

MOC3051M, MOC3052M

6-Pin DIP Random-Phase Optoisolators Triac Drivers (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_{RMS} for 1 Minute
 - DIN EN/IEC60747-5-2

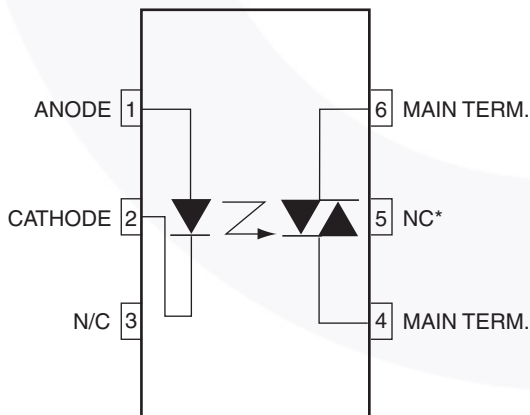
Applications

- 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

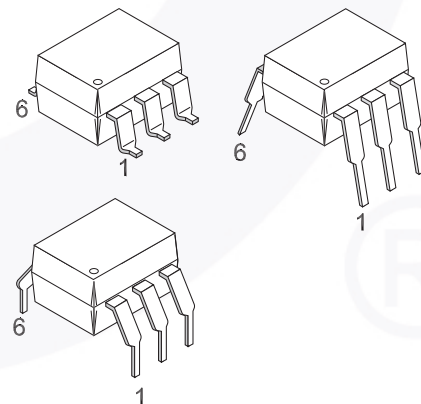


Figure 2. Package Outlines

Safety and Insulation Ratings

As per DIN EN/IEC60747-5-2. This optocoupler is suitable for “safe electrical insulation” only within the safety limit data. Compliance with the safety ratings is ensured by means of protective circuits.

| Symbol | Parameter | Min. | Typ. | Max. | Unit |
|-------------------|--|-----------------|----------|------|-------------------|
| | Installation Classifications per DIN VDE 0110/1.89 see Table 1 | | | | |
| | For Rated Mains Voltage < 150 V _{RMS} | | I-IV | | |
| | For Rated Mains Voltage < 300 V _{RMS} | | I-IV | | |
| | Climatic Classification | | 40/85/21 | | |
| | Pollution Degree (DIN VDE 0110/1.89) | | 2 | | |
| CTI | Comparative Tracking Index | 175 | | | |
| V _{PR} | Input to Output Test Voltage, Method b, V _{IORM} × 1.875 = V _{PR} , 100% Production Test with t _m = 1 s, Partial Discharge < 5 pC | 1594 | | | |
| | Input to Output Test Voltage, Method a, V _{IORM} × 1.5 = V _{PR} , Type and Sample Test with t _m = 60 s, Partial Discharge < 5 pC | 1275 | | | |
| V _{IORM} | Maximum Working Insulation Voltage | 850 | | | V _{peak} |
| V _{IOTM} | Highest Allowable Over Voltage | 6000 | | | V _{peak} |
| | External Creepage | 7 | | | mm |
| | External Clearance | 7 | | | mm |
| | External Clearance (for Option T, 0.4" Lead Spacing) | 10.16 | | | mm |
| | Insulation Thickness | 0.5 | | | mm |
| R _{IO} | Insulation Resistance at T _S , V _{IO} = 500 V | 10 ⁹ | | | 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 | Units |
|---------------------|--|--------------------|----------------------|
| Total Device | | | |
| T_{STG} | Storage Temperature | -40 to +150 | $^\circ\text{C}$ |
| T_{OPR} | Operating Temperature | -40 to +85 | $^\circ\text{C}$ |
| T_{SOL} | Lead Solder Temperature (Wave Solder) | 260 for 10 seconds | $^\circ\text{C}$ |
| T_J | Junction Temperature Range | -40 to +100 | $^\circ\text{C}$ |
| V_{ISO} | Isolation Surge Voltage ⁽¹⁾ (Peak AC Voltage, 60 Hz, 1 Second Duration) | 7500 | Vac(pk) |
| P_D | Total Device Power Dissipation at 25°C | 330 | mW |
| | Derate Above 25°C | 4.4 | mW/ $^\circ\text{C}$ |
| Emitter | | | |
| I_F | Continuous Forward Current | 60 | mA |
| V_R | Reverse Voltage | 3 | V |
| P_D | Total Device Power Dissipation at 25°C | 100 | mW |
| | Derate Above 25°C | 1.33 | mW/ $^\circ\text{C}$ |
| Detector | | | |
| V_{DRM} | Off-State Output Terminal Voltage | 600 | V |
| I_{TSM} | Peak Repetitive Surge Current (PW = 100 μs , 120 pps) | 1 | A |
| P_D | Total Power Dissipation at 25°C Ambient | 300 | mW |
| | Derate Above 25°C | 4 | mW/ $^\circ\text{C}$ |

Note:

1. Isolation surge voltage, V_{ISO} , is an internal device breakdown rating. For this text, pins 1 and 2 are common, and pins 4, 5 and 6 are common.

