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Welcome

Welcome to the third and final edition of the TracePQM Newsletter. The project formally concluded on 31 May 2019, with the final meeting and an open workshop taking place on 27-28 May, hosted by the Czech Metrology Institute. In this newsletter you can read about the main outcomes of the research, an account of the final workshop, and find a list of the peer reviewed publications relating to the work.

Project Summary

The project "Traceability Routes for electrical power quality measurements", TracePQM for short, was concerned with the use of digital sampling techniques to measure waveforms in order to determine accurate, traceable values of electrical power and power quality parameters. While measuring systems of this type were already in existence in large national metrology institutes, they were, in the main, "bespoke" designs that could only be adapted by other users with difficulty. The TracePQM project set out to design, construct and validate a modular measuring system using readily available components that could be easily adopted by laboratories with a modest level of resources and experience in the field.

The most challenging aspect of the design was the software tool needed to acquire the sampled data and process it so as to deliver values for the required PQ parameters and their associated uncertainties. In fact, two versions of this software tool were successfully developed and tested and are freely available to the end user community to download and use. Moreover, the tools may be easily modified to expand their functionality by adding new data acquisition modules or calculation algorithms. It was quickly found that the software tools had many applications outside of electrical power measurements such as, for example, in impedance measurements.

Another important aspect of the research was the extension of traceability for power and power quality measurements up to a frequency of 1 MHz. As well as developing the software tool needed to acquire the data from high speed digitizers, it was necessary to characterize the hardware (voltage dividers, current shunts and digitizers) over the entire frequency range so that their contribution to the final measurement uncertainty could be reliably assessed. This involved the development and validation of calibration methods, some of which were described in peer reviewed publications.

As a useful resource for those who need to develop a reference standard for power and power quality measurements, or who are already active in the field, a Good Practice Guide was produced which describes the hardware components and their characterization, the software tools for data acquisition and processing as well as a user's guide for the operation of the software tool.

Finally, the close interaction between the project partners and with stakeholders provided opportunities for networking and co-operation which will continue in the future, benefitting the entire community and improving the European measurement infrastructure in this important field.

Project Highlights

Calibration Techniques

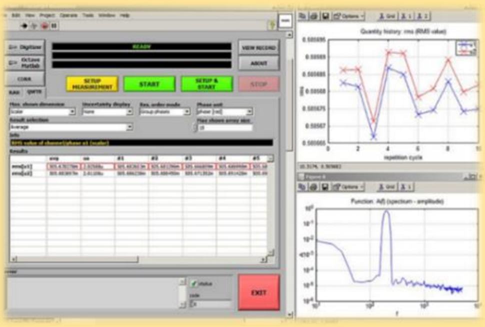
In order to ensure that the measurement results produced by the set-up are traceable to the SI, it is necessary to characterize all of its component parts, namely the voltage dividers, current shunts and digitizers. To achieve the target level of uncertainty for the measuring system parameters such as, for example, the level dependence of current shunts and voltage dividers and the phase angle errors between the input channels of the digitizer must be measured so that the appropriate corrections can be applied.

One example of the calibration techniques developed within the project was a novel method developed by RISE to measure the absolute value of the phase difference between the input current and the output voltage of a coaxial current shunt. The method is a simplified procedure that does not involve time consuming ac-dc transfer method or the need for specially designed time constant standards.

It was shown that the method could achieve uncertainties of ±200 μΩ/Ω and ±400 μrad for the ac resistance and phase angle of the shunt respectively at a frequency of 1 MHz. The reliability of these uncertainty estimates was verified by means of an informal tri-lateral comparison of the characterization of ac resistance and phase angle of current shunts between RISE, BEV and CMI.

Sampling Tools

Two open software tools were developed which handle the control of the instrumentation, the data acquisition and the data processing. One of the tools, referred to as Traceable Wattmeter (TWM) uses a National Instruments LabView virtual instrument to perform the sampling and GNU Octave or MATLAB for data processing.



TWM Front Panel

The other tool, referred to as Traceable power and Power Quality Analyser (TPQA) differs from TWM in that the sampling part of the application was developed on the National Instrument LabWindows/CVI platform.

TPQA Front Panel

Both systems provide the user with a convenient way to configure the digitizers (Keysight 3458A multimeters for the low frequency set-up and NI 5922 digitizers for the high frequency set-up) and store corrections. Once configured, data acquisition is straightforward and the data may be processed live for immediate display of the measured values or saved for later batch processing.

