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

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Contact:

Post	**Name (Email)**
Head of Laboratory	Mr C M Tsui (cmtsui@itc.gov.hk)
Senior Electronics Engineer	Dr Steven Yang (steven.yang@itc.gov.hk)
Electronics Engineer (DC, HV, Magnetism)	Mr Cliff Wong (cliff.wong@itc.gov.hk)
Electrical and Mechanical Engineer (LF, Impedance, Power)	Dr Kelvin Sin (kelvin.sin@itc.gov.hk)
Electronics Engineer (RF and Microwave)	Dr Terry Lai (terry.lai@itc.gov.hk)

This report gives a brief summary on key activities in the field of electricity and magnetism at the Standards and Calibration Laboratory (SCL), Hong Kong in 2019-2021.

Quantum Metrology

- The laboratory has setup a Programmable Josephson Voltage Standard (PJVS) by NIST in 2018. The system was upgraded in 2020 to support automated leakage measurement, the development for ac measurement which was planned in 2020 was postponed due to the outbreak of COVID-19.
- The laboratory has completed the piloting of an inter-laboratory comparison on 10 V and 1.018 V DC voltages with GULFMET (GULFMET.EM.BIPM-K11) using two Zener voltage reference standards as transfer standards. The linking laboratories are BIPM and KRISS (Korea), and the participating laboratories are EMI (United Arab Emirates), SASO (Saudi Arabia) and IMBIH (Bosnia and Herzegovina). The measurement results were approved for equivalence on 10 September 2020.

Direct Current

- The laboratory has setup an automatic potentiometer system to back up the existing voltage ratio box and DCC potentiometer for DC voltage dissemination.
- The laboratory has developed procedure for the calibration of small DC current sources/ammeters using an ultra-low noise current amplifier system.
- The laboratory has planned to develop high current calibration capability.

Low Frequency and Power

- The laboratory has planned to setup a duplicate multi-junction thermal convertor for automated AC/DC voltage build up.

- The laboratory is in the process of developing an alternate primary power calibration technique which is based on digital sampling. The new system will use auto range current transformer and resistive voltage dividers developed by NMIA for high precision automated calibration.

RF and microwave

- The laboratory is in the process of setting up a new 2.4 mm microcalorimeter system by NIM. The system can calibrate thermocouple type power sensors up to 50 GHz. With this new system, the RF power primary calibration standard will be extended from 18 GHz to 50 GHz in 2021.
- The laboratory has developed procedure for the calibration of RF power amplifiers.
- The laboratory has developed procedure for the calibration of oscilloscopes with rise time down to 300 ps.
- The laboratory has developed procedure for the calibration of oscilloscope calibrators with fast pulse generation and square wave based on digital sampling technique.
- The laboratory will develop procedures to extend the frequency range of S-parameter measurement capability from 40 GHz to 110 GHz. The supported connector types will include coaxial 1.85 mm, coaxial 1 mm and waveguide WR-10.

EMC/EMI

- The laboratory has developed new measurement model for the impedance measurement of Line Impedance Stabilization Networks (LISN) / Artificial Mains Networks (AMN) in accordance with CISPR 16-1-2 Ed 2.1 2017-11.
- The laboratory is the process of developing calibration services of loop antenna in accordance with the CISPR 16-1-6:2014/AMD1:2017.

Medical Testing Equipment

- The laboratory has been working on the calibration of medical testing equipment since 2013, as the local hospitals and medical institutes were looking for traceable calibration of their medical testing equipment. For electrical type medical testing equipment, SCL has developed calibration services for electrical safety analysers, defibrillator analysers and electro-cardio graph (ECG) simulators. The laboratory will continue the calibration service development for electro-surgical analysers (ESA).

Status of Key and Supplementary Comparisons

- APMP.EM-K5.1 (Comparison of AC power at 50 Hz/60 Hz)
    - Measurement completed in May 2012. Draft B report received in Dec 2018. Pending for approval.

- APMP.EM.RF-K8.CL (Calibration factor of power meters)

- Measurement completed in Aug 2012. Draft A report received in April 2019. Pending for draft B report.

- APMP.EM-K12 (Comparison of AC-DC Current Transfer Standards)
  - Measurement completed in April 2014. Draft B report received in July 2019. Pending for approval.

- APMP.EM-S8 (Comparison on digital multimeter)
  - Measurement completed in February 2015. Draft B report received in May 2019. Pending for approval.

- GULFMET.EM.BIPM-K11 (Comparison on 10 V and 1.018 V DC Voltages)
  - Approved for equivalence on 10 September 2020.

- GULFMET.EM.S1 (Comparison of Resistance Standards at 100 Ω)
  - Measurement completed in March 2017. Draft B report received in Nov 2019. Pending for approval.

