EMPIR Call 2016 – Energy, Environment, Normative and Research Potential

Selected Research Topic number: **SRT-g08**
Version: 1.0

Title: Applied measurements to enable the reliable operation of smart grids

Abstract

The EU target of 50 % renewable energy sources will require revolutionary advances in the technology and operational mechanisms used to control electricity grids in order to balance supply-and-demand of energy. Measurement is an essential element for this Smart Grid revolution and this research topic develops, extends and applies techniques in the following key applications: i) power quality (PQ) propagation/location, ii) supraharmonics, iii) phasor measurement unit (PMU) field-applications and iv) synchronisation/timing of measurements. Developing and applying these techniques in grids is essential for maintaining the stability, security and quality of supply in the presence of an increasing amount of renewable energy supply.

Keywords

Smart Grids, power quality, phasor measurement units (PMU), supraharmonics, wide-area measurement systems, synchrophasor, timing, renewables, electricity distribution, electricity transmission

Background to the Metrological Challenges

Smart Grids are needed to control balance of the supply and demand of electricity against the background of increasing levels of intermittent renewable energy sources (RES). Failure to control this balance results initially in a poor quality of supply which effects consumers and grid apparatus, but ultimately results in power blackout. Applied measurements in Smart Grids can be used to plan, monitor and manage their operation under the increasing presence of renewable energy sources.

Poor power quality (PQ) results from connections to the grid: on the supply-side from the proliferation of power convertors essential to the operation of many RES; on the demand-side from high volumes of consumer products that present non-linear loads and from single-source large industrial loads. PQ propagation measurements campaigns are in progress in ENG52 SmartGrid II and have concentrated on power system harmonics. This has generated many issues that need addressing, including the effects of power transformers on harmonic propagation and development of a method to adapt harmonics limits to grid types. Advances are also required in PQ location reliability, building on feasibility studies carried out in SmartGrid II.

Supraharmonics have recently been identified as a new threat to the stable operation of Smart Grids. The combined push towards higher energy efficiency and reduction of traditional power frequency harmonics have resulted in a significant increase of emissions in the frequency range 2 to 150 kHz. These emissions are caused by grid connections such as RES installations and mass-market products using switching frequencies in the supraharmonic range. As a result, more and more cases of interferences have been documented by CENELEC in a series of reports that now runs to three parts [1].

PMUs have been developed as the key tools to dynamically monitor the stability of grids and prevent blackouts. Yet these instruments and their resulting synchrophasor measurements are highly-complex to understand and apply. This represents a barrier to the take-up of PMU technology amongst utilities and a reluctance to use and trust the PMU measurements and grid applications based on these measurements. SmartGrid II will largely solve the traceability issues of PMUs, however much field-based work is still required if utilities are to adopt these new instruments into business-as-usual.

Accurate timing is a key requirement for reliable PMU and PQ propagation / source location applications. Utilities have serious concerns on the reliability of the present GPS-based time traceability. For example, PMU-based applications will only be used by utilities to support operation-critical decisions if their timing reliability is secured. Therefore, there is a need to evaluate the reliability of the present GPS-based timing as well as to evaluate and develop reliable alternatives.

Objectives

Proposers should address the objectives stated below, which are based on the PRT submissions. Proposers may identify amendments to the objectives or choose to address a subset of them in order to maximise the overall impact, or address budgetary or scientific / technical constraints, but the reasons for this should be clearly stated in the protocol.

The JRP shall focus on developing and optimizing metrological techniques in grids to maintain stability, security and quality of supply in the presence of an increasing amount of renewable energy.

The specific objectives are

1. To develop on-site measurement techniques and new analysis tools to determine the propagation and location of PQ disturbances including harmonics, transients and unbalance in distribution networks.
2. To develop measurement methods and investigate the propagation of supraharmonics (2 to 150 kHz) in typical low voltage (LV) network topologies with the aim to characterise the typical supraharmonic emission from devices and installations as basis for the development of generic models for supra-harmonics and understanding of potential issues such as product/appliance compatibility.
3. To enable the field application of PMUs, developing and demonstrating a metrological approach to stability monitoring and dynamic grid behaviour. These applications include: measurement and prediction of origination of sub-synchronous power oscillations, and correlating them to RES generation in the grid; detection of other dynamic events including fault location and switching events and determining their impact on grid stability; PMU-based dynamic line rating using changes in resistance of overhead lines and cables to estimate temperature. In all applications, the impact of uncertainty of PMU measurement chains and latency will be assessed.
4. To carry out a study on the synchronisation of PQ sampling and PMUs in Smart Grids, to include: reliability aspects of presently used GPS-based timing (accuracies of GPS receivers and conditioned oscillators) in typical grid scenarios; the impact of data timing and latency issues on PQ and PMU applications; evaluation and possible trials of alternative synchronisation schemes (e.g. “white rabbit”).
5. To facilitate the take up of the technology and measurement infrastructure developed in the project by the measurement supply chain, standards developing organisations (CENELEC, IEC) and end users (electricity generators, network operators, utility companies).

These objectives will require large-scale approaches that are beyond the capabilities of single National Metrology Institutes and Designated Institutes. To enhance the impact of the research, the involvement of the appropriate user community such as industry, standardisation and regulatory bodies is strongly recommended, both prior to and during methodology development.

Proposers should establish the current state of the art, and explain how their proposed research goes beyond this. In particular, proposers should outline the achievements of the EMRP projects ENG04 SmartGrid and ENG52 SmartGrid II and how their proposal will build on those.

EURAMET expects the average EU Contribution for the selected JRPs in this TP to be 2.0 M€, and has defined an upper limit of 2.3 M€ for this project.

EURAMET also expects the EU Contribution to the external funded partners to not exceed 35 % of the total EU Contribution to the project.

Any industrial partners that will receive significant benefit from the results of the proposed project are expected to be unfunded partners.

Potential Impact

Proposals must demonstrate adequate and appropriate participation/links to the “end user” community, describing how the project partners will engage with relevant communities during the project to facilitate knowledge transfer and accelerate the uptake of project outputs. Evidence of support from the “end user” community (e.g. letters of support) is also encouraged.

You should detail how your JRP results are going to:

- Address the SRT objectives and deliver solutions to the documented needs,
- Feed into the development of urgent documentary standards through appropriate standards bodies,
- Transfer knowledge to the energy sector.

You should detail other impacts of your proposed JRP as specified in the document “Guide 4: Writing Joint Research Projects (JRPs)”

You should also detail how your approach to realising the objectives will further the aim of EMPIR to develop a coherent approach at the European level in the field of metrology and include the best available contributions from across the metrology community. Specifically the opportunities for:

- improvement of the efficiency of use of available resources to better meet metrological needs and to assure the traceability of national standards
- the metrology capacity of EURAMET Member States whose metrology programmes are at an early stage of development to be increased
- organisations other than NMIs and DIs to be involved in the work

Time-scale

The project should be of up to 3 years duration.

Additional information

The references were provided by PRT submitters; proposers should therefore establish the relevance of any references.

[1] CENELEC SC205A, Main communication systems, Study report on Electromagnetic Interference between Electrical Equipment / Systems in the frequency range below 150 kHz