Progress Report on Electrical Metrology at CENAM - México
2017 - 2018
Presented for the CCEM meeting 2019

Submitted by David Avilés

Low frequency

Programmable Josephson Voltage Standard (PJVS)

Some years ago, a PJVS has been developed based in a NIST 10 V chip. Recently calibration systems based in the PJVS were developed for Zeners, AC voltage sources, AC voltage meters and thermal voltage converters.

A PJVS, a low thermal EMFs scanner and a nano-voltmeter were integrated in a system to perform automatic calibration of Zener voltage standards with an accuracy in the order of 200 nV (k=2).

A system to calibrate AC voltage sources (high accuracy calibrators) was developed based in a PJVS by implementing the differential sampling technique. The achieved accuracy for 1V (RMS), 60 Hz is about 0.3 μV/V (k = 2).

Once an AC voltage source is calibrated against the PJVS, it is used to calibrate high resolution voltmeters, that are used to measure RMS voltage by sampling techniques.

The AC-DC voltage difference of thermal voltage converters, calibrated at PTB, has been compared with measurements using the PJVS. The differences are lower than the uncertainty given by PTB.

Contact: David Avilés, caviles@cenam.mx

Digitally Assisted Impedance Bridge

This project was defined with the initial objective of establishing the traceability chain between the Quantized Hall resistance reproduced in CENAM and the capacitance measurements. Through the development of this project, experience in the development of digital measurement systems will also be obtained. Through these digital systems, it will be possible to increase the frequency ranges of the impedance measurements.

During this period the bridge circuit was designed and evaluated and the assembly of injection and detection transformers was started. A set of transformers is being manufactured. Besides, to establish resistance references in the audio frequency range, the pieces that will integrate the set of resistors with flat frequency response (1 Ω, 10 Ω, 100 Ω, 1 kΩ, 10 kΩ and 100 kΩ) were designed and machined.

Contact: Aleph Pacheco, apacheco@cenam.mx

Capacitance Measurement System from 1 pF to 1 nF (extension of frequency range to 50 Hz – 20 kHz)

To date, the impedance laboratory offers capacitance calibration services for a frequency of 1 kHz only. Various sectors of the country related to electrical, electronic, automotive, communications and industrial services among others, require capacitance measurements to verify compliance with product specifications and measure quantities involved in production processes such as pressure, relative humidity, acoustic signals, through capacitive transductors. There are high accuracy digital capacitance meters in the market whose frequency operation is between 50 Hz to 20 kHz at a maximum voltage of 0.75V. It is expected that in the next few years the users of these instruments will require their calibration, for which it is necessary to extend the frequency range of the national capacitance standard to support the calibration services.

Contact: Felipe Hernández, fhernand@cenam.mx

Standards for Electrical Power Quality Disturbances

Spectral measurements under static conditions.

This standard has been developed to provide traceability to the measurements of power quality for harmonic and interharmonic spectral components in amplitude and phase. This standard is required in the electricity sector, where there are issues that affect infrastructure, facilities and demotivate industrial productivity. For static conditions there are international normalization, the standard developed in CENAM fulfill the requirements of the IEC 61000-4-30 for harmonics measurements.

Measurements in dynamic conditions.

This standard is ongoing and will provide traceability to the measurements of power quality parameters, such as: sags, swells, voltage interruptions, fundamental frequency deviations, flicker, phase modulation, spectral components in 3D representation and rapid change of voltage, among others. These parameters are measured in the electric sector in order to quantify their effect on transmission and distribution lines and in installed transformers. We are currently working on the development of a high accuracy digital sampling system along with a real-time processor embedded in a single processing platform for the aforementioned disturbances. This system will be the basis of the national power quality standard under dynamic conditions and for a traveling standard for a key comparison of power quality in the SIM region.

It will be the base of the implementation of more advanced control systems for electric power networks based on more reliable measurements. This national standard supports the achievement of national goals in smart grid issues. During 2018 the optimization of the first real-time measurement prototype was continued, with measurement capacities of up to 50 harmonics in 200 ms observation windows, during 2019 new capabilities such as flicker and phasor measurements are implemented in the platform.

In addition, we started with the uncertainty estimation, being the contribution of the analog-digital converter the largest component of uncertainty. This component was evaluated in linearity and in effective resolution.

Contact: René Carranza, rcarranz@cenam.mx

Reference system for Synchrophasor calibration

This project was defined with the objective of providing traceability to wide-area meters in power electric networks known as PMU's. These meters are fundamental for the operational control of electricity networks in Mexico; currently there are more than 250 meters deployed in different substations, which provide information on the state that the network keeps close to real time.

