♦ PRECISION INSTRUMENTS FOR TEST AND MEASUREMENT ♦

SRL Series

Resistance Standard
Operation Manual

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SRL im/Sept. 2023

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WARRANTY

We warrant that this product is free from defects in material and workmanship and, when properly used, will perform in accordance with applicable IET specifications. If within one year after original shipment, it is found not to meet this standard, it will be repaired or, at the option of IET, replaced at no charge when returned to IET. Changes in this product not approved by IET or application of voltages or currents greater than those allowed by the specifications shall void this warranty. IET shall not be liable for any indirect, special, or consequential damages, even if notice has been given to the possibility of such damages.

THIS WARRANTY IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESSED OR IMPLIED, INCLUDING BUT NOT LIMITED TO, ANY IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS FOR ANY PARTICULAR PURPOSE.

Safety Symbols

General definitions of safety symbols used on the instrument or in manuals are listed below.

Caution symbol: the product is marked with this symbol when it is necessary for the user to refer to the instruction manual.

Hazardous voltage symbol: the product is marked with this symbol when high voltage maybe present on the product and an electrical shock hazard can exist.

Indicates the grounding protect terminal, which is used to prevent electric shock from the leakage on chassis. The ground terminal must connect to earth before using the product

Direct current.

Alternating current.

Frame or chassis terminal. A connection to the frame (chassis) of the equipment which normally includes all exposed metal structures.

On supply.

Off supply.

Hot surface. Avoid contact. Surfaces are hot and may cause personal injury if touched.

Waste Electrical and Electronic Equipment (WEEE) Directive 2002/96/EC
This product complies with the WEEE Directive (2002/96/EC) marking requirements.
The affixed label indicates that you must not discard this electrical/ electronic product in domestic household waste.
Product Category: With reference to the equipment types in the WEEE directive Annex 1, this product is classified as a “Monitoring and Control instrumentation” product.

Do not dispose of electrical appliances as unsorted municipal waste, use separate collection facilities.

Contact your local government for information regarding the collection systems available. If electrical appliances are disposed of in landfills or dumps, hazardous substances can leak into the groundwater and get into the food chain, damaging your health and well-being.

When replacing old appliances with new one, the retailer is legally obligated to take back your old appliances for disposal.

Proposition 65 Warning for California Residents

WARNING: Cancer and Reproductive Harm - www.P65Warnings.ca.gov.

This product may contain chemicals known to the State of California to cause cancer, birth defects, or other reproductive harm

⚠ SAFETY PRECAUTIONS ⚠

The following general safety precautions must be observed during all phases of operation, service, and repair of this instrument. Failure to comply with these precautions or with specific WARNINGS elsewhere in this manual may impair the protection provided by the equipment. Such noncompliance would also violate safety standards of design, manufacture, and intended use of the instrument.

IET Labs assumes no liability for the customer's failure to comply with these precautions.

The SRL is an indoor use product.

DANGEROUS PROCEDURE WARNINGS

Comply with all WARNINGS - Procedures throughout in this manual and instructions on the instrument prevent you from potential hazard. These instructions contained in the warnings must be followed.

BEFORE APPLYING POWER

Verify that all safety precautions are taken. Make all connections to the instrument before applying power. Note the instrument's external markings described under "Safety Symbols".

- DO NOT Operate in an Explosive Atmosphere
- Do not operate the instrument in the presence of inflammable gasses or fumes
- Operation of any electrical instrument in such an environment clearly constitutes a safety hazard
- Use Caution around live circuits and whenever hazardous voltages > 45 V are present
- Operators must not remove instrument covers
- Component replacement and internal adjustments must be made by qualified maintenance personnel only
- DO NOT substitute parts or modify the instrument
- When working with high voltages; post warning signs, train personnel and keep unauthorized personnel away.

To avoid the danger of introducing additional hazards, do not install substitute parts or perform unauthorized modifications to the instrument.

