

September 2009

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

# **Features**

- Excellent I<sub>FT</sub> stability—IR emitting diode has low degradation
- High isolation voltage—minimum 7500 peak VAC
- Underwriters Laboratory (UL) recognized— File #E90700, Volume 2
- 600V peak blocking voltage
- IEC60747-5-2 approved (File #94766)
  - Ordering option V (e.g. MOC3052VM)

# **Applications**

- Solenoid/valve controls
- Lamp ballasts
- Static AC power switch
- Interfacing microprocessors to 115 and 240 Vac peripherals
- Solid state relay
- Incandescent lamp dimmers
- Temperature controls
- Motor controls

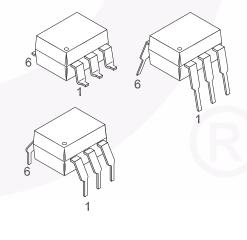
# **Description**

The MOC3051M and MOC3052M consist of a AlGaAs infrared emitting diode optically coupled to a non-zero-crossing silicon bilateral AC switch (triac). These devices isolate low voltage logic from 115 and 240 Vac 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**

# ANODE 1 CATHODE 2 N/C 3 \*DO NOT CONNECT (TRIAC SUBSTRATE)

# **Package Outlines**



# **Absolute Maximum Ratings** (T<sub>A</sub> = 25°C unless otherwise specified.)

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.

| Symbol           | Parameters  | Value          | Units   |
|------------------|---|----------------|---------|
| TOTAL DI         | EVICE   | 1              | ı       |
| T <sub>STG</sub> | Storage Temperature   | -40 to +150    | °C      |
| T <sub>OPR</sub> | Operating Temperature   | -40 to +85     | °C      |
| T <sub>SOL</sub> | Lead Solder Temperature (Wave Solder)   | 260 for 10 sec | °C      |
| TJ               | Junction Temperature Range  | -40 to +100    | °C      |
| V <sub>ISO</sub> | Isolation Surge Voltage <sup>(1)</sup> (peak AC voltage, 60Hz, 1 sec. duration) | 7500           | Vac(pk) |
| P <sub>D</sub>   | Total Device Power Dissipation @ 25°C   | 330            | mW      |
|                  | Derate above 25°C   | 4.4            | mW/°C   |
| EMITTER          |   |                |         |
| I <sub>F</sub>   | Continuous Forward Current  | 60             | mA      |
| V <sub>R</sub>   | Reverse Voltage   | 3              | V       |
| $P_{D}$          | Total Device Power Dissipation @ 25°C   | 100            | mW      |
|                  | Derate above 25°C   | 1.33           | mW/°C   |
| DETECTO          | DR .  |                |         |
| $V_{DRM}$        | Off-State Output Terminal Voltage   | 600            | V       |
| I <sub>TSM</sub> | Peak Repetitive Surge Current (PW = 100µs, 120pps)                              | 1              | Α       |
| P <sub>D</sub>   | Total Power Dissipation @ 25°C Ambient  | 300            | mW      |
|                  | Derate above 25°C   | 4              | mW/°C   |
|                  | ·   |                | •       |

# Note:

1. Isolation surge votlage, V<sub>ISO</sub>, 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<sub>A</sub> = 25°C unless otherwise specified.)

# **Individual Component Characteristics**

| Symbol           | Parameters                                 | Test Conditions                                  | Min. | Тур.* | Max. | Units |
|------------------|--|--|------|-------|------|-------|
| EMITTER          |  |  |      |       |      | !     |
| V <sub>F</sub>   | Input Forward Voltage                      | I <sub>F</sub> = 10mA                            |      | 1.18  | 1.5  | V     |
| I <sub>R</sub>   | Reverse Leakage Current                    | V <sub>R</sub> = 3V                              |      | 0.05  | 100  | μA    |
| DETECTO          | DETECTOR                                   |  |      |       |      |       |
| I <sub>DRM</sub> | Peak Blocking Current, Either Direction    | $V_{DRM}$ , $I_F = 0^{(2)}$                      |      | 10    | 100  | nA    |
| V <sub>TM</sub>  | Peak On-State Voltage, Either Direction    | I <sub>TM</sub> = 100mA peak, I <sub>F</sub> = 0 |      | 1.7   | 2.5  | V     |
| dv/dt            | Critical Rate of Rise of Off-State Voltage | I <sub>F</sub> = 0 (Figure 7, @ 400V)            | 1000 |       |      | V/µs  |

