

**MOTOROLA**  
**SEMICONDUCTOR**  
 TECHNICAL DATA

**1N3909 thru 1N3913**  
**MR1396**

**Designers Data Sheet**

**STUD MOUNTED**  
**FAST RECOVERY POWER RECTIFIERS**

... designed for special applications such as dc power supplies, inverters, converters, ultrasonic systems, choppers, low RF interference, sonar power supplies and free wheeling diodes. A complete line of fast recovery rectifiers having typical recovery time of 150 nanoseconds providing high efficiency at frequencies to 250 kHz.

1N3911 and MR1396 are  
 Motorola Preferred Devices

**FAST RECOVERY**  
**POWER RECTIFIERS**  
 50-600 VOLTS  
 30 AMPERES



CASE 42A-01  
 DO-203AB  
 METAL

**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              | 1N3909          | 1N3910 | 1N3911 | 1N3912 | 1N3913 | MR1396 | Unit  |
|--|---------------------|-----------------|--------|--------|--------|--------|--------|-------|
| Peak Repetitive Reverse Voltage  | V <sub>RRM</sub>    | 50              | 100    | 200    | 300    | 400    | 600    | Volts |
| Working Peak Reverse Voltage   | V <sub>RWM</sub>    |                 |        |        |        |        |        |       |
| DC Blocking Voltage  | V <sub>R</sub>      |                 |        |        |        |        |        |       |
| Non Repetitive Peak Reverse Voltage  | V <sub>RSM</sub>    | 75              | 150    | 250    | 350    | 450    | 650    | Volts |
| RMS Reverse Voltage  | V <sub>R(RMS)</sub> | 35              | 70     | 140    | 210    | 280    | 420    | Volts |
| Average Rectified Forward Current (Single phase, resistive load, T <sub>C</sub> = 100°C) | I <sub>O</sub>      | ← 30 →          |        |        |        |        |        | Amps  |
| Non Repetitive Peak Surge Current (surge applied at rated load conditions)               | I <sub>FSM</sub>    | ← 300 →         |        |        |        |        |        | Amp   |
| Operating Junction Temperature Range   | T <sub>J</sub>      | ← -65 to +150 → |        |        |        |        |        | °C    |
| Storage Temperature Range  | T <sub>stg</sub>    | ← -65 to +175 → |        |        |        |        |        | °C    |

**MECHANICAL CHARACTERISTICS**

**CASE:** Welded, hermetically sealed

**FINISH:** All external surfaces corrosion resistant and readily solderable

**POLARITY:** Cathode to Case

**WEIGHT:** 17 Grams (Approximately)

**MOUNTING TORQUE:** 25 in.-lbs max.

**THERMAL CHARACTERISTICS**

| Characteristic                       | Symbol           | Max | Unit |
|--------------------------------------|------------------|-----|------|
| Thermal Resistance, Junction to Case | R <sub>θJC</sub> | 1.2 | °C/W |

**\*ELECTRICAL CHARACTERISTICS**

| Characteristic   | Symbol         | Min | Typ | Max | Unit  |
|--|----------------|-----|-----|-----|-------|
| Instantaneous Forward Voltage<br>(I <sub>F</sub> = 93 Amp, T <sub>J</sub> = 150°C) | V <sub>F</sub> | —   | 1.2 | 1.5 | Volts |
| Forward Voltage<br>(I <sub>F</sub> = 30 Amp, T <sub>C</sub> = 25°C)                | V <sub>F</sub> | —   | 1.1 | 1.4 | Volts |
| Reverse Current (rated dc voltage)<br>T <sub>C</sub> = 25°C                        | I <sub>R</sub> | —   | 10  | 25  | μA    |
| T <sub>C</sub> = 100°C   |                | —   | 0.5 | 1.0 | mA    |

