PRESSEMITTEILUNG vom 2012-07-03

High-End Kalibrierung als Beitrag auf der CPEM 2012, Washington DC, USA

Die "Conference on Precision Electromagnetic Measurements", besser bekannt als CPEM, widmet sich elektrischen Messungen in der höchsten Genauigkeitsklasse. Die Physikalisch-Technische-Bundesanstalt (PTB) präsentiert dort die ersten Ergebnisse der Untersuchungen zur Entwicklung eines sog. Quantenkalibrators, der in Zusammenarbeit mit der esz AG und Supracon entsteht. Auf Basis von programmierbaren Josephson-Kontakten sollen erstmalig auch Wechselspannungen mit der Genauigkeit der von Naturkonstanten synthetisierbar sein.

esz AG calibration & metrology ist eines der führenden wie modernsten Metrologielabore Europas. Arbeitsschwerpunkt ist die Kalibrierung industrieller Messtechnik.

Passgenaue Lösungen, ein großes Leistungsportfolio sowie Kosten-Transparenz zeichnen esz AG calibration & metrology aus. So vertrauen namhafte, weltweit agierende Unter-nehmen schon seit über 30 Jahren auf die Professionalität dieses Metrologielabors mit Hauptsitz in Eichenau.

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A Voltage Calibrator based on programmable Josephson arrays

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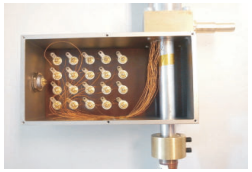
Abstract

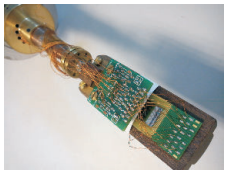
We present a Voltage Calibrator based on a 10 V programmable Josephson array that is simple to use, provides DC and AC calibration up to kHz range for industry-common equipment, and ensures direct traceability to a quantum-based standard.

System and Setup

- 10 V programmable array with 69632 Josephson junctions operated at 70 GHz
- Commercially available bias sources:
  - Bias sources connections: optically isolated
  - Amplitude resolution: 20 µA
  - Maximum voltage amplitude: ± 12 V
  - Rise times < 100 ns
  - Long output stability with less than 20 µA drift over 600 minutes
- Probe with heater



Probe connections



Probe sample holder

- Miniature Millimeter Wave Synthesizer
  - Computer controlled
  - Bandwidth: 69 - 73 GHz
  - Power: 0 - 150 mW

The whole system is automated and time-synchronized.

Acknowledgments

The authors would like to acknowledge Alexander Katkov for fruitful discussions and his help on the construction of the heater. This work is supported by the German Federal Ministry of Economics and Technology as MNPQ project.

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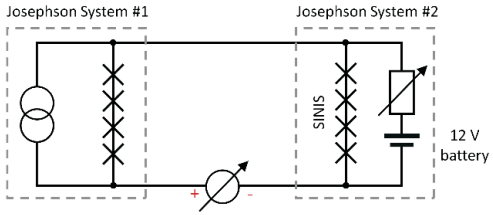
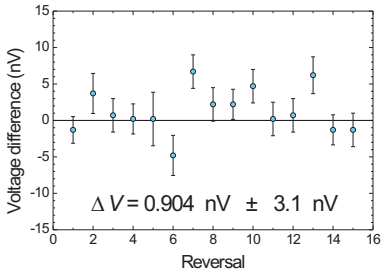
DC Verification

Direct comparison at 10 V



- The chart below shows the results of the direct comparison with 15 reversals of 20 readings each
- One reversal measurement time = 1 min
- The error bars on every point are type-A standard uncertainties ($k = 1$)
- The results demonstrate an excellent agreement after 15 minutes



Measurement results for comparison made between the Josephson Calibrator and a 10 V SINIS array

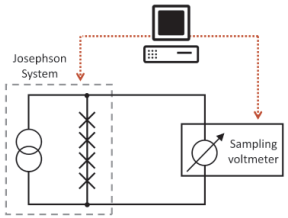
Typical Zener calibration

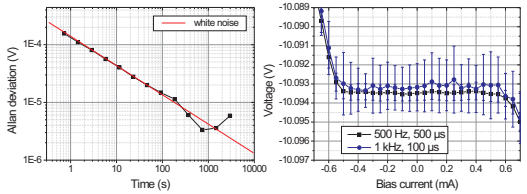
	voltage [V]	stdev [µV]
Zener 732A (mains on)	10.000 012 315	0.43
Zener 732A (mains off)	10.000 012 380	0.46
voltage JVS	10.000 069 045	
thermal EMF	0.000 000200	
frequency	69.63 GHz	

Standard deviation for 20 readings in each polarity

AC Measurements

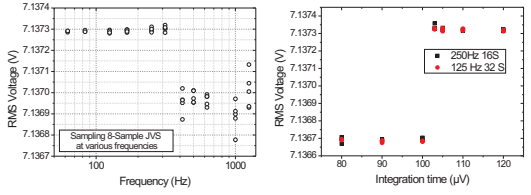
AC measurements are made by sampling the synthesized waveform at various times, such that the uncertainty caused by the transients are ignored.





Left graph: Allan deviation of a 1 kHz 4-sample synthesized wave of the Josephson Calibrator at 7.1 rms. Fluctuation of the measurements obey white noise statistics up to an integration time of 15 minutes.

Right graph: 1 mA quantized 10 V step observed at 1 kHz, when sampling a square wave.

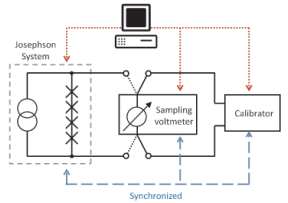


The voltage jump between 300 Hz to 400 Hz is due to an aperture time change around 100 µs, causing the internal input resistor of the sampling voltmeter to switch modes.

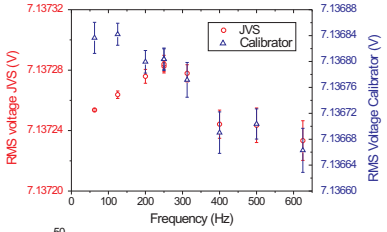
To maintain a minimum aperture time of 100 µs, frequencies above 400 Hz must have a mininum sample number of 8.

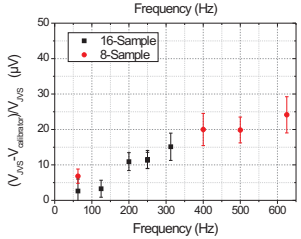
Preliminary Results

Setup of the Josephson system connected to the device under test



The two graphs below show the measured RMS voltage from sampling measurements of the Josephson Calibrator and a conventional calibrator.





The Josephson voltage is synthesized in 16 and 8 samples, where 8 samples for higher frequencies (400 Hz to 625 Hz) to maintain a minimum aperture time of 100 µs.

Measurements are within the AC specification of the calibrator, which is about 50 µV.

Summary and Outlook

Direct comparison and Zener calibration have proven the high accuracy and stability in the DC function of the Josephson Calibrator.

The AC function is so far limited by the aperture time and noise of the calibrator. For frequencies higher than 600 Hz, it will require a different sampling voltmeter or to measure the voltage differentially.

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