COMPARATIVE STUDY OF VOLTAGE DEPENDENCE AND SELF HEATING IN PRECISION HV DIVIDER

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Abstract: This paper focused to determination of Voltage dependence of Precision High Voltage divider and Self Heating of HV resistance. High Voltage resistive divider is a Primary standard of DC High Voltage measurements. The traceability of HV measurements is directly related to dividerôs traceability, to scale the voltage from Josephson voltage standard, which is primary standard of DC voltage. The change in effective resistance ratio with Voltage depends upon self heating of resistance, electrostatic stress and leakage current. The design of divider and Precision source minimise the above factor which is also discussed in this paper. The relative ratio change due to High Voltage of HV divider in both positive and negative Polarity is about 0.1 ppm /kV.

Keywords: HV Divider, Voltage dependence, Self Heating, Stability, Traceability

1. INTRODUCTION

National Physical laboratory (India) has very Precise Resistive divider for DC High voltage measurement. The thick film resistors connected a large number of one mega ohm units in series. The temperature coefficient is reduced to a negligible minimum by choosing some resistors with positive and others with negative coefficient used in dividers are selected for low temperature and voltage dependence and they are aged by heat treatment to obtain a good stability. The guard circuit is used to reduce to leakage by corona, electrostatic shielding to minimize the stay capacitance effect. To minimize the leakage current Teflon supporting structure is used. The design of HV divider minimizes the specific factors effect the ratio of divider [1].

The voltage dependence of HV divider by increasing of voltage is very important characteristic to determine the ratio. It depend upon self heating, Electrostatic stress and leakage current of divider. Therefore one of the most important considerations in establishing the dc HV standard using the HV divider is to evaluate precisely the voltage dependence and self heating of HV divider.

The precise study is carried out under stable condition of HV divider in controlled environment, the stability of output in Positive and Negative Polarity are shown in Fig (1) and Fig (2). The Voltage source used in this study is highly stable at the level of 10 ppm at 100 kV in positive and negative Polarity, the stability of Voltage source at 75 kV of Positive Polarity is shown in Fig (3). Hypo terminal commands are use to communicate HV source through optical fiber cable. The software used to analyzed the data in Visual basic 6.0

2. METHODOLOGY

The traceability of DC high voltage standard is to scale the voltage from Primary standard of DC Voltage through 1000V calibrator. This known 1000V from calibrator is applied to HV divider. The value indicated at the dividerôs lower end (10 V tap) is measured on the calibrated DVM after HV simulation with input impedance of DVM kept at 100 GΩ for 10 V tap. The voltage between 10 kV and 100kV was applied to HV measuring resistance in 5 kV steps with 20-25 minutes continuous warm-up time at set values. The time interval was obtained by stability study of divider in Positive and Negative Polarity [2].The linearity of divider was establish between 10 and 100 kV by comparison with a stable 300 kV divider under well define measurement condition.

The above study Establish the traceability of HV divider, the resistance of HV section change with applied voltage because of self heating. Therefore most important consideration to evaluate the Voltage dependence to determine the Electrostatic stress, leakage current and Heating in HV divider.

The precision High Voltage supply of 10 ppm is used to determine the high voltage characteristics of HV divider at 25 kV,50 kV,75 kV and 100 kV is shown in Fig (4) with the ratio 10000:1 (10V output) under stable condition.

The voltage coefficient measurement is investigated between 10 kV to 100 kV at temperature 23 ± 1ºC and relative humidity 50 ± 3%

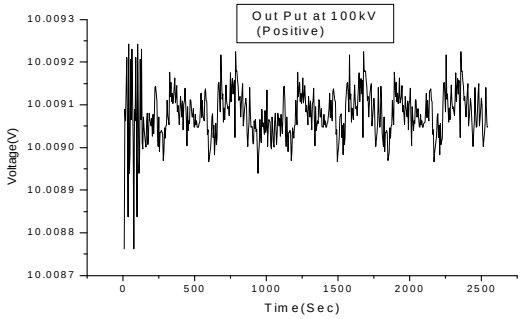

Fig.(1) Stability of out put of HV divider at 100 kV (Positive)

$\Gamma(V_1) = V_1 / m_1$, $\Gamma(V_2) = V_2 / m_2$

$C = [\Gamma(V_2) - \Gamma(V_1)] / (V_2 - V_1)$

Where : $\Gamma(V_1)$=Ratio at Voltage V_1, m_1= divider out put at V_1

$\Gamma(V_2)$=Ratio at Voltage V_2, m_2= divider out put at V_2

C = Voltage coefficient

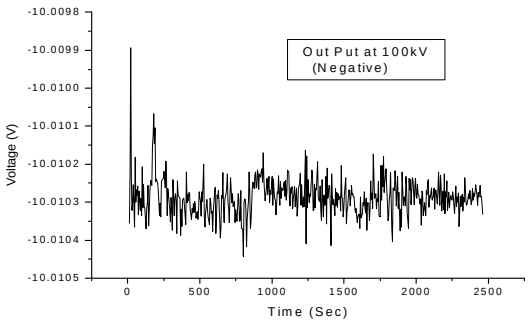

Fig. (2) Stability of HV divider at100 kV (Negative)

