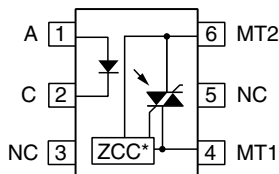
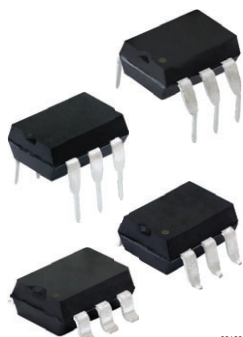


# Optocoupler, Phototriac Output, Zero Crossing, High dV/dt, Low Input Current



\*Zero crossing circuit



## FEATURES

- Low trigger current  $I_{FT} = 2 \text{ mA}$
- $I_{TRMS} = 300 \text{ mA}$
- High static  $dV/dt \geq 10\,000 \text{ V}/\mu\text{s}$
- Load voltage up to 800 V
- Zero voltage crossing detector
- Material categorization: for definitions of compliance please see [www.vishay.com/doc?99912](http://www.vishay.com/doc?99912)



**RoHS**  
COMPLIANT

## APPLICATIONS

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

## AGENCY APPROVALS

- [UL 1577](#)
- [cUL](#)
- [DIN EN 60747-5-5 \(VDE 0884-5\)](#), available with option 1
- [FIMKO](#)

## LINKS TO ADDITIONAL RESOURCES



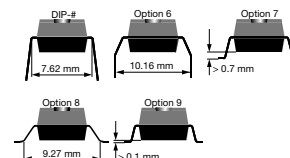
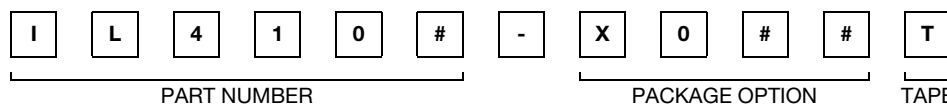
## DESCRIPTION

The IL410 and IL4108 consist of an optically coupled GaAs IRLED to a photosensitive thyristor system with integrated noise suppression and zero crossing circuit.

The thyristor system enables low trigger currents of 2 mA and features a  $dV/dt$  ratio of greater than 10 kV/ $\mu\text{s}$  and load voltages up to 800 V.

The IL410 and IL4108 are a perfect microcontroller friendly solution to isolate low voltage logic from high voltage 120 V<sub>AC</sub>, 240 V<sub>AC</sub>, and 380 V<sub>AC</sub> lines and to control resistive, inductive, or capacitive AC loads like motors, solenoids, high power thyristors or TRIACs, and solid-state relays.

## ORDERING INFORMATION



| AGENCY CERTIFIED / PACKAGE      | BLOCKING VOLTAGE $V_{DRM}$ (V) |                             |
|---------------------------------|--------------------------------|-----------------------------|
| <b>UL, cUL, CSA, FIMKO</b>      | <b>600</b>                     | <b>800</b>                  |
| DIP-6                           | IL410                          | IL4108                      |
| DIP-6, 400 mil, option 6        | IL410-X006                     | -                           |
| SMD-6, option 7                 | IL410-X007T <sup>(1)</sup>     | IL4108-X007T <sup>(1)</sup> |
| SMD-6, option 8                 | IL410-X008T                    | -                           |
| SMD-6, option 9                 | IL410-X009T                    | IL4108-X009T <sup>(1)</sup> |
| <b>VDE, UL, cUL, CSA, FIMKO</b> | <b>600</b>                     | <b>800</b>                  |
| DIP-6                           | IL410-X001                     | -                           |
| DIP-6, 400 mil, option 6        | IL410-X016                     | IL4108-X016                 |
| SMD-6, option 7                 | IL410-X017                     | IL4108-X017                 |
| SMD-6, option 9                 | IL410-X019T                    | -                           |

