Report to the 31st meeting of the Consultative Committee for Electricity and Magnetism (CCEM) on NIS Activities and Research Development in the Field of Electricity and Magnetism from March 2017 to March 2019

By

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In this report, a brief description of NIS activities and research development in the field of electricity and magnetism during the period from March 2017 to March 2019 is presented.

1. Published CMCs
In October 2017, the following CMCs had been published on the BIPM website: [https://kcdb.bipm.org/appendixC/country_list_search.asp?CountSelected=EG&type=EM](https://kcdb.bipm.org/appendixC/country_list_search.asp?CountSelected=EG&type=EM)

<table>
<thead>
<tr>
<th>Calibration or Measurement Service</th>
<th>Measured Level or Range</th>
<th>Measurement Conditions/Independent Variable</th>
<th>Expanded Uncertainty</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>DC resistance standards and sources:</strong> Intermediate values</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Fixed resistor</strong></td>
<td>Potentiometer ratio bridge</td>
<td>1.00E+06 to 1.00E+06 Ω</td>
<td>Applied voltage</td>
</tr>
<tr>
<td><strong>Temperature</strong></td>
<td>25 °C to 35 °C</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>DC resistance standards and sources:</strong> High values</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Fixed resistor</strong></td>
<td>Potentiometer ratio bridge</td>
<td>1.00E+07 to 1.00E+08 Ω</td>
<td>Applied voltage</td>
</tr>
<tr>
<td><strong>Temperature</strong></td>
<td>20 °C to 35 °C</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>DC voltage sources:</strong> Single valves</td>
<td><strong>DC solid state voltage standard</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>DC current sources:</strong> Low values</td>
<td><strong>Standard Capacitor, Voltage Source, High Resistance Standard</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Capacitance, low-loss capacitors:</strong></td>
<td>Fused Silica Capacitors</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Frequency</strong></td>
<td>1000 Hz, 1592 Hz</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>AC/DC current transfer difference:</strong></td>
<td><strong>AC/DC transfer standard plus shunt</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The BIPM key comparison database, October 2017

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2. Comparisons

2.1 Final report on Bi-Lateral capacitance comparisons, BIPM.EM-K14.a and b, had been published:
http://iopscience.iop.org/article/10.1088/0026-1394/54/1A/01008

2.2 Final report on comparison of attenuation and reflection measurements for coaxials at 100 MHz, 1 GHz and 10 GHz – Type N Connector, AFRIMETS.EM.RF-S1, had been published:
https://iopscience.iop.org/article/10.1088/0026-1394/56/1A/01003/meta

2.3 Final Report on COOMET Key Comparison of Power, COOMET.EM-K5, is under review.

2.4 Draft B of AFRIMETS.EM-S1 supplementary comparison, resistance standards at 1 Ω, 10 Ω, 100 Ω, 1 kΩ and 10 kΩ, had been finished.

2.5 Draft B of the Bi-Lateral Comparison of 50/60 Hz Energy, SIM.EM-S14, had been finished.

2.6 Draft A of the Digital Multi-meter Comparison, P1-APMP.EM-S8, had been finished.

3. Projects

Summary for 15RPT01 RFMicrowave project, “Development of RF and microwave metrology capability”, has been issued in October 2018.

4. Activities with the AFRIMETS

4.1 Prof. Dr. Mohammed Helmy Abd El-Raouf, Vice Chair of AFRIMETS TCEM, participated in two meetings of AFRIMETS technical committee for electricity and magnetism (TCEM):

4.2 Comparisons with the AFRIMETS

NIS is contributing in the following comparisons plan that were approved by the AFRIMETS TCEM:

<table>
<thead>
<tr>
<th>Year</th>
<th>Identifier</th>
<th>Description</th>
<th>Participants</th>
<th>Pilot</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015</td>
<td>AFRIMETS.EM-S1</td>
<td>DC resistance at 1 Ω, 10 Ω, 100 Ω, 1 kΩ and 10 kΩ</td>
<td>NMISA, LPEE/LNM, DEF-NAT, KEBS, NIS, UNBS, NMIE</td>
<td>NMISA</td>
<td>Draft B had been issued</td>
</tr>
<tr>
<td>2017</td>
<td>AFRIMETS.EM.RF-S1</td>
<td>RF attenuation</td>
<td>NMISA, NIS, DEF-NAT</td>
<td>NMISA</td>
<td>Final report had been published</td>
</tr>
<tr>
<td>2019</td>
<td>AFRIMETS.EM-S2</td>
<td>ACV: 200 mV, 200 V @ 40 Hz and 1 kHz. ACI: 100 mA, 1 A @ 40 Hz and 1 kHz. DCI: 10 mA and 1 A. DCV: 100 V and 1000 V Artefact : 6 ½ DMM</td>
<td>NMISA, LPEE/LNM, DEF-NAT, KEBS, NIS, UNBS, NMIE, SON-NMI, SIRDC-NMI</td>
<td>DEF-NAT / NIS</td>
<td>Planned</td>
</tr>
<tr>
<td>2020</td>
<td>AFRIMETS.EM-K?</td>
<td>AC Power and energy 50V to 300V 5 mA to 120A 10W to 36000W, VAR PF 0 to 1 i/c 45 Hz to 65 Hz Artefact : Zera Com-303</td>
<td>NMISA, LPEE/LNM, DEF-NAT, KEBS, NIS</td>
<td>NIS</td>
<td>Planned</td>
</tr>
<tr>
<td>2021</td>
<td>AFRIMETS.EM-S?</td>
<td>AC-DC transfer in Voltage : 1 to 4 V@ 10 Hz to 1 MHz 500 V to 1000 V @ 40 Hz to 100 kHz Artefact : to be identified</td>
<td>NMISA, DEF-NAT, NIS, NMIE, KEBS</td>
<td>NMISA</td>
<td>Planned</td>
</tr>
<tr>
<td>2022</td>
<td>AFRIMETS.EM-S?</td>
<td>DC &amp; AC High Voltage</td>
<td>NMISA, NIS, LPEE/LNM, DEF-NAT</td>
<td>NIS</td>
<td>Planned</td>
</tr>
<tr>
<td>2023</td>
<td>AFRIMETS.EM-S?</td>
<td>DC : 1 kV, 10 kV, 20 kV, 50 kV &amp; 100 kV AC @50Hz : 1 kV, 10 kV, 20 kV, 50 kV &amp; 100 kV Artefact : to be identified</td>
<td>NMISA, NIS, DEF-NAT</td>
<td>NMISA</td>
<td>Planned</td>
</tr>
</tbody>
</table>
5. Research Activities

