100525	R31
S5360	R	SYN	R6100625	R31
S5370	R	SYN	R6100725	R31
S5380	R	SYN	R6100825	R31
S5390	R	SYN	R6100925	R31
S5410	R	SYN	R6100130	R31
S5430	R	SYN	R6100230	R31
S5430	R	SYN	R6100330	R31
S5440	R	SYN	R6100430	R31
S5450	R	SYN	R6100530	R31
S5460	R	SYN	R6100630	R31
S5470	R	SYN	R6100730	R31
S5480	R	SYN	R6100830	R31
S5490	R	SYN	R6100930	R31
S6010	R	SYN	CF	CF
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S6030	R	SYN	CF	CF
S6040	R	SYN	CF	CF
S6050	R	SYN	CF	CF
S6060	R	SYN	CF	CF
S6070	R	SYN	CF	CF
S6080	R	SYN	CF	CF
S6090	R	SYN	CF	Cf
S6121	A	SAR	MB11A06V10	A3
S6121-1	A	SAR	MB11A06V20	A3
S6121-6	A	SAR	MB11A06V80	A3
S6121-7	A	SAR	MB11A06W10	A3
S6210A	S	RCA	T400011608	S13
S6210B	S	RCA	T400021608	S13
S6210D	S	RCA	T400041608	S13
S6210M	S	RCA	T400061608	S13
S6211	A	SAR	MB11A02V20	A3
S6211-1	A	SAR	MB11A02V40	A3
S6211-2	A	SAR	MB11A02V60	A3
S6211-3	A	SAR	MB11A02V80	A3
S6230	A	SAR	MB11A02V20	A3
S6230-1	A	SAR	MB11A02V40	A3

Part Number	Type	Mfgr.	Suggested Ⓦ Replacement	Page
S6230-2	A	SAR	MB11A02V60	A3
S6230-3	A	SAR	MB11A02V80	A3
S6230-4	A	SAR	MB11A02W10	A3
S6305	R	SYN	CF	CF
S6310	R	SYN	CF	CF
S6315	R	SYN	CF	CF
S6323-1	A	SAR	MB12A10V10	A3
S6323-2	A	SAR	MB12A10V20	A3
S6323-3	A	SAR	MB12A10V30	A3
S6323-4	A	SAR	MB12A10V40	A3
S6323-5	A	SAR	MB12A10V50	A3
S6323-6	A	SAR	MB12A10V60	A3
S6324-2	A	SAR	MB11A02V20	A3
S6324-4	A	SAR	MB11A02V40	A3
S6324-6	A	SAR	MB11A02V60	A3
S6324-8	A	SAR	MB11A02V80	A3
S6324-10	A	SAR	MB11A02W10	A3
S6325	R	SYN	CF	CF
S6327-1	A	SAR	MB11A06V10	A3
S6327-2	A	SAR	MB11A06V20	A3
S6327-4	A	SAR	MB11A06V40	A3
S6327-6	A	SAR	MB11A06V60	A3
S6327-8	A	SAR	MB11A06V80	A3
S6327-10	A	SAR	MB11A06W10	A3
S6330	R	SYN	CF	CF
S6335	R	SYN	CF	CF
S6340	R	SYN	CF	CF
S6345	R	SYN	CF	CF
S6350	R	SYN	CF	CF
S6360	R	SYN	CF	CF
S6370	R	SYN	CF	CF
S6380	R	SYN	CF	CF
S6390	R	SYN	CF	CF
S6458-05	A	SAR	MB12A25V05	A3
S6458-2	A	SAR	MB12A25V20	A3
S6458-4	A	SAR	MB12A25V40	A3
S6458-6	A	SAR	MB12A25V60	A3
S20020	R	SYN	IN1202A	R13
S20025	R	SYN	R310+212	CF
S20040	R	SYN	IN1204A	R13
S20050	R	SYN	IN1205A	R13
S21100	R	SYN	IN3624	R13
S23130	R	SYN	R6001325	R31
S23140	R	SYN	IN3744	R31
S23150	R	SYN	R6001525	R31
S23160	R	SYN	R6001625	R31
S31100	R	SYN	R4101022	R15
S32100	R	SYN	R4101030	CF
S34050	R	SYN	IN1183A	R15
S34100	R	SYN	R4101040	R15
S36100	R	SYN	R4041060	R17
S42100	R	SYN	R5101015	R23
S42110	R	SYN	R5001115	R23
S42120	R	SYN	R5001215	R23
S42130	R	SYN	R5001315	R23
S42140	R	SYN	R5001415	R23
S42150	R	SYN	SO	R23
S42160	R	SYN	SO	R23
S43100	R	SYN	R5101015	R23
S43110	R	SYN	R5001115	R23
S43120	R	SYN	R5001215	R23
S43130	R	SYN	R5001315	R23
S43140	R	SYN	R5001415	R23
S43150	R	SYN	SO	R23
S43160	R	SYN	SO	R23
S50305	R	SYN	R6100025	R31
S50310	R	SYN	R6100125	R31
S50315	R	SYN	R610+125	R31
S50320	R	SYN	R6100225	R31
S50325	R	SYN	R610+225	R31
S50330	R	SYN	R6100325	R31
S50335	R	SYN	R610+325	R31
S50340	R	SYN	R6100425	R31
S50345	R	SYN	R610+425	R31
S50350	R	SYN	R6100525	R31
S50360	R	SYN	R6100625	R31
S50370	R	SYN	R6100725	R31
S50380	R	SYN	R6100825	R31
S50390	R	SYN	R6100925	R31
S50405	R	SYN	R6100030	R31
S50410	R	SYN	R6100130	R31
S50415	R	SYN	R610+130	R31
S50420	R	SYN	R6100230	R31
S50425	R	SYN	R610+230	R31

Part Number	Type	Mfgr.	Suggested Ⓦ Replacement	Page
S50430	R	SYN	R6100330	R31
S50435	R	SYN	R610+330	R31
S50440	R	SYN	R6100430	R31
S50445	R	SYN	R610+430	R31
S50450	R	SYN	R6100530	R31
S50460	R	SYN	R6100630	R31
S50470	R	SYN	R6100730	R31
S50480	R	SYN	R6100830	R31
S50490	R	SYN	R6100930	R31
S51100	R	SYN	IN3273	R27
S53100	R	SYN	R6101025	R31
S53120	R	SYN	R6001225	R31
S54100	R	SYN	R6101030	R31
S60100	R	SYN	CF	CF
S63100	R	SYN	CF	CF
S63110	R	SYN	CF	CF
S63120	R	SYN	CF	CF
S63130	R	SYN	CF	CF
S63150	R	SYN	CF	CF
S63160	R	SYN	CF	CF
S503100	R	SYN	R6101025	R31
S503110	R	SYN	R6001125	R31
S503120	R	SYN	R6001225	R31
S504100	R	SYN	R6101030	R31
S504110	R	SYN	R6001130	R31
S504120	R	SYN	R6001230	R31
SB..............	A	WES	SB............	A69
SBR05	A	SET	MB11A02V05	A3
SBR10	A	SET	MB11A02V10	A3
SBR10A05	A	SET	MB12A10V05	A3
SBR10A1	A	SET	MB12A10V10	A3
SBR10A2	A	SET	MB12A10V20	A3
SBR10A4	A	SET	MB12A10V40	A3
SBR10A6	A	SET	MB12A10V60	A3
SBR15	A	SET	MB11A02V10	A3
SBR25	A	SET	MB11A02V20	A3
SBR45	A	SET	MB11A02V40	A3
SBR65	A	SET	MB11A02V60	A3
SBR85	A	SET	MB11A02V80	A3
SC..............	A	WES	SC............	A69
SCBA05	A	SET	MB12A25V05	A3
SCBA1	A	SET	MB12A25V10	A3
SCBA2	A	SET	MB12A25V20	A3
SCBA4	A	SET	MB12A25V40	A3
SCBA6	A	SET	MB12A25V60	A3
SD..............	A	WES	SD............	A69
SDA117A	A	SSD	MB11A02V05	A3
SDA117B	A	SSD	MB11A02V10	A3
SDA117C	A	SSD	MB11A02V20	A3
SDA117D	A	SSD	MB11A02V40	A3
SDA117E	A	SSD	MB11A02V60	A3
SDA117F	A	SSD	MB11A02V80	A3
SDA117G	A	SSD	MB11A02W10	A3
SDA138A	A	SSD	MB11A06V05	A3
SDA138B	A	SSD	MB11A06V10	A3
SDA138C	A	SSD	MB11A06V20	A3
SDA138D	A	SSD	MB11A06V40	A3
SDA138E	A	SSD	MB11A06V60	A3
SDA138F	A	SSD	MB11A06V80	A3
SDA138G	A	SSD	MB11A06W10	A3
SE..............	A	WES	SE............	A69
SH..............	A	WES	SH............	A69
SN..............	A	WES	SN............	A69
SQ..............	A	WES	SQ............	A69
SS..............	A	WES	SS............	A69
ST2FR10P	R	SAR	IN3890	R57
ST2FR20P	R	SAR	IN3891	R57
ST2FR30P	R	SAR	IN3892	R57
ST2FR40P	R	SAR	IN3893	R57
ST2FR60P	R	SAR	R3020612	R55
ST3FR20	R	SAR	IN3911	R57
ST3FR30	R	SAR	IN3912	R57
ST3FR40	R	SAR	IN3913	R57
ST3FR60	R	SAR	R4020630	R57
ST3FR100P	R	SAR	IN3910	R57
ST4FR10P	R	SAR	IN3910	R57
ST4FR20	R	SAR	IN3911	R57
ST4FR30	R	SAR	IN3912	R57
ST4FR40	R	SAR	IN3913	R57
ST4FR60	R	SAR	R4020630	R57
ST5A10P	R	SAR	R4040160	R17
ST5A20P	R	SAR	R4040260	R17
ST5A30P	R	SAR	R4040360	R17
ST5A40P	R	SAR	R4040460	R17
ST5A50P	R	SAR	R4040560	R17

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Part Number	Type	Mfgr.	Suggested Ⓦ Replacement	Page
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ST5A80P	R	SAR	R4040860	R17
ST5A100P	R	SAR	R4041060	R17
ST5A120P	R	SAR	R4041260	R17
ST6A10N	R	SAR	CF	CF
ST6A10P	R	SAR	CF	CF
ST6A20N	R	SAR	CF	CF
ST6A20P	R	SAR	CF	CF
ST6A30N	R	SAR	CF	CF
ST6A30P	R	SAR	CF	CF
ST6A40N	R	SAR	CF	CF
ST6A40P	R	SAR	CF	CF
ST6A50N	R	SAR	CF	CF
ST6A50P	R	SAR	CF	CF
ST6A60N	R	SAR	CF	CF
ST6A60P	R	SAR	CF	CF
ST6A80N	R	SAR	CF	CF
ST6A80P	R	SAR	CF	CF
ST6A100N	R	SAR	CF	CF
ST6A100P	R	SAR	CF	CF
ST6A120N	R	SAR	CF	CF
ST6A120P	R	SAR	CF	CF
ST6A140N	R	SAR	CF	CF
ST6A140P	R	SAR	CF	CF
ST16A10N	R	SAR	CF	CF
ST16A10P	R	SAR	CF	CF
ST16A20N	R	SAR	CF	CF
ST16A20P	R	SAR	CF	CF
ST16A30N	R	SAR	CF	CF
ST16A30P	R	SAR	CF	CF
ST16A40N	R	SAR	CF	CF
ST16A40P	R	SAR	CF	CF
ST16A50N	R	SAR	CF	CF
ST16A50P	R	SAR	CF	CF
ST16A60N	R	SAR	CF	CF
ST16A60P	R	SAR	CF	CF
ST16A80N	R	SAR	CF	CF
ST16A80P	R	SAR	CF	CF
ST16A100N	R	SAR	CF	CF
ST16A100P	R	SAR	CF	CF
ST16A120N	R	SAR	CF	CF
ST16A120P	R	SAR	CF	CF
ST16A140N	R	SAR	CF	CF
ST16A140P	R	SAR	CF	CF
ST210E	R	SAR	IN3616	R13
ST210P	R	SAR	IN1200A	R13
ST220E	R	SAR	IN3617	R13
ST220P	R	SAR	IN1201A	R13
ST230E	R	SAR	IN3619	R13
ST230P	R	SAR	IN1203A	R13
ST240E	R	SAR	IN3620	R13
ST240P	R	SAR	IN1204A	R13
ST250E	R	SAR	IN3621	R13
ST250P	R	SAR	IN1205A	R13
ST260E	R	SAR	IN3622	R13
ST260P	R	SAR	IN1206A	R13
ST280E	R	SAR	IN3622	R13
ST280P	R	SAR	IN3671A	R13
ST310P	R	SAR	IN2155	R13
ST320P	R	SAR	IN2156	R13
ST330P	R	SAR	IN2157	R13
ST340P	R	SAR	IN2158	R13
ST350P	R	SAR	IN2159	R13
ST360P	R	SAR	IN2160	R13
ST380P	R	SAR	R4100825	CF
ST410P	R	SAR	IN1184A	R15
ST420P	R	SAR	IN1186A	R15
ST430P	R	SAR	IN1187A	R15
ST440P	R	SAR	IN1188A	R15
ST450P	R	SAR	IN1189A	R15
ST460P	R	SAR	IN1190A	R15
ST480P	R	SAR	R4100840	R15
ST810N	R	SAR	CE	CF
ST810P	R	SAR	CF	CF
ST820N	R	SAR	CF	CF
ST820P	R	SAR	CF	CF
ST830N	R	SAR	CF	CF
ST830P	R	SAR	CF	CF
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ST850P	R	SAR	CF	CF
ST860N	R	SAR	CF	CF
ST860P	R	SAR	CF	CF
ST880N	R	SAR	CF	CF
ST880P	R	SAR	CF	CF
ST910N	R	SAR	IN4045R	R29
ST910P	R	SAR	IN4045	R29
ST920N	R	SAR	IN4047R	R29
ST920P	R	SAR	IN4047	R29
ST930N	R	SAR	IN4049R	R29
ST930P	R	SAR	IN4049	R29
ST940N	R	SAR	IN4050R	R29
ST940P	R	SAR	IN4050	R29
ST950N	R	SAR	IN4051R	R29
ST950P	R	SAR	IN4051	R29
ST960N	R	SAR	IN4052R	R29
ST960P	R	SAR	IN4052	R29
ST980N	R	SAR	IN4054R	R29
ST980P	R	SAR	IN4054	R29
ST1110P	R	SAR	R4040170	R17
ST1120P	R	SAR	R4040270	R17
ST1130P	R	SAR	R4040370	R17
ST1140P	R	SAR	R4040470	R17
ST1150P	R	SAR	R4040570	R17
ST1160P	R	SAR	R4040670	R17
ST1180P	R	SAR	R4040870	R17
ST1610N	R	SAR	R5110115	R23
ST1610P	R	SAR	R5100115	R23
ST1620N	R	SAR	R5110215	R23
ST1620P	R	SAR	R5100215	R23
ST1630N	R	SAR	R5110315	R23
ST1630P	R	SAR	R5100315	R23
ST1640N	R	SAR	R5110415	R23
ST1640P	R	SAR	R5100415	R23
ST1660N	R	SAR	R5110615	R23
ST1660P	R	SAR	R5100615	R23
ST1680N	R	SAR	R5110815	R23
ST1680P	R	SAR	R5100815	R23
ST2010N	R	SAR	R6110130	R31
ST2010P	R	SAR	R6100130	R31
ST2020N	R	SAR	R6110230	R31
ST2020P	R	SAR	R6100230	R31
ST2030N	R	SAR	R6110330	R31
ST2030P	R	SAR	R6100330	R31
ST2040N	R	SAR	R6110430	R31
ST2040P	R	SAR	R6100430	R31
ST2050N	R	SAR	R6110530	R31
ST2050P	R	SAR	R6100530	R31
ST2060N	R	SAR	R6110630	R31
ST2060P	R	SAR	R6100630	R31
ST2080N	R	SAR	R6110830	R31
ST2080P	R	SAR	R6100830	R31
ST2100E	R	SAR	IN3624	R13
ST2100P	R	SAR	IN3673A	R13
ST2120E	R	SAR	R3101216	R13
ST2120P	R	SAR	R3101212	R13
ST2210N	R	SAR	R7010105	R35
ST2210P	R	SAR	R7000105	R35
ST2220N	R	SAR	R7010205	R35
ST2220P	R	SAR	R7000205	R35
ST2230N	R	SAR	R7010305	R35
ST2230P	R	SAR	R7000305	R35
ST2240N	R	SAR	R7010405	R35
ST2240P	R	SAR	R7000405	R35
ST2250N	R	SAR	R7010505	R35
ST2250P	R	SAR	R7000505	R35
ST2260N	R	SAR	R7010605	R35
ST2260P	R	SAR	R7000605	R35
ST2280N	R	SAR	R7010805	R35
ST2280P	R	SAR	R7000805	R35
ST3100P	R	SAR	R4101025	CF
ST3120P	R	SAR	R4101225	CF
ST4100P	R	SAR	R4101040	R15
ST4120P	R	SAR	R4101240	CF
ST8100N	R	SAR	CF	CF
ST8100P	R	SAR	CF	CF
ST8120N	R	SAR	CF	CF
ST8120P	R	SAR	CF	CF
ST8140N	R	SAR	CF	CF
ST8140P	R	SAR	CF	CF
ST9100N	R	SAR	IN4056R	R29
ST9100P	R	SAR	IN4056	R29
ST9120N	R	SAR	R6011228	CF
ST9120P	R	SAR	R6001228	CF
ST9140N	R	SAR	R6011428	CF
ST9140P	R	SAR	R6001428	CF
ST11100P	R	SAR	R4041070	R17
ST11120P	R	SAR	R4041270	R17
ST16100N	R	SAR	R5111015	R23
ST16100P	R	SAR	R5101015	R23
ST16120N	R	SAR	R5011215	R23
ST16120P	R	SAR	R5001215	R23
ST16140N	R	SAR	R5011415	R23
ST16140P	R	SAR	R5001415	R23
ST20100N	R	SAR	R6111030	R31
ST20100P	R	SAR	R6101030	R31
ST20120N	R	SAR	R6011230	R31
ST20120P	R	SAR	R6001230	R31
ST20140N	R	SAR	R6011430	R31
ST20140P	R	SAR	R6001430	R31
ST22100N	R	SAR	R7011005	R35
ST22100P	R	SAR	R7001005	R35
ST22120N	R	SAR	R7011205	R35
ST22120P	R	SAR	R7001205	R35
ST22140N	R	SAR	R7011405	R35
ST22140P	R	SAR	R7001405	R35
T4V0XX22	S	WES	T400XX22	S13
T9G9XX08	S	WES	T9G0XX08	S61
T9G0XX10	S	WES	T9G0XX10	S61
T9G0XX12	S	WES	T9G0XX12	S61
T9GHXX08	S	WES	T9GHXX08	S61
T9GHXX09	S	WES	T9GHXX09	S61
T40RXX22	S	WES	T40RXX22	S95
T72HXX25	S	WES	T72HXX25	S89
T72HXX35	S	WES	T72HXX35	S89
T72HXX45	S	WES	T72HXX45	S89
T92HXX06	S	WES	T9GHXX08	S93
T92HXX07	S	WES	T9GHXX09	S93
T400XX10	S	WES	T400XX10	S13
T400XX16	S	WES	T400XX16	S13
T400XX22	S	WES	T400XX22	S13
T500XX40	S	WES	T400XX40	S23
T500XX80	S	WES	T500XX80	S23
T507XX40	S	WES	T507XX40	S23
T507XX70	S	WES	T507XX70	S77
T507XX80	S	WES	T507XX80	S77
T510XX50	S	WES	T510XX50	S27
T510XX80	S	WES	T510XX80	S27
T520XX13	S	WES	T520XX13	S41
T527XX12	S	WES	T527XX12	S83
T527XX13	S	WES	T527XX13	S83
T527XX60	S	WES	T527XX60	S83
T600XX13	S	WES	T600XX13	S83
T600XX15	S	WES	T600XX15	S33
T600XX18	S	WES	T600XX18	S33
T607XX13	S	WES	T607XX13	S79
T607XX15	S	WES	T607XX15	S79
T607XX18	S	WES	T607XX18	S79
T610XX13	S	WES	T610XX13	S33
T610XX15	S	WES	T610XX15	S33
T610XX18	S	WES	T610XX18	S33
T620XX13	S	WES	T620XX15	S43
T620XX15	S	WES	T620XX15	S43
T620XX20	S	WES	T620XX20	S43
T620XX30	S	WES	T620XX30	S43
T625XX25	S	WES	T625XX25	S47
T625XX30	S	WES	T625XX30	S47
T625XX40	S	WES	T625XX40	S47
T627XX15	S	WES	T627XX15	S87
T627XX20	S	WES	T627XX20	S87
T627XX25	S	WES	T627XX25	S87
T680XX18	S	WES	T680XX18	S73
T700XX25	S	WES	T700XX25	S37
T700XX30	S	WES	T700XX30	S37
T700XX35	S	WES	T700XX35	S37
T707XX20	S	WES	T707XX25	S81
T707XX25	S	WES	T707XX25	S81
T707XX28	S	WES	T707Xx28	S81
T707XX30	S	WES	T707XX30	S81
T707XX33	S	WES	T707XX33	S81
T720XX35	S	WES	T720XX35	S51
T720XX45	S	WES	T720XX45	S51
T720XX55	S	WES	T720XX55	S51
T727XX25	S	WES	T727XX35	S91
T727XX35	S	WES	T727XX35	S91
T727XX40	S	WES	T727XX40	S91
T727XX45	S	WES	T727XX45	S91
T727XX48	S	WES	T727XX48	S91
T760XX30	S	WES	T760XX30	S71
T780XX35	S	WES	T780XX35	S75
T920XX06	S	WES	T920XX06	S55
T920XX07	S	WES	T920XX07	S55
T920XX08	S	WES	T920XX08	S55
T920XX09	S	WES	T920XX09	S55

Note: Manufacturer's Codes, Product Type Notes and Ⓦ Replacement Notes are listed on page G3

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VH048	A	VAR	MB11A06V05	A3
VH148	A	VAR	MB11A06V10	A3
VH248	A	VAR	MB11A06V20	A3
VH448	A	VAR	MB11A06V40	A3
VH648	A	VAR	MB11A06V60	A3
VH848	A	VAR	MB11A06V80	A3
VJ048	A	VAR	MB12A10V05	A3
VJ148	A	VAR	MB12A10V10	A3
VJ248	A	VAR	MB12A10V20	A3
VJ448	A	VAR	MB12A10V40	A3
VJ648	A	VAR	MB12A10V60	A3
VK048	A	VAR	MB12A25V05	A3
VK148	A	VAR	MB12A25V10	A3
VK248	A	VAR	MB12A25V20	A3
VK448	A	VAR	MB12A25V40	A3
VK648	A	VAR	MB12A25V60	A3
VS048	A	VAR	MB11A02V05	A3
VS148	A	VAR	MB11A02V10	A3
VS248	A	VAR	MB11A02V20	A3
VS448	A	VAR	MB11A02V40	A3
VS648	A	VAR	MB11A02V60	A3
VS848	A	VAR	MB11A02V80	A3
ZBCP-05	R	SOL	IN3879	R55
ZBCP-1	R	SOL	IN3880	R55
ZBCP-2	R	SOL	IN3881	R55
ZBCP-3	R	SOL	IN3882	R55
ZCCP-05	R	SOL	IN3889	R55
ZCCP-1	R	SOL	IN3890	R55
ZCCP-2	R	SOL	IN3891	R55
ZCCP-3	R	SOL	IN3892	R55
ZECN-05	R	SOL	IN3899	R57
ZECN-1	R	SOL	IN3900	R57
ZECN-2	R	SOL	IN3901	R57
ZECN-3	R	SOL	IN3901	R57
2PP5	A	PPC	MB11A02V05	A3
2PP10	A	PPC	MB11A02V10	A3
2PP20	A	PPC	MB11A02V20	A3
2PP40	A	PPC	MB11A02V40	A3
2PP60	A	PPC	MB11A02V60	A3
2PP80	A	PPC	MB11A02V80	A3
2PP100	A	PPC	MB11A02W10	A3
5SCBR05	A	PPC	MB11A06V05	A3
5SCBR1	A	SET	MB11A06V10	A3
5SCBR2	A	SET	MB11A06V20	A3
5SCBR4	A	SET	MB11A06V40	A3
5SCBR6	A	SET	MB11A06V60	A3
6A1	R	ATS	R3400106	R9
6A2	R	ATS	R3400206	R9
6A4	R	ATS	R3400406	R9
6A6	R	ATS	R3400606	R9
6A05	R	ATS	R3400006	R9
6A15	R	SOL	IN1341A	R13
6A30	R	SOL	IN1341A	R13
6A50	R	SOL	IN1341A	R13
6A100	R	SOL	IN1342A	R13
6A200	R	SOL	IN1344A	R13
6A300	R	SOL	IN1345A	R13
6A400	R	SOL	IN1346A	R13
6A500	R	SOL	IN1347A	R13
6A600	R	SOL	IN1348A	R13
6A700	R	SOL	IN3987	R13
6A800	R	SOL	IN3988	R13
6A900	R	SOL	IN3989	R13
6A1000	R	SOL	IN3990	R13
6A1200	R	SOL	R3101206	CF
6F5A	R	IR	IN1341A	R13
6F10A	R	IR	IN1342A	R13
6F20A	R	IR	IN1344A	R13
6530A	R	IR	IN1345A	R13
6F40A	R	IR	IN1346A	R13
6F50A	R	IR	IN1347A	R13
6F60A	R	IR	IN3988	R13
6F80A	R	IR	IN3988	R13
6F100A	R	IR	IN3990	R13
6FK20	R	IR	IN3881	R55
6FL5	R	IR	IN3879	R55
6FL10	R	IR	IN3880	R55
6FL30	R	IR	IN3882	R55
6FL40	R	IR	IN3883	R55
6FL60	R	IR	R3020606	R55
6FLR5	R	IR	IN3879R	R55
6FLR10	R	IR	IN3880R	R55

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6FLR30	R	IR	IN3882R	R55
6FLR40	R	IR	IN3883R	R55
6FLR50	R	IR	R3030506	R55
6FLR60	R	IR	R3030606	R55
6FR5A	R	IR	IN1341AR	R13
6FR10A	R	IR	IN1342AR	R13
6FR20A	R	IR	IN1344AR	R13
6FR30A	R	IR	IN1346AR	R13
6FR40A	R	IR	IN1346AR	R13
6FR50A	R	IR	IN1347AR	R13
6FR60A	R	IR	IN1348AR	R13
6FR80A	R	IR	IN3988AR	R13
6FR100A	R	IR	IN3990	R13
6PP5	A	PPC	MB11A06V05	A3
6PP10	A	PPC	MB11A06V10	A3
6PP20	A	PPC	MB11A06V20	A3
6PP40	A	PPC	MB11A06V40	A3
6PP60	A	PPC	MB11A06V60	A3
6PP80	A	PPC	MB11A06V80	A3
6PP100	A	PPC	MB11A06W10	A3
6VL50	R	IR	R3020506	R55
10H3P	R	SAR	R3100106	CF
10HR30	R	SAR	R3020106	CF
10RC10A	S	IR	T400011608	S13
10RC20A	S	IR	T400021608	S13
10RC30A	S	IR	T400031608	S13
10RC40A	S	IR	T400041608	S13
10RC50A	S	IR	T400051608	S13
10RC60A	R	IR	T400061608	S13
10RC70A	S	IR	T400071608	S13
10RC80A	S	IR	T400081608	S13
10RC90A	S	IR	T400091608	S13
10RC100A	S	IR	T400101608	S13
10RC110A	S	IR	T400111608	S13
10RC120A	S	IR	T400121608	S13
12A700	R	SOL	IN3670A	R13
12A800	R	SOL	IN3671A	R13
12A900	R	SOL	IN3672A	R13
12A1000	R	SOL	IN3673A	R13
12F5A	R	IR	IN1199A	R13
12F10A	R	IR	IN1200A	R13
12F20A	R	IR	IN1202A	R13
12F30A	R	IR	IN1203A	R13
12F40A	R	IR	IN1204A	R13
12F50A	R	IR	IN1205A	R13
12F60A	R	IR	IN1206A	R13
12F80A	R	IR	IN3671A	R13
12F100A	R	IR	IN3673A	R13
12FL5	R	IR	IN3889	R55
12FL10	R	IR	IN3890	R55
12FL20	R	IR	IN3891	R55
12FL30	R	IR	IN3892	R55
12FL40	R	IR	IN3893	R55
12FL50	R	IR	R3020512	R55
12FL60	R	IR	R3020612	R55
12FLR5	R	IR	IN3889R	R55
12FLR10	R	IR	IN3890R	R55
12FLR20	R	IR	IN3891R	R55
12FLR30	R	IR	IN3892R	R55
12FLR40	R	IR	IN3893R	R55
12FLR50	R	IR	R3030512	R55
12FLR60	R	IR	R3030612	R55
12FR5A	R	IR	IN1199AR	CF
12FR10A	R	IR	IN1200AR	CF
12FR20A	R	IR	IN1202AR	CF
12FR30A	R	IR	IN1203AR	CF
12FR40A	R	IR	IN1204AR	CF
12FR50A	R	IR	IN1205AR	CF
12FR60A	R	IR	IN1206AR	CF
12FR80A	R	IR	IN3671AR	CF
12FR100A	R	IR	IN3673AR	CF
15PP5	A	PPC	MB12A10V05	A3
15PP10	A	PPC	MB12A10V10	A3
15PP20	A	PPC	MB12A10V20	A3
15PP40	A	PPC	MB12A10V40	A3
15PP60	A	PPC	MB12A10V60	A3
16RC10A	S	IR	T400012208	S13
16RC20A	S	IR	T400022208	S13
16RC30A	S	IR	T400032208	S13
16RC40A	S	IR	T400042208	S13
16RC50A	S	IR	T400052208	S13
16RC60A	S	IR	T400062208	S13
20H3P	R	SAR	IN1344	R13
20HR3P	R	SAR	IN3881	R55

Part Number	Type	Mfgr.	Suggested Ⓦ Replacement	Page
22RC10	S	IR	CF	CF
22RC20	S	IR	CF	CF
22RC30	S	IR	CF	CF
22RC40	S	IR	CF	CF
22RC50	S	IR	CF	CF
22RC60	S	IR	CF	CF
25PP5	A	PPC	MB12A25V05	A3
25PP10	A	PPC	MB12A25V10	A3
25PP20	A	PPC	MB12A25V20	A3
25PP40	A	PPC	MB12A25V40	A3
25PP60	A	PPC	MB12A25V60	A3
30DBIT	A	IR	MB11A02V10	A3
30DB2T	A	IR	MB11A02V20	A3
30DB3T	A	IR	MB11A02V30	A3
30DB4T	S	IR	MB11A02V40	A3
30DB5T	A	IR	MB11A02V50	A3
30DB6T	A	IR	MB11A02V60	A3
30DB8T	A	IR	MB11A02V80	A3
30DB05T	A	IR	MB11A02V10	A3
30DB10T	A	IR	MB11A02W10	A3
30H3P	R	SAR	IN1345	R13
30HR30	R	SAR	IN3882	R55
36RA50	S	IR	T510055004AQ	S27
36RA60	S	IR	T510065004AQ	S27
36RA80	S	IR	T500088004AQ	S23
36RA100	S	IR	T500108004AQ	S23
36RA110	S	IR	T500118004AQ	S23
36RA120	S	IR	T500128004AQ	S23
36RA130	S	IR	T500138004AQ	S23
36RA140	S	IR	T500148004AQ	S23
36RA150	S	IR	T500158004AQ	S23
36RC10A	S	IR	T510015007AQ	S27
36RC20A	S	IR	T510025007AQ	S27
36RC30A	S	IR	T510035007AQ	S27
36RC40A	S	IR	T510045007AQ	S27
36RC50A	S	IR	T510055007AQ	S27
36RC60A	S	IR	T510065007AQ	S27
36RC80A	S	IR	T500088007AQ	S23
36REH60	S	IR	T515068004AQ	CF
36REH80	S	IR	T505088004AQ	CF
36REH100	S	IR	T505108004AQ	CF
36REH110	S	IR	T505118004AQ	CF
36REH120	S	IR	T505128004AQ	CF
36REH130	S	IR	T505138004AQ	CF
37RA50	S	IR	T510055004AB	S27
37RA60	S	IR	T510065004AB	S27
37RA80	S	IR	T500088004AA	S23
37RA100	S	IR	T500108004AA	S23
37RA110	S	IR	T500118004AA	S23
37RA130	S	IR	T500138004AA	S23
37RA140	S	IR	T500148004AA	S23
37RA150	S	IR	T500158004AA	S23
37RC10A	S	IR	T510015007AB	S27
37RC20A	S	IR	T510025007AB	S27
37RC30A	S	IR	T510035007AB	S27
37RC40A	S	IR	T510045007AB	S27
37RC50A	S	IR	T510055007AB	S27
37RC60A	S	IR	T510065007AB	S27
37RC80A	S	IR	T500088007AA	S23
37REH60	S	IR	T515068004AA	CF
37REH80	S	IR	T505088004AA	CF
37REH100	S	IR	T505108004AA	CF
37REH110	S	IR	T505118004AA	CF
37REH120	S	IR	T505128004AA	CF
37REH130	S	IR	T505138004AA	CF
37T	S	WCE	T500XX4005AA	S23
38T	S	WCE	T500XX4005AA	S23
39T	S	WCE	T500XX8005AA	S23
40A50	R	SOL	IN1183A	CF
40A100	R	SOL	IN1184A	CF
40A150	R	SOL	IN1185A	CF
40A200	R	SOL	IN1186A	CF
40A300	R	SOL	IN1187A	CF
40A400	R	SOL	IN1188A	CF
40A500	R	SOL	IN1189A	CF
40A600	R	SOL	IN1190	CF
40H3P	R	SAR	R3100406	CF
40HF5	R	IR	IN1183A	R15
40HF10	R	IR	IN1184A	R15
40HF20	R	IR	IN1186A	R15
40HF30	R	IR	IN1187A	R15
40HF40	R	IR	IN1188A	R15
40HF50	R	IR	IN1189A	R15
40HF60	R	IR	IN1190A	R15
40HF80	R	IR	R4100840	R15

Note: Manufacturer's Codes, Product Type Notes and Ⓦ Replacement Notes are listed on page G3

Part Number	Type	Mfgr.	Suggested Ⓦ Replacement	Page
40HF100	R	IR	R4101040	R15
40HFR5	R	IR	IN1183AR	R15
40HFR10	R	IR	IN1184AR	R15
40HFR20	R	IR	IN1186AR	R15
40HFR30	R	IR	IN1187AR	R15
40HFR40	R	IR	IN1188AR	R15
40HFR50	R	IR	IN1189AR	R15
40HFR60	R	IR	IN1190AR	R15
40HFR80	R	IR	R4110840	R15
40HFR100	R	IR	R4111040	R15
40HR3P	R	SAR	IN3883	R55
45KL10A	R	IR	R5100115	R23
45KL20A	R	IR	R5100215	R23
45KL30A	R	IR	R5100315	R23
45KL40A	R	IR	R5100415	R23
45KL50A	R	IR	R5100515	R23
45KL60A	R	IR	R5100615	R23
45KL80	R	IR	R5100815	R23
45KL100A	R	IR	R5101015	R23
45KL120A	R	IR	R5001215	R23
45KLR10A	R	IR	R5110115	R23
45KLR20A	R	IR	R5110215	R23
45KLR30A	R	IR	R5110315	R23
45KLR40A	R	IR	R5110415	R23
45KLR50A	R	IR	R5110515	R23
45KLR60A	R	IR	R5110615	R23
45KLR80A	R	IR	R5110815	R23
45KLR100A	R	IR	R5111015	R23
45KLR120A	R	IR	R5011215	R23
45L5	R	IR	R5D00015	R23
45L10	R	IR	R5D00115	R23
45L15	R	IR	R5D0+115	R23
45L20	R	IR	R5D00215	R23
45L25	R	IR	R5D0+215	R23
45L30	R	IR	R5D00315	R23
45L35	R	IR	R5D0+315	R23
45L40	R	IR	R5D00415	R23
45L45	R	IR	R5D0+415	R23
45L50	R	IR	R5D00515	R23
45L60	R	IR	R5D00615	R23
45L70	R	IR	R5D00715	R23
45L80	R	IR	R5D00815	R23
45L90	R	IR	R5D00915	R23
45L100	R	IR	R5D01015	R23
45L120	R	IR	R5C01215	R23
45LR5	R	IR	R5D10015	R23
45LR10	R	IR	R5D10115	R23
45LR15	R	IR	R5D1+115	R23
45LR20	R	IR	R5D10215	R23
45LR25	R	IR	R5D1+215	R23
45LR30	R	IR	R5D10315	R23
45LR35	R	IR	R5D1+315	R23
45LR40	R	IR	R5D10415	R23
45LR45	R	IR	R5D1+415	R23
45LR50	R	IR	R5D10515	R23
45LR60	R	IR	R5D10615	R23
45LR70	R	IR	R5D10715	R23
45LR80	R	IR	R5D10815	R23
451R90	R	IR	R5D10915	R23
45LR100	R	IR	R5D11015	R23
45LR120	R	IR	R5C11215	R23
46T	S	WCE	T680XX2504BT	CF
47T	S	WCE	T680XX2504BT	CF
50H3P	R	SAR	IN1347A	R13
55C10	S	SYN	T510018005AQ	S27
55C10B	S	SYN	T510018005AQ	S27
55C10F	S	SYN	T510018005AB	S27
55C101L	S	SYN	T510018005AQ	S27
55C20	S	SYN	T510028005AQ	S27
55C20B	S	SYN	T510028005AQ	S27
55C20F	S	SYN	T510028005AB	S27
55C201L	S	SYN	T510028005AQ	S27
55C25	S	SYN	T510038005AQ	S27
55C25B	S	SYN	T510038005AQ	S27
55C25F	S	SYN	T510038005AB	S27
55C251L	S	SYN	T510038005AQ	S27
55C30	S	SYN	T510038005AQ	S27
55C30B	S	SYN	T510038005AQ	S27
55C30F	S	SYN	T510038005AB	S27
55C301L	S	SYN	T510038005AQ	S27
55C35	S	SYN	T510048005AQ	S27
55C35B	S	SYN	T510048005AQ	S27
55C35F	S	SYN	T510048005AB	S27
55C351L	S	SYN	T510048005AQ	S27
55C40	S	SYN	T510048005AQ	S27
55C40B	S	SYN	T510048005AQ	S27
55C40F	S	SYN	T510048005AB	S27
55C401L	S	SYN	T510048005AQ	S27
55C45	S	SYN	T510058005AQ	S27
55C45B	S	SYN	T510058005AQ	S27
55C45F	S	SYN	T510058005AB	S27
55C45IL	S	SYN	T510058005AQ	S27
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55C70F	S	SYN	T500078005AA	S23
55C70IL	S	SYN	T500078005AQ	S23
55C80	S	SYN	T500088005AQ	S23
55C80B	S	SYN	T500088005AQ	S23
55C80F	S	SYN	T500088005AA	S23
55C80IL	S	SYN	T500088005AQ	S23
55C90	S	SYN	T500098005AQ	S23
55C90B	S	SYN	T500098005AQ	S23
55C90F	S	SYN	T500098005AA	S23
55C90IL	S	SYN	T500098005AQ	S23
55C100	S	SYN	T500108005AQ	S23
55C100B	S	SYN	T500108005AQ	S23
55C100F	S	SYN	T500108005AA	S23
55C100IL	S	SYN	T500108005AQ	S23
55C110	S	SYN	T500118005AQ	S23
55C110B	S	SYN	T500118005AQ	S23
55C110F	S	SYN	T500118005AA	S23
55C110IL	S	SYN	T500118005AQ	S23
55C120	S	SYN	T500128005AQ	S23
55C120B	S	SYN	T500128005AQ	S23
55C120F	S	SYN	T500128005AA	S23
55C120IL	S	SYN	T500128005AQ	S23
55C130	S	SYN	T500138005AQ	S23
55C130B	S	SYN	T500138005AQ	S23
55C130F	S	SYN	T500138005AA	S23
55C130IL	S	SYN	T500138005AQ	S23
55C140	S	SYN	T500148005AQ	S23
55C140B	S	SYN	T500148005AQ	S23
55C140F	S	SYN	T500148005AA	S23
55C140IL	S	SYN	T500148005AQ	S23
55C15	S	SYN	T510028005AQ	S27
55C15B	S	SYN	T510028005AQ	S27
55C15F	S	SYN	T510028005AB	S27
55C15IL	S	SYN	T510028005AQ	S27
55C150	S	SYN	T500158005AQ	S23
55C150B	S	SYN	T500158005AQ	S23
55C150F	S	SYN	T500158005AA	S23
55C150IL	S	SYN	T500158005AQ	S23
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60FB1L	A	IR	MB11A06V10	A3
60FB2L	A	IR	MB11A06V20	A3
60FB4L	A	IR	MB11A06V40	A3
60FB6L	A	IR	MB11A06V60	A3
60FB8L	A	IR	MB11A06V80	A3
60H3P	R	SAR	IN1348A	R13
60HR3P	R	SAR	R3020606	R55
60S1	R	IR	R3400106	R9
60S2	R	IR	R3400206	R9
60S4	R	IR	R3400406	R9
60S6	R	IR	R3400606	R9
60S8	R	IR	R3400806	R9
60S05	R	IR	R3400006	R9
61T	S	WCE	T680XX1804BT	CF
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70C10B	S	SYN	T510018005AQ	S27
70C10F	S	SYN	T510018005AB	S27
70C10IL	S	SYN	T510018005AQ	S27
70C15	S	SYN	T510028005AQ	S27
70C15B	S	SYN	T510028005AQ	S27
70C15F	S	SYN	T510028005AB	S27
70C20	S	SYN	T510028005AQ	S27
70C20B	S	SYN	T510028005AQ	S27
70C20F	S	SYN	T510028005AB	S27
70C20IL	S	SYN	T510028005AQ	S27
70C25	S	SYN	T510038005AQ	S27
70C25B	S	SYN	T510038005AQ	S27
70C25F	S	SYN	T510038005AB	S27
70C25IL	S	SYN	T510038005AQ	S27
70C30	S	SYN	T510038005AQ	S27
70C30B	S	SYN	T510038005AQ	S27
70C30F	S	SYN	T507088044AQ	S27
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70C35	S	SYN	T510048005AQ	S27
70C35B	S	SYN	T510048005AQ	S27
70C35F	S	SYN	T510048005AB	S27
70C35IL	S	SYN	T510048005AQ	S27
70C40	S	SYN	T510048005AQ	S27
70C40B	S	SYN	T510048005AQ	S27
70C40F	S	SYN	T510048005AB	S27
70C40IL	S	SYN	T510048005AQ	S27
70C45	S	SYN	T510058005AQ	S27
70C45B	S	SYN	T510058005AQ	S27
70C45F	S	SYN	T510058005AB	S27
70C45IL	S	SYN	T510058005AQ	S27
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70C50B	S	SYN	T510058005AQ	S27
70C50F	S	SYN	T510058005AB	S27
70C50IL	S	SYN	T510058005AQ	S27
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70C60F	S	SYN	T510068005AB	S27
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70C70F	S	SYN	T500078005AA	S23
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70C100B	S	SYN	T500108005AQ	S23
70C100F	S	SYN	T500108005AA	S23
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70C110F	S	SYN	T500118005AA	S23
70C110IL	S	SYN	T500118005AQ	S23
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70C120B	S	SYN	T500128005AQ	S23
70C120F	S	SYN	T500128005AA	S23
70C120IL	S	SYN	T500128005AQ	S23
70C130	S	SYN	T500138004AQ	S23
70C130B	S	SYN	T500138005AQ	S23
70C130F	S	SYN	T500138005AA	S23
70C130IL	S	SYN	T500138005AQ	S23
70C140	S	SYN	T500148004AQ	S23
70C140B	S	SYN	T500148005AQ	S23
70C140F	S	SYN	T500148005AA	S23
70C140IL	S	SYN	T500148005AQ	S23
70C150	S	SYN	T500158004AQ	S23
70C150B	S	SYN	T500158005AQ	S23
70C150F	S	SYN	T500158005AA	S23
70C15IL	S	SYN	T510028005AQ	S27
70C150IL	S	SYN	T500158005AQ	S23
70H10	R	IR	R4040170	R17
70H20	R	IR	R4040270	R17
70H30	R	IR	R5040370	R17
70H40	R	IR	R4040470	R17
70H50	R	IR	R4040570	R17
70H60	R	IR	R4040670	R17
70H80	R	IR	R4040870	R17
70H100	R	IR	R4041070	R17
70HR10	R	IR	R4050170	R17
70HR20	R	IR	R4050270	R17
70HR30	R	IR	R4050370	R17
70HR40	R	IR	R4050470	R17
70HR50	R	IR	R4050570	R17
70HR60	R	IR	R4050670	R17
70HR80	R	IR	R4050870	R17
70HR100	R	IR	R4051070	R17
70ST	S	WCE	T600XX1804BT	S33
70T	S	WCE	T780XX3504BY	S75
70U5	R	IR	R6100030	R31
70U10	R	IR	R6100130	R31
70U15	R	IR	R610+130	R31
70U20	R	IR	R6100230	R31
70U25	R	IR	R610+230	R31

Note: Manufacturer's Codes, Product Type Notes and Ⓦ Replacement Notes are listed on page G3

GENERAL

Part Number	Type	Mfgr.	Suggested Ⓦ Replacement	Page
70U30	R	IR	R6100330	R31
70U40	R	IR	R6100430	R31
70U45	R	IR	R610+430	R31
70U50	R	IR	R6100530	R31
70U60	R	IR	R6100630	R31
70U70	R	IR	R6100730	R31
70U80	R	IR	R6100830	R31
70U90	R	IR	R6100930	R31
70U100	R	IR	R6101030	R31
70U120	R	IR	R6001230	R31
70UR5	R	IR	R6110030	R31
70UR10	R	IR	R6110130	R31
70UR15	R	IR	R611+130	R31
70UR20	R	IR	R6110230	R31
70UR25	R	IR	R611+230	R31
70UR30	R	IR	R6110330	R31
70UR35	R	IR	R611+330	R31
70UR40	R	IR	R6110430	R31
70UR45	R	IR	R611+430	R31
70UR50	R	IR	R6110530	R31
70UR60	R	IR	R6110630	R31
70UR70	R	IR	R6110730	R31
70UR80	R	IR	R6110830	R31
70UR90	R	IR	R6110930	R31
70UR100	R	IR	R6111030	R31
70UR120	R	IR	R6011230	R31
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71RA60	S	IR	T510068004AQ	S27
71RA80	S	IR	T500088004AQ	S23
71RA100	S	IR	T500108004AQ	S23
71RA110	S	IR	T500118004AQ	S23
71RA120	S	IR	T500128004AQ	S23
71RA130	S	IR	T500138004AQ	S23
71RA140	S	IR	T500148004AQ	S23
71RA150	S	IR	T500158004AQ	S23
71RB50	S	IR	T510058004AQ	S27
71RB60	S	IR	T510068004AQ	S27
71RB80	S	IR	T500088004AQ	S23
71RB100	S	IR	T500108004AQ	S23
71RB110	S	IR	T500118004AQ	S23
71RB120	S	IR	T500128004AQ	S23
71RB130	S	IR	T500138004AQ	S23
71RB140	S	IR	T500148004AQ	S23
71RB150	S	IR	T500158004AQ	S23
71RC5B	S	IR	T510018007AQ	S27
71RCIOA	S	IR	T510018007AQ	S27
71RC10B	S	IR	T510018007AQ	S27
71RC15B	S	IR	T510028007AQ	S27
71RC20B	S	IR	T510028007AQ	S27
71RC20A	S	IR	T510028007AQ	S27
71RC25B	S	IR	T510038007AQ	S27
71RC30A	S	IR	T510038007AQ	S27
71RC30B	S	IR	T510038007AQ	S27
71RC40A	S	IR	T510048007AQ	S27
71RC40B	S	IR	T510048007AQ	S27
71RC50A	S	IR	T510058007AQ	S27
71RC50B	S	IR	T510058007AQ	S27
71RC60A	S	IR	T510068007AQ	S27
71RC60B	S	IR	T510068007AQ	S27
71RC80A	S	IR	T500088007AQ	S23
71REH60	S	IR	T515068004AQ	CF
71REH80	S	IR	T505088004AQ	CF
71REH100	S	IR	T505108004AQ	CF
71REH110	S	IR	T505118004AQ	CF
71REH120	S	IR	T505128004AQ	CF
71REH130	S	IR	T505138004AQ	CF
71T	S	WCE	T780XX3504BY	S75
72RA50	S	IR	T510058004AB	S27
72RA60	S	IR	T510068004AB	S27
72RA80	S	IR	T500088004AA	S23
72RA60	S	IR	T510068004AB	S27
72RA80	S	IR	T500088004AA	S23
72RA100	S	IR	T500108004AA	S23
72RA110	S	IR	T500118004AA	S23
72RA120	S	IR	T500128004AA	S23
72RA130	S	IR	T500138004AA	S23
72RA140	S	IR	T500148004AA	S23
72RA150	S	IR	T500158004AA	S23
72RB50	S	IR	T510058004AB	S27
72RB60	S	IR	T510068004AB	S27
72RB80	S	IR	T500088004AA	S23
72RB100	S	IR	T500108004AA	S23
72RB110	S	IR	T500118004AA	S23
72RB120	S	IR	T500128004AA	S23

Part Number	Type	Mfgr.	Suggested Ⓦ Replacement	Page
72RB130	S	IR	T500138004AA	S23
72RB140	S	IR	T500148004AA	S23
72RB150	S	IR	T500158004AA	S23
72RC2B	S	IR	T510018004AB	S27
72RC5B	S	IR	T510018004AB	S27
72RC10A	S	IR	T510018007AB	S27
72RC10B	S	IR	T510018004AB	S27
72RC15B	S	IR	T510028004AB	S27
72RC20A	S	IR	T510028007AB	S27
72RC20B	S	IR	T510028004AB	S27
72RC25B	S	IR	T510038004AB	S27
72RC30A	S	IR	T510038007AB	S27
72RC30B	S	IR	T510038004AB	S27
72RC40A	S	IR	T510048007AB	S27
72RC40B	S	IR	T510048004AB	S27
72RC50A	S	IR	T510058007AB	S27
72RC50B	S	IR	T510058004AB	S27
72RC60A	S	IR	T510068007AB	S27
72RC60B	S	IR	T510068004AB	S27
72RC80A	S	IR	T500088007AA	S23
72REH60	S	IR	T515068004AA	CF
72REH80	S	IR	T505088004AA	CF
72REH100	S	IR	T505108004AA	CF
72REH110	S	IR	T505118004AA	CF
72REH120	S	IR	T505128004AA	CF
72REH130	S	IR	T505138004AA	CF
73T	S	WCE	T780XX3504BY	S75
74T	S	WCE	T780XX3504BY	S75
80H3P	R	SAR	IN3988	R13
80T	S	WCE	T780XX3504BY	S75
81RL10	S	IR	T507018054Aq	S277
81RL20	S	IR	T507028054AQ	S77
81RL30	S	IR	T507038054AQ	S77
81RL40	S	IR	T507048054AQ	S77
81RL50	S	IR	T507058054AQ	S77
81RL60	S	IR	T507068054AQ	S77
81RL80	S	IR	T507088054AQ	S77
81RL100	S	IR	T507108054AQ	S77
81RLA50	S	IR	T510058004AQ	S27
81RLA60	S	IR	T510068004AQ	S27
81RLA80	S	IR	T500088004AQ	523
81RLA100	S	IR	T500108004AQ	S23
81RLA110	S	IR	T500118004AQ	S23
81RLA120	S	IR	T500128004AQ	S23
81RLB50	S	IR	T507058044AQ	S77
81RLB60	S	IR	T507068044AQ	S77
81RLB80	S	IR	T507088044Aq	S77
81RLB100	S	IR	T507108044AQ	S77
81RLB110	S	IR	T507118044AQ	S77
81RLB120	S	IR	T507128044AQ	S77
81RM10	S	IR	T507018064AQ	S77
81RM20	S	IR	T507028064AQ	S77
81RM30	S	IR	T507038064AQ	S77
81RM40	S	IR	T507048064AQ	S77
81RM50	S	IR	T507058064AQ	S77
81RM60	S	IR	T507068064AQ	S77
81RM80	S	IR	T507088064AQ	S77
81RM100	S	IR	T507108064AQ	S77
81T	S	WCE	T780XX3504BY	S75
82RL10	S	IR	T507018054AA	S77
82RL20	S	IR	T507028054AA	S77
82RL30	S	IR	T507038054AA	S77
82RL40	S	IR	T507048054AA	S77
82RL50	S	IR	T507058054AA	S77
82RL60	S	IR	T507068054AA	S77
82RL80	S	IR	T507088054AA	S77
82RL100	S	IR	T507108054AA	S77
82RLA50	S	IR	T510058004AB	S27
82RLA60	S	IR	T510068004AB	S27
82RLA80	S	IR	T500088004AA	S23
82RLA100	S	IR	T500108004AA	S23
82RLA110	S	IR	T500118004AA	S23
82RLA120	S	IR	T500128004AA	S23
82RLB50	S	IR	T507058044AA	S77
82RLB60	S	IR	T507068044AA	S77
82RLB80	S	IR	T507088044AA	S77
82RLB100	S	IR	T507108044AA	S77
82RLB110	S	IR	T507118044AA	S77
82RLB120	S	IR	T507128044AA	S77
82RM10	S	IR	T507018064AA	S77
82RM20	S	IR	T507028064AA	S77
82RM30	S	IR	T507038064AA	S77
82RM40	S	IR	T507048064AA	S77
82RM50	S	IR	T507058064AA	S77
82RM60	S	IR	T507068064AA	S77

Part Number	Type	Mfgr.	Suggested Ⓦ Replacement	Page
82RM80	S	IR	T507088064AA	S77
82RM100	S	IR	T507108064AA	S77
84T	S	WCE	T780XX3504BY	S75
91T	S	WCE	T780XX3504BY	S75
94T	S	WCE	T780XX3504BY	S75
100C10	S	SYN	T610011304BT	S33
100C10B	S	SYN	T610011304BT	S33
100C15	S	SYN	T610021304BT	S33
100C15B	S	SYN	T610021304BT	S33
100C20	S	SYN	T610021304BT	S33
100C20B	S	SYN	T610021304BT	S33
100C25	S	SYN	T610031304BT	S33
100C25B	S	SYN	T610031304BT	S33
100C30	S	SYN	T610031304BT	S33
100C30B	S	SYN	T610031304BT	S33
100C35	S	SYN	T610041304BT	S33
100C35B	S	SYN	T610041304BT	S33
100C40	S	SYN	T610041304BT	S33
100C40B	S	SYN	T610041304BT	S33
100C45	S	SYN	T610051304BT	S33
100C45B	S	SYN	T610051304BT	S33
100C50	S	SYN	T610051304BT	S33
100C50B	S	SYN	T610051304BT	S33
100C60	S	SYN	T610061304BT	S33
100C60B	S	SYN	T610061304BT	S33
100C70	S	SYN	T600071304BT	S33
100C70B	S	SYN	T600071304BT	S33
100C80	S	SYN	T600081304BT	S33
100C80B	S	SYN	T600081304BT	S33
100C90	S	SYN	T600091304BT	S33
100C90B	S	SYN	T600091304BT	S33
100C100	S	SYN	T600101304BT	S33
100C100B	S	SYN	T600101304BT	S33
100C110	S	SYN	T600111304BT	S33
100C110B	S	SYN	T600111304BT	S33
100C120	S	SYN	T600121304BT	S33
100C120B	S	SYN	T600121304BT	S33
100C130	S	SYN	T600131304BT	S33
100C130B	S	SYN	T600131304BT	S33
100C140	S	SYN	T600141304BT	S33
100C140B	S	SYN	T600141304BT	S33
100C150	S	SYN	T600151304BT	S33
100C150B	S	SYN	T600151304BT	S33
100H3P	R	SAR	IN3990	R13
100PB1P	A	IR	MB12A10V10	A3
100PB2P	A	IR	MB12A10V20	A3
100PB3P	A	IR	MB12A10V30	A3
100PB4P	A	IR	MB12A10V40	A3
100PB5P	A	IR	MB12A10V50	A3
100PB6P	A	IR	MB12A10V60	A3
100PB05P	A	IR	MB12A10V05	A3
101KL40S15	R	IR	R5020410FJ	R59
101KL40S20	R	IR	R5020410EJ	R59
101KL40S30	R	IR	R5020410CJ	R59
101KL60S15	R	IR	R5020610FJ	R59
101KL60S20	R	IR	R5020610EJ	R59
101KL60S30	R	IR	R5020610CJ	R59
101KL80S15	R	IR	R5020810FJ	R59
101KL80S20	R	IR	R5020810EJ	R59
101KL80S30	R	IR	R5020810CJ	R59
101KL100S15	R	IR	R5021010FJ	R59
101KL100S20	R	IR	R5021010EJ	R59
101KL100S30	R	IR	R5021010CJ	R59
101KL120S20	R	IR	R5021210EJ	R59
101KL120S30	R	IR	R5021210CJ	R59
101KL130S30	R	IR	R5021310CJ	R59
101KL140S30	R	IR	R5021410CJ	R59
101KL150S30	R	IR	SO	R59
101KL160S30	R	IR	SO	R59
101KLR40S15	R	IR	R5030410FJ	R59
101KLR40S20	R	IR	R5030410EJ	R59
101KLR40S30	R	IR	R5030410CJ	R59
101KLR60S15	R	IR	R5030610FJ	R59
101KLR60S20	R	IR	R5030610EJ	R59
101KLR60S30	R	IR	R5030610CJ	R59
101KLR80S15	R	IR	R5030810FJ	R59
101KLR80S20	R	IR	R5030810EJ	R59
101KLR80S30	R	IR	R5030810CJ	R59
101KLR100S15	R	IR	R5031010FJ	R59
101KLR100S20	R	IR	R5031010EJ	R59
101KLR100S30	R	IR	R5031010CJ	R59
101KLR120S20	R	IR	R5031210EJ	R59
101KLR120S30	R	IR	R5031210CJ	R59
101KLR130S30	R	IR	R5031310CJ	R59
101KLR140S30	R	IR	R5031410CJ	R59

Note: Manufacturer's Codes, Product Type Notes and Ⓦ Replacement Notes are listed on page G3

Assemblies, Rectifiers, Thyristors, & Transistors
MASTER CROSS REFERENCE TYPE NUMBER INDEX
JEDEC and Industry Part Numbers

GENERAL

Part Number	Type	Mfgr.	Suggested Ⓦ Replacement	Page
101KLR150S30	R	IR	SO	R59
101KLR160S30	R	IR	SO	R59
101RA50	S	IR	T610051303BT	S33
101RA60	S	IR	T610061303BT	S33
101RA80	S	IR	T600081303BT	S33
101RA100	S	IR	T600101303BT	S33
101RA110	S	IR	T600111303BT	S33
101RA120	S	IR	T600121303BT	S33
107	T	WES	CF	CF
108	T	WES	CF	CF
118	T	WES	CF	CF
118UA33	T	WES	CF	CF
118UA46	T	WES	CF	CF
118ZN	R	TUN	W118ZN	CF
118ZP	R	TUN	W118ZP	CF
119ZN	R	TUN	W119ZN	CF
119ZP	R	TUN	W119ZP	CF
120H3P	R	SAR	R3101206	CF
125PAL10	S	IR	T627012054DN	S87
125PAL20	S	IR	T627022054DN	S87
125PAL30	S	IR	T627032054DN	S87
125PAL50	S	IR	T627052054DN	S87
125PAL60	S	IR	T627062054DN	S87
125PAL80	S	IR	T627082054DN	S87
125PAL100	S	IR	T627102054DN	S87
125PALB50	S	IR	T627052044DN	S87
125PALB60	S	IR	T627062044DN	S87
125PALB80	S	IR	T627082044DN	S87
125PALB100	S	IR	T627102044DN	S87
125PALB110	S	IR	T627112044DN	S87
125PALB120	S	IR	T627122044DN	S87
125PAM10	S	IR	T627012064DN	S87
125PAM20	S	IR	T627022064DN	S87
125PAM30	S	IR	T627032064DN	S87
125PAM50	S	IR	T627052064DN	S87
125PAM60	S	IR	T627062064DN	S87
125PAM80	S	IR	T627082064DN	S87
125PAM100	S	IR	T627102064DN	S87
125PL10	S	IR	T627012054DN	S87
125PL20	S	IR	T627022054DN	S87
125PL30	S	IR	T627032054DN	S87
125PL50	S	IR	T627052054DN	S87
125PL60	S	IR	T627062054DN	S87
125PL80	S	IR	T627082054DN	S87
125PL100	S	IR	T627102054DN	S87
125PL110	S	IR	T627112054DN	S87
125PL120	S	IR	T627122054DN	S87
125PLB50	S	IR	T627052044DN	S87
125PLB60	S	IR	T627062044DN	S87
125PLB80	S	IR	T627082044DN	S87
125PLB100	S	IR	T627102044DN	S87
125PLB110	S	IR	T627112044DN	S87
125PLB120	S	IR	T627122044DN	S87
125PM10	S	IR	T627012064DN	S87
125PM20	S	IR	T627022064DN	S87
125PM30	S	IR	T627032064DN	S87
125PM50	S	IR	T627052064DN	S87
125PM60	S	IR	T627062064DN	S87
125PM80	S	IR	T627082064DN	S87
125PM100	S	IR	T627102064DN	S87
125PM110	S	IR	T627112064DN	S87
125PM120	S	IR	T627122064DN	S87
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140PAL40	S	IR	T627042064DN	S87
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140PAM60	S	IR	T627062084DN	S87
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140PM30	S	IR	T627032084DN	S87
140PM40	S	IR	T627042084DN	S87
140PM50	S	IR	T627052084DN	S87
140PM60	S	IR	T627062084DN	S87
141AZN	R	TUN	W141AZN	CF
141AZP	R	TUN	W141AZP	CF
141ZNP	R	TUN	W141ZN	CF
141ZP	R	TUN	W141ZP	CF
150C10	S	SYN	T610011504BT	S33
150C10B	S	SYN	T610011504BT	S33
150C15	S	SYN	T610021504BT	S33
150C15B	S	SYN	T610021504BT	S33
150C20	S	SYN	T610021504BT	S33
150C20B	S	SYN	T610021504BT	S33
150C25	S	SYN	T610031504BT	S33
150C25B	S	SYN	T610031504BT	S33
150C30	S	SYN	T610031504BT	S33
150C30B	S	SYN	T610031504BT	S33
150C35	S	SYN	T610041504BT	S33
150C35B	S	SYN	T610041504BT	S33
150C40	S	SYN	T610041504BT	S33
150C40B	S	SYN	T610041504BT	S33
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150C45B	S	SYN	T610051504BT	S33
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150C50B	S	SYN	T610051504BT	S33
150C60	S	SYN	T610061504BT	S33
150C60B	S	SYN	T610061504BT	S33
150C70	S	SYN	T600071504BT	S33
150C70B	S	SYN	T600071504BT	S33
150C80	S	SYN	T600081504BT	S33
150C80B	S	SYN	T600081504BT	S33
150C90	S	SYN	T600091504BT	S33
150C90B	S	SYN	T600091504BT	S33
150C100	S	SYN	T600101504BT	S33
150C100B	S	SYN	T600101504BT	S33
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150C120B	S	SYN	T600121504BT	S33
150C130	S	SYN	T600131504BT	S33
150C130B	S	SYN	T600131504BT	S33
150C140	S	SYN	T600141504BT	S33
150C140B	S	SYN	T600141504BT	S33
150C150	S	SYN	T600151504BT	S33
150C150B	S	SYN	T600151504BT	S33
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150K15A	R	IR	R510+115	R23
150K20A	R	IR	R5100215	R23
150K25A	R	IR	R510+215	R23
150K30A	R	IR	R5100315	R23
150K40A	R	IR	R5100415	R23
150K50A	R	IR	R5100515	R23
150K60A	R	IR	R5100615	R23
150K70A	R	IR	R5100715	R23
150K80A	R	IR	R5100815	R23
150K90A	R	IR	R5100915	R23
150K100A	R	IR	R5101015	R23
150K120A	R	IR	R5001215	R23
150KR10A	R	IR	R5110115	R23
150KR15A	R	IR	R511+115	R23
150KR20A	R	IR	R5110215	R23
150KR25A	R	IR	R511+215	R23
150KR30A	R	IR	R5110315	R23
150KR40A	R	IR	R5110415	R23
150KR50A	R	IR	R5110515	R23
150KR60A	R	IR	R5110615	R23
150KR70A	R	IR	R5110715	R23
150KR80A	R	IR	R5110815	R23
150KR90A	R	IR	R5110915	R23
150KR100A	R	IR	R5111015	R23
150KR120A	R	IR	R5011215	R23
150L10A	R	IR	R5D00115	R23
150L15A	R	IR	R5D0+115	R23
150L20A	R	IR	R5D00215	R23
150L25A	R	IR	R5D0+215	R23
150L30A	R	IR	R5D00315	R23
150L40A	R	IR	R5D00415	R23
150L50A	R	IR	R5D00515	R23
150L60A	R	IR	R5D00615	R23
150L70A	R	IR	R5D00715	R23
150L80A	R	IR	R5D00815	R23
150L90A	R	IR	R5D00915	R23
150L100A	R	IR	R5D01015	R23
150L120A	R	IR	R5C01215	R23
150LR10A	R	IR	R5D10115	R23
150LR15A	R	IR	R5D1+115	R23
150LR20A	R	IR	R5D10215	R23
150LR25A	R	IR	R5D1+215	R23
150LR30A	R	IR	R5D10315	R23
150L40A	R	IR	R5D10415	R23
150LR50A	R	IR	R5D10515	R23
150LR60A	R	IR	R5D10615	R23
150LR70A	R	IR	R5D10715	R23
150LR80A	R	IR	R5D10815	R23
150LR90A	R	IR	R5D10915	R23
150LR100A	R	IR	R5D11015	R23
150LR120A	R	IR	R5C11215	R23
151-XX	T	WES	151-XX	CF
151RA50	S	IR	T610051504BT	S33
151RA60	S	IR	T610061504BT	S33
151RA80	S	IR	T600081504BT	S33
151RA100	S	IR	T600101504BT	S33
151RA110	S	IR	T600111504BT	S33
151RA120	S	IR	T600121504BT	S33
151RA130	S	IR	T600131504BT	S33
151RA140	S	IR	T600141504BT	S33
151RA150	S	IR	T600151504BT	S33
151RB50	S	IR	T610051503BT	S33
151RB60	S	IR	T610061503BT	S33
151RB80	S	IR	T600081503BT	S33
151RB100	S	IR	T600101503BT	S33
151RB110	S	IR	T600111503BT	S33
151RB120	S	IR	T600121503BT	S33
151RB130	S	IR	T600131503BT	S33
151RB140	S	IR	T600141503BT	S33
151RB150	S	IR	T600151503BT	S33
151RC10	S	IR	T610011504BT	S33
151RC10A	S	IR	T610011504BT	S33
151RC20	S	IR	T610021504BT	S33
151RC20A	S	IR	T610021504BT	S33
151RC30	S	IR	T610031504BT	S33
151RC30A	S	IR	T610031504BT	S33
151RC40	S	IR	T610041504BT	S33
151RC40A	S	IR	T610041504BT	S33
151RC50	S	IR	T610051504BT	S33
151RC50A	S	IR	T610051504BT	S33
151RC60	S	IR	T610061504BT	S33
151RC60A	S	IR	T610061504BT	S33
151RC80	S	IR	T600081504BT	S33
151RC80A	S	IR	T600081504BT	S33
151RF5	S	IR	T607001563BT	S79
151RF10	S	IR	T607011563BT	S79
151RF15	S	IR	T607021563BT	S79
151RF20	S	IR	T607021563BT	S79
151RF25	S	IR	T607031563BT	S79
151RF30	S	IR	T607031563BT	S79
151RF40	S	IR	T607041563BT	S79
151RF50	S	IR	T607051563BT	S79
151RF60	S	IR	T607061563BT	S79
151RL50	S	IR	T607051553BT	S79
151RL60	S	IR	T607061553BT	S79
151RL80	S	IR	T607081553BT	S79
151RL100	S	IR	T607101553BT	S79
151R110	S	IR	T607111553BT	S79
151RL120	S	IR	T607121553BT	S79
151RM50	S	IR	T607051563BT	S79
151RM60	S	IR	T607061563BT	S79
151RM80	S	IR	T607081563BT	S79
151RM100	S	IR	T607101563BT	S79
151RM110	S	IR	T607111563BT	S79
151RM120	S	IR	T607121563BT	S79
151-XX	T	WES	151-XX	T15
152-XX	T	WES	152-XX	T15
153-XX	T	WES	153-XX	T17
154-XX	T	WES	154-XX	T17
156H21	T	WES	CF	CF
161RL10	S	IR	T607011864BT	S79
161RL20	S	IR	T607021864BT	S79
161RL30	S	IR	T607031864BT	S79
161RL40	S	IR	T607041864BT	S79
161RL50	S	IR	T607051864BT	S79
161RL60	S	IR	T607061864BT	S79
161RM10	S	IR	T607011884BT	S79
161RM20	S	IR	T607021884BT	S79
161RM30	S	IR	T607031884BT	S79
161RM40	S	IR	T607041884BT	S79
161RM50	S	IR	T607051884BT	S79
161RM60	S	IR	T607061884BT	S79
163-XX	T	WES	163-XX	T23
164-XX	T	WES	164-XX	T23
171C10	S	SYN	T620012004DN	S43
171C10B	S	SYN	T620012004DN	S43

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Assemblies, Rectifiers, Thyristors, & Transistors

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JEDEC and Industry Part Numbers

Part Number	Type	Mfgr.	Suggested Ⓦ Replacement	Page
171C15	S	SYN	T620022004DN	S43
171C15B	S	SYN	T620022004DN	S43
171C20	S	SYN	T620022004DN	S43
171C20B	S	SYN	T620022004DN	S43
171C25	S	SYN	T620032004DN	S43
171C25B	S	SYN	T620032004DN	S43
171C30	S	SYN	T620032004DN	S43
171C30B	S	SYN	T620032004DN	S43
171C35	S	SYN	T620042004DN	S43
171C35B	S	SYN	T620042004DN	S43
171C40	S	SYN	T620042004DN	S43
171C40B	S	SYN	T620042004DN	S43
171C45	S	SYN	T620052004DN	S43
171C45B	S	SYN	T620052004DN	S43
171C50	S	SYN	T620052004DN	S43
171C50B	S	SYN	T620052004DN	S43
171C60	S	SYN	T620062004DN	S43
171C60B	S	SYN	T620062004DN	S43
171C70	S	SYN	T620072004DN	S43
171C70B	S	SYN	T620072004DN	S43
171C80	S	SYN	T620082004DN	S43
171C80B	S	SYN	T620082004DN	S43
171C90	S	SYN	T620092004DN	S43
171C90B	S	SYN	T620092004DN	S43
171C100	S	SYN	T620102004DN	S43
171C100B	S	SYN	T620102004DN	S43
171C110	S	SYN	T620112004DN	S43
171C110B	S	SYN	T620112004DN	S43
171C120	S	SYN	T620122004DN	S43
171C120B	S	SYN	T620122004DN	S43
171C130	S	SYN	T620132004DN	S43
171C130B	S	SYN	T620132004DN	S43
171C140	S	SYN	T620142002DN	S43
171C140B	S	SYN	T620142004DN	S43
171C150	S	SYN	T620152004DN	S43
171C150B	S	SYN	T620152004DN	S43
175PA50	S	IR	T620052003DN	S43
175PA60	S	IR	T620062003DN	S43
175PA80	S	IR	T620082003DN	S43
175PA100	S	IR	T620102003DN	S43
175PA110	S	IR	T620112003DN	S43
175PA120	S	IR	T620122003DN	S43
175PA130	S	IR	T620132003DN	S43
175PA140	S	IR	T620142003DN	S43
175PA150	S	IR	T620152003DN	S43
175RA50	S	IR	T610051804BT	S33
175RA60	S	IR	T610061804BT	S33
175RA80	S	IR	T600081804BT	S33
175RA100	S	IR	T600101804BT	S33
175RA110	S	IR	T600111804BT	S33
175RA120	S	IR	T600121804BT	S33
200UB5	R	IR	R6100020	R31
200UB10	R	IR	R6100120	R31
200UB20	R	IR	R6100220	R31
200UB30	R	IR	R6100320	R31
200UB40	R	IR	R6100420	R31
200UB50	R	IR	R6100520	R31
200UB60	R	IR	R6100620	R31
200UBR5	R	IR	R6110020	R31
200UBR10	R	IR	R6110120	R31
200UBR20	R	IR	R6110220	R31
200UBR30	R	IR	R6110320	R31
200UBR40	R	IR	R6110420	R31
200UBR50	R	IR	R6110520	R31
200UBR60	R	IR	R6110620	R31
201A	R	WES	201A	CF
201B	R	WES	201B	CF
201D	R	WES	201D	CF
201F	R	WES	201F	CF
201H	R	WES	201H	CF
201K	R	WES	201K	CF
201M	R	WES	201M	CF
201P	R	WES	201P	CF
201S	R	WES	201S	CF
201V	R	WES	201V	CF
201Z	R	WES	201Z	CF
201ZD	R	WES	201ZD	CF
202A	R	WES	202A	CF
202B	R	WES	202B	CF
202D	R	WES	202D	CF
202F	R	WES	202F	CF
202H	R	WES	202H	CF
202K	R	WES	202K	CF
202M	R	WES	202M	CF
202P	R	WES	202P	CF
202S	R	WES	202S	CF

Part Number	Type	Mfgr.	Suggested Ⓦ Replacement	Page
202V	R	WES	202V	CF
202Z	R	WES	202Z	CF
202ZD	R	WES	202ZD	CF
203A	R	WES	203A	CF
203B	R	WES	203B	CF
203D	R	WES	203D	CF
203F	R	WES	203F	CF
203H	R	WES	203H	CF
203K	R	WES	203K	CF
203M	R	WES	203M	CF
203P	R	WES	203P	CF
203S	R	WES	203S	CF
203V	R	WES	203V	CF
203Z	R	WES	203Z	CF
203ZD	R	WES	203ZD	CF
209A	S	WES	209A	CF
209B	S	WES	209B	CF
209C	S	WES	209C	CF
209D	S	WES	209D	CF
209E	S	WES	209E	CF
209F	S	WES	209F	CF
209H	S	WES	209H	CF
209K	S	WES	209K	CF
209M	S	WES	209M	CF
209P	S	WES	209P	CF
209S	S	WES	209S	CF
209V	S	WES	209V	CF
209Z	S	WES	209Z	CF
209ZB	S	WES	209ZB	CF
209ZD	S	WES	209ZD	CF
209ZF	S	WES	209ZF	CF
209ZH	S	WES	209ZH	CF
209ZK	S	WES	209ZK	CF
209ZM	S	WES	209ZM	CF
211A	S	WES	211A	CF
211B	S	WES	211B	CF
211C	S	WES	211C	CF
211D	S	WES	211D	CF
211E	S	WES	211E	CF
211F	S	WES	211F	CF
211H	S	WES	211H	CF
211K	S	WES	211K	CF
211M	S	WES	211M	CF
211P	S	WES	211P	CF
211S	S	WES	211S	CF
211V	S	WES	211V	CF
211Z	S	WES	211Z	CF
211ZB	S	WES	211ZB	CF
211ZD	S	WES	211ZD	CF
211ZF	S	WES	211ZF	CF
211ZH	S	WES	211ZH	CF
211ZK	S	WES	211ZK	CF
211ZM	S	WES	211ZM	CF
212A	S	WES	212A	CF
212B	S	WES	212B	CF
212C	S	WES	212C	CF
212D	S	WES	212D	CF
212E	S	WES	212E	CF
212F	S	WES	212F	CF
212H	S	WES	212H	CF
212K	S	WES	212K	CF
212M	S	WES	212M	CF
212P	S	WES	212P	CF
212S	S	WES	212S	CF
212V	S	WES	212V	CF
212Z	S	WES	212Z	CF
213A	S	WES	213A	CF
213A51	S	WES	213A51	CF
213B	S	WES	213B	CF
213B51	S	WES	213B51	CF
213C	S	WES	213C	CF
213C51	S	WES	213C51	CF
213D	S	WES	213D	CF
213D51	S	WES	213D51	CF
213E	S	WES	213E	CF
213E51	S	WES	213E51	CF
213F	S	WES	213F	CF
213F51	S	WES	213F51	CF
213H	S	WES	213H	CF
213H51	S	WES	213H51	CF
213K	S	WES	213K	CF
213K51	S	WES	213K51	CF
213M	S	WES	213M	CF
213M51	S	WES	213M51	CF
213P	S	WES	213P	CF

Part Number	Type	Mfgr.	Suggested Ⓦ Replacement	Page
213P51	S	WES	213P51	CF
213S	S	WES	213S	CF
213S51	S	WES	213S51	CF
213V	S	WES	213V	CF
213V51	S	WES	213V51	CF
213Z	S	WES	213Z	CF
213Z51	S	WES	213Z51	CF
218A	S	WES	218A	CF
218B	S	WES	218B	CF
218C	S	WES	218C	CF
218D	S	WES	218D	CF
218E	S	WES	218E	CF
218F	S	WES	218F	CF
218H	S	WES	218H	CF
218K	S	WES	218K	CF
218M	S	WES	218M	CF
218P	S	WES	218P	CF
218S	S	WES	218S	CF
218V	S	WES	218V	CF
218Z	S	WES	218Z	CF
218ZB	S	WES	218ZB	CF
218ZD	S	WES	218ZD	CF
218ZF	S	WES	218ZF	CF
218ZH	S	WES	218ZH	CF
218ZK	S	WES	218ZK	CF
218ZM	S	WES	218ZM	CF
219A	S	WES	219A	CF
219A51	S	WES	219A51	CF
219B	S	WES	219B	CF
219B51	S	WES	219B51	CF
219C	S	WES	219C	CF
219C51	S	WES	219C51	CF
219D	S	WES	219D	CF
219D51	S	WES	219D51	CF
219E	S	WES	219E	CF
219E51	S	WES	219E51	CF
219F	S	WES	219F	CF
219F51	S	WES	219F51	CF
219H	S	WES	219H	CF
219H51	S	WES	219H51	CF
219K	S	WES	219K	CF
219K51	S	WES	219K51	CF
219M	S	WES	219M	CF
219M51	S	WES	219M51	CF
219P	S	WES	219P	CF
219P51	S	WES	219P51	CF
219S	S	WES	219S	CF
219S51	S	WES	219S51	CF
219V	S	WES	219V	CF
219V51	S	WES	219V51	CF
219Z	S	WES	219Z	CF
219Z51	S	WES	219Z51	CF
219ZB	S	WES	219ZB	CF
219ZB51	S	WES	219ZB51	CF
219ZD	S	WES	219ZD	CF
219ZD51	S	WES	219ZD51	CF
219ZF	S	WES	219ZF	CF
219ZF51	S	WES	219ZF51	CF
219ZH	S	WES	219ZH	CF
219ZH51	S	WES	219ZH51	CF
219ZK	S	WES	219ZK	CF
219ZK51	S	WES	219ZK51	CF
219ZM	S	WES	219ZM	CF
219ZM51	S	WES	219ZM51	CF
220A	S	WES	220A	CF
220B	S	WES	220B	CF
220D	S	WES	220D	CF
220F	S	WES	220F	CF
220H	S	WES	220H	CF
220K	S	WES	220K	CF
220M	S	WES	220M	CF
220P	S	WES	220P	CF
220S	S	WES	220S	CF
220V	S	WES	220V	CF
220Z	S	WES	220Z	CF
220ZB	S	WES	220ZB	CF
220ZD	S	WES	220ZD	CF
220ZF	S	WES	220ZF	CF
220ZH	S	WES	220ZH	CF
220ZK	S	WES	220ZK	CF
220ZM	S	WES	220ZM	CF
221ZB	S	WES	CF	CF
221ZF	S	WES	CF	CF
221ZH	S	WES	CF	CF
221ZK	S	WES	CF	CF

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Part Number	Type	Mfgr.	Suggested Ⓦ Replacement	Page
221ZM	S	WES	CF	CF
222A	S	WES	222A	CF
222B	S	WES	222B	CF
222C	S	WES	222C	CF
222D	S	WES	222D	CF
222F	S	WES	222F	CF
222H	S	WES	222H	CF
222K	S	WES	222K	CF
222M	S	WES	222M	CF
222P	S	WES	222P	CF
222S	S	WES	222S	CF
222V	S	WES	222V	CF
222Z	S	WES	222Z	CF
222ZB	S	WES	222ZB	CF
222ZD	S	WES	222ZD	CF
222ZF	S	WES	222ZF	CF
222ZH	S	WES	222ZH	CF
222ZK	S	WES	222ZK	CF
222ZM	S	WES	222ZM	CF
223D	S	WES	223D	CF
223F	S	WES	223F	CF
223H	S	WES	223H	CF
223K	S	WES	223K	CF
223M	S	WES	223M	CF
223P	S	WES	223P	CF
223S	S	WES	223S	CF
223V	S	WES	223V	CF
223Z	S	WES	223Z	CF
223ZB	S	WES	223ZB	CF
223ZD	S	WES	223ZD	CF
223ZF	S	WES	223ZF	CF
223ZH	S	WES	223ZH	CF
223ZK	S	WES	223ZK	CF
223ZM	S	WES	223ZM	CF
224B	S	WES	224B	CF
224D	S	WES	224D	CF
224F	S	WES	224F	CF
224H	S	WES	224H	CF
224K	S	WES	224K	CF
224M	S	WES	224M	CF
224P	S	WES	224P	CF
224S	S	WES	224S	CF
224V	S	WES	224V	CF
224Z	S	WES	224Z	CF
224ZD	S	WES	224ZD	CF
224ZH	S	WES	224ZH	CF
224ZM	S	WES	224ZM	CF
227A	S	WES	227A	CF
227B	S	WES	227B	CF
227C	S	WES	227C	CF
227D	S	WES	227D	CF
227E	S	WES	227E	CF
227F	S	WES	227F	CF
227H	S	WES	227H	CF
227K	S	WES	227K	CF
227M	S	WES	227M	CF
227P	S	WES	227P	CF
227S	S	WES	227S	CF
227V	S	WES	227V	CF
227Z	S	WES	227Z	CF
227ZB	S	WES	227ZB	CF
227ZD	S	WES	227ZD	CF
227ZF	S	WES	227ZF	CF
227ZH	S	WES	227ZH	CF
227ZK	S	WES	227ZK	CF
228A	S	WES	228A	CF
228B	S	WES	228B	CF
228D	S	WES	228D	CF
228F	S	WES	228F	CF
228H	S	WES	228H	CF
228K	S	WES	228K	CF
228M	S	WES	228M	CF
228P	S	WES	228P	CF
228S	S	WES	228S	CF
228V	S	WES	228V	CF
228Z	S	WES	228Z	CF
228ZB	S	WES	228ZB	CF
228ZD	S	WES	228ZD	CF
228ZF	S	WES	228ZF	CF
228ZH	S	WES	228ZH	CF
228ZK	S	WES	228ZK	CF
228ZM	S	WES	228ZM	CF
229A	S	WES	229A	CF
229B	S	WES	229B	CF
229D	S	WES	229D	CF

Part Number	Type	Mfgr.	Suggested Ⓦ Replacement	Page
229E	S	WES	229E	CF
229F	S	WES	229F	CF
229H	S	WES	229H	CF
229K	S	WES	229K	CF
229M	S	WES	229M	CF
229P	S	WES	229P	CF
229S	S	WES	229S	CF
229V	S	WES	229V	CF
229Z	S	WES	229Z	CF
229ZB	S	WES	229ZB	CF
229ZD	S	WES	229ZD	CF
229ZF	S	WES	229ZF	CF
229ZH	S	WES	229ZH	CF
229ZK	S	WES	229ZK	CF
229ZM	S	WES	229ZM	CF
231T	S	WCE	CF	CF
233T	S	WCE	CF	CF
234T	S	WCE	CF	CF
240A	S	WES	T4000022	S13
240B	S	WES	T4000122	S13
240D	S	WES	T4000222	S13
240F	S	WES	T4000322	S13
240H	S	WES	T4000422	S13
240M	S	WES	T4000622	S13
240P	S	WES	T4000722	S13
240PAL10	S	IR	T627012564DN	S87
240PAL20	S	IR	T627022564DN	S87
240PAL30	S	IR	T627032564DN	S87
240PAL40	S	IR	T627042564DN	S87
240PAL50	S	IR	T627052564DN	S87
240PAL60	S	IR	T627062564DN	S87
240PAL80	S	IR	T627082564DN	S87
240PAL100	S	IR	T627102564DN	S87
240PAM10	S	IR	T627012584DN	S87
240PAM20	S	IR	T627022584DN	S87
240PAM30	S	IR	T627032584DN	S87
240PAM40	S	IR	T627042584DN	S87
240PAM50	S	IR	T627052584DN	S87
240PAM60	S	IR	T627062584DN	S87
240PAM80	S	IR	T627082584DN	S87
240S	S	WES	T4000822	S13
240V	S	WES	T4000922	S13
240M	S	WES	T4000622	S13
240Z	S	WES	T4001022	S13
240ZB	S	WES	T4001122	S13
240ZD	S	WES	T4001222	S13
241C10	S	SYN	T620013004DN	S43
241C10B	S	SYN	T620013004DN	S43
241C15	S	SYN	T620023004DN	S43
241C15B	S	SYN	T620023004DN	S43
241C20	S	SYN	T620023004DN	S43
241C20B	S	SYN	T620023004DN	S43
241C25	S	SYN	T620033004DN	S43
241C25B	S	SYN	T620033004DN	S43
241C30	S	SYN	T620033004DN	S43
241C30B	S	SYN	T620033004DN	S43
241C35	S	SYN	T620043004DN	S43
241C35B	S	SYN	T620043004DN	S43
241C40	S	SYN	T620043004DN	S43
241C40B	S	SYN	T620043004DN	S43
241C45	S	SYN	T620053004DN	S43
241C45B	S	SYN	T620053004DN	S43
241C50	S	SYN	T620053004DN	S43
241C50B	S	SYN	T620053004DN	S43
241C60	S	SYN	T620063004DN	S43
241C60B	S	SYN	T620063004DN	S43
241C70	S	SYN	T620073004DN	S43
241C70B	S	SYN	T620073004DN	S43
241C80	S	SYN	T620083004DN	S43
241C80B	S	SYN	T620083004DN	S43
241C90	S	SYN	T620093004DN	S43
241C90B	S	SYN	T620093004DN	S43
241C100	S	SYN	T620103004DN	S43
241C100B	S	SYN	T620103004DN	S43
241C110	S	SYN	T620113004DN	S43
241C110B	S	SYN	T620113004DN	S43
241C120	S	SYN	T620123004DN	S43
241C120B	S	SYN	T620123004DN	S43
241C130	S	SYN	T620133004DN	S43
241C130B	S	SYN	T620133004DN	S43
241C140	S	SYN	T620143004DN	S43
241C140B	S	SYN	T620143004DN	S43
241C150	S	SYN	T620153004DN	S43
241C150B	S	SYN	T620153004DN	S43
241T	S	WCE	CF	CF

Part Number	Type	Mfgr.	Suggested Ⓦ Replacement	Page
242T	S	WCE	CF	CF
244T	S	WCE	CF	CF
250A	S	WES	250A	CF
250A51	S	WES	250A51	CF
250B	S	WES	250B	CF
250B51	S	WES	250B51	CF
250C	S	WES	250C	CF
250C51	S	WES	250C51	CF
250D	S	WES	250D	CF
250D51	S	WES	250D51	CF
250E	S	WES	250E	CF
250E51	S	WES	250E51	CF
250F	S	WES	250F	CF
250F51	S	WES	250F51	CF
250JB1P	A	IR	MB12A25V10	A3
250JB2P	A	IR	MB12A25V20	A3
250JB3P	A	IR	MB12A25V30	A3
250JB4P	A	IR	MB12A25V40	A3
250JB5P	A	IR	MB12A25V50	A3
250JB6P	A	IR	MB12A25V60	A3
250JB05P	A	IR	MB12A25V05	A3
250K	S	WES	250K	CF
250K51	S	WES	250K51	CF
250M	S	WES	250M	CF
250M51	S	WES	250M51	CF
250P	S	WES	250P	CF
250P51	S	WES	250P51	CF
250PA50	S	IR	T620053004DN	S43
250PA60	S	IR	T620063004DN	S43
250PA80	S	IR	T620083004DN	S43
250PA100	S	IR	T620103004DN	S43
250PA110	S	IR	T620113004DN	S43
250PA120	S	IR	T620123004DN	S43
250PA130	S	IR	T620133004DN	S43
250PA140	S	IR	T620143004DN	S43
250PA150	S	IR	T620153004DN	S43
250PA160	S	IR	T620163004DN	S43
250PAC10	S	IR	T620013004DN	S43
250PAC20	S	IR	T620023004DN	S43
250PAC30	S	IR	T620033004DN	S43
250PAC40	S	IR	T620043004DN	S43
250PAC50	S	IR	T620053004DN	S43
250PAC60	S	IR	T620063004DN	S43
250PAL10	S	IR	T627012554DN	S87
250PAL20	S	IR	T627022554DN	S87
250PAL30	S	IR	T627032554DN	S87
250PAL40	S	IR	T627042554DN	S87
250PAL50	S	IR	T627052554DN	S87
250PAL60	S	IR	T627062554DN	S87
250PAM10	S	IR	T6270125B4DN	S87
250PAM20	S	IR	T6270225B4DN	S87
250PAM30	S	IR	T6270325B4DN	S87
250PAM40	S	IR	T6270425B4DN	S87
250PAM50	S	IR	T6270525B4DN	S87
250PAM60	S	IR	T6270625B4DN	S87
250RA10	S	IR	T700012504BY	S37
250RA20	S	IR	T700022504BY	S37
250RA30	S	IR	T700032504BY	S37
250RA40	S	IR	T700042504BY	S37
250RA50	S	IR	T700052504BY	S37
250RA60	S	IR	T700062504BY	S37
250RA80	S	IR	T700082504BY	S37
250RA100	S	IR	T700102504BY	S37
250RA110	S	IR	T700112504BY	S37
250RA120	S	IR	T700122504BY	S37
250RA130	S	IR	T700132504BY	S37
250RA140	S	IR	T700142504BY	S37
250RA150	S	IR	T700152504BY	S37
250RA160	S	IR	T700162504BY	S37
250RA170	S	IR	T700172504BY	S37
250RL60	S	IR	T707063024BY	S81
250RL80	S	IR	T707083024BY	S81
250RL100	S	IR	T707103024BY	S81
250RL110	S	IR	T707113024BY	S81
250RL120	S	IR	T707123024BY	S81
250S	S	WES	250S	CF
250S51	S	WES	250S51	CF
250V	S	WES	250V	CF
250V51	S	WES	250V51	CF
250Z	S	WES	250Z	CF
250Z51	S	WES	250Z51	CF
250ZB	S	WES	250ZB	CF
250ZB51	S	WES	250ZB51	CF
250ZD	S	WES	250ZD	CF
250ZD51	S	WES	250ZD51	CF

Note: Manufacturer's Codes, Product Type Notes and Ⓦ Replacement Notes are listed on page G3

Assemblies, Rectifiers, Thyristors, & Transistors
MASTER CROSS REFERENCE TYPE NUMBER INDEX
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Part Number	Type	Mfgr.	Suggested Ⓦ Replacement	Page
250ZF	S	WES	250ZF	CF
250ZF51	S	WES	250ZF51	CF
250ZH	S	WES	250ZH	CF
250ZH51	S	WES	250ZH51	CF
250ZK	S	WES	250ZK	CF
250ZK51	S	WES	250ZK51	CF
250ZM	S	WES	250ZM	CF
250ZM51	S	WES	250ZM51	CF
251A	S	WES	251A	CF
251A51	S	WES	251A51	CF
251B	S	WES	251B	CF
251B51	S	WES	251B51	CF
251C	S	WES	251C	CF
251C51	S	WES	251C51	CF
251D	S	WES	251D	CF
251D51	S	WES	251D51	CF
251E	S	WES	251E	CF
251E51	S	WES	251E51	CF
251F	S	WES	251F	CF
251F51	S	WES	251F51	CF
251H	S	WES	251H	CF
251H51	S	WES	251H51	CF
251K	S	WES	251K	CF
251K51	S	WES	251K51	CF
251M	S	WES	251M	CF
251M51	S	WES	251M51	CF
251P	S	WES	251P	CF
251P51	S	WES	251P51	CF
251S	S	WES	251S	CF
251S51	S	WES	251S51	CF
251UL40S15	S	IR	R6020425FJ	R63
251UL40S20	R	IR	R6020425EJ	R63
251UL40S30	R	IR	R6020425CJ	R63
251UL60S15	R	IR	R6020625FJ	R63
251UL60S20	R	IR	R6020625EJ	R63
251UL60S30	R	IR	R6020625CJ	R63
251UL80S15	R	IR	R6020825FJ	R63
251UL80S20	R	IR	R6020825EJ	R63
251UL80S30	R	IR	R6020825CJ	R63
251UL100S15	R	IR	R6021025FJ	R63
251UL100S20	R	IR	R6021025EJ	R63
251UL100S30	R	IR	R6021025CJ	R63
251UL120S20	R	IR	R6021225EJ	R63
251UL120S30	R	IR	R6021225CJ	R63
251UL130S30	R	IR	R6021325CJ	R63
251UL140S30	R	IR	R6021425CJ	R63
251UL150S30	R	IR	R6021525CJ	R63
251UL160S30	R	IR	R6021625CJ	R63
251ULR40S15	R	IR	R6030425FJ	R63
251ULR40S20	R	IR	R6030425EJ	R63
251ULR40S30	R	IR	R6030425CJ	R63
251ULR60S15	R	IR	R6030625FJ	R63
251ULR60S20	R	IR	R6030625EJ	R63
251ULR60S30	R	IR	R6030625CJ	R63
251ULR80S15	R	IR	R6030825FJ	R63
251ULR80S20	R	IR	R6030825EJ	R63
251ULR80S30	R	IR	R6030825CJ	R63
251ULR100S15	R	IR	R6031025FJ	R63
251ULR100S20	R	IR	R6031025EJ	R63
251ULR100S30	R	IR	R6031025CJ	R63
251ULR120S20	R	IR	R6031225EJ	R63
251ULR120S30	R	IR	R6031225CJ	R63
251ULR130S30	R	IR	R6031325CJ	R63
251ULR140S30	R	IR	R6031425CJ	R63
251ULR150S30	R	IR	R6031525CJ	R63
251ULR160S30	R	IR	R6031625CJ	R63
251V	S	WES	251V	R63
251V51	S	WES	251V51	CF
251Z	S	WES	251Z	CF
251Z51	S	WES	251Z51	CF
251ZB	S	WES	251ZB	CF
251ZB51	S	WES	251ZB51	CF
251ZD	S	WES	251ZD	CF
251ZD51	S	WES	251ZD51	CF
251ZF	S	WES	251ZF	CF
251ZF51	S	WES	251ZF51	CF
251ZH	S	WES	251ZH	CF
251ZH51	S	WES	251ZH51	CF
251ZK	S	WES	251ZK	CF
251ZK51	S	WES	251ZK51	CF
251ZM	S	WES	251ZM	CF
251ZM51	S	WES	251ZM51	CF
254A	S	WES	254A	CF
254A51	S	WES	254A51	CF
254B	S	WES	254B	CF
254B51	S	WES	254B51	CF
254C	S	WES	254C	CF
254C51	S	WES	254C51	CF
254D	S	WES	254D	CF
254D51	S	WES	254D51	CF
254E	S	WES	254E	CF
254E51	S	WES	254E51	CF
254F	S	WES	254F	CF
254F51	S	WES	254F51	CF
254H	S	WES	254H	CF
254H51	S	WES	254H51	CF
254K	S	WES	254K	CF
254K51	S	WES	254K51	CF
254P	S	WES	254P	CF
254P51	S	WES	254P51	CF
254V	S	WES	254V	CF
254V51	S	WES	254V51	CF
254Z	S	WES	254Z	CF
254Z51	S	WES	254Z51	CF
254ZB	S	WES	254ZB	CF
254ZB51	S	WES	254ZB51	CF
254ZF	S	WES	254ZF	CF
254ZF51	S	WES	254ZF51	CF
254ZH	S	WES	254ZH	CF
254ZH51	S	WES	254ZH51	CF
254ZK	S	WES	254ZK	CF
254ZK51	S	WES	254ZK51	CF
256T	S	WCE	CF	CF
258T	S	WCE	CF	CF
260A	S	WES	260A	CF
260B	S	WES	260B	CF
260D	S	WES	260D	CF
260F	S	WES	260F	CF
260H	S	WES	260H	CF
260K	S	WES	260K	CF
260M	S	WES	260M	CF
260P	S	WES	260P	CF
260RL10	S	IR	T707013364BY	S81
260RL20	S	IR	T707023364BY	S81
260RL30	S	IR	T707033364BY	S81
260RL40	S	IR	T707043364BY	S81
260RL50	S	IR	T707053364BY	S81
260RL60	S	IR	T707063364BY	S81
260RM10	S	IR	T707013384BY	S81
260RM20	S	IR	T707023384BY	S81
260RM30	S	IR	T707033384BY	S81
260RM40	S	IR	T707043384BY	S81
260RM50	S	IR	T707053384BY	S81
260RM60	S	IR	T707063384BY	S81
260V	S	WES	260V	CF
260Z	S	WES	260Z	CF
260ZB	S	WES	260ZB	CF
260ZD	S	WES	260ZD	CF
260ZF	S	WES	260ZF	CF
260ZH	S	WES	260ZH	CF
260ZK	S	WES	260ZK	CF
260ZM	S	WES	260ZM	CF
261	S	WES	CF	CF
261A	S	WES	261A	CF
261B	S	WES	261B	CF
261D	S	WES	261D	CF
261F	S	WES	261F	CF
261H	S	WES	261H	CF
261K	S	WES	261K	CF
261M	S	WES	261M	CF
261P	S	WES	261P	CF
261S	S	WES	261S	CF
261V	S	WES	261V	CF
261Z	S	WES	261Z	CF
261ZB	S	WES	261ZB	CF
261ZD	S	WES	261ZD	CF
261ZF	S	WES	261ZF	CF
261ZH	S	WES	261ZH	CF
261ZK	S	WES	261ZK	CF
261ZM	S	WES	261ZM	CF
263A	S	WES	263A	CF
263B	S	WES	263B	CF
263C	S	WES	263C	CF
263E	S	WES	263E	CF
263F	S	WES	263F	CF
263H	S	WES	263H	CF
263K	S	WES	263K	CF
263M	S	WES	263M	CF
263P	S	WES	263P	CF
263S	S	WES	263S	CF
263V	S	WES	263V	CF
263Z	S	WES	263Z	CF
263ZB	S	WES	263ZB	CF
263ZD	S	WES	263ZD	CF
263ZF	S	WES	263ZF	CF
263ZH	S	WES	263ZH	CF
263ZK	S	WES	263ZK	CF
263ZM	S	WES	263ZM	CF
270A	S	WES	270A	CF
270B	S	WES	270B	CF
270C	S	WES	270C	CF
270P	S	WES	270P	CF
270S	S	WES	270S	CF
270V	S	WES	270V	CF
270Y30B60	S	WES	270Y30B60	CF
270Y30B70	S	WES	270Y30B70	CF
270Y30B80	S	WES	270Y30B80	CF
270Y30B90	S	WES	270Y30B90	CF
270Y30C10	S	WES	270Y30C10	CF
270Y30C11	S	WES	270Y30C11	CF
270Y30C12	S	WES	270Y30C12	CF
270Y30C13	S	WES	270Y30C13	CF
270Y30C14	S	WES	270Y30C14	CF
270Y30C15	S	WES	270Y30C15	CF
270Y30C16	S	WES	270Y30C16	CF
270Y30C17	S	WES	270Y30C17	CF
270Y30C18	S	WES	270Y30C18	CF
270Y30C19	S	WES	270Y30C19	CF
270Y30C20	S	WES	270Y30C20	CF
270Z	S	WES	270Z	CF
270ZB	S	WES	270ZB	CF
270ZD	S	WES	270ZD	CF
270ZF	S	WES	270ZF	CF
270ZH	S	WES	270ZH	CF
270ZK	S	WES	270ZK	CF
271A	S	WES	271A	CF
271B	S	WES	271B	CF
271C	S	WES	271C	CF
271D	S	WES	271D	CF
271F	S	WES	271F	CF
271H	S	WES	271H	CF
271K	S	WES	271K	CF
271M	S	WES	271M	CF
271P	S	WES	271P	CF
271S	S	WES	271S	CF
271V	S	WES	271V	CF
271Z	S	WES	271Z	CF
271ZB	S	WES	271ZB	CF
271ZD	S	WES	271ZD	CF
271ZF	S	WES	271ZF	CF
271ZH	S	WES	271ZH	CF
272	S	WES	CF	CF
272A	S	WES	272A	CF
272B	S	WES	272B	CF
272C	S	WES	272C	CF
272D	S	WES	272D	CF
272F	S	WES	272F	CF
272H	S	WES	272H	CF
272K	S	WES	272K	CF
272M	S	WES	272M	CF
272P	S	WES	272P	CF
272S	S	WES	272S	CF
272V	S	WES	272V	CF
272Z	S	WES	272Z	CF
272ZB	S	WES	272ZB	CF
272ZD	S	WES	272ZD	CF
272ZF	S	WES	272ZF	CF
272ZH	S	WES	272ZH	CF
273	S	WES	CF	CF
273A	S	WES	273A	CF
273B	S	WES	273B	CF
273D	S	WES	273D	CF
273F	S	WES	273F	CF
273H	S	WES	273H	CF
273K	S	WES	273K	CF
273M	S	WES	273M	CF
273P	S	WES	273P	CF
273S	S	WES	273S	CF
273V	S	WES	273V	CF
273Z	S	WES	273Z	CF
273ZB	S	WES	273ZB	CF
273ZD	S	WES	273ZD	CF
273ZF	S	WES	273ZF	CF
273ZH	S	WES	273ZH	CF
273ZK	S	WES	273ZK	CF

Note: Manufacturer's Codes, Product Type Notes and Ⓦ Replacement Notes are listed on page G3

Assemblies, Rectifiers, Thyristors, & Transistors
MASTER CROSS REFERENCE TYPE NUMBER INDEX
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Part Number	Type	Mfgr.	Suggested Ⓦ Replacement	Page
273ZM	S	WES	273ZM	CF
275U5A	R	IR	IN4044	R29
275U10A	R	IR	IN4045	R29
275U15A	R	IR	IN4046	R29
275U20A	R	IR	IN4047	R29
275U25A	R	IR	IN4048	R29
275U30A	R	IR	IN4049	R29
275U40A	R	IR	IN4050	R29
275U50A	R	IR	IN4051	R29
275U60A	R	IR	IN4052	R29
275U70A	R	IR	IN4053	R29
275U80A	R	IR	IN4054	R29
275U90A	R	IR	IN4055	R29
275U100A	R	IR	IN4056	R29
275U110A	R	IR	R6001128	CF
275U120A	R	IR	R6001228	CF
275UR5A	R	IR	IN4044R	R29
275UR10A	R	IR	IN4045R	R29
275UR15A	R	IR	IN4046R	R29
275UR20A	R	IR	IN4047R	R29
275UR25A	R	IR	IN4048R	R29
275UR30A	R	IR	IN4049R	R29
275UR40A	R	IR	IN4050R	R29
275UR50A	R	IR	IN4051R	R29
275UR60A	R	IR	IN4052R	R29
275UR70A	R	IR	IN4053R	R29
275UR80A	R	IR	IN4054R	R29
275UR90A	R	IR	IN4055R	R29
275UR100A	R	IR	IN4056R	R29
275UR110A	R	IR	R6011128	CF
275UR120A	R	IR	R6011228	CF
276A	S	WES	276A	CF
276B	S	WES	276B	CF
276D	S	WES	276D	CF
276F	S	WES	276F	CF
276H	S	WES	276H	CF
276K	S	WES	276K	CF
276M	S	WES	276M	CF
276P	S	WES	276P	CF
276S	S	WES	276S	CF
276V	S	WES	276V	CF
276Z	S	WES	276Z	CF
276ZB	S	WES	276ZB	CF
276ZF	S	WES	276ZF	CF
276ZH	S	WES	276ZH	CF
276ZK	S	WES	276ZK	CF
276ZM	S	WES	276ZM	CF
278B	S	WES	278B	CF
278D	S	WES	278D	CF
278F	S	WES	278F	CF
278H	S	WES	278H	CF
278K	S	WES	278K	CF
278M	S	WES	278M	CF
278P	S	WES	278P	CF
278S	S	WES	278S	CF
278V	S	WES	278V	CF
278Z	S	WES	278Z	CF
278ZH	S	WES	278ZH	CF
278ZM	S	WES	278ZM	CF
282A	S	WES	282A	CF
282B	S	WES	282B	CF
282D	S	WES	282D	CF
282H	S	WES	282H	CF
282K	S	WES	282K	CF
282M	S	WES	282M	CF
282P	S	WES	282P	CF
282S	S	WES	282S	CF
282V	S	WES	282V	CF
282Z	S	WES	282Z	CF
282ZB	S	WES	282ZB	CF
282ZD	S	WES	282ZD	CF
282ZF	S	WES	282ZF	CF
282ZH	S	WES	282ZH	CF
282ZK	S	WES	282ZK	CF
283A	S	WES	283A	CF
283B	S	WES	283B	CF
283C	S	WES	283C	CF
283D	S	WES	283D	CF
283H	S	WES	283H	CF
283M	S	WES	283M	CF
283P	S	WES	283P	CF
283S	S	WES	283S	CF
283V	S	WES	283V	CF
283Z	S	WES	283Z	CF
283ZB	S	WES	283ZB	CF

Part Number	Type	Mfgr.	Suggested Ⓦ Replacement	Page
283ZD	S	WES	283ZD	CF
283ZF	S	WES	283ZF	CF
283ZH	S	WES	283ZH	CF
286B	S	WES	286B	CF
286D	S	WES	286D	CF
286F	S	WES	286F	CF
286H	S	WES	286H	CF
286K	S	WES	286K	CF
286M	S	WES	286M	CF
286P	S	WES	286P	CF
286S	S	WES	286S	CF
286V	S	WES	286V	CF
286Y30B60	S	WES	286Y30B60	CF
286Y30B70	S	WES	286Y30B70	CF
286Y30B80	S	WES	286Y30B80	CF
286Y30B90	S	WES	286Y30B90	CF
286Y30C10	S	WES	286Y30C10	CF
286Y30C11	S	WES	286Y30C11	CF
286Y30C12	S	WES	286Y30C12	CF
286Y30C13	S	WES	286Y30C13	CF
286Y30C14	S	WES	286Y30C14	CF
286Y30C15	S	WES	286Y30C15	CF
286Y30C16	S	WES	286Y30C16	CF
286Y30C17	S	WES	286Y30C17	CF
286Y30C18	S	WES	286Y30C18	CF
286Y30C19	S	WES	286Y30C19	CF
286Y30C20	S	WES	286Y30C20	CF
286Z	S	WES	286Z	CF
286ZD	S	WES	286ZD	CF
286ZH	S	WES	286ZH	CF
286ZM	S	WES	286ZM	CF
286ZP	S	WES	286ZP	CF
288B	S	WES	288B	CF
288D	S	WES	288D	CF
288F	S	WES	288F	CF
288H	S	WES	288H	CF
288K	S	WES	288K	CF
288M	S	WES	288M	CF
288P	S	WES	288P	CF
288S	S	WES	288S	CF
288V	S	WES	288V	CF
288Z	S	WES	288Z	CF
288ZD	S	WES	288ZD	CF
288ZH	S	WES	288ZH	CF
288ZM	S	WES	288ZM	CF
300A	R	WES	R5100010	R23
300AR	R	WES	R5110010	R23
300B	R	WES	R5100110	R23
300BR	R	WES	R5110110	R23
300C	R	WES	R510+110	R23
300CR	R	WES	R511+110	R23
300D	R	WES	R5100210	R23
300DR	R	WES	R5110210	R23
300E	R	WES	R510+210	R23
300ER	R	WES	R511+210	R23
300F	R	WES	R5100310	R23
300FR	R	WES	R5110310	R23
300G	R	WES	R510+310	R23
300GR	R	WES	R511+310	R23
300H	R	WES	R5100410	R23
300HR	R	WES	R5110410	R23
300K	R	WES	R5100510	R23
300KR	R	WES	R5110510	R23
300PA50	S	IR	T620053004DN	S43
300PA60	S	IR	T620063004DN	S43
300PA80	S	IR	T620083004DN	S43
300PA100	S	IR	T620103004DN	S43
300PA110	S	IR	T620113004DN	S43
300PA120	S	IR	T620123004DN	S43
300PAC10	S	IR	T620013004DN	S43
300PAC20	S	IR	T620023004DN	S43
300PAC30	S	IR	T620033004DN	S43
300PAC40	S	IR	T620043004DN	S43
300PAC50	S	IR	T620053004DN	S43
300PAC60	S	IR	T620063004DN	S43
300RA10	S	IR	T700013004BY	S37
300RA20	S	IR	T700023004BY	S37
300RA30	S	IR	T700033004BY	S37
300RA40	S	IR	T700043004BY	S37
300RA50	S	IR	T700053004BY	S37
300RA60	S	IR	T700063004BY	S37
300RA80	S	IR	T700083004BY	S37
300RA100	S	IR	T700103004BY	S37
300RA110	S	IR	T700113004BY	S37
300RA120	S	IR	T700123004BY	S37

Part Number	Type	Mfgr.	Suggested Ⓦ Replacement	Page
300RA130	S	IR	T700133004BY	S37
300RA140	S	IR	T700143004BY	S37
300RA150	S	IR	T700153004BY	S37
300RA160	S	IR	T700163004BY	S37
300RA170	S	IR	T700173004BY	S37
300RB10	S	IR	T700013004BY	S37
300RB20	S	IR	T700023004BY	S37
300RB30	S	IR	T700033004BY	S37
300RB40	S	IR	T700043004BY	S37
300RB50	S	IR	T700053004BY	S37
300RB60	S	IR	T700063004BY	S37
300RB80	S	IR	T700083004BY	S37
300RB100	S	IR	T700103004BY	S37
300RB110	S	IR	T700113004BY	S37
300RB120	S	IR	T700123004BY	S37
300RB130	S	IR	T700133004BY	S37
300RB140	S	IR	T700143004BY	S37
300RB150	S	IR	T700153004BY	S37
300RB160	S	IR	T700163004BY	S37
300RB170	S	IR	T700173004BY	S37
300U10A	R	IR	R6100130	R31
300U15A	R	IR	R610+130	R31
300U20A	R	IR	R6100230	R31
300U25A	R	IR	R610+230	R31
300U30A	R	IR	R6100330	R31
300U40A	R	IR	R6100430	R31
300U50A	R	IR	R6100530	R31
300U60A	R	IR	R6100630	R31
300U70A	R	IR	R6100730	R31
300U80A	R	IR	R6100830	R31
300U90A	R	IR	R6100930	R31
300U100A	R	IR	R6101030	R31
300U120A	R	IR	R6001230	R31
300UR10A	R	IR	R6110130	R31
300UR15A	R	IR	R611+130	R31
300UR20A	R	IR	R6110230	R31
300UR25A	R	IR	R611+230	R31
300UR30A	R	IR	R6110330	R31
300UR40A	R	IR	R6110430	R31
300UR50A	R	IR	R6110530	R31
300UR60A	R	IR	R6110630	R31
300UR70A	R	IR	R6110730	R31
300UR80A	R	IR	R6110830	R31
300UR90A	R	IR	R6110930	R31
300UR100A	R	IR	R6111030	R31
300UR120A	R	IR	R6011230	R31
301C10	S	SYN	T620013004DN	S43
301C10B	S	SYN	T620013004DN	S43
301C15	S	SYN	T620023004DN	S43
301C15B	S	SYN	T620023004DN	S43
301C20	S	SYN	T620023004DN	S43
301C20B	S	SYN	T620023004DN	S43
301C25	S	SYN	T620033004DN	S43
301C25B	S	SYN	T620033004DN	S43
301C30	S	SYN	T620033004DN	S43
301C30B	S	SYN	T620033004DN	S43
301C35	S	SYN	T620043004DN	S43
301C35B	S	SYN	T620043004DN	S43
301C40	S	SYN	T620043004DN	S43
301C40B	S	SYN	T620043004DN	S43
301C45	S	SYN	T620053004DN	S43
301C45B	S	SYN	T620053004DN	S43
301C50	S	SYN	T620053004DN	S43
301C50B	S	SYN	T620053004DN	S43
301C60	S	SYN	T620063004DN	S43
301C60B	S	SYN	T620063004DN	S43
301C70	S	SYN	T620073004DN	S43
301C70B	S	SYN	T620073004DN	S43
301C80	S	SYN	T620083004DN	S43
301C80B	S	SYN	T620083004DN	S43
301C90	S	SYN	T620093004DN	S43
301C90B	S	SYN	T620093004DN	S43
301C100	S	SYN	T620103004DN	S43
301C100B	S	SYN	T620103004DN	S43
301C110	S	SYN	T620113004DN	S43
301C110B	S	SYN	T620093004DN	S43
301C120	S	SYN	T620123004DN	S43
301C120B	S	SYN	T620123004DN	S43
301C130	S	SYN	T620133004DN	S43
301C130B	S	SYN	T620133004DN	S43
301C140	S	SYN	T620143004DN	S43
301C140B	S	SYN	T620143004DN	S43
301C150	S	SYN	T620153004DN	S43
301C150B	S	SYN	T620153004DN	S43
301U80	R	IR	R6100830	R31

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MASTER CROSS REFERENCE TYPE NUMBER INDEX
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Part Number	Type	Mfgr.	Suggested Ⓦ Replacement	Page
301U100	R	IR	R6101030	R31
301U120	R	IR	R6001230	R31
301U140	R	IR	R6001430	R31
301U160	R	IR	R6001630	R31
301U180	R	IR	R6001830	R31
301U200	R	IR	R6002030	R31
301U210	R	IR	R6002130	R31
301U220	R	IR	R6002230	R31
301U240	R	IR	R6002430	R31
301U250	R	IR	R6002530	R31
301UR80	R	IR	R6110830	R31
301UR100	R	IR	R6111030	R31
301UR120	R	IR	R6011230	R31
301UR140	R	IR	R6011430	R31
301UR160	R	IR	R6011630	R31
301UR180	R	IR	R6011830	R31
301UR200	R	IR	R6012030	R31
301UR210	R	IR	R6012130	R31
301UR220	R	IR	R6012230	R31
301UR240	R	IR	R6012430	R31
301UR250	R	IR	R6012530	R31
302A	R	WES	IN1184A	R15
302B	R	WES	IN1184A	R15
302C	R	WES	IN1186A	R15
302D	R	WES	IN1186A	R15
302E	R	WES	IN1188A	R15
302F	R	WES	IN1188A	R15
302G	R	WES	IN1188A	R15
302H	R	WES	IN1188A	R15
302K	R	WES	IN1190A	R15
302M	R	WES	IN1190A	R15
302P	R	WES	R4100840	R15
302S	R	WES	R4100840	R15
302Z	R	WES	R4101040	R15
303A	R	WES	IN1184A	R15
303B	R	WES	IN1184A	R15
303D	R	WES	IN1186A	R15
303F	R	WES	IN1188A	R15
303H	R	WES	IN1188A	R15
303M	R	WES	IN1190A	R15
303S	R	WES	R4100840	R15
303Z	R	WES	R4101040	R15
304A	R	WES	IN1200A	R13
304B	R	WES	IN1200A	R13
304D	R	WES	IN1202A	R13
304F	R	WES	IN1204A	R13
304H	R	WES	IN1204A	R13
304M	R	WES	IN1206A	R13
304S	R	WES	IN3671A	R13
304Z	R	WES	IN3673A	R13
305	R	WES	CF	CF
318	R	WES	CF	CF
319A	R	WES	CF	CF
319B	R	WES	CF	CF
319C	R	WES	CF	CF
319D	R	WES	CF	CF
319E	R	WES	CF	CF
319F	R	WES	CF	CF
319G	R	WES	CF	CF
319H	R	WES	CF	CF
319K	R	WES	CF	CF
320C.............	D	WES	CF	CF
322A	R	WES	CF	CF
322B	R	WES	CF	CF
322C	R	WES	CF	CF
322D	R	WES	CF	CF
322E	R	WES	CF	CF
322F	R	WES	CF	CF
322G	R	WES	CF	CF
322H	R	WES	CF	CF
322K	R	WES	CF	CF
325	R	WES	CF	CF
326A	R	WES	CF	CF
326B	R	WES	CF	CF
326C	R	WES	CF	CF
326D	R	WES	CF	CF
326E	R	WES	CF	CF
326F	R	WES	CF	CF
326G	R	WES	CF	CF
326H	R	WES	CF	CF
326K	R	WES	CF	CF
327A	R	WES	CF	CF
327B	R	WES	CF	CF
327C	R	WES	CF	CF
327D	R	WES	CF	CF
327E	R	WES	CF	CF
327F	R	WES	CF	CF
327G	R	WES	CF	CF
327H	R	WES	CF	CF
327K	R	WES	CF	CF
328A	R	WES	CF	CF
328B	R	WES	CF	CF
328C	R	WES	CF	CF
328D	R	WES	CF	CF
328E	R	WES	CF	CF
328F	R	WES	CF	CF
328G	R	WES	CF	CF
328H	R	WES	CF	CF
328K	R	WES	CF	CF
329A	R	WES	IN3260	R27
329B	R	WES	IN3261	R27
329C	R	WES	IN3262	R27
329D	R	WES	IN3263	R27
329E	R	WES	IN3264	R27
329F	R	WES	IN3265	R27
329G	R	WES	IN3266	R27
329H	R	WES	IN3267	R27
329K	R	WES	IN3268	R27
331A	R	WES	CF	CF
331B	R	WES	CF	CF
331C	R	WES	CF	CF
331D	R	WES	CF	CF
331F	R	WES	CF	CF
331H	R	WES	CF	CF
331K	R	WES	CF	CF
331M	R	WES	CF	CF
331T	S	WCE	T620XX2004DN	S43
332A	R	WES	CF	CF
332B	R	WES	CF	CF
332C	R	WES	CF	CF
332D	R	WES	CF	CF
332F	R	WES	CF	CF
332H	R	WES	CF	CF
332K	R	WES	CF	CF
332M	R	WES	CF	CF
332T	S	WCE	T620XX2004DN	S43
333A	R	WES	CF	CF
333B	R	WES	CF	CF
333C	R	WES	CF	CF
333D	R	WES	CF	CF
333F	R	WES	CF	CF
333H	R	WES	CF	CF
333K	R	WES	CF	CF
333M	R	WES	CF	CF
333T	R	WES	T620XX2004DN	S43
334A	R	WCE	CF	CF
334B	R	WES	CF	CF
334C	R	WES	CF	CF
334D	R	WES	CF	CF
334F	R	WES	CF	CF
334H	R	WES	CF	CF
334K	R	WES	CF	CF
334M	R	WES	CF	CF
334T	S	WCE	T620XX3004DN	S43
335A	R	WES	IN1184AR	R15
335B	R	WES	IN1184AR	R15
335D	R	WES	IN1186AR	R15
335F	R	WES	IN1188AR	R15
335H	R	WES	IN1188AR	R15
335M	R	WES	IN1190AR	R15
336..............	D	WES	CF	CF
336A	R	WES	IN1184AR	R15
336B	R	WES	IN1184AR	R15
336D	R	WES	IN1186AR	R15
336F	R	WES	IN1188AR	R15
336H	R	WES	IN1188AR	R15
336M	R	WES	IN1190AR	R15
337A	R	WES	IN1199AR	R15
337B	R	WES	IN1200AR	R15
337D	R	WES	IN1202AR	R15
337F	R	WES	IN1204AR	R15
337H	R	WES	IN1204AR	R15
337M	R	WES	IN1206AR	R15
338A	R	WES	CF	CF
338B	R	WES	CF	CF
338C	R	WES	CF	CF
338D	R	WES	CF	CF
338F	R	WES	CF	CF
338H	R	WES	CF	CF
338K	R	WES	CF	CF
338M	R	WES	CF	CF
339A	R	WES	IN3161	R31
339B	R	WES	IN3162	R31
339C	R	WES	IN3163	R31
339D	R	WES	IN3164	R31
339E	R	WES	IN3165	R31
339F	R	WES	IN3166	R31
339G	R	WES	IN3167	R31
339H	R	WES	IN3168	R31
339K	R	WES	IN3169	R31
341A	R	WES	IN1199A	R13
341B	R	WES	IN1200A	R13
341D	R	WES	IN1202A	R13
341F	R	WES	IN1204A	R13
341H	R	WES	IN1204A	R13
341M	R	WES	IN1206A	R13
344T	S	WCE	T620XX3004DN	S43
346A	R	WES	IN1199A	R13
346B	R	WES	IN1200AR	R13
346D	R	WES	IN1202AR	R13
346F	R	WES	IN1204AR	R13
346H	R	WES	IN1204AR	R13
346M	R	WES	IN1206AR	R13
350PL50	S	IR	T727053544DN	S91
350PL60	S	IR	T727063544DN	S91
350PL80	S	IR	T727083544DN	S91
350PL100	S	IR	T727103544DN	S91
350PL110	S	IR	T727113544DN	S91
350PL120	S	IR	T727123544DN	S91
350PM50	S	IR	T727053554DN	S91
350PM60	S	IR	T727063554DN	S91
350PM80	S	IR	T727083554DN	S91
350PM100	S	IR	T727103554DN	S91
350PM110	S	IR	T727113554DN	S91
350PM120	S	IR	T727123554DN	S91
350RA10	S	IR	T700013504BY	S37
350RA20	S	IR	T700023504BY	S37
350RA30	S	IR	T700033504BY	S37
350RA40	S	IR	T700043504BY	S37
350RA50	S	IR	T700053504BY	S37
350RA60	S	IR	T700063504BY	S37
350RA80	S	IR	T700083504BY	S37
350RA100	S	IR	T700103504BY	S37
350RA110	S	IR	T700113504BY	S37
350RA120	S	IR	T700123504BY	S37
350RA130	S	IR	T700133504BY	S37
350RA140	S	IR	T700143504BY	S37
350RA150	S	IR	T700153504BY	S37
350RA160	S	IR	T700163504BY	S37
350RA170	S	IR	T700173504BY	S37
351T	S	WCE	T627XX2544DN	S87
352T	S	WCE	T627XX1584DN	S87
353T	S	WCE	T627XX15B4DN	S87
356A	R	WES	IN3260R	R27
356B	R	WES	IN3261R	R27
356C	R	WES	IN3262R	R27
356D	R	WES	IN3263R	R27
356F	R	WES	IN3265R	R27
356H	R	WES	IN3267R	R27
356K	R	WES	IN3268R	R27
356M	R	WES	IN3269R	R27
357A	R	WES	IN3161R	R27
357B	R	WES	IN3162R	R27
357C	R	WES	IN3163R	R27
357D	R	WES	IN3164R	R27
357F	R	WES	IN3166R	R27
357H	R	WES	IN3168R	R27
357K	R	WES	IN3169R	R27
357M	R	WES	IN3170R	R27
359A	R	WES	IN4816	R9
359B	R	WES	IN4817	R9
359D	R	WES	IN4818	R9
359F	R	WES	IN4819	R9
359H	R	WES	IN4820	R9
359K	R	WES	IN4821	R9
359M	R	WES	IN4822	R9
359P	R	WES	IN5052	R9
359S	R	WES	IN5053	R9
359Z	R	WES	IN5054	R9
366A	R	WES	IN1199A	R13
366B	R	WES	IN1200A	R13
366D	R	WES	IN1202A	R13
366F	R	WES	IN1204A	R13
366H	R	WES	IN1204A	R13
366K	R	WES	IN1206A	R13
366M	R	WES	IN1206A	R13

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367A	R	WES	IN1200A	R13
367B	R	WES	IN1200A	R13
367D	R	WES	IN1202A	R13
367F	R	WES	IN1204A	R13
367H	R	WES	IN1204A	R13
367M	R	WES	IN1206A	R13
368A	R	WES	IN3615	R13
368AR	R	WES	IN3615R	R13
368B	R	WES	IN3616	R13
368BR	R	WES	IN3616R	R13
368D	R	WES	IN3618	R13
368DR	R	WES	IN3618R	R13
368F	R	WES	IN3619	R13
368FR	R	WES	IN3619R	R13
368BR	R	WES	IN3620	R13
368HR	R	WES	IN3620R	R13
368K	R	WES	IN3621	R13
368KR	R	WES	IN3621R	R13
368M	R	WES	IN3622	R13
368MR	R	WES	IN3622R	R13
374A	R	WES	R5100010XXZT	R23
374B	R	WES	R5100110XXZT	R23
374C	R	WES	R510+110XXZT	R23
374D	R	WES	R5100210XXZT	R23
374F	R	WES	R5100310XXZT	R23
374H	R	WES	R5100410XXZT	R23
374K	R	WES	R5100510XXZT	R23
374M	R	WES	R5100610XXZT	R23
376A	R	WES	376A	CF
376B	R	WES	376B	CF
376C	R	WES	376C	CF
376D	R	WES	376D	CF
376F	R	WES	376F	CF
376H	R	WES	376H	CF
376K	R	WES	376K	CF
376M	R	WES	376M	CF
377A	R	WES	377A	CF
377B	R	WES	377B	CF
377C	R	WES	377C	CF
377D	R	WES	377D	CF
377F	R	WES	377F	CF
377H	R	WES	377H	CF
377K	R	WES	377K	CF
377M	R	WES	377M	CF
384A	R	WES	IN5391	R9
384B	R	WES	IN5392	R9
384D	R	WES	IN5393	R9
384F	R	WES	IN5394	R9
384H	R	WES	IN5395	R9
384K	R	WES	IN5396	R9
384M	R	WES	IN5397	R9
384S	R	WES	IN5398	R9
384Z	R	WES	IN5399	R9
387A	R	WES	IN3899	R57
387AR	R	WES	IN3899R	R57
387B	R	WES	IN3900	R57
387BR	R	WES	IN3900R	R57
387D	R	WES	IN3901	R57
387DR	R	WES	IN3901R	R57
387F	R	WES	IN3902	R57
387H	R	WES	IN3903	R57
387M	R	WES	CF	R57
389A	R	WES	IN3909	R57
389AR	R	WES	IN3909R	R57
389B	R	WES	IN3910	R57
389BR	R	WES	IN3910R	R57
389D	R	WES	IN3911	R57
389DR	R	WES	IN3911R	R57
389H	R	WES	IN3912	R57
389M	R	WES	CF	R57
398A	R	WES	IN5400	R9
398B	R	WES	IN5401	R9
398C	R	WES	IN5402	R9
398F	R	WES	IN5403	R9
398H	R	WES	IN5404	R9
398K	R	WES	IN5405	R9
398M	R	WES	IN5406	R9
398S	R	WES	IN5407	R9
398Z	R	WES	IN5408	R9
400A	R	WES	400A	CF
400B	R	WES	400B	CF
400C	R	WES	400C	CF
400D	R	WES	400D	CF
400E	R	WES	400E	CF
400F	R	WES	400F	CF

Part Number	Type	Mfgr.	Suggested Replacement	Page
400G	R	WES	400G	CF
400H	R	WES	400H	CF
400K	R	WES	400K	CF
400M	R	WES	400M	CF
400P	R	WES	400P	CF
400S	R	WES	400S	CF
400V	R	WES	400V	CF
400Z	R	WES	400Z	CF
401A	R	WES	401A	CF
401B	R	WES	401B	CF
401C	R	WES	401C	CF
401D	R	WES	401D	CF
401E	R	WES	401E	CF
401F	R	WES	401F	CF
401G	R	WES	401G	CF
401H	R	WES	401H	CF
401K	R	WES	401K	CF
401M	R	WES	401M	CF
401P	R	WES	401P	CF
401PDA40L15	R	IR	R6220440FJ	R67
401PDA40L20	R	IR	R6220440EJ	R67
401PDA40L30	R	IR	R6220440CJ	R67
401PDA60L15	R	IR	R6220640FJ	R67
401PDA60L20	R	IR	R6220640EJ	R67
401PDA60L30	R	IR	R6220640CJ	R67
401PDA80L15	R	IR	R6220840FJ	R67
401PDA80L20	R	IR	R6220840EJ	R67
401PDA80L30	R	IR	R6220840CJ	R67
401PDA100L20	R	IR	R6221040EJ	R67
401PDA100L30	R	IR	R6221040CJ	R67
401PDA120L20	R	IR	R6221240EJ	R67
401PDA120L30	R	IR	R6221240CJ	R67
401PDA130L30	R	IR	R6221340CJ	R67
401PDA140L30	R	IR	R6221440CJ	R67
401PDA160L30	R	IR	R6221640CJ	R67
401PDL40S15	R	IR	R6220440FJ	R67
401PDL40S20	R	IR	R6220440EJ	R67
401PDL40S30	R	IR	R6220440CJ	R67
401PDL60S15	R	IR	R6220640FJ	R67
401PDL60S20	R	IR	R6220640EJ	R67
401PDL60S30	R	IR	R6220640CJ	R67
401PDL80S15	R	IR	R6220840FJ	R67
401PDL80S20	R	IR	R6220840EJ	R67
401PDL80S30	R	IR	R6220840CJ	R67
401PDL100S20	R	IR	R6221040FJ	R67
401PDL100S30	R	IR	R6221040CJ	R67
401PDL120S20	R	IR	R6221240EJ	R67
401PDL120S30	R	IR	R6221240CJ	R67
401PDL130S30	R	IR	R6221340CJ	R67
401S	R	IR	401S	CF
401V	R	WES	401V	CF
401Z	R	WES	401Z	CF
402A	R	WES	R4040070	R17
402B	R	WES	R4040170	R17
402D	R	WES	R4040270	R17
402F	R	WES	R4040370	R17
402M	R	WES	R4040670	R17
402P	R	WES	R4040770	R17
402S	R	WES	R4040870	R17
402V	R	WES	R4040970	R17
402Z	R	WES	R4041070	R17
402ZD	R	WES	R4041270	R17
403A	R	WES	R4100140	CF
403B	R	WES	R4100140	CF
403D	R	WES	R4100240	CF
403H	R	WES	R4100440	CF
403M	R	WES	R4100640	CF
404A	R	WES	IN1199A	R13
404B	R	WES	IN1200A	R13
404D	R	WES	IN1202A	R13
404F	R	WES	IN1203A	R13
404H	R	WES	IN1204A	R13
404K	R	WES	IN1205A	R13
404M	R	WES	IN1206A	R13
407A	R	WES	IN1199A	R13
407B	R	WES	IN1200A	R13
407D	R	WES	IN1202A	R13
407F	R	WES	IN1203A	R13
407H	R	WES	IN1204A	R13
407K	R	WES	IN1205A	R13
407M	R	WES	IN1206A	R13
408A	R	WES	IN1199A	R13
408B	R	WES	IN1200A	R13
408D	R	WES	IN1202A	R13
408H	R	WES	IN1204A	R13

Part Number	Type	Mfgr.	Suggested Replacement	Page
408M	R	WES	IN1206A	R13
409A	R	WES	IN1199A	R13
409B	R	WES	IN1200A	R13
409D	R	WES	IN1202A	R13
409F	R	WES	IN1203A	R13
409H	R	WES	IN1204A	R13
409K	R	WES	IN1205A	R13
409M	R	WES	IN1206A	R13
410A	R	WES	410A	CF
410AR	R	WES	410AR	CF
410B	R	WES	410B	CF
410BR	R	WES	410BR	CF
410C	R	WES	410C	CF
410CR	R	WES	410CR	CF
410D	R	WES	410D	CF
410DR	R	WES	410DR	CF
410F	R	WES	410F	CF
410FR	R	WES	410FR	CF
410H	R	WES	410H	CF
410HR	R	WES	410HR	CF
410K	R	WES	410K	CF
410M	R	WES	410M	CF
410MR	R	WES	410MR	CF
410S	R	WES	410S	CF
410SR	R	WES	410SR	CF
410Z	R	WES	410Z	CF
410ZR	R	WES	410ZR	CF
411A	R	WES	411A	CF
411AR	R	WES	411AR	CF
411B	R	WES	411B	CF
411BR	R	WES	411BR	CF
411C	R	WES	411C	CF
411CR	R	WES	411CR	CF
411D	R	WES	411D	CF
411F	R	WES	411F	CF
411FR	R	WES	411FR	CF
411H	R	WES	411H	CF
411HR	R	WES	411HR	CF
411K	R	WES	411K	CF
411KR	R	WES	411KR	CF
411M	R	WES	411M	CF
411MR	R	WES	411MR	CF
411S	R	WES	411S	CF
411SR	R	WES	411SR	CF
411Z	R	WES	411Z	CF
411ZR	R	WES	411ZR	CF
412A	R	WES	IN1184A	R15
412B	R	WES	IN1184A	R15
412D	R	WES	IN1186A	R15
412H	R	WES	IN1188A	R15
412M	R	WES	IN1190A	R15
413A	R	WES	IN1184A	R15
413B	R	WES	IN1184A	R15
413D	R	WES	IN1186A	R15
413H	R	WES	IN1188A	R15
413M	R	WES	IN1190A	R15
416A	R	WES	R4040070	R17
416B	R	WES	R4040170	R17
416H	R	WES	R4040470	R17
416K	R	WES	R4040570	R17
416M	R	WES	R4040670	R17
416P	R	WES	R4040770	R17
416S	R	WES	R4040870	R17
416V	R	WES	R4040970	R17
416Z	R	WES	R4041070	R17
417A	R	WES	IN1184A	R15
417B	R	WES	IN1184A	R15
417D	R	WES	IN1186A	R15
417H	R	WES	IN1188A	R15
417M	R	WES	IN1190A	R15
418A	R	WES	IN1184A	R15
418B	R	WES	IN1184A	R15
418D	R	WES	IN1186A	R15
418H	R	WES	IN1188A	R15
418M	R	WES	IN1190A	R15
419A	R	WES	IN1184A	R15
419B	R	WES	IN1184A	R15
419D	R	WES	IN1186A	R15
419H	R	WES	IN1188A	R15
419M	R	WES	IN1190A	R15
420PA50	S	IR	T720054504DN	S51
420PA60	S	IR	T720064504DN	S51
420PA80	S	IR	T720084504DN	S51
420PA100	S	IR	T720104504DN	S51
420PA110	S	IR	T720114504DN	S51
420PA120	S	IR	T720124504DN	S51

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MASTER CROSS REFERENCE TYPE NUMBER INDEX
JEDEC and Industry Part Numbers

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420PA130	S	IR	T720134504DN	S51
420PA140	S	IR	T720144504DN	S51
420PA150	S	IR	T720154504DN	S51
420PA160	S	IR	T720164504DN	S51
420PA170	S	IR	T720174504DN	S51
420PB50	S	IR	T720054504DN	S51
420PB60	S	IR	T720064504DN	S51
420PB80	S	IR	T720084504DN	S51
420PB100	S	IR	T720104504DN	S51
420PB110	S	IR	T720114504DN	S51
420PB120	S	IR	T720124504DN	S51
420PB130	S	IR	T720134504DN	S51
420PB140	S	IR	T720144504DN	S51
420PB150	S	IR	T720154504DN	S51
420PB160	S	IR	T720164504DN	S51
420PB170	S	IR	T720174504DN	S51
420PBL50	S	IR	T727054524DN	S91
420PBL60	S	IR	T727064524DN	S91
420PBL80	S	IR	T727084524DN	S91
420PBL100	S	IR	T727104524DN	S91
420PBL110	S	IR	T727114524DN	S91
420PBL120	S	IR	T727124524DN	S91
420PBM50	S	IR	T727054544DN	S91
420PBM60	S	IR	T727064544DN	S91
420PBM80	S	IR	T727084544DN	S91
420PBM100	S	IR	T727104544DN	S91
420PBM110	S	IR	T727114544DN	S91
420PBM120	S	IR	T727124544DN	S91
420PL60	S	IR	T727064524DN	S91
420PL80	S	IR	T727084524DN	S91
420PL100	S	IR	T727104524DN	S91
420PL110	S	IR	T727114524DN	S91
420PL120	S	IR	T727124524DN	S91
420PM60	S	IR	T727064544DN	S91
420PM80	S	IR	T727084544DN	S91
420PM100	S	IR	T727104544DN	S91
420PM110	S	IR	T727114544DN	S91
420PM120	S	IR	T727124544DN	S91
424A	R	WES	IN3909	R57
424B	R	WES	IN3910	R57
424D	R	WES	IN3911	R57
424F	R	WES	IN3912	R57
424H	R	WES	IN3913	R57
425A	R	WES	IN3909	R57
425B	R	WES	IN3910	R57
425D	R	WES	IN3911	R57
425H	R	WES	IN3913	R57
429A	R	WES	429A	CF
429AR	R	WES	429AR	CF
429B	R	WES	429B	CF
429BR	R	WES	429BR	CF
429C	R	WES	429C	CF
429CR	R	WES	429CR	CF
429D	R	WES	429D	CF
429DR	R	WES	429DR	CF
429E	R	WES	429E	CF
429ER	R	WES	429ER	CF
429F	R	WES	429F	CF
429FR	R	WES	429FR	CF
429G	R	WES	429G	CF
429GR	R	WES	429GR	CF
429H	R	WES	429H	CF
429HR	R	WES	429HR	CF
429K	R	WES	429K	CF
429KR	R	WES	429KR	CF
429M	R	WES	429M	CF
429MR	R	WES	429MR	CF
429RC70	R	WES	CF	CF
430PL10	S	IR	T727014864DN	S91
430PL20	S	IR	T727024864DN	S91
430PL30	S	IR	T727034864DN	S91
430PL40	S	IR	T727044864DN	S91
430PL50	S	IR	T727054864DN	S91
430PL60	S	IR	T727064864DN	S91
430PM10	S	IR	T727014884DN	S91
430PM20	S	IR	T727024884DN	S91
430PM30	S	IR	T727034884DN	S91
430PM40	S	IR	T727044884DN	S91
430PM50	S	IR	T727054884DN	S91
430PM60	S	IR	T727064884DN	S91
435B	R	WES	R4050170	R17
435D	R	WES	R4050270	R17
435F	R	WES	R4050370	R17
435H	R	WES	R4050470	R17
435M	R	WES	R4050670	R17
435P	R	WES	R4050770	R17
435S	R	WES	R4050870	R17
435V	R	WES	R4050970	R17
435Z	R	WES	R4051070	R17
435ZD	R	WES	R4051270	R17
439A	R	WES	439A	CF
439AR	R	WES	439AR	CF
439B	R	WES	439B	CF
439BR	R	WES	439BR	CF
439C	R	WES	439C	CF
439CR	R	WES	439CR	CF
439D	R	WES	439D	CF
439DR	R	WES	439DR	CF
439E	R	WES	439E	CF
439ER	R	WES	439ER	CF
439F	R	WES	439F	CF
439FR	R	WES	439FR	CF
439G	R	WES	439G	CF
439GR	R	WES	439GR	CF
439H	R	WES	439H	CF
439HR	R	WES	439HR	CF
439K	R	WES	439K	CF
439KR	R	WES	439KR	CF
439M	R	WES	439M	CF
439MR	R	WES	439MR	CF
441A	R	WES	R3100012	CF
441B	R	WES	R3100112	CF
441D	R	WES	R3100212	CF
441F	R	WES	R3100312	CF
441H	R	WES	R3100412	CF
441K	R	WES	R3100512	CF
441M	R	WES	R3100612	CF
441P	R	WES	R3100712	CF
441S	R	WES	R3100812	CF
441V	R	WES	R3100912	CF
441Z	R	WES	R3101012	CF
442T	S	WCE	T720XX5504DN	S51
444T	S	WCE	CF	CF
446A	R	WES	IN1199AR	R13
446B	R	WES	IN1200AR	R13
446D	R	WES	IN1202AR	R13
446F	R	WES	IN1203AR	R13
446H	R	WES	IN1204AR	R13
446K	R	WES	IN1205AR	R13
446M	R	WES	IN1206AR	R13
446P	R	WES	IN3670AR	R13
446S	R	WES	IN3671AR	R13
446V	R	WES	IN3672AR	R13
446Z	R	WES	IN3673AR	R13
450PF5	S	IR	T727014884DN	S91
450PF10	S	IR	T727014884DN	S91
450PF20	S	IR	T727024884DN	S91
450PF30	S	IR	T727034884DN	S91
450PF50	S	IR	T727054884DN	S91
450PF60	S	IR	T727064884DN	S91
456T	S	WCE	T720XX5504DN	S51
458T	S	WCE	T720XX5504DN	S51
462T	S	WCE	CF	CF
464T	S	WCE	T920XX0903DW	S55
466T	S	WCE	CF	CF
470PA50	S	IR	T720055504DN	S51
470PA60	S	IR	T720065504DN	S51
470PA80	S	IR	T720085504DN	S51
470PA100	S	IR	T720105504DN	S51
470PA110	S	IR	T720115504DN	S51
470PA120	S	IR	T720122504DN	S51
470PA130	S	IR	T720135504DN	S51
470PA140	S	IR	T720145504DN	S51
470PA150	S	IR	T720155504DN	S51
470PA160	S	IR	T720165504DN	S51
470PB50	S	IR	T720055504DN	S51
470PB60	S	IR	T720065504DN	S51
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470PB140	S	IR	T720145504DN	S51
470PB150	S	IR	T720155504DN	S51
470PB160	S	IR	T720165504DN	S51
470T	S	WCE	T727XX4524DN	S91
471PD120	R	IR	R6201250	R39
471PD140	R	IR	R6201450	R39
471PD160	R	IR	R6201650	R39
471PD180	R	IR	R6201850	R39
471PD200	R	IR	R6202050	R39
471PDA120	R	IR	R6201250	R39
471PDA140	R	IR	R6201450	R39
471PDA160	R	IR	R6201650	R39
471PDA180	R	IR	R6201850	R39
471PDA200	R	IR	R6202050	R39
471T	S	WCE	CF	CF
472T	S	WCE	T727XX4064DN	S91
473T	S	WCE	T727XX4874DN	S91
474T	S	WCE	T727XX4554DN	S91
476T	S	WCE	T727XX4534DN	S91
477T	S	WCE	T727XX3534DN	S91
478A	R	WES	IN3879	R55
478AR	R	WES	IN3879R	R55
478B	R	WES	IN3880	R55
478BR	R	WES	IN3880R	R55
478D	R	WES	IN3881	R55
478DR	R	WES	IN3881R	R55
478F	R	WES	IN3882	R55
478H	R	WES	IN3883	R55
478T	S	WCE	T720XX3504DN	S51
479A	R	WES	IN3889	R57
479B	R	WES	IN3890	R57
479D	R	WES	IN3891	R57
479F	R	WES	IN3892	R57
479H	R	WES	IN3893	R57
489A	R	WES	IN3909	R57
489B	R	WES	IN3910	R57
489D	R	WES	IN3911	R57
489F	R	WES	IN3912	R57
489H	R	WES	IN3913	R57
500PA5	S	IR	T720015504DN	S51
500PA10	S	IR	T720015504DN	S51
500PA20	S	IR	T720025504DN	S51
500PA30	S	IR	T720035504DN	S51
500PA40	S	IR	T720045504DN	S51
500PA50	S	IR	T720055504DN	S51
500PA60	S	IR	T720065504DN	S51
500PBQ50	S	IR	T727054544DN	S91
500PBQ60	S	IR	T727064544DN	S91
500PBQ80	S	IR	T727084544DN	S91
500PBQ100	S	IR	T727104544DN	S91
500PBQ110	S	IR	T727114544DN	S91
500PBQ120	S	IR	T727124544DN	S91
500V5A	R	IR	R7000005	R35
500V10A	R	IR	R7000105	R35
500V20A	R	IR	R7000205	R35
500V30A	R	IR	R7000305	R35
500V40A	R	IR	R7000405	R35
500V50A	R	IR	R7000505	R35
500V60A	R	IR	R7000605	R35
500VR10A	R	IR	R7010105	R35
500VR20A	R	IR	R7010205	R35
500VR30A	R	IR	R7010305	R35
500VR40A	R	IR	R7010405	R35
500VR5A	R	IR	R7010005	R35
500VR50A	R	IR	R7010505	R35
500VR60A	R	IR	R7010605	R35
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501PBQ60	S	IR	T727064554DN	S91
501PBQ80	S	IR	T727084554DN	S91
501PBQ100	S	IR	T727104554DN	S91
501PBQ110	S	IR	T727114554DN	S91
501PBQ120	S	IR	T727124554DN	S91
501V60B	R	IR	R7000605	R35
501V80B	R	IR	R7000805	R35
501V100B	R	IR	R7001005	R35
501V120	R	IR	R7001204	R35
501V120B	R	IR	R7001205	R35
501V140	R	IR	R7001404	R35
501V140B	R	IR	R7001405	R35
501V160	R	IR	R7001604	R35
501V180	R	IR	R7001804	R35
501V200	R	IR	R7002004	R35
501V210	R	IR	R7002104	R35
501V220	R	IR	R7002204	R35
501V230	R	IR	R7002304	R35
501V240	R	IR	R7002404	R35
501VR60B	R	IR	R7010605	R35
501VR80B	R	IR	R7010805	R35
501VR100B	R	IR	R7011005	R35
501VR120	R	IR	R7011204	R35
501VR120B	R	IR	R7011205	R35
501VR140	R	IR	R7011404	R35

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501VR140B	R	IR	R7011405	R35
501VR160	R	IR	R7011604	R35
501VR180	R	IR	R7011804	R35
501VR200	R	IR	R7012004	R35
501VR210	R	IR	R7012104	R35
501VR220	R	IR	R7012204	R35
501VR230	R	IR	R7012304	R35
501VR240	R	IR	R7012404	R35
507C.............	D	WES	CF	CF
508C.............	D	WES	CF	CF
550PA5	S	IR	T720015504DN	S51
550PA10	S	IR	T720015504DN	S51
550PA20	S	IR	T720025504DN	S51
550PA30	S	IR	T720035504DN	S51
550PA40	S	IR	T720045504DN	S51
550PA50	S	IR	T720055504DN	S51
550PA60	S	IR	T720065504DN	S51
550PB50	S	IR	T720055504DN	S51
550PB60	S	IR	T720065504DN	S51
550PB80	S	IR	T720085504DN	S51
550PB100	S	IR	T720105504DN	S51
550PB110	S	IR	T720115504DN	S51
550PB120	S	IR	T720125504DN	S51
550PB130	S	IR	T720135504DN	S51
550PB140	S	IR	T720145504DN	S51
550PB150	S	IR	T720155504DN	S51
550PB160	S	IR	T720165504DN	S51
550PBQ10	S	IR	CF	CF
550PBQ20	S	IR	CF	CF
550PBQ30	S	IR	CF	CF
550PBQ40	S	IR	CF	CF
550PBQ50	S	IR	CF	CF
550PBQ60	S	IR	CF	CF
600PB170	S	IR	T920170604DW	S55
600PB180	S	IR	T920180604DW	S55
600PB190	S	IR	T920190604DW	S55
600PB200	S	IR	T920200604DW	S55
600PB210	S	IR	T920210604DW	S55
600PB220	S	IR	T920220604DW	S55
600PB230	S	IR	T920230604DW	S55
600PB240	S	IR	T920240604DW	S55
600PB250	S	IR	T920250604DW	S55
651PDB50L20	R	IR	R7220508EJ	R71
651PDB50L30	R	IR	R7220508DJ	R71
651PDB50L25	R	IR	R7220508CJ	R71
651PDB60L20	R	IR	R7220608EJ	R71
651PDB60L25	R	IR	R7220608DJ	R71
651PDB80L20	R	IR	R7220808EJ	R71
651PDB80L25	R	IR	R7220508CJ	R71
651PDB80L30	R	IR	R7220808DJ	R71
651PDB100L25	R	IR	R7221008DJ	R71
651PDB100L30	R	IR	R7221008CJ	R71
651PDB120L25	R	IR	R7221208DJ	R71
651PDB120L30	R	IR	R7220508CJ	R71
651PDB130L30	R	IR	R7221308CJ	R71
651PDB140L30	R	IR	R7220508CJ	R71
651PDB160L30	R	IR	R7221608CJ	R71
651PDL50S20	R	IR	R7220508EJ	R71
651PDL50S25	R	IR	R7220508DJ	R71
651PDL50S30	R	IR	R7220508CJ	R71
651PDL60S20	R	IR	R7220608EJ	R71
651PDL60S25	R	IR	R72206080J	R71
651PDL80S20	R	IR	R7220808EJ	R71
651PDL80S25	R	IR	R7220808DJ	R71
651PDL80S30	R	IR	R7220808CJ	R71
651PDL100S25	R	IR	R72210080J	R71
651PDL100S30	R	IR	R7221008CJ	R71
651PDL110S25	R	IR	R7221108DJ	R71
651PDL110S30	R	IR	R7221108CJ	R71
651PDL120S25	R	IR	R7221208DJ	R71
651PDL120S30	R	IR	R7221208CJ	R71
661T	S	WCE	T920XX0503DW	S55
662T	S	WCE	T920XX0703DW	S55
666T	S	WCE	T920XX1003DW	S55
668T	S	WCE	T920XX1003DW	S55
669T	S	WCE	T920XX1003DW	S55
673-1	A	UNI	MB11A02V10	A3
673-2	A	UNI	MB11A02V20	A3
673-3	A	UNI	MB11A02V30	A3
673-4	A	UNI	MB11A02V40	A3
673-5	A	UNI	MB11A02V50	A3
673-6	A	UNI	MB11A02V60	A3
679-1	A	UNI	MB12A25V10	A3
679-2	A	UNI	MB12A25V20	A3
679-4	A	UNI	MB12A25V40	A3
679-6	A	UNI	MB12A25V60	A3
680-1	A	UNI	MB12A10V10	A3
680-2	A	UNI	MB12A10V20	A3
680-4	A	UNI	MB12A10V40	A3
680-6	A	UNI	MB12A10V60	A3
697-1	A	UNI	MB11A06V10	A3
697-2	A	UNI	MB11A06V20	A3
697-3	A	UNI	MB11A06V30	A3
697-4	A	UNI	MB11A06V40	A3
697-5	A	UNI	MB11A06V50	A3
697-6	A	UNI	MB11A06V60	A3
700PA50	S	IR	T920050704DW	S55
700PA60	S	IR	T920060704DW	S55
700PA80	S	IR	T920080704DW	S55
700PA100	S	IR	T920100704DW	S55
700PA110	S	IR	T920110704DW	S55
700PA120	S	IR	T920120704DW	S55
700PA130	S	IR	T920130704DW	S55
700PA140	S	IR	T920140704DW	S55
700PA150	S	IR	T920150704DW	S55
700PA160	S	IR	T920160704DW	S55
700PA170	S	IR	T920170704DW	S55
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700PK80	S	IR	T920080704DW	S55
700PK100	S	IR	T920100704DW	S55
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700PK160	S	IR	T920160704DW	S55
700PK170	S	IR	T920170704DW	S55
710A	R	WES	710A	CF
710AR	R	WES	710AR	CF
710B	R	WES	710B	CF
710BR	R	WES	710BR	CF
710C	R	WES	710C	CF
710CR	R	WES	710CR	CF
710D	R	WES	710D	CF
710DR	R	WES	710DR	CF
710E	R	WES	710E	CF
710ER	R	WES	710ER	CF
710F	R	WES	710F	CF
710FR	R	WES	710FR	CF
710H	R	WES	710H	CF
710HR	R	WES	710HR	CF
710K	R	WES	710K	CF
710KR	R	WES	710KR	CF
710M	R	WES	710M	CF
710MR	R	WES	710MR	CF
710P	R	WES	710P	CF
710PR	R	WES	710PR	CF
710S	R	WES	710S	CF
710SR	R	WES	710SR	CF
710V	R	WES	710V	CF
710VR	R	WES	710VR	CF
710Z	R	WES	710Z	CF
710ZD	R	WES	710ZD	CF
710ZDR	R	WES	710ZDR	CF
710ZR	R	WES	710ZR	CF
720A	R	WES	720A	CF
720AR	R	WES	720AR	CF
720B	R	WES	720B	CF
720BR	R	WES	720BR	CF
720C	R	WES	720C	CF
720CR	R	WES	720CR	CF
720D	R	WES	720D	CF
720DR	R	WES	720DR	CF
720F	R	WES	720F	CF
720FR	R	WES	720FR	CF
720H	R	WES	720H	CF
720HR	R	WES	720HR	CF
720K	R	WES	720K	CF
720KR	R	WES	720KR	CF
720M	R	WES	720M	CF
720MR	R	WES	720MR	CF
720S	R	WES	720S	CF
720SR	R	WES	720SR	CF
720Z	R	WES	720Z	CF
720ZR	R	WES	720ZR	CF
750PB110	S	IR	T920110804DW	S55
750PB120	S	IR	T920120804DW	S55
750PB130	S	IR	T920130804DW	S55
750PB140	S	IR	T920140804DW	S55
750PB150	S	IR	T920150804DW	S55
750PB160	S	IR	T920160804DW	S55
750PB170	S	IR	T920170804DW	S55
750PB180	S	IR	T920180804DW	S55
760P	R	WES	760P	CF
760S	R	WES	760S	CF
760V	R	WES	760V	CF
760Z	R	WES	760Z	CF
760ZB	R	WES	760ZB	CF
760ZD	R	WES	760ZD	CF
760ZF	R	WES	760ZF	CF
760ZH	R	WES	760ZH	CF
760ZK	R	WES	760ZK	CF
760ZM	R	WES	760ZM	CF
761P	R	WES	761P	CF
761S	R	WES	761S	CF
761V	R	WES	761V	CF
761Z	R	WES	761Z	CF
761ZB	R	WES	761ZB	CF
761ZD	R	WES	761ZD	CF
761ZF	R	WES	761ZF	CF
761ZH	R	WES	761ZH	CF
761ZK	R	WES	761ZK	CF
761ZM	R	WES	761ZM	CF
770A	R	WES	770A	CF
770B	R	WES	770B	CF
770C	R	WES	770C	CF
770D	R	WES	770D	CF
770F	R	WES	770F	CF
770H	R	WES	770H	CF
770K	R	WES	770K	CF
770M	R	WES	770M	CF
770S	R	WES	770S	CF
770Z	R	WES	770Z	CF
770ZD	R	WES	770ZD	CF
770ZH	R	WES	770ZH	CF
771A	R	WES	771A	CF
771B	R	WES	771B	CF
771C	R	WES	771C	CF
771D	R	WES	771D	CF
771F	R	WES	771F	CF
771H	R	WES	771H	CF
771K	R	WES	771K	CF
771M	R	WES	771M	CF
771S	R	WES	771S	CF
771Z	R	WES	771Z	CF
771ZD	R	WES	771ZD	CF
771ZH	R	WES	771ZH	CF
782A	R	WES	R6200030	R39
782B	R	WES	R6200130	R39
782C	R	WES	R620+130	R39
782D	R	WES	R6200230	R39
782F	R	WES	R6200330	R39
782H	R	WES	R6200430	R39
782K	R	WES	R6200530	R39
782M	R	WES	R6200630	R39
783A	R	WES	783A	CF
783B	R	WES	783B	CF
783D	R	WES	783D	CF
783F	R	WES	783F	CF
783H	R	WES	783H	CF
783K	R	WES	783K	CF
783M	R	WES	783M	CF
783S	R	WES	783S	CF
783Z	R	WES	783Z	CF
783ZD	R	WES	783ZD	CF
783ZH	R	WES	783ZH	CF
783ZK	R	WES	783ZK	CF
783ZM	R	WES	783ZM	CF
784A	R	WES	CF	CF
784B	R	WES	CF	CF
784C	R	WES	CF	CF
784D	R	WES	CF	CF
784F	R	WES	CF	CF
784H	R	WES	CF	CF
784K	R	WES	CF	CF
784M	R	WES	CF	CF
784S	R	WES	CF	CF
784Z	R	WES	CF	CF
785A	R	WES	CF	CF
785B	R	WES	CF	CF
785C	R	WES	CF	CF
785D	R	WES	CF	CF
785F	R	WES	CF	CF

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Part Number	Type	Mfgr.	Suggested Ⓦ Replacement	Page
785H	R	WES	CF	CF
785K	R	WES	CF	CF
785M	R	WES	CF	CF
785S	R	WES	CF	CF
785Z	R	WES	CF	CF
788A	R	WES	788A	CF
788AR	R	WES	788AR	CF
788B	R	WES	788B	CF
788BR	R	WES	788BR	CF
788C	R	WES	788C	CF
788CR	R	WES	788CR	CF
788D	R	WES	788D	CF
788DR	R	WES	788DR	CF
788F	R	WES	788F	CF
788FR	R	WES	788FR	CF
788H	R	WES	788H	CF
788HR	R	WES	788HR	CF
788K	R	WES	788K	CF
788KR	R	WES	788KR	CF
788M	R	WES	788M	CF
788MR	R	WES	788MR	CF
788S	R	WES	788S	CF
788SR	R	WES	788SR	CF
788Z	R	WES	788Z	CF
788ZD	R	WES	788ZD	CF
788ZDR	R	WES	788ZDR	CF
788ZH	R	WES	788ZH	CF
788ZHR	R	WES	788ZHR	CF
788ZK	R	WES	788ZK	CF
788ZKR	R	WES	788ZKR	CF
788ZM	R	WES	788ZM	CF
788ZMR	R	WES	788ZMR	CF
788ZR	R	WES	788ZR	CF
788ZS	R	WES	788ZS	CF
788ZSR	R	WES	788ZSR	CF
788ZZ	R	WES	788ZZ	CF
788ZZD	R	WES	788ZZD	CF
788ZZDR	R	WES	788ZZDR	CF
788ZZR	R	WES	788ZZR	CF
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789B	R	WES	789B	CF
789BR	R	WES	789BR	CF
789C	R	WES	789C	CF
789CR	R	WES	789CR	CF
789D	R	WES	789D	CF
789DR	R	WES	789DR	CF
789F	R	WES	789F	CF
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789HR	R	WES	789HR	CF
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789ZDR	R	WES	789ZDR	CF
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789ZHR	R	WES	789ZHR	CF
789ZK	R	WES	789ZK	CF
789ZKR	R	WES	789ZKR	CF
789ZM	R	WES	789ZM	CF
789ZMR	R	WES	789ZMR	CF
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790B	R	WES	790B	CF
790C	R	WES	790C	CF
790D	R	WES	790D	CF
790F	R	WES	790F	CF
790H	R	WES	790H	CF
790K	R	WES	790K	CF
790M	R	WES	790M	CF
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790ZM	R	WES	790ZM	CF
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790ZZ	R	WES	790ZZ	CF
790ZZD	R	WES	790ZZD	CF
790ZZK	R	WES	790ZZK	CF
791A	R	WES	IN3161R	R31
791B	R	WES	IN3162R	R31
791C	R	WES	IN3163R	R31
791D	R	WES	IN3164R	R31
791F	R	WES	IN3166R	R31
791H	R	WES	IN3168R	R31
791K	R	WES	IN3169R	R31
791M	R	WES	IN3170R	R31
791S	R	WES	IN3172R	R31
791Z	R	WES	IN3174R	R31
791ZD	R	WES	R6011224	CF
791ZH	R	WES	R6011424	CF
791ZK	R	WES	R6011524	CF
791ZM	R	WES	R6011624	CF
791ZS	R	WES	R6011824	CF
791ZZ	R	WES	R6012024	CF
791ZZK	R	WES	791ZZK	CF
791ZZD`	R	WES	791ZZD	CF
801PD60B	R	IR	R7200612	R43
801PD80B	R	IR	R7200812	R43
801PD100B	R	IR	R7201012	R43
801PD120	R	IR	R7201209	R43
801PD120B	R	IR	R7201212	R43
801PD140	R	IR	R7201409	R43
801PD140B	R	IR	R7201412	R43
801PD160	R	IR	R7201609	R43
801PD180	R	IR	R7201809	R43
801PD200	R	IR	R7202009	R43
801PDB60B	R	IR	R7200612	R43
801PDB80B	R	IR	R7200812	R43
801PDB100B	R	IR	R7201012	R43
801PDB120	R	IR	R7201209	R43
801PDB120B	R	IR	R7201212	R43
801PDB140	R	IR	R7201409	R43
801PDB140B	R	IR	R7201412	R43
801PDB180	R	IR	R7201809	R43
801PDB160	R	IR	R7201609	R43
801PDB200	R	IR	R7202009	R43
801PDB210	R	IR	R7202109	R43
801PDB220	R	IR	R7202209	R43
801PDB230	R	IR	R7202309	R43
801PDB240	R	IR	R7202409	R43
809A	S	WES	809A	CF
809A51	S	WES	809A51	CF
809B	S	WES	809B	CF
809B51	S	WES	809B51	CF
809C	S	WES	809C	CF
809C51	S	WES	809C51	CF
809D	S	WES	809D	CF
809D51	S	WES	809D51	CF
809E	S	WES	809E	CF
809E51	S	WES	809E51	CF
809F	S	WES	809F	CF
809F51	S	WES	809F51	CF
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809P51	S	WES	809P51	CF
809S	S	WES	809S	CF
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809ZM51	S	WES	809ZM51	CF
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850PA80	S	IR	T920080904DW	S55
850PA100	S	IR	T920100904DW	S55
850PA110	S	IR	T920110904DW	S55
850PA120	S	IR	T920120904DW	S55
850PA130	S	IR	T920130904DW	S55
850PA140	S	IR	T920140904DW	S55
850PA150	S	IR	T920150904DW	S55
850PA160	S	IR	T920160904DW	S55
850PK50	S	IR	T920050904DW	S55
850PK60	S	IR	T920060904DW	S55
850PK80	S	IR	T920080904DW	S55
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850PK160	S	IR	T920160904DW	S55
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900PB80	S	IR	T920080904DW	S55
900PB100	S	IR	T920100904DW	S55
900PB110	S	IR	T920110904DW	S55
900PB120	S	IR	T920120904DW	S55
1000PA50	S	IR	T920051004DW	S55
1000PA60	S	IR	T920061004DW	S55
1000PA100	S	IR	T920101004DW	S55
1000PA110	S	IR	T920111004DW	S55
1000PA120	S	IR	T920121004DW	S55
1000PA130	S	IR	T920131004DW	S55
1000PA140	S	IR	T920141004DW	S55
1000PA150	S	IR	T920151004DW	S55
1000PA160	S	IR	T920161004DW	S55
1000PK50	S	IR	T920051004DW	S55
1000PK60	S	IR	T920061004DW	S55
1000PK80	S	IR	T920081004DW	S55
1000PK100	S	IR	T920101004DW	S55
1000PK110	S	IR	T920111004DW	S55
1000PK120	S	IR	T920121004DW	S55
1000PK130	S	IR	T920131004DW	S55
1000PK140	S	IR	T920141004DW	S55
1000PK150	S	IR	T920151004DW	S55
1000PK160	S	IR	T920161004DW	S55
1200PN120	S	IR	TA20121204DY	S67
1200PN130	S	IR	TA20131204DY	S67
1200PN140	S	IR	TA20141204DY	S67
1200PN150	S	IR	TA20151204DY	S67
1200PN160	S	IR	TA20161204DY	S67
1200PN170	S	IR	TA20171204DY	S67
1200PN180	S	IR	TA20181204DY	S67
1200PN190	S	IR	TA20191204DY	S67
1200PN200	S	IR	TA20201204DY	S67
1200PN210	S	IR	TA20211204DY	S67
1200PN220	S	IR	TA20221204DY	S67
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1561-XX04	T	WES	1561-XX04	CF
1561-XX08	T	WES	1561-XX08	CF
1561-XX10	T	WES	1561-XX10	CF
1561-XX15	T	WES	1561-XX15	CF
1571-XX20	T	WES	1571-XX20	CF
1571-XX25	T	WES	1571-XX25	CF
1600PN120	S	IR	CF	CF
1600PN130	S	IR	CF	CF
1600PN140	S	IR	CF	CF
1600PN150	S	IR	CF	CF
1600PN160	S	IR	CF	CF
1601PDK120	R	IR	R9201216	R47
1601PDK140	R	IR	R9201416	R47
1601PDK160	R	IR	R9201616	R47
1601PDK180	R	IR	R9201816	R47
1601PDK200	R	IR	R9202016	R47
1601PDK220	R	IR	R9202216	R47
1601PDK240	R	IR	SO	CF
1601PDK250	R	IR	SO	CF
2001PD60	R	IR	R9200620	R47
2001PD80	R	IR	R9200820	R47
2001PD100	R	IR	R9201020	R47
2001PD120	R	IR	R9201220	R47
2001PD140	R	IR	R9201420	R47
2001PD160	R	IR	R9201620	R47
2001PDK60	R	IR	R9200620	R47
2001PDK80	R	IR	R9200820	R47

Note: Manufacturer's Codes, Product Type Notes and Ⓦ Replacement Notes are listed on page G3

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GENERAL

Part Number	Type	Mfgr.	Suggested Ⓦ Replacement	Page
2001PDK100	R	IR	R9201020	R47
2001PDK120	R	IR	R9201220	R47
2001PDK140	R	IR	R9201420	R47
2001PDK160	R	IR	R9201620	R47
2181B	S	WES	2181B	CF
2181D	S	WES	2181D	CF
2181F	S	WES	2181F	CF
2181H	S	WES	2181H	CF
2181K	S	WES	2181K	CF
2181M	S	WES	2181M	CF
2181P	S	WES	2181P	CF
2181S	S	WES	2181S	CF
2181V	S	WES	2181V	CF
2181Z	S	WES	2181Z	CF
2182B	S	WES	2182B	CF
2182D	S	WES	2182D	CF
2182F	S	WES	2182F	CF
2182H	S	WES	2182H	CF
2182K	S	WES	2182K	CF
2182M	S	WES	2182M	CF
2182P	S	WES	2182P	CF
2182S	S	WES	2182S	CF
2182V	S	WES	2182V	CF
2182Z	S	WES	2182Z	CF
2182ZD	S	WES	2182ZD	CF
2191A	S	WES	2191A	CF
2191A51	S	WES	2191A51	CF
2191B	S	WES	2191B	CF
2191B51	S	WES	219B51	CF
2191D	S	WES	2191D	CF
2191D51	S	WES	2191D51	CF
2191F	S	WES	2191F	CF
2191F51	S	WES	2191F51	CF
2191H	S	WES	2191H	CF
2191H51	S	WES	2191H51	CF
2191K	S	WES	2191K	CF
2191K51	S	WES	2191K51	CF
2191M	S	WES	2191M	CF
2191M51	S	WES	2191M51	CF
2191P	S	WES	2191P	CF
2191P51	S	WES	2191P51	CF
2191S	S	WES	2191S	CF
2191S51	S	WES	2191S51	CF
2191V	S	WES	2191V	CF
2191V51	S	WES	2191V51	CF
2191Z	S	WES	2191Z	CF
2191Z51	S	WES	2191Z51	CF
2192A	S	WES	2192A	CF
2192A51	S	WES	2192A51	CF
2192B	S	WES	2192B	CF
2192B51	S	WES	2192B51	CF
2192D	S	WES	2192D	CF
2192D51	S	WES	2192D51	CF
2192F	S	WES	2192F	CF
2192F51	S	WES	2192F51	CF
2192H	S	WES	2192H	CF
2192H51	S	WES	2192H51	CF
2192K	S	WES	2192K	CF
2192K51	S	WES	2192K51	CF
2192M	S	WES	2192M	CF
2192M51	S	WES	2192M51	CF
2192P	S	WES	2192P	CF
2192P51	S	WES	2192P51	CF
2192S	S	WES	2192S	CF
2192S51	S	WES	2192S51	CF
2192V	S	WES	2192V	CF
2192V51	S	WES	2192V51	CF
2192Z	S	WES	2192Z	CF
2192Z51	S	WES	2192Z51	CF
2193A	S	WES	2193A	CF
2193B	S	WES	2193B	CF
2193D	S	WES	2193D	CF
2193F	S	WES	2193F	CF
2193H	S	WES	2193H	CF
2193K	S	WES	2193K	CF
2193M	S	WES	2193M	CF
2193P	S	WES	2193P	CF
2193S	S	WES	2193S	CF
2193V	S	WES	2193V	CF
2193Z	S	WES	2193Z	CF
2201A	S	WES	2201A	CF
2201B	S	WES	2201B	CF
2201D	S	WES	2201D	CF
2201F	S	WES	2201F	CF
2201H	S	WES	2201H	CF
2201K	S	WES	2201K	CF
2201M	S	WES	2201M	CF
2201P	S	WES	2201P	CF
2201S	S	WES	2201S	CF
2201V	S	WES	2201V	CF
2201Z	S	WES	2201Z	CF
2201ZB	S	WES	2201ZB	CF
2201ZD	S	WES	2201ZD	CF
2202A	S	WES	2202A	CF
2202B	S	WES	2202B	CF
2202D	S	WES	2202D	CF
2202F	S	WES	2202F	CF
2202H	S	WES	2202H	CF
2202K	S	WES	2202K	CF
2202M	S	WES	2202M	CF
2202P	S	WES	2202P	CF
2202S	S	WES	2202S	CF
2202V	S	WES	2202V	CF
2202Z	S	WES	2202Z	CF
2202ZB	S	WES	2202ZB	CF
2202ZD	S	WES	2202ZD	CF
2231A	S	WES	2231A	CF
2231B	S	WES	2231B	CF
2231D	S	WES	2231D	CF
2231F	S	WES	2231F	CF
2231H	S	WES	2231H	CF
2231K	S	WES	2231K	CF
2231M	S	WES	2231M	CF
2231P	S	WES	2231P	CF
2231S	S	WES	2231S	CF
2231V	S	WES	2231V	CF
2231Z	S	WES	2231Z	CF
2231ZB	S	WES	2231ZB	CF
2231ZD	S	WES	2231ZD	CF
2232A	S	WES	2232A	CF
2232B	S	WES	2232B	CF
2232D	S	WES	2232D	CF
2232F	S	WES	2232F	CF
2232H	S	WES	2232H	CF
2232K	S	WES	2232K	CF
2232M	S	WES	2232M	CF
2232P	S	WES	2232P	CF
2232S	S	WES	2232S	CF
2232V	S	WES	2232V	CF
2232Z	S	WES	2232Z	CF
2232ZB	S	WES	2232ZB	CF
2232ZD	S	WES	2232ZD	CF
2241B	S	WES	2241B	CF
2241D	S	WES	2241D	CF
2241F	S	WES	2241F	CF
2241H	S	WES	2241H	CF
2241K	S	WES	2241K	CF
2241M	S	WES	2241M	CF
2241P	S	WES	2241P	CF
2241S	S	WES	2241S	CF
2241V	S	WES	2241V	CF
2241Z	S	WES	2241Z	CF
2242B	S	WES	2242B	CF
2242D	S	WES	2242D	CF
2242F	S	WES	2242F	CF
2242H	S	WES	2242H	CF
2242K	S	WES	2242K	CF
2242M	S	WES	2242M	CF
2242P	S	WES	2242P	CF
2242S	S	WES	2242S	CF
2242V	S	WES	2242V	CF
2242Z	S	WES	2242Z	CF
2242ZD	S	WES	2242ZD	CF
2248B	S	WES	2248B	CF
2248D	S	WES	2248D	CF
2248F	S	WES	2248F	CF
2248H	S	WES	2248H	CF
2248K	S	WES	2248K	CF
2248M	S	WES	2248M	CF
2248P	S	WES	2248P	CF
2248S	S	WES	2248S	CF
2248V	S	WES	2248V	CF
2248Z	S	WES	2248Z	CF
2248ZD	S	WES	2248ZD	CF
2271B	S	WES	2271B	CF
2271D	S	WES	2271D	CF
2271F	S	WES	2271F	CF
2271H	S	WES	2271H	CF
2271K	S	WES	2271K	CF
2271M	S	WES	2271M	CF
2271P	S	WES	2271P	CF
2271S	S	WES	2271S	CF
2271V	S	WES	2271V	CF
2271Z	S	WES	2271Z	CF
2272B	S	WES	2272B	CF
2272D	S	WES	2272D	CF
2272F	S	WES	2272F	CF
2272H	S	WES	2272H	CF
2272K	S	WES	2272K	CF
2272M	S	WES	2272M	CF
2272P	S	WES	2272P	CF
2272S	S	WES	2272S	CF
2272V	S	WES	2272V	CF
2272Z	S	WES	2272Z	CF
2272ZD	S	WES	2272ZD	CF
2291B	S	WES	2291B	CF
2291D	S	WES	2291D	CF
2291F	S	WES	2291F	CF
2291H	S	WES	2291H	CF
2291K	S	WES	2291K	CF
2291M	S	WES	2291M	CF
2291P	S	WES	2291P	CF
2291S	S	WES	2291S	CF
2291V	S	WES	2291V	CF
2291Z	S	WES	2291Z	CF
2292B	S	WES	2292B	CF
2292D	S	WES	2292D	CF
2292F	S	WES	2292F	CF
2292H	S	WES	2292H	CF
2292K	S	WES	2292K	CF
2292M	S	WES	2292M	CF
2292P	S	WES	2292P	CF
2292S	S	WES	2292S	CF
2292V	S	WES	2292V	CF
2292Z	S	WES	2292Z	CF
2292ZD	S	WES	2292ZD	CF
2501B	S	WES	2501B	CF
2501D	S	WES	2501D	CF
2501F	S	WES	2501F	CF
2501H	S	WES	2501H	CF
2501K	S	WES	2501K	CF
2501M	S	WES	2501M	CF
2502B	S	WES	2502B	CF
2502D	S	WES	2502D	CF
2502F	S	WES	2502F	CF
2502H	S	WES	2502H	CF
2502K	S	WES	2502K	CF
2502M	S	WES	2502M	CF
2502P	S	WES	2502P	CF
2502S	S	WES	2502S	CF
2503B	S	WES	2503B	CF
2503D	S	WES	2503D	CF
2503F	S	WES	2503F	CF
2503H	S	WES	2503H	CF
2503K	S	WES	2503K	CF
2503M	S	WES	2503M	CF
2503P	S	WES	2503P	CF
2503S	S	WES	2503S	CF
2503V	S	WES	2503V	CF
2503Z	S	WES	2503Z	CF
2503ZD	S	WES	2503ZD	CF
2503ZH	S	WES	2503ZH	CF
2505B	S	WES	2505B	CF
2505D	S	WES	2505D	CF
2505F	S	WES	2505F	CF
2505H	S	WES	2505H	CF
2505K	S	WES	2505K	CF
2505M	S	WES	2505M	CF
2505P	S	WES	2505P	CF
2505S	S	WES	2505S	CF
2505V	S	WES	2505V	CF
2505Z	S	WES	2505Z	CF
2511B	S	WES	2511B	CF
2511D	S	WES	2511D	CF
2511F	S	WES	2511F	CF
2511H	S	WES	2511H	CF
2511K	S	WES	2511K	CF
2511M	S	WES	2511M	CF
2511P	S	WES	2511P	CF
2511S	S	WES	2511S	CF
2511V	S	WES	2511V	CF
2511Z	S	WES	2511Z	CF
2512A	S	WES	2512A	CF
2512B	S	WES	2512B	CF
2512D	S	WES	2512D	CF

Note: Manufacturer's Codes, Product Type Notes and Ⓦ Replacement Notes are listed on page G3

Assemblies, Rectifiers, Thyristors, & Transistors
MASTER CROSS REFERENCE TYPE NUMBER INDEX
JEDEC and Industry Part Numbers

Part Number	Type	Mfgr.	Suggested Ⓦ Replacement	Page
2512F	S	WES	2512F	CF
2512H	S	WES	2512H	CF
2512K	S	WES	2512K	CF
2512M	S	WES	2512M	CF
2512P	S	WES	2512P	CF
2512S	S	WES	2512S	CF
2512V	S	WES	2512V	CF
2512Z	S	WES	2512Z	CF
2513B	S	WES	2513B	CF
2513D	S	WES	2513D	CF
2513F	S	WES	2513F	CF
2513H	S	WES	2513H	CF
2513K	S	WES	2513K	CF
2513M	S	WES	2513M	CF
2513P	S	WES	2513P	CF
2513S	S	WES	2513S	CF
2513V	S	WES	2513V	CF
2513Z	S	WES	2513Z	CF
2513ZB	S	WES	2513ZB	CF
2513ZD	S	WES	2513ZD	CF
2515B	S	WES	2515B	CF
2515D	S	WES	2515D	CF
2515H	S	WES	2515H	CF
2515K	S	WES	2515K	CF
2515M	S	WES	2515M	CF
2515P	S	WES	2515P	CF
2515S	S	WES	2515S	CF
2515V	S	WES	2515V	CF
2515Z	S	WES	2515Z	CF
2541A	S	WES	2541A	CF
2541A51	S	WES	2541A51	CF
2541B	S	WES	2541B	CF
2541B51	S	WES	2541B51	CF
2541D	S	WES	2541D	CF
2541D51	S	WES	2541D51	CF
2541F	S	WES	2541F	CF
2541F51	S	WES	2541F51	CF
2541H	S	WES	2541H	CF
2541H51	S	WES	2541H51	CF
2541K	S	WES	2541K	CF
2541K51	S	WES	2541K51	CF
2541M	S	WES	2541M	CF
2541M51	S	WES	2541M51	CF
2541P	S	WES	2541P	CF
2541P51	S	WES	2541P51	CF
2541S	S	WES	2541S	CF
2541S51	S	WES	2541S51	CF
2541V	S	WES	2541V	CF
2541V51	S	WES	2541V51	CF
2541Z	S	WES	2541Z	CF
2541Z51	S	WES	2541Z51	CF
2542A	S	WES	2542A	CF
2542A51	S	WES	2542A51	CF
2542B	S	WES	2542B	CF
2542B51	S	WES	2542B51	CF
2542D	S	WES	2542D	CF
2542D51	S	WES	2542D51	CF
2542F	S	WES	2542F	CF
2542F51	S	WES	2542F51	CF
2542H	S	WES	2542H	CF
2542H51	S	WES	2542H51	CF
2542K	S	WES	2542K	CF
2542K51	S	WES	2542K51	CF
2542M	S	WES	2542M	CF
2542M51	S	WES	2542M51	CF
2542P	S	WES	2542P	CF
2542P51	S	WES	2542P51	CF
2542S	S	WES	2542S	CF
2542S51	S	WES	2542S51	CF
2542V	S	WES	2542V	CF
2542V51	S	WES	2542V51	CF
2542Z	S	WES	2542Z	CF
2542Z51	S	WES	2542Z51	CF
2543A	S	WES	2543A	CF
2543A51	S	WES	2543A51	CF
2543B	S	WES	2543B	CF
2543B51	S	WES	2543B51	CF
2543D	S	WES	2543D	CF
2543D51	S	WES	2543D51	CF
2543F	S	WES	2543F	CF
2543F51	S	WES	2543F51	CF
2543H	S	WES	2543H	CF
2543H51	S	WES	2543H51	CF
2543K	S	WES	2543K	CF
2543K51	S	WES	2543K51	CF

Part Number	Type	Mfgr.	Suggested Ⓦ Replacement	Page
2543M	S	WES	2543M	CF
2543M51	S	WES	2543M51	CF
2543P	S	WES	2543P	CF
2543P51	S	WES	2543P51	CF
2543S	S	WES	2543S	CF
2543S51	S	WES	2543S51	CF
2601B	S	WES	2601B	CF
2601D	S	WES	2601D	CF
2601F	S	WES	2601F	CF
2601H	S	WES	2601H	CF
2601K	S	WES	2601K	CF
2601M	S	WES	2601M	CF
2601P	S	WES	2601P	CF
2601PDN120	R	IR	CF	CF
2601PDN140	R	IR	CF	CF
2601PDN160	R	IR	CF	CF
2601PDN180	R	IR	CF	CF
2601PDN200	R	IR	CF	CF
2601PDN220	R	IR	CF	CF
2601PDN240	R	IR	CF	CF
2601PDN250	R	IR	CF	CF
2601S	S	WES	2601S	CF
2601V	S	WES	2601V	CF
2601Z	S	WES	2601Z	CF
2602B	S	WES	2602B	CF
2602D	S	WES	2602D	CF
2602F	S	WES	2602F	CF
2602H	S	WES	2602H	CF
2602K	S	WES	2602K	CF
2602M	S	WES	2602M	CF
2602P	S	WES	2602P	CF
2602S	S	WES	2602S	CF
2602V	S	WES	2602V	CF
2602Z	S	WES	2602Z	CF
2605B	S	WES	2605B	CF
2605D	S	WES	2605D	CF
2605F	S	WES	2605F	CF
2605H	S	WES	2605H	CF
2605K	S	WES	2605K	CF
2605M	S	WES	2605M	CF
2605P	S	WES	2605P	CF
2605S	S	WES	2605S	CF
2605V	S	WES	2605V	CF
2605Z	S	WES	2605Z	CF
2611B	S	WES	2611B	CF
2611B	S	WES	2611B	CF
2611D	S	WES	2611D	CF
2611F	S	WES	2611F	CF
2611H	S	WES	2611H	CF
2611K	S	WES	2611K	CF
2611M	S	WES	2611M	CF
2611P	S	WES	2611P	CF
2611S	S	WES	2611S	CF
2611V	S	WES	2611V	CF
2611Z	S	WES	2611Z	CF
2612B	S	WES	2612B	CF
2612D	S	WES	2612D	CF
2612F	S	WES	2612F	CF
2612H	S	WES	2612H	CF
2612K	S	WES	2612K	CF
2612M	S	WES	2612M	CF
2612P	S	WES	2612P	CF
2612S	S	WES	2612S	CF
2612V	S	WES	2612V	CF
2612Z	S	WES	2612Z	CF
2612ZD	S	WES	2612ZD	CF
2615B	S	WES	2615B	CF
2615D	S	WES	2615D	CF
2615F	S	WES	2615F	CF
2615H	S	WES	2615H	CF
2615K	S	WES	2615K	CF
2615M	S	WES	2615M	CF
2615P	S	WES	2615P	CF
2615S	S	WES	2615S	CF
2615V	S	WES	2615V	CF
2615Z	S	WES	2615Z	CF
2631B	S	WES	2631B	CF
2631D	S	WES	2631D	CF
2631F	S	WES	2631F	CF
2631H	S	WES	2631H	CF
2631K	S	WES	2631K	CF
2631M	S	WES	2631M	CF
2631P	S	WES	2631P	CF
2631S	S	WES	2631S	CF
2632B	S	WES	2632B	CF
2632D	S	WES	2632D	CF

Part Number	Type	Mfgr.	Suggested Ⓦ Replacement	Page
2632F	S	WES	2632F	CF
2632H	S	WES	2632H	CF
2632K	S	WES	2632K	CF
2632M	S	WES	2632M	CF
2632P	S	WES	2632P	CF
2632S	S	WES	2632S	CF
2632V	S	WES	2632V	CF
2721A	S	WES	2721A	CF
2721B	S	WES	2721B	CF
2721D	S	WES	2721D	CF
2721F	S	WES	2721F	CF
2721H	S	WES	2721H	CF
2721K	S	WES	2721K	CF
2721M	S	WES	2721M	CF
2721P	S	WES	2721P	CF
2721S	S	WES	2721S	CF
2721V	S	WES	2721V	CF
2721Z	S	WES	2721Z	CF
2722A	S	WES	2722A	CF
2722B	S	WES	2722B	CF
2722D	S	WES	2722D	CF
2722F	S	WES	2722F	CF
2722H	S	WES	2722H	CF
2722K	S	WES	2722K	CF
2722M	S	WES	2722M	CF
2722P	S	WES	2722P	CF
2722S	S	WES	2722S	CF
2722V	S	WES	2722V	CF
2722Z	S	WES	2722Z	CF
2722ZD	S	WES	2722ZD	CF
2731A	S	WES	2731A	CF
2731B	S	WES	2731B	CF
2731D	S	WES	2731D	CF
2731F	S	WES	2731F	CF
2731H	S	WES	2731H	CF
2731K	S	WES	2731K	CF
2731M	S	WES	2731M	CF
2731P	S	WES	2731P	CF
2731S	S	WES	2731S	CF
2731V	S	WES	2731V	CF
2731Z	S	WES	2731Z	CF
2731ZD	S	WES	2731ZD	CF
2732A	S	WES	2732A	CF
2732B	S	WES	2732B	CF
2732D	S	WES	2732D	CF
2732F	S	WES	2732F	CF
2732H	S	WES	2732H	CF
2732K	S	WES	2732K	CF
2732M	S	WES	2732M	CF
2732P	S	WES	2732P	CF
2732S	S	WES	2732S	CF
2732V	S	WES	2732V	CF
2732Z	S	WES	2732Z	CF
2732ZD	S	WES	2732ZD	CF
2761B	S	WES	2761B	CF
2761D	S	WES	2761D	CF
2761F	S	WES	2761F	CF
2761H	S	WES	2761H	CF
2761K	S	WES	2761K	CF
2761M	S	WES	2761M	CF
2761P	S	WES	2761P	CF
2761S	S	WES	2761S	CF
2761V	S	WES	2761V	CF
2761Z	S	WES	2761Z	CF
2762A	S	WES	2762A	CF
2762B	S	WES	2762B	CF
2762D	S	WES	2762D	CF
2762F	S	WES	2762F	CF
2762H	S	WES	2762H	CF
2762K	S	WES	2762K	CF
2762M	S	WES	2762M	CF
2762P	S	WES	2762P	CF
2762S	S	WES	2762S	CF
2762V	S	WES	2762V	CF
2762Z	S	WES	2762Z	CF
2762ZD	S	WES	2762ZD	CF
2781A	S	WES	2781A	CF
2781B	S	WES	2781B	CF
2781D	S	WES	2781D	CF
2781F	S	WES	2781F	CF
2781H	S	WES	2781H	CF
2781K	S	WES	2781K	CF
2781M	S	WES	2781M	CF
2781P	S	WES	2781P	CF
2781S	S	WES	2781S	CF

Note: Manufacturer's Codes, Product Type Notes and Ⓦ Replacement Notes are listed on page G3

Part Number	Type	Mfgr.	Suggested Ⓦ Replacement	Page
2781V	S	WES	2781V	CF
2781Z	S	WES	2781Z	CF
2782A	S	WES	2782A	CF
2782B	S	WES	2782B	CF
2782D	S	WES	2782D	CF
2782F	S	WES	2782F	CF
2782H	S	WES	2782H	CF
2782K	S	WES	2782K	CF
2782M	S	WES	2782M	CF
2782P	S	WES	2782P	CF
2782S	S	WES	2782S	CF
2782V	S	WES	2782V	CF
2782Z	S	WES	2782Z	CF
2782ZD	S	WES	2782ZD	CF
3001PDN60	R	IR	CF	CF
3001PDN80	R	IR	CF	CF
3001PDN100	R	IR	CF	CF
3001PDN120	R	IR	CF	CF
3001PDN140	R	IR	CF	CF
3001PDN160	R	IR	CF	CF
40108	R	RCA	IN1199A	R13
40108R	R	RCA	IN1199AR	R13
40109	R	RCA	IN1200A	R13
40109R	R	RCA	IN1200AR	R13
40110	R	RCA	IN1202A	R13
40110R	R	RCA	IN1202AR	R13
40111	R	RCA	IN1203A	R13
40111R	R	RCA	IN1203AR	R13
40112	R	RCA	IN1204A	R13
40112R	R	RCA	IN1204AR	R13
40113	R	RCA	IN1205A	R13
40113R	R	RCA	IN1205AR	R13
40114	R	RCA	IN1206A	R13
40114R	R	RCA	IN1206AR	R13
40115	R	RCA	IN3671A	R13
40115R	R	RCA	IN3671AR	R13
40208	R	RCA	IN1191	R15
40208R	R	RCA	IN1191R	R15
40209	R	RCA	IN1192	R15
40209R	R	RCA	IN1192R	R15
40210	R	RCA	IN1194	R15
40210R	R	RCA	IN1194R	R15
40211	R	RCA	IN1195	R15
40211R	R	RCA	IN1195R	R15
40212	R	RCA	IN1196	R15
40212R	R	RCA	IN1196R	R15
40213	R	RCA	IN1197	R15
40213R	R	RCA	IN1197R	R15
40214	R	RCA	IN1198	R15
40214R	R	RCA	IN1198R	R15
40741	S	RCA	T400011008	S13
40742	S	RCA	T400021008	S13
40743	S	RCA	T400031008	S13
40754	S	RCA	T400011608	S13
40755	S	RCA	T400021608	S13
40756	S	RCA	T400061608	S13
40757	S	RCA	T400041608	S13
40956	R	RCA	IN1183A	R15
40956R	R	RCA	IN1183AR	R15
40957	R	RCA	IN1184A	R15
40957R	R	RCA	IN1184AR	R15
40958	R	RCA	IN1186A	R15
40958R	R	RCA	IN1186AR	R15
40959	R	RCA	IN1188A	R15
40959R	R	RCA	IN1188AR	R15
40960	R	RCA	IN1190A	R15
40960R	R	RCA	IN1190AR	R15
43879	R	RCA	IN3879	R55
43879R	R	RCA	IN3879R	R55
43880	R	RCA	IN3880	R55
43880R	R	RCA	IN3880R	R55
43881	R	RCA	IN3881	R55
43881R	R	RCA	IN3881R	R55
43882	R	RCA	IN3882	R55
43882R	R	RCA	IN3882R	R55
43883	R	RCA	IN3883	R55
43883R	R	RCA	IN3883R	R55
43884	R	RCA	R3020606	R55
43884R	R	RCA	R3030606	R55
43889	R	RCA	IN3889	R55
43889R	R	RCA	IN3889R	R55
43890	R	RCA	IN3890	R55
43890R	R	RCA	IN3890R	R55
43891	R	RCA	IN3891	R55
43891R	R	RCA	IN3891R	R55
43892	R	RCA	IN3892	R55
43892R	R	RCA	IN3892R	R55
43893	R	RCA	IN3893	R55
43893R	R	RCA	IN3893R	R55
43894	R	RCA	R3020612	R55
43894R	R	RCA	R3030612	R55
43899	R	RCA	IN3899	R57
43899R	R	RCA	IN3899R	R57
43900	R	RCA	IN3900	R57
43900R	R	RCA	IN3900R	R57
43901	R	RCA	IN3901	R57
43901R	R	RCA	IN3901R	R57
43902	R	RCA	IN3902	R57
43902R	R	RCA	IN3902R	R57
43903	R	RCA	IN3903	R57
43903R	R	RCA	IN3903R	R57
43904	R	RCA	R4020620	R57
43904R	R	RCA	R4030620	R57

Note: Manufacturer's Codes, Product Type Notes and Ⓦ Replacement Notes are listed on page G3

Power Semiconductor Products
Selling Policy
Assemblies, Rectifiers, Thyristors, & Transistors

54-000

GENERAL

Acceptance of Orders

The conditions stated below shall take precedence over any conditions which may appear on your standard form, and no provisions or conditions of such form, except as expressly stated herein shall be binding on Westinghouse. Notice of objection to any additional or different terms is hereby given.©

Order Entry

Send all orders for quantities shown in PL 54-020 to our authorized full line Westinghouse distributor. Orders for larger quantities may go to:

Westinghouse Electric Corporation
Semiconductor Division
Youngwood, Pennsylvania 15697
Telephone: 412-925-7272
TWX: 510-468-2840

Standard Conditions of Sale

Price Policy

Prices are firm for orders specifying delivery within six months from acceptance of order by Westinghouse. Shipments scheduled beyond six months from order acceptance, or held or postponed beyond such six months at the request of buyer, are subject to price adjustment to price in effect at time of shipment. Such adjustment will not apply to products scheduled for shipment within thirty days of the date of notification to buyer of the price adjustment.

Minimum Billing

The minimum order shall be **$250.00** plus transportation charges.

Taxes

The prices do not include any Federal, State or Local property, license, privilege, sales, use, excise, gross receipts or other like taxes which may now or hereafter be applicable to, measured by or imposed upon or with respect to the transaction, the property, its sale, its value or its use, or any services performed in connection therewith. Purchaser agrees to pay or reimburse any such taxes which Westinghouse or Westinghouse's subcontractors or suppliers are required to pay.

Terms of Payment

Terms of payment are net within 30 days from date of shipment.

Payments

If, in the judgment of Westinghouse, the financial condition of the purchaser, at any time during the manufacturing period, or at any time product is ready for shipment, does not justify the terms of payment specified, Westinghouse may require full or partial payment in advance.

Delivery

F.O.B.-P.S.-Frt./Coll. (Transportation charges, not allowed). This product is delivered Free on Board, Point of Shipment, Freight Collect (Transportation Charges not allowed).

Loss, Damage, or Delay

Westinghouse shall not be liable for failure to perform or for delay in performance due to fire, flood, strike or other labor difficulty, act of any governmental authority or of the purchaser, riot, embargo, car shortage, wrecks or delay in transportation, inability to obtain necessary labor, materials, or manufacturing facilities from usual sources or due to any other cause beyond its reasonable control.

In the event of delay in performance due to any such cause, the date of delivery or time for completion will be postponed by such length of time as may be reasonably necessary to compensate for the delay.

Warranty

Lifetime Guarantee

Westinghouse warrants to the original purchaser that it will correct any defects in workmanship or material, by repair or replacement, F.O.B. factory or, at its option, issue credit at the original purchase price, for any silicon power semiconductor bearing this symbol ✚ during the life of the equipment in which it is originally installed, provided said device is used within manufacturer's published ratings and applied in accordance with good engineering practice.

Other Semiconductor Products

Westinghouse, in connection with products sold, agrees to correct any defect or defects in workmanship or material which may develop under proper or normal use during the period of one year from the date of shipment, by repair or replacement f.o.b. factory, of the defective part or parts, or, at its option, issue credit at the original purchase price.

Developmental Products

Westinghouse semiconductor products designated at the time of sale to be developmental are warranted to meet the applicable preliminary specifications in effect at time of order entry. If any failure to comply with such preliminary specifications appears within 12 months from date of shipment, Westinghouse will correct such non-compliance by repair or replacement f.o.b. factory, or, at its option, issue credit at the original purchase price.

The foregoing warranties are exclusive and in lieu of all other warranties of quality whether written, oral, or implied (including any warranty of merchantability or fitness for purpose).

Correction of non-conformities in the manner and for the periods of time specified above shall constitute fulfillment of all liabilities of Westinghouse to the purchaser whether based on contract, negligence or otherwise in respect to such products.

Limitation of Liability

Neither party shall be liable for special, indirect, incidental or consequential damages. The remedies of the purchaser set forth herein are exclusive and the liability of Westinghouse with respect to any contract or sale or anything done in connection therewith, whether in contract, or in tort (including negligence) shall not exceed the price of the equipment or part on which such liability is based.

Patents

Westinghouse shall at its own expense, defend any suits or proceedings brought against the purchaser, and/or its vendees, mediate and immediate, so far as based on an allegation that any goods, material, equipment, device or article (hereinafter referred to as product) or any part thereof furnished hereunder constitutes an infringement of any claim of any patent of the United States, other than a claim covering a process performed by said product or another product produced by said product, provided that such product is not supplied according to purchaser's design, and is used as sold by Westinghouse, if purchaser

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January 2, 1978
Supersedes Selling Policy 54-000, pages 1 and 2,
Dated February 26, 1976

Patents, Continued
shall have made all payments then due hereunder, and if Westinghouse is notified promptly in writing and given authority, information and assistance for the defense of said suit or proceeding, and Westinghouse shall pay all damages and costs awarded in any suit or proceeding so defended, provided that this indemnity shall not extend to any infringement based upon the combination of said product or any part or parts thereof with another product or things not furnished hereunder unless Westinghouse is a contributory infringer. Westinghouse shall not be responsible for any settlement of such suit or proceeding made without its written consent. In case the product or any part thereof furnished hereunder is in any suit or proceeding so defended held to constitute infringement, and its use is enjoined, Westinghouse shall, at its own option and its own expense, either procure for the purchaser the right to continue using said product or part thereof; or replace it with a non-infringing product; or modify it so it becomes non-infringing; or remove it and refund the purchase price and the transportation and installation costs thereof. The foregoing states the entire liability of Westinghouse with respect of patent infringement by said product or any part thereof.

To the extent that said product, or any part thereof, is supplied according to purchaser's design or instructions, or is modified by purchaser, or combined by purchaser with another product or things not furnished hereunder except to the extent that Westinghouse is a contributory infringer, or is used by purchaser to perform a process, or produce another product, and by reason of said design, instruction, modification, combination, performance, or production, a suit or proceeding is brought against Westinghouse, purchaser agrees to indemnify Westinghouse in the manner and to the extent Westinghouse indemnifies purchaser in the preceding paragraph insofar as the terms thereof are appropriate.

Title – Risk of Loss
The product shall remain the personal property of Westinghouse until fully paid for in cash, and the purchaser agrees to perform all acts which may be necessary to perfect and assure the retention of title to such property by Westinghouse. Risk of loss of the product, or any part of the same, shall pass to the purchaser upon delivery of such product or part, F.O.B., point of shipment.

© Changed since previous issue.

The purchaser should immediately inspect each shipment, and if there is evidence of loss or damage during transit, should file a claim against the carrier. Westinghouse may assist with such claims, but will not accept any responsibility for the claims. Any adjustments in such cases are between the purchaser and the carrier.

License Notice
The sale of any product hereunder does not convey any license, express or implied, under any patent claims on circuits, systems or processes, or on any combination of the product with other devices, elements or things.

Termination©
Any order may be terminated by the purchaser only upon payment of reasonable cancellation charges which will be determined by Westinghouse in conjunction with expenses and commitments incurred.

The minimum charge for an order which is cancelled after Engineering has been completed prior to release to Production will be $250.00, or 2% of the selling price, whichever is greater. If an order is cancelled after it has been released to Production, an additional charge will be made in proportion to the percentage of completion of the order. The additional charge will be based on material, labor, and overhead costs plus a 15% markup to compensate for disruption in scheduling, disruption in planned production, lost profit, and other indirect costs.

Returning Product
Authorization and shipping instructions for the return of any product must be obtained by the purchaser from Westinghouse before returning the product. Product must be returned with complete identification in accordance with Westinghouse instructions or it will not be accepted. Where a purchaser requests authorization to return product for reasons of his own, he will be charged for placing the returned goods in salable condition (restocking charge) and for any outgoing and incoming transportation paid by Westinghouse.

In no event will Westinghouse be responsible for product returned without proper authorization and identification.

DELIVERY LEAD TIME GUIDELINES

GENERAL

This schedule is to be used for general planning guidelines only. These typical factory lead times listed do not include order transmittal time to the semiconductor factory or shipping time to the user's plant. Please contact Westinghouse for specific requirements. Check with the local authorized distributor for off-the-shelf delivery on most rectifier, SCR, transistor, and modular rectifier assembly products.

There are several points worth noting about power semiconductors when planning for volume purchases. Semiconductors are yield dependent devices — once manufactured, if they don't meet the desired specification, they usually cannot be altered or modified. Also, ordering the highest current rating, highest voltage rating, and fastest turn-off time device in a given product family usually results in a longer lead time due to lower production yield. As with most any type of manufactured product, unforeseen delays in shipping product due to late parts delivery, parts shortages, receipt of inferior or out-of-spec component parts, can occur. The actual quantity required by the user of a given semiconductor type as well as the general market demand for the device can also affect the product's lead time. Therefore, the user should work closely with the manufacturer to assure on-time delivery of the needed semiconductors.

The best way to assure a steady flow of semiconductors into your plant is to enter a purchase order on the manufacturer with scheduled monthly releases. An alternate approach would be a purchase agreement to buy a certain number of power semiconductors (particular type) in a specified period of time. The purpose of either of these approaches is to provide the semiconductor manufacturer with better planning visibility so that the factory can match its production schedule to your actual requirements.

