

## APPLICATION NOTE 39

### A guide to compliant Flicker measurements - Are you fully compliant to IEC61000-3-3 and IEC61000-3-11?

A number of IEC61000-3-3 and IEC61000-3-11 flicker measurement systems are available on the market and many claim to provide compliant level measurements. Unfortunately, suppliers of such systems are usually unable to provide meaningful or traceable evidence of compliance that a prospective customer may reasonably request.

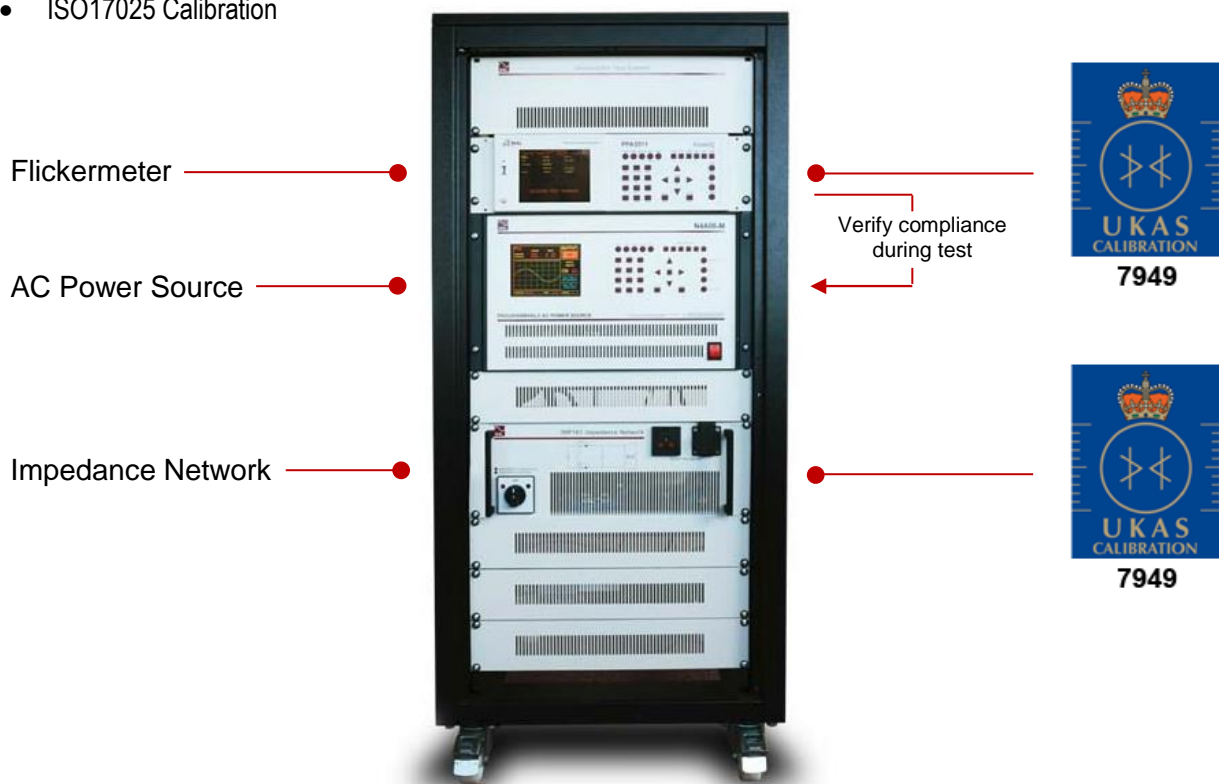
When N4L decided to add EMC solutions to our range of power measurement applications, it was natural for us to maintain the philosophy that we apply to all our measurement products, namely, to provide traceable evidence of compliance for all measured functions. This was a considerable undertaking because very few laboratories (including national labs) offer sufficient coverage of the associated standards. In particular, “d” testing in accordance with IEC61000-4-15 and verification of an impedance network in accordance with IEC61000-3-3/11 were not available from a single ISO17025 accredited laboratory.

Subsequently, N4L invested in the development of test equipment and test procedures to provide ISO17025 accredited calibration in accordance with IEC61000-4-15 (defining the requirements of Flickermeters) and IEC61000-3-3/11 (defining the test limits and requirements of a compliant AC power source and Impedance Network).

