JRP Summary Report for SIB62 ‘HF Circuits’

“Metrology for new electrical measurement quantities in high-frequency circuits”

Background

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. This project will develop the state-of-the-art in the measurement of waveguides, coaxial lines and printed circuit boards (PCBs) that are critical components in these high-frequency systems and will use dissemination techniques to deliver National Measurement Institute (NMI)-levels of traceability directly to the end-users. This will be achieved by forming a Europe-wide consortium of NMIs from the partners in this project.

Need for the project

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 instruments now offer new types of measurement quantities and/or existing quantities that fall beyond the scope currently supported by European (and other) NMIs and as a result end-user requirements for calibration and traceability to the International System of units (SI) cannot be met.

New, applied, metrology is needed, at NMI level, to enable 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 project will benefit all sectors of the electrical and electronics industries involved in high-frequency devices and systems.

Many of these issues impact the progress indicated by the International Technology Roadmap for Semiconductors (ITRS) and the roadmap compiled by the EURAMET Technical Committee on Electricity and Magnetism (TC-EM). The project also aligns with broader European visions, as outlined in the Europe 2020 Strategy and echoed in the EURAMET 2020 Strategy – for example, relating to flagship European initiatives such as “A Digital Agenda for Europe”.

Scientific and technical objectives

New advanced techniques will be developed for implementing and disseminating measurement traceability to users of metrology services – i.e. other NMIs, accredited laboratories, instrumentation manufacturers and end-users (in industry and academia). The project will achieve this by addressing the following key scientific and technical objectives:

- Traceability and verification techniques to support millimetre-wave and submillimetre-wave electronics and electromagnetics in coaxial line (to 110 GHz) and waveguide (to 1.1 THz)
- Traceability and verification techniques to support multi-port device configurations including the use of electronic calibration units for Vector Network Analysers
- Traceability and verification techniques to support high-speed digital PCBs for Signal Integrity applications, including differential transmission lines

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- Traceability and verification techniques to support large-signal / non-linear device characterisation (e.g. high-power transistors and power amplifiers) and nano-scale devices (e.g. carbon-nano-tubes, graphene-related electronics and organic macromolecules)
- Input to European and International industry-level documentation:
  - a revised version of "EURAMET Guidelines on the Evaluation of Vector Network Analysers", Guide cg-12;
  - the development of IEEE standard P1785 for millimetre- and submillimetre-wave waveguides;
  - the revision of IEEE standard P287 for precision coaxial connectors at RF, microwave and millimetre-wave frequencies;
  - input to an IEEE Special Interest Group that is reviewing documentary standardisation needs in the area of defining nonlinear measurement quantities.

Expected results and potential impact

The primary outcome from this project will be the public availability of an extensive range of traceability services for end-users that match the current capabilities of state-of-the-art measurement instrumentation, such as Vector Network Analysers. These services will enable all end-users to demonstrate traceability to SI for their measurements and tests. This will enable end-users to be able to justify performance indicators (such as product specifications) used in both scientific and commercial arenas.

The immediate impact of this project will be due to the radically improved measurement capabilities of the participating NMIs. This will lead to greatly improved access to, and dissemination of, measurement traceability for European accredited testing and calibration laboratories and the manufacturers of test instrumentation. This, in turn, will lead to greatly improved measurement traceability for all end-users, including customers and suppliers of devices and systems.

The key areas of long-term social impact are: medical diagnostics (e.g. breast cancer scanners); security and detection systems (e.g. airport security scanners); consumer electronics (e.g. computers and smartphones). Key areas of long-term environmental impact are: climate-change monitoring (via detection of atmospheric gases); improving the energy efficiency of components and systems used in mobile communications (e.g. smartphones and base stations). Key areas of long-term financial impact are: emerging technologies based on nanostructures (e.g. carbon-based electronics); consumer electronics (e.g. computers and smartphones) where state-of-the-art performance establishes a commercial edge.

<table>
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