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HV-com² - Support for standardisation of high-voltage testing with composite and combined wave shapes (WP3)

Introduction

Current standards (e. g. IEC 62895 for DC cables) require that measurements with superimposed voltages be performed in accordance with IEC 60060-2. However, it is only pointed out that the measurement of the individual voltage components must meet the requirements according to IEC 60060-2. The possibility of mutual influence due to the superposition is neglected. A practical example regarding a possible mutual influence could be that a DC bias on the capacitors inside the divider might lead to inaccuracies regarding the impulse voltage measurement based on voltage dependent capacitors.

Therefore, the central research question of WP3 (Existing measuring systems at testing laboratories) was to what extent the presence of one voltage waveform influences the performance of a measurement system based on universal voltage dividers (RCR dividers) with respect to the other voltage waveform. From the point of view of calibration, these investigations shall help to answer the question of whether it is sufficient to calibrate measurement systems for composite voltages with the respective voltage forms individually or whether calibration must be carried out with composite voltages. From a practical point of view, the main question is to what extent a DC voltage affects the measurement of superimposed lightning as well as switching impulse (LI, SI) voltages (Fig. 1).

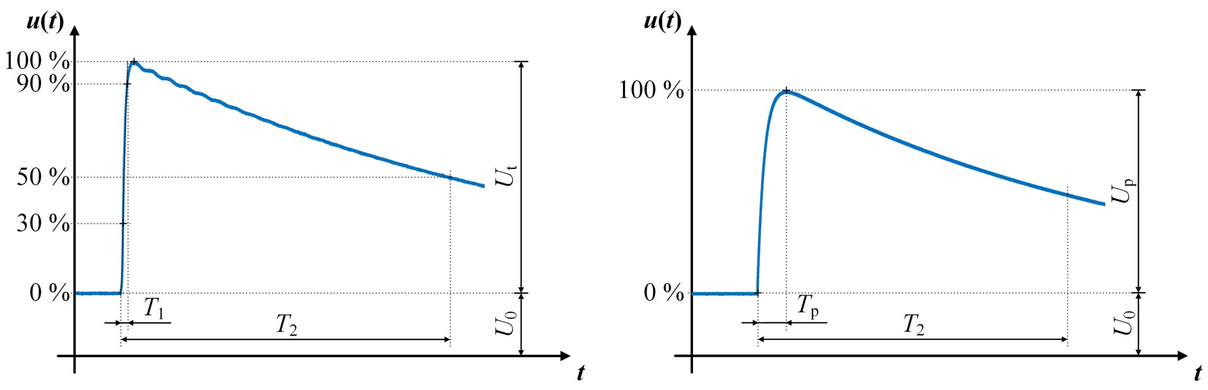


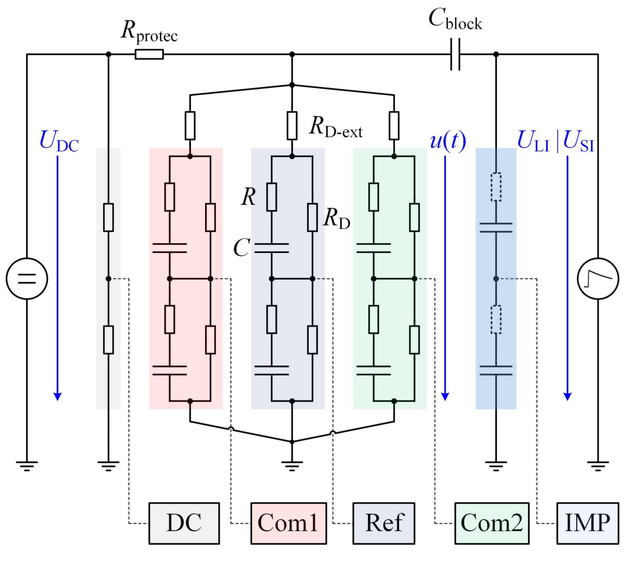
Fig. 1: Exemplary voltage waveforms of a DC voltage superimposed with a lightning impulse voltage (left) and a switching impulse voltage (right)

Comparison Campaign

To assess the effects of the mixed voltage stress on measurement linearity and measurement uncertainty occurring during composite voltage tests, the measurement results of two commercially available measurement systems from different manufacturers, based on universal voltage dividers, were compared with a reference measurement system developed in the HV-com² project during a comparison campaign, which took place at the high voltage laboratory at Graz University of Technology. In light of the increasing importance of HVDC equipment, the investigations focused on the combination of DC and LI as well as SI voltages. The dividers were tested up to a DC voltage of ±350 kV, superimposed with LI and SI voltage amplitudes of ±1100 kV and ±1000 kV respectively.

