The Certification of Power Quality Analysers

The quality of electrical power is essential for the smooth operation of equipment and networks. The disturbances are monitored with power quality analysers. METAS recently completed its first certification of a commercial power quality analyser developed in Switzerland by the firm Camille Bauer AG. This new service was built on the expertise developed over the last few years with generation, acquisition and analysis of complex signals.

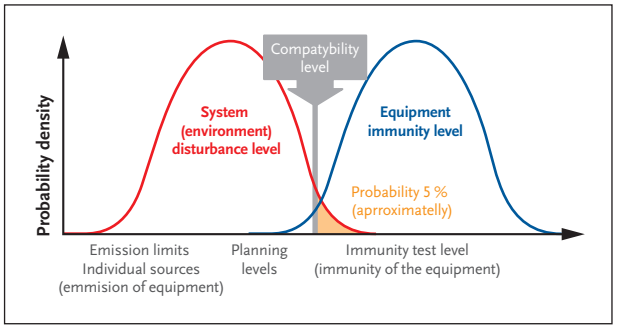
Jean-Pierre Braun and Charles Ané

The delivery of electrical power energy has been in the form of alternating current (AC) since the days of the feud between Thomas Edison and Nikola Tesla. In such systems, the voltage and the current waveforms are sinusoidal with a frequency of 50 Hz or 60 Hz. This choice of waveform is rooted in the use of induction machines for the generation of electrical power. The currents were also sinusoidal as most traditional loads such as lamps, heating devices and motors were predominantly linear loads.

What is power quality?

The apparition of power electronic devices such as thyristors and triacs in the 70's lead to the development of modern control systems such as lamp dimmers, motor drives which enabled significant gain in efficiency and flexibility. The drawback was that these loads were nonlinear and consumed non-sinusoidal currents. This resulted in a steady increase of harmonic pollution in power systems which increases system losses. In the 80's, the proliferation of computers and microprocessor-based systems rendered modern loads much more sensitive to the perturbations present in the power system. The problem of simultaneous increase of load sensitivity and emission of perturbations resulted in the term of «Power Quality». The spread of photovoltaic generation is further acerbating the problem with the generation of disturbances of much higher frequencies.

1: Power quality is an important factor for the proper operation of power networks and their loads.



2: Principle of electromagnetic compatibility: emissions of power quality disturbances must be limited while the susceptibility of the devices connected to the power system must be reduced.

Standardisation

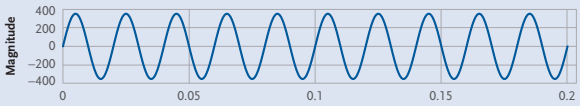
As with other electromagnetic compatibility issues, the emissions of power quality disturbances must be limited while the susceptibility of the devices connected to the power system must be reduced. Figure 2 illustrates this basic principle of electromagnetic compatibility.

The principle relies on establishing for each type of disturbances a compatibility level that is used to co-ordinate emission and immunity limits. The compatibility levels are based on economic and technical trade-offs. For standardisation purposes, power quality is considered as a low frequency disturbance in the range of direct current (DC) to 9 kHz with ongoing plans to extend this range to 150 kHz. The IEC committee SC 77A is responsible for the various standards.

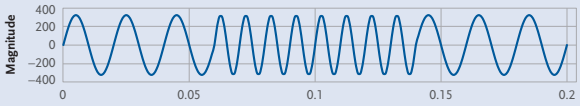
In addition to setting emission and susceptibility limits, the measurement method for the various disturbances must also be standardised. Prior the late 90's, several disturbances had no standardised measurement methods. This led to disagreements when comparing measurements made using instruments from different manufacturers. Today, a suite of standards is commonly used to measure the power quality disturbances and most power quality analysers conform to these standards.

However, the strong standardisation of the measurement methods did not lead to uniform implementations of power quality analysers. In some instances, different instruments based on the above standard did not yield comparable results. This forced the creation of additional standards which define classes of instruments as well as standardised test methods

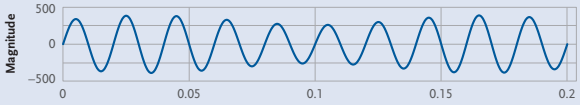
The main disturbances present in a power system are:



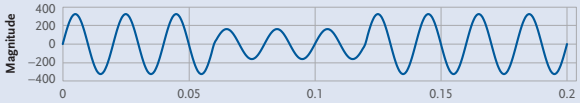
Magnitude of supply voltage
A nominal value is set for each segment of a power system. However, due to voltage drops caused by line impedances and fluctuating loads, the actual supply voltage changes continuously.



