

VTT

Modular wideband high voltage divider

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Result of co-operation within HV-com² project

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Design

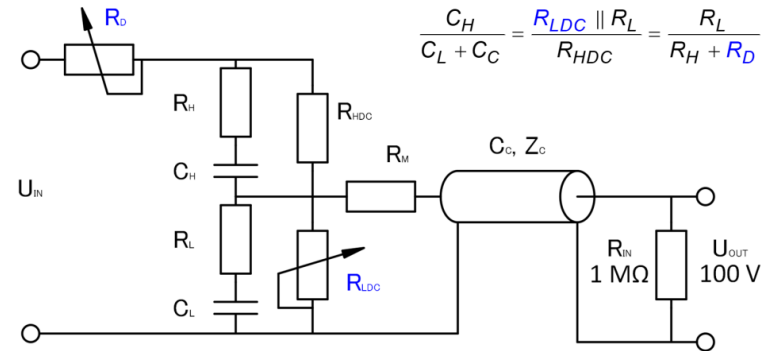
- Target specifications
- Topology
- High-voltage arm
- Low-voltage arm
- External damping resistor

Target values

	Target	2x100 kV
Maximum peak input voltage:	200 kV	200 kV
Scale factor	1000:1	2000:1
HV capacitance	500 pF	425 pF
HV resistance	1000 M Ω	1.2 G Ω
Insulation	Gas, preferably air	Air

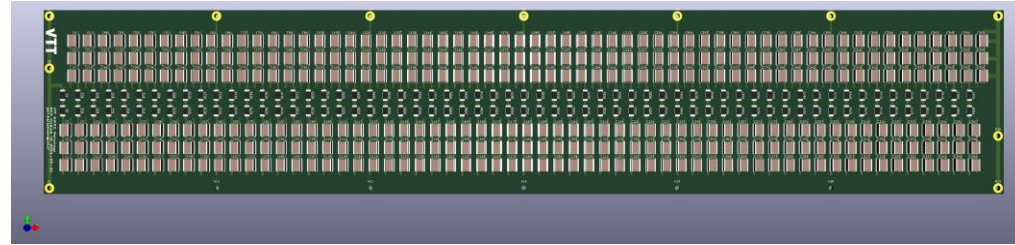
Nominal values

Number of modules:	1	2	4
Maximum peak input voltage:	100 kV	200 kV	400 kV
Scale factor	1000:1	2000:1	4000:1
HV capacitance (C_H):	850 pF	425 pF	212 pF
HV resistance (R_{HDC}):	600 M Ω	1.2 G Ω	2.4 G Ω
Internal damping (R_H):	120 Ω	240 Ω	480 Ω
External damping (R_D):	125 Ω	250 Ω	500 Ω
LF time constant ($C_H R_{HDC}$):	0.5 s		
HF time constant ($C_H R_H$):	0.2 μ s		



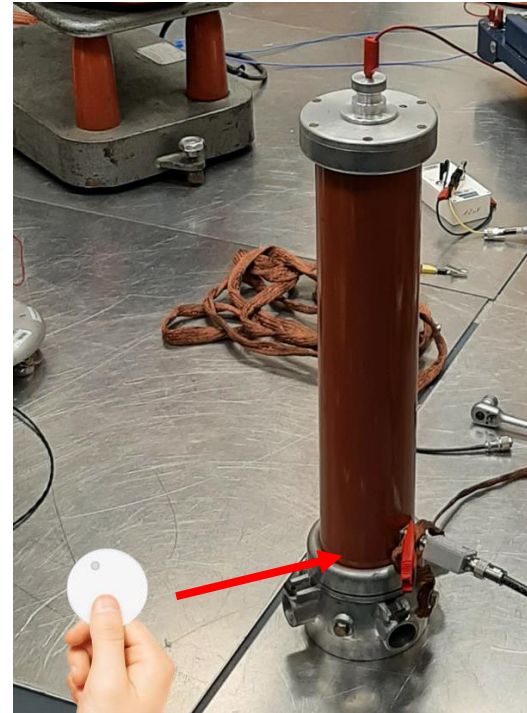
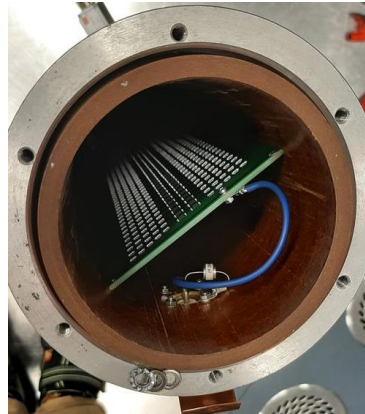
High-voltage arm PCB