TYPICAL FACTORY LEAD TIMES

Data Book Location (Page Numbers)	Product Type	Current Ranges (Amperes)	Voltage Range (Volts)	Shipping Quantity	Typical Factory Lead Time (Weeks)
ASSEMBLIES					
A3,A4	Modular Rectifier	2-25	50-1000	500	1-2
A5-A36	Gold Line	12-1650	100-2000	100	4-8
A39-A44	Air Cooled Disc	197-8700	100-4000	100	4-8
A45-A51	Liquid Cooled Disc	588-13,580	100-4000	100	4-8
A52-A55	Liquid Cooled Manifold	900-2200(RMS)	1200-3000	100	4-8
A65-A66	Sinks and Kits	—	—	50	4-12
A69-A75	H.V. Stacks, Channel	.5-325	1K-688K	50	6-8
A76-A79	H.V. Stacks, Plate	6-450	2K-72K	50	6-10
RECTIFIERS		**General Purpose**			
R9-R12	Axial Lead Mount	1-6	50-1000	1000	2-4
R13,R14	Stud Mount	3-16	50-1000	500	1-2
R15-R18	Stud Mount	15-70	50-1200	500	1-2
R19-R26	Stud Mount	100-150	100-1400	100	2-4
R27-R38	Stud Mount	160-550	50-4000	100	2-4
R39-R54	Disc Mount	300-2200	100-4000	100	4-6
		Fast Recovery			
R55-R58	Stud Mount	6-30	50-600	100	2-6
R59-R66	Stud Mount	80-250	50-1600	100	4-6
R67-R78	Disc Mount	350-1400	100-3200	100	4-8
THYRISTORS		**Phase Control SCR's**			
S9-S18	Stud Mount	10-22	25-1200	100	2-4
S19-530	Stud Mount	40-80	25-1500	100	4-6
S31-S40	Stud Mount	125-350	50-2200	100	4-6
S41-S54	Disc Mount	125-550	100-2200	100	4-6
S55-S70	Disc Mount	600-1400	100-3000	100	6-8
S71,S72	Integral H.S.	300	100-2000	50	4-6
S73-S76	Flat Base	175-350	100-1600	50	4-6
		Fast Switching SCR's			
S77-S82	Stud Mount	40-325	100-1200	100	4-8
S83-S94	Disc Mount	60-900	100-2200	100	6-10
		RBDT's			
S95,S96	Stud Mount	22	600-1000	100	6-8
S97,S98	Disc Mount	125	600-1000	100	6-10
TRANSISTORS		**General Purpose**			
T5-T14	TO-66/TQ-3	.5-15*	40-150	1000	4-6
		High S.O.A.			
T15-T32	Stud Mount	1.5-25*	30-250	100	4-6
		High Power Fast Switching			
T33,T34	Stud Mount	50*	400-500	50	8-12
T33,T34	Disc Mount	50*	400-500	50	8-12

*Gain Rated Current

For volume users of high power semiconductors, Westinghouse offers a program that can help save you and your company time and money. Westinghouse will carry your safety stock, at no cost to you, in the form of a bonded element inventory selected to your specifications and with guaranteed delivery time for encapsulating these elements into any device package you desire. In addition, this program will allow Westinghouse to respond more rapidly to sudden increases in your production levels. Therefore, by letting Westinghouse carry your safety stock, you not only get a guaranteed delivery lead time, but your company realizes an improvement in its cash flow as a result of the reduction in committed captial. For fast delivery and prompt service, specify Westinghouse power semiconductors.

MILITARY and HIGH RELIABILITY PRODUCTS

GENERAL

Westinghouse has been a pioneer in the manufacture of reliable power semiconductors for both commercial and military applications worldwide. From simple conditioning tests to a full-scale high reliability test program, Westinghouse can deliver a product to meet any required level of reliability.

A complete line of high power military rectifiers are available in both standard and reverse polarity. The JAN type numbers and their respective ratings are as follows:

VOLTAGE RATING	100 Ampere/DO-8 Package MIL-S-19500/246 TYPE NUMBER	240 Ampere/DO-9 Package MIL-S-19500/211 TYPE NUMBER
200V	JAN 1N3289, R	JAN 1N3164, R
400V	JAN 1N3291, R	JAN 1N3168, R
600V	JAN 1N3293, R	JAN 1N3170, R
800V	JAN 1N3294, R	JAN 1N3172, R
1,000V	JAN 1N3295, R	JAN 1N3174, R

For copies of the military specifications, contact the Commanding Officer, Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, Pa. 15120.

Westinghouse power semiconductors have been selected for use in a variety of high reliability programs.

- NAVY NUCLEAR (SVFC)
- APOLLO
- SATURN MISSILE
- NIKE X
- BQQ SONAR
- SHILLELAGH
- AIRBORNE CAMERA SYSTEM
- MARK 46/48
- MOL PROGRAM
- AWG 10
- A.A.F.S.S.
- LEM PROJECT
- PHASE ARRAY RADAR
- SPRINT/SPARTAN (A.B.M.)
- C5A
- SEA SPARROW
- AIR LAUNCH CRUISE MISSILE
- F15, F16
- KC 135
- ARSR-3
- TPS-43
- D2W
- SST
- SQS56
- DE1160
- SIRDIPS
- TRC-170
- LORAN C
- TRIDENT SUBMARINE
- E2C RADAR

For the utmost in reliability, specify Westinghouse power semiconductors.

Application Data
MOUNTING POWER SEMICONDUCTORS
Assemblies, Rectifiers, Thyristors, and Transistors

Introduction
Semiconductor devices control large amounts of power with high efficiency and reliability. With ever-increasing circuit and device power levels, the requirement for adequate cooling of semiconductors is mandatory. The problem for the user is to properly assemble the devices into equipment without reducing their capability. Regardless of whether the device is a lead mount, stud type, flat base or disc, certain mounting procedures must be adhered to in order to get the most reliable device operation. The amount of heat involved requires proper mounting to prevent unwanted temperature rise or damage to the semiconductor. This AD sheet discusses proper mounting methods and surface preparation required for successfully applying semiconductors.

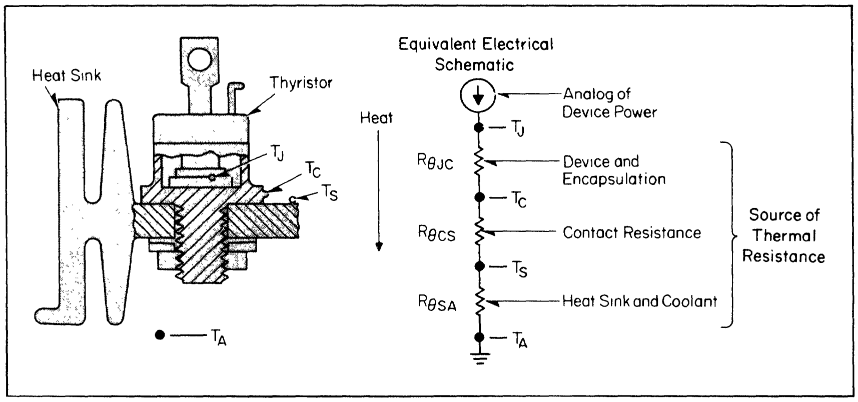

Fig. 1: Mechanical-Electrical Analog of Stud Mounted Device.

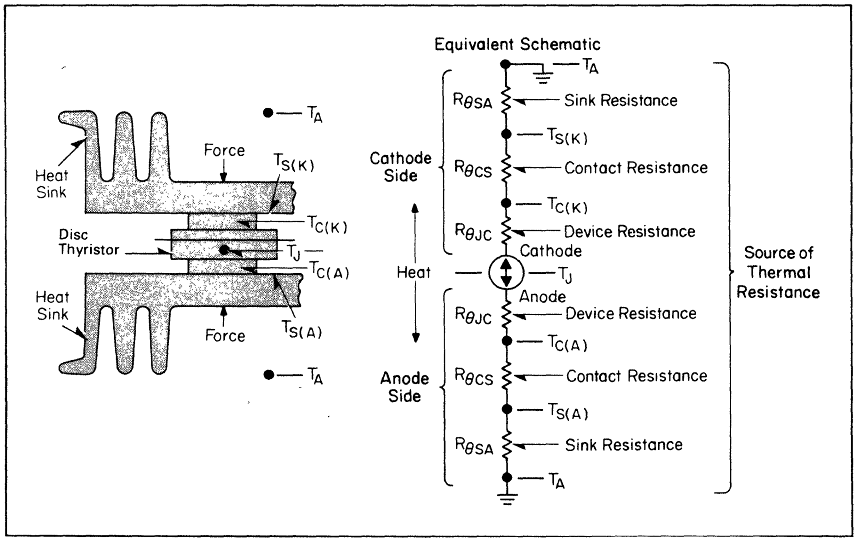

Fig. 2: Mechanical-Electrical Analog of Disc Mounted Device with Double Sided Cooling.

Thermal Resistance Analogs
Semiconductor heat flow is conveniently depicted by the thermal-electrical analog illustrated in Figures 1 and 2. These figures show the heat flow paths for the stud and disc type devices, respectively. The discussion will cover one heat flow path as in Figure 1, but apply equally to Figure 2. In the diagrams, the following quantities are analogs.

Mechanical Parameter		Analog	
T	—Temperature	**V**	—Voltage
ΔT	—Temperature Difference	**ΔV**	—Voltage Difference
***R_θ**	—Thermal Resistance	**R**	—Electrical Resistance
P	—Heat Source	**I**	—Current Source

***R_θ** —Units of °C/Watt
P —Units of Watts

Thermal losses at the junction and in device resistance must be conducted through device and package to the ambient. Under stable operating conditions, the resulting **ΔT**, between the junction and the ambient is expressed as

$$\Delta T_{JA} = P \times R_{\theta JA}$$

For stud and disc types R_θ is made up of three quantities so the thermal equation may be written:

$$\Delta T_{JA} = P(R_{\theta JC} + R_{\theta CS} + R_{\theta SA})$$

Stud type thermal resistance ($R_{\theta JC}$) is determined by device design. The heat sink thermal resistance, ($R_{\theta SA}$), is similarly fixed by the dissipator selected and the amount of coolant used. The remaining thermal resistance quantity, $R_{\theta CS}$, is the variable which should be reduced to lowest practical levels by proper mounting procedures. These procedures include preparation and treatment of the mating surfaces, use of joint compounds, and applying the required force to the mating surfaces.

When using disc devices the $R_{\theta JC}$ value is effected by how well the recommended mounting force is applied. The case to sink properties for this double side cooled device responds in the same manner described for stud type devices.

Lead mount semiconductors have their internal resistance predetermined by how well they are soldered together. The axial lead, bonded directly onto the wafer takes heat out of the body and radiates it to the surrounding ambient. A detailed thermal analysis is provided in the lead mount data sheet.

These lead mount devices are not affected by load force, and surface finish as are the higher power devices mentioned previously.

Surface Requirements
The condition of the sink mounting surface is one of the most important mounting details. The following sections describe what limits should be met on flatness and surface finish to minimize mounting resistance due to surface problems.

a. Surface Flatness
Surface flatness is specified as a total indicator reading (TIR), measuring the maximum distance between the crests and valleys of the mounting surface. The flatness of the mounting plane is referenced to the maximum deviation measured in the device mounting area.

For satisfactory mounting, the device seating area should be held from .0005 to .001 TIR. Commercial extruded heat sinks do not have comparable flatness values. In addition, cast sinks, rough plates, etc. will require additional treatment.

b. Surface Finish

A second sink condition of importance is surface finish. All surfaces have a roughness factor. This value is expressed in microinches and is the average of the deviations above and below mean value of the deviations.

In general, the surface finish should be approximately 30-60 microinches, which is the equivalent finish supplied on Westinghouse semiconductor devices. Finer finishes add undue cost and, in general, do not result in lower contact drop at the mounting interfaces.

Table 1 shows the approximate surface roughness obtainable with various production methods. Generally speaking, mill finish or machined surfaces on copper or aluminum will be satisfactory if they are flat and free from deep scratches. Castings or rough extrusions should be spotfaced to insure flatness and finish. A suitable procedure is to measure a sample surface on a production run, and if satisfactory, proceed with production based on machining techniques. Periodic sample testing will assure that tool wear, etc., is not affecting the desired values.

Table 1 Surface Texture vs. Process

All Values are in Micro-inch Average Deviation

Process	Normal Range (Min.) Average Tooling
Polish	4 to 16
Hone	4 to 32
Grind	4 to 63
Electrolytic Grind	8 to 32
Barrel Finish	8 to 32
Bore, Turn	16 to 250
Die Cast	32 to 63
Broach, Ream	32 to 125
Mill	32 to 250

Treated Mounting Surfaces

To produce a reliably low electrical and thermal resistance between the contacting surfaces it is necessary that they be free of all foreign material, oxides, and films. Freshly machined surfaces are generally free of these contaminants if used immediately. Bear in mind that freshly bared aluminum forms an oxide film in a matter of seconds. Other types of metals, such as copper and steel, oxidize more slowly.

As a precautionary measure, all mating surfaces, and particularly aluminum, should be used immediately after machining. If they are stored, a cleaning operation is good practice. A satisfactory cleaning technique is to polish the mounting area with No. 000 fine steel wool, followed by an alcohol or warm soap and water wipe.

Many aluminum heat sinks are black anodized for appearance, durability, and performance; however, anodizing is an electrical and thermal insulator which offers resistance to heat flow. Therefore, it must be removed from the mounting area. Another treated aluminum finish is irridite, or chromate acid dip, which offers low resistances because of its thin surface. But, for optimum performance, the device seating area should be spotfaced to remove the irridite finish. For economy, paint is sometimes used for sinks. When this finish is used, cleaning is mandatory, because of high thermal and electrical resistance.

Thermal Compounds

Following all the prescribed procedures previously listed, it is still possible to have air voids between mating surfaces. To optimize contacts, thermal joint compounds are used.

The formula for thermal resistance of any substance is:

$$R\theta = \rho t/A$$

where $R\theta$ = thermal resistance of the film in °C/Watt

ρ = specific thermal resistance of the film

t = average film thickness of the film in inches

A = film area in square inches

The values of ρ will vary from .10°C inches per watt for copper film to 1200°C inches per watt for air, whereas a satisfactory joint compound will have a resistivity of approximately 60°C inches/watt. Therefore, the voids, deep scratches, and imperfections which are filled with joint compound, will have a thermal resistance of about 1/20th of the original value.

Westinghouse recommends the use of Alcoa #2 electrical joint compound to fill these voids. This compound contains an active chemical in a grease type medium that dissolves the oxide film, present on most heatsink mounting surfaces, and seals the joint against moisture. Some compounds attack the surface, with localized action going relatively deep. With this compound, however, the surface is lightly etched with no deep localized attack; it attacks the oxide and not the metal.

All heat exchanging surfaces should be cleaned as mentioned previously. Apply Alcoa #2 compound to all heat exchanging surfaces sparingly with the use of a spatula or lintless brush. Another method is to place a predetermined minimal amount at or around the center of the contact area and then rotate the device back and forth while pressing it into the heat sink. In this fashion, excess compound will be forced out and may be wiped clean. Prolonged skin contact with the compound should be avoided since it does contain a fluoride base. It is recommended that after using the compound, any skin areas which were in contact with the compound should be washed clean.

Other approved thermal compounds are Dow Corning 342 available from Dow Corning Corporation in Midland, Michigan or Silicone Oil SF 1154 available from the General Electric Company.

Mounting Pressures

Optimum mounting pressures for device types have been determined by empirical tests. Based on the results of these experiments, the device tabulations were generated for Table 2. Lower than recommended torques or forces can result in overheating and higher values may result in cracked silicon or internal contact problems. For higher or lower torque and force values, contact Westinghouse.

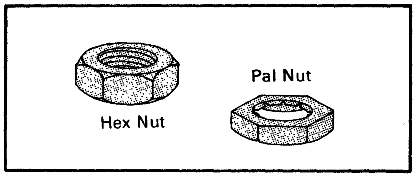

Fig. 3-A: Typical Non-insulating Hardware Kit.

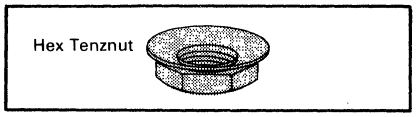

Fig. 3-B: Alternate Non-insulating Hardware.

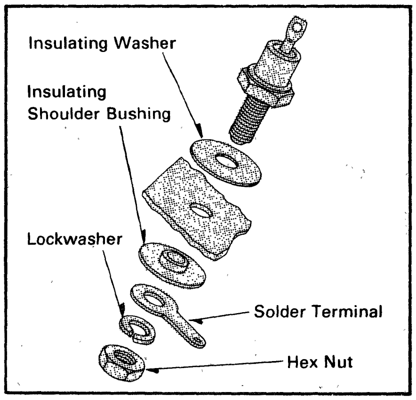

Fig. 3-C: Typical Insulating Hardware Kit Assembly.

Standard mounting hardware for stud devices includes a nut and locking washer, or a pal nut. With either combination, the nut should be carefully tightened applying the torque indicated for the type of device shown in Table 2.

An illustration of standard mounting hardware for stud devices is shown in Figure 3. Standard hardware kits are available to accomodate mounting all semiconductor types. The appropriate kit is identified by a code number as shown in the last three columns of Table 2. These codes are explained in Table 3 as to what components come in each kit.

Alcoa #2 Joint Compound is available from ... Alcoa Conducta Products Company, Division of Aluminum Company of America, Pittsburgh, Pennsylvania.

Application Data
MOUNTING POWER SEMICONDUCTORS
Assemblies, Rectifiers, Thyristors, and Transistors

Table II Semiconductor Mounting Torque, Force, and Hardware

Package Description	Package Outline	(W) /Applicable JEDEC Series Types	Mounting Torque Lb-In (N-M)	Mounting Hardware Codes		
				Non-insulating	Insulating	Tenz Nut
Stud Mount Stud Size .190-32	DO-4	**Rectifier** R302/R303/R310/R311/IN1199, A,B IN1341, A, B/IN1612/IN3615/IN3670, A IN3987/IN4458	20 (2.22)	31	32	25
.250-28	DO-5 DO-5 TO-48 MT-52	**Rectifier** R402/R403/R404/R405/R410/R411/ IN248, A,B, C/IN1183, A/IN1191, A IN2154/IN3208/IN3765 **RBDT** T40R **SCR** T400/2N681/2N1842, A **Transistor** 153/154/2N3429	30 (3.33)	14	34	37
.312-24	MT-1 MT-33	**Transistor** 151/152/2N1015/2N1016/2N2226 163/164/2N2757/2N3470	50 (5.56)	56	17	19
.375-24	DO-8	**Rectifier** R500/R501/R502/R503/R510/R511/ IN3288A/IN4587	120 (13.35)	99	—	98
.500-20	DO-30 TO-94/ TO-83	**Rectifier** R5DO/R5D1 **SCR** T500/T507/T510/2N1792/2N1909/ 2N2023/2N4361/2N4371	130 (14.46)	02	—	01
.750-16	DO-9 R70 TO-93 T70 D60	**Rectifier** R600/R601/R602/R603/R610/R611 IN2054/IN3161/IN3260/IN3735/IN4044 R700/R701 **SCR** T600/T607/T610/2N3884 T700/T707 **Transistor** D6OT	360 (40.06)	03	—	04
Diamond Base Mount	TO-66 TO-3	2N3054/2N3441 2N3055/2N3232-33/2N3236/2N3442/ 2N3771, 2, 3/2N4347-48	10 (1.11) 10 (1.11)	— —	22* 20*	— —
Axial Lead Mount	DO-41 DO-27 DO-15 ~DO-27 R34	IN4001-07 IN4816-22/IN5052-54 IN5391-99 IN5400-08 R340	Solder Leads to Terminals	None Required		
Flat Base Mount	T68 T78	T680 (2.4" Square Base) T780 (Studless)	25 (2.78) Per Bolt Spring flat and parallel to mounting plane	Four .312-24 bolts supplied by Customer 26**	 —	 —
Integral Heat-Sink Mount	T76	T760/T767	Bolt used for electrical connection only.	.5-20 Bolt supplied by customer.		

*(2) .138-40 Bolts required per device. Bolts supplied by customer.
**(2) .312-24 Bolts required per device. Bolts supplied by customer.

Table II Semiconductor Mounting Torque, Force, and Hardware (Continued)

Package Description	Package Outline	Ⓦ/Applicable JEDEC Series Types	Mounting Force LB (KN)	Mounting Hardware Codes
Disc Mount Interface Dia. In. (mm) .75 (19.05)	R62	**Rectifier** R620/R622 **RBDT** T62R	1400 (6.2)	Clamp Purchased Separately
	T52	**SCR** T520/T527	1000/4.5	
	T62	T620/T625/T627	1400 (6.2)	
	D62	**Transistor** D62T	1400 (6.2)	
1.34 (34.04)	R72	**Rectifier** R720/R722	2400 (10.7)	
	T72	**SCR** T720/T727/T72H		
1.75 (44.45)	R92	**Rectifier** R920	5500 (24.5)	
	T92	**SCR** T920		
1.90 (48.26)	R9G	R9G0/R9G2	6000 (26.7)	
	T9G	**SCR** T9G0/T9GH		
2.48 (62.99)	RA2	**Rectifier** RA20	12000 (53.4)	
	TA2	**SCR** TA20		

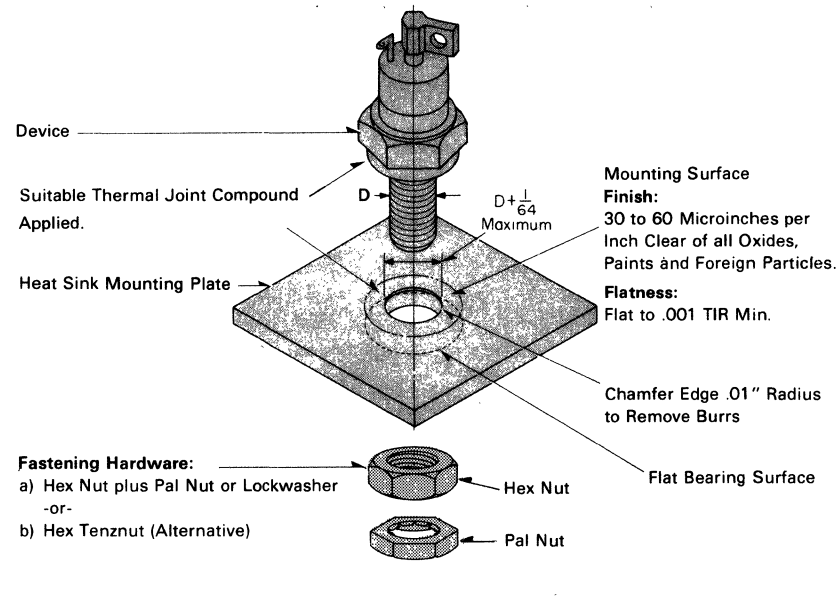

Fig. 4: Recommended Mounting Practices and Finishes for Stud Mount Devices.

Mounting of Stud Type Devices
Figure 4 presents an exploded view of a stud-type device and shows the various recommendations of surface flatness and finish. It should be noted that the diameter of the mounting hole should not exceed the diameter of the stud by more than 1/64" and that the edge of the hole should have a chamfer not exceeding .01" radius.

The fastening hardware shown consists of a nut and a locking feature, either pal nut or lock washer. Either type will work as long as proper torque is applied. It is very important to apply the torque with a good torque wrench such as those sold by P.A. Sturtevant Co. and Snap-On Tools Corporation or other reputable firms.

It should be noted that Westinghouse does not recommend as standard practice drilling and tapping holes for mounting stud type devices. This is due to the need for 1/10 of a degree perpendicularity necessary between the hole and mounting surface.

Mounting Flat-Base Devices
In mounting flat-base devices the required pressure is obtained by fastening the device corners or edges with bolts. The pressure should be applied in a staggered fashion such as tightening opposite corners to one half the

recommended torque as per Table 2 and then finally apply the necessary remaining torque in the same staggered fashion. Special "studless" devices are mounted by mounting springs as shown in Figure 5. Proper mounting pressure is applied when the spring is flat and parallel to the heat sink surface.

Mounting Discs

Disc's achieve higher current ratings due to improved heat transfer capabilities. This is made possible by two heat paths and greater heat conduction area. Since these devices are fabricated without mounting features, such as studs, plates or retainer assemblies, the devices must be mounted with external force.

The required clamping force must be applied perpendicular to the disc surfaces and should be uniformly distributed over the total contact areas. To achieve this, the clamping system must assure sink-device parallelism via appropriate clamp construction and mounting technique.

Westinghouse offers a clamp which provides uniform distribution of the required pressure. This distribution of pressure is accomplished by a ball and socket type gimbaling mechanism. The force is applied via a spring bar or bars depending on the magnitude of the force to be delivered. This clamp is available with a mechanical force gauge to acknowledge what force is applied. The stud length is variable to accomodate different lengths of clamping columns.

An exploded view of an assembly consisting of a disc type semiconductor with double side cooling and the Westinghouse clamp is shown in Figure 6.

A recommended procedure for mounting disc types is as follows:

1. Check mounting surfaces of semiconductor and heat exchanger to insure no large scratches, nicks or irregularities are present.
2. Mounting surfaces should be free of oxides, films or foreign materials in order to have good heat exchanging properties. Surfaces should be rubbed lightly with 000 steel wool and swabbed with alcohol immediately prior to assembly. Surfaces should not be touched after cleaning. Parts may be placed on a lint free surface until final assembly.
3. Pre-assemble any roll locating pins to be used with a light hammer into the center dowel hole in each heat sink if necessary. A gauge block is useful to prevent excessive length of this pin.
4. Polarity of the device should be checked prior to assembly to insure the device is installed in the desired direction.
5. For assembly the contact surfaces of the semiconductor and heat sink should be

Table III Semiconductor Mounting Hardware

CODE NUMBER	TYPE	HARDWARE DESCRIPTION
01	Tenz nut	.5-20 Nut-washer combination
02	Non-insulating	.5-20 Hex nut and pal nut
03	Non-insulating	.75-16 Hex nut and pal nut
04	Tenz nut	.75-16 Nut-washer combination
14	Non-insulating	.25-28 Hex nut and pal nut
17	Insulating	.312-24 Nut, mica washer, glass sleeve, solder lug, pal nut and shoulder bushing
19	Tenz nut	.312-24 Nut washer combination
20	Insulating	Mica sheet and (2) bushings
22	Insulating	Mica sheet and (2) bushings
25	Tenz nut	.190-32 Nut-washer combination
26	Spring bracket	Spring, spacer and safety bracket. Bolts supplied by customer
31	Non-insulating	.190-32 Nut and lock washer
32	Insulating	.190-32 Nut, shoulder bushing, mica washer, lockwasher and solder lug
34	Insulating	.25-28 Nut, shoulder bushing, mica washer, lockwasher and solder lug
37	Tenz nut	.25-28 Nut-washer combination
98	Tenz nut	.375-24 Nut-washer combination
99	Non-insulating	.375-24 Hex nut and pal nut

Note: Semiconductor Device Hardware is supplied upon request only. Most standard non-insulating hardware kits are available free of charge if specifically requested when ordering devices. Insulating kits, tenz nuts, and other special hardware kits are available at extra cost—consult factory.

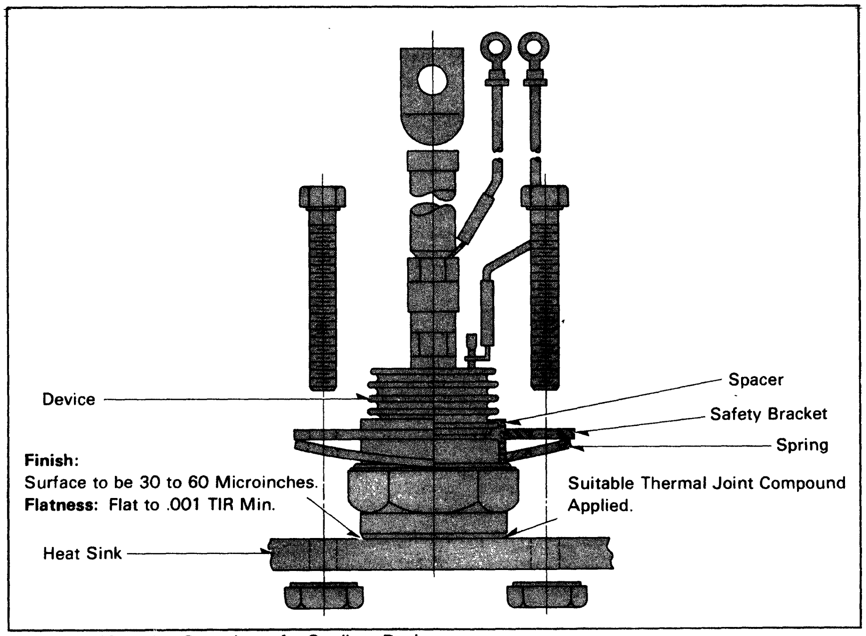

Fig. 5: Mounting Procedures for Studless Device.

Application Data
MOUNTING POWER SEMICONDUCTORS
Assemblies, Rectifiers, Thyristors, and Transistors

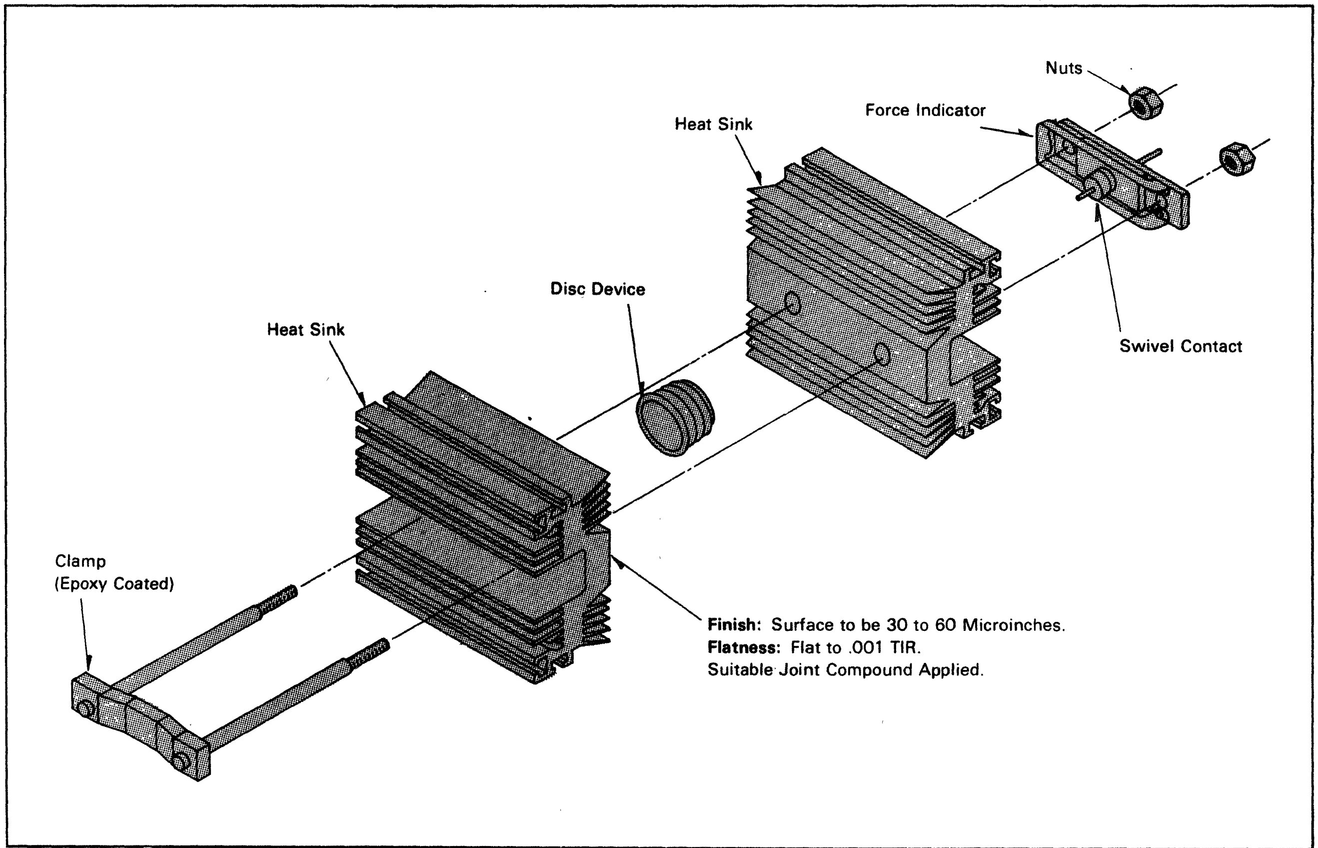

Fig. 6: Mounting Procedure For Disc Mounted Devices (Exploded View).

lightly coated with Alcoa #2 (or suitable substitute). The device should then be centered on the heat sink. If dowel pin locators are used the device should be placed with its locator holes over the projections. The device should then be rotated through 180° to distribute the compound.

6. The appropriate clamp may now be inserted through the heat sink. The clamp force bar with mechanical force gauge must be initially adjusted to give a zero force reading. The spring bar may now be placed over the studs and the centering pin located in the hole provided. The nuts may now be finger tightened, in an even fashion such that approximately the same number of threads show above each nut.
7. To achieve the correct mounting force apply either half or quarter turns per nut in a staggered fashion until the gauge indicates the correct force.

Remounting Disc Devices

In some instances devices must be replaced in the field. The procedure to be used is similar to the mounting procedure just outlined with the following additions:

1. **Removing the Device**
   Disassembly should be made by loosening the clamp nuts in a staggered fashion, i.e., one half turn from one nut, one half turn from the other, etc., until the nuts can be removed by hand.
2. **Re-Zeroing Clamp Gauge**
   Make sure that the gauge is set to zero before using again. This is done simply by bending the indicator until a zero force is indicated.
3. **Cleaning and Coating of Clamp Threads**
   While the clamp is disassembled, clean the threads with a light brushing and then wipe with a cloth. Prior to using the clamp a coating of Anti-Seize or Never-Seez non-galling compound should be applied to the threads.

WARNING:
Due to the high load forces placed on these clamps breakage could occur when torsional force is being applied to the threads resulting in the broken bolt becoming a flying projectile. Safety precautions must be taken to prevent bodily harm.

As indicated earlier, proper device loading is necessary to guarantee good thermal performance. With disc devices power dissipating properties are also affected by loading effectiveness. Figures 7a and 7b illustrate the typical effect of mounting force on thermal performance and device forward voltage drop for discs.

Parallel Mounting of Disc Devices

For applications requiring greater current output than can be obtained from one device, two or more devices can be readily paralleled. It is necessary, however, to take simple precautions to allow for possible variations in height of the devices. A rigid heat sink may be used and will serve as a base for the units to be paralleled, but the other side of the devices should be cooled by individual heat sinks. Individual clamps are required for each device to provide the required pressure.

Stack Mounting of Disc Devices

The flat symmetrical design of the disc package permits stacking the devices to obtain a number of circuit configurations. A single clamping device can be used with the length of bolt adjusted to clamp the total

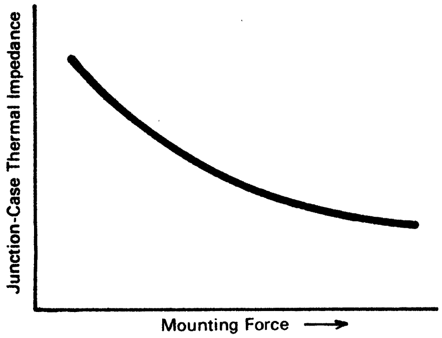

Fig. 7A: Typical Junction-Case Thermal Impedance Variation as a Function of Mounting Force for Disc Type Devices.

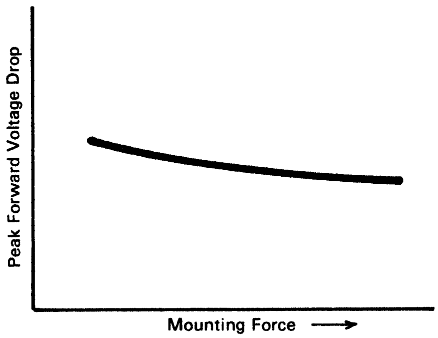

Fig. 7B: Typical Forward Voltage Drop Variation as a Function of Mounting Force For Disc Type Devices.

length of the stack. The limit of stacking, of course, depends on the rigidity of the assembly and the amount of expansion and contraction which can be tolerated during operation. Both problems can be solved by proper fixture design for assembly and by selection of springs with suitable load-deflection characteristics. When stacking devices in one clamped column it is necessary to keep sink mounting surfaces parallel to within .0005 inch if devices are to be mounted on both sides of the sink such as in many plate designs.

Figure 8 shows the basic configurations which may be obtained in a single stack. These include parallel, series, center tap, doubler and three-phase, full wave circuits. Many others are possible. The diagrams use diode circuits for simplicity of illustration. They are applicable to SCR's connected in series and to complete isolated circuits wherein insulated spacers may replace devices in the mechanical assembly.

Heat Sink Considerations

The previous discussion referred indiscriminately in the various sections to either plate-type or to extruded heat sinks. The plate-type is the simplest to use and may be of copper, aluminum or any thermally conductive material. The aluminum extrusions are the most common heat sinks presently used and furnish a greater exposed surface for heat transfer to the ambient atmosphere.

The heat-transfer characteristics of any heat sink, under normal convection conditions, can be greatly enhanced by using either forced air or some liquid coolant. The use of a liquid coolant is considerably more efficient. Liquid cooled sinks are generally cast or machined. Either is highly efficient but cast heat sinks have very little waste in fabrication and have very low pressure drop. The flow of coolant through the sinks is usually controlled to hold the semiconductor temperature to the designed maximum level.

A complete line of air and liquid cooled heat sinks are available to accommodate all disc type semiconductors. In addition, Westinghouse offers a full line of air and liquid cooled assemblies for all power semiconductors.

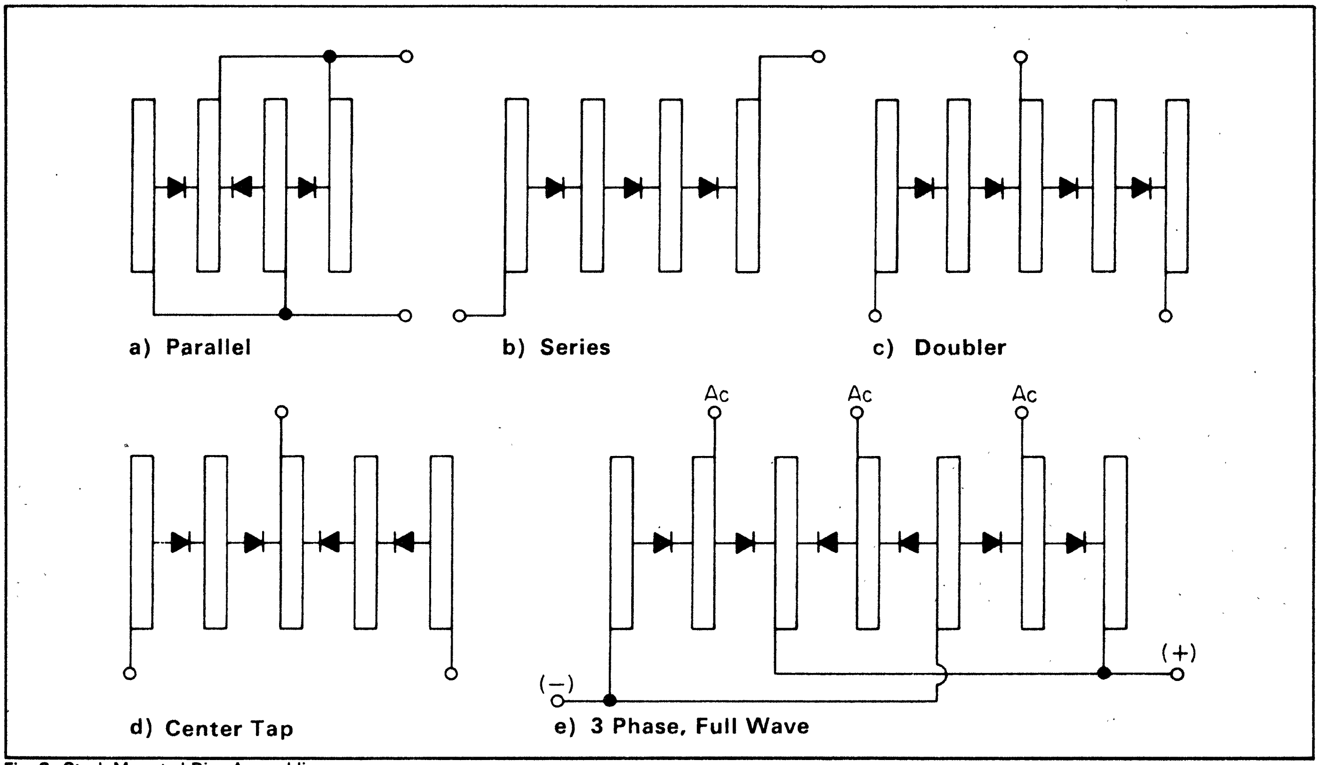

Fig. 8: Stack Mounted Disc Assemblies.

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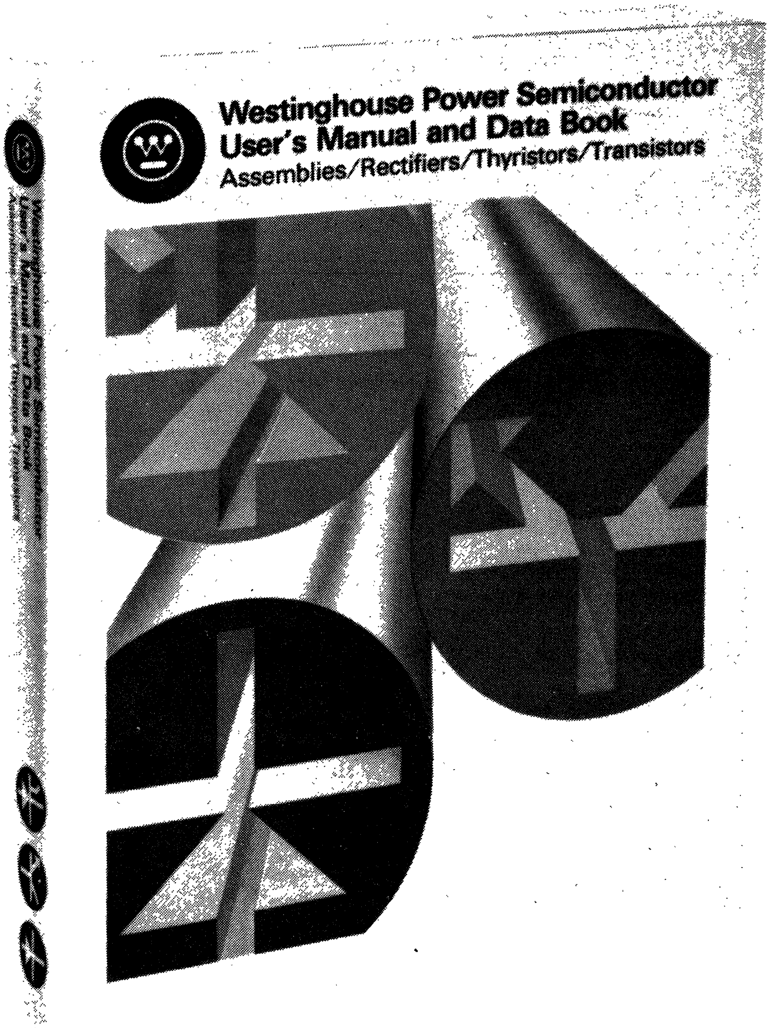

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Application Data
SCR GATE TURN-ON CHARACTERISTICS
Gate Drive Requirements

Introduction
The Silicon Controlled Rectifier (SCR) is a thyristor which attains its power control function by gate turn-on. The gate signal causes the SCR to revert from a forward blocking or off-state condition to a current conducting or on-state condition. Turning on an SCR should be simple, but circuit considerations and device trade-offs add some complexity. With an understanding of gate terminology, trade-offs and requirements of an SCR, a designer will have better guidelines for specifying gate turn-on requirements.

V/I Characteristics of an SCR
The SCR is a three terminal thyristor, properly defined as a Reverse Blocking Triode Thyristor. The V/I characteristics relationship is shown in Figure 1.

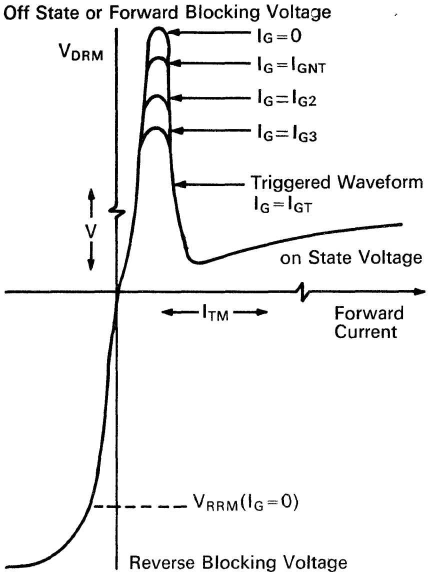

Figure 1. Voltage Current Characteristics Using Gate Control.

Without a gate control signal, the thyristor blocks voltages in both directions, so that power flow is inhibited. To initiate power flow, the SCR is gated only when it is in the forward blocking (V_{DRM}) off state. Increasing the gate signal I_G from 0 to I_{GT} shows that the SCR's ability to block voltage decreases until it turns on. The reverse blocking voltage characteristic (V_{RRM}) is like a rectifier diode. If one were to leave on a gate signal while the SCR becomes reverse biased, it is possible that the SCR would fail due to increased leakage current.

The SCR can be turned on by three methods; viz.,

- The recommended application of a gate current and voltage to the gate cathode potential leads.
- Two-terminal turn-on by exceeding the non-repetitive forward blocking (off-state) voltage rating, referred to at times as V_{BO} turn-on.
- dv/dt turn-on due to high dv/dt causing capacitive current triggering action.

The last two methods are not recommended for repetitively turning on an SCR because of restricted anode current rise time (di/dt) and magnitude.

To turn off an SCR in an AC phase control circuit is relatively easy. Suppress the gate signal and the reversal of the AC line voltage causes commutation from the conduction state back to the off state. Of course, there are circuits which require sophisticated methods to achieve turn-off commutation such as choppers and inverters. These are available in the literature.

Gate Parameters and Characteristics
Because of the myriad of SCR applications, a dc gate test condition (Figure 2) with a resistive load was chosen to permit both the manufacturer and the user to ascertain basic gate parameters. It was not intended to reflect operational application requirements. These dc gate trigger requirements are normally given on SCR data sheets.

- I_{GT} is a dc gate current which causes the SCR to latch into conduction and remain "on" (hold); referred to as gate trigger current.
- V_{GT} is the dc gate cathode voltage which causes the SCR to latch into conduction and remain "on" (hold); referred to as gate trigger voltage.
- I_{GNT} is a dc gate current which, when applied to the gate cathode terminal, will still permit the SCR to block rated V_{DRM}; referred to as non-trigger gate current.
- V_{GNT} is a dc gate voltage which, when applied to the gate cathode terminal, will still permit the SCR to block rated V_{DRM}; referred to as non-trigger gate voltage.

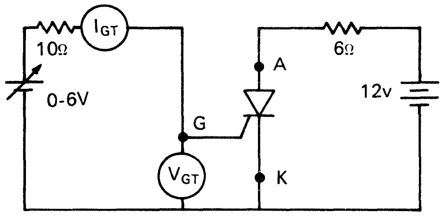

Figure 2. DC Gate Characteristics Test Circuit.

There are other gate parameters which must also be considered and are subsequently covered. They include peak gate trigger current for pulse operation, I_{GTM}; peak and average gate power, P_{GM} and $P_{G(AV)}$; and peak reverse gate voltage, V_{GRM}. The rated values are given in the data sheets.

The maximum gate triggering characteristics for Westinghouse di/namic gate SCR's is given in Figure 3. The di/namic or amplifying gate SCR consists of a pilot and main

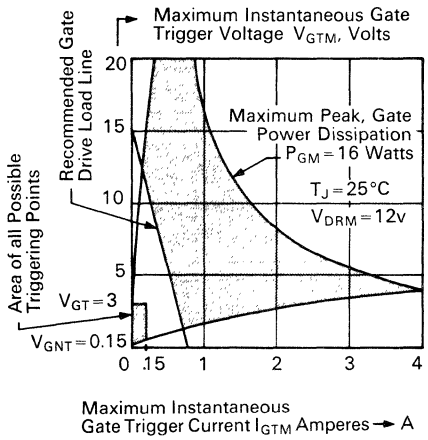

Figure 3. Maximum Gate Triggering Characteristics for Westinghouse di/namic Gate SCR's.

Application Data
SCR GATE TURN-ON CHARACTERISTICS
Gate Drive Requirements

GENERAL

SCR on the same element; this new gating structure provides improved characteristics over previous designs. Note that the ratings are at 25°C and that a recommended load line for moderate di/dt applications is given.

The characteristic effect of junction temperature versus gate trigger current/voltage is depicted in Figure 4 with an SCR I_{GT}=150ma. Note that as an SCR is heated to 125°C, the required gate current to trigger typically is one-half the 25°C value, and that the —40°C value is approximately twice the 25°C value.

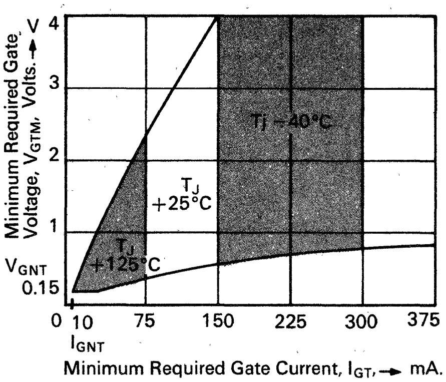

Figure 4. Typical Gate Triggering Range for Various Junction Temperatures.

To relate the measured value of dc gate trigger current to pulsed gate operation required in some applications, the following information is needed and is shown in Figure 5. Whether the SCR design is a conventional center fire gate, di/namic gate, or other, it is necessary to increase the gate drive amplitude for pulse widths less than 20 microseconds. This is due to the charge turn-on concept ($q = \int I_{GT}\, dt_p$) described in the referenced literature. The minimum gate trigger requirements versus pulse widths are given with respect to junction temperature. This insures that the SCR will latch on and remain on (if provided in circuit) but is not the optimum gate drive requirements.

Gate Drive Requirements

The present di/namic gate SCR may be triggered with either Soft Gate Drive or Hard Gate Drive. Predecessor devices with center firing and edge firing gates required hard gate drive to achieve uniform current conduction and low switching losses. However, even with the di/namic gate and newer interdigitated geometries, applications still exist which require hard gate drive.

Hard Gate Drive

Demanding applications where hard gate drive is suggested include inverter and chopper circuits of capacitive type loads where high repetitive di/dt is evident; heavy industrial phase control operation with inductive load (or power factor control) and systems where electrical noise is troublesome requiring noise-immune thyristors and gate signal suppression circuitry (up to I_{GT}). Figure 6 is the suggested Hard Gate Drive for an individual SCR. The cases of anode current conduction interval ≤ 20 μs or picket fence gate firing are not shown. Reference must be made to the Minimum Pulsed Gate Trigger Requirements (Figure 5) to obtain the proper value of I_{GT}. This value of I_{GT} is then used for the Hard Gate Drive I_{GTM} determination.

Soft Gate Drive shown in Figure 7 is perfectly adequate for resistive and inductive load applications. In general, a gate drive transistor can be eliminated from the gate firing circuitry, providing a cost reduction. If a snubber network is always available to discharge upon signal initiation, soft gate drive may be adequate even for some high di/dt applications, but further assistance is advised from an application engineer.

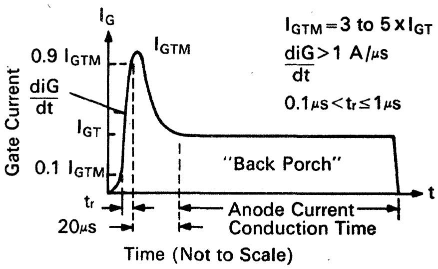

Figure 6. Hard Gate Drive.

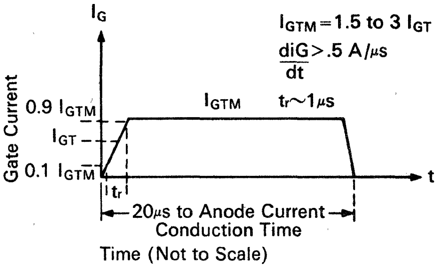

Figure 7. Soft Gate Drive.

Example: A Westinghouse T920 has a data sheet I_{GT}=200 ma @ 25°C. The recommended gate drive, to cover all types of load variations @ T_J=—40°C start-up is as follows:

I_{GT} @ —40°C = 2 x I_{GT} @ 25°C (from Figure 4)
I_{GT} @ —40°C = 400 ma
Hard Gate Drive—I_{GT} = 3.3 to 5 x I_{GT} @ —40°C
Answer I_{GT} = 1.3A peak (Min. value)

The conduction period of the anode current "back porch" must have a gate current no lower than the I_{GT} @ —40°C; i.e., 400 ma to ensure conduction for low power factor loads.

Recommended Gating Practices

A di/namic gate SCR is optimized to provide fast turn-on and low switching losses with a soft gate drive signal. Recognition of situations where di/namic gate action is limited along with a number of recommended design practices are given below.

- Gate the SCR when the anode voltage is positive. Allowing a positive gate while the SCR becomes reverse biased limits device reliability.
- Design the gate firing sequence such that the snubber network across the SCR is charged prior to gate signal. This gives good di/namic gate action.
- If a dc gate signal is used in a multi-phase system a soft gate drive signal does not

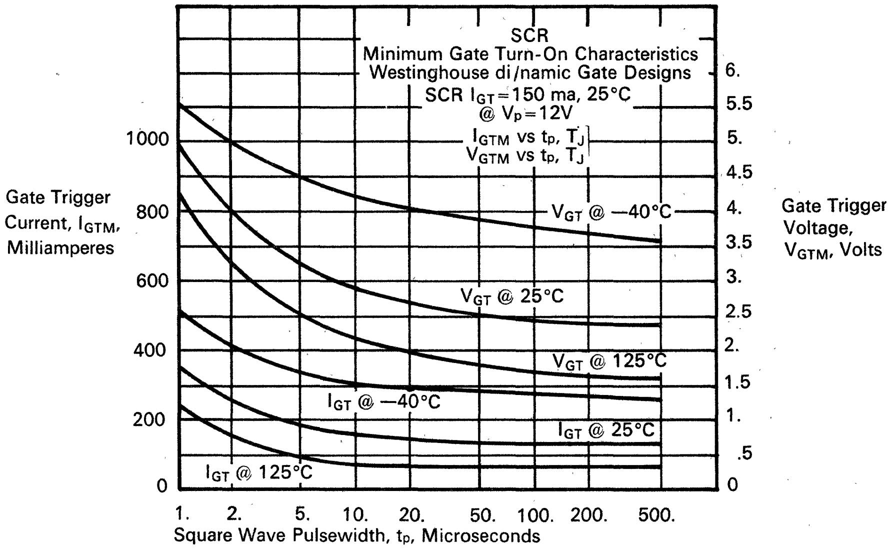

Figure 5. Minimum Pulsed Gate Trigger Requirements.

give good di/namic gate action. No snubber discharge is possible after time zero which results in poor di/namic gate action. In addition, Westinghouse SCR's have high noise-immune characteristics (I_{GNT}) meaning they do not false trigger at very low gate currents. For this particular application hard gate drive is required.

- The gate drive circuitry should have a 1 to 2A average 100V diode in series with the gate and across the gate cathode terminals as shown in Figure 8. These will eliminate two possible failure modes of an SCR. The diodes in series with the gate will prevent negative gate current flow while the diode across the gate cathode limits the reverse gate voltage, V_{GRM}, to ~ 2V by diode clamping.

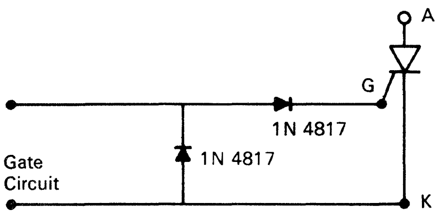

Figure 8. Protected Gate Cathode

- Provide open circuit gate voltage>20V to prevent gate drive extinction. The instantaneous gate cathode voltage can exceed the source voltage in high di/dt applications.

- Inductive loads can be troublesome if the gate drive is insufficient in amplitude or width. Existing recommended practice is the use of the "picket fence" or hard gate drive. A picket fence is a high frequency gate signal varying from 1 to 15KHz, 200μs to 50μs wide within a 60Hz envelope such that the SCR is continuously gated. The average gate current rating is maintained. In hard gate drive circuits, the "back porch" anticipates worse-case power factor; making the gate pulse width wide enough to ensure SCR latching and holding.

- To prevent noise pickup in the gate potential connections, twist together the gate cathode potential leads of the SCR and use either a twisted wire pair from the gate pulse amplifiers circuit or a coax-type shielded cable. Locate the wires as close as possible to the SCR but away from magnetics or high current carrying members in the circuit. Of course, the gate cathode lead lengths should be as short as possible.

- To minimize △ delay time variations between SCR's, use hard gate drive with as high a gate current risetime (di_G/dt) as possible; ref. Figure 6.

- Always use a resistor in series with each gate lead if triggering more than one SCR from the same source. Generally, 10 to 25Ω is used to diminish input gate cathode impedance variations.

- Use single point triggering if gating more than one device from the same source.

- If highest total circuit reliability is desired, a power burn-in of the complete gate firing board at rated temperatures and power will eliminate weak components and infant mortality.

Series Operation
Present application techniques are such that, in many designs, circuit applications exceed device blocking capabilities. For this reason, series connected SCR applications have been, and are prevalent. Figure 9 shows a typical circuit connection, including the compensating components required for proper operation. In such a series connection the last device to turn on may be subject to an overvoltage and dissipates the most energy. A high drive gate signal from a single source is required to minimize delay times and switching losses. The resistors R_B are for static voltage balancing due to blocking voltage, leakage current differences. The snubber capacitor C is not only for dv/dt but also for Q_{RR} variations.

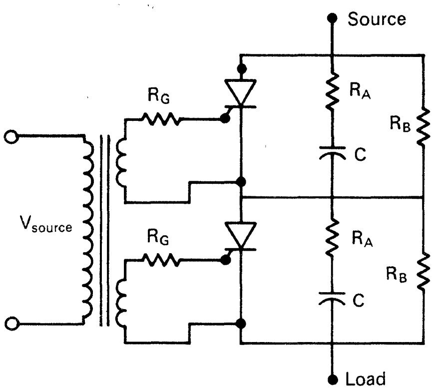

Figure 9. Typical Series Connection with Single Point Triggering.

It should also be noted that the gate circuitry employs individual resistors. To neglect this point is dangerous, since one low impedance gate consumes an excess of the available energy by voltage clamping of the transformer, thus reducing the energy available to the other devices and possibly causing overvoltage destruction of the device with the maximum delay. In such applications, a good overdrive gate signal is recommended.

One should specify matched △ delay times and △ Q_{RR} (if not diode clamped) for each series connected group of SCR's to optimize voltage sharing.

Parallel Operation
Discrete SCR's must be paralleled because they lack the required current handling capability, redundancy is required or because reduced junction temperature operation is desired. It is understood that the required type of gate drive circuit is dependent upon the particular circuit and load characteristics.

A specific gate firing problem is encountered with parallel operation of devices. In situations where anode reactors are employed, as shown in Figure 10, care should be exercised because as device "a" turns on, its voltage is supported by the reactor. Until the slow device "b" turns on, no current, except magnetizing current, flows. Therefore, device "a" has low turn-on losses. Device "b" on the other hand has the circuit voltage plus the transformed voltage across it while switching half the load current, and so is stressed harder due to delay variations. Therefore, in this instance the designer should consider the delay variations in gate pulse amplifier design, assuming single point triggering. It must be recognized that with a di/namic gate device and low magnetizing current (~I_L), di/namic gate action may not be achieved and high gate drive is recommended.

The necessity for economy sometimes dictates the operation of thyristors without balancing components, as illustrated in Figure 10(b). Unlike the previously described situation, with balancing reactors, device "a" turns on first and is more severely stressed as it must switch both the R-C network energy and the load current. If the load is capacitive or resistive a di/dt problem may exist. The combination of di/dt, device "b" turn-on with very low anode voltages, and long delay times, dictates hard gate drive.

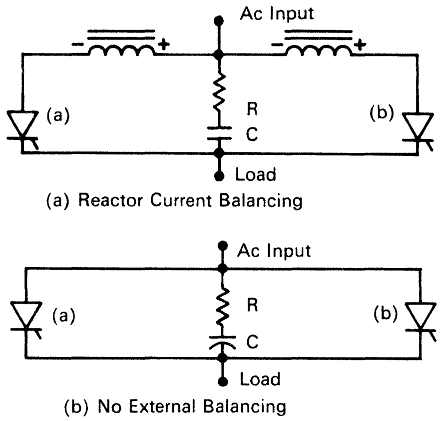

Figure 10. Parallel Operation of Thyristors.

It is also wise in this type of operation to select device characteristics which provide matching voltage drops and turn-on times. In inverter or commutating SCR applications, the di/namic forward voltage drop matching permits current sharing while steady state voltage drop matching is not necessary.

Application Data
SCR GATE TURN-ON CHARACTERISTICS
Gate Drive Requirements

Gate Firing Circuits

A gate trigger circuit can become quite sophisticated such as in an inverter application. Trigger logic circuits have been designed to do many things—

- Trigger the proper SCR's.
- Suppress the gate at overtemperature conditions.
- Crowbar (trigger) or suppress at fault conditions or overvoltage.
- Not trigger at low gate signal levels or predetermined pulse widths.

These type of circuits require design time and in many cases practical experience. If your experience or time is limited, consider the commercial gate firing circuit manufacturers to implement your required SCR circuit. Shown in Figure 11 are three examples of an SCR's hard gate firing circuit for phase control operation.

In the first circuit, a Shockley diode (4E20-8) provides the trigger pulse by voltage breakover, with AC line synchronization on the primary. In the second circuit, the Westinghouse T507 or other fast turn-on SCR is the trigger pulse, which can be gated within any point of the positive AC voltage. The negative AC voltage causes the SCR to line commutate off. The DC circuit uses a transistor to trigger, since an SCR in this circuit would not naturally commutate off. In all three circuits, the negative gate voltage is clamped by the diode across the gate cathode terminals. Other gate firing circuits are available in the Westinghouse SCR Designer's Handbook and those of other manufacturers.

Summary

The information provided herein will allow the designer or user to assess the merits of a gate trigger circuit. It is important that the gate drive circuit provide a signal which compensates for temperature and circuit effects. The reliability of a circuit is dependent upon every item within it. A proper gate drive signal will not guarantee improved circuit reliability but certainly is a proper step in achieving total reliability.

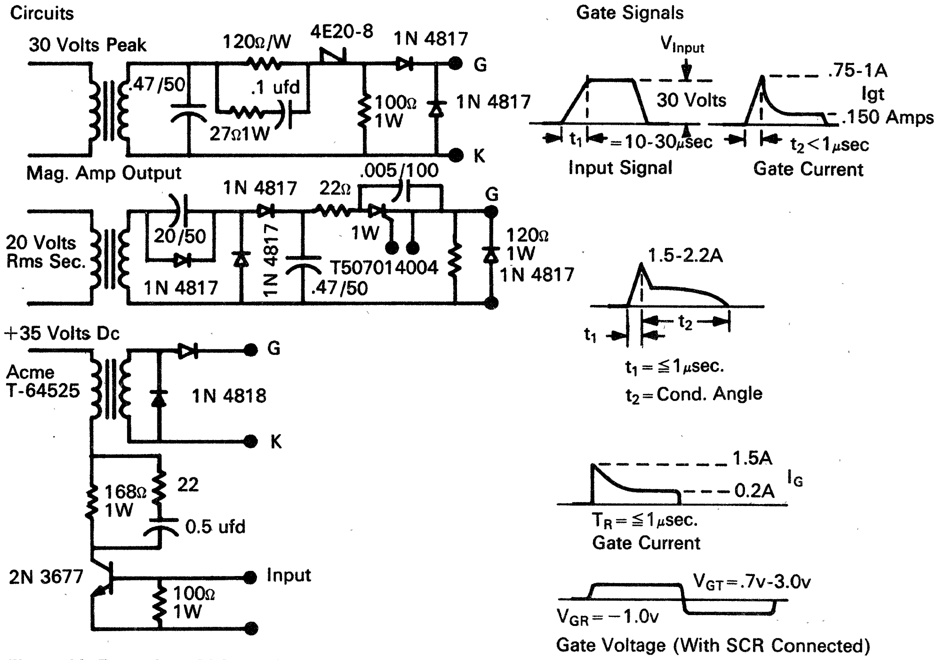

Figure 11. Examples of High Drive Circuitry.

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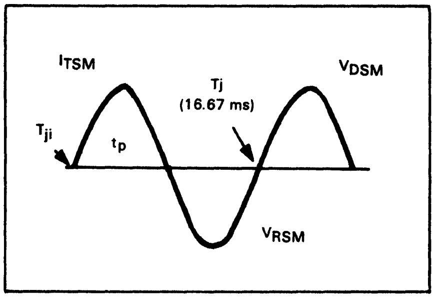
Application Data
THYRISTOR SURGE SUPRESSION RATINGS
Phase Control SCR'S

During the design of any power circuit incorporating thyristors, the designer is faced with choosing between several techniques for protecting the thyristors from load induced faults which would subject them to inordinately high levels of forward current. Many of these faults are of short duration and self-clearing. Conventional fault clearing techniques employing breakers or fuses are costly to maintain as they require varying periods of "downtime" either to reset the breakers or replace blown fuses. A better approach to limiting faults of this nature is surge suppression.

Thyristor Surge Suppression
Surge suppression is a fault clearing technique utilized in AC circuits in which the thyristor "rides thru" the first half cycle of surge current. The gate drive is inhibited at this point and the thyristor recovers to the blocking state isolating the load fault. Gate drive can be re-instituted following the successful clearing of the fault allowing continued use of the equipment with essentially zero downtime due to the load induced fault.

Design of circuits employing surge suppression is more difficult than conventional designs for several reasons. Fault sensing logic must be employed to sense and clear the fault and then perhaps automatically re-institute circuit operation. The exact magnitude of the worst case current fault must be known to properly coordinate the thyristors. Of prime importance, a definitive set of surge suppression ratings must be available for the thyristors to facilitate proper derating for reliable operation.

To aid in your design of a surge suppression circuit, a number of graphs have been developed. The first graph A has been designed to facilitate the determination of the magnitude and width of a fault current pulse given the ratio of resistance (R) to inductive reactance (X_L) of the circuit during a fault. Graphs B-1 through B-17 for Westinghouse phase control thyristors give the maximum permissible single cycle surge current that can be reliably utilized in a surge suppression circuit. These current levels are presented as functions of the base width and initial peak junction temperature as the figure illustrates. Graph C gives the voltage rating factor applicable to all Westinghouse phase control devices. Their use is outlined and an illustrative example is as follows:



Procedural Outline

1. Determination of fault current magnitude and pulse width.
   Determine the equivalent resistance
   a. (R) and inductive reactance (X_L) from detailed analysis of voltage source and circuit loop impedances.
   b. Determine the offset factor, K, from the graph A, given the value of $\frac{R}{X_L}$.
   Then $I_{T(asm)} = K \times I_{T(sm)}$ where:
   $I_{T(asm)}$ is the peak value of asymmetric surge current
   $I_{T(sm)}$ is the peak value of symmetric surge current given by:

$$I_{T(sm)} = \frac{V}{(R^2 + X_L^2)^{1/2}}$$

   Where: V is the peak open circuit voltage.
   R is the value of circuit resistance.
   X_L is the value of circuit inductive reactance.

   c. Determine the asymmetric surge current base width from Graph A given the value of $\frac{R}{X_L}$.

2. Selection of proper thyristor for an anticipated surge.
   a. Select the proper family of thyristors suited to the specified operating current—voltage—mechanical configuration and cooling requirements of the equipment. Refer to the Westinghouse Short Form Catalog (54-000) or specific data sheets for this information.
   b. Refer to the appropriate *Surge Suppression Rating* Graph B-1 through B-17 for the specific thyristor selected in 2a.
   (1) Calculate or estimate the peak junction temperature of the thyristor prior to the anticipated surge. Worst case will be 125°C.
   (2) On the Surge Suppression Rating graph B-1 through B-17, locate the specific ordinate scale pertaining to the anticipated surge current pulse width.
   (3) Locate the specific magnitude of surge current on this scale.
   (4) Move horizontally on this value of surge current until you intersect the peak initial junction temperature curve as determined in 2.b.1.
   (5) Read the peak junction temperature from the abscissa scale.
   (6) Refer to Graph C for the *Voltage Rating Factor.* Find the value of the maximum junction temperature following surge given in 2.b.5 on the abscissa scale. Follow this value of temperature vertically until you intersect the "standard" curve. The value of the Voltage Rating Factor, F, corresponding to this intersection is the minimum F factor which can be used to establish the device voltage rating by the following expression.

$$V_{Rating} = F \times V_P$$

   Where:
   - V_{Rating} is the minimum rated voltage for the thyristor, V_{DRM} and V_{RRM}.
   - F is the voltage rating factor.
   - V_P is the peak forward voltage seen by the thyristor following a surge.

3. If the voltage rating derived above is greater than that attainable for the device in question there are several options open:
   a. Repeat 6 using the "selected" curve. If an acceptable rating is attained, a device may be specially selected and tested by the manufacturer to perform at the specified operating levels. Contact your Westinghouse Applications engineer for details if you require a specially selected device.
   b. A higher current rated thyristor can be specified and the calculations outlined in 2b-1 thru 2b-6 repeated.
   c. Two thyristors can be operated in series to attain the specified voltage rating.

Application Data
THYRISTOR SURGE SUPPRESSION RATINGS
Phase Control SCR'S

Design Example

Given:

- Maximum junction temperature prior to surge, $T_{ji}=110°C$.
- Circuit equivalent resistance, R=.01 ohms.
- Circuit equivalent inductive reactance, $X_L=.025$ ohms.
- Peak open circuit voltage, $V_P=400V$.
- Assume a 1000V, T920 type thyristor will be used for this application for steady state current and reliable voltage derating requirements.

Find:
Magnitude and width of fault current pulse.
Acceptable device rating for this application.
Procedure:

$$\frac{R}{X_L} \text{ ratio} = \frac{.01}{.025} = 0.40$$

From Graph A find the offset factor, K=1.28

- Calculate magnitude of symmetric surge current $I_{T(sm)}$.

$$I_{T(sm)} = \frac{V}{(R^2+X_L^2)^{1/2}} = \frac{400}{[(.01)^2+(.025)^2]^{1/2}}$$

$$=14{,}855A$$

- Calculate magnitude of asymmetric surge current $I_{T(asm)}$.

$$I_{T(asm)} = K \cdot I_{T(sm)} = 1.28 \cdot 14{,}860 = 19{,}000A$$

- Find asymmetric surge current pulse width from Graph A for $\frac{R}{X_L}=.40$.

Pulse base width=11.9 msec.

Initial device selection T920, 900 ampere device.
Initial junction temperature given as 110°C.
From surge suppression rating curve for T920—09 (Graph B-16).
12 msec. ordinate scale—19000A peak using T_{ji} curve for 110°C.

Peak $T_j=173°C$ from graph.

Examining the Voltage Rating Factor curve for a standard device at 173°C, *NO* F factor is available in the standard rating. The 900 ampere standard device cannot be used under the stated conditions.

First Option:
Evaluate the T920—1000 ampere device.

$T_{ji}=110°C$

from surge suppression curve for T920—10 (Graph B-17).
12 msec. ordinate scale—19,000A using peak $T_{ji}=110°C$ curve.

Peak $T_j=163°C$

Using the Voltage Rating Factor curve for a standard device at Peak $T_j=163°C$,

$F=3.2$

$V_{Rating}=F \cdot V_P=3.2 \cdot 400=1280$ volts

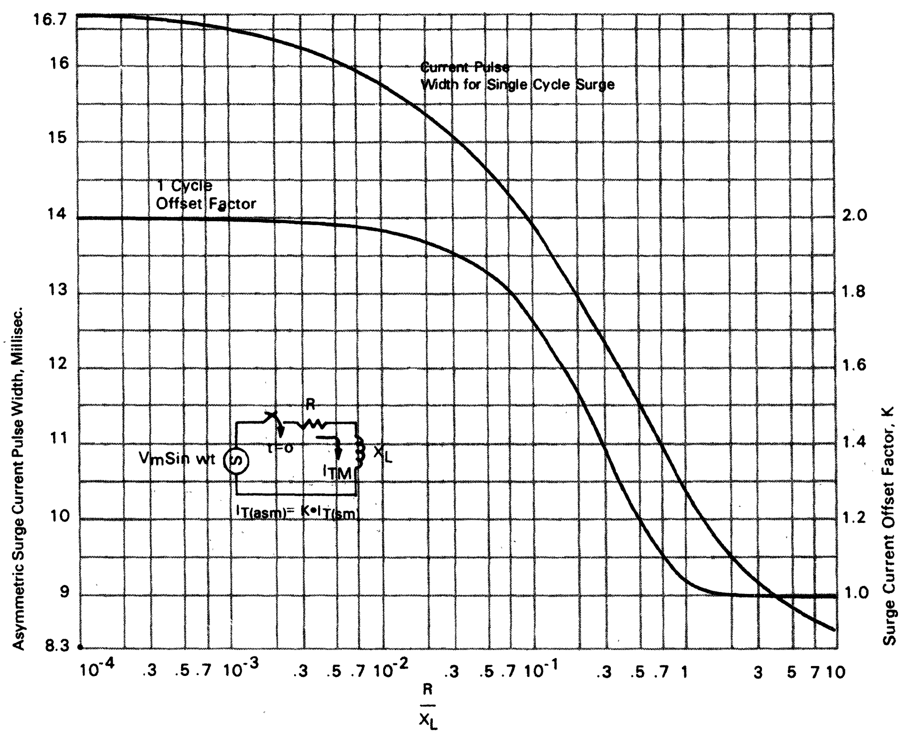
A standard 1300 volt—1000 ampere T920 thyristor fulfills the minimum requirement for this application.

Second Option:
Using the special selection curve of Graph C for $T_j=173°C$; F=2.6.

$V_{Rating}=2.6 \times 400=1040$ V.

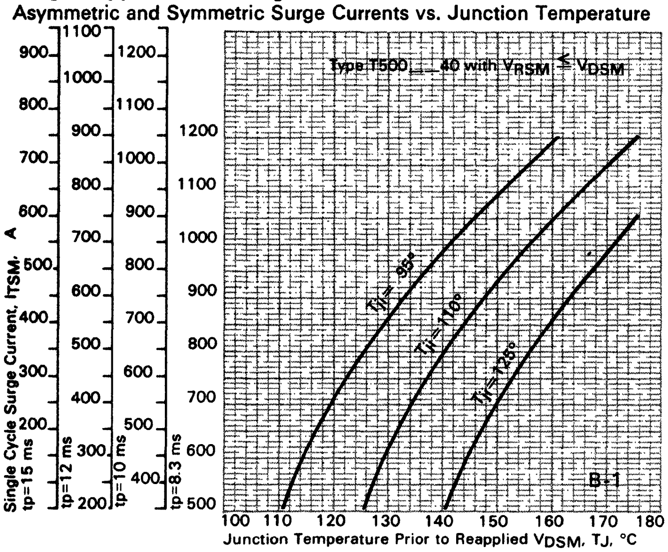
A specially selected 1100 volt—900 ampere T920 thyristor may also be used.

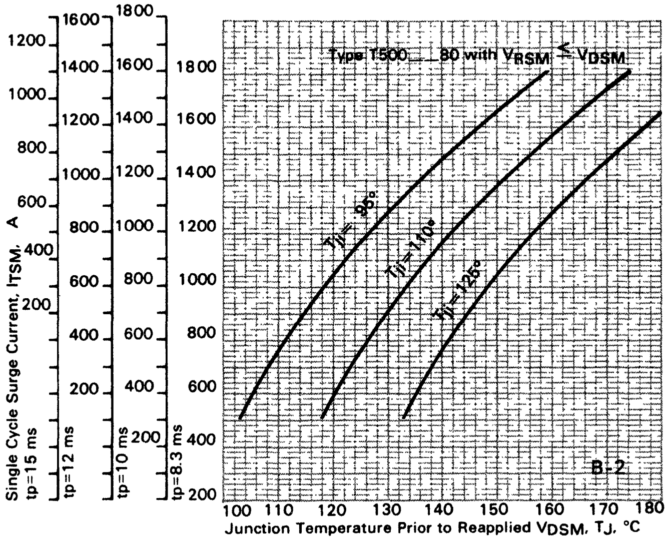
Surge Current Offset Factor— Pulse Width—Graph A

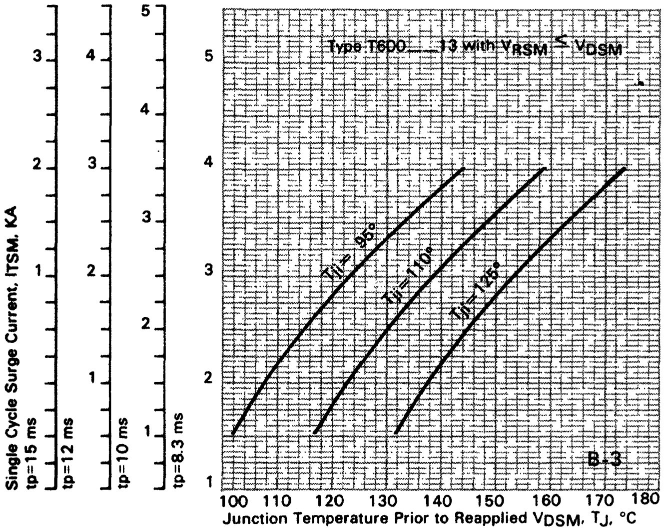


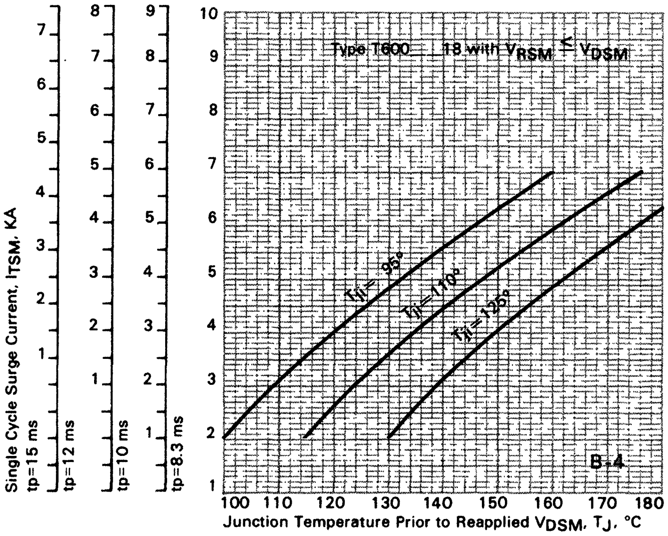
THYRISTOR SURGE SUPRESSION RATINGS
Phase Control SCR'S

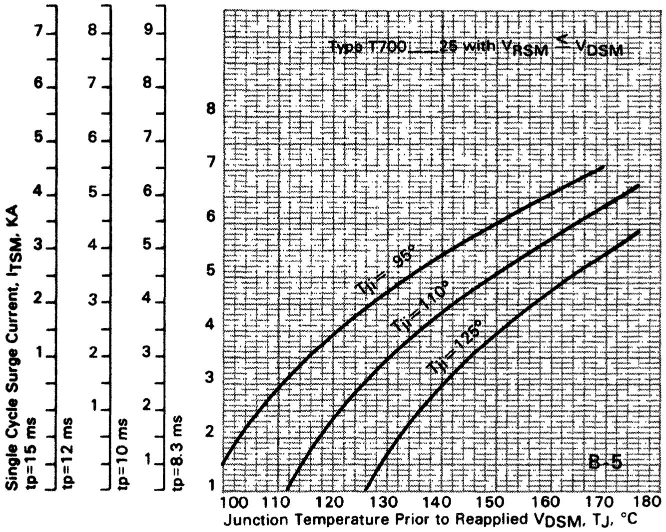
Surge Suppression Rating for Phase Control SCR's—STUD MOUNT
Asymmetric and Symmetric Surge Currents vs. Junction Temperature

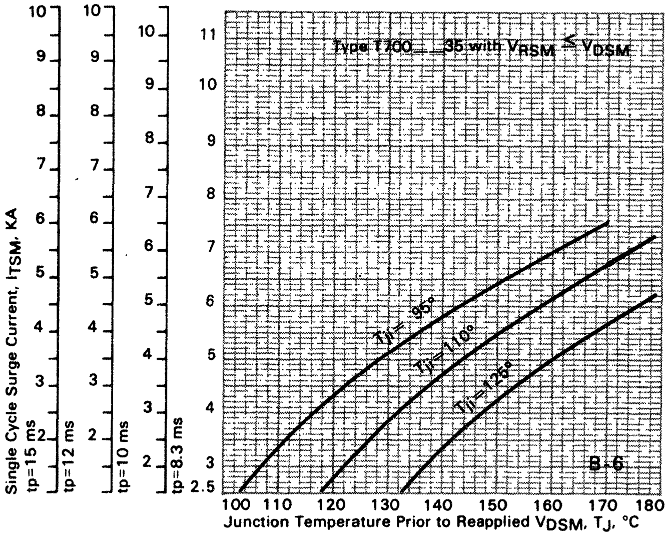






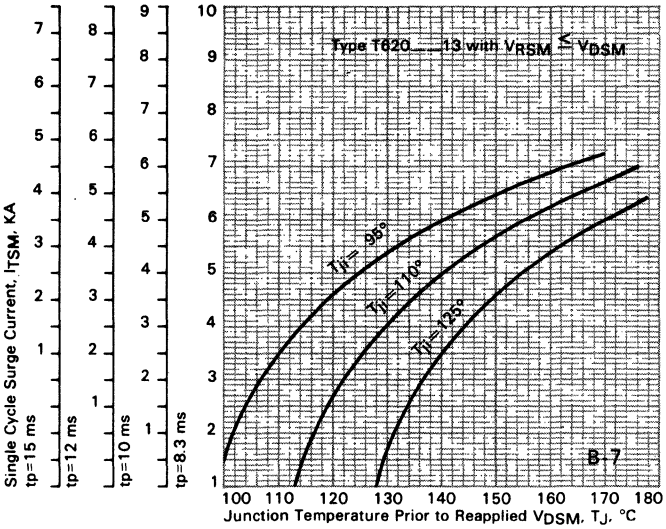


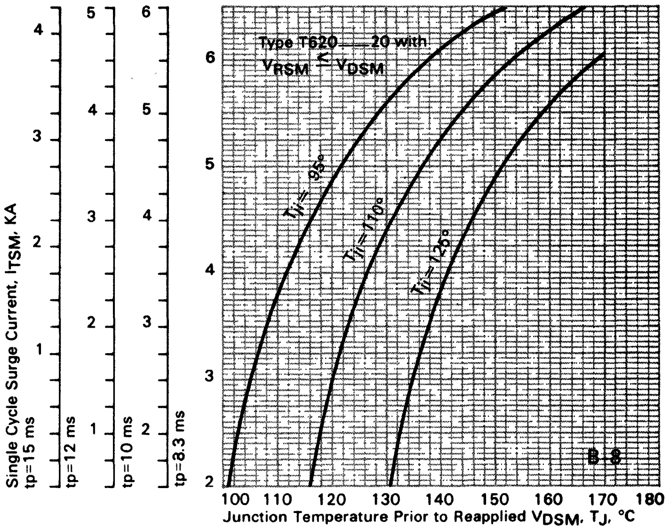


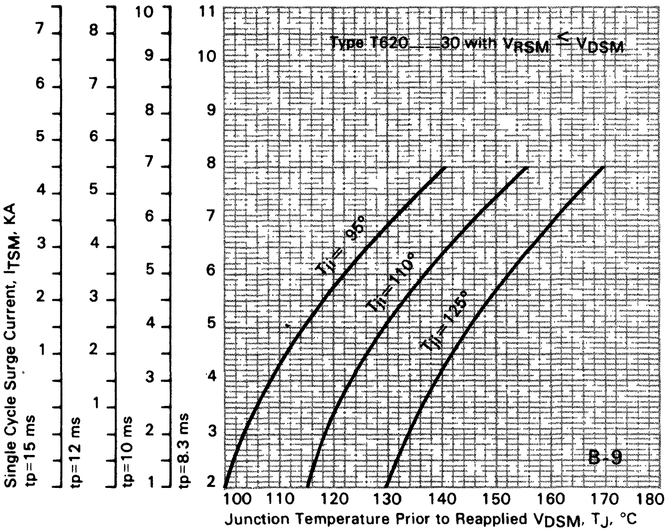


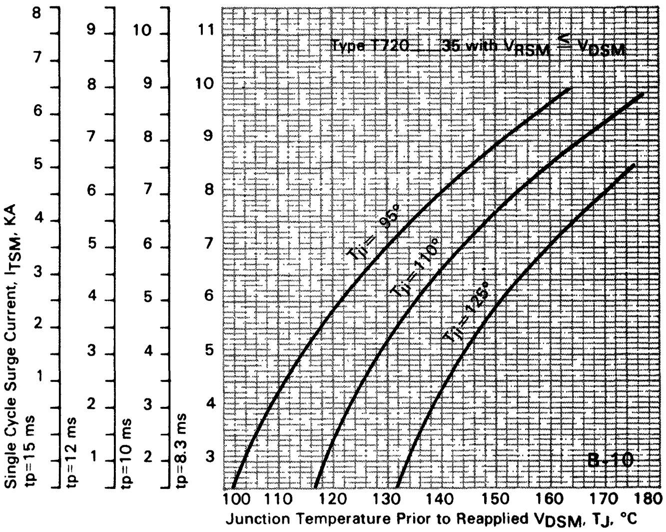
Application Data
THYRISTOR SURGE SUPPRESSION RATINGS
Phase Control SCR'S

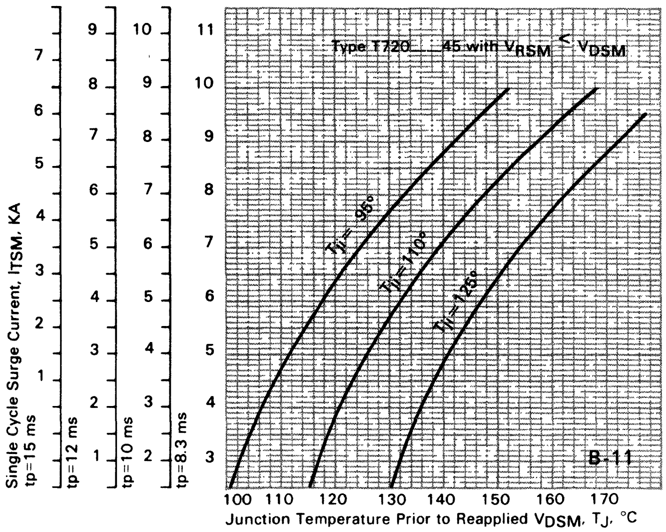
Surge Suppression Rating for Phase Control SCR's—DISC MOUNT
Asymmetric and Symmetric Surge Currents vs. Junction Temperature

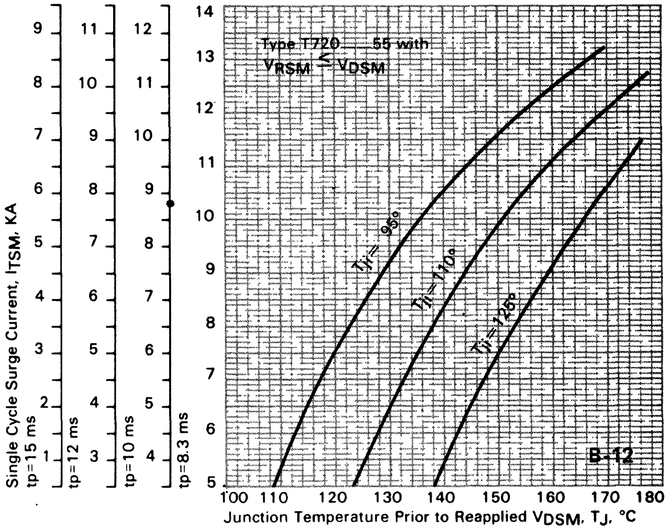






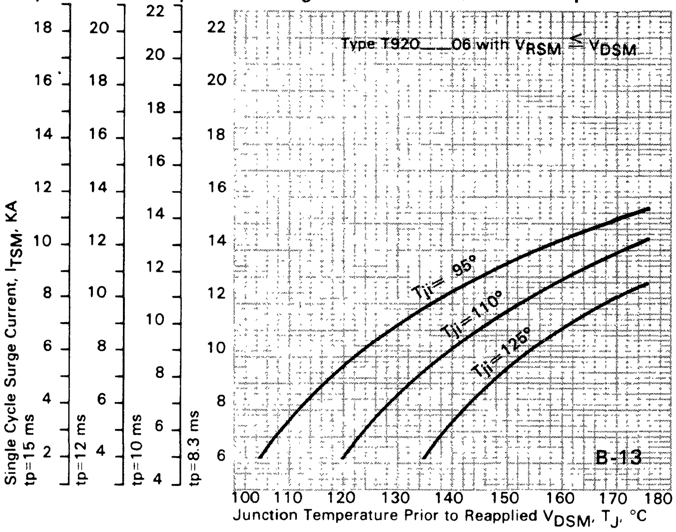


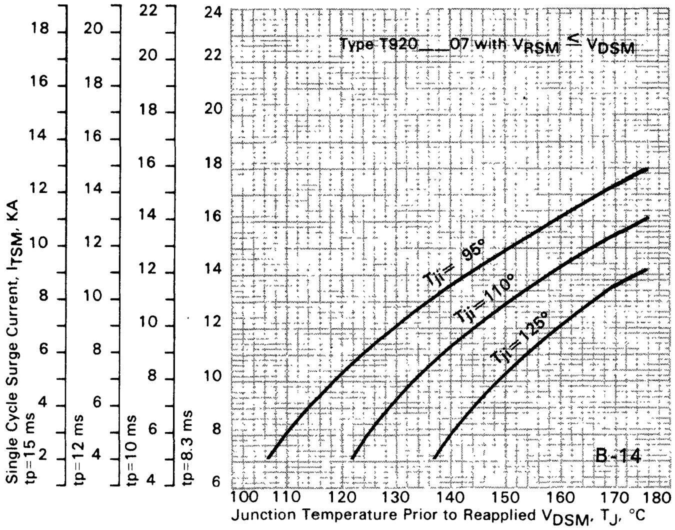


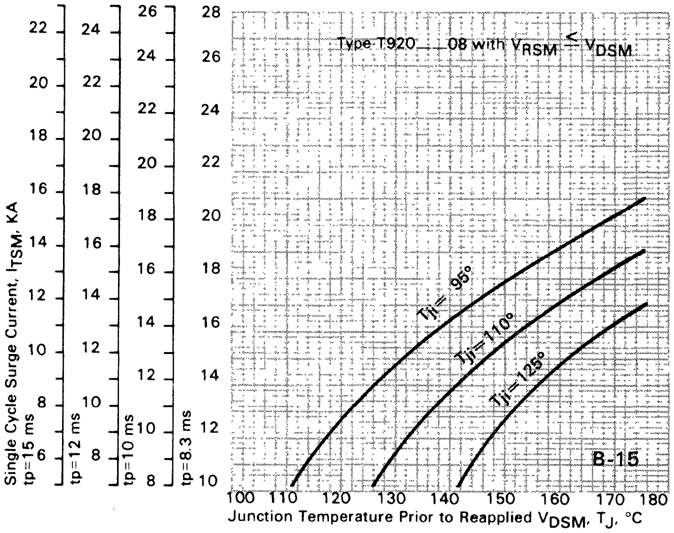


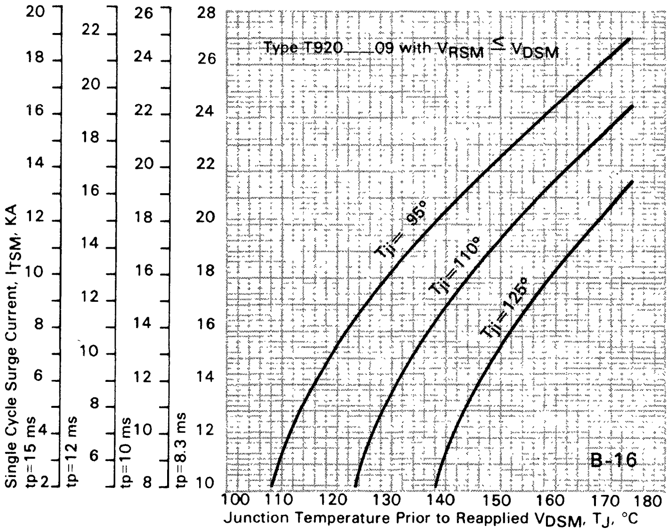
Surge Suppression Rating for Phase Control SCR's—DISC MOUNT

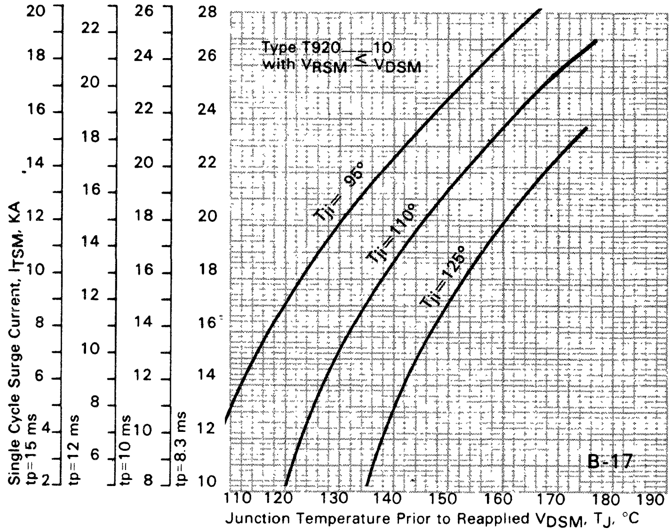
Asymmetric and Symmetric Surge Currents vs. Junction Temperature











Application Data
THYRISTOR SURGE SUPPRESSION RATINGS
Phase Control SCR'S

Conclusion
A detailed procedure has been outlined which will aid in specifying a device for a given surge suppression requirement. The surge suppression ratings arrived at by this technique are intended to be maximum ratings similar to the maximum blocking voltage and conduction current specifications on device data sheets. As such, a certain degree of derating from this maximum operating condition would greatly increase the reliability of operation. This derating is intended to buffer the detrimental effects of variations in circuit parameters from the values used in the determination of the device specifications.

In addition, care must be taken throughout the design of the equipment. The gate drives must be well shielded so as not to present appreciable noise currents to the thyristor during the surge suppression interval. These noise currents could cause retriggering due to the increased gate sensitivity of the device at the high junction temperature following a surge.

RC dv/dt suppression networks are required to hold the reapplied dv/dt to less than the data sheet rating to prevent dv/dt triggering following the surge. This is the predominant surge suppression failure mode and thus great care should be taken in the suppression network design.

Secondary fault protection techniques must be employed in the event the thyristor fails to successfully suppress the fault. This is usually provided by slow speed fuses or circuit breakers.

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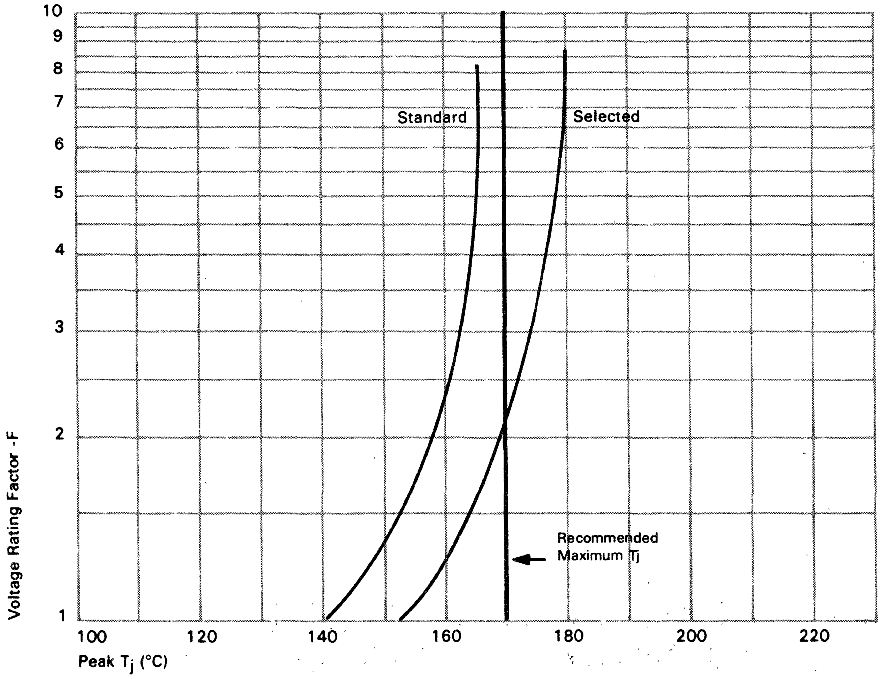
Voltage Rating Factor—Graph C



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ILLINOIS, Chicago	Westinghouse	312/887-8922
INDIANA, Indianapolis	S A I Marketing	317/844-7196
IOWA, Cedar Rapids	Dy-Tronix, Inc	319/377-8275
MARYLAND, Baltimore	Westinghouse	301/828-5400
MASSACHUSETTS, Boston	Westinghouse	617/237-6950
MASSACHUSETTS, East Longmeadow	Gerber Sales Corporation	413/525-3059
MASSACHUSETTS, Waltham	Gerber Sales Corporation	617/890-8040
MICHIGAN, Brighton	S A I Marketing	313/227-1786
MICHIGAN, Grand Rapids	S A I Marketing	616/942-2504
MINNESOTA, Minneapolis	Comstrand Inc	612/571-0000
MISSOURI, St Louis	Dy-Tronix, Inc	314/731-5799
MISSOURI, Independence	Dy-Tronix, Inc	314/731-5799
NEW JERSEY, Haddonfield	Thomas Associates	609/854-3011
NEW JERSEY, Ringwood	JL Sales Assoc	201/962-6315
NEW MEXICO, Albuquerque	Lindberg Co	505/881-1006
NEW YORK, Clinton	Advanced Components Corp, Inc	315/853-6438
NEW YORK, Endicott	Advanced Components Corp, Inc	607/785-3191
NEW YORK, Hempstead	Westinghouse	516/489-2200
NEW YORK, Syracuse	Advanced Components Corp, Inc	315/699-2671
NEW YORK, Scottsville	Advanced Components Corp, Inc	716/889-1429
NORTH CAROLINA, Charlotte	Westinghouse	704/377-3471
OHIO, Cincinnati	S A I Marketing	313/761-5432
OHIO, Cleveland	S.A I Marketing	216/292-2982
OHIO, Dayton	S.A I Marketing	513/435-3181
OHIO, Dayton	Westinghouse	513/228-9627
PENNSYLVANIA, Youngwood	Westinghouse	412/925-7272
TEXAS, Dallas	Kruvand Associates, Inc	214/691-4592
TEXAS, Houston	Kruvand Associates, Inc	713/780-9710
UTAH, Salt Lake City	Lindberg Co	801/534-1500
WASHINGTON, Seattle	Quadra Sales Corp	206/883-3550
WISCONSIN, Milwaukee	Westinghouse	414/786-0260

Canada

MANITOBA, Winnipeg	Westinghouse Canada Ltd	204/772-9401
ONTARIO, Burlington	Westinghouse Canada Ltd	416/639-6010
QUEBEC, Lachine	Westinghouse Canada Ltd	514/631-94[illegible]1
USA-Washington, Seattle	Quadra Sales Corporation	206/454-4946

Authorized Westinghouse Power Semiconductor Distributors

ALABAMA, Birmingham	Ack Semiconductors	205/322-0588
ALABAMA, Huntsville	Hamilton/Avnet	205/533-1170
ARIZONA, Phoenix	Hamilton/Avnet	602/275-7851
CALIFORNIA, Costa Mesa	Avnet Electronics	714/754-6111
CALIFORNIA, Los Angeles	Hamilton Electro Sales	213/558-2121
CALIFORNIA, Mt View	Hamilton/Avnet	415/961-7000
CALIFORNIA, San Diego	Hamilton/Avnet	714/279-2421
COLORADO, Denver	Hamilton/Avnet	303/534-1212
CONNECTICUT, Georgetown	Hamilton/Avnet	203/762-0361
CONNECTICUT, North Haven	Cramer	203/239-5641
FLORIDA, Hollywood	Cramer	305/923-8181
FLORIDA, Ft Lauderdale	Hamilton/Avnet	305/971-3491
FLORIDA, Orlando	Cramer	305/894-1511
GEORGIA, Atlanta	Cramer	404/448-9050
GEORGIA, Atlanta	Hamilton/Avnet	404/448-0800
GEORGIA, Atlanta	Specialty Distributing	404/873-2521
GEORGIA, Augusta	Specialty Distributing	404/722-1526
ILLINOIS, Chicago	Complete Reading Electric	312/454-1234
ILLINOIS, Chicago	Hamilton/Avnet	312/678-6310
ILLINOIS, Chicago	Semiconductor Specialists	312/279-1000
INDIANA, Ft Wayne	Ft Wayne Electronics	219/423-3422
INDIANA, Indianapolis	RA-DIS-CO	317/637-5571
KANSAS, Kansas City	Hamilton/Avnet	913/888-8900
MARYLAND, Baltimore	Hamilton/Avnet	301/796-5000
MARYLAND, Rockville	Cramer (Washington, D C)	301/948-0110
MASSACHUSETTS, Boston	Cramer	617/969-7700
MASSACHUSETTS, Boston	Hamilton/Avnet	617/933-8020
MASSACHUSETTS, Boston	Schweber	617/890-8484
MICHIGAN, Detroit	Hamilton/Avnet	313/522-4700
MICHIGAN, Detroit	Semiconductor Specialists	313/478-2700
MICHIGAN, Detroit	Sheridan Sales	313/477-3800
MINNESOTA, Minneapolis	Hamilton/Avnet	612/941-3801
MINNESOTA, Minneapolis	Schweber	612/941-5280
MINNESOTA, Minneapolis	Semiconductor Specialists	612/854-8841
MISSOURI, Kansas City	L-COMP	816/221-2400
MISSOURI, Kansas City	Semiconductor Specialists	816/452-3900
MISSOURI, St Louis	Hamilton/Avnet	314/731-1144
MISSOURI, St Louis	Semiconductor Specialists	314/731-2400
NEW JERSEY, Camden	General Radio Supply Co	609/964-8560
NEW JERSEY, Cedar Grove	Hamilton/Avnet	201/239-0800
NEW JERSEY, Little Falls	Cramer	201/785-4300
NEW JERSEY, Moorestown	Arrow Electronics	609/235-1900
NEW JERSEY, Mt Laurel	Hamilton/Avnet	609/234-2133
NEW JERSEY, Somerset	Schweber	201/469-6008
NEW MEXICO, Albuquerque	Hamilton/Avnet	505/765-1500
NEW YORK, L I	Cramer	516/231-5600
NEW YORK, L I	Hamilton/Avnet	516/333-5800
NEW YORK, L I	Schweber	516/334-7474
NEW YORK, Rochester	Cramer	716/275-0300
NEW YORK, Rochester	Hamilton/Avnet	716/442-7820
NEW YORK, Rochester	Schweber	716/461-4000
NEW YORK, Syracuse	Cramer	315/437-6671
NEW YORK, Syracuse	Hamilton/Avnet	315/437-2642
NORTH CAROLINA, Winston-Salem	Cramer	919/725-8711
OHIO, Cincinnati	Sheridan Sales	513/761-5432
OHIO, Cleveland	Hamilton/Avnet	216/461-1400
OHIO, Cleveland	Sheridan Sales	216/831-0130
OHIO, Columbus	Hughes Peters	614/294-5351
OHIO, Dayton	Hamilton/Avnet	513/433-0610
PENNSYLVANIA, Pittsburgh	CAM/RPC	412/782-3770
TEXAS, Dallas	Altair	214/231-5166
TEXAS, Dallas	Hamilton/Avnet	214/661-8661
TEXAS, Houston	Altair	713/462-3029
TEXAS, Houston	Complete Reading Electric	713/224-5731
TEXAS, Houston	Hamilton/Avnet	713/780-1771
UTAH, Salt Lake City	Hamilton/Avnet	801/972-2800
WASHINGTON, Seattle	Hamilton/Avnet	206/746-8750
WEST VIRGINIA, Charleston	McJunkin	304/348-4965
WISCONSIN, Milwaukee	Taylor Electronics	414/241-4321
WISCONSIN, Milwaukee	Hamilton/Avnet	414/784-4510

Canada

BRITISH COLUMBIA, Vancouver	R-A-E Industrial Electronics	604/687-2621
MANITOBA, Winnipeg	Cam-Gard Supply	204/786-8481
ONTARIO, Mississauga	Schweber	416/678-9050
ONTARIO, Ottawa	Hamilton/Avnet	613/226-1700
ONTARIO, Toronto	Cesco Electronics	416/661-0220
ONTARIO, Toronto	Hamilton/Avnet	416/677-7432
ONTARIO, Toronto	Semiconductor Specialists	416/678-1444
QUEBEC, Montreal	Hamilton/Avnet	514/331-6443

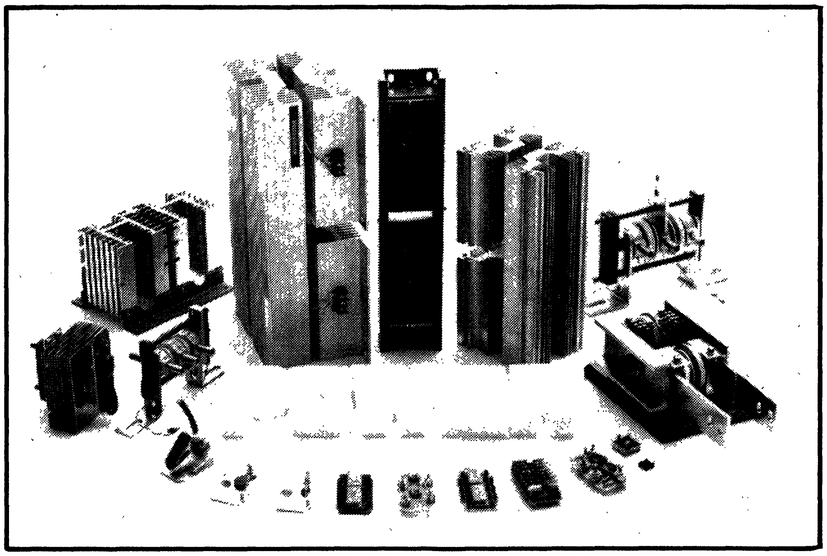
ASSEMBLIES

INTRODUCTION

Westinghouse has an extensive line of assembly capabilities with over twenty years of design experience. These products include Modular Bridges, Gold Line-Stud Mount, Air and Liquid Cooled-Disc, High Voltage Stacks, and Custom Designs in a variety of circuit configurations as identified on the following pages.

Westinghouse assemblies offer you savings in money, manpower, and time. Pre-engineered modular designs are available wth expert application assistance. All devices and heat sinks are thermally matched for optimum performance with guarteed ratings and are 100% factory tested. Buying assemblies rather than discrete components minimizes or eliminates tooling and set up charges and means single supplier contact for negotiating, purchasing, and expediting materials. Multiple incoming inspections, inventory investment, assembly time, and other handling costs are reduced. Thus, buying assemblies can save time and money while allowing a company to use its manpower and resources on programs that offer a greater return on investment. Buyers of assemblies also benefit by buying products which utilize the latest assembly techniques as well as those that incorporate the state-of-the-art in power semiconductors and heat sinks.

In addition to the industry's broadest line of "catalog" assemblies, Wesinghouse can offer custom designs to meet virtually any requirement - consumer, industrial, or military. As a semiconductor manufacturer and a knowledgeable assembly supplier who deals with numerous materials and vendors worldwide, Westinghouse can help you minimize your total system cost by optimizing your custom design.



ASSEMBLY PRODUCT INDEX

ASSEMBLIES

ASSEMBLIES

Regardless of heat sink type - plate, fabrication, or extrusion; device type - standard, special, or military; mounting, cooling, and clamping requirements; or other special components - resistors, capacitors, fuses, thermostats, etc., Westinghouse can help. To get this free "added value" service, simply call Westinghouse on your next design project.

All Westinghouse assemblies carry a one year warranty. In addition, spare parts and replacement assemblies are readily available for most designs. Save time and money; consider an assembly and specify Westinghouse!

AVAILABLE CIRCUIT CONFIGURATIONS (SHADED AREAS)

RECTIFIER

RECTIFIER	MODULAR	GOLD LINE	AIR COOLED DISC	LIQUID COOLED DISC	MANIFOLD	HIGH VOLTAGE STACKS	CUSTOM
Single Device		■	■	■			■
Parallel			■	■	■	■	■
Doubler		■	■	■		■	■
Center Tap (Pos. or Neg.)		■	■	■		■	■
Tripler				■		■	■
Quadrupler						■	■
Sextupler						■	■
1Ø Bridge	■	■	■	■		■	■
1Ø Double Half Wave						■	■
3Ø Half Wave		■	■	■		■	■
3Ø Bridge		■	■	■		■	■
3Ø WYE (Interphase Transformer)		■	■	■			■
3Ø 12 Pulse		■	■	■		■	■
6Ø Star		■	■	■			■

HALF CONTROL-RECTIFIER/SCR

HALF CONTROL-RECTIFIER/SCR	MODULAR	GOLD LINE	AIR COOLED DISC	LIQUID COOLED DISC	MANIFOLD	HIGH VOLTAGE STACKS	CUSTOM
Doubler		■	■	■			■
AC Switches			■	■	■		■
Center Tap (Pos. or Neg.)							■
Tripler				■			■
1Ø Bridge		■	■	■			■
3Ø Bridge		■	■	■			■

FULL CONTROL - SCR

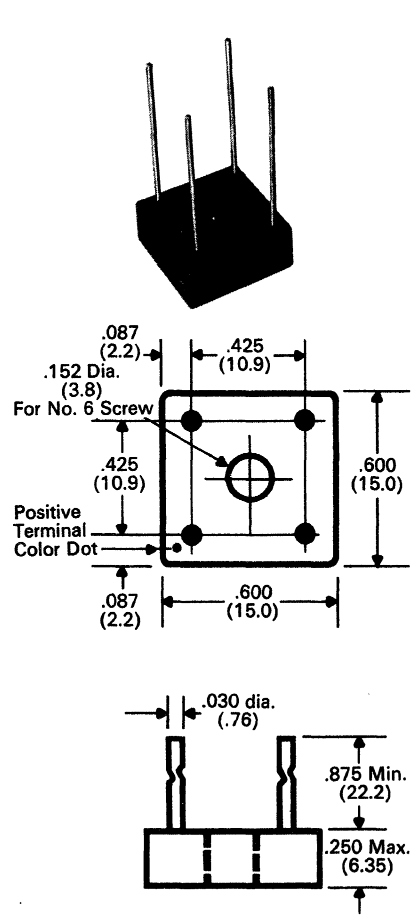
FULL CONTROL - SCR	MODULAR	GOLD LINE	AIR COOLED DISC	LIQUID COOLED DISC	MANIFOLD	HIGH VOLTAGE STACKS	CUSTOM
Single Device		■	■	■			■
Parallel			■	■	■		■
AC Switches		■	■	■	■		■
Doubler		■	■	■			■
Center Tap (Pos. or Neg.)		■	■	■			■
Tripler				■			■
1Ø Bridge		■	■	■			■
3Ø Half Wave			■	■			■
3Ø Bridge		■	■	■			■
3Ø WYE (Interphase Transformer)		■	■	■			■
3Ø 12-Pulse		■	■	■			■
6Ø Star		■	■	■			■

Modular ASSEMBLIES MB11, MB12

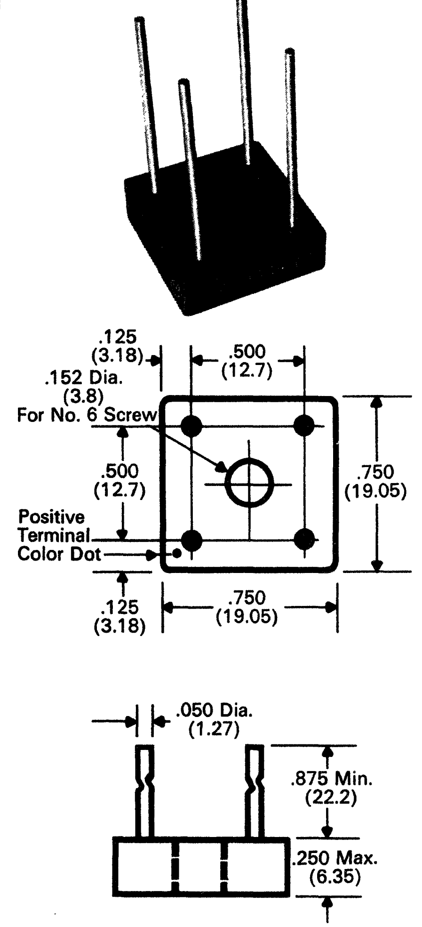
2-25 Amp. Rectifier

Dimensions: Inches (Millimeters)

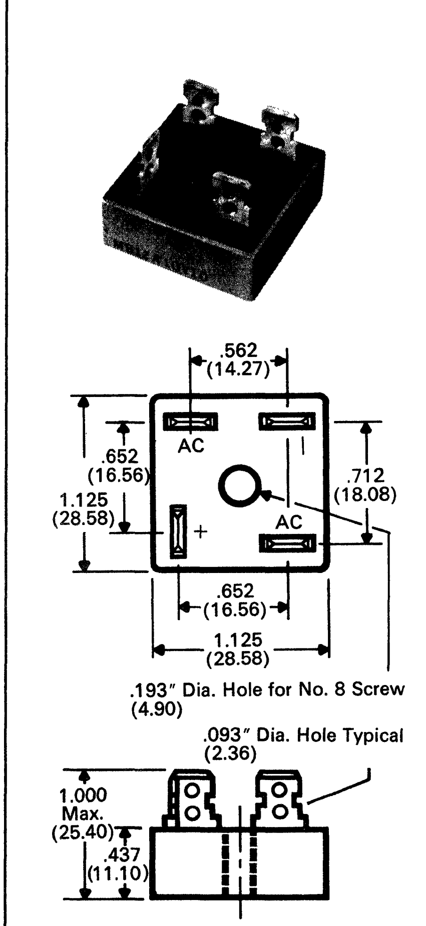
MB11A02 Series



MB11A06 Series



MB12A10 & MB12A25 Series



Features:
- Single phase bridge circuit
- Positive terminal polarity key (MB12)
- Electrically isolated case
- Low V_f, low leakage
- High surge current ratings

Applications:
- Motor control, AC to DC converters
- Power supplies, battery chargers

Benefits:
- Economy
- Availability
- Easy assembly hook-up
- 25 to 50% reduction in assembly time

Ordering Guide

To order a Westinghouse Modular Assembly simply add the appropriate voltage code suffix from the table to the basic type number of the assembly you have selected. For example, to order the assembly MB12A25 with a 400 Volt rating, add the voltage code suffix—V40. Now the complete ten digit type number description is MB12A25V40.

Module:	Assembly/Cell Voltage Rating	Voltage Code
MB11A02	50	V05
MB11A06	100	V10
MB12A10	200	V20
MB12A25	300	V30
	400	V40
	600	V60
	800	V80
	1000	W10

2-25 Amp. Rectifier

Modular ASSEMBLIES MB11, MB12

Maximum Ratings and Characteristics

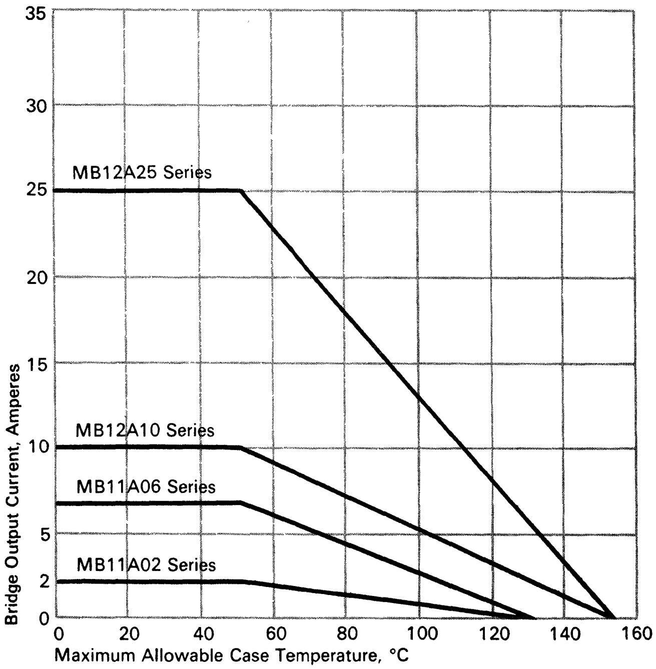
	MB11A02 Series	MB11A06 Series	MB12A10 Series	MB12A25 Series
Repetitive Peak Reverse Voltage (PRV)	50-1000V	50-1000V	50-600V	50-600V
Average DC Output Current* at 50°C	2A	6A	10A	25A
Peak One Cycle (Non-repetitive, 60Hz) Surge Current	50A	125A	200A	300A
Forward Voltage Drop per cell at 25°C	1.0 V at 1.0 A DC	1.0 V at 3.0 A DC	1.2 V at 5 A DC	1.2 V at 12.5 A DC
Reverse Leakage per cell at rated PRV at 25°C	10μA	10μA	10μA	10μA
Thermal Resistance—Junction to Case (typical)	—	—	1.5°C/W	1.5°C/W
Operating Temperature Range	−55°C to +125°C	−55°C to +125°C	−55°C to +150°C	−55°C to +150°C
Storage Temperature Range	−55°C to +150°C	−55°C to +150°C	−55°C to +150°C	−55°C to +150°C

*NOTE: 60Hz, resistive or inductive load; for capacitive load, derate current by 20%.

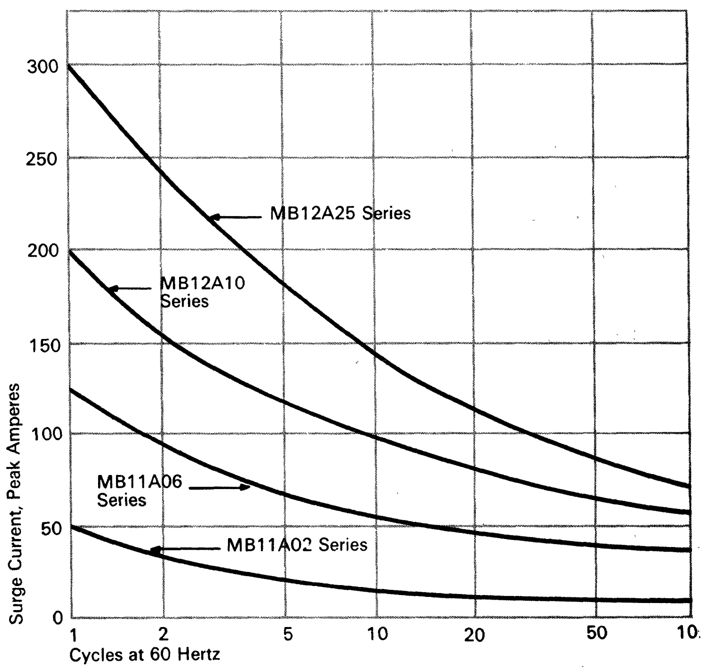
Mechanical Characteristics

	MB11A02 Series	MB11A06 Series	MB12A10 Series	MB12A25 Series
Case	Electrically Isolated Case	Electrically Isolated Case	Electrically Isolated Metal Case	Electrically Isolated Metal Case
Mounting Position	Any	Any	Any	Any
Mounting Torque	10 in.-lb. Max. (#6 Screw)	10 in.-lb. Max. (#6 Screw)	20 in.-lb. Max. (#8 Screw)	20 in.-lb. Max. (#8 Screw)
Weight	3.5 grams	6 grams	31 grams	31 grams
Terminals/Leads	.030″ Dia. Leads	.050″ Dia. Leads	.25″ Universal Faston	.25″ Universal Faston
Polarity Marking	Positive Output: Color dot Negative Output: Diagonally opposite positive output	Positive Output: Color dot Negative Output: Diagonally opposite positive output	Inputs: AC Positive Output: + Negative Output: −	Inputs: AC Positive Output: + Negative Output: −

Bridge Output Current Versus Temperature



Non-Repetitive Surge Current Versus Time



How to Select an Assembly

I. Circuit Funtion
   A. Rectifier (contains rectifiers only) — Go to Page A6
   B. Half Control (contains both rectifiers ard SCR's) — Go to Page A16
   C. Full Contro' (contains SCR's only) — Go to Pag .24

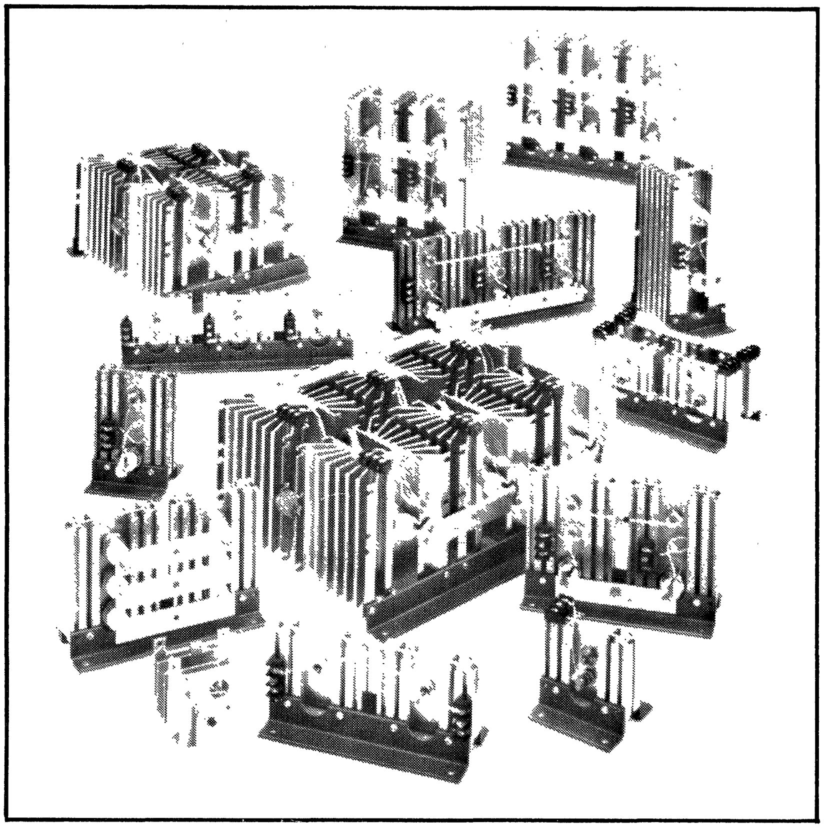
II. Circuit Configuration — Select the configuration desired and then turn to the page number referenced.

III. Current Rating — The assemblies are listed in order of increasing current rating on each page. Select the one that best meets your requirements. Each assembly has a table of current ratings as a function of various ambient temperatures, air flow velocity and conduction or delay angles for half and full control assemblies.

IV. Mounting — Select the type number for either floor or wall mounting. Most assemblies offer both types of mounting.

V. Vc:tage Rating — Now from the range of voltage ratings shown, select the voltage rating you require from the voltage code suffix table.

NOTE: Additional electrical and mechanical data on the assembly you have chosen can be found by referring to the respective key numbers.



For information on current and voltage ratings not shown or for any special electric.. and/or mechanical requirements as well as additional information on any of the Gold-Line Assemblies listed, contact your nearest Westinghouse Sales Office.

Features

- Pre-engineered Design
- Fully Tested Assemblies
- Guaranteed Assembly Ratings
- Easy to Read Rating Charts
- General Recommendations for Fuses, Voltraps, Gate Drives, R-C Networks
- Complete Information for Assembly Application
- Value Engineered Design
- Compact Size
- Light Weight
- Low Cost
- Full Range of Current and Voltage Ratings
- All Standard Circuit Configurations Available
- Most Assemblies Built from Stock
- Gold Chromate Finish
- Insulated Mounting
- JEDEC and MIL Approved Devices Available for Most Designs
- Resistor/Capacitor Networks and other Special Frame Modifications Available.

Assembly Ordering Guide

To order a Westinghouse Gold-Line Assembly, simply add the appropriate voltage code suffix from the table below to the basic Type number of the assembly you have selected. For example, to order the assembly – GB23A41 with a 600 volt rating, add the voltage code suffix – V60. Now the complete ten digit type number description is GB23A41V60.

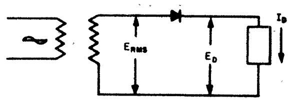
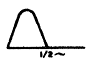
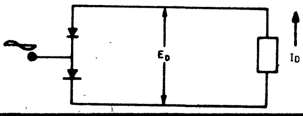
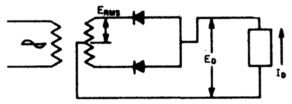
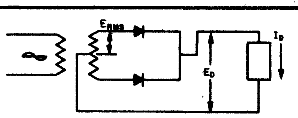
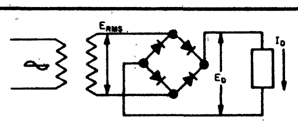
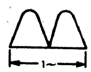
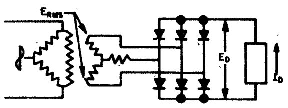
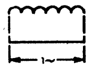
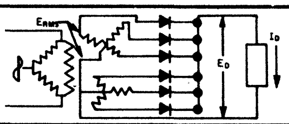
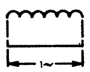
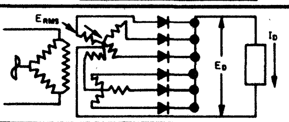
Voltage Code Suffix Table

Assembly/Device Voltage Rating	Voltage Code
100	V10
200	V20
300	V30
400	V40
600	V60
800	V80
1000	W10
1200	W12
1400	W14
1600	W16
2000	W20

Rectifier Assemblies

This section describes the circuit configurations available for Rectifier Assemblies. (assemblies using rectifiers only). The chart below shows the schematics, waveform, recommended diode voltage ratings, the basic current ratings available, and the page number where specific rating information for each assembly can be found.

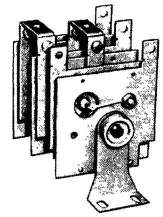
On each page the assemblies for a given circuit configuration are listed in order of increasing current rating. The tabulated current ratings for each assembly type number are given as a function of ambient temperature and as a function of air velocity (linear feet per minute – LFM). Refer to the mechanical and electrical keys specified for the assembly you have selected to obtain assembly weight and dimensions and other electrical data and recommendations.

Circuit		Assembly Output				
Configuration	Schematic	Wave Form	E_D = Avg. Voltage	E_a = RMS Voltage	Ripple (%)	I_F(AVG)/RE
R – Single Rectifier			.45 E_{RMS}	.707 E_{RMS}	121	I_D
D – Doubler		(See Single Phase Bridge "B" or Three Phase "E").				
N – Neg Center Tap			.900 E_{RMS}	1.0 E_{RMS}	48	½I_D
C – Pos Center Tap			.900 E_{RMS}	1.0 E_{RMS}	48	½I_D
B – Single Phase Bridge			.900 E_{RMS}	1.0 E_{RMS}	48	½I_D
E – Three Phase Bridge			1.350 E_{RMS}	1.351 E_{RMS}	4	⅓I_D
S – Six Phase Star			1.350 E_{RMS}	1.351 E_{RMS}	4	⅙I_D
Y – Three Phase Wye (with Interphase Transformer)			1.170 E_{RMS}	1.171 E_{RMS}	4	⅙I_D

Description of Rectifier Assemblies Pictured on the Right

I. Westinghouse GE11A61, 3ϕ Bridge, 35-61 Amps, 100-800 Volts on 3 x 3 plates.
II. Westinghouse GE15B30, 3ϕ Bridge, 100-300 Amps, 100-1600 Volts on 1¼ x 4 x 5 heat sinks.
III. Westinghouse GE16B45, 3ϕ Bridge, 225-450 Amps, 100-1600 Volts on 4 x 4 x 5 heat sinks.
IV. Westinghouse GE19B53, 3ϕ Bridge, 280-530 Amps, 100-2000 Volts on 5 x 5 x 6 heat sinks.
V. Westinghouse GE19B83, 3ϕ Bridge, 520-830 Amps, 100-2000 Volts on 5 x 5 x 6 heat sinks.

Actual Diode Peak Reverse Voltage	Recommended Rectifier Diode Repetitive Voltage Rating	Available Assemblies — Output Current Ratings (Amperes) AVG: Natural Convection @ 40°C	Available Assemblies — Output Current Ratings (Amperes) AVG: Forced Convection @40°C & 1000 LFM	For Specific Rating Info See Page
1.41 E_{RMS} or π E_D	2.8 E_{RMS} or 6.28 E_D	12 to 190	22 to 300	A8
		12 to 120	45 to 610	A9
2.828 E_{RMS} or π E_D	5.7 E_{RMS} or 6.28 E_D	26 to 380	45 to 610	A11
2.828 E_{RMS} or π E_D	5.7 E_{RMS} or 6.28 E_D	26 to 380	45 to 610	A10
1.414 E_{RMS} or 1.57 E_D	2.8 E_{RMS} or 3.2 E_D	26 to 380	45 to 610	A12
1.414 E_{RMS} or 1.05 E_D	2.8 E_{RMS} or 2.1 E_D	35 to 520	61 to 830	A13
2.828 E_{RMS} or 2.1 E_D	5.7 E_{RMS} or 4.2 E_D	57 to 850	100 to 1360	A14
2.45 E_{RMS} or 2.1 E_D	4.9 E_{RMS} or 4.2 E_D	70 to 1050	120 to 1670	A15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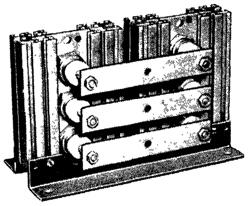
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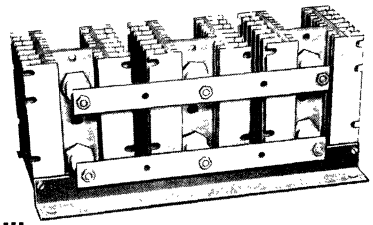
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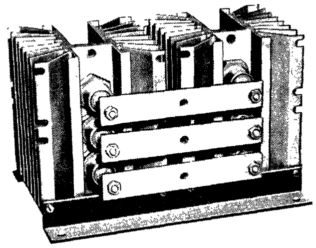
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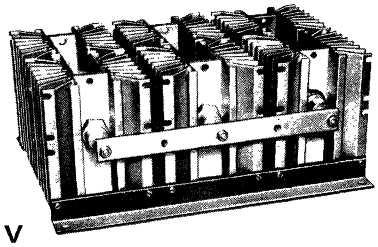
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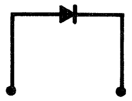
Rectifier

Stud Mount ASSEMBLIES Gold Line

ASSEMBLIES



Single Rectifier R

Current Rating 12-22 Amps / Voltage Ratings 100-800 Volts

Mounting	Type Number	Mech. Data Pg. A34-35	Elec. Data Pg. A33
Floor	GR11A22	F/W-1	E-1
Wall	(same)		

Output Current (Avg. Amps.)

Maximum Ambient Temperature / Air Velocity (LFM) ➡	1000	400	250	150	N.C.
40°C	22	19	17	15	12
60°C	19	17	15	14	11
80°C	16	14	13	11	9

Current Rating 20-38 Amps / Voltage Ratings 100-1000Volts

Mounting	Type Number	Mech. Data Pg. A34-35	Elec. Data Pg. A33
Floor	GR12A38	F/W-6	E-2
Wall	(same)		

Output Current (Avg. Amps.)

Maximum Ambient Temperature / Air Velocity (LFM) ➡	1000	400	250	150	N.C.
40°C	38	34	30	26	20
60°C	32	29	25	22	17
80°C	28	25	22	20	15

Current Rating 40 Amps / Voltage Ratings 100-1000Volts

Mounting	Type Number	Mech. Data Pg. A34-35	Elec. Data Pg. A33
Floor	GR13A40	F-7	E-2
Wall	GR43A40	W-9	

Output Current (Avg. Amps.)

Maximum Ambient Temperature / Air Velocity (LFM) ➡	1000	400	250	150	N.C.
40°C	40	40	40	40	40
60°C	40	40	40	40	40
80°C	40	40	40	40	34

Current Rating 70-140 Amps / Voltage Ratings 100-1600 Volts

Mounting	Type Number	Mech. Data Pg. A34-35	Elec. Data Pg. A33
Floor	GR15B14	F-9	E-3
Wall	GR45B14	W-11	

Output Current (Avg. Amps.)

Maximum Ambient Temperature / Air Velocity (LFM) ➡	1000	400	250	150	N.C.
40°C	140	110	99	90	70
60°C	125	101	90	80	55
80°C	103	85	75	65	47

Current Rating 110-150 Amps / Voltage Ratings 100-1600 Volts

Mounting	Type Number	Mech. Data Pg. A34-35	Elec. Data Pg. A33
Floor	GR16B15	F-19	E-3
Wall	GR46B15	W-21	

Output Current (Avg. Amps.)

Maximum Ambient Temperature / Air Velocity (LFM) ➡	1000	400	250	150	N.C.
40°C	150	146	136	126	110
60°C	150	127	118	110	93
80°C	126	108	99	92	78

Current Rating 190-300 Amps / Voltage Ratings 100-2000 Volts

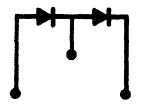
Mounting	Type Number	Mech. Data Pg. A34-35	Elec. Data Pg. A33
Floor	GR19B30	F-33	E-6
Wall	GR49B30	W-33	

Output Current (Avg. Amps.)

Maximum Ambient Temperature / Air Velocity (LFM) ➡	1000	400	250	150	N.C.
40°C	300	281	266	247	190
60°C	256	237	224	208	160
80°C	216	200	189	175	135

Stud Mount ASSEMBLIES Gold Line

Rectifier



Doubler
D

Current Rating / Voltage Ratings

	12-20 Amps, 100- 800 Volts			18-32 Amps, 100-1000 Volts			19-40 Amps, 100-1000 Volts		
	Type Number	Mech. Data Pg. A34-35	Elec. Data Pg. A33	Type Number	Mech. Data Pg. A34-35	Elec. Data Pg. A33	Type Number	Mech. Data Pg. A34-35	Elec. Data Pg. A33
Mounting Floor	GD11A20	F/W-2	E-1	GD12A32	F/W-7	E-2	GD14A40	F-8	E-2
Mounting Wall	(same)			(same)			GD44A40	W-10	

Output Current (Avg. Amps.)

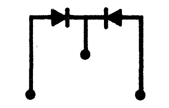
Air Velocity (LFM) ➡	1000	400	250	150	N.C.	1000	400	250	150	N.C.	1000	400	250	150	N.C.
Maximum Ambient Temperature 40°C	20	18	16	15	12	32	31	28	24	18	40	36	33	30	19
60°C	17	15	14	13	10	30	27	24	21	16	33	32	27	25	16
80°C	15	13	12	11	9	26	23	21	18	14	26	24	20	19	13

Current Rating / Voltage Ratings

	45-135 Amps, 100-1600 Volts			75-150 Amps, 100-1600 Volts			190-300 Amps, 100-2000 Volts		
	Type Number	Mech. Data Pg. A34-35	Elec. Data Pg. A33	Type Number	Mech. Data Pg. A34-35	Elec. Data Pg. A33	Type Number	Mech. Data Pg. A34-35	Elec. Data Pg. A33
Mounting Floor	GD15B13	F-10	E-3	GD16B15	F-19	E-3	GD19B30	F-35	E-4
Mounting Wall	GD45B13	W-12		GD46B15	W-21		GD49B30	W-35	

Output Current (Avg. Amps.)

Air Velocity (LFM) ➡	1000	400	250	150	N.C.	1000	400	250	150	N.C.	1000	400	250	150	N.C.
Maximum Ambient Temperature 40°C	135	104	92	81	45	150	124	110	93	75	300	270	253	228	190
60°C	110	85	75	66	37	118	100	88	75	60	266	240	222	201	159
80°C	85	65	58	51	29	90	76	68	57	46	224	204	188	170	146



Pos. Center Tap
C

Current Rating 26-45 Amps — Voltage Ratings 100-800 Volts

Mounting	Type Number	Mech. Data Pg. A34-35	Elec. Data Pg. A33
Floor	GC11A45	F/W-3	E-1
Wall	(same)		

Output Current (Avg. Amps.)

Air Velocity (LFM) → Maximum Ambient Temperature	1000	400	250	150	N.C.
40°C	45	40	36	33	26
60°C	38	34	31	28	22
80°C	31	28	25	23	18

Current Rating 40-76 Amps — Voltage Ratings 100-1000 Volts

Mounting	Type Number	Mech. Data Pg. A34-35	Elec. Data Pg. A33
Floor	GC12A76	F/W-8	E-2
Wall	(same)		

Output Current (Avg. Amps.)

Air Velocity (LFM) → Maximum Ambient Temperature	1000	400	250	150	N.C.
40°C	76	76	68	59	40
60°C	65	57	52	45	34
80°C	55	49	44	38	29

Current Rating 60-80 Amps — Voltage Ratings 100-1000 Volts

Mounting	Type Number	Mech. Data Pg. A34-35	Elec. Data Pg. A33
Floor	GC14A80	F-8	E-2
Wall	GC44A80	W-10	

Output Current (Avg. Amps.)

Air Velocity (LFM) → Maximum Ambient Temperature	1000	400	250	150	N.C.
40°C	80	80	80	80	60
60°C	80	80	80	75	50
80°C	80	74	68	61	41

Current Rating 90-270 Amps — Voltage Ratings 100-1600 Volts

Mounting	Type Number	Mech. Data Pg. A34-35	Elec. Data Pg. A33
Floor	GC15B27	F-10	E-3
Wall	GC45B27	W-12	

Output Current (Avg. Amps.)

Air Velocity (LFM) → Maximum Ambient Temperature	1000	400	250	150	N.C.
40°C	270	207	185	162	90
60°C	220	170	152	133	74
80°C	150	115	103	90	50

Current Rating 155-300 Amps — Voltage Ratings 100-1600 Volts

Mounting	Type Number	Mech. Data Pg. A34-35	Elec. Data Pg. A33
Floor	GC16B30	F-19	E-3
Wall	GC46B30	W-21	

Output Current (Avg. Amps.)

Air Velocity (LFM) → Maximum Ambient Temperature	1000	400	250	150	N.C.
40°C	300	279	248	209	155
60°C	265	225	200	169	125
80°C	212	180	160	135	100

Current Rating 270-510 Amps — Voltage Ratings 100-2000 Volts

Mounting	Type Number	Mech. Data Pg. A34-35	Elec. Data Pg. A33
Floor	GC19B51	F-34	E-4
Wall	GC49B51	W-34	

Output Current (Avg. Amps.)

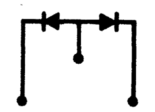
Air Velocity (LFM) → Maximum Ambient Temperature	1000	400	250	150	N.C.
40°C	510	454	426	378	270
60°C	496	395	370	330	235
80°C	360	321	302	266	190

Current Rating 380-610 Amps — Voltage Ratings 100-2000 Volts

Mounting	Type Number	Mech. Data Pg. A34-35	Elec. Data Pg. A33
Floor	GC19B61	F-35	E-4
Wall	GC49B61	W-35	

Output Current (Avg. Amps.)

Air Velocity (LFM) → Maximum Ambient Temperature	1000	400	250	150	N.C.
40°C	610	564	532	490	380
60°C	520	480	455	418	325
80°C	425	393	371	342	265



Neg. Center Tap
N

Current Rating 26-45 Amps; Voltage Ratings 100-800 Volts

Mounting	Type Number	Mech. Data Pg. A34-35	Elec. Data Pg. A33
Floor	GN11A45	F/W-3	E-1
Wall	(same)		

Output Current (Avg. Amps.)

Air Velocity (LFM) → Maximum Ambient Temperature	1000	400	250	150	N.C.
40°C	45	40	36	33	26
60°C	38	34	31	28	22
80°C	31	28	25	23	18

Current Rating 40-76 Amps; Voltage Ratings 100-1000Volts

Mounting	Type Number	Mech. Data Pg. A34-35	Elec. Data Pg. A33
Floor	GN12A76	F/W-8	E-2
Wall	(same)		

Output Current (Avg. Amps.)

Air Velocity (LFM) → Maximum Ambient Temperature	1000	400	250	150	N.C.
40°C	76	76	68	59	40
60°C	65	57	52	45	34
80°C	55	49	44	38	29

Current Rating 60-80 Amps; Voltage Ratings 100-1000Volts

Mounting	Type Number	Mech. Data Pg. A34-35	Elec. Data Pg. A33
Floor	GN14A80	F-8	E-2
Wall	GN44A80	W-10	

Output Current (Avg. Amps.)

Air Velocity (LFM) → Maximum Ambient Temperature	1000	400	250	150	N.C.
40°C	80	80	80	80	60
60°C	80	80	80	75	50
80°C	80	74	68	61	41

Current Rating 90-270 Amps; Voltage Ratings 100-1600 Volts

Mounting	Type Number	Mech. Data Pg. A34-35	Elec. Data Pg. A33
Floor	GN15B27	F-10	E-3
Wall	GN45B27	W-12	

Output Current (Avg. Amps.)

Air Velocity (LFM) → Maximum Ambient Temperature	1000	400	250	150	N.C.
40°C	270	207	185	162	90
60°C	220	170	152	133	74
80°C	150	115	103	90	50

Current Rating 155-300 Amps; Voltage Ratings 100-1600 Volts

Mounting	Type Number	Mech. Data Pg. A34-35	Elec. Data Pg. A33
Floor	GN16B30	F-19	E-3
Wall	GN46B30	W-21	

Output Current (Avg. Amps.)

Air Velocity (LFM) → Maximum Ambient Temperature	1000	400	250	150	N.C.
40°C	300	279	248	209	155
60°C	265	225	200	169	125
80°C	212	180	160	135	100

Current Rating 270-510 Amps; Voltage Ratings 100-2000 Volts

Mounting	Type Number	Mech. Data Pg. A34-35	Elec. Data Pg. A33
Floor	GN19B51	F-34	E-4
Wall	GN49B51	W-34	

Output Current (Avg. Amps.)

Air Velocity (LFM) → Maximum Ambient Temperature	1000	400	250	150	N.C.
40°C	510	454	426	378	270
60°C	496	395	370	330	235
80°C	360	321	302	266	190

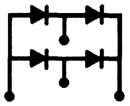
Current Rating 380-610 Amps; Voltage Ratings 100-2000 Volts

Mounting	Type Number	Mech. Data Pg. A34-35	Elec. Data Pg. A33
Floor	GN19B61	F-35	E-4
Wall	GN49B61	W-35	

Output Current (Avg. Amps.)

Air Velocity (LFM) → Maximum Ambient Temperature	1000	400	250	150	N.C.
40°C	610	564	532	490	380
60°C	520	480	455	418	325
80°C	425	393	371	342	265

Stud Mount ASSEMBLIES Gold Line



1 ϕ Bridge
B

Current Rating	26-45 Amps			45-76 Amps			60-80 Amps		
Voltage Ratings	100- 800 Volts			100-1000Volts			100-1000Volts		
	Type Number	Mech. Data Pg. A34-35	Elec. Data Pg. A33	Type Number	Mech. Data Pg. A34-35	Elec. Data Pg. A33	Type Number	Mech. Data Pg. A34-35	Elec. Data Pg. A33
Mounting Floor	GB11A45	F/W-4	E-1	GB12A76	F/W-9	E-2	GB14A80	F-11	E-2
Mounting Wall	(same)			(same)			GB44A80	W-13	

Output Current (Avg. Amps.)

Air Velocity (LFM) ➡		1000	400	250	150	N.C.	1000	400	250	150	N.C.	1000	400	250	150	N.C.
Maximum Ambient Temperature	40°C	45	40	36	33	26	76	76	68	59	45	80	80	80	80	60
	60°C	38	34	31	28	22	65	57	52	45·	34	80	80	80	75	50
	80°C	31	28	25	23	18	55	49	44	38	29	80	74	68	61	41

Current Rating	90-270 Amps			155-300 Amps			270-510 Amps		
Voltage Ratings	100-1600 Volts			100-1600 Volts			100-2000 Volts		
	Type Number	Mech. Data Pg. A34-35	Elec. Data Pg. A33	Type Number	Mech. Data Pg. A34-35	Elec. Data Pg. A33	Type Number	Mech. Data Pg. A34-35	Elec. Data Pg. A33
Mounting Floor	GB15B27	F-15	E-3	GB16B30	F-21	E-3	GB19B51	F-37	E-4
Mounting Wall	GB45B27	W-17		GB46B30	W-23		GB49B51	W-37	

Output Current (Avg. Amps.)

Air Velocity (LFM) ➡		1000	400	250	150	N.C.	1000	400	250	150	N.C.	1000	400	250	150	N.C.
Maximum Ambient Temperature	40°C	270	207	185	162	90	300	279	248	209	155	510	454	426	378	270
	60°C	220	170	152	133	74	265	225	200	169	125	496	395	370	330	235
	80°C	150	115	103	90	50	212	180	160	135	100	360	321	302	266	190

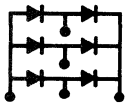
Current Rating	380-610 Amps		
Voltage Ratings	100-2000 Volts		
	Type Number	Mech. Data Pg. A34-35	Elec. Data Pg. A33
Mounting Floor	GB19B61	F-41	E-4

Output Current (Avg. Amps.)

Air Velocity (LFM) ➡		1000	400	250	150	N.C.
Maximum Ambient Temperature	40°C	610	564	532	490	380
	60°C	520	480	455	418	325
	80°C	425	393	371	342	265

Stud Mount ASSEMBLIES Gold Line

Rectifier



3 ϕ Bridge
E

35-61 Amps — 100- 800 Volts

Current Rating: 35-61 Amps
Voltage Ratings: 100- 800 Volts

Mounting	Type Number	Mech. Data Pg. A34-35	Elec. Data Pg. A33
Floor	GE11A61	F/W-5	E-1
Wall	(same)		

Output Current (Avg. Amps.)

Air Velocity (LFM) ➡ Maximum Ambient Temperature	1000	400	250	150	N.C.
40°C	61	54	49	45	35
60°C	52	46	42	38	30
80°C	45	40	36	33	26

55-100 Amps — 100-1000Volts

Mounting	Type Number	Mech. Data Pg. A34-35	Elec. Data Pg. A33
Floor	GE12B10	F/W-10	E-2
Wall	(same)		

Output Current (Avg. Amps.)

Air Velocity (LFM) ➡ Maximum Ambient Temperature	1000	400	250	150	N.C.
40°C	100	92	84	73	55
60°C	91	81	73	63	48
80°C	78	69	62	54	41

70-120 Amps — 100-1000Volts

Mounting	Type Number	Mech. Data Pg. A34-35	Elec. Data Pg. A33
Floor	GE14B12	F-14	E-2
Wall	GE44B12	W-16	

Output Current (Avg. Amps.)

Air Velocity (LFM) ➡ Maximum Ambient Temperature	1000	400	250	150	N.C.
40°C	120	120	116	107	70
60°C	116	115	96	87	58
80°C	94	85	72	70	47

100-300 Amps — 100-1600 Volts

Mounting	Type Number	Mech. Data Pg. A34-35	Elec. Data Pg. A33
Floor	GE15B30	F-16	E-3
Wall	GE45B30	W-18	

Output Current (Avg. Amps.)

Air Velocity (LFM) ➡ Maximum Ambient Temperature	1000	400	250	150	N.C.
40°C	300	230	205	180	100
60°C	246	189	168	148	82
80°C	189	145	130	113	63

180-380 Amps — 100-1600 Volts

Mounting	Type Number	Mech. Data Pg. A34-35	Elec. Data Pg. A33
Floor	GE16B38	F-21	E-3
Wall	GE46B38	W-23	

Output Current (Avg. Amps.)

Air Velocity (LFM) ➡ Maximum Ambient Temperature	1000	400	250	150	N.C.
40°C	380	323	288	243	180
60°C	307	261	232	196	145
80°C	234	198	176	149	110

225-450 Amps — 100-1600 Volts

Mounting	Type Number	Mech. Data Pg. A34-35	Elec. Data Pg. A33
Floor	GE16B45	F-23	E-3
Wall	GE46B45	W-25	

Output Current (Avg. Amps.)

Air Velocity (LFM) ➡ Maximum Ambient Temperature	1000	400	250	150	N.C.
40°C	450	405	361	303	225
60°C	393	333	290	249	185
80°C	297	252	224	188	140

280-530 Amps — 100-2000 Volts

Mounting	Type Number	Mech. Data Pg. A34-35	Elec. Data Pg. A33
Floor	GE19B53	F-38	E-4
Wall	GE49B53	W-38	

Output Current (Avg. Amps.)

Air Velocity (LFM) ➡ Maximum Ambient Temperature	1000	400	250	150	N.C.
40°C	530	470	443	393	280
60°C	456	405	382	336	240
80°C	360	321	302	266	190

370-700 Amps — 100-2000 Volts

Mounting	Type Number	Mech. Data Pg. A34-35	Elec. Data Pg. A33
Floor	GE19B70	F-40	E-4
Wall	GE49B70	W-40	

Output Current (Avg. Amps.)

Air Velocity (LFM) ➡ Maximum Ambient Temperature	1000	400	250	150	N.C.
40°C	700	628	581	526	370
60°C	611	552	510	461	325
80°C	517	468	432	391	275

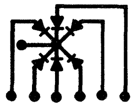
520-830 Amps — 100-2000 Volts

Mounting	Type Number	Mech. Data Pg. A34-35	Elec. Data Pg. A33
Floor	GE19B83	F-43	E-4
Wall			

Output Current (Avg. Amps.)

Air Velocity (LFM) ➡ Maximum Ambient Temperature	1000	400	250	150	N.C.
40°C	830	770	730	672	520
60°C	730	675	638	588	455
80°C	617	570	540	500	385

Stud Mount ASSEMBLIES Gold Line



6 ϕ Star

Current Rating 114-195 Amps
Voltage Ratings 100-1000 Volts

Mounting	Type Number	Mech. Data Pg. A34-35	Elec. Data Pg. A33
Floor	GS14B19	F-12	E-2
Wall	GS44B19	W-14	

Output Current (Avg. Amps.)

Air Velocity (LFM) ➡ Maximum Ambient Temperature	1000	400	250	150	N.C.
40°C	**195**	195	189	171	**114**
60°C	189	187	156	142	95
80°C	153	138	117	114	77

Current Rating 163-490 Amps
Voltage Ratings 100-1600 Volts

Mounting	Type Number	Mech. Data Pg. A34-35	Elec. Data Pg. A33
Floor	GS15B49	F-17	E-3
Wall	GS45B49	W-19	

Output Current (Avg. Amps.)

Air Velocity (LFM) ➡ Maximum Ambient Temperature	1000	400	250	150	N.C.
40°C	**490**	375	344	294	**163**
60°C	401	308	274	241	134
80°C	308	236	212	184	103

Current Rating 294-620 Amps
Voltage Ratings 100-1600 Volts

Mounting	Type Number	Mech. Data Pg. A34-35	Elec. Data Pg. A33
Floor	GS16B62	F-22	E-3
Wall	GS46B62	W-24	

Output Current (Avg. Amps.)

Air Velocity (LFM) ➡ Maximum Ambient Temperature	1000	400	250	150	N.C.
40°C	**620**	526	469	396	**294**
60°C	501	425	378	320	236
80°C	382	323	288	243	118

Current Rating 367-735 Amps
Voltage Ratings 100-1600 Volts

Mounting	Type Number	Mech. Data Pg. A34-35	Elec. Data Pg. A33
Floor	GS16B73	F-24	E-3
Wall	GS46B73	W-26	

Output Current (Avg. Amps.)

Air Velocity (LFM) ➡ Maximum Ambient Temperature	1000	400	250	150	N.C.
40°C	**735**	660	588	494	**367**
60°C	641	543	473	406	302
80°C	484	411	366	307	228

Current Rating 457-870 Amps
Voltage Ratings 100-2000 Volts

Mounting	Type Number	Mech. Data Pg. A34-35	Elec. Data Pg. A33
Floor	GS19B87	F-39	E-4
Wall	GS49B87	W-39	

Output Current (Avg. Amps.)

Air Velocity (LFM) ➡ Maximum Ambient Temperature	1000	400	250	150	N.C.
40°C	**870**	767	722	641	**457**
60°C	744	661	623	548	392
80°C	587	523	492	433	310

Current Rating 603-1150 Amps
Voltage Ratings 100-2000 Volts

Mounting	Type Number	Mech. Data Pg. A34-35	Elec. Data Pg. A33
Floor	GS19C11	F-40	E-4
Wall	GS49C11	W-40	

Output Current (Avg. Amps.)

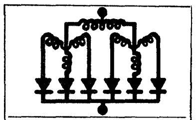
Air Velocity (LFM) ➡ Maximum Ambient Temperature	1000	400	250	150	N.C.
40°C	**1150**	1022	947	853	**603**
60°C	997	899	832	753	530
80°C	843	764	704	638	448

Current Rating 850-1360 Amps
Voltage Ratings 100-2000 Volts

Mounting	Type Number	Mech. Data Pg. A34-35	Elec. Data Pg. A33
Floor	GS19C13	F-43	E-4

Output Current (Avg. Amps.)

Air Velocity (LFM) ➡ Maximum Ambient Temperature	1000	400	250	150	N.C.
40°C	**1360**	1253	1190	1095	**850**
60°C	1190	1100	1038	959	742
80°C	1005	930	880	815	628



3 ϕ Wye
(With Interphase Transformer)

Current Rating 140-240 Amps, Voltage Ratings 100-1000Volts

Mounting	Type Number	Mech. Data Pg. A34-35	Elec. Data Pg. A33
Floor	GY14B24	F-12	E-2
Wall	GY44B24	W-14	

Output Current (Avg. Amps.)

Maximum Ambient Temperature / Air Velocity (LFM)	1000	400	250	150	N.C.
40°C	240	240	232	210	140
60°C	232	230	192	174	116
80°C	188	170	144	140	94

Current Rating 200-600 Amps, Voltage Ratings 100-1600 Volts

Mounting	Type Number	Mech. Data Pg. A34-35	Elec. Data Pg. A33
Floor	GY15B60	F-17	E-3
Wall	GY45B60	W-19	

Output Current (Avg. Amps.)

Maximum Ambient Temperature / Air Velocity (LFM)	1000	400	250	150	N.C.
40°C	600	460	410	360	200
60°C	492	378	336	296	164
80°C	378	290	260	226	126

Current Rating 360-760 Amps, Voltage Ratings 100-1600 Volts

Mounting	Type Number	Mech. Data Pg. A34-35	Elec. Data Pg. A33
Floor	GY16B76	F-22	E-3
Wall	GY46B76	W-24	

Output Current (Avg. Amps.)

Maximum Ambient Temperature / Air Velocity (LFM)	1000	400	250	150	N.C.
40°C	760	646	576	486	380
60°C	614	522	464	392	290
80°C	468	396	354	298	220

Current Rating 450-900 Amps, Voltage Ratings 100-1600 Volts

Mounting	Type Number	Mech. Data Pg. A34-35	Elec. Data Pg. A33
Floor	GY16B90	F-24	E-3
Wall	GY46B90	W-26	

Output Current (Avg. Amps.)

Maximum Ambient Temperature / Air Velocity (LFM)	1000	400	250	150	N.C.
40°C	900	810	722	606	450
60°C	736	666	580	498	370
80°C	594	504	448	376	280

Current Rating 560-1060 Amps, Voltage Ratings 100-2000 Volts

Mounting	Type Number	Mech. Data Pg. A34-35	Elec. Data Pg. A33
Floor	GY19C10	F-39	E-4
Wall	GY49C10	W-39	

Output Current (Avg. Amps.)

Maximum Ambient Temperature / Air Velocity (LFM)	1000	400	250	150	N.C.
40°C	1060	940	886	786	560
60°C	912	810	764	672	480
80°C	720	642	604	532	380

Current Rating 740-1400 Amps, Voltage Ratings 100-2000 Volts

Mounting	Type Number	Mech. Data Pg. A34-35	Elec. Data Pg. A33
Floor	GY19C14	F-40	E-4
Wall	GY49C14	W-40	

Output Current (Avg. Amps.)

Maximum Ambient Temperature / Air Velocity (LFM)	1000	400	250	150	N.C.
40°C	1400	1256	1162	1052	740
60°C	1222	1104	1020	922	650
80°C	1034	936	864	782	550

Current Rating 1040-1670 Amps, Voltage Ratings 100-2000 Volts

Mounting	Type Number	Mech. Data Pg. A34-35	Elec. Data Pg. A33
Floor	GY19C16	F-43	E-4

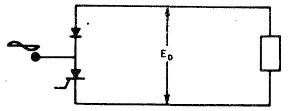
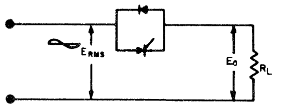
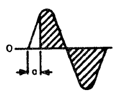
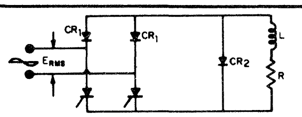
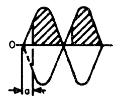
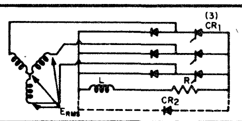
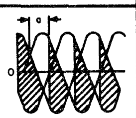
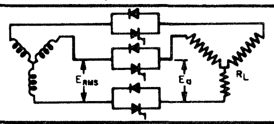
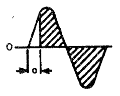
Output Current (Avg. Amps.)

Maximum Ambient Temperature / Air Velocity (LFM)	1000	400	250	150	N.C.
40°C	1670	1540	1460	1344	1040
60°C	1460	1350	1276	1176	910
80°C	1234	1140	1080	1000	770

Half Control Assemblies

This section describes the standard circuit configurations available for Half Control Assemblies (assemblies using both rectifiers and SCR's). The chart below shows the schematics, waveform, recommended SCR and diode voltage ratings, the basic current ratings available, and the page number where specific rating information for each assembly can be found.

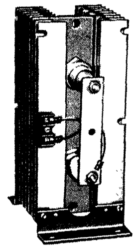
On each page the assemblies for a given circuit configuration are listed in order of increasing current rating. The tabulated current ratings for each assembly type number are given as a function of ambient temperature, as a function of the conduction or delay angle, and as a function of the air velocity (linear feet per minute – LFM). The conduction angle is defined as the number of electrical degrees the SCR conducts current. The delay angle is defined as the number of electrical degrees the gate trigger pulse is delayed from the time the anode voltage on the SCR starts positive. Refer to the mechanical and electrical keys specified for the assembly you have selected to obtain assembly weight and dimensions and other electrical data and recommendations.

Circuit		Assembly Output			
Configuration	Schematic	Waveform	Maximum Voltage E_d=Avg. E_a=RMS	Maximum SCR Voltage	Maximum Diode Voltage
D – Doubler		(See: Single Phase Bridge "B" or Three Phase Bridge "E")			
A – Single Phase AC Switch			$E_a = E_{RMS}$	1.4 E_{RMS}	1.4 E_{RMS}
B – Single Phase Bridge			$E_d = .90\ E_{RMS}$	1.4 E_{RMS}	1.4 E_{RMS}
E – Three Phase Bridge			$E_d = 1.35\ E_{RMS}$	2.45 E_{RMS}	2.45 E_{RMS}
F – Three Phase AC Switch			$E_a = E_{RMS}$	1.4 E_{RMS}	1.4 E_{RMS}

Description of Half Control Assemblies Pictured on the Right

- **I** Westinghouse GA28B32, 1ϕ AC Switch 180-320 Amps, 100-1600 Volts on 4 x 4 x 9 heat sinks.
- **II** Westinghouse GB28B29, 1ϕ Bridge, 161-290 Amps, 100-1600 Volts on 4 x 4 x 9 heat sinks.
- **III** Westinghouse GE28B42, 3ϕ Bridge, 232-420 Amps, 100-1600 Volts on 4 x 4 x 9 heat sinks.
- **IV** Westinghouse GE24B11, 3ϕ Bridge 54-110 Amps, 100-1000 Volts on 1¼ x 4 x 5 heat sinks.
- **V** Westinghouse GF24A89, 3ϕ AC Switch 42-89 Amps, 100-1000 Volts on 1¼ x 4 x 5 heat sinks.

	Available Assemblies		
	Output Current Ratings (Amperes)		
Recommended SCR & Diode Voltage Rating	Natural Convection at 40°C	Forced Convection at 40°C & 1000 LFM	For Specific Rating Info See Page
	12 to 77	19 to 140	A18
2.8 E_{RMS}	28 RMS to 180 RMS	46 RMS to 320 RMS	A19
2.8 E_{RMS} or 3.9 E_d	26 to 161	41 to 290	A20
4.9 E_{RMS} or 2.1 E_d	37 to 232	58 to 420	A21
2.8 E_{RMS}	28 RMS to 180 RMS	46 RMS to 320 RMS	A22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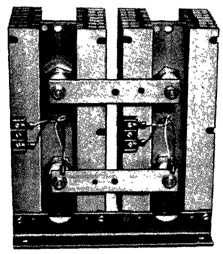
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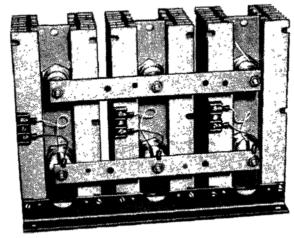
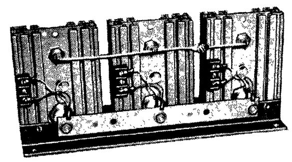
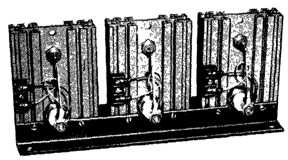
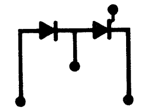

III


IV


V

Stud Mount ASSEMBLIES Gold Line



Doubler D

12-19 Amps, 100-1000 Volts

Mounting	Type Number	Mech. Data Pg. A34-35	Elec. Data Pg. A33
Floor	GD23A19	F-1	E-5
Wall	GD53A19	W-1	

Output Current (Avg. Amps.) — Air Velocity (LFM)

Maximum Ambient Temperature	Delay Angle	1000	400	250	150	N.C.
40°C	0	19	17	16	15	12
	60	17	16	15	14	12
	90	16	14	13	12	10
	120	12	12	11	10	9
	150	8	8	8	7	6
60°C	0	16	14	13	12	10
	60	15	13	12	11	9
	90	13	11	11	10	8
	120	11	9	9	8	7
	150	8	7	6	6	5
80°C	0	11	10	9	8	6
	60	10	9	8	7	6
	90	9	8	7	6	5
	120	8	8	6	6	5
	150	6	5	5	5	4

18-36 Amps, 100-1000 Volts

Mounting	Type Number	Mech. Data Pg. A34-35	Elec. Data Pg. A33
Floor	GD24A36	F-9	E-6
Wall	GD54A36	W-11	

Output Current (Avg. Amps.) — Air Velocity (LFM)

Maximum Ambient Temperature	Delay Angle	1000	400	250	150	N.C.
40°C	0	36	35	32	28	18
	60	33	33	30	27	17
	90	28	28	27	24	16
	120	23	23	23	21	14
	150	16	16	16	16	11
60°C	0	35	29	26	23	14
	60	32	27	25	22	13
	90	28	25	22	20	12
	120	23	21	19	18	11
	150	16	16	16	14	9
80°C	0	27	22	20	18	10
	60	25	21	19	17	9
	90	21	19	17	15	8
	120	19	16	15	13	7
	150	15	13	12	10	6

36 Amps, 100-1200 Volts

Mounting	Type Number	Mech. Data Pg. A34-35	Elec. Data Pg. A33
Floor	GD27A36	F-27	E-6
Wall	GD57A36	W-27	

Output Current (Avg. Amps.) — Air Velocity (LFM)

Maximum Ambient Temperature	Delay Angle	1000	400	250	150	N.C.
40°C	0	36	36	36	36	36
	60	33	33	33	33	33
	90	28	28	28	28	28
	120	23	23	23	23	23
	150	16	16	16	16	16
60°C	0	36	36	36	36	29
	60	33	33	33	33	27
	90	28	28	28	28	25
	120	23	23	23	23	21
	150	16	16	16	16	16
80°C	0	35	33	30	28	21
	60	33	31	29	27	20
	90	28	27	25	24	17
	120	23	22	22	21	16
	150	16	16	16	16	12

47-72 Amps, 100-1200 Volts

Mounting	Type Number	Mech. Data Pg. A34-35	Elec. Data Pg. A33
Floor	GD27A72	F-27	E-7
Wall	GD57A72	W-27	

Output Current (Avg. Amps.) — Air Velocity (LFM)

Maximum Ambient Temperature	Delay Angle	1000	400	250	150	N.C.
40°C	0	72	68	63	57	47
	60	67	63	59	54	43
	90	56	56	54	49	40
	120	45	45	45	42	35
	150	32	32	32	32	28
60°C	0	59	55	51	47	36
	60	55	52	48	44	34
	90	50	46	43	40	31
	120	42	40	38	35	27
	150	32	31	30	27	22
80°C	0	45	41	38	35	26
	60	41	39	36	33	24
	90	37	34	32	30	22
	120	32	30	28	26	19
	150	25	23	22	21	16

63-110 Amps, 100-1600 Volts

Mounting	Type Number	Mech. Data Pg. A34-35	Elec. Data Pg. A33
Floor	GD28B11	F-28	E-8
Wall	GD58B11	W-28	

Output Current (Avg. Amps.) — Air Velocity (LFM)

Maximum Ambient Temperature	Delay Angle	1000	400	250	150	N.C.
40°C	0	110	104	93	81	63
	60	105	98	89	79	61
	90	88	88	81	72	57
	120	71	71	71	64	50
	150	49	49	49	49	40
60°C	0	92	83	75	65	49
	60	87	80	72	63	47
	90	79	73	65	58	43
	120	69	64	58	52	38
	150	49	49	46	41	32
80°C	0	69	62	55	48	34
	60	65	59	53	47	32
	90	61	55	49	44	30
	120	54	48	43	39	27
	150	42	38	35	31	23

77-140 Amps, 100-1600 Volts

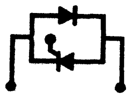
Mounting	Type Number	Mech. Data Pg. A34-35	Elec. Data Pg. A33
Floor	GD28B14	F-28	E-9
Wall	GD58B14	W-28	

Output Current (Avg. Amps.) — Air Velocity (LFM)

Maximum Ambient Temperature	Delay Angle	1000	400	250	150	N.C.
40°C	0	140	126	111	97	77
	60	134	121	107	94	74
	90	121	110	98	88	69
	120	98	94	84	75	59
	150	69	69	68	60	48
60°C	0	113	102	91	79	60
	60	109	99	88	77	57
	90	99	90	79	70	53
	120	86	77	69	61	46
	150	68	62	56	50	37
80°C	0	82	74	67	57	41
	60	81	73	65	56	39
	90	74	66	59	53	36
	120	64	58	52	46	31
	150	50	47	42	37	26

Stud Mount ASSEMBLIES Gold Line

Half Control



1 φ AC Switch A

Current Rating: 28-46 Amps — Voltage Ratings: 100-1000 Volts

Mounting	Type Number	Mech. Data Pg. A34-35	Elec. Data Pg. A33
Floor	GA23A46	F-1	E-5
Wall	GA53A46	W-1	

Output Current (RMS Amps.)

Maximum Ambient Temperature	Delay Angle	1000	400	250	150	N.C.
40°C	0	**46**	40	38	34	**28**
	90	47	42	39	35	30
	120	48	43	40	36	31
	150	49	44	41	38	32
	180	50	45	43	40	34
60°C	0	38	33	31	28	22
	90	39	34	32	29	24
	120	40	35	33	30	25
	150	41	37	34	31	26
	180	42	38	36	33	27
80°C	0	29	25	23	21	16
	90	30	26	24	22	17
	120	31	27	25	23	17
	150	32	28	26	24	19
	180	33	29	27	26	21

Current Rating: 42-89 Amps — Voltage Ratings: 100-1200 Volts

Mounting	Type Number	Mech. Data Pg. A34-35	Elec. Data Pg. A33
Floor	GA24A89	F-9	E-6
Wall	GA54A89	W-11	

Output Current (RMS Amps.)

Maximum Ambient Temperature	Delay Angle	1000	400	250	150	N.C.
40°C	0	**89**	82	74	66	**42**
	90	89	87	82	73	48
	120	89	89	86	77	51
	150	89	89	89	84	56
	180	89	89	89	87	64
60°C	0	81	68	61	54	33
	90	86	75	67	60	34
	120	89	78	70	63	39
	150	89	85	77	69	43
	180	89	89	85	78	50
80°C	0	61	50	45	40	23
	90	63	53	47	42	24
	120	64	54	48	43	25
	150	70	59	53	47	27
	180	76	64	58	52	30

Current Rating: 85-89 Amps — Voltage Ratings: 100-1200 Volts

Mounting	Type Number	Mech. Data Pg. A34-35	Elec. Data Pg. A33
Floor	GA27A89	F-27	E-6
Wall	GA57A89	W-27	

Output Current (RMS Amps.)

Maximum Ambient Temperature	Delay Angle	1000	400	250	150	N.C.
40°C	0	**89**	89	89	89	**85**
	90	89	89	89	89	89
	120	89	89	89	89	89
	150	89	89	89	89	89
	180	89	89	89	89	89
60°C	0	89	89	89	86	68
	90	89	89	89	89	69
	120	89	89	89	89	73
	150	89	89	89	89	76
	180	89	89	89	89	82
80°C	0	80	76	71	66	49
	90	83	79	74	69	52
	120	85	81	75	70	53
	150	89	85	80	74	56
	180	89	89	83	78	60

Current Rating: 106-170 Amps — Voltage Ratings: 100-1200 Volts

Mounting	Type Number	Mech. Data Pg. A34-35	Elec. Data Pg. A33
Floor	GA27B17	F-27	E-7
Wall	GA57B17	W-27	

Output Current (RMS Amps.)

Maximum Ambient Temperature	Delay Angle	1000	400	250	150	N.C.
40°C	0	**170**	157	147	134	**106**
	90	174	164	154	141	111
	120	177	168	157	144	113
	150	177	177	176	156	127
	180	177	177	177	168	136
60°C	0	136	128	120	108	83
	90	143	134	126	113	85
	120	146	137	128	116	88
	150	155	145	136	126	98
	180	168	159	150	138	106
80°C	0	102	96	88	80	58
	90	108	101	94	85	60
	120	111	109	97	88	62
	150	117	110	103	95	70
	180	126	118	112	102	74

Current Rating: 147-260 Amps — Voltage Ratings: 100-1600 Volts

Mounting	Type Number	Mech. Data Pg. A34-35	Elec. Data Pg. A33
Floor	GA28B26	F-28	E-8
Wall	GA58B26	W-28	

Output Current (Avg. Amps.)

Maximum Ambient Temperature	Delay Angle	1000	400	250	150	N.C.
40°C	0	**260**	240	216	196	**147**
	90	274	256	230	204	159
	120	279	264	237	208	165
	150	279	279	254	227	180
	180	279	279	273	250	198
60°C	0	211	193	173	153	112
	90	225	205	188	161	120
	120	232	212	196	166	125
	150	250	230	206	184	137
	180	272	251	226	202	151
80°C	0	156	143	128	112	78
	90	169	154	137	120	83
	120	175	160	142	124	86
	150	189	171	155	138	95
	180	202	187	169	151	103

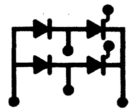
Current Rating: 180-320 Amps — Voltage Ratings: 100-1600 Volts

Mounting	Type Number	Mech. Data Pg. A34-35	Elec. Data Pg. A33
Floor	GA28B32	F-28	E-9
Wall	GA58B32	W-28	

Output Current (Avg. Amps.)

Maximum Ambient Temperature	Delay Angle	1000	400	250	150	N.C.
40°C	0	**320**	297	260	227	**180**
	90	341	313	276	242	193
	120	360	321	286	250	200
	150	378	346	308	270	212
	180	390	375	337	302	235
60°C	0	260	237	209	181	135
	90	278	252	223	193	145
	120	288	260	232	200	150
	150	310	282	252	223	164
	180	341	309	277	247	180
80°C	0	191	175	153	132	92
	90	209	188	167	141	98
	120	218	195	174	146	102
	150	233	210	190	166	110
	180	256	233	208	185	122

Air Velocity (LFM) columns: 1000, 400, 250, 150, N.C.



1 φ Bridge
B

Current Rating	26-41 Amps			38-80 Amps			78-80 Amps		
Voltage Ratings	100-1000 Volts			100-1000 Volts			100-1200 Volts		
	Type Number	Mech. Data Pg. A34-35	Elec. Data Pg. A33	Type Number	Mech. Data Pg. A34-35	Elec. Data Pg. A33	Type Number	Mech. Data Pg. A34-35	Elec. Data Pg. A33
Mounting Floor	GB23A41	F-2	E-5	GB24A80	F-13	E-6	GB27A80	F-29	E-6
Mounting Wall	GB53A41	W-2		GB54A80	W-15		GB57A80	W-29	

Output Current (Avg. Amps.)

Maximum Ambient Temperature	Conduction Angle	1000	400	250	150	N.C.	1000	400	250	150	N.C.	1000	400	250	150	N.C.
40°C	180	41	36	34	30	26	80	74	66	59	38	80	80	80	80	78
40°C	120	36	32	30	27	23	67	67	61	54	35	66	66	66	66	66
40°C	90	31	28	26	24	21	57	57	54	49	32	56	56	56	56	56
40°C	60	24	23	22	20	18	45	45	45	43	28	46	46	46	46	46
40°C	30	17	17	16	13	12	31	31	31	31	22	32	32	32	32	32
60°C	180	34	30	27	24	20	73	61	54	48	29	80	80	80	78	60
60°C	120	30	26	25	22	18	65	55	50	44	27	66	66	66	66	54
60°C	90	26	23	21	20	17	57	49	45	40	24	56	56	56	56	50
60°C	60	21	19	18	16	14	45	43	38	35	22	46	46	46	46	42
60°C	30	15	14	13	12	10	31	31	31	27	17	32	32	32	32	32
80°C	180	23	20	18	16	13	56	46	41	36	20	72	68	64	60	44
80°C	120	20	18	17	13	12	50	41	38	33	19	66	61	58	54	40
80°C	90	18	16	14	13	11	43	38	34	31	17	56	54	50	48	34
80°C	60	16	15	13	13	10	38	32	29	27	15	46	46	44	42	32
80°C	30	12	11	10	10	8	30	27	23	21	12	32	32	32	32	24

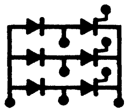
Air Velocity (LFM) →

Current Rating	94-150 Amps			130-230 Amps			161-290 Amps		
Voltage Ratings	100-1200 Volts			100-1600 Volts			100-1600 Volts		
	Type Number	Mech. Data Pg. A34-35	Elec. Data Pg. A33	Type Number	Mech. Data Pg. A34-35	Elec. Data Pg. A33	Type Number	Mech. Data Pg. A34-35	Elec. Data Pg. A33
Mounting Floor	GB27B15	F-29	E-7	GB28B23	F-30	E-8	GB28B29	F-30	E-9
Mounting Wall	GB57B15	W-29		GB58B23	W-30		GB58B29	W-30	

Output Current (Avg. Amps.)

Maximum Ambient Temperature	Conduction Angle	1000	400	250	150	N.C.	1000	400	250	150	N.C.	1000	400	250	150	N.C.
40°C	180	150	140	130	120	94	230	215	194	171	130	290	262	227	202	161
40°C	120	133	127	118	108	86	211	196	177	157	122	268	241	214	187	148
40°C	90	113	113	108	99	80	177	177	162	144	114	242	220	196	172	137
40°C	60	91	91	91	85	69	142	142	142	127	101	196	188	168	150	118
40°C	30	63	63	63	63	55	99	99	99	99	81	138	138	136	120	96
60°C	180	122	113	105	97	72	192	174	158	138	100	234	212	186	162	122
60°C	120	110	104	96	88	68	174	160	143	127	93	218	196	176	152	114
60°C	90	99	92	86	80	63	158	144	130	116	86	198	179	159	140	106
60°C	60	85	80	75	70	54	139	128	116	104	77	172	154	138	122	92
60°C	30	63	62	59	55	44	99	99	92	83	64	136	124	112	100	74
80°C	180	96	83	76	71	49	143	130	118	104	70	174	157	137	118	84
80°C	120	82	77	71	66	47	129	120	107	94	64	161	145	130	112	78
80°C	90	75	69	65	60	45	120	107	96	86	58	148	133	117	107	73
80°C	60	64	59	56	52	38	107	96	86	78	53	128	116	104	92	62
80°C	30	50	47	44	41	32	84	77	70	63	46	100	94	84	74	56

Air Velocity (LFM) →



3 φ Bridge
E

37-58 Amps, 100-1000 Volts

Mounting	Type Number	Mech. Data Pg. A34-35	Elec. Data Pg. A33
Floor	GE23A58	F-4	E-5
Wall	GE53A58	W-5	E-5

Output Current (Avg. Amps.)

Maximum Ambient Temperature	Delay Angle	1000	400	250	150	N.C.
40°C	0	58	52	48	44	37
	60	52	48	45	41	35
	90	47	42	39	36	31
	120	36	35	33	30	27
	150	25	25	24	20	18
60°C	0	48	43	40	36	30
	60	45	39	37	33	27
	90	39	34	32	30	25
	120	32	28	27	24	21
	150	23	21	19	18	15
80°C	0	34	30	27	24	19
	60	30	27	25	20	18
	90	27	24	21	19	16
	120	24	23	19	19	15
	150	18	16	15	15	12

54-110 Amps, 100-1000 Volts

Mounting	Type Number	Mech. Data Pg. A34-35	Elec. Data Pg. A33
Floor	GE24B11	F-18	E-6
Wall	GE54B11	W-20	E-6

Output Current (Avg. Amps.)

Maximum Ambient Temperature	Delay Angle	1000	400	250	150	N.C.
40°C	0	110	106	95	85	54
	60	100	100	91	81	52
	90	85	85	82	73	47
	120	68	68	68	64	42
	150	47	47	47	47	34
60°C	0	104	87	78	69	41
	60	97	82	75	66	40
	90	85	74	67	61	37
	120	68	64	58	53	32
	150	47	47	47	42	26
80°C	0	81	67	59	53	29
	60	75	62	56	50	28
	90	64	56	51	46	25
	120	58	49	44	40	22
	150	44	38	35	31	18

110 Amps, 100-1200 Volts

Mounting	Type Number	Mech. Data Pg. A34-35	Elec. Data Pg. A33
Floor	GE27B11	F-31	E-6
Wall	GE57B11	W-31	E-6

Output Current (Avg. Amps.)

Maximum Ambient Temperature	Delay Angle	1000	400	250	150	N.C.
40°C	0	110	110	110	110	110
	60	99	99	99	99	99
	90	84	84	84	84	84
	120	69	69	69	69	69
	150	48	48	48	48	48
60°C	0	108	108	108	108	87
	60	99	99	99	99	81
	90	84	84	84	84	75
	120	69	69	69	69	63
	150	48	48	48	48	48
80°C	0	105	99	90	84	63
	60	99	93	87	81	60
	90	84	81	75	72	51
	120	69	67	66	63	48
	150	48	48	48	48	30

140-220 Amps, 100-1200 Volts

Mounting	Type Number	Mech. Data Pg. A34-35	Elec. Data Pg. A33
Floor	GE27B22	F-31	E-7
Wall	GE57B22	W-31	E-7

Output Current (Avg. Amps.)

Maximum Ambient Temperature	Delay Angle	1000	400	250	150	N.C.
40°C	0	220	203	189	171	140
	60	200	190	177	162	129
	90	168	168	162	148	121
	120	136	136	136	127	104
	150	95	95	95	95	83
60°C	0	177	165	153	140	108
	60	165	156	144	132	102
	90	149	139	129	120	94
	120	127	120	113	105	81
	150	95	93	89	82	65
80°C	0	134	122	114	105	77
	60	123	116	107	99	71
	90	112	103	97	90	67
	120	96	89	84	78	58
	150	75	70	66	62	47

188-330 Amps, 100-1600 Volts

Mounting	Type Number	Mech. Data Pg. A34-35	Elec. Data Pg. A33
Floor	GE28B33	F-32	E-8
Wall	GE58B33	W-32	E-8

Output Current (Avg. Amps.)

Maximum Ambient Temperature	Delay Angle	1000	400	250	150	N.C.
40°C	0	330	312	278	243	188
	60	314	295	266	236	183
	90	265	265	243	216	171
	120	213	213	213	190	151
	150	148	148	148	148	121
60°C	0	275	250	224	196	147
	60	260	240	217	190	141
	90	236	218	196	175	129
	120	208	192	174	156	115
	150	148	148	137	124	96
80°C	0	208	186	165	145	103
	60	195	178	159	141	96
	90	182	164	146	132	91
	120	161	144	129	117	80
	150	125	115	105	94	68

232-420 Amps, 100-1600 Volts

Mounting	Type Number	Mech. Data Pg. A34-35	Elec. Data Pg. A33
Floor	GE28B42	F-32	E-9
Wall	GE58B42	W-32	E-9

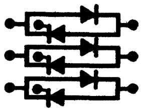
Output Current (Avg. Amps.)

Maximum Ambient Temperature	Delay Angle	1000	400	250	150	N.C.
40°C	0	420	378	334	291	232
	60	402	364	322	282	222
	90	362	330	294	264	206
	120	294	282	252	225	177
	150	207	207	204	180	144
60°C	0	338	306	272	236	180
	60	327	296	264	230	170
	90	297	268	238	210	158
	120	258	231	207	183	138
	150	204	186	168	150	111
80°C	0	246	222	198	171	123
	60	242	218	194	168	117
	90	222	198	176	159	108
	120	192	174	156	138	93
	150	150	141	126	111	78

Air Velocity (LFM): 1000, 400, 250, 150, N.C.

Half Control

Stud Mount ASSEMBLIES Gold Line



3 φ AC Switch F

ASSEMBLIES

Current Rating 28-46 Amps — Voltage Ratings 100-1000 Volts

Mounting	Type Number	Mech. Data Pg. A34-35	Elec. Data Pg. A33
Floor	GF23A46	F-4	E-5
Wall	GF53A46	W-6	

Output Current (RMS Amps.)

Maximum Ambient Temperature	Delay Angle	1000	400	250	150	N.C.
40°C	0	46	40	38	34	28
	90	48	43	40	36	31
	120	49	44	41	38	32
	150	50	45	43	40	34
	180	50	47	45	42	36
60°C	0	38	33	31	28	22
	90	40	35	33	30	25
	120	41	37	34	31	26
	150	42	38	36	33	27
	180	43	40	37	35	30
80°C	0	29	25	23	21	16
	90	31	27	25	23	17
	120	32	28	26	24	19
	150	33	29	27	26	21
	180	33	31	29	28	22

Current Rating 42-89 Amps — Voltage Ratings 100-1000 Volts

Mounting	Type Number	Mech. Data Pg. A34-35	Elec. Data Pg. A33
Floor	GF24A89	F-18	E-6
Wall	GF54A89	W-20	

Output Current (RMS Amps.)

Maximum Ambient Temperature	Delay Angle	1000	400	250	150	N.C.
40°C	0	89	82	74	66	42
	90	89	89	80	71	46
	120	89	89	86	77	51
	150	89	89	89	84	56
	180	89	89	89	89	64
60°C	0	81	68	61	54	33
	90	85	72	66	57	36
	120	89	78	70	63	39
	150	89	85	77	69	43
	180	89	89	85	78	50
80°C	0	61	50	45	40	23
	90	64	54	48	43	25
	120	70	59	53	47	27
	150	76	64	58	52	30
	180	83	72	66	60	36

Current Rating 85-89 Amps — Voltage Ratings 100-1200 Volts

Mounting	Type Number	Mech. Data Pg. A34-35	Elec. Data Pg. A33
Floor	GF27A89	F-31	E-6
Wall	GF57A89	W-31	

Output Current (RMS Amps.)

Maximum Ambient Temperature	Delay Angle	1000	400	250	150	N.C.
40°C	0	89	89	89	89	85
	90	89	89	89	89	89
	120	89	89	89	89	89
	150	89	89	89	89	89
	180	89	89	89	89	89
60°C	0	89	89	89	86	68
	90	89	89	89	89	73
	120	89	89	89	89	76
	150	89	89	89	89	82
	180	89	89	89	89	89
80°C	0	80	76	71	66	49
	90	85	81	75	70	53
	120	89	85	80	74	56
	150	89	89	83	78	60
	180	89	89	89	87	87

Current Rating 106-170 Amps — Voltage Ratings 100-1200 Volts

Mounting	Type Number	Mech. Data Pg. A34-35	Elec. Data Pg. A33
Floor	GF27B17	F-31	E-7
Wall	GF57B17	W-31	

Output Current (RMS Amps.)

Maximum Ambient Temperature	Delay Angle	1000	400	250	150	N.C.
40°C	0	170	157	147	134	106
	90	177	168	157	144	113
	120	177	177	170	156	127
	150	177	177	177	168	136
	180	177	177	177	177	155
60°C	0	136	128	120	108	83
	90	146	137	128	116	88
	120	155	145	136	126	98
	150	168	159	150	138	106
	180	177	174	164	152	122
80°C	0	102	96	88	80	58
	90	111	104	97	88	62
	120	117	110	103	95	70
	150	126	118	112	102	74
	180	140	132	125	115	88

Current Rating 147-260 Amps — Voltage Ratings 100-1600 Volts

Mounting	Type Number	Mech. Data Pg. A34-35	Elec. Data Pg. A33
Floor	GF28B26	F-32	E-8
Wall	GF58B26	W-32	

Output Current (RMS Amps.)

Maximum Ambient Temperature	Delay Angle	1000	400	250	150	N.C.
40°C	0	260	240	216	196	147
	90	279	264	237	208	165
	120	279	279	254	227	180
	150	279	279	273	250	198
	180	279	279	279	279	228
60°C	0	211	193	173	153	112
	90	232	212	196	166	125
	120	250	230	206	184	137
	150	272	251	226	202	151
	180	279	279	261	234	178
80°C	0	156	143	128	112	78
	90	175	160	142	124	86
	120	189	171	155	138	95
	150	202	187	169	151	103
	180	235	218	197	177	125

Current Rating 180-320 Amps — Voltage Ratings 100-1600 Volts

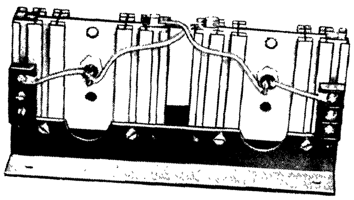
Mounting	Type Number	Mech. Data Pg. A34-35	Elec. Data Pg. A33
Floor	GF28B32	F-32	E-9
Wall	GF58B32	W-32	

Output Current (RMS Amps.)

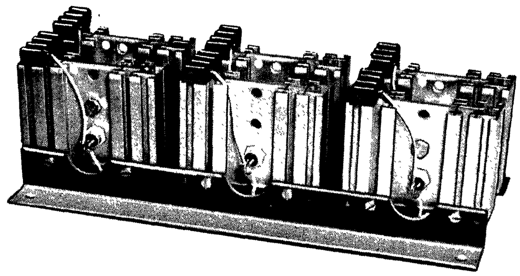
Maximum Ambient Temperature	Delay Angle	1000	400	250	150	N.C.
40°C	0	320	297	260	227	180
	90	360	321	286	250	200
	120	378	346	308	270	212
	150	390	375	337	302	235
	180	390	390	385	344	278
60°C	0	260	237	209	181	135
	90	288	260	232	200	150
	120	310	282	252	223	164
	150	341	309	277	247	180
	180	381	356	317	285	216
80°C	0	191	175	153	132	92
	90	218	195	174	146	102
	120	233	210	190	166	110
	150	256	233	208	185	122
	180	290	267	240	215	150

Column headings 1000, 400, 250, 150, N.C. = Air Velocity (LFM).

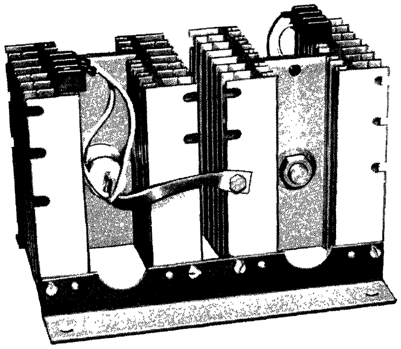
Full Control Assemblies



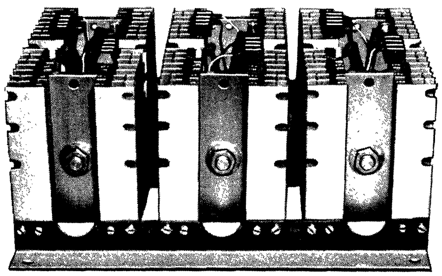
I Westinghouse GA33A49, 1ϕ AC Switch 34-49 Amps, 100-1200 Volts on 1¼ x 4 x 3 heat sinks.



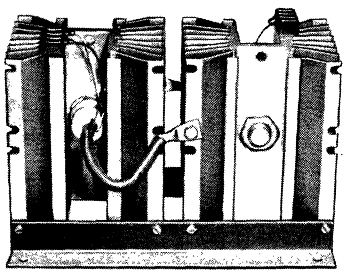
IV Westinghouse GF33A49, 3ϕ AC Switch, 34-49 Amps, 100-1200 Volts on 1¼ x 4 x 3 heat sinks.



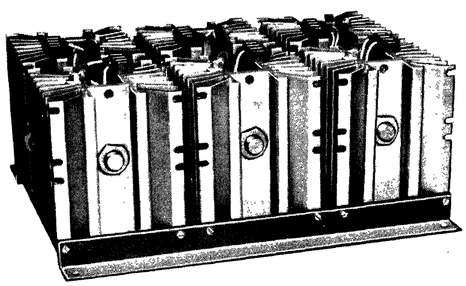
II Westinghouse GA36B16, 1ϕ AC Switch, 104-160 Amps, 100-1200 Volts on 4 x 4 x 5 heat sinks.



V Westinghouse GF36B16, 3ϕ AC Switch 104-160 Amps, 100-1200 Volts on 4 x 4 x 5 heat sinks.



III Westinghouse GA39B34, 1ϕ AC Switch 222-340 Amps, 100-1600 Volts on 5 x 5 x 6 heat sinks.

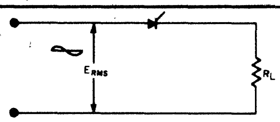
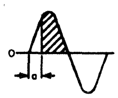
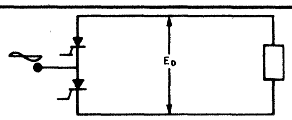
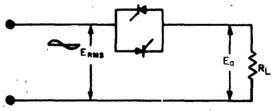
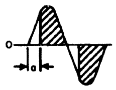
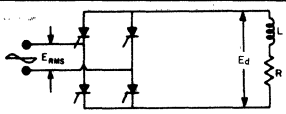
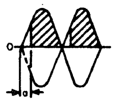
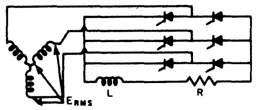
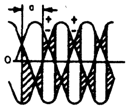
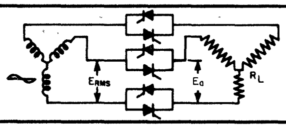
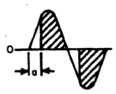


VI Westinghouse GF39B34, 3ϕ AC Switch 222-340 Amps, 100-1600 Volts on 5 x 5 x 6 heat sinks.

Full Control Assemblies

This section describes the standard circuit configurations available for Full Control Assemblies (assemblies using SCR's only). The chart below shows the schematics, waveform, recommended SCR voltage ratings, the basic current ratings available, and the page number where specific rating information for each assembly can be found.

On each page the assemblies for a given circuit configuration are listed in order of increasing current rating. The tabulated current ratings for each assembly type number are given as a function of ambient temperature, as a function of the conduction or delay angle, and as a function of the air velocity (linear feet per minute – LFM). The conduction angle is defined as the number of electrical degrees the SCR conducts current. The delay angle is defined as the number of electrical degrees the gate trigger pulse is delayed from the time the anode voltage on the SCR starts positive. Refer to the mechanical and electrical keys specified for the assembly you have selected to obtain assembly weight and dimensions and other electrical data and recommendations.

Circuit		Assembly Output		
Configuration	Schematic	Waveform	Maximum Voltage E_d=Avg. E_a=RMS	Maximum SCR Voltage
T – Single SCR			E_d=.45 E_{RMS} E_a=.707 E_{RMS}	1.4 E_{RMS}
D – Doubler		(See: Single Phase Bridge "B" or Three Phase Bridge "E")		
A – Single Phase AC Switch			E_a=E_{RMS}	1.4 E_{RMS}
B – Single Phase Bridge			E_d=.90 E_{RMS}	1.4 E_{RMS}
E – Three Phase Bridge			E_d=1.35 E_{RMS}	2.45 E_{RMS}
F – Three Phase AC Switch			E_a=E_{RMS}	1.4 E_{RMS}

Description of Full Control Assemblies Pictured on the Right

VII. Westinghouse GB33A44, 1ϕ Bridge, 34-44 Amps, 100-1200 Volts on 1¼ x 4 x 3 heat sinks.

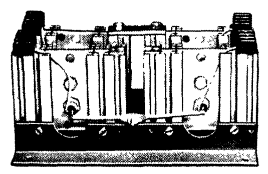
VIII. Westinghouse GB36B14, 1ϕ Bridge, 93-140 Amps, 100-1200 Volts on 4 x 4 x 5 heat sinks.

IX. Westinghouse GB39B31, 1ϕ Bridge, 196-310 Amps, 100-1600 Volts on 5 x 5 x 6 heat sinks.

X. Westinghouse GE36B20, 3ϕ Bridge, 135-200 Amps, 100-1200 Volts on 4 x 4 x 5 heat sinks.

XI. Westinghouse GE39B44, 3ϕ Bridge, 285-440 Amps, 100-1600 Volts on 5 x 5 x 6 heat sinks.

Recommended SCR Repetitive Voltage Rating	Available Assemblies Output Current Ratings (Amperes) Natural Convection at 40°C	Forced Convection at 40°C & 1000 LFM	For Specific Rating Info See Page
2.8 E_{RMS} or 6.2 E_d	17 to 98	22 to 150	A26
	15 to 105	20 to 150	A27
2.8 E_{RMS}	34 RMS to 222 RMS	49 RMS to 340 RMS	A28
2.8 E_{RMS} or 3.1 E_d	34 to 196	44 to 310	A29
4.9 E_{RMS} or 2.1 E_d	45 to 285	60 to 440	A30
2.8 E_{RMS}	34 RMS to 222 RMS	49 RMS to 340 RMS	A31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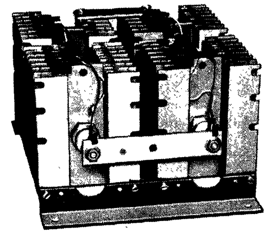
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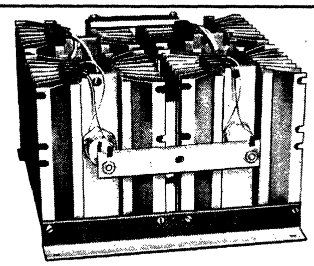
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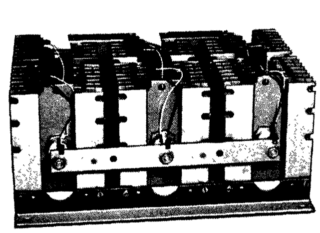
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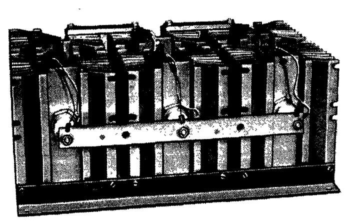
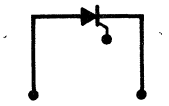

XI

Stud Mount ASSEMBLIES Gold Line



Single SCR
T

Current Rating 17-22 Amps — Voltage Ratings 100-1200 Volts

Mounting	Type Number	Mech. Data Pg. A34-35	Elec. Data Pg. A33
Floor	GT33A22	F-1	E-5
Wall	GT63A22	W-1	

Output Current (Avg. Amps.)

Maximum Ambient Temperature	Conduction Angle	1000	400	250	150	N.C.
40°C	180	**22**	21	19	18	**17**
	120	19	18	17	16	14
	90	16	15	14	14	12
	60	13	13	12	11	10
	30	8	8	8	8	7
60°C	180	19	17	16	15	13
	120	16	15	14	13	12
	90	14	13	12	11	10
	60	11	10	9	9	8
	30	7	7	7	6	6
80°C	180	15	13	12	11	10
	120	13	12	11	10	8
	90	11	10	9	8	7
	60	8	8	7	7	6
	30	6	6	5	5	5

Current Rating 36-40 Amps — Voltage Ratings 100-1200 Volts

Mounting	Type Number	Mech. Data Pg. A34-35	Elec. Data Pg. A33
Floor	GT36A40	F-19	E-6
Wall	GT66A40	W-21	

Output Current (Avg. Amps.)

Maximum Ambient Temperature	Conduction Angle	1000	400	250	150	N.C.
40°C	180	**40**	40	40	40	**36**
	120	33	33	33	33	32
	90	28	28	28	28	28
	60	22	22	22	22	22
	30	16	16	16	16	16
60°C	180	40	40	39	37	28
	120	33	33	33	33	26
	90	28	28	28	28	23
	60	22	22	22	22	20
	30	16	16	16	16	16
80°C	180	34	32	30	28	21
	120	30	28	27	25	19
	90	27	25	24	23	17
	60	22	21	20	19	14
	30	16	16	15	14	11

Current Rating 47-71 Amps — Voltage Ratings 100-1200 Volts

Mounting	Type Number	Mech. Data Pg. A34-35	Elec. Data Pg. A33
Floor	GT36A71	F-19	E-7
Wall	GT66A71	W-21	

Output Current (Avg. Amps.)

Maximum Ambient Temperature	Conduction Angle	1000	400	250	150	N.C.
40°C	180	**71**	66	63	59	**47**
	120	64	60	56	52	42
	90	57	54	51	48	39
	60	45	45	45	42	34
	30	32	32	32	32	32
60°C	180	57	54	51	48	37
	120	52	49	46	43	33
	90	47	44	42	39	30
	60	41	39	36	35	27
	30	32	30	29	27	21
80°C	180	43	41	38	36	27
	120	39	37	34	32	24
	90	36	33	32	30	22
	60	31	29	28	26	20
	30	24	23	22	21	16

Current Rating 77-120 Amps — Voltage Ratings 100-1600 Volts

Mounting	Type Number	Mech. Data Pg. A34-35	Elec. Data Pg. A33
Floor	GT39B12	F-33	E-8
Wall	GT69B12	W-33	

Output Current (Avg. Amps.)

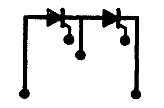
Maximum Ambient Temperature	Conduction Angle	1000	400	250	150	N.C.
40°C	180	**120**	112	105	96	**77**
	120	105	103	96	88	73
	90	89	89	89	81	67
	60	71	71	71	71	59
	30	50	50	50	50	47
60°C	180	98	91	85	78	60
	120	89	83	78	71	57
	90	82	76	72	66	53
	60	71	66	62	58	47
	30	50	50	50	46	38
80°C	180	72	68	63	57	43
	120	67	62	58	52	41
	90	62	58	55	50	39
	60	54	50	47	44	35
	30	42	40	38	35	28

Current Rating 98-150 Amps — Voltage Ratings 100-1600 Volts

Mounting	Type Number	Mech. Data Pg. A34-35	Elec. Data Pg. A33
Floor	GT39B15	F-33	E-9
Wall	GT69B15	W-33	

Output Current (Avg. Amps.)