Return the instrument to an IET Labs for service and repair to ensure that safety features are maintained in operational condition.

WARNING

OBSERVE ALL SAFETY RULES
WHEN WORKING WITH HIGH VOLTAGES OR LINE VOLTAGES.

Dangerous voltages may be present inside this instrument. Do not open the case
Refer servicing to qualified personnel

HIGH VOLTAGES MAY BE PRESENT AT THE TERMINALS OF THIS INSTRUMENT

WHENEVER HAZARDOUS VOLTAGES (> 45 V) ARE USED, TAKE ALL MEASURES TO AVOID ACCIDENTAL CONTACT WITH ANY LIVE COMPONENTS.

USE MAXIMUM INSULATION AND MINIMIZE THE USE OF BARE CONDUCTORS WHEN USING THIS INSTRUMENT.

Use extreme caution when working with bare conductors or bus bars.

WHEN WORKING WITH HIGH VOLTAGES, POST WARNING SIGNS AND KEEP UNREQUIRED PERSONNEL SAFELY AWAY.

CAUTION

DO NOT APPLY ANY VOLTAGES OR CURRENTS TO THE TERMINALS OF THIS INSTRUMENT IN EXCESS OF THE MAXIMUM LIMITS INDICATED ON THE FRONT PANEL OR THE OPERATING GUIDE LABEL.

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Chapter 1
INTRODUCTION

1.1 Introduction

The SRL Series (Figure 1.1) are extremely stable, precise, laboratory or portable resistance standards. Their ruggedness and small size plus their virtually zero temperature coefficient makes the SRL Series ideal for any applications outside of laboratory environment within the temperature range of 18°C to 28°C. The temperature chart provided with each unit enhances the accuracy by indicating the deviation from nominal for the operating temperature range in 0.5°C increments. Because of the low temperature coefficient, they require no oil-or-temperature bath.

The SRL series units are available in values ranging from 1 mΩ to 2 TΩ, with custom values available, to satisfy any need. They are built with precision resistors and use no adjustable resistors of any kind.

To further reduce errors caused by temperature changes, the SRL units are built with a temperature coefficient of near zero at 23°C. The binding posts are constructed of low-thermal emf material.

Figure 1-1: SRL Series Resistance Standard

Chapter 2
SPECIFICATIONS

For convenience to the user, the pertinent specifications are given in an **OPERATION GUIDE**, shown in Figures 2-1 and 2-2, affixed to the case of the instrument.

SPECIFICATIONS

Accuracy and other specifications:

See Table 2-1.

Retrace:

1 Ω to 19 MΩ: Permanent shift in resistance value is <2 ppm for 23°C to 0°C to 23°C cycle, and 23°C to 40°C to 23°C cycle

Calibration Report:

Initial SI traceable calibration data provided in 0.5°C increments for temperature range of 18°C to 28°C as shown in Figure 2-2.

Calibration Conditions:

Three of four-wire Kelvin measurements, low power, at 23°C; two wire for 1 MΩ and over. Traceable to SI

Terminals:

Gold-plated, tellurium-copper, low-thermal-emf binding posts on standard 3/4 inch spacing. A **GROUND** terminal is provided on all units.

≤190 kΩ: four 5-way binding posts for 4-terminal measurement

<190 kΩ: two 5-way binding posts

≥100 MΩ: two 5-way binding posts with **GUARD**

Other available terminals:

- DMM direct input compatibles
- bnc, Triax, and custom connectors

Transit Case:

Optional **Model SRC-100** lightweight transit case with handle, suitable for transporting and storing two units. The case provides mechanical protection and insulation from temperature changes during transportation or shipping.

