Immunity Testing to IEC Specifications

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Interference generators can be used in product design and development stages, as well as in the CE mark certification process.

INTRODUCTION

The European Union of 15 member countries has a population of 370 million people and it represented 16% of U.S. exports in 1995. Since January 1, 1996 manufacturers of electronic equipment have had to meet the Electromagnetic Compatibility (EMC) guidelines of EC Council Directive 89/336/EEC.

The legally prescribed test requirements for EMC standards in the EU were issued by CENELEC, the European Committee for Electrotechnical Standardization. These are called the generic standards. They are EN50081 and EN50082. EN 50081 covers the standards for emission in the residential, commercial and light industrial environment (EN 50081-1) and the industrial environment (EN 50081-2). EN 50082 covers the standards for immunity in the residential, commercial and light industrial environment (EN 50082-1) and the industrial environment (EN50082-2).

The generic standards apply to products for which no dedicated product or product family standard exists. If a product or product family standard exists, it supercedes the generic standards in prescribing the test requirements. The generic standards prescribe the test requirements. They refer to what is known as the Basic Standards to define the tests to be performed, the test methods, the test setup and the specifications of the generator used to simulate interference phenomena. This article will focus on five of the European Standards from CENELEC used in the immunity portion of the standards used for CE mark certification.

BASIC STANDARDS FOR EMC IMMUNITY

The generic standards from CENELEC refer to basic specifications issued by the International Electrotechnical Commission (IEC). The IEC promotes standardization in the fields of electricity, electronics and related technologies. IEC 1000-3 covers emission specifications and IEC 1000-4 covers immunity specifications. The specifications are further broken down into sections. CENELEC has also adopted the same numbering system and refers to the specifications as ENs or European Norms. They are EN61000-3 and EN61000-4. The immunity portion of the specifications are listed in Table 1.

INTERFERENCE GENERATION

The basic standards also specify the generator to be used for simulating the interfering phenomena. But, since the disturbance phenomena have to be determined and measured first, the basic standards and the generator requirements usually lag behind the real environmental conditions. As a result, the standards are subjected to constant changes. To reduce the cost of the generator used for testing to the immunity standards, it must be versatile and capable of covering as many of the foreseen specification changes as possible.

Testing of one's own product is a requirement for the CE mark. This viewpoint is satisfactory; however, immunity testing of a manufactured product is also valuable as a tool to achieving customer satisfaction with the end product. If a product is not susceptible to ESD and fast transients, for instance, it will not fail as readily during normal use. This is not only important from a performance standpoint, but from a safety and legal liability standpoint as well. Therefore, it is useful to use interference generators in the product design and development stage, as well as in the CE mark certification process.

BURST

The burst pulses, also called electrical fast transients (EFT), are created on public power lines by electrical arcs across switch contacts during openings of the switch. The nature of the loads connected to the power lines causes short bursts of pulses across the switch which can generate interference in electrical/electronic equipment connected to the lines. Figure 1 shows the bursts called out by IEC 1000-4-4. The pulses within the 15 millisecond burst period are defined by the specification as having a frequency of 5 kHz. However, recent draft proposals of IEC 1000-4-4 increase the frequency of the pulses up to 100 kHz. The burst pulses are applied in peak voltage levels from 500 volts to 4 kV on the power supply lines of the Equipment Under Test

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European Norm	IEC Specification	Area of Application
EN 61000-4-2	IEC 1000-4-2	Electrostatic discharge (ESD)
EN 61000-4-3	IEC 1000-4-3	Radiated EM field
EN 61000-4-4	IEC 1000-4-4	Burst/electrical fast transients (EFT)
EN 61000-4-5	IEC 1000-4-5	Surge
EN 61000-4-6	IEC 1000-4-6	Conducted radio frequency disturbances
EN 61000-4-8	IEC 1000-4-8	Power frequency magnetic field
EN 61000-4-9*	IEC 1000-4-9*	Pulse magnetic field
EN 61000-4-11	IEC 1000-4-11	Voltage dips, interruptions
*EN 61000-4-9 and IEC1000-4-9 are not required by the generic standards but are referenced here for later use in this article.		

Table 1. *ENs and IEC Specs Referenced by the Generic Immunity Standards EN 50082-1 and EN 50082-2.*

(EUT). Because the burst pulses can be radiated into equipment signal lines (from nearby power leads), the burst pulses are also required to be capacitively coupled to the signal leads.

The burst test is a low energy test, and as such it is not destructive. The burst test is particularly hard on complex digital equipment with high clock frequencies. The test can cause degradation of performance, loss of function, uncontrolled process sequences, failures in programmable equipment, loss of information stored in memory and incorrect data processing.

