



## Report on Electricity and Magnetism Metrology Activities at the National Metrology Centre (NMC), A\*STAR, Singapore

For the CCEM 33<sup>rd</sup> meeting (2023)

*Electromagnetics and Time Metrology 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 32<sup>nd</sup> meeting of the CCEM in April 2021.

### **Relocation of Laboratories**

NMC has been relocated to CleanTech 3 at the Singapore's Jurong Innovation District (JID) in mid 2022. The JID is part of a growing ecosystem of R&D centres, technology partners, training providers and Factories of the Future set to bring Singapore's advanced manufacturing sector to new heights.

Due to the COVID-19 pandemic that delayed the completion of the new buildings at CleanTech 3, interim laboratories were set up to provide critical calibration services to the industry before the laboratories were moved into the new laboratory building.

The laboratories at CleanTech 3 are currently in the process of commissioning the equipment and measurement systems to resume operation.

### **Digitalisation**

NMC is currently working on digitalisation initiatives proposal aiming for operation cost and value optimization. The initiatives cover areas in (1) digitalizing and automating for better interactions among NMC's customer support team, customers, and the laboratories for calibration and measurement services (CMS), (2) an enhanced Job Management System to perform diverse data analysis and management of CMS, (3) an intelligent laboratory environmental conditions monitoring system with performance assessment of the sensors and data quality management for use in calibration and measurement activities; (4) digitalisation and automation of measurement data processing for a higher efficiency and productivity of CMS and better maintenances of the existing measurement equipment, and (5) digitalisation of calibration report generation and approval process. Feasibility trial on digital calibration certificate (DCC) has been initiated at NMC to assess the requirements and implementation issues.

NMC is working on developing data-driven calibration algorithm and its applications in different scenarios for traceability dissemination in sensor networks.

### **CIPM MRA Implementation**

The DC and low frequency calibration and measurement capabilities (CMCs) from the 2019 peer review have been accepted and published at the KCDB 2.0 after the inter and intra RMO reviews.

### **DC and Low Frequency Laboratory**

The laboratory has completed an Operation and Technology Roadmap (OTR) for electrical quantum standards. Collaborative capability development project with National University of Singapore (NUS) and A\*STAR's Institute of Material Research (IMRE) on graphene-based resistance standards and overseas NMIs and BIPM study visits were carried to refine the OTR focus and strategy to link to the Singapore National Quantum Strategy framework.

The laboratory is working on metrology capabilities for electrification such as performance evaluation of energy storage battery and electric vehicle charging infrastructure. The laboratory is currently working with the A\*STAR Advanced Remanufacturing and Technology Centre (ARTC) on performance evaluation for Lithium battery for second life applications.

NMC has completed a 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 the building air-condition unit in the testbed site to assess the energy saving of the proposed system.

An NMC led A\*STAR collaborative aerospace project on insulation design of high voltage cables for future aerospace applications is near completion. The project draws on the expertise from the 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.

Work is currently carried out to reinstate measurement systems in the new laboratories and the laboratory will continue the work to extend the range of current measurement capabilities to 1000 A to support the emerging measurement needs from the transport electrification trend in Singapore.

### **RF and Microwave Laboratory**

The laboratory has completed a collaboration project with an aircraft maintenance, repair and overhaul (MRO) company to develop a cost effective radome transmissivity testing system for testing aircraft radome after repair for conformance to aviation standards. The project also included measurement capability development for the company to achieve accreditation of their services.

The laboratory has completed an A\*STAR collaboration project to develop magnetic and microwave particle sensing technologies for use in high flowrate media dosage measurement for ferrous and non-ferrous media. The work has led to a patented working prototype for high flowrate ferrous media dosage measurement unit for use for flow rate measurement in sandblasting and shot peening processes for aerospace, automotive and marine industries, precision powder dosage unit for Additive Manufacturing (AM) industry and Fast-Moving Consumer-Goods (FMCG) industry.

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### **Comparisons:**

- APMP.EM-K12: APMP Key Comparison of AC-DC Current Transfer Standards. Report Draft B submitted.
- CCEM Pilot Study Dielectric Material Measurement, pending Draft A report

- CCEM.RF-K26: CIPM Key Comparison of Attenuation at 18 GHz, 26.5 GHz and 40 GHz using a step attenuator, Draft A report
- CCEM.RF-K5c.CL: CIPM Key Comparison of Scattering Coefficients by Broad-Band Methods 0.1 GHz - 33 GHz, 3.5 mm connector, Draft B report
- CCEM-K6c: CIPM Key Comparison of AC-DC Voltage Transfer Standards in the frequency range 1 MHz and 100 MHz, scheduled 4 Sep - 12 Nov 2022 (Rescheduled to 2023)
- CCEM.RF-K28.W: CIPM Key Comparison of RF Power from 18 GHz to 26.5 GHz in Rectangular Waveguide, 2023-2024

