TRANSIENT IMMUNITY STANDARDS: IEC 61000-4-x

On January 1, 1996, exports into Europe began facing some tough transient immunity standards. The International Electrotechnical Commission (IEC), a world-wide organization promoting international cooperation on questions concerning standardization in electrical & electronic fields, has developed transient immunity standards which have become minimum requirements for manufacturers wanting to do business in the European Community (EC). The basic standards for immunity testing had become known as the IEC 801-X standards, but recently underwent a numbering change to IEC 61000-4-X. Three of the IEC standards deal with transient immunity:

- IEC 61000-4-2 : Electrostatic Discharge (ESD)
- IEC 61000-4-4 : Electrical Fast Transient/Burst (EFT)
- IEC 61000-4-5 : Surge Immunity

The following sections provide a summary of each of the transient immunity standards.

IEC 61000-4-2 - ELECTROSTATIC DISCHARGE (ESD) STANDARD

IEC 61000-4-2 addresses one of the most common forms of transients in electronic systems : Electrostatic discharge (ESD). ESD results from conditions which allow the build up of electrical charge from contact and separation of two non-conductive materials. When the charged body is brought in proximity of another object of lower potential, energy is released in the form of electrostatic discharge.

The standard defines immunity requirements for ESD which can be coupled into the equipment directly or through radiation. Direct coupling includes any user accessible entry points such as I/O ports, switches, computer keyboards, panel displays, and equipment housings. Radiated coupling results from the discharge between two bodies which are external to the system.

Because the human body is one of the most common generators of ESD, the IEC standard defines a test set up which is designed to simulate an ESD event from a human body. The “Human Body Model” as it is referred to, is considered a valid representation of worst case ESD stresses. Discharge into equipment may be through direct contact (Contact discharge method) or just prior to contact (Air discharge method). Contact discharge is the preferred test method, but air discharge is used where contact discharge cannot be applied.

The ESD threat is divided into four threat levels depending on material and ambient humidity (See Table 1). Threat level 1 is considered the least severe while threat level 4 is the most severe. Levels 1 & 2 are reserved for equipment which is installed in a controlled environment and in the presence of anti-static materials. Level 3 is used for equipment which is sparsely but not continuously handled. Level 4 is required for any equipment which is continuously handled.

IEC 61000-4-2 also specifies the ESD current waveform and parameters shown in Figure1 & Table 2. The rise time is extremely fast, defined as 0.7 to 1ns, with a second peak at 30ns and a total duration of only 60ns. The total energy contained within the pulse is approximately a few hundred microjoules.

Transient voltage suppression (TVS) diodes are an ideal choice for meeting the ESD transient immunity requirements of IEC 61000-4-2 and have proved to be capable of suppressing ESD events. The extremely fast response time of the TVS diode is essential for responding to the 1ns rise time of the ESD pulse. Additionally, TVS diodes are capable of clamping the incoming transient to a low enough level as not to cause damage to the protected semiconductor. Al-

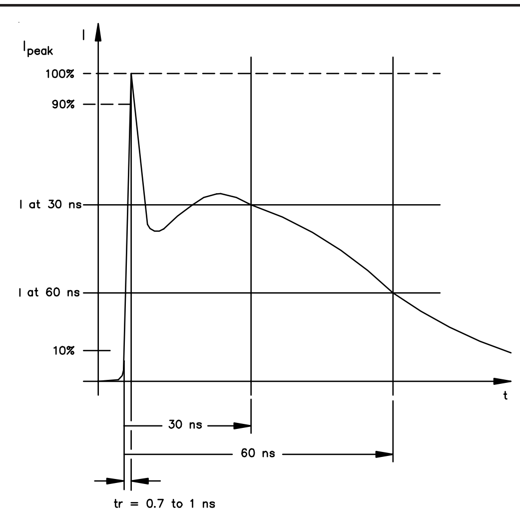

Figure 1 - ESD Waveform

Class	Relative Humidity as low as	Anitstatic Material	Synthetic Material	Maximum Charge Voltage	Test Voltage (Contact Discharge)	Test Voltage (Air Discharge)
	%			kV	kV	kV
1	35	X		2	2	2
2	10	X		4	4	4
3	50		X	8	6	8
4	10		X	15	8	15

Table 1 - IEC 61000-4-2 Severity Levels and Test Voltages

Level	Indicated Voltage	First peak current of discharge +/- 10%	Risetime (tr) with discharge switch	Current (+/- 30%) at 30 ns	Current (+/- 30%) at 60 ns
	kV	A	ns	A	A
1	2	7.5	0.7 to 1	4	2
2	4	15	0.7 to 1	8	4
3	6	22.5	0.7 to 1	12	6
4	8	30	0.7 to 1	16	8

Table 2 - IEC 61000-4-2 Waveform Parameters

though axial leaded devices are effective ESD suppressors, surface mount devices offer the best choice. All TVS diode devices and families offered by Semtech may be used to suppress ESD to level 4 of IEC 61000-4-2. The fast response and low clamping levels make TVS diodes suitable for ESD suppression on data and I/O ports.

