Measurement Assurance Program for Resistance Parameter

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ABSTRACT

The Proficiency Testing Program is assuming greater importance in the light of the new standard ISO/IEC 17025 for laboratory accreditation. This is a means to evaluate the competence of the laboratories and to ensure that the measurements carried out by the laboratories for the same parameter of a physical quantity have close agreement. In view of its importance, the Standardization Testing & Quality Certification (STQC) Directorate, under the Ministry of Communications & Information Technology having a network of 22 testing & calibration laboratories all over the country, organized the first inter laboratory Measurement Assurance Program (MAP) for the resistance parameter. Ten laboratories, all accredited by the National Accreditation Body, participated in the program. The details of the process followed in organizing this program, analysis of the results of the participating labs and evaluation of their Performance form the subject matter of this paper.

1. INTRODUCTION

The testing and calibration laboratories complying to the new international standard ISO/IEC 17025 [1] are now required to prove their competence through their satisfactory Performance in the proficiency testing programs. This is to ensure that the measurements carried out by the laboratories for the same parameter of a physical quantity have close agreement. The laboratories satisfactory Performance in the Proficiency Testing provides an objective evidence of traceability to a common reference and builds up customers' confidence in the services provided by the laboratories. Thus satisfactory Performance in the Proficiency Testing Program is gaining importance for survival in the competitive environment. As such the laboratories are now looking for participation in the proficiency testing programs normally organized by the accreditation body or by others.

Considering the importance of Proficiency Testing and the non-availability of such programs to many of the laboratories, STQC organized the first proficiency-testing Program for Resistance Parameter through inter laboratory comparison, with an objective to assess the comparability of results amongst the participant Laboratories. It was also intended to compare the uncertainty evaluation methods, information contents in the certificate so as to bring in harmony in practices among the STQC Labs. . A total of ten laboratories participated in the program of which five are under STQC. Participation of the other laboratories included are on voluntary basis. The design steps taken in organizing this program, analysis of results and Performance evaluation of the participant labs were done as per ISO/IEC Guide 43.1"Proficiency Testing by Inter laboratory comparisons" [2] and the same is detailed in the following sections..

2.DESIGN STEPS:

2.1.SELECTION OF THE PT TYPE:

The measurement comparison program was selected wherein it was decided to circulate two resistance standards to the participating laboratories and the individual laboratory results to be compared with the reference value assigned by the coordinating laboratory. It was decided to evaluate the Performance based on the

$$E_n = \frac{C_{lab} - C_{ref}}{\sqrt{U^2_{lab} + U^2_{ref}}} \qquad \text{----------} \qquad (1)$$

Where C_{lab} is the participants result & C_{ref} is the assigned value by the reference lab. U_{lab} is the uncertainty of the participant result and U_{ref} is the Uncertainty of the reference laboratory's assigned value.

2.2 SELECTION OF THE CO-ORDINATING/REFERENCE LABORATORY:

The High Precision Calibration Centre at ETDC Bangalore being the highest echelon laboratory amongst the STQC labs was chosen as the reference lab for assigning value to the artifacts. The assigned value was not made known to the participating lab until the completion of program. The same lab did the co-ordination of the program

2.3 SELECTION OF THE ARTEFACT

Two standard resistors belonging to the reference lab, Tinsley 5685A & 5685B of nominal value 1 ohm & 1 k Ohm respectively were selected. These artifacts are hermetically sealed wire wound precision resistors of ±2 ppm stability and temperature coefficient of 1 ohm resistor is negligible where as that of 1 k ohm is 3 ppm/^{0}C.

2.4 ESTABLISHING NUMBER OF PARTICIPANTS:

In order that the program is economically viable and that the circulation of the artifacts is completed in reasonable time, it was decided to include ten laboratories in the program of which five of them are STQC Labs viz ERTL (West), (North)(East), ETDC (Chennai) and ETDC (Hyderabad) Where ETDC and ERTL refers to Electronics Test & Development Centre and Electronics Regional Test Laboratory respectively. The other laboratories included are Agilent Technologies India Ltd, & Bharath Electronics Ltd from Bangalore, Hindustan Aeronautics Ltd, Electronics Corporation of India Ltd, Bharath Dynamics Ltd from Hyderabad. The participation of non-STQC laboratories was on voluntary basis .All the participant laboratories were accredited by NABL. In order to maintain confidentiality of the identity, the individual participant laboratories were assigned code numbers for use in the final report. The laboratory identity is made known only to minimum number of people involved in the activity. Participating

labs were informed regarding the aim of the program, their confirmation for participation was obtained and program schedule was prepared.

