Safety Standards for Digital Isolator

Description

This application note explains an overview of safety standards for Digital Isolator.

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Digital isolators are signal transmission devices with electrical "isolation".

There are types of isolation methods like "magnetic coupling" and "capacitive coupling", and TOSHIBA's digital isolators adopt "magnetic coupling". Digital isolators with magnetic coupling transmit signals by utilizing magnetic energy.

Examples of applications are industrial automation (programmable logic controllers, I/O interfaces), and motor control. Digital isolators are mainly used to isolate and transmit signals between low voltage and high voltage line, so the designs are needed to follow specified safety standards to keep human safeties.

Safety standards are established in each country based on international standards. Typical examples are the German VDE and DIN standards, the U.S. UL standards, and the Chinese GB standards.

This manual explains summaries of safety standards for Digital Isolator.

1. Structure of standards

International Electrotechnical Commission (IEC) has established international standards in the electric, electronic, and telecommunications fields. Regional standards have been established based on these international standards including the regional voltages and other factors. In addition, national standards (Figure 1.1) have been established based on international and regional standards. To obtain certification of these standards, it is necessary to apply to the certification organizations in each country and pass the tests based on each standard.

International standard (IEC standards)
: International standards established by IEC nations
IEC : International Electrotechnical Commission)

Regional standard (e.g. EN (European Norm) in Europe)
: Applicable to a particular region based on IEC standard and standardized to regional conditions

National standard (e.g. UL in the United States, DIN in Germany)
: Applicable to particular nations or region based on IEC and regional standards, standardized to local conditions

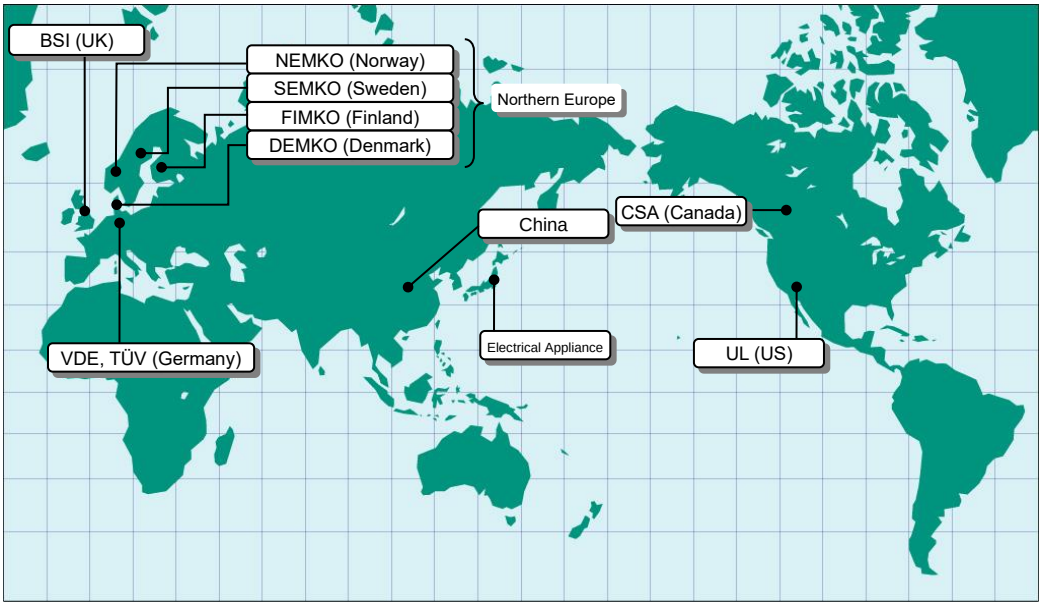


Figure 1-1 Major certification authorities and associated standards

Next, the representative organizations for certification are explained.

UL : Underwriters Laboratories Inc.

UL has conducted establishments, tests, and certifications of various safety standards ranging from materials to products. Products certified by UL should be marked with UL markings on their packaging, etc. UL certification should be obtained when exporting products including electric products and electric components to the U.S.

