

**32<sup>nd</sup> meeting of the CCEM**  
**14 – 15 April 2021 web conference**

**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 was set up. It has been compared with multimeters calibrated with the Josephson standard in order to validate it.

CEM participated in the QuADC project and characterised the dividers and buffer amplifier developed in the project with respect to temperature, humidity, pressure and voltage level dependence. Furthermore, it led the Impact work package.

The first phase of the project to develop a new low current measuring system based on the method of charging capacitors has been completed. It allows to measure low currents and also capacitors on DC. Now, we plan to extend the system to generate current not only to measure but to combine with a voltage source to calibrate high value resistance standards

### **DC Resistance**

The high resistance dual source bridge has been fully updated with a new source, new electrometer and new software. The Type A uncertainties have improved by a factor of 3.

The lab participated in the now finished GRACE project, working mainly in the development of electrical characterization of graphene sheets by contact methods.

A new services of calibration of resistance ratio bridges have been presented in the EURAMET.EM.16.2019 review process. Now it's in the Inter-RMO review phase.

Calibration of standard resistors and reference groups is ongoing.

### **AC laboratory**

The set of measurement to step-up for voltage and current have been completely repeated and the results are fully compatible with the last realization.

Perform routine calibration of customers thermal converters, calibrators, digital multimeters and ac/dc difference of resistors and resistive dividers.

The laboratory has actively participated in the CPEM 2020 with an oral presentation.

A new step up digital chain has been performed as an activity of the DIG-AC project.

## **Power and Energy Standards**

Within our participation in the project TRACE-PQM, in collaboration with Ireland NMI staff, the new software developed during the project was validated at CEM facilities.

An automated high accuracy current transformer developed by NMIA has been acquired. Integration in our system is in progress.

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 RADIANT travelling standards.

## **Impedance**

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

A digital impedance bridge for the realisation of the inductance scale in the range of acoustic frequencies is under development.

The reference capacitor has been calibrated at BIPM.

### **Participation in EMPIR projects (2017-2021)**

- 15RPT04 Trace PQM: *Traceability routes for electrical power quality measurements.*
- 15SIB04 QuADC: *Waveform metrology based on spectrally pure Josephson voltages.*
- 16NRM01 GRACE: *Developing electrical characterisation methods for future graphene electronics.*
- 17RPT03 DIG-AC: *A digital traceability chain for AC voltage and current.*
- 19RPT01 Quantum Power: *Quantum traceability for AC power standards.*
- 20FUN03 COMET, *Two dimensional lattices of covalent- and metal-organic frameworks for the quantum Hall resistance standard.* This new project has been approved and it will begin in June. It's coordinated by CEM.

### **Publications**

- [1] *Contribution of Metrology to electric mobility*, J. Diaz de Aguilar, AutoRevista N° 2.358, March 2021
- [2] *La metrología como elemento de apoyo en la electro-movilidad*, Javier Díaz de Aguilar, CEM Webinar on Metrology for a digital, sustainable and clean industry, 25<sup>th</sup> February 2021
- [3] *Temperature influence on the establishment of a digital voltage reference*, Javier Díaz de Aguilar et al., Precision Electromagnetic Measurements Digest CPEM 2020.
- [4] *Present and Future of High-Temperature Superconductor Quantum-based Voltage Standards*, F. Raso et al., IEEE Instruments And Measurement Magazine, Volume: 23, Issue: 2, April 2020
- [5] *Temperature influence on the frequency response of the Keysight 3458A digital multimeter*, Y. A. Sanmamed, IMEKO TC4 2019 Conference Digest.
- [6] *Guide for sampling power and power quality measurements*, J. Diaz et al., First edition, May 31, 2019, ISBN 978-80-905619-3-9.
- [7] *La definición del amperio en el SI revisado*, Y.A. Sanmamed et al., e-medida, n° 15, December 2019.
- [8] *New measurement system for low dc current at CEM*, based in the principle of charging capacitor, Félix Raso, Quantum and Precision Metrology (QPM 2019) Krakow, Poland.
- [9] *Customers' needs summary in PQ area*, Yolanda Álvarez, Workshop proyecto EMPIR TracePQM, Brno, 2019.

- [11] *Good Practice Guides on Contact Methods: Measurement of sheet resistance of Graphene films with the van der Pauw method*, Laura Matías, Joint Workshop IEC/TC 113 and EMPIR GRACE on the electrical characterization of grapheme, Madrid, 2019
- [12] *Good Practice Guides on Contact Methods Measurement of sheet resistance of graphene film with In-line 4-Point Probe Method*, Laura Matías, Joint Workshop IEC/TC 113 and EMPIR GRACE on the electrical characterization of grapheme, Madrid, 2019.
- [13] *Proyectos europeos de investigación para la aplicación de tecnologías cuánticas a la metrología*, Javier Díaz de Aguilar, Quantum Technologies in Spain. The future is now, Madrid, 2019.
- [14] *Update on EURAMET.EM-K13 and Flicker*, Javier Díaz de Aguilar, EURAMET TC-EM, Bucharest, 2019.
- [15] *Metrología para el desarrollo de baterías y estaciones de carga eficientes*, Javier Díaz de Aguilar, COP25 Chile Madrid, 2019.