Field sensor for linearity measurement of High Voltage AC capacitors

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Abstract: This project focusses on developing an efficient method for linearity determination of HV capacitors with a target calibration uncertainty for HVAC of 80 µV/V up to 800 kV. The field probe method employing a circular double-sided Cu plate with 30 cm diameter and a dielectric thickness of 1.6 mm is tested and characterised for this purpose.

Introduction

In a typical AC voltage calibration of a HVAC capacitor, the scale factor determination is done by direct comparison with a reference measuring system at several voltage levels comprising at least the minimum level of the assigned measurement range of the measuring system under test and the maximum level of the reference measuring system. The linearity test is intended to provide an extension of the validity of the scale factor from the maximum voltage at which a calibration has been carried out by direct comparison, up to five times the maximum voltage. The output of the measuring system under test shall be compared with the output of the electric field probe that has proven its linearity or can be presumed to be linear over the full voltage range.

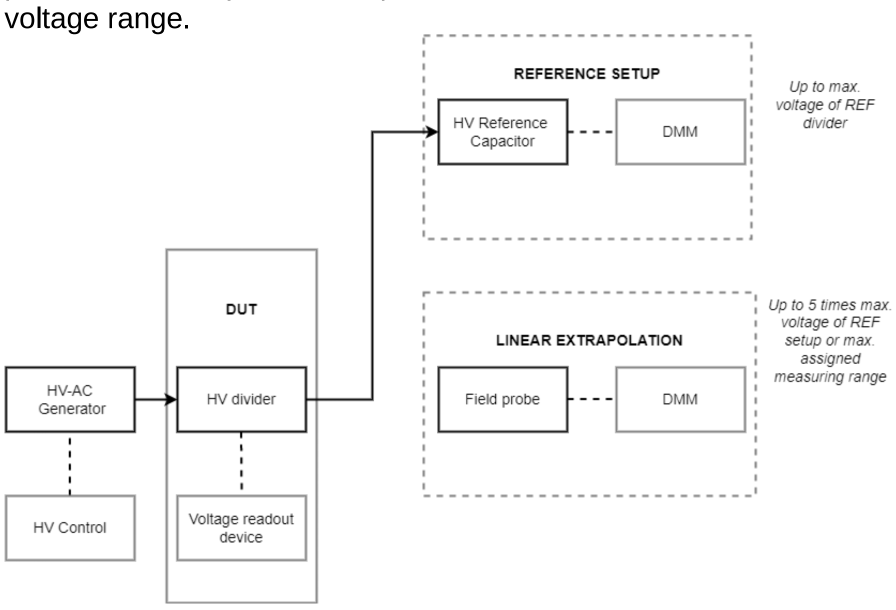

Figure 1: Schematic of the measurement setup

Design & Specifications

Pancake field probe

After several investiagtions and laborious testing the double-sided Cu plate was found to have the best performance in terms of linearity of output voltage. The Cu plate has a 1.6 mm thick dielectric layer and a capacitance of 2.196 nF.

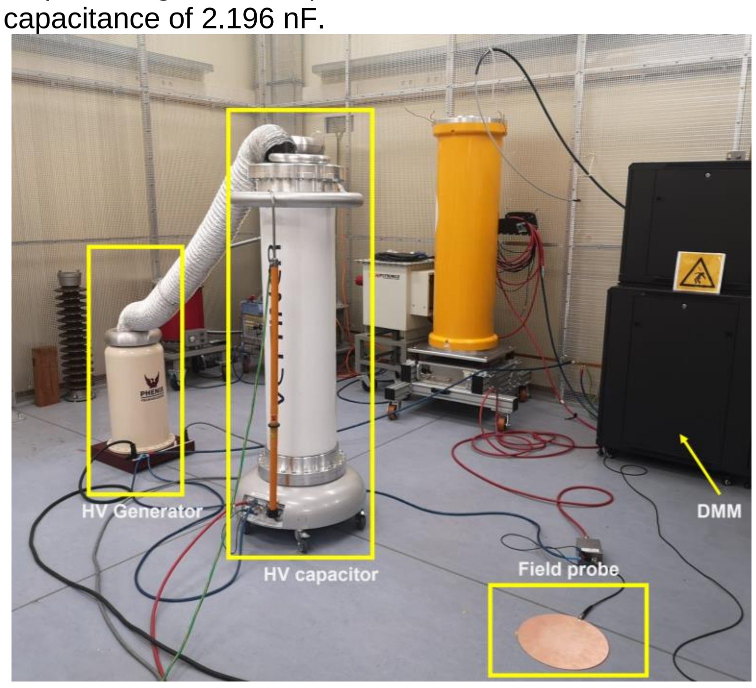

Figure 2: Laboratory setup

For the voltage read out the HP 3458 is used in the DC mode with a fixed input impedance and INT trigger. The HP is fixed to 10 V range for the readout of the field probe to optimize the full-scale resolution of the output voltage.

Measurement

performance of the field sensor is presented in terms of the deviation of the scale factor from the average scale factor. The following index is used for the purpose;

$$u_{b1} = \frac{1}{\sqrt{3}} \cdot \left(\frac{R_g}{R_m} - 1\right)$$

Where

Rg is the mean value of scale factor (U_REF/U_DUT) at voltage level g

Rm is the mean value of the scale factors Rg.

The mean value of the scale factor at voltage level g is calculated based on 10 measurements.

Performance

The performance of the field probe varies with several parameters such as distance from the HV capacitor and distance from ground objects. To increase the effectiveness of this method, it is recommended to maintain a suitable distance to the HV capacitor in such a way that the measured output voltage is not lower than 1% for the specified DMM range of 10 V. And a similar distance from grounded objects also needs to be maintained.

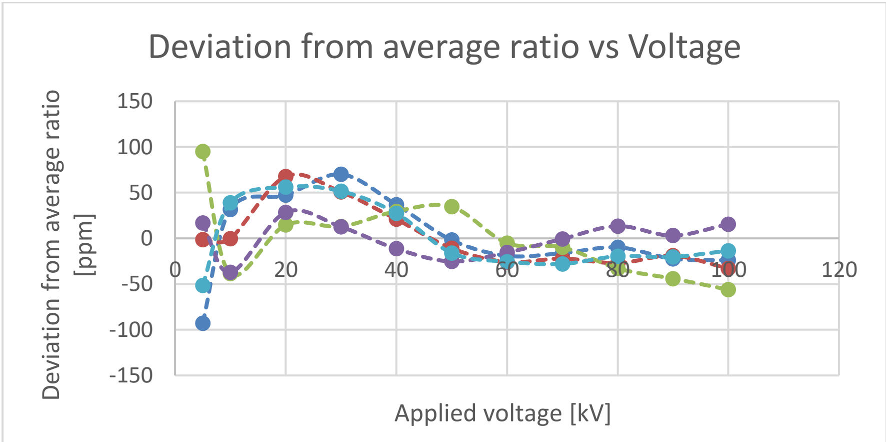

Figure 3: Performance of the field probe sensor at different laboratory configurations.

The field probe demonstrates a poor coupling at the lower voltage levels. This can be inferred from the large deviation from the average ratios at voltages lower than 30 kV. A maximum deviation of 95 ppm at the lower voltage levels has been estimated. There were no signs of corona during the measurements made and hence the associated non-linearities have not been investigated.

Future work

The linearity of the field sensor needs to be extended to HVAC levels up to 800 kV. This will enable the validation of the linearity and help ascertain effects from other sources such as corona at HV.

Conclusions

A portable field sensor has been developed with a well-known non-linearity that can be further used for the linearity extension of HVAC capacitors.

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