EMPIR Call 2018 – Health, SI Broader Scope, Normative and Research Potential

Selected Research Topic number: **SRT-s04**
Version: 1.0

Title: Metrology for the next generation of modulated radio frequency signals

Abstract

Ultra-high speed and density communications, such as 5G and beyond, are lacking detailed knowledge of modulated radio frequency signal properties that will guarantee advanced functionality, interoperability and safety. These new developments are accompanied by highly specialised measurement equipment such as spectrum, communication and vector signal analysers for which calibration capabilities are missing. By establishing traceability for new derived quantities such as error-vector magnitude (EVM), bit-error rate, adjacent channel power ratio and others, the scope of the SI would be widened. As a result calibration labs would be able to offer new and improved services to the measurement equipment and communication component industries in order for them to develop new products.

Keywords

Waveform metrology, mixed-signal analysis, d-parameters, analogue-to-digital converters, vector-signal analysers, pulse-generators.

Background to the Metrological Challenges

With the increasing complexity of systems and protocols required to support higher information density (4G+, 5G) at higher levels of efficiency (trade-off between linearity and nonlinearity in a non-50 Ohm environment), the exact knowledge of digital and analogue signal properties, quality factors and adherence to spectral limits with known measurement uncertainty becomes crucial for system design and operation. The quantification of the impact of impedance on the signal quality or an approach to characterise that impact is also very important. Properties such as exact waveform, modulation depth and shift and full measurement uncertainty including correlation information between single measurements are also becoming more important for remote-sensing systems such as automotive radar, as integration is increasing and interoperability and safety are becoming more important in autonomous traffic systems of the future. Reliable measurement of radiated signal field strength is required to prove conformity with safety limits. The increasing requirements of development departments and quality control in mass production, together with improved quality management standards result in a strong demand for new calibration capabilities.

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 the development of metrological capacity in radio frequency (RF) waveform metrology, mixed-signal oscilloscope and device characterisation and traceability for modulation quantities.

The specific objectives are

1. To apply waveform metrology methods to real-time-oscilloscopes and enable full characterisation of at least one example of electric pulse generators used as: a) calibrators for electromagnetic compatibility (EMC) test equipment, b) pulse-modulated radio-frequency sources used for ultra-wideband communications (UWB), and c) automotive radar.
2. To establish and document a practical and manufacturer-independent traceability chain based on real-time oscilloscopes and signal analysers. This should cover full measurement uncertainty analysis from basic amplitude and phase modulation properties to more complex

EURAMET MSU, Hampton Road, Teddington, Middlesex, TW11 0LW, UK
Phone: +44 20 8943 6666 Email: msu@npl.co.uk
msu.euramet.org

The EMPIR initiative is co-funded by the European Union's Horizon 2020 research and innovation programme and the EMPIR Participating States

digital modulation metrics such as: error-vector magnitude (EVM) and appropriate quality metrics for Long-Term Evolution (LTE), 5G, beyond 5G, to support traceable calibration of vector signal and communication analysers.

3. To characterise mixed signal systems as needed to fully access the characteristics of fast analogue-to-digital converters by evaluating measurements procedures and performance characteristics (e.g. uncertainty) of new metrics such as D-parameters and by developing and characterising novel sub-Nyquist methods to extract RF specific features in 5G.

4. To assess digital-signal quality metrics and field-strength of radiated signals in 5G, Long-Term Evolution (LTE), Universal Mobile Telecommunications System (UMTS), Institute of Electrical and Electronics Engineers (IEEE) 802.11, 820.15.3 and 802.15.4 communication formats, including constellation metrology in Orthogonal Frequency Division Multiple Access (OFDMA) systems. To establish full measurement uncertainty assessment by investigating hardware and channel influence on digital signal properties.

5. To enable National Metrology Institutes to achieve uncertainties of less than 1 % for these measurements and to establish, for industry and calibration laboratories, new services (e.g. for EVM) by developing and publishing technical IEEE and VDE/VDI guidelines for the different measurement procedures and by interacting with standards bodies at the definition of RF communication schemes (IEEE 802.15).

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 work, the involvement of the larger community of metrology R&D resources outside Europe is recommended. A strong industry involvement is expected in order to align the project with their needs and guarantee an efficient knowledge transfer into industry.

Proposers should establish the current state of the art, and explain how their proposed project goes beyond this. In particular, proposers should outline how their proposal will go beyond the achievements of EMRP IND16 Ultrafast, EMRP IND51 MORSE and EMPIR 14IND10 MET5G.

EURAMET expects the average EU Contribution for the selected JRPs in this TP to be 1.8 M€, and has defined an upper limit of 2.1 M€ for this project.

EURAMET also expects the EU Contribution to the external funded partners to not exceed 20 % of the total EU Contribution across all selected projects in this TP.

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 communications 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.