Automated Resistance Measurement Systems w/ Sub-PPM Accuracies

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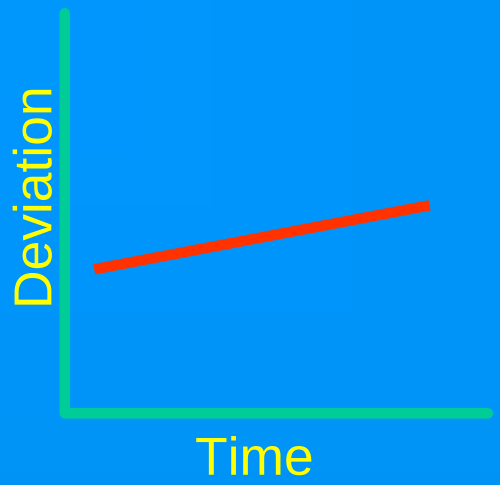
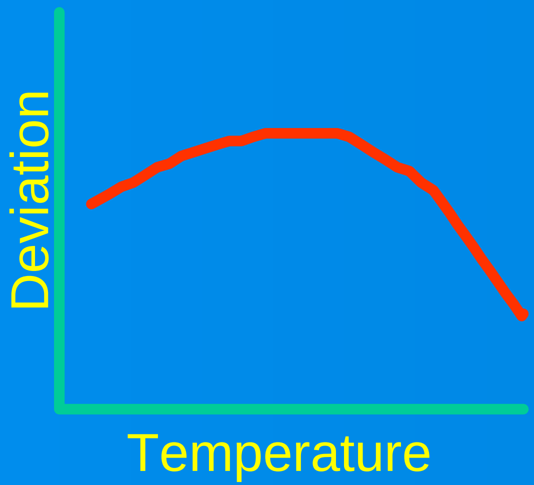
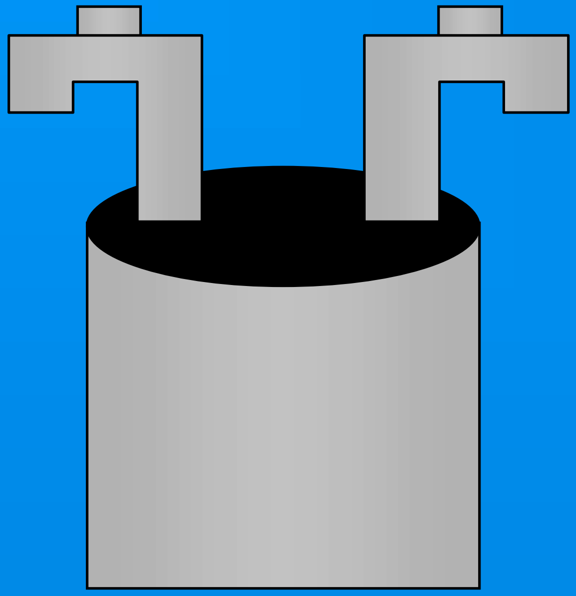
Measurements International

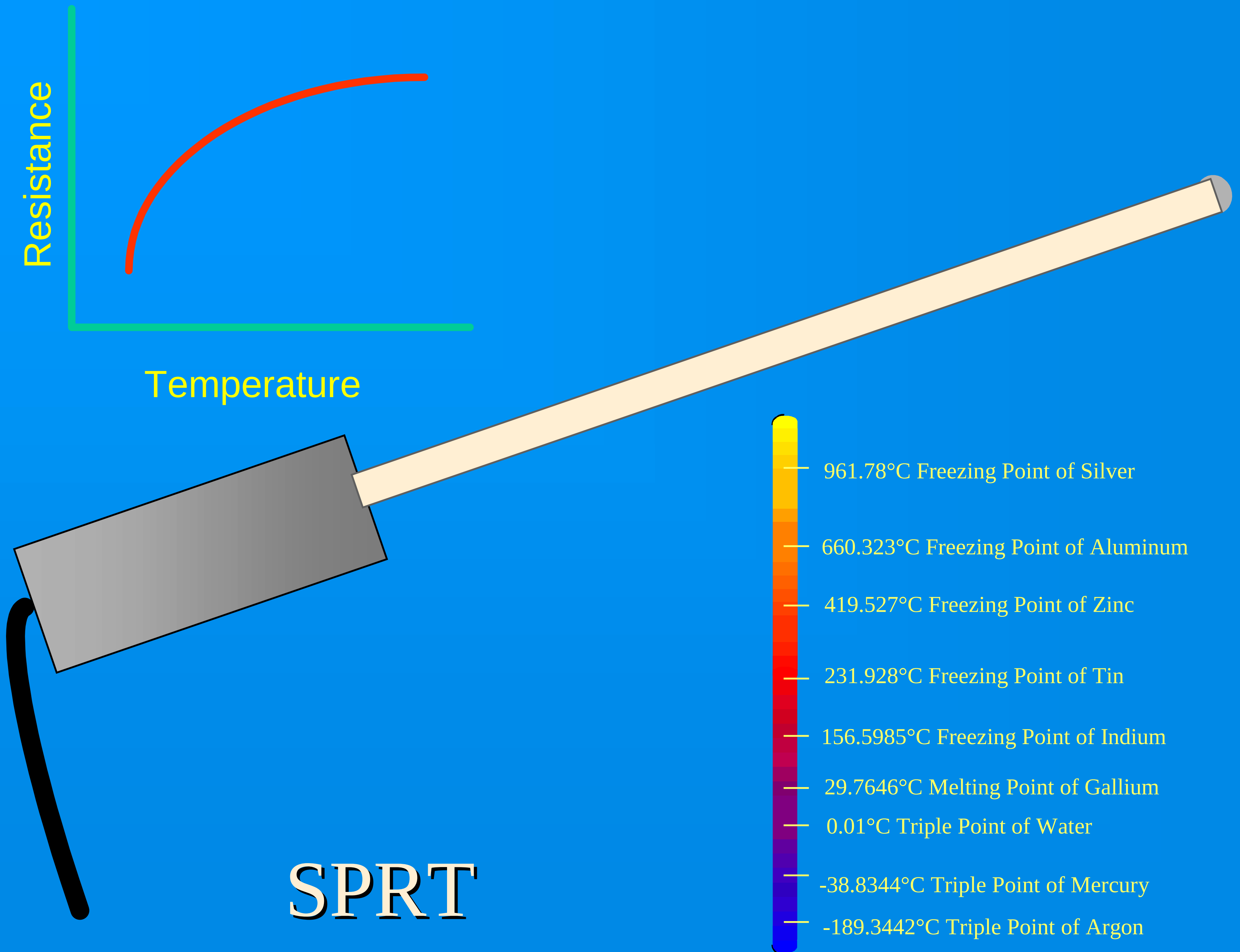
E(Volts) = **R(Ohms)** x I(Amps)







Standard Resistor


Resistance
Temperature
961.78°C Freezing Point of Silver
660.323°C Freezing Point of Aluminum
419.527°C Freezing Point of Zinc
231.928°C Freezing Point of Tin
156.5985°C Freezing Point of Indium
29.7646°C Melting Point of Gallium
0.01°C Triple Point of Water
-38.8344°C Triple Point of Mercury
-189.3442°C Triple Point of Argon
SPRT

Measuring Resistance Ratios:

Passing a current through two or more resistors in series and measuring the ratio of voltages developed across the resistors

