

# HRRS SERIES

## High Resistance Decade Substituter User and Service Manual



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◆ PRECISION INSTRUMENTS FOR TEST AND MEASUREMENT ◆



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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.



## 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 High Resistance Decade Substituter (HRRS Series) is a family of instruments offering a broad choice of high range, excellent performance resistance sources (Figure 1.1). High-resistance design is implemented with special resistors, switches, binding posts, and construction-design to allow high resistance performance without sacrificing other electrical properties.

The HRRS Series employs state-of-the-art precision resistors of various types for high accuracy, high stability, and low temperature and voltage coefficients.

The standard models offer a choice of one to seven decades. For custom units, models up to 11 decades are available. The panels are clearly labeled showing the step size and maximum allowable applied input for each decade. Higher voltage models up to >10 kV are also available from IET Labs.

The binding posts are insulated with Kel-F high-resistance, non-moisture-absorbing material ensure low leakage.

With a resolution as low as 10  $\Omega$  and a maximum available resistance of over 1 T $\Omega$  (= 1000 G $\Omega$ ; = 1000 kM $\Omega$ ), the HRRS Series may be used for exacting precision high-value resistance applications. Steps up to 10 T $\Omega$  are also available from IET Labs,

Applications include calibration of meters and megohmmeters, and checking of electrochemical and biomedical sensors and instruments. These instruments are useful wherever small currents and

high resistances are required, such as in testing high-impedance amplifiers and the insulation of low-power circuits.

The HRRS series complements the HARS series which provides resistance steps as low as 1 m $\Omega$ . The units may be rack-mounted to serve as components in measurement and control systems.



**Figure 1-1: HRRS Series High Resistance Decade Substituter**

# 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.

### 2.1 Specifications

Resistance per step	Total decade resistance	Accuracy 18-28°C; <50% RH			Max voltage per step (V)	Maximum voltage (V)	Temperature coefficient (±ppm/°C)	Voltage coefficient (±ppm/V)	Stability (±ppm/yr)	Resistor type
		Q	B	F						
10 Ω	100 Ω	±(0.01%+2 mΩ)	±(0.03%+2 mΩ)	±(0.10%+2 mΩ)	2.5	25	15	-	10	Wirewound, non-inductive
100 Ω	1 kΩ	±(0.01%+2 mΩ)	±(0.03%+2 mΩ)	±(0.10%+2 mΩ)	8	80	5	-	10	
1 kΩ	10 kΩ	±0.01%	±0.03%	±0.10%	23	230	5	-	10	
10 kΩ	100 kΩ	±0.01%	±0.03%	±0.10%	70	700	5	-	10	
100 kΩ	1 MΩ	±0.01%	±0.03%	±0.10%	230	2000	5	-	10	
1 MΩ	10 MΩ	±0.01%	±0.03%	±0.10%	1000**	2000	15	<1	25	Metal-oxide film
10 MΩ	100 MΩ	±0.03%	±0.10%	±1%	1000**	2000	15	<1	50	
100 MΩ	1 GΩ	±0.10%	±0.20%	±1%	2000	2000	15	1	100	High-voltage film
1 GΩ	10 GΩ	±0.20%	±0.50%	±1%	2000	2000	50	1	500	
10 GΩ	100 GΩ	±0.50%	±1%	±1%	2000	2000	50	2	500	
100 GΩ	1 TΩ	See HRRS-5kV Series if these values are required.								
1 TΩ	10 TΩ									

\*\*To apply up to 2000 V for the first step, use the preceding decade at its "10" position. e.g. to obtain 1 MΩ with 2000 V max, set 100 kΩ switch to position "10."