CSA : Canadian Standard Association

CSA has established the safety of the equipment connected to a commercial power supply in Canada. U.S. and Canada can be mutually approved by MRA(Multi Recognition Agreement), so UL (U.S.) certified products for Canada can use cUL marking to indicate that the product meets CSA safety standards.

VDE : Verband Der Elektrotechnik Elektronik Informationstechnik e.V,
(Association of German Electrical Engineers)

VDE has established and certified its own and national standards (DIN standards).

CQC (China Quality Certification center)

CQC conducts the inspections and approvals of the national standards compliance management system [CCC (China Compulsory Certification)] for products imported into China.

2. Component standards and equipment standards

Safety standards related to digital isolators include Component standards and equipment standards. Table 2.1 shows each example.

The equipment standards are established in consideration of the safety of the entire equipment. The standards such as IEC 62368-1 apply to the equipment for information / communication and audio/video, and IEC 61800-5 apply to variable speed drive systems (inverters, servo amplifiers, and electric motors). These safety standards define insulation spacing, insulation strength etc. Digital isolators used for the isolation in the equipment have been certified based on the tests for these requirements.

Component standards ensure the functional safety of individual components. The component standards related to digital isolators are UL 1577 and IEC 60747-17.

Component standards and equipment ones are independent, but the contents of the standards are mutually compatible in some cases. Details will be explained in the following section 3.

Table 2-1 Component standards and equipment standards

Safety standards		International standards	Regional standards (EN: European standards)	National standards
Equipment standards	Information / communication and audio/video equipment	IEC 62368-1	EN IEC 62368-1	DIN EN IEC 62368-1 GB4943.1 etc.
	Household electrical appliance	IEC 60335-1	EN IEC 60335-1	DIN EN IEC 60335-1 etc.
	Variable speed drive system	IEC 61800-5	EN IEC 61800-5	DIN EN IEC 61800-5 etc.
	Solar power system	IEC 62109-1	EN IEC 62109-1	DIN EN IEC 62109-1 etc.
	Industrial controller	IEC 61010-1	EN IEC 61010-1	DIN EN IEC 61010-1 etc.
	Low-voltage system	IEC 60664-1	EN IEC 60664-1	DIN EN IEC 60664-1 etc.
Component standards	Photocouplers	-	-	UL1577 (Note1) CSA component acceptance notice No.5A (CA5A)
		IEC 60747-5-5	EN IEC 60747-5-5	DIN EN IEC 60747-5-5
	Magnetic / Capacitive coupler (Digital isolator)	IEC 60747-17	EN IEC 60747-17	DIN EN IEC 60747-17 （VDE 0884-17）

Note1: UL1577 includes digital isolators as applicable products

IEC 62368-1: Audio/video, information and communication technology equipment - Part 1: Safety requirements

IEC 60335-1: Household and similar electrical appliances - Safety - Part 1 General requirements

IEC 61800-5-1: Adjustable speed electrical power drive systems - Part 5-1 Safety requirements - Electrical, thermal and energy

IEC 62109-1: Safety of power converters for use in photovoltaic power systems - Part 1 General requirements

IEC 61010-1: Safety requirements for electrical equipment for measurement, control, and laboratory use - Part 1 General requirements

IEC 60664-1: Insulation coordination for equipment within low-voltage systems - Part 1 Principles, requirements, and tests

IEC 60747-5-5: Semiconductor devices - Discrete devices - Part 5-5 Optoelectronic devices – Photocoupler

IEC 60747-17: Semiconductor devices - Part 17 Magnetic and capacitive coupler for basic and reinforced insulation

Each country's certification organization judges the conformities for safety standards and issues certifications. Table 2.2 shows the main safety standards for digital isolators. Each digital isolator has acquired safety standards according to its application. Please refer to our website or individual datasheets.

Table 2-2 Main safety standards for digital isolators

Certification Organization	Safety standards	Description
UL	UL 1577 CA5A (cUL)	Certified based on dielectric strength, etc.
VDE	DIN EN 60747-17 EN 62368-1	Certified based on partial-discharge test, TDDB test(Note2), etc.
CQC	GB4943.1 GB8898	Certified based on insulation distance, insulation resistance, dielectric strength test, etc.

