Report to the 30th meeting of the CCEM about

NIS Activities in the Field of Electricity and Magnetism

Assoc. Prof. Dr. Mohammed Helmy Abd El-Raouf
Head of Electrical Quantities Metrology Department
National Institute of Standards (NIS), Egypt
Vice Chair of AFRIMETS TCEM
1. NIS History, Mission and Structure

In 1962, Egypt joined the meter convention and became a member of the Bureau International des Poids et Measures, BIPM. The National Institute of Standards (NIS) was established in 1963 as one of the Egyptian research institutes. NIS as the Egyptian national metrology institute is an old member of the BIPM and currently an active member in the regional metrology organization AFRIMETS. Due to the affiliation of NIS to the Ministry of Higher Education & Scientific Research, NIS is interested in scientific research in all of its activities.

The general tasks of NIS are to realize, maintain and develop the Egyptian national standards of the basic and derived units. NIS provides the industrial and governmental as well as private organizations with traceability of their measurements to the national and international standards. NIS is also responsible for operating the National Measurement System.

1.1 Main NIS Responsibilities & Objectives

- Realization and dissemination of SI Units.
- Maintaining the Egyptian National Measurement Standards.
- NIS represents Egypt in the international and regional metrology organizations such as AFRIMET and BIPM.
- Offering Tractability of Measurement to the SI Units.
- Operate the national laboratory of professionally test
- Provide calibration services to end user in the area that, are not available in the industrial laboratory.
- Training courses in measurement technologies and related subjects, consultancies and courses. These activities are all end user oriented and run on economic basis.
- To share and organize the international, regional and national metrology programs, quality and accreditation activities.
- Conduct Research & Development in Metrology and Advanced Measurement Technology.
1.2 General NIS Structure and Electricity & Magnetism Manpower

NIS has a division dedicated for electrical metrology consists of three laboratories with well-qualified staff members with PhDs and MScs. The main staff of the Electricity and Magnetism (EM) laboratories is as follows:

<table>
<thead>
<tr>
<th>Laboratory Name</th>
<th>Staff</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electrical Quantities</td>
<td>4 Professor emeritus&lt;br&gt;1 Ph.D. (Professor)&lt;br&gt;3 Ph.D. (Associate Professor)&lt;br&gt;3 Ph.D. students&lt;br&gt;1 M.Sc. student&lt;br&gt;1 Engineer&lt;br&gt;2 Technicians</td>
</tr>
<tr>
<td>High Voltage</td>
<td>2 Professor emeritus&lt;br&gt;1 Ph.D. students&lt;br&gt;4 Engineers&lt;br&gt;1 Technician</td>
</tr>
<tr>
<td>Microwave</td>
<td>1 Ph.D.&lt;br&gt;1 Ph.D. student</td>
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</tbody>
</table>
2. Activities and Capabilities of NIS in the Field of Electricity and Magnetism

In the following sections a brief description of NIS activities and capabilities in the field of electricity and magnetism are introduced. More technical information and detailed data are demonstrated in a supplementary presentation entitled “NIS Activities in the Field of Electricity and Magnetism”, which will be presented on Friday 24 March 2017, as part of the agenda point “review of membership and observer ship” during the CCEM meeting.

2.1 Electrical Quantities Laboratory

The department is responsible for maintaining and disseminating the national electrical standards for the quantities of DC voltage and current, resistance, capacitance, inductance and AC/DC transfer. Also, the activities of the information technology laboratory are related to this department. Calibration of the standards and electrical equipments of scientific and industrial laboratories are performed. Scientific research is carried out to improve the calibration measurement capabilities of the department. The following activities are performed:

1. Maintenance and dissemination of the national electrical standards for DC voltage, resistance, capacitance, inductance and AC/DC transfer, through the traceability to the SI units.
2. Improving and establishing the quality of the primary, secondary and reference standards by continuous highly accurate internal calibrations.
3. Establishment and development of the measurement standards and methods to realize and maintain the highest levels of accuracy due to many scientific researches.
4. Verifying degree of equivalence of measurements within the department with other national laboratories through international comparisons.
5. Calibration of all related standards and instruments such as voltage and current sources, multi-meters, meggers, testers, RCL meters, and ....etc.
6. Giving consultation and training for all purposes related to accurate electrical measurements for industry in Egypt, Middle East region and African countries.
7. Many activities related to the information technology field.