### Note

<sup>(1)</sup> Also available in tubes, do not put T on the end



| <b>ABSOLUTE MAXIMUM RATINGS</b> ( $T_{amb} = 25\text{ }^{\circ}\text{C}$ , unless otherwise specified) |                                                        |        |            |             |       |
|--------------------------------------------------------------------------------------------------------|--------------------------------------------------------|--------|------------|-------------|-------|
| PARAMETER                                                                                              | TEST CONDITION                                         | PART   | SYMBOL     | VALUE       | UNIT  |
| <b>INPUT</b>                                                                                           |                                                        |        |            |             |       |
| 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 from 25 °C                                                                                      |                                                        |        |            | 1.33        | mW/°C |
| <b>OUTPUT</b>                                                                                          |                                                        |        |            |             |       |
| Peak off-state voltage                                                                                 |                                                        | IL410  | $V_{DRM}$  | 600         | V     |
|                                                                                                        |                                                        | IL4108 | $V_{DRM}$  | 800         | V     |
| RMS on-state current                                                                                   |                                                        |        | $I_{TM}$   | 300         | mA    |
| Single cycle surge current                                                                             |                                                        |        |            | 3           | A     |
| Total power dissipation                                                                                |                                                        |        | $P_{diss}$ | 500         | mW    |
| Derate from 25 °C                                                                                      |                                                        |        |            | 6.6         | mW/°C |
| <b>COUPLER</b>                                                                                         |                                                        |        |            |             |       |
| Pollution degree (DIN VDE 0109)                                                                        |                                                        |        |            | 2           |       |
| Storage temperature range                                                                              |                                                        |        | $T_{stg}$  | -55 to +150 | °C    |
| Ambient temperature                                                                                    |                                                        |        | $T_{amb}$  | -55 to +100 | °C    |
| Soldering temperature <sup>(1)</sup>                                                                   | Max. ≤ 10 s dip soldering<br>≥ 0.5 mm from case bottom |        | $T_{sld}$  | 260         | °C    |

**Notes**

- 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.
- <sup>(1)</sup> Refer to reflow profile for soldering conditions for surface mounted devices (SMD). Refer to wave profile for soldering conditions for through hole devices (DIP).