Maximum Ambient Temperature	Conduction Angle	1000	400	250	150	N.C.
40°C	180	**150**	144	134	121	**98**
	120	142	132	124	112	92
	90	124	119	113	102	85
	60	99	99	97	90	74
	30	70	70	70	70	60
60°C	180	124	115	108	97	76
	120	115	107	99	91	73
	90	105	98	92	83	67
	60	90	85	79	73	59
	30	70	67	64	59	48
80°C	180	92	86	80	72	53
	120	86	79	74	68	53
	90	80	74	68	62	48
	60	69	64	60	55	43
	30	55	54	49	45	36



Doubler
D

Current Rating / Voltage Ratings

15-20 Amps, 100-1200 Volts

Mounting	Type Number	Mech. Data Pg. A34-35	Elec. Data Pg. A33
Floor	GD33A20	F-3	E-5
Wall	GD63A20	W-3	

Output Current (Avg. Amps.)

Maximum Ambient Temperature	Delay Angle	1000	400	250	150	N.C.
40°C	0	**20**	19	18	17	**15**
	60	18	16	15	15	12
	90	13	12	11	11	10
60°C	0	17	16	15	14	12
	60	15	14	13	12	10
	90	11	10	10	9	8
80°C	0	13	12	11	10	9
	60	11	10	10	9	8
	90	9	8	8	7	6

34-36 Amps, 100-1200 Volts

Mounting	Type Number	Mech. Data Pg. A34-35	Elec. Data Pg. A33
Floor	GD36A36	F-20	E-6
Wall	GD66A36	W-22	

Output Current (Avg. Amps.)

Maximum Ambient Temperature	Delay Angle	1000	400	250	150	N.C.
40°C	0	**36**	36	36	36	**34**
	60	32	32	32	32	31
	90	22	22	22	22	22
60°C	0	36	36	36	35	31
	60	32	32	32	32	25
	90	22	22	22	22	20
80°C	0	32	30	29	27	20
	60	29	27	26	24	18
	90	22	21	20	19	15

45-68 Amps, 100-1200 Volts

Mounting	Type Number	Mech. Data Pg. A34-35	Elec. Data Pg. A33
Floor	GD36A68	F-20	E-7
Wall	GD66A68	W-22	

Output Current (Avg. Amps.)

Maximum Ambient Temperature	Delay Angle	1000	400	250	150	N.C.
40°C	0	**68**	64	60	56	**45**
	60	62	58	55	52	41
	90	45	45	45	42	34
60°C	0	55	52	49	46	35
	60	50	47	45	42	32
	90	41	39	38	36	28
80°C	0	42	39	37	34	25
	60	38	35	34	32	23
	90	31	29	28	26	19

Current Rating / Voltage Ratings

75-114 Amps, 100-1600 Volts

Mounting	Type Number	Mech. Data Pg. A34-35	Elec. Data Pg. A33
Floor	GD39B11	F-36	E-8
Wall	GD69B11	W-36	

Output Current (Avg. Amps.)

Maximum Ambient Temperature	Delay Angle	1000	400	250	150	N.C.
40°C	0	**114**	109	101	92	**75**
	60	101	101	96	86	72
	90	71	71	71	69	58
60°C	0	94	87	81	74	58
	60	88	82	77	70	55
	90	69	65	63	57	46
80°C	0	70	65	60	55	41
	60	66	62	57	52	40
	90	53	50	47	43	34

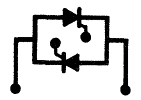
95-150 Amps, 100-1600 Volts

Mounting	Type Number	Mech. Data Pg. A34-35	Elec. Data Pg. A33
Floor	GD39B15	F-36	E-9
Wall	GD69B15	W-36	

Output Current (Avg. Amps.)

Maximum Ambient Temperature	Delay Angle	1000	400	250	150	N.C.
40°C	0	**150**	138	129	118	**95**
	60	137	128	120	108	88
	90	98	98	98	90	74
60°C	0	120	112	104	95	79
	60	113	105	97	88	69
	90	90	85	80	74	59
80°C	0	90	84	78	70	53
	60	83	78	70	64	48
	90	69	64	60	54	43

Air Velocity (LFM) shown across columns.



1 φ AC Switch
A

Current Rating 34-49 Amps — Voltage Ratings 100-1200 Volts

Mounting	Type Number	Mech. Data Pg. A34-35	Elec. Data Pg. A33
Floor	GA33A49	F-3	E-5
Wall	GA63A49	W-4	

Output Current (RMS Amps.)

Maximum Ambient Temperature	Conduction Angle	1000	400	250	150	N.C.
40°C	180	49	44	42	39	34
	120	50	47	44	41	36
	90	50	48	45	42	38
	60	50	49	46	44	39
	30	50	50	48	46	41
60°C	180	40	37	35	32	28
	120	42	38	36	34	29
	90	43	40	37	35	31
	60	44	41	39	37	32
	30	45	42	40	38	34
80°C	180	31	28	26	25	21
	120	33	30	28	27	22
	90	33	31	29	27	24
	60	34	32	30	29	25
	30	35	33	31	30	26

Current Rating 80-89 Amps — Voltage Ratings 100-1200 Volts

Mounting	Type Number	Mech. Data Pg. A34-35	Elec. Data Pg. A33
Floor	GA36A89	F-20	E-6
Wall	GA66A89	W-22	

Output Current (RMS Amps.)

Maximum Ambient Temperature	Conduction Angle	1000	400	250	150	N.C.
40°C	180	89	89	89	89	80
	120	89	89	89	89	86
	90	89	89	89	89	89
	60	89	89	89	89	89
	30	89	89	89	89	89
60°C	180	89	89	88	83	64
	120	89	89	89	89	68
	90	89	89	89	89	72
	60	89	89	89	89	76
	30	89	89	89	89	86
80°C	180	76	71	67	64	47
	120	81	76	70	66	49
	90	85	80	76	72	53
	60	88	84	80	76	58
	30	89	89	86	81	62

Current Rating 104-160 Amps — Voltage Ratings 100-1200 Volts

Mounting	Type Number	Mech. Data Pg. A34-35	Elec. Data Pg. A33
Floor	GA36B16	F-20	E-7
Wall	GA66B16	W-22	

Output Current (RMS Amps.)

Maximum Ambient Temperature	Conduction Angle	1000	400	250	150	N.C.
40°C	180	160	148	140	131	104
	120	171	161	152	142	113
	90	178	172	162	153	122
	60	178	178	175	175	137
	30	178	178	178	178	150
60°C	180	129	121	114	107	80
	120	140	132	124	115	88
	90	148	140	132	124	95
	60	160	153	144	136	105
	30	178	168	160	150	118
80°C	180	97	91	86	80	57
	120	107	100	94	86	62
	90	112	106	100	93	68
	60	121	115	108	103	75
	30	133	127	121	115	86

Current Rating 174-223 Amps — Voltage Ratings 100-1600 Volts

Mounting	Type Number	Mech. Data Pg. A34-35	Elec. Data Pg. A33
Floor	GA39B22	F-36	E-8
Wall	GA69B22	W-36	

Output Current (RMS Amps.)

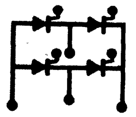
Maximum Ambient Temperature	Conduction Angle	1000	400	250	150	N.C.
40°C	180	223	223	223	212	174
	120	223	223	223	223	193
	90	223	223	223	223	210
	60	223	223	223	223	223
	30	223	223	223	223	223
60°C	180	217	203	189	172	135
	120	223	222	208	190	150
	90	223	223	223	207	164
	60	223	223	223	223	182
	30	223	223	223	223	211
80°C	180	160	149	139	126	95
	120	178	165	155	141	106
	90	192	179	168	154	118
	60	208	196	185	170	152
	30	223	223	212	186	154

Current Rating 222-340 Amps — Voltage Ratings 100-1600 Volts

Mounting	Type Number	Mech. Data Pg. A34-35	Elec. Data Pg. A33
Floor	GA39B34	F-36	E-9
Wall	GA69B34	W-36	

Output Current (RMS Amps.)

Maximum Ambient Temperature	Conduction Angle	1000	400	250	150	N.C.
40°C	180	340	320	300	272	222
	120	377	350	328	298	244
	90	390	378	355	323	265
	60	390	390	382	355	290
	30	390	390	390	390	333
60°C	180	280	260	245	220	175
	120	305	285	267	242	190
	90	327	305	287	263	206
	60	355	330	314	292	230
	30	390	376	357	330	267
80°C	180	208	192	180	162	125
	120	228	210	200	180	135
	90	247	230	215	197	147
	60	275	257	247	230	172
	30	305	286	270	250	195



1 φ Bridge
B

Current Rating: 34-44 Amps
Voltage Ratings: 100-1200 Volts

Mounting	Type Number	Mech. Data Pg. A34-35	Elec. Data Pg. A33
Floor	GB33A44	F-5	E-5
Wall	GB63A44	W-7	E-5

Output Current (Avg. Amps.)

Maximum Ambient Temperature	Conduction Angle	1000	400	250	150	N.C.
40°C	180	44	41	38	36	34
40°C	120	38	35	33	31	27
40°C	90	31	30	28	27	24
40°C	60	25	25	23	22	20
40°C	30	17	17	17	16	14
60°C	180	37	34	32	30	26
60°C	120	32	30	28	26	23
60°C	90	27	25	24	22	20
60°C	60	22	20	19	18	17
60°C	30	15	14	14	13	13
80°C	180	29	26	24	22	19
80°C	120	25	23	22	20	17
80°C	90	21	20	18	17	15
80°C	60	17	16	15	14	13
80°C	30	12	12	11	11	10

Current Rating: 73-80 Amps
Voltage Ratings: 100-1200 Volts

Mounting	Type Number	Mech. Data Pg. A34-35	Elec. Data Pg. A33
Floor	GB36A80	F-25	E-6

Output Current (Avg. Amps.)

Maximum Ambient Temperature	Conduction Angle	1000	400	250	150	N.C.
40°C	180	80	80	80	80	73
40°C	120	66	66	66	66	65
40°C	90	57	57	57	57	57
40°C	60	45	45	45	45	45
40°C	30	32	32	32	32	32
60°C	180	80	80	79	74	57
60°C	120	66	66	66	66	52
60°C	90	57	57	57	57	47
60°C	60	45	45	45	45	40
60°C	30	32	32	32	32	32
80°C	180	68	64	60	56	42
80°C	120	60	57	54	51	38
80°C	90	54	51	48	46	35
80°C	60	45	43	41	39	29
80°C	30	32	32	30	29	23

Current Rating: 93-140 Amps
Voltage Ratings: 100-1200 Volts

Mounting	Type Number	Mech. Data Pg. A34-35	Elec. Data Pg. A33
Floor	GB36B14	F-25	E-7

Output Current (Avg. Amps.)

Maximum Ambient Temperature	Conduction Angle	1000	400	250	150	N.C.
40°C	180	140	132	125	117	93
40°C	120	128	128	121	104	84
40°C	90	113	113	102	96	77
40°C	60	90	90	89	84	68
40°C	30	63	63	63	63	53
60°C	180	114	108	102	95	74
60°C	120	104	98	92	86	66
60°C	90	94	88	83	78	60
60°C	60	82	78	72	69	54
60°C	30	63	60	57	54	42
80°C	180	86	81	76	72	54
80°C	120	78	73	68	64	48
80°C	90	71	66	63	59	43
80°C	60	62	58	55	52	40
80°C	30	48	45	43	41	31

Current Rating: 154-240 Amps
Voltage Ratings: 100-1600 Volts

Mounting	Type Number	Mech. Data Pg. A34-35	Elec. Data Pg. A33
Floor	GB39B24	F-42	E-8

Output Current (Avg. Amps.)

Maximum Ambient Temperature	Conduction Angle	1000	400	250	150	N.C.
40°C	180	240	224	210	192	154
40°C	120	210	205	192	175	145
40°C	90	178	178	178	162	134
40°C	60	142	142	142	142	118
40°C	30	99	99	99	99	93
60°C	180	196	182	170	156	120
60°C	120	178	166	156	142	114
60°C	90	163	152	144	131	106
60°C	60	142	132	124	115	94
60°C	30	99	99	99	92	75
80°C	180	144	136	126	114	86
80°C	120	133	124	116	104	82
80°C	90	123	115	109	99	78
80°C	60	107	100	94	87	69
80°C	30	84	80	75	70	55

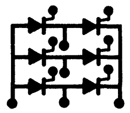
Current Rating: 196-310 Amps
Voltage Ratings: 100-1600 Volts

Mounting	Type Number	Mech. Data Pg. A34-35	Elec. Data Pg. A33
Floor	GB39B31	F-42	E-9

Output Current (Avg. Amps.)

Maximum Ambient Temperature	Conduction Angle	1000	400	250	150	N.C.
40°C	180	310	288	268	242	196
40°C	120	283	264	248	224	184
40°C	90	254	238	226	204	170
40°C	60	198	198	194	179	148
40°C	30	140	140	140	140	119
60°C	180	248	230	216	194	152
60°C	120	230	214	198	182	146
60°C	90	210	196	184	166	134
60°C	60	180	169	158	146	118
60°C	30	140	134	127	118	96
80°C	180	184	172	160	144	106
80°C	120	172	158	148	135	105
80°C	90	160	148	136	124	96
80°C	60	137	128	120	110	86
80°C	30	110	103	97	90	71

Air Velocity (LFM) columns: 1000, 400, 250, 150, N.C.



3 φ Bridge
E

Current Rating	45-60 Amps	103-110 Amps	135-200 Amps
Voltage Ratings	100-1200 Volts	100-1200 Volts	100-1200 Volts

Mounting	Type Number	Mech. Data Pg. A34-35	Elec. Data Pg. A33
Floor	GE33A60	F-6	E-5
Wall	GE63A60	W-8	E-5
Floor	GE36B11	F-26	E-6
Floor	GE36B20	F-26	E-7

Output Current (Avg. Amps.) — Maximum Ambient Temperature / Delay Angle / Air Velocity (LFM)

Temp.	Delay Angle	45-60 A: 1000	400	250	150	N.C.	103-110 A: 1000	400	250	150	N.C.	135-200 A: 1000	400	250	150	N.C.
40°C	0	**60**	57	54	51	**45**	**110**	110	110	110	**103**	**200**	192	180	168	**135**
40°C	60	54	49	46	44	37	96	96	96	96	94	186	174	166	156	123
40°C	90	38	37	34	33	30	66	66	66	66	66	135	135	135	126	102
60°C	0	52	48	45	42	36	109	109	109	105	82	165	156	147	138	105
60°C	60	45	41	39	37	31	96	96	96	96	75	150	141	135	126	96
60°C	90	34	31	30	28	25	66	66	66	66	60	123	117	109	103	79
80°C	0	40	36	33	31	27	97	91	87	81	60	126	117	111	102	79
80°C	60	34	31	30	28	24	87	82	78	73	54	114	106	102	96	69
80°C	90	26	24	23	22	19	66	64	61	57	45	93	88	84	78	57

Current Rating	225-340 Amps	285-440 Amps
Voltage Ratings	100-1600 Volts	100-1600 Volts

Mounting	Type Number	Mech. Data Pg. A34-35	Elec. Data Pg. A33
Floor	GE39B34	F-44	E-8
Floor	GE39B44	F-44	E-9

Output Current (Avg. Amps.) — Maximum Ambient Temperature / Delay Angle / Air Velocity (LFM)

Temp.	Delay Angle	225-340 A: 1000	400	250	150	N.C.	285-440 A: 1000	400	250	150	N.C.
40°C	0	**340**	321	303	276	**225**	**440**	414	388	354	**285**
40°C	60	303	303	288	258	216	411	384	360	324	264
40°C	90	213	213	213	207	174	294	294	294	270	222
60°C	0	282	261	243	222	174	360	336	312	285	222
60°C	60	264	246	231	210	165	336	315	291	264	207
60°C	90	207	196	186	171	138	270	255	240	222	179
80°C	0	210	195	180	165	123	270	252	234	210	159
80°C	60	198	186	171	156	120	249	234	210	192	144
80°C	90	159	150	141	129	102	207	192	180	168	129

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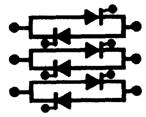
Full Control



3 φ AC Switch
F

Current Rating 34-49 Amps / Voltage Ratings 100-1200 Volts

Mounting	Type Number	Mech. Data Pg. A34-35	Elec. Data Pg. A33
Floor	GF33A49	F-6	E-5
Wall	GF63A49	W-8	E-5

Output Current (RMS Amps.)

Maximum Ambient Temperature	Delay Angle	1000	400	250	150	N.C.
40°C	0	**49**	44	42	39	**34**
	90	49	46	43	41	36
	120	49	48	46	43	39
60°C	0	40	37	35	32	28
	90	42	38	36	34	30
	120	43	40	38	36	32
80°C	0	31	28	26	25	21
	90	33	30	29	27	23
	120	34	32	30	28	25

Current Rating 80-88 Amps / Voltage Ratings 100-1200 Volts

Mounting	Type Number	Mech. Data Pg. A34-35	Elec. Data Pg. A33
Floor	GF36A88	F-26	E-6

Output Current (RMS Amps.)

Maximum Ambient Temperature	Delay Angle	1000	400	250	150	N.C.
40°C	0	**88**	88	88	88	**80**
	90	88	88	88	88	87
	120	88	88	88	88	88
60°C	0	88	88	88	84	64
	90	88	88	88	88	70
	120	88	88	88	88	78
80°C	0	76	72	67	64	48
	90	81	76	72	68	51
	120	88	84	80	76	58

Current Rating 104-160 Amps / Voltage Ratings 100-1200 Volts

Mounting	Type Number	Mech. Data Pg. A34-35	Elec. Data Pg. A33
Floor	GF36B16	F-26	E-7

Output Current (RMS Amps.)

Maximum Ambient Temperature	Delay Angle	1000	400	250	150	N.C.
40°C	0	**160**	149	140	132	**104**
	90	172	162	153	143	114
	120	177	177	176	165	133
60°C	0	128	120	114	106	80
	90	140	132	124	116	90
	120	160	153	142	135	104
80°C	0	98	91	86	81	58
	90	106	100	94	88	65
	120	122	116	110	103	76

Current Rating 174-270 Amps / Voltage Ratings 100-1600 Volts

Mounting	Type Number	Mech. Data Pg. A34-35	Elec. Data Pg. A33
Floor	GF39B27	F-44	E-8

Output Current (RMS Amps.)

Maximum Ambient Temperature	Delay Angle	1000	400	250	150	N.C.
40°C	0	**270**	251	235	215	**174**
	90	285	280	260	240	198
	120	285	285	285	280	235
60°C	0	217	203	189	172	135
	90	242	227	212	195	157
	120	279	288	250	230	187
80°C	0	160	150	139	126	95
	90	182	170	160	147	112
	120	212	200	190	172	136

Current Rating 222-340 Amps / Voltage Ratings 100-1600 Volts

Mounting	Type Number	Mech. Data Pg. A34-35	Elec. Data Pg. A33
Floor	GF39B34	F-44	E-9

Output Current (RMS Amps.)

Maximum Ambient Temperature	Delay Angle	1000	400	250	150	N.C.
40°C	0	**340**	320	298	271	**222**
	90	379	350	330	303	248
	120	390	390	383	352	293
60°C	0	278	258	240	218	173
	90	310	285	268	247	193
	120	353	333	313	288	232
80°C	0	208	192	180	162	123
	90	238	217	202	186	138
	120	272	253	238	220	170

Air Velocity (LFM) columns: 1000, 400, 250, 150, N.C.

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Electrical Data

Tables I and II provide General Recommendations for Transient Voltage Protection. Tables III and IV must be used in conjunction with the electrical key specified with each of the assembly type numbers. These tables cover non-repetitive surge ratings, I^2t ratings, general fuse recommendations, recommended gate drive requirements, and recommended RC dv/dt networks for the devices used in the Gold Line Assemblies.

Circuit conditions and economics will dictate which protective devices, if any, are necessary for reliable operation.

Table I General Recommendations for Voltrap® Transient Voltage Suppression for Gold-Line Assemblies

This table can be used as a general guide with any Gold Line Assembly. Knowing the Assembly Input Power Transformer KVA and the Secondary Line to Line Voltage, one can obtain the size of the Voltrap® required. The Voltraps® should be connected across each device with the shortest lead lengths practical. For more information regarding the selection and application of Westinghouse Voltraps®, send for T.D. 16-435, pp. 1-14 – Westinghouse Electric Co., General Control Division, Buffalo, N. Y. 14240.

Assembly Input Power Transformer KVA	Secondary Line to Line Voltages (Volts)					
	12	24	60	120	240	480
1	S04	S03	S01	S01	S01	S01
2	S05	S04	S02	S01	S01	S01
5	S06	S05	S03	S02	S01	S01
10	S06	S05	S04	S03	S01	S01
20	..	S06	S04	S03	S02	S01
50	..	..	S05	S04	S03	S01
100	..	..	..	S05	S04	S03
200	..	..	..	..	S05	S04
500	..	..	..	..	..	S05

Table II General Recommendations for RC Transient Voltage Suppression Across the DC Output Terminals for Gold-Line Assemblies

This table can be used as a general guide with any Gold Line Assembly. R-C networks are generally used when Voltraps® are not considered economical. Only carbon or non-inductive wound power resistors and extended foil or computer grade electrolytic capacitors should be used. The R-C network with the shortest lead lengths possible should be connected across the DC Output Terminals of the Rectifier Assembly.

R = Resistor (ohms)
P = Power Rating of Resistor (watts)
C = Capacitor (microfarads)
V = Voltage Rating of Capacitor (volts)

General recommendations assume that the transformer and line inductance are less than $R^2C/4$.

Assembly DC Output Current Amperes		Secondary Line to Line Voltage (Volts)					
		12	24	60	120	240	480
10	R	6	12	30	60	120	240
	P	1	1	1	1	2	5
	C	10	5	2	1	.5	.25
	V	50	100	150	300	600	1000
20	R	3	6	15	30	60	120
	P	1	1	1	2	5	10
	C	20	10	4	2	1	.5
	V	50	100	150	300	600	1000
50	R	1.2	2.4	6	12	24	48
	P	1	1	2	5	10	20
	C	50	25	10	5	2.5	1.25
	V	50	100	150	300	600	1000
100	R	.6	1.2	3	6	12	24
	P	1	2	5	10	20	50
	C	100	50	20	10	5	2.5
	V	50	100	150	300	600	1000
200	R	.3	.6	1.5	3	6	12
	P	2	5	10	20	50	100
	C	200	100	40	20	10	5
	V	50	100	150	300	600	1000
500	R	.12	.24	.6	1.2	2.4	4.8
	P	5	10	20	50	100	150
	C	500	250	100	50	25	12.5
	V	50	100	150	300	600	1000
1000	R	.06	.12	.3	.6	1.2	2.4
	P	10	20	50	100	150	250
	C	1000	500	200	100	50	25
	V	50	100	150	300	600	1000

Table III Electrical Data and General Fuse Recommendations for Rectifier Gold-Line Assemblies

This chart lists the non-repetitive 1-3-5-10 cycle surge current ratings and I^2t ratings for the rectifiers used in the Gold Line Assemblies. In addition, general fuse recommendations are presented. Fuses must be mounted in series with each device. The numbers listed in the table are Chase-Shawmut (Newburyport, Mass.) Form 101 Amp-Trap®. Equivalent fuse types are available from several companies. A partial listing of these companies include:

1. Bussmann Mfg. Div.
   McGraw Edison Co.
   St. Louis, Missouri 63107
2. The Carbone Corporation
   Boonton, New Jersey 07005
3. English Electric Co., Limited
   Fusegear Division
   Liverpool, England

Electrical Data Number	I_{FSM} Surge (Amperes) 1	3	5	10	I^2t (Amp²–Sec)	Line Voltage (Volts)	Fuse
E-1	250	180	155	130	260	120 240 480	A13 x 30 A25 x 30 A60 x 30
E-2	500	365	310	245	1000	120 240 480	A13 x 50 A25 x 50 A60 x 30
E-3	3000	2400	2150	1800	37,200	120 240 480	A13 x 250 A25 x 300 A60 x 100
E-4	5500	4500	4100	3500	125,000	120 240 480	A13 x 400 A25 x 400 A60 x 250

Table IV Electrical Data and General Gate Drive, Fuse, and RC dv/dt Network Recommendations for Half and Full Control Gold Line Assemblies

This table lists the non-repetitive 1-3-5-10 cycle surge current ratings, I^2t ratings and general fuse recommendations for Half Control and Full Control Gold Line Assemblies. The fuse types shown are Chase-Shawmut Form 101 Amp-Trap®. Their address and the addresses of other fuse manufacturers are listed under Table III. The fuses must be mounted in series with each device.

In addition this chart lists the general gate requirements for the SCR's used in these assemblies. Commercial gate firing packages are available from Firing Circuits, Inc. Norwalk, Conn. 06852), Vectrol, Inc. (Rockville, Md.) and others. For additional information on selecting gate triggering requirements and designing gate drive circuitry **refer to the Westinghouse SCR Gate Turn on Characteristics.**

Also, listed in this table are RC dv/dt networks for dv/dt suppression. These RC dv/dt networks must be placed with short lead lengths across each device (rectifiers and SCR's) in the assembly. Only carbon or non-inductive wound power resistors and only extended foil AC voltage rated capacitors should be used.

R = Resistor (ohms)
P = Power Rating of Resistor (watts)
C = Capacitor (microfarads)
V = Voltage Rating of Capacitor (volts)

Electrical Data Number	Gate To Trigger Values @ 25°C	Recommended Gate Current @1.0 μsec (Rise Time)	I_{TSM} Surge (Amperes) 1	3	5	10	I^2t (Amp²-sec)	Line Voltage (Volts)	Fuse	RC dv/dt Network R	P	C	V
E-5	40 ma 3.0 Volts	150 ma	150	110	98	90	90	120 240 480	A13 x 50 A25 x 50 A60 x 30	10 10 20	1w 1w 2w	.1 .1 .1	300 600 1000
E-6	100 ma 3.0 Volts	350 ma	1200	950	870	800	6,000	120 240 480	A13 x 100 A25 x 100 A60 x 60	20 20 20	1w 2w 5w	.25 .25 .25	300 600 1000
E-7	100 ma 3.0 Volts	350 ma	1600	1250	1150	1080	10,700	120 240 480	A13 x 100 A25 x 50 A60 x 80	20 20 20	1w 2w 5w	.25 .25 .25	300 600 1000
E-8	150 ma 3.0 Volts	500 ma	3300	2400	2200	2000	45,000	120 240 480	A13 x 300 A25 x 300 A60 x 150	30 30 30	2w 5w 15w	.5 .5 .5	300 600 1000
E-9	150 ma 3.0 Volts	500 ma	5000	3600	3350	3100	100,000	120 240 480	A13 x 400 A25 x 400 A60 x 200	30 30 30	2w 5w 15w	.5 .5 .5	300 600 1000

Mechanical Data

Tables V, VI and VII list the length, width and height, drill plan, mounting hole dimensions and approximate weight for each assembly. These tables are divided into "floor-type" mounting, "wall-type mounting", and "floor and wall type mounting", and must be used in conjunction with the mechanical key specified with each of the assembly type numbers.

Color coding for terminal identification is in accordance with NEMA standards.

Color Code: Yellow – A.C. terminals (input)
Red – Positive terminal (output)
Black – Negative terminal (output)

The material for Westinghouse Gold Line heat sinks is aluminum with gold chromate finish. Mounting feet and other mechanical support materials are of flame retardant, non-tracking, NEMA Class B (130°C continuous operation) insulation.

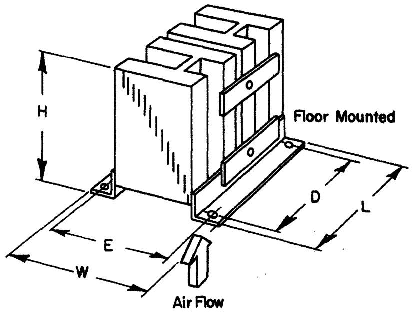

Table V

Floor Mounted Number	Approximate Assembly Weight (Lbs.)	Dimensions in Inches Length L	Width W	Height H	Drill Plan D	E	Mounting Hole Diameter
F-1	.8	4.125	3.875	3.875	3.00	2.75	.34
F-2	1.6	8.750	3.875	3.875	7.62	2.75	.34
F-3	1.6	8.750	3.875	4.125	7.62	2.75	.34
F-4	2.4	13.375	3.875	3.875	12.25	2.75	.34
F-5	2.4	8.750	6.125	4.375	7.62	4.94	.34
F-6	3.4	13.375	6.125	4.375	12.25	4.94	.34
F-7	.7	4.125	3.875	3.875	3.00	2.75	.34
F-8	.8	4.125	3.875	5.750	3.00	2.75	.34
F-9	1.2	4.125	4.375	5.875	3.00	2.75	.34
F-10	1.4	4.125	3.875	5.750	3.00	2.75	.34
F-11	2.0	8.750	3.875	5.875	7.62	2.75	.34
F-12	2.2	8.750	3.875	6.062	7.62	2.75	.34
F-13	2.4	8.750	4.625	5.875	7.62	2.75	.34
F-14	2.8	8.750	3.875	5.750	7.62	2.75	.34
F-15	2.8	8.750	4.125	5.750	7.62	2.75	.34
F-16	3.3	8.750	4.125	5.750	7.62	2.75	.34
F-17	3.3	8.750	4.125	6.062	7.62	2.75	.34
F-18	3.6	13.375	4.625	5.875	12.25	2.75	.34
F-19	2.7	4.125	6.625	5.750	3.00	5.50	.34
F-20	5.6	8.750	6.625	6.250	7.62	5.50	.34
F-21	5.6	8.750	6.625	5.750	7.62	5.50	.34
F-22	5.9	8.750	6.625	6.062	7.62	5.50	.34
F-23	8.2	13.375	6.625	5.750	12.25	5.50	.34
F-24	8.2	13.375	6.625	6.062	12.25	5.50	.34
F-25	10.8	9.250	11.625	6.250	7.62	10.50	.34
F-26	16.2	13.875	11.625	6.250	12.25	10.50	.34
F-27	4.8	4.125	6.625	9.562	3.00	5.50	.34
F-28	5.0	4.125	7.375	9.562	3.00	5.50	.34
F-29	9.6	8.750	6.625	9.562	7.62	5.50	.34
F-30	10.0	8.750	7.250	9.562	7.62	5.50	.34
F-31	14.4	13.375	6.625	9.562	12.25	5.50	.34
F-32	15.1	13.375	7.250	9.562	12.25	5.50	.34
F-33	4.4	5.125	7.875	6.750	4.00	6.50	.34
F-34	4.6	5.125	7.625	6.750	4.00	6.50	.34
F-35	8.0	10.750	7.625	7.125	9.62	6.50	.34
F-36	9.0	10.750	7.625	7.250	9.62	6.50	.34
F-37	9.0	10.750	7.625	6.750	9.62	6.50	.34
F-38	10.2	10.750	7.625	6.750	9.62	6.50	.34
F-39	10.2	10.750	7.625	7.125	9.62	6.50	.34
F-40	13.5	16.375	7.625	6.750	15.25	6.50	.34
F-41	15.5	10.750	12.625	6.750	9.62	11.50	.34
F-42	15.8	11.250	14.000	7.250	9.62	12.50	.34
F-43	23.4	16.375	12.625	6.750	15.25	11.50	.34
F-44	23.6	16.875	14.000	7.250	15.25	12.50	.34

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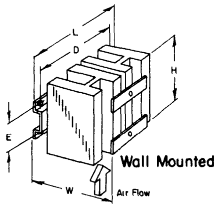


Table VI

Wall Mounted Number	Approximate Assembly Weight (lbs.)	Dimensions in Inches Length L	Width W	Height H	Drill Plan D	E	Mounting Hole Diameter
W-1	.8	5.062	3.500	3.062	4.69	....	.28 slots
W-2	1.6	10.000	3.750	4.688	9.25	3.75	.34
W-3	1.6	10.000	3.000	3.125	9.25	3.75	.34
W-4	1.6	10.000	3.000	4.688	9.25	3.75	.34
W-5	2.4	14.625	3.750	4.688	13.88	3.75	.34
W-6	2.4	14.625	3.000	4.688	13.88	3.75	.34
W-7	2.4	10.000	5.750	4.688	9.25	3.75	.34
W-8	3.4	14.625	5.750	4.688	13.88	3.75	.34
W-9	.7	5.062	3.380	3.380	4.69	....	.28 slots
W-10	.8	5.062	3.380	5.062	4.69	....	.28 slots
W-11	1.2	5.062	4.500	5.062	4.69	....	.28 slots
W-12	1.4	5.062	4.500	5.062	4.69	....	.28 slots
W-13	2.0	10.000	3.250	5.125	9.25	3.75	.34
W-14	2.2	10.000	3.000	5.626	9.25	3.75	.34
W-15	2.4	10.000	4.250	5.125	9.25	3.75	.34
W-16	2.8	10.000	3.250	5.125	9.25	3.75	.34
W-17	2.8	10.000	4.000	5.125	9.25	3.75	.34
W-18	3.3	10.000	4.000	5.125	9.25	3.75	.34
W-19	3.3	10.000	4.000	5.625	9.25	3.75	.34
W-20	3.6	14.625	4.250	5.125	13.88	3.75	.34
W-21	2.7	5.375	6.125	5.062	4.62	3.75	.34
W-22	5.6	10.000	6.125	5.125	9.25	3.75	.34
W-23	5.6	10.000	5.880	5.125	9.25	3.75	.34
W-24	5.9	10.000	5.880	5.625	9.25	3.75	.34
W-25	8.2	14.620	5.880	5.125	13.88	3.75	.34
W-26	8.2	14.620	5.880	5.625	13.88	3.75	.34
W-27	4.8	5.375	6.125	9.125	4.62	3.75	.34
W-28	5.0	5.375	7.000	9.125	4.62	3.75	.34
W-29	9.6	10.000	6.125	9.125	9.25	3.75	.34
W-30	10.0	10.000	7.000	9.125	9.25	3.75	.34
W-31	14.4	14.625	6.125	9.125	13.88	3.75	.34
W-32	15.1	14.625	7.000	9.125	13.88	3.75	.34
W-33	4.4	6.375	7.625	6.062	5.62	3.75	.34
W-34	4.6	6.375	6.750	6.062	5.62	3.75	.34
W-35	8.0	12.000	6.750	6.625	11.25	3.75	.34
W-36	9.0	12.000	7.625	6.125	11.25	3.75	.34
W-37	9.0	12.000	6.750	6.125	11.25	3.75	.34
W-38	10.2	12.000	6.750	6.125	11.25	3.75	.34
W-39	10.2	12.000	6.750	6.625	11.25	3.75	.34
W-40	13.5	17.625	6.750	6.125	6.50	3.75	.34

Table VII

Floor or Wall Mounted Number	Approximate Assembly Weight (lbs.)	Dimensions in Inches Length L	Width W	Height H	Drill Plan D	E	Mounting Hole Slots
F/W-1	.2	3.125	3.062	4.500	2.25	1.00	.22 x .47
F/W-2	.3	3.560	3.062	4.500	2.69	1.00	.22 x .47
F/W-3	.4	4.000	3.062	4.500	3.12	1.00	.22 x .47
F/W-4	.5	4.438	3.062	4.500	3.56	1.00	.22 x .47
F/W-5	.7	5.750	3.062	4.500	4.88	1.00	.22 x .47
F/W-6	.6	3.500	5.062	6.500	2.62	2.50 and 1.00	.28 x .56 .22 x .47
F/W-7	.7	4.060	5.062	6.500	3.19	2.50 and 1.00	.28 x .56 .22 x .47
F/W-8	.8	4.625	5.062	6.500	3.75	2.50 and 1.00	.28 x .56 .22 x .47
F/W-9	1.0	5.188	5.062	6.500	4.31	2.50 and 1.00	.28 x .56 .22 x .47
F/W-10	1.5	6.875	5.062	6.500	6.00	2.50 and 1.00	.28 x .56 .22 x .47

ASSEMBLIES

Thermal Data

Forced Air Cooling

The rating charts presented in this brochure cover natural convection and four forced air conditions: 150, 250, 400, and 1000 linear feet per minute (LFM). The air velocity is measured in LFM as it approaches the sink. From the rating charts, it can be seen that the current ratings of a given assembly can be increased considerably by using forced air. All air flow velocity measurements are per JEDEC RS-282, SEC 7-13.

The following is a partial listing of Manufacturers of blowers and fans:

1. W. W. Grainger, Inc.
   3812 Penn Ave.
   Pittsburgh, Pennsylvania 15201
2. Rotron, Inc.
   Woodstock, New York 12498
3. Rotating Components
   1560 5th Ave.
   Bay Shore, New York 11706
4. Pamotor, Inc.
   770 Airport Blvd.
   Burlingame, California
5. IMC Magnetics Corporation
   Eastern Division
   507 Main Street
   Westbury, New York

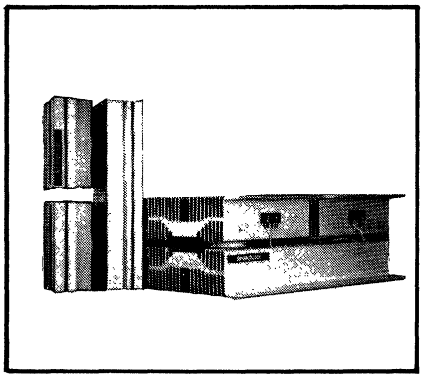
Oil Cooling

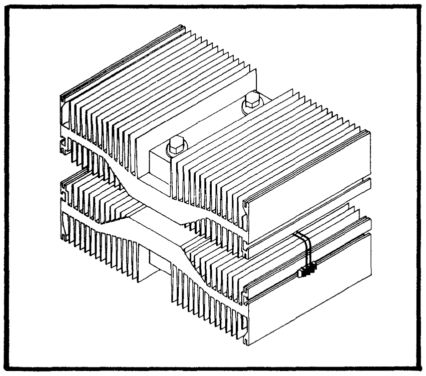
Current ratings for assemblies which are immersed in natural convected oil are approximately equivalent to the 1000 LFM air flow ratings listed in this catalog.

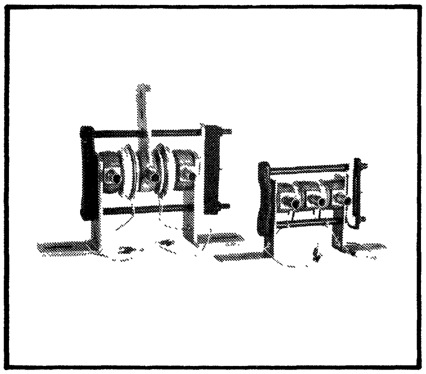
Temperature Conversion

Fahrenheit	Centigrade
−40	−40
− 4	−20
32	0
59	15
68	20
77	25
86	30
95	35
104	40
113	45
122	50
131	55
140	60
149	65
158	70
167	75
176	80
194	90
212	100
302	150
338	170
392	200

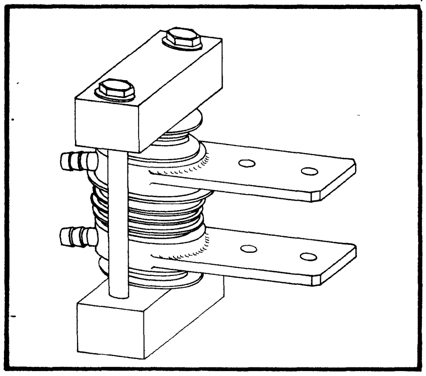
Disc
ASSEMBLIES
Air and Liquid Cooled

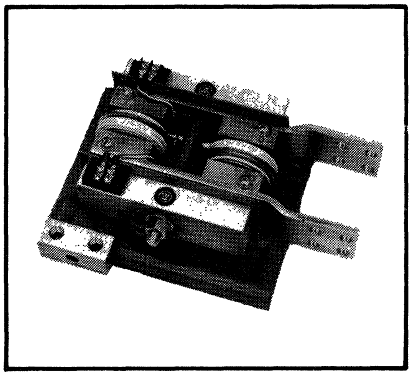

Air Cooled Assembly Modules.


New High Current Air Cooled Module.


Liquid Cooled Assembly Modules.

*Also see Page A38, Series Circuit.


New High Current Water Cooled Module.


Liquid Cooled Manifold AC-Switch.

Disc ASSEMBLIES
Air and Liquid Cooled

Ordering Information All assemblies in this section are keyed to a standard twelve digit part number which describes the assembly frame, heat sink, and device type. Simply insert the two digit voltage code for the desired assembly voltage rating.

Voltage Code Make sure the desired assembly voltage rating does not exceed the **Maximum Voltage Available** for the assembly under consideration. Then, using Table I, select the appropriate two digit voltage code. Inserting this two digit voltage code into the 9th and 10th positions of the assembly part number completes the required ordering information for all standard designs.

Available Circuits Table II lists the standard circuits available from Westinghouse. A complete index by circuit type is given on page A37. The shaded areas of Table II denote circuits with ratings published in this section. PC (positive center tap - common cathode connection) is available; use the corresponding single phase bridge data for the appropriate current rating. Likewise, the PN (negative centertap - common anode connection) is available; use the corresponding single phase bridge data for the appropriate current rating. Series and parallel circuits are also available.

Parallel Circuits This type of circuit is usually specified when paralleling two or more devices to obtain higher current ratings than available in a single device. Two common techniques for paralleling devices are direct and forced sharing; both techniques usually require specially factory matched test selection to assure proper device performance in the application. The standard Westinghouse PP circuit is provided with common anode connection; common cathode parallel circuit connections can be provided on request.

Series Circuit This type of circuit is usually specified when seriesing two or more devices to obtain higher voltage ratings than available in a single device. This type of circuit generally requires special QRR matching and other test matching to assure proper voltage sharing across each device in the application.

Standard air cooled assembly modules are only available for two devices in series. To order, simply specify PS frame connection. For current ratings, refer to the appropriate PR on PT circuit frame data; for assembly outline drawings, refer to the PD frame mechanical data.

Liquid cooled assembly ratings for two and three devices in series are presented in this section along with their outline drawings. For applications requiring four or more devices in series, consult Westinghouse for a custom module.

Liquid Cooled R/C Tabs Tab type, .250 push-on terminals are an option available on Westinghouse liquid cooled heat sinks. This option makes the connection of resistors, capacitors,and/or voltage protection devices directly across the semiconductor device an easy task. To order this feature, add suffix "RC" to the standard twelve digit type number - i.e. PDW6T6201230RC.

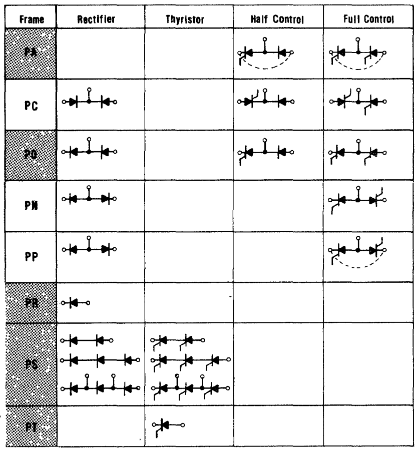
Kits and Sinks Standard air and liquid cooled disc assembly kits are available to the user who needs design flexibility on small quantity custom designs that might require non-standard factory configurations. Air cooled heat sink extrusions, designed by Westinghouse to optimize the cooling of large area power semiconductors. are available in mill lengths or cut-to-order lengths. See pages A65 and A66 for more information on Westinghouse kits and sinks.

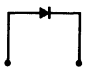
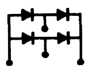
FRAME AND SINK TYPE				DEVICE TYPE				VOLTAGE CODE		DEVICE CURRENT	
1	2	3	4	5	6	7	8	9	10	11	12

TABLE I
Voltage Code

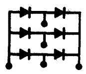
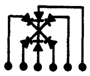
Assembly Device Voltage Rating	Voltage
100	01
200	02
400	04
600	06
800	08
1000	10
1200	12
1400	14
1600	16
1800	18
2000	20
2200	22
2400	24
2600	26
2800	28
3000	30
4000	40

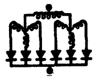
TABLE II
STANDARD AVAILABLE CIRCUITS



Circuit Schematic / Configuration	Assembly Module Type (Order By This Number)	Voltage Code	Device Maximum Voltage Available (V)	T Ambient = 40°C N.C.	300	500	1000	1500	T Ambient = 50°C N.C.	300	500	1000	1500	T Ambient = 60°C N.C.	300	500	1000	1500	ELEC. DATA	MECH. DATA
				INLET AIR VELOCITY--LINEAR FEET PER MINUTE / OUTPUT CURRENT, AVERAGE AMPS																
 Single Rectifier R	PRA6R620	30	1200	187	339	377	401	407	186	326	368	391	397	164	300	338	368	372	E-1	M-10
		30	2000	179	319	355	378	384	168	302	342	363	369	145	279	314	341	346		
		30	3000	147	281	313	333	338	135	263	297	316	321	123	245	276	300	304		
	PRA6R620	40	1200	210	368	414	448	457	197	353	396	431	438	183	337	379	411	420	E-2	
		40	2000	190	344	387	419	427	177	327	367	399	406	163	308	347	376	384		
	PRA6R620	50	1200	217	395	444	482	492	202	375	424	459	469	188	355	403	436	445	E-3	
	PRA7R720	06	1200	216	417	484	537	549	200	401	464	518	529	188	383	444	494	507	E-4	M-12
		06	2000	196	386	448	497	508	180	371	429	479	489	166	350	405	451	463		
		06	4000	159	335	389	431	441	145	313	362	404	413	130	289	335	373	383		
	PRA7R720	09	1200	255	487	564	623	639	238	460	536	592	607	218	438	512	567	580	E-5	
		09	2000	228	450	521	576	591	210	424	494	546	559	192	398	465	515	527		
ONE ASSEMBLY REQUIRED	PRA7R720	12	1200	349	643	755	842	865	326	611	721	802	824	303	579	682	762	783	E-6	
	PRA9R920	11	1200	600	930	1033	1183	1275	576	875	990	1150	1230	513	855	947	1110	1180	E-7	M-14
		11	2000	540	875	970	1128	1190	500	835	930	1080	1155	435	800	878	1030	1100		
		11	3000	410	775	860	1000	1040	376	720	810	945	1010	330	665	745	875	935		
	PRA9R920	16	1200	615	987	1104	1280	1372	560	947	1055	1225	1300	530	915	1000	1075	1260	E-8	
		16	2000	510	930	1025	1192	1270	500	830	1020	1135	1220	495	840	920	1090	1150		
	PRA9R920	20	1200	790	1185	1340	1608	1722	678	1138	1277	1537	1635	633	1090	1222	1440	1766	E-9	
	PRA9R9G0	13	1200	645	965	1087	1305	1370	610	930	1040	1230	1315	550	885	995	1170	1250	E-10	M-14
		13	2000	580	910	1020	1200	1275	525	865	970	1140	121.5	465	810	915	1085	1155		
		13	3000	435	795	900	1050	1120	390	735	845	990	1050	350	690	780	930	985		
	PRA9R9G0	18	1200	678	1015	1153	1368	1455	640	967	1100	1308	1390	570	920	1048	1248	1326	E-11	
		18	2000	598	949	1072	1280	1360	550	898	1020	1216	1290	532	845	965	1150	1225		
	PRA9R9G0	22	1200	810	1258	1442	1742	1967	770	1193	1371	1658	1775	686	1128	1297	1570	1682	E-12	
 1 φ Bridge	PDA6R620	30	1200	394	678	754	802	814	370	652	736	782	794	308	600	676	736	744	E-1	M-11
		30	2000	356	638	710	756	768	336	604	684	726	738	290	558	628	682	692		
		30	3000	294	562	626	666	676	270	526	594	632	642	246	490	552	600	608		
	PDA6R620	40	1200	420	736	828	896	914	384	706	792	862	876	366	674	758	822	840	E-2	
		40	2000	380	688	774	838	854	354	654	734	798	812	326	616	694	752	768		
	PDA6R620	50	1200	434	790	888	964	984	404	750	848	918	938	376	710	806	872	890	E-3	
	PDA7R720	06	1200	432	834	968	1074	1098	400	802	928	1036	1058	376	766	888	988	1014	E-4	M-13
		06	2000	392	772	896	994	1016	360	742	858	958	978	332	700	810	902	926		
		06	4000	318	670	778	862	882	290	626	724	808	826	260	578	670	746	766		
	PDA7R720	09	1200	510	974	1128	1246	1278	476	920	1072	1184	1214	436	876	1024	1134	1160	E-5	
		09	2000	456	900	1042	1152	1182	420	848	988	1092	1118	384	796	930	1030	1054		
TWO ASSEMBLIES REQUIRED	PDA7R720	12	1200	687	1285	1510	1683	1730	651	1222	1441	1604	1647	606	1159	1364	1524	1565	E-6	
	PDA9R920	11	1200	1200	1860	2066	2366	2550	1150	1750	1980	2300	2460	1026	1710	1894	2220	2360	E-7	M-15
		11	2000	1080	1750	1940	2256	2380	1000	1670	1860	2160	2310	870	1600	1756	2060	2200		
		11	3000	820	1550	1720	2000	2080	750	1440	1620	1890	2020	660	1330	1490	1750	1870		
	PDA9R920	16	1200	1230	1974	2208	2560	2744	1120	1894	2110	2450	2600	1060	1830	2000	2150	2520	E-8	
		16	2000	1020	1860	2050	2384	2540	1000	1660	2040	2270	2440	990	1680	1840	2180	2300		
	PDA9R920	20	1200	1580	2370	2680	3216	2444	1356	2276	2554	3074	3270	1266	2180	2444	2880	3532	E-9	
	PDA9R9G0	13	1200	1290	1930	2174	2610	2740	1220	1860	2080	2460	2630	1100	1770	1990	2340	2500	E-10	M-15
		13	2000	1160	1820	2040	2400	2550	1050	1730	1940	2280	2430	930	1620	1830	2170	2310		
		13	3000	870	1590	1800	1100	2240	780	1470	1690	1980	2100	700	1380	1560	1860	1970		
	PDA9R9G0	18	1200	1356	2030	2306	2736	2910	1280	1934	2200	2616	2780	1140	1840	2096	2496	2652	E-11	
		18	2000	1196	1898	2144	2560	2720	1100	1796	2040	2432	2580	1064	1690	1930	2300	2450		
	PDA9R9G0	22	1200	1620	2516	2884	3484	3934	1540	2386	2742	3316	3550	1372	2256	2594	3140	3364	E-12	

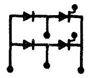
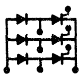
Disc ASSEMBLIES Air Cooled

Circuit Schematic / Configuration	Assembly Module Type (Order By This Number) / Voltage Code	Device Maximum Voltage Available (V)	T Ambient = 40°C N.C.	300	500	1000	1500	T Ambient = 50°C N.C.	300	500	1000	1500	T Ambient = 60°C N.C.	300	500	1000	1500	ELEC. DATA	MECH. DATA
			INLET AIR VELOCITY--LINEAR FEET PER MINUTE / OUTPUT CURRENT, AVERAGE AMPS																
 3 φ Bridge	PDA6R620_ _30	1200	568	958	1057	1125	1142	532	920	1032	1097	1114	498	846	954	1028	1042	E-1	
	30	2000	514	902	995	1060	1076	483	854	959	1019	1035	448	786	887	955	968		
	30	3000	423	795	877	934	948	388	743	834	886	900	353	691	779	839	851		
	PDA6R620_ _40	1200	599	1036	1165	1256	1279	562	994	1116	1207	1229	524	953	1067	1156	1180	E-2	
	40	2000	542	968	1089	1174	1195	505	920	1033	1118	1138	468	872	976	1058	1080		
	PDA6R620_ _50	1200	626	1115	1252	1360	1385	584	1064	1194	1295	1322	542	1007	1137	1231	1255	E-3	M-11
	PDA7R720_ _06	1200	627	1186	1381	1515	1554	579	1140	1321	1462	1496	548	1092	1259	1401	1434	E-4	
	06	2000	569	1098	1274	1402	1438	521	1055	1222	1352	1384	483	1001	1154	1284	1314		
	06	4000	461	953	1106	1217	1248	420	890	1031	1141	1168	379	827	954	1061	1086		
	PDA7R720_ _09	1200	736	1389	1596	1766	1810	689	1313	1519	1676	1718	633	1249	1456	1604	1642	E-5	
THREE ASSEMBLIES REQUIRED	09	2000	658	1284	1475	1632	1673	607	1210	1400	1545	1583	566	1135	1324	1458	1493		
	PDA7R720_ _12	1200	993	1823	2141	2401	2471	929	1733	2038	2282	2348	865	1643	1933	2163	2224	E-6	M-13
	PDA9R920_ _11	1200	1740	2625	2760	3360	3540	1635	2514	2790	3234	3255	1440	2205	2676	3105	3300	E-7	
	11	2000	1560	2355	2730	3135	3360	1410	2340	2475	3000	3060	1290	2235	2496	2880	3060		
	11	3000	1170	2175	2400	2784	2946	1065	1914	2259	2625	2805	960	1875	2085	2460	2625		
	PDA9R920_ _16	1200	1710	2760	3075	3570	3858	1509	2625	2925	3396	3645	1380	2496	2772	3270	3495	E-8	
	16	2000	1506	2520	2895	3360	3540	1290	2250	2688	3174	3390	1209	2265	2520	2985	3200		
	PDA9R920_ _20	1200	2400	3605	3840	4524	4851	1860	3255	3645	4290	4644	1770	3105	3495	4134	4365	E-9	M-15
	PDA9R9G0_ _13	1200	1755	2634	2985	3570	3750	1665	2355	2835	3360	3585	1476	2385	2700	3216	3420	E-10	
	13	2000	1560	2448	2766	3300	3510	1410	2340	2655	3135	3330	1260	2205	2505	2970	3165		
	13	3000	1170	2130	2430	2883	3060	1050	1965	2265	2700	2886	948	1845	2115	2520	2685		
	PDA9R9G0_ _18	1200	1890	2835	3201	3789	4026	1776	2694	3060	3627	3852	1590	2571	2910	3450	3675	E-11	
	18	2000	1677	2640	2988	3546	3765	1524	2514	2838	3366	3576	1326	2370	2685	3189	3384		
	PDA9R9G0_ _22	1200	2283	3531	4014	4812	5151	2166	3351	3825	4590	4908	1935	3174	3636	4350	4647	E-12	M-15
 6φ Star	PRA6R620_ _30	1200	845	1477	1598	1687	1714	793	1439	1553	1636	1657	735	1367	1500	1579	1597	E-1	
	30	2000	793	1387	1500	1584	1609	741	1344	1451	1528	1547	682	1268	1392	1464	1482		
	30	3000	700	1224	1324	1398	1420	646	1172	1265	1332	1349	591	1099	1206	1269	1284		
	PRA6R620_ _40	1200	935	1616	1794	1933	1969	880	1543	1723	1850	1883	826	1473	1648	1769	1800	E-2	
	40	2000	877	1516	1683	1813	1847	822	1441	1609	1727	1758	766	1366	1529	1641	1670		
	PRA6R620_ _50	1200	1036	1758	1968	2115	2153	973	1682	1884	2027	2062	911	1606	1793	1939	1972	E-3	M-10
	PRA7R720_ _06	1200	927	1807	2056	2259	2297	897	1820	2045	2249	2298	834	1698	1957	2144	2191	E-4	
	06	2000	902	1759	2002	2199	2236	836	1696	1906	2096	2142	771	1570	1810	1983	2026		
	06	4000	793	1546	1759	1932	1965	725	1471	1653	1818	1858	659	1342	1547	1695	1732		
	PRA7T720_ _09	1200	1183	2199	2519	2760	2820	1106	2105	2403	2651	2707	1030	2013	2288	2518	2579	E-5	
SIX ASSEMBLIES REQUIRED	09	2000	1107	2057	2356	2582	2638	1029	1958	2235	2466	2518	952	1860	2115	2327	2384		
	12	1200	1646	3033	3482	3831	3925	1549	2912	3332	3687	3766	1452	2791	3183	3514	3602	E-6	M-12
	PRA9R920_ _11	1200	2250	4050	4488	5412	5520	2040	3852	4302	5010	5340	1872	3660	4080	4788	5118	E-7	
	11	2000	2100	3780	4182	4908	5220	1908	3588	3978	4650	5005	1698	3390	3780	4422	4770		
	11	3000	1860	3312	3690	4290	4608	1650	3090	3480	4050	4332	1500	2880	3210	3768	4050		
	PRA9R920_ _16	1200	2550	4200	4770	5550	5880	2160	4026	4500	5682	5850	1830	3780	4320	5000	5382	E-8	
	16	2000	2382	3960	4380	5196	5550	1908	3726	4170	4968	5460	1530	3450	3960	4650	5000		
	PRA9R920_ _20	1200	3690	5418	6060	7200	7716	3420	5130	5870	6888	7482	2922	4920	5520	6480	6960	E-9	M-14
	PRA9R9G0_ _13	1200	2610	4050	4620	5460	5820	2460	3840	4410	5250	5538	2190	3648	4200	4980	5292	E-10	
	13	2000	2310	3750	4290	5130	5430	2100	3540	4050	4860	5118	1800	3330	3840	4590	4890		
	13	3000	1710	3180	3720	4440	4770	1530	3000	3468	4170	4440	1380	2760	3180	3870	4140		
	PRA9R9G0_ _18	1200	2808	4440	5052	5946	6300	2592	4212	4818	5700	6030	2268	4002	4566	5448	5610	E-11	
	18	2000	2412	4122	4698	5586	5922	2160	3894	4470	5316	5640	1848	3654	4200	5040	5340		
	PRA9R9G0_ _22	1200	3780	5730	6516	7746	8232	3564	5466	6210	7398	7866	3192	5208	5916	7038	7494	E-12	M-14

Circuit / Schematic / Configuration	Assembly Module Type (Order By This Number)	Voltage Code	Device Maximum Voltage Available (V)	$T_{Ambient}$ = 40°C					$T_{Ambient}$ = 50°C					$T_{Ambient}$ = 60°C					ELEC. DATA	MECH. DATA
				INLET AIR VELOCITY--LINEAR FEET PER MINUTE																
				N.C.	300	500	1000	1500	N.C.	300	500	1000	1500	N.C.	300	500	1000	1500		
				OUTPUT CURRENT, AVERAGE AMPS																
	PRA6R620	30	1200	1132	1916	2114	2250	2284	1064	1840	2064	2194	2228	[illegible]	1692	1908	2056	2084	E-1	
		30	2000	1028	1804	1990	2120	2152	966	1708	1918	2038	2070	[illegible]	1572	1774	1910	1936		
		30	3000	946	1590	1754	1868	1896	776	1486	1668	1772	1800	[illegible]	1382	1558	1678	1702		
3 φ Wye (With Interphase Transformer)	PRA6R620	40	1200	1198	2072	2330	2512	2558	1124	1988	2232	2414	2458	[illegible]	1906	2134	2312	2360	E-2	
		40	2000	1084	1936	2178	2348	2390	1010	1840	2066	2236	2276	[illegible]	1744	1952	2116	2160		M-11
	PRA6R620	50	1200	1252	2230	2504	2720	2770	1168	2128	2388	2590	2644	[illegible]	2014	2274	2462	2510	E-3	
	PRA7R720	06	1200	1264	2372	2762	3030	3108	1158	2280	2642	2924	2992	[illegible]	2184	2518	2802	2864	E-4	
		06	2000	1138	2196	2548	2804	2876	1042	2110	2444	2704	2768	888	2002	2308	2568	2628		
		06	4000	922	1906	2212	2434	2496	840	1780	2062	2282	2336	756	1654	1908	2122	2172		
	PRA7R720	09	1200	1470	2778	3192	3532	3620	1378	2626	3038	3352	3436	1268	2498	2912	3208	3284	E-5	M-13
		09	2000	1316	2568	2950	3264	3346	1214	2420	2800	3090	3166	1112	2270	2648	2916	2986		
SIX	PRA7R720	12	1200	1986	3646	4282	4802	4942	1858	3466	4076	4564	4696	1730	3286	3866	4326	4448	E-6	
ASSEMBLIES	PRA9R920	11	1200	3480	5250	5520	6720	7080	3270	5028	5580	6510	6510	2880	4410	5352	6210	6600	E-7	
REQUIRED		11	2000	3120	4710	5460	6270	6720	2820	2680	4950	6000	6120	2580	4470	4992	5760	6120		
		11	3000	2340	4350	4800	5568	5852	2130	3828	4518	5250	5610	1920	3750	4170	4920	5250		
	PRA9R920	16	1200	3420	5520	6150	7140	7716	3018	5250	5850	6792	7290	2760	4992	5544	6540	6990	E-8	
		16	2000	3012	5040	5790	6720	7080	2580	4500	5376	6348	6780	2418	4530	5040	5970	6400		
	PRA9R920	20	1200	2800	7210	7680	9048	9702	3720	6510	7290	8580	9288	3540	6210	6990	8268	8730	E-9	M-15
	PRA9R9G0	13	1200	3510	5268	5970	7140	7500	3330	4710	5670	6720	7170	2952	4770	5400	6432	6840	E-10	
		13	2000	3120	4896	5532	6600	7020	2820	4680	5310	6270	6660	2620	4410	5010	5940	6330		
		13	3000	2340	4260	4860	5766	6120	2100	3930	4530	5400	5772	1890	3690	4230	5040	5370		
	PRA9R9G0	18	1200	3780	5670	6402	7578	8052	3552	5388	6120	7254	7704	3160	5142	5820	6900	7350	E-11	M-15
		18	2000	3354	5280	5976	7092	7530	3048	5028	5676	6732	7152	2652	4740	5370	6378	6768		
	PRA9R9G0	22	1200	4566	7062	8028	9624	10302	4332	6702	7650	9180	9816	3870	6348	7272	8700	9294	E-12	

Half Control

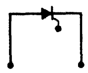
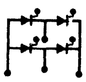
Disc ASSEMBLIES Air Cooled

Circuit Schematic / Configuration	Assembly Module Type (Order By This Number)	Voltage Code	Device Maximum Voltage Available (V)	$T_{Ambient}$ = 40°C N.C.	300	500	1000	1500	$T_{Ambient}$ = 50°C N.C.	300	500	1000	1500	$T_{Ambient}$ = 60°C N.C.	300	500	1000	1500	ELEC. DATA	MECH. DATA
				INLET AIR VELOCITY--LINEAR FEET PER MINUTE — OUTPUT CURRENT, AVERAGE AMPS																
 1 φ Bridge	PDA6T6R6	15	1500	156	300	334	356	376	142	272	304	334	344	128	244	278	306	308	E-1-13	M-11
		20	1500	167	337	383	418	427	149	308	349	381	389	132	276	315	343	350	E-1-14	
		30	1500	190	381	433	474	484	171	348	395	431	440	151	311	356	388	396	E-1-15	
	PDA6T6R6	25	1200	168	364	408	441	456	156	338	378	412	426	144	312	350	382	394	E-2-16	
		34	1200	176	412	462	500	516	180	384	430	468	480	168	356	398	434	448	E-2-17	
		40	1200	244	570	606	650	668	238	504	558	614	628	234	468	528	564	580	E-2-18	
	PDA7T7R7	35	2000	201	435	504	560	573	179	395	459	508	521	157	352	411	456	467	E-4-19	M-13
		45	2000	223	480	558	615	631	198	436	508	562	576	180	391	454	504	518	E-4-20	
		55	1500	245	545	639	712	730	220	493	576	645	663	190	442	514	573	589	E-4-21	
TWO ASSEMBLIES REQUIRED	PDA9T9R9	06	3000	390	776	872	1028	1106	343	704	790	932	1003	286	626	707	831	896	E-5-22	M-15
		07	2200	437	861	962	1132	1213	385	779	876	1026	1105	333	695	782	919	987	E-5-23	
		08	2200	480	939	1051	1234	1324	423	849	957	1119	1203	366	759	852	1004	1077	E-5-24	
		09	1600	525	1055	1185	1402	1508	461	950	1075	1267	1366	396	845	954	1131	1218	E-5-25	
		10	1600	573	1178	1322	1561	1680	501	1056	1201	1412	1521	428	934	1060	1263	1357	E-7-26	
	PDA9T9R9	G8	3000	366	810	930	1090	1160	316	740	840	994	1060	276	670	760	900	960	E-10-27	
		1G	2000	516	1010	1140	1360	1450	460	928	1040	1244	1330	400	824	940	1124	1200	E-10-28	
		12	1600	636	1260	1450	1760	1880	560	1150	1316	1590	1710	460	1020	1180	1424	1520	E-10-29	
 3 φ Bridge	PDA6T6R6	15	1500	220	424	473	503	532	200	385	430	472	486	181	345	393	432	436	E-1-13	M-11
		20	1500	240	480	545	594	607	215	439	497	543	555	189	394	449	489	500	E-1-14	
		30	1500	272	542	616	673	688	244	496	561	613	627	216	444	507	552	564	E-1-15	
	PDA6T6R6	25	1200	237	515	577	625	645	220	478	534	583	602	203	442	495	540	557	E-2-16	
		34	1200	249	582	654	707	730	255	543	608	662	679	238	504	563	614	634	E-2-17	
		40	1200	345	764	857	920	945	337	713	790	869	889	331	662	747	798	821	E-2-18	
	PDA7T7R7	35	2000	291	621	721	797	817	259	567	655	727	746	227	506	590	652	668	E-4-19	M-13
		45	2000	321	689	795	875	896	286	625	729	801	1202	251	560	651	725	743	E-4-20	
		55	1500	364	785	921	1023	1050	313	710	832	928	953	270	635	741	827	850	E-4-21	
THREE ASSEMBLIES REQUIRED	PDA9T9R9	06	3000	565	1119	1259	1483	1597	498	1016	1140	1347	1447	432	906	1020	1203	1298	E-5-22	M-15
		07	2200	630	1235	1382	1623	1744	557	1125	1257	1476	1586	484	1003	1131	1322	1421	E-5-23	
		08	2200	691	1350	1509	1774	1902	611	1225	1375	1611	1736	531	1093	1231	1444	1552	E-5-24	
		09	1600	760	1523	1713	2027	2177	668	1376	1552	1836	1981	577	1223	1382	1636	1764	E-5-25	
		10	1600	828	1714	1922	2264	2433	727	1547	1746	2055	2214	626	1363	1557	1838	1978	E-7-26	
	PDA9T9R9	G8	3000	516	1146	1316	1542	1641	447	1047	1188	1406	1500	390	948	1075	1273	1358	E-10-27	
		1G	2000	730	1429	1613	1924	2052	651	1313	1471	1760	1882	566	1166	1332	1590	1698	E-10-28	
		12	1600	900	1783	2052	2490	2660	792	1627	1862	2250	2420	651	1443	1670	2015	2151	E-10-29	

ASSEMBLIES

Disc ASSEMBLIES Air Cooled

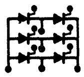
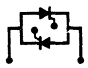
Full Control

Circuit Schematic / Configuration	Assembly Module Type (Order By This Number)	Voltage Code	Device Maximum Voltage Available (V)	T Ambient = 40°C N.C.	300	500	1000	1500	T Ambient = 50°C N.C.	300	500	1000	1500	T Ambient = 60°C N.C.	300	500	1000	1500	ELEC. DATA	MECH. DATA
				INLET AIR VELOCITY--LINEAR FEET PER MINUTE / OUTPUT CURRENT, AVERAGE AMPS																
 Single SCR T	PTA6T620	15	1500	78	150	167	178	188	71	136	152	167	172	64	122	139	153	154	E-13	M-10
		20	1500	84	169	191	209	213	75	154	175	190	195	68	138	158	172	175	E-14	
		30	1500	95	191	216	237	242	85	174	197	215	220	75	156	178	192	198	E-15	
	PTA6T625	25	1200	84	182	204	221	228	78	169	189	206	213	72	156	175	191	197	E-16	M-10
		30	1200	88	206	231	250	258	90	192	215	234	240	84	178	199	217	224	E-17	
		40	1200	122	270	303	325	334	119	252	279	307	314	117	234	264	282	290	E-18	
	PTA7T720	35	2000	101	218	252	280	287	89	197	229	254	261	78	176	206	228	234	E-19	M-12
		45	2000	111	240	279	308	315	99	218	254	281	288	90	196	227	252	259	E-20	
		55	1500	123	272	319	356	365	110	247	288	322	331	95	221	257	287	294	E-21	
ONE ASSEMBLY REQUIRED	PTA9T920	06	3000	195	388	436	514	553	171	352	395	466	502	148	313	354	416	448	E-22	M-14
		07	2200	218	430	481	566	607	192	390	438	513	552	167	347	391	460	494	E-23	
		08	2200	240	470	525	617	662	212	425	478	559	602	183	379	426	502	539	E-24	
		09	1600	263	527	593	701	754	230	475	538	633	683	198	422	477	566	609	E-25	
		10	1600	288	589	661	781	840	250	528	601	706	761	214	467	530	631	679	E-26	
	PTA9T9G0	08	3000	183	405	465	545	580	158	370	420	497	530	138	335	380	450	480	E-27	M-14
		10	2000	258	505	570	680	725	230	464	520	622	665	200	412	470	562	600	E-28	
		12	1600	318	630	725	880	940	280	575	658	795	855	230	510	590	712	760	E-29	
	PTAATA20	12	2200																E-30	M-28
		14	2200																E-31	
 1 ϕ Bridge	PDA6T620	15	1500	156	300	334	356	376	142	272	304	334	344	128	244	278	306	308	E-13	M-11
		20	1500	167	337	383	418	427	149	308	349	381	389	132	276	315	343	350	E-14	
		30	1500	190	381	433	474	484	171	348	395	431	440	161	311	356	388	396	E-15	
	PDA6T625	25	1200	168	364	408	441	456	156	338	378	412	426	144	312	350	382	394	E-16	M-11
		30	1200	176	412	462	500	516	180	384	430	468	480	168	356	398	434	448	E-17	
		40	1200	244	570	606	650	668	238	504	558	614	628	234	468	528	564	580	E-18	
	PDA7T720	35	2000	201	435	504	560	573	179	395	459	508	521	157	352	411	456	467	E-19	M-13
		45	2000	223	480	558	615	631	198	436	508	562	576	180	391	454	504	518	E-20	
		55	1500	245	545	639	712	730	220	493	576	645	663	190	442	514	573	589	E-21	
TWO ASSEMBLIES REQUIRED	PDA9T920	06	3000	390	776	872	1028	1106	343	704	790	932	1003	296	626	707	831	896	E-22	M-15
		07	2200	437	861	962	1132	1213	385	779	876	1026	1105	333	695	782	919	987	E-23	
		08	2200	480	939	1051	1234	1324	423	849	957	1119	1203	366	759	852	1004	1077	E-24	
		09	1600	525	1055	1185	1402	1508	461	950	1075	1267	1366	396	845	954	1131	1218	E-25	
		10	1600	573	1178	1322	1561	1680	501	1056	1201	1412	1521	428	934	1060	1263	1357	E-26	
	PDA9T9G0	18	3000	366	810	930	1090	1160	316	740	840	994	1060	276	670	760	900	960	E-27	M-15
		10	2000	516	1010	1140	1360	1450	460	928	1040	1244	1330	400	824	940	1124	1200	E-28	
		12	1600	636	1260	1450	1760	1880	560	1150	1316	1590	1710	460	1020	1180	1424	1520	E-29	
	PDAATA20	12	2200																E-30	M-29
		14	2200																E-31	

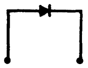
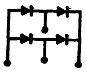
ASSEMBLIES

Full Control

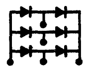
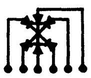
Disc ASSEMBLIES Air Cooled

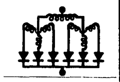
Circuit Schematic / Configuration	Assembly Module Type (Order By This Number)	Voltage Code	Device Maximum Voltage Available (V)	$T_{Ambient}$ = 40°C N.C.	300	500	1000	1500	$T_{Ambient}$ = 50°C N.C.	300	500	1000	1500	$T_{Ambient}$ = 60°C N.C.	300	500	1000	1500	ELEC. DATA	MECH. DATA
				INLET AIR VELOCITY – LINEAR FEET PER MINUTE / OUTPUT CURRENT, AVERAGE AMPS																
 3 φ Bridge	PDA6T620	15	1500	228	424	473	503	532	200	385	430	472	486	181	345	393	432	436	E-13	M-11
		20	1500	240	480	545	594	607	216	439	497	543	555	189	394	449	489	500	E-14	
		30	1500	272	542	616	673	688	244	496	561	613	627	216	444	507	552	564	E-15	
	PDA6T625	25	1200	237	515	577	625	645	220	478	534	583	602	203	442	495	540	557	E-16	
		30	1200	249	582	654	707	730	256	543	608	662	679	238	504	563	614	634	E-17	
		40	1200	345	764	857	920	945	337	713	790	869	889	331	662	747	798	821	E-18	
	PDA7T720	35	2000	291	621	721	797	817	259	567	655	727	746	227	506	590	652	668	E-19	M-13
		45	2000	321	689	795	875	896	286	625	729	801	1202	251	560	651	725	743	E-20	
THREE ASSEMBLIES REQUIRED		55	1500	354	785	921	1023	1050	313	710	832	928	953	270	635	741	827	850	E-21	
	PDA9T920	06	3000	565	1119	1259	1483	1597	498	1016	1140	1347	1447	432	906	1020	1203	1298	E-22	M-15
		07	2200	630	1235	1382	1628	1744	557	1125	1257	1476	1586	484	1003	1131	1322	1421	E-23	
		08	2200	691	1350	1509	1774	1902	611	1225	1375	1611	1736	531	1093	1231	1444	1552	E-24	
		09	1600	760	1523	1713	2027	2177	668	1376	1552	1836	1981	577	1223	1382	1636	1764	E-25	M-15
		10	1600	828	1714	1922	2264	2433	727	1547	1746	2055	2214	626	1363	1557	1838	1978	E-26	
	PDA9T9G0	08	3000	516	1146	1316	1542	1641	447	1047	1188	1406	1500	390	948	1075	1273	1358	E-27	
		10	2000	730	1429	1613	1924	2052	651	1313	1471	1760	1882	566	1166	1332	1590	1698	E-28	
		12	1600	900	1783	2052	2490	2660	792	1627	1862	2250	2420	651	1443	1670	2015	2151	E-29	
	PDAATA20	12	2200																E-30	
		14	2200																E-31	M-29
 1 φ AC Switch A AMPS RMS	PAA6T620	15	1500	171	330	367	391	413	156	299	334	367	378	140	268	306	336	339	E-13	M-11
		20	1500	184	371	420	459	468	164	338	384	419	428	145	303	347	377	385	E-14	
		30	1500	211	420	475	521	532	188	382	434	474	484	166	342	392	427	436	E-15	
	PAA6T625	25	1200	184	400	448	486	501	171	371	415	453	468	158	343	385	420	433	E-16	
		30	1200	193	453	508	550	567	198	422	473	514	528	184	391	437	477	492	E-17	
		40	1200	268	594	666	715	734	261	554	613	675	690	257	514	580	620	638	E-18	
	PAA7T720	35	2000	221	479	554	616	631	197	434	504	559	573	172	387	453	502	514	E-19	M-13
TWO ASSEMBLIES REQUIRED		45	2000	245	528	614	677	694	218	479	558	618	634	198	431	499	555	570	E-20	
		55	1500	270	599	703	783	803	242	542	634	709	729	208	486	565	630	648	E-21	
	PAA9T920	06	3000	429	854	959	1130	1216	377	775	869	1025	1103	326	688	778	915	985	E-22	M-15
		07	2200	480	947	1058	1245	1335	423	857	963	1129	1215	367	764	860	1011	1086	E-23	
		08	2200	528	1033	1156	1357	1457	466	934	1053	1231	1323	403	835	938	1104	1185	E-24	
		09	1600	578	1160	1304	1542	1659	507	1045	1183	1393	1503	435	929	1049	1245	1340	E-25	M-15
		10	1600	630	1296	1455	1717	1848	551	1162	1321	1553	1673	471	1028	1166	1389	1493	E-26	
	PAA9T9G0	08	3000	402	891	1023	1199	1276	348	814	924	1093	1166	304	737	836	990	1056	E-27	
		10	2000	568	1111	1254	1496	1595	508	1020	1144	1368	1463	440	906	1034	1236	1320	E-28	
		12	1600	700	1386	1595	1936	2068	616	1265	1448	1749	1881	506	1122	1298	1566	1672	E-29	
	PAAATA20	12	2200																E-30	
		14	2200																E-31	M-29

ASSEMBLIES

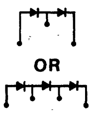
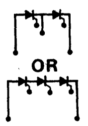
Circuit (Schematic Configuration)	Assembly Module Type (Order By This Number)	Voltage Code	Device Maximum Voltage Available (V)	TWater = 25°C, 1.0	1.2	1.5	3.0	5.0	TWater = 40°C, 1.0	1.2	1.5	3.0	5.0	ELEC. DATA	MECH. DATA
				INLET WATER FLOW RATE -- GALLONS PER MINUTE / OUTPUT CURRENT, AVERAGE AMPS											
 Single Rectifier R	PRW6R620	30	1200	588	594	601	618	626	542	548	554	570	577	E-1	M-1
		30	2000	553	559	565	581	589	518	523	529	545	552		
		30	3000	493	498	504	518	525	454	459	464	478	484		
	PRW6R620	40	1200	599	604	610	626	633	562	567	574	589	596	E-2	
		40	2000	562	567	573	588	594	525	530	536	550	557		
	PRW6R620	50	1200	680	687	695	715	724	639	645	653	672	681	E-3	
SINGLE ASSEMBLY REQUIRED	PRW7R720	06	1200	820	830	846	878	895	766	777	790	823	839	E-4	M-4
		06	2000	771	.781	796	826	842	716	726	739	770	785		
		06	4000	683	692	705	732	746	627	636	647	674	687		
	PRW7R720	09	1200	959	971	988	1030	1048	899	910	926	964	985	E-5	
		09	2000	900	912	928	967	984	840	851	865	901	919		
	PRW7R720	12	1200	1186	1202	1219	1262	1282	1113	1128	1149	1191	1211	E-6	
	PRW9R920	11	1200	1497	1522	1553	1628	1670	1410	1432	1462	1533	1577	E-7	M-7
		11	2000	1410	1432	1462	1533	1577	1323	1342	1370	1435	1475		
		11	3000	1255	1280	1308	1370	1408	1158	1177	1200	1267	1300		
	PRW9R920	16	1200	1592	1640	1675	1767	1820	1510	1535	1572	1650	1700	E-8	
		16	2000	1510	1535	1572	1650	1700	1406	1430	1465	1540	1590		
	PRW9R920	20	1200	2080	2120	2170	2280	2348	1940	1982	2028	2140	2197	E-9	
	PRW9R9G0	13	1200	1625	1654	1693	1788	1844	1535	1563	1600	1685	1740	E-10	M-7
		13	2000	1535	1563	1600	1685	1740	1435	1467	1498	1580	1633		
		13	3000	1370	1397	1430	1510	1560	1263	1288	1320	1398	1440		
	PRW9R9G0	18	1200	1756	1793	1841	1940	2000	1648	1680	1726	1830	1900	E-11	
		18	2000	1648	1680	1726	1830	1900	1535	1563	1602	1702	1765		
	PRW9R9G0	22	1200	2272	2317	2376	2517	2608	2130	2175	2228	2363	2445	E-12	
 1 φ Bridge	PDW6R620	30	1200	1176	1188	1202	1236	1252	1084	1096	1108	1140	1154	E-1	M-3
		30	2000	1106	1118	1130	1162	1178	1036	1046	1058	1090	1104		
		30	3000	986	996	1008	1036	1056	908	918	928	956	968		
	PDW6R620	40	1200	1198	1208	1220	1252	1266	1124	1134	1148	1178	1192	E-2	
		40	2000	1124	1134	1146	1176	1188	1050	1060	1072	1100	1114		
	PDW6R620	50	1200	1360	1374	1390	1430	1448	1278	1290	1306	1344	1362	E-3	
TWO ASSEMBLIES REQUIRED	PDW7R720	06	1200	1640	1660	1692	1756	1790	1532	1554	1580	1646	1678	E-4	M-6
		06	2000	1542	1562	1592	1652	1684	1432	1452	1478	1540	1570		
		06	4000	1366	1384	1410	1464	1492	1254	1272	1294	1348	1374		
	PDW7R720	09	1200	1918	1942	1976	2060	2096	1798	1820	1852	1928	1970	E-5	
		09	2000	1800	1824	1856	1934	1968	1680	1702	1730	1802	1838		
	PDW7R720	12	1200	2373	2403	2438	2523	2564	2227	2256	2292	2382	2422	E-6	
	PDW9R920	11	1200	2994	3044	3106	3256	3340	2820	2864	2924	3066	3154	E-7	M-9
		11	2000	2820	2864	2924	3066	3154	2646	2684	2540	2870	2950		
		11	3000	2510	2560	2616	2740	2816	2316	2354	2400	2534	2600		
	PDW9R920	16	1200	3184	3280	3350	3534	3640	3020	3070	3144	3300	3400	E-8	
		16	2000	3020	3070	3144	3300	3400	2800	2860	2930	3080	3180		
	PDW9R920	20	1200	4160	4280	4340	4560	2696	2880	3965	4056	4280	4394	E-9	
	PDW9R9G0	13	1200	3250	3308	3386	3576	3688	3070	3126	3200	3370	3480	E-10	M-9
		13	2000	3070	3126	3200	3370	3480	2870	2934	2996	3160	3266		
		13	3000	2740	2794	2860	3010	3120	2526	2576	2640	2796	2880		
	PDW9R9G0	18	1200	3512	3586	3682	3880	4000	3296	3360	3452	3660	3800	E-11	
		18	2000	3296	3360	3452	3660	3800	3075	3126	3204	3404	3530		
	PDW9R9G0	22	1200	4544	4634	4752	5034	5216	4160	4350	4456	4726	4890	E-12	

Disc ASSEMBLIES Liquid Cooled

Circuit / Schematic Configuration	Assembly Module Type (Order By This Number)	Voltage Code	Device Maximum Voltage Available (V)	T Water = 25°C 1.0	1.2	1.5	3.0	5.0	T Water = 40°C 1.0	1.2	1.5	3.0	5.0	ELEC. DATA	MECH. DATA
				INLET WATER FLOW RATE -- GALLONS PER MINUTE / OUTPUT CURRENT, AVERAGE AMPS											
 3 φ Bridge	PDW6R620	30	1200	1642	1657	1676	1724	1745	1549	1565	1584	1627	1647	E-1	M-3
		30	2000	1544	1558	1576	1621	1641	1448	1463	1480	1521	1539		
		30	3000	1376	1389	1405	1445	1463	1270	1283	1298	1334	1350		
	PDW6R620	40	1200	1669	1681	1701	1743	1763	1570	1584	1602	1644	1662	E-2	
		40	2000	1567	1578	1597	1637	1655	1467	1480	1497	1536	1553		
	PDW6R620	50	1200	1904	1921	1942	1995	2020	1789	1806	1827	1881	1906	E-3	
	PDW7R720	06	1200	2298	2327	2364	2458	2503	2112	2141	2177	2269	2310	E-4	M-6
		06	2000	2162	2189	2224	2312	2355	2010	2037	2072	2160	2198		
		06	4000	1915	1939	1970	2048	2086	1760	1784	1814	1891	1925		
	PDW7R720	09	1200	2686	2723	2770	2877	2929	2518	2553	2595	2703	2756	E-5	
THREE		09	2000	2521	2557	2601	2701	2750	2353	2386	2425	2526	2576		
ASSEMBLIES	PDW7R720	12	1200	3368	3406	3456	3569	3638	3177	3217	3269	3381	3429	E-6	
REQUIRED	PDW9R920	11	1200	4095	4170	4260	4455	4590	3855	3924	4005	4200	4320	E-7	M-9
		11	2000	3855	3924	4005	4200	4320	3600	3660	3744	3930	4050		
		11	3000	3420	3486	3564	3744	3861	3150	3210	3279	3450	3546		
	PDW9R920	16	1200	4425	4485	4590	4821	4950	4150	4245	4320	4536	4656	E-8	
		16	2000	4146	4245	4320	4536	4656	3879	3960	4041	4248	4362		
	PDW9R920	20	1200	5736	5850	5991	6309	6516	5355	5460	5580	5904	6615	E-9	
	PDW9R9G0	13	1200	4455	4545	4650	4920	5070	4200	4284	4389	4626	4791	E-10	M-9
		13	2000	4200	4284	4389	4626	4791	3936	4014	4104	4332	4479		
		13	3000	3744	3816	3906	4134	4278	3463	3516	3606	3816	3939		
	PDW9R9G0	18	1200	4794	4887	4998	5289	5466	4515	4602	4716	4977	5151	E-11	
		18	2000	4515	4602	4716	4977	5151	4230	4308	4410	4556	4815		
	PDW9R9G0	22	1200	6300	6426	6600	6987	7224	5874	6006	6174	6540	6792	E-12	
 6φ Star	PRW6R620	30	1200	2463	2483	2525	2581	2605	2340	2361	2387	2453	2482	E-1	M-1
		30	2000	2329	2347	2387	2441	2463	2197	2216	2241	2302	2329		
		30	3000	2094	2111	2147	2195	2215	1939	1956	1978	2032	2056		
	PRW6R620	40	1200	2511	2533	2559	2625	2647	2380	2400	2423	2482	2513	E-2	
		40	2000	2376	2396	2421	2483	2505	2233	2251	2273	2328	2357		
	PRW6R620	50	1200	2901	2928	2961	3041	3079	2744	2768	2798	2871	2905	E-3	
	PRW7R720	06	1200	3467	3513	3568	3702	3765	3182	3222	3270	3394	3456	E-4	M-4
		06	2000	3276	3319	3372	3498	3558	3098	3136	3183	3304	3364		
		06	4000	2938	2977	3024	3137	3191	2722	2756	2797	2903	2956		
	PRW7R720	09	1200	4096	4146	4210	4372	4449	3887	3940	3999	4146	4216	E-5	
		09	2000	3871	3919	3979	4132	4205	3636	3686	3741	3878	3944		
SIX	PRW7R720	12	1200	5023	5077	5145	5312	5392	4763	4811	4874	5027	5100	E-6	
ASSEMBLIES	PRW9R920	11	1200	6288	6390	6540	6828	7020	5928	6018	6150	6456	6630	E-7	M-7
REQUIRED		11	2000	5928	6018	6150	6456	6630	5550	5640	5760	6186	6216		
		11	3000	5280	5376	5496	5760	5940	4866	4962	5058	5328	5490		
	PRW9R920	16	1200	6876	6972	7116	7422	7602	6486	6612	6726	7026	7200	E-8	
		16	2000	6486	6612	6726	7026	7200	5940	6210	6312	6618	6786		
	PRW9R920	20	1200	9054	9216	9420	9900	10188	8508	8652	8832	9300	9570	E-9	
	PRW9R9G0	13	1200	6834	6954	7122	7512	7746	6438	6570	6737	7080	7320	E-10	M-7
		13	2000	6438	6570	6737	7080	7320	6600	6168	6300	6660	6870		
		13	3000	5760	5868	6006	6342	6570	5322	5418	5550	5868	6060		
	PRW9R9G0	18	1200	7374	7500	7668	8070	8298	7002	7122	7272	7632	7872	E-11	
		18	2000	7002	7122	7272	7632	7872	6600	6708	6846	7200	7422		
	PRW9R9G0	22	1200	9864	10062	10302	10842	11142	9270	9456	9678	10248	10578	E-12	

Circuit / Schematic Configuration	Assembly Module Type (Order By This Number)	Voltage Code	Device Maximum Voltage Available (V)	TWater = 25°C 1.0	1.2	1.5	3.0	5.0	TWater = 40°C 1.0	1.2	1.5	3.0	5.0	ELEC. DATA	MECH. DATA
				INLET WATER FLOW RATE -- GALLONS PER MINUTE / OUTPUT CURRENT, AVERAGE AMPS											
 3 φ Wye (With Interphase Transformer)	PRW6R620	30	1200	3284	3314	3352	3448	3490	3098	3130	3168	3254	3294	E-1	M-1
		30	2000	3088	3116	3152	3242	3282	2895	2926	2960	3042	3078		
		30	3000	2752	2778	2810	2890	2925	2540	2566	2596	2668	2700		
	PRW6R620	40	1200	3338	3362	3402	3486	3526	3140	3168	3204	3288	3224	E-2	
		40	2000	3134	3156	3194	3274	3310	2934	2960	2994	3072	3106		
	PRW6R620	50	1200	3808	3842	3884	3990	4040	3578	3612	3654	3762	3812	E-3	
	PRW7R720	06	1200	4596	4654	2728	4916	5006	4224	4282	4354	4538	4620	E-4	M-4
		06	2000	4324	4378	4448	4624	4710	4020	4074	4144	4320	4396		
		06	4000	3830	3878	3940	4096	4172	3520	3568	2628	3782	3850		
	PRW7R720	09	1200	5370	5446	5540	5754	5858	5036	5106	5190	5406	5512	E-5	
		09	2000	5042	5114	5202	5402	5500	4706	4772	4850	5052	5152		
SIX	PRW7R720	12	1200	6736	6812	6912	7138	7276	6364	6434	6538	6762	6858	E-6	
ASSEMBLIES	PRW9R920	11	1200	8190	8340	8520	8910	9180	7710	7848	8010	8400	8640	E-7	M-7
REQUIRED		11	2000	7710	7848	8010	8400	8640	7200	7320	7488	7860	8100		
		11	3000	6840	6972	7128	7488	7722	6300	6420	6558	6900	7092		
	PRW9R920	16	1200	8850	8970	9180	9642	9900	8300	8490	4640	9072	9312	E-8	
		16	2000	8296	8490	4640	9072	9312	7758	7920	8082	8496	8724		
	PRW9R920	20	1200	11470	11700	11982	12618	13032	10710	10920	11160	11808	13230	E-9	
	PRW9R9G0	13	1200	8910	9090	9300	9840	10140	8400	8568	8778	9252	9582	E-10	M-7
		13	2000	8400	8568	8778	9252	9582	7872	8028	8208	8664	8958		
		13	3000	7488	7632	7812	8264	8556	6906	7032	7212	7632	7878		
	PRW9R9G0	18	1200	9588	9774	9996	10578	10932	9030	9204	9432	9954	10302	E-11	
		18	2000	9030	9030	9204	9432	10302	8460	8618	8820	9112	9630		
	PRW9R9G0	22	1200	12600	12852	13200	13974	14448	11748	12012	12348	13080	13584		

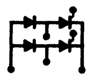
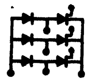
Disc
ASSEMBLIES
Liquid Cooled

Circuit / Schematic Configuration	Assy. Module Type (Order By This Number) / Voltage Code	Device Max. Volt. Avail. (V)	T_{Water} = 25°C, 1.0	1.2	1.5	3.0	5.0	T_{Water} = 40°C, 1.0	1.2	1.5	3.0	5.0	ELEC. DATA	MECH. DATA
			INLET WATER FLOW RATE -- GALLONS PER MINUTE / OUTPUT CURRENT, AVERAGE AMPS											
 SERIES RECTIFIER	PSW6R620 30	1200	588	594	601	618	626	542	548	554	570	577	E-1	M-2/ M-3 or M-17/ M-20
	30	2000	553	559	565	581	589	518	523	529	545	552		
	30	3000	493	498	504	518	525	454	459	464	478	484		
	PSW6R620 40	1200	599	604	610	626	633	562	567	574	589	596	E-2	
	40	2000	562	567	573	588	594	525	530	536	550	557		
	PSW6R620 05	1200	680	687	695	715	724	639	645	653	672	681	E-3	
SINGLE ASSEMBLY REQUIRED	PSW7R720 06	1200	820	830	846	878	895	766	777	790	823	839	E-4	M-5/ M-6 or M-18/ M-21
	06	2000	771	781	796	826	842	716	726	739	770	785		
	06	4000	683	692	705	732	746	627	636	647	674	687		
	PSW7R720 09	1200	959	971	988	1030	1048	899	910	926	964	985	E-5	
	09	2000	900	912	928	967	984	840	851	865	901	919		
	PSW7R720 12	1200	1186	1202	1219	1262	1282	1113	1128	1149	1191	1211	E-6	
	PSW9R920 11	1200	1497	1522	1553	1628	1670	1410	1432	1462	1533	1577	E-7	M-8/ M-9 or M-19/ M-22
	11	2000	1410	1432	1462	1533	1577	1323	1342	1370	1435	1475		
	11	3000	1255	1280	1308	1370	1408	1158	1177	1200	1267	1300		
	PSW9R920 16	1200	1592	1640	1675	1767	1820	1510	1535	1572	1650	1700	E-8	
	16	2000	1510	1535	1572	1650	1700	1406	1430	1465	1540	1590		
	PSW9R920 20	1200	2080	2120	2170	2280	2348	1940	1982	2028	2140	2197	E-9	
	PSW9R9G0 13	1200	1625	1654	1693	1788	1844	1535	1563	1600	1685	1740	E-10	M-8/ M-9 or M-19/ M-22
	13	2000	1535	1563	1600	1685	1740	1435	1467	1498	1580	1633		
	13	3000	1370	1397	1430	1510	1560	1263	1288	1320	1398	1440		
	PSW9R920 18	1200	1756	1793	1841	1940	2000	1648	1680	1726	1830	1900	E-11	
	18	2000	1648	1680	1726	1830	1900	1535	1563	1602	1702	1765		
	PSW9R920 22	1200	2272	2317	2376	2517	2608	2130	2175	2228	2363	2445	E-12	
 SERIES THYRISTOR	PSW6T620 15	1500	265	268	272	280	285	236	238	242	249	253	E-13	M-2/ M-3 or M-17/ M-20
	20	1500	306	309	313	323	327	271	274	278	286	290	E-14	
	30	1500	347	351	355	367	372	307	311	314	324	329	E-15	
	PSW6T625 25	1200	315	318	325	333	336	287	289	295	303	306	E-16	
	30	1200	359	364	370	380	384	326	330	337	346	349	E-17	
	40	1200	456	463	474	480	486	415	422	432	442	444	E-18	
SINGLE ASSEMBLY REQUIRED	PSW7T720 35	2200	424	430	436	451	459	378	383	389	403	410	E-19	M-5/ M-6 or M-18/ M-21
	45	2200	473	478	486	503	512	420	425	432	449	457	E-20	
	55	1600	558	564	572	593	603	493	499	508	528	538	E-21	
	PSW9T920 06	3000	693	709	721	758	779	612	625	635	669	688	E-22	M-8/ M-9 or M-19/ M-22
	07	2200	756	772	784	825	848	669	684	696	721	750	E-23	
	08	2200	823	841	854	898	924	728	744	755	796	817	E-24	
	09	1600	947	968	983	1037	1067	833	852	867	914	940	E-25	
	10	1600	1057	1081	1098	1158	1192	929	951	967	1020	1050	E-26	
	PSW9T9G0 08	3000	734	747	765	810	837	652	665	680	720	745	E-27	
	10	2000	915	930	955	1005	1035	820	830	855	900	930	E-28	
	12	1600	1200	1220	1250	1330	1370	1060	1080	1110	1170	1215	E-29	
	PSWATA20 12	2200	1320	1360	1400	1490	CF	1160	1190	1230	1310	CF	E-30	M-27 or C-F.
	14	2200	1490	1530	1585	1660	CF	1325	1360	1400	1485	CF	E-31	

*Consult factory for exact type number before ordering.

Disc ASSEMBLIES Liquid Cooled

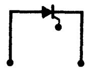
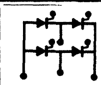
Half Control

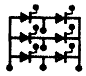
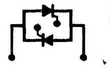
Circuit / Schematic Configuration	Assembly Module Type (Order By This Number)	Voltage Code	Device Maximum Voltage Available (V)	T Water = 25°C, 1.0	1.2	1.5	3.0	5.0	T Water = 40°C, 1.0	1.2	1.5	3.0	5.0	ELEC. DATA	MECH. DATA
				INLET WATER FLOW RATE -- GALLONS PER MINUTE / OUTPUT CURRENT, AVERAGE AMPS											
 1 φ Bridge	PDW6T6R6	15	1500	530	536	544	560	570	472	476	484	498	506	E-13	M-3
		20	1500	611	618	626	645	654	543	548	556	573	580	E-14	
		30	1500	694	701	711	733	743	616	621	629	648	658	E-15	
	PDW6T6R6	25	1200	630	636	650	666	672	574	578	590	606	612	E-16	
		3H	1200	718	728	740	760	768	652	660	674	692	698	E-17	
		40	1200	912	926	948	960	972	830	844	864	884	888	E-18	
	PDW7T7R7	35	2200	849	859	872	903	917	756	766	777	806	820	E-19	M-6
		45	2200	945	957	971	1007	1024	840	851	864	898	914	E-20	
		55	1600	1115	1128	1145	1186	1206	986	999	1015	1056	1075	E-21	
	PDW9T9R9	06	3000	1387	1419	1442	1517	1556	1224	1250	1271	1338	1377	E-22	M-9
TWO ASSEMBLIES REQUIRED		07	2200	1511	1545	1568	1651	1696	1338	1368	1391	1462	1501	E-23	
		08	2200	1646	1681	1708	1797	1847	1455	1488	1511	1591	1634	E-24	
		09	1600	1893	1936	1967	2075	2135	1667	1704	1733	1828	1880	E-25	M-9
		10	1600	2113	3161	2196	2316	2385	1859	1903	1934	2040	2099	E-26	
*OUTPUT CURRENT AMPS RMS	PDW9T9R9	G8	3000	1468	1494	1530	1620	1674	1304	1330	1360	1440	1490	E-27	
		1G	2000	1830	1860	1920	2010	2070	1640	1660	1710	1800	1860	E-28	
		12	1600	2400	2440	2500	2660	2740	2120	2160	2220	2340	2430	E-29	
 3 φ Bridge	PDW6T6R6	15	1500	763	750	761	784	798	679	666	677	697	708	E-13	M-3
		20	1500	872	881	892	919	931	772	780	790	815	827	E-14	
		30	1500	987	998	1010	1044	1059	876	885	896	924	936	E-15	
	PDW6T6R6	25	1200	882	890	910	932	940	803	809	826	848	856	E-16	
		3H	1200	1005	1019	1036	1064	1075	912	924	943	968	977	E-17	
		40	1200	1276	1296	1327	1344	1360	1162	1181	1209	1237	1243	E-18	
	PDW7T7R7	35	2200	1205	1220	1238	1283	1304	1077	1090	1107	1149	1167	E-19	M-6
		45	2200	1348	1365	1388	1442	1468	1196	1217	1233	1279	1301	E-20	
		55	1600	1598	1618	1642	1701	1728	1424	1444	1469	1525	1548	E-21	
	PDW9T9R9	06	3000	2003	2047	2079	2190	2252	1766	1806	1835	1939	1993	E-22	M-9
		07	2200	2175	2223	2260	2376	2442	1929	2970	2001	2105	2165	E-23	
THREE ASSEMBLIES REQUIRED		08	2200	2364	2416	2453	2583	2655	2097	2145	2180	2290	2353	E-24	
		09	1600	2734	2798	2846	3002	3089	2410	2464	2505	2643	2721	E-25	
		10	1600	3057	3128	3181	3369	3478	2693	2753	2800	2953	3025	E-26	
	PDW9T9R9	G8	3000	2055	2091	2142	2268	2343	1825	1862	1904	2106	2086	E-27	
		1G	2000	2562	2604	2674	2814	2898	2296	2324	2394	2520	2604	E-28	
		12	1600	3360	3416	3500	3724	3836	2968	3024	3108	3276	3402	E-29	

Full Control

Disc ASSEMBLIES Liquid Cooled

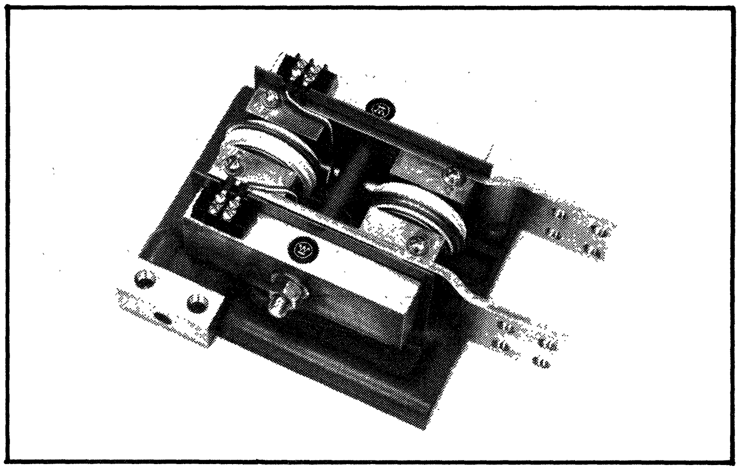
ASSEMBLIES

Circuit / Schematic Configuration	Assembly Module Type (Order By This Number)	Voltage Code	Device Maximum Voltage Available (V)	T_{Water} = 25°C, 1.0	1.2	1.5	3.0	5.0	T_{Water} = 40°C, 1.0	1.2	1.5	3.0	5.0	ELEC. DATA	MECH. DATA
				INLET WATER FLOW RATE -- GALLONS PER MINUTE; OUTPUT CURRENT, AVERAGE AMPS											
 Single SCR T	PTW6T620	15	1500	265	268	272	280	285	236	238	242	249	253	E-13	M-1
		20	1500	306	309	313	323	327	271	274	278	286	290	E-14	
		30	1500	347	351	355	367	372	307	311	314	324	329	E-15	
	PTW6T625	25	1200	316	318	325	333	336	287	289	295	303	306	E-16	
		30	1200	359	364	370	380	384	326	330	337	346	349	E-17	
		40	1200	456	463	474	480	486	416	422	432	442	444	E-18	
	PTW7T720	35	2200	424	430	436	451	459	378	383	389	403	410	E-19	M-4
		45	2200	473	478	486	503	512	420	425	432	449	457	E-20	
		55	1600	558	564	572	593	603	493	499	508	528	538	E-21	
	PTW9T920	06	3000	693	709	721	758	779	612	625	635	669	688	E-22	M-7
SINGLE ASSEMBLY REQUIRED		07	2200	756	772	784	825	848	669	684	696	721	750	E-23	
		08	2200	823	841	854	898	924	728	744	755	796	817	E-24	
		09	1600	947	968	983	1037	1067	833	852	867	914	940	E-25	
		10	1600	1057	1081	1098	1158	1192	929	951	967	1020	1050	E-26	
	PTW9T9G0	08	3000	734	747	765	810	837	652	665	680	720	745	E-27	
		10	2000	915	930	955	1005	1035	820	830	855	900	930	E-28	
		12	1600	1200	1220	1250	1330	1370	1060	1080	1110	1170	1215	E-29	
	PTWATA20	12	2200	1320	1360	1400	1490	CF	1160	1190	1230	1310	CF	E-30	M-26
	PTWATA20	14	2200	1490	1530	1585	1660	CF	1325	1360	1400	1485	CF	E-31	
 1 φ Bridge	PDW6T620	15	1500	530	536	544	560	570	472	476	484	498	506	E-13	M-3
		20	1500	611	618	626	645	654	543	548	556	573	580	E-14	
		30	1500	694	701	711	733	743	615	621	629	648	658	E-15	
	PDW6T625	25	1200	630	636	650	666	672	574	578	590	606	612	E-16	
		30	1200	718	728	740	760	768	652	660	674	692	698	E-17	
		40	1200	912	926	948	960	972	830	844	864	884	888	E-18	
	PDW7T720	35	2200	849	859j	872	903	917	756	766	777	806	820	E-19	M-6
		45	2200	945	957	971	1007	1024	840	851	864	898	914	E-20	
		55	1600	1115	1128	1145	1186	1206	986	999	1015	1056	1075	E-21	
TWO ASSEMBLIES REQUIRED	PDW9T920	06	3000	1387	1419	1442	1517	1556	1224	1250	1271	1338	1377	E-22	M-9
		07	2200	1511	1545	1568	1651	1696	1338	1368	1391	1462	1501	E-23	
		08	2200	1646	1681	1708	1797	1847	1455	1488	1511	1591	1634	E-24	
		09	1600	1893	1936	1967	2075	2135	1667	1704	1733	1828	1880	E-25	
		10	1600	2113	3161	2196	2316	2385	1859	1903	1934	2040	2099	E-26	
	PDW9T9G0	08	3000	1468	1494	1530	1620	1674	1304	1330	1360	1440	1490	E-27	M-9
		10	2000	1830	1860	1920	2010	2070	1640	1660	1710	1800	1860	E-28	
		12	1600	2400	2440	2500	2660	2740	2120	2160	2220	2340	2430	E-29	
	PDWATA20	12	2200	2640	2720	2800	2980	CF	2320	2380	2460	2620	CF	E-30	M-27
	PDWATA20	14	2200	2980	3060	3170	3320	CF	2650	2720	2800	2970	CF	E-31	

Circuit / Schematic Configuration	Assembly Module Type (Order By This Number)	Voltage Code	Device Maximum Voltage Available (V)	T_{Water} = 25°C 1.0	1.2	1.5	3.0	5.0	T_{Water} = 40°C 1.0	1.2	1.5	3.0	5.0	ELEC. DATA	MECH. DATA
				INLET WATER FLOW RATE -- GALLONS PER MINUTE / OUTPUT CURRENT, AVERAGE AMPS											
 3 φ Bridge	PDW6T620	15	1500	763	750	761	784	798	679	666	677	697	708	E-13	M-3
		20	1500	872	881	892	919	931	772	780	790	815	827	E-14	
		30	1500	987	998	1010	1044	1059	876	885	896	924	936	E-15	
	PDW6T625	25	1200	882	890	910	932	940	803	809	826	848	856	E-16	
		30	1200	1006	1019	1036	1064	1075	912	924	943	968	977	E-17	
		40	1200	1276	1296	1327	1344	1360	1162	1181	1209	1237	1243	E-18	
	PDW7T720	35	2200	1205	1220	1238	1283	1304	1077	1090	1107	1149	1167	E-19	M-6
		45	2200	1348	1365	1388	1442	1468	1198	1217	1233	1279	1301	E-20	
		55	1600	1598	1618	1642	1701	1728	1424	1444	1469	1525	1548	E-21	
	PDW9T920	06	3000	2003	2047	2079	2190	2252	1766	1806	1835	1939	1993	E-22	M-9
		07	2200	2175	2223	2260	2376	2442	1929	2970	2001	2105	2165	E-23	
THREE ASSEMBLIES REQUIRED		08	2200	2364	2416	2453	2583	2655	2097	2145	2180	2290	2353	E-24	
		09	1600	2734	2798	2846	3002	3089	2410	2464	2505	2643	2721	E-25	
		10	1600	3057	3128	3181	3369	3478	2693	2753	2800	2953	3025	E-26	
	PDW9T9G0	08	3000	2056	2091	2142	2268	2343	1825	1862	1904	2106	2086	E-27	
		10	2000	2582	2604	2674	2814	2898	2298	2324	2394	2520	2604	E-28	
		12	1600	3360	3416	3500	3724	3836	2968	3024	3108	3276	3402	E-29	
	PDWATA20	12	2200	3748	3862	3976	4231	CF	3294	3379	3493	1310	CF	E-30	M-27
	PDWATA20	14	2200	4231	4345	4501	4717	CF	3763	3862	3976	4217	CF	E-31	
 1 φ AC Switch	PAW6T620	15	1500	583	589	598	616	627	519	523	532	547	556	E-13	M-3
		20	1500	672	679	688	710	720	597	603	611	630	638	E-14	
		30	1500	763	771	782	806	818	676	683	692	713	723	E-15	
	PAW6T625	25	1200	693	699	715	732	739	631	635	649	666	673	E-16	
		30	1200	789	800	814	836	844	717	726	741	761	767	E-17	
		40	1200	1003	1018	1042	1056	1069	913	928	950	972	976	E-18	
	PAW7T720	35	2200	934	945	959	992	1009	832	842	855	887	902	E-19	M-6
		45	2200	1040	1053	1068	1108	1126	923	936	951	988	1005	E-20	
		55	1600	1227	1241	1259	1305	1326	1086	1099	1117	1161	1183	E-21	
	PAW9920	06	3000	1525	1561	1586	1668	1715	1346	1376	1398	1472	1515	E-22	M-9
ONE ASSEMBLY REQUIRED		07	2200	1662	1699	1725	1816	1866	1472	1505	1530	1608	1651	E-23	
		08	2200	1811	1849	1878	1977	2032	1601	1636	1662	1750	1798	E-24	
		09	1600	2083	2129	2164	2282	2348	1833	1875	1907	2011	2068	E-25	
		10	1600	2324	2377	2415	2547	2623	2044	2093	2127	2244	2309	E-26	
*OUTPUT CURRENT AMPS RMS	PAW9T9G0	08	3000	1614	1643	1683	1782	1841	1434	1463	1496	1584	1639	E-27	
		10	2000	2013	2046	2101	2211	2277	1804	1826	1881	1980	2046	E-28	
		12	1600	2640	2684	2750	2926	3014	2332	2376	2442	2574	2673	E-29	
	PAWATA20	12	2200	2904	2992	3080	3278	CF	2552	2618	2706	2882	CF	M-30	M-27
	PAWATA20	14	2200	3278	3366	3487	3652	CF	2916	2992	3080	3267	CF	E-31	

Disc Assemblies Manifold

- Eleven current ratings available
- Manifold base providing easy mounting and 18" isolating liquid path
- 3N221 and 3N222 types available
- ¼-18 N.P.T. (2) brass fitting supplied with grounding wire
- Water temperature sensing thermostats available for assembly protection



The Westinghouse AC manifold switch provides a fast-access, high performance assembly that has been rated for continuous or duty cycle applications. All mounting and electrical connections meet the JEDEC outlines. Water connections can be made (V) vertical or (H) horizontal. The electrical connections may be supplied either (S) short tangs or (L) tangs. Refer to Ⓦ outlines M-16 under mechanical data, this section.

AVAILABLE DESIGNS

FRAME	DEVICE	VOLTAGE		CURRENT		H_2O INLET	TANG
PAM7	T720	1000 through 2200	10 — 22	350 450 550	35 45 55	H V	L S
PAM9	T920	1000 through 3000	10 — 30	600 700 800 900 1000	06 07 08 09 10		
PAM9	T9G0	1000 through 3000	10 — 30	800 1000 1200	08 10 12		

↑ Refer to Product Data Sections for complete device information.

Storage Temperature* .... -40°C to 65°C
Maximum Ambient Temperature .... 65°
Maximum Water Pressure (INLET) .... 60 psig
Maximum Water Temperature (INLET) .... 50°C
Maximum Pressure Drop, 1.25 GPM .... 10 PSIG
*Manifold must be purged of water to avoid freeze up at low temperatures.

EXAMPLE: Obtain optimum device performance for your application by selecting proper order code PAM7 with T7201255 SCR's rated at 1240A RMS with 1.25 GPM t_{water} = 40°C and vertical H^2O connection, short tang electrical connections.

FRAME AND SINK TYPE				DEVICE TYPE				VOLTAGE CODE		DEVICE CURRENT		H_2O	TANG
P	A	M	7	T	7	2	0	1	2	5	5	V	S
1	2	3	4	5	6	7	8	9	10	11	12	13	14

HANDLING PRECAUTIONS:

When the switch is to be placed in operation, all surface moisture must be eliminated before power is applied, otherwise catastrophic electrochemical failure can be induced.

Coordination between cooling water temperature and the prevailing humidity is necessary to avoid condensation on water cooled metallic surfaces and electrical insulation. Ordinarily, this is no problem with 40°C cooling water. With lower temperature water, humidity control may be necessary to completely stop condensation.

MOUNTING POSITIONS: No restrictions

WATER QUALITY:

The cooling water shall have the following quality:

A neutral or slightly alkaline reaction, i,e, a pH between 7.0 and 9.0.

A chloride content of not more than 20 parts per million; a nitrate content of not more than 10 parts per million; and a sulphate content of not more than 100 parts per million.

A total solids content of not more than 250 parts per million.

A total hardness, as calcium carbonate, of not more than 250 parts per million.

No chemial additives to be used.

MOUNTING

Visually examine the switch before it is mounted to see that it has not been damaged during handling.

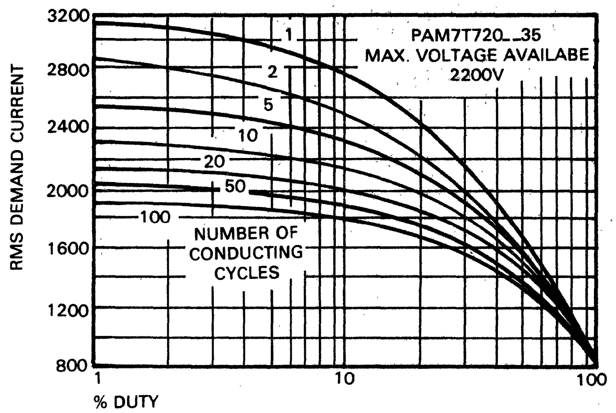
When mounting the insulating base, the following precautions should be taken to avoid distorting the plastic part, a cause of breakage and/or leakage.

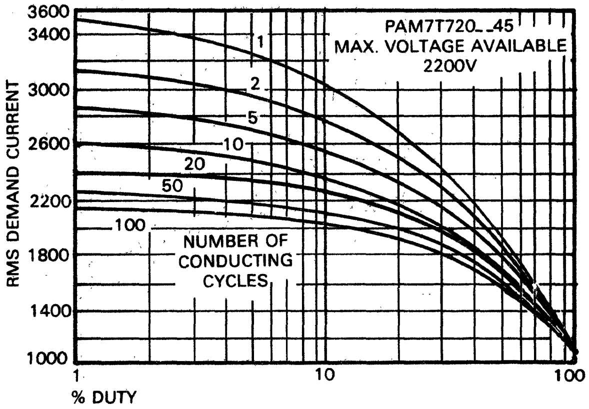
The mounting surface is to be flat within .030".

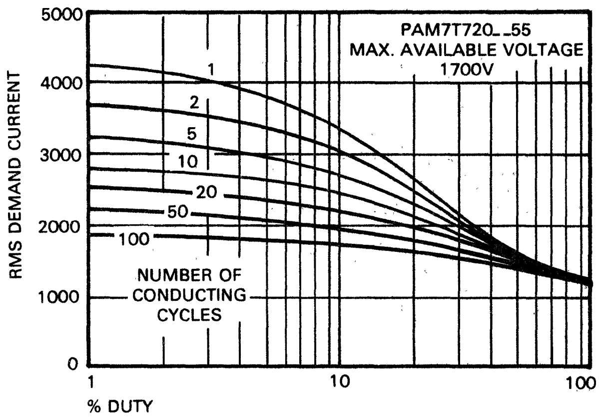
Bolts or nuts which are used to hold the switch into the equipment shall be used with a flat washer against the plastic base. Torque values shall not be exceeded. (8ft-lbs. max. for ¼" screw).

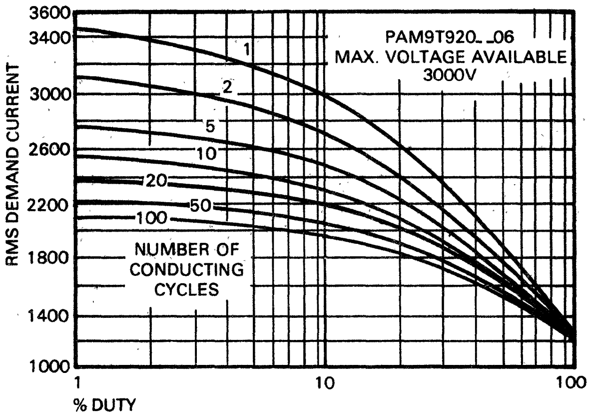
For pipe connections, a sealing agent, joint compound, shall be used in order to limit the torque needed and in order to get a water -tight joint.

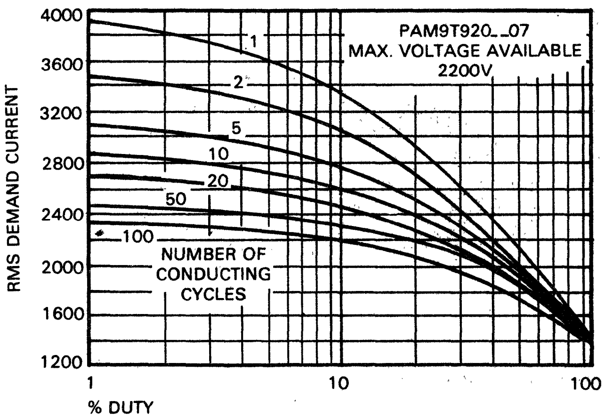
RMS DEMAND CURRENT, AMPS VS. PERCENT DUTY **TWATER = 40°C, 1.25 GPM**

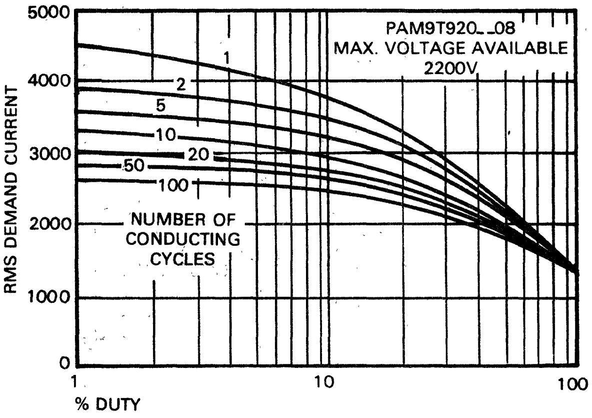




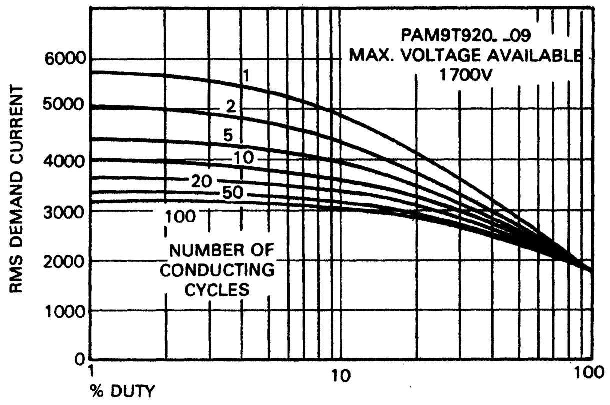


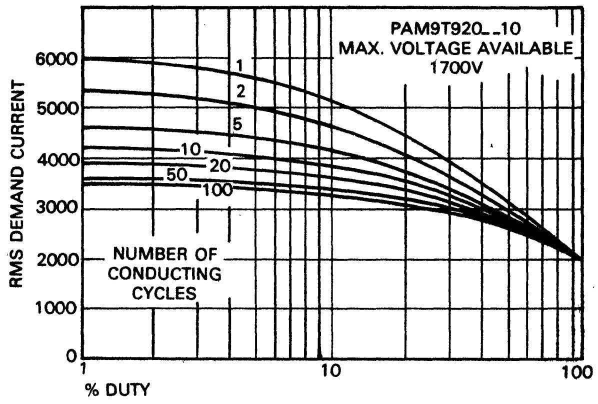


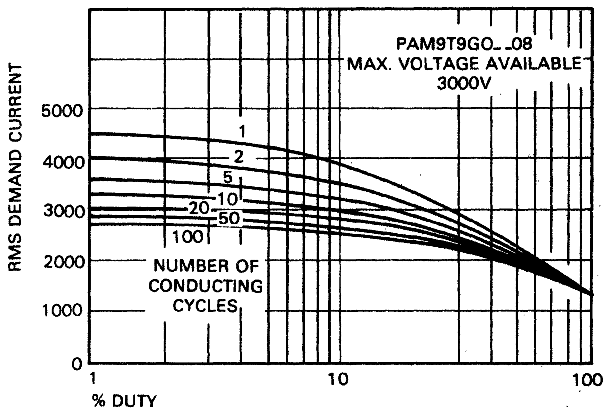


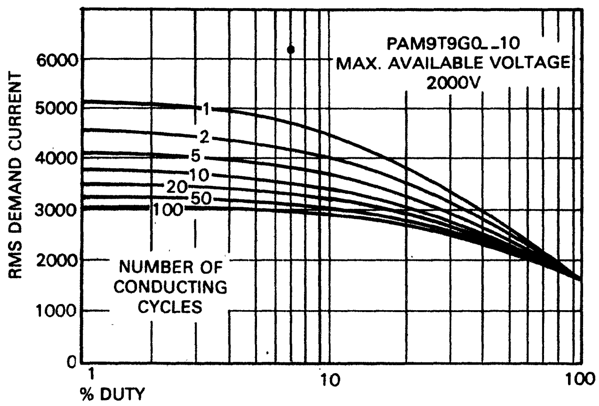


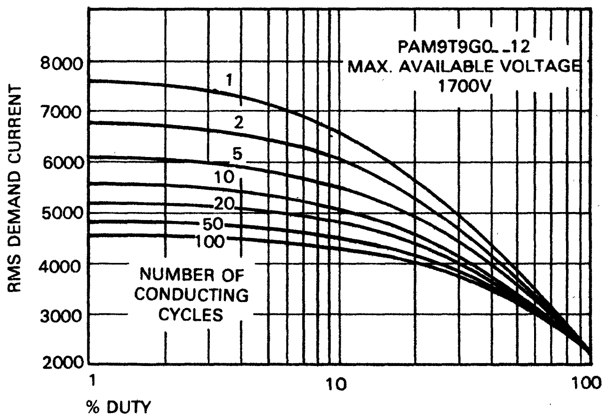
RMS DEMAND CURRENT, AMPS VS. PERCENT DUTY   TWATER = 40°C, 1.25 GPM

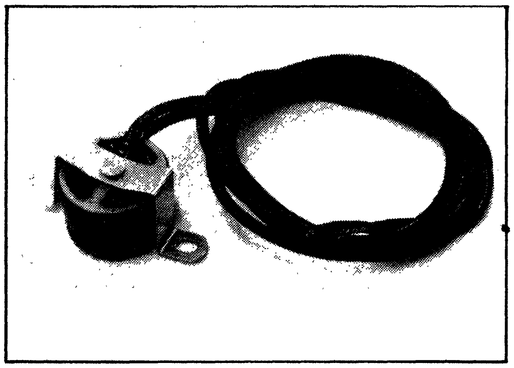











OPTIONAL THERMOSTAT

Electrical Data

Disc ASSEMBLIES Air and Liquid Cooled

RECTIFIER

ELEC	DEVICE TYPE	MAX. DESIGN VOLTAGE	SURGE (Amperes) 1 ∿	3 ∿	10 ∿	I²t (A² SEC.)
E-1	R620__30	1200V	5500	4300	3300	125,000
	R620__30	2000V				
	R620__30	3000V				
E-2	R620__40	1200V	6000	4700	3600	150,000
	R620__40	2000V				
E-3	R620__50	1200V	6500	5050	3900	175,000
E-4	R720__06	1200V	7000	5250	4350	204,000
	R720__06	2000V				
	R720__06	4000V				
E-5	R720__09	1200V	8500	6350	5300	301,000
	R720__09	2000V				
E-6	R720__12	1200V	12,500	9,400	7,800	650,700
E-7	R920__11	1200V	16,000	12,000	10,000	1,100,000
	R920__11	2000V				
	R920__11	3000V				
E-8	R920__16	1200V	21,500	16,000	13,300	1,925,000
	R920__16	2000V				
E-9	R920__20	1200V	30,000	22,000	18,500	3,700,000
E-10	R9G0__13	1200V	16,000	12,000	10,000	1,100,000
	R9G0__13	2000V				
	R9G0__13	3000V				
E-11	R9G0__18	1200V	21,500	16,000	13,300	1,925,000
	R9G0__18	2000V				
E-12	R9G0__22	1200V	30,000	22,000	18,500	3,700,000

SCR

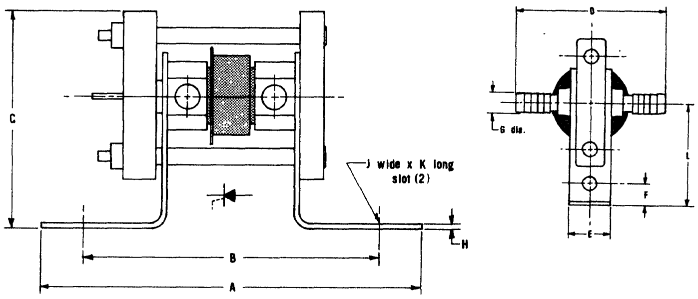
ELEC.	DEVICE TYPE	IGT (MA)	dv/dt* V/µs	di/dt** A/µs	SURGE (Amperes) 1 ∿	3 ∿	10 ∿	I²t A² SEC
E-13	T620__15	150	1000	800	3300	2400	2000	45,000
E-14	T620__20				4000	2900	2500	64,400
E-15	T620__30				5500	3900	3400	120,000
E-16	T625__25	150	1000	800	2800	2000	1700	32,500
E-17	T625__30				3600	2600	2250	54,000
E-18	T625__40				5000	3500	3000	100,000
E-19	T720__35	150	1000	800	7000	5040	4340	205,000
E-20	T720__45				8400	6050	5200	295,000
E-21	T720__55				10,000	7200	6200	416,000
E-22	T920__06	200	1000	800	13,000	9750	8000	700,000
E-23	T920__07				15,000	10,800	9000	937,000
E-24	T920__08				17,000	12,200	10,200	1,203,000
E-25	T920__09				25,000	18,700	15,400	2,600,000
E-26	T920__10				27,000	20,200	16,700	3,040,000
E-27	T9G0__08	200	1000	800	13,000	9750	8000	700,000
E-28	T9G0__10				17,000	12,200	10,200	1,203,000
E-29	T9G0__12				27,000	20,200	16,700	3,040,000
E-30	TA20__12	200	1000	800	30,000	25,000	18,000	3.75×10^6
E-31	TA20__14				35,000	30,000	22,000	5.11×10^6

↑ Refer to product data sections for complete device information.

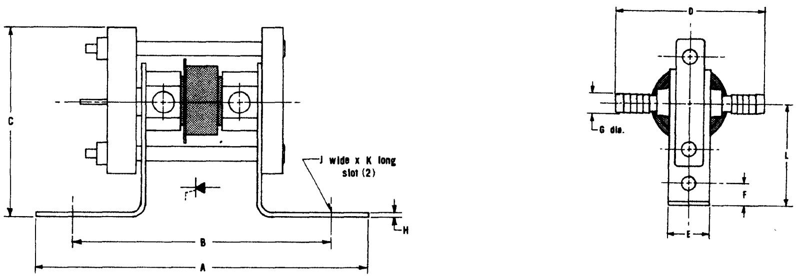
*Typical — 300 V/µs minimum.
**Non-repetitive value

Disc
ASSEMBLIES
Liquid Cooled

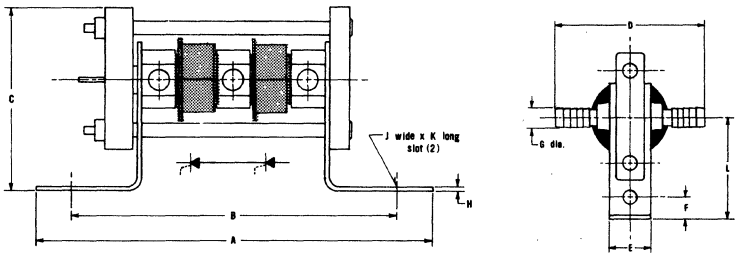
Mechanical Data



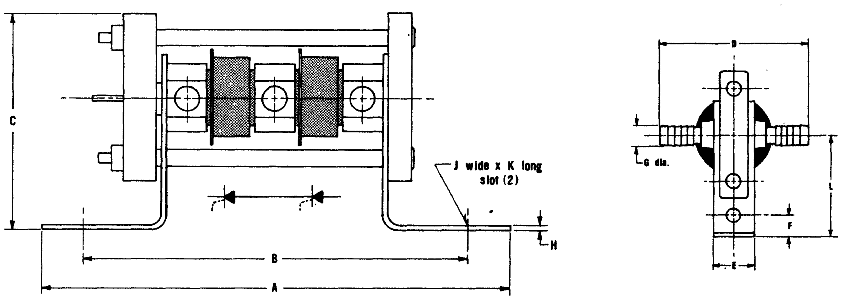
Dimension	M-1 W-6 inches	M-1 W-6 mm	M-4 W-7 inches	M-4 W-7 mm
A	8.25 max.	209.6 max.	8.75 max.	222.3 max.
B	6.12	155.4	6 62	168.2
C	5 06 max.	128.5 max	5 06 max	128 5 max
D	5.00 max.	127.0 max.	5 00 max	127 0 max
E	1.25	31.7	1 25	31 7
F	.62	15.7	62	15 7
G	.53 ref.	13.5 ref	53 ref.	13 5 ref.
H	.125	3.17	125	3 17
J	.44	11.10	44	11 10
K	1.31	33.32	1 31	33.32
L	3 00 ref	76.2 ref.	3.00 ref.	76.2 ref
approx. wt.	lbs	kgs	lbs	kgs
	2 75	1.25	3.25	1 48



Dimension	M-7 W-9 inches	M-7 W-9 mm
A	9.11 max.	231 4 max
B	7 05	179 1
C	6 52 max.	165 6 max
D	5.38 max.	136 7 max
E	2 00	50 8
F	88	22.4
G	53 ref.	13.5 ref
H	.250	6 35
J	.44	11.10
K	1 53	38 89
L	4.00 ref	101.6 ref
approx. wt.	lbs	kgs
	7 00	3 18

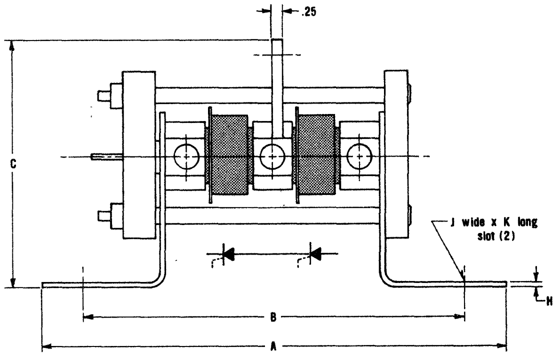


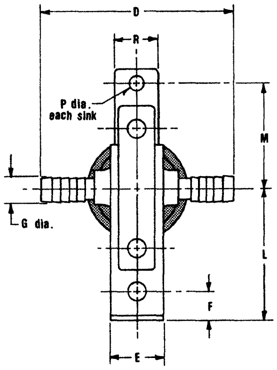
Dimension	M-2 W-6 inches	M-2 W-6 mm	M-5 W-7 inches	M-5 W-7 mm
A	9.70 max.	246.4 max.	10 61 max	269.5 max
B	7.54	191.5	8 59	218 2
C	5.06 max	128.5 max.	5 06 max.	128.5 max.
D	5.00 max.	127.0 max.	5 00 max	127 0 max.
E	1.25	31.8	1 25	31 8
F	.62	15.7	62	15 7
G	53 ref.	13.5 ref	53 ref	13.5 ref
H	.125	3.18	125	3 18
J	.44	11.10	44	11 10
K	1.312	33.32	1.312	33 32
L	3.00 ref	76.2 ref	3 00	76.2 ref
approx. wt.	lbs	kgs	lbs	kgs
	3.25	1.48	4 25	1 93



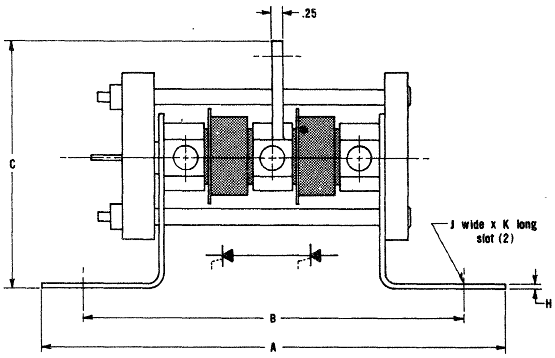
Dimension	M-8 W-9 inches	M-8 W-9 mm
A	11.06 max.	280.9 max.
B	9.00	228.6
C	6.52 max.	165.6 max.
D	5.38 max.	136.7 max.
E	2.00	50.8
F	.88	22.4
G	.53 ref.	13.5
H	.250	6.35
J	.44	11.10
K	1.531	38.89
L	4.00 ref.	101.6 ref.
approx. wt.	lbs	kgs
	8.75	3.98

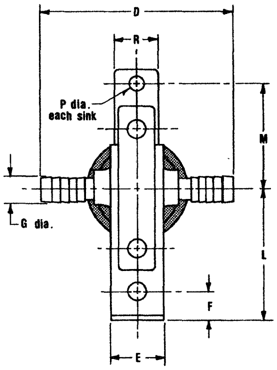
Disc ASSEMBLIES Liquid Cooled



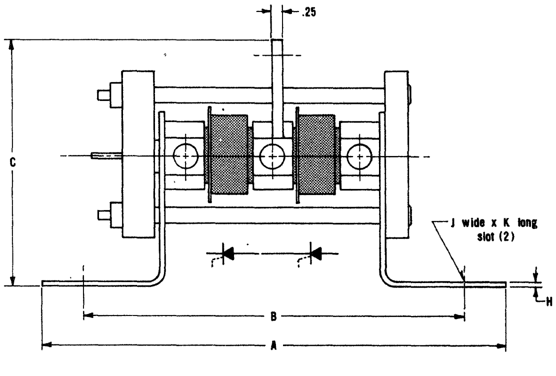


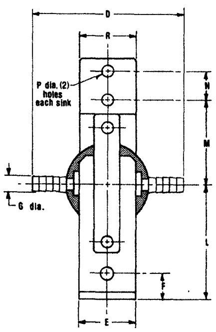
Dimension	M-3 W-6 inches	M-3 W-6 mm
A	9.70 max.	246.4 max.
B	7.54	191.5
C	5.88 max	149 4 max.
D	5.00 max.	127.0 max.
E	1.25	31.8
F	.62	15.7
G	.53	13.56 ref.
H	.125	3.18
J	.44	11.10
K	1.312	33.32
L	3 00 ref.	76.2 ref.
M	2.38	60.5
N		
P	.375	9 53
R	1.00	25.4
approx. wt.	lbs 3 25	kgs 1.50





Dimension	M-6 W-7 inches	M-6 W-7 mm
A	10 61 max	269.5 max.
B	8 6	218.2
C	5.88 max.	149.4 max
D	5.00 max.	127.0 max.
E	1 25	31.8
F	.62	15.7
G	.53 ref.	13.56 ref.
H	.125	3.18
J	.44	11 10
K	1 312	33 32
L	3.00 ref.	76.2 ref
M	2.38	60.5
N		
P	375	9.53
R	1.00	25.4
approx. wt.	lbs 7.00	kgs 3.17

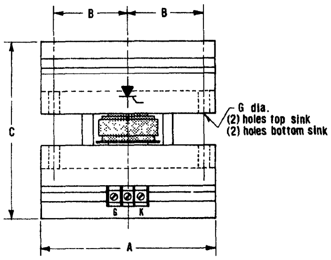


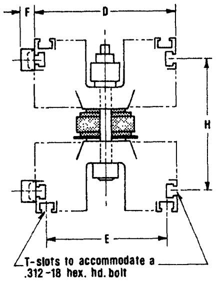


Dimension	M-9 W-9 inches	M-9 W-9 mm
A	11.06 max.	280.9 max.
B	9 00	228.6
C	8.56 max.	217.4 max.
D	5.38 max.	136 7 max.
E	2.00	50.8
F	.88	22.4
G	53 ref.	13.5 ref.
H	.250	6 35
J	.44	11.10
K	1.531	38.89
L	4.00 ref.	101 6 ref.
M	3.00	76 2
N	1.00	25.4
P	.375	9.53
R	2.00	50 8
approx. wt.	lbs 9.25	kgs 4.22

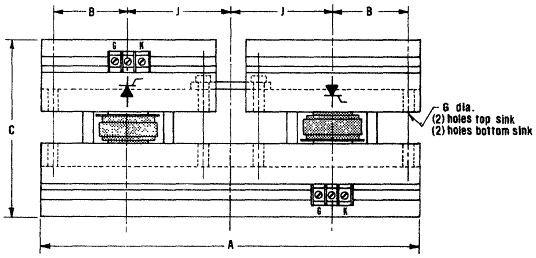
Disc ASSEMBLIES Air Cooled

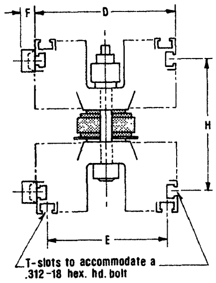
Mechanical Data



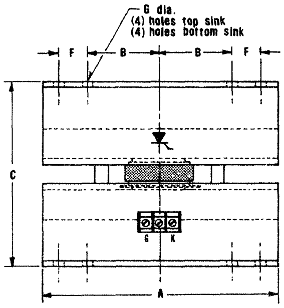


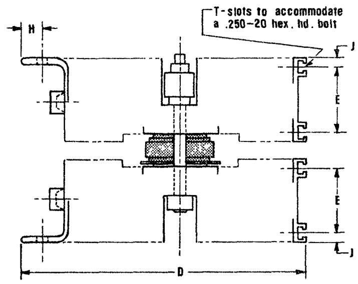
Dimension	M-10 A-6		M-12 A-7	
	inches	mm	inches	mm
A	6.125 max	155.78 max.	6 125 max	155.78 max
B	2.56	65.0	2 56	65 0
C	5 75 max	146 0 max	6 25 max	158 8 max
D	5 125 max	130 18 max	5 125 max	130 18 max
E	4 25 ref	107.9 ref	4 25 ref	107 9 ref.
F	50 ref	12.7 ref	50 ref	12 7 ref
G	344	8 74	344	8 74
H	4 02 ref.	102 1 ref.	4 52 ref.	114 8 ref
approx. wt.	lbs	kgs	lbs	kgs
	≃ 7 0	≃ 3.2	≃ 7.5	≃ 3 4
cross sect. area per sink	sq. inches	sq. cm	sq. inches	sq cm
	≃ 6 2	≃ 40 0	≃ 6 2	≃ 40 0



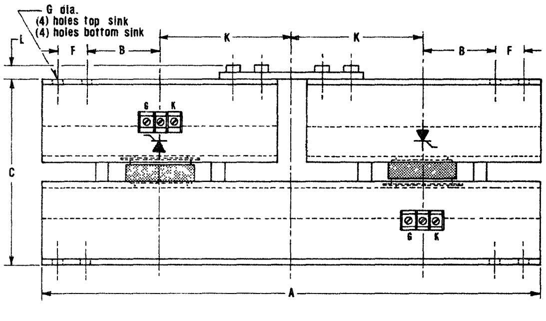


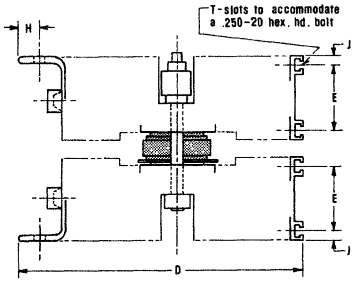
Dimension	M-11 A-6		M-13 A-7	
	inches	mm	inches	mm
A	13 125 max	333 4	13 125	333 4
B	2 56	65.0	2 56	65 0
C	5.75 max.	146 0 max	6 25 max	158 8 max
D	5 125 max.	130.18 max	5 125 max.	130 18 max
E	4.25 ref.	107.9 ref	4 25 ref	107 9 ref
F	50 ref.	12.7 ref.	.50 ref	12 7 ref.
G	344	8.75	.344	8 75
H	4.02 ref.	102 1	4.52 ref.	114 8
J	3 50 ref.	88 9	3.50 ref	88 9
approx. wt.	lbs	kgs	lbs	kgs
	14.75	6 7	15 75	7 1
cross sect. area per sink	sq. inches	sq. cm	sq. inches	sq. cm
	≃ 6.2	40.0	≃ 6.2	.40.0





Dimension	M-14 A-9	
	inches	mm
A	8.125 max.	206 38 max
B	2 50	63 5
C	6.44 max	163.6 max
D	9 938 max	252 43 max
E	2 25 ref	57.2 ref
F	1 00	25.4
G	375	9.53
H	75 ref	19.1 ref
J	315 ref	8 00 ref.
approx. wt.	lbs	kgs
	16.5	7 5
cross sect. area per sink	sq. inches	sq. cm
	≃10 5	67 7

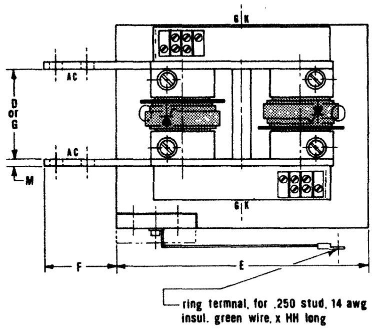


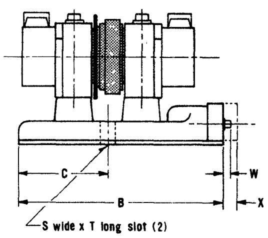


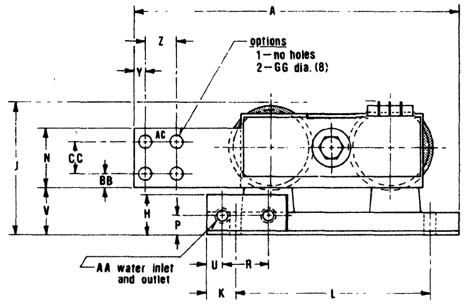
Dimension	M-15 A-9	
	inches	mm
A	17 125 max.	434.28 max
B	2 50	63.5
C	6 44 max.	163 6 max
D	9 938 max.	252 43 max
E	2 250 ref.	57 15 ref
F	1.00	25 4
G	.375	9.53
H	750 ref.	19 05 ref.
J	315 ref.	8 00 ref
K	4.50 ref	114.3 ref.
L	.578 ref.	14 68 ref
approx. wt.	lbs	kgs
	35 0	15.9
cross sect. area per sink	sq. inches	sq. cm
	≃10 5	67 7

MANIFOLD SWITCH

HS & VS ARRANGEMENT



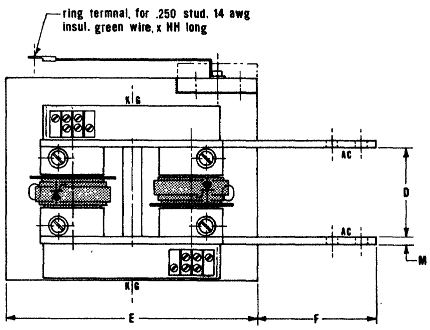


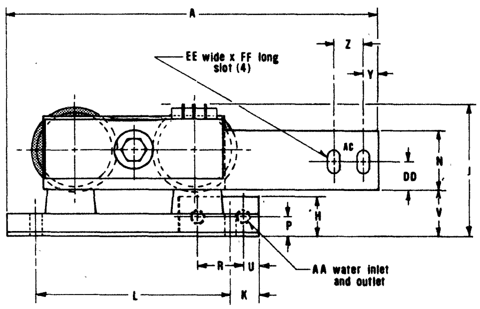


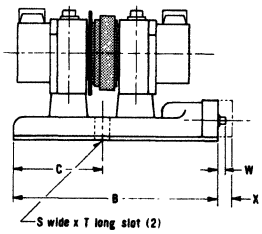
M-16

Dimension	HS & VS	
	inches	mm
A	10 94 ref.	277.9 ref.
B	6 88	174 8
C	3 00	76.2
D	3 00	76.2
E	8 50	215.9
F	2 44	62.0
G	3 25	82.6
H	1.38	35 1
J	4.50 max	114 3 max
K	1.00	25.4
L	6.50	165.1
M	.25	6.4
N	2 00	50 8
P	72	18 3
R	1 50	38 1
S	37	9 4
T	50	12.7
U	56	14 2
V	1 56	39 6
W	300 max	7.6 max
X	55 max	14 0 max
Y	38	9.7
Z	1 06	26 9
AA	¼ - 18 NPT	
BB	47	11.9
CC	1 06	26 9
DD		
EE		
FF		
GG	44	11 2
HH	8 50	215 9

HL & VL ARRANGEMENT



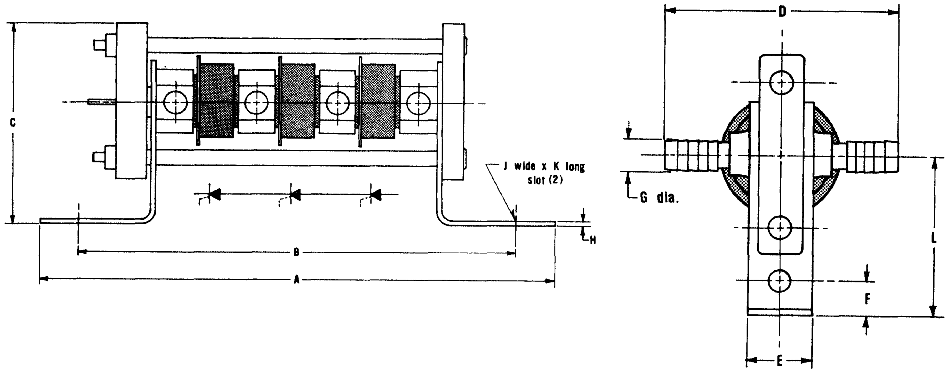




Dimension	HL & VL	
	inches	mm
A	12.50 ref	317.5 ref
B	6 88	174 8
C	3 00	76 2
D	3 00	76.2
E	8 50	215 9
F	4 00	101 6
G		
H	1 38	35 1
J	4.50 max	114.3 max.
K	1 00	25 4
L	6.50	165.1
M	25	6 4
N	2 00	50.8
P	.72	18.2
R	1.50	38.1
S	37	9.4
T	.50	12.7
U	56	14.2
V	1.56	39.6
W	300 max	7.6 max.
X	55 max	14.0 max.
Y	.50	12.7
Z	1.00	25.4
AA	¼ - 18 NPT	
BB		
CC		
DD	1.00	25.4
EE	.375	9.5
FF	.75	19.1
GG		
HH	8.50	215.9

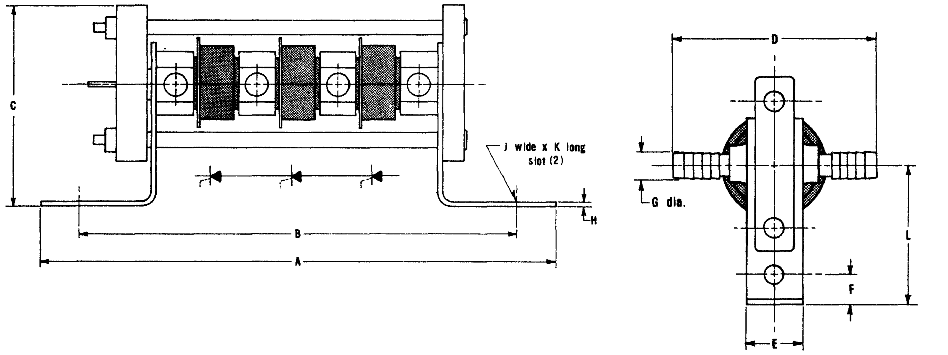
Disc ASSEMBLIES Liquid Cooled

Mechanical Data



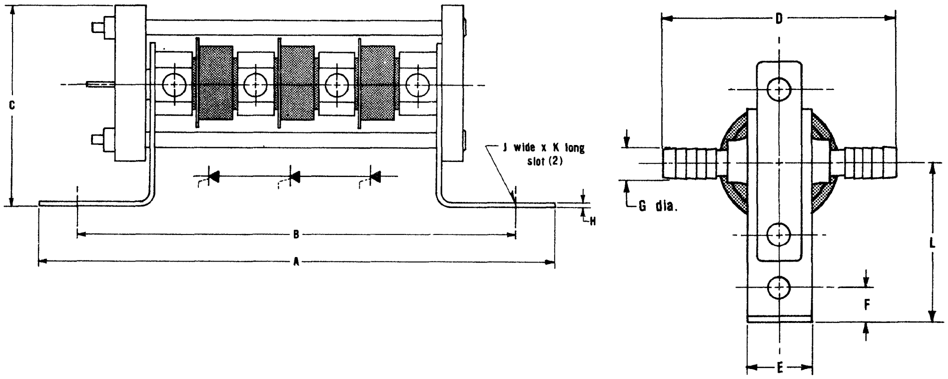
M-17

Dimension	W-8 inches	W-8 mm
A	11.15 max.	283.2 max.
B	8.98	228.1
C	5.06 max.	128.5 max.
D	5.00 max.	127.0 max.
E	1.25	31.8
F	.62	15.7
G	.53 ref.	13.5 ref.
H	.125	3.18
J	.44	11.10
K	1.312	33.32
L	3.00 ref.	76.2 ref.
approx. wt.	lbs 4.6	kgs 2.1



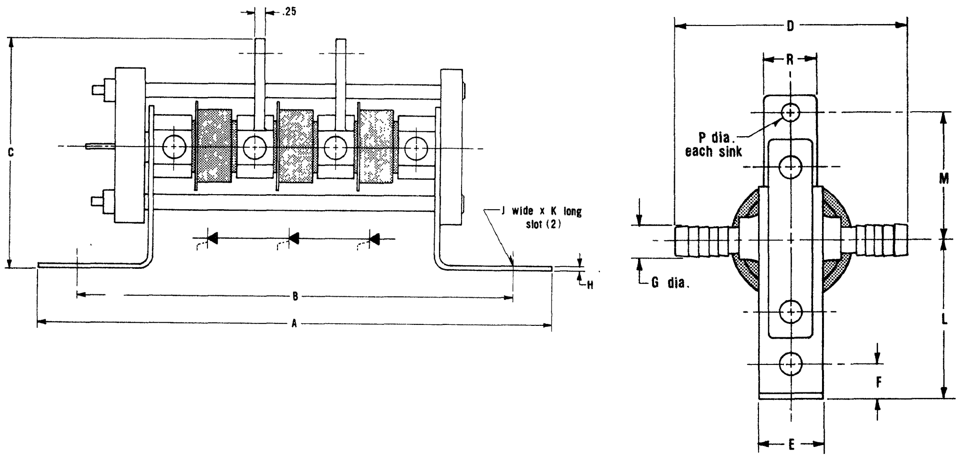
M-18

Dimension	W-7 inches	W-7 mm
A	12.55 max.	318.8 max.
B	10.54	267.7
C	5.06 max.	128.5 max.
D	5.00 max.	127.0 max.
E	1.25	31.8
F	.62	15.7
G	.53 ref.	13.5 ref.
H	.125	3.18
J	.44	11.10
K	1.312	33.32
L	3.00 ref.	76.20 ref.
approx. wt.	lbs 5.19	kgs 2.36



M-19

Dimension	W-9 inches	W-9 mm
A	13.02 max.	330.7 max.
B	10.95	278.1
C	6.52 max.	165.2 max.
D	5.38 max.	136.7 max.
E	2.00	50.8
F	.88	22.4
G	.53 ref.	13.5 ref.
H	.250	6.35
J	.44	11.10
K	1.531	38.89
L	4.00 ref.	101.6 ref.
approx. wt.	lbs 12.3	kgs 5.51

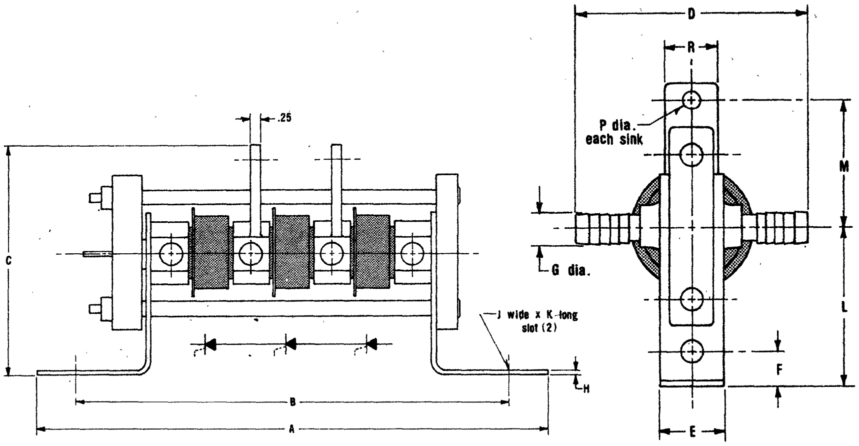


M-20

Dimension	W-6 inches	W-6 mm
A	11.12 max.	282.4 max.
B	9.06	230.1
C	5.88 max.	149.4 max.
D	5.00 max.	127.0 max.
E	1.25	31.8
F	.62	15.7
G	.53 ref.	13.46 ref.
H	.125	3.18
J	.44	11.10
K	1.312	33.32
L	3.00 ref.	76.2 ref.
M	2.38	60.5
N		
P	.375	9.53
R	1.00	25.4
approx. wt.	lbs 4.91	kgs 2.23

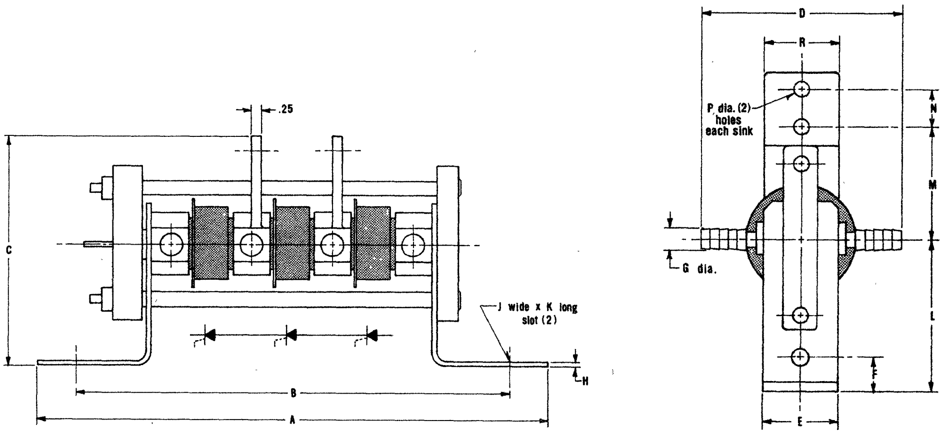
Mechanical Data

Disc ASSEMBLIES Liquid Cooled



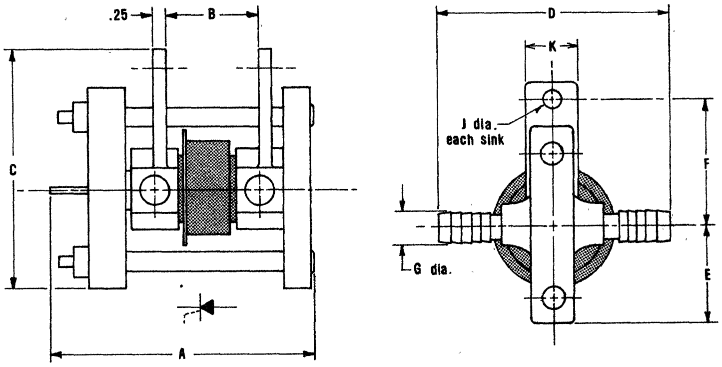
M-21

Dimension	W-7	
	inches	mm
A	12.62 max.	320.5 max.
B	10.56	268.2
C	5.88 max.	149.4 max.
D	5.00 max.	127.0 max.
E	1.25	31.85
F	.62	15.7
G	.53 ref.	13.46 ref.
H	.125	3.18
J	.44	11.10
K	1.312	33.32
L	3.00 ref.	76.2 ref.
M	2.38	60.5
N		
P	.375	9.53
R	1.00	25.4
approx. wt.	lbs	kgs
	9.00	4.09



M-22

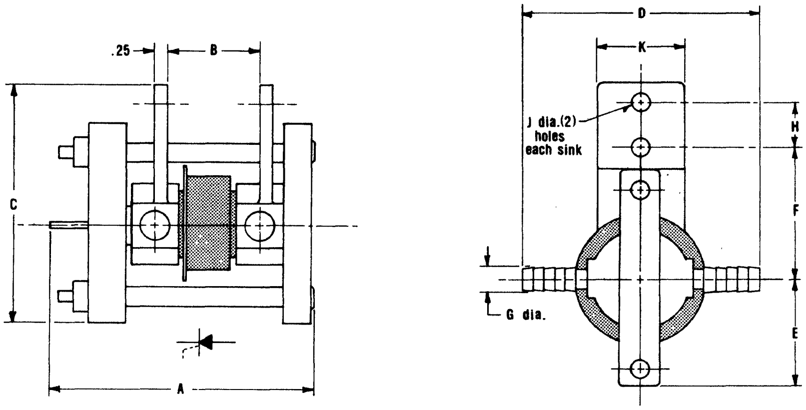
Dimension	W-9	
	inches	mm
A	13.03 max.	331.0 max.
B	10.94	277.9
C	8.56 max.	217.4 max.
D	5.38 max.	136.7 max.
E	2.00	50.8
F	.88	22.4
G	.53 ref.	13.46 ref.
H	.250	6.35
J	.44	11.10
K	1.531	38.89
L	4.00 ref.	101.6 ref.
M	3.00	76.2
N	1.00	25.4
P	.375	9.53
R	2.00	50.8
approx. wt.	lbs	kgs
	13.25	6.02



Dimension	M-23 W-6		M-24 W-7	
	inches	mm	inches	mm
A	5.00 max.	127.0 max.	5.50 max.	139.7 max.
B	1.20	30.5	1.70	43.2
C	4.95 max.	125.7 max.	4.95 max.	125.7 max.
D	5.00 max.	127.0 max.	5.00 max.	127.0 max.
E	1.92 ref.	48.8 ref.	1.92 ref.	48.8 ref.
F	2.38	60.5	2.38	60.5
G	.53 ref.	13.5 ref.	.53 ref.	13.5 ref.
H				
J	.38	9.53	.38	9.53
K	1.00	25.4	1.00	25.4
approx. wt.	lbs	kgs	lbs	kgs
	3.0	1.36	7.0	3.18

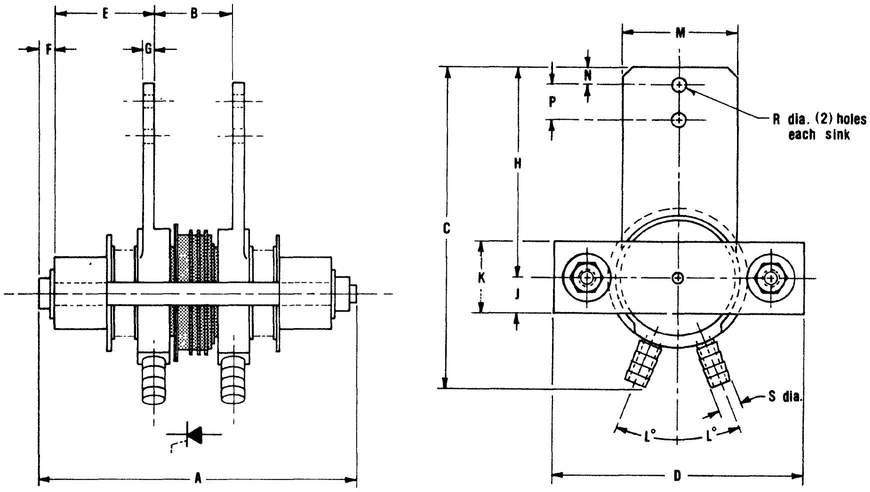
Disc ASSEMBLIES Liquid Cooled

Mechanical Data



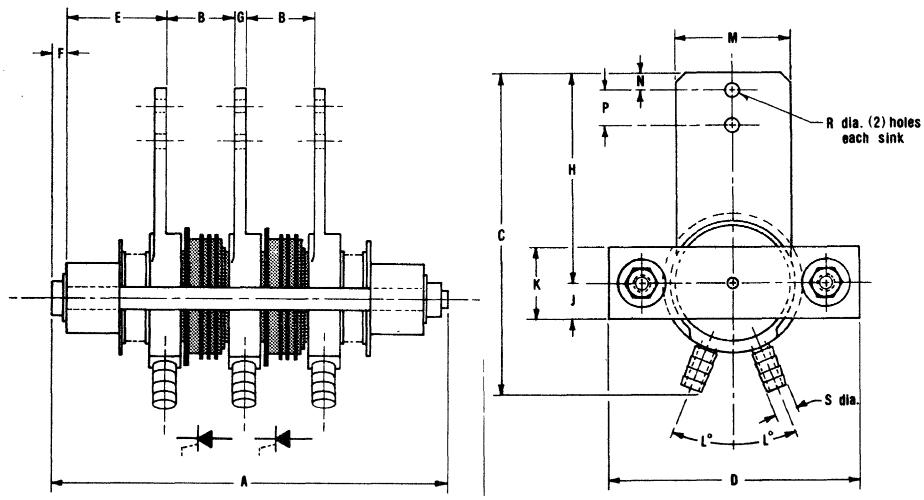
M-25

Dimension	W-9	
	Inches	mm
A	5.91 max.	150.1 max.
B	1.70	43.2
C	7.16 max.	181.9 max.
D	5.38 max.	136.7 max.
E	2.41 ref.	61.2 ref.
F	3.00	76.2
G	.53 ref.	13.5 ref.
H	1.00	25.40
J	.38	9.53
K	2.00	50.8
approx. wt.	lbs	kgs
	9.25	4.22



M-26

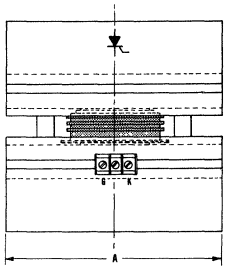
Dimension	W-A	
	inches	mm
A	9.25 max.	235.0 max.
B	2.18	55 4
C	9.31 max.	236.5 max.
D	7.06 max.	179.3 max
E	2.82	71 6
F	.42 ref.	10 7 ref
G	.31	7.9
H	6.00	152.4
J	1.00	25.4
K	2.00	50.8
L	22°	22°
M	3.25	82.6
N	.50	12.7
P	1.00	25.4
R	375	9.53
S	.62 ref.	15.7 ref.
approx. wt.	lbs	kgs
	14.94	6.79

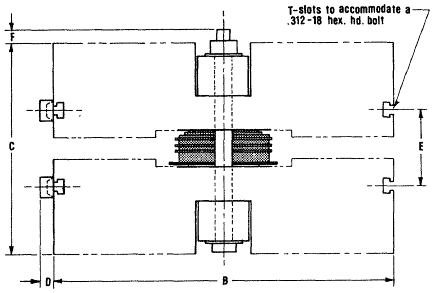


M-27

Dimension	W-A	
	inches	mm
A	11.50 max.	292.1 max.
B	1.87	47.5
C	9.31 max.	236.5 max.
D	7.06 max.	179.3 max.
E	2.82	71.6
F	.42 ref.	10.7 ref.
G	.31	7.9
H	6.00	152.4
J	1.00	25.4
K	2.00	50.8
L	22°	22°
M	3.25	82.6
N	.50	12.7
P	1.00	25.4
R	.375	9.53
S	.62 ref.	15.7 ref.
approx. wt.	lbs	kgs
	20.75	9.43

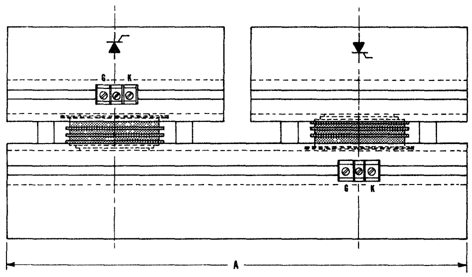
Disc ASSEMBLIES Air Cooled

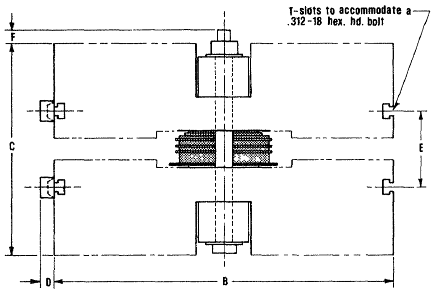




M-28

Dimension	A-A	
	inches	mm
A	10 12 max	257.1 max.
B	12 69 max	322.3 max.
C	7 84 max.	199.1 max.
D	50 ref	12.7 ref.
E	2.78	70.6
F	**.578**	**14.68**
approx. wt.	lbs	kgs
	≃ 44 6	≃ 20.2
cross sect. area per sink	sq. inches	sq. cm
	≃ 18 29	≃ 118.0





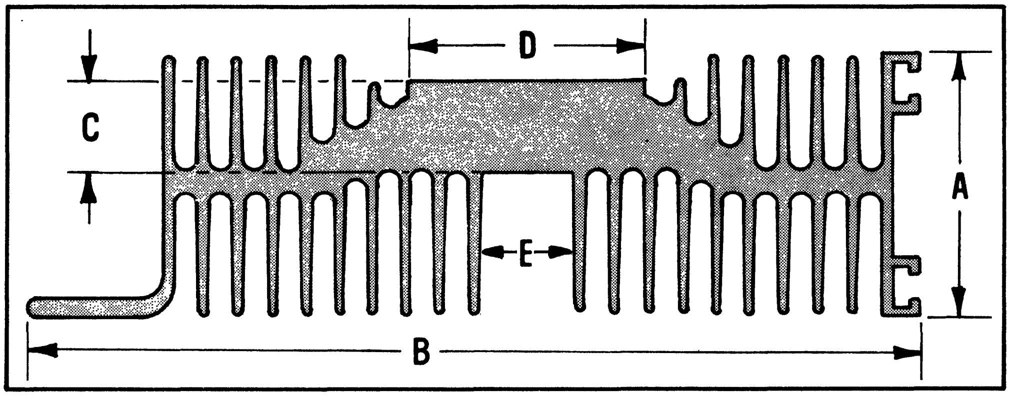
M-29

Dimension	A-A	
	inches	mm
A	21 12 max.	536 4 max.
B	12 69 max	322.3 max.
C	7.84 max	199.1 max.
D	50 ref	12.7 ref.
E	2 78	70.6
F	**.578**	**14.68**
approx. wt.	lbs	kgs
	≃ 91 0	41.3
cross sect. area per sink	sq. inches	sq. cm
	18.29	118.0

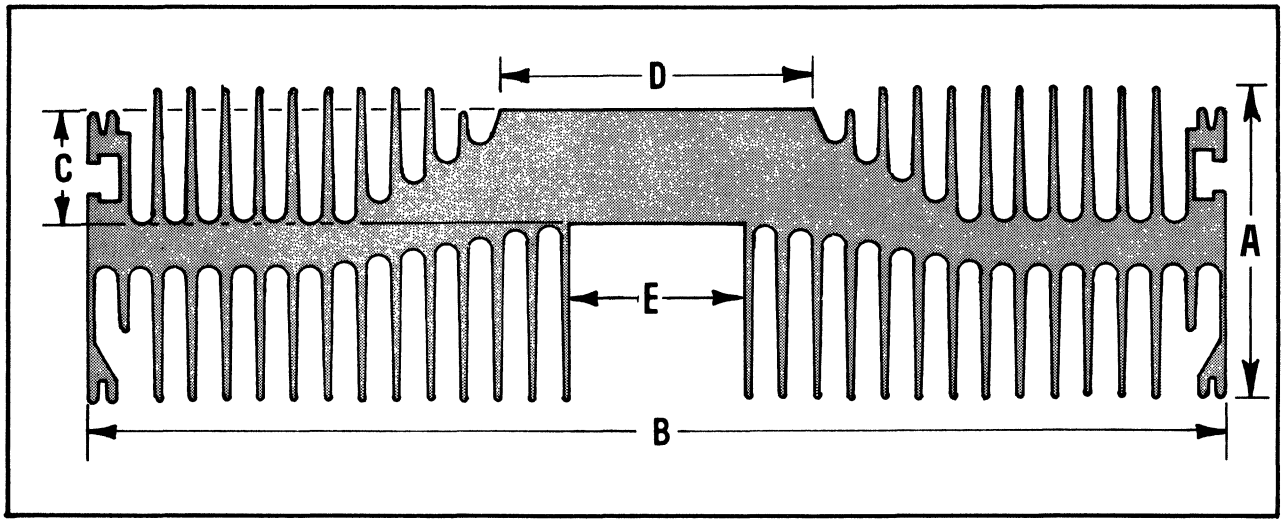
DISC ASSEMBLIES
Sinks and Kits

- One piece aluminum extrusion
- Cooling for 50 mm-75mm disc devices
- A9 available in 3 or 6 foot lengths
- AA available in 7 foot lengths
- Cut to length sections also available

EXTRUSION NO. A9, ½ SCALE



EXTRUSION NO. AA, ½ SCALE



A9			INFORMATION
DIMENSION	IN	MM	
A	2.85	72	Material 6101-T1
B	9.80	249	Lbs./Foot 11.6
C	1.00	24	Thermal Impedance At 1000 LFM
D	2.85	72	.034°C/W
E	1.00 Min.	24	In²/in 100

AA			INFORMATION
Dimension	In	MM	
A	3.5	89	Material 6101-T1
B	12.6	319	Lbs./Foot 21.9
C	1.25	32	Thermal Impedance C.F.
D	3.5	89	
E	1.95 Min.	50	In²/in 165

DISC ASSEMBLIES
Sinks and Kits

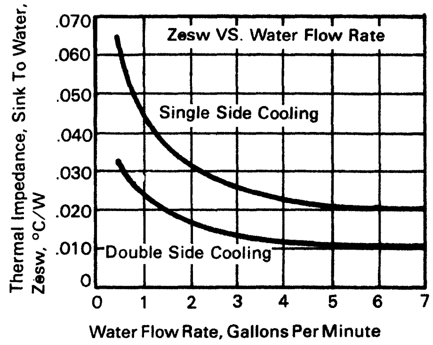
- Fully rated and proven designs
- Includes all necessary hardware for mounting, clamping
- Machine finished mounting surfaces
- Gate terminals provided with air cooled designs
- Complete thermal characteristic curves provided
- Clamps/sinks optimized for each device package

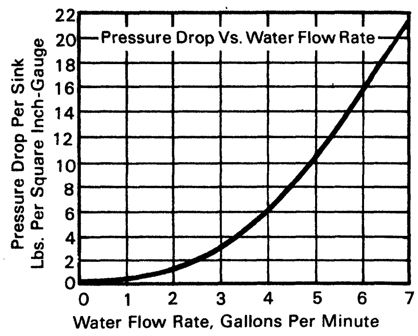
C-F — Consult Factory

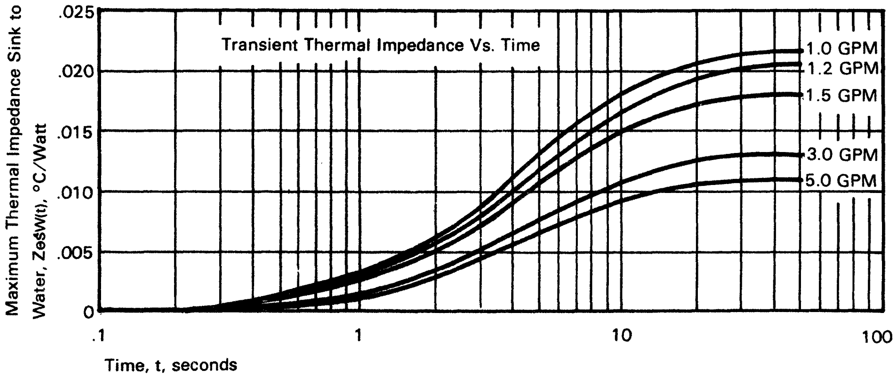
KIT NUMBER	LIQUID COOLED KIT	MOUNTING DEVICE OUTLINE	MECHANICAL DATA	THERMAL DATA
PRW6M010KT	Single Rectifier	R62	M1	
PRW6M230KT	Single Rectifer	R62	M23	
PTW6M010KT	Single SCR	T62	M1	
PTW6M230KT	Single SCr	T62	M23	T-1
PAW6M030KT	AC Switch	R62/T62	M3	
PDW6M030KT	Doubler - Bridge Leg	R62/T62	M3	
PSW6M020KT	Series - two	R62/T62	M2	
PSW6M170KT	Series - three	R62/T62	M17	
PRW7M040KT	Single Rectifier	R72	M4	
PRW7M240KT	Single Rectifier	R72	M24	
PTW7M040KT	Single - SCR	T72	M4	
PTW7M240KT	Single -SCR	T72	M24	T-2
PAW7M060KT	AC Switch external connection required	R72/T72	M6	
PDW7M060KT	Doubler - Bridge Leg	R72/T72	M6	
PSW7M050KT	Series - two	R72/T72	M5	
PSW7M180KT	Series - three	R72/T72	M18	
PRW9M070KT	Single Rectifier	R92	M7	
PRW9M250KT	Single Rectifier	R92	M25	
PTW9M070KT	Single SCR	T92	M7	
PTW9M250KT	Single SCR	T92	M25	
PAW9M090KT	AC Switch external Connection Required	R92/T92	M9	T-3
PDW9M090KT	Doubler - Bridge Leg	R92/T92	M9	
PSW9M080KT	Series - two	R92/T92	M8	
PSW9M190KT	Series - three	R92/T92	M19	
PTWAM260KT	Single SCR	TA2	M26	
PAWAM270KT	AC Switch External Connection Required	TA2	M27	C-F
PDWAM270KT	Doubler - Bridge Leg	TA2	M27	
PSWAM__KT	Series, Contact Factory	TA2		

KIT NUMBER	AIR COOLED KITS	MOUNTING DEVICE OUTLINE	MECHANICAL DATA	THERMAL DATA
PRA6M100KT	Single Rectifier	R62	M10	
PTA6M100KT	Single SCR	T62	M10	T-4
PAA6M110KT	AC Switch	R62/T62	M11	
PDA6M110KT	Doubler-Bridge Leg	R62/T62	M11	
PRA7M120KT	Single Rectifier	R72	M12	
PTA7M120KT	Single SCR	T72	M12	T-4
PAA7M130KT	AC Switch	R72/T72	M13	
PDA7M130KT	Doubler-Bridge Leg	R72/T72	M13	
PRA9M140KT	Single Rectifier	R92	M14	
PTA9M140KT	Single SCR	T92	M14	T-5
PAA9M150KT	AC Switch	R92/T92	M15	
PDA9M150KT	Doubler-Bridge Leg	R92/T92	M15	
PRAAM280KT	Single Rectifier	----	M28	
PTAAM280KT	Single SCR	TA2	M28	
PAAAM290KT	AC Switch	TA2	M29	
PDAAM290KT	Doubler-Bridge Leg	TA2	M29	CF

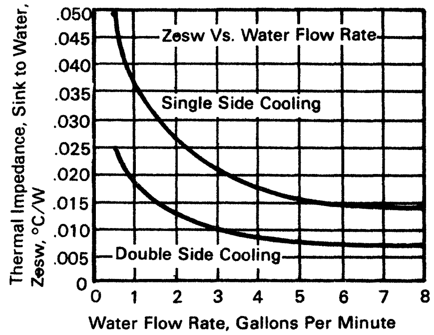
T-1, T-2, W6 AND W7 SINKS

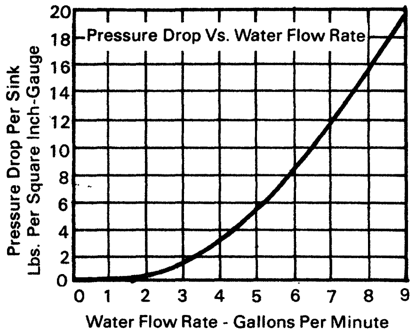


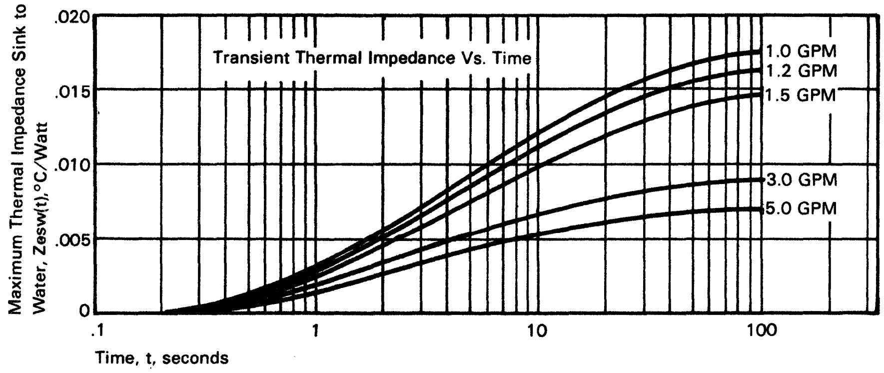




T-3, W9 SINK

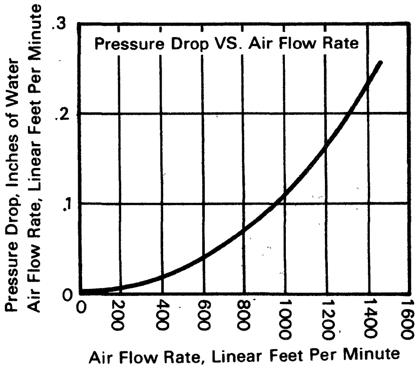


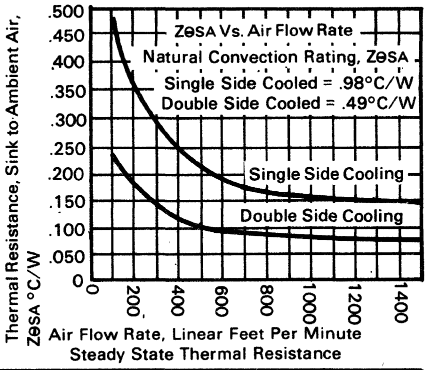


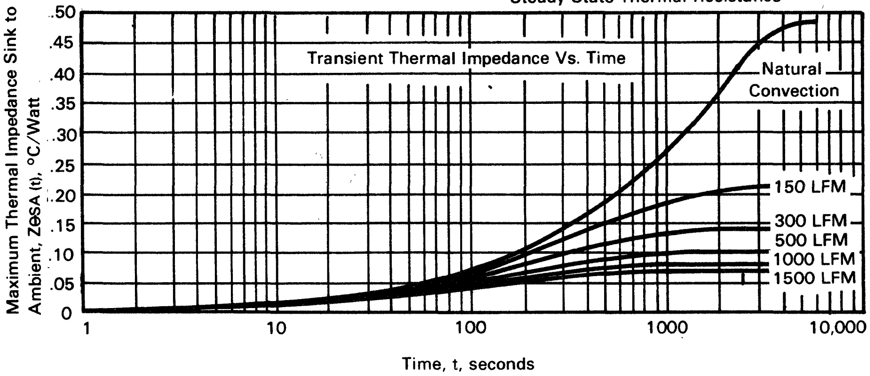


Disc ASSEMBLIES Air Cooled

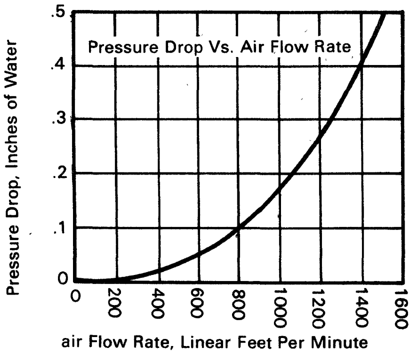
T-4, A6 AND A7 SINKS

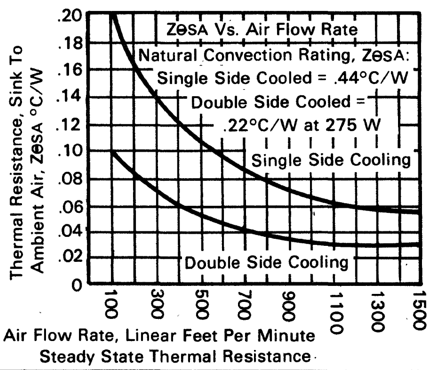


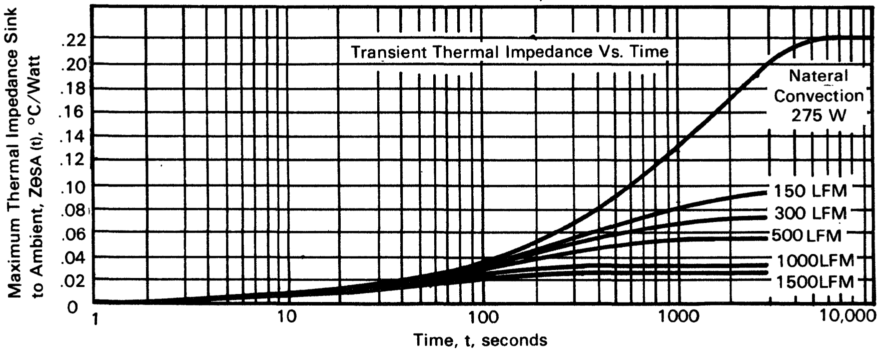




T-5, A9 SINK







High Voltage Stacks, Rectifier ASSEMBLIES
Channel Design

Features and Benefits
- Fully compensated modules for high reliability
- All terminations supplied for ease of installation
- Eight standard modules for wide range of current capability
- Vari-length channels for Package standardization
- High density packaging for compact designs
- Ratings for oil and air cooling
- Internal wiring available for complex circuit configurations
- Increased ratings by seriesing and/or paralleling individual channels
- Expert application assistance
- Special custom designs available on request

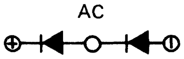
Applications
- RF generators
- Radio and TV transmitters
- Radar modulators
- Industrial precipitators
- Fusion and high voltage research
- Dielectric heating
- Voltage multipliers
- Electron Beam Welding

Standard Available Circuit Configurations

SH1

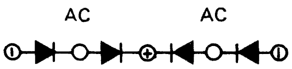
Half Wave (Single Leg)

SD1



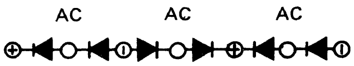
Doubler (Two Legs)

SB5

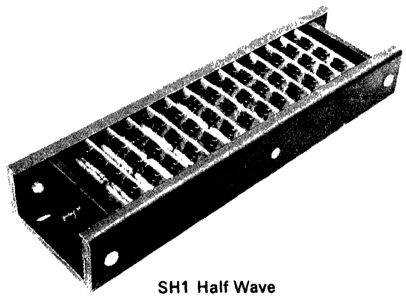


Single Phase

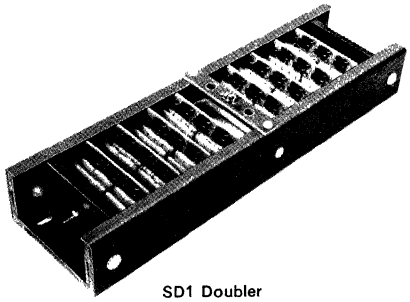
SE5



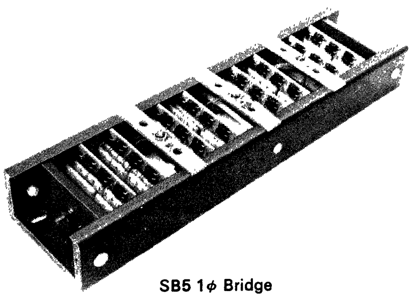
Three Phase



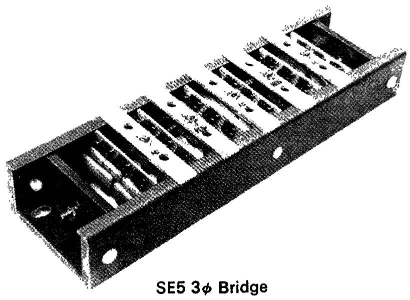
SH1 Half Wave



SD1 Doubler

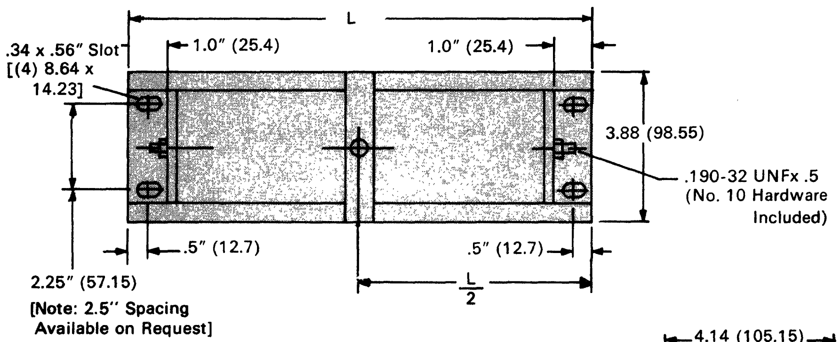


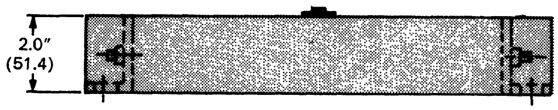
SB5 1φ Bridge

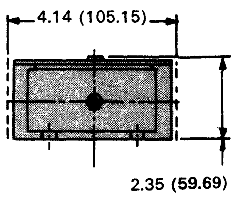


SE5 3φ Bridge

Dimensions in Inches (Millimeters)







*Obtain the Channel Length L From Table III Using the Channel Number (11th and 12th Digits of Product Description Number)

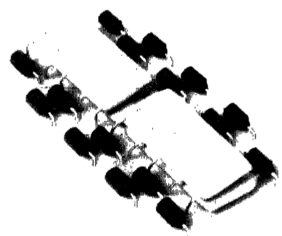
High Voltage Stacks, Rectifier
ASSEMBLIES
Channel Design

ASSEMBLIES

These modules, consisting of silicon diodes and compensating network, provide the optimum in steady state and transient voltage division. The design of the stacks provides for cooling by free convection air, forced convection air, or oil.

Design Modules

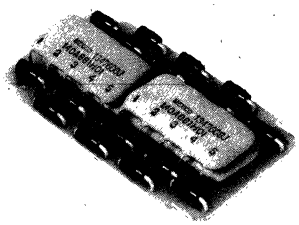
2A01



1.5 Amp Lead Mount		
Cells/Module	16	
Volts/Cell		
Voltage/Code	.7Kv	P
	1.0Kv	Z*
Surge 60Hz	50A	1 ~
	34A	3 ~
	22A	10 ~

*Oil Only

3A03

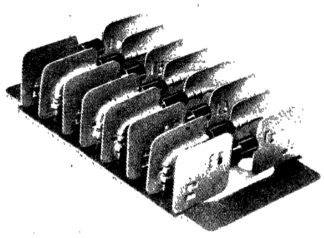


3.0 Amp Lead Mount		
Cells/Module	16	
Volts/Cell		
Voltage/Code	.7Kv	P
	1.0Kv	Z*
Surge 60Hz	200A	1 ~
	138A	3 ~
	90A	10 ~

*Oil Only

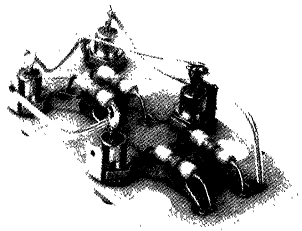
4A05

* *



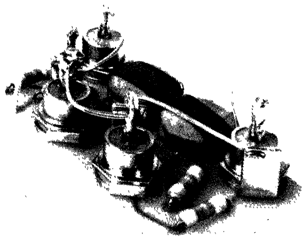
3.0 Amp Lead Mount		
Cells/Module	8	
Volts/Cell		
Voltage/Code	.7Kv	P
	1.0Kv	Z
Surge 60Hz	200A	1 ~
	138A	3 ~
	90A	10 ~

5A09



12 Amp DO-4 Stud Mount		
Cells/Module	4	
Volts/Cell	.6Kv	M
Voltage/Code	.8Kv	S
	1.0Kv	Z
Surge 60Hz	240A	1 ~
	170A	3 ~
	105A	10 ~

6A14

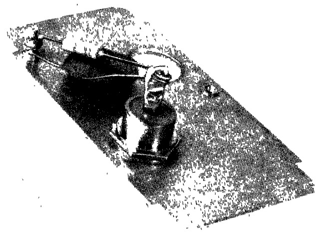


60 Amp, DO-5 Stud		
Cells/Module	4	
Volts/Cell	.6Kv	M
Voltage/Code	.8Kv	S
	1.0Kv	Z
Surge 60Hz	1000A	1 ~
	815A	3 ~
	615A	10 ~

7A12

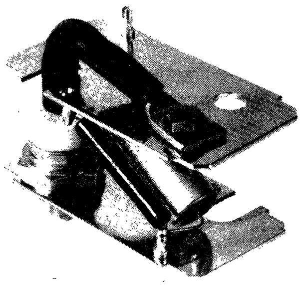
12 Amp, DO-4 Stud		
Cells/Module	1	
Volts/Cell	.6Kv	M
Voltage/Code	.8Kv	S
	1.0Kv	Z
Surge 60Hz	240A	1 ~
	170A	3 ~
	105A	10 ~

8A36



60 Amp, DO-5 Stud		
Cells/Module	1	
Volts/Cell	.6Kv	M
Voltage/Code	.8Kv	S
	1.0Kv	Z
Surge 60Hz	1000A	1 ~
	815A	3 ~
	615A	10 ~

9B11



150 Amp, DO-8 Stud		
Cells/Module	1	
Volts/Cell	.6Kv	M
Voltage/Code	.8Kv	S
	1.0Kv	Z
Surge 60Hz	3000A	1 ~
	2375A	3 ~
	1750A	10 ~

Notes:
- Mounting: Any position for oil cooling or forced convection; horizontal for free air convection.
- Max. ambient operating temperature for free air convection is based upon compensating network maximum ratings.
- Storage temperature: —55°C to 100°C.
- Surge ratings are per JEDEC and for non-repetitive applications. For repetitive faults, consult Westinghouse.
- JAN/military qualified Rectifiers are available on 9B11 modules.

* * This Design is also available with 6A Lead Mount Rectifiers — See next section.

High Voltage Stacks, Rectifier ASSEMBLIES
Channel Design

Module Electrical Characteristics Current Output vs Ambient Temperature/Max. PRV

Cooling Conditions: Air Flow	Temp. °C	2A01	3A03	4A05	5A09	6A14	7A12	8A36	9B11
Natural Convection	40	.65	.8	2.6	2.4	4.0	12.0	15.0	33.0
	50	.6	.65	2.4	2.25	3.75	11.5	12.0	32.0
	60	.5	.55	1.75	2.15	3.5	7.2	8.0	30.0
150 LFM	40	.9	1.1	3.2	4.2	6.8	12.0	22.0	47.0
	50	.83	1.0	3.0	3.9	6.3	12.0	20.8	44.0
	60	.76	0.9	2.8	3.6	5.8	12.0	19.3	41.0
300 LFM	40	1.1	1.35	3.7	5.6	8.8	12.0	28.5	69.0
	50	1.0	1.25	3.5	5.15	8.1	12.0	27.0	64.0
	60	0.9	1.15	3.3	4.75	7.4	12.0	25.0	60.0
500 LFM	40	1.3	2.3	4.1	7.2	10.8	12.0	32.0	82.0
	50	1.2	2.15	3.9	6.65	9.9	12.0	30.0	78.0
	60	1.1	2.0	3.65	6.1	9.1	12.0	28.0	73.0
1000 LFM	40	1.5	2.7	4.5	8.8	14.0	12.0	36.5	108.0
	50	1.5	2.5	4.2	8.3	13.0	12.0	35.0	101.0
	60	1.35	2.3	3.8	7.8	12.0	12.0	33.0	96.0
Oil	40	1.5	3.0	5.0	10.3	19.5	12.0	36.5	108.0
	60	1.5	3.0	5.0	8.4	15.7	12.0	35.0	96.0
	85	1.1	1.8	3.6	5.8	11.0	12.0	28.0	80.0
Maximum Voltage Rating Per Module PRV (Air or Oil)		11.2Kv (16.0Kv Oil Only)	11.2Kv (16.0Kv Oil Only)	5.6Kv 8.0Kv	2.4Kv 3.2Kv 4.0Kv	2.4Kv 3.2Kv 4.0Kv	.6Kv .8Kv 1.0Kv	.6Kv .8Kv 1.0Kv	.6Kv .8Kv 1.0Kv

Circuit

SH1

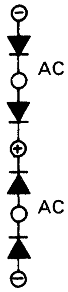

Half Wave (Single Leg)

SD1


Doubler (Two Legs)

Air Flow	Temp. °C	2A01	3A03	4A05	5A09	6A14	7A12	8A36	9B11
Natural Convection	40	1.3 Amps	1.6	5.2	4.8	8.0	24.0	30.0	66.0
	50	1.2	1.3	4.8	4.5	7.5	23.0	24.0	64.0
	60	1.0	1.1	3.5	4.3	7.0	14.4	16.0	60.0
150 LFM	40	1.8 Amps	2.2	6.4	8.4	13.6	24.0	44.0	94.0
	50	1.66	2.0	6.0	7.8	12.6	24.0	41.6	88.0
	60	1.52	1.8	5.6	7.2	11.6	24.0	38.6	82.0
300 LFM	40	2.2 Amps	2.7	7.4	11.2	17.6	24.0	57.0	138.0
	50	2.0	2.5	7.0	10.3	16.2	24.0	54.0	128.0
	60	1.8	2.3	6.6	9.5	14.8	24.0	50.0	120.0
500 LFM	40	2.6 Amps	4.6	8.2	14.4	21.6	24.0	64.0	164.0
	50	2.4	4.3	7.8	13.3	19.8	24.0	60.0	156.0
	60	2.2	4.0	7.3	12.2	18.2	24.0	56.0	146.0
1000 LFM	40	3.0 Amps	5.4	9.0	17.6	28.0	24.0	73.0	216.0
	50	3.0	5.0	8.4	16.6	26.0	24.0	70.0	202.0
	60	2.7	4.6	7.6	15.6	24.0	24.0	66.0	192.0
Oil	40	3.0 Amps	6.0	10.0	20.6	39.0	24.0	73.0	216.0
	60	3.0	6.0	10.0	16.8	31.5	24.0	70.0	192.0
	85	2.2	3.6	7.2	11.6	22.0	24.0	56.0	160.0
Maximum Voltage Rating Per Module PRV (Air or Oil)		11.2Kv (16.0Kv Oil Only)	11.2Kv (16.0Kv Oil Only)	5.6Kv 8.0Kv	2.4Kv 3.2Kv 4.0Kv	2.4Kv 3.2Kv 4.0Kv	.6Kv .8Kv 1.0Kv	.6Kv .8Kv 1.0Kv	.6Kv .8Kv 1.0Kv

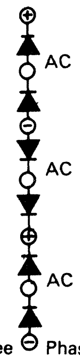
Circuit

SB5


Single Phase (Open Negative—External Wiring Required)

Air Flow	Temp. °C	2A01	3A03	4A05	5A09	6A14	7A12	8A36	9B11
Natural Convection	40	1.95	2.4	7.8	7.2	12.0	36.0	45.0	99.0
	50	1.8	1.95	7.2	6.7	11.2	34.5	36.0	96.0
	60	1.5	1.65	5.2	6.4	10.5	21.6	24.0	90.0
150 LFM	40	2.7	3.3	9.6	12.6	20.4	36.0	66.0	141.0
	50	2.5	3.0	9.0	11.7	18.9	36.0	62.4	132.0
	60	2.3	2.7	8.4	10.8	17.4	36.0	57.9	123.0
300 LFM	40	3.3	4.05	11.1	16.8	26.4	36.0	85.5	207.0
	50	3.0	3.75	10.5	15.4	24.3	36.0	81.0	192.0
	60	2.7	3.45	9.9	14.2	22.2	36.0	75.0	180.0
500 LFM	40	3.9	6.9	12.3	21.6	32.4	36.0	96.0	246.0
	50	3.6	6.45	11.7	19.9	29.7	36.0	90.0	234.0
	60	3.3	6.0	10.9	18.3	27.3	36.0	84.0	219.0
1000 LFM	40	4.5	8.1	13.5	26.4	42.0	36.0	109.5	324.0
	50	4.5	7.5	12.6	24.9	39.0	36.0	105.0	303.0
	60	4.0	6.9	11.4	23.4	36.0	36.0	99.0	288.0
Oil	40	4.5	9.0	15.0	30.9	58.5	36.0	109.5	324.0
	60	4.5	9.0	15.0	25.2	47.2	36.0	105.0	288.0
	85	3.3	5.4	10.8	17.4	33.0	36.0	84.0	240.0
Maximum Voltage Rating Per Module PRV (Air or Oil)		11.2Kv (16.0 Kv Oil Only)	11.2Kv (16.0Kv Oil Only)	5.6Kv 8.0Kv	2.4Kv 3.2Kv 4.0Kv	2.4Kv 3.2Kv 4.0Kv	.6Kv .8Kv 1.0Kv	.6Kv .8Kv 1.0Kv	.6Kv .8Kv 1.0Kv

Circuit

SE5


Three Phase (Partially Open—External Wiring Required)

ASSEMBLIES

High Voltage Stacks, Rectifier
ASSEMBLIES
Channel Design

ASSEMBLIES

Ordering Information

Circuit	Module	Cell	Number of Modules per Leg	Channel Number
SH1 SD1 SB5 SE5	2A01 3A03 4A05 5A09 6A14 7A12 8A36 9B11	M (.6 Kv) P (.7 Kv) S (.8 Kv) Z (1.0 Kv)	01 through 43 • **Check** Table I below for maximum voltage allowed per leg vs. circuit configuration. • **Check** Table II A below for maximum number of modules allowed for each circuit configuration.	01 through 43 Formula for Channel Number Channel Number=(N×S)+C N=Total number of modules in channel S=Module spacing factor, Table II B C=Channel circuit factor, Table II C

Table I—Maximum Stack Voltage per Leg vs. Circuit Configuration

Module	Maximum Module Voltage	Cooling—Oil or Air	Circuit Configuration SH1	SD1	SB5	SE5
2A01	16 Kv	Oil	688 Kv	336 Kv	160 Kv	96 Kv
2A01	11.2 Kv	Air	313.6 Kv	156.8 Kv	67.2 Kv	44.8 Kv
3A03	16 Kv	Oil	688 Kv	336 Kv	160 Kv	96 Kv
3A03	11.2 Kv	Air	313.6 Kv	156.8 Kv	67.2 Kv	44.8 Kv
4A05	8.0 Kv	Air or Oil	168 Kv	80 Kv	40 Kv	24 Kv
5A09	4.0 Kv	Air or Oil	172 Kv	84 Kv	40 Kv	24 Kv
6A14	4.0 Kv	Air or Oil	84 Kv	40 Kv	20 Kv	12 Kv
7A12	1.0 Kv	Air or Oil	43 Kv	21 Kv	10 Kv	6 Kv
8A36	1.0 Kv	Air or Oil	43 Kv	21 Kv	10 Kv	6 Kv
9B11	1.0 Kv	Air or Oil	21 Kv	—	—	—

Table II—A, B, C

Module	A Max. Allowed Total Modules vs. Circuit Configuration — Circuit SH1	SD1	SB5	SE5	B S Module Spacing Factor	C C Channel Circuit Factor — Circuit SH1	SD1	SB5	SE5
2A01, 3A03 (Oil Only)	43	42	40	36	1.0	0	1	3	5
5A09, 7A12 & 8A36	43	42	40	36	1.0	0	1	3	5
2A01, 3A03 (Air)	28	28	24	24	1.5	0	1	3	5
4A05, 6A14	21	20	20	18	2.0	0	1	3	5
9B11	21				2.0	1			

Table III

Channel No.	Length Inches	(mm)	Channel No.	Length Inches	(mm)
01	4.25	108	23	20.75	527
02	5.00	127	24	21.50	546
03	5.75	146	25	22.25	565
04	6.50	165	26	23.00	584
05	7.25	184	27	23.75	603
06	8.00	203	28	24.50	622
07	8.75	222	29	25.25	641
08	9.50	241	30	26.00	660
09	10.25	260	31	26.75	679
10	11.00	279	32	27.50	698
11	11.75	298	33	28.25	717
12	12.50	318	34	29.00	737
13	13.25	337	35	29.75	756
14	14.00	356	36	30.50	775
15	14.75	375	37	31.25	794
16	15.50	394	38	32.00	813
17	16.25	413	39	32.75	832
18	17.00	432	40	33.50	851
19	17.75	451	41	34.25	870
20	18.50	470	42	35.00	889
21	19.25	489	43	35.75	908
22	20.00	508			

Example Required is a single phase bridge rated (with safety factor) at 15 KV per leg, I_{DC} output of 12 amps at 40°C ambient natural convection, and non-repetitive single cycle surge rating of 140 amps.

Step 1 Select Module for current and surge from information.

Result 7A12, this number is inserted as the 4 through 7 digits in the product description number.

