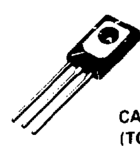
Triacs
Silicon Bidirectional Thyristors

. . . 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 3-221.

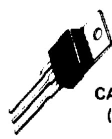
- Blocking Voltages to 400 Volts
- Load Current Controlled Up to 40 A
- Glass Passivated Junctions for Greater Parameter Uniformity and Stability
- Gate Triggering Guaranteed in Four Modes
- Designed for Use with MOC Series Optoisolators Having Triac Driver Outputs
- MAC3010/MAC3030 Are Recommended For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

MAC3010
MAC3020
MAC3030
MAC3040
Series

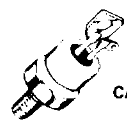
TRIACs
4, 8, 15, 25 and 40
AMPERES RMS
250 thru 400 VOLTS



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

3

MAXIMUM RATINGS

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

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.

—4 CURRENT RATING

ELECTRICAL CHARACTERISTICS (T_C = 25°C, and Either Polarity of MT2 to MT1 Voltage unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Peak Blocking Current (Note 1) (V_D = 250 V, T_J = 110°C)	I_{DRM}	—	—	2.0	mA
Peak On-State Voltage (Either Direction) (I_{TM} = 6 A Peak; Pulse Width ≤ 2.0 ms, Duty Cycle ≤ 2.0%)	V_{TM}	—	—	2.0	Volts
Gate Trigger Current, Continuous dc (V_D = 12 V, R_L = 100 Ω) MT2(+), G(+); MT2(−), G(−)	I_{GT}	—	—	30	mA
Gate Trigger Voltage, Continuous dc (V_D = 12 V, R_L = 100 Ω) MT2(+), G(+); MT2(−), G(−)	V_{GT}	—	—	2.0	Volts
(V_D = 250 V, R_L = 10 k Ω, T_J = 110°C) MT2(+), G(+); MT1(−), G(−)		0.2	—	—	
Holding Current (V_D = 12 V, I_{TM} = 200 mA, Gate Open)	I_H	—	—	40	mA
Gate Controlled Turn-On Time (V_D = 250 V, I_{TM} = 6 A pk, I_G = 100 mA)	tgt	—	1.5	—	μs
Critical Rate of Rise of Commutation Voltage (V_D = 250 V, I_{TM} = 6 A pk, Commutating di/dt = 3.1 A/ms, Gate Unenergized, T_C = 85°C)	dv/dt(C)	—	5.0	—	V/μs
Critical Rate of Rise of Off-State Voltage (V_D = 250 V, Exponential Waveform, T_C = 110°C)	dv/dt	—	20	—	V/μs

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.

3

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

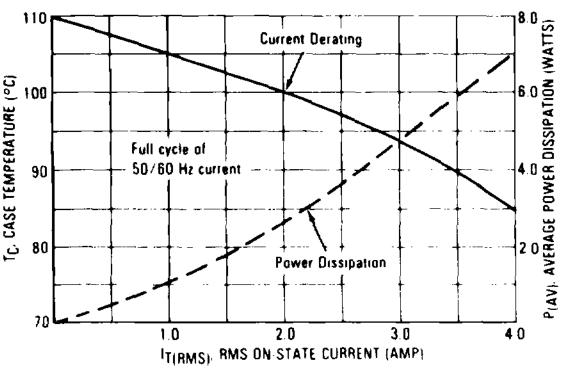
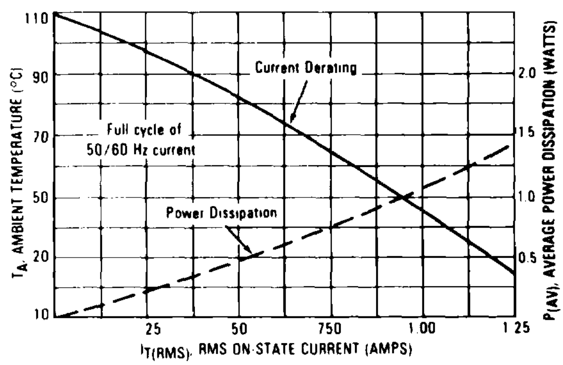


