APPLICATION NOTE #121A

EOS1 / EOS3 Option
Electronic Output Switch for IEC 61000-4-11 AC Source Compliance

Includes IEC 61000-4-11 Standard Edition 2.0

Figure 1: Electronic Output Switch option.

Introduction

The IEC 61000-4-11 standard concerns testing and measurement techniques that verify the immunity of electrical (and electronic) products from "voltage dips, short interruptions, and voltage variations". Although the standard is European, it has found widespread use as a basis for design verification testing throughout the world.

There are many ways to test a product to verify immunity from line variations, and some form of standardization, for comparison purposes, is desirable. However, IEC 61000-4-11 leaves many options available, and does not specify which tests and test levels should apply to a particular type of product.

The standard also seeks to specify the parametric requirements of an AC source suitable for performing the specified tests. Generally, these requirements go beyond what is necessary on a particular product. For example, it is neither necessary nor cost effective to have an inrush current capability significantly greater than that needed by the product to be tested. In this application note we will explain the tests specified in the standard and draw conclusions concerning the capabilities of suitable AC power sources to perform those tests. In particular, the use of the optional Electronic Output Switch (EOS) on the iX Series power source models is explained. This option allows the AC source to meet the required generator specifications called out in this IEC test standard.

Background Information

Mains voltage dips and short interruptions can be caused by a wide variety of phenomena. Possible causes are faulty loads on an adjacent branch circuit causing a circuit breaker to operate. High power loads such as welders, motors and electric heaters may also cause voltage variations.

Other events such as power lines downed by storms or lightning strikes may cause mains disruptions. In the case of a fault in the power distribution grid, an automatic recovery circuit may cycle open and closed several times within a short period attempting to clear the fault. This will likely result in a sequence of short voltage interruptions as seen by downstream loads. Voltage variations are typically caused by high power loads that have continuously varying power levels, rather than by abruptly switching on and off. These voltage changes can affect the operation of and sometimes even damage nearby electrical and electronic equipment. Consequently, immunity testing for these types of events should be performed to ensure safe and reliable product operation. The IEC 61000-4-11 Immunity standard aims to define a uniform test and evaluation method to verify immunity for such line voltage anomalies. As a guide to the test parameters to be applied to the equipment under test (EUT), this standard advises the typical number of occurrences per annum (in Europe) for various durations of line voltage reduction or interruption. (See Table 1).

Depth	Duration			
Voltage Reduction	10 to 100 ms	100 to 500 ms	500 ms to 1 s	1 s to 3 s
10 to < 30 %	61	66	12	6
30 to < 60 %	8	36	4	1
60 to < 100 %	2	17	3	2
100 %	0	12	24	5

Table 1: Number of typical line disturbances

Applicable Standards

IEC 61000-4-11 was first published in 1994 (Edition 1.0) with a first amendment in 2000. Its scope includes electrical and electronic equipment with an input current rating not greater than 16A per phase. It is one of the required tests in the Generic Residential, Commercial and Light Industrial immunity standard EN50082-1: 1997 and is also under consideration to be included in the Generic Industrial immunity standard EN50082-2. It is also included in several product specific standards such as the EN 61326-1 which went into effect in mid 1999 and covers testing instruments, data acquisition and control systems. Other product family standards should be checked for applicability.

IEC 61000-4-11 Edition 2.0

A new IEC 61000-4-11 standard edition was released in March 2004. The new Edition 2.0 now references IEC 61000-2-8, "Environment - Voltage dips and short interruptions on public electric power supply systems with statistical measurement results."

This Edition 2.0 cancels and replaces the first edition and it's amendment. It differs from these in the following areas:

1. Preferred test values and durations have been added for the different EMC environment classes 1, 2, 3 and user class X.
2. The recommended voltage dip and interruption durations are shorter.
3. A new test level of 80% of Unom was added for voltage dips test. The 70% test level remains as well, however, and is still used in all product standards.
4. Voltage variations are now done using an abrupt voltage change from Unom instead of a voltage sweep. The change from the reduced level back to Unom is still a sweep however.
5. All durations for voltage variations are now expressed in no. of cycles of the fundamental AC frequency instead of seconds. The number of cycles for 50 Hz and 60 Hz is chosen so that the time intervals are the same.
6. Tests for three phase systems have been specified.

Timing is shown in Figure 2 for a 40 % of Unom Dip and Figure 3 for a voltage interruption. The duration of the dip or interruption is defined in number of cycles of the fundamental frequency. The actual change in voltage can occur at a set phase angle, e.g. 0° or 90°.

The change in Edition 2.0 for the voltage variation is illustrated in Figures 4 and 5. Figure 4 shows the original voltage variation timing diagram. The line represents the RMS voltage level as it changes as a function of time.