#### The Flicker test system overview

A compliant flicker measurement system involves four key components;

- Flickermeter/Analyzer
- AC Power Source
- Impedance Network
- ISO17025 Calibration



- **Flickermeter/Analyzer**

The heart of a compliant Flicker solution (and usually also Harmonics in accordance with IEC61000-3-2) is the measurement system. The system should be proven to provide traceable measurement of:

1. IFS - Instantaneous Flicker Sensation (Pinst) – proven with sinusoidal and rectangular modulation
2. Pst – Perceptibility Short Term
3.  $d_c$  - short term event
4.  $d_{max}$  - short term event
5.  $T_{max}$  - short term event
6. Frequency change
7. Distorted voltage with multiple zero crossing
8. Harmonics with sidebands – Verification of Bandwidth
9. Phase jumps
10. Rectangular changes with duty cycle

All of these 10 items are specifically defined within IEC61000-4-15 (Flickermeter – Functional & design specifications) as the necessary tests for Flicker measurement and minimum Flickermeter type test protocol.

While not traditionally part of the functionality expected of a Flickermeter, the IEC61000-3-3/11 standards also define levels of THD, crest factor, voltage regulation and frequency stability that the voltage source must maintain during a Flicker test. Clearly, these values cannot be proven by a general statement of compliance from an AC Source supplier, they can only be truly known by measurement of these values during the test of specific Equipment Under Test (EUT).

The ideal solution is for the Flickermeter measurement device to also confirm compliance with the THD, crest factor, voltage regulation and frequency stability criteria of the voltage source. This has several advantages:

- A. Both Flicker measurement and voltage source compliance measurement come from a single instrument
- B. It is considered good metrology practice for measurement of an AC source to be independent of the source itself
- C. Cost of system ownership is reduced because the AC source does not require independent calibration

### ***PPA55x1 series ISO17025 traceable compliance***

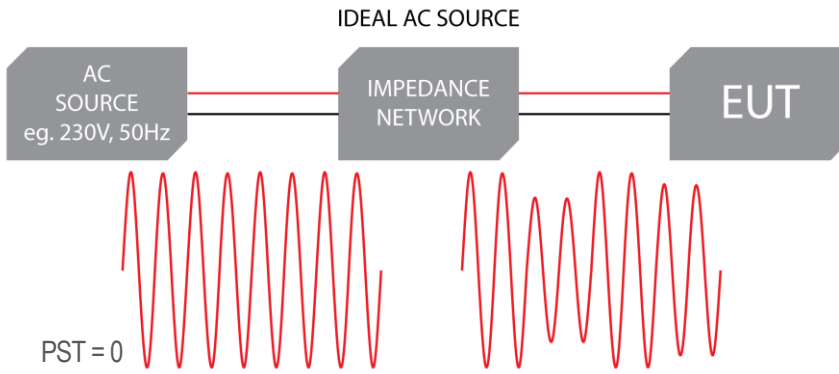
Traceable compliance with the measurement accuracy required in all 10 items above is proven via our ISO17025 accredited laboratory. The N4L laboratory is presently the only ISO17025 accredited facility with a schedule of accreditation that includes all 10 measurement functions.

- **AC Power Source**

For any compliant flicker measurement, the test system must apply a very pure and stable sinusoidal waveform from the AC source to the reference impedance, so that measured flicker values at the output of the impedance network are attributable only to the Equipment Under Test. Evidence that source purity is maintained throughout a flicker test is achieved within a fully compliant IEC61000-3-3 system by monitoring THD, crest factor, voltage regulation and frequency stability during the test period and presenting these measured values against limits defined by the standard.

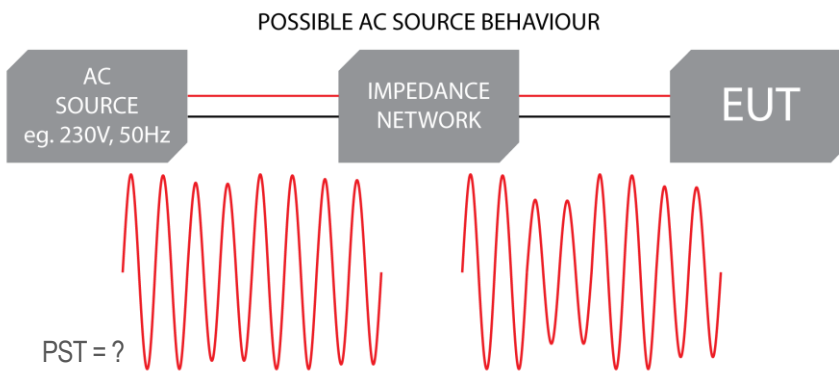
Where a flicker test result is marginal, a user may want to establish what proportion of the measured value is attributable to any imperfection of the AC source. Clearly, there is no such thing as a perfect source and this is recognised by the standard in the permitted limits of distortion but this still leaves the potential question, “what proportion of the total measured value may be associated with the AC source?” Unfortunately, the relative contribution of an AC source cannot be assumed on the basis of an AC source supplier specification, since the nature of load presented by any EUT during a test cannot be anticipated.

