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Digital isolators compliance to IEC 61010-1 edition 3.0 safety requirements

Introduction

Created by the International Electrotechnical Commission (IEC), IEC 61010-1 is an international standard that specifies safety requirements for electrical end-equipment used for measurement, control, and laboratory use. Manufacturers in industries such as test and measurement, industrial process control, agriculture, laboratory use, and material preparation and analysis have to certify equipment to this standard in their respective markets. Semiconductor component manufacturers, such as Texas Instruments (TI), help make the end-equipment maker's life easier by complying with this standard's applicable isolation safety requirements.

The first edition was published in 1990 while the second and third were released in 2001 and 2010, respectively. The mandatory date for the European Union to transition to the third edition was October 1, 2013. In North America, Underwriters Laboratories Inc. (UL) and Canadian Standards Association (CSA) have announced January 1, 2018 as the effective date for this latest edition.

Second and third edition differences

Significant changes have been made in the third edition of this standard. These cover a wide array of safety specifications such as insulation, mechanical hazards, temperature, radiation, ergonomic, risk assessment process, pollution mitigation, and many others.

This paper focuses on insulation requirements and how TI isolators facilitate our customers' compliance with these requirements.

In the second edition, no specific requirements for internal distance through insulation were applicable to isolation devices, but in the third edition, insulation requirements have been rewritten. Specific requirements have been added for solid insulation and thin-film insulation. Those requirements are discussed later in this paper. Sub-clause 6.7 of the third edition now contains the insulation requirements for mains and secondary circuits of overvoltage category II up to 300 V(AC or DC). Overvoltage category II is used for plug-connected or permanently-connected equipment that is intended to be supplied from the building wiring. The insulation requirements for all other circuits have been moved to a new Annex K

Digital isolator compliance

Clause 6 specifies protection against electric shock, and sub-clause 6.7 focuses on insulation requirements. In this section the following classes of solid insulations are specified:

- 1) Molded and potted parts
- 2) Inner insulating layers of printed wiring boards
- 3) Thin-film insulation

At first glance, it appears that digital isolators from TI fall either under molded and potted parts or the thin-film insulation category. Let's take a deeper dive into this concept.

Molded and potted parts

IEC 61010-1 edition 3.0 specifies that conductors located on an interface between the same two layers must be separated by at least 0.4 mm for basic, supplementary, and reinforced insulation. See **Figure 1**, item L.

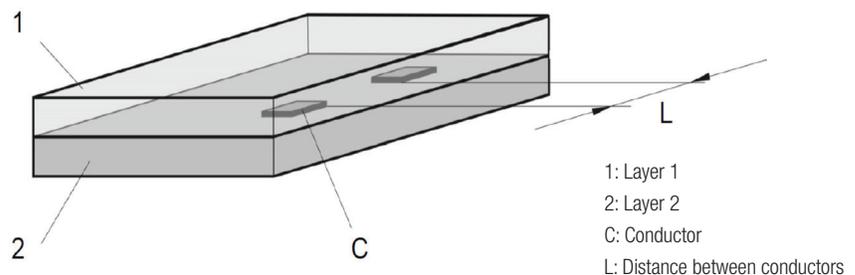


Figure 1. Illustrated is the distance between conductors on an interface between two layers (Source: IEC 61010-1 edition 3.0, sub-clause 6.7.2.2.2*)

Internal structure of isolators

If we look at the internal structure of a typical isolator from TI (**Figure 2**), it may appear that it fits the description of molded and potted parts as described in the third edition. Similar to **Figure 1**, item L in **Figure 2** is the distance between chip pads of the split lead frame where isolator transmit and receive chips sit on top of their respective pads. After closer inspection, it becomes evident that the mold compound separating the two pads is not the main source of isolation between the two chips. As a matter of fact, transmit and receive chips are connected together through an inter-chip bond wire, B.

