



# VSL Reference Measuring System for Lightning Impulse Voltage Calibrations

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**Abstract** VSL has developed a reference measuring system with rated voltage of 1200 kV for on-site calibration of lightning impulse voltage measuring systems. The VSL reference system has been used for the calibration and tuning of a 4000 kV damped capacitive voltage divider at the Delft University of Technology. Based on the results of a comparison campaign at TU Delft with several reference measuring systems from other NMIs, VSL has applied for CMCs of test voltage ( $U_t$ ), front time ( $T_1$ ) and time-to-half value ( $T_2$ ) with uncertainties of 0.7 %, 3.0 % and 1.5 % respectively up to 600 kV and 1.2 %, 5.0 % and 3.0 % respectively up to 1200 kV. Together with additional linearity experiments, VSL is now able to provide lightning impulse voltage calibrations up to 3000 kV on-site.

## Introduction

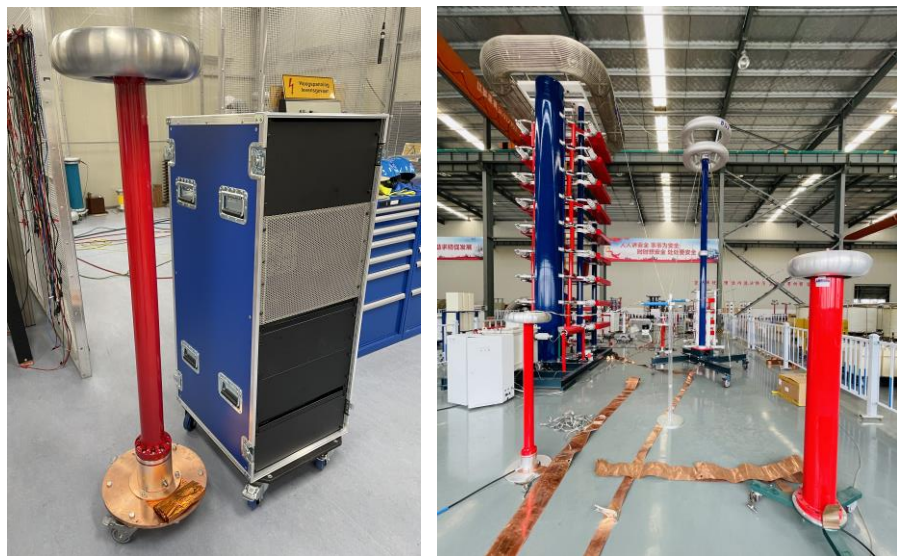
Lightning impulse (LI) voltage measuring systems used in test laboratories of high-voltage (HV) equipment manufacturers need to be calibrated periodically to ensure the amplitude and waveform applied during testing of their products satisfy the requirement of related standards, e.g. IEC 60060. To serve this need, VSL has built a 1200 kV reference measuring system to provide calibration services at customer's premises up to 3000 kV.

## System setup

The VSL reference system consists of a HV divider, a transmission cable, an impulse measurement unit, and analysis software.

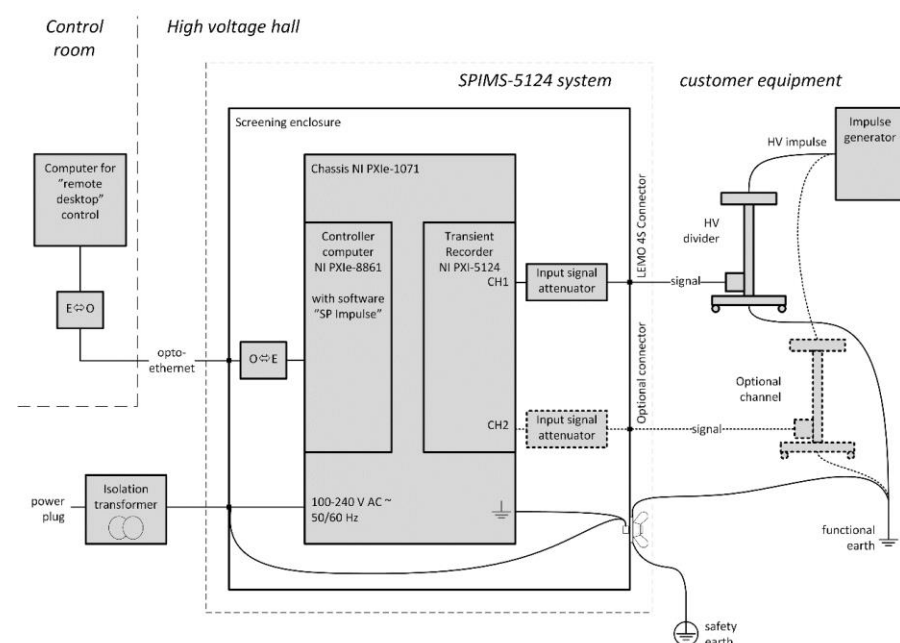
The voltage divider is of resistive type with two stages, each with rated voltage of 600 kV; the two stages can be stacked to achieve a 1200 kV measuring system. The output is designed as a triaxial connector with 50  $\Omega$  characteristic impedance for EMC and noise shielding.

