Publishable Summary for 15RPT04 TracePQM
Traceability routes for electrical power quality measurements

Overview

The diversification of electric power generation to include sources with fluctuating output power such as solar and wind and the growing number of appliances employing switched-mode power supplies, has led to increased demands for traceable, accurate measurement of electrical power and power quality (PQ) parameters. Conventional power measurements based on thermal converters only provide information about the root-mean-square (RMS) value which is not sufficient for PQ measurements that need to address complex waveforms. New measurement setups based on alternative measurement techniques are required and whilst a few national metrology institutes (NMIs) have developed metrology grade power and PQ measurement systems based on sampling techniques, these systems are not generally available and no laboratories can offer calibration services for all the required PQ tests. This project will help to address this issue by developing and validating a modular metrology grade system for the measurement of power and PQ parameters using digital sampling techniques.

Need

Traceable measurement of PQ parameters requires the establishment of an appropriate measurement setup, software to control the instruments and collect the data, and algorithms to process the data including the calculation of the power, the PQ parameters and their associated uncertainties. The development of all parts of a sampling power and PQ measurement system with associated software and the calibration and validation of the system requires significant effort and time and is generally beyond the capacity of individual institutes such as smaller or emerging NMIs/DIs, universities, calibration laboratories and manufacturers of PQ instrumentation etc. Furthermore the independent development of all parts of the sampling power and PQ measurement system from scratch in every institute would result in duplication of existing designs and devices and waste resources. In addition traceability has not been fully established for all components of the PQ measurement setup, and harmonised calibration methods with extended ranges for transducers and wideband digitizers are therefore required.

Successful implementation of such a power and PQ measurement system requires knowledge and expertise in at least four fields. Firstly it is essential to design a proper, interference-free interconnection scheme of the components of the measurement system, i.e. the digitizers, current shunts and voltage dividers. Secondly it is necessary to design software capable of controlling the digitizers that will, among other things, ensure synchronization of particular digitizer channels. Thirdly the sampled voltage and current waveforms must be mathematically processed to obtain the required parameters such as power, power factor, and various PQ parameters. The waveform processing also needs to incorporate the calculation of the measurement uncertainties. Finally performance of the measurement setup needs to be validated to ensure traceability to the SI. The design of the measurement setup must be flexible and allow new digitizers or PQ algorithms to be easily incorporated without the need to rebuild the entire system in order to cater for continuously developing customer's needs and to reflect documentary standards which define requirements for PQ meters. Ideally any solution should focus on maximising the use of the capabilities of existing hardware components such as the bandwidth for wideband digitizers and the record length extension for sampling multimeters which are now limiting factors for complex PQ parameter measurements.

Objectives

The overall aim of this project is to develop and validate a modular metrology grade system for the measurement of power and PQ parameters using digital sampling techniques. The specific scientific and technical objectives of the project are:

1. To design a modular, metrology grade measurement setup for sampled electrical power and PQ parameters measurements, including a review of existing measurement and calibration methods, associated hardware and software, investigation of the optimum use of equipment already available within the NMIs/DIs and extension of traceability for power and PQ measurements up to 1 MHz.
2. To develop and validate a modular measurement setup for sampled electrical power and PQ parameters measurements, which can be easily established at NMIs/DIs and at other organisations. The target uncertainties of the modular measurement setup are at least four times smaller than the tolerances specified in documentary standards for PQ meters, e.g. the target expanded uncertainties for the amplitude of voltage harmonics of the modular measurement setup are 1.25 % of the measured voltage harmonic for measured values higher or equal to 1 % of the nominal voltage and 0.012 % of the nominal voltage for measured values lower than 1 % of the nominal voltage.
3. To develop an open software tool for instrumentation control, data acquisition and the calculation of electrical power and PQ parameters with full uncertainty estimation.
4. To develop and make available a good practice guide for the assembly and operation of the modular measurement setup including the calibration of all components so as to establish full traceability to the SI of the electrical power and PQ parameters measured. The guide will include the manual for the open software tool to assist users in the extension and modification of the modular measurement setup.
5. For each partner to develop an individual strategy for the long-term operation of the research capability developed during the project, including regulatory support, research collaborations, quality schemes and accreditation, together with a strategy for offering calibration services from the facilities established to customers in their own country and neighbouring countries. The individual strategies will be discussed within the consortium and with other EURAMET NMIs/DIs, to ensure that a coordinated and optimised approach to the development of traceability in this field will be implemented for Europe as a whole.