Electrical Characteristics

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

Individual Component Characteristics

| Symbol | Parameters | Test Conditions | Min. | Typ.* | Max. | Units |
|------------------|--|---|------|-------|------|------------------|
| EMITTER | | | | | | |
| V_F | Input Forward Voltage | $I_F = 10\text{ mA}$ | | 1.18 | 1.5 | V |
| I_R | Reverse Leakage Current | $V_R = 3\text{ V}$ | | 0.05 | 100 | μA |
| DETECTOR | | | | | | |
| I_{DRM} | Peak Blocking Current, Either Direction | $V_{\text{DRM}} = 600\text{ V}$, $I_F = 0^{(2)}$ | | 10 | 100 | nA |
| V_{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 12, at 400V) | 1000 | | | V/ μs |

Transfer Characteristics

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

Isolation Characteristics

| Symbol | Characteristic | Test Conditions | Min. | Typ.* | Max. | Units |
|------------------|--------------------------------|---|------|-----------|------|------------------|
| V_{ISO} | Input-Output Isolation Voltage | $f = 60\text{ Hz}$, $t = 1\text{ Minute}$ | 4170 | | | V_{RMS} |
| R_{ISO} | Isolation Resistance | $V_{\text{I-O}} = 500\text{ V}_{\text{DC}}$ | | 10^{11} | | Ω |
| C_{ISO} | Isolation Capacitance | $V = 0\text{ V}$, $f = 1\text{ MHz}$ | | 0.2 | | pF |

*Typical values at $T_A = 25^\circ\text{C}$

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_{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).

Typical Performance Curves

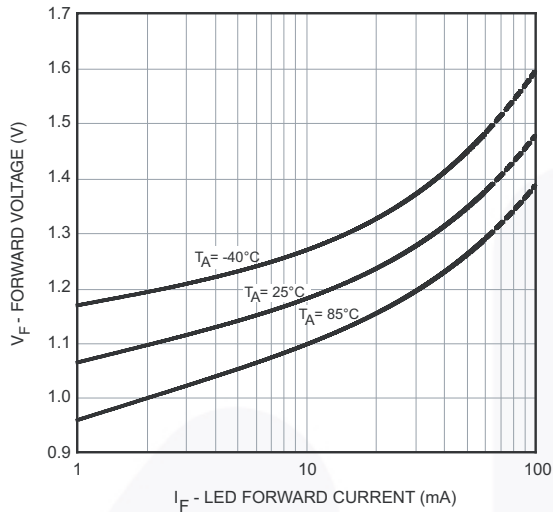


Figure 3. LED Forward Voltage vs. Forward Current

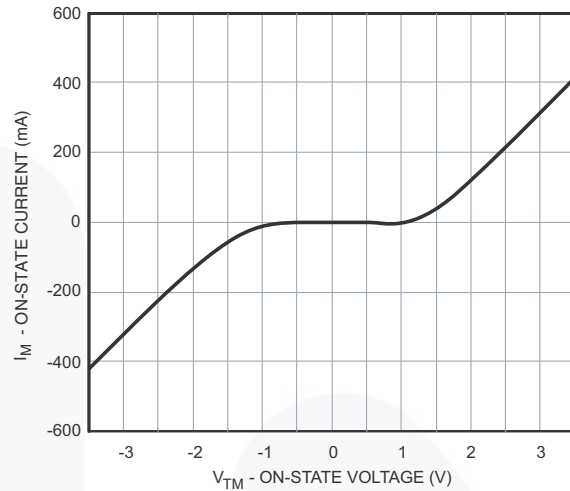


Figure 4. On-State Characteristics

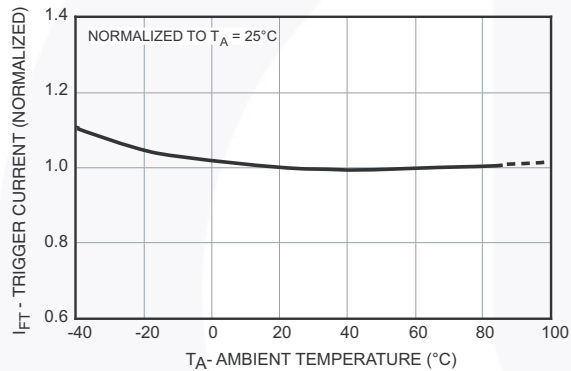


Figure 5. Trigger Current vs. Ambient Temperature

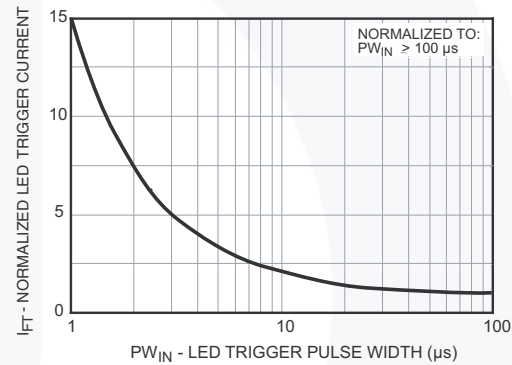


Figure 6. LED Current Required to Trigger vs. LED Pulse Width

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 μs 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 μs

I_{FT} (pulsed) = 10 mA \times 5 = 50 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_{FT} 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_{FT} versus the reapplied voltage rise with a V_p of 400V. This dv/dt condition simulates a worst case commutating dv/dt amplitude.

