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**by MOC2R60–10/D**

*Advance Information*

# POWER OPTO™ Isolator

## 2 Amp Random-Phase Triac Output

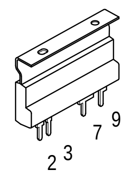
**MOC2R60-10***
**MOC2R60-15**

***Motorola Preferred Devices**

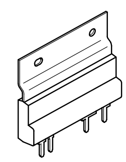
**OPTOISOLATOR**
**2 AMPS**
**RANDOM–PHASE**
**TRIAC OUTPUT**
**600 VOLTS**

This device consists of a gallium arsenide infrared emitting diode optically coupled to a random phase triac driver circuit and a power triac. It is capable of driving a load of up to 2 amps (rms) directly, on line voltages from 20 to 280 volts AC (rms).

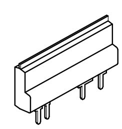
- Provides Normally Open Solid State AC Output with 2 Amp Rating
- 70 Amp Single Cycle Surge Capability
- Phase Controllable
- High Input-Output Isolation of 3750 vac (rms)
- Static dv/dt Rating of 400 Volts/µs Guaranteed
- 2 Amp Pilot Duty Rating Per UL508 ¶117 (Overload Test) and ¶118 (Endurance Test) [File No. 129224]
- CSA Approved [File No. CA77170-1]. VDE Approval in Process.
- Exceeds NEMA 2-230 and IEEE472 Noise Immunity Test Requirements (See Figure 17)




**CASE 417-02**
**Style 2**
PLASTIC PACKAGE

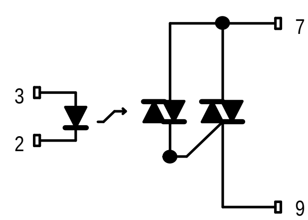


**CASE 417A-02**
**Style 1**
PLASTIC PACKAGE



**CASE 417B-01**
**Style 1**
PLASTIC PACKAGE

**DEVICE SCHEMATIC**




1, 4, 5, 6, 8. NO PIN
2. LED CATHODE
3. LED ANODE
7. MAIN TERMINAL 2
9. MAIN TERMINAL 1

**DEVICE RATINGS** ($T_A$ = 25°C unless otherwise noted)

| Rating | Symbol | Value | Unit |
|---|---|---|---|
| **INPUT LED** | | | |
| Forward Current — Maximum Continuous | $I_F$ | 50 | mA |
| Forward Current — Maximum Peak (PW = 100µs, 120 pps) | $I_F$(pk) | 1.0 | A |
| Reverse Voltage — Maximum | $V_R$ | 6.0 | V |
| **OUTPUT TRIAC** | | | |
| Output Terminal Voltage — Maximum Transient (1) | $V_{DRM}$ | 600 | V(pk) |
| Operating Voltage Range — Maximum Continuous (f = 47 – 63 Hz) | $V_T$ | 20 to 280 | Vac(rms) |
| On-State Current Range (Free Air, Power Factor ≥ 0.3) | $I_T$(rms) | 0.03 to 2.0 | A |
| Non-Repetitive Single Cycle Surge Current — Maximum Peak (t = 16.7 ms) | $I_{TSM}$ | 70 | A |
| Main Terminal Fusing Current (t = 8.3 ms) | $I^2T$ | 26 | $A^2$sec |
| Load Power Factor Range | PF | 0.3 to 1.0 | — |
| Junction Temperature Range | $T_J$ | – 40 to 125 | °C |
| **TOTAL DEVICE** | | | |
| Input-Output Isolation Voltage — Maximum (2) 47 – 63 Hz, 1 sec Duration | $V_{ISO}$ | 3750 | Vac(rms) |
| Thermal Resistance — Power Triac Junction to Case (See Figure 18) | $R_{\theta JC}$ | 8.0 | °C/W |
| Ambient Operating Temperature Range | $T_{oper}$ | – 40 to +100 | °C |
| Storage Temperature Range | $T_{stg}$ | – 40 to +150 | °C |
| Lead Soldering Temperature — Maximum (1/16″ From Case, 10 sec Duration) | $T_L$ | 260 | °C |

1. Test voltages must be applied within dv/dt rating.
2. Input-Output isolation voltage, $V_{ISO}$, is an internal device dielectric breakdown rating. For this test, pins 2, 3 and the heat tab are common, and pins 7 and 9 are common.

POWER OPTO is a trademark of Motorola, Inc.

This document contains information on a new product. Specifications and information herein are subject to change without notice.