Publications

[1] H.W. Lai, Michael W. K. Chow and K.Y. Chan, "Calibration of Electrostatic Discharge (ESD) Generator in accordance with IEC61000-4-2: 2008 at SCL," *NCSLI Measure J. Meas. Sci.*, Vol. 12 (3), pp. 32 to 40, 2018. (published online on 7 May 2019)

[2] Steven Yang, Y. C. Chau, "Calibration of Residual Current Device (RCD) Testers," *NCSLI 2019 Conf*, August 2019.

[3] C. M. Tsui, Aaron Y. K. Yan and H. W. Lai, "Speeding up Monte Carlo Computations by Parallel Processing Using a GPU for Uncertainty Evaluation in Accordance with GUM Supplement 2," *NCSLI Measure J. Meas.* Vol. 12 (3), pp. 41 to 56, 2018. (published online on 23 Jan 2020).

[4] Steven Yang, Y. C. Chau, "Calibration of Residual Current Device (RCD) Testers," *NCSLI Measure J. Meas.* Vol. 12 (4), pp. 28 to 37, 2018. (published online on 31 Jan 2020).

[5] 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," accepted by *NCSLI Measure J. Meas.* on 28 Apr 2020.

[6] H. W. LAI, Steven Yang, K. Y. Chan, C. M. Tsui, K. M. Luk, "Conformity Assessment on Antenna Voltage Reflection Coefficient Measurement," *IEEE APS/URSI 2020*, July 2020.

[7] Cliff Wong, Y. N. Yip, Steven Yang, "Comparison of DC Current Generation Systems at Picoampere Level," *NCSLI 2020 Conf.*, August 2020.

[8] H. W. Lai, C. M. Tsui, C. K. Ma, Steven Yang, "Calibration of Line Impedance Stabilization Network / Artificial Mains Network in accordance with CISPR 16-1-2 Ed 2.1 2017-11," *NCSLI 2020 Conf.*, August 2020.

[9] Steven Yang, S. Cular, A. Rüfenacht, C. J. Burroughs, P. D. Dresselhaus, S. P. Benz and M. N. Ng "Direct DC Voltages Comparison between two Programmable Josephson Voltage Standards at SCL," *CPEM 2020*, August 2020.

[10] H. W. Lai, C. M. Tsui, Steven Yang, C. K. Ma, "On Propagation of Uncertainties

through the Measurement Models of Two Calibration Methods for Microwave Power Splitters," *CPEM 2020*, August 2020.
[11] H. W. Lai, C. M. Tsui, C. K. Ma, Steven Yang, "Calibration of Electrical Fast Transient/Burst Generator in Accordance with IEC 61000-4-4 Edition 3.0 2012-04," *CPEM 2020*, August 2020.
[12] Xiaohai Cui, Wenze Yuan, Y. S. Meng, H. W. Lai, Steven Yang, Brandon Lim, "Comparison of Type-N Microcalorimeter Measurements among NIM, NMC and SCL," *CPEM 2020*, August 2020.
[13] Steven Yang, C.M. Tsui, Stephane Solve, Kyu-Tae Kim, Srdan Calija, Jon Bartholomew and Abdullah Alrobaish, "GULFMET key comparison of DC voltage at 1.018 V and 10 V," 2020 *Metrologia* **57** 01012.

International Technical Activities

- SCL staff member has served as peer reviewer in the DC and impedance areas for NMC, Singapore in Nov 2019.
- SCL staff members are serving as APMP and GULFMET TCEM review board members. We have served in the on-going GULFMET intra-RMO CMC review and EURAMET/AFRIMET inter-RMO CMC review in 2021.
- SCL is the pilot laboratory of GULFMET.EM.BIPM-K11 Comparison on 10 V and 1.018 V DC Voltages. The measurement results were approved for equivalence in September 2020.
- SCL is the support group of GULFMET.EM-S1 Comparison of Resistance Standards at 100 Ω. Draft B report was issued in November 2019.

Quality Matters

SCL's management system conforms to ISO/IEC 17025 and ISO/IEC 17043. SCL has been formally accredited by Hong Kong Accreditation Service (HKAS) under the Hong Kong Laboratory Accreditation Scheme (HOKLAS) since 1996 for calibration services and 2015 for proficiency testing services. The last peer reviews for EM related areas were completed in 2018/2019 (as listed in table below) with transition to the latest version of ISO/IEC 17025:2017 led by HKAS. The next peer review schedule for EM related areas were planned in December 2020, however, they were postponed due to the outbreak of COVID-19.

Areas	**Assessors**	**Date**
Direct current, low frequency and high voltage	Dr Murray EARLY (MSL, New Zealand)	10-13 December 2018
Magnetism	Dr Qing HE (NIM, CHINA)	11 December 2018
Radio frequency	Prof Xiaohai CUI (NIM, CHINA)	17-18 January 2019

Up to March 2021, the SCL has 66 EM related entries listed in Appendix C of the CIPM MRA.

-End of report-