Calibration of High Voltage Capacitance and Dissipation Factors Bridge

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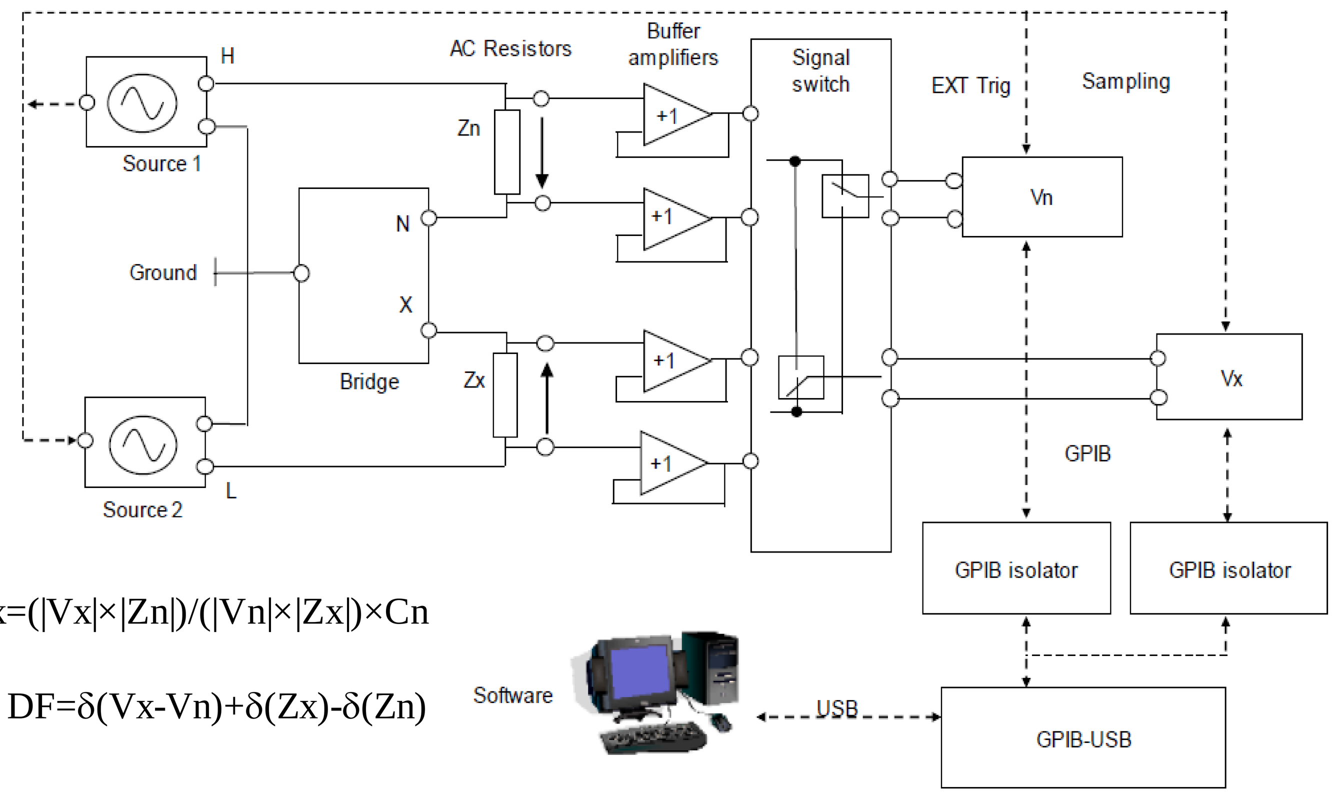
Introduction

A method for the calibration of LNE's high voltage capacitance and dissipation factor bridge. The bridge is based on the fact that it forms the capacitance and the dissipation factor values from the complex relationships of its input currents. The calibration of the bridge was performed at 50 Hz by simulating the complex currents using two high-accuracy synchronized sources. The measurement of the currents was carried out using standard resistors associated with a precision digital ratio-and-phase measuring system. The dissipation factor values were varied from -0.01 to +0.01, and the ratio of the bridge was configured at 1, 10, and 100. The current values were varied from 0.5 mA to 1 A, which cover a large range of capacitors subject to very high voltage levels. For the measurement of capacitance, the standard uncertainty is 1,75 µF/F when the bridge is configured at the ratio 1, and about 2,5 µF/F for ratios up to 100. For the dissipation factors, the standard uncertainty is 1,5.10-6 for the ratio 1, and 2.0.10-6 for ratios up to 100.

