

Comparison of Results of Calibration of Isolation Current Transformer by Conventional Method & Two Power Comparator Method

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Abstract— This paper describes the calibration of Isolation Current Transformer by two methods, by conventional method and by two comparator based calibration method. A conventional method has limitations that we get fixed ratios and hence can go up to lower value of 1A. The uncertainties of the calibration system are in the order of 0.005 % for the ratio error and 0.01 crad for the phase displacement of the current transformer at 50 Hz. The power comparator based measurements can be done at test currents from 10 mA to 160A.

Index Terms— Current Transformer, Power comparator, uncertainties

I. INTRODUCTION

Isolation Current Transformers (ICTs) are three phase electronically error compensated current transformers with a ratio of 1:1 and primary currents from 10m A to 200 A . They are widely used in stationary energy meter calibration/ test systems to isolate the reference current path of the test system from the current path of the energy meters, which have to be tested on phantom loading system in the laboratory.

II. NEED OF MEASUREMENT:

The voltage and current paths of a conventional energy meter cannot be separated, since while connecting the meter on actual load, the meter draws voltages as well as current from the same phase terminal and the energy meter is sealed in general when it is received in the laboratory for testing purpose & cover cannot be opened. If the error of the

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Isolation current transformer is not included, we may get wrong results.

III. METHOD OF CALIBRATION:

Isolating current transformers (ICTs) are three phase electronically error compensated current transformers with a ratio of 1:1 and maximum primary currents from 10mA to 160A.

In a conventional method we have to use two high precision current transformers, since the ICT is 1:1 and if the primary current is given in 160 to 1A values, the two precision current transformers are to be connected in input and output side, so that we can reach to the same value on the output side of the transformers and can be compared by a Automatic/Current Instrument Transformer Test Set (AITTS/ CTTS).

While in a two comparator method two commercial high precision power comparators [5] are used to read the values of currents. The assumption at this stage is taken that the two comparators are of exactly same type (COM 3003 or COM 3000) so that we can take the phase difference between the two as nil.

The required ac current source is part of the stationary energy meter test system which is used for testing the energy meters having internally connected link between voltage and current points of the meter. In Fig 1 one ac source is shown which supplies the same voltage to the two comparators and therefore the voltage in the two comparators will be at the same phase while the current from the ac source is given to the input side of the ICT and in one of the comparator which is taken as <N> just to designate the reference comparator. The secondary side of the ICT will also be at the same current level since the ratio of ICT is 1:1. Now the current to the other comparator, which is taken as <X>, is given in series with the secondary side of the ICT

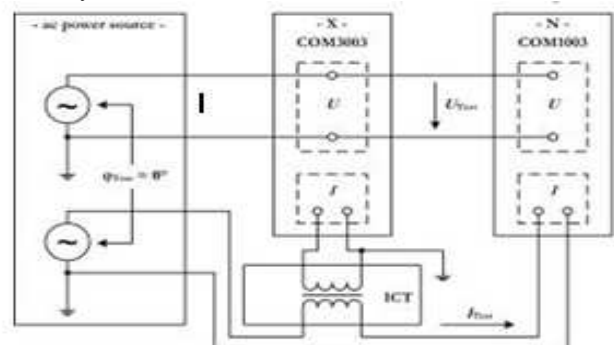
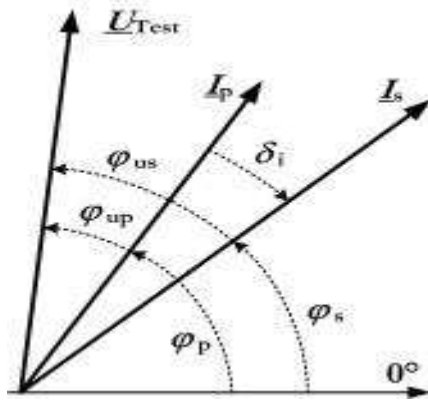


Fig. 1 connection of ICT with two comparator

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Fig, 2 phasor diagram for phase displacement between I_p and I_s

A. Connecting cables:

Proper copper connecting wires are used for making connections to the reference standards and isolation current Transformers

Environmental Conditions

Temperature : $(25 \pm 1)^\circ\text{C}$
 Humidity : $(50 \pm 10)\%$

In the Fig. 2,e U_{Test} is the voltage given to the two comparators. Φ_P and Φ_S are the phases of the two currents, input current to ICT, I_p and output current from ICT, I_s and Φ_{UP} and Φ_{US} are the phase differences between the test voltage and input current to ICT, I_p and output current from ICT, I_s respectively. The ratio error is calculated by the magnitude of the two currents, Input to ICT and output from the ICT, while δ_i is the phase displacement of the ICT, i.e. the phase difference in the input and output currents of the ICT.

