30th meeting of the CCEM
22 – 24 March 2017 at BIPM

Activities from CEM Electricity and Magnetism Division

The activities of the Electricity and Magnetism Division are mainly directed to give fulfilment to the following fundamental points:

a) Establishment, maintenance, conservation, development and dissemination of the national standards of/for the measurement units corresponding to the electrical quantities in DC and LF. Therefore, the requirements established in the Mutual Recognition Arrangement are fulfilled in their entirety:

- Participation in international key comparisons.
- Declaration of the optimal Calibration and Measurement Capabilities, CMC.
- Implantation of a quality system in the laboratories of the Electricity Division.

b) Execution of research, development and technological innovation projects: National and EMPIR projects.
c) Search and optimisation of methods for the improvement of uncertainty values, the extension of the existing measurement ranges and the beginning of activities in new quantities.

The technical activities can be summarised as follows:

DC Voltage

Routine calibrations of Zener references and high accuracy voltmeters with the Josephson conventional standard are going on. Additionally, we routinely calibrate DC voltage and current meters and sources too with conventional systems.

A new automatic calibration system up to 1 000 V based on the Step Reference Method is being setting up. It will be compared with our automatic potentiometer and with multimeters calibrated with the Josephson standard in order to validate it.

In the framework of its participation in the EMRP project JRP SIB53 AIM QuTE, *automated impedance metrology extending the quantum toolbox for electricity*, the laboratory had developed a new system in order to generate very low AC voltage with phase controlled to verify the linearity of AC null detectors, especially lock-in amplifiers. The range has been extended by adding a phase locked calibrator.

Also in AIM QuTE project, a two terminal-pair bridge based on a single programmable Josephson array has been assembled, driven by a new MIKES bias source specifically designed for this application. Four terminal-pair version of the bridge is on development now.

CEM participates in the QuADC project and will characterise the dividers and buffer amplifier developed in the project with respect to temperature, humidity, pressure and voltage level dependence. Furthermore, it leads the Impact work package.

The laboratory will participate in the success proposal of the EMPIR project GRACE on graphene electric characterization. The kick-off meeting of the project was held at INRIM in May.

The laboratory is participating too in the Spanish national project TRATELO on a possible new quantum voltage standard based on a laser diode frequency. Our mission in the project is to compare our Josephson standard with the new length standard.

The laboratory has actively participated in the CPEM 2016 with three poster presentations, and it has participated in Technical Subcommittee satellite meetings.

Furthermore, a project to develop a new low current measuring system based on the method of charging capacitors is near of completion.

DC Resistance

A new resistance bridge calibrator RBC 100 has been acquired. We have started to develop the new resistance bridge calibration system based on it. This new system will improve the accuracy of these calibrations considerably and it will allow us to calibrate more accurate equipment.

The resistance laboratory has finished a study on the new prototype RTS (resistive transfer standard QHR to 10 kΩ) obtaining very good results. The Warshawsky bridge forming our new room temperature QHR transfer measuring system with the RTS is being re-assembled in order to improve its performance.

Three new services of resistance meter calibration have been approved in the EURAMET.EM.13.2015 review process. A new service of calibration of resistance ratio meters will be proposed in the next one.

Calibration of standard resistors and reference groups is ongoing.

AC laboratory

Within the activities related with its participation in the EMRP JRP SIB 59 Q-Wave, research has been carried on the characterization of Analog-to Digital converters including uncertainty estimation.

Intensive work has been carried out dealing with the coordination of EMPIR RPT01 ACQ-PRO project, including the organization of three face to face meetings and a teleconference. As a project activities the laboratory has carried out a research visit related with quantum standards at NPL and PTB facilities. Within the project activities a pioneering intercomparison on AC quantum voltage standards is arranged and will take place in the first half of 2017. The BIPM, NPL and PTB comparison will serve as a basis for future worldwide bilateral and pilot comparisons of ACQ standards.

The laboratory is collaborating in the EMPIR project TRACE PQM and is leading a work package. The kick-off meeting of the project was held at Brno Check Republic.

The laboratory has actively participated in the CPEM 2016 with two oral presentations, chairing a session and collaboration on the Technical Subcommittees satellite meetings.

The laboratory is collaborating on the elaboration of several "Potential Research Topic", PRT for the EURAMET call 2017.

The laboratory has carried out several high precision calibrations of AC voltage and current standards for the Spanish laboratories.

Power and Energy Standards

New services, with improved ranges and uncertainty values and based on the power and energy digital sampling system, have been approved in the last review process in EURAMET.

The work in order to optimise the method and the uncertainty values of the primary power standard by using the digital sampling method has finished. This method is based on Artificial Neural Networks (ANNs) for spectrum analysis and fundamental frequency estimation of asynchronously sampled signals.

