Report on Electricity and Magnetism Metrology Activities at the National Metrology Centre (NMC), Singapore
For the CCEM 31st meeting (2019)

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This report highlights key activities in the field of electricity and magnetism at the National Metrology Centre, Singapore, since the 30th meeting of the CCEM.

Electrical DC and Low Frequency Laboratory

- *Voltage*

  A new programmable Josephson Voltage Standard system has been installed in the electrical metrology laboratory. Apart for generating dc voltage steps and stepwise AC waveforms in kHz range, the system is capable to be used as a quantum voltmeter for applications such as low frequency AC-DC difference, ratio, resistance and impedance measurements. The laboratory is currently working on the performance verification of the new system against the existing Josephson Voltage System.

- *Resistance*

  The laboratory has completed setting up of a new quantized Hall resistance (QHR) standard and cryogenic current comparator (CCC) resistance bridge after resolving the system problems and rectified the faults. We are currently reinstating the scaling arrangement of the resistance standards to trace to the QHR. The laboratory has completed comparison measurements for BIPM.EM.K13a and BIPM.K13b to verifying the scaling of the resistance. The BIPM.EM.K12 is scheduled to be held in March 2019. The laboratory is working with NMIJ on the APMP TC Initiative project TCI-2014-04-TCEM to study the transport characteristic of the ultra-stable 100 Ω resistors using the new QHR and CCC system.

- *AC-DC Difference, Power and Energy*

  The laboratory is working on optimizing the AC-DC voltage transfer measurement systems to improve the efficiency of the measurement process with the aim of reducing the measurement uncertainty and measurement time. The optimized system will also be used on the AC-DC current transfer system to extend the AC-DC current difference scaling from 20 A to 100 A.

  The calibration and measurement capabilities of power and energy has been upgraded to three phase 100 A range. This upgrade includes capabilities in measurement and calibration of power quality parameters and verification of phasor measurement unit (PMU). 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, smart grid condition monitoring applications, and advance manufacturing preventative condition monitoring. The laboratory is currently embarking research projects with industry on projects in green building energy efficiency monitoring and quality assessment of energy measurement data.

  The laboratory continues on developing new measurement capability to support industry and research institutes on characterisation of dielectric properties of materials. The laboratory has

started an aerospace industry project to review the dielectric property requirements in medium voltage power distribution system on board airplanes for use in electrification of aircraft.

RF and Microwave Laboratory

- *Works on RF and Microwave Power*

  The laboratory is working on the replacement and upgrading of a Type-N microcalorimeter and related reference standards. The existing Type-N Power Measurement system from NIST is going to retire due to aging problem; and a new Type-N Power Measurement system from NIM is obtained. The laboratory is carrying out the transfer of reference value of the CN mount from the old microcalorimeter to the new microcalorimeter. A performance comparison with a thermistor mount is also conducted.

- *Works on Material Measurements*

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

Comparisons:

- BIPM.EM-K13.a: Comparison of resistance standards (Resistance: 1 Ω) Dec 2018
- BIPM.EM-K13.b: Comparison of resistance standards (Resistance: 10 kΩ) Dec 2018
- BIPM.EM-K12: Quantum Hall resistance standards and their scaling to other resistance values, Mar 2019
- Tri-lateral (NMC, NIM, SCL) comparison of Primary Type-N Power Measurement system Feb to Mar 2019
- CCEM Pilot Study on Dielectric Material Measurements Mar 2019
- CCEM-K6c Intercomparisons of thermal transfer standards Aug – Oct 2020

Training Courses, Seminars and Talks

Date	Courses, Seminars and Talks
21 May 2018	Module on Power Measurement for Measurement & Verification of Central Chilled-Water Plant Efficiency
27 Aug 2018	Module on Power Measurement for Measurement & Verification of Central Chilled-Water Plant Efficiency

Participation in International Meetings/Activities

Date	Event
9-12 Apr 2018	Chua Sze Wey conducted CIPM MRA Peer Review of electrical DC and impedance quantities for MSL organised by IANZ (New Zealand)
7-13 Jul 2018	Meng Yusong attended 2018 Conference on Precision Electromagnetic measurements (CPEM 2018),Power and Energy Experts Meeting, and CCEM WGRMO Meeting
23-28 Nov 2018	Chua Sze Wey, Jing Tao, Shan Yueyan, and Meng Yusong attended 2018 Asia Pacific Metrology Programme (APMP) TCEM meeting and workshop

Conference Papers / Technical Publications

1. Louis Marais, Steven Yang, Brenda Lam, Liu Yue , Thomas John , P S Negi, Hiroaki Sakuma ,Eiji Watabe , Chua Sze Wey , Chalit Kumtawee, Yaowaret Pimsut," Comparison of standards for the calibration of voltage, current and resistance meters", *Metrologia*, Volume 55, Technical Supplement, 01005, 2018

2. S. Manandhar, Y. H. Lee, Y. S. Meng, F. Yuan, and J. T. Ong, "GPS-derived PWV for rainfall nowcasting in tropical region," *IEEE Transactions on Geoscience and Remote Sensing*, vol. 56, no. 8, pp. 4835-4844, Aug. 2018.