2.5 INSTRUCTIONS TO PARTICIPANTS:

The documents that were to be sent along with the artifact were prepared. This included study plan, program schedule, measurement sheet Performa and instructions to be complied by the lab, data sheet of the artifacts, precautions in handling the item and during measurements, documents to be submitted, time schedule for sending the results etc. Participant Labs were allowed to use their own method. The maximum current to the artifact was also indicated in order to prevent damage to the artifact. The result Performa included the data on temperature & humidity at the time of measurement, standards used and the associated uncertainties, traceability details etc. to be filled in by the participant lab. Further the labs were also asked to submit the copy of the certificates of reference standards and measurement uncertainty estimation details. For consistency in statistical treatment of results standardized result sheets were prepared and also the participants were asked to submit report in their usual format and uncertainty computation details. This was mainly to see the uniformity in the reporting of the results by the laboratories

2.6 MOVEMENT OF ARTIFACTS:

The movement of the artifact started from December 2000 as per the following schedule. At least 2 weeks time was given to every lab for the measurements to be carried out:-

ETDC (Bangalore) - ERTL (Calcutta) – ETDC (Bangalore)
ETDC(Bangalore) - Agilent Technologies (Bangalore)
ETDC(Bangalore) - BEL (Bangalore) – ERTL (North) – ETDC (Bangalore)
ETDC (Bangalore) - ETDC (Chennai) - ETDC (Bangalore)
ETDC (Bangalore) - ETDC (Hyderabad) - ECIL (Hyderabad)
HAL(Hyderabad) - BDL (Hyderabad) - ETDC (Bangalore)
ETDC (Bangalore) - ERTL (Bombay)

Where
BEL refers to Bharat Electronics Ltd.
ECIL refers to Electronics Corporation of India Ltd,
BDL refers to Bharat Dynamics Ltd

The movement of the artifact was completed by November 2001. The measurement on the artifact was made by the reference lab at intermediate points of circulation for stability check. The transportation of the artifact was done in person by the co-coordinating lab.

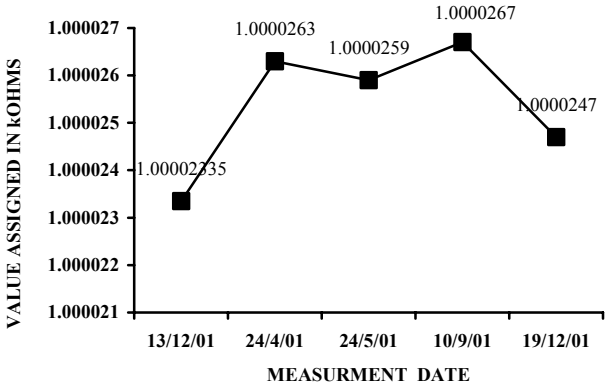
2.6 ESTABLISHING THE REFERENCE VALUE &STABILITY OF THE ARTIFACT

The reference laboratory carried out repeat measurements on the artifacts just before the circulation, in between circulation and at the end of the circulation at an ambient temperature of 25^{o} C ± 1^{o} C. The uncertainty associated with the measurement was evaluated by using Type

A & Type B evaluation. Type B uncertainty included the stability, temperature coefficient & calibration uncertainty of the reference standard. Since the temperature coefficient of the reference standard (1k ohm) was 3 ppm per degree Celsius the uncertainty associated with the ambient temperature measurement formed a significant contributing factor in the estimation of the total uncertainty..

The stability of the artifact was ensured by making measurements on the artifact during the circulation. The plot of the artifact assigned value vs. date of measurement is shown in Fig.1 & Fig.2 for the two values of resistance 1 kohm & 1 ohm. It was observed that the artifact was stable to ±2 ppm. The mean value of the measurements was taken as the reference values for analyzing the results of the participant Labs. The variation from the mean contributed to Type A uncertainty.