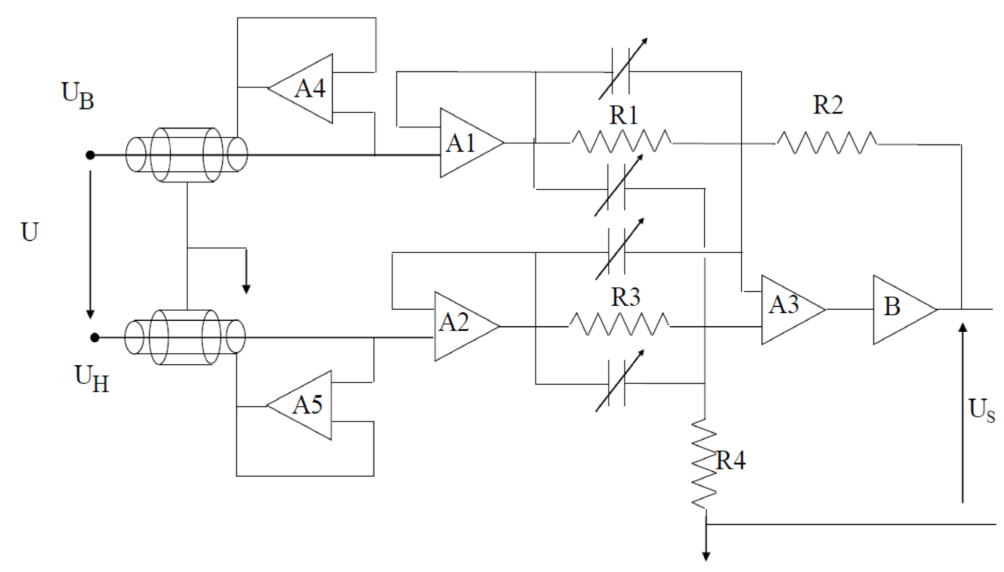
Principle of measurements



$$C_x = (|V_x| \times |Z_n|) / (|V_n| \times |Z_x|) \times C_n$$

$$DF = \delta(V_x - V_n) + \delta(Z_x) - \delta(Z_n)$$

Calibration of capacitance and DFs Bridge by comparison to standard resistors



	Stage Zx	Stage Zn
Ratio Error (µV/V)	13.5 ± 1.0	15.8 ± 1.0
Phase error (µrad)	-0.7 ± 1,0	-1.9 ± 1,0

