MOTOROLA
SEMICONDUCTOR
TECHNICAL DATA

MR500 MR501 MR502 MR504 MR506 MR508 MR510

Designers Data Sheet

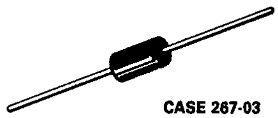
MINIATURE SIZE, AXIAL LEAD MOUNTED STANDARD RECOVERY POWER RECTIFIERS

. . . designed for use in power supplies and other applications having need of a device with the following features:

- High Current to Small Size
- High Surge Current Capability
- Low Forward Voltage Drop
- Economical Plastic Package
- Available in Volume Quantities

STANDARD RECOVERY POWER RECTIFIERS

50-1000 VOLTS
3 AMPERE



CASE 267-03
PLASTIC

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Designer's Data for "Worst Case" Conditions

The Designers Data sheets permit the design of most circuits entirely from the information presented. Limit curves – representing boundaries on device characteristics – are given to facilitate "worst case" design.

MAXIMUM RATINGS

Rating	Symbol	MR500	MR501	MR502	MR504	MR506	MR508	MR510	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	50	100	200	400	600	800	1000	Volts
Non-Repetitive Peak Reverse Voltage	V_{RSM}	75	150	250	450	650	850	1050	Volts
Average Rectified Forward Current (Single phase resistive load, T_Z = 95°C, PC Board Mounting) (1) (EIA Standard Conditions L = 1/32", T_L = 85°C)	I_O	3.0 8.0							Amp
Non-Repetitive Peak Surge Current (surge applied at rated load conditions)	I_{FSM}	100 (one cycle)							Amp
Operating and Storage Junction Temperature Range (2)	T_J, T_{stg}	-65 to +175							°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient (Recommended Printed Circuit Board Mounting, See Note 2).	$R_{\theta JA}$	28	°C/W

ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	Min	Typ	Max	Unit
Instantaneous Forward Voltage (3)	v_F				Volts
(i_F = 9.4 Amp, T_J = 175°C)		–	0.9	1.0	
(i_F = 9.4 Amp, T_J = 25°C)		–	1.04	1.1	
Reverse Current (rated dc voltage) (3)	I_R				μA
T_J = 25°C		–	0.1	5.0	
T_J = 100°C		–	2.8	25	

(1) Derate for reverse power dissipation.
(2) Derate as shown in Figure 1.
(3) Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2.0%.

MECHANICAL CHARACTERISTICS

Case: Transfer Molded Plastic
Finish: External Leads are Plated, Leads are readily Solderable
Polarity: Indicated by Cathode Band
Weight: 1.1 Grams (Approximately)
Maximum Lead Temperature for Soldering Purposes:
300°C, 1/8" from case for 10 s at 5.0 lb. tension

NOTE 1: DETERMINING MAXIMUM RATINGS

Reverse power dissipation and the possibility of thermal runaway must be considered when operating this rectifier at reverse voltages above 200 volts. Proper derating may be accomplished by use of equation (1):

$$T_{A(max)} = T_{J(max)} - R_{\theta JA}P_{F(AV)} - R_{\theta JA}P_{R(AV)} \quad (1)$$

where

$T_{A(max)}$ = Maximum allowable ambient temperature

$T_{J(max)}$ = Maximum allowable junction temperature (175°C or the temperature at which thermal runaway occurs, whichever is lowest.)

$P_{F(AV)}$ = Average forward power dissipation

$P_{R(AV)}$ = Average reverse power dissipation

$R_{\theta JA}$ = Junction-to-ambient thermal resistance

Figure 1 permits easier use of equation (1) by taking reverse power dissipation and thermal runaway into consideration. The figure solves for a reference temperature as determined by equation (2):

$$T_R = T_{J(max)} - R_{\theta JA}P_{R(AV)} \quad (2)$$

Substituting equation (2) into equation (1) yields:

$$T_{A(max)} = T_R - R_{\theta JA}P_{F(AV)} \quad (3)$$

Inspection of equations (2) and (3) reveals that T_R is the ambient temperature at which thermal runaway occurs or where T_J = 175°C, when forward power is zero. The transition from one boundary condition to the other is evident on the curves of Figure 1 as a difference in the rate of change of the slope in the vicinity of 165°C. The data of Figure 1 is based upon dc conditions. For use in common rectifier circuits, Table 1 indicates suggested factors for an equivalent dc voltage to use for conservative design; i.e.:

$$V_{R(equiv)} = V_{in(PK)} \times F \quad (4)$$

The Factor F is derived by considering the properties of the various rectifier circuits and the rectifiers reverse characteristics.