**Preferred** devices are Motorola recommended choices for future use and best overall value.

REV 1

**ELECTRICAL CHARACTERISTICS** ($T_A$ = 25°C unless otherwise noted)

| Characteristic | Symbol | Min | Typ | Max | Unit |
|---|---|---|---|---|---|
| **INPUT LED** | | | | | |
| Forward Voltage ($I_F$ = 10 mA) | $V_F$ | 1.00 | 1.17 | 1.50 | V |
| Reverse Leakage Current ($V_R$ = 6.0 V) | $I_R$ | — | 1.0 | 100 | μA |
| Capacitance | C | — | 18 | — | pF |
| **OUTPUT TRIAC** | | | | | |
| Off-State Leakage, Either Direction ($I_F$ = 0, $V_{DRM}$ = 400 V) | $I_{DRM}$(1) | — | 0.25 | 100 | μA |
| Critical Rate of Rise of Off-State Voltage (Static) ($V_{in}$ = 400 vac(pk)) (1) (2) | dv/dt(s) | 400 | — | — | V/μs |
| Holding Current, Either Direction ($I_F$ = 0, $V_D$ = 12 V, $I_T$ = 200 mA) | $I_H$ | — | 10 | — | mA |
| **COUPLED** | | | | | |
| LED Trigger Current Required to Latch Output Either Direction (Main Terminal Voltage = 2.0 V) (3) (4) MOC2R60-10<br>MOC2R60-15 | $I_{FT}$(on) | — | 7.0<br>12 | 10<br>15 | mA |
| On-State Voltage, Either Direction ($I_F$ = Rated $I_{FT}$(on), $I_{TM}$ = 2.0 A) | $V_{TM}$ | — | 0.96 | 1.3 | V |
| Commutating dv/dt (Rated $V_{DRM}$, $I_T$ = 30 mA – 2.0 A(rms), $T_A$ = – 40 + 100°C, f = 60 Hz) (2) | dv/dt (c) | 5.0 | — | — | V/μS |
| Common-mode Input-Output dv/dt (2) | dv/dt(cm) | — | 40,000 | — | V/μS |
| Input-Output Capacitance (V = 0, f = 1.0 MHz) | $C_{ISO}$ | — | 1.3 | — | pF |
| Isolation Resistance ($V_{I-O}$ = 500 V) | $R_{ISO}$ | $10^{12}$ | $10^{14}$ | — | Ω |

1. Per EIA/NARM standard RS–443, with $V_P$ = 200 V, which is the instantaneous peak of the maximum operating voltage.
2. Additional dv/dt information, including test methods, can be found in Motorola applications note AN1048/D.
3. All devices are guaranteed to trigger at an $I_F$ value less than or equal to the max $I_{FT}$. Therefore, the recommended operating $I_F$ lies between the device's maximum $I_{FT}$(on) limit and the Maximum Rating of 50 mA.
4. Current–limiting resistor required in series with LED.