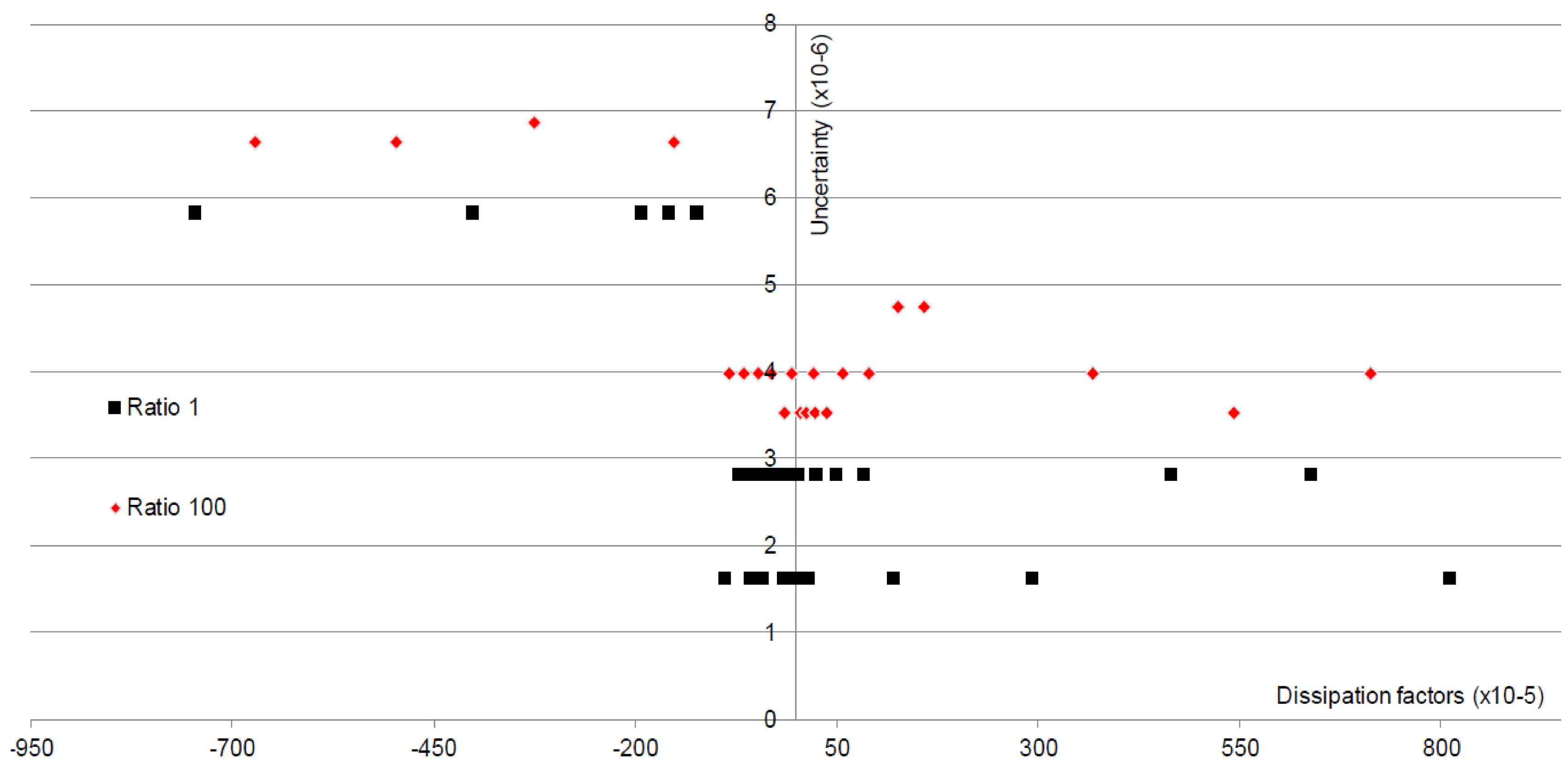
Principle of the buffer

I_N (mA)	I_X/I_N	R_N (kΩ)	R_X (kΩ)
0.10	1	10	10
0.50	1	2	2
0.67	1	1.50	1.50
1.00	1	1	1
1.00	10	1	0.10
1.00	100	1	0.01
3.33	1	0.30	0.30
5.00	1	0.20	0.20
5.00	10	0.20	0.02
5.00	100	0.20	0.002
6.67	1	0.15	0.15
10.00	1	0.10	0.10
10.00	10	0.10	0.01
10.00	100	0.10	0.001

Set of resistor used to calibrate the capacitance bridge

Additional steps to the calibration procedure of the bridge were used.
At ratio 1, |Zn|/|Zx| was determined by a second measurement step. The bridge was disconnected and the same current was applied to both resistors in series.
At ratio≠ 1, |Zn|/|Zx| was calibrated separately but the measuring system was self calibrated by measuring the same voltage.

Uncertainty of measurements:

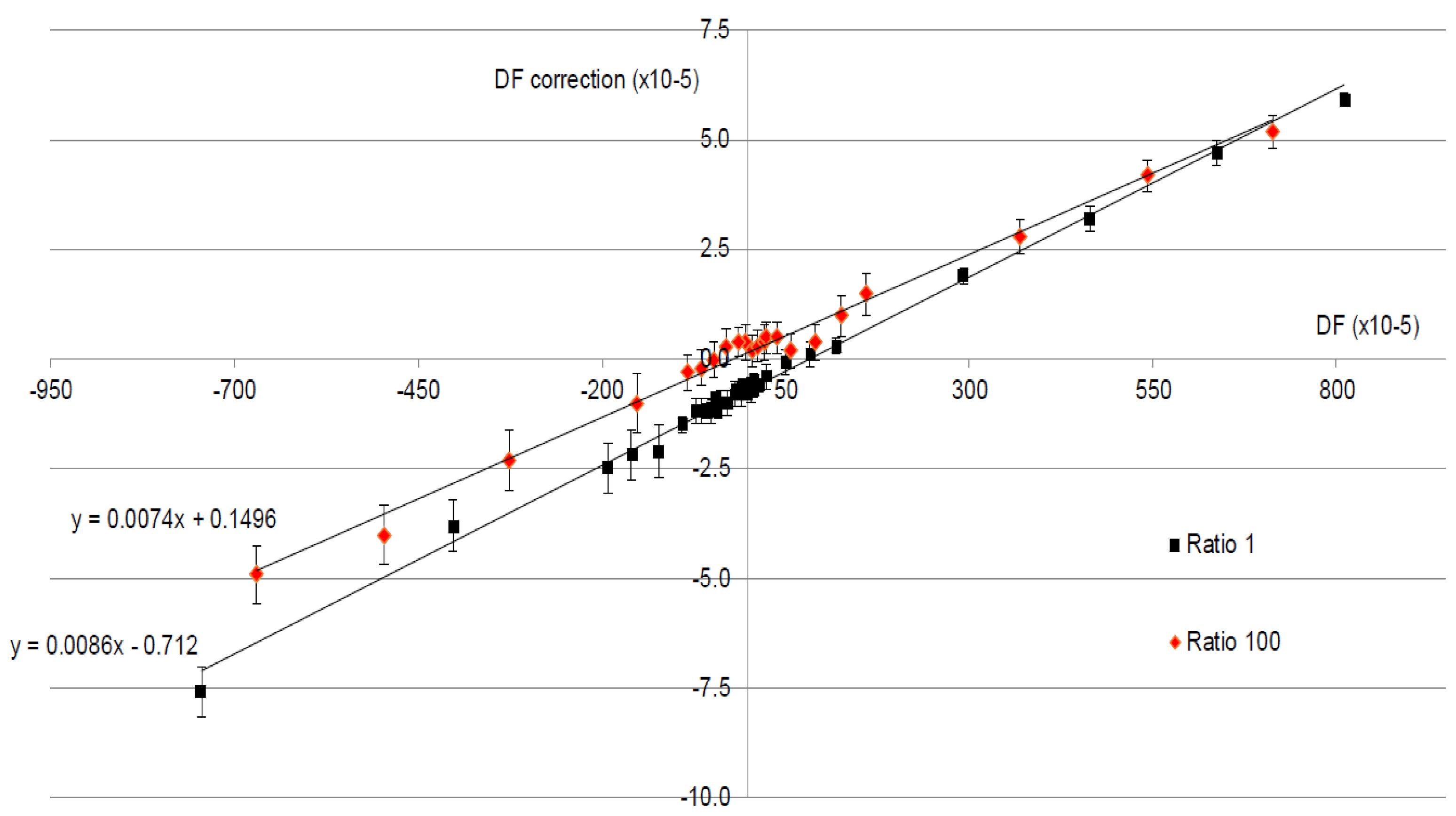


Uncertainty of measurement for dissipation factor

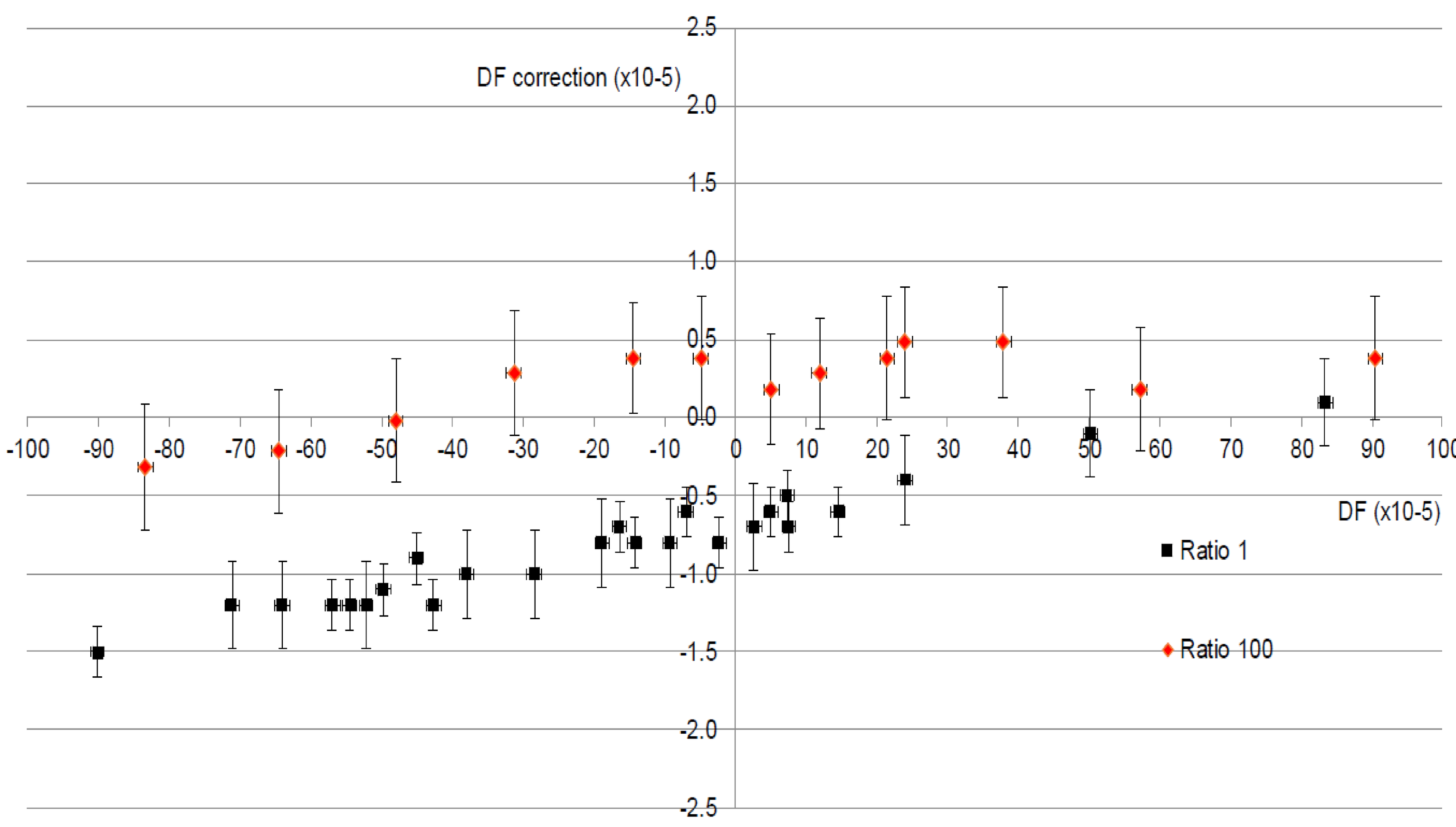
I_N (mA)	I_X/I_N	u_{repeat}	u_{res}	u (Vx/Vn)	u (Zn/Zx)	u (Z_n)	u (Zx)	U (k=2)
0.5	1	1	0.29	1	1	-	-	3.5
0.67	1	1	0.29	1	1	-	-	3.5
1	1	1	0.29	1	1	-	-	3.5
1	10	1	0.29	1	-	1.25	1.25	4.6
1	100	1	0.29	1	-	1.25	1.25	4.6
3.33	1	1	0.29	1	1	-	-	3.5
5	1	1	0.29	1	1	-	-	3.5
1	10	1	0.29	1	-	1.25	1.25	4.6
1	100	1	0.29	1	-	1.25	1.25	4.6
6.67	1	1	0.29	1	1	-	-	3.5
1	1	1	0.29	1	1	-	-	3.5
1	10	1	0.29	1	1	1.25	1.25	5.0
1	100	1	0.29	1	1	1.25	1.25	5.0

Uncertainty of measurement for capacitance

Results



Calibration of LNE's bridge for DFs at ratios of 1 and 100 and at In=10 mA. Results for DF up to ±0.008



Calibration of LNE's bridge for DFs at ratios of 1 and 100 and at In=10 mA. Results for DF up to ±0.001

For the capacitance it was demonstrated that the correction in capacitance is strongly affected by the number of turns of the auxiliary winding responsible for fine balancing of the capacitance. A linear dependence was determined; it was equal to 3,3 µF/F for each 0.1 turn. When the this winding was at 1 turn, the correction factor is 33 µF/F. To determine this correction, the winding was fixed at a desired value, from 0,1 turn to 1 turn by a step of 0,1 turn for each measurement.. The fine balance was performed by adjusting the amplitude of the current sources. For this reason, high resolution current sources were used for this purpose, e.g fluke 5700A

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