Figure 5 shows the new Edition 2.0 voltage variation timing. This new variation is intended to better simulate the effects of motor loads starting up on the mains voltage.

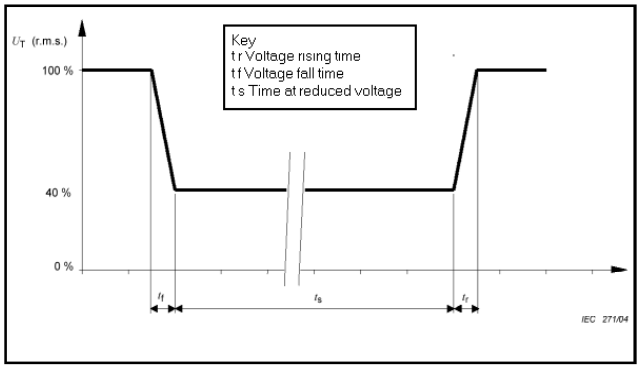

Figure 2: IEC 1000-4-11 Voltage Dip 40%.

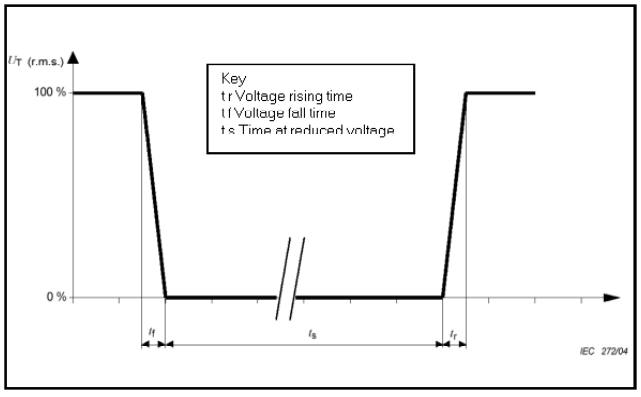

Figure 3: IEC 1000-4-11 Voltage Interrupt.

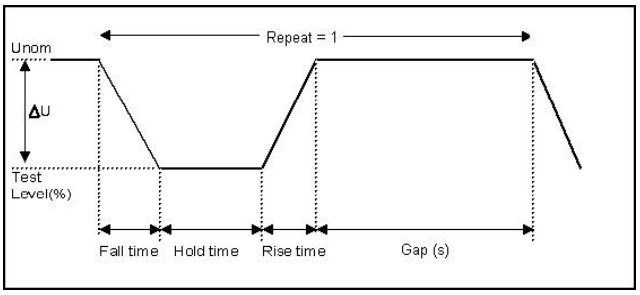

Figure 4: IEC 1000-4-11 Voltage Variation Edition 1.0.

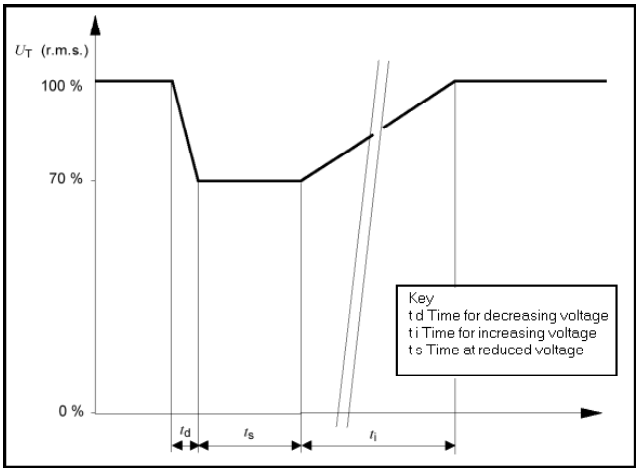

Figure 5: IEC 1000-4-11 Voltage Variation Edition 2.0.

Test Levels

IEC 61000-4-11 is a basic EMC standard and therefore defines methods of generating and applying consistently reproducible tests as well as suggested test levels. The new Edition 2.0 now references IEC 61000-2-8, “Environment - Voltage dips and short interruptions on public electric power supply systems with statistical measurement results.” This has resulted in new test values and durations for the different EMC environment classes 1, 2, 3 and user class X.

However, it is the Generic Immunity standards, as well as the Product Family standards, that specify the test levels and pass/fail performance criteria applied to a particular class of equipment. The Voltage variation portion of the IEC 61000-4-11 generic test standard is specified only as an optional test in the basic standard and none of the following standards mandate it. Test levels for dips and short interruptions are specified as shown in Table 2. Consult the product standard for your specific product category to determine the appropriate test levels and durations to be used.

Pass / Fail Criteria

The EUT operation must be monitored for changes in performance during and immediately after the test is applied. The EUT must remain safe at all times and no damage may occur during the test. Other classifications of performance are as follows:

Criterion A: EUT operates normally during the test and its performance is within the manufacturer’s specifications.

