Calibrate Your Power Analyzers and Flickermeters

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Regular calibration helps ensure compliance to harmonics and flicker requirements.

Effective power analysis is essential when you develop AC mains-powered products, particularly if your products need to comply with EN 61000-3-2 (based on IEC 61000-3-2) and EN 61000-3-3 (based on IEC 61000-3-3). These two EMC standards apply to equipment that draw 16 A of current or less.[1,2] EN 61000-3-2 sets limits on the distortion from harmonic currents that a product can place on its AC mains supply. EN 61000-3-3 sets limits on the "flicker" caused by voltage changes that a product can impose on its AC mains supply.

To ensure your products comply with these two standards, you must properly calibrate the equipment you use to measure harmonic distortion and flicker in a compliance test. Calibration compensates for the effects of any variables in a measurement system.

To calibrate EN 61000-3-2 power harmonics analyzers and EN 61000-3-3 flickermeters, you need to generate waveforms with known characteristics. Your calibration equipment should have a test uncertainty ratio (TUR) of at least 3:1 over the equipment it calibrates. Otherwise, the total of the uncertainties in your test equipment will take it outside the range that the standard demands; you'll render the calibration worthless.

Calibrating for EN 61000-3-2

Testing a product to EN 61000-3-2 requires equipment that measures and analyzes steady state and fluctuating harmonic currents in accordance with the Class A, B, C, and D categories that the standard defines. To perform compliance tests, you need a power analyzer that can take voltage, current, power, and frequency measurements. These measurements include rms values, average values, real and apparent power, power factors, crest factors, and the level of steady-state and fluctuating harmonics that a product places on the AC mains. The standard mandates that test equipment capture 16 cycles of an AC current waveform and measure the waveform's characteristics continuously and simultaneously with the current harmonics. In addition, the EN 61000-3-2 standard states that "the total error of the measurement equipment... shall not exceed 5% of the permissible limits or 0.2% of the rated current of the tested equipment, whichever is greater."

To calibrate a power analyzer, you need signals of known voltage, current, power, and harmonic content. At first glance, generating power in a reference load and measuring that power with a precision instrument may appear useful in calibrating a power analyzer, but this approach has flaws. First, a load that can provide a true link between theoretical and actual performance is difficult to design because of factors such as temperature drift and electrical disturbances. Second, even if you could create such a load, you still must make some calibration measurements without the load. In general, reference loads don't provide you with an *absolute* calibration method.

To perform an absolute calibration, you need purely sinusoidal reference

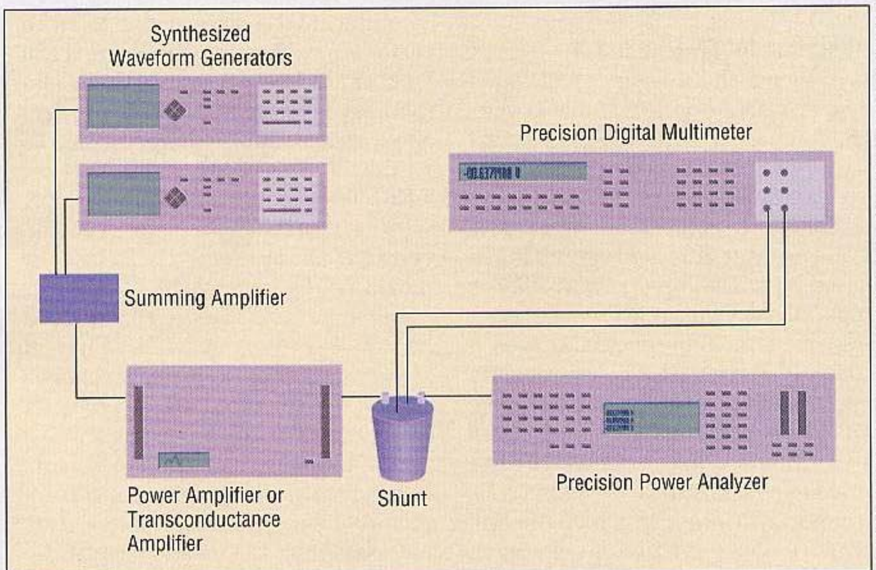

FIGURE 1 Phase-locked sine and square wave signals from two synthesized waveform generators provide a calibration source for harmonics and flicker analysis test equipment. A precision DMM provides calibration traceability.

