♦ PRECISION INSTRUMENTS FOR TEST AND MEASUREMENT ♦

HRRS-10kV SERIES

High Resistance
10 kV Decade Substituter
User and Service Manual

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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.

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 qulified 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.

Contents

Figures

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Chapter 1

INTRODUCTION

The High Resistance 10 kV Decade Substituter (**HRRS-10kV** Series), Figure 1.1, 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 (1 TΩ=1000 GΩ=1000 kMΩ) and higher, offering a broad choice of high range, excellent performance resistance sources. It is based on the IET HRRS series with the extended capability for operating at up to 10 kV (higher voltages are available). High values of resistance are available for use at high voltages, without sacrificing accuracy, stability, and temperature and power coefficients of resistance.

The HRRS-10kV Series employs state-of-the-art precision resistors of various types as suited to each decade. It is 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 ten decades. The panels are clearly labeled showing the step size and maximum voltage limitations for each decade. Custom requirements outside of the standard models can be satisfied.

The unit employs special high voltage, low leakage switches. The binding posts are insulated with Kel-F high resistance hydrophobic (non-moisture absorbing) material to assure that no significant leakage occurs between them.

A guard terminal is provided; it may be used to reduce internal leakage to the body of the switches.

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

The HRRS-10kV series complements 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. Figures 1.1 and 1.2 shows two of the possible configurations.

Figure 1.1. HRRS-10kV Series Single decade High Resistance Decade Substituter

Figure 1.2. HRRS-10kV Series 7-decade High Resistance Decade Substituter

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Chapter 2

SPECIFICATIONS

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

SPECIFICATIONS

Decade Resistance	Resistance per step	Accuracy Option			Max Voltage (whichever applies first)	Maximum Voltage	Temp. Coefficient ±ppm/°C	Voltage Coefficient ±ppm/V	Stability ±ppm/year
		Q	B	F					
100 Ω	10 Ω	±0.01%	±0.03%	±0.1%	2.5 V	25 V	15	0	10
1 kΩ	100 Ω	±0.01%	±0.03%	±0.1%	8 V	80 V	5	0	10
10 kΩ	1 kΩ	±0.01%	±0.03%	±0.1%	23V	230 V	5	0	10
100 kΩ	10 kΩ	±0.01%	±0.03%	±0.1%	70 V	700 V	5	0	10
1 MΩ	100 kΩ	±0.01%	±0.03%	±0.1%	230 V	2000 V	5	0	10
10 MΩ	1 MΩ	±0.03%	±0.1%	±0.5%	1000 V	10000 V	15	0.2	10
100 MΩ	10 MΩ	±0.03%	±0.1%	±1%	5000 V	10000 V	15	0.2	25
1 GΩ	100 MΩ	±0.1%	±0.2%	±1%	10000 V	10000 V	25	1.5	100
10 GΩ	1 GΩ	±0.2%	±0.5%	±1%	10000 V	10000 V	25	5	500
100 GΩ	10 GΩ	±0.5%	±1%	±1%	10000 V	10000 V	25	5	500
1 TΩ	100 GΩ	±0.5%	±1%	±1%	10000 V	10000 V	200	5	500
10 TΩ	1 TΩ	±3-5%	±5-10%	±5-10%	10000 V	10000 V	200	5	500
100 TΩ	10 TΩ	±10%	±20%	±20%	10000 V	10000 V	350	50	2000

Zero Resistance: <3 mΩ per decade at dc.

Operating Conditions: 10°C to 23°C; <50% RH.

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

Setting of value:

Standard: 11 positions, "0"-"10"; silver contacts, high voltage switch.

Binding Posts (optional): units use binding posts and shorting links in lieu of rotary switches to set resistance values.

Dimensions: 43.2 cm W x 14.2 cm H x 13.5 cm D (17" x 5.6" x 5.3") for 3 and 4 decades.

48.2 cm W x 22.2 cm H x 33 cm D (19" x 8.75 " x 13") for 7, 8 and 9 decades.

48.2 cm W x 30.1 cm H x 21.6 cm D (19" x 12.2" x 8.5") for 10 and 11 decades.