**\*REVERSE RECOVERY CHARACTERISTICS**

| Characteristic   | Symbol               | Min | Typ | Max | Unit |
|--|----------------------|-----|-----|-----|------|
| Reverse Recovery Time<br>(I <sub>F</sub> = 1.0 Amp to V <sub>R</sub> = 30 Vdc, Figure 16)    | t <sub>rr</sub>      | —   | 150 | 200 | ns   |
| (I <sub>FM</sub> = 36 Amp, di/dt = 25 A/μs, Figure 17)                                       |                      | —   | 200 | 400 |      |
| Reverse Recovery Current<br>(I <sub>F</sub> = 1.0 Amp to V <sub>R</sub> = 30 Vdc, Figure 16) | I <sub>RM(REC)</sub> | —   | 1.5 | 2.0 | Amp  |

\*Indicates JEDEC Registered Data for 1N3908 Series

3

FIGURE 1 - FORWARD VOLTAGE

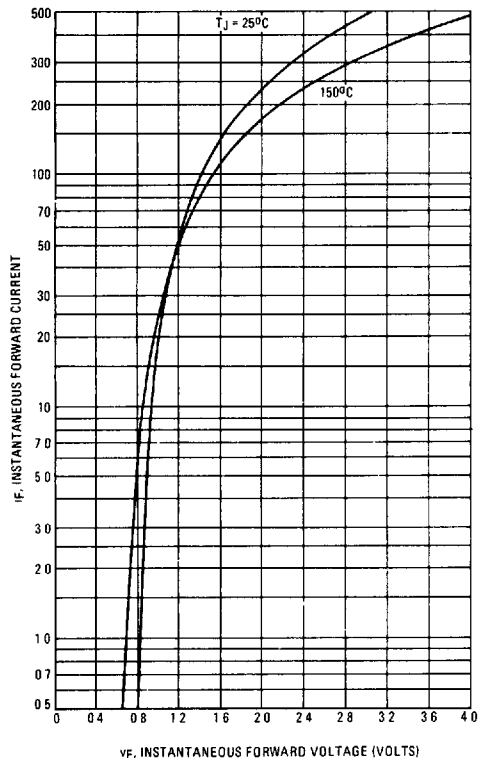
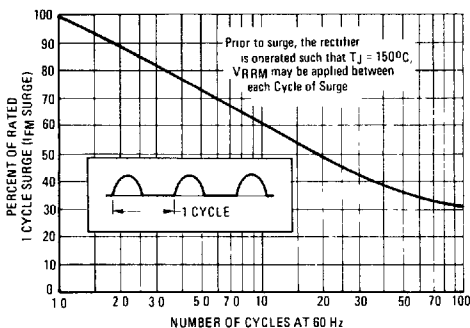


FIGURE 2 - MAXIMUM SURGE CAPABILITY



NOTE 1

DUTY CYCLE  $D = t_p/t_1$   
 PEAK POWER  $P_{pk}$  is peak of an equivalent square power pulse

To determine maximum junction temperature of the diode in a given situation the following procedure is recommended

The temperature of the case should be measured using a thermocouple placed on the case at the temperature reference point (see Note 3). The thermal mass connected to the case is normally large enough so that it will not significantly respond to heat surges generated in the diode as a result of pulsed operation once steady-state conditions are achieved. Using the measured value of  $T_C$  the junction temperature may be determined by

