4EP2-15

Josephson standards for a new AC quantum voltage infrastructure (in the scope of the ACQ-PRO EMPIR project)

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What is ACQ-PRO?

Propagation of AC quantum voltage standards between NMIs

Objectives

To investigate common devices in industry and scientific research institutes at different voltages and frequencies up to which level these instruments are useful as transfer standards for quantum AC voltage comparisons.

Conclusion

- Comparisons of two AC-QVMs via calibration of conventional devices at ppm level and below!
- Differences due to different measurement integration windows need further investigation.

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EURAMET European Association of National Metrology Institutes

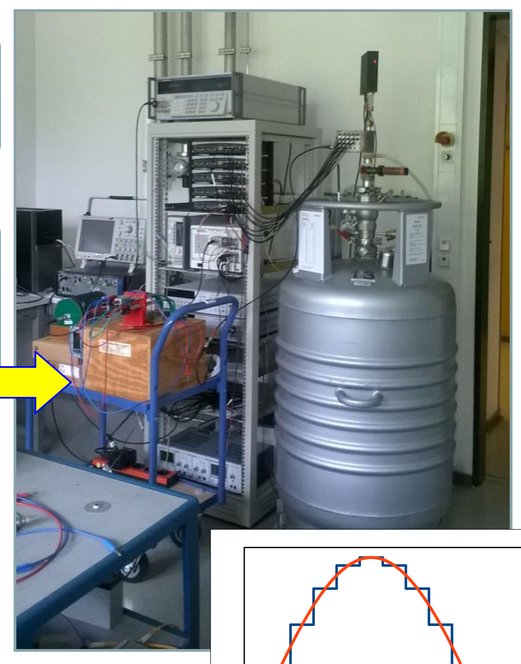
EMPIR EURAMET The EMPIR initiative is co-funded by the European Union's Horizon 2020 research and innovation programme and the EMPIR Participating States — European Metrology Programme for Innovation and Research

AC-Quantum Voltmeter at PTB

Two different AC-QVMs employed:

1. Commercially available NPL bias source to drive a programmable 2 V array with 16384 junctions (14 bits) operating at 70 GHz

2. Five LeCroy ArbStudio 1104 modules, each having 4 output channels, to drive a programmable 10 V array with 69632 junctions (22 bits, only 16 used) operating at 70 GHz

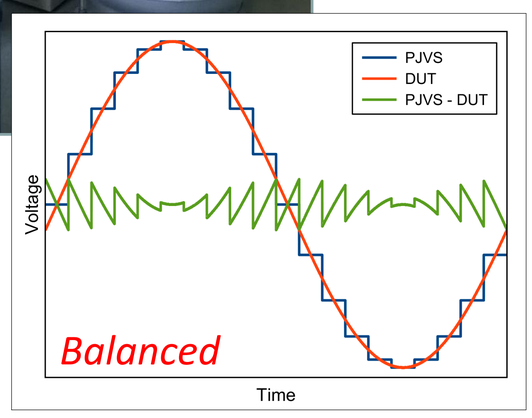


Differential measurement **PJVS-DUT**

Deletion of ringing points close to the transients

Reconstruction:

$$(\text{PJVS-DUT})_{meas} + \text{PJVS}_{exact}$$



70 GHz phase-locked oscillator: MMWS Jülicher Squid

Sampler: NI-PXI5922A

PJVS waveform: 20 samples per period

Phase shift by "clock-detuning"

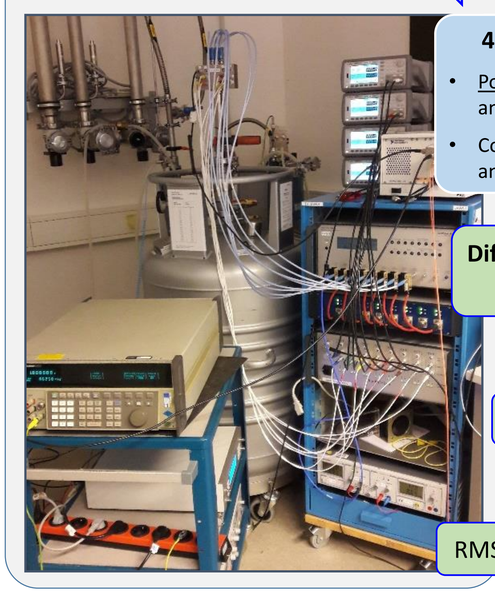
JAWS (pulse-driven JVS) at PTB

Two JAWS systems employed for different voltage ranges:

1 V JAWS
63000 triple-stacked junctions
8 arrays (**4** chips)
1 x 8-channel PPG Sympuls
4 x 2-channel waveform generators
1 x 8-channel *IV*-Box

AC-coupling
Compensation
Isolation

2 x 100 mV JAWS
15000 triple-stacked junctions
2 arrays (**1** chip)
1 x 2-channel PPG Sympuls
1 x 2-channel waveform generator
1 x 2-channel *IV*-Box

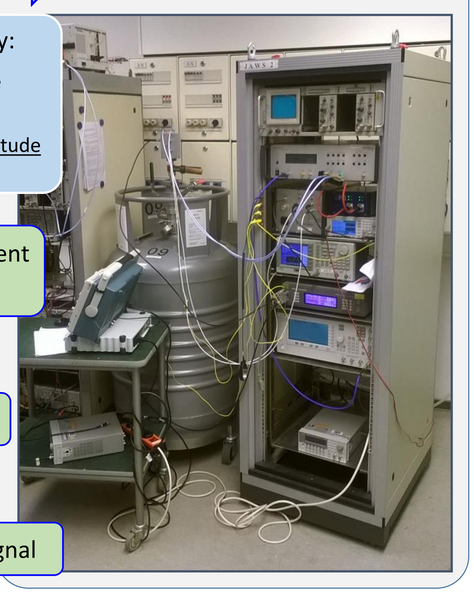


4 parameters per array:
- Positive and negative pulse amplitudes
- Compensation signal amplitude and phase

Differential measurement JAWS-DUT

Phase adjustment

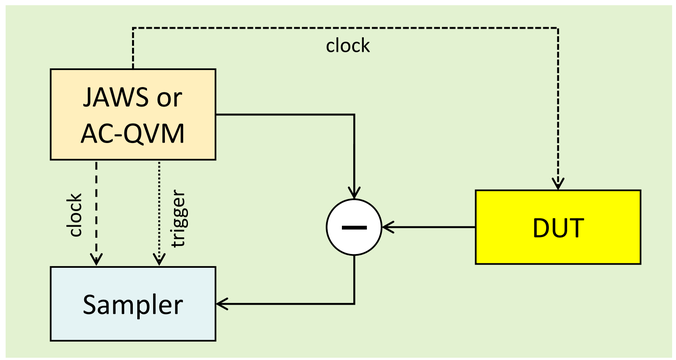
RMS of the difference signal

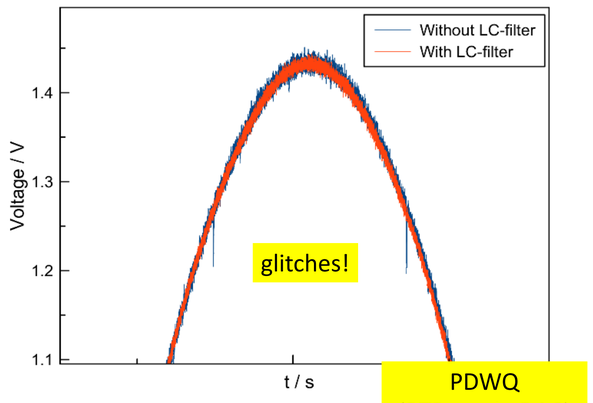


Sampler: NI-PXI5922A / Lock-in amplifier

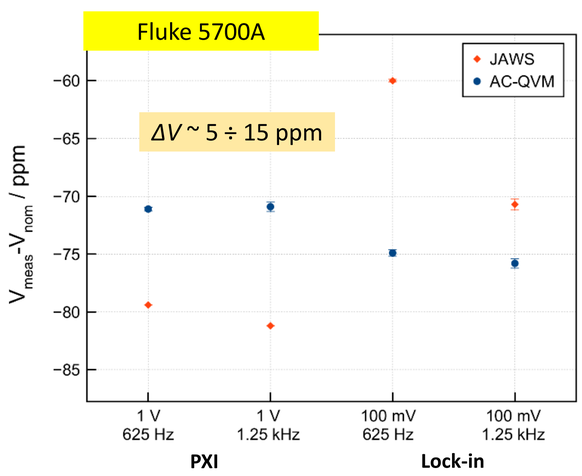
Phase shift by "clock-detuning"