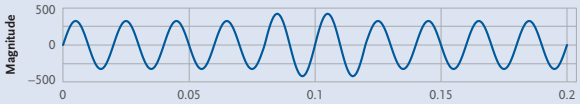
Power frequency variations
While the rated frequency of a power system is set to a nominal value, the actual frequency fluctuates around this value and reflects instantaneous mismatches between generation and consumption of energy.



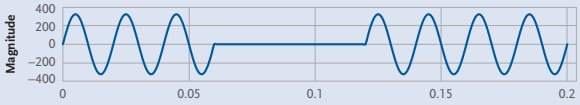
Flicker
Voltage fluctuations in a power system can modulate the brightness of a lamp. This fluctuation of lighting can cause an impression of unsteadiness of visual sensation.



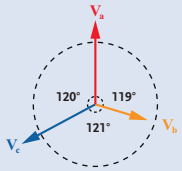
Voltage dips
Temporary reduction of the voltage magnitude below a specified threshold and lasting between half a cycle and 60 s.



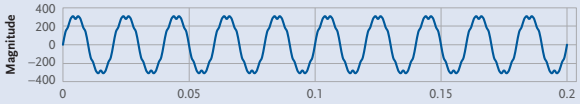
Voltage swells
Temporary increase of the voltage magnitude above a specified threshold and lasting between half a cycle and 60 s.



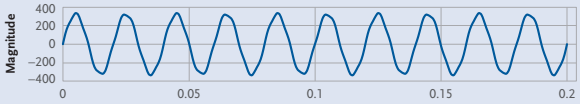
Voltage interruptions
Interruptions of the power supply lasting between half a second and three minutes. They can cause the shutdown or damage sensitive processes or systems.



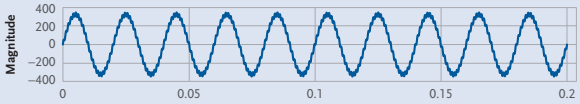
Unbalance
Occurs in three phase systems when the effective voltages of each phase and/or when the phase angles between the phases are not equal. They can cause reverse torque in electrical motors.



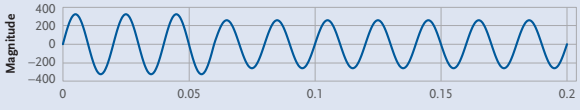
Harmonics
Components of a voltage or current whose frequency are an integer multiple of the fundamental frequency.



Interharmonics
Components of a voltage or current whose frequency are not an integer multiple of the fundamental frequency.



Mains signalling
Mains signalling is used to change the tariff in electricity meters used in a distribution network. The frequency is set between 250 Hz and 3000 Hz and is generally set between two harmonics of the fundamental frequency. Mains signalling can stimulate the resonances existing in a distribution network.



Rapid voltage changes
A rapid voltage change occurs typically when a large load is connected to a power system or during a transformer tap change. A rapid voltage change can lead to a visible change of illumination in lamps.

The most relevant standards are

IEC 61000-4-30:
Testing and measurement techniques
Power quality measurement methods
This standard defines how power quality analysers should measure the various power quality disturbances previously described. It defines two classes of instruments: A and S. The former is used when continuity of measurement is required or when two or more instruments are required to make time synchronised measurements, e.g., in case of litigation. The latter is less demanding in terms of processing and is used for surveys or power quality assessment.

IEC 61000-4-15:
Testing and measurement techniques
Flickermeter – Functional and design specifications
This standard defines how flicker is to be measured. Flicker is probably the most complex power quality measurement as it is based on a model that includes the behaviour of a 60 W incandescent lamp subjected to voltage fluctuations, the band pass response of the human eye as well as a the Rashbass model of the human visual sensitivity to light modulation.

IEC 61000-4-7:
Testing and measurement techniques
General guide on harmonics and interharmonics measurements and instrumentation, for power supply systems and equipment connected thereto
This standard specifies the measurement of harmonics in a power system. The method is based on FFT analysis, but uses a grouping method for adjacent bins to minimise the effect of magnitude fluctuation. The method is also used to minimise leakage effects in interharmonic measurements.

