FAIRCHILD SEMICONDUCTOR®

March 2014

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

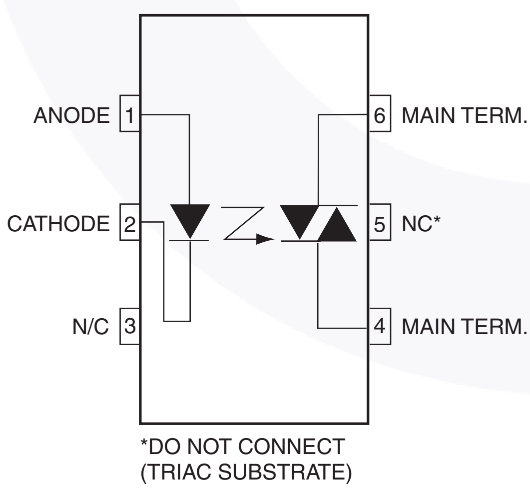


Figure 1. Schematic

Package Outlines

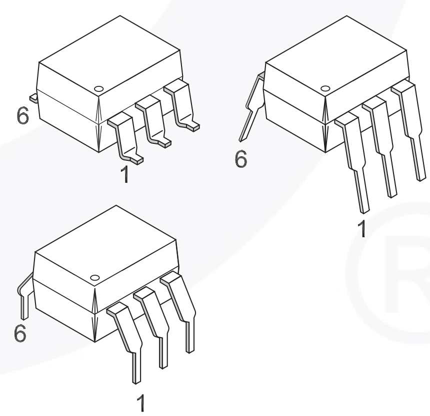


Figure 2. Package Outlines

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} x 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} x 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°C unless otherwise specified.

Symbol	Parameters	Value	Units
Total Device			
T_{STG}	Storage Temperature	-40 to +150	°C
T_{OPR}	Operating Temperature	-40 to +85	°C
T_{SOL}	Lead Solder Temperature (Wave Solder)	260 for 10 seconds	°C
T_J	Junction Temperature Range	-40 to +100	°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/°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/°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/°C

Note:

1. Isolation surge votlage, 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°C unless otherwise specified.

Individual Component Characteristics

Symbol	Parameters	Test Conditions	Min.	Typ.*	Max.	Units
EMITTER						
V_F	Input Forward Voltage	I_F = 10 mA		1.18	1.5	V
I_R	Reverse Leakage Current	V_R = 3 V		0.05	100	µA
DETECTOR						
I_{DRM}	Peak Blocking Current, Either Direction	V_{DRM} = 600 V, I_F = 0(2)		10	100	nA
V_{TM}	Peak On-State Voltage, Either Direction	I_{TM} = 100 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 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 Hz, t = 1 Minute	4170			V_{RMS}
R_{ISO}	Isolation Resistance	V_{I-O} = 500 V_{DC}		10^{11}		Ω
C_{ISO}	Isolation Capacitance	V = 0 V, f = 1 MHz		0.2		pF

*Typical values at T_A = 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, 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

