

Report on Electricity and Magnetism Metrology Activities at the Standards and Calibration Laboratory (SCL) Hong Kong, China

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This report gives a brief summary on key activities in the field of electricity and magnetism (EM) at the Standards and Calibration Laboratory (SCL), Hong Kong, China in 2021-2023.

Quantum Metrology

- The laboratory set up a Programmable Josephson Voltage Standard (PJVS) in 2018. The system was upgraded in 2020 to support automated leakage current measurement. The development for stepwise AC measurement was postponed due to the outbreak of COVID-19.

Direct Current

- The development of high current calibration capability up to 400 A was delayed because of late delivery of the high current source arising from the outbreak of COVID-19.
- Accreditation was granted to SCL for calibration of clamp meters over the extended range of 100 A to 400 A using a new current coil.
- A new procedure for calibration of earth fault loop impedance is under development.

Low Frequency and Power

- The laboratory is developing an alternate primary power calibration technique based on digital sampling. The new system will use auto range current transformer and resistive voltage dividers for high precision automated calibration.
- The laboratory will develop an automated AC/DC voltage build up using two new sets of AC/DC thermal voltage convertors.
- The laboratory will develop a procedure for calibration of LCR meters using a new impedance simulator.

RF and microwave

- The laboratory has developed a procedure for calibration of Type N co-axial S-parameter measurement system for frequencies from 10 MHz to 18 GHz using a four port Vector Network Analyser.
- The laboratory is developing 2.4 mm thermocouple type power sensors calibration service for frequencies up to 50 GHz using a new 2.4 mm coaxial microcalorimeter system.
- The laboratory is developing calibration procedure for 3.5 mm coaxial S-parameter measurement system for frequencies from 10 MHz to 26.5 GHz by using a four port Vector Network Analyser.
- The laboratory will develop procedures to use the VNA Tools II for the uncertainty calculation of 2.4 mm coaxial S-parameter measurement system for frequencies from 10 MHz to 40 GHz.
- The laboratory will develop procedures to extend the frequency range of S-parameter measurement capability to 110 GHz. Supported connector types will include 1.85 mm coaxial, 1 mm coaxial and WR-10 waveguide.

EMC/EMI

- The laboratory has developed the following procedures:
 - a. calibration of EMF meters for frequencies up to 90 MHz by using a TEM cell and for frequencies up to 6 GHz by using a GTEM cell;
 - b. calibration of loop antennas in accordance with CISPR 16-1-6:2014-12 Ed. 1.0 + AMD1:2017;
 - c. calibration of ESD simulators over the extended range of 8 kV to 30 kV.

Digitalization

- SCL has participated in the APMP digital transformation focus group (DXFG) and GULFMET digital transformation focus group (DTFG) for the exchange of ideas and learning objectives with peer laboratories.
- SCL keeps track of the latest development on digital calibration certificate (DCC) and created proof-of-concept software demo to generate DCCs from customized Excel and Word files for evaluation purposes.

International Technical Activities

- SCL staff members are serving as APMP TCEM review board members. We have served in the GULFMET intra-RMO CMC review, APMP intra-RMO CMC review and EURAMET/AFRIMET inter-RMO CMC review in 2021.
- SCL is the support group of GULFMET.EM-S8 Comparison of Calibration of Multimeter.

Status of Key and Supplementary Comparisons (in progress/pending for final report approval)

- APMP.EM-K5.1 (Comparison of AC power at 50 Hz/60 Hz)
Measurement completed in May 2012.
- APMP.EM.RF-K8.CL (Calibration factor of power meters)
Measurement completed in Aug 2012.
- APMP.EM-K12 (Comparison of AC-DC Current Transfer Standards)
Measurement completed in April 2014.
- APMP.EM-S8 (Comparison on digital multimeter)
Measurement completed in February 2015.
- GULFMET.EM-S1 (Comparison of Resistance Standards at 100 Ω)
Measure scheduled in March 2017.
- GULFMET.EM-S8 (Comparison of Calibration of Multimeter)
Measurements completed in October 2022.
- APMP.EM-K1.1P (Comparison on Standard Resistors 1 Ω & 10 k Ω)
Measurement scheduled in April 2023.
- CCEM.RF-K28.W (RF power from 18 GHz to 26.5 GHz in rectangular waveguide)
Measurement scheduled in August 2023.

