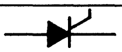
2N4151 (SILICON)
thru
2N4198



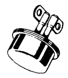
THYRISTORS

. . . multi-purpose PNPN silicon controlled rectifiers suited for industrial, consumer, and mulitary applications. Offered in a choice of space-saving, economical packages for mounting versatility.

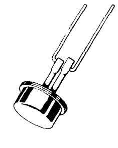
- Uniform Low-Level Noise-Immune Gate Triggering — I_{GT} = 10 mA (Typ) @ T_C = 25°C
- Low Forward "On" Voltage — v_T = 1.0 V (Typ) @ 5.0 Amp @ 25°C
- High Surge-Current Capability — I_{TSM} = 100 Amp Peak
- Fatigue-Free Solder Construction
- Shorted Emitter Construction

SILICON CONTROLLED RECTIFIERS

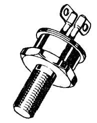
8-AMPERE RMS
25 thru 600 VOLTS



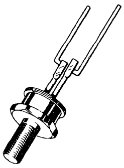
2N4151-58
CASE 85



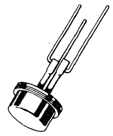
2N4159-66
CASE 85L



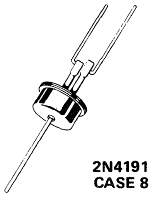
2N4167–74
CASE 86



2N4175-82
CASE 86L



2N4183-90
CASE 87L



2N4191-98
CASE 88L

MAXIMUM RATINGS

(Apply over operating temperature range and for all case types unless otherwise noted)

Rating	Symbol	Value	Unit
*Peak Reverse Blocking Voltage (1)	V_{RRM}		Volts
2N4151, 59, 67, 75, 83, 91		25	
2N4152, 60, 68, 76, 84, 92		50	
2N4153, 61, 69, 77, 85, 93		100	
2N4154, 62, 70, 78, 86, 94		200	
2N4155, 63, 71, 79, 87, 95		300	
2N4156, 64, 72, 80, 88, 96		400	
2N4157, 65, 73, 81, 89, 97		500	
2N4158, 66, 74, 82, 90, 98		600	
Forward Current RMS	$I_{T(RMS)}$	8.0	Amp
*Peak Forward Surge Current (One cycle, 60 Hz, T_J = -40 to +100°C)	I_{TSM}	100	Amp
Circuit Fusing Considerations (T_J = -40 to +100°C; $t \leq 8.3$ ms)	I^2t	40	A^2s
*Peak Gate Power	P_{GM}	5.0	Watt
*Average Gate Power	$P_{G(AV)}$	0.5	Watt
*Peak Gate Current	I_{GM}	2.0	Amp
Peak Gate Voltage (2)	V_{GM}	10	Volts
*Operating Temperature Range	T_J	-40 to +100	°C
*Storage Temperature Range	T_{stg}	-40 to +150	°C
Stud Torque 2N4167-2N4182		15	in. lb.

THERMAL CHARACTERISTICS

Characteristic	Symbol	Typ	Max	Unit
Thermal Resistance, Junction to Case	$R\theta_{JC}$	1.5	2.5*	°C/W
Thermal Resistance, Case to Ambient (See Fig. 11) 2N4151-66, 2N4183-98	$R\theta_{CA}$	50	–	°C/W

(1) Ratings apply for zero or negative gate voltage. Devices should not be tested for blocking capability in a manner such that the voltage applied exceeds the rated blocking voltage.
(2) Devices should not be operated with a positive bias applied to the gate concurrently with a negative potential applied to the anode.
*Indicates JEDEC Registered Data