Dimensions:

8.6 cm H x 10.5 cm W x 12.7 cm D (3.4” x 4.15” x 5”)

Weight:

0.73 kg (1.6 lb)

SRL-1 Ω STANDARD RESISTOR

Adjustment to Nominal:	±2 ppm	Max. Current:	500 mA
Max. Change from 23°C value (18°C to 28°C):	±3 ppm	Stability:	8 ppm per year max; 2 ppm typical.
Operating Temperature Range:	18°C to 28°C	Retrace:	<2 ppm for for max. temp. cycles.
Max. Voltage:	0.5 V		

$R_t = R_{23}[1 + \alpha (t - 23) + \beta (t - 23)^2]$; α= -1.6E-07 β= -2.4E-08

Date Calibrated	19-Jun-2001				
Temperature (°C)	23.0°C				
Relative Humidity	N/A				
Resistance R_{23}	1.000 003 3 Ω				
Test Conditions	N/A				
Meas. Uncertainty	N/A				
By	JOS				
Recommended Due	19-Jun-2002				

Model: SRL-1 SN: B2-9240246

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Figure 2-1: OPERATION GUIDE affixed to unit

Temperature Calibration Chart

Model: SRL-1

SN: B2-9240246 Report No: 0

Alpha: -1.6E-07 Beta: -2.4E-08

Measured value at 23°C: 1.000 003 3 Ω

Temperature (°C)	Resistance Ω	Deviation from Nominal (ppm)
18.0	1.000 003 5 Ω	3.5
18.5	1.000 003 5 Ω	3.5
19.0	1.000 003 6 Ω	3.6
19.5	1.000 003 6 Ω	3.6
20.0	1.000 003 6 Ω	3.6
20.5	1.000 003 6 Ω	3.6
21.0	1.000 003 5 Ω	3.5
21.5	1.000 003 5 Ω	3.5
22.0	1.000 003 4 Ω	3.4
22.5	1.000 003 4 Ω	3.4
23.0	1.000 003 3 Ω	3.3
23.5	1.000 003 2 Ω	3.2
24.0	1.000 003 1 Ω	3.1
24.5	1.000 003 0 Ω	3.0
25.0	1.000 002 9 Ω	2.9
25.5	1.000 002 7 Ω	2.7
26.0	1.000 002 6 Ω	2.6
26.5	1.000 002 4 Ω	2.4
27.0	1.000 002 3 Ω	2.3
27.5	1.000 002 1 Ω	2.1
28.0	1.000 001 9 Ω	1.9

Date: 19-Jun-2001 Traceable to NIST

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Figure 2-2: Temperature Calibration Chart