A solution to this question is to measure voltage purity both before and after the impedance network, therefore identifying the level of total flicker attributable to imperfection of the source. N4L provide such an option in our ‘F2’ version of the PPA5511 Harmonics and Flicker Analyzer.



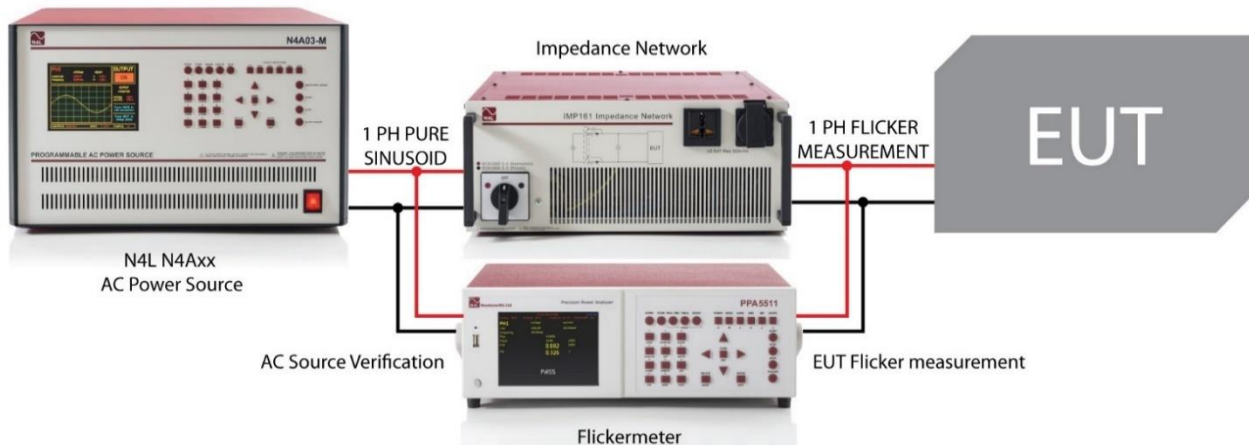
In a perfect or 'ideal' system, the AC source providing power would have no impedance or distortion and therefore flicker measurements would not be influenced by the source.

In this case, PST measurement is known to represent only the voltage change across the impedance network caused by load change of the EUT.



In a real system, the source will have some level of impedance and some level of distortion, so EUT load change will have some influence on the signal applied to the impedance network.

While the standards only require analysis of the signal quality at the output of the impedance network where flicker is measured, it can be helpful to know the level of distortion on the AC source output if EUT test results are marginal.

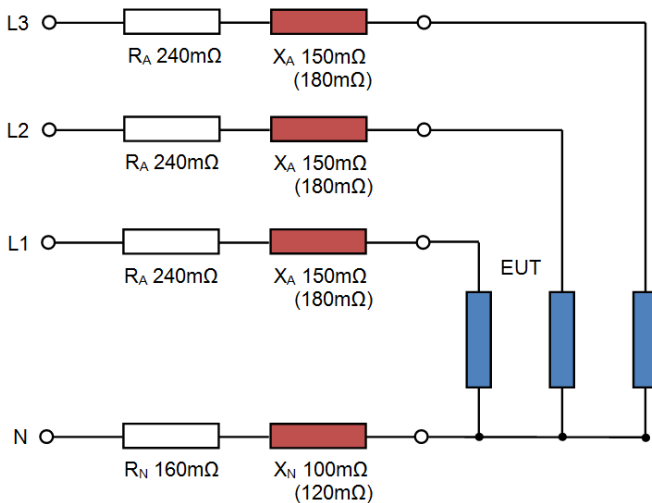


The F2 version of the PPA5511 single phase analyzer incorporates an additional voltage Flicker input so that full flicker measurements before and after the impedance network can be made. It is important to recognise that the nature of flicker computation does not permit the derivation of flicker measurements attributable only to the EUT by subtraction of measured flicker at the source. For example, if the EUT flicker was measured as PST 1.05 and the measured flicker at the source was PST 0.1, you cannot presume that flicker attributable only to the EUT is PST 0.95. However, by quantifying the input and output flicker values, a user can reasonably understand the relative performance of an EUT in a way that is not possible when knowing only the total flicker values.

