



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 VAC_{RMS} for 1 Minute
 - DIN EN/IEC60747-5-5

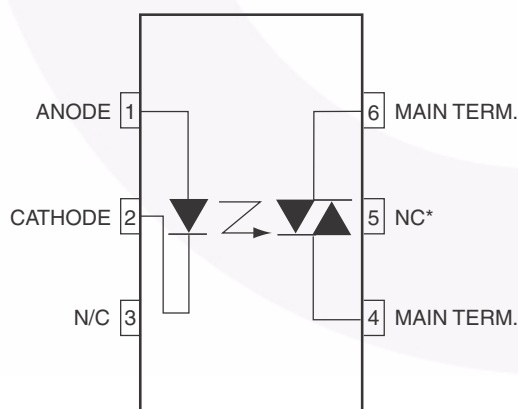
Applications

- 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

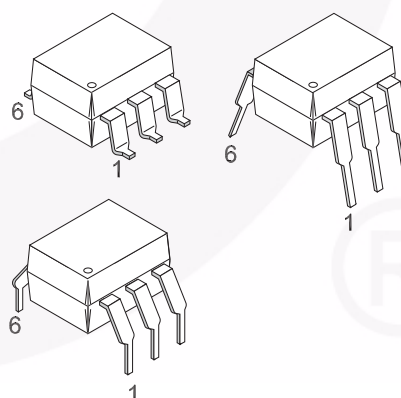


Figure 2. Package Outlines

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 _{RMS} | I–IV |
| | < 300 V _{RMS} | I–IV |
| Climatic Classification | | 40/85/21 |
| Pollution Degree (DIN VDE 0110/1.89) | | 2 |
| Comparative Tracking Index | | 175 |

| Symbol | Parameter | Value | Unit |
|-------------------|--|-------------------|-------------------|
| V _{PR} | Input-to-Output Test Voltage, Method A, V _{IORM} × 1.6 = V _{PR} , Type and Sample Test with t _m = 10 s, Partial Discharge < 5 pC | 1360 | V _{peak} |
| | 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 | V _{peak} |
| 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 TV, 0.4" Lead Spacing) | ≥ 10 | mm |
| DTI | Distance Through Insulation (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 | Unit |
|---------------------|--|--------------------|----------------------|
| Total Device | | | |
| 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°C Ambient | 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 Power Dissipation at 25°C Ambient | 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 Non-Repetitive Surge Current (Single Cycle 60 Hz Sine Wave) | 1 | A |
| P_D | Total Power Dissipation at 25°C Ambient | 300 | mW |
| | Derate Above 25°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 |
|------------------|--|---|------|------|------|------------------|
| EMITTER | | | | | | |
| 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 | μA |
| DETECTOR | | | | | | |
| I_{DRM} | Peak Blocking Current, Either Direction | $V_{\text{DRM}} = 600\text{ V}$, $I_F = 0^{(1)}$ | | 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 13, at 400V) | 1000 | | | V/ μs |

Transfer Characteristics

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

Isolation Characteristics

| Symbol | Characteristic | Test Conditions | Min. | Typ. | Max. | Unit |
|------------------|---|---|------|-----------|------|---------------------|
| V_{ISO} | Input-Output Isolation Voltage ⁽³⁾ | $f = 60\text{ Hz}$, $t = 1\text{ Minute}$ | 4170 | | | $V_{\text{AC RMS}}$ |
| 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 |

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).
- Isolation voltage, V_{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

