FLUKE®

Calibration

Power and energy calibration: key test and measurement issues

Application note

Traditionally, power and energy calibration has been accomplished by placing a reference meter and a device under test (DUT) in series or parallel, downstream of a common power supply. In a world of linear loads and sinusoidal waves, this methodology worked well. As modern electronic loads have introduced harmonic distortion into power grids, meters calibrated with pure sinusoids are no longer capable of accurately measuring power or energy. Today there is a better way to run this calibration. Using a new class of instrument, an electrical power standard, a signal may be directly sourced to the DUT.

These test signals are:
- Accurate
- Traceable
- Sinusoidal and distorted in specified simultaneous combinations
- Compliant with modern IEC 61050 standards

This application note will:
- Introduce you to the new 6105A Electrical Power Standard
- Introduce you to applications for this new instrument
- Show how the 6105A can be used to satisfy IEC 61050 and 62053 standards.

What is the 6105A?

The 6105A is a single-box solution for generating reference-standard signals to test energy meters, power-quality analyzers, and similar equipment with sufficient accuracy to guarantee the repeatable results that international standards demand. It consists of independent voltage and current channels that can source more than 1 kV and 20 A with typical accuracies as good as 0.005 % or 50 ppm. It can work alone for single-phase applications, or form the heart of a modular system that provides outputs to drive two, three, and four phases—that is, three-phases plus neutral—as well as offering a current amplifier option that sources as much as 80 A.

It's important to understand that the 6105A isn't an ac power source—there are plenty of those already—but a reference-quality instrument that uniquely combines highly flexible voltage and current sources. The 6105A makes it easy to add phenomena such as flicker and harmonic distortion to either or both of its output channels, providing sufficient flexibility to meet any international power-quality standards today or for the foreseeable future—including the ability to freely combine phenomena such as harmonics and interharmonics.

Used alone or as the heart of a multi-phase system, the 6105A rivals phase standards with millidegree accuracy for its variable voltage-to-current phase relationships. This ability is essential for reference-quality active and reactive power measurements. Crucially, the 6105A dispenses with the need for the difficult-to-verify homebrew arrays of signal sources and power amplifiers that engineers have previously had to build in order to calibrate electrical energy and power-quality instrumentation.

Who needs a 6105A?

The 6105A's main application lies with calibrating and verifying instruments that directly measure electrical energy and electrical power quality. These instruments range from domestic and industrial energy meters to power-quality analyzers, as well as more specialized instruments that measure parameters such as flicker. Because international standards increasingly demand that electrical and electronic equipment generates minimal amounts of powerline interference, any R&D lab that's involved in power work—from domestic appliances to lighting equipment to motor controls and much more besides—invariably owns a power Analyzer, and similar equipment appears throughout the manufacturer's production and QA chain to ensure that products meet their design parameters. Large concerns that maintain their own EMC test labs are potential 6105A customers, as are any manufacturers of energy meters, power-quality analyzers, UPSs and components for use in this type of equipment—notably ICs and current transducers.

The legal requirement for manufacturers to gain CE approval for electrical and electronic equipment that's sold in the European Union has led to a whole new industry of third-party specialist test houses within this region. Here, national governments have appointed an array of so-called notified bodies—that is, test houses that are qualified to assess various types of equipment—to facilitate the CE marking process. Any test house that offers EMC test services is a potential 6105A user. Lists of European test houses appear on the web at sites such as www.ce-marking.org.

International standards also demand that utility companies make power quality measurements to ensure that they deliver good product. This aspect applies regardless of region—each of which has its own statutory demands—making electricity generators and distributors potential 6105 customers. For their part, many industrial users measure their supplies to ensure that what they receive is good—but often far more importantly, to verify that site plant isn't generating unacceptable levels of powerline interference. The tool that plant engineers invariably use is again the power quality Analyzer that portable instruments such as Fluke's 430 series typify. Like other users, it's essential that any instruments that may be used to audit power quality are routinely and traceably calibrated, stimulating demand for a reference instrument with the 6105A's capabilities.

