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Welcome

Welcome to the second edition of the TracePQM Newsletter. The purpose of the newsletter is to keep our stakeholders and other interested parties informed about the progress of the project. We hope that readers of the newsletter will be stimulated to provide advice and feedback to the project team. PQ measurement results are often gathered and assessed by personnel whose primary background is not in the field of metrology so we start by taking a look at metrological traceability in this economically important field of measurement. Dr Alexandru Stafanov of ESB Networks, the Irish national distribution service provider gives us a stakeholder's view of the project. We report some of the technical highlights of the project to date as well as the dissemination activities to keep stakeholders informed.

Traceability of power quality measurement results

Metrological traceability, as defined in the International vocabulary of metrology, is a property of a measurement result whereby it can be related to a reference through a documented, unbroken chain of calibrations, each contributing to the measurement uncertainty. Traceability ensures that different measuring methods and instruments, used at different times and in different places produce reliable, compatible and comparable measurement results. The need for trustworthy and objective results that are accepted by all is very important in the field of electrical power where issues of safety and contractual obligations arise.

Traceability routes for the quantities traditionally measured in the field of electricity such as voltage, current, and power are well established and well understood. One might even say that they are taken for granted. The same cannot be said for some power quality parameters. Take, for example, the measurement of voltage flicker. The standard IEC 61000-4-15 describes the design and performance of an instrument for measuring voltage flicker. It is based on the lamp-eye-brain model and consists of five functional blocks. The important measurable quantities defined in the standard are the short- and long-term flicker severity (P_{ST} and P_{LT}). P_{ST} and P_{LT} are the most widely used means of expressing numerically the negative effect that flicker causes on humans. It is important that commercially available flicker meters, based on the IEC design, should provide the same measurement result for the same input signal. In other words, the measurement results that they produce should be traceable and the definition of traceability

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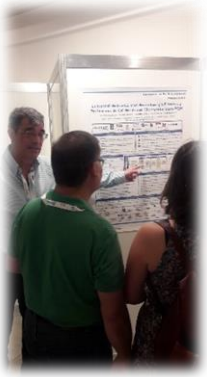
presupposes access to a reference standard. This requirement holds true for all power quality parameters.

This is where project *TracePQM* comes in. Its core objective is to produce a reference standard for power and power quality parameters which is accurate, modular, versatile and of transparent design. Metrology and calibration laboratories who are involved in the provision of a traceability chain for power quality parameters can easily construct suitable reference standards based on this work.

Impact and Dissemination of Results

In order to raise awareness of the project among stakeholders presentations have been made at several conferences



Javier Diaz de Aquilar Rois of CEM explains the project objectives to attendees at the the 6th Congreso Espanol de Metrologia.

An oral presentation entitled ""EMPIR Project 15RPT04 Trace PQM: Traceability Routes for Electrical Power Quality Measurements" was presented by Raul Caballero Santos of CEM at the international metrology conference CIM 2017 in September 2017. An accompanying paper was published in the conference proceedings and is available here https://cfmetrologie.edpsciences.org/articles/metrology/pdf/2017/01/metrology_metr2017_04001.pdf

A Stakeholder's View

ESB Networks delivers electricity to the homes and businesses of 2.3 million electricity customers in Ireland in a safe and efficient manner. The distribution system transports electricity from the bulk supply points to all electricity users. ESB Networks is the licensed Distribution System Operator (DSO) being responsible for planning, construction, operation, maintenance, and development of the electricity network across the country. The recent changes in electricity generation and consumption for the power grid may have an impact on power quality. The changes include the integration of renewable generation such as solar and wind farms and connection of disturbing nonlinear loads such as datacentres. The solar and wind farms use power electronic converters. The converters distort voltage waveforms leading to high levels of voltage and current harmonics. The harmonic emissions must be monitored and kept below admissible limits to mitigate the impact on system operation and power equipment, e.g., excessive heating and premature failure of power transformers. Calibrated recording instruments are needed for voltage disturbance detection and extended voltage and current waveform captures to better understand power quality issues. Furthermore, the voltage characteristics of electricity supplied must be monitored for compliance with EN 50160 power quality standard. Power quality

monitoring is also important to establish the baseline for impact assessment on disturbance levels of heat pumps and electric vehicles.

