Establishment of an Instrument Transformer Calibration System at SASO NMCC

S. S. Alanazi[1], A. R. Alayli[1], R. A. Alrumie[1], A. M. Alrobaish[1], B. Ayhan[2] and H. Çaycı[2]

[1]The National Measurement and Calibration Center, PO. B 3437 Riyadh 11471 Kingdom of Saudi Arabia
ss.anazi@saso.gov.sa

[2]TÜBİTAK Ulusal Metroloji Enstitüsü (UME), P.K.54, 41470, Gebze-Kocaeli, Turkey

Abstract — **A calibration system for instrument transformers, based on the comparison method, has been established at SASO NMCC. Ratio error and phase displacement measurements are performed by using the calibration system up to 4000 A for current transformers and up to 36 kV for voltage transformers at 60 Hz. Calibration uncertainties for both current and voltage transformers are well below the industrial and metrological needs in the country. Bilateral comparisons between SASO NMCC and TÜBİTAK UME have been performed in order to evaluate the performance of the calibration system.**

***Index Terms* — Instrument transformers, measurement standard, phase displacement, ratio error, uncertainty.**

I. Introduction

Instrument transformers are designed to scale high currents and high voltages at a power grid to compatible values for measuring and protection instruments. For instrument transformers which are used for billing and protection purposes, almost all National Metrology Institutes establish and maintain instrument transformer measurement systems within their Power & Energy Laboratories.

SASO NMCC has established a combined instrument transformer calibration system within the last three years with the support of TÜBİTAK UME in the design and evaluation. Ranges in the reference devices and measurement capabilities of both current and voltage transformer calibration systems were determined according to the customer needs in the country. Two bilateral comparisons were carried out to show the performance of the established systems.

II. Measurement Systems

Calibration of instrument transformers is commonly performed by comparison with a reference transformer by using a bridge (test set). Basically, the ratio error (ε) and phase displacement (δ) of an instrument transformer against a reference transformer with the same ratio is determined by direct comparison of their secondaries. Since reference transformer is assumed to be ideal and error-free, the bridge directly gives ratio and phase differences between two secondaries as in-phase and quadrature errors of the calibrated instrument transformer [1-3].

Current transformer (CT) measurement system consists of a home-made multi-ratio reference current transformer with the ratios of 5-10-20-50-100-200-500-1000-2000-4000 A : 5 A, a commercial current comparison bridge, and a home-made CT burden set, Fig. 1 below. Reference CT is an electronically compensated current comparator (ECCC) with ratio and phase errors less than 10×10^{-6} and 10 μrad, respectively [4].

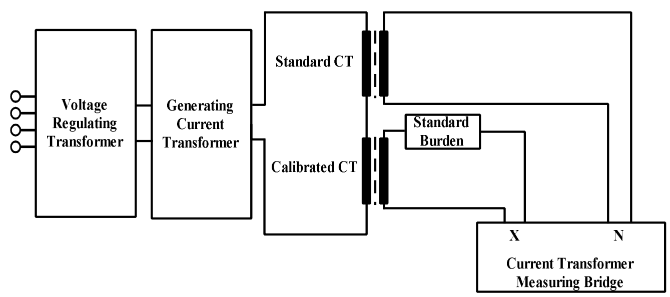

Fig. 1. Current transformer calibration circuit.

Voltage Transformer (VT) measurement system mainly comprises a reference voltage transformer, a voltage measuring bridge and a standard voltage burden set, Fig. 2 below. Since the commercial reference VT has limited ranges in the primary and secondaries, the calibration points and ranges of the bridge have great priority [5].

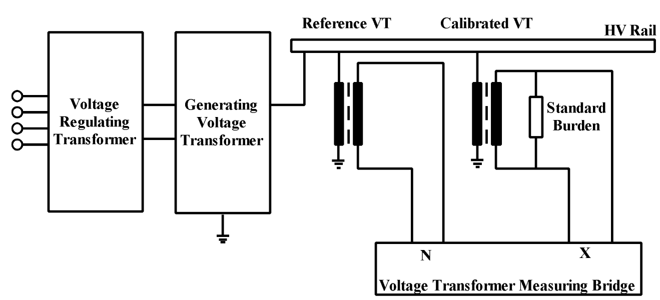

Fig. 2. Voltage transformer calibration circuit.

Both current and voltage transformer burden sets are designed to be switched automatically from the system software. System software used for control of test sequences and bridges, reading out measuring data, correcting errors of the reference transformers and calculating the uncertainties has been developed with the support of TÜBİTAK UME.

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III. Evaluation of The System Accuracy

To evaluate the performance of these calibration systems, bilateral comparisons between SASO NMCC and TÜBİTAK UME were carried out at five different current ratios and four different test points (5 %, 20 %, 100 % and 120 %) for CT measurements while at two different voltage ratios and three different test points (80 %, 100 % and 120 %) for VT measurements.

Table 1. Differences between the CT measurement results.

Current Ratio	Applied Current	Difference between UME and NMCC	
A / A	%	Δε (%)	Δδ (crad)
10 / 5	120	0.001	0.001
	100	0.001	0.002
	20	0.000	0.002
	5	0.000	0.002
50 / 5	120	0.002	0.001
	100	0.001	0.001
	20	0.000	0.002
	5	-0.002	0.003
100 / 5	120	0.002	0.000
	100	0.001	0.001
	20	0.001	0.001
	5	-0.001	-0.001
500 / 5	120	0.002	-0.001
	100	0.000	0.001
	20	0.000	0.001
	5	0.001	0.001
1500 / 5	120	0.001	0.000
	100	0.000	0.000
	20	0.000	0.001
	5	0.000	0.001

Table 1 presents the differences between CT measurement results in the range of 10 A / 5 A - 1500 A / 5 A with a burden of 12.5VA (cos φ =0.9) at 60 Hz. Where, Δε and Δδ are differences in ratio error and phase displacement, respectively. And, differences between VT measurement results of two Institutes for 20 kV and 30 kV voltage ratios with a burden of 25 VA (cos φ = 0.7) at 60 Hz are given in Table 2.

Table 2. Differences between the VT measurement results.

Voltage Ratio	Applied Voltage	Difference between UME and NMCC	
V/V	%	Δε (%)	Δδ (crad)
20000 / 120	120	-0.002	0.000
	100	-0.002	0.000
	80	-0.001	0.000
30000 / 120	120	0.000	-0.002
	100	-0.001	-0.001
	80	-0.001	-0.001

The expanded uncertainties (k = 2) of SASO NMCC measurements were estimated to be within 100×10^{-6} in ratio error and 100 μrad in phase displacement for CT measurements. Similarly, estimated uncertainties for VT measurements are 150×10^{-6} and 150 μrad.

The comparison results indicate that the instrument transformer calibration system of SASO NMCC is in good agreement with its defined measurement uncertainties. And, these calculated uncertainties could be improved with the calibration of reference devices periodically.

IV. Future Work

Both current and voltage transformer calibration systems are needed to be re-evaluated for better measurement uncertainties and for their traceability to the national standards.

A self calibration method will be applied to the reference current transformer. A step-up calibration method will be applied to the reference voltage transformer. A calibration system will be established for current and voltage transformer bridges. Finally, existing systems will be upgraded for the calibration of electronic voltage and current transformers [6].

V. Conclusion

An instrument calibration system has been established at SASO NMCC. The accuracy of the calibration system is ensured by investigation of all probable error sources, and by testing their performance in bilateral comparisons. Further research work is planned for improvement in the measurement uncertainties.

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