IEC 801: The Transient Immunity Standard Defined

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Today there are literally dozens of standards which address transient immunity, including ANSI/IEEE C62.41-1991, FCC Part 68, and CCITT Report K17. One standard which has received a great deal of attention in recent years is IEC 801. Unlike the standards mentioned above, IEC 801 applies to almost every electronic/electrical product; like many IEC documents, 801 defines minimum product reliability levels for any product sold in the European Common Market.

IEC 801 defines three transient immunity standards to ensure product reliability.

IEC 801 IMMUNITY STANDARDS

The IEC 801 standard was set forth by the European Community in order to define the transient immunity requirements of equipment sold in the European market. The standards describing transient immunity are presently numbered IEC 801-X, but these will undergo a numbering change to "IEC 1000-4-X."

- IEC 801-2 (1991): Electrostatic Discharge (ESD)
- IEC 801-4 (1988): Electrical Fast Transient/Burst (EFT)
- IEC 801-5 (Draft): Surge Immunity

This article provides a summary of each of these transient immunity standards.

IEC 801-2: ELECTROSTATIC DISCHARGE STANDARD

IEC 801-2 addresses one of the most common forms of transients in electronic systems: electrostatic discharge (ESD). ESD results from conditions which allow the buildup of electrical charge from contact and separation of two nonconductive materials. When the charged body is brought into proximity with 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 equipment directly or through radiation. Direct coupling includes any user-accessible entry points, such as input/output ports, switches, computer keyboards, panel displays, and equipment housings. Radiated coupling results from the discharge between two bodies which are external to the system.

The standard defines a test setup which is designed to simulate an ESD event from a human body. The "Human Body Model" 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).

The ESD threat is divided into four threat levels, which are dependent on material and ambient humidity (Table 1). Threat level 1 is considered the least severe while threat level 4 is the most severe. Levels 1 and 2 are reserved for equipment which is installed in a controlled environment and in the presence of antistatic materials. Level 3 is used for equipment which is not continuously handled. Level 4 is required for any equipment which is continuously handled. This generally includes equipment in a typical home or office environment.

IEC 801-2 also specifies the ESD current waveform and parameters (Figure 1 and Table 2). The rise time (t_r) is extremely fast, defined as 0.7 to 1 ns, with a second peak at 30 ns and a total duration of only 60 ns. 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

Class	Relative Humidity as low as	Antistatic 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 801 Severity Levels and Test Voltages.*

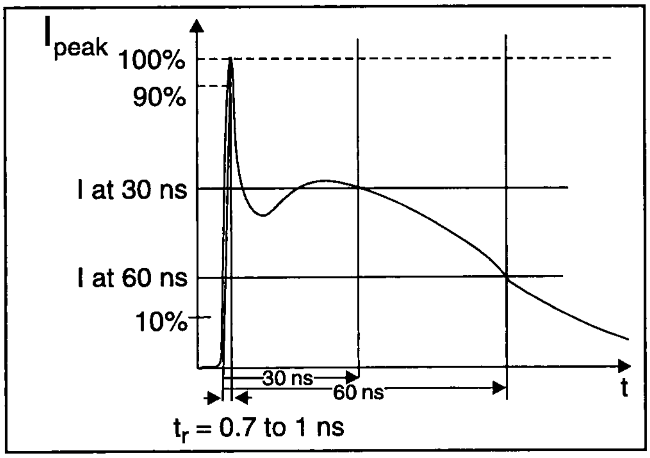

Figure 1. *ESD Waveform.*

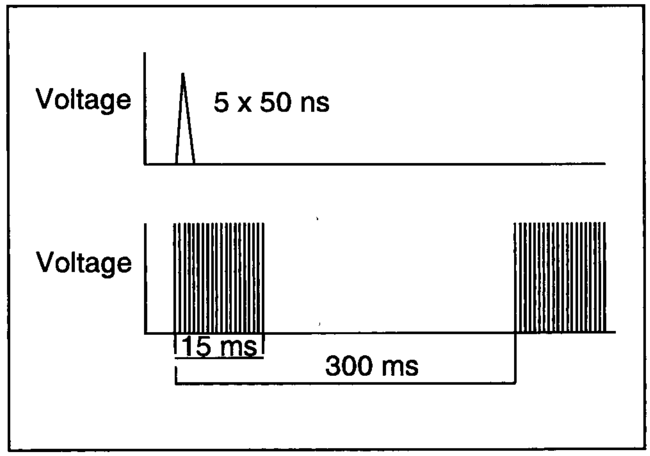

Figure 2. *EFT Burst.*

Level	Indicated Voltage	First peak current of discharge +/- 10%	Rise time (t_r) with discharge switch	Current (+/- 30 %) at 30 ns	Current (+/1- 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 801-2 Waveform Parameters.*