For these reasons, the burst test should be the first test performed on an EUT. In order to take into account the constantly increasing clock frequencies of microprocessor applications, higher burst pulse frequencies exceeding the 5 kHz specified frequency and even higher than the 100 kHz proposed frequency should be used in developmental testing. If the burst testing is done at 5 kHz, it would take many tests to find and isolate a burst susceptibility design problem. If, for example, the EUT were to have a clock frequency of 10 MHz, the 5 kHz burst pulse tests only every 2,000th function state. The test piece's critical states are likely to be among the 1999 function states not tested. If the testing is done at 100 kHz or higher, the design problems can be quickly discovered because more function states are tested at one time.

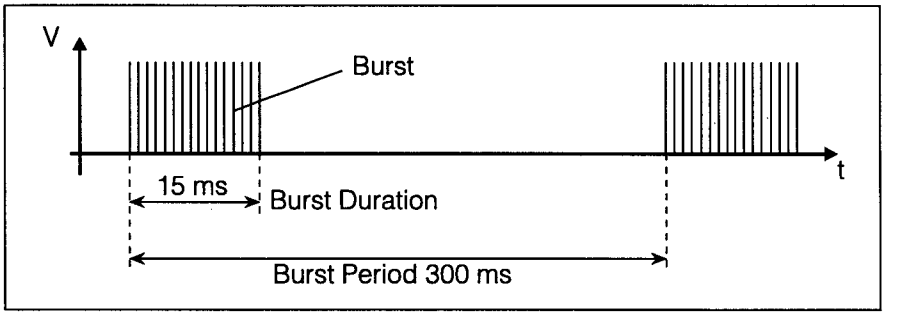

Figure 1. *Fast Transient/Burst According to IEC 1000-4-4.*

SURGE

IEC 1000-4-5 prescribes tests for simulating the effects of lightning discharges as well as voltage surges caused by switching disturbances in power stations. The surge waveforms are defined by the specification as shown in Figures 2 and 3. The peak voltage for the voltage waveform in Figure 2 varies between 500 V and 4.0 kV. The peak current in Figure 3 is between 250 A and 2.0 kA.

IEC 1000-4-5 requires that surge pulses be applied to the EUT at a rate of "at least one per minute." The test also requires the pulse to be applied at 0, 90, 180, and 270 degrees of the power input waveform and that pulses be applied from line to line and from the line(s) to earth of the power leads. The peak voltage level of the surge pulse is adjusted in steps starting at 500 V, to 1000 V and 2000 V. In total, 320 pulses are required. The simulator must have sufficient energy available to complete this test in a timely matter. The generator should use a high energy power supply and electronic switches to deliver all 320 pulses. This efficiency is important in saving time, because if a generator meets the bare minimum of one pulse per minute, the test will take 5 hours and 20 minutes.

The surge test can be destructive to the EUT if adequate protection is not incorporated into the design. Therefore, this test should be carried out after a successful burst test.

The coupling and decoupling networks for applying the burst and surge pulses can be contained within the generator. For coupling to the signal leads for both burst and surge pulses, external coupling/decoupling networks are required. A built-in peak reading voltage and current meter helps to simplify the testing procedure.