## TYPICAL CHARACTERISTICS

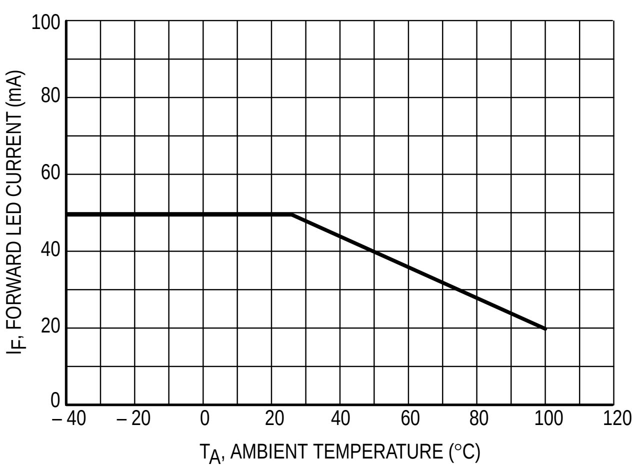



**Figure 1. Maximum Allowable Forward LED Current versus Ambient Temperature**

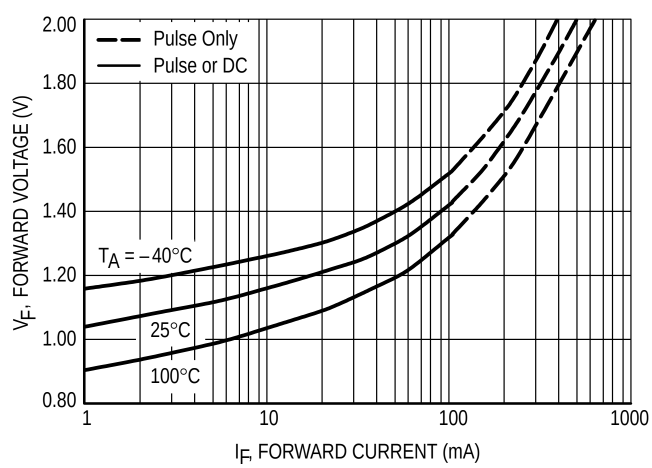



**Figure 2. LED Forward Voltage versus LED Forward Current**

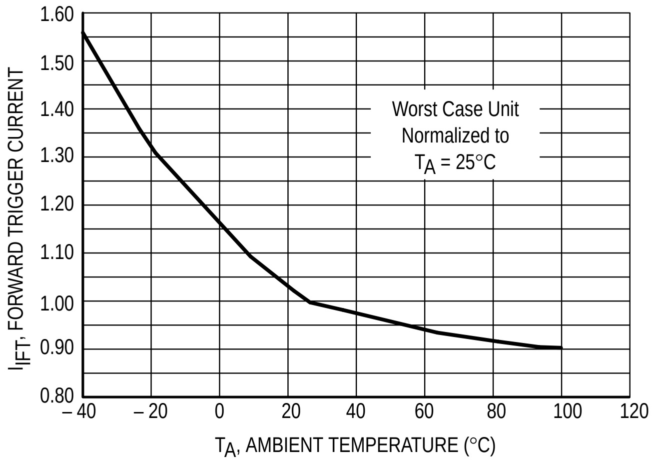



**Figure 3. Forward LED Trigger Current versus Ambient Temperature**

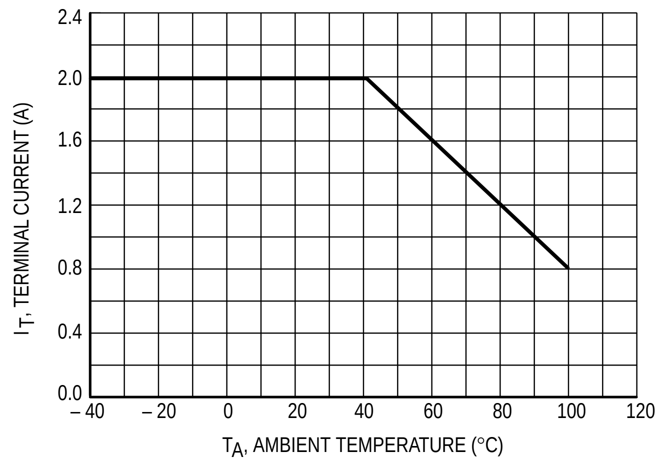



**Figure 4. Maximum Allowable On-State RMS Output Current (Free Air) versus Ambient Temperature**

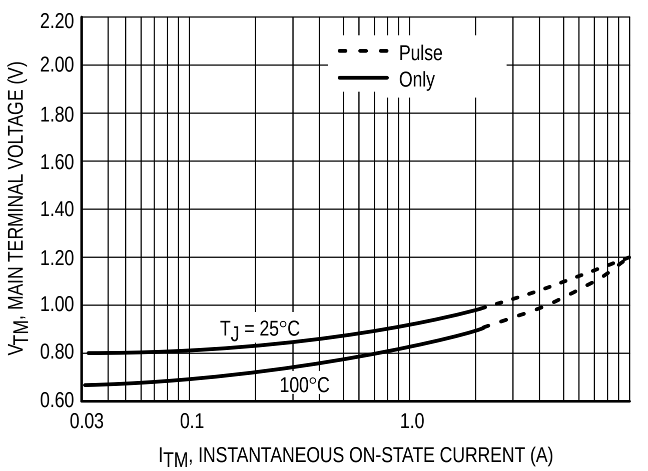



**Figure 5. On-State Voltage Drop versus Output Terminal Current**

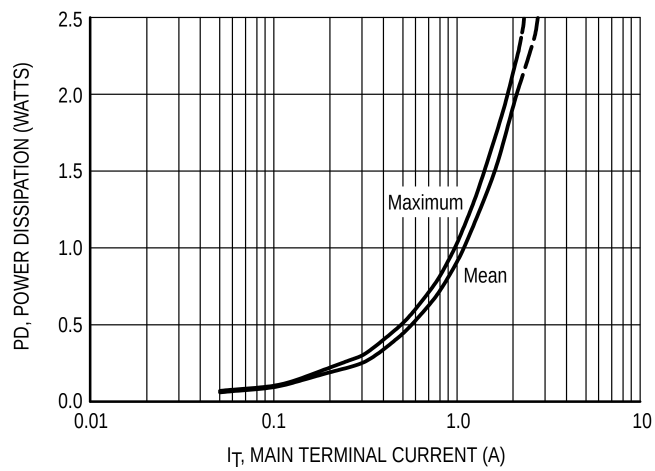



**Figure 6. Power Dissipation versus Main Terminal Current**

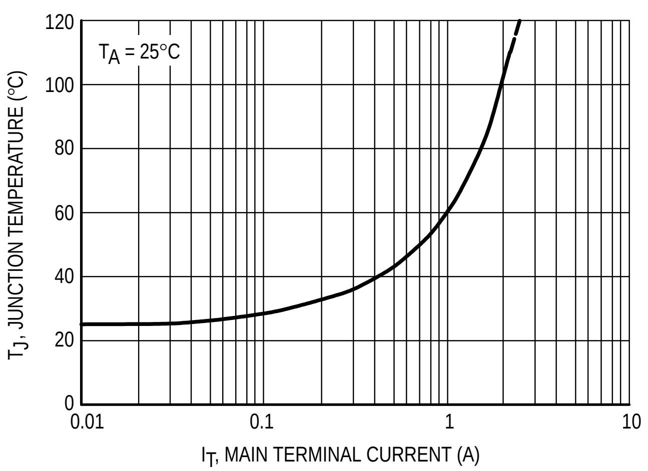



**Figure 7. Junction Temperature versus Main Terminal RMS Current (Free Air)**

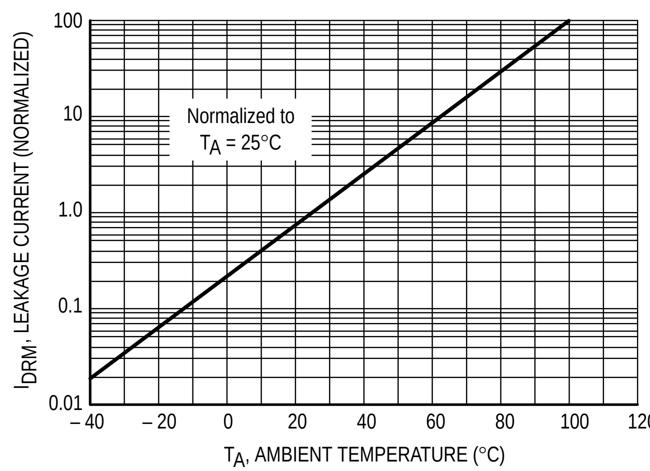



