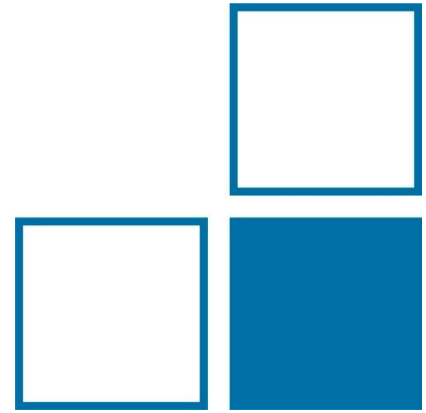
Physikalisch-Technische Bundesanstalt
Braunschweig und Berlin
Nationales Metrologieinstitut

HV-com²

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

Dr. Johann Meisner
Instrument Transformers and High Voltage Metrology



Overview

- Introduction
- „State of art“ and „needs“
- Project „HV-com²“
  - Low Voltage
  - High Voltage
  - Validation
- Conclusion

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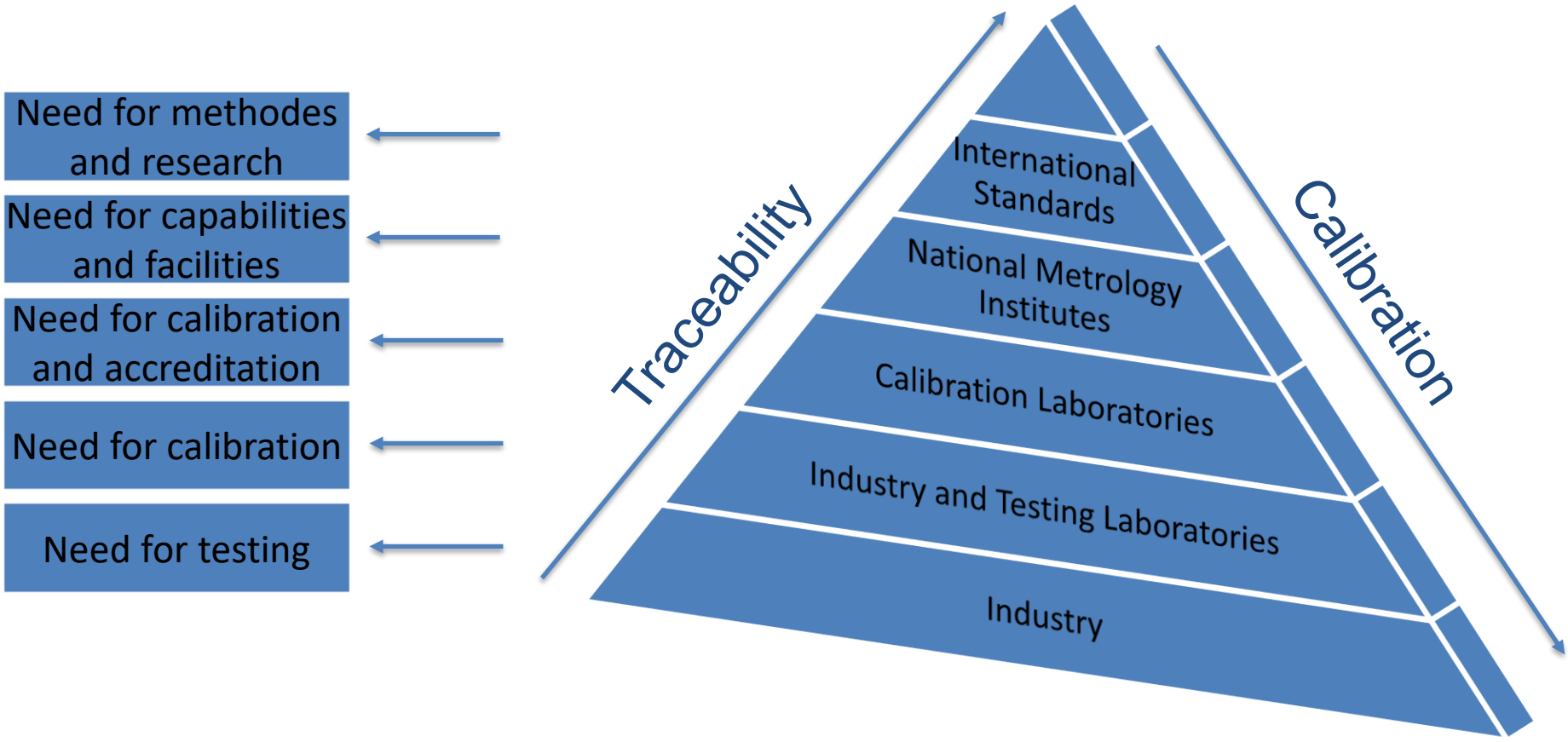
Calibration and Traceability



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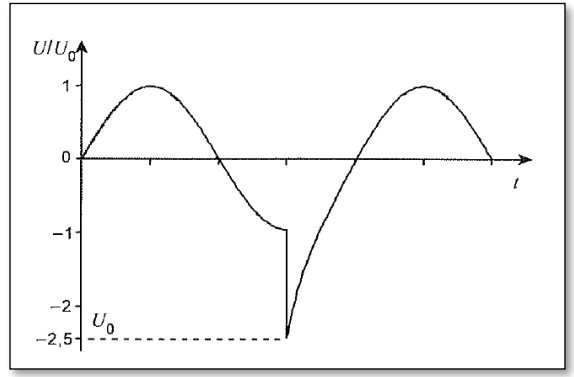
Combined and composite wave shapes

HVAC or HVDC → Combined or Composite Wave Shape ← Lightning Impulse or Switching Impulse