FIGURE 2 — CURRENT DERATING AND POWER DISSIPATION REFERENCE: AMBIENT TEMPERATURE



-8, -15, -25 CURRENT RATINGS

ELECTRICAL CHARACTERISTICS (T_C = 25°C, and Either Polarity of MT2 to MT1 Voltage unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
Peak Forward or Reverse Blocking Current	I_{DRM}, I_{RRM}				
(Rated V_{DRM} or V_{RRM}) T_J = 25°C		—	—	10	μA
T_J = 125°C		—	—	2	mA
Peak On-State Voltage (I_{TM} = $\sqrt{2}$ $I_{T(RMS)}$ A Peak; Pulse Width ≈ 2 ms, Duty Cycle ≤ 2%)	V_{TM}				Volts
MAC3030-8		—	—	1.6	
MAC3030-15		—	—	1.6	
MAC3030-25		—	—	1.85	
Gate Trigger Current (Continuous dc) (V_D = 12 V, R_L = 100 Ohms) MT2(+), G(+); MT2(–), G(–) All Types	I_{GT}	—	—	40	mA
Gate Trigger Voltage (Continuous dc) (V_D = 12 V, R_L = 100 Ohms)	V_{GT}				Volts
MT2(+), G(+); MT2(–), G(–) All Types		—	—	2	
(T_J = 125°C, R_L = 10 k Ohms) MT2(+), G(+); MT1(–), G(–) All Types		0.2	—	—	
Holding Current (V_D = 12 V, I_{TM} = 200 mA, Gate Open)	I_H	—	—	40	mA
Gate Controlled Turn-On Time (I_{TM} = 2 $I_{T(RMS)}$ A Peak, I_G = 100 mA)	t_{gt}	—	1.5	—	μs
Critical Rate of Rise of Commutation Voltage (I_{TM} = 2 $I_{T(RMS)}$ A Peak, Commutating di/dt = 0.52 $I_{T(RMS)}$ A/ms, Gate Unenergized, T_C = 80°C)	dv/dt(c)	—	5	—	V/μs
Critical Rate of Rise of Off-State Voltage (Exponential Waveform, T_C = 125°C)	dv/dt	—	40	—	V/μs

3

FIGURE 2 — RMS CURRENT DERATING

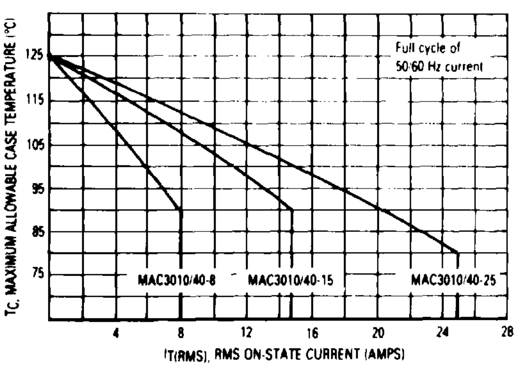
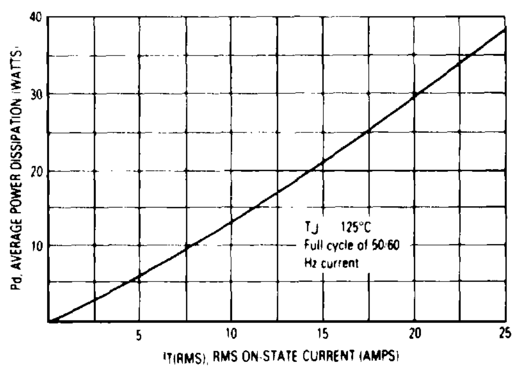


FIGURE 3 — ON-STATE POWER DISSIPATION



-40, -40I CURRENT RATINGS

ELECTRICAL CHARACTERISTICS (T_C = 25°C, and Either Polarity of MT2 to MT1 Voltage unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
Peak Forward or Reverse Blocking Current (Rated V_{DRM} or V_{RRM}) T_J = 25°C	I_{DRM}, I_{RRM}	—	—	10	μA
T_J = 110°C		—	—	2	mA
Peak On-State Voltage (Either Direction) (I_{TM} = 56 A Peak; Pulse Width ≤ 2 ms, Duty Cycle ≤ 2%)	V_{TM}	—	—	1.85	Volts
Gate Trigger Current (Continuous dc) (V_D = 12 V, R_L = 100 Ω) MT2(+), G(+); MT2(−), G(−)	I_{GT}	—	—	40	mA
Gate Trigger Voltage (Continuous dc) (V_D = 12 V, R_L = 100 Ω) MT2(+), G(+); MT2(−), G(−)	V_{GT}	—	—	2	
(R_L = 10 kΩ, T_J = 110°C) MT2(+), G(+); MT1(−), G(−)		0.2	—	—	Volts
Holding Current (V_D = 12 V, I_{TM} = 200 mA, Gate Open)	I_H	—	—	50	mA
Gate Controlled Turn-On Time (I_{TM} = 56 A pk, I_G = 200 mA)	t_{gt}	—	1.5	—	μs
Critical Rate of Rise of Commutation Voltage (I_{TM} = 56 A pk, Commutating di/dt = 22 A/ms, Gate Unenergized, T_C = 60°C)	dv/dt(c)	—	5	—	V/μs
Critical Rate of Rise of Off-State Voltage (Exponential Waveform, T_C = 110°C)	dv/dt	—	30	—	V/μs