3. F. Yuan, Y. H. Lee, Y. S. Meng, and J. T. Ong, "Characterization of dual-polarized radar data for the convective rain melting layer detection in a tropical region," *Remote Sensing*, vol. 10, no. 11, Nov. 2018.

4. Y. Zhang, F. Nian, G. Yuan, B. Yang, Y. S. Meng, C. Xu, Z. He, X. Guo, and S. Liang, "Removing random phase contributions of sweeping local oscillator from modulated RF measurements," *IEEE Transactions on Microwave Theory and Techniques*, vol. 66, no. 12, Dec. 2018

5. S. Kumar, Y. H. Lee, and Y. S. Meng, "Radio-wave propagation in tunnel structures at ISM band: A preliminary study," 2018 *IEEE International Conference on Intelligent Rail Transportation* (IEEE ICIRT 2018), Singapore, Dec. 2018.

6. Y. S. Meng and Y. Shan, "Note on handling source mismatch in RF power measurement and metrology," 2018 *Conference on Precision Electromagnetic Measurements*, Paris, France, Jul. 2018.

7. Y. S. Meng, J. Deng, and Y. Shan, "Traceable site-VSWR measurements for validating anechoic chamber," 2018 *Conference on Precision Electromagnetic Measurements*, Paris, France, Jul. 2018.

8. W. Yuan, X. Cui, Y. Li, and Y. S. Meng, "Development of a WR-6 waveguide microcalorimeter for thermoelectric power sensor," 2018 *Conference on Precision Electromagnetic Measurements*, Paris, France, Jul. 2018.

9. Y. Huang, W. Yuan, X. Cui, Y. S. Meng, and Y. Li, "WR-42 waveguide microcalorimeter for thermistor mount calibration," 2018 *Conference on Precision Electromagnetic Measurements*, Paris, France, Jul. 2018.

10. S. Manandhar, S. Dev, Y. H. Lee, and Y. S. Meng, "Analyzing solar irradiance variation from GPS and cameras," 2018 *USNC-URSI Radio Science Meeting* (Joint with AP-S Symposium), Boston, Massachusetts, Jul. 2018, pp. 93-94.

11. S. Manandhar, S. Dev, Y. H. Lee, and Y. S. Meng, "On the importance of PWV in detecting precipitation," 2018 *USNC-URSI Radio Science Meeting* (Joint with AP-S Symposium), Boston, Massachusetts, Jul. 2018, pp. 89-90.

12. F. Yuan, Y. H. Lee, S. Manandhar, and Y. S. Meng, "Investigation of melting layer for convective rain in tropical region," 2018 *USNC-URSI Radio Science Meeting* (Joint with AP-S Symposium), Boston, Massachusetts, Jul. 2018, pp. 87-88.

13. S. Manandhar, Y. H. Lee, Y. S. Meng, F. Yuan and S. Dev, "A potential low cost remote sensing using GPS derived PWV," 2018 *IEEE International Geoscience and Remote Sensing Symposium*, Valencia, Spain, Jul. 2018, pp. 903-906.

14. S. Manandhar, S. Dev, Y. H. Lee, S. Winkler, and Y. S. Meng, "Systematic study of weather variables for rainfall detection," 2018 IEEE *International Geoscience and Remote Sensing Symposium*, Valencia, Spain, Jul. 2018, pp. 3035-3038.

15. S. Manandhar, S. Dev, Y. H. Lee, Y. S. Meng, and S. Winkler, "A data-driven approach to detect precipitation from meteorological sensor data," 2018 *IEEE International Geoscience and Remote Sensing Symposium*, Valencia, Spain, Jul. 2018, pp. 3880-3883.

16. Y. H. Lee, S. Manandhar, Y. S. Meng, and K. S. Kumar, "Accuracy assessment of MODIS derived precipitable water vapor," (Invited), 2018 IEEE 7th *Asia-Pacific Conference on Antennas and Propagation*, Auckland, New Zealand, Aug. 2018., pp. 554-555.

17. S.W. Chua, " Reinstatement of primary resistance standard at NMC and progress report on the transport behaviour of 100-Ω standard resistors pilot study", Presented at the *APMP TCEM Workshop on DC and Quantum Standards*, 23 Nov 2018, Singapore.

18. J.Tao, " Encapsulation of High Power Semiconductor Devices: Design and Performance Determination", Presented at the *APMP TCEM Workshop on Metrology for Industry*, 23 Nov 2018, Singapore.

19. S.W. Chua, "Measurements for Green Building", Presented at the *APMP Focus Group on Energy Efficiency's Metrology for Energy Workshop*, 24 Nov 2018, Singapore.

20. B.Lim, Y.S. Meng, I.Teo, " Microwave Primary Power Measurement :Microcalorimeter System, Transfer of Reference Values and Performance Comparison", Presented at *the APMP TCEM Workshop on New Trends in RF Metrology and Measurements*, 27 Nov 2018, Singapore.

21. V. Chidambaram, T. Jing, R.B. Yang, M. Shakerzidah, K.H. Lim, "Novel Solution for High Temperature Dielectric Application to Encapsulate High Voltage Power Semiconductor Devices*", IEEE Transactions on Components, Packaging and Manufacturing Technology*, 2019, vol 9, issue 1, pp. 3-9.