$$T_J = T_C + \Delta T_{JC}$$

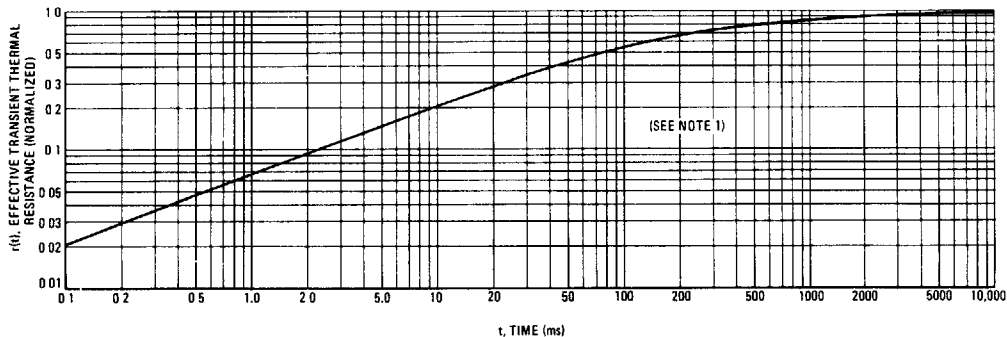
where  $\Delta T_{JC}$  is the increase in junction temperature above the case temperature. It may be determined by

$$\Delta T_{JC} = P_{pk} R_{\theta JC} [D + (1 - D) (r(t_1 + t_p) + r(t_p) - r(t_1))]$$

where

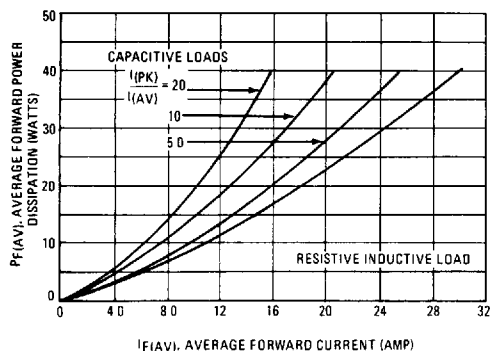
- $r(t)$  = normalized value of transient thermal resistance at time  $t$  from Figure 3
- $r(t_1 + t_p)$  = normalized value of transient thermal resistance at time  $t_1 + t_p$