Why must we calibrate equipment?

Like any other precision instrument, energy meters, flickermeters, and power-quality analyzers need regular calibration to ensure reliable measurement results. While international standards specify the absolute accuracy requirements for various measurements, it's almost invariably a legal requirement that users maintain any equipment used to demonstrate standards compliance in

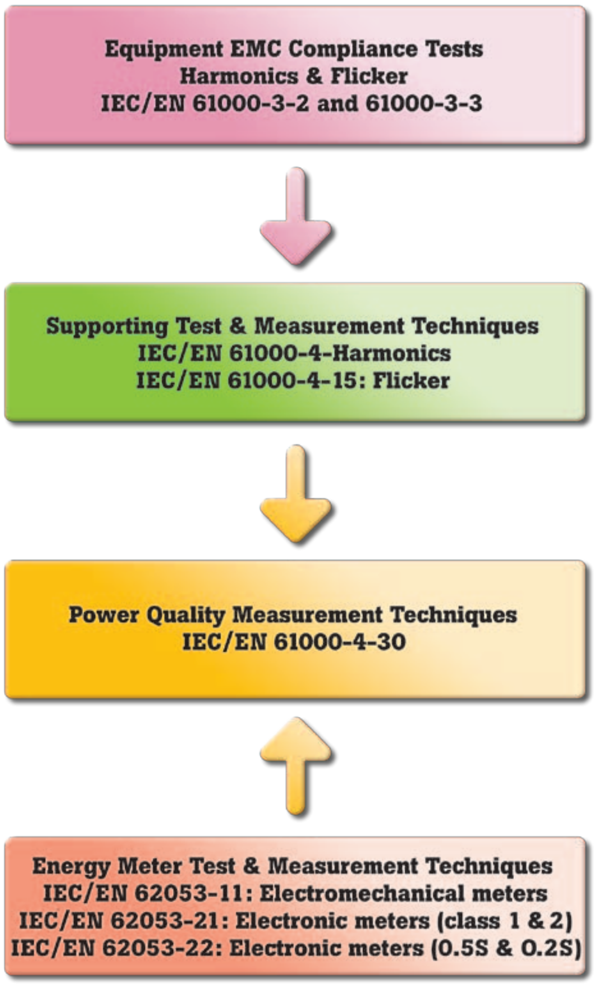


Figure 1 shows a simplifi ed overview of the relationships between the necessity for standards compliance and the need for reference-quality measurement abilities.

a state that meets the respective standards' accuracy parameters. Together with the independent product assessment that CE and similar marking brings, this obligation drives the demand for commercial laboratories that are capable of calibrating power analyzers and similar equipment. These labs need the accuracy and ease-of-use that the 6105A provides.

At the top of the measurement hierarchy, the national standards laboratories that maintain power measurements are prime candidates for the 6105A. In this context, the instrument is perfect for generating the highly accurate and stable waveforms with the phase coherence that power reference work requires. The instrument is also invaluable at a much lower level as a waveform generator for design evaluation work—particularly in the rapidly growing world of electricity meter design, where everyday domestic meters now approach the accuracy and measurement ability of traditional power-quality analyzers.

You keep mentioning standards—which ones do the 6105A help users satisfy?

