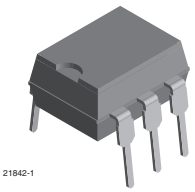
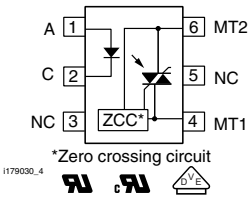
# Optocoupler, Phototriac Output, Zero Crossing, Very Low Input Current




## FEATURES

- High input sensitivity: $I_{FT}$ = 1.3 mA, PF = 1.0; $I_{FT}$ = 3.5 mA, typical PF < 1.0
- Zero voltage crossing
- 600 V, 700 V, and 800 V blocking voltage
- 300 mA on-state current
- High dV/dt 10 000 V/µs
- Isolation test voltage 5300 $V_{RMS}$
- Very low leakage < 10 µA
- Compliant to RoHS Directive 2002/95/EC and in accordance to WEEE 2002/96/EC

Pb-free

e3

RoHS COMPLIANT

## DESCRIPTION

The IL4116, IL4117, and IL4118 consists of an AlGaAs IRLED optically coupled to a photosensitive zero crossing TRIAC network. The TRIAC consists of two inverse parallel connected monolithic SCRs. These three semiconductors devices are assembled in a six pin 300 mil dual in-line package.

High input sensitivity is achieved by using an emitter follower phototransistor and a cascaded SCR predriver resulting in an LED trigger current of less than 1.3 mA (DC).

The IL4116, IL4117, IL4118 uses zero cross line voltage detection circuit witch consists of two enhancement MOSFETs and a photodiode. The inhibit voltage of the network is determined by the enhancement voltage of the n-channel FET. The P-channel FET is enabled by a photocurrent source that permits the FET to conduct the main voltage to gate on the n-channel FET. Once the main voltage can enable the n-channel, it clamps the base of the phototransistor, disabling the first stage SCR predriver.

The blocking voltage of up to 800 V permits control of off-line voltages up to 240 $V_{AC}$, with a safety factor of more than two, and is sufficient for as much as 380 $V_{AC}$. Current handling capability is up to 300 mA RMS continuous at 25 °C.

The IL4116, IL4117, IL4118 isolates low-voltage logic from 120 $V_{AC}$, 240 $V_{AC}$, and 380 $V_{AC}$ lines to control resistive, inductive, or capacitive loads including motors, solenoids, high current thyristors or TRIAC and relays.

Applications include solid-state relays, industrial controls, office equipment, and consumer appliances.

## APPLICATIONS

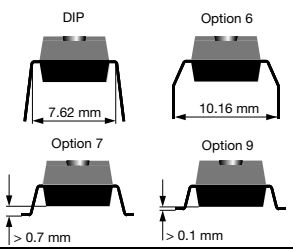
- Solid state relay
- Lighting controls
- Temperature controls
- Solenoid/valte controls
- AC motor drives/starters

## AGENCY APPROVALS

- UL1577, file no. E52744 system code H or J, double protection
- CSA 93751
- BSI IEC60950; IEC60065
- DIN EN 60747-5-5 (VDE 0884) available with option 1
- FIMKO

## ORDERING INFORMATION

| I | L | 4 | 1 | 1 | # | - | X | 0 | # | # | T |
|---|---|---|---|---|---|---|---|---|---|---|---|
| PART NUMBER | | | | | | | PACKAGE OPTION | | | | TAPE AND REEL |




| AGENCY CERTIFIED/PACKAGE | BLOCKING VOLTAGE $V_{DRM}$ (V) | | |
|---|---|---|---|
| **UL, cUL, BSI, FIMKO** | **600** | **700** | **800** |
| DIP-6 | IL4116 | IL4117 | IL4118 |
| DIP-6, 400 mil, option 6 | IL4116-X006 | - | IL4118-X006 |
| SMD-6, option 7 | IL4116-X007T (1) | IL4117-X007 | IL4118-X007T (1) |
| SMD-6, option 9 | IL4116-X009T (1) | - | IL4118-X009T (1) |
| **VDE, UL, cUL, BSI, FIMKO** | **600** | **700** | **800** |
| DIP-6 | IL4116-X001 | IL4117-X001 | IL4118-X001 |
| DIP-6, 400 mil, option 6 | IL4116-X016 | - | IL4118-X016 |
| SMD-6, option 7 | - | - | IL4118-X017 |
| SMD-6, option 9 | IL4116-X019T (1) | - | - |

