

## APPLICATION NOTE 5993

# UNDERSTANDING THE SAFETY CERTIFICATION OF DIGITAL ISOLATORS

*Abstract: This application note summarizes the international safety standards and certifications that apply to digital isolators. Our example shows how to use a data sheet and the standards' specifications to determine which digital isolator is optimal for an application.*

## Introduction

Digital isolators provide signal isolation and the level shifting required for the correct operation of many circuits. Equally important, they insulate the user from electric shock. With basic human safety considerations so pertinent here, these isolators must undergo extensive testing and certification to ensure user safety. This article briefly summarizes the international safety standards and certifications that apply to digital isolators. An example exercise using the [MAX1493x](#) family shows how an IC designer must use a datasheet and the standard's specification tables to determine which digital isolator will be optimal for an application.

## Basics of International Safety Standards

The International Electrotechnical Commission (IEC)<sup>1</sup> is the organization that publishes the international standards for electrical safety. Regional specifications are handled by bodies such as the UL (U.S.A.), CSA (Canada), VDE (Germany), and CNCA (China);<sup>2</sup> actual testing and certifications are done by the UL, CSA, VDE, and TUV in Germany, and CQC in China.

Safety standards can be separated into three broad categories: equipment standards, support standards, and component certification standards. Developed over time in many geographic areas and across many industries, safety certifications evolved into a plethora of standards. In recent years great progress has been made toward harmonizing these standards. When you see multiple prefixes on a standard, it indicates a harmonized standard that meets the requirements of those entities. For example, a mixed standard identified as BS EN IEC meets the British Standards Institute (BS), European Norms (EN), and IEC. This harmonization of standards is a very slow process but very much needed. Until this is achieved, component suppliers will have to meet as many of the requirements as possible to be able to sell their devices worldwide.

## Equipment Standards

Equipment safety standards apply, as you would expect, to end equipment which is assembled from multiple components. These standards cover a variety of safety concerns including insulation, pressurized gasses, and the strength of electrical cords. The IEC 61010-1 (safety requirements for electrical equipment for measurement, control, and laboratory use) is concerned with the transient voltages that equipment will experience and the characteristics of the insulation used. This standard does not specifically address isolators. In fact, neither the word "isolator" nor "isolation" is found anywhere in this IEC standard. It is, nonetheless, relevant to isolators because it specifies both the transient voltage and the minimum creepage and clearance distances for the insulation. The insulation of a marketed isolator must, therefore, be compatible with these IEC requirements.

## Support Standards

Support standards provide definitions, methods, or requirements that are applicable to numerous other standards. Support standards help with harmonization. An example is IEC 60664-1 (Insulation coordination for equipment within low-voltage systems). Once again this standard does not specifically mention isolation or isolator.

## Component Certification Standards

Component certification standards apply to specific components that can be used in a variety of applications. These standards define the required tests, sample size, and preconditioning. They may also define terms and information that are required for the datasheet. With a few exceptions, these standards do not set performance levels. Instead, the performance requirements are "according to the manufacturer's specifications."

## Component-Level Certifications

It will be useful now to take a quick look at the specifications that directly impact the manufacture of digital isolators.

### UL1577

The UL1577 specification is for optical isolators, but is also used to qualify capacitive and inductive isolators. The rating is based strictly on the voltage breakdown and does not include any requirements on clearance or creepage. To be certified under this standard, a device must withstand the isolation voltage,

$V_{ISO}$  (specified by each manufacturer, usually  $2.5kV_{RMS}$  or  $5kV_{RMS}$ ), for 1 minute. In addition, the specification allows a production test of 120% of the isolation voltage for 1s. Devices passing these requirements (plus the 150% of  $V_{ISO}$  Overload Test and the Thermal Aging Test) are certified with a single protection rating. A double protection rating requires survivability to a 20kV discharge test (applied 50 times) and a 1s production test of the rated isolation RMS voltage or  $2.5kV_{RMS}$ , whichever is greater.

### IEC60747-5 and VDE0884-10

The IEC is working on a capacitive and magnetic isolator specific specification (IEC60747-17), which is still in draft mode at the time of this composition. For now, the IEC60747-5 and the German VDE0884-10 standards are used to certify digital isolators.