**Zero resistance**

<3 mΩ per decade

**Environmental conditions**

**Operating Conditions:** 10°C to 40°C; <50% RH

**Storage conditions:** -40°C to 70°C

**Terminals**

Two five-way binding posts on 2 special, low-leakage, Kel-F insulating sockets, and one metal ground binding post electrically connected to the case

**Max voltage to case**

2000 V peak

**Mechanical:**

Model	Dimensions	Weight
3 Decade	31.2 cm W x 8.9 cm H x 10.2 cm D (12.3" x 3.5" x 4.0")	1.4 kg (3.0 lb)
4-5 Decade	37.5 cm W x 8.9 cm H x 10.2 cm D (14.8" x 3.5" x 4.0")	1.6 kg (4.0 lb)
6-7 Decade	43.9 cm W x 8.9 cm H x 10.2 cm D (17.3" x 3.5" x 4.0")	2 kg (4.5 lb)
8-9 Decade	48.3 cm W x 17.8 cm H x 19.7 cm D (19.0" x 7.0" x 7.8")	5.1 kg (11 lb)



## 2.2 Ordering Information

Model	Total resistance	Number of decades	Resolution
HRRS-* <b>3-1M</b>	1.11 G $\Omega$	3	1 M $\Omega$
HRRS-* <b>3-10M</b>	11.1 G $\Omega$	3	10 M $\Omega$
HRRS-* <b>3-100M</b>	111 G $\Omega$	3	100 M $\Omega$
HRRS-* <b>4-100k</b>	1.111 G $\Omega$	4	100 k $\Omega$
HRRS-* <b>4-1M</b>	11.11 G $\Omega$	4	1 M $\Omega$
HRRS-* <b>4-10M</b>	111.1 G $\Omega$	4	10 M $\Omega$
HRRS-* <b>5-10k</b>	1.111 1 G $\Omega$	5	10 k $\Omega$
HRRS-* <b>5-100k</b>	11.111 G $\Omega$	5	100 k $\Omega$
HRRS-* <b>5-1M</b>	111.11 G $\Omega$	5	1 M $\Omega$
HRRS-* <b>6-1k</b>	1.111 11 G $\Omega$	6	1 k $\Omega$
HRRS-* <b>6-10k</b>	11.111 1 G $\Omega$	6	10 k $\Omega$
HRRS-* <b>6-100k</b>	111.111 G $\Omega$	6	100 k $\Omega$

Model	Total resistance	Number of decades	Resolution
HRRS-* <b>7-100</b>	1.111 111 G $\Omega$	7	100 $\Omega$
HRRS-* <b>7-1k</b>	11.111 11 G $\Omega$	7	1 k $\Omega$
HRRS-* <b>7-10k</b>	111.111 1 G $\Omega$	7	10 k $\Omega$
HRRS-* <b>8-10</b>	1,111.111 1 M $\Omega$	8	10 $\Omega$
HRRS-* <b>8-100</b>	11.111 111 G $\Omega$	8	100 $\Omega$
HRRS-* <b>8-1k</b>	111.111 11 G $\Omega$	8	1 k $\Omega$
HRRS-* <b>9-10</b>	11,111.111 1 M $\Omega$	9	10 $\Omega$
HRRS-* <b>9-100</b>	111.111 111 G $\Omega$	9	100 $\Omega$

To specify accuracy, replace \* with "Q," "B," or "F" as required

### Options

- RM**: Rack mountable case for standard 19" rack
- K**: Kelvin-type 4-terminal posts
- RO**: Rear output

# HRRS SERIES HIGH-RESISTANCE DECADE SUBSTITUTER OPERATING GUIDE

## CONSULT INSTRUCTION MANUAL FOR PROPER INSTRUMENT OPERATION

Resistance per decade	Total decade resistance	Accuracy 18-28°C: <50% RH			Max voltage per step (V)	Max Voltage (V)	TC (ppm/°C)	VC (ppm/V)	Stability (ppm/Yr)	Resistor Type
		Q	B	F						
10 Ω	100 Ω	±(0.01%+2 mΩ)	±(0.03%+2 mΩ)	±(0.10%+2 mΩ)	2.5	25	15	-	10	Wirewound, non-inductive
1 KΩ	1 KΩ	±(0.01%+2 mΩ)	±(0.03%+2 mΩ)	±(0.10%+2 mΩ)	8	80	5	-	10	
10 KΩ	10 KΩ	±0.01%	±0.03%	±0.10%	23	230	5	-	10	Metal-oxide film
100 KΩ	100 KΩ	±0.01%	±0.03%	±0.10%	70	700	5	-	10	
1 MΩ	1 MΩ	±0.01%	±0.03%	±0.10%	230	2000	5	-	10	High-voltage film
10 MΩ	10 MΩ	±0.01%	±0.03%	±0.10%	1000**	2000	15	<1	25	
100 MΩ	100 MΩ	±0.10%	±0.10%	±1%	1000**	2000	15	<1	50	High-voltage film
1 GΩ	1 GΩ	±0.20%	±0.50%	±1%	1000**	2000	50	1	100	
10 GΩ	100 GΩ	±0.50%	±1%	±1%	1000**	2000	50	2	500	

