APPLICATION NOTE #116B

IEC AC Immunity Testing using the iX Series

IEC 61000-4-11
IEC 61000-4-13d
IEC 61000-4-14
IEC 61000-4-17
IEC 61000-4-28
IEC 61000-4-29p

Introduction

Demand for regulatory testing is forcing many manufacturers of AC powered equipment to increase their in-house test capabilities. As the number of standards that apply to their products increases, so does the amount of test equipment needed to meet all these requirements. Fortunately, the use of a programmable AC power source, and a special control program that supports several IEC test standards, can eliminate the need for additional equipment.

With a programmable AC source capable of simulating a large number of AC events, one unit can often be used to meet different test standards. This application note describes the use of the California instruments Graphical User Interface program to test for IEC 61000-4-11, IEC 61000-4-13, IEC 61000-4-14, IEC 6100-4-17 and IEC 61000-4-28 compliance and IEC 61000-4-29 pre-compliance. Note that IEC 61000-4-13 is presently in draft form and may change. The user's ability to revise the operation of the program to cover future changes to the test standard is described.

Windows Control Program

All IEC standards referred to in this application note require precisely timed changes in AC voltage and/or frequency. Not only is the duration of these changes and their magnitude specified, many of them have to occur at specific phase angles. This requires the use of the AC Source's transient programming capability.

The IEC 61000-4-13 harmonics and interharmonics test calls for the generation of interharmonics. This requires the use of an optional interharmonics generator, which operates asynchronously from the main timebase of the AC source. Option -413 provides this additional hardware capability.

The CIGUI32 program offers built in support for these IEC tests while removing the complexity of programming the AC source's transient system. The user only has to select the nominal voltage, frequency, test type and test levels required.

Test Results

The CIGUI32 is not always capable of determining a PASS or FAIL result. This is due to the subjective nature of the PASS or FAIL criteria set forth in these standards. Specifically, the following pass or fail conditions are defined:

"The test results shall be classified on the basis of the operating conditions and functional specifications of the equipment under test, as in the following, unless different specifications are given by product committees or product specifications.

a) Normal performance within the specification limits.

b) Temporary degradation or loss of function or performance which is self-recoverable.

c) Temporary degradation or loss of function or performance which requires operator intervention or system reset.

d) Degradation or loss of function which is not recoverable due to damage of equipment (components) or software, or loss of data.

As a general rule, the test result is positive if the equipment shows its immunity, for the duration of the application of the test, and at the end of the test the EUT fulfills the functional requirements established in the technical specification."

For all test standards covered in this application note, the iX Series measurements may be used to check the load current of the device under test so the user can determine if the device still operates at the end of the test sequence. This does not cover conditions such as EUT processor lockup or loss of data. *The user always makes the final PASS or FAIL determination for each unit under test.*

IEC 61000-4-11

The IEC 61000-4-11 test involves a series of voltage dips and variations that simulate real world conditions that may occur on AC power distribution networks. This test is to ensure a product's immunity from such voltage anomalies. Voltage dips occur at zero degree phase angles using different levels. Both levels and phase angles can be changed if needed. Typical test levels are 0 %, 40 % and 70 % of the nominal test voltage.

Voltage variations are performed at 40 % and 0 % of the nominal test voltage. These variations consists of specified voltage rise and fall times as shown in Fig. 1.

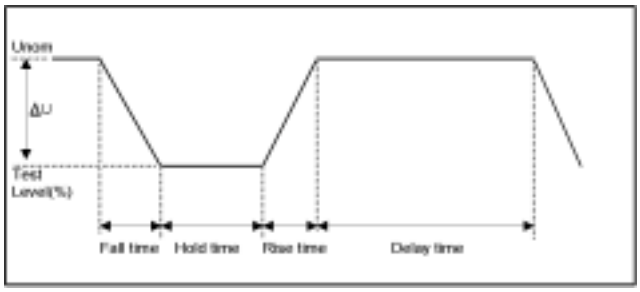


Figure 1: Voltage Variations Timing.

Each dip or variation is repeated three times with a minimum of 10 second intervals between them.

The CIGUI32 offers an IEC 61000-4-11 test window (Figure 2 and Figure 3) that allows the user to select between "Voltage Dips" and "Voltage Variations" test modes. Nominal voltage and frequency can be set prior to each test run. For products that can be operated from a range of voltage input values, the same test must be run at the lowest and highest nominal value supported.

