



# Primary Standards Laboratory Metrology

## DC Electrical

## Fact sheet

The Primary Standards Laboratory (PSL) maintains a wide variety of primary dc standards to assure accurate and traceable measurements for its customers. Capabilities include voltage, current, resistance, and ratio devices.

The primary dc standards are directly traceable either to the National Institute of Standards and Technology (NIST), to fundamental physical constants, or to self-calibration/ratio techniques. The primary standards include both laboratory and portable Josephson Array Voltage Standard, a set of Thomas 1-ohm resistors, high-voltage dividers, Hamon transfer standards, and various ratio devices (current comparators, potentiometers, ratio sets, and cryogenic current comparator). These standards support a variety of measurement systems, including a teraohmmeter, automated resistance calibration system, shunt calibration system, and intermediate- and high-voltage calibration systems.

### Capabilities

Below is a representative sample of our best k=2 expanded uncertainties. We are accredited under Lab Code 105002-0 by the National Institute of Standards and Technology/ National Voluntary Laboratory Accreditation Program (NIST/NVLAP). For full details,

<http://ts.nist.gov/standards/scopes/1050020.pdf>

#### •VOLTAGE

J-Volt (10V)	±0.017 ppm
J-Volt (1.0 to 1.018V)	±0.14 ppm
0 V to 10V	± (0.5 ppm + 0.2µV)
10 V to 300V	± 1.4 ppm
300 V to 1200 V	± 4.0 ppm
1.0 kV to 100 kV	± 106 ppm
100 kV to 200 kV	± 140 ppm

#### •RESISTANCE

Thomas 1Ω Resistor	±0.055 ppm
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#### •STANDARD RESISTORS

0.0001Ω to 0.1Ω	± 5 to 0.21 ppm
1.0Ω to 10kΩ	± 0.055 to 0.15 ppm
100kΩ to 1GΩ	± 0.2 to 5 ppm
10 GΩ to 1PΩ	± 470 to 6700 ppm

#### •SHUNTS

0.1 A to 2500 A	± 2.5 ppm
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#### •RATIO DEVICES

1:1 to 1:100,000	± 0.5x10 <sup>-7</sup>
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### Major Resources

- DC voltage measurements start with the Josephson Array Voltage Standard that can generate voltages between zero and 10 volts and calibrate Zener voltage standards with an accuracy of better than ± 0.02 ppm at 10 volts.



Josephson Array Voltage Standard

- Ratio devices are self-calibrating, but require stable auxiliary equipment for the calibration process. Standard resistors and various ratio sets, including double-ratio, direct-reading, and universal ratio sets, are used to determine ratio.



## Major Resources (Cont.)

- The Zener standards are used in the intermediate voltage system where voltages to 1200 volts are obtained using an automated intermediate voltage system. Precision high-voltage resistors calibrated by NIST are used in a special high-voltage calibration facility with controlled temperature and humidity to extend the range to 200,000 V.



**1200 VDC Automated Calibration System**

The standard of resistance is maintained using a group of Thomas 1  $\Omega$  resistors that are calibrated periodically by NIST. The uncertainty assigned to these resistors by NIST is  $\pm 0.035$  ppm. Transfer of the ohm to higher and lower resistance values is obtained using resistance ratio devices. Typical uncertainties for resistors are listed under Capabilities - see

<http://ts.nist.gov/standards/scopes/1050020.pdf>

An automated teraohmmeter is used to extend the resistance measurements to  $1\text{P}\Omega$  ( $10^{15} \Omega$ ).

- A high-current facility is used to calibrate shunts to 2500A using an automated current comparator and a standard resistor. A new, pneumatically actuated, reversing switch improves and simplifies calibrations.
- Ratio devices are self-calibrating, but require stable auxiliary equipment for the calibration process. Standard resistors and various ratio sets, including double-ratio, direct-reading, and universal ratio sets, are used to determine ratio.

## Selected Accomplishments

- Development of a portable Josephson Array Voltage Standard jointly with NIST, which is being used to transfer the volt to DOE/NNSA and NASA metrology laboratories.
- Use of new, ultra-high precision, state-of-the-art, automated measurement systems in the areas of voltage, resistance, very high resistance and current, replaced older, manually operated systems.

- Developed automated pressure/vacuum system to measure the pressure coefficient of voltage of solid state voltage standards.
- HV measurement system used to calibrate HV resistors, dividers and power supplies to 200 kV.
- Development of a cryogenic current comparator jointly with NIST, which is to be used to transfer the ohm.



**Cryogenic Current Comparator System**

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