Nominal Value	Model Number	Initial Adjustment	Stability per year (max change)	TC 18-28°C from 23 °C α and β supplied with each unit	Max Applied Power			Typical change at 1 kHz	Terminals
					0 ppm change*	1 ppm change**	3 ppm change**		
1 mΩ	SRL-0.001	±100 ppm	±50 ppm	±25 ppm/°C				**<100 ppm**	4 bp's + gnd
10 mΩ	SRL-0.01	±5 ppm	±15 ppm	±5 ppm/°C	25 mW	50 mW	200 mW		
100 mΩ	SRL-0.1	±5 ppm	±12 ppm	±2 ppm/°C	50 mW	100 mW	250 mW		
190 mΩ	SRL-0.19	±5 ppm	±12 ppm	±2 ppm/°C	50 mW	100 mW	250 mW		
200 mΩ	SRL-0.2	±5 ppm	±12 ppm	±2 ppm/°C	50 mW	100 mW	250 mW		
1 Ω	SRL-1	±2 ppm	±8 ppm	±0.5 ppm/°C	175 mW	350 mW	850 mW		
1.9 Ω	SRL-1.9	±2 ppm	±8 ppm	±0.3 ppm/°C	175 mW	350 mW	850 mW		
10 Ω	SRL-10	±2 ppm	±8 ppm	±0.3 ppm/°C	100 mW	200 mW	500 mW		
19 Ω	SRL-19	±2 ppm	±8 ppm	±0.3 ppm/°C	100 mW	200 mW	500 mW		
25 Ω	SRL-25	±2 ppm	±8 ppm	±0.3 ppm/°C	100 mW	200 mW	500 mW		
50 Ω	SRL-50	±2 ppm	±8 ppm	±0.3 ppm/°C	100 mW	200 mW	500 mW		
100 Ω	SRL-100	±2 ppm	±6 ppm	±0.3 ppm/°C	100 mW	200 mW	500 mW		
400 Ω	SRL-400	±2 ppm	±6 ppm	±0.3 ppm/°C	100 mW	200 mW	500 mW		
1 kΩ	SRL-1K	±2 ppm	±6 ppm	±0.3 ppm/°C	100 mW	200 mW	500 mW		
1.9 kΩ	SRL-1.9K	±2 ppm	±6 ppm	±0.2 ppm/°C	100 mW	200 mW	500 mW		
10 kΩ	SRL-10K	±2 ppm	±4 ppm	±0.15 ppm/°C	100 mW	200 mW	500 mW		
19 kΩ	SRL-19K	±2 ppm	±4 ppm	±0.2 ppm/°C	100 mW	200 mW	500 mW		
50 kΩ	SRL-50K	±2 ppm	±4 ppm	±0.2 ppm/°C	100 mW	200 mW	500 mW		
100 kΩ	SRL-100K	±2 ppm	±6 ppm	±0.2 ppm/°C	100 mW	200 mW	500 mW	**<200 ppm**	
190 kΩ	SRL-190K	±2 ppm	±8 ppm	±0.2 ppm/°C	100 mW	200 mW	500 mW		
1 MΩ	SRL-1M	±2 ppm	±8 ppm	±0.2 ppm/°C	100 mW	200 mW	500 mW	**<1000 ppm**	2 bp's + gnd
1.9 MΩ	SRL-1.9M	±2 ppm	±9 ppm	±0.3 ppm/°C	100 mW	200 mW	500 mW		2 bp's + gnd
10 MΩ	SRL-10M	±2 ppm	±9 ppm	±0.3 ppm/°C	500 V	1000 V	2500 V	**<2 %**	2 bp's + gnd
19 MΩ	SRL-19M	±2 ppm	±10 ppm	±0.4 ppm/°C	1000 V	2000 V	5000 V	**NA**	2 bp's + gnd
100 MΩ	SRL-100M	±10 ppm	±20 ppm	±5 ppm/°C	2000 V	4000 V	5000 V		2 bp's + gnd + guard
1 GΩ	SRL-1G	±0.1%	±200 ppm	±23 ppm/°C	5000 V				
10 GΩ	SRL-10G	±0.1%	±500 ppm	±25 ppm/°C	5000 V				
100 GΩ	SRL-100G	±0.3%	±500 ppm	±25 ppm/°C	5000 V				
1 TΩ	SRL-1T	±0.5%	±500 ppm	±50 ppm/°C	5000 V				
XXX Ω	**SRL-XXX**	**customer-selected value and power specifications**							

*** negligible effect of self-heating; do not exceed voltage limits where given.**

**** non-permanent self-heating change; exceeding power given for 3 ppm change may cause a permanent change in the resistance.**

Table 2-1: SRL Specifications

Chapter 3
OPERATION

3.1 Initial Inspection and Setup

This instrument was carefully inspected before shipment. It should be in proper electrical and mechanical order upon receipt.

An **OPERATION GUIDE** is attached to the case of the instrument to provide ready reference to specifications.

3.2 Connections

The SRL series has three different types of connections listed below.

3.2.1 Connections for values ≤190 kΩ

Values ≤190 kΩ have four insulated low thermal emf binding posts for four-terminal measurements as shown in Figure 3-1. The fifth binding post is connected to the case. For high-resistance models (e.g. >10 kΩ) two-terminal measurements may be made by shorting **HI** to **HI** and **LO** to **LO**, preferably with shorting links or other substantial means.

