



## Optocouplers in Switching Power Supplies

The following provide information on how to use optocouplers in designs to protect against electric shock. Safety standards for optocouplers are intended to prevent injury or damage due to electric shock. Two levels of electrical interface are normally used:

- Reinforced, or safe insulation is required in an optocoupler interface between a hazardous voltage circuit (like an AC line) and a touchable safety extra low voltage (SELV) circuit.
- Basic insulation is required in an optocoupler interface between a hazardous voltage circuit and a non-touchable extra low voltage (ELV) circuit.

The most widely used insulation for optocouplers in switch-mode power supply is reinforced insulation (class II). The following information enables the designer to understand the safety aspects, the basic concept of the DIN EN 60747-5-2(VDE0884)/ DIN EN 60747-5-5 pending and the design requirements for applications.

### FACTS AND INFORMATION <sup>(1)</sup>

Optocouplers for line-voltage separation must have several national standards. The most accepted standards are:

- UL for America
- UL/CSA for Canada
- CQC for China
- BSI for Great Britain
- FIMKO, SEMKO, NEMKO, DEMKO for Nordic countries (Europe)
- VDE for Germany

Today, most manufacturers operate on a global scale. Therefore, it is important to understand and meet those requirements.

The DIN EN 60747-5-2(VDE0884)/ DIN EN 60747-5-5 pending is a major safety standard in the world.

The DIN EN 60747-5-2(VDE0884)/ DIN EN 60747-5-5 pending standard and IEC 60047C/199/CD standards may become part of IEC 60747-5.

If design engineers work with VISHAY optocouplers, they will find some terms and definitions in the data sheets which relate to DIN EN 60747-5-2(VDE0884)/DIN EN 60747-5-5 pending.

#### Note

<sup>(1)</sup> See safety agency application note for more information

### Rated Isolation Voltages

$V_{ISO}$  is the voltage between the input terminals and the output terminals.

Note: All voltages are peak voltages!

- $V_{IOWM}$  is a maximum rms. voltage value of the optocouplers assigned by VISHAY. This characterizes the long term withstand capability of its insulation
- $V_{IORM}$  is a maximum recurring peak (repetitive) voltage value of the optocoupler assigned by VISHAY. This characterizes the long-term withstand capability against recurring peak voltages
- $V_{IOTM}$  is an impulse voltage value of the optocoupler assigned by VISHAY. This characterizes the long-term withstand capability against transient over voltages.

Isolation test voltage for routine tests is at factor 1.875 higher than the specified  $V_{IOWM}/V_{IORM (peak)}$ .

A partial discharge test is a different test method to the normal isolation voltage test. This method is more sensitive and will not damage the isolation behavior of the optocoupler like other test methods probably do. The DIN EN 60747-5-2 (VDE 0884)/DIN EN 60747-5- 5 pending therefore does not require a minimum thickness through insulation. The philosophy is that a mechanical distance only does not give you an indication of the safety reliability of the coupler. It is recommended that construction together with the assembling performance. The **partial discharge test method** can monitor this more reliably.

The following tests must be done to guarantee this safety requirement.

100 % test (piece by piece) for one second at a voltage level of specified  $V_{IOWM}/V_{IORM (peak)}$  multiplied by 1.875 <sup>(1)</sup> test criteria is partial discharge less than 5 pC.

A lotwise test at  $V_{IOTM}$  for 10 s and at a voltage level of specified  $V_{IOWM}/V_{IORM (peak)}$  multiplied by 1.5 for 1 min <sup>(1)</sup> test criteria is partial discharge less than 5 pC.

### Design Example

The line AC voltage is 380  $V_{RMS}$ . Your application class is III (DIN/VDE 0110 Part 1/1.89). According to table 1, you must calculate with a maximum line voltage of 600 V and a transient over voltage of 6000 V.



**TABLE 1 - RECOMMENDED TRANSIENT OVERVOLTAGES RELATED TO AC/DC LINE VOLTAGE (PEAK VALUES)**

$V_{IOWM}/V_{IORM}$ up to	Appl. Class I	Appl. Class II	Appl. Class III	Appl. Class IV
50 V	350 V	500 V	800 V	1500 V
100 V	500 V	800 V	1500 V	2500 V
150 V	800 V	1500 V	2500 V	4000 V
300 V	1500 V	2500 V	4000 V	6000 V
600 V	2500 V	4000 V	6000 V	8000 V
1000 V	4000 V	6000 V	8000 V	12000 V

Now select the TCDDT1100 from our VISHAY coupler program. The next voltage step of 380 V is 600 V ( $V_{IOWM}$ ). The test voltages are 1600 V for the TCDDT1100 for the routine test and 6000 V/1300 V for the sample test.

The DIN EN 60747-5-2 (VDE 0884)/DIN EN 60747-5-5 pending together with the isolation test voltages also require very high isolation resistance, tested at an ambient temperature of 100 °C.

Apart from these tests for the running production, the VDE Testing and Approvals Institute also investigates the total construction of the optocoupler.

The DIN EN 60747-5-2 (VDE 0884)/DIN EN 60747-5-5 pending requires life tests in a very special sequence; 5 lots for 5 different subgroups are tested.

