Understanding Optical Isolation Technologies

Frequently Asked Questions

How do I know whether I need isolation in my system?

In electrical circuits, isolation is required when passing information between high and low voltage parts of a system. End equipment standards help to define which level of isolation is needed to ensure safe operation. The threshold of human safety requiring reinforced protection starts at 42V DC or 60V AC, and for some sensitive integrated circuits, the voltage level for desired protection may be even lower.

What is the difference between isolation and insulation?

Although both terms are often used interchangeably, isolation refers to the ability to reject high voltage noise (dv/dt) while insulation refers to how high a voltage the insulation barrier can withstand before breakdown. Isolation is also commonly known as Common Mode Transient Immunity (CMTI) and Insulation as Maximum Working Insulation Voltage (V_{IORM}) or Input-Output Momentary Withstand Voltage ($_{VISO}$).

How many different levels of insulation are there?

There are three main levels of insulation called functional, basic and reinforced. Functional insulation is needed for correct operation between different potentials in a system. Basic insulation provides protection for users from electrical shock, as long as the insulation barrier remains intact. Reinforced or double insulation provides fail safe operation in that should one level of insulation fail a second level will continue to protect the user.

What types of isolation devices are available?

In the market today, isolation devices based on optical technology (optocouplers) are still mainly being used. However, alternative isolation devices based on magnetic, capacitive and RF technologies are available and becoming more prominent in many applications.

How are optocouplers certified?

Optocouplers are mainly certified according to the component level standards UL 1577 for the withstand voltage and IEC/EN/DIN EN 60747-5-5 for the working voltage. Certificates are usually posted on the website or available through Sales. In addition, there is a regulatory guide available from Broadcom to help map the component level certification to end equipment standards.

What is the withstand voltage as defined by UL 1577?

The withstand voltage is a safety parameter defined by the dielectric voltage-withstand test according to UL 1577. This is a one minute type test, where a voltage is applied between the input and output terminals of the isolator (destructive test). Typical withstand voltage ratings are 2500-5000 V_{RMS}. This is the maximum voltage the insulation barrier needs to hold up to for one minute and is not related to high voltage over product lifetime. During manufacturing, each isolator is tested at 1.2x the rated dielectric insulation voltage for one second. UL 1577 can be used to certify optocouplers as well as non-optical isolator technologies.

What is the working voltage as defined by IEC 60747-5-5?

In applications where there are significant potential differences, the most important safety parameter is the maximum working insulation voltage (V_{IORM}) as defined by IEC/EN/DIN EN 60747-5-5. This standard uses partial discharge testing to determine the working voltage level that the optical insulation must survive over the lifetime of the device. The philosophy underlying the partial discharge testing is that insulation for safe electrical isolation needs to withstand not only a breakdown voltage, but also a voltage that prevents any degradation due to high electrical fields which may cause the insulation to break down over time or over repetitive cycles. In production, partial discharge test is performed for 1 second at 1.875x V_{IORM}.

Can partial discharge testing be used on non-optical isolators?

Theoretically it can be done, however practically it is not valid as the dominant failure mechanism in these alternative technologies is different. Alternative technologies use very thin insulation barriers of about 20µm that do not trap charge and hence cannot be detected by a partial discharge test. Alternative isolators, which passed partial discharge testing failed just hours later when subjected to a high voltage stress test (which optocouplers passed).

What are the relevant aging mechanisms for non-optical isolators?

In magnetic isolators using spin on polymide coatings, there is a higher dielectric stress which activates space charge degradation. The dominant failure mechanism is space charge aging, which reduces the breakdown voltage over time. Currently it is not possible to test for space charge degradation in a finished product. In capacitve or magnetic isolators using thin film SiO_2, the dominant failure mechanism is specific to the SiO_2 technology and is called time dependent dielectric breakdown (TDDB). The test method to determine TDDB is destructive and cannot be tested in production.

How are the non-optical devices certified for working voltage?

There is a draft standard available from VDE called VDE0884-11 which uses type testing and statistical modeling to predict high voltage lifetime. One concern regarding this standard is that it currently allows for a failure rate of 1ppm when classified for reinforced isolation and 1000ppm for basic isolation. Another concern is that there is no continuous production monitoring of the high voltage aging mechanism.

How does the insulation coordination safety standard IEC 60664 relate to the optocoupler safety standard IEC 60747-5-5?

The IEC 60664 defines the working voltage as the highest RMS value of the AC or DC voltage across any particular insulation which can occur when the equipment is supplied at rated voltage in both open circuit conditions or in normal operating conditions. These voltages are then used to determine the required creepage and clearance specifications. The optocoupler safety standard falls back on the IEC 60664 for its insulation coordination guidance.

Will the LED in optocouplers degrade over time?

The lifetime of the LED will inherently depend on its quality grade. The LED used in low cost consumer grade phototransistor optocouplers could potentially degrade faster than an LED used in industrial or automotive grade photo-IC optocouplers. Broadcom has done extensive testing and provides LED lifetime performance data for all of its industrial and automotive grade optocouplers. Worst case predictions show a degradation of less than 10% for over 30 years of lifetime in the field.

Who is responsible to assure that end equipment is properly certified for safe isolation?

At the end of the day, it is the responsibility of the equipment manufacturer to assure that their product is compliant to the necessary safety standards and that their equipment can be operated fail safe. Usually it is the internal quality and safety engineers who are responsible for the correct approvals. Broadcom, as a component manufacturer, can only make product recommendations, but at the end of the day it is the equipment manufacturer who is liable.

Resources

White Paper: Building Safe and Reliable Electrical Systems with Optocouplers
White Paper: Calculate Reliable LED Lifetime Performance in Optocouplers
Understanding Isolation Handbook
Regulatory Guide to Isolation Circuits

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