Methodology

The composite test voltages were generated according to the circuit proposed in IEC 60060-1 (Fig. 2). A protection resistor was used to protect the DC source, while a blocking capacitor was chosen to prevent constant DC stress on the impulse generator. Every investigated universal divider was used in combination with its respective transient recorder and evaluation software, thus forming a complete measurement system. The mean error compared to the reference systems as well as between the two commercial systems was then calculated for each quantity shown in Fig. 1.



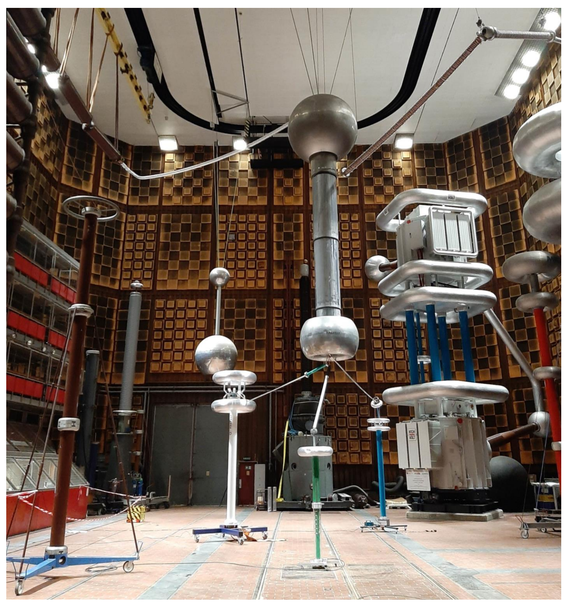


Fig. 2: Test circuit for composite voltages (left), laboratory setup (right)

Results

The evaluations showed that both commercial measurement systems exhibit a slight deviation from the reference system with regard to all mean errors investigated. However, the mean errors are nearly constant over the whole voltage range and rarely exceed 1% with respect to the voltage parameters and 2% with respect to the time parameters (Fig. 3 and 4). Similarly good results were obtained when comparing the dividers with each other over an extended voltage range up to 1100 kV.