Example: Find $T_{A(max)}$ for MR510 operated in a 400 Volt dc supply using a full wave center-tapped circuit with capacitive filter such that I_{DC} = 6.0 A, ($I_{F(AV)}$ = 3.0 A), $I_{(PK)}/I_{(AV)}$ = 10, Input Voltage = 283 V(rms) (line to center tap), $R_{\theta JA}$ = 28°C/W.

Step 1: Find $V_{R(equiv)}$. Read F = 1.11 from Table 1 ∴
$V_{R(equiv)}$ = 1.41)(283)(1.11) = 444 V

Step 2: Find T_R from Figure 1. Read T_R = 167°C @ V_R = 444 V & $R_{\theta JA}$ = 28°C/W.

Step 3: Find $P_{F(AV)}$ from Figure 8. Read $P_{F(AV)}$ = 4 W @ $\frac{I_{PK}}{I_{AV}}$ = 10 & $I_{F(AV)}$ = 3.0 A

Step 4: Find $T_{A(max)}$ from equation (3). $T_{A(max)}$ = 167-(28)(4) = 55°C.

TABLE I — VALUES FOR FACTOR F

Circuit	Half Wave		Full Wave, Bridge		Full Wave Center-Tapped*†	
Load	Resistive	Capacitive*	Resistive	Capacitive	Resistive	Capacitive
Sine Wave	0.45	1.11	0.45	0.55	0.90	1.11
Square Wave	0.61	1.22	0.61	0.61	1.22	1.22

*Note that $V_{R(PK)} \approx 2 V_{in(PK)}$ †Use line to center tap voltage for V_{in}.

FIGURE 1 — MAXIMUM REFERENCE TEMPERATURE

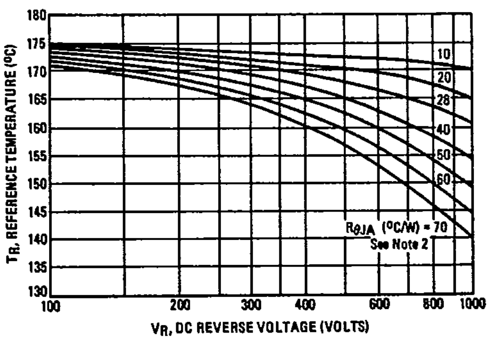
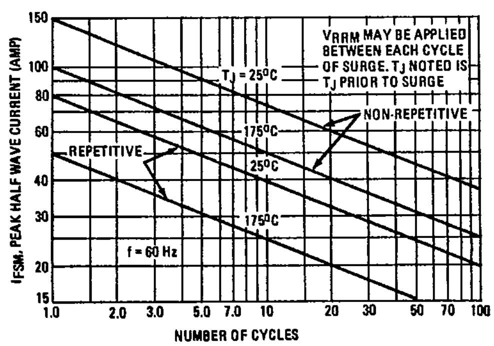


FIGURE 2 — MAXIMUM SURGE CAPABILITY



MR500, MR501, MR502, MR504, MR506, MR508, MR510

CURRENT DERATING
(Reverse Power Loss Neglected)