**Figure 8. Leakage with LED Off versus Ambient Temperature**

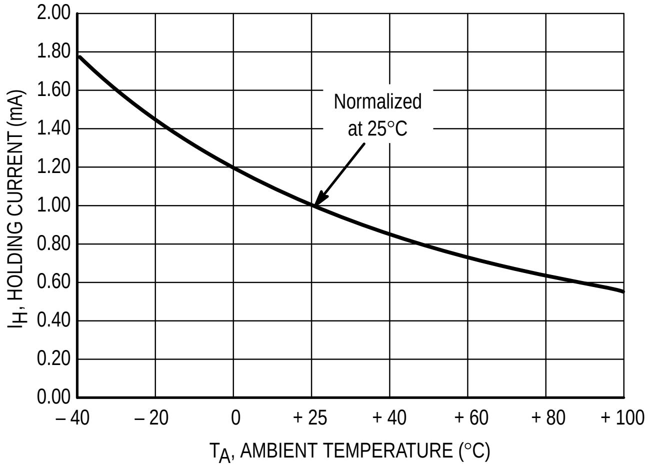



**Figure 9. Holding Current versus Ambient Temperature**

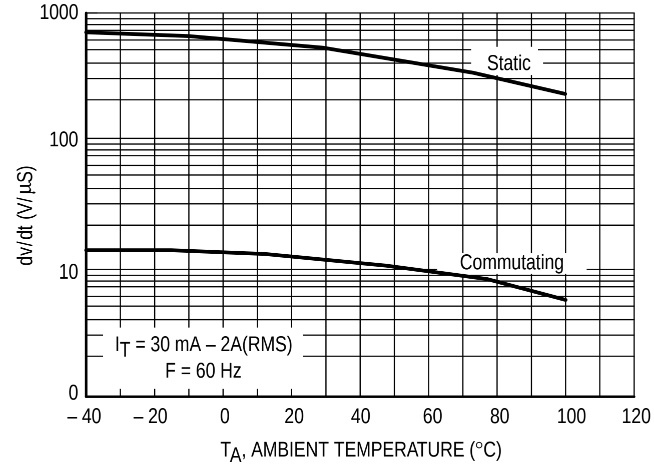



**Figure 10. dv/dt versus Ambient Temperature**

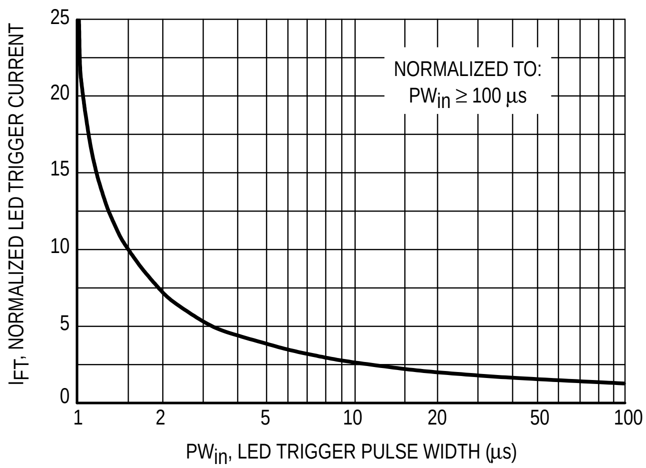



**Figure 11. LED Current Required to Trigger versus LED Pulse Width**

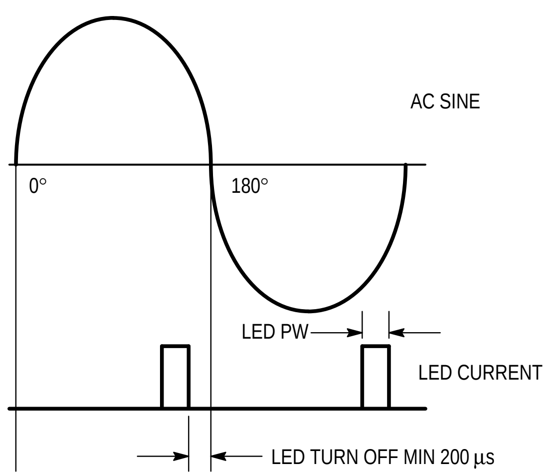



**Figure 12. Minimum Time for LED Turn-Off to Zero Cross of AC Trailing Edge**

### Phase Control Considerations

### LED Trigger Current versus PW (normalized)

The Random Phase POWER OPTO Isolators 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 11. This graph shows the dependency of the trigger current $I_{FT}$ versus the pulse width t (PW). The reason for the $I_{FT}$ dependency on 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 mA, Trigger pulse width PW = 3 µs
