



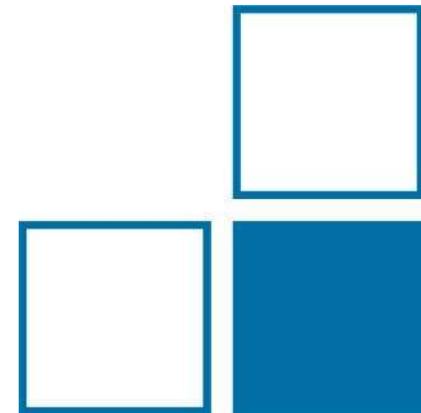
Physikalisch-Technische Bundesanstalt
Braunschweig und Berlin
Nationales Metrologieinstitut

HV-com²

Support for standardisation of high voltage testing with composite and combined wave shapes

Standardisierung von Hochspannungsprüfungen mit zusammengesetzten und kombinierten Spannungsformen

Johann Meisner
AG 2.31 – Messwandler und
Hochspannungsmesstechnik



Introduction

„State of art“ and „needs“

Project „HV-com²“

Low Voltage

High Voltage

Validation

Conclusion

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Change of Europeans el. Energy System

Change from traditional to renewable generation of electrical energy

- Change of transmission grid
- Change of distribution grid
- More cables
- More HVDC
- ...

→ Need of new testing and calibration methods and facilities



Solar power



wind power



decentralisation

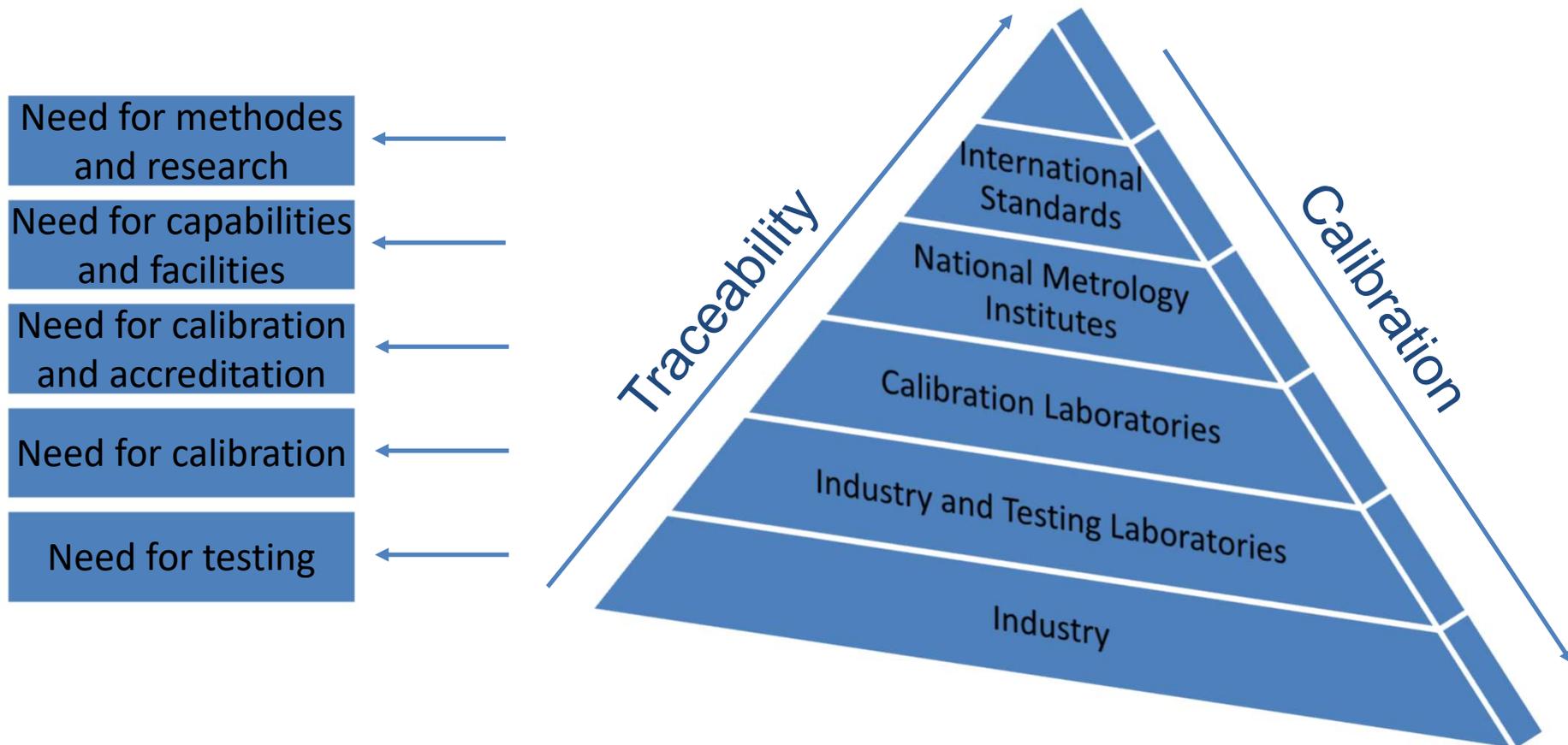


Grid for e-mobility



Smart Grid

PTB Calibration and Traceability



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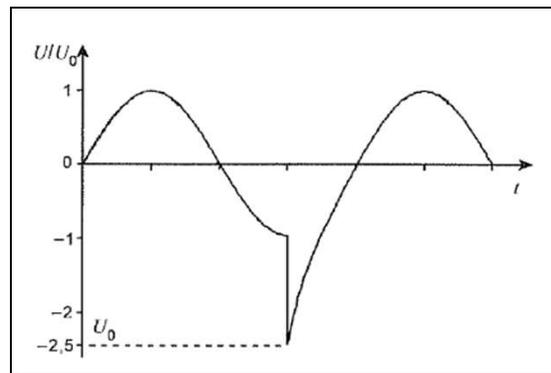
PTB Combined and composite wave shapes

