Publishable JRP Summary Report for ENG61 FutureGrid
Non-conventional voltage and current sensors for future power grids

Background

The drive for increased reliance on renewable or low carbon energy in Europe has led to more distributed energy sources such as wind farms and solar power being connected to the power network, leading to an increase in harmonics of the waveforms.

Instruments for measuring electrical power have undergone significant improvement since the introduction of sampling systems. For example smart meters for energy measurement, power analysers for power quality measurement, and phasor measurement units for power flow analysis have all opened up completely new possibilities to collect information about the state of the power grid. These modern instruments and protection devices are connected to the low voltage side of installed current or voltage transformers with limited bandwidth in order to observe the state of the power grid, to protect the grid, or to allow metering / billing. However, the performance of these setups is limited by the characteristics of the conventional transformers which are currently installed on power networks.

New, non-conventional technologies are being more and more widely applied e.g. optical Faraday effect based sensors, hybrid electrical/optical sensors and air core Rogowski coils for current measurement; and voltage dividers or optical Pockels effect based systems for voltage measurement or upgrading of conventional instrument transformers with digital or optical readouts. These solutions are potential replacements for traditional instrument transformers for power frequency measurement on medium and high voltage power lines, and they show great promise in enabling lightweight, accurate measurement systems for voltage and current, both for fundamental and harmonic frequencies. However, at present they lack the level of accuracy needed for metrological applications.

Need for the project

This JRP focuses on the possibilities of novel non-conventional sensors for current or voltage measurement. Many of these technologies are already applied and promise wider bandwidth, and lighter weight, but they are not yet of the required metrological accuracy. The first generation of measurement systems installed in the European power network is getting old, and the systems are being replaced. Therefore there is a need to ensure that appropriate technology is available that enables reliable and robust control and billing in future power networks.

The European standardisation bodies CEN and CENELEC were invited by EURAMET to put forward their testing and measurement needs relating to the EMRP Call 2013 Energy and Environment. This JRP responds to the needs identified by CENELEC technical committees TC13 and TC38.

From a metrological point of view there is a need to find complementary solutions for the calibration of new non-conventional technologies. The traditional voltage and current transformers work well on power frequency; but new solutions are needed for NMIs to be able to provide accurate calibration of the sensors required for power quality measurements on medium and high voltage networks.

The connection of distributed renewable energy sources to the electrical transmission grid such as wind farms will lead to a higher presence of harmonics in the transmitted waveform. The need to determine these harmonic voltages and currents poses new requirements for the measurement infrastructure associated with the generation, delivery, and protection of the electrical network. In addition, both the bandwidth of these traditional instrument transformers and the capabilities of the current measurement and communication network do not match that of modern low voltage instrumentation.

Due to many factors such as the design, manufacturing tolerances, burden or temperature, the frequency response varies significantly between different makes of traditional voltage transformers. Moreover, the weight of these devices makes their transport for calibration impractical. Solutions based on alternative technologies are not yet mature enough for wider application for on-site calibration or power quality measurements on high voltage grid and thus require further research.

Scientific and technical objectives

The aim of the JRP is to support wider application of novel sensor technologies in future power networks. In order to complement the emergence of the new technologies, the most promising of them have been selected.

The specific objectives are to:

- design, manufacture and characterise a wideband sensor based on optical Faraday effect for traceable calibration of non-conventional and conventional current sensors on medium and high voltage networks;
- apply a magnetic shielding technique on Rogowski coil to improve its applicability for onsite measurement and calibration;
- develop a precision voltage sensor for calibration of non-conventional and conventional sensors in a medium voltage network;
- develop traceability for new non-conventional techniques not yet commercially available, such as using fibre Bragg grating for interrogation of sensor network, or measurement of capacitive current flow through high voltage capacitor for PQ measurements;
- test the applicability of the sensors developed in the JRP on existing medium and/or high voltage substations;
- develop services for calibration of non-conventional sensors with analogue output; and
- develop services for the calibration of transformers and non-conventional sensors with digital output in line with IEC 61850-9-2.

Expected results and potential impact

Since the widespread deregulation of EU electricity markets it is estimated that some 70 % of electrical energy is traded on the open market. As a consequence of this, cross-border trade in bulk wholesale electricity within and between EU and non-EU countries is increasing. The reliable and traceable metering of electricity is an essential enabler of this cross border trading system. Measurable, assured power quality between networks is also required to prevent the propagation of grid failures and to pinpoint their origin. Furthermore, introduction of the sensors capable of detecting power quality phenomena also in medium and high voltage lines will help in this.

The outputs from the JRP related to non-conventional sensors will:

- enable manufacturers of equipment to calibrate their products for more precise measurements through the introduction of new calibration methods or non-conventional sensors;
- enable traceable measurement of power quality on medium and high voltage power lines through the development and characterisation of sensors based on emerging technologies;
- provide tools for grid owners for better and more flexible control of their networks through verifying the performance of the developed sensors by on-site demonstrations;
- provide new calibration infrastructure supporting manufacturers of non-conventional sensors to verify the correct performance according to international standards; and

- provide guidance for standardisation bodies on how to improve the guidance for calibration methods for non-conventional sensors through the provision of good practice guides on installation and calibration of non-conventional sensors.

Whilst manufacturers of non-conventional sensors will be the initial beneficiaries of this research, it is the security and environmental integrity of Europe's electricity system that will benefit from the application of the new techniques. Without this research, technological drive will continue, but its implementation will be less efficient, less effective and will lack the credibility required for fair trade in an energy market with an annual value measured in billions of euros.

The importance of the non-conventional sensors is demonstrated by the billions of Euros in infrastructural development that national grid companies are investing in the management of their network. The metrology developed within this JRP will enable wider introduction of non-conventional sensors, which will help address the limitations of the existing measurement capabilities. Existing instrumentation has been designed to measure the fundamental frequency only, and the power quality issues emerging due to the wider application of renewable energy sources and switchmode systems are currently unmeasurable.

JRP start date and duration:	01 June 2014, 36 months
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