**Note**
(1) Also available in tubes, do not put T on the end.



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| **ABSOLUTE MAXIMUM RATINGS** [1] ($T_{amb}$ = 25 °C, unless otherwise specified) | | | | | |
|---|---|---|---|---|---|
| **PARAMETER** | **TEST CONDITION** | **PART** | **SYMBOL** | **VALUE** | **UNIT** |
| **INPUT** | | | | | |
| Reverse voltage | | | $V_R$ | 6 | V |
| Forward current | | | $I_F$ | 60 | mA |
| Surge current | | | $I_{FSM}$ | 2.5 | A |
| Power dissipation | | | $P_{diss}$ | 100 | mW |
| Derate linearly from 25 °C | | | | 1.33 | mW/°C |
| Thermal resistance | | | $R_{th}$ | 750 | °C/W |
| **OUTPUT** | | | | | |
| Peak off-state voltage | | IL4116 | $V_{DRM}$ | 600 | V |
| | | IL4117 | $V_{DRM}$ | 700 | V |
| | | IL4118 | $V_{DRM}$ | 800 | V |
| RMS on-state current | | | $I_{DRM}$ | 300 | mA |
| Single cycle surge | | | | 3 | A |
| Power dissipation | | | $P_{diss}$ | 500 | mW |
| Derate linearly from 25 °C | | | | 6.6 | mW/°C |
| Thermal resistance | | | $R_{th}$ | 150 | °C/W |
| **COUPLER** | | | | | |
| Creepage distance | | | | ≥ 7 | mm |
| Clearance distance | | | | ≥ 7 | mm |
| Storage temperature | | | $T_{stg}$ | - 55 to + 150 | °C |
| Operating temperature | | | $T_{amb}$ | - 55 to + 100 | °C |
| Isolation test voltage | | | $V_{ISO}$ | 5300 | $V_{RMS}$ |
| Isolation resistance | $V_{IO}$ = 500 V, $T_{amb}$ = 25 °C | | $R_{IO}$ | ≥ $10^{12}$ | Ω |
| | $V_{IO}$ = 500 V, $T_{amb}$ = 100 °C | | $R_{IO}$ | ≥ $10^{11}$ | Ω |
| Lead soldering temperature [2] | 5 s | | $T_{sld}$ | 260 | °C |

**Notes**

[1] Stresses in excess of the absolute maximum ratings can cause permanent damage to the device. Functional operation of the device is not implied at these or any other conditions in excess of those given in the operational sections of this document. Exposure to absolute maximum ratings for extended periods of the time can adversely affect reliability.

[2] Refer to reflow profile for soldering conditions for surface mounted devices (SMD). Refer to wave profile for soldering conditions for through hole devices (DIP).