| <b>ELECTRICAL CHARACTERISTICS</b> ( $T_{amb} = 25\text{ }^{\circ}\text{C}$ , unless otherwise specified) |                                                                                                                     |      |                              |        |      |      |                                |
|----------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------|------|------------------------------|--------|------|------|--------------------------------|
| PARAMETER                                                                                                | TEST CONDITION                                                                                                      | PART | SYMBOL                       | MIN.   | TYP. | MAX. | UNIT                           |
| <b>INPUT</b>                                                                                             |                                                                                                                     |      |                              |        |      |      |                                |
| Forward voltage                                                                                          | $I_F = 10\text{ mA}$                                                                                                |      | $V_F$                        | -      | 1.16 | 1.35 | V                              |
| Reverse current                                                                                          | $V_R = 6\text{ V}$                                                                                                  |      | $I_R$                        | -      | 0.1  | 10   | $\mu\text{A}$                  |
| Input capacitance                                                                                        | $V_F = 0\text{ V}$ , $f = 1\text{ MHz}$                                                                             |      | $C_{IN}$                     | -      | 25   | -    | pF                             |
| Thermal resistance, junction to ambient                                                                  |                                                                                                                     |      | $R_{thja}$                   | -      | 750  | -    | $^{\circ}\text{C/W}$           |
| <b>OUTPUT</b>                                                                                            |                                                                                                                     |      |                              |        |      |      |                                |
| Off-state current                                                                                        | $V_D = V_{DRM}$ , $T_{amb} = 100\text{ }^{\circ}\text{C}$ ,<br>$I_F = 0\text{ mA}$                                  |      | $I_{DRM}$                    | -      | 10   | 100  | $\mu\text{A}$                  |
| On-state voltage                                                                                         | $I_T = 300\text{ mA}$                                                                                               |      | $V_{TM}$                     | -      | 1.7  | 3    | V                              |
| Surge (non-repetitive), on-state current                                                                 | $f = 50\text{ Hz}$                                                                                                  |      | $I_{TSM}$                    | -      | -    | 3    | A                              |
| Trigger current 1                                                                                        | $V_D = 5\text{ V}$                                                                                                  |      | $I_{FT1}$                    | -      | -    | 2    | mA                             |
| Trigger current 2                                                                                        | $V_D = 220\text{ V}_{RMS}$ , $f = 50\text{ Hz}$ ,<br>$T_j = 100\text{ }^{\circ}\text{C}$ , $t_{pIF} > 10\text{ ms}$ |      | $I_{FT2}$                    | -      | -    | 6    | mA                             |
| Trigger current temp. gradient                                                                           |                                                                                                                     |      | $\Delta I_{FT1}/\Delta T_j$  | -      | 7    | 14   | $\mu\text{A}/^{\circ}\text{C}$ |
|                                                                                                          |                                                                                                                     |      | $\Delta I_{FT2}/\Delta T_j$  | -      | 7    | 14   | $\mu\text{A}/^{\circ}\text{C}$ |
| Inhibit voltage temp. gradient                                                                           |                                                                                                                     |      | $\Delta V_{DINH}/\Delta T_j$ | -      | -20  | -    | $\text{mV}/^{\circ}\text{C}$   |
| Off-state current in inhibit state                                                                       | $I_F = I_{FT1}$ , $V_D = V_{DRM}$                                                                                   |      | $I_{DINH}$                   | -      | 50   | 200  | $\mu\text{A}$                  |
| Holding current                                                                                          |                                                                                                                     |      | $I_H$                        | -      | 65   | 500  | $\mu\text{A}$                  |
| Latching current                                                                                         | $V_T = 2.2\text{ V}$                                                                                                |      | $I_L$                        | -      | -    | 500  | $\mu\text{A}$                  |
| Zero cross inhibit voltage                                                                               | $I_F = \text{rated } I_{FT}$                                                                                        |      | $V_{IH}$                     | -      | 15   | 25   | V                              |
| Critical rate of rise of off-state voltage                                                               | $V_D = 0.67\text{ }V_{DRM}$ , $T_j = 25\text{ }^{\circ}\text{C}$                                                    |      | $dV/dt_{cr}$                 | 10 000 | -    | -    | $\text{V}/\mu\text{s}$         |
|                                                                                                          | $V_D = 0.67\text{ }V_{DRM}$ , $T_j = 80\text{ }^{\circ}\text{C}$                                                    |      | $dV/dt_{cr}$                 | 5000   | -    | -    | $\text{V}/\mu\text{s}$         |
| Critical rate of rise of voltage at current commutation                                                  | $V_D = 230\text{ V}_{RMS}$ ,<br>$I_D = 300\text{ mA}_{RMS}$ , $T_J = 25\text{ }^{\circ}\text{C}$                    |      | $dV/dt_{crq}$                | -      | 8    | -    | $\text{V}/\mu\text{s}$         |
|                                                                                                          | $V_D = 230\text{ V}_{RMS}$ ,<br>$I_D = 300\text{ mA}_{RMS}$ , $T_J = 85\text{ }^{\circ}\text{C}$                    |      | $dV/dt_{crq}$                | -      | 7    | -    | $\text{V}/\mu\text{s}$         |
| Critical rate of rise of on-state current commutation                                                    | $V_D = 230\text{ V}_{RMS}$ ,<br>$I_D = 300\text{ mA}_{RMS}$ , $T_J = 25\text{ }^{\circ}\text{C}$                    |      | $dI/dt_{crq}$                | -      | 12   | -    | $\text{A/ms}$                  |
| Thermal resistance, junction to ambient                                                                  |                                                                                                                     |      | $R_{thja}$                   | -      | 150  | -    | $^{\circ}\text{C/W}$           |
| <b>COUPLER</b>                                                                                           |                                                                                                                     |      |                              |        |      |      |                                |
| Critical rate of rise of coupled input/output voltage                                                    | $I_T = 0\text{ A}$ , $V_{RM} = V_{DM} = V_{DRM}$                                                                    |      | $dV_{IO}/dt$                 | 10 000 | -    | -    | $\text{V}/\mu\text{s}$         |
| Common mode coupling capacitance                                                                         |                                                                                                                     |      | $C_{CM}$                     | -      | 0.01 | -    | pF                             |
| Capacitance (input to output)                                                                            | $f = 1\text{ MHz}$ , $V_{IO} = 0\text{ V}$                                                                          |      | $C_{IO}$                     | -      | 0.8  | -    | 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.

