♦ PRECISION INSTRUMENTS FOR TEST AND MEASUREMENT ♦

HRRS 5kV AND 10kV SERIES

High Resistance, 5kV and 10kV Decade Substituter

User and Service Manual

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HRRS 5kV and 10kV im/May 2025

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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.

Revision History	
Revision	**Description**
November 2017	Initial release
February 2021	new pictures and reference to shielding when in use
August 2023	Clarify Accuracy specifications
April 2024	added 1 Ω specifications
April 2025	“F” version obsolete

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 HRRS complies with EN 60477.

If an instrument is marked CAT I (IEC Measurement Category I), or it is not marked with a measurement category, its measurement terminals must not be connected to line-voltage mains.

The HRRS 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".

GROUND THE INSTRUMENT
This is a Safety Class I instrument. To minimize shock hazard, the instrument chassis and cabinet must be connected to an electrical ground. The power terminal and the power cable must meet International Electrotechnical Commission (IEC) safety standards.

SAFETY PRECAUTIONS CONTINUED

CAUTION

- 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.

Do not apply any voltage or currents to the terminals of the instrument in excess of the maximum limits indicated in the specifications section of this manual.

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.

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.

Disposal

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

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Chapter 1
INTRODUCTION

1.1 Overview

The High Resistance, 5kV and 10 kV Decade Substituters (Figure 1-1 and Figure 1-2) is a family of instruments that answers the need of the calibration and test community for decades and working standards that go up to 10 TΩ, offering a broad choice of high-range, excellent performance resistance sources. High values of resistance are available for use at high voltages, without sacrificing accuracy, stability, and temperature and power coefficients of resistance.

The HRRS-5kV/HRRS-10kV units employ state-of-the-art precision resistors. They are designed specifically for operation at high voltage, with very low leakage to minimize degradation of accuracy.

The standard models offer a choice of one to nine decades. The panels are clearly labeled showing the step size and maximum allowable applied input for each decade. Custom requirements outside of the standard models can be satisfied.

To ensure low leakage, the connection terminals are insulated with Kel-F high-resistance, non-moisture-absorbing material.

With a resolution as low as 10 Ω and a maximum available resistance of 10 TΩ, these High-Resistance, High-Voltage units may be used for exacting precision high-value resistance applications that require voltages of up to 5kV or 10 kV.

Applications include calibration of meters and megohmmeters, and checking of electrochemical and biomedical sensors and instruments. These instruments are useful wherever high resistances are required, such as in testing high-impedance amplifiers and the insulation of low-power circuits.

The HRRS 5kV and 10kV series complement the HARS series which provides resistance steps as low as 1 mΩ. The units may be rack-mounted to serve as components in measurement and control systems.

Figure 1-1: Example of an HRRS-5kV unit with 7 decades

Figure 1-2: Example of an HRRS-10kV unit with 4 decades

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			HRRS-5kV		HRRS-10kV		Temperature coefficient (±ppm/°C)	Voltage coefficient (±ppm/V)	Stability (±ppm/ yr)	Resistor type
		Q	B	F Obsolete 2025	Max voltage per step (V)	Maximum voltage (V)	Max voltage per step (V)	Maximum voltage (V)				
1 Ω	10 Ω	±(0.01%+2 mΩ)	±(0.03%+2 mΩ)	±(0.10%+2 mΩ)	2.5	25	2.5	25	20	-	20	Wirewound, non-inductive
10 Ω	100 Ω	±(0.01%+2 mΩ)	±(0.03%+2 mΩ)	±(0.10%+2 mΩ)	2.5	25	2.5	25	15	-	10	
100 Ω	1 kΩ	±(0.01%+2 mΩ	±(0.03%+2 mΩ)	±(0.10%+2 mΩ)	8	80	8	80	5	-	10	
1 kΩ	10 kΩ	±0.01%	±0.03%	±0.10%	23	230	23	230	5	-	10	
10 kΩ	100 kΩ	±0.01%	±0.03%	±0.10%	70	700	70	700	5	-	10	
100 kΩ	1 MΩ	±0.01%	±0.03%	±0.10%	230	2300	230	2300	5	-	10	
1 MΩ	10 MΩ	±0.01%	±0.03%	±0.10%	1000	5000	1000	10,000	15	<1	25	
10 MΩ	100 MΩ	±0.03%	±0.10%	±1%	5000	5000	5000 (*10,000)	10,000	25	<1	50	High-voltage film
100 MΩ	1 GΩ	±0.10%	±0.20%	±1%	5000	5000	10,000	10,000	25	1	100	
1 GΩ	10 GΩ	±0.20%	±0.50%	±1%	5000	5000	10,000	10,000	25	1	500	
10 GΩ	100 GΩ	±0.50%	±1%	±1%	5000	5000	10,000	10,000	25	2	500	
100 GΩ	1 TΩ	±0.50%	±1%	±1%	5000	5000	10,000	10,000	100	5	500	
1 TΩ	10 TΩ	±3%	±5%	±10%	5000	5000	10,000	10,000	300	<20 (10 ppm typical)	500	