2.2 High Voltage Laboratory

High Voltage lab can achieve traceability to SI Unit for measuring and sourcing AC & DC high voltage and high current instruments. This lab can achieve traceability to SI unit for measuring and sourcing power and energy instruments based on the primary standard of electrical power and energy at NIS. Also, HV lab can perform
tests that are related to these activities according to international standards. In addition to that, scientific research is carried out to improve the calibration measurement capabilities of the laboratory. The following activities are performed:

1. Calibration of AC H.V. measuring & sourcing instruments more than 1 kV up to 400 kVAC and 200 kVDC.
2. Calibration of AC current measuring & sourcing instruments more than 20 A up to 5000 AAC and 2000 ADC.
3. Calibration of partial discharge calibrators up to 2000 pC.
4. Calibration of transformer oil testers up to 60 kV.
5. Calibration of transformers turns ratio meters.
6. Calibration of MEGGERS more than 100 MΩ up to 611 GΩ, with DC voltage source up to 5 kVDC.
7. Calibration of electrical safety testers.
8. Safety tests for electrical household appliances.
10. Calibration of power and energy measuring and sourcing instruments.
11. Performing the TYPE TEST for all kinds of energy meters.
12. Testing of phase sequence indicators
13. Calibration of power, current, and voltage transducers.

2.3 **Microwave Laboratory**

This lab is responsible for realizing, maintaining, and developing the national primary standard of high frequency (HF) power for Egypt using Microcalorimeter in the frequency range 10 MHz-18 GHz. Participation in the International Inter-comparisons. Conducting research for enhancing the accuracy and uncertainty of measurements in the microwave metrology. Providing traceability to SI for Electromagnetic Compatibility (EMC) measurements. The following activities are performed:

1. Participation in the international comparisons for radio frequencies.
2. Calibration of microwave power sensors, signal generators, and cable & antenna analyzers, …etc.
3. Circuit characterization (measurement of scattering parameters and attenuation coefficient) in the frequency range 10 MHz - 40 GHz.
4. Measuring the harmonic content and distortion of signals in the frequency range of 9 kHz - 30 GHz.
5. Providing training, and Consultations.
2.4 List of the Main NIS Comparisons in the field of EM:

1. DC voltage sources: BIPM.EM-K11.a (Comparison of 1.018 V DC Voltage References).
2. DC voltage sources: BIPM.EM-K11.b (Comparison of 10 V DC Voltage References).
3. DC current sources: EUROMET.EM-S24 (Comparison of ultra-low DC current sources).
4. DC resistance standards and sources: EURAMET.EM-k2.1 (Comparison of Resistance Standards at 10 MΩ and 1 GΩ), Values: (100 kΩ to 1 MΩ) and (10 MΩ to 100 MΩ).
7. AC/DC current transfer difference: SIM.EM-K12 (Inter-Comparison of AC-DC current transfer standards), Values (10 mA, 5 A) @ Frequencies (10 Hz, 55 Hz, 1 kHz, and 10 kHz).
8. AC/DC current transfer difference: EURAMET.EM-K12 (Inter-Comparison of AC-DC current transfer standards), Values (10 mA, 5 A) @ Frequencies (10 Hz, 55 Hz, 1 kHz, and 10 kHz).
10. Radio Frequencies: AFRIMETS.EM.RF-S1 (Attenuation and reflection for coaxial), the technical protocol of this comparison has been prepared, and it is already registered in the KCDB.

2.5 Published and Some of the Submitted CMCs:
In last October, the following CMCs and others were submitted to the AFRIMET TCEM chair for intra-RMO review:

<table>
<thead>
<tr>
<th>Calibration or Measurement Service</th>
<th>Measurand Level or Range</th>
<th>Measurement Conditions/Independent Variable</th>
<th>Expanded Uncertainty</th>
<th>Reference Standard used in calibration</th>
</tr>
</thead>
<tbody>
<tr>
<td>DC voltage sources: single values</td>
<td>DC solid state voltage standard</td>
<td>DC solid state voltage standard</td>
<td>1.018</td>
<td>10 V Temperature</td>
</tr>
<tr>
<td>DC current sources: low values</td>
<td>Standard Capacitor , Voltage Source , High Resistance Standard</td>
<td>Current Generator: current generated by charging or discharging a gas-filled capacitor With Software Controlled for Nonlinearity Compensation</td>
<td>1E-13</td>
<td>1E-10 A Ambient temperature</td>
</tr>
<tr>
<td>Capacitance: low-loss capacitors</td>
<td>Fused Silica Capacitors</td>
<td>Direct method</td>
<td>10</td>
<td>100 pF Fixed Capacitance</td>
</tr>
<tr>
<td>AC/DC current transfer difference</td>
<td>AC/DC transfer standard plus shunt</td>
<td>Comparison with another AC/DC transfer standard</td>
<td>10 mA</td>
<td>5A Frequency</td>
</tr>
</tbody>
</table>