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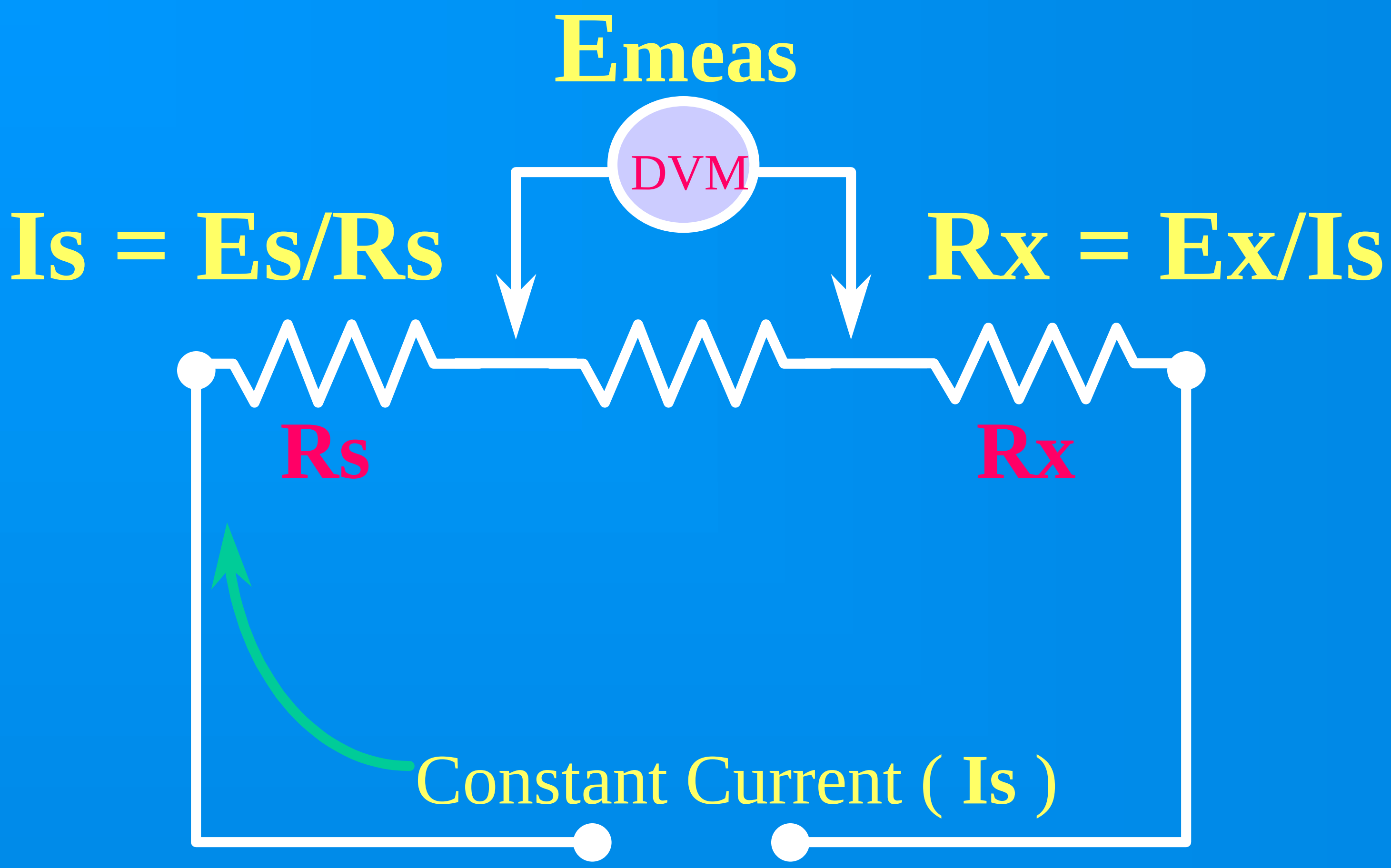
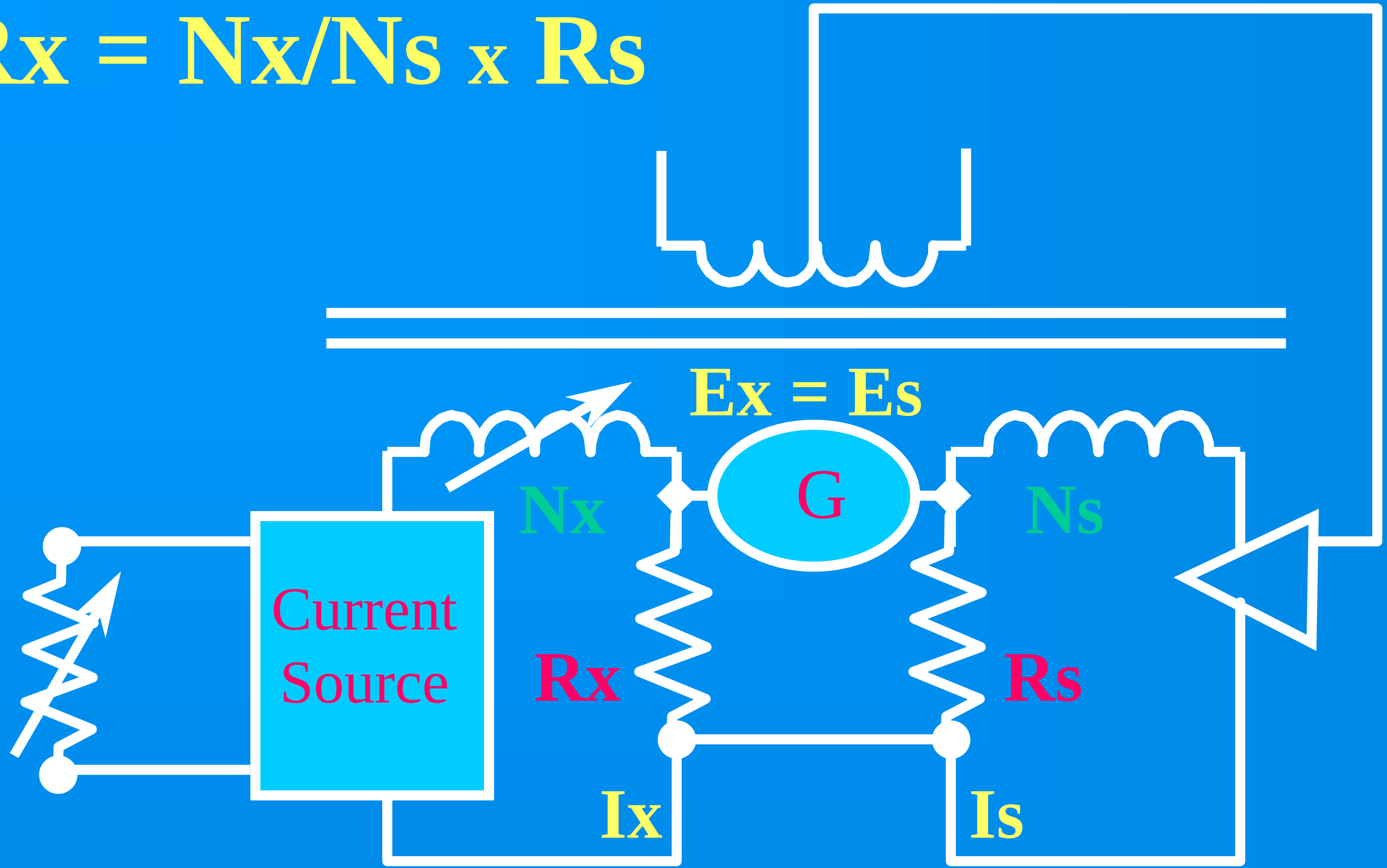
Passing known ratios of current through each pair of resistors until the voltage drop across each resistor is equal



Voltage Ratios:

$R_x = N_x / N_s \times R_s$

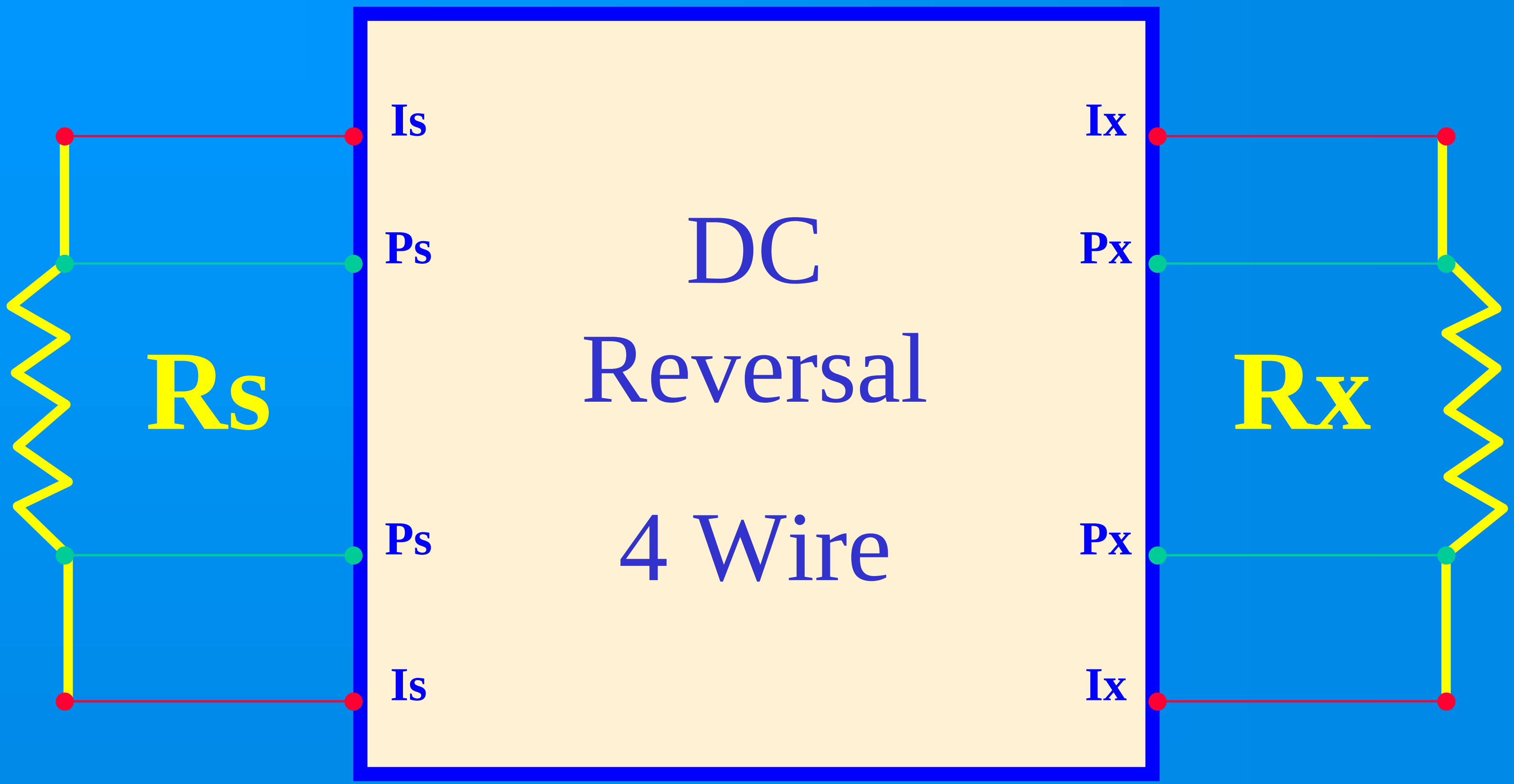


$I_s R_s = I_x R_x$

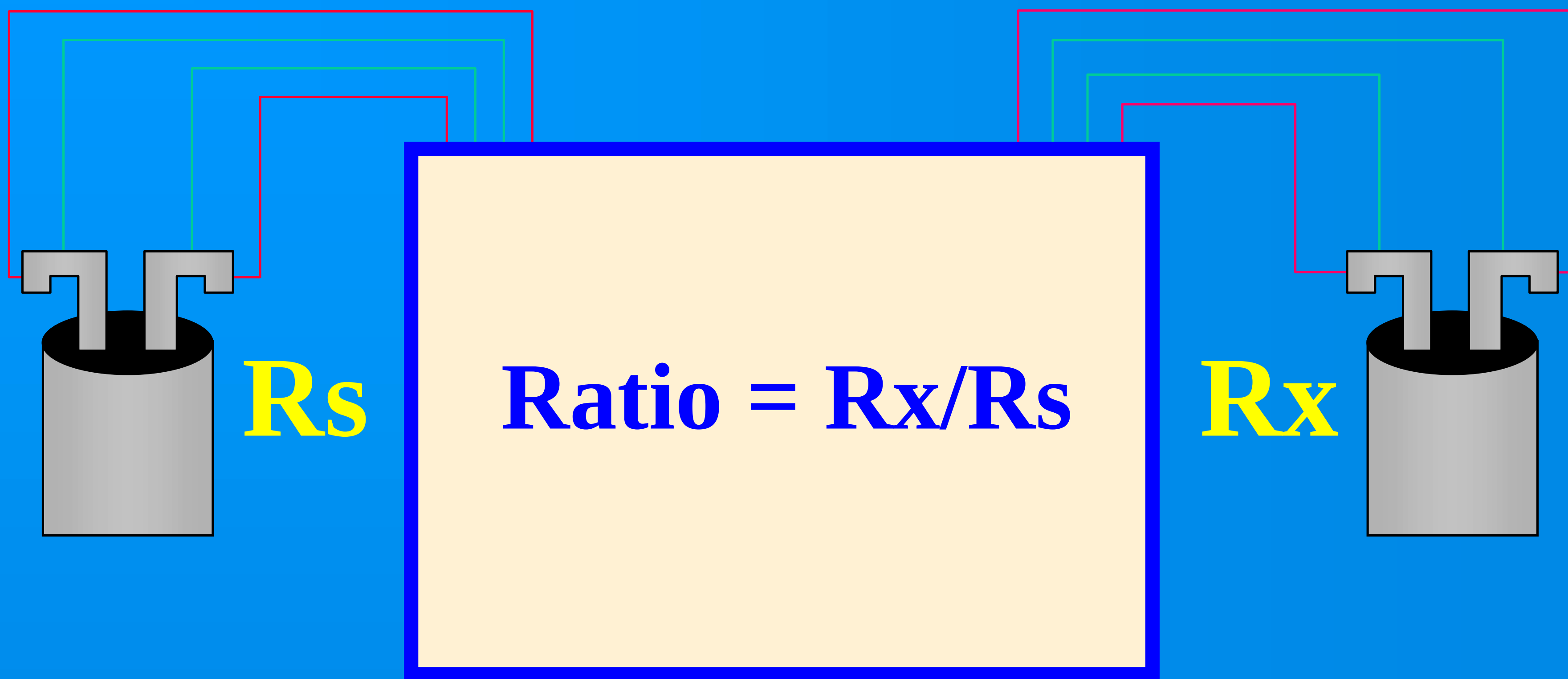
$I_s N_s = I_x N_x$

Current Ratios:

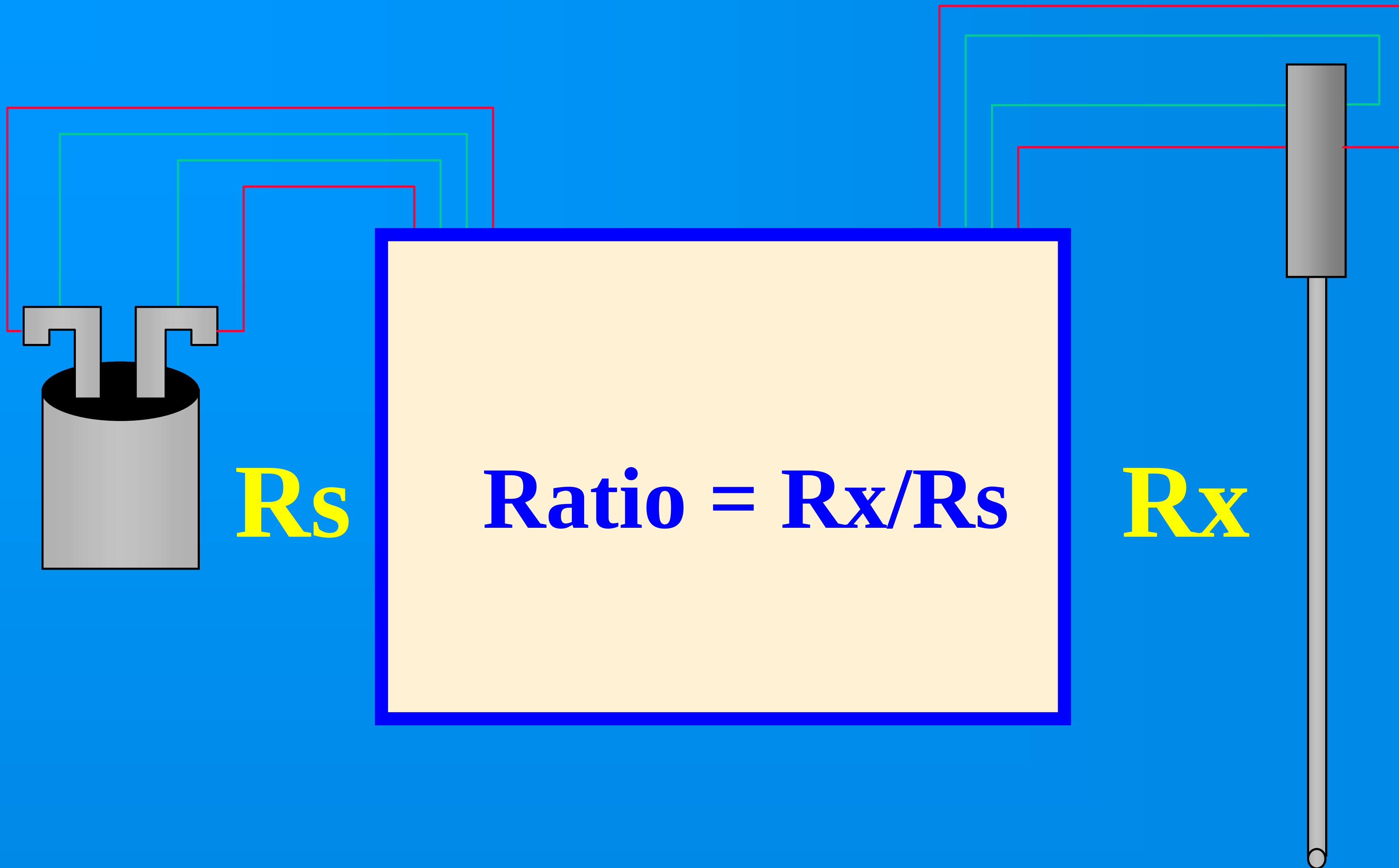
< .1 ppm



Ratio Measurement Device



Resistor Ratio Measurement



SPRT Ratio Measurement

Two New Technologies:

< .1 PPM Measurement Systems

High Resistance: 1000 Ohm - 1G Ohm

Binary Voltage Divider Technology

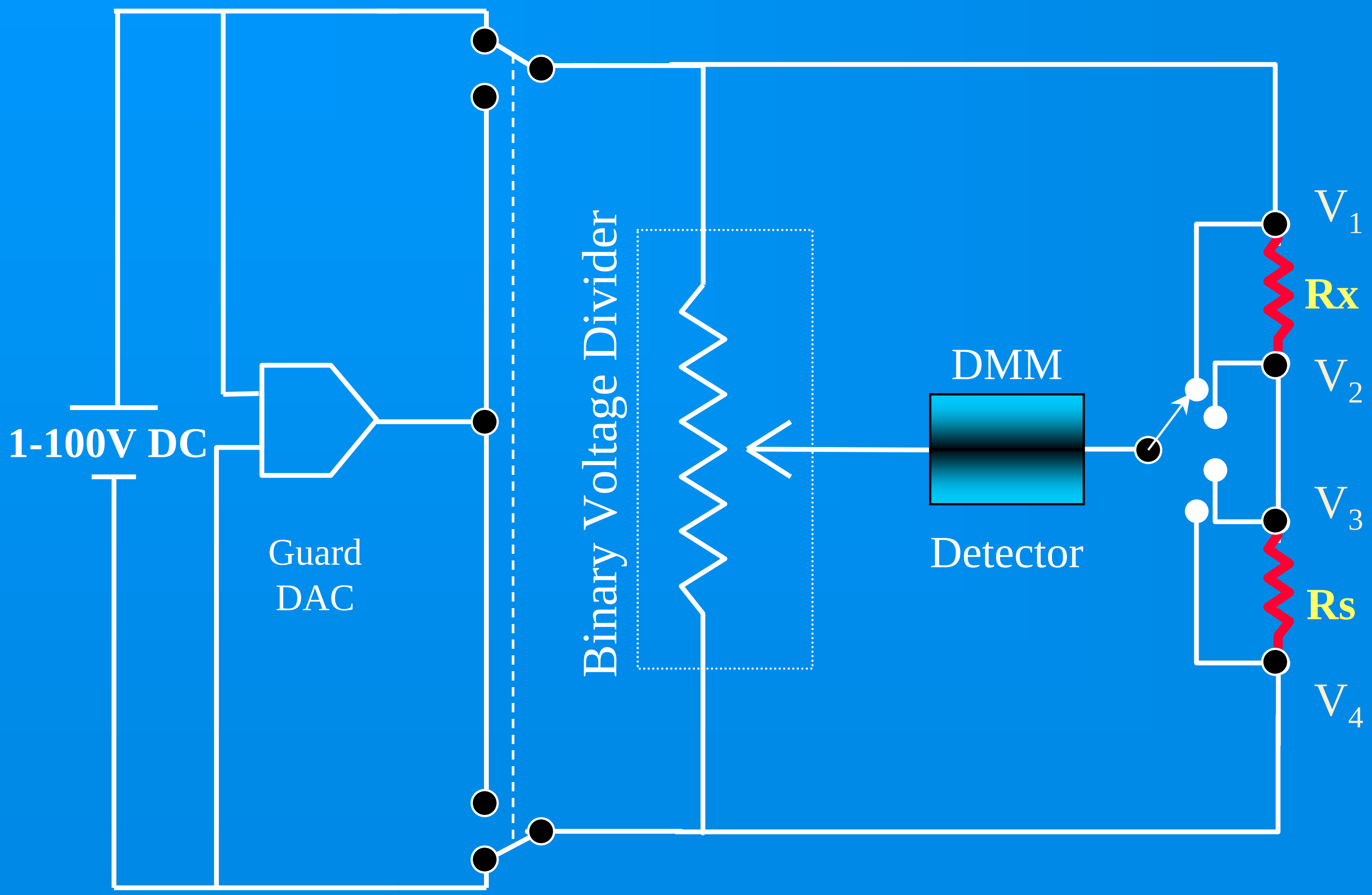
Low Resistance: .001 Ohm - 10K Ohm

Binary Wound Direct Current Comparator Technology

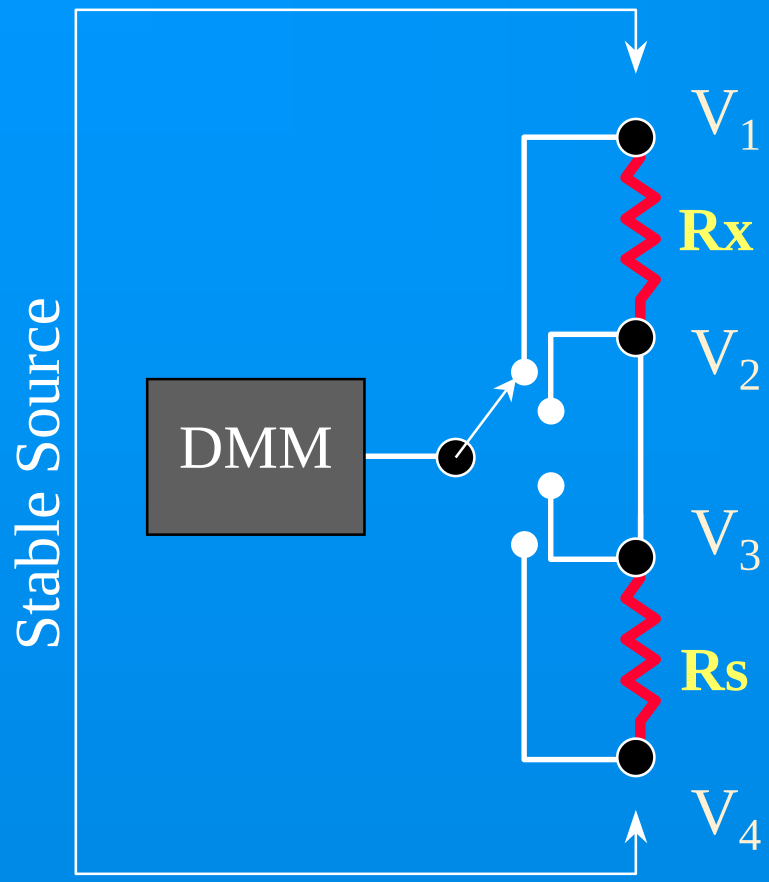
Binary Voltage Divider:

- History
- Limitations
- Advantages
- Applications
- Block Diagram

Binary Voltage Divider:



Ratio Measurement Calculation:



$$R = \frac{Rx}{Rs}$$

$$R = \frac{V_1 - V_2}{V_3 - V_4}$$

$$R = \frac{V_1/E - V_2/E}{V_3/E - V_4/E}$$

$$R = \frac{r_1 - r_2}{r_3 - r_4}$$

Rx = Rs x Ratio

Binary Voltage Divider:

1K to 10M Ohm:	<0.1 ppm
10M to 100M Ohm:	<0.5 ppm
100M to 1G Ohm:	<5 ppm

All Four Wire Measurements @ 1-100 Volts DC

Range:	1K to 1G Ohms
Resolution:	DVM / Detector Dependant
Ratio:	1:1, 10:1, 100:1, 1000:1
Linearity:	Self Calibration to ±0.01 ppm

Binary Voltage Divider:

- Source Voltage: 1 to 100 Volts
- 4 - Four Terminal Inputs via Rear Panel
- All Communication over IEEE488
- Windows Operating Software
- Self Calibrating - *w/ stored corrections*

Binary Voltage Divider:

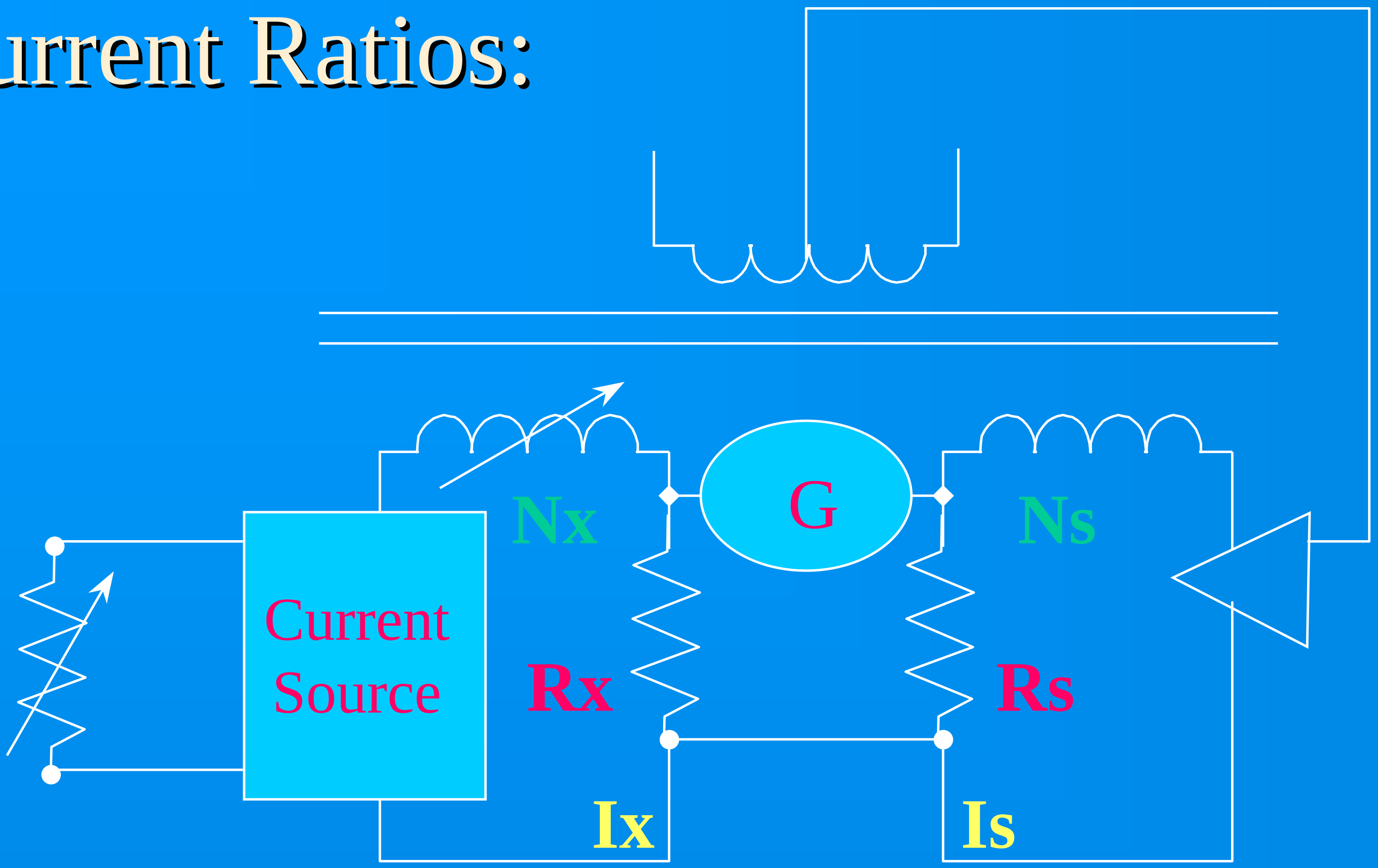
- Primary Std. for 10K to 1G Build Up
- Automatically Assigns Values and Calculates Uncertainties
- Voltage Coefficients of High Value Air Resistors
- Automated Potentiometer - *Voltage Maintenance*

Direct Current Comparator:

Binary Wound

- History
- Limitations
- Advantages
- Applications
- Block Diagram

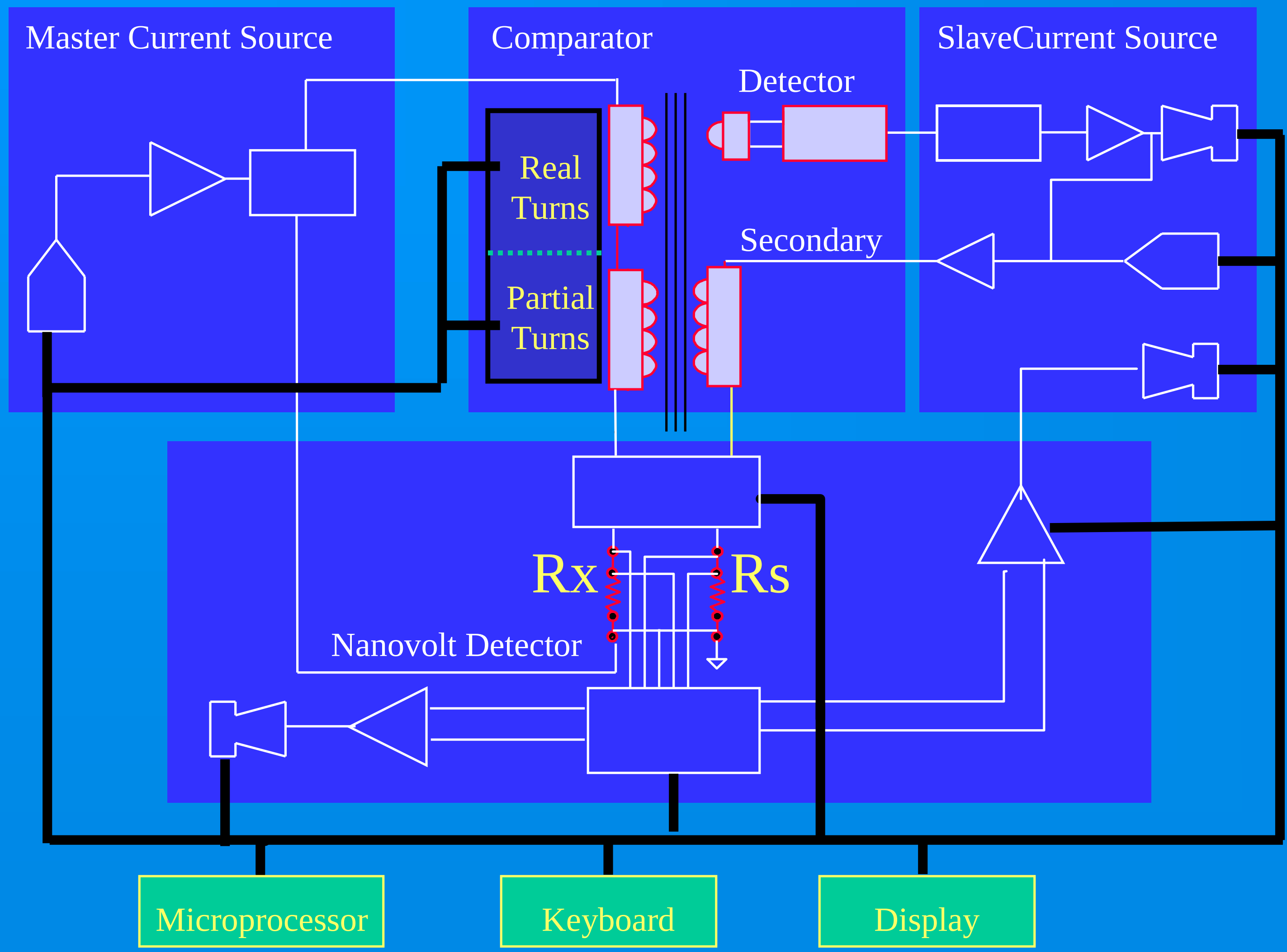
Current Ratios:



$E_s = E_x$ $\quad$ $I_sR_s = I_xR_x$ $\quad$ $I_sN_s = I_xN_x$

$$R_x = N_x/N_s \times R_s$$

Direct Current Comparator: *Binary Wound*



Direct Current Comparator:

Binary Wound

. 1u to 1.0u Ohm:	<10 ppm	100 to 2000 Amps
1.0u to 1.0m Ohm:	<1.0 ppm	100 to 2000 Amps
1.0m to 100m Ohm:	<0.2 ppm	1 to 100 Amps
100m to 10K Ohm:	<0.1 ppm	10mA to 10 Amps
1.0 to 10K Ohm:	<0.1 ppm	10uA to 150mA
10K to 10K:	<0.2 ppm	10uA to 2mA

Range: 0.001 to 10K Ohms Resolution: ±0.001 ppm of Full Scale

Ratio: 0 to 13 Linearity: Self Calibration to ±0.01 ppm

Direct Current Comparator:

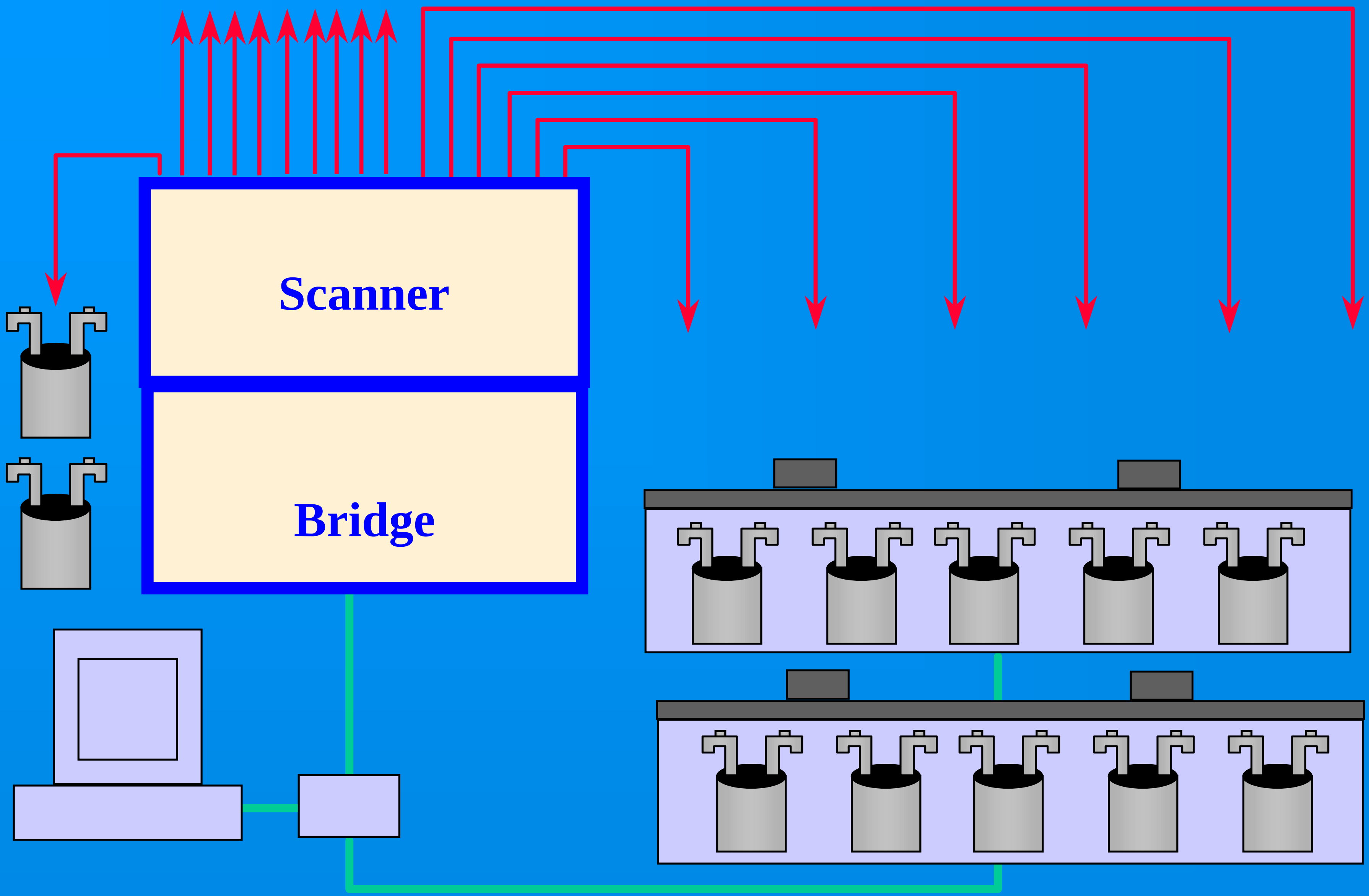
Binary Wound

- Low Current & Voltage Noise
- Range Extenders to 20,000 Amps
- Measurement Speed
- Verifiable Throughout Range
- Manual or IEEE488 Interface
- Windows Operating Software
- Self Calibration - *no stored corrections*