IEC 61000-4-4 - ELECTRICAL FAST TRANSIENT (EFT) STANDARD

Electrical fast transients occur as a result of arcing contacts in switches and relays. EFT disturbances are common in industrial environments where electro-mechanical switches are used to connect and disconnect inductive loads. IEC 61000-4-4 specifies the EFT threat in both power and data lines. The electrical fast transient is described in terms of a voltage across a 50Ω load from a generator having a nominal dynamic source impedance of 50Ω. The output occurs as a burst of high voltage spikes at a repetition rate ranging from 2kHz to 5kHz. The burst length is defined as 15ms with bursts repeated every 300ms. Each individual burst pulse is a double exponential waveform with a rise time of 5ns and a total duration of 50ns. A diagram showing the EFT waveform and the EFT burst

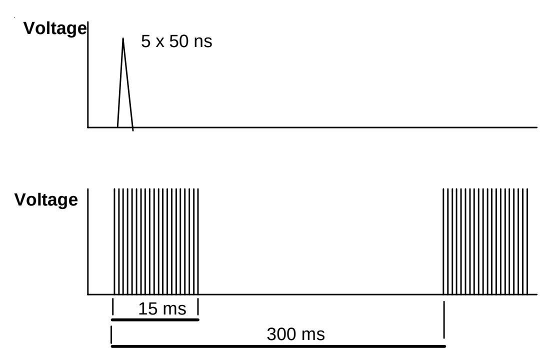

Figure 2 - EFT Burst

repetition rate and burst period is shown in Figure 2. Four severity levels are defined in terms of an open circuit voltage as a function of installation environment. The installation environments are defined as :

1 - Well Protected
2 - Protected
3 - Typical Industrial
4 - Severe Industrial

	Peak Amplitude			
	Power Supply Port		I/O, Signal, Data & Control Lines	
Level	V_{OC} (kV)	I_{SC} (A)	V_{OC} (kV)	I_{SC} (A)
1	0.5	10	0.25	5
2	1	20	0.5	10
3	2	40	1	20
4	4	80	2	40

Table 3 - IEC 61000-4-4 Severity Levels

Table 3 provides the open-circuit voltages for each threat level and for both power supply and data lines. Short circuit current values are estimated by dividing the EFT open-circuit voltage by its 50Ω source impedance. This represents the worse case stresses
seen by the suppression element.

Like ESD, EFT can be especially fatal on data and I/O lines. The fast rise time of the EFT pulses demands a suppression element with the same characteristics as that which are required for suppression of an ESD pulse. Again TVS diodes offer the best solution for suppressing the expected transient energy while keeping clamping voltages across the protected elements to a minimum. Additionally, the extremely fast response time of TVS diodes is essential for responding to the 5ns rise time of the EFT pulse. Due to the repetitive nature of the EFT pulses, TVS diodes with slightly higher power handling capability will be required for protection at threat level 4.

IEC 61000-4-5 - SURGE STANDARD

IEC 61000-4-5 addresses the most severe transient conditions on both power and data lines. These are transient caused by lightning strikes and switching. Switching transients may be the result of power system switching, load changes in power distribution systems, or short circuit fault conditions. Lightning transients may result from a direct strike or induced voltages and currents due to an indirect strike.
The IEC 61000-4-5 standard defines a transient entry point and a set of installation conditions. The transient is defined in terms of a generator producing a given waveform and having a specified open circuit voltage and source impedance. Two surge waveforms are specified : the 1.2 x 50µs open-circuit voltage waveform and the 8 x 20µs short-circuit current waveform (Figures 3 & 4 respectively).