Criterion B: EUT operates normally after the test. No change of operating state or loss of data is allowed during the test, however a degradation of performance is allowed.

Criterion C: EUT operates normally after the test but may first require operator intervention or a self recovery procedure to restore normal function. A loss of function or data is allowed.

Criterion D: EUT suffers degradation or loss of function during or after the test which is not recoverable due to damage of equipment (components) or software, or loss of data.

Since these pass or fail criteria cannot be evaluated by the test equipment directly, the operator must decide if the EUT passed or failed based on the applicable criterion.

Standard	*Product Category*	*Test Levels*	*Pass/Fail Criteria*
EN50082-1: 1997	Generic Immunity – Residential, Commercial and Light Industrial	0% (0V) for 5 sec 70% for 10 ms 40% for 100 ms	C B C
EN50082-2: 1995	Generic Immunity – Industrial	N/A	N/A
EN50082-2: Draft	Generic Immunity – Industrial	0% (0V) for 5 sec 70% for 10 ms 40% for 100 ms	C B C
EN61326-1	Immunity for electrical equipment intended for professional, industrial process and educational use.	0 % (0V) for 1 cycle 0 % for 0.5 cycle 0° 0 % for 0.5 cycle 180°	
EN55104	Immunity for Household Appliances, Tools and Similar Apparatus	0% (0V) for 10 ms 70% for 1000 ms 40% for 200 ms	Manufacturer specific

Table 2: Product Test standards and test levels.

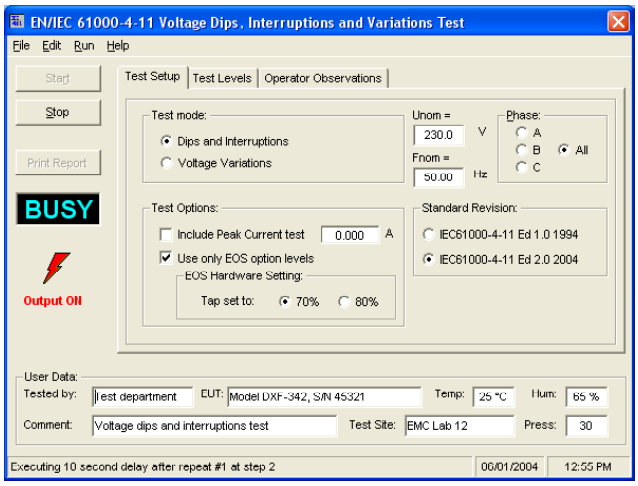

Figure 6: IEC 1000-4-11 GUI Test screen.

The generic test standard does not define PASS or FAIL criteria. However, criterion a) is clearly a PASS, b) is usually also interpreted as a PASS. Even c) can be defined as a PASS , if that is the way the performance of the product to these non-standard line input conditions is defined. However, specific product standards may call out the applicable pass or fail criteria as shown in Table 2.

iX Series IEC 1000-4-11 Test Option

The test requirements for IEC 61000-4-11 immunity testing can be met using the i Series or iX Series AC power source as the generator. A 5000 VA power source provides 16.6 Arms current at up to 300 Vac and offers an IEC 61000-4-11 test option (option -411). This test option enables voltage dips and variations tests to run from the front panel or via the IEEE-488 or RS232C interface.

Support for both single (5001iX-EOS1) and three phase (15003iX-EOS3) test systems is available.

The included Windows Graphical User Interface program allows the end-user to select from several generic product standards or define product specific test sequences. The GUI software provides the means to print test reports. Support for Edition 2.0 of the IEC 61000-4-11 test standard has been added as of revision 1.20 of the Cigui32 GUI software. The following features were added in this GUI release:

Test sequences for EMC classes 1, 2 and 3 for both 50 and 60 Hz fundamental frequency.

User selection between Ed 1.0 or Ed 2.0 test modes.

Support for abrupt voltage variation change per Ed 2.0. (Requires iX/i Series firmware revision 2.39 or higher).

Data entry in cycles for voltage variations mode when Ed 2.0 mode is selected.

Generator Requirements

The IEC 61000-4-11 test standard not only covers the test methods, it also stipulates requirements for the test generator (AC power source) to be used during the test. While most of the requirements are easy to meet with a modern AC power source, some requirements are very demanding and appear out of place in view of the actual tests applied to the EUT. Nevertheless, the 5001iX in combination with the Electronic Output Switch (EOS) meets all requirements of the standard in accordance with section 6.1.2. and Annex A, section 1.2 for peak current capability.

Basic Requirements

The following generator requirements can be met with the 5001iX AC power source without the EOS option. Generator specifications shall be verified using a 100 Ohm resistive load of suitable power rating.