ORDERING INFORMATION

Model*	Total Resistance (Ω)	No. of Decades	Resolution (Ω)
HRRS-B-1G-10kV	10 G	1	1 G
HRRS-B-1-10G-10kV	100 G	1	10 G
HRRS-F-1-100G-10kV	1 T	1	100 G
HRRS-K-1-10T-10kV	100 T	1	1 T
HRRS-B-2-1M-10kV	110 M	2	1 M
HRRS-B-2-10M-10kV	1.1 G	2	10 M
HRRS-B-2-100M-10kV	11 G	2	100 M
HRRS-B-2-1G-10kV	110 G	2	1 G
HRRS-B-2-10G-10kV	1.1 T	2	10 G
HRRS-B-2-100G-10kV	11.1 T	2	100 G
HRRS-B-3-100K-10kV	111 M	3	100 k
HRRS-B-3-1M-10kV	1.11 G	3	1 M
HRRS-B-3-10M-10kV	11.1 G	3	10 M
HRRS-B-3-100M-10kV	111 G	3	100 M
HRRS-B-3-1G-10kV	1.11 T	3	1 G
HRRS-B-3-10G-10kV	11.1 T	3	10 G
HRRS-B-4-10K-10kV	111.1 M	4	10 k
HRRS-B-4-100K-10kV	1.111 G	4	100 k
HRRS-B-4-1M-10kV	11.11 G	4	1 M
HRRS-B-4-10M-10kV	111.1 G	4	10 M
HRRS-B-4-100M-10kV	1.111 T	4	100 M
HRRS-B-4-1G-10kV	11.11 T	4	1 G
HRRS-B-5-1K-10kV	111.11 M	5	1 k
HRRS-B-5-10K-10kV	1.111 1 G	5	10 k
HRRS-B-5-100K-10kV	11.111 G	5	100 k
HRRS-B-5-1M-10kV	111.11 G	5	1 M
HRRS-B-5-10M-10kV	1.111 1 T	5	10 M
HRRS-B-5-100M-10kV	11.111 T	5	100 M

Model*	Total Resistance (Ω)	No. of Decades	Resolution (Ω)
HRRS-B-6-10-10kV	11.111 1 M	6	10
HRRS-B-6-100-10kV	111.111 M	6	100
HRRS-B-6-1K-10kV	1.111 11 G	6	1 k
HRRS-B-6-10K-10kV	11.111 1 G	6	10 k
HRRS-B-6-100K-10kV	111.111 G	6	100 k
HRRS-B-6-1M-10kV	1.111 11 T	6	1 M
HRRS-B-6-10M-10kV	11.111 1 T	6	10 M
HRRS-B-7-10-10kV	111.111 1 M	7	10
HRRS-B-7-100-10kV	1.111 111 G	7	100
HRRS-B-7-1K-10kV	11.111 11 G	7	1 k
HRRS-B-7-10K-10kV	111.111 1 G	7	10 k
HRRS-B-7-100K-10kV	1.111 111 T	7	100 k
HRRS-B-7-1M-10kV	11.111 11T	7	1 M
HRRS-B-8-1-10kV	111.111 11M	8	1
HRRS-B-8-10-10kV	1.111 111 1 G	8	10
HRRS-B-8-100-10kV	11.111 111 G	8	100
HRRS-B-8-1K-10kV	111.111 11 G	8	1 K
HRRS-B-8-10K-10kV	1.111 111 1 T	8	10 K
HRRS-B-8-100K-10kV	11.111 111 T	8	100 K
HRRS-B-9-0.1-10kV	111.111 111 M	9	0.1
HRRS-B-9-1-10kV	1.111 111 11G	9	1
HRRS-B-9-10-10kV	11.111 111 1 G	9	10
HRRS-B-9-100-10kV	111.111 111 G	9	100
HRRS-B-9-1K-10kV(0.6T)	1.111 111 1 T	9	1 k
HRRS-B-9-1K-10kV	1.111 111 1 T	9	1 k
HRRS-B-9-10K-10kV	11.111 111 1 T	9	10 K

***** Replace "**B**" with "**Q**" for higher grade accuracy; replace "**B**" with "**F**" for 1% accuracy.

Single Decade Version See HARS-X data sheet (p. 16)

OPTIONS:

- **RM** Rack mountable case for standard 19" rack
- **K** Kelvin type 4-terminal binding posts
- **RO** Rear outputs
- **BP** Binding posts in lieu of rotary switches

HRRS-10 kV SERIES High Voltage High Resistance Decade Substituter Operating Guide