- Size
 - 95 mm x 500 mm
 - Capacitance: 850 pF
- Components
 - Film resistors:
 - Existing module: 25 ppm/K, 200 V
 - 2 ppm/K direct replacement possible
 - Capacitors:
 - NP0, 30 ppm/K, 1 kV
 - With damping resistors in series
- Nominal voltage
 - 100 kV
 - PCBs can be stacked for higher voltage rating



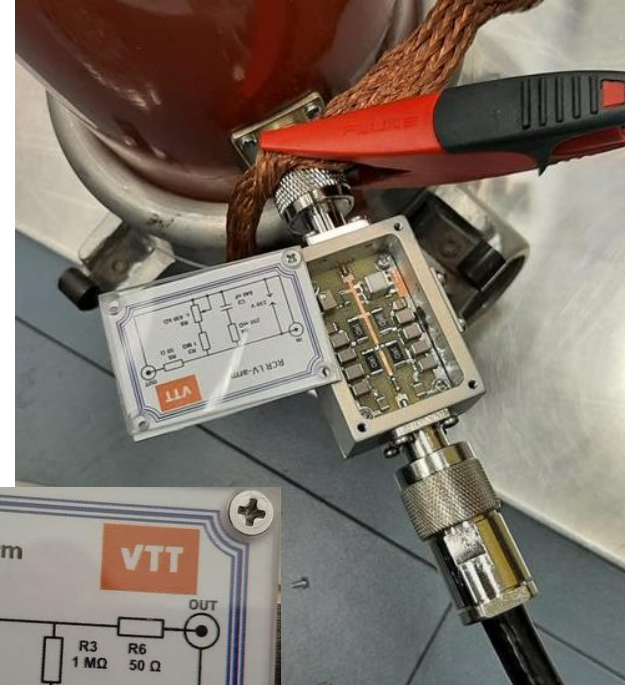
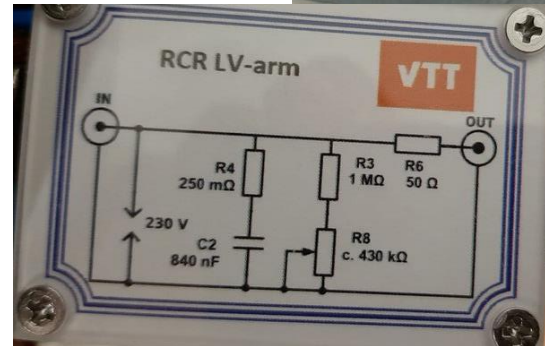
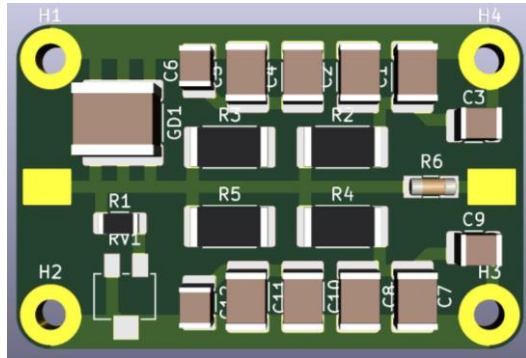
100 kV prototype

- Impedance
 - Resistance: 600 M Ω
 - Capacitance: 850 pF
- Maximum voltage
 - DC: 100 kV
 - AC_{RMS}: 70 kV
 - Impulse peak: 100 kV
- Mechanical
 - Diameter: 140 mm
 - Length: 590 mm
 - Weight: ?? kg
 - BT Temperature sensor inside



Low-voltage arm and cable

- Adjustable resistance
 - to match AC and DC scale factors
- N-connectors
- Low-loss Ecoflex 10 PLUS cable
 - 100 % shield coverage



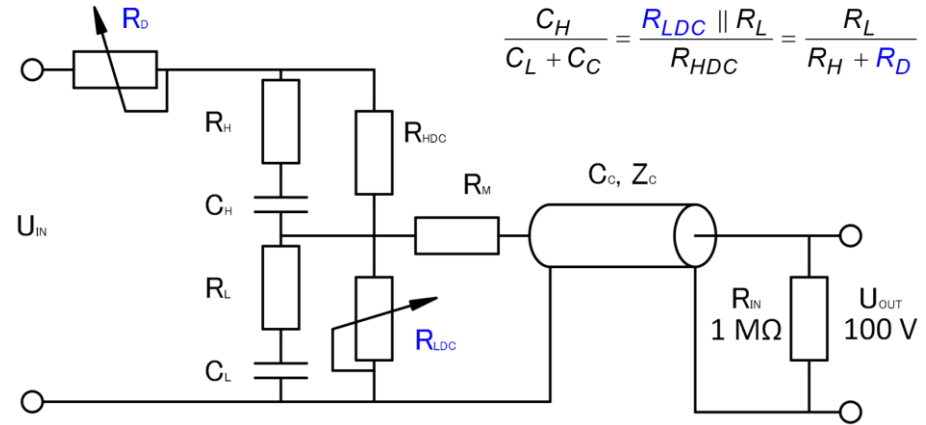
External damping

- Needed to optimize response for rise-time $< 1 \mu\text{s}$
- Allen Bradley ceramic resistor discs
- Nominal resistance c. 150Ω