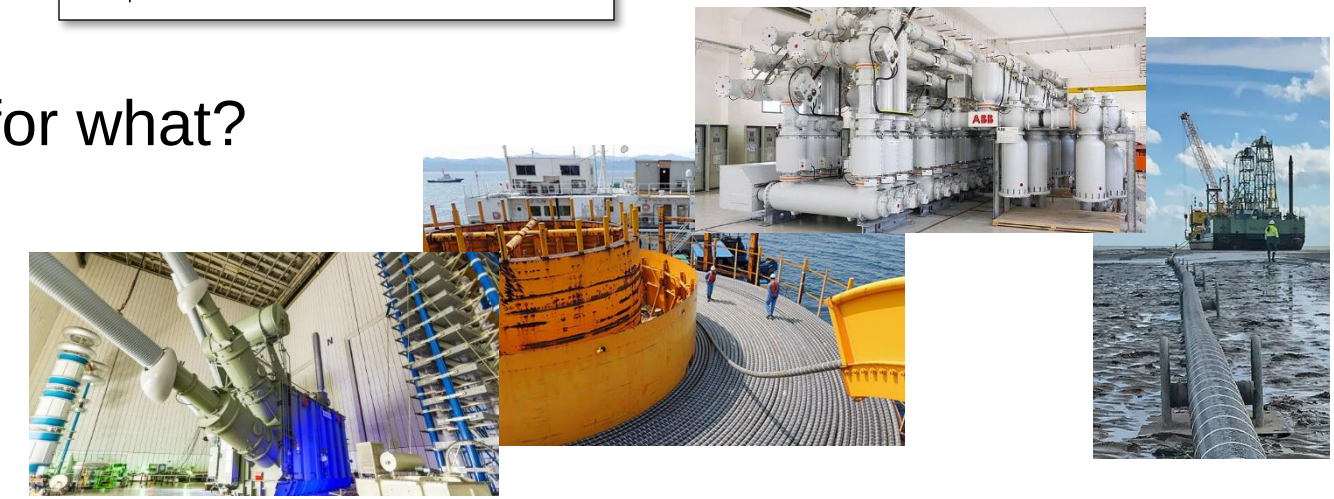
IEC 60060 – 1 High-voltage test techniques - Part 1: General definitions and test requirements



-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?

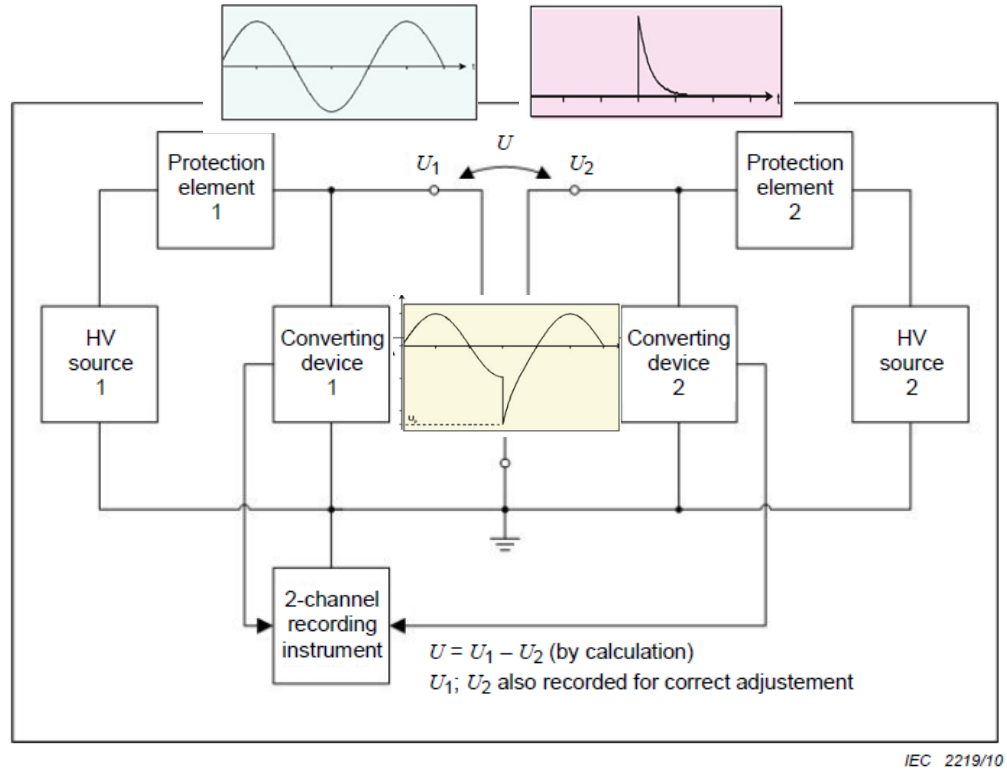
- GIS testing
- Cabel testing
- Transformer testing
- ...