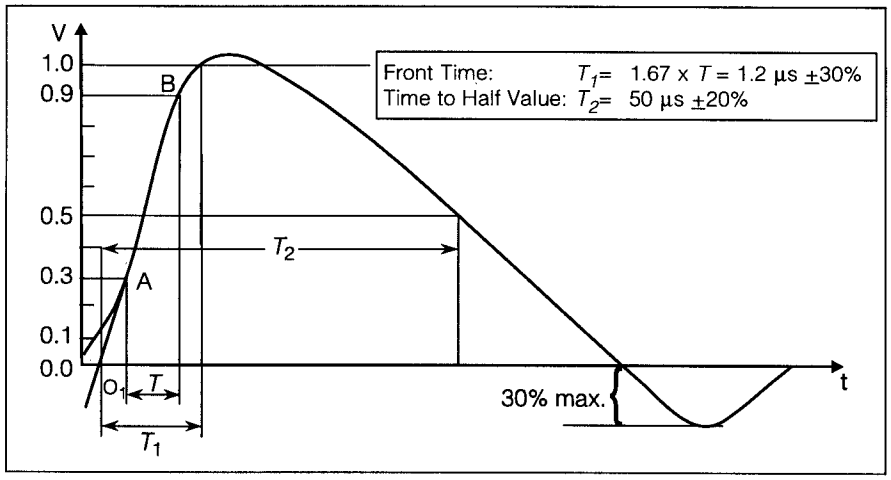

Figure 2. *Waveform of Open Circuit Voltage (1.2/50 µs).*

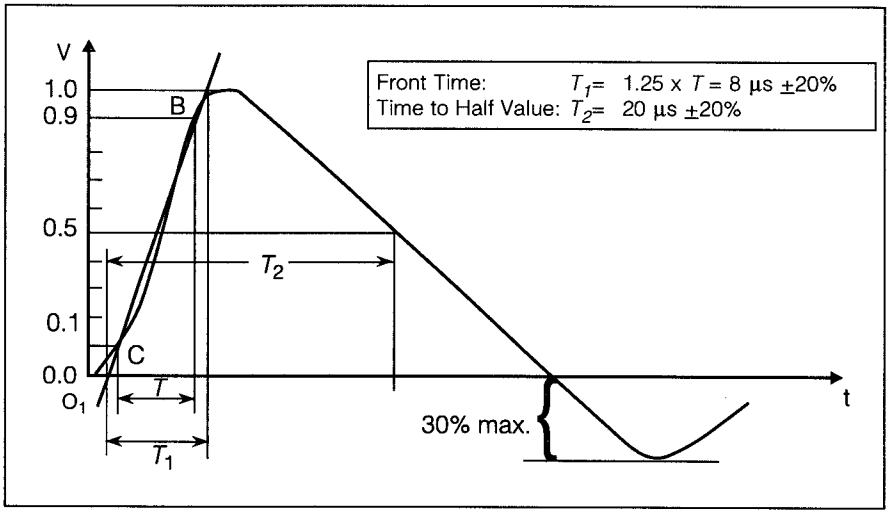

Figure 3. *Waveform of Short Circuit Current (8/20 µs).*

Test Level % V_t	Voltage Dip and Short Interruptions % V_t	Duration (in period)
0	100	0.5*
		1
40	60	5
		10
		25
70	30	50
		x

*For 0.5 period, the test shall be made in positive and negative polarity, i.e., starting at 0° and 180°, respectively.

NOTES
1. One or more of the above test levels and durations may be chosen.
2. If the EUT is tested for voltage dips of 100%, it is generally unnecessary to test for other levels for the same durations. However, for some cases (safeguard systems or electro-mechanical devices) it is not true. The product specification or product committee shall give an indication of the applicability of this note.
3. "x" is an open duration. This duration can be given in the product specification. Utilities in Europe have measured dips and short interruptions of duration between one half a period and 3,000 periods, but duration of less than 50 periods are most common.
4. Any duration may apply to any test level.

Table 2. *Test Levels for Voltage Dips and Interruptions.*

POWER FAIL SIMULATION

IEC 1000-4-11 specifies the levels for testing supply line dips, interruptions and variations. Voltage dips and short interruptions are caused by faults in the networks, brown-outs or sudden large changes in the load on the lines. The line voltage variations are caused by continuously varying loads connected to the network.

These phenomena are random in nature. When large rotating machines are connected to the network, they can act as generators on the power lines during interruptions resulting in gradual variations in the line voltage rather than abrupt interruptions. The line voltage dips and interruptions are required tests of IEC 1000-4-11, but the voltage variations are optional dependent on the EUT product specification and the product's sensitivity to voltage variations. The specifications for the voltage dips and short interruptions are given in Table 2. Table 3 shows the optional power supply variations test levels.

POWER FREQUENCY MAGNETIC FIELD IMMUNITY TESTING

IEC 1000-4-8 describes the tests and levels for power frequency magnetic fields and IEC 1000-4-9 defines the tests and levels used for pulsed magnetic field immunity testing. These two specifications are grouped together because they are very similar. Magnetic fields can affect the reliable operation of electrical and electronic equipment. The power frequency magnetic field simulates power frequency current in conductors or leakage from transformers or other current carrying conductors in the area. Pulse magnetic fields are generated by lightning strikes on buildings and other metal structures near electrical or electronic equipment. The surge output of the generator is connected directly to a 1 m x 1 m square coil for IEC 1000-4-9. Generators are available which control the current in the 1 m x 1 m square coil to accomplish IEC 1000-4-8 testing.

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Voltage Test Level	Time for Decreasing Voltage	Time at Reduced Voltage	Time for Increasing Voltage
40% V_t	2s ± 20%	1s ± 20%	2s ± 20%
0% V_t	2s ± 20%	1s ± 20%	2s ± 20%
	x	x	x

NOTE: "x" represents an open set of durations and can be given in the product specification.

Table 3. *Timing of Short-term Supply Voltage Variations.*

CONCLUSION

Manufacturers must test and certify that their equipment meets the EC directive and they must apply a CE mark as proof of this. Current and pending changes to the specifications that describe the tests to be made, place more stringent requirements on the equipment used for CE mark testing. Indeed, future changes will require that the testing equipment be able to expand its capabilities without causing the equipment to become useless. Generators are available which can perform immunity testing for five of the standards used for CE mark certification.

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