ESB Networks uses permanent recording instruments for power quality monitoring. The instruments are compliant with IEC 61000-4-30 Class A standard. They are permanently installed at the connection points of independent power producers and bulk supply points on the 110 kV, 38 kV, 20 kV, and 10 kV networks operated by ESB Networks. The instruments record the voltage and current waveforms and calculate power quality parameters such as power frequency, supply voltage variations, rapid voltage changes, flicker severity, voltage unbalance, harmonics and interharmonics, voltage interruptions, voltage dips and swells, and transient overvoltages. However, traceability and accuracy of power quality parameters are important for monitoring and mitigation of power quality issues. The main challenge is to ensure traceability of power quality measurements and for this reason utilities rely on metrology institutes and laboratories for power quality calibration services according to IEC standards. ESB Networks supports TracePQM Project to develop and validate a modular metrology grade system for traceable and accurate measurement of power and power quality parameter

Technical Highlights

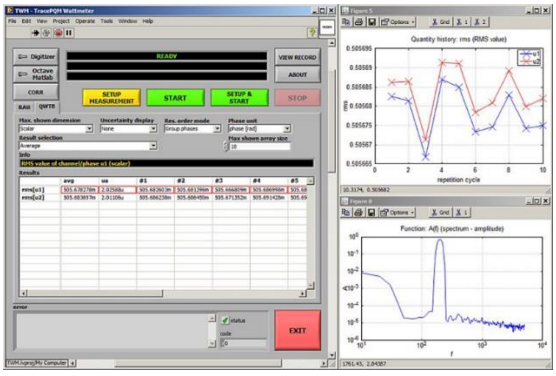
The project started in June 2016 and is now beyond its halfway point. Progress has been satisfactory and here are some of the highlights of the work so far.

Selection of designs for the measurement set-ups

After a worldwide of survey of existing designs of reference-level measurement set-ups for power and PQ parameters based on digitizing techniques, two optimum designs have been drawn up. One is for low frequency measurements and will use popular sampling multimeters Keysight 3458A as digitizers. This will enable expanded uncertainties of below 2 x 10^{-5} to be achieved. The other design, which is based on the National Instruments 5922 high resolution digitizer, will cater for wideband measurements with lower accuracy. A detailed report on the system designs has been drafted.

TracePQM WattMeter (TWM)

One of the key tasks within the project is the development of the modular software tool for data acquisition and development. It is this tool that will make the measurement systems truly flexible and adaptable. The development of the application, called **T**racePQM **W**att**M**eter (TWM), is well underway and a first version has already been released and is under test at several institutes.



It is composed of two main components:

- User interface and instrument control written in LabVIEW,
- GNU Octave or Matlab calculation scripts for data processing.

Both components are connected together into the single interactive application using GOLPI interface to form a single interactive application. The reason for this complication is so that the calculation module can be used separately, for example to batch process large amounts of measurements offline. It

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can be also used to obtain new PQ parameters from already recorded data or to run computationally expensive uncertainty calculations. The TWM concept is modular, so it can be simply extended by adding digitizer drivers while the rest of the application stays unchanged. Adding a new algorithm to calculate new PQ parameter is just a matter of adding few m-files.

The TWM tool was made publicly available under MIT license. Therefore the tool or its parts can be freely used even now, in a development stage. Current development version and working build are freely available at GitHub: https://github.com/smaslan/TWM .

Calibration of the system's hardware components

The voltage dividers, current shunts and digitizers used to scale the input signals to the digitizer input range must be calibrated. The corrections, determined at calibration, can be incorporated in the data processing stage to achieve the required measurement accuracy. The devices must be calibrated for both amplitude and phase. The general approach is for two or more NMIs to develop different calibration methods which can then be compared via a measurement intercomparison. In this way, the uncertainty estimates of the methods can be tested. Considerable progress has been made. For example, a new primary calculable standard for phase angle with a claimed expanded uncertainty below 0.7 mrad/MHz has been developed which has particular relevance to the calibration of current shunts up to a frequency of 1 MHz.

Good Practice Guide

Work on the Good Practice Guide is underway. The guide will consist of three chapters:

- Chapter 1: Description of the modular measurement set
- Chapter 2: Calibration methods for the modular measurement setup components
- Chapter 3 : User's guide for the open software tool

Introducing the project team…

Following on from the previous project newsletter, we introduce several more partners of the project consortium. In this issue we introduce you to the researchers from partners in Croatia, Bosnia and Herzogovina, Italy and Norway.

Primary Electromagnetic Laboratory (PEL) is part of the University of Zagreb Faculty of Electrical Engineering and Computing (FER) and the Croatian Metrology Institute (HMI) – therefore the acronym is HMI/FER-PEL. HMI/FER-PEL maintains Croatian standards of electrical quantities and has a tradition in the field of electrical measurements for more than 90 years.

Damir Ilić has 24 years of experience in electrical metrology, he obtained Ph.D. in 1999, and since 2009 is Head of HMI/FER-PEL

Ivan Leniček has 19 years of experience in electrical metrology, he obtained Ph.D. in 2006, and since 2009 is Deputy of Head of HMI/FER-PEL.