| ELECTRICAL CHARACTERISTICS ($T_{amb}$ = 25 °C, unless otherwise specified) | | | | | | | |
|---|---|---|---|---|---|---|---|
| **PARAMETER** | **TEST CONDITION** | **PART** | **SYMBOL** | **MIN.** | **TYP.** | **MAX.** | **UNIT** |
| **INPUT** | | | | | | | |
| Forward voltage | $I_F$ = 20 mA | | $V_F$ | | 1.3 | 1.5 | V |
| Breakdown voltage | $I_R$ = 10 µA | | $V_{BR}$ | 6 | 30 | | V |
| Reverse current | $V_R$ = 6 V | | $I_R$ | | 0.1 | 10 | µA |
| Capacitance | $V_F$ = 0 V, f = 1 MHz | | $C_O$ | | 40 | | pF |
| Thermal resistance, junction to lead | | | $R_{thjl}$ | | 750 | | °C/W |
| **OUTPUT** | | | | | | | |
| Repetitive peak off-state voltage | $I_{DRM}$ = 100 µA | IL4116 | $V_{DRM}$ | 600 | 650 | | V |
| | | IL4117 | $V_{DRM}$ | 700 | 750 | | V |
| | | IL4118 | $V_{DRM}$ | 800 | 850 | | V |
| Off-state voltage | $I_{D(RMS)}$ =70 µA | IL4116 | $V_{D(RMS)}$ | 424 | 460 | | V |
| | | IL4117 | $V_{D(RMS)}$ | 494 | 536 | | V |
| | | IL4118 | $V_{D(RMS)}$ | 565 | 613 | | V |
| Off-state current | $V_D$ = 600, $T_{amb}$ = 100 °C | | $I_{D(RMS)}$ | | 10 | 100 | µA |
| On-state voltage | $I_T$ = 300 mA | | $V_{TM}$ | | 1.7 | 3 | V |
| On-state current | PF = 1, $V_{T(RMS)}$ = 1.7 V | | $I_{TM}$ | | | 300 | mA |
| Surge (non-repetitive, on-state current) | f = 50 Hz | | $I_{TSM}$ | | | 3 | A |
| Holding current | $V_T$ = 3 V | | $I_H$ | | 65 | 200 | µA |
| Latching current | $V_T$ = 2.2 V | | $I_L$ | | | 500 | µA |
| LED trigger current | $V_{AK}$ = 5 V | | $I_{FT}$ | | 0.7 | 1.3 | mA |
| Zero cross inhibit voltage | $I_F$ = rated $I_{FT}$ | | $V_{IH}$ | | 15 | 25 | V |
| Critical rate of rise off-state voltage | $V_{RM}$, $V_{DM}$ = 400 VAC | | $dV/dt_{cr}$ | 10 000 | | | V/µs |
| | $V_{RM}$, $V_{DM}$ = 400 VAC, $T_{amb}$ = 80 °C | | $dV/dt_{cr}$ | | 2000 | | V/µs |
| Critical rate of rise of voltage at current commutation | $V_D$ = 230 $V_{RMS}$, $I_D$ = 300 $mA_{RMS}$, $T_J$ = 25 °C | | $dV/dt_{crq}$ | | 8 | | V/µs |
| | $V_D$ = 230 $V_{RMS}$, $I_D$ = 300 $mA_{RMS}$, $T_J$ = 85 °C | | $dV/dt_{crq}$ | | 7 | | V/µs |
| Critical rate of rise of on-state current commutation | $V_D$ = 230 $V_{RMS}$, $I_D$ = 300 $mA_{RMS}$, $T_J$ = 25 °C | | $dV/dt_{crq}$ | | 12 | | A/ms |
| Thermal resistance, junction to lead | | | $R_{thjl}$ | | 150 | | °C/W |
| **COUPLER** | | | | | | | |
| Critical state of rise of coupler input-output voltage | $I_T$ = 0 A, $V_{RM}$ = $V_{DM}$ = 424 VAC | | $dV_{(IO)}/dt$ | 10 000 | | | V/µs |
| Capacitance (input to output) | f = 1 MHz, $V_{IO}$ = 0 V | | $C_{IO}$ | | 0.8 | | pF |
| Common mode coupling capacitance | | | $C_{CM}$ | | 0.01 | | pF |

**Note**

- Minimum and maximum values are testing requirements. Typical values are characteristics of the device and are the result of engineering evaluation. Typical values are for information only and are not part of the testing requirements.