Step 2 Select Cell voltage letter code from information. Note, highest voltage available would give most compact design but may affect delivery at times; also, the higher voltage cells operate the snubber components and diodes closer to maximum ratings.

Result Z (1.0 KV), this letter code is inserted as the 8th digit in the product description number.

Step 3 Obtain Number of modules required per leg by dividing required voltage per leg (with safety factor) by module voltage (number of cells per module times cell voltage).

$$\frac{15\text{ KV}}{1\text{ Cell/Module}\times 1\text{ KV/Cell}} = 15\text{ modules}$$

Result 15 (9th and 10th digits of product description number).

Step 4 Select (Trial I) Circuit configuration available for your requirement; check Tables I and II for feasibility. This case, a *SB5* 7A1215, would not be feasible because 60 modules exceed the maximum channel length.

Select (Trial II) By dividing assembly into next standard circuit configuration, a doubler design (SD1 can be considered as indicated in Trial 1.

Result *SD1* works (1st, 2nd, and 3rd digit of the product description number). Two assemblies are now required for a complete single phase bridge.
Note: This assembly could have been reduced to single leg components by using the *SH1* circuit (four assemblies would then be required). The added cost for this is minimal and may be desired should parts or spares standardization be practical.

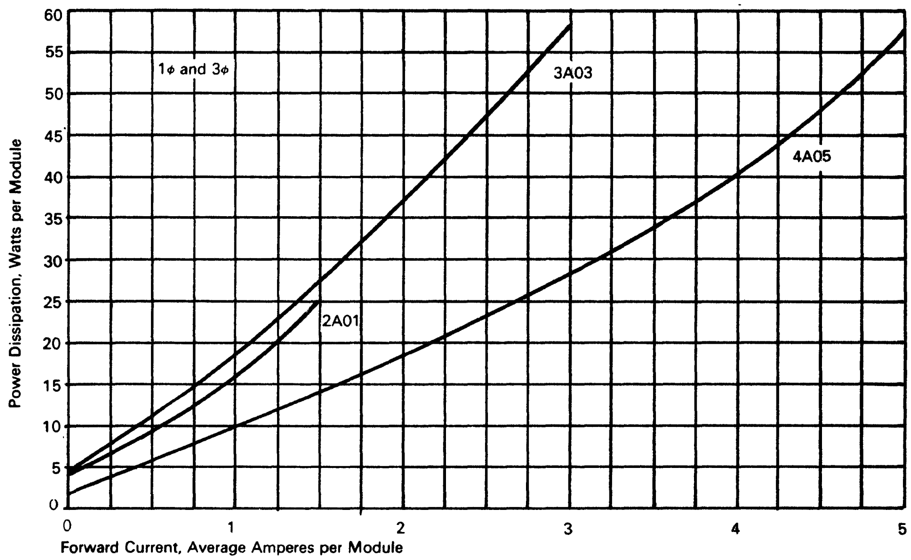
Step 5 Calculate Channel number using total number of modules per stack channel (N) and multiplying by module spacing factor (S) per Table II B, then adding the channel circuit factor (C) per Table II C. N=15 modules/leg×2 legs =30 modules.
Channel number=(N×S)+C
=(30×1)+1=31.

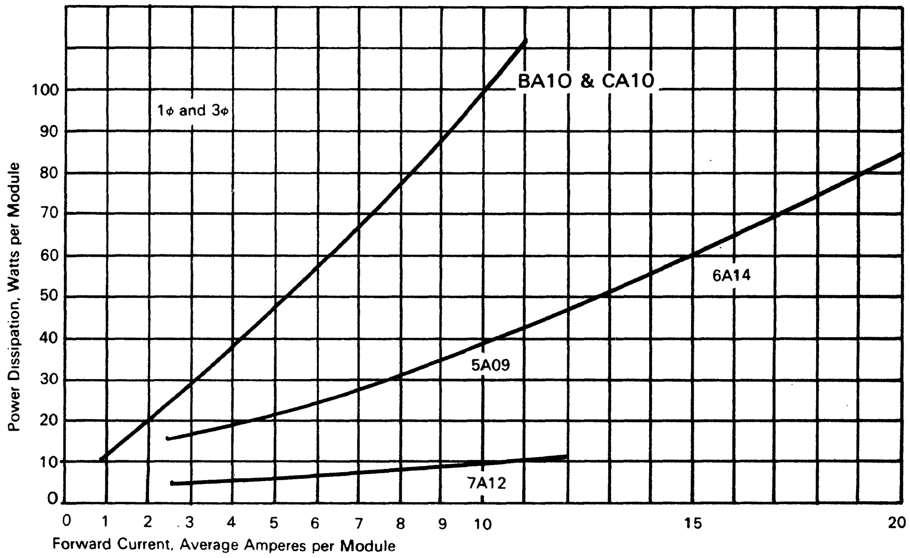
Result 31 (11th and 12th digits of product description number).

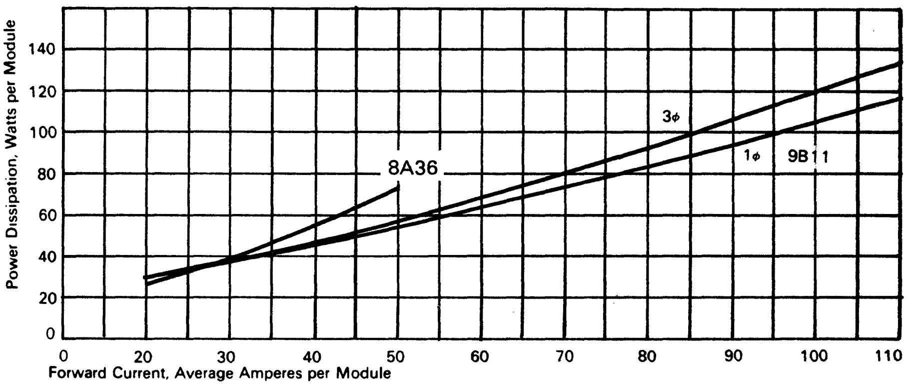
Answer SD17A12Z1531 (Two doubler assemblies will be required for this single phase bridge example).

Step	4			1				2	3		5	
Product Description Number	Circuit S	D	1	Module 7	A	1	2	Cell Z	Module/Leg 1	5	Channel Number 3	1
	1	2	3	4	5	6	7	8	9	10	11	12

Electrical Characteristics Average Power Dissipation per Module





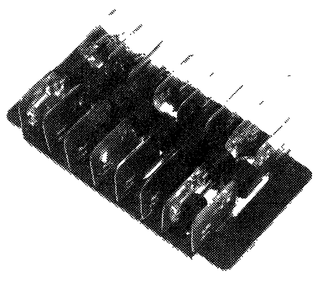
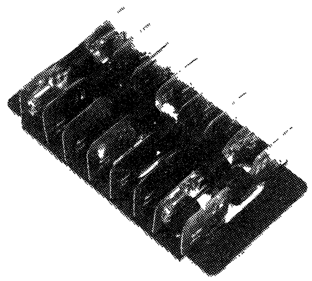


High Voltage Stacks, Rectifier
ASSEMBLIES
Channel Design

ASSEMBLIES

Design Modules

These modules, consisting of silicon diodes and compensating network, provide the optimum in steady state and transient voltage division. The design of the stacks provides for cooling by free convection air, forced convection air, or oil.

BA10			CA10		
					
6.0 Amp Lead Mount			6.0 Amp Lead Mount		
Cells/Module	8		Cells/Module	8	
Volts/Cell	.6Kv	M	Volts/Cell	.6Kv	M
	.8Kv	S			
Voltage/Code			Voltage/Code		
Surge 60Hz	240A	1 ~	Surge 60Hz	400A	1 ~
	170A	3 ~		280A	3 ~
	105A	10 ~		175A	10 ~

Ordering Information

See previous section, High Voltage Stack Channel Design for ordering details in conjunction with tables below.

Circuit	Module	Cell	Number of Modules per Leg	Channel Number
SH1 SD1 SB5 SE5	BA10 CA10	M(.6Kv) S(.8Kv)	01 through 21 • Check Table 1 below for maximum voltage allowd per leg vs. circuit configuration. • Check Table II A below for maximum number of modules allowed for each circuit configuration.	01 through 43 Formula for Channel Number Channel Number = (NxS)+C N=Total number of modules in channel S=Module spacing factor, Table II B C=Channel circuit factor, Table II C

Table I — Maximum Stack Voltage per Leg vs. Circuit Configuration

Module	Maximum Module Voltage	Cooling - Oil or Air	Circuit Configuration			
			SH1	SD1	SB5	SE5
BA10	6.4KV	Oil or Air	134KV	64KV	32KV	19KV
CA10	4.8KV	Oil or Air	100KV	48KV	24KV	14KV

Table II — A, B, C

Module	A Max. Allowed Total Modules vs. Circuit Configuration				B S Module Spacing Factor	C Channel Circuit Factor			
	Circuit					Circuit			
	SH1	SD1	SB5	SE5		SH1	SD1	SB5	SE5
BA10 or CA10	21	20	20	18	2.0	0	1	3	5

High Voltage Stacks, Rectifier
ASSEMBLIES
Channel Design

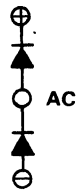
Cooling Conditions: Air Flow	Temp, °C	BA10	CA10
Natural Convection	40	3.1	3.1
	50	2.8	2.8
	60	2.6	2.6
150 LFM	40	4.3	4.3
	50	4.0	4.0
	60	3.6	3.6
300 LFM	5.3	5.3	5.3
	50	5.0	5.0
	60	4.6	4.6
500 LFM	40	6.2	6.2
	50	5.8	5.8
	60	5.4	5.4
1000 LFM	40	7.0	7.0
	50	6.6	6.6
	60	6.2	6.2
Oil	40	10.6	10.6
	60	9.0	9.0
	85	7.0	7.0
Maximum Voltage Rating Per Module PRV (Air or Oil)		6.4KV	4.8KV

Circuit

SH1

Half Wave (Single Leg)

SD1

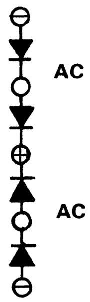


Doubler (Two Legs)

Natural Convection	40	6.2	6.2
	50	5.6	5.6
	60	5.2	5.2
150 LFM	40	8.6	8.6
	50	8.0	8.0
	60	7.2	7.2
300 LFM	40	10.6	10.6
	50	10.0	10.0
	60	9.2	9.2
500 LFM	40	12.4	12.4
	50	11.6	11.6
	60	10.8	10.8
1000 LFM	40	14.0	14.0
	50	13.2	13.2
	60	12.4	12.4
Oil	40	21.2	21.2
	60	18.0	18.0
	85	14.0	14.0
Maximum Voltage Rating Per Module PRV (Air or Oil)		6.4KV	4.8KV

Circuit

SB5

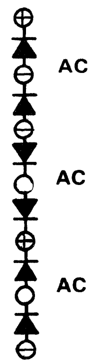


Single Phase (Open Negative-External Wiring Required)

Natural Convection	40	9.3	9.3
	50	8.4	8.4
	60	7.8	7.8
150 LFM	12.9	12.9	12.9
	50	12.0	12.0
	60	10.8	10.8
300 LFM	40	15.9	15.9
	50	15.0	15.0
	60	13.8	13.8
500 LFM	40	18.6	18.6
	50	17.4	17.4
	60	16.2	16.2
1000 LFM	40	21.0	21.0
	50	19.8	19.8
	60	18.6	18.6
Oil	40	31.8	31.8
	60	27.0	27.0
	85	21.0	21.0
Maximum Voltage Rating Per Module PRV (Air or Oil)		6.4KV	4.8KV

Circuit

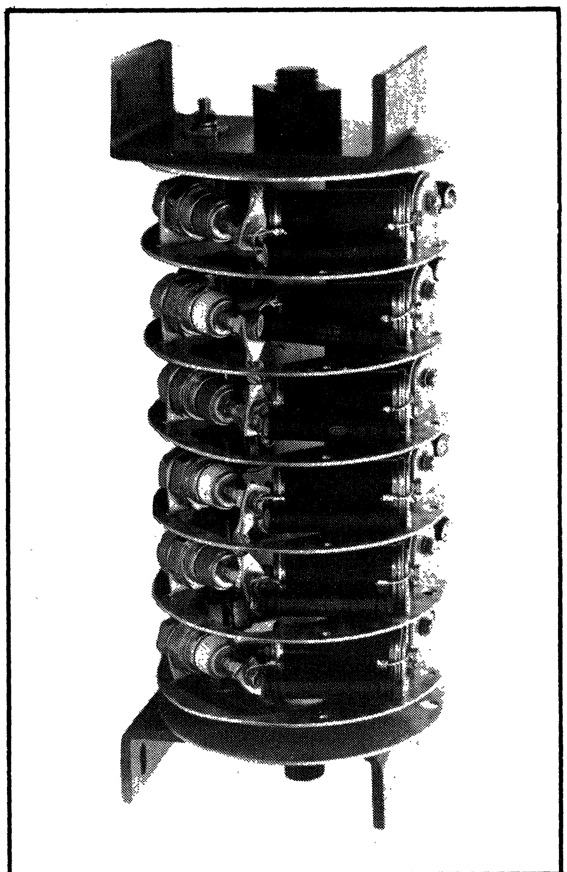
SE5



Three Phase (Partially Open-External Wiring Required)

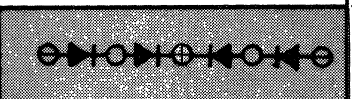
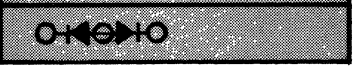
ASSEMBLIES

High Voltage Stacks, Rectifier
ASSEMBLIES
Plate Design

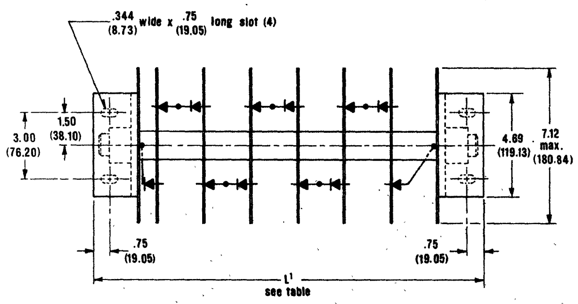


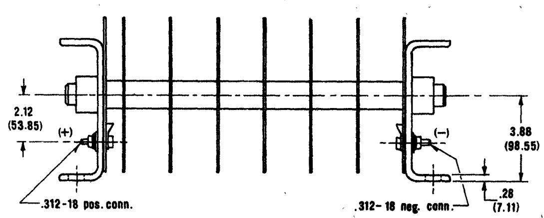
Features and Benefits:
- Fully Compensated Modules For High Reliability
- Vari-Length Design For Circuit and Mounting Flexibility
- High Density Packaging For Compact Designs
- Ratings For Air and Oil Cooling
- Expert Applications Assistance
- Special Designs Available on Request
- High Repetitive Surge Ratings
- Compression Bonded Encapsulation For Thermal Cycling Capability
- Availability, Present High Volume Device Production

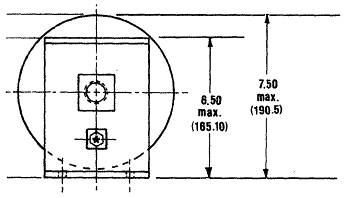
Applications:
- Fusion and High Voltage Research
- High Voltage Free-Wheeling Rectifiers
- Laser Supply Charging Diodes
- Magnetic Metal Forming Supplies

Circuits	
HB1	
HC1	
HD1	
HH1	
HN1	

DIMENSION IN INCHES (MILLIMETERS)



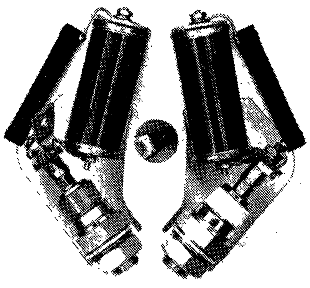




High Voltage Stacks, Rectifier ASSEMBLIES
Plate Design

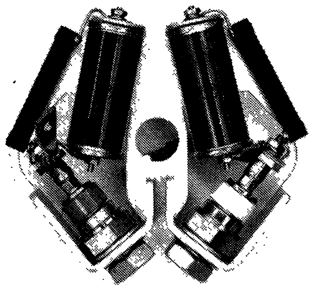
Design Modules

Type 76A,B,C,D



Heatsink Plate Only

Type B6,A,B,C,D

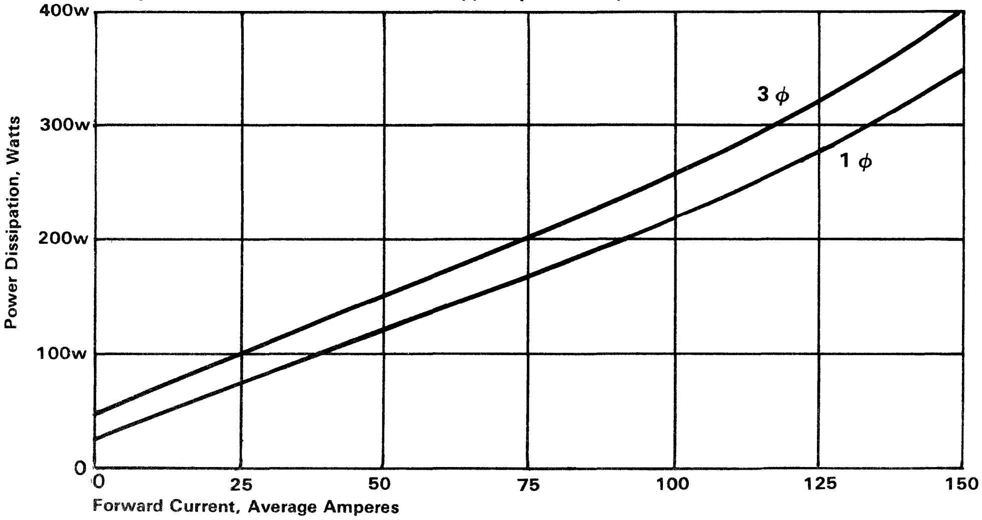


Added Heatsink

Module Cell Types

	76A or B6A		76B or B6B		76C or B6C		76D or B6D	
Cells/Module	2		2		2		2	
Cell Voltage KV	2.0	20	2.0	20	2.0	20	2.0	20
	2.3	23	2.3	23	2.3	23	2.3	23
	2.5	25	2.5	25	2.5	25		
	2.8	28	2.8	28				
	3.0	30	3.0	30				
Code								
Surge 60 ∿ (Amps)	2000	1 ∿	5500	1 ∿	6000	1 ∿	6500	1 ∿
	1800	3 ∿	4300	3 ∿	4700	3 ∿	5050	3 ∿
	1450	10 ∿	3300	10 ∿	3600	10 ∿	3900	10 ∿

Average Power Dissipation Per Module (2400 Volts applied per module)



High Voltage Stacks, Rectifier
ASSEMBLIES
Plate Design

ASSEMBLIES

Module Electrical Characteristics Current Output vs. Ambient Temperature/Max. PRV

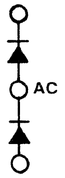
Cooling Conditions: Air Flow	Temp, °C	76A	76B	76C	76D	B6A	B6B	B6C	B6D
Natural Convection	40	12	14	18	18	8	9	12	12
	50	11	12	13	13	6	7	8	8
	60	6	7	8	8	3	4	5	5
150 LFM	40	23	35	47	54	29	46	63	70
	50	20	32	44	49	24	41	58	60
	60	19	29	39	46	20	36	40	40
300 LFM	40	28	42	56	62	44	62	80	89
	50	26	39	52	58	37	56	75	83
	60	23	35	47	54	31	50	69	71
500 LFM	40	32	47	62	68	53	72	93	103
	50	27	42	57	64	44	66	88	98
	60	23	38	53	60	38	60	82	91
1000 LFM	40	33	50	67	73	58	86	114	126
	50	30	46	62	69	54	80	106	120
	60	24	41	58	64	49	74	99	116
Oil	40	111	121	131	134	130	138	146	150
	60	92	100	108	110	108	118	128	131
	85	64	70	76	76	82	90	98	100
Maximum Voltage Rating Per Module PRV (Air or Oil)		6KV	6KV	5KV	4.6KV	6KV	6KV	5KV	4.6KV

Circuit

HHI

Half Wave (Single Leg)

HDI

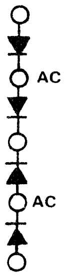


Doubler (Two Legs)

Cooling Conditions: Air Flow	Temp, °C	76A	76B	76C	76D	B6A	B6B	B6C	B6D
Natural Convection	40	24	28	36	36	16	18	24	24
	50	22	24	26	26	12	14	16	16
	60	12	14	16	16	6	8	10	10
150LFM	40	43	70	94	108	58	92	126	140
	50	40	64	88	98	48	82	116	120
	60	38	58	78	92	40	72	80	80
300 LFM	40	56	84	112	124	88	124	160	178
	50	52	78	104	116	74	112	150	166
	60	46	70	94	108	62	100	138	142
500 LFM	40	64	94	124	126	106	144	186	206
	50	34	84	114	128	88	132	176	196
	60	46	76	106	120	76	120	164	182
1000 LFM	40	66	100	134	146	116	172	228	252
	50	60	92	124	138	108	160	212	240
	60	48	82	116	128	98	148	198	232
Oil	40	222	242	262	268	260	276	292	300
	60	184	200	216	220	216	236	256	262
	85	128	140	152	152	164	180	196	200
Maximum Voltage Rating Per Module PRV (Air or Oil)		6KV	6KV	5KV	4.6KV	6KV	6KV	5KV	4.6KV

Circuit

HBI

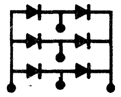


Single Phase

(Open Negative - External Wiring Required)

Cooling Conditions: Air Flow	Temp, °C	76A	76B	76C	76D	B6A	B6B	B6C	B6D
Natural Convection	40	36	42	54	54	24	27	36	36
	50	33	36	39	39	18	21	24	24
	60	18	21	24	24	9	12	15	15
150 LFM	40	69	105	141	162	87	138	189	210
	50	60	96	132	147	72	123	174	180
	60	57	87	117	138	60	108	120	120
300 LFM	40	84	126	168	186	132	186	240	267
	50	78	117	156	174	111	168	225	249
	60	69	105	141	162	93	150	207	213
500 LFM	40	96	141	186	204	159	216	279	309
	50	81	126	171	192	132	198	264	294
	60	69	114	159	180	116	180	246	273
1000 LFM	40	99	150	201	219	174	258	342	378
	50	90	138	186	207	162	240	318	360
	60	72	123	174	192	147	222	297	348
Oil	40	333	363	392	402	390	414	438	450
	60	276	300	324	330	324	354	384	393
	85	192	210	228	228	246	270	294	300
Maximum Voltage Rating Per Module PRV (Air or Oil)		6KV	6KV	5KV	4.6KV	6KV	6KV	5KV	4.6KV

Circuit



3 ϕ Bridge

THREE HDI REQUIRED OR SIX HHI REQUIRED

Ordering Information

Circuit Configuration	Plate Design	Module		Diode Voltage		Total No. of Modules	Application
Code (See Front Page)	See Pictures	Rectifier I∿ Surge	Code	VRRM	Code	Code	Code
HB1	7	2000A	6A	2KV	20	01	AA
HC1	B	5500A	6B	2.3KV	23	Thru	Thru
HD1		6000A	6C	2.5KV	25	12	22
HH1		6500A	6D	2.8KV	28		Factory
HN1				3.0KV	30		Assigned

Table II
Dimension In Inches

Frame

Code	Dimension	Tolerance
HB1	9.80	
HC1	6.60	
HD1	6.60	±.080
HH1	5.00	
HN1	6.60	

Plus
Module

Code	Dimension	Tolerance
01	2.09	
02	4.19	
03	6.28	
04	8.38	
05	10.47	+.013
06	12.56	−.003
07	14.66	Per
08	16.75	Module
09	18.85	
10	20.94	
11	23.03	
12	25.13	

EXAMPLE: Required is a single phase bridge rated (with safety factor) at 60KV per leg, IDC output of 250 amps and a non-repetitive 3 cycle surge rating of 4500 amps (consult Ⓦ for repetitive surge applications).

STEP 1 — SELECT: Module for current and surge from module electrical characteristics tables.

RESULT: B6C Module
B6C, This number will be inserted as the 4 through 6 digits in product description number.

STEP 2 — SELECT: Call voltage code from design module cell types.

RESULT: 25 (2.5KV), This number code is inserted as 7 through 8 digits.

STEP 3 — OBTAIN: Number of modules required per leg by dividing required voltage per leg (with safety factor) by module voltage (2 times cell voltage).

$$\frac{60\text{KV (Total}}{5\text{KV (Per Module)}} = 12$$

RESULT: 12 Modules, This number code is inserted as 9 through 10 digits.

STEP 4 — SELECT: Circuit configuration available for your requirement by checking maximum allowed modules from Table II.

RESULT: HH1 configuration is the only available design. Four assemblies are required, HH1 is the 1 through 3 digits.

STEP 5 — OBTAIN: High voltage stack length from Table II frame adder and module dimension adder.

RESULT: (HH1) 5.00"+ .080" plus (12 modules) 25.13

$$= 30.13 \begin{matrix} +.093 \\ -.083 \end{matrix}$$

STEP	4			1			2		3		5	
Product Description Number	Circuit (Frame)			Module			Cell (Voltage)		Total Module Required		Application Code	
	HH1			B6C			25		12		Factory Assigned	
Digits	1	2	3	4	5	6	7	8	9	10	11	12

High Voltage Stacks Assemblies Applications Work Sheet

(make copy for each use)

Name ____________ Company ____________
Phone ____________ X ______ Address ____________
Job Function ____________ Section ______ City ____________ State ______
Bldg. ____________ Zip ______

Please complete a copy of this form for each different application. Forward this form to Westinghouse Electric Corporation, Semiconductor Division, Attention: Sales Department, Youngwood, Pa. 15697 for complete quotation. If you need faster service, please call (412) 925-7272 for a quote.

Circuit
- ☐ Clipper
- ☐ Charger
- ☐ De-Queing
- ☐ Doubler
- ☐ I ϕ Bridge
- ☐ 3 ϕ Bridge
- ☐ 3ϕ, 12 Pulse Bridge
- ☐ Other, explain ____________

Application
- ☐ Transmitter
- ☐ R F Generator
- ☐ Precipitator
- ☐ Accelerator
- ☐ Hi-Voltage Test Equipment
- ☐ Voltage Multiplier
- ☐ Other ____________

Cooling ☐ Air
- ☐ Natural Convection, Altitude ______ ft., amb. temp. °C ______
- ☐ Forced Air, LFM ______, amb. temp. °C ______

☐ Oil Type ______ Mfg. ______ amb. temp. °C ______

Current Max. Output Current, I_{DC} ______ ☐ RMS ☐ Average Waveform ______
Duty Cycle, Time On ______ Time Off ______ Every ______
Cycling (Number of cycles required this application) ______
Fault Surge 1~ ______ Time ______ ms
3~ ______ Time ______ ms
10~ ______ Time ______ ms
Transformer KVA ______ Percent Impedance ______
Number of faults expected/lifetime ______ Note: JEDEC surge is a non-repetitive value. Westinghouse will advise device for requirement.

Voltage Input Voltage Supply ______ KV AC ☐ DC ☐
Safety Factor Required: Voltage ______, Current ______
Circuit Protection: ☐ Fuse ☐ Circuit Breaker ☐ Other, explain

Distance from ground plane (stacks) mounted from:
Bottom ______ Top ______ Sides ______

Other Considerations ____________

Problems experienced in the past ____________

☐ New Design ☐ Conversion ☐ Replacement MFG/Type No. ______
Number/System ______
Budgetary cost for this system ______ Number of systems required ______
Timetable ______ Long range potential ______

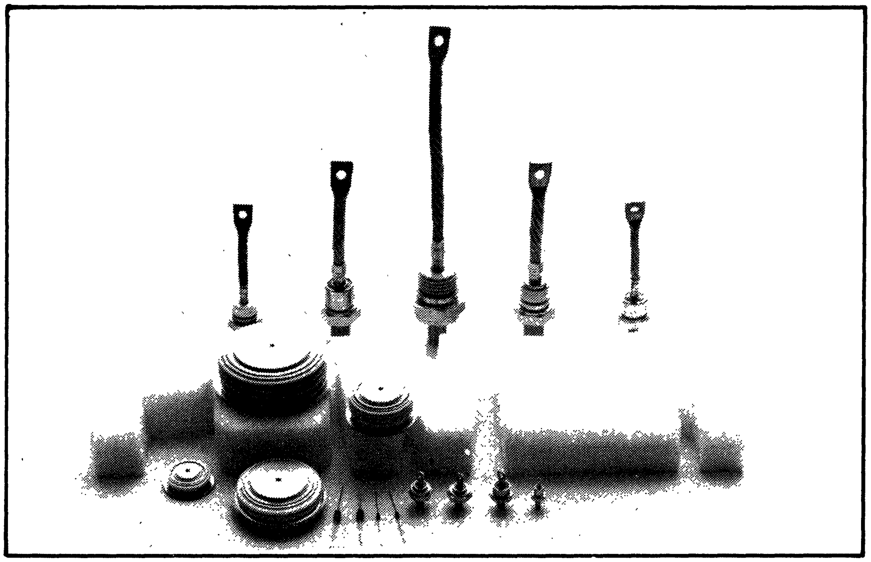
Westinghouse Assembly Recommended ____________

Negotiation Number ______ Recommended by ______ Date ______

RECTIFIERS

INTRODUCTION

Westinghouse introduced the first silicon rectifier in 1952. Today, Westinghouse offers a complete line of General Purpose and Fast Recovery rectifiers. All Ⓦ rectifier elements use N-type silicon providing soft recovery characteristics which minimize rectifier spike voltages and reduce transient protection requirements. Westinghouse uses an exclusive irradiation process to manufacture fast recovery rectifiers. This process provides precise control for better availability, soft recovery characteristics for less circuit ringing and reduced transient protection, high voltage capabilities up to 3200 volts with low reverse leakage currents, and fast recovery times — 200 nanoseconds for low current (6-30 ampere) rectifiers and 1.5 to 5.0 microseconds for high current (80-1400 ampere) rectifiers.



RECTIFIER PRODUCT INDEX

RECTIFIERS

The axial lead mount package is the most popular for one to six ampere general purpose rectifier (diode) applications. The axial lead mount design features silver plated copper leads offering excellent heat conduction, solderability, and corrosion resistance. Several axial lead mount types are available with a chamfered body on the cathode end to insure proper polarity identification and correct assembly. Tape and reeling capability is available for those customers using automatic insertion equipment.

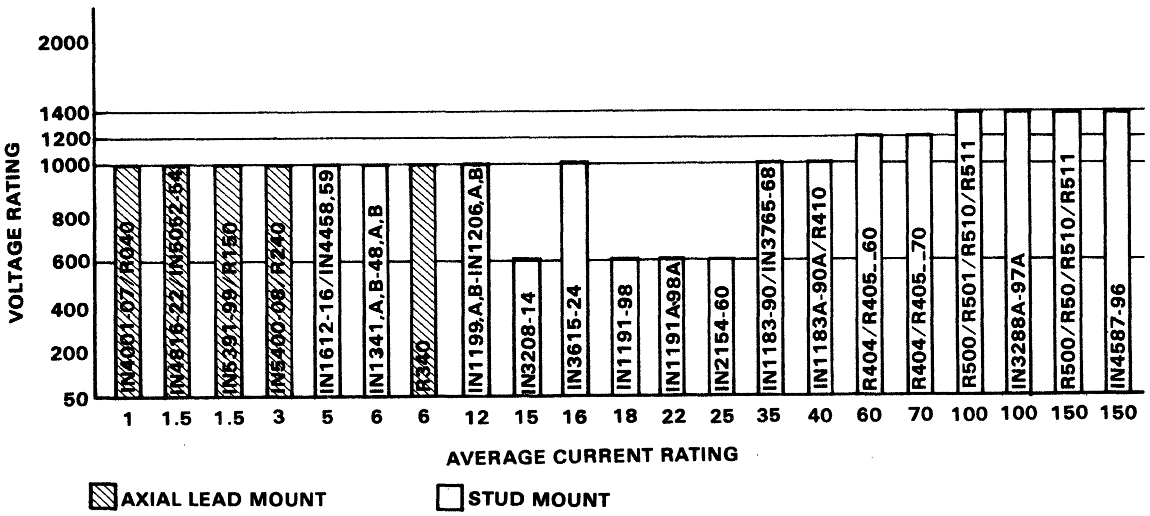
All stud mount rectifiers are available in **both** standard and reverse polarity. Color-coded glass or ceramic seals on all stud mount rectifiers make polarity identification easy and minimize the possibility of installing a device of the wrong polarity. Stud mount rectifiers (80 amperes and above) feature compression bonded encapsulation (CBE). This CBE package encapsulation technique reduces thermal fatigue inherent in conventional solder construction devices by eliminating solder joints.

Ⓦ disc mount rectifiers offer more amperes per dollar than any other package type. These devices feature double-sided cooling and have reversible mounting polarity. These all-copper non-magnetic packages are ideal in high frequency applications where magnetic noise can be a problem. In addition, the disc glazed ceramic seals are convoluted for long creepage paths which are especially important in applications where dirt, humidity and other contaminants can accumulate and cause arc-over.

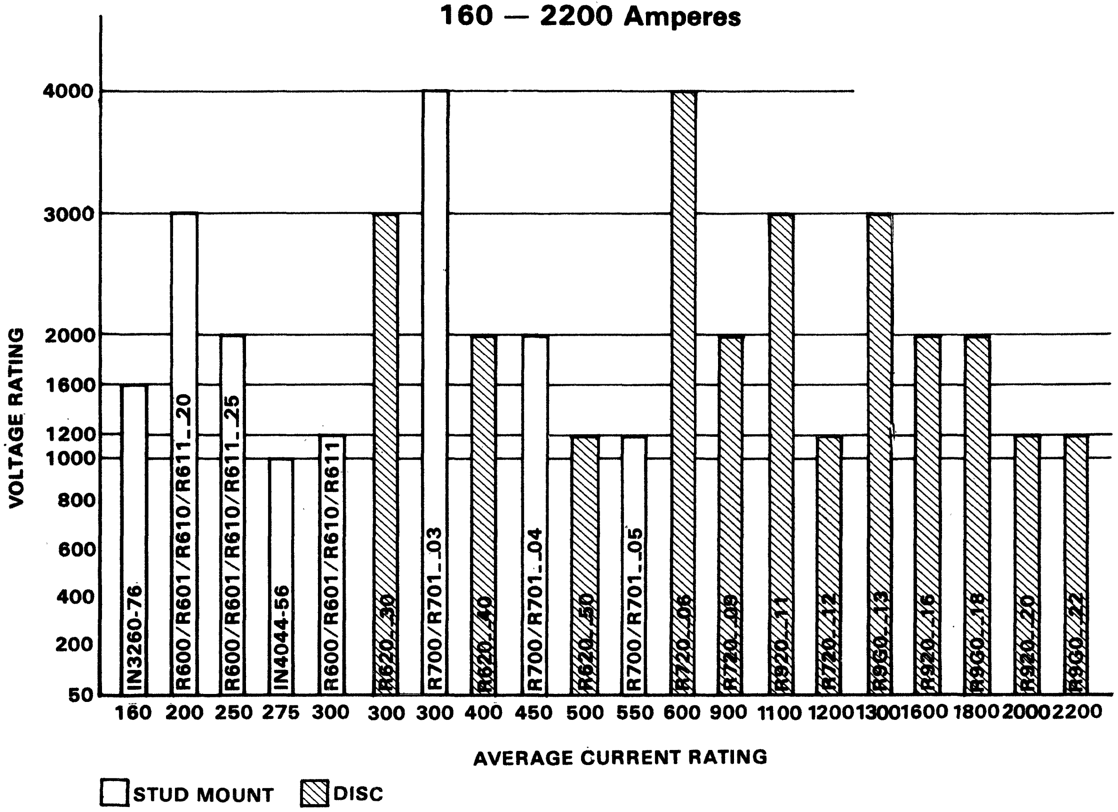
Military rectifiers are available in both polarities in the popular stud mount DO-8 and DO-9 packages: JAN IN3289-95 series and JAN IN3164-74 series. Complete test facilities are available for matching devices for series and/or parallel operation, for special test parameter selection, and for full-scale high reliability requirements. Ⓦ offers a Lifetime Guarantee on all rectifiers bearing this symbol ✚. Specify Westinghouse Rectifiers.

RECTIFIER CAPABILITY GRAPHS

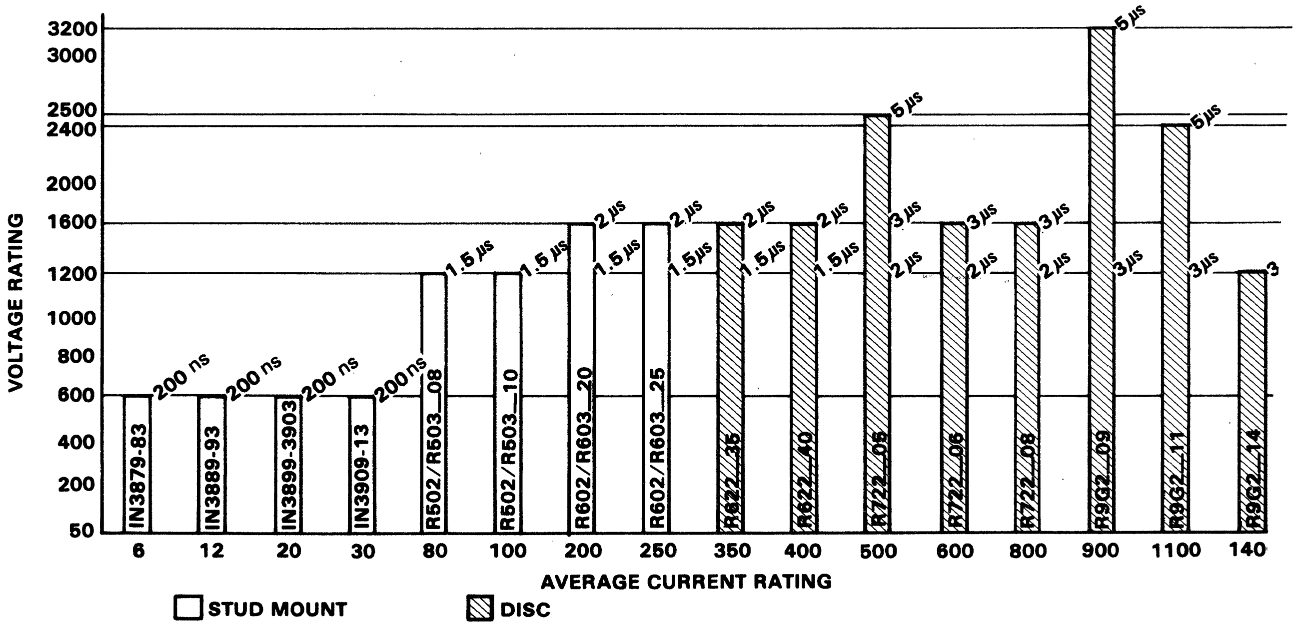
GENERAL PURPOSE RECTIFIERS
1 — 150 Amperes



GENERAL PURPOSE RECTIFIERS
160 — 2200 Amperes



FAST RECOVERY RECTIFIERS
6 — 1400 Amperes



Note: Reverse recovery times shown represent fastest currently available at given voltage rating.

RECTIFIER SELECTOR GUIDE

GENERAL PURPOSE RECTIFIERS
1 — 15 Amperes

JEDEC/TYPE	IN4001-07	IN4816-22 IN5052-54	IN5391-99	IN5400-08	* IN1612-16 IN4458,59	* IN1341,A,B- IN1348,A,B IN3987-90	R340	* IN1199,A,B- IN1206,A,B IN3670,A-73,A	* IN3208-14
AVERAGE CURRENT	1	1.5	1.5	3	5	6	6	12	15
ONE CYCLE SURGE	30	50	50	200	150	150	400	240	250
VOLTAGE 50	IN4001	IN4816	IN5391	IN5400	IN1612	IN1341,A,B	R3400006	IN1199,A,B	IN3208
100	IN4002	IN4817	IN5392	IN5401	IN1613	IN1342,A,B	R3400106	IN1200,A,B	IN3209
150						IN1343,A,B		IN1201,A,B	
200	IN4003	IN4818	IN5393	IN5402	IN1614	IN1344,A,B	R3400206	IN1202,A,B	IN3210
300		IN4819	IN5394	IN5403		IN1345,A,B	R3400306	IN1203,A,B	IN3211
400	IN4004	IN4820	IN5395	IN5404	IN1615	IN1346,A,B	R3400406	IN1204,A,B	IN3212
500		IN4821	IN5396	IN5405		IN1347,A,B	R3400506	IN1205,A,B	IN3213
600	IN4005	IN4822	IN5397	IN5406	IN1616	IN1348,A,B	R3400606	IN1206,A,B	IN3214
700		IN5052				IN3987	R3400706	IN3670,A	
800	IN4006	IN5053	IN5398	IN5407	IN4458	IN3988	R3400806	IN3671,A	
900						IN3989	R3400906	IN3672,A	
1000	IN4007	IN5054	IN5399	IN5408	IN4459	IN3990	R3401006	IN3673,A	
PACKAGE TYPE	DO-41	DO-27	DO-15	~DO-27	DO-4	DO-4	R34	DO-4	DO-5
PAGE NUMBER	R9	R9	R9	R9	R13	R13	R9	R13	R15

*For JEDEC Reverse Polarity Units — add suffix "R".

GENERAL PURPOSE RECTIFIERS
16 — 70 Amperes

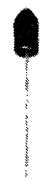
JEDEC/TYPE	* IN3615-24	* IN1191-98	* IN1191A-98A	* IN2154-60	* IN1183-90 IN3765-68	*/** IN1183A-90A R410—40	** R404—60	** R404—70
AVERAGE CURRENT	16	18	22	25	35	40	60	70
ONE CYCLE SURGE	300	220	500	400	500	800	1200	1200
VOLTAGE 50	IN3615	IN1191	IN1191A	IN2154	IN1183	IN1183A	R4040060	R4040070
100	IN3616	IN1192	IN1192A	IN2155	IN1184	IN1184A	R4040160	R4040170
150	IN3617	IN1193	IN1193A		IN1185	IN1185A		
200	IN3618	IN1194	IN1194A	IN2156	IN1186	IN1186A	R4040260	R4040270
300	IN3619	IN1195	IN1195A	IN2157	IN1187	IN1187A	R4040360	R4040370
400	IN3620	IN1196	IN1196A	IN2158	IN1188	IN1188A	R4040460	R4040470
500	IN3621	IN1197	IN1197A	IN2159	IN1189	IN1189A	R4040560	R4040570
600	IN3622	IN1198	IN1198A	IN2160	IN1190	IN1190A	R4040660	R4040670
700					IN3765			
800	IN3623				IN3766	R4100840	R4040860	R4040870
900					IN3767			
1000	IN3624				IN3768	R4101040	R4041060	R4041070
1200						R4101240	R4041260	R4041270
PACKAGE TYPE	DO-4	DO-5	DO-5	DO-5	DO-5	DO-5	DO-5	DO-5
PAGE NUMBER	R13	R15	R15	R15	R15	R15	R17	R17

*For JEDEC Reverse Polarity Units — add suffix "R"
**For Reverse Polarity Units R410—R411
R404—R405


DO-41


DO-27


DO-15


~DO-27


R34

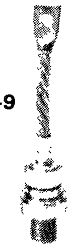

DO-4

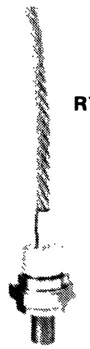

DO-5


DO-5
(R404)

RECTIFIER SELECTOR GUIDE


DO-8


DO-9


R70

R62


R72


GENERAL PURPOSE RECTIFIERS
100 — 300 Amperes

	**	*	**	*	*	**	**	*	**
JEDEC/TYPE	R500..10 R510..10	IN3288A- 97A	R500..15 R510..15	IN4587-96	IN3260-78	R600..20 R610..20	R600..25 R610..25	IN4044-56	R600..30 R610..30
AVERAGE CURRENT	100	100	150	150	160	200	250	275	300
ONE CYCLE SURGE	2300	2300	3000	3000	2000	5500	6000	5000	6500
VOLTAGE 50					IN3260			IN4044	
100	R5100110	IN3288A	R5100115	IN4587	IN3261	R6100120	R6100125	IN4045	R6100130
150					IN3262			IN4046	
200	R5100210	IN3289A	R5100215	IN4588	IN3263	R6100220	R6100225	IN4047	R6100230
250					IN3264			IN4048	
300	R5100310	IN3290A	R5100315	IN4589	IN3265	R6100320	R6100325	IN4049	R6100330
350					IN3266				
400	R5100410	IN3291A	R5100415	IN4590	IN3267	R6100420	R6100425	IN4050	R6100430
500	R5100510	IN3292B	R5100515	IN4591	IN3268	R6100520	R6100525	IN4051	R6100530
600	R5100610	IN3293A	R5100615	IN4592	IN3269	R6100620	R6100625	IN4052	R6100630
700	R5100710		R5100715		IN3270	R6100720	R6100725	IN4053	R6100730
800	R5100810	IN3294A	R5100815	IN4593	IN3271	R6100820	R6100825	IN4054	R6100830
900	R5100910		R5100915		IN3272	R6100920	R6100925	IN4055	R6100930
1000	R5101010	IN3295A	R5101015	IN4594	IN3273	R6101020	R6101025	IN4056	R6101030
1200	R5001210	IN3296A	R5001215	IN4595	IN3274	R6001220	R6001225		R6001230
1400	R5001410	IN3297A	R5001415	IN4596	IN3275	R6001420	R6001425		
1600					IN3276	R6001620	R6001625		
2000						R6002020	R6002025		
2500						R6002520			
3000						R6003020			
PACKAGE TYPE	DO-8	DO-8	DO-8	DO-8	DO-9	DO-9	DO-9	DO-9	DO-9
PAGE NUMBER	R23	R19	R23	R21	R27	R31	R31	R29	R31

*For JEDEC Reverse Polarity Units — add suffix "R".
**For Reverse Polarity Units — R500 — R501
R510 — R511
R600 — R601
R610 — R611

GENERAL PURPOSE RECTIFIERS
300 — 600 Amperes

		**		**		**	
TYPE	R620..30	R700..03	R620..40	R700..04	R620..50	R700..05	R720..06
AVERAGE CURRENT	300	300	400	450	500	550	600
ONE CYCLE SURGE	5500	6000	6000	8500	6500	10 000	7000
VOLTAGE 100	R6200130	R7000103	R6200140	R7000104	R6200150	R7000105	R7200106
200	R6200230	R7000203	R6200240	R7000204	R6200250	R7000205	R7200206
300	R6200330	R7000303	R6200340	R7000304	R6200350	R7000305	R7200306
400	R6200430	R7000403	R6200440	R7000404	R6200450	R7000405	R7200406
500	R6200530	R7000503	R6200540	R7000504	R6200550	R7000505	R7200506
600	R6200630	R7000603	R6200640	R7000604	R6200650	R7000605	R7200606
800	R6200830	R7000803	R6200840	R7000804	R6200850	R7000805	R7200806
1000	R6201030	R7001003	R6201040	R7001004	R6201050	R7001005	R7201006
1200	R6201230	R7001203	R6201240	R7001204	R6201250	R7001205	R7201206
1400	R6201430	R7001403	R6201440	R7001404			R7201406
1600	R6201630	R7001603	R6201640	R7001604			R7201606
2000	R6202030	R7002003	R6202040	R7002004			R7202006
2200	R6202230	R7002203					R7202206
2500	R6202530	R7002503					R7202506
2800	R6202830	R7002803					R7202806
3000	R6203030	R7003003					R7203006
3500		R7003503					R7203506
4000		R7004003					R7204006
PACKAGE TYPE	R62	R70	R62	R70	R62	R70	R72
PAGE NUMBER	R39	R35	R39	R35	R39	R35	R43

** For Reverse Polarity Units — R700 — R701

RECTIFIER SELECTOR GUIDE

GENERAL PURPOSE RECTIFIERS
900 — 2200 Amperes


R72


R92


R9G

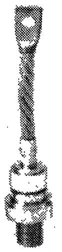
TYPE	R720__09	R920__11	R720__12	R9G0__13	R920__16	R9G0__18	R920__20	R9G0__22
AVERAGE CURRENT	900	1100	1200	1300	1600	1800	2000	2200
ONE CYCLE SURGE	8500	16,200	12,500	16,200	21,500	21,500	30,000	30,000
VOLTAGE 100	R7200109	R9200111	R7200112	R9G00113	R9200116	R9G00118	R9200120	R9G00122
200	R7200209	R9200211	R7200212	R9G00213	R9200216	R9G00218	R9200220	R9G00222
300	R7200309	R9200311	R7200312	R9G00313	R9200316	R9G00318	R9200320	R9G00322
400	R7200409	R9200411	R7200412	R9G00413	R9200416	R9G00418	R9200420	R9G00422
500	R7200509	R9200511	R7200512	R9G00513	R9200516	R9G00518	R9200520	R9G00522
600	R7200609	R9200611	R7200612	R9G00613	R9200616	R9G00618	R9200620	R9G00622
800	R7200809	R9200811	R7200812	R9G00813	R9200816	R9G00818	R9200820	R9G00822
1000	R7201009	R9201011	R7201012	R9G01013	R9201016	R9G01018	R9201020	R9G01022
1200	R7201209	R9201211	R7201212	R9G01213	R9201216	R9G01218	R9201220	R9G01222
1400	R7201409	R9201411		R9G01413	R9201416	R9G01418		
1600	R7201609	R9201611		R9G01613	R9201616	R9G01618		
1800	R7201809	R9201811		R9G01813	R9201816	R9G01818		
2000	R7202009	R9202011		R9G02013	R9202016	R9G02018		
2200		R9202211		R9G02213				
2400		R9202411		R9G02413				
2600		R9202611		R9G02613				
2800		R9202811		R9G02813				
3000		R9203011		R9G03013				
PACKAGE TYPE	R72	R92	R72	R9G	R92	R9G	R92	R9G
PAGE NUMBER	R43	R47	R43	R51	R47	R51	R47	R51

RECTIFIER SELECTOR GUIDE

DO-4

DO-5

DO-8



DO-9

FAST RECOVERY RECTIFIERS
6 — 250 Amperes

JEDEC/TYPE	*/** IN3879-83 R302..06	*/** IN3889-93 R302..12	*/** IN3899-93 R402..20	*/** IN3903-13 R402..30	** R502..08	** R502..10	** R602..20	** R602..25
AVERAGE CURRENT	6	12	20	30	80	100	200	250
ONE CYCLE SURGE	75	150	225	300	2200	2500	4500	5000
VOLTAGE 50	IN3879	IN3889	IN3899	IN3909	R5020008	R5020010	R6020020	R6020025
100	IN3880	IN3890	IN3900	IN3910	R5020108	R5020110	R6020120	R6020125
200	IN3881	IN3891	IN3901	IN3911	R5020208	R5020210	R6020220	R6020225
300	IN3882	IN3892	IN3902	IN3912	R5020308	R5020310	R6020320	R6020325
400	IN3883	IN3893	IN3903	IN3913	R5020408	R5020410	R6020420	R6020425
500	R3020506	R3020512	R4020520	R4020530	R5020508	R5020510	R6020520	R6020525
600	R3020606	R3020612	R4020620	R4020630	R5020608	R5020610	R6020620	R6020625
800					R5020808	R5020810	R6020820	R6020825
1000					R5021008	R5021010	R6021020	R6021025
1200					R5021208	R5021210	R6021220	R6021225
1400							R6021420	R6021425
1600							R6021620	R6021625
REVERSE RECOVERY TIME	200 ns	200 ns	200 ns	200 ns	1.5 μs	1.5 μs	1.5-2 μs	1.5-2 μs
PACKAGE TYPE	DO-4	DO-4	DO-5	DO-5	DO-8	DO-8	DO-9	DO-9
PAGE NUMBER	R55	R55	R57	R57	R59	R59	R63	R63

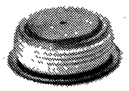
*For JEDEC Reverse Polarity Units - add suffix "R"

**For Reverse Polarity Units — R302—R303
R402—R403
R502—R503
R602—R603

R62

R72

R9G



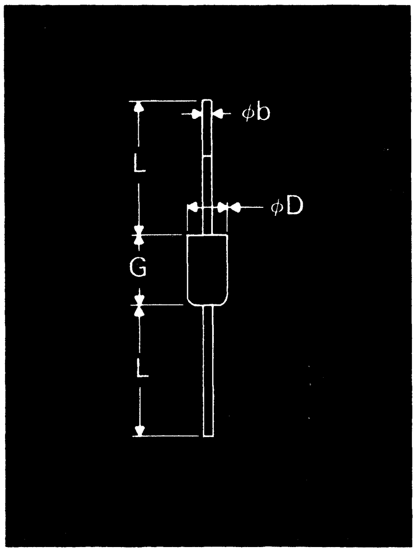
FAST RECOVERY RECTIFIERS
350 — 1400 Amperes

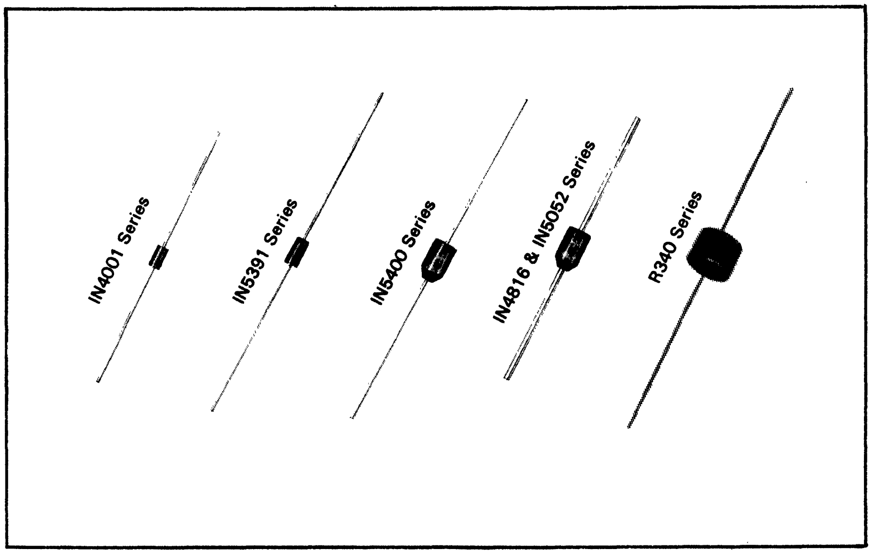
TYPE	R622..35	R622..40	R722..05	R722..06	R722..08	R9G2..09	R9G2..11	R9G2..14
AVERAGE CURRENT	350	400	500	600	800	900	1100	1400
ONE CYCLE SURGE	4500	5000	7000	9500	11,000	12000	15000	25000
VOLTAGE 100	R6220135	R6220140	R7220105	R7220106	R7220108	R9G20109	R9G20111	R9G20114
200	R6220235	R6220240	R7220205	R7220206	R7220208	R9G20209	R9G20211	R9G20214
300	R6220335	R6220340	R7220305	R7220306	R7220308	R9G20309	R9G20311	R9G20314
400	R6220435	R6220440	R7220405	R7220406	R7220408	R9G20409	R9G20411	R9G20414
500	R6220535	R6220540	R7220505	R7220506	R7220508	R9G20509	R9G20511	R9G20514
600	R6220635	R6220640	R7220605	R7220606	R7220608	R9G20609	R9G20611	R9G20614
800	R6220835	R6220840	R7220805	R7220806	R7220808	R9G20809	R9G20811	R9G20814
1000	R6221035	R6221040	R7221005	R7221006	R7221008	R9G21009	R9G21011	R9G21014
1200	R6221235	R6221240	R7221205	R7221206	R7221208	R9G21209	R9G21211	R9G21214
1400	R6221435	R6221440	R7221405	R7221606	R7221408	R9G21409	R9G21411	
1600	R6221635	R6221640	R7221605	R7221606	R7221608	R9G21609	R9G21611	
2000			R7222005•			R9G22009	R9G22011	
2400			R7222405			R9G22409	R9G22411	
2500			R7222505			R9G22509		
2600						R9G22609		
3000						R9G23009		
3200						R9G23209		
REVERSE RECOVERY TIME	1.5-2 μs	1.5-2 μs	2-5 μs	2-3 μs	2-3 μs	3-5 μs	3-5 μs	3 μs
PACKAGE TYPE	R62	R62	R72	R72	R72	R9G	R9G	R9G
PAGE NUMBER	R67	R67	R71	R71	R71	R75	R75	R75

General Purpose
RECTIFIERS

IN4001-07/IN5391-99/IN4816-22 IN5052-54/IN5400-08/R340

1-6 Amps. Avg. Up to 1000 Volts





Symbol	Conforms to DO-41				Conforms to DO-15				Conforms to DO-27			
	1N4001 Series				1N5391 Series				1N4816 & 1N5052 Series			
	Inches		Millimeters		Inches		Millimeters		Inches		Millimeters	
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
ϕb	.028	.034	.712	.863	.027	.035	.686	.889	.028	.036	.712	.914
ϕD	.080	.107	2.04	2.71	.104	.140	2.65	3.55	.190	.210	4.83	5.33
G	.160	.205	4.07	5.20	.230	.300	5.85	7.62	.285	.375	7.24	9.52
L	1.10	—	28.0	—	1.00	—	25.40	—	1.125	—	28.58	—

Symbol	Conforms to ∿ DO-27				R34 Outline			
	1N5400 Series				R340			
	Inches		Millimeters		Inches		Millimeters	
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
ϕb	.046	.056	.712	.914	.046	.056	.712	.914
ϕD	.190	.210	4.83	5.33	.360	.390	9.14	9.91
G	.285	.375	7.24	9.52	.250	.350	6.35	8.89
L	1.125	—	28.58	—	1.250	—	31.75	—

Features:
- All diffused design
- Low forward voltage drops
- Standard JEDEC outlines
- Lifetime Guarantee

Applications:
- Phase control
- Motor control
- Power supplies
- Light dimmers

1-6 Amps. Avg. Up to 1000 Volts

General Purpose RECTIFIERS

IN4001-07/IN5391-99/IN4816-22 IN5052-54/IN5400-08/R340

Ordering Information

V_{RRM} (V)	Forward Current, $I_{F(av)}$				
V	1 Amp	1.5 Amp	1.5 Amp	3 Amp	**6 Amp**
50	1N4001	1N4816	1N5391	1N5400	R3400006
100	1N4002	1N4817	1N5392	1N5401	R3400106
200	1N4003	1N4818	1N5393	1N5402	R3400206
300	···	1N4819	1N5394	1N5403	R3400306
400	1N4004	1N4820	1N5395	1N5404	R3400406
500	···	1N4821	1N5396	1N5405	R3400506
600	1N4005	1N4822	1N5397	1N5406	R3400606
700	···	1N5052	···	···	...
800	1N4006	1N5053	1N5398	1N5407	R3400806
900	···	···	···	···	...
1000	1N4007	1N5054	1N5399	1N5408	R3401006

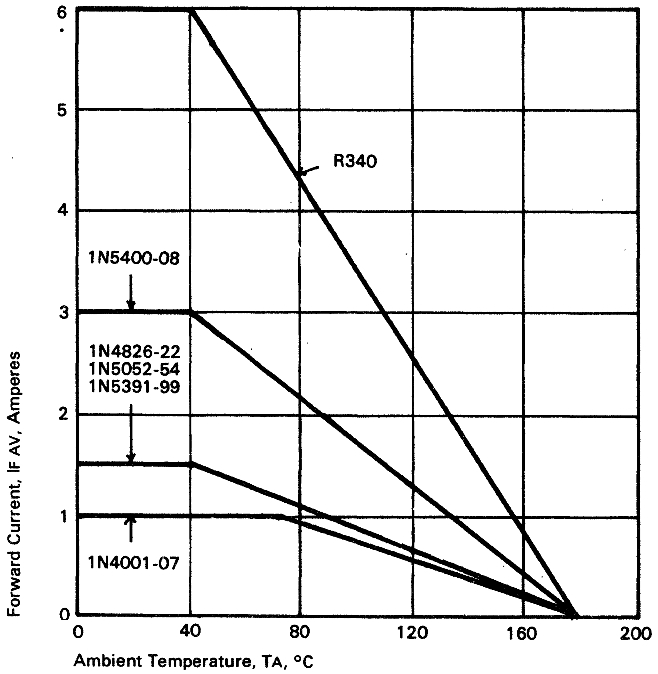
Ratings and Characteristics

All Types	Symbol											
Repetitive peak reverse voltage, V............	V_{RRM}	50	100	200	300	400	500	600	700	800	900	1000
Non-repetitive transient peak reverse voltage, ①.	V_{RSM}	100	200	300	400	525	650	800	900	1000	1100	1200

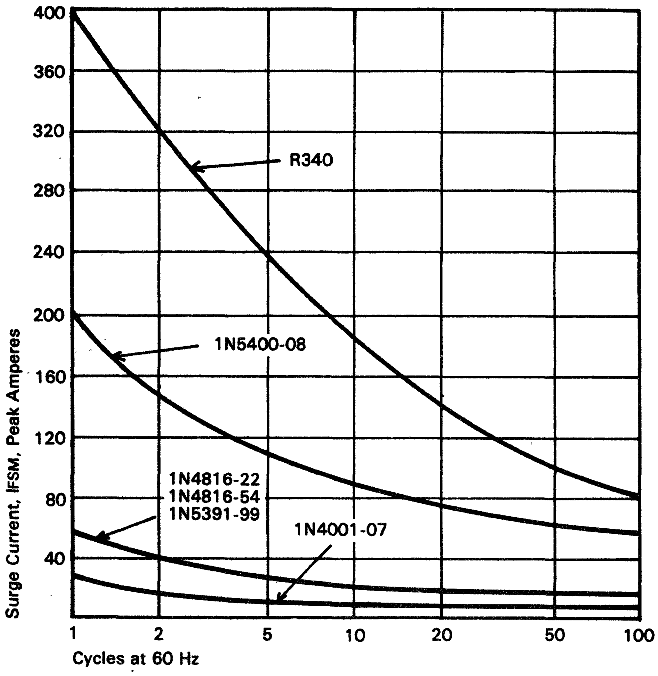
	Symbol	1N4001-07	1N4816 thru 1N5399	1N5400-08	R340 Series
Max forward current, amperes, ②	$I_{F(av)}$	1.0	1.5	3.0	6.0
Max current ratings, amperes, ②	$I_{F(av)}$	← See Graph A →			
Max ½ cycle (60 Hz) peak surge current (under load), amperes....................	I_{FSM}	30	50	200	400
Max I^2t (t<8 ms) amps²-second.............	I^2t	3.5	10	165	650
Max forward voltage drop, peak volts	V_{FM}	Graph C	Graph D	Graph E	Graph F
Max peak reverse current at rated V_{RRM}, μa					
T_A= 25°C........................	I_{RRM}	10	10	10	50
T_A=150°C........................	I_{RRM}	300	300	500	500
Max operating ambient and storage temp......	T_A & T_{stg}	← T_A=−65°C to +175°C, T_{stg}=−65° to +175°C →			

① Non-recurrent, 8.3 millisecond maximum duration ½ sine wave pulse, T_J=0° to 175°C.

Graph A—Maximum allowable forward current versus ambient temperature for resistive load (derate 20% for capacitive load).



Graph B—Maximum allowable peak current versus surge time starting from maximum rated load.

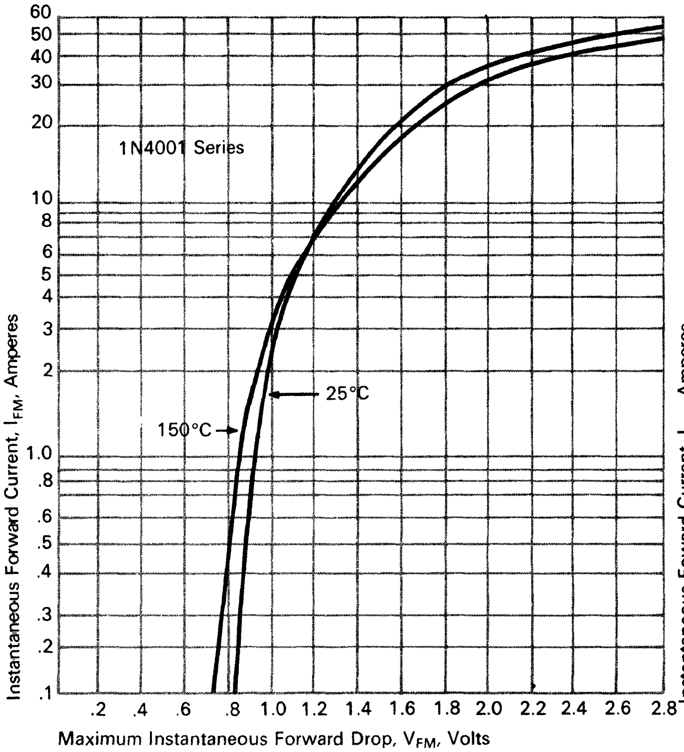


General Purpose RECTIFIERS

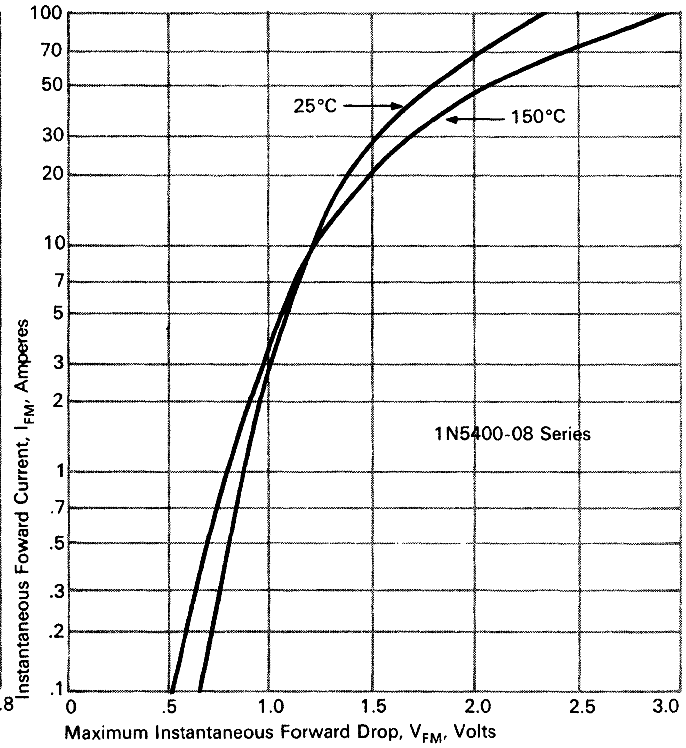
IN4001-07/IN5391-99/IN4816-22
IN5052-54/IN5400-08/R340

**1-6 Amps. Avg.
Up to 1000 Volts**

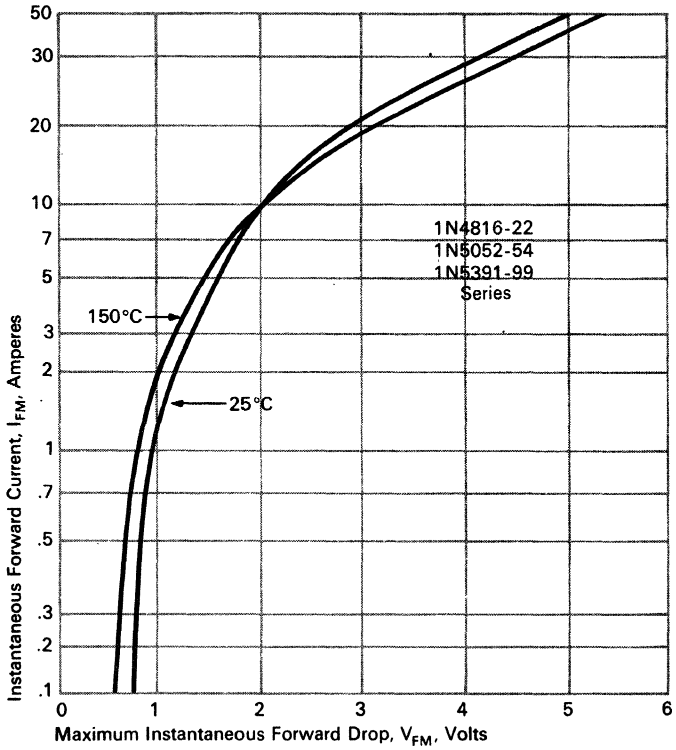
Graph C—Maximum forward voltage drop of a single diode at 25°C and 150°C junction temperature.



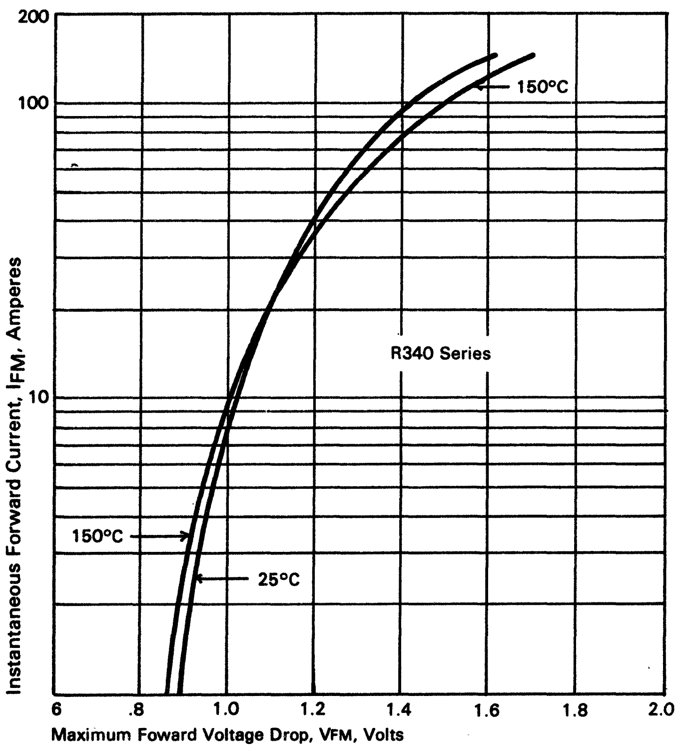
Graph D—Maximum forward voltage drop of a single diode at 25°C and 150°C junction temperature.



Graph E—Maximum forward voltage drop of a single diode at 25°C and 150°C junction temperatures.



Graph F—Maximum forward voltage drop of a single diode at 25°C and 150°C junction temperature.



How To Determine The Operating Junction Temperature of The Lead Mount Rectifier

When using a lead mounted rectifier as with all semiconductors, the maximum junction temperature should never be exceeded. The derating curves shown in graph A are the maximum currents at specified ambient temperatures when the lead mount is terminated in a heat sink within ½ inch of the body. When the lead mounted rectifier is terminated on a terminal strip, printed circuit board or is mounted in an enclosed area, the rectifier could be operating above or below the maximum junction temperature because of the heat sinking area.

To calculate the operating junction temperature, a lead temperature measurement must be made. First a thermocouple is soldered to the lead. A small amount of solder should be used, since excess solder will add to the area of the lead and will give erroneous readings. The thermocouple should be soldered 0.2 inch from the body of the rectifier. Excessive temperature and excessive time should be avoided when soldering to the rectifier lead.

Then the lead mount is operated at the maximum current encountered in the application and the lead temperature is stabilized. The temperature, forward voltage drop and current are recorded. The junction temperature is then calculated using the following formmula:

$$T_J = (T_A - T_{AO}) + T_L + (R_{\theta JL} \times P)$$

where T_J = Junction Temperature

T_A = Highest ambient temperature to be encountered in the application.

T_{AO} = The operating ambient temperature at which the lead temperature was measured.

T_L = Measured lead temperature

$R_{\theta JL}$ = The value obtained from Graph G for thermal resistance junction to lead at 0.2 inch from the body.

P = The average power calculated from the current and voltage readings.

If the lead temperature is measured at the maximum operating ambient temperature, the formula for calculating the junction temperature reduces to:

$$T_J = T_L + (R_{\theta JL} \times P)$$

Example:

The R340 lead mount rectifier is mounted on a printed circuit board to one inch square copper pads on each lead. The leads were ½" measured from the body of the rectifier to the printed circuit board. All measurements are made in accordance with EIA standard RS-282. The following was measured.

I = 6A Avg.
$V_{F(av)}$ = 1.1V
P = 6.5W
T_L = 123°C
T_A = T_{AO} =25°C
$R_{\theta JL}$ = 9°C/W (From Graph G)

The junction temperature can be calculated as follows:

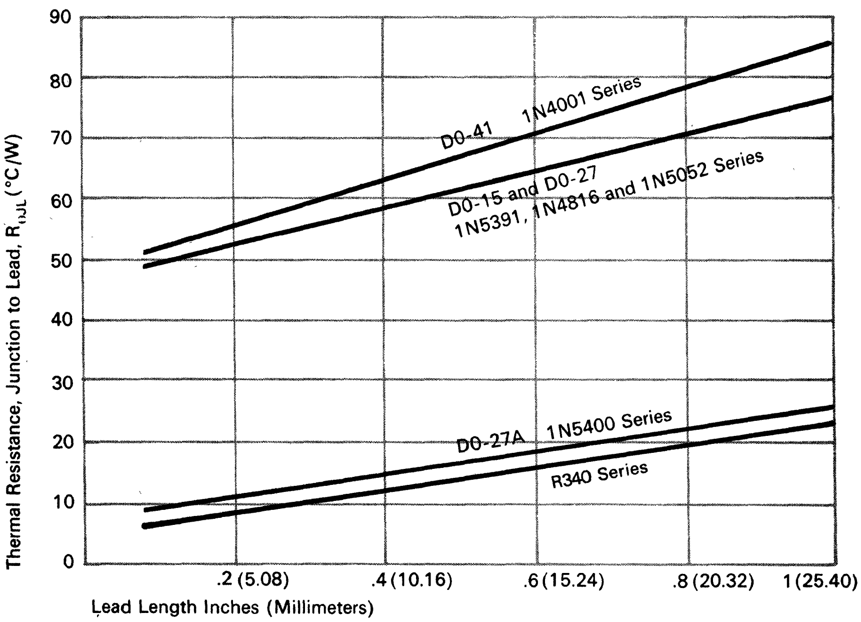
$$T_J = T_L + (R_{\theta JL} \times P)$$
$$= 123 + (9 \times 6.5)$$
$$= 181.5°C$$

This example shows that one inch square pads on each lead is not sufficient since the junction temperature exceeds the 175°C maximum. This junction temperature can be reduced by increasing the copper pads, by reducing the length of the leads or by increasing the air flow.

To take full advantage of the thermal transfer capabilities offered by the leads of lead mounted devices, the following are important points to remember:

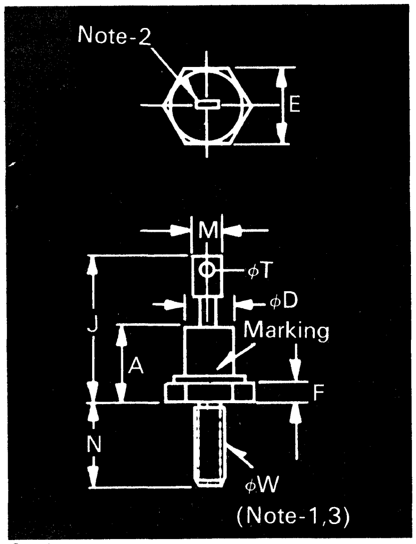
- Avoid placing semiconductor devices which produce heat in locations where air circulation is restricted.
- Place heat-producing devices on top of a chassis, instead of below, and preferably on one that is vertically mounted.
- A 35-mil lead provides approximately 0.1 square inch of radiating surface per inch of length. For this reason one should not trim off needed cooling capacity.
- Terminal posts and mounting brackets frequently provide more cooling area than the device lead. If possible, take advantage of the cooling offered by terminals and mounting brackets. Mount heat-producing devices close to terminals or brackets.
- Check the ambient temperature inside cabinets. If it is excessive, install a fan: forced air can reduce thermal resistance by as much as 500 per cent.

Graph G—Steady State Thermal Resistance Junction to Lead vs Lead Length



General Purpose Rectifiers R310/R311/JEDEC Types

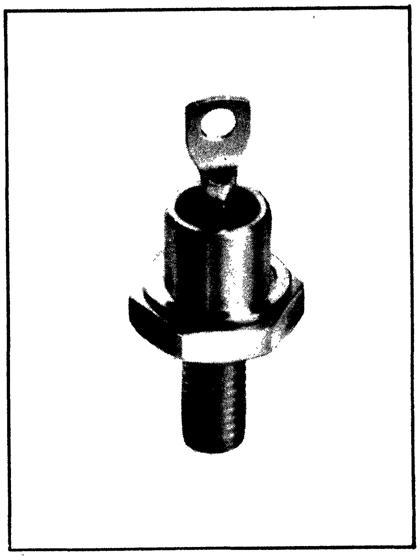
3—16 A. Avg. Up to 1000 Volts



Conforms to DO-4 Outline

Symbol	Inches Min.	Inches Max.	Millimeters Min.	Millimeters Max.
A		.405		10.29
ϕD		.424		10.77
E	.424	.437	10.77	11.10
F	.075	.175	1.91	4.45
J		.800		20.32
M		.250		6.35
N	.422	.453	10.72	11.51
ϕT	.060	.105	1.52	2.67
ϕW	10-32 UNF-2A			

Glass to Metal Seal—
Creepage & Strike Distance = .07 in. min. (1.75 mm)
(In accordance with NEMA standards.)
Finish—Nickel Plate.
Approx. Weight—.2 oz (6g)
R310—Standard Polarity—Gray Glass
R311—Reverse Polarity—Yellow Glass.



Matrix Key Letter	A	B	C	D	E	F	G	H	I
Current $I_F(AV)$ @T_C, °C	3 @150°	5 @150°	6 @150°	6 @150°	6 @150°	12 @150°	12 @150°	12 @150°	16 @150°
I_{FSM}	40	150	150	150	160	240	240	250	300
I^2t for Fusing	6	90	90	90	105	240	240	260	375
V_{FM}@$I_F(AV)$ & 25°C	1.5	1.5	1.4	1.4	1.2	1.8	1.3	1.2	1.2
$R_{\theta JC}$	5.0	3.0	3.0	3.0	3.0	2.0	2.0	2.0	1.0
T_J (Oper) Range	−65 to 175	−65 to 175	−65 to 190	−65 to 200	−65 to 200	−65 to 190	−65 to 200	−65 to 200	−65 to 200
T_{stg} Range	−65 to 175	−65 to 200	−65 to 200	−65 to 200	−65 to 200	−65 to 200	−65 to 200	−65 to 200	−65 to 200
Voltage–V_{RRM}									
50	1N1581	1N1612	1N1341	1N1341A	1N1341B	1N1199	1N1199A	1N1199B	1N3615
100	1N1582	1N1613	1N1342	1N1342A	1N1342B	1N1200	1N1200A	1N1200B	1N3616
150			1N1343	1N1343A	1N1343B	1N1201	1N1201A	1N1201B	1N3617
200	1N1583	1N1614	1N1344	1N1344A	1N1344B	1N1202	1N1202A	1N1202B	1N3618
300	1N1584		1N1345	1N1345A	1N1345B	1N1203	1N1203A	1N1203B	1N3619
400	1N1585	1N1615	1N1346	1N1346A	1N1346B	1N1204	1N1204A	1N1204B	1N3620
500	1N1586		1N1347	1N1347A	1N1347B	1N1205	1N1205A	1N1205B	1N3621
600	1N1587	1N1616	1N1348	1N1348A	1N1348B	1N1206	1N1206A	1N1206B	1N3622
700				1N3987		1N3670	1N3670A		
800		1N4458		1N3988		1N3671	1N3671A		1N3623
900				1N3989		1N3672	1N3672A		
1000		1N4459		1N3990		1N3673	1N3673A		1N3624
IRRM @ 25°C	← 200 μA →								
IRRM @ 175°C	← 3Ma →								

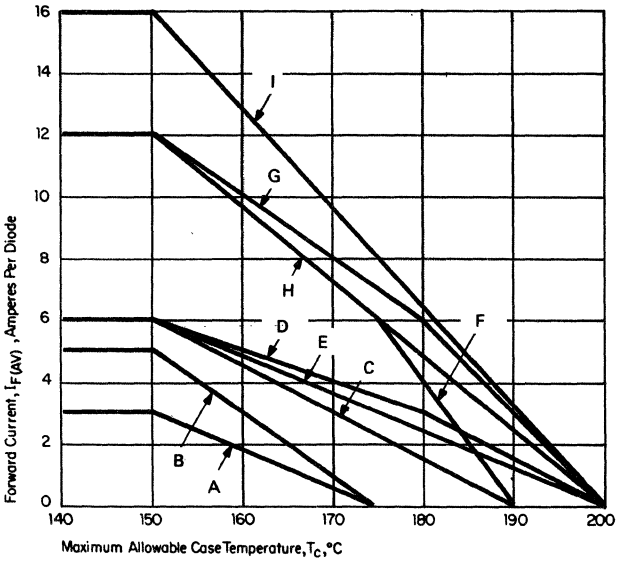
Features:
- Diffused junction
- Low leakage current
- Lifetime Guarantee

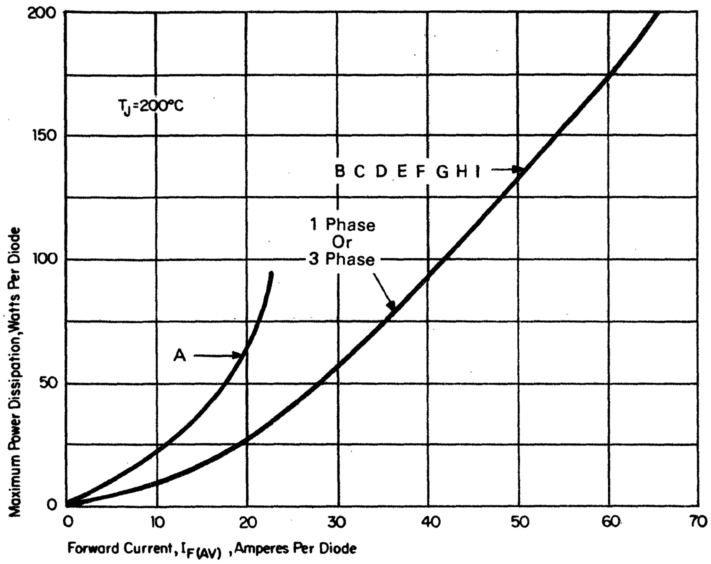
Applications:
- Power Supplies
- DC to DC Converters
- Battery Chargers
- Machine Tool Controls

NOTES:
1. Complete threads to extend to within 2½ threads of seating plane.
2. Angular orientation of this terminal is undefined.
3. 10-32 UNF-2A maximum pitch diameter of plated threads shall be basic pitch diameter (.1697″, 4.29 mm) Ref. (Screw thread standards for federal services 1957) Handbook H28 P1.

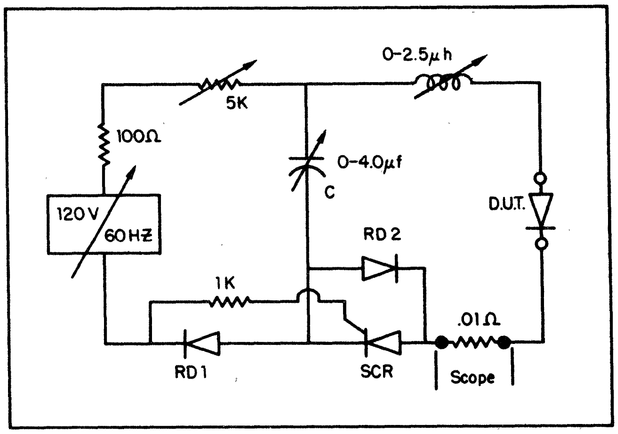
3—16 A. Avg. Up to 1000 Volts

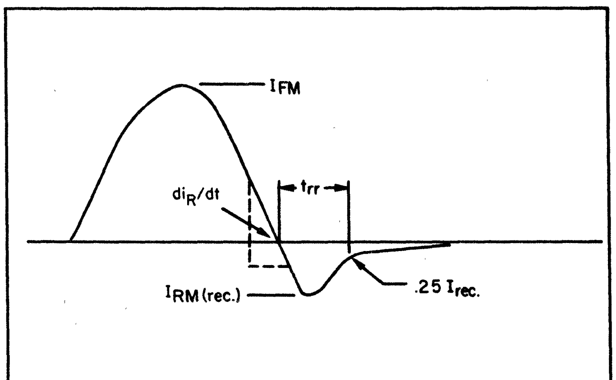
General Purpose Rectifiers R310/R311/JEDEC Types





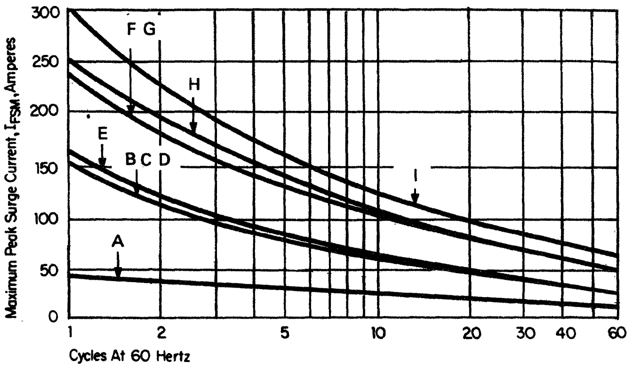
JEDEC Circuit





Recovery Time Waveform

Non Repetitive Surge Current Versus Time

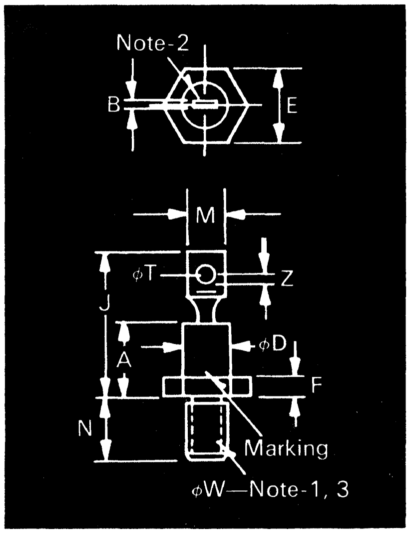


Typical Recovery Time Ranges

Westing-house Device Family	JEDEC Circuit Test Conditions	Typical t_{rr}
R310, R311	I_{FM} =36 A, diR/dt=25 A/μs	1-2 μs

General Purpose Rectifiers R410/R411/JEDEC Types

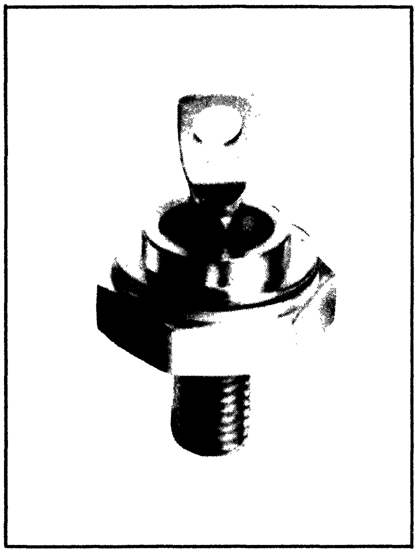
15—40 A. Avg. Up to 1000 Volts



Conforms to DO-5 Outline

Symbol	Inches Min.	Inches Max.	Millimeters Min.	Millimeters Max.
A		.450		11.43
B		.080		2.03
φD		.667		16.94
E	.667	.687	16.94	17.45
F	.060	.200	1.52	5.08
J		1.000		25.40
M		.375		9.53
N	.422	.453	10.72	11.51
φT	.140	.175	3.56	4.45
Z	.156		3.96	
φW	¼-28 UNF-2A			

Glass To Metal Seal—
Creepage & Strike Distance = .09 in. min. (2.46 mm)
(In accordance with NEMA standards.)
Finish—Nickel Plate.
Approx. Weight—.6 oz (18g)
R410—Standard Polarity—Gray Glass
R411—Reverse Polarity—Yellow



Matrix Key Letter	A	B	C	D	E	F	G	H	I
Current $I_F(AV)$ @T_C, °C	15 @150°	18 @150°	20 @150°	20 @150°	20 @150°	22 @150°	25 @145°	35 @140°	40 @150°
I_{FSM}	250	220	350	350	350	500	400	500	800
I^2t for Fusing	260	200	510	510	510	1050	675	1050	2600
V_{FM}@$I_F(AV)$ & 25°C	1.5	2.35	1.5	1.5	1.2	2.0	1.8	1.7	1.2
$R_{\theta JC}$	2.0	1.5	2.0	2.0	1.5	1.5	1.5	1.0	1.0
T_J (Oper) Range	−65 to 175	−65 to 175	−65 to 175	−65 to 175	−65 to 175	−55 to 200	−65 to 200	−55 to 200	−55 to 200
T_{stg} Range	−65 to 175	−65 to 175	−65 to 175	−65 to 175	−65 to 175	−65 to 200	−65 to 200	−65 to 200	−65 to 200

Voltage—V_{RRM}	A	B	C	D	E	F	G	H	I
50	**1N3208**	1N1191	1N248A	1N248B	1N248C	**1N1191A**	1N2154	**1N1183**	**1N1183A**
100	**1N3209**	1N1192	1N249A	1N249B	1N249C	**1N1192A**	1N2155	**1N1184**	**1N1184A**
150		1N1193				1N1193A		1N1185	1N1185A
200	**1N3210**	1N1194	1N250A	1N250B	1N250C	**1N1194A**	1N2156	**1N1186**	**1N1186A**
300	1N3211	1N1195				1N1195A	1N2157	1N1187	1N1187A
400	**1N3212**	1N1196				**1N1196A**	1N2158	**1N1188**	**1N1188A**
500	1N3213	1N1197				1N1197A	1N2159	1N1189	1N1189A
600	**1N3214**	1N1198				**1N1198A**	1N2160	**1N1190**	**1N1190A**
700								1N3765	
800						**R4100822**		**1N3766**	R4100840
900								1N3767	
1000						**R4101022**		**1N3768**	R4101040
I_{RRM} @ 25°	← 100μA →								
I_{RRM} @ 190°C	← 5.0 mA →								

NOTES:
1. Complete threads to extend to within 2½ threads of seating plane.
2. Angular orientation of this terminal is undefined.
3. ¼-28 UNF-2A. Maximum pitch diameter of plated threads shall be basic pitch diameter (.2268", 5.74 mm) Ref. (Screw thread standards for federal services 1957) Handbook H28 1957 P1.

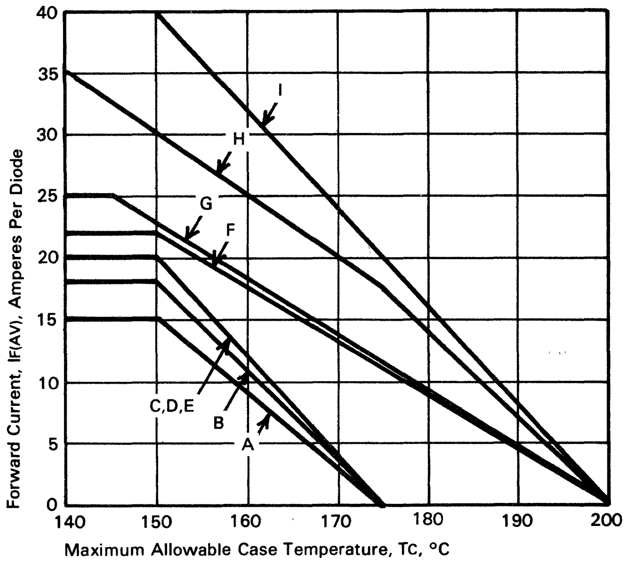
Features:
- Diffused Junction
- Low Leakage Current
- Low VF
- Lifetime Guarantee

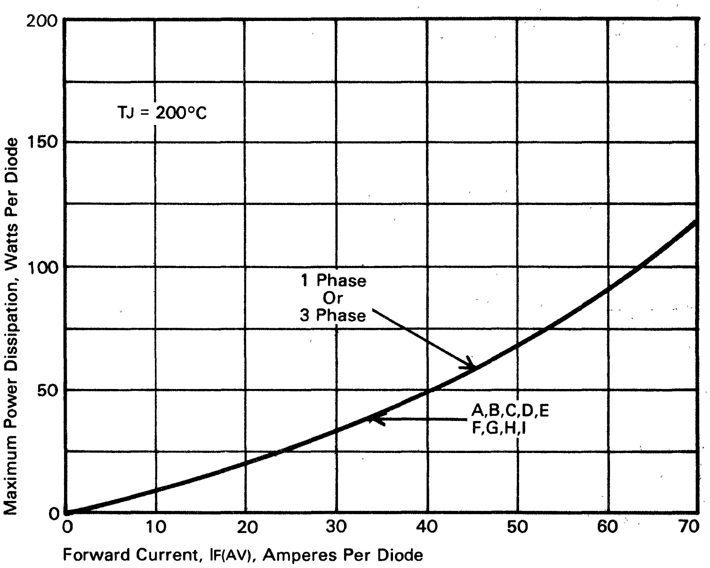
Applications:
- Power Supplies
- DC to DC Converters
- Battery Chargers
- Magnetic Amplifiers

For JEDEC Reverse Polarity Add Suffix R, i.e., IN1191AR.

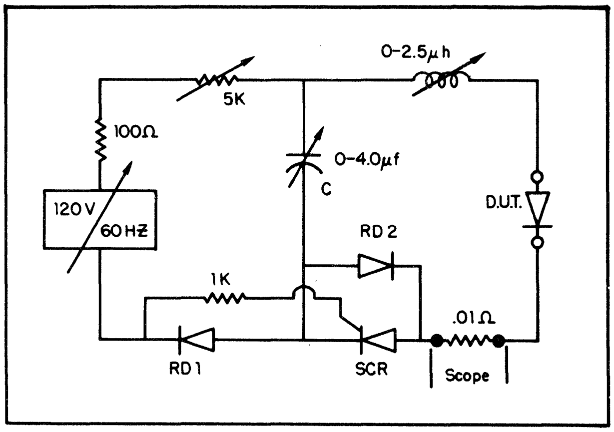
15—40 A. Avg. Up to 1000 Volts

General Purpose Rectifiers R410/R411/JEDEC Types

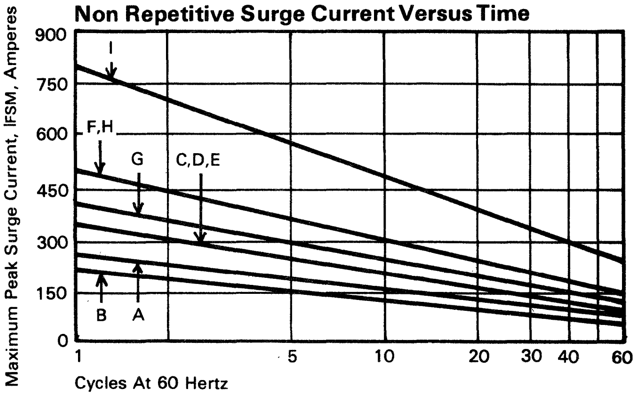


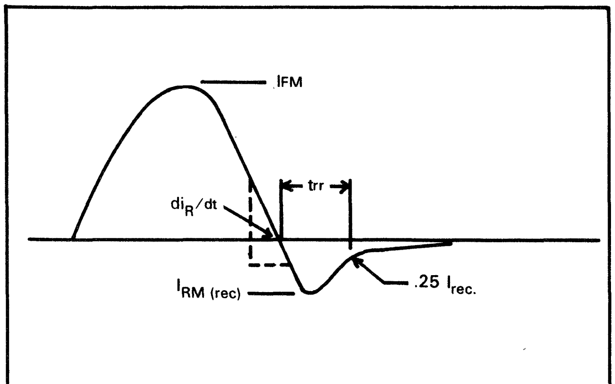


JEDEC Circuit



Non Repetitive Surge Current Versus Time





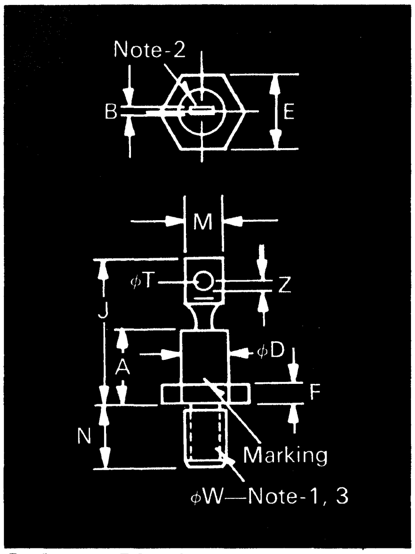
Recovery Time Waveform

Typical Recovery Time Ranges

Westinghouse Device Family	Test conditions	Typical trr
R410, R411	I_{FM} = 100 A, di_R/dt = 25 A/μs	2-4μs

General Purpose Rectifier R404/R405

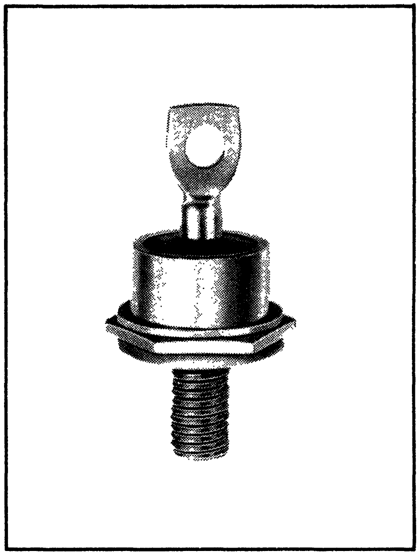
60 and 70 Amperes Up to 1000 Volts



Conforms to DO-5 Outline

Symbol	Inches Min.	Inches Max.	Millimeters Min.	Millimeters Max.
A		.450		11.43
B		.080		2.03
ϕD		.667		16.94
E	.667	.687	16.94	17.45
F	.060	.200	1.52	5.08
J		1.000		25.40
M		.375		9.53
N	.422	.453	10.72	11.51
ϕT	.140	.175	3.56	4.45
Z	.156		3.96	
ϕW	¼-28 UNF-2A			

Glass To Metal Seal—
Creepage & Strike Distance = .09 in. min. (2.46 mm)
(In accordance with NEMA standards.)
Finish—Nickel Plate.
Approx. Weight—.6 oz (18g)
R404, —Standard Polarity— Gray Glass
R405, —Reverse Polarity— Yellow Glass



NOTES:
1. Complete threads to extend to within 2½ threads of seating plane.
2. Angular orientation of this terminal is undefined.
3. ¼-28 UNF-2A. Maximum pitch diameter of plated threads shall be basic pitch diameter (.2268", 5.74 mm) Ref. (Screw thread standards for federal services 1957) Handbook H28 1957 P1.

Features:
- Copper base package
- Hard solder construction
- Proven reliability in aircraft applications
- Specially designed for cyclic loading and rotating applications

Applications:
- Aircraft power systems
- Communications equipment
- High reliability power supplies
- Motor controls

Ordering Information

Type	Voltage		Current	
Code	VRRM (V)	Code	IF(AV) (A)	Code
R404 (Std. Polarity)	50	00	60	60
	100	01		
	200	02		
	300	03		
	400	04		
R405	500	05	70	70
	600	06		
	800	08		
(Rev. Polarity)	1000	10		

Parameter	R404__60	R404__70
Current I_F (AV) @T_C, °C	60A @130	70A @130
I_{FSM}	1000 A	1200 A
I^2t for Fusing	4160 A^2sec	5600 A^2sec
V_{FM} @$I_{F(AV)}$ & 25°C	1.7 V	1.7 V
I_{RRM}@ 190°C	5MA	5MA
$R_{\theta JC}$	0.75°C/W	0.65°C/W
T_J (Oper) Range	—65 to 200°C	—65 to 200°C
T_{stg} Range	—65 to 200°C	—65 to 200°C

Example

Obtain optimum device performance for your application by selecting proper Order Code.

TYPE R404, forward polarity, rated at 70A average with V_{RRM} = 400V, order as:

Type				Voltage		Current	
R	4	0	4	0	4	7	0

60 and 70 Amperes Up to 1000 Volts

General Purpose Rectifier R404/R405

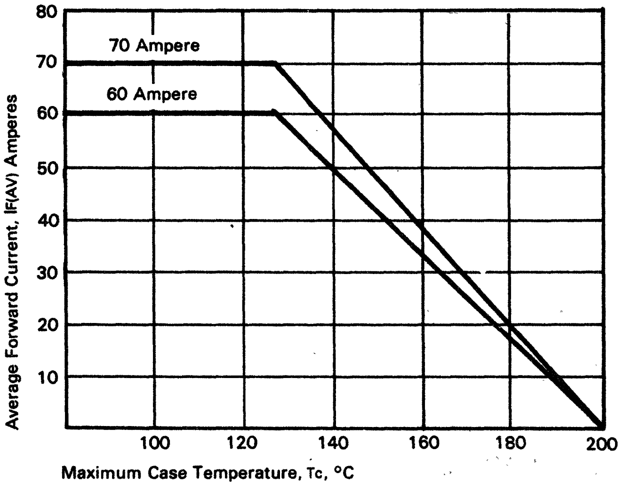
Voltage

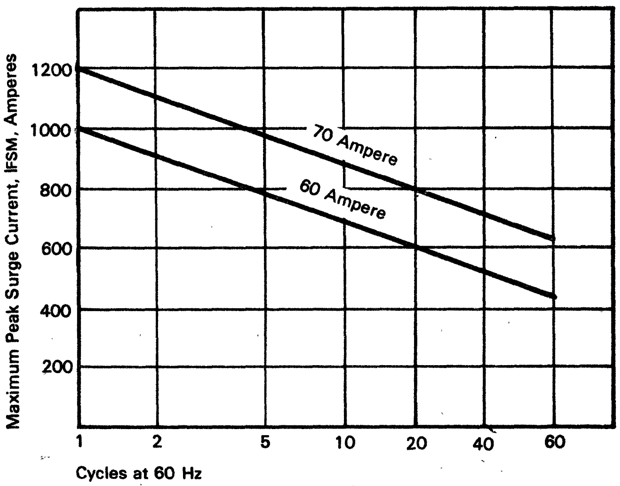
Blocking State Maximums	Symbol									
Repetitive peak reverse voltage, V	V_{RRM}	50	100	200	300	400	500	600	800	1000
Non-repetitive transient peak reverse voltage, voltage t_p<5.0 msec. V	V_{RSM}	100	150	300	400	500	600	700	900	1100
Reverse leakage current, mA peak, 25 °C.......	I_{RRM}	← 100 µA →								

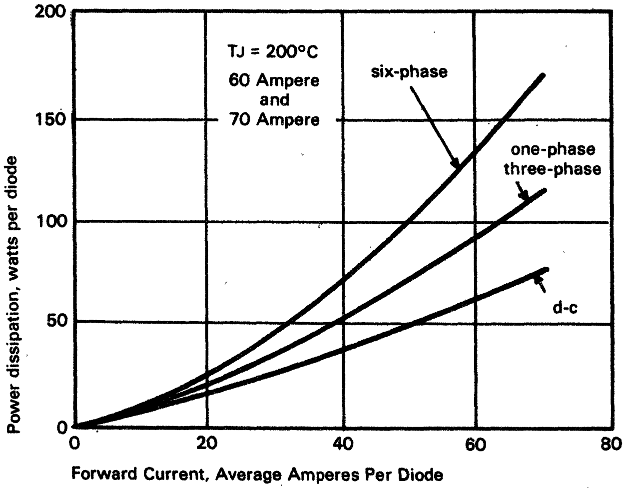
Typical Recovery Time Range

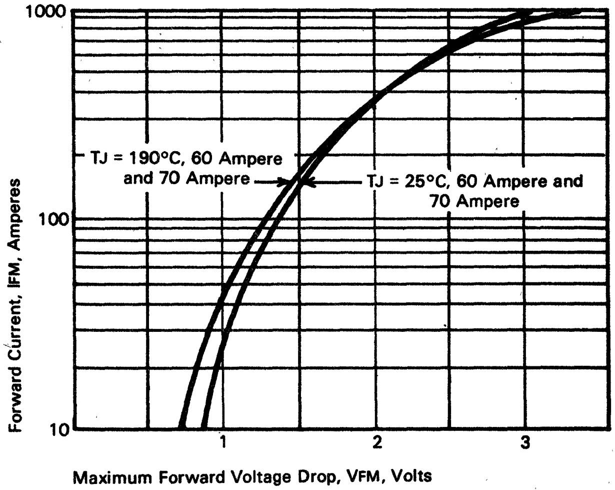
Test Conditions: JEDEC Circuit

I_{FM} = 100 A, di_R/dt = 25A/µs t_{rr} = 2-4 µs





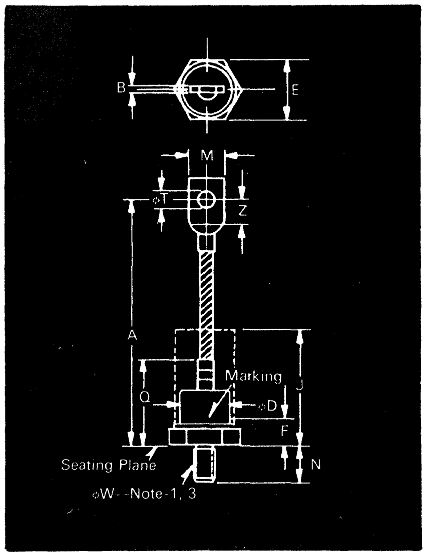




RECTIFIER

General Purpose Rectifiers IN3288A, AR - 97A, AR

100 A. Avg. Up to 1400 Volts



Conforms to DO-8 Outline

Symbol	Inches Min.	Inches Max.	Millimeters Min.	Millimeters Max.
A	4.18	4.62	106.17	117.35
B	.050	.100	1.27	2.54
ϕD	.860	1.000	21.84	25.40
E	1.031	1.063	26.19	27.00
F	.255	.400	6.48	10.16
J	2.50		63.50	
M	.437	.650	11.10	16.51
N	.605	.645	15.37	16.38
Q		1.675		42.54
ϕT	.250	.291	6.35	7.39
Z	.310		7.87	
ϕW	⅜-24 UNF-2A			

Creep & Strike—Distance:
Ceramic Seal—.66 in. min. (16.94 mm).
Glass Seal —.16 in. min. (4.11 mm).
(In accordance with NEMA standards.)
Finish—Nickel Plate.
Approx. Weight—3.5 oz (99g)
Standard Polarity—White Ceramic
Reverse Polarity—Pink Ceramic
Standard Polarity—Gray Glass
Reverse Polarity—Yellow Glass

1. Complete threads to extend to within 2½ threads of seating plane.
2. Angular orientation of terminal is undefined.
3. Pitch diameter of ⅜-24 UNF-2A (coated) threads (ASA B1.1-1960).
4. Dimension "J" denotes seated height with lead bent at right angle.

Maximum Ratings and Characteristics
Blocking State (T_J = 200°C)

• **Available as JAN types**

	Symbol	1N3288A	•1N3289A	1N3290A	•1N3291A	1N3292B	1N3293A	•1N3294A	•1N3295A	1N3296A ④	•1N3297A ④
		JEDEC Number ①③									
* Repetitive Peak Reverse Voltage, Volts	V_{RRM}	100	200	300	400	500	600	800	1000	1200	1400
* Non-repetitive Peak Reverse Voltage, Volts	V_{RSM}	200	300	400	525	650	800	1050	1300	1600	1800
* Max. Allowable d-c Blocking Voltage, Volts	V_R	100	200	300	400	500	600	800	1000	1200	1400
* Max. Peak Reverse Current at Rated V_{RRM} 100 Amperes Avg. Forward Current, Single Phase @ T_C = 130°C, ma	I_{RRM}	24	24	24	24	21	17	13	11	9	7

Conducting State (T_J = 200°C)		All Types
* Max. (fca) ②, Forward Current @ T_C = 130°C, Amperes	$I_{F(AV)}$	100
RMS Forward Current, Amps	$I_{F(RMS)}$	160
* Max. Peak ½ Cycle Surge Current (at 60 Hz) (Under Load), Amps	I_{FSM}	2,300
I^2t for Fusing (at 60 Hz Half-Wave), Amps²—Sec	I^2t	22,000
* Max. Forward Voltage Drop @ 100 Amperes Average, T_C = 130°C, Peak Volts	V_{FM}	1.5
Thermal Characteristics		
* Oper. Junction Temp. Range, °C	T_J	−40 ③ to +200
* Storage Temperature Range, °C	T_{stg}	−40 ③ to +200
Max. Thermal Resistance, °C/Watt		
* Junction to Case	$R_{\theta JC}$	.40
Case to Sink, Lubricated Mounting Surface	$R_{\theta CS}$	.15

Mounting: Recommended stud mounting torque, 120 in.-lbs. lubricated.
Consult recommended mounting procedures.

① Order reverse polarity units by designating R.
② Full cycle average measured with DC meter.
③ Ceramic package available.
④ Ceramic seal supplied

*** JEDEC Registered Parameters.**

100 A. Avg. Up to 1400 Volts

General Purpose Rectifiers IN3288A, AR - 97A, AR

RECTIFIER

Electrical Characteristics

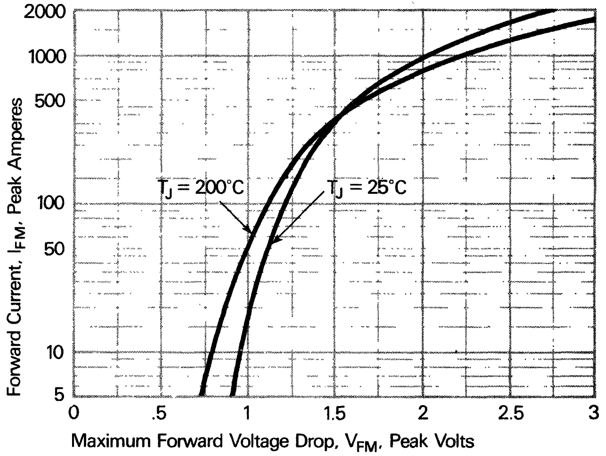


Figure 1. Forward Current vs. Forward Voltage.

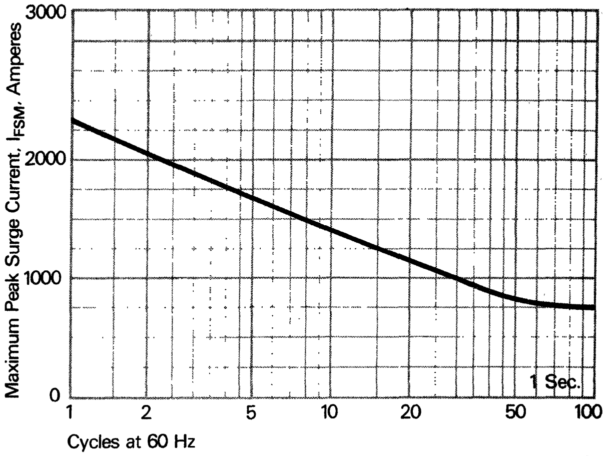


Figure 2. Maximum allowable surge current at rated load conditions.

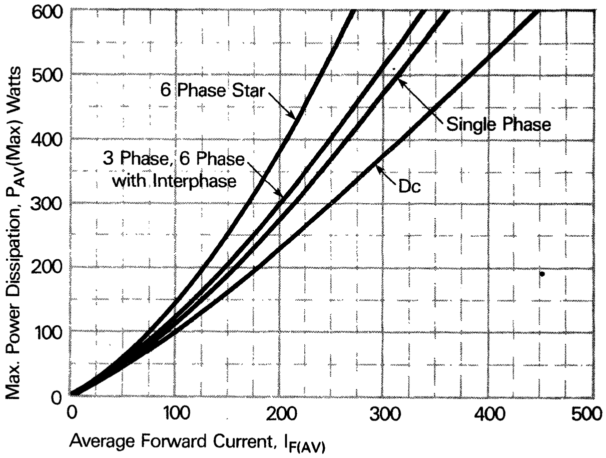


Figure 3. Power dissipation vs. Average forward current.

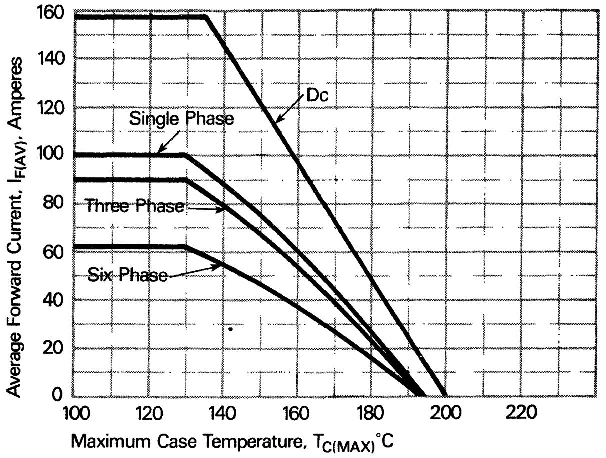


Figure 4. Forward Current vs. Case Temperature.

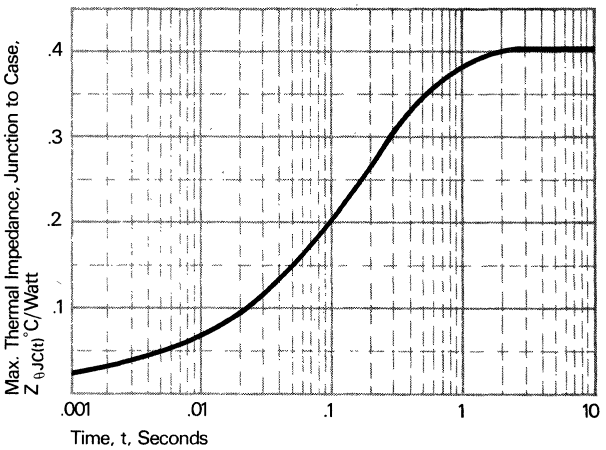


Figure 5. Transient thermal impedance vs. time.

Features:

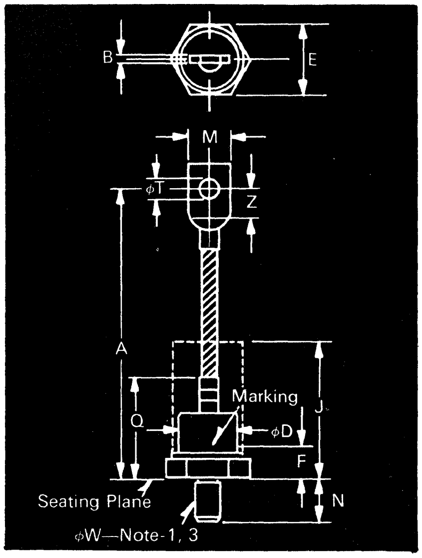
- Standard and Reverse Polarities with Color Coded Seals.
- High Surge Current Ratings.
- Electrical Selection for Parallel and Series Operation.
- Compression Bonded Encapsulation.
- Lifetime Guarantee

Applications:

- Welders.
- Battery Chargers.
- Electrochemical Refining.
- Metal Reduction.
- General Industrial High Current Rectification.

General Purpose Rectifiers IN4587,R - 96, R

150 A. Avg. Up to 1400 Volts



Conforms to DO-8 Outline

Symbol	Inches Min.	Inches Max.	Millimeters Min.	Millimeters Max.
A	4.18	4.62	106.17	117.35
B	.050	.100	1.27	2.54
φD	.860	1.000	21.84	25.40
E	1.031	1.063	26.19	27.00
F	.255	.400	6.48	10.16
J	2.50		63.50	
M	.437	.650	11.10	16.51
N	.605	.645	15.37	16.38
Q		1.675		42.54
φT	.250	.291	6.35	7.39
Z	.310		7.87	
φW	⅜-24 UNF-2A			

Creep & Strike—Distance:
.66 in. min. (16.94 mm). , Ceramic
.16 in. min. (4.11 mm). , Glass
(In accordance with NEMA standards.)
Finish—Nickel Plate.
Approx. Weight—3.5 oz (99g)
Standard Polarity—White Ceramic
Reverse Polarity—Pink Ceramic
Standard Polarity—Gray Glass
Reverse Polarity—Yellow Glass

1. Complete threads to extend to within 2½ threads of seating plane.
2. Angular orientation of terminal is undefined.
3. Pitch diameter of ⅜-24 UNF-2A (coated) threads (ASA B1.1-1960).
4. Dimension "J" denotes seated height with lead bent at right angle.

	Symbol	JEDEC Number① ③ 1N4587	1N4588	1N4589	1N4590	1N4591	1N4592	1N4593	1N4594	• 1N4595	• 1N4596
* Repetitive Peak Reverse Voltage, Volts	V_{RRM}	100	200	300	400	500	600	800	1000	1200	1400
* Non-repetitive Peak Reverse Voltage, Volts	V_{RSM}	200	300	400	525	650	800	1050	1300	1600	1800
* Max. Allowable d-c Blocking Voltage, Volts	V_R	100	200	300	400	500	600	800	1000	1200	1400
* Max. (fca) ②, Reverse Current at Rated V_{RRM} 150 Amperes Avg. Forward Current, Single Phase @ T_C = 110°C, ma	$I_{R(AV)}$	9.5	9.5	9.0	9.0	8.0	6.5	5.5	4.5	4.0	3.5

Conducting State (T_J = 200°C)		All Types
* Max. (fca) ②, Forward Current @ T_C 110°C, Amperes	$I_{F(AV)}$	150
RMS Forward Current, Amps	$I_{F(RMS)}$	236
* Max. Peak ½ Cycle Surge Current (at 60 Hz) (Under Load), Amps	I_{FSM}	3,000
I^2t for Fusing (at 60 Hz Half-Wave), Amps²—Sec	I^2t	37,200
* Max. Forward Voltage Drop @ 150 Amperes Average, T_C = 110°C, Peak Volts	V_{FM}	1.35
Thermal Characteristics		
* Oper. Junction Temp. Range, °C	T_J	−65 to +200
* Storage Temperature Range, °C	T_{stg}	−65 to +200
Max. Thermal Resistance, °C/Watt		
Junction to Case	$R_{\theta JC}$	.35
Case to Sink, Lubricated Mounting Surface	$R_{\theta CS}$	.15

*** JEDEC Registered parameters.**

• **Ceramic Seal Supplied**

Mounting: **Recommended stud mounting torque, 120 in.-lbs. lubricated.**

Consult recommended mounting procedures.

① Order reverse polarity units by designating R.
② Full cycle average measured with DC meter.
③ Ceramic package available.

150 A. Avg. Up to 1400 Volts

General Purpose Rectifiers IN4587,R - 96, R

Electrical Characteristics

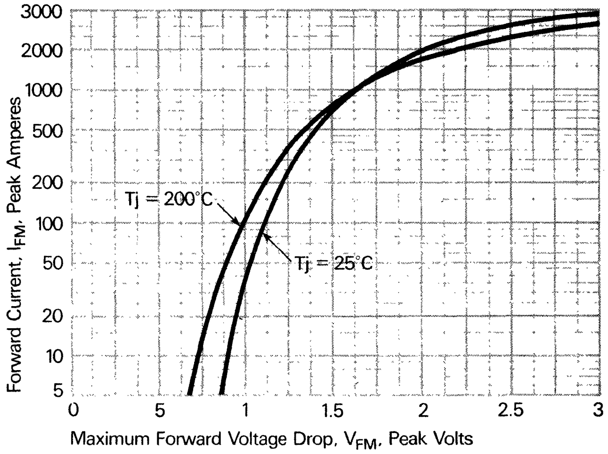


Figure 1. Forward current vs. Forward voltage.

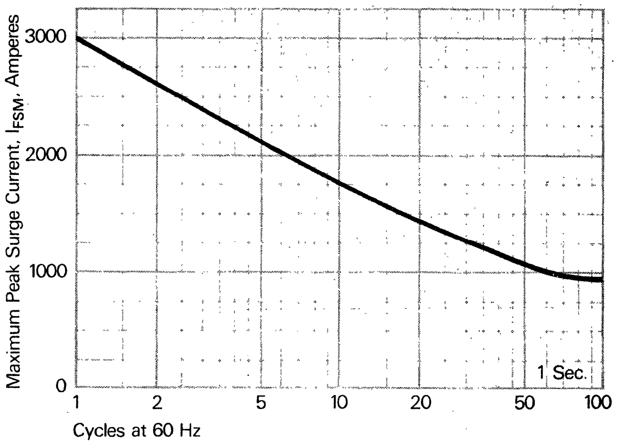


Figure 2. Maximum allowable surge current at rated load conditions.

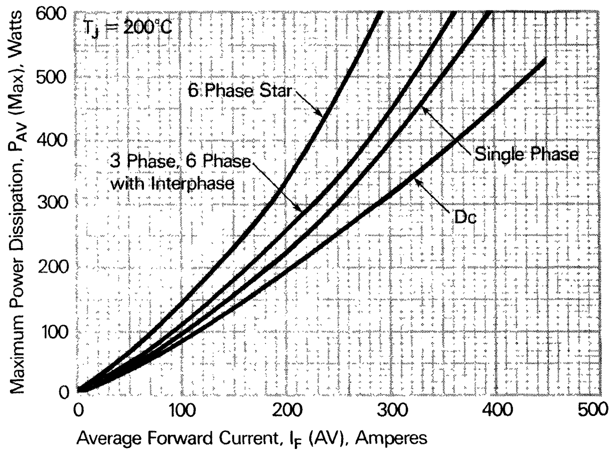


Figure 3. Power dissipation vs. Average forward current.

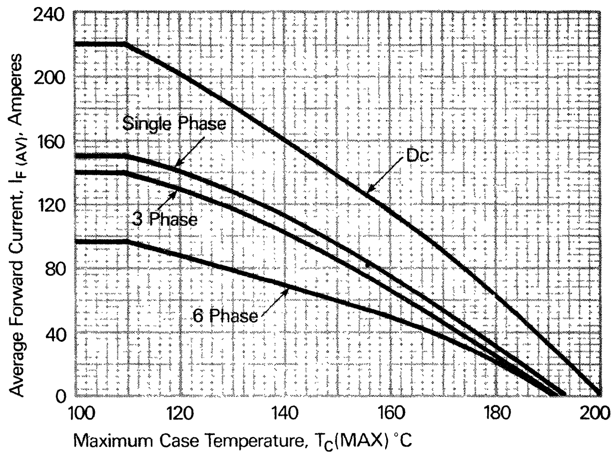


Figure 4. Forward current vs. Case temperature.

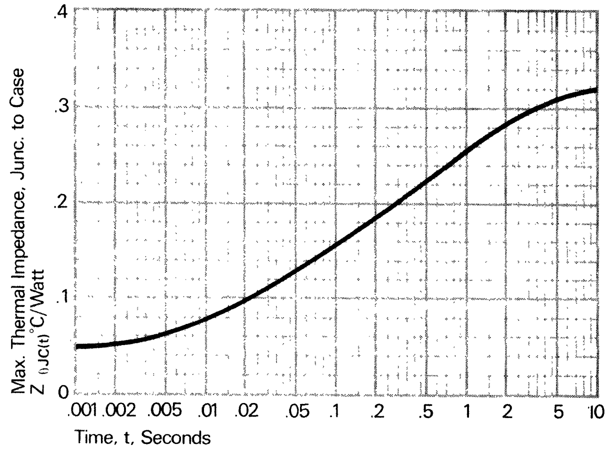


Figure 5. Transient thermal impedance vs. time.

Features:

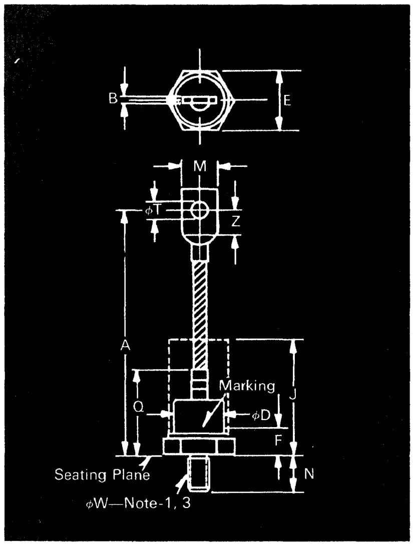
- Standard and Reverse Polarities with Color Coded Seals.
- High Surge Current Ratings.
- Electrical Selection for Parallel and Series Operation.
- Compression Bonded Encapsulation.
- Lifetime Guarantee.

Applications:

- Welders.
- Battery Chargers.
- Electrochemical Refining.
- Metal Reduction.
- General Industrial High Current Rectification.

General Purpose Rectifier R510/R511 and R500/R501

100 — 150 A Avg. Up to 1400 Volts

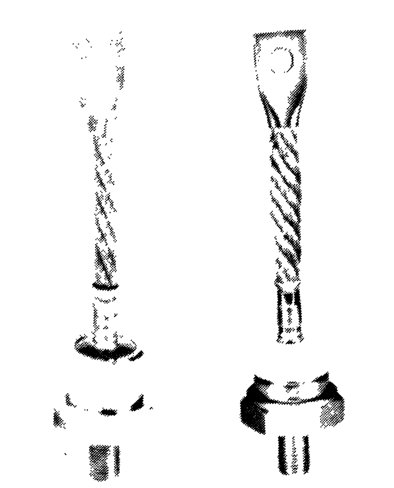


Conforms to DO-8 Outline

Symbol	Inches Min.	Inches Max.	Millimeters Min.	Millimeters Max.
A	4.18	4.62	106.17	117.35
B	.050	.100	1.27	2.54
ϕD	.860	1.000	21.84	25.40
E	1.031	1.063	26.19	27.00
F	.255	.400	6.48	10.16
J	2.50		63.50	
M	.437	.650	11.10	16.51
N	.605	.645	15.37	16.38
Q		1.675		42.54
ϕT	.250	.291	6.35	7.39
Z	.310		7.87	
ϕW	⅜-24 UNF-2A			

Creep & Strike—Distance:
R500,501—.66 in. min. (16.94 mm).
R510,511—.16 in. min. (4.11 mm).
(In accordance with NEMA standards.)
Finish—Nickel Plate.
Approx. Weight—3.5 oz (99g)
R500—Standard Polarity—White Ceramic
R501—Reverse Polarity—Pink Ceramic
R510—Standard Polarity—Gray Glass
R511—Reverse Polarity—Yellow Glass

1. Complete threads to extend to within 2½ threads of seating plane.
2. Angular orientation of terminal is undefined.
3. Pitch diameter of ⅜-24 UNF-2A (coated) threads (ASA B1.1-1960).
4. Dimension "J" denotes seated height with lead bent at right angle.



R510/511 R500/501

Features
- Standard and Reverse Polarities with Color Coded Seals.
- Flag Lead and Stud Top Terminals Available.
- High Surge Current Ratings.
- Special Electrical Selection for Parallel and Series Operation.
- Compression Bonded Encapsulation.
- ½" Stud Package Available.
- Lifetime Guarantee

Applications
- Welders.
- Battery Chargers.
- Electrochemical Refining.
- Metal Reduction.
- General Industrial High Current Rectification.

Ordering Information

Type	Voltage		Current		Recovery Time		Recovery Time Circuit		Leads	
Code	V_{RRM} (V)	Code	$I_{F(av)}$ (A)	Code	t_{rr} (μsec)	Code	Circuit	Code	Case	Code
R510	100	01	100	10	7	X	JEDEC	X	DO-8	WA
(Standard Polarity)	200	02	150	15	(typ)					(150A)
R511	300	03								
(Reverse Polarity)	400	04								WC
*R5D0	500	05								(100A)
(Standard Polarity)	600	06								
*R5D1	700	07								
(Reverse Polarity)	800	08								
	900	09								
	1000	10								
R500	1100	11								
(Standard Polarity)	1200	12								
R501	1300	13								
(Reverse Polarity)	1400	14								

Example
Obtain optimum device performance for your application by selecting proper Order Code.

Type R510 rated at 150A average with V_{RRM} = 300V, and standard flexible lead—order as:

Type				Voltage		Current		Time	Circuit	Leads	
R	5	1	0	0	3	1	5	X	X	W	A

* ½" Stud package similar to DO-30 case.

100 — 150 A Avg. Up to 1400 Volts

General Purpose Rectifier R510/R511 and R500/R501

Voltage

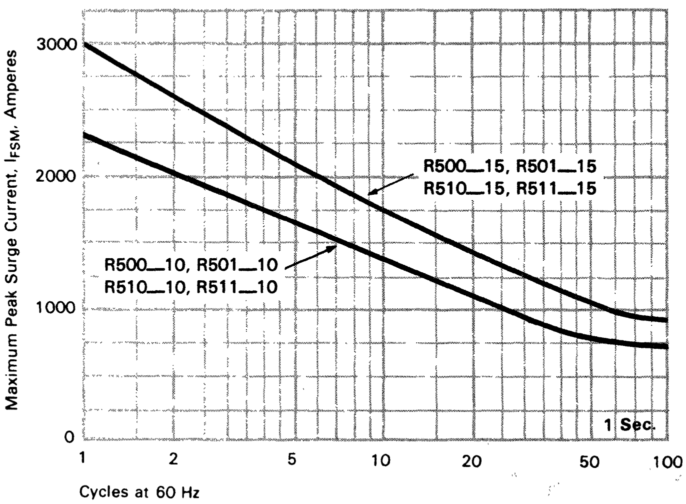
Blocking State Maximums ①	Symbol														
Repetitive peak reverse voltage, V . . .	V_{RRM}	100	200	300	400	500	600	700	800	900	1000	1100	1200	1300	1400
Non-repetitive transient peak reverse voltage, tp<5.0 msec., V	V_{RSM}	200	300	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500
		← R510 ALL TYPES →													
		← R500 ALL TYPES →													
Reverse leakage current, mA peak . .	I_{RRM}	← 30 →													

Current

Conducting State Maximums	Symbol	R510_10, R511_10 R500_10, R501_10	R510_15, R511_15 R500_15, R501_15
RMS forward current, A	$I_{F(rms)}$	160	236
Ave. forward current, A	$I_{F(av)}$	100	150
One-half cycle surge current②, A	I_{FSM}	2300	3000
3 cycle surge current②, A	I_{FSM}	1875	2375
10 cycle surge current②, A	I_{FSM}	1350	1750
I^2t for fusing (for times=8.3 ms) A^2 sec.	I^2t	22,000	37,500
Forward voltage drop at I_{FM}=470 A and T_J=25°C, V	V_{FM}	1.55	1.40
Forward voltage drop at rated single phase average current and case temperature, V	V_{FM}	1.37	1.35
Typical Reverse Recovery Time I_{FM}=314A, tp=40μs, diR/dt=25A/μs, T_C=25°C, μs	t_{rr}	← 7 →	

Thermal and Mechanical

	Symbol	
Max. mounting torque, in lb. ③		120
Thermal resistance Case to sink, lubricated, °C/Watt	$R\theta CS$	.20
Min., Max. oper. junction temp., °C	T_J	← −65 to 200 →
Min., Max. storage temp., °C .	T_{stg}	← −65 to 200 →

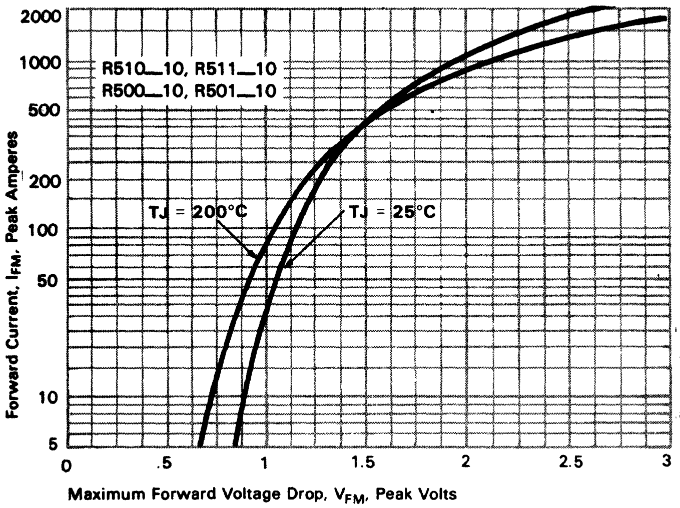


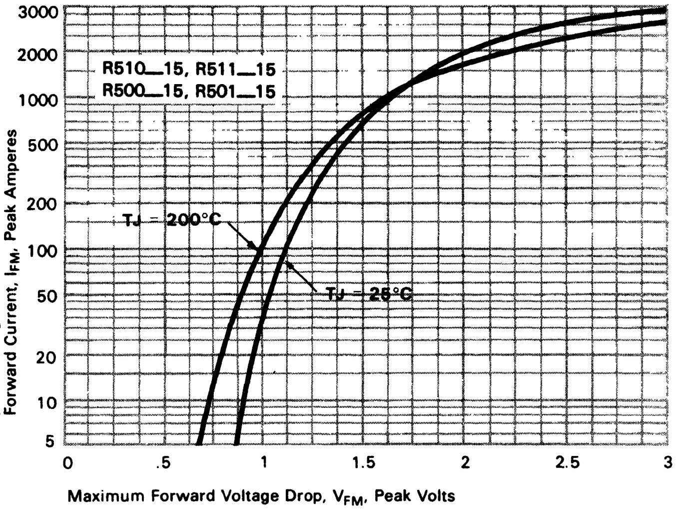
① At maximum TJ
② Per JEDEC RS-282, 4.01 F.3.
③ For R5DO ½" stud package use 130 in.-lb.

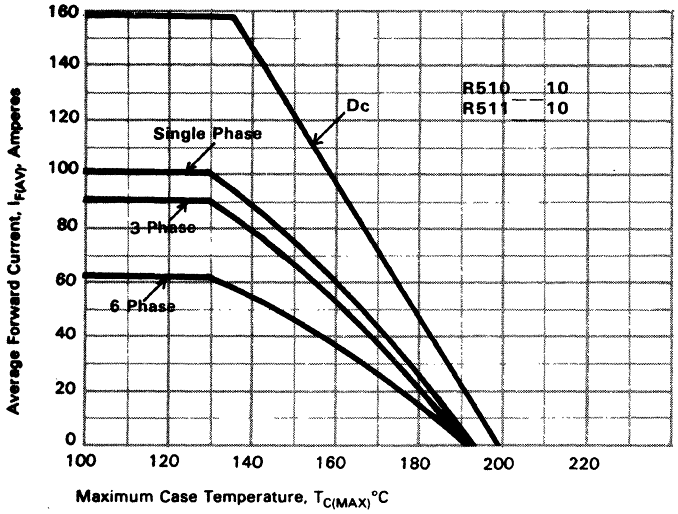
RECTIFIER

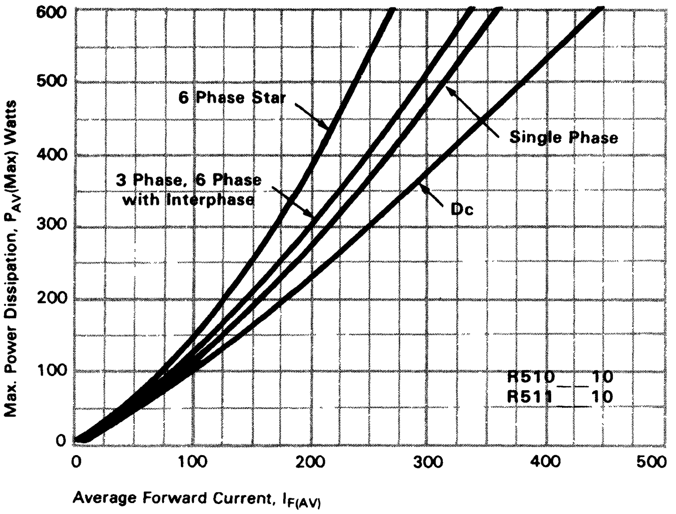
General Purpose Rectifier R510/R511 and R500/R501

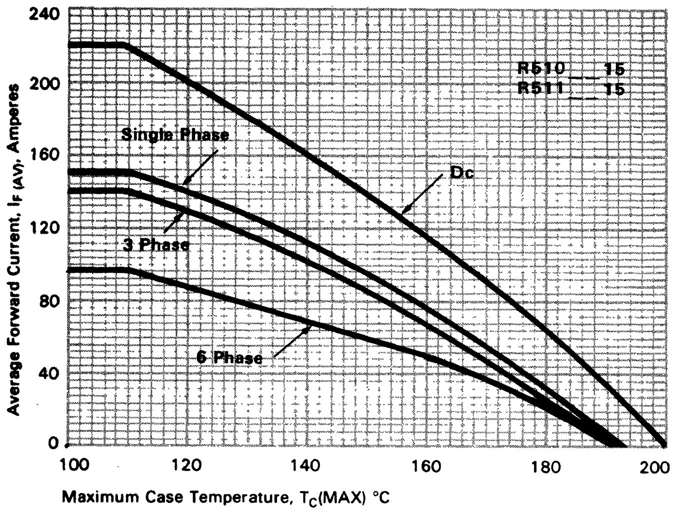
100 — 150 A Avg. Up to 1400 Volts

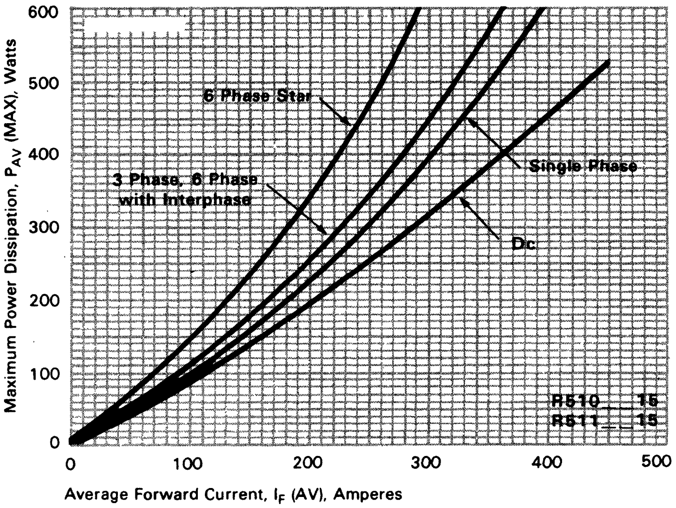






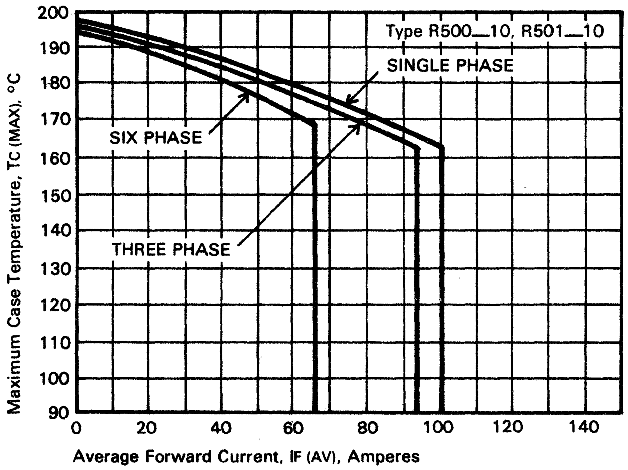


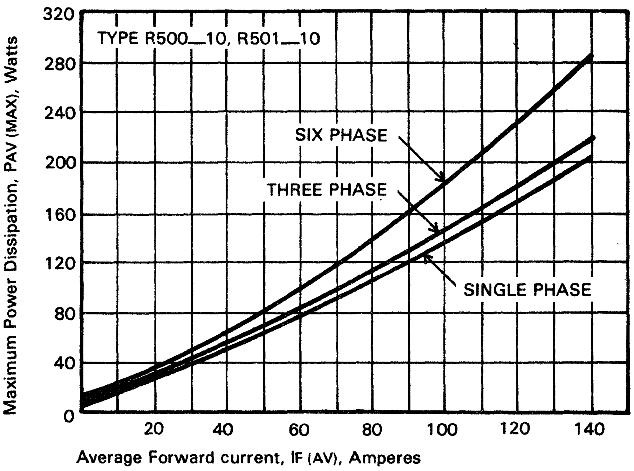


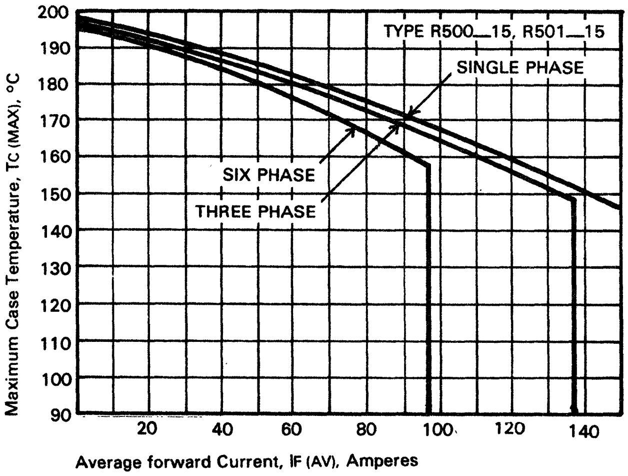


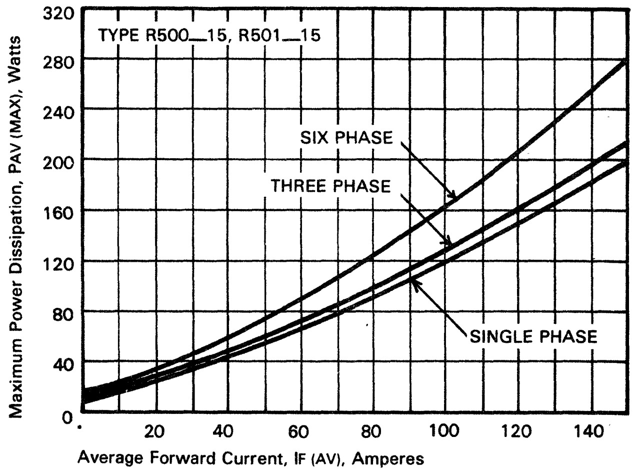
100 — 150 A Avg. Up to 1400 Volts

General Purpose Rectifier R510/R511 and R500/R501



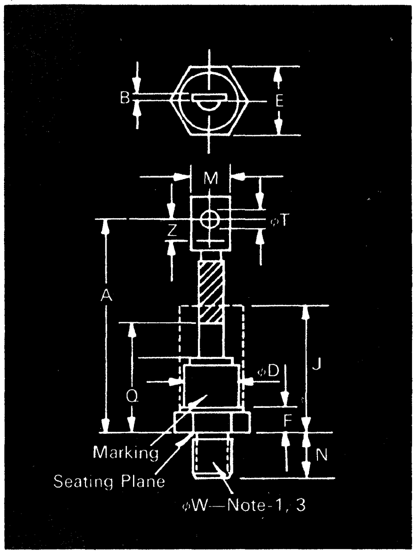






General Purpose Rectifiers IN3260,R - IN3276,R

160 A. Avg. Up to 1600 Volts

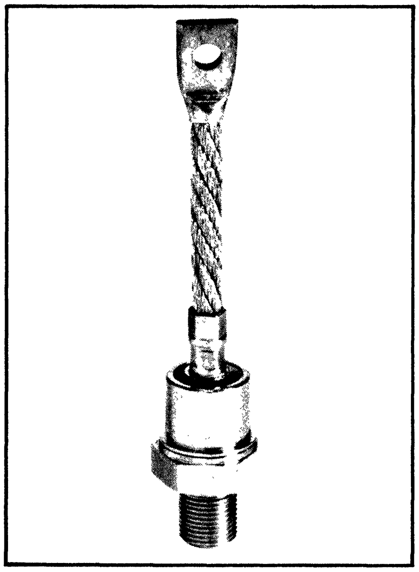


Conforms to DO-9 Outline

Symbol	Inches Min.	Inches Max.	Millimeters Min.	Millimeters Max.
A	5.32	6.00	135.13	152.40
B	.063	.172	1.60	4.37
ϕD	.980	1.065	24.89	27.05
E	1.212	1.250	30.78	31.75
F	.250	.630	6.35	16.00
J	3.250		82.55	
M	.530	.755	13.46	19.18
N	.660	.749	16.76	19.02
Q		2.250		57.15
ϕT	.330	.350	8.38	8.89
Z	.440		11.18	
ϕW	¾-16 UNF-2A			

Creep & Strike Distance:
.49 in. min. (12.52 mm). , Ceramic
.13 in. min. (3.43 mm). , Glass
(In accordance with NEMA standards.)
Finish—Nickel Plate.
Approx. Weight—8 oz. (226g)
Standard Polarity—White Ceramic
Reverse Polarity—Pink Ceramic
Standard Polarity—Gray Glass
Reverse Polarity—Yellow Glass

1. Complete threads to extend to within 2½ threads of seating plane.
2. Angular orientation of terminal is undefined.
3. Pitch diameter of ¾-16 UNF-2A (coated) threads (ASA B1.1-1960).
4. Dimension "J" denotes seated height with lead bent at right angle.



RECTIFIER

Maximum Ratings and Characteristics Blocking State (T_J = 190°C) — Symbol / JEDEC Number ①③	1N3260	1N3261	1N3262	1N3263	1N3264	1N3265	1N3266	1N3267	1N3268	1N3269	1N3270	1N3271	1N3272	1N3273	• 1N3274	• 1N3275	• 1N3276
* Repetitive Peak Reverse Voltage Volts .... V_{RRM}	50	100	150	200	250	300	350	400	500	600	700	800	900	1000	1200	1400	1600
* Non-repetitive Transient Peak Reverse Voltage, Volts . V_{RSM}	100	200	250	300	350	400	450	525	650	800	925	1050	1175	1300	1600	1800	2000
* Allowable d-c blocking voltage, Volts .... V_R	40	80	120	160	200	240	280	320	400	480	560	640	720	800	960	1120	1280
* Max. (fca) ②, reverse current at rated V_{RRM} (rep); 160 amperes avg. forward current, single phase @ Tc=125°C, ma ...... $I_{R(AV)}$	← 12 → (all types)																

Conducting State (T_J = 190°C)	Symbol	All Types
* Max. (fca) ②, Forward Current at T_C=130°C, amps ...	$I_{F(AV)}$	160
RMS Forward Current, Amps	$I_{F(RMS)}$	250
* Max. Peak ½ Cycle Surge Current (at 60 Hz) (Under Load), Amps	I_{FSM}	2,000
I^2t for Fusing (at 60 Hz Half-Wave), Amps²—Sec......	I^2t	16,700
* Max. Forward Voltage Drop ② @ 160 amperes average, T_C=125°C, peak volts ..	V_{FM}	1.6
Thermal Characteristics		
* Oper. Junction Temp. Range, °C	T_J	−65 to +190
* Storage Temperature Range, °C	T_{stg}	−65 to +175
Max. Thermal Resistance, °C/Watt		
* Junction to Case	$R_{\theta JC}$	0.30
Case to Sink, Lubricated Mounting Surface	$R_{\theta CS}$	.15

• Ceramic seal supplied.

* JEDEC registered parameters.

Mounting: Recommended stud mounting torque; 360 in.-lbs. lubricated.

① Order reverse polarity units by designating R.
② Full cycle average measured with DC meter.
③ Ceramic package available.

160 A. Avg. Up to 1600 Volts

General Purpose Rectifiers IN3260,R - IN3276,R

RECTIFIER

Electrical Characteristics

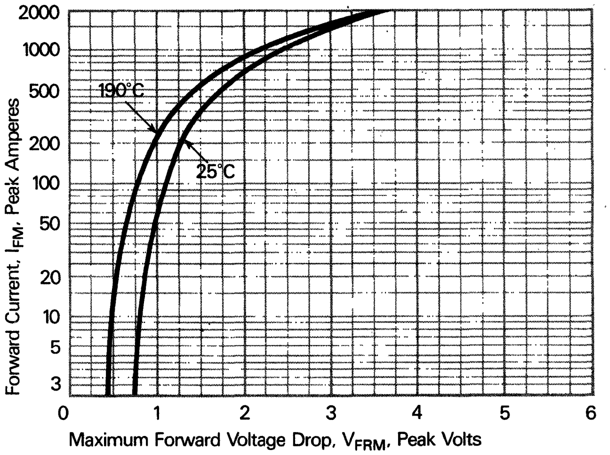


Figure 1. Forward current vs. forward voltage.

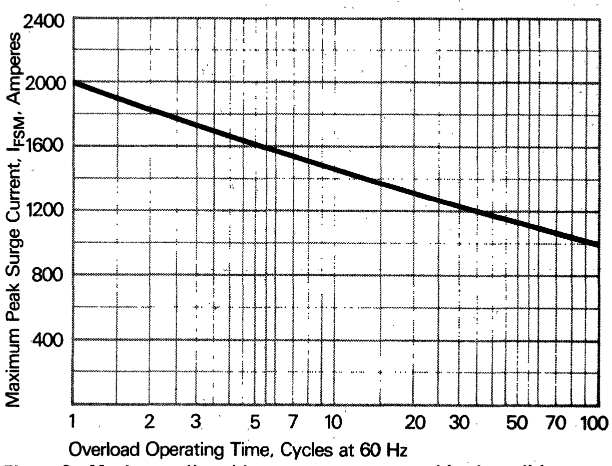


Figure 2. Maximum allowable surge current at rated load conditions.

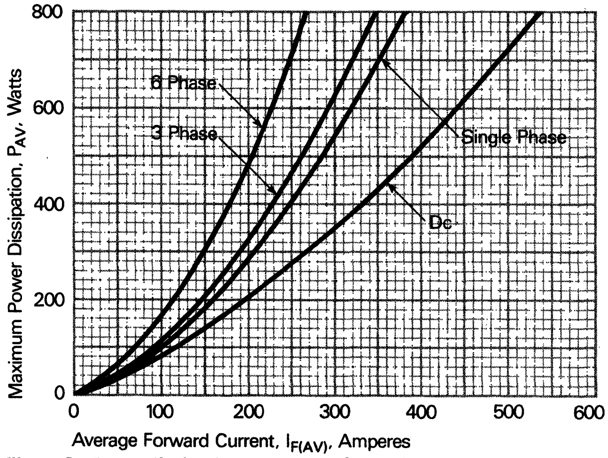


Figure 3. Power dissipation vs. average forward current.

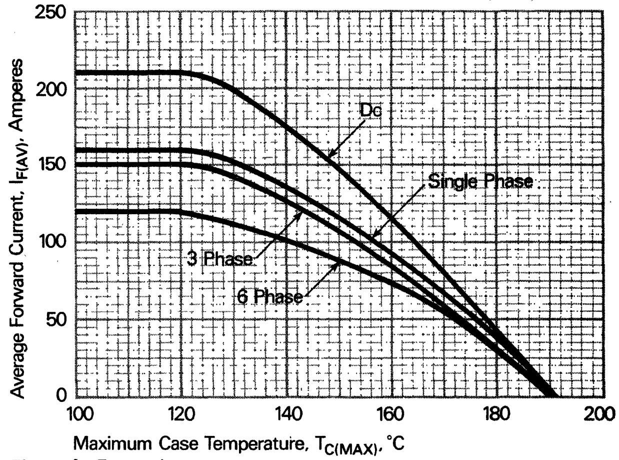


Figure 4. Forward current vs. case temperature.

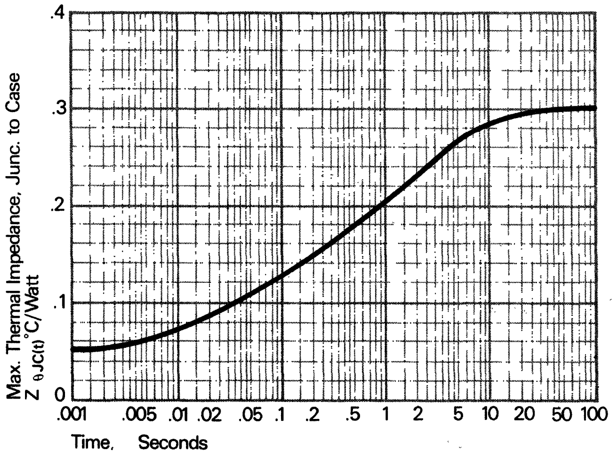


Figure 5. Transient thermal impedance versus time.

Features:

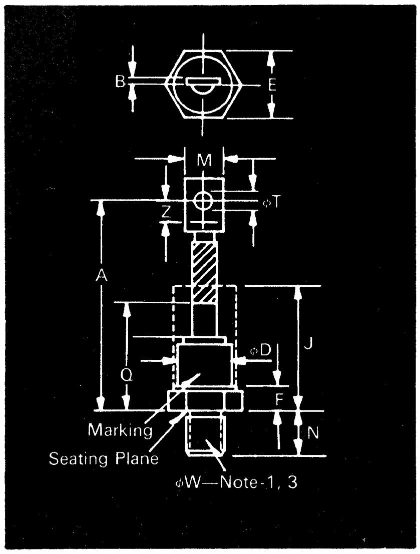
- Standard and Reverse Polarities with Color Coded Seals
- High Surge Current Ratings
- Electrical Selection for Parallel and Series Operation
- Compression Bonded Encapsulation
- Lifetime Guarantee

Applications:

- Welders
- Battery Chargers
- Electrochemical Refining
- Metal Reduction
- General Industrial High Current Rectification

General Purpose Rectifiers IN4044,R - IN4056,R

275 A. Avg. Up to 1000 Volts

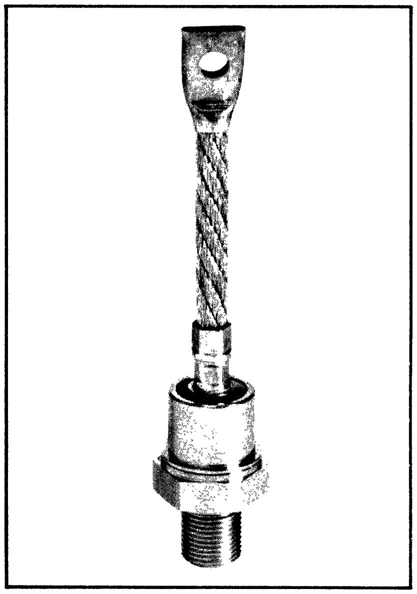


Conforms to DO-9 Outline

Symbol	Inches Min.	Inches Max.	Millimeters Min.	Millimeters Max.
A	5.32	6.00	135.13	152.40
B	.063	.172	1.60	4.37
φD	.980	1.065	24.89	27.05
E	1.212	1.250	30.78	31.75
F	.250	.630	6.35	16.00
J	3.250		82.55	
M	.530	.755	13.46	19.18
N	.660	.749	16.76	19.02
Q		2.250		57.15
φT	.330	.350	8.38	8.89
Z	.440		11.18	
φW	¾-16 UNF-2A			

Creep & Strike Distance:
.49 in. min. (12.52 mm)., Ceramic
.13 in. min. (3.43 mm)., Glass
(In accordance with NEMA standards.)
Finish—Nickel Plate.
Approx. Weight—8 oz. (226g)
Standard Polarity—White Ceramic
Reverse Polarity—Pink Ceramic
Standard Polarity—Gray Glass
Reverse Polarity—Yellow Glass

1. Complete threads to extend to within 2½ threads of seating plane.
2. Angular orientation of terminal is undefined.
3. Pitch diameter of ¾-16 UNF-2A (coated) threads (ASA B1.1-1960).
4. Dimension "J" denotes seated height with lead bent at right angle.



JEDEC number① ③

Maximum Ratings and Characteristics Blocking State (T_J = 190°C)	Symbol	1N4044	1N4045	1N4046	1N4047	1N4048	1N4049	1N4050	1N4051	1N4052	1N4053	1N4054	1N4055	1N4056
* Repetitive Peak Reverse Voltage, Volts	V_{RRM}	50	100	150	200	250	300	400	500	600	700	800	900	1000
* Non-repetitive Peak Reverse Voltage, Volts	V_{RSM}	100	200	250	300	350	400	525	650	800	925	1050	1175	1300
* Max. allowable d-c blocking voltage, Volts	V_R	50	100	150	200	250	300	400	500	600	700	800	900	1000
* Max. (fca) ②, reverse current at rated V_{RRM}; 275 amperes avg. forward current, single phase @ T = 120°C, ma.	$I_{R(AV)}$	← 15 →												

Conducting State (T_J = 190°C)	Symbol	All Types
* Ave. Forward Current (180° Conduction) @ T = 120°C, amps ②	$I_{F(AV)}$	275
RMS Forward Current, amps	$I_{F(RMS)}$	435
* Max. Peak ½ Cycle Surge Current (at 60 Hz), amps	I_{FSM}	5,000
I^2t for Fusing (at 60 Hz half-wave), amps^2—sec	I^2t	104,000
* Max. Forward Voltage Drop @ 275 amperes average, T_C = 120°C, peak volts	V_{FM}	1.35
Thermal Characteristics		
* Oper. Junction Temp. Range, °C.	T_J	−65 to +190
* Storage Temperature Range, °C	T_{stg}	−65 to +190
Max. Thermal Resistance, °C/Watt		
Junction to Case	$R_{\theta JC}$	.17
Case to Sink, Lubricated Mounting Surface	$R_{\theta CS}$	.15

Mechanical Characteristics

Finish: Nickel-plated case to maintain low contact resistance and to prevent corrosion.

Mounting: Recommended stud mounting torque; 360 in.-lbs.
Consult recommended mounting procedures.

* JEDEC registered parameters.

① Order reverse polarity units by designating 1N4044R, etc.

② Full cycle average (measured with a d-c meter).

③ Ceramic package available.

275 A. Avg.
Up to 1000 Volts

General Purpose Rectifiers IN4044,R - IN4056,R

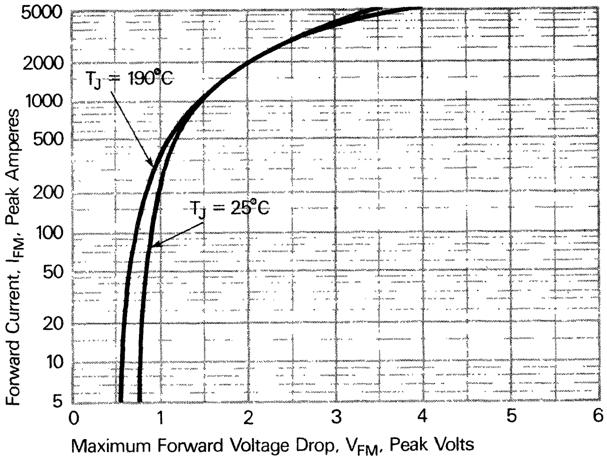


Figure 1. Forward current vs. forward voltage.

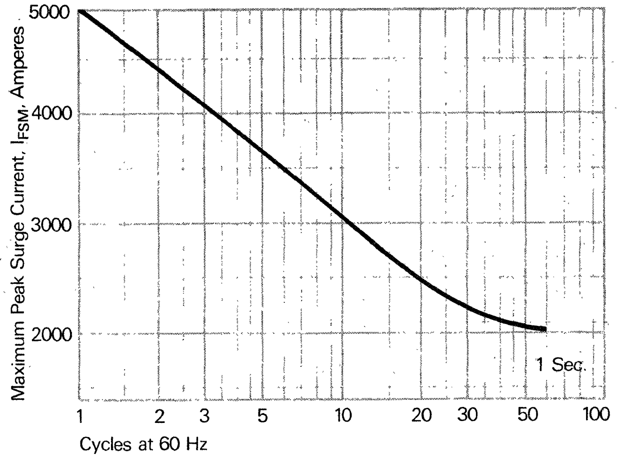


Figure 2. Maximum allowable surge current at rated load conditions.

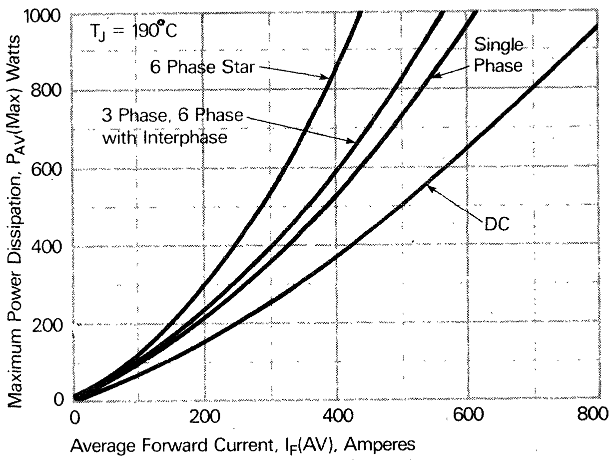


Figure 3. Power dissipation vs. Average forward current.

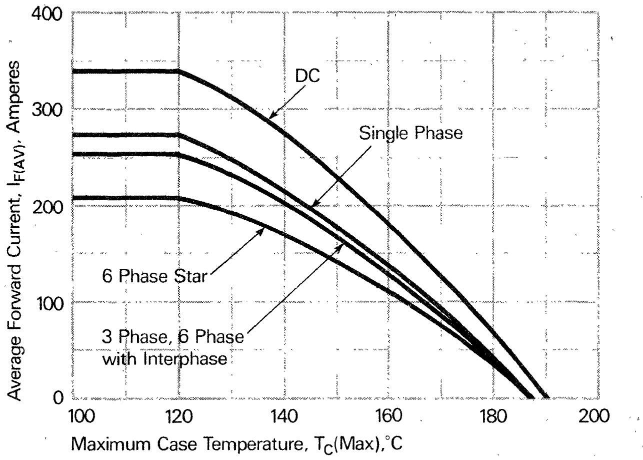


Figure 4. Forward current vs. Case temperature.

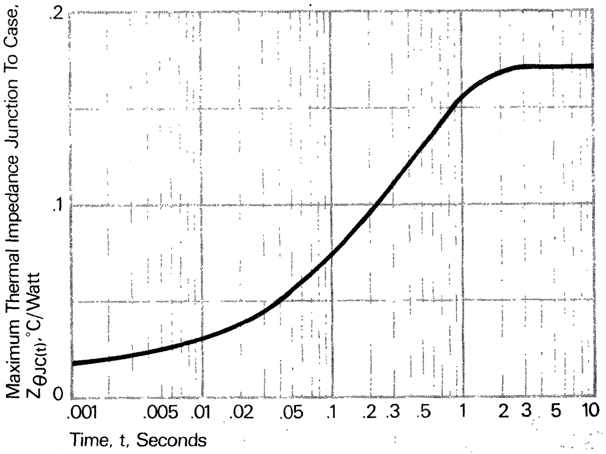


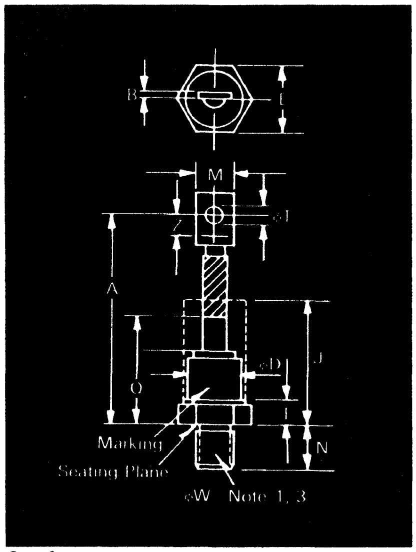
Figure 5. Transient thermal impedance vs. time.

Features:
- Standard and Reverse Polarities with color Coded Seals
- High Surge Current Ratings
- Electrical Selection for Parallel and Series Operation
- Lifetime Guarantee

Applications:
- Welders
- Battery Chargers
- Electrochemical Refining
- Metal Reduction
- General Industrial High Current Rectification

General Purpose RECTIFIER R610/R611 And R600/R601

200 — 300 A Avg. Up to 3000 Volts

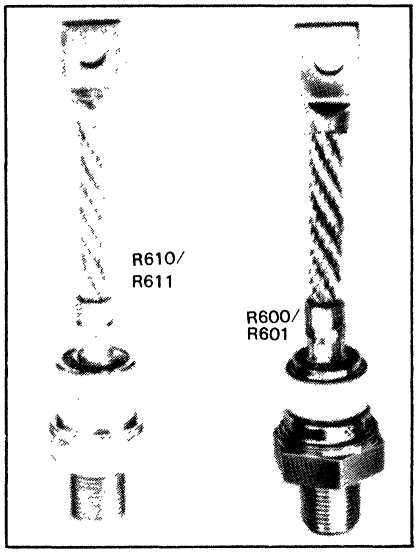


Conforms to DO-9 Outline

Symbol	Inches Min.	Inches Max.	Millimeters Min.	Millimeters Max.
A	5.32	6.00	135.13	152.40
B	.063	.172	1.60	4.37
φD	.980	1.065	24.89	27.05
E	1.212	1.250	30.78	31.75
F	.250	.630	6.35	16.00
J	3.250		82.55	
M	.530	.755	13.46	19.18
N	.660	.749	16.76	19.02
Q		2.250		57.15
φT	.330	.350	8.38	8.89
Z	.440		11.18	
φW	¾-16 UNF-2A			

Creep & Strike Distance:
R600,601—.49 in. min. (12.52 mm).
R610,611—.13 in. min. (3.43 mm).
(In accordance with NEMA standards.)
Finish—Nickel Plate.
Approx. Weight—8 oz. (226g)
R600—Standard Polarity—White Ceramic
R601—Reverse Polarity—Pink Ceramic
R610—Standard Polarity—Gray Glass
R611—Reverse Polarity—Yellow Glass

1. Complete threads to extend to within 2½ threads of seating plane.
2. Angular orientation of terminal is undefined.
3. Pitch diameter of ¾-16 UNF-2A (coated) threads (ASA B1.1-1960).
4. Dimension "J" denotes seated height with lead bent at right angle.



Applications

- Welders
- Battery Chargers
- Electrochemical Refining
- Metal Reduction
- General Industrial High Current Rectification

Features

- Standard and Reverse Polarities
- Flag Lead and Stud Top Terminals Available
- High Surge Current Ratings
- High Rated Blocking Voltages
- Special Electrical Selection for Parallel and Series Operation
- Glazed Ceramic Seal Gives High Voltage Creepage and Strike Paths
- Compression Bonded Encapsulation
- JAN Types Available
- Lifetime Guarantee

Ordering Information

Type	Voltage		Current		Recovery Time		Recovery Time Circuit		Leads	
Code	V_{RRM} (V)	Code	$I_{F(av)}$ (A)	Code	t_{rr} µsec	Code	Circuit	Code	Case	Code
R610 (Standard Polarity)	100	01	200	20	13	X	JEDEC	X	DO-9	YA
	200	02								
R611 (Reverse Polarity)	400	04	250	25	11	X				
	600	06								
	800	08	300	30	9 (typical)	X				
	1000	10								
R600 (Standard Polarity)	1200	12								
	1400	14								
R601 (Reverse Polarity)	1600	16								
	1800	18								
	2000	20								
	2200	22								
	2400	24								
	2600	26								
	2800	28								
	3000	30								

Example

Obtain optimum device performance for your application by selecting proper Order Code.

Type R610 rated at 250A average with V_{RRM} = 300V, and standard flexible lead — order as:

Type				Voltage		Current		Time	Circuit	Leads	
R	6	1	0	0	3	2	5	X	X	Y	A

Example

Obtain optimum device performance for your application by selecting proper Order Code.

Type R600 rated at 300A average with V_{RRM} = 1200 V, and standard flexible lead — order as:

Type				Voltage		Current		trr	Circuit	Leads	
R	6	0	0	1	2	3	0	X	X	Y	A

200 — 300 A Avg.
Up to 3000 Volts

General Purpose
RECTIFIER
R610/R611 And R600/R601

RECTIFIER

Voltage

Blocking State Maximums ①

Parameter	Symbol																
Repetitive peak reverse voltage , V	V_{RRM}	100	200	400	600	800	1000	1200	1400	1600	1800	2000	2200	2400	2600	2800	3000
Non-repetitive transient peak reverse voltage, $V \leq 5.0$ msec	V_{RSM}	200	300	500	700	1000	1200	1400	1600	1800	2000	2200	2400	2600	2800	3000	3200
		← R600__20 →							← R600__20 →				← R600__20 →				
		← R600__25 →							← R600__25 →								
		← R600__30 →															
		← R610 (All types) →															
Min., Max. oper. junction temp., °C	T_J	← −65 to 190 →						← −65 to 175 →					← −65 to 150 →				
Min., Max. storage temp., °C	T_{stg}	← −65 to 190 →						← −65 to 190 →					← −65 to 190 →				
Typical Reverse Recovery Time $I_{FM} = 785A$, $tp = 100\mu s$, $di_R/dt = 25A/\mu s$, $T_C = 25°C$, μs	t_{rr}	9						11					13				
Reverse leakage current, mA peak	I_{RRM}	← 50 →															

Current

Conducting State Maximums

	Symbol	R600‥20 R610‥20 R601‥20 R611‥20	R600‥25 R610‥25 R601‥25 R611‥25	R600‥30 R610‥30 R601‥30 R611‥30
RMS forward current, A	$I_{F(rms)}$	315	400	470
Ave. forward current, A	$I_{F(av)}$	200	250	300
One-half cycle surge current②, A	I_{FSM}	5500	6000	6500
3 cycle surge current②, A	I_{FSM}	4300	4700	5050
10 cycle surge current②, A	I_{FSM}	3300	3600	3900
I^2t for fusing (for times 8.3 ms) A^2 sec.	I^2t	125,000	150,000	175,000
Forward voltage drop at I_{FM} = 800 A and T_J = 25°C, V	V_{FM}	1.7	1.5	1.4
Forward voltage drop at rated single phase average current and case temperature, V	V_{FM}	1.45	1.45	1.45

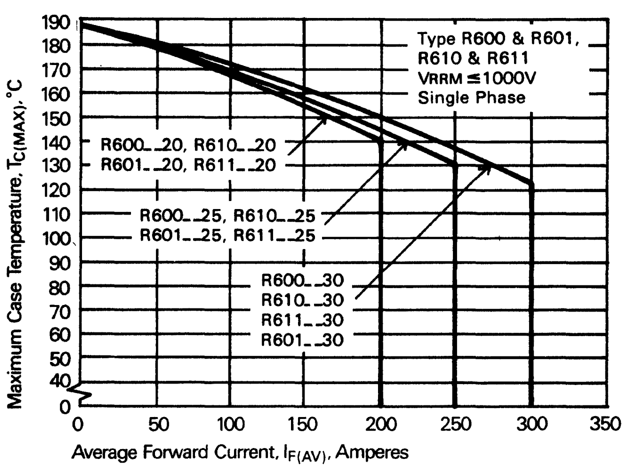
Thermal and Mechanical

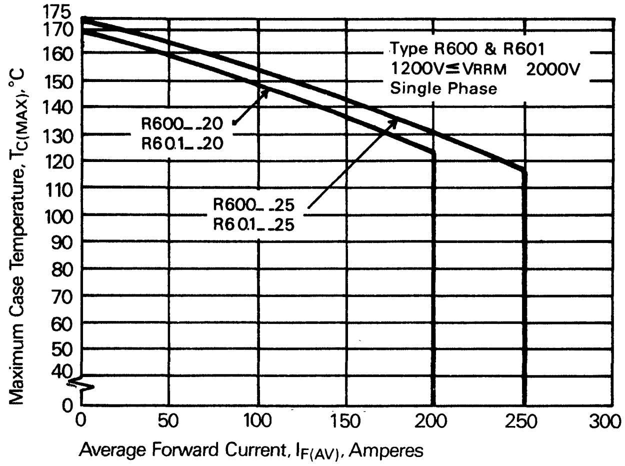
	Symbol	
Max. mounting torque, in lb.③		360
Thermal resistance ③ Case to sink, lubricated, °C/Watt	$R_{\theta CS}$	.10

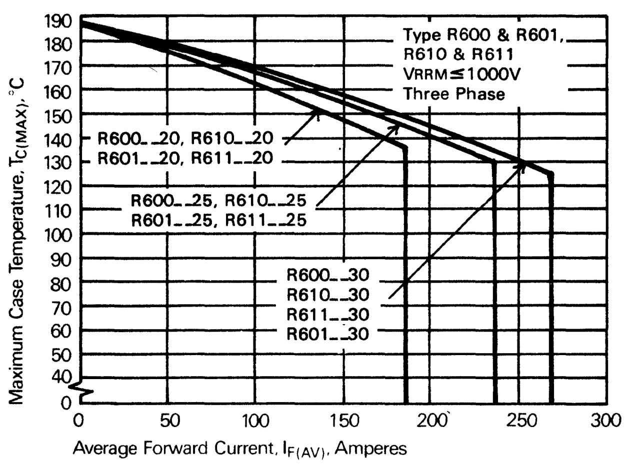
① At maximum TJ
② Per JEDEC RS-282, 4.01 F.3.
③ Consult recommended mounting procedures.

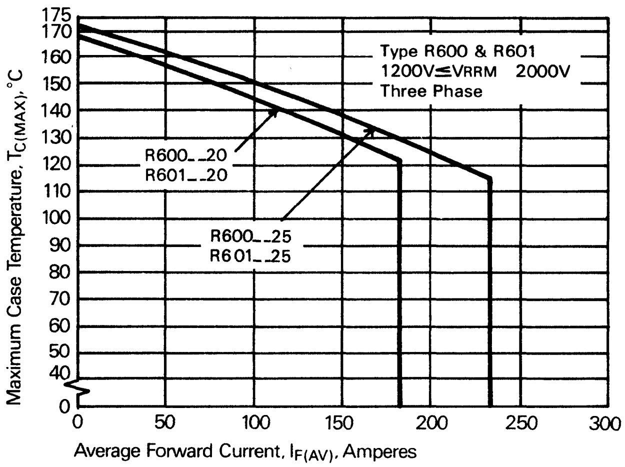
General Purpose
RECTIFIER
R610/R611 And R600/R601

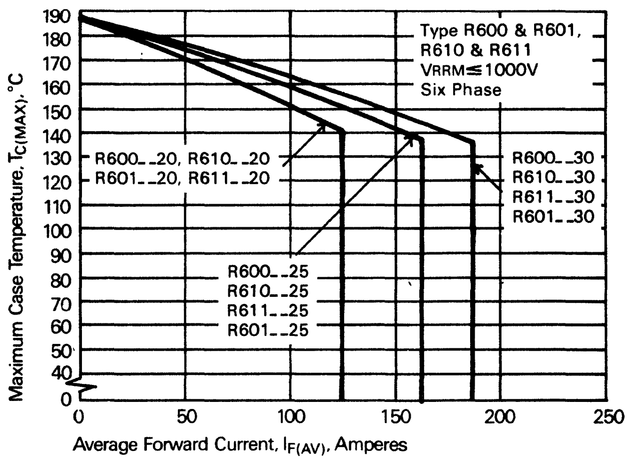
200 — 300 A Avg.
Up to 3000 Volts

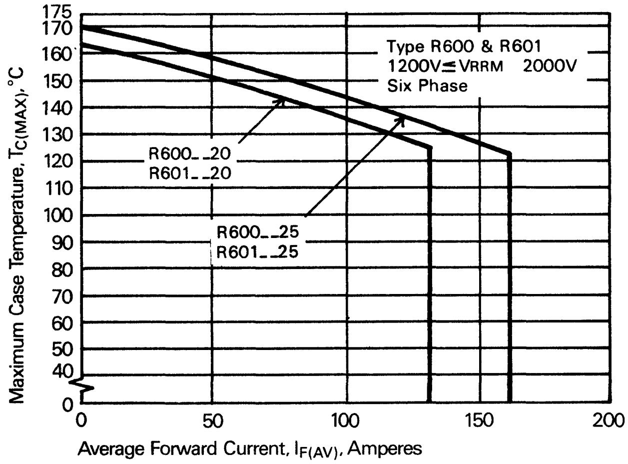




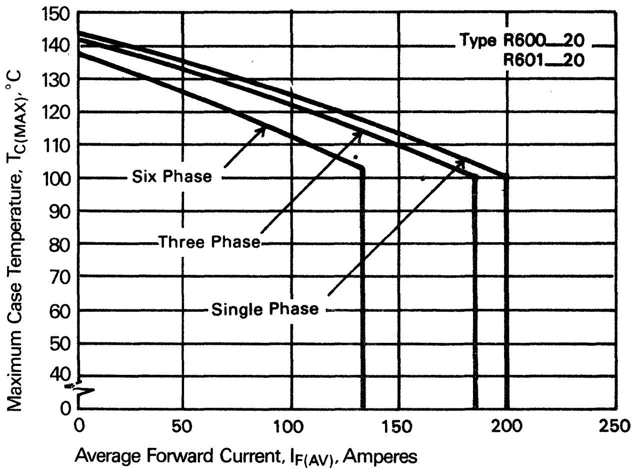


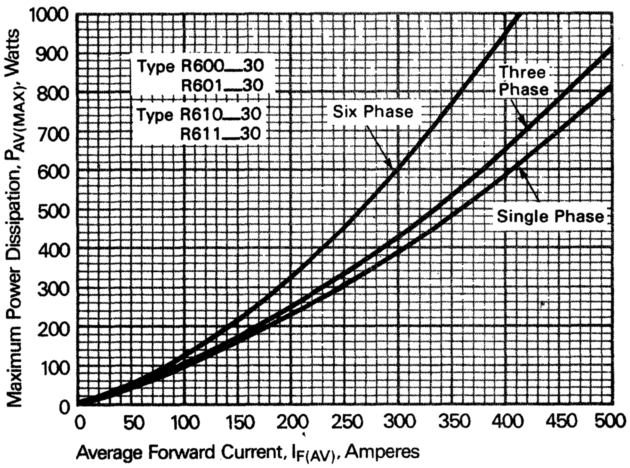


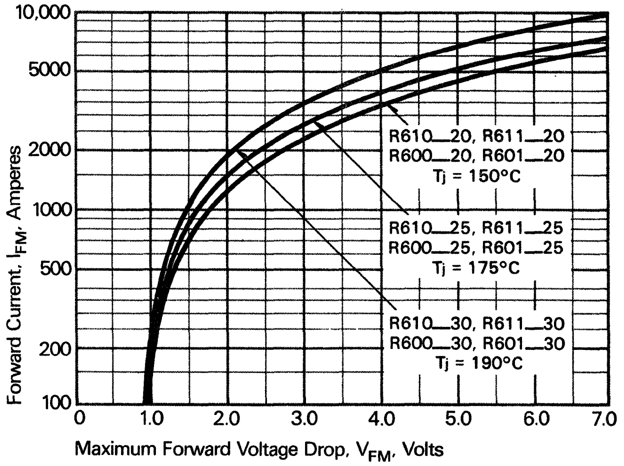


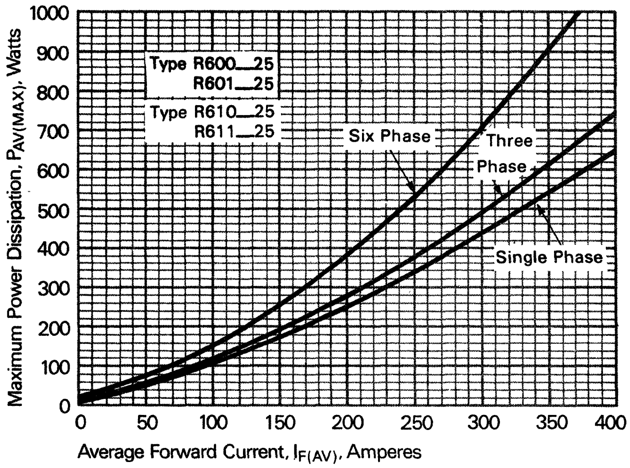


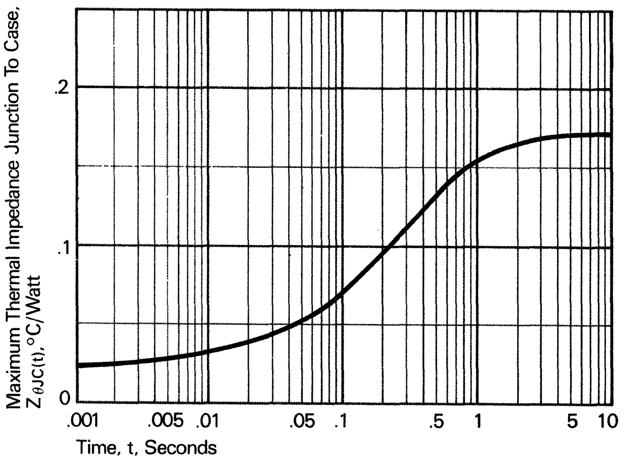
General Purpose RECTIFIER
R610/R611 And R600/R601

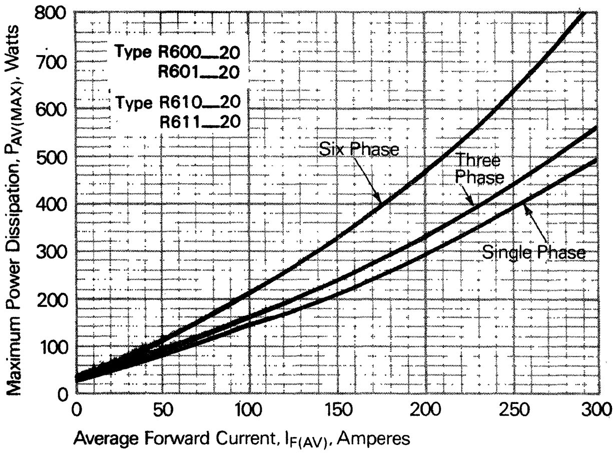






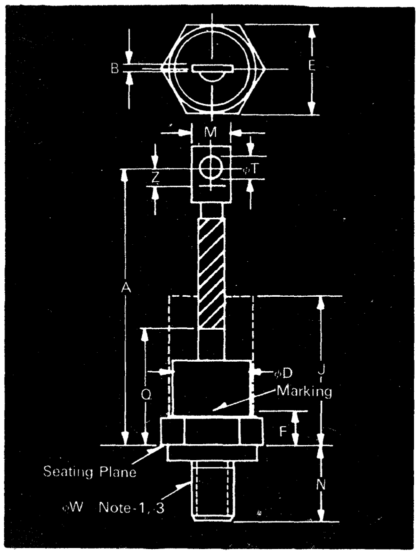






General Purpose Rectifiers R700/R701

300-550 A. Avg. Up to 4000 Volts

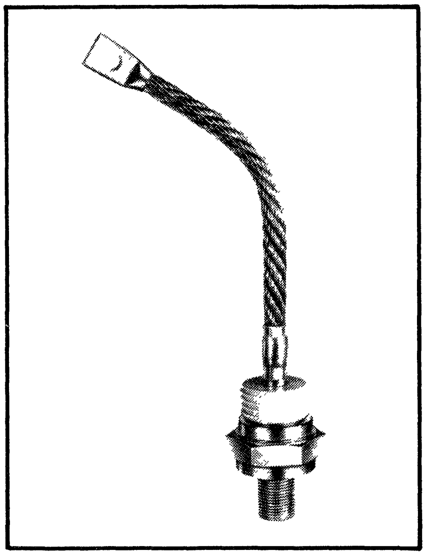


R7 Outline

Symbol	Inches Min.	Inches Max.	Millimeters Min.	Millimeters Max.
A	9.76	10.00	247.90	254.00
B	.063	.172	1.60	4.37
φD		1.490		37.85
E	1.620	1.750	41.15	44.45
F	.430	.810	10.92	20.57
J	4.000		101.60	
M	.530	.755	13.46	19.18
N	1.04	1.08	26.42	27.43
Q		3.100		78.74
φT	.330	.350	8.38	8.89
Z	.440		11.18	
φW	¾-16 UNF-2A			

Creep Distance—2.12 in. min. (53.98 mm).
Strike Distance—1.20 in. min. (30.48 mm).
(In accordance with NEMA standards.)
Finish—Nickel Plate.
Approx. Weight—16 oz. (454g).
R700—Standard Polarity—White Ceramic
R701—Reverse Polarity—Pink Ceramic

1. Complete threads to extend to within 2½ threads of seating plane.
2. Angular orientation of terminal is undefined.
3. Pitch diameter of ¾-16 UNF-2A (coated) threads (ASA B1.1-1960).
4. Dimension "J" denotes seated height with lead bent at right angle.



Features:
- Standard and Reverse Polarities
- Flag Lead and Stud Top Terminals Available
- Flat Base, Flange Mounted Design Available
- High Surge Current Ratings
- High Rated Blocking Voltages
- Electrical Selection for Parallel And Series Operation
- Color Coded Seals
- High Voltage Creepage and Strike Paths
- Compression Bonded Encapsulation
- Lifetime Guarantee

Applications:
- Welders.
- Battery Chargers.
- Electrochemical Refining.
- Metal Reduction.
- General Industrial High Current Rectification.

Ordering Information

Type	Voltage		Current		Recovery Time		Recovery Time Circuit		Leads	
Code	V_{RRM} (V)	Code	$I_{F\,(av)}$ (A)	Code	t_{rr} µsec	Code	Circuit	Code	Case	Code
R700 (Standard Polarity) R701 (Reverse Polarity)	100	01	300	03	15	X	JEDEC	X	R70	UA
	200	02	450	04	11	X				
	400	04	550	05	9	X				
	600	06			(typical)					
	800	08								
	1000	10								
	1200	12								
	1400	14								
	1600	16								
	1800	18								
	2000	20								
	2200	22								
	2400	24								
	2600	26								
	2800	28								
	3000	30								
	3500	35								
	4000	40								

Example

Obtain optimum device performance for your application by selecting proper Order Code.

Type R700 rated at 450 A average with V_{RRM}=1000V, and standard flexible lead—order as:

Type			Voltage		Current		trr	Circuit	Leads	
R	7	0	0	1	0	0	4	X	X	U	A

300-550 A. Avg. Up to 4000 Volts

General Purpose Rectifiers R700/R701

Voltage

Blocking State Maximums① Symbol

Parameter	Symbol																	
Repetitive peak reverse voltage, V	V_{RRM}	100	200	400	600	800	1000	1200	1400	1600	1800	2000	2200	2400	2600	2800	3000	3500	4000
Non-repetitive transient peak reverse voltage, t≤5.0 m sec, V	V_{RSM}	200	300	500	700	1000	1200	1400	1600	1800	2000	2200	2400	2600	2800	3000	3200	3700	4200

Parameter	Symbol	100–1200 V	1400–2000 V	2200–4000 V
Types		R700-—03 R700-—04 R700-—05	R700-—03 R700-—04	R700-—03
Reverse leakage current, mA peak	I_{RRM}	50	50	50
Switching				
Typical Reverse Recovery Time I_{FM}=1500A, tp=190μs diR/dt=25A/μs, T_C=25°C, μs	t_{rr}	9	11	15
Thermal and Mechanical				
Min., Max. oper. junction temp., °C	T_J	—65 to 200	—65 to 175	—65 to 150
Min., Max. storage temp., °C	T_{stg}	—65 to 200	—65 to 200	—65 to 200
Max. mounting torque, in lb.③		360	360	360
Thermal resistance③ Junction to case, °C/Watt	$R_{\theta JC}$	.12	.12	.12
Case to sink, lubricated, °C/Watt	$R_{\theta CS}$	.04	.04	.04

Current

Conducting State Maximums

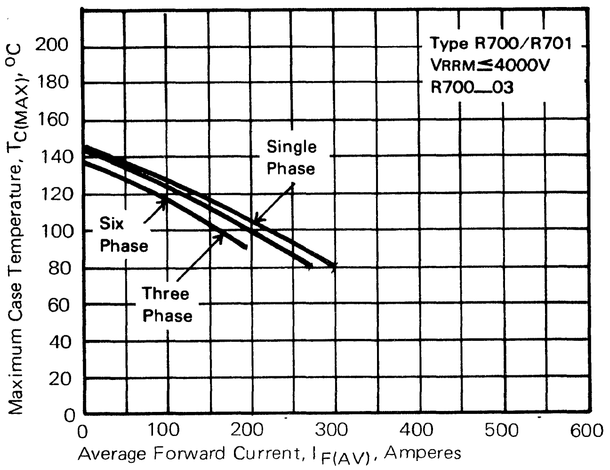
Parameter	Symbol	R700-—03 R701-—03	R700-—04 R701-—04	R700-—05 R701-—05
RMS forward current, A	$I_{F(rms)}$	470	700	865
Ave. forward current, A	$I_{F(av)}$	300	450	550
One-half cycle surge current②, A	I_{FSM}	7000	8500	10,000
3 cycle surge current②, A	I_{FSM}	'5250	6400	7500
10 cycle surge current②, A	I_{FSM}	4200	5100	6000
I^2t for fusing (for times= 8.3 ms) A^2 sec	I^2t	204,000	266,000	416,500
Forward voltage drop at I_{FM}=1500 A and T_J=25°C, V	V_{FM}	2.15	1.6	1.4
Forward voltage drop at rated single phase average current and case temperature, V	V_{FM}	1.45	1.45	1.1

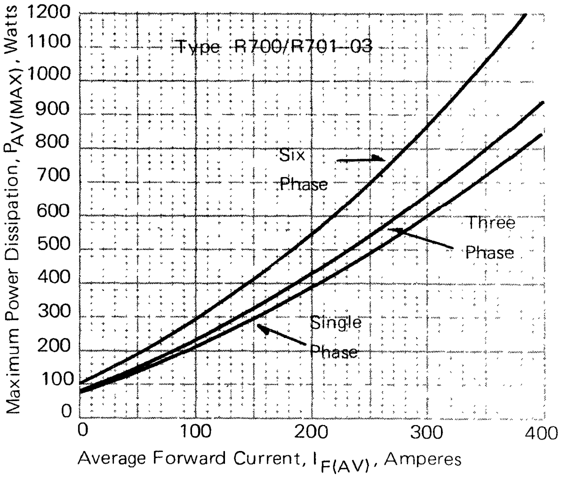
1 At maximum TJ
2 Per JEDEC RS-282, 4.01 F.3.
3 Consult Westinghouse recommended mounting procedures.

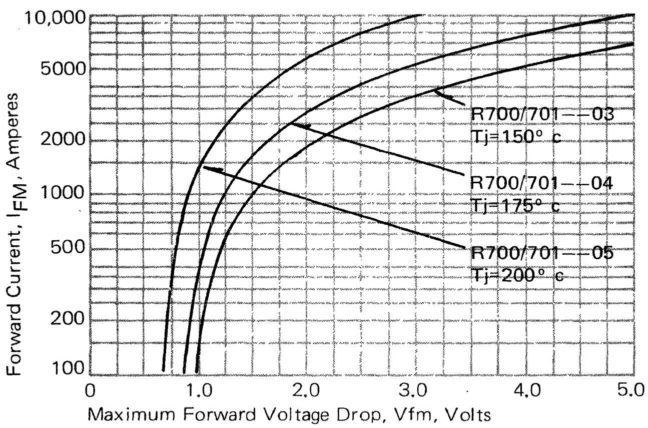
RECTIFIER

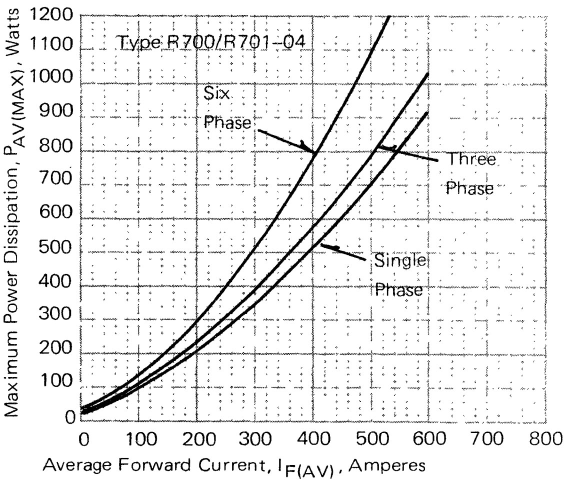
General Purpose RECTIFIERS R700/R701

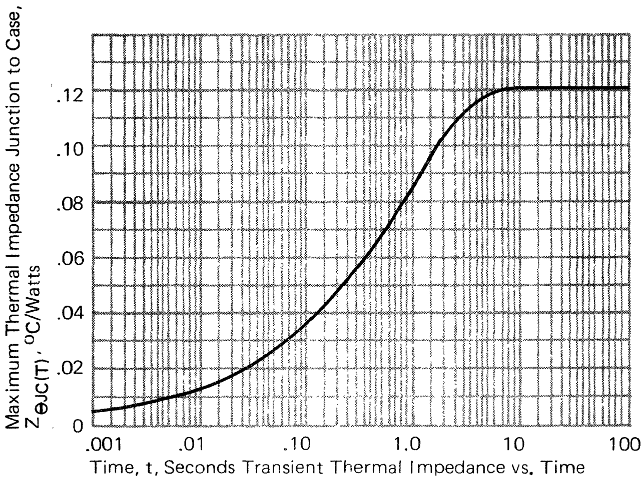
300 — 550 A. Avg. Up to 4000 Volts

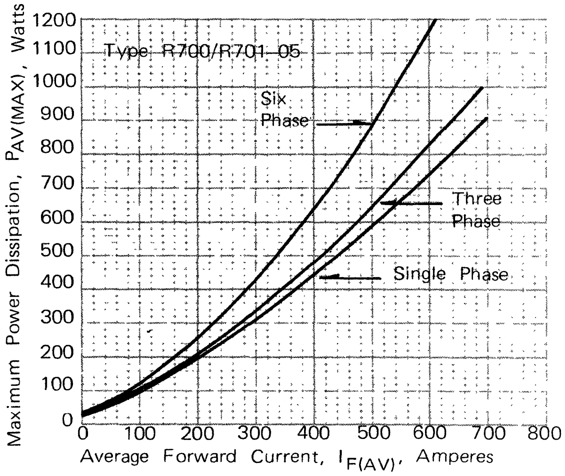






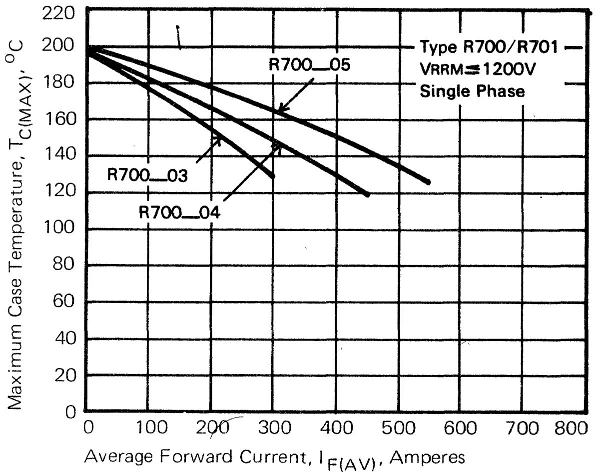


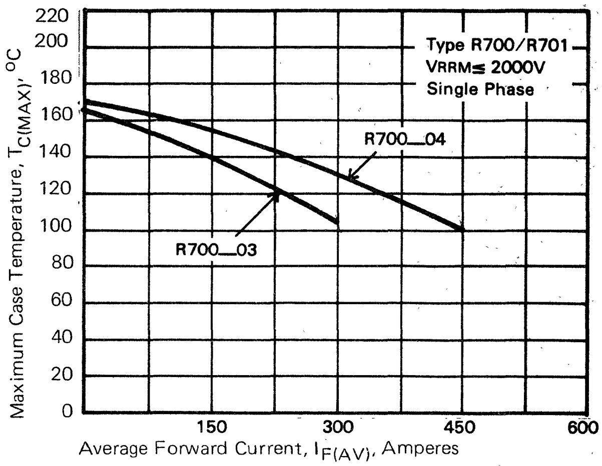


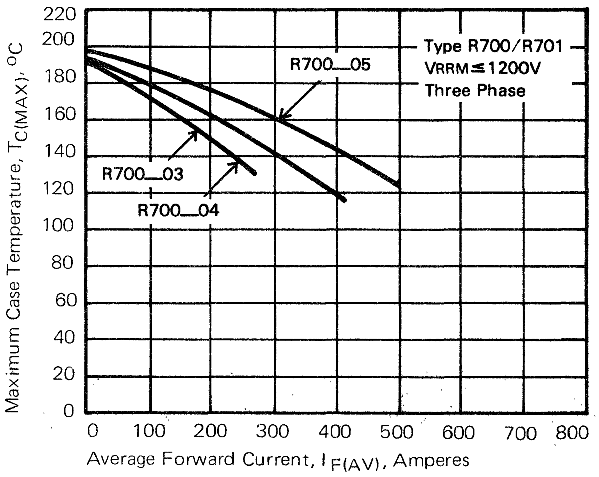


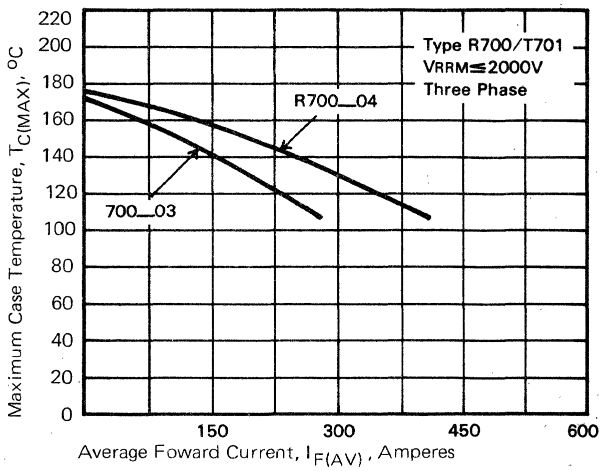
RECTIFIER

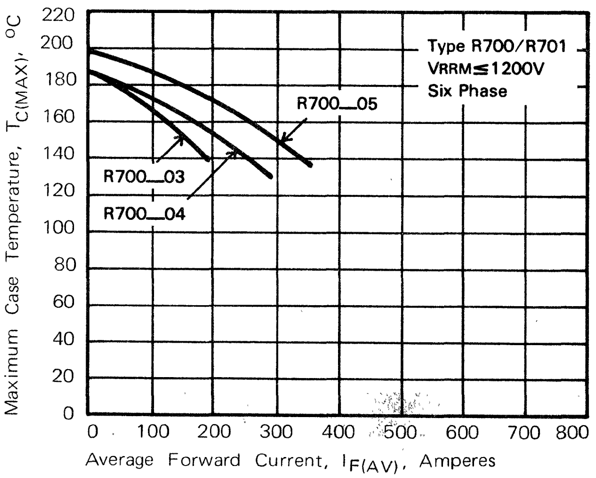
General Purpose Rectifiers R700/R701

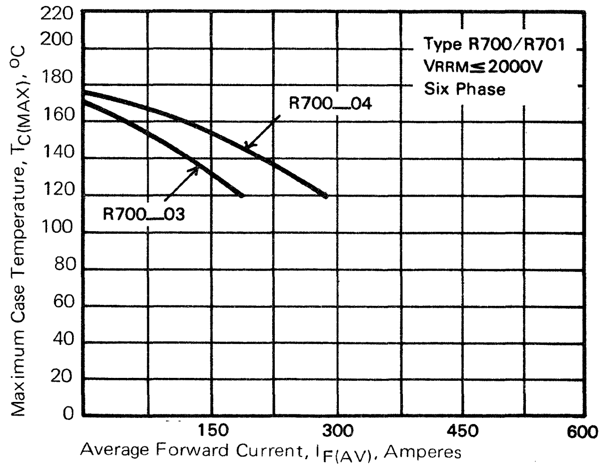








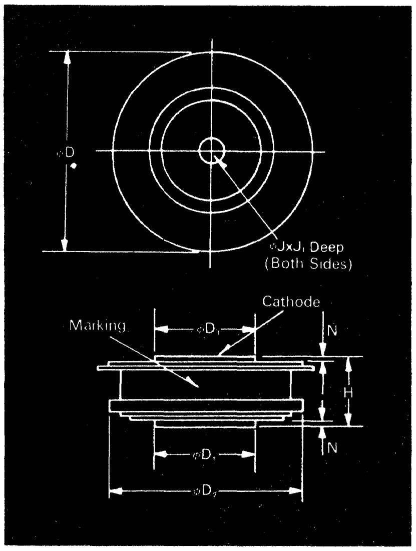




RECTIFIER

General Purpose Rectifiers R620

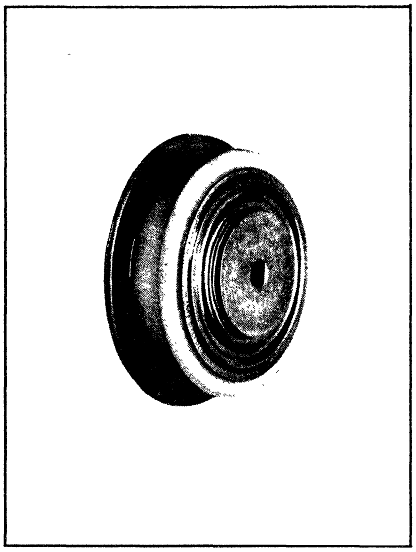
300-500 A. Avg. Up to 3000 Volts



R62 Outline

Symbol	Inches Min.	Inches Max.	Millimeters Min.	Millimeters Max.
ϕD	1.610	1.650	40.89	41.91
ϕD_1	.745	.755	18.92	19.18
ϕD_2	1.420	1.460	36.07	37.08
H	.500	.560	12.70	14.22
ϕJ	.135	.145	3.43	3.68
J_1	.072	.082	1.83	2.08
N	.030		.76	

Creep Distance—.49 in. min. (12.60 mm).
Strike Distance—.52 in. min. (13.21 mm).
(In accordance with NEMA standards).
Finish—Nickel Plate.
Approx. Weight—2.3 oz (66g).
1. Dimension "H" is clamped dimension.