During this period, we continued with the implementation of a real-time processing platform that includes four stages: 1) data acquisition at high rate, 2) processing through reference measurement method in a real-time platform, 3) synchronization stage and 4) development of communications. During 2018, stages one through two were carried out and the characterization of the synchronization stage was started, the GPS-based system synchrony module was developed, governed by a 10 MHz signal of high metrological quality. This stage will be completed during the first semester of 2019.

Contact: René Carranza, rcarranz@cenam.mx

Standard of magnetic susceptibility of materials.

This standard based on the Gouy balance method was developed to provide traceability and reliability to magnetic susceptibility measurements of feebly magnetic, paramagnetic and diamagnetic materials, which require sectors such as auto parts, metal-mechanics and standard mass manufacturers, for the design and construction of devices, used in the automotive industry and calibration laboratories.

Contact: Marco Antonio Escobar, mescobar@cenam.mx

Radiofrequency

Radiofrequency power standard (extension of frequency range to 50 GHz)

The frequency range of the radiofrequency power standard was increased up to 50 GHz by developing a 2.4 mm coaxial line microcalorimeter. It is a twin type microcalorimeter operated in a water bath with tight temperature control, which has been developed in a cooperation program with KRISS. The extension of the frequency range for this quantity allows continuity in the offering of calibration and measurement services in the radiofrequency power laboratory. CENAM serves mainly calibration laboratories and those at the manufacturing industries as well.

Contact: Mariano Botello, mbotello@cenam.mx

Reflection and Transmission coefficient calibration (extension of frequency range to 50 GHz)

The current needs of customers and external users of CENAM in these quantities, as in the case of the RF power laboratory, go to 50 GHz and are addressed with this extension in the frequency range. The reflection and transmission coefficients laboratory provide calibration and measurement services in type N, 3.5 mm, 2.92 and 2.4 mm coaxial connectors.

Contact: Susana Padilla, spadilla@cenam.mx

Antenna and electromagnetic fields calibration (Extension of the frequency range to 40 GHz)

The calibration and measurement services of this laboratory are requested mainly by testing laboratories who evaluate conformity with telecommunication regulations and electromagnetic compatibility standards. The frequency scope of these services goes to 40 GHz for antenna factor and realized antenna gain. The traceability has been established by means of a set of standard gain horns and a set of half wavelength standard dipoles. The lower frequency range coverage for these services goes down to 30 MHz with measurements performed in an open area test site.

The request of services for probe calibration has increased in recent times tough service is still limited in the frequency range, in the electric field strength levels and in the type of probes which can be calibrated. The service will be improved by the use of a uniform electric field generation TEM cell that will also improve the calibration uncertainty.

Contact: Luis Carrión, lcarrion@cenam.mx

Electromagnetic Compatibility

The calibration of electrostatic discharge guns has been provided for a while up to 8 kV, however since the EMC standards and their requirements have evolved and now require that discharges with peak voltages up to 30 kV be used, work is in progress to fulfill that limit which will allow increasing the offer of calibration services. Other calibration services provided by this laboratory are absorbing clamps from 30 MHz to 300 MHz, line impedance stabilization networks (LISN) form 10 kHz to 30 MHz and some types of special waveform generators.

Contact: Miguel Angel Muñoz, mmunoz@cenam.mx

Published articles

- Characterization of a Type-N Coaxial Microcalorimeter for use as Microwave Power Standard at CENAM, Mariano Botello-Perez, Thomas P. Crowley, Israel Garcia-Ruiz; Hildeberto Jardon-Aguilar, IEEE Trans. Instrum and Meas., February 2019.

CPEM 2018

- CENAM's Primary Standard for High Frequency Power up to 50 GHz, Mariano Botello-Perez, Jae-Yong Kwon, Israel Garcia-Ruiz,, Hildeberto Jardon-Aguilar.
- DC voltage traceability to microvolt and nanovolt levels, David Avilés, Enrique Navarrete.
- Frequency dependence evaluation of CENAM calculable resistors, Alepth H. Pacheco Estrada and Frédéric Overney.

- Method to cool down Josephson junction arrays with applied biasing, Enrique Navarrete, David Avilés.
- Programmable Josephson Voltage Standards Comparisons at 10 V-DC, 1 V and 7 V RMS, 50 Hz between BIPM and CENAM, David Avilés, Stephane Solve, Jesús Medina, Regis Chayramy, Enrique Navarrete.