FIGURE 3 — PC BOARD MOUNTING

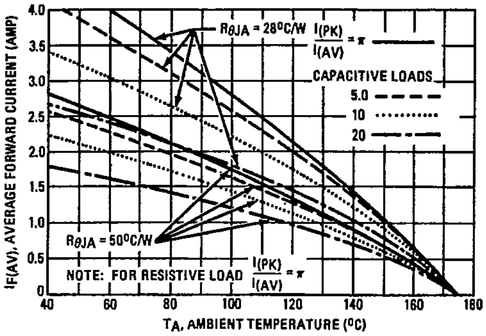


FIGURE 4 — SEVERAL LEAD LENGTHS

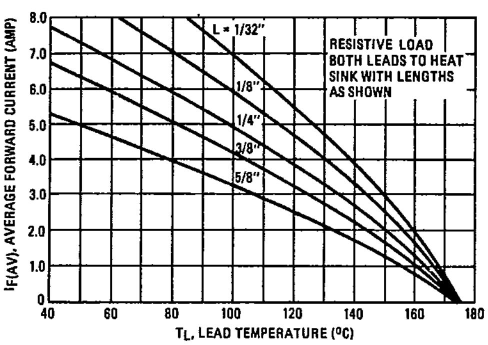


FIGURE 5 — 1/8" LEAD LENGTH

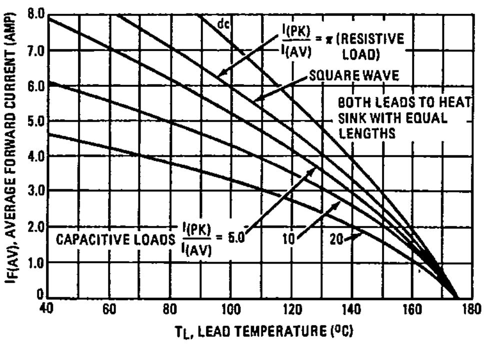


FIGURE 6 — MAXIMUM FORWARD VOLTAGE

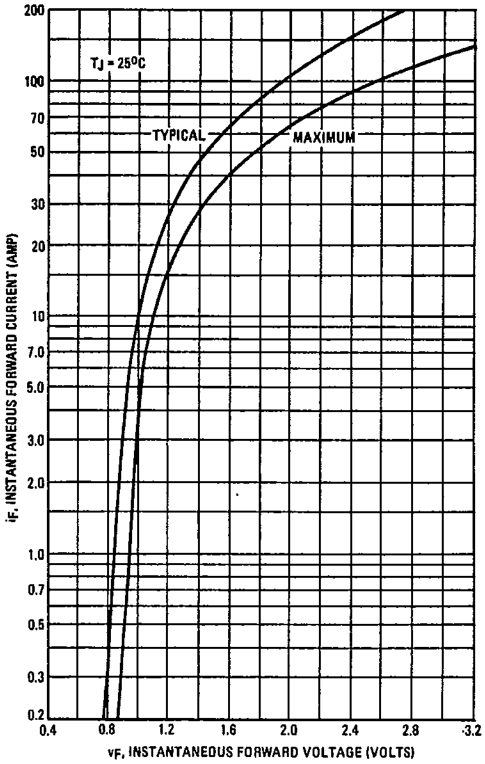
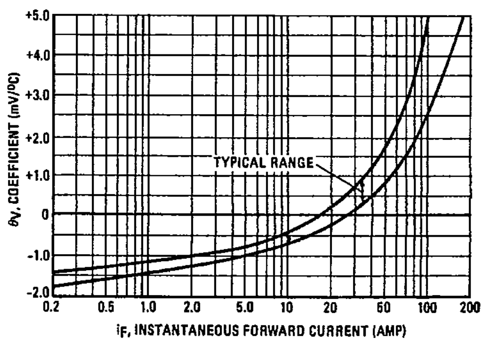


FIGURE 7 — FORWARD VOLTAGE TEMPERATURE COEFFICIENT



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MR500, MR501, MR502, MR504, MR506, MR508, MR510

FIGURE 8 – FORWARD POWER DISSIPATION

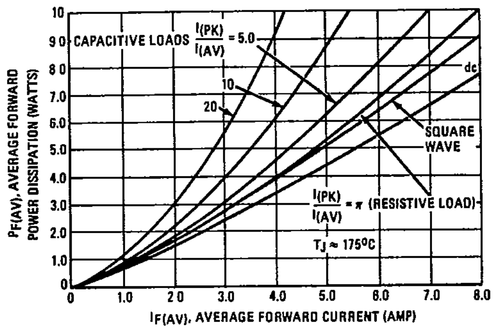
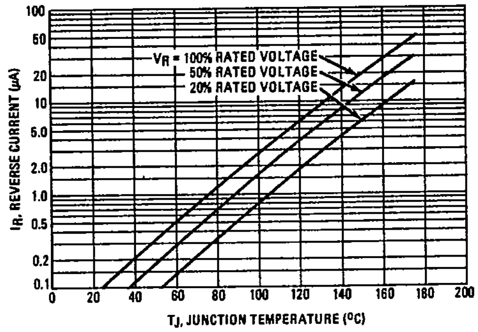


FIGURE 9 – TYPICAL REVERSE CURRENT



THERMAL CHARACTERISTICS

FIGURE 10 – THERMAL RESPONSE

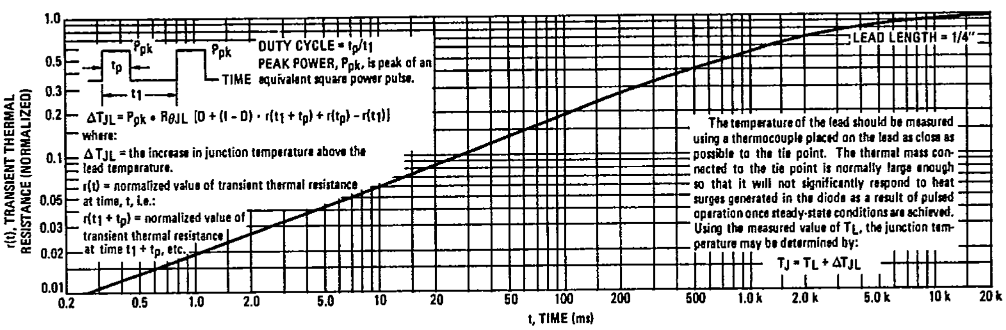
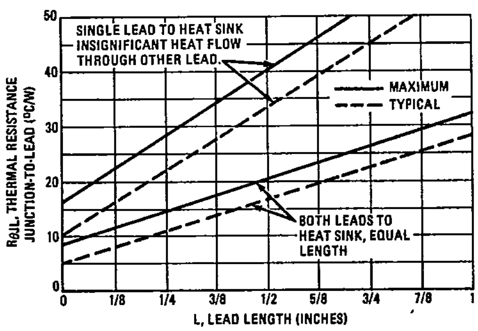