| SWITCHING CHARACTERISTICS | | | | | | | |
|---|---|---|---|---|---|---|---|
| **PARAMETER** | **TEST CONDITION** | **PART** | **SYMBOL** | **MIN.** | **TYP.** | **MAX.** | **UNIT** |
| Turn-on time | $V_{RM}$ = $V_{DM}$ = 424 VAC | | $t_{on}$ | | 35 | | µs |
| Turn-off time | PF = 1, $I_T$ = 300 mA | | $t_{off}$ | | 50 | | µs |

## TYPICAL CHARACTERISTICS ($T_{amb}$ = 25 °C, unless otherwise specified)

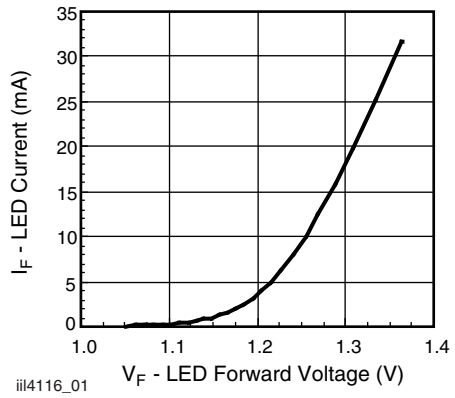



Fig. 1 - LED Forward Current vs. Forward Voltage

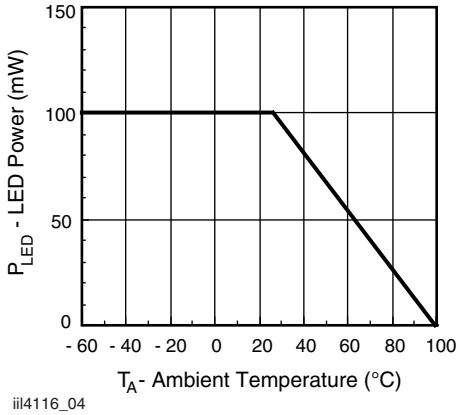



Fig. 4 - Maximum LED Power Dissipation

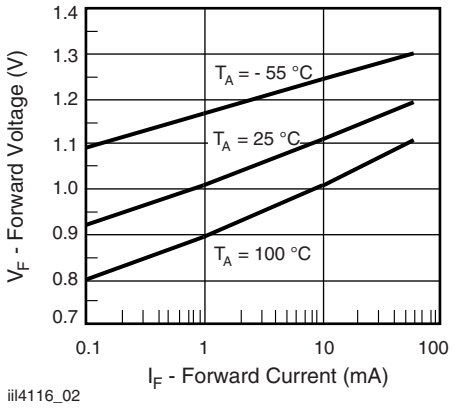



Fig. 2 - Forward Voltage vs. Forward Current

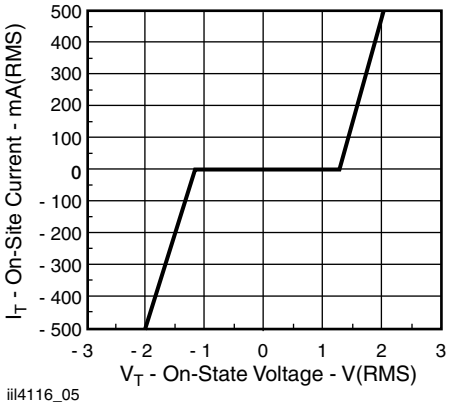



Fig. 5 - On-State Terminal Voltage vs. Terminal Current

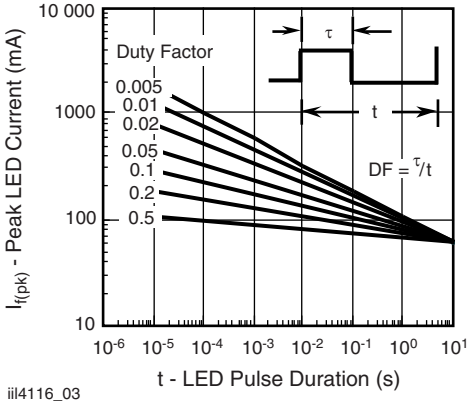



Fig. 3 - Peak LED Current vs. Duty Factor, τ

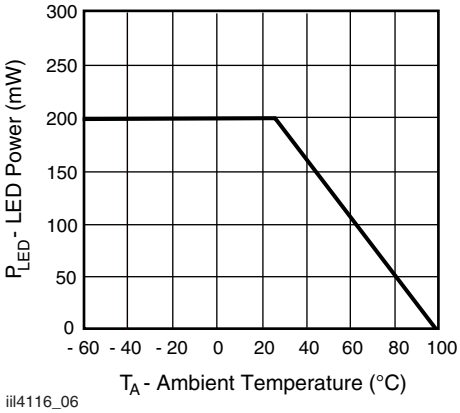



Fig. 6 - Maximum Output Power Dissipation

## TRIGGER CURRENT VS. TEMPERATURE AND VOLTAGE

The trigger current of the IL4116, IL4117, IL4118 has a positive temperature gradient and also is dependent on the terminal voltage as shown as the fig. 7.

