

Electrical Cluster contact

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This report highlights key activities in the field of electricity and magnetism at the National Metrology Centre (NMC), Singapore, since the 31st meeting of the CCEM in March 2019.

CIPM MRA Implementation

The calibration and measurement capabilities (CMCs) from the 2015 peer review have been accepted into the KCDB 2.0 after the inter and intra RMO reviews.

NMC's CMC in the DC and low frequency areas were assessed the fourth time by peers in November 2019. The on-site assessments were carried out in accordance to the ISO/IEC 17025 requirements under the framework of the CIPM MRA. The assessment was conducted by following peers led by a quality system assessor from the Singapore Accreditation Council (SAC): Dr. Shao Haiming (NIM, China) for High Voltage and AC quantities and Dr. Steven Yang (SCL, Hong Kong) for DC Quantities and Impedance. NMC's new and revised DC and low frequency areas CMCs are in the process of submission to KCDB 2.0 for inter and intra RMO review. The scheduled on-site peer assessment of the RF and microwave laboratory in January 2020 has been delayed due to the COVID-19 pandemic situation.

Relocation of Laboratories

The electrical metrology laboratories are to be relocated to Singapore's Jurong Innovation District (JID). The JID is home to a manufacturing ecosystem of R&D centres, technology partners, training providers and Factories of the Future.

The COVID-19 pandemic has delayed the completion of the new NMC building and the laboratories will move to the new building in mid 2021. Interim laboratories were set up to continuously provide critical calibration services to the industry during this period.

Electrical DC and Low Frequency Laboratory

- **Voltage**

The laboratory has adjusted the realized and maintained unit of dc voltage in accordance to the Josephson Constant K_J on 20 May 2019.

The laboratory has completed the setup of a new programmable Josephson voltage standard (PJVS) system. The system has been validated against the existing Josephson array primary voltage standard and will be used for realization and dissemination of the SI volt and developmental work in quantum based AC voltage measurement standard.

- **Resistance**

The laboratory has adjusted the realized and maintained unit of resistance in accordance to the von Klitzing Constant R_K on 20 May 2019.

The laboratory has completed a BIPM on-going bilateral comparison on quantum Hall resistance standards and their scaling to other resistance values (BIPM.EM-K12) with the new quantized Hall resistance (QHR) standard and cryogenic current comparator (CCC) resistance bridge. The laboratory has also completed an APMP Technical Committee Initiative project TCI-2014-04-TCEM in collaboration with NMIJ on Pilot Study of the transport behaviour of 100- Ω standard resistors for use in APMP key comparisons.

The laboratory is in discussion with research institutes on collaboration project on graphene based resistance standard as part of A*STAR's Research, Innovation and Enterprise (RIE 2025) Initiatives.

- **Power and Energy**

The laboratory has completed the optimization of the AC-DC voltage and current transfer measurement systems to improve the efficiency of the measurement process. The AC-DC current transfer measurement range has been extended from 20 A to 100 A.

The laboratory has extended the range of dc current shunt measurement capability to 100 A and will be extending the range to 1000 A to support the emerging measurement needs from the transport electrification trend in Singapore.

Work has begun in 2019 to establish calibration of ratio error and phase displacement of current transformer up to 1000 A range. These capabilities are to support energy efficiency related electrical measurements in green building energy efficiency measurement and verification.

- **Industry Metrology Activities**

The laboratory is part of an NMC led green building energy efficiency collaborative project with the industry on self-diagnosis and self-healing indoor air quality sensor network to enhance effectiveness of demand-controlled ventilation. The laboratory is responsible in establishing reliable energy consumption measurement of air-condition unit in the testbed site to assess the energy saving of the proposed system

The laboratory continues on developing new measurement capability to support industry and research institutes on characterisation of dielectric properties of materials. The laboratory is leading an A*STAR collative aerospace project on insulation design of high voltage cables for future aerospace applications. The project draws on the expertise from laboratory's previous aerospace industry projects on dielectric property requirements and measurement in medium voltage power distribution system on board aircraft for use in electrification of aircraft.