Tersa Street, El-Haram, El-Giza – EGYPT
Box: 136 Giza Code No. 12211
Fax: 33867451- Tel: 33879241
3. Planned AFRIMETS Comparisons

<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, KEB, NIS, SIRDC-NMI, UNBS, ZABS</td>
<td>NMISA</td>
<td>Ongoing</td>
</tr>
<tr>
<td>2017</td>
<td>AFRIMETS.RF-S?</td>
<td>RF attenuation</td>
<td>NMISA, NIS, DEF-NAT</td>
<td>NMISA</td>
<td>Planned</td>
</tr>
<tr>
<td>2018</td>
<td>AFRIMETS.EM-K?</td>
<td>DC voltage at 1,018 V and 10 V reference</td>
<td>NMISA, LPEE/LNM, DEF-NAT, KEB, NIS</td>
<td>NIS</td>
<td>Planned</td>
</tr>
<tr>
<td>2019</td>
<td>AFRIMETS.EM-S?</td>
<td>Digital Multimeter, ACV: 200 mV, 200 V @ 40 Hz and 1 kHz. AC: 100 mA, 1 A @ 40 Hz and 1 kHz. DC: 10 mA and 1 A. DCV: 100 V and 1000 V</td>
<td>NMISA, LPEE/LNM, DEF-NAT, KEB, NIS</td>
<td>DEF-NAT</td>
<td>Planned</td>
</tr>
<tr>
<td>2020</td>
<td>AFRIMETS.EM-K?</td>
<td>AC Power and energy</td>
<td>NMISA, LPEE/LNM, DEF-NAT, KEB, NIS</td>
<td>NIS</td>
<td>Planned</td>
</tr>
<tr>
<td>2021</td>
<td>AFRIMETS.EM-S?</td>
<td>AC-DC transfer</td>
<td>NMISA, DEF-NAT, NIS</td>
<td>NMISA</td>
<td>Planned</td>
</tr>
</tbody>
</table>
4. Research and Development Activities of NIS in the EM fields

In the remaining part of this report, research activities in each filed of the electricity and magnetism at NIS are presented.

4.1 DC Voltage and Current

4.1.1 S. S. Solve, R. Chayramy, M. Stock, Hala M. Abdel Mageed, Omar M. Aladdin and M. Helmy A. Raouf “Bilateral Comparison of 1 V and 10 V Standards between the NIS (Egypt) and the BIPM”, August to September 2014”, (part of the ongoing BIPM key comparison BIPM.EM-K11.a and b), Metrologia, Vol. 52, 2015, Tech. Suppl., 01011.

As part of the ongoing BIPM key comparison BIPM.EM-K11.a and b, a comparison of the 1 V and 10 V voltage reference standards of the BIPM and the National Institute of Standards (NIS), Giza, Egypt, was carried out from August to September 2014. Two BIPM Zener diode-based travelling standards (Fluke 732B), BIPM_B (ZB) and BIPM_C (ZC), were transported as hand luggage on board an airplane to NIS and back to BIPM. At NIS, the reference standard for DC voltage is a Josephson Voltage Standard. The output EMF (Electromotive Force) of each travelling standard was measured by direct comparison with the primary standard. At the BIPM, the travelling standards were calibrated, before and after the measurements at NIS, with the Josephson Voltage Standard. The comparison result shows that the voltage standards maintained by NIS and the BIPM were equivalent, within their stated standard uncertainties, on the mean date of the comparison.


A new automatic system for calibrating the solid-state DC voltage reference standards (Zener Diode reference standards) has been established at National Institute of Standards (NIS), Egypt to disseminate the unit of volt in the country. Besides, this system has been implemented as a coherent structure that, from the national DC voltage reference standards, can disseminate the traceability of all the instruments under calibration. The system consists of a set of programmable instruments and proper software. Design and the implementation of the system software have been discussed in details. The system validation has been carried out for the measurement repeatability and the results compatibility in both automatic and manual modes.