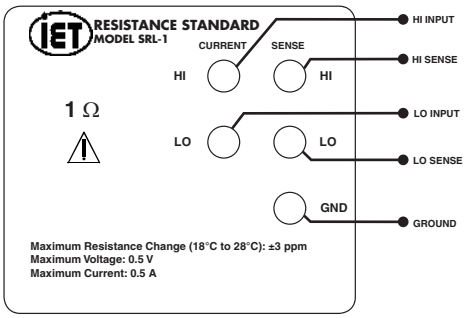


Figure 3-1: Connections for values ≤190 kΩ

Binding Post	Function
CURRENT HI	Current input from source (e.g. ohmmeter)
CURRENT LO	Current return to source (e.g. ohmmeter)
SENSE HI	Measurement point for a four-wire ohmmeter
SENSE LO	Measurement point for a four-wire ohmmeter
GND	Guard or shield

Table 3-1: Connections for values ≤190 kΩ

3.2.2 Connections for values > 190 kΩ and <100 MΩ

Values > 190 kΩ and <100 MΩ have two insulated, low thermal emf binding posts for two-terminal measurements as shown in Figure 3-2. The third binding post is connected to the case.

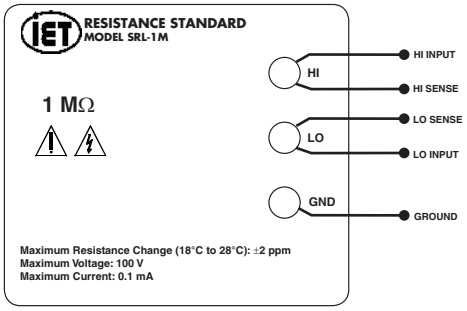


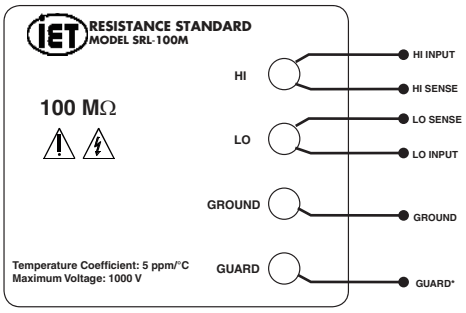
Figure 3-2: Connections for values > 190 kΩ and <100 MΩ

Binding Post	Function
HI	Input from source (e.g. ohmmeter)
SENSE LO	Measurement point
GND	Guard or shield

Table 3-2: Connections for values > 190 kΩ and <100 MΩ

3.2.3 Connections for values ≥100 MΩ

Values ≥100 MΩ have two insulated, low thermal emf binding posts for two-terminal measurements as shown in Figure 3-3. The third binding post, labeled **GROUND**, is connected to the case. The fourth binding post, labeled **GUARD**, is connected to an internal case that contains the resistor.



If no* **GUARD *point exists on the measuring instrument, it may be connected to* **GROUND**.

Figure 3-3: Connections for values ≥100 MΩ

Binding Post	Function
HI	Input from source (e.g. ohmmeter)
SENSE LO	Measurement point
GROUND	Shield
GUARD	Interrupts leakage from the internal resistor to the case and other components of the unit

Table 3-3: Connections for values ≥100 MΩ

3.3 Thermal emf Considerations

High-quality, gold-plated, tellurium-copper binding posts serve to minimize the thermal emf effects which would artificially reflect a change in dc resistance measurements. All other conductors within the instrument, as well as the solder used, contain no metals or junctions that could contribute to thermal emf problems.

There nevertheless may be some minute thermal emf generated at the test leads where they contact the gold banana jacks. This voltage will also be eliminated if a meter with so called "True Ohm" capability is used. Otherwise the generated emf may represent itself as a false component of the dc resistance measurement.

Always use low emf test leads when working with SRL models. In particular, avoid brass or steel conductors.