FIGURE 11 – STEADY-STATE THERMAL RESISTANCE



NOTE 2 – AMBIENT MOUNTING DATA

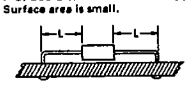
Data shown for thermal resistance junction-to-ambient ($R_{\theta JA}$) for the mountings shown is to be used as typical guideline values for preliminary engineering or in case the tie point temperature cannot be measured.

TYPICAL VALUES FOR $R_{\theta JA}$ IN STILL AIR

MOUNTING METHOD	LEAD LENGTH, L (IN)				$R_{\theta JA}$
	1/8	1/4	1/2	3/4	
1	50	51	53	55	°C/W
2	58	59	61	63	°C/W
3	28				°C/W

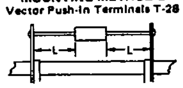
MOUNTING METHOD 1

P.C. Board Where Available Copper Surface area is small.



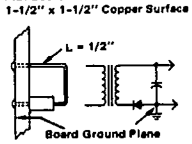
MOUNTING METHOD 2

Vector Push-In Terminals T-28



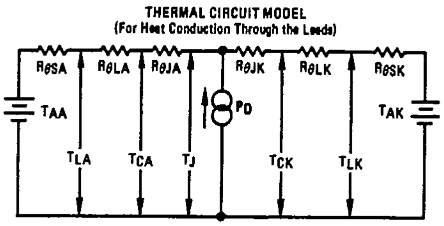
MOUNTING METHOD 3

P.C. Board with 1-1/2" x 1-1/2" Copper Surface



MR500, MR501, MR502, MR504, MR506, MR508, MR510

FIGURE 12 – APPROXIMATE THERMAL CIRCUIT MODEL



Use of the above model permits junction to lead thermal resistance for any mounting configuration to be found. For a given total lead length, lowest values occur when one side of the rectifier is brought as close as possible to the heat sink. Terms in the model signify:

T_A = Ambient Temperature
T_L = Lead Temperature
T_C = Case Temperature
T_J = Junction Temperature
$R_{\theta S}$ = Thermal Resistance, Heat Sink to Ambient
$R_{\theta L}$ = Thermal Resistance, Lead to Heat Sink
$R_{\theta J}$ = Thermal Resistance, Junction to Case
P_D = Total Power Dissipation = $P_F + P_R$
P_F = Forward Power Dissipation
P_R = Reverse Power Dissipation

(Subscripts A and K refer to anode and cathode sides respectively.)
Values for thermal resistance components are:

$R_{\theta L}$ = 46°C/W/IN. Typically and 48°C/W/IN Maximum.
$R_{\theta J}$ = 10°C/W Typically and 16°C/W Maximum.

The maximum lead temperature may be found as follows:

$$T_L = T_{J(max)} - \Delta T_{JL}$$

where $\Delta T_{JL} \approx R_{\theta JL}$

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TYPICAL DYNAMIC CHARACTERISTICS
(T_J = 25°C)