Note2: TDDB Test (Time Dependent Dielectric Breakdown):
A test to evaluate the breakdown phenomena of a semiconducting oxide over time, continuously energizing it.

3. The contents of each safety standard

This section explains an overview of the safety standards for digital isolators.

3.1. UL1577

UL 1577 is a component standard for digital isolators and photocouplers. The certification involves the tests for isolation voltages, where a high AC sine wave voltage of 50Hz or 60Hz is applied for one minute to determine if there is any insulation breakdown between the input and output. The isolation voltages of our digital isolators are examined in accordance with the requirements of UL 1577.

3.2. DIN EN IEC 60747-17 (VDE 0884-17)

DIN EN IEC 60747-17 is a component standard for digital isolators. Isolation performance is specified by partial discharge and TDDB tests. Partial discharge tests confirm that the electric charges generated by corona discharge are less than 5 pC under the test condition shown in Fig. 3.1 Method B.

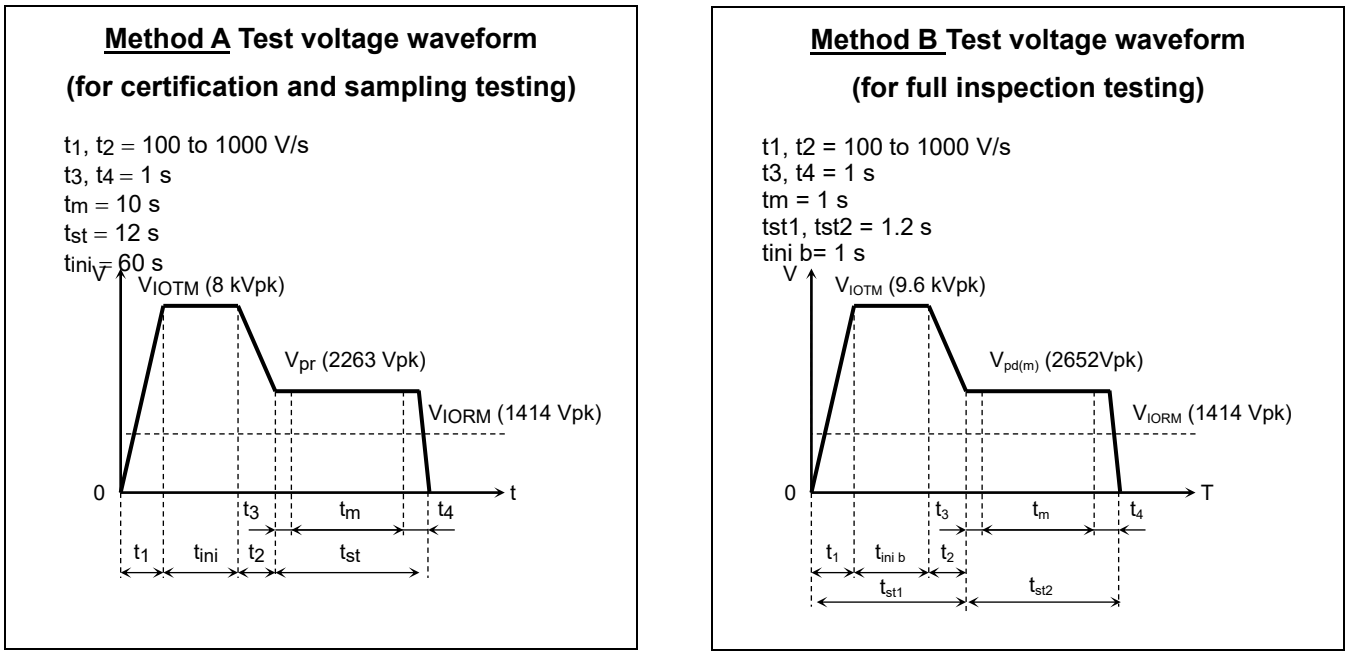


Figure 3-1 DEN EN IEC 60747-17 test voltage waveform (DCL54xx01 Series)

3.3. IEC 62368-1

IEC 62368-1 is defined for the information/communication and audio/video equipment and specified to reduce the risk of electric shock and damage to persons. The creepage distance and clearance for isolation components are varied depending on the surrounding environments and the classification of insulating materials. The physical parameter specifications are defined in IEC 60664-1.

