This report highlights key activities in the field of electricity and magnetism at the National Metrology Centre, Singapore, since the 29th meeting of the CCEM.

**Electrical DC and Low Frequency Laboratory**

- **Resistance**

  The laboratory is in the process of re-establishing the quantized Hall resistance (QHR) standard and cryogenic current comparator (CCC) resistance bridge to realize the unit of ohm. The CCC resistance bridge is based on NPL (UK)’s dual SQUID detectors design for both the current and voltage balance. Work is currently on evaluating the system performance and improving its immunity to interference from the surrounding. The laboratory will be optimising its resistance scaling arrangement based on the re-established reference resistance and to seek comparisons to validate the QHR system performance.

- **AC-DC Transfer and AC Quantities**

  The laboratory has completed piloting the second loop of APMP key comparison of AC-DC current transfer standards (APMP-EM K12) using 10 mA PMJTC and 5 A coaxial current shunt. Draft A of the comparison report is currently in progress.

  The laboratory is working with government agencies and industry to support energy efficiency related electrical measurements and knowledge transfer for green building energy efficiency measurement and verification and smart grid condition monitoring applications.

- **Electrical Characterisation of Devices and Materials**

  The laboratory has set up measurement system for electrical characterisation of MEMS and semiconductor devices. The system is capable of performing DC parametric and high frequency spectrum impedance measurements. The measurement capabilities are available to semiconductor and electronics industry, as well as research institutes to cater their needs in precision small signal and impedance spectroscopy characterisation measurements for devices and materials from DC to 3 GHz. Work is currently on determining the residual parameters of capacitance standards to extrapolate the maintained 1 kHz reference capacitance values to high frequency to provide the traceability of measurement for the impedance spectroscopy measurement system.

  The laboratory is also working on developing new measurement capability to support industry and research institutes on characterisation of electrical strength, dielectric permittivity, and loss angle of materials. The work is a follow up development of an NMC led A*STAR collaboration aerospace project to develop high temperature dielectric material for encapsulating high voltage power semiconductor devices. The laboratory is to start another aerospace project on the medium voltage power distribution system on board airplanes.
The laboratory has established a new characterisation service to evaluate low energy high voltage impulses from conducted energy devices such as stun guns to support the government regulatory agency. Such devices are hazardous or fatal and are regulated under the national Firearm Act.

- **Proficiency Test**

  A proficiency test (PT) on digital multimeter DC parameters was conducted as part of NMC’s on-going Measurement Assurance Programme for the industry in 2016. The PT adopted DC parameters and test values of the APMP-EM-S8 Supplementary Comparison on DMM.

**RF and Microwave Laboratory**

Under A*STAR’s Technology for Enterprise Capability Upgrading (T-UP) scheme that directly assists small and medium enterprise (SME) innovate and develop new capabilities and knowledge to increase their productivity and competitiveness, Dr Meng Yusong, Scientist from the RF and Microwave Laboratory was attached to a local SME company to help the development of a high speed portable network analyser. A measurement method using mixed-mode S-parameters was developed to achieve the metrological traceability to SI units and allowed the company to obtain an ETL certification with Level V accuracy specifications up to 1000 MHz. The attachment also helped the company to propose revisions to current cabling standard of Telecommunications Industry Association (TIA) such as measurement error models. The work also enabled the company to produce the first instrument in the world capable of certifying 40 Gbps Ethernet copper cabling systems.

**Comparisons:**

- APMP.EM-K3: Key Comparison on 10 mH Inductance. Schedule to be confirmed.
- APMP.EM-S10: Supplementary Comparison on 100 mH. Schedule to be confirmed.
- APMP.EM-K1.1: Key Comparison on DC resistance; 1 Ω and 10 kΩ. Schedule to be confirmed.