Fig. 1. Map Resistor Stability Data (1KΩ)



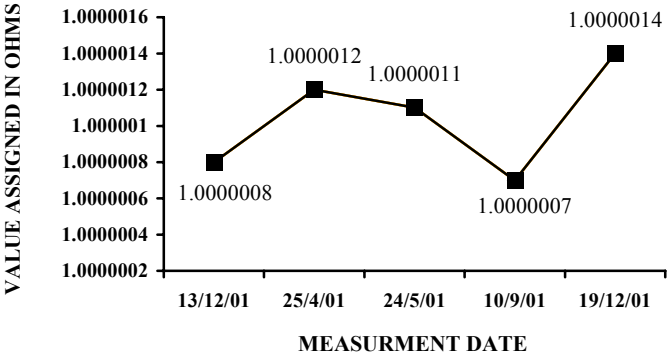


Fig. 2. Map Resistor Stability Data (1Ω)

3. ANALYSIS OF RESULT & PERFORMANCE EVALUATION:

The results from most of the participating labs were received within two weeks from the date of measurements as per the schedule. The analysis of the result was done after the closure of the circulation of the artifact and receipt of the results from all the participating laboratories. Corrections were applied to the participants result for measurement done at temperature other than 25^{o}C for 1 k ohm resistor. The uncertainty as reported by the individual labs were considered for comparison of results. The measurement results of participant laboratory were compared with that of the reference laboratory by two different methods.

i) E_n Values
ii) Graphical method

En values evaluated by using expression 1 in section 2. En values obtained for different Laboratories indicated by their code is tabulated in Table I & II for the two values of resistance 1Ohm & 1 k Ohm respectively. The Performance of the laboratories is judged based on the En value as well as the laboratory bias (deviation from mean value) as conclusion purely on En value could be sometimes misleading. For | En | less than or equal to 1 Performance is considered satisfactory .For | En | greater than 1 Performance is unsatisfactory and the laboratory need to investigate and take corrective action. It is seen from table I & II that the Performance of all the laboratories based on En value are in general satisfactory in case of 1 ohm and all except one(Lab code 2) in case of 1 k ohm . However the bias of the measured result by Lab 1 & 2 for 1 ohm & 1 k ohm is quite large. This is more clear in the graphical comparison shown in Fig. 3 & 4 for 1 Ohm & 1 kohm respectively. The doted line shown indicates the reference laboratory measurement uncertainty. The labs with larger bias (Lab 1 & 2) need to investigate on the cause.

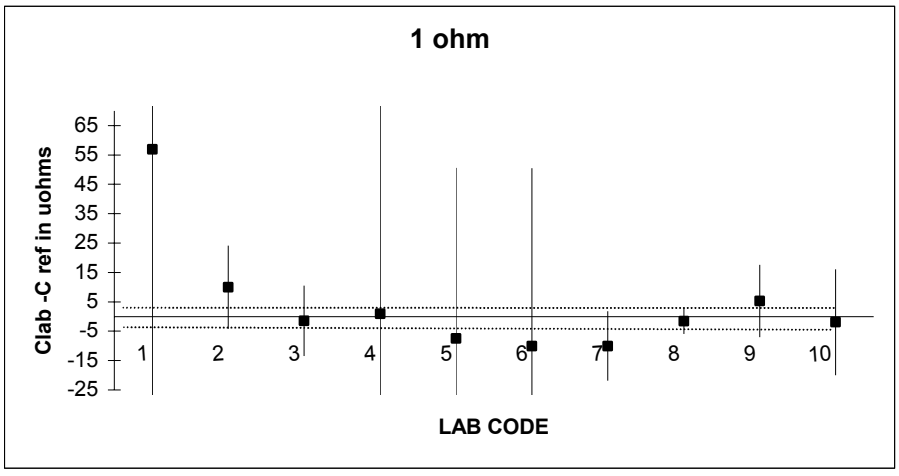


Fig.3 Laboratory's Performance; Graphical Comparison

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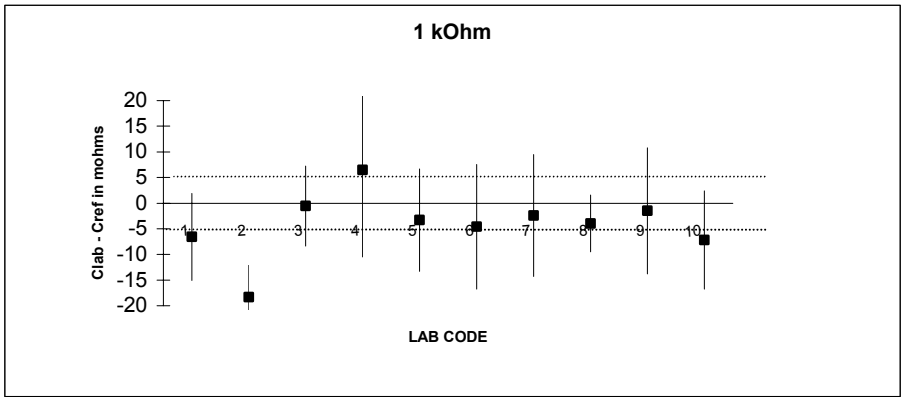