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
*Peak Forward Blocking Voltage (1) (T_J = 100°C)	2N4151, 59, 67, 75, 83, 91	V_{DRM}	25	–	–	Volts
	2N4152, 60, 68, 76, 84, 92		50	–	–	
	2N4153, 61, 69, 77, 85, 93		100	–	–	
	2N4154, 62, 70, 78, 86, 94		200	–	–	
	2N4155, 63, 71, 79, 87, 95		300	–	–	
	2N4156, 64, 72, 80, 88, 96		400	–	–	
	2N4157, 65, 73, 81, 89, 97		500	–	–	
	2N4158, 66, 74, 82, 90, 98		600	–	–	
*Peak Forward Blocking Current (Rated V_{DRM} @ T_J = 100°C, gate open)		I_{DRM}	–	–	2.0	mA
*Peak Reverse Blocking Current (Rated V_{DRM} @ T_J = 100°C, gate open)		I_{RRM}	–	–	2.0	mA
Gate Trigger Current (Continuous dc) (2) (Anode Voltage = 7.0 Vdc, R_L = 100 Ω)		I_{GT}	–	–	30	mA
*(Anode Voltage = 7.0 Vdc, R_L = 100 Ω T_C = -40°C)			–	–	60	
Gate Trigger Voltage (Continuous dc) (Anode Voltage = 7.0 Vdc, R_L = 100 Ω)		V_{GT}	–	–	1.5	Volts
*(Anode Voltage = 7.0 Vdc, R_L = 100 Ω, T_C = -40°C)			–	–	2.5	
*(Anode Voltage = 7.0 Vdc, R_L = 100 Ω, T_J = 100°C)			0.2	–	–	
*Forward "On" Voltage (pulsed, 1.0 ms max, duty cycle ≤ 1%) (I_F = 15.7 A)		V_T	–	–	2.0	Volts
Holding Current (Anode Voltage = 7.0 Vdc, gate open)		I_H	–	–	30	mA
*(Anode Voltage = 7.0 Vdc, gate open, T_C = -40°C)			–	–	60	
Turn-On Time ($t_d + t_r$) (I_G = 20 mAdc, I_F = 5.0 Adc)		t_{on}	–	1.0	–	μs
Turn-Off Time (I_F = 5.0 Adc, I_R = 5.0 Adc)		t_{off}	–	15	–	μs
(I_F = 5.0 Adc, I_R = 5.0 Adc, T_J = 100°C) (V_{FXM} = rated voltage) (dv/dt = 30 V/μs)			–	25	–	
Forward Voltage Application Rate (Gate open, T_J = 100°C)		dv/dt	–	50	–	V/μs

(1) Ratings apply for zero or negative gate voltage. These devices should not be tested with a constant current source for forward or reverse blocking capability such that the voltage applied exceeds the rated blocking voltage.

(2) For optimum operation, i.e. faster turn-on, lower switching losses, best di/dt capability, recommended I_{GT} = 200 mA minimum.

*Indicates JEDEC Registered Data

TYPICAL TRIGGER CHARACTERISTICS

FIGURE 1 – CONSTANT CURRENT TRIGGERING

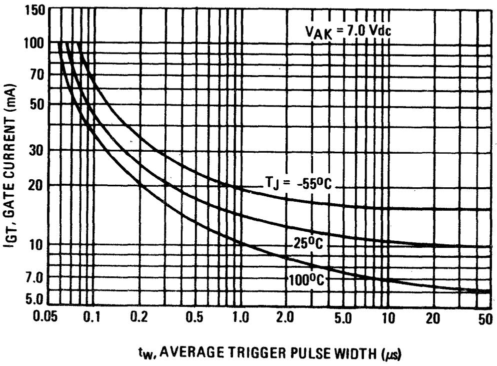
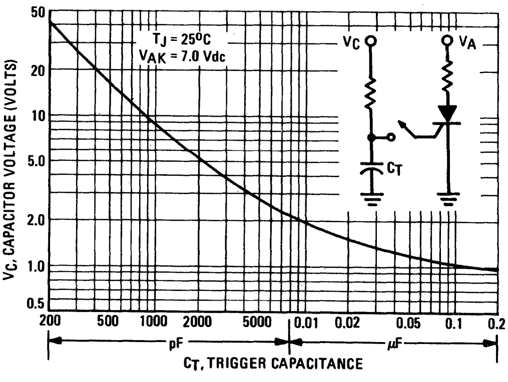