Test progress is displayed at the bottom of the screen. Any test in progress can be aborted if needed. Test parameters cannot be changed while a test is in progress.

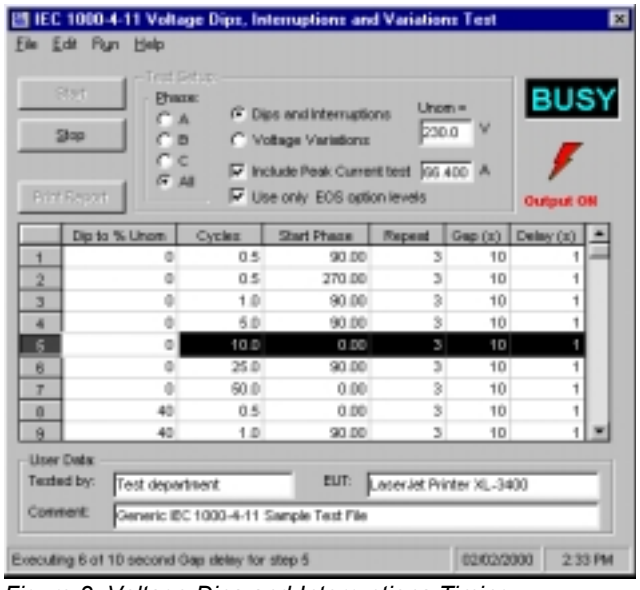


Figure 2: Voltage Dips and Interruptions Timing.

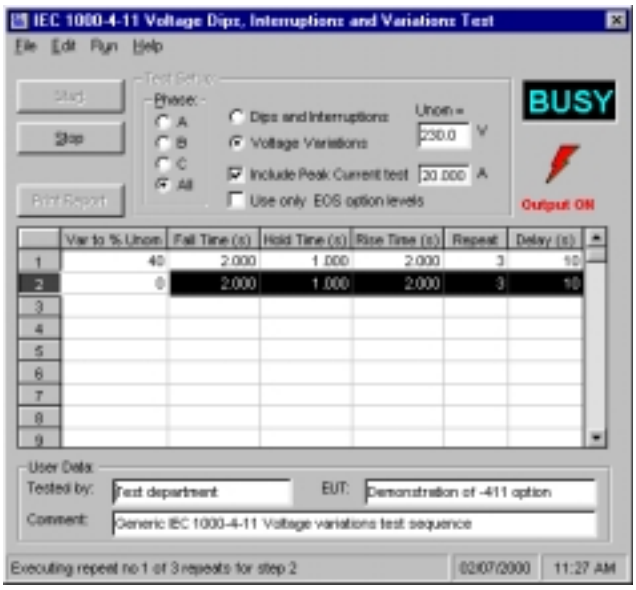


Figure 3: Voltage Variations Timing.

AC Source compliance

The IEC 61000-4-11 also covers AC source requirements for full compliance testing. Most of these requirements are easily met by the iX Series AC/DC power sources. Some, however, are not trivial and warrant more attention:

- 500 A EUT inrush current capability
- 1 to 5 msec rise and fall time at source output
- Current capability at reduced voltage levels

The inrush current requirement of 500 Amps however is not practical, as it would raise the price of the AC source considerably. Since most EUT's don't pull this kind of inrush current, sizing an AC source for this current level is impractical. Instead, the standard allows the source to measure the peak inrush current to the EUT and verify that it does not exceed the capabilities of the AC source. The GUI provides a "peak inrush current pre-test" option in the IEC 61000-4-11 test window for this purpose. If the peak inrush current of the EUT, as defined in the IEC standard, exceeds the AC source capability, a warning is issued to the operator.

To fully meet the AC source qualification for IEC 61000-4-11 testing, option -EOS can be added to the iX Series AC/DC power source to ensure output rise and fall times between 1 and 5 micro seconds. This option also ensures the source's ability to deliver higher rms currents at reduced voltage levels for constant power products. Specifically, 5001iX with -EOS option meets the 23 A at 70% and 40 A at 40 % of Unom requirement called out in the IEC 61000-4-11 standard.

IEC 61000-4-13

The IEC 61000-4-13 test is aimed at evaluating the immunity of AC powered products when subjected to harmonics, interharmonics and main signaling frequencies. Specifically, this test looks for the occurrence of resonance points. Resonances occur typically at higher frequencies and could potentially lead to overheating of the EUT.

