Calibration of Voltage Transformer Test Sets using a Digital Sampling Wattmeter.

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1. Introduction

This paper describes the use of the NPL Digital Sampling Wattmeter (DSWM) [1] to calibrate voltage transformer test sets. These are instruments used to calibrate transformers by comparing the unknown transformer with a standard transformer whose properties are known.

The standard transformer can be calibrated in a traceable fashion by a method such as that described in Ref [2].

2. Measurement procedure

The test set operates by connecting the secondaries of the two transformers to be compared to the two inputs as indicated in Fig 1. The same high voltage is then applied to the transformers. The transformers are usually similar, so that the secondary voltages are similar, eg 100 V . The test set is then used to measure the ratio and the difference in phase between the two input voltages. If the ratio error and phase displacement of the standard is known then the ratio error and phase displacement of the transformer under test can be calculated.

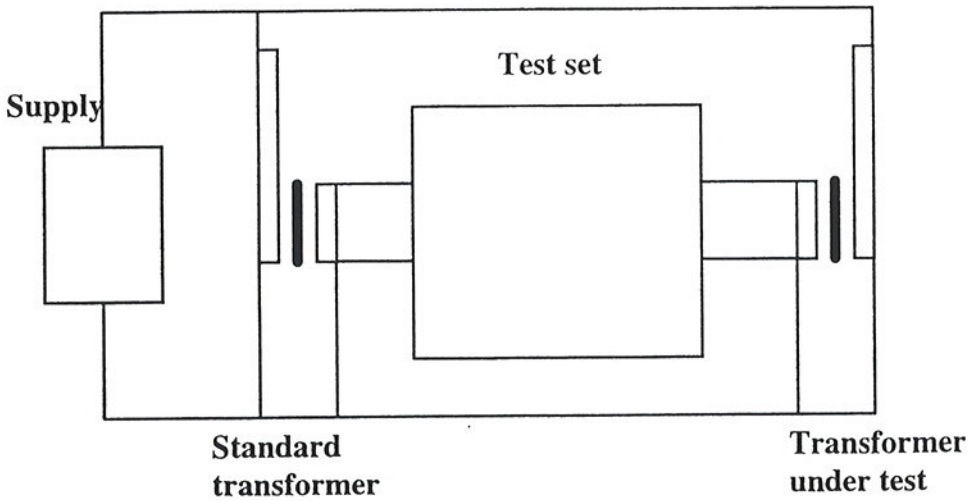

Figure 1. Transformer test set

To calibrate the test set it is necessary to apply voltages to the standard input and the test input of the test set whose ratio and phase difference are known. In this method the input

voltages are adjusted to be approximately what is required and are connected to the test set and the DSWM which are connected in parallel as shown in Fig 2.