HVAC
or
HVDC

Combined or
Composite
Wave Shape

Lightning Impulse
or
Switching Impulse

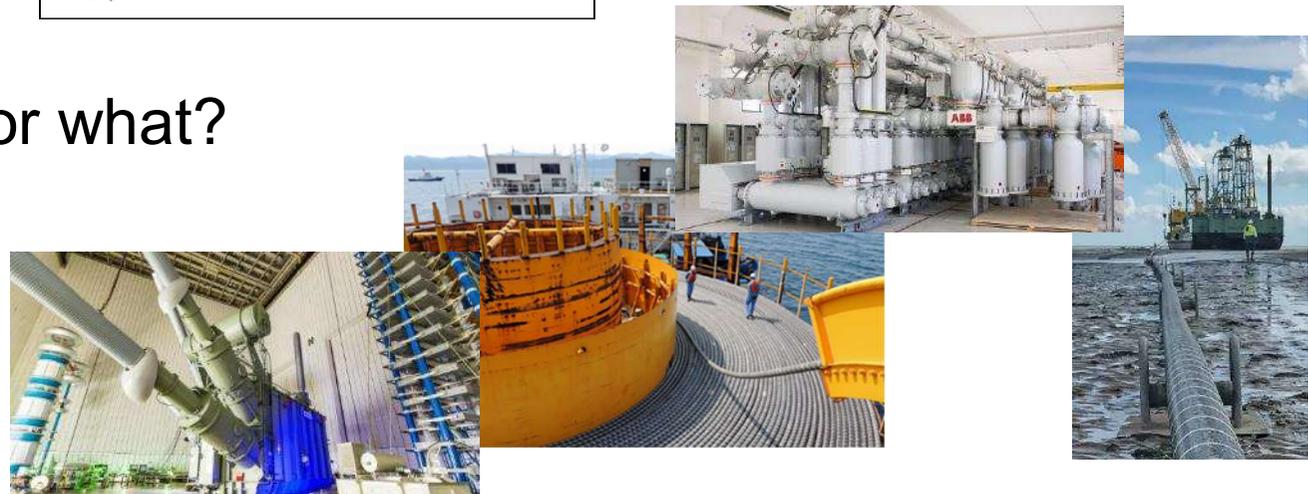
IEC 60060 – 1 High-voltage test techniques
- Part 1: General definitions and test requirements
→ Review started!



-Describes the circuits for composite and combined tests
-Gives no requirements for test voltage
-Does not deal with time parameters

For whom and for what?

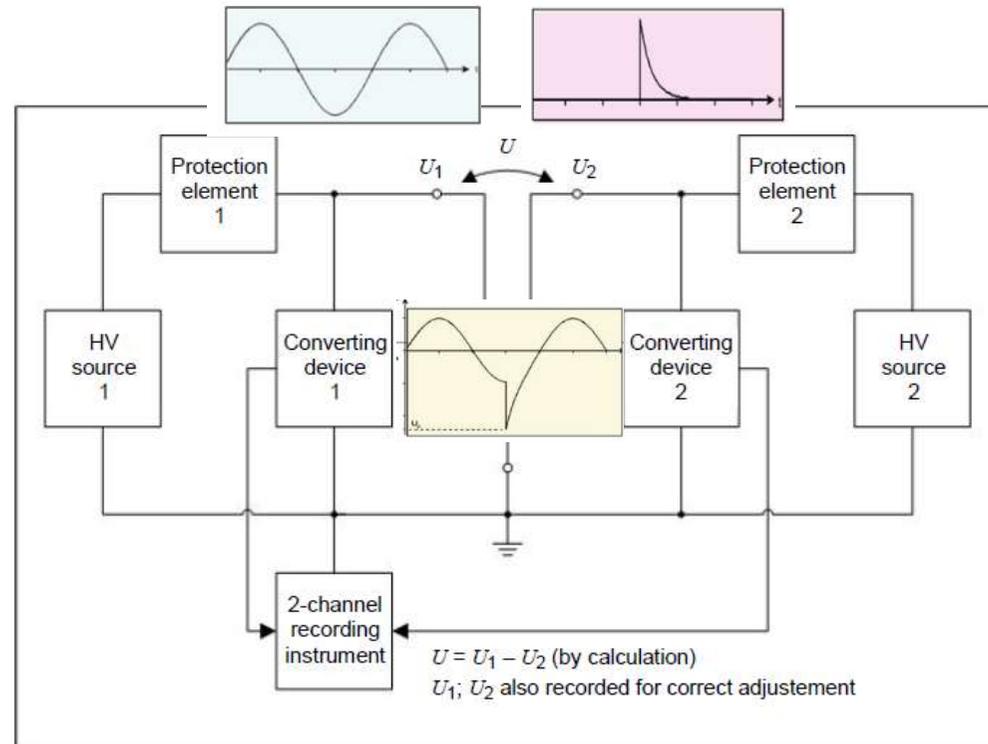
- GIS testing
- Cable testing
- Transformer testing
- ...



<https://global-sei.com/power-cable-business/products/hvdc/>
https://www.zfk.de/fileadmin/Bilderdatenbank_NEU/Technik/Energie_gasolierte_Schaltanlage_c_ABB.jpg