Features:
- High Surge Current Ratings
- High Rated Blocking Voltages
- Special Electrical Selection For Parallel and Series Operation
- Available in Factory Assembled Water or Air Heat Exchangers
- Single or double-sided cooling
- Long creepage & strike paths
- Hermetic seal
- Lifetime Guarantee

Applications:
- Rectification
- Free Wheeling
- Battery Chargers
- Resistance Welding

Ordering Information

Type	Voltage		Current		Recovery Time		Recovery Time Circuit		Leads	
Code	V_{RRM} (V)	Code	$I_{F(av)}$ (A)	Code	t_{rr} µsec	Code	Circuit	Code	Case	Code
R620	100	01	300	30	11	X	JEDEC	X	R62	00
	200	02								
	400	04	400	40	9	X				
	600	06								
	800	08	500	50	6 (typical)	X				
	1000	10								
	1200	12								
	1400	14								
	1600	16								
	1800	18								
	2000	20								
	2200	22								
	2400	24								
	2600	26								
	2800	28								
	3000	30								

Example

Obtain optimum device performance for your application by selecting proper Order Code.

Type R620 rated at 400A average with $V_{RRM} = 1000V$, Order as:

Type				Voltage		Current		trr	Circuit	Leads	
R	6	2	0	1	0	4	0	X	X	0	0

RECTIFIER

300-500 A. Avg. Up to 3000 Volts

General Purpose Rectifiers R620

Voltage

Blocking State Maximums ①

	Symbol																
Repetitive peak reverse voltage , V	V_{RRM}	100	200	400	600	800	1000	1200	1400	1600	1800	2000	2200	2400	2600	2800	3000
Non-repetitive transient peak reverse voltage, $t \leq 5.0$ m sec	V_{RSM}	200	300	500	700	1000	1200	1400	1600	1800	2000	2200	2400	2600	2800	3000	3200

	Symbol			
		R620 _ _ 30	R620 _ _ 30	R620 _ _ 30
		R620 _ _ 40	R620 _ _ 40	
		R620 _ _ 50		
Reverse leakage current, mA peak	I_{RRM}	50	50	50

Switching

	Symbol			
Typical Reverse Recovery Time $I_{FM} = 785A$, $t_p = 100\mu s$ $diR/dt = 25A/\mu s$, $T_C = 25°C$, μs	trr	6	9	11

Thermal and Mechanical

	Symbol			
Min., Max. oper. junction temp., °C	T_J	−65 to 190	−65 to 175	−65 to 150
Min., Max. storage temp., °C	T_{stg}	−65 to 190	−65 to 190	−65 to 190
Min., Max. mounting force, lb③		1000 to 1400	1000 to 1400	1000 to 1400
Thermal resistance③ with double sided cooling Junction to case, °C/Watt	$R_{\theta JC}$	.095	.095	.095
Case to sink, lubricated °C/Watt	$R_{\theta CS}$	.02	.02	.02

Current

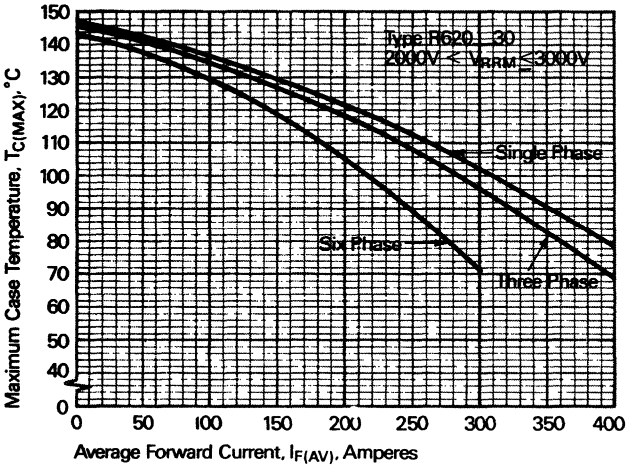
Conducting State Maximums	Symbol	R620 _ _ 30	R620 _ _ 40	R620 _ _ 50
RMS forward current, A	$I_{F(rms)}$	470	625	785
Ave. forward current, A	$I_{F(av)}$	300	400	500
One-half cycle surge current②, A ..	I_{FSM}	5500	6000	6500
3 cycle surge current②, A	I_{FSM}	4300	4700	5050
10 cycle surge current②, A	I_{FSM}	3300	3600	3900
I^2t for fusing (for times = 8.3 ms) A^2 sec.	I^2t	125,000	150,000	175,000
Max I^2t of package (t=8.3 ms), A^2sec	I^2t	20×10^6	20×10^6	20×10^6
Forward voltage drop at I_{FM} = 800 A and $T_J = 25°C$, V	V_{FM}	1.7	1.5	1.4
Forward voltage drop at rated single phase average current and case temperature, V	V_{FM}	1.7	1.85	1.85

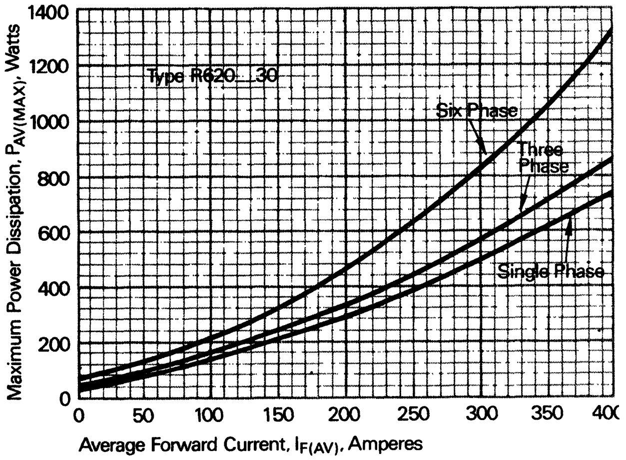
① At maximum TJ
② Per JEDEC RS-282, 4.01 F.3.
③ Consult recommended mounting procedures.

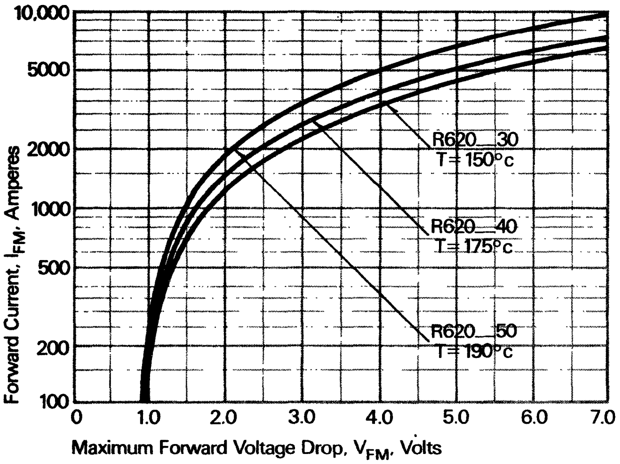
RECTIFIER

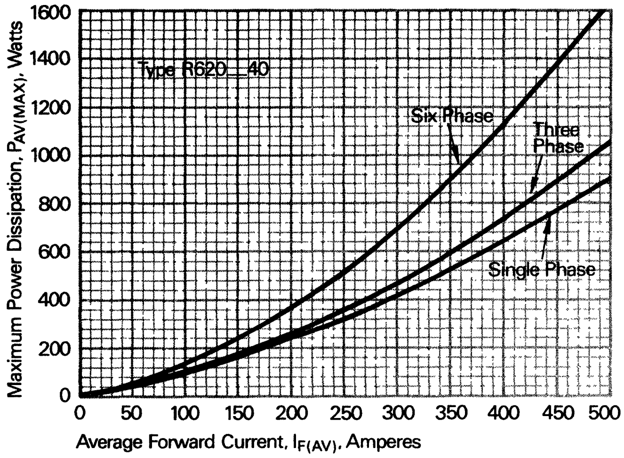
General Purpose RECTIFIERS R620

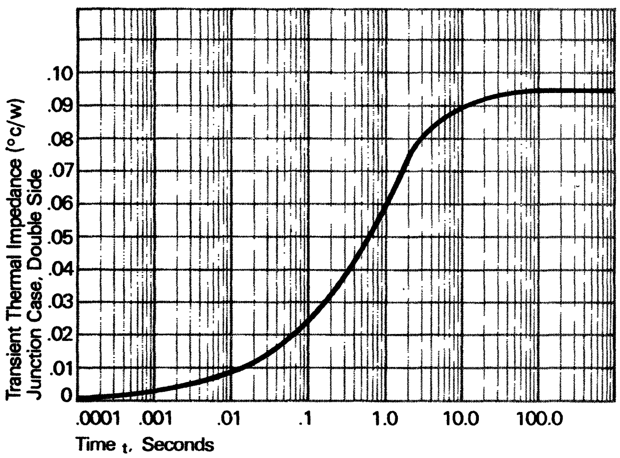
300-500 A Avg. Up to 3000 Volts

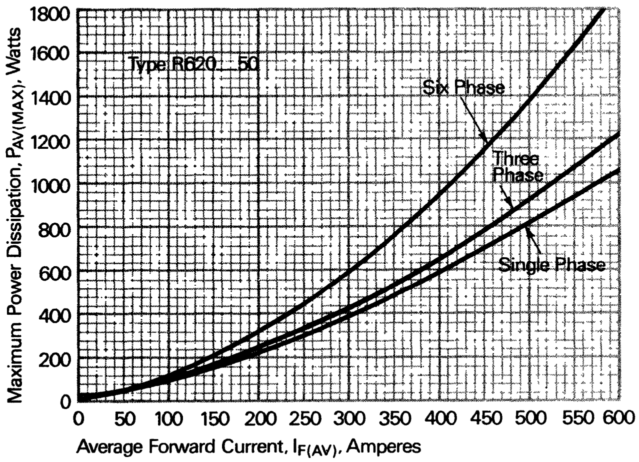




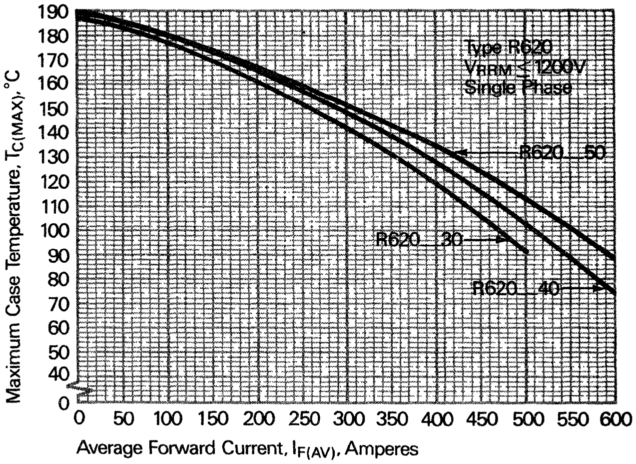


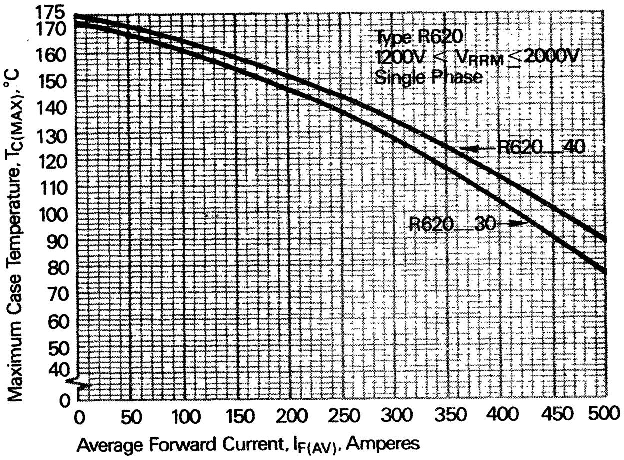


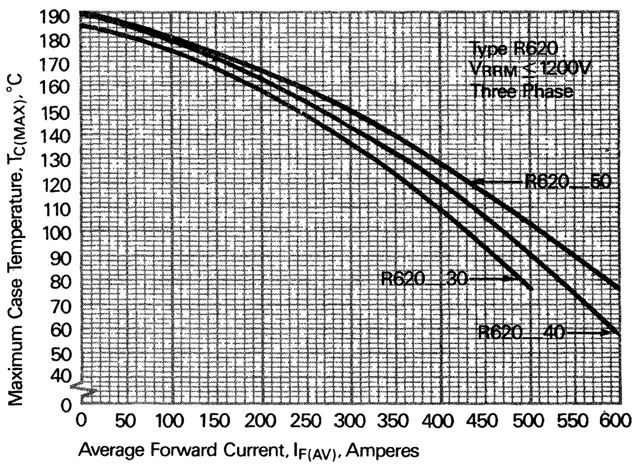


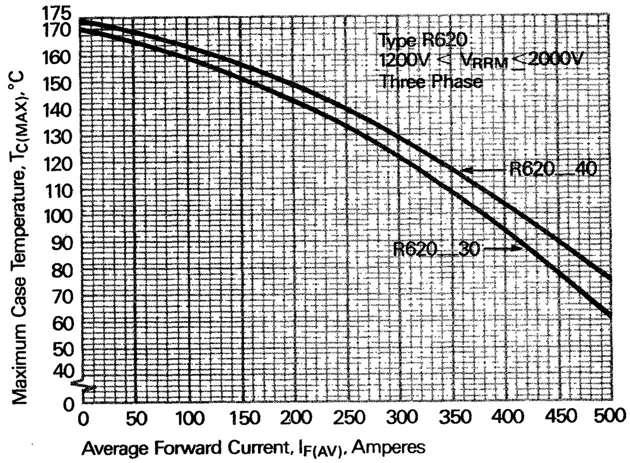


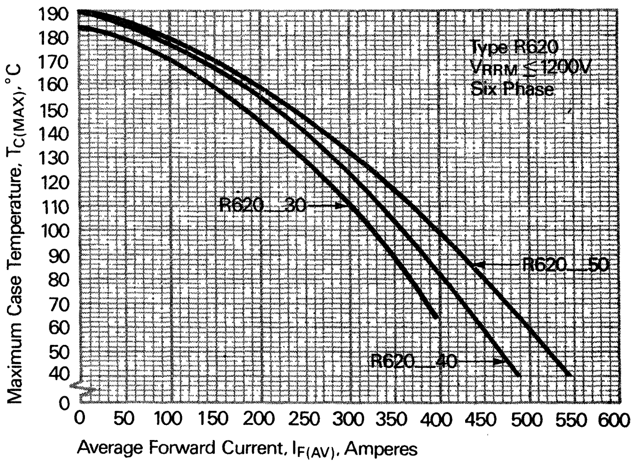
General Purpose RECTIFIERS R620

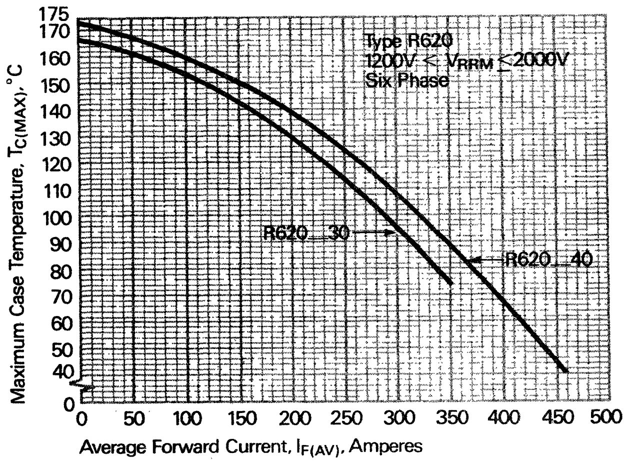






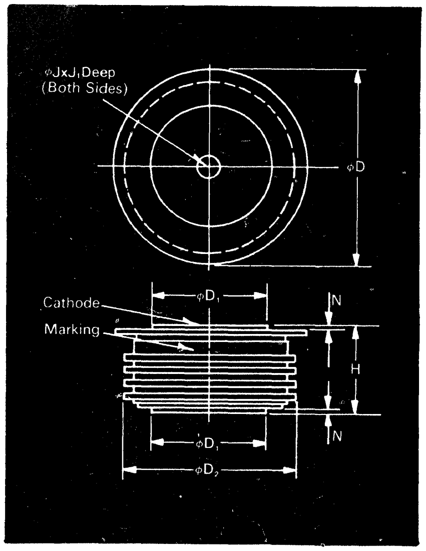






General Purpose Rectifiers R720

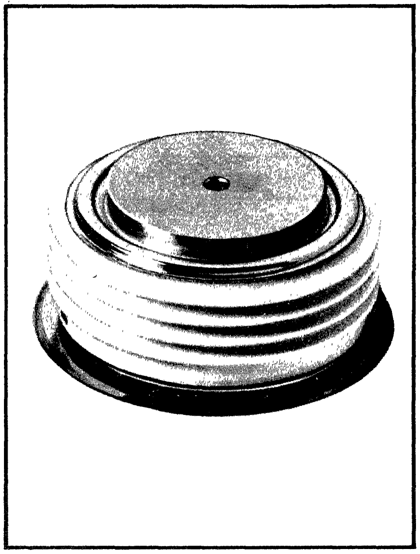
600-1200 A. Avg. Up to 3000 Volts



R72 Outline

Symbol	Inches Min.	Inches Max.	Millimeters Min.	Millimeters Max.
ϕD	2.250	2.290	57.15	58.17
ϕD_1	1.333	1.343	33.86	34.11
ϕD_2	2.030	2.090	51.56	53.09
H	1.020	1.060	25.91	26.92
ϕJ	.135	.145	3.43	3.68
J_1	.075	.090	1.91	2.29
N	.040		1.02	

Creep Distance—1.15 in. min. (29.36 mm).
Strike Distance—1.02 in. min. (2591 mm).
(In accordance with NEMA standards.)
Finish—Nickel Plate.
Approx. Weight—8 oz. (227g).
1. Dimension "H" is clamped dimension.



Features:
- High Surge Current Ratings
- High Rated Blocking Voltages
- Special Electrical Selection For Parallel and Series Operation
- Available in Factory Assembled Water or Air Heat Exchangers
- Lifetime Guarantee
- **Single or double-sided cooling**
- **Long creepage & strike paths**
- **Hermetic seal**

Applications:
- **Rectification**
- **Free Wheeling**
- **Battery Chargers**
- **Resistance Welding**

Ordering Information

Type	Voltage		Current		Recovery Time		Recovery Time Circuit		Leads	
Code	V_{RRM} (V)	Code	$I_{F(av)}$ (A)	Code	t_{rr} µsec	Code	Circuit	Code	Case	Code
R720	100	01	600	06	13	X	JEDEC	X	R72	00
	200	02								
	400	04	900	09	10					
	600	06								
	800	08	1200	12	7					
	1000	10			(typical)					
	1200	12								
	1400	14								
	1600	16								
	1800	18								
	2000	20								
	2200	22								
	2400	24								
	2600	26								
	2800	28								
	3000	30								

Example

Obtain optimum device performance for your application by selecting proper Order Code.

Type R720 rated at 900A average with V_{RRM}=1000V, Order as:

Type				Voltage		Current		trr	Circuit	Leads	
R	7	2	0	1	0	0	9	X	X	0	0

600-1200 A. Avg. Up to 3000 Volts

General Purpose Rectifiers R720

RECTIFIER

Voltage

Blocking State Maximums ①

	Symbol																
Repetitive peak reverse voltage , V	V_{RRM}	100	200	400	600	800	1000	1200	1400	1600	1800	2000	2200	2400	2600	2800	3000
Non-repetitive transient peak reverse voltage, $t \leq 5.0$ m sec	V_{RSM}	200	300	500	700	1000	1200	1400	1600	1800	2000	2200	2400	2600	2800	3000	3200

	Symbol	100–1200 V	1400–2000 V	2200–3000 V
		R720_ _06	R720_ _06	R720_ _06
		R720_ _09	R720_ _09	
		R720_ _12		
Reverse leakage current, mA peak	I_{RRM}	50	50	50

Switching

	Symbol	100–1200 V	1400–2000 V	2200–3000 V
Typical Reverse Recovery Time $I_{FM} = 1500$ $t_p = 190\mu s$ $diR/dt = 25A/\mu s$, $T_C = 25°C$, μs	trr	7	10	13

Thermal and Mechanical

	Symbol	100–1200 V	1400–2000 V	2200–3000 V
Min., Max. oper. junction temp., °C	T_J	−65 to 200	−65 to 175	−65 to 150
Min., Max. storage temp., °C	T_{stg}	−65 to 200	−65 to 200	−65 to 200
Min., Max. mounting force, lb③		2000 to 2400	2000 to 2400	2000 to 2400
Thermal resistance③ with double sided cooling Junction to case, °C/Watt	$R_{\theta JC}$	.055	.055	.055
Case to sink, lubricated °C/Watt	$R_{\theta CS}$	.02	.02	.02

Current

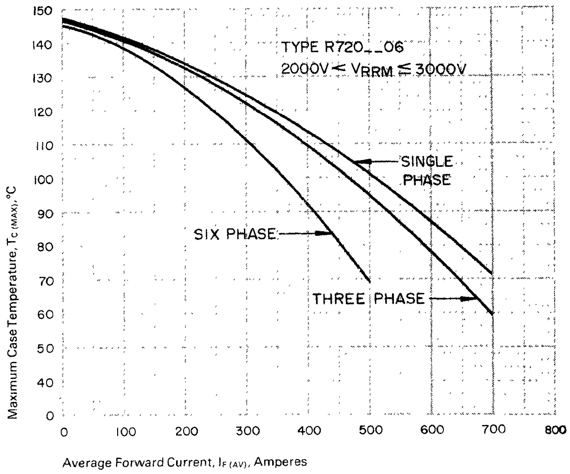
Conducting State Maximums

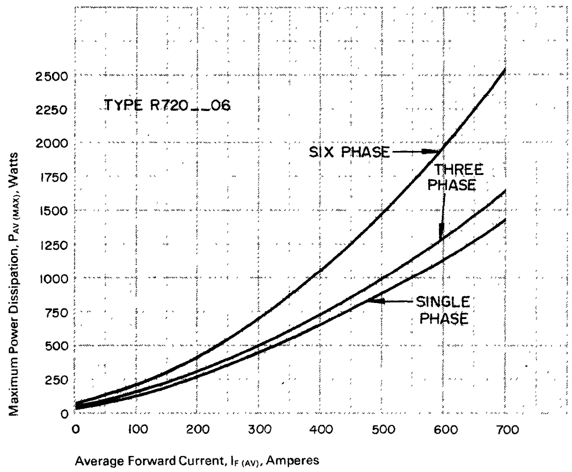
	Symbol	R720 _ _ 06	R720 _ _ 09	R720 _ _ 12
RMS forward current, A	$I_{F(rms)}$	945	1415	1885
Ave. forward current, A	$I_{F(av)}$	600	900	1200
One-half cycle surge current②, A ..	I_{FSM}	7000	8500	12500
3 cycle surge current②, A	I_{FSM}	5250	6350	9400
10 cycle surge current②, A	I_{FSM}	4350	5300	7800
I^2t for fusing (for times =8.3 ms) A^2 sec.	I^2t	204,000	301,000	650,700
Max I^2t of package (t=8.3 ms), A^2sec	I^2t	80×10^6	80×10^6	80×10^6
Forward voltage drop at I_{FM} = 1500A and T_J = 25°C, V	V_{FM}	1.8	1.6	1.2
Forward voltage drop at rated single phase average current and case temperature, V	V_{FM}	2.1	2.1	1.6

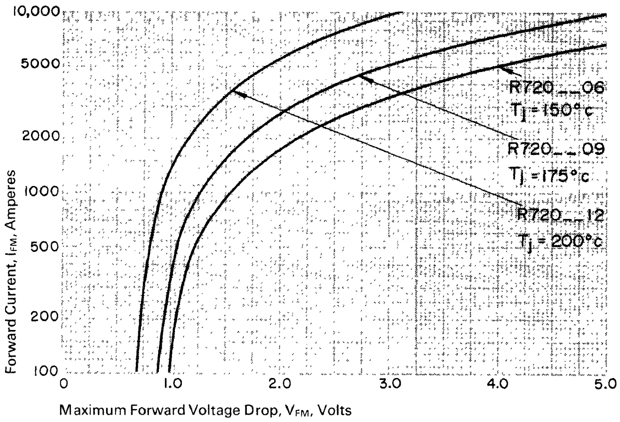
① At maximum TJ
② Per JEDEC RS-282, 4.01 F.3.
③ Consult recommended mounting procedures.

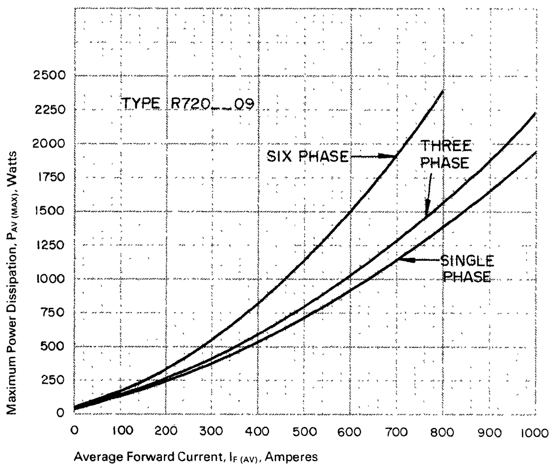
General Purpose Rectifiers R720

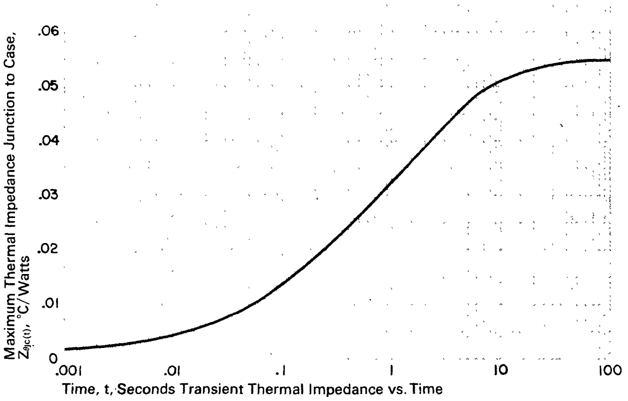
600-1200 A. Avg. Up to 3000 Volts

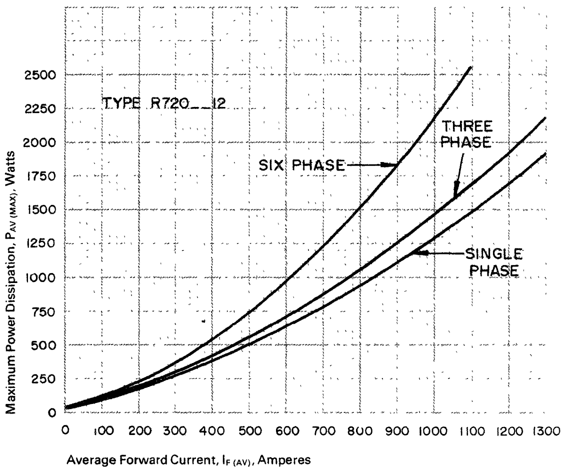






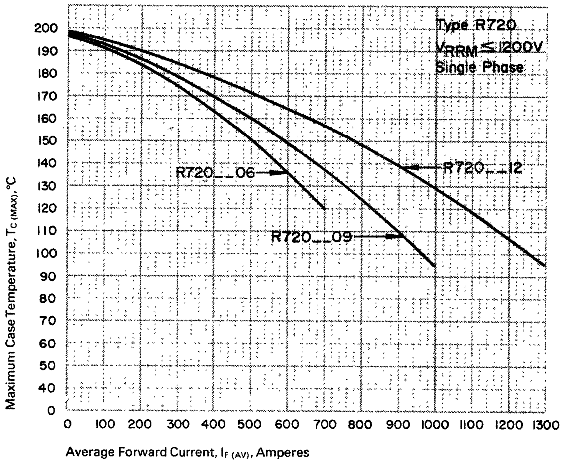


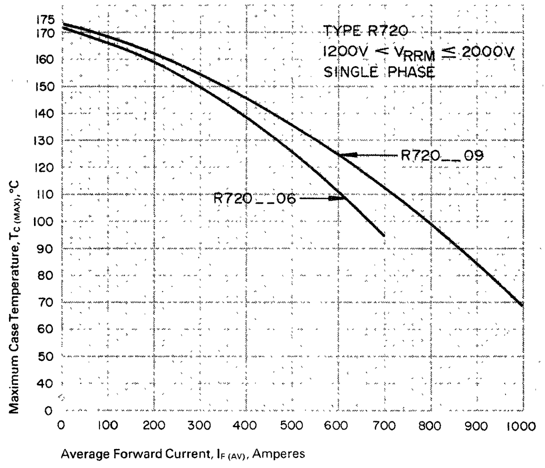


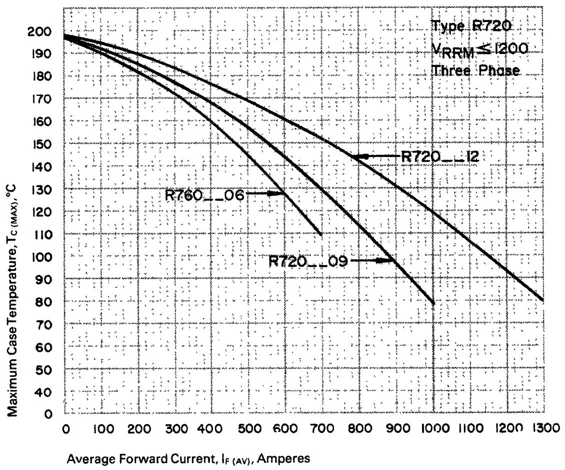


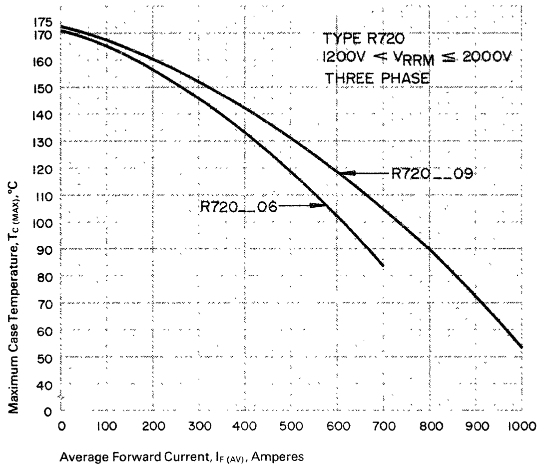
RECTIFIER

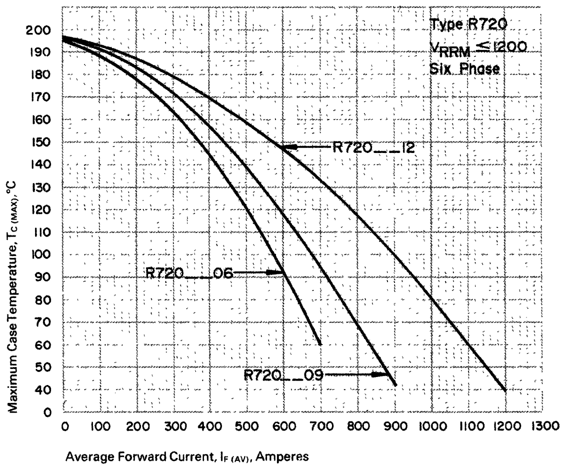
General Purpose Rectifiers R720

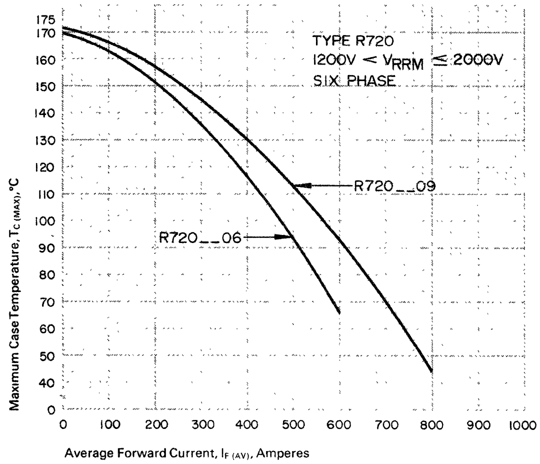






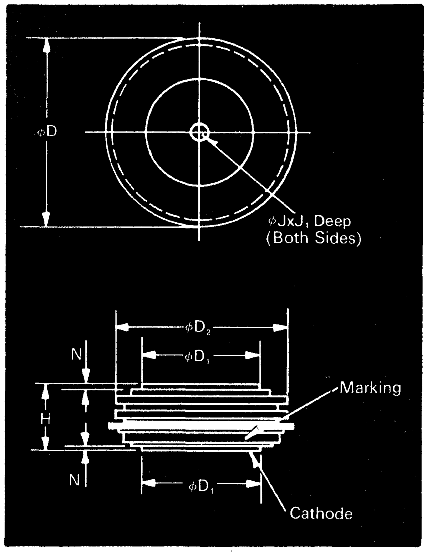






General Purpose RECTIFIERS R920

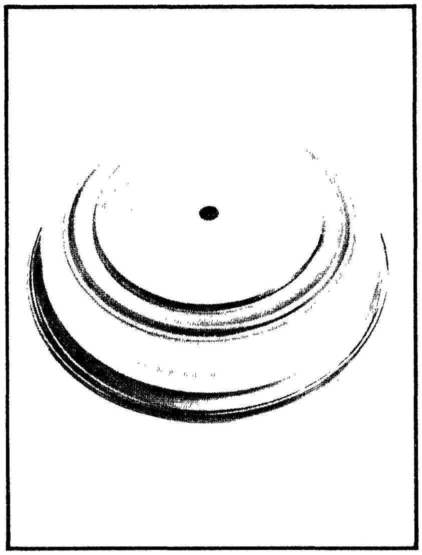
1100-2000 A Avg. Up to 3000 Volts



R92 Outline

Symbol	Inches Min.	Inches Max.	Millimeters Min.	Millimeters Max.
ϕD	2.880	2.920	73.15	74.17
ϕD_1	1.744	1.755	44.30	44.58
ϕD_2	2.580	2.700	65.53	68.58
H	1.020	1.060	25.91	26.92
ϕJ	1.35	.145	3.43	3.68
J_1	.075	.090	1.91	2.29
N	.060		1.27	

Creep Distance—.80 in. min. (20.32 mm).
Strike Distance—1.02 in. min. (25.91 mm).
(In accordance with NEMA standards.)
Finish—Nickel Plate.
Approx. Weight—16 oz. (454g.)
1. Dimension "H" is clamped dimension.



Features:
- High Surge Current Ratings
- High Rated Blocking Voltages
- Special Electrical Selection For Parallel and Series Operation
- Available in Factory Assembled Water or Air Heat Exchangers
- Single or double-sided cooling
- Long creepage & strike paths
- Hermetic seal
- Lifetime guarantee

Applications:
- Rectification
- Free Wheeling
- Battery Chargers
- Resistance Welding

Ordering Information

Type	Voltage		Current		Recovery Time		Recovery Time Circuit		Leads	
Code	V_{RRM} (V)	Code	$I_{F(av)}$ (A)	Code	t_{rr} μsec	Code	Circuit	Code	Case	Code
R920	100	01	1100	11	25	X	JEDEC	X	R92	00
	200	02								
	400	04	1600	16	20					
	600	06								
	800	08	2000	20	15 (typical)					
	1000	10								
	1200	12								
	1400	14								
	1600	16								
	1800	18								
	2000	20								
	2200	22								
	2400	24								
	2600	26								
	2800	28								
	3000	30								

Example

Obtain optimum device performance for your application by selecting proper Order Code.

Type R920 rated at 1600A average with V_{RRM} = 1000V, Order as:

Type			Voltage		Current		trr	Circuit	Leads	
R	9	2	0	1	0	1	6	X	X	0	0

1100 — 2000 A Avg. Up to 3000 Volts

General Purpose RECTIFIERS R920

RECTIFIER

Voltage

Blocking State Maximums ①

Parameter	Symbol																
Repetitive peak reverse voltage , V	V_{RRM}	100	200	400	600	800	1000	1200	1400	1600	1800	2000	2200	2400	2600	2800	3000
Non-repetitive transient peak reverse voltage, $V \leq 5.0$ m sec	V_{RSM}	200	300	500	700	1000	1200	1400	1600	1800	2000	2200	2400	2600	2800	3000	3200

Parameter	Symbol	100–1200	1400–2000	2200–3000
		R920__11	R920__11	R920__11
		R920__16	R920__16	
		R920__20	R920__20	
Reverse leakage current, mA peak	I_{RRM}	100	75	50

Switching

Parameter	Symbol	100–1200	1400–2000	2200–3000
Typical Reverse Recovery Time $I_{FM} = 1500$ $t_p = 190\mu s$ $diR/dt = 25A/\mu s$, $T_C = 25°C$, μs	t_{rr}	12	15	20

Thermal and Mechanical

Parameter	Symbol	100–1200	1400–2000	2200–3000
Min., Max. oper. junction temp., °C	T_J	−65 to 190	−65 to 175	−65 to 150
Min., Max. storage temp., °C	T_{stg}	−65 to 190	−65 to 190	−65 to 190
Min., Max. mounting force, lb③		5000 to 5500	5000 to 5500	5000 to 5500
Thermal resistance③ with double sided cooling Junction to case, °C/Watt	$R_{\theta JC}$	.03	.03	.03
Case to sink, lubricated °C/Watt	$R_{\theta CS}$	.01	.01	.01

Current

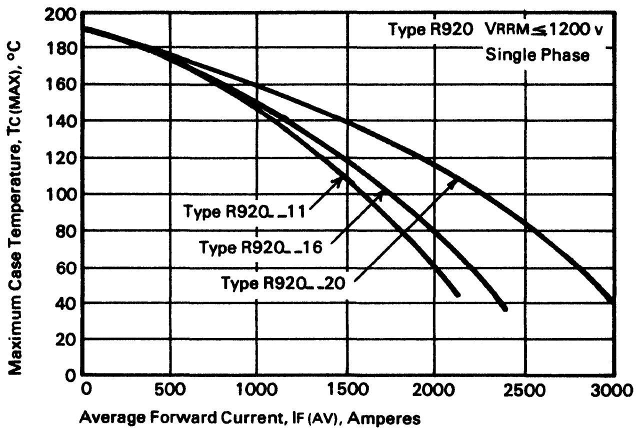
Conducting State Maximums

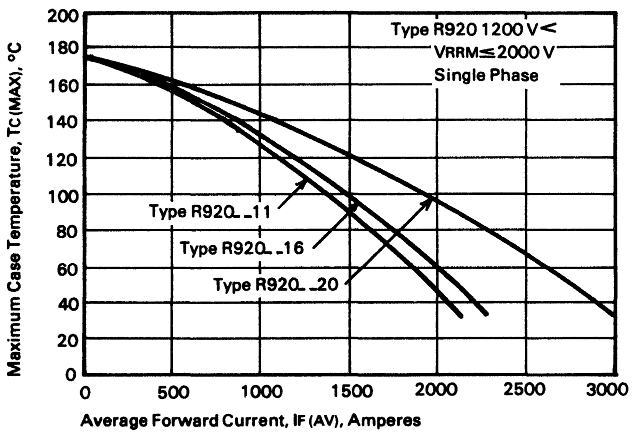
Parameter	Symbol	R920 _ _ 11	R920 _ _ 16	R920 _ _ 20
RMS forward current, A	$I_{F(rms)}$	1725	2500	3140
Ave. forward current, A	$I_{F(av)}$	1100	1600	2000
One-half cycle surge current②, A	I_{FSM}	16,000	21,500	30,000
3 cycle surge current②, A	I_{FSM}	12,000	16,000	22,000
10 cycle surge current②, A	I_{FSM}	10,000	13,300	18,500
I^2t for fusing (for times $\geq$ 8.3 ms) A^2 sec.	I^2t	1,100,000	1,925,000	3,700,000
Max I^2t of package (t=8.3 ms), A^2sec	I^2t	90×10^6	90×10^6	90×10^6
Forward voltage drop at I_{FM} = 1500A and T_J = 25°C, V	V_{FM}	1.45	1.20	1.05
Forward voltage drop at rated single phase average current and case temperature, V	V_{FM}	1.55	1.50	1.45

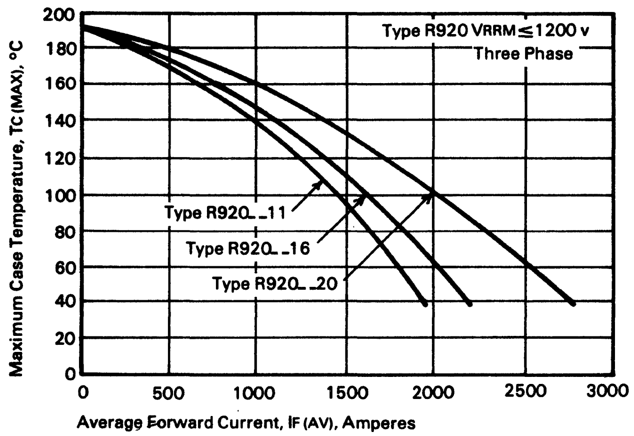
① At maximum TJ
② Per JEDEC RS-282, 4.01 F.3.
③ Consult recommended mounting procedures.

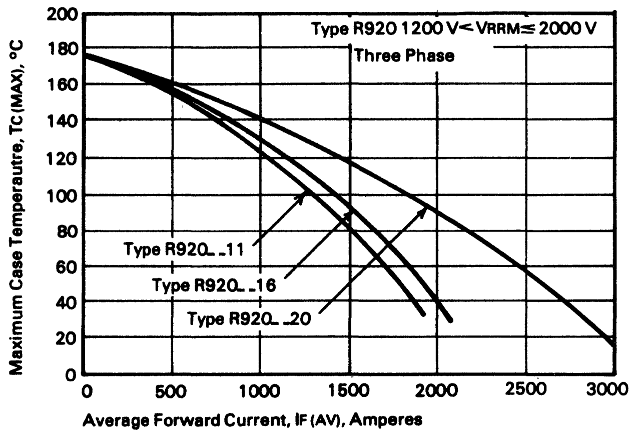
General Purpose RECTIFIERS R920

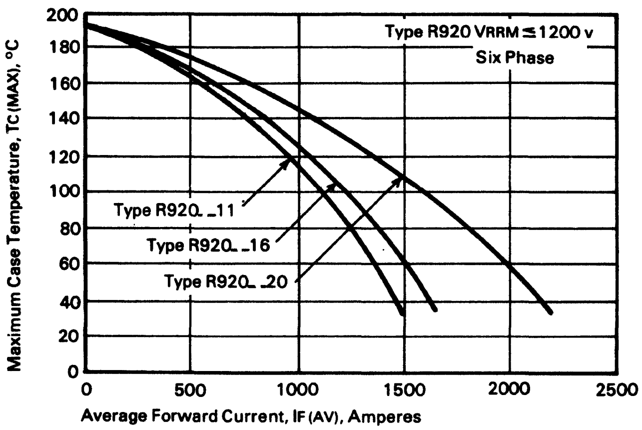
1100 — 2000 A Avg. Up to 3000 Volts

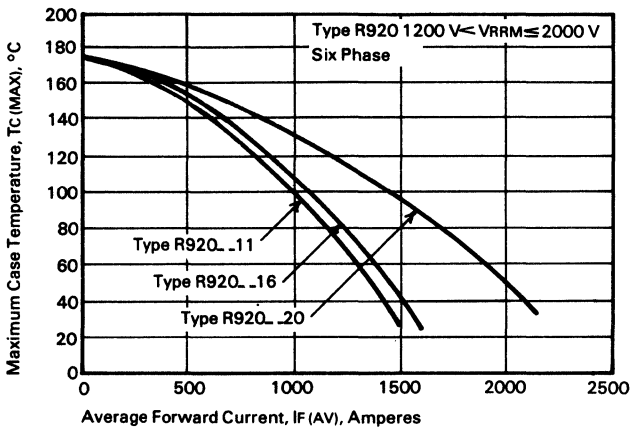






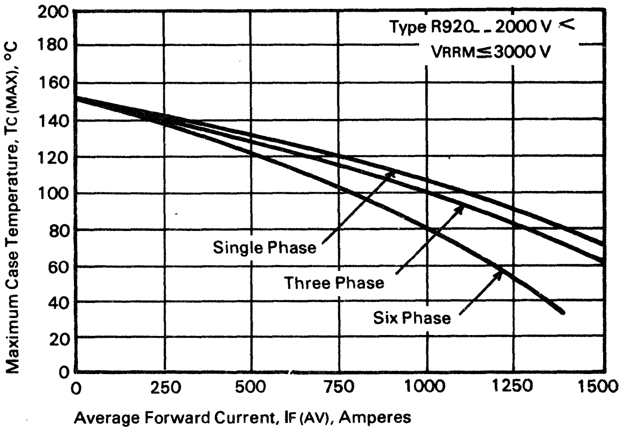


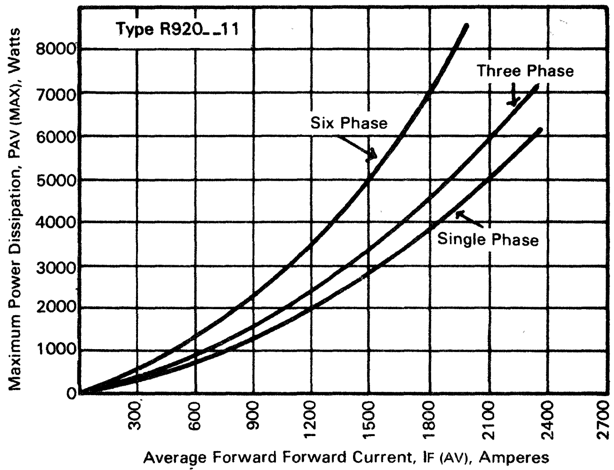


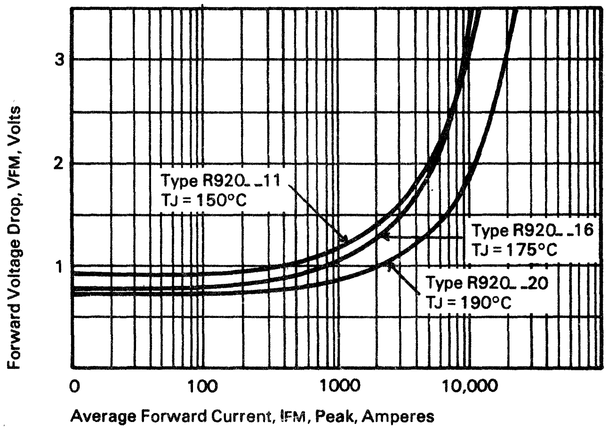


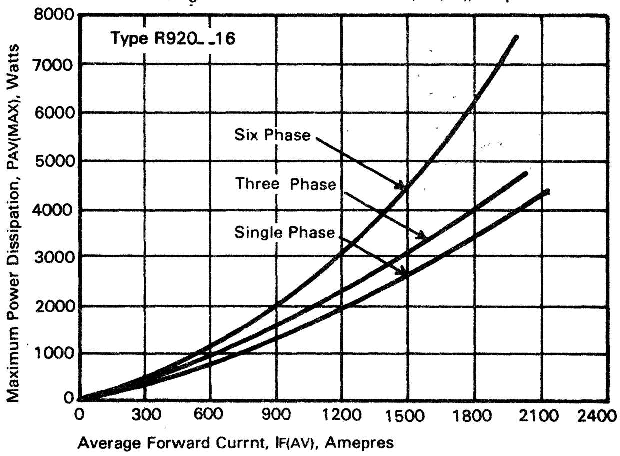
1100 — 2000 A Avg.
Up to 3000 Volts

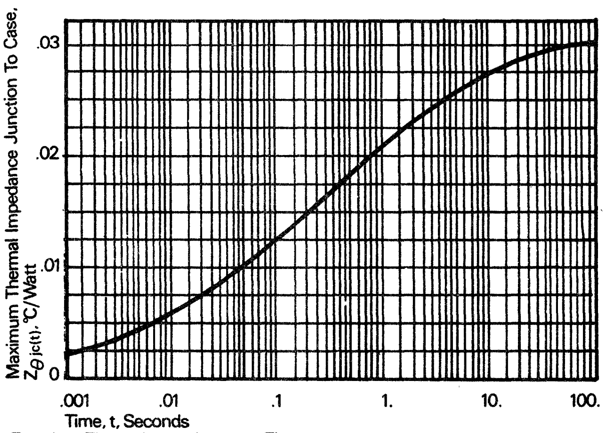
General Purpose
RECTIFIERS
R920



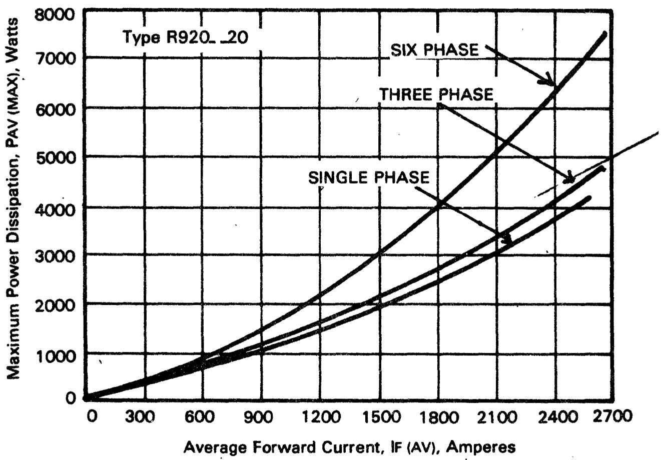






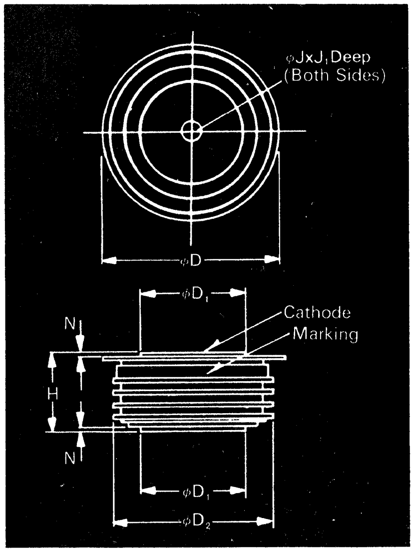


Transient Thermal Impedance vs. Time



General Purpose RECTIFIER R9G0

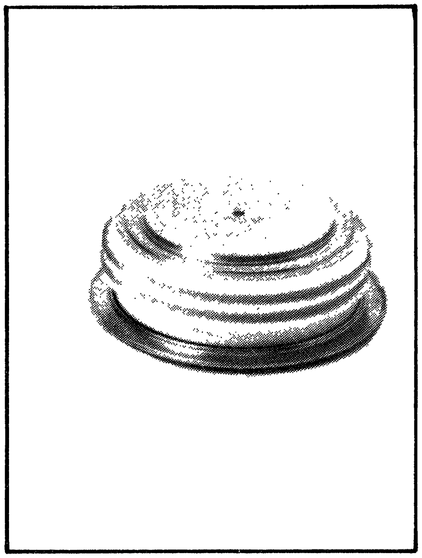
1300 — 2200 A Avg. Up to 3000 Volts



R9G Outline

Symbol	Inches Min.	Inches Max.	Millimeters Min.	Millimeters Max.
φD	2.850	2.900	72.39	73.66
φD_1	1.845	1.855	46.86	47.12
φD_2	2.560	2.640	65.02	67.06
H	1.020	1.060	25.91	26.92
φJ	.135	.145	3.43	3.68
J_1	.075	.090	1.91	2.29
N	.050		1.27	

Creep Distance—1.15 in. min. (29.36 mm).
Strike Distance—1.02 in. min. (25.91 mm).
(In accordance with NEMA standards.)
Finish—Nickel Plate.
Approx. Weight—1 lb. (454g.)
1. Dimension "H" is Clamped Dimension.



Features:
- High Surge Current Ratings
- High Rated Blocking Voltages
- Special Electrical Selection For Parallel and Series Operation
- Available in Factory Assembled Water or Air Heat Exchangers
- Low Thermal Impedance
- Single or double-sided cooling
- Long creepage & strike paths

Applications:
- Rectification
- Free Wheeling
- Battery Chargers
- Resistance Welding
- Cathodic Protection

Ordering Information

Type	Voltage		Current		Recovery Time		Recovery Time Circuit		Leads	
Code	V_{RRM} (V)	**Code**	$I_{F(av)}$ (A)	**Code**	t_{rr} µsec	**Code**	Circuit	**Code**	Case	**Code**
R9G0	100	**01**	1300	**13**	25	**X**	JEDEC	**X**	R9G	**00**
	200	**02**								
	400	**04**	1800	**18**	20					
	600	**06**								
	800	**08**	2200	**22**	15					
	1000	**10**			(typical)					
	1200	**12**								
	1400	**14**								
	1600	**16**								
	1800	**18**								
	2000	**20**								
	2200	**22**								
	2400	**24**								
	2600	**26**								
	2800	**28**								
	3000	**30**								

Example

Obtain optimum device performance for your application by selecting proper Order Code.

Type R9G0 rated at 1800A average with V_{RRM} = 1000V, Order as:

Type				Voltage		Current		trr	Circuit	Leads	
R	9	G	0	1	0	1	8	X	X	0	0

RECTIFIER

1300 — 2200 A Avg.
Up to 3000 Volts

General Purpose
RECTIFIER
R9G0

Voltage

Blocking State Maximums ①

Parameter	Symbol															
Repetitive peak reverse voltage , V	V_{RRM}	100	200	400	600	800	1000	1200	1400	1600	1800	2000	2200	2400	2600	2800	3000
Non-repetitive transient peak reverse voltage, $V \leq 5.0$ m sec	V_{RSM}	200	300	500	700	1000	1200	1400	1600	1800	2000	2200	2400	2600	2800	3000	3200
		← R9G0_13 →							← R9G0_13 →				← R9G0_13 →				
		← R9G0_18 →							← R9G0_18 →								
		← R9G0_22 →							← R9G0_22 →								
Reverse leakage current, mA peak	I_{RRM}	← 100 →							← 75 →				← 50 →				

Switching

	Symbol	$V_{RRM} \leq 1200V$	$1200V < V_{RRM} \leq 2000V$	$2000V < V_{RRM} \leq 3000V$
Typical Reverse Recovery Time $I_{FM} = 1500$ $t_p = 190\mu s$ $di_R/dt = 25A/\mu s$, $T_C = 25°C$, μs	t_{rr}	15	20	25

Thermal and Mechanical

	Symbol	$V_{RRM} \leq 1200V$	$1200V < V_{RRM} \leq 2000V$	$2000V < V_{RRM} \leq 3000V$
Min., Max. oper. junction temp., °C	T_J	−65 to 190	−65 to 175	−65 to 150
Min., Max. storage temp., °C	T_{stg}	−65 to 190	−65 to 190	−65 to 190
Min., Max. mounting force, lb③		5000 to 6000	5000 to 6000	5000 to 6000
Thermal resistance③ with double sided cooling				
Junction to case, °C/Watt	$R_{\theta JC}$	.023	.023	.023
Case to sink, lubricated °C/Watt	$R_{\theta CS}$	.075	.075	.075

Current

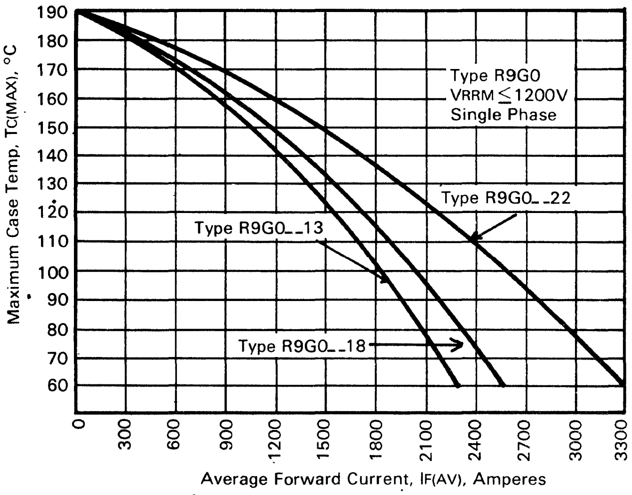
Conducting State Maximums

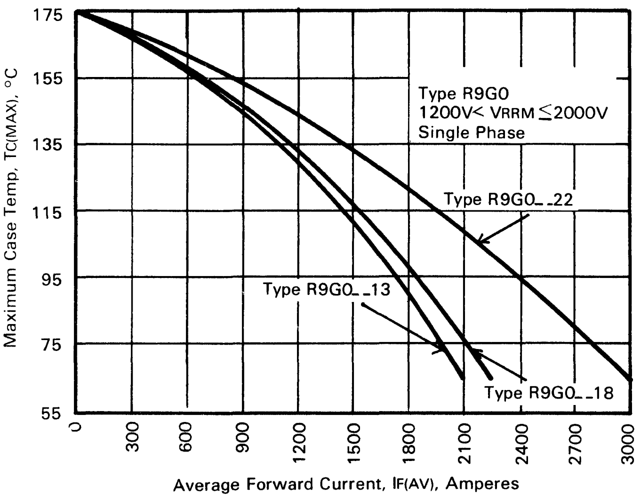
	Symbol	R9G0_13	R9G0_18	R9G0_22
RMS forward current, A	$I_{F(rms)}$	2040	2825	3455
Ave. forward current, A	$I_{F(av)}$	1300	1800	2200
One-half cycle surge current②, A	I_{FSM}	16,000	21,500	30,000
3 cycle surge current②, A	I_{FSM}	12,000	16,000	22,000
10 cycle surge current②, A	I_{FSM}	10,000	13,3000	18,500
I^2t for fusing (for times 8.3 ms) A^2 sec.	I^2t	1,100,000	1,925,000	3,700,000
Max I^2t of package (t=8.3 ms), A^2sec	I^2t	90x10[6]	90x10[6]	90x10[6]
Forward voltage drop at I_{FM} = 1500A and T_J = 25°C, V	V_{FM}	1.45	1.20	1.05
Forward voltage drop at rated single phase average current and case temperature, V	V_{FM}	1.55	1.50	1.45

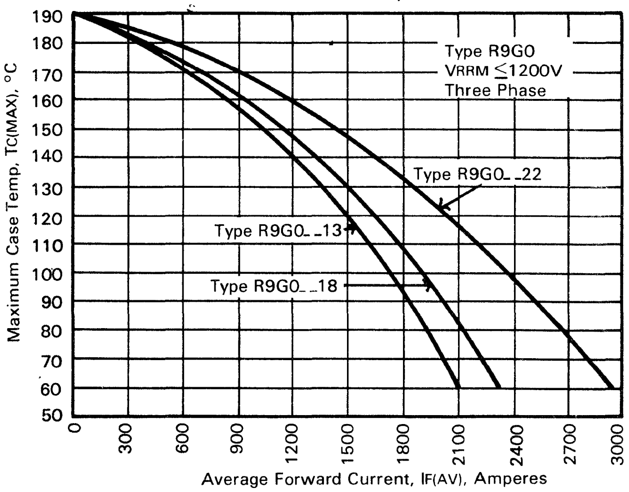
① At maximum TJ
② Per JEDEC RS-282, 4.01 F.3.
③ Consult recommended mounting procedures.

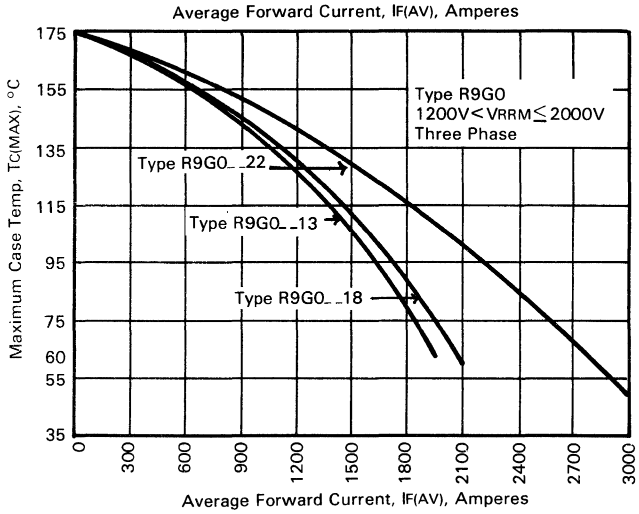
General Purpose RECTIFIER R9G0

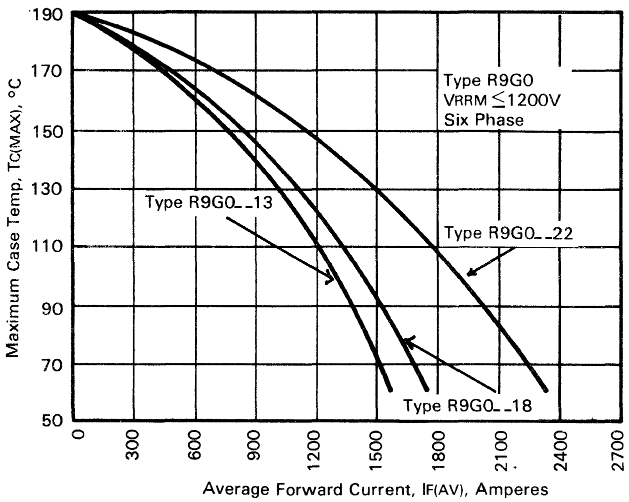
1300 — 2200 A Avg. Up to 3000 Volts

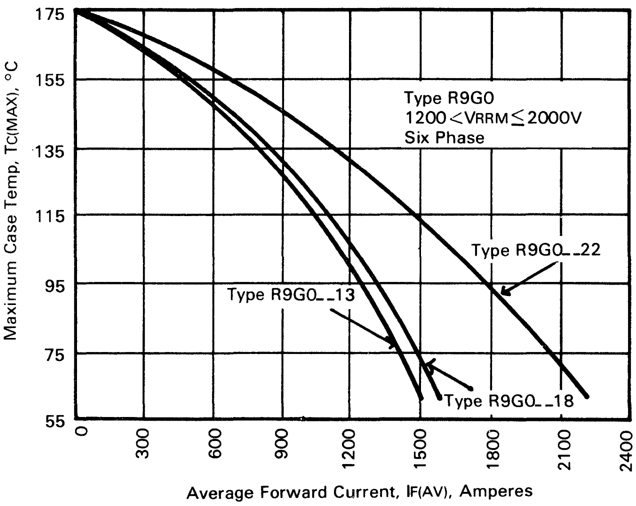








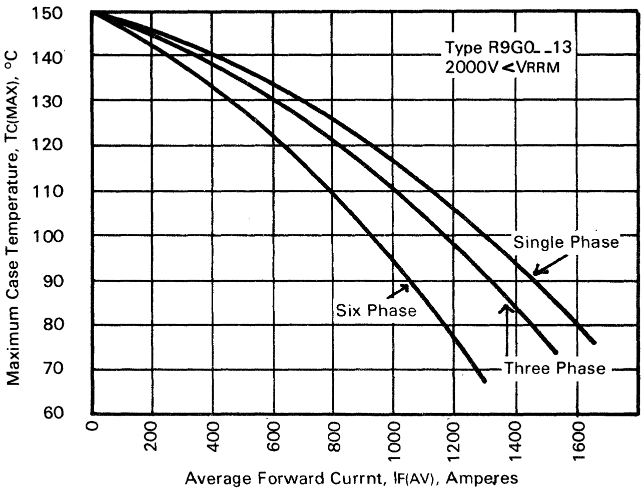


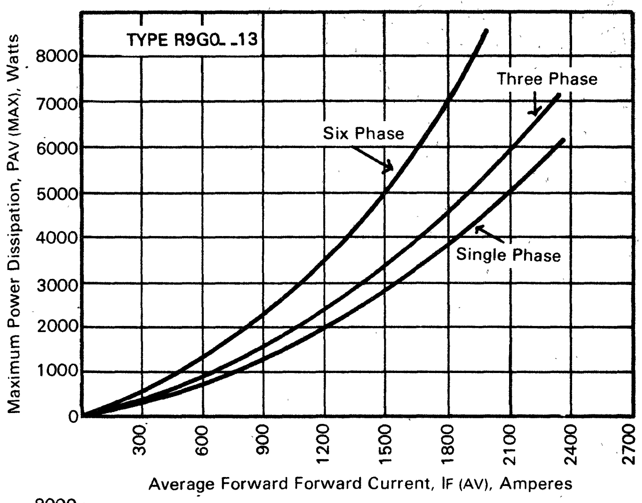


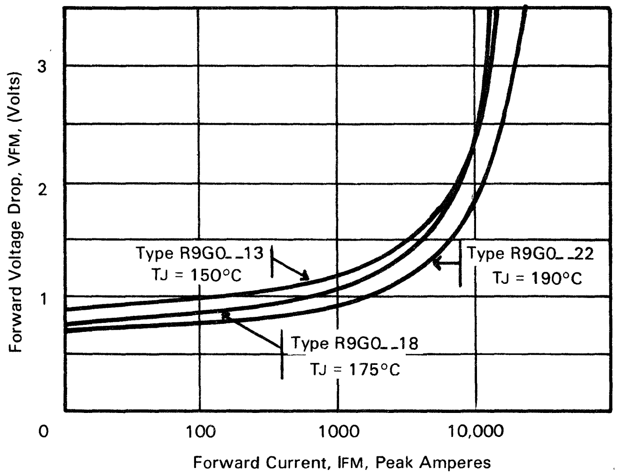
1300 — 2200 A Avg.
Up to 3000 Volts

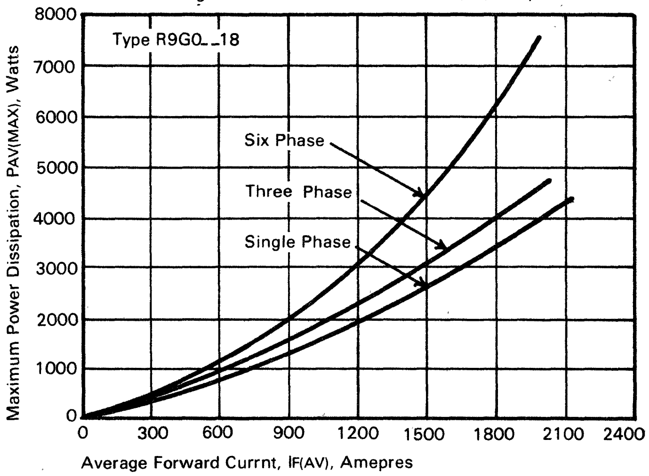
General Purpose RECTIFIER R9G0

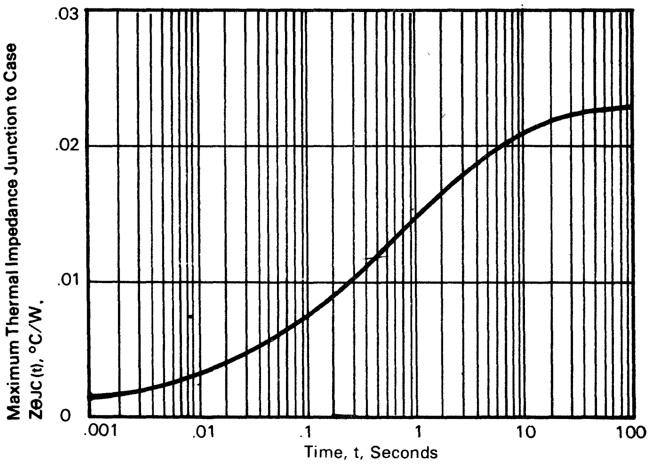
RECTIFIER



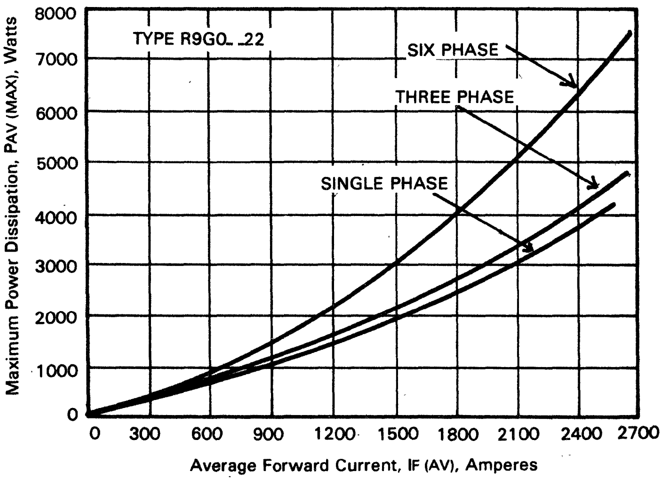






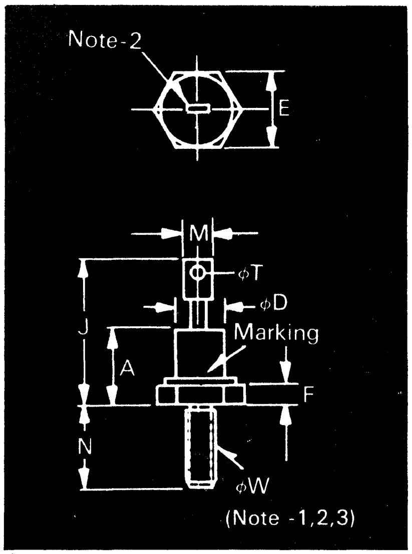


Transient Thermal Impedance Vs. Time



Fast Recovery RECTIFIERS IN3879 — 83, R/IN3889 — 93, R R302/R303

6 — 12 A. Avg. Up to 600 Volts 200 ns

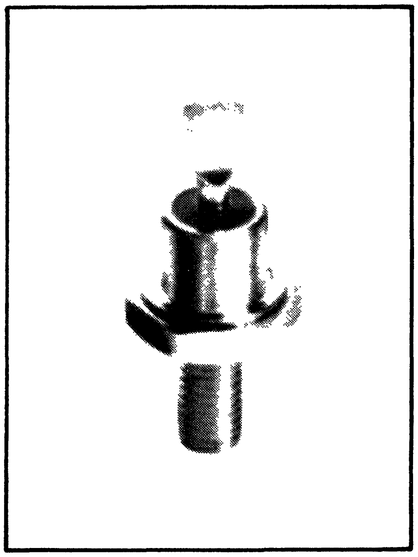


Conforms to DO-4 Outline

Symbol	Inches Min.	Inches Max.	Millimeters Min.	Millimeters Max.
A		.405		10.29
φD		.424		10.77
E	.424	.437	10.77	11.10
F	.075	.175	1.91	4.45
J		.800		20.32
M		.250		6.35
N	.422	.453	10.72	11.51
φT	.060	.105	1.52	2.67
φW	10-32 UNF-2A			

Glass to Metal Seal—
Creepage & Strike Distance = .07 in. min. (1.75 mm)
(In accordance with NEMA standards.)
Finish—Nickel Plate.
Approx. Weight—.2 oz (6g)
Standard Polarity—Green Glass
Reverse Polarity— Brown Glass

NOTES:
1. Complete threads to extend to within 2½ threads of seating plane.
2. Angular orientation of this terminal is undefined.
3. 10-32 UNF-2A maximum pitch diameter of plated threads shall be basic pitch diameter (.1697", 4.29 mm) Ref. (Screw thread standards for federal services 1957) Handbook H28 P1.



Features:
- Diffused Construction
- Fast Recovery
- Reverse Polarity Available
- Low VF

Applications:
- Computer Power Supplies
- Control Circuits
- Free Wheeling Applications
- By-Pass Rectifiers

Ordering Information

Voltage Rating	6A JEDEC R302/R303	12A JEDEC R302/R303
50	IN3879	IN3889
100	IN3880	IN3890
200	IN3881	IN3891
300	IN3882	IN3892
400	IN3883	IN3893
500	R3020506	R3020512
600	R3020606	R3020612

R302 — Standard
R303 - Reverse
For JEDEC Reverse Polarity add suffice R, i.e., IN3879R
①See JEDEC Circuit

Electrical Characteristics

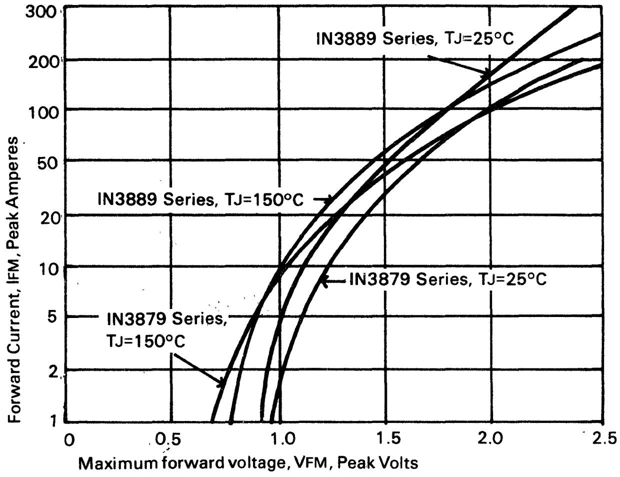
Parameters	IN3879,R To IN3883,R	IN3889,R To IN3893,R
Current $I_{F(AV)}$ @ T_C, °C	* 6A @ 100	* 12A @ 100
I_{FSM}	* 75A	* 150A
I^2t for Fusing	25	90
V_{FM} @ $I_{F(AV)}$ & 25°C	1.5V	1.5V
	* 3.0 MA	* 3.0 MA
	3.0°C/W	3.0 °C/W
T_J (OPER) Range	* —65 to 150°C	* —65 to 150°C
T_{stg} Range	* —65 to 175°C	* —65 to 175°C
t_{RR} ①	* 200 ns	* 200 ns

* JEDEC Registered Parameters

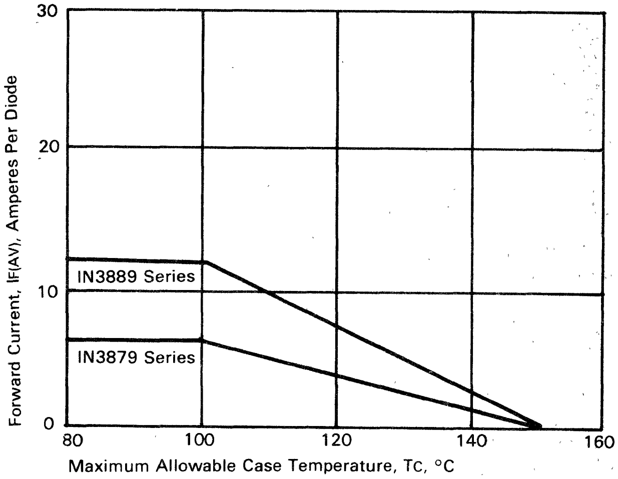
6 — 12 A. Avg. Up to 600 Volts 200 ns

Fast Recovery RECTIFIERS IN3879 — 83, R/IN3889 — 93, R R302/R303

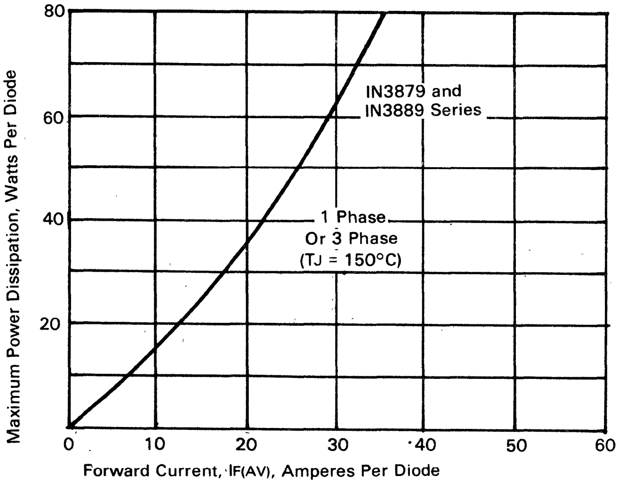
RECTIFIER



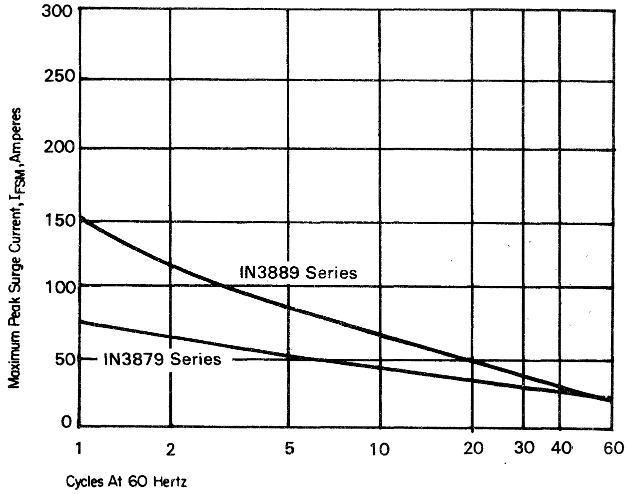
Current Versus Temperature



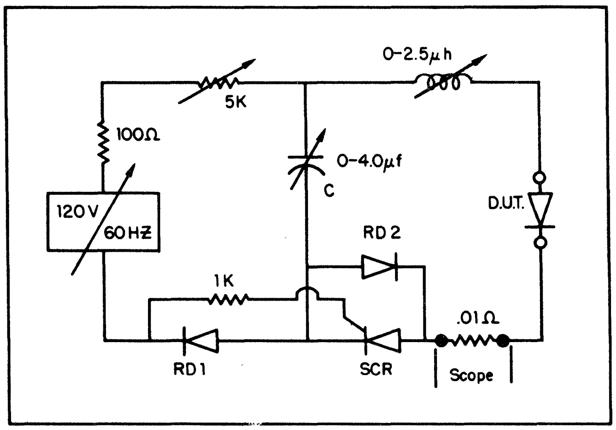
Power Versus Current



Non Repetitive Surge Current Versus Time

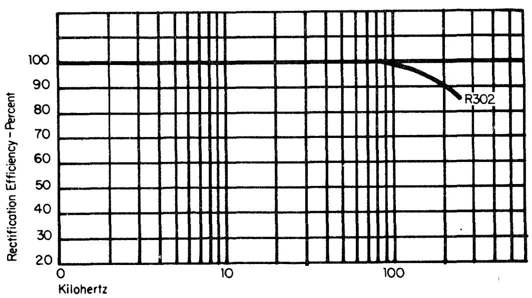


JEDEC Circuit



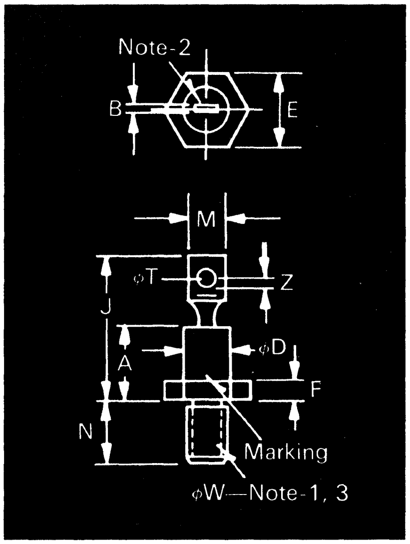
Reverse Recovery Time IN3879 and IN3889 Series
IFM=36A, diR/dt=25A/usec trr=200 NS

Normalized Rectifier Efficiency Versus Frequenc



Fast Recovery Rectifiers IN3899-93,R/IN3909-13,R R402/R403

20—30A. Avg. Up to 600 Volts 200 ns

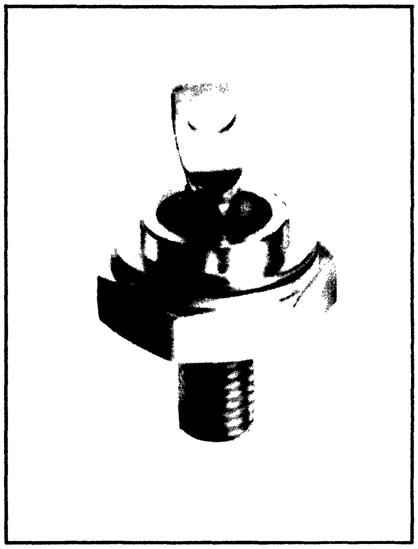


Conforms to DO-5 Outline

Symbol	Inches Min.	Inches Max.	Millimeters Min.	Millimeters Max.
A		.450		11.43
B		.080		2.03
φD		.667		16.94
E	.667	.687	16.94	17.45
F	.060	.200	1.52	5.08
J		1.000		25.40
M		.375		9.53
N	.422	.453	10.72	11.51
φT	.140	.175	3.56	4.45
Z	.156		3.96	
φW	¼-28 UNF-2A			

Glass To Metal Seal—
Creepage & Strike Distance = .09 in. min. (2.46 mm)
(In accordance with NEMA standards.)
Finish—Nickel Plate.
Approx. Weight—.6 oz (18g)
Standard Polarity—Green Glass
Reverse Polarity—Brown Glass

NOTES:
1. Complete threads to extend to within 2½ threads of seating plane.
2. Angular orientation of this terminal is undefined.
3. ¼-28 UNF-2A. Maximum pitch diameter of plated threads shall be basic pitch diameter (.2268″, 5.74 mm) Ref. (Screw thread standards for federal services 1957) Handbook H28 1957 P1.



Features:
- Diffused Construction
- Fast Recovery
- Reverse Polarity available
- Low Profile Package
- Low V_F

Applications:
- Computer Power Supplies
- Control Circuits
- Free Wheeling applications
- Bypass Rectifiers

RECTIFIER

ORDERING INFORMATION

VOLTAGE RATING	20A JEDEC R402/R403	30A JEDEC R402/R403
50	①IN3899	①IN3909
100	IN3900	IN3910
200	IN3901	IN3911
300	IN3902	IN3912
400	IN3903	IN3913
500	R4020520	R4020530
600	R4020620	R4020630

R402 — Standard
R403 — Reverse

① For JEDEC reverse polarity add suffix R, i.e., IN3899R.
② See JEDEC circuit.

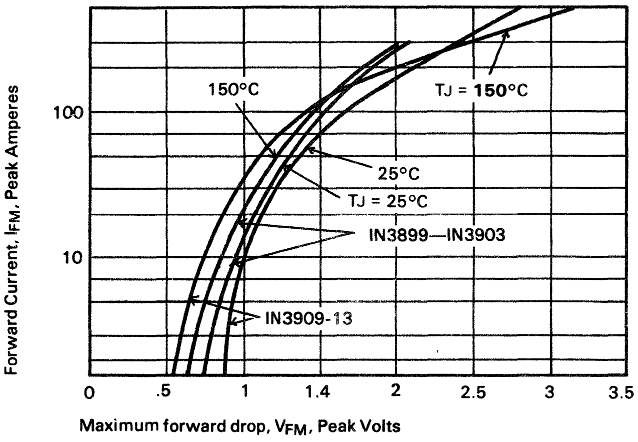
ELECTRICAL CHARACTERISTICS

PARAMETERS	IN3899,R TO IN3903,R	IN3909,R TO IN3913,R
Current $I_{F(AV)}$ @ T_C, °C	*20 A @100°C	*30 A @100°C
I_{FSM}	*225 A	*300 A
I^2t for Fusing	210A²sec	375A²sec
V_{FM} @ $I_{F(AV)}$ @ 25°C	1.5 V	1.5 V
I_{RRM} @ 100°C	*6.0 MA	*10.0 MA
$R_{\theta JC}$	1.0°C/W	1.0°C/W
$T_{J\,(OPER)}$ Range	*-65 to 150°C	*-65 to 150°C
T_{stg} Range	*-65 to 175°C	*-65 to 175°C
② trr	200 ns	200 ns

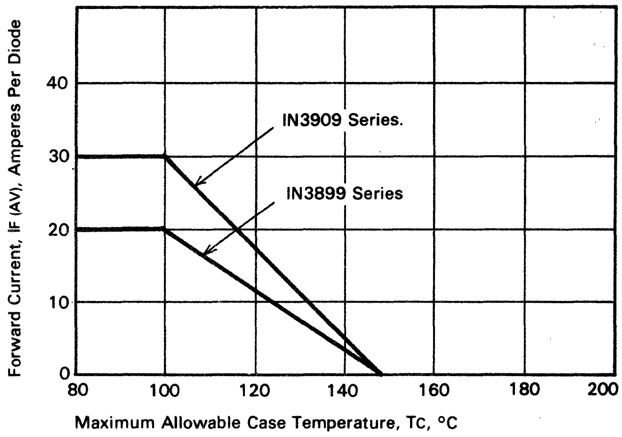
* JEDEC Registered Parameters.

20—30A. Avg. Up to 600 Volts 200 ns

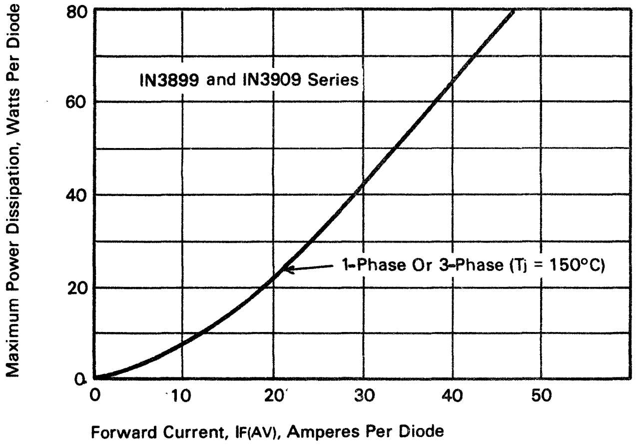
Fast Recovery Rectifiers IN3899-93,R/IN3909-13,R R402/R403

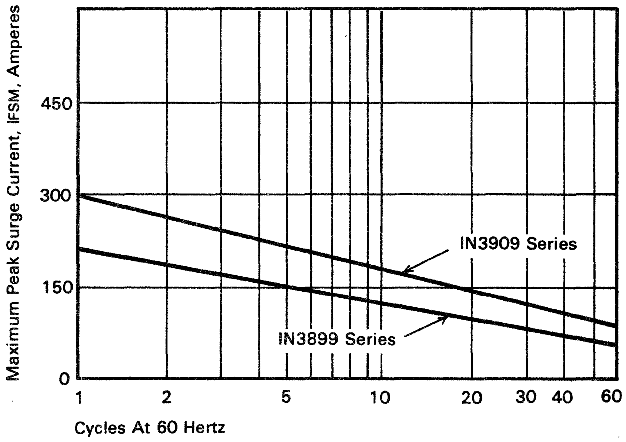


Current Versus Temperature

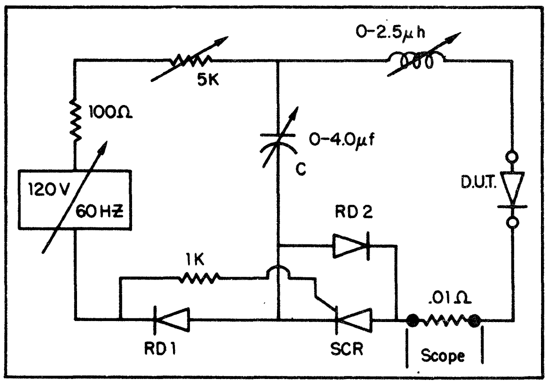


Power Versus Current





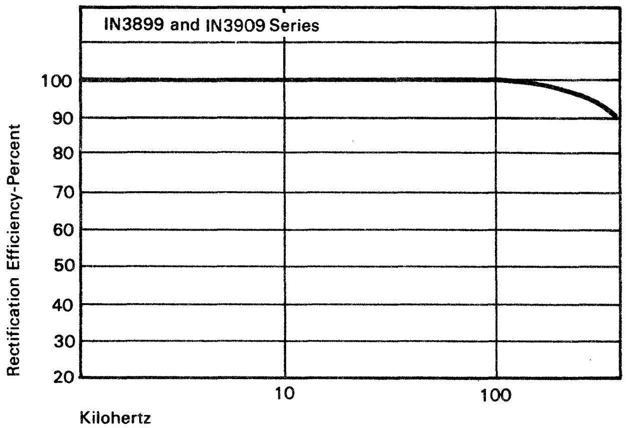
JEDEC Circuit



Reverse Recovery Time IN3899 and IN3909 Series

IFM = 100 A, diR/dt = 25 A/us

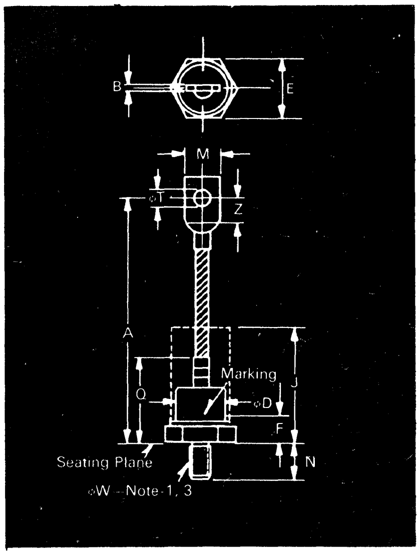
Normalized Rectifier Efficiency Versus Frequency



RECTIFIER

Fast Recovery RECTIFIER R502/R503

80 — 100A Avg. Up to 1200 Volts 1.5 — 3 μs

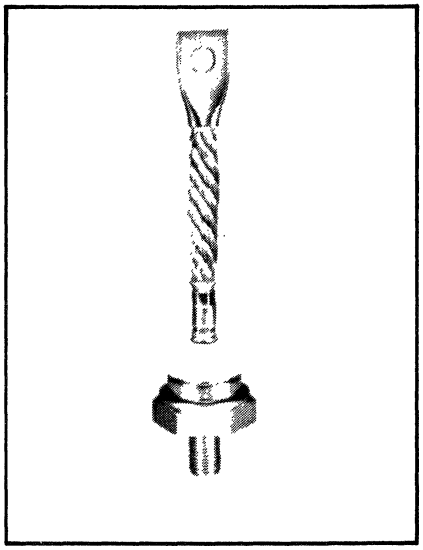


Conforms to DO-8 Outline

Symbol	Inches Min.	Inches Max.	Millimeters Min.	Millimeters Max.
A	4.18	4.62	106.17	117.35
B	.050	.100	1.27	2.54
ϕD	.860	1.000	21.84	25.40
E	1.031	1.063	26.19	27.00
F	.255	.400	6.48	10.16
J	2.50		63.50	
M	.437	.650	11.10	16.51
N	.605	.645	15.37	16.38
Q		1.675		42.54
ϕT	.250	.291	6.35	7.39
Z	.310		7.87	
ϕW	⅜-24 UNF-2A			

Creep & Strike—Distance:
.66 in. min. (16.94 mm).
(In accordance with NEMA standards.)
Finish—Nickel Plate.
Approx. Weight—3.5 oz (99g)
Standard Polarity—White Ceramic
Reverse Polarity—Pink Ceramic

1. Complete threads to extend to within 2½ threads of seating plane.
2. Angular orientation of terminal is undefined.
3. Pitch diameter of ⅜-24 UNF-2A (coated) threads (ASA B1.1-1960).
4. Dimension "J" denotes seated height with lead bent at right angle.



Features:
- Fast Recovery Times
- Standard and Reverse Polarities
- Flag Lead and Stud Top Terminals Available
- High Surge Current Ratings
- High Rated Blocking Voltages
- Special Electrical Selection for Parallel and Series Operation
- Glazed Ceramic Seal Gives High Voltage Creepage and Strike Paths
- Compression Bonded Encapsulation for Thermal Cycling Capability in Excess of 100, 000 Thermal Cycles
- Lifetime Guarantee

Applications:
- Inverters
- Choppers
- Transmitters
- Free Wheeling

Ordering Information

Type	Voltage		Current		Recovery Time		Recovery Time Circuit		Leads	
Code	V_{RRM} (V)	Code	$I_{F(av)}$ (A)	Code	t_{rr} μsec	Code	Circuit	Code	Case	Code
R502 (Standard Polarity)	100	**01**	80	**08**	1.5	**F**	JEDEC	**J**	DO-8	**WA**
	200	**02**								
R503 (Reverse Polarity)	300	**03**	100	**10**	2.0	**E**	JEDEC	**J**	DO-8	**WA**
	400	**04**								
	500	**05**			3.0	**C**	JEDEC	**J**	DO-8	**WA**
	600	**06**								
	700	**07**								
	800	**08**								
	900	**09**								
	1000	**10**								
	1100	**11**								
	1200	**12**								

Example

Obtain optimum device performance for your application by selecting proper Order Code.

Type R502 rated at 100A average with $V_{RRM} = 1000V$, recovery time = 1.5 μsec, and standard flexible lead—order as

Type			Voltage		Current		trr	Circuit	Leads	
R	5	0	2	1	0	1	0	F	J	W	A

80 — 100A. Avg. Up to 1200 Volts 1.5 — 3 μs

Fast Recovery RECTIFIER R502/R503

RECTIFIER

Voltage ④

Blocking State Maximums ①

	Symbol												
Repetitive peak reverse voltage, V	V_{RRM}	100	200	300	400	500	600	700	800	900	1000	1100	1200
Non-repetitive transient peak reverse voltage, $V \leq 5.0$ msec	V_{RSM}	200	300	400	500	600	800	900	1000	1100	1200	1300	1400
Reverse leakage current, mA peak	I_{RRM}	← 45 →											

Switching

($T_J = 25°C$)

Max. Reverse Recovery Time $I_{FM} = 314A$ tp = 40 μs $dI_R/dt = 25A/\mu s$, Tc = 25°C, μs	trr	← 1.5, 2.0 & 3.0 →

Thermal and Mechanical

Min., Max. oper. junction temp., °C	T_J	—40 to 175
Min., Max. storage temp., °C	T_{stg}	—40 to 175
Max. mounting torque, in lb. ② ③		120
Thermal resistance ③		
Junction to case, °C/Watt	$R_{\theta JC}$	.27
Case to sink, lubricated, °C/Watt	$R_{\theta CS}$	.12

Current

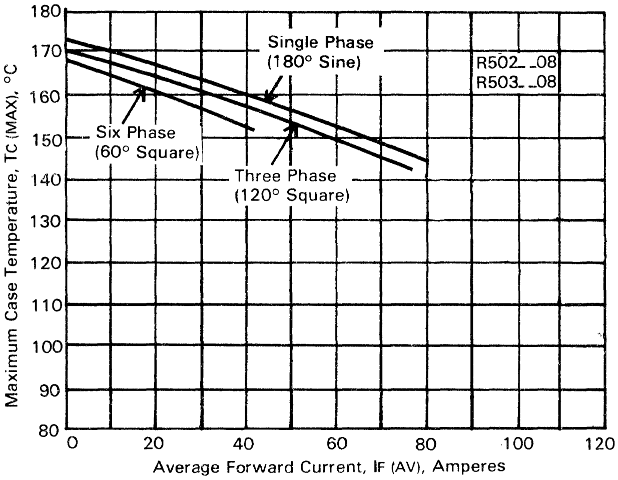
Conducting State Maximums

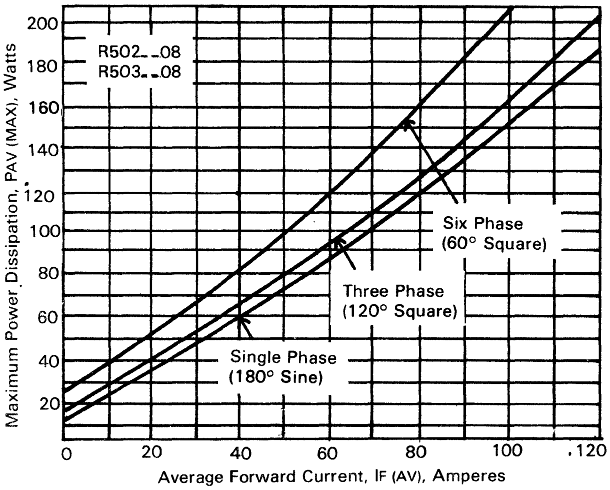
		R502__08 R503__08	R502__10 R503__10
RMS forward current, A	$I_{F(rms)}$	125	157
Ave. forward current, A	$I_{F(av)}$	80	100
One-half cycle surge current②, A	I_{FSM}	3000	3500
3 cycle surge current②, A	I_{FSM}	2500	2900
10 cycle surge current②, A	I_{FSM}	1800	2150
I^2t for fusing (for times = 8.3 ms) A^2 sec.	I^2t	37,500	51,000
Forward voltage drop at I_{FM} = 314 A and $T_J = 25°C$, V	V_{FM}	1.65	1.45
Forward voltage drop at rated single phase average current and case temperature, V	V_{FM}	1.60	1.50

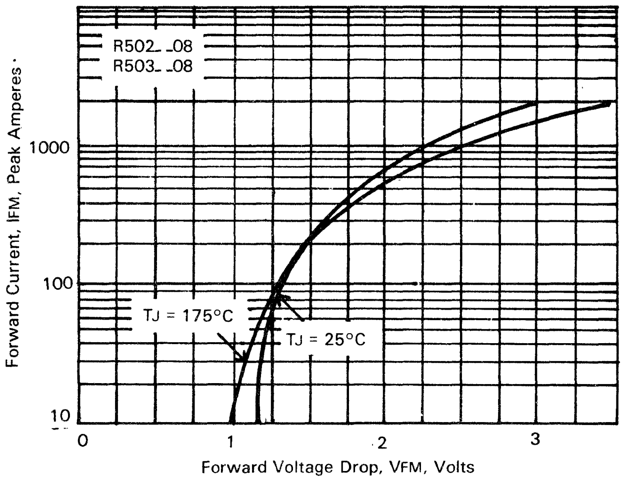
① At maximum TJ
② Per JEDEC RS-282, 4.01 F.3.
③ Consult recommended mounting procedures.
④ For higher voltages contact Westinghouse.

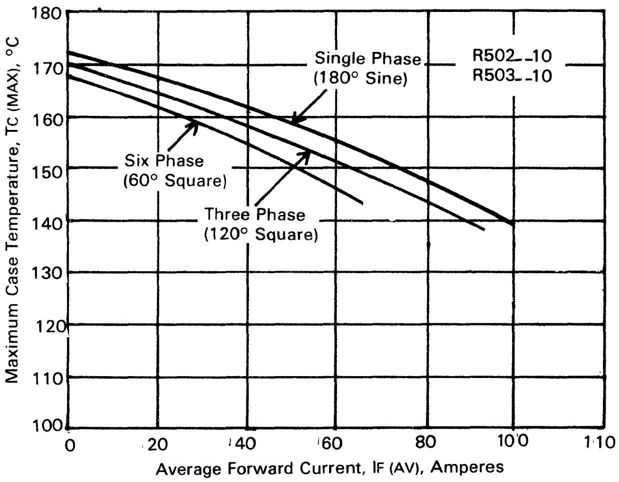
Fast Recovery RECTIFIER R502/R503

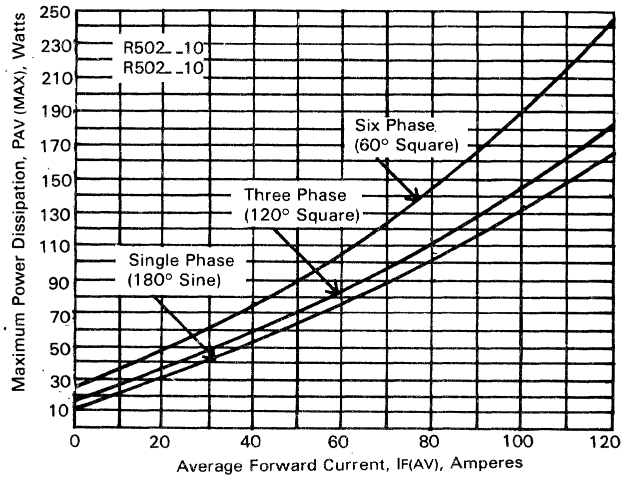
80 — 100A Avg.
Up to 1200 Volts
1.5 — 3 μs

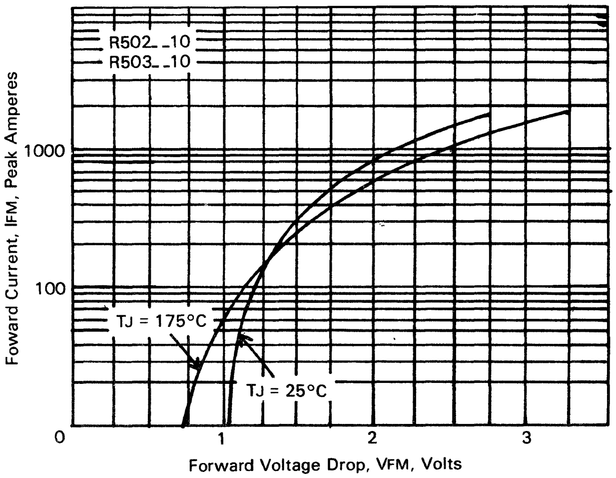








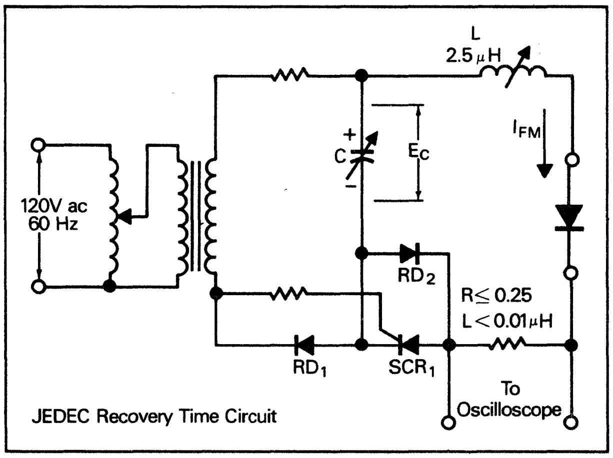




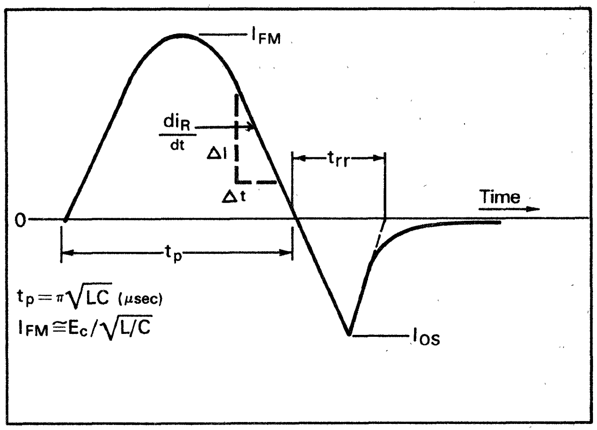
RECTIFIER

80 — 100A. Avg.
Up to 1200 Volts
1.5 — 3 μs

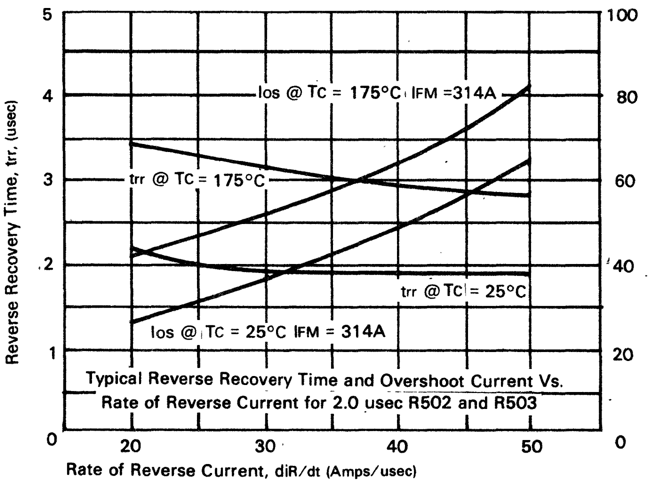
Fast Recovery
RECTIFIER
R502/R503



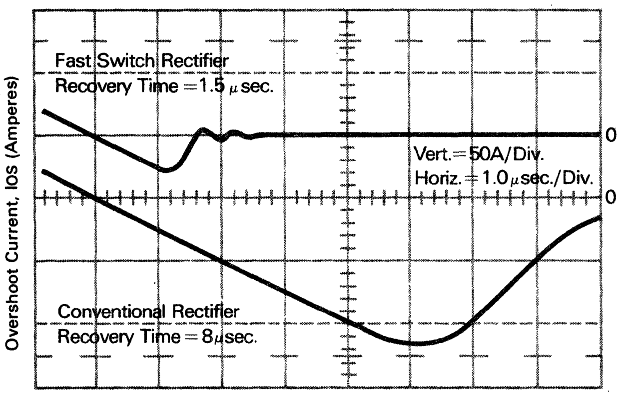
JEDEC Recovery Time Circuit



Recovery Time Waveform



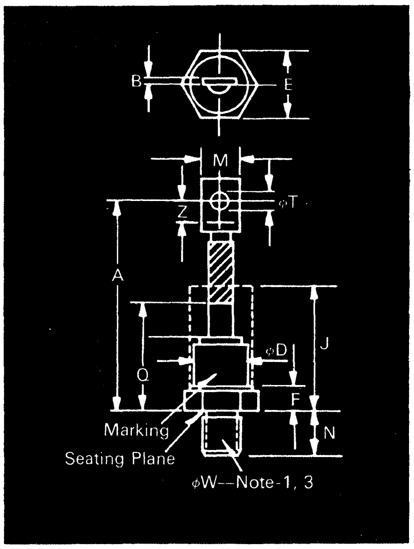
Typical Reverse Recovery Time and Overshoot Current Vs. Rate of Reverse Current for 2.0 usec R502 and R503



Recovery Time Comparison for Fast Switch and Conventional Rectifiers

Fast Recovery Rectifiers R602/R603

200-250A Avg. Up to 1600 Volts 1.5 — 3.0 μsec

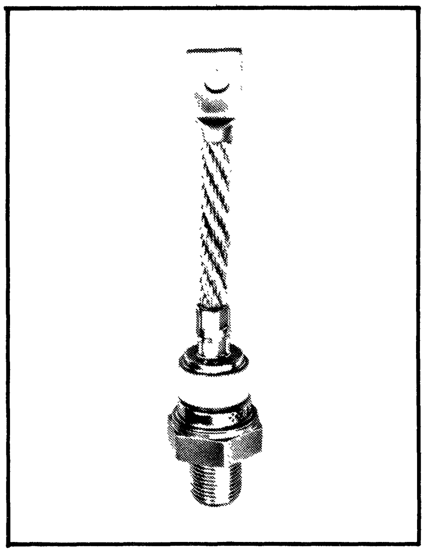


Conforms to DO-9 Outline

Symbol	Inches Min.	Inches Max.	Millimeters Min.	Millimeters Max.
A	5.32	6.00	135.13	152.40
B	.063	.172	1.60	4.37
φD	.980	1.065	24.89	27.05
E	1.212	1.250	30.78	31.75
F	.250	.630	6.35	16.00
J	3.250		82.55	
M	.530	.755	13.46	19.18
N	.660	.749	16.76	19.02
Q		2.250		57.15
φT	.330	.350	8.38	8.89
Z	.440		11.18	
φW	¾-16 UNF-2A			

Creep & Strike Distance:
.49 in. min. (12.52 mm).
(In accordance with NEMA standards.)
Finish—Nickel Plate.
Approx. Weight—8 oz. (226g)
Standard Polarity—White Ceramic
Reverse Polarity—Pink Ceramic

1. Complete threads to extend to within 2½ threads of seating plane.
2. Angular orientation of terminal is undefined.
3. Pitch diameter of ¾-16 UNF-2A (coated) threads (ASA B1.1-1960).
4. Dimension "J" denotes seated height with lead bent at right angle.



Features:

- Fast Recovery Times
- Standard and Reverse Polarities
- Flag Lead and Stud Top Terminals Available
- High Surge Current Ratings
- High Rated Blocking Voltages
- Special Electrical Selection for Parallel and Series Operation
- Glazed Ceramic Seal Gives High Voltage Creepage and Strike Paths
- Compression Bonded Encapsulation for Thermal Cycling Capability in Excess of 100,000 Thermal Cycles
- Lifetime Guarantee

Applications:

- Inverters
- Choppers
- Transmitters
- Free Wheeling

Ordering Information

Type	Voltage		Current		Recovery Time		Recovery Time Circuit		Leads	
Code	V_{RRM} (V) *	Code	$I_{F(av)}$ (A)	Code	t_{rr} μsec	Code	Circuit	Code	Case	Code
R602 (Standard Polarity) R603 (Reverse Polarity)	100	01	200	20	1.5	F	JEDEC	J	DO-9	YA
	200	02								
	400	04	250	25	2.0	E				
	600	06								
	800	08			3.0	C				
	1000	10								
	1200	12								
	1400	14								
	1600	16								

* For higher voltages, consult factory.

Example

Obtain optimum device performance for your application by selecting proper Order Code.

Type R602 rated at 250A average with V_{RRM} = 1000V. Recovery time = 1.5 μsec, and standard flexible lead — order as:

Type				Voltage		Current		trr	Circuit	Leads	
R	6	0	2	1	0	2	5	F	J	Y	A

200-250A Avg. Up to 1600 Volts 1.5 — 3.0 μsec

Fast Recovery Rectifiers R602/R603

RECTIFIER

Voltage

Blocking State Maximums ①	Symbol									
Repetitive peak reverse voltage, V	V_{RRM}	100	200	400	600	800	1000	1200	1400	1600
Non-repetitive transient peak reverse voltage, $V \leq 5.0$ msec	V_{RSM}	200	300	500	700	1000	1200	1400	1600	1800
Reverse leakage current, mA peak	I_{RRM}	← 50 →							← 50 →	

Switching

	Symbol		
Max. Reverse Recovery Time $I_{FM} = 785A$, tp = 100μs, $di_R/dt = 25A/\mu s$, $T_C = 25°C$, μs	t_{rr}	← 1.5, 2.0 & 3.0 →	← 2.0 & 3.0 →

Thermal and Mechanical

	Symbol	$V_{RRM} \leq 1200V$	$1200V < V_{RRM} \leq 1600V$
Min., Max. oper. junction temp., °C	T_J	−40 to 175	−40 to 175
Min., Max. storage temp., °C	T_{stg}	−40 to 200	−40 to 200
Max. mounting torque, in lb.		360	360
Thermal resistance Junction to case, °C/Watt	$R_{\theta JC}$	.17	.17
Case to sink, lubricated, °C/Watt	$R_{\theta CS}$	.10	.10

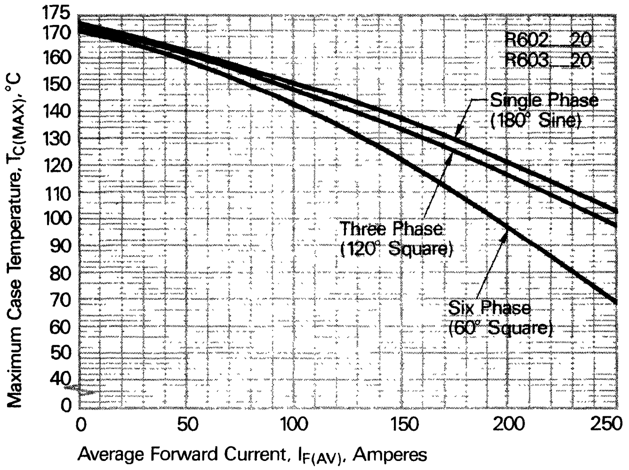
Current

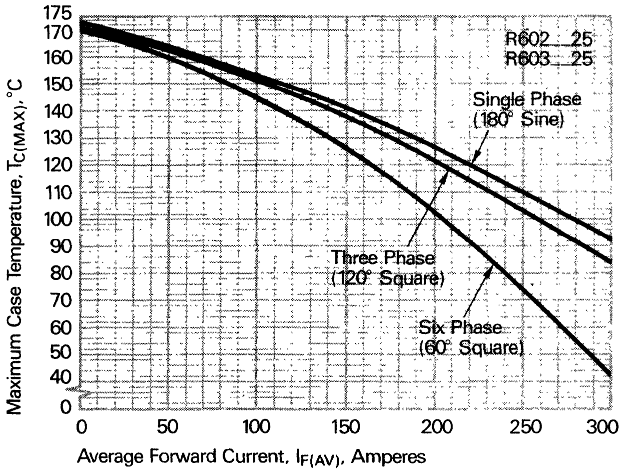
Conducting State Maximums	Symbol	R602 — — 20 R603 — — 20	R602 — — 25 R603 — — 25
RMS forward current, A	$I_{F(rms)}$	315	400
Ave. forward current, A	$I_{F(av)}$	200	250
One-half cycle surge current②, A	I_{FSM}	4500	5000
3 cycle surge current②, A	I_{FSM}	3500	3900
10 cycle surge current②, A	I_{FSM}	2700	3000
I^2t for fusing (for times ≥ 8.3 ms) A^2 sec.	I^2t	85,000	104,000
Forward voltage drop at I_{FM} = 800 A and $T_J = 25°C$, V	V_{FM}	1.85	1.65
Forward voltage drop at rated single phase average current and case temperature, V	V_{FM}	1.65	1.58

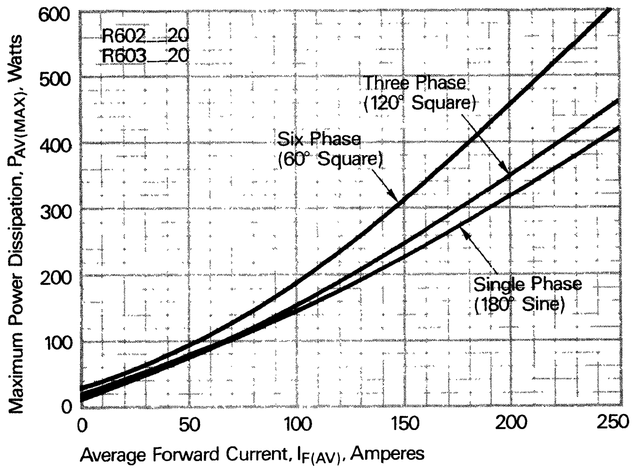
① At maximum TJ
② At 60 Hertz.

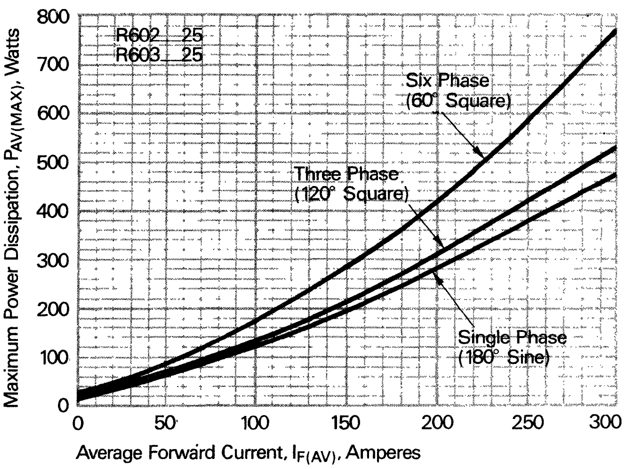
Fast Recovery Rectifiers R602/R603

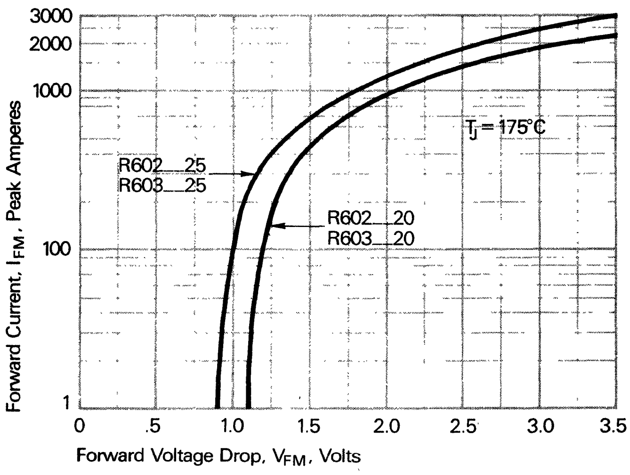
200-250A Avg. Up to 1600 Volts 1.5 — 3.0 μsec

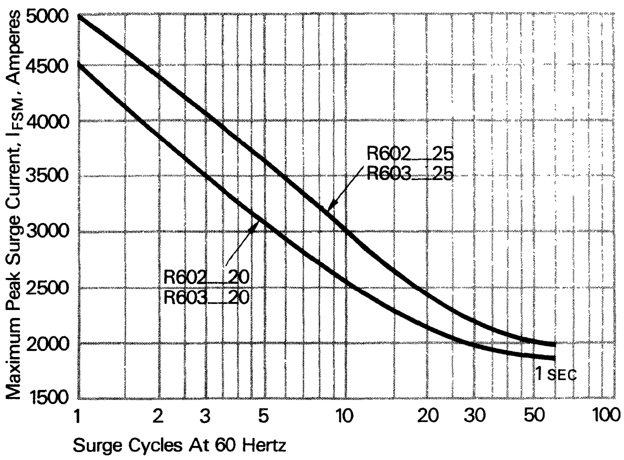










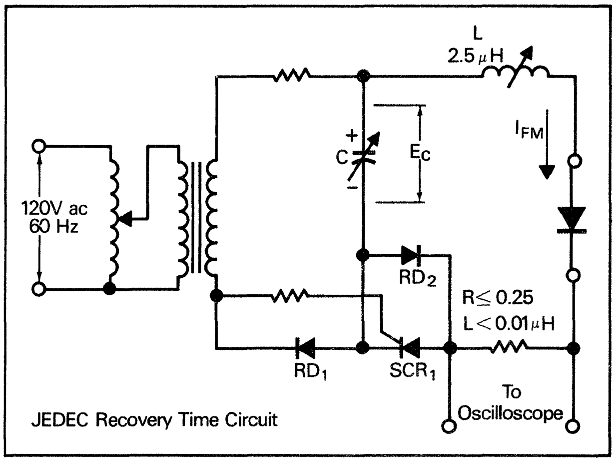


RECTIFIER

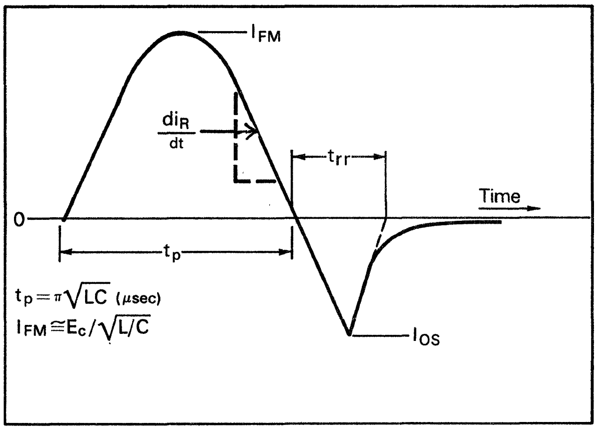
200-250A Avg.
Up to 1600 Volts
1.5 — 3.0 μsec

Fast Recovery Rectifiers R602/R603

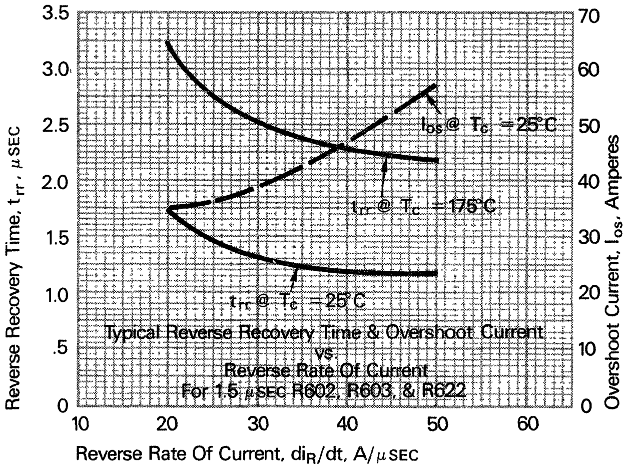
RECTIFIER

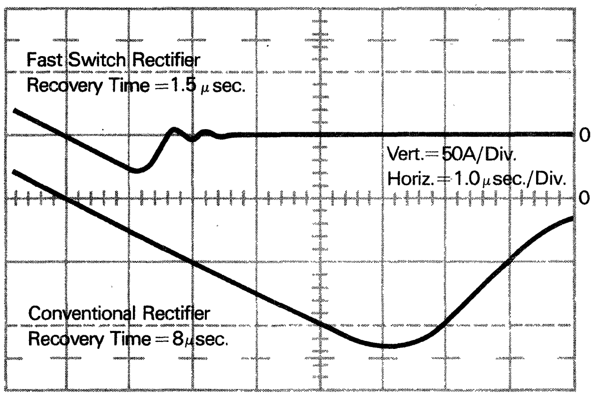


JEDEC Recovery Time Circuit

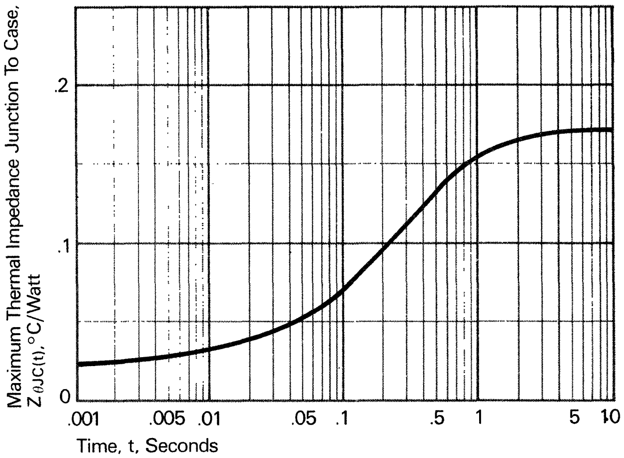


Recovery Time Waveform



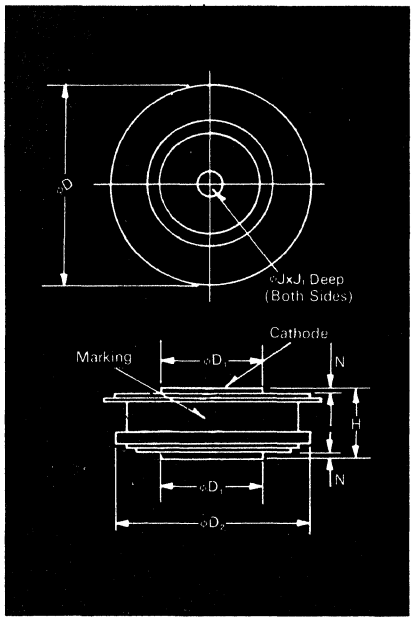


Recovery Time Comparison for Fast Switch and Conventional Rectifiers



Fast Recovery Rectifiers R622

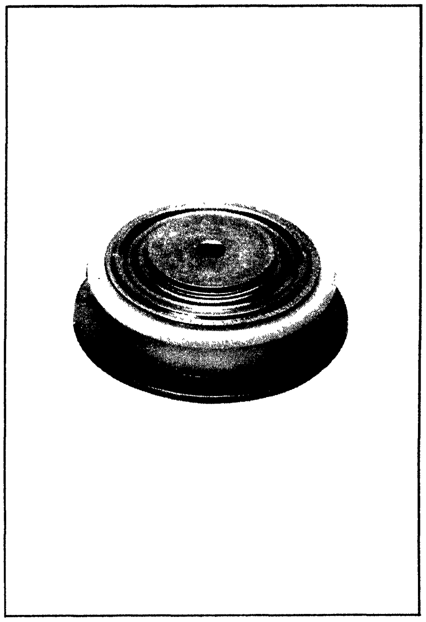
350-400 A. Avg. Up to 1600 Volts 1.5 — 3.0 µs



R62 Outline

Symbol	Inches Min.	Inches Max.	Millimeters Min.	Millimeters Max.
ϕD	1.610	1.650	40.89	41.91
ϕD_1	.745	.755	18.92	19.18
ϕD_2	1.420	1.460	36.07	37.08
H	.500	.560	12.70	14.22
ϕJ	.135	.145	3.43	3.68
J_1	.072	.082	1.83	2.08
N	.030		.76	

Creep Distance—.49 in. min. (12.60 mm).
Strike Distance—.52 in. min. (13.21 mm).
(In accordance with NEMA standards).
Finish—Nickel Plate.
Approx. Weight—2.3 oz (66g).
1. Dimension "H" is clamped dimension.



Features:
- Fast Recovery Times
- High Surge Current Ratings
- High Rated Blocking Voltages
- Special Electrical Selection For Parallel and Series Operation
- Non Magnetic Package
- Single or double-sided cooling
- Long creepage & strike paths
- Hermetic seal
- Lifetime Guarantee

Applications:
- Inverters
- Choppers
- Transmitters
- Free Wheeling

Ordering Information

Type	Voltage		Current		Recovery Time		Recovery Time Circuit		Leads	
Code	V_{RRM} (V)*	Code	$I_{F(av)}$ (A)	Code	t_{rr} µsec	Code	Circuit	Code	Case	Code
R622	100	01	350	35	1.5	F	JEDEC	J	R62	00
	200	02								
	400	04	400	40	2.0	E				
	600	06								
	800	08			3.0	C				
	1000	10								
	1200	12								
	1400	14								
	1600	16								

*for higher voltages, consult factory

Example

Obtain optimum device performance for your application by selecting proper Order Code.

Type R622 rated at 400A average with V_{RRM} = 1200V, and 1.5 µsec recovery time order as:

Type				Voltage		Current		trr	Circuit	Leads	
R	6	2	2	1	2	4	0	F	J	0	0

RECTIFIER

350-400 A. Avg.
Up to 1600 Volts
1.5 — 3.0 μs

Fast Recovery Rectifiers R622

RECTIFIER

Voltage

Blocking State Maximums ①	Symbol									
Repetitive peak reverse voltage , V	V_{RRM}	100	200	400	600	800	1000	1200	1400	1600
Non-repetitive transient peak reverse voltage, V $\leq$ 5.0 msec	V_{RSM}	200	300	500	700	1000	1200	1400	1600	1800
Reverse leakage current, mA peak	I_{RRM}	← 50 (100–1200) →							← 50 (1400–1600) →	

Switching

	Symbol	100–1200	1400–1600
Max. Reverse Recovery Time I_{FM} = 785A, tp = 100μs diR/dt = 25A/μs, T_C = 25°C, μs	trr	1.5, 2.0, 3.0	2.0, 3.0

Thermal and Mechanical

	Symbol		
Min., Max. oper. junction temp., °C	T_J	—40 to 175	—40 to 175
Min., Max. storage temp., °C	T_{stg}		—40 to 200
Min., Max. mounting force, lb			1000 to 1400
Thermal resistance with double sided cooling Junction to case, °C/Watt	$R_{\theta JC}$		.095
Case to sink, lubricated °C/Watt	$R_{\theta CS}$		.02

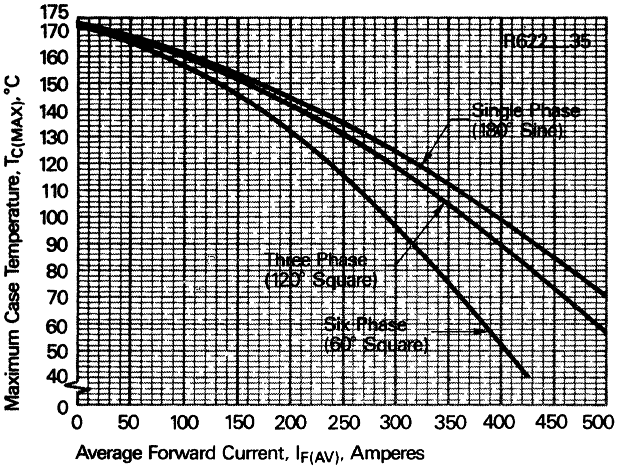
Current

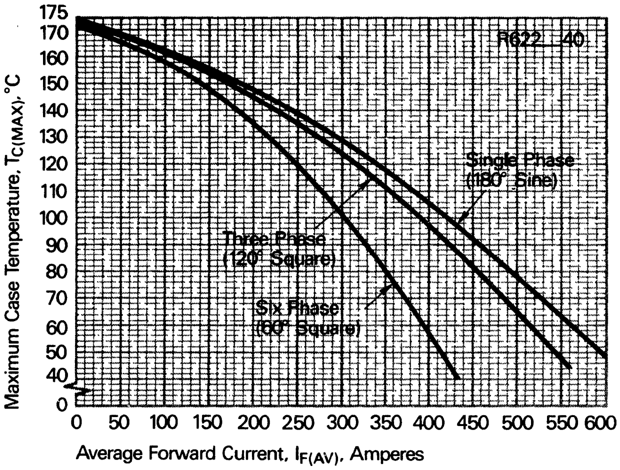
Conducting State Maximums	Symbol	R622 — — 35	R622 — — 40
RMS forward current, A	$I_{F(rms)}$	550	625
Ave. forward current, A	$I_{F(av)}$	350	400
One-half cycle surge current②, A	I_{FSM}	4500	5000
3 cycle surge current②, A	I_{FSM}	3500	3900
10 cycle surge current②, A	I_{FSM}	2700	3000
I^2t for fusing (for times = 8.3 ms) A^2 sec.	I^2t	85,000	104,000
Max I^2t of package (t=8.3 ms). A^2 sec.	I^2t	20×10^6	20×10^6
Forward voltage drop at I_{FM} = 800 A and T_J = 25°C, V	V_{FM}	1.85	1.65
Forward voltage drop at rated single phase average current and case temperature, V	V_{FM}	2.25	2.00

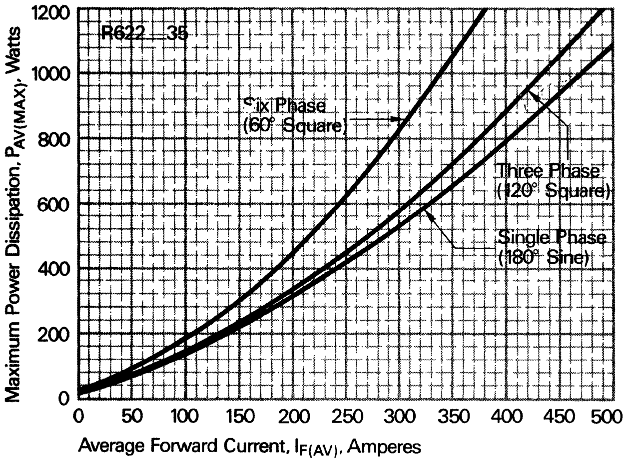
① At maximum TJ
② At 60 Hertz

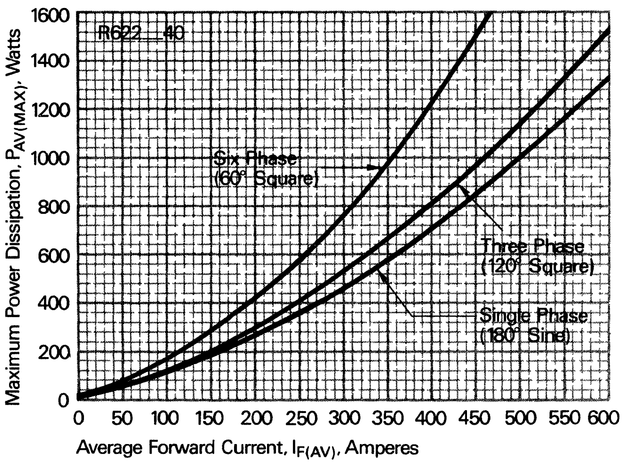
Fast Recovery Rectifiers R622

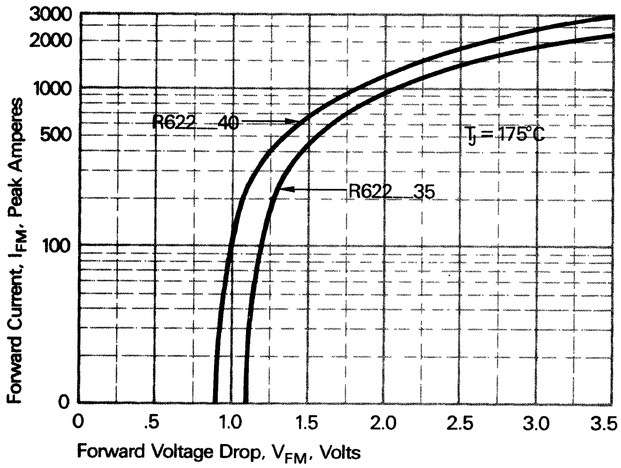
350-400 A. Avg.
Up to 1600 Volts
1.5 — 3.0 µs

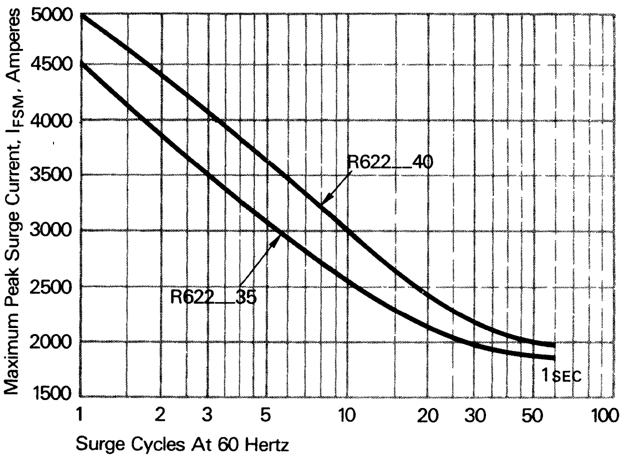










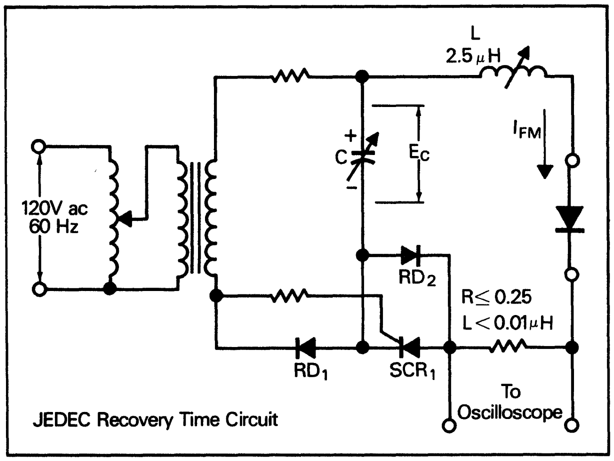


RECTIFIER

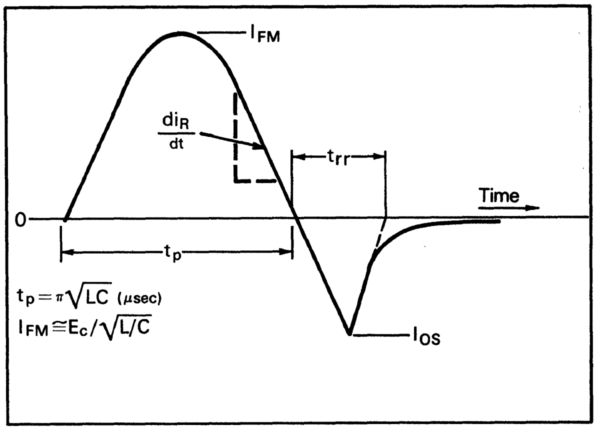
RECTIFIER

350-400 A. Avg. Up to 1600 Volts 1.5 — 3.0 μs

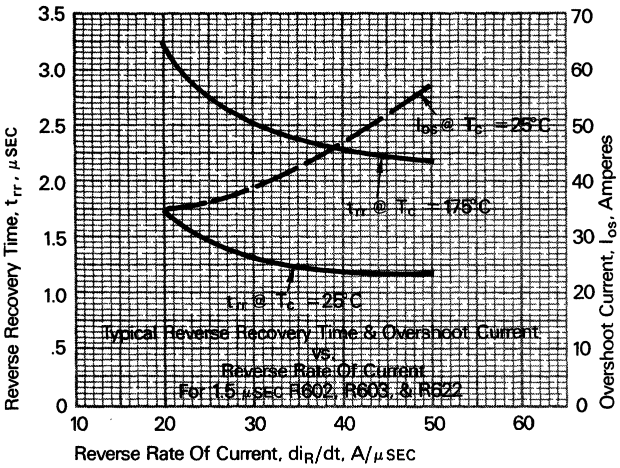
Fast Recovery Rectifiers R622

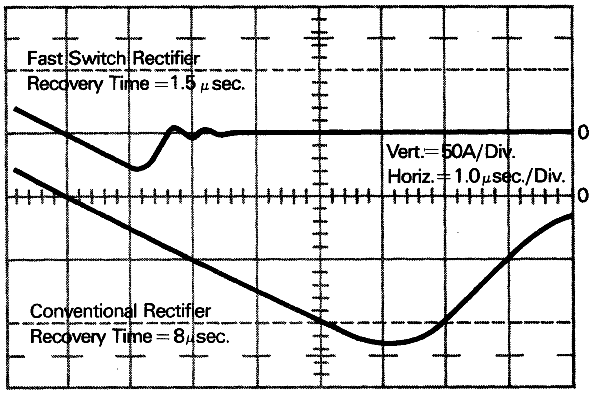


JEDEC Recovery Time Circuit

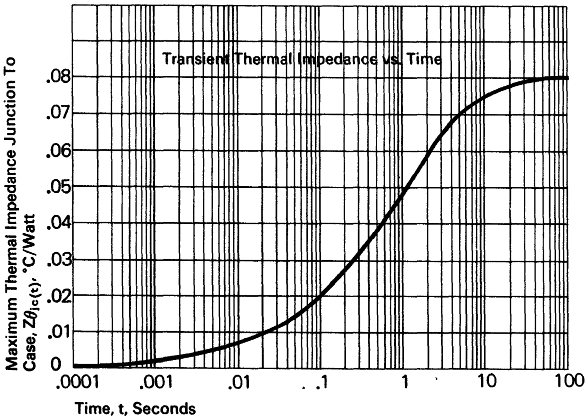


Recovery Time Waveform



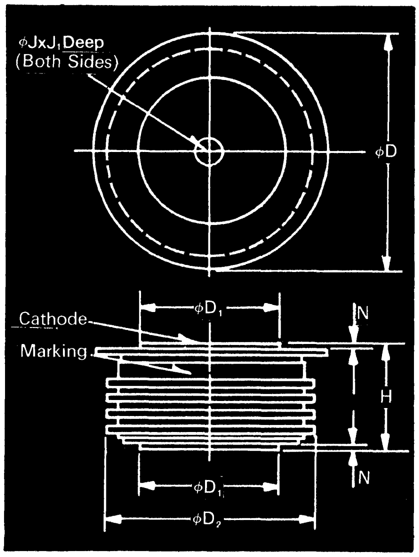


Recovery Time Comparison for Fast Switch and Conventional Rectifiers



Fast Recovery Rectifiers R722

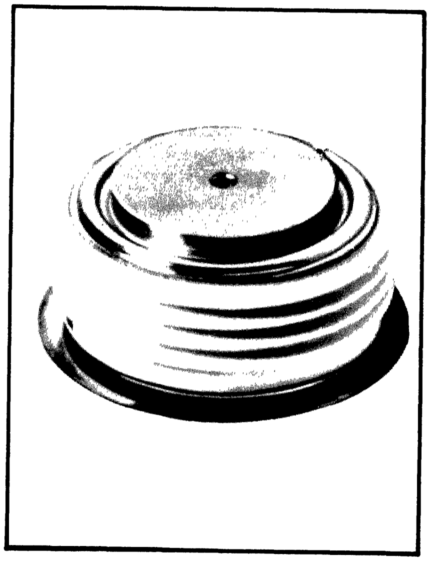
500-800 A. Avg.
Up to 2500 Volts
2.0 — 5.0 μsec



R72 Outline

Symbol	Inches Min.	Inches Max.	Millimeters Min.	Millimeters Max.
ϕD	2.250	2.290	57.15	58.17
ϕD_1	1.333	1.343	33.86	34.11
ϕD_2	2.030	2.090	51.56	53.09
H	1.020	1.060	25.91	26.92
ϕJ	.135	.145	3.43	3.68
J_1	.075	.090	1.91	2.29
N	.040	.	1.02	

Creep Distance—1.15 in. min. (29.36 mm).
Strike Distance—1.02 in. min. (2591 mm).
(In accordance with NEMA standards.)
Finish—Nickel Plate.
Approx. Weight—8 oz. (227g).
1. Dimension "H" is clamped dimension.



Features:
- Fast Recovery Times
- High Surge Current Ratings
- High Rated Blocking Voltages
- Special Electrical Selection For Parallel and Series Operation
- Non Magnetic Package
- Lifetime Guarantee

Applications:
- Inverters
- Choppers
- Transmitters
- Free Wheeling

Ordering Information

Type Code	Voltage V_{RRM} (V)	Code	Current $I_{F(av)}$ (A)	Code	Recovery Time t_{rr} μsec	Code	Recovery Time Circuit	Code	Leads Case	Code
R722	100	01	500	05	2.0	E	JEDEC	X	R72	00
	200	02								
	400	04	600	06	3.0	C				
	600	06								
	800	08	800	08	5.0	A				
	1000	10								
	1200	12								
	1400	14								
	1600	16								
	1800	18								
	2000	20								
	2200	22								
	2400	24								
	2500	25								

Example

Obtain optimum device performance for your application by selecting proper Order Code.

Type R722 rated at 800A average with $V_{RRM} = 1200V$ and recovery time = 3.0 μsec.

Type				Voltage		Current		trr	Circuit	Leads	
R	7	2	2	1	2	0	8	C	J	0	0

500-800 A. Avg. Up to 2500 Volts 2.0 — 5.0 μsec

Fast Recovery Rectifiers R722

RECTIFIER

Voltage

Blocking State Maximums ①

	Symbol																
Repetitive peak reverse voltage , V	V_{RRM}	100	200	300	600	800	1000	1200	1400	1600	1800	2000	2100	2200	2300	2400	2500
Non-repetitive transient peak reverse voltage, $t \leq 5.0$ msec	V_{RSM}	200	300	400	800	1000	1200	1400	1600	1800	2000	2200	2300	2400	2500	2600	2700
		◄ R722— —05 ►									◄ R722— —05 ►						
		◄ R722— —06 ►															
		◄ R722— —08 ►															
Reverse leakage current, mA peak	I_{RRM}	◄ 50 ►									◄ 50 ►						

Switching

	Symbol																
Max. Reverse Recovery Time $I_{FM} = 1500$ $t_p = 190\mu s$ $di_R/dt = 25A/\mu s$, $T_C = 25°C$, μs	t_{rr}	◄ 2.0, 3.0 ►							◄ 3.0, 5.0 ►		◄ 5.0 ►						

Thermal and Mechanical

	Symbol																
Min., Max. oper. junction temp., °C	T_J	◄ —40 to 175 ►									◄ —40 to 150 ►						
Min., Max. storage temp., °C	T_{stg}	—40 to 190															
Min., Max. mounting force, lb③		2000 to 2400															
Thermal resistance③ with double sided cooling Junction to case, °C/Watt	$R_{\theta JC}$	.055															
Case to sink, lubricated °C/Watt	$R_{\theta CS}$	.02															

Current

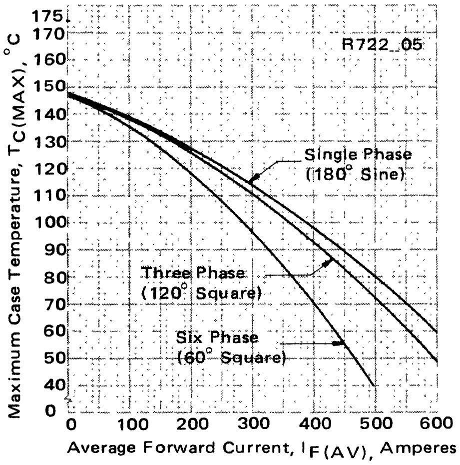
Conducting State Maximums

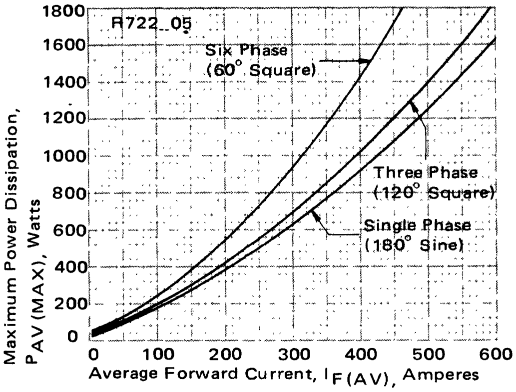
	Symbol	R722— —05	R722— —06	R722— —08
RMS forward current, A	$I_{F(rms)}$	785	945	1250
Ave. forward current, A	$I_{F(av)}$	500	600	800
One-half cycle surge current②, A .	I_{FSM}	7000	9500	11000
3 cycle surge current②, A	I_{FSM}	5040	6840	7920
10 cycle surge current②, A ...	I_{FSM}	4200	5700	6600
I^2t for fusing (for times = 8.3 ms) A^2 sec.	I^2t	205,000	375,000	504,000
Max I^2t of package (t=8.3 ms), A^2sec	I^2t	80×10^6	80×10^6	80×10^6
Forward voltage drop at I_{FM} = 1500A and T_J = 25°C, V	V_{FM}	2.6	1.8	1.65

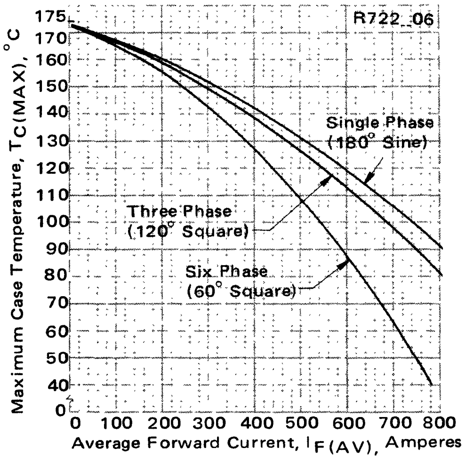
1 At maximum TJ
2 Per JEDEC RS-282, 4.01 F.3.
3 Consult Westinghouse recommended mounting procedures.

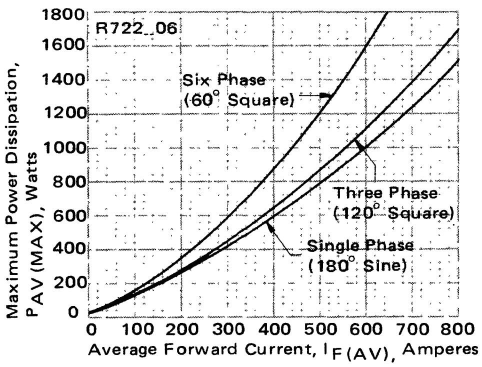
Fast Recovery Rectifiers R722

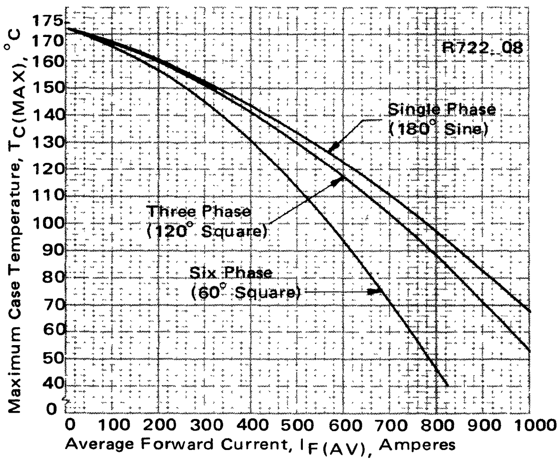
500-800 A. Avg. Up to 2500 Volts 2.0 — 5.0 μsec

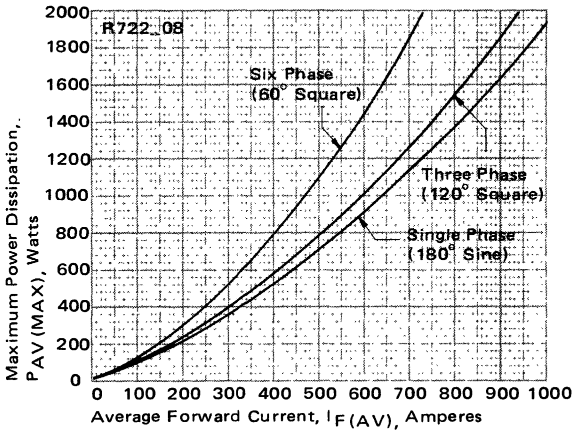






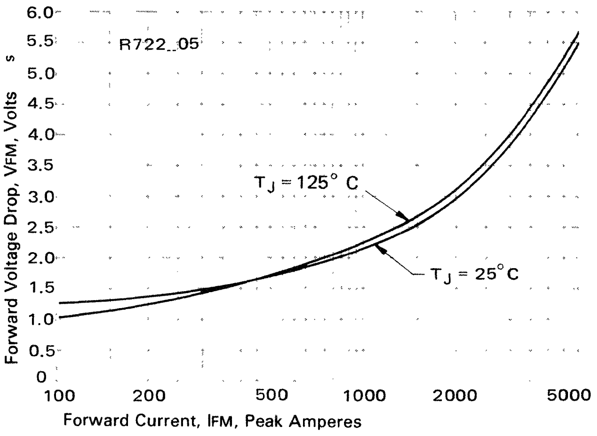


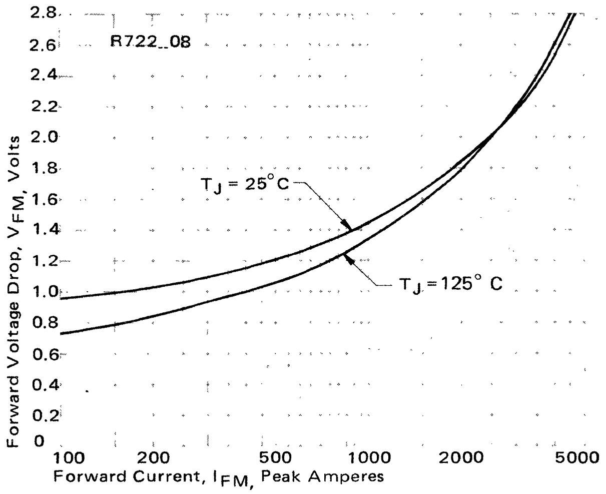


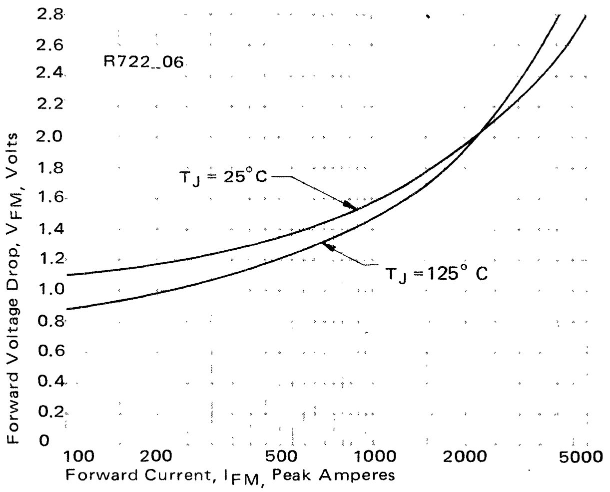


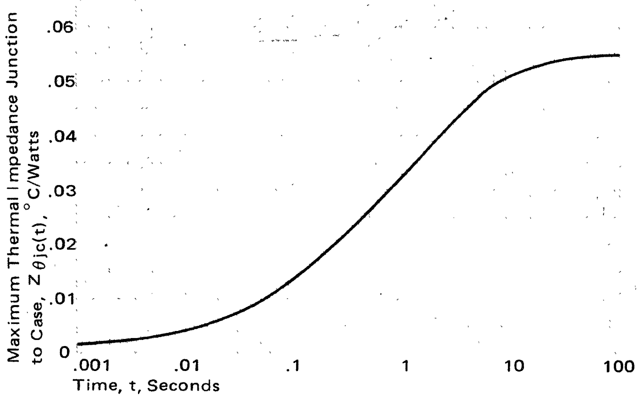
500-800 A. Avg.
Up to 2500 Volts
2.0 — 5.0 µsec

Fast Recovery Rectifiers R722

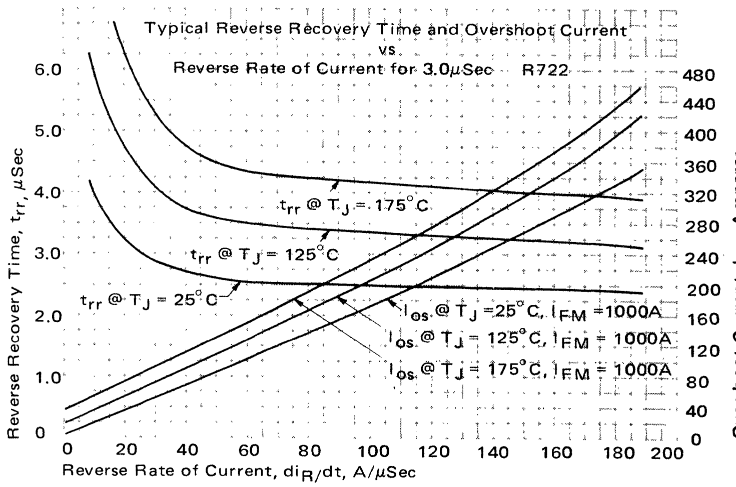


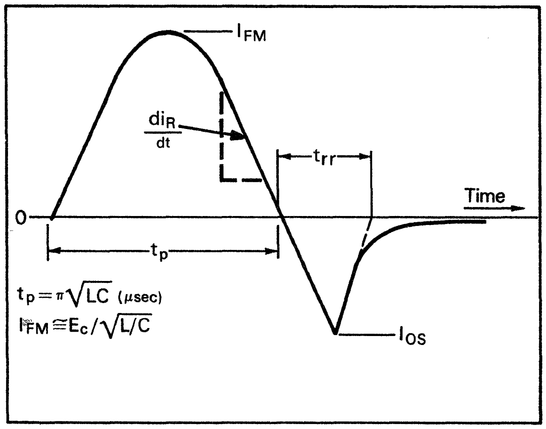






Transient Thermal Impedance vs. Time

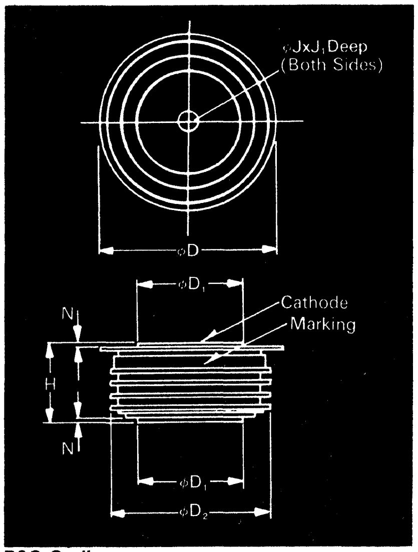




Recovery Time Waveform

Fast Recovery RECTIFIER R9G2

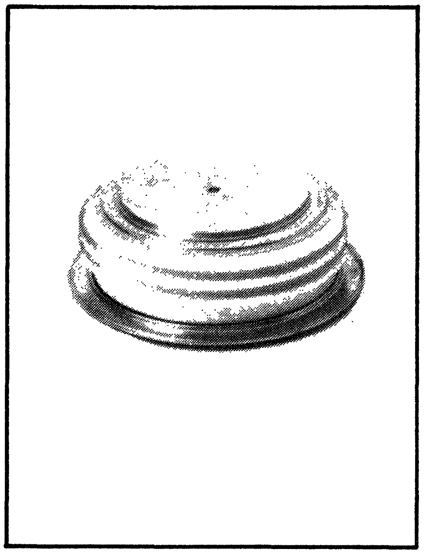
900 — 1400 A Avg. Up to 3200 Volts 3.0 — 5.0 μs



R9G Outline

Symbol	Inches Min.	Inches Max.	Millimeters Min.	Millimeters Max.
φD	2.850	2.900	72.39	73.66
ϕD_1	1.845	1.855	46.86	47.12
ϕD_2	2.560	2.640	65.02	67.06
H	1.020	1.060	25.91	26.92
φJ	.135	.145	3.43	3.68
J_1	.075	.090	1.91	2.29
N	.050		1.27	

Creep Distance—1.15 in. min. (29.36 mm).
Strike Distance—1.02 in. min. (25.91 mm).
(In accordance with NEMA standards.)
Finish—Nickel Plate.
Approx. Weight—1 lb. (454 g.)
1. Dimension "H" is Clamped Dimension.



Features:
- Fast Recovery Times
- High Surge Current Ratings
- High Rated Blocking Voltages
- Special Electrical Selection For Parallel and Series Operation
- Non Magnetic Package

Applications:
- Chopper
- DC to AC Inverters
- Transmitters
- High Frequency Rectification

Type	Voltage		Current		Recovery Time		Recovery Time Circuit		Leads	
Code	V_{RRM} (V)	Code	$I_{F(av)}$ (A)	Code	μsec	Code	Circuit	Code	Case	Code
R9G2	100	01	900	09	3.0	C	JEDEC	J	R9G	00
	200	02								
	400	04	1100	11	5.0	A	JEDEC	J		
	600	06								
	800	08	1400	14						
	1000	10								
	1200	12								
	1400	14								
	1600	16								
	1800	18								
	2000	20								
	2200	22								
	2400	24								
	2600	26								
	2800	28								
	3000	30								
	3200	32								

Example
Obtain optimum device performance for your application by selecting proper Order Code.

Type R9G2 rated ar 1400 A average with V_{RRM} = 1200V and recovery time = 3.0 μsec.

Type				Voltage		Current		trr	Circuit	Leads	
R	9	G	2	1	2	1	4	C	J	0	0

900 — 1400 A Avg.
Up to 3200 Volts
3.0 — 5.0 μs

Fast Recovery RECTIFIER R9G2

RECTIFIER

Voltage

Blocking State Maximums ①	Symbol			
Repetitive peak reverse voltage , V	V_{RRM}	100 200 400 600 800 1000 1200	1400 1600 1800 2000	2200 2400 2600 2800 3000 3200
Non-repetitive transient peak reverse voltage, V ≤ 5.0 m sec	V_{RSM}	200 300 500 700 1000 1200 1400	1600 1800 2000 2200	2400 2600 2800 3000 3200 3400
		R9G2__09	R9G2__09	R9G2__09
		R9G2__11	R9G2__11	
		R9G2__14		
Reverse leakage current, mA peak	I_{RRM}	100	75	50

Switching

Switching		$V_{RRM} \leq 1200V$	$1200V < V_{RRM} \leq 2000V$	$2000V < V_{RRM} \leq 3200V$
Max. Reverse Recovery Time I_{FM} = 1500 t_p = 190us di_R/dt = 25A/us, T_C = 25°C, μs...........	t_{rr}	3.0, 5.0	5.0	5.0

Thermal and Mechanical

Thermal and Mechanical		$V_{RRM} \leq 1200V$	$1200V < V_{RRM} \leq 2000V$	$2000V < V_{RRM} \leq 3200V$
Min., Max. oper. junction temp., °C........	T_J	—40 to 150	—40 to 150	—40 to 150
Min., Max. storage temp., °C..............	T_{stg}	—40 to 190	—40 to 190	—40 to 190
Min., Max. mounting force, lb. ③		5000 to 6000	5000 to 6000	5000 to 6000
Thermal resistance ③ with double sided cooling				
Junction to case, °C/Watt	$R_{\Theta JC}$	.023	.023	.023
Case to sink, lubricated °C/Watt	$R_{\Theta CS}$	.075	.075	.075

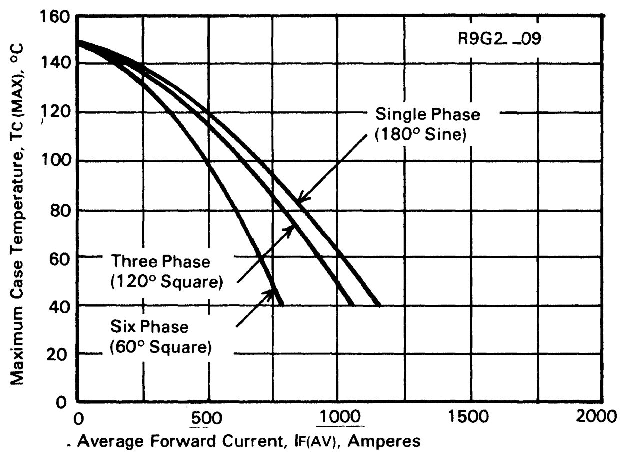
Current

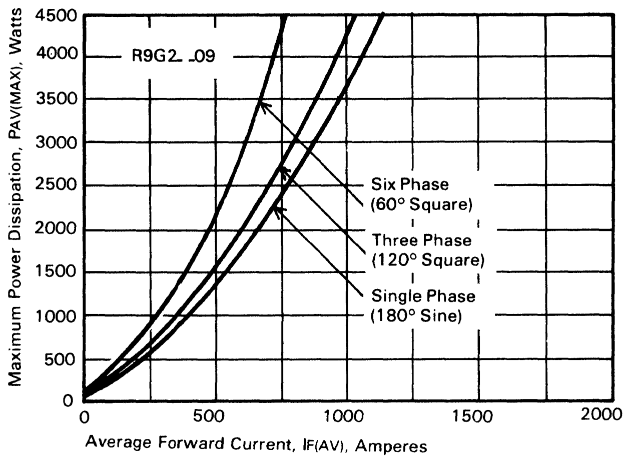
Conducting State Maximums		R9G2__09	R9G2__11	R9G2__14
RMS forward current, A	$I_{F(rms)}$	1,415	1,730	2,200
Ave. forward current, A..................	$I_{F(av)}$	900	1,100	1,400
One-half cycle surge current, A ②	I_{FSM}	12,000	15,000	25,000
3 cycle surge current, A ②	I_{FSM}	8,600	10,750	17,900
10 cycle surge current, A ②............	I_{FSM}	7,200	9,000	15,000
I^2t for fusing (for times=8.3 ms) A^2 sec.	I^2t	600,000	940,000	2,600,000
Max I^2t of package (t = 8.3 ms), A^2sec	I^2t	90×10^6	90×10^6	90×10^6
Forward voltage drop at I_{FM} = **3,000A and T_J = 25°C, V**	V_{FM}	4.80	3.10	2.50

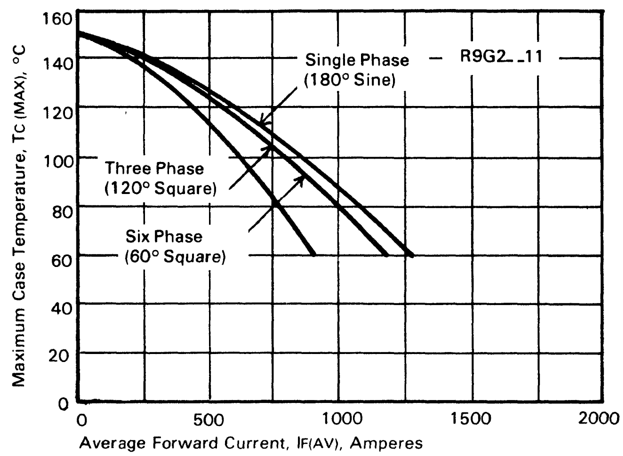
① At maximum T_J
② Per JEDEC RS-282, 4.01 F.3.
③ Consult recommended mounting procedures.

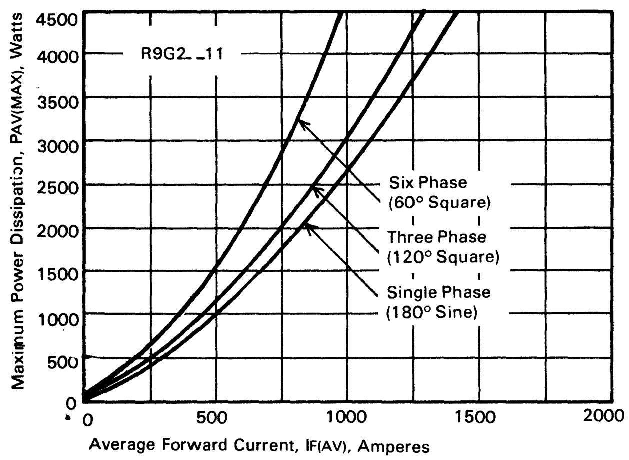
Fast Recovery RECTIFIER R9G2

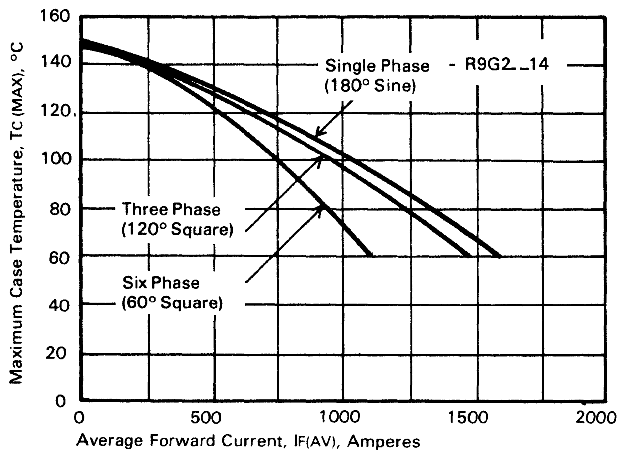
900 — 1400 A Avg.
Up to 3200 Volts
3.0 — 5.0 μs

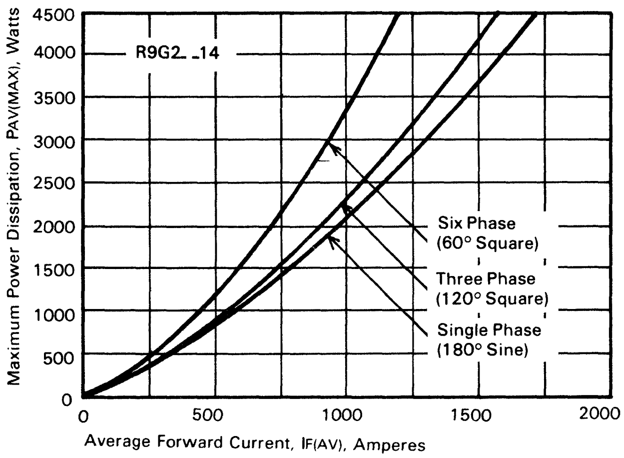






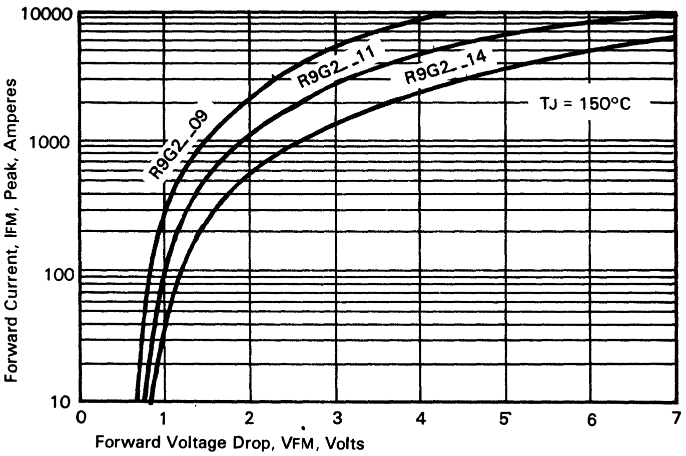


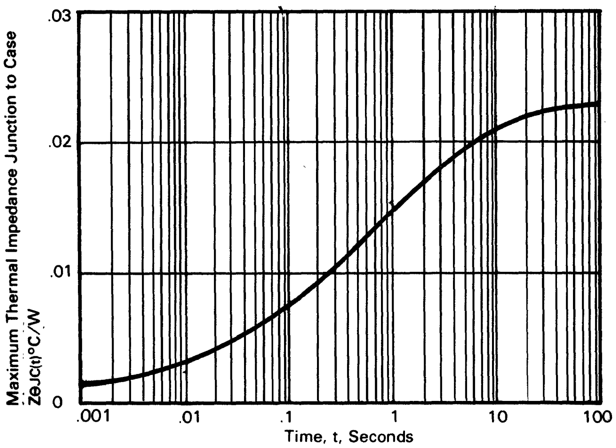




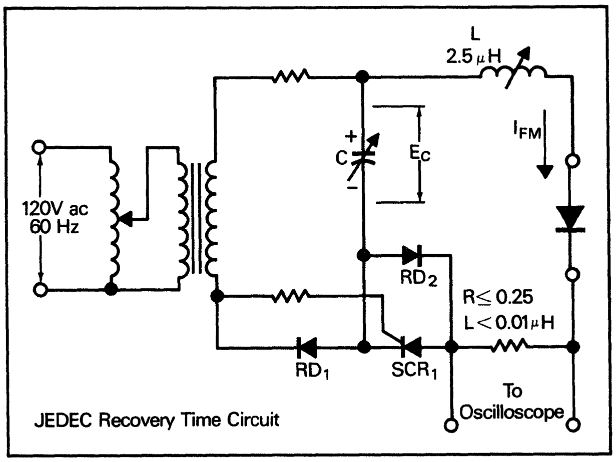
900 — 1400 A Avg. Up to 3200 Volts 3.0 — 5.0 µs

Fast Recovery RECTIFIER R9G2

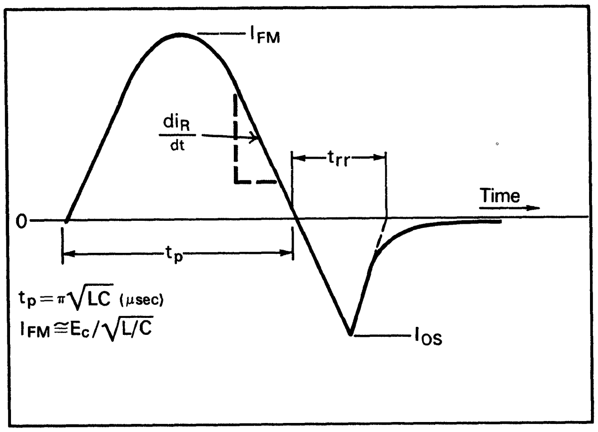




Transient Thermal Impedance Vs. Time



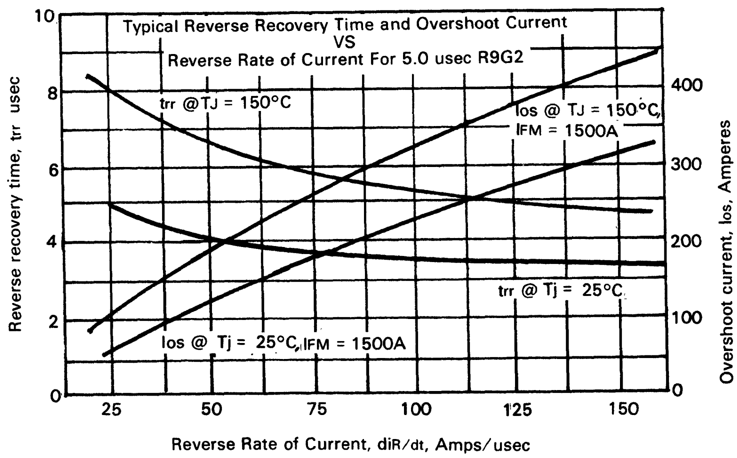
JEDEC Recovery Time Circuit

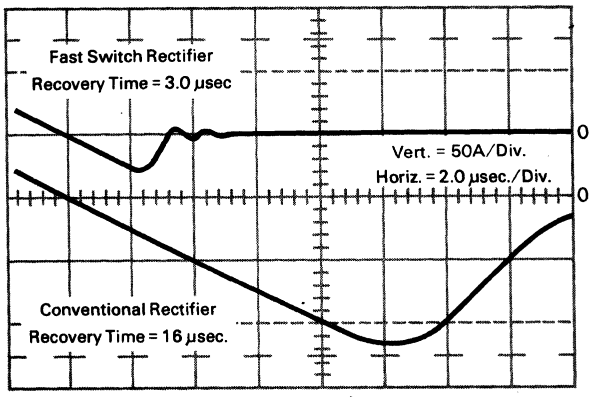


$t_p = \pi\sqrt{LC}$ (µsec)

$I_{FM} \cong E_c/\sqrt{L/C}$

Recovery Time Waveform

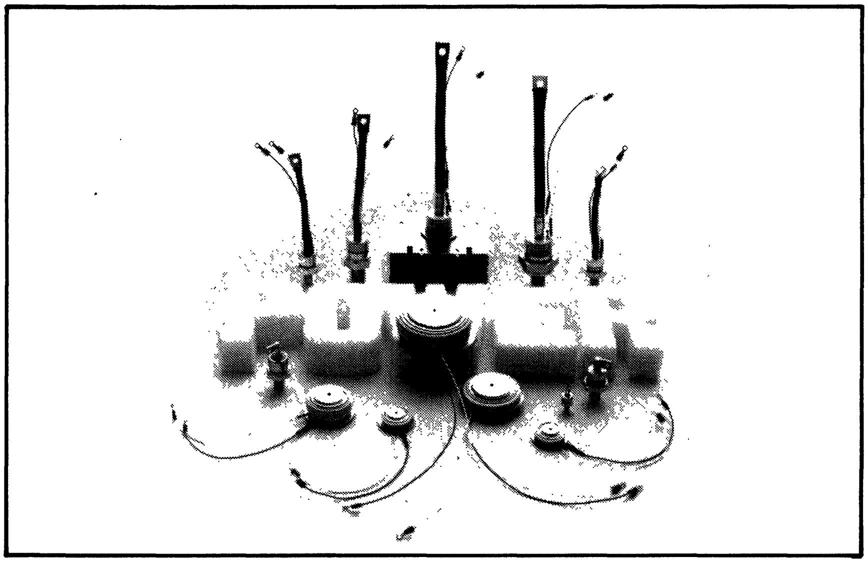




Recovery Time Comparison for Fast Switch and Conventional Rectifiers

RECTIFIER

THYRISTORS
SCR's and RBDT's



INTRODUCTION

Westinghouse thyristors are designed, manufactured, and tested to insure the circuit designer "state-of-the-art" flexibility in design and dependability in operation. Westinghouse high power SCR's feature all-diffused elements and are available in a variety of packages: stud, disc, integral heat sink, and flat base. These SCR's offer high surge current capability with optimized forward voltage drops, soft firing and high di/dt capability with center-fired di/namic gate designs, and the industry's highest guaranteed dv/dt capability with shorted-emitter designs. All high power Westinghouse stud mount devices utilize compression bonded encapsulation (CBE) construction which reduces thermal fatigue by eliminating solder joints. Westinghouse disc devices feature non-magnetic packages and are cold-welded to avoid thermal stresses on the semiconductor elements during encapsulation.

Westinghouse Phase Control SCR's offer package I^2t or explosion ratings for most ceramic packages; in addition, surge suppression ratings are available which enable the designer to better utilize the full capability of Westinghouse SCR's. The Westinghouse T625 now offers the designer of a 150°C operating junction temperature SCR; this device features higher current ratings and better overload characteristics for motor control applications.

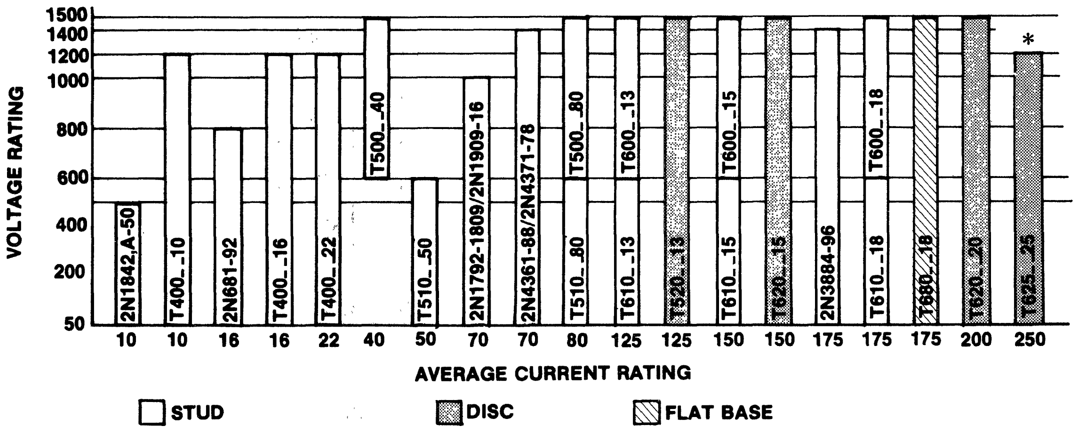
Westinghouse Fast Switching SCR's offer turn-off times as low 10 microseconds as a result of an exclusive irradiation process. These center-fired di/namic gate designs all feature low switching losses, high di/dt, low I_{GT}, high current, high voltage, low recovered charges, and fast turn-off times. The Westinghouse mid-gate structure (available only as a T72H or T9GH) is interdigitated gate design which optimizes the device for higher peak currents and narrower pulse widths while providing low switching losses and faster turn-on and turn-off capability.

The Westiinghouse Reverse Blocking Diode Thyristor (RBDT) offers the control of an SCR without the complex firing circuitry. This device blocks voltage in the forward direction until the appropriate dv/dt pulse is applied. The RBDT offers excellent di/dt capability up to 3,000A/us, and seriesing is easily accomplished for high voltage applications.

Westinghouse offers extensive testing capability for series and/or parallel matching, special parameter selection, or full high reliability screening. Westing- offers a Lifetime Guarantee on all SCR's bearing the symbol ✦. In addition, all Westinghouse thyristors are available on factory assembled and tested air or water cooled heat exchangers in a variety of circuit configurations. Specify Westinghouse Power Thyristors.

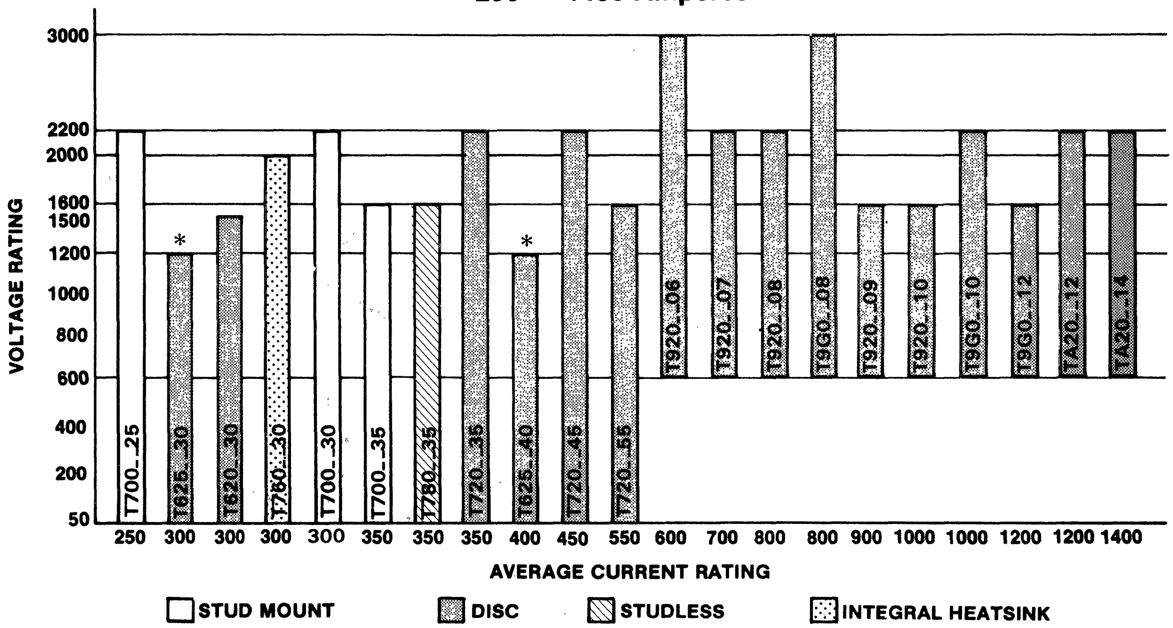
THYRISTOR (SCR/RBDT) PRODUCT INDEX

PHASE CONTROL SCR'S
10 — 250 Amperes



*150°C JUNCTION TEMPERATURE

PHASE CONTROL SCR'S
250 — 1400 Amperes

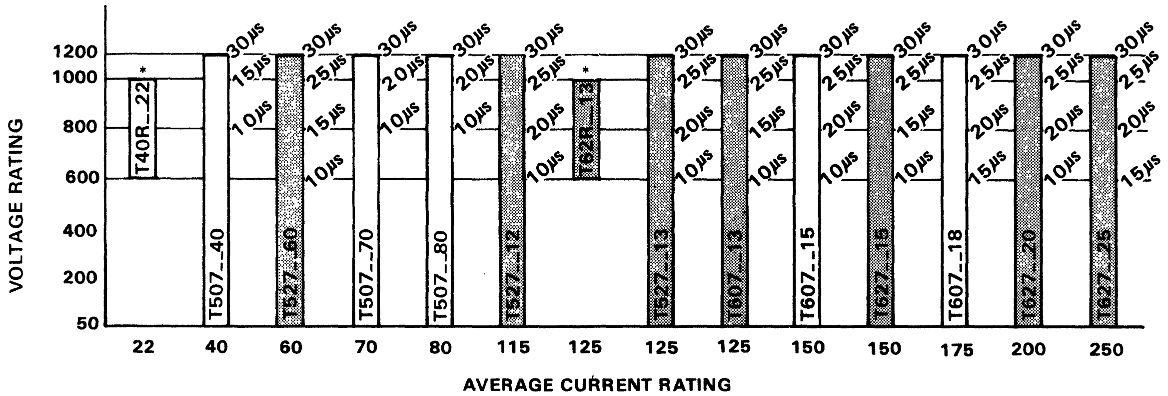


*150°C JUNCTION TEMPERATURE

THYRISTOR

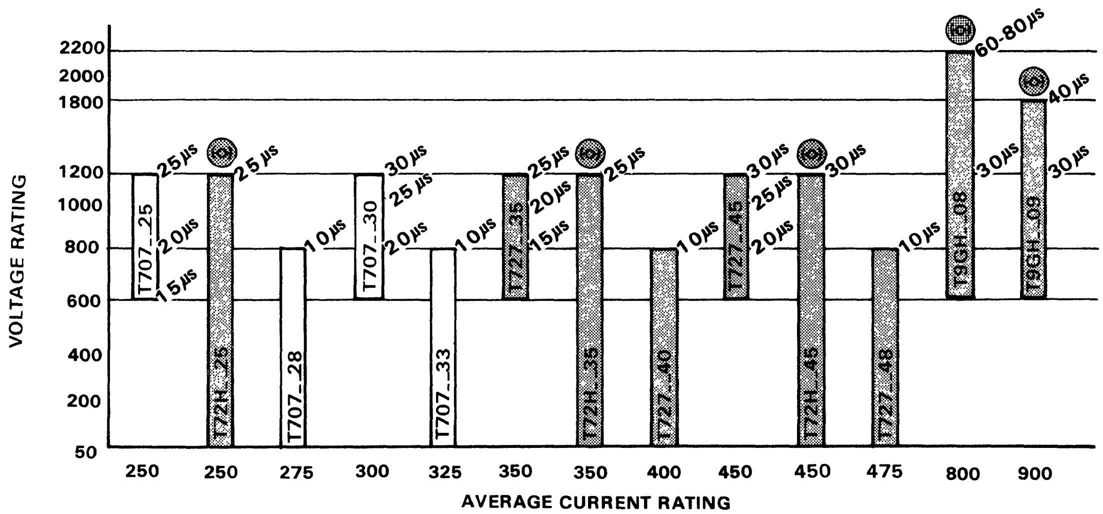
THYRISTOR CAPABILITY GRAPHS

FAST SWITCHING SCR'S & RBDT'S
22 — 250 Amperes



NOTE: Turn off times shown represent fastest currently available at given voltage rating.

FAST SWITCHING SCR'S
250 — 900 Amperes



NOTE: Turn off times shown represent fastest currently available at given voltage rating.

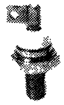
THYRISTOR

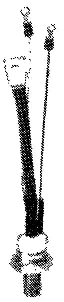
THYRISTOR SELECTOR GUIDE

PHASE CONTROL SCR'S
10 — 70 Amperes

TO-48

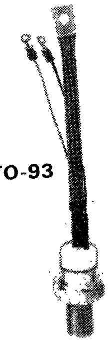
TO-83





TO-94

JEDEC/ TYPE	2N1842,A-2N1850,A	T400__10	2N681-92	T400__16	T400__22	T500__40	T510__50	2N1792-1807/ 2N1909-2N1916
AVERAGE CURRENT	10	10	16	16	22	40	50	70
ONE CYCLE SURGE	125	150	150	250	360	1200	1200	1000
VOLTAGE 25	2N1842,A		2N681					2N1909
50	2N1843,A	T4000010	2N682	T4000016	T4000022		T5100050	2N1792/2N1910
100	2N1844,A	T4000110	2N683	T4000116	T4000122		T5100150	2N1793/2N1911
150	2N1845,A		2N684					2N1794/2N1912
200	2N1846,A	T4000210	2N685	T4000216	T4000222		T5100250	2N1795/2N1913
250	2N1847,A		2N686					2N1796/2N1914
300	2N1848,A	T4000310	2N687	T4000316	T4000322		T5100350	2N1797/2N1915
400	2N1849,A	T4000410	2N688	T4000416	T4000422		T5100450	2N1798/2N1916
500	2N1850,A	T4000510	2N689	T4000516	T4000522		T5100550	2N1799/2N1805
600		T4000610	2N690	T4000616	T4000622		T5100650	2N1800/2N1806
700		T4000710	2N691	T4000716	T4000722	T5000740		2N1801/2N1807
800		T4000810	2N692	T4000816	T4000822	T5000840		2N1802
900		T4000910		T4000916	T4000922	T5000940		2N1803
1000		T4001010		T4001016	T4001022	T5001040		2N1804
1200		T4001210		T4001216	T4001222	T5001240		
1400						T5001440		
1500						T5001540		
PACKAGE TYPE	TO-48	TO-48	TO-48	TO-48	TO-48	TO-83/TO-94	TO-83/TO-94	TO-83/TO-94
PAGE NUMBER	S9	S13	S11	S13	S13	S23	S27	S19



TO-93

PHASE CONTROL SCR'S
70 — 175 Amperes

T52/T62

JEDEC/ TYPE	2N4361-68/ 2N4371-78	T500__80 T510__80	T600__13 T610__13	T520__13	T600__15 T610__15	T620__15	2N3884-96	T600__18 T610__18
AVERAGE CURRENT	70	80	125	125	150	150	175	175
ONE CYCLE SURGE	1600	1800	3300	1600	4000	3300	4500	5500
VOLTAGE 50		T5100080	T6100013	T5200013	T6100015	T6200015	2N3884	T6100018
100	2N4361/2N4371	T5100180	T6100113	T5200113	T6100115	T6200115	2N3885	T6100118
200	2N4362/2N4372	T5100280	T6100213	T5200213	T6100215	T6200215	2N3886	T6100218
300		T5100380	T6100313	T5200313	T6100315	T6200315	2N3887	T6100318
400	2N4363/2N4373	T5100480	T6100413	T5200413	T6100415	T6200415	2N3888	T6100418
500		T5100580	T6100513	T5200513	T6100515	T6200515	2N3889	T6100518
600	2N4364/2N4374	T5100680	T6100613	T5200613	T6100615	T6200615	2N3890	T6100618
700		T5000780	T6000713	T5200713	T6000715	T6200715	2N3891	T6000718
800	2N4365/2N4375	T5000880	T6000813	T5200813	T6000815	T6200815	2N3892	T6000818
900		T5000980	T6000913	T5200913	T6000915	T6200915	2N3893	T6000918
1000	2N4366/2N4376	T5001080	T6001013	T5201013	T6001015	T6201015	2N3894	T6001018
1200	2N4367/2N4377	T5001280	T6001213	T5201213	T6001215	T6201215	2N3895	T6001218
1500		T5001580	T6001513	T5201513	T6001515	T6201515		T6001518
PACKAGE TYPE	TO-94/TO-83	TO-94/TO-83	TO-93	T52	TO-93	T62	TO-93	TO-93
PAGE NUMBER	S21	S23/S27	S33	S41	S33	S43	S31	S33

THYRISTOR SELECTOR GUIDE

PHASE CONTROL SCR'S
175 — 300 Amperes

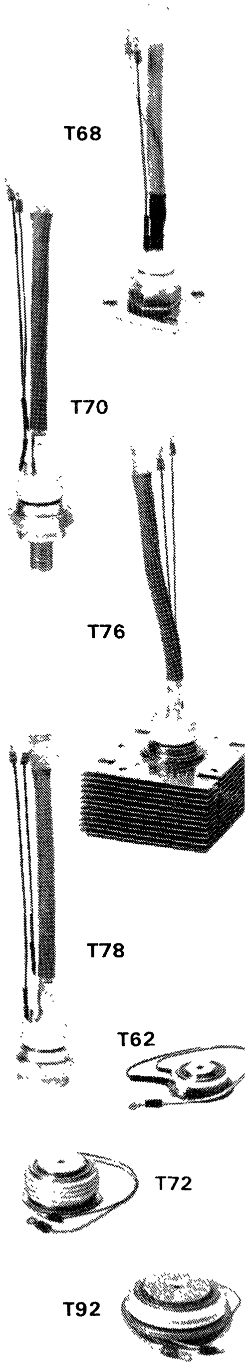
TYPE	T680__18	T620__20	T625__25 *	T700__25	T625__30 *	T620__30	T760__30	T700__30
AVERAGE CURRENT	175	200	250	250	300	300	300	300
ONE CYCLE SURGE	5500	4000	2800	7000	3600	5500	8400	8400
VOLTAGE 100	T6800118	T6200120	T6250125	T7000125	T6250130	T6200130	T7600130	T7000130
200	T6800218	T6200220	T6250225	T7000225	T6250230	T6200230	T7600230	T7000230
300	T6800318	T6200320	T6250325	T7000325	T6250330	T6200330	T7600330	T7000330
400	T6800418	T6200420	T6250425	T7000425	T6250430	T6200430	T7600430	T7000430
500	T6800518	T6200520	T6250525	T7000525	T6250530	T6200530	T7600530	T7000530
600	T6800618	T6200620	T6250625	T7000625	T6250630	T6200630	T7600630	T7000630
700	T6800718	T6200720	T6250725	T7000725	T6250730	T6200730	T7600730	T7000730
800	T6800818	T6200820	T6250825	T7000825	T6250830	T6200830	T7600830	T7000830
900	T6800918	T6200920	T6250925	T7000925	T6250930	T6200930	T7600930	T7000930
1000	T6801018	T6201020	T6251025	T7001025	T6251030	T6201030	T7601030	T7001030
1200	T6801218	T6201220	T6251225	T7001225	T6251230	T6201230	T7601230	T7001230
1400	T6801418	T6201420		T7001425		T6201430	T7601430	T7001430
1500	T6801518	T6201520		T7001525		T6201530	T7601530	T7001530
1600				T7001625			T7601630	T7001630
1800				T7001825			T7601830	T7001830
2000				T7002025			T7602030	T7002030
2200				T7002225				T7002230
PACKAGE TYPE	T68	T62	T62	T70	T62	T62	T76	T70
PAGE NUMBER	S73	S43	S47	S37	S47	S43	S71	S37

* HIGH TEMPERATURE - 150°C

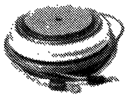
PHASE CONTROL
350 - 700 Amperes

TYPE	T700__35	T780__35	T720__35	T625__40 *	T720__45	T720__55	T920__06	T920__07
AVERAGE CURRENT	350	350	350	400	450	550	600	700
ONE CYCLE SURGE	10,000	10,000	7000	5000	8400	10,000	13,000	15,000
VOLTAGE 100	T7000135	T7800135	T7200135	T6250140	T7200145	T7200155		
200	T7000235	T7800235	T7200235	T6250240	T7200245	T7200255		
300	T7000335	T7800335	T7200335	T6250340	T7200345	T7200355		
400	T7000435	T7800435	T7200435	T6250440	T7200445	T7200455		
500	T7000535	T7800535	T7200535	T6250540	T7200545	T7200555		
600	T7000635	T7800635	T7200635	T6250640	T7200645	T7200655	T9200606	T9200607
700	T7000735	T7800735	T7200735	T6250740	T7200745	T7200755	T9200706	T9200707
800	T7000835	T7800835	T7200835	T6250840	T7200845	T7200855	T9200806	T9200807
900	T7000935	T7800935	T7200935	T6250940	T7200945	T7200955	T9200906	T9200907
1000	T7001035	T7801035	T7201035	T6251040	T7201045	T7201055	T9201006	T9201007
1200	T7001235	T7801235	T7201235	T6251240	T7201245	T7201255	T9201206	T9201207
1400	T7001435	T7801435	T7201435		T7201445	T7201455	T9201406	T9201407
1600	T7001635	T7801635	T7201635		T7201645	T7201655	T9201606	T9201607
1800			T7201835		T7201845		T9201806	T9201807
2000			T7202035		T7202045		T9202006	T9202007
2200			T7202235		T7202245		T9202206	T9202207
2500							T9202506	
2800							T9202806	
3000							T9203006	
PACKAGE TYPE	T70	T78	T72	T62	T72	T72	T92	T92
PAGE NUMBER	S37	S75	S51	S47	S51	S51	S55	S55

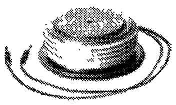
* HIGH TEMPERATURE - 150°C



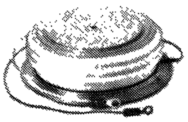
THYRISTOR SELECTOR GUIDE



T92



T9G



TA2

PHASE CONTROL SCR'S
800 — 1400 Amperes

TYPE	T920__08	T9G0__08	T920__09	T920__10	T9G0__10	T9G0__12	TA20__12	TA20__14
AVERAGE CURRENT	800	800	900	1000	1000	1200	1200	1400
ONE CYCLE SURGE	17,000	13,000	25,000	27,000	17,000	27,000	30,000	35,000
VOLTAGE 600	T9200608	T9G00608	T9200609	T9200610	T9G00610	T9G00612	TA200612	TA200614
700	T9200708	T9G00708	T9200709	T9200710	T9G00710	T9G00712	TA200712	TA200714
800	T9200808	T9G00808	T9200809	T9200810	T9G00810	T9G00812	TA200812	TA200814
900	T9200908	T9G00908	T9200909	T9200910	T9G00910	T9G00912	TA200912	TA200914
1000	T9201008	T9G01008	T9201009	T9201010	T9G01010	T9G01012	TA201012	TA201014
1200	T9201208	T9G01208	T9201209	T9201210	T9G01210	T9G01212	TA201212	TA201214
1400	T9201408	T9G01408	T9201409	T9201410	T9G01410	T9G01412	TA201412	TA201414
1600	T9201608	T9G01608	T9201609	T9201610	T9G01610	T9G01612	TA201612	TA201614
1800	T9201808	T9G01808			T9G01810		TA201812	TA201814
2000	T9202008	T9G02008			T9G02010		TA202012	TA202014
2200	T9202208	T9G02208			T9G02210		TA202212	TA202214
2400		T9G02408						
2600		T9G02608						
2800		T9G02808						
3000		T9G03008						
PACKAGE TYPE	T92	T9G	T92	T92	T9G	T9G	TA2	TA2
PAGE NUMBER	S55	S61	S55	S55	S61	S61	S67	S67

THYRISTOR SELECTOR GUIDE

FAST SWITCHING SCR'S and RBDT'S
22 — 125 Amperes

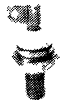
TYPE	T40R__22 *	T507__40	T527__60	T507__70	T507__80	T527__12	T62R__13 *
AVERAGE CURRENT	22	40	60	70	80	115	125
ONE CYCLE SURGE	300	1000	1000	1200	1400	1200	4000
VOLTAGE 100		T5070140	T5270160	T5070170	T5070180	T5270112	
200		T5070240	T5270260	T5070270	T5070280	T5270212	
300		T5070340	T5270360	T5070370	T5070380	T5270312	
400		T5070440	T5270460	T5070470	T5070480	T5270412	
500		T5070540	T5270560	T5070570	T5070580	T5270512	
600	T4040622	T5070640	T5270660	T5070670	T5070680	T5270612	T62R0613
700		T5070740	T5270760	T5070770	T5070780	T5270712	
800	T40R0822	T5070840	T5270860	T5070870	T5070880	T5270812	T62R0813
900		T5070940	T5270960	T5070970	T5070980	T5270912	
1000	T40R1022	T5071040	T5271060	T5071070	T5071080	T5271012	T62R1013
1200		T5071240	T5271260	T5071270	T5071280	T5271212	
TURN OFF TIME	50 μs	10-50 μs	10-50 μs	10-50 μs	10-50 μs	10-50 μs	50 μs
PACKAGE TYPE	DO-5	TO-83/TO-94	T52	TO-83/TO-94	TO-83/TO-94	T52	T62R
PAGE NUMBER	S95	S77	S83	S77	S77	S83	S97

'RBDT - Reverse Blocking Diode Thyristor

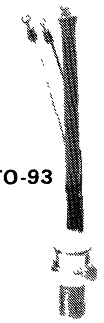
FAST SWITCHING SCR'S
125 — 250 Amperes

TYPE	T527__13	T607__13	T607__15	T627__15	T607__18	T627__20	T627__25
AVERAGE CURRENT	125	125	150	150	175	200	250
ONE CYCLE SURGE	1400	3500	4000	3500	4500	4000	4500
VOLTAGE 100	T5270113	T6070113	T6070115	T6270115	T6070118	T6270120	T6270125
200	T5270213	T6070213	T6070215	T6270215	T6070218	T6270220	T6270225
300	T5270313	T6070313	T6070315	T6270315	T6070318	T6270320	T6270325
400	T5270413	T6070413	T6070415	T6270415	T6070418	T6270420	T6270425
500	T5270513	T6070513	T6070515	T6270515	T6070518	T6270520	T6270525
600	T5270613	T6070613	T6070615	T6270615	T6070618	T6270620	T6270625
700	T5270713	T6070713	T6070715	T6270715	T6070718	T6270720	T6270725
800	T5270813	T6070813	T6070815	T6270815	T6070818	T6270820	T6270825
900	T5270913	T6070913	T6070915	T6270915	T6070918	T6270920	T6270925
1000	T5271013	T6071013	T6071015	T6271015	T6071018	T6271020	T6271025
1200	T5271213	T6071213	T6071215	T6271215	T6071218	T6271220	T6271225
TURN OFF TIME	10-50 μs	10-50 μs	10-50 μs	10-50 μs	15-50 μs	10-50 μs	15-50 μs
PACKAGE TYPE	T52	TO-93	TO-93	T62	TO-93	T62	T62
PAGE NUMBER	S83	S79	S79	S87	S79	S87	S87


DO-5 (T40R)


TO-83

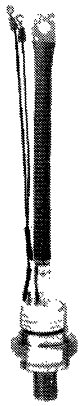

TO-94


TO-93

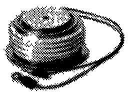

T52/T62


T62R

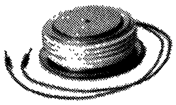
THYRISTOR SELECTOR GUIDE



T70



T72



T9G

FAST SWITCHING SCR'S
250 — 350 Amperes

TYPE	T707__25	*T72H__25	T707__28	T707__30	T707__33	T727__35	*T72H__35
AVERAGE CURRENT	250	250	275	300	325	350	350
ONE CYCLE SURGE	7000	6000	7000	8000	8000	7000	7000
VOLTAGE 100		T72H0125	T7070128		T7070133		T72H0135
200		T72H0225	T7070228		T7070233		T72H0235
300		T72H0325	T7070328		T7070333		T72H0335
400		T72H0425	T7070428		T7070433		T72H0435
500		T72H0525	T7070528		T7070533		T72H0535
600	T7070625	T72H0625	T7070628	T7070630	T7070633	T7270635	T72H0635
700	T7070725	T72H0725	T7070728	T7070730	T7070733	T7270735	T72H0735
800	T7070825	T72H0825	T7070828	T7070830	T7070833	T7270835	T72H0835
900	T7070925	T72H0925		T7070930		T7270935	T72H0935
1000	T7071025	T72H1025		T7071030		T7271035	T72H1035
1200	T7071225	T72H1225		T7071230		T7271235	T72H1235
TURN OFF TIME	15-50 μs	25-50 μs	10-50 μs	20-50 μs	10-50 μs	15-50 μs	25-50 μs
PACKAGE TYPE	T70	T72	T70	T70	T70	T72	T72
PAGE NUMBER	S81	S89	S81	S81	S81	S91	S89

* di/namic mid-gate design

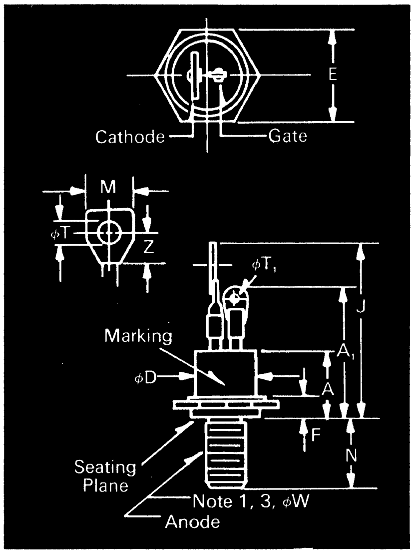
FAST SWITCHING SCR'S
400 — 900 Amperes

TYPE	T727__40	T727__45	*T72H__45	T727__48	*T9GH__08	*T9GH__09
AVERAGE CURRENT	400	450	450	475	800	900
ONE CYCLE SURGE	7000	8000	7500	8000	10,000	13,000
VOLTAGE 100	T7270140		T72H0145	T7270148		
200	T7270240		T72H0245	T7270248		
300	T7270340		T72H0345	T7270348		
400	T7270440		T72H0445	T7270448		
500	T7270540		T72H0545	T7270548		
600	T7270640	T7270645	T72H0645	T7270648	T9GH0608	T9GH0609
700	T7270740	T7270745	T72H0745	T7270748	T9GH0708	T9GH0709
800	T7270840	T7270845	T72H0845	T7270848	T9GH0808	T9GH0809
900		T7270945	T72H0945		T9GH0908	T9GH0909
1000		T7271045	T72H1045		T9GH1008	T9GH1009
1200		T7271245	T72H1245		T9GH1208	T9GH1209
1400					T9GH1408	T9GH1409
1600					T9GH1608	T9GH1609
1800					T9GH1808	T9GH1809
2000					T9GH2008	
2200					T9GH2208	
TURN OFF TIME	10-50 μs	20-50 μs	30-50 μs	10-50 μs	30-80 μs	30-80 μs
PACKAGE TYPE	T72	T72	T72	T72	T9G	T9G
PAGE NUMBER	S91	S91	S89	S91	S93	S93

* di/namic mid-gate design

Phase Control SCR 2N1842,A—2N1850,A

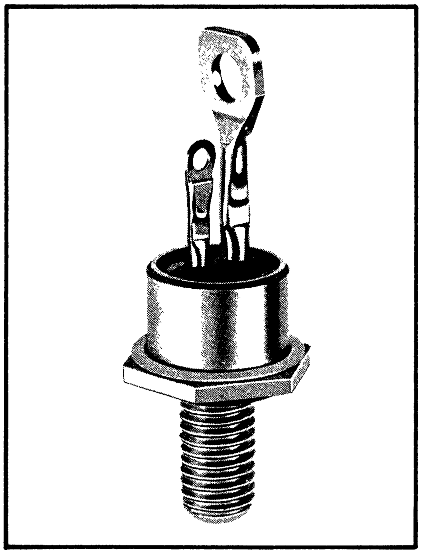
10 A Avg Up to 500 Volts



Symbol	Inches Min.	Inches Max.	Millimeters Min.	Millimeters Max.
A	.330	.505	8.38	12.83
A_1		.880		22.35
φD		.544		13.82
E	.544	.562	13.82	14.27
F	.113	.152	2.87	3.86
J		1.193		30.30
M	.210	.300	5.33	7.62
N	.422	.453	10.72	11.51
φT	.125	.165	3.18	4.19
$φT_1$	.060	.075	1.52	1.91
Z	.120		3.05	
φW	¼-28 UNF-2A			

Approx. Weight—.33 oz. (10 g).