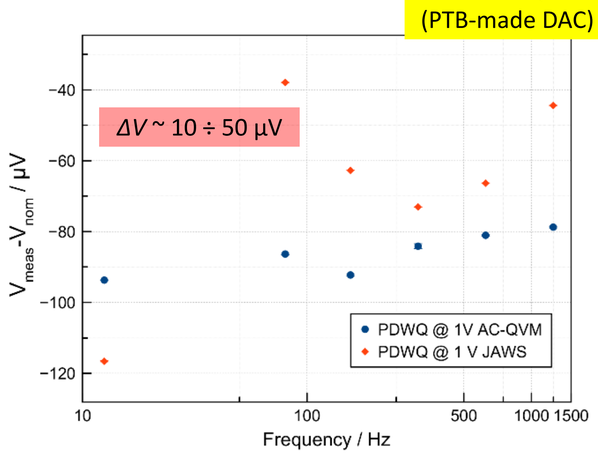
Indirect comparison of AC-QVM and JAWS





PDWQ (PTB-made DAC)



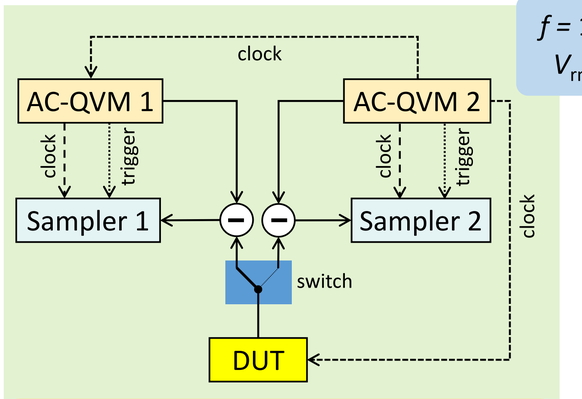


- Different labs, interferences, ground loops, …
- JAWS measures only the component at the reference frequency

- PDWQ has glitches → dependence on recorded window
- PDWQ is not stable → measurements performed in different weeks

… further investigation is required!

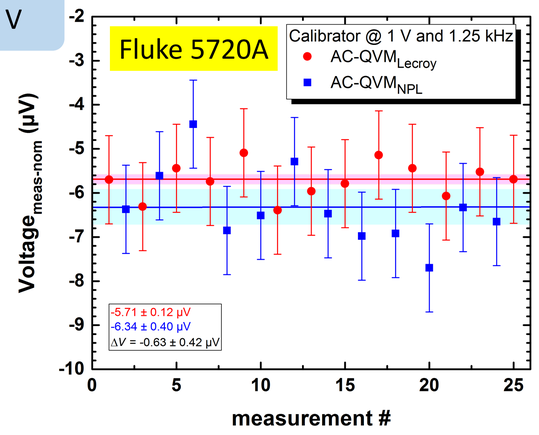
Real-time indirect comparison of two AC-QVMs



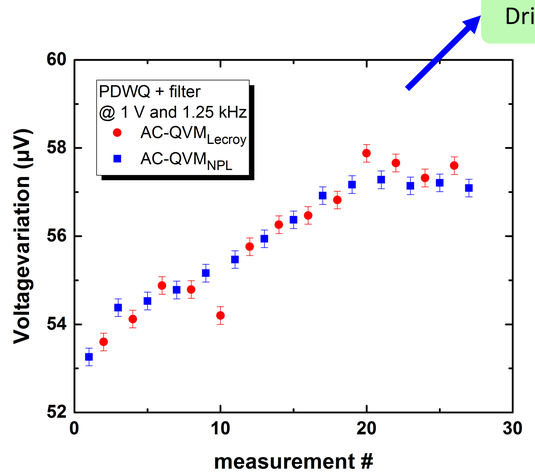
f = 1.25 kHz
V_{rms} = 1 V

DUT waveform alternately sent to either AC-QVM 1 or AC-QVM 2 by means of a software-controlled switch

ΔV = (-0.63 ± 0.42) µV, *k=1*



Drift corrected!



ΔV = (0.01 ± 0.30) µV, *k=1*

PDWQ + low-pass filter