
Title: Metrology for ultrafast electronics and high-speed communications

Abstract

The increased need for unoccupied and unregulated bandwidth for future wireless short-range communication systems as well as for new remote sensing applications will require increasing use of frequencies in the millimetre wave range and the more efficient use of bandwidth. This development brings challenges in metrology regarding channel and antenna characterisation, digital signal and waveform metrology, power and frequency measurements that currently hinder the successful development of next generation communication technologies in Europe. Offering solutions to these challenges will enable European industry to play a global lead role in next generation communications and sensing.

Conformity with the Work Programme

This Call for JRP's conforms to the EMRP 2008, section on "Grand Challenges" related to *Industry* on pages 31 and 32.

Keywords

Ultrafast Electronics, High-Speed Communications, Channel Characterisation, Antenna Characterisation, Millimetre and Sub-Millimetre Waves, Digital Modulation Properties, Waveform Metrology, Radio Frequency Combs, Electro-Optic Sampling Techniques, Millimetre-wave power measurement, microcalorimetry, pulsed-power measurement, traceable HF power sensors, direct power comparison.

Background to the Metrological Challenges

For many years, the frequencies used by communication and sensing systems have increased as more and more services had to be accommodated in the available spectrum. Today, car-radar at 77 GHz and wireless personal area networks at 60 GHz mark the frontier for widespread commercial technology. While the frequencies above that have previously only been used in fundamental research, new compact sources and detectors are now appearing on the market that enable practical applications, including sensing and communications (see, e.g., www.radiometer-physics.de). The increased speed of signal transmission and processing for these applications requires the integration of ultrafast electronic devices. Today, opto-electronic converters with cut-off frequencies beyond 10 GHz and microwave integrated circuits and solid-state amplifiers with operational frequencies well beyond 100 GHz are available. However, the improvement of such devices as well as the design of systems making use of their full potential requires new metrology. The establishment of a solid basis for traceable measurements in this millimetre wave region of the electromagnetic spectrum requires the development of electrical and optical measurement techniques, in particular for channel sounding, antenna characterisation, signal property evaluation, waveform metrology and frequency measurements.

HF power in the frequency range 50 to 170 GHz, is also one of the key quantities required by industry as well as free-space quantities such as power density, electric and magnetic field strength as they are used to verify compliance with radiation safety limits.

Scientific and Technological 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 JRP-protocol.

The focus of this topic is to provide the metrological tools and methods to foster the development of new technologies in the area of high-speed communication and remote sensing. The specific objectives are:

- 1) To establish traceability for industrial millimetric HF power standards by implementation of fast, efficient and precise power calibration methods and development of traceable power transfer standards and high precision calibration facilities beyond the current state of the art.
- 2) To develop time-domain waveform metrology allowing for complete characterisation of ultrafast devices and wideband sources used for traceable measurements
- 3) To compare and validate frequency and time domain measurement techniques for the characterisation of future high-speed communication systems
- 4) To perform propagation measurements and channel and antenna characterisation in millimetric and sub-millimetric bands
- 5) To provide quantitative and reliable evaluation of high-speed communication system performance by traceable measurement of digital modulation properties
- 6) To develop frequency combs for traceable frequency measurements in industrial applications covering the entire radio frequency / microwave range

Proposers shall give priority to work that meets documented industrial needs and that which supports transfer into industry e.g. by cooperation and/or by standardisation.

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

Potential Impact

Proposals must demonstrate adequate and appropriate participation/links to the “end user” community. This may be through the inclusion of unfunded JRP partners or collaborators, or by including links to industrial/policy advisory committees, standards committees or other bodies. Evidence of support from the “end user” community (eg letters of support) is encouraged.

Where a European Directive is referenced in the proposal, the relevant paragraphs of the Directive identifying the need for the project should be quoted and referenced. It is not sufficient to quote the entire Directive per se as the rationale for the metrology need. Proposals must also clearly link the identified need in the Directive with the expected outputs from the project.

You should also detail other Impacts of your proposed JRP as detailed in the document “Guidance for writing a JRP”

You should explain how your JRP results are going to:

- feed into the development of urgent standards through appropriate standards bodies
- transfer knowledge to the communications, sensing and electronics sectors.

You should also detail how your approach to realising the objectives will further the aim of the EMRP to develop a coherent approach at the European level in the field of metrology. 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 Member States and countries associated with the Seventh Framework Programme whose metrology programmes are at an early stage of development to be increased
- outside researchers and research organisations other than NMIs and DIs to be involved in the work

Time-scale

The project should be of 3 years duration.