The test therefore not only stipulates the generation of harmonics and interharmonics at various levels with respect to the fundamental, it also requires analysis of the current versus frequency response of the EUT as the superimposed harmonics and interharmonics are swept through the frequency spectrum. The iX Series AC/DC power systems have a built in power analyzer which is used for this purpose.

Harmonics are generated with the arbitrary waveform generation capability of the standard iX Series source controller. To generate interharmonics which are truly independent of the programmed fundamental frequency, a second signal generator (Option -413) is added to the iX Series.

The IEC 61000-4-13 standard calls out three EUT product classes, each requiring different test levels. Test levels for class 2 and 3 are defined while test levels for class X can be set by the various product committees. Class X test levels used by the iX Series controller can be programmed by the operator. Class 2 and 3 test levels are fixed.

Test Steps

The -413 offers four test steps that can be run individually or in sequence:

- Flat top curve
- Overswing curve
- Frequency Sweep
- Individual Harmonics & Interharmonics

Flat top and Overswing curves consist of fixed combinations of harmonics superimposed on the output of the AC source. The EUT is exposed to this stimulus for a specified period of time.

The frequency sweep test generates harmonics and interharmonics at discrete time intervals. The superimposed frequency is swept from 16 Hz to 2000 Hz for 50 Hz nominal EUT's and from 20 Hz to 2400 Hz for 60 nominal EUT's. During this sweep period, the current is measured and recorded in order to detect the presence of resonance points in the EUT. Resonance points are defined by the standard as a reduction of - 3 dB from a maximum in the range of f_{res} to 1.5 x f_{res}.

Figure 4: IEC 61000-4-13 Test Window

This data is also provided at the end of the test and can be displayed on both the front panel or the PC.

At the end of each test method, the operator is prompted to determine if the EUT continues to function as expected. This operator feedback is tracked for reporting purposes. It is also possible to run all test methods consecutively and only prompt the operator at the end of the entire test run. This allows testing to be performed without operator intervention, a significant advantage as the total test time exceeds one half hour.

Interharmonic generator control

The interharmonic generator may also be used for non-IEC testing, if required. A separate screen allows the interharmonic generator frequency and amplitude to be programmed. The same can be accomplished over the bus. This allows more generic immunity testing which falls outside of the scope of IEC 61000-4-13 to be performed with the same instrument.

Optional IEC 725 Impedance network

Product committees may determine that an impedance network should be used at the output of the AC source to more realistically simulate real world conditions. The objective is to find possible resonances between the line and the EUT that could be excited by harmonics. In this case, the iX Series AC/DC source's programmable output impedance is used to insert the desired network impedance. An option check box is provided in the GUI 413 test window for this purpose.

The impedance value used is the same one used for IEC 61000-3-3 Flicker testing, as specified by IEC 725. The impedance values for 50 Hz and 60 Hz are shown in the table below.

Line Freq.	Line voltage	Phase	Neutral
50 Hz	240 / 400 V	0.24 + j 0.15	0.16 + j0.10
60 Hz	120 / 208 V	0.10 + j 0.04	0,10 + j 0.03
	347 / 600 V	0.29 + j 0.07	0.30 + j 0.04

It is possible however that certain product categories may require different impedance values. Specifically, product committees are free to realize additional tests with other impedance values considered to be of significant interest with regard to interactions with the EUT. Since the impedance network on the iX Series is programmable, the need for multiple lumped impedances is avoided. This represents a considerable cost savings compared to AC power systems that lack this capability.