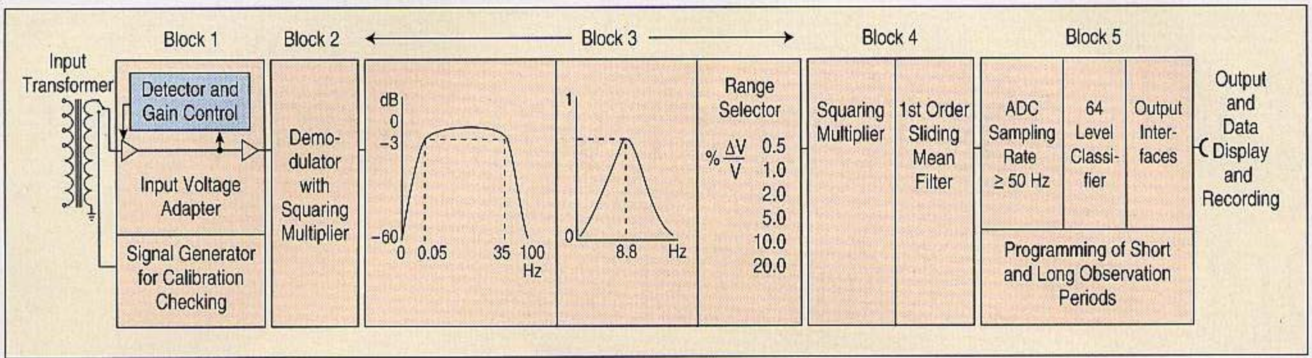

FIGURE 2 IEC 61000-4-15 defines the functional blocks of an IEC flickermeter.

inputs that are free from distortion. **Figure 1** shows a calibration setup that sums two signals, one each from a synthesized waveform generator. The signals may, for example, be 50 Hz, 1 V and 1 kHz, 1 mV. The output of the summing amplifier feeds a power amplifier or transconductance amplifier that generate "real world" voltage and current levels that you connect to the input of the power analyzer under test. Adjust the input signal to cover several voltage and current levels and verify that the power analyzer is reading within published specifications. If you wish, you can adjust the power analyzer to a tighter tolerance. The precision DMM measures the rms current passing through the shunt and provides your calibration with absolute traceability to a national laboratory such as NIST in the US (*www.nist.gov*) or NPL in the UK (*www.npl.co.uk*).

Calibrating for EN 61000-3-3

To measure the amount of flicker a product places on the AC mains voltage, you need a flickermeter. Flickermeters duplicate a person's ability to detect flickering light. Flickermeters use digital filters and statistical analysis to process line voltage changes caused by a load, producing a "flicker value." That value represents the effects of the voltage fluctuations on a human observer. Key measurements are P_{st} (short-term flicker severity evaluated in minutes) and P_{lt} (longer-term flicker severity evaluated over a period of hours by using successive P_{st} values). You must perform flicker measurements for voltage changes caused by manual switching or less frequent changes in AC mains conditions. These measurements use a range of voltage fluctuation limits (specified in EN 61000-3-3) that look at relative voltage changes. These measurements require test systems that can capture and store events regardless of the test duration.

Calibrating a flickermeter is relatively straightforward. IEC 61000-4-15[3] (formerly IEC 868, and a document referenced by EN 61000-3-3) provides precise details of how to use a flickermeter in an immunity test. **Figure 2** shows the functional blocks of an IEC flickermeter as specified in IEC 61000-4-15. The document specifies more than 140 input conditions for verifying flickermeter accuracy using sine wave and rectangular wave modulation of the AC mains voltage.

As with the harmonic calibration, the equipment used to calibrate a flickermeter includes two phase-locked signal generators, a voltage amplifier, and a precision DMM. To perform a calibration, modulate a 230 VAC sine wave with sine waves and rectangular waves at multiple frequencies and amplitudes according to Tables 1 and 2 in section 4 of EN61000-4-15. Sections 4 and 5 of EN 61000-4-15 explain that for specified voltage changes, a flickermeter should read a given value of P_{st}. For example, a flickermeter should read $P_{st} = 1$ (±5%) for specific values of voltage change $\Delta V/V$ (%) and changes per minute. If you triple the value of $\Delta V/V$, then P_{st} should become 3.

Don't underestimate the importance of carrying out both the rectangular and sine-wave modulation tests and examining the results against the published requirements. Simply using the results from a rectangular modulation test can lead to calibration errors because the sum of the positive and negative errors from the harmonics of the rectangular modulation may cancel each other out. The canceling effect can disguise measurement inaccuracies and even lead you to pass an out-of-calibration flickermeter. T&MW

FOOTNOTES

1. EN61000-3-2 (IEC 1000-3-2) (1998-04): *Electromagnetic compatibility (EMC) - Part 3-2: Limits - Limits for harmonic current emissions (equipment input current ≤16 A per phase)*, International Electrotechnical Commission, Geneva, Switzerland, *www.iec.ch*.

2. EN61000-3-3 (IEC 1000-3-3) (1994-12): *Electromagnetic compatibility (EMC) - Part 3: Limits - Section 3: Limitation of voltage fluctuations and flicker in low-voltage supply systems for equipment with rated current ≤16 A*. International Electrotechnical Commission, Geneva, Switzerland, *www.iec.ch*.

3. IEC 61000-4-15 (1997-11): *Electromagnetic compatibility (EMC) - Part 4: Testing and measurement techniques - Section 15: Flickermeter - Functional and design specifications*. International Electrotechnical Commission, Geneva, Switzerland, *www.iec.ch*.

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