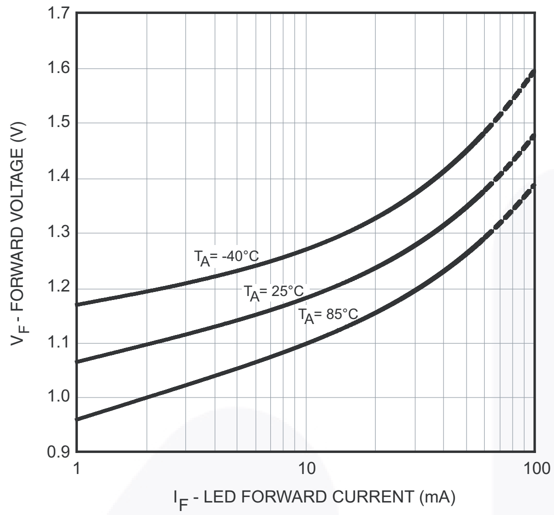


Figure 3. LED Forward Voltage vs. Forward Current

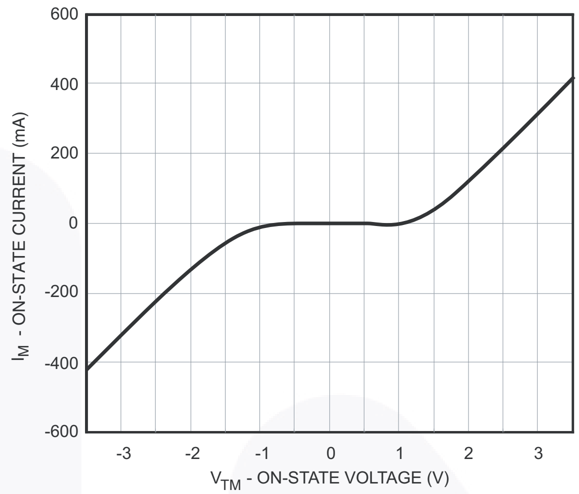


Figure 4. On-State Characteristics

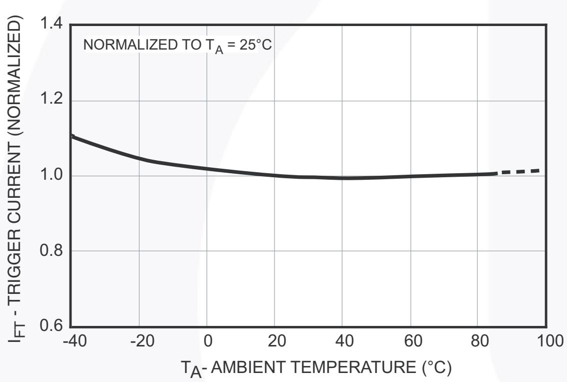


Figure 5. Trigger Current vs. Ambient Temperature

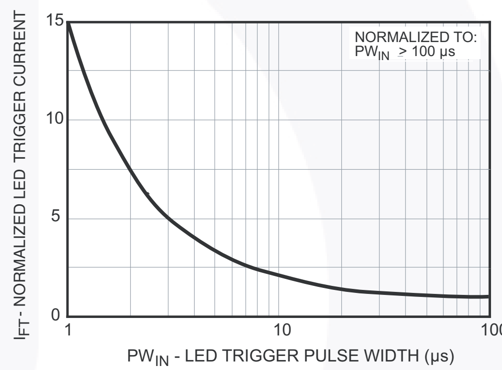


Figure 6. LED Current Required to Trigger vs. LED Pulse Width

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°C, I_{FT} = 10 mA
I_{FT} at -40°C = 10 mA x 1.1 = 11 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 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°. 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 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/µs. The data sheet specified I_{FT} is therefore applicable for all practical inductive loads and load factors.