	Requirement	5001iX
Voltage regulation		
@ 100 % Unom	< 5 %	< 2 %
@ 80 % Unom	< 7 %	< 2 %
@ 70 % Unom	< 7 %	< 2 %
@ 40 % Unom	< 10 %	< 2 %
Output current		
@ 100 % Unom	16 A RMS	18.5 A RMS
Phase shifting	0 to 360°	0 to 360°
Phase relationship *(Voltage / power frequency.)*	< ± 10°	< ± 1.5 °
Output Impedance	predominantly resistive	predominantly resistive

Rise and Fall times for voltage dips.

One of the requirements of the test generator is to produce rise and fall times between 1 and 5 microseconds at phase angles of 90° and 270° into a 100 Ohm resistive load. To meet these rise and fall time requirements would normally require an AC power source with an output bandwidth in excess of 70 kHz. This would preclude the use of small, efficient and lightweight switching AC power sources such as the 5001iX. To avoid the need for expensive, inefficient and bulky linear amplifiers, the EOS option provides an electronic means of switching between the various voltage dip levels with the required rise and fall times. The same EOS unit also meets the over and undershoot specifications of less than 5 %.

RMS current capability and voltage regulation at reduced voltage levels.

The EOS unit is also required to increase the available RMS current to the EUT at reduced voltage levels. The following table shows the IEC 1000-4-11 standard generator requirements and the 5001iX-EOS capability for comparison.

Voltage % Unom	IEC 1000-4-11		5001iX-EOS	
100	16 A RMS	< 5 %	18.5 A RMS	< 2 %
80	20 A RMS for 5 secs	< 5 %	23.1 A RMS indefinitely	< 2 %
70	23 A RMS for 3 secs	< 5 %	26.4 A RMS indefinitely	< 3 %
40	40 A RMS for 3 secs	< 5 %	46.2 A RMS indefinitely	< 5 %

Peak Current Capability

There are two allowable means of meeting the EUT peak inrush current requirement. One is to use a generator with a peak current delivery capability of 500 Amps at 220 to 240 Volt or 250 Amps at 100 to 120 Volt. This capability must be verified using a full bridge rectifier and a 1700 uF capacitor load discharged into a 100 to 10k Ohm resistor. The generator output is switched from 0 % to 100 % at both 90° and 270°. Tests are performed with the generator output at 0 % for 5 minute and 5 second intervals before switching to 100 %.

If the inrush capability of the generator does not meet the 500 A requirement, it is allowed to use the generator and still be fully compliant with the standard as long as the EUT does not require more than 70 % of the available generator peak current capability. In this case, it is necessary to measure the EUT inrush current requirement using the same test method as described above, only this time using the actual EUT as the load. The 5001iX GUI program performs this measurement automatically and notifies the operator if the EUT inrush current exceeds this 70 % level. The 5001iX has a rated peak output current of 92 Amps, which means EUT's requiring up to 64.4 Amps peak inrush current can be tested with full compliance.

If the EUT peak current requirement is more than 70% of the generator's capability, the test may still be run but a note is added to the test report indicating the generator may limit the inrush current to the EUT.

Upgrading Existing Systems

Customers who own 5001iX-EOS1, 15003iX-EOS3, 5001iX-411 or 15003iX-411 test systems and wish to upgrade to support IEC 61000-4-11, Edition 2.0 should contact customer service (support@calinst.com).

A complete upgrade requires the following items:

Update iX/i Series firmware revision to version 2.39 or higher.

Download version 1.20 of CIGui32 from the California Instruments website.

Download updated user manuals for i/iX Series from the California Instruments website.

Upgrade EOS1/EOS3 to revision 2 hardware. This hardware upgrade adds an 80% tap and requires the EOS be returned to the factory.

Summary

The 5001iX-EOS1 provides a fully compliant test system for IEC 1000-4-11 testing of products that may be used anywhere in the world. Frequency conversion from any line frequency to the mandated 50 or 60 Hz is provided through the AC power source. The 15003iX-EOS3 supports three phase applications with more than 16 Amps at 230 Volt per phase. New versions of the EOS units now support both 70% and 80% dip levels in addition to the 0 and 40% levels to conform to Edition 2.0 of the IEC 61000-4-11 test standard.

The same EOS1 (single phase) or EOS3 (three phase) option can be ordered with the 5001iX-CTS or 15003iX-CTS compliance test systems available from California Instruments.

These turn-key test systems provide full compliance testing for IEC 61000-3-2 (Harmonics), IEC 61000-3-3 (Flicker) and IEC 61000-4-11 (Voltage Dips and Interruptions) as well as other IEC 61000-4 immunity test standards.

Contact California Instruments:

TEL: 858-677-9040

FAX: 858-677-0940

Email: sales@calinst.com

Web page: http://www.calinst.com

California Instruments

9689 Towne Centre Drive, San Diego, CA 92121-1964 (858) 677-9040 FAX : (858) 677-0940