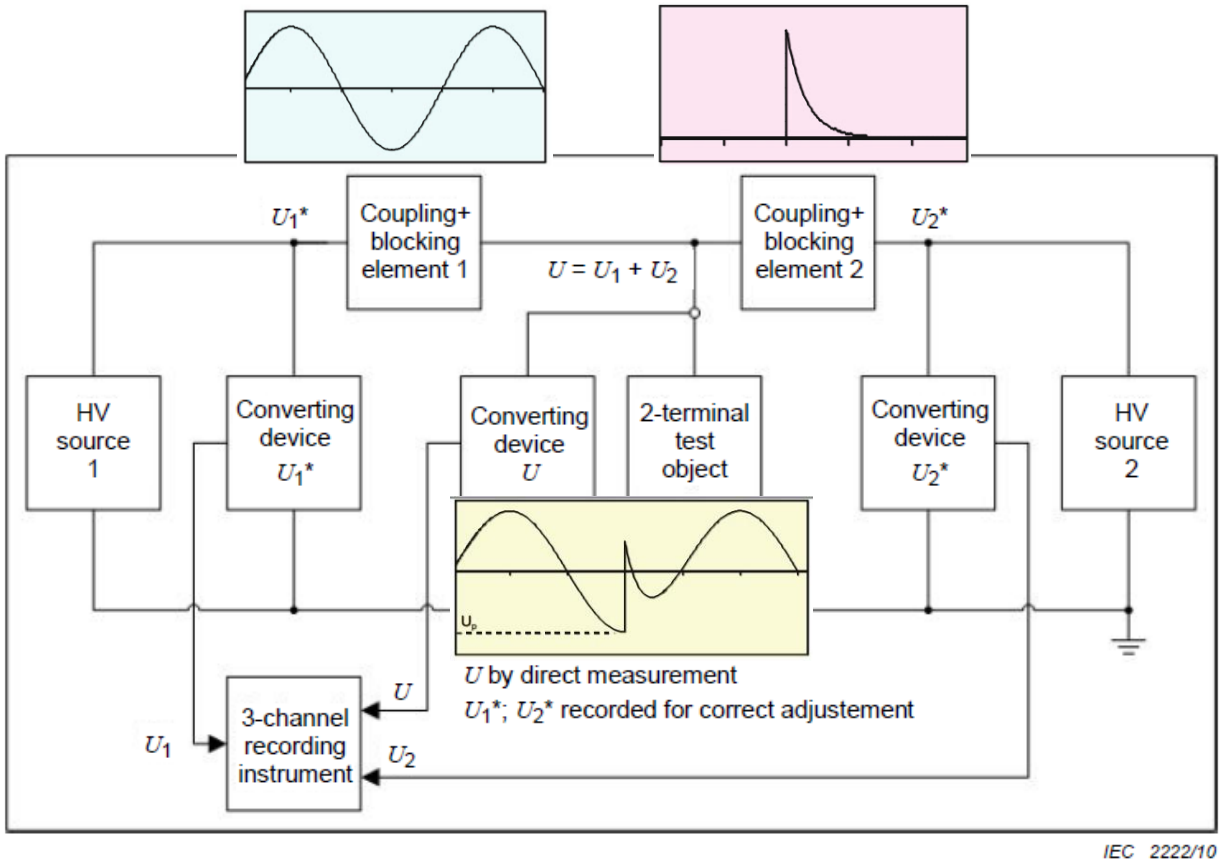
https://global-sei.com/power-cable-business/products/hvdc/ https://www.energate-messenger.de/news/163845/zwei-konverter-fuer-eine-hgue-leitung
https://www.zfk.de/fileadmin/Bilderdatenbank_NEU/Technik/Energie_gasisolierte_SChaltanlage_c_ABB.jpg

Combined voltage test

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



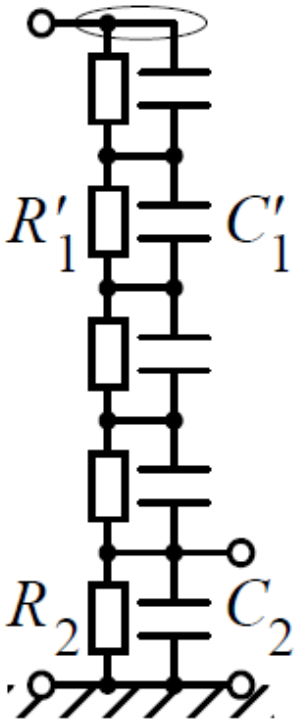
Composite voltage test



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

Testing and calibration

Universal R-C-Divider



A. Küchler, „Hochspannungstechnik“

- Calibration Dividers/Systems with HVAC, HVDC and Impulses separately
  - HVAC scale factor → 998
  - HVDC scale factor → 1002
  - Impulse scale factor → 987
- Costumers must choose scale factor for composite wave shapes themselves