FIGURE 3 - THERMAL RESPONSE



SINE WAVE INPUT

FIGURE 4 - FORWARD POWER DISSIPATION



SQUARE WAVE INPUT

FIGURE 5 - FORWARD POWER DISSIPATION

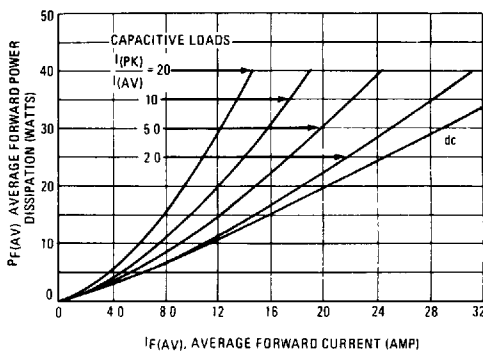


FIGURE 6 - CURRENT DERATING

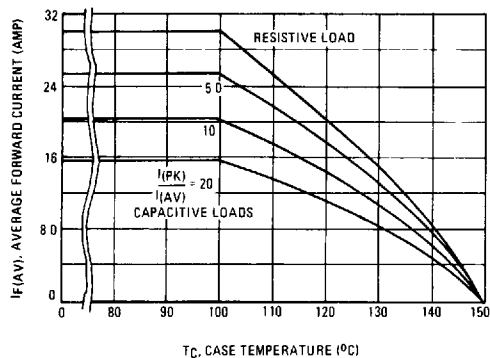


FIGURE 7 - CURRENT DERATING

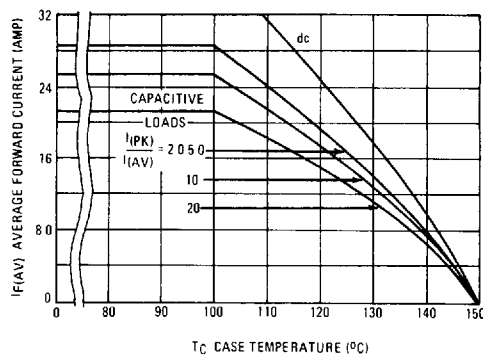


FIGURE 8 - TYPICAL REVERSE CURRENT

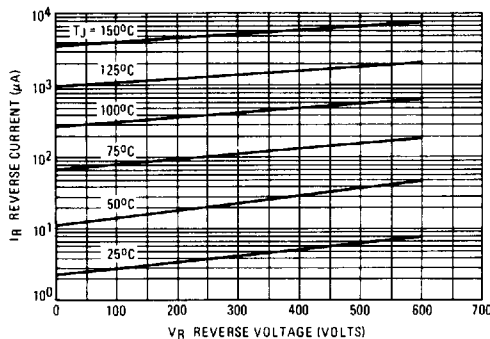
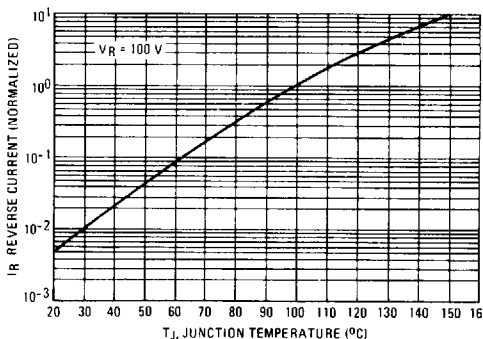


FIGURE 9 - NORMALIZED REVERSE CURRENT



TYPICAL DYNAMIC CHARACTERISTICS

FIGURE 10 - FORWARD RECOVERY TIME

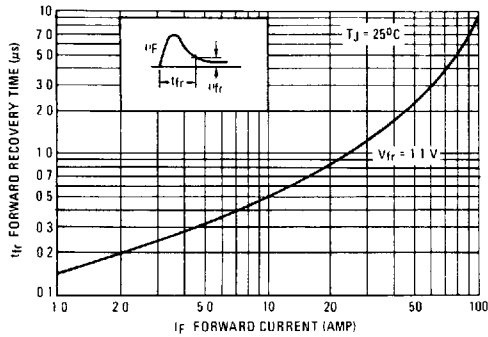
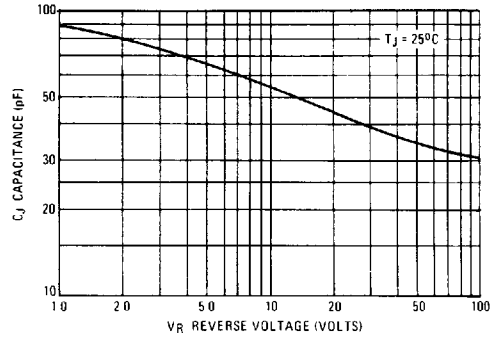


FIGURE 11 - JUNCTION CAPACITANCE



TYPICAL RECOVERED STORED CHARGE DATA

FIGURE 12 -  $T_J = 25^\circ\text{C}$  (SEE NOTE 2)

