BIPM Capacity Building & Knowledge Transfer Programme

2018 BIPM - TÜBİTAK UME Project Placement

REPORT

Project Name	up grading the existing calibration method of standard resistor and getting international accreditation for clamp meter calibration up to 1000 A.
Description	Improve the NMIE staff skill through training, Reducing the existing accredited CMC of reference standard resistor, and published the NMIE standard resistance CMC in KCDB data base. To get accreditation of clamp meter calibration up to 1000 A, Give service users who take their reference standard resistor below our CMC capability, Given accredited service in clamp meter for industries and manufacturer
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Abstract

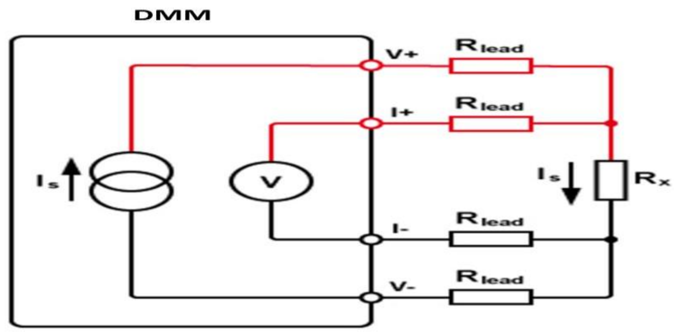
Research was conducted on the methods and system for resistance measurements to gain in-depth knowledge and experience in the area with the aim of improving the accuracy of resistance measurements performed at the National Metrology Institute of Ethiopia (NMIE). method and system of calibration of clamp meter

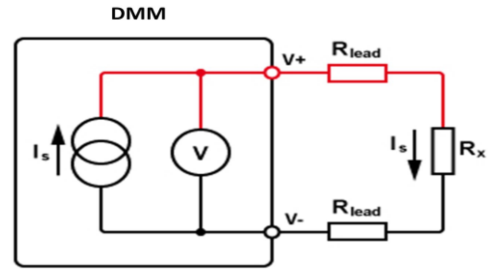
The research is conducted for two method of measuring the resistance by two wire and four wire measurement system are used in the study. In both measurement method we use different cable length to determine the length of cable affected the measurement. This report presents the result of the measurement method and length of cable effect on the measurement.

Motivation & Introduction

In the performance of high-level resistance calibrations, the accuracy is affected by the method, environmental temperature, cable and personnel error. The NMIE electrical Laboratory sought training on this subject in a well-equipped external laboratory in order to gain knowledge and experience in line with the aim of improving the accuracy of its resistance calibration services. The BIPM and the National Metrology Institute of Turkey (TÜBİTAK UME) joint training initiative entitled 2019 "BIPM - TÜBİTAK UME project placements" presented a good opportunity to obtain the required knowledge and experience. The objective of the research was to gain theoretical knowledge and practical experience to carry out measurements to determine resistance measurement, understand the measurement system, identify system elements, updated the existing calibration procedures, uncertainty budget and then to perform measurements. The overall intention of establishing the capability to update the existing uncertainty budget and take action for published the CMCs in BIPM KCDB data base.

For the work described in this report, a DMM 3458A was calibrated against the reference resistor 1Ω and 10 kΩ. as shown in the figure





Four wire connection method **Two wire connection method**

Research

The measurement of resistance standard is carried by different techniques that is voltmeter – Amperemeter method, standard resistor comparison by using voltmeter and current source, ohmmeter, Digital multimeter, direct current bridge circuit and direct current comparator resistance bridg based on the above techniques I have learned both the digital multimeter and direct current comparator resistance bridge techniques. They have two connection method for measuring low resistance measurement. two-wire method and Four-wire method in the two-wire method $V_m/I = R_s + (2*R_{lead})$ the main problem for this method is the lead resistance (R_{lead}). Since test current (I) causes small but significant voltage drop across the lead resistance, the voltage (V_m) measured by the meter will not be exactly the same as the voltage (V_r)directly across the test resistance (R_S), and considerable error can result. Typical lead resistance lie in the range of 1 mΩ to 10 mΩ. Due to the limitation of the two wire method four wire method is general preferred for low resistance measurement. This is done by experimentally

For two wire resistance measurement $V_m = Ir_c + IR_x + Ir_c = I (R_x + 2r_c)$

For four wire resistance measurement $V_m = I_2 . r_c + I_x . R_x + I_2 r_c = I_x + R_x + 2 I_2 r_c$