### **Training Courses, Seminars and Talks**

<b>Date</b>	<b>Courses, Seminars and Talks</b>
9 Apr 2021	High Voltage Testing Techniques and Safety Measures
8 Jun 2021	Training on the operation and maintenance of Radome Transmissivity Testing Tool
3 Aug 2021	Uncertainty Evaluation in Electrical Measurements
18 Aug 2021	Uncertainty Evaluation in High Frequency Metrology
23, 27 Sep 2021	Training on RF Calibration and Measurement for Aerospace Industry
5 Oct 2021	Metrological Traceability of Measurement Results, Singapore Accreditation Council Assessors Enclave 2021
11, 19 Nov 2021	Training on Digital Multimeters (DMM) Calibration Services
24-28 Jan 2022	Training on welding machine calibrations
8 Feb 2022	A*STAR-NPL Joint Workshop on Quantum Metrology
10 May 2022	ISO/IEC 17025: Accreditation to its 2017 Version
8 Sept 2022	RF Measurement and Calibration: General Concept and Practice
18 Oct 2022	Advance in Oscilloscope
20-22 Sep 2022	Calibration of Digital Multimeters and the Uncertainty Evaluation
8 Nov 2022	Quality Assurance (operation and maintenance) of Radome Transmissivity Testing Tool

### **Participation in International Meetings/Activities**

<b>Date</b>	<b>Event</b>
22-26 Feb 2021	BIPM -The International System of Units (SI) in FAIR digital data
29 Mar 2021	KCDB 2.0 Technical Exchanges
6,7, 8,13, 14, 15 Apr 2021	Meetings of Consultative Committee on Electricity and Magnetism (CCEM) and its working groups: WGRMO, WGLF and GTRF
6 May 2021	JCGM Workshop: An overview of the VIM 4
20 May 2021	World Metrology Day Singapore 2021
2,3 Jun 2021	EURAMET Quantum and DC
30 Aug to 3 Sep 2021	IMEKO 2021 Conference and World Congress IMEKO TC25 - Advances and Directions in Quantum Metrology
22 Nov 2021	Technical meeting on Kibble balance
8 Feb 2022	A*STAR-NPL Joint Workshop on Quantum Metrology
7-15 Mar 2022	Study Visit to NPL and PTB
20 May 2022	World Metrology Day Singapore 2021

20-21 Jun 2022	Peer Review Electrical Labs of KRISS
29 Jun 2022	APMP Metrology for Digital Transformation Workshop
24 Aug 2022	APMP “SI units: Practical realizations and how to assure measurement traceability” for Electrical quantity
15 Sep 2022	CCEM Webinar on 'The CCEM strategy 2020-2030 and the future of electromagnetic metrology'
23-30 Sep 2022	Study Visit to BIPM, PTB, NPL (University of Strathclyde)
26 Oct 2022	Visit by EMI
7 Nov 2022	APMP-APAC PT Working Group Meeting
11 Nov 2022	DEC-MEDEA Workshop on "Leading your NMI to 2035"
14 Nov 2022	APMP EEFG Workshop and Meeting
24-25 Nov 2022	APMP TCEM Meeting
1 Dec 2022	CCEM GTRF Informal Meeting
26 Jan 2023	CCEM Webinar on 'The evolution of voltage metrology to the latest generation of Josephson voltage standards'

### **Conference / Technical Publications**

1. Pierre Gournay, Benjamin Rolland, Sze Wey Chua, Kuang Hoong Lim and Eddie Tan Boon Teck, “On-site comparison of Quantum Hall Effect resistance standards of the NMC A\*STAR and the BIPM: Ongoing key comparison BIPM.EM-K12”, Metrologia, Volume 58, Number 1A, 8 October 2021.
2. S. Manandhar, Y. S. Meng, and Y. H. Lee, “Investigation on the relation between zenith total delay and atmospheric particulate matter (PM2.5),” in Proc. 2021 IEEE International Symposium on Antennas and Propagation and USNC-URSI Radio Science Meeting, Singapore, Dec. 2021.
3. Chua Sze Wey, Kuan Eng Johnson Goh, Andrew T.S. Wee, Calvin Pei Yu Wong, Zhang Lei, and Han Xuanding, Graphene based Quantized Hall Resistance Standard, A\*STAR's Quantum Newsletter vol 1, Issue 10, 1 Aug 2022.