➢ There are no reference dividers

➢ There are no calibration servives

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Research Project „HV-com²“

EMPIR

EURAMET

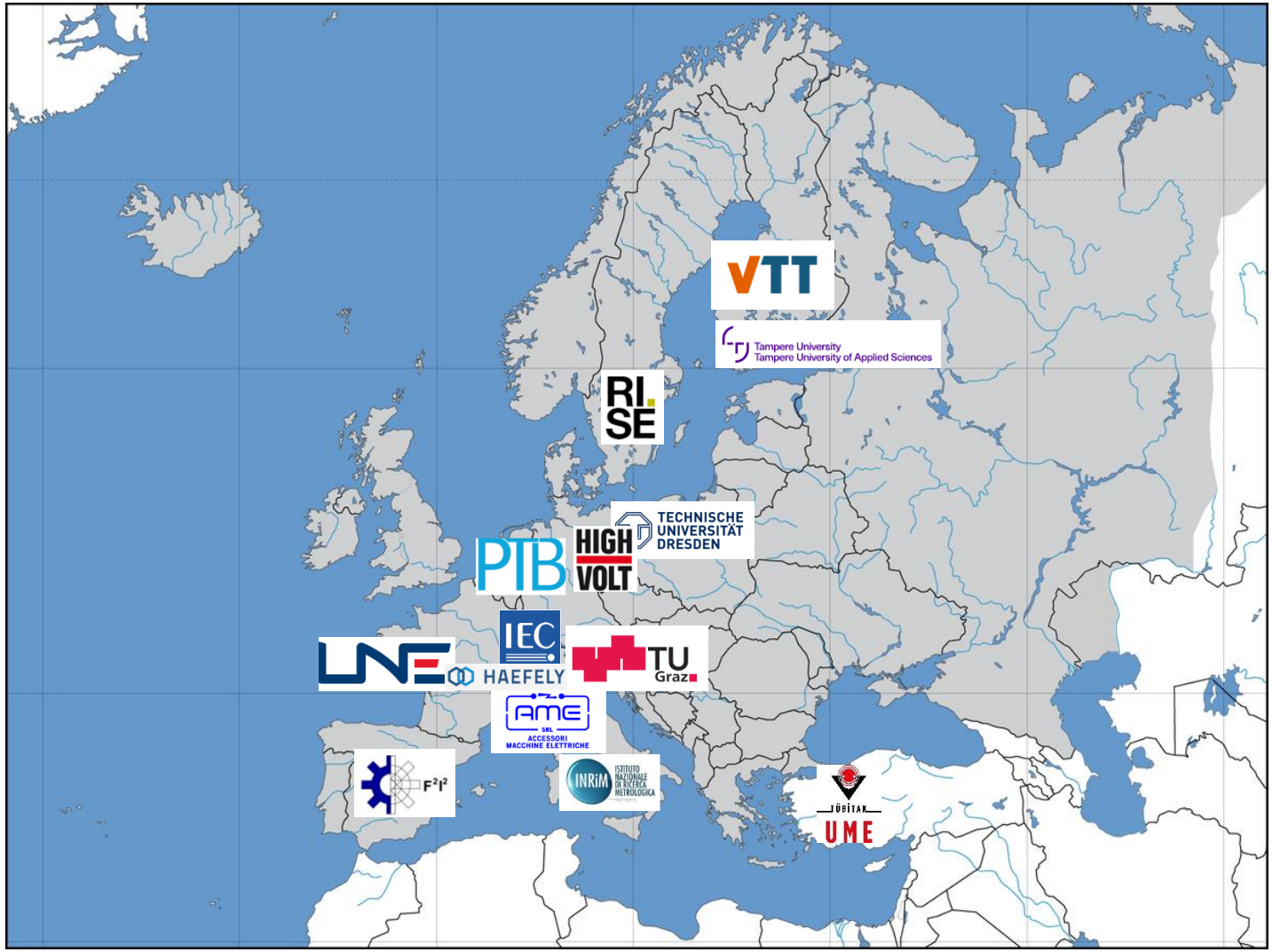
The EMPIR initiative is co-funded by the European Union's Horizon 2020 research and innovation programme and the EMPIR Participating States

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

19NRM07 HV-com²

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

Research Project „HV-com²“



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

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WP1: Definitions, software and instrumentation

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

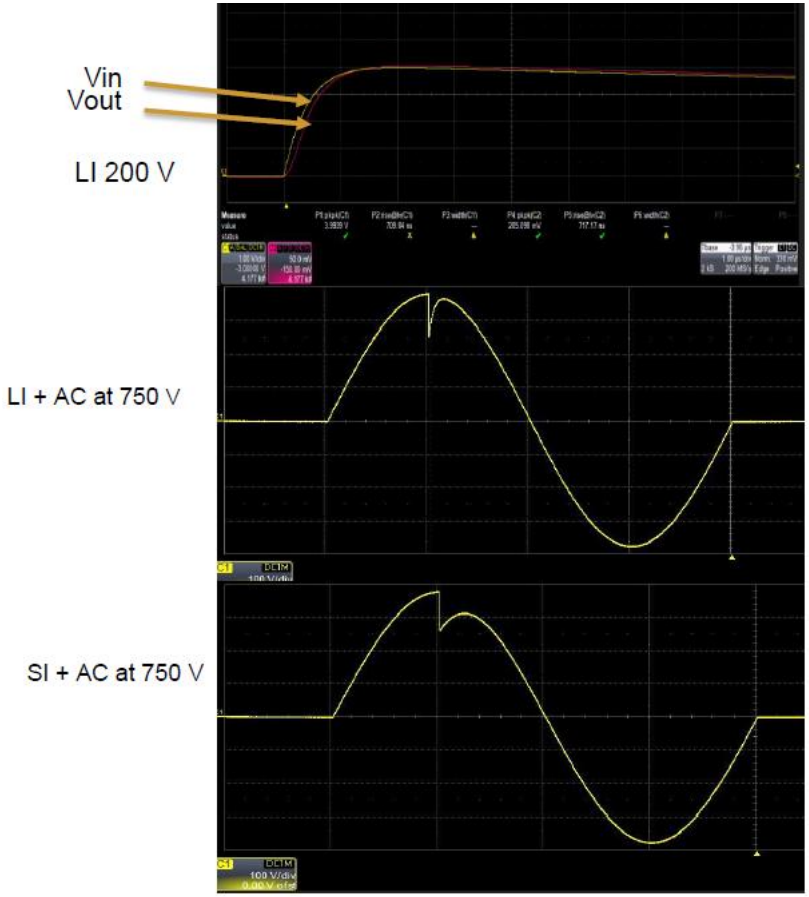
- Recomendation for standardisation in TC 42
  → IEC 60060 series
  → IEC 61083 series

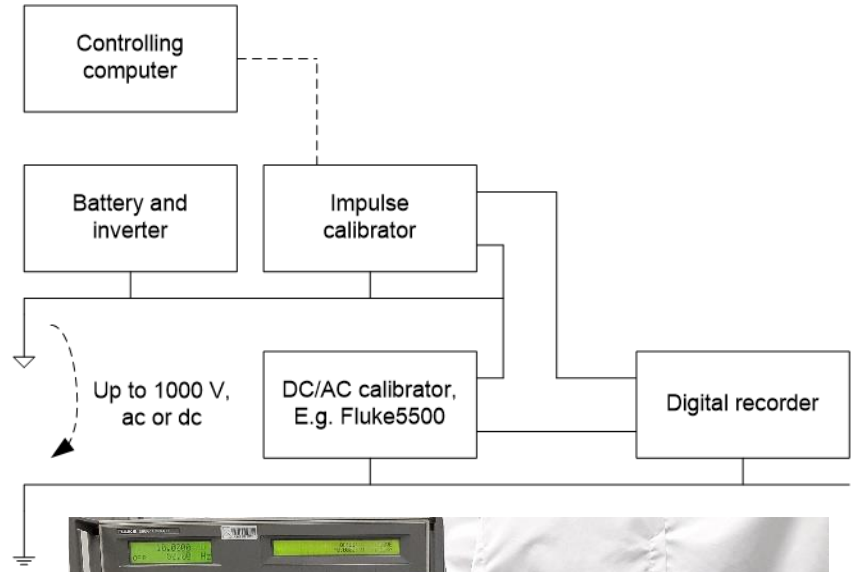
WP1: Definitions, software and instrumentation

