CALIBRATION: THE KEY TO meaningful power measurements

To meet today's demands for the most accurate and precise power measurements, the instruments need to be properly calibrated to national and international standards. **Clive Davis** & **Erik Kroon** from Yokogawa explain

As more and more innovation focuses on energy efficiency and the use of renewable energy resources, engineers are increasingly demanding accuracy and precision from their power measurements. At the same time, new standards such as IEC62301 Ed2.0 and EN50564:2011, covering standby power consumption, and the SPEC guidelines, covering power consumption in data centres, demand more precise and accurate testing to ensure compliance.

To meet these challenges, R&D teams are coming to terms with the need for new levels of precision in power measurement. These levels of precision can, however, only be achieved if the measuring instruments are properly calibrated with reference to national and international standards.

THE NEED FOR CALIBRATION

'Calibration' can be defined as the comparison of an instrument's performance with a standard of known accuracy.

No measurement is ever correct - there is always an unknown, finite, non-zero difference between a measured value and the corresponding 'true' value. In other words, a user can never be 100% sure that an instrument is operating within its specified tolerance limits. But, steps can be taken to minimise the possibility of a measurement falling outside specified tolerance or uncertainty bands.

Regular traceable calibration is a method for gaining quantifiable confidence in a measurement system by comparing the instrument's performance to a standard of known accuracy.

However, all laboratory standards and even national standards have uncertainties of measurement; hence it is difficult to be 100% confident that an instrument is operating within its stated tolerance limits.

PRECISE OPERATION

It is important to understand the difference between 'calibration' and 'adjustment'. Calibration is the comparison of a measuring instrument (an unknown) against an equal or better standard. A standard in a measurement is therefore the reference.

Instruments are adjusted initially at the factory to indicate a value that is as close as possible to the reference value. The uncertainties of the reference standard used in the adjustment process will also dictate the confidence that the indicated value is 'correct'.

As the instrument ages, the indicated value may drift due to environmental factors (such as temperature, humidity, oxidation, loading etc.) which will also be dependent on the quality of its design and manufacture. To ensure that the instrument continues to operate within the manufacturer's tolerances, it should be compared to the reference value on a regular basis (usually annually). If necessary, the instrument can then be re-adjusted.

If there is no appreciable change in the calibrated results, this means that the instrument's design is inherently highly stable. There is therefore no need to adjust it, and the user can also rely on the fact that the unit will exhibit the same stability on a day-by-day basis.

POWER MEASUREMENTS

Regular calibration by a laboratory, which can provide very low measurement uncertainties at the specific measurement points applicable to individual users, should enable instrument makers and their customers to have confidence in their test results.

However, with power measurements in particular, the situation is not so clear cut, to the extent that the accuracy figures quoted in manufacturers' specifications – and indeed some of the parameters listed in calibration certificates issued by well-established test houses – can be meaningless when taken out of context.

One key area which is often neglected in traditional specifications is that of power measurements at high frequencies. Traditionally, AC power meters are calibrated at frequencies from 50 to 440Hz. Nowadays, however, there is a demand for power measurement at high frequencies on devices such as switch-mode power supplies, electronic lighting ballasts, soft starters in motor controls and frequency converters in traction applications.

Calibration of high-frequency power has lagged behind the development of power meters to address these applications, and few national laboratories can provide traceability up to 100kHz.

There are a number of other parameters involved in power measurements that determine the performance of an instrument in a particular application. It is no longer sufficient merely to list voltage and current specifications: today's power environment needs to address variables such as phase shift, power factor and the effects of distorted waveforms.

It is also important to calibrate the instrument under the right conditions. Many test houses still use pure sine waves at 50Hz to calibrate power meters, which renders the results virtually useless for users carrying out tests under 'real world' conditions.

Yokogawa, however, has the capability to use pure sine waves up to 100kHz. It is the only industrial (i.e. non-government or national) organisation to offer traceability up to 100kHz and thus is the only power meter manufacturer which can directly prove the performance of its own instruments.

Yokogawa therefore has the ability to provide evidence that shows its instruments perform

Figure 1: Yokogawa's state-of-the-art European Standards Laboratory at Amersfoort

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within their specifications. There is, unfortunately, a perceived 'down side' to this scenario, in that Yokogawa's specifications are relatively conservative and their 'true' accuracy can be as much as ten times better than the specification. The reason for this is that the specifications are determined by the Japanese manufacturing plant, and are in turn linked to the conservative uncertainties established by the local national laboratory.

It is therefore important for users of power measuring instruments to look at the actual 'calibrated' performance of different manufacturers' products rather than just comparing specifications. This is the key thinking behind Yokogawa's policy of having its own European Standards Laboratory with minimal uncertainties and capabilities which are almost second to none. It is also reflected in the attention paid to the design of the input circuits in the company's precision power analysers, with an emphasis on wideband, high-linearity characteristics.

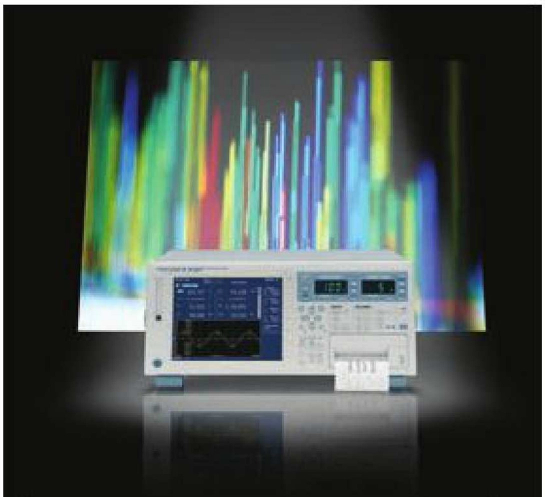

Figure 2:
The Yokogawa WT3000 power analyser

EUROPEAN STANDARDS LABORATORY

Yokogawa's state-of-the-art European Standards Laboratory at Amersfoort, The Netherlands, includes wideband and high accurate power-meter calibration systems as well as systems for calibrating oscilloscopes, recorders and optical products (Figure 1).

In addition to the high-frequency AC calibration capabilities described above, Yokogawa also offers calibration of external current transducers at currents of up to 1200A with very precise phase calibration to cater for the measurement of power as well as current. It also has the capability to carry out calibration at low power factors down to 0.001.

The laboratory has developed a high-accuracy power measurement system based on two sampling voltmeters and synchronisation devices using two-stage inductive voltage dividers and electronic current compensated transformers with an AC shunt resistor. The measurement uncertainty of this low-frequency sampling wattmeter is less than 20 parts per million (10^6) for active, reactive and apparent power for frequencies between 45 and 60 Hz.

The Yokogawa European Standards Laboratory is also traceable to international standards according to ISO9001.

HIGH ACCURACY

An indication of the high standards established by the laboratory is provided by a recent official Interlaboratory Comparison on low frequency (LF) power, in which different accredited laboratories measured an object (a power meter) and the results were compared to reference values. This showed that the Yokogawa WT3000 power analyser (Figure 2) proved to have the required accuracy, stability and ruggedness to enable it to be used as the measurement object in this interlaboratory comparison. The Yokogawa European Standards Laboratory also had the best stated uncertainties (even better than many National Standards laboratories).

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