RF and Microwave Laboratory

- **RF and Microwave Power**

The laboratory is working on the replacement and upgrading of the Type-N microcalorimeter and related reference standards with a new Type-N Power Measurement system in cooperation with NIM. Validation comparison of the new system against the reference value of the CN mount from the existing microcalorimeter has been completed. A trilateral comparison among NIM, SCL and NMC on primary type-N power measurement system using a thermistor mount has also been conducted.

- **Material Measurements**

The laboratory is working on the development of material measurement system for dielectric properties, and is participating in CCEM pilot study.

- **Industry Metrology Activities**

The laboratory is in collaboration with A*STAR's Advanced Remanufacturing and Technology Centre (ARTC) to develop high flowrate media dosage units based on magnetic and microwave particle sensing technologies for ferrous and non-ferrous media for usage in sandblasting and shot peening processes.

The laboratory is in collaboration with local aerospace industry to develop a radome transmissivity testing system for testing of aircraft radome after repair for conformance to aviation standards.

Comparisons:

- APMP.EM-K12: APMP Key Comparison of AC-DC Current Transfer Standards. Draft B completed.
- BIPM.EM-K13.a: Comparison of 1 Ω resistance standards, Final report published.
- BIPM.EM-K13.b: Comparison of 10 k Ω resistance standards, Final report published.
- BIPM.EM-K12: Quantum Hall resistance standards and their scaling to other resistance values, Draft A in progress.
- Trilateral (NMC, NIM, SCL) comparison of Primary Type-N Power Measurement system Feb to Mar 2019.
- CCEM Pilot Study Dielectric Material Measurement, Jan 2020, measurement completed and results to be submitted.
- CCEM-K6c Comparison of thermal transfer standards scheduled Aug - Oct 2020 (Rescheduled to 2022).

Training Courses, Seminars and Talks

Date	Courses, Seminars and Talks
March 2019	Proficiency Testing on Resistance Measurement at 100 Ω and 10 k Ω for accredited laboratories, <i>Lim Kuan Hoong, Eddie Tan</i>
26 Apr 2019	Industrial Seminar on Resistance Measurement - Challenges & Solutions, <i>Lim Kuan Hoong, Chua Sze Wey</i>
24 May 2019	World Metrology Day 2019 Conference , Metrology for Future of Manufacturing, “The SI Revision - Implementation of the subtle but profound changes“, <i>Chua Sze Wey</i>
8 Oct 2019	Measurement Assurance Program (MAP) course: RF Measurement and Calibration: General Concept and Practice, <i>Meng Yusong</i>
8 Nov 2019	Measurement Assurance Program (MAP) course: Advance in Oscilloscope, <i>Meng Yusong</i>
13 Jul 2020	Managing the Calibration Intervals of Measurement Instruments, <i>Chua Sze Wey</i>
9 Jun 2020	ISO/IEC 17025: Accreditation to its New Version, <i>Jing Tao</i>
2 Dec 2020	Power Sensor Calibration with Uncertainty Evaluation: From Fundamental to Advanced Techniques on 02 Dec 2020, <i>Meng Yusong</i>
10 Feb 2021	Factors to Consider when Evaluating Measurement Uncertainty in Electrical Measurements, <i>Jing Tao</i>
24 Feb 2021	Precision Resistance Measurements, <i>Lim Kuan Hoong</i>
18 Mar 2021	High-frequency Electromagnetic Measurements with Better Confidence, <i>Meng Yusong</i>

Participation in International Meetings/Activities

Date	Event
26-29 Mar 2019	CCEM meeting and the WGLF, GT-RF, WGRMO and the workshop, <i>Meng Yusong</i>
10 Sep 2019	International Conference on Advanced Surface Enhancement (INCASE 2019), Singapore, <i>Meng Yusong</i> .
Aug 2020	Conference on Precision Electromagnetic Measurements (CPEM 2020) virtual conference, <i>Lim Kuan Hoong</i>

22-23 Sep 2020	ASEAN Metrology Expert Group on Metrology meeting (EGM), <i>Chua Sze Wey</i>
30 Oct 2020	Singapore International Energy Week (SIEW) Thinktank Roundtable on UNESCAP Sustainable Connectivity in Asia-Pacific: Cross-border Integration to Support Increased Power System Sustainability and Resilience, <i>Jing Tao</i>
2-27 Nov 2020	APMP General Assembly, TCEM, Energy Efficiency Focus Group, APMP-APAC PT WG on-line meetings, Chua Sze Wey, Meng Yusong, <i>Jing Tao</i>
22-26 Feb 2021	BIPM on-line workshop "The International System of Units (SI), <i>Chua Sze Wey, Meng Yusong, Jing Tao, et.al</i>