These standards are based on a partial discharge test rather than voltage breakdown, and on the isolation withstand voltage. The partial discharge test involves ramping the voltage to the maximum transient overvoltage,  $V_{TO}$ , for 60s. The voltage is then reduced to  $1.5 \times V_{TO}$ , where  $V_{TO}$  is the maximum

repetitive peak isolation voltage for 10s. (If the waveform is sinusoidal, then  $V_{IORM}$  is the peak value of  $V_{IOWM}$ , which is the maximum working isolation voltage in RMS.) Partial discharge of up to 5pC is allowed. During production, the test time is reduced for 1s and the test voltage is  $1.875 \times V_{IORM}$ . Once again, 5pC is the partial discharge threshold.

To be granted a Reinforced Insulation certification, the VDE0884-10 includes an additional 10kV surge voltage requirement. The various insulation grades are defined in **Table 1**.

**Table 1. Definition of Insulation Grades**

Insulation Grade	Certification Description
Functional	Insulation necessary for correct operation of equipment. No protection against shock.
Basic	Insulation that provides basic protection against shock.
Supplementary	Independent insulation applied to Basic Insulation to reduce the risk of electric shock in the event of a failure of the Basic Insulation.
Double	Insulation consists of both Basic and Supplementary Insulation grades.
Reinforced	Single insulation system that provides a degree of protection against electric shock equivalent to Double Insulation.

Basic Insulation protects against shock as long as the insulation remains intact. However, a redundant (supplementary) system is usually required to protect operators from shock in case one of the insulations fails. Reinforced Insulation is a single insulation system which provides protection equivalent to Double Insulation.

### System-Level Certifications

The IEC also has a series of standards which provides certifications at the system level. The system-level standards most used for applications requiring isolation are:

- IEC60950-1: information technology equipment
- IEC61010-1: measurement, control and lab equipment
- IEC60601-1: medical equipment

In addition to Functional Insulation certification, system-level certifications specify the insulation levels required to protect the user from shock. They include physical dimensions, such as creepage and clearance, environmental conditions, and of course, the ability of the device to withstand specific test voltages.

### Creepage and Clearance

Creepage is the shortest distance along the surface of the insulating material between two conductive parts, i.e., two pins. Clearance is the shortest distance in air between those same two surfaces. (Clearance does not need to be line of sight.) See **Figure 1**.

Figure 1. Creepage and clearance for semiconductor packages.

For simple geometries, creepage and clearance may be the same, but normally creepage is larger than clearance. The requirements for creepage can be reduced based on the comparative tracking index (CTI), which is the measure of the electrical breakdown (tracking) properties of the insulating material. A higher CTI allows for smaller creepage. **Table 2** shows the material classification according to the CTI index.

**Table 2. Comparative Tracking Index**

Material Group	Comparative Tracking Index (CTI)
I	600 CTI
II	400 CTI < 600
IIIa	175 CTI < 400
IIIb	100 CTI < 175

Another characteristic that determines the creepage requirements is the level of contamination in the environment, specified by the pollution degree. A higher level of pollution will require higher creepage. Pollution degree is classified according to **Table 3**.

**Table 3. Pollution Degree Classifications**

Classification	Classification Description
Pollution Degree	No pollution or dry, non-conductive pollution occurs.

Classification	Classification Description
Pollution Degree 1	No pollution or dry, non-conductive pollution occurs.
Pollution Degree 2	Normally, non-conductive pollution can occur. The occasional, temporary conductivity caused by condensation is expected to occur.
Pollution Degree 3	Subject to conductive pollution or to dry non-conductive pollution that could become conductive because of condensation.
Pollution Degree 4	The pollution is conductive.

Together, the pollution degree classification and the highest working voltage in which the system will be operating determine the creepage requirements for IEC certification per the IEC specs noted above. For example, **Table 4** lists the minimum creepage requirements in millimeters under IEC60950-1.