3

FIGURE 4 — RMS CURRENT DERATING

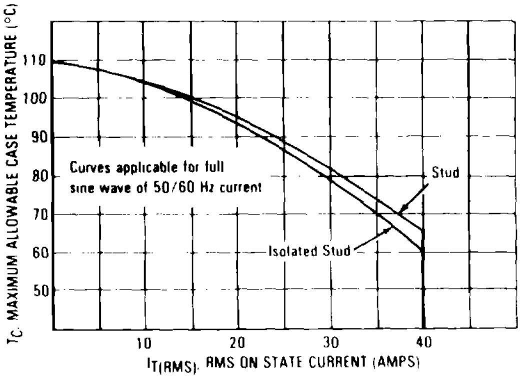
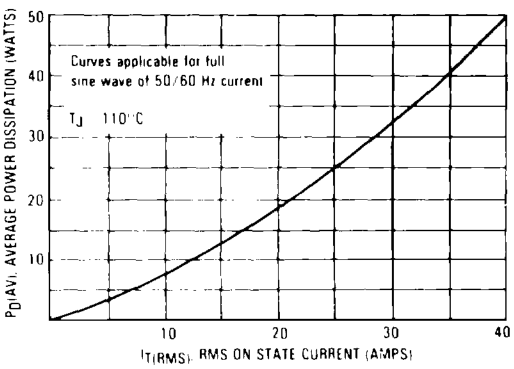


FIGURE 5 — ON-STATE POWER DISSIPATION



USING THE MOC OPTO COUPLERS AND MAC TRIAC SERIES DEVICES

The MOCXXXX Opto Coupler can be used as a triac driver with MACXXXX-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:

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

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

$$R_C\,(min) = \frac{187\ V}{1.2\ A} = 155.8\ ohms$$

In practice, this would be a 180 ohm resistor.

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

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

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 MOC3040 and MAC3040 −25 V_{IH} = 40 V, V_{TM} = 3.0 V, and I_{GT} = 40 mA.

$$R_C\,(max) = \frac{40\ V - 3.0\ V}{40\ mA} = 930\ ohms$$

In practice, the gate is driven two or three times I_{GT} to guarantee complete turn on. R_C (max) would be 460 ohms or 310 ohms.

The line voltage at turn on is:

$$V_{Line\ at\ turn\ on} = R_C \cdot I_{GT} + V_{TM}(coupler) + V_{GT}(triac)$$

For the above example V_{GT}(triac) = 2.0 V, I_{GT} = 80 mA, R_C = 210 ohms.

$$V_{Line\ at\ turn\ on} = (210)(0.08\ A) + 3.0\ V + 2.0\ V = 22\ V$$

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

When the dv/dt of the circuit exceeds the capability of the coupler or triac, a R_SC_S network is placed across the main terminals of the triac. In most applications the snubber used for the triac will also protect the coupler. The R_S also limits the energy from the C_S destroying the gate region on the first use of the triac.

Since the power factor of the board (cosine of the I-V phase shift) is not always known, a typical design can be a starting point for scope verification.

For power factor = 0.1, 110 V nominal line.

$$V_{turn\ off\ voltage} = V_{pk} \sin\phi \approx V_{pk} \approx 187\ V$$

Setting the dv/dt $_C$ (triac) equal to the circuit $V_{Turn\ off}$ over the snubber time constant and solving for R_S:

$$dv/dt\ C\,(triac) = \frac{V_{Turn\ off}}{R_S C_S}$$

$$R_S = \frac{V_{Turn\ off}}{dv/dt\,(c)\,C_S}$$

For MAC3030-25 dv/dt (c) = 5.0 V/μs, and choosing C_S = 0.1 μF

$$R_S = \frac{187\ V}{(5.0\ V/\mu s)(0.1\ \mu F)}$$

$$R_S = 374\ ohms$$

In practice, R_S is selected empirically. For more details see AN1048 (Section 1).