\*\*To apply up to 2000 V for the first step, use the preceding decade at its "10" position, e.g. to obtain 1 MΩ with 2000 V max, set 100 KΩ switch to position "10."

### WARNING



Observe all safety rules when working with high voltages or line voltages. Connect the (G) terminal 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 switches; c) Post warning signs and keep personnel safely away.



MODEL: HRRS-Q-2-100M  
SN: B2-1306578

Keep unit in a sealed environment when not in use. Maintain binding post area clean for minimum electrical leakage.

**Zero resistance**  
<3 mΩ per decade

#### Terminals

Two five-way binding posts on 2 special, low-leakage, Kel-F insulating sockets, and one metal ground binding post electrically connected to the case

#### Environmental conditions

**Operating conditions:** 10°C to 40°C; <50% RH  
**Storage conditions:** -40°C to 70°C

**Max voltage to case**  
2000 V peak



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HRRS BLBL/01-16-2013

Figure 2-1: HRRS sample label

# 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 Dial Setting

Whenever the dials are used in positions 0-9, the resulting resistance is 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	0
10	1	0	0	0	0
0			0	0	
__10			1	0	
<b>TOT</b>	<b>3</b>	<b>7</b>	<b>0</b>	<b>1</b>	<b>0</b>

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

10	1	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
<b>TOT</b>	<b>1</b>	<b>1</b>	<b>1</b>	<b>1</b>	<b>1.0</b>

### 3.3 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 <50% RH. This is especially important if high resistances are involved.

### 3.4 Storage

If this instrument is to be stored for any lengthy period of time, it should be sealed in plastic and stored in a dry location. It should not be subjected to temperature extremes beyond the specifications. Extended exposure to such temperatures can result in an irreversible change in resistance, and require recalibration.

# Chapter 4

## MAINTENANCE

### 4.1 Maintainability and Reliability

It is possible to maintain Model HRRS indefinitely. It is reliable due to its closed design and sealed switches and resistors. The unit is resistant to electromagnetic interference (EMI) because of its metal enclosure.

### 4.2 Preventive Maintenance

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

The front panel should be periodically 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 Verification of Performance

#### 4.3.1 Calibration Interval

The **HRRS** 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.

#### 4.3.2 General Considerations

It is important, whenever testing the HRRS 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 have a 4:1 TUR capability for each value calibrated. Note that the accuracy varies for different decades. 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 HRRS Substituter to stabilize for a number of hours at the nominal operating temperature of 23°C, and at nominal laboratory conditions of humidity. There should be no temperature gradients across the unit under test.

**⚠ WARNING ⚠**

**Connect the G (GND) terminal to earth or other suitable 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.**

**Use maximum insulation and minimize the use of bare conductors.**

**REMOVE POWER WHEN ADJUSTING SWITCHES.**

**Post warning signs and keep personnel safely away.**

**4.3.3 Calibration Procedure**

To calibrate the HRRS unit, proceed as follows

1. Confirm that the leakage resistance between either binding post and the case ground is  $>10^{13}\Omega$ .  
*If this is not obtained, clean the area around the binding posts as described in Section 4.2.*
2. Confirm the zero resistance of the unit.
3. Determine the allowable upper and lower limits for each resistance setting of each decade based on the specified accuracy (See Specifications on Page 2).
4. Confirm that the resistances fall within these limits after subtraction of the zero resistance.  
*If any resistances fall outside thee limits, the associated switch assembly may require service or replacement.*

**4.4 Schematic**

Refer to Figure 4-2 for a schematic of the HRRS unit.