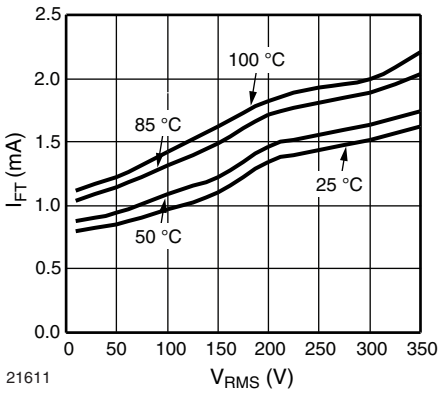



Fig. 7 - Trigger Current vs.
Temperature and Operating Voltage (50 Hz)

For the operating voltage 250 $V_{RMS}$ over the temperature range - 40 °C to 85 °C, the $I_F$ should be at least 2.3 x of the $I_{FT1}$ (1.3 mA, max.).

Considering - 30 % degradation over time, the trigger current minimum is $I_F$ = 1.3 x 2.3 x 130 % = 4 mA

## INDUCTIVE AND RESISTIVE LOADS

For inductive loads, there is phase shift between voltage and current, shown in the fig. 8.

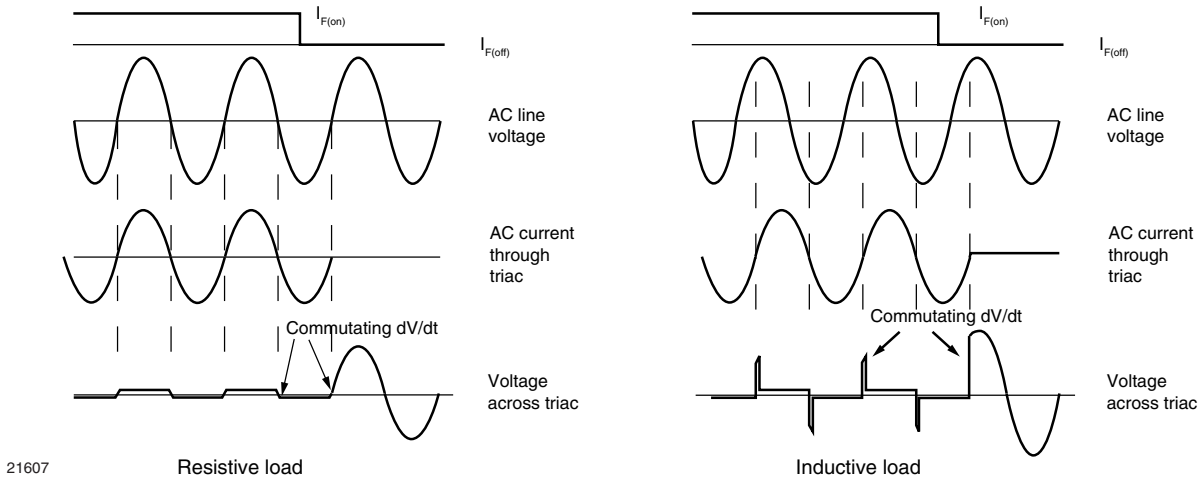



Fig. 8 - Waveforms of Resistive and Inductive Loads

The voltage across the triac will rise rapidly at the time the current through the power handling triac falls below the holding current and the triac ceases to conduct. The rise rate of voltage at the current commutation is called commutating dV/dt. There would be two potential problems for ZC phototriac control if the commutating dV/dt is too high. One is lost control to turn off, another is failed to keep the triac on.