Conference / Technical Publications

1. S. Y. Huang, Omkar, Y. Yoshida, A. J. G. Inda, X. Chia, W. C. Mu, **Y. S. Meng**, and W. Yu, "Microstrip line-based glucose sensor for noninvasive continuous monitoring using the main field for sensing and multivariable crosschecking," *IEEE Sensors Journal*, vol. 19, no. 2, pp. 535-547, Jan. 2019.
2. **S. Manandhar**, J. H. Tan, Y. H. Lee, and **Y. S. Meng**, "GPS slant path residuals for rainfall detection," in *Proc. 2019 USNC-URSI Radio Science Meeting (Joint with AP-S Symposium)*, Atlanta, Georgia, Jul. 2019, pp. 109-110.
3. F. Yuan, Y. H. Lee, **Y. S. Meng**, **S. Manandhar**, and J. T. Ong, "High-resolution ITU-R cloud attenuation model for satellite communications in tropical region," *IEEE Transactions on Antennas and Propagation*, vol. 67, no. 9, pp. 6115-6122, Sep. 2019.
4. **Y. S. Meng**, K. Ahluwalia, M. Ang, M. A. Shukri, A. Goh, C. Lee, and K. H. Tan, "Investigation of microwave sensor application on conventional shot peening media dosage unit," In *Conference Book of 1st International Conference on Advanced Surface Enhancement (INCASE 2019)*, Singapore, Sep. 2019, pp. 110.
5. **S. Manandhar**, S. Dev, Y. H. Lee, **Y. S. Meng**, and S. Winkler, "A data-driven approach for accurate rainfall prediction," *IEEE Transactions on Geoscience and Remote Sensing*, vol. 57, no. 11, pp. 9323 - 9331, Nov. 2019.
6. **S. Manandhar**, S. J. J. Ang, Y. H. Lee, and **Y. S. Meng**, "Seasonal water vapor pressure models for cloud detection," in *Proc. 2019 Asia-Pacific Microwave Conference (APMC)*, Singapore, Dec. 2019.
7. Xiaohai Cui, **Yusong Meng**, Wenze Yuan, and Yong Li, "Theoretical Analysis and Determination of the Correction Factor for a Waveguide Microcalorimeter," *Sensors*, vol. 20, no. 1, 245, Jan. 2020.
8. Kalyankar Shravan Kumar, Yee Hui Lee, and **Yusong Meng**, "Spectrum Survey in 2.4 GHz ISM Band for a MRT Station Located in Singapore," 2020 IEEE International Symposium on Antennas and Propagation and North American Radio Science Meeting, 5-10 July 2020, Montréal, Québec, Canada, pages 75-76.
9. **Shilpa Manandhar**, Yee Hui Lee, and **Yusong Meng**, "Importance of Hydrostatic Delay Models in Deriving PWV from GPS Signal Delays," 2020 IEEE International Symposium on Antennas and Propagation and North American Radio Science Meeting, 5-10 July 2020, Montréal, Québec, Canada, pages 155-156.
10. **Lim Kuan Hoong**, Takehiko Oe, **Chua Sze Wey**, and Nobu-hisa Kaneko, "Pilot Study on Transport Behaviour of 100- Ω Standard Resistors for Use in APMP Key Comparisons," Conference on Precision Electromagnetic Measurements (CPEM 2020), Aug, 2020.
11. Wenze Yuan, **Yusong Meng**, Hau Wah Lai, Steven Shing Lung Yang, Brandon Wee Siong Lim, and Xiaohai Cui, "Comparison of Type-N Microcalorimeter Measurements among NIM, NMC and SCL," Conference on Precision Electromagnetic Measurements (CPEM 2020), Aug. 2020.
12. Kalyankar Shravan Kumar, Yee Hui Lee, and **Yusong Meng**, "Two-Slope Path Loss Model for Curved-Tunnel Environment With Concept of Break Point," *IEEE Transactions on Intelligent Transportation Systems*, Accepted, 202, DOI 10.1109/TITS.2020.3012724