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

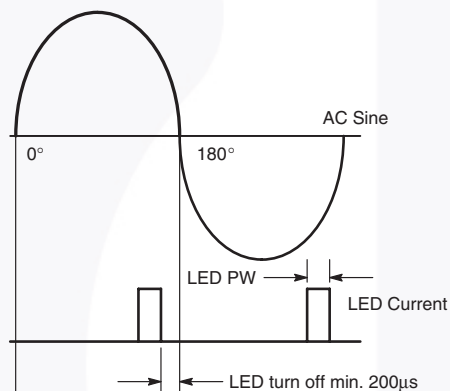


Figure 7. Minimum Time for LED Turn Off to Zero Cross of AC Trailing Edge

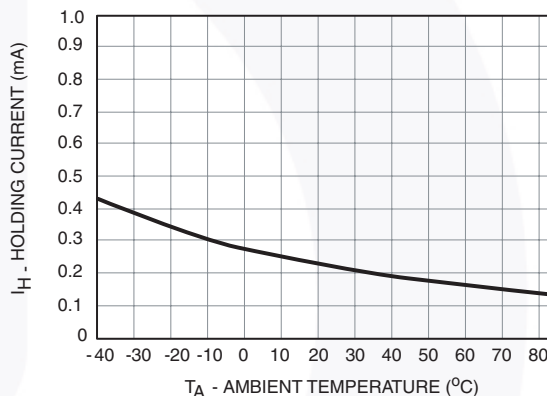


Figure 8. Holding Current, I_H vs. Temperature

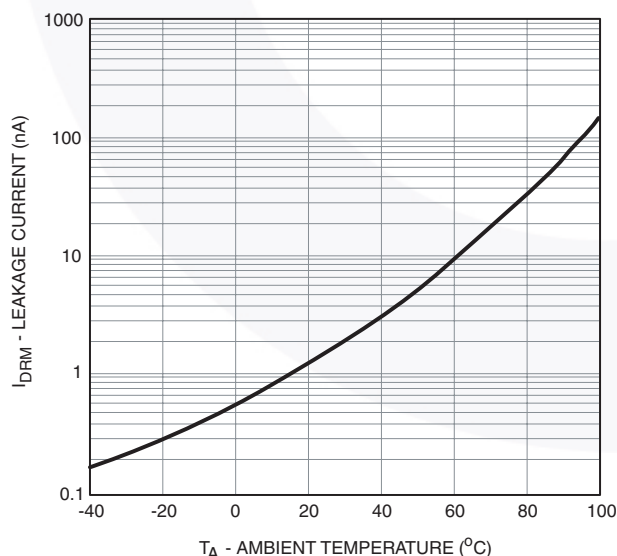


Figure 9. Leakage Current, I_{DRM} vs. Temperature

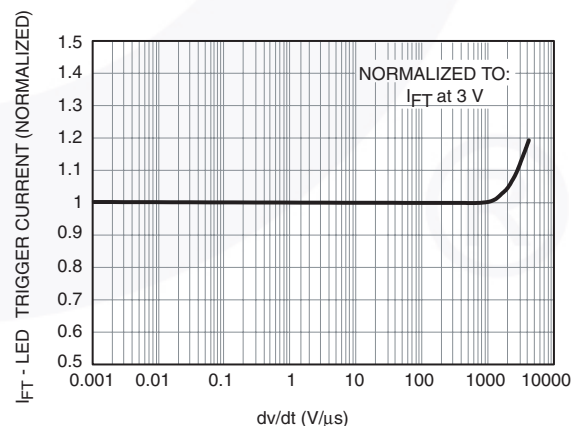


Figure 10. LED Trigger Current, I_{FT} vs. dv/dt

t(delay), t(f) versus I_{FT}

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_{FT} 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_{TEST} 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_{RC} is measured at this point and recorded.