1. Complete threads to extend to within 2½ threads of seating plane.
2. Contour and angular orientation of terminals is undefined.
3. Pitch diameter of ¼-28 UNF-2A (coated) threads (ASA B1.1-1960).



Conforms to TO-48

Maximum Ratings and Characteristics

JEDEC Types: 2N1842, $T_J=100°C$; 2N1842A, $T_J=125°C$

Blocking State	Symbol	2N1842 2N1842A	2N1843 2N1843A	2N1844 2N1844A	2N1845 2N1845A	2N1846 2N1846A	2N1847 2N1847A	2N1848 2N1848A	2N1849 2N1849A	2N1850 2N1850A
*Repetitive Peak Forward and Reverse Voltage, volts	V_{DRM} V_{RRM}	25	50	100	150	200	250	300	400	500
*Non-repetitive Transient Peak Forward and Reverse Voltage, t≤5.0 msec, V	V_{RSM}	35	75	150	225	300	350	400	500	600
*Forward and Reverse Leakage Current, (full cycle average) mA	$I_{D(AV)}$ $I_{R(AV)}$	②22.5	②19.0	②12.5	6.5	6.0	5.5	5.0	4.0	3.0

Conducting State (Max. Values at Max. T_J)	Symbol	2N1842 Series①
RMS Forward Current, amps	I_{TRMS}	16
*Ave. Forward Current (180°Conduction) amps	I_{TAV}	10
Surge Current (at 60 Hz): *½ Cycle, amps	I_{TSM}	125
3 Cycles, amps	I_{TSM}	90
10 Cycles, amps	I_{TSM}	75
I^2t for Fusing (at 60 Hz half-wave), amps² sec	I^2t	60
Forward Voltage Drop at $T_J=25°C$ I_{TM} = 10 A, volts	V_{TM}	1.6

Thermal Characteristics	Symbol	
*Oper. Junction Temp. Range, °C	T_J	−40 to +100①
*Storage Temperature Range, °C	T_{stg}	−40 to +125①
Max. Thermal Impedance, °C/Watt: Junction to Case	$R\theta_{JC}$	1.3
Max. Thread Torque, Lubricated, in. lbs.		30

* JEDEC Registered Parameters.

Gate Parameters (Max. values at $T_J=25°C$)	Symbol	2N1842 Series①
Gate Current to Trigger ($V_{FB}=12V$), ma.	I_{GT}	80
Gate Voltage to Trigger over temperature range ($V_{FB}=12V$), volts	V_{GT}	3.5①
*Non-Triggering Gate Voltage (Rated V_{FB}), T_{Jmax}, volts	V_{GNT}	.3①
*Peak Forward Gate Current, amps	I_{GFM}	2
*Peak Reverse Gate Voltage, volts	V_{GRM}	5
*Peak Gate Power, watts	P_{GM}	5
*Average Gate Power, watts	$P_{G(AV)}$	.5

Switching State	Symbol	
Typical Turn-On Time, $I_T=10$ A, 10-90%, $V_{DRM}=10$ volts, $T_J=25°C$, μsec	t_{on}	3
Min. di/dt, Linear to 5.0 I_{TAV}, amps/μsec	di/dt	25
Typical Turn-Off Time, $I_F=10$ A, T_J max, $di_R/dt=10$ A/μsec., dv/dt= 20V/μsec. Linear to .8 V_{DRM}, μsec	tq	50
Typ. dv/dt, Exp. to V_{DRM} volts/μsec	dv/dt	100

① 2N1842A Series is the same except: T_J and $T_{stg}=-65$ to $+125$; $V_{GT}=3.7$; $V_{GNT}=.25$.
② Actual test limit 6.5 mA.

10 A Avg
Up to 500 Volts

Phase Control SCR 2N1842,A—2N1850,A

Electrical Characteristics

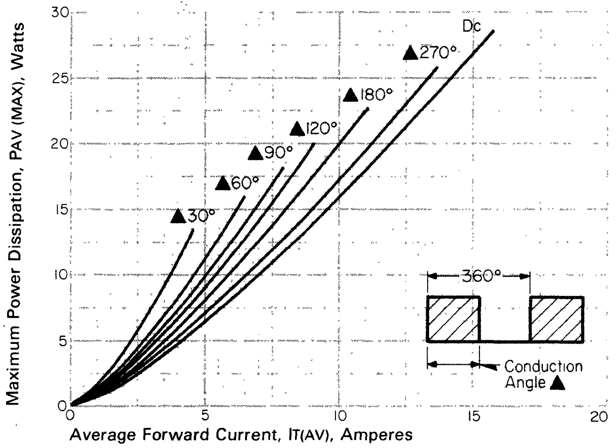


Figure 1. Power dissipation vs forward current, rectangular wave.

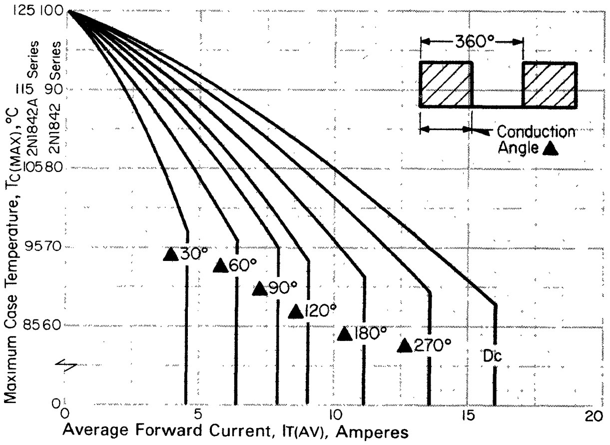


Figure 2. Case temperature vs forward current, rectangular wave.

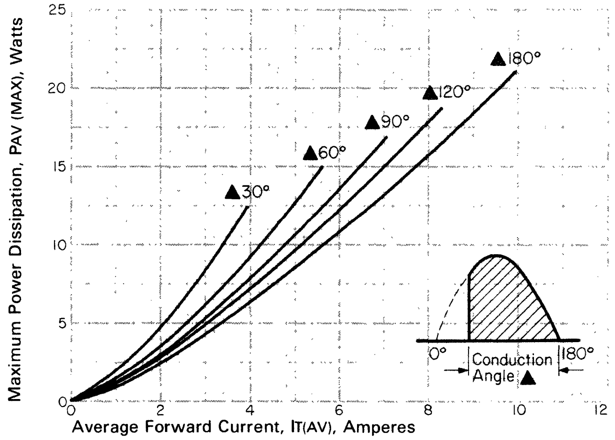


Figure 3. Power dissipation vs forward current, half-wave sinusoid.

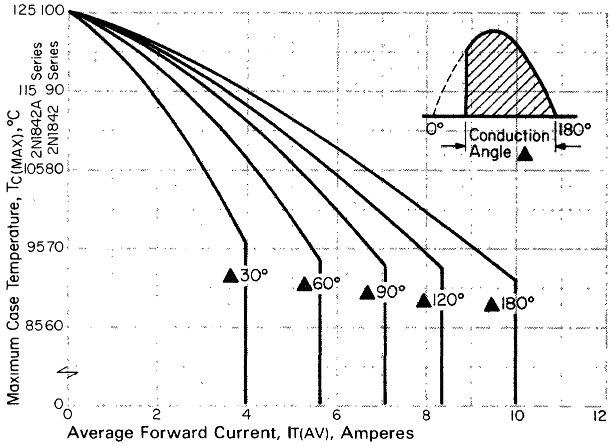


Figure 4. Case temperature vs forward current, half-wave sinusoid.

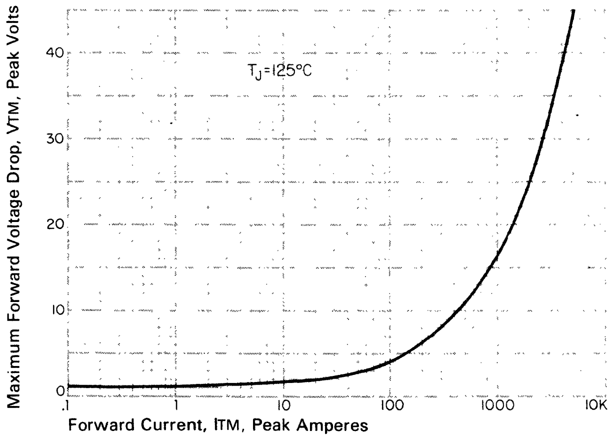


Figure 5. Forward voltage vs forward current.

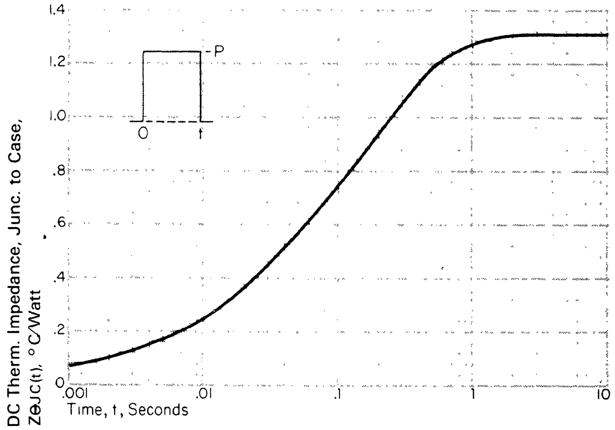
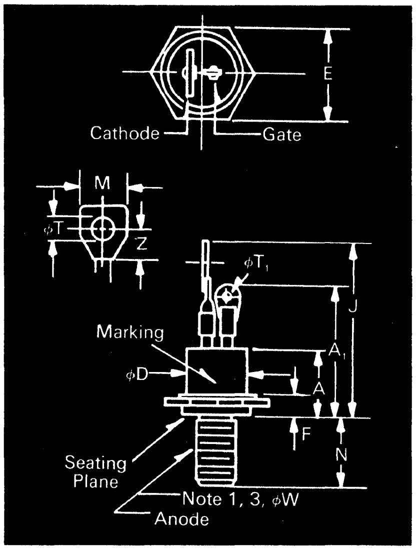


Figure 6. Transient thermal impedance vs time.

THYRISTOR

Phase Control SCR 2N681-2N692

16 A Avg Up to 800 Volts

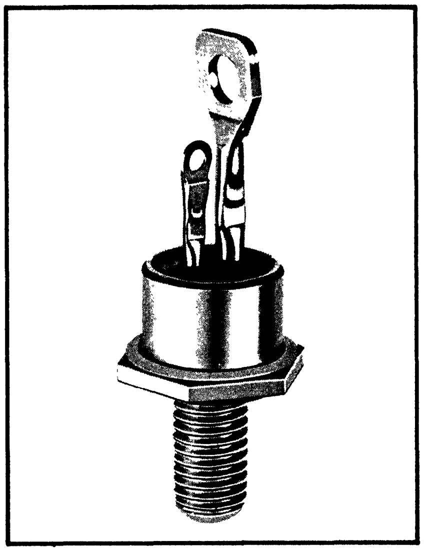


Comforms to TO-48 Outline

Symbol	Inches Min.	Inches Max.	Millimeters Min.	Millimeters Max.
A	.330	.505	8.38	12.83
A_1		.880		22.35
φD		.544		13.82
E	.544	.562	13.82	14.27
F	.113	.152	2.87	3.86
J		1.193		30.30
M	.210	.300	5.33	7.62
N	.422	.453	10.72	11.51
φT	.125	.165	3.18	4.19
$φT_1$	.060	.075	1.52	1.91
Z	.120		3.05	
φW	¼-28 UNF-2A			

Creep & Strike Distance.
.27 in. min. (6.96 mm).
(In accordance with NEMA standards.)
Finish—Nickel Plate.
Approx. Weight—.33 oz. (10 g).

1. Complete threads to extend to within 2½ threads of seating plane.
2. Contour and angular orientation of terminals is undefined.
3. Pitch diameter of ¼-28 UNF-2A (coated) threads (ASA B1.1-1960).



Maximum Ratings and Characteristics

Blocking State (T_J=125°C)

	Symbol	2N681	2N682	2N683	2N684	2N685	2N686	2N687	2N688	2N689	2N690	2N691	2N692
*Repetitive Peak Forward and Reverse Voltage, volts....	V_{DRM} V_{RRM}	25	50	100	150	200	250	300	400	500	600	700	800
*Non-repetitive Transient Peak Forward and Reverse Voltage, t ≤5.0 msec,V.	V_{RSM}	35	75	150	225	300	350	400	500	600	780	840	960
*Forward and Reverse Leakage Current, (full cycle average) mA	$I_{D(av)}$ $I_{R(av)}$	6.5	6.5	6.5	6.5	6.0	5.5	5.0	4.0	3.0	2.5	2.25	2.0

(The header "JEDEC Type" spans all twelve type columns.)

Conducting State (T_J=125°C)

	Symbol	All Types
RMS Forward Current, amps..........	$I_{T(rms)}$	25
*Ave. Forward Current (180° Conduction) amps..........	$I_{T(av)}$	16
Surge Current (at 60 Hz): *½ Cycle, amps.	I_{TSM}	150
3 Cycles, amps.	I_{TSM}	110
10 Cycles, amps.	I_{TSM}	90
I^2t for Fusing (at 60 Hz half-wave), amps^2 sec..........	I^2t	90
Forward Voltage Drop at T_J=25°C I_F=16 Adc, volts..........	V_{TM}	1.7

Thermal Characteristics

	Symbol	
*Oper. Junction Temp. Range, °C.......	T_J	−65 to +125
*Storage Temperature Range, °C........	T_{stg}	−65 to +150
Max. Thermal Impedance, °C/Watt: Junction to Case..........	$R\theta_{JC}$	1.3
Max. Thread Torque, Lubricated, in. lbs.. ...		30

Gate Parameters (T_J=25°C)

	Symbol	All Types
Gate Current to Trigger (V_{FB}=12V), ma.	I_{GT}	40
Gate Voltage to Trigger Over Temperature Range (V_{FB}=12V), volts	V_{GT}	3.0
*Non-Triggering Gate Voltage at T_J= 125°C (Rated V_{FB}), volts..........	V_{GNT}	.25
*Peak Forward Gate Current, amps......	I_{GFM}	5
*Peak Reverse Gate Voltage, volts.......	V_{GRM}	5
*Peak Gate Power, watts..........	P_{GM}	5
*Average Gate Power, watts..........	$P_{G(AV)}$	.5

Switching State

	Symbol	
Typical Turn-On Time, I_T=10 A, 10-90%, V_{DRM}=10 volts, T_J=25°C, μsec.....	t_{on}	3
Min. di/dt, Linear to 5.0 $I_{T(av)}$ amps/μsec..........	di/dt	25
Typical Turn-Off Time, I_T=10 A, T_J= 125°C, di_R/dt=10 A/μsec., dv/dt= 20V/μsec. Linear to .8 V_{DRM} μsec.....	t_q	50
Typ. dv/dt, Exp. to V_{DRM} volts/μsec.....	dv/dt	100

* JEDEC Registered Parameters.

THYRISTOR

16 A Avg
Up to 800 Volts

Phase Control SCR 2N681-2N692

Electrical Characteristics

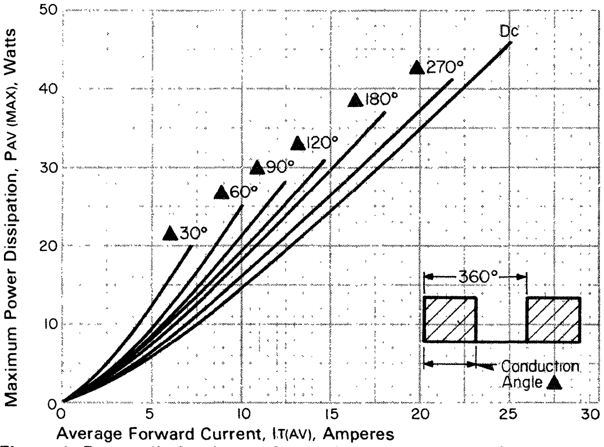


Figure 1. Power dissipation vs forward current, rectangular wave.

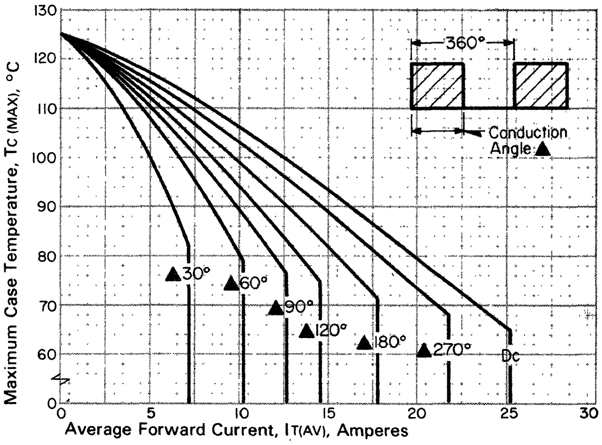


Figure 2. Case temperature vs forward current, rectangular wave.

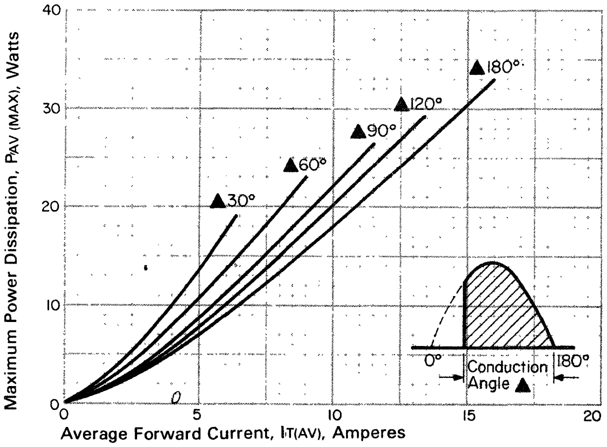


Figure 3. Power dissipation vs forward current, half-wave sinusoid.

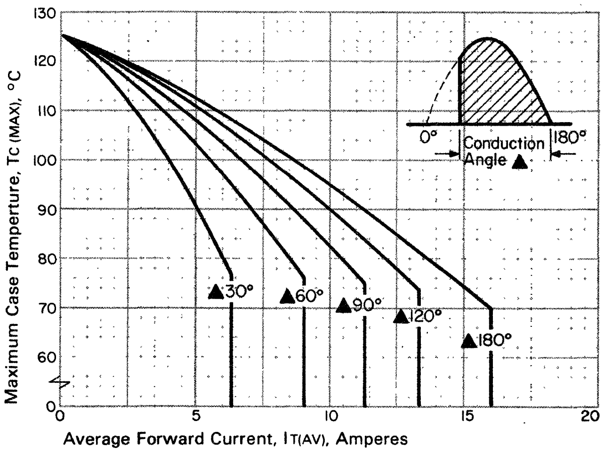


Figure 4. Case temperature vs forward current, half-wave sinusoid.

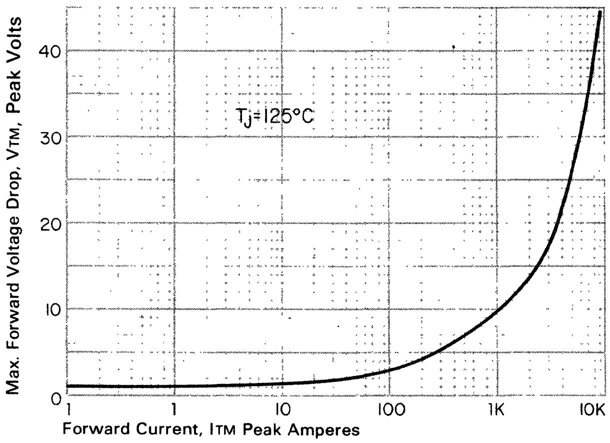


Figure 5. Forward voltage vs forwaro current.

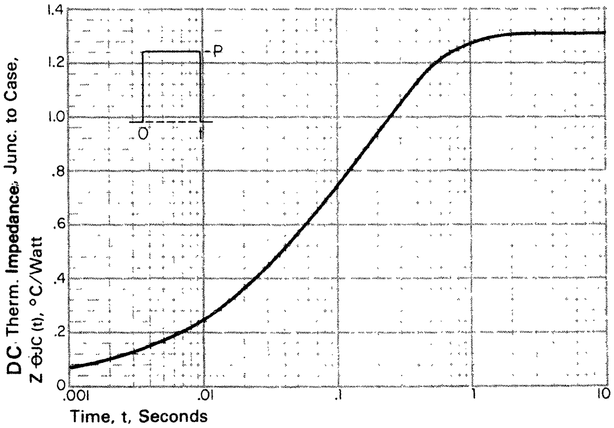
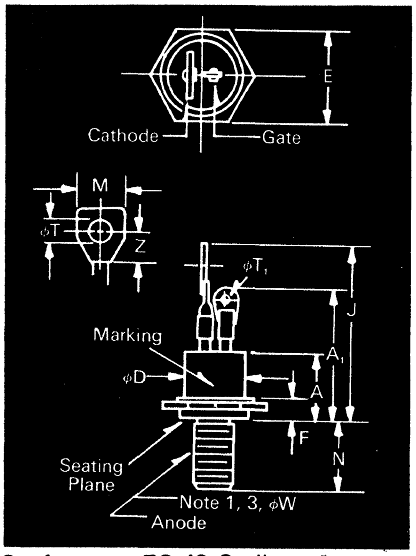


Figure 6. Transient thermal impedance vs time.

Phase Control SCR T400/2N5204-07

10-22 A. Avg. Up to 1200 Volts

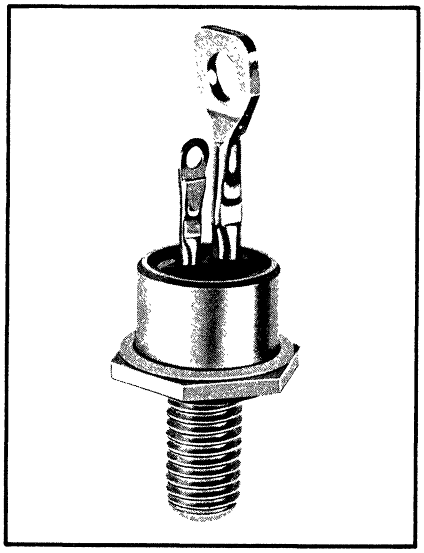


Conforms to TO-48 Outline

Symbol	Inches Min.	Inches Max.	Millimeters Min.	Millimeters Max.
A	.330	.505	8.38	12.83
A_1		.880		22.35
φD		.544		13.82
E	.544	.562	13.82	14.27
F	.113	.152	2.87	3.86
J		1.193		30.30
M	.210	.300	5.33	7.62
N	.422	.453	10.72	11.51
φT	.125	.165	3.18	4.19
$φT_1$	.060	.075	1.52	1.91
Z	.120		3.05	
φW	¼-28 UNF-2A			

Finish—Nickel Plate.
Approx. Weight—.33 oz. (10 g).

1. Complete threads to extend to within 2½ threads of seating plane.
2. Contour and angular orientation of terminals is undefined.
3. Pitch diameter of ¼-28 UNF-2A (coated) threads (ASA B1.1-1960).



Ordering Information

Type	Voltage		Current		Turn-off		Gate Current		Leads	
Code	V_{DRM} and V_{RRM} (V)	Code	$I_{T(av)}$ (A)	Code	tq µsec	Code	I_{GT} (ma)	Code	Case	Code
T400	50 100 200 300 400 500 600 700 800 900 1000 1100 1200	00 01 02 03 04 05 06 07 08 09 10 11 12	10 16 22	10 16 22	not specified 75	0 1	40 80	8 6	TO-48	00
2N5204 2N5205 2N5206 2N5207	600 800 1000 1200		22 Amperes		75 µsec (typ.)		40 mA.		TO-48	

Example

Obtain optimum device performance for your application by selecting proper order codes.

Type T400 rated 35 Amps RMS with V_{RRM}/V_{DRM}=1200 V, I_{GT}= 40 ma and tq=75 µsec max. Order as

Type				Voltage		Current		Turn Off	Gate Current	Leads	
T	4	0	0	0	3	2	2	1	8	0	0

THYRISTOR

10-22 A. Avg. Up to 1200 Volts

Phase Control SCR T400/2N5204-07

Blocking State	Symbol	Type T400 Order Code 00	01	02	03	04	05	06	07	08	09	10	11	12	2N5204	2N5205	2N5206	2N5207
Repetitive Peak Forward and Reverse Voltage ①, volts	V_{DRM} V_{RRM}	50	100	200	300	400	500	600	700	800	900	1000	1100	1200	600	800	1000	1200
Non-repetitive Transient Peak, Reverse Voltage, volts ≦5.0 msec	V_{RSM}	75	150	300	400	500	600	700	800	900	1000	1100	1200	1300	720	960	1200	1440
Peak Forward and Reverse Leakage Current mA	I_{DRM}① I_{RRM}	6.5	6.5	6.0	5.0	4.0	3.5	3.0	2.5	2.2	2.0	1.8	1.6	1.5	3.3	2.5	2.0	1.7

Current—Select Order Code 10, 16, 22

Conducting State (T_C=120°C)	Symbol	Order Code 10	16	22
Max. rms forward current, amps	$I_{T(rms)}$	16	25	35
Max. ave forward current, amps	$I_{T(av)}$	10	16	22
Max. ½-cycle② surge current, amps	I_{TSM}	150	250	360 †
Max. I^2T for fusing (at 60 Hz half-wave), ampere² seconds	I^2t	90	260	540 †
Max. forward voltage drop at I_T= 3.14X $I_{T(AV)}$ Adc and T_J = 25°C, Vdc	V_{TM}	2.3	2.3	2.3

Switching State	Symbol	T400	JEDEC
Min. critical dv/dt, exponential to V_{DRM}, T_J = 125°C volts/μsec	dv/dt	50	100
Min. di/dt, JEDEC Std. #7, Sec. 5.1.2.4. A/μsec	di/dt	150	100

† JEDEC TYPES HAVE
I_{TSM} = 300 A.
I^2t = 375 A²sec

Turn Off—Select Order Code 1 or 0

	Symbol		Order Code
Max. turn-off time, I_T=10, T_C=120°C, di_R/dt=5A/μsec reapplied dv/dt=100 V/μsec linear to rated V_{DRM}, μsec	t_q	75	1
		t_q not specified	0

Gate Current—Select Order Code 8 or 6

	Symbol		Order Code
Max. gate current to trigger at T_C=25°C, mA	I_{GT}	40	8
		80	6

① Applies for zero or negative gate voltage.
② At 60 Hertz.

Ratings and Characteristics	Symbol	All Types
Max. holding current, mA	I_H	100
Thermal and Mechanical Characteristics		
Min., Max. oper. junction temp., °C	T_j	—40 to + 125
Min., Max. storage temp., °C	T_{stg}	—40 to + 150
Max. thread torque, in.-lbs.		30
Max. thermal resistance Junction to case, °C/watt	$R_{\theta jc}$	1.6
JEDEC TYPES	$R_{\theta jc}$	1.5
Gate Parameters (T_C—25°C) T400		
Max. gate voltage to trigger at V_D=5V, T_C=—40 to +120°C	V_{GT}	3
Max. non-triggering gate voltage, T_C= +120°C and rated V_{DRM}, volts	V_{GDM}	.25
Peak forward gate current, amps	I_{GTM}	5
Peak reverse gate voltage, volts	V_{GRM}	10
Peak gate power, watts	P_{GM}	25
Average gate power, watts	$P_{G(AV)}$	2
JEDEC TYPES		
Peak reverse gate voltage, volts	V_{GRM}	5
Peak gate power, watts	P_{GM}	60
Average gate power, watts	$P_{G(AV)}$	10

THYRISTOR

Phase Control SCR T400/2N5204-07

10-22 A. Avg. Up to 1200 Volts

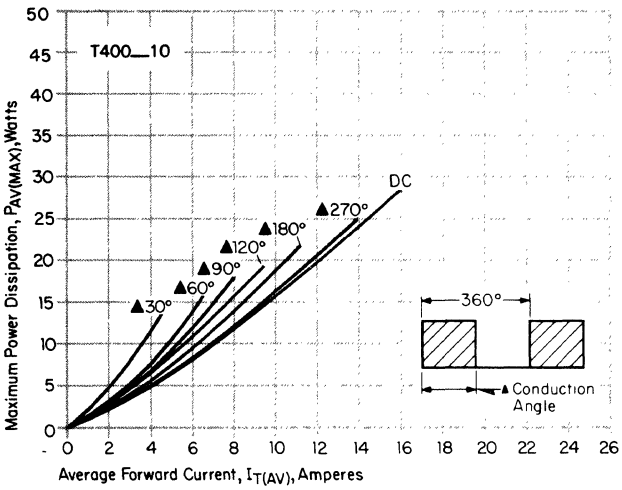


Figure 1. Power dissipation vs. forward current, rectangular wave.

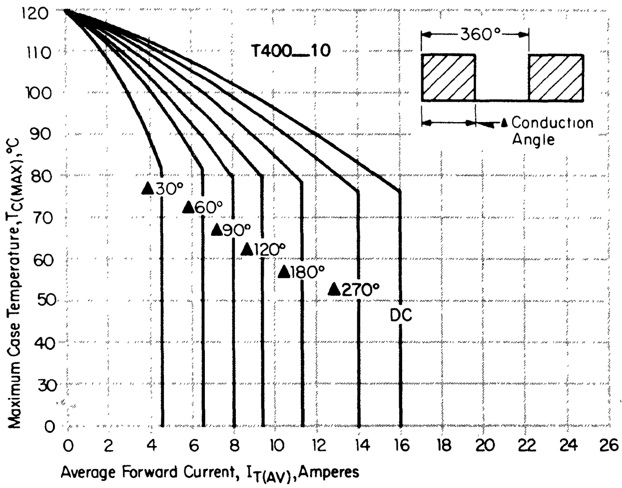


Figure 2. Case temperature vs. forward current, rectangular wave.

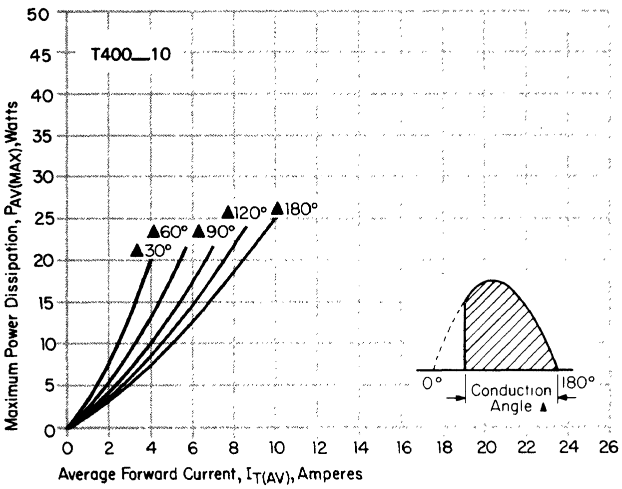


Figure 3. Power dissipation vs. forward current, half wave sinusoid.

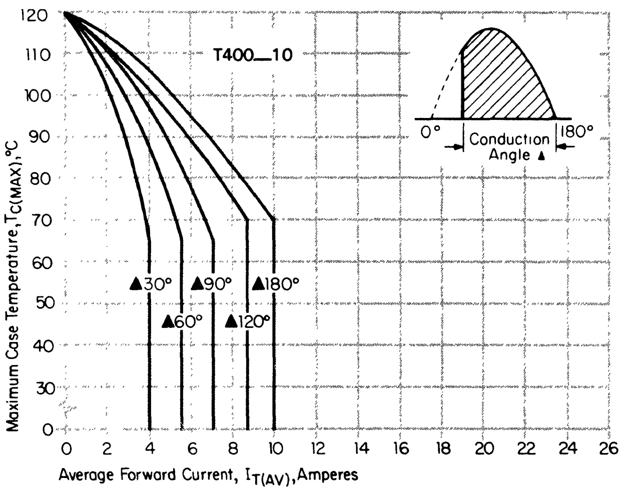


Figure 4. Case temperature vs. forward current, half wave sinusoid.

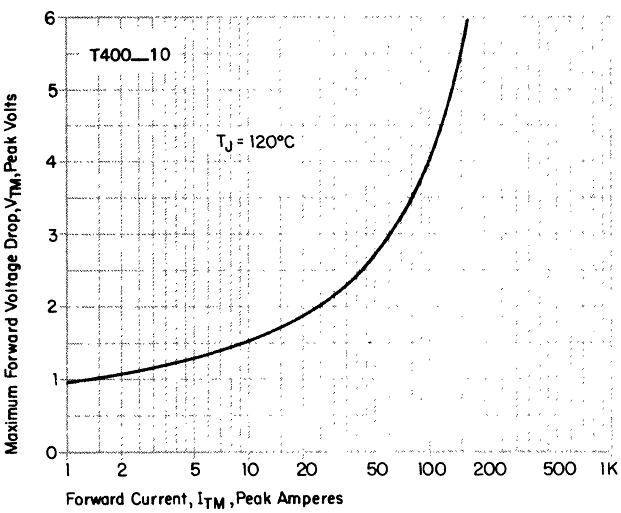


Figure 5. Forward voltage vs. forward current.

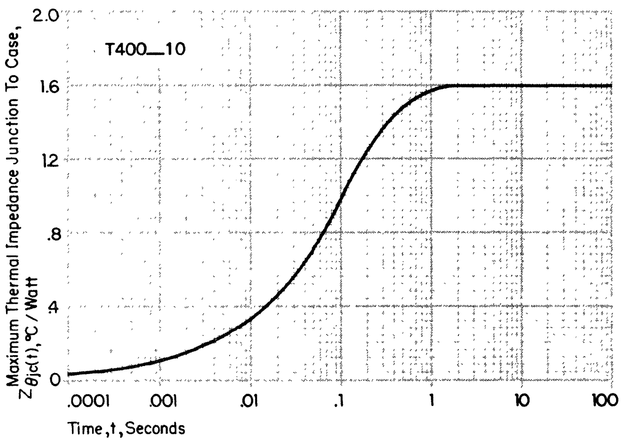


Figure 6. Transient thermal impedance vs. time.

THYRISTOR

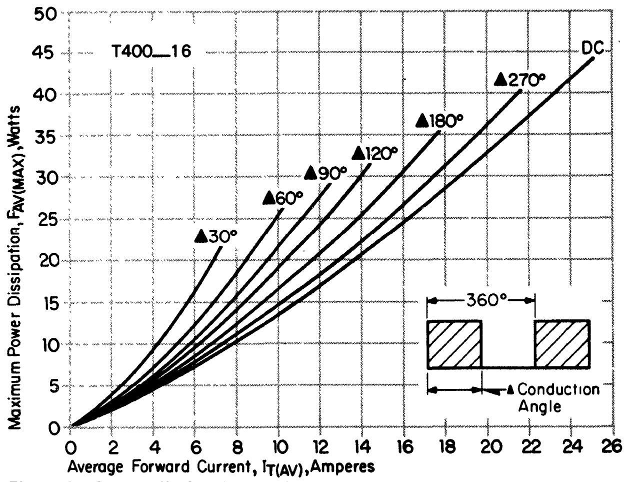


Figure 7. Power dissipation vs. forward current, rectangular wave.

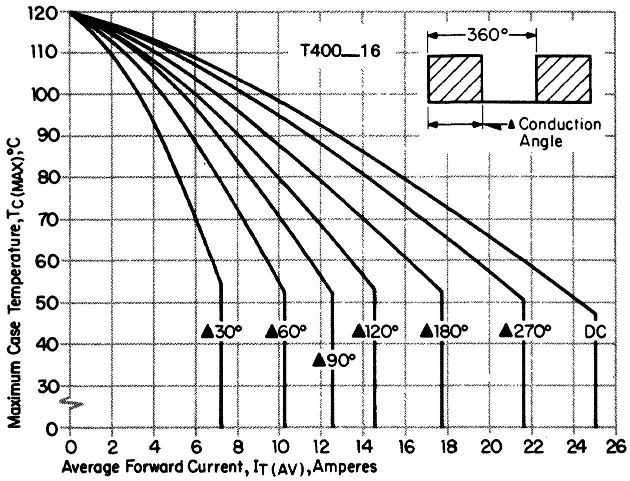


Figure 8. Case temperature vs. forward current, rectangular wave.

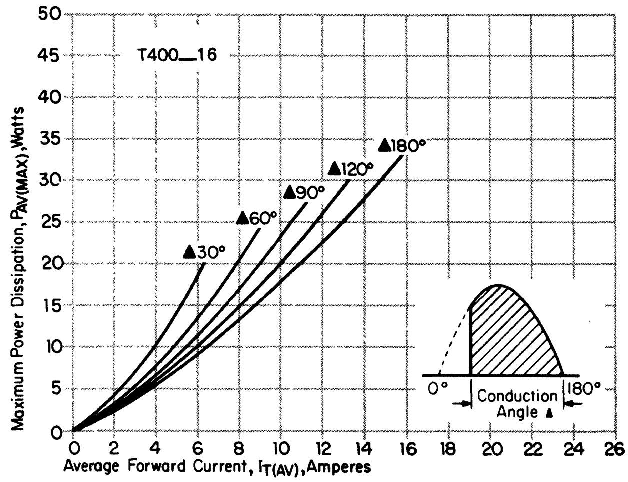


Figure 9. Power dissipation vs. forward current, half wave sinusoid.

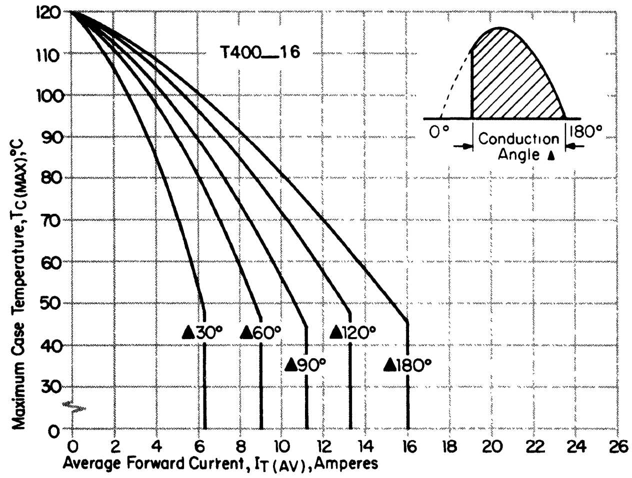


Figure 10. Case temperature vs. forward current, half wave sinusoid.

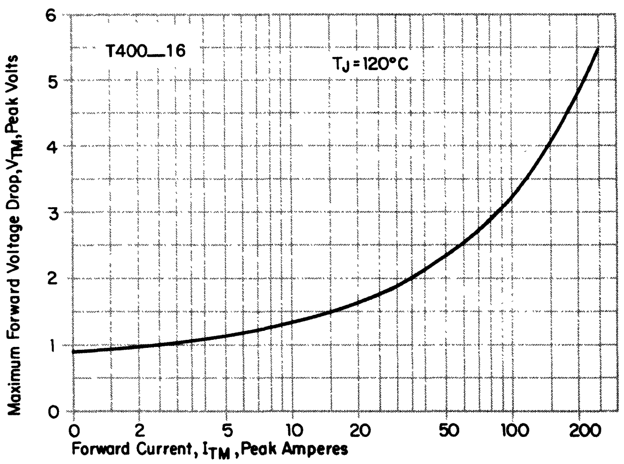


Figure 11. Forward voltage vs. forward current.

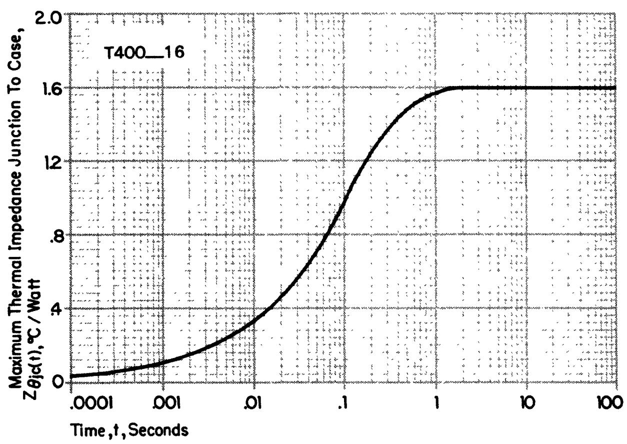


Figure 12. Transient thermal impedance vs. time.

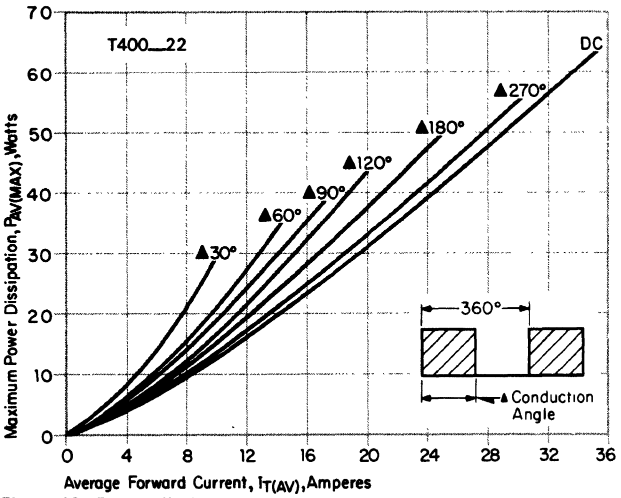


Figure 13. Power dissipation vs. forward current, rectangular wave.

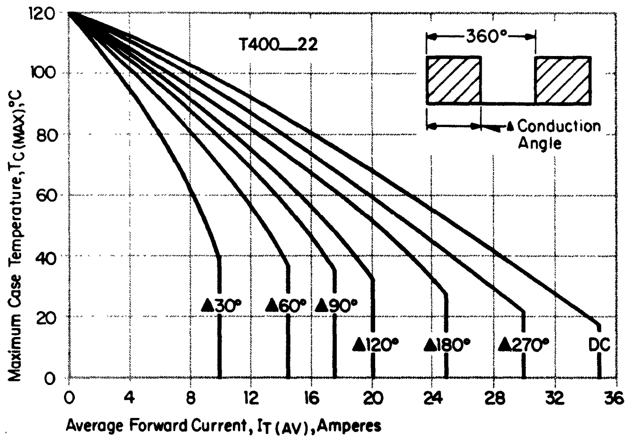


Figure 14. Case temperature vs. forward current, rectangular wave.

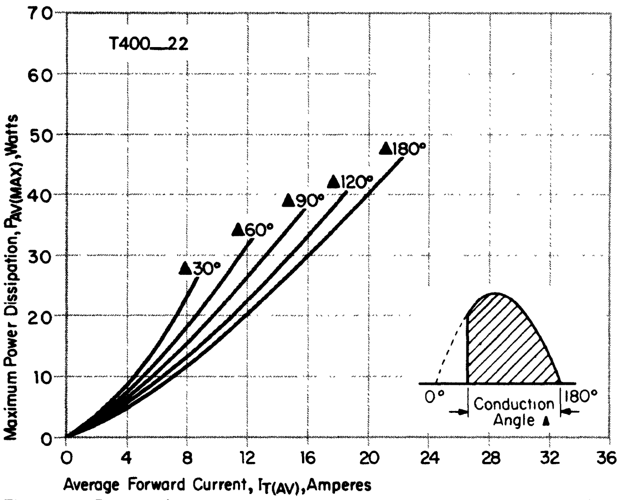


Figure 15. Power dissipation vs. forward current, half wave sinusoid.

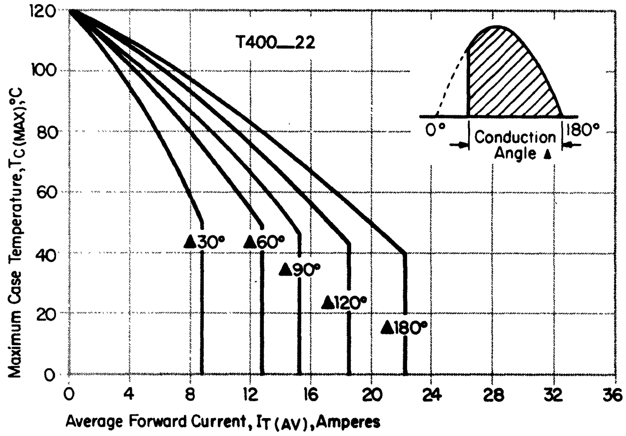


Figure 16. Case temperature vs. forward current, half wave sinusoid.

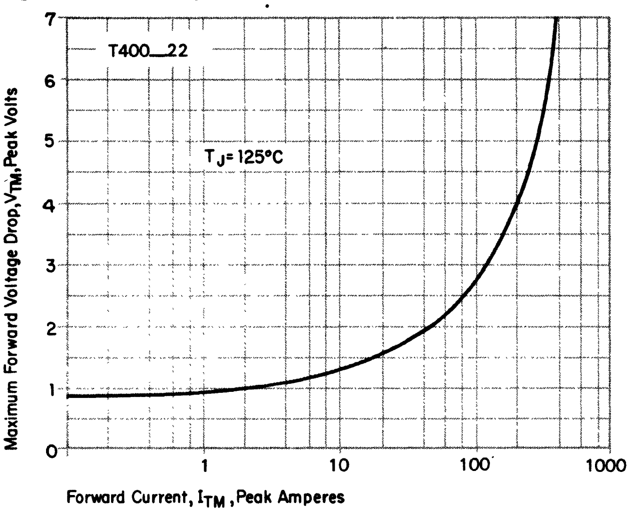


Figure 17. Forward voltage vs. forward current.

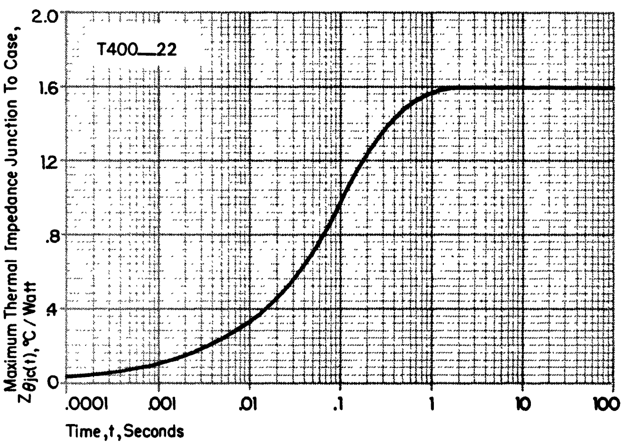


Figure 18. Transient thermal impedance vs. time.

THYRISTOR

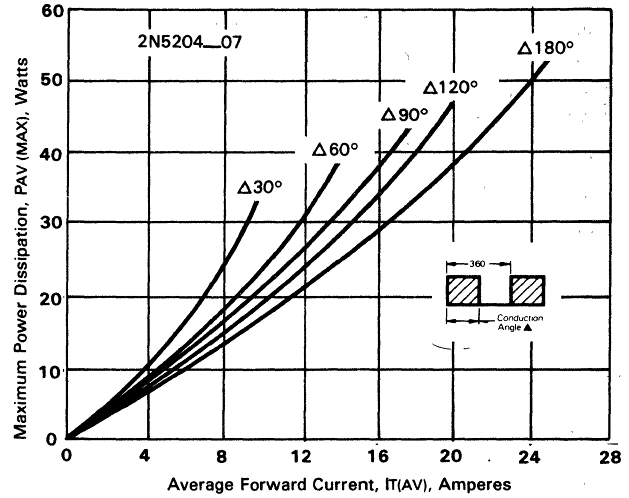


Figure 19. Power dissipation vs. forward current, rectangular wave.

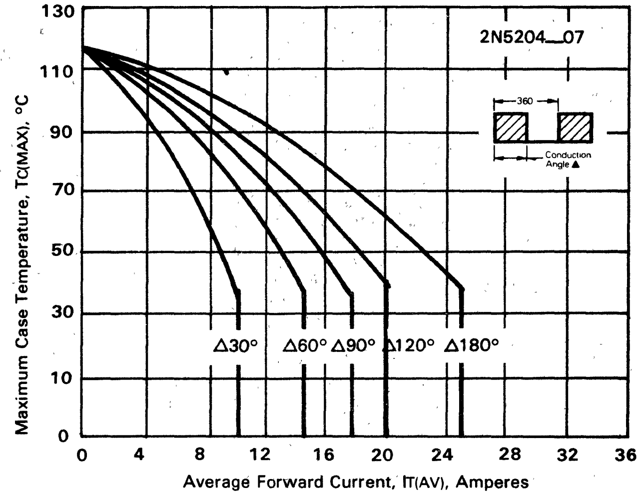


Figure 20. Case temperature vs. forward current, rectangular wave.

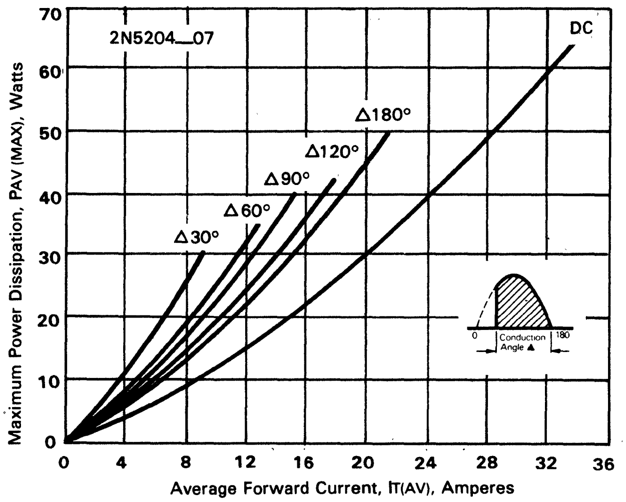


Figure 21. Power dissipation vs. forward current, half wave sinusoid.

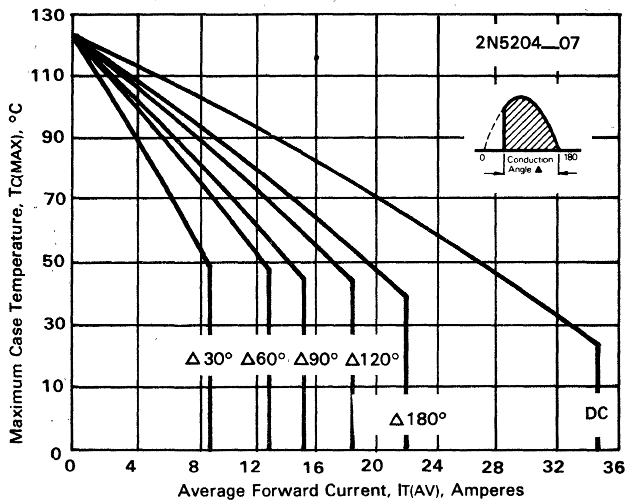


Figure 22. Case temperature vs. forward current, half wave sinusoid.

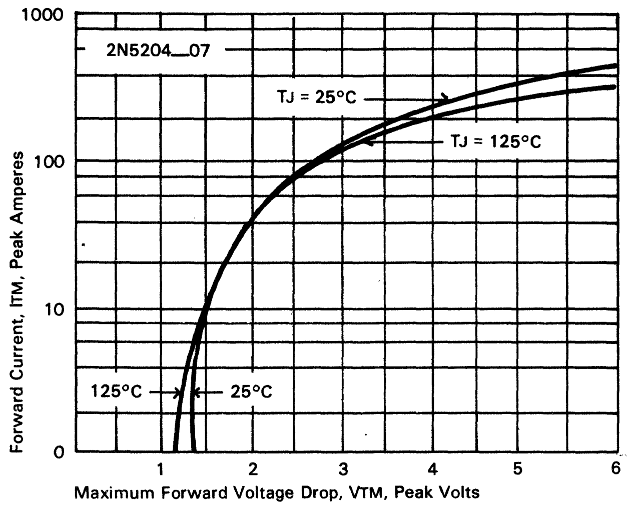


Figure 23. Forward voltage vs. forward current.

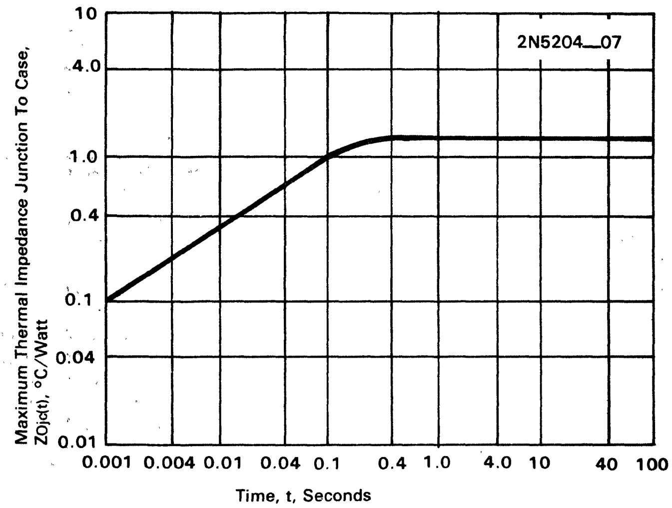
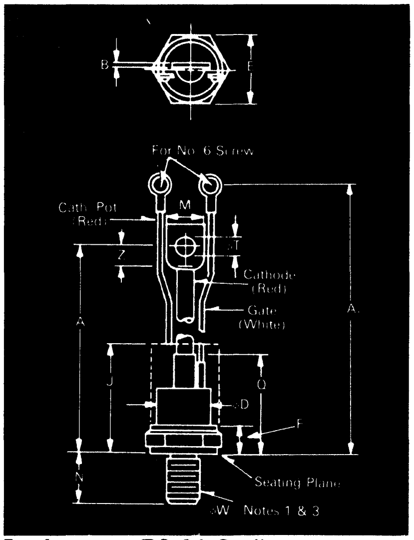


Figure 24. Transient thermal impedance vs. time.

Phase Control SCR 2N1909/2N1792 Series

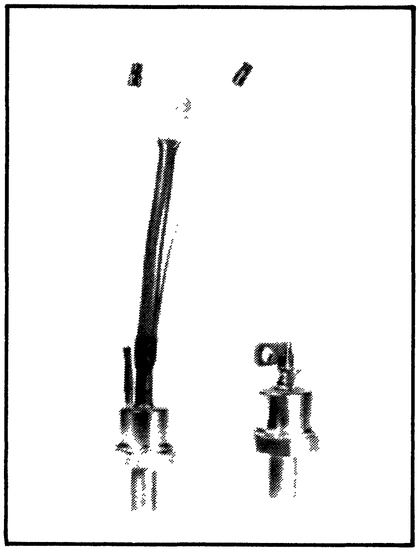
70 A Avg. Up to 600 Volts



Symbol	Inches Min.	Inches Max.	Millimeters Min.	Millimeters Max.
A	5.775	6.265	146.69	159.13
A_1	6.850	7.500	173.99	190.50
B	.055	.075	1.40	1.91
ϕD	.860	1.000	21.84	25.40
E	1.031	1.063	26.19	27.00
F	.255	.400	6.48	10.16
J	2.50		63.50	
M	.437	.650	11.10	16.51
N	.796	.827	20.24	21.01
Q		1.675		42.55
ϕT	.260	.291	6.60	7.39
Z	.250		6.35	
ϕW	½-20 UNF-2A			

Creep & Strike Distance.
.10 in. min. (2.54 mm).
(In accordance with NEMA standards.)
Finish—Nickel Plate.
Approx. Weight—5 oz. (142 g).

1. Complete threads to extend to within 2½ threads of seating plane.
2. Angular orientation of terminals is undefined.
3. Pitch diameter of ½-20 UNF-2A (coated) threads (ASA B1.1-1960).
4. Dimension "J" denotes seated height with leads bent at right angles.



For TO-83 Outline, see page S23.

Conforms to TO-94 Outline

Features:
- Center fired, di/namic gate
- All diffused design
- Low gate current
- Compression Bonded Encapsulation
- Low V_{TM}
- Lifetime Guarantee

Applications:
- Phase control
- Power supplies
- Motor control
- Light dimmers

Voltage

Blocking State Maximums (T_J = 125°C) ②	Symbol *	2N1909	2N1910 2N1792	2N1911 2N1793	2N1912 2N1794	2N1913 2N1795	2N1914 2N1796	2N1915 2N1797	2N1916 2N1798	2N1805 2N1799	2N1806 2N1800
Repetitive peak forward blocking voltage, V	V_{DRM}	25	50	100	150	200	250	300	400	500	600
Repetitive peak reverse voltage, V	V_{RRM}	25	50	100	150	200	250	300	400	500	600
Non-repetitive transient peak reverse voltage, t ≤ 5.0 msec, V	V_{RSM}	35	75	150	225	300	350	400	500	600	700
Forward leakage current, mA peak	I_{DRM}	20	20	20	20	18	16	14	12	10	10
Reverse leakage current, mA peak	I_{RRM}	20	20	20	20	18	16	14	12	10	10

Note: For better ratings & higher voltages, see T500 series.

Current

Conducting State Maximums (T_J = 125°C)	Symbol	
RMS forward current, A	$I_{T(rms)}$	110
Ave. forward current, A	$I_{T(av)}$	70
One-half cycle surge current③, A	I_{TSM}	1000
I^2t for fusing (for times ≥ 8.3 ms) A^2 sec.	I^2t.	4000
Forward voltage drop at I_{TM}=500A and T_J = 25°C, V	V_{TM}	2.3

Switching

(T_J = 25°C)	Symbol	
Typical turn-off time, I_T = 50A T_J = 125°C, di_R/dt = 5 A/μsec, reapplied dv/dt = 20V/μsec linear to 0.8 V_{DRM}, μ sec	tq	100
Typ. turn-on-time, I_T = 100A V_D = 100V④, μsec	t_{on}	4
Min. critical dv/dt, exponential to V_{DRM} T_J = 125°C, V/μsec②⑤	dv/dt	300
Min. di/dt① non-repetitive, JEDEC, A/μsec ①④⑥	di/dt	800

Gate

Maximum Parameters (T_J = 25°C)	Symbol	
Gate current to trigger at V_D = 12V, mA	I_{GT}	70
Gate voltage to trigger at V_D = 12V, V	V_{GT}	3
Non-triggering gate voltage, T_J = 125°C, and rated V_{DRM}, V	V_{GDM}	.25
Peak forward gate current, A	I_{GTM}	4
Peak reverse gate voltage, V	V_{GRM}	5
Peak gate power, Watts	P_{GM}	16
Average gate power, Watts	$P_{G(av)}$	3

Thermal and Mechanical

	Symbol	
Min., Max. oper. junction temp., °C	T_J	−40 to + 125
Min., Max. storage temp., °C	Tstg	−40 to + 150
Max. mounting torque, in lb.①		130
Max. Thermal resistance① Junction to case, °C/Watt	$R_{\theta JC}$	.40
Case to sink, lubricated °C/Watt	$R_{\theta CS}$	.12

① Consult recommended mounting procedures.
② Applies for zero or negative gate bias.
③ Per JEDEC RS-397, 5.2.2.1.
④ With recommended gate drive.
⑤ Higher dv/dt ratings available, consult factory.
⑥ Per JEDEC standard RS-397, 5.2.2.6.

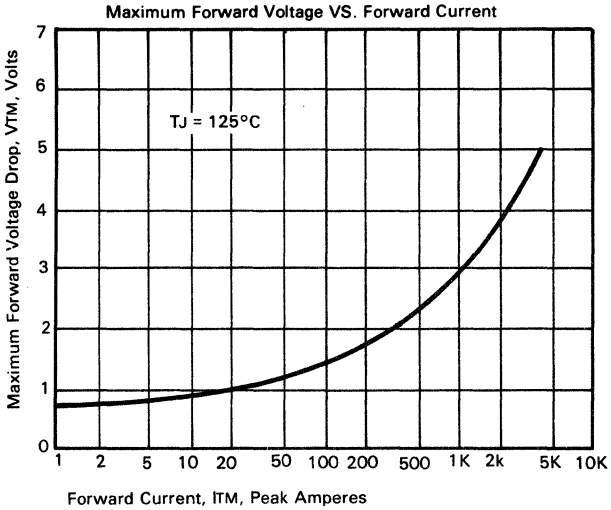
*2N1909 Series in TO-49 PKG
2N1792 Series in TO-83 PKG

70 A Avg.
Up to 600 Volts

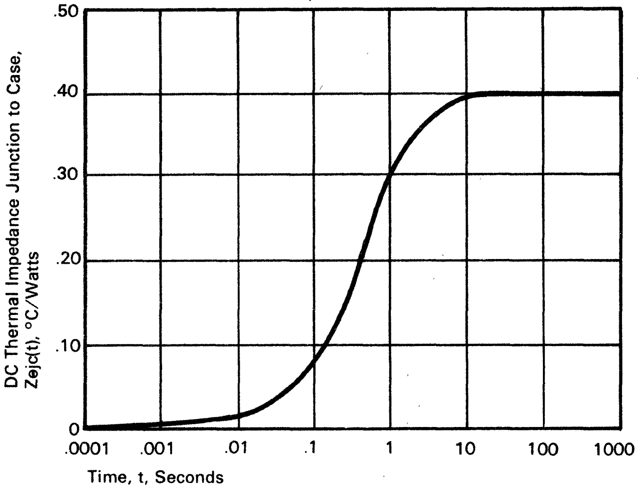
Phase Control SCR 2N1909/2N1792 Series

THYRISTOR

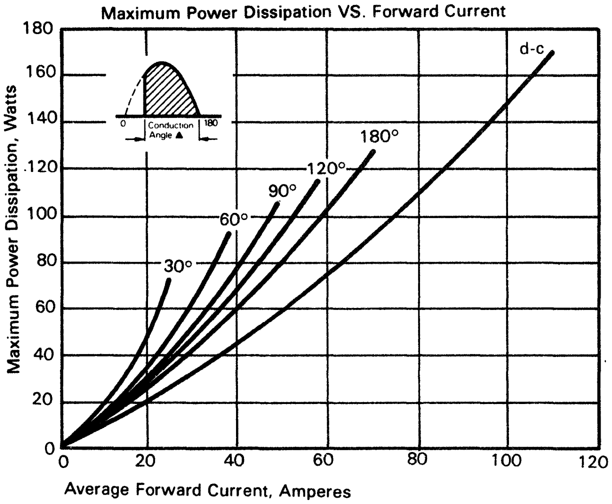
Maximum Forward Voltage VS. Forward Current



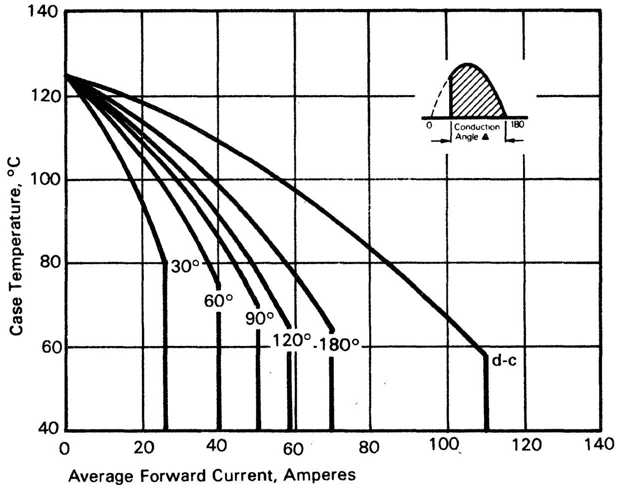
Transient Thermal Impedance VS. Time



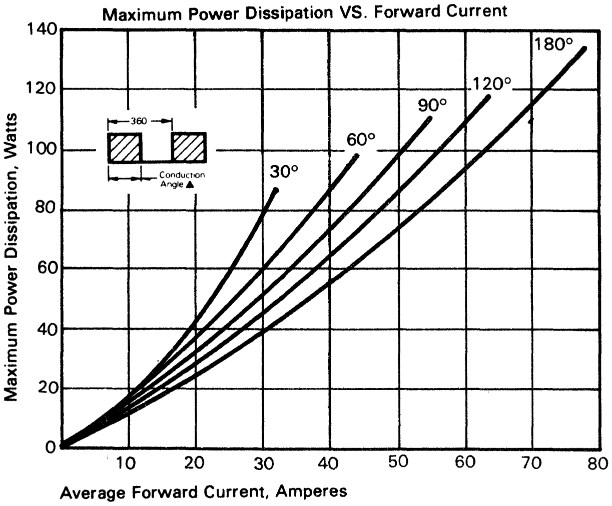
Maximum Power Dissipation VS. Forward Current



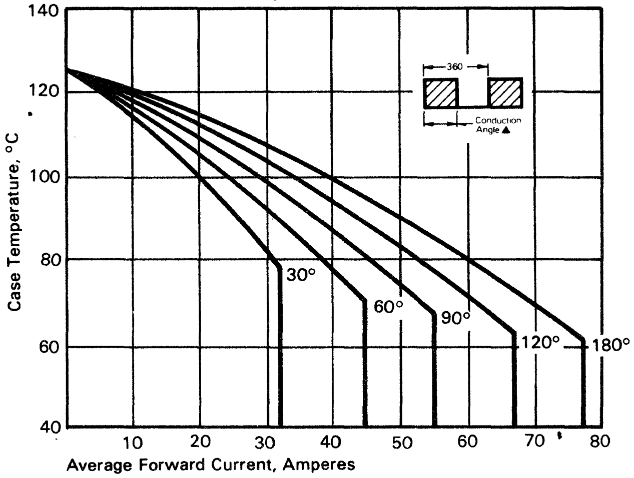
Maximum Case Temperature VS. Forward Current



Maximum Power Dissipation VS. Forward Current

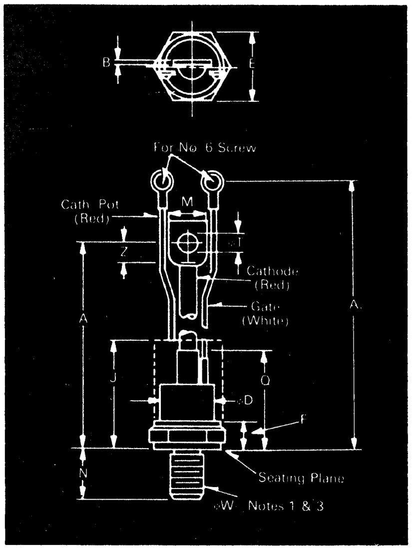


Maximum Case Temperature VS. Forward Current



Phase Control SCR 2N4361/2N4371 Series

70 A Avg. Up to 1400 Volts

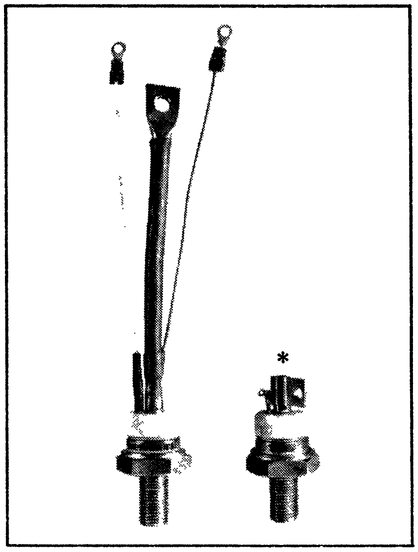


Conforms to TO-94 Outline

Symbol	Inches Min.	Inches Max.	Millimeters Min.	Millimeters Max.
A	5.775	6.265	146.69	159.13
A_1	6.850	7.500	173.99	190.50
B	.055	.075	1.40	1.91
φD	.860	1.000	21.84	25.40
E	1.031	1.063	26.19	27.00
F	.255	.400	6.48	10.16
J	2.50		63.50	
M	.437	.650	11.10	16.51
N	.796	.827	20.24	21.01
Q		1.675		42.55
φT	.260	.291	6.60	7.39
Z	.250		6.35	
φW	½-20 UNF-2A			

Creep & Strike Distance.
.50 in. min. (12.85 mm).
.10 in. min. (2.54 mm). **
(In accordance with NEMA standards.)
Finish—Nickel Plate.
Approx. Weight—5 oz. (142 g).

1. Complete threads to extend to within 2½ threads of seating plane.
2. Angular orientation of terminals is undefined.
3. Pitch diameter of ½-20 UNF-2A (coated) threads (ASA B1.1-1960).
4. Dimension "J" denotes seated height with leads bent at right angles.



* For TO-83 Outline, see page S23.

Features:
- All diffused design
- Low gate current
- Low V_{TM}
- Compression Bonded Encapsulation
- Low Thermal Impedance

Applications:
- Phase control
- Power supplies
- Motor control
- Light dimmers

Voltage

Blocking State Maximums (2) (T_J = 125°C)	Symbol	2N4361** 2N4371	2N4362** 2N4372	2N4363** 2N4373	2N4364** 2N4374	2N4365 2N4375	2N4366 2N4376	2N4367 2N4377	2N4368* 2N4378
Repetitive peak forward blocking voltage, V	V_{DRM}	100	200	400	600	800	1000	1200	1400
Repetive peak reverse voltage, V	V_{RRM}	100	200	400	600	800	1000	1200	1400
Non-repetitive transient peak reverse voltage, t≤5 msec, V	V_{RSM}	200	300	500	700	950	1200	1450	1700
Forward leakage current, mA peak	I_{DRM}	← 10 →							
Reverse leakage current, mA peak	I_{RRM}	← 10 →							

Current

Conducting State Maximums (T_J = 125°C)	Symbol	
RMS forward current, A	$I_{T(rms)}$	110
Ave. forward current, A	$I_{T(av)}$	70
One-half cycle surge current, A (3)	I_{TSM}	1600
3 cycle surge current, A (3)	I_{TSM}	1250
10 cycle surge current, A (3)	I_{TSM}	1080
I^2t for fusing (for times 8.3 ms) A^2sec	I^2t	10,700
Forward voltage drop at I_{TM} = 500A and T_J = 25°C, V	I_{TM}	2.5

Thermal and Mechanical

	Symbol	
Min., Max. oper. junction temp., °C	T_J	−40 to +125
Min., Max. storage temp., °C	T_{stg}	−40 to +150
Max. mounting torque, (1) in lb.		130
Max. Thermal resistance (1) Junction to case, °C/Watt	$R_{\theta JC}$	.28
Case to sink, lubricated °C/Watt	$R_{\theta CS}$	.12

Switching

(T_J = 25°C)	Symbol	
Typical turn-off time, I_T = 50A T_J = 125°C, di_R/dt = 5 A/μsec, reapplied dv/dt = 20V/μsec linear to 0.8 V_{DRM}, μsec	tq	100
Typ. turn-on-time, I_T = 100A V_D = 100V, μsec	ton	4
Min critical dv dt exponential to V_{DRM} T 125 C, V μsec (5)	dv/dt	100
Min di dt non repetitive A μsec	di/dt	800

(1) (4) (6)

Gate

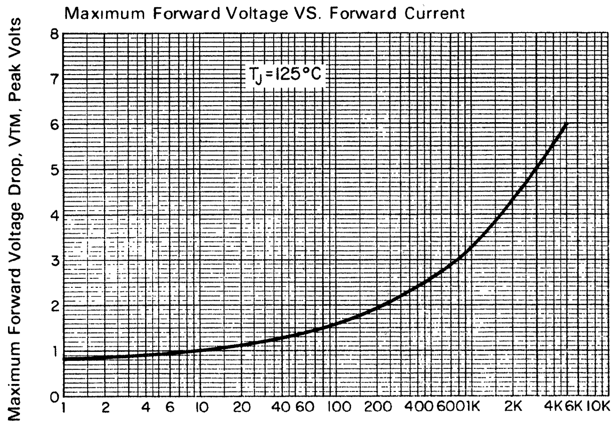
Maximum Parameters (T_J 25 C)	Symbol	
Gate current to trigger at V_D 12V mA	IGT	250
Gate voltage to trigger at V_D 12V V	VGT	3
Non-triggering gate voltage. T_J 125 C, and rated V_{DRM}, V	VGDM	0 15
Peak forward gate current, A	IGTM	4
Peak reverse gate voltage, V	VGRM	5
Peak gate power, Watts	PGM	15
Average gate power, Watts	PG(av)	3

(1) Consult recommended mounting procedures.
(2) Applies for zero or negative gate bias.
(3) Per JEDEC RS-397, 5.2.2.1.
(4) With recommended gate drive.
(5) Higher dv/dt ratings available, consult factory.
(6) Per JEDEC standard RS-397, 5.2.2.6.
*2N4361 Series in TO-94 PKG.
2N4371 Series in TO-83 PKG.
**Glass-to-metal seal package.

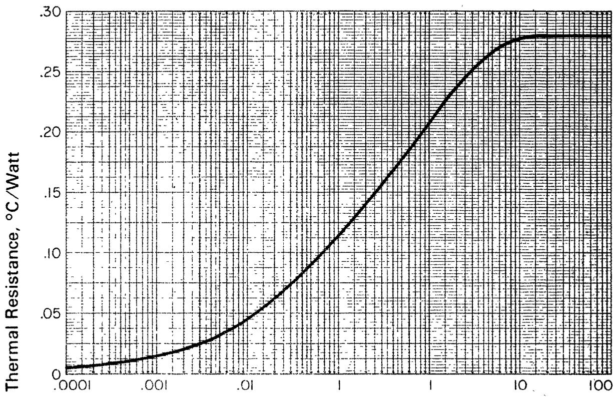
70 A Avg. Up to 1400 Volts

Phase Control SCR 2N4361/2N4371 Series

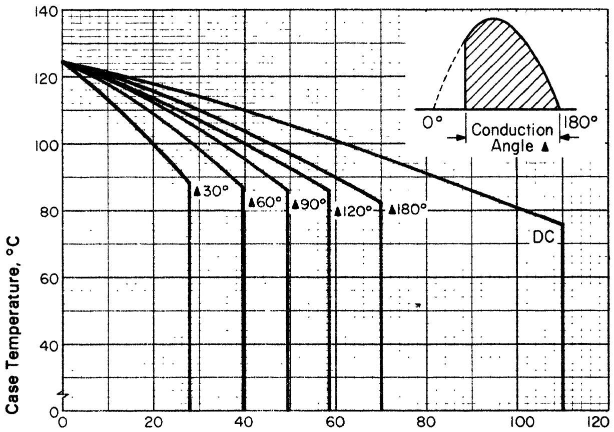
Maximum Forward Voltage VS. Forward Current



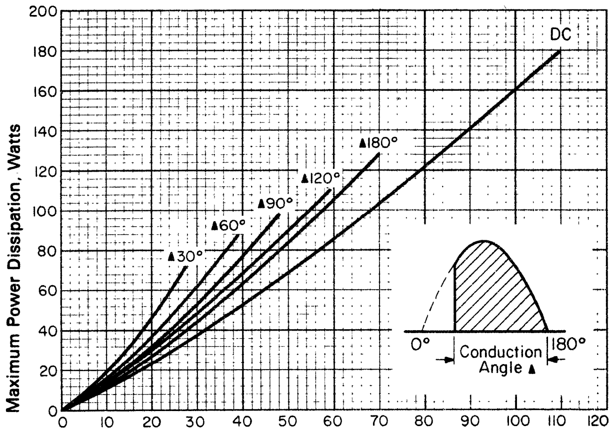
Transient Thermal Impedance VS. Time



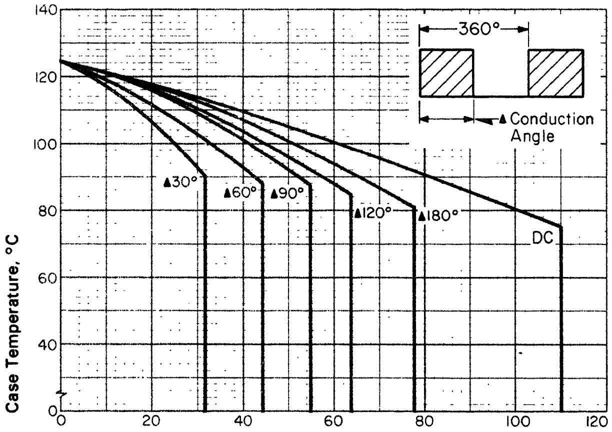
Maximum Case Temperature VS. Forward Current



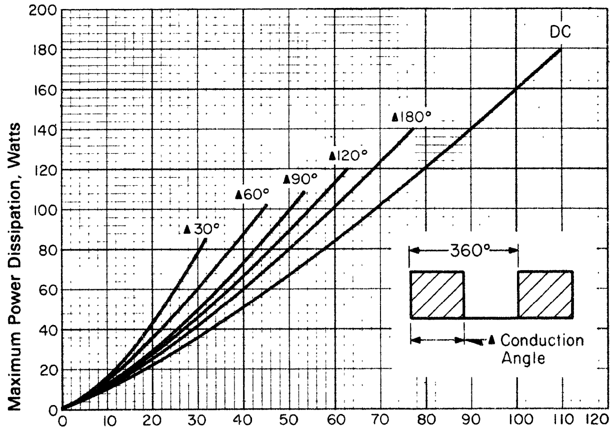
Maximum Power Dissipation VS. Forward Current



Maximum Case Temperature VS. Forward Current



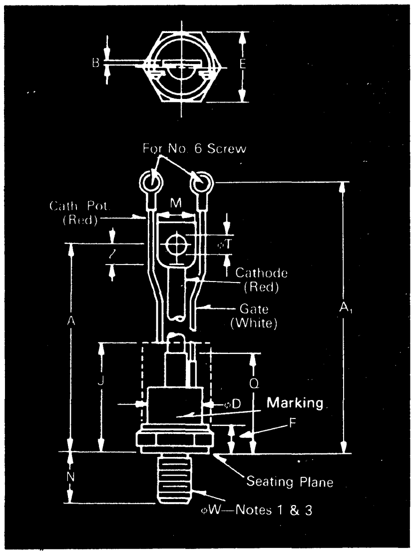
Maximum Power Dissipation VS. Forward Current



THYRISTOR

Phase Control SCR T500

40-80 A Avg Up to 1500 Volts

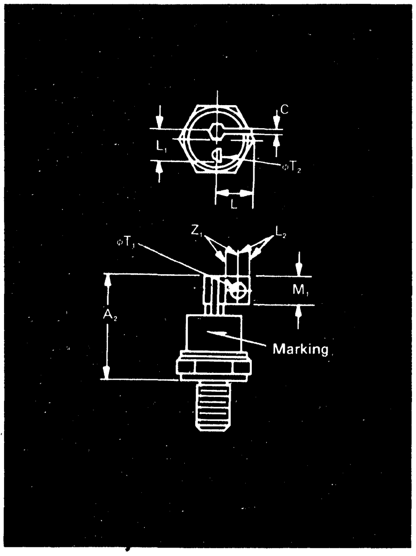


Conforms to TO-94 Outline

Symbol	Inches Min.	Inches Max.	Millimeters Min.	Millimeters Max.
A	5.775	6.265	146.69	159.13
A_1	6.850	7.500	173.99	190.50
B	.055	.075	1.40	1.91
ϕD	.860	1.000	21.84	25.40
E	1.031	1.063	26.19	27.00
F	.255	.400	6.48	10.16
J	2.50		63.50	
M	.437	.650	11.10	16.51
N	.796	.827	20.24	21.01
Q		1.675		42.55
ϕT	.260	.291	6.60	7.39
Z	.250		6.35	
ϕW	½-20 UNF-2A			

Creep & Strike Distance.
T500—.50 in. min. (12.85 mm).
(In accordance with NEMA standards.)
Finish—Nickel Plate.
Approx. Weight—5 oz. (142 g).

1. Complete threads to extend to within 2½ threads of seating plane.
2. Angular orientation of terminals is undefined.
3. Pitch diameter of ½-20 UNF-2A (coated) threads (ASA B1.1-1960).
4. Dimension "J" denotes seated height with leads bent at right angles.

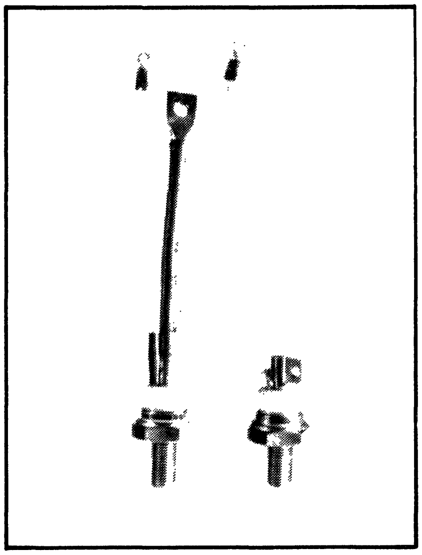


Conforms to TO-83 Outline

Symbol	Inches Min.	Inches Max.	Millimeters Min.	Millimeters Max.
A_2		1.810		45.97
C	.070	.110	1.78	2.79
L		.650		16.51
L_1	.420	.520	10.67	13.21
L_2	.180		4.57	
M_1	.360	.470	9.14	11.94
ϕT_1	.190	.235	4.83	5.97
ϕT_2	.060	.080	1.52	2.03
Z_1	.180		4.57	
ϕW	½-20 UNF-2A			

Approx. Weight—4 oz. (114 g).

1. Basic dimensions of TO-94 and TO-83 are same except as noted.



Features:

- Center fired, di/namic gate
- All diffused design
- Low VTM
- Compression Bonded Encapsulation
- Low Thermal Impedance
- High Surge Current Capability
- Low gate current
- Lifetime Guarantee

Applications:

- Phase control • Motor control
- Power supplies • Light dimmers

Ordering Information

Type	Voltage*		Current		Turn-off		Gate Current		Leads	
Code	VDRM and VRRM (V)	**Code**	IT(av) (A)	**Code**	tq μsec	**Code**	IGT (ma)	**Code**	Case	**Code**
	700	**07**	40	**40**	100	0			TO-94	**AQ**
T500	800	**08**			(typ)		100	**5**		
	900	**09**					150	**4**		
	1000	**10**	80	**80**			**		TO-83	**AA**
	1100	**11**								
	1200	**12**								
	1300	**13**								
	1400	**14**								
	1500	**15**								

* for 600 volts and below, see T510
**For lower I GT consult factory.

Example
Obtain optimum device performance for your application by selecting proper Order Code.

Type T500 rated at 80A average with VDRM =1000 volts IGT=150 ma, and standard flexible lead order as:

Type				Voltage		Current		Turn-Off	Gate Current	Leads	
T	5	0	0	1	0	8	0	0	4	A	Q

40-80 A Avg.
Up to 1500 Volts

Phase Control SCR T500

Voltage

Blocking State Maximums ② (T_J=125°C)	Symbol									
Repetitive peak forward blocking voltage, V	V_{DRM}	700	800	900	1000	1100	1200	1300	1400	1500
Repetitive peak reverse voltage, V	V_{RRM}	700	800	900	1000	1100	1200	1300	1400	1500
Non-repetitive transient peak reverse voltage, t<5.0 msec, V	V_{RSM}	850	950	1100	1200	1300	1450	1550	1700	1800
Forward leakage current, mA peak	I_{DRM}	← 10 →								
Reverse leakage current, mA peak	I_{RRM}	← 10 →								

Current

Conducting State Maximums (T_J=125°C)	Symbol	T500_ _40	T500_ _80
RMS forward current, A	$I_{T(rms)}$	63	125
Ave. forward current, A	$I_{T(av)}$	40	80
One-half cycle surge current③, A	I_{TSM}	1200	1800
3 cycle surge current③, A	I_{TSM}	950	1300
10 cycle surge current③, A	I_{TSM}	800	1170
I^2t for fusing (for times≥8.3 ms) A^2 sec	I^2t	6000	13,500
Forward voltage drop at I_{TM}=500A and T_J=25°C, V	V_{TM}	3.7	2.2

Switching

(T_J=25°C)	Symbol	
Typical turn-off time, I_T=50A T_J=125°C, di_R/dt=5 A/μsec, reapplied dv/dt=20V/μsec linear to 0.8 V_{DRM}, μsec	t_q	100
Typ. turn-on-time, I_T=100A V_D=100V④, μsec	t_{on}	4
Min. critical dv/dt, exponential to V_{DRM} T_J=125°C, V/μsec②⑤	dv/dt	300
Min. di/dt non-repetitive①④⑥ A/μsec	di/dt	800

Thermal and Mechanical

	Symbol	
Min., Max. oper. junction temp., °C	T_J	−40 to +125
Min., Max. storage temp., °C	T_{stg}	−40 to +150
Max. mounting torque, in lb.①		130
Thermal resistance① Junction to case, °C/Watt	$R_{\Theta JC}$	.28
Case to sink, lubricated °C/Watt	$R_{\Theta CS}$	.12

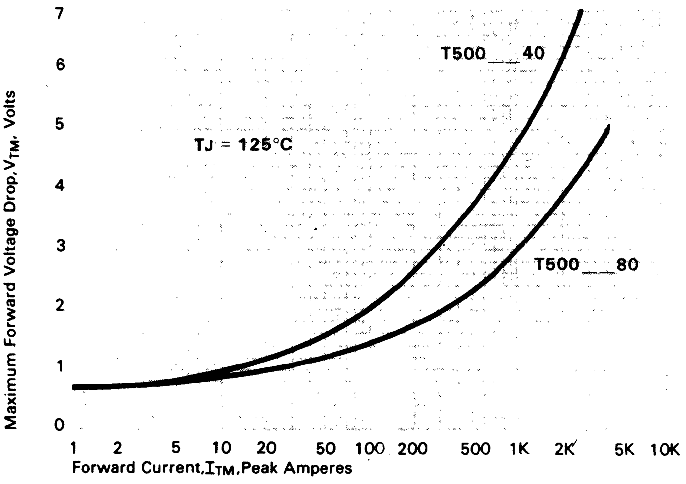
Gate

Maximum Parameters (T_J=25°C)	Symbol	
Gate current to trigger at V_D =12V, mA	I_{GT}	See Ordering Info.
Gate voltage to trigger at V_D =12V, V	V_{GT}	3
Non-triggering gate voltage, T_J =125°C, and rated V_{DRM}, V	V_{GDM}	0.15
Peak forward gate current, A	I_{GTM}	4
Peak reverse gate voltage, V	V_{GRM}	5
Peak gate power, Watts	P_{GM}	16
Average gate power, Watts	$P_{G(av)}$	3

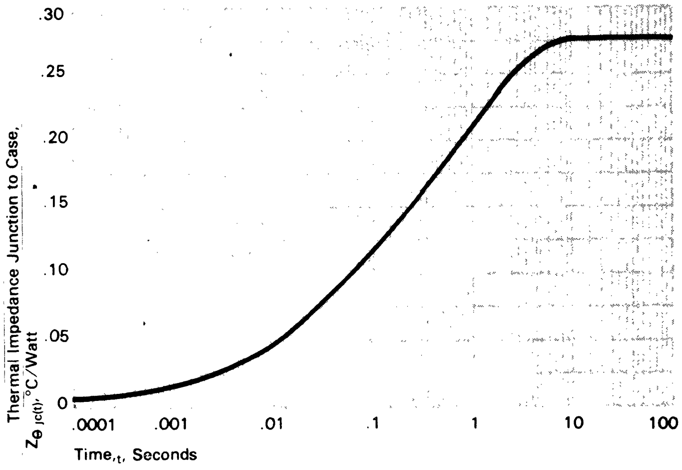
① Consult recommended mounting procedures.
② Applies for zero or negative gate bias.
③ Per JEDEC RS-397, 5.2.2.1.
④ With recommended gate drive.
⑤ Higher dv/dt ratings available, consult factory.
⑥ Per JEDEC STD RS-397, 5.2.2.6.

THYRISTOR

Maximum Forward Voltage VS. Forward Current



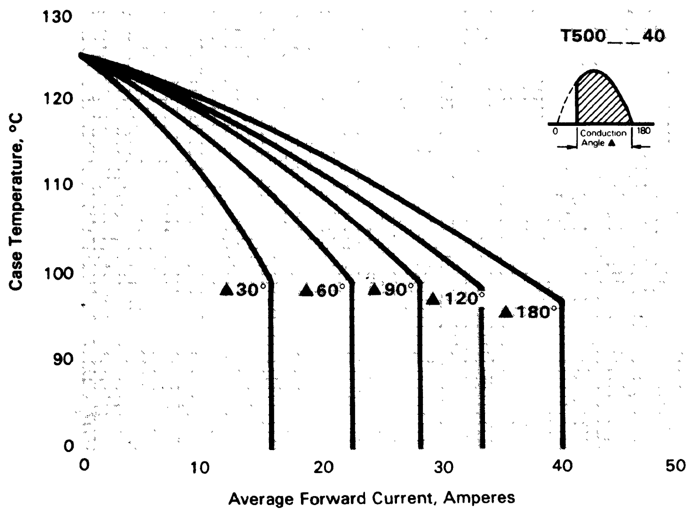
Transient Thermal Impedance VS. Time



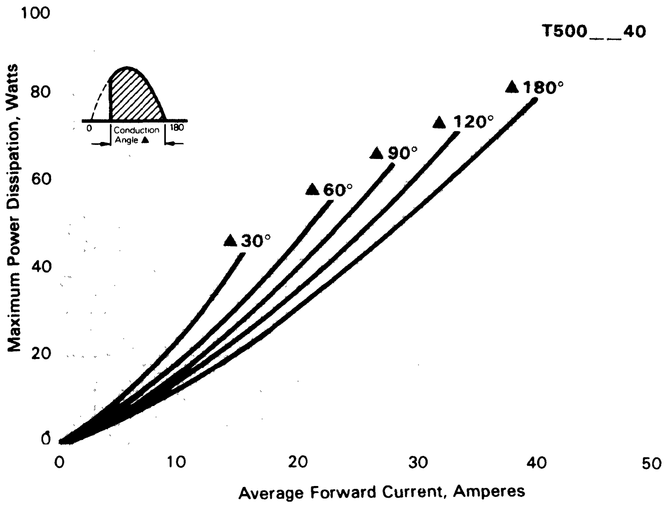
Phase Control SCR T500

40-80 A Avg. Up to 1500 Volts

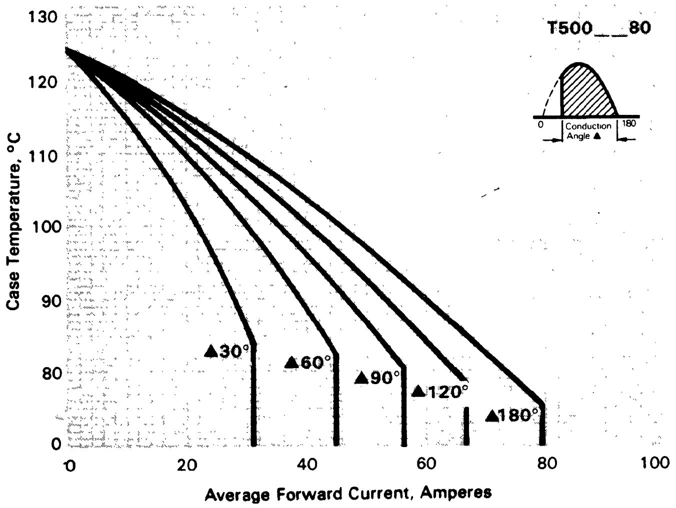
Maximum Case Temperature VS. Forward Current



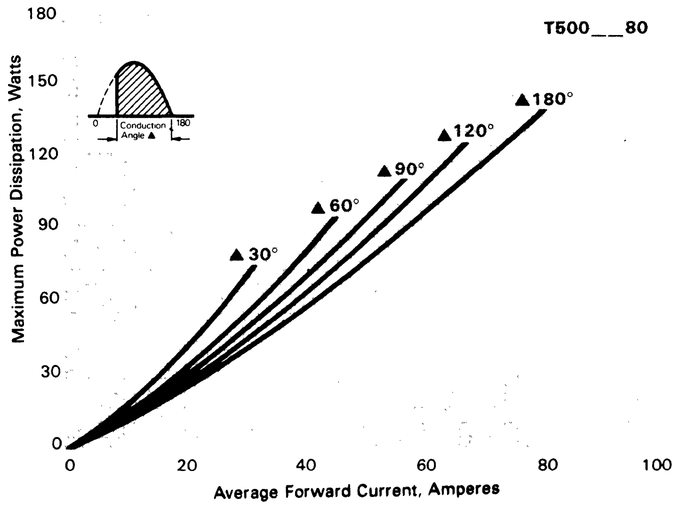
Maximum Power Dissipation VS. Forward Current



Maximum Case Temperature VS. Forward Current



Maximum Power Dissipation VS. Forward Current

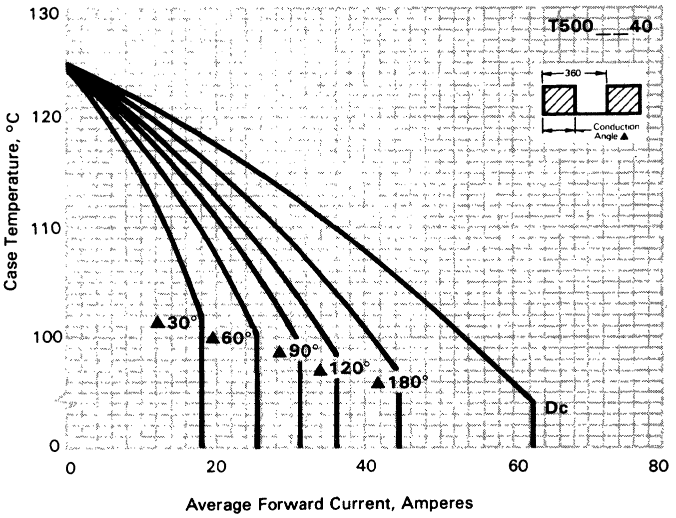


THYRISTOR

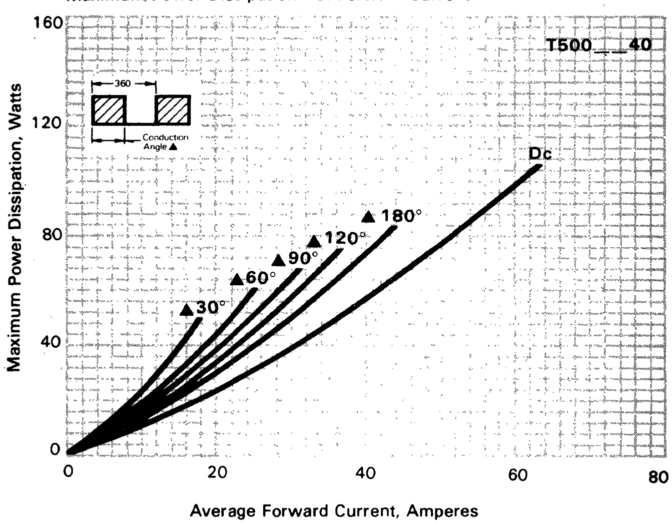
40-80 A Avg
Up to 1500 Volts

Phase Control
SCR
T500

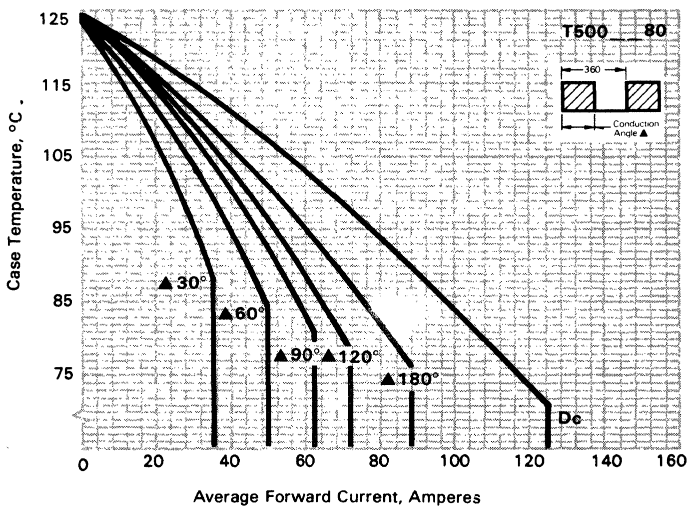
Maximum Case Temperature VS. Forward Current



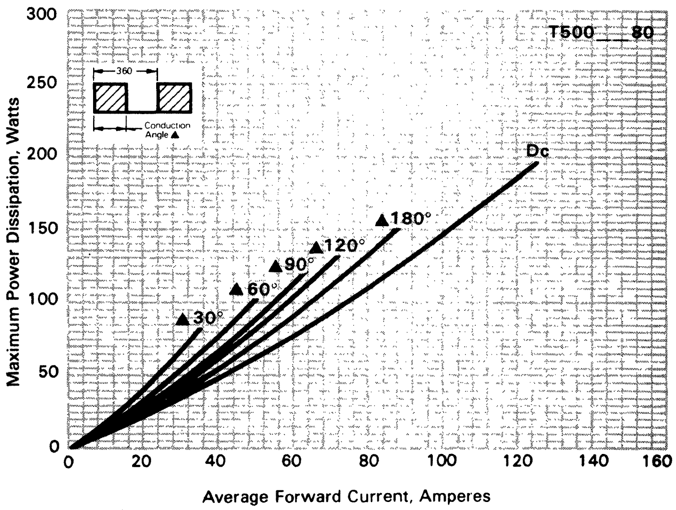
Maximum Power Dissipation VS. Forward Current



Maximum Case Temperature VS. Forward Current



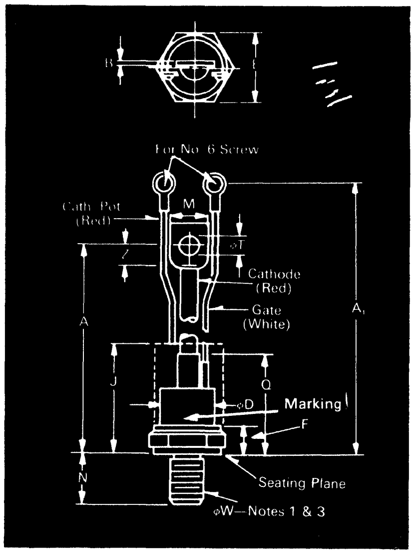
Maximum Power Dissipation Vs. Forward Current



THYRISTOR

Phase Control SCR T510

50-80A Avg. Up to 600 Volts

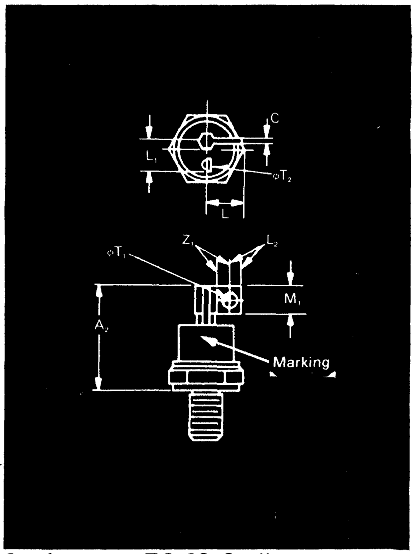


Conforms to TO-94 Outline

Symbol	Inches Min.	Inches Max.	Millimeters Min.	Millimeters Max.
A	5.775	6.265	146.69	159.13
A_1	6.850	7.500	173.99	190.50
B	.055	.075	1.40	1.91
ϕD	.860	1.000	21.84	25.40
E	1.031	1.063	26.19	27.00
F	.255	.400	6.48	10.16
J	2.50		63.50	
M	.437	.650	11.10	16.51
N	.796	.827	20.24	21.01
Q		1.675		42.55
ϕT	.260	.291	6.60	7.39
Z	.250		6.35	
ϕW	½-20 UNF-2A			

Creep & Strike Distance.
T500—.50 in. min. (12.85 mm).
T510—.10 in. min. (2.54 mm).
(In accordance with NEMA standards.)
Finish—Nickel Plate.
Approx. Weight—5 oz. (142 g).

1. Complete threads to extend to within 2½ threads of seating plane.
2. Angular orientation of terminals is undefined.
3. Pitch diameter of ½-20 UNF-2A (coated) threads (ASA B1.1-1960).
4. Dimension "J" denotes seated height with leads bent at right angles.

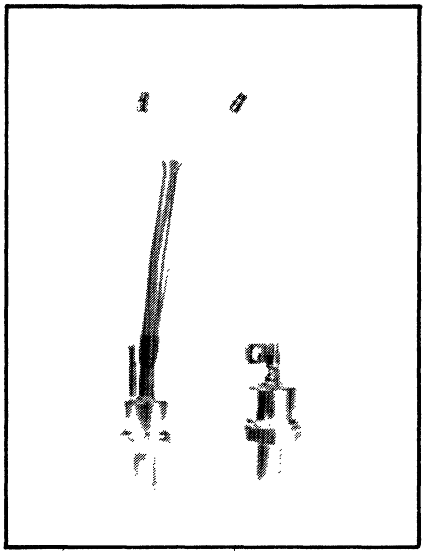


Conforms to TO-93 Outline

Symbol	Inches Min.	Inches Max.	Millimeters Min.	Millimeters Max.
A_2		1.810		45.97
C	.070	.110	1.78	2.79
L		.650		16.51
L_1	.420	.520	10.67	13.21
L_2	.180		4.57	
M_1	.360	.470	9.14	11.94
ϕT_1	.190	.235	4.83	5.97
ϕT_2	.060	.080	1.52	2.03
Z_1	.180		4.57	
ϕW	½-20 UNF-2A			

Approx. Weight—4 oz. (114 g).

1. Basic dimensions of TO-94 and TO-83 are same except as noted.



Features:
- Center fired di/namic gate
- All diffused design
- Low VTM
- Compression Bonded Encapsulation
- Hermetic glass to metal seal
- Low gate current
- Lifetime Guarantee

Applications:
- Phase control
- Power supplies
- Light dimmers
- Motor control

Ordering Information

Type	Voltage		Current		Turn-off		Gate current		Leads	
Code	V_{DRM} and V_{RRM} (V) *	Code	$I_{T\ (av)}$ (A)	Code	tq μsec	Code	I_{GT} (ma)	Code	Case	Code
	50	00	50	50	50 (typical)	0	70	7	TO-94	AQ
T510	100	01					100	5		
	200	02					150	4		
	300	03	80	80					TO-83	AB
	400	04								
	500	05								
	600	06								

*for 700 volts and above see T500

Example
Obtain optimum device performance for your application by selecting proper Order Code.

Type T510 rated at 80A average with V_{DRM} = 300 volts I_{GT} = 70ma, and standard flexible lead order as:

Type				Voltage		Current		Turn-Off	Gate Current	Leads	
T	5	1	0	0	3	8	0	0	7	A	Q

THYRISTOR

50-80A Avg.
Up to 600 Volts

Phase Control SCR T510

Voltage

Blocking State Maximums ② (T_J = 125°C)	Symbol							
Repetitive peak forward blocking voltage, V	V_{DRM}	50	100	200	300	400	500	600
Repetitive peak reverse voltage, V	V_{RRM}	50	100	200	300	400	500	600
Non-repetitive transient peak reverse voltage, $t \leq 5.0$ msec, V	V_{RSM}	100	200	300	400	500	600	700
Forward leakagecurrent, mA peak	I_{DRM}	←			10			→
Reverse leakage current, mA peak	I_{RRM}	←			10			→

Current

Conducting State Maximums (T_J = 125°C)	Symbol	T510 — — 50	T510 — — 80
RMS forward current, A	$I_{T(rms)}$	80	125
Ave. forward current, A	$I_{T(av)}$	50	80
One-half cycle surge current③, A	I_{TSM}	1200	1600
3 cycle surge current③, A	I_{TSM}	950	1250
10 cycle surge current③, A	I_{TSM}	800	1080
I^2t for fusing (for times ≥ 8.3 ms) A^2 sec.	I^2t.	6000	10,700
Forward voltage drop at I_{TM} = 500A and T_J = 25°C, V	V_{TM}	2.6	1.8

Switching

(T_J = 25°C)	Symbol	
Typical turn-off time, I_T = 50A T_J = 125°C, di_R/dt = 5 A/μsec, reapplied dv/dt = 20V/μsec linear to 0.8 V_{DRM}, μ sec	tq	100
Typ. turn-on-time, I_T = 100A V_D = 100V④, μsec	t_{on}	4
Min. critical dv/dt, exponential to V_{DRM} T_J = 125°C, V/μsec②⑤	dv/dt	300
Min. di/dt non-repetitive. A/μsec ①④⑥	di/dt	100

Gate

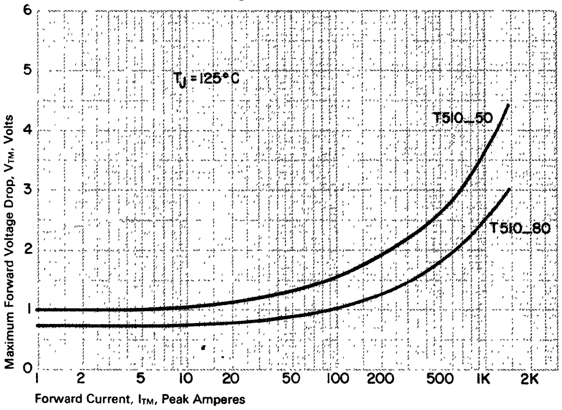
Maximum Parameters (T_J = 25°C)	Symbol	
Gate current to trigger at V_D = 12V, mA	I_{GT}	See Ordering Info.
Gate voltage to trigger at V_D = 12V, V	V_{GT}	3
Non-triggering gate voltage, T_J = 125°C, and rated V_{DRM}, V	V_{GDM}	0.15
Peak forward gate current, A	I_{GTM}	4
Peak reverse gate voltage, V	V_{GRM}	5
Peak gate power, Watts	P_{GM}	16
Average gate power, Watts	$P_{G(av)}$	3

Thermal and Mechanical

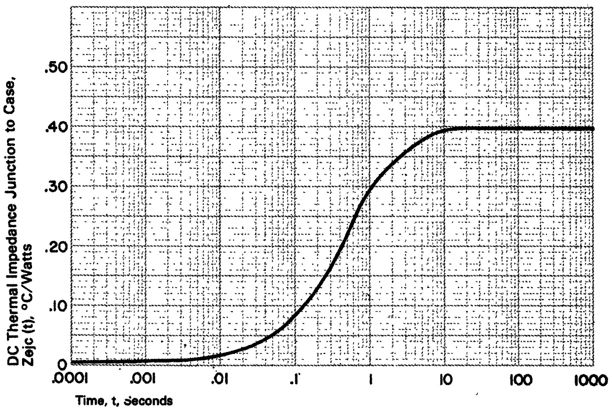
	Symbol	
Min., Max. oper. junction temp., °C	T_J	−40 to + 125
Min., Max. storage temp., °C	Tstg	−40 to + 150
Max. mounting torque, in lb.①		130
Max. Thermal resistance①		
Junction to case, °C/Watt	$R_{\theta JC}$	.40
Case to sink, lubricated °C/Watt	$R_{\theta CS}$	.12

① Applies for zero or negative gate bias.
② Consult recommended mounting procedures.
③ Per JEDEC RS—397, 5.2.2.1.
④ With recommended gate drive.
⑤ Higher dv/dt ratings available, consult factory.
⑥ Per JEDEC standard RS-397, 5.2.2.6.

Maximum Forward Voltage VS. Forward Current



Transient Thermal Impedance VS. Time

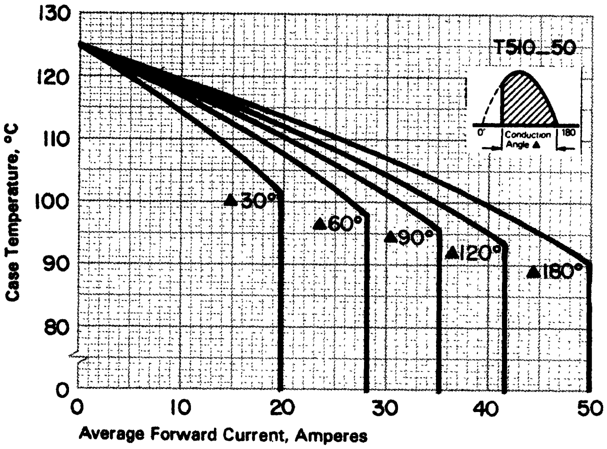


THYRISTOR

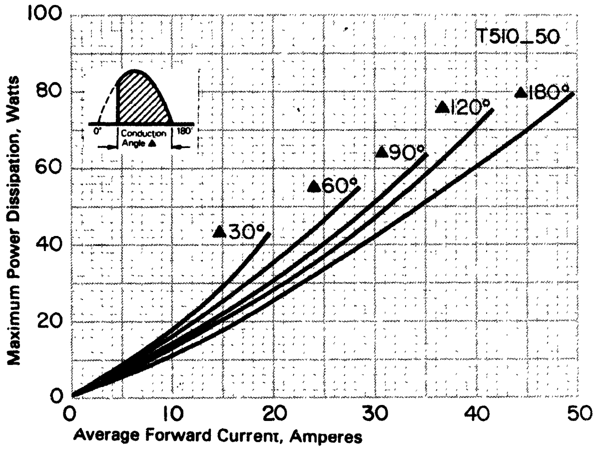
Phase Control SCR T510

50-80A Avg.
Up to 600 Volts

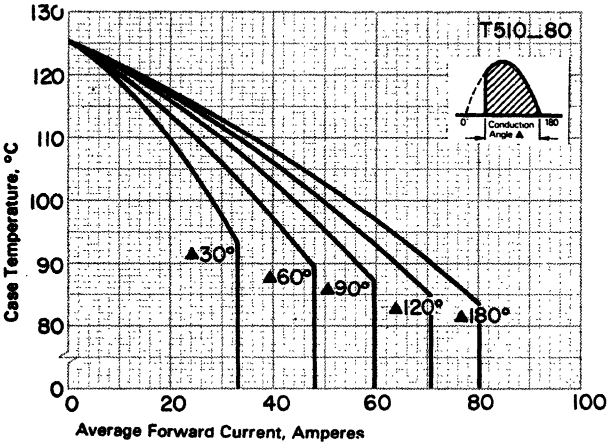
Maximum Case Temperature VS. Forward Current



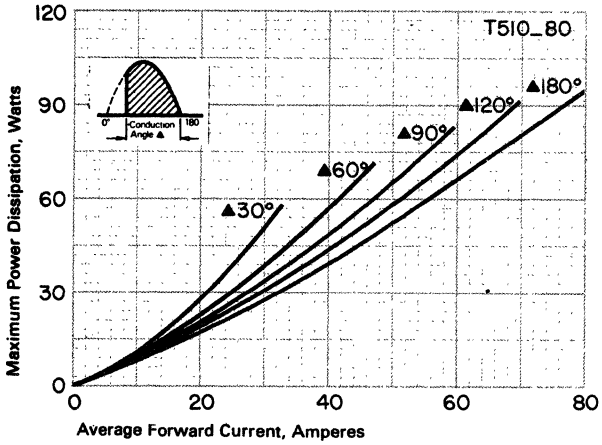
Maximum Power Dissipation VS. Forward Current



Maximum Case Temperature VS. Forward Current

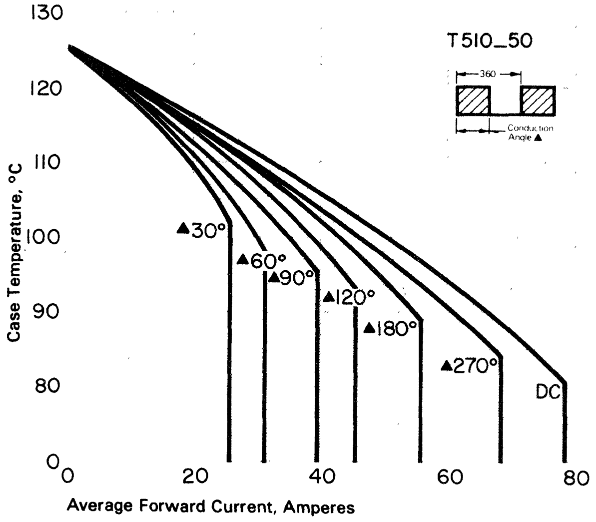


Maximum Power Dissipation VS. Forward Current

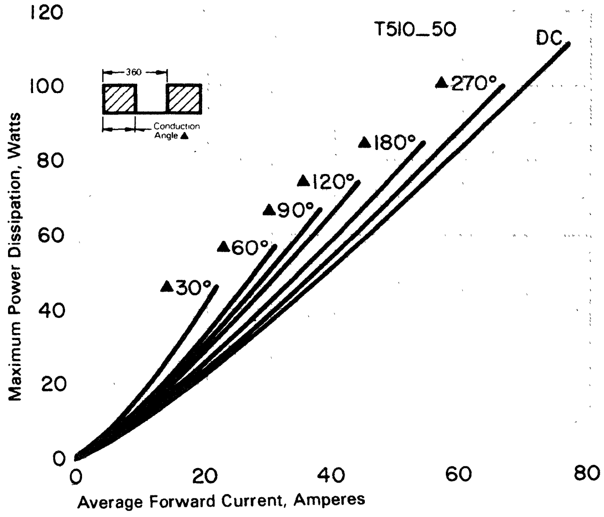


THYRISTOR

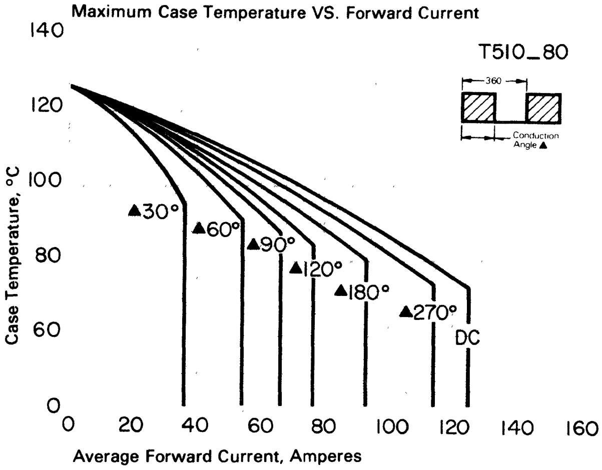
Maximum Case Temperature VS. Forward Current



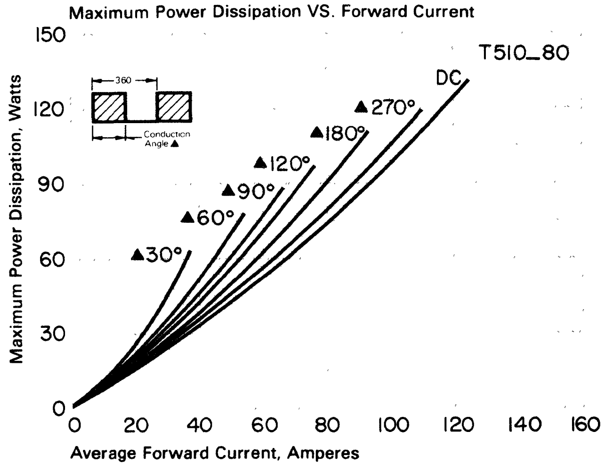
Maximum Power Dissipation VS. Forward Current



Maximum Case Temperature VS. Forward Current



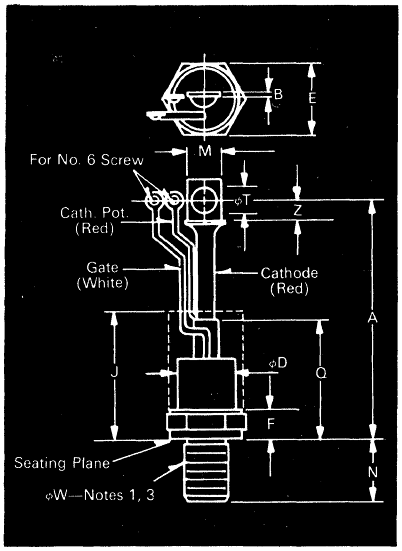
Maximum Power Dissipation VS. Forward Current



THYRISTOR

Phase Control SCR 2N3884 Series

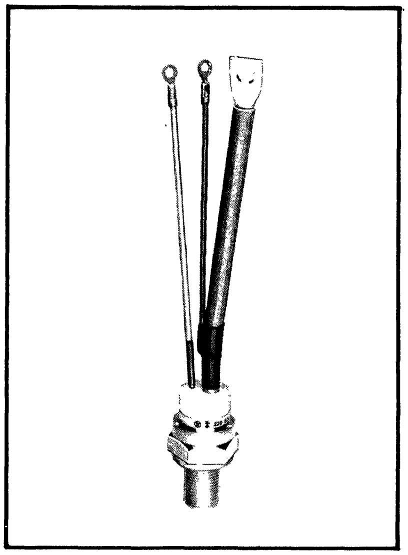
175 A. Avg. Up to 1200 Volts



Symbol	Inches Min.	Inches Max.	Millimeters Min.	Millimeters Max.
A	7.750	8.100	196.85	205.74
A_1	7.750	8.100	196.85	205.74
B	.063	.172	1.60	4.37
ϕD	.980	1.090	24.89	27.69
E	1.212	1.250	30.78	31.75
F	.250	.630	6.35	16.00
J	3.25		82.55	
M	.530	.755	13.46	19.18
N	1.040	1.077	26.42	27.36
Q		2.250		57.15
ϕT	.260	.290	6.60	7.37
Z	.340		8.64	
ϕW	¾-16 UNF-2A			

Creep & Strike Distance:
.69 in. min. (17.60 mm).
(In accordance with NEMA standards.)
Finish—Nickel Plate.
Approx. Weight—8 oz. (227 g).

1. Complete threads to extend to within 2½ threads of seating plane.
2. Angular orientation of terminals is undefined.
3. Pitch diameter of ¾-16 UNF-2A (coated) threads (ASA B1.1—1960).
4. Dimension "J" denotes seated height with leads bent at right angles.



Features:
- Center fired di/namic gate
- All diffused design
- Guaranteed dv/dt (300 v/μs)
- Low gate current
- Low VTM
- Low thermal Impedance
- High surge current capability
- Compression Bonded Encapsulation
- Lifetime Guarantee

Applications:
- Phase Control
- Power Supplies
- Motor Control
- Light Dimmers

Voltage

Blocking State Maximums ② (T_J = 125°C)

	Symbol	2N3884	2N3885	2N3886	2N3887	2N3888	2N3889	2N3890	2N3891	2N3892	2N3893	2N3894	2N2895
Repetitive peak forward blocking voltage, V ..	V_{DRM}	50	200	200	300	400	500	600	700	800	900	1000	1200
Repetitive peak reverse voltage, V	V_{RRM}	50	100	200	300	400	500	600	700	800	900	1000	1200
Non-repetitive transient peak reverse voltage, t≤5.0 msec,V	V_{RSM}	150	200	300	400	500	600	720	850	960	1080	1200	1320
Forward leakage current, mA peak	I_{DRM}	← 25 →											
Reverse leakage current, mA peak	I_{RRM}	← 25 →											

Current

Conducting State Maximums (T_J = 125°C)

	Symbol	
RMS forward Current, A	$I_{T(rms)}$	275
Ave. forward current, A	$I_{T(av)}$	175
One-half cycle surge current, A③	I_{TSM}	4500
I^2t for fusing (for times 8.3)A^2 sec	I^2t	84,000
Forward voltage drop at I_{TM} = 625A and T_J = 25°C, V	V_{TM}	1.55

Thermal and Mechanical

	Symbol	
Min., Max. oper, junction temp., °C	T_J	—40 to +125
Min., Max. storage temp.,°C	Tstg	—40 to + 150
Max. mounting torque, in lb.①		360
Max. Thermal resistance ① Junction to case, °C/Watt	$R_{\theta JC}$	.13
Case to sink, lubricated,① °C/Watt	$R_{\theta CS}$	.075

Switching

(T_J = 25°C)	Symbol	
Typical turn-off time, I_T = 150A T_J = 125°C, dirR/dt = 12.5A/μsec, reapplied dv/dt = 20V/μsec linear to 0.8 V_{DRM}, μsec	tq	100
Typ. turn-on-time, I_T = 100A V_D = 100V④, μsec	ton	5
Min. critical dv/dt, exponential to V_{DRM} T_J = 125°C, V/μsec②⑤....	dv/dt	300
Min. di/dt non-repetitive, A/μsec①④⑥............	di/dt	800

Gate

Maximum Parameters

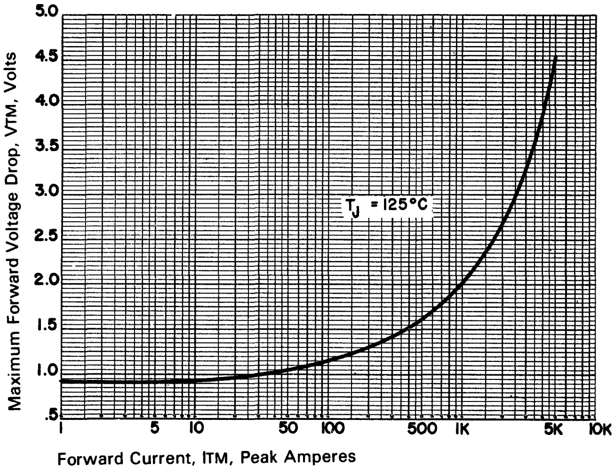
(T_J = 25°C)	Symbol	
Gate current to trigger at V_D = 12V, mA	I_{GT}	150
Gate voltage to trigger at V_D = 12V,V	V_{GT}	3
Non-triggering gate voltage,T_J = 125°C, and rated V_{DRM},V	V_{GDM}	0.15
Peak forward gate current, A	I_{GTM}	4
Peak reverse gate voltage, V......	V_{GRM}	5
Peak gate power, Watts	PGM	15
Average gate power, Watts.......	PG(av)	3

① Consult recommended mounting procedures.
② Applies for zero or negative gate bias.
③ Per JEDEC RS-397, 5.2.2.1.
④ With recommended gate drive.
⑤ Higher dv/dt ratings available, consult factory.
⑥ Per JEDEC standard RS-397, 5.2.2.6.

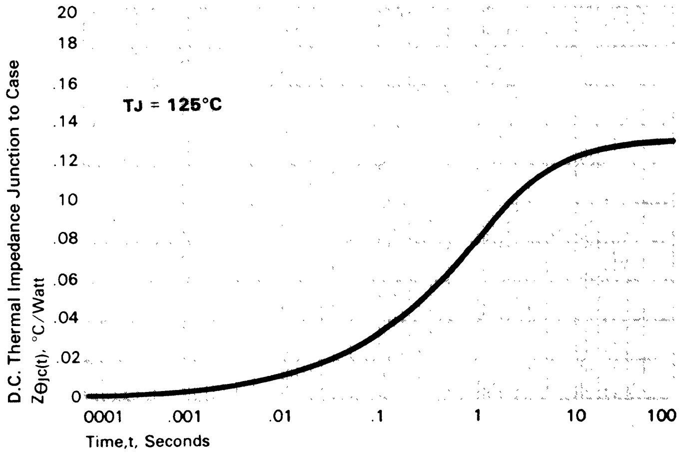
175 A. Avg.
Up to 1200 Volts

Phase Control SCR 2N3884 Series

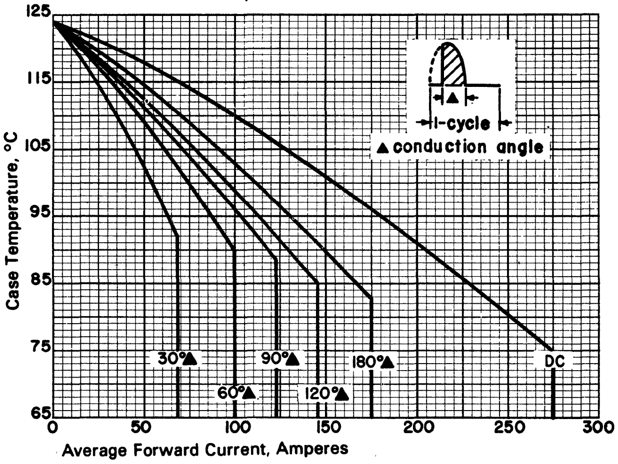
Maximum Forward Voltage VS. Forward Current



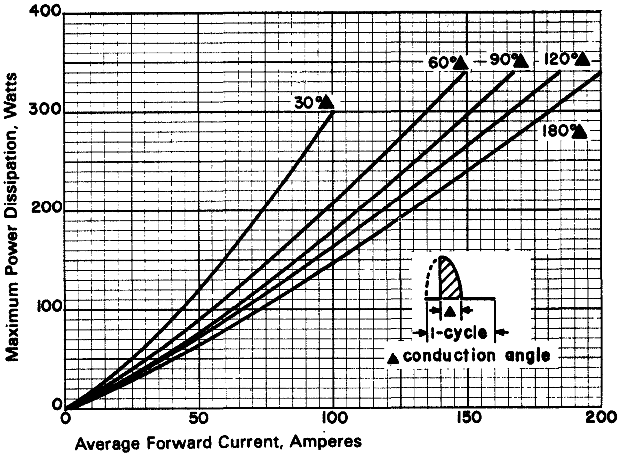
Transient Thermal Impedance VS. Time



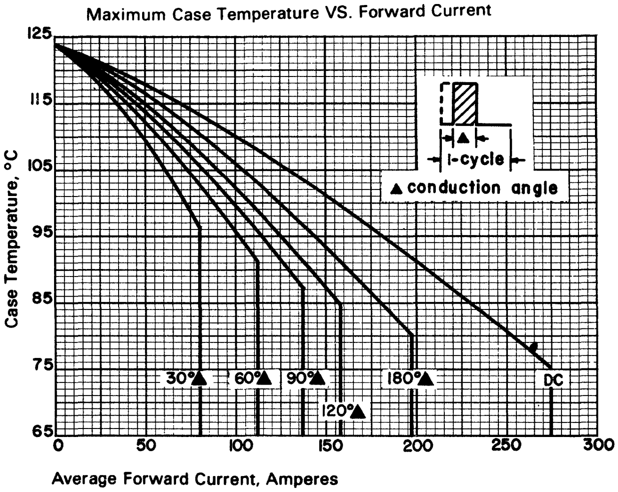
Maximum Case Temperature VS. Forward Current



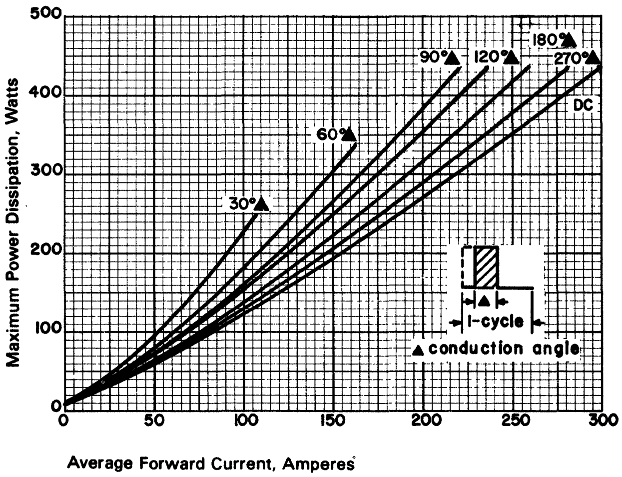
Maximum Power Dissipation VS. Forward Current



Maximum Case Temperature VS. Forward Current

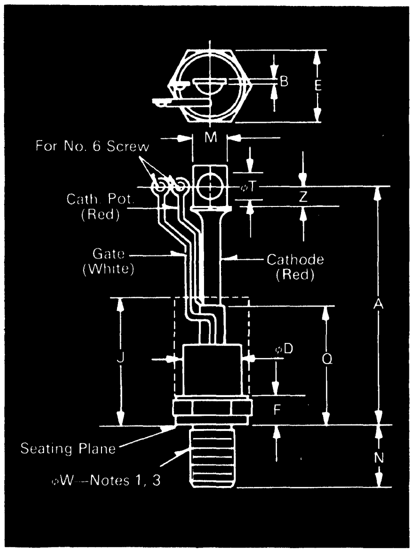


Maximum Power Dissipation VS. Forward Current



Phase Control SCR T600/T610

125-175 A Avg. Up to 1500 Volts

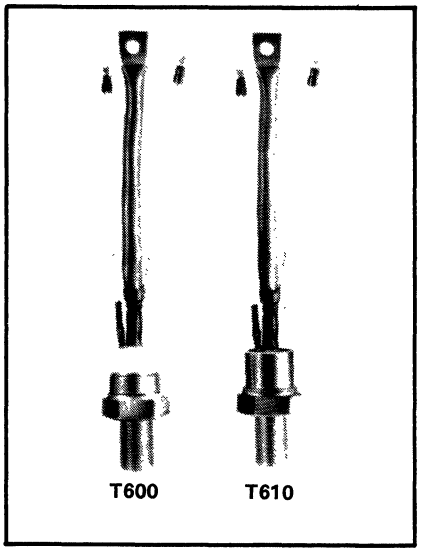


Conforms to TO-93 Outline

Symbol	Inches Min.	Inches Max.	Millimeters Min.	Millimeters Max.
A	7.750	8.100	196.85	205.74
A_1	7.750	8.100	196.85	205.74
B	.063	.172	1.60	4.37
ϕD	.980	1.090	24.89	27.69
E	1.212	1.250	30.78	31.75
F	.250	.630	6.35	16.00
J	3.25		82.55	
M	.530	.755	13.46	19.18
N	1.040	1.077	26.42	27.36
Q		2.250		57.15
ϕT	.260	.290	6.60	7.37
Z	.340		8.64	
ϕW	¾-16 UNF-2A			

Creep & Strike Distance:
T600—.69 in. min. (17.60 mm).
T610—.12 in. min. (3.05 mm).
(In accordance with NEMA standards.)
Finish—Nickel Plate.
Approx. Weight—8 oz. (227 g).

1. Complete threads to extend to within 2½ threads of seating plane.
2. Angular orientation of terminals is undefined.
3. Pitch diameter of ¾-16 UNF-2A (coated) threads (ASA B1.1—1960).
4. Dimension "J" denotes seated height with leads bent at right angles.



Ceramic Package I^2t (case rupture) rating: 20 x 10^6 A^2sec.

Features:
- Center fired di/namic gate
- All diffused design
- Low gate current
- Low V_{TM}
- Low Thermal Impedance
- High surge current capability
- Compression Bonded Encapsulation
- Lifetime Guarantee

Applications:
- Phase Control
- Motor Control
- Power Supplies
- Welders
- Light Dimmers

Ordering Information

Type	Voltage		Current		Turn-off		Gate Current		Leads	
Code	V_{DRM} and V_{RRM} (V)	Code	$I_{T(av)}$ (A)	Code	tq (µsec)	Code	IGT (ma)	Code	Case	Code
T610	100	01	125	13	100	0	150	4	TO-93	BT
	200	02			(typ)		*			
	300	03	150	15						
	400	04								
	500	05	175	18						
	600	06								
T600	700	07								
	800	08								
	900	09								
	1000	10								
	1100	11								
	1200	12								
	1300	13								
	1400	14								
	1500	15								

* for lower I_{GT} consult factory

Example
Obtain optimum device performance for your application by selecting proper Order Code.

Type T600 rated at 175A average with V_{DRM} = 1000V, I_{GT}=150 ma, and standard flexible lead—order as:

Type				Voltage		Current		Turn Off	Gate Current	Leads
T	6	0	0	1	0	1	8	0	4	B T

THYRISTOR

125-175 A Avg
Up to 1500 Volts

Phase Control SCR T600/T610

THYRISTOR

Voltage

Blocking State Maximums ② (T_J=125°C)	Symbol	T610						T600								
Repetitive peak forward blocking voltage, V	V_{DRM}	100	200	300	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500
Repetitive peak reverse voltage, V	V_{RRM}	100	200	300	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500
Non-repetitive transient peak reverse voltage, t ≤5.0 msec, V	V_{RSM}	200	300	400	500	600	700	850	950	1100	1200	1300	1450	1550	1700	1800
Forward leakage current, mA peak	I_{DRM}	← 25 →														
Reverse leakage current, mA peak	I_{RRM}	← 25 →														

Current

Conducting State Maximums (T_J=125°C)	Symbol	T600_ _13 T610_ _13	T600_ _15 T610_ _15	T600_ _18 T610_ _18
RMS forward current, A	$I_{T(rms)}$	200	235	275
Ave. forward current, A	$I_{T(av)}$	125	150	175
One-half cycle surge current③, A	I_{TSM}	3300	4000	5500
3 cycle surge current③, A	I_{TSM}	2400	3000	3900
10 cycle surge current③, A	I_{TSM}	2000	2400	3400
I^2t for fusing (for times>8.3 ms) A^2 sec	I^2t	45,000	66,000	120,000
Forward voltage drop at I_{TM}=625A and T_J=25°C, V	V_{TM}	2.05	1.8	1.55

Switching

(T_J=25°C)	Symbol	
Typical turn-off time, I_T=150A T_J=125°C, di_R/dt=12.5 A/μsec, reapplied dv/dt=20V/μsec linear to 0.8 V_{DRM}, μsec	t_q	100
Typ. turn-on-time, I_T=100A V_D=100V④, μsec	t_{on}	5
Min. critical dv/dt, exponential to V_{DRM} T_J=125°C, V/μsec②⑤	dv/dt	300
Min. di/dt non-repetitive, A/μsec ①④⑥	di/dt	800

Gate

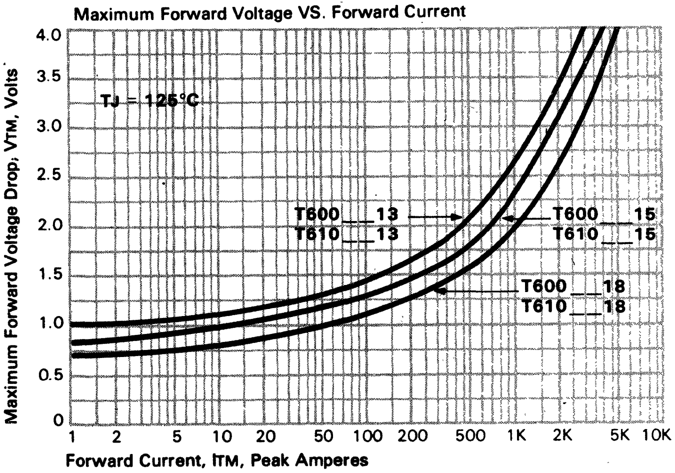
Maximum Parameters (T_J=25°C)	Symbol	
Gate current to trigger at V_D=12V, mA	I_{GT}	150
Gate voltage to trigger at V_D=12V, V	V_{GT}	3
Non-triggering gate voltage, T_J =125°C, and rated V_{DRM}, V	V_{GDM}	0.15
Peak forward gate current, A	I_{GTM}	4
Peak reverse gate voltage, V	V_{GRM}	5
Peak gate power, Watts	P_{GM}	16
Average gate power, Watts	$P_{G(av)}$	3

Thermal and Mechanical

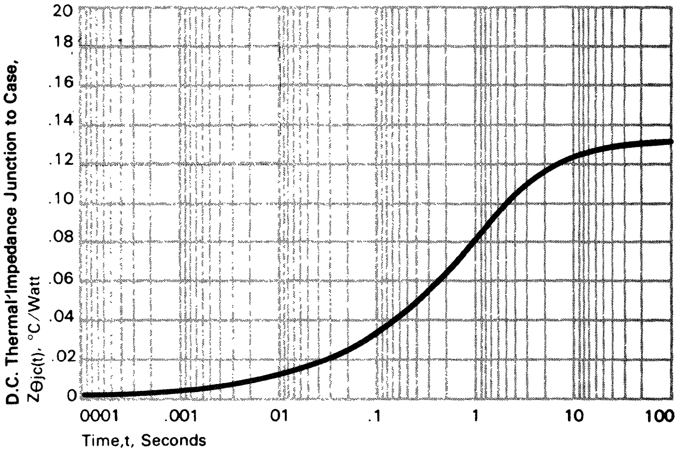
	Symbol	
Min., Max. oper. junction temp., °C	T_J	−40 to +125
Min., Max. storage temp., °C	T_{stg}	−40 to +150
Max. mounting torque, in lb.①		300
Thermal resistance① Junction to case, °C/Watt	$R\theta_{JC}$	.13
Case to sink, lubricated, °C/Watt	$R\theta_{CS}$	.075

① Consult recommended mounting procedures.
② Applies for zero or negative gate bias.
③ Per JEDEC RS-397, 5.2.2.1.
④ With recommended gate drive.
⑤ Higher dv/dt ratings available, consult factory.
⑥ Per JEDEC standard RS-397, 5.2.2.6.

Maximum Forward Voltage VS. Forward Current



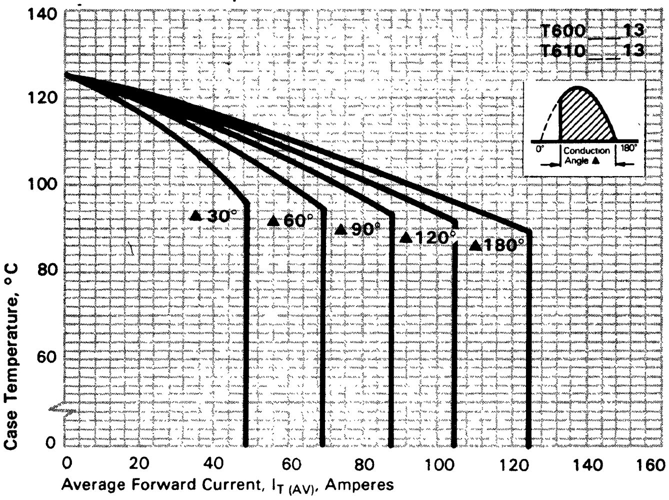
Transient Thermal Impedance VS. Time



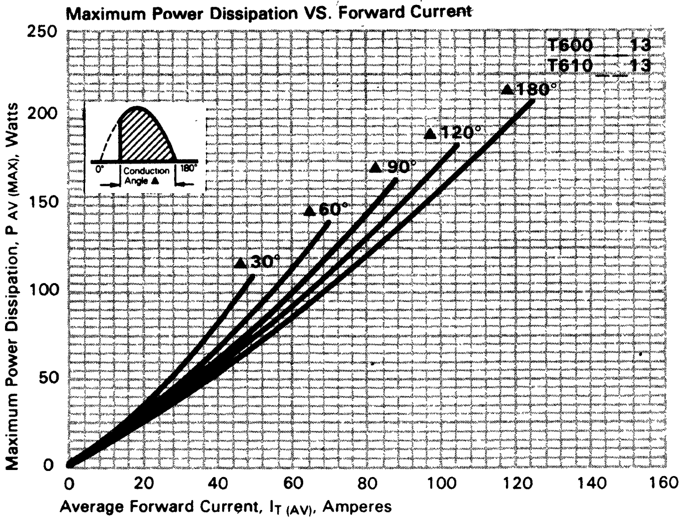
Phase Control SCR T600/T610

125-175 A Avg Up to 1500 Volts

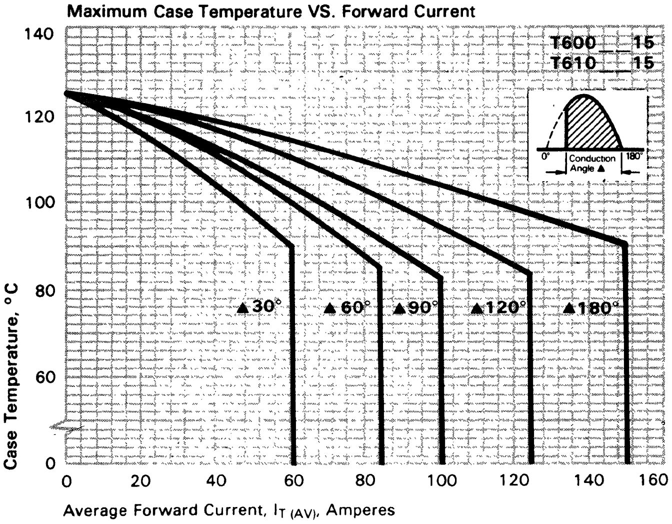
Maximum Case Temperature VS. Forward Current



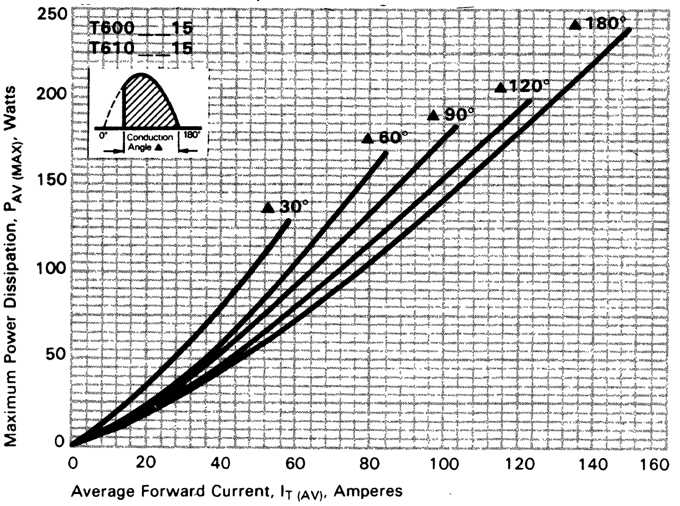
Maximum Power Dissipation VS. Forward Current



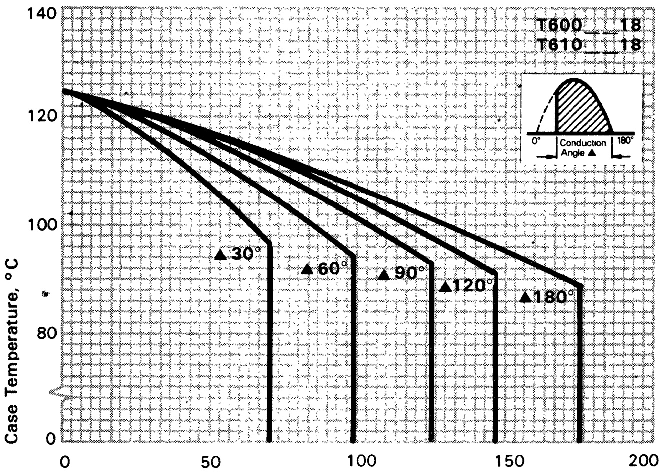
Maximum Case Temperature VS. Forward Current



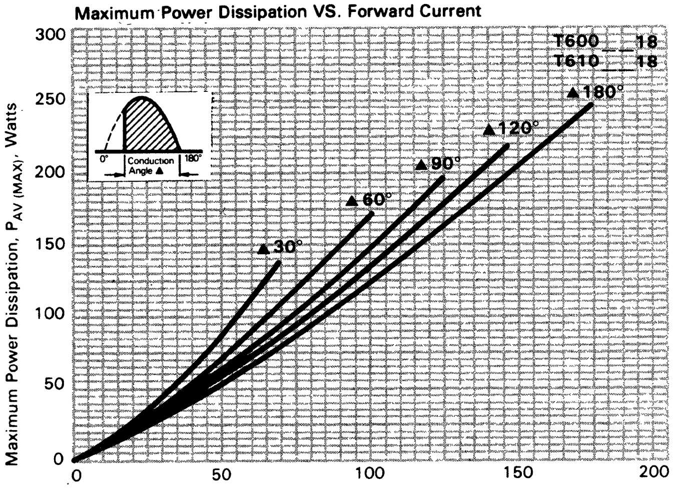
Maximum Power Dissipation VS. Forward Current



Maximum Case Temperature VS. Forward Current



Maximum Power Dissipation VS. Forward Current



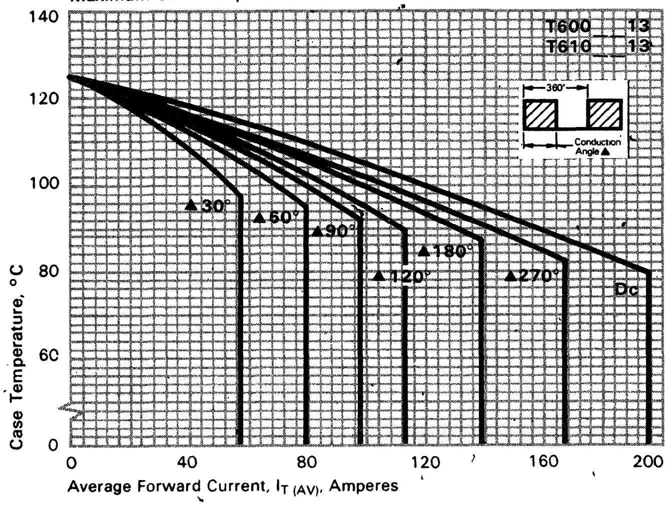
THYRISTOR

125-175 A Avg
Up to 1500 Volts

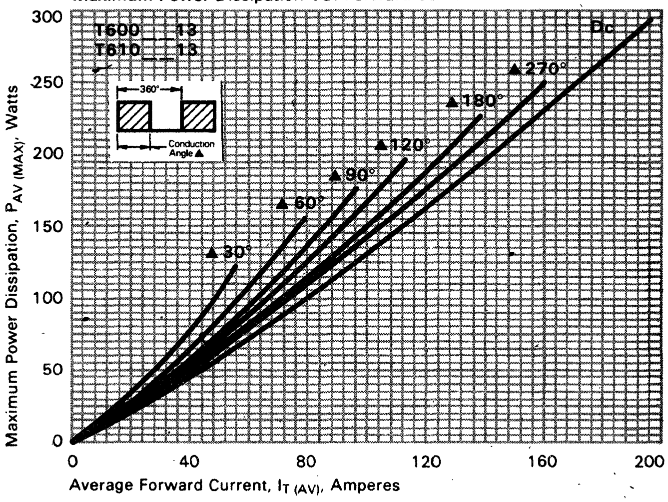
Phase Control SCR T600/T610

THYRISTOR

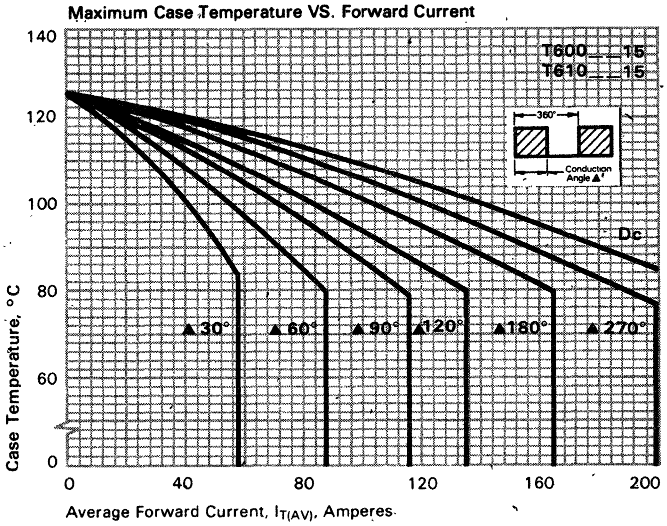
Maximum Case Temperature VS. Forward Current



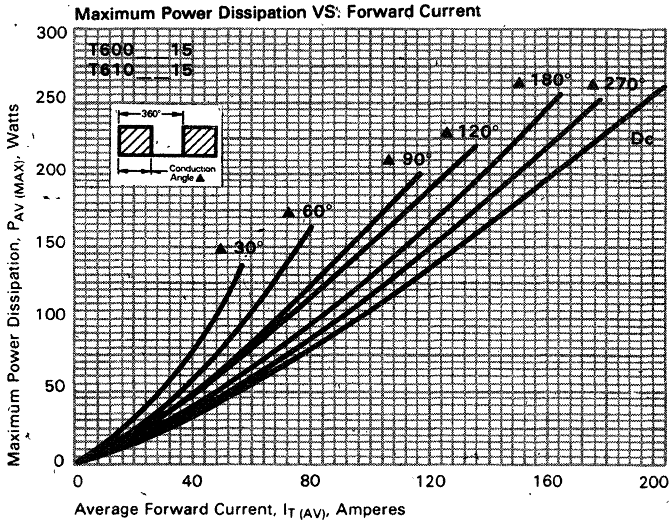
Maximum Power Dissipation VS. Forward Current



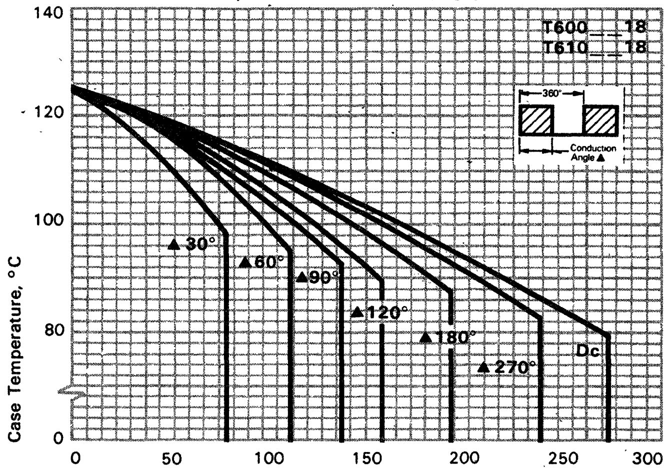
Maximum Case Temperature VS. Forward Current



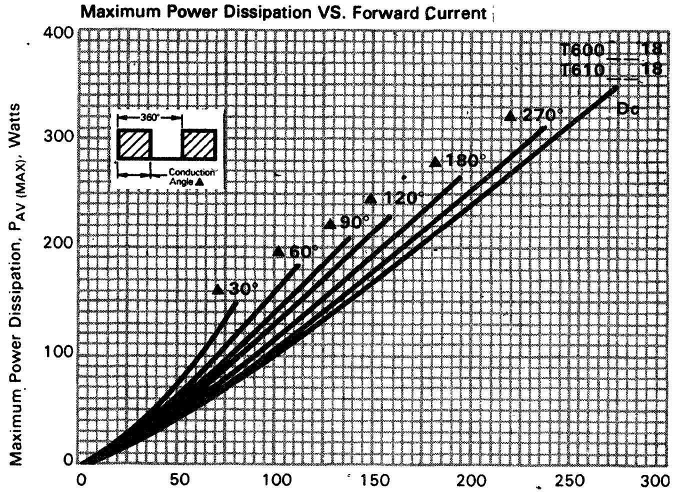
Maximum Power Dissipation VS. Forward Current



Maximum Case Temperature VS. Forward Current

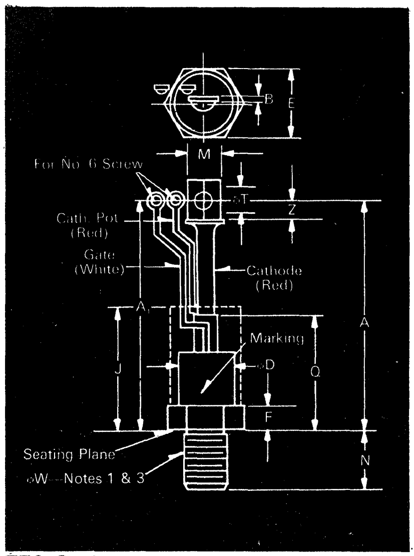


Maximum Power Dissipation VS. Forward Current



Phase Control SCR T700

250-350 A Avg. Up to 2200 Volts

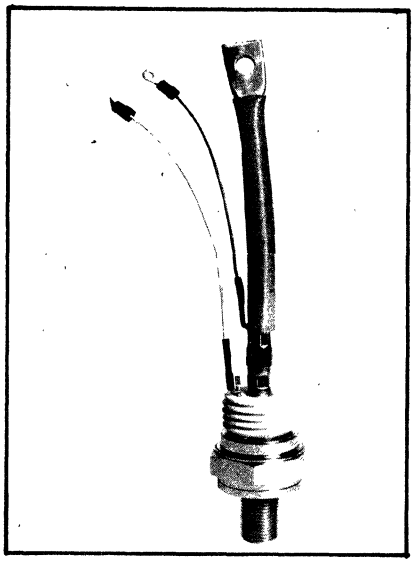


T70 Outline

Symbol	Inches Min.	Inches Max.	Millimeters Min.	Millimeters Max.
A	9.76	10.00	247.90	254.00
A_1	10.18	10.42	258.57	264.67
B	.063	.172	1.60	4.37
ϕD		1.490		37.85
E	1.620	1.750	41.15	44.45
F	.430	.810	10.92	20.57
J	4.000		101.60	
M	.530	.755	13.46	19.18
N	1.04	1.08	26.42	27.43
Q		3.100		78.74
ϕT	.330	.350	8.38	8.89
Z	.440		11.18	
ϕW	¾-16 UNF-2A			

Creep Distance—1.76 in. min. (44.91 mm).
Strike Distance— .81 in. min. (20.70 mm).
(In accordance with NEMA standards.)
Finish—Nickel Plate.
Approx. Weight—16 oz. (454 g).

1. Complete threads to extend to within 2½ threads of seating plane.
2. Angular orientation of terminals is undefined.
3. Pitch diameter of ¾-16 UNF-2A (coated) threads (ASA B1.1-1960).
4. Dimension "J" denotes seated height with leads bent at right angles.



Package I^2t (case rupture) rating: 15 x 10^6 A^2sec.

Features:
- Center fired di/namic gate
- All diffused design
- Low T_{TM}
- Compression Bonded Encapsulation
- Guaranteed dv/dt (300 v/μs)
- High surge capability
- Long creep and strike
- Westinghouse Lifetime Guarantee

Applications:
- Phase Control
- Welding
- Power Supplies
- Motor Control

Ordering Information

Type	Voltage		Current		Turn-off		Gate current		Leads	
Code	V_{DRM} and V_{RRM} (V)	Code	$I_{T(av)}$ (A)	Code	tq μsec	Code	I_{GT} (ma)	Code	Case	Code
T700	100	01	250	25	150	0	150 *	4	T70	BY
	200	02			(typical)					
	400	04	300	30						
	600	06								
	800	08	350	35						
	1000	10								
	1200	12								
	1300	13								
	1400	14								
	1500	15								
	1600	16								
	1700	17								
	1800	18								
	2000	20								
	2200	22								

* For lower I_{GT} consult factory

Example

Obtain optimum device performance for your application by selecting proper Order Code.

Type T700 rated at 350 A average with V_{DRM} = 1000V, I_{GT} = 150 ma, and standard flexible lead—order as:

Type				Voltage		Current		Turn Off	Gate Current	Leads	
T	7	0	0	1	0	3	5	0	4	B	Y

THYRISTOR

250-350 A Avg. Up to 2200 Volts

Phase Control SCR T700

Voltage

Blocking State Maximums ② (T_J = 125°C)

	Symbol															
Repetitive peak forward blocking voltage , V	V_{DRM}	100	200	400	600	800	1000	1200	1300	1400	1500	1600	1700	1800	2000	2200
Repetitive peak reverse voltage , V	V_{RRM}	100	200	400	600	800	1000	1200	1300	1400	1500	1600	1700	1800	2000	2200
Non-repetitive transient peak reverse voltage, t ≤ 5.0 msec,V	V_{RSM}	200	300	500	700	950	1200	1450	1550	1700	1800	1900	2050	2150	2400	2600
Forward leakage current, mA peak	I_{DRM}	← 30 →														
Reverse leakage current, mA peak	I_{RRM}	← 30 →														

Current

Conducting State Maximums (T_J = 125°C)

	Symbol	T700 _ _ 25	T700 _ _ 30	T700 _ _ 35
RMS forward current, A	$I_{T(rms)}$	400	470	550
Ave. forward current, A	$I_{T(av)}$	250	300	350
One-half cycle surge current③, A	I_{TSM}	7000	8400	10,000
3 cycle surge current③, A	I_{TSM}	5040	6050	7200
10 cycle surge current③, A	I_{TSM}	4340	5200	6200
I^2t for fusing (for times ≥ 8.3 ms) A^2 sec.	I^2t	205,000	295,000	416,000
Forward voltage drop at I_{TM} = 3000 and T_J = 25°C, V	V_{TM}	3.30	2.75	2.15

Switching

(T_J = 25°C)

	Symbol	
Typical turn-off time, I_T = 250A, T_J = 125°C, di_R/dt = 25 A/μsec, reapplied dv/dt = 20V/μsec linear to 0.8 V_{DRM}, μ sec	t_q	150
Typ. turn-on-time, I_T = 100A V_D = 100V④, μsec	t_{on}	7
Min. critical dv/dt, exponential to V_{DRM}, T_J = 125°C, V/μsec②⑤	dv/dt	300
Min. di/dt non-repetitive, A/μsec ①④⑥	di/dt	800

Thermal and Mechanical

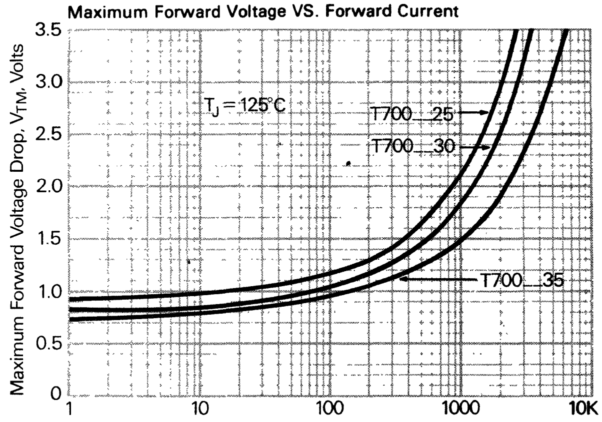
	Symbol	
Min., Max. oper. junction temp., °C	T_J	—40 to +125
Min., Max. storage temp., °C	Tstg	—40 to +150
Max. mounting torque, in lb. ① lubricated		360
Thermal resistance ① Junction to case, °C/Watt	$R_{\theta JC}$	.10
Case to sink, lubricated, °C/Watt	$R_{\theta CS}$	.05

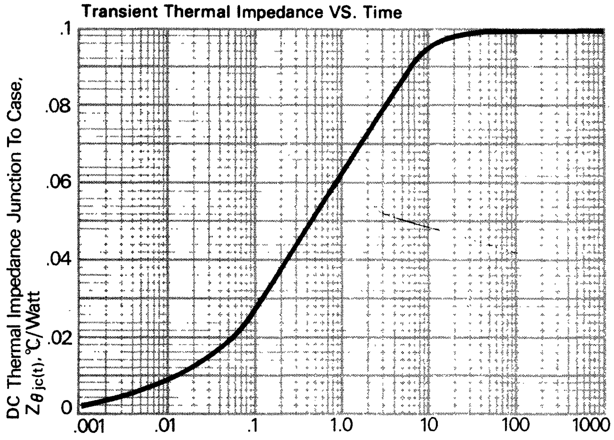
Gate

Maximum Parameters (T_J = 25°C)

	Symbol	
Gate current to trigger at V_D = 12V, mA	I_{GT}	150
Gate voltage to trigger at V_D = 12V, V	V_{GT}	3
Non-triggering gate voltage, T_J = 125°C, and rated V_{DRM}, V	V_{GDM}	0.15
Peak forward gate current, A	I_{GTM}	4
Peak reverse gate voltage, V	V_{GRM}	5
Peak gate power, Watts	P_{GM}	16
Average gate power, Watts	$P_{G(av)}$	3

① Consult recommended mounting procedures.
② Applies for zero or negative gate bias.
③ Per JEDEC RS397, 5.2.2.1.
④ With recommended gate drive.
⑤ Higher dv/dt ratings available, consult factory.
⑥ Per JEDEC standard RS-397, 5.2.2.6.



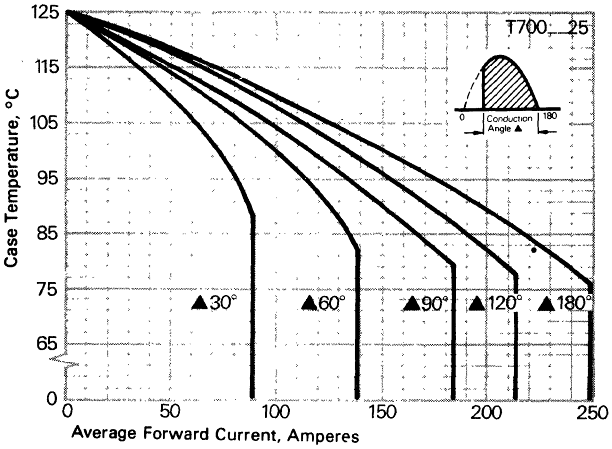


THYRISTOR

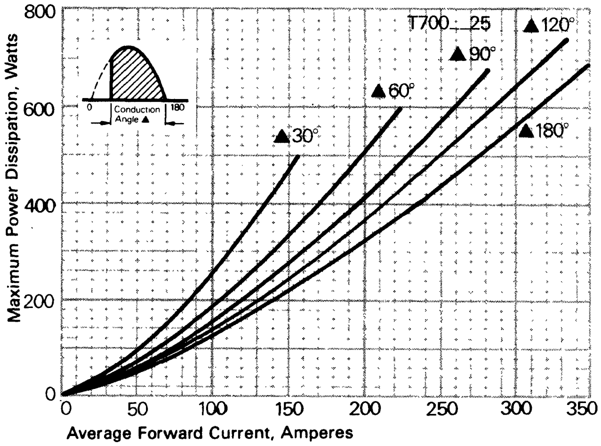
Phase Control SCR T700

250-350 A Avg. Up to 2200 Volts

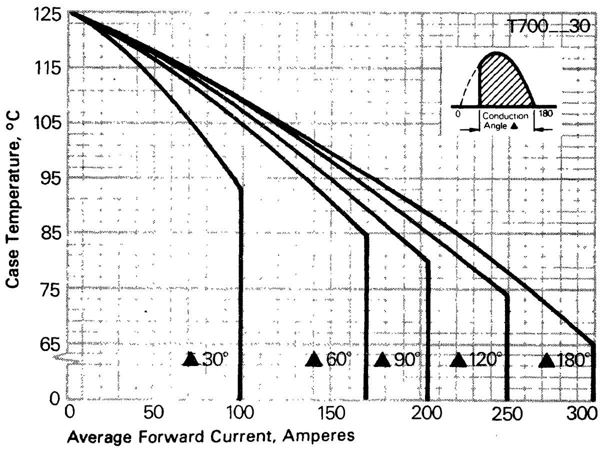
Maximum Case Temperature VS. Forward Current



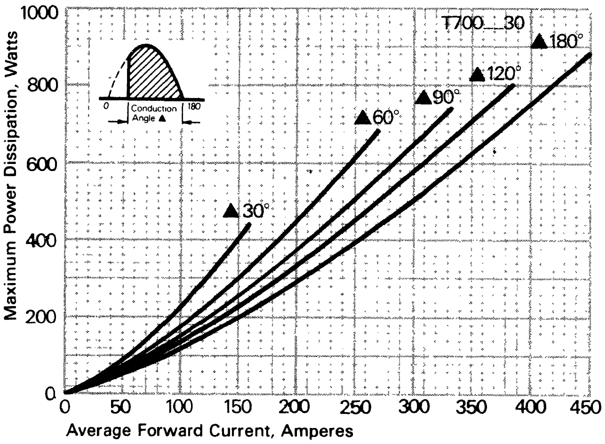
Maximum Power Dissipation VS. Forward Current



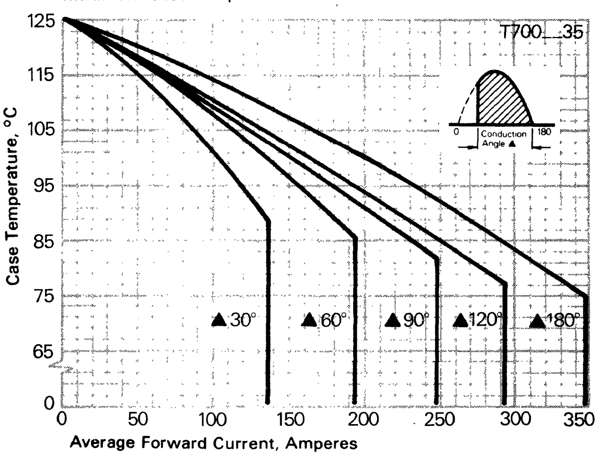
Maximum Case Temperature VS. Forward Current



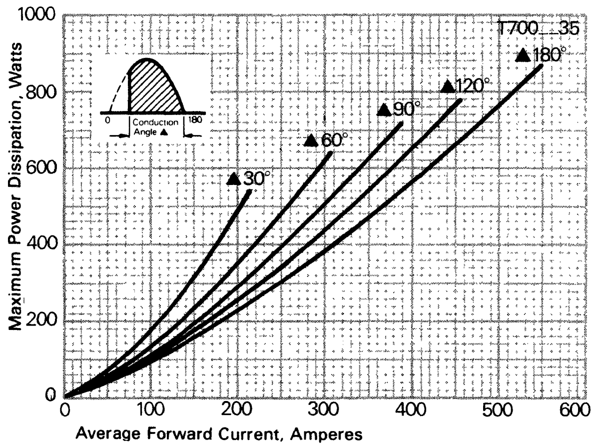
Maximum Power Dissipation VS. Forward Current



Maximum Case Temperature VS. Forward Current



Maximum Power Dissipation VS. Forward Current

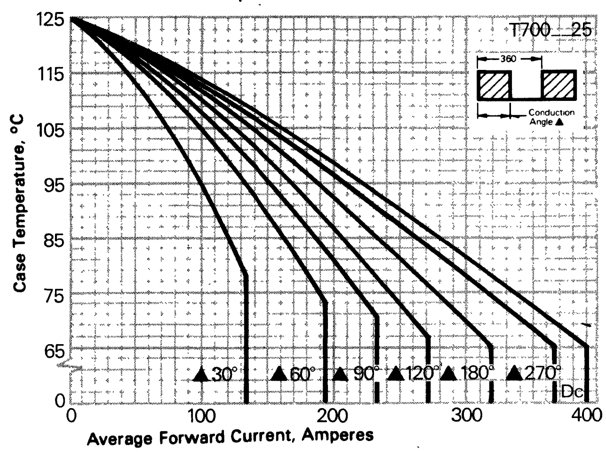


THYRISTOR

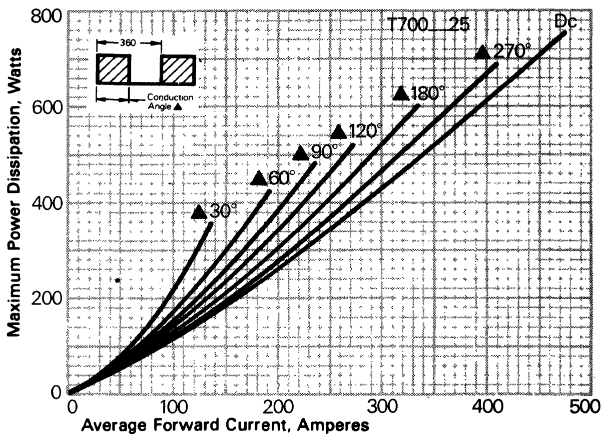
250-350 A Avg. Up to 2200 Volts

Phase Control SCR T700

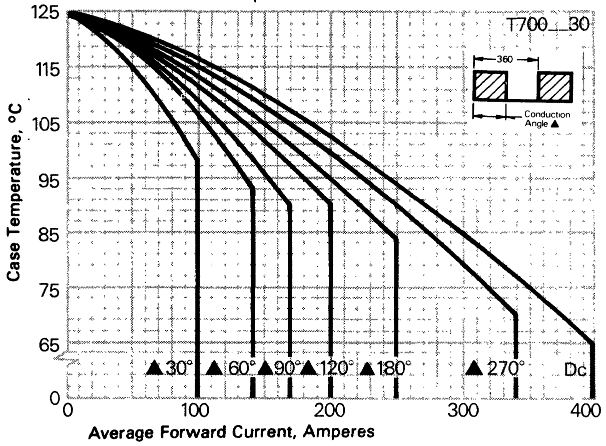
Maximum Case Temperature VS. Forward Current



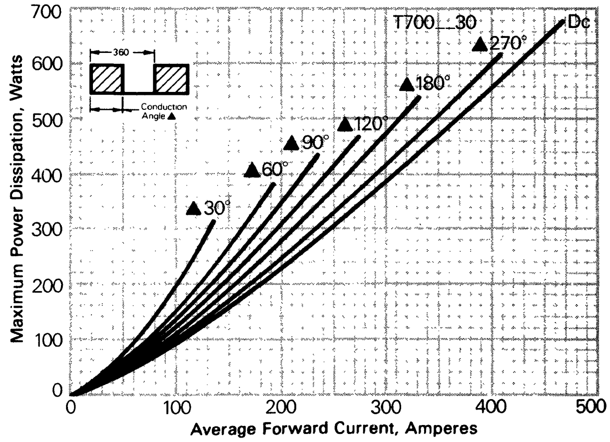
Maximum Power Dissipation Vs. Forward Current



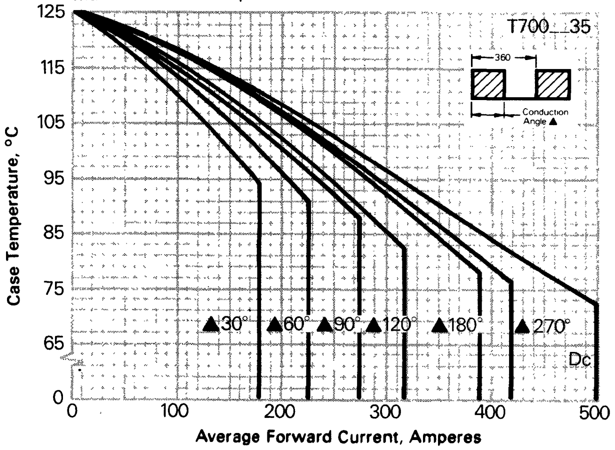
Maximum Case Temperature VS. Forward Current



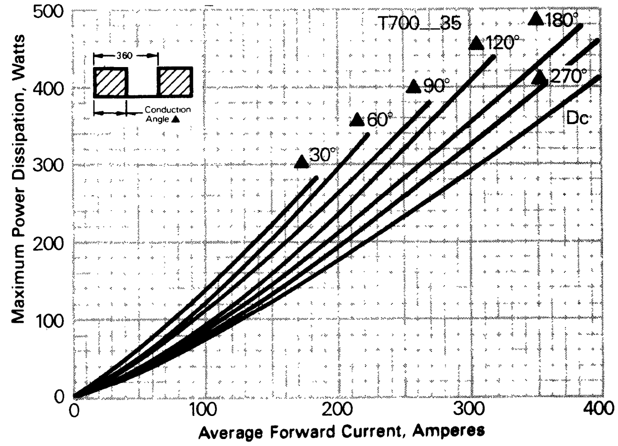
Maximum Power Dissipation Vs. Forward Current



Maximum Case Temperature VS. Forward Current



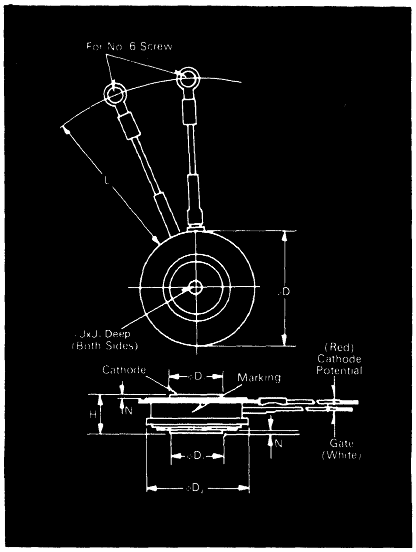
Maximum Power Dissipation VS. Forward Current



THYRISTOR

Phase Control SCR T520

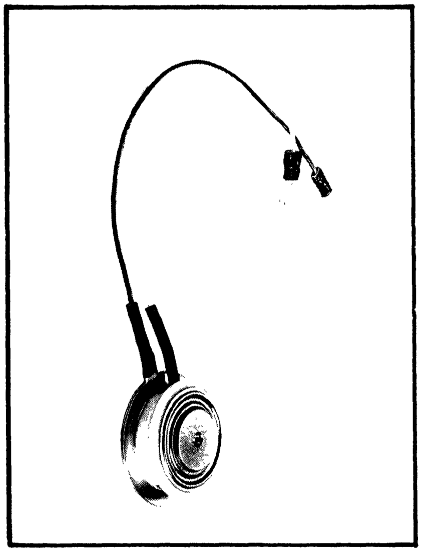
125 A Avg. Up to 1500 Volts



T52 Outline

Symbol	Inches Min.	Inches Max.	Millimeters Min.	Millimeters Max.
ϕD	1.610	1.650	40.89	41.91
ϕD_1	.745	.755	18.92	19.18
ϕD_2	1.420	1.460	36.07	37.08
H	.500	.560	12.70	14.22
ϕJ	.135	.145	3.43	3.68
J_1	.072	.082	1.83	2.08
L	7.75	8.50	196.85	215.90
N	.030		.76	

Creep Distance—.34 in. min. (8.64 mm).
Strike Distance—.52 in. min. (13.21 mm).
(In accordance with NEMA standards.)
Finish—Nickel Plate.
Approx. Weight—2.3 oz. (66 g).
1. Dimension "H" is clamped dimension.



Package I^2t (case rupture) rating: 20 x 10^6 A^2sec.

Voltage

Blocking State Maximums ②(TJ=125°C)	Symbol															
Repetitive peak forward blocking voltage, V	V_{DRM}	100	200	300	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500
Repetitive peak reverse voltage, V	V_{RRM}	100	200	300	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500
Non-repetitive transient peak reverse voltage, t <5.0 msec, V	V_{RSM}	200	300	400	500	600	700	850	950	1100	1200	1300	1450	1550	1700	1800
Forward leakage current, mA peak	I_{DRM}	← 25 →														
Reverse leakage current, mA peak	I_{RRM}	← 25 →														

Current

Conducting State Maximums (T_J=125°C)	Symbol	T520 — 13
RMS forward current, A	$I_{T(rms)}$	200
Ave. forward current, A	$I_{T(av)}$	125
One-half cycle surge current③, A	I_{TSM}	1600
3 cycle surge current③, A	I_{TSM}	1250
10 cycle surge current③, A	I_{TSM}	1080
I^2t for fusing (for times>8.3 ms) A^2 sec.	I^2t	10,700
Forward voltage drop at I_{TM}= 500A and T_J=25°C, V	V_{TM}	2.2

Switching

(T_J=25°C)	Symbol	
Typical turn-off time, I_T=150A T_J=125°C, di_R/dt=12.5 A/µsec, reapplied dv/dt=20V/µsec linear to 0.8 V_{DRM}, µsec	t_q	100
Typ. turn-on-time, I_T=100A V_D=100V④, µsec	t_{on}	4
Min. critical dv/dt, exponential to V_{DRM} T_J=125°C, V/µsec②⑤	dv/dt	300
Min. di/dt non-repetitive, JEDEC A/µsec ①④⑥	di/dt	500

Gate

Maximum Parameters (T_J=25°C)	Symbol	
Gate current to trigger at V_D=12V, mA	I_{GT}	100
Gate voltage to trigger at V_D=12V, V	V_{GT}	3
Non-triggering gate voltage, T_J =125°C, and rated V_{DRM}, V	V_{GDM}	0.15
Peak forward gate current, A	I_{GTM}	4
Peak reverse gate voltage, V	V_{GRM}	5
Peak gate power, Watts	P_{GM}	16
Average gate power, Watts	$P_{G(av)}$	3

Thermal and Mechanical

	Symbol	
Min., Max. oper. junction temp., °C	T_J	−40 to +125
Min., Max. storage temp., °C	T_{stg}	−40 to +150
Max. mounting force in lb.①		800 to 1000
Thermal resistance① Junction to case, °C/Watt	$R_{\theta JC}$	.12
Case to sink, lubricated, °C/Watt	$R_{\theta CS}$	.02

① Consult recommended mounting procedures.
② Applies for zero or negative gate bias.
③ Per JEDEC RS397, 5.2.2.1.
④ With recommended gate drive.
⑤ Higher dv/dt ratings available, consult factory.
⑥ Per JEDEC standard RS-397, 5.2.2.6.

Example

Obtain optimum device performance for your application by selecting proper Order Code.

Type T520 rated at 125A average with V_{DRM}= 1000V, I_{GT}= 100 ma, and standard flexible lead—order as:

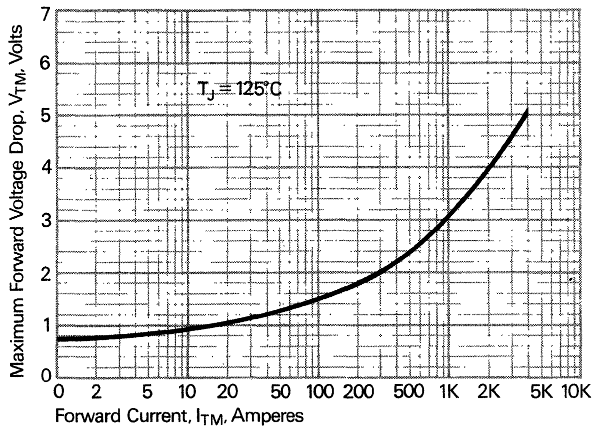
Type				Voltage		Current		Turn Off	Gate Current	Leads	
T	5	2	0	1	0	1	3	0	5	D	N

125 A Avg.
Up to 1500 Volts

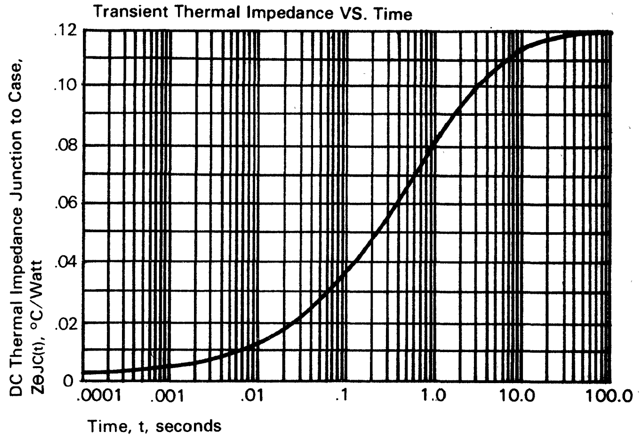
Phase Control SCR T520

THYRISTOR

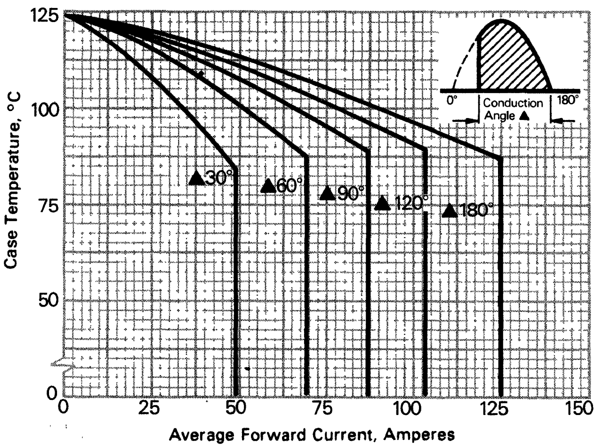
Maximum Forward Voltage VS. Forward Current



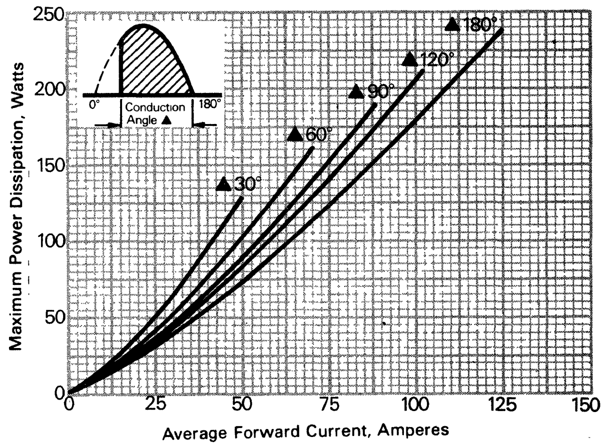
Transient Thermal Impedance VS. Time



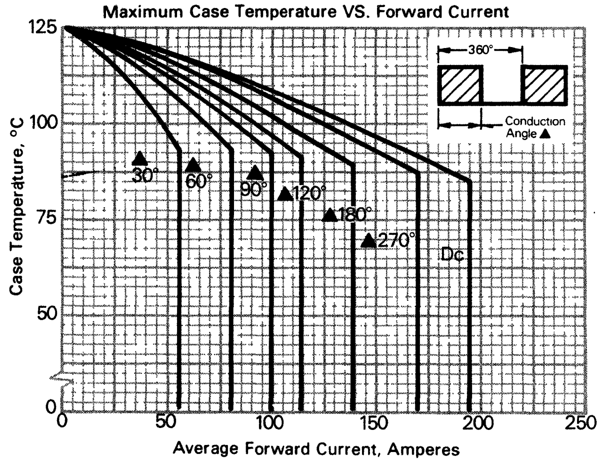
Maximum Case Temperature VS. Forward Current



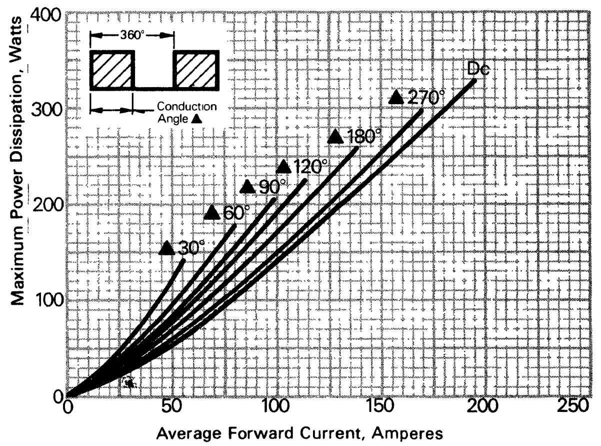
Maximum Power Dissipation VS. Forward Current



Maximum Case Temperature VS. Forward Current

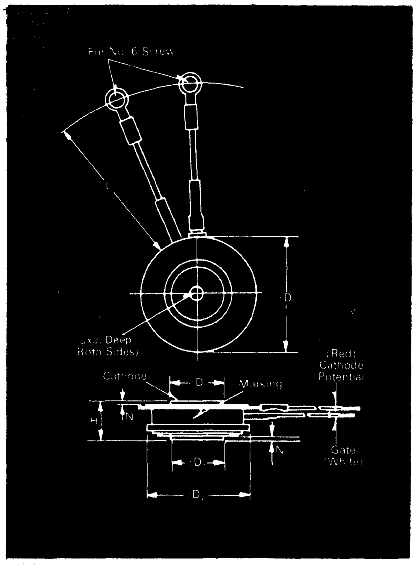


Maximum Power Dissipation VS. Forward Current



Phase Control SCR T620

150—300 A. Avg. Up to 1500 Volts



T62 Outline

Symbol	Inches Min.	Inches Max.	Millimeters Min.	Millimeters Max.
ϕD	1.610	1.650	40.89	41.91
ϕD_1	.745	.755	18.92	19.18
ϕD_2	1.420	1.460	36.07	37.08
H	.500	.560	12.70	14.22
ϕJ	.135	.145	3.43	3.68
J_1	.072	.082	1.83	2.08
L	7.75	8.50	196.85	215.90
N	.030		.76	

Creep Distance—.34 in. min. (8.64 mm).
Strike Distance—.52 in. min. (13.21 mm).
(In accordance with NEMA standards.)
Finish—Nickel Plate.
Approx. Weight—2.3 oz. (66 g).
1. Dimension "H" is clamped dimension.

Package I^2t (case rupture) rating: 20×10^6 A^2sec.

Features:
- Center fired di/namic gate
- All diffused design
- Guaranteed dv/dt (300 v/μs)
- Low gate current
- Low VTM
- Low Thermal Impedance
- High surge current capability
- Lifetime Guarantee

Applications.
- Phase Control
- Power Supplies
- Motor Controls

Ordering Information

Type	Voltage		Current		Turn-off		Gate current		Leads	
Code	V_{DRM} and V_{RRM} (V)	Code	$I_{T(av)}$ (A)	Code	tq (μsec)	Code	I_{GT} (ma)	Code	Case	Code
T620	100	01	150	15	100	0	150	4	T62	[illegible]
	200	02								
	300	03	200	20	(typical)					
	400	04								
	500	05	300	30						
	600	06								
	700	07								
	800	08								
	900	09								
	1000	10								
	1100	11								
	1200	12								
	1300	13								
	1400	14								
	1500	15								

Example

Obtain optimum device performance for your application by selecting proper order code.

Type T 620 rated at 300 A average with V_{DRM} = 1000V, I_{GT} = 150 ma, and standard flexible lead—order as:

Type			Voltage		Current		Turn Off	Gate Current	Leads	
T	6	2	0	1	0	3	0	0	4	D	N

THYRISTOR

150—300 A. Avg. Up to 1500 Volts

Phase Control SCR T620

Voltage

Blocking State Maximums ② (T_J = 125°C)

	Symbol															
Repetitive peak forward blocking voltage, V	V_{DRM}	100	200	300	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500
Repetitive peak reverse voltage, V	V_{RRM}	100	200	300	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500
Non-repetitive transient peak reverse voltage, t ≤ 5.0 msec, V	V_{RSM}	200	300	400	500	600	700	850	950	1100	1200	1300	1450	1550	1700	1800
Forward leakage current, mA peak	I_{DRM}	← 25 →														
Reverse leakage current, mA peak	I_{RRM}	← 25 →														

Current

Conducting State Maximums (T_J = 125°C)

	Symbol	T620 _ _ 13	T620 _ _ 20	T620 _ _ 30
RMS forward current, A	$I_{T(rms)}$	235	315	470
Ave. forward current, A	$I_{T(av)}$	150	200	300
One-half cycle surge current③, A	I_{TSM}	3300	4000	5500
3 cycle surge current③, A	I_{TSM}	2400	2900	3900
10 cycle surge current③, A	I_{TSM}	2000	2500	3400
I^2t for fusing (for times ≥ 8.3 ms) A^2 sec.	I^2t	45,000	64,400	120,000
Forward voltage drop at I_{TM} = 625A and T_J = 25°C, V	V_{TM}	2.6	2.05	1.55

Switching

(T_J = 25°C)

	Symbol	
Typical turn-off time, I_T = 150A T_J = 125°C, di_R/dt = 12.5 A/μsec, reapplied dv/dt = 20V/μsec linear to 0.8 V_{DRM}, μ sec	t_q	100
Typ. turn-on-time, I_T = 100A V_D = 100V④, μsec	t_{on}	5
Min. critical dv/dt, exponential to V_{DRM}, T_J = 125°C, V/μsec② ⑤	dv/dt	300
Min. di/dt non-repetitive, A/μsec ①④⑥	di/dt	800

Gate

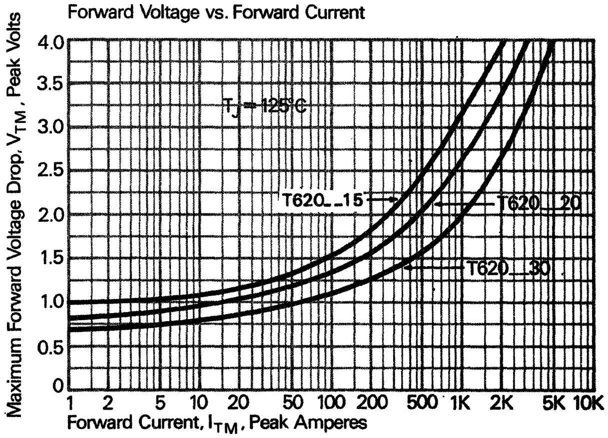
Maximum Parameters (T_J = 25°C)

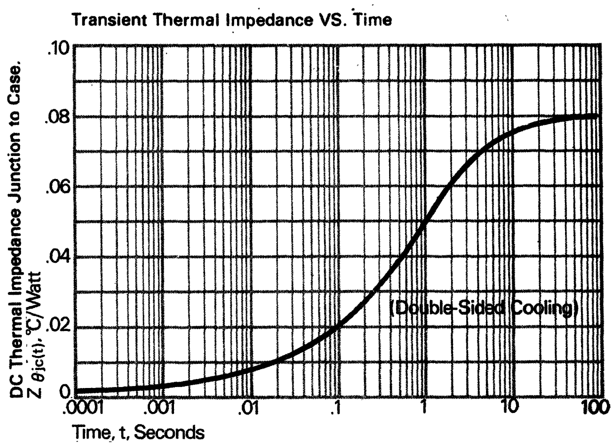
	Symbol	
Gate current to trigger at V_D = 12V, mA	I_{GT}	150
Gate voltage to trigger at V_D = 12V, V	V_{GT}	3
Non-triggering gate voltage, T_J = 125°C, and rated V_{DRM}, V	V_{GDM}	0.15
Peak forward gate current, A	I_{GTM}	4
Peak reverse gate voltage, V	V_{GRM}	5
Peak gate power, Watts	P_{GM}	16
Average gate power, Watts	$P_{G(av)}$	3

Thermal and Mechanical

	Symbol	
Min., Max. oper. junction temp., °C	T_J	−40 to +125
Min., Max. storage temp., °C	Tstg	−40 to +150
Min., Max. mounting force, lb.①		1000 to 1400
Thermal resistance with double sided cooling ①		
Junction to case, °C/Watt	$R_{\theta JC}$	.08
Case to sink, lubricated, °C/Watt	$R_{\theta CS}$	.02

① Consult recommended mounting procedures.
② Applies for zero or negative gate bias.
③ Per JEDEC RS-397, 5.2.2.1.
④ With recommended gate drive.
⑤ Higher dv/dt ratings available, consult factory.
⑥ Per JEDEC standard RS-397, 5.2.2.6.



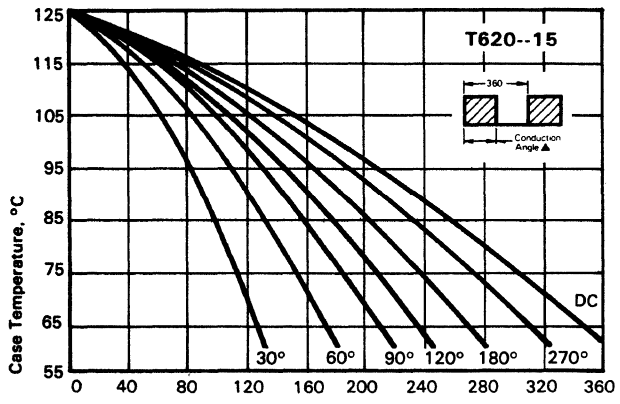


THYRISTOR

Phase Control SCR T620

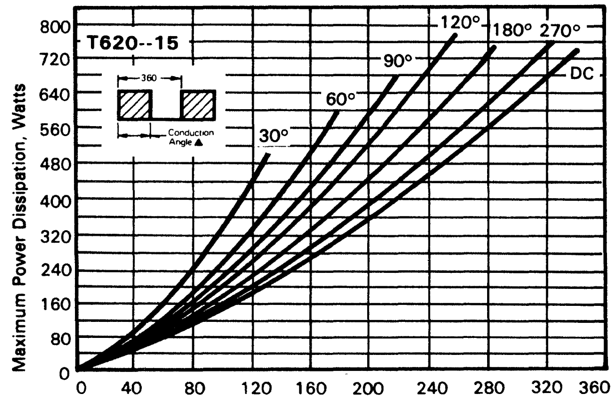
150—300 A. Avg. Up to 1500 Volts

Maximum Case Temperature VS. Forward Current



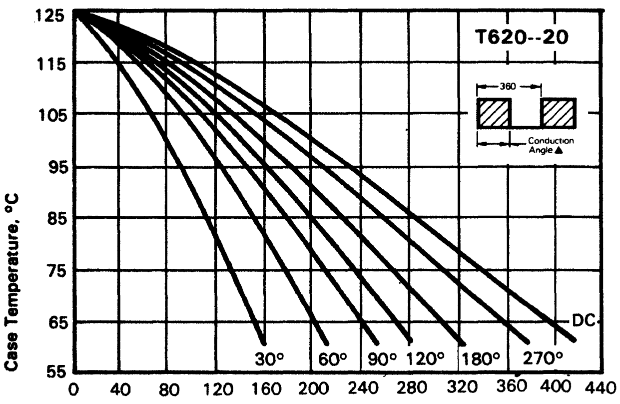
Average Forward Current, Amperes

Maximum Power Dissipation VS. Forward Current



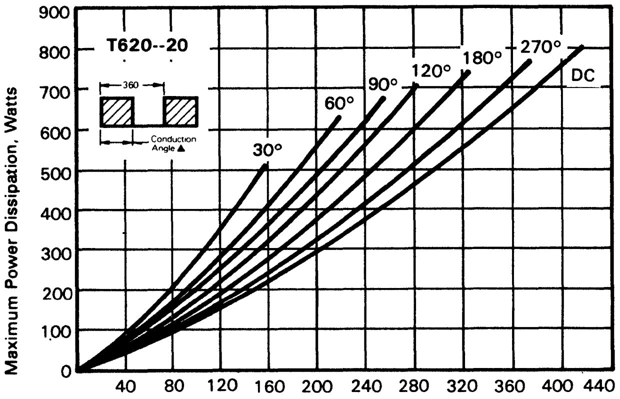
Average Forward Current, Amperes

Maximum Case Temperature VS. Forward Current



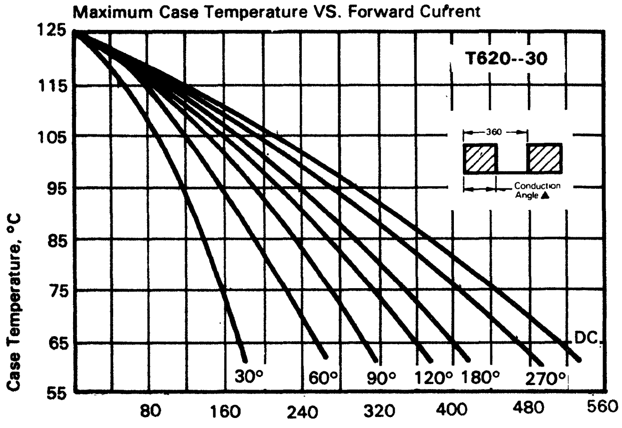
Average Forward Current, Amperes

Maximum Power Dissipation VS. Forward Current



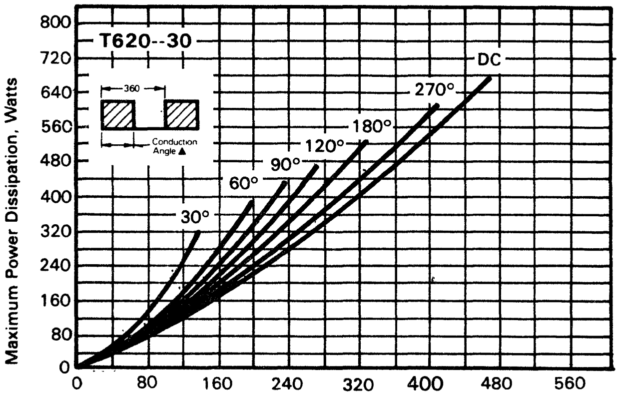
Average Forward Current, Amperes

Maximum Case Temperature VS. Forward Current



Average Forward Current, Amperes

Maximum Power Dissipation VS. Forward Current

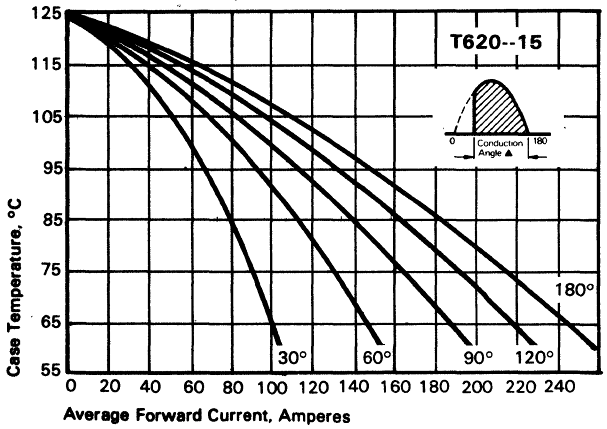


Average Forward Current, Amperes

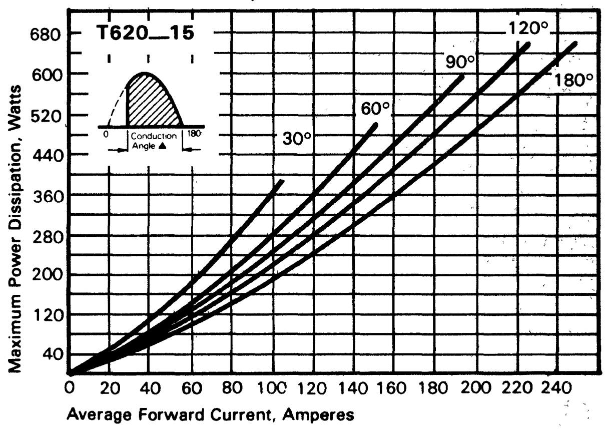
THYRISTOR

Phase Control SCR T620

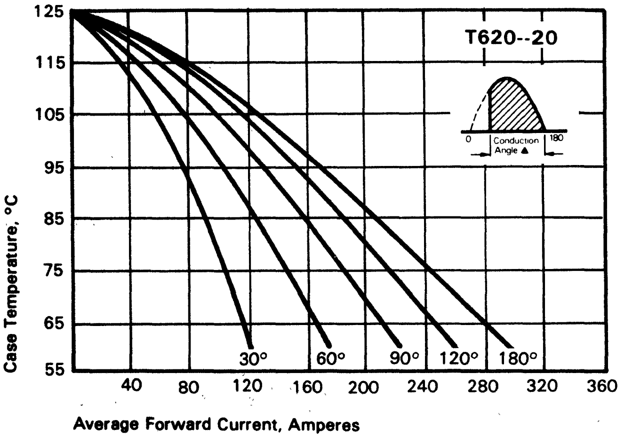
Maximum Case Temperature VS. Forward Current



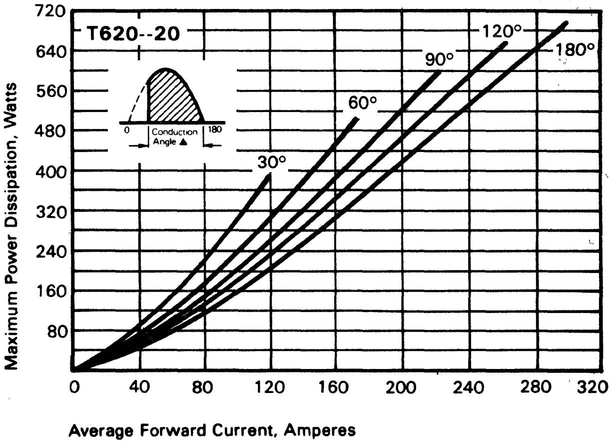
Maximum Power Dissipation VS. Forward Current



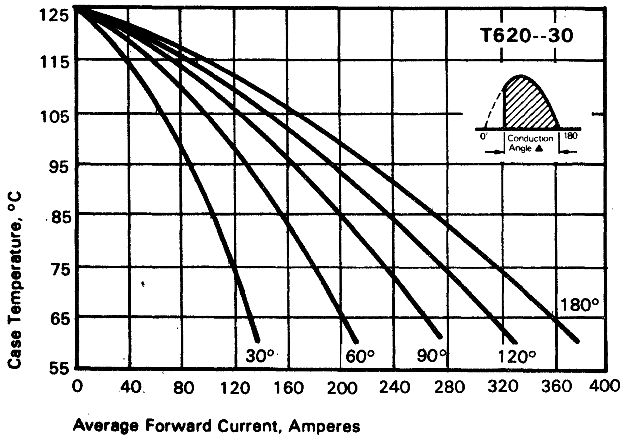
Maximum Case Temperature VS. Forward Current



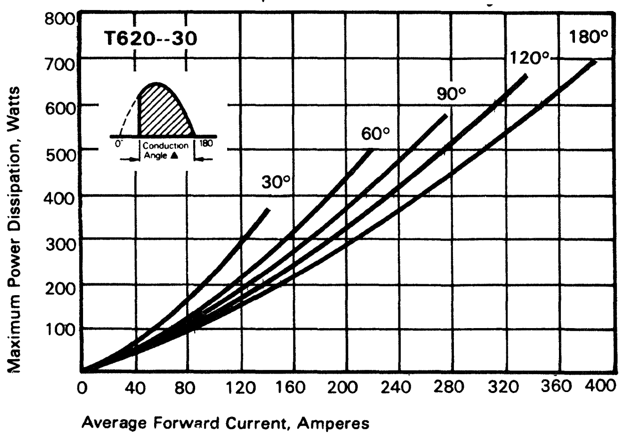
Maximum Power Dissipation VS. Forward Current



Maximum Case Temperature VS. Forward Current



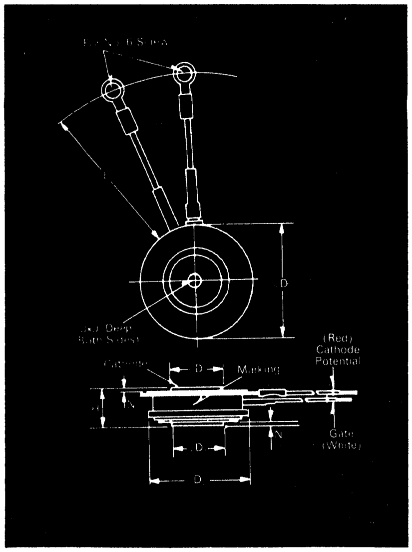
Maximum Power Dissipation VS. Forward Current



THYRISTOR

Phase Control, Hi-temp SCR T625

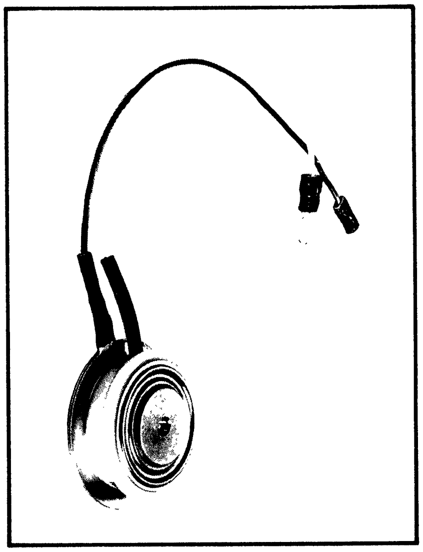
250—400 A. Avg. Up to 1200 Volts



T62 Outline

Symbol	Inches Min.	Inches Max.	Millimeters Min.	Millimeters Max.
ϕD	1.610	1.650	40.89	41.91
ϕD_1	.745	.755	18.92	19.18
ϕD_2	1.420	1.460	36.07	37.08
H	.500	.560	12.70	14.22
ϕJ	.135	.145	3.43	3.68
J_1	.072	.082	1.83	2.08
L	7.75	8.50	196.85	215.90
N	.030		.76	

Creep Distance—.34 in. min. (8.64 mm).
Strike Distance—.52 in. min. (13.21 mm).
(In accordance with NEMA standards.)
Finish—Nickel Plate.
Approx. Weight—2.3 oz. (66 g).
1. Dimension "H" is clamped dimension.