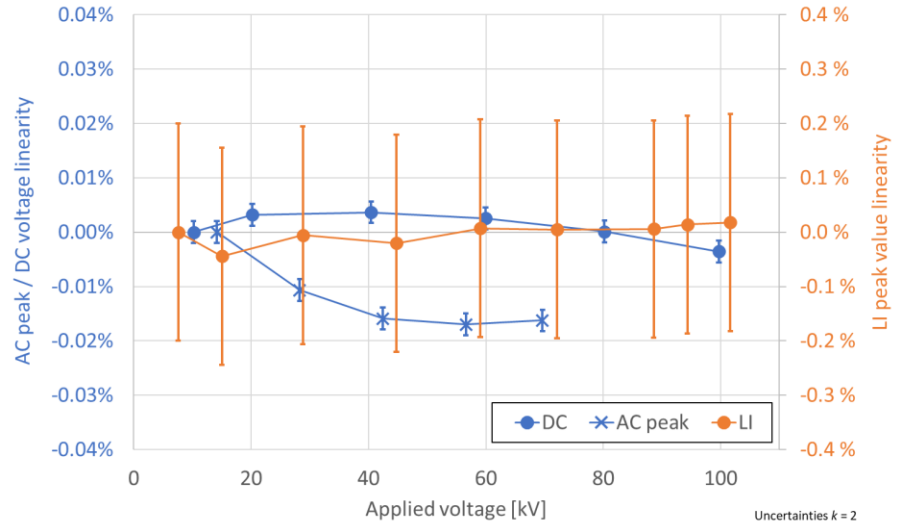
Tuning for flat frequency response

- Frequency response is sensitive to changes in cable capacitance (C_C) and input impedance of the metering instrument (R_{IN}).
 - Capacitive ratio dominates between 0.3 Hz and 800 kHz
 - Trimmer R_{LDC} adjusts response < 0.3 Hz.
 - External damping resistor (R_D) adjusts response > 800 kHz.



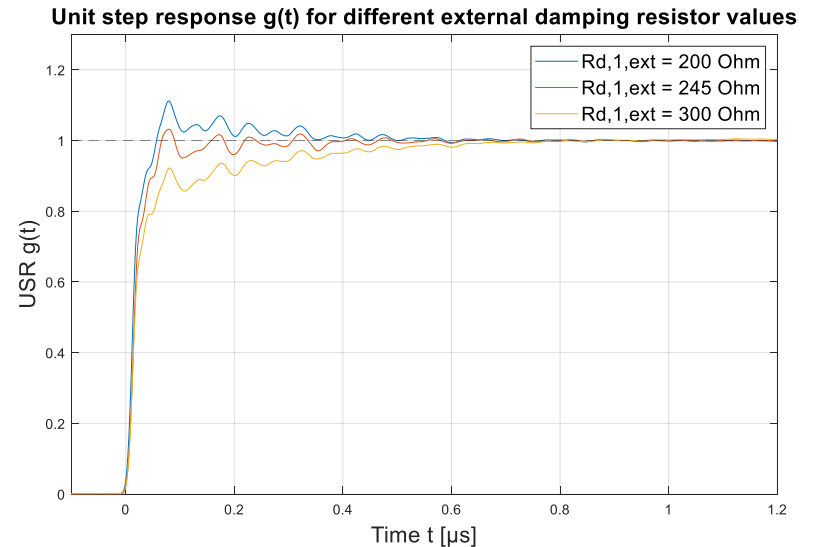
Linearity (100 kV)

- Voltage linearity of the divider was tested with DC, AC, and LI (lightning impulse)



Step response (200 kV)

- Adjustment by changing the front resistor value



Comparison @PTB (400 kV)

- Composite
 - DC and LI
 - DC and SI
 - AC and LI
 - AC and SI

- Combined
 - AC and LI

- See poster



Conclusions

- Designed and built using off-the-shelf components connected massively in series and parallel.
- Can be used also for calibration of universal dividers used during combined and composite voltage testing.
- First characterization of 100 kV and 200 kV systems show that the measurement uncertainty is lower than 0.1 % for the test voltage value for all voltage types.
- The 200 kV divider is tested PD free up to its nominal voltage.
- The 400 kV setup has been successfully used as the reference system in a comparison with commercial measuring systems.

- Proper metrological characterization still to be done...

... and then some more related progress:

- FFII, duplicate design
- TUBITAK, duplicate design with more rugged housing
- RISE, alternative design based on PP foil capacitors
- LNE, alternative design based on PP film capacitors
- PTB, alternative design based on PP capacitors

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