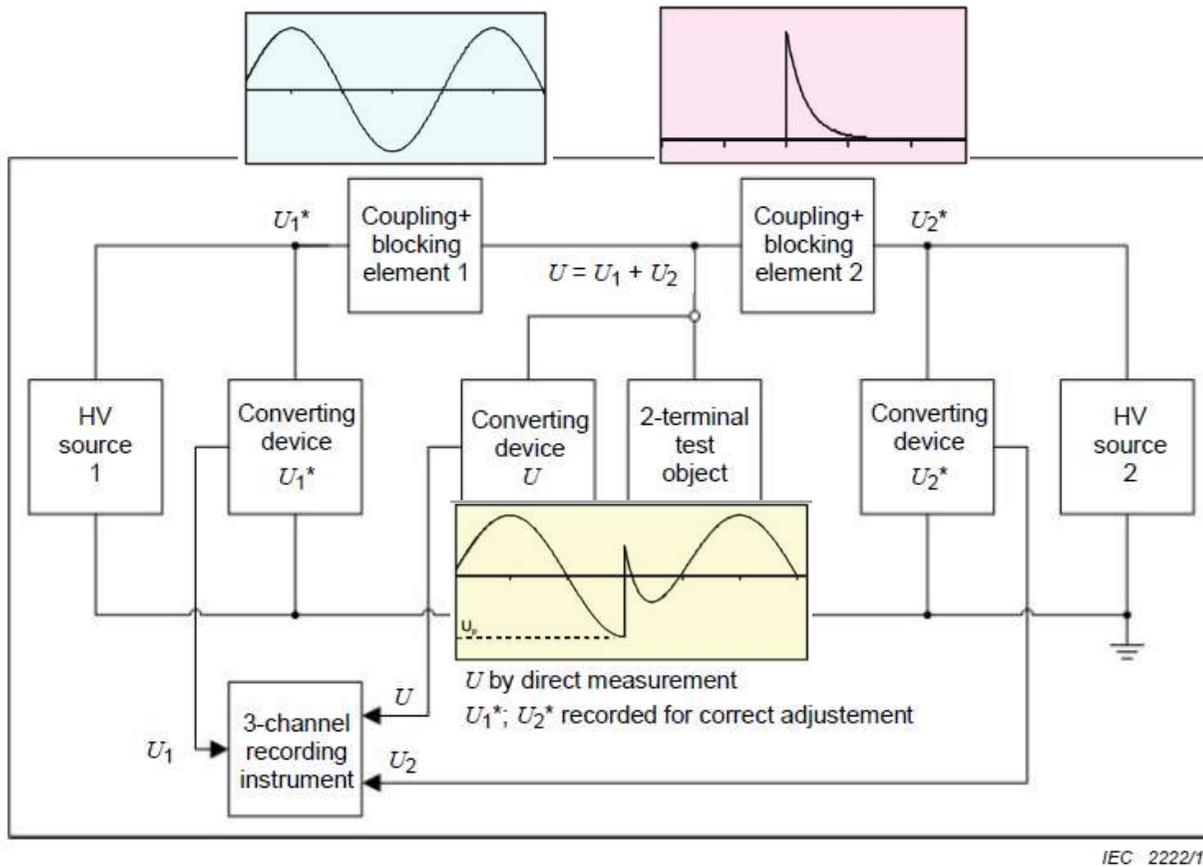
<https://www.energate-messenger.de/news/163845/zwei-konverter-fuer-eine-hg-ue-leitung>

- Blocking elements for protection
- Different measuring devices
- Calculation of combined voltage



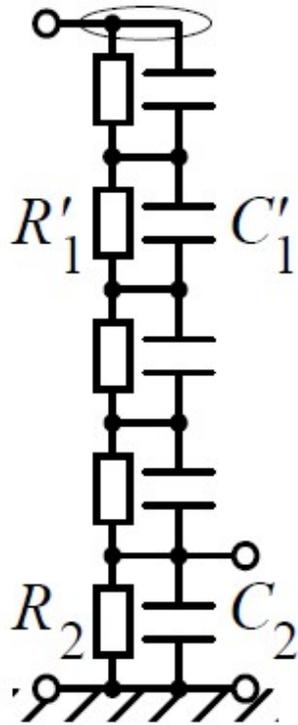
IEC 2219/10

PTB Composite voltage test



- Blocking elements for protection
- One measuring devices
- Real measurement of compositee voltage

Universal R-C-Divider



A. Küchler, „Hochspannungstechnik“

- Testing Dividers/Systems with HVAC, HVDC and Impulses separately
 - HVAC scale factor $\rightarrow 998$
 - HVDC scale factor $\rightarrow 1002$
 - Impulse scale factor $\rightarrow 987$
- Customers must choose scale factor for composite wave shapes themselves
- There are no reference dividers
- There are no calibration services
- There is no clear standardisation

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The EMPIR initiative is co-funded by the European Union's Horizon 2020 research and innovation programme and the EMPIR Participating States



**Support for standardisation of high voltage testing with
composite and combined wave shapes**

19NRM07 HV-com²

<https://www.ptb.de/empir2020/hv-com2/home/>

PTB Research Project „HV-com²“



<https://simple.wikipedia.org/wiki/Europe>

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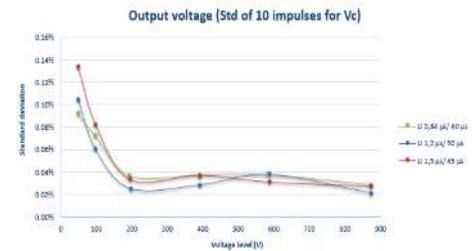
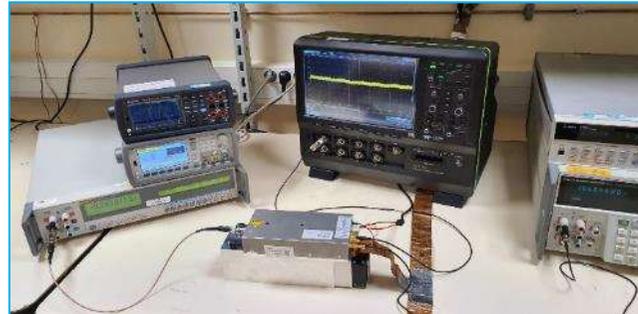
- Parameter for superimposed wave shapes
- LV generators
- LV measurement instruments (transient recorders)
- Software for superimposed wave shapes
- Comparison of different digitizers and generators

- Recommendation for standardisation in TC 42
 - IEC 60060 series
 - IEC 61083 series