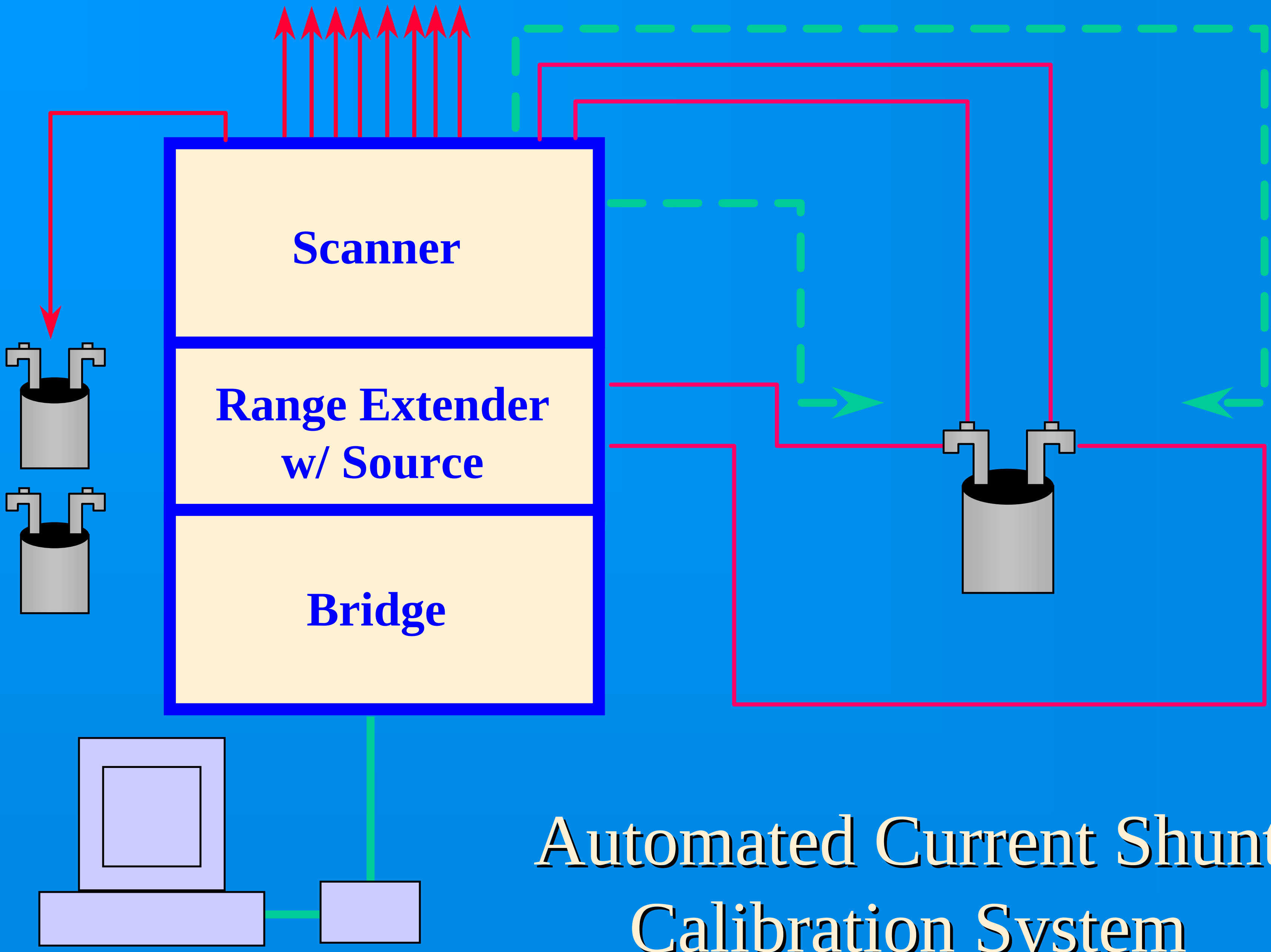
Direct Current Comparator:

Binary Wound

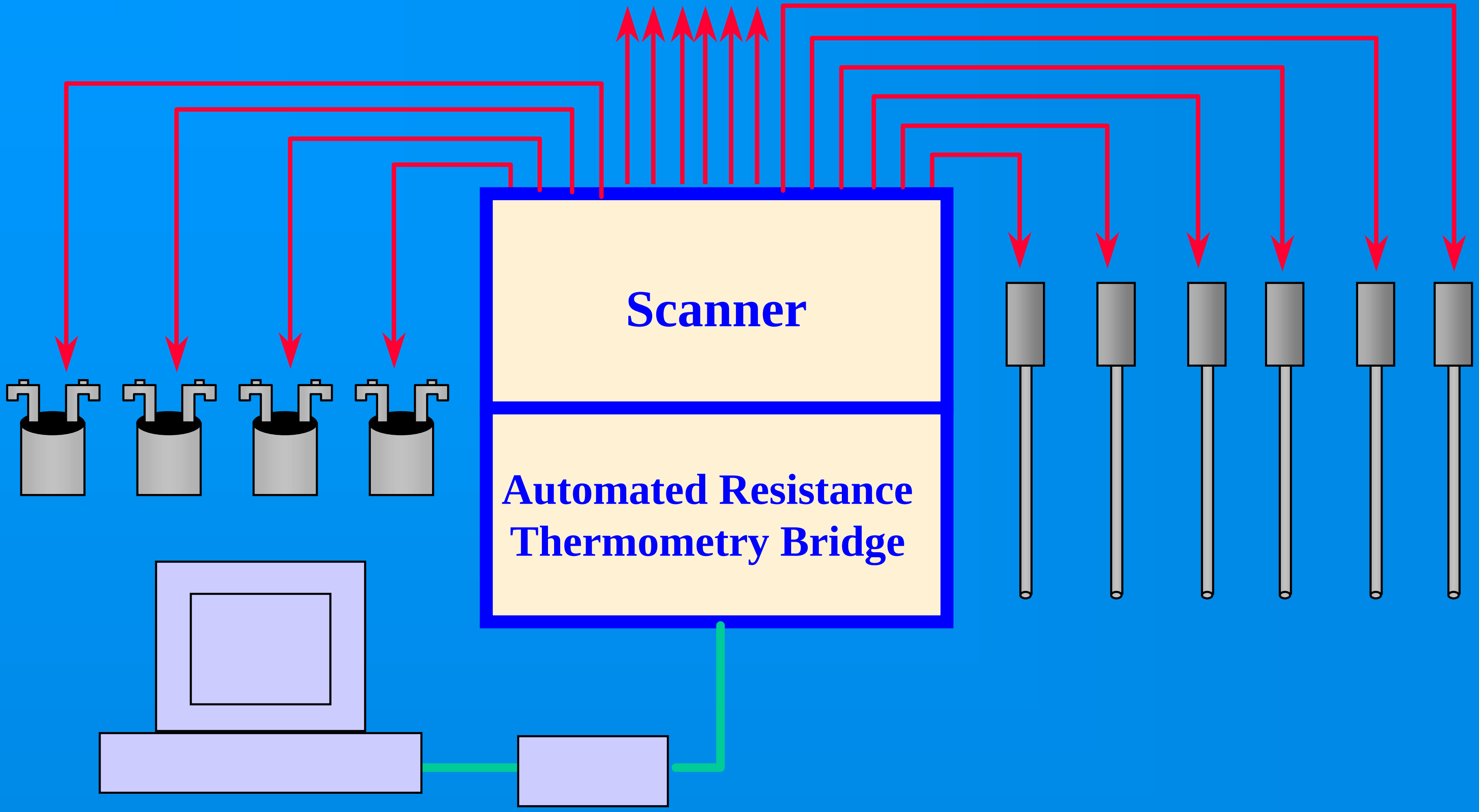
- Primary Resistance Intercomparison < 10K Ohms
- Automated DC Thermometry Bridge
- Automated Current Shunt System
- 13:1 Ratio - QHE Applications



