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September 2015

# MOC3051M, MOC3052M 6-Pin DIP Random-Phase Triac Driver Optocoupler (600 Volt Peak)

## Features

- Excellent  $I_{FT}$  Stability—IR Emitting Diode Has Low Degradation
- 600 V Peak Blocking Voltage
- Safety and Regulatory Approvals
  - UL1577, 4,170  $V_{AC,RMS}$  for 1 Minute
  - DIN EN/IEC60747-5-5

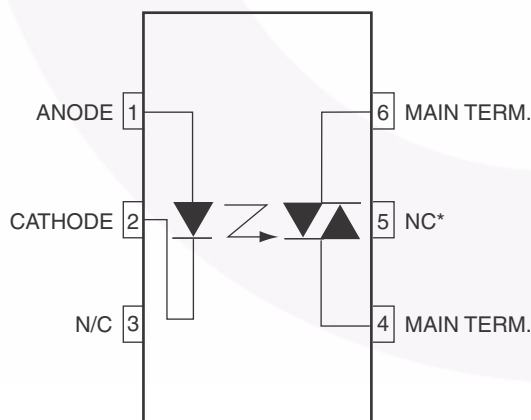
## Applications

- Solenoid/Valve Controls
- Lamp Ballasts
- Static AC Power Switch
- Interfacing Microprocessors to 115  $V_{AC}$  and 240  $V_{AC}$  Peripherals
- Solid State Relay
- Incandescent Lamp Dimmers
- Temperature Controls
- Motor Controls

## Description

The MOC3051M and MOC3052M consist of a GaAs infrared emitting diode optically coupled to a non-zero-crossing silicon bilateral AC switch (triac). These devices isolate low voltage logic from 115  $V_{AC}$  and 240  $V_{AC}$  lines to provide random phase control of high current triacs or thyristors. These devices feature greatly enhanced static  $dv/dt$  capability to ensure stable switching performance of inductive loads.

## Schematic



\*DO NOT CONNECT  
(TRIAC SUBSTRATE)

Figure 1. Schematic

## Package Outlines

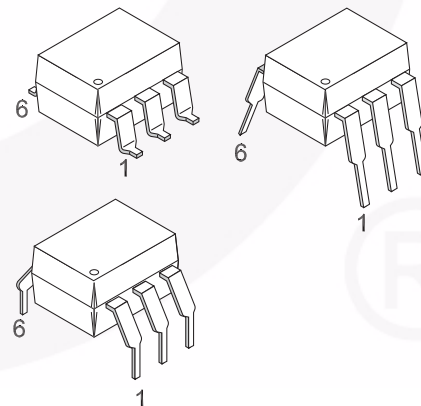


Figure 2. Package Outlines

MOC3051M, MOC3052M — 6-Pin DIP Random-Phase Triac Driver Optocoupler (600 Volt Peak)

## Safety and Insulation Ratings

As per DIN EN/IEC 60747-5-5, this optocoupler is suitable for “safe electrical insulation” only within the safety limit data. Compliance with the safety ratings shall be ensured by means of protective circuits.

Parameter		Characteristics
Installation Classifications per DIN VDE 0110/1.89 Table 1, For Rated Mains Voltage	< 150 V <sub>RMS</sub>	I–IV
	< 300 V <sub>RMS</sub>	I–IV
Climatic Classification		40/85/21
Pollution Degree (DIN VDE 0110/1.89)		2
Comparative Tracking Index		175

Symbol	Parameter	Value	Unit
V <sub>PR</sub>	Input-to-Output Test Voltage, Method A, V <sub>IORM</sub> × 1.6 = V <sub>PR</sub> , Type and Sample Test with t <sub>m</sub> = 10 s, Partial Discharge < 5 pC	1360	V <sub>peak</sub>
	Input-to-Output Test Voltage, Method B, V <sub>IORM</sub> × 1.875 = V <sub>PR</sub> , 100% Production Test with t <sub>m</sub> = 1 s, Partial Discharge < 5 pC	1594	V <sub>peak</sub>
V <sub>IORM</sub>	Maximum Working Insulation Voltage	850	V <sub>peak</sub>
V <sub>IOTM</sub>	Highest Allowable Over-Voltage	6000	V <sub>peak</sub>
	External Creepage	≥ 7	mm
	External Clearance	≥ 7	mm
	External Clearance (for Option TV, 0.4" Lead Spacing)	≥ 10	mm
DTI	Distance Through Insulation (Insulation Thickness)	≥ 0.5	mm
R <sub>IO</sub>	Insulation Resistance at T <sub>S</sub> , V <sub>IO</sub> = 500 V	> 10 <sup>9</sup>	Ω