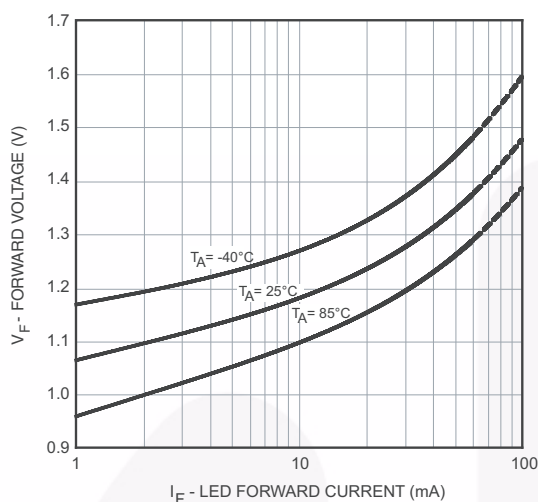


Figure 3. LED Forward Voltage vs. Forward Current

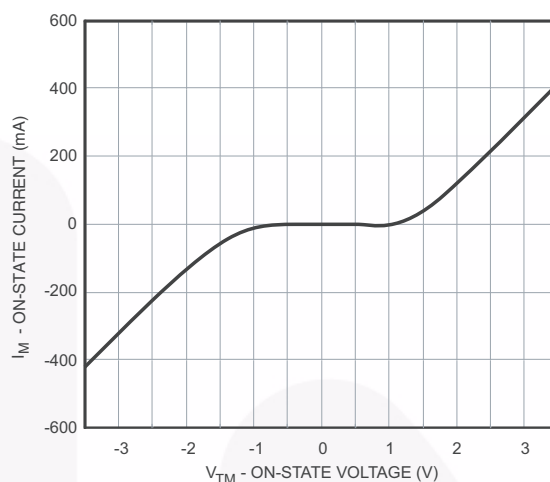


Figure 4. On-State Characteristics

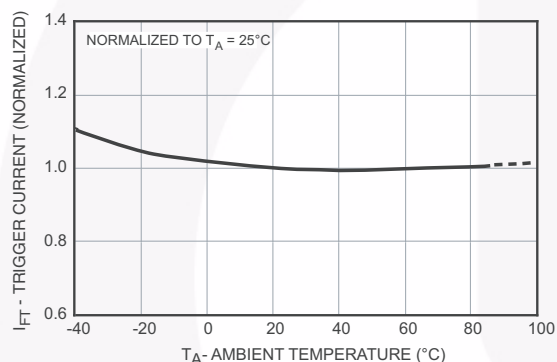


Figure 5. Trigger Current vs. Ambient Temperature

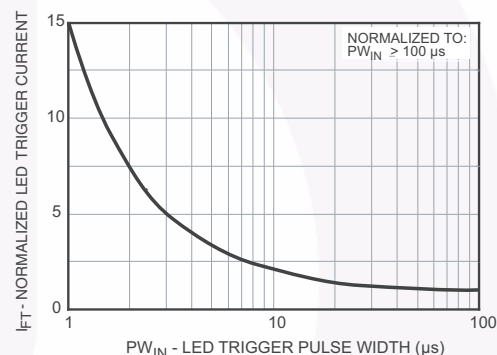


Figure 6. LED Current Required to Trigger vs. LED Pulse Width

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 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 $PW = 3\text{ }\mu\text{s}$

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

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 $200\ \mu\text{s}$ 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 $1000\text{V}/\mu\text{s}$. The data sheet specified I_{FT} is therefore applicable for all practical inductive loads and load factors.