EN 50160:
Voltage characteristics of public distribution systems
This standard sets the acceptable limits for the power quality disturbances in the low, medium and high voltage networks. The actual values are measured with the methods described in the previous three standards. This standard is used throughout Europe and is commonly referred to in case of litigation.

for these instruments. This resulted in a need for the certification of such products. The following standards are now used for the certification of power quality analysers:

IEC 62586-1: Power quality measurement in power supply systems – Part 1: Power quality instruments
IEC 62586-2: Power quality measurement in power supply systems – Part 2: Functional tests and uncertainty requirements

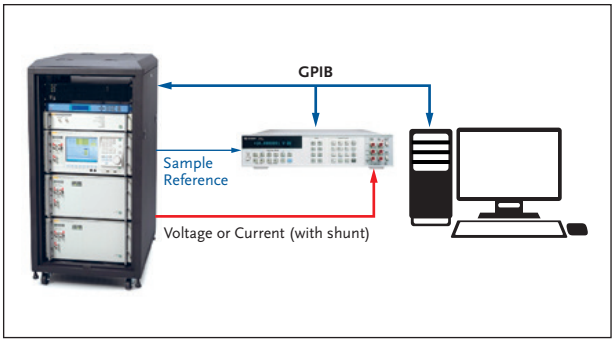
It is with these two standards that METAS conducts the certification of power analysers. Compliance to these ensures the conformity to the power quality measurement standards.

The METAS power quality infrastructure

In order to test, calibrate or certify a power quality analyser it is necessary to be able to generate single or three phase voltage and current waveforms in which the various power quality disturbances can be added. Additionally, the source must be capable to generate the various test patterns demanded by the standard IEC 62586-2. Furthermore, all generated signals must be traceable to the SI. The test system must acquire and store the large amount of data generated by power quality analysers. In effect, such instruments continuously measure disturbances in a gapless fashion over different time intervals, namely over 10 cycles, 150 cycles, 10 minutes and 2 hours. Moreover, all these measurements are made on all phases (voltage and current). As no standard presently defines the format of these data, a data readout must be tailored for each specific instrument. For the waveform generation, a three phase Fluke calibrator 6105A is used in conjunction with a Phasor Measurement Unit (PMU) calibrator developed by METAS. The former is primarily used for signals having no known relation with time while the latter is used for UTC-synchronised waveforms and for test signals that cannot be generated with the Fluke calibrator. Although not strictly required by the test standard, the synchronisation of some disturbances to UTC greatly facilitates the testing of events such as sags.

Contrary to ordinary power measurements, power quality measurements are not compared against a reference instrument, but against signals whose parameters have been characterised. The traceability of the 6105A calibrator was established within the framework of another METAS project. The calibration of the 6105A calibrator is greatly facilitated by its provision of a clock whose frequency is an integer multiple of the fundamental frequency. This permits the synchronous sampling of waveforms with a 3458A multi-meter. The samples are processed by a specific algorithm for each disturbance. Figure 5 shows the calibration set-up for the Fluke calibrator.

3: For the waveform generation, a three phase Fluke calibrator 6105A is used in conjunction with a Phasor Measurement Unit (PMU) calibrator developed by METAS.



5: Power quality measurements are not compared against a reference instrument, but against signals whose parameters have been characterised.

7: More than 150 separate tests must be passed for the certification of a power quality analyser according to the standard IEC 62586-2.

The PQ certification process

Figure 6 shows the Camille Bauer PQ3000 three phase (voltage and current) power quality analyser. The instrument is designed for both 50 Hz and 60 Hz systems. The instrument is a class A power quality analyser as specified by the standard IEC 61000-4-30. The instrument can be configured directly by a web browser while the data are exported via an Ethernet port. A special readout software was developed in order to extract and save the data in a file. The software allows the simultaneous readout of two instruments. Figure 7 shows the complete test set-up.

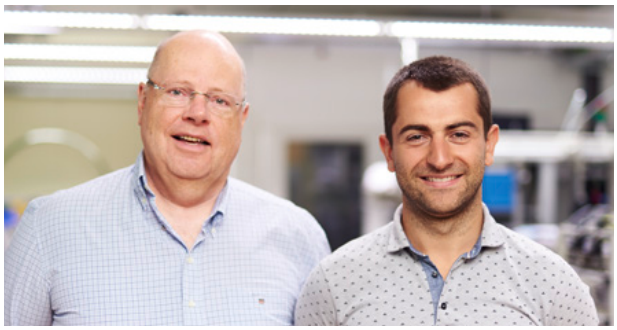
The PQ3000 was tested according to the standard IEC 62586-2 both for 230 V / 50 Hz and 120 V / 60 Hz. This represents a suite of more than 150 separate tests that must be applied to all phases. A certificate of compliance is issued once all tests have been passed successfully. The independent certification is often required by the users of power quality analysers.

With the completion of this project, METAS has become one of the few laboratories capable to fully certify power quality analysers. Future plans include the full automation of the certification process. This will be similar to the automation of the MID certification of revenue meters completed a few years ago. This is consistent with the strategy of the Laboratory Electrical Energy and Power of developing new measurement expertise and to transform them into cost-effective services.