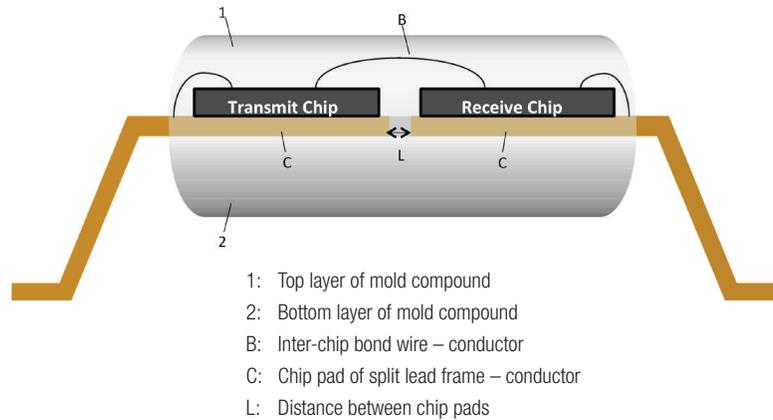


Figure 2. Depicted is the internal structure of a two-chip digital isolator.

The main source of isolation between the two sides is a capacitor integrated on the chip (**Figure 3**).

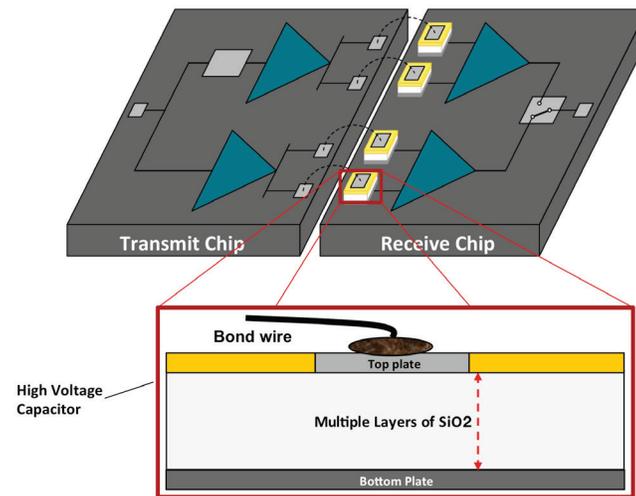


Figure 3. An integrated high-voltage capacitor is the main source of isolation.

The isolators are designed such that, in the case of high-voltage stress within rated specifications, the capacitors fail before the mold compound between the chip pads breaks down. This leads us to the next section, thin-film insulation.

Thin-film insulation

Sub-clause 6.7.2.2.4 allows thin-film insulation to be used for basic, supplementary and reinforced insulation. This section specifies thin-film insulators where conductors are either located between the same two layers (**Figure 4**) or across two or more layers of insulation (**Figure 5**).

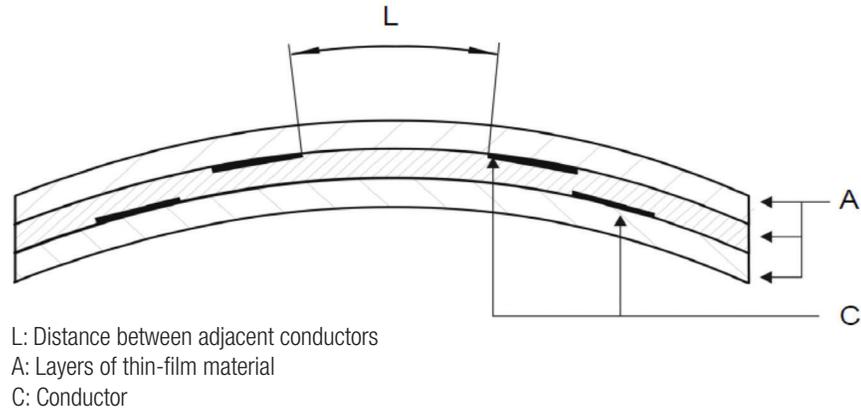


Figure 4. The distance between conductors located between the same two layers
(Source: IEC 61010-1 edition 3.0, sub-clause 6.7.2.2.4*)