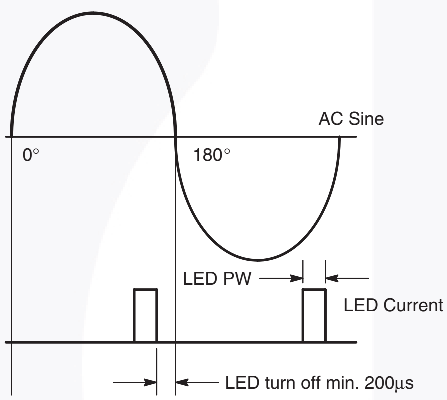


Figure 7. Minimum Time for LED Turn Off to Zero Cross of AC Trailing Edge

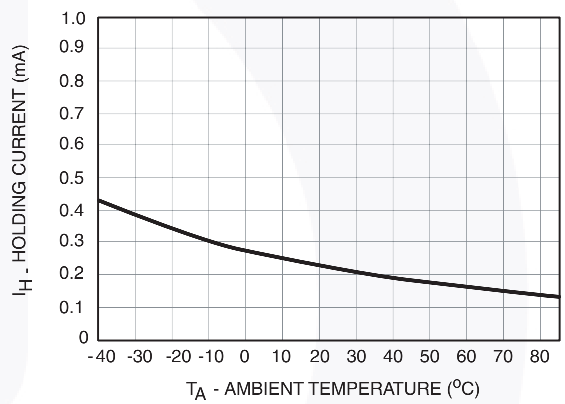


Figure 8. Holding Current, I_H vs. Temperature

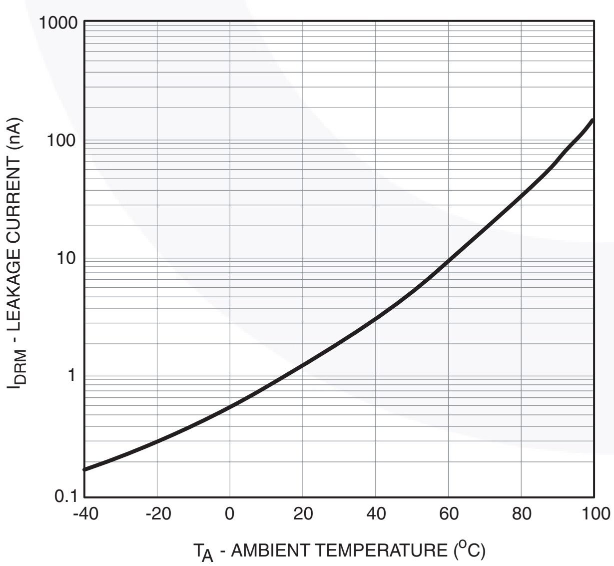


Figure 9. Leakage Current, I_{DRM} vs. Temperature

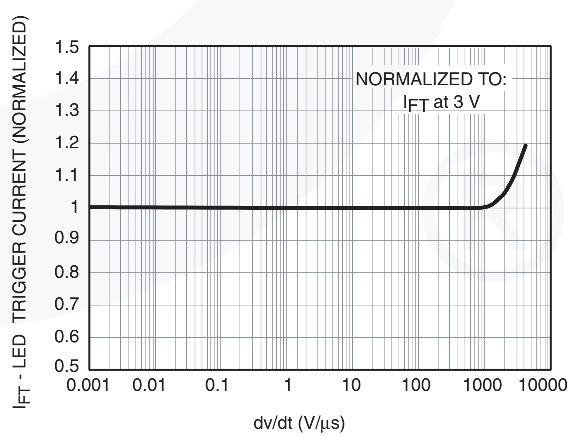


Figure 10. LED Trigger Current, I_{FT} vs. dv/dt

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.

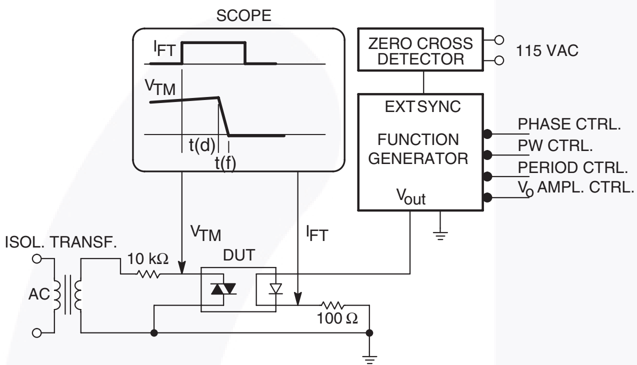


Figure 11. Switching Time Test Circuit

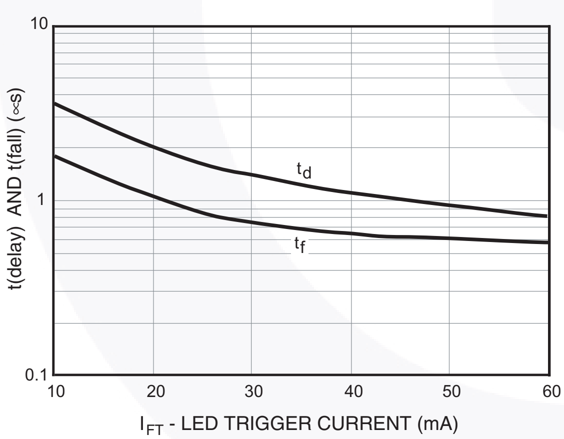


Figure 12. Delay Time, t(d), and Fall Time, t(f), vs. LED Trigger Current

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.

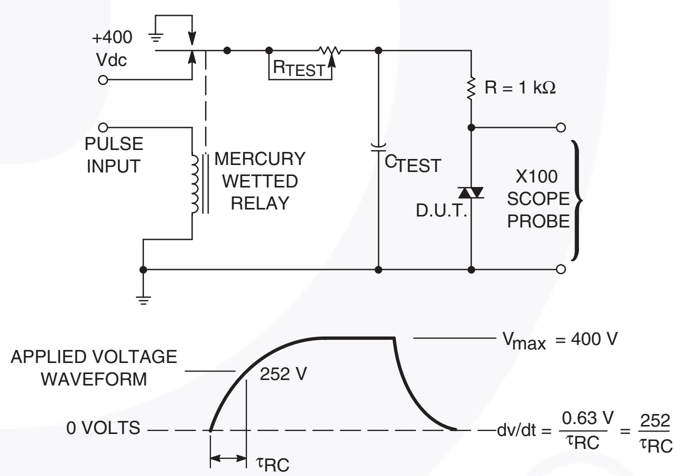


Figure 13. Static dv/dt Test Circuit

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.