**To apply up to 10 kV at 10 MΩ, set the 1 MΩ decade to its "10" position.*

*** Tested at low voltages except >10 MΩ at ≤ 200 V (Fluke 8508A HiV mode), ≥ 100 MΩ at 1000 V and > 60 sec dwell*

Zero resistance:

<10 mΩ per decade

Environmental conditions:

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

Storage conditions: -40°C to 70°C

Terminals:

3 five-way binding posts on a low-leakage Kel-F plate, and one metal ground binding post electrically connected to the case or front panel for -WT

Mechanical:

Model	Dimensions (behind panel)	Weight (nominal)
3-4 Decade Benchtop	43.2 cm W x 13.33 cm H x 13.46 cm D (17" x 5.25" x 5.3")	3.4 kg (7.5 lbs)
5-6-7 Decade Benchtop	48.3 cm W x 22.2 cm H x 16.38 cm D (19" x 8.75" x 6.45")	7.7 kg (17 lbs)
8-9 Decade Benchtop	43.2 cm W x 31 cm H x 16.38 cm D (17" x 12.25" x 6.45")	7.7 kg (17 lbs)
3-4 Decade Rack mount	48.3 cm W x 13.33 cm H x 13.46 cm D (19" x 5.25" x 5.3")	3.4 kg (7.5 lbs)
5 to 9 Decade Rack mount	48.3 cm W x 31 cm H x 16.38 cm D (19" x 12.25" x 6.45")	7.7 kg (17 lbs)
-WT Case	50.2 cm W x 40 D x 18.8 H (19.78" x 15.77" x 7.41")	9.1 kg (20 lbs)

2.2 Ordering Information

Model	Total resistance	Number of decades	Resolution
HRRS-*-3-10k-**	11.1 MΩ	3	10 kΩ
HRRS-*-3-100k-**	111 MΩ	3	100 kΩ
HRRS-*-3-1M-**	1.11 GΩ	3	1 MΩ
HRRS-*-3-10M-**	11.1 GΩ	3	10 MΩ
HRRS-*-3-100M-**	111 GΩ	3	100 MΩ
HRRS-*-3-1G--WT**	1.11 TΩ	3	1 GΩ
HRRS-*-3-10G--WT**	11.1 TΩ	3	10 GΩ
HRRS-*-4-1k-**	11.11 MΩ	4	1 kΩ
HRRS-*-4-10k-**	111.1 MΩ	4	10 kΩ
HRRS-*-4-100k-**	1.111 GΩ	4	100 kΩ
HRRS-*-4-1M-**	11.11 GΩ	4	1 MΩ
HRRS-*-4-10M-**	111.1 GΩ	4	10 MΩ
HRRS-*-4-100M--WT**	1.111 TΩ	4	100 MΩ
HRRS-*-4-1G--WT**	11.11 TΩ	4	1 GΩ
HRRS-*-5-100-**	11.111 MΩ	5	100 Ω
HRRS-*-5-1k-**	111.11 MΩ	5	1 kΩ
HRRS-*-5-10k-**	1.111 1 GΩ	5	10 kΩ
HRRS-*-5-100k-**	11.111 GΩ	5	100 kΩ
HRRS-*-5-1M-**	111.11 GΩ	5	1 MΩ
HRRS-*-5-10M--WT**	1.111 1 TΩ	5	10 MΩ
HRRS-*-5-100M--WT**	11.111 TΩ	5	100 MΩ
HRRS-*-6-10-**	11.111 1 MΩ	6	10 Ω
HRRS-*-6-100-**	111.111 MΩ	6	100 Ω
HRRS-*-6-1k-**	1.111 11 GΩ	6	1 kΩ
HRRS-*-6-10k-**	11.111 1 GΩ	6	10 kΩ
HRRS-*-6-100k-**	111.111 GΩ	6	100 kΩ
HRRS-*-6-1M--WT**	1.111 11 TΩ	6	1 MΩ
HRRS-*-6-10M--WT**	11.111 1 TΩ	6	10 MΩ