| <b>SWITCHING CHARACTERISTICS</b> ( $T_{amb} = 25\text{ }^{\circ}\text{C}$ , unless otherwise specified) |                             |      |          |      |      |      |               |
|---------------------------------------------------------------------------------------------------------|-----------------------------|------|----------|------|------|------|---------------|
| PARAMETER                                                                                               | TEST CONDITION              | PART | SYMBOL   | MIN. | TYP. | MAX. | UNIT          |
| Turn-on time                                                                                            | $V_{RM} = V_{DM} = V_{DRM}$ |      | $t_{on}$ | -    | 35   | -    | $\mu\text{s}$ |

**SAFETY AND INSULATION RATINGS**

| PARAMETER                                    | TEST CONDITION                                                   | SYMBOL     | VALUE          | UNIT               |
|----------------------------------------------|------------------------------------------------------------------|------------|----------------|--------------------|
| Climatic classification                      | According to IEC 68 part 1                                       |            | 55 / 100 / 21  |                    |
| Comparative tracking index                   |                                                                  | CTI        | 175            |                    |
| Maximum rated withstanding isolation voltage | $t = 1 \text{ min}$                                              | $V_{ISO}$  | 4420           | $V_{RMS}$          |
| Maximum transient isolation voltage          |                                                                  | $V_{IOTM}$ | 10 000         | $V_{peak}$         |
| Maximum repetitive peak isolation voltage    |                                                                  | $V_{IORM}$ | 890            | $V_{peak}$         |
| Isolation resistance                         | $V_{IO} = 500 \text{ V}, T_{amb} = 25 \text{ }^{\circ}\text{C}$  | $R_{IO}$   | $\geq 10^{12}$ | $\Omega$           |
|                                              | $V_{IO} = 500 \text{ V}, T_{amb} = 100 \text{ }^{\circ}\text{C}$ | $R_{IO}$   | $\geq 10^{11}$ | $\Omega$           |
| Output safety power                          |                                                                  | $P_{SO}$   | 400            | mW                 |
| Input safety current                         |                                                                  | $I_{SI}$   | 275            | mA                 |
| Safety temperature                           |                                                                  | $T_S$      | 175            | $^{\circ}\text{C}$ |
| Creepage distance                            |                                                                  |            | $\geq 7$       | mm                 |
| Clearance distance                           |                                                                  |            | $\geq 7$       | mm                 |
| Insulation thickness                         |                                                                  | DTI        | $\geq 0.4$     | mm                 |

**Note**

- As per IEC 60747-5-5, § 7.4.3.8.2, this optocoupler is suitable for “safe electrical insulation” only within the safety ratings. Compliance with the safety ratings shall be ensured by means of protective circuits.

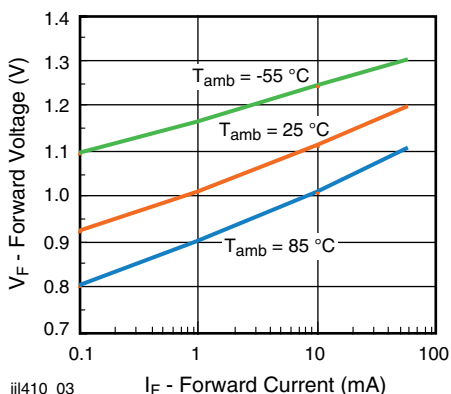
**TYPICAL CHARACTERISTICS** ( $T_{amb} = 25 \text{ }^{\circ}\text{C}$ , unless otherwise specified)