$I_{FT}$ (pulsed) = 10 mA x 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 degrees. Turn on at zero degrees means full power, and turn on at 180 degrees 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 degrees the 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 12. This assures that the device has time to switch off. Shorter times may cause loss off control at the following half cycle.

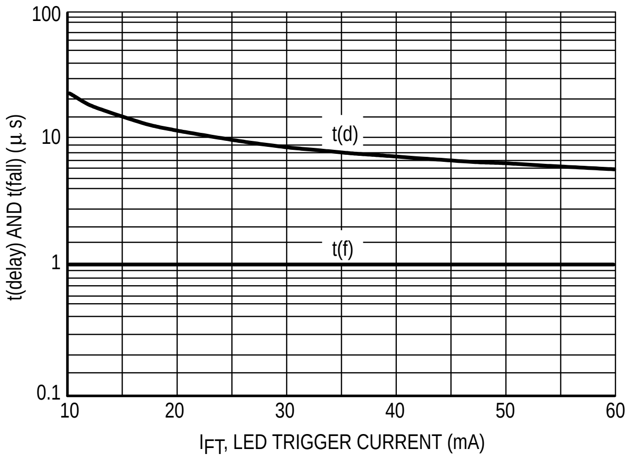



**Figure 13. Delay Time, t(d), and Fall Time, t(f), versus LED Trigger Current**

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

The POWER OPTO Isolators turn on switching speed consists of a turn on delay time t(d) and a fall time t(f). Figure 13 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 $I_{FT}$ versus LED PW.

The turn on transition time t(f) combined with the power triacs turn on time is important to the power dissipation of this device.

