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

Prof. Dr. Mohammed Helmy Abd El-Raouf
Head of Electrical Quantities Metrology Department
National Institute of Standards (NIS), Egypt
Vice Chair of AFRIMETS TCEM
mohammed_makka@yahoo.com

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

Calibration and Measurement Capabilities

Electricity and Magnetism, Egypt, NIS (National Institute for Standards)

KCDB

Calibration or Measurement Service			Measurand Level or Range			Measurement Conditions/Independent Variable		Expanded Uncertainty							
Quantity	Instrument or Artifact	Instrument Type or Method	Minimum value	Maximum value	Units	Parameter	Specifications	Value	Units	Coverage Factor	Level of Confidence	Is the expanded uncertainty a relative one?	Uncertainty Matrix	Comments	NMI Service Identifier
DC resistance standards and sources: intermediate values	Fixed resistor	Potentiometric ratio bridge	1.00E+05	1.00E+06	Ω	Applied voltage	10 V	4 to 41	µΩ/Ω	2	95%	Yes	2.1	Approved on 22 Sep 2017	21.1.1
						Temperature	20 °C to 30 °C								
DC resistance standards and sources: high values	Fixed resistor	Potentiometric ratio bridge	1.00E+07	1.00 E+08	Ω	Applied voltage	20 V	94 to 760	µΩ/Ω	2	95%	Yes	2.1	Approved on 22 Sep 2017	21.1.2
						Temperature	20 °C to 30 °C								
DC voltage sources: single vaues	DC solid state voltage standard	Direct Comparison with primary standard (JVS)	1.018	10	V	Temperature	23 °C ± 2°C	0.03 to 0.2	µV/V	2	95%	Yes	1.1.1	Approved on 22 Sep 2017	21.3.1
DC current sources:low values	Standard Capacitor , Voltage Source , High Resistance Standard	Current Generator: current generated by charging or discharging a gas-filled capacitor With Software Controlled for Nonlinearity Compensation	1.00E-13	1.00E-10	A	Ambient temperature	23 °C to 24 °C	9.1E-16 to 7.6E-14	A	2	95%	No	3.1.1	Approved on 22 Sep 2017	21.5.1
						Ambient humidity	45 % to 50 %								
Capacitance: low-loss capacitors	Fused Silica Capacitors	Direct method	10	100	pF	Fixed Capacitance	10 pF, 100 pF	0.63 to 0.70	µF/F	2	95%	Yes	4.2.1	Approved on 22 Sep 2017	21.2.1
						Frequency	1000 Hz, 1592 Hz								
AC/DC current transfer difference	AC/DC transfer standard plus shunt	Comparsion with another AC/DC transfer standard	10	5000	mA	Frequency	10 Hz, 55 Hz, 1 kHz, 10 kHz	4 to 19	µA/A	2	95%	Yes	6.1.1	Approved on 22 Sep 2017	21.4.1

The BIPM key comparison database, October 2017 1/6

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):

4.1.1 "2017 AFRIMETS TC-EM Meeting", 31 July 2017, Pretoria, South Africa.
4.1.2 "2018 AFRIMETS TC-EM Meeting", 16-17 July 2018, Enugu, Nigeria.

Tersa Street, El-Haram, El-Giza – EGYPT
Box: 136 Giza Code No. 12211
Fax: (+202) 33862224 - Tel: (+202) 33879241

4.2 Comparisons with the AFRIMETS

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

Year	Identifier	Description	Participants	Pilot	Status
2015	AFRIMETS.EM-S1	DC resistance at 1 Ω, 10 Ω, 100 Ω , 1 kΩ and 10 kΩ	NMISA, LPEE/LNM, DEF-NAT, KEBS, NIS, UNBS, NMIE	NMISA	Draft B had been issued
2017	AFRIMETS.EM.RF-S1	RF attenuation	NMISA, NIS, DEF-NAT	NMISA	Final report had been published
2019	AFRIMETS.EM-S2	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	NMISA, LPEE/LNM, DEF-NAT, KEBS, NIS, UNBS, NMIE, SON-NMI, SIRDC-NMI	DEF-NAT / NIS	Planned
2020	AFRIMETS.EM-K?	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	NMISA, LPEE/LNM, DEF-NAT, KEBS, NIS	NIS	Planned
2021	AFRIMETS.EM-S?	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	NMISA, DEF-NAT, NIS , NMIE, KEBS	NMISA	Planned
2022	AFRIMETS.EM-S?	DC & AC High Voltage DC : 1 kV , 10 kV, 20 kV , 50 kV & 100 kV AC @50Hz : 1 kV , 10 kV, 20 kV, 50 kV & 100 kV Artefact : to be identified	NMISA, NIS , LPEE/LNM, DEF-NAT	NIS	Planned
2023	AFRIMETS.EM-S?	Radio Frequency power. Points to be decided Artefact : to be identified	NMISA, NIS, DEF-NAT	NMISA	Planned

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

M. Helmy A. Raouf, A. Eliwa Gad, et al., "Fully Automated Inductance Measuring System Using New Fabricated Inductance Box", MAPAN-Journal of Metrology Society of India, Vol. 32, No. 3, PP. 199-205, September 2017

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 ±5×10^{-4} to ±5×10^{-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, 20kΩ 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

1. **M. Helmy A. Raouf, "Completely Automated System for Capacitance Measurement through New Accurate Capacitance Box", International Journal of Metrology and Quality Engineering, Vol. 8, No. 22, PP. 1-8, October 2017.**

2. **Heba A. M. Hamed, Rasha S. M. Ali, M. Helmy A. Raouf, et al., "Precise Bridge for Impedance Measurement Based on Programmable Waveform Generators", International Journal of Scientific & Engineering Research, Vol. 9, No. 2, PP. 1368 – 1372, February 2018.**

3. **Rasha S. M. Ali "Applied Signal Effect in the Potentiometric Method on the Resistance Measurements Accuracy", International Journal of Metrology and Quality Engineering, Vol. 9, 2018.**

4. **Hala M. Abdel Mageed, and Mamdouh Halawa "Technical Method for Traceability Achievement of DC Voltage Measurements up to 5 kV at NIS, Egypt", IEEE Conference on Precision Electromagnetic Measurements, CPEM 2018 Digest.**

5. **Rasha S. M. Ali "Modified Construction for Thermal Voltage Converter Multipliers Resistors", IEEE Conference on Precision Electromagnetic Measurements, CPEM 2018 Digest.**

6. **Heba A. M. Hamed, Rasha S. M. Ali, M. Helmy A. Raouf, et al., "Automatic AC Bridge for Resistance, Capacitance, and Inductance Measurement", International Journal of Scientific & Engineering Research, Vol. 8, No. 10, PP. 921 – 924, October 2017.**