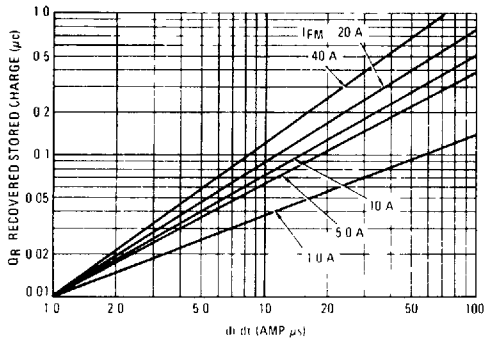


FIGURE 13 -  $T_J = 75^\circ\text{C}$

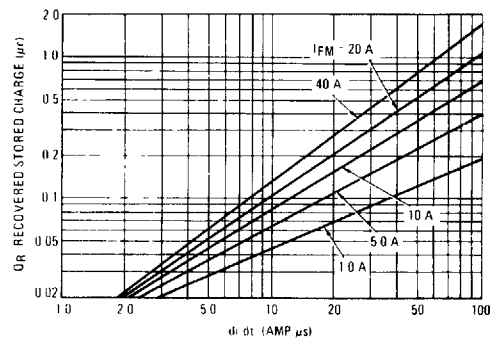


FIGURE 14 -  $T_J = 100^\circ\text{C}$

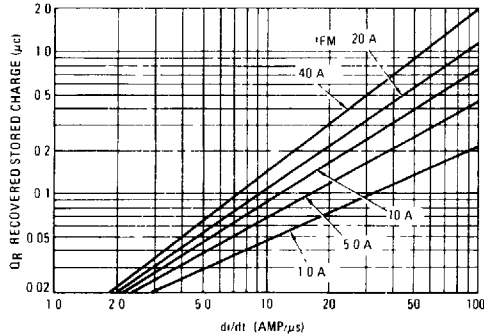
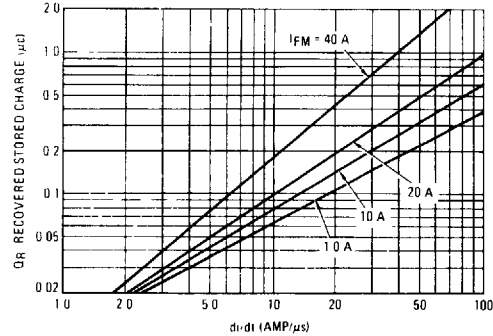
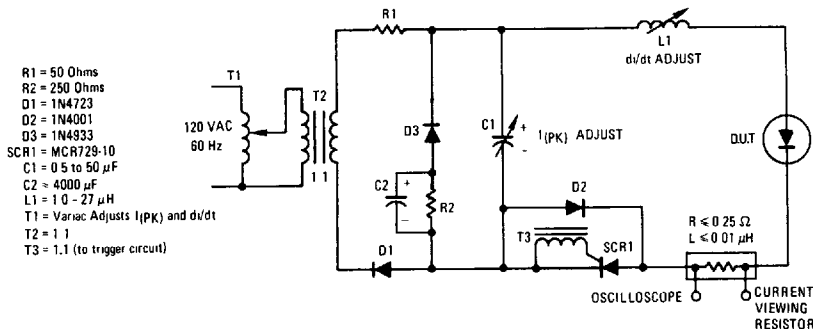


FIGURE 15 -  $T_J = 150^\circ\text{C}$



3

FIGURE 16 — JEDEC REVERSE RECOVERY CIRCUIT



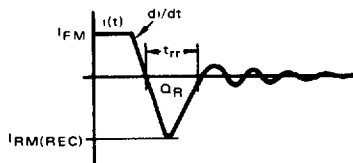
NOTE 3

Reverse recovery time is the period which elapses from the time that the current, thru a previously forward biased rectifier diode, passes thru zero going negatively until the reverse current recovers to a point which is less than 10% peak reverse current.

Reverse recovery time is a direct function of the forward current prior to the application of reverse voltage.

For any given rectifier, recovery time is very circuit dependent. Typical and maximum recovery time of all Motorola fast recovery power rectifiers are rated under a fixed set of conditions using  $I_F = 1.0$  A,  $V_R = 30$  V. In order to cover all circuit conditions, curves are given for typical recovered stored charge versus commutation  $di/dt$  for various levels of forward current and for junction temperatures of 25°C, 75°C, 100°C, and 150°C.

To use these curves, it is necessary to know the forward current level just before commutation, the circuit commutation  $di/dt$ , and the operating junction temperature. The reverse recovery test current waveform for all Motorola fast recovery rectifiers is shown.



From stored charge curves versus  $di/dt$ , recovery time ( $t_{rr}$ ) and peak reverse recovery current ( $I_{RM(REC)}$ ) can be closely approximated using the following formulas.

$$t_{rr} = 1.41 \times \left[ \frac{Q_R}{di/dt} \right]^{1/2}$$

$$I_{RM(REC)} = 1.41 \times [Q_R \times di/dt]^{1/2}$$