Quality Matters

SCL's management system conforms to ISO/IEC 17025 and ISO/IEC 17043. SCL has been accredited by Hong Kong Accreditation Service (HKAS) under the Hong Kong Laboratory Accreditation Scheme (HOKLAS) for calibration services and proficiency testing services since 1994 and 2015 respectively. The last peer reviews for EM related areas were completed in 2023 (as listed in table below). The recent two biennial peer reviews for EM related areas, which were scheduled for Dec 2020 and Dec 2022, were postponed to mid-2021 and early 2023 respectively due to COVID-19. The following peer reviews were conducted remotely through an online platform.

<u>Areas</u>	<u>Assessors</u>	<u>Date</u>
Direct current, low frequency and high voltage	Dr CHEN Shih-fang (CMS, Chinese Taipei)	February 2023
	Dr LEE Hyung-Kew (KRISS, South Korea)	January 2023
	Dr CHUA Sze-vey (NMC, Singapore)	July 2021
Magnetism	Dr PARK Po-gyu (KRISS, South Korea)	January 2023
	Mr ZHANG Wei (NIM, China)	August 2021
Radio frequency	Dr KANG No-Weon (KRISS, South Korea)	February 2023
	Dr SHAN Yueyan (NMC, Singapore)	August 2021

Up to February 2023, SCL has 66 EM related entries listed in Appendix C of the CIPM MRA.

Publications

- [1] S S L Yang, "Generalized Least Square Analysis in the GULFMET DC Voltage Inter-Laboratory Comparison," CPEM 2022, December 2022.
- [2] H W Lai, W M Ho and S L Yang, "Comparison of Magnetic Antenna Factor of Loop Antennas between Two TEM Cell Characteristic Impedance Evaluation Methods," CPEM 2022, December 2022.
- [3] H W Lai, C K Ma, S L S Yang, C M Tsui, "Calibration of Loop Antennas in Accordance with CISPR 16-1-6:2014+AMD1:2017 at SCL," NCSLI Measure J. Meas. Sci., vol. 14, (1), pp. 24-39, 2022.
- [4] C F Au Yeung, H F Tsang, S S L Yang, C M Tsui, "Calibration of Ultrasonic Flaw Detectors in Accordance with ISO 22232-1:2020," NCSLI Measure J. Meas. Sci., vol. 14, (1), pp. 50-55, 2022.
- [5] H W Lai, C K Ma, S S L Yang, "Comparison of Characteristic Impedance Evaluation Methods for Transverse Electromagnetic (TEM) Cells," NCSLI 2022 Conf., August 2022.
- [6] C F Au Yeung, S L Yang, "Calibration of Oscilloscope Bandwidth using Signal Generator," NCSLI 2022 Conf., August 2022.
- [7] H W Lai, C K Ma, S S L Yang and C M Tsui, "Calibration of Electric Field Probes at the Standards and Calibration Laboratory (SCL)," IEEE APS/URSI 2022, July 2022.
- [8] H W Lai, C K Ma, S L Yang and C M Tsui, "Calibration of Loop Antennas in accordance with CISPR 16-1-6:2014+AMD1:2017", NCSLI 2021 Conf., August 2021.

- [9] C F Au Yeung, H F Tsang, S L Yang and C M Tsui, "Calibration of Ultrasonic Flaw Detectors in accordance with ISO 22232-1:2020", NCSLI 2021 Conf., August 2021.
- [10] S H Wong, S L Yang and C M Tsui, "Automatic Meter Reading using Deep Learning", NCSLI 2021 Conf., August 2021.
- [11] H W Lai, C K Ma, S S L Yang and C M Tsui, "Comparison of Characteristic Impedance Calibration Methods for Transverse Electromagnetic (TEM) Cell at Standards and Calibration Laboratory (SCL)", IEEE APS/URSI 2021, December 2021.
- [12] Régis Chayramy, Steven Yang, Oliver Power and Stephane Solve, "Metrology of Zener-based Secondary Voltage Standards," J. Meas. Sci. Technol., 32, 105019, July 2021.
- [13] H W Lai, C M Tsui, C K Ma and S S L Yang, "Calibration of Line Impedance Stabilization Networks / Artificial Mains Networks in accordance with CISPR 16-1-2 Ed 2.1 2017-11," NCSLI Measure J. Meas. Sci., vol. 13, (4), pp. 22-32, 2021.
- [14] H W Lai, C M Tsui and H W Li, "Computer Aided Verification of Voltage Dips and Short Interruptions Generators for Electromagnetic Compatibility Immunity Test in Accordance with IEC 61000-4-11: 2004 + AMD: 2017," NCSLI Measure J. Meas. Vol. 13 (1), pp. 28 to 39, 2021.

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