Fig. 1 - Forward Voltage vs. Forward Current

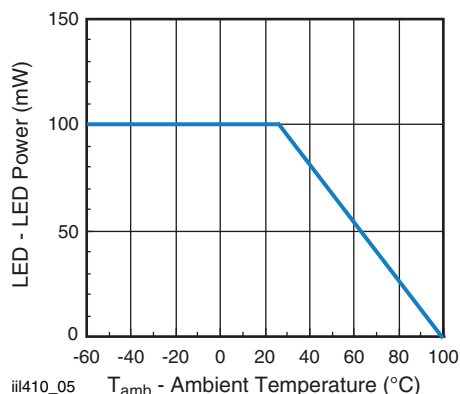


Fig. 3 - Maximum LED Power Dissipation

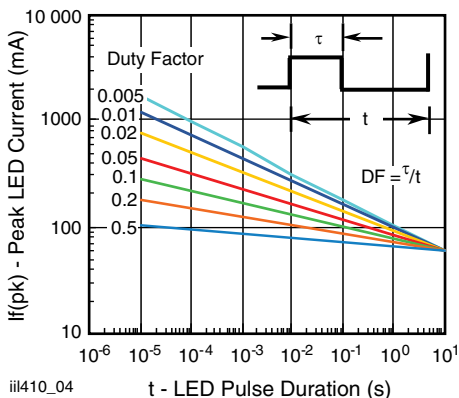
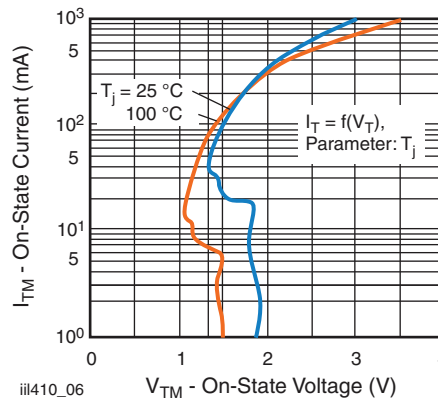

Fig. 2 - Peak LED Current vs. Duty Factor,  $\tau$ 


Fig. 4 - Typical Output Characteristics

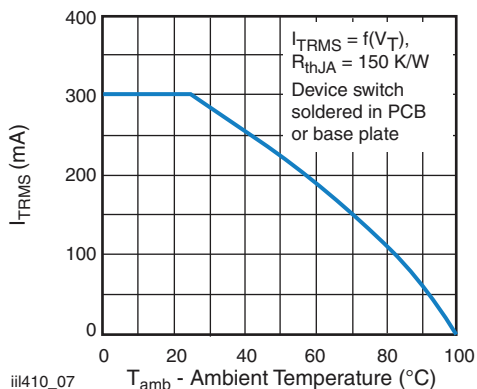


Fig. 5 - Current Reduction

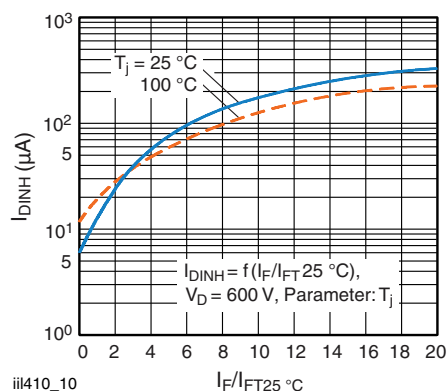
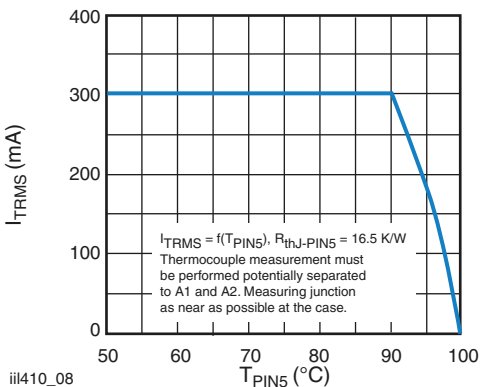

Fig. 8 - Off-State Current in Inhibited State vs.  $I_F/I_{FT} 25^\circ\text{C}$ 


Fig. 6 - Current Reduction

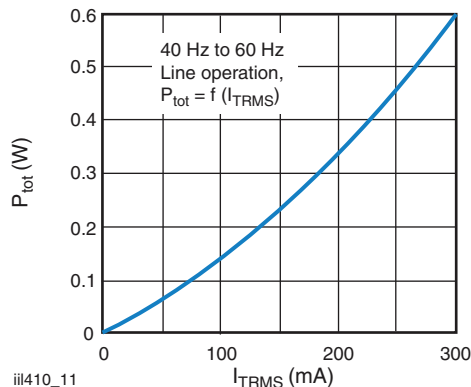


Fig. 9 - Power Dissipation 40 Hz to 60 Hz Line Operation

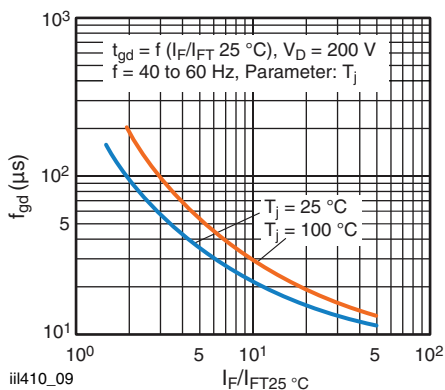


Fig. 7 - Typical Trigger Delay Time

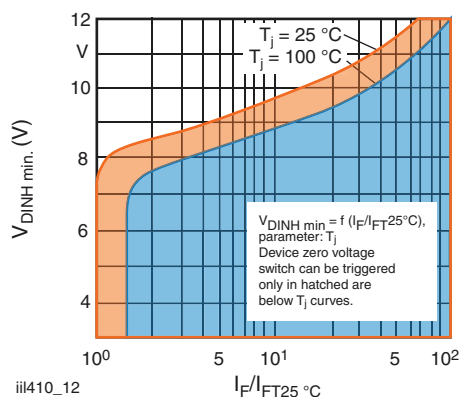


Fig. 10 - Typical Static Inhibit Voltage Limit

## TRIGGER CURRENT VS. TEMPERATURE AND VOLTAGE

The trigger current of the IL410, 4108 has a positive temperature gradient and also is dependent on the terminal voltage as shown as the Fig. 11.

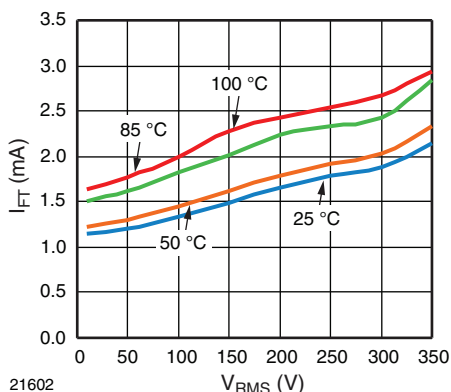


Fig. 11 - Trigger Current vs. Temperature and Operating Voltage (50 Hz)

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  $I_{FT1}$  (2 mA, max.).

Considering -30 % degradation over time, the trigger current minimum is  $I_F = 2 \times 2.3 \times 130 \% = 6 \text{ mA}$ .

## INDUCTIVE AND RESISTIVE LOADS

For inductive loads, there is phase shift between voltage and current, shown in the Fig. 12.

