European Partnership on Metrology
Call 2023 –Fundamental Metrology, Industry, Normative and Research Potential

Selected Research Topic number: **SRT-n10**
Version: 1.0

Title: Support for standardisation of sample-by-sample waveform uncertainty computation

Abstract

The control and regulation of time-dependent electrical signals is the backbone of modern communication technologies, like wireless and fibre-optic networks, in which information is encoded and transmitted using high-frequency waveform-modulation schemes. The ever-increasing frequencies and data rates challenge data processing devices and analysis methods. Waveform correction procedures are required to correct distorted signals and to advance the understanding of electrical systems and devices. A rigorous measurement uncertainty is key to assuring performance of the measurement and analysis process.

Keywords

Full waveform metrology, sample-by-sample analysis, correlation analysis, signal processing, signal reconstruction, signal correction

Background to the Metrological Challenges

The accurate analysis of the time-dependent step-like and impulse-like electrical signals is important to successfully employ advanced communication technologies. These measurements, therefore, must have an associated rigorous measurement uncertainty analysis that considers a variety of influence factors. Furthermore, the waveforms (the measured representation of a signal) must be corrected to account for system-related alteration of the signal during the transmission and reception processes, while all these correction processes must have an associated measurement uncertainty.

At present, the waveforms are often analysed to obtain a small set of parameters (rise time, transition duration, amplitude, …) that provide basic information on the shape of the waveform. This set of parameters is commonly used to characterise an instrument output or an instrument response function. These parameters, with their corresponding measurement uncertainty, are utilised for the selection, comparison, and/or the performance tracking of electronic equipment and instruments. However, waveforms (and the signals they represent) typically have a highly structured and complex association between amplitude and time. For such a system with many degrees of freedom, the reduction to a smaller set of parameters does not necessarily describe that waveform correctly or accurately. To ensure a comprehensive representation of the signal, a standardised description and model of the measurement process and associated measurement uncertainty analysis is required, taking into account sample-by-sample uncertainties, correlations, correction algorithms, environmental effects, system noise, electromagnetic interference, etc. Moreover, complex measurement systems often operate in different domains: equivalent time domain (digital sampling oscilloscopes), sampled time domain (digital real-time oscilloscopes) and frequency domain (vector network analysers), with associated uncertainties in each domain. To exchange and convert data from and within such instruments by parameter or by omitting correlations within the uncertainty propagation inevitably results in loss of accuracy and even in data misinterpretation. This can be overcome by a full-waveform-based approach considering the uncertainty of each sample and the correlations between the errors in each sample. Up to now, the mechanisms to map the uncertainties from one domain into the other are not fully developed.

The current related standards (IEC 60469:2013 and IEC 62754:2017) lack the inclusion of waveform-correction/-reconstruction/-deconvolution effects in the uncertainty analysis, a multivariate uncertainty analysis for full waveforms as well as for waveform parameters, the expression of the sample-by-sample measurement uncertainty and the consideration of correlation effects.

EURAMET MSU,
Phone: +44 20 8943 6666 Email: part.msu@euramet.org
Metpart.eu

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 sample-by-sample waveform uncertainty computation.

The specific objectives are

1. To assess the signal quality along the data generation/transmission/reception path of advanced measurement instruments through the establishment of a multivariate and sample-by-sample measurement uncertainty analysis. To evaluate the amplitude and timebase measurement uncertainties for each datum (sample) in the time-varying electrical signal waveform for equivalent time domain, sampled time domain and frequency time domain instrumentation. To provide mechanisms to map the uncertainties from one domain into the other.
2. To develop validated data processing methods for the correction of real-time measurement effects, environmental effects, waveform corrections for known amplitude and timebase errors of the measurement system, and waveform reconstruction. To develop an accurate representation of the actual signal and perform multivariate uncertainty analyses on the associated measurement corrections.
3. To develop validated computationally fast waveform-correction methods including measurement-uncertainty-analysis.
4. To contribute to the revision of IEC-60469:2013 and IEC-62754:2017 and the development of new documentary standards by providing the data, methods, guidelines and recommendations, which are necessary for the standardisation of waveform correction procedures, to IEC TC 85. Outputs should be in a form that can be incorporated into the standards at the earliest opportunity and communicated through a variety of media to the standards community and to end users.

The proposed research shall be justified by clear reference to the measurement needs within strategic documents published by the relevant Regulatory body or 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. The proposal must name a “Chief Stakeholder”, not a member of the consortium, but a representative of the user community that will benefit from the proposed work. The “Chief Stakeholder” should write a letter of support explaining how their organisation will make use of the outcomes from the research, be consulted regularly by the consortium during the project to ensure that the planned outcomes are still relevant, and be prepared to report to EURAMET on the benefits they have gained from the project.

Proposers should establish the current state of the art and explain how their proposed research goes beyond this.

EURAMET expects the average EU Contribution for the selected JRPs in this TP to be 1.0 M€ and has defined an upper limit of 1.3 M€ for this project.

EURAMET also expects the EU Contribution to the external funded beneficiaries to not exceed 30 % of the total EU Contribution across all selected projects in this TP.

Any industrial beneficiaries that will receive significant benefit from the results of the proposed project are expected to be beneficiaries without receiving funding or associated 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,
- Facilitate improved industrial capability or improved quality of life for European citizens in terms of personal health, protection of the environment and the climate, or energy security,

- Transfer knowledge to the communication technology 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 the Partnership 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] 011_IEC TC85 WG22 Sample-by-sample waveform uncertainty calculation

http://metpart.eu/nrm-call-2023