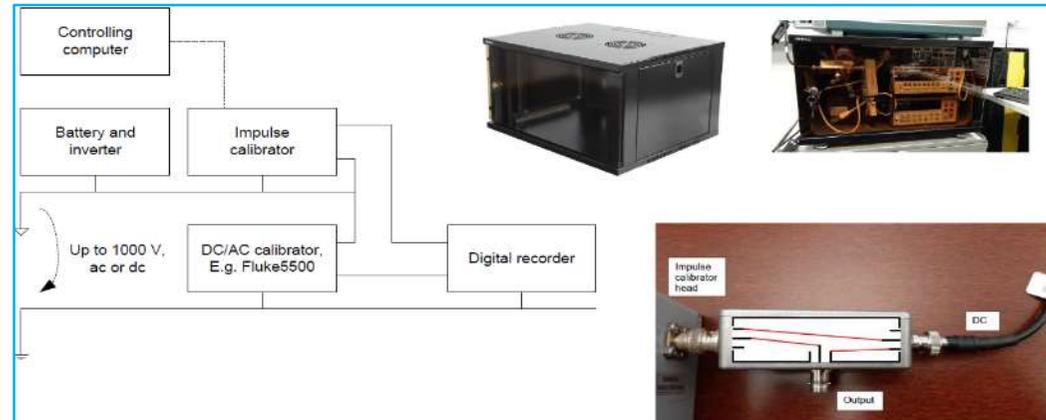
PTB Low voltage generators

3 proposals were agreed :

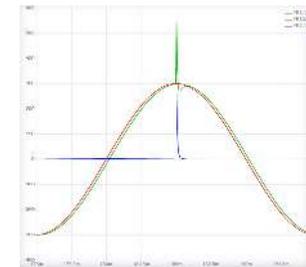
- ✓ HV amplifiers for generating wave shapes



- ✓ Solution based on series arrangements of two sources (AC/DC calibrator and impulses calibrator)

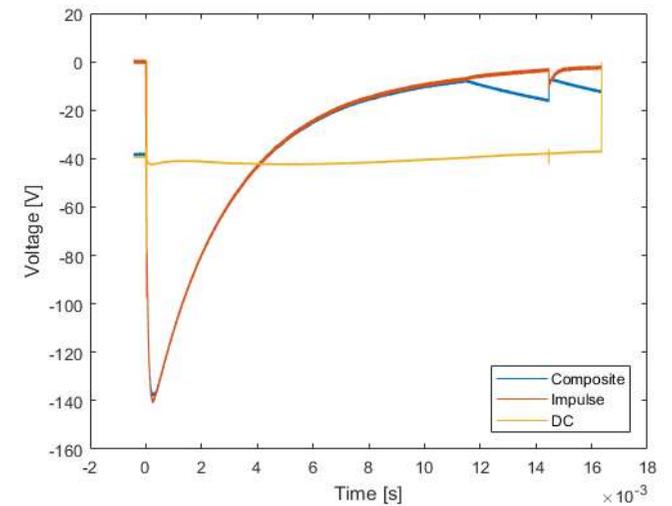
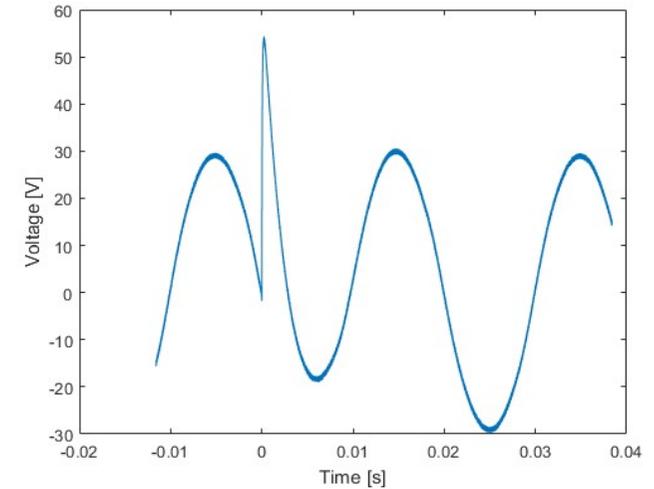
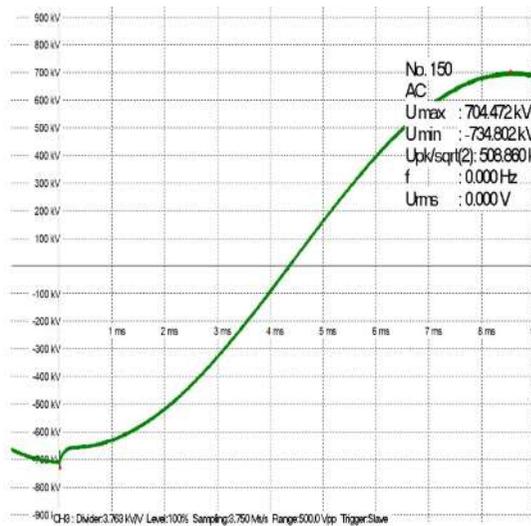
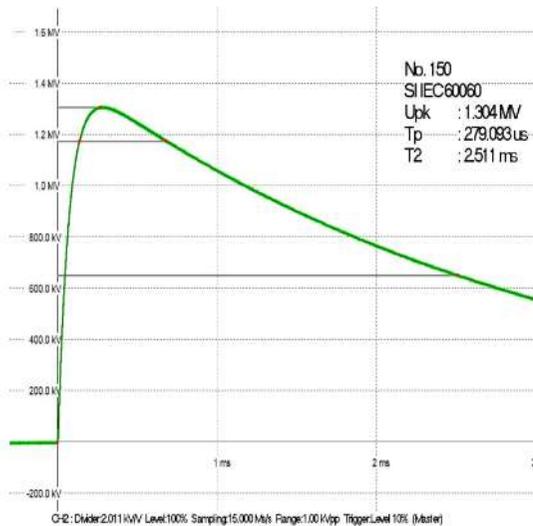


- ✓ Solution based on parallel arrangements of two sources (AC/DC calibrator and impulses calibrator) using blocking elements





- Development of software is in progress
- Reference waveforms were collected to be used for the evaluation of software