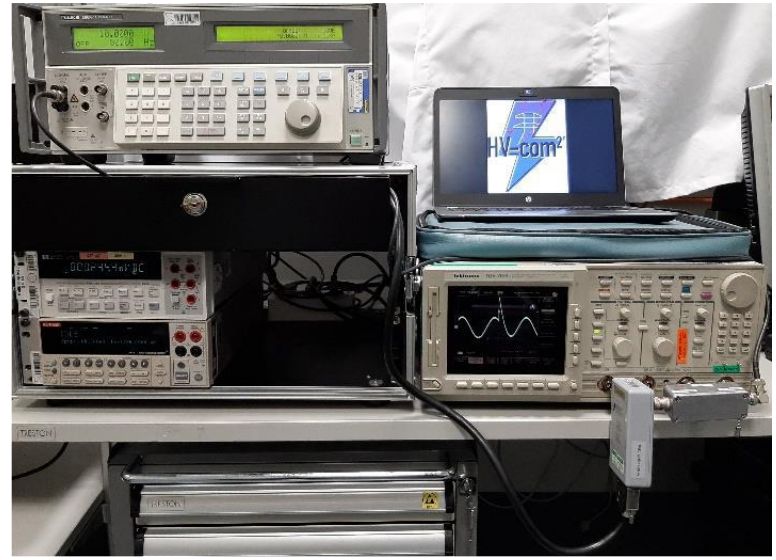
- Recommendation Reports was submitted to TC 42 ‘High-voltage and high-current test techniques’ for the ongoing revision of the IEC 60060 series.
- Composite and combined wave shapes traceability to the International System of Units was ensured up to 1 kV using developed standard calibrators with up to 900 V and an uncertainty < 0.2% for the amplitude and 1% for the time parameters.
- Composite and combined wave shapes parameters were evaluated using the developed software.
- Requirements of the IEC 61083 were verified for LVMI through an Interlaboratory comparison.
- Calibration test procedures and uncertainty budget estimate were established for LVMI calibration.

Low voltage generators

LV shapes → HV Amplifier → HV shapes < 1000 V







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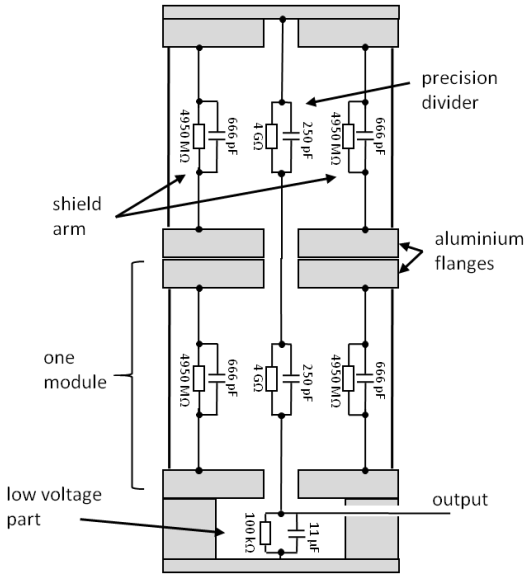
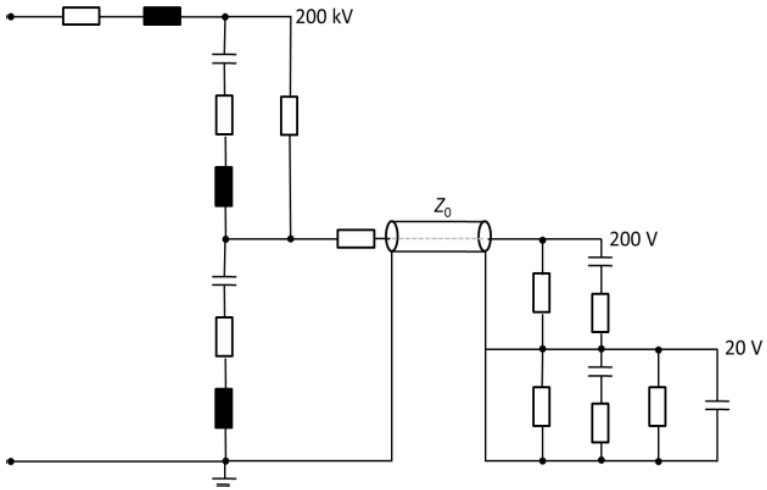
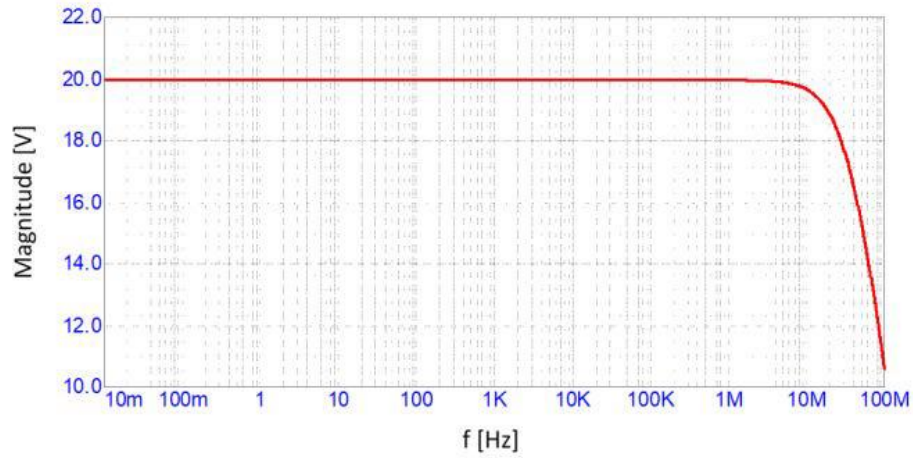
WP 2: Traceable reference systems



