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## Dutch Metrology Institute

**Abstract** VSL, the National Metrology Institute of the Netherlands, is a leading institute in the area of power and energy measurements, especially in measurements supporting Smart Grids. Activities focus on supporting stability and quality of our present and future electricity supply, and on ensuring fair trade. VSL facilities range from a primary power setup for power measurements at the level of a few  $\mu\text{W}/\text{VA}$ , to setups for power quality measurement, synchrophasor unit testing, and on-site HV revenue metering.

### Primary Power

Power calibrator; custom-made current and voltage transformers, sampling voltmeters.

- Measurement range: 50 – 60 Hz, 0 – 1000 V, 0 – 80 A, PF = 1 to 0i,c
- Synchronised sampling
- Overall uncertainty < 20  $\mu\text{W}/\text{VA}$
- Commercial power meter used as transfer in less accurate calibrations

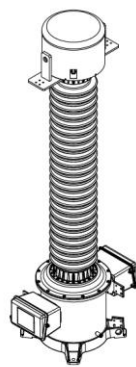
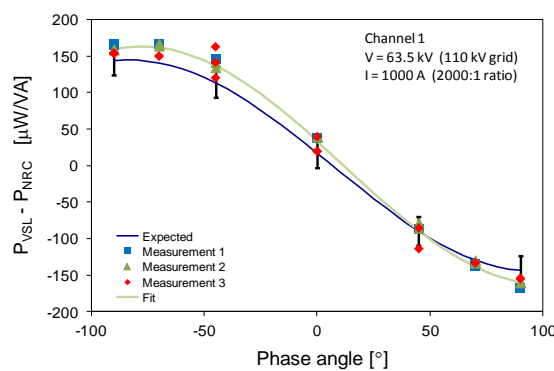
Present development: reduce uncertainty to better than 5  $\mu\text{W}/\text{VA}$ .



### On-site HV revenue metering (150 kV, 5000 A)

System composed of 3 VTs, 3 CTs and a reference power meter.

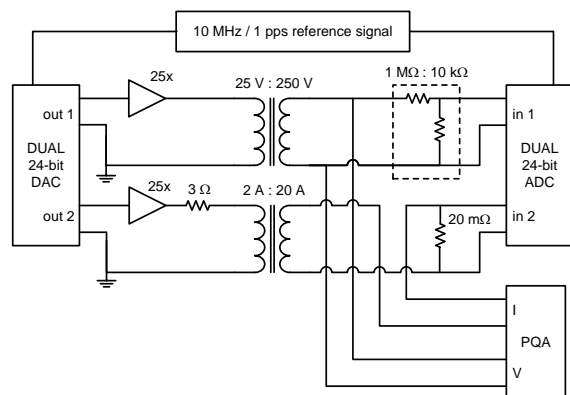
- Components calibrated with uncertainties 20 ppm and 20  $\mu\text{rad}$
- VSL system in excellent agreement with NRC system  
⇒ on-site uncertainty of around 300 ppm (0.03 %)



### Power Quality (PQ)

Traceable measurement of PQ according to IEC 61000-4-30

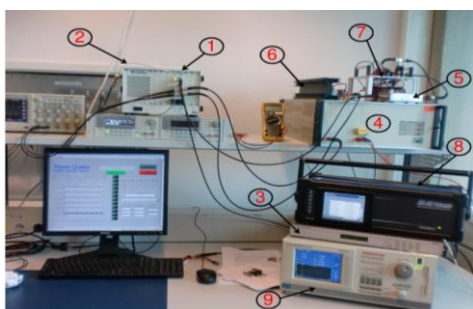
- Signals: harmonics, THD, dips and swells, flicker
- Fully automated measurement and data-analysis
- Applications: PQA calibrations, on-site PQ grid measurements



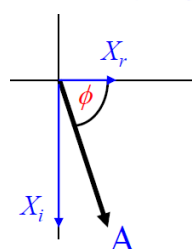
### Phasor Measurement Units (PMUs)

Testing of PMUs according to IEEE C37.118.1-2013 standard

- Static signals and dynamic signals (future)
- Automation of setup and data analysis
- Applications: PMU testing and calibrations; grid monitoring; HV line impedance determination; Dynamic Line Rating



$$x(t) = \sqrt{2} A \cos(2\pi f t + \phi)$$



### High Voltage DC (200 kV) and AC (100 kV)

Calibration of 200 kV DC dividers, 100 kV AC dividers / transformers

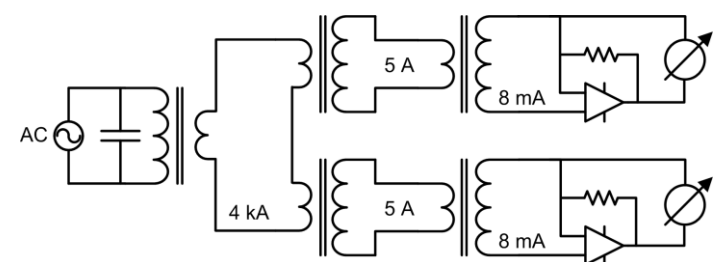
- DC reference: 0 – 200 kV, performance < 10 ppm (wideband)
- AC reference: 0 – 100 kV, 50 – 60 Hz, uncertainty < 50 ppm
  - Measurement based on a sampling bridge
  - Traceability: HV capacitance, HVCB bridge (20 ppm /  $\mu\text{rad}$ )



### AC current transducers (up to 5000 A)

Calibration of current transducers (CTs, Rogowski coils, zero-flux devices, shunts)

- Frequency range 50 Hz – 5000 Hz
- Custom-made step-down transformers and current buffers, NRC reference CT, sampling voltmeters
- Asynchronous sampling
- Flexible in transducer ratio and burden
- Primary current 1 % - 120 %
- Uncertainty at 50 Hz: 5 ppm, 5  $\mu\text{rad}$



### Open-able core CT (2000 A, on-site)

Split enhanced-core CT, can be connected on-site in a grid system without breaking the line (live connection possible).

- 400 : 1 ratio, maximum 2000 A
- Magnitude error < 10  $\mu\text{A}/\text{A}$ , phase error < 30  $\mu\text{rad}$
- Core is made self aligning to reduce error