Changing Test Levels

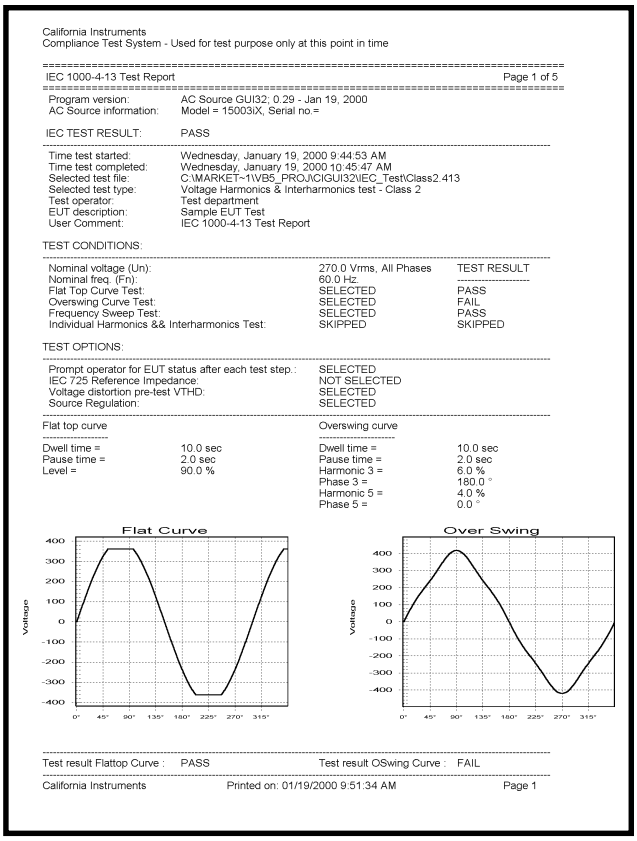
The IEC 61000-4-13 test covers two product classes for which the interharmonic levels are described and one product class X for which interhamonic levels can be set by the various product committees, as long as the levels are equal to or higher than those of class 3. The -413 option for the iX Series AC/DC power system allows class X levels to be programmed to meet these requirements. Class 2 and 3 levels are pre-defined and cannot be changed by the operator.

AC Source qualification

As with most IEC 61000-4 tests, the AC source used must meet certain performance requirements. Most of these requirements are easily within the specification of the iX Series. The output voltage distortion however is a function of the EUT and therefore must be verified prior to the test with the EUT connected. The built in power analyzer of the iX Series is used to accomplish this task. The operator can enable the V_{thd} pre-test in the GUI 4-13 test window. Voltage distortion test results are included in the 4-13 test report.

Test Report

At the end of the test, the operator can print a complete IEC 61000-4-13 test report. This report contains all test setup and measurement data.



California Instruments
Compliance Test System - Used for test purpose only at this point in time

IEC 1000-4-13 Test Report — Page 1 of 5

Program version:	AC Source GUI32; 0.29 - Jan 19, 2000
AC Source information:	Model = 15003iX, Serial no.=
IEC TEST RESULT:	PASS
Time test started:	Wednesday, January 19, 2000 9:44:53 AM
Time test completed:	Wednesday, January 19, 2000 10:45:47 AM
Selected test file:	C:\MARKET~1\WB5_PROJ\CIGUI32\IEC_Test\Class2.413
Selected test type:	Voltage Harmonics & Interharmonics test - Class 2
Test operator:	Test department
EUT description:	Sample EUT Test
User Comment:	IEC 1000-4-13 Test Report

TEST CONDITIONS:

Nominal voltage (Un):	270.0 Vrms, All Phases	TEST RESULT
Nominal freq. (Fn):	60.0 Hz	----------
Flat Top Curve Test:	SELECTED	PASS
Overswing Curve Test:	SELECTED	FAIL
Frequency Sweep Test:	SELECTED	PASS
Individual Harmonics && Interharmonics Test:	SKIPPED	SKIPPED

TEST OPTIONS:

Prompt operator for EUT status after each test step.:	SELECTED
IEC 725 Reference Impedance:	NOT SELECTED
Voltage distortion pre-test VTHD:	SELECTED
Source Regulation:	SELECTED

Flat top curve		Overswing curve	
Dwell time =	10.0 sec	Dwell time =	10.0 sec
Pause time =	2.0 sec	Pause time =	2.0 sec
Level =	90.0 %	Harmonic 3 =	6.0 %
		Phase 3 =	180.0 °
		Harmonic 5 =	4.0 %
		Phase 5 =	0.0 °

Test result Flattop Curve : PASS Test result OSwing Curve : FAIL

California Instruments Printed on: 01/19/2000 9:51:34 AM Page 1

IEC 61000-4-14

The IEC 61000-4-14 test involves a series of voltage fluctuations not unlike those in the voltage variations portion of IEC 61000-4-11. The voltage fluctuations can be made using one of two methods, both of which are supported by the iX AC Source. The first method steps the voltage up or down in 5 one period long interval steps. This is illustrated in Figure 5. Voltage changes occur at random phase angles. The second method ramps the voltage over a 0.25 cycle period starting at 90 degrees. Regardless of the method choosen, a total of 12 different sequences, three repeats each, are run using the nominal voltage value with and without an offset. Both incremental and decremental voltage changes occur.