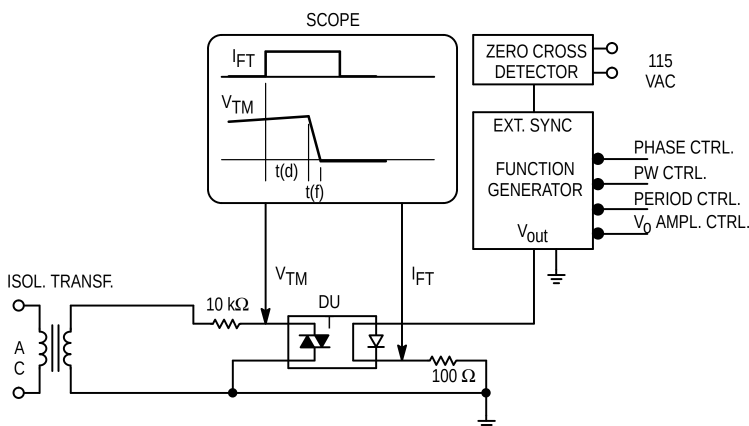



**Figure 14. Switching Time Test Circuit**

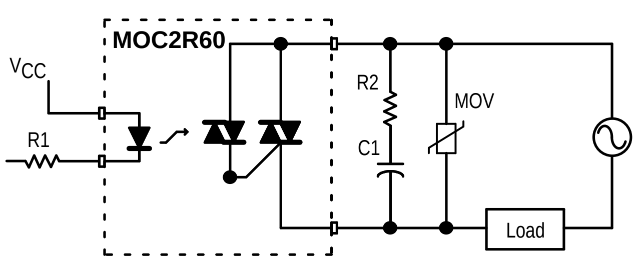



**Figure 15. Typical Application Circuit**

Select the value of R1 according to the following formulas:

(1) $R1 = (V_{CC} – V_F) / Max. I_{FT}$ (on) per spec.

(2) $R1 = (V_{CC} – V_F) / 0.050$

Typical values for C1 and R2 are 0.01 µF and 39 Ω, respectively. You may adjust these values for specific applications. The maximum recommended value of C1 is 0.022 µF. See application note AN1048 for additional information on component values.

The MOV may or may not be needed depending upon the characteristics of the applied AC line voltage. For applications where line spikes may exceed the 600 volts rating of the MOC2R60, an MOV is required.

Use care to maintain the minimum spacings as shown. Safety and regulatory requirements dictate a minimum of 8.0 mm between the closest points between input and output conducting paths, Pins 3 and 7. Also, 0.070 inches distance is required between the two output Pins, 7 and 9.

Keep pad sizes on Pins 7 and 9 as large as possible for optimal performance.

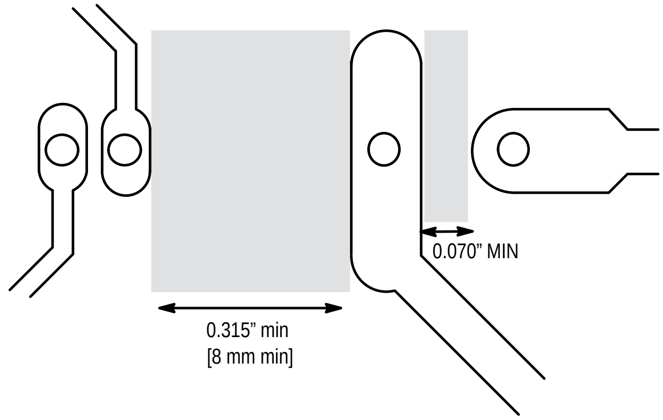



**Figure 16. PC Board Layout Recommendations**

Each device, when installed in the circuit shown in Figure 17, shall be capable of passing the following conducted noise tests:

- IEEE 472 (2.5 KV)
- Lamp Dimmer (NEMA Part DC33, § 3.4.2.1)
- NEMA ICS 2-230.45 Showering Arc
- MIL-STD-461A CS01, CS02 and CS06

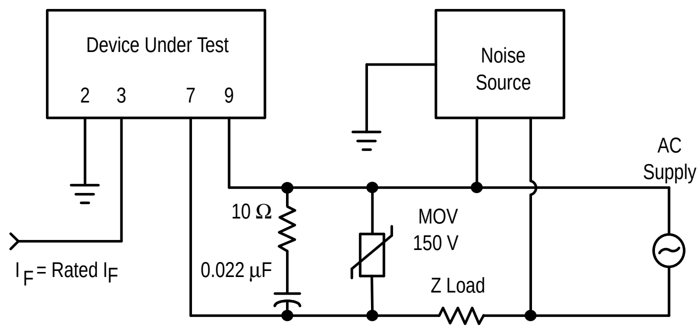
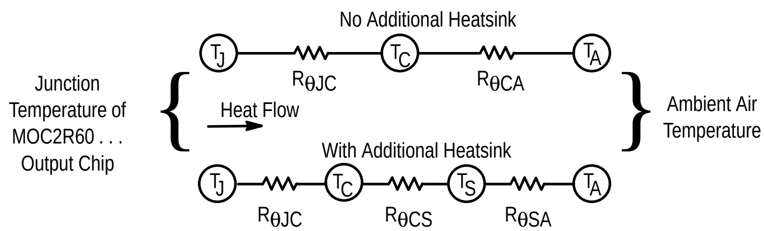