The divider has been validated by comparison with the LI reference measurement system of the national metrology institute of China (NIM) and has also been calibrated by the NMI of Sweden (RISE).



VSL divider compared with the 700 kV LI reference measuring system of NIM

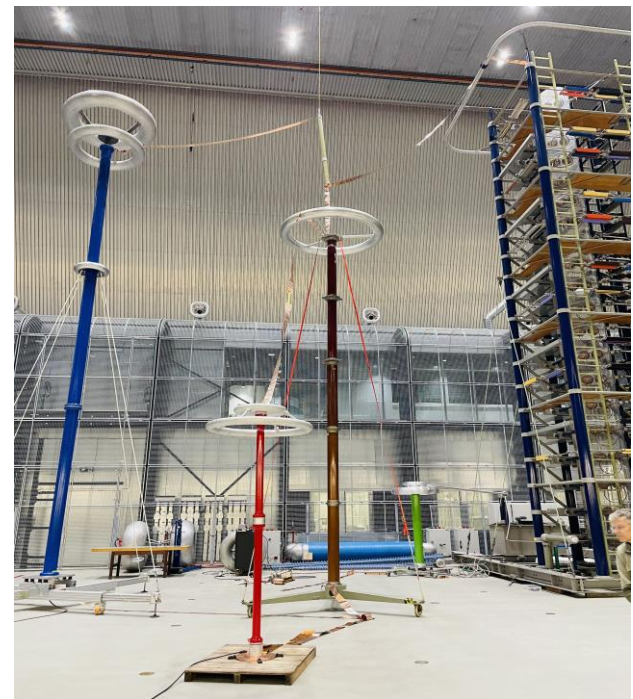
The impulse measurement unit is also designed with a triaxial input, converted to coaxial signal transmission by an attenuator and terminator inside of the rack. A 12-bit NI 5124 digitizer with 150 MHz bandwidth and 200 MS/s sample rate is used for waveform recording. The analysis software is designed according to the definition in the IEC 60060 standard, and has been verified according to IEC 61083.



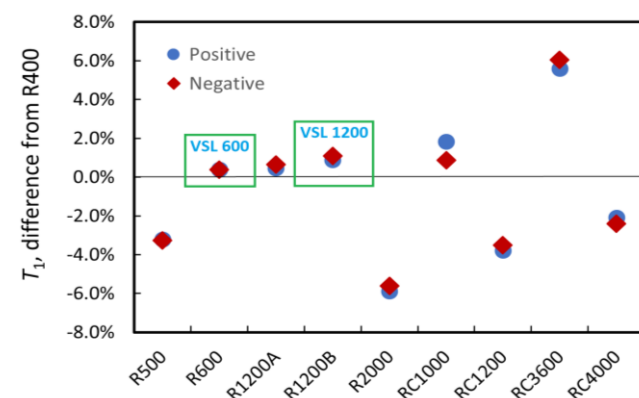
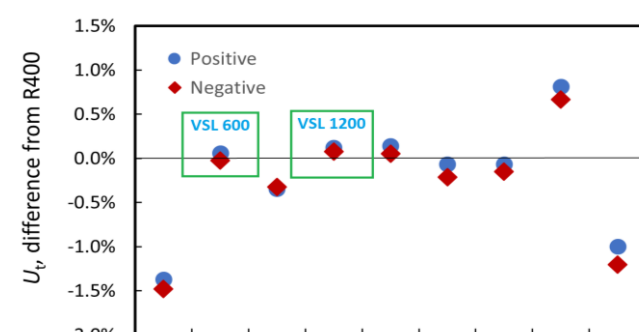
VSL reference measuring system for on-site LI voltage calibrations

## LI Comparison Campaign

A comparison between LI measuring systems from several national metrology institutes, universities and industrial companies was held at TU Delft in October 2022.



Comparison between the VSL 1200 kV LI measuring system and a LI measuring system based on a 3600 kV damped capacitive voltage divider at TU Delft



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

A reference measuring system for on-site lightning impulse voltage calibration has been developed by VSL, and its accuracy has been verified by a comparison campaign. Based on the uncertainty analysis and comparison results, VSL has applied CMCs of test voltage ( $U_t$ ), front time ( $T_1$ ) and time-to-half value ( $T_2$ ) for 0.7 %, 3.0 % and 1.5 % up to 600 kV and 1.2 %, 5.0 % and 3.0 % up to 1200 kV.

This project has received funding from the European Metrology Program for Innovation and Research co-financed by the Participating States and in part by the European Union's Horizon 2020 Research and Innovation Program. Additional funding was received from The Dutch Ministry of Economic Affairs and Climate.