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High Voltage

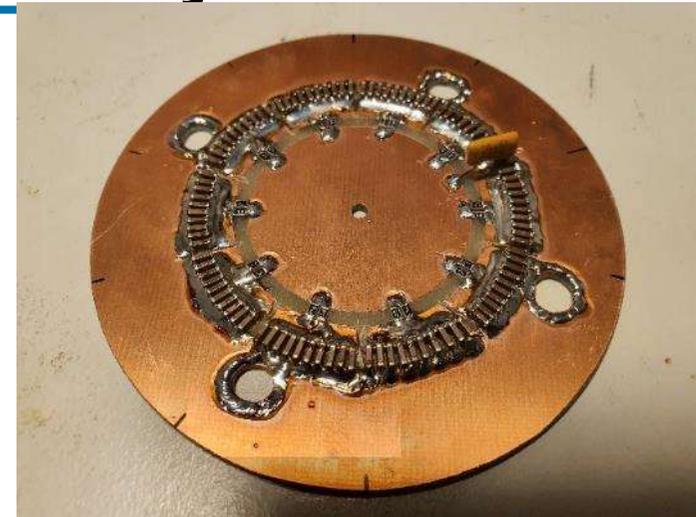
Validation

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PTB WP 2: Traceable reference systems



Task 2.1: Design and construction of a modular universal voltage divider (active)

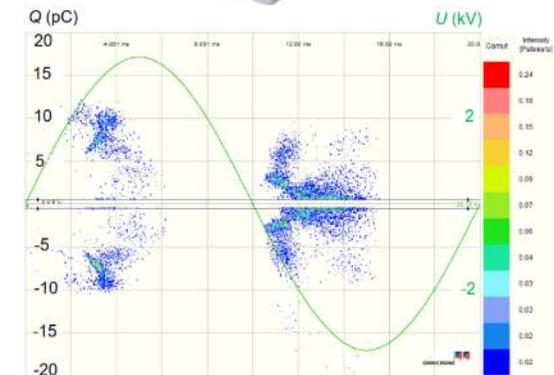
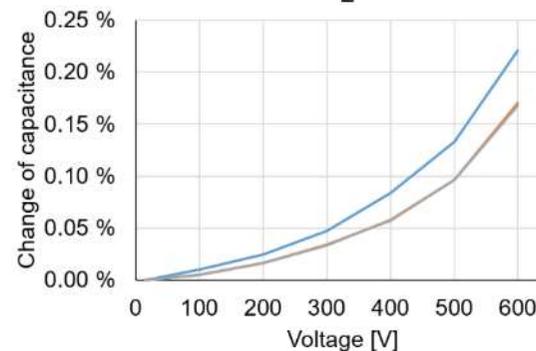
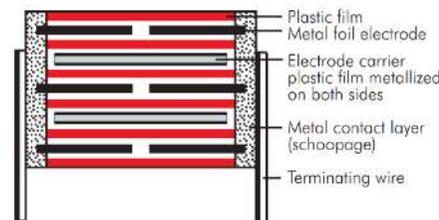
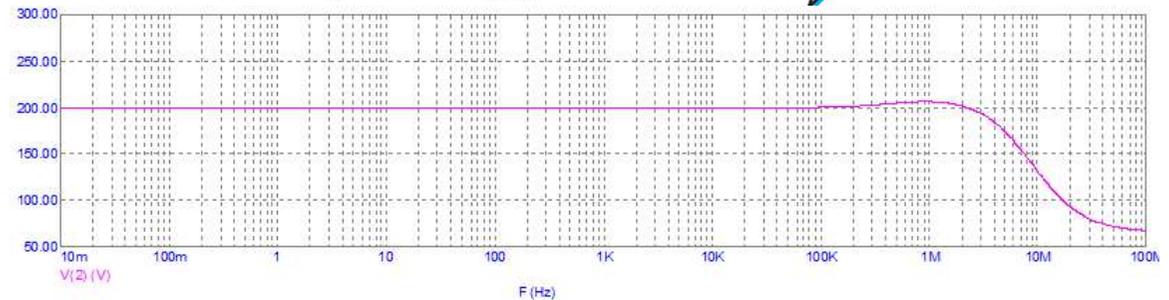
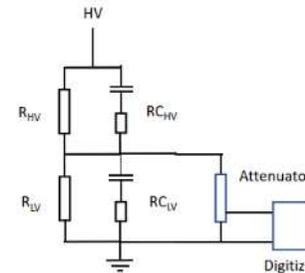


Task 2.2: Measurement campaign at PTB to study the accuracy limits of the reference measurement systems that are used for measuring composite and combined waveforms

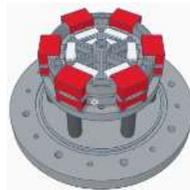


PTB Modular universal voltage divider

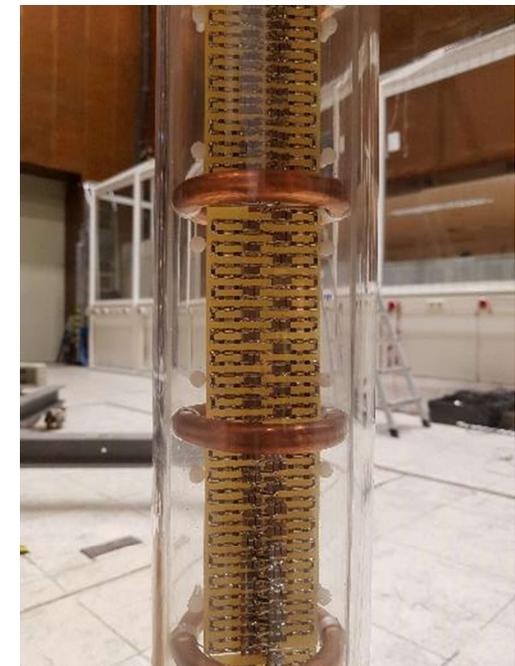
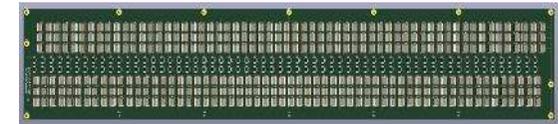
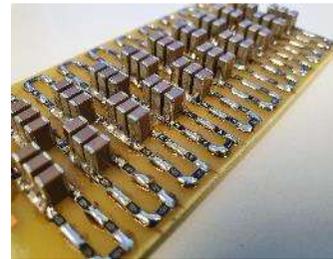
- 7 design proposals in the beginning
- Main design principles were agreed
→ RCR structure
- Simulations to support the design
- Finding suitable components
- Component characterization and testing
(capacitors)
- Mechanical design



