

# Triacs

## Silicon Bidirectional Thyristors

... designed for full-wave ac power control applications, and specifically designed to be used in conjunction with MOC30XX opto couplers in circuits similar to that shown on page 3-189.

- Blocking Voltages to 400 Volts
- Load Current Controlled Up to 40 A
- Glass Passivated Junctions for Greater Parameter Uniformity and Stability
- Gate Triggering Guaranteed in Four Modes
- Designed for Use with MOC Series Optoisolators Having Triac Driver Outputs
- MAC3010/MAC3030 Are Recommended For Use With MOC3010/MOC3030 Optoisolators
- MAC3020/MAC3040 Are Recommended For Use With MOC3020/MOC3040 Optoisolators

### MAC3010 MAC3020 MAC3030 MAC3040 Series

**TRIACs**  
**4, 8, 15, 25 and 40**  
**AMPERES RMS**  
**250 thru 400 VOLTS**

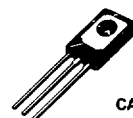


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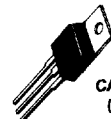
#### MAXIMUM RATINGS ( $T_J = 25^\circ\text{C}$ unless otherwise noted.)

| Rating                                                                               | Symbol              | Current Ratings |            |             |            |             | Unit             |
|--------------------------------------------------------------------------------------|---------------------|-----------------|------------|-------------|------------|-------------|------------------|
|                                                                                      |                     | -4              | -8         | -15         | -25        | -40<br>-40I |                  |
| On-State RMS Current (see Figure 1)<br>(Full Cycle Sine Wave 50 to 60 Hz)            | I <sub>T(RMS)</sub> | 4               | 8          | 15          | 25         | 40          | Amps             |
| Peak Non-Repetitive Surge Current<br>(One Full Cycle, 60 Hz, T <sub>J</sub> = 110°C) | I <sub>TSM</sub>    | 30              | 80         | 150         | 250        | 300         | Amps             |
| Circuit Fusing Considerations<br>{T <sub>J</sub> = -40 to +110°C, t = 8.3 ms}        | I <sup>2</sup> t    | 3.6             | 26         | 90          | 260        | 370         | A <sup>2</sup> s |
| Peak Gate Voltage (t ≤ 2 μs)                                                         | V <sub>GM</sub>     | ± 5             | ± 10       | ± 10        | ± 10       | ± 10        | Volts            |
| Peak Gate Power (t ≤ 2 μs)                                                           | P <sub>GM</sub>     | 10              | 20         | 20          | 20         | 20          | Watts            |
| Average Gate Power<br>(T <sub>C</sub> = 80°C, t ≤ 8.3 ms)                            | P <sub>G(AV)</sub>  | 0.5             | 0.5        | 0.5         | 0.5        | 0.5         | Watts            |
| Peak Gate Current (t ≤ 2 μs)                                                         | I <sub>GM</sub>     | 11              | 12         | 12          | 12         | 12          | Amps             |
| Operating Junction Temperature Range                                                 | T <sub>J</sub>      | *               |            | -40 to +125 |            | *           | °C               |
| Storage Temperature Range                                                            | T <sub>stg</sub>    | -40 to +150     |            |             |            |             | °C               |
| Mounting Torque                                                                      | —                   | 6               | 8          | 8           | 8          | 30          | in. lb.          |
| MAC3010/MAC3030, Note 1<br>(T <sub>J</sub> = 25 to 125°C)<br>MAC3020/MAC3040         | V <sub>DRM</sub>    | 250<br>400      | 250<br>400 | 250<br>400  | 250<br>400 | 250<br>400  | Volts            |

Note 1.  $V_{\text{DRM}}$  for all types can be applied on a continuous basis. Blocking voltages shall not be tested with a constant current source such that the voltage ratings of the devices are exceeded.