The sequence for the main group is as follows:

- Cycle test
- Vibration
- Shock
- Dry heat
- Accelerated damp heat
- Low temperature storage (normally - 55 °C)
- Damp heat steady state
- Final measurements

Finally there is another chapter concerning the safety ratings. This is described in DIN EN 60747-5-2 (VDE 0884)/DIN EN 60747-5-5 pending.

The maximum safety ratings are the electrical, thermal and mechanical conditions that exceed the absolute maximum ratings for normal operations. The philosophy is that optocouplers must withstand a certain exceeding of the input current, output power dissipation, and temperature for at least 72 h. This is a simulated space of time where failures may occur. It is the designer's task to create his design inside of the maximum safety ratings.

Optocouplers - approved to the DIN EN 60747-5-2 (VDE 0884)/DIN EN 60747-5-5 pending - must consequently pass all tests undertaken. This enables you to go ahead and start your design.

## LAYOUT DESIGN RULES

The previous chapter described the important safety requirements for the optocoupler itself; but the knowledge of the creepage distance and clearance path is also important for the design engineer if the coupler is to be mounted onto the circuit board. Although several different creepage distances refer to different safety standards, e.g. IEC 60065 for TV or the IEC 60950 for office equipment, computer, data equipment etc. there is one distance which dominates switching power supplies: This is the 8 mm spacing requirement between the two circuits: The hazardous input voltage (AC 240 power-line voltage) and the safety low voltage.

This 8 mm spacing is related to the 250 V power line and defines the shortest distance between the conductive parts (either from the input to the output leads) along the case of the optocoupler, or across the surface of the print board between the solder eyes of the optocoupler input/ output leads, as shown in figure 1. The normal distance input to output leads of an optocoupler is 0.3". This is too tight for the 8 mm requirement. The designer now has two options: He can provide a slit in the board, but then the airgap is still low or.

Depending on the product, option 1 or the "G" version can be used e.g. SFH619-X001 or TCDDT1100G.

"G" stands for a wide-spaced lead form of 0.4" and meets the 8 mm spacing.

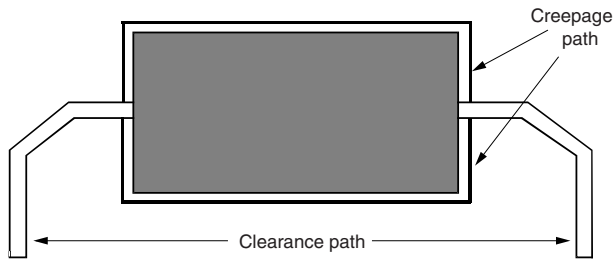
The spacing requirements of the 8 mm must also be taken into consideration for the layout of the board.

Figures 2 and 3 provide examples for your layout.

The creepage distance is also related to the resistance of the tracking creepage current stability. The plastic material of the optocoupler itself and the material of the board must provide a specified creepage current resistance.

The behavior of this resistance is tested with special test methods described in the IEC 112. The term is CTI (comparative tracking index).

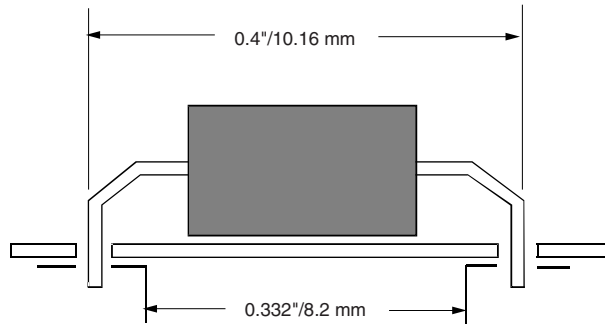
The DIN EN 60747-5-2 (VDE 0884)/DIN EN 60747-5-5 pending requires a minimum of a CTI of 175.



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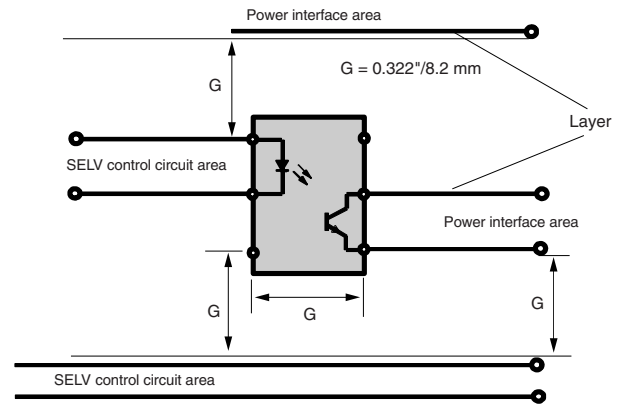
Fig. 1 - Isolation Creepage/Clearance Path along the Body

(The creepage path is the shortest distance between conductive parts along the surface of the isolation material. The clearance path is the shortest distance between conductive parts.)



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Fig. 2 - Isolation Creepage/Clearance Path after Mounting on a Board (Side View)



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Fig. 3 - "Top View of Optocoupler Mounting on a Board" (Clearance on PC Board: 0.322/8.2 mm, Creepage Path on PC Board is 0.322/8.2 mm)

Not only the solder eyes of the coupler itself on the board must have the 8 mm distance, but also all layers located between the SELV areas and the power interface areas.