Model	Total resistance	Number of decades	Resolution
HRRS-*-7-10-**	111.111 1 MΩ	7	10 Ω
HRRS-*-7-100-**	1.111 111 GΩ	7	100 Ω
HRRS-*-7-1k-**	11.111 11 GΩ	7	1 kΩ
HRRS-*-7-10k-**	111.111 1 GΩ	7	10 kΩ
HRRS-*-7-100k--WT**	1.111 111 TΩ	7	100 kΩ
HRRS-*-7-1M--WT**	11.111 11 TΩ	7	1 MΩ
HRRS-*-8-10-**	1,111.111 1 MΩ	8	10 Ω
HRRS-*-8-100-**	11.111 111 GΩ	8	100 Ω
HRRS-*-8-1k-**	111.111 11 GΩ	8	1 kΩ
HRRS-*-8-10k--WT**	1.111 111 1TΩ	8	10 kΩ
HRRS-*-8-100k--WT**	11.111 111 1 TΩ	8	100 kΩ
HRRS-*-9-10-**	11.111 111 1 GΩ	9	10 Ω
HRRS-*-9-100-**	111.111 111 GΩ	9	100 Ω
HRRS-*-9-1k--WT**	1.111 111 11 TΩ	9	1 kΩ
HRRS-*-9-10k--WT**	11.111 111 1 TΩ	9	10 kΩ

**To specify accuracy grade, replace * with "Q," or "B," as required.*

***To specify voltage, replace ** with either "5kV" or "10kV."*
Remove -WT to specify metal housing. (not recommended for humid environments)

Options

-WT Watertight case

-RM: Rack mountable case for standard 19" rack

Note -WT and -RM are mutually exclusive

HRRS-5kV SERIES HIGH-RESISTANCE, 5kV DECADE SUBSTITUTER OPERATING GUIDE

CONSULT INSTRUCTION MANUAL FOR PROPER INSTRUMENT OPERATION

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	0	10	Wirewound, non-inductive
100 Ω	1 kΩ	±(0.01%+2 mΩ	±(0.03%+2 mΩ)	±(0.10%+2 mΩ)	8	80	5	0	10	
1 kΩ	10 kΩ	±0.01%	±0.03%	±0.10%	23	230	5	0	10	
10 kΩ	100 kΩ	±0.01%	±0.03%	±0.10%	70	700	5	0	10	
100 kΩ	1 MΩ	±0.01%	±0.03%	±0.10%	230	2300	5	0	10	
1 MΩ	10 MΩ	±0.01%	±0.03%	±0.10%	1000	5000	15	0.2	25	
10 MΩ	100 MΩ	±0.03%	±0.10%	±1%	5000	5000	25	<1	50	High-voltage film
100 MΩ	1 GΩ	±0.10%	±0.20%	±1%	5000	5000	25	1	100	
1 GΩ	10 GΩ	±0.20%	±0.50%	±1%	5000	5000	25	1	500	
10 GΩ	100 GΩ	±0.50%	±1%	±1%	5000	5000	25	1	500	
100 GΩ	1 TΩ	±0.50%	±1%	±1%	5000	5000	100	2	500	
1 TΩ	10 TΩ	±3%	±5%	±10%	5000	5000	300	<20 (10 ppm typical)	500	

Tested at low voltages except 10 MΩ at 20 V, 1 GΩ at 100 V, ≥10 GΩ at 1000 V

Zero resistance:
<10 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

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

MODEL: HRRS-B-9-1K-5kV SN: C1-1250517

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.

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HRRS-5kV lbl/01-17-2013

Figure 2-1: Typical operating guide

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.

It is important to note that for resistance settings > 10 MΩ measurement is taken after 60 seconds. Use of auto-reversing or short measurement times will result in a low resistance measurement which maybe out of specification.