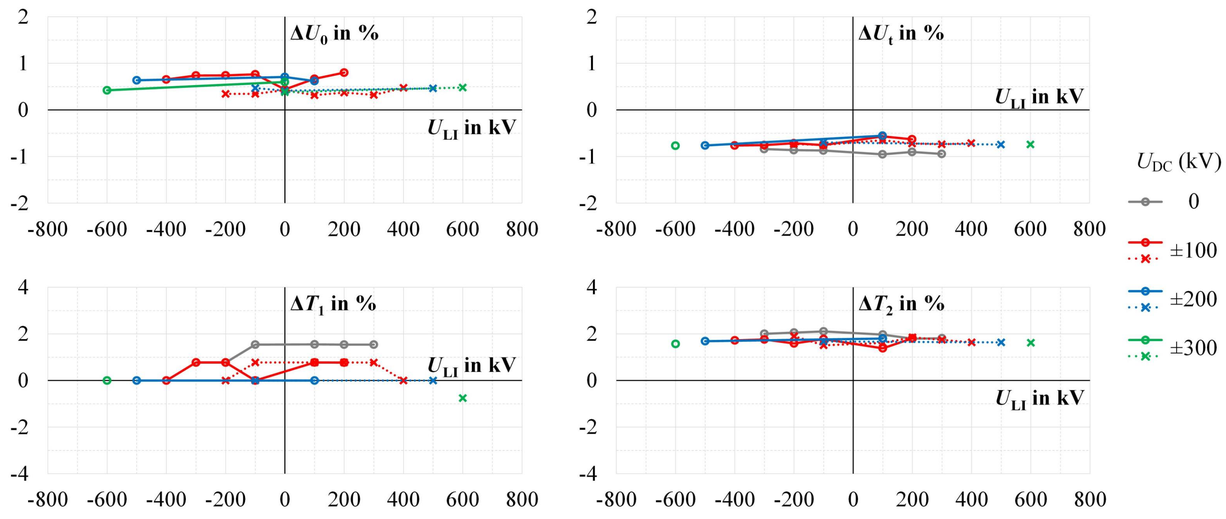


Fig. 3: Mean errors for DC+LI composite voltages, Com1 compared with Ref

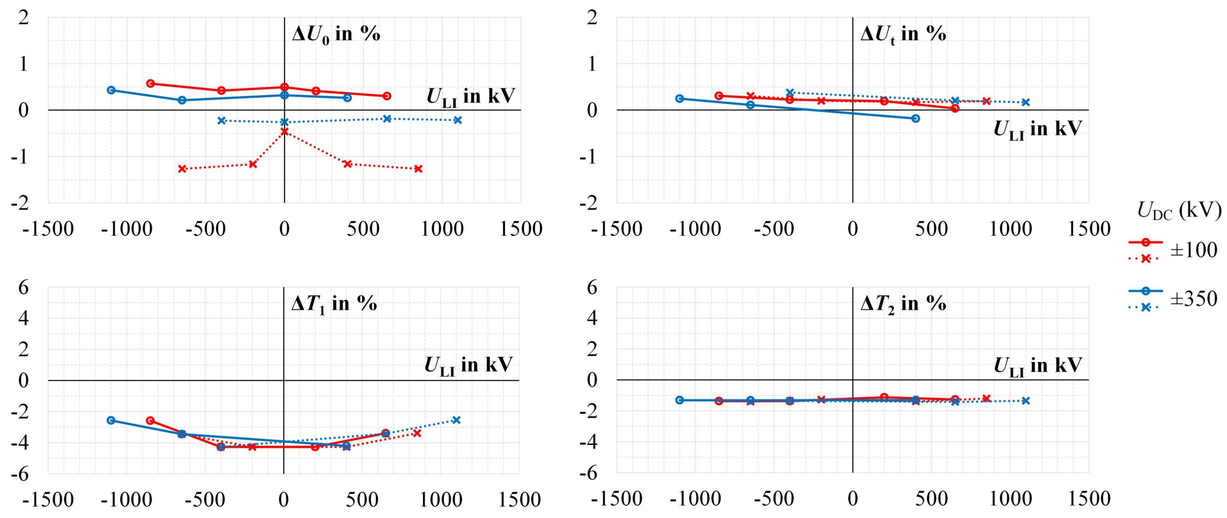


Fig. 4: Mean errors for DC+LI composite voltages, Com1 compared with Com2

Conclusion

The performed investigations demonstrate that commercially available measurement systems based on universal voltage dividers are capable of analyzing DC+LI/SI superimposed voltages with the accuracy required for high voltage testing. All systems retained their high overall accuracy during all superimposed voltage tests, especially regarding their dynamic behaviour. A DC component, which was considered to be particularly critical, did not have any negative effect on the performance of the investigated measurement systems.

Moreover, the collected results suggest that it is sufficient to calibrate a measurement system based on universal voltage dividers for use with composite voltages with the respective individual voltages. For this, however, the scale factors for the different voltage waveforms should agree within ±1%. Furthermore, it should be ensured that the deviation regarding the time parameters (individual voltage component and composite voltage) does not exceed ±2%.

Publications

Details about the comparison campaigns performed in HV-com² may be found in:

[1] Pischler et al.: “Performance of Universal Voltage Dividers for Measurement of Superimposed Voltages”, *23rd ISH*, Glasgow, UK, 2023.

[2] Dowbysch et al.: “Measuring HVDC-Impulse Composite Voltages with High-Voltage Dividers: Laboratory Comparison and Error Analysis”, *23rd ISH*, Glasgow, UK, 2023.

EMPIR
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