**Figure 17. Test Circuit for Conducted Noise Tests**




Terms in the model signify:

$T_A$ = Ambient temperature
$T_S$ = Optional additional heat sink temperature
$T_C$ = Case temperature
$T_J$ = Junction temperature
$P_D$ = Power dissipation

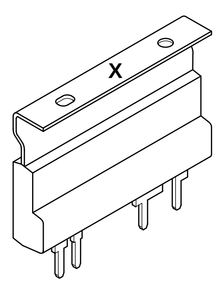
$R_{\theta SA}$ = Thermal resistance, heat sink to ambient
$R_{\theta CA}$ = Thermal resistance, case to ambient
$R_{\theta CS}$ = Thermal resistance, heat sink to case
$R_{\theta JC}$ = Thermal resistance, junction to case

Values for thermal resistance components are: $R_{\theta CA}$ = 36°C/W/in maximum
$R_{\theta JC}$ = 8.0°C/W maximum

The design of any additional heatsink will determine the values of $R_{\theta SA}$ and $R_{\theta CS}$.

$T_C - T_A = P_D (R_{\theta CA})$

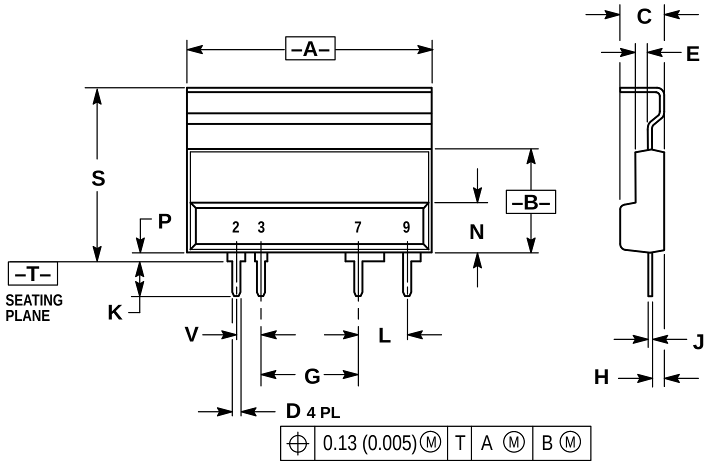
$= P_D (R_{\theta JC}) + R_{\theta SA})$, where $P_D$ = Power Dissipation in Watts.




Thermal measurements of $R_{\theta JC}$ are referenced to the point on the heat tab indicated with an 'X'. Measurements should be taken with device orientated along its vertical axis.

**Figure 18. Approximate Thermal Circuit Model**

## PACKAGE DIMENSIONS



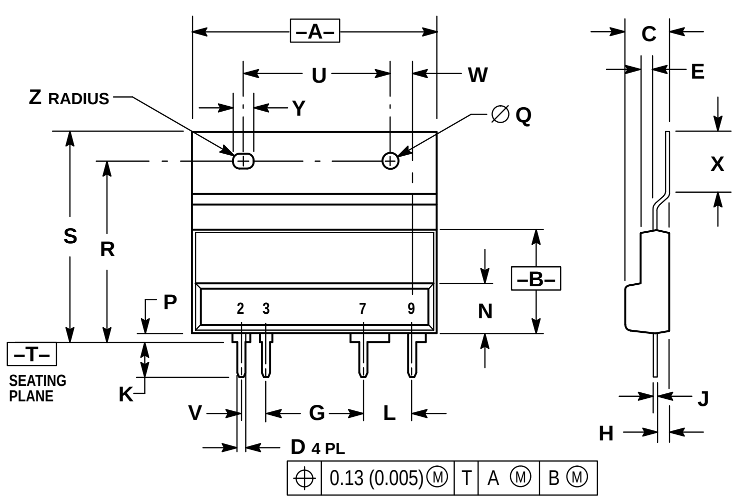

NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.

| DIM | INCHES MIN | INCHES MAX | MILLIMETERS MIN | MILLIMETERS MAX |
|---|---|---|---|---|
| A | 0.965 | 1.005 | 24.51 | 25.53 |
| B | 0.416 | 0.436 | 10.57 | 11.07 |
| C | 0.170 | 0.190 | 4.32 | 4.83 |
| D | 0.025 | 0.035 | 0.64 | 0.89 |
| E | 0.040 | 0.060 | 1.02 | 1.52 |
| G | 0.400 BSC | | 10.16 BSC | |
| H | 0.040 | 0.060 | 1.02 | 1.52 |
| J | 0.012 | 0.018 | 0.30 | 0.46 |
| K | 0.134 | 0.154 | 3.40 | 3.91 |
| L | 0.200 BSC | | 5.08 BSC | |
| N | 0.190 | 0.210 | 4.83 | 5.33 |
| P | 0.023 | 0.043 | 0.58 | 1.09 |
| S | 0.695 | 0.715 | 17.65 | 18.16 |
| V | 0.100 BSC | | 2.54 BSC | |