- Two designs based on foil capacitors
 - Characterization of the designs is under progress



- Design based on SMD components (NP0 capacitors)
 - Hand assembled version for testing



- Fixed component values per 100 kV → different types of modules can be combined
- Building the additional modules should be finished till the end of 2021

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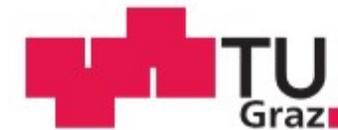
High Voltage

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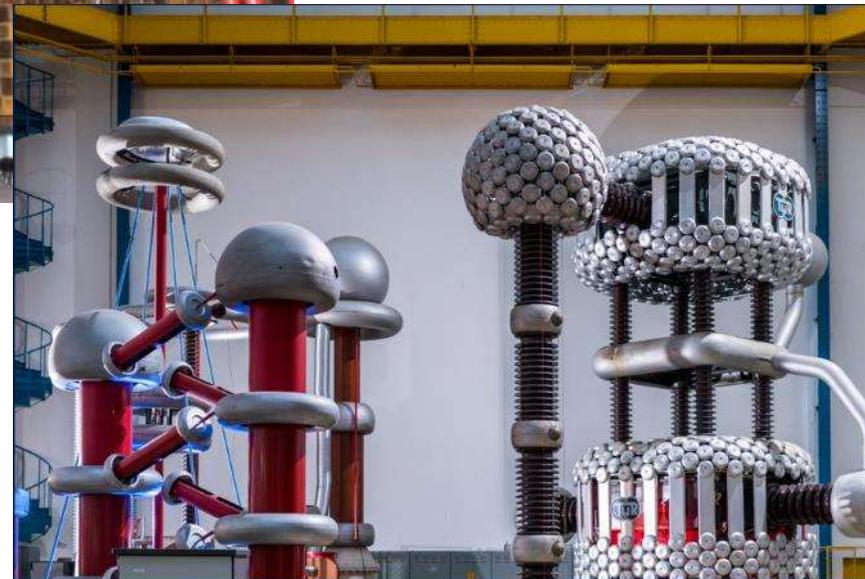
Conclusion

