♦ PRECISION INSTRUMENTS FOR TEST AND MEASUREMENT ♦

R-X SERIES

Decade Resistor

User and Service Manual

Effectivity: Serial Numbers beginning with P2
RX im/August, 2002

IET LABS, INC.
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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 MERCHANTIBILITY OR FITNESS FOR ANY PARTICULAR PURPOSE.

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WARNING

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

ELECTRICAL SHOCK HAZARD. DO NOT OPEN CASE.
REFER SERVICING TO QUALIFIED PERSONNEL.

HIGH VOLTAGE MAY BE PRESENT WITH **HIGH VOLTAGE OPTIONS.**

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.

REMOVE POWER WHEN HANDLING UNIT.

POST WARNING SIGNS AND KEEP 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.

Chapter 1

INTRODUCTION

The **RX** Series of High-Accuracy Decade Resistors is a family of instruments providing a broad range of high-performance resistance sources. Any number of decades from three to seven is available, with steps of 1 mΩ to 1 MΩ.

The **RX** Series is a precision resistance source with excellent characteristics of stability, temperature coefficient, power coefficient, and frequency response.

The **RX** Series employs very-low-resistance switches with fine-silver contacts and fine-silver alloy wipers. A special design keeps zero resistance to less than 2 mΩ per decade. Self cleaning keeps the silver contacts from becoming tarnished when unused, or when only low currents are passed through them. This is most often the case when only minute test currents are drawn by digital multimeters or other test instruments. Contact resistance is stable and remains low and repeatable.

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 employed, contain no metals or junctions that could contribute to thermal emf problems.

The standard models offer a choice of three through seven decades. The panels are clearly labeled showing the step size and maximum current for each decade.

With a resolution as low as 1 mΩ and a maximum available resistance of over 11 MΩ, the **RX** Series may be used for exacting precision measurement applications requiring high accuracy, good stability, and low zero-resistance. They can be used as components of dc and ac bridges, for calibration, as transfer standards, and as RTD simulators.

The **RX** Series may be rack-mounted to serve as components in measurement and control systems.

Figure 1.1. RX Series High-Accuracy Decade Resistor

Chapter 2

SPECIFICATIONS

For convenience to the user, the pertinent specifications are given in an **OPERATING GUIDE** affixed to the case of the instrument. Figure 2.1 shows a typical example.

SPECIFICATIONS

Model number code:

The digit following the letter "R" represents the number of decades. The number after the hyphen represents the full-scale resistance (with all switches set to ten) in ohms. A "K" denotes kilohms. A suffix "RC" indicates that the unit is equipped with angles for 19-inch relay-rack mounting.

Example: R7-111.1111K-RC is a seven decade rack-mounting unit with 111.1111K (111,111.11 ohms) with all switches set to ten. It is possible to set the box to higher resistance values by setting switches to eleven, instead of ten, but the total resistance value must then be calculated by adding the values set for the individual decades, which is time-consuming and can lead to errors.

Resistance per Step	Total Decade Resistance	Stability (±ppm/year)	Long Term Stability (±ppm/3 years)	Temperature Coefficient (±ppm/°C)	Max. Power (W/step)	Maximum current (per decade)	Maximum voltage (per step)
1 mΩ	10 mΩ	100	700	50	0.025	5 A	5 mV
10 mΩ	100 mΩ	50	350	20	0.2	4 A	40 mV
100 mΩ	1 Ω	30	50	20	0.25	1.6 A	0.16 V
1 Ω	10 Ω	10	25	20	0.6	0.8 A	0.8 V
10 Ω	100 Ω	10	25	15	0.6	0.25 A	2.5 V
100 Ω	1 kΩ	10	25	5	0.6	80 mA	8 V
1 kΩ	10 kΩ	10	25	5	0.5	23 mA	23 V
10 kΩ	100 kΩ	10	25	5	0.5	7 mA	70 V
100 kΩ	1 M Ω	10	25	5	0.5*	2.3* mA	230 V*
1 MΩ	10 MΩ	10	25	10	0.5*	0.7* mA	700 V*

*Subject to maximum of 2000 V.

Accuracy: After subtraction of zero resistance, at 23°C; traceable to NIST: ±(0.01% + 2 mΩ).