# **Transfer Characteristics**

| Symbol          | DC Characteristics                   | Test Conditions             | Device   | Min. | Тур.* | Max. | Units |
|-----------------|--------------------------------------|-----------------------------|----------|------|-------|------|-------|
| I <sub>FT</sub> | LED Trigger Current,                 | Main terminal               | MOC3051M |      |       | 15   | mA    |
|                 | Either Direction                     | Voltage = 3V <sup>(3)</sup> | MOC3052M |      |       | 10   |       |
| I <sub>H</sub>  | Holding Current,<br>Either Direction |                             | All      |      | 220   |      | μA    |

# **Isolation Characteristics**

| Symbol           | Characteristic                    | Test Conditions           | Min. | Тур.*            | Max. | Units   |
|------------------|-----------------------------------|---------------------------|------|------------------|------|---------|
| V <sub>ISO</sub> | Input-Output Isolation<br>Voltage | f = 60Hz, t = 1 sec.      | 7500 |                  |      | Vac(pk) |
| R <sub>ISO</sub> | Isolation Resistance              | V <sub>I-O</sub> = 500VDC |      | 10 <sup>11</sup> |      | Ω       |
| C <sub>ISO</sub> | Isolation Capacitance             | V = 0V, f = 1MHz          |      | 0.2              |      | pF      |

<sup>\*</sup>Typical values at T<sub>A</sub> = 25°C

#### Notes:

- 2. Test voltage must be applied within dv/dt rating.
- 3. All devices are guaranteed to trigger at an  $I_F$  value less than or equal to max  $I_{FT}$ . Therefore, recommended operating  $I_F$  lies between max. 15A for MOC3051M, 10mA for MOC3052M and absolute max.  $I_F$  (60mA).

# **Safety and Insulation Ratings**

As per IEC 60747-5-2, 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.

| Symbol            | Parameter   | Min.            | Тур.      | Max. | Unit              |
|-------------------|---|-----------------|-----------|------|-------------------|
|                   | Installation Classifications per DIN VDE 0110/1.89 Table 1  |                 |           |      |                   |
|                   | For Rated Main Voltage < 150Vrms  |                 | I-IV      |      |                   |
|                   | For Rated Main voltage < 300Vrms  |                 | I-IV      |      |                   |
|                   | Climatic Classification   |                 | 55/100/21 |      |                   |
|                   | Pollution Degree (DIN VDE 0110/1.89)  |                 | 2         |      |                   |
| CTI               | Comparative Tracking Index  | 175             |           |      |                   |
| V <sub>PR</sub>   | Input to Output Test Voltage, Method b, V <sub>IORM</sub> x 1.875 = V <sub>PR</sub> , 100% Production Test with tm = 1 sec, Partial Discharge < 5pC | 1594            |           |      | V <sub>peak</sub> |
|                   | Input to Output Test Voltage, Method a, V <sub>IORM</sub> x 1.5 = V <sub>PR</sub> , Type and Sample Test with tm = 60 sec, Partial Discharge < 5pC  | 1275            |           |      | V <sub>peak</sub> |
| V <sub>IORM</sub> | Max. Working Insulation Voltage   | 850             |           |      | V <sub>peak</sub> |
| $V_{IOTM}$        | Highest Allowable Over Voltage  | 6000            |           |      | V <sub>peak</sub> |
|                   | External Creepage   | 7               |           |      | mm                |
|                   | External Clearance  | 7               | 1         |      | mm                |
|                   | Insulation Thickness  | 0.5             |           |      | mm                |
| RIO               | Insulation Resistance at Ts, V <sub>IO</sub> = 500V   | 10 <sup>9</sup> |           |      | Ω                 |

# **Typical Performance Curves**

Figure 1. LED Forward Voltage vs. Forward Current

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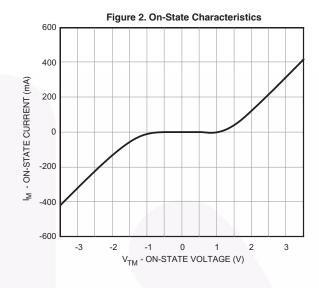
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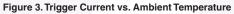
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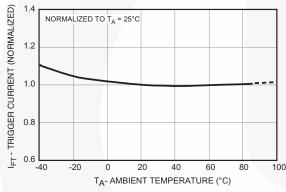
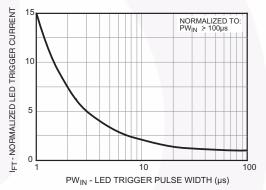


Figure 4. LED Current Required to Trigger vs. LED Pulse Width



# I<sub>F</sub> vs. Temperature (normalized)

Figure 3 shows the increase of the trigger current when the device is expected to operate at an ambient temperature below 25°C. Multiply the normalized  $I_{\text{FT}}$  shown this graph with the data sheet guaranteed  $I_{\text{FT}}$ .