CASE 77-07  
(TO-225AA)  
STYLE 5  
-4



CASE 221A-04  
(TO-220AB)  
STYLE 4  
-8, -15, -25



CASE 263-04  
STYLE 2  
-40



CASE 311-02  
STYLE 2  
-40I

## MAC3010, MAC3020, MAC3030, MAC3040 Series

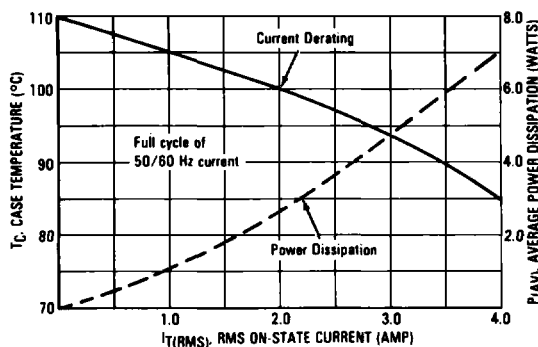
### —4 CURRENT RATING

**ELECTRICAL CHARACTERISTICS** ( $T_C = 25^\circ\text{C}$ , and Either Polarity of MT2 to MT1 Voltage unless otherwise noted)

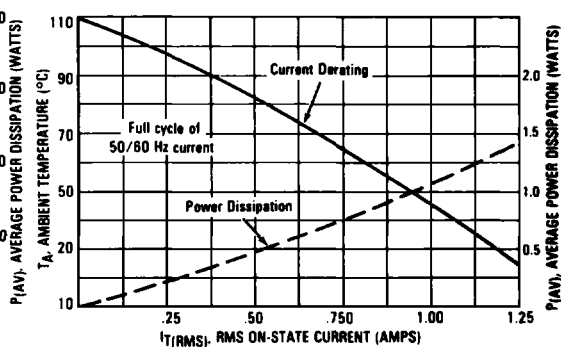
| Characteristic                                                                                                                                                                                                                             | Symbol           | Min          | Typ | Max | Unit                   |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------|--------------|-----|-----|------------------------|
| Peak Blocking Current (Note 1)<br>( $V_D = 250\text{ V}$ , $T_J = 110^\circ\text{C}$ )                                                                                                                                                     | $I_{\text{DRM}}$ | —            | —   | 2.0 | mA                     |
| Peak On-State Voltage (Either Direction)<br>( $I_{\text{TM}} = 6\text{ A}$ Peak; Pulse Width $\leq 2.0\text{ ms}$ ,<br>Duty Cycle $\leq 2.0\%$ )                                                                                           | $V_{\text{TM}}$  | —            | —   | 2.0 | Volts                  |
| Gate Trigger Current, Continuous dc<br>( $V_D = 12\text{ V}$ , $R_L = 100\ \Omega$ )<br>MT2(+), G(+); MT2(-), G(-)                                                                                                                         | $I_{\text{GT}}$  | —            | —   | 3.0 | mA                     |
| Gate Trigger Voltage, Continuous dc<br>( $V_D = 12\text{ V}$ , $R_L = 100\ \Omega$ )<br>MT2(+), G(+); MT2(-), G(-)<br><br>( $V_D = 250\text{ V}$ , $R_L = 10\text{ k}\ \Omega$ , $T_J = 110^\circ\text{C}$ )<br>MT2(+), G(+); MT1(-), G(-) | $V_{\text{GT}}$  | —<br><br>0.2 | —   | 2.0 | Volts                  |
| Holding Current<br>( $V_D = 12\text{ V}$ , $I_{\text{TM}} = 200\text{ mA}$ , Gate Open)                                                                                                                                                    | $I_{\text{H}}$   | —            | —   | 40  | mA                     |
| Gate Controlled Turn-On Time<br>( $V_D = 250\text{ V}$ , $I_{\text{TM}} = 6\text{ A}$ pk, $I_G = 100\text{ mA}$ )                                                                                                                          | $t_{\text{gt}}$  | —            | 1.5 | —   | $\mu\text{s}$          |
| Critical Rate of Rise of Commutation Voltage<br>( $V_D = 250\text{ V}$ , $I_{\text{TM}} = 5.7\text{ A}$ pk,<br>Commutating $di/dt = 2.0\text{ A/ms}$ ,<br>Gate Unenergized, $T_C = 85^\circ\text{C}$ )                                     | $dv/dt(C)$       | —            | 5.0 | —   | $\text{V}/\mu\text{s}$ |
| Critical Rate of Rise of Off-State Voltage<br>( $V_D = 250\text{ V}$ , Exponential Waveform, $T_C = 110^\circ\text{C}$ )                                                                                                                   | $dv/dt$          | —            | 20  | —   | $\text{V}/\mu\text{s}$ |

