MOC3051M, MOC3052M, MOC3053M

6-Pin DIP Random-Phase Triac Driver Optocoupler (600 Volt Peak)

The MOC3051M, MOC3052M and MOC3053M 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.

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

Typical 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

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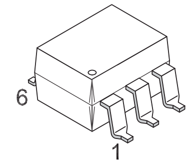
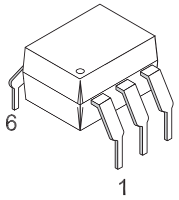


PDIP6
CASE 646BY



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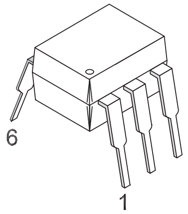

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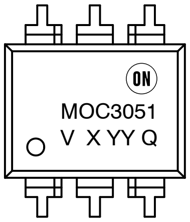
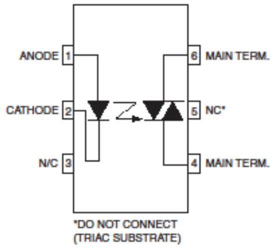
MARKING DIAGRAM



ON = ON Semiconductor Logo
MOC3051 = Device Code
V = DIN EN/IEC60747−5−5 Option
X = One−Digit Year Code
YY = Two−Digit Work Week,
Q = Assembly Package Code

PIN CONNECTIONS



ORDERING INFORMATION

See detailed ordering, marking and shipping information on page 9 of this data sheet.

May, 2019 − Rev. 3

SAFETY AND INSULATIONS 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} x 1.6 = V_{PR}, Type and Sample Test with t_m = 10 s, Partial Discharge < 5 pC	1360	Vpeak
	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	Vpeak
V_{IORM}	Maximum Working Insulation Voltage	850	Vpeak
V_{IOTM}	Highest Allowable Over−Voltage	6000	Vpeak
	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

MAXIMUM RATINGS T_A = 25°C unless otherwise specified.

Symbol	Parameter	Value	Unit
TOTAL DEVICE			
T_{STG}	Storage Temperature	−40 to +150	°C
T_{OPR}	Operating Temperature	−40 to +85	°C
T_J	Junction Temperature Range	−40 to +100	°C
T_{SOL}	Lead Solder Temperature	260 for 10 seconds	°C
P_D	Total Device Power Dissipation at 25°C Ambient	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 Power Dissipation at 25°C Ambient	100	mW
	Derate Above 25°C	1.33	mW/°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/°C

Stresses exceeding those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise specified)

INDIVIDUAL COMPONENT CHARACTERISTICS

Symbol	Parameters	Characteristic	Min	Typ	Max	Unit
EMITTER						
V_F	Input Forward Voltage	I_F = 10 mA		1.18	1.50	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 (Note 1)		10	100	nA
V_{TM}	Peak On−State Voltage, Either Direction	I_{TM} = 100 mA peak, I_F = 0		2.2	2.5	V
dv/dt	Critical Rate of Rise of Off−State Voltage	I_F = 0, V_{DRM} = 600 V	1000			V/μs

TRANSFER CHARACTERISTICS

Symbol	DC Characteristic	Test Conditions	Device	Min	Typ	Max	Unit
I_{FT}	LED Trigger Current, Either Direction	Main Terminal Voltage = 3 V (Note 2)	MOC3051M			15	mA
			MOC3052M			10	
			MOC3053M			6	
I_H	Holding Current, Either Direction		All		540		μA

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise specified) (continued)

INDIVIDUAL COMPONENT CHARACTERISTICS

Symbol	Characteristic	Test Conditions	Min	Typ	Max	Unit
ISOLATION CHARACTERISTICS						
V_{ISO}	Input−Output Isolation Voltage (Note 3)	f = 60 Hz, t = 1 Minute	4170			VAC_{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

1. Test voltage must be applied within dv/dt rating.
2. All devices will trigger at an I_F value greater than or equal to the maximum I_{FT} specification. For optimum operation over temperature and lifetime of the device, the LED should be biased with an I_F that is at least 50% higher than the maximum I_{FT} specification. The I_F should not exceed the absolute maximum rating of 60 mA.
   Example: For MOC3052M, the minimum I_F bias should be 10 mA x 150% = 15 mA.
3. 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 CHARACTERISTICS

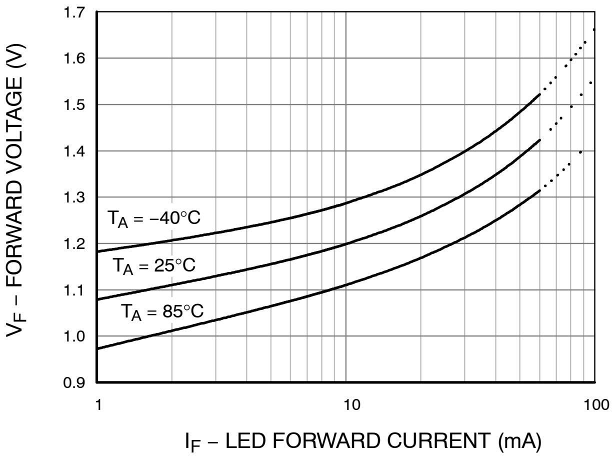


Figure 1. LED Forward Voltage vs. Forward Current

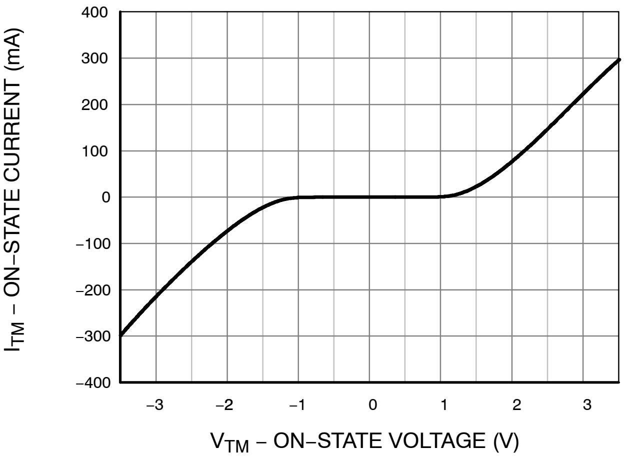


Figure 2. On−State Characteristics

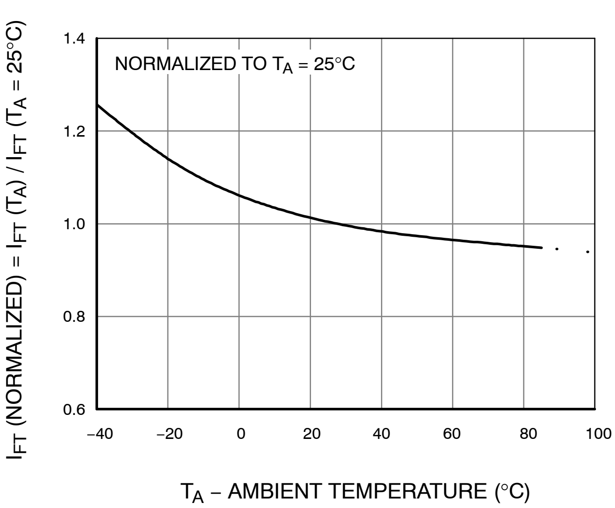


Figure 3. LED Trigger Current vs. Ambient Temperature

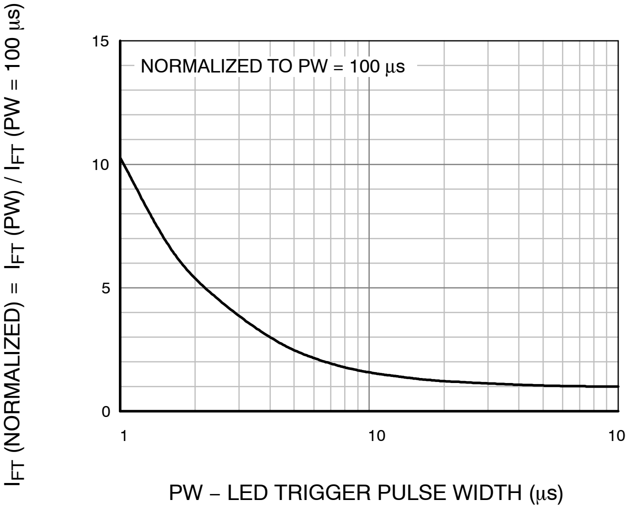


Figure 4. LED Trigger Current vs. LED Pulse Width

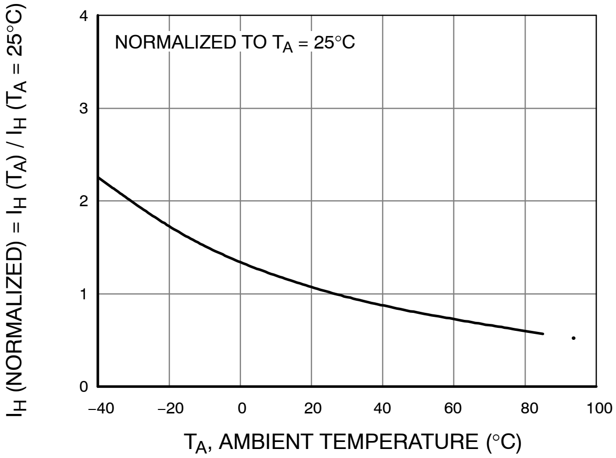


Figure 5. Holding Current vs. Ambient Temperature

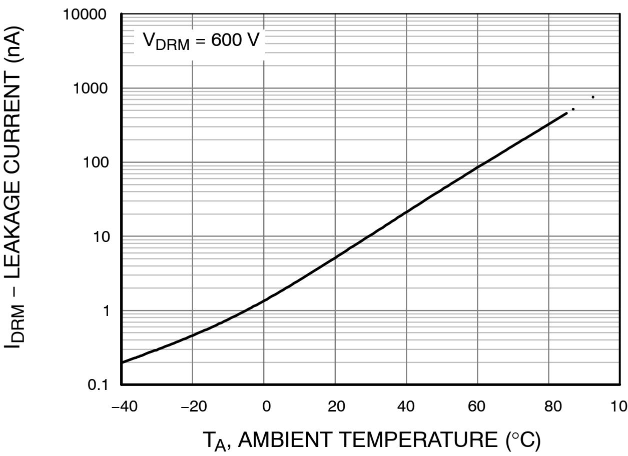


Figure 6. Leakage Current vs. Ambient Temperature

APPLICATIONS INFORMATION

Basic Triac Driver Circuit

The random phase triac drivers MOC3051M, MOC3052M and MOC3053M can allow snubberless operations in applications where load is resistive and the 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 7 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.

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 8 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 super−imposed onto the AC line voltage. In order to pass this environment noise test a modified snubber network as shown in Figure 9 is recommended.

LED Trigger Current versus Temperature

Recommended operating LED control current I_F lies between the guaranteed I_{FT} and absolute maximum I_F. 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 datasheet guaranteed I_{FT} with the normalized I_{FT} shown on this graph and an allowance for LED degradation over time.

Example:

I_{FT} = 10 mA, LED degradation factor = 20%

I_F at −40°C = 10 mA × 1.25 × 120% = 15 mA

LED Trigger Current vs. Pulse Width

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 increased amplitude as shown on Figure 4. This graph shows the dependency of the trigger current I_{FT} versus the pulse width. I_{FT} in this graph 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:

I_{FT} = 10 mA, Trigger PW = 4 μs

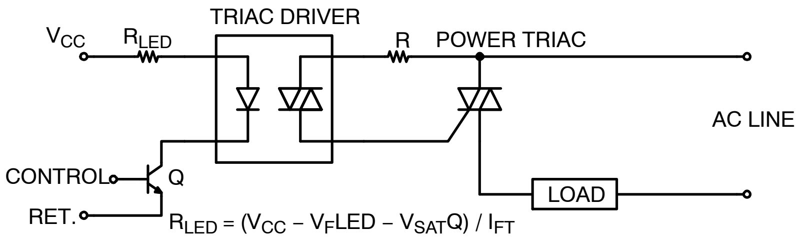
I_F (pulsed) = 10 mA × 3 = 30 mA

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 10. This assures that the triac driver has time to switch off. Shorter times may cause loss of control at the following half cycle.

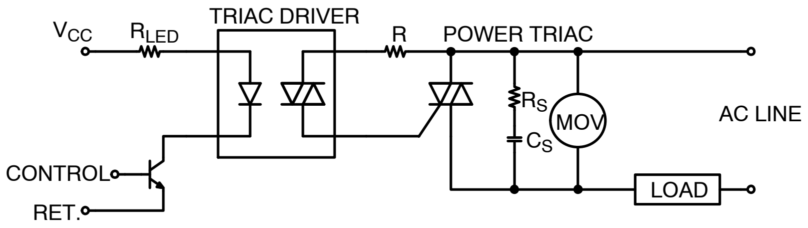
Static dv/dt

Critical rate of rise of off−state voltage or static dv/dt is a triac characteristic that rates its ability to prevent false triggering in the event of fast rising line voltage transients when it is in the off−state. When driving a discrete power triac, the triac driver optocoupler switches back to off−state once the power triac is triggered. However, during the commutation of the power triac in application where the load is inductive, both triacs are subjected to fast rising voltages. The static dv/dt rating of the triac driver optocoupler and the commutating dv/dt rating of the power triac must be taken into consideration in snubber circuit design to prevent false triggering and commutation failure.



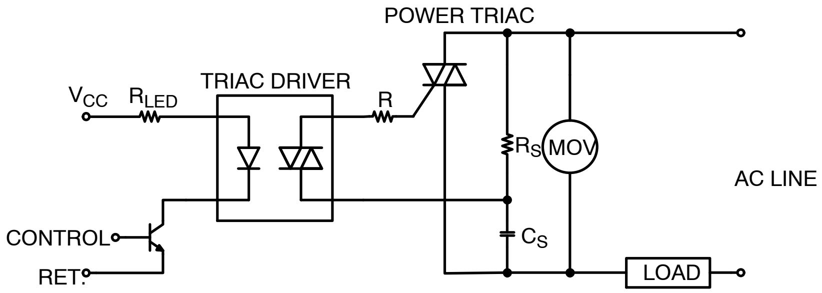
$R_{LED} = (V_{CC} - V_FLED - V_{SAT}Q) / I_{FT}$
$R = V_PAC / I_{TSM}$

Figure 7. Basic Driver Circuit



Typical Snubber values $R_S = 33\ \Omega$, $C_S = 0.01\ \mu F$
MOV (Metal Oxide Varistor) protects power triac and
driver from transient overvoltages > V_{DRM} max

Figure 8. 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 9. Triac Driver Circuit for Extremely Noisy Environments

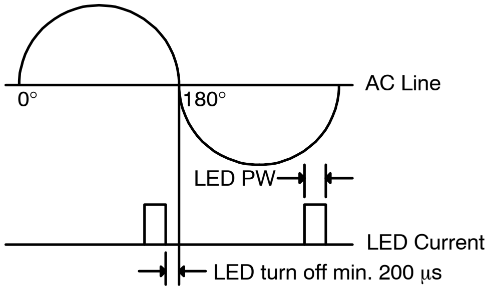


Figure 10. Minimum Time for LED Turn Off to Zero Crossing

REFLOW PROFILE

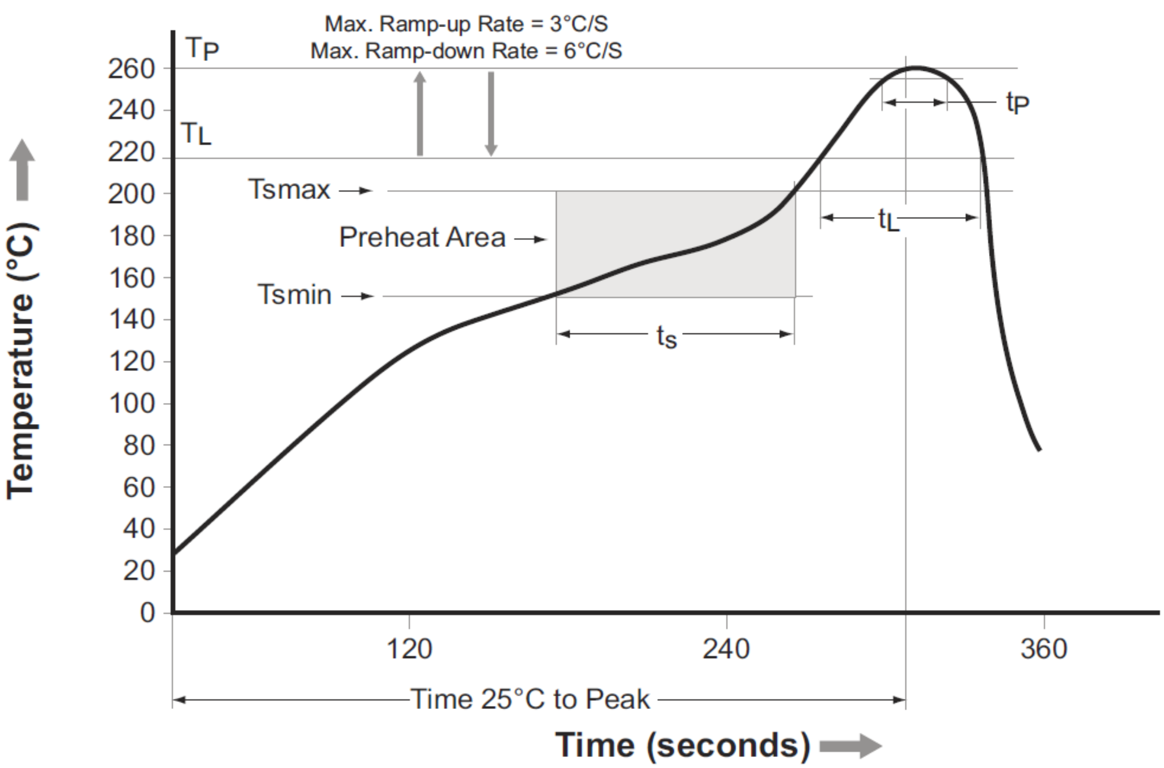


Figure 11. Reflow Profile

Profile Feature	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

ORDERING INFORMATION (Note 4)

Device	Package	Shipping
MOC3051M	DIP 6−Pin	Tube (50 Units)
MOC3051SM	SMT 6−Pin (Lead Bend)	Tube (50 Units)
MOC3051SR2M	SMT 6−Pin (Lead Bend)	Tape and Reel (1000 Units)
MOC3051VM	DIP 6−Pin, DIN EN/IEC60747−5−5 Option	Tube (50 Units)
MOC3051SVM	SMT 6−Pin (Lead Bend), DIN EN/IEC60747−5−5 Option	Tube (50 Units)
MOC3051SR2VM	SMT 6−Pin (Lead Bend), DIN EN/IEC60747−5−5 Option	Tape and Reel (1000 Units)
MOC3051TVM	DIP 6−Pin, 0.4” Lead Spacing, DIN EN/IEC60747−5−5 Option	Tube (50 Units)

4. The product orderable part number system listed in this table also applies to the MOC3052M and MOC3053M product families.

MECHANICAL CASE OUTLINE
PACKAGE DIMENSIONS

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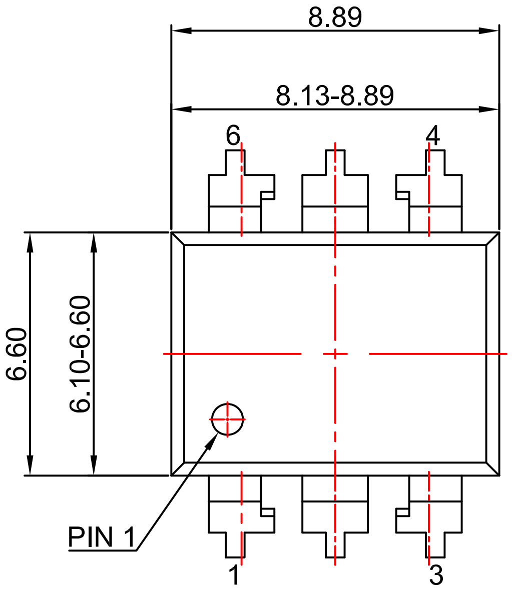
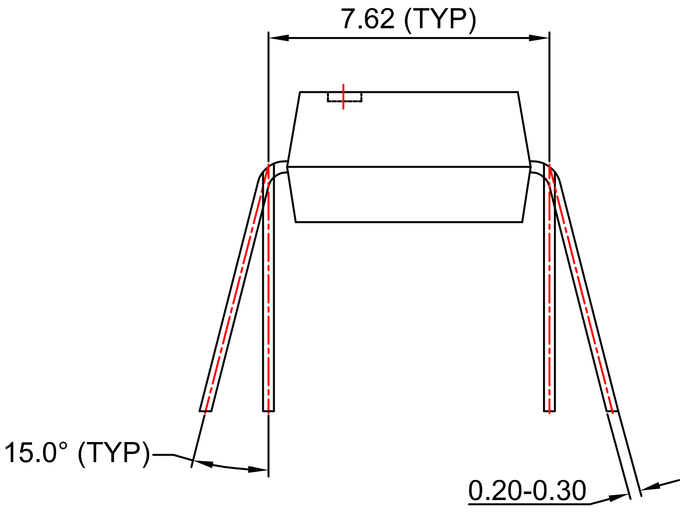
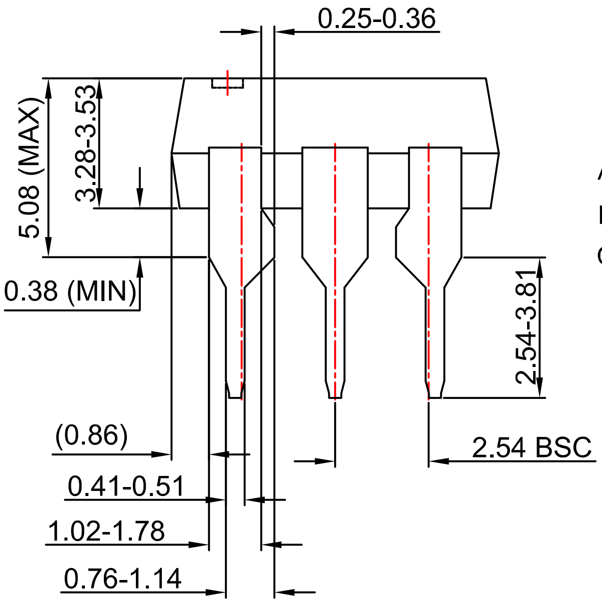
CASE 646BX
ISSUE O

DATE 31 JUL 2016







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MECHANICAL CASE OUTLINE
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CASE 646BY
ISSUE A

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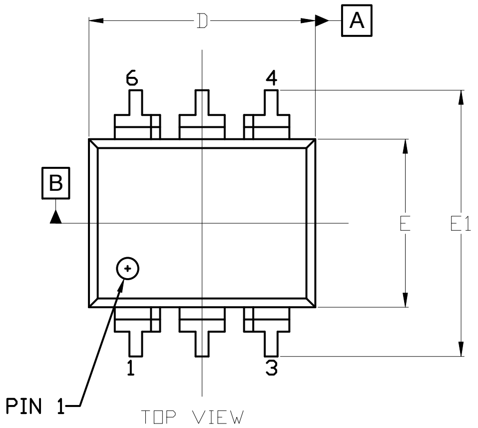
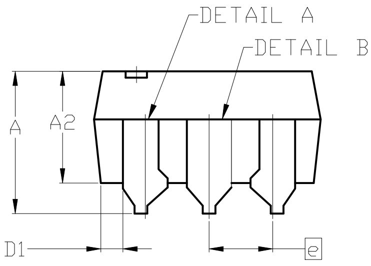


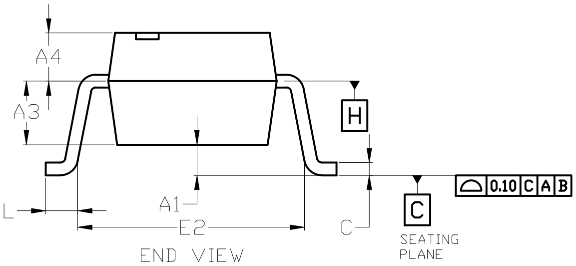
TOP VIEW

NOTES:
1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 2009.
2. CONTROLLING DIMENSION: MILLIMETERS
3. DIMENSIONS A, A1, AND L ARE MEASURED WITH THE PACKAGE SEATED.
4. DIMENSIONS D, D1, AND E1 DO NOT INCLUDE MOLD FLASH OR PROTRUSIONS. MOLD FLASH OR PROTRUSIONS ARE NOT TO EXCEED 2.54mm.
5. PACKAGE CONTOUR IS OPTIONAL (ROUNDED OR SQUARE CORNERS).
6. CENTER LINE OF CORNER LEADS ARE LOCATED BY LOCATING THE CENTER OF FEATURE b2 AND b3.

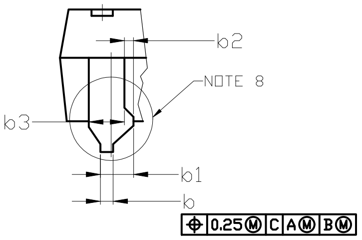
DIM	MILLIMETERS		
	MIN.	NOM.	MAX.
A	---	---	4.80
A1	0.38	---	---
A2	3.28	3.40	3.53
A3	2.49 REF		
A4	1.89 REF		
b	0.41	0.46	0.51
b1	0.76	0.92	1.14
b2	0.25	0.28	0.36
b3	1.02	1.40	1.78
b4	1.778 REF		
c	0.20	0.25	0.30
D	8.13	8.51	8.89
D1	0.86 REF		
E	6.10	6.35	6.60
E1	8.43	9.17	9.90
E2	8.13 REF		
e	2.54 BSC		
L	0.16	0.52	0.88



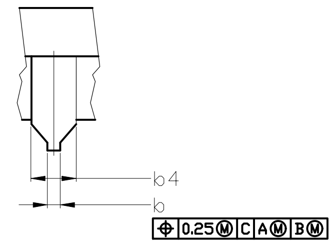
SIDE VIEW



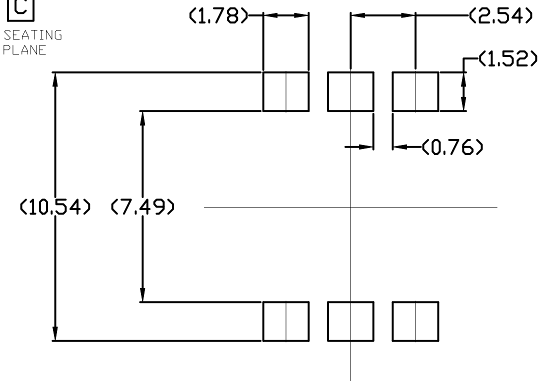
END VIEW



DETAIL A
CORNER LEADS



DETAIL B
MIDDLE LEADS



RECOMMENDED MOUNTING FOOTPRINT

* For additional information on our Pb-Free strategy and soldering details, please download the ON Semiconductor Soldering and Mounting Techniques Reference Manual, SOLDERRM/D.

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MECHANICAL CASE OUTLINE
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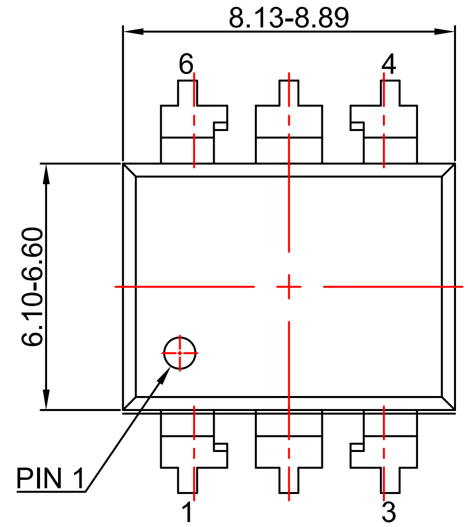
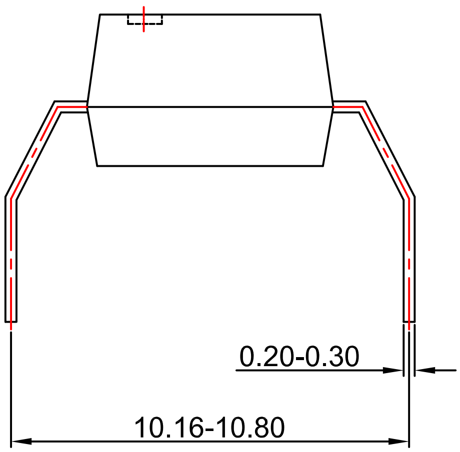
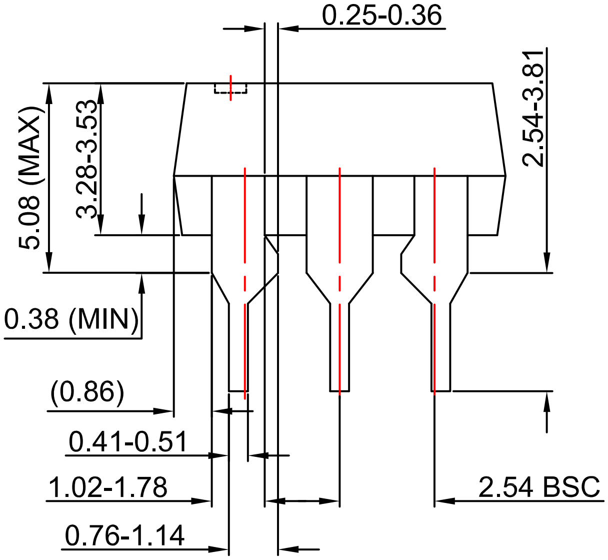
ISSUE O

DATE 31 JUL 2016







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