• **Impedance Network**

In the context of IEC61000-3-3/11 Flicker measurement, an impedance network is designed to provide a known and repeatable simulation of a low voltage power line. Used in conjunction with an AC power source, this power line simulation permits Flickermeter measurements to be made in a controlled source environment, so that the impact of any EUT load changes on a 'typical' low voltage supply can be reliably quantified.

IEC61000-3-3/11 Impedance Network 50Hz (60Hz)



The defined circuit is not complicated and it is easy to imagine that such a circuit would be simple to reproduce. However, a fully compliant Impedance Network is not easy to manufacture or calibrate.

While the nominal values of resistance and inductance are easily verified at a low current, the challenge is to maintain these values with necessary linearity over a very wide operating current range. The range covers up to 16Arms for the IEC61000-3-3 standard and 75A for the IEC61000-3-11 standard.

N4L Impedance Networks maintain a compliant impedance at all current levels by using specially designed air core inductors that will remain linear and not saturate over their complete operating range. It should be clear to the reader that any error in the resistor or inductor values will surface as an error within the flicker measurement. It is therefore important to verify the impedance of the flicker network and N4L have developed a technique to do just that and have gained accreditation to ISO17025 (UKAS). At the time of writing, N4L are the only accredited laboratory offering ISO17025 impedance network calibration up to 40Arms.

• **ISO17025 Accredited Calibration**

The previous three sections have explained how a Flickermeter, AC Source and Impedance network combine to provide a Flicker test system.

In common with other fields of metrology, the primary issue for any user is the integrity of measured values and this becomes particularly important when measurements are related to standards compliance, where evidence of traceability will usually be required.

It should be clear from the preceding sections that IEC61000-3-3/11 testing is particularly complex in this respect and any supplier claiming to offer a compliant test system should be asked to provide appropriate evidence for each and every part of the standards.

The image here is a section from the 'schedule of accreditation' awarded to N4L that confirms our unique ability to calibrate all functions discussed in this guide at ISO17025 accredited level.

UKAS ISO/IEC 17025:2005		Schedule of Accreditation issued by United Kingdom Accreditation Service 2 Pine Trees, Chertsey Lane, Staines-upon-Thames, TW18 3HR, UK	
Accredited to ISO/IEC 17025:2005		Newtons4th Ltd Issue No: 005 Issue date: 15 May 2017	
Calibration performed at main address only			
Measured Quantity Instrument or Gauge	Range	Calibration and Measurement Capability (CMC) Expressed as an Expanded Uncertainty (k= 2)	Remarks
Flicker to IEC61000-4-15	Pinet (sinusoidal modulation) Pinet (rectangular modulation) fmod: 5 Hz to 30 Hz fmod: 30.5Hz fmod: 31 Hz to 33.33 Hz Pst d <sub>u</sub> and d <sub>nn</sub> 0 % to 5 %	0.36 % 0.30 % 1.0 % 0.30 % 0.25 % 0.015 % of steady state	With respect to a nominal steady state of 100 V to 230 V at 50 Hz.
	T <sub>max</sub>	Half cycle count	This is a counting function and therefore there is no associated uncertainty. The result may also be reported as time corresponding to the nominal frequency (1/2T).
	Frequency changes Distorted voltage with multiple zero crossings Harmonics with sidebands Phase jumps Rectangular changes with duty cycle	1.5 % 1.1 % 1.3 % 1.0 % 1.0 %	
Power measurement as measured by Calibrator	45 Hz to 2 MHz 1 W to 2 W 2 W to 5 W	0.28 % 0.21 %	
CALIBRATION OF IMPEDANCE NETWORKS	16 Hz to 880 Hz:		
Resistance	33 m $\Omega$ to 400 $\Omega$	0.48 % to 0.10 %	Phase angle 0° to ±95°
Reactance	33 m $\Omega$ to 400 $\Omega$	0.48 % to 0.10 %	Phase angle ±5° to ±90°