Twelve algorithms for the calculation of power and power quality parameters were developed and validated. Just a few of the algorithms are shown in the following table

A notable feature of these algorithms is that they include the evaluation of the measurement uncertainties associated with the measured parameters. Algorithms for the estimation of other PQ parameters may be easily added by simply appending the appropriate m-files.

All in all, these ready-to-use software applications will prove an invaluable tool to anyone who needs to make accurate, simultaneous measurement of one or more time-varying signals.

Algorithm	Parameters
TWM-MFSF, TWM-WFFT	Multi-harmonic estimation (offset, amplitudes, phases, frequency)
TWM-Flicker	Flicker measurement as per IEC 61000-4-15
TWM-HCRMS, TWM-InDiSwell	Events detector as per IEC 61000-4-30
TWM-PSFE, TWM-FPNLSF	Single-harmonic est. (offset, amplitude, phase, frequency)
TWM-WRMS	RMS estimator for non-coherent (time integrating)
TWM-PWRTDI	Power P, Q, S, PF for non-coherent (time integrating)
TWM-PWRFFT	Power P, Q, S, PF for coherent (FFT)
TWM-MODTDPS	AM modulation estimator
TWM-THDWFFT	THD estimator

The tools are free to download via the following links:

https://github.com/smaslan/TWM

https://github.com/btrinchera/TPQA

"The free availability of the TWM sampling tool proved to be invaluable in in the development of a measuring system for the phase of current shunts up to a frequency of 100 kHz."

Martin Garcocz, Bundesamt fur Eich- und Vermessumgswesen

EMPIR EURAMET
The EMPIR initiative is co-funded by the European Union's Horizon 2020 research and innovation programme and the EMPIR Participating States

Good Practice Guide

The document "Guide for Sampling Power and Power Quality Measurements" , which is available to download from the TracePQM website, is a comprehensive guide for those making measurements of power or power quality quantities using digital sampling techniques.

The guide runs to 245 pages and in it you will find detailed descriptions of the modular measurement systems developed within the project, a survey of the calibration methods for digitizers, current shunts and voltage dividers, and a complete user's guide for the open software tools. Together with the free sampling tools it makes available all of the "soft" resources needed to establish a metrology-grade measurement set up for power and power quality measurements.

Final Meeting and Workshop

On 27-28 May 2019, the Czech Metrology Institute hosted the final project meeting and workshop for project partners, collaborators and stakeholders.

Audience at the TracePQM Workshop

In addition to a series of presentations on the outcomes of the research, attendees had the opportunity to see demonstrations of the modular measurement set-up in action.

Stanislav Maslan demonstrates the TWM sampling tool to workshop attendees

Copies of the workshop presentations will be available to download from the TracePQM web site.

"Project TracePQM brings very useful tools for development of Power Quality meters. Their free availability also expands calibration services from independent testing laboratories."

Jan Souček, MEgA, a.s

EMPIR EURAMET
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The future….

Although the project is officially terminated, the development of the SW tools will continue within various R&D projects that will incorporate them. The recommendations from the SW validation tasks will be implemented and many small bugs fixed in the following months. The good practice guide will be extended mainly in the SW tool documentation section according as the tools are extended. Also, integration of new algorithms for more specific measurements is likely to happen in following years. Currently, the TWM tool is planned to be used as part of a low-impedance bridge in scope of EMPIR LiBforSecUse project, so an algorithm for comparing impedances will be added.

The project website will be maintained for the foreseeable future. Should you require additional information about the project outcomes, please contact the following:

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Peer Reviewed Publications

Four-Terminal Pair Digital Sampling Impedance Bridge up to 1MHz
Bergsten, T., Skalicka, T., Šíra, M., Maslan, S. IEEE Trans.Instrum.Meas. 68 (2019), 1860 - 1869

Characterization of an analog-to-digital converter frequency response by a Josephson arbitrary waveform synthesizer
Méndez, A., Sanmamed, Y.A., Behr, R., Caballero, R., Kieler, O., Salinas, J.R., Diaz de Aguilar, J. Meas. Sci. Tech. 30 (2019), 035006

Realization of Absolute Phase and AC Resistance of Current Shunts by Ratio Measurements Rydler, K.E., Bergsten, T.
IEEE Trans.Instrum.Meas. 68 (2019), 2041-2046

EMPIR project TracePQM: Traceability routes for electrical power quality measurements
Pokatilov, A., Philominraj, A., Ndilimabaka, H., Ellingsberg, K., Trinchera, B., Lončarević, J., Ilić, D., Caballero Santos, R., Diaz de Aguilar, J., Yovcheva, A., Nováková Zachovalová, V., Power, O., Voljc, B., Tarasso, V. and Çaycı, H 18th International Congress of Metrology (2017), 0400

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