A new automated very low D.C current source was implemented for generating D.C current in the ranges of pico and femto ampere. This new improved low current source is based on the idea of applying a linear voltage ramp to a differentiator reference standard capacitor. Faithfully, this new system enhanced the very low-current calibrations capabilities of Egypt and the Arabian/African region. To get full confidence in this work, NIS participated in EUROMET.EM-S24: “Comparison of small current sources”. The nominal values of the eight measuring points of that comparison were +100 fA, -100 fA, +1 pA, -1 pA, +10 pA, -10 pA, +100 pA, and -100 pA ranges.
4.1.4 Some of the Key Publications


4.2 Resistance


This paper describes the procedures made at National Institute of Standards (NIS), Egypt to establish accurate resistance measurements for high value resistance standards in the range from 100 kΩ to 100 MΩ, which are done automatically. Guarded Hamon transfer standards have been used at NIS for scaling to high resistance levels up to 100 MΩ. The used method at NIS for the high resistance measurements, above 100 kΩ, is the DMM-based method, which works automatically. The scaling process from the NIS 10 kΩ resistance standard up to 100 MΩ value is made using two Hamon transfer standards. The automatic measurement improved the quality of the calibration of high value resistance; eliminating the noise due to the operator and errors that result from transcribing data.


An automated measuring system is developed for improving the calibration of high value standard resistors in the meg-ohm range at the National Institute of Standards (NIS), Egypt. This system is suitable for the calibration of the standard resistances from 100 kΩ to 100 MΩ using the DMM-based method by the substitution technique. The unknown resistor and the standard resistor are indirectly compared in the same position using a dummy resistor as a short-term reference standard. The system operation is automatically controlled by using a LabVIEW program which is especially developed for this purpose. The performance of this system is evaluated by comparing the measurement results obtained from this technique with those obtained by the direct comparison DMM-based method. It is found that the span of the expanded uncertainty of measurement with this method is from 4.1 μΩ/Ω to 27 μΩ/Ω, whereas its span is from 40 μΩ/Ω to 110 μΩ/Ω for the direct comparison method.

A new automated Resistance Box (RB) has been presented that mainly consists of three decades. They have the same design, but each has four different internal resistive elements. Each decade generates 15 different output resistance values; therefore, it is more economical and practical compared to the other usual decades, which produce only 10 values by using 10 internal resistive elements per decade. 4096 resistance values can be obtained by the all possible combinations of the new RB decades. Design, fabrication process, and characterization of the new RB are demonstrated in detail including its main specifications and advantages. 4096 resistance steps could be obtained by all possible combinations, but 1666 of them are different from each other. The minimum number of the used resistive elements leads to minimum power losses, cost, and maintenance effort with better electrical properties and performance. The relative deviation of output resistance steps from their rated values is less than or equal ±50 ppm, whereas the relative uncertainty because of the summation effect is less than or equal ± 6.0 ppm. The huge number of the output resistance steps enables the new resistance box to be used dependably for manual and fully automated calibrations of the resistance meters and their linearity checking.

4.2.4 Some of the Key Publications and Patents


4.3 Low Frequency Impedance


A programmable bridge has been constructed by using two arbitrary waveform generators and DVM as a null-detector for capacitance and resistance measurements. Methodology of this bridge has been introduced demonstrating the best way to get accurate ratio measurements up to the accuracy level of $10^{-5}$. Our bridge has been used, through this research, to get resistance to resistance and capacitance to resistance ratios at different frequencies. It has been used to measure resistance to resistance ratio (R-R) as well as capacitance to resistance ratio (C-R), at 1592 Hz. A reasonable agreement between the resistance ratio measurements has been noticed through the performed comparisons with the currently used IVD bridge at 1 kHz. The relative bridge asymmetry error is in the order of $10^{-7}$ with high quality measured standards. Measurements repeatability using this reliable bridge is less than 2.6 ppm on the average, while the evaluated expanded uncertainty is less than 11 ppm, for both in – phase and quadrature – phase measurements.


Some of traceability chains for the ac resistance measurements are based on ac/dc resistors. Performance of two types of them with different values has been investigated for their optimum utilization. Tinsley and Cambridge ac/dc resistors have been measured as dc resistors using different measurement methods and as ac resistors at various frequencies. DC direct method using digital reference multimeter is more accurate for the resistance values 1 Ω, 10 Ω, 100 Ω, and 1 kΩ. While the results obtained for the values 10 kΩ and 100 kΩ are very near by using the dc direct and ratio techniques. The 100 mΩ resistor could be measured very precisely using DCCB than V-I method. The resistors frequency dependence has been obtained and illustrated using $R_s$ and $R_p$ functions of an accurate LCR meter.

