Tech Note

What is EMC? 4 questions about EMI, radiated emissions, ESD and EFT in isolated systems

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Introduction

Digital isolators are integrated devices used to isolate digital signals and transfer digital communication across an isolation barrier. Digital isolators are often expected to withstand hostile electrical conditions in order to protect human users and sensitive equipment. Ideally this is done so the isolator appears invisible to the protected circuit, relaying information without adding complexity. In reality, all electrical components have an impact on the system. Electromagnetic compatibility (EMC) refers to the ability of equipment to function properly in its electromagnetic environment. Knowing how a digital isolator performs in terms of EMC allows a system designer to select devices that generate minimal unwanted radiated emissions while providing reliable protection from received electromagnetic energy such as ESD and EFT.

What are Radiated Emissions?

Electromagnetic interference (EMI) is an induced disturbance in an electrical circuit caused by an external electromagnetic field. Because EMI depends on many factors and is difficult to accurately predict, it is important to minimize known sources of interference during circuit design and layout. Radiated emissions are a type of EMI which refers to mid-to-high frequency noise produced by a device while operating under normal conditions. International standard EN55032:2010 requires radiated emissions testing be conducted between 30 MHz to 1 GHz and up to 6 GHz depending on a device's internal oscillator frequency. For the test described in this common industrial standard, the equipment under test (EUT) is placed 10 meters away from the measurement antenna in an anechoic chamber as shown in Figure 1 below.

With the equipment operating normally, the antenna measures received emissions in dB μV/m over the range of tested frequencies. To pass this standard test, measurements must remain below defined thresholds, shown in Table 1-1, for all measured frequencies.

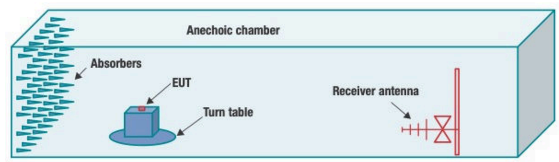

Figure 1. Radiated emissions measurement setup

Table 1. CISPR 32 emissions limits for class B devices

Frequency (MHz)	Limit (dBuV/m)
30 - 230	30
230 - 1000	37

What Affects Emissions Measurements?

It is important that the equipment under test is powered and operating under normal conditions (as would be seen in the equipment's final use case) while conducting radiated emissions measurements. Emissions vary depending on device configuration and power usage, thus testing should be completed to reflect the worst-case operating conditions for emissions. Carefully selecting equipment's supply voltages, communication data rates, and device variants can help a system designer reduce overall emissions.

The amount of energy present in a radiated electromagnetic field is proportional to the energy contained in the original conducted signal. This means that by reducing the energy in a communication signal, less energy will be radiated into the environment. Using lower supply voltages for signaling devices where possible will help reduce these energies.

As data rate increases, parasitic capacitive loads charge and discharge more often, increasing the overall average current. For this reason, higher data rate signals and their harmonics can appear in emissions measurements which can cause interference in other parts of the system. Similarly the fast slew rate required for such rates contain high frequencies that can also contribute to emissions. Figure 2 and Figure 3 show the radiated emissions performance of TI's ISO7741 device at two different data rates. In both cases, ISO7741 devices show significant margin to CISPR32's limit line.

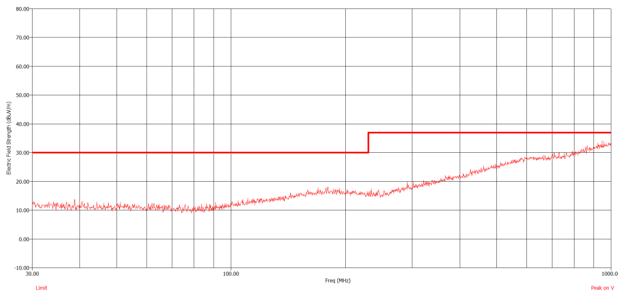

Figure 2. ISO7741 radiated emissions performance at 1 Mbps, Vcc=5.5 V

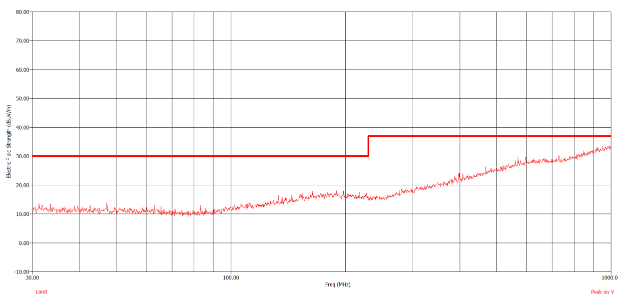

Figure 3. ISO7741 radiated emissions performance at 10 Mbps, Vcc=5.5 V

Operating devices at lower data rates and using devices with slower slew rates (rated at lower data rates) can reduce the amount of high frequencies present in a system and reduce emissions from these harmonics. In systems where lowering data rate is not desired or possible, designers may optimize PCB layout, place strategic impedances, and use EMC shielding methods to reduce the impact of the high frequencies on emissions.

What is Electrostatic Discharge (ESD)?

ESD testing is conducted to measure how much electrostatic discharge stress a device or equipment can withstand before becoming inoperable. The JEDEC standard provides device-level tests to model different energy sources, including the human body model (HBM), charged device model (CDM), and machine model (MM) – waveforms for which can be seen in Figure 4. IEC 61000-4-2 offers a similar standard test for equipment-level tests. These standards model high-current, short-duration strikes to represent the characteristics of a real discharge event. Each test is conducted up to a peak test voltage to characterize the level a device or system can withstand. Example values for IEC 61000-4-2 are shown in Table 1-2.