	Peak Amplitude			
	On Power Supply		On I/O Signal, Data & Control Lines	
Level	V_{oc}	I_{sc}	V_{oc}	I_{sc}
1	0.5 kV	10 A	0.25 kV	5 A
2	1 kV	20 A	0.5 kV	10 A
3	2 kV	40 A	1 kV	20 A
4	4 kV	80 A	2 kV	40 A

Table 3. *IEC 801-4 Severity Levels.*

immunity requirements of IEC 801-2. The extremely fast response time of the TVS diode is essential for responding to the 1 ns rise time of the ESD pulse. Additionally, TVS diodes are capable of clamping the incoming transient to a level which is low enough to prevent damage to the protected semiconductor. Although axial leaded devices are effective ESD suppressors, surface-mount devices offer the best choice. The fast response and low clamping levels make TVS diodes suitable for ESD suppression on data and I/O ports.

IEC 801-4: ELECTRICAL FAST TRANSIENT STANDARD

Electrical fast transients (EFT) occur as a result of arcing contacts in switches and relays. EFT disturbances are common in industrial environments where electromechanical switches are used to connect and disconnect inductive loads.

IEC 801-4 specifies the EFT threat in both power and data lines. The EFT is described in terms of a voltage across a 50-ohm load from a generator having a nominal dynamic source impedance of 50 ohms.

In the current revision of IEC 801-4, the output occurs as a burst of high voltage spikes at a repetition rate of 5 kHz for peak voltages less than 1 kV and of 2.5 kHz for a peak voltage of 2 kV. (IEC 1000-4-4 will raise the maximum transient frequency repetition rate to 100 kHz at all voltage levels.) The burst length is defined as 15 ms (1 ms for the 100 kHz test in IEC 1000-4-4) with bursts repeated every 300 ms. The burst sequence is to last over a time interval to be specified at no less than 1 minute. Each individual burst pulse has a rise time of 5 ns with a total duration of 50 ns. The EFT waveform and the EFT burst repetition rate and burst period are 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

Table 3 provides the open-circuit voltages (V_{oc}) for each threat level and for both power supply and data lines. Short-circuit current (I_{sc}) values are estimated by dividing the EFT open-circuit voltage by its 50-ohm source impedance. This represents the worst-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 those 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 5-ns 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 801-5: SURGE STANDARD

IEC 801-5 addresses the most severe transient conditions on both power and data lines. These are transients 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.

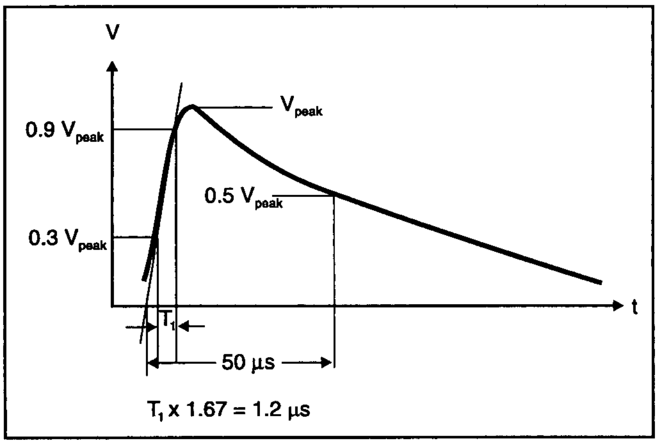

Figure 3. *IEC 801-5 Voltage Impulse Waveform.*

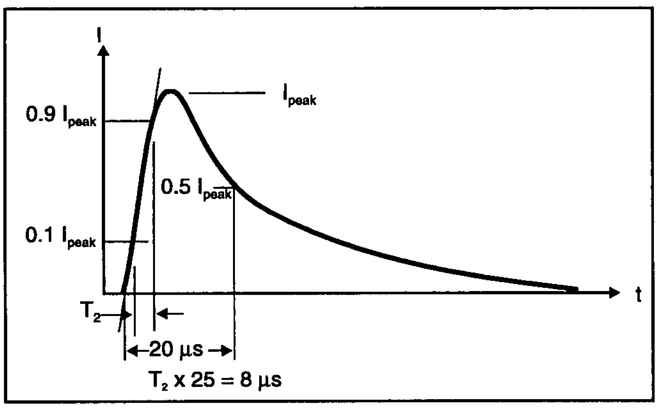

Figure 4. *IEC 801-5 Current Impulse Waveform.*

The IEC 801-5 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 50 µs open-circuit voltage waveform and the 8 x 20 µs short-circuit current waveform (Figures 3 and 4 respectively).