3.4. IEC 60355-1

IEC 60335-1 is a safety standard for equipment applied to household electrical appliances. The isolation tests under the voltage conditions specified in Table 3.2. are required.

Table 3-1 Insulation test voltage in IEC 60335-1

Rated voltage	Basic insulation	Supplementary insulation	Reinforced insulation
Safety extra-low voltage (SELV) <25Vac/60Vdc	500 Vac	–	–
≤ 130V	1000 Vac	1500 Vac	2500 Vac
＞130V	1000 Vac	2750 Vac	3750 Vac

4. Main parameters and terms

This section explains the main parameters and terminologies related to the safety standard for digital isolator.

4.1. Overvoltage category

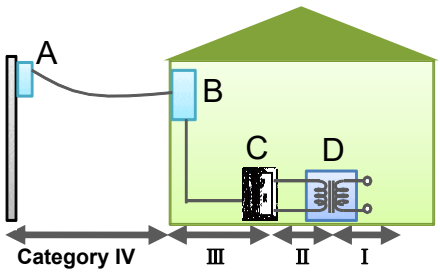
The overvoltage category is a classification that indicates the permissible value of transient overvoltage that electrical equipment can withstand. Categories are divided into the following four categories. The higher overvoltage category means the greater the risk of overvoltage exposure. Overvoltage category IV is for equipment installed in areas that may be exposed to high voltages from transmission lines such as power meters. In overvoltage category III, the overvoltage is reduced by a protective circuit, such as a distribution board. In general, fixed installations such as air conditioners are designed for category III overvoltage. Household appliances such as televisions and refrigerators that are plugged into wall outlets are usually classified as overvoltage category II.

Overvoltage category I: Secondary circuit of equipment plugged into hard-wired outlet or equivalent

Overvoltage category II: Primary circuit of equipment plugged into hard-wired outlet or equivalent, such as common and household appliances

Overvoltage category III: Equipment connected to building distribution board either directly or through a power outlet or equivalent, such as industrial equipment

Overvoltage category IV: Equipment connected outside the distribution board, for instance, to wiring between the pole transformer and the switchboard, such as power meter.



A: Pole-mounted transformer
B: Distribution board
C: Power outlet
D: Isolation

Figure 4-1 The overview of overvoltage categories

Table 4-1 Acceptable transient voltage values

Nominal voltage Vrms	Acceptable transient voltage values (V)			
	Category I	Category II	Category III	Category IV
50	330	500	800	1500
100	500	800	1500	2500
150	800	1500	2500	4000
300	1500	2500	4000	6000
600	2500	4000	6000	8000
1000	4000	6000	8000	12000

4.2. Pollution degree

This section classifies the pollution degree based on the operating environment of electrical equipment. As the pollution degree increases, higher parameters such as creepage distance and clearance are required.

Pollution degree 1: Pollutants are either non-existent or present only in dry, non-conductive form, for example, potted and fully sealed devices that prevent ingress of dust and humidity.

Pollution degree 2: Pollutants are entirely non-conductive but could potentially be rendered conductive by condensation,
for example, at the typical office or home environment.

Pollution degree 3: Either conductive pollutants are present, or condensation could cause dry, non-conductive pollutants to become conductive; for example,
at a manufacturing facility.

Pollution degree 4: Conductive matter is present on an ongoing basis (such as dust particles, rain or snow),
for example, in an outdoor environment.

4.3. CTI (Comparative Tracking Index)

Tracking is a phenomenon in which repeated micro-discharges on the surface of an insulating material create conductive paths that lead to dielectric breakdown. IEC 60112 defines CTI as the maximum possible voltage before droplets of ammonium chloride solution on the surface of the insulating material cause tracking, under the given test conditions. IEC 60664-1 groups molded materials according to CTI value

Material Group I: 600 ≤ CTI

Material Group II: 400 ≤ CTI < 600

Material Group IIIa: 175 ≤ CTI < 400

Material Group IIIb: 100 ≤ CTI < 175

IEC 60664-1: Insulation coordination for equipment within low-voltage systems - Part 1: Principles, requirements, and tests

IEC 60112: Method for the determination of the proof and the comparative tracking indices of solid insulating materials

4.4. Types of insulation

Types of insulation are classified into five types in IEC 62368-1.

