Technical White Paper

Why are Digital Isolators Certified to Meet Electrical Equipment Standards?

ABSTRACT

If you look at typical data sheets of digital isolators from Texas Instruments, you will notice that these semiconductor components are certified to a number of international electrical equipment standards such as IEC 62368-1, IEC 60601-1 and IEC 61010-1. These standards outline safety requirements for audio/video, communication, information technology, medical, measurement, control, and laboratory use equipment; Figure 1-1 shows some common electrical equipment that use digital isolators for insulation. Now, you may be wondering how and why a digital isolator, which is one small component of a large and complex piece of equipment, is certified to the equipment standards? We'll explore this subject here.

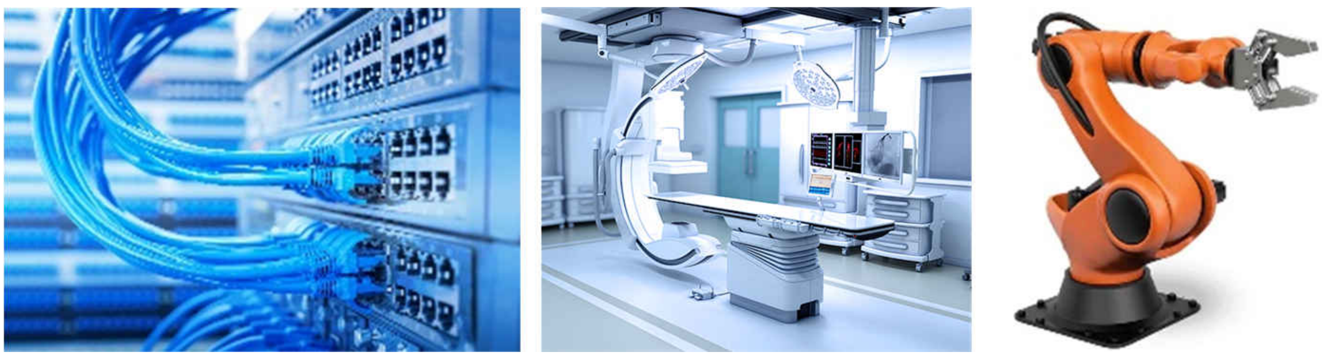

Figure 1-1. Common Electrical Equipment that use Certified Digital Isolators

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1 Introduction

Although the equipment has to comply with all required clauses of the standard, semiconductor components such as digital isolators are only certified to specific clauses of the standard that deal with high voltage insulation and safety. When equipment manufacturers pick certified digital isolators for their design, they are confident that the insulation performance has already been verified by a third-party certification agency. Also, the equipment manufacturer will not need to repeat the time consuming and expensive insulation-related environmental and high voltage tests when they certify their equipment. To certify digital isolators, approving agencies need technology and inner construction details of the semiconductor components. This information can easily be shared by the manufacturers of these devices with the agencies. This makes the equipment certifications process a lot easier by cutting down on time and expense. Therefore, it should not come as a surprise that equipment manufacturers prefer to design with certified digital isolators.

Now we will discuss the various standard clauses that deal with digital isolators. We can broadly place these clauses in three categories: critical distances, environmental tests and high voltage tests.

2 Critical Distances

Creepage, clearance, and distance through insulation (DTI) are critical distances that are evaluated in any equipment certification of digital isolators. Clearance is the shortest distance in air between two conductive parts and creepage is the shortest distance along the surface of a solid insulation material between two conductive parts across the isolation barrier. DTI, on the other hand, is the shortest distance within an insulating material interposed between two conductive parts. For digital isolators, the primary insulation is provided by thin-film layers of silicon dioxide (SiO2) or polymer-based dielectric applied across a high voltage capacitor or transformer. Additionally, the mold compound coating between the two sides of the isolator provide secondary insulation. The digital isolators are designed so that the high voltage breakdown almost always occurs across the thin-film dielectric layers of the capacitor or transformer. Insulation voltage ratings depend on the quality of solid insulation used and length of these critical distances.