Note 1: Ratings apply for open gate conditions. Thyristor devices shall not be tested with a constant current source for blocking voltage such that the voltage applied exceeds the rated blocking voltage.

**FIGURE 1 — CURRENT DERATING AND  
POWER DISSIPATION  
REFERENCE: CASE TEMPERATURE**



**FIGURE 2 — CURRENT DERATING AND  
POWER DISSIPATION  
REFERENCE: AMBIENT TEMPERATURE**



## MAC3010, MAC3020, MAC3030, MAC3040 Series

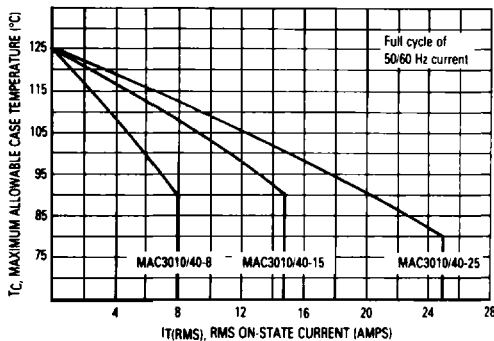
### -8, -15, -25 CURRENT RATINGS

**ELECTRICAL CHARACTERISTICS** ( $T_C = 25^\circ\text{C}$ , and Either Polarity of MT2 to MT1 Voltage unless otherwise noted.)

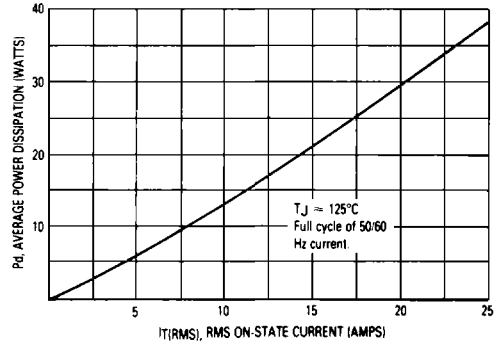
| Characteristic                                                                                                                                                                                                | Symbol             | Min         | Typ         | Max                | Unit                         |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------|-------------|-------------|--------------------|------------------------------|
| Peak Forward or Reverse Blocking Current<br>(Rated $V_{DRM}$ or $V_{RRM}$ ) $T_J = 25^\circ\text{C}$<br>$T_J = 125^\circ\text{C}$                                                                             | $I_{DRM}, I_{RRM}$ | —<br>—      | —<br>—      | 10<br>2            | $\mu\text{A}$<br>$\text{mA}$ |
| Peak On-State Voltage<br>( $I_{TM} = \sqrt{2} I_{T(RMS)}$ A Peak; Pulse Width $\leq 2$ ms, Duty Cycle $\leq 2\%$ )<br>MAC3030-8<br>MAC3030-15<br>MAC3030-25                                                   | $V_{TM}$           | —<br>—<br>— | —<br>—<br>— | 1.6<br>1.6<br>1.85 | Volts                        |
| Gate Trigger Current (Continuous dc)<br>( $V_D = 12$ V, $R_L = 100$ Ohms)<br>MT2(+), G(+); MT2(-), G(-) All Types                                                                                             | $I_{GT}$           | —           | —           | 40                 | mA                           |
| Gate Trigger Voltage (Continuous dc)<br>( $V_D = 12$ V, $R_L = 100$ Ohms)<br>MT2(+), G(+); MT2(-), G(-) All Types<br>( $T_J = 125^\circ\text{C}$ , $R_L = 10$ k Ohms)<br>MT2(+), G(+); MT1(-), G(-) All Types | $V_{GT}$           | —<br>0.2    | —<br>—      | 2<br>—             | Volts                        |
| Holding Current<br>( $V_D = 12$ V, $I_{TM} = 200$ mA, Gate Open)                                                                                                                                              | $I_H$              | —           | —           | 40                 | mA                           |
| Gate Controlled Turn-On Time<br>( $I_{TM} = 2 I_{T(RMS)}$ A Peak, $I_G = 100$ mA)                                                                                                                             | $t_{gt}$           | —           | 1.5         | —                  | $\mu\text{s}$                |
| Critical Rate of Rise of Commutation Voltage<br>( $I_{TM} = \sqrt{2} I_{T(RMS)}$ A Peak, Commutating $di/dt = 0.36 I_{TM}$<br>A/ms, Gate Unenergized, $T_C = 80^\circ\text{C}$ )                              | $dv/dt(c)$         | —           | 5           | —                  | $\text{V}/\mu\text{s}$       |
| Critical Rate of Rise of Off-State Voltage<br>(Exponential Waveform, $T_C = 125^\circ\text{C}$ )                                                                                                              | $dv/dt$            | —           | 40          | —                  | $\text{V}/\mu\text{s}$       |