There are many research activities in the field of electricity and magnetism at NIS. Some of them are listed in the following sections:

5.1 Low Frequency Impedance


The main aim of this paper is to construct a new inductance box providing a huge number of automated inductance steps, which are used in the laboratories to perform full automatic calibration of inductance meters. So, new inductance box has been fabricated using 12 inductors connected to their 12 reed relays and controlled by only one microcontroller to generate 15 inductance steps per decade. The relative deviation of output inductance steps from their rated values is in the range from $\pm 5 \times 10^{-4}$ to $\pm 5 \times 10^{-3}$, while the maximum relative uncertainty due to the summation effect is less than 60 ppm. It is also practically proved that the new inductance box has better electrical performance than the ordinary old one due to its higher accuracy and lower summation effect uncertainties. The new fabricated inductance box could be used to perform full automatic inductance measurements at the National Institute of Standards (NIS), Egypt, for the first time.

5.2 AC/DC Voltage and Current

Rasha S. M. Ali, “Effect of modified multipliers resistors on measurement of AC voltages above 50 V”, Measurement 126, PP.378-381, 2018

The effect of the modified multiplier resistor on the measurement accuracy of ac voltages higher than 50 V is studied and evaluated in this paper. Modification in construction is made in the multiplier design which used for higher voltages. Ten resistors are radially connected in series and mounted on a high insulation PCB instead of using one resistor which has higher power rating and thickness.
The introduced multipliers values which are established at the National Institute of Standards (NIS), Egypt are 10 kΩ, 20 kΩ and 40 kΩ for voltages 50 V, 100 V, and 200 V respectively. The high voltage modified multipliers are joined with single junction thermo-elements to produce the modified thermal voltage converters (TVCs). The modified TVCs are calibrated against other standard TVCs at different frequencies 20 Hz, 55 Hz, 1 kHz, 10 kHz, and 100 kHz. The ac-dc transfer differences of the modified TVCs are compared with the traditional TVCs to evaluate its performance. They introduce lower ac-dc differences than the traditional ones specifically at higher voltages and frequencies. The modified TVCs performance is also evaluated by comparing their measurement accuracy and precision at range 100 V with the traditional TVCs.

5.3 DC Voltage and Current

Hala M. Abdel Mageed, Mamdouh Halawa, Omar M. Aladdin “Achievement of Traceability for DC Voltage and Current Measurements up to 5 kV and 1 A”, International Journal of Engineering & Technology, Vol. 7, No. 4, PP. 3766-3769, 2018

National Institute of Standards is the National Metrology Institute of Egypt, which realizes units of measurements according to the International System of Units. The DC Josephson Voltage Standard is used as a primary standard to reproduce the unit of volt and provide traceability of measurements to the SI units. JVS, Zener diode reference standards, standard resistors, multifunction calibrators and voltage dividers of NIS maintain the DC voltage & current and provide the traceability to all Egyptian industrial governmental and private sectors. In this paper, the measurements traceability of DC voltages from 10 mV up to 5 kV and DC currents from 100 μA up to 1 A has been achieved. In this method, the Fluke 5720A multifunction calibrator has been calibrated in its DC voltage and current functions to cover the range of 1 kV and 1 A. To extend the voltage range to 5 kV, a universal high voltage divider has been used. The DC voltage calibrations have been performed using a Fluke 732B Zener diode reference standard, which is traceable to International System of Units via the
NIS DC voltage primary standard. Relevant DC voltage and current measurements, associated with their expanded uncertainties, are presented in this work.

5.4 Resistance

Rasha S.M. Ali, and M. Helmy A. Raouf, “Verification of the Main Ratios of the 6010C Automatic Bridge Used for Resistance Measurement”, MAPAN-Journal of Metrology Society of India, Published online, November 2018

The main ratios of the Measurements International corporation (MI) 6010C automatic resistance bridge have been verified in this paper. The used method for verification is the exchanging method where the two resistors are interchanged, and then the offset error is computed. Then, this method has been evaluated by two other comparison methods for the 1:1 and 1:10 ratios. The expanded uncertainties at the different ratios are also evaluated. The studies on a verification of the mentioned ratios of the MI6010C DCC bridge had been rarely reported. Based on the obtained results, the introduced verification method can be reliably used to verify any MI6010C DCC bridge that serves at any measurement laboratory.

5.5 List of Other Publications


