A study of air force cooling on self heated wire wound Precision High Voltage divider though Automation

To cite this article: Kartik et al 2018 J. Phys.: Conf. Ser. 1065 052005

View the article online for updates and enhancements.
A study of air force cooling on self heated wire wound Precision High Voltage divider though Automation

Kartik, K.B.Ravat and Thomas John
National Physical Laboratory, New Delhi 110012 (India)

E-mail: kbravat@nplindia.org

Abstract. This paper focussed on air force cooling over self heated wire wound high voltage divider. The deviation in resistance value depend upon the material used in resistance, type of construction and its temperature coefficients. The self heating of resistance play significant role in calibration of HV divider. The construction of HV divider reduces the temperature coefficient minimum by choosing some resistance with positive and negative temperature coefficient. When these resistances are proper arranged in series, the total resistance changes lower than that of individual but still influenced with the working temperature inside of the resistive divider due to self heating of individual resistor with gradually increasing of voltage. The comparative study of self heating of resistance and air force cooling of wire wound divider at laboratory environment condition 25°C ±1°C and relative humidity 50 ± 3%. The study has been done continuously with gradually increasing voltage from 1 kV to 100 kV DC under stable condition of source traceable to Josephson voltage standard. The fiber optic converter is used for communication between computer system and HV power source. The precise study of air cooling by modification of HV divider though advance graphical software has been developed in NPL to determined divider ratio. The combine uncertainty in ratio determination has improved from 35 ppm to 20 ppm by using air force cooling

1. Introduction

Temperature coefficient is very important characteristics of high voltage resistive divider to determine of ratio. The deviation of ratio depends upon material used in resistance, voltage coefficient of resistance, type of resistance, measurement technique and construction of divider. High voltage resistive divider consists of wire wound resistances which are connected in series. The resistance are selected for low temperature coefficient and low voltage dependence and aged by heat treatment to obtain stability. The comparative study of self heated wire wound resistive divider and air force cool HV divider consists of Nickel chromium based alloy (EVANOHM) wire under stabilized condition.

The voltage dependence of HV divider by increasing of voltage is very important characteristics to determine the ratio of divider. [1] It depends upon self heating, electrostatic stress and leakage current of divider. Self heating occurs whenever there is power dissipation in resistors which always heat up the resistors, thereby changing its value and voltage drop. This effect can be reduce by flow of air inside of cylinder of HV divider constantly and reduce the temperature of cylinder.

The software has developed in LabVIEW at NPL to automation of DC high voltage Metrology. Graphical software develops to determine the, stability of divider, evaluation of data in graphical form. It can see the graph of stability instantly and evaluate the result of self heating and air force cooling.
along with graph. The LabVIEW execution system built for multiprocessing, it creates multiple threads and writes code to communicate among threads. It can recognize opportunities for multithreading in virtual instruments (VIs) and execution system handles multithreading communications. The software help to comparative study of self heated and air force cooled resistive divider

2. Measurement arrangements

2.1 Standard HV Divider
The NPL (I) standard divider consists of a high voltage arm of 100 ruthenium oxide based thick film resistors of 1MΩ each and thick film 10 kΩ low voltage arm. The traceability of the HV divider scales the voltage from Josephson voltage standard, which is primary standard of DC voltage [2]. The total ratio Uncertainty is within ± 15 parts in $10^6$ at 100 kV.

2.2 Wire wound Divider (UUC Divider)
High Precision commercial divider consists of a high voltage arm of 100 Nickel Chromium (Ni 73.5%, Cr 20%, Al 2.5%, Cu 2%, Mg 1%, Si 1%) alloy of wire wound resistors 1MΩ each and shield by aluminium anodize tube. The low voltage arm consists of 10 kΩ wire wound resistor. The ratio variation is ± 35 parts in $10^6$ at 100 kV traceable from National standard. The modification has been done for improvement of stability and uncertainty of wire wound divider, ground clearance has been increased from bottom of divider from 3 cm to 10 cm for effective suction of air, fan fixed below the divider for air force cooling.