PTB WP 3: Approved measuring systems

- Comparison Measurements at TU Graz and TU Dresden

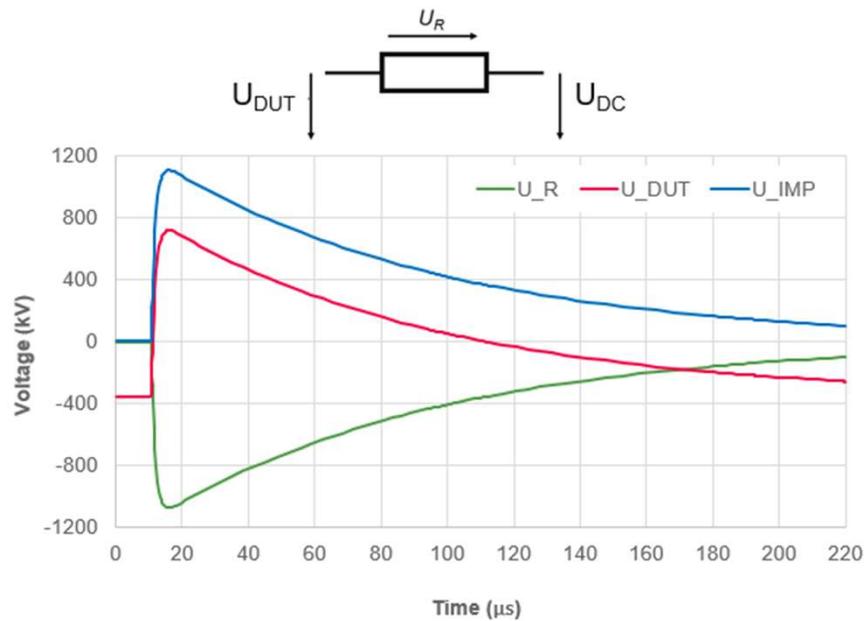


<https://www.tugraz.at/institute/hspt/>

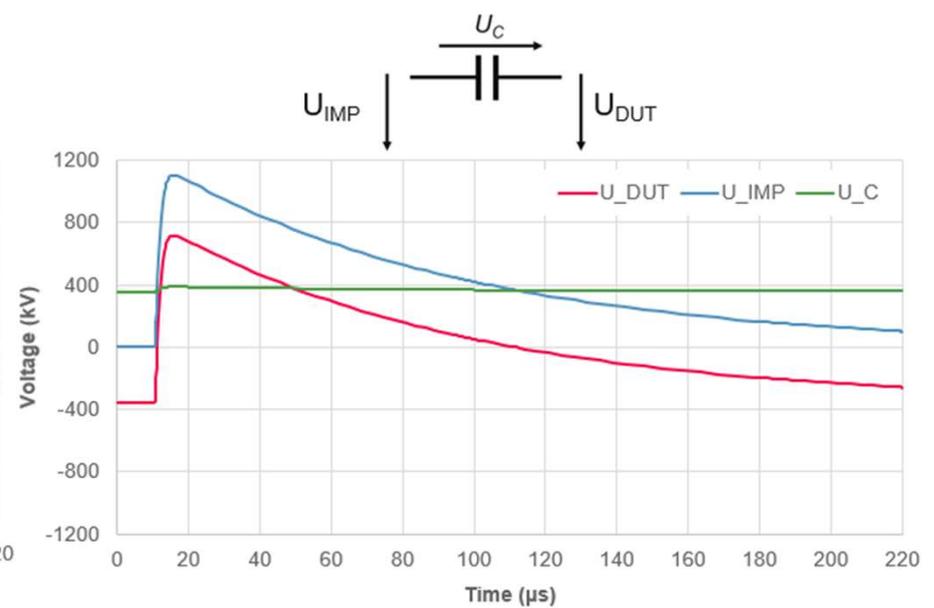


<https://tu-dresden.de/ing/elektrotechnik/ieeh/das-institut#intro>

- Voltage across protection resistor



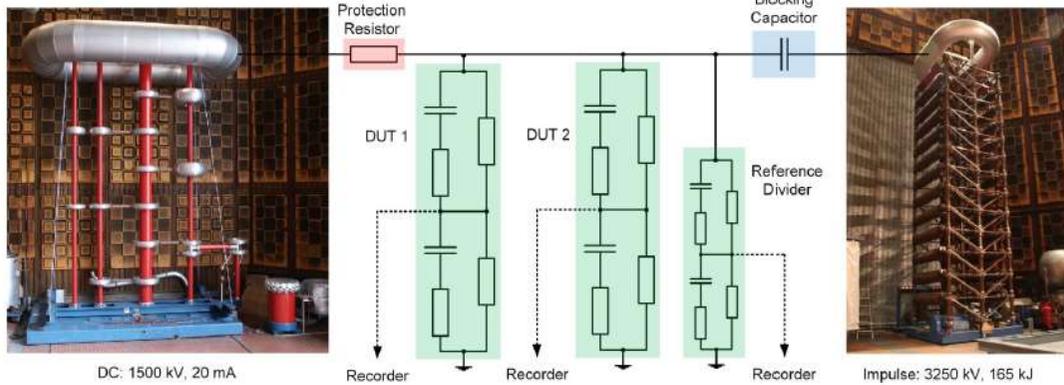
- Voltage across coupling capacitor



Example DC-/LI+: $U_{DC} = -320 \text{ kV}$, $U_p = 750 \text{ kV}$

PTB WP 3: Approved measuring systems

$U < 300 \text{ kV}$

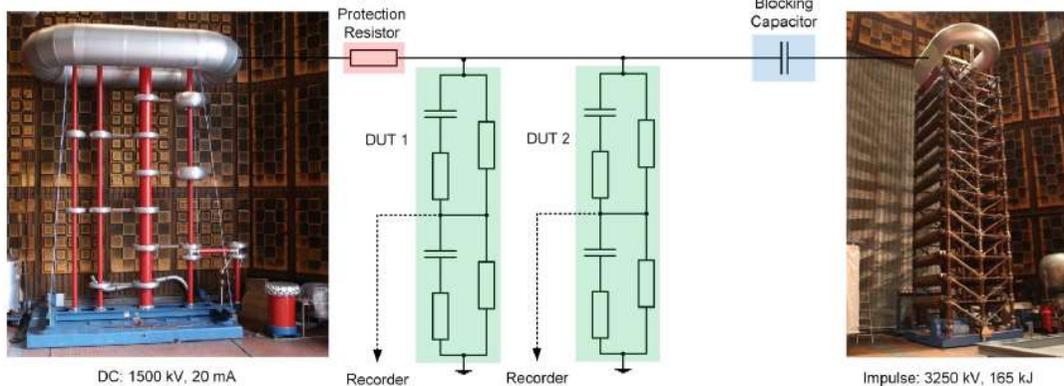


DC: 1500 kV, 20 mA

Impulse: 3250 kV, 165 kJ

Reference Divider: PTB
DUT 1: Haefely
DUT 2: HighVolt
Test Sources: TUG
Blocking Elements: TUG