Progress beyond the state of the art

The project will go beyond the state of the art by making innovative and optimum use of equipment that is already available within the NMIs/DIs and maximising the capabilities of the chosen hardware components in order to develop a modular measurement system for power and PQ parameters. The possibility of implementing continuous sampling with sampling multimeters for measurements that require long interval waveform records will be investigated. Methods to improve the stability and temperature dependence of wideband digitizers will be studied. Traceable methods for the calibration of particular components for frequencies up to 100 kHz will be developed together with an extension of the frequency range up to 1 MHz.

The modular power and PQ measurement setup will be accompanied by an open software tool for instrumentation control, data acquisition and data processing, so that the end user community can add functionality for any other digitizers or PQ algorithms by simply adding new modules. A unified system of calibration datasets for every component used in the setup (i.e. digitizers, current shunts and voltage dividers) will be implemented so that adding or interchanging the components will only require different datasets to be loaded into the system. The algorithms implemented for calculation of the PQ parameters will be accompanied by a numerical calculator of the measurement uncertainty and, for computationally expensive algorithms, by a quick uncertainty estimator based on a previous Monte Carlo uncertainty analysis.

In addition the project will extend the research capabilities and calibration services in power and PQ metrology across more European countries. Coordinated activities of the participating NMIs/DIs will speed up the research in this field and reduce unnecessary parallel investigations and developments, thus saving resources.

Results

The overall goal of this project is to develop and validate a modular and well documented metrology grade system for the measurement of power and PQ parameters by means of digital sampling techniques and to ensure both the lowest possible uncertainties and the highest possible bandwidth using commercially available components. However these contradictory requirements cannot be met by a single measurement setup. Therefore the new system will consist of two macro-setups, one of which will cater for low frequency measurements at the best accuracy level and the other for wideband measurements, but with reduced accuracy.

An open software tool for instrumentation control, data acquisition and data processing will be implemented to allow further modification and extension of the developed setup.

A good practice guide will be developed to assist end-users in the design, construction, extension and modification of the modular measurement setup for power and PQ quantities.

All partners will develop individual strategies for the long-term development of their research capability in power and PQ metrology. These will include possibilities for collaborations within the research community in their country, the establishment of full traceability, quality schemes, accreditation, participation in key comparisons, and submission of CMCs to the KCDB. The plans will also include a strategy for offering calibration services from the facilities established to customers in their own country and in neighbouring countries.

To support the establishment of the new CMCs of the participating NMIs/DIs a comparison protocol for a future supplementary comparison in power and PQ measurement will be prepared.

Impact

The open software tool and good practice guide will be publicly available to all interested parties, i.e. NMIs/DIs, calibration laboratories, industry, universities and individual practitioners. They will serve both as a quick starting point for the establishment of an expandable modular sampling power and PQ measurement system and as a reference to speed up the design of a new system if required. The universal access to the open software tool and good practice guide and the easy to implement modular design of the power and PQ measurement setup will lead to the improvement of the power and PQ measurement capabilities within Europe, not only within the partner NMIs/DIs but also through the early uptake of the knowledge and project outputs by other interested parties, such as other NMIs/DIs or calibration laboratories.

The improved European power and PQ measurement capabilities will contribute to the metrological basis necessary for policy makers and energy suppliers in all European countries to help to guarantee a stable and secure energy supply to customers. This project will also assist with the growth and development of the energy infrastructure by providing wider European access to traceable measurement capabilities for power and PQ quantities. The modular design and open software tool will enable straightforward future expandability of the measurement setup to cater for continuously developing customer's needs. The strong interaction with stakeholders through a stakeholder committee will help the project to focus on the end-user's needs.

The project will also incorporate early phase knowledge transfer from experienced NMIs to the less experienced NMIs. This will be achieved by means of workshops organised together with the project meetings and also through the active participation of less experienced NMIs in the development of the new system.

The strategies for the long-term development and use of partners' capabilities will ensure fast uptake and maximum use of the project's results that will lead to the establishment of new calibration services or to the improvement of existing measurement capabilities in every participating country.

The preparation of a supplementary comparison in the field of power and PQ will support the validation of the new measurement setups after the end of the project.

The results of the project will be presented at conferences, submitted for publication in peer reviewed journals, disseminated via international and European electricity related technical committees, and will be presented to relevant legal metrology organisations. At the end of the project a stakeholder workshop will be organised that will be open to anyone and which will help to ensure the uptake of the project's outputs by potential end-users.

Project start date and duration:	01 June 2016 (36 months)	
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