

Bilateral Comparison LF Power up to 100 kHz

Erik Kroon

Yokogawa Europe Solutions B.V.
erik.kroon@nl.yokogawa.com

Abstract — Nowadays there is more need for traceability for distorted power waveforms. Therefore a power calibration system was developed at the European Standards Laboratory of Yokogawa Europe Solutions B.V. This system has the capability to calibrate electrical power meters from DC, 10 Hz up to 100 kHz. To evaluate the calibration system traceability, a bilateral comparison was carried out between the Yokogawa European Standards Laboratory and the National Standards Institute of Sweden (RISE).

Index Terms — Calibration, Power measurement, Power system harmonics, Measurement, Uncertainty.

I. INTRODUCTION

As more and more innovation focuses on energy efficiency and the use of renewable energy resources, engineers are increasingly demanding accuracy and precision from their power measurements. At the same time, standards such as IEC62301 Ed2.0 and EN50564:2011, covering standby power consumption, demand more precise and accurate testing to ensure compliance. One key area which is often neglected in traditional specifications is that of power measurements at high frequencies. Traditionally, AC power meters are calibrated at frequencies from 50 to 60 Hz. Nowadays, however, there is a demand for power measurement at high frequencies on devices such as switch-mode power supplies, electronic lighting ballasts, soft starters in motor controls and frequency converters in traction applications. Calibration of high-frequency power has lagged behind the development of power meters to address these applications, and few national laboratories can provide traceability up to 100 kHz: the frequency at which instruments have to be calibrated to provide accurate results in these application sectors.

II. YOKOGAWA EUROPEAN STANDARDS LABORATORY

In Amersfoort (The Netherlands), a calibration laboratory was set up to provide traceability for wide band electrical power meters. Started in 1990 as a small laboratory for in-house calibration for ISO9001 production tools, it's now an accredited laboratory specialized on electrical power analyzers. In addition of accurate 50 – 60 Hz power calibrations it is able to perform power calibrations up to 100 kHz. Using an own developed wideband power calibration system, traceability is provided to Yokogawa power meter users. For the uncertainty needed, we have chosen to build up the traceability internally. This is due to

lack of commercial power calibrators that can operate to 100 kHz power with sufficient uncertainty. The references for power in this system are modified Yokogawa power analyzers, optimized for best stability. The calibration of this system is done in the Yokogawa European Standards Laboratory itself.

III. TRACEABILITY POWER UP TO 100 KHz

Due to the higher frequency influence in the calibration system, like leakage due to parasitic capacities in the wiring harness and loading effects, the calibration is done as a complete system with a selected reference plane. The reference planes are the connectors of the calibration system where it is connected to the power meter under calibration. Traceability is built up via voltage, current and phase. Voltage is measured using an AC Voltmeter, while for current the AC Voltmeter measured the Voltage drop over an AC shunt. The AC shunt is traceable to DC resistance and the AC/DC difference. The phase is traceable to a phase standard and corresponding phase bridges.

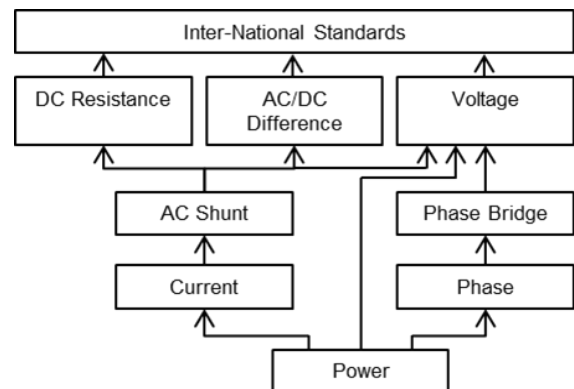


Fig. 1. Traceability for power up to 100 kHz.

IV. THE COMPARISON

A. Selecting the comparison laboratory

The amount of national laboratories with the traceability for power up to 100 kHz is very limited. We have selected the national standard institute of Sweden (RISE). There is no dependency between Yokogawa and RISE, due to the fact both laboratories build up their own traceability.

B. Selecting the transfer standard

A stable transfer standard is needed with wideband power capability. The used standard is a Yokogawa WT3000T Precision Power Analyzer. This selected standard is owned by the European Standards Laboratory and used for comparisons and crosschecks exclusive. Hence, the behavior and stability is well known for years.