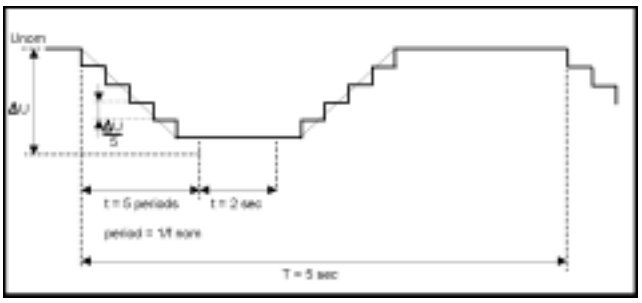


Figure 5: IEC 61000-4-14 Voltage Change Step Method.

The IEC 1000-4-14 standard was officially published in 1999. Since different product categories may require different test levels and durations, the CIGUI offers the ability to change test durations and levels easily on screen.

The CIGUI32 offers an IEC 1000-4-14 test window (Figure 6) that allows the user to select the test level appropriate for the device under test. Test levels are based on the nature of the AC network for which the unit under test is intended. Test level 1 applies to class 2 networks, test level 2 applies to class 3 networks. Class 2 and 3 are specified in IEC 1000-2-4, Classification of electromagnetic environments. The correct test level must be selected by the user prior to running the test.

Nominal line voltage and line frequency can be set prior to each test run. For products that can be operated from a range of voltage input values, the same test must be run at the lowest and highest nominal value supported.

All test parameters such as nominal voltage levels, EUT class and test periods can be specified in a test setup file for each type of EUT. This allows a complete test setup to be recalled from disk for any specific class of EUT. Information concerning the test applied to the EUT is also incorporated in the test report generated at the end of the test run.

Test progress is displayed at the bottom of the screen. Any test in progress can be aborted if needed. Test parameters cannot be changed while a test is in progress.

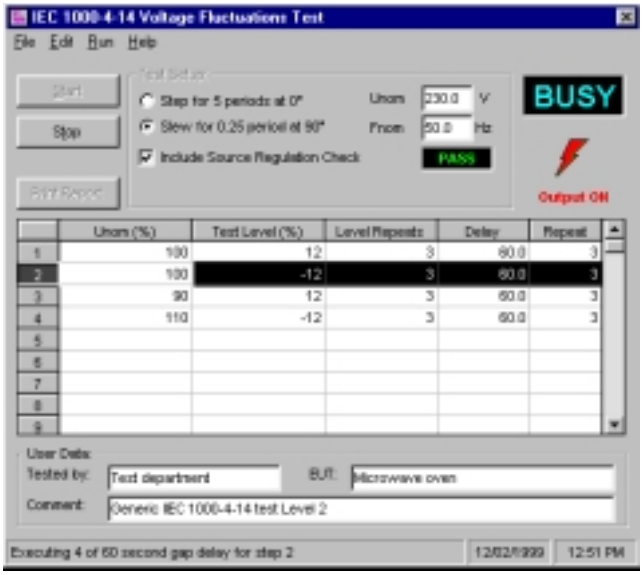


Figure 6: IEC 61000-4-14 Voltage Fluctuations Test Window.

At the end of the test, a test report can be printed which contains information about the test result and test sequence applied to the EUT.

IEC 61000-4-17

The IEC 61000-4-17 standard covers testing of DC powered products for ripple immunity. Ripple can be caused by a variety of sources, one of which is the AC line frequency passing through the DC supply to some extent.

The iX Series has full support for DC output up to 300 V DC and may be used to test a wide variety of DC products for IEC 61000-4-17 ripple immunity.

Figure 7: IEC 61000-4-17 DC Ripple Test Window.

The CIGUI offers the ability to change test durations and levels to accommodate different ripple immunity test levels and AC line voltage settings. In addition to the levels called out in the IEC test standard, the user can specify custom test levels if needed.

The CIGUI32 offers an IEC 61000-4-17 test window (Figure 7) that allows the user to select the Test level, nominal DC voltage, low or high DC voltage range of the EUT and AC line frequency. Test times default to the standard 10 minutes but can be set from 0.1 to 9999 minutes.