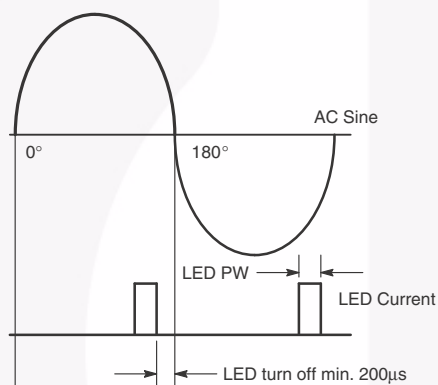


Figure 7. Minimum Time for LED Turn Off to Zero Cross of AC Trailing Edge

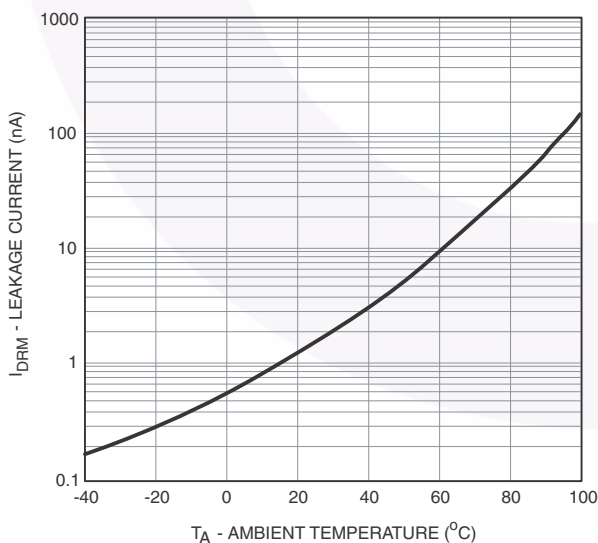


Figure 9. Leakage Current, I_{DRM} vs. Temperature

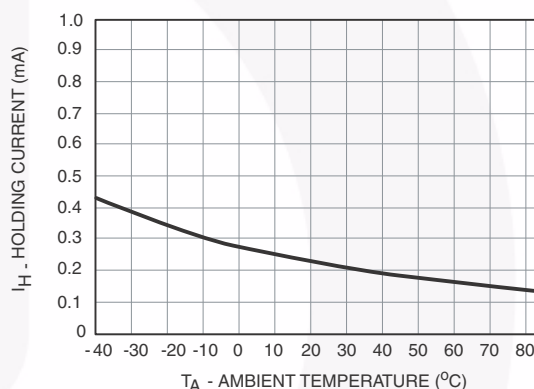


Figure 8. Holding Current, I_H vs. Temperature

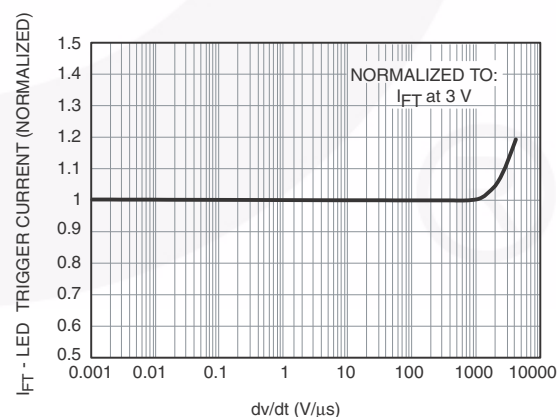


Figure 10. LED Trigger Current, I_{FT} vs. dv/dt

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.

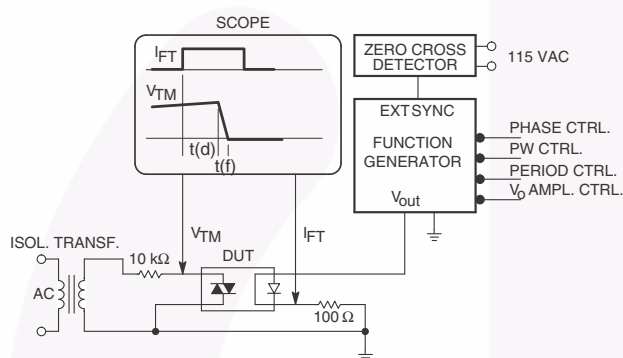


Figure 11. Switching Time Test Circuit

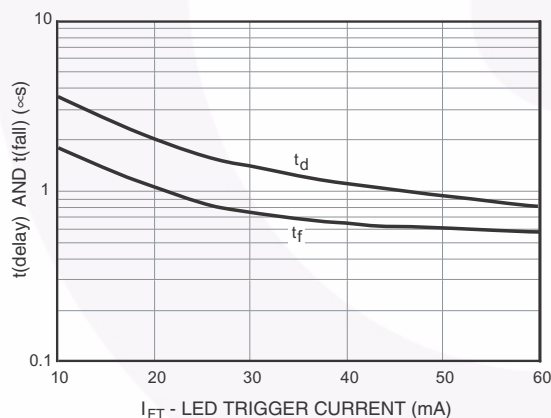


Figure 12. Delay Time, $t(d)$, and Fall Time, $t(f)$, vs. LED Trigger Current

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.

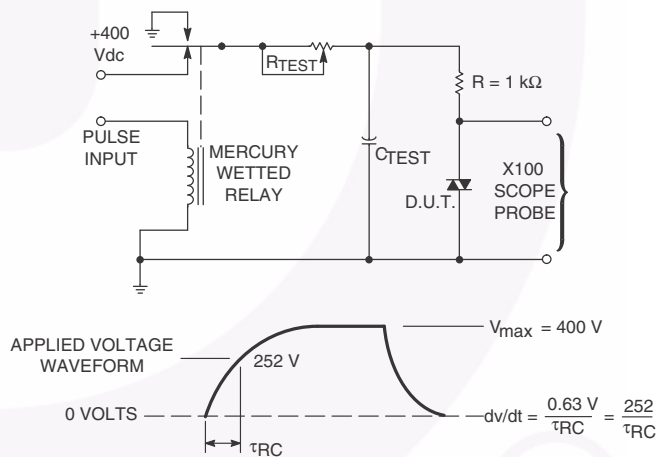


Figure 13. Static dv/dt Test Circuit

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.