A new accurate capacitance box has been demonstrated to be used for calibration of capacitance measurement devices. The introduced capacitance box has been established by twelve capacitors connected to their corresponding twelve reed relays and controlled by only one micro-controller. 1666 different capacitance values, with minimum number of internal capacitive elements, could be produced by this new capacitance box compared to 1111 steps that are produced by the ordinary corresponding box. The presented capacitance box has relative accuracy in the range from ±5×10⁻⁵ to ±5×10⁻⁴. A fully accurate automated capacitance measurement system has been constructed and used for the first time at NIS, Egypt, by using the new fabricated capacitance box and completely controlled by a specially designed LabVIEW program. Full specifications of this capacitance box will be presented in details, through an extended paper, including its voltage and frequency dependence, long-term stability and uncertainty calculations.

4.3.4 Some of the Key Publications and Patents

4.4 AC/DC Voltage and Current


Accurate calibration of ac voltages up to 1000 V by using thermal converters requires range resistors connected in series with the converter. In this work, multi-range internal range resistors are designed and implemented at NIS to cover the ac voltage ranges from 10 V to 750 V. Six range resistors are mounted in series with a single-junction thermo-element in the same box to provide a new thermal voltage converter (TVC). The advantage of the internal range resistors combined with the thermo-element is the removal of the contact resistance between the range resistor connector and the thermo-element connector. It also protects the connector from wear due to repeat connection cycles. The implementation of multi-range internal range resistors limits the number of TEs and reduces the cost. The required range resistor is selected by using a 6-pin selector switch. The new TVC ranges are automatically calibrated against other standard TVCs at different frequencies by using a LabVIEW program to determine their ac-dc transfer difference at each range. It is found that the frequency dependence of the new TVC by using the new internal range resistors is good especially at the frequencies up to 20 kHz for higher ac voltages due to smaller distributed capacitances and inductances.


In this work, some improvements are presented to the previously introduced automated multi-range multipliers system. In this old system, these multipliers; range resistors are selected automatically by using electronic relays controlled by a micro-controller that connects the suitable multiplier to the thermal voltage converter to calibrate the required ac voltage. The modifications done on the old system are mainly in used resistors and connectors. The ac-dc transfer differences for the improved and the old multipliers systems combined with the same thermal converter are determined automatically against another standard thermal voltage converter. The obtained ac-dc differences results and their repeatability; Type A for both systems are compared to evaluate the performance of the new one. The improved system achieves relatively very small ac-dc differences in the 200 V range at the various frequencies. The results show that the improved system is more precise and reliable than the old one in ac voltage calibrations especially in the high voltage and frequency ranges. This improvement is occurred because of the frequency effect compensation due to reducing the reactance of the new system structure.


The paper describes an interlaboratory comparison program between the National Institute of Standards (NIS), Egypt and the Istituto Nazionale di Ricerca Metrological (I.N.Ri.M.), Italy for measuring low ac voltages. The aim of this program is to demonstrate the technical competence of both institutes. The interlaboratory comparison has been carried out under the framework of the executive program of scientific and technological cooperation between Italy and Egypt. A Fluke model 792A has been used as a travelling standard, which was calibrated against the reference standard of NIS and I.N.Ri.M. at 10, 20, 50, 100 and 200 mV at 40 Hz, 1 kHz, 10 kHz and 20 kHz. The standards of
the two institutes, NIS and I.N.Ri.M., have been used to calibrate the traveling standard at 10, 20, 50, 100 and 200 mV at frequencies of 40 Hz, 1 kHz, 10 kHz and 20 kHz. The ac–dc transfer difference results of the traveling standard are evaluated then compared at the intended frequencies. The comparison results and the efficiency test \( E_n \) values show a good agreement between the NIS and the I.N.Ri.M. systems in assigning ac–dc transfer difference for the ranges 200, 100 and 50 mV at 40 Hz, 1 kHz, 10 kHz and 20 kHz. However, there is disagreement between the results of 20 and the 10 mV at 10 and 20 kHz, due to the inductive errors in the NIS radial resistors, which has a great effect on the higher frequencies. So, in the near future a corrective action will be taken for NIS μPots at the high frequencies to overcome this effect of high inductance. Such as using resistors independent of frequency and have lower skin effect. Furthermore, the output connector should be connected to the circular resistors with a precise mounting that assures the almost perfect coaxial distribution of the input current.