All test parameters, such as nominal DC voltage level, test level and test time, can be specified in a test setup file for each type of EUT. This allows a complete test setup to be recalled from disk for any specific type of EUT. Information concerning the test applied to the EUT is also incorporated in the test report generated at the end of the test run.

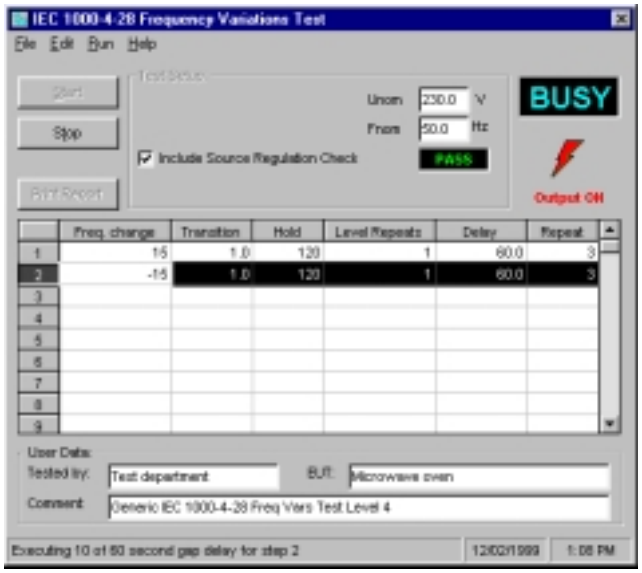


Figure 8: IEC 61000-4-28 Frequency Variations Window.

IEC 61000-4-28

The IEC 61000-4-28 is the only AC voltage related test standard that involves frequency changes. This precludes the use of variacs or multi-tap transformers to perform these tests. The frequency changes are small and reflect actual frequency variations that may occur in the public utility network. Frequency changes occur at the zero crossing of the AC waveform. (0 degree phase angle) The standard calls out different types of product categories for which different test levels apply. Levels 1 through 3 are available, as is a user defined test level, level X. Test levels are set by the relevant product committees.

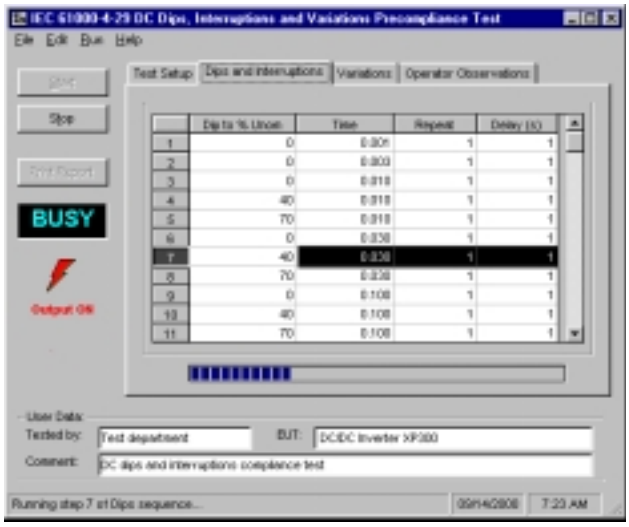
The CIGUI offers the ability to change test durations and levels to accommodate different product categories.

The CIGUI32 offers an IEC 61000-4-28 test window (Figure 8) that allows the user to select the Device Under Test class. Nominal voltage and frequency can be set prior to each test run.

All test parameters, such as nominal voltage levels, EUT class and test periods, can be specified in a test setup file for each type of EUT. This allows a complete test setup to be recalled from disk for any specific class of EUT. Information concerning the test applied to the EUT is also incorporated in the test report generated at the end of the test run.

IEC 61000-4-29p

The IEC 61000-4-29 is a DC voltage dips, interuptions and variations test. It is is similar in nature to IEC 61000-4-11. Due to DC voltage rise and fall time limitations of the test generator, this test is provided for pre-compliance testing only. The user interface and test reports are similar to that of the other IEC immunity tests. A sample test screen is shown below.



Conclusions

All IEC 61000-4 tests described in this application note can be performed using the iX Series AC/DC power system. In addition, the Compliance Test System (CTS) also provides the ability to perform IEC 61000-3-2 (Harmonics) and IEC 61000-3-3 (Flicker) testing. This allows both emissions and immunity testing using a single AC power system.

The California Instruments CTS system represents a comprehensive yet easy to use AC power compliance test system.

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