Zero Resistance: <2 mΩ per decade, at dc.

Maximum Voltage to Case: 1000 V peak.

Switch Type: 11 positions; "0"-"10"; solid silver contacts and silver-alloy wipers.

Switch Capacitance: <0.15 pF per switch, low-loss.

Terminals: Low-thermal-emf beryllium-copper binding posts with standard 3/4 inch spacing, plus shield terminal.

Mechanical:

Model	Dimensions	Weight
3-4 decades	37.5 cm W x 8.9 cm H x 10.2 cm D (14.8" x 3.5" x 4")	1.7 kg (3.8 lb)
5 decades	43.9 cm W x 8.9 cm H x 10.2 cm D (17.3" x 3.5" x 4")	2.0 kg (4.3 lb)
6 decades		2.2 kg (4.8 lb)
7 decades		2.4 kg (5.3 lb)

RX SERIES DECADE RESISTANCE BOX

CONSULT INSTRUCTION MANUAL FOR PROPER INSTRUMENT OPERATION

Resistor Type: Resistance wire for 0.1 Ω steps and under; wirewound, noninductive for 1 Ω through 1 MΩ steps.

Accuracy: ±(0.01% + 2 mΩ) after subtraction of zero resistance, at 23°C; traceable to NIST.

Zero Resistance: ≤2 mΩ per decade.

Power per Step: 0.025 W for 1 mΩ steps;
0.16 W for 10 mΩ steps;
0.25 W for 100 mΩ steps;
0.5 W for 1 Ω through 1 M Ω steps;

Switch Type: Solid silver contacts.

Temperature Coefficient: <±20 ppm/°C for 0.1 Ω and 1 Ω steps;
<±10 ppm/°C for all other steps;
switch wiring affects TC below 1 Ω steps.

Inductance: Less than 0.8 μH with all decades set to zero, for a six decade box.

Capacitance: Less than 0.15 pF per decade with **LOW** terminal connected to shield.

Breakdown Voltage: Greater than 1000 Vdc or peak ac, from **HIGH** or **LOW** terminal to case.

WARNING **MODEL: R6-111.111 K** **SN:**

Observe all safety rules when working with high voltages or line voltages. Connect the shield to earth ground in order to maintain the case at a safe voltage. Whenever hazardous voltages (>45 V) are used, take all measures to avoid accidental contact with any live components: a) Use maximum insulation and minimize the use of bare conductors. b) Remove power when adjusting the capacitor. c) Post warning signs and keep personnel safely away.

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Figure 2.1. Typical Operating Guide Affixed to Unit

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

3.2 Connection

3.2.1 General Considerations

The **RX** Series Decade Resistors provides three terminals labeled **H** (high), **L** (low), and **G** (ground). The **H** and **L** terminals are connected to the ends of the resistance being set; the **G** terminal is connected to the case. The **G** terminal may be used as a guard or shield terminal. It may also be connected (using a shorting link) to the **L** terminal to allow two-terminal as opposed to three-terminal measurements.

In order to make the most stable measurements, determine which is the more sensitive of the two user leads, i.e. the one going into a higher impedance. This lead should be connected to the more protected one of the two **RX** terminals. That would either be the **RX** terminal that is shorted to the case, or the **L** terminal when neither is connected to the case.

3.2.2 Electrical Considerations

In order to make proper use of the full performance capabilities of the **RX** unit, especially if low resistance values or low-resistance increments are important, care must be taken in connecting to it's terminals.

In particular, in order to keep contact resistance to a minimum, the most substantial and secure connections should be made. The binding posts accept banana plugs, telephone tips, spade lugs, alligator clips, and bare wire. The largest or heaviest mating connection should be made, and, where applicable, the binding posts should be securely tightened.

These considerations may be relaxed whenever single milliohms are considered significant for the task being performed.

3.2.3 Four-Wire Kelvin-Lead Connections

Whenever possible, 4-wire Kelvin leads, the ideal connection, should be employed. Such a connection minimizes the effects of contact resistance and approaches ideal performance.

If the four terminals are available as clamps similar to alligator clips, they may be connected to the necks of the binding posts. If the four terminals are available separately, the optimal connection is shown in Figure 3.1, where the current leads are introduced into the top of the binding posts, and the voltage leads at the necks.

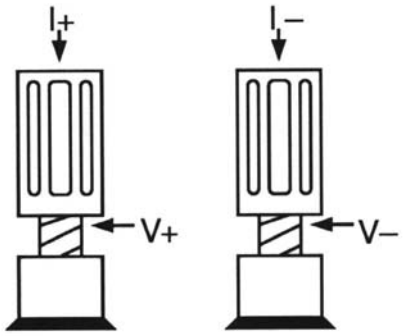


Figure 3.1 Optimal 4-Wire Kelvin Lead Connection

3.2.4 Thermal emf Considerations

The highest-quality low-ernf components are used in the **RX** Series. There nevertheless may be some minute thermal emf generated at the test leads where they contact the gold banana jacks.

This emf will not reflect itself if an ac measurement instrument is employed. It will also be eliminated if a meter with so called "True Ohm" capability is used. Otherwise it may represent itself as a false component of the dc resistance measurement.

3.3 Dial Setting

Whenever the dials are used in positions 0-9, the resulting resistance is simply read directly. Both the decimal point and the steps are clearly marked on the panel.

For additional flexibility and range, each decade provides a "10" position setting. This "10" position on any one decade equals the "1" position on the next higher decade. It adds about 11% to the nominal total decade resistance.

To determine the resistance obtained when one or more "10" settings are used, simply add "1" to the next higher decade. For example, a setting of 3-6-10-0-10 Ω becomes:

```
  3          3 0 0 0 0
  6            6 0 0 0
 10            1 0 0 0
  0                0 0
 10                1 0
 ____________________________
TOTAL        3 7 0 1 0
```

and a setting of 10-10-10-l0-10.10 Ω becomes:

```
  10         1 0 0 0 0 0.0
  10           1 0 0 0 0.0
  10             1 0 0 0.0
  10               1 0 0.0
  10                 1 0.0
 .10                   1.0
 ____________________________
TOTAL++      1 1 1 1 1 1.0
```

3.4 Environmental Conditions

For optimal accuracy, the decade box should be used in an environment of 23°C. It should be allowed to stabilize at that temperature after any significant temperature variation.

Humidity should be maintained at laboratory conditions. This is especially important if high resistances are involved.

Chapter 4

MAINTENANCE

4.1 Verification of Performance

4.1.1 Calibration Interval

The **RX** Series instruments should be verified for performance at a calibration interval of twelve (12) months. This procedure may be carried out by the user if a calibration capability is available, by IET Labs, or by a certified calibration laboratory.

If the user should choose to perform this procedure, then the considerations below should be observed.

4.1.2 General Considerations

It is important, whenever testing the **RX** Series Decade Units, to be very aware of the capabilities and limitations of the test instruments used. A resistance bridge may be employed, and there are direct-reading resistance meters or digital multimeters available that can verify the accuracy of these units, especially when used in conjunction with standards that can serve to confirm or improve the accuracy of the testing instrument

Such test instruments must be significantly more accurate than ±(l00ppm+2 mΩ) for all applicable ranges, allowing for a band of uncertainty of the instrument itself. A number of commercial bridges and meters exist that can perform this task; consult IET Labs.

It is important to allow both the testing instrument and the **RX** Decade to stabilize for a number of hours at the nominal operating temperature of 23^{O}C, and at nominal laboratory conditions of humidity. There should be no temperature gradients across the unit under test.

Substantial Kelvin type 4-wire test terminals should be used to obtain accurate low-resistance readings. It is convenient, once the zero resistance has been determined, to subtract it from the remaining measurements. This can be done automatically by many instruments which have an offset subtraction capability.

4.1.3 Initial Procedure

1. Verify that the zero resistance of the unit is <2 mΩ/decade.

2. Determine the allowable upper and lower limits for each resistance setting of each decade based on the specified accuracy. For the **RX** Series, the limits for any resistance "R" are: [R±(0.0001 R + 2 mΩ)].

3. Confirm that the resistances fall within these limits after subtraction of the zero resistance.

4. If any resistances fall outside these limits, the associated resistor or switch assembly will require either trimming or replacement.

   Any decade below 1 Ω/step requires factory service if readings are out-of-tolerance.

4.1.4 Trimming Procedure

1. See Figure 4.1 for the location of trimmers. R1 is always the ordinal value (1 Ω, 10 kΩ, etc.). The R1's of some decades will not require any adjustment; these will not have an associated trimmer.

   All decades are adjusted using the same procedure, and may be done in any order.

2. Set the decade being adjusted to switch position 1, and adjust trimmer R1A to as close to the nominal value as possible, but in any case to within the spec limits calculated above.

3. Set the switch to position **2** and adjust R2A as above.

4. Set the switch to position **4** and adjust R3A.

5. Set the switch to position **6** and adjust R4A.

6. Set the switch to position **8** and adjust R5A.

7. Set the switch to position **10** and adjust R6A.

8. Check the intermediate positions (3, 5, 7 & 9); for optimum results, it may be necessary to "tweak" the previously made adjustments.

9. Adjust all remaining decades using the above procedure.

4.1.5 Repackaging for Shipment

If the instrument is to be returned to IET Labs, contact the Service Department at the number or address, shown on the frontcover of this manual, to obtain a "Returned Material Authorization" (RMA) number and any special shipping instructionsor assistance. Proceed as follows:

1. Attach a tag to the instrument identifying the owner and indicate the service or repair to be accomplished. Include the modelnumber, the full serial number of the instrument, the RMA number, and shipping address.

2. Wrap the instrument in heavy paper or plastic.

3. Protect the front panel and any other protrusions with cardboardor foam padding.

4. Place instrument in original container or equally substantial heavy carton.

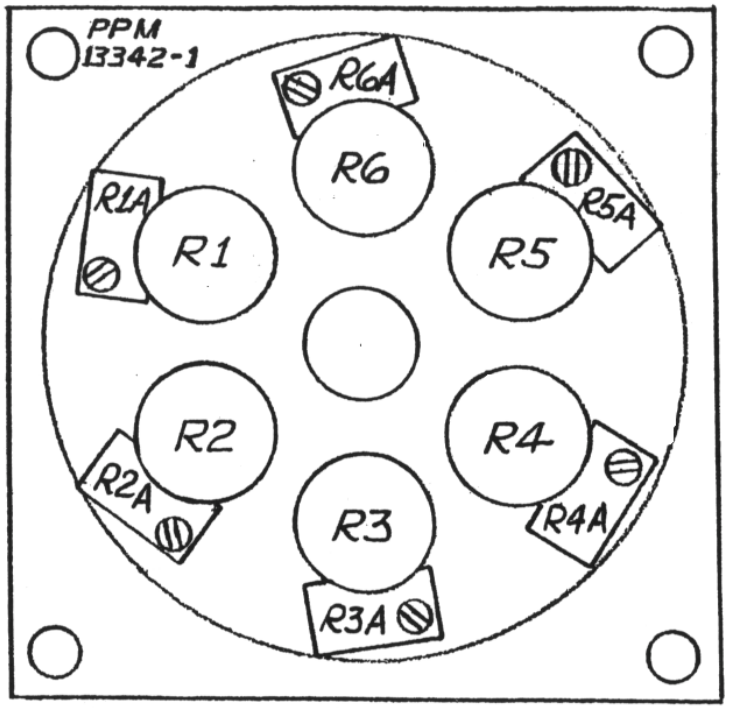
5. Use packing material around all sides of instrument.

6. Seal with strong tape or bands.

7. Mark shipping container "DELICATE INSTRUMENT," "FRAGILE," etc.

4.1.6 Storage

If this instrument is to be stored for any extended period of time, it should be sealed in plastic and stored in a dry location. It should not be exposed to temperatures below -40°C or above +71°C. Relative humidity may be 0 to 100% non-condensing. Extended exposure to temperature extremes can resultin an irreversible change in resistance and would require recalibration.



VIEWED FROM COMPONENT SIDE

Note: R1 is Ordinal Value (1Ω, 10KΩ, etc.)

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SCALE: 2X	APPROVED BY: AJB	DRAWN BY J.L.K.
DATE: 11-27-96		REVISED AB

P/L: SWITCH ASSEMBLY

MODEL S-12

DRAWING NUMBER 13342-3A