3.4 Temperature Coefficient Constants

The change of resistance with temperature for each standard is accurately expressed by the equation:

$$R_t=R_{23}[1+a(t-23)+ß(t-23)^2]$$

R_t=Resistance at (°C)

R_{23} = Resistance at 23°C

a = Slope of the curve (ppm/°C) at 23°C

ß = Rate of change of slope of the curve (ppm/°C^2)

The values of *a* and ß are given with each unit. Experience shows that these values do not change appreciably with time and hence need to be determined only once.

The resistance vs. temperature relationship is shown in Figure 3-4. The value at any temperature may be obtained from the above formula, or the temperature calibration chart shown in Figure 3-5.

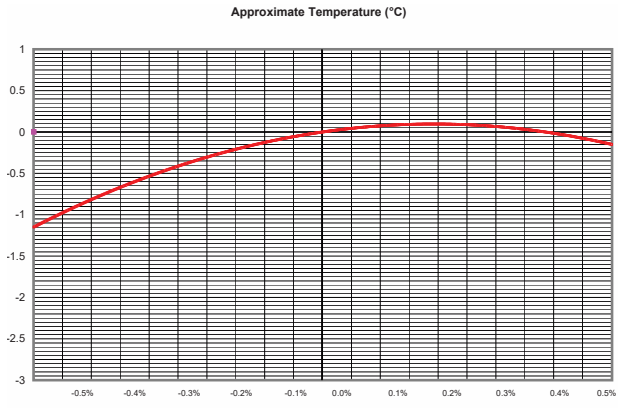


Figure 3-4: Resistance vs. temperature relationship

Temperature Calibration Chart

Model: SRL-1

SN: B2-9240246 Report No: 0

Alpha: -1.6E-07 Beta: -2.4E-08

Measured value at 23°C: 1.000 003 3 Ω

Temperature (°C)	Resistance Ω	Deviation from Nominal (ppm)
18.0	1.000 003 5 Ω	3.5
18.5	1.000 003 5 Ω	3.5
19.0	1.000 003 6 Ω	3.6
19.5	1.000 003 6 Ω	3.6
20.0	1.000 003 6 Ω	3.6
20.5	1.000 003 6 Ω	3.6
21.0	1.000 003 5 Ω	3.5
21.5	1.000 003 5 Ω	3.5
22.0	1.000 003 4 Ω	3.4
22.5	1.000 003 4 Ω	3.4
23.0	1.000 003 3 Ω	3.3
23.5	1.000 003 2 Ω	3.2
24.0	1.000 003 1 Ω	3.1
24.5	1.000 003 0 Ω	3.0
25.0	1.000 002 9 Ω	2.9
25.5	1.000 002 7 Ω	2.7
26.0	1.000 002 6 Ω	2.6
26.5	1.000 002 4 Ω	2.4
27.0	1.000 002 3 Ω	2.3
27.5	1.000 002 1 Ω	2.1
28.0	1.000 001 9 Ω	1.9

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Figure 3-5: Temperature Calibration Chart

3.5 Environmental Conditions

3.5.1 Operating Temperature

For optimal accuracy, SRL Models should be used in an environment of 23°C ±5°C. They should be allowed to stabilize at those temperatures after any significant temperature variation. For determination of accuracy for other temperatures consult the Temperature Calibration Chart provided with each unit. The calculated resistance value is provided between 18°C and 28°C in 0.5°C increments. Figure 2-2 shows an example of this table.

3.5.2 Storage Temperature

The SRL Series should be maintained within the storage temperature range of 0°C to 40°C to retain its accuracy within the specified limits.

3.6 Shipping and Handling

The SRL Series should not be exposed to any excessive shock or temperature extremes. The option SRC-100, a lightweight transit case capable of storing two SRL units, is recommended for shipping or transporting the models.