Besides, the CEM Measurement Assurance Program (MAP) continues in order to ensure the traceability of the electrical energy measurement in Spain. This program is based on a set from RADIAN travelling standards.

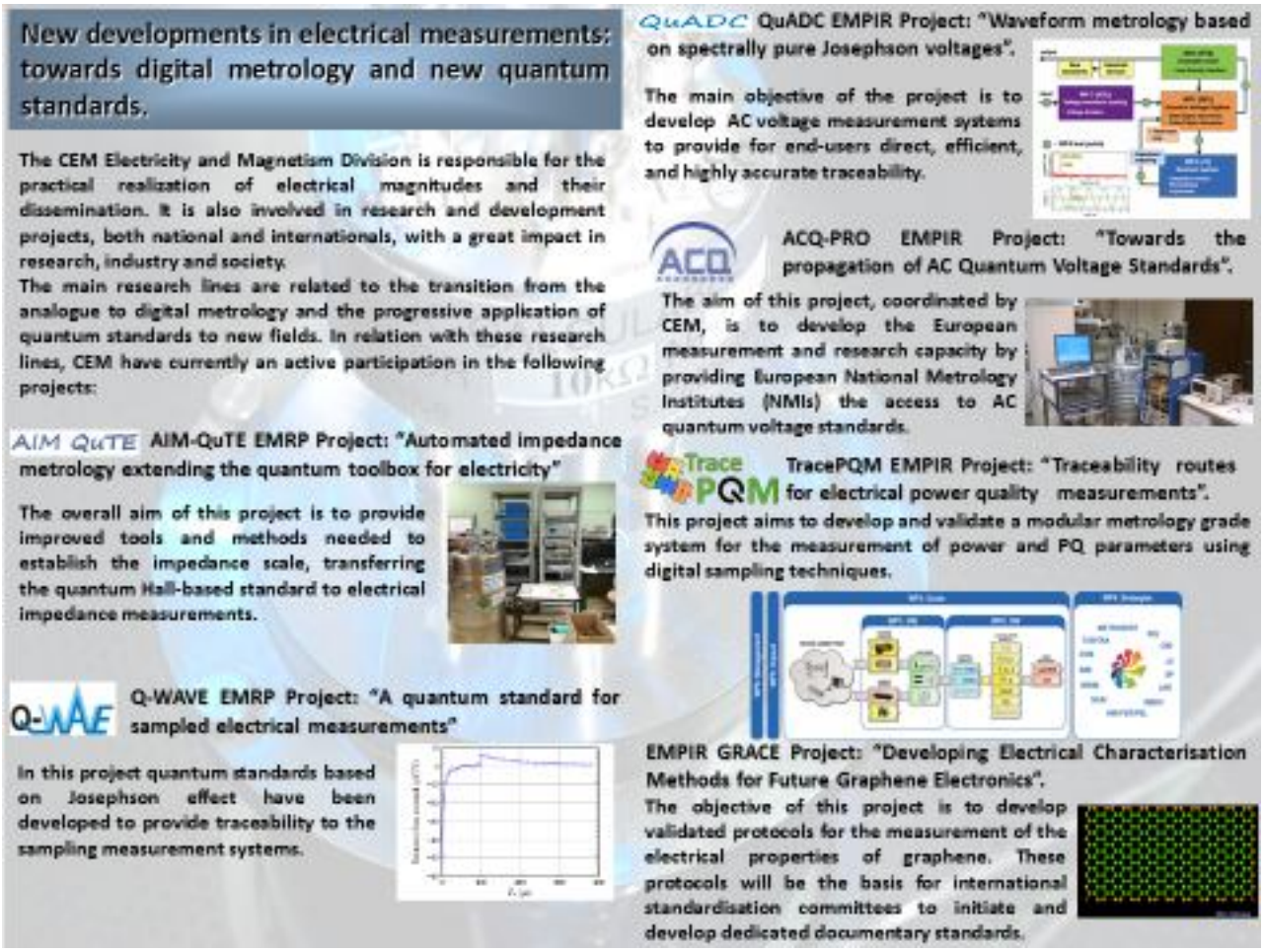
Impedance

The laboratory is participating on the EURAMET.EM.14.2016 review process with two new CMCs in AC voltage ratio (real and imaginary part) at 1 kHz, supported by CCEM-K7 comparison.

The laboratory continues with the activities leading to the impedance standards maintenance and dissemination.

During the 21st IMEKO-TC4 held in Budapest (Hungary) in September 2016 the laboratory has actively participated with a poster.