3 Environmental Tests

Digital isolators are subjected to environmental stresses such as thermal cycling, humidity and maximum operating temperature tests to ensure long-term reliability of the insulation under adverse conditions. During thermal cycling tests, a component is subjected to cold and hot temperature cycles for at least 3 days. The sample is subjected 10 times to such cycles of temperature variation. So, the minimum stress time for thermal cycling is 30 days. Humidity conditioning is typically carried out for two days in a chamber containing air with a relative humidity of 93% ± 3% and temperature is maintained within 2 °C of any value between 20 °C and 42 °C so that condensation does not occur. For tropical conditions, the time duration is increased to five days. Maximum temperature test is performed when the device is operated in worst-case ambient temperature and other conditions such as supply voltage, frequency, and external loadings. The digital isolator is operated in this mode until thermal stability is achieved.

4 High-Voltage Tests

Each of the three equipment standards mentioned earlier require digital isolators to be subjected to dielectric tests after thermal cycling, humidity and maximum temperature tests. The dielectric test after thermal cycling and humidity preconditioning is performed according to the voltage specification of each standard for basic and reinforced insulation, but the test voltage is multiplied by 1.6. This 60% margin is added on top of the already high transient voltage due to thinner DTI of digital isolators. The 60% dielectric test margin is not required after maximum operating temperature test. IEC 60601-1, Medical equipment standard, requires an additional defibrillation-proof test which requires 5000 V_{DC} discharges of both positive and negative polarities applied to the digital isolator. This is followed by a 4000 V_{RMS} dielectric test across the isolation barrier. Finally, the mold compound coatings used by the digital isolators need to be evaluated for Comparative Tracking Index (CTI) according to IEC 60112 to determine their resistance against tracking or carbonization under consistently high working voltage stress. Mold compounds with the best performance are classified as Material Group I and they have CTI ≥ 600 V and the lowest category or Material Group IIIB mold compounds have CTI between 100 V and just under 175 V.

Table 4-1 summarizes the clauses of the three most common IEC standards that are used to certify digital isolators for use in high voltage safety applications.

Table 4-1. IEC Standard Clauses Used to Certify Digital Isolators

Evaluation	Clause of Standard		
	IEC 62368-1: 2018	IEC 60601-1 Ed3:2005 +A1:2012	IEC 61010-1: Ed3:2010 +A1:2016
Creepage	5.4.3	8.9	6.7.2.1 or Tables K.1 to K.4
Clearance	5.4.2	8.9	6.7.2.1 or Tables K.1 to K.4
Distance through insulation	5.4.4.2 or evaluated by 5.4.4.4, 5.4.7	8.8.2 and/or evaluated by 8.9.3.2 and/or Layers and/or 8.9.3.3	6.7.2.2.2 or Table K.9 or Layers. N/A for reinforced; Accepted per clause 14.1a) based on IEC 62368-1.
Thermal cycling	5.4.1.5.3, 5.4.7	8.9.3.4	6.7.2.2.2 Form A.17
Humidity	5.4.8, Five days (tropical)	5.7, Two days	6.8.2, Two days
Dielectric after thermal cycling	5.4.9.1, times 1.6 (for 60% margin)	8.8.3, times 1.6 (for 60% margin)	6.7.2.2.1 or Tables K.1 to K.7 times 1.6 (for 60% margin)
Temperature test	5.4.1.4	11	10
Dielectric after temperature test	5.4.9.1	8.8.3	6.7.2 or Tables K.1 to K.7
Defibrillation test	N/A	8.5.5.1	N/A
IEC 60112 evaluation and material classification	5.4.3.3	8.9.1.7	6.7.1.3

5 Conclusion

Certification of digital isolators to equipment standards is not only possible but highly recommended for semiconductor suppliers as it makes the equipment manufacturer's safety approval process much easier. Additionally, semiconductor suppliers are in the best position to provide digital isolators' construction details to certification agencies as required. Digital isolators are certified to specific clauses of these standards that deal with high voltage insulation and safety. Equipment manufacturers will almost always choose a certified digital isolator for use in their equipment than one that is not certified.

For a complete list of certified isolators from Texas Instruments, see Digital Isolators – Certifications.

6 References

1. IEC 62368-1 Edition 3.0, Audio/video, information and communication technology equipment – Part 1: Safety requirements, October 2018
2. IEC 60601-1 Edition 3.0+A1, Medical electrical equipment – Part 1: General requirements for basic safety and essential performance, December 2005 and July 2012
3. IEC 61010-1 Edition 3.0+A1, Safety requirements for electrical equipment for measurement, control, and laboratory use – Part 1: General requirements, June 2010 and December 2016
4. IEC 60112 Edition 5.0, Method for the determination of the proof and the comparative tracking indices of solid insulating materials, October 2020