C. The Comparison

The transfer standard was calibrated multiple times at the Yokogawa European Standards Laboratory before it was sent to [1], RISE. The applied voltage and current (sine waves) was 100 V and 1 A on the fixed range of 100 V and 1 A. The update rate was 2 seconds. No filters or special settings were selected. The results were taken over an average of 16 measurements after the reading was stable. The frequency for the calibration was 1 kHz, 10 kHz, 50 kHz and 100 kHz, while the power factor was set to 1. This gives the amplitude deviations results. Next the power factor was changed to 0 (inductive) to measure the phase influence. After these measurements the transfer standard was sent to Sweden. RISE calibrated the transfer standard by using the same settings and values. After receiving the transfer standard back at the Yokogawa European Standards Laboratory the calibration was repeated. A little drift was observed from the transfer standard at the frequency of 50 kHz and 100 kHz at power factor 1. After linear interpolation, this was well in the combined uncertainties of the comparison.

From the results the $|E_n|$ factor was calculated. The factors where all < 1 . Hereby the numeric results:

Frequency [kHz]	Power [W]	Yokogawa before RISE [W]	Yokogawa after RISE [W]	Uncertainty k=2 [W]	RISE [W]	Uncertainty k=2 [W]	En
1	100.0	100.021	100.019	0.025	100.023	0.012	0.10
10	100.0	100.027	100.040	0.027	100.041	0.020	0.27
50	100.0	100.04	100.06	0.03	100.04	0.10	0.07
100	100.0	100.02	100.13	0.03	100.06	0.20	0.01

Table 1. Comparison results Power factor 1.

Frequency [kHz]	Power [W]	Yokogawa before RISE [W]	Yokogawa after RISE [W]	Uncertainty k=2 [W]	RISE [W]	Uncertainty k=2 [W]	En
1	0.000	0.002	0.003	0.100	-0.002	0.012	0.04
10	0.000	-0.126	-0.115	0.126	-0.134	0.020	0.09
50	0.00	-0.35	-0.43	0.54	-0.64	0.10	0.48
100	0.00	-0.88	-0.74	1.04	-1.23	0.20	0.38

Table 2. Comparison results Power factor 0 (inductive).

The graphical presentation of the results:

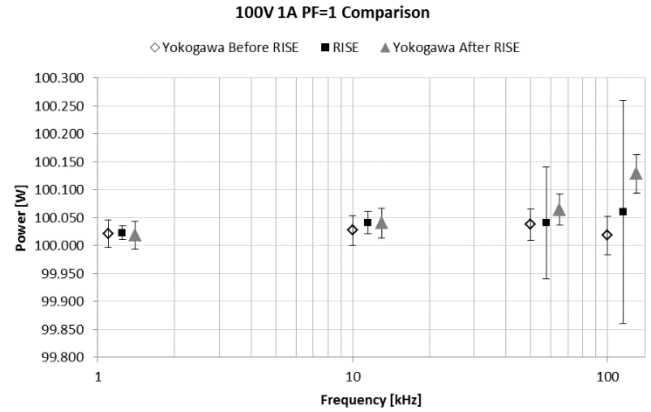


Fig. 2. Comparison results Power factor 1.

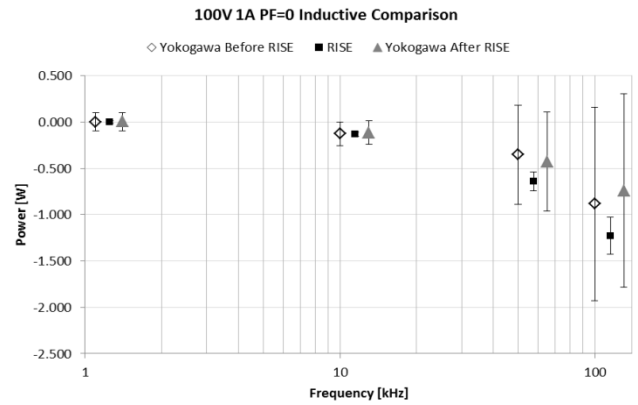


Fig. 3. Comparison results Power factor 0 (inductive).

V. CONCLUSION

The comparison shows a good result and gives confidence in the power calibration system at the Yokogawa European Standards Laboratory. As far we know this was the first comparison for power on 100 kHz at power factor 0 worldwide.

ACKNOWLEDGEMENT

The author would like to thank Tobias Bergsten (RISE) and Gert Rietveld (VSL) for discussions and advice.

REFERENCES

- [1] T. Bergsten, V. Tarasso and K. E. Rydler, "An electrical power reference system Up to 1 MHz," *2016 Conference on Precision Electromagnetic Measurements (CPEM 2016)*, Ottawa, ON, 2016, pp. 1-2.