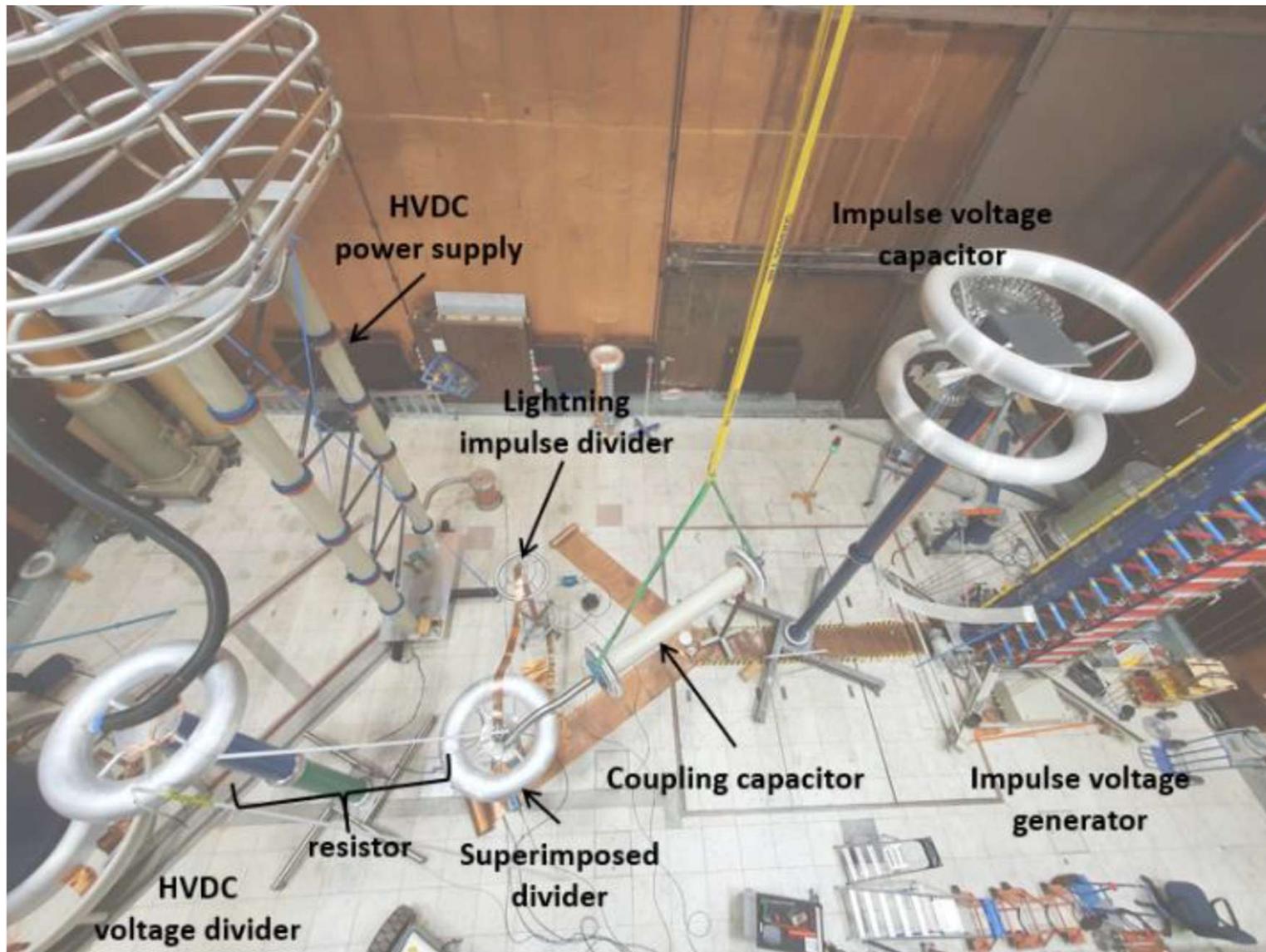
$U > 700 \text{ kV}$



DC: 1500 kV, 20 mA

Impulse: 3250 kV, 165 kJ

HV Laboratory: 35 m x 25 m x 21 m



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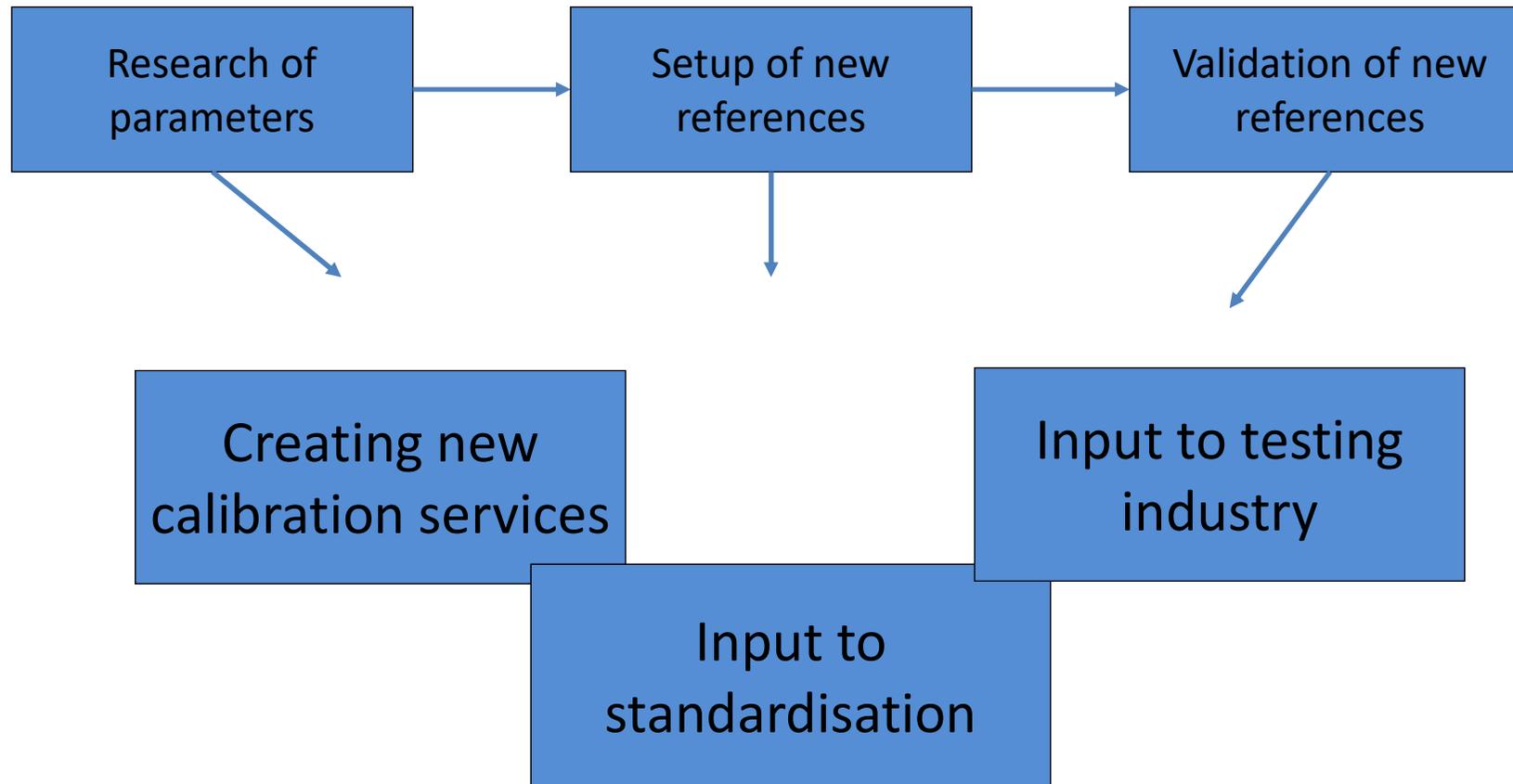
High Voltage

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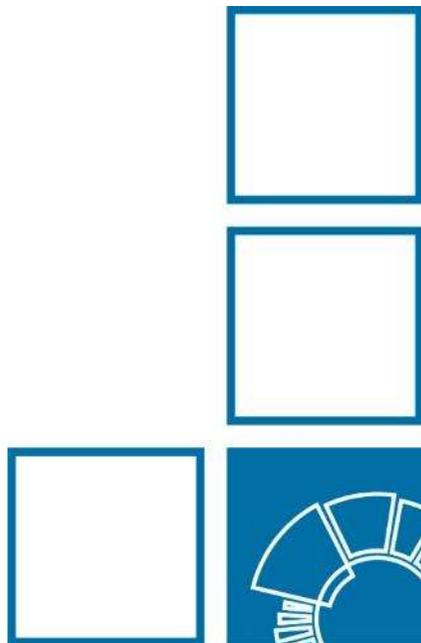


Support for standardisation of high voltage testing with
composite and combined wave shapes
19NRM07 HV-com²



Thanks you!!

- Ernst Gockenbach, IEC TC 42, (H. Schorn)
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- Kari Lahti, Tampere University, Finland
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