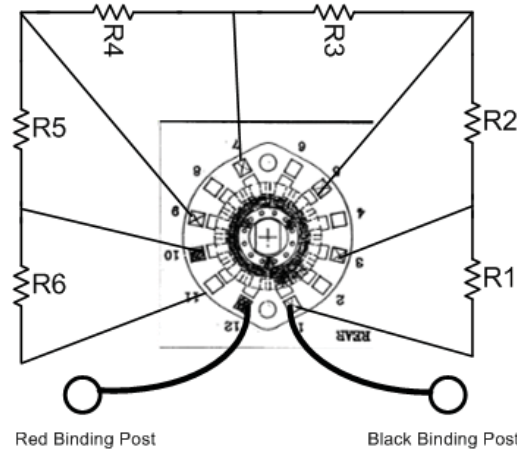


Figure 4-1: Resistor Position on HRRS Switch

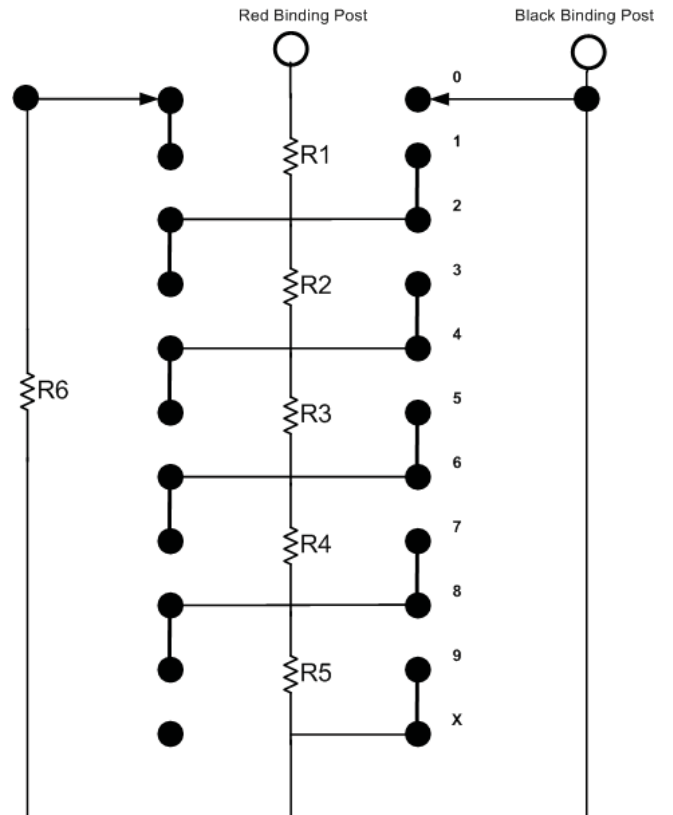


Figure 4-2: HRRS Schematic Single Decade

### 4.5 Replaceable Parts

Model Ref	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
4	HARS-X-4300-KNB	Knob Assembly
Not Shown	HARS-X-3100	Foot
Not Shown	HRRS-*-SW-10	10 Ω/step Decade Switch Assembly
Not Shown	HRRS-*-SW-100	100 Ω/step Decade Switch Assembly
Not Shown	HRRS-*-SW-1k	1 kΩ/step Decade Switch Assembly
Not Shown	HRRS-*-SW-10k	10 kΩ/step Decade Switch Assembly
Not Shown	HRRS-*-SW-100k	100 kΩ/step Decade Switch Assembly
Not Shown	HRRS-*-SW-1M	1 MΩ/step Decade Switch Assembly
Not Shown	HRRS-*-SW-10M	10 MΩ/step Decade Switch Assembly
Not Shown	HRRS-*-SW-100M	100 MΩ/step Decade Switch Assembly
Not Shown	HRRS-*-SW-1G	1 GΩ/step Decade Switch Assembly
Not Shown	HRRS-*-SW-10G	10 GΩ/step Decade Switch Assembly

To specify accuracy, replace \* with "Q," "B," or "F" as required

**Table 4-1: Replaceable Parts**



**Figure 4-2: Replaceable Parts**

