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APMP Intercomparison of DC Voltage Standard at NPSL Islamabad

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Inter-comparison of DC voltage standards has now become the most suitable and authenticated means for maintaining the international tractability of national standards all over the world. The results of an intercomparison on DC voltage standards carried out at National Physical & Standards Laboratory (NPSL) Islamabad are presented and discussed.

Key words: Metrology, Travelling standard, Traceability, Uncertainty.

Introduction

Voltage is an important quantity in electrical measurements and together with the unit of resistance (the ohm), forms the basis for electrical metrology standards.

Generally in metrology, the unit of voltage is maintained through physical standards based on electro-chemical cells and zenor based electronic standards with a traceable reference to Josephson junction voltage standard "JVS" (Steve Spang 1980; Hu Yan 1980; Frankle 1982; Revd 1994; Witt 1995).

Modern trends and approaches in metrology provide an appropriate and authenticated mean for maintaining the International Traceability of National Standards, through inter-comparisons (Lo *et al* 1994).

A such inter-comparison programe for DC voltage standard, arranged by Asia Pacific Metrology Programe (APMP) was undertaken at NPSL, Islamabad during June/July 1997. This was the first APMP intercomparison programe of electrical standards undertaken at NPSL.

The programe was coordinated by National Measurement Center (NMC) of Productivity and Standards Board (PSB) Singapore. A well characterized Fluke-732-B, DC Reference Standard was used as the 'Travelling Standard' among the participating laboratories.

A total number of fifteen countries of Asia Pacific region including Pakistan participated in the subject intercomparison programe.

The National Standards/Measurement Laboratories of following countries took part in the inter-comparison.

(Name in sequensial order):

1	NMC/PSB	(A)	Singapore
2	SIRIM	(B)	Malaysia
3	HKGSCL	(C)	Hong Kong/China
4	ETL	(D)	Japan
5	KRISS	(E)	Korea (South)
6	NML	(F)	Australia
7	TISTR	(G)	Thailand
8	KIM-UPI	(H)	Indonesia
9	ITDI	(I)	Philippines
10	CMS/ITRI	(J)	Taiwan
11	NIM	(K)	P R China
12	NPSL	(L)	Pakistan
13	MSB	(M)	Mauritius
14	MUSSD	(N)	Sri-Lanka
15	NPL	(O)	India

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Pre-intercomparison measurement arrangements. The Fluke 732-B, S.No.6265612, travelling standard alongwith its external battery charger and testostar logger (for automatic recording of temperature and relative humidity) reached the NPSL - Islamabad on 05.07.1997 at about 5.00 PM, after necessary custom clearance formalities. The initial check measurements were taken as instructed in the APMP comparison documents (Liu L X 1996). 'Things to be done' and the following observations were recorded.

Date:-	05.07.1997
Time:-	05.00 PM
Temperature:-	23.50°C
Relative humidity:-	50%
In-cal indicator	On Position
Internal battery out put	13.91 VDC
Thermister resistance (required not <20 K. Ohm)	23.00 K. Ohm
EMF output (nominal)	1.018000 VDC
EMF output (nominal)	10.00000 VDC

Experimental set-up and techniques for inter-comparison measurements. The inter-comparison measurements between the APMP travelling standard (732-B, Fluke) and the NPSL