Chapter 4
MAINTENANCE

4.1 Maintainability and Reliability

It is possible to maintain SRL units indefinitely. They are reliable due to their closed, rugged design and sealed resistors. The units are resistant to electromagnetic interference (EMI) because of their metal enclosure.

4.2 Preventive Maintenance

Keep the SRL units in a clean environment. This will help prevent possible contamination.

The front panel may be cleaned to eliminate any leakage paths from near or around the binding posts. To clean the front panel:

Wipe the front panel clean using alcohol and a lint-free cloth.

4.3 Calibration

The SRL units may be employed as stand-alone instruments or as an integral components of a system. If used as part of a system, they should be calibrated as part of the overall system to provide an optimum system calibration.

If an SRL model is employed as a stand-alone device, the following should be observed:

- Calibration Interval
- General Considerations
- Required Equipment
- Calibration Procedure

4.3.1 Calibration Interval

The recommended SRL Series calibration interval is twelve (12) months.

If the instrument is used to transfer resistance values only, recalibration is not required, assuming that there has been no drastic change of value.

4.3.2 General Considerations

Before starting the calibration procedure, you need to consider the following:

- Calibration environment should be 23°C and less than 50% relative humidity.
- Test instruments should be sufficiently more accurate than the SRL unit, and/or the uncertainty of the measurement instrumentation has to be considered in the calibration Test Uncertainty Ratio (TUR).
- The testing equipment and the SRL unit should stabilize at laboratory conditions for at least 24 hours.
- Kelvin type 4-wire test leads should be used to obtain accurate low resistance measurements.
- Steps should be taken to minimize thermal emf effects, such as using a meter with “True Ohm” capacity.
- Accepted metrology practices should be followed.

4.3.3 Required Equipment

Many combinations of standards, transfer standards, meters, and bridges may be used to calibrate this instrument. The following are some possible choices:

- Resistance Standards or Transfer Standards for the required values with traceable calibrations, such as the following standards available from IET Labs
  - SR-102 100 Ω
  - SR-103 1 kΩ
  - SR-104 10 kΩ
  - SRL series
- Precision resistance measurement bridge or multimeter, with a transfer accuracy of ±l ppm. Options include:
  - Measurements International Model 6010C, 6000B
  - ESI model 242, 242A, 242C, or 242D
  - A high-precision, high-stability digital multimeter (e.g. Fluke 8508A) along with a set of resistance standards for ratio mode.

4.3.4 Calibration Procedure

To calibrate an SRL unit, proceed as follows:

1. Set up the calibration equipment in the resistance measurement mode.
2. Confirm the resistance of the unit.
   Allow a confidence band for the uncertainty of the measuring instrument and setup.
3. Confirm that the resistance is consistent with historical measurements.

4.4 Replaceable Parts List

Reference	IET Pt No	Description
1	BP-1000-RD	Binding Post, Red
2	BP-1000-BK	Binding Post, Black
3	BP-1000-GN	Binding Post, Green
3	BP-1000-BL	Binding Post, Blue
Not Shown	SRL-*-Res	SRL resistor assembly

*Replace * with nominal resistance value*

Table 4-1: Replaceable Parts List

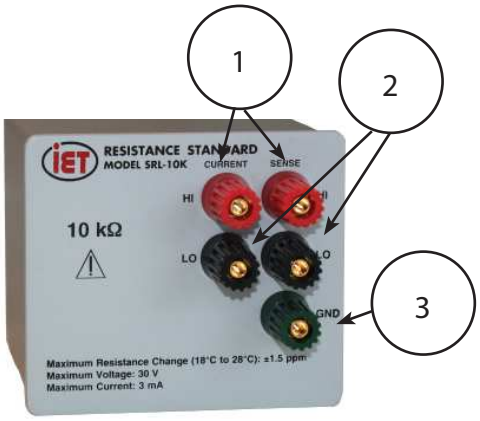

Figure 4-1: SRL Replaceable Parts