4.4.4 Some of the Key Publications

4.5 High Voltage, Power & Energy

4.5.1 This Lab has Primary Standard of Power & Energy Measurements (2100B) which is designed to generate voltages up to 600 V and currents to 100 A at any power factor. This device can calibrate power meters, energy meters, power transducers and all VA measurements. Recently in 2017, the Lab Staff had a training for two weeks on the operation and the Uncertainty Calculations of this device by the TÜBİTAK UME, Turkey. EU funded twinning project.

4.5.2 Hala M Abdel Mageed, Ali M El-Rifaie, Omar M Aladdin, “Traceability of DC high voltage measurements using the Josephson voltage standard”, Measurement, Vol. 58, pp. 269-273, Dec. 2014. This paper introduces a new methodology for obtaining high voltage DC measurements traceability to the International System of Units at NIS. The traceability has been achieved via the NIS automated 10 V DC Josephson Voltage Standard (JVS). A 100 kV DC voltage divider with a nominal voltage ratio of 10,000:1 is being used with its display in parallel with a high sensitive digital voltmeter. The traceability has been realized by calibrating this digital voltmeter via the JVS system and then it has been used to calibrate the divider display readings. Moreover, the divider ratio has been accurately calibrated using a traceable calibrator source on its high voltage side and the calibrated digital voltmeter on its low voltage side. Accurate and traceable high voltage values have been obtained associated with their expanded uncertainties. Enhanced uncertainty results have been attained using this calibration methodology. The expanded uncertainty has a maximum value of 0.06% for the low range measurements (1–10 kV), while it decreases to about 0.05% for the high range measurements (20–100 kV).

4.5.3 Ali M El-Rifaie, Hala M Abdel Mageed, and Omar M Aladdin, “Enhancement of AC high voltage measurements’ uncertainty using a high voltage divider calibration method”, International Journal of Metrology and Quality Engineering, Vol. 6, No.2, 2015. A high voltage divider calibration technique has been used to enhance the uncertainty of high voltage AC measurements up to 100 kV at NIS. Traceability of the AC high voltage measurements to SI units has been obtained as well. The KVM100 divider and display have been automatically calibrated using specially constructed LabVIEW programs. Applying the actual turn’s ratio, the actual values of the Phenix-KVM100 readings as well as calibration uncertainties have been automatically calculated and stored in the prepared excel sheets. The relative expanded uncertainties for the voltage ranges do not exceed 0.05% of their values. These relative expanded uncertainties have been decreased to 0.01% at the higher ranges. Improved uncertainty results have been attained using this automatic calibration methodology.

4.5.4 Key Publications
4.6 RF & Microwave

4.6.1 The primary standard is realized by a type-N twin-load coaxial microcalorimeter setup, which is being operated in the frequency range 10 MHz to 18 GHz and power range 1 mw to 10 mw. Microcalorimeter, which is used for effective efficiency measurement of thermistor mounts, is the primary level measurement system of the microwave power measurements. At these measurements, in addition to the power measurement from a power meter using a thermistor mount, temperature change due to the power loss of a thermistor mount is measured as voltage. Effective efficiency is calculated from these two measurements. The expanded uncertainty of the measured effective efficiency using this setup is 2.9 mW/W.


This paper describes a new coaxial twin-load microcalorimeter, which was designed and fabricated to be installed at the national metrology institute of Egypt (NIS). Each component of the microcalorimeter measurement setup was measured and characterized separately to ensure its performance. The effective efficiency of a type-N thermistor mount at different frequency points was measured using the designed microcalorimeter setup. A comparison between these measured values and the corresponding effective efficiency measured by the microcalorimeter setup of the national metrology institute of Turkey (TÜBİTAK UME) was done to validate the accuracy of the new setup.

4.6.3 International Project, EMPIR -15RPT01 (RMicrowave): "Development of RF and microwave metrology capability", which is funded by the European Union’s Horizon 2020 research and innovation programme. The overall objective of this project is to improve the European measurement and research capability for RF&MW metrology and to establish a basis for future cooperation between European NMIs. This will enable less developed European NMIs to build necessary research capacity, as well as improving their calibration and measurement capabilities (CMCs) and reducing the increasing technological gap between NMIs.

4.6.4 Key Publications

5. List of Common Publications