### Lost control to turn off

If the commutating dV/dt is too high, more than its critical rate ($dV/dt_{crq}$), the triac may resume conduction even if the LED drive current $I_F$ is off and control is lost.

In order to achieve control with certain inductive loads of power factors is less than 0.8, the rate of rise in voltage (dV/dt) must be limited by a series RC network placed in parallel with the power handling triac. The RC network is called snubber circuit. Note that the value of the capacitor increases as a function of the load current as shown in fig. 9.

### Failed to keep on

As a zero-crossing phototriac, the commutating dV/dt spikes can inhibit one half of the TRIAC from keeping on If the spike potential exceeds the inhibit voltage of the zero cross detection circuit, even if the LED drive current $I_F$ is on.

This hold-off condition can be eliminated by using a snubber and also by providing a higher level of LED drive current. The higher LED drive provides a larger photocurrent which causes the triac to turn-on before the commutating spike has activated the zero cross detection circuit. Fig. 10 shows the relationship of the LED current for power factors of less than 1.0. The curve shows that if a device requires 1.5 mA for a resistive load, then 1.8 times (2.7 mA) that amount would be required to control an inductive load whose power factor is less than 0.3 without the snubber to dump the spike.

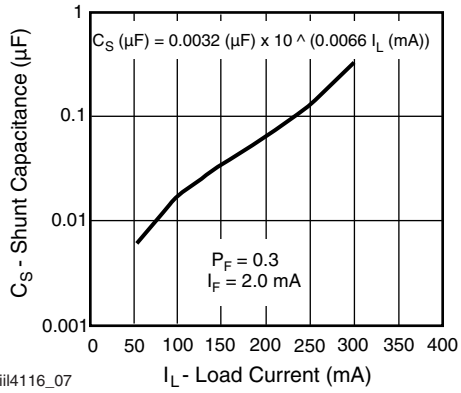



Fig. 9 - Shunt Capacitance vs. Load Current vs. Power Factor

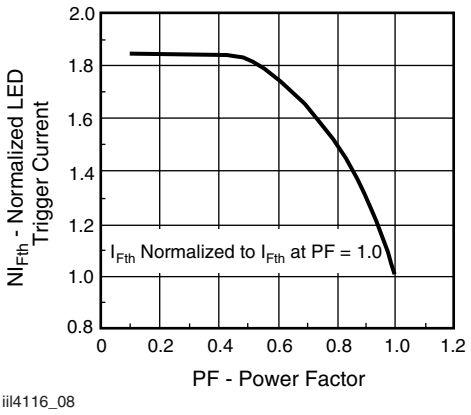



Fig. 10 - Normalized LED Trigger Current

## APPLICATIONS

Direct switching operation:

The IL4116, IL4117, IL4118 isolated switch is mainly suited to control synchronous motors, valves, relays and solenoids. Fig. 11 shows a basic driving circuit. For resistive load the snubber circuit $R_S$ $C_S$ can be omitted due to the high static dV/dt characteristic.

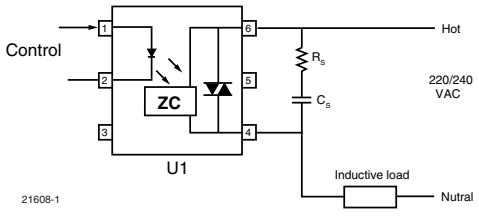



Fig. 11 - Basic Direct Load Driving Circuit

Indirect switching operation:

The IL4116, IL4117, IL4118 switch acts here as an isolated driver and thus enables the driving of power thyristors and power triacs by microprocessors. Fig. 12 shows a basic driving circuit of inductive load. The resister R1 limits the driving current pulse which should not exceed the maximum permissible surge current of the IL4116, IL4117, IL4118. The resister $R_G$ is needed only for very sensitive thyristors or triacs from being triggered by noise or the inhibit current.

