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Development of measuring systems for high voltages and high currents calibration and testing

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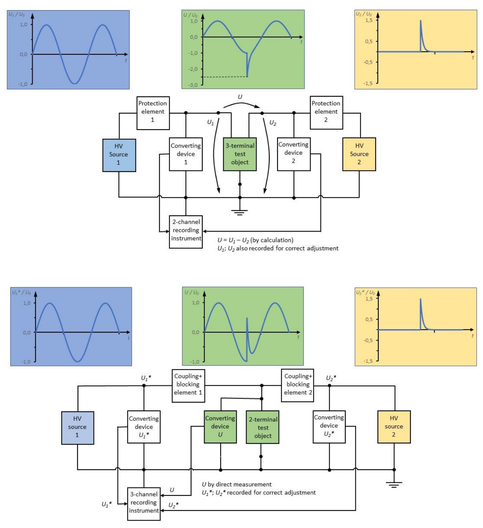
Research context and motivation

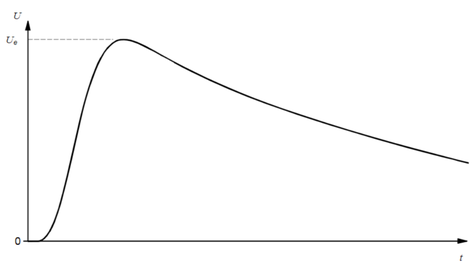
- My research activity is performed in the framework of the research area for the Laboratorio Alte Tensioni e Forti Correnti (LATFC) of Istituto Nazionale di Ricerca Metrologica (INRiM), where I'm deeply studying the problems related to high voltage and high current calibration and test measurements. This activities are very important for the reliability of the electrical network, because an accurate measurement of the electrical phenomena enables us considering the system operation more trustable, safe for the workers and secure to function in the electrical grid.
- The increasing energy production by renewables, with the consequent reduction of the inertia of the electrical system, require an improvement of the network resilience, also reached by performing new tests on the components. With my research activity I intend to enhance my expertise on high voltage and high current tests and become an acknowledged reference scientist in the field.

Addressed research questions/problems

- To improve the resilience of the network, with other partners of the European project HV-com^2 I am studying high voltage tests with combined and composite waveforms that are complex phenomena to simulate, in two different types of tests, the superposition of a lightning impulse during the normal condition of the electrical components. With this project we studied the suggestion to send to the Technical Committee for the next version of the IEC 60060 series. We need to investigate how to perform the tests and the calibrations, also considering the identification of the parameters to be measured. The first two figures show the schematic of these complex phenomena.



- Another important research question is: "How to reduce the uncertainty of the measuring systems for high voltage measurements?". Specifically in this year I focused my attention on the measurements of lightning impulse waveforms, mostly related with the European project.