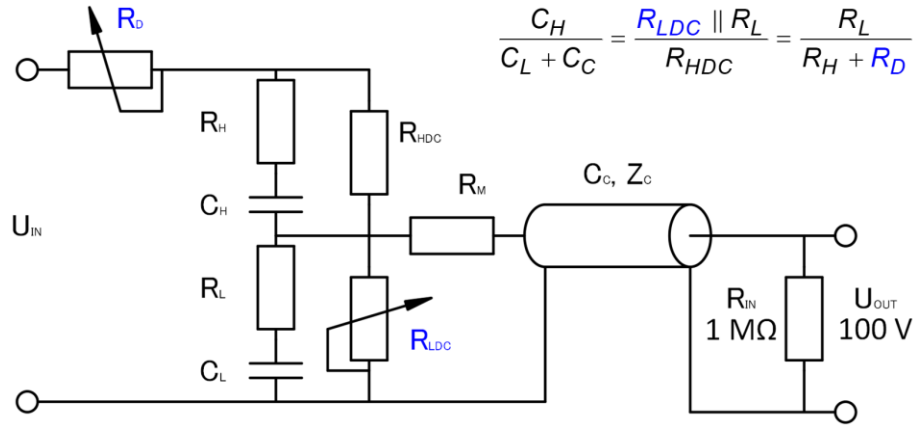
- Modular reference divider
  - 200 kV modules
  - 400 kV modules
  - At least 4 NMIs
- Setup of the circuits
- Detrmine the uncertainty (<2%)
- Comparison of NMIs new references





WP 2: Traceable reference systems

- Designed and built of Dividers
- 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...



$$\frac{C_H}{C_L + C_C} = \frac{R_{LDC} \parallel R_L}{R_{HDC}} = \frac{R_L}{R_H + R_D}$$

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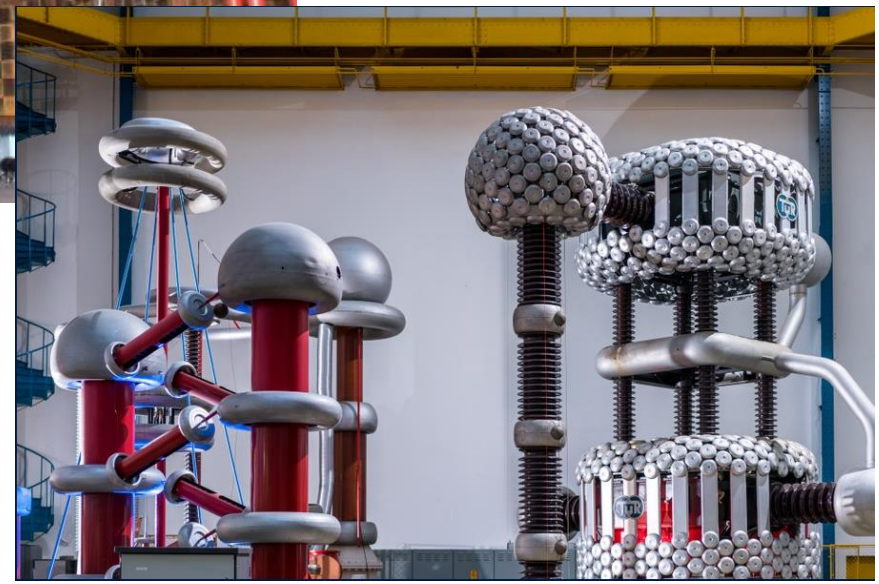
WP 3: Approved measuring systems