**Table 4. Basic Insulation Creepage Requirements in mm per IEC609501-1**

Working Voltage (RMS or DC)	Pollution						
	Pollution Degree 1	Pollution Degree 2			Pollution Degree 3		
	Material Group I, II, IIIa, IIIb	Material Group I	Material Group II	Material Group IIIa, IIIb	Material Group I	Material Group II	Material Group IIIa, IIIb
50	0.18	0.6	0.85	1.2	1.5	1.7	1.9
100	0.25	0.71	1.0	1.4	1.8	2.0	2.2
200	0.42	1.0	1.4	2.0	2.5	2.8	3.2
250	0.56	1.25	1.8	2.5	3.3	3.6	4.0
400	1.0	2.0	2.8	4.0	5.0	5.6	6.3
500	1.3	2.5	3.6	5.0	6.3	7.1	8.0

The values in Table 4 are for Basic Insulation certification. Creepage requirements for Reinforced Insulation certification are 2x the values listed in Table 4.

The IEC60950-1 also specifies the voltage used for testing electrical strength, held for 60s, based on the equipment's working voltage and the appropriate grade of insulation certification sought (i.e., Functional, Basic, Supplemental, or Reinforced). **Table 5** summarizes the test voltages required, assuming an Overvoltage Category II (portable equipment supplied from a wall outlet).

**Table 5. Test Voltages for Electric Strength Tests**

Working Voltage					
Insulation Grade	$\leq 210 V_{PK}$ or DC	$210V_{PK} < U$ or DC	$410 V_{PK}$	$410V_{PK} < U$ or DC	$1.41 kV_{PK}$
Test Voltage					
Basic ( $V_{RMS}$ )	1,000	1,500		2,814	
Reinforced ( $V_{RMS}$ )	2,000	3,000		3,000	

**Applying the Data to an Application**

The minimum creepage/clearance for digital isolators certified by one of the standards noted above must be listed in their datasheet. We will use the above information as an example, Assume that you are considering two isolators, available in both narrow-body and wide-body SO packages. Your application is telecom equipment powered by 220VAC. You want to determine which component package is optimal for the application. From Table 4, the designer will need 8.0mm of creepage ( $250V_{RMS}$ , pollution degree 3, and Reinforced insulation certification category) for Material Group III or 6.4mm of creepage for Material Group I. The wide-body SO package would meet either requirement. If the narrow-body device was preferred for the application, some form of conformal coating may be needed. Finally, Table 5 indicates that the device will need to pass the 3kV test voltage for a Reinforced insulation rating.

**Conclusion**

Signal isolation is a necessity in today's circuits not only for functionality, but equally important, to provide the user with the required protection from electric shock. The designer is aided—or confused—today by the slew of international and regional standards and certifications that are available. While a digital isolator is not specifically mentioned in IEC standards today, the UL1577, IEC60747-5, VDE0884-10 standards are the key component-level certifications required for digital isolators. Additionally, certification under the IEC60950-1, IEC61010-1, and IEC60601-1 standards may be required, depending on the end application.

## References

1. For the IEC standards, start with their website at [www.iec.ch/index.htm](http://www.iec.ch/index.htm).
2. For basic information on these entities, see: UL in the U.S.A. at [www.ul.com](http://www.ul.com); CSA in Canada at [www.csagroup.org/](http://www.csagroup.org/); VDE in Germany at [www.vde.com/en/](http://www.vde.com/en/); CNCA in China at [www.cnca.gov.cn/cnca/cncatest/20040420/column/227.htm](http://www.cnca.gov.cn/cnca/cncatest/20040420/column/227.htm); TUV Rheinland in Germany at [www.tuv.com](http://www.tuv.com); TUV Sud in Germany at [www.tuv-sud.com](http://www.tuv-sud.com); and CQC in China at [www.cqc.com.cn/english/](http://www.cqc.com.cn/english/).

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## Related Parts

<a href="#">MAX14930</a>	4-Channel, 2.75kV <sub>RMS</sub> Digital Isolators	<a href="#">Free Samples</a>
<a href="#">MAX14931</a>	4-Channel, 2.75kV <sub>RMS</sub> Digital Isolators	
<a href="#">MAX14932</a>	4-Channel, 2.75kV <sub>RMS</sub> Digital Isolators	
<a href="#">MAX14934</a>	Four-Channel, 5kV <sub>RMS</sub> Digital Isolators	
<a href="#">MAX14935</a>	Four-Channel, 5kV <sub>RMS</sub> Digital Isolators	
<a href="#">MAX14936</a>	Four-Channel, 5kV <sub>RMS</sub> Digital Isolators	

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