

Towards a new DC Grids Metrology: Definitional Uncertainty and Operational Challenges



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DC microgrids represent a promising solution for integrating more and more renewable energy sources in power systems and thus helping the achievement of carbon footprint reduction. However, such converter-interfaced resources are expected to introduce higher volatility and increase distortion levels, e.g. DC ripple.

The current framework for DC measurements is intended for stationary conditions and does not provide an univocal definition of the measurand (DC voltage, current, or power).

In the next future, metrology shall address the issues related to the definition of DC energy and DC power quality. This effort has two main objectives. On one side, to establish a clear and rigorous definition of the measurands to be agreed and shared among normative and regulation committees. On the other side, to develop metrological setups capable of guaranteeing traceability even in realistic distorted conditions.

Measurand definition

In the [IEC 62052-11:2020](#), the DC power is introduced as the product of DC voltage and current, in turn defined as the average value of voltage and current signals. The standard, though, does not specify neither the **sampling rate** nor the **window length** to be used for the average computation.

The [EN 50470-4:2023](#) states the **frequencies up to 10 Hz** shall be considered as part of the measurement signal and the window length shall be long enough to minimize the effect of AC power components.

- ➔ How to discriminate DC variability (up to 10 Hz) from grid disturbances?
- ➔ How to define suitable tests for the characterization of DC energy meter?
- ➔ How to deal with different power contributions in DC and AC domains?

Proposed approach

Time-domain are inherently affected by definitional uncertainty:

- They depend on the selected sampling rate and window length
- They do not guarantee a robust rejection of spurious components

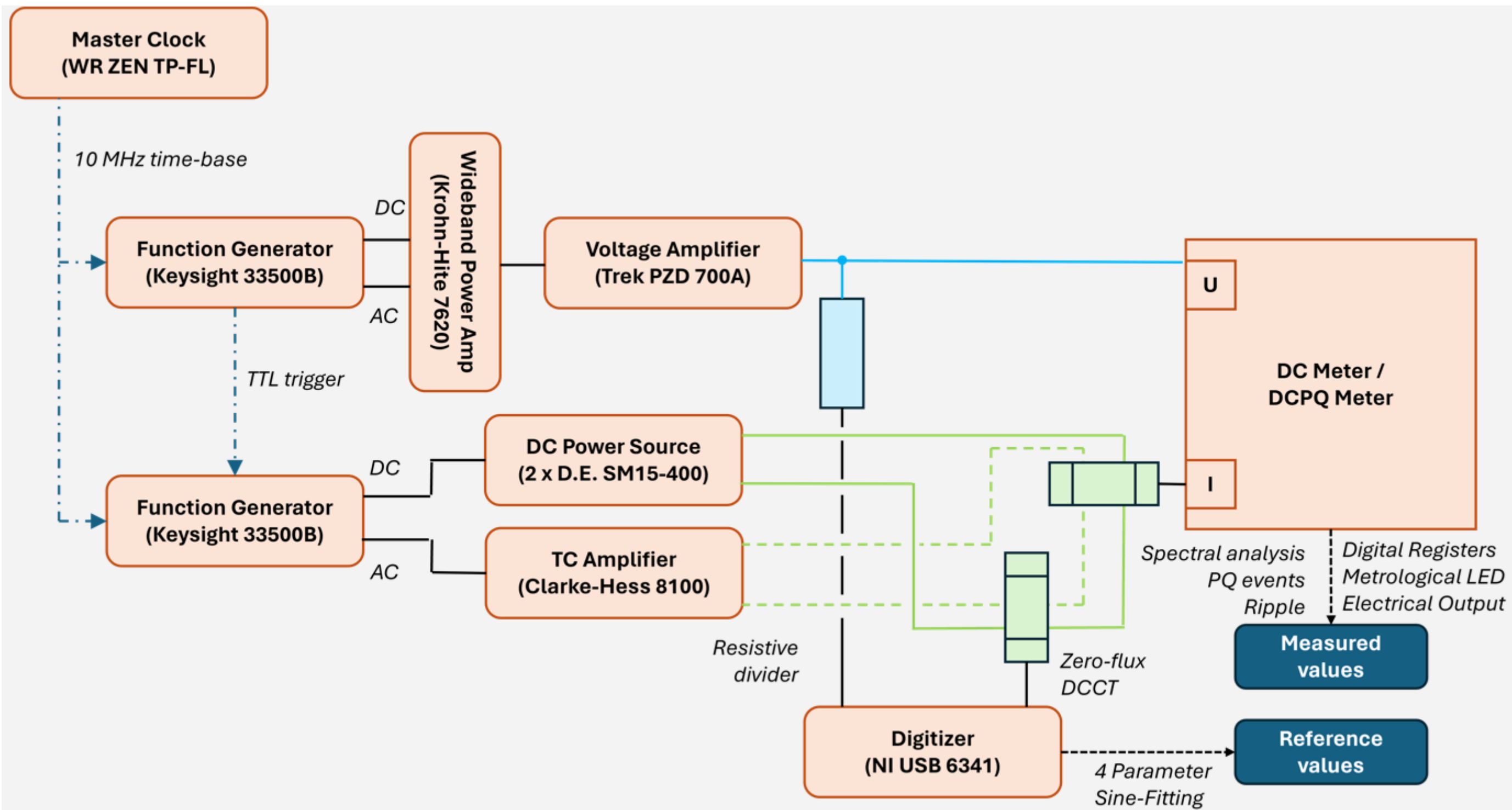
SOLUTION: phasor-based analysis as per traditional AC power quality analysis promises:

- Definition of a bandwidth, independently from the window length
- Possibility to evaluate phase angles between voltage and current ripples

DC power calibration facility

METAS developed a **new calibration setup** for DC revenue and power quality meters:

- Full traceability for both DC and AC part
- DC phantom power from 80 W to 800 kW
- AC distortion from 10 to 150 kHz
- Time disciplined to UTC(CH)



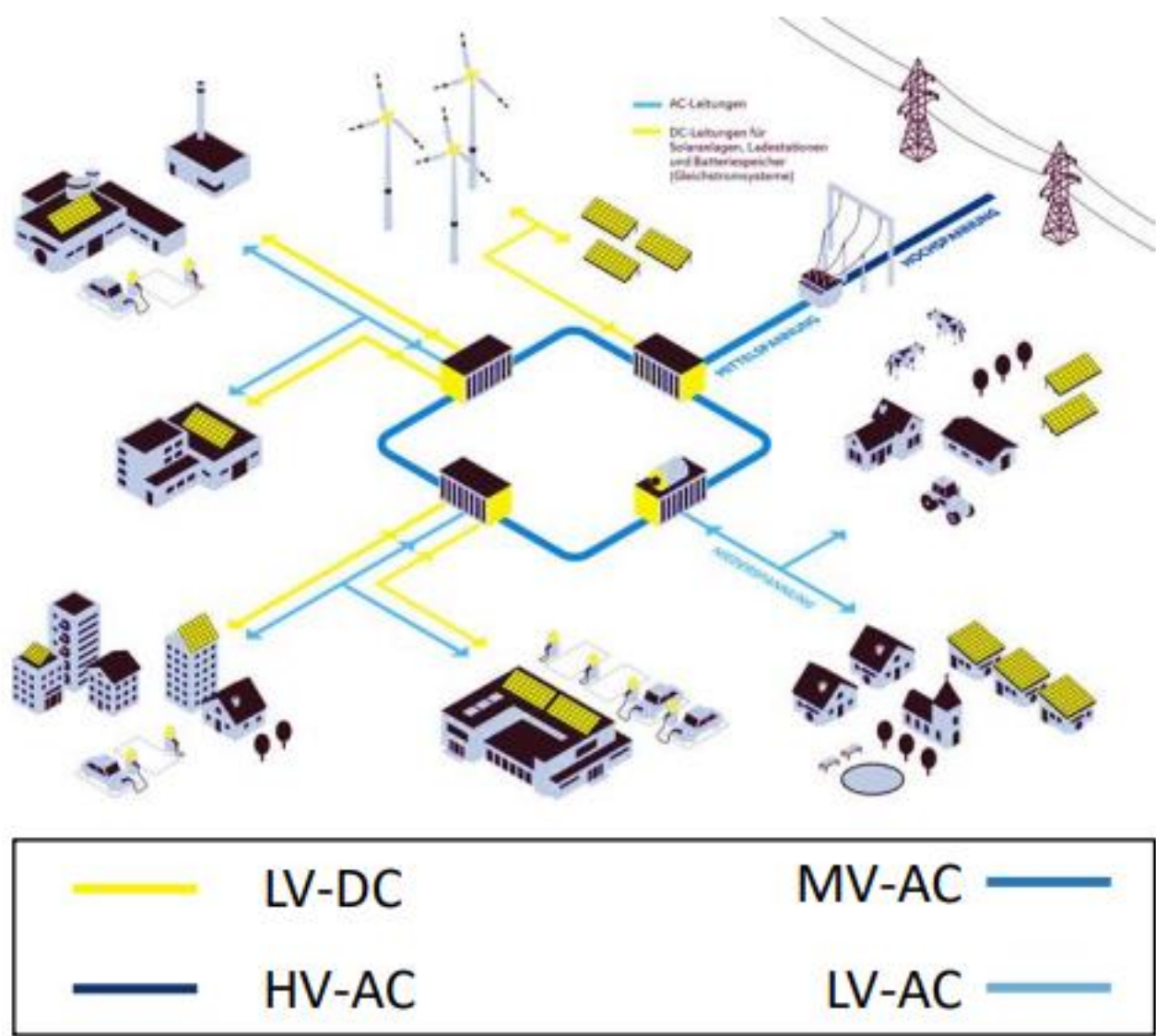
Need for interoperability

DC microgrids are not supposed to exist only as islanded portions of the network, but they are interconnected to the AC bulk system.

Their **monitoring and control infrastructure** shall be compatible with the AC counterpart:

- 200-ms window as per AC power quality
- Common time reference (e.g., GPS)
- Similar disturbance definitions (e.g., dips, swells, “harmonics”, etc.)