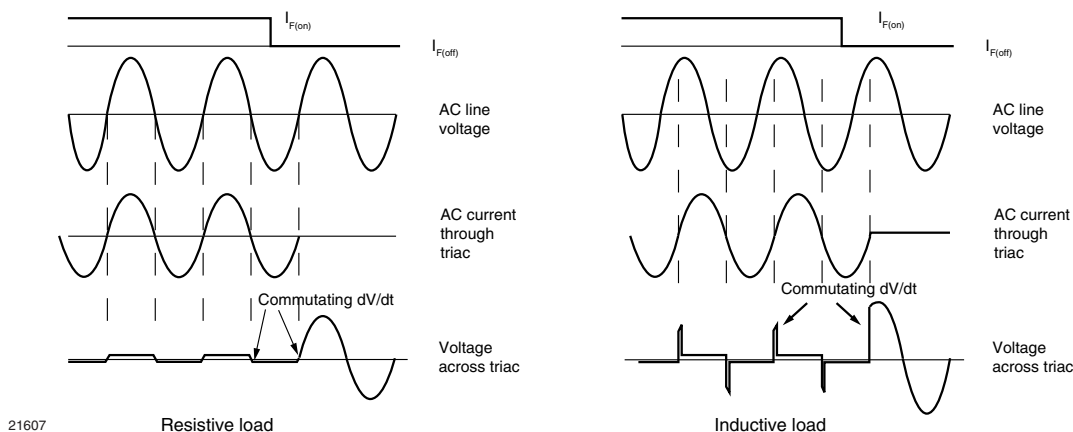


Fig. 12 - Waveforms of Resistive and Inductive Loads

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. 13.

### 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. 14 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.

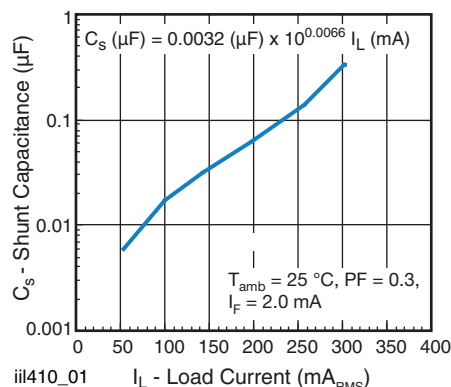


Fig. 13 - Shunt Capacitance vs. Load Current

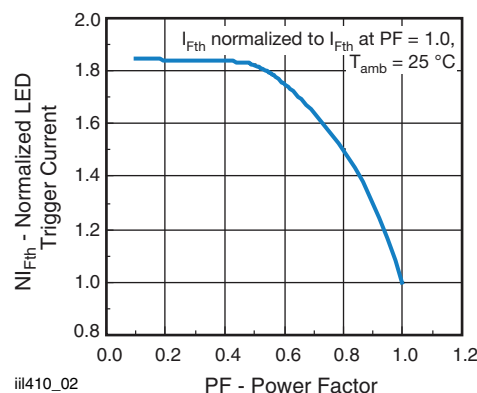


Fig. 14 - Normalized LED Trigger Current vs. Power Factor

## APPLICATIONS

Direct switching operation:

The IL410, IL4108 isolated switch is mainly suited to control synchronous motors, valves, relays and solenoids. Fig. 15 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.

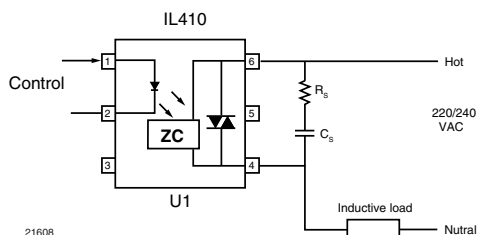


Fig. 15 - Basic Direct Load Driving Circuit

Indirect switching operation:

The IL410, IL4108 switch acts here as an isolated driver and thus enables the driving of power thyristors and power triacs by microprocessors. Fig. 16 shows a basic driving circuit of inductive load. The resistor  $R_1$  limits the driving current pulse which should not exceed the maximum permissible surge current of the IL410, IL4108. The resistor  $R_G$  is needed only for very sensitive thyristors or triacs from being triggered by noise or the inhibit current.