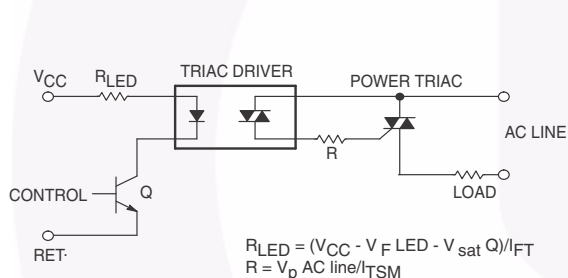


Figure 14. Basic Driver Circuit

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.

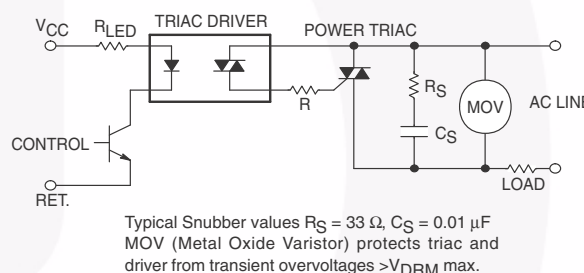


Figure 15. Triac Driver Circuit for Noisy Environments

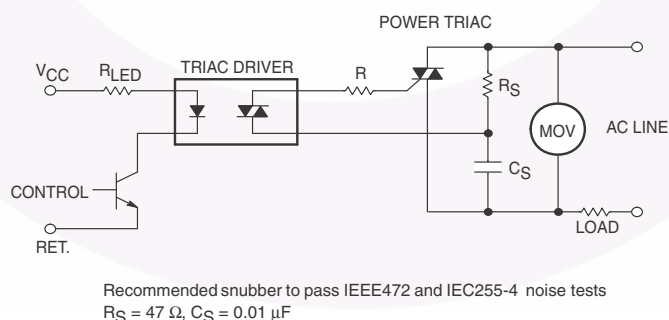
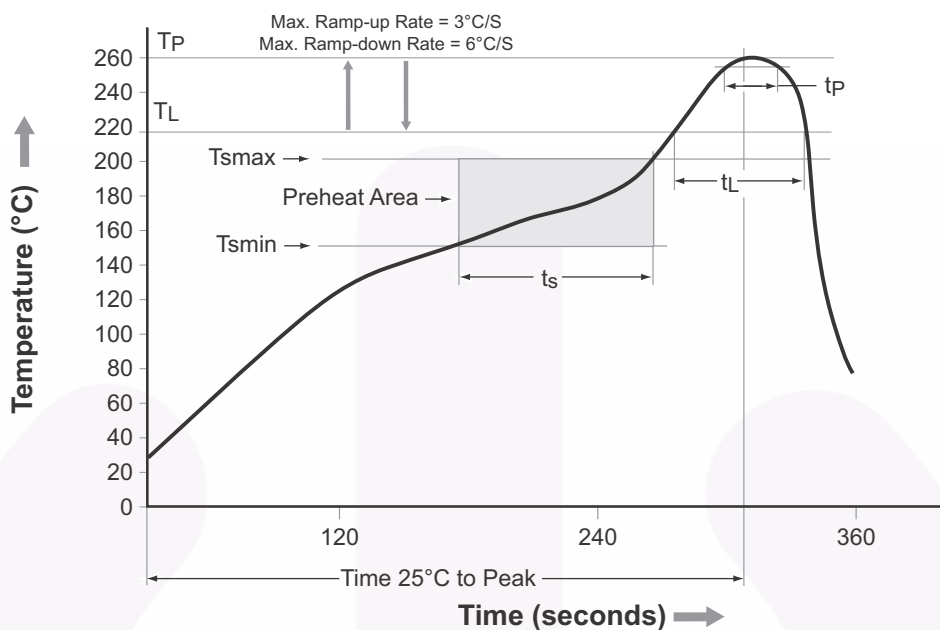


Figure 16. Triac Driver Circuit for Extremely Noisy Environments

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