➔ **Phasor-based analysis** is easy extension of AC approach to DC scenario

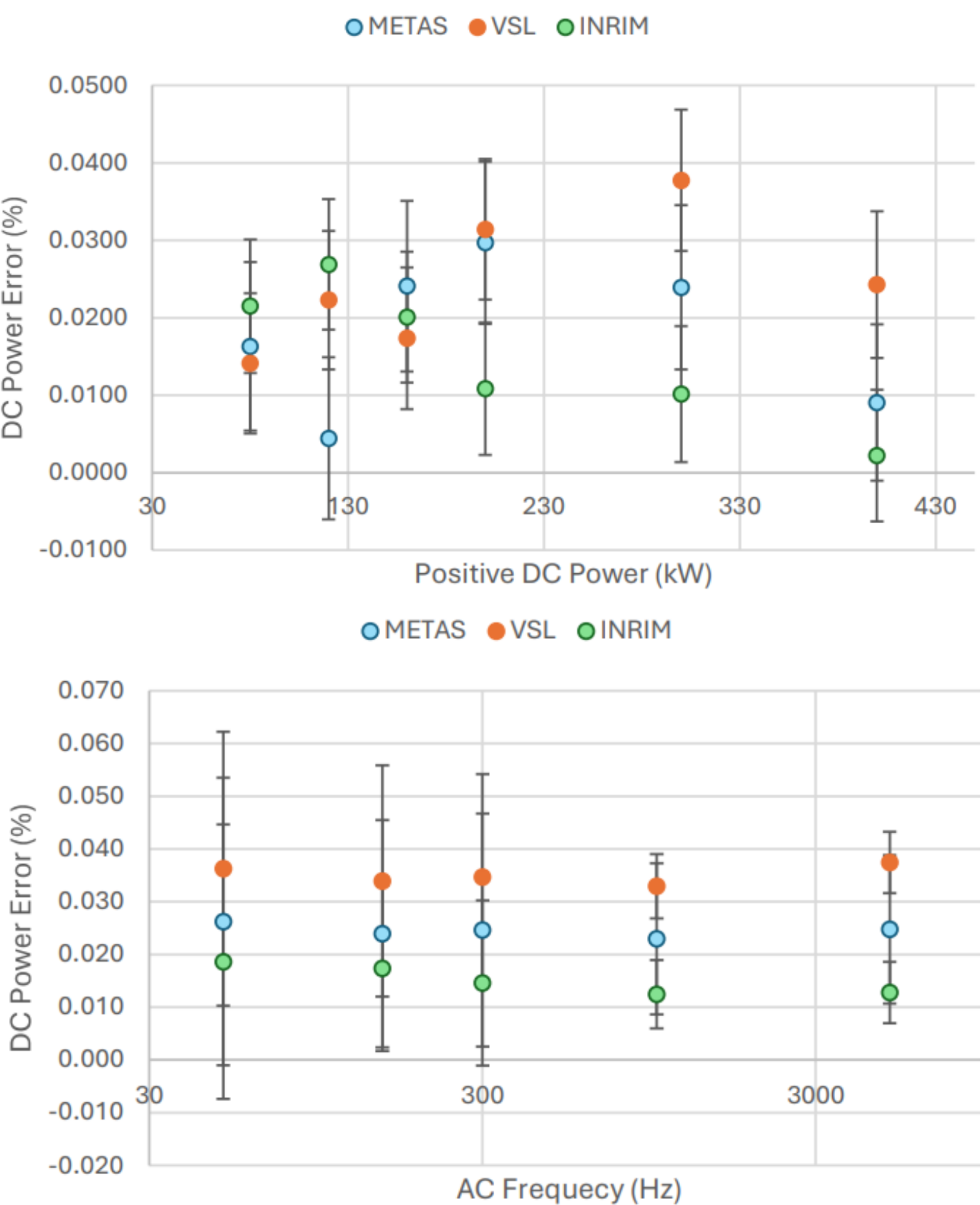


Inter-laboratory comparison

METAS, VSL, and INRIM carried out an extensive [inter-laboratory comparison](#) for DC power measurements in nominal and distorted conditions.

To this end, a fully-calibrated transfer standard has been implemented on a NI cRIO-9068 that reproduces the behavior of a golden DC meter with bandwidth of 10 Hz.

The overlap and the limited uncertainty among all the considered variation range confirms the quality of the calibration setups.



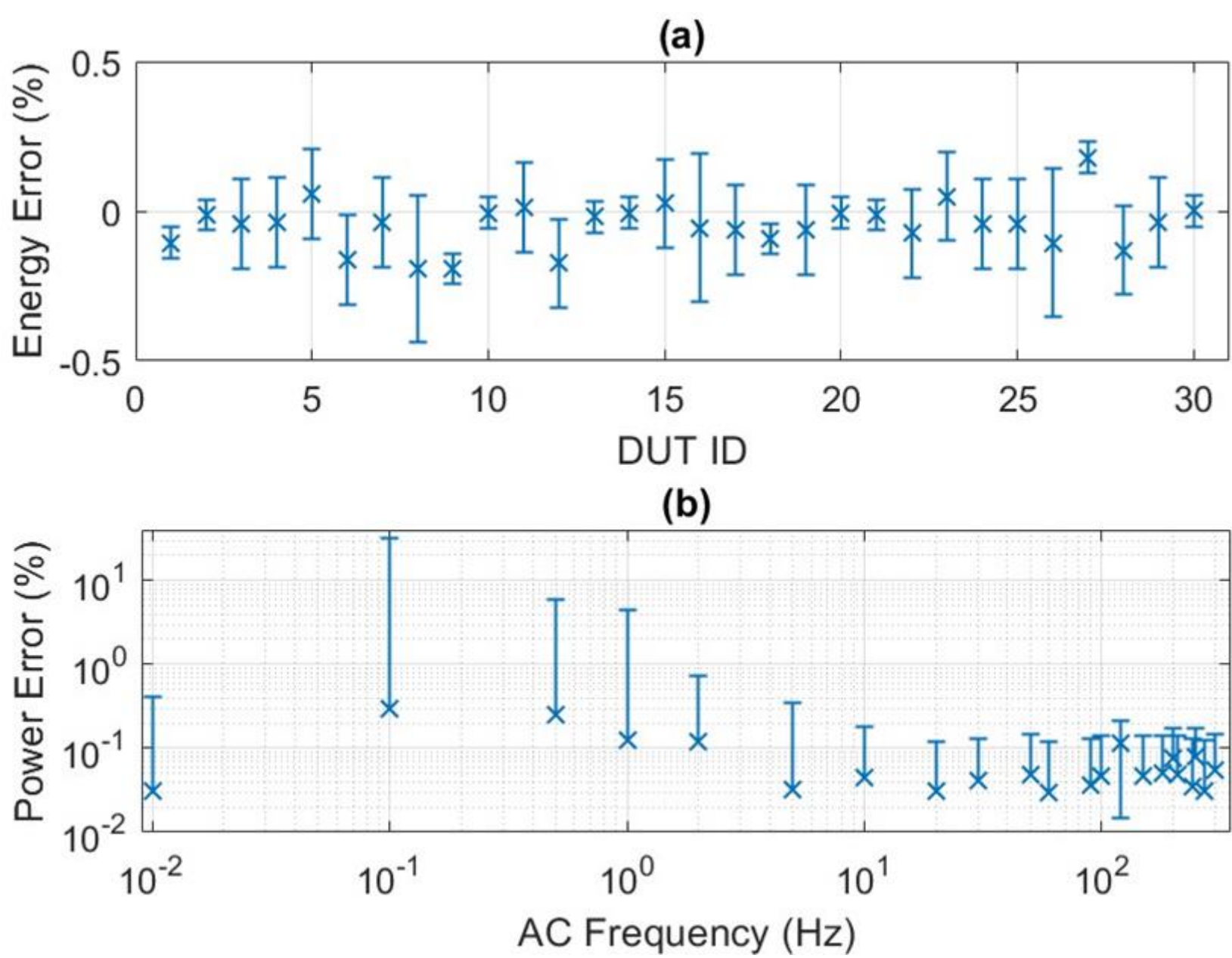
NOMINAL:
The transfer standard error is consistent in all setups by less than 200 ppm

DISTORTED:
Similar results can be obtained even in the presence of 10 % ripple at different AC frequencies

Commercial device testing

As further validation, the setup was used to calibrate a batch of 30 DC revenue meters, certified as class 1.0.

First, we performed a dosage test to evaluate their compliance with the class. Markers and vertical bars denote mean and 95th percentile variation range over 5 repetitions.



source: <https://www.dzq.de/>

At the same test-point (350 kW), we added a 10 % AC component on the voltage channel. We varied the AC frequency between 0.01 and 300 Hz. We considered the instantaneous power as given by the pulse output over 5 minute test.

- ➔ For AC frequencies > 10 Hz, the performance is ideal
- ➔ For AC frequencies ≤ 10 Hz, a high discrepancy is noticed

➔ **NEED FOR CLEAR DEFINITION OF DC POWER IN DISTORTED CONDITIONS**

References

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3. G. Frigo and J. Braun, «Measurement Setup for a DC Power Reference for Electricity Meter Calibration,» 2022 20th International Conference on Harmonics & Quality of Power (ICHQP), Naples, Italy, 2022, pp. 1-5.
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Project report and
Publications' list