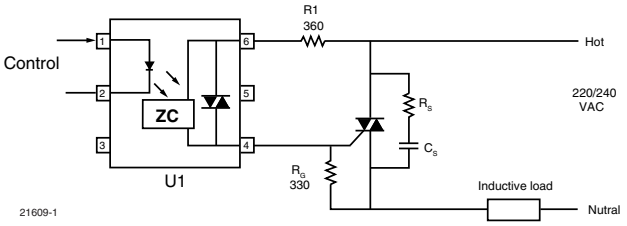
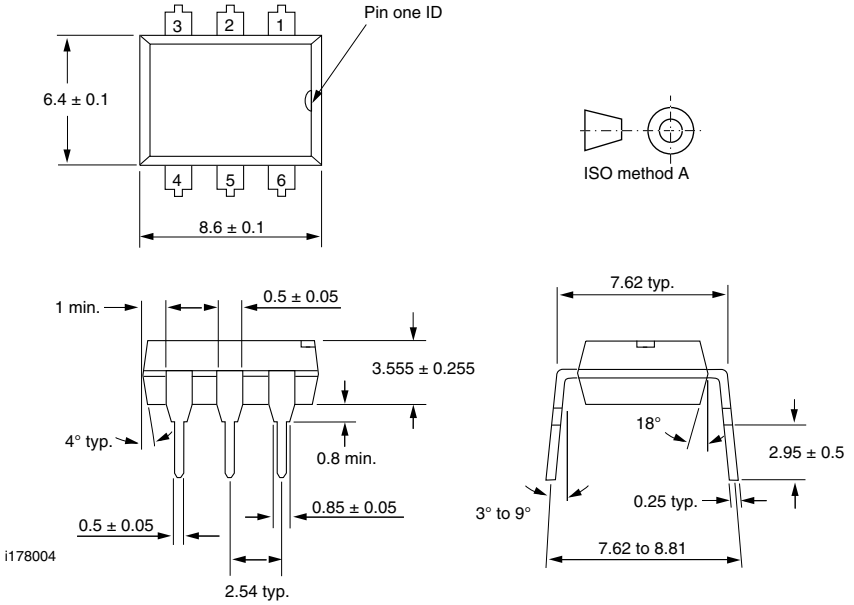
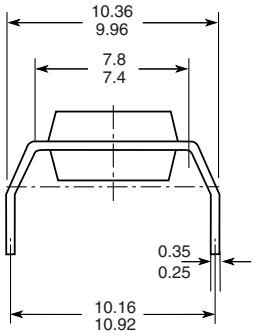



Fig. 12 - Basic Power Triac Driver Circuit

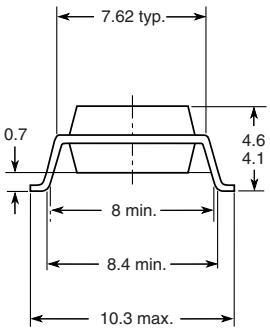
**PACKAGE DIMENSIONS** in millimeters



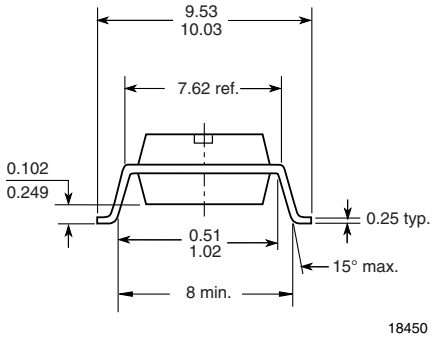

**Option 6**




**Option 7**




**Option 9**



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