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 and 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 and 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 50 µs waveform are given. Corresponding current values are calculated by dividing the open-circuit voltages by the source impedances. The

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		Power Supply Coupling Mode		Unsym. Lines (long distance bus) Coupling Mode		Sym. Lines Coupling Mode	Data Bus (short distance) Coupling Mode
		Line-Line Zs=2 Ohms	Line-GND Zs=12 Ohms	Line-Line Zs=42 Ohms	Line-GND Zs=42 Ohms	Line-GND Zs=42 Ohms	Line-GND Zs=42 Ohms
0	voltage	No Requirement					
	current						
1	voltage	(n/a)	0.5 kV	(n/a)	0.5 kV	1.0 kV	(n/a)
	current		42 A		12 A	24 A	
2	voltage	0.5 kV	1.0 kV	0.5 kV	1.0 kV	1.0 kV	0.5 kV
	current	250 A	83 A	12 A	24 A	24 A	12 A
3	voltage	1.0 kV	2.0 kV	1.0 kV	2.0 kV	2.0 kV	(n/a)
	current	500 A	167 A	24 A	48 A	48 A	
4	voltage	2.0 kV	4.0 kV	2.0 kV	4.0 kV	(n/a)	(n/a)
	current	1 kA	333 A	48 A	95 A		
5	voltage	(Note 1)	(Note 1)	2.0 kV	4.0 kV	4.0 kV	
	current			48 A	95 A	95 A	
Wave-Forms	voltage	(1.2 x 50 µs)	(1.2 x 50 µs)	(1.2 x 50 µs)	(1.2 x 50 µs)	(1.2 x 50 µs)	
	current	(8 x 20 µs)	(8 x 20 µs)	(1.2 x 50 µs)	(1.2 x 50 µs)	(1.2 x 50 µs)	(1.2 x 50 µs)
Note 1: Depends on class of local power system.							

Table 4. *IEC 801-5 Threat Levels as a Function of Installation Class.*

continued until the term $X_{n,n+1}$ is less than the error tolerance, 0.5 dB.

This is expressed as follows:

$$(X_{n,n+1}) < 0.5 \text{ dB} \qquad (2)$$

When this condition is satisfied, equivalence will have been established for an error tolerance of ± 0.5 dB. When the process reaches the point where Equation 2 is satisfied for the specified error tolerance, any additional steps in the process will result in the value of $X_{n,n+1}$ approaching the residual measurement error of the RSA measurement and then remaining constant. This only holds true, of course, if the error tolerance value selected is greater than the residual error.

This condition can be expressed as:

$$(X_{n,n+1}) > \text{Residual Error} \qquad (3)$$

The continuation of this process will result in equivalent values of $X_{n,n+1}$ for each step in the process within the bounds of the residual measurement error. Since the size of the OATS increases with each step of the process, it can be stated that after the step in which Equation 3 is satisfied, any increase in the size of the OATS will result in equivalent values of $X_{n,n+1}$. In order for this to occur the RSA data must also remain equivalent with each step. If this is true for n steps and also for n+1 steps, then it must also be true for an infinite number of steps and thus the OATS site attenuation characteristics are proven to be equivalent to those of an IHSBPC. Other polarizations and antenna separations can be verified in a similar manner.

The equivalent OATS, which will be designated ideal (IOATS), can then be used to compare the RSA data of other sites, both OATS and semi-anechoic chambers. The application of this method will greatly reduce the error tolerance associated with radiated EMI measurements.

SUMMARY

This article provides an analysis of the normalized site attenuation method. An alternative approach was proposed to characterize measurement sites by modeling the OATS with an infinite half space bounded by a perfect conductor.

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short-circuit current values are more useful in choosing a suppression element. The short-circuit current stress levels are defined with the 8 x 20 µs waveform for power supply applications with a 2-ohm source impedance. For data lines requiring a 43-ohm source impedance, the short-circuit current waveform is defined as 1.2 x 50 µs. For telecommunications applications, the open-circuit voltage is defined as 10 x 700 µs and the short-circuit current is a 5 x 300 µs waveform. The source impedance is given as 40 ohms.

The type of suppression element needed for IEC 801-5 class surges depends upon the threat level and installation class. For line-to-line surges on incoming power, metal oxide varistors (MOVs) provide the best choice. The large disc-shaped structure of the MOV allows for high surge current capability. TVS diodes may be combined with the MOVs to utilize the best attributes of both types of suppression devices. TVS diodes with a minimum power rating of 1500 W are recommended when used in conjunction with MOVs. TVS diodes are the best choice for data line applications and secondary board level protection because of their superior clamping voltage characteristics and instantaneous response time. A TVS diode with a minimum power rating of 300 W to 500 W is recommended for peak transient currents of 24 A or less. For higher current levels, devices rated for 500 W to 1500 W are the best choice.

CONCLUSION

Any equipment manufacturer who plans to sell in the European market will have to meet the requirements of IEC 801 (or under the new designation, IEC 1000-4-X). IEC 801 defines three transient immunity standards which provide equipment suppliers with a susceptibility 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 which level of transient protection is needed. Transient suppression devices must be carefully chosen for each of the standards.

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