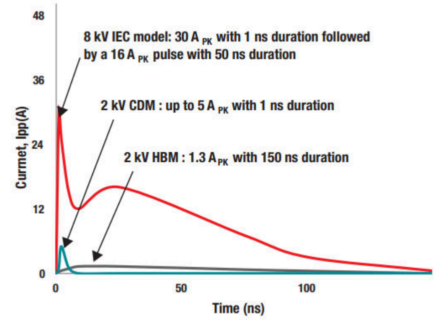

Figure 4. Comparison of ESD test model waveforms

Table 2. IEC61000-4-2 test voltage levels

Level	Contact Discharge	Air Discharge
	Test Voltage (+- kV)	Test Voltage (+- kV)
1	2	2
2	4	4
3	6	8
4	8	15

ESD protection and immunity is a consideration for many devices, but protection for isolators proves to have its own challenges. Non-isolated ESD test methods stress supply and data lines with respect to the local ground. Typical protection methods such as TVS diodes provide a safe path to ground for the energy in ESD strikes. Because isolated systems have separate grounds, TVS diodes cannot provide protection in the same way. This is because the energy in an across-the-barrier strike is presented as common mode to “single-side” or “local” ESD protection. A local TVS diode would not clamp due to a large voltage difference between isolated ground planes.

Some industries require equipment to provide a certain level of ESD immunity for user safety and product longevity. The simplest method of increasing system-level ESD capabilities is to choose robust devices with high individual ESD ratings. As shown in Figure 5 below, TI's ISO77xx family has the highest level of ESD protection among similar devices, reducing the number of external components needed for system protection. When even higher levels are required, external components such as Y-capacitors and gas discharge tubes (GDT) may be used to attenuate and dissipate energy from a discharge. Though external solutions can provide extra protection, they may add cost, board size, or operational constraints.

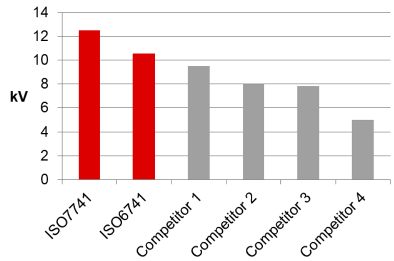

Figure 5. ISO77xx family ESD rating vs competition

What are Electrically Fast Transients (EFT)?

Like ESD testing and ratings, EFT ratings are a measure of device and equipment robustness, but with a different focus on cause and system impact. Switching-transients from inductive loads or relay-contact-bounce present stresses that are less likely to cause device damage than ESD strikes, but may instead interrupt normal system behavior. These transients are thus simulated differently under IEC 61000-4-4, shown in Figure 6 below, which models short rise-time, repetitive, low energy pulses to challenge system performance under such disruptive conditions. Similar to ESD, these tests are conducted up to a specified voltage level like shown in Table 1-3.

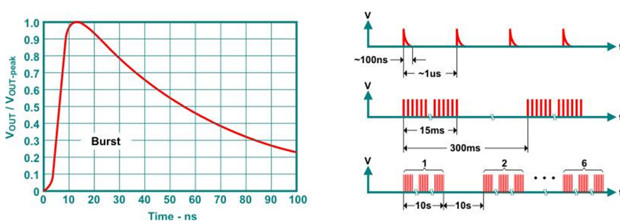

Figure 6. Waveform and timing diagram for EFT pulse test cycle

Table 3. IEC 61000-4-4 EFT Test Voltage Levels

Level	On Power Port, PE	On I/O, Data and Control Ports
	Test Voltage (kV)	Test Voltage (kV)
1	0.5	0.25
2	1	0.5
3	2	1
4	4	2

EFT events may occur on power and ground lines from switching loads or on signal lines from relay bounce or other induced-switching transients. Both injection types can cause glitches in an associated signal line. This could appear as a bit error and may result in data corruption or system lock-up. To reduce the risk of these failures, robust devices rated to resist such transients may be selected for use in a design. External filtering components such as decoupling capacitors, RC networks, and common-mode chokes may also be used to attenuate high frequency switching noise seen by a susceptible device. Figure 7 below shows the high EFT resiliance provided by TI's ISO77xx family compared to what is offered by similar competitor devices. These test levels were achieved with 0 bit errors.

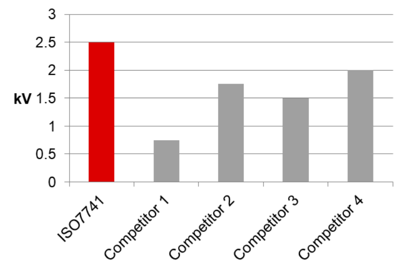

Figure 7. ISO77xx family EFT rating vs competition

Conclusion

This document describes how electrical components can interact with their electromagnetic environment and how negative interactions can be limited. Selecting devices that provide reliable protection from received electromagnetic energy and minimize unwanted radiated emissions is a fundamental way to increase a system's EMC performance and meet standard requirements. This, combined with EMC mitigation techniques, ensures correct operation of equipment in different electromagnetic environments. Texas instrument's ISO77xx family of digital isolators offers industry leading EMC performance with minimal radiated emissions while operating robustly under ESD and EFT disturbances.

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