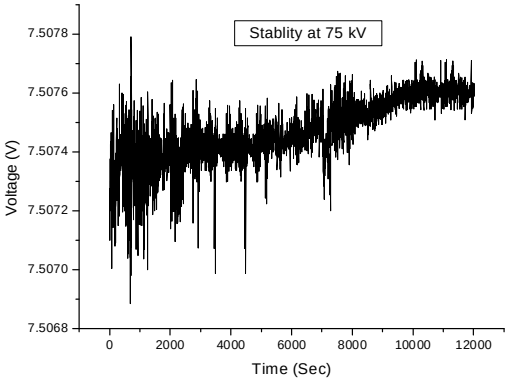

Fig. (3) Stability of Precision HV source at 75 kV (Positive)

3. RESULT

Fig.(5) Shows typical ratio comparison (10000:1) of Self Heating and voltage dependence, the relation of scale factor and applied voltage, the voltage dependence of scale factor of Precision HV divider is less than 0.1ppm/kV in Positive and Negative Polarity[3]. The stability of HV divider at 25 kV, 50 kV, 75 kV and 100 kV in Positive and Negative Polarity, the maximum change is 2 $X10^{-6}$ and time to stabilize from 20-25 minutes.

According to Table (1) the Expended Uncertainty of HV Divider is 15 $X10^{-6}$ confidence level of 95%, k=2

4. CONCLUSION

It has been shown that the ratio drifts due to the effect of high voltage against the self heating of divider significant from 75 kV to 100 kV. The relative ratio change due to High Voltage of HV divider is about 0.1 ppm /kV, where as ratio drift due to self heating of resistors is insignificant after 75 kV in both polarities. The study provides increased confidence in the uncertainty estimate.

5. REFERENCES

[1] Ahmet Merev,Ozcan Kalenderli ñThe construction of a DC high voltage precision dividerò Journal of Electrostatics 67(2009) 741-745

[2] S.K,Mahajan,K.B.Ravat & P.C.Kothari ñ Traceability of 100 kV dc high voltage measurements at NPL,Indiaò Indian Journal of Pure and Applied Physics 44 (2006) 478-481

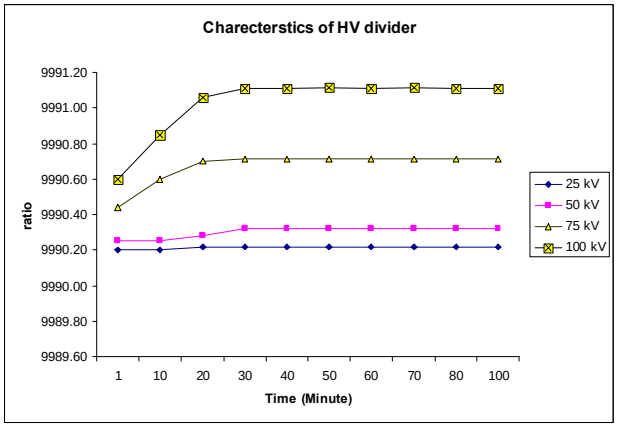

Fig. (4) Characteristics of HV Divider at 25,50,75,100 kV

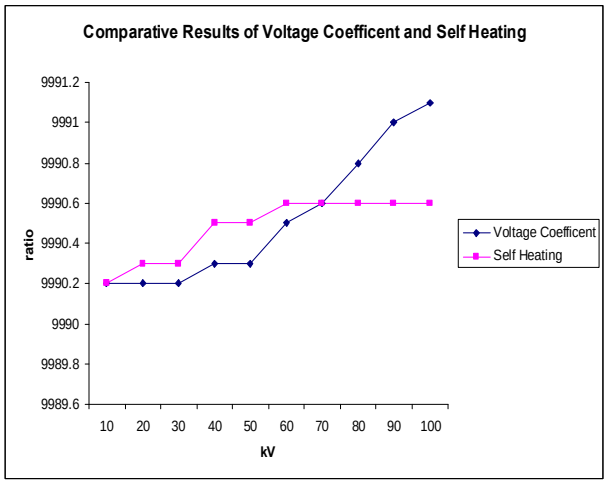

Fig.(5) Ratio Comparison of Voltage dependence and Self Heating

Table 1
Uncertainty budget

Uncertainty in	Estt. Unc. (ppm)	Std Unc (ppm)	D.F
DVM	6	3	30
Calibrator	3.5	1.25	∞
Voltage Coeff	10	5.77	∞
Temp Coeff	2	1.15	∞
Stability	2	1	∞
Repeatability	2.3	2.3	2
Com. Unc		7.3	0.0
Effective deg of freedom		392.6	2.0
Exp Unc k=2		14.69	

[3] YiLi,Juris Rungis, Kyu-Tae Kim et ., ñInterlaboratory Comparison of High Direct Voltage Resistor DividersòIEEE Transaction and Measurement 48 No.2(1999) 158-161