Package I^2t (case rupture) rating: 20 x 10^6 A^2sec.

Features:
- Center fired di/namic gate
- Full 150°C Junction Temperature Rating
- All diffused design
- Low gate current
- Low V_{TM}
- Low Thermal Impedance
- High surge current capability
- Lifetime Guarantee

Applications:
- Phase Control
- Motor Control
- Power Supplies
- Plating supplies

Ordering Information

Type	Voltage		Current		Turn-off		Gate Current		Leads	
Code	V_{DRM} and V_{RRM} (V)	Code	$I_{T(av)}$ (A)	Code	tq (µsec)	Code	I_{GT} (ma)	Code	Case	Code
T625	100	01	250	25	150 (typ)	0	150	4	T62	DN
	200	02								
	300	03	300	30						
	400	04								
	500	05	400	40						
	600	06								
	700	07								
	800	08								
	900	09								
	1000	10								
	1100	11								
	1200	12								

Example
Obtain optimum device performance for your application by selecting proper Order Code.

Type T625 rated at 400A average with V_{DRM}= 1000V, I_{GT}=150 ma, and standard lead—order as:

	Type			Voltage		Current		Turn-Off	Gate Current	Lead	
T	6	2	5	1	0	4	0	0	4	D	N

250—400 A. Avg. Up to 1200 Volts

Phase Control, Hi-temp SCR T625

Voltage

Blocking State Maximums ② (T_J=150°C)	Symbol	T625											
Repetitive peak forward blocking voltage, V	V_{DRM}	100	200	300	400	500	600	700	800	900	1000	1100	1200
Repetitive peak reverse voltage, V	V_{RRM}	100	200	300	400	500	600	700	800	900	1000	1100	1200
Non-repetitive transient peak reverse voltage, t≤5.0 msec, V	V_{RSM}	200	300	400	500	600	700	850	950	1100	1200	1300	1450
Forward leakage current, mA peak	I_{DRM}	← 50 →											
Reverse leakage current, mA peak	I_{RRM}	← 50 →											

Current

Conducting State Maximums (T_J=150°C)	Symbol	T625— —25	T625— —30	T625— —40
RMS forward current, A	$I_{T(rms)}$	390	470	625
Ave. forward current, A	$I_{T(av)}$	250	300	400
One-half cycle surge current③, A	I_{TSM}	2800	3600	5000
3 cycle surge current③, A	I_{TSM}	2000	2600	3500
10 cycle surge current③, A	I_{TSM}	1700	2250	3000
I^2t for fusing (for times>8.3 ms) A^2 sec	I^2t	32,500	54,000	100,000
Forward voltage drop at I_{TM}=625A and T_J=25°C, V	V_{TM}	2.60	2.05	1.55

Switching

(T_J=25°C)	Symbol	
Typical turn-off time, I_T=150A T_J=150°C, di_R/dt=12.5 A/μsec, reapplied dv/dt=20V/μsec linear to 0.8 V_{DRM}, μsec	t_q	150
Typ. turn-on-time, I_T=100A V_D=500V④, μsec	t_{on}	3
Min. critical dv/dt, exponential to V_{DRM} T_J=150°C, V/μsec②⑤	dv/dt	300
Min. di/dt repetitive, A/μsec ①④⑥	di/dt	200
Min. di/dt non-repetitive, A/μsec ①④⑥	di/dt	800

Gate

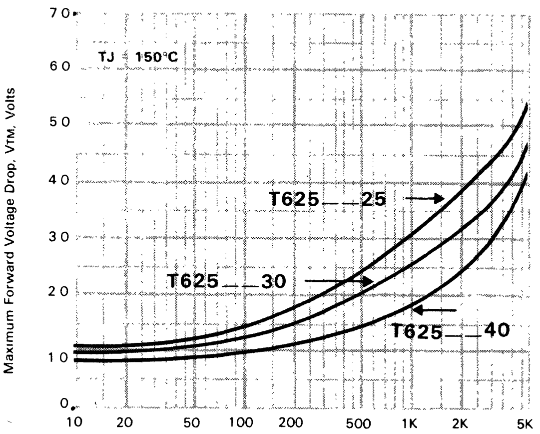
Maximum Parameters (T_J=25°C)	Symbol	
Gate current to trigger at V_D=12V, mA	I_{GT}	150
Min. Gate Current to trigger at V_D=12V, mA	$I_{GT(min)}$	25
Gate voltage to trigger at V_D=12V, V.	V_{GT}	3
Non-triggering gate voltage, T_J =150°C, and rated V_{DRM}, V	V_{GDM}	0.25
Peak forward gate current, A	I_{GTM}	4
Peak reverse gate voltage, V	V_{GRM}	5
Peak gate power, Watts	P_{GM}	16
Average gate power, Watts	$P_{G(av)}$	3

Thermal and Mechanical

	Symbol	
Min., Max. oper. junction temp., °C	T_J	−40 to +150
Min., Max. storage temp., °C	T_{stg}	−40 to +150
Min., Max. Mounting Force, lb①		1000 to 1400
Thermal resistance with double sided cooling① Junction to case, °C/Watt	$R\theta JC$	.08
Case to sink, lubricated, ① °C/Watt	$R\theta CS$	.02

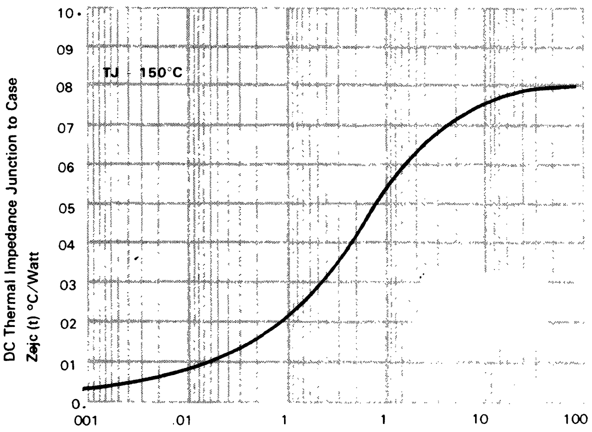
① Consult recommended mounting procedures.
② Applies for zero or negative gate bias.
③ Per JEDEC RS-397, 5.2.2.1.
④ With recommended gate drive.
⑤ Higher dv/dt ratings available, consult factory.
⑥ Per JEDEC standard RS-397, 5.2.2.6.

Maximum Forward Voltage VS. Forward Current



Forward Current, ITM, Peak Amperes

Transient Thermal Impedance VS. Time



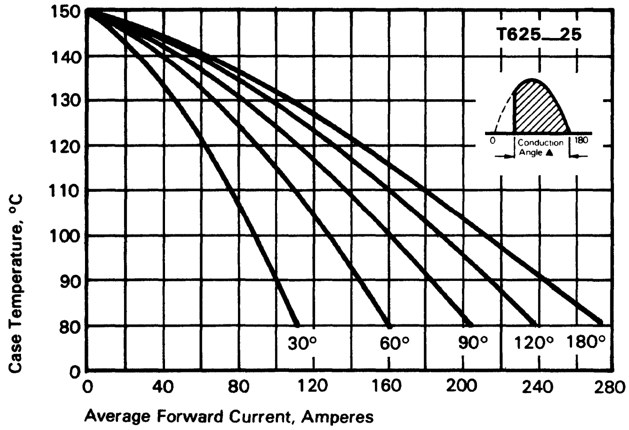
Time, t, Seconds

THYRISTOR

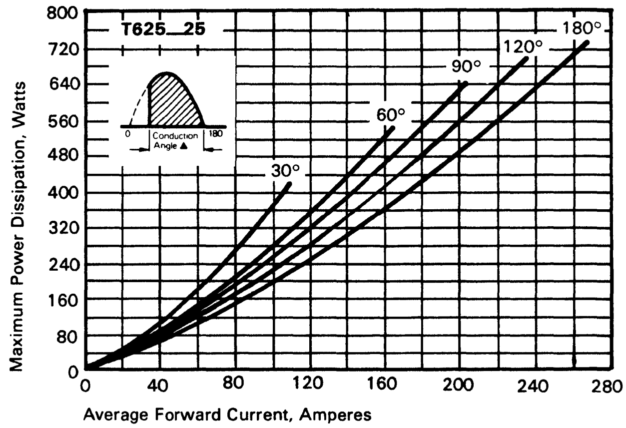
Phase Control, Hi-temp SCR T625

250—400 A. Avg. Up to 1200 Volts

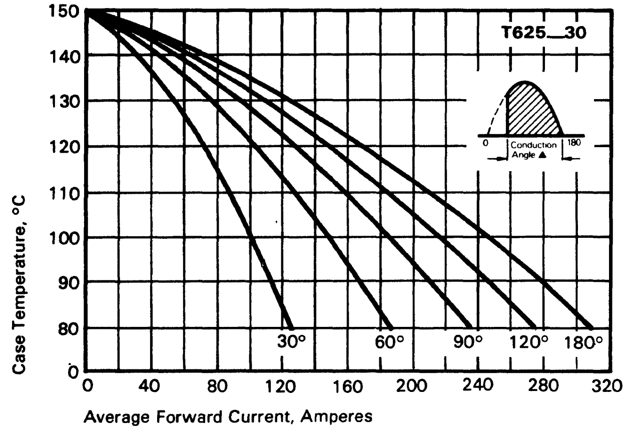
Maximum Case Temperature VS. Forward Current



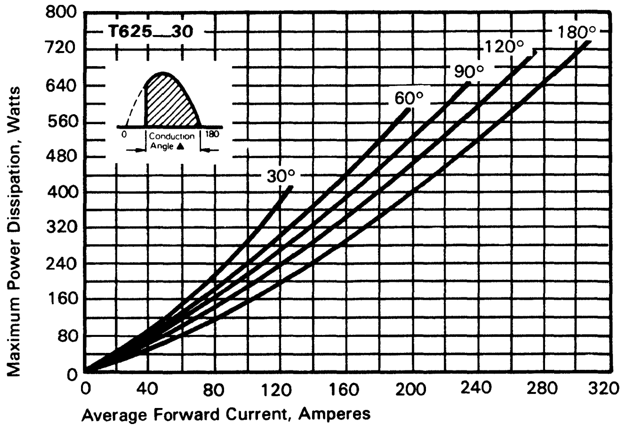
Maximum Power Dissipation VS. Forward Current



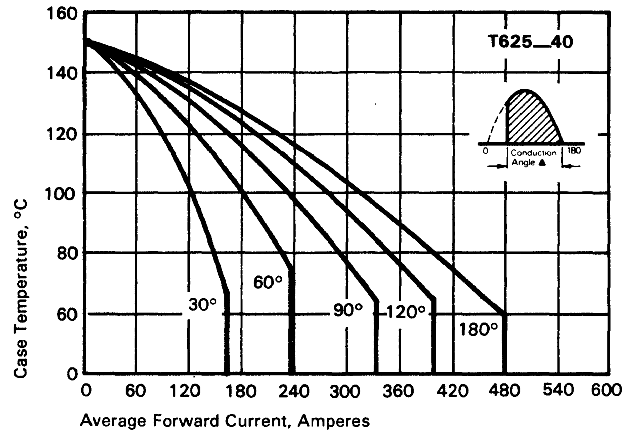
Maximum Case Temperature VS. Forward Current



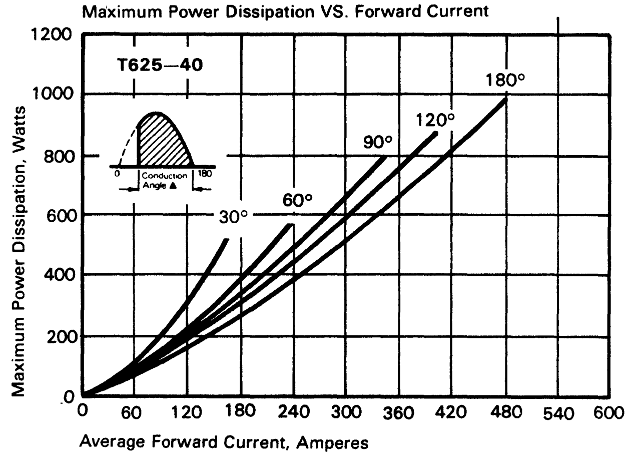
Maximum Power Dissipation VS. Forward Current



Maximum Case Temperature VS. Forward Current



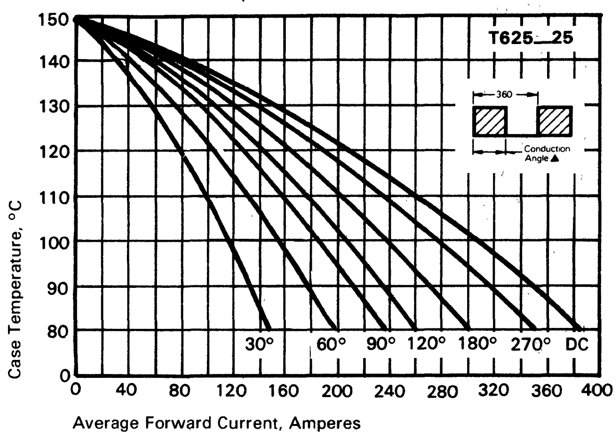
Maximum Power Dissipation VS. Forward Current



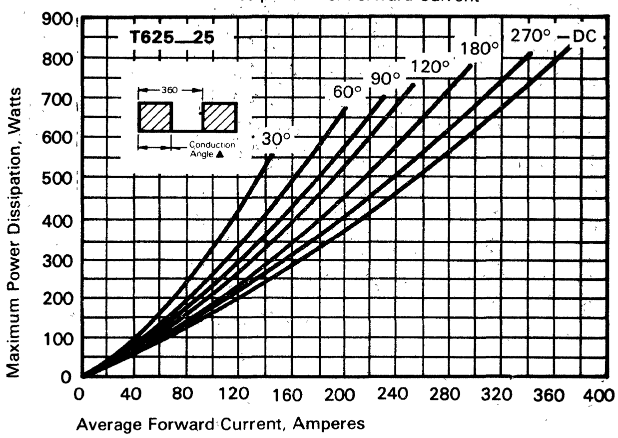
250—400 A. Avg. Up to 1200 Volts

Phase Control, Hi-temp SCR T625

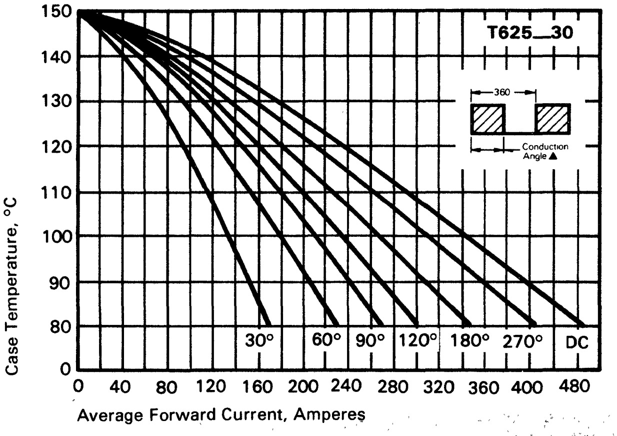
Maximum Case Temperature VS. Forward Current



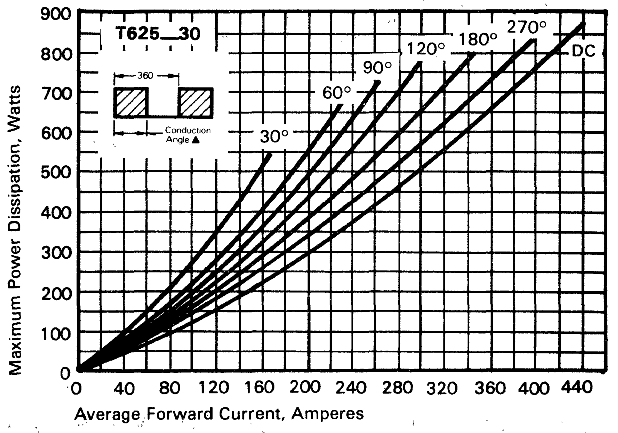
Maximum Power Dissipation Vs. Forward Current



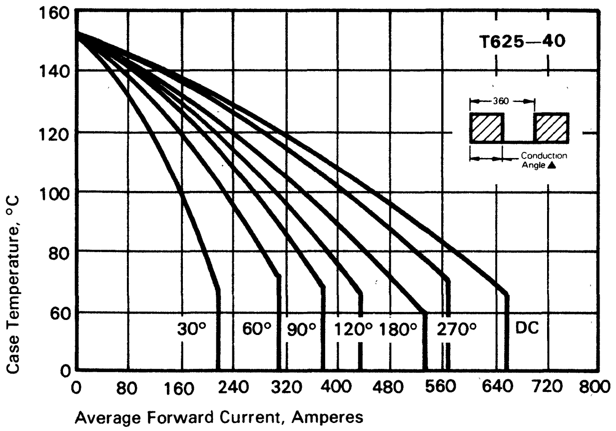
Maximum Case Temperature VS. Forward Current



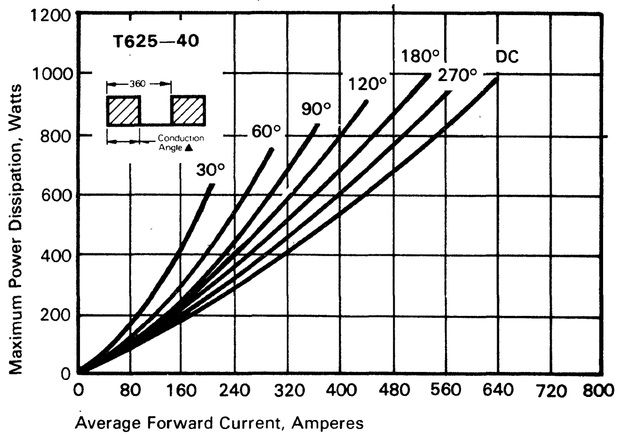
Maximum Power Dissipation VS. Forward Current



Maximum Case Temperature VS. Forward Current



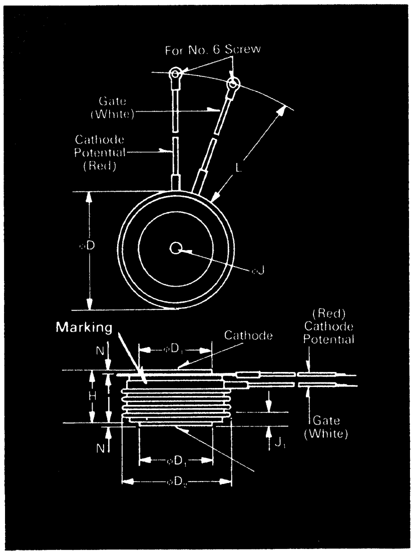
Maximum Power Dissipation VS. Forward Current



THYRISTOR

Phase Control SCR T720

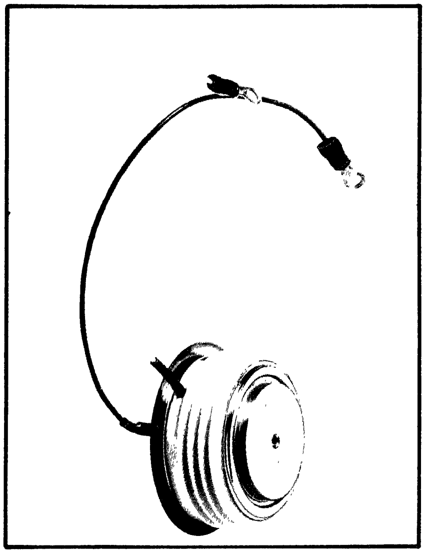
350-550 A Avg Up to 2200 Volts



T72 Outline

Symbol	Inches Min.	Inches Max.	Millimeters Min.	Millimeters Max.
ϕD	2.250	2.290	57.15	58.17
ϕD_1	1.333	1.343	33.86	34.11
ϕD_2	2.030	2.090	51.56	53.09
H	1.020	1.060	25.91	26.92
ϕJ	.135	.145	3.43	3.68
J_1	.075	.090	1.91	2.29
L	7.75	8.50	196.85	215.90
N	.040		1.02	

Creep Distance—1.00 in. min. (25.40 mm).
Strike Distance—1.02 in. min. (25.91 mm).
(In accordance with NEMA standards.)
Finish—Nickel Plate.
Approx. Weight—8 oz. (227 g).
1. Dimension "H" is a clamped dimension.



Package I^2t (case rupture) rating: 80 x 10^6 A^2sec.

Features:
- Center fired di/namic gate
- All diffused design
- Low gate current
- Low V_{TM}
- Low Thermal Impedance
- High surge current capability
- Lifetime Guarantee

Applications:
- Phase Control
- Motor Control
- Power Supplies
- Welding

Ordering Information

Type	Voltage		Current		Turn-off		Gate current		Leads	
Code	V_{DRM} and V_{RRM} (V)	**Code**	$I_{T(av)}$ (A)	**Code**	tq (μsec)	**Code**	I_{GT} (ma)	**Code**	Case	**Code**
T720	100	**01**	350	**35**	150 (typical)	**0**	150	**4**	T72	**DN**
	200	**02**								
	400	**04**	450	**45**						
	600	**06**								
	800	**08**	550	**55**						
	1000	**10**								
	1200	**12**								
	1300	**13**								
	1400	**14**								
	1500	**15**								
	1600	**16**								
	1700	**17**								
	1800	**18**								
	2000	**20**								
	2200	**22**								

Example

Obtain optimum device performance for your application by selecting proper order code.

Type T720 rated at 550A average with V_{DRM} = 1000V, I_{GT} = 150 ma, and standard flexible lead—order as:

Type			Voltage		Current		Turn Off	Gate Current	Leads	
T	7	2	0	1	0	5	5	0	4	D	N

THYRISTOR

350-550 A Avg
Up to 2200 Volts

Phase Control SCR T720

Voltage

Blocking State Maximums ② (T_J = 125°C)

	Symbol															
Repetitive peak forward blocking voltage, V	V_{DRM}	100	200	400	600	800	1000	1200	1300	1400	1500	1600	1700	1800	2000	2200
Repetitive peak reverse voltage, V	V_{RRM}	100	200	400	600	800	1000	1200	1300	1400	1500	1600	1700	1800	2000	2200
Non-repetitive transient peak reverse voltage, t ≤ 5.0 msec, V	V_{RSM}	200	300	500	700	950	1200	1450	1550	1700	1800	1900	2050	2150	2400	2600

T720 _ _ 55: 100 through 1600 V

T720 _ _ 35, T720 _ _ 45: 100 through 2200 V

	Symbol	
Forward leakage current, mA peak	I_{DRM}	30
Reverse leakage current, mA peak	I_{RRM}	30

Current

Conducting State Maximums (T_J = 125°C)

	Symbol	T720 _ _ 35	T720 _ _ 45	T720 _ _ 55
RMS forward current, A	$I_{T(rms)}$	550	700	850
Ave. forward current, A	$I_{T(av)}$	350	450	550
One-half cycle surge current③, A	I_{TSM}	7000	8400	10,000
3 cycle surge current③, A	I_{TSM}	5040	6050	7200
10 cycle surge current③, A	I_{TSM}	4340	5200	6200
I^2t for fusing (for times ≥ 8.3 ms) A^2 sec.	I^2t	205,000	295,000	416,000
Forward voltage drop at I_{TM} = 3000 A and T_J = 25°C, V	V_{TM}	3.30	2.75	2.15

Switching

(T_J = 25°C)

	Symbol	
Typical turn-off time, I_T = 250A, T_J = 125°C, di_R/dt = 25 A/μsec, reapplied dv/dt = 20V/μsec linear to 0.8 V_{DRM}, μ sec	t_q	150
Typ. turn-on-time, I_T = 100A V_D = 100V④, μsec	t_{on}	7
Min. critical dv/dt, exponential to V_{DRM}, T_J = 125°C, V/μsec②⑤	dv/dt	300
Min. di/dt non-repetitive, A/μsec ①④⑥	di/dt	600

Thermal and Mechanical

	Symbol	
Min., Max. oper. junction temp., °C	T_J	−40 to +125
Min., Max. storage temp., °C	Tstg	−40 to +150
Min., Max. mounting force, lb.①		2000 to 2400
Max. Thermal resistance① With double sided cooling Junction to case, °C/Watt	$R_{\theta JC}$	.06
Case to sink, lubricated, °C/Watt	$R_{\theta CS}$	.02

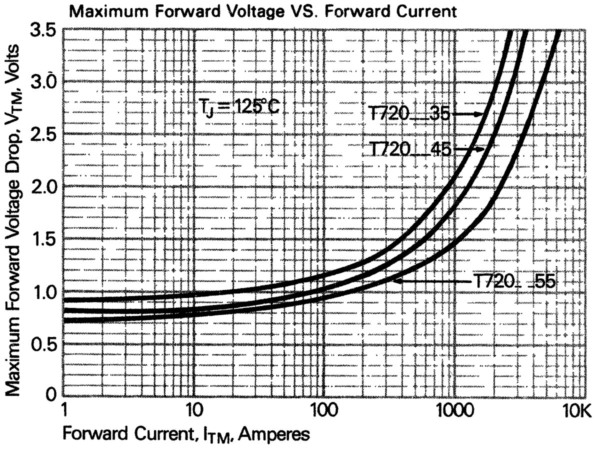
Gate

Maximum Parameters (T_J = 25°C)

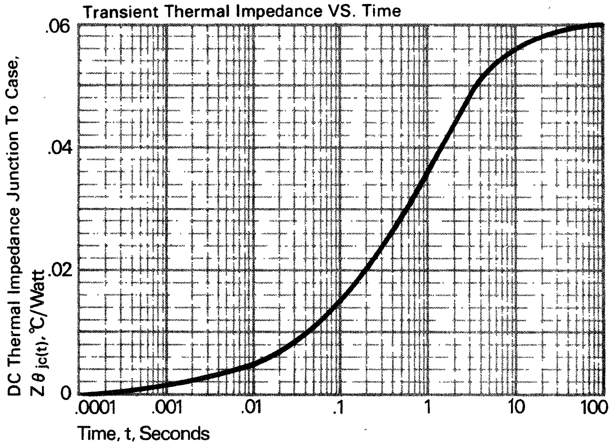
	Symbol	
Gate current to trigger at V_D = 12V, mA	I_{GT}	150
Gate voltage to trigger at V_D = 12V, V	V_{GT}	3
Non-triggering gate voltage, T_J = 125°C, and rated V_{DRM}, V	V_{GDM}	0.15
Peak forward gate current, A	I_{GTM}	4
Peak reverse gate voltage, V	V_{GRM}	5
Peak gate power, Watts	P_{GM}	16
Average gate power, Watts	$P_{G(av)}$	3

① Consult recommended mounting procedures.
② Applies for zero or negative gate bias.
③ Per JEDEC RS-397, 5.2.2.1.
④ With recommended gate drive.
⑤ Higher dv/dt ratings available, consult factory.
⑥ Per JEDEC standard RS-397, 5.2.2.6.

Maximum Forward Voltage VS. Forward Current



Transient Thermal Impedance VS. Time

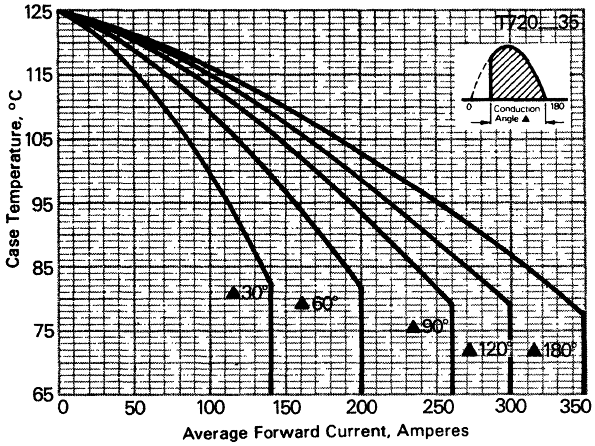


Phase Control SCR T720

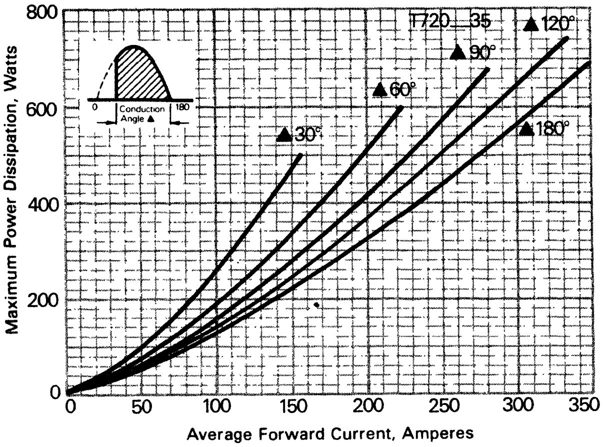
350-550 A Avg Up to 2200 Volts

THYRISTOR

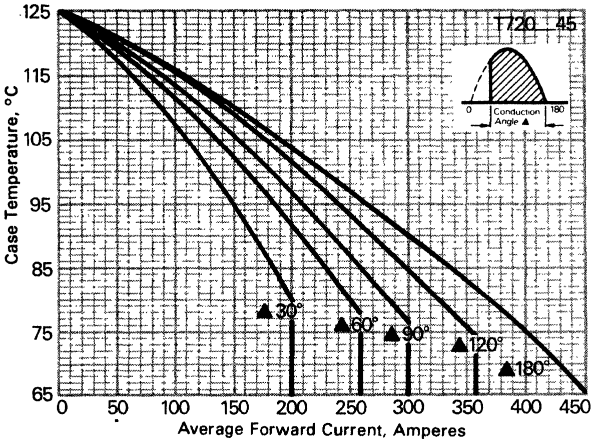
Maximum Case Temperature VS. Forward Current



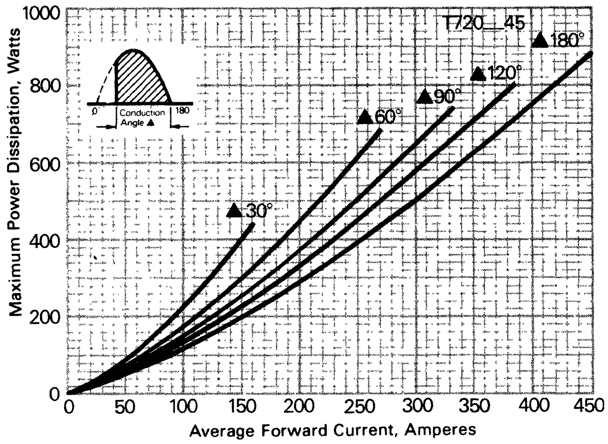
Maximum Power Dissipation VS. Forward Current



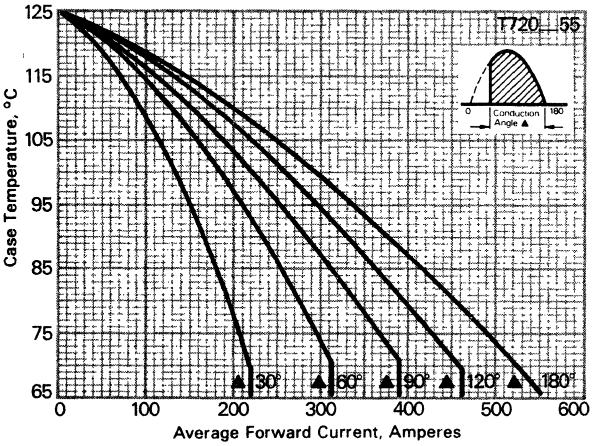
Maximum Case Temperature VS. Forward Current



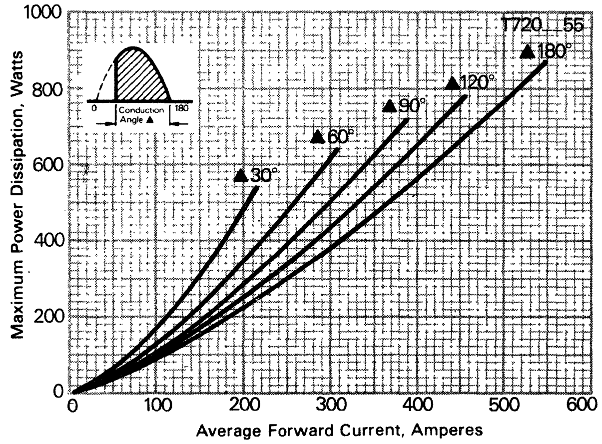
Maximum Power Dissipation VS. Forward Current



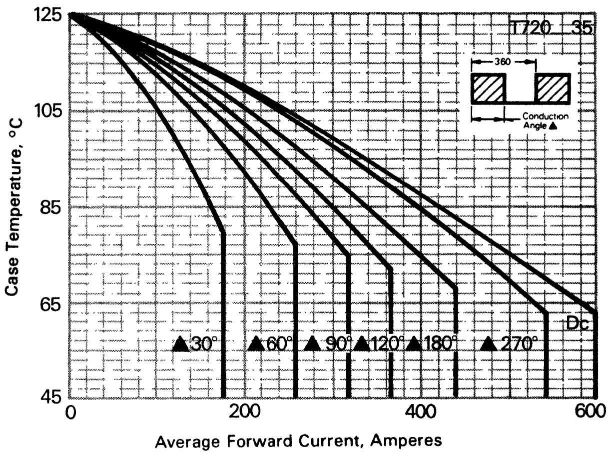
Maximum Case Temperature VS. Forward Current



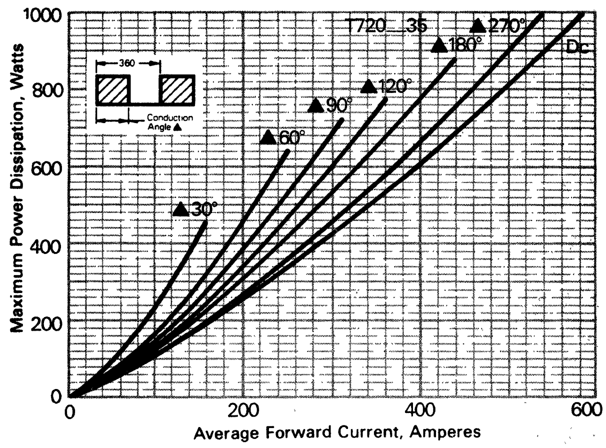
Maximum Case Temperature VS. Forward Current



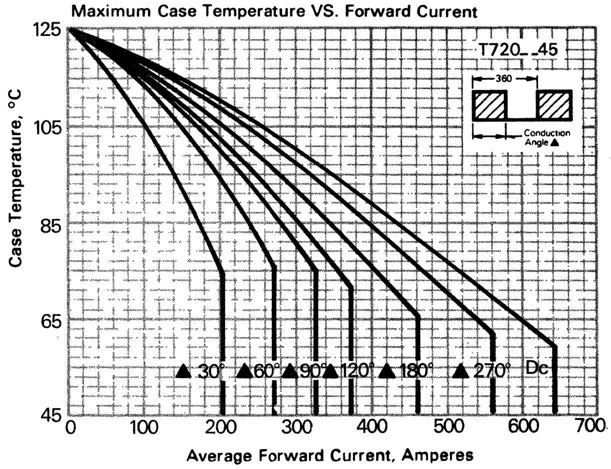
Maximum Case Temperature VS. Forward Current



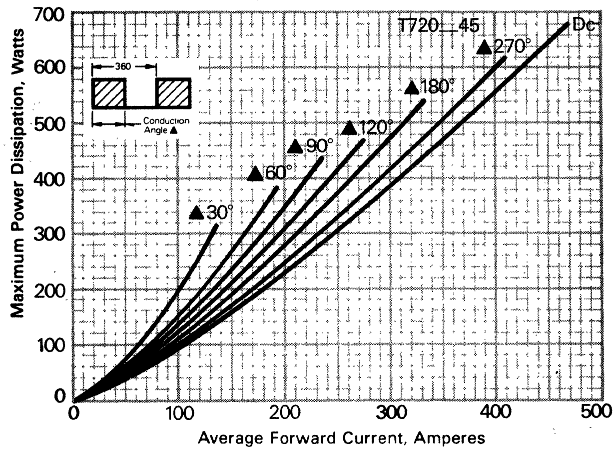
Maximum Power Dissipation Vs. Forward Current



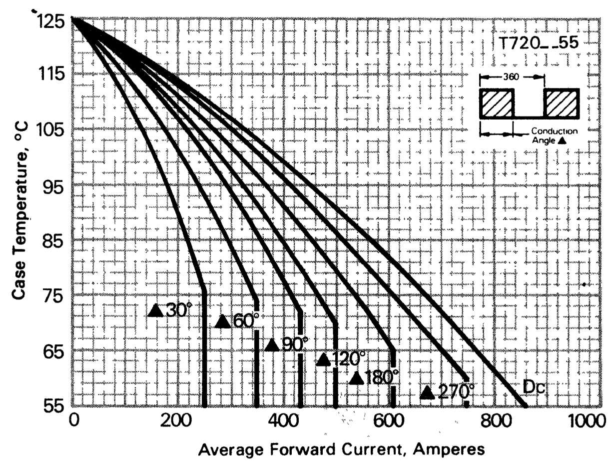
Maximum Case Temperature VS. Forward Current



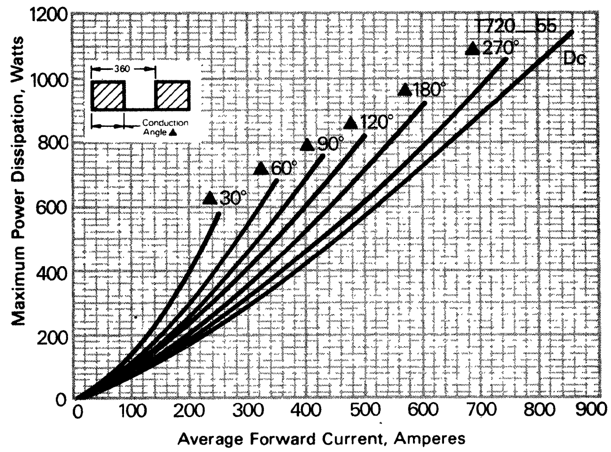
Maximum Power Dissipation VS. Forward Current



Maximum Case Temperature VS. Forward Current



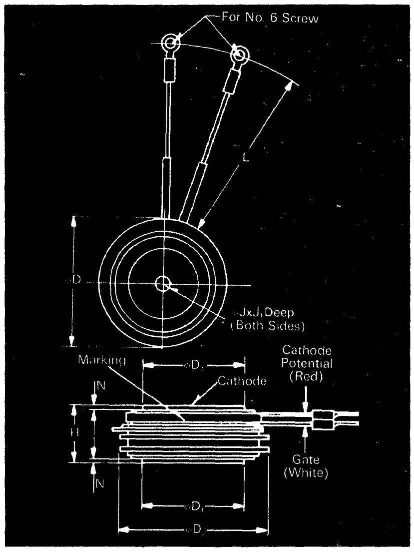
Maximum Power Dissipation VS. Forward Current



THYRISTOR

Phase Control SCR T920

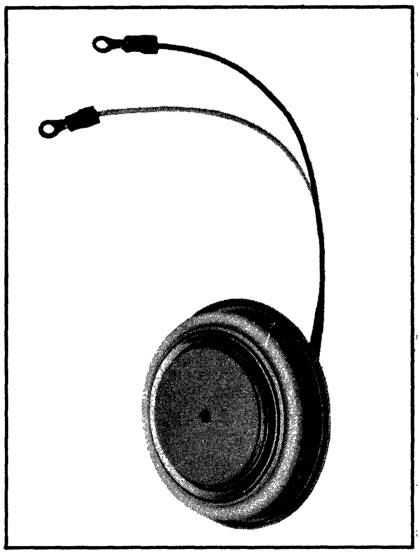
600 — 1000 A Avg. Up to 3000 Volts



T92 Outline

Symbol	Inches Min.	Inches Max.	Millimeters Min.	Millimeters Max.
ϕD	2.880	2.920	73.15	74.17
ϕD_1	1.744	1.755	44.30	44.58
ϕD_2	2.580	2.700	65.53	68.58
H	1.020	1.060	25.91	26.92
ϕJ	.135	.145	3.43	3.68
J_1	.075	.090	1.91	2.29
L	11.50	12.50	292.10	317.50
N	.060		1.27	

Creep Distance—.80 in. min. (20.32 mm).
Strike Distance—1.02 in. min. (25.91 mm).
(In accordance with NEMA standards.)
Finish—Nickel Plate.
Approx. Weight—16 oz. (454 g).
1. Dimension "H" is a clamped dimension.



Package I^2t (Case rupture) rating:
90 x 10^6 A^2sec.

Features:
- Center fired di/namic gate
- All diffused design
- Guaranteed dv/dt (300 v/μs)
- Low gate current with soft gate control
- Low V_{TM}
- Low Thermal Impedance
- High surge current capability
- Westinghouse Lifetime Guarantee

Applications:
- Phase Control
- Motor Control
- Power Supplies

Ordering Information

Type	Voltage		Current		Turn-off		Gate current		Leads	
Code	V_{DRM} and V_{RRM} (V)	Code	$I_{T(av)}$ (A)	Code	tq (μsec)	Code	I_{GT} (ma)	Code	Case	Code
T920	600	06			400	0	200	3	T92	DW
	800	08			(typical)					
	1000	10	600	06						
	1200	12								
	1400	14								
	1600	16	700	07	250	0				
	1800	18			(typical)					
	2000	20	800	08						
	2200	22								
	2400	24	900	09	150	0				
	2600	26			(typical)					
	2800	28	1000	10						
	3000	30								

Note: Lower voltage devices available. Consult factory representative.

Example

Obtain optimum device performance for your application by selecting proper order code.

Type T920 rated at 600 A average with V_{DRM} = 2600V. I_{GT} = 200 ma. and standard 12 inch leads—order as:

Type				Voltage		Current		Turn Off	Gate Current	Leads	
T	9	2	0	2	6	0	6	0	3	D	W

THYRISTOR

600 — 1000 A Avg. Up to 3000 Volts

Phase Control SCR T920

Voltage②

Blocking State Maximums (T_J = 125°C)

	Symbol													
Repetitive peak forward blocking voltage, V	V_{DRM}	600	800	1000	1200	1400	1600	1800	2000	2200	2400	2600	2800	3000
Repetitive peak reverse voltage, V	V_{RRM}	600	800	1000	1200	1400	1600	1800	2000	2200	2400	2600	2800	3000
Non-repetitive transient peak reverse voltage, t 5.0 msec, V	V_{RSM}	700	900	1100	1300	1500	1700	1900	2100	2300	2800	3000	3200	3400

Voltage vs. Type No. Availability:
- T920_09 — T920_10 (600–1800 V)
- T920_07 — T920_08 (600–2200 V)
- T920_06 (600–3000 V)

	Symbol	
Forward leakage current, mA peak	I_{DRM}	60
Reverse leakage current, mA peak	I_{RRM}	60

Current

Conducting State Maximums (T_J = 125°C)	Symbol	T920_06	T920—07	T920—08	T920—09	T920—10
RMS forward current, A	$I_{T(rms)}$	940	1100	1255	1415	1570
Ave. forward current, A	$I_{T(av)}$	600	700	800	900	1000
One-half cycle surge current③, A	I_{TSM}	13,000	15,000	17,000	25,000	27,000
3 cycle surge current③, A	I_{TSM}	9,750	10,800	12,200	18,700	20,200
10 cycle surge current③, A	I_{TSM}	8,000	9000	10,200	15,400	16,700
I^2t for fusing (t=8.3 ms), A^2sec	I^2t	700,000	937,000	1,203,000	2,600,000	3,040,000
Max I^2t of package (t=8.3 ms), A^2sec	I^2t	90 x 10^6	90 x 10^6	90 x 10^6	90 x 10^6	90 x 10^6
Forward voltage drop at I_{TM} = 3000 and T_J = 25°C, V	V_{TM}	3.0	2.55	2.10	1.90	1.70

Switching

(T_J=25°C)	Symbol	Min	Typ	Max	Min	Typ	Max	Min	Typ	Max
Turn-off time, I_T=250A T_J=125°C, di_R/dt=50 A/μsec reapplied dv/dt= 20V/μsec linear to 0.8 V_{DRM}, μsec	tq		400			250			150	
Turn-On and Delay Time I_{TM}=1000A④, tp=450 μsec	ton		3.5			3.5			2.5	
μsec	td		1.5	V_D = 1100V		1.5	V_D = 600V		1.0	V_D= 600V
Critical dv/dt exponential to V_{DRM} T_J=125°C, V/μsec②⑤	dv/dt	300	1000		300	1000		300	1000	
di/dt④non-repetitive, ①④⑥ A/μsec	di/dt			800			800			800
Latching Current V_D=75V, mA	I_L		150	500		400	1000		300	500
Holding Current V_D=75V, mA	I_H		150	500		150	500		150	500

Gate

(T_J=25°C)	Symbol	Min	Typ	Max
Gate current to trigger at V_D=12V, mA	I_{GT}		100	200
Gate voltage to trigger at V_D=12V, V	V_{GT}		1.5	3.0
Non-triggering gate voltage, T_J=125°C, and rated V_{DRM}, V	V_{GDM}			.15
Non-triggering Gate Current at V_D=12V, mA	I_{GNT}		20	
Peak forward gate current, A	I_{GTM}			4
Peak reverse gate voltage, V	V_{GRM}			5
Peak gate power, Watts	P_{GM}			16
Average gate power, Watts	$P_{G(av)}$			3

Thermal and Mechanical

	Symbol	Min	Typ	Max
Oper. junction temp., °C	T_J	—40		125
Storage temp., °C	T_{stg}	—40		150
Mounting force, lb.①		5000		5500
Thermal resistance with double sided cooling①				
Junction to case, °C/Watt	$R\theta_{JC}$		.028	.03
Case to sink, lubricated, °C/Watt	$R\theta_{CS}$		.008	.01

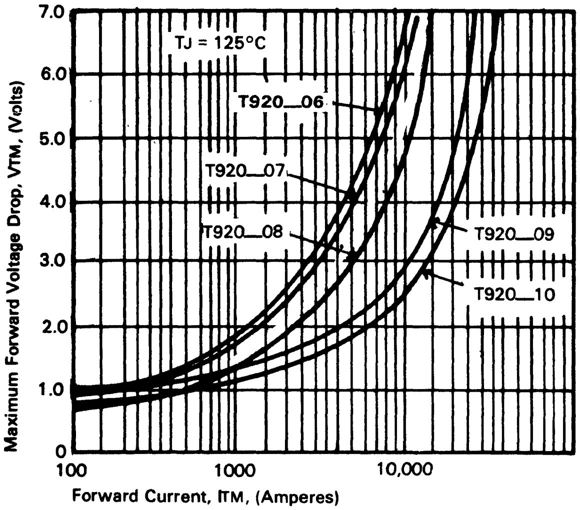
① Consult recommended mounting procedures.
② Applies for zero or negative gate bias.
③ Per JEDEC RS-397, 5.2.2.1.
④ With recommended gate drive.
⑤ Higher dv/dt ratings available, consult factory.
⑥ Per JEDEC standard RS-397, 5.2.2.6.

THYRISTOR

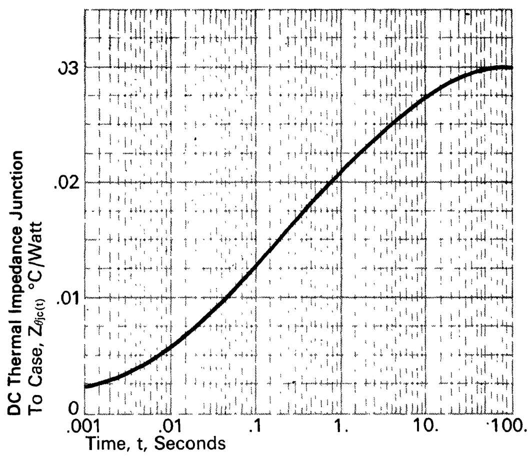
Phase Control SCR T920

600 — 1000 A Avg. Up to 3000 Volts

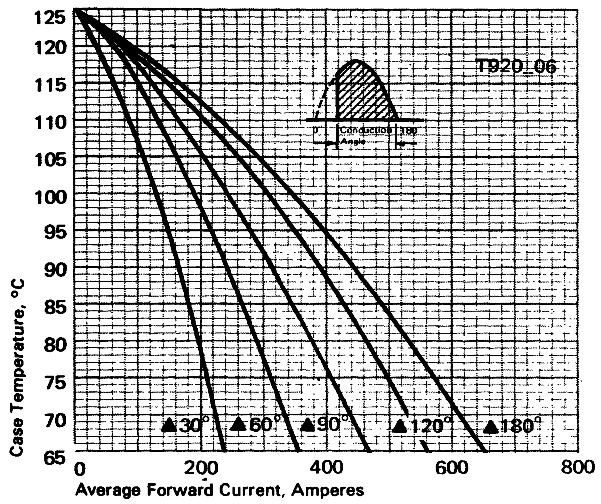
Maximum Forward Voltage VS. Forward Current



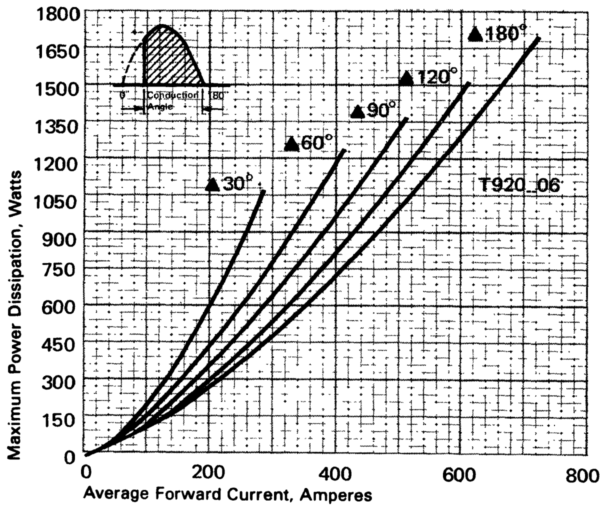
Transient Thermal Impedance VS. Time



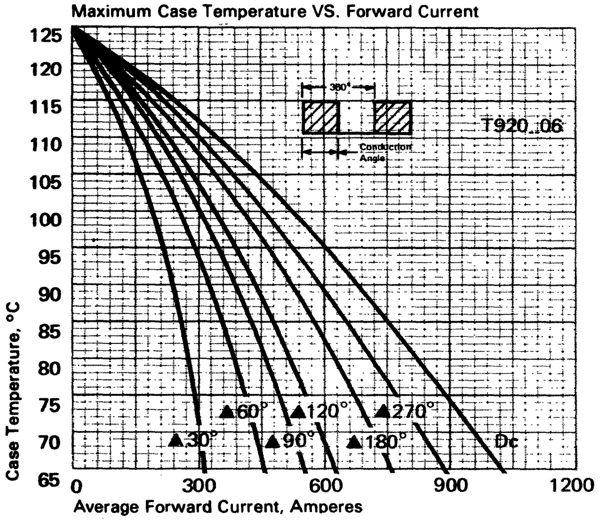
Maximum Case Temperature VS. Forward Current



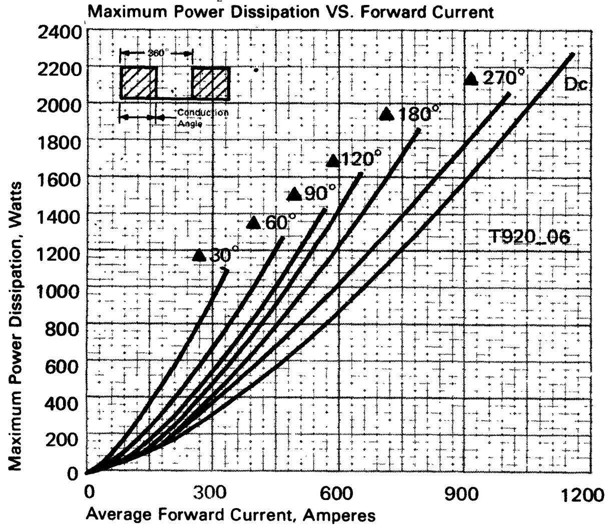
Maximum Power Dissipation VS. Forward Current



Maximum Case Temperature VS. Forward Current



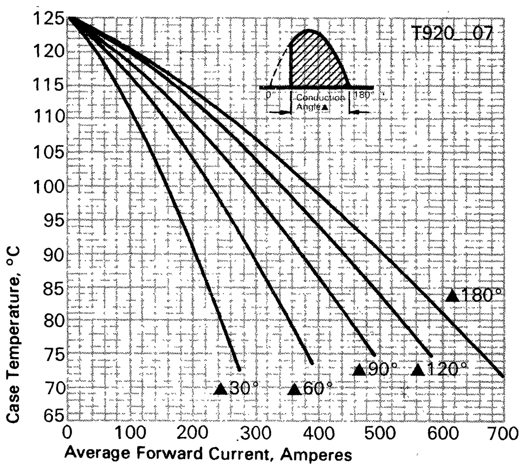
Maximum Power Dissipation VS. Forward Current



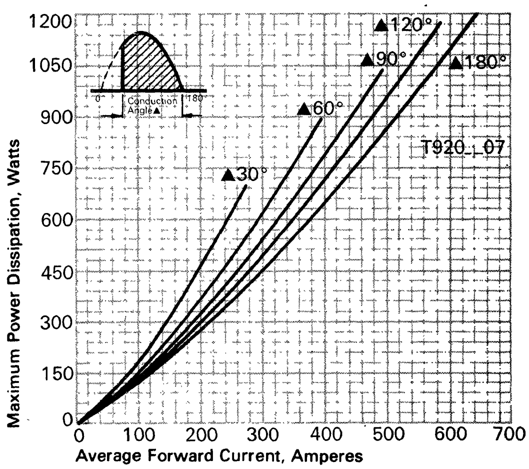
THYRISTOR

Phase Control SCR T920

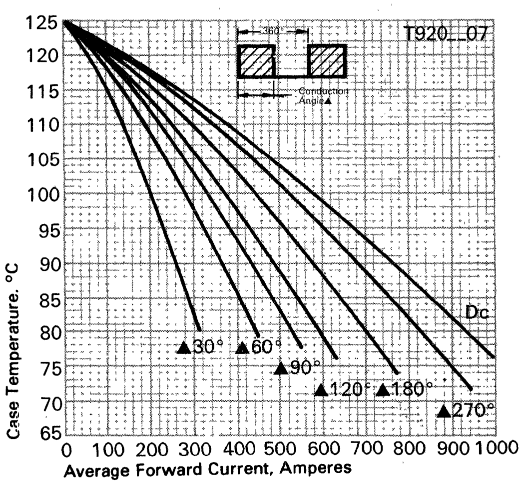
Maximum Case Temperature VS. Forward Current



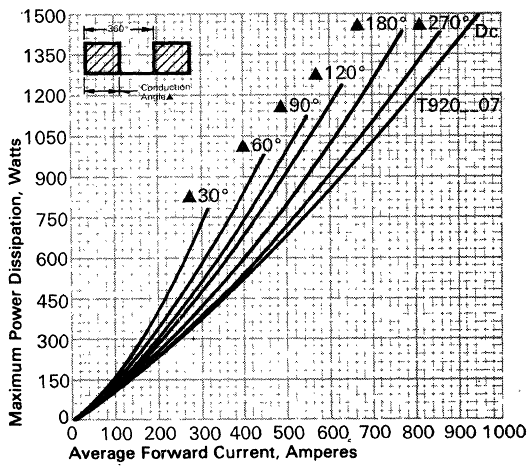
Maximum Power Dissipation VS. Forward Current



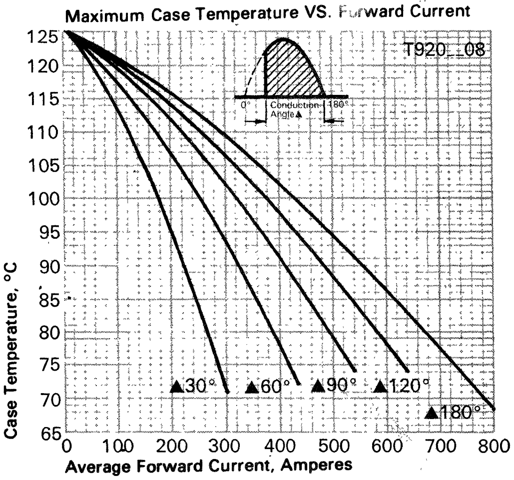
Maximum Case Temperature VS. Forward Current



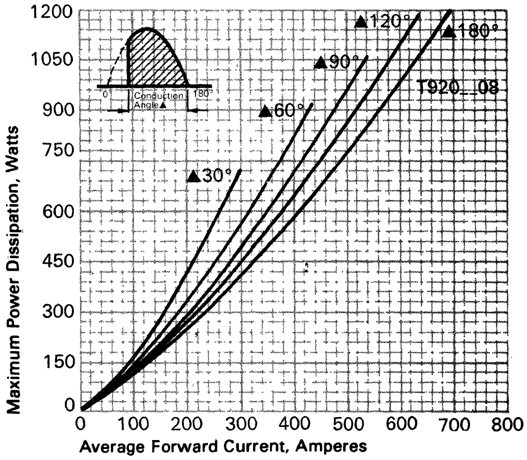
Maximum Power Dissipation VS. Forward Current



Maximum Case Temperature VS. Forward Current



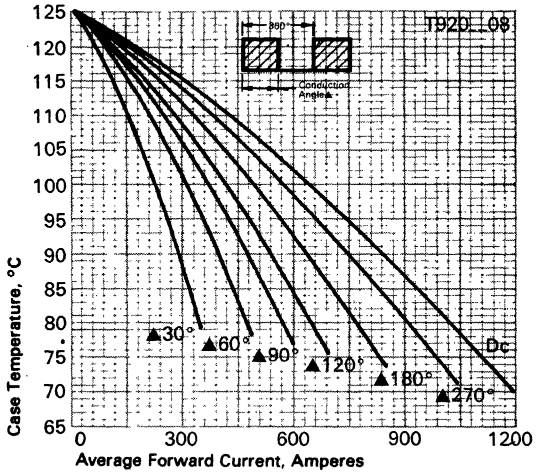
Maximum Power Dissipation VS. Forward Current



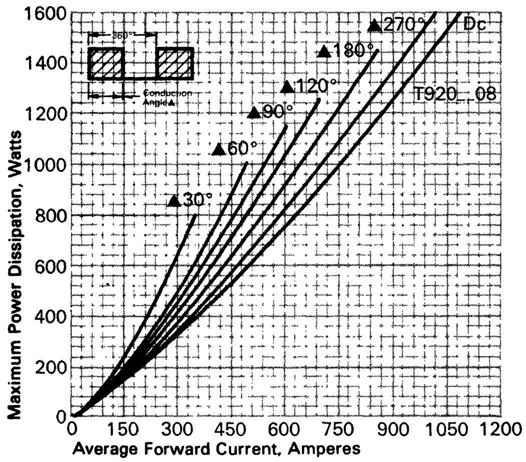
Phase Control
SCR
T920

600 — 1000 A Avg.
Up to 3000 Volts

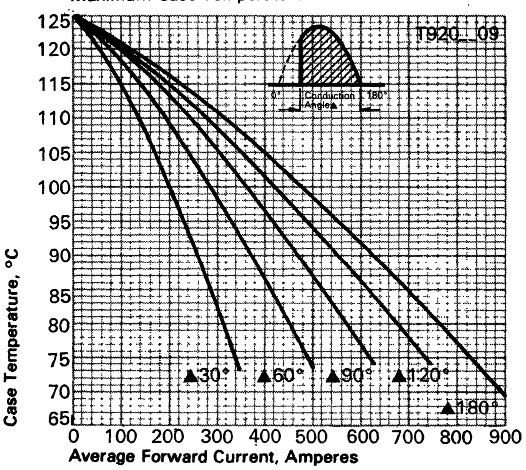
Maximum Case Temperature VS. Forward Current



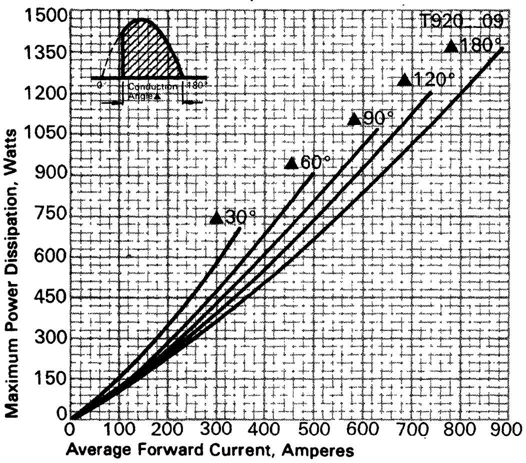
Maximum Power Dissipation VS. Forward Current



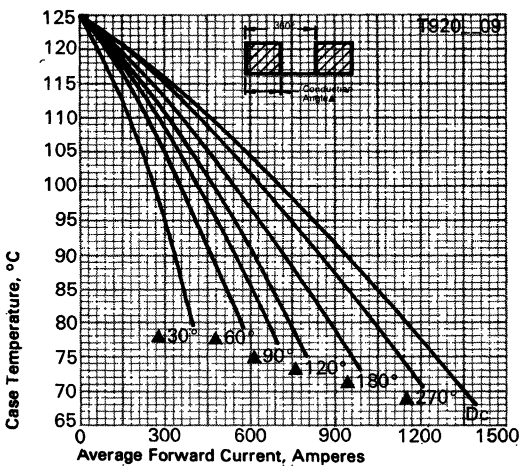
Maximum Case Temperature VS. Forward Current



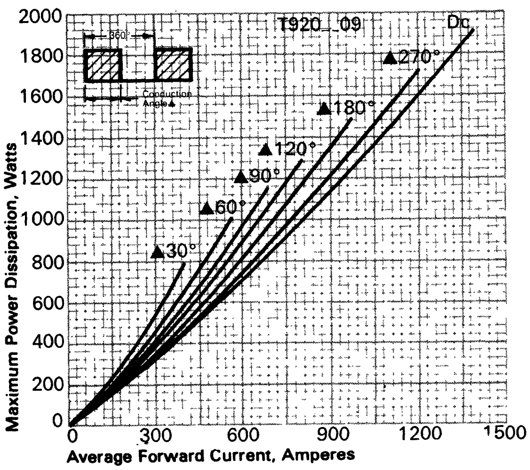
Maximum Power Dissipation VS. Forward Current

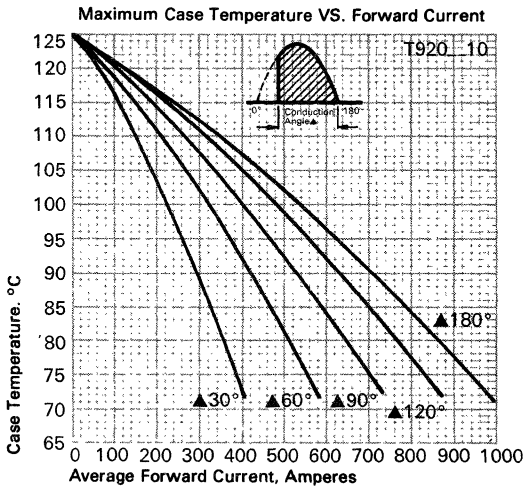


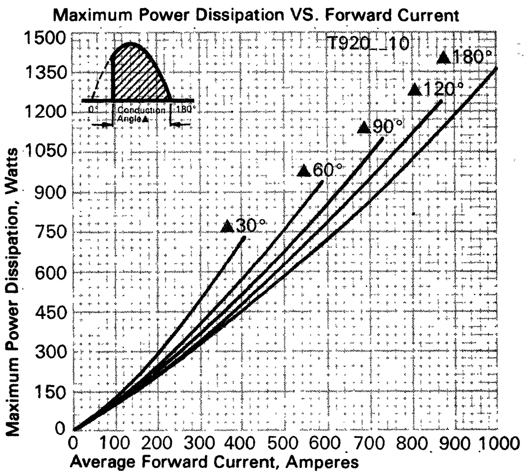
Maximum Case Temperature VS. Forward Current

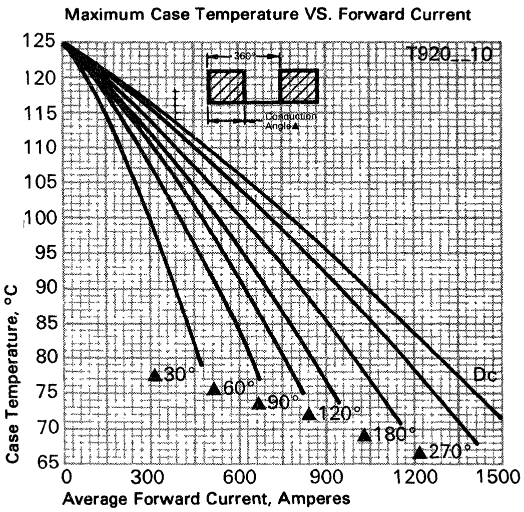


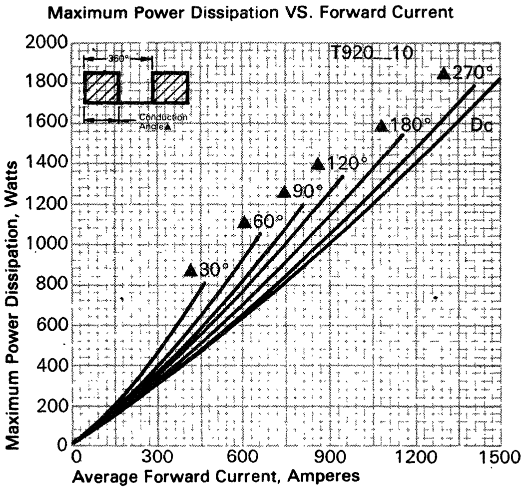
Maximum Power Dissipation VS. Forward Current




Maximum Case Temperature VS. Forward Current
T920__10
Conduction Angle▲
Case Temperature. °C
Average Forward Current, Amperes
▲30°
▲60°
▲90°
▲120°
▲180°


Maximum Power Dissipation VS. Forward Current
T920__10
Conduction Angle▲
Maximum Power Dissipation, Watts
Average Forward Current, Amperes
▲30°
▲60°
▲90°
▲120°
▲180°

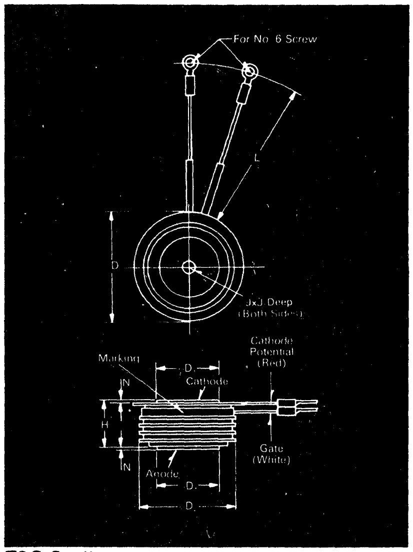

Maximum Case Temperature VS. Forward Current
T920__10
360°
Conduction Angle▲
Case Temperature, °C
Average Forward Current, Amperes
▲30°
▲60°
▲90°
▲120°
▲180°
▲270°
Dc


Maximum Power Dissipation VS. Forward Current
T920__10
360°
Conduction Angle▲
Maximum Power Dissipation, Watts
Average Forward Current, Amperes
▲30°
▲60°
▲90°
▲120°
▲180°
▲270°
Dc

THYRISTOR

Phase Control SCR T9G0

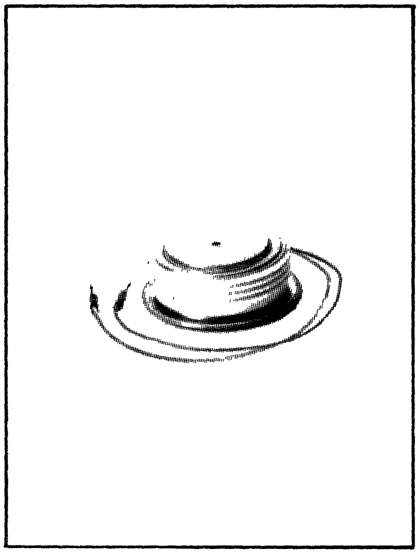
800 — 1200 A. Avg. Up to 3000 Volts



T9G Outline

Symbol	Inches Min.	Inches Max.	Millimeters Min.	Millimeters Max.
ϕD	2.850	2.900	72.39	73.66
ϕD_1	1.845	1.855	46.86	47.12
ϕD_2	2.560	2.640	65.02	67.06
H	1.020	1.060	25.91	26.92
ϕJ	.135	.145	3.43	3.68
J_1	.075	.090	1.91	2.29
L	11.50	12.50	292.10	317.50
N	.050		1.27	

Creep Distance—1.00 in. min. (25.40 mm).
Strike Distance—1.02 in. min. (25.91 mm).
(In accordance with NEMA standards.)
Finish—Nickel Plate.
Approx. Weight— 1 lb. (454g).
1. Dimension "H" is a clamped dimension.



Package I^2t (case rupture) rating:
90 x $10^6 A^2$sec.

Features:
- Center fired di/namic gate
- All diffused design
- Guaranteed dv/dt (300 v/µs)
- Low gate current with soft gate control
- Low V_{TM} • Strain Buffer
- Low Thermal Impedance
- High surge current capability
- Westinghouse Lifetime Guarantee

Applications:
- Phase Control
- Motor Control
- Power Supplies

Type	Voltage		Current		Turn-off		Gate current		Leads	
Code	V_{DRM} and V_{RRM} (V)	Code	$I_{T(av)}$ (A)	Code	tq (µsec)	Code	I_{GT} (ma)	Code	Case	Code
T9G0*	600	06								
	800	08								
	1000	10	800	08	400	0	200	3	T9G	DH
	1200	12			(typical)					
	1400	14	1000	10	250	0				
	1600	16			(typical)					
	1800	18								
	2000	20	1200	12	150	0				
	2200	22			(typical)					
	2400	24								
	2600	26								
	2800	28								
	3000	30								

Note; Lower voltage devices available. Consult factory representative.

Example

Obtain optimum device performance for your application by selecting proper order code.

Type T9G0 rated at 800 A average with V_{DRM} = 2600V. I_{GT} = 200 ma. and standard 12 inch leads—order as:

Type				Voltage		Current		Turn Off	Gate Current	Leads	
T	9	G	0	2	6	0	8	0	3	D	H

***Note:** For voltage Vs. Current Availability see next page.

THYRISTOR

800 — 1200 A. Avg.
Up to 3000 Volts

Phase Control SCR T9G0

Voltage ② TJ = 125°C

	Symbol													
Repetitive peak forward blocking, V	VDRM	600	800	1000	1200	1400	1600	1800	2000	2200	2400	2600	2800	3000
Repetitive peak reverse, V	VRRM	600	800	1000	1200	1400	1600	1800	2000	2200	2400	2600	2800	3000
Non-repetitive transient peak reverse voltage, t ≤ 5.0 msec, V	VRSM	700	900	1100	1300	1500	1700	1900	2100	2300	2500	2700	2900	3100
Voltage vs. Type No. Availability		← T9G0_12 (600–1800) →												
		← T9G0_10 (600–2200) →												
		← T9G0_08 (600–3000) →												
Blocking State Maximums														
Forward leakage current, mA peak	IDRM	← 60 →												
Reverse leakage current, mA peak	IRRM	← 60 →												

Current

Conducting State Maximums	Symbol	T9G0_08	T9G0_10	T9G0_12
RMS forward current, A	IT(rms)	1250	1590	1880
Ave. forward current, A	IT(av)	800	1000	1200
One-half cycle surge current, A ③	ITSM	13,000	17,000	27,000
3 cycle surge current, A ③	ITSM	9,750	12,200	20,200
10 cycle surge current, A ③	ITSM	8,000	10,200	16,700
I^2t for fusing (t = 8.3 ms) A^2sec	I^2t	700,000	1,203,000	3,040,000
Max. I^2t of package t = 8.3 ms), A^2sec	I^2t	90 x 10^6	90 x 10^6	90 x 10^6
Forward voltage drop at ITM = 3000A and TJ = 25°C, V	VTM	3.0	2.10	1.70

Switching

(TJ = 25°C)	Symbol	Min.	Typ.	Max.	Min.	Typ.	Max.	Min.	Typ.	Max.
Turn-off time, IT = 250A TJ = 125°C, diR/dt = 50 A/μsec reapplied dv/dt = 20V/μsec linear to 0.8 VDRM, μsec	tq		400			250			150	
Turn-On and Delay Time ④ ITM = 1000A, tp = 450 μsec	ton		3.5			3.5			2.5	
VD = 1500V, μsec	td		1.5			1.5			1.0	
Critical dv/dt exponential to VDRM TJ = 125°C, V/μsec ②⑤	dv/dt	300	1000		300	1000		300	1000	
di/dt non-repetitive, A/μsec ①④⑥	di/dt			800			800			800
Latching Current VD = 75V, mA	IL		500	1250		400	1000		300	500
Holding Current VD = 75V, mA	IH		150	500		150	500		150	500

Gate

(TJ = 25°C)	Symbol	Min.	Typ.	Max.
Gate current to trigger at VD = 12V, mA	IGT	30	100	200
Gate voltage to trigger at VD = 12V, V	VGT		1.5	3.0
Non-triggering gate voltage, TJ = 125°C, and rated VDRM, V	VGDM			.15
Non-triggring Gate Current at VD = 12V, mA	IGNT			20
Peak forward gate current, A	IGTM			4
Peak reverse gate voltage, V	VGRM			5
Peak gate power, Watts	PGM			16
Average gate power, Watts	PG(av)			3

Thermal and Mechanical

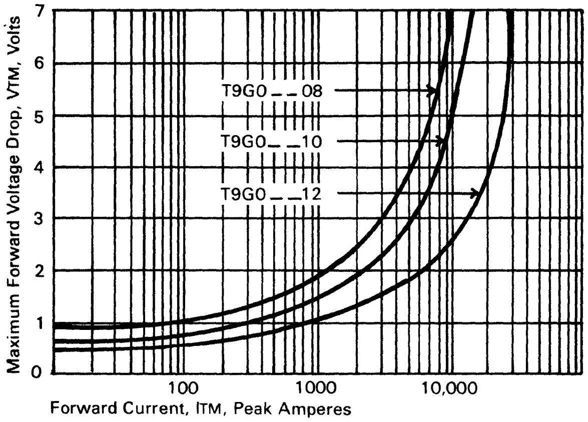
	Symbol	Min.	Typ.	Max.
Oper. junction temp., °C	TJ	—40		125
Storage temp., °C	Tstg	—40		150
Mounting force, lb ①		5000		5500
Thermal resistance ① with double sided cooling				
Junction to case, °C/Watt	RΘJC			.023
Case to sink, lubricated, °C/Watt	RΘCS		.006	.0075

① Consult recommended mounting procedures.
② Applies for zero or negative gate bias.
③ Per JEDEC RS-397, 5.2.2.1.
④ With recommended gate drive.
⑤ Higher dv/dt ratings available, consult factory.
⑥ Per JEDEC standard RS-397, 5.2.2.6.

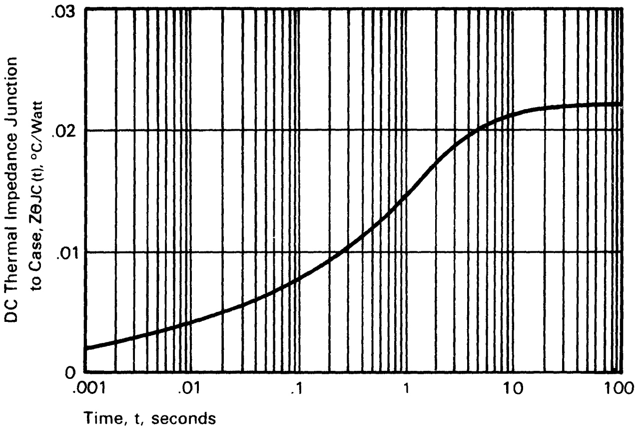
Phase Control SCR T9G0

800 — 1200 A. Avg. Up to 3000 Volts

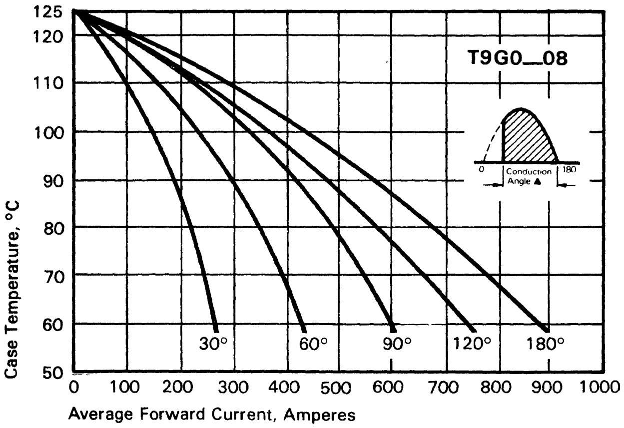
Maximum Forward Voltage VS. Forward Current



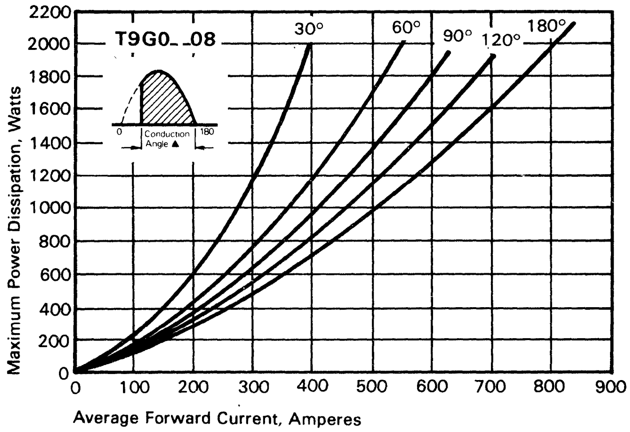
Transient Thermal Impedance VS. Time



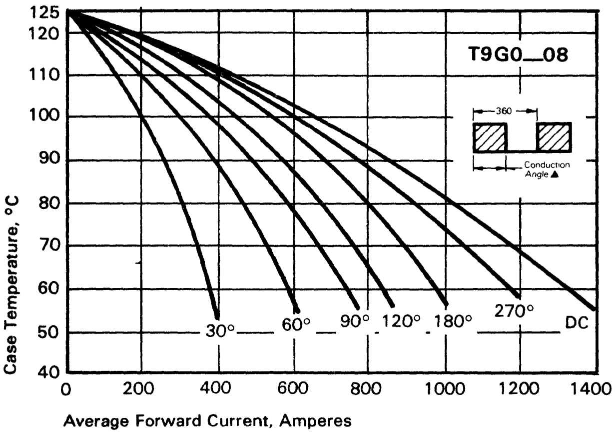
Maximum Case Temperature VS. Forward Current



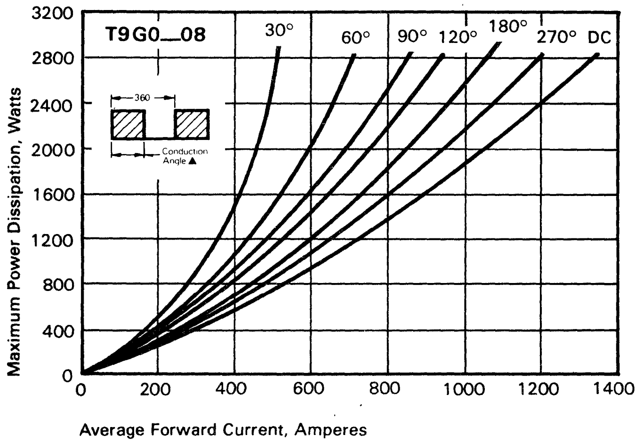
Maximum Power Dissipation VS. Forward Current



Maximum Case Temperature VS. Forward Current



Maximum Power Dissipation VS. Forward Current

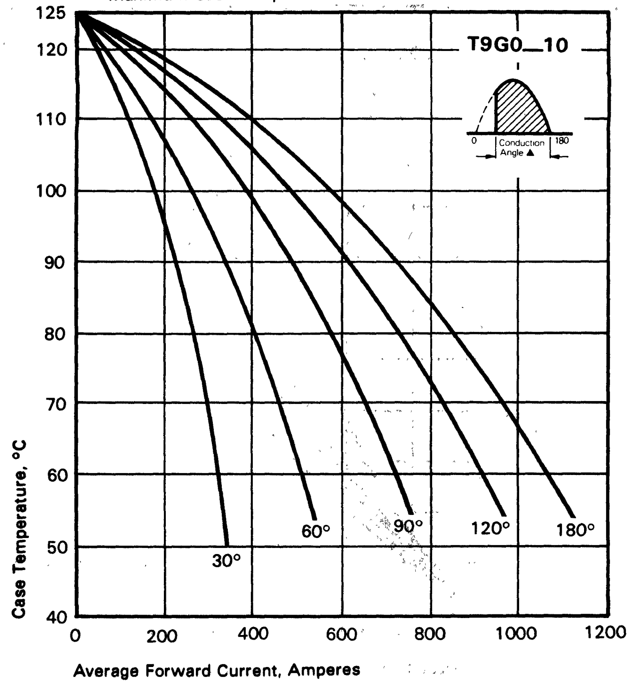


THYRISTOR

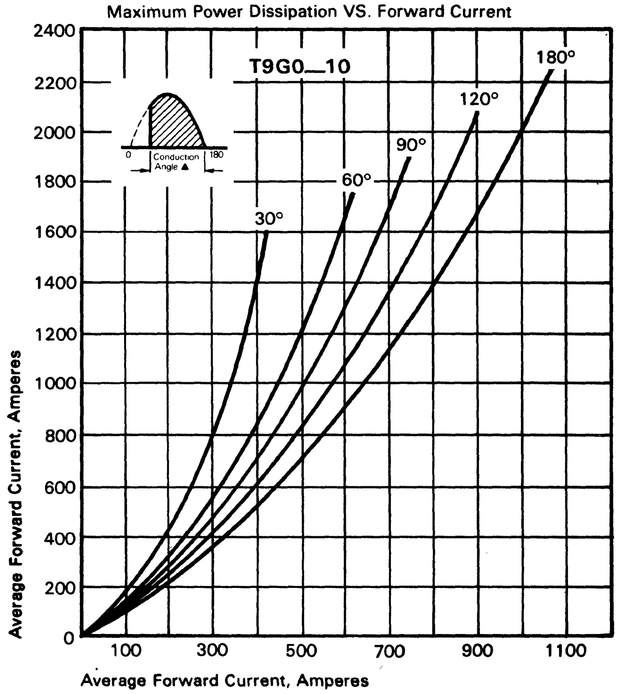
800 — 1200 A. Avg.
Up to 3000 Volts

Phase Control SCR T9G0

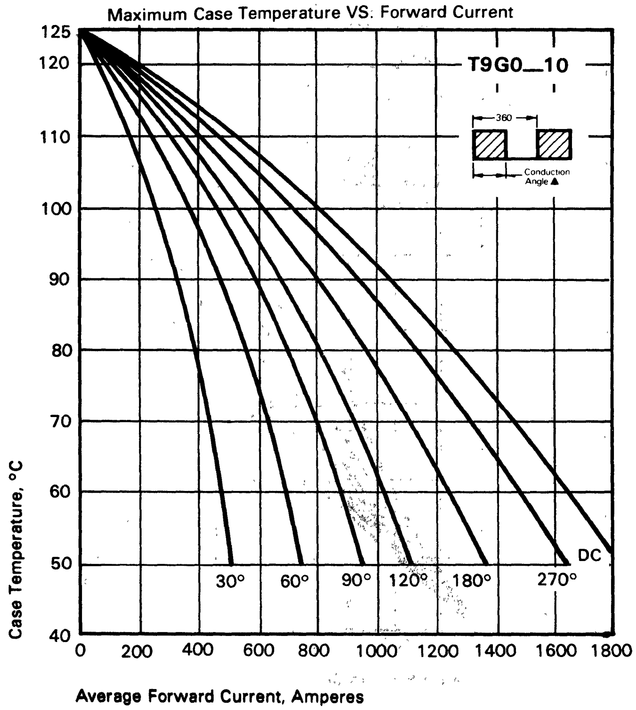
Maximum Case Temperature VS. Forward Current



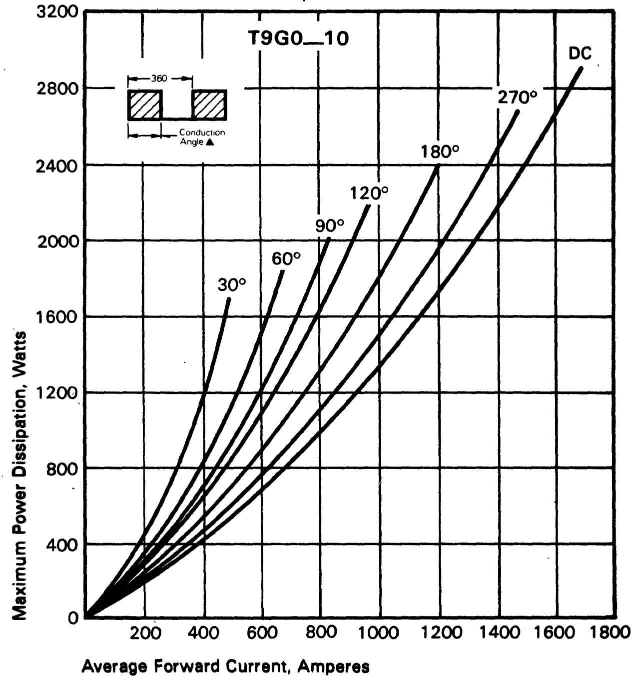
Maximum Power Dissipation VS. Forward Current



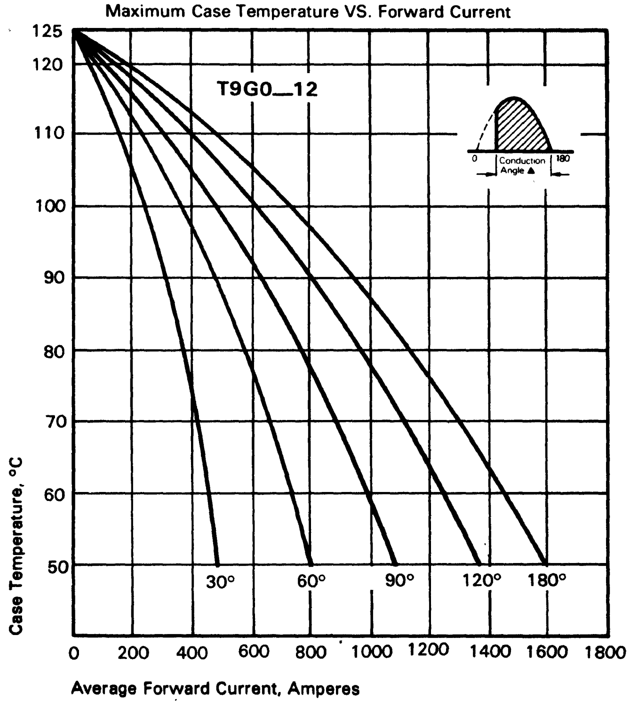
Maximum Case Temperature VS. Forward Current



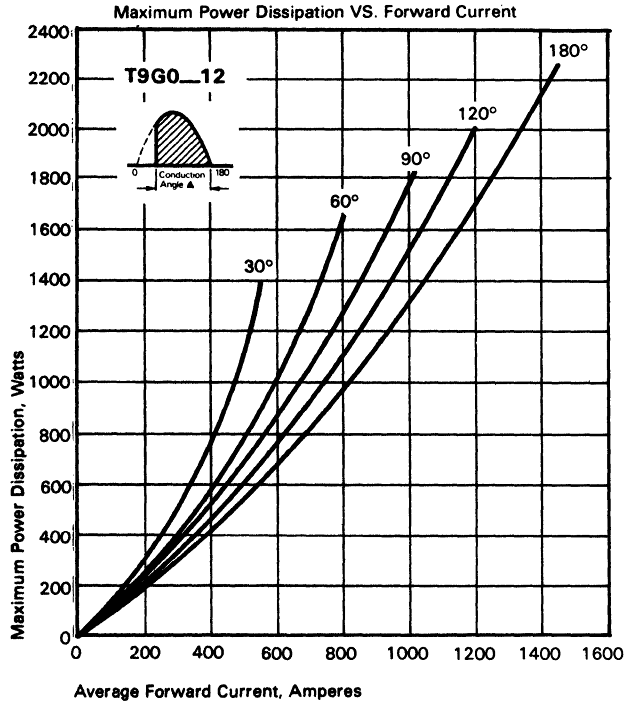
Maximum Power Dissipation Vs. Forward Current



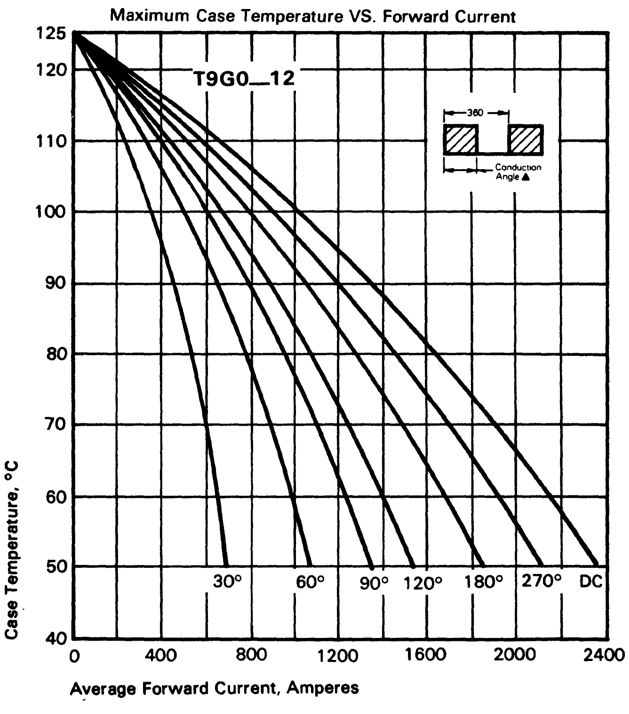
THYRISTOR



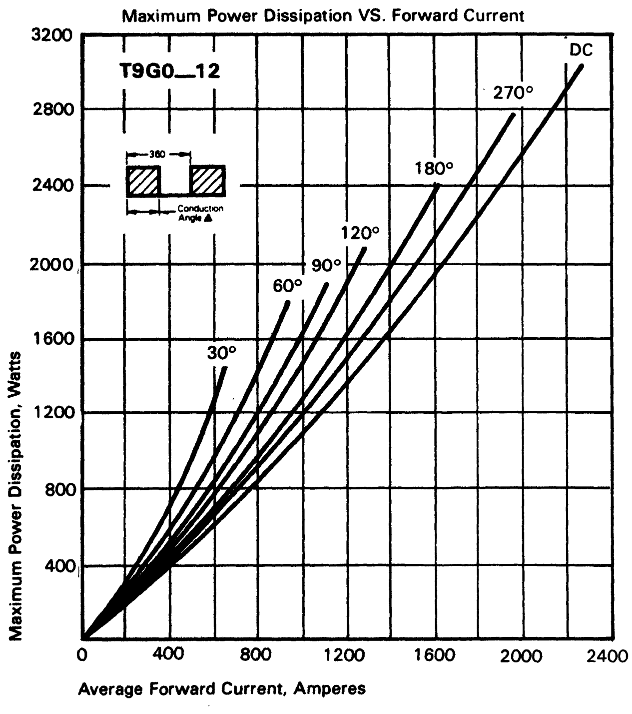
Maximum Case Temperature VS. Forward Current
T9G0__12
Conduction Angle ▲
Case Temperature, °C
Average Forward Current, Amperes
30° 60° 90° 120° 180°



Maximum Power Dissipation VS. Forward Current
T9G0__12
Conduction Angle ▲
Maximum Power Dissipation, Watts
Average Forward Current, Amperes
30° 60° 90° 120° 180°



Maximum Case Temperature VS. Forward Current
T9G0__12
360
Conduction Angle ▲
Case Temperature, °C
Average Forward Current, Amperes
30° 60° 90° 120° 180° 270° DC

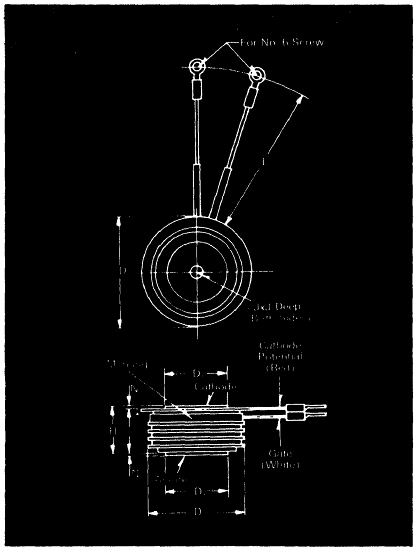


Maximum Power Dissipation VS. Forward Current
T9G0__12
360
Conduction Angle ▲
Maximum Power Dissipation, Watts
Average Forward Current, Amperes
30° 60° 90° 120° 180° 270° DC

THYRISTOR

Phase Control SCR TA20

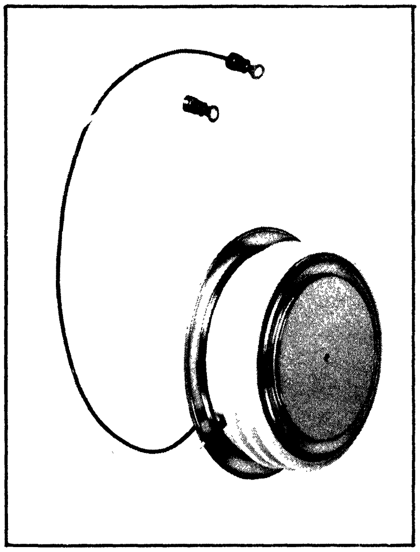
1200—1400 A. Avg. Up to 2200 Volts



TA2 Outline

Symbol	Inches Min.	Inches Max.	Millimeters Min.	Millimeters Max.
ϕD	3.910	3.950	99.31	100.33
ϕD_1	2.470	2.480	62.74	63.00
ϕD_2	3.440	3.560	87.38	90.42
H	1.260	1.300	32.00	33.02
ϕJ	.135	.145	3.43	3.68
J_1	.075	.090	1.91	2.29
L	11.50	12.50	292.10	317.50
N	.050		1.27	

Creep Distance—1.82 in. min. (46.23 mm.)
Strike Distance—1.26 in. min. (32.00mm).
(In accordance with NEMA standards.)
Finish—Nickel Plate.
Approx. Weight—2.1 lb. (950 g).
1. Dimension "H" is a clamped dimension.



Package I^2t (Case Rupture) Rating: 125 x $10^6 A^2$ sec.

Features:
- di/namic Gate design
- All diffused design
- Guaranteed dv/dt (300 v/μs)
- Low gate current with soft gate control
- Low V TM
- Low Thermal Impedance
- High surge current capability
- I^2t package rating
- Lifetime Guarantee

Aplications:
- Steel Mill Drives
- Crane Controls
- Motor Controls

Ordering Information

Type	Voltage		Current		Turn-off		Gate current		Leads	
Code	V_{DRM} and V_{RRM} (V)	Code	$I_{T(av)}$ (A)	Code	tq (μsec)	Code	I_{GT} (ma)	Code	Case	Code
TA20	600	06	1200	12	250 (typical)	0	200	3	TA2	DH
	800	08								
	1000	10	1400	14						
	1200	12								
	1400	14								
	1500	15								
	1600	16								
	1700	17								
	1800	18								
	1900	19								
	2000	20								
	2100	21								
	2200	22								

NOTE: LOWER VOLTAGE DEVICES AVAILABLE CONSULT FACTORY REPRESENTATIVE

Example

Obtain optimum device performance for your application by selecting proper order code.

Type TA20 rated 1200 A Average with V_{DRM}=2000V, I_{GT}=200 ma, and standard 12 inch leads—order as:

Type				Voltage		Current		Turn Off	Gate Current	Leads	
T	A	2	0	2	0	1	2	0	3	D	H

THYRISTOR

1200—1400 A. Avg. Up to 2200 Volts

Phase Control SCR TA20

THYRISTOR

Voltage

Blocking State Maximums ② (T_J = 125°C)

	Symbol													
Repetitive peak forward blocking voltage, V	V_{DRM}	600	800	1000	1200	1400	1500	1600	1700	1800	1900	2000	2100	2200
Repetitive peak reverse voltage, V	V_{RRM}	600	800	1000	1200	1400	1500	1600	1700	1800	1900	2000	2100	2200
Non-repetitive transient peak reverse voltage, t≤ 5.0 msec, V	V_{RSM}	700	900	1100	1300	1500	1600	1700	1800	1900	2000	2100	2200	2300
Forward leakage current, mA peak	I_{DRM}	← 75 →												
Reverse leakage current, mA peak	I_{RRM}	← 75 →												

Current

Conducting State Maximums (T_J = 125°C)

	Symbol	TA20—12	TA20—14
RMS forward current, A	$I_{T(rms)}$	1900	2200
Ave. forward current, A	$I_{T(av)}$	1200	1400
One-half cycle surge current③, A	I_{TSM}	30,000	35,000
3 cycle surge current③, A	I_{TSM}	25,000	30,000
10 cycle surge current③, A	I_{TSM}	18,000	22,000
I^2t for fusing (t=8.3 ms) A^2sec	I^2t	3.75×10^6	5.1×10^6
Max I^2t of package (t=8.3 ms), A^2sec	I^2t	125×10^6	125×10^6
Forward voltage drop at I_{TM} = 6000A and T_J = 25°C, V	V_{TM}	2.40	2.00

Gate

(T_J=25°C)

	Symbol	Min	Typ	Max
Gate current to trigger at V_D=12V, mA	I_{GT}	30	150	200
Gate voltage to trigger at V_D=12V, V	V_{GT}		1.5	3.0
Non-triggering gate voltage, T_J=125°C, and rated V_{DRM}, V	V_{GNT}			.15
Peak forward gate current, A	I_{GTM}			4
Peak reverse gate voltage, V	V_{GRM}			5
Peak gate power, Watts	P_{GM}			16
Average gate power, Watts	$P_{G(av)}$			3

Switching

(T_J=25°C)

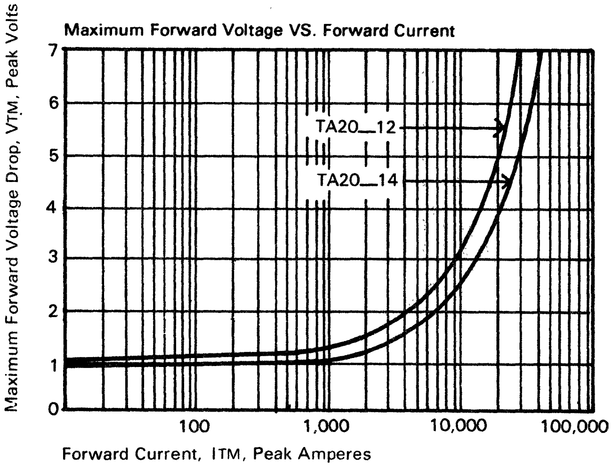
	Symbol	Min	Typ	Max
Turn-off time, I_T=250A T_J=125°C, di_R/dt=50 A/μsec reapplied dv/dt= 20V/μsec linear to 0.8 V_{DRM}, μsec	tq		250	
Turn-On and Delay Time I_{TM}=1000A④, tp=450 μsec	ton		4.5	
V_D=1100V, μsec	td		2.5	
Critical dv/dt exponential to V_{DRM} T_J=125°C, V/μsec②⑤	dv/dt	300	1000	
di/dt non-repetitive, ①④⑥ A/μsec	di/dt			800
Latching Current V_D=75V, mA	I_L		400	1000
Holding Current V_D=75V, mA	I_H		150	500

Thermal and Mechanical

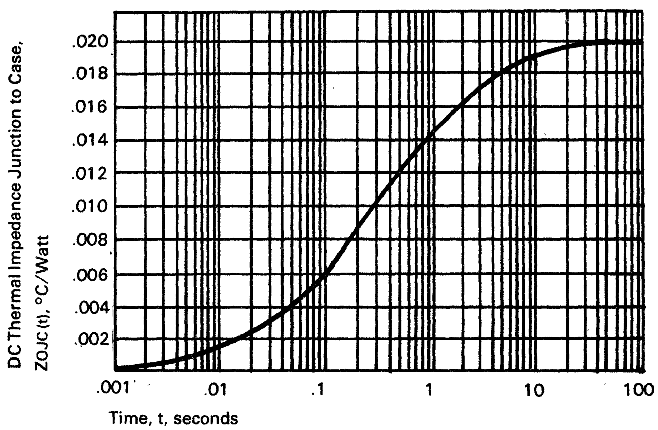
	Symbol	Min	Typ	Max
Oper. junction temp., °C	T_J	—40		125
Storage temp., °C	T_{stg}	—40		150
Mounting force, lb.①		8500	11,000	
Thermal resistance with double sided cooling① Junction to case, °C/Watt	$R\theta_{JC}$		.015	.02
Case to sink, lubricated, °C/Watt	$R\theta_{CS}$		.006	.0075

① Consult recommended mounting procedures.
② Applies for zero or negative gate bias.
③ Per JEDEC RS-397, 5.2.2.1.
④ With recommended gate drive.
⑤ Higher dv/dt ratings available, consult factory.
⑥ Per JEDEC standard RS-397, 5.2.2.6.

Maximum Forward Voltage VS. Forward Current



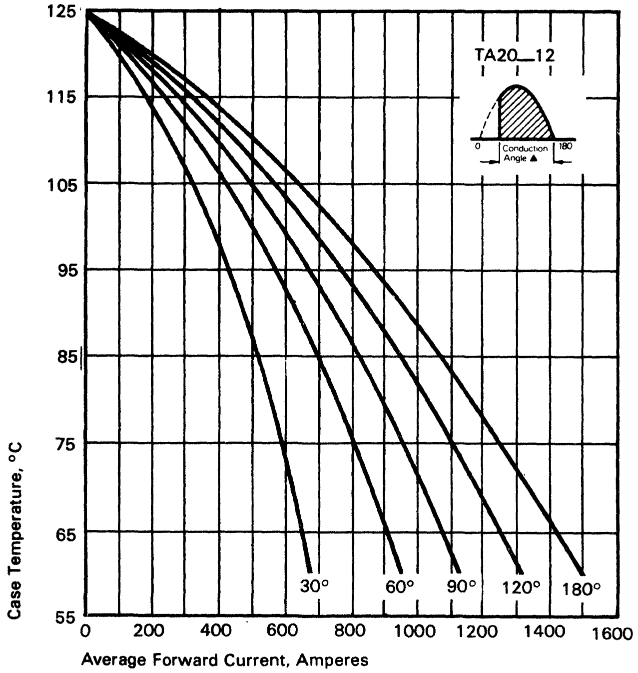
Transient Thermal Impedance VS. Time



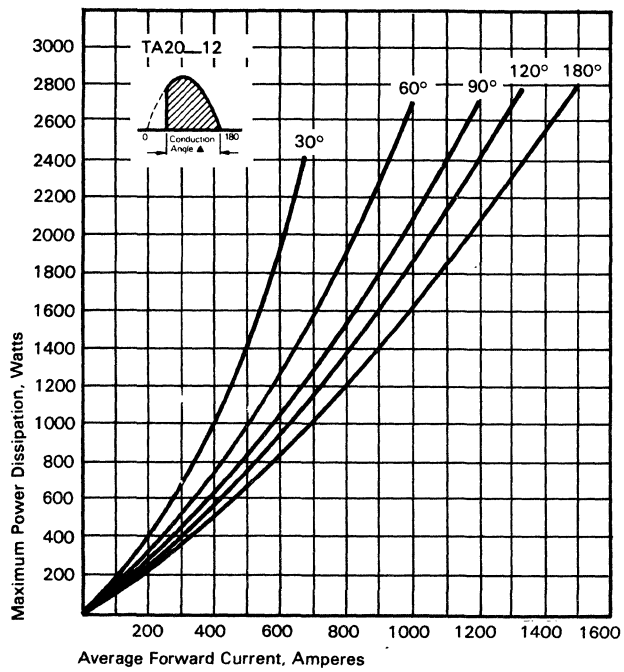
Phase Control SCR TA20

1200—1400 A. Avg. Up to 2200 Volts

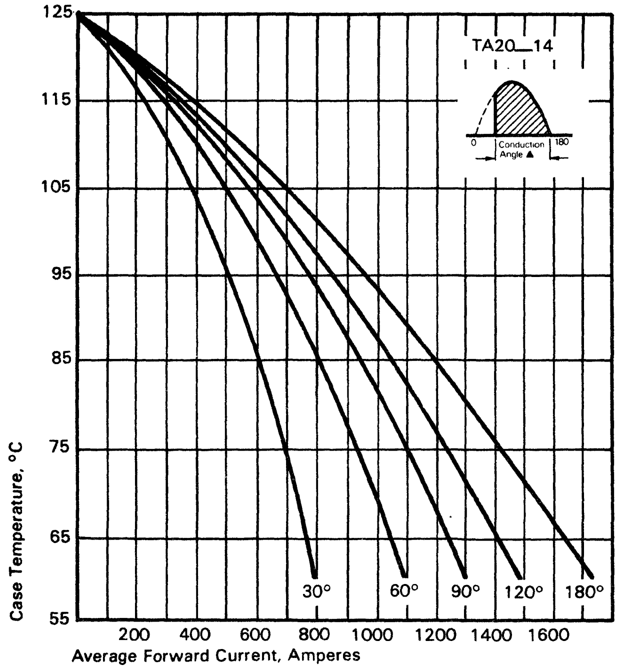
Maximum Case Temperature VS. Forward Current



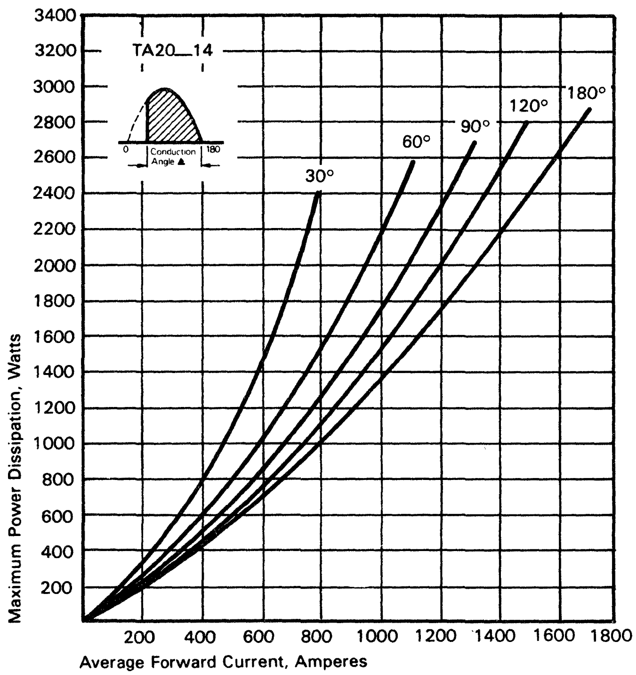
Maximum Power Dissipation VS. Forward Current



Maximum Case Temperature VS. Forward Current



Maximum Power Dissipation VS. Forward Current



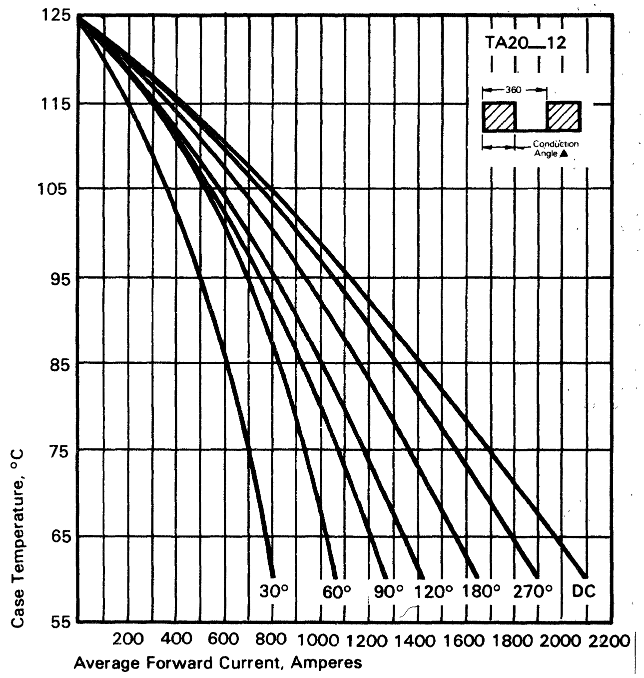
THYRISTOR

1200—1400 A. Avg.
Up to 2200 Volts

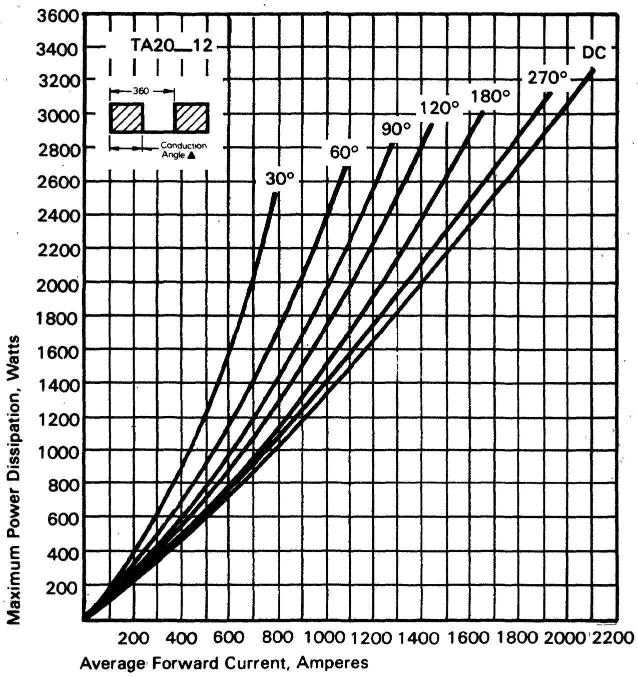
Phase Control
SCR
TA20

THYRISTOR

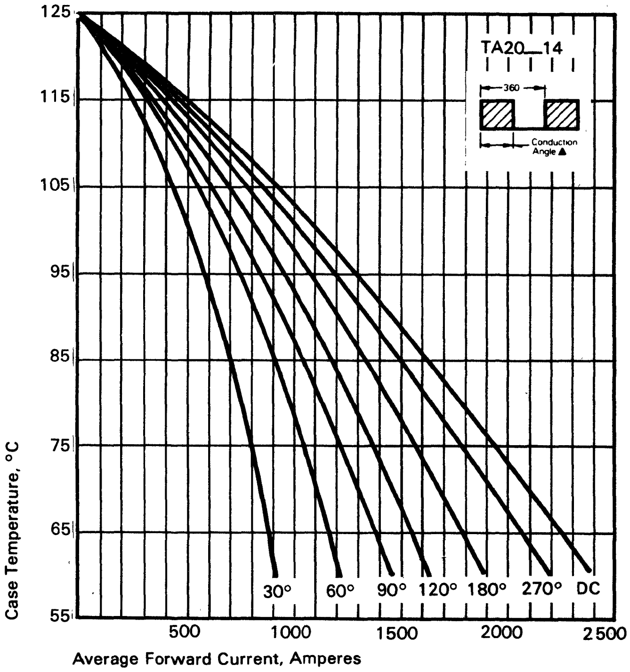
Maximum Case Temperature VS. Forward Current



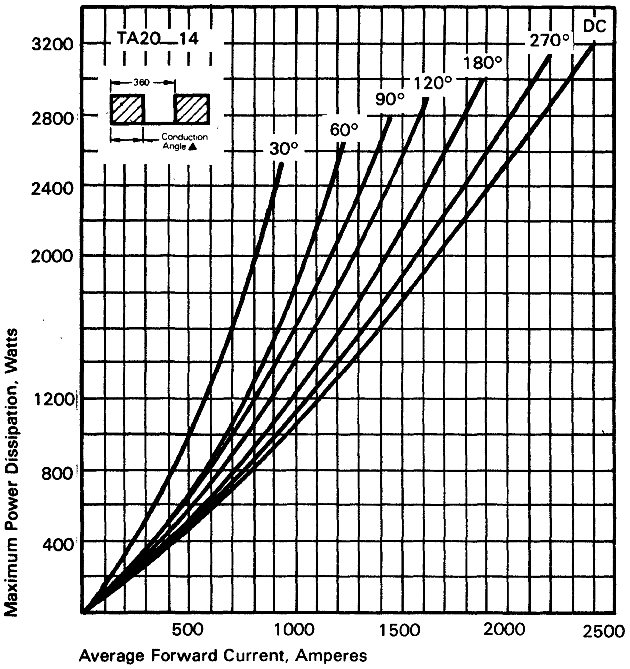
Maximum Power Dissipation VS. Forward Current



Maximum Case Temperature VS. Forward Current

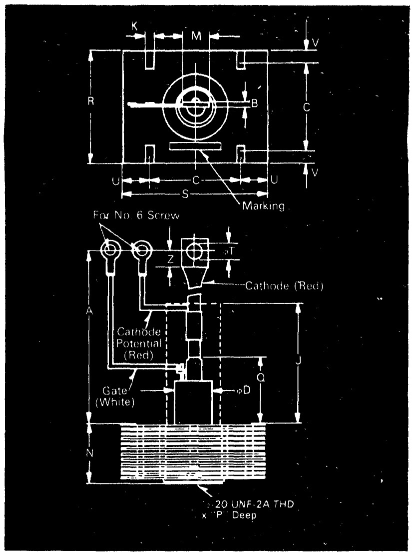


Maximum Power Dissipation VS. Forward Current



Phase Control SCR T760

300 A Avg. Up to 2000 Volts

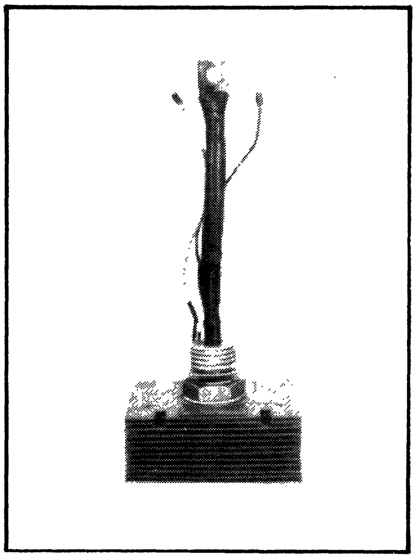


T76 Outline

Symbol	Inches Min.	Inches Max.	Millimeters Min.	Millimeters Max.
A	9.00	10.00	228.60	254.00
B	.063	.172	1.60	4.37
C	2.980	3.020	75.69	76.71
ϕD		1.490		37.85
J	3.750		95.25	
K	.272	.292	6.91	7.42
M	.530	.755	13.46	19.18
N	2.030	2.150	51.56	54.61
P	.500		12.70	
Q		2.670		67.81
R	3.937	4.063	100.00	103.20
S	4.937	5.063	125.40	128.60
ϕT	.330	.350	8.38	8.89
U	.970	1.030	24.64	26.16
V	.470	.530	11.94	13.46
Z	.440		11.18	

Creep Distance—1.76 in. min. (44.91 mm).
Strike Distance—.81 in. min. (20.70 mm).
(In accordance with NEMA standards.)
Finish—Nickel Plate.
Approx. Weight—5 lb. (2.3 kg.).

1. Angular orientation of terminals are undefined.
2. Pitch diameter of ½-20 UNF-2A (coated) threads (ASA B1.1-1960).
3. Dimension "J" denotes seated height with leads bent at right angles.



Package I^2 (case rupture) rating: 15 x 10^6 A^2sec.

Voltage ②

Blocking State Maximums (T_J = 125°C)

	Symbol															
Repetitive peak forward blocking voltage, V	V_{DRM}	100	200	400	600	800	1000	1200	1300	1400	1500	1600	1700	1800	2000	2200
Repetitive peak reverse voltage, V	V_{RRM}	100	200	400	600	800	1000	1200	1300	1400	1500	1600	1700	1800	2000	2200
Non-repetitive transient peak reverse voltage, $t \leq$ 5.0 msec, V	V_{RSM}	200	300	500	700	950	1200	1450	1550	1700	1800	1900	2050	2150	2400	2600

T760 _ _ 30 (all voltage grades)

	Symbol	
Forward leakage current, mA peak	I_{DRM}	30
Reverse leakage current, mA peak	I_{RRM}	30

Current

Conducting State Maximums (T_J = 125°C)

	Symbol	T760 _ _ 30
RMS forward current, A	$I_{T(rms)}$	470
Ave. forward current, A	$I_{T(av)}$	300
One-half cycle surge current③, A	I_{TSM}	8400
3 cycle surge current③, A	I_{TSM}	6050
10 cycle surge current③, A	I_{TSM}	5200
I^2t for fusing (for times $\geq$ 8.3 ms) A^2 sec.	I^2t	295,000
Forward voltage drop at I_{TM} = 3000A and T_J = 25°C, V	V_{TM}	3.30

Switching

(T_J = 25°C)

	Symbol	
Typical turn-off time, I_T = 250A, T_J = 125°C, di_R/dt = 25 A/μsec, reapplied dv/dt = 20V/μsec linear to 0.8 V_{DRM}, μ sec	t_q	150
Typ. turn-on-time, I_T = 100A V_D = 100V④, μsec	t_{on}	7
Min. critical dv/dt, exponential to V_{DRM}, T_J = 125°C, V/μsec②⑤	dv/dt	300
Min. di/dt non-repetitive, A/μsec①④⑥	di/dt	800

Gate

Maximum Parameters (T_J = 25°C)

	Symbol	
Gate current to trigger at V_D = 12V, mA	I_{GT}	150
Gate voltage to trigger at V_D = 12V, V	V_{GT}	3
Non-triggering gate voltage, T_J = 125°C, and rated V_{DRM}, V	V_{GDM}	0.15
Peak forward gate current, A	I_{GTM}	4
Peak reverse gate voltage, V	V_{GRM}	5
Peak gate power, Watts	P_{GM}	16
Average gate power, Watts	$P_{G(av)}$	3

Thermal and Mechanical

	Symbol	
Min., Max. oper. junction temp., °C	T_J	—40 to +125
Min., Max. storage temp., °C	Tstg	—40 to +150
Max. mounting torque, in lb.		300

Max. Thermal Impedance, °C/Watt
Junction to Ambient @ 1000 LFM airflow .... θ_{JA} 0.18

① Consult recommended mounting procedures.
② Applies for zero or negative gate bias.
③ Per JEDEC RS-397, 5.2.2.1.
④ With recommended gate drive.
⑤ Higher dv/dt ratings available, consult factory.
⑥ Per JEDEC standard RS-397, 5.2.2.6.

Example

Obtain optimum device performance for your application by selecting proper Order Code.

Type T760 rated at 300 A average with V_{DRM} = 1000V, I_{GT} = 150 ma, and standard flexible lead—order as:

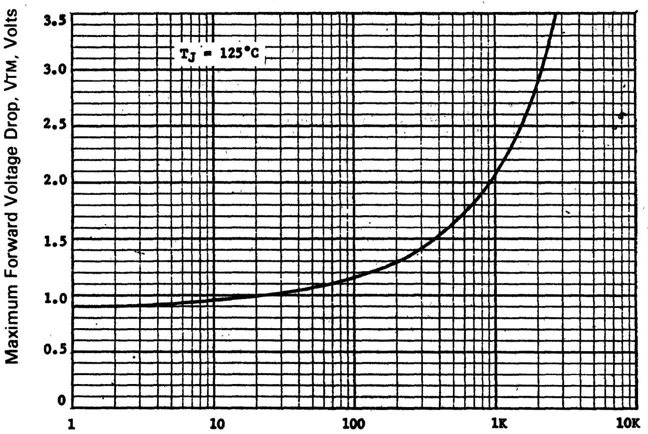
Type				Voltage		Current		Turn Off	Gate Current	Leads	
T	7	6	0	1	0	3	0	0	4	B	Y

THYRISTOR

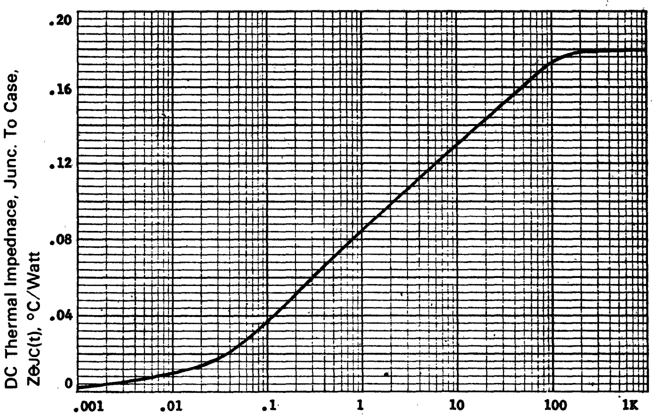
300 A Avg.
Up to 2000 Volts

Phase Control SCR T760

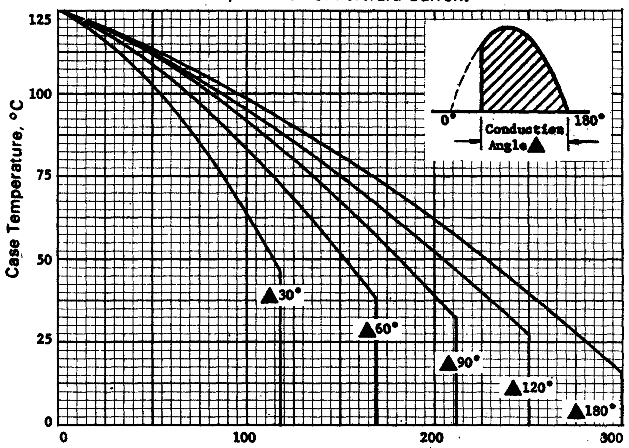
Maximum Forward Voltage VS. Forward Current



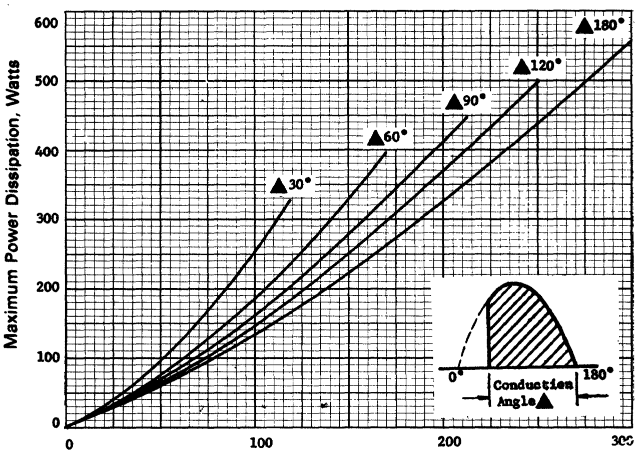
Transient Thermal Impedance VS. Time



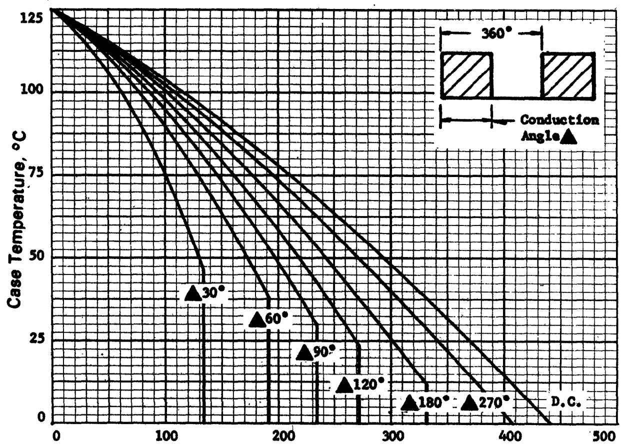
Maximum Case Temperature VS. Forward Current



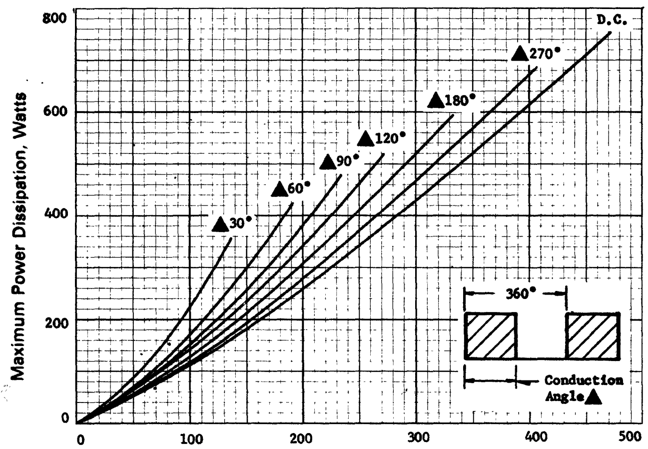
Maximum Power Dissipation VS. Forward Current



Maximum Case Temperature VS. Forward Current



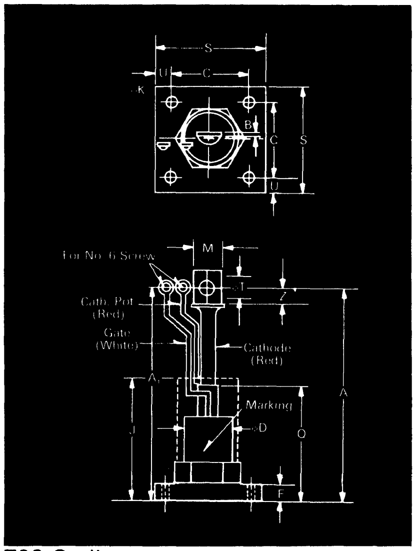
Maximum Power Dissipation VS. Forward Current



THYRISTOR

Phase Control SCR T680

175 A. Avg. Up to 1500 Volts

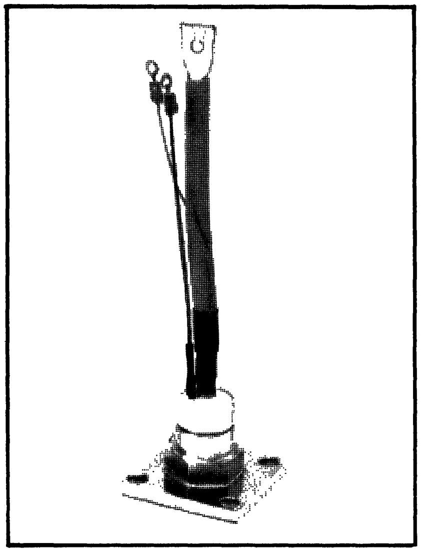


T68 Outline

Symbol	Inches Min.	Inches Max.	Millimeters Min.	Millimeters Max.
A	9.760	10.250	247.90	260.35
A_1	10.000	10.750	254.00	273.05
B	.063	.172	1.60	4.37
C	1.790	1.830	45.47	46.48
ϕD	.980	1.090	24.89	27.69
F	.245	.255	6.22	6.48
J	4.250		107.95	
ϕK	.338	.348	8.59	8.84
M	.530	.755	13.46	19.18
Q		2.750		69.85
S	2.390	2.430	60.71	61.72
ϕT	.330	.350	8.38	8.89
U	.280	.320	7.11	8.13
Z	.440		11.18	

Creep & Strike Distance. .69 in. min. (17.60 mm).
(In accordance with NEMA standards.)
Finish—Nickel Plate.
Approx. Weight—16 oz. (454 g).

1. Angular orientation of terminals is undefined.
2. Dimension "J" denotes seated height with leads bent at right angles.



Voltage

Blocking State Maximums ② (T_J=125°C)	Symbol															
Repetitive peak forward blocking voltage, V	V_{DRM}	100	200	300	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500
Repetitive peak reverse voltage, V	V_{RRM}	100	200	300	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500
Non-repetitive transient peak reverse voltage, t ≤ 5.0 msec, V	V_{RSM}	200	300	400	500	600	700	850	950	1100	1200	1300	1450	1550	1700	1800
Forward leakage current, mA peak	I_{DRM}	← 25 →														
Reverse leakage current, mA peak	I_{RRM}	← 25 →														

Current

Conducting State Maximums (T_J=125°C)	Symbol	T680__18
RMS forward current, A	$I_{T(rms)}$	275
Ave. forward current, A	$I_{T(av)}$	175
One-half cycle surge current③, A	I_{TSM}	5500
3 cycle surge current③, A	I_{TSM}	3900
10 cycle surge current③, A	I_{TSM}	3400
I^2t for fusing (for times>8.3 ms) A^2 sec	I^2t	120,000
Forward voltage drop at I_{TM}=625A and T_J=25°C, V	V_{TM}	1.55

Switching

(T_J=25°C)	Symbol	
Typical turn-off time, I_T=150A T_J=125°C, di_R/dt=12.5 A/μsec, reapplied dv/dt=20V/μsec linear to 0.8 V_{DRM}, μsec	t_q	150
Typ. turn-on-time, I_T=100A V_D=100V④, μsec	t_{on}	5
Min. critical dv/dt, exponential to V_{DRM} T_J=125°C, V/μsec ②⑤	dv/dt	300
Min. di/dt non-repetitive, A/μsec ①④⑥	di/dt	800

① Consult recommended mounting procedures.
② Applies for zero or negative gate bias.
③ Per JEDEC RS-397, 5.2.2.1.
④ With recommended ‹ e drive.
⑤ Higher dv/dt ratings available, consult factory.
⑥ Per JEDEC standard RS-397, 5.2.2.6.

Gate

Maximum Parameters (T_J=25°C)	Symbol	
Gate current to trigger at V_D=12V, mA	I_{GT}	150
Gate voltage to trigger at V_D=12V, V	V_{GT}	3
Non-triggering gate voltage, T_J =125°C, and rated V_{DRM}, V	V_{GDM}	0.15
Peak forward gate current, A	I_{GTM}	4
Peak reverse gate voltage, V	V_{GRM}	5
Peak gate power, Watts	P_{GM}	16
Average gate power, Watts	$P_{G(av)}$	3

Thermal and Mechanical

	Symbol	
Min., Max. oper. junction temp., °C	T_J	−40 to +125
Min., Max. storage temp., °C	T_{stg}	−40 to +150
Max. mounting torque each bolt, in-lb.①		25
Thermal resistance① Junction to case, °C/Watt	$R\theta_{JC}$	.155
Case to sink, lubricated, °C/Watt	$R\theta_{CS}$	.05

Example

Obtain optimum device performance for your application by selecting proper Order Code.

Type T680 rated at 175A average with V_{DRM} = 1000V, I_{GT} = 150 ma, and standard flexible lead—order as:

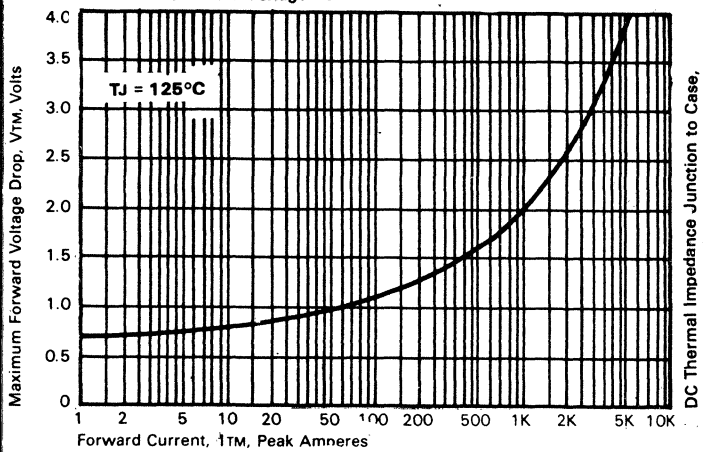
Type				Voltage		Current		Turn Off	Gate Current	Leads	
T	6	8	0	1	0	1	8	0	4	B	T

THYRISTOR

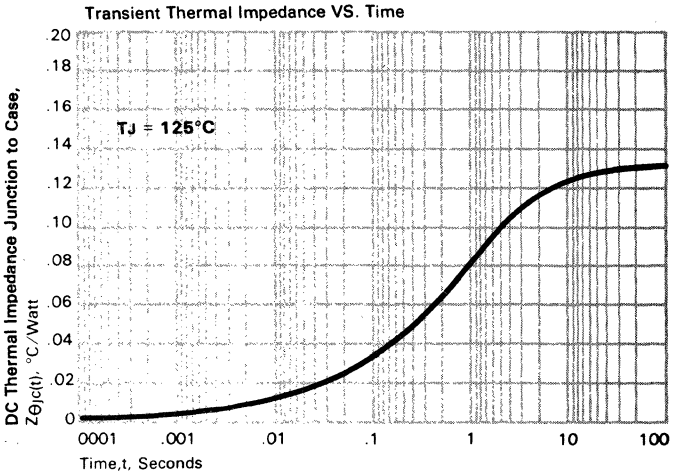
175 A. Avg. Up to 1500 Volts

Phase Control SCR T680

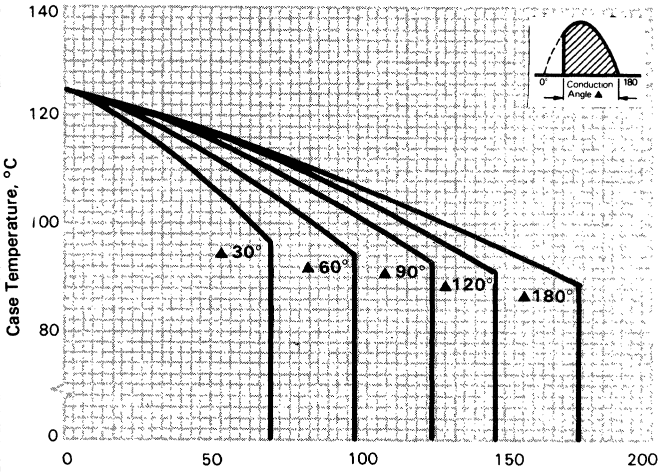
Maximum Forward Voltage VS. Forward Current



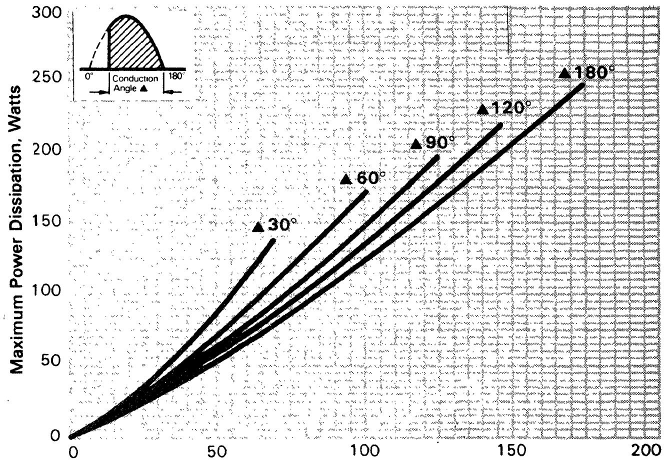
Transient Thermal Impedance VS. Time



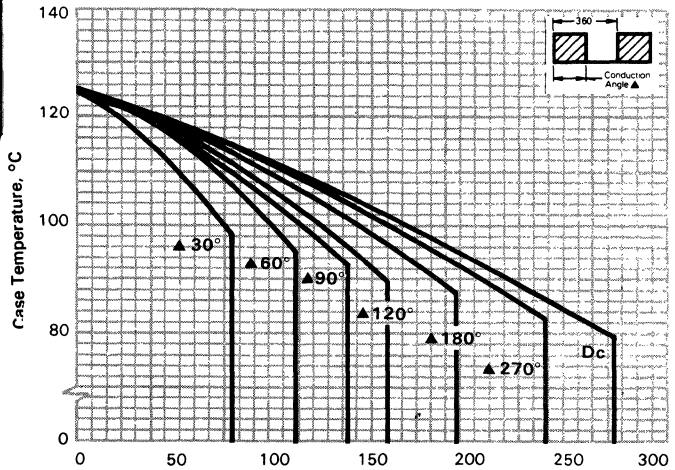
Maximum Case Temperature VS. Forward Current



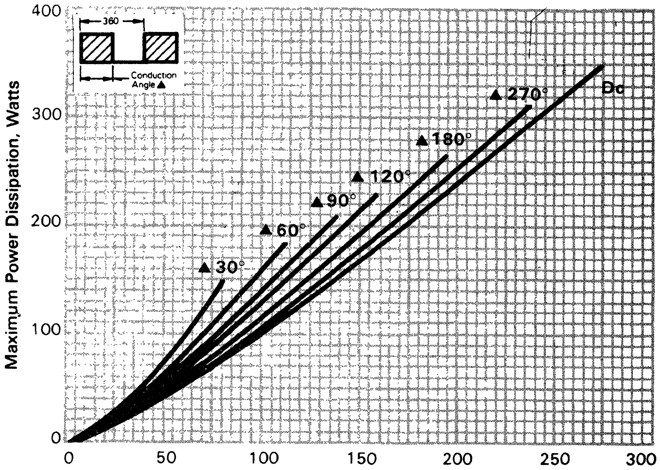
Maximum Power Dissipation VS. Forward Current



Maximum Case Temperature VS. Forward Current



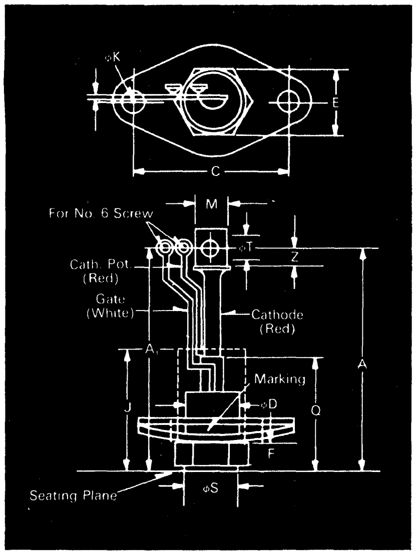
Maximum Power Dissipation VS. Forward Current



THYRISTOR

Phase Control SCR T780

350 A Avg. Up to 1600 Volts

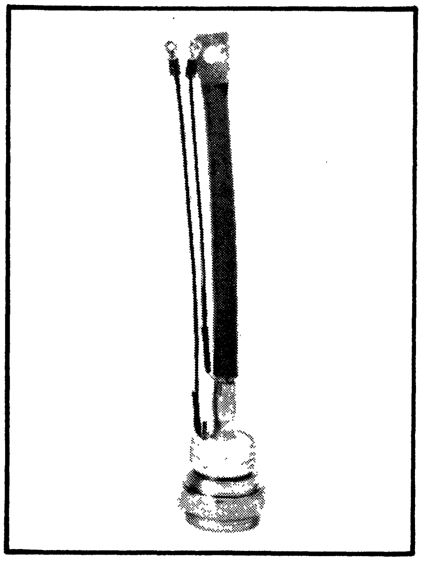


T78 Outline

Symbol	Inches Min.	Inches Max.	Millimeters Min.	Millimeters Max.
A	9.76	10.00	247.90	254.00
A₁	10.18	10.42	258.57	264.67
B	.063	.172	1.60	4.37
C	2.48	2.52	62.99	64.00
φD		1.490		37.85
E	1.620	1.750	41.15	44.45
F	.430	.810	10.92	20.57
J	4.00		101.60	
φK	.360	.400	9.14	10.16
M	5.30	.755	13.46	19.18
Q		3.10		78.74
φS	1.590	1.610	40.39	40.89
φT	.330	.350	8.38	8.89
Z	.440		11.18	

Creep Distance—1.76 in min. (44.91 mm).
Strike Distance—.81 in min. (20.70 mm)
(In accordance with NEMA standards.)
Finish—Nickel Plate.
Approx. Weight—16 oz. (454 g).

1. Angular orientation of terminals are undefined.
2. Dimension "J" denotes seated height with leads bent at right angles.



Package I²t (case rupture) rating: 15 x 10⁶ A²sec.

Voltage

Blocking State Maximums ② (T_J = 125°C)

	Symbol											
Repetitive peak forward blocking voltage, V	V_{DRM}	100	200	400	600	800	1000	1200	1300	1400	1500	1600
Repetitive peak reverse voltage V	V_{RRM}	100	200	400	600	800	1000	1200	1300	1400	1500	1600
Non-repetitive transient peak reverse voltage, t ≤ 5.0 msec, V	V_{RSM}	200	300	500	700	950	1200	1450	1550	1700	1800	1900
		T780 _ _ 35										
Forward leakage current, mA peak	I_{DRM}	30										
Reverse leakage current, mA peak	I_{RRM}	30										

Current

Conducting State Maximums (T_J = 125°C)

	Symbol	T780 _ _ 35
RMS forward current, A	$I_{T(rms)}$	550
Ave. forward current, A	$I_{T(av)}$	350
One-half cycle surge current③, A	I_{TSM}	10,000
3 cycle surge current③, A	I_{TSM}	7200
10 cycle surge current③, A	I_{TSM}	6200
I^2t for fusing (for times ≥ 8.3 ms) A² sec.	I^2t	416,000
Forward voltage drop at I_{TM} = 3000A and T_J = 25°C, V	V_{TM}	2.15

Switching

(T_J = 25°C)

	Symbol	
Typical turn-off time, I_T = 250A, T_J = 125°C, di_R/dt = 25 A/μsec, reapplied dv/dt = 20V/μsec linear to 0.8 V_{DRM}, μ sec	t_q	150
Typ. turn-on-time, I_T = 100A V_D = 100V④, μsec	t_{on}	7
Min. critical dv/dt, exponential to V_{DRM}, T_J = 125°C, V/μsec② ⑤	dv/dt	300
Min. di/dt non-repetitive, JEDEC Std. #7, A/μsec ①④⑥	di/dt	800

Thermal and Mechanical

	Symbol	
Min., Max. oper. junction temp., °C	T_J	—40 to +125
Min., Max. storage temp., °C	Tstg	—40 to +150
Max. Thermal resistance ①		
Junction to case, °C/Watt	$R_{\theta JC}$	.10
Case to sink, lubricated, °C/Watt	$R_{\theta CS}$	.05

Gate

Maximum Parameters (T_J = 25°C)

	Symbol	
Gate current to trigger at V_D = 12V, mA	I_{GT}	150
Gate voltage to trigger at V_D = 12V, V	V_{GT}	3
Non-triggering gate voltage, T_J = 125°C, and rated V_{DRM}, V	V_{GDM}	0.15
Peak forward gate current, A	I_{GTM}	4
Peak reverse gate voltage, V	V_{GRM}	5
Peak gate power, Watts	P_{GM}	16
Average gate power, Watts	$P_{G(av)}$	3

① Consult recommended mounting procedures.
② Applies for zero or negative gate bias.
③ Per JEDEC RS397, 5.2.2.1.
④ With recommended gate drive.
⑤ Higher dv/dt ratings available, consult factory.
⑥ Per JEDEC standard RS-397, 5.2.2.6.

Example
Obtain optimum device performance for your application by selecting proper Order Code.

Type T780 rated at 350A average with V_{DRM} = 1000V, I_{GT} = 150 ma, and standard lead—order as:

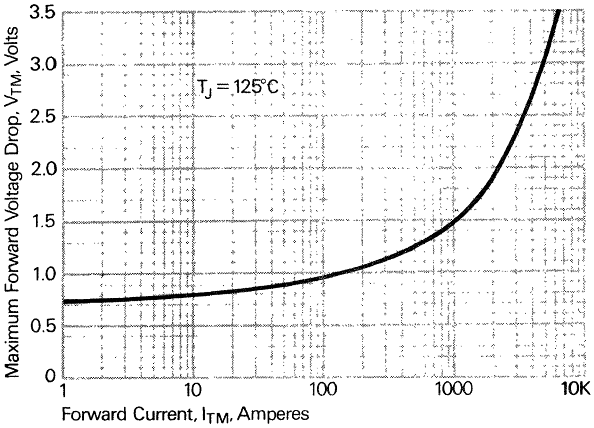
Type				Voltage		Current		Turn-Off	Gate Current	Lead
T	7	8	0		0	3	5	0	4	BY

THYRISTOR

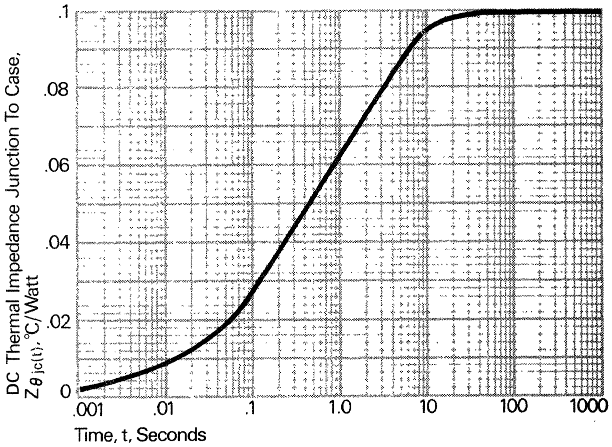
350 A Avg. Up to 1600 Volts

Phase Control SCR T780

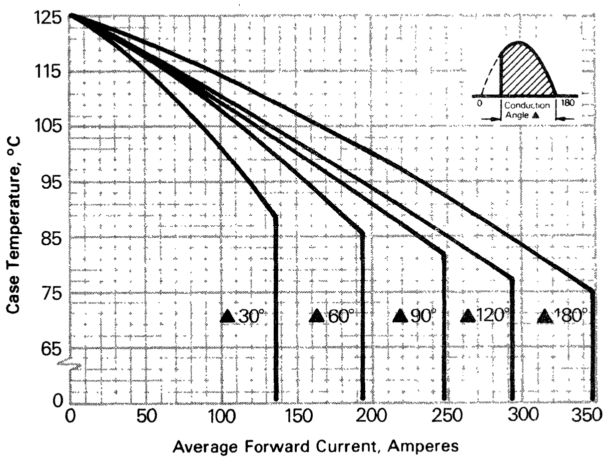
Maximum Forward Voltage VS. Forward Current



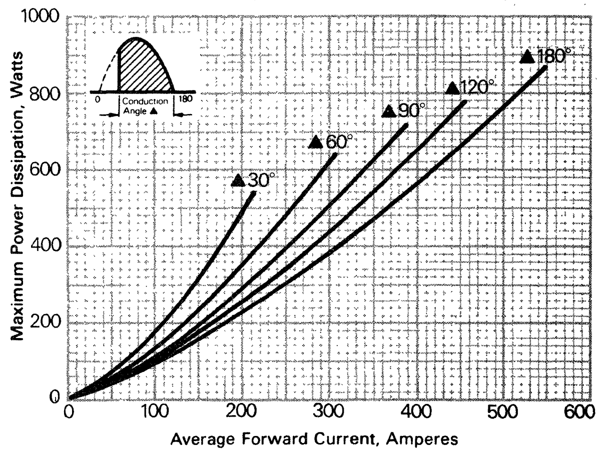
Transient Thermal Impedance VS. Time



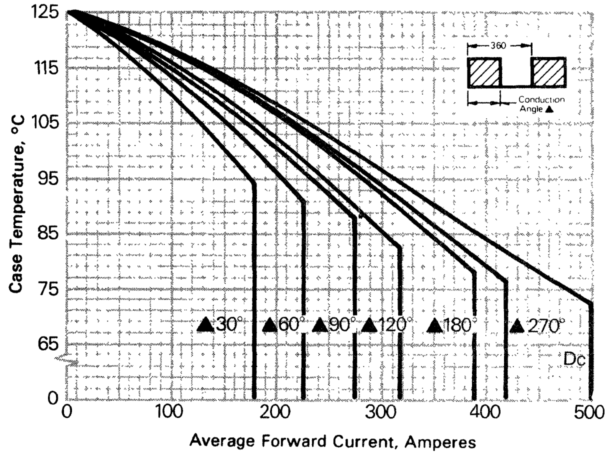
Maximum Case Temperature VS. Forward Current



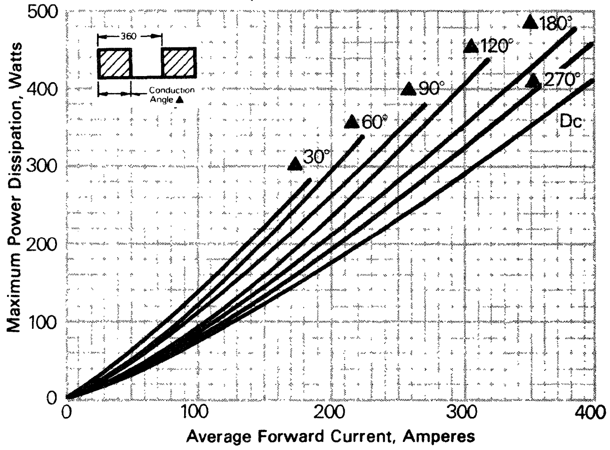
Maximum Power Dissipation VS. Forward Current



Maximum Case Temperature VS. Forward Current

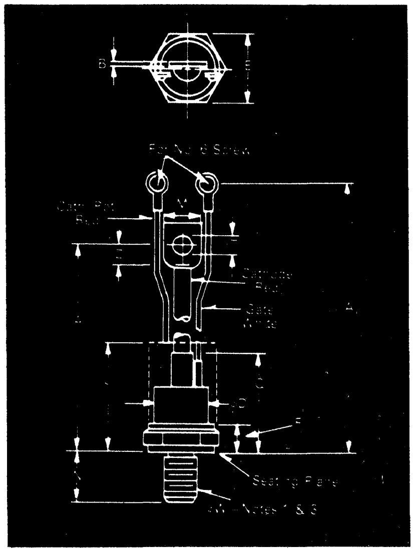


Maximum Power Dissipation VS. Forward Current



Fast Switching SCR T507

40—80 A. Avg. Up to 1200 Volts 10 — 50 μs

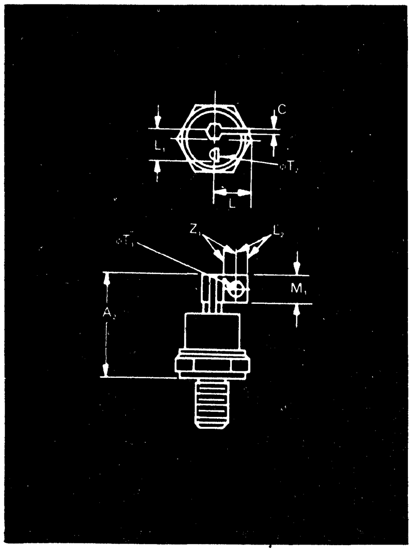


Conforms to TO-94 Outline

Symbol	Inches Min.	Inches Max.	Millimeters Min.	Millimeters Max.
A	5.775	6.265	146.69	159.13
A_1	6.850	7.500	173.99	190.50
B	.055	.075	1.40	1.91
ϕD	.860	1.000	21.84	25.40
E	1.031	1.063	26.19	27.00
F	.255	.400	6.48	10.16
J	2.50		63.50	
M	.437	.650	11.10	16.51
N	.796	.827	20.24	21.01
Q		1.675		42.55
ϕT	.260	.291	6.60	7.39
Z	.250		6.35	
ϕW	½-20 UNF-2A			

Creep & Strike Distance.
T500—.50 in. min. (12.85 mm).
(In accordance with NEMA standards.)
Finish—Nickel Plate.
Approx. Weight—5 oz. (142 g).

1. Complete threads to extend to within 2½ threads of seating plane.
2. Angular orientation of terminals is undefined.
3. Pitch diameter of ½-20 UNF-2A (coated) threads (ASA B1.1-1960).
4. Dimension "J" denotes seated height with leads bent at right angles.

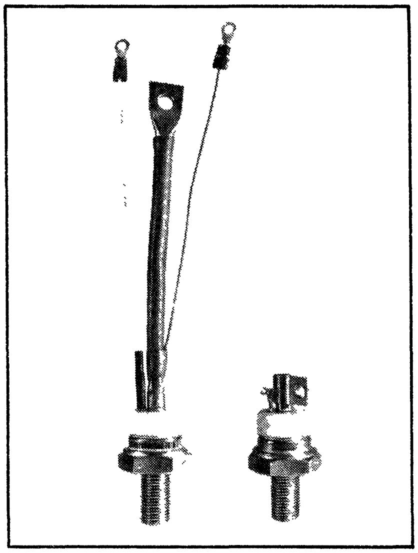


Conforms to TO-83 Outline

Symbol	Inches Min.	Inches Max.	Millimeters Min.	Millimeters Max.
A_2		1.810		45.97
C	.070	.110	1.78	2.79
L		.650		16.51
L_1	.420	.520	10.67	13.21
L_2	.180		4.57	
M_1	.360	.470	9.14	11.94
ϕT_1	.190	.235	4.83	5.97
ϕT_2	.060	.080	1.52	2.03
Z_1	.180		4.57	
ϕW	½-20 UNF-2A			

Approx. Weight—4 oz. (114 g).

1. Basic dimensions of TO-94 and TO-83 are same except as noted.



Note: High frequency sine and square wave data available, consult factory.

Features:
- Center fired di/namic
- High di/dt with soft gate control
- High frequency operation
- Sinusoidal waveform operation to 20 KHz
- Rectangular waveform operation to 20 KHz
- Low dynamic forward voltage drop
- Low switching losses at high frequency
- Lifetime Guarantee

Applications:
- Inverters for
  UPS
  Induction Heating
  AC Motor Control
- Switching power supplies
- Cycloconverters
- Choppers
- Crowbars

Ordering Information

Type	Voltage		Current		Turn-off		Gate current		Leads	
Code	V_{DRM} and V_{RRM} (V)	**Code**	$I_{T(av)}$ (A)	**Code**	tq (μsec)	**Code**	I_{GT} (ma)	**Code**	Case	**Code**
T507	100	**01**	40	**40**	10	**8**	150	**4**	TO-94	**AQ**
	200	**02**			15	**7**				
	300	**03**	70	**70**	20	**6**			TO-83	**AA**
	400	**04**			25	**B**				
	500	**05**	80	**80**	30	**5**				
	600	**06**			40	**4**				
	700	**07**			50	**3**				
	800	**08**								
	900	**09**								
	1000	**10**								
	1100	**11**								
	1200	**12**								

Example

Obtain optimum device performance for your application by selecting proper Order Code.

Type T 507 rated at 80 A average with $V_{DRM} = 1000V$, $I_{GT} = 150$ ma, tq = 30 μsec max. and flex leads—order as:

Type			Voltage		Current		Turn Off	Gate Current	Leads	
T	5	0	7	1	0	8	0	5	4	A	Q

40—80 A. Avg.
Up to 1200 Volts
10 — 50 μs

Fast Switching SCR T507

Voltage

Blocking State Maximums ② (T_J = 125°C)

	Symbol												
Repetitive peak forward blocking voltage, V	V_{DRM}	100	200	300	400	500	600	700	800	900	1000	1100	1200
Repetitive peak reverse voltage, V	V_{RRM}	100	200	300	400	500	600	700	800	900	1000	1100	1200
Non-repetitive transient peak reverse voltage, t ≤ 5.0 msec, V	V_{RSM}	200	300	400	500	600	700	800	900	1000	1100	1200	1300
Forward leakage current, mA peak	I_{DRM}	← 15 →											
Reverse leakage current, mA peak	I_{RRM}	← 15 →											

Current

Conducting State Maximums (T_J = 125°C)

	Symbol	T507 _ _ 40	T507 _ _ 70	T507 _ _ 80
RMS forward current, A	$I_{T(rms)}$	63	110	125
Ave. forward current, A	$I_{T(av)}$	40	70	80
One-half cycle surge current③, A	I_{TSM}	1000	1200	1400
I^2t for fusing (for times ≥ 8.3 ms) A^2 sec.	I^2t	4000	6000	8150
Forward voltage drop at I_{TM} = 500A and T_J = 25°C, V	V_{TM}	4.2	3.5	3.2
Min. repetitive di/dt ①④⑥ A/μsec	di/dt	100	100	150

Switching

(T_J = 25°C)

	Symbol	
Max. turn-off time, I_T = 50A, T_J = 125°C, di_R/dt = 5 A/μsec, reapplied dv/dt = 20V/μsec linear to 0.8 V_{DRM}, μ sec ⑤⑦	t_q	10 to 50
Typ. turn-on-time, I_T = 100A V_D = 100V④, μsec	t_{on}	3.5
Min. critical dv/dt, exponential to V_{DRM}, T_J = 125°C, V/μsec②⑤	dv/dt	200
Min. di/dt non-repetitive, A/μsec ①④⑥	di/dt	800

Gate

Maximum Parameters (T_J = 25°C)

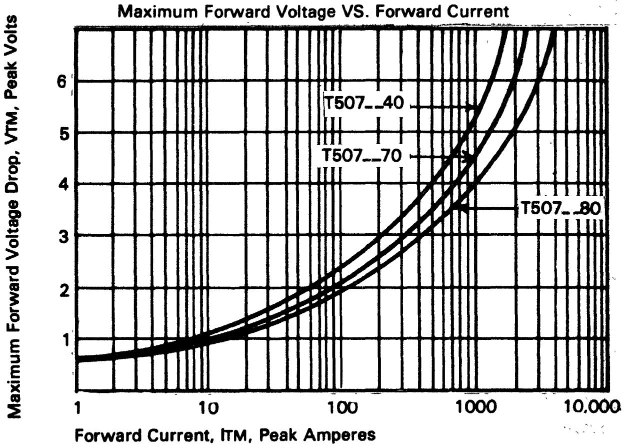
	Symbol	
Gate current to trigger at V_D = 12V, mA	I_{GT}	150
Gate voltage to trigger at V_D = 12V, V	V_{GT}	3
Non-triggering gate voltage, T_J = 125°C, and rated V_{DRM}, V	V_{GDM}	0.15
Peak forward gate current, A	I_{GTM}	4
Peak reverse gate voltage, V	V_{GRM}	5
Peak gate power, Watts	P_{GM}	16
Average gate power, Watts	$P_{G(av)}$	3

Thermal and Mechanical

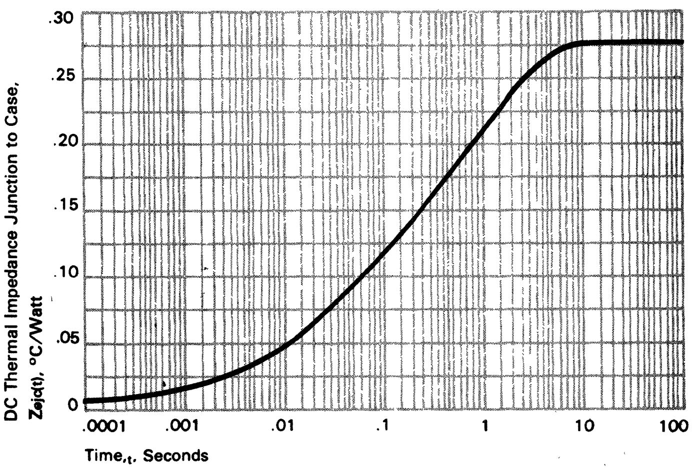
	Symbol	
Min., Max. oper. junction temp., °C	T_J	−40 to +125
Min., Max. storage temp., °C	Tstg	−40 to +150
Max. mounting torque, in lb. ①		130
Max. Thermal resistance ①		
Junction to case, °C/Watt	$R_{\theta JC}$	.28
Case to sink, lubricated, °C/Watt	$R_{\theta CS}$	.12

① Consult recommended mounting procedures.
② Applies for zero or negative gate bias.
③ Per JEDEC RS-397, 5.2.2.1.
④ With recommended gate drive.
⑤ Higher dv/dt ratings available, consult factory.
⑥ Per JEDEC standard RS-397, 5.2.2.6.
⑦ For operation with antiparallel diode, consult factory.

Maximum Forward Voltage VS. Forward Current



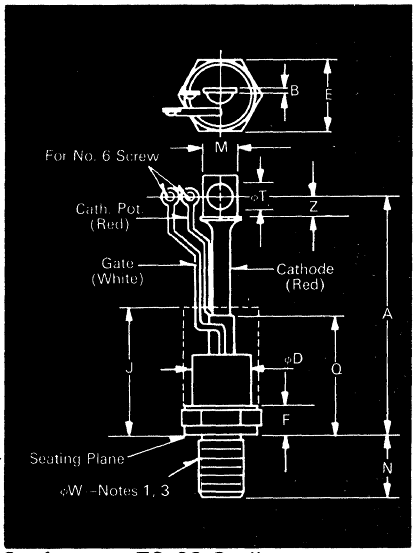
Transient Thermal Impedance VS. Time



THYRISTOR

Fast Switching SCR T607

125 — 175 A. Avg. Up to 1200 Volts 10 — 60 µs

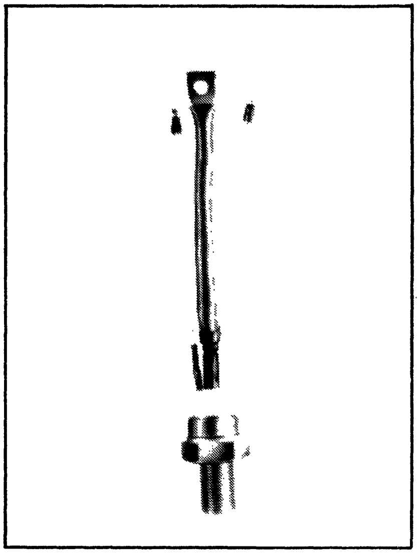


Conforms to TO-93 Outline

Symbol	Inches Min.	Inches Max.	Millimeters Min.	Millimeters Max.
A	7.750	8.100	196.85	205.74
A_1	7.750	8.100	196.85	205.74
B	.063	.172	1.60	4.37
ϕD	.980	1.090	24.89	27.69
E	1.212	1.250	30.78	31.75
F	.250	.630	6.35	16.00
J	3.25		82.55	
M	.530	.755	13.46	19.18
N	1.040	1.077	26.42	27.36
Q		2.250		57.15
ϕT	.260	.290	6.60	7.37
Z	.340		8.64	
ϕW	¾-16 UNF-2A			

Creep & Strike Distance:
.69 in. min. (17.60 mm).
(In accordance with NEMA standards.)
Finish—Nickel Plate.
Approx. Weight—8 oz. (227 g).

1. Complete threads to extend to within 2½ threads of seating plane.
2. Angular orientation of terminals is undefined.
3. Pitch diameter of ¾-16 UNF-2A (coated) threads (ASA B1.1—1960).
4. Dimension "J" denotes seated height with leads bent at right angles.



Note: High frequency sine and square wave data available, consult factory.

Features:
- Center fire, di/namic gate
- High di/dt with soft gate control
- High frequency operation
- Sinusoidal waveform operation to 20 KHz
- Rectangular waveform operation to 20 KHz
- Low dynamic forward voltage drop
- Low switching losses at high frequency
- Westinghouse Lifetime Guarantee

Applications:
- Inverters for
  UPS
  AC motor control
  Induction heating
- Cycloconverters
- Choppers

Ordering Information

Type	Voltage		Current		Turn-off		Gate current		Leads	
Code	V_{DRM} and V_{RRM} (V)	**Code**	$I_{T(av)}$ (A)	**Code**	tq μsec	**Code**	I_{GT} (ma)	**Code**	Case	**Code**
T607	100	**01**	125	**13**	10	**8**	150	**4**	TO-93	**BT**
	200	**02**			15	**7**				
	300	**03**	150	**15**	20	**6**				
	400	**04**			25	**B**				
	500	**05**	175	**18**	30	**5**				
	600	**06**			40	**4**				
	700	**07**			50	**3**				
	800	**08**			60	**2**				
	900	**09**								
	1000	**10**								
	1100	**11**								
	1200	**12**								

Example

Obtain optimum device performance for your application by selecting proper Order Code.

Type T 607 rated at 175A average with $V_{DRM} = 1000V$, $I_{GT} = 150$ ma, tq = 30 μsec and standard flex lead — order as

Type				Voltage		Current		Turn Off	Gate Current	Leads	
T	6	0	7	1	0	1	8	5	4	B	T

THYRISTOR

125 — 175 A. Avg. Up to 1200 Volts 10 — 60 μs

Fast Switching SCR T607

Voltage

Blocking State Maximums ② (T_J = 125°C)

	Symbol												
Repetitive peak forward blocking voltage, V . .	V_{DRM}	100	200	300	400	500	600	700	800	900	1000	1100	1200
Repetitive peak reverse voltage, V	V_{RRM}	100	200	300	400	500	600	700	800	900	1000	1100	1200
Non-repetitive transient peak reverse voltage, t ≤ 5.0 m sec, V	V_{RSM}	200	300	400	500	600	700	800	900	1000	1100	1200	1300
Forward leakage current, mA peak	I_{DRM}	← 25 →											
Reverse leakage current, mA peak	I_{RRM}	← 25 →											

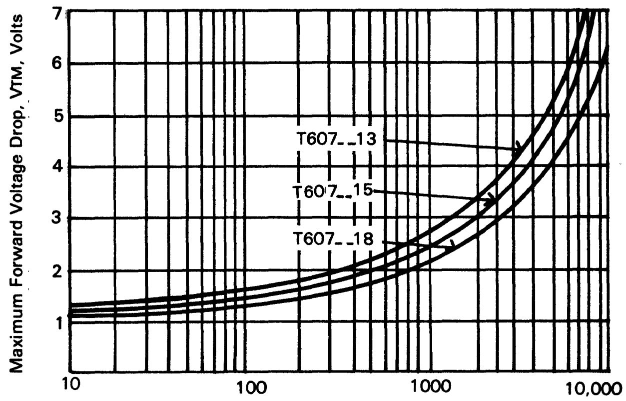
Current

Conducting State Maximums (T_J = 125°C)	Symbol	T607_ _ 13	T607_ _ 15	T607_ _ 18
RMS forward current, A	$I_{T(rms)}$	200	235	275
Ave. forward current, A	$I_{T(av)}$	125	150	175
One-half cycle surge current③, A . .	I_{TSM}	3500	4000	4500
I^2t for fusing (for times ≥ 8.3 ms), A^2·sec.	I^2t	50,000	65,000	84,000
Forward voltage drop at I_{TM} = 625A and T_J = 25°C, V	V_{TM}	2.35	2.1	1.85
Min. repetitive di/dt ①④⑥, A/μsec . . .	di/dt	200	250	300

Switching

(T_J = 25°C)	Symbol	
Max. turn-off time, I_T = 150 A, T_J = 125°C, di_R/dt = 12.5 A/μsec, reapplied dv/dt = 20V/μ sec linear to .8V DRM, μsec ⑤⑦ .	t_q	10 to 60
Typ. turn-on-time, I_T = 100A V_D = 100V④, μsec	t_{on}	3.5
Min. critical dv/dt, exponential to V_{DRM} · T_J = 125°C, V/μsec②⑤.	dv/dt	300
Min. di/dt non-repetitive, ①④⑥, A/μsec	di/dt	800

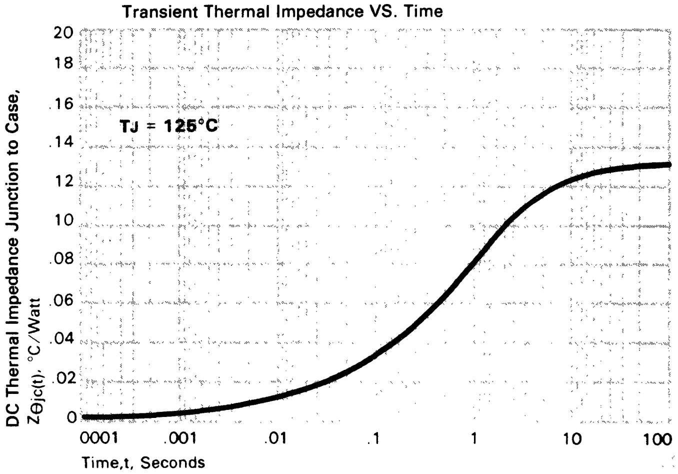
Maximum Forward Voltage VS. Forward Current



Gate

Maximum Parameters (T_J = 25°C)	Symbol	
Gate current to trigger at V_D = 12V, mA	I_{GT}	150
Gate voltage to trigger at V_D = 12V, V . . .	V_{GT}	3
Non-triggering gate voltage, T_J = 125°C, and rated V_{DRM}, V	V_{GDM}	0.15
Peak forward gate current, A	I_{GTM}	4
Peak reverse gate voltage, V	V_{GRM}	5
Peak gate power, Watts	P_{GM}	16
Average gate power, Watts	$P_{G(av)}$	3

Transient Thermal Impedance VS. Time



Thermal and Mechanical

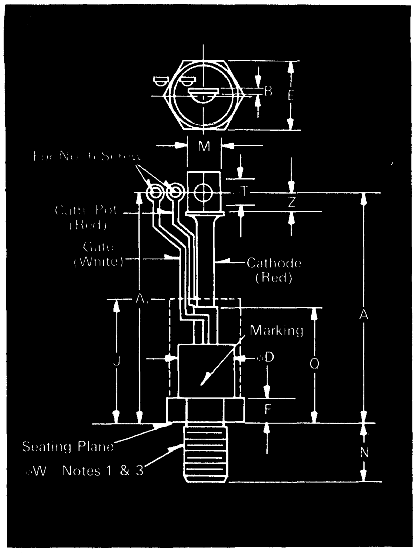
	Symbol	
Min., Max. oper. junction temp., °C	T_J	−40 to +125
Min., Max. storage temp., °C	Tstg	−40 to +150
Max. mounting torque, in lb. ①		300
Max. Thermal resistance ①		
Junction to case, °C/Watt	$R_{\theta JC}$	.13
Case to sink, lubricated, °C/Watt	$R_{\theta CS}$	.08

① Consult recommended mounting procedures.
② Applies for zero or negative gate bias.
③ Per JEDEC RS-397, 5.2.2.1.
④ With recommended gate drive.
⑤ Higher dv/dt ratings available, consult factory.
⑥ Per JEDEC standard RS-397, 5.2.2.6.
⑦ For operation with antiparallel diode, consult factory.

THYRISTOR

Fast Switching SCR T707

250-325 A Avg. Up to 1200 Volts 10 - 60 μs

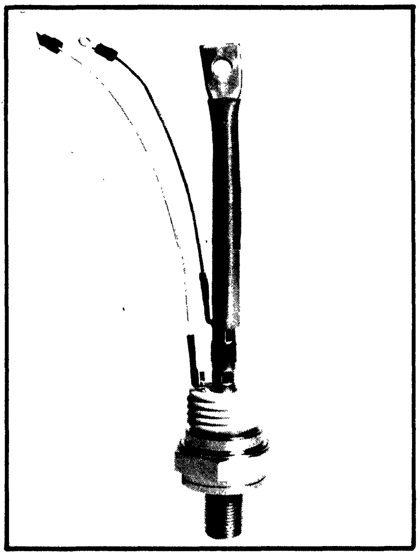


T70 Outline

Symbol	Inches Min.	Inches Max.	Millimeters Min.	Millimeters Max.
A	9.76	10.00	247.90	254.00
A_1	10.18	10.42	258.57	264.67
B	.063	.172	1.60	4.37
ϕD		1.490		37.85
E	1.620	1.750	41.15	44.45
F	.430	.810	10.92	20.57
J	4.000		101.60	
M	.530	.755	13.46	19.18
N	1.04	1.08	26.42	27.43
Q		3.100		78.74
ϕT	.330	.350	8.38	8.89
Z	.440		11.18	
ϕW	¾-16 UNF-2A			

Creep Distance—1.76 in. min. (44.91 mm).
Strike Distance— .81 in. min. (20.70 mm).
(In accordance with NEMA standards.)
Finish—Nickel Plate.
Approx. Weight—16 oz. (454 g).

1. Complete threads to extend to within 2½ threads of seating plane.
2. Angular orientation of terminals is undefined.
3. Pitch diameter of ¾-16 UNF-2A (coated) threads (ASA B1.1-1960).
4. Dimension "J" denotes seated height with leads bent at right angles.



Note: High frequency sine and square wave data available, consult factory.

Features:

- Center fired di/namic gate
- High di/dt with soft gate control
- High frequency operation
- Sinusoidal waveform operation to 20 KHz
- Rectangular waveform operation to 20 KHz
- Low dynamic forward voltage drop
- Low switching losses at high frequency
- Westinghouse Lifetime Guarantee

Applications:

- Inverters for
  UPS
  Induction heating
  AC motor drives
- Cycloconverters
- Choppers
- Crowbar

Ordering Information

Type	Voltage		Current		Turn-off		Gate current		Leads	
Code	V_{DRM} and V_{RRM} (V)	**Code**	$I_{T(av)}$ (A)	**Code**	tq μsec	**Code**	I_{GT} (ma)	**Code**	Case	**Code**
T707	100	**01**			10	**8**	150	**4**	T70	**BY**
	200	**02**	275	**28**	15	**7**				
	300	**03**			20	**6**				
	400	**04**			25	**8**				
	500	**05**	325	**33**	30	**5**				
	600	**06**			40	**4**				
	700	**07**			50	**3**				
	800	**08**	250	**25**	30	**5**				
	900	**09**	300	**30**	40	**4**				
	1000	**10**			50	**3**				
	1100	**11**			60	**2**				
	1200	**12**								

Example

Obtain optimum device performance for your application by selecting proper Order Code.

Type T 707 rated at 300 A average with V_{DRM} = 1000V, I_{GT} = 150 ma, tq = 30 μsec and standard flex lead — order as

Type				Voltage		Current		Turn Off	Gate Current	Leads	
T	7	0	7	1	0	3	0	5	4	B	Y

THYRISTOR

250-325 A Avg. Up to 1200 Volts 10 - 60 μs

Fast Switching SCR T707

Voltage

Blocking State Maximums② (T_J = 125°C)

	Symbol												
Repetitive peak forward blocking voltage , V	V_{DRM}	100	200	300	400	500	600	700	800	900	1000	1100	1200
Repetitive peak reverse voltage V	V_{RRM}	100	200	300	400	500	600	700	800	900	1000	1100	1200
Non-repetitive transient peak reverse voltage, t ≤ 5.0 msec, V	V_{RSM}	200	300	400	500	600	700	800	900	1000	1100	1200	1300
Type designation vs. Voltage availability		← T707_ _28; T707_ _33 (100–800) →											
		← T707_ _25; T707_ _30 (100–1200) →											
Forward leakage current, mA peak	I_{DRM}	← 30 →											
Reverse leakage current, mA peak	I_{RRM}	← 30 →											

Current

Conducting State Maximums (T_J = 125°C)

	Symbol	T707_ _28	T707_ _33	T707_ _25	T707_ _30
RMS forward current, A	$I_{T(rms)}$	430	500	400	475
Ave. forward current, A	$I_{T(av)}$	275	325	250	300
One-half cycle surge current③, A	I_{TSM}	7000	8000	7000	8000
I^2t for fusing (for times ≥ 8.3 ms) A^2 sec.	I^2t	205,000	265,000	205,000	265,000
Forward voltage drop at I_{TM} = 3000A and T_J = 25°C, V	V_{TM}	2.50	2.30	2.90	2.60
Min. repetitive di/dt , A/μsec ①④⑥	di/dt	300	400	300	400

Switching

(T_J = 25°C)

	Symbol	
Max. turn-off time, I_T = 400A, T_J = 125°C, di_R/dt = 25 A/μsec, reapplied dv/dt = 20V/μsec. linear to .8V DRM, μsec⑤⑦	t_q	10 to 60
Typ. turn-on-time, I_T = 1000A V_D = 300V④, μsec	t_{on}	3.0
Min. critical dv/dt, exponential to V_{DRM}, T_J = 125°C, V/μsec②⑤	dv/dt	300
Min. di/dt, non-repetitive,①④⑥ A/μsec	di/dt	800

Gate

Maximum Parameters (T_J = 25°C)

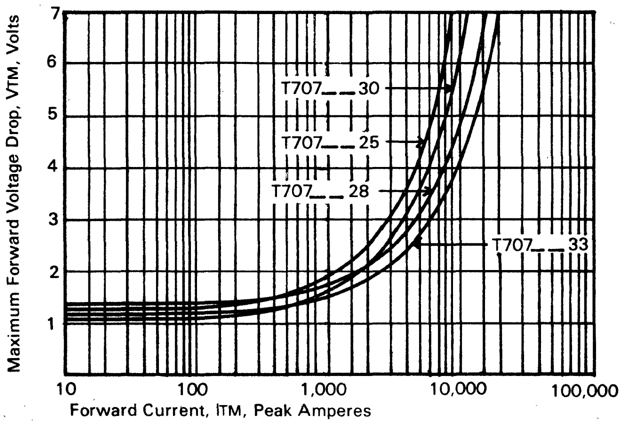
	Symbol	
Gate current to trigger at V_D = 12V, mA	I_{GT}	150
Gate voltage to trigger at V_D = 12V, V	V_{GT}	3
Non-triggering gate voltage, T_J = 125°C, and rated V_{DRM}, V	V_{GDM}	0.15
Peak forward gate current, A	I_{GTM}	4
Peak reverse gate voltage, V	V_{GRM}	5
Peak gate power, Watts	P_{GM}	16
Average gate power, Watts	$P_{G(av)}$	3

Thermal and Mechanical

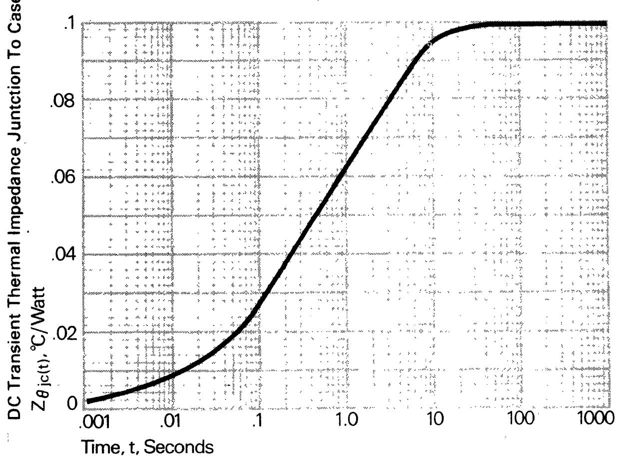
	Symbol	
Min., Max. oper. junction temp., °C	T_J	−40 to +125
Min., Max. storage temp., °C	Tstg	−40 to +150
Max. mounting torque, in lb. ①		360
Max. Thermal resistance ① Junction to case, °C/Watt	$R_{\theta JC}$	.10
Case to sink, lubricated, °C/Watt	$R_{\theta CS}$	.05

① Consult recommended mounting procedures.
② Applies for zero or negative gate bias.
③ Per JEDEC RS-397, 5.2.2.1.
④ With recommended gate drive.
⑤ Higher dv/dt ratings available, consult factory.
⑥ Per JEDEC standard RS-397, 5.2.2.6.
⑦ For operation with antiparallel diode, consult factory.

Maximum Forward Voltage Drop, Vs. Forward Current



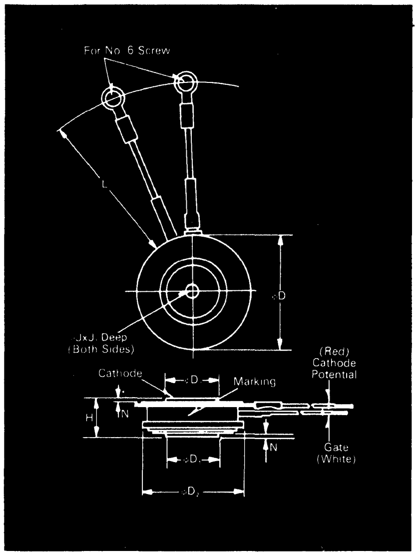
Transient Thermal Impedance VS. Time



THYRISTOR

Fast Switching SCR T527

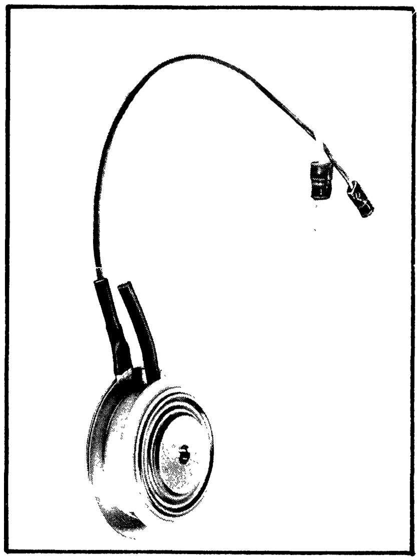
60 — 125 A. Avg. Up to 1200 Volts 10 to 50 μs



T52 Outline

Symbol	Inches Min.	Inches Max.	Millimeters Min.	Millimeters Max.
ϕD	1.610	1.650	40.89	41.91
ϕD_1	.745	.755	18.92	19.18
ϕD_2	1.420	1.460	36.07	37.08
H	.500	.560	12.70	14.22
ϕJ	.135	.145	3.43	3.68
J_1	.072	.082	1.83	2.08
L	7.75	8.50	196.85	215.90
N	.030		.76	

Creep Distance—.34 in. min. (8.64 mm).
Strike Distance—.52 in. min. (13.21 mm).
(In accordance with NEMA standards.)
Finish—Nickel Plate.
Approx. Weight—2.3 oz. (66 g).
1. Dimension "H" is clamped dimension.



Note: High frequency sine and square wave data available, consult factory.

Features:
- Center fired di/namic gate
- High di/dt with soft gate control
- High frequency operation
- Sinusoidal waveform operation to 20 KHz
- Rectangular waveform operation to 20 KHz
- Low dynamic forward voltage drop
- Low switching losses at high frequency
- Lifetime Guarantee

Applications:
- Inverters for
  - UPS
  - Induction Heating
  - Motor Control
- Choppers
- Crowbars

THYRISTOR

Ordering Information

Type	Voltage		Current		Turn-off		Gate current		Leads	
Code	V_{DRM} and V_{RRM} (V)	**Code**	$I_{T(av)}$ (A)	**Code**	tq μsec	**Code**	I_{GT} (ma)	**Code**	Case	**Code**
T527	100	**01**	60	**60**	10	**8**	150	**4**	T62	**DN**
	200	**02**	115	**12**	15	**7**				
	300	**03**	125	**13**	20	**6**				
	400	**04**			30	**5**				
	500	**05**			40	**4**				
	600	**06**			50	**3**				
	700	**07**								
	800	**08**								
	900	**09**								
	1000	**10**								
	1100	**11**								
	1200	**12**								

Example

Obtain optimum device performance for your application by selecting proper Order Code.

Type T527 rated at 115 A average with $V_{DRM} = 800V$, $I_{GT} = 150$ ma, tq $= 20$ μsec max. and flex leads—order as:

Type				Voltage		Current		Turn Off	Gate Current	Leads	
T	5	2	7	0	8	1	2	6	4	D	N

60 — 125 A. Avg. Up to 1200 Volts 10 to 50 μs

Fast Switching SCR T527

Voltage

Blocking State Maximums ① (T_J = 125°C)

	Symbol												
Repetitive peak forward blocking voltage, V	V_{DRM}	100	200	300	400	500	600	700	800	900	1000	1100	1200
Repetitive peak reverse voltage, V	V_{RRM}	100	200	300	400	500	600	700	800	900	1000	1100	1200
Non-repetitive transient peak reverse voltage, t 5 0 msec, V	V_{RSM}	200	300	400	500	600	700	800	900	1000	1100	1200	1300
Forward leakage current, mA peak	I_{DRM}	← 25 →											
Reverse leakage current, mA peak	I_{RRM}	← 25 →											

Current

Conducting State Maximums (T_J = 125°C)

	Symbol	T527_ _60	T527_ _12	T527_ _13
RMS forward current, A	$I_{T(rms)}$	95	180	200
Ave. forward current, A	$I_{T(av)}$	60	115	125
One-half cycle surge current③, A	I_{TSM}	1000	1200	1400
I^2t for fusing (for times ≥ 8.3 ms) A^2 sec.	I^2t	4000	6000	8150
Forward voltage drop at I_{TM} = 500A and T_J = 25°C, V	V_{TM}	4.2	3.5	3.2
Min. repetitive di/dt, A/μsec ①④⑥	di/dt	100	100	150

Switching

(T_J = 25°C)

	Symbol	
Max. turn-off time, I_T = 50A, T_J = 125°C, di_R/dt = 5 A/μsec, reapplied dv/dt = 20V/μsec linear to 0.8 V_{DRM}, μ sec ⑤⑦	t_q	10 to 50
Typ. turn-on-time, I_T = 100A V_D = 100V④, μsec	t_{on}	3.5
Min. critical dv/dt, exponential to V_{DRM}, T_J = 125°C, V/μsec②⑤	dv/dt	300
Min. di/dt non-repetitive, A/μsec ①④⑥	di/dt	400

Gate

Maximum Parameters (T_J = 25°C)

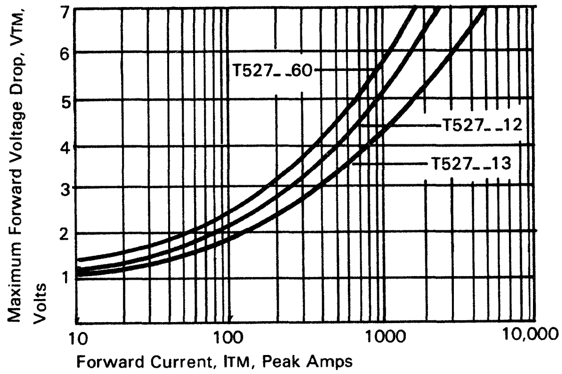
	Symbol	
Gate current to trigger at V_D = 12V, mA	I_{GT}	150
Gate voltage to trigger at V_D = 12V, V	V_{GT}	3
Non-triggering gate voltage, T_J = 125°C, and rated V_{DRM}, V	V_{GDM}	0.15
Peak forward gate current, A	I_{GTM}	4
Peak reverse gate voltage, V	V_{GRM}	5
Peak gate power, Watts	P_{GM}	16
Average gate power, Watts	$P_{G(av)}$	3

Thermal and Mechanical

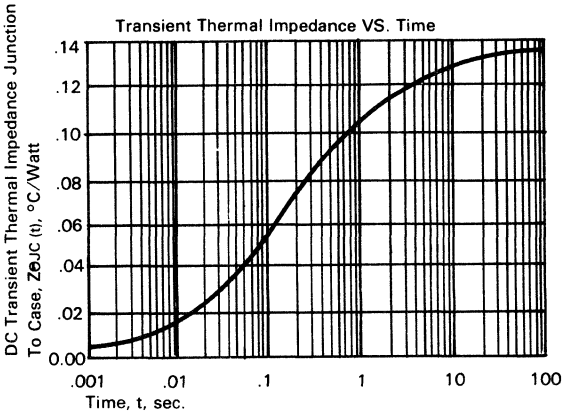
	Symbol	
Min., Max. oper. junction temp., °C	T_J	−40 to +125
Min., Max. storage temp., °C	Tstg	−40 to +150
Max. mounting force, lb.①		800 to 1000
Max Thermal resistance doubled side cooled Junction to case, °C/Watt	$R_{\theta JC}$	.135
Case to sink, lubricated, °C/Watt	$R_{\theta CS}$	.02

① Consult recommended mounting procedures.
② Applies for zero or negative gate bias.
③ Per JEDEC RS-397, 5.2.2.1.
④ With recommended gate drive.
⑤ Higher dv/dt ratings available, consult factory.
⑥ Per JEDEC standard RS-397, 5.2.2.6.
⑦ For operation with antiparallel diode, consult factory.

