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Jung, Jae Kap; So, Eddy; Lee, Sang Hwa; Bennett, David

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A COMPARISON OF SYSTEMS BETWEEN KRISS AND NRC TO EVALUATE PERFORMANCE CHARACTERISTICS OF A 400 kV CAPACITIVE VOLTAGE DIVIDER

Jae Kap Jung¹, Eddy So², Sang Hwa Lee¹, and David Bennett²

¹KRISS, Korea Research Institute of Standards and Science, Daejeon, Korea

²NRC, National Research Council of Canada, Ottawa, Canada

Abstract

KRISS has established a reference 400 kV capacitive voltage divider for the purpose of calibrating industrial high voltage measuring systems on-site. In order to confirm the performance characteristics of the divider, a comparison of the calibration systems between KRISS and NRC with the divider used as the transfer standard was conducted. The paper presents the comparison results of its performance evaluations.

Introduction

As part of KRISS' high voltage program, and to address the need of the Korean electrical power industry to obtain traceability of AC high voltage measurements, KRISS has established a reference 400 kV capacitive voltage divider. This reference voltage divider is meant to be used not only as an in-house reference measuring system, but also as reference for on-site calibrations of industrial high voltage measurement systems. Since KRISS high voltage laboratory has a high voltage source of only up to 200 kV, the overall performance characteristics of the 400 kV capacitive voltage divider was evaluated by doing a comparison of systems between KRISS and NRC to calibrate the capacitive voltage divider at KRISS up to 200 kV only and at NRC up to 400 kV.

The objective of the comparison is to verify whether, within the uncertainty of the measurements, there would be good agreement of the measured and calculated voltage dependency performance characteristics of the 400 kV divider, when measured at KRISS up to only 200 kV and at NRC up to 400 kV. Such agreement would allow KRISS to calibrate the 400 kV divider up to only 200 kV, and also to extrapolate the divider performance at voltages up to 400 kV, based on the measured and calculated voltage dependency performance characteristics of the divider. Therefore, KRISS reference 400 kV capacitive divider was used as the transfer standard in

the comparison of systems between KRISS and NRC to evaluate its performance characteristics.

Transfer Standard

The divider is a commercial 400 kV capacitive voltage divider, consisting of two units of 200 kV voltage dividers which could be stacked on top of each other for an operating voltage of up to 400 kV. Each 200 kV unit consists of a high voltage capacitor C_H with a nominal capacitance of 1000 pF in series with a low voltage capacitor C_L with a capacitance of 1421 nF (secondary unit), as shown in Figure 1. The secondary unit is commonly used in the two units of 200 kV voltage dividers. The secondary output voltage of the divider at either 200 kV or 400 kV is nominally 140 V.

Figure 1. Capacitive Voltage Divider

Calibration Systems

The calibration systems used for comparisons at KRISS and NRC are similar and are based on an NRC-developed current-comparator-based high voltage capacitance bridge (CCB HV Capacitance Bridge) [1] with a basic uncertainty ($k=2$) of 10×10^{-6} . The KRISS system is a commercial version of the NRC CCB HV Capacitance Bridge. Figure 2 shows the basic calibration circuit for the voltage dividers. Measurements of the ratio and phase errors in each 200 kV unit and in cascade for 400 kV operation

were done at 20 %, 40 %, 60 %, 80 %, 100 % of 200 kV, and of 400 kV, respectively. These measurements were done at a test frequency of 60 Hz with no load and a resistive burden of 1 M Ω at the secondary output terminals, respectively.

At KRISS, to minimize the loading effect on the voltage divider due to the low voltage reference capacitor C_{LS} , a unity-gain buffer amplifier A was used in series with C_{LS} , as shown in Figure 2.

Figure 2. Basic calibration circuit for voltage divider

At NRC, no unity-gain buffer amplifier was used. Instead, the loading effect on the voltage divider by the low voltage capacitor C_{LS} was checked/evaluated by connecting a capacitor with a capacitance of the same order of magnitude as C_{LS} in parallel with C_L and connected to ground. The changes in the balance readings of the bridge were then observed and accounted for as a correction due to the loading effect.

Comparison Results

A test result of the comparison of one of the two 200 kV units at the different test voltages up to 100 % of rated voltage is shown in Table 1. Table 1 (a) shows the measured ratios and phase errors with no load at the secondary output voltage terminals, while Table 1 (b) shows the measured ratios and phase errors with a 1 M Ω load connected to the secondary output voltage terminals. From Table 1, it can be seen that the differences in the measurement results of ratio and phase errors between that of KRISS and NRC at no load was not more than $(0.1/1440) = 70 \times 10^{-6}$ and 238 μ rad, respectively. At 1 M Ω load, the difference was not more than $(0.13/1440) = 90 \times 10^{-6}$ and 282 μ rad, respectively.

The complete test results of the two units of 200 kV voltage dividers and their cascade arrangement for 400 kV operations will be presented and discussed, including sources of errors and uncertainties. Also, the voltage dependency performance characteristics of the voltage dividers at 200 kV and 400 kV will be presented and analyzed.

Table 1. Test Results of a 200 kV unit

Measured No Load Ratio			
200 kV (%)	KRISS	NRC	KRISS-NRC
20	1439.21	1439.14	0.07
40	1439.46	1439.50	-0.04
60	1439.47	1439.56	-0.09
80	1439.36	1439.45	-0.09
100	1439.15	1439.25	-0.10

Measured No Load Phase Error in μ rad			
200 kV (%)	KRISS	NRC	KRISS-NRC
20	-557	-664	87
40	-349	-422	73
60	-282	-338	56
80	-247	-237	-10
100	-204	34	-238

(a)

Measured 1 M Ω Load Ratio			
200 kV (%)	KRISS	NRC	KRISS-NRC
20	1439.28	1439.15	0.13
40	1439.52	1439.51	0.01
60	1439.53	1439.57	-0.04
80	1439.43	1439.47	-0.04
100	1439.22	1439.24	-0.02

Measured 1 M Ω Load Phase Error in μ rad			
200 kV (%)	KRISS	NRC	KRISS-NRC
20	1309	1220	89
40	1497	1438	59
60	1558	1524	34
80	1592	1633	-41
100	1631	1913	-282

(b)

Conclusion

The test results of one of the 200 kV units indicate that the transfer standard could be considered to be suitable for use as a reference voltage divider of an accuracy class of better than 0.05 %. This means that for a TUR (test uncertainty ratio) ≥ 4 , the voltage divider could be used as a reference AC measuring system for in-house/on-site calibrations of industrial high voltage measurement systems of accuracy class of ≥ 0.2 %.

Reference

- [1] W. J. M. Moore and P. N. Miljanic, "The current comparator", *IEE Electrical Measurement Series*, vol. 4, London, United Kingdom, Peter Peregrinus Ltd, 1988.