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

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.

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.

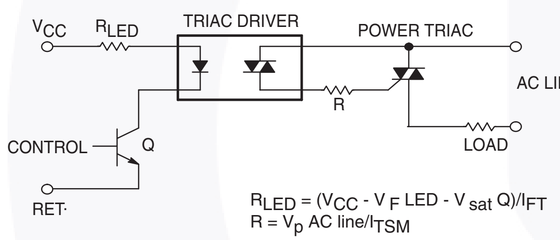


Figure 14. Basic Driver Circuit

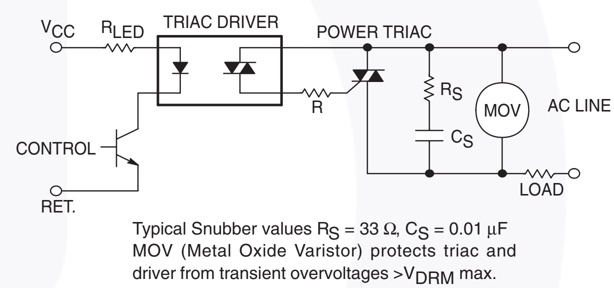


Figure 15. Triac Driver Circuit for Noisy Environments

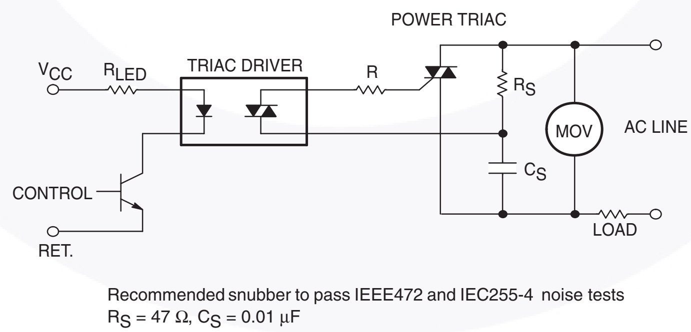
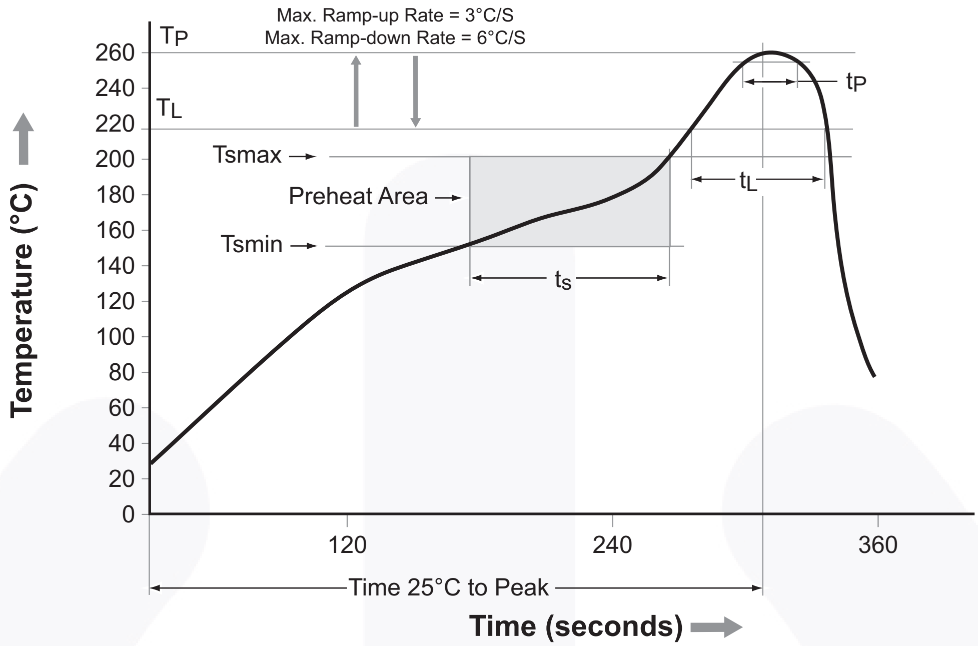


