National Measurement Institute, Australia
Report on Research and Development Activities in Electricity and Magnetism
CCEM Meeting, March 2025

DC AND LOW FREQUENCY

New Programmable Josephson Voltage Standard (PJVS)

NMIA has acquired a new PJVS system from NIST for the realisation of the volt. Following months of evaluations, the Electricity Section of NMIA has completed the establishment of Australia's new quantum volt, the primary reference for voltage. This included a comparison with the outgoing standard, which resulted in an agreement of the order of one part in 10^{10}. The new fully automated standard provides traceability to most electrical measurements, including electronic voltage references, digital multimeters, calibrators and resistive voltage dividers.

New Josephson Arbitrary Waveform Synthesizer (JAWS)

The Electricity Section of NMIA acquired a new 2-volt JAWS system from NIST. During its commissioning, the NIST-NMIA team used the NIST quantum system to perform the first quantum ac-dc transfer measurement. The measured ac-dc difference of the NMI working standard (Fluke 792) agreed very closely with the NMI calibration report based on thermal voltage converters. The measurements provide additional confidence in the ac voltage measurements that NMIA has been providing to its external and internal clients. NMIA is now evaluating the new JAWS and will commence work to apply the new quantum standard to the characterisation of NMIA's primary standards at the lowest attainable level of uncertainly.

Extending Frequency and Current Range of Automated Calibration of Current Transformers and AC Resistors.

NMIA has hosted two visits from Dr Jin Hyeok Kim (KRISS), who worked with NMIA colleagues on extending the range of the calibration of the NMIA Precision Multi-Range Current Transformer to currents up to 200 A and frequencies up to 3 kHz. The same setup [1] will be used to calibrate precision resistors (current shunts) over the same range. The work uses a new range of NMIA current shunts with nominal currents up to 100 A.

[1] Ilya Budovsky, "Calibration of Precision Current Transformers and AC Resistors by Comparison using Two Sampling Digital Voltmeters," in CPEM 2020 Digest.

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IMPEDANCE

Calculable capacitor and precision four-port ac capacitance bridge

A new calculable capacitor and associated impedance measurement chain is being designed and built at NMIA with a target accuracy below 5 nF/F. Progress this year has focussed on the optical interferometry system and the quadrature source for the associated capacitance bridge.

Previously, the optical and electrical axes of the capacitor had been aligned. This year, locking to the TEM00 cavity mode by modulation of the lower guard electrode was successfully implemented. Locking of the laser frequency to an iodine reference has also been successfully tested. Generation of a secondary carrier through modulation of the primary frequency is now being refined. Locking of this secondary carrier to the TEM01 cavity mode will enable the required sub-nanometre precision in the differential length measurement via phase comparison between cavity modes.

The quadrature source that will provide the quadrature balance injection for the capacitance bridge has now been completed. Preliminary evaluation showed a phase error of approximately ±15 millidegrees, which will contribute an uncertainty of approximately 3 nF/F.

Active Arm Bridge

An active arm bridge for the automated measurement of resistance in the range 10 MΩ to 100 TΩ, with test voltages up to 1000 V, is in the final stages of development. The measurement uncertainty of the new system is of the order of 100 μΩ/Ω (k = 2) at the 1 TΩ range, which is considerably lower than the guarded Wheatstone bridge currently in use.

High-current resistance measurement system

A new fully-automated system to calibrate dc resistors and shunts down to 10 μΩ, with test currents up to 1000 A, has been commissioned. The new system provides similar uncertainties to the older manual system, but with considerable improvements in ease of use and safety. Further work to take full advantage of the new system and reduce measurement uncertainties is in progress.

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HIGH VOLTAGE

Onsite test and calibration services

The high-voltage team have been actively engaging with Australia's power industry during the energy transition. The team improved its onsite calibration and testing capability. A frequency-tuned resonant test system has been acquired for testing equipment with high capacitance, for instance synchronous condensers, which supports the power quality of renewable integrated power networks. A portable 250 kV inductance-tuned resonant test system has been acquired for performing onsite voltage withstand tests for 330 kV system equipment. In addition, a new instrument transformer test set and electronic burden have been acquired and calibrated for onsite use, which improves the efficiency of testing and provides redundancy of capabilities.

The team will keep improving its capabilities for testing 500 kV system equipment. The facility is planning to upgrade its power supply circuit in order to maximise the output

capacity of the 800 kV AC voltage source (100 kVA) acquired last year. The team is also procuring a 350 kV standard capacitor and a 350 kV portable voltage source for testing 500 kV system equipment onsite.

Development of precision measurement equipment

The high-voltage team successfully delivered a 600 kV HVDC voltage divider with a best uncertainty of 200 ppm to Korea Research Institute of Standards and Science (KRISS). The equipment was built and calibrated in NMIA's Lindfield site and commissioned at the cable testing facility of Korea Electric Power Corporation (KEPCO).

The team is also developing a 30 kV switching impulse divider to Korea Electrotechnology Research Institute (KERI).

International comparison

The high-voltage team is co-organising a voltage transformer international comparison with VTT, China Electric Power Research Institute (CEPRI), PTB, RISE and VSL. The comparison is on a 20 kV VT and 100 kV VT. The comparison is expected to start in early 2025 and complete in 2028.

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DIGITAL SI

Dr Ilya Budovsky has been Charing the new CCEM Task Group on Digitalisation. The Task Group has been working with BIPM towards establishing machine readability of quantities and CMCs in Electricity and Magnetism.

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