2.3 Methodology
The comparative study of wire wound HV divider self heating and with air force cooling has been carried out to determined deviation in uncertainty and stability from 1kV to 100 kV. The standard divider and wire wound (UUC) divider are put in parallel with Precision DC High Voltage Source up to 100 kV under stable condition. The output voltage at lower end of the standard divider as well as UUC divider is measured with the help of two separate calibrated voltmeters. The voltage between 10 and 100kV applied to HV divider in 10 kV steps with warm up time at set value. [2] The stability time of High voltage source obtain by plotting our put voltage at the lower end by using divider and DVM over 4 hr. Shown in Fig (1)

![Fig. 1. Comparative study of air force HV Divider](image1)

![Fig. 2. Ratio comparisons of HV Divider](image2)
The divider was temperature stabilised at the measurement temperature for 24 hours. The change in output voltage with respect to time recorded after 25 minute of stability time of both dividers condition self heating and with air force cooling of wire wound divider. The study was conducted at 1 kV to 100 kV at (1 kV, 12.5 kV, 25 kV, 50 kV, 75 kV and 100 kV) steps up to 20 minutes the Graph is shown in Fig 3 and Fig 4 (50 kV and 100 kV)

Further the comparative study of Wire wound HV divider self heating and with air cooling, change in ratio was recorded continuously during step voltage changes of 20 minute duration up to maximum voltage of 100 kV. Noise level of output is reduced by measurement duration of each data point in a run present at a value up to 300 power line cycles (6s at 50 Hz). The maximum temperature of resistance cylinder goes to 50°C, the air force cooling reduce the temperature of cylinder up to 25°C

The Change in ratio between 25°C to 50°C temperature coefficient were computed for (25–50) °C ± 1 °C and Relative Humidity 50 ± 3% [4][5]

\[ \alpha = \frac{1}{(T_{50} - T_{25})} \{1 - (\Gamma_{50} / \Gamma_{25})\} \]

\( \alpha \) = temperature coefficient / °C
\( T \) = temperature °C
\( \Gamma \) = ratio of divider

2.4 Software developed for Automation

The software is prepared to communicate between PC and digital interface RS232 of High voltage source for control, determine the measure value at output of source and stability time. The Hyperterminal commands are used by set MS window PC’s to “VT52 emulation” for communicating to HV source.

The fibre optic converter is used for communication between computer system and HV power supply. The fibre optic converter is safe and failure-free data communication. Its resolution 16 Bit, Insulation voltage 2kV DC and control commands according to SCPI standard. The connection is galvanic isolated. In case of any male function the converter prevent potential shifts and failure caused by it. Software has been developed using LabVIEW to automate divider ratio determination setup, which also gives the output of divider in graphical form.

3. Results

Fig (2) Shows Typical ratio comparison (10000:1) Wire wound HV divider self heating and with air force cooling the relation of scale factor and applied voltage Influenced with rise temperature of resistance cylinder from 25°C to 50°C. The temperature dependence of Wire wound HV divider (Nickel chromium based alloy) is about 5 ppm /°C. The scale factor of prolonged voltage applied is decreased after 75 kV. The air force cooling significant effect to improve stability and uncertainty from 35 ppm to 20 ppm

Fig (3) and Fig (4) Graph shows the output of voltage with air cooling and Self heating (without cooling) of wire wound HV divider, a drift in ratio has been seemed after 75 kV in Wire wound divider, the drift appears is gradually reduced in air force cooling. The possible cause may be thermal expansion of wound wire and leakage current between turns, as shown in Fig. (2)

4 Conclusions

Wire wound divider is significant influenced with temperature and voltage, the drift in ratio after 75 kV is likely due to the lack of heat treatment in wire wound resistance [3].
Fig. 3 Graph Comparative voltage output of Wire wound HV Divider Self heating (without cooling) and with Air force cooling at 50 kV

Fig. 4 Graph Comparative voltage output of Wire wound HV Divider self heating (without cooling) and with Air force cooling at 100 kV

REFERENCES

[1] Yi. Li, Juris Rungis, Tao Jing et. “International Comparison of a Resistive Divider at 100 kV DC” IEEE Transactions on Instrumentation and Measurements, vol.50, pp.436-439, 2001

[2] S.K. Mahajan, K.B. Ravat and P. C. Kothari, “Traceability of 100 kV dc high voltage measurements at NPL, India” Indian Journal of Pure and Applied Physics, vol.44, pp.478-481, 2006.

[3] Rainer Marx “New Concept of PTBs Standard Divider for Direct Voltages of up to 100 kV” IEEE Transactions on Instrumentation and Measurements, vol.50, No.2, pp.426-429, 2001

[4] Stability Study of Precision High Voltage Resistive Divider by Automation Kanishk Ravat, K.B. Ravat and Anil Kishore Saxena CPEM 2010 Digest, Daejeon (KOREA), 3-18 June 2010 pp. 661-662

[5] Comparative Study of Temperature Influence on Thick film and Wire wound Precision HV Resistive Divider K.B. Ravat CPEM 2012 Digest, Washington DC (USA), 1-6, July 2012 pp. 136-137