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**FIGURE 2 — RMS CURRENT DERATING**



**FIGURE 3 — ON-STATE POWER DISSIPATION**

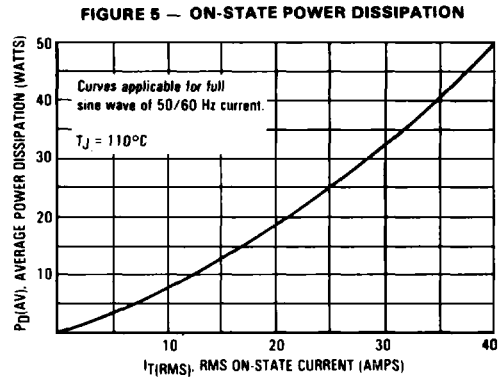
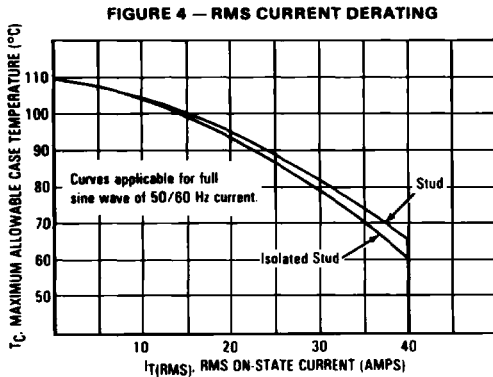


## MAC3010, MAC3020, MAC3030, MAC3040 Series

### -40, -40I CURRENT RATINGS

ELECTRICAL CHARACTERISTICS ( $T_C = 25^\circ\text{C}$ , and Either Polarity of MT2 to MT1 Voltage unless otherwise noted.)