STYLE 2:
PIN 2. LED CATHODE
3. LED ANODE
7. TRIAC MT
9. TRIAC MT

**CASE 417–02**
**PLASTIC**
**STANDARD HEAT TAB**
**ISSUE C**

**ORDER "F" SUFFIX**
**HEAT TAB OPTION**
**(EX: MOC2R60–10F)**

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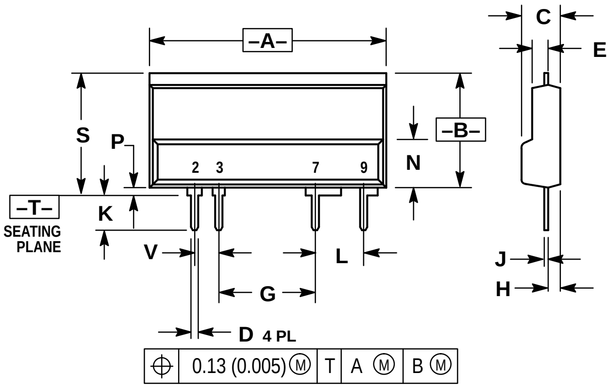
| D | 0.025 | 0.035 | 0.64 | 0.89 |
| E | 0.040 | 0.060 | 1.02 | 1.52 |
| G | 0.400 BSC | | 10.16 BSC | |
| H | 0.040 | 0.060 | 1.02 | 1.52 |
| J | 0.012 | 0.018 | 0.30 | 0.46 |
| K | 0.134 | 0.154 | 3.40 | 3.91 |
| L | 0.200 BSC | | 5.08 BSC | |
| N | 0.190 | 0.210 | 4.83 | 5.33 |
| P | 0.023 | 0.043 | 0.58 | 1.09 |
| Q | 0.057 | 0.067 | 1.45 | 1.70 |
| R | 0.734 | 0.754 | 18.64 | 19.15 |
| S | 0.840 | 0.870 | 21.34 | 22.10 |
| U | 0.593 | 0.613 | 15.06 | 15.57 |
| V | 0.100 BSC | | 2.54 BSC | |
| W | 0.074 | 0.094 | 1.88 | 2.39 |
| X | 0.265 | 0.295 | 6.73 | 7.49 |
| Y | 0.079 | 0.089 | 2.01 | 2.26 |
| Z | 0.026 | 0.036 | 0.66 | 0.91 |

STYLE 1:
PIN 2. LED CATHODE
3. LED ANODE
7. TRIAC MT
9. TRIAC MT

**CASE 417A–02**
**PLASTIC**
**FLUSH MOUNT HEAT TAB**
**ISSUE A**

## PACKAGE DIMENSIONS — CONTINUED

**ORDER "C" SUFFIX**
**HEAT TAB OPTION**
**(EX: MOC2R60–10C)**




NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.

| | INCHES | | MILLIMETERS | |
|---|---|---|---|---|
| DIM | MIN | MAX | MIN | MAX |
| A | 0.965 | 1.005 | 24.51 | 25.53 |
| B | 0.416 | 0.436 | 10.57 | 11.07 |
| C | 0.170 | 0.190 | 4.32 | 4.83 |
| D | 0.025 | 0.035 | 0.64 | 0.89 |
| E | 0.040 | 0.060 | 1.02 | 1.52 |
| G | 0.400 BSC | | 10.16 BSC | |
| H | 0.040 | 0.060 | 1.02 | 1.52 |
| J | 0.012 | 0.060 | 0.30 | 0.46 |
| K | 0.134 | 0.154 | 3.40 | 3.91 |
| L | 0.200 BSC | | 5.08 BSC | |
| N | 0.190 | 0.210 | 4.83 | 5.33 |
| P | 0.023 | 0.043 | 0.58 | 1.09 |
| S | 0.439 | 0.529 | 11.15 | 13.44 |
| V | 0.100 BSC | | 2.54 BSC | |

STYLE 1:
PIN 2. LED CATHODE
3. LED ANODE
7. TRIAC MT
9. TRIAC MT

**CASE 417B–01**
**PLASTIC**
**CUT HEAT TAB**
**ISSUE O**



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