## Absolute Maximum Ratings

Stresses exceeding the absolute maximum ratings may damage the device. The device may not function or be operable above the recommended operating conditions and stressing the parts to these levels is not recommended. In addition, extended exposure to stresses above the recommended operating conditions may affect device reliability. The absolute maximum ratings are stress ratings only.  $T_A = 25^\circ\text{C}$  unless otherwise specified.

Symbol	Parameters	Value	Unit
<b>Total Device</b>			
$T_{STG}$	Storage Temperature	-40 to +150	$^\circ\text{C}$
$T_{OPR}$	Operating Temperature	-40 to +85	$^\circ\text{C}$
$T_J$	Junction Temperature Range	-40 to +100	$^\circ\text{C}$
$T_{SOL}$	Lead Solder Temperature	260 for 10 seconds	$^\circ\text{C}$
$P_D$	Total Device Power Dissipation at $25^\circ\text{C}$ Ambient	330	mW
	Derate Above $25^\circ\text{C}$	4.4	mW/ $^\circ\text{C}$
<b>Emitter</b>			
$I_F$	Continuous Forward Current	60	mA
$V_R$	Reverse Voltage	3	V
$P_D$	Total Power Dissipation at $25^\circ\text{C}$ Ambient	100	mW
	Derate Above $25^\circ\text{C}$	1.33	mW/ $^\circ\text{C}$
<b>Detector</b>			
$V_{DRM}$	Off-State Output Terminal Voltage	600	V
$I_{TSM}$	Peak Non-Repetitive Surge Current (Single Cycle 60 Hz Sine Wave)	1	A
$P_D$	Total Power Dissipation at $25^\circ\text{C}$ Ambient	300	mW
	Derate Above $25^\circ\text{C}$	4	mW/ $^\circ\text{C}$

## Electrical Characteristics

$T_A = 25^\circ\text{C}$  unless otherwise specified.

### Individual Component Characteristics

Symbol	Parameters	Test Conditions	Min.	Typ.	Max.	Unit
<b>EMITTER</b>						
$V_F$	Input Forward Voltage	$I_F = 10\text{ mA}$		1.18	1.50	V
$I_R$	Reverse Leakage Current	$V_R = 3\text{ V}$		0.05	100	$\mu\text{A}$
<b>DETECTOR</b>						
$I_{\text{DRM}}$	Peak Blocking Current, Either Direction	$V_{\text{DRM}} = 600\text{ V}, I_F = 0^{(1)}$		10	100	nA
$V_{\text{TM}}$	Peak On-State Voltage, Either Direction	$I_{\text{TM}} = 100\text{ mA peak}, I_F = 0$		1.7	2.5	V
dv/dt	Critical Rate of Rise of Off-State Voltage	$I_F = 0$ (Figure 13, at 400V)	1000			V/ $\mu\text{s}$

### Transfer Characteristics

Symbol	DC Characteristics	Test Conditions	Device	Min.	Typ.	Max.	Unit
$I_{\text{FT}}$	LED Trigger Current, Either Direction	Main Terminal Voltage = $3\text{ V}^{(2)}$	MOC3051M			15	mA
			MOC3052M			10	
$I_{\text{H}}$	Holding Current, Either Direction		All		220		$\mu\text{A}$

### Isolation Characteristics

Symbol	Characteristic	Test Conditions	Min.	Typ.	Max.	Unit
$V_{\text{ISO}}$	Input-Output Isolation Voltage <sup>(3)</sup>	$f = 60\text{ Hz}, t = 1\text{ Minute}$	4170			$V_{\text{AC RMS}}$
$R_{\text{ISO}}$	Isolation Resistance	$V_{\text{I-O}} = 500\text{ V}_{\text{DC}}$		$10^{11}$		$\Omega$
$C_{\text{ISO}}$	Isolation Capacitance	$V = 0\text{ V}, f = 1\text{ MHz}$		0.2		pF

