



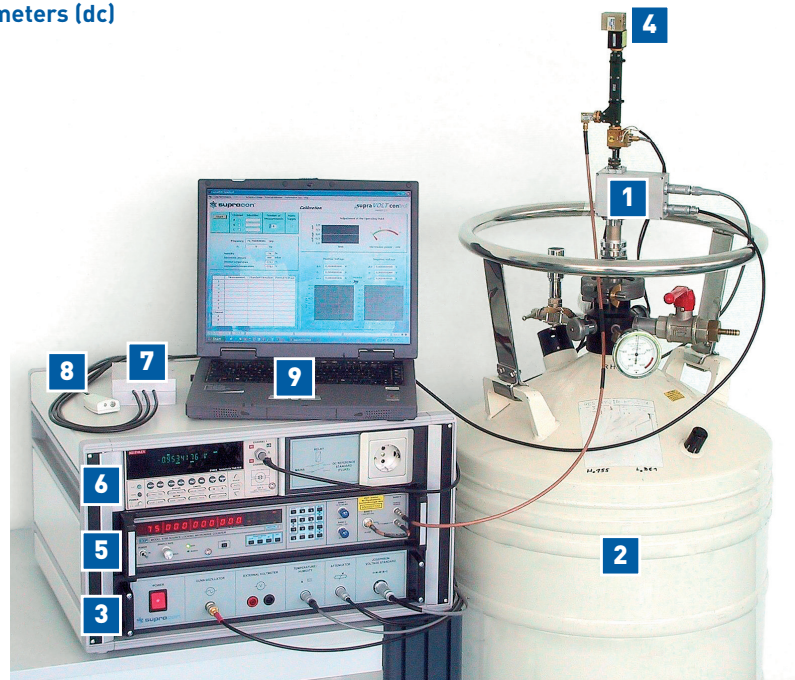
DESCRIPTION

supraVOLTcontrol is a complete 3-channel microprocessor controlled 10V Josephson voltage standard (**JVS**) system developed in the Institute for Physical High Technology Jena (IPHT). It facilitates a variety of dc voltage calibrations and measuring functions:

- ▶ **Calibration of secondary voltage standards**
 - ▶ **Calibration of linearity and accuracy of voltmeters (dc)**
- in the voltage range of 0 to +/-10V.

supraVOLTcontrol consists of the following components:

1. **Cryoprobe with JVS circuit**
 2. Liquid **He Dewar** or **Cryocooler** (optional)
 3. **JVS Electronics** unit
 4. **Microwave electronics** unit includes: 75GHz Gunn oscillator, isolator, directional coupler, mixer, voltage controlled attenuator
 5. **EIP source locking microwave counter**
 6. Keithley nanovoltmeter as **Null detector**
 7. 3-channel **Polarity reversal switch**
 8. Sensors for temperature, humidity and barometric pressure
 9. Host computer with IEEE interface
- GPS 10 MHz reference frequency** receiver (optional)



SPECIFICATIONS

Typical calibration accuracy

(direct comparison to a second Josephson voltage standard)

$$\pm 4\text{ nV @ } 10\text{ V} \quad AV/V_{10\text{V}} = 4 \times 10^{-10}$$

Typical calibration accuracy of secondary voltage standards

(limited by the noise of the secondary voltage standard)

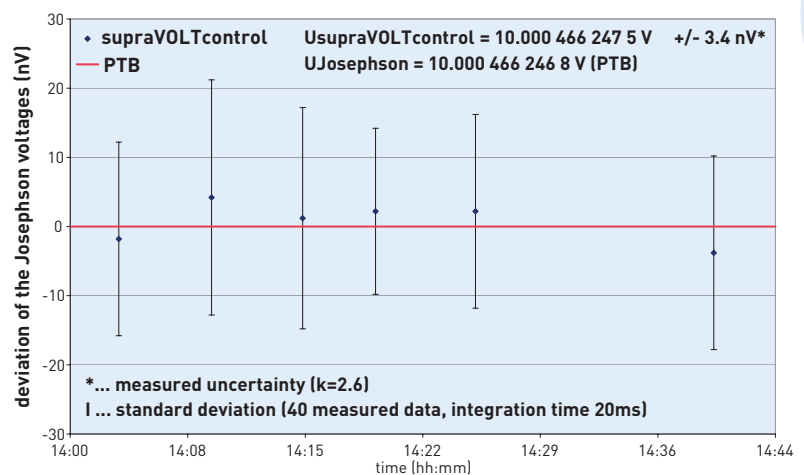
$$\pm 20 \text{ nV @ } 1\text{ V} \quad AV/V_{1\text{V}} = 2 \times 10^{-8}$$

$$\pm 100 \text{ nV @ } 10\text{ V} \quad AV/V_{10\text{V}} = 1 \times 10^{-8}$$

Thermal voltage of wires and reversal switch
< 10nV @ all 3 channels

Typical gain factor g of external voltmeter
(depends on the type of voltmeter)

$$Ag/g < 3 \times 10^{-7}$$



Direct comparison of supraVOLTcontrol with the Josephson voltage standard of the Physikalisch-Technische Bundesanstalt (PTB) @ 10V. The measured voltage difference corresponds to an accuracy of 7×10^{-11} with a measurement uncertainty of 3.4×10^{-10} .

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JOSEPHSON VOLTAGE STANDARD CIRCUIT

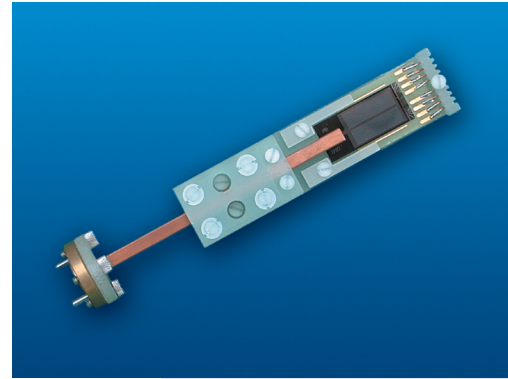
- ▶ Chip carrier with a 10 Volt Josephson voltage standard circuit.
- ▶ 10 Volt Josephson voltage standard circuit with 19700 SIS Josephson junctions (JJ), the operating frequency is 75 GHz.

$$V = n / K_{J90} \times f$$

definition in 1990: $K_{J90} = 483.597,9 \text{ GHz/V}$

V	Josephson voltage	K_{J90}	Josephson constant
n	integer	f	operating frequency

With this formula the voltage will be traced back to a frequency, and frequencies can be controlled extraordinary precisely.



CALIBRATION MODES

supracon Calibration of Secondary Standards **supraVOLTcontrol** Version 2.0

Start Channel Identifier Number of Measurements Mains Supply
 Print A Fluke 732A B C B on off

frequency 74.70000000 GHz
 σ 1

humidity 60 %
 barometric pressure 991 mbar
 internal temperature 35.9 °C
 environment temperature 26.2 °C

Adjustment of the Operating Point

voltage / mV 9.9
9.5
9.0
8.5
7.9
time

microwave power / mW 0 5 10 15

Positive Voltage ΔU 0.000046957 V σ 0.00000432 V UJ+ 10.000050248 V
 Negative Voltage ΔU -0.000046983 V σ 0.00000457 V UJ- -10.000050248 V

Polarity

48.7
48.0
47.5
47.0
46.5
46.0
45.5
45.0
time / s 29.6 29.0 29.5

Measurement	Standard Deviation	Thermal Voltage	
1	10.000003189 V	410 nV	-186 nV
2	10.000003277 V	385 nV	-122 nV
3	10.000003268 V	483 nV	132 nV
4	10.000003359 V	437 nV	-214 nV
5	10.000003358 V	541 nV	-34 nV
6	10.000003255 V	429 nV	-193 nV
7	10.000003369 V	390 nV	-254 nV
8	10.000003278 V	444 nV	25 nV
Channel	Average	Average Deviation	
A	10.000003294 V	63 nV	
B			
C			



▶ DC reference standards (e.g. FLUKE 732A)

supraVOLTcontrol calibration of dc reference voltages

supracon Calibration of an external Voltmeter **supraVOLTcontrol** Version 2.0

Start Select Voltmeter and Range
 Keithley 2001 20 V
 number of data points 15
 CONFIGURE VOLTMETER

UJ / V	Udvm / V	S / nV	
1	-9.997424	-9.997526	4218
2	-8.569221	-8.569305	4264
3	-7.140399	-7.140464	3293
4	-5.708025	-5.708080	4006
5	-4.284301	-4.284341	3645
6	-2.856252	-2.856280	1990
7	-1.428821	-1.428842	2823
8	0.000000	0.000013	2951
9	1.429130	1.429153	2348
10	2.857334	2.857374	2348
11	4.287082	4.287125	2459
12	5.714667	5.714729	2573
13	7.143790	7.143876	4845
14	8.572001	8.572096	2119
15	10.001749	10.001845	2828

Gain Factor 1.0000102

difference voltage (Udvm - UJ) / μ V 120
100
80
60
40
20
0
-20
-40
-60
-80
-100
-120
josephson voltage (UJ) / V -11 -5 0 5 11

microwave power / mW 0 5 10 15
 voltage / mV 12.1
10.0
8.0
5.0
time



▶ external voltmeters (e.g. Keithley 2001)

supraVOLTcontrol calibration of linearity and gain factor