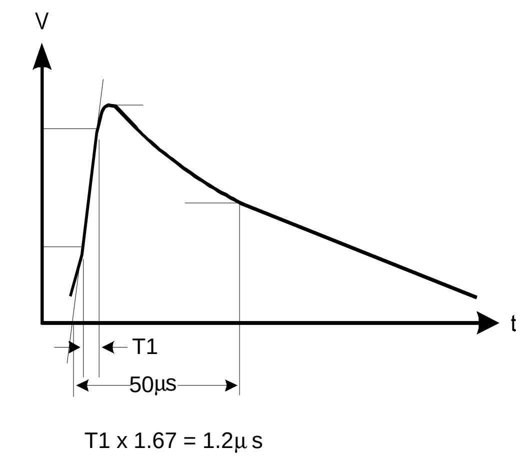

Figure 3 - IEC 61000-4-5 Voltage Impulse

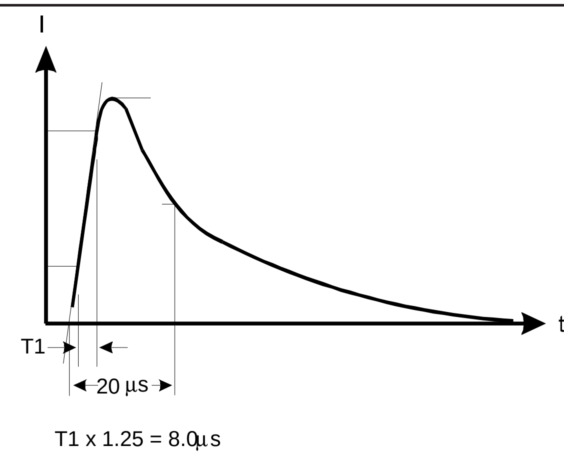

Figure 4 - IEC 61000-4-5 Current Impulse

Class		Power Supply		Unsym Lines (Long Distance Bus)		Sym Lines	Data Bus (Short Distance)
		Coupling Mode		Coupling Mode		Coupling Mode	Coupling Mode
		Line-Line Zs=2 Ω	Line-GND Zs=12 Ω	Line-Line Zs=42 Ω	Line-GND Zs=42 Ω	Line-GND Zs=42 Ω	Line-GND Zs=42 Ω
0	voltage	NO REQUIREMENT					
	current						
1	voltage	(n/a)	0.5KV	(n/a)	0.5KV	1.0KV	(n/a)
	current		42A		12A	24A	
2	voltage	0.5KV	1.0KV	0.5KV	1.0KV	1.0KV	0.5KV
	current	250A	83A	12A	24A	24A	12A
3	voltage	1.0KV	2.0KV	1.0KV	2.0KV	2.0KV	(n/a)
	current	500A	167A	24A	48A	48A	
4	voltage	2.0KV	4.0KV	2.0KV	4.0KV	(n/a)	(n/a)
	current	1KA	333A	48A	95A		
5	voltage	(NOTE 1)	(NOTE 1)	2.0KV	4.0KV	4.0KV	
	current			48A	95A	95A	
WAVE FORMs	voltage	(1.2 x 50µs)	(1.2 x 50µs)	(1.2 x 50µs)	(1.2 x 50µs)	(1.2 x 50µs)	(1.2 x 50µs)
	current	(8 x 20µs)	(8 x 20µs)	(8 x 20µs)	(8 x 20µs)	(8 x 20µs)	(8 x 20µs)

Note 1: Depends on class of local power supply system.

Table 4 - IEC 61000-4-5 Severity Levels

Transient stress levels for each entry point into the system are defined by installation class. The six classes are defined as :

Class 0 : Well Protected Environment
Class 1 : Partially Protected Environment
Class 2 : Well Separated Cables
Class 3 : Cables Run in Parallel
Class 4 : Multi - Wire Cables for both Electronic & Electrical circuits
Class 5 : Connection to telecommunications cables and overhead power lines (Low density populated areas)

A class 0 environment is considered the lowest threat level a has no transient stress requirements. The class 5 environment is the most severe and requires the highest transient stress level testing.

Table 4 summarizes threat levels as a function of installation class. Values of voltage stress using the 1.2 x 50µs waveform are given. Corresponding current values are calculated by dividing the open-circuit voltages by the source impedances. The short-circuit current values are more useful in choosing a suppression element. The short circuit current stress levels are defined with the 8 x 20µs waveform for power supply applications with a 2Ω source impedance. For data lines requiring a 42Ω source impedance, the short-circuit current waveform is defined as 8 x 20µs. For telecommunications applications, the open-circuit voltage is defined as 10 x 700µs

and the short-circuit current is a 5 x 300μs waveform. The source impedance is given as 40Ω.
The type of suppression element needed for IEC 61000-4-5 class surges depends upon the threat level and installation class. For power supply applications high power devices are required. A discrete device or an assembly may be required depending on the application. TVS diodes are the best choice for data line applications and secondary board level protection because of their superior clamping voltage characteristics and fast response time.

CONCLUSION

Any OEM equipment manufacturer who plans to sell in the European market will have to meet the requirements of IEC 61000-4. IEC defines three transient immunity standards which provide equipment suppliers with a susceptibilty level which can be designed against to produce more reliable products. Each of the transient immunity standards defines transient sources, entry paths into a system, severity levels, and test methods. Equipment application will determine what level of transient protection is needed. Transient suppression devices must be carefully chosen for each of the standards.

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- IEC Publication 1000-4-5 “*Electromagnetic Compatibility for Industrial Process Measurement and Control Equipment - Part 4, Surge Immunity Test,*” International Electromechanical Commission, 1995

SOURCES FOR STANDARDS

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