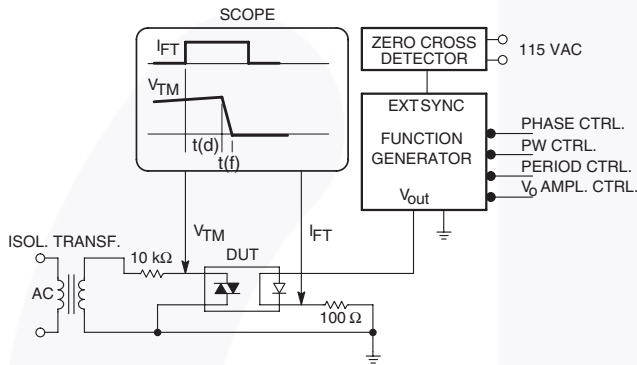


Figure 11. Switching Time Test Circuit

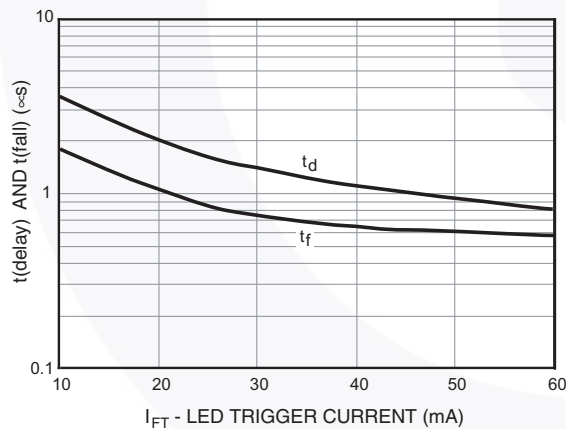


Figure 12. Delay Time, t(d), and Fall Time, t(f), vs. LED Trigger Current

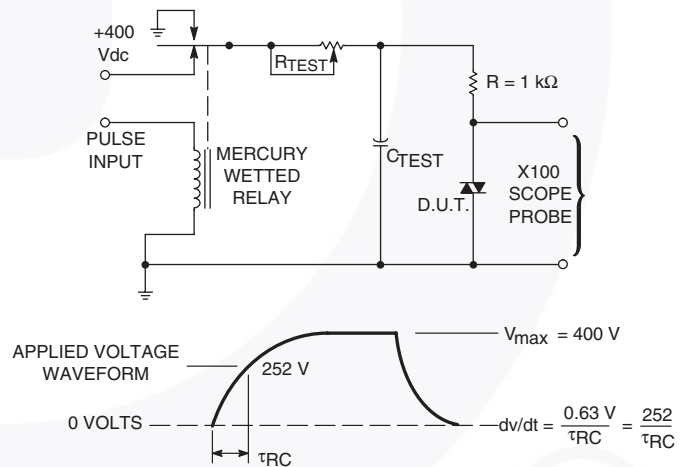


Figure 13. Static dv/dt Test Circuit

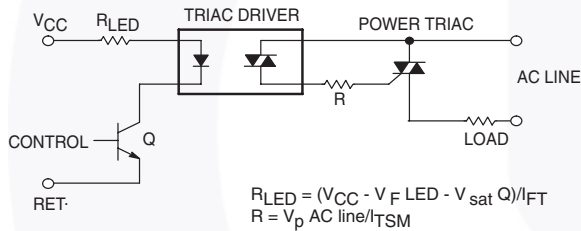
Applications Guide

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

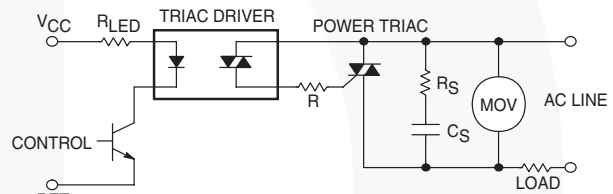
Triac Driver Circuit for Noisy Environments

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

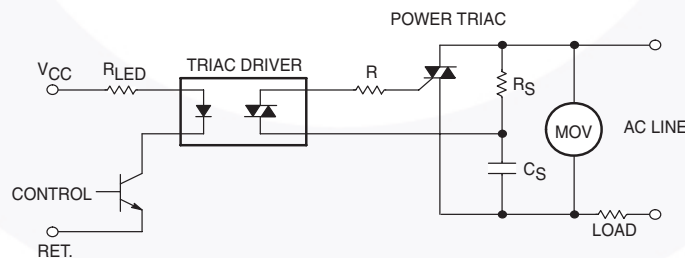
As specified in the noise standards IEEE472 and IEC255-4.

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 $> V_{DRM} \text{ max.}$

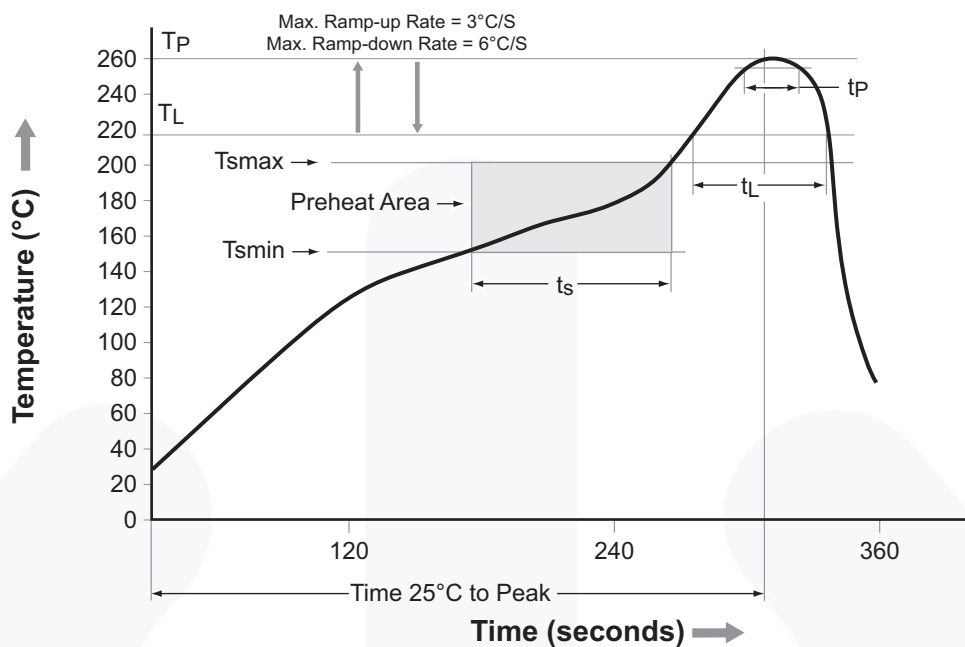
Figure 15. Triac Driver Circuit for Noisy Environments



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



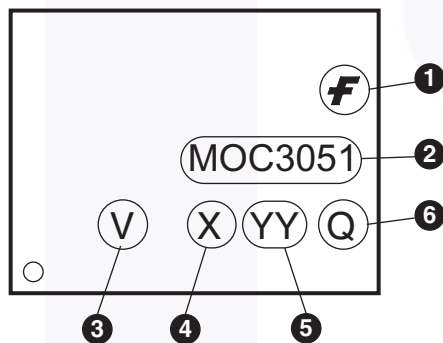
| Profile Feature | Pb-Free Assembly Profile |
|---|---------------------------|
| Temperature Minimum (T _{smin}) | 150°C |
| Temperature Maximum (T _{smax}) | 200°C |
| Time (t _s) from (T _{smin} to T _{smax}) | 60 seconds to 120 seconds |
| Ramp-up Rate (T _L to T _P) | 3°C/second maximum |
| Liquidous Temperature (T _L) | 217°C |
| Time (t _L) Maintained Above (T _L) | 60 seconds to 150 seconds |
| Peak Body Package Temperature | 260°C +0°C / -5°C |
| Time (t _p) within 5°C of 260°C | 30 seconds |
| Ramp-down Rate (T _P to T _L) | 6°C/second maximum |
| Time 25°C to Peak Temperature | 8 minutes maximum |

Figure 17. Reflow Profile

Ordering Information

| Option | Order Entry Identifier (Example) | Description |
|-----------|----------------------------------|---|
| No option | MOC3051M | Standard Through Hole Device |
| S | MOC3051SM | Surface Mount Lead Bend |
| SR2 | MOC3051SR2M | Surface Mount; Tape and Reel |
| V | MOC3051VM | DIN EN/IEC60747-5-2 (VDE) |
| TV | MOC3051TVM | DIN EN/IEC60747-5-2 (VDE), 0.4" Lead Spacing |
| SV | MOC3051SVM | DIN EN/IEC60747-5-2 (VDE), Surface Mount |
| SR2V | MOC3051SR2VM | DIN EN/IEC60747-5-2 (VDE), Surface Mount, Tape and Reel |

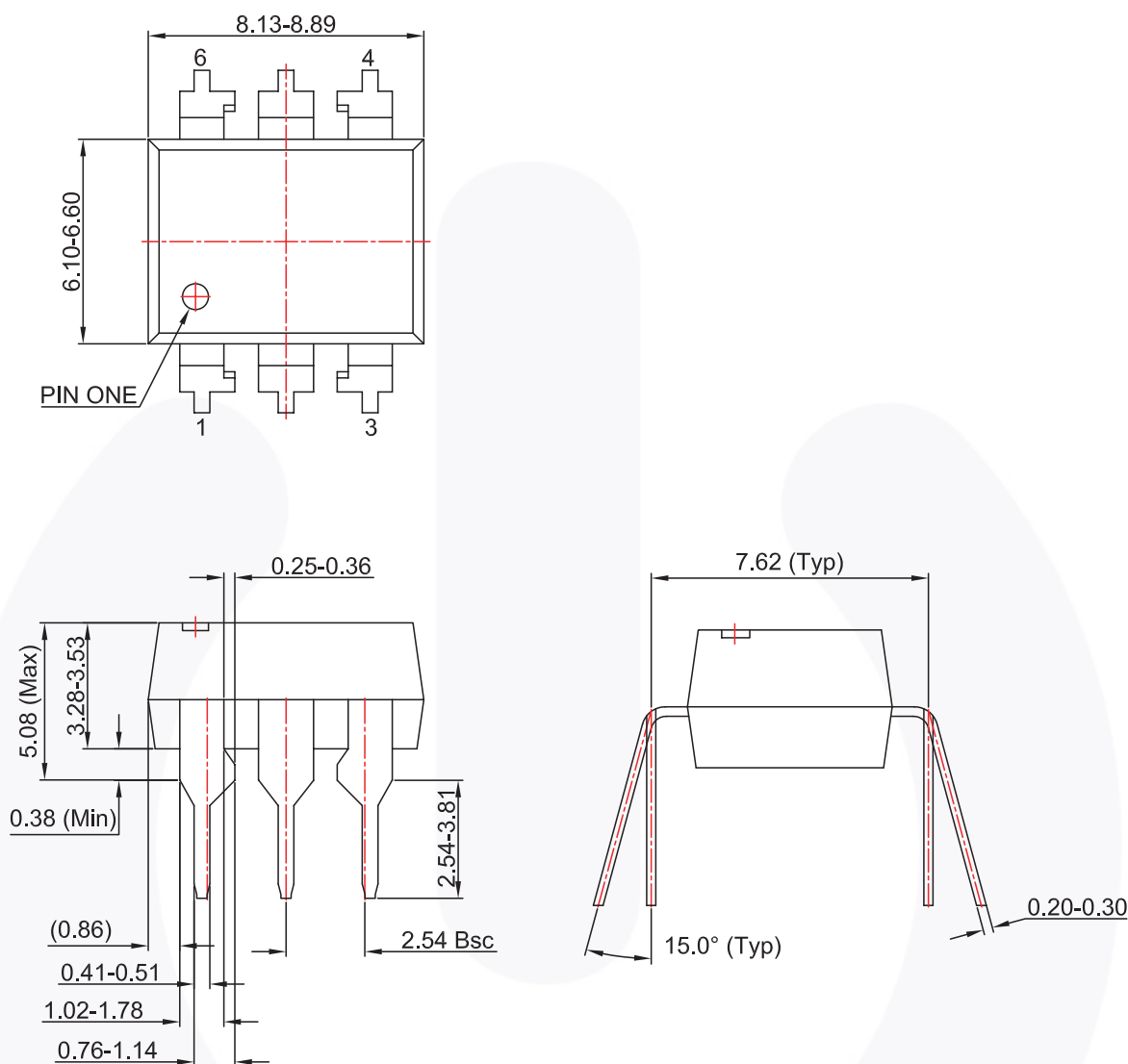
Marking Information



| Definitions | |
|-------------|--|
| 1 | Fairchild logo |
| 2 | Device number |
| 3 | DIN EN/IEC60747-5-2 (VDE) mark (Note: Only appears on parts ordered with VDE option – See order entry table) |
| 4 | One-digit year code, e.g., '3' |
| 5 | Two-digit work week, ranging from '01' to '53' |
| 6 | Assembly package code |

*Note – Parts that do not have the 'V' option (see definition 3 above) that are marked with date code '325' or earlier are marked in portrait format.

Package Dimensions



NOTES:

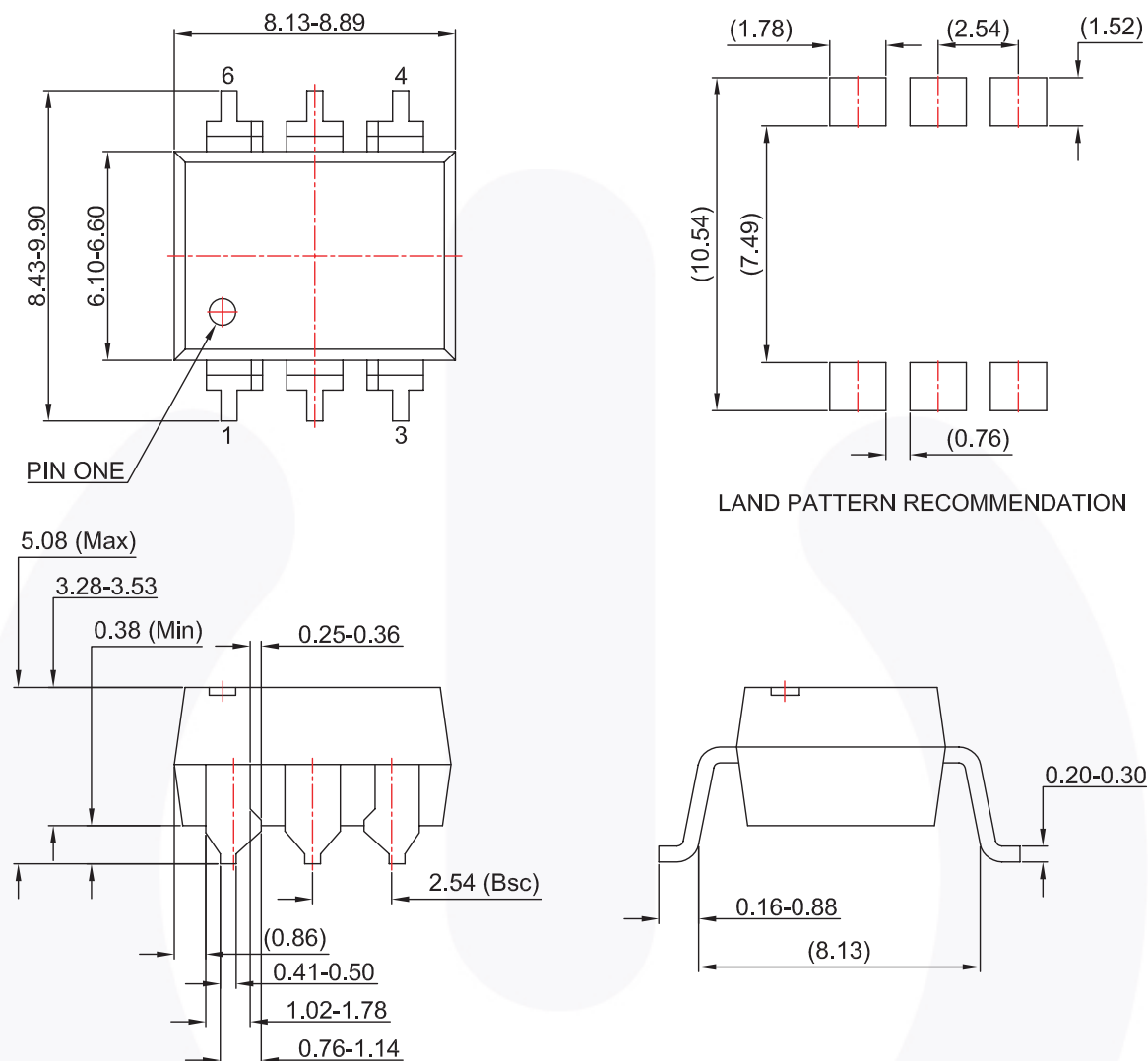
- A) NO STANDARD APPLIES TO THIS PACKAGE.
- B) ALL DIMENSIONS ARE IN MILLIMETERS.
- C) DIMENSIONS ARE EXCLUSIVE OF BURRS, MOLD FLASH, AND TIE BAR EXTRUSION
- D) DRAWING FILENAME AND REVISION: MKT-N06BREV3.

Figure 18. 6-Pin DIP Through Hole

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Package Dimensions (Continued)



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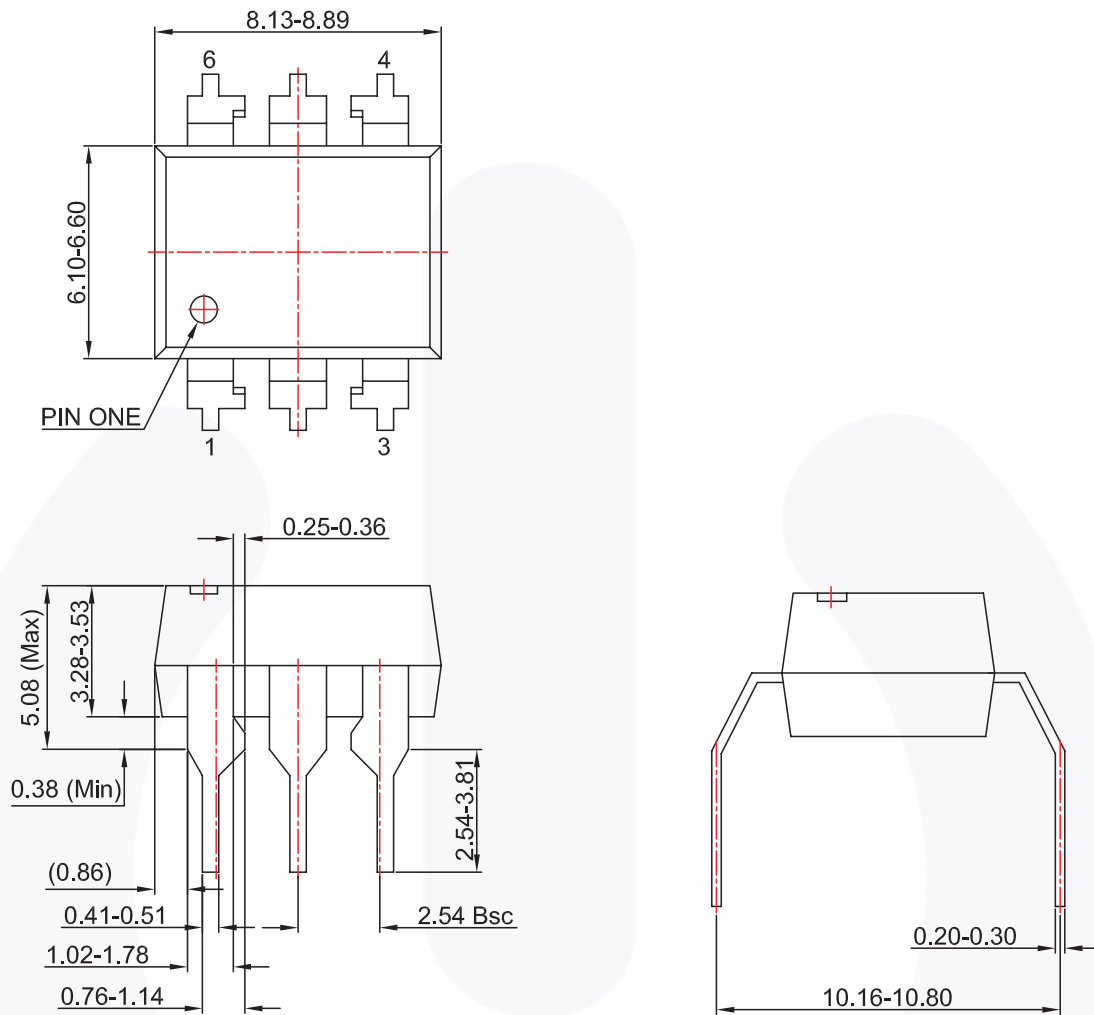
Figure 19. 6-Pin DIP Surface Mount

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Package Dimensions (Continued)



NOTES:

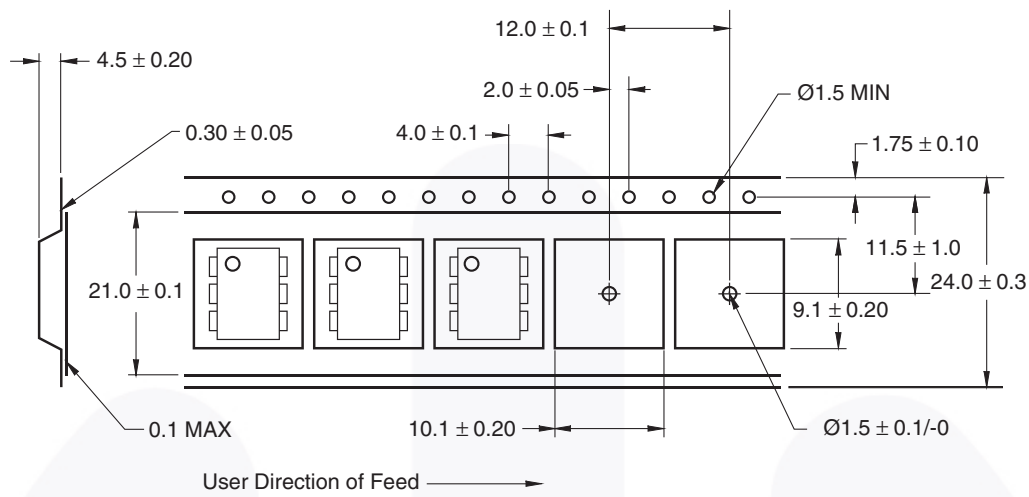
- A) NO STANDARD APPLIES TO THIS PACKAGE.
- B) ALL DIMENSIONS ARE IN MILLIMETERS.
- C) DIMENSIONS ARE EXCLUSIVE OF BURRS, MOLD FLASH, AND TIE BAR EXTRUSION
- D) DRAWING FILENAME AND REVISION: MKT-N06DREV3.

Figure 20. 6-Pin DIP 0.4" Lead Spacing

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Tape Dimensions








Note:
All dimensions are in millimeters.

Figure 21. Tape Dimensions



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| DEUXPEED® | ISOPLANAR™ | SignalWise™ | TinyWire™ |
| Dual Cool™ | Making Small Speakers Sound Louder and Better™ | SmartMax™ | TranSiC™ |
| EcoSPARK® | MegaBuck™ | SMART START™ | TriFault Detect™ |
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As used herein:

- Life support devices or systems are devices or systems which, (a) are intended for surgical implant into the body or (b) support or sustain life, and (c) whose failure to perform when properly used in accordance with instructions for use provided in the labeling, can be reasonably expected to result in a significant injury of the user.
- A critical component in any component of a life support, device, or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.

ANTI-COUNTERFEITING POLICY

Fairchild Semiconductor Corporation's Anti-Counterfeiting Policy. Fairchild's Anti-Counterfeiting Policy is also stated on our external website, www.fairchildsemi.com, under Sales Support.

Counterfeiting of semiconductor parts is a growing problem in the industry. All manufacturers of semiconductor products are experiencing counterfeiting of their parts. Customers who inadvertently purchase counterfeit parts experience many problems such as loss of brand reputation, substandard performance, failed applications, and increased cost of production and manufacturing delays. Fairchild is taking strong measures to protect ourselves and our customers from the proliferation of counterfeit parts. Fairchild strongly encourages customers to purchase Fairchild parts either directly from Fairchild or from Authorized Fairchild Distributors who are listed by country on our web page cited above. Products customers buy either from Fairchild directly or from Authorized Fairchild Distributors are genuine parts, have full traceability, meet Fairchild's quality standards for handling and storage and provide access to Fairchild's full range of up-to-date technical and product information. Fairchild and our Authorized Distributors will stand behind all warranties and will appropriately address any warranty issues that may arise. Fairchild will not provide any warranty coverage or other assistance for parts bought from Unauthorized Sources. Fairchild is committed to combat this global problem and encourage our customers to do their part in stopping this practice by buying direct or from authorized distributors.

PRODUCT STATUS DEFINITIONS

Definition of Terms

| Datasheet Identification | Product Status | Definition |
|--------------------------|-----------------------|---|
| Advance Information | Formative / In Design | Datasheet contains the design specifications for product development. Specifications may change in any manner without notice. |
| Preliminary | First Production | Datasheet contains preliminary data; supplementary data will be published at a later date. Fairchild Semiconductor reserves the right to make changes at any time without notice to improve design. |
| No Identification Needed | Full Production | Datasheet contains final specifications. Fairchild Semiconductor reserves the right to make changes at any time without notice to improve the design. |
| Obsolete | Not In Production | Datasheet contains specifications on a product that is discontinued by Fairchild Semiconductor. The datasheet is for reference information only. |

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