FIGURE 13 – FORWARD RECOVERY TIME

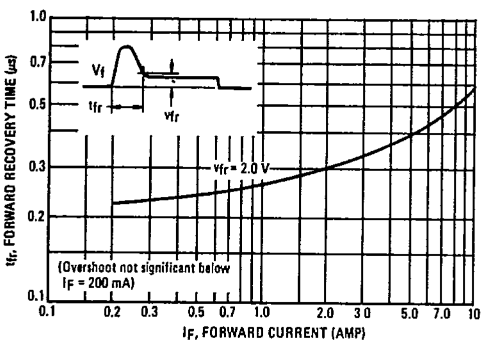


FIGURE 14 – REVERSE RECOVERY TIME

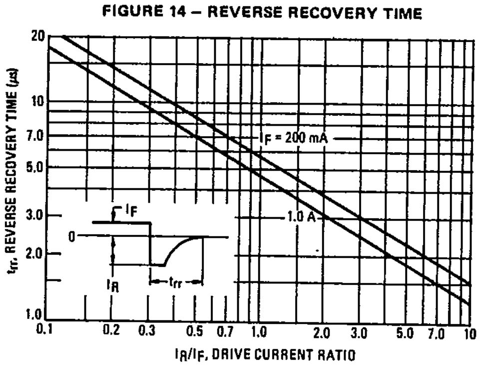


FIGURE 15 – RECTIFICATION WAVEFORM EFFICIENCY

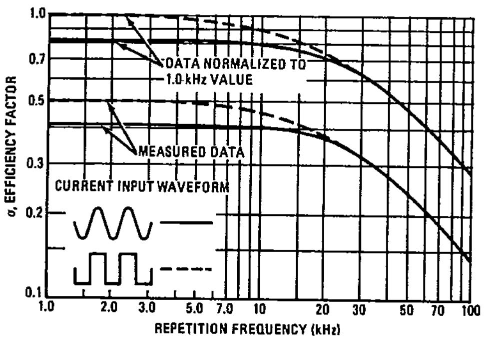
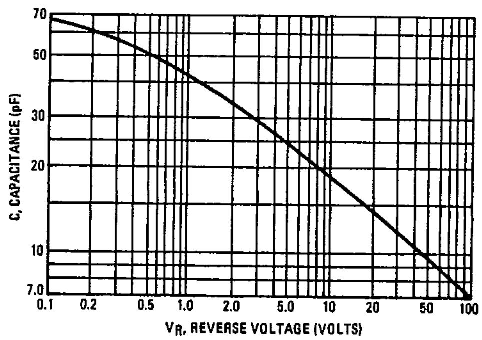


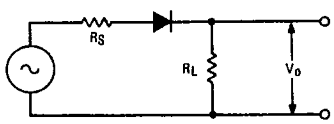
FIGURE 16 – JUNCTION CAPACITANCE



MR500, MR501, MR502, MR504, MR506, MR508, MR510

RECTIFIER EFFICIENCY NOTE

FIGURE 17 – SINGLE-PHASE HALF-WAVE RECTIFIER CIRCUIT



The rectification efficiency factor σ shown in Figure 15 was calculated using the formula:

$$\sigma = \frac{P_{(dc)}}{P_{(rms)}} = \frac{\frac{V^2{}_o(dc)}{R_L}}{\frac{V^2{}_o(rms)}{R_L}} \cdot 100\% = \frac{V^2{}_o(dc)}{V^2{}_o(ac) + V^2{}_o(dc)} \cdot 100\% \quad (1)$$

For a sine wave input $V_m \sin(\omega t)$ to the diode, assumed lossless, the maximum theoretical efficiency factor becomes:

$$\sigma_{(sine)} = \frac{\frac{V^2{}_m}{\pi^2 R_L}}{\frac{V^2{}_m}{4R_L}} \cdot 100\% = \frac{4}{\pi^2} \cdot 100\% = 40.6\% \quad (2)$$

For a square wave input of amplitude V_m, the efficiency factor becomes:

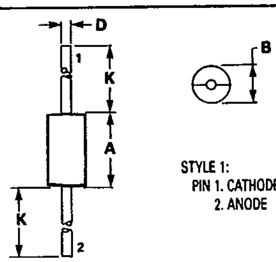
$$\sigma_{(square)} = \frac{\frac{V^2{}_m}{2R_L}}{\frac{V^2{}_m}{R_L}} \cdot 100\% = 50\% \quad (3)$$

(A full wave circuit has twice these efficiencies)

As the frequency of the input signal is increased, the reverse recovery time of the diode (Figure 14) becomes significant, resulting in an increasing ac voltage component across R_L which is opposite in polarity to the forward current, thereby reducing the value of the efficiency factor σ, as shown on Figure 15.

It should be emphasized that Figure 15 shows waveform efficiency only; it does not provide a measure of diode losses. Data was obtained by measuring the ac component of V_o with a true rms ac voltmeter and the dc component with a dc voltmeter. The data was used in Equation 1 to obtain points for the figure.

OUTLINE DIMENSIONS



STYLE 1:
PIN 1. CATHODE
2. ANODE

NOTES:
1. DIMENSIONING & TOLERANCING PER ANSI Y14.5, 1982.
2. CONTROLLING DIMENSION: INCH.

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	9.40	9.65	0.370	0.380
B	4.83	5.33	0.190	0.210
D	1.22	1.32	0.048	0.052
K	25.40	—	1.000	—

CASE 267-03
PLASTIC