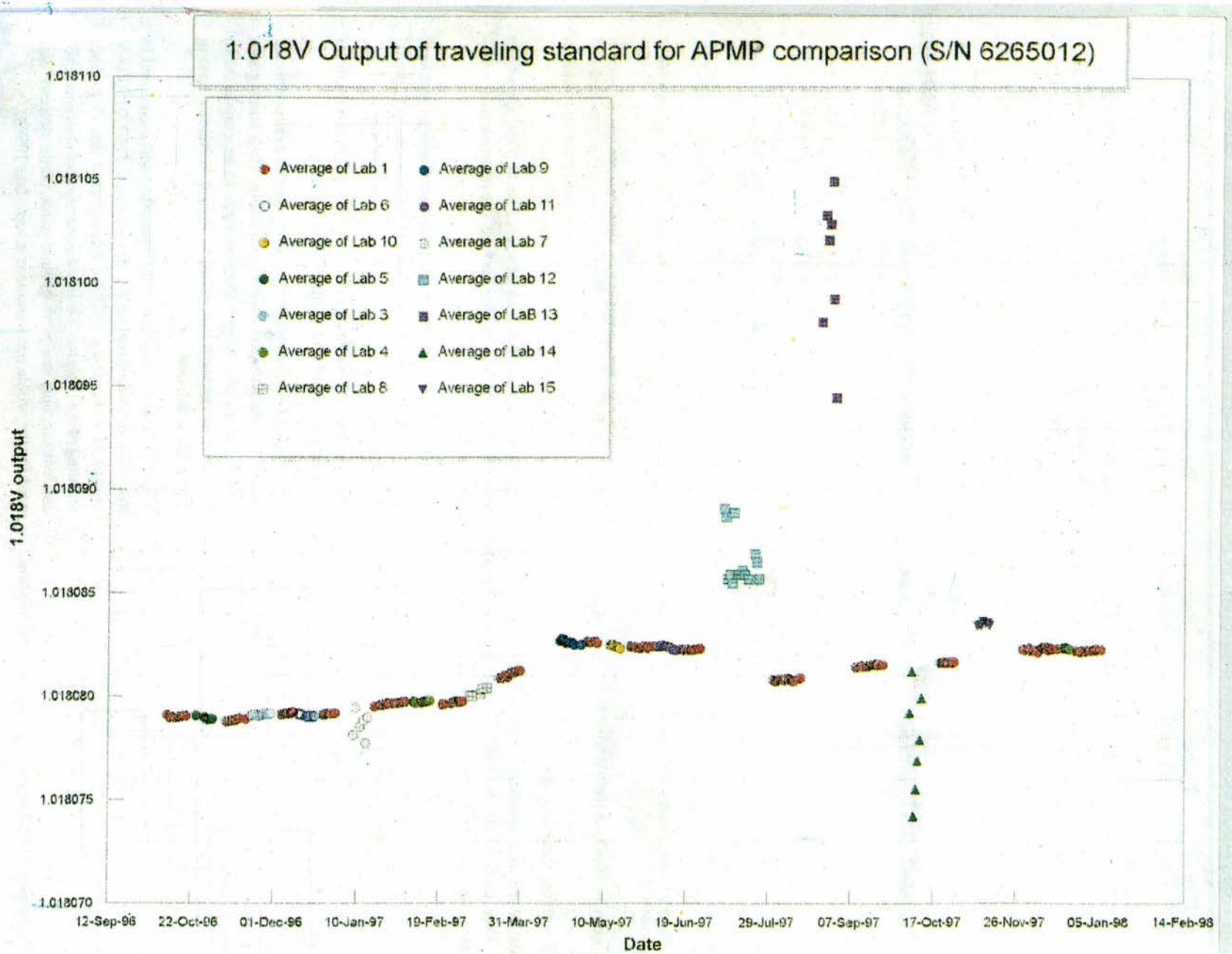

Fig 2. Graphic representation showing average measured values of (1.018000 V) by participating laboratories.

Table 1
Intercomparison measurement data/results of APMP DC voltage travelling standard, fluke 732-B

S No	Date	Temperature (Avg)°C	Relative humidity (Avg) %	Pressure (Avg) Pa	Measured voltage (Avg) V	Standard deviation(V)
1	07-07-97	23.3	50	0.996×10^5	1.0180891	2.683×10^{-7}
2	08-07-97	23.4	50	0.996×10^5	1.0180887	1.095×10^{-7}
3	09-07-97	23.4	48	0.996×10^5	1.0180857	1.095×10^{-7}
4	10-07-97	23.4	47	0.991×10^5	1.0180859	1.095×10^{-7}
5	11-07-97	22.3	48	0.991×10^5	1.0180855	2.683×10^{-7}
6	12-07-97	22.7	47	0.993×10^5	1.0180889	1.095×10^{-7}
7	14-07-97	22.6	51	0.993×10^5	1.0180859	1.095×10^{-7}
8	15-07-97	22.8	50	0.993×10^5	1.0180859	1.095×10^{-7}
9	16-07-97	22.8	50	0.993×10^5	1.0180861	2.683×10^{-7}
10	17-07-97	23.2	51	0.993×10^5	1.0180859	1.095×10^{-7}
11	19-07-97	23.1	51	0.993×10^5	1.0180857	2.190×10^{-7}
12	22-07-97	23.7	52	0.996×10^5	1.0180869	1.095×10^{-7}
13	23-07-97	22.1	51	0.996×10^5	1.0180865	2.683×10^{-7}
14	24-07-97	22.5	52	0.996×10^5	1.0180857	1.095×10^{-7}

Note. Formula used to calculate the standard deviation (sample)

$$\underset{(n-1)}{\text{S.D. }(\delta)} = \sqrt{\frac{\Sigma x^2 - (\Sigma\ \bar{x}^2)}{n-1}}$$

Where $\bar{x}$ is the arithmetical mean of the observations and x is the difference of individual observation from the mean, n is the total number of observations recorded.

reference voltage standard (SCO-106, JRL) was carriedout according to the procedure recommended and provided by the APMP with the travelling standard.