#### Example:

 $T_A = -40$ °C,  $I_{FT} = 10$  mA  $I_{FT}$  @ -40°C = 10 mA x 1.4 = 14 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 $\mu$ s must have an increased amplitude as shown on Figure 4. This graph shows the dependency of the trigger current  $\mu$ r versus the pulse width can be seen on the chart delay t(d) versus the LED trigger current.

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

# Example:

Guaranteed  $I_{FT}$  = 10 mA, Trigger pulse width PW = 3 $\mu$ s  $I_{FT}$  (pulsed) = 10 mA x 5 = 50mA

# 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 200ms before AC zero cross as shown in Figure 5. This assures that the triac driver has time to switch off. Shorter times may cause loss of control at the following half cycle.

# IFT 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 8 shows the dependency of the triac drivers  $I_{\text{FT}}$  versus the reapplied voltage rise with a Vp 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/ms. The data sheet specified  $I_{FT}$  is therefore applicable for all practical inductive loads and load factors.



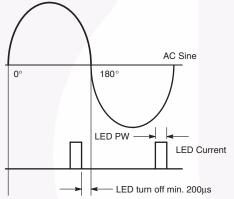
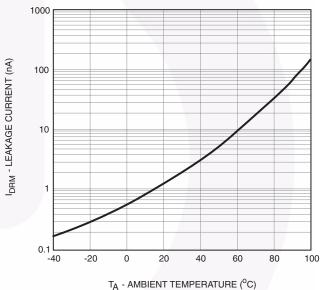
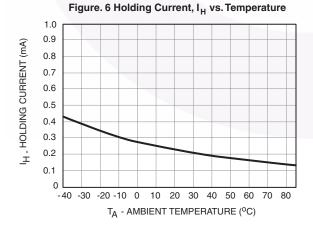
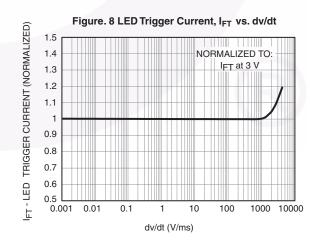


Figure 5. Minimum Time for LED Turn-Off to Zero
Cross of AC Trailing Edge







# t(delay), t(f) versus IFT

The triac driver's turn on switching speed consists of a turn on delay time t(d) and a fall time t(f). Figure 9 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.

# **Switching Time Test Circuit**

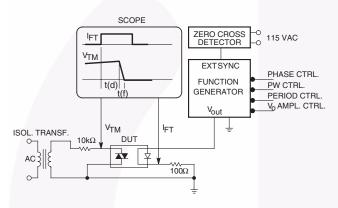
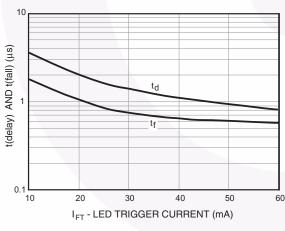
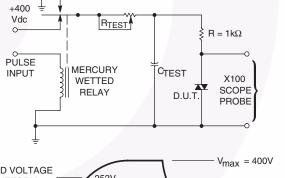


Figure 9. Delay Time, t(d), and Fall Time, t(f), vs. LED Trigger Current





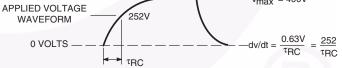


Figure 10. Static dv/dt Test Circuit

# **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 11 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 1A.

# $R = Vp AC/I_{TM} max rep. = Vp AC/1A$

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.

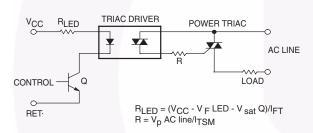


Figure 11. Basic Driver Circuit

# **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 12 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 13 is recommended.

