

Title: Metrology for new electrical measurement quantities in high-frequency circuits

Abstract

The lack of traceability for newly developed instrumentation in the radio frequency (RF), microwave and millimetre-wave areas of technology is a barrier to the development and trading of equipment in high value, high impact fields - for example, medical, security, consumer electronics and environmental monitoring uses. There is also a need for dissemination techniques to deliver NMI-levels of traceability directly to the end-users. This SRT calls for the development of state-of-the-art measurement of waveguides, coaxial lines and printed circuit boards (PCBs) which are critical components in these high-frequency systems.

Conformity with the Work Programme

This Call for JRPs conforms to the EMRP Outline 2008, section on “Grand Challenges” related to Industry & Fundamental Metrology on pages 3, 11, 14 and 31.

Keywords

High-frequency, electromagnetics, microwave and millimetre frequencies, S-parameters, vector network analysis, multiport circuits, coaxial, waveguide, on-wafer

Background to the Metrological Challenges

Existing requirements coming from cutting-edge high-frequency industrial electronics applications have driven test equipment manufacturers to develop new types of instrumentation. These new classes of instrumentation now offer new types of measurement quantities and/or existing quantities that fall beyond the scope currently supported by European NMIs and as a result end-user requirements for calibration and traceability cannot be met. New, applied, metrology is needed, at NMI level, to enable the exploitation of these new instrumentation capabilities by industrial end-users where lack of traceability has an impact on trading and the supply chain - for example, in medical, security, consumer electronics and environmental monitoring. The outcomes from this activity can potentially benefit all sectors of the electrical and electronics industries involved in characterisation/modelling of high-frequency devices and systems. Many of these issues impact the progress indicated by the International Technology Roadmap for Semiconductors [1].

The current state-of-the-art for high-frequency electronics and electromagnetics applications has brought about a new generation of test equipment. Key functionalities include:

- Waveguide systems that apply S-parameters to new frequency ranges, i.e. 0.1 to 1.0 THz
- Multiport systems for PCB and on-wafer circuits that have introduced differential parameters in both time- and frequency-domains for applications such as digital signal integrity
- Large-signal and nonlinear network analysis that have introduced new measurands such as X-parameters, S-functions, etc..

Many manufacturers already use such systems but there is currently no traceability or verification in place to enable users to quantify the quality and reliability of measurements. In addition, the new measurands use different representations to provide information about the same underlying measurement situation. These representations are currently inconsistent with each other and so cannot be compared in a meaningful way. This has a detrimental impact on customer / supplier interactions.

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 JRP shall focus on the traceability of measurements in the areas of millimetre-wave and sub-millimetre-wave electronics and electromagnetics, high-speed digital printed circuit boards and multiport configurations, and large-signal / nonlinear device characterisation.

The specific objectives are:

1. To establish traceability for reflection and transmission measurements in metallic waveguides to 1100 GHz and in coaxial lines to 110 GHz
2. To establish traceability for multi-port vector network analyser techniques and automatic (electronic) calibration techniques
3. To establish traceability for differential S-parameter measurements on planar circuits to test signal integrity
4. To establish traceability for nonlinear measurements and extreme load impedances
5. To improve the vector measurement uncertainty and verification processes and to develop international guides and standards

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.

The total eligible cost of any proposal received for this SRT is expected to be significantly above the 2.7 M€ guideline for proposals in this call. The available budget for integral Research Excellence Grants is 42 months of effort.

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 (e.g. letters of support) is encouraged.

You should detail how your JRP results are going to:

- feed into the development of urgent documentary standards through appropriate standards bodies
- transfer knowledge to the electronics and electrical industry sectors.

You should detail other impacts of your proposed JRP as detailed in the document “Guide 4: Writing a Joint Research Project”

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 and includes 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 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 & research 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] www.itrs.net