

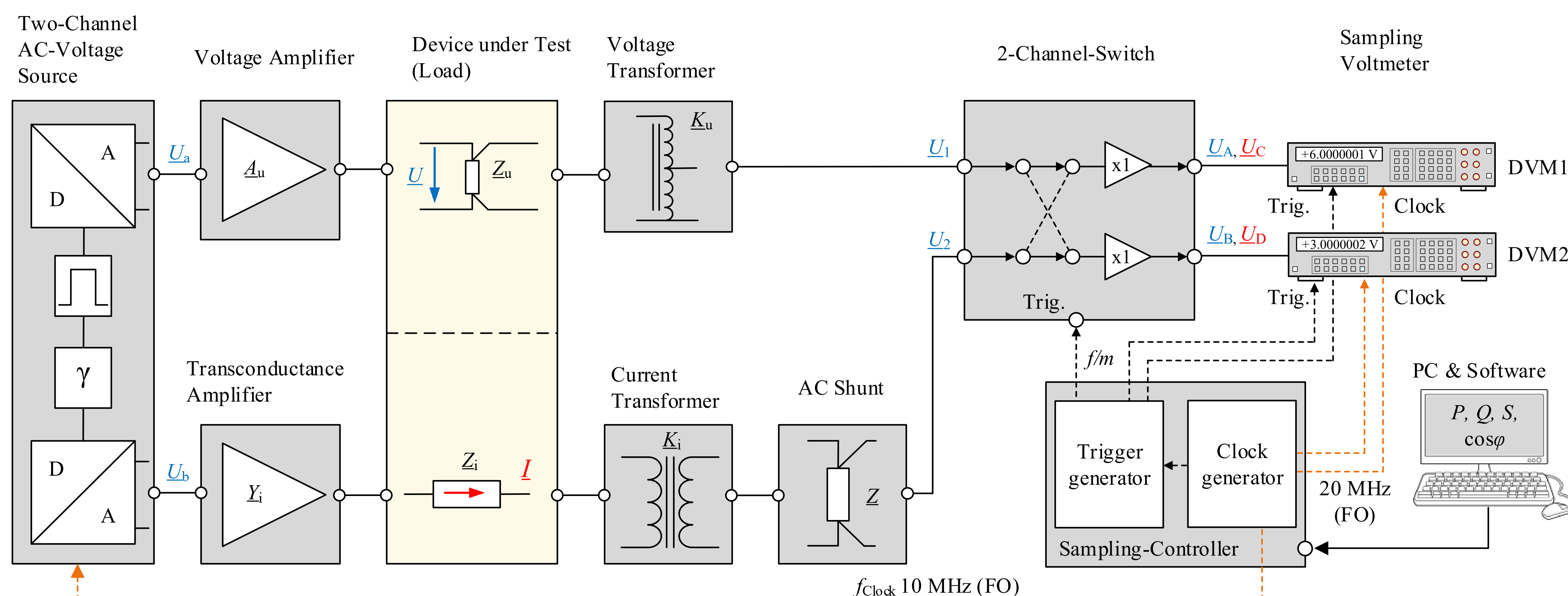
Modernisation and Optimisation of PTB's Primary AC Power Standard

Introduction

- The **PTB primary AC power standard** has been optimised for **precise and traceable power measurements** supporting industry, energy transition, and international standards.
- A **new measurement system** enables voltages up to **480 V** and currents up to **100 A** in a frequency range of **16.67 Hz – 400 Hz**.
- New sensors, electronics, and software** improve **accuracy, stability, and reliability** while reducing measurement uncertainty **across the frequency range** and **independent of signal amplitude**.