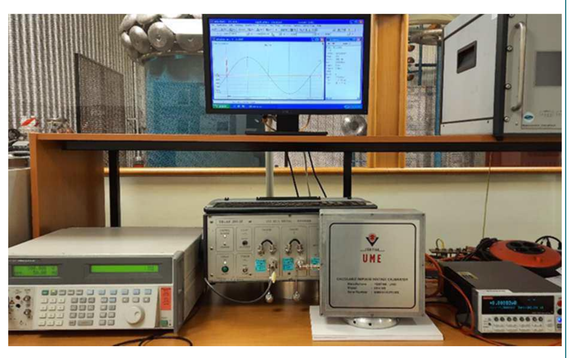


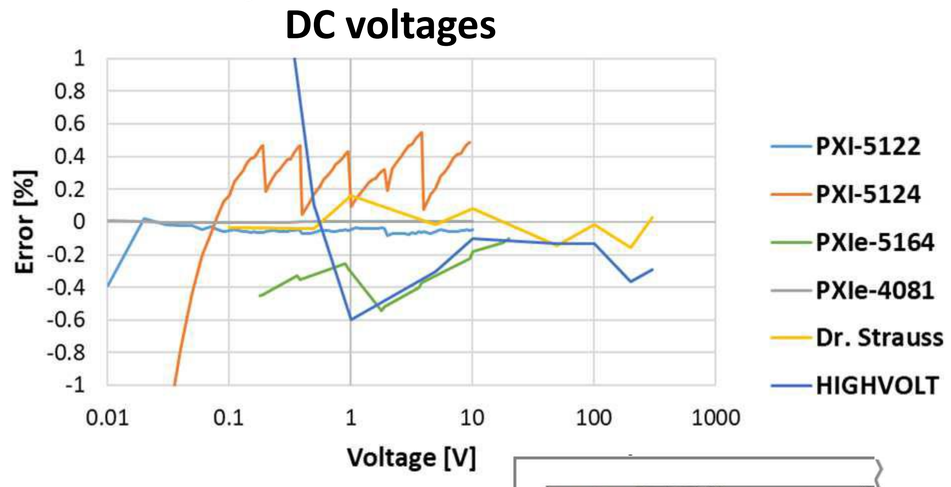
Novel contributions

- Together with the INRiM team, we performed a characterization of different digitizers for complex phenomena like combined and composite waveforms with the intention of verify which could be the best way to acquire and elaborate those waveforms.
- Together with the INRiM team, we had participated to an inter-laboratory comparison between the partner of the HV-com^2 European project that has the purpose to verify the capability to measure the composite and combined voltage waveform up to 1 kV.
- For this comparison I had to develop a voltage divider with a scale factor of about one hundred that permits to reduce 1 kV to 10 V in order to use a NI scope card that has 10 V as maximum scale, with time response compliance with standard for reference systems.
- Another contribution was the development of the software capable to measure those complex phenomena, this software was compared with the software developed by other participants, the INRiM software was in line with the other participants in the comparison.
- To reduce the uncertainty of the lightning impulse measuring system for voltage up to 200 kV I performed a complete reanalysis of the international comparison document EURAMET.EM-S42 to verify the feasibility of the reduction of uncertainty without performing any changes on the hardware of the system.

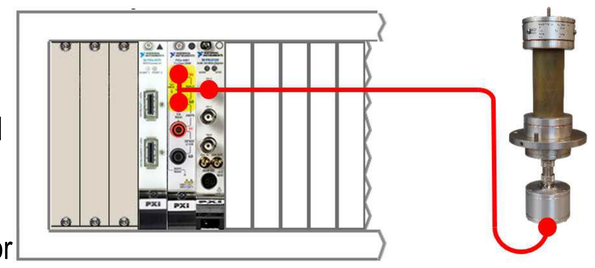
Adopted methodologies

- For the characterization of the digitizers, realized in collaboration with TUBITAK, we used calculable and referable calibrators capable to reproduce the phenomena of our interest.
- For each waveform (DC, AC, LI, SI) we characterize all the ranges and compared the results to evaluate the best solution, for example the results for DC voltages are reported in the figure below.

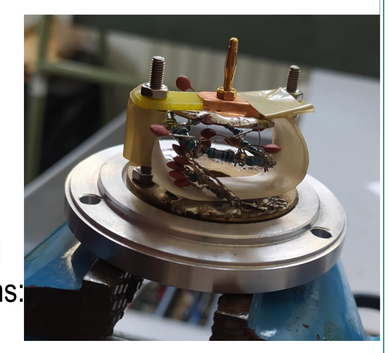




- During this characterization we realized that the best solution to acquire combined and composite waveforms is to use two specialized digitizers: one for slow waveform, and another one specialized for fast phenomenon.



- This work was presented at the EUROCON 2023
- Since I had to measure many different voltage waveforms, I chose a compensated voltage divider that permit to have a good behavior for the step response, to verify the scale factor of the divider I use a calibrator as voltage source and a digital multimeter to measure the output of the divider and perform the calibration of the divider with different waveforms: DC, AC, high frequency AC.



- To develop the software capable to measure those complex waveform I had to use LabVIEW language that allows to create virtual instruments and perform many different measurements.
- To perform the reduction of the uncertainty of the lightning impulse measuring system I had to study the literature referring to the comparison and realize a sheet that permits the recalculation of all results.
- This work was presented at the IMEKO TC4 international symposium.

Future work

- The study of the changes to be made to reduce the uncertainty with the improvement of hardware and software for lightning impulse measuring system for voltages up to 600 kV
- Study of the "running arc" (experiment of the short circuit) to investigate if this kind of experiments could be used to improve the test of internal arc measurements and make some suggestions to the technical committee for reliability of electrical network and devices.

Publications

- Published works: 2 journals, 3 conferences
- Galliana, F., Caria, S.E., and Roccato, P.E., "Towards a traceable divider for composite voltage waveforms below 1 kV", Electrical Engineering, no. 104, 2022, pp. 1121-1130, DOI: 10.1007/s00202-021-01368-5 (09/08/2021) issue April 2022
- Caria, S.E., Merev, A., Roccato, P.E., Dedeoglu, S., "Characterization of Digitizers for Combined and Composite Waveform", IEEE EUROCON 2023 - 20th International Conference on Smart Technologies, 06-08 July 2023, DOI: 10.1109/EUROCON56442.2023.10198941

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