

Improved TU Delft 4000 kV LI generator and divider for comparison campaign

Wei Zhao¹, Paul van Nes², Jari Hällström³, Imke Splinter^{1,2},
Luis Castro Heredia², Saliha Abdul Madhar¹, Gert Rietveld¹

¹ VSL, Delft, the Netherlands, www.vsl.nl, wzhao@vsl.nl

² Delft University of Technology, Delft, the Netherlands

³ VTT Technical Research Centre of Finland, Espoo, Finland

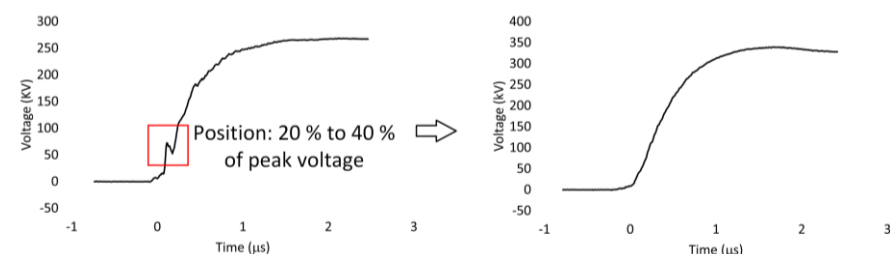
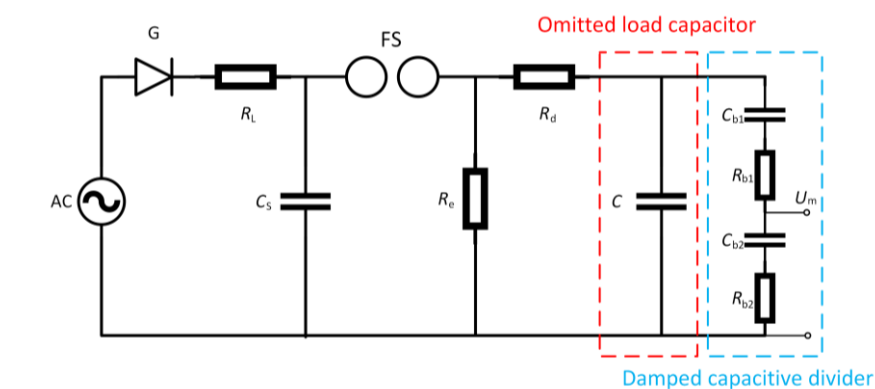
Abstract An international lightning impulse voltage comparison and linearity research campaign was held in October 2022. To prepare for the campaign, VSL, TU Delft and VTT have characterized and tuned the TU Delft 4000 kV LI generator and divider. The front oscillations of the LI generator have been reduced significantly, and the divider's dynamic response has been improved using the VSL LI measuring system as reference. The final comparison campaign results indicate the benefit of the calibration and modification on the LI generator and the divider.

Introduction

A lightning impulse (LI) voltage comparison and linearity research campaign with test voltages up to 3000 kV was held at Delft University of Technology in October 2022. To assure consistency of the measurement results from measuring systems of different institutes, two LI generators with rated voltage of 1000 kV and 4000 kV have been tuned to reduce front oscillations and produce smooth LI waveforms. Furthermore, the 4000 kV TU Delft divider has been characterized and modified to improve the accuracy, using the VSL LI measuring system as reference.

Tuning LI generators

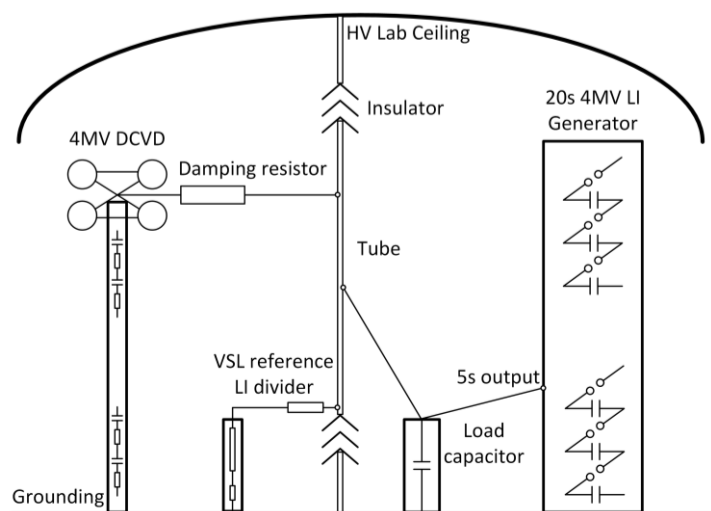
Oscillations during the rising period of the LI waveform strongly influence the consistency of measurement and test results. After circuit analysis and experiments, we found that one reason is the load capacitor of the LI generator is often omitted when a damped capacitive voltage divider (DCVD) is used as the measurement unit, especially if only a few stages of the LI generator are used, e.g., if 5 stages of a 20-stage 4000 kV LI generator are used to produce test voltages less than 1000 kV.



Front oscillation influence (left) reduced by adding a HV capacitor as load (right)

Rectangular and triangular measuring loop

A rectangular loop is preferred for step response measurements and comparison tests as indicated by IEC 60060, however, a triangular loop can also be used as an alternative. Both circuits were checked by comparison of the VSL reference LI measuring system and the TU Delft measuring system. The results did not show a significant difference, so both circuits were accepted for use in the comparison campaign.



Example measuring circuit that was checked and finetuned

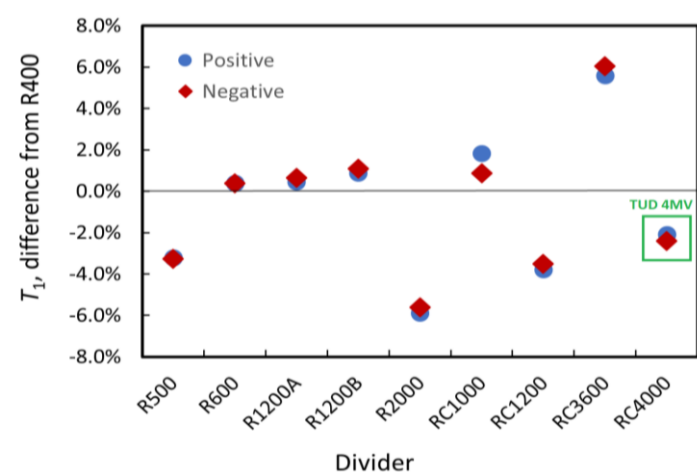
Tuning of the TU Delft 4000 kV divider

In preparation for the international comparison campaign, VSL, TU Delft and VTT jointly characterized and modified the TU Delft 4000 kV divider. Using the VSL measuring system as reference, the T_1 error of the 4000 kV divider was significantly reduced from -18 % to 3 %.



Tuning the 4000 kV DCVD of TU Delft with the VSL LI measuring system

The final comparison results indicated that, after the modification of the TU Delft 4000 kV divider, the T_1 measurement results agreed well with other participating institutes.



Results of the 400 kV international comparison campaign. A R400 system is used as reference, and to make the link to the worldwide comparison Euramet.EM-S42

Conclusions

To prepare for an international LI comparison campaign, VSL, TU Delft, and VTT have tuned the TU Delft 4000 kV LI generator to produce smooth LI waveforms, especially with reduced front oscillations for more consistent T_1 measurements. In addition, the 4000 kV TU Delft divider was modified and improved for time parameter measurements, with the VSL LI measuring system as the calibration reference. The final comparison results confirmed the good performance of the 4000 kV divider and the benefit of the calibrations and modifications.

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