**Training Courses, Seminars and Talks**

<table>
<thead>
<tr>
<th>Date</th>
<th>Courses, Seminars and Talks</th>
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<tbody>
<tr>
<td>3-4 Mar 2015</td>
<td>High Voltage Measurement and Testing Techniques</td>
</tr>
<tr>
<td>18 May and 28 Sep 2015</td>
<td>Power Measurement module for Measurement &amp; Verification of Central Chilled-Water Plant Efficiency</td>
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<tr>
<td>8-9 Oct 2015</td>
<td>Estimation of Uncertainty in Electrical Measurement</td>
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<tr>
<td>25-26 Nov 2015</td>
<td>Measurement Using Data Logger</td>
</tr>
<tr>
<td>20-21 Jan 2016</td>
<td>Power Measurement for Energy Efficiency Monitoring</td>
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</tbody>
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25-28 April 2016 | Training in RF and Microwave Metrology (Measurement of power and signal parameters)
---|---
5-6 May 2016 | Course on Digital Multimeters and their Calibration
10 May 2016 | Basic RF Metrology: Fundamentals and Uncertainty
25 Jul and 1 Nov 2016 | Course on Power Measurement module for Measurement & Verification of Central Chilled-Water Plant Efficiency
24 Aug 2016 | Industry Talk on Calibration and Testing of Phasor Measurement Unit to meet IEEE standard
25 Aug 2016 | Course on High Voltage Generation and Stun Device Tests
2 Sep 2016 | Course on Uncertainty Evaluation in Electrical Measurement
20 Oct 2016 | Course on Measurement Using Data Logger

### Participation in International Meetings/Activities

<table>
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<tr>
<th>Date</th>
<th>Event</th>
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<tbody>
<tr>
<td>2-6 Feb 2015</td>
<td>Dr Jing Tao conducted peer review of NRC</td>
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<tr>
<td>9-13 Mar 2015</td>
<td>Dr Jing Tao attended CCEM and its working groups meetings</td>
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<tr>
<td>1-3 July 2015</td>
<td>Dr Meng Yusong attended 2015 IEEE 4th Asia-Pacific Conference on Antennas and Propagation</td>
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<tr>
<td>29 Oct 2015</td>
<td>Regional Workshop on Measurement Challenges in Renewable Energy and Climate Science (RECS)</td>
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<tr>
<td>1 Nov 2015</td>
<td>APMP Focus Group for Energy Efficiency (EEFG) meeting</td>
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<tr>
<td>2-3 Nov 2015</td>
<td>APMP TCEM meeting and Workshop</td>
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<tr>
<td>18 to 21 May 2016</td>
<td>Dr Meng Yusong attended 2016 Asia-Pacific International Symposium on Electromagnetic Compatibility</td>
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<tr>
<td>13 to 17 June 2016</td>
<td>Dr Meng Yusong attached to GE’s Jack Welch Technology Centre in Bangalore, India</td>
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<tr>
<td>10 to 15 July 2016</td>
<td>Dr Meng Yusong attended 2016 Conference on Precision Electromagnetic Measurements (CPEM 2016)</td>
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<tr>
<td>10 July 2016</td>
<td>Dr Meng Yusong attended Informal Meeting of the APMP TCEM before CPEM2016</td>
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<tr>
<td>10 July 2016</td>
<td>Dr Meng Yusong attended CCEM Working Group of Regional Metrology Organisations (WG-RMO) before CPEM2016</td>
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<tr>
<td>14-15 Nov 2016</td>
<td>APMP TCEM meeting and Workshop</td>
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<tr>
<td>7-9 Dec 2016</td>
<td>Dr Shan Yueyan conducted peer review of NIMT on RF area</td>
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### Conference Papers / Technical Publications


S. Cui and Y. S. Meng, Equivalent input noise measurement and its associated measurement uncertainties for MEMS microphones, *2015 XXI IMEKO World Congress “Measurement in Research and Industry”*, Prague, Czech Republic, Aug.-Sep. 2015


X. Cui, Y. S. Meng, Y. Shan, W. Yuan, C. Ma, and Y. Li, Evaluation and validation of a national WR-15 (50 to 75 GHz) power measurement system, *2014 84th ARFTG Microwave Measurement Conference (ARFTG)* Digest, Boulder, CO, USA, Dec. 2014.


X. Cui, Y. S. Meng, Y. Shan, and Y. Li, Microwave power measurements: standards and transfer techniques, New *Trends and Developments in Metrology*, Chapter 1, pp. 3-20, InTech, DOI: 10.5772/60442, Jul. 2016.