IV. RESULTS:

For the comparisons of the results from two methods, several readings are collected for different current values and keeping the voltage at reference value of 240V. After applying the correction for current values for both the comparators, we are sure that the difference in current values are data for calculating the ratio errors and the phase difference between the two currents would be phase error of the Isolation Current Transformer. To compare the results four tables have been formed. Table A shows the values taken by two comparator method. The ratio errors are calculated by dividing the two current values and subtracting the ideal value 1.0. The phase errors are calculated by subtracting the phase of current of the 1st comparator from the phase of the 2nd comparator. The phase errors are calculated in minutes.

Current(A)	Ratio Error %	Phase Error (minutes)
120	-0.0037	-0.0491
5	-0.0030	+0.0326
1	+0.0206	+0.2639

Table A : Errors by two comparator method

Current(A)	Ratio Error %	Phase Error (minutes)
120	-0.0070	-0.1200
5	-0.0065	-0.0320
1	+0.0095	+0.0700

Table B: Errors by conventional method.

Current(A)	Ratio Error %	Phase Error (minutes)
120	-0.0002	0.0
5	-0.0004	0.0
1	-0.0005	0.0

Table C: Standard CT Errors

Current(A)	Ratio Error %	Phase Error (minutes)
120	-0.0026	-0.1000
5	-0.0027	-0.0870
1	-0.0092	-0.2210

Table D: Eltel CT errors

Current(A)	Ratio Error %	Phase Error (minutes)
120	-0.0042	-0.0200
5	-0.0034	+0.0550
1	+0.0192	+0.2910

Table E: Final Errors (B-C-D)

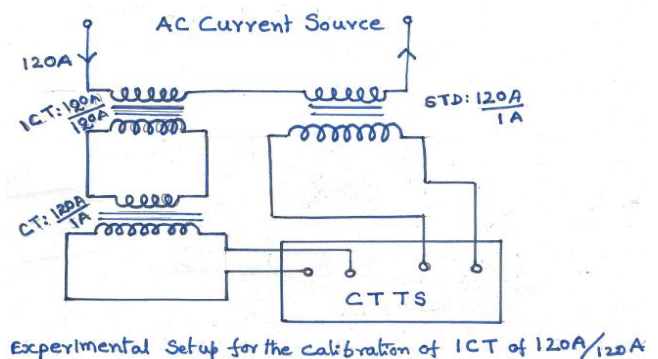


Fig 3: Calibration by conventional method

In the conventional method (Fig.3), current is given to both Isolation current transformer as well as to a std. CT which gives output as 1 A. This is given to one terminal of a Current Transformer Test Set (CTTS). In the same way, since current in the output of the isolation current transformer would be same as the input current, we connect another CT (Eltel CT has been connected for example) whose output will again be at 1A level and this is given to the other terminal of the CTTS. The CTTS compares the two input currents which are at 1 A level and gives the ratio and phase errors. Table A shows the errors taken by two comparator method while the table B shows the errors taken by the conventional method in which two other CT,s are involved to step down the currents to 1A level.

Hence to compare the errors taken by the two method, we have to subtract the errors of table C & D from the table B errors to find the actual errors of the Isolation Current transformer. Table E shows these errors. Now if we compare the errors of table A and table E, we find they are comparable within the uncertainty limits which are 40 ppm for ratio and 0.10 minutes for phase.

ACKNOWLEDGEMENT

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REFERENCES:

- [1] Power comparator based on –site calibration of Isolating current transformers, MAPAN, Journal of metrology society of India, vol 24, no. 1, 2009 , pp 67-72
- [2] Indian Standard Specification, ac Static Watthour Meters, Class 1 And 2, (IS-13779:1999)
- [3] Indian Standard Specification, ac Static Transformer Operated Watthour And Var-Hour Meters, Class 0.2S And 0.5S (IS-14697:1999)
- [4] W.J.M. Moore and P.N. Miljanic, The current comparator, IEEE Electrical Measurement Series, 4, Peter Peregrinus Ltd. London (1998)
- [5] COM 3003, COM303-3 , COM3000, www.zera.de/products/meter-test/comparator-com3003
- [6] Manual on Standardization of AC Static Electrical Energy Meters., 304:2008
- [7] International Standard, Electricity metering equipment (AC) General requirements, tests and test conditions (IEC 62052-11:2003-2)
- [8] International Standard, Electricity metering equipment (a.c.) Particular requirements- IEC (62053-21:2003-01), Static meters for active energy (Classes 1 and 2)
- [9] International Standard, Electricity metering equipment (a.c.) Particular requirements- IEC (62053-23:2003-01), Static meters for reactive energy (Classes 2 and 3)



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