IMBIH

The Institute of Metrology of Bosnia and Herzegovina (IMBIH) represents the national metrology institute in Bosnia and

Herzegovina, and, as an umbrella institution for the field of metrology in B&H, The main activities/responsibilities of IMBIH are establishing the metrology system in B&H, realization of the national measurement standards in B&H and ensuring traceability of national standards with international standards.

Jasmina Lončarević is the head of IMBIH Laboratory for electrical quantities and Time and Frequency, with almost 30 years experience in the field of electrical quantities.

Srđan Čalija is an expert advisor with more than 6 years experience in the field of electrical quantity measurements. He is participating in the EURAMET Project JRP ENG52 SmartGrid II "Measurement tools for Smart Grid stability and quality".

Vladimir Milojević is an expert associate with more than 6 years of experience in the field of electrical quantity measurements. He has participated in the EURAMET Project ENG04-ESRMG01 SmartGrids "Metrology for Smart Electrical Grids" and he is participating in EURAMET Project JRP ENG52 SmartGrid II "Measurement tools for Smart Grid stability and quality".

INRIM is a public research centre acting as Italy's national metrology institute (NMI) and its mission is to realise, maintain and develop the national reference standards of the measurement units of the International System (SI). Further areas of expertise concern the basic and applied research in many fields - such as materials science, nanoscience, quantum optics, studies on the fundamental constants of physics - as well as the development of new measurement technologies and instruments to enhance the metrology activity. INRiM has wide experience in electrical quantities measurements based on quantum electrical standards as well as conventional standards and has participated in several EMRP/EMPIR – JRP projects such as Power & Energy, ENG04 SmartGrids, ENG52 SmartGrid II, SIB59 Q-WAve, SIB53 AIM QuTE, 15SIB04 QuADC.

Bruno Trinchera has more than 12 years expertise in AC electrical standards. He is responsible for AC voltage and current as well as power and energy national standards. He is involved in the development of AC quantum voltage standards and has worked for several years in the field of digital coaxial bridges for electrical impedance metrology. He also has wide experience with software tools, algorithms, measurement automation and digital signal processing.

Danilo Serazio joined INRIM in 1995. He is involved in electrical power and energy measurement and development of mechanical and electrical equipment employed in ac and dc measurements.

Justervesenet (JV) is a governmental agency under the Ministry of Trade, Industry and Fisheries. JV is responsible for the Norwegian metrology infrastructure and for ensuring its national and international acceptance. JV is responsible for the maintenance of the national measurement standards and Legal Metrology. Our research activity includes work in optical radiometry, electrical metrology and signal analysis, in addition to other fields. JV has long experience in developments of current shunts and voltage dividers for AC/DC transfer. We have been involved in previous EMRP/iMERA-Plus projects such as ProVolt, Q-Wave, NewStar and Power & Energy. In Electricity, we are currently also involved in the EMPIR projects QuADC, ACQ-PRO, ADVENT, MeterEMI and DIG-AC.

Kristian Ellingsberg has 15 years experience in the field of Power & Energy. He has developed the sampling watt meter at JV and is the contact person for TC-EM SC Power & Energy.

Helge Malmbekk, Ph.D has been at JV for 5 years and is the head of the Electrical group. He has experience in AC/DC transfer and is involved in the development of AC Josephson Voltage Standards at JV. He is the contact person for TC-EM and SCs LF and DC & QM.

Scheduled events		
Event	**Date**	**Location**
Teleconference	Aug 2018	-
Final meeting	May 2019	TUBITAK, Turkey
Final workshop	May 2019	TUBITAK, Turkey

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Collaborators and Stakeholder Committee

Our **stakeholder committee** which will provide a formal and enduring link between the project partners and the stakeholders throughout the project has expanded to fifteen members. It includes representatives from instrument manufacturers, distribution service providers, test laboratories, and academic institutions. Stakeholder committee members are kept fully informed of project developments and are encouraged to provide feedback and advice.

Members of TracePQM Stakeholder Committee	
Jan Souček	MEgA - Měřící Energetické Aparáty, a.s
Alexandru Stefanov	ESB Networks
Terence O'Donnell	UCD Energy Institute
John McAuley	Compliance Engineering Ireland
Irvin Sirotic	METREL d.d.
Andrei Klimenko	L-CARD
Alfonso Alcántara	Red Electrica de Espana
Marie Havlíková	Brno University of Technology
Plamen Tzvetkov	Technical University of Sofia
George Milushev	UniTech Control Ltd
Geoff Ives	Fluke Calibration
Tapio Lehtonen	VTT Technical Research Centre of Finland
Andreas Christensen	Trescal
Jan Kraus	KMB Systems sro
Garrett Kelly	Powerpoint Engineering

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