This section further defines the requirements for insulation through the layers of thin-film dielectric. Following are excerpts from the standard:

REINFORCED INSULATION through the layers of thin-film insulation shall also have adequate electric strength. One of the following methods shall be used:

- The thickness through the insulation is at least 0.4 mm*
- The insulation consists of at least two separate layers of thin-film materials, each of which is RATED by the manufacturer of the material for an electric strength of at least the value of the test voltage of **Table 5** for BASIC INSULATION*
- The insulation consists of at least three separate layers of thin-film materials, any two of which have been tested to exhibit adequate electric strength*

Voltage line-to-neutral AC(RMS) or DC	1 min AC Test Voltage		1 min DC Test Voltage	
	Basic Insulation and supplementary insulation (V)	Reinforced insulation (V)	Basic insulation and supplementary insulation (V)	Reinforced insulation (V)
≤ 150	1350	2700	1900	3800
> 150 ≤ 3 00	1500	3000	2100	4200

Table 5. Test voltages for solid insulation in mains circuits of overvoltage category II up to 300 V.
(Source: IEC 61010-1 edition 3.0, sub-clause 6.7.2.2.1, Table 5*)

TI Isolators as thin-film insulators

TI isolators use high-voltage capacitors for insulation. These capacitors are manufactured in advanced CMOS processes using multiple layers of inter-metal dielectric (IMD), primarily made up from Silicon dioxide (SiO₂) (**Figure 5**). Even though TI doesn't meet the 0.4 mm insulation thickness requirements for 'a' (see excerpt on previous page), it easily meets the alternative requirements of 'b' or 'c', depending on the process technology of products being certified. TI provides this information to certification agencies as requested and successfully meets the requirements.

Before the implementation of third edition in Europe, many TI isolators were tested by international certification agencies such as Verband der Elektrotechnik Elektronik informationstechnik e.V. (VDE), Technischer Überwachungsverein (TÜV) and CSA for compliance with the second edition. In response to Europe's enforcement of the third edition, TI has initiated the certification process of all its products to help end-equipment manufacturers meet these requirements. VDE and TÜV have completed the certification process for many of TI's isolation devices and several product families are CSA-certified now, with the remainder scheduled to be certified.

CSA has gone one step further by testing digital isolators for capacitor pulse test for Y2 rating according to IEC 60384-14. TI isolators have passed the test.

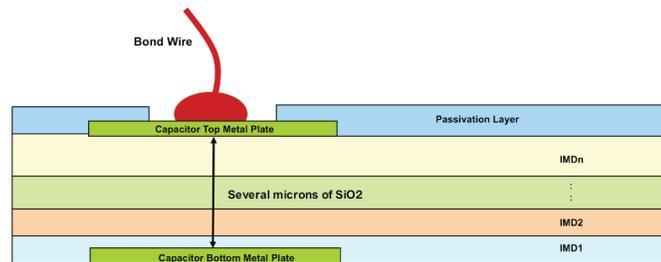


Figure 5. High-voltage capacitor with multiple layers of inter-metal dielectric.

Conclusion

Certified isolators from TI are compliant to IEC 61010-1 edition 3.0 requirements evidenced by major international regulatory agencies such as VDE, TÜV and CSA having completed testing and evaluation of these devices to help ensure they meet the latest requirements.

References

- 1) International Standard IEC 61010-1, Safety requirements for electrical equipment for measurement, control, and laboratory use, Part 1: General requirements, edition 3.0, 2010-06
- 2) International Standard IEC 61010-1, Safety requirements for electrical equipment for measurement, control, and laboratory use, Part 1: General requirements, second edition, 2001-02
- 3) For more information on digital isolators from Texas Instruments, visit: www.ti.com/isolators

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