- Functional insulation: Minimum level of insulation required to ensure intended operation. Will not prevent electric shock but should reduce the likelihood of sparking.
- Basic insulation: Base level of protection from electric shock.
- Supplementary insulation: Additional independent insulation designed to decrease the risk of electric shock in the event of damage to the basic insulation.
- Double insulation: Combination of basic and supplementary insulation.
- Reinforced insulation: Single insulation layer deemed equivalent to double insulation in terms of protection from electric shock.

4.5. Insulation protection class

IEC 62368-1 classifies the insulation-protection classes for electric shock into three classes.

Class I: Provides basic insulation against electric shock, and conductive parts that people may contact are connected to protective ground in building wiring in the event of damage to the basic insulation.

Class II: Protection against electric shock is not only provided by basic insulation, but also separated by double insulation consisting of basic insulation and additional insulation or reinforced insulation.

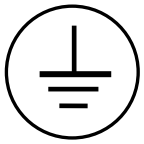
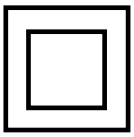
Class III: Uses a SELV power supply to ensure that voltage cannot cause electric shock.

Class I electrical equipment must be connected to protective earth. For permanently connected equipment, the protective earth terminal must be labeled as shown in Table 4.2.

Class II equipment should be provided with supplementary insulation to prevent dangerous voltage in the event of damage to the basic insulation, and normally labeled as table4.2

Class III electrical equipment fitted with a SELV (Separated Extra Low Voltage) power supply is incapable of causing an electric shock, so the safety requirements do not apply. Types of insulation are classified into five types in IEC 62368-1.

Table 4-2 Insulation protection class marks

Class I protection earth	Class II
	

5. Structural parameters for digital isolators

The required physical separation for insulated parts varies depending on the operating environment and type of insulation. The structural parameters of a digital isolator are shown in Table 5.1 and Figure 5.1.

Table 5-1 Structural parameters for digital isolators

Parameter	Description
Creepage Distance	Shortest distance along the surface of insulating material between the two conductors (input and output)
Clearance Distance	Shortest distance in air clearance between the two conductors (input and output)
Internal isolation thickness	Thickness of the insulating layer (oxide) formed on IC chip