Maximum Forward Voltage VS. Forward Current



Transient Thermal Impedance VS. Time

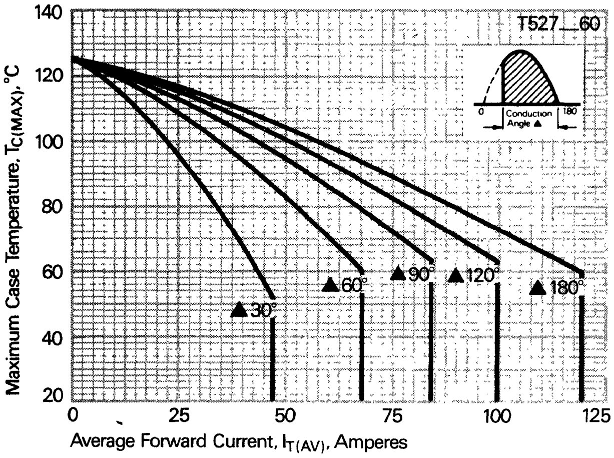


THYRISTOR

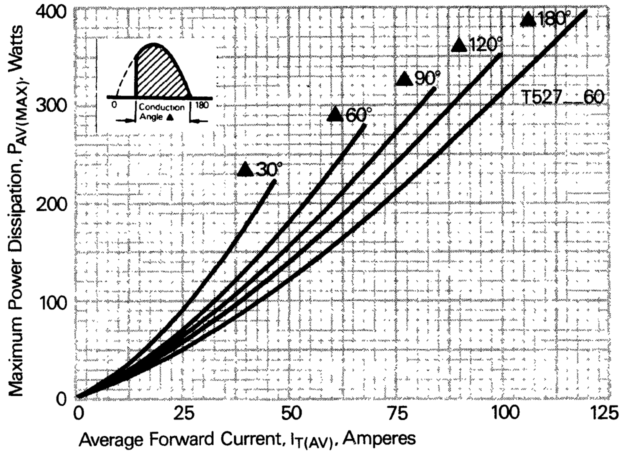
Fast Switching SCR T527

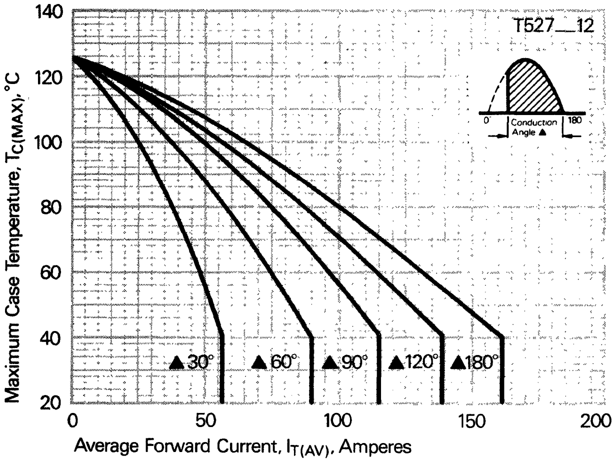
60 — 125 A. Avg.
Up to 1200 Volts
10 to 50 μs

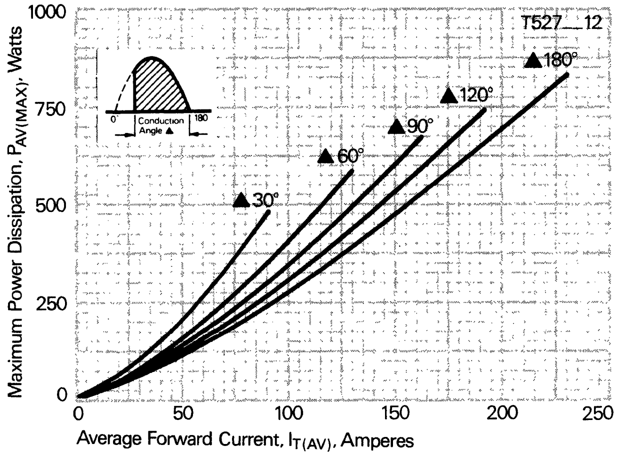
Case Temperature vs. Forward Current — **Double Sided Cooling**

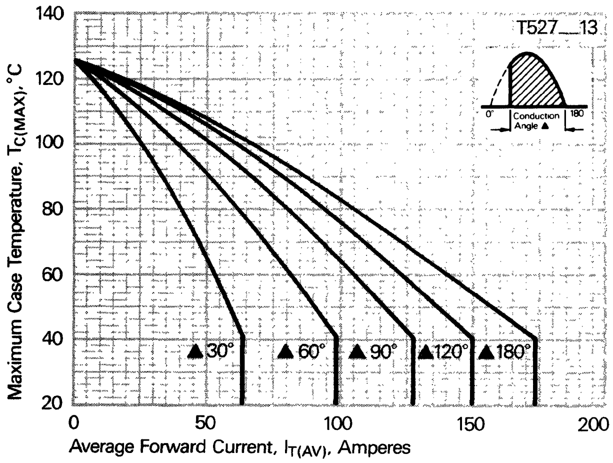


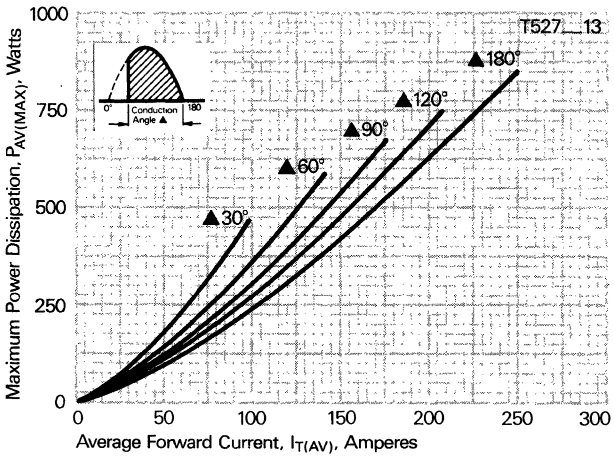
Power Loss vs. Forward Current









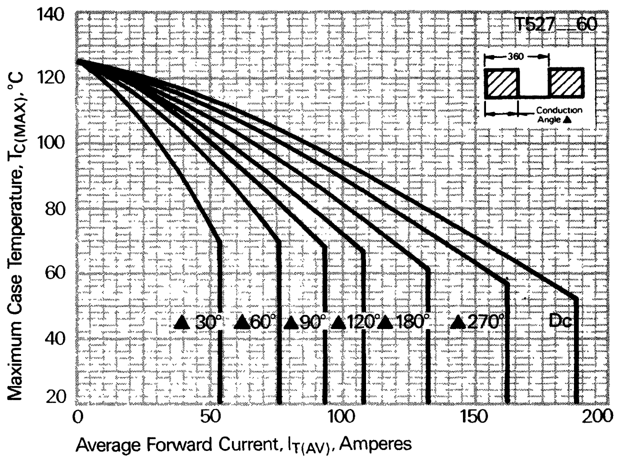


60 — 125 A. Avg.
Up to 1200 Volts
10 to 50 μs

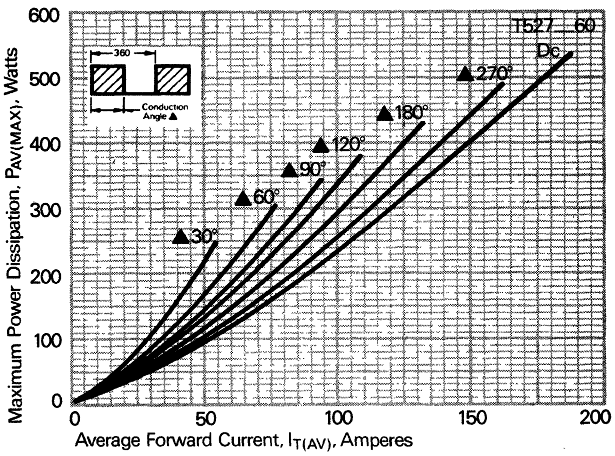
Fast Switching
SCR
T527

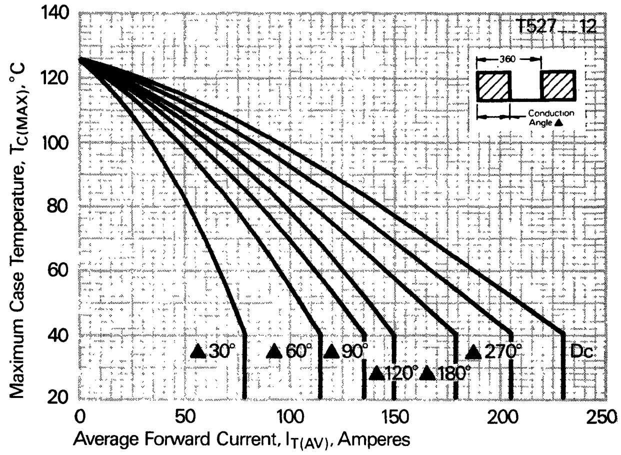
THYRISTOR

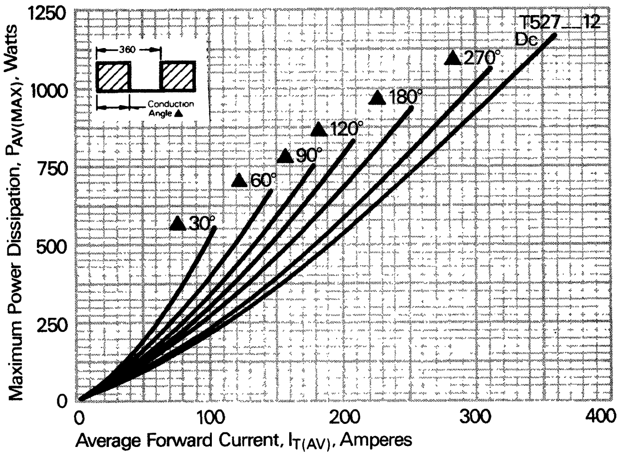
Case Temperature vs. Forward Current — **Double Sided Cooling**

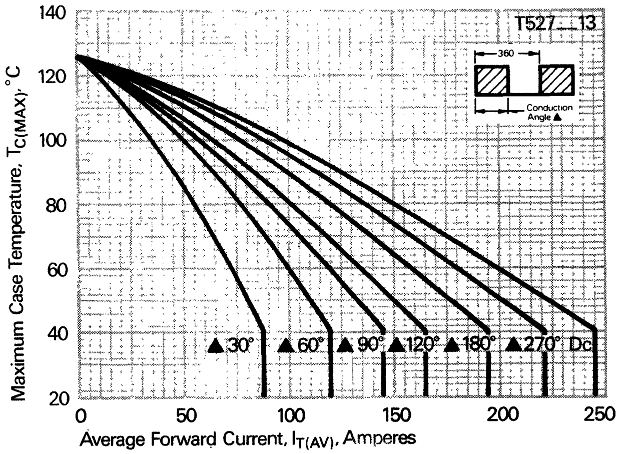


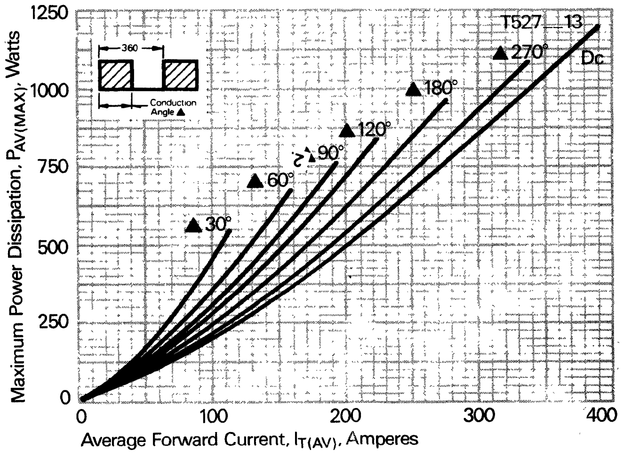
Power Loss vs. Forward Current





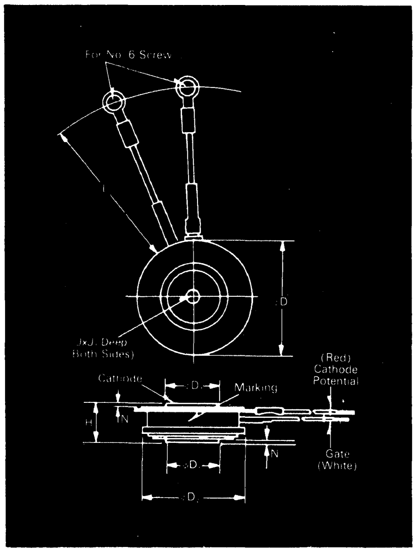






Fast Switching SCR T627

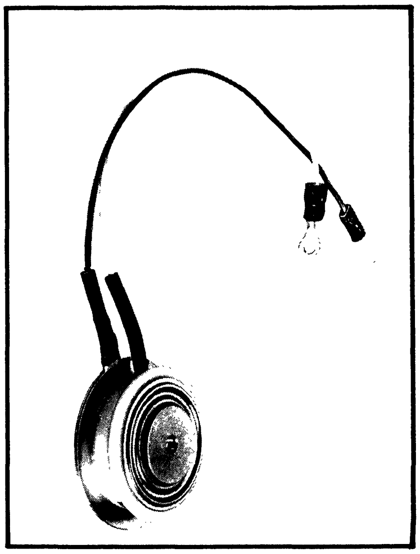
150—250 A. Avg. Up to 1200 Volts 10—50 µs



T62 Outline

Symbol	Inches Min.	Inches Max.	Millimeters Min.	Millimeters Max.
ϕD	1.610	1.650	40.89	41.91
ϕD_1	.745	.755	18.92	19.18
ϕD_2	1.420	1.460	36.07	37.08
H	.500	.560	12.70	14.22
ϕJ	.135	.145	3.43	3.68
J_1	.072	.082	1.83	2.08
L	7.75	8.50	196.85	215.90
N	.030		.76	

Creep Distance—.34 in. min. (8.64 mm).
Strike Distance—.52 in. min. (13.21 mm).
(In accordance with NEMA standards.)
Finish—Nickel Plate.
Approx. Weight—2.3 oz. (66 g).
1. Dimension "H" is clamped dimension.



Features:
- Center fired di/namic gate
- High di/dt with soft gate control
- High frequency operation
- Sinusoidal waveform operation to 20 KHz
- Rectangular waveform operation to 20 KHz
- Low dynamic forward voltage drop
- Low switching losses at high frequency

Applications:
- Inverters for
  - Ups
  - Induction Heating
  - Motor Control
- Choppers
- Crowbars

Note: High frequency sine and square wave data available, consult factory.

Ordering Information

Type	Voltage		Current		Turn-off		Gate current		Leads	
Code	V_{DRM} and V_{RRM} (V)	**Code**	$I_{T(av)}$ (A)	**Code**	tq (usec)	**Code**	I_{GT} (ma)	**Code**	Case	**Code**
T627	100	**01**	150	**15**	10	**8**	150	**4**	T62	**DN**
	200	**02**	200	**20**	15	**7**				
	300	**03**	250	**25**	20	**6**				
	400	**04**			30	**5**				
	500	**05**			40	**4**				
	600	**06**			50	**3**				
	700	**07**								
	800	**08**								
	900	**09**								
	1000	**10**								
	1100	**11**								
	1200	**12**								

Example

Obtain optimum device performance for your application by selecting proper Order Code.

Type T627 rated at 200 A average with $V_{DRM} = 1000V$, $I_{GT} = 150$ ma, tq = 20 μsec max. and flex leads—order as:

Type				Voltage		Current		Turn Off	Gate Current	Leads	
T	6	2	7	1	0	2	0	6	4	D	N

THYRISTOR

150—250 A. Avg. Up to 1200 Volts 10—50 μs

Fast Switching SCR T627

THYRISTOR

Voltage

Blocking State Maximums ② (T_J = 125°C)

	Symbol												
Repetitive peak forward blocking voltage, V	V_{DRM}	100	200	300	400	500	600	700	800	900	1000	1100	1200
Repetitive peak reverse voltage, V	V_{RRM}	100	200	300	400	500	600	700	800	900	1000	1100	1200
Non-repetitive transient peak reverse voltage, t ≤ 5.0 msec, V	V_{RSM}	200	300	400	500	600	700	800	900	1000	1100	1200	1300
Forward leakage current, mA peak	I_{DRM}	← 25 →											
Reverse leakage current, mA peak	I_{RRM}	← 25 →											

Current

Conducting State Maximums (T_J = 125°C)

	Symbol	T627_ _15	T627_ _20	T627_ _25
RMS forward current, A	$I_{T(rms)}$	235	315	400
Ave. forward current, A	$I_{T(av)}$	150	200	250
One-half cycle surge current③, A	I_{TSM}	3500	4000	4500
I^2t for fusing (for times ≥ 8.3 ms) A^2 sec.	I^2t	50,000	65,000	84,000
Forward voltage drop at I_{TM} = 625A and T_J = 25°C, V	V_{TM}	2.35	2.1	1.85
Min. repetitive di/dt④, A/μsec①④⑥	di/dt	200	250	300

Switching

(T_J = 25°C)

	Symbol	
Max. turn-off time, I_T = 150A, T_J = 125°C, di_R/dt = 12.5 ⑦ A/μsec, reapplied dv/dt = 20V/μsec ⑤ linear to 0.8 V_{DRM}, μ sec	t_q	10 to 50
Typ. turn-on-time, I_T = 100A V_D = 100V④, μsec	t_{on}	3.5
Min. critical dv/dt, exponential to V_{DRM}, T_J = 125°C, V/μsec②⑤	dv/dt	300
Min. di/dt A/μsec ①④⑥	di/dt	800

Gate

Maximum Parameters (T_J = 25°C)

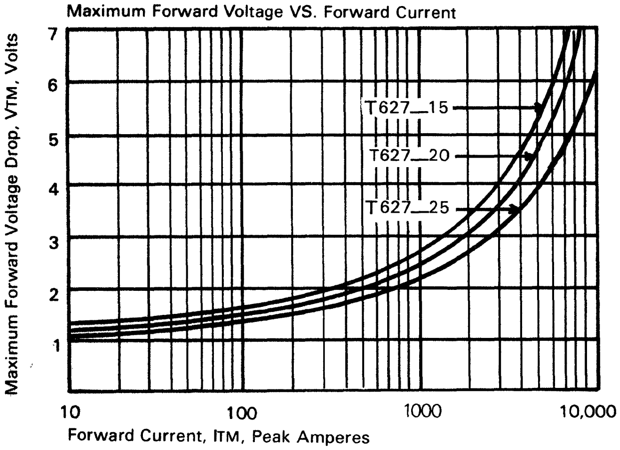
	Symbol	
Gate current to trigger at V_D = 12V, mA	I_{GT}	150
Gate voltage to trigger at V_D = 12V, V	V_{GT}	3
Non-triggering gate voltage, T_J = 125°C, and rated V_{DRM}, V	V_{GDM}	0.15
Peak forward gate current, A	I_{GTM}	4
Peak reverse gate voltage, V	V_{GRM}	5
Peak gate power, Watts	P_{GM}	16
Average gate power, Watts	$P_{G(av)}$	3

Thermal and Mechanical

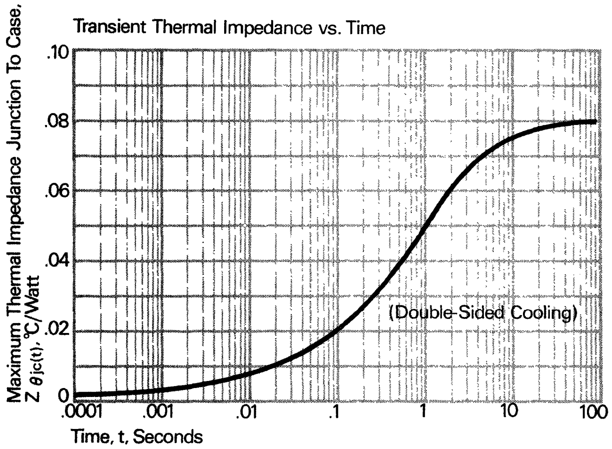
	Symbol	
Min., Max. oper. junction temp., °C	T_J	−40 to +125
Min., Max. storage temp., °C	Tstg	−40 to +150
Min., Max. Mounting Force, lb.①		1000 to 1400
Max. thermal resistance, Double side cooled Junction to case, °C/Watt	$R_{\theta JC}$	.08
Case to sink, lubricated, °C/Watt	$R_{\theta CS}$	.02

① Consult recommended mounting procedures.
② Applies for zero or negative gate bias.
③ Per JEDEC RS-397, 5.2.2.1.
④ With recommended gate drive.
⑤ Higher dv/dt ratings available, consult factory.
⑥ Per JEDEC standard RS-397, 5.2.2.6.
⑦ For operation with antiparallel diode, consult factory.

Maximum Forward Voltage VS. Forward Current

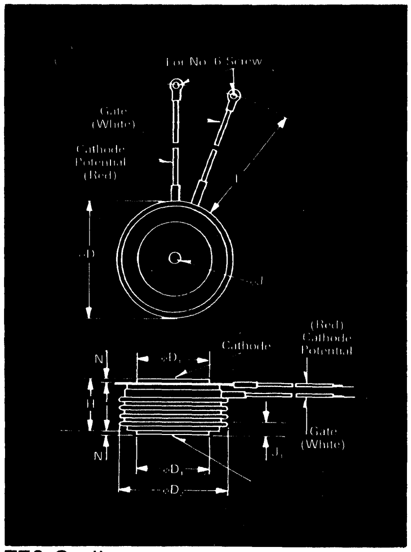


Transient Thermal Impedance vs. Time



Fast Switching SCR T72H

250—450 A. Avg. Up to 1200 Volts 25 — 50 µs

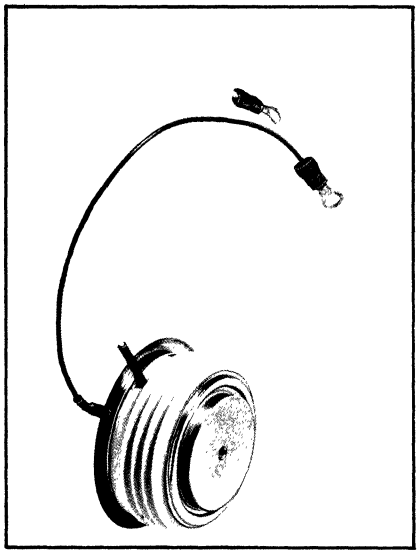


T72 Outline

Symbol	Inches Min.	Inches Max.	Millimeters Min.	Millimeters Max.
ϕD	2.250	2.290	57.15	58.17
ϕD_1	1.333	1.343	33.86	34.11
ϕD_2	2.030	2.090	51.56	53.09
H	1.020	1.060	25.91	26.92
ϕJ	.135	.145	3.43	3.68
J_1	.075	.090	1.91	2.29
L	7.75	8.50	196.85	215.90
N	.040		1.02	

Creep Distance—1.00 in. min. (25.40 mm).
Strike Distance—1.02 in. min. (25.91 mm).
(In accordance with NEMA standards.)
Finish—Nickel Plate.
Approx. Weight—8 oz. (227 g).

1. Dimension "H" is a clamped dimension.



Features:

- Midway, di/namic Gate structure
- Hard Commutation Turn-Off
- Forward Blocking Capabilities to 1200 Volts
- Low Switching Losses at High Frequency
- Soft Commutation (Feedback Diode) Testing Available

Applications:

- Induction Heating
- Transportation
- Inverters

Note: High frequency sine and square wave data available, consult factory.

Ordering Information

Type	Voltage		Current		Turn-off		Gate current		Leads	
Code	VDRM and VRRM (V)	Code	IT(av) (A)	Code	tq (µsec)	Code	IGT (ma)	Code	Case	Code
T72H	100	01	250	25	25	8	150	4	T72	DN
	200	02	350	35	30	5				
	300	03	450	45	40	4				
	400	04			50	3				
	500	05								
	600	06								
	700	07								
	800	08								
	900	09								
	1000	10								
	1100	11								
	1200	12								

Example

Obtain optimum device performance for your application by selecting proper Order Code.

Type T72H rated at 450 A average with VDRM = 1000V, I_{GT} = 150 ma, t_q = 30 µsec max. and flex leads—order as:

Type				Voltage		Current		Turn Off	Gate Current	Leads	
T	7	2	H	1	0	4	5	5	4	D	N

THYRISTOR

250—450 A. Avg.
Up to 1200 Volts
25 — 50 μs

Fast Switching SCR
T72H

THYRISTOR

Voltage ②

Blocking State Maximums (T_J = 125°C)

	Symbol												
Repetitive peak forward blocking voltage, V	V_{DRM}	100	200	300	400	500	600	700	800	900	1000	1100	1200
Repetitive peak reverse voltage, V	V_{RRM}	100	200	300	400	500	600	700	800	900	1000	1100	1200
Non-repetitive transient peak reverse voltage, t ≤ 5.0 msec, V	V_{RSM}	200	300	400	500	600	700	800	900	1000	1100	1200	1300
Forward leakage current, mA peak	I_{DRM}	← 35 →											
Reverse leakage current, mA peak	I_{RRM}	← 35 →											

Current

Conducting State Maximums (T_J = 125°C)

	Symbol	T72H_ _25	T72H_ _35	T72H_ _45
RMS forward current, A	$I_{T(rms)}$	400	550	700
Ave. forward current, A	$I_{T(av)}$	250	350	450
One-half cycle surge current③, A	I_{TSM}	6000	7000	7500
3 cycle surge current③, A	I_{TSM}	4320	5040	5300
10 cycle surge current③, A	I_{TSM}	3720	4340	4650
I^2t for fusing (for times ≥ 8.3 ms) A^2 sec.	I^2t	150,000	205,000	234,000
Forward voltage drop at ITM = 3000A and T_J = 25°C, V	V_{TM}	3.80	3.45	3.10
Min. repetitive di/dt①④⑥ A/μsec	di/dt	400	500	600

Switching

(T_J = 25°C)

	Symbol	
Max. turn-off time, IT = 1000A, TJ = 125°C tp = 100 μsec. dirR/dt = 50 A/μsec., reapplied dv/dt = 50 V/μsec. linear to 0.8 VDRM, μsec. ⑤⑦	tq	25 to 50
Typ. delay time, ITM = 1000A TD = .8 VDRM④, μsec	td	.5
Min. critical dv/dt exponential to .8 VDRM, TJ = 125°C, V/μsec ②⑤	dv/dt	300
Min. di/dt, non-repetitive, A/μsec ①④⑥	di/dt	1200

Gate

Maximum Parameters (T_J = 25°C)

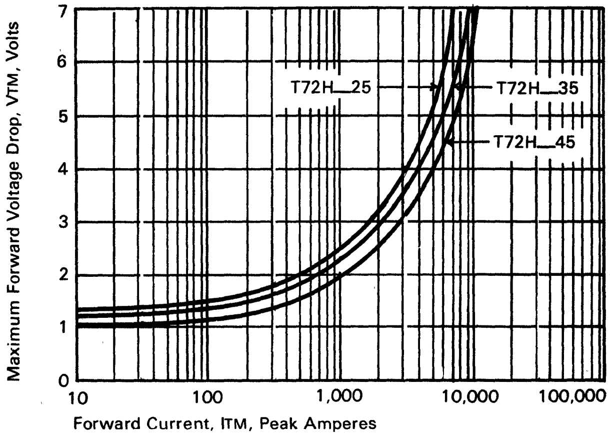
	Symbol	
Gate current to trigger at V_D = 12V, mA	I_{GT}	150
Gate voltage to trigger at V_D = 12V, V	V_{GT}	3
Non-triggering gate voltage, T_J = 125°C, and rated V_{DRM}, V	V_{GDM}	.25
Peak forward gate current, A	I_{GTM}	4
Peak reverse gate voltage, V	V_{GRM}	5
Peak gate power, Watts	P_{GM}	16
Average gate power, Watts	$P_{G(av)}$	3

Thermal and Mechanical

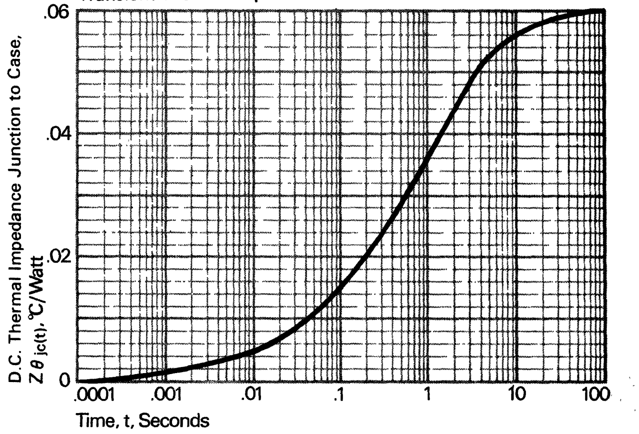
	Symbol	
Min., Max. oper. junction temp., °C	T_J	−40 to +125
Min., Max. storage temp., °C	Tstg	−40 to +150
Max. mounting force, lb. ... ①		2000 to 2400
Thermal resistance①, double-side cooling, junction to case, °C/Watt	$R_{\theta JC}$	.06
Case to sink, lubricated, °C/Watt	$R_{\theta CS}$	.02

① Consult recommended mounting procedures.
② Applies for zero or negative gate bias.
③ Per JEDEC RS-397, 5.2.2.1.
④ With recommended gate drive.
⑤ Higher dv/dt ratings available, consult factory.
⑥ Per JEDEC standard RS-397, 5.2.2.6.
⑦ For operation with antiparallel diode, consult factory.

Maximum Forward Voltage VS. Forward Current

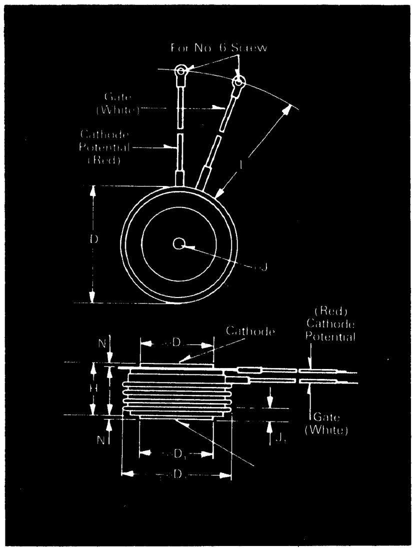


Transient Thermal Impedance VS. Time



Fast Switching SCR T727

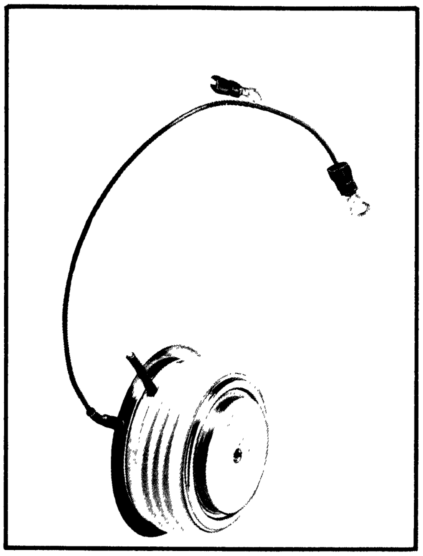
350 — 475 A. Avg. Up to 1200 Volts 10 — 60 μs



T72 Outline

Symbol	Inches Min.	Inches Max.	Millimeters Min.	Millimeters Max.
ϕD	2.250	2.290	57.15	58.17
ϕD_1	1.333	1.343	33.86	34.11
ϕD_2	2.030	2.090	51.56	53.09
H	1.020	1.060	25.91	26.92
ϕJ	.135	.145	3.43	3.68
J_1	.075	.090	1.91	2.29
L	7.75	8.50	196.85	215.90
N	.040		1.02	

Creep Distance—1.00 in. min. (25.40 mm).
Strike Distance—1.02 in. min. (25.91 mm).
(In accordance with NEMA standards.)
Finish—Nickel Plate.
Approx. Weight—8 oz. (227 g).
1. Dimension "H" is a clamped dimension.



Note: High frquency sine and square wave data available, consult factory.

Features:
- Center fired di/namic gate
- High di/dt with soft gate control
- High frequency operation
- Sinusoidal waveform operation to 20KHz
- Rectangular waveform operation to 20KHz
- Low dynamic forward voltage drop
- Low switching losses at high frequency
- Lifetime Guarantee

Applications:
- Inverters
  UPS
  Induction heating
  AC motor drives
- Cycloconverters
- Choppers
- Crowbars

Ordering Information

Type	Voltage		Current		Turn-off		Gate current		Leads	
Code	V_{DRM} and V_{RRM} (V)	Code	$I_{T(av)}$ (A)	Code	tq (μsec)	Code	I_{GT} (ma)	Code	Case	Code
T727	100	01			10	8	150	4	T72	DN
	200	02			15	7				
	300	03			20	6				
	400	04	400	40	25	B				
	500	05	475	48	30	5				
	600	06			40	4				
	700	07	350	35	50	3				
	800	08	450	45	25	B				
	900	09			30	5				
	1000	10			40	4				
	1100	11			50	3				
	1200	12			60	2				

Example

Obtain optimum device performance for your application by selecting proper Order Code.

Type T727 rated at 450 A average with V_{DRM} = 1000V, I_{GT} = 150 ma, t_q = 30 μsec max. and flex leads—order as:

Type				Voltage		Current		Turn Off	Gate Current	Leads	
T	7	2	7	1	0	4	5	5	4	D	N

THYRISTOR

350 — 475 A. Avg. Up to 1200 Volts 10 — 60 μs

Fast Switching SCR T727

Voltage

Blocking State Maximums ② (T_J = 125°C)

	Symbol												
Repetitive peak forward blocking voltage , V	V_{DRM}	100	200	300	400	500	600	700	800	900	1000	1100	1200
Repetitive peak reverse voltage , V	V_{RRM}	100	200	300	400	500	600	700	800	900	1000	1100	1200
Non-repetitive transient peak reverse voltage, t ≤ 5.0 msec, V	V_{RSM}	200	300	400	500	600	700	800	900	1000	1100	1200	1300
type designation vs. voltage availability		T727__40—T727__48 (100–800)											
		T727__35—T727__45 (100–1200)											
Forward leakage current, mA peak	I_{DRM}	30											
Reverse leakage current, mA peak	I_{RRM}	30											

Current

Conducting State Maximums (T_J = 125°C)

	Symbol	T727——40	T727——48	T727——35	T727——45
RMS forward current, A	$I_{T(rms)}$	625	750	550	700
Ave. forward current, A	$I_{T(av)}$	400	475	350	450
One-half cycle surge current③, A	I_{TSM}	7000	8000	7000	8000
I^2t for fusing (for times ≥ 8.3 ms) A^2 sec.	I^2t	205,000	265,000	205,000	265,000
Forward voltage drop at I_{TM} = 3000A and T_J = 25°C, V	V_{TM}	2.50	2.30	2.90	2.60
Min. repetitive di/dt A/μsec ①④⑥	di/dt	300	400	300	400

Switching

(T_J = 25°C)

	Symbol	
Max. turn-off time, I_T = 400A T_J = 125°C, di_R/dt = 25 A/μsec, reapplied dv/dt = 20V/μsec linear to 0.8 V_{DRM}, μ sec ⑤⑦	t_q	10 to 60
Typ. turn-on-time, I_T = 1000A V_D = 300V ④, μsec	t_{on}	3.0
Min. critical dv/dt, exponential to V_{DRM}, T_J = 125°C, V/μsec②⑤	dv/dt	300
Min. di/dt non-repetitive, A/μsec ①④⑥	di/dt	800

Gate

Maximum Parameters (T_J = 25°C)

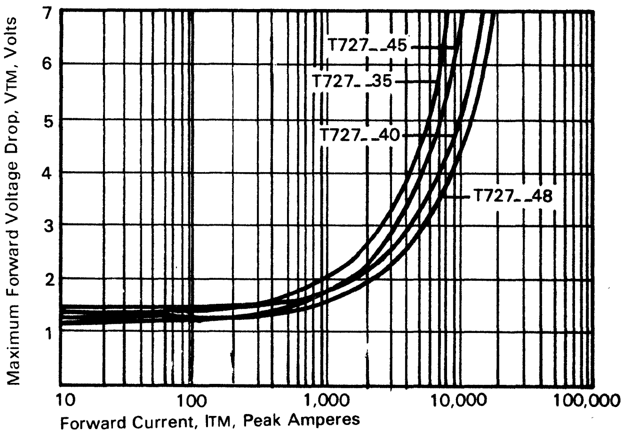
	Symbol	
Gate current to trigger at V_D = 12V, mA	I_{GT}	150
Gate voltage to trigger at V_D = 12V, V	V_{GT}	3
Non-triggering gate voltage, T_J = 125°C, and rated V_{DRM}, V	V_{GDM}	0.15
Peak forward gate current, A	I_{GTM}	4
Peak reverse gate voltage, V	V_{GRM}	5
Peak gate power, Watts	P_{GM}	16
Average gate power, Watts	$P_{G(av)}$	3

Thermal and Mechanical

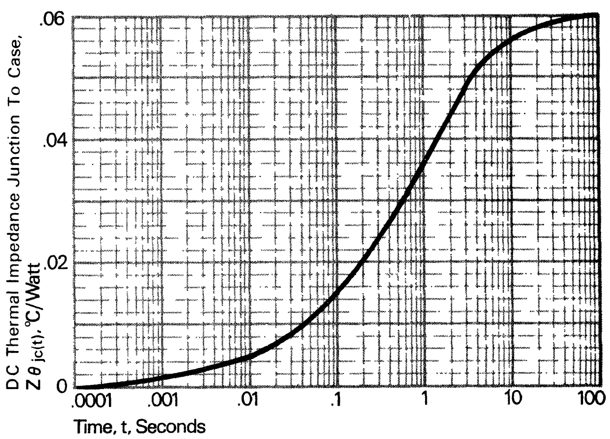
	Symbol	
Min., Max. oper. junction temp., °C	T_J	−40 to +125
Min., Max. storage temp., °C	Tstg	−40 to +150
Max. mounting torque, in lb. ①		2000 to 2400
Max. Thermal resistance ① Double side cooled Junction to case, °C/Watt	$R_{\theta JC}$	.06
Case to sink, lubricated, °C/Watt	$R_{\theta CS}$	.02

① Consult recommended mounting procedures.
② Applies for zero or negative gate bias.
③ Per JEDEC RS-397, 5.2.2.1.
④ With recommended gate drive.
⑤ Higher dv/dt ratings available, consult factory.
⑥ Per JEDEC standard RS-397, 5.2.2.6.
⑦ For operation with antiparallel diode, consult factory.

Maximum Forward Voltage Drop VS Forward Current



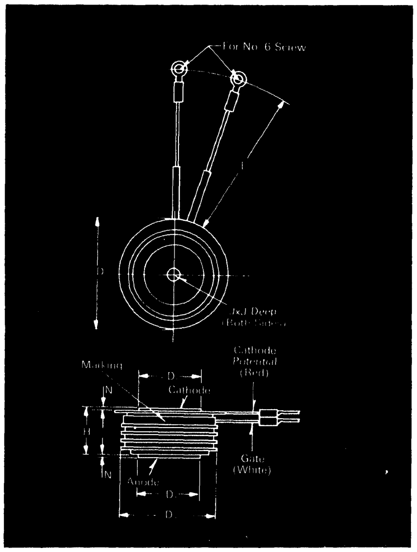
Transient Thermal Impedance VS. Time



THYRISTOR

Fast Switching SCR T9GH

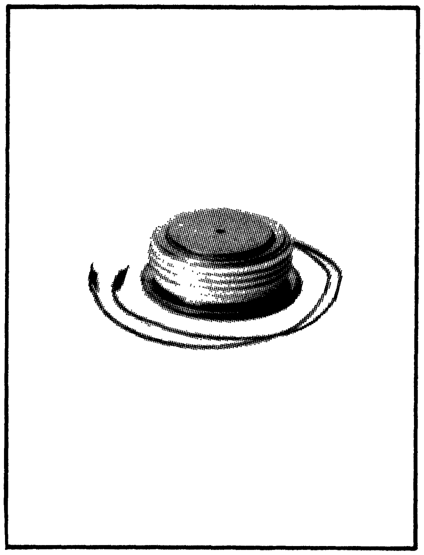
800 - 900 A Avg. Up to 2200 Volts 40 — 100 μs



T9G Outline

Symbol	Inches Min.	Inches Max.	Millimeters Min.	Millimeters Max.
ϕD	2.850	2.900	72.39	73.66
ϕD_1	1.845	1.855	46.86	47.12
ϕD_2	2.560	2.640	65.02	67.06
H	1.020	1.060	25.91	26.92
ϕJ	.135	.145	3.43	3.68
J_1	.075	.090	1.91	2.29
L	11.50	12.50	292.10	317.50
N	.050		1.27	

Creep Distance—1.00 in. min. (25.40 mm).
Strike Distance—1.02 in. min. (25.91 mm).
(In accordance with NEMA standards.)
Finish—Nickel Plate.
Approx. Weight—2 lb. (908 g).
1. Dimension "H" is a clamped dimension.



Features:
- Midway, di/namic Gate Structure
- Hard Commutation Turn-Off
- Forward Blocking Capabilities to 2200V
- Low Switching Losses at High Frequency
- Soft Commutation (Feedback Diode) Testing Available

Applications:
- Induction Heating
- Transportation
- Inverters

Note: High frequency Sine and Square wave data available, consult factory.

Ordering Information

Type	Voltage		Current		Turn-off		Gate current		Leads	
Code	V_{DRM} and V_{RRM} * (V)	Code	$I_{T(av)}$ (A)	Code	tq (μsec)	Code	I_{GT} (ma)	Code	Case	Code
T9GH	600	06	800	08	40	4	300	2	T9G	DH
	800	08	900	09	50	3				
	1000	10			60	2				
	1200	12			70	C				
	1400	14			80	I				
	1500	15			100	K				
	1600	16								
	1700	17								
	1800	18								
	1900	19								
	2000	20								
	2100	21								
	2200	22								

Example

Obtain optimum device performance for your application by selecting proper order code.

Type T9GH rated at 800A average with V_{DRM} = 1800V
tq = 50 usec.
I_{GT} = 300 ma, and standard 12 inch leads -- order as:

Type				Voltage		Current		Turn Off	Gate Current	Leads	
T	9	G	H	1	8	0	8	3	2	D	H

*for lower voltages consult factory

THYRISTOR

800 - 900 A Avg.
Up to 2200 Volts
40 — 100 μs

Fast Switching SCR T9GH

Voltage

Blocking State Maximums ② (T_J = 125°C)

	Symbol													
Repetitive peak forward blocking voltage , V . .	V_{DRM}	600	800	1000	1200	1400	1500	1600	1700	1800	1900	2000	2100	2200
Repetitive peak reverse voltage, V	V_{RRM}	600	800	1000	1200	1400	1500	1600	1700	1800	1900	2000	2100	2200
Non-repetitive transient peak reverse voltage, t ≤ 5.0 msec, V	V_{RSM}	700	900	1100	1300	1500	1600	1700	1800	1900	2000	2100	2200	2300
Forward leakage current, mA peak	I_{DRM}	◄—— 60 ——►												
Reverse leakage current, mA peak	I_{RRM}	◄—— 60 ——►												

Current

Conducting State Maximums (T_J = 125°C)

	Symbol	T9GH_ _08	T9GH_ _09
RMS forward current, A	$I_{T(rms)}$	1250	1400
Ave. forward current, A	$I_{T(av)}$	800	900
One-half cycle surge current③, A . .	I_{TSM}	10,000	13,000
3 cycle surge current③, A	I_{TSM}	7,500	9,750
10 cycle surge current③, A	I_{TSM}	6,200	8,000
I^2t for fusing (t=8.3 ms) A^2sec	I^2t	416,000	700,000
Max I^2t of package (t=8.3 ms), A^2sec	I^2t	90×10^6	90×10^6
Forward voltage drop at I_{TM} = 3000A and T_J = 25°C, V	V_{TM}	2.95	2.50
Min. Repetitive di/dt A/usec. ⑦④⑥	di/dt	300	400

Gate

(T_J=25°C)

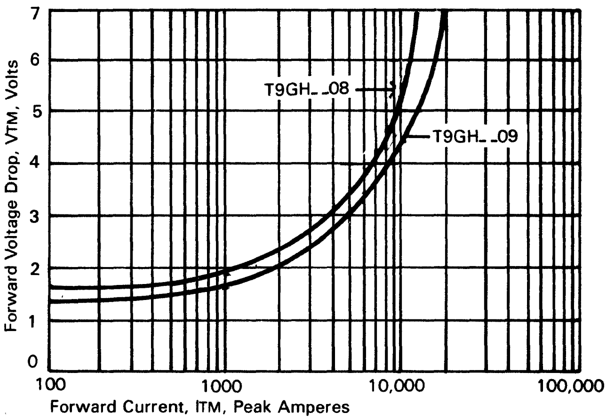
	Symbol	Min	Typ	Max
Gate current to trigger at V_D=12V, mA . .	I_{GT}		200	300
Gate voltage to trigger at V_D=12V, V	V_{GT}		1.5	3.0
Non-triggering gate voltage, T_J=125°C, and rated V_{DRM}, V	V_{GDM}			.15
Non-triggering Gate Current at V_D=12V, mA	I_{GNT}		20	
Peak forward gate current, A	I_{GTM}			10
Peak reverse gate voltage, V	V_{GRM}			5
Peak gate power, Watts	P_{GM}			60
Average gate power, Watts	$P_{G(av)}$			3

Switching

(T_J=25°C)

	Symbol	Min	Typ	Max
HARD COMMUTATION: ⑦				
Turn-off time, I_T = 500A, 50V≤V_R≤V_{RRM} T_J = 125°C, diR/dt = 25 A/μsec, reapplied dv/dt = ⑤ 20V/usec linear to 0.8 V_{DRM}, μsec	tq	40		100
Turn-On and Delay Time ④				
I_{TM} = 1000A, tp = 450, μsec	ton		3.0	
V_D = 1100V, μsec	td		1.5	
Critical dv/dt exponential to V_{DRM} T_J = 125°C, V/μsec⑦⑤	dv/dt	400		
di/dt @ non-repetitive, ⑦④⑥ A/μsec	di/dt			1000
Latching Current V_D = 75V, mA	I_L		500	1000
Holding Current V_D = 75V, mA	I_H		300	800

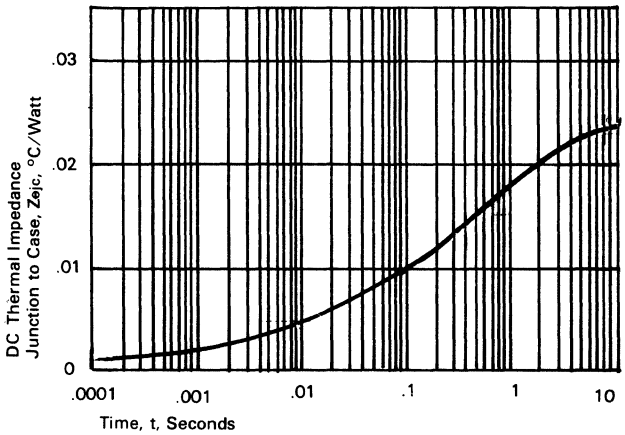
Maximum Forward Voltage Drop Vs. forward Current



Thermal and Mechanical

	Symbol	Min	Typ	Max
Oper. junction temp., °C	T_J	—40		125
Storage temp., °C	T_{stg}	—40		150
Mounting force, lb.①		5000		5500
Thermal resistance with double sided cooling①				
Junction to case, °C/Watt	$R\theta_{JC}$			.023
Case to sink, lubricated, °C/Watt	$R\theta_{CS}$	.006		.0075

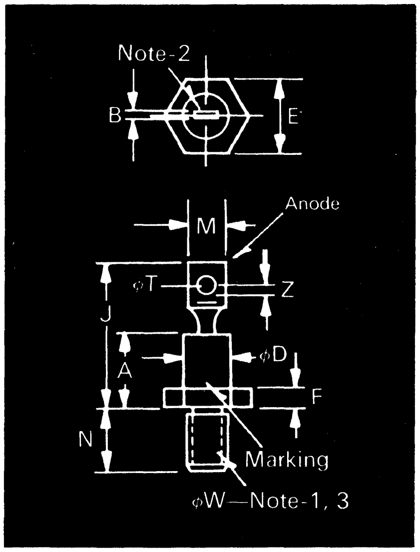
Transient Thermal Impedance VS. Time



① Consult recommended mounting procedures.
② Applies for zero or negative gate bias.
③ Per JEDEC RS-397, 5.2.2.1.
④ With recommended gate drive.
⑤ Higher dv/dt ratings available, consult factory.
⑥ Per JEDEC standard RS-397, 5.2.2.6.
⑦ For operation with antiparallel diode, consult factory.

Reverse Blocking Diode Thyristor RBDT T40R

22 A Avg. Up to 1000 Volts

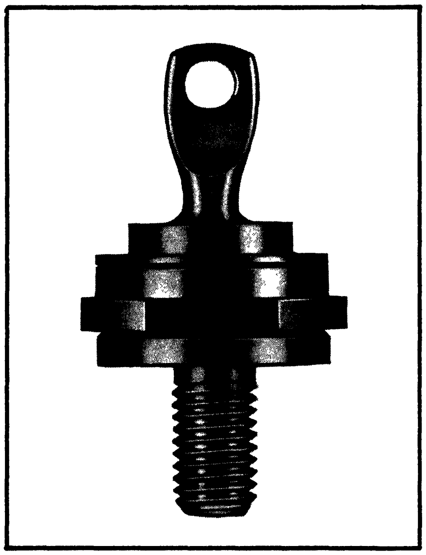


Conforms to DO-5 Outline

Symbol	Inches Min.	Inches Max.	Millimeters Min.	Millimeters Max.
A		.450		11.43
B		.080		2.30
φD		.667		16.94
E	.667	.687	16.94	17.45
F	.060	.200	1.52	5.08
J		1.000		25.40
M		.375		9.53
N	.422	.453	10.72	11.51
φT	.140	.175	3.56	4.45
Z	.156		3.96	
φW	¼-28 UNF-2A			

Glass To Metal Seal—
Creepage & Strike Distance = .09 in. min. (2.46 mm)
(In accordance with NEMA standards.)
Finish—Nickel Plate.
Approx. Weight—.6 oz (18g)

NOTES:
1. Complete threads to extend to within 2½ threads of seating plane.
2. Angular orientation of this terminal is undefined.
3. ¼-28 UNF-2A. Maximum pitch diameter of plated threads shall be basic pitch diameter (.2268", 5.74 mm) Ref. (Screw thread standards for federal services 1957) Handbook H28 1957 P1.



Features
- di/dt of 2000 to 4000 A/us
- compression Bonded Encapsulation
- All Diffused Design
- Low V_{TM}
- JEDEC DO-5 Package

Applications:
- Radar Modulators
- Laser Pulsers

Application

The reverse blocking diode thyristor is a two-terminal, four-layer PNPN switch. In the forward direction, the device will initially block voltage to its rated V_{DRM}. However, upon application of a trigger voltage, it switches to a low impedance state where it remains until the anode current is reduced below the holding current.

The T40R employs an all diffused design and is packaged in the standard DO-5 outline case. The exclusive Westinghouse CBE (compression bonded encapsulation) construction technique is employed to eliminate solder joints and, thereby, failures caused by thermal fatique.

These devices are ideal for pulse work because of their high di/dt and fast switching capabilities. Radar modulators and laser pulsers are two prime examples of the kinds of applications particularly suited to the Westinghouse T40R.

Ordering Information

Type	Voltage		Current		Turn off		di/dt		Leads	
Code	V_{DRM} (V)	Code	IT(av) (A) *	Code	tq (µsec)	Code	di/dt (A/µsec)	Code	Case	Code
T40R	600	06	22	22	50 typ.	0	2000	2	DO-5	00
	800	08					3000	3		
	1000	10					4000	4		

*Average current rating assigned for ordering information only.

Example

Obtain optimum device performance for your application by selecting proper Order Code.

Type T40R rated at 22A average with V_{DRM} = 800V, and di/dt = 2000A/us – order as.

Type				Voltage		Current		Turn Off	di/dt	Leads	
T	4	0	R	0	8	2	2	0	2	0	0

THYRISTOR

22 A Avg. Up to 1000 Volts

Reverse Blocking Diode Thyristor RBDT T40R

Voltage

Blocking State	Symbol	T_J (°C)	Min.	Typ.	Max.	Units
Repetitive Peak Forward Blocking Voltage	V_{DRM}	25 to 125	600			V
			800			V
			1000			V
Repetitive Peak Forward Leakage Current	I_{DRM}	25		300	500	μa
at V_{DRM}		125		3	5	ma
Holding Current	I_H	25		15	100	ma

Current

Conducting State	Symbol	T_J (°C)	Min.	Typ.	Max.	Units
RMS Forward Current at T_C = 40°C ①	$I_{T(rms)}$	125			35	A
Average Forward Current at T_C = 40°C ①	$I_{T(av)}$	125			22	A
One-half Cycle Surge Current at T_C = 40°C ①	I_{TSM}	125			300	A
I^2t For Fusing (For Times ≧ 8.3 ms)	I^2t	125			370	A^2sec.
Forward Voltage Drop at I_{TM} = 1000A, Pulse Width = 300μs, Duty Cycle = 2%	V_{TM}	25		4	6	V

Switching

	Symbol	T_J (°C)	Min.	Typ.	Max.	Units
Rate of Rise of Current, Sine Wave ①						
at Pulse Width/2 = 0.5μs to 800A	di/dt	25	2000			A/μs
at Pulse Width/2 = 0.5μs to 1200A	di/dt	25	3000			A/μs
at Pulse Width/2 = 0.25μs to 800A	di/dt	25	4000			A/μs
Dynamic Forward Voltage Drop at I_{TM} = 1000A Sine Wave, Pulse Width/2 = 4μs, Duty Cycle = .25%	$V_{TM(DYN)}$	25		20	40	V
Pulse Trigger Voltage at dv/dt ≧ 5000 V/μs, Pulse Width ≧ 200 ns	V_T	25 to 125	V_{DRM} + 50	1050	1500	V
Pulse Trigger Current at V_T (Circuit dependent value)	I_T	25 to 125		10		A
Trigger Response Time at V_T, I_T for 90% to 10% of V_{DRM}	t_{on}	25		100	200	ns
Turn-Off Time at I_{TM} = 300A Sine Wave, Pulse Width = 8μs	t_q	25		50		μs
dv/dt = 20 V/μs to 600V		100		100		μs
Rate of Change of Voltage	dv/dt	25	200	400		V/μs
Exponential to V_{DRM}		100	20	100		V/μs

Thermal and Mechanical

	Symbol	Min.	Typ.	Max.	Units
Operating Junction Temperature	T_J	−40		125	°C
Storage Temperature	T_{stg}	−40		150	°C
Mounting Torque ②				30	in.lb.
Thermal Resistance ②					
Junction to Case	$R_{\theta JC}$			1.25	°C/W
Case to Sink, Lubricated	$R_{\theta CS}$			.25	°C/W

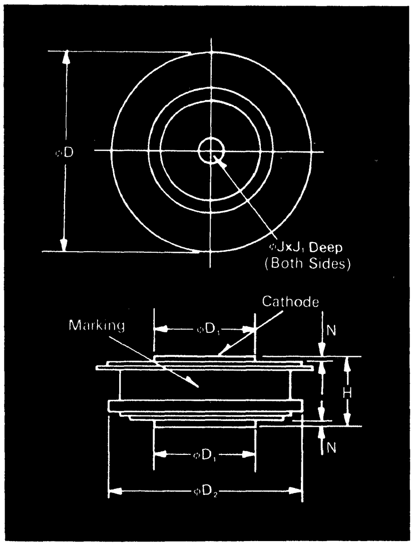
① At 60 Hertz.

② Consult recommended mounting procedures.

THYRISTOR

Reverse Blocking Diode Thyristor RBDT T62R

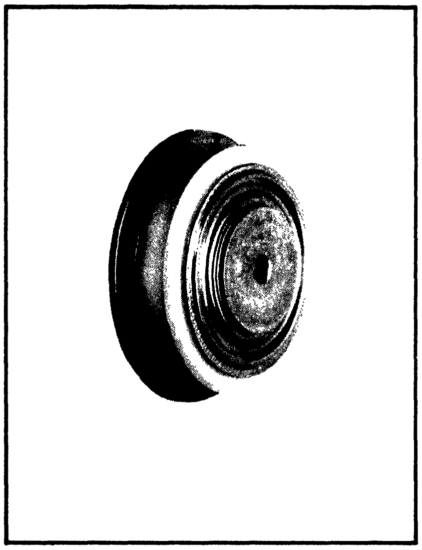
125 A. Avg. Up to 1000 Volts



T62R Outline

Symbol	Inches Min.	Inches Max.	Millimeters Min.	Millimeters Max.
ϕD	1.610	1.650	40.89	41.91
ϕD_1	.745	.755	18.92	19.18
ϕD_2	1.420	1.460	36.07	37.08
H	.500	.560	12.70	14.22
ϕJ	.135	.145	3.43	3.68
J_1	.072	.082	1.83	2.08
N	.030		.76	

Creep Distance—.49 in. min. (12.60 mm).
Strike Distance—.52 in. min. (13.21 mm).
(In accordance with NEMA standards).
Finish—Nickel Plate.
Approx. Weight—2.3 oz (66g).
1. Dimension "H" is clamped dimension.



Features:
- di/dt of 2000 to 3000 A/μsec
- All diffused Design
- Low V_{TM}
- High peak switching currents

Application

The reverse blocking diode thyristor is a two-terminal, four-layer PNPN switch. In the forward direction, the device will initially block voltage to its rated V_{DRM}. However, upon application of a trigger voltage, it switches to a low impedance state where it remains until the anode current is reduced below the holding current.

These devices are ideal for pulse work because of their high di/dt and fast switching capabilities. Radar modulators and laser pulsers are two prime examples of the kinds of applications particularly suited to the Westinghouse T62R.

Ordering Information

Type	Voltage		Current		Turn-off		di/dt		Leads	
Code	V_{DRM} (V)	Code	IT(av)* (A)	Code	tq (μsec)	Code	di/dt A/μsec	Code	Case	Code
T62R	600	06	125	13	50 typ.	0	2000	2	R62	00
	800	08					3000	3		
	1000	10								

*Average current rating assigned for ordering information only.

Example

Obtain optimum device performance for your application by selecting proper Order Code.

Type T62R rated at 125 A average, with V_{DRM} = 800V, order as:

Type				Voltage		Current		Turn Off	di/dt	Leads	
T	6	2	R	0	8	1	3	0	2	0	0

THYRISTOR

125 A. Avg. Up to 1000 Volts

Reverse Blocking Diode Thyristor RBDT T62R

THYRISTOR

Voltage

Blocking State	Symbol	T_J (°C)	Min.	Typ.	Max.	Units
Repetitive Peak Forward Blocking Voltage	VDRM	25 to 125	600 800 1000			V V V
Repetitive Peak Reverse Blocking Voltage	VRRM	25 to 175	100			V
Repetitive Peak Forward Leakage Current at VDRM	IDRM	25 125		7 15	5 10	ma ma
Repetitive Peak Reverse Leakage Current VRRM	IRRM	25 125		15 25	10 15	ma ma
Holding Current	IH	25	3	100	15	ma

Current

Conducting State	Symbol	T_J (°C)	Max.	Units
Peak Forward Pulse Current ①	ITM	125	2500	A
RMS Forward Current	IT(RMS)	125	200	A
One-half Cycle Surge Current (For Times≤8.3 ms)	ITSM	125	3000	A
I^2t For Fusing (For Times≤8.3 ms)	I^2t	125	37,500	A^2sec.
I^2t of package (For Times = 8.3 ms)	I^2t	125	20 x 10^6	A^2sec.

Switching

	Symbol	T_J (°C)	Min.	Typ.	Max.	Units
Current Rate of Rise						
Code 2, 2000 A @ 1 µsec	di/dt	25	2000			A/µs
Code 3, 2000 A @ .667 µsec	di/dt	25	3000			A/µs
Energy per Pulse at ITM = 2500A Square Wave Pulse Width = 3 µs	W.S./ Pulse	125 25			.30 .19	W.S./Pulse W.S./Pulse
Pulse Trigger Voltage at dv/dt ≥ 5000 V/µs, Pulse Width ≥ 200 ns	VT	25 to 125	VDRM + 150	1050	1600	V
Pulse Trigger Current at VT (Circuit dependent value)	IT	25 to 125		70		A
Peak Dynamic Forward Voltage Drop at ITM = 2500A	VTM (DYN)	25		8	10	V
Turn-Off Time at ITM = 2500A Square Wave Pulse Width = 3 µs, dv/dt = 20 V/µs to 600V	tq	25 100	50	100 250	200	µs µs
Critical Rate of Change of Voltage Exponential to VDRM	dv/dt	125	20	100		V/µs

Thermal and Mechanical

	Symbol	Min.	Max.	Units
Operating Junction Temperature	Tj	-40	125	°C
Storage Temperature	Tstg.	-40	150	°C
Mounting Force ②		1000	1400	lb.
Thermal Resistance, double-sided cooling, ②				
Junction to Case	RθJC		.095	°C/W
Case to Sink, Lubricated	RθCS		.02	°C/W

① This value is for a 3 µsec, 400 Hz pulse, 2500 A peak. Consult factory for other pulse ratings.

② Consult recommended mounting procedures.

TRANSISTORS

INTRODUCTION

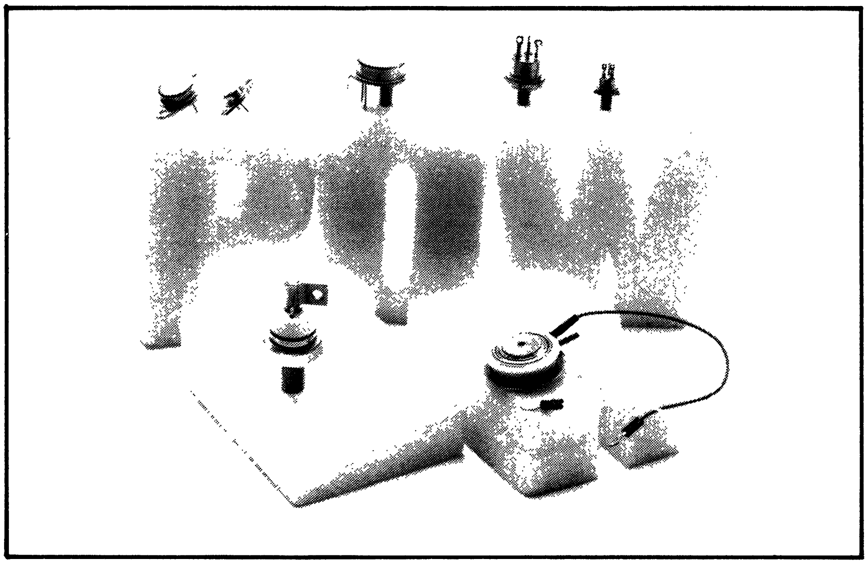
Ⓦ offers a wide range of power transistors designed to match the equipment manufacturer's technical and economic requirements. The designer can choose from various processes, ratings, and package styles to optimize an application: general purpose single-diffused types for economical ruggedness; high S.O.A. alloy types for the ultimate in reliability; and high power, fast switching tripled-diffused types for "state-of-the-art" voltage and power capability.

For linear applications (amplifiers and regulators), general purpose transistors in TO-66 and TO-3 packages offer the most "watts per dollar" value. Excellent Safe Operating Area (SOA) make these types ideal for inductive loads such as DC motor controls or 60 and 400 hertz inverters.

High S.O.A. alloy process transistors from Ⓦ have been used in numerous critical aerospace and defense programs. Alloy construction, hard solder/moly bonding, and hermetic, copper stud, cases have generated a record of superb performance and reliability. For inductive load switching, the forward and reverse bias Safe Operating Areas (SOA) of these devices make alloy the clear choice over other processes.

The newest addition to the Ⓦ transistor line is the super-powered family of triple-diffused switching types. Up to 500 volts of sustaining voltage capability is coupled with a gain rating at 50 amperes; but brute power is not the only feature of the D60T family — switching times under a microsecond and Compression Bonded Encapsulation (CBE) open a new area of application for designers of high speed inverters, switching regulators, AC motor drives and VLF radio transmitters.

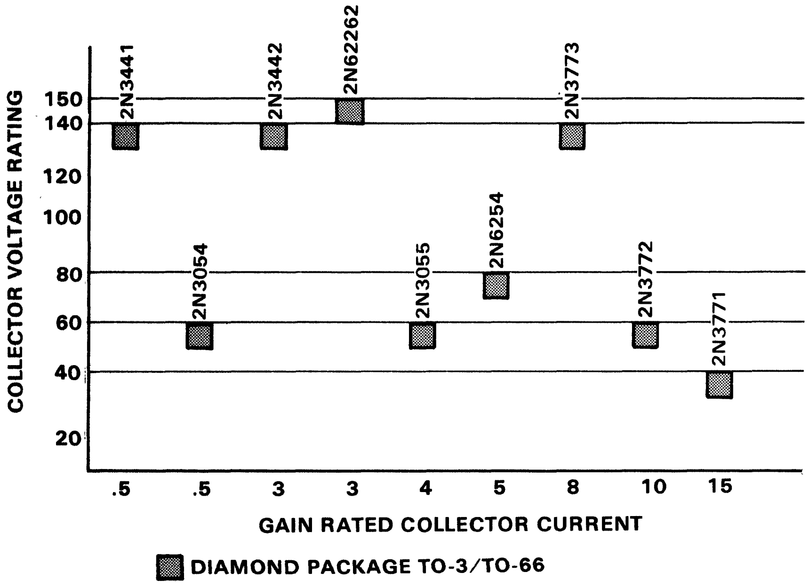
Complete test facilities are available for matching, special selection, or high reliability screening. Ⓦ offers a Lifetime Guarantee on all transistors bearing this symbol ✤. Specify Westinghouse Power Transistors.



TRANSISTOR PRODUCT INDEX

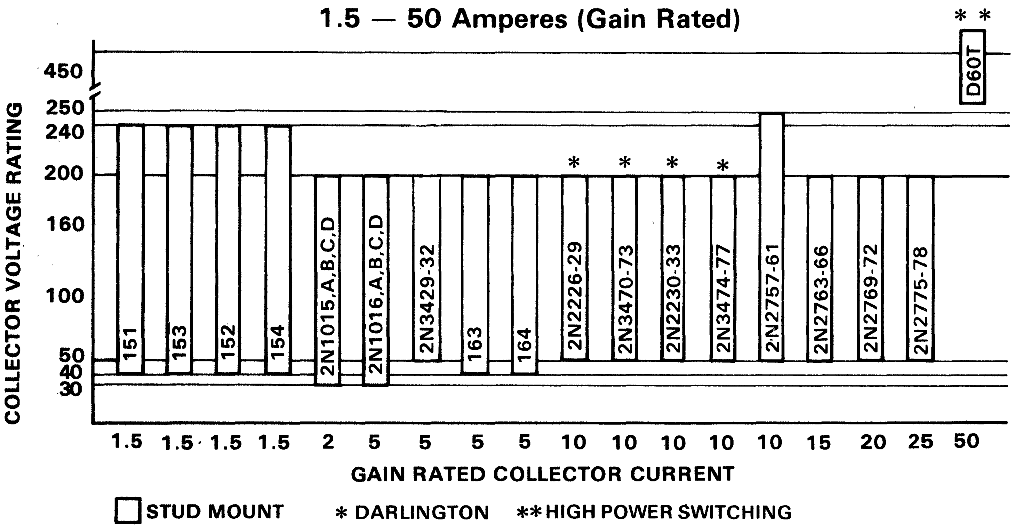
GENERAL PURPOSE NPN POWER TRANSISTORS

.5 — 15 Amperes (Gain Rated)



HIGH S.O.A. & HIGH POWER SWITCHING NPN POWER TRANSISTORS

1.5 — 50 Amperes (Gain Rated)



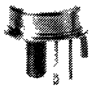
TRANSISTOR SELECTOR GUIDE

GENERAL PURPOSE NPN POWER TRANSISTORS
4 — 30 Amperes

JEDEC TYPE	2N3441	2N3054	2N3442	2N6262	2N3055	2N6254	2N3773	2N3772	2N3771
PEAK CURRENT	4	4	15	15	15	30	30	30	
PEAK CURRENT	4	4	15	15	15	15	30	30	30
GAIN RATED CURRENT	.5	.5	3	3	4	5	6	10	15
VOLTAGE 40									2N3771
60		2N3054			2N3055			2N3772	
80						2N6254			
140	2N3441		2N3442				2N3773		
150				2N6262					
CUTOFF FREQUENCY	1 MHz	1 MHz	1 MHz	1 MHz	1 MHz	1 MHz	1 MHz	1 MHz	1 MHz
PACKAGE TYPE	TO-66	TO-66	TO-3	TO-3	TO-3	TO-3	TO-3	TO-3	TO-3
PAGE NUMBER	T5	T5	T7	T9	T7	T9	T11	T11	T11


TO-66

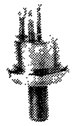
TO-3



TO-82

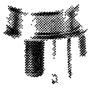
HIGH S.O.A. NPN POWER TRANSISTORS
6 — 20 Amperes

JEDEC/TYPE	151	153	152	154	2N1015, A,B,C,D	2N1016, A,B,C,D	2N3429-32	163	164
PEAK CURRENT	6	7.5	6	7.5	7.5	7.5	7.5	20	20
GAIN RATED CURRENT	1.5	1.5	1.5	1.5	2	5	5	5	5
VOLTAGE 30					2N1015	2N1016			
40	151-04	153-04	152-04	154-04				163-04	164-04
50	151-05	153-05	152-05	154-05	2N1015A	2N1016A	2N3429	163-05	164-05
60	151-06	153-06	152-06	154-06				163-06	164-06
70	151-07	153-07	152-07	154-07				163-07	164-07
80	151-08	153-08	152-08	154-08				163-08	164-08
90	151-09	153-09	152-09	154-09				163-09	164-09
100	151-10	153-10	152-10	154-10	2N1015B	2N1016B	2N3430	163-10	164-10
120	151-12	153-12	152-12	154-12				163-12	164-12
140	151-14	153-14	152-14	154-14				163-14	164-14
150					2N1015C	2N1016C	2N3431		
160	151-16	153-16	152-16	154-16				163-16	164-16
180	151-18	153-18	152-18	154-18				163-18	164-18
200	151-20	153-20	152-20	154-20	2N1015D	2N1016D	2N3432	163-20	164-20
220	151-22	153-22	152-22	154-22					
240	151-24	153-24	152-24	154-24					
250									
CUTOFF FREQUENCY	.5 MHz	.5 MHz	.5 MHz	.5 MHz	.5 MHz	.5 MHz	.5 MHz	.5 MHz	.5 MHz
PACKAGE TYPE	TO-82	MT-52	TO-82	MT-52	TO-82	TO-82	MT-52	MT-33	MT-33
PAGE NUMBER	T15	T17	T15	T17	T19	T19	T21	T23	T23

MT-52



MT-33

TRANSISTOR SELECTOR GUIDE



TO-82

MT-33

D60

HIGH S.O.A. and HIGH POWER SWITCHING NPN POWER TRANSISTORS

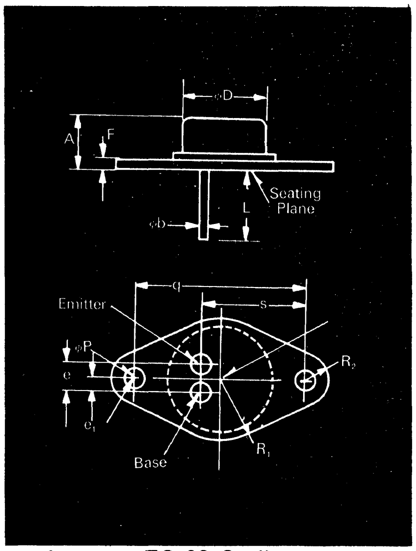
10 — 200 Amperes

JEDEC/ TYPE	2N2226-29*	2N3470-73*	2N2230-33*	2N3474-77*	2N2757-61	2N2763-66	2N2769-72	2N2775-78	D60T**
PEAK CURRENT	10	10	10	10	30	30	30	30	200
GAIN RATED CURRENT	10	10	10	10	10	15	20	25	50
VOLTAGE 50	2N2226	2N3470	2N2230	2N3474	2N2757	2N2763	2N2769	2N2775	
100	2N2227	2N3471	2N2231	2N3475	2N2758	2N2764	2N2770	2N2776	
150	2N2228	2N3472	2N2232	2N3476	2N2759	2N2765	2N2771	2N2777	
200	2N2229	2N3473	2N2233	2N3477	2N2760	2N2766	2N2772	2N2778	
250					2N2761				
450									D60T4550
CUTOFF FREQUENCY	.5 MHz	.5 MHz	.5MHz	.5MHz	.5MHz	.5 MHz	.5 MHz	.5 MHz	12 MHz
PACKAGE TYPE	TO-82	MT-33	TO-82	MT-33	MT-33	MT-33	MT-33	MT-33	D60
PAGE NUMBER	T25	T27	T25	T27	T29	T29	T29	T29	T33

*Darlington
**Also Available in Disc Package — D62T

NPN Power TRANSISTORS 2N3054/2N3441

4 Amperes 90/120 Volts



Conforms to TO-66 Outline

Symbol	Inches Min.	Inches Max.	Millimeters Min.	Millimeters Max.
A	.250	.340	6.35	8.64
ϕb	.028	.034	.71	.86
ϕD	.470	.500	11.94	12.70
e	.190	.210	4.83	5.33
e_1	.095	.105	2.41	2.67
F	.050	.075	1.27	1.91
L	.360		9.14	
ϕP	.142	.152	3.61	3.86
q	.950	.970	24.13	24.64
R_1		.350		8.89
R_2		.145		3.68
S	.570	.590	14.48	14.99

Finish—Nickel Plate.
Approx. Weight—.25 oz. (7 g).

Features:
- No forward bias secondary breakdown up to full voltage rating
- High reverse bias S.O.A. for inductive loads
- Low thermal resistance
- Hermetically sealed
- 25 watt dissipation
- 100% Power tested
- Lifetime Guarantee

Applications:
- Series and shunt regulators
- High-fidelity amplifiers
- Power switching circuits
- Solenoid drivers

Test	Symbol	2N3054	2N3441
Collector Voltage	$V_{CEO\,(sus)}$	**55**	**140**

Maximum Ratings and Characteristics
Tc = 25°C unless specified

	Symbol	JEDEC 2N3054	JEDEC 2N3441	Units
* Operating and storage temperature		—65 To 200	—65 To 200	°C
* Collector-emitter sustaining voltage	$V_{CEO\,(sus)}$	55	140	Volts
* collector-base voltage	V_{CBO}	90	160	Volts
* Emitter-base voltage	V_{EBO}	7	7	Volts
* collector-emitter voltage V_{BE} = - 1.5V.	V_{CEV}	90	160	Volts
* Continous collector current	I_C	4	3	Amps
* Continous base current	I_B	2	2	Amps
* Thermal resistance	$R_{\theta JC}$	6	7	°C/W
* Power dissipation	P_T	25	25	Watts

*JEDC registered parameters.

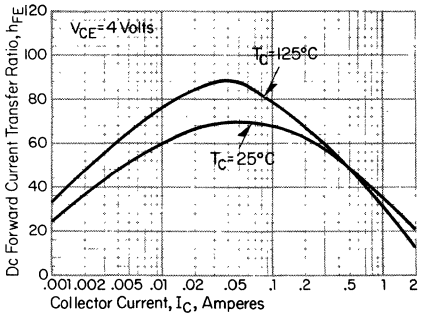
4 Amperes 90/120 Volts

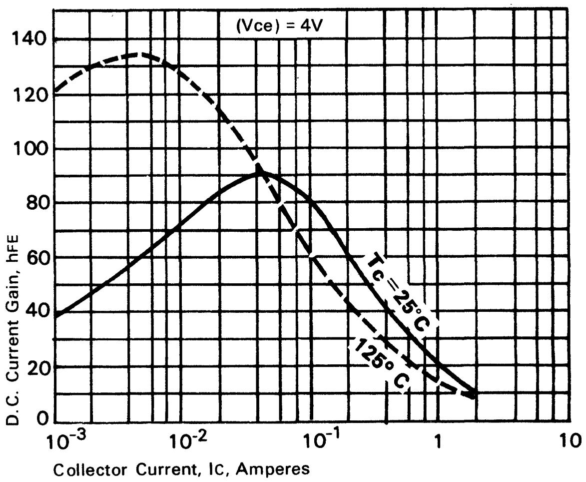
NPN Power TRANSISTORS 2N3054/2N3441

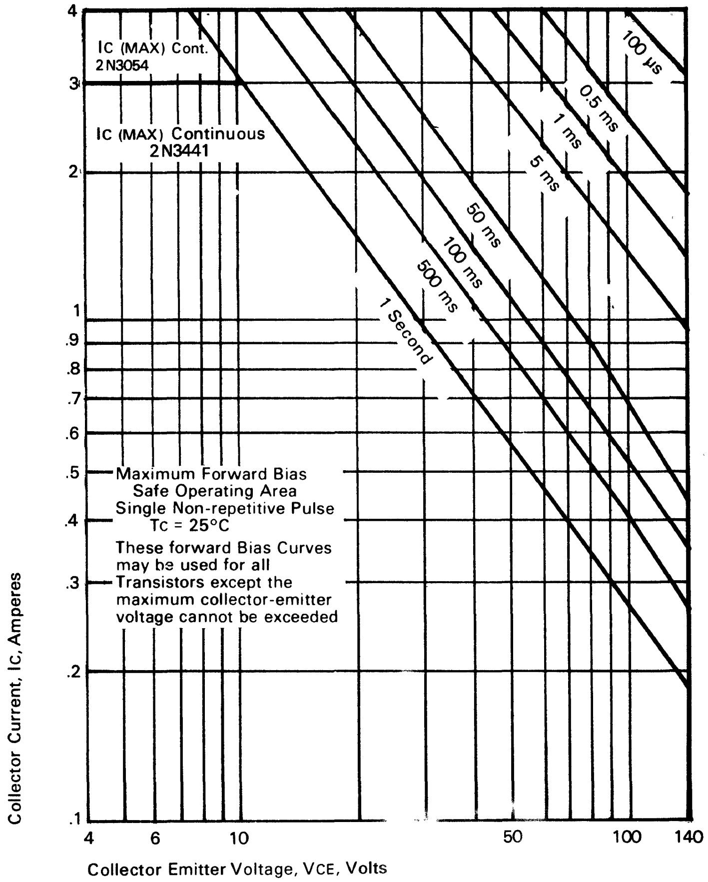
Electrical Specifications
T c = 25°C unless otherwise specified

Test	Symbol	Test Conditions	2N3054 Min	2N3054 Max	2N3441 Min	2N3441 Max	Units
* D.C. Current Gain	h_{FE}	V_{CE} = 4V I_C = 0.5A	25	150	25	100	
* Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C = 0.5A I_B = 0.05A		1.0		1.0	V
* Base-Emitter Saturation Voltage	V_{BE}	I_C = 0.5A V_{CE} = 4.0V		1.7		1.7	V
* Emitter Cutoff Current	I_{EBO}	V_{EB} = 7.0V		1.0		1.0	mA
Turn-On Time	t_{on}	I_C = 0.5A		4		4	μsec
Storage Time	t_s	V_{CC} = 30V		2		2	μsec
Fall Time	t_f	I_B(on) = I_B(off) = 0.05A		4		4	μsec
Output Capacitance	C_{ob}	V_{CB} = 10V, f = 1MHZ		375		375	pF
Gain-Bandwidth	F_T	V_{CE} = 10V, I_C = 0.2A		800		800	KHz
Beta Cutoff Frequency	f_{hfe}	V_{CE} = 4V, I_C = .1A		25		25	KHz
Second Breakdown Collector Current	$I_{S/B}$	V_{CE} = 60V V_{CE} = 120V		.42		.21	A

Typical Characteristics



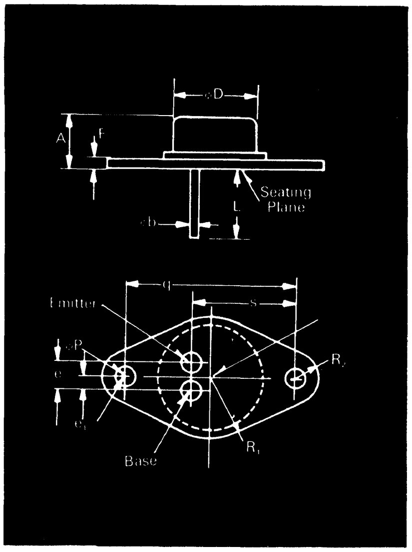




TRANSISTOR

NPN Power TRANSISTORS 2N3055/2N3442

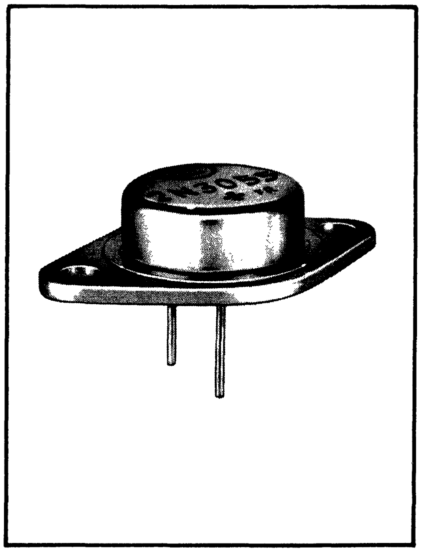
10/15 Ampere 60/140 Volts



Conforms to TO-3 Outline

Symbol	Inches Min.	Inches Max.	Millimeters Min.	Millimeters Max.
A	.250	.450	6.35	11.43
ϕb	.038	.043	.97	1.09
ϕD		.875		22.23
e	.420	.440	10.67	11.18
e_1	.205	.225	5.21	5.72
F		.135		3.43
L	.312		7.92	
ϕP	.151	.161	3.84	4.09
q	1.177	1.197	29.90	30.40
R_1		.525		13.34
R_2		.188		4.78
S	.655	.675	16.64	17.15

Finish—Nickel Plate.
Approx. Weight—.58 oz. (16.5 g).



Features:
- **High reverse bias S.O.A. for inductive loads**
- **Low thermal resistance**
- **Hermetically sealed TO-3 type package**
- 117 watt dissipation
- 100% Power tested
- Lifetime guarantee

Applications
- **Series and shunt regulators**
- **High-fidelity amplifiers**
- **Power switching circuits**
- **Solenoid drivers**

Voltage Matrix

Tc = 25°C

Test	Symbol	2N3055	2N3442
Collector Voltage	$V_{CEO(sus)}$	**60**	**140**

Maximum Ratings and Characteristics

Tc=25°C unless specified

	Symbol	2N3055	2N3442	Units
* Operating and storage temperature		— 65 TO 200	—65 TO 200	°C
* Collector-emitter sustaining voltage	$V_{CEO(sus)}$	60	140	Volts
* Collector-base voltage	V_{CBO}	100	160	Volts
* Emitter-base voltage	V_{EBO}	7	7	Volts
Collector-emitter voltage V_{BE} = —1.5V	V_{CEV}	100	160	Volts
* Continuous collector current	I_C	15	10	Amperes
* Continuous base current	I_B	7	7	Amperes
Linear power derating factor from Tc =25°C		.67	.67	W/°C
* Thermal resistance	$R_{\theta JC}$	1.5	1.5	°C/W
* Power dissipation	P_T	115	117	Watts
Power dissipation Tc = 100°C	P_T	67	67	Watts

* JEDEC Registered Parameters

10/15 Ampere 60/140 Volts

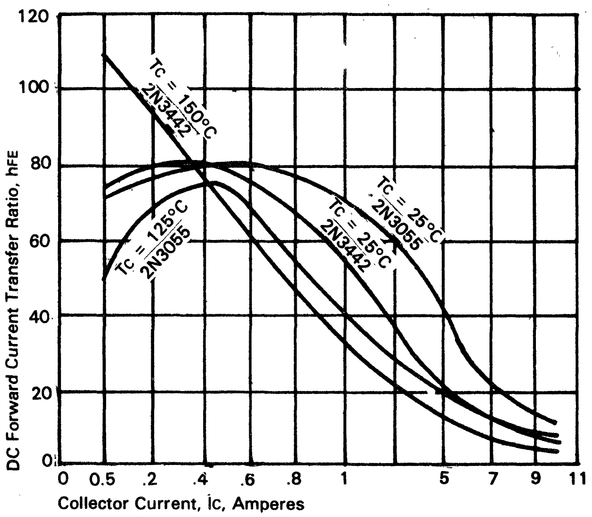
NPN Power TRANSISTORS 2N3055/2N3442

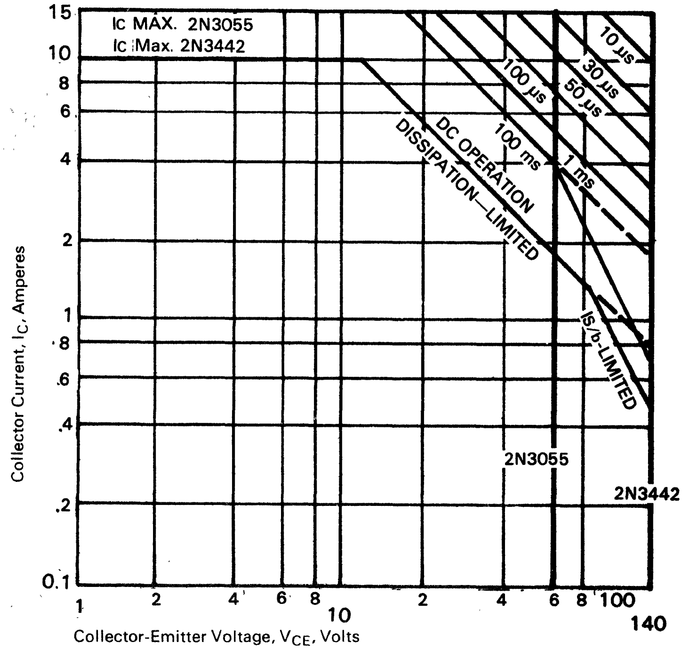
CHARACTERISTIC	SYMBOL	DC COLLECTOR VOLTAGE V	DC EMITTER OR BASE VOLTAGE V		DC CUR— RENT A		LIMITS				UNITS
							2N3055		2N3442		
		V_{CE}	V_{EB}	V_{BE}	I_C	I_B	MIN.	MAX.	MIN.	MAX.	
* Collector-Cutoff Curent: With base open	I_{CEO}	30 120				0 0		0.7 —		— 10	mA
With base-emitter junction reverse-biased	I_{CEV}	140 100		-1.5 -1 5				— 5		 —	
At T_C = 150°C	I_{CEV}	140 100		-1.5 -1.5				— 30		30 —	
* Emitter-Cutoff Current	I_{EBO}		7					5		5	mA
* DC Forward Current Transfer Ratio ①	h_{FE}	4			3 4		— 20	— 70	20 —	70 —	
* Base-to-Emitter Voltage ①	V_{BE}	4			3 4			— 1.8		1.7 —	V
* Collector-to-Emitter Saturation Voltage ①	V_{CE} (sat)				4 3	0.4 0.3		1.1 —		— 1.0	V
Gain-Bandwidth Product	f_T	10			1		800			800	kHz
Forward-Bias Second Break-down Collector Current	$I_{S/b}$	60 78			1.95 1.5		1 —			— 1	sec.

* JEDEC Registered Parameters

① Pulse Test 300 microsecond, 2% Duty Cycle

Typical Characteristics

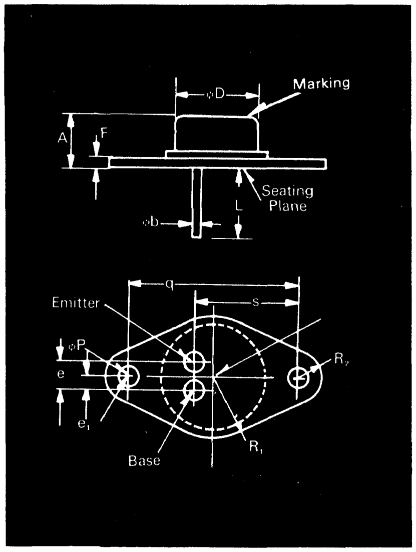




TRANSISTOR

NPN Power TRANSISTORS 2N6254/2N6262

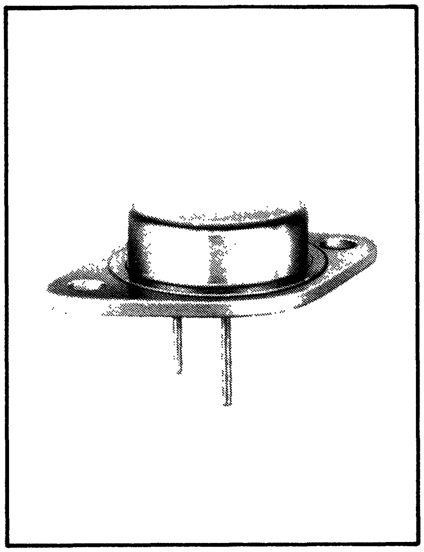
15 Amperes 80/150 Volts



Conforms to TO-3 Outline

Symbol	Inches Min.	Inches Max.	Millimeters Min.	Millimeters Max.
A	.250	.450	6.35	11.43
ϕb	.038	.043	.97	1.09
ϕD		.875		22.23
e	.420	.440	10.67	11.18
e_1	.205	.225	5.21	5.72
F		.135		3.43
L	.312		7.92	
ϕP	.151	.161	3.84	4.09
q	1.177	1.197	29.90	30.40
R_1		.525		13.34
R_2		.188		4.78
S	.655	.675	16.64	17.15

Finish—Nickel Plate.
Approx. Weight—.58 oz. (16.5 g).



Features:
- No forward bias secondary breakdown to 80 Volts
- High reverse bias S.O.A. for inductive loads
- Low thermal resistance
- Hermetically sealed TO-3 type package
- 150 watt dissipation
- 100% Power tested
- Lifetime Guarantee

Applications
- High Power Switching
- Amplifiers
- Servo Systems
- Regulators
- Modulators

Voltage Matrix Tc = 25°C

Test	Symbol	2N6254	2N6262
Collector Voltage	$V_{CEO\,(sus)}$	80	150

Maximum Ratings and Characteristics
Tc = 25°C unless specified

	Symbol	2N6254	2N6262	Units
* Operating and storage temperature		—65 To 200	—65 To 200	°C
* Collector-emitter sustaining voltage	$V_{CEO\,(sus)}$	80	150	Volts
* Collector-base voltage	V_{CBO}	100	170	Volts
* Emitter-base voltage	V_{EBO}	7	7	Volts
* collector-emitter voltage V_{BE} = - 1.5.	V_{CEV}	90	170	Volts
* Continuous collector current	I_C	15	15	Ampere
* Continous base current	I_B	7	7	Ampere
* Linear power derating factor from T_C = 25°C		.855	.855	W/°C
* Thermal resistance	$R_{\theta JC}$	1.17	1.17	°C/W
* Power dissipation	P_T	150	150	Watts
Power dissipation T_C = 100°C	P_T	86	86	Watts

* JEDEC Registered Parameters

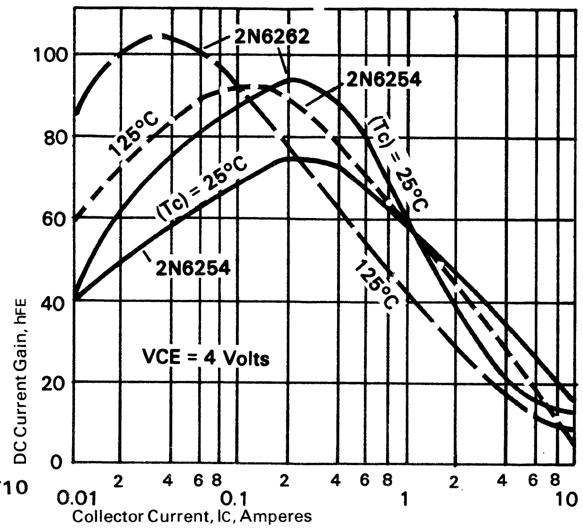
15 Amperes
80/150 Volts

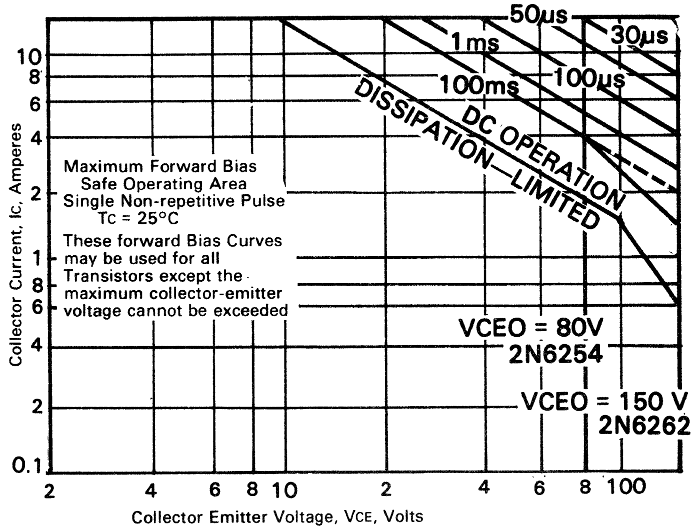
NPN Power TRANSISTORS 2N6254/2N6262

ELECTRICAL CHARACTERIESTICS (T c) = 25°C

CHARACTERISTIC	SYMBOL	DC COLLECTOR VOLTAGE V	DC EMITTER OR BASE VOLTAGE V		DC CURRENT A		LIMITS				UNITS
							2N6254		2N6262		
		VCE	VEB	VBE	Ic	IB	MIN.	MAX.	MIN.	MAX.	
*Collector-Cutoff Current: with base open	I CEO	60 110				0 0		1.0		1.0	
With base-emitter junction reverse-biased	I CEV	100 150		-1.5 -1.5				0.5		0.1	mA
At Tc = 150°C	I CEV	30 150		-1.5 -1.5				5.0		2.0	
Emitter-Cutoff Current	I EBO		7					0.5		0.2	mA
*DC Forward Current Transfer Ratio	hFE	2 2			3 5		20	70	20	70	
*Base-to-Emitter Voltage	VBE	2 2			5 3			1.5		1.0	
*Collector-to-Emitter Saturation Voltage	VCE (sat)				5 3	0.5 0.3		0.5		0.5	V
Gain-Bandwidth Product	fT	4			1		800			800	kHz
Forward-Bias Second Breakdown Collector Current	I S/b	80 100			1.92 1.5			1		1	s

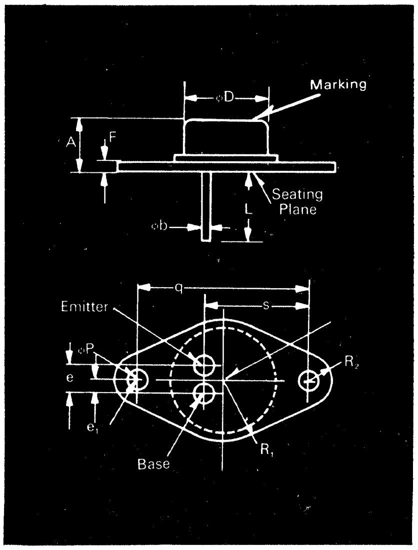
* JEDEC Registered Parameters.





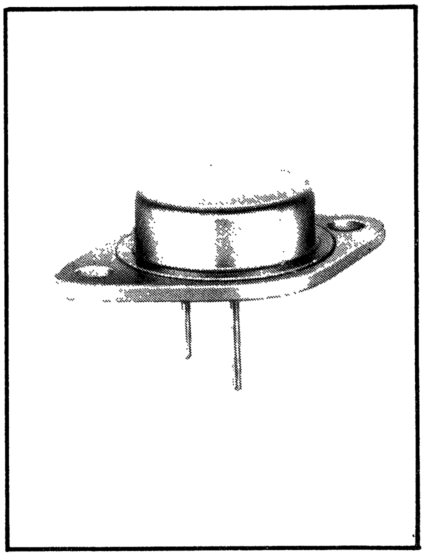
NPN Power TRANSISTORS 2N3771/2N3772/2N3773

16-30 Amperes 40-140 Volts



Symbol	Inches Min.	Inches Max.	Millimeters Min.	Millimeters Max.
A	.250	.450	6.35	11.43
ϕb	.038	.043	.97	1.09
ϕD		.875		22.23
e	.420	.440	10.67	11.18
e_1	.205	.225	5.21	5.72
F		.135		3.43
L	.312		7.92	
ϕP	.151	.161	3.84	4.09
q	1.177	1.197	29.90	30.40
R_1		.525		13.34
R_2		.188		4.78
S	.655	.675	16.64	17.15

Finish—Nickel Plate.
Approx. Weight—.58 oz. (16.5 g).



Conforms to TO-3 Outline

Features:
- No forward bias secondary breakdown to 100 volts D.C.
- High reverse bias S.O.A. for inductive loads
- Low thermal resistance
- Hermetically sealed TO-3 type package
- 150 watt dissipation
- 100% Power tested
- Lifetime Guarantee

Applications:
- Series and shunt regulators
- High-fidelity amplifiers
- Power switching circuits
- Solenoid drivers

Test	Symbol	2N3771	2N3772	2N3773
Collector Voltage	$V_{CEO\,(sus)}$	40	60	140

Maximum Ratings and Characteristics
Tc = 25°C unless specified

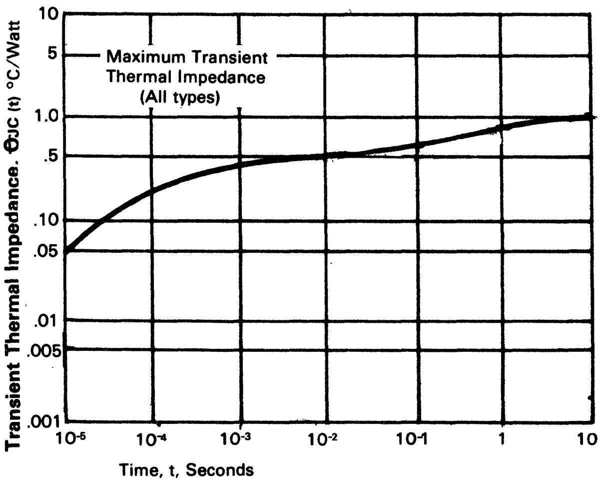
	Symbol	2N3771	2N3772	2N3773	Units
Operating and storage temperature		*–65 to 200	*–65 to 200	*–65 to 200	°C
Collector-emitter sustaining voltage	$V_{CEO(sus)}$	*40	*60	*140	Volts
Collector-base voltage	V_{CBO}	*50	*100	*160	Volts
Emitter-base voltage	V_{EBO}	*5	*7	*7	Volts
Collector-emitter voltage $V_{BE} = -1.5V$	V_{CEV}	*50	*100	*160	Volts
Continuous collector current	I_C	*30	*20	*16	Amperes
Continuous base current	I_E	*7.5	*5	*4	Amperes
Linear power derating factor from T_C = 25°C		*.855	*.855	*.855	W/°C
Thermal resistance	$R_{\theta JC}$	1.17	1.17	1.17	°C/W
Power dissipation	P_T	*150	*150	*150	Watts
Power dissipation T_C = 100°C	P_T	86	86	86	Watts

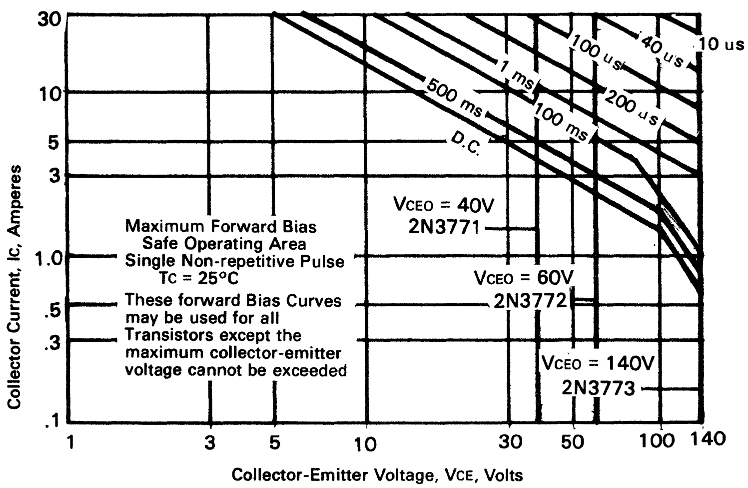
* Registered Parameters

16-30 Amperes 40-140 Volts
NPN Power TRANSISTORS 2N3771/2N3772/2N3773

ELECTRICAL CHARACTERISTICS
(Tc) = 25°C

Characteristic	Symbol	TEST CONDITIONS: DC Collector Voltage (V) VCB	VCE	DC Emitter or Base Voltage, (V) VEB	VBE	DC Current (A) IC		IB	LIMITS 2N3771 Min.	2N3771 Max.	2N3772 Min.	2N3772 Max.	2N3773 Min.	2N3773 Max.	Units
* DC Forward Current Transfer Ratio	HFE		4 4 4 4 4 4			30 20 16 15 10 8			5 — — 15 — —	— — — 60 — —	— 5 — — 15 —	— — — — 60 —	— — 5 — — 15	— — — — — 60	
* Collector-Cutoff Current: With emitter open	ICBO	Rated VCEO								2*		5*		2	mA
With base-emitter junction reverse-biased	ICEV		50 100 140		−1.5 −1.5 −1.5					2 — —		— 5 —		— — 2	mA
With base-emitter junction reverse-biased & Tc = 150°C	ICEV		30 30 140		−1.5 −1.5 −1.5					10 — —		— 10 —		— — 10	mA
With base open	ICEO		30 50 120					0 0 0		10 — —		— 10 —		— — 10	mA
* Emitter-Cutoff Current	IEBO			5 7		0 0				5 —		— 5		— 5	mA
* Base-to-Emitter Voltage	VBE		4 4 4			15 10 8				2.7 — —		— 2.2 —		— — 2.2	V
* Collector-to-Emitter Saturation Voltage	VCE (sat)					15 10 8		1.5 1 0.8		2 — —		— 1.4 —		— — 1.4	V
Second-Breakdown Collector Current With base forward-biased & 1—s, nonrepetitive pulse	Is/b		100 60 40							— — 3.75		— 2.5 —		1.5 — —	A
Second-Breakdown Energy With base reverse biased & L = 40 mH, RBE = 100	Es/b			−1.5 −4.0		5 2.5			500 —		500 —		— 125		mJ



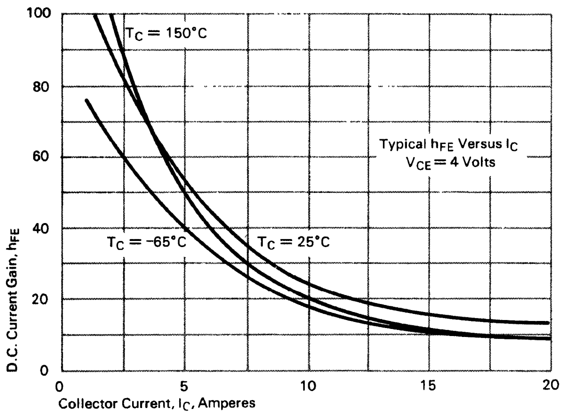


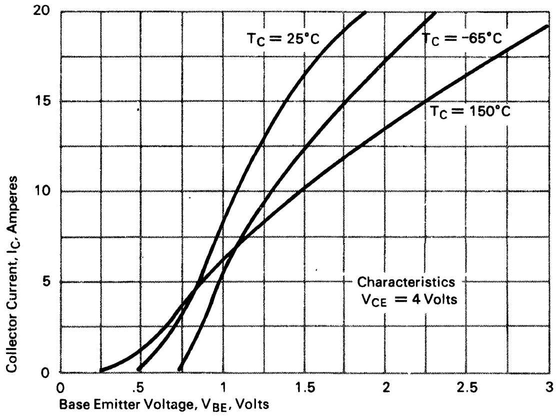
TRANSISTOR

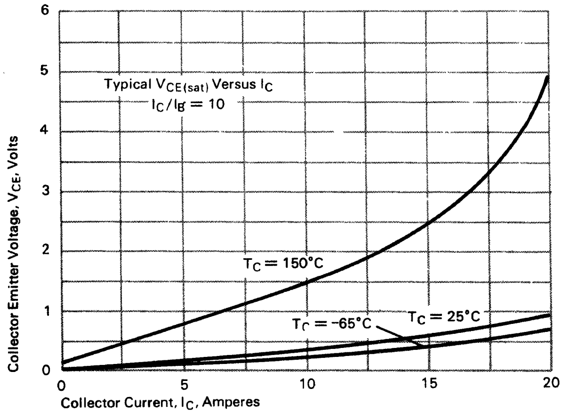
NPN Power TRANSISTORS 2N3771/2N3772/2N3773

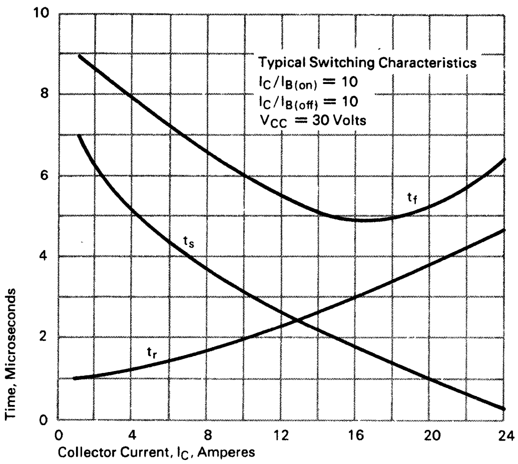
16-30 Amperes
40-140 Volts

Typical Characteristics 2N3771

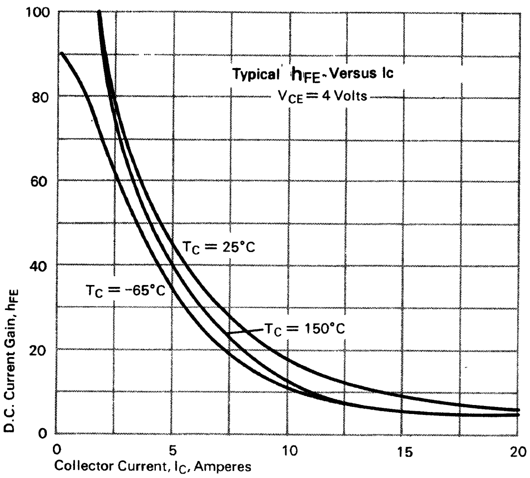


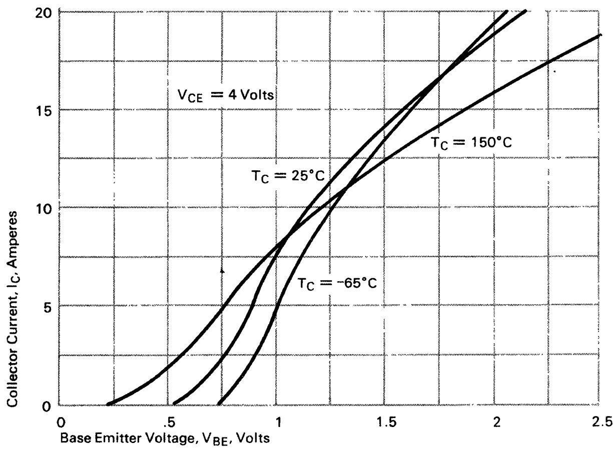






Typical Characteristics 2N3772

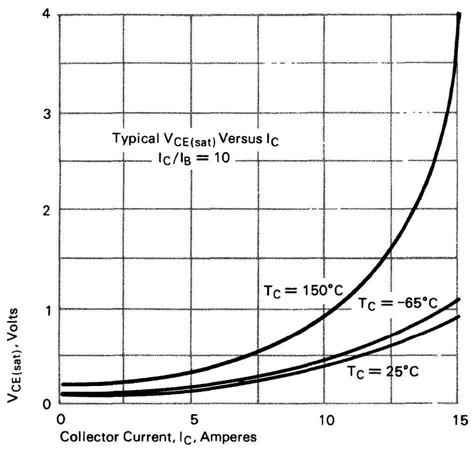


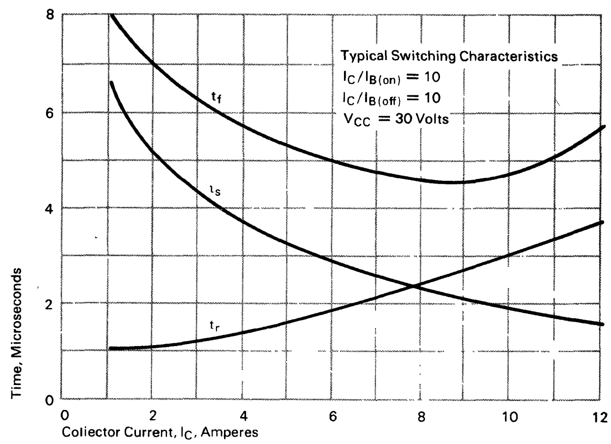


TRANSISTOR

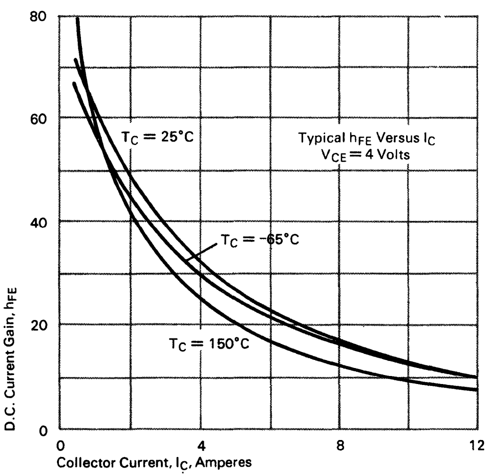
NPN Power TRANSISTORS 2N3771/2N3772/2N3773

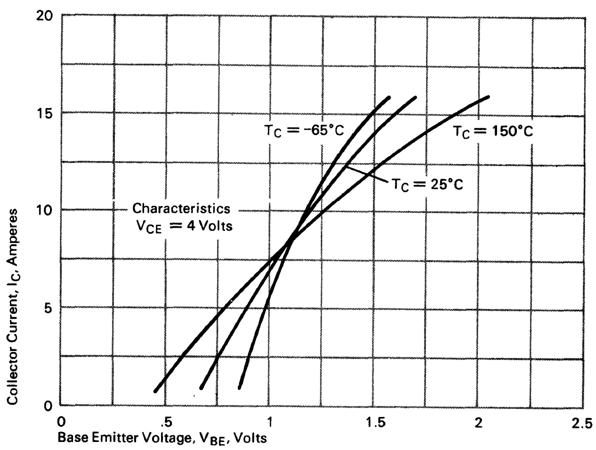
Typical Characteristics 2N3772

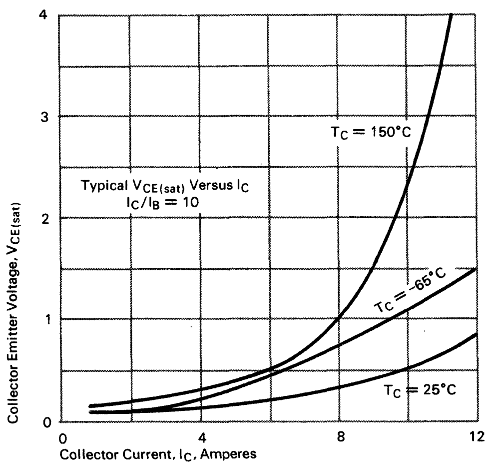


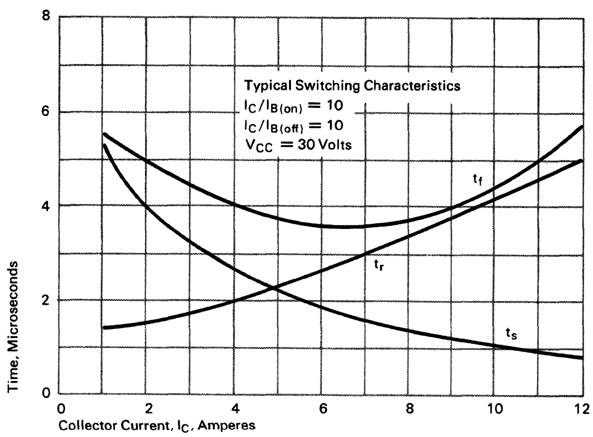


Typical Characteristics 2N3773



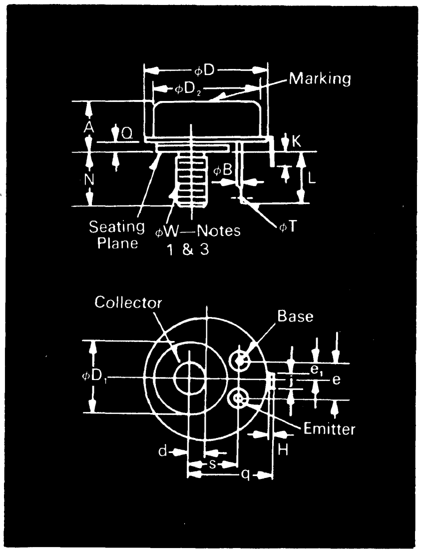






NPN Power TRANSISTORS 151/152

6 Amperes 40—240 Volts

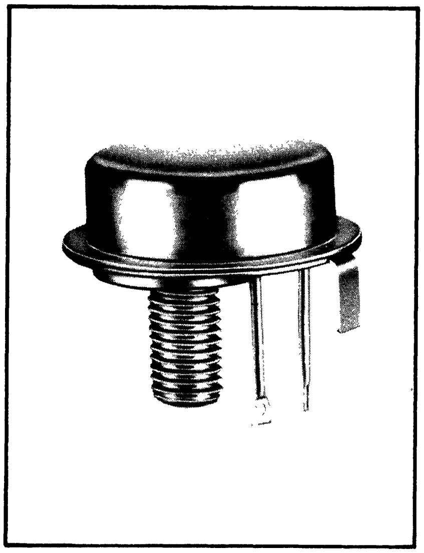


Conforms to MT-1 Outline

Symbol	Inches Min.	Inches Max.	Millimeters Min.	Millimeters Max.
A	.500	.560	12.70	14.22
φB	.045	.060	1.14	1.52
d	.140	.170	3.56	4.32
φD	1.240	1.280	31.50	32.51
ϕD_1	.730	.770	18.54	19.56
ϕD_2		1.125		28.58
e	.360	.400	9.14	10.16
e_1	.180	.200	4.57	5.08
H	.014	.025	.36	.64
j	.140	.170	3.56	4.32
K	.130	.190	3.30	4.83
L	.550	.590	13.97	14.99
N	.550	.590	13.97	14.99
q	.810	.850	20.57	21.59
Q	.105	.140	2.67	3.56
S	.480	.520	12.19	13.21
φT	.050	.070	1.27	1.78
φW	5/16-24 UNF-2A			

Finish—Nickel Plate.
Approx. Weight—.9 oz. (25 g).

1. Complete threads to extend to within 2½ threads of seating plane.
2. Contour and angular orientation of terminals is undefined.
3. Pitch diameter of 5/16-24 UNF-2A (coated) threads (ASA B1.1-1960).



Features:
- Gold Alloy Process
- No forward bias secondary breakdown to 150 volts
- High reverse bias S.O.A. for inductive loads
- Low thermal resistance with copper base
- 175 watt dissipation
- Protection from thermal fatigue with hard solder and molybdenum construction
- 25 volt VEBO
- Low VCE(sat)
- Lifetime Guarantee

Applications:
- High Power Switching
- Amplifiers
- Servo Systems
- Regulators
- Modulators

151 — Low Gain Series
152 — High Gain Series

Maximum Ratings

Voltage

Type		VCBO	VCEO
151-04	152-04	65	40
151-06	152-06	85	60
151-08	152-08	105	80
151-10	152-10	125	100
151-12	152-12	145	120
151-14	152-14	165	140
151-16	152-16	185	160
151-18	152-18	205	180
151-20	152-20	225	200
151-22	152-22	245	220
151-24	152-24	265	240

Maximum Ratings and Characteristics
Tc = 25°C unless specified

	Symbol	151 /152	Units
Operating and storage temperature		—65 to 150	°C
Collector-emitter sustaining voltage	VCEO (sus)	40 to 240	Volts
Collector-base voltage	VCBO	VCEO (sus) + 25	Volts
Emitter-base voltage	VEBO	25	Volts
Continuous collector current	IC	6	Amps
Continuous base current	IB	3	Amps
Linear power derating factor from TC = 80°C		1.4	W/°C
Thermal resistance	RΘJC	.71	°C/W
Power dissipation	PT	175	Watts
Power dissipation TC = 100°C	PT	70	Watts

6 Amperes 40—240 Volts

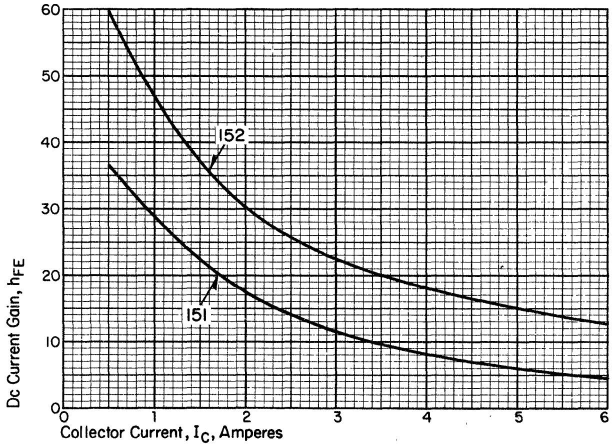
NPN Power TRANSISTORS 151/152

Electrical Characteristics

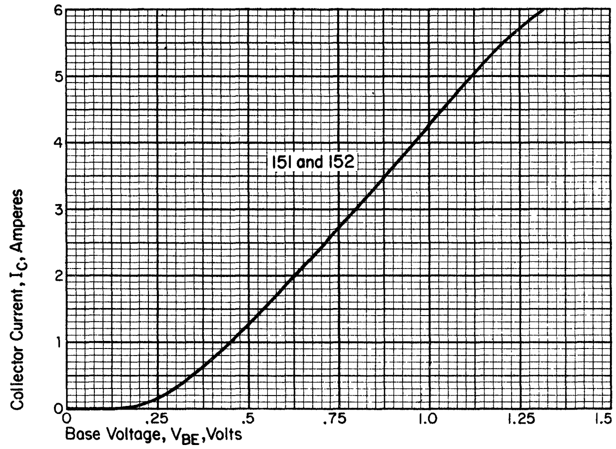
T_C=25°C unless otherwise specified

	Symbol	Type 151 Min.	Type 151 Max.	Type 152 Min.	Type 152 Max.
Collector cut-off current at V_{CEX}=max. rating, V_{BE}=−1.5 Vdc, mAdc	I_{CEX}	..	10	..	10
Collector cut-off current at V_{CEX}=max. rating, T_C=150°C, V_{BE}=−1.5 Vdc, mAdc	I_{CEX}	..	20	..	20
Emitter cut-off current at V_{EB}=25 Vdc, I_C=0, T_C=150°C, mAdc	I_{EBO}	..	20	..	20
Turn-on time at V_{CC}=12 Vdc, I_C=1.5A, I_B=.4A, microseconds	t_{on}	..	7	..	..
Turn-on time at V_{CC}=12 Vdc, I_C=1.5A, I_B=.25A, microseconds	t_{on}	..	..	..	7
Turn-off time at V_{CC}=12 Vdc, V_{BE}=−25 Vdc, I_C=1.5A, I_B=−.4A, microseconds	t_{off}	..	14	..	..
Turn-off time at V_{CC}=12 Vdc, V_{BE}=−25 Vdc, I_C=1.5A, I_B=−.25A, microseconds	t_{off}	..	..	..	14
Collector-emitter saturation voltage at I_C=1.5 Adc, I_B=0.25 Adc, Vdc	$V_{CE(sat)}$	..	1.30	..	1.25
Base-emitter voltage at I_C=1.5 Adc, I_B=0.25 Adc, Vdc	$V_{BE(sat)}$	..	2.5	..	2.0
Dc current gain at V_{CE}=4 Vdc, I_C=1.5 Adc	h_{FE}	11	..	18	..
Collector-emitter sustaining voltage, base open, Ic = 200ma	VCEO (sus)	See Voltage Table			
Second breakdown Collector Current, VCE = 150V, Tc = 80°C (one second test), forward bias, Amperes	Is/B	···	.68	···	.68
Second breakdown energy, base reverse biased, L =250 mh, RB = 50 ohms, VBE = —6.0 volts, Ic = 2.0 Amperes, Joules	Es/B	···	.50	···	.50
Gain-bandwidth, VCE = 10 Volts, Ic = 0.5 Amps, Kilohertz	ft	250	···	250	···

Typical Characteristics

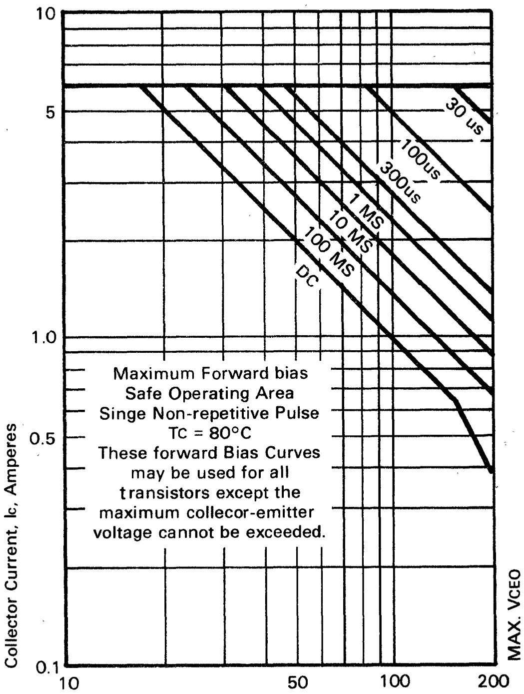


Typical dc gain versus collector current at Tc=25°C.



Typical base voltage vs. collctor current Characteristics at Tc = 25°C

Safe Operating Area

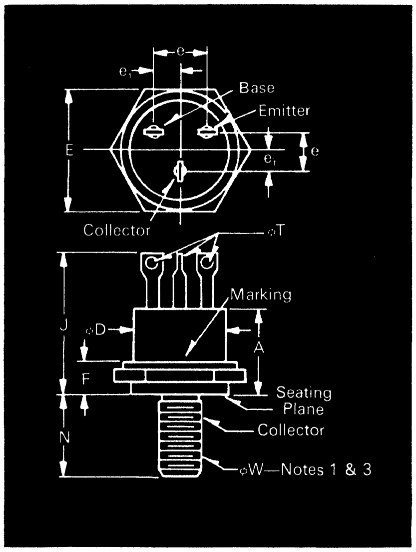


Collector Voltage VCE, Volts
Tc = 80°C

TRANSISTOR

NPN Power TRANSISTORS 153/154

7.5 amperes 40-240 Volts

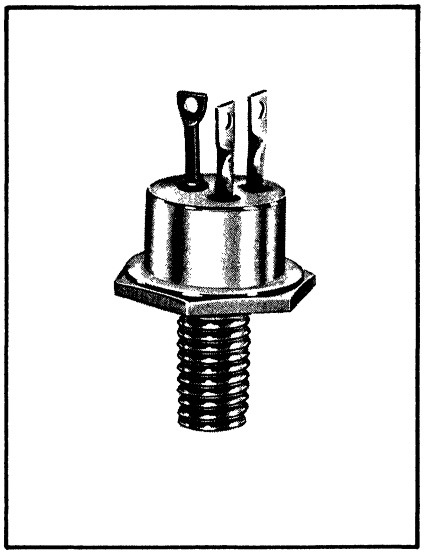


Conforms to MT-52 Outline

Symbol	Inches Min.	Inches Max.	Millimeters Min.	Millimeters Max.
A	.340	.406	8.64	10.31
ϕD	.400	.440	10.16	11.18
e	.160	.190	4.06	4.83
e_1	.080	.095	2.03	2.41
E	.544	.562	13.82	14.27
F	.100	.140	2.54	3.56
J		.710		18.03
N	.422	.453	10.72	11.51
ϕT	.040	.055	1.02	1.40
ϕW	¼-28 UNF-2A			

Finish—Nickel Plate.
Approx. Weight—.25 oz. (7 g).

1. Complete threads to extend to within 2½ threads of seating plane.
2. Contour and angular orientation of terminals is undefined.
3. Pitch dia. of ¼-28 UNF-2A (coated) threads (ASA B1.1-1960).



Features:

- Gold Alloy Process
- No forward bias secondary breakdown to 150 volts
- High reverse bias S.O.A. for inductive loads
- Low thermal resistance with copper base
- 150 watt dissipation
- Protection from thermal fatigue with hard solder and molybdenum construction
- 25 volt V_{EBO}
- Low VCE (sat)
- Lifetime Guarantee

Applications

- High Power Switching
- Amplifiers
- Servo Systems
- Regulators
- Modulators

153 — Low Gain Series
154 — High Gain Series

Maximum Ratings

Voltage

Type		V_{CBO}	$V_{CEO\,(sus)}$
153-04	154-04	65	40
153-06	154-06	85	60
153-08	154-08	105	80
153-10	154-10	125	100
153-12	154-12	145	120
153-14	154-14	165	140
153-16	154-16	185	160
153-18	154-18	205	180
153-20	154-20	225	200
153-22	154-22	245	220
153-24	154-24	265	240

Maximum Ratings and Characteristics
Tc = 25°C unless specified

	Symbol	Type 153 154	Units
Operating and storage temperature		–65 To 175	°C
Collector-emitter sustaining voltage	$V_{CEO\,(sus)}$	40 To 240	Volts
Collector-base voltage	V_{CBO}	$V_{CEO\,(sus)}$ + 25	Volts
Emitter-base voltage	V_{EBO}	25	Volts
Continuous collector current	I_C	7.5	Amps
Continuous base current	I_B	3.	Amps
Linear power derating factor from Tc = 25°C		1.33	W/°C
Thermal resistance	$R_{\theta JC}$	.75	°C/W
Power dissipation	P_T	200	Watts
Power dissipation Tc = 100°C	P_T	100	Watts

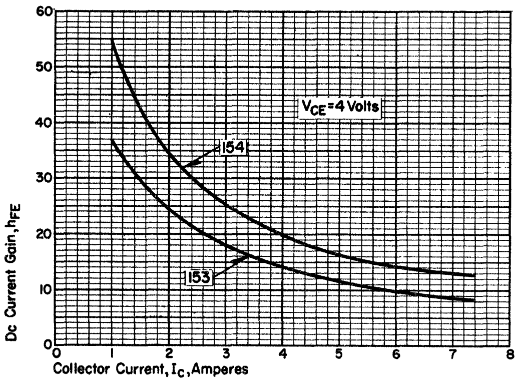
7.5 amperes 40-240 Volts

NPN Power TRANSISTORS 153/154

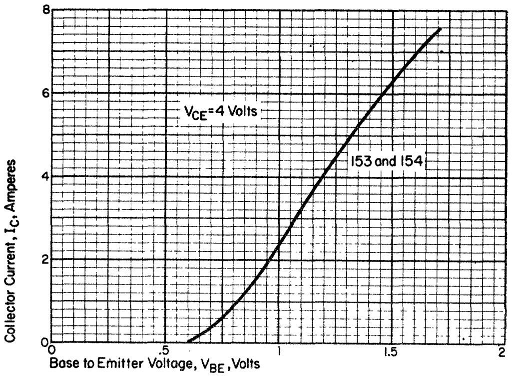
Electrical Characteristics
Tc = 25°C unless otherwise specified

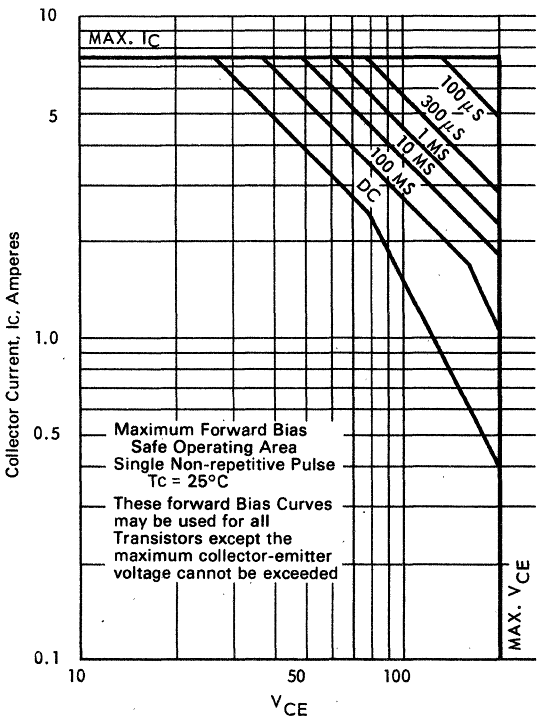
Test	Symbol	Test Conditions	All Types Min.	All Types Max.	Units
D.C. Current Gain (153 types)	h_{FE}	V_{CE} = 4, I_C = 1.5A	15		
D.C. Current Gain (154 types)	h_{FE}	V_{CE} = 4, I_C = 1.5A	25		
Collector-Emitter Saturation Voltage (153)	$V_{CE\,(sat)}$	I_C = 1.5A, I_B = 250 mA		13	V
Collector-Emitter Saturation Voltage (154)	$V_{CE\,(sat)}$	I_C = 1.5A, I_B = 250 mA		1.25	V
Base-Emitter Saturation Voltage (153)	$V_{BE\,(sat)}$	I_C = 1.5A, I_B = 250 mA		2.5	V
Base-Emitter Saturation Voltage (154)	$V_{BE\,(sat)}$	I_C = 1.5A, I_B = 250 mA		2.0	V
Emitter Cutoff Current	I_{EBO}	V_{EB} = 25V, T_C = 175°C		20	mA
Turn-On Time	t_{on}	I_C = 1.5A		5	µsec
Storage Time	t_s	V_{CC} = 12V,		5	µsec
Fall Time	t_f	$I_{B\,(ON)} = I_{B\,(OFF)}$ = 0.3A		5	µsec
Output Capacitance	C_{ob}	V_{CB} = 10V.f = 1 MHz		750	pF
Gain-Bandwidth	f_T	V_{CE} = 10V, I_C = 0.5A	250		KHz
Beta Cutoff Frequency	f_{hfe}	V_{CE} = 12V, I_C = 1.5A	14		KHz
Second Breakdown Forward Biased,	I_{SB}	V_{CE} = 80V., t = 1.0 second T_C = 25°C		2.5	A
Collector Current Second Breakdown, Reversed Biased		L = ImH, V_{BB} =- V, R_B = 20Ω , I_C = 5.6A	15.5		mJ

Typical Characteristics



Typical dc gain versus collector current Tc = 25°C.



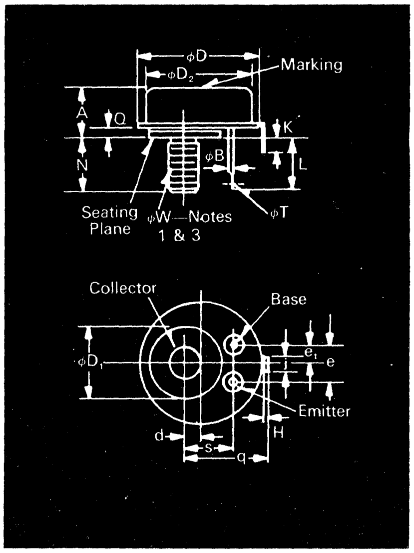


Collector Emitter Voltage, VCE, Volts

TRANSISTOR

NPN Power TRANSISTORS 2N1015/2N1016

7.5 Amperes 30-250 Volts

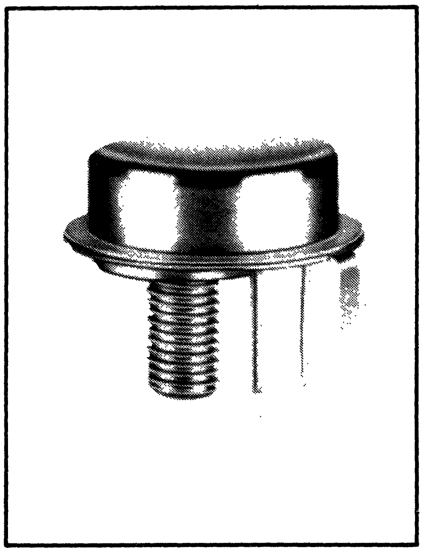


Conforms to TO-82 Outline

Symbol	Inches Min.	Inches Max.	Millimeters Min.	Millimeters Max.
A	.500	.560	12.70	14.22
φB	.045	.060	1.14	1.52
d	.140	.170	3.56	4.32
φD	1.240	1.280	31.50	32.51
$φD_1$	.730	.770	18.54	19.56
$φD_2$		1.125		28.58
e	.360	.400	9.14	10.16
e_1	.180	.200	4.57	5.08
H	.014	.025	.36	.64
j	.140	.170	3.56	4.32
K	.130	.190	3.30	4.83
L	.550	.590	13.97	14.99
N	.550	.590	13.97	14.99
q	.810	.850	20.57	21.59
Q	.105	.140	2.67	3.56
S	.480	.520	12.19	13.21
φT	.050	.070	1.27	1.78
φW	5/16-24 UNF-2A			

Finish—Nickel Plate.
Approx. Weight—.9 oz. (25 g).

1. Complete threads to extend to within 2½ threads of seating plane.
2. Contour and angular orientation of terminals is undefined.
3. Pitch diameter of 5/16-24 UNF-2A (coated) threads (ASA B1.1-1960).



Features:
- Gold Alloy Process
- No forward bias secondary breakdown to 100 Volts
- High reverse bias S.O.A. for inductive loads
- Low thermal resistance with copper base
- 150 watt dissipation
- Protection from thermal fatigue with hard solder and molydenum construction
- 25 volt V_{EBO}
- Low $V_{CE(sat)}$
- Lifetime Guarantee

Applications:
- High Power Switching
- Amplifiers
- Servo Systems
- Regulators
- Modulators

Maximum Ratings
Voltage

JEDEC		$V_{CEO(SOS)}$
2N1015 ✚	2N1016 ✚	30
2N1015A✚	2N1016A✚	60
2N1015B✚	2N1016B✚	100
2N1015C✚	2N1016C✚	150
2N1015D✚	2N1016D✚	200
2N1015E✚	2N1016E✚	250

Maximum Ratings and Characteristics
T c = 25°C unless specified

	Symbol	JEDEC 2N1015, 2N1016	Units
* Operating and storage temperature		— 65 TO 150	°C
Collector-emitter sustaining voltage	$V_{CEO(sus)}$	30 TO 250	Volts
* Emitter-base voltage	V_{EBO}	25	Volts
* Continous collector current	I_C	7.5	Amps
* Continous base current	I_B	5	Amps
* Thermal resistance	$R_{θJC}$	.87	°C/W
* Power dissipation T_c = 45°C	P_T	150	Watts
Power dissipation T_c = 100°C	P_T	87	Watts

* JEDEC Registered Parameters

TRANSISTOR

7.5 Amperes
30-250 Volts

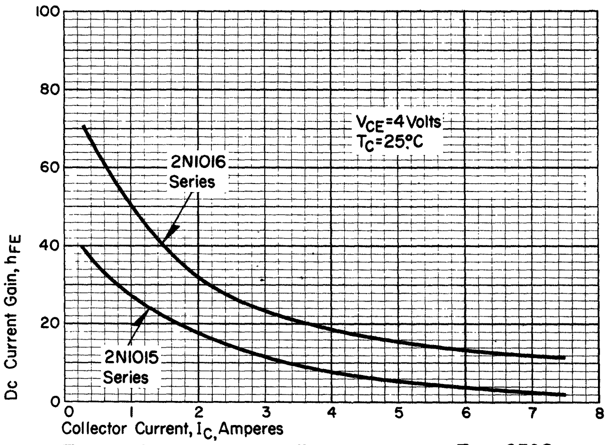
NPN Power TRANSISTORS 2N1015/2N1016

Electrical Characteristics
T_C=25°C unless otherwise specified

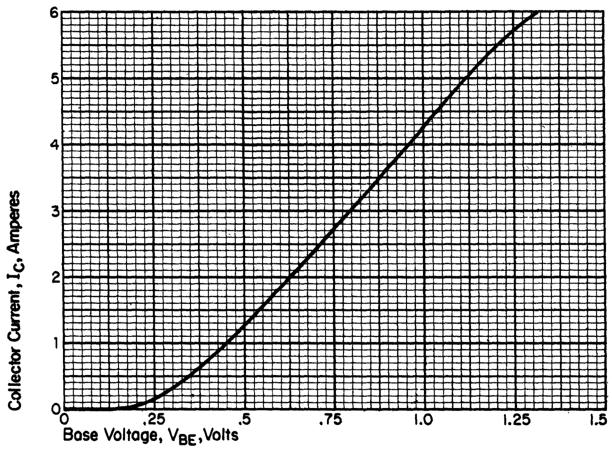
	Symbol	Minimum	Typical	Max.	Units
2N1015/2N1016					
Collector current at $V_{CEX}=V_{CE}$ (from max. ratings), T_J=150°C, V_{BE}=−1.5 Vdc	I_{CEX}	..	2	*20	mAdc
Emitter current at V_{EB}=25 Vdc, I_C=0, T_J=150°C	I_{EBO}	..	3	*20	mAdc
Switching time, delay plus rise time	t_d+t_r	..	3	....	μsec
Storage plus fall time	t_s+t_f	..	7	....	μsec
Second breakdown, Collector Current, V_{CE} = 100 V., T_C = 45°C (one second test), forward bias, Amperes	$I_{S/B}$	..	..	1.5	Adc
Second breakdown energy, base reverse biased, L = 250 mh., R_B = 50 ohms, V_{BE} =−6.0 volts, I_C = 2.0 Amperes, Joules	$E_{S/B}$	..	..	0.5	Joule
Gain-bandwidth, V_{CE} = 10 volts, I_C = 0.5 Amps, Kilohertz	ft	250	..	..	Khz.
2N1015					
Dc current gain at V_{CE}=4 Vdc, I_C=2 Adc	h_{FE}	*10	14	....	.....
Base voltage, at I_C=2 Adc, I_B=300 mAdc	V_{BE} (sat)	..	1.15	....	Vdc
Beta cut-off frequency	f_{hfe}	..	25	....	kHz
2N1016					
Dc current gain at V_{CE}=4 Vdc, I_C=5 Adc	h_{FE}	*10	18	....	.....
Base voltage, at I_C=5 Adc, I_B=750 mAdc	V_{BE} (sat)	..	1.25	....	Vdc
Beta cut-off frequency	f_{hfe}	..	30	....	kHz

*JEDC registered parameters.

Typical Characteristics

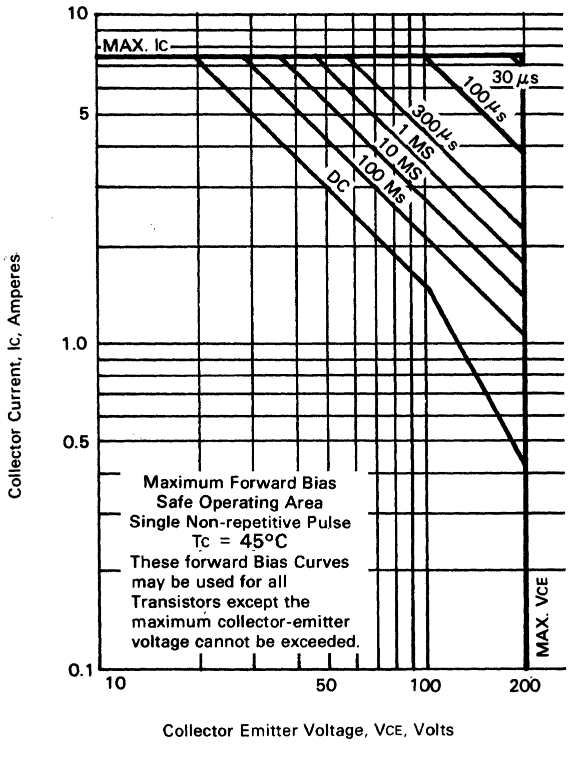


Typical dc gain versus collector current at Tc = 25°C.



Typical base voltage vs. Collector Current characteristics at Tc = 25°C.

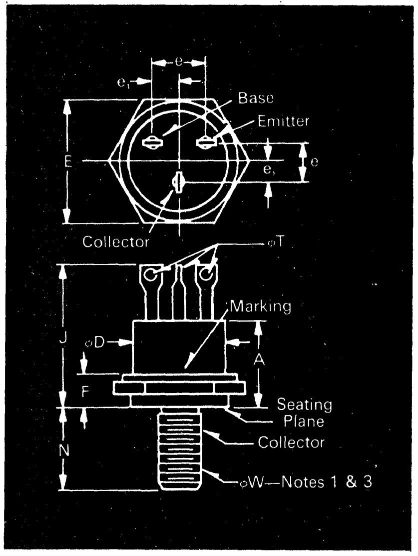
SAFE OPERATING AREA



TRANSISTOR

NPN Power TRANSISTORS 2N3429-33

7.5 Amperes 50-250 Volts

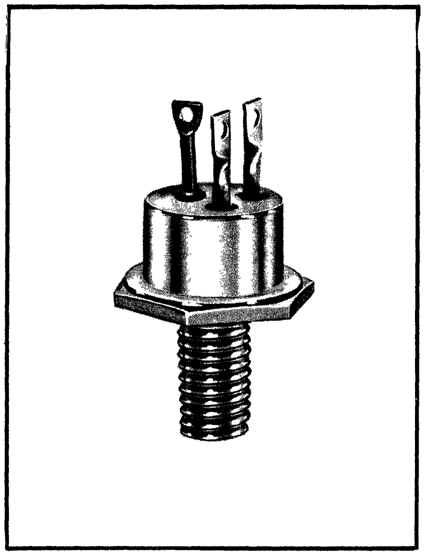


Conforms to MT-52 Outline

Symbol	Inches Min.	Inches Max.	Millimeters Min.	Millimeters Max.
A	.340	.406	8.64	10.31
φD	.400	.440	10.16	11.18
e	.160	.190	4.06	4.83
e_1	.080	.095	2.03	2.41
E	.544	.562	13.82	14.27
F	.100	.140	2.54	3.56
J		.710		18.03
N	.422	.453	10.72	11.51
φT	.040	.055	1.02	1.40
φW	¼-28 UNF-2A			

Finish—Nickel Plate.
Approx. Weight—.25 oz. (7 g).

1. Complete threads to extend to within 2½ threads of seating plane.
2. Contour and angular orientation of terminals is undefined.
3. Pitch dia. of ¼-28 UNF-2A (coated) threads (ASA B1.1-1960).



Features:
- Gold Alloy Process
- No forward bias secondary breakdown to 150 volts
- High reverse bias S.O.A. for inductive loads
- Low thermal resistance with copper base
- 150 watt dissipation
- Protection from thermal fatique with hard solder and molybdenum construction
- 25 volt B_{EBO}
- Low $V_{CE(sat)}$
- Lifetime Guarantee

Applications:
- High Power Switching
- Amplifiers
- Servo Systems
- Regulators
- Modulators

Test	Symbol	Test Conditions	2N3429	2N3430	2N3431	2N3432	2N3433
*Collector-Emitter Sustaining Voltage	$V_{CEO(sus)}$	Base Open L=1H I_C=200mA	50	100	150	200	250
*Collector Cutoff Voltage	V_{CEV}	I_{CEV}=2mA V_{EB}=1.5V					
*Collector Cutoff Voltage	V_{CEV}	I_{CEV}=10mA V_{EB}=1.5V T_C=175°C					

Maximum Ratings and Characteristics*

T_C=25°C unless specified

	Symbol	All Types
*Operating and storage temperature		—65°C to 175°C
*Collector-emitter sustaining voltage	$V_{CEO(sus)}$	50 volts to 250 volts
*Emitter-base voltage	V_{EBO}	25 volts
*Collector-emitter voltage, V_{EB}=1.5V, T_C=175°C	V_{CEV}	50 volts to 250 volts
*Continuous collector current	I_C	7.5 amperes
*Continuous base current	I_B	3 amperes
*Linear power derating factor from T_C=60°C		1.33 W/°C
*Thermal resistance	$R_{\theta JC}$	0.75°C/W
*Power dissipation, T_C=60°C	P_T	150 watts

*JEDEC registered parameters

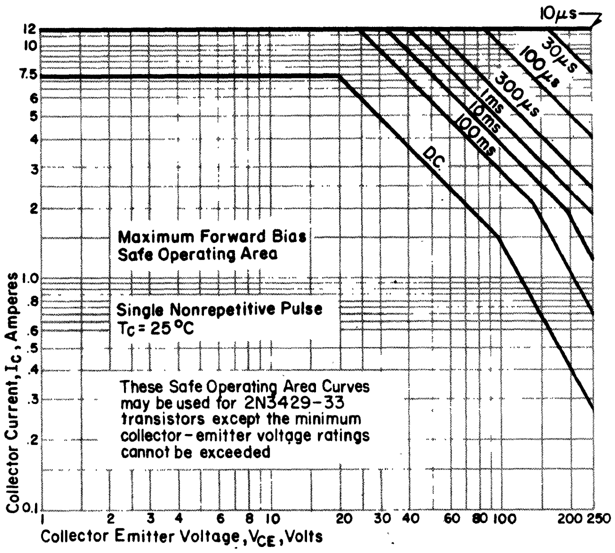
TRANSISTOR

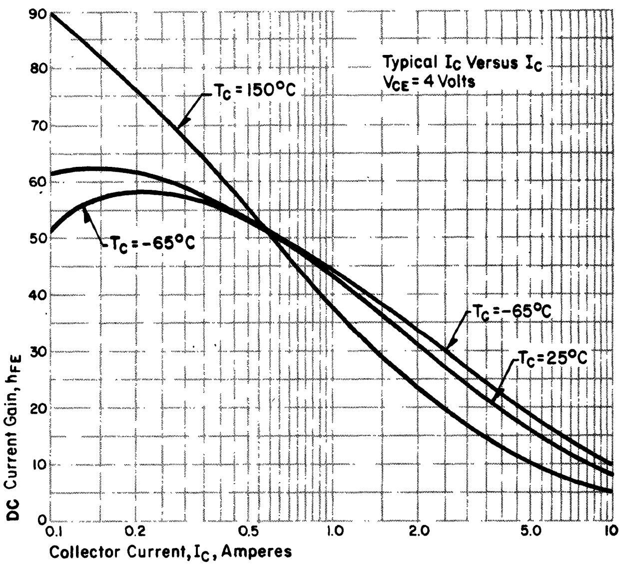
7.5 Amperes 50-250 Volts

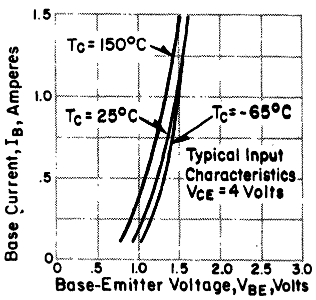
NPN Power TRANSISTORS 2N3429-33

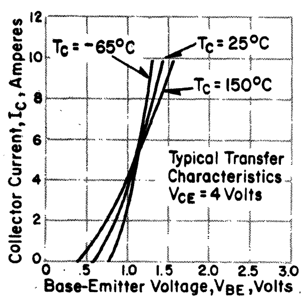
Test	Symbol	Test Conditions	All Types		Units
			Min.	Max.	
*D.C. Current Gain	h_{FE}	V_{CE}=2V, I_C=5A	10	35	
*Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C=5A, I_B=750mA		1.0	V
*Base-Emitter Saturation Voltage	$V_{BE(sat)}$	I_C=5A, I_B=750mA		2.0	V
*Emitter Cutoff Current	I_{EBO}	V_{EB}=25V, T_C=175°C		10	mA
*Turn-On Time	t_{on}	I_C=5A,		5	μsec
*Storage Time	t_s	V_{CC}=12V,		4	μsec
*Fall Time	t_f	I_B(on)=I_B(off)=1.5A		8	μsec
Output Capacitance	C_{ob}	V_{CB}=10V, f=1MHz		750	pF
Gain-Bandwidth	f_T	V_{CE}=10V, I_C=0.5A	250		KHz
*Beta Cutoff Frequency	f_{hfe}	V_{CE}=12V, I_C=5A	20		KHz
Second Breakdown forward Biased, collector current	I_{SB}	V_{CE}=30V, I_C=5A t=I second, T_C = 25°C		1.5	A
Second Breakdown reversed biased	E_{SB}	L=ImH, V_{BB}=−2V, R_B= 20Ω, I_C=5.6A	15.5		mJ

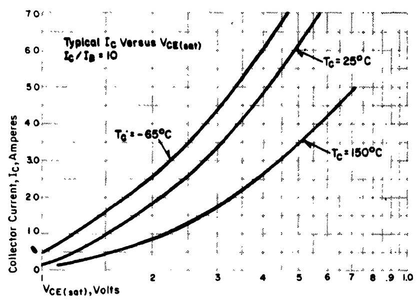
*JEDEC registered data.







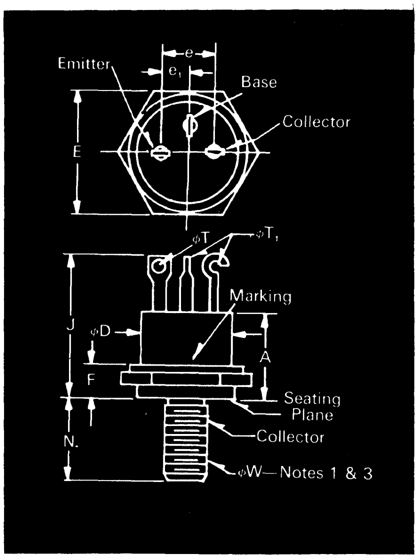




TRANSISTOR

NPN Power TRANSISTORS 163/164

20 Amperes 40-200 Volts

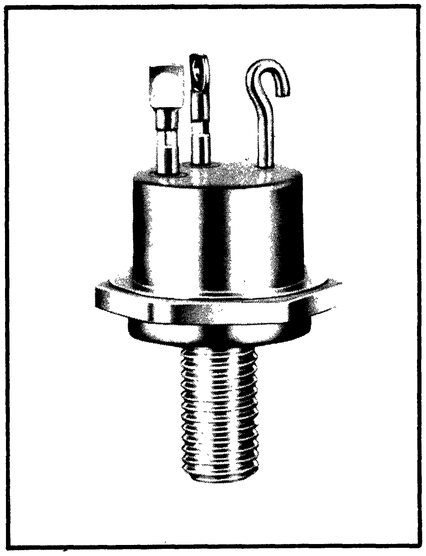


Conforms to MT-33 Outline

Symbol	Inches Min.	Inches Max.	Millimeter Min.	Millimeter Max.
A	.600	.650	15.24	16.51
φD	.650	.700	16.51	17.78
e_1	.185	.205	4.70	5.21
e	.390	.410	9.91	10.41
E	.855	.875	21.72	22.23
F	.156	.250	3.96	6.35
J	1.016	1.076	25.81	27.33
N	.560	.600	14.22	15.24
φT	.090	.100	2.29	2.54
$φT_1$	.060	.080	1.52	2.03
φW	5/16-24 UNF-2A			

Finish—Nickel Plate.
Approx. Weight—1 oz (28 g).

1. Complete threads to extend to within 2½ threads of seating plane.
2. Contour and angular orientation of terminals is undefined.
3. Pitch dia. of 5/16-24 UNF-2A (coated) threads (ASA B1.1-1960).



Features:
- Gold Alloy Process
- No forward bias secondary breakdown to 67 volts
- High reverse bias S.O.A. for inductive loads
- Low thermal resistance with copper base
- 150 watt dissipation
- Protection from thermal fatigue with hard solder and molybdenum construction
- 25 volt V_{EBO}
- Low $V_{CE\,(sat)}$
- Lifetime Guarantee

Applications:
- High Power Switching
- Amplifiers
- Servo Systems
- Regulators
- Modulators

163 — Low Gain Series
164 — High Gain Series

Maximum Ratings

Voltage

Type		V_{CBO}	$V_{CEO\,(sus)}$
163-04	164-04	55	40
163-06	164-06	75	60
163-08	164-08	95	80
163-10	164-10	115	100
163-12	164-12	135	120
163-14	164-14	155	140
163-16	164-16	175	160
163-18	164-18	195	180
163-20	164-20	215	200

Maximum Ratings and Characteristics
Tc = 25°C unless specified

	Symbol	Type 163 164	Units
Operating and storage temperature		— 65 TO 175	°C
Collector-emitter sustaining voltage	$V_{CEO\,(sus)}$	40 TO 200	Volts
Collector-base voltage	V_{CBO}	$V_{CEO\,(sus)}$ + 15	Volts
Emitter-base voltage	V_{EBO}	15	Volts
Continuous collector current	I_C	30	AMPS
Continuous base current	I_B	7.5	AMPS
Thermal resistance	$R_{\theta JC}$	.5	°C/W
Power dissipation Tc = 75°C	P_T	200	Watts
Power dissipation Tc = 100°C	P_T	150	Watts

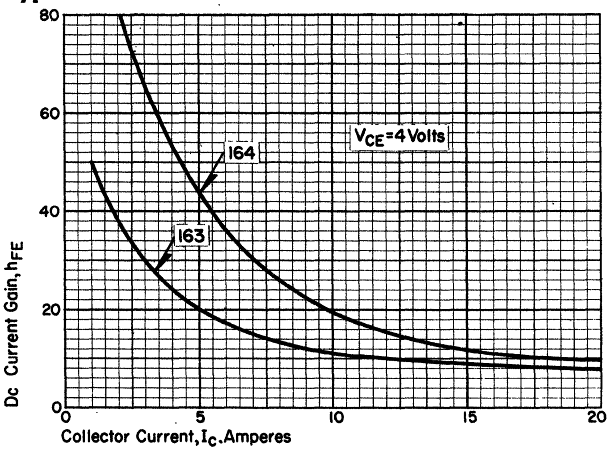
20 Amperes 40-200 Volts

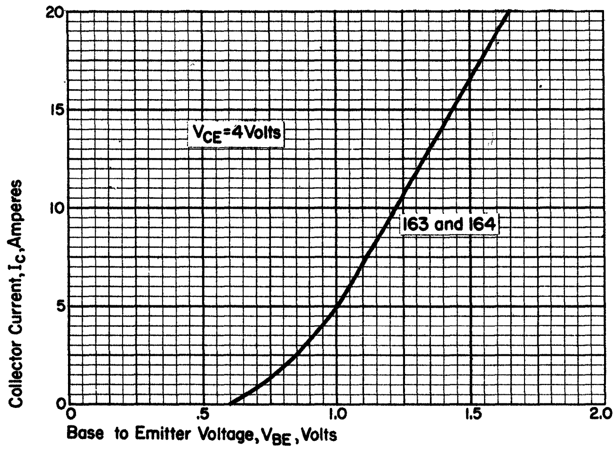
NPN Power TRANSISTORS 163/164

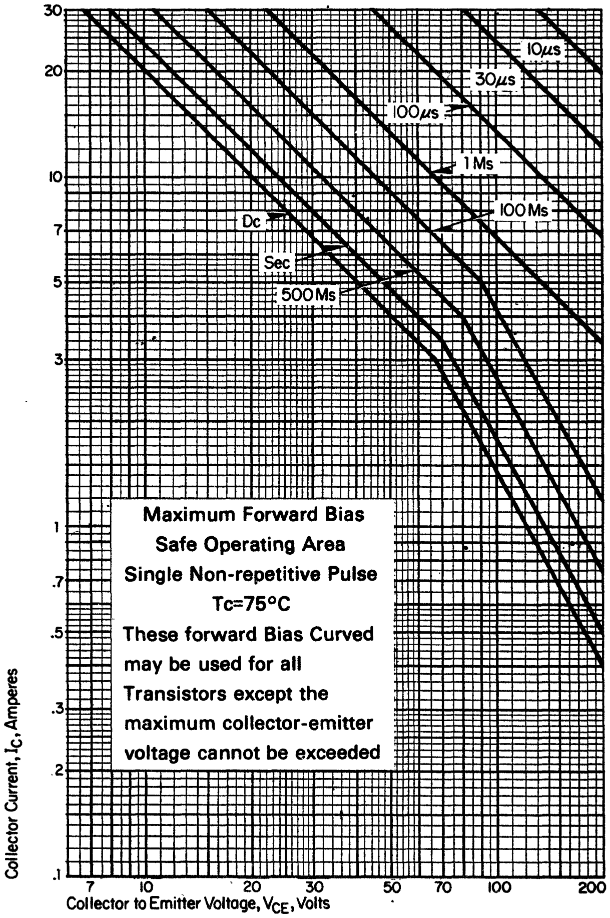
Electrical Specifications Tc=25°C unless otherwise specified

Test	Symbol	Test Conditions	163 Min.	163 Max.	164 Min.	164 Max.	Units
D.C. Current Gain	h_{FE}	V_{CE}=4V, I_C=5A	15		25		
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C=5A, I_B=0.5A		1.1		1.0	V
Base-Emitter Saturation Voltage	$V_{BE(sat)}$	I_C=5A, I_B=0.5A		2.2		2.0	V
Emitter Cutoff Current	I_{EBO}	V_{EB}=15V, Tc=175°C		25		25	mA
Turn-On Time	t_{on}	I_C=5A		6		6	μsec.
Storage Time	t_s	V_{CC}=12V.		5		5	μsec.
Fall Time	t_f	I_B(on)=I_B(off)=0.6A.		7		7	μsec.
Output Capacitance	C_{ob}	V_{CB}=10V,f=1MHZ		1500		1500	pF
Gain-Bandwidth	f_T	V_{CE}=10v, I_C=1.0A	250		250		KHz
Beta Cutoff Frequency	f_{hfe}	V_{CE}=12V, I_C=5A	10		10		KHz
Second Breakdown Forward Biased, Collector Current	I_{SB}	V_{CE}=67V, 1 second Tc=75°C		3		3	A
Second Breakdown Energy Reverse Biased	Es/b	Vcc=30V Ic=5A L=.4H Tc= 25°C		1		1	J

Typical Characteristics



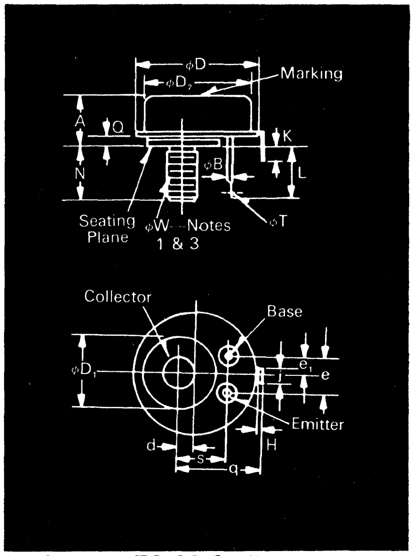




TRANSISTOR

NPN Power, Darlington TRANSISTORS 2N2226-33

10 Ampere 50 — 200 Volts

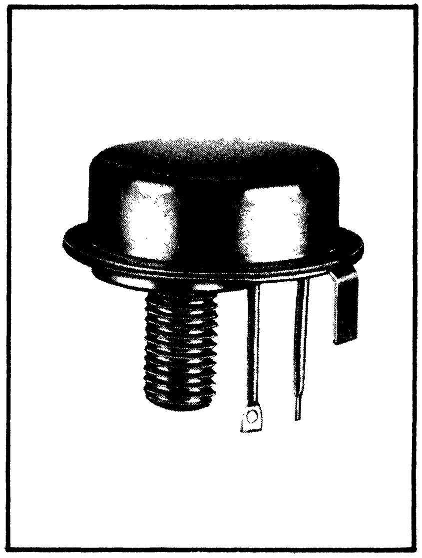


Conforms to TO-82 Outline

Symbol	Inches Min.	Inches Max.	Millimeters Min.	Millimeters Max.
A	.500	.560	12.70	14.22
ϕB	.045	.060	1.14	1.52
d	.140	.170	3.56	4.32
ϕD	1.240	1.280	31.50	32.51
ϕD_1	.730	.770	18.54	19.56
ϕD_2		1.125		28.58
e	.360	.400	9.14	10.16
e_1	.180	.200	4.57	5.08
H	.014	.025	.36	.64
j	.140	.170	3.56	4.32
K	.130	.190	3.30	4.83
L	.550	.590	13.97	14.99
N	.550	.590	13.97	14.99
q	.810	.850	20.57	21.59
Q	.105	.140	2.67	3.56
S	.480	.520	12.19	13.21
ϕT	.050	.070	1.27	1.78
ϕW	5/16-24 UNF-2A			

Finish—Nickel Plate.
Approx. Weight—.9 oz. (25 g).

1. Complete threads to extend to within 2½ threads of seating plane.
2. Contour and angular orientation of terminals is undefined.
3. Pitch diameter of 5/16-24 UNF-2A (coated) threads (ASA B1.1-1960).



Features

- Gold Alloy Process
- No forward bias secondary breakdown to 100 volts
- High reverse bias S.O.A. for inductive loads
- Low thermal resistance with copper base
- 150 watt dissipation
- Protection from thermal fatigue with hard solder and molybdenum construction
- 25 volt V_{EBO}
- Low $V_{CE(sat)}$
- Lifetime Guarantee

Applications

- High Power Switching
- Amplifiers
- Servo Systems
- Regulators
- Modulators

Test	Symbol	2N2226 2N2230	2N2227 2N2231	2N2228 2N2232	2N2229 2N2233
Collector Voltage Sustaining	$V_{CEO(sus)}$	50	100	150	200

Maximum Ratings and Characteristics Tc = 25°C unless specified	Symbol	JEDEC 2N2226-33	Units
* Operating and storage temperature		—65 To 150	°C
Collector-emitter sustaining voltage	$V_{CEO\,(sus)}$	50 To 200	Volts
* Emitter-base voltage	V_{EBO}	15	Volts
* Continuous collector current	I_C	10	AMPS
* Continuous base current	I_B	1	AMPS
* Thermal resistance	$R_{\theta JC}$	.5	°C/W
* Power dissipation Tc = 75°C	P_T	150	Watts
Power dissipation Tc = 100°C	P_T	100	Watts

* JEDEC Registered Parameters

10 Ampere 50 — 200 Volts

NPN Power, Darlington TRANSISTORS 2N2226-33

Electrical Characteristics 2N2226-29

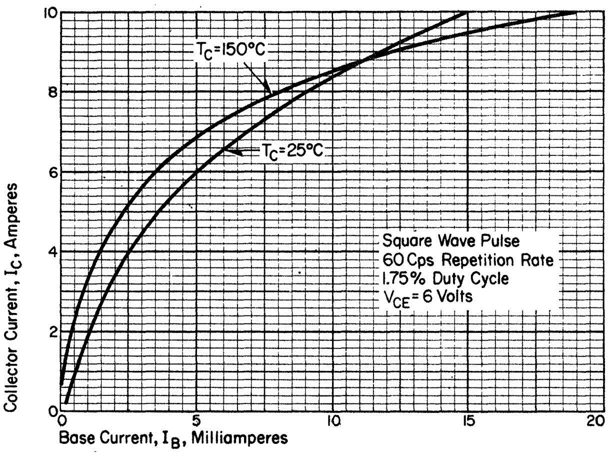
T_C=25°C unless otherwise specified

	Symbol	Minimum	Typical	Max.	Units
Collector current at V_{CEX}=V_{CE} (from max. ratings), T_C=150°C, V_{BE}=−1.5 Vdc...	I_{CEX}	...	......	20	mAdc
Emitter current at V_{BE}=−15 Vdc, I_C=0....................................	I_{EBO}	...	......	15	mAdc
Emitter current at V_{BE}=−15 Vdc, I_C=0, T_C=150°C..........................	I_{EBO}	...	......	30	mAdc
Gain bandwidth product at I_C=10 Adc....................................	f_T	...	500	.....	kc
Saturation voltage at I_C=10 Adc, I_B=150m Adc	V_{CE}(sat)	...	2.2	3.5	Vdc
Dc current gain at V_{CE}=6 Vdc, I_C=10 Adc..............................	h_{FE}	100	360	....	.....
Base voltage, at I_C=10 Adc, I_B=150 mAdc..............................	V_{BE} (sat)	...	3.0	4.0	Vdc
Beta cut-off frequency at V_{CE}=12 Vdc, I_C=7 Adc..........................	f_{hfe}	...	10	.....	kc
Turn-on time at I_C=10 Adc, $I_{B\ on}$=400 mAdc, V_{CE}=12 Vdc.................	t_d+t_r	...	4.5	.....	μsec
Turn-off time at I_C=10 Adc, $I_{B\ off}$=−400 mAdc, V_{CE}=12 Vdc, $V_{BE\ off}$=−15 Vdc.	t_s+t_f	...	25	.....	μsec

Electrical Characteristics 2N2230-33

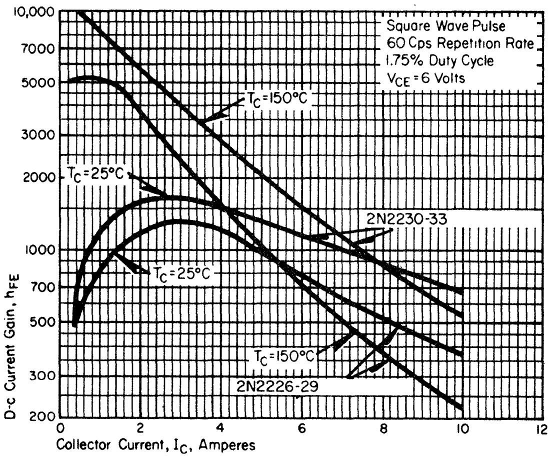
T_C=25°C unless otherwise specified

	Symbol	Minimum	Typical	Max.	Units
Collector current at V_{CEX}=V_{CE} (from max. ratings), T_C=150°C, V_{BE}=−1.5 Vdc...	I_{CEX}	...	......	20	mAdc
Emitter current at V_{BE}=−15 Vdc, I_C=0....................................	I_{EBO}	...	......	15	mAdc
Emitter current at V_{BE}=−15 Vdc, I_C=0, T_C=150°C..........................	I_{EBO}	...	......	30	mAdc
Gain bandwidth product at I_C=10 Adc....................................	f_T	...	500	.....	kc
Saturation voltage at I_C=10 Adc, I_B=150m Adc	V_{CE}(sat)	...	2.2	3.5	Vdc
Dc current gain at V_{CE}=6 Vdc, I_C=10 Adc..............................	h_{FE}	400	660	.....	.....
Base voltage, at I_C=10 Adc, I_B=40 mAdc..............................	V_{BE} (sat)	...	3.0	4.0	Vdc
Beta cut-off frequency at V_{CE}=12 Vdc, I_C=7 Adc..........................	f_{hfe}	...	7	.....	kc
Turn-on time at I_C=10 Adc, $I_{B\ on}$=200 mAdc, V_{CE}=12 Vdc.................	t_d+t_r	...	5	.....	μsec
Turn-off time at I_C=10 Adc, $I_{B\ off}$=−200 mAdc, V_{CE}=12 Vdc, $V_{BE\ off}$=−15 Vdc.	t_s+t_f	...	29	.....	μsec

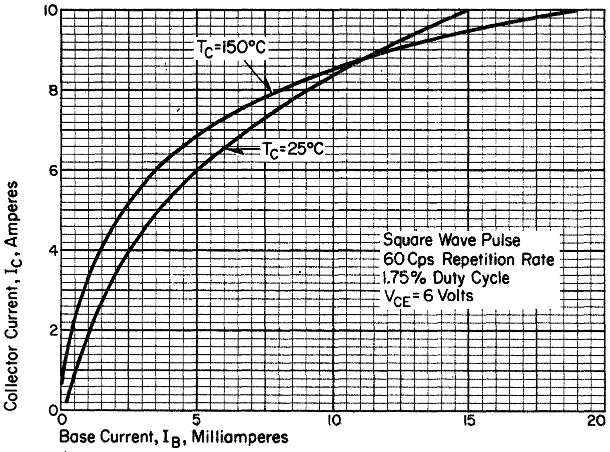


Forward current transfer characteristics.

2N2226-29

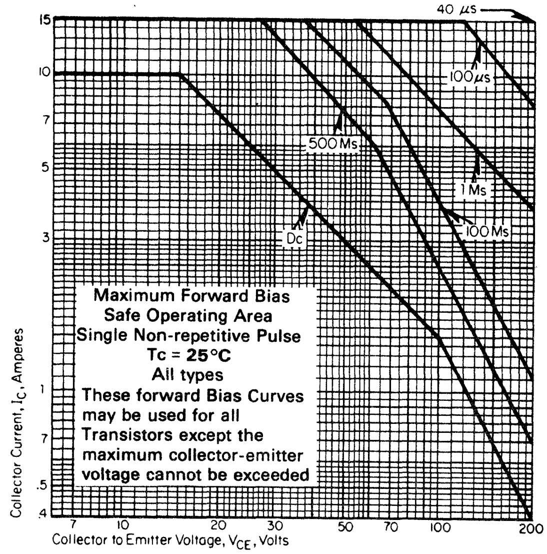


Dc gain versus collector current.



Forward current transfer characteristics.

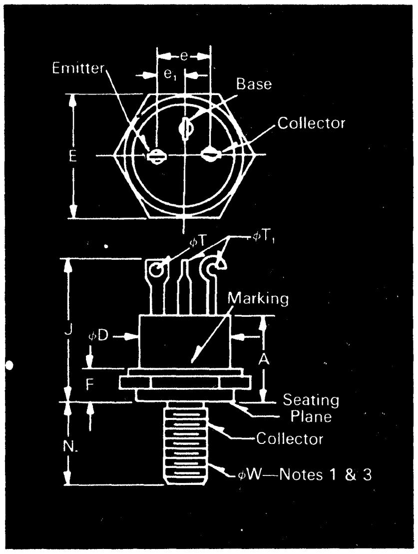
2N2230-33



TRANSISTOR

NPN Power, Darlington TRANSISTORS 2N3470-77

10 Amperes 50-200 Volts

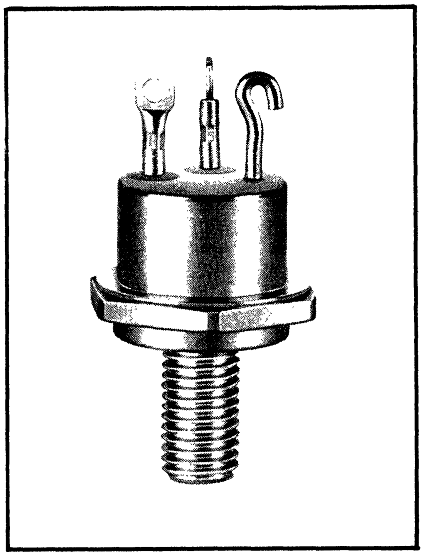


Conforms to MT-33 Outline

Symbol	Inches Min.	Inches Max.	Millimeter Min.	Millimeter Max.
A	.600	.650	15.24	16.51
ϕD	.650	.700	16.51	17.78
e_1	.185	.205	4.70	5.21
e	.390	.410	9.91	10.41
E	.855	.875	21.72	22.23
F	.156	.250	3.96	6.35
J	1.016	1.076	25.81	27.33
N	.560	.600	14.22	15.24
ϕT	.090	.100	2.29	2.54
$ϕT_1$	.060	.080	1.52	2.03
ϕW	5/16-24 UNF-2A			

Finish—Nickel Plate.
Approx. Weight—1 oz (28 g).

1. Complete threads to extend to within 2½ threads of seating plane.
2. Contour and angular orientation of terminals is undefined.
3. Pitch dia. of 5/16-24 UNF-2A (coated) threads (ASA B1.1-1960).



Low Gain Series	High Gain Series
2N3470	2N3474
2N3471	2N3475
2N3472	2N3476
2N3473	2N3477

Features:

- Gold Alloy Process
- No forward bias secondary breakdown to 100 volts
- High reverse bias S.O.A. for inductive loads
- Low thermal resistance with copper base
- 150 watt dissipation
- Protection from thermal fatigue with hard solder and molybdenum construction
- 25 volt V_{EBO}
- Low $V_{CE\,(sat)}$
- Lifetime Guarantee

Applications:

- High Power Switching
- Amplifiers
- Servo Systems
- Regulators
- Modulators

Voltage Matrix $T_C = 25°C$

Test	Symbol	2N3470 2N3474	2N3471 2N3475	2N3472 2N3476	2N3473 2N3477
Collector * Voltage (sustaining)	$V_{CEO\,(sus)}$	50	100	150	200

Maximum Ratings and Characteristics * $T_C = 25°C$ unless specified	Symbol	JEDEC 2N3470-77	Units
* Operating and storage temperature		– 65 TO 150	°C
Collector-emitter sustaining voltage	$V_{CEO\,(sus)}$	50 TO 200	Volts
* Emitter-base voltage	V_{EBO}	15	Volts
* Continuous collector current	I_C	10	AMPS
* Continous base current	I_B	1	AMPS
* Thermal resistance	$R_{\theta JC}$	.5	°C/W
* Power dissipation $T_C = 75°C$	P_T	150	Watts
* Power dissipation $T_C = 100°C$	P_T	100	Watts

*Jedec Registered Parameters

10 Amperes 50-200 Volts

NPN Power, Darlington TRANSISTORS 2N3470-77

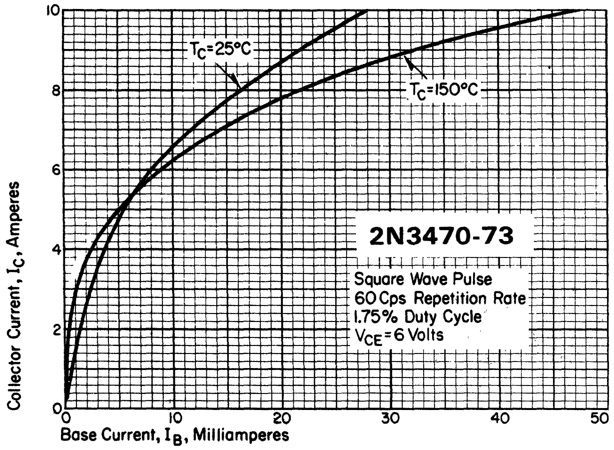
TRANSISTOR

Electrical Characteristics 2N3470-73 $T_C=25°C$ unless otherwise specified

	Symbol	Minimum	Typical	Max.	Units
Collector current at $V_{CEX}=V_{CE}$ (from max. ratings), $T_C=150°C$, $V_{BE}=-1.5$ Vdc...	I_{CEX}	...	......	20	mAdc
Emitter current at $V_{BE}=-15$ Vdc, $I_C=0$..................................	I_{EBO}	...	......	15	mAdc
Emitter current at $V_{BE}=-15$ Vdc, $I_C=0$, $T_C=150°C$........................	I_{EBO}	...	......	30	mAdc
Gain bandwidth product at $I_C=10$ Adc......................................	f_T	...	500	.....	kc
Saturation voltage at $I_C=10$ Adc, $I_B=150$m Adc	V_{CE}(sat)	...	2.2	3.5	Vdc
Dc current gain at $V_{CE}=6$ Vdc, $I_C=10$ Adc..............................	h_{FE}	100	360	....	.....
Base voltage, at $I_C=10$ Adc, $I_B=150$ mAdc................................	V_{BE} (sat)	...	3.0	4.0	Vdc
Beta cut-off frequency at $V_{CE}=12$ Vdc, $I_C=7$ Adc..........................	f_{hfe}	...	10	.....	kc
Turn-on time at $I_C=10$ Adc, $I_{B\ on}=400$ mAdc, $V_{CE}=12$ Vdc..................	t_d+t_r	...	4.5	.....	μsec
Turn-off time at $I_C=10$ Adc, $I_{B\ off}=-400$ mAdc, $V_{CE}=12$ Vdc, $V_{BE\ off}=-15$ Vdc.	t_s+t_f	...	25	.....	μsec

Electrical Characteristics 2N3474-77 $T_C=25°C$ unless otherwise specified

	Symbol	Minimum	Typical	Max.	Units
Collector current at $V_{CEX}=V_{CE}$ (from max. ratings), $T_C=150°C$, $V_{BE}=-1.5$ Vdc...	I_{CEX}	...	......	20	mAdc
Emitter current at $V_{BE}=-15$ Vdc, $I_C=0$..................................	I_{EBO}	...	......	15	mAdc
Emitter current at $V_{BE}=-15$ Vdc, $I_C=0$, $T_C=150°C$........................	I_{EBO}	...	......	30	mAdc
Gain bandwidth product at $I_C=10$ Adc......................................	f_T	...	500	.....	kc
Saturation voltage at $I_C=10$ Adc, $I_B=150$m Adc	V_{CE}(sat)	...	2.2	3.5	Vdc
Dc current gain at $V_{CE}=6$ Vdc, $I_C=10$ Adc..............................	h_{FE}	400	660	.....	.....
Base voltage, at $I_C=10$ Adc, $I_B=40$ mAdc.................................	V_{BE} (sat)	...	3.0	4.0	Vdc
Beta cut-off frequency at $V_{CE}=12$ Vdc, $I_C=7$ Adc..........................	f_{hfe}	...	7	.....	kc
Turn-on time at $I_C=10$ Adc, $I_{B\ on}=200$ mAdc, $V_{CE}=12$ Vdc..................	t_d+t_r	...	5	.....	μsec
Turn-off time at $I_C=10$ Adc, $I_{B\ off}=-200$ mAdc, $V_{CE}=12$ Vdc, $V_{BE\ off}=-15$ Vdc.	t_s+t_f	...	29	.....	μsec



Forward current transfer characteristics.

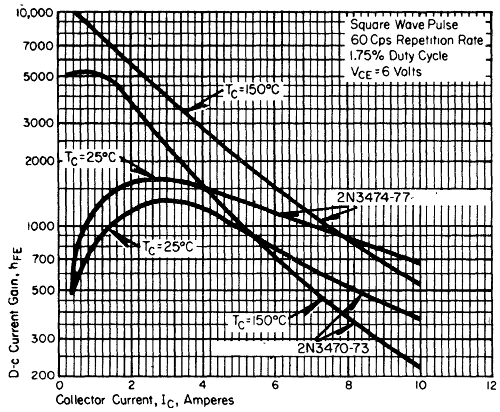
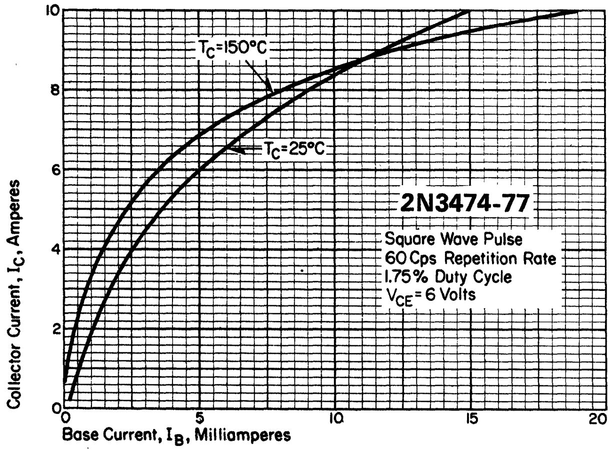
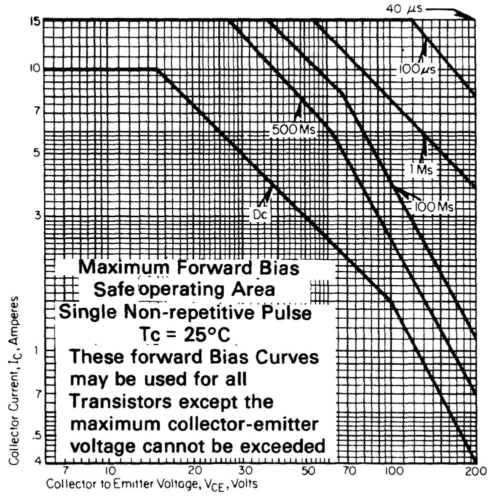


Figure 10. Dc gain versus collector current.

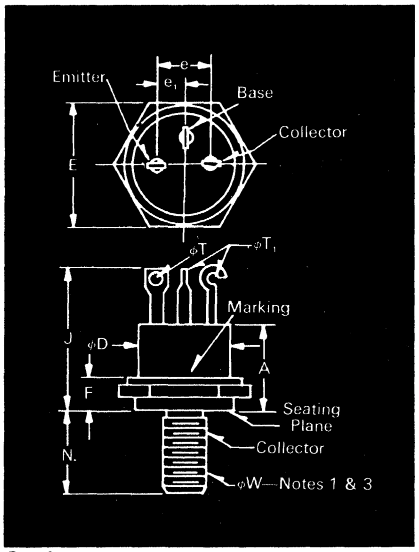


Forward current transfer characteristics.



NPN Power TRANSISTORS 2N2757-78

30 Amperes 50-250 Volts

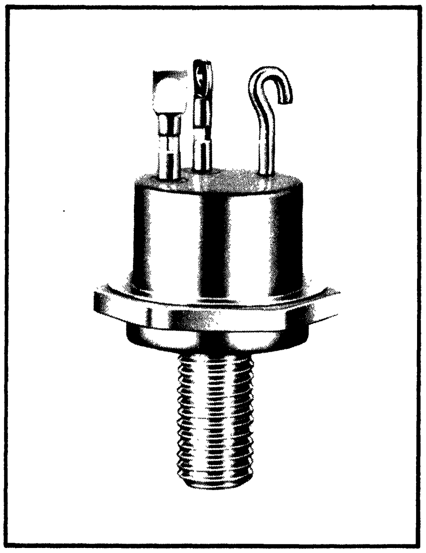


Conforms to MT-33 Outline

Symbol	Inches Min.	Inches Max.	Millimeter Min.	Millimeter Max.
A	.600	.650	15.24	16.51
φD	.650	.700	16.51	17.78
e_1	.185	.205	4.70	5.21
e	.390	.410	9.91	10.41
E	.855	.875	21.72	22.23
F	.156	.250	3.96	6.35
J	1.016	1.076	25.81	27.33
N	.560	.600	14.22	15.24
φT	.090	.100	2.29	2.54
$φT_1$	.060	.080	1.52	2.03
φW	5/16-24 UNF-2A			

Finish—Nickel Plate.
Approx. Weight—1 oz (28 g).

1. Complete threads to extend to within 2½ threads of seating plane.
2. Contour and angular orientation of terminals is undefined.
3. Pitch dia. of 5/16-24 UNF-2A (coated) threads (ASA B1.1-1960).



Features:
- Gold Alloy Process
- No forward bias secondary breakdown to 67 volts
- High reverse bias S.O.A. for inductive loads
- Low thermal resistance with copper base
- 150 watt dissipation
- Protection from thermal fatigue with hard solder and molybdenum construction
- 25 volt V_{EBO}
- Low $V_{CE\,(sat)}$
- Lifetime Guarantee

Applications:
- High Power Switching
- Amplifiers
- Servo Systems
- Regulators
- Modulators

Maximum Ratings

Voltage

JEDEC				$V_{CED\,(sus)}$
2N2757	2N2763	2N2769	2N2775	50
2N2758	2N2764	2N2770	2N2776	100
2N2759	2N2765	2N2771	2N2777	150
2N2760	2N2766	2N2772	2N2778	200
2N2761				250

Maximum Ratings and Characteristics T_C = 25°C unless specified	Symbol	JEDEC 2N2757-78+	Units
* Operating and storage temperature		− 65 to 175	°C
Collector-emitter sustaining voltage	$V_{CEO\,(sus)}$	50 to 250	Volts
* Emitter-base voltage	V_{EBO}	15	Volts
* Continuous collector current	I_C	30	AMPS
* Continuous base current	I_B	7.5	AMPS
* Thermal resistance	$R_{\theta JC}$	.5	°C/W
* Power dissipation T_C = 75°C	P_T	200	Watts
Power dissipation T_C = 100°C	P_T	150	Watts

* JEDEC Registered parameters

30 Amperes
50-250 Volts

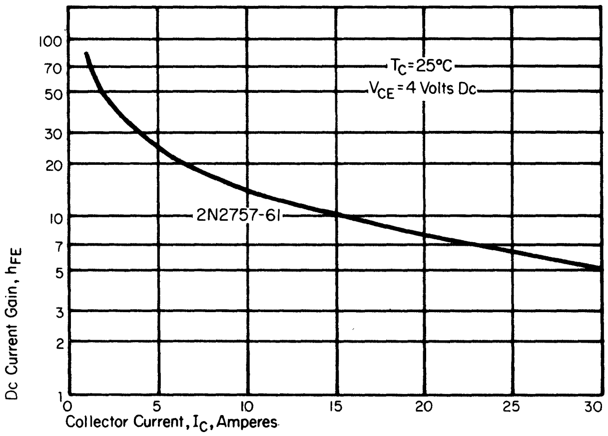
NPN Power TRANSISTORS 2N2757-78

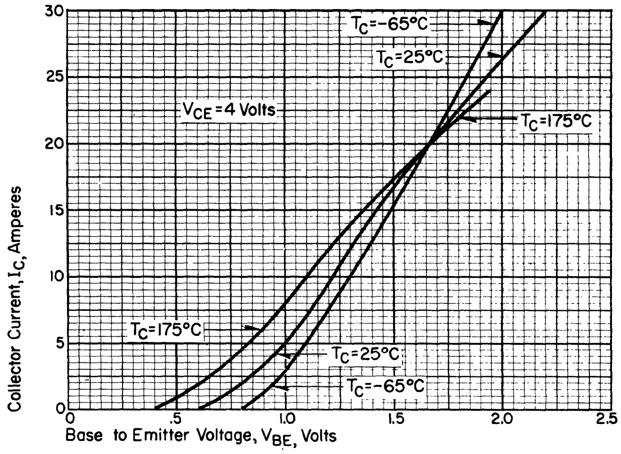
Electrical Characteristics, 2N2757-61 Series

T_C=25°C unless otherwise specified

	Symbol	Minimum	Typical	Max.	Units
Min. collector-emitter sustaining voltage at I_C=200 ma, I_B=0	$V_{CEO(SUS)}$	Refer voltage ratings			
Collector current at $V_{CEX}=V_{CE}$ (Ref. voltage ratings), T_C=175°C, V_{BE}=−1.5 Vdc.	I_{CEX}	..	8	30	mAdc
Emitter current at V_{BE}=−15 Vdc, I_C=0, T_C=175°C	I_{EBO}	..	4	25	mAdc
Saturation voltage at I_C=10 Adc, I_B=2 Adc	V_{CE} (sat)	..	0.4	1.5	Vdc
Dc current gain at V_{CE}=4 Vdc, I_C=10 Adc	h_{FE}	10	14.0	....	....
Base voltage, at I_C=10 Adc, I_B=2 Adc	V_{BE}(sat)	..	1.35	2.5	Vdc
Beta cut-off frequency at V_{CE}=12 Vdc, I_C=2.5 Adc	f_{hfe}	..	14.0	....	kHz
Turn-on time at I_C=10 Adc, $I_{B\ on}$=3 Adc, V_{CE}=12 Vdc	t_d+t_r	..	3.0	....	μsec
Turn-off time at I_C=10 Adc, $I_{B\ off}$=−3 Adc, V_{CE}=12 Vdc, $V_{BE\ off}$=−15 Vdc	t_s+t_f	..	9.0	....	μsec

Typical Characteristics, 2N2757-61 Series



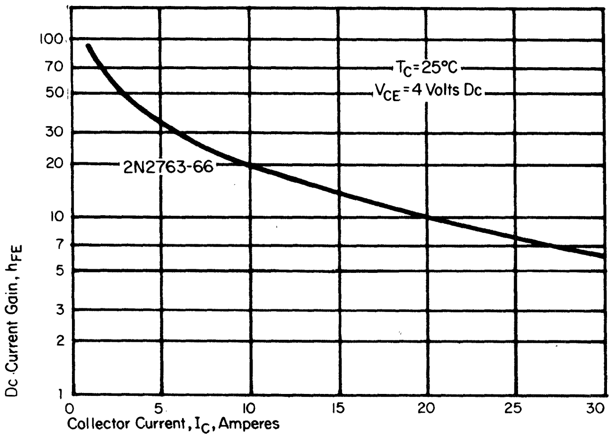


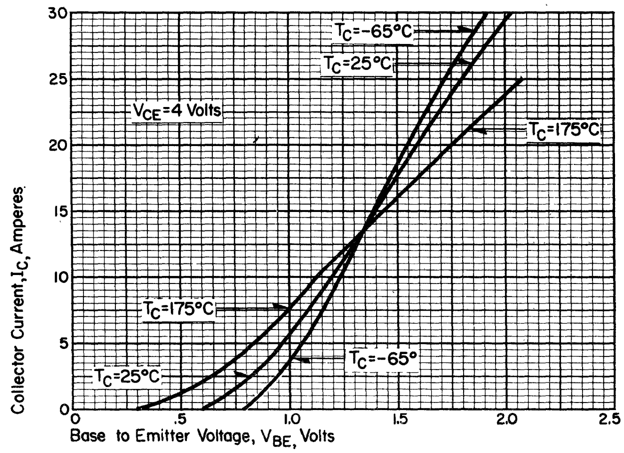
Electrical Characteristics, 2N2763-66 Series

T_C=25°C unless otherwise specified

	Symbol	Minimum	Typical	Max.	Units
Min. collector-emitter sustaining voltage at I_C=200 ma, I_B=0	$V_{CEO(SUS)}$	Refer voltage ratings			
Collector current at $V_{CEX}=V_{CE}$ (Ref. voltage ratings), T_C=175°C, V_{BE}=−1.5 Vdc.	I_{CEX}	..	8	30	mAdc
Emitter current at V_{BE}=−15 Vdc, I_C=0, T_C=175°C	I_{EBO}	..	4	25	mAdc
Saturation voltage at I_C=15 Adc, I_B=3 Adc	V_{CE} (sat)	..	0.63	1.5	Vdc
Dc current gain at V_{CE}=4 Vdc, I_C=15 Adc	h_{FE}	10	13.5	....	....
Base voltage, at I_C=15 Adc, I_B=3 Adc	V_{BE} (sat)	..	1.50	2 5	Vdc
Beta cut-off frequency at V_{CE}=12 Vdc, I_C=3.75 Adc	f_{hfe}	..	14.5	....	kHz
Turn-on time at I_C=15 Adc, $I_{B\ on}$=4.5 Adc, V_{CE}=12 Vdc	t_d+t_r	..	3.8	....	μsec
Turn-off time at I_C=15 Adc, $I_{B\ off}$=−4.5 Adc, V_{CE}=12 Vdc, $V_{BE\ off}$=−15 Vdc	t_s+t_f	..	10	....	μsec

Typical Characteristics, 2N2763-66 Series





TRANSISTOR

NPN Power TRANSISTORS 2N2757-78

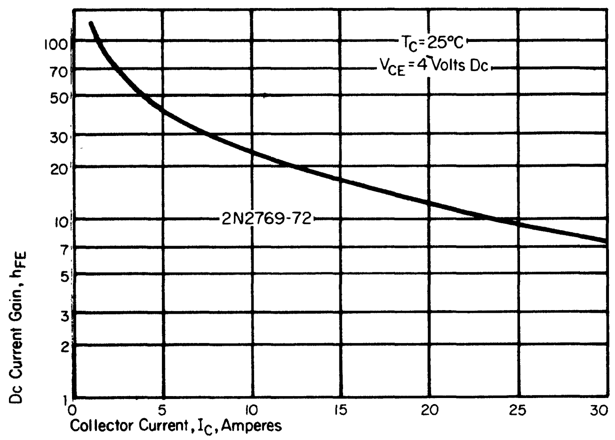
30 Amperes 50-250 Volts

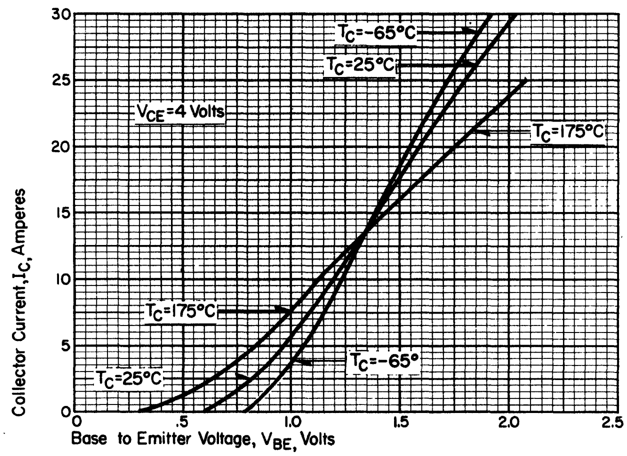
Electrical Characteristics, 2N2769-72 Series

T_C=25°C unless otherwise specified

	Symbol	Minimum	Typical	Max.	Units
Min. collector-emitter sustaining voltage at I_C=200 ma, I_B=0	$V_{CEO(SUS)}$	Refer voltage ratings			
Collector current at $V_{CEX}=V_{CE}$ (Ref. voltage ratings), T_C=175°C, V_{BE}=−1.5 Vdc	I_{CEX}	..	8	30	mAdc
Emitter current at V_{BE}=−15 Vdc, I_C=0, T_C=175°C	I_{EBO}	..	4	25	mAdc
Saturation voltage at I_C=20 Adc, I_B=4 Adc	V_{CE} (sat)	..	0.74	1.5	Vdc
Dc current gain at V_{CE}=4 Vdc, I_C=20 Adc	h_{FE}	10	12.5	.....	....
Base voltage, at I_C=20 Adc, I_B=4 Adc	V_{BE} (sat)	..	1.8	2.5	Vdc
Beta cut-off frequency at V_{CE}=12 Vdc, I_C=5 Adc	f_{hfe}	..	16.0	.....	kHz
Turn-on time at I_C=20 Adc, $I_{B\ on}$=6 Adc, V_{CE}=12 Vdc	t_d+t_r	..	4.0	.....	μsec
Turn-off time at I_C=20 Adc, $I_{B\ off}$=−6 Adc, V_{CE}=12 Vdc, $V_{BE\ off}$=−15 Vdc	t_s+t_f	..	10.0	.....	μsec

Typical Characteristics, 2N2769-72 Series



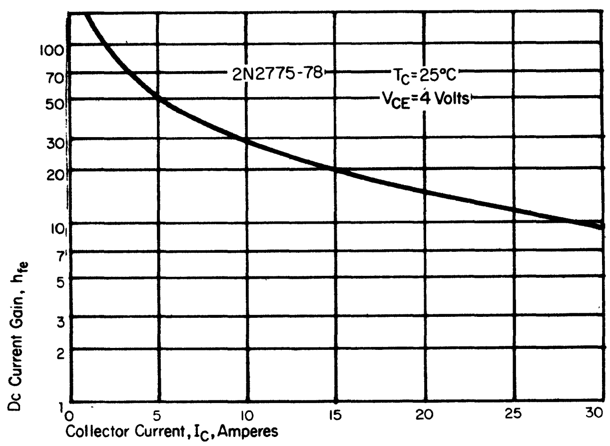


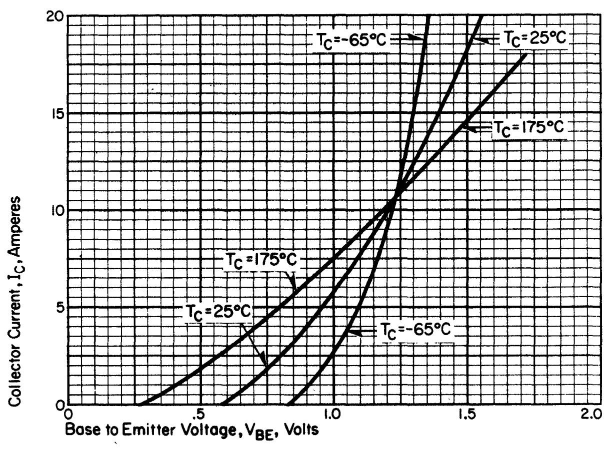
Electrical Characteristics, 2N2775-78 Series

T_C=25°C unless otherwise specified

	Symbol	Minimum	Typical	Max.	Units
Min. collector-emitter sustaining voltage at I_C=200 ma, I_B=0	$V_{CEO(SUS)}$	Refer voltage ratings			
Collector current at $V_{CEX}=V_{CE}$ (Ref. voltage ratings), T_C=175°C, V_{BE}=−1.5 Vdc	I_{CEX}	..	8	30	mAdc
Emitter current at V_{BE}=−15 Vdc, I_C=0, T_C=175°C	I_{EBO}	..	4	25	mAdc
Saturation voltage at I_C=25 Adc, I_B=5 Adc	V_{CE} (sat)	..	0.87	1.50	Vdc
Dc current gain at V_{CE}=4 Vdc, I_C=25 Adc	h_{FE}	10	12.0	....	....
Base voltage, at I_C=25 Adc, I_B=5 Adc	V_{BE} (sat)	..	1.9	2.5	Vdc
Beta cut-off frequency at V_{CE}=12 Vdc, I_C=5 Adc	f_{hfe}	..	14.0	....	kHz
Turn-on time at I_C=25 Adc, $I_{B\ on}$=7.5 Adc, V_{CE}=12 Vdc	t_d+t_r	..	4.5	....	μsec
Turn-off time at I_C=25 Adc, $I_{B\ off}$=−7.5 Adc, V_{CE}=12 Vdc, $V_{BE\ off}$=−15 Vdc	t_s+t_f	..	10.0	....	μsec

Typical Characteristics, 2N2775-2778 Series

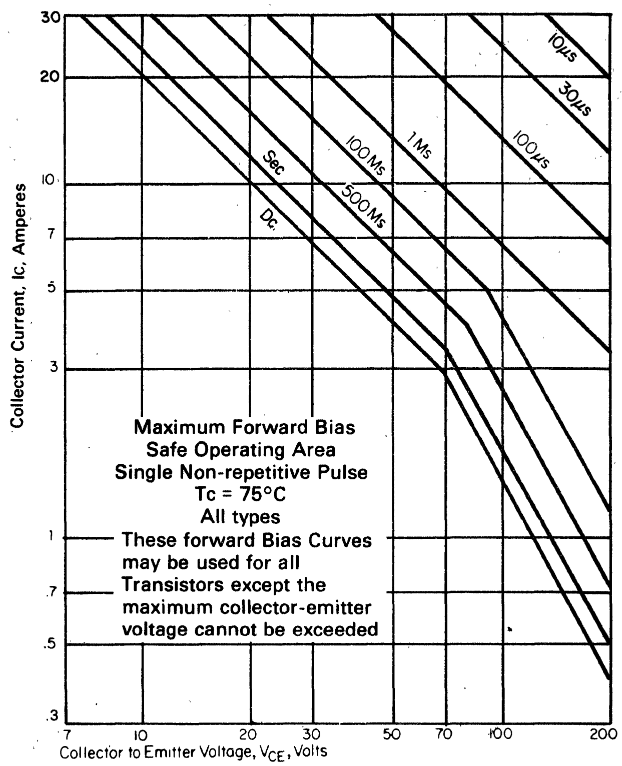




TRANSISTOR

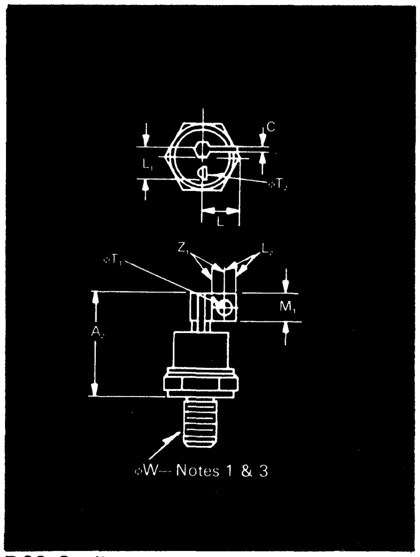
Safe Operating Information, 2N2757 through 2N2778

	Symbol	Maximum	Units
Second Breakdown, forward bias, collector current (VCE = 67V., One Second, Tc = 75°C)	Is/B	3.0	Amperes
Second Breakdown, reverse bias, energy (VCE = 30V., Ic = 5.0A., L = 0.4 mH., Tc = 25°C)	Es/B	1.0	Joule



NPN Power Switching TRANSISTORS D60T/D62T

200 Amperes 400—500 Volts

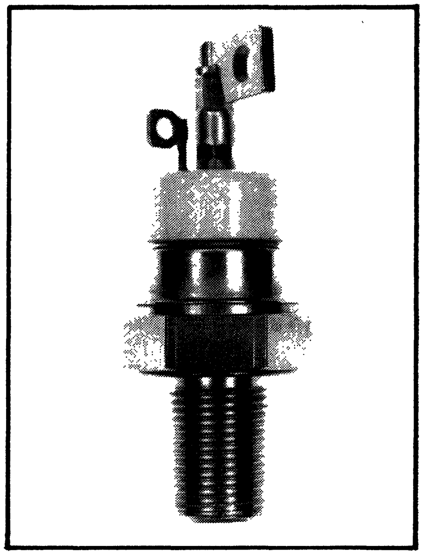


D60 Outline

Symbol	Inches Min.	Inches Max.	Millimeters Min.	Millimeters Max.
A_2		2.500		63.50
C	.110	.140	2.79	3.55
L		.812		20.62
L_1	.500	.600	12.70	15.24
L_2	.250		6.35	
M_1	.440	.560	11.17	14.22
ϕT_1	.260	.290	6.60	7.36
ϕT_2	.145	.160	3.68	4.06
Z_1	.640		16.25	
ϕW	¾-16 UNF-2A			

Creep & Strike Distance.
D60T - .690 in. min. (17.60 mm).
(In accordance with NEMA standards.)
Finish—Nickel Plate.
Approx. Weight—8 oz. (227 g).

1. **Complete threads to extend to within 2½ threads of seating plane.**
2. **Angular orientation of terminals is undefined.**
3. **Pitch diameter of 3/4-16 UNF-2A (COATED) threads (ASA B1.1-1960).**



Maximum Ratings
Collector Current (peak): 200 Amperes
Collector Current (continuous): 100 Amperes
Base Current (continuous): 20 Amperes
Power Dissipation: 625 Watts at Tc = 75°C
Operating and Storage Temperature: -50°C to +200°C

Applications
- High Frequency Inverters
- Motor Controls
- Switching Regulators
- VLF Transmitters

Features
- Triple Diffused Design
- CBE Construction
- 625 Watt Power Capability

Ordering Information

Type	Voltage			Current		Gain	
Code	VCEO (SUS)	VCBO	Code	IDC	Code	HFE	Code
D60T (Stud) D62T * (Disc)	400 450 500	400 450 500	40 45 50	40 50 60	40 50 60	10	10

***Note: Disc package (D62T) available, consult factory.**

Example:
Obtain device performance for your application by selecting proper Order Code.

Type				Voltage		Current		Gain
D	6	0	T	4	0	5	0	10

The above number describes a stud mount transistor. rated at 400 volts, with a gain of 10 at 50 amperes.

DEVELOPMENTAL PRODUCT

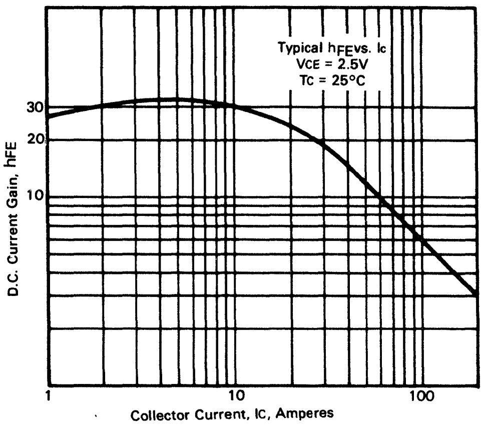
These devices are developmental types intended for engineering evaluation. Specifications and data are subject to change without prior notice. Westinghouse assumes no obligation for notice of change or future manufacture of these products.

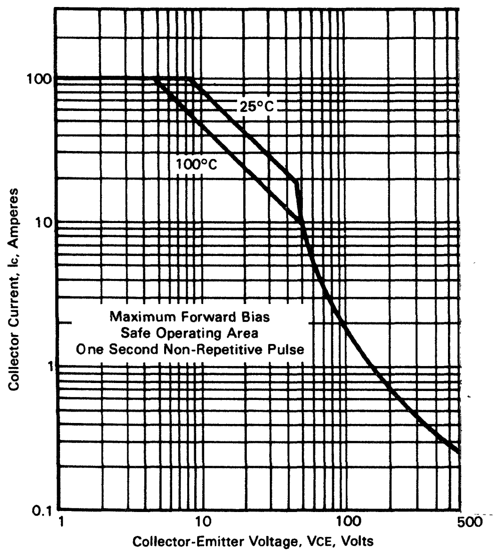
200 Amperes
400—500 Volts

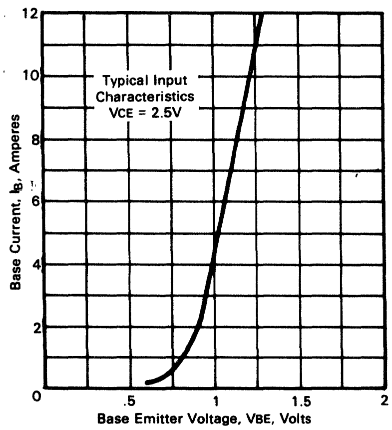
NPN Power Switching TRANSISTORS D60T/D62T

Electrical Characteristics* (TCASE = 25°C unless otherwise specified)

Symbol	Characteristic		Test Conditions	Min.	Typ.	Max.	Units
VCEO (SUS)	Collector-Emitter Sustaining Voltage		IC = 200mA IB = 0 300μs Pulse		See Page T33		
ICEV	Collector Cutoff Current (Base Emitter Reverse Biased)		At Rated VCE VBE (OFF) = -1.5V,		10	100	μA
ICEV	Collector Cutoff Current (Base Emitter Reverse Biased)		At Rated VCE VBE (OFF) = -1.5V, TC = 150°C		.8	3	mA
IEBO	Emitter Cutoff Current		VEB = 7V			1	mA
HFE	DC Current Gain		IC = 50A, VCE = 2.5V	10	15		
hFE	DC Current Gain		IC = 90A, VCE = 2.5V		5		
VCE (SAT)	Collector-Emitter Saturation Voltage		IC = 50A, IB = 6A		.75	1.25	Volts
VBE (SAT)	Base-Emitter Saturation Voltage		IC = 50A, IB = 6A		1.0	1.5	Volts
COB	Output Capacitance		fTEST = 1 MHz, VCB = 10V		2500		μμf
f_T	Gain-Bandwidth Product		fTEST = 1 MHz, IC = 5A, VCE = 10V	7	10		MHz
RΘJC	Thermal Resistance Junction to Case		VCE = 20V			0.2	°C/W
t_D	Turn-On Delay	Resistive Load Switch Times	VCC = 200V, IC = 50A			100	ns
t_r	Rise Time		IB1 = IB2 = 6A, tp = 100μs			0.5	μs
t_s	Storage Time		Duty Cycle < 2%			2.5	μs
t_f	Fall Time					0.5	μs







Consult factory for additional pulsed S.O A. capability curves.

TRANSISTOR