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
 10          1 0 0 0
  0            0 0
 10            1 0
-----------------------
TOT          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
-----------------------
TOT       1 1 1 1 1 1.0
```

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 for 24 hours after any significant temperature variation.

Temperature coefficients are listed and can be used for temperatures other than 23°C.

Humidity should be maintained at <50% RH. This is especially important if high resistances above 1 GΩ are involved. Prolonged expose to high humidity can cause electrical leakage. This leakage causes the resistance to be lower than the calibrated value.

The -WT version utilizes a watertight case to minimize effect of humidity when the case is closed. The case should be kept closed when not in use.

3.4 Electromagnetic Interference

The HRRS series are resistant to electromagnetic interference (EMI) because of their metal enclosure except for the -WT version.

EMI can be a significant source of error when measuring high resistance values.

The green GND binding post on all HRRS Decade Resistors should be connected to earth ground to minimize errors due to EMI.

Figure 3-1: HRRS-WT in faraday enclosure

3.5 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 models HRRS-5kV and HRRS-10kV indefinitely. They are reliable due to their closed design and sealed switches and resistors.

The units are resistant to electromagnetic interference (EMI) because of their metal enclosure with the exception of the -WT version.

4.2 Preventive Maintenance and Cleaning

Keep the units 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.

No other maintenance is required.

4.3 Verification of Performance

4.3.1 Calibration Interval

The HRRS 5kV and 10kV 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 5kV and 10kV Series units, to be 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-5kV/10kV 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 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 SETTING SWITCHES.

Post warning signs and keep personnel safely away.

4.3.3 Calibration Procedure

To calibrate the HRRS-5kV/10kV unit, proceed as follows

1. Confirm that the leakage resistance between either binding post and the case ground is $>10^6$ times the highest unit resistance, but may be as low at 1 TΩ.
   If this is not obtained, clean the area around the binding posts as described in Section 4.2.
2. Determine the allowable upper and lower limits for each resistance setting of each decade based on the specified accuracy (See Specifications on page 2).
3. Confirm that the resistances fall within these limits.
   If any resistances fall outside thee limits, the associated switch assembly may require service or replacement.

4.4 Schematic

Figure 4-1 shows a schematic of an HRRS-5kV/10kV unit.

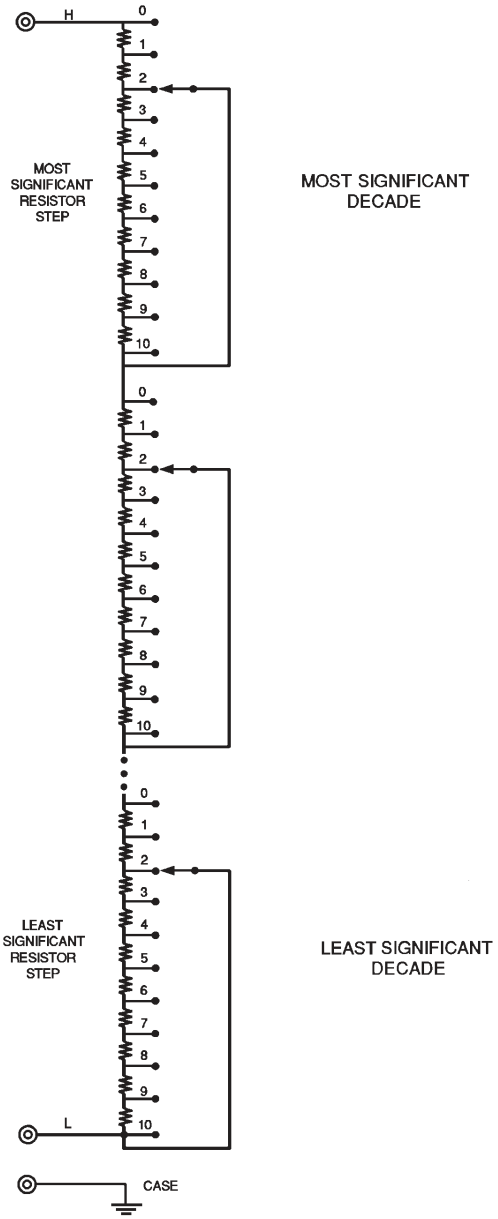

Figure 4-1: HRRS 5kV and 10kV Series Schematic Diagram

4.5 Replaceable Parts

Model Ref	IET part number	Description
1	BP-1000-RD	Binding Post, Red
2	BP-1000-BK	Binding Post, Black
3	BP-1000-BL	Binding Post, Blue
4	BP-1000-GN	Binding Post, Green
5	HARS-X-4300-KNB	Knob Assembly
Not Shown	HARS-X-3100	Foot
Not Shown	HRRS-*-SW-1-**	1 Ω/step Decade Switch Assembly
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
Not Shown	HRRS-*-SW-100G-**	100 GΩ/step Decade Switch Assembly
Not Shown	HRRS-*-SW-1T-**	1 TΩ/step Decade Switch Assembly

**To specify accuracy grade, replace * with "Q," "B," or "F" as required.*
***To specify voltage, replace ** with either "5kV" or "10kV."*

Table 4-1: Replaceable Parts

Figure 4-2: Replaceable Parts