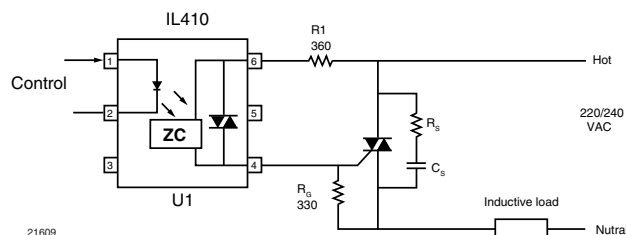
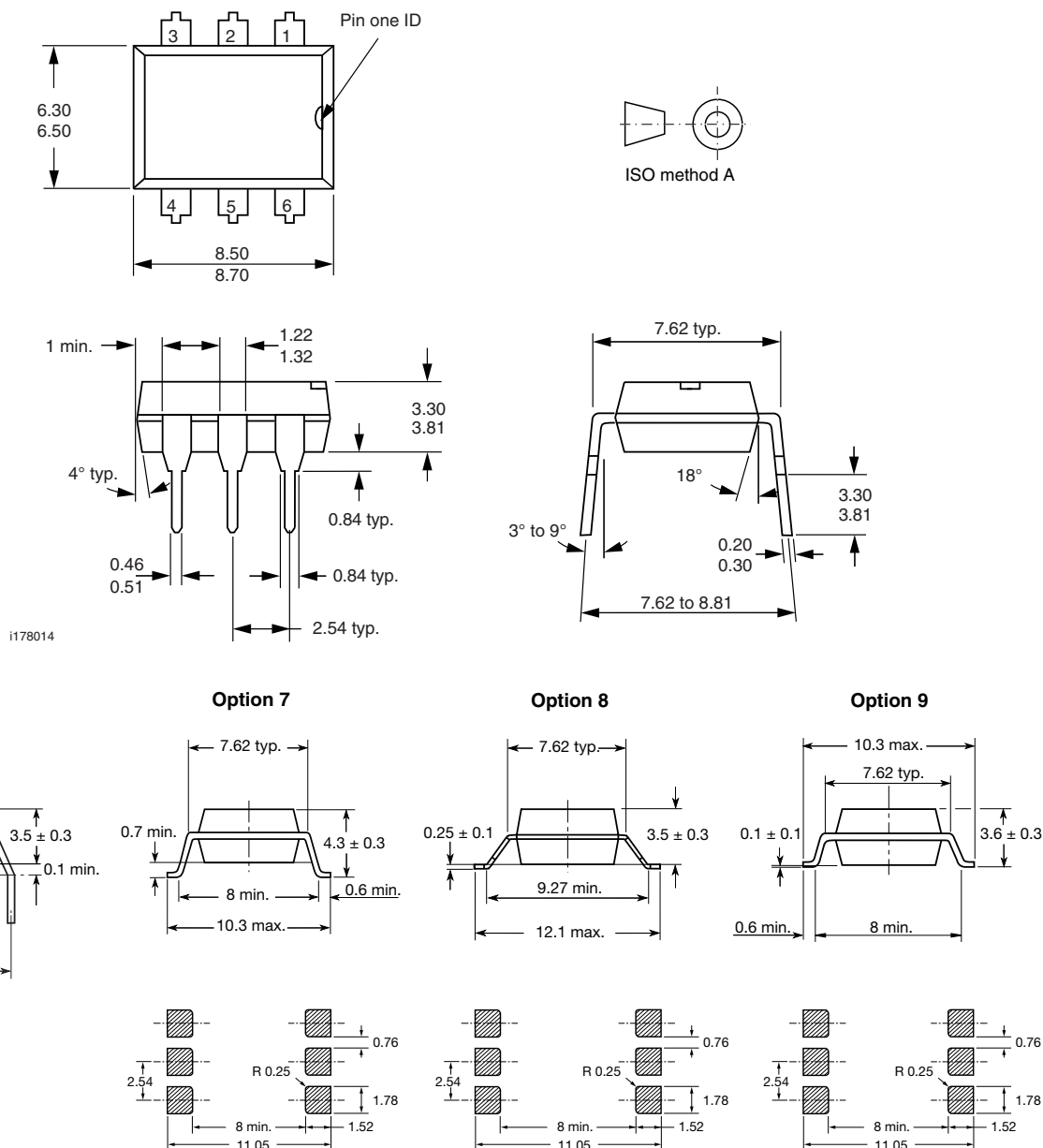


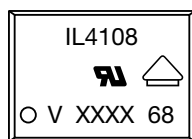
Fig. 16 - Basic Power Triac Driver Circuit



**PACKAGE DIMENSIONS** in millimeters



**PACKAGE MARKING** (example)



**Notes**

- XXXX = LMC (lot marking code)
- Only options 1, 7, and 8 are reflected in the package marking
- The VDE Logo is only marked on option 1 parts
- Tape and reel suffix (T) is not part of the package marking



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