| Characteristic                                                                                                                                                                                                                                  | Symbol     | Min      | Typ    | Max     | Unit                         |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|----------|--------|---------|------------------------------|
| Peak Blocking Current<br>( $V_D = \text{Rated } V_{DRM}$ ) $T_J = 25^\circ\text{C}$<br>$T_J = 110^\circ\text{C}$                                                                                                                                | $I_{DRM}$  | —<br>—   | —<br>— | 10<br>2 | $\mu\text{A}$<br>$\text{mA}$ |
| Peak On-State Voltage (Either Direction)<br>( $I_{TM} = 56 \text{ A Peak}$ ; Pulse Width $\leq 2 \text{ ms}$ , Duty Cycle $\leq 2\%$ )                                                                                                          | $V_{TM}$   | —        | —      | 1.85    | Volts                        |
| Gate Trigger Current (Continuous dc)<br>( $V_D = 12 \text{ V}$ , $R_L = 100 \Omega$ )<br>MT2(+), G(+); MT2(-), G(-)                                                                                                                             | $I_{GT}$   | —        | —      | 40      | $\text{mA}$                  |
| Gate Trigger Voltage (Continuous dc)<br>( $V_D = 12 \text{ V}$ , $R_L = 100 \Omega$ )<br>MT2(+), G(+); MT2(-), G(-)<br>( $V_D = \text{Rated } V_{DRM}$ , $R_L = 10 \text{ k}\Omega$ , $T_J = 110^\circ\text{C}$ )<br>MT2(+), G(+); MT1(-), G(-) | $V_{GT}$   | —<br>0.2 | —<br>— | 2<br>—  | Volts                        |
| Holding Current<br>( $V_D = 12 \text{ V}$ , $I_{TM} = 200 \text{ mA}$ , Gate Open)                                                                                                                                                              | $I_H$      | —        | —      | 50      | $\text{mA}$                  |
| Gate Controlled Turn-On Time<br>( $I_{TM} = 56 \text{ A pk}$ , $I_G = 200 \text{ mA}$ )                                                                                                                                                         | $t_{gt}$   | —        | 1.5    | —       | $\mu\text{s}$                |
| Critical Rate-of-Rise of Commutation Voltage<br>( $I_{TM} = 56 \text{ A pk}$ , Commutating $di/dt = 20.2 \text{ A/ms}$ ,<br>Gate Unenergized, $T_C = 60^\circ\text{C}$ )                                                                        | $dv/dt(c)$ | —        | 5      | —       | $\text{V}/\mu\text{s}$       |
| Critical Rate-of-Rise of Off-State Voltage<br>(Exponential Waveform, $T_C = 110^\circ\text{C}$ )                                                                                                                                                | $dv/dt$    | —        | 30     | —       | $\text{V}/\mu\text{s}$       |



## MAC3010, MAC3020, MAC3030, MAC3040 Series

### USING THE MOC OPTO COUPLERS AND MAC TRIAC SERIES DEVICES

The MOCXXX Opto Coupler can be used as a triac driver with MACXXX-X by selecting  $R_C$  to limit the surge current thru the coupler and yet supply enough gate drive to the triac to guarantee complete turn on. The maximum surge current rating of the coupler ( $I_{TSM}$ ) determines the minimum value of  $R_C$ :

$$R_C (\min) = \frac{V_{in(pk)}}{I_{TSM} (\text{coupler})}$$

For high line 110 Vac nominal voltage:  $V_{in(pk)} = 187 \text{ V}$ .

$$R_C (\min) = \frac{187 \text{ V}}{1 \text{ A}} = 187 \text{ Ohms}$$

In practice, this would be a 180 Ohm resistor.

The maximum gate drive required determines the maximum value of  $R_C$ :

$$R_C (\max) = \frac{V_{IH} - V_{TM}}{I_{GT}(\text{triac})}$$

Where  $V_{IH}$  is the inhibit voltage of the coupler and  $V_{TM}$  is the on-state voltage of the triac in the coupler.

For the MOC3041 and MAC3040 - 25,  $V_{IH} = 20 \text{ V}$ ,  $V_{TM} = 3.0 \text{ V}$ , and  $I_{GT} = 40 \text{ mA}$ .

$$R_C (\max) = \frac{20 \text{ V} - 3.0 \text{ V}}{40 \text{ mA}} = 425 \text{ Ohms}$$

#### Resistive Loads

Resistive heating elements and incandescent lamps are typical loads for the triac. Cold incandescent lamps can draw 5-6 times their hot RMS value on start up. The triac must be specified to sustain the repetitive surge ( $I_{TSM}$ ). In practice, the RMS value is chosen at two times actual so the surge rating of the triac will be very high.

#### Inductive Loads

Motors, solenoids, and magnets are typical problem loads for the triac and coupler. Since the triac turns off as the current approaches zero, but the inductive voltage is still high, it appears to the triac as a rise in applied voltage. If this rate of rise in voltage exceeds the  $dv/dt$  commutating of the triac or the  $dv/dt$  static of the coupler, the triac will turn back on.

#### Snubber Network

See AN982 and AN1048 (Section 1), for snubber design information.