FIGURE 2 – CAPACITIVE DISCHARGE TRIGGERING



CURRENT DERATING

FIGURE 3 – MAXIMUM CASE TEMPERATURE

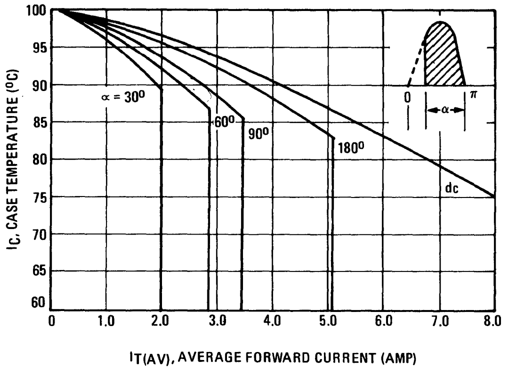


FIGURE 4 – MAXIMUM AMBIENT TEMPERATURE

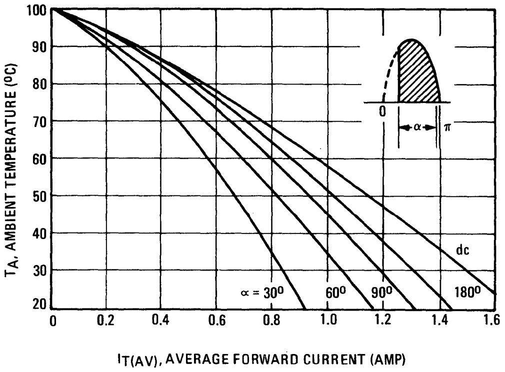


FIGURE 5 – FORWARD POWER DISSIPATION

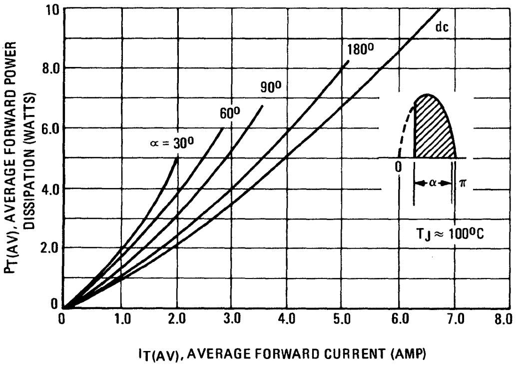


FIGURE 6 – MAXIMUM SURGE CAPABILITY

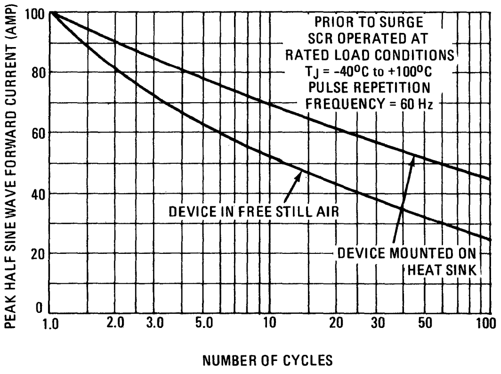


FIGURE 7 – THERMAL RESPONSE

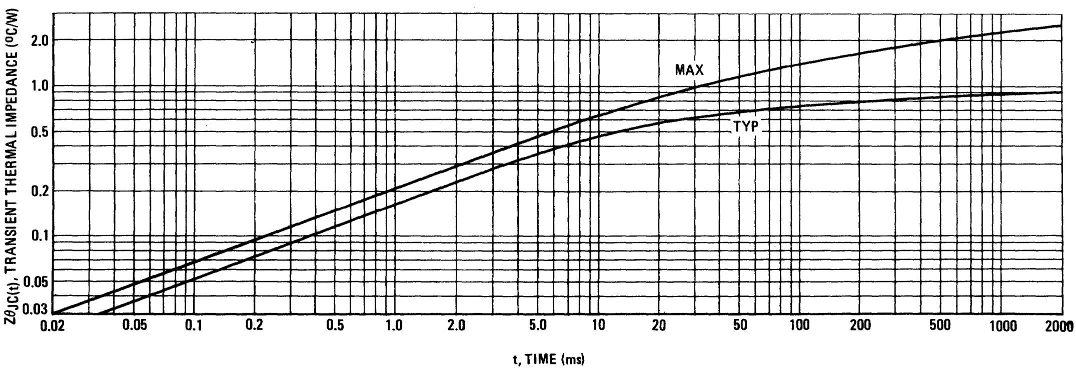


FIGURE 8 – FORWARD VOLTAGE

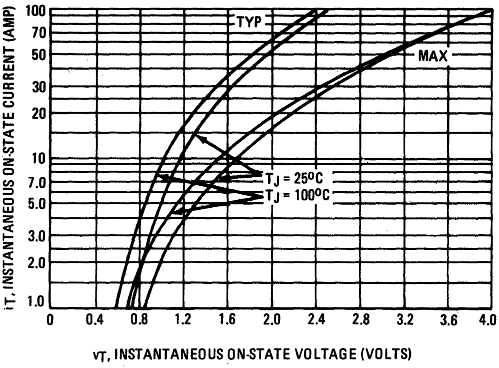


FIGURE 9 – HOLDING CURRENT

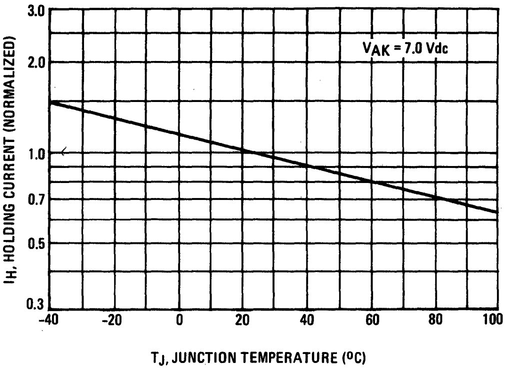


FIGURE 10 – TYPICAL THERMAL RESISTANCE OF PLATES

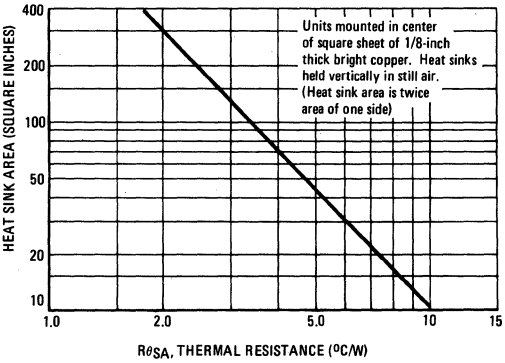
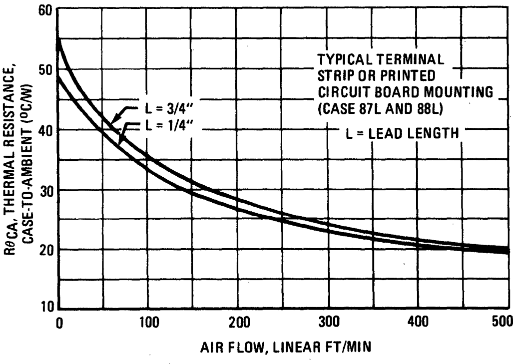


FIGURE 11 – CASE-TO-AMBIENT THERMAL RESISTANCE



MOUNTING and THERMAL INFORMATION

The versatility of the Motorola SCR can-type package affords a variety of mounting methods to meet individual requirements. Depending upon the thermal resistance value between the SCR case and a heat sink, any mounting method which satisfies the current derating curves may be used. Possible mounting media include: solder, epoxy cements; clips (fuse, resistor, transistor, special); clamps; commercial or special dissipators, retainers, coolers, and radiators.

When mounting the SCR's to a heat sink, the following recommendations apply:

A. Heat Sink Contact

1. Since the silicon die is located in the case bottom, (opposite end from tubed header point A as shown on the mechanical outline drawing, Figure 12.) the heat sink contact should be made with case bottom for proper heat transfer.

B. General Soldering Precautions

1. Solder — Use solder with melting points between +175°C and +225°C. The commonly-used tin-lead alloy solders have melting points of +188°C (60/40 alloy) and +214°C (50/50 alloy).
2. Flux (when used) — Non-corrosive resin preferred.
3. When soldering to the device terminals or leads, use of a heat dissipator between soldering point and SCR case is recommended.

C. Case Soldering Methods

1. Heat Sink Materials:
   a. Copper and most of its alloys present no problem in soldering and would probably be the most favorable heat sink material.
   b. Stainless steel is difficult to solder. However, using a strong acid-filled solder, satisfactory soldering can be achieved.
   c. In most cases where soldering is difficult, such as with aluminum, proper preparation with a tin coating on the material can bring about good results.

Depending on specific needs, soldering can be effected by using either hot plate, oven, or belt feed furnace. In all cases, temperature must be controlled.

