

Report on Electricity and Magnetism Metrology Activities at the National Metrology Centre (NMC), A*STAR, Singapore

For the 34th CCEM meeting (2025)

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This report highlights the key activities in the field of electricity and magnetism at the National Metrology Centre, Singapore, since the 33rd meeting of the CCEM in March 2023.

Relocation of Laboratories

NMC has finished its relocation to CleanTech 3 at the Singapore's Jurong Innovation District (JID). Due to some delays stemming from the COVID-19 pandemic, as well as some infrastructural issues, all the electrical and radiofrequency labs finally fully resumed operations in 2024. The labs have also undergone an internal quality assessment to verify and validate the measurement systems to support service resumption.

CIPM MRA Implementation

The peer review of the RF and Microwave Laboratory has been conducted successfully conducted on 8-9 Apr 2024. A new phase noise calibration and measurement capability (CMC) has been proposed during 2024 peer review and is being submitted for inter RMO review.

The peer review of the Electrical DC & LF Laboratory has been conducted successfully on 23-27 Sep 2024. New CMCs were added for determination of temperature coefficients of resistors. The new and revised Electrical DC&LF calibration and measurement capabilities (CMCs) is being submitted to KCDB 2.0 for inter RMO review.



DC and Low Frequency Laboratory

The Laboratory has completed a collaborative project within A*STAR titled "Extracting Value from End-of-Life Electric Vehicle Battery Packs". The project focuses on two main areas: quick Lithium-ion battery diagnostics and automated battery disassembly. The team has successfully reduced the time required for estimating the battery state of health (SOH) using electrochemical impedance spectroscopy, with results showing high accuracy in SOH estimation. This work is being carried into the second phase to continue the study into other Lithium-ion battery chemistries as well as applying machine learning algorithms to integrate various SOH methods.

NMC has also partnered with several other A*STAR institutes to establish the A*STAR Battery Centre (A*BC). Within A*BC, a battery testing facility (A*BTF) was set up to focus on battery testing and measurement. This testing facility is in the process of obtaining ISO 17025 accreditation through Singapore's accreditation council laboratory accreditation scheme (SAC-SINGLAS). This initiative was driven by the need to establish a comprehensive local test and measurement facility to support both research needs as well as industry testing, such as battery cycling as well as battery safety testing.

The Laboratory is continuing the work to extend the range for current measurement capabilities to 1000 A to support the emerging measurement needs from the transport electrification trend in Singapore. Work has also initiated to identify key metrology areas to develop measurement capabilities to support the semiconductor industry in Singapore. In the AC/DC difference areas, the Laboratory is in the midst of upgrading the existing AC-DC transfer measurement systems, including an extending of the current range to 100 A, strengthening the system control algorithms and improving the measurement uncertainty. The Laboratory has also initiated work on upgrading the low current measurement capabilities to prepare for future application under cryogenic measurement condition.

In the area of resistance metrology, the Laboratory is working on updating its capabilities with graphene-based resistance standards. To mitigate the impact of liquid helium supply chain challenges on the calibration processes, the Laboratory is also working on updating the quantum Hall system with helium recirculating capabilities. Additionally, efforts are underway in the Laboratory's metrology capabilities in accuracy evaluation of resistance bridge ratio in supporting the thermometry measurement.

RF and Microwave Laboratory

The laboratory has completed an industry project to develop magnetic and microwave particle sensing technologies for use in high flowrate media dosage measurement for ferrous and non-ferrous media. The work has led to a patented working prototype for high flowrate ferrous media dosage measurement unit for use for flow rate measurement in sandblasting and shot peening processes for aerospace, automotive and marine industries, precision powder dosage unit for Additive Manufacturing (AM) industry and Fast-Moving Consumer-Goods (FMCG) industry.

In addition, the RF Lab has successfully completed an industry project, developed an innovative, low-cost, and integrable microwave sensing module for regulating the solid flow rate.

The laboratory is currently working with A*STAR Institute of Microelectronics (IME) on on-wafer RF metrology to support semiconductor industry.