Decade Resistance	Resistance per step	Accuracy Option**			Max Voltage* per step	Maximum* Voltage	Temp. Coefficient ±ppm/°C	Voltage Coefficient ±ppm/V	Stability ±ppm/year
		Q	B	F					
100 Ω	10 Ω	±0.01%	±0.03%	±0.1%	2.5 V		15	0	10
1 kΩ	100 Ω	±0.01%	±0.03%	±0.1%	8 V		5	0	10
10 kΩ	1 kΩ	±0.01%	±0.03%	±0.1%	23V		5	0	10
100 kΩ	10 kΩ	±0.01%	±0.03%	±0.1%	70 V		5	0	10
1 MΩ	100 kΩ	±0.01%	±0.03%	±0.1%	230 V		5	0	10
10 MΩ	1 MΩ	±0.03%	±0.1%	±0.5%	1000 V	1000 V	15	0.2	10
100 MΩ	10 MΩ	±0.03%	±0.1%	±1%	5000 V	10000 V	15	0.2	25
1 GΩ	100 MΩ	±0.1%	±0.2%	±1%	10000 V	10000 V	25	1.5	100
10 GΩ	1 GΩ	±0.2%	±0.5%	±1%	10000 V	10000 V	25	5	500
100 GΩ	10 GΩ	±0.5%	±1%	±1%	10000 V	10000 V	25	5	500
1 TΩ	100 GΩ	±0.5%	±1%	±1%	10000 V	10000 V	200	5	500
10 TΩ	1 TΩ	±3-5%	±5-10%	±5-10%	10000 V	10000 V	200	5	500
100 TΩ	10 TΩ	±10%	±20%	±20%	10000 V	10000 V	350	50	2000

*Subject to maximum of 10000 V (dc + ac peak)

Resistor Type: Wirewound non-inductive for 0.1 MΩ steps and under; precious metal-oxide film resistors for 1, 10, and 100 MΩ steps; laboratory grade precision high voltage film resistors for 1 GΩ steps and over.

Zero Resistance: 3 mΩ per decade, typical at dc.

Operating Conditions: +10°C to +40°C; 0 to 50% RH.

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

MODEL: HRRS-Q-1-1T-10kV SN: B2-0731119

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 10kV label/p1/HRRS 10kV genl/8-21-07;85%

Figure 2.1. Typical Operating Guide affixed to unit

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Chapter 3

INSTALLATION

3.1 Initial Inspection

IET instruments receive a careful mechanical and electrical inspection before shipment. Upon receipt, verify that the contents are intact and as ordered. The instrument should also be given a visual and operational inspection.

If any shipping damage is found, contact the carrier and IET Labs. If any operational problems are encountered, contact IET Labs and refer to the warranty at the beginning of this manual. IET Labs will work with you until you are satisfied that your instrument is operating to fulfill the needs of your applications.

Save all original packing material for convenience, in case shipping of the instrument should become necessary.

3.2 Installation

For a rack-mount model, installation on a 19 inch rack may be made using the slots in the rack mounting ears. A mounting location that does not expose the unit to excessive heat contamination, or dust is recommended.

For bench models, no installation is required, because this instrument series is not powered. Since it is a high accuracy instrument, provide a bench space that will not expose it to abuse, contamination, or dust, and will keep it protected from temperature extremes.

For all high resistance instruments, it is highly recommended that they be stored in sealed containers or any other well sealed environment to minimize any contamination that would lead to electrical leakage and degradation of performance. Low or controlled humidity is recommended.

Minimize handling of the binding post area and especially the Kel-F insulating washers.

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

3.3 Repackaging for Shipment

If the instrument is to be returned to IET Labs, contact the Service Department, using the contact information shown on the front cover of this manual, to obtain a "Returned Material Authorization" (RMA) number and any special shipping instructions or 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 model number, 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 cardboard or 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...

3.4 Storage

If this instrument is to be stored for any lengthy period of time, it should be placed in a sealed container with desiccant, 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

OPERATION

4.1. Connection

4.1.1 General Considerations

The HRRS-10kV Series Decade unit provides four terminals labeled **H** (high), **L** (low), **GUARD** and **GROUND**. The **H** and **L** terminals are connected to the ends of the resistor being set. The **G** terminal is connected to the case. The **GUARD** terminal is connected to the metal internal switch body which acts as a partial cage to short circuit leakage to the guard circuit provided by the user. This functions by providing an active zero voltage to "short circuit" any leakage current. The **GROUND** terminal is connected to the case of the unit and may be used as a shield.