As anyone who has looked will know, international standards can be difficult to understand. The European Community currently leads the pack with its comprehensive type approvals that electrical and electronic equipment must satisfy to acquire the CE mark that's necessary for sale or use within the region. Keep in mind that similar—and in many instances, exactly the same—requirements exist around the world. Unsurprisingly, precisely which standards apply to what equipment depends on the type of equipment and its application. These are the commonest specifications that concern the 6105A, along with their respective areas of influence:

- IEC 61050-3-2: harmonic emission limits for equipment that draws ≤ 16 A per phase
- IEC 61050-3-3: flicker control for the same equipment

Equipment manufacturers have to satisfy both of these standards, which in turn drives the need for suitable measurement instrumentation and the reference instruments that are necessary to maintain them. The major measurement methods appear within these standards:

- IEC 61050-4-7: guide to harmonics and interharmonics measurements and instrumentation
- IEC 61050-4-15: functional and design specifications for a flickermeter
- IEC 61050-4-30: power-quality measurement techniques

A separate group relates to energy meters, with these applying to the commonest uses:

- IEC 62053-11: requirements for electromechanical active-energy meters
- IEC 62053-21: requirements for electronic active-energy meters, classes 1 & 2
- IEC 62053-22: requirements for electronic active-energy meters, 0.2S & 0.5S

Give me some example specifications

One of the several areas where the 6105A truly excels is in its ability to simultaneously mix-and-match harmonic and interharmonic waveforms onto either the voltage or the current signals, or both. The ability on the voltage side is essential to meet the requirements in IEC 61050-4-30, which specifies an absolute voltage uncertainty of ≤ 0.1 % for Class-A instruments such as the power analyzers that are used for standards compliance work. The specification insists that the instrument-under-test maintains this accuracy in the presence of harmonics, interharmonics, and flicker—which means that any calibration source must be capable of producing composite waveforms with substantially better than ≤ 0.1 % uncertainty to guarantee sufficient margin between itself and the instrument-under-test.

The 6105A satisfies these requirements with typical accuracies within the 0.01 % to 0.02 % region, which it maintains across a wide range of waveforms—alone or in combinations of harmonics and interharmonics—going out to the 100th harmonic frequency.

OK, show me a typical application

Because today's energy meters and power analyzers are functionally indistinguishable, we'll examine just a power analyzer example. Also keep in mind that the 6105A is equally suitable for testing flicker meters—devices that measure the short-term supply-line voltage variations that cause lamps to pulse between dim and bright—where international standards similarly apply. In each case, the general arrangement connects the 6105A's voltage outputs to the instrument-under-test's voltage inputs, preferably in a four-wire sense configuration that minimizes connection errors. We also connect the 6105A's current outputs to the test instrument's input channel, often by looping a suitable conductor from the 6105A's current high terminal, through the test instrument's current transformer, and back to the 6105A's current low terminal. Figure 2 and 3 show a typical setup.

FLUKE ®
Calibration

Figure 2 Setup for calibration of one channel of a Fluke 434 with a Fluke Calibration 6105A.

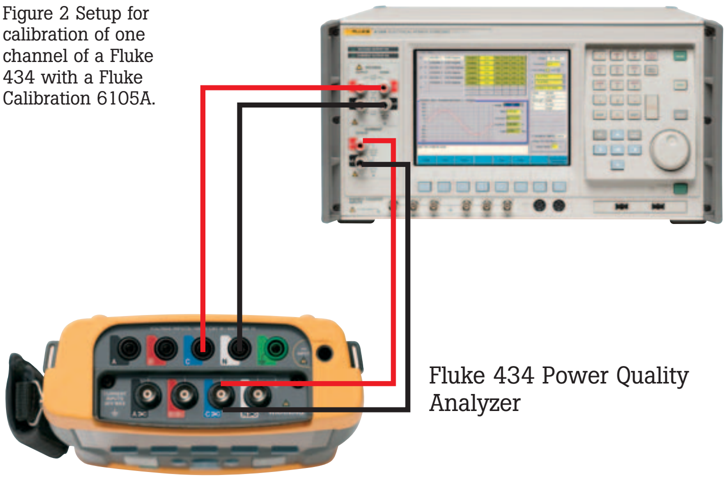
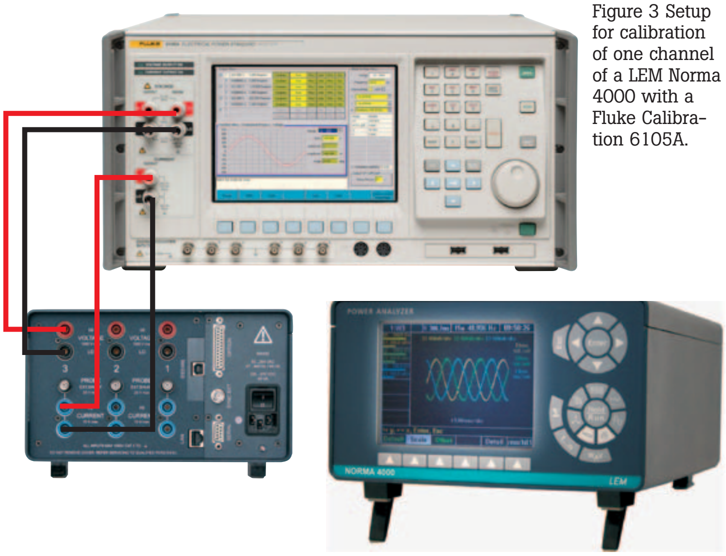


Figure 3 Setup for calibration of one channel of a LEM Norma 4000 with a Fluke Calibration 6105A.



What happens outside Europe?

With similar product compliance specifications now in place in every region, industrialized nations throughout the world have similar product test requirements to those within the European Community, both for domestic sales and for external trade. For instance, countries as diverse as Australia and Saudi Arabia almost exactly follow the EC's approach, and the IEC specifications are well accepted in the Far East too. In some places, the urge to be "green" in every respect is a major market driver. Like many Japanese companies, Sony prides itself on offering consumers the most harmonious electronics that technology can build. These considerations extend to energy consumption and powerline quality effects.

What about the US?

While American manufacturers are all too familiar with the IEC specifications due to the international nature of the industry, the US has not as yet embraced these same standards for domestic use. Internally, it mostly uses *IEEE Standard 1159-1995, IEEE Recommended Practice for Monitoring Electric Power Quality* to tackle line-borne interference artefacts including harmonic distortion, flicker, sags and swells, transients, and interruptions. Notably, this specification requires voltage and current measurements out to the 100^{th} harmonic—which the 6105A can accommodate—whereas the IEC standards only require measurements to the 40^{th} instance.

What ISN'T the 6105A good for?

As we said at the start, the 6105A isn't an ac power source. It can source up to 50 VA from its voltage terminals, and this ability is essential for testing energy meters that derive their internal supplies from the ac line supply. Such meters have statutory maximum energy demands around 2 VA so the accuracy degradation is insignificant, especially in the 6105A's four-wire sense mode.

However, the instrument can't supply the high currents from its voltage terminals that the 61050-4-x immunity tests require. These standards exist to establish the equipment-under-test's resistance to phenomena such as static voltage variations, dips and swells, transients, and short interruptions. That is, they require power generation equipment, not the measurement equipment that the 6105A is designed to calibrate. Such voltage sources are available from a raft of third-party manufacturers, including Agilent, California Instruments, EMC Partner, EMV, Haefely EMC, Schaffner, and many more besides.

Crucially, no-one else offers anything like the 6105A's functionality—it's a unique and invaluable addition to the power engineer's toolset.

Fluke Calibration
PO Box 9090, Everett, WA 98206 U.S.A.

Fluke Europe B.V.
PO Box 1186, 5602 BD
Eindhoven, The Netherlands

For more information call:
In the U.S.A. (877) 355-3225 or
Fax (425) 446-5116
In Europe/M-East/Africa +31 (0) 40 2675 200 or
Fax +31 (0) 40 2675 222
In Canada (800)-36-FLUKE or
Fax (905) 890-6866
From other countries +1 (425) 446-5500 or
Fax +1 (425) 446-5116
Web access: http://www.flukecal.com

Printed in U.S.A. 12/2011 4125260B A-EN-N
Pub ID 11069-eng