Comparisons:

- CCEM.RF-P1 Pilot Study on Dielectric Material Measurement, Final Report, published May 2023.
- APMP.EM-K12: APMP Key Comparison of AC-DC Current Transfer Standards. DOI: 10.1088/0026-1394/61/1A/01003, 2024
- CCEM.RF-K26: CIPM Key Comparison of Attenuation at 18 GHz, 26.5 GHz and 40 GHz Using A Step Attenuator. DOI: 10.1088/0026-1394/61/1A/01001, 2024.
- CCEM.RF-K5c.CL: CIPM Key Comparison of Scattering Coefficients by Broad-Band Methods 0.1 GHz - 33 GHz, 3.5 mm connector, Final Report published 2025.
- CCEM-K6c: CIPM Key Comparison of AC-DC Voltage Transfer Standards in the frequency range 1 MHz and 100 MHz, Pending Draft A report.
- CCEM.RF-K28.W: CIPM Key Comparison of RF Power from 18 GHz to 26.5 GHz in Rectangular Waveguide, Pending Draft A report.
- CCEM.RF-K5.d.CL: CCEM Collapsing Star-type Key Comparison in Coaxial Scattering Parameter Measurements 2.4 mm Line System 9 kHz - 50 GHz, Measurements in progress.
- CCEM-K12: CCEM Key International Comparison of AC-DC Current Transfer Standards , scheduled Nov – Dec 2025
- APMP.EM- K5 Key Comparison of Electric Power Standards, scheduled mid 2025.

Training Courses, Seminars and Talks

Date	Courses, Seminars and Talks
15 Aug 23	PT preparation for DC Current measurement
17 Nov 23	RF Measurement and Calibration: General Concept and Practice
6 Dec 23	High Voltage Testing Techniques and Safety Measures
16 Jan 24	DMM Calibrations and the CMC Calculations
1 Feb 24	Precision Resistance Measurement
16 Apr 24	Uncertainty Evaluating in Shot Flow Valve Calibrations
4 Jul 24	ISO/IEC 17025: Accreditation to its 2017 Version
26 Jul 24	RF Measurement and Calibration: General Concept and Practice
25 Nov 24	Electrical measurement uncertainty evaluation and concepts

Participation in International Meetings/Activities

Date	Event
22 May 23	CIPM Briefing on the establishment of a Forum for Metrology and Digitalization
12-15 Jun 23	APMP Mid-year meeting
27-30 Nov 23	APMP TCEM Meeting/Workshops
4 Dec 23	APMP EC-TCC meeting

5 Dec 23	APMP Directors' Workshop
20 Mar 24	BIPM Workshop on Accelerating the Adoption of Quantum Technologies through Measurements and Standards
19 Mar 24	APMP-APAC Workshop on Proficiency Testing
26-28 Jun 24	Peer Review for SNSU-BSN
20-21 Jun 24	Scientific visit to CMS/ITRI
24-28 Jun 24	APMP Mid-year Meeting (Bohol, Philippines)
5-7 Aug 24	Peer review for CMS/ITRI
13-15 Aug 24	Scientific visit to NIST
25-29 Nov 24	APMP TCEM Meeting/Workshops/EC-TCC meeting
16-18 Dec 24	Scientific visit to KRISS
20-22 Jan 25	Peer review for SCL
18-21 Jan 25	Scientific visit to KRISS and NMIJ

Conference Papers / Technical Publications

1. Jing Tao, Thomas Hagen, Steven Yang, Hiroyuki Fujiki, Hyung-Kew Lee, Zhang Jiangtao, Eugene Golovins, Chalit Kumtawee, Muhammad Azwan Bin Ibrahim, and Hsiu-Ju Tsai. "APMP Key Comparison of AC-DC Current Transfer Standards: Final Report." *Metrologia* 61, no. 1A (April 2024): 01003. <https://doi.org/10.1088/0026-1394/61/1A/01003>
2. Rhodes, T. L., W. A. Peebles, Lei Zeng, Valerian Hall-Chen, Kevin Ronald, S. Kubota, Yusong Meng, et al. "Design of a Low Frequency, Density Profile Reflectometer System for the MAST-U Spherical Tokamak." *Review of Scientific Instruments* 95, no. 8 (August 14, 2024): 083528. <https://doi.org/10.1063/5.0219578>