#### Notes:

- Test voltage must be applied within dv/dt rating.
- All devices are guaranteed to trigger at an  $I_F$  value less than or equal to max  $I_{\text{FT}}$ . Therefore, the recommended operating  $I_F$  lies between maximum  $I_F$  (15 mA for MOC3051M, 10 mA for MOC3052M) and absolute maximum  $I_F$  (60 mA).
- Isolation voltage,  $V_{\text{ISO}}$ , is an internal device dielectric breakdown rating. For this test, pins 1 and 2 are common, and pins 4, 5 and 6 are common.

## Typical Performance Curves

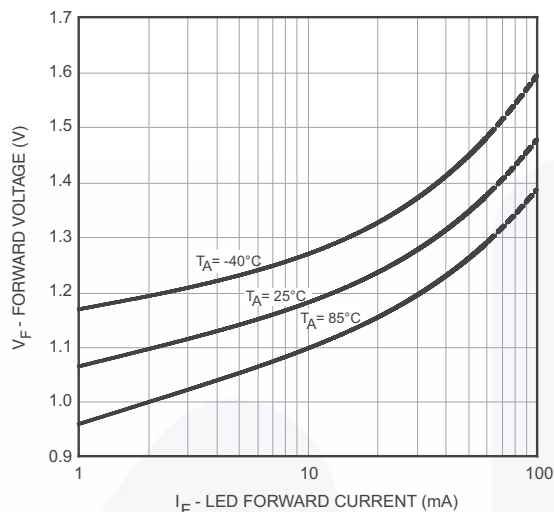


Figure 3. LED Forward Voltage vs. Forward Current

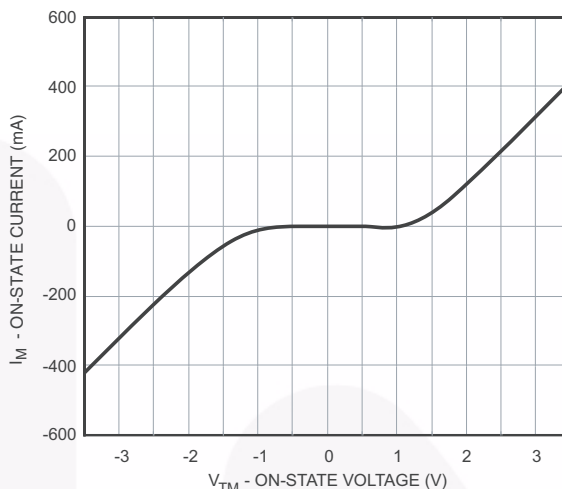


Figure 4. On-State Characteristics

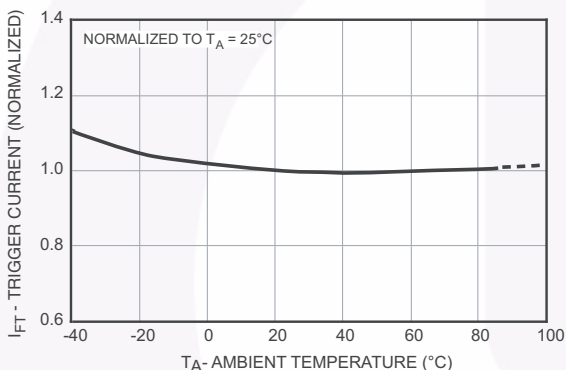


Figure 5. Trigger Current vs. Ambient Temperature

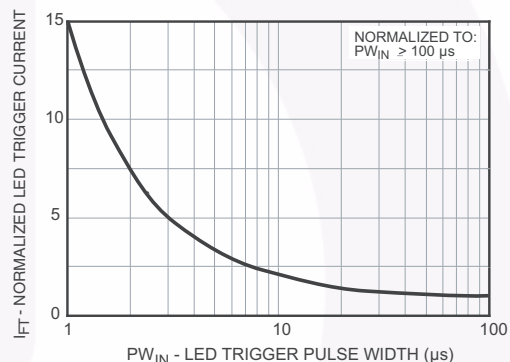


Figure 6. LED Current Required to Trigger vs. LED Pulse Width

### $I_F$ vs. Temperature (normalized)

Figure 5 shows the increase of the trigger current when the device is expected to operate at an ambient temperature below 25°C. Multiply the normalized  $I_{FT}$  shown on this graph with the data sheet guaranteed  $I_{FT}$ .

*Example:*

$T_A = 25^\circ\text{C}$ ,  $I_{FT} = 10\text{ mA}$

$I_{FT}$  at  $-40^\circ\text{C} = 10\text{ mA} \times 1.1 = 11\text{ mA}$

### Phase Control Considerations

#### LED Trigger Current versus PW (normalized)

Random Phase Triac drivers are designed to be phase controllable. They may be triggered at any phase angle within the AC sine wave. Phase control may be accomplished by an AC line zero cross detector and a variable pulse delay generator which is synchronized to the zero

cross detector. The same task can be accomplished by a microprocessor which is synchronized to the AC zero crossing. The phase controlled trigger current may be a very short pulse which saves energy delivered to the input LED. LED trigger pulse currents shorter than 100  $\mu\text{s}$  must have an increased amplitude as shown on Figure 6. This graph shows the dependency of the trigger current  $I_{FT}$  versus the pulse width can be seen on the chart delay  $t(d)$  versus the LED trigger current.

$I_{FT}$  in the graph  $I_{FT}$  versus (PW) is normalized in respect to the minimum specified  $I_{FT}$  for static condition, which is specified in the device characteristic. The normalized  $I_{FT}$  has to be multiplied with the devices guaranteed static trigger current.

*Example:*

Guaranteed  $I_{FT} = 10\text{ mA}$ , Trigger pulse width  $PW = 3\ \mu\text{s}$

$I_{FT}(\text{pulsed}) = 10\text{ mA} \times 5 = 50\text{ mA}$

### Minimum LED Off Time in Phase Control Applications

In Phase control applications one intends to be able to control each AC sine half wave from 0° to 180°. Turn on at 0° means full power and turn on at 180° means zero power. This is not quite possible in reality because triac driver and triac have a fixed turn on time when activated at zero degrees. At a phase control angle close to 180° the driver's turn on pulse at the trailing edge of the AC sine wave must be limited to end 200 μs before AC zero cross as shown in Figure 7. This assures that the triac driver has time to switch off. Shorter times may cause loss of control at the following half cycle.

### I<sub>FT</sub> versus dv/dt

Triac drivers with good noise immunity (dv/dt static) have internal noise rejection circuits which prevent false

triggering of the device in the event of fast raising line voltage transients. Inductive loads generate a commutating dv/dt that may activate the triac drivers noise suppression circuits. This prevents the device from turning on at its specified trigger current. It will in this case go into the mode of "half waving" of the load. Half waving of the load may destroy the power triac and the load.

Figure 10 shows the dependency of the triac drivers I<sub>FT</sub> versus the reapplied voltage rise with a V<sub>p</sub> of 400V. This dv/dt condition simulates a worst case commutating dv/dt amplitude.

It can be seen that the I<sub>FT</sub> does not change until a commutating dv/dt reaches 1000V/μs. The data sheet specified I<sub>FT</sub> is therefore applicable for all practical inductive loads and load factors.

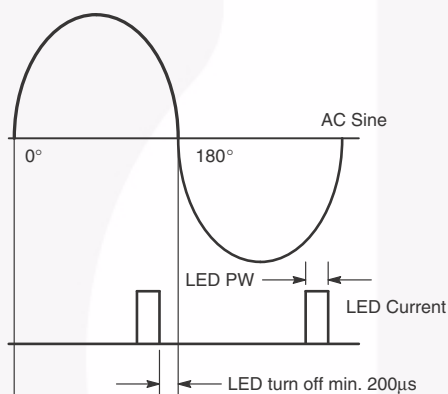


Figure 7. Minimum Time for LED Turn Off to Zero Cross of AC Trailing Edge

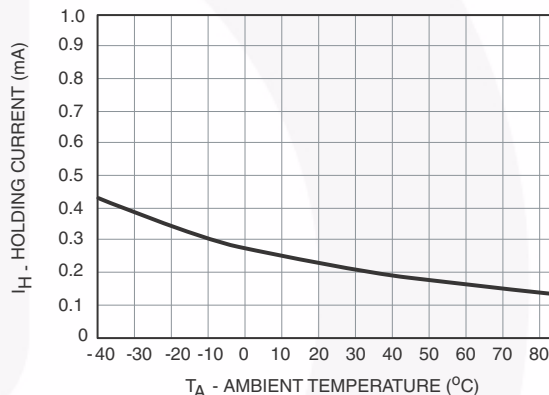


Figure 8. Holding Current, I<sub>H</sub> vs. Temperature

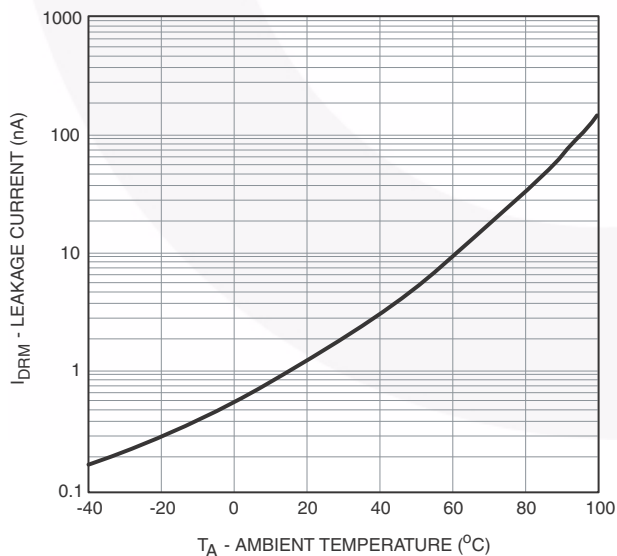


Figure 9. Leakage Current, I<sub>DRM</sub> vs. Temperature

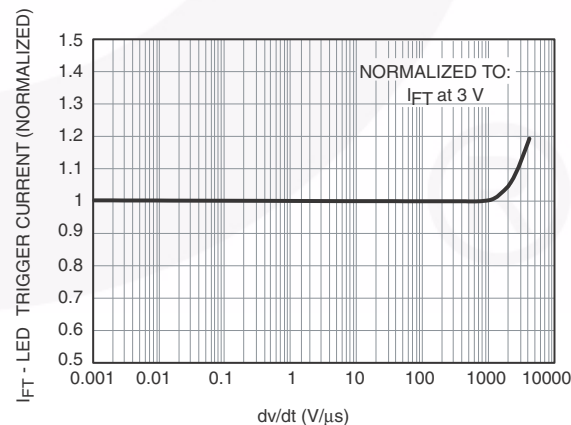


Figure 10. LED Trigger Current, I<sub>FT</sub> vs. dv/dt

### t(delay), t(f) versus I<sub>FT</sub>

The triac driver's turn on switching speed consists of a turn on delay time t(d) and a fall time t(f). Figure 12 shows that the delay time depends on the LED trigger current, while the actual trigger transition time t(f) stays constant with about one micro second.

The delay time is important in very short pulsed operation because it demands a higher trigger current at very short trigger pulses. This dependency is shown in the graph I<sub>FT</sub> vs. LED PW.

The turn on transition time t(f) combined with the power triac's turn on time is important to the power dissipation of this device.

1. The mercury wetted relay provides a high speed repeated pulse to the D.U.T.
2. 100x scope probes are used, to allow high speeds and voltages.
3. The worst-case condition for static dv/dt is established by triggering the D.U.T. with a normal LED input current, then removing the current. The variable R<sub>TEST</sub> allows the dv/dt to be gradually increased until the D.U.T. continues to trigger in response to the applied voltage pulse, even after the LED current has been removed. The dv/dt is then decreased until the D.U.T. stops triggering. τ<sub>RC</sub> is measured at this point and recorded.

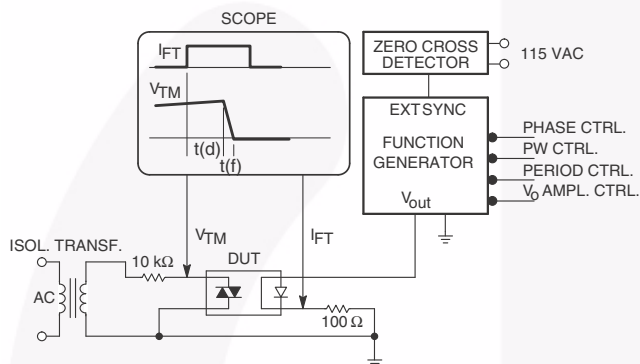


Figure 11. Switching Time Test Circuit

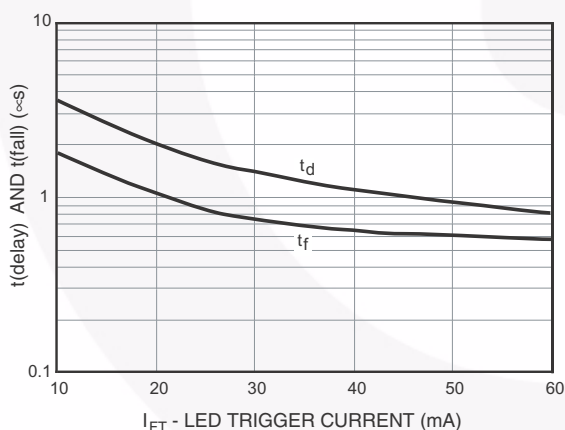


Figure 12. Delay Time, t(d), and Fall Time, t(f), vs. LED Trigger Current

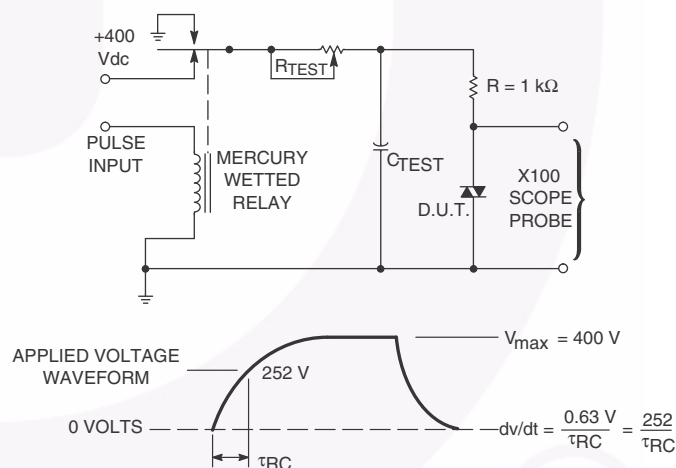


Figure 13. Static dv/dt Test Circuit



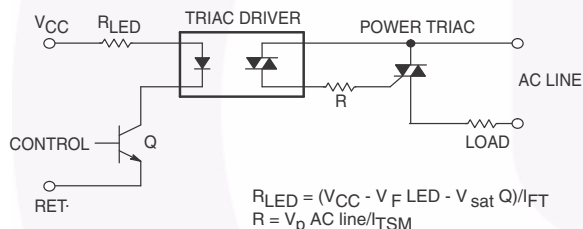
## Applications Guide

### Basic Triac Driver Circuit

The new random phase triac driver family MOC3052M and MOC3051M are very immune to static dv/dt which allows snubberless operations in all applications where external generated noise in the AC line is below its guaranteed dv/dt withstand capability. For these applications a snubber circuit is not necessary when a noise insensitive power triac is used. Figure 14 shows the circuit diagram. The triac driver is directly connected to the triac main terminal 2 and a series Resistor R which limits the current to the triac driver. Current limiting resistor R must have a minimum value which restricts the current into the driver to maximum 1 A.

$$R = V_p AC / I_{TM} \text{ max rep.} = V_p AC / 1 A$$

The power dissipation of this current limiting resistor and the triac driver is very small because the power triac carries the load current as soon as the current through driver and current limiting resistor reaches the trigger current of the power triac. The switching transition times for the driver is only one micro second and for power triacs typical four micro seconds.



$$R_{LED} = (V_{CC} - V_{F LED} - V_{sat Q}) / I_{FT}$$

$$R = V_p AC \text{ line} / I_{TSM}$$

Figure 14. Basic Driver Circuit

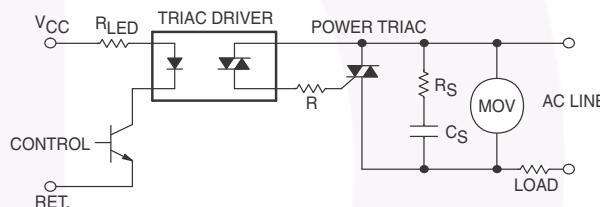
### Triac Driver Circuit for Noisy Environments

When the transient rate of rise and amplitude are expected to exceed the power triacs and triac drivers maximum ratings a snubber circuit as shown in Figure 15 is recommended. Fast transients are slowed by the R-C snubber and excessive amplitudes are clipped by the Metal Oxide Varistor MOV.

### Triac Driver Circuit for Extremely Noisy Environments

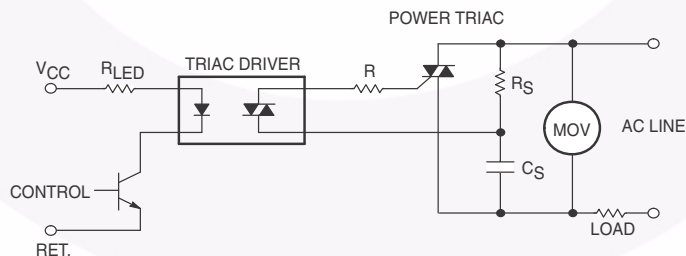
As specified in the noise standards IEEE472 and IEC255-4.

Industrial control applications do specify a maximum transient noise dv/dt and peak voltage which is superimposed onto the AC line voltage. In order to pass this environment noise test a modified snubber network as shown in Figure 16 is recommended.



Typical Snubber values  $R_S = 33 \Omega$ ,  $C_S = 0.01 \mu F$   
MOV (Metal Oxide Varistor) protects triac and driver from transient overvoltages  $> V_{DRM \text{ max.}}$

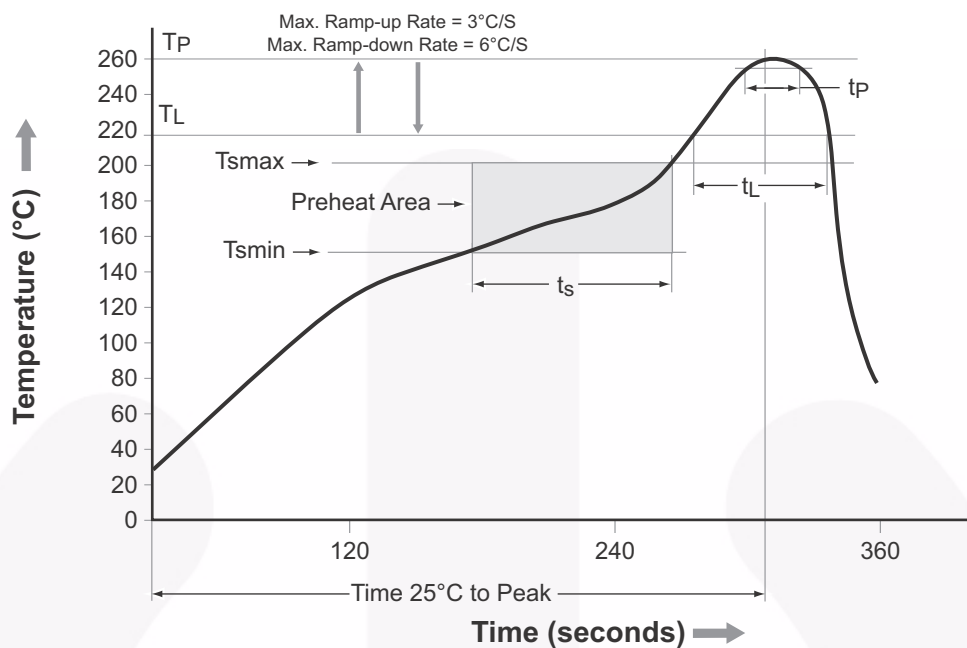
Figure 15. Triac Driver Circuit for Noisy Environments



Recommended snubber to pass IEEE472 and IEC255-4 noise tests  
 $R_S = 47 \Omega$ ,  $C_S = 0.01 \mu F$

Figure 16. Triac Driver Circuit for Extremely Noisy Environments

## Reflow Profile



Profile Feature	Pb-Free Assembly Profile
Temperature Minimum (T <sub>smin</sub> )	150°C
Temperature Maximum (T <sub>smax</sub> )	200°C
Time (t <sub>s</sub> ) from (T <sub>smin</sub> to T <sub>smax</sub> )	60 seconds to 120 seconds
Ramp-up Rate (T <sub>L</sub> to T <sub>P</sub> )	3°C/second maximum
Liquidous Temperature (T <sub>L</sub> )	217°C
Time (t <sub>L</sub> ) Maintained Above (T <sub>L</sub> )	60 seconds to 150 seconds
Peak Body Package Temperature	260°C +0°C / -5°C
Time (t <sub>p</sub> ) within 5°C of 260°C	30 seconds
Ramp-down Rate (T <sub>P</sub> to T <sub>L</sub> )	6°C/second maximum
Time 25°C to Peak Temperature	8 minutes maximum

Figure 17. Reflow Profile

### Ordering Information<sup>(4)</sup>

Part Number	Package	Packing Method
MOC3051M	DIP 6-Pin	Tube (50 Units)
MOC3051SM	SMT 6-Pin (Lead Bend)	Tube (50 Units)
MOC3051SR2M	SMT 6-Pin (Lead Bend)	Tape and Reel (1000 Units)
MOC3051VM	DIP 6-Pin, DIN EN/IEC60747-5-5 Option	Tube (50 Units)
MOC3051SVM	SMT 6-Pin (Lead Bend), DIN EN/IEC60747-5-5 Option	Tube (50 Units)
MOC3051SR2VM	SMT 6-Pin (Lead Bend), DIN EN/IEC60747-5-5 Option	Tape and Reel (1000 Units)
MOC3051TVM	DIP 6-Pin, 0.4" Lead Spacing, DIN EN/IEC60747-5-5 Option	Tube (50 Units)

**Note:**

4. The product orderable part number system listed in this table also applies to the MOC3052M product families.

### Marking Information

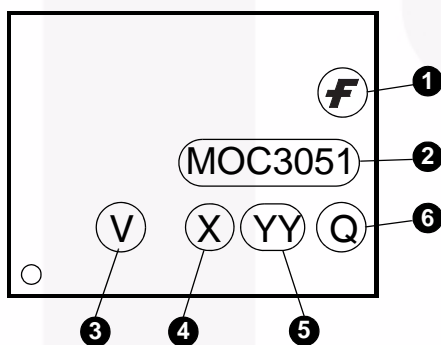


Figure 18. Top Mark

Top Mark Definitions	
1	Fairchild Logo
2	Device Number
3	DIN EN/IEC60747-5-5 Option (only appears on component ordered with this option)
4	One-Digit Year Code, e.g., '5'
5	Two-Digit Work Week, Ranging from '01' to '53'
6	Assembly Package Code



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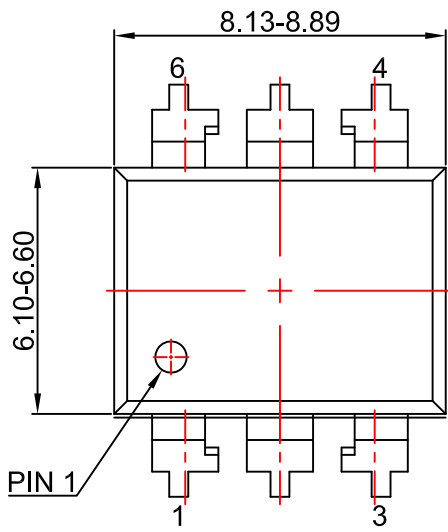
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