The APMP travelling standard and the NPSL reference standard were connected in back to back measurement configuration, for their 1.018000 volt (nominal) outputs, as shown in (Fig.1).

Before the actual comparison measurements, the following steps were taken as per requirement of measurement conditions (Liu 1996).

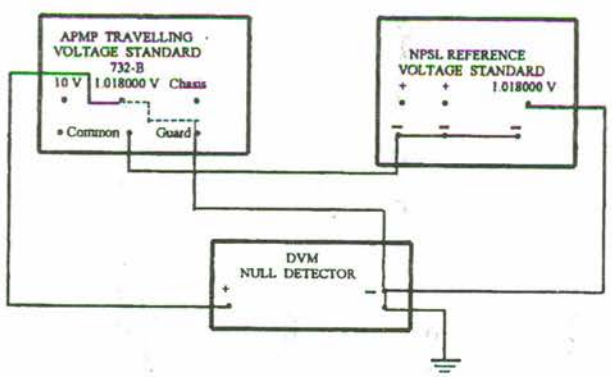

Fig 1. Connection Block Diagram for Inter-comparison Setup.

AC power was withdrawn from the travelling standard and NPSL reference standard, so that both were to be operated on battery, during comparison measurements.

The IN-CAL indicator was observed to be ON. One-hour relaxation time was given before the comparison measurements.

The 1.018000-volt output of the travelling standard was kept on float with out connecting COM (LO) terminal to "Guard" chasis or other.

NO connection between the two COM (LO) terminals of travelling standard 732-B Fluke were made.

The COM (LO) terminals of both the standards were connected together using shielded-twisted pair cable. Thus leaving +ve (HIGH) terminals of both the standards to be connected to the input of the detector/precision digital voltmeter having microvolt resolution.

The 1.018000-V output of APMP standard was connected to the +VE input terminal of the detector and the 1.018000-V output of Laboratory (NPSL) Standard to the -VE input terminal of the detector. To avoid generation of spurious EMF and leakage, only one earth-ground point, on the detector was used for the whole measurement setup. (Liu 1996).