There are a number of ways to connect the test instrument to the resistance decade. Frequently, it is only necessary to connect to the two resistance terminals. The guard terminal is used to minimize errors from leakage current at high resistance, so its use will depend on the value of the resistance being used. The ground terminal is used to shield the unit from external interference. Depending on the instrument being used, better results may be obtained by shorting either the Low or High terminal to Ground.

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 test instrument impedance. This lead should be connected to the HRRS terminal that is shorted to the case, or to the **L** terminal whenever neither is connected to the case, i.e. the more protected one of the two HRRS terminals.

4.1.2 Electrical Considerations

To make proper use of the full performance capabilities of the HRRS unit, care should be taken to obtain good results with the very high resistance values involved.

Whenever possible, shielding should be employed. The case itself can be grounded using the **G** terminal, and shielded cables to the other terminals should be employed.

Because of the high resistances involved, leakage from all sources should be kept to a minimum. The ambient humidity should be under 50% RH. Also, the instrument should be kept clean, and should not be handled at the terminals. Any contamination could act as a leakage across the device resistance. The unit may be cleaned with alcohol.

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

Since high resistance applications are invariably associated with high voltages, it is important to observe all precautions and safety rules.

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.

4.2 Dial Setting

Whenever the dials are used for positions 0-9, the resulting resistance is simply read off from the panel dial setting in a direct fashion. 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 any 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 MΩ becomes:

3	30000
6	6000
10	1000
0	00
10	10
TOTAL	37010

and 10-10-10-10.-10 MΩs become

10	1000000.0
10	100000.0
10	10000.0
10	1000.0
10	100.0
.10	1.0
TOTAL	1111111.0

4.3 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 at least two hours after any significant temperature variation. Humidity should be maintained <50% RH.

Chapter 5

Maintenance

5.1 Preventive Maintenance

Keep the HRRS-10kV Decade Substituter in a clean, air-conditioned environment. This will ensure that the unit will seldom require cleaning. The unit is packaged in a closed case which will also help prevent contamination.

Keep unit in a closed container when not in use.

Do not touch the binding posts with bare hands. This will minimize the possibility of shunt leakage across the internal resistors. Clean the binding posts regularly with alcohol or naphtha. Do not use any cleaners or solvents which can leave a residue.

Do not open the case of the unit. This will help maintain optimal accuracy and stability. If you need to open the unit, handle the internal components with gloves.

In normal service, the switches do not require additional lubrication. IET applies light lubrication on the switches. This lubrication is usually sufficient for the life of the switches, and it helps protect switches from collecting dust.

5.2 Verification of Performance

5.2.1 Calibration Interval

Calibrate the HRRS-5kV unit every twelve (12) months. Calibration procedure can be performed by any of the following:

- Your laboratory (if a proper facility is available)
- IET Labs
- Certified calibration laboratory

5.3 General Considerations for Calibration

If you choose to calibrate the unit yourself, observe the following procedure.

Be aware of the capabilities and limitations of the test instruments. To confirm the accuracy of your test instruments, use **bridges**, **direct reading resistance meters**, or **digital meters**. If you use these together with **standards**, you can further improve the accuracy of your testing equipment.

Test instruments must be *sufficiently* more accurate than the specified accuracies on HRRS-10kV. Such instruments are available. Consult IET for more information.

Before you begin the calibration procedure, stabilize the HRRS-10kV. Keep it for at least eight (8) hours at 23°C and nominal laboratory humidity. There should be no temperature gradients across the unit under test.

Follow proper metrology practices during calibration.

5.3.1 Calibration Procedure

1. Confirm the zero resistance of the unit.

2. Determine the allowable upper and lower limits for each resistance setting of each decade following the specified accuracy given in the Specifications Section of Chapter 2.

3. Confirm that the resistances fall within these limits.

4. If any resistances fall outside these limits, the associated switch assembly should be repaired or replaced. Refer to the Parts List below for the appropriate part number.

5.4 Schematic and Replacement Parts

If you choose to repair the unit yourself, follow the procedure below.

For a schematic of the HRRS-10kV decade unit, refer to Figure 5.1.

To locate the replacement parts use Table 5.2 and Figure 5.2.

For assembly instructions refer to Section 5.6.

5.5 Troubleshooting

If the calibration procedure results in a failure, use the schematic of Figