Title: SAR measurement using vector probes

Abstract

The development of modular wireless communication devices, such as smartphones, with multiple communication protocols (e.g. Long Term Evolution (LTE), Near field communication (NFC), Code division multiple access (CDMA)), has resulted in an increase in the number of protocols needed to test human exposure (to such devices) including the measurement of the specific absorption rate (SAR). New measurement systems exist that can rapidly image the SAR using arrays of vector probes in sealed phantoms, however the traceability and uncertainty levels for these systems has not been established. Improved metrology for SAR measurements is also needed to support the development of IEC 62209-3. This standard currently under development by IEC TC 106 intends to standardise SAR measurements with vector probes and will be used to assess the majority of wireless telecommunications devices across Europe.

Keywords

Vector probe array, specific absorption rate (SAR), time-domain sensors, multiple-input and multiple-output (MIMO), electric field imaging, multivariate uncertainty propagation

Background to the Metrological Challenges

The development of mobile phones is ever-increasing with 1.3 billion smartphones sold worldwide in 2014. The number of telecommunication protocols tested during the production phase of such smartphones to assess SAR is also increasing, particularly with the arrival of 5G. In fact, SAR measurements using conventional single probe systems, as defined in IEEE/IEC 62209-1 and 2, have become over-burdensome in terms of the time required to test a device. For example, assessing the SAR from a modern smartphone, which may have more than 30 transmission bands and include LTE, CDMA, Universal Mobile Telecommunications System, Enhanced Data rates for GSM Evolution, IEEE 802.11, Bluetooth with multiple-input and multiple-output (MIMO) and NFC, can take up to five weeks testing over three test shifts a day. Further to this, modular devices with multiple combinations of wireless modules within a single chassis cannot be adequately tested using current protocols, and future communications standards such as 5G will incorporate complex MIMO antennas that cannot be adequately assessed using the systems specified in current standards, as they do not measure phase.

In order to improve the time-to-market of smartphones, time-domain probes and vector probe arrays have been developed and combined with advanced signal processing techniques. The measurement of electric fields by this means is faster (SAR evaluation is shortened by a factor of at least 100 compared to traditional systems using robot scanning) and gives almost instantaneous measurements of the SAR. The systems use arrays of phasor probes that measure the magnitude and relative phase of the electric fields embedded inside a sealed phantom.

Methods for the calibration of SAR using single probes are well established in IEC62209-1 and 2 and yield calibration expanded uncertainties of approximately 10 % at $k = 2$. However, these methods cannot be applied to arrays of sensors, mainly due to their physical size, and they do not calibrate the phase measurement for the vector probe, which is important for the accuracy of the field reconstruction. Further to this, it is the performance of the whole array of sensors that is of interest and this cannot be determined from measurements of individual sensors. Therefore, the IEC is developing a new standard IEC62209-3 to standardise SAR measurements with vector probe arrays, however this has highlighted the challenges of establishing traceability and uncertainty analysis for vector-based measurement systems. As a result there is a current reliance on the validation of SAR measurements using reference sources, and although this is suitable for a small range of existing devices with reference sources, it does not translate to new devices under development (and without reference sources).

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 SAR measurement using vector probes.

The specific objectives are

1. To develop traceable methods for the calibration of time-domain probes and probe arrays up to 6 GHz. In addition to verify the accuracy of such measurement systems after calibration and to determine the properties of associated sealed phantoms.
2. To establish methods for uncertainty propagation through multivariate models, using the principles given in the 'Guide to the expression of uncertainty in measurement' (GUM). This should include identifying the sources of measurement uncertainties and their propagation through multivariate transformations and developing single vector probe systems for use on scanning systems.
3. To verify the reliability of measurement systems for a wide range of transmitter types and improve the measurement of telecommunication signals and SAR measurement for a wide range of device types. This should include the development of improved data processing used with time-domain probes.
4. To develop test protocols for MIMO and modular devices using vector probe arrays in order to determine the maximum SAR value (worst case) by combining MIMO signal figures.
5. To facilitate the uptake of the developed measurement systems and contribute to the standards development work of the technical committee IEC TC 106 on the successful adoption of IEC 62209-3 standard vector-based SAR measurement systems in Europe. In addition, to ensure that the outputs of the project are aligned with the needs of IEC TC 106 and in a form that can be incorporated into the standards at the earliest opportunity.

The proposed research shall be justified by clear reference to the measurement needs within strategic documents published by the relevant 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.

Proposers should establish the current state of the art, and explain how their proposed research goes beyond this and iMERA-Plus T4.J07 EMF & SAR and EMRP JRP SIB62 HF Circuits.

EURAMET expects the average EU Contribution for the selected JRPs in this TP to be 0.6 M€, and has defined an upper limit of 0.8 M€ for this project.

EURAMET also expects the EU Contribution to the external funded partners to not exceed 30 % of the total EU Contribution to the project.

Any industrial partners that will receive significant benefit from the results of the proposed project are expected to be unfunded 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, in particular IEC TC106,
- Transfer knowledge to the wireless telecommunications sector and those involved in the regulation of this 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.