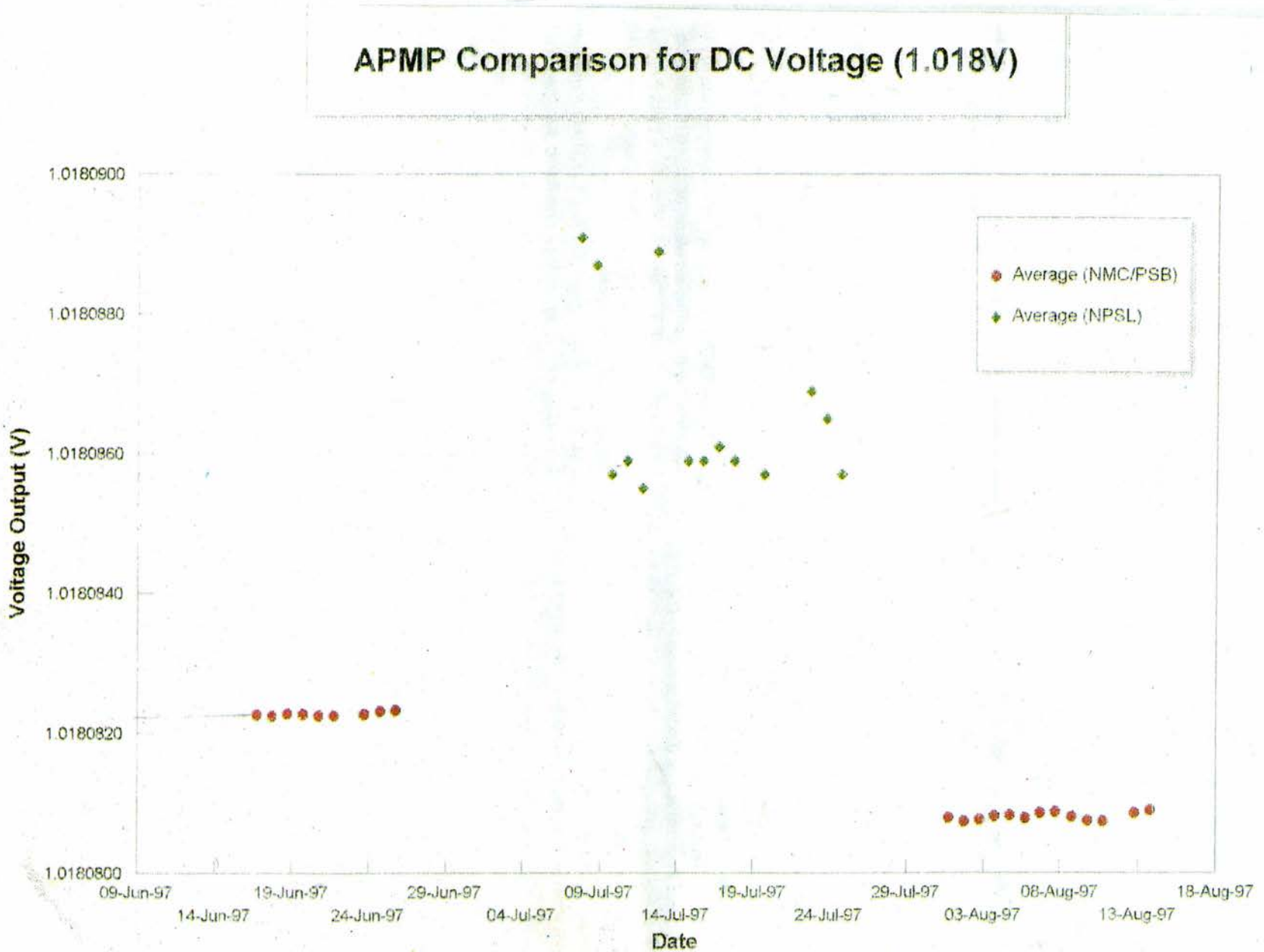

Fig 3. Graphic representation showing the difference in average values of APMP travelling standard (1.018000 V), measured by NPSL Pakistan and NMC Singapore.

Table 2
Estimated budget for total/combined measurement uncertainty

Output value of the standard 732-B, fluke	Type "A" uncertainty (PPb)	Type "B" uncertainty (PPb)	Total/Combined uncertainty (PPb)
1.018000 V	175.6	19.6	176.7

Note. Total type 'A' uncertainty due to scatter of measurement data was calculated by statistical method. Total type 'B' uncertainty was calculated taking into account the different influential factors for measurement. The total/combined uncertainty was calculated by using the RSS (root-sum square) method.

The voltage difference between the two standards 1.018000-volt output was measured by differential method. (Steve Spang 1980, Revd 1994). Data of measurements were taken and recorded daily from 07.07.97 to 24.07.1997.

Results and Discussion

The results of the measurement data collected and computed are given in Table 1. Beside, standard deviations and the corresponding average values for different sets of measurements are also given in the same table. Table 2 incorporates the estimated budget for total/combined measurement uncertainty. The National Physical & Standards Laboratory (NPSL) Islamabad, Pakistan was designated as lab-12 by the APMP in this comparison program.

In Fig 2 graphic representation shows the average value of 1.018000-volt measured by the participating laboratories.

The analysis of the graph shows that the total spread of variance in the comparison measurement carried out by NPSL is within 0.8×10^{-6} to 1.8×10^{-6} volt. Fig 3 shows the graphic representation regarding the difference in average value of APMP-travelling standards output voltage (1.018000V) measured by NPSL-Pakistan and NMC/PSB Singapore. They differ by 35.2×10^{-6} volt with each other (Liu Ling Xiang *et al* 1998). The magnitude of this difference may be due to environmental conditions prevailing in the two concerned laboratories because with stable laboratory environment conditions, more consistent and repeatable results can be achieved.

However, the APMP comparison program for DC voltage has provided a useful opportunity for checking and improving the relevant measurement competency at NPSL and maintaining the "International Traceability" of "National Standards" which is the stringent requirement of metrology and ISO-9000 standards.

Regular participation in such programs will definitely be useful for NPSL, in improving the measurement techniques and status of national standards maintained at NPSL.

References

Frankle R B 1982 *Secondary standard of EMF in a standards laboratory.* APMP Regional Workshop on Metrology. CSIRO, DAP, Sydney, Australia, pp 281-302.

Hu Yan Rui 1980 The characteristics of standard cells with a low temperature co-efficient. *IIEE Trans Inst Meas IM* **29**(4) 243-247.

Liu L X 1996 APMP *Document on inter comnparison of DC voltage using travelling standard.* NMC/PSB, Singapore.

Liu Ling Xiang, Sim T Y, Tan K S, Chua H A 1998 *Preliminary report on the results of APMP Comparison of DC voltage.* NMC, Singapore.

Lo C M, Lee D W K, Chua S W, Ang C K 1994 *Report on inter-comparison of voltage standards between NIM (China)*, SCL (Hong Kong) and SISIR (Singapore).

Steve Spang 1980 *Standard cels & comparison of standard cells, calibration philosophy in practice*, Jhon Fluke International Corporation Washington USA, pp 27-33.

Witt T J 1995 Realization and comparison of voltage standards. *IIEE Trans Int Meas IM* **44**(2) 166-170.