EMPIR Call 2015 – Health, SI, Normative and Research Potential

Selected Research Topic number: **SRT-n12**
Version: 1.0

Title: Standard tests and requirements for Rate-of-Change of Frequency (ROCOF) measurements in SmartGrids

Abstract

The EU target of 50% renewable energy sources will require revolutionary mechanisms to balance supply-and-demand of electricity. Measurement is an essential element for the control systems that will ensure continuity and quality of electricity supply. Rate-of-Change of Frequency (ROCOF) is an essential control metric used to make sub-second control decisions to maintain grid stability. ROCOF measurement is highly susceptible to disturbances and effects typical in real networks. Many algorithms and techniques to measure ROCOF have been proposed, yet despite the vital nature of this parameter, no appropriate standardisation for ROCOF testing exists.

Keywords

Grid Stability, Renewable Integration, Smart Grids, Frequency Control, ROCOF, PMU, Frequency Support, Islanding Detection, Loss of Mains Detection

Background to the Metrological Challenges

Supply and demand of electricity in traditional electrical networks can be readily controlled by calling-up additional carbon intensive thermal-plant. Future networks incorporating a target of 50 % renewable energy sources (RES) will be subject to highly intermittent generation and much reduced inertia. In order to avoid blackouts and poor power quality (PQ), new control and instrumentation will be required to monitor the health of the network and real-time control actions will be initiated based on these measurements to maintain supply.

The electricity industry is dominated by grid-codes and industry standards (engineering recommendations) to ensure smooth interaction between the various facets of what is often described as the world's most complex system. Many new grid codes are emerging anticipating network operational issues in the 50% RES scenario. International standards groups such as ENSTO-E, IEEE, "International Smart Grid Action Network" (ISGAN) and "Smart Grid International Research Facility Network" (SIRFN) are coordinating this industry driven process.

Current and anticipated future problems in the area of grid-stability, protection and control have spawned a new generation of grid instrumentation and relays. The Phasor measurement unit (PMU) and relays each use an essential metric, the "rate of change of frequency" (ROCOF - measured in Hz/s), to determine changes in systems inertia and the dynamically varying real-time balance between supply and demand. ROCOF is also used to detect and recover from Loss-of-Mains (LOM), a situation that occurs in faults where parts of the network become "islanded" from the wider synchronised-network.

The problem of ROCOF measurement is particularly challenging, and is more relevant than ever due to the increasing proportion of RESs and high-power non-linear (i.e. power electronic) devices connected to the network.

ROCOF measurements are available in commercial instruments (PMUs and relays). The PMU standard IEEE C37.118.1(a) notably relaxes the ROCOF compliance requirements during certain tests, and limits certain test conditions to "nominal frequency only". The PMU standards committee did *not* design the standard with the intention of demonstrating good ROCOF performance. The argument is that a user wanting to measure ROCOF should use a G81(R) relay. However, there are **no** standards governing the implementation of G81(R) devices. Unintentionally, IEEE C37.118.1(a) is the **only** standard which regulates power-system ROCOF assessment, but it contains many loopholes for ROCOF assessment in real-world PQ conditions.

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For LOM protection relays, the trip settings historically are in the region of 0.125 - 0.2 Hz/s. However, many existing “ROCOF” relays are known to trip spuriously during various PQ deviations. Many of these real-world power-quality conditions will cause IEEE C37.118.1(a)-compliant PMUs to output ROCOF values significantly in excess of probable ROCOF range.

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 metrology research necessary to support standardisation in the Rate Of Change Of Frequency (ROCOF) for electrical power in Smart Grids.

The specific objectives are

1. To review and develop algorithms to reliably and accurately measure ROCOF over the full range of network conditions.
2. To develop a library of standard-test-waveforms representative of typical PQ events on electricity networks, including extreme events, in order to adequately test ROCOF algorithms and instrumentation containing these algorithms.
3. To test selected ROCOF algorithms and associated instrumentation utilising the standard waveform library via simulations as well as actual laboratory tests with synthesised waveforms.
4. To clarify system-requirements (specifications for digitising, transducers response, time-windows) required to make usable, accurate, and reliable ROCOF measurements for a variety of control and protection purposes.
5. To work closely with the European and International Standards Developing Organisations, and the users of the Standards they develop, to ensure that the outputs of the project are aligned with their needs, communicated quickly to those developing the standards, and in a form that can be incorporated into Standards at the earliest opportunity. To specify standard-waveforms, ROCOF test requirements and appropriate limits for the PMU standard IEC/IEEE 60255-118-1 and for the Distribution Code and Engineering Recommendation G59. To support CENELEC TC8 new work item on ROCOF (2015) and initiate new standards for “Class 81R” frequency measurement relays (pre-normative).

The proposed research shall be justified by clear reference to the measurement needs within strategic documents published by the relevant Standards Developing Organisation or by a letter signed by the convenor of the respective TC/WG. EURAMET encourages proposals that include representatives from industry, regulators and standardisation bodies actively participating in the projects.

Proposers should establish the current state of the art, and explain how their proposed project goes beyond this. In particular, proposers should outline the achievements of the EMRP projects ENG04 SmartGrid, ENG52 SmartGrid II and ENG63 GridSens projects and how their proposal will build on those.

EURAMET expects the average EU Contribution for the selected JRPs in this TP to be 0.4 M€, and has defined an upper limit of 0.5 M€ for this project.

EURAMET also expects the EU Contribution to the external funded partners to not exceed 30 % of the total EU Contribution to the project. Any deviation from this must be justified.

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 electrical power measurement 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.