2. Hot Plate — The hot plate is probably the most effective and flexible method of soldering. The following method is recommended:
   a. Set surface temperature of hot plate to a maximum of 225°C.
   b. Place heat sinks on hot plate for approximately 5 minutes.
   c. Place ⅛"-¼" diameter solder preform on area of heat sink to be soldered.
   d. After solder becomes liquid, place device on this area applying slight pressure and rotating the device slightly to assure good contact. Flux may be used here if required. Frequently, suitable wetting can be achieved mechanically when the device is rotated in the liquid solder, depending upon the device surface conditions.
   e. Remove heat sinks from heat source and free air cool.
3. Oven — When soldering is performed in an oven, use a solder preform (disc, 0.300" x 0.010") or flatten solder wire (⅛"-¼") before placing it on the heat sink. For an inert atmosphere such as N_2, dry air, etc., a flux is recommended. If H_2N_2 is available and used, flux should not be required. Again, temperature must be controlled.
4. Belt Feed Furnace — The procedures are much the same as with the oven method, with the exception that possibly a jig would be required to hold the device and the heat sink in the proper position.

D. Epoxy Mounting Suggestions

1. There are many good commercial epoxies available today, such as Hysol's "HY-TAC" kit or 3M's "Scotch Cast #9". Suitable mounting may be obtained by following the epoxy manufacturer's recommendations for mixing and then cementing the thyristor to the mounting surface with a slight pressure and rotary movement. If improved thermal conductivity is desired, powdered alumina (325 mesh) may be mixed into the epoxy in a proportion of 70% (epoxy) to 30% (alumina). If electrical insulation is desired between the thyristor and a heatsink, thin fiberglass tape (course surface) or mica discs may be used.

The primary reason for specifying mounting details is to help maintain the junction temperature of the SCR at a safe level and hence provide satisfactory operation. The fundamental relationship between junction temperature and heat sinks can be expressed as follows:

$$T_J = T_A + R\theta_{JA}\,P_D$$

where:

T_J = junction temperature (100°C max operating for these devices)
T_A = ambient temperature
$R\theta_{JA}$ = junction-to-ambient thermal resistance
= $R\theta_{JC} + R\theta_{CA}$ (with $R\theta_{CA} = R\theta_{CS} + R\theta_{SA}$ when heat sink used)
$R\theta_{JC}$ = junction-to-case thermal resistance
$R\theta_{CA}$ = case-to-ambient thermal resistance
$R\theta_{CS}$ = case-to-heat sink thermal resistance
$R\theta_{SA}$ = heat sink-to-ambient thermal resistance
P_D = average power dissipated in the SCR

It is more accurate to base circuit designs upon the case temperature. The preferred method to determine case temperature is to place a thermocouple on the package at point A as shown on the mechanical outline drawing, Figure 12. Even when used in free air, the mass of the package is large enough so that it will not respond to heat surges generated at a 60 Hz rate or higher once steady-state conditions are achieved.

For operation with a heat sink, normally, the $R\theta_{CS}$ portion of $R\theta_{CA}$ will range between 0.2 and 1°C/W for the can type SCR's, depending upon the particular mounting. $R\theta_{CA}$ is approximately 0.2°C/W for the stud packages when used with a thermal grease. Likewise, the $R\theta_{SA}$ portion of $R\theta_{CA}$ will vary with the shape, material, and configuration of the heat sink as well as with the surrounding conditions. Figure 10 is a very basic guide to $R\theta_{SA}$.

For free air operation, in instances where the case temperature cannot be measured or for preliminary engineering work, the case temperature can be estimated by using values of case-to-ambient thermal resistance, obtained from Figure 11 and the relation:

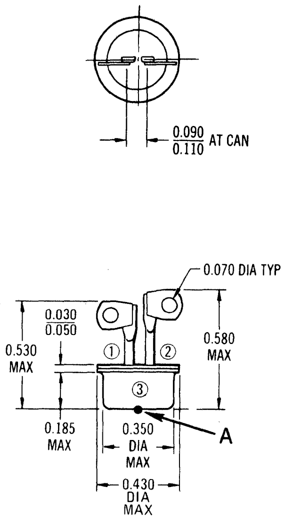
$$T_C = R\theta_{CA}\,P_D + T_A$$

The graph of Figure 11 indicates that the lead length of the SCR and the thermal mass of the connection to the lead will influence the value of $R\theta_{CA}$.