Fig 4 Laboratory's Performance: Graphical comparison

Laboratory's Performance - En Value Tables

Table I

Resistance: 1 Ohm

Lab Code	C_{lab} in Ohms	U_{lab} in ppm	C_{ref} in Ohms	U_{ref} in ppm	En
01	1.000058	95	1.0000010	4.11	0.60
02	1.000011	14.15	1.0000010	4.11	0.68
03	0.9999996	12	1.0000010	4.11	-0.11
04	1.000002	74	1.0000010	4.11	0.01
05	0.9999936	58	1.0000010	4.11	-0.13
06	0.999991	60.56	1.0000010	4.11	-0.17
07	0.999991	11.8	1.0000010	4.11	-0.80
08	0.9999995	4.39	1.0000010	4.11	- 0.26
09	1.0000063	12.3	1.0000010	4.11	0.41
10	0.9999991	18	1.0000010	4.11	-0.11

Table II

Resistance: 1 k Ohm

Lab Code	C_{lab} in Ohms	U_{lab} in ppm	C_{ref} in Ohms	U_{ref} in ppm	En
01	1000.0188	8.5	1000.02539	5.2	-0.66
02	1000.0071	6.16	1000.02539	5.2	-2.27
03	1000.02484	7.8	1000.02539	5.2	-0.06
04	1000.0319	17	1000.02539	5.2	0.37
05	1000.0221	10	1000.02539	5.2	-0.29
06	1000.0208	12.16	1000.02539	5.2	-0.35
07	1000.0203	11.9	1000.02539	5.2	-0.18
08	1000.02146	5.54	1000.02539	5.2	-0.52
09	1000.0239	12.3	1000.02539	5.2	-0.11
10	1000.01820	9.6	1000.02539	5.2	-0.66

4. OTHER OBSERVATIONS:

4.1 Uncertainty Estimation:

Out of the 10 participant laboratories 8 laboratories have adopted Type A & Type B evaluation method, 2 of them adopted random & systematic approach which need to be changed. The coverage factor k was taken as 1.96 for confidence level of 95%by all the Labs. In most of the cases the uncertainty reported by the participant laboratory deferred from the accredited capability [3]. One of the reasons could due to the measurement traceability established to other NMI (NIST, USA: NPL UK: NRC Canada) while enhancing the capability after accreditation

4.2 Formal Certificate Content:

The observations in the certificates were made for compliance to ISO/IEC 17025 Standard. As regards the name & address of the Lab and that of the customer details only partial information were furnished by most of the Labs The date of receipt & condition of receipt of

the item was provided only by 3 laboratories. Few laboratories indicated the temp at the time of measurement and few others indicated the normal laboratory environment maintained. Variations are observed in the method of reporting measurement results. Measurement uncertainty along with the measured value were reported only by few labs. All the labs included cal validity of the reference standards used, date of calibration and calibration procedure. The statement on measurement traceability, report reproduction formalities and validity of the report results were included only by few labs. The measurement result included measurement uncertainty data by 4 laboratories & confidence level by 2 laboratories

5.CONCLUSION S:

ETDC Bangalore as the coordinating laboratory has gained good experience in organizing the Program. Although the participant's laboratories have utilized different methods for the measurement and have established measurement traceability to different NMI's, the Program has confirmed the general agreement in the results reported and traceability to a common reference. The laboratories adopting older method for measurement uncertainty estimation need to change over to Type A & B evaluation method as per the guidance document for estimation of measurement uncertainty. [4 & 5]. Further as per the requirement of ISO/IEC 17025 the laboratories need to include the measurement uncertainty and the confidence level along with the measured value. One time participation in the PT program by the laboratories and their satisfactory Performance is not that all laboratories have to look for the technical competence. The scope of laboratories is not limited to one parameter and the asset of the laboratories including the personnel keep changing. Hence laboratories are required to participate in PT Program on a continuous basis. Keeping this in view it is intended by STQC to organize one program every year so as to cover main scope of accreditation of the lab in its network

6. ACKNOWLEDGEMENT:

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REFERENCES:

[1] International Standard ISO/IEC17025 General requirement for the competence of testing & calibration laboratories. 1999(E)
[2] ISO/IEC. Guide43.1 Proficiency testing by inter laboratory comparison Part-1Development & operation of Proficiency testing schemes 1996.
[3] NABL 141Guidelines for estimation and Expression of Uncertainty in Measurement April 2000.
[4] Guide to the Expression of uncertainty in measurements 1993 ISO Geneva
[5] NABL 501 Directory of NABL accredited calibration laboratories July 2000.