Participation in EMRP and EMPIR projects (2015-2017)



CEM participation in EMRP and EMPIR projects (2015-2017)

New publications (2015-2016)

[1] *Procedures for improved characterization of ADC parameters*, J. Diaz de Aguilar Rois, EMRP SIB59 Q-Wave. Deliverable D4.3.3, 6th Meeting Q-Wave Project, Torino (Italy), 4-5 November 2015.

[2] *Metrology to enable improved underwater EMC testing MU-EMC*, R. Caballero Santos, EMPIR Environment Call 2016, PRT preparation workshop, Torino (Italy), 1st December 2015.

[3] *Evaluación de la aplicación de los resultados del proyecto Q-Wave en normas sobre convertidores digitales, J.* Diaz de Aguilar Rois, AENOR/CTN 82/SC 4. Meeting 1/2016, Madrid (Spain), 13rd January 2016.

[4] *From the concept to the project: CEM experience on a capacity building successful proposal (ACQPRO), J.* Diaz de Aguilar Rois, Training on drafting proposals (PRT, JRP, SIP and RMG) for EMPIR, Madrid (Spain), 4th February 2016.

[5] *Project activities and deliverables (ACQPRO),* J. Diaz de Aguilar Rois, ACQ-PRO Teleconference Progress Meeting, Madrid (Spain), 16th February 2016.

[6] *Research Mobility Grants Presentation,* R. Caballero, ACQ-PRO Teleconference Progress Meeting, Madrid (Spain), 16th February 2016.

[7] *Towards an Impedance Bridge Based on a Single Programmable Josephson Voltage Standard,* F. Raso, 2A. Hortelano, R. Behr, L. Palafox, and T. Hagen. Final dissemination workshop of EMRP projects AIM QuTE, GraphOhm and Q-WAVE, Prague, 18-20 May 2016.

[8] *Method of Calibration of Lock In Amplifiers in Linearity,* F. Raso, A. Hortelano, M.M. Izquierdo. Final dissemination workshop of EMRP projects AIM QuTE, GraphOhm and Q-WAVE, Prague, 18-20 May 2016.

[9] *Characterization of Analog-to-Digital Converters.* Y.A. Sanmamed, J. Diaz de Aguilar Rois, Final dissemination workshop of EMRP projects AIM QuTE, GraphOhm and Q-WAVE, Prague, 18-20 May 2016.

[10] *WP4: Long-term development plans for power and PQ measurements for each partner.* J. Diaz de Aguilar Rois, Kick-off Meeting TRACE-PQM project, Brno, 9-10 June 2016.

[11] *Characterization of the frequency response of Analog-to-Digital Converters* , J. Diaz de Aguilar , J.R. Salinas , R. Lapuh , A. Mendez , F. Garcia Lagos , and Y.A. Sanmamed, Conference on Precision Electromagnetic Measurements (CPEM) 2016, Ottawa (Canada), 10-15 July 2016.

[12] *Harmonics and Interharmonics Spectral Analysis by ANN* , J.R. Salinas , F. García-Lagos, J. Díaz de Aguilar , G. Joya , R. Lapuh and F. Sandoval, , Conference on Precision Electromagnetic Measurements (CPEM) 2016, Ottawa (Canada), 10-15 July 2016.

[13] *Stable arbitrary waveform generator as a transfer standard for ADC calibration,* J. Nissila, M. Šíra, J. Lee, T. Öztürk, M. Arifovic, J. Diaz de Aguilar, R. Lapuh, and R. Behr. Conference on Precision Electromagnetic Measurements (CPEM) 2016, Ottawa (Canada), 10-15 July 2016.

[14] *Towards an Impedance Bridge Based on a Single Programmable Josephson Voltage Standard* , F. Raso, A. Hortelano, R. Behr, L. Palafox, and T. Hagen. Conference on Precision Electromagnetic Measurements (CPEM) 2016, Ottawa (Canada), 10-15 July 2016.

[15] *Method of Calibration of Lock In Amplifiers in Linearity,* F. Raso, A. Hortelano, M.M. Izquierdo. Conference on Precision Electromagnetic Measurements (CPEM) 2016, Ottawa (Canada), 10-15 July 2016.

[16] *Proposal for a New Quantum Voltage Standard based in Optical Frequency measurements,* E. Bernabeu, F. J. Torcal-Milla , F. I. Raso, E. Prieto, T. Morlanes , M. Sáenz-Nuño, T. Sánchez-Carazo, R. Vigara R., Conference on Precision Electromagnetic Measurements (CPEM) 2016, Ottawa (Canada), 10-15 July 2016.

[17] *AC Resistance measurement system at CEM.* Y.A. Sanmamed, Diaz de Aguilar Rois, J. and M. Neira, 21st IMEKO-TC4 Conference 2016, Budapest, 7-10 September 2016.

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