Overview of PTB's AC power primary standard

- Generation:** Implementation of an ultra-stable (20-bit DAC) two-channel AC voltage source from CMI*
- Precise scaling of high currents and voltages:** Through a newly developed **inductive voltage divider** and a **modular thermostatically controlled current-to-voltage converter**.
- Sampling core:** Modernised method with **channel swapping** and two **DVMs**, reducing MU.
- Control and synchronisation:** Managed by a newly developed **sampling controller**.
- Flexible synchronisation** via internal quartz oscillator, TTL, or fiber-optic interfaces

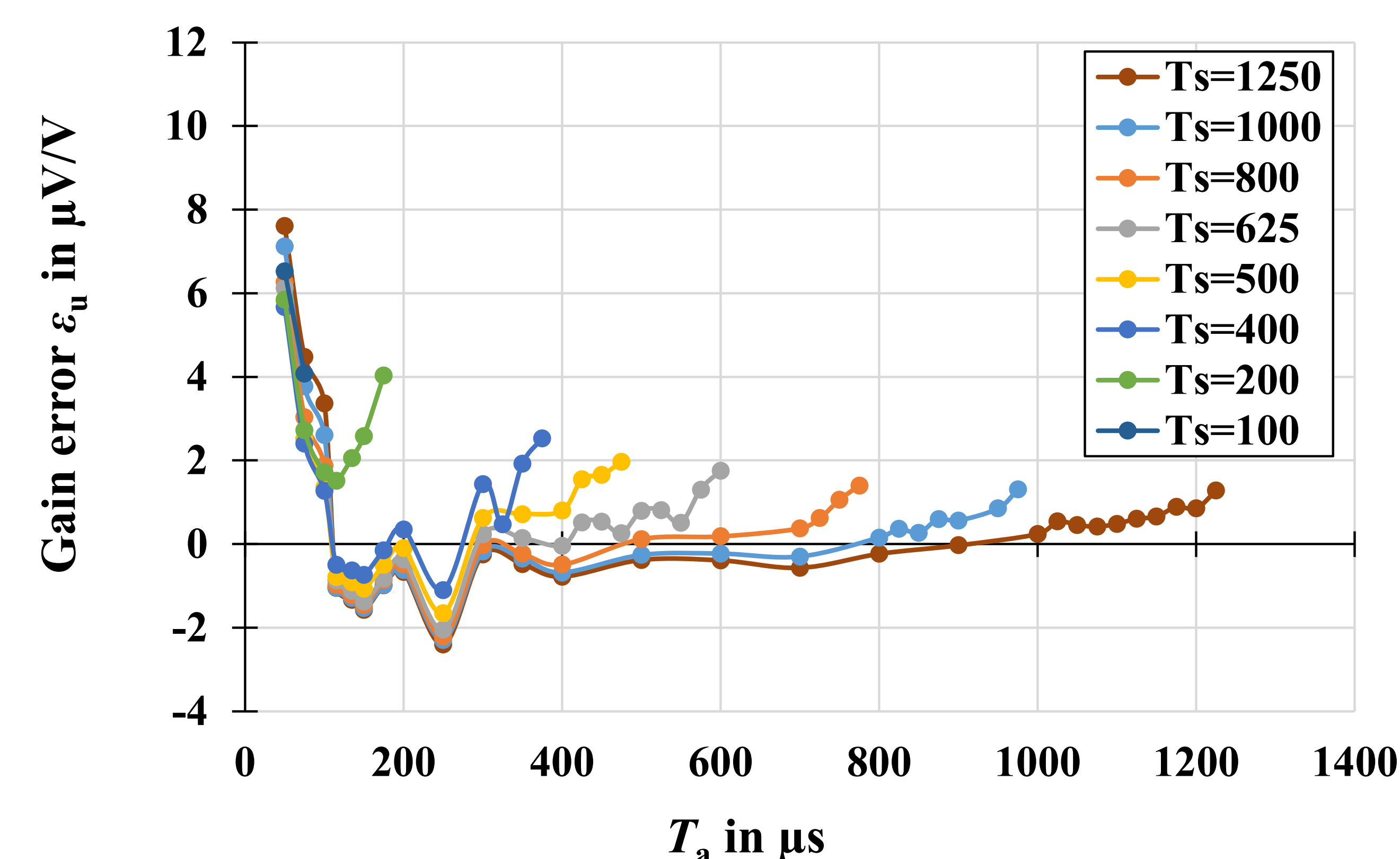


* CMI = Czech metrology institute

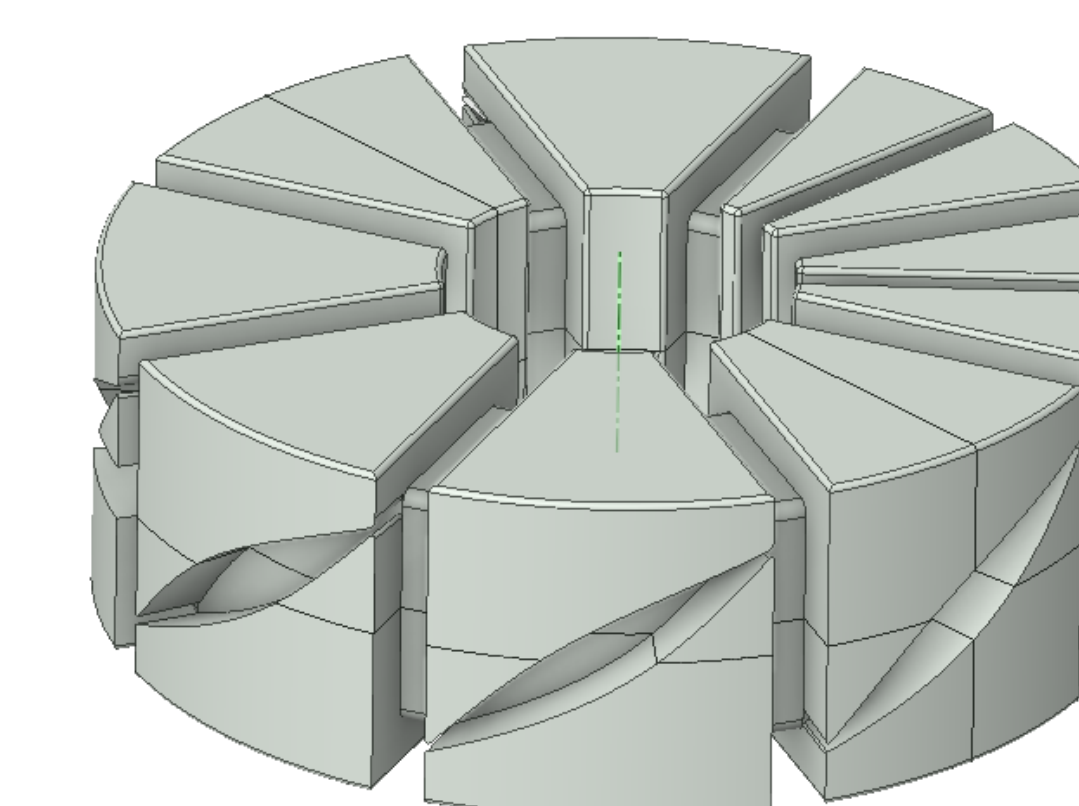
Measurement results

- Current transformer:** Electronically error-compensated design achieving **10^{-7} accuracy**, reducing measurement uncertainty by a factor of **~3**.
- Voltage divider:** Inductive voltage divider with **$<0.3 \mu\text{V/V}$ deviation**, reducing measurement uncertainty by a factor of **4-5**.
- Reduction of measurement deviation and uncertainty achieved through a **3D-printed symmetrical winding support**, additionally relieving the second stage from the first via a **choke**.
- The **sampling gain error** of the used DVMs needs to be determined at DC. The **typical measurement deviation** is **$<1 \times 10^{-6}$** .

Combined Sampling Gain Error of DVM1 and DVM2



3D model of the voltage divider



Conclusion

- Continuous development & modernisation** ensure long-term reliability at NMI level
- Innovative **approaches to measurement sensors and sampling methods** significantly reduce the basic errors and measurement uncertainties.
- 3D printing processes** show great potential for improved efficiency & precision