$V_m = I_x . R_x + 2.10^{-9} I_x . r_c =$

$V_m = I_x . R_x$ it shows the cable resistance estimated to zero

Other research is conducted the effect of cable length for resistance measuring to investigate this effect I can use different length cable that is 20 cm, 50 cm, 1m, and 12m. with the same reference resistance value 1 Ω. And see the effect of the cable resistance in two and four wire method

The second techniques to learn is measurement of reference resistance using a resistance bridge

The model equation is Rx = Rs*r

Rs = Rs + δRs drift + δ Rstemp. + δRs power

r = (r + δr resolution) + δRbridge - δRtemp. So

$R_x = R_s * r = (R_s + \delta Rs_{drift} + \delta Rs_{temp.} + \delta Rs_{power}) * (r + \delta r_{resolution}) + \delta R_{bridge} - \delta Rx_{temp.}$

where Rx: measured resistance value

Rs: Reference resistance value

δRs_{drift}: The drift of reference resistance value

δRs_{temp}: Temperature coefficient of the reference resistance

δRs_{power}: power coefficient of the reference resistance

r: the ratio of the resistance from bridge which is $r = R_x/R_s$

$\delta r_{resolution}$: resolution of the bridge from manufacturer or catalogue

δR_{bridge}: drift of the bridge from manufacturer or catalogue

$\delta Rx_{temp.}$: temperature coefficient of the measured resistance

the power coefficient can be calculated by from two different resistor value with different current value which is

Power coefficient (P.C) = $(1/R_{nominal})(R_1–R_2/R_1I_1^2–R_2I_2^2)$

The uncertainty contribution becomes

Quantity	**Estimation**	**Value**	**Unit**	**Probability Distribution**	**sensitivity Coefficient**	**Unit**	**Uncertainty Contribution**
***R*s**	1000.00058	1.0	Ω	Normal	10	---	5
r	10	0.001	---	Normal	1000	Ω	0.5
δRs_{drift}	0	0.1	Ω	Rectangular	10	---	0.57
δR_{bridge}	0	1.2	Ω	Normal	1	---	0.6
$\delta Rs_{temperat.}$	0	1.3	Ω	Rectangular	10	---	7.5
$\delta r_{resolution}$	0	0.01	----	Rectangualr	1000	Ω	5.8
$Rx_{temperature}$	0	0.2	Ω	Rectangular	-1	---	-0.12
R_{power}	0	1.0	Ω	Rectangular	10	----	5.78
R_x	1000.00058						
				Combined uncertainty			13.2
				Expanded uncertainty			26.4

Lectures were given on the international aspect of metrology in which it was explained that the metrology provides measurements that are stable, comparable and coherent. The world economy, society and citizens depend on the international “quality infrastructure” which depends on metrology. Quality infrastructure is an element to support the economic development by ensuring effective operation of local markets and allowing access to foreign market by reduction of Technical Barriers to Trade (TBTS) through an internationally recognized metrology institute. To provide mutual recognition of calibration CPIM MRA was created. Under the CIPM MRA, the calibration and measurement capabilities (CMCs) of signatory NMIs are the fundamental object of mutual recognition. In addition, CIPM MRA requires that all signatory NMIs establish and maintain an appropriate Quality System (QS). Consultative Committees of the CIPM (CCs), the Regional Metrology Organizations (RMOs) and the BIPM are responsible for carrying out the key and supplementary comparisons. Key and Supplemental comparisons provide evidence of the equivalence of NMI measurement capabilities. Metrology institute can get recognition either through accreditation or through RMOs. The process to get the CMCs approved through RMOs is to submit CMCs for intra-regional review to be reviewed by TC-RMO then TC chair, upload it to JCRB for inter-review by other RMOs and after been approved it will be published in Appendix C of the KCDB.

Conclusions and Future Work

To conclude, the main purpose in this project was to learn how to build and operate a resistance measurement using resistance bridge to measure reference resistance values along with some important techniques to ensure highly accurate results with low uncertainties. With the knowledge gained through my studies, I will produce a project plan to develop the capabilities at NMIE for measurements of reference resistance values using a bridge, I have already done the reference resistance of NMIE drift at UME and up dated the existing uncertainty budget and participate in an inter-laboratory comparison and submit CMCs.

Acknowledgements

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