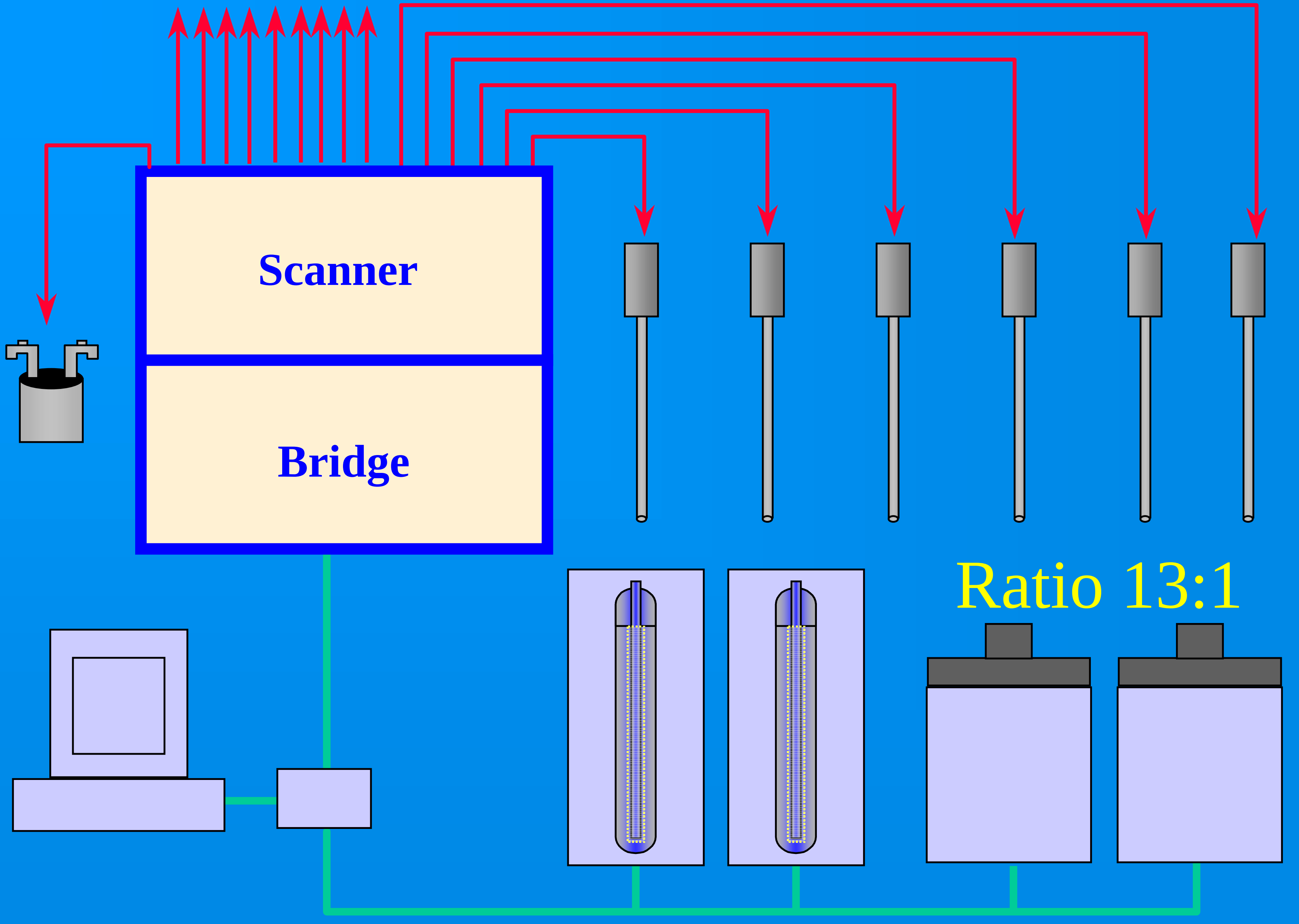
Automated Resistor Calibration



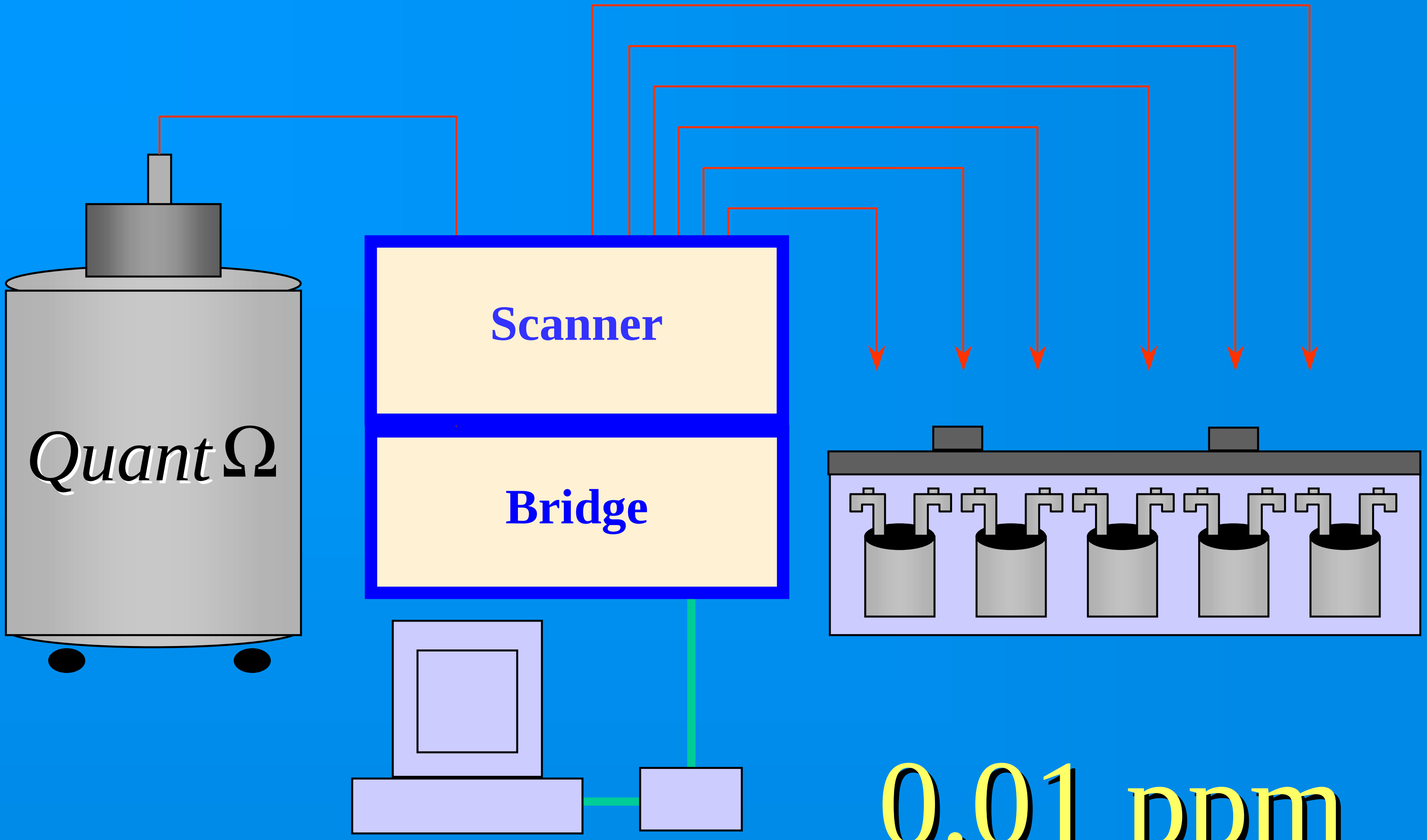
Automated Current Shunt Calibration System



Multiple Channel Automation



Automated Temperature Calibration



0.01 ppm

Automated QHE Resistance System

Automation Requirements:

- Multiple Channels
- Windows Interface
- Task Programmable
- Mathematics Capabilities
- System Verification
- Document Generation
- Customization
- Turn Key System
- No Manual Intervention

Laboratory Issues:

- **Speed**
- **Accuracy**
- **Measurement Range**
- **Reliability**
- **Complete Automation**
- **Verifiable**

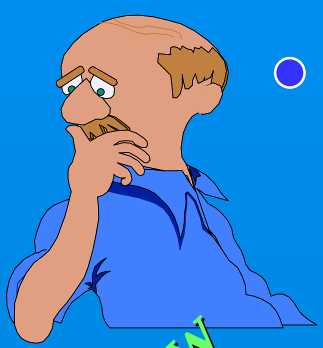
The Facts:

- Multiple System Advantage
- Speed and Accuracy
- Turn-Key System
- Proven Technology

Automation?

DC Metrology Standards

AC Power Standards



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