- Comparison Measurements at TU Graz and TU Dresden

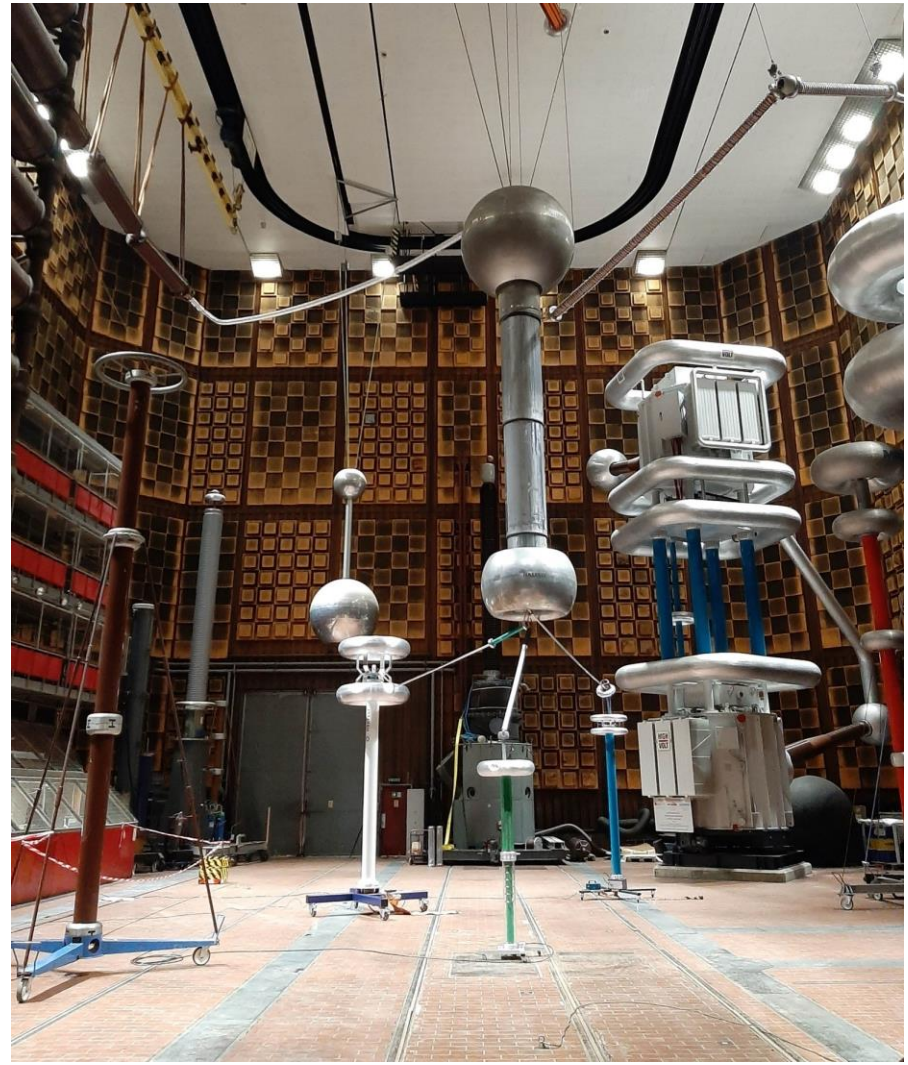
https://www.tugraz.at/institute/hspt/



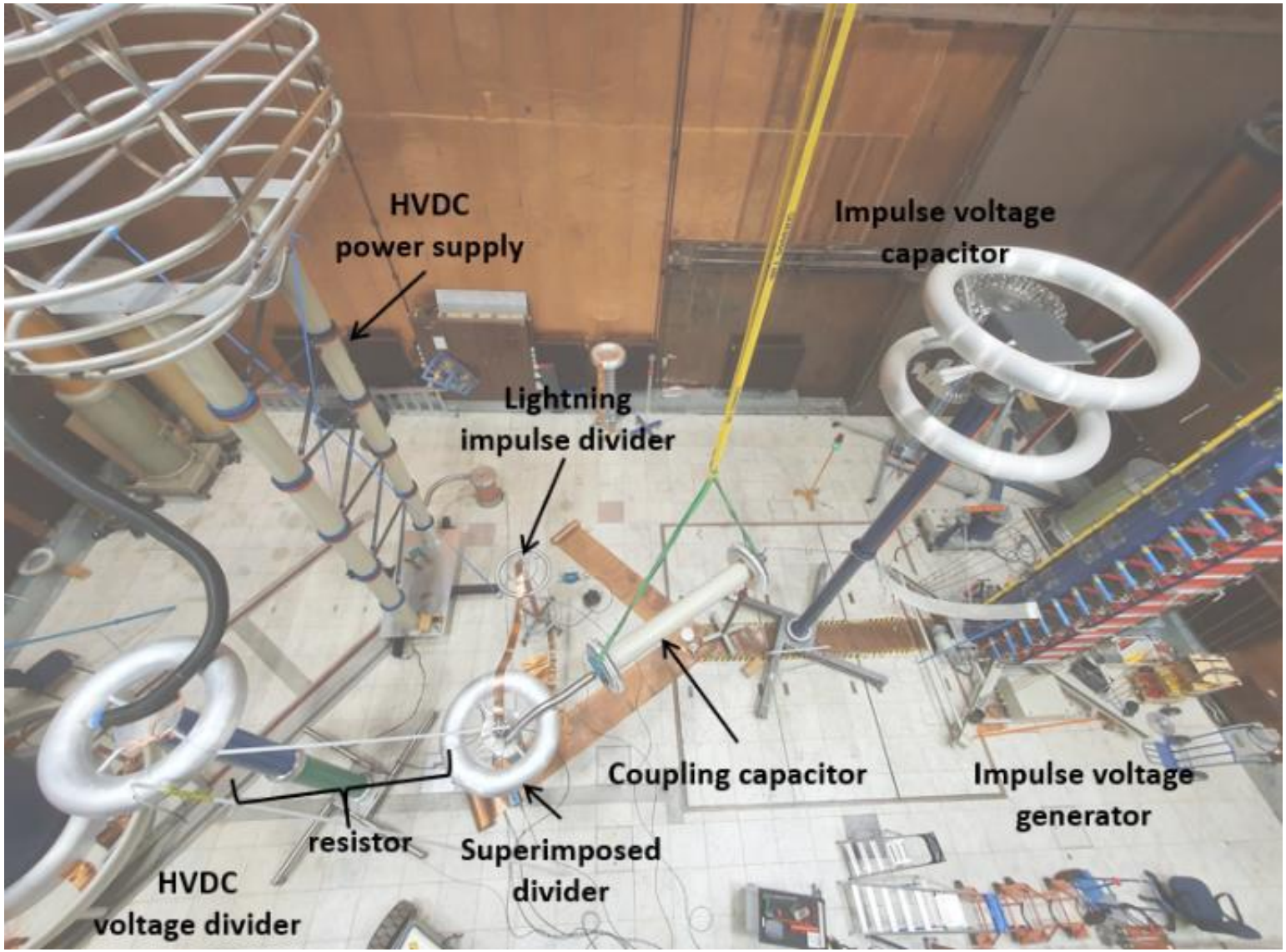
https://tu-dresden.de/ing/elektrotechnik/ieeh/das-institut#intro

WP 3: Approved measuring systems

- Commercially available measurement systems based on universal voltage dividers are capable of analyzing DC+LI/SI superimposed voltages with the accuracy required for high voltage testing.
- All systems retained their high overall accuracy during all superimposed voltage tests, especially regarding their dynamic behaviour.
- A DC component did not have any negative effect on the performance of the measurement systems.
- It is sufficient to calibrate a measurement system based on universal voltage dividers for use with composite voltages with the respective individual voltages.
  - Scale factors for the different voltage waveforms should agree within ±1%.
  - Deviation regarding time parameters should not exceed ±2%.



State of work



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Standardisation

- Two separate clauses, one for composite and one for combined
- Definitions for voltage tests
- Parameter and tolerances for superimposed wave shapes
- Measurement of the test voltage (e.g. two different sampling rates)
- Test procedures

- Two separate clauses, one for composite and one for combined
- Same structure as in LI or SI
- Requirements for approved measuring systems
- Use of inversal dividers (3% scale factor match)

→ **Both CDVs are out now!**

Conclusion

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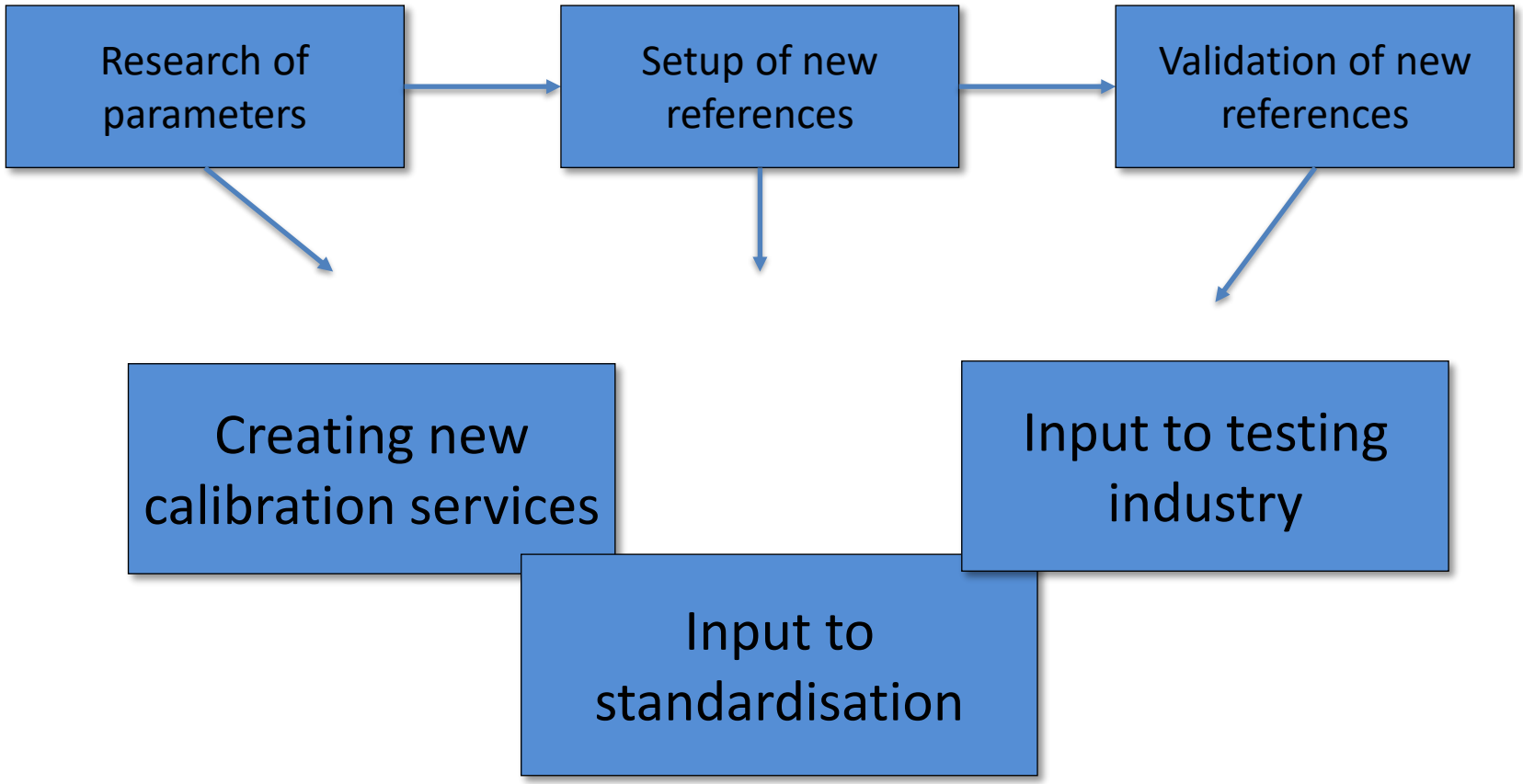

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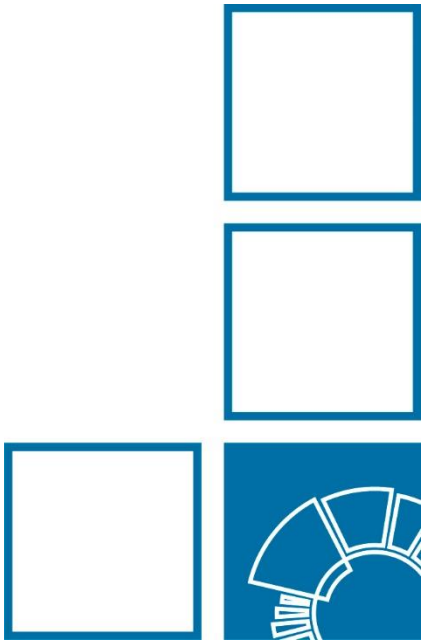

Physikalisch-Technische Bundesanstalt
Braunschweig und Berlin
Bundesallee 100
38116 Braunschweig

Dr. Johann Meisner
Telefon: 0531 592-2310
E-Mail: johann.meisner@ptb.de
www.ptb.de