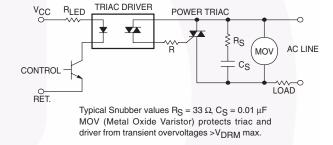
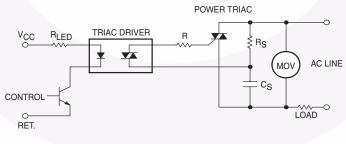


Figure 12. Triac Driver Circuit for Noisy Environments

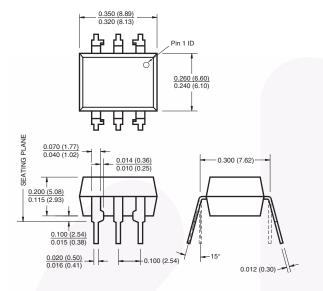


Recommended snubber to pass IEEE472 and IEC255-4 noise tests RS = 47 $\Omega$ , CS = 0.01 $\mu$ F

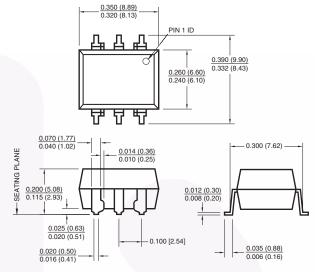
Figure 13. Triac Driver Circuit for Extremely Noisy Environments

# **Package Dimensions**

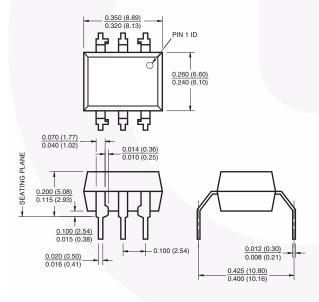
# **Through Hole**



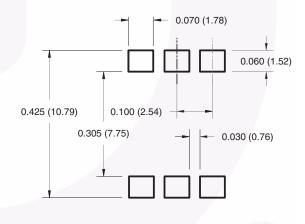
# **Surface Mount**



# 0.4" Lead Spacing



# Recommended Pad Layout for Surface Mount Leadform



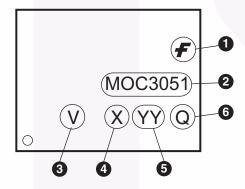
# Note:

All dimensions are in inches (millimeters).

# **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           |
| Т         | MOC3051TM                        | 0.4" Lead Spacing                      |
| V         | MOC3051VM                        | VDE 0884                               |
| TV        | MOC3051TVM                       | VDE 0884, 0.4" Lead Spacing            |
| SV        | MOC3051SVM                       | VDE 0884, Surface Mount                |
| SR2V      | MOC3051SR2VM                     | VDE 0884, Surface Mount, Tape and Reel |

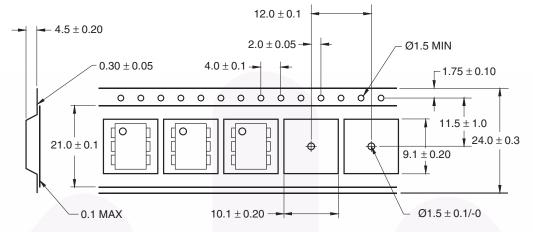
# **Marking Information**



| Definitions |  |  |  |  |  |
|-------------|--|--|--|--|--|
| 1           | Fairchild logo   |  |  |  |  |
| 2           | Device number  |  |  |  |  |
| 3           | 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  |  |  |  |  |

<sup>\*</sup>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.

# **Tape Dimensions**

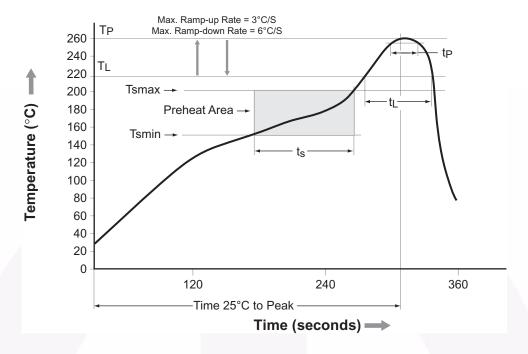


User Direction of Feed

# Note:

All dimensions are in millimeters.

# **Reflow Profile**



| Profile Freature  | Pb-Free Assembly Profile |
|---|--------------------------|
| Temperature Min. (Tsmin)                                  | 150°C                    |
| Temperature Max. (Tsmax)                                  | 200°C                    |
| Time (t <sub>S</sub> ) from (Tsmin to Tsmax)              | 60-120 seconds           |
| Ramp-up Rate (t <sub>L</sub> to t <sub>P</sub> )          | 3°C/second max.          |
| Liquidous Temperature (T <sub>L</sub> )                   | 217°C                    |
| Time (t <sub>L</sub> ) Maintained Above (T <sub>L</sub> ) | 60-150 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 max.          |
| Time 25°C to Peak Temperature                             | 8 minutes max.           |





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|--------------------------|-----------------------|---|--|--|--|
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