6: Camille Bauer PQ3000: three phase (voltage and current) power quality analyser designed for both 50 Hz and 60 Hz systems.

METAS's services for power quality analysers include:

Testing **Essai** **Prova**	Determination of one or more characteristics of an object of conformity assessment, according to a procedure.
Calibration **Étalonnage** **Taratura**	Set of operations that establish, under specified conditions, the relationship between values of quantities indicated by a measuring instrument or measuring system, or values represented by a material measure or a reference material, and the corresponding values realised by standards.
Certification **Certification** **Certificazione**	Third-party attestation related to products, processes, systems or persons.



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Die Zertifizierung von Netzqualitätsmessgeräten

Die Qualität elektrischer Energie ist für den reibungslosen Betrieb von elektrischen Geräten und Netzen entscheidend. Idealerweise ist die Spannung konstant, die Netzfrequenz stabil, das Signal perfekt sinusförmig. In der Realität unterliegen Netzqualität und Versorgungszuverlässigkeit jedoch komplexen Schwankungen. Störungen des Netzes (von Photovoltaikanlagen bis zu Dimmern) führen auf verschiedenen Ebenen zu Problemen, wie Oberschwingungen, Flicker und Spannungsschwankungen.

Die Störungen der Netzqualität werden mit so genannten Netzqualitätsmessgeräten gemessen. Diese Geräte müssen wiederum geprüft, kalibriert und zertifiziert werden, damit sie ihre Aufgaben zuverlässig erfüllen können. Als eines der ersten Labore zertifiziert das METAS Netzqualitätsmessgeräte rückführbar. Dabei muss ein Gerät mehr als 150 Tests bestehen, bevor das Zertifikat ausgestellt werden kann. Kürzlich konnte erstmals ein Gerät von Camille Bauer zertifiziert werden. Aufgrund der Nachfrage umfassen zukünftige Pläne den Ausbau dieser Dienstleistung und die vollständige Automatisierung des Zertifizierungsprozesses.

Certification des instruments de mesure de la qualité du réseau

La qualité du réseau est décisive pour une bonne exploitation des appareils et réseaux électriques. Dans l'idéal, la tension est constante, la fréquence du réseau stable, le signal parfaitement sinusoïdal. En réalité, la qualité du réseau et la fiabilité de l'approvisionnement sont soumises à des variations complexes. Les perturbations du réseau (des installations photovoltaïques aux variateurs) causent des dérangements à plusieurs niveaux, par exemple des harmoniques, des scintillements (flickers) et des variations de tension.

Les perturbations du réseau sont mesurées avec des instruments de mesure de la qualité du réseau, qui doivent être à leur tour vérifiés, étalonnés et certifiés pour que le travail soit effectué de manière précise. METAS est l'un des premiers instituts à même de certifier les instruments de mesure de la qualité du réseau de manière traçable. Il faut qu'un instrument de mesure réussisse plus de 150 tests pour que le certificat puisse être délivré. Récemment, un instrument de mesure de l'entreprise Camille Bauer a pu être certifié pour la première fois. Au vu de la demande, des projets futurs concerneront le développement de la prestation de certification et l'automatisation complète de la procédure de certification.

Certificazione di strumenti di misurazione della qualità della rete

La qualità dell'energia elettrica è fondamentale per il perfetto funzionamento delle apparecchiature e reti elettriche. Idealmente la tensione è costante, la frequenza di rete stabile ed il segnale perfettamente sinusoidale. In realtà, tuttavia, la qualità della rete e l'affidabilità dell'alimentazione sono soggette a fluttuazioni complesse. Le ripercussioni sulla rete (dagli impianti fotovoltaici fino ai dimmer) causano disturbi quali le distorsioni armoniche, i flicker (sfarfallamenti) e le fluttuazioni di tensione su diversi livelli.

I disturbi della qualità della rete viene misurata mediante i cosiddetti strumenti di misurazione della qualità della rete. Per poter assumere i loro compiti in modo affidabile, questi apparecchi devono a loro volta essere controllati, tarato e certificati. Il METAS è uno dei primi laboratori in grado di certificare gli strumenti di misurazione della qualità della rete in maniera riconducibile. Prima che il certificato possa essere rilasciato, un apparecchio deve superare più di 150 test. Recentemente, un apparecchio di Camille Bauer ha potuto essere certificato per la prima volta. A causa della domanda i progetti per il futuro prevedono il potenziamento di questo servizio e la completa automatizzazione del processo di certificazione.