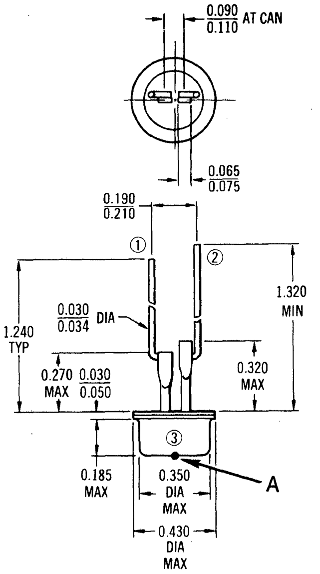
For convenience, Figure 4 shows derating information when the parts are in a still air ambient mounted on a typical P.C. board.

FIGURE 12 – OUTLINE DIMENSIONS

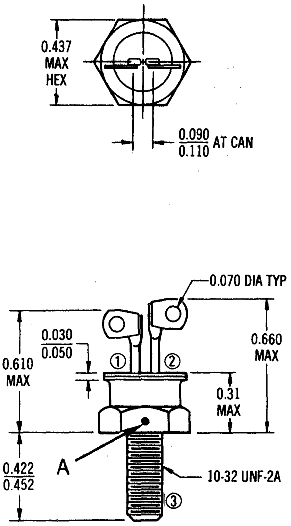
**2N4151-58
CASE 85**



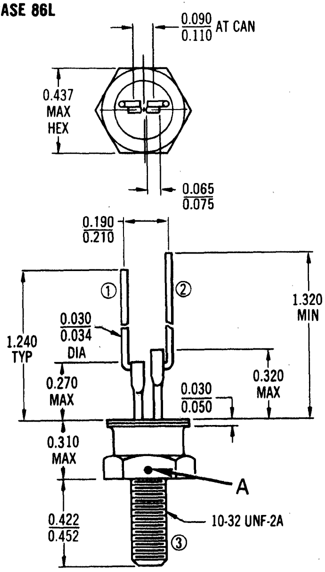
**2N4159-66
CASE 85L**



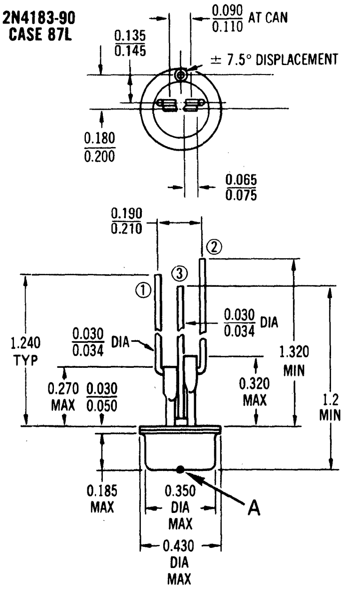
**2N4167-74
CASE 86**



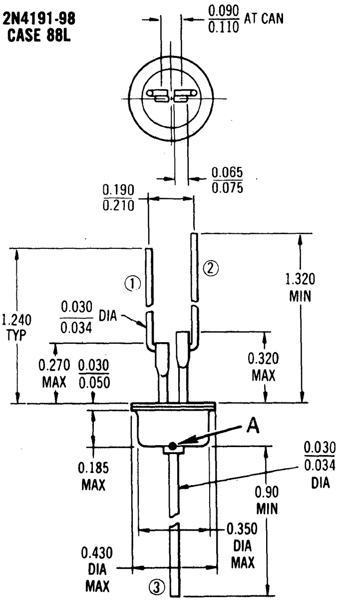
**2N4175-82
CASE 86L**



**2N4183-90
CASE 87L**



**2N4191-98
CASE 88L**



LEAD	STYLE 1 (Thyristors)
①	GATE
②	CATHODE
③	ANODE

NOTES:

1. The case (anode) leads for the 2N4183-90 and 2N4191-98 series may be attached by either soldering or welding techniques.

2. On all package types: Manufacturer may optionally use a small metal tab on the case perimeter opposite the gate terminal for terminal identification purposes.

3. Point A indicates temperature reference point