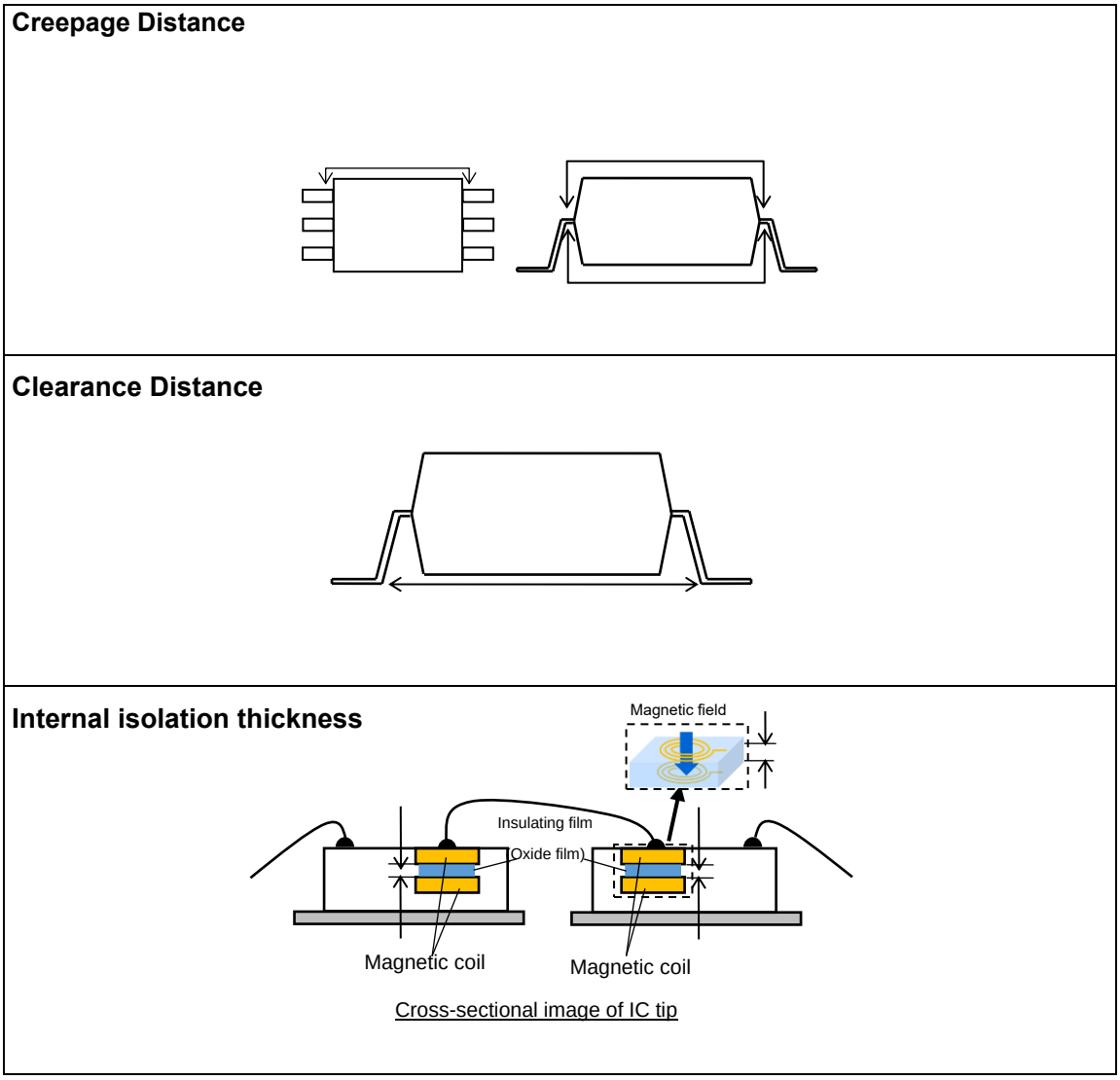


Figure 5-1 Structural parameters for digital isolators

5.1. Types of insulation

Defined as the creepage distance of the package, and required distance is decided including CTI value of the package material (material grouping). In addition, the creepage distance must be equal to or greater than the clearance distance. For example, the smallest creepage length for Group I with a CTI of 600 or greater is shown in Table5.2. Basically, the space distance required for reinforced insulation is twice the distance required for basic insulation.

Table 5-2 Minimum creepage distance based on IEC 62368-1 definitions

Unit : [mm]

Maximum working voltage Vrms	Basic insulation	Reinforced insulation
160	0.8	1.6
200	1.0	2.0
250	1.25	2.5
320	1.6	3.2
400	2.0	4.0
630	3.2	6.4
800	4.0	8.0

Above chart is assuming Group I materials and pollution degree 2,

Linear interpolation can be used for voltages between the figures given above.

5.2. Clearance distance

Clearance distances are specified in IEC 60664-1 and determined by various conditions such as overvoltage category and pollution degree. The higher isolation voltage requires the longer distances. In the case of the altitudes of 2000m or higher, increase the clearance distance by a certain factor is needed.

5.3. Insulation thickness

The IEC 62368-1 equipment standard does not specify a minimum insulation thickness for functional and basic insulation, but it specifies that a minimum insulation thickness is more than 0.4mm for supplementary and reinforced insulation. However, minimum insulation thickness requirements do not apply to products that are compliant with IEC 60747-17.

6. Conclusion

This document explains overview of safety standards for Digital Isolator, but there may be other conditions what is not mentioned in this document. When selecting a digital isolator, please refer to the original text of the most suitable and latest safety standards.

Revision history

Version	Date	Details
Rev. 1.0	2024-12-11	First Edition

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