Figure 16. Triac Driver Circuit for Extremely Noisy Environments

Reflow Profile



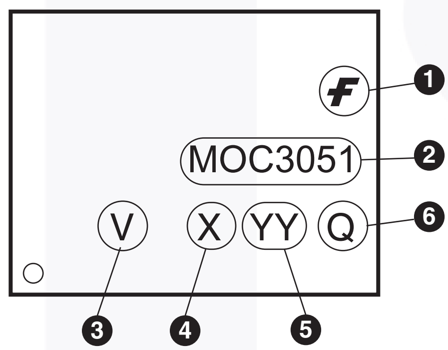
Profile Freature	Pb-Free Assembly Profile
Temperature Minimum (Tsmin)	150°C
Temperature Maximum (Tsmax)	200°C
Time (t_S) from (Tsmin to Tsmax)	60 seconds to 120 seconds
Ramp-up Rate (T_L to T_P)	3°C/second maximum
Liquidous Temperature (T_L)	217°C
Time (t_L) Maintained Above (T_L)	60 seconds to 150 seconds
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

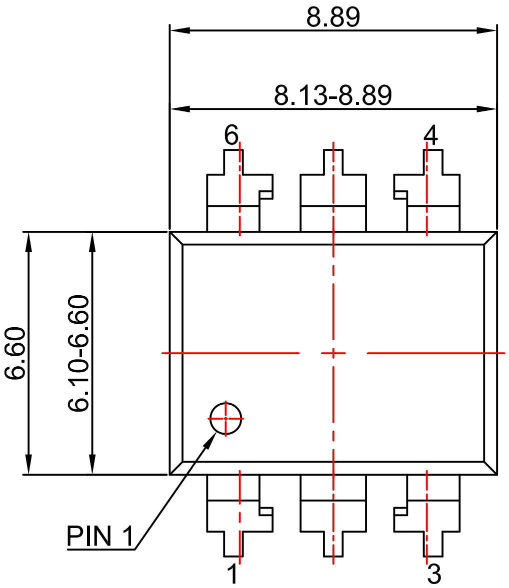
Option	Order Entry Identifier (Example)	Description
No option	MOC3051M	Standard Through Hole Device
S	MOC3051SM	Surface Mount Lead Bend
SR2	MOC3051SR2M	Surface Mount; Tape and Reel
V	MOC3051VM	DIN EN/IEC60747-5-2 (VDE)
TV	MOC3051TVM	DIN EN/IEC60747-5-2 (VDE), 0.4" Lead Spacing
SV	MOC3051SVM	DIN EN/IEC60747-5-2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

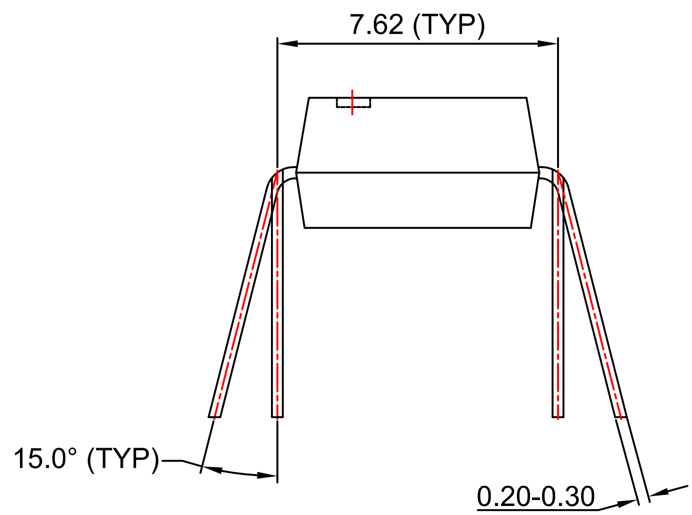
Marking Information

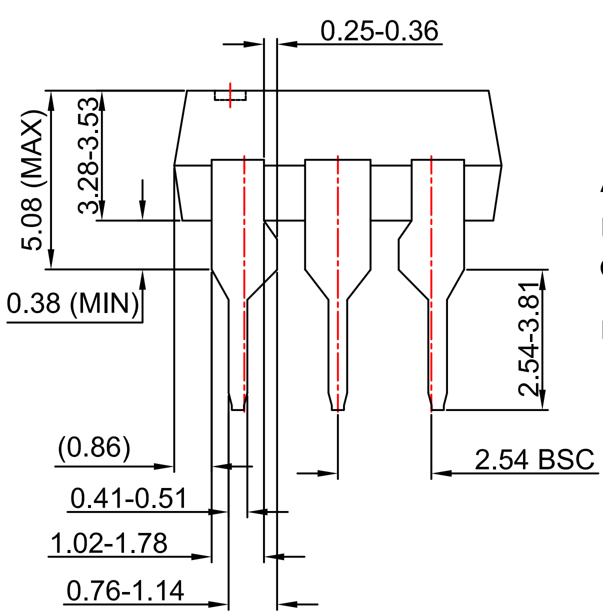


Definitions	
1	Fairchild logo
2	Device number
3	DIN EN/IEC60747-5-2 (VDE) mark (Note: Only appears on parts ordered with VDE option – See order entry table)
4	One-digit year code, e.g., ‘3’
5	Two-digit work week, ranging from ‘01’ to ‘53’
6	Assembly package code

*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.







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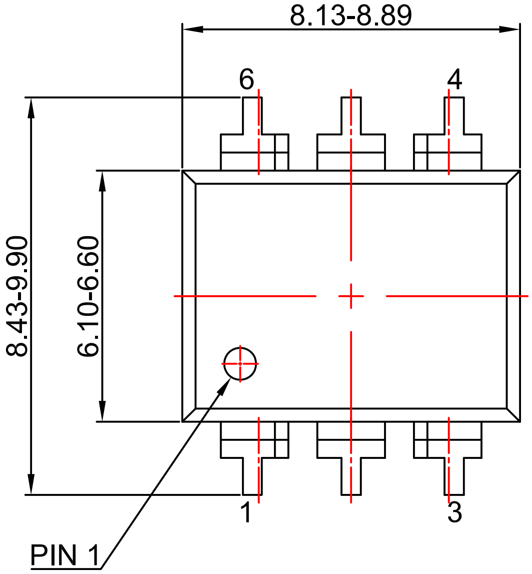
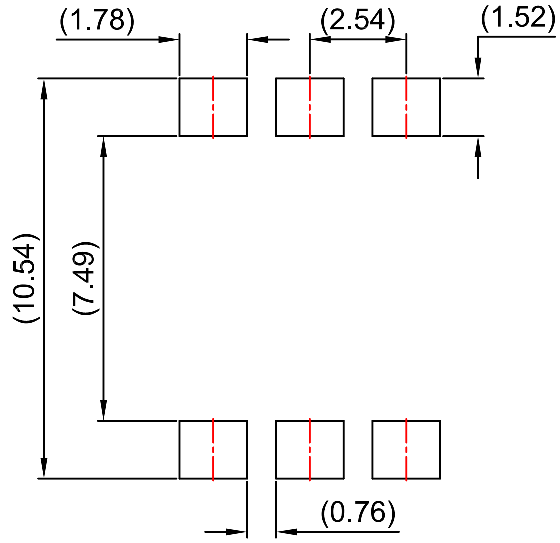
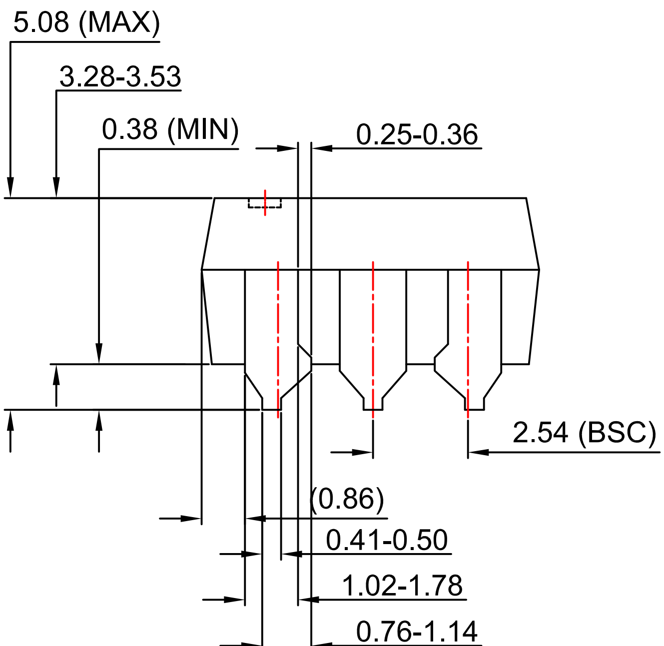
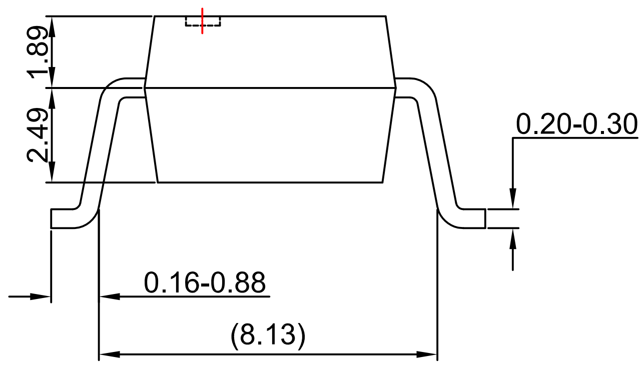




LAND PATTERN RECOMMENDATION





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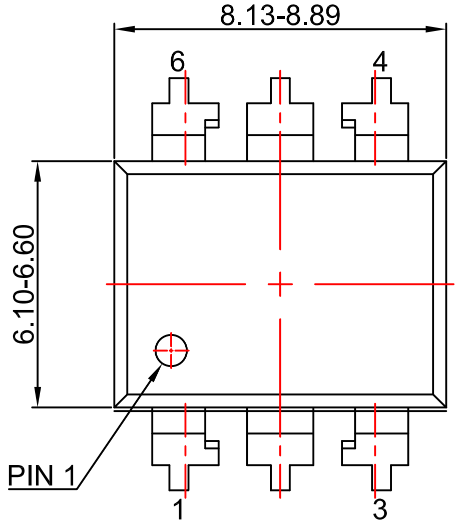

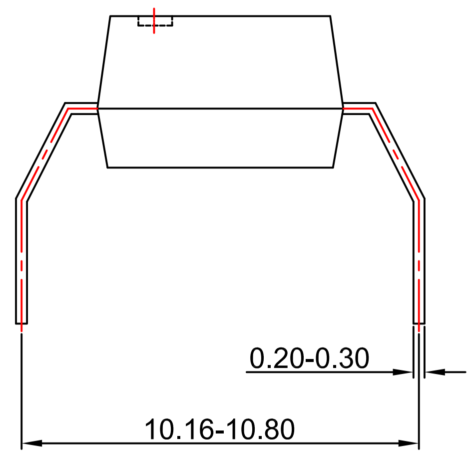

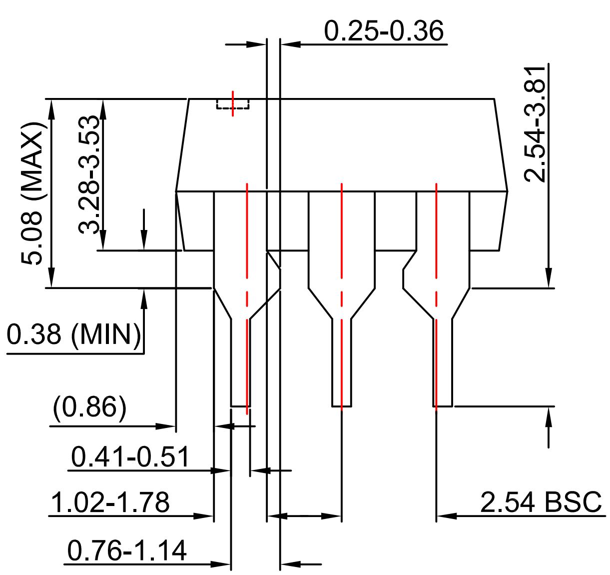

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TinyPower™
TinyPWM™
TinyWire™
TranSiC™
TriFault Detect™
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PRODUCT STATUS DEFINITIONS

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.
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