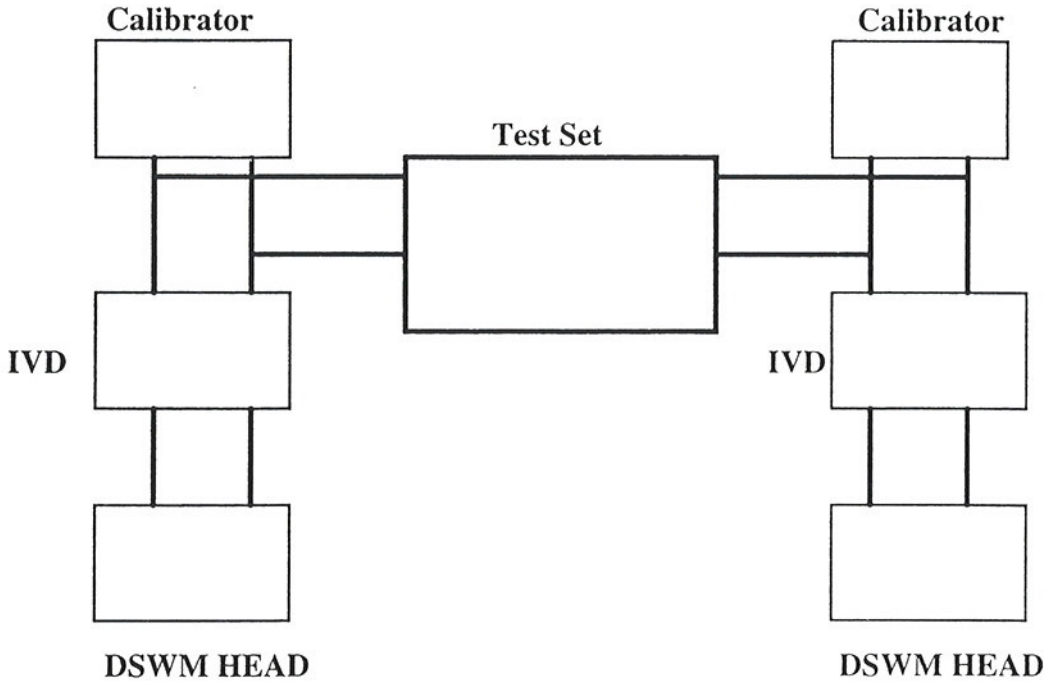

Figure 2 Measurement circuit

The two voltages are supplied from voltage calibrators and are very stable in amplitude. The calibrators are phase locked in such a way that the relative phase can be varied by means of a variable time delay. Inductive voltage dividers (IVD) are used to reduce the 100 V applied to the test set to the 1 V level at which the DSWM measurement heads operate.

The inductive voltage dividers are calibrated for voltage ratio and phase. The phase change involved is negligible at the accuracies required in this work.

The ratio and phase difference of the two voltages are then measured using the DSWM and the values obtained compared to the readings of the test set and the instrument error calculated. The DSWM has a very high input impedance and does not have any significant loading effect on the measurements. The DSWM samples the two waveforms and performs a Fourier transform to obtain their amplitude and phase. From this information the ratio and relative phase of the two waveforms can be calculated.

The test set used in this work had various ranges up to 20% voltage error and 20 centiradian phase error. The measurements described here were made at the lower ranges of 0.2% and 2% ratio error and 0.2 centiradian and 2 centiradian phase error as these are the ranges most likely to be used for good transformers.

3. Results

The measurements obtained on the 0.2 centiradian and the 0.2% ratio error range are shown in Tables 1 and 2. The phase measurements were made with nominally zero voltage ratio error and similarly the ratio error measurements were made with nominally zero phase difference.

The main contribution to the uncertainty for phase measurements is the random scatter in the measurements of the applied phase as measured by the DUT and the DSWM. For the ratio error measurements the main uncertainty is the system uncertainty of the DSWM.

"Phase Angle" 0.2 centiradian range		
Nominal reading centiradian	Instrument error centiradian	uncertainty centiradian
+0.19	–0.0023	0.0008
+0.15	–0.0010	0.0008
+0.10	–0.0013	0.0008
–0.10	–0.0002	0.0008
–0.15	–0.0002	0.0008
–0.19	–0.0007	0.0008

Table 1. Measurements of phase error at zero ratio error

"Ratio Error" 0.2 % range		
Nominal reading %	Instrument error %	uncertainty %
+0.19	+0.0011	0.0017
+0.15	+0.0011	0.0017
+0.10	+0.0008	0.0017
–0.10	–0.0000	0.0017
–0.15	+0.0001	0.0017
–0.19	+0.0002	0.0017

Table 2. Measurements of ratio error at zero phase error

Combined Voltage and Phase Error measurements

Voltage Errors and Phase Errors at +0.19%, +1.9%, -0.19 centiradians, and -1.9 centiradians were applied simultaneously to the Transformer Test Set at 100 V. The error in the instrument indication is given in Table 3.

Voltage Error and Phase Error at 100 V					
"Ratio Error"		"Phase Angle"		Uncertainties	
Nominal Reading %	Instrument Error %	Nominal Reading centiradians	Instrument Error centiradians	Voltage Error %	Phase Error centiradians
Applied Voltage 100 V					
+0.19	-0.002	+0.19	-0.0009	0.0017	0.0007
–0.19	-0.006	–0.19	-0.0006	0.0017	0.0008
+1.9	-0.005	+1.9	+0.0009	0.0017	0.0007
-1.9	+0.006	–1.9	-0.0051	0.0017	0.0007

Table 3 Measurements with ratio and phase errors applied simultaneously.

4. Conclusions

We have demonstrated that the Digital Sampling Wattmeter system can be adapted to make accurate calibrations of voltage transformer test sets.

5. Acknowledgments

The authors gratefully acknowledge the loan of a test set from Mr Roland Brunisholz of Tettex Instruments.
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6. References

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