



### 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. Cryocooler with a 10 Volt SIS Josephson junction array and the 75 GHz microwave electronics installed in the 19" rack
2. JVS control electronics unit
3. EIP 578B source looking microwave counter
4. Keithley nanovoltmeter as Null detector
5. 3-channel Polarity reversal switch
6. Sensors for temperature, humidity and barometric pressure
7. Host Computer with IEEE interface
8. Compressor unit with 2 kW input power

GPS 10 MHz reference frequency receiver (optional)



### SPECIFICATIONS

#### Typical calibration accuracy

(direct comparison to a second Josephson voltage standard)

$$\pm 5\text{ nV @ } 10\text{ V} \quad AV/V_{10\text{V}} = 5 \times 10^{-10}$$

#### Typical calibration accuracy of secondary voltage standards

(limited by the noise of the secondary voltage standard)

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

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

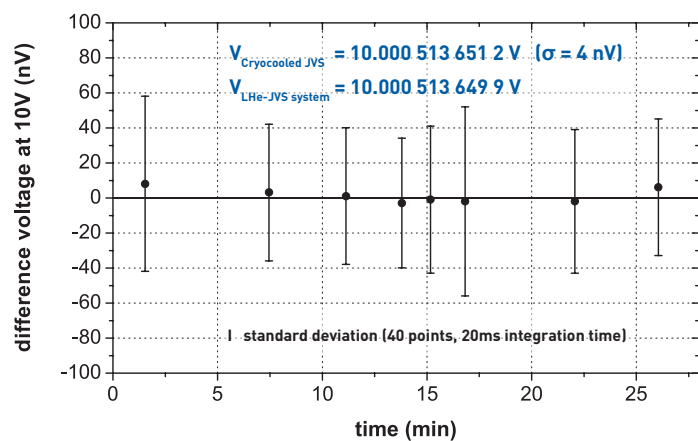
Thermal voltage of wires and reversal switch

$$\leftarrow 10\text{ nV @ all 3 channels}$$

#### Typical gain factor g of external voltmeter

(depends on the type of voltmeter)

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



Direct comparison between a liquid helium cooled and a pulse tube cooler Josephson voltage standard system at a voltage of 10 Volt. Altogether eight measurements were made in about 25 minutes. The error bars denote the standard deviation of the mean value of a single plus-minus-measurement with 20 points for each polarity. The result of the direct comparison is a difference of 1.3 nV at 10 V with an uncertainty of  $5 \times 10^{-10}$ .

The information contained in this document is subject to change without notice at any time.





### JOSEPHSON VOLTAGE STANDARD CIRCUIT

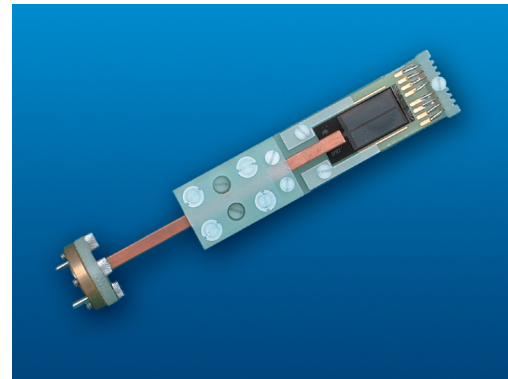
- ▶ Chip carrier with a 10 Volt Josephson voltage standard circuit.
- ▶ 10 Volt Josephson voltage standard circuit with 19700 SIS Josephson junctions (JJ), the operating frequency is 75 GHz.

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

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

<b>V</b>	Josephson voltage	<b>K<sub>J90</sub></b>	Josephson constant
<b>n</b>	integer	<b>f</b>	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 Hz

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

Measurement	Standard Deviation	Thermal Voltage
1	10.00003189 V	410 nV
2	10.00003277 V	385 nV
3	10.00003268 V	483 nV
4	10.00003359 V	437 nV
5	10.00003358 V	541 nV
6	10.00003255 V	429 nV
7	10.00003369 V	390 nV
8	10.00003278 V	444 nV
Average	10.00003294 V	63 nV

Adjustment of the Operating Point

voltage / mV: 9.9, 9.5, 9.0, 8.5, 7.9  
 time: [graph]  
 microwave power / mW: [dial]

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

[graphs: ΔU / mV vs time / s]



▶ 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 / mV
1	-9.997424	-9.997526
2	-8.56221	-8.56305
3	-7.140399	-7.140464
4	-5.708025	-5.708080
5	-4.284301	-4.284341
6	-2.856252	-2.856280
7	-1.428821	-1.428842
8	0.000000	0.000013
9	1.429130	1.429153
10	2.857334	2.857374
11	4.287082	4.287125
12	5.714667	5.714729
13	7.143798	7.143876
14	8.572001	8.572096
15	10.001749	10.001845

Gain Factor 1.0000102

[graphs: difference voltage (Udvm - UJ) / μV vs josephson voltage (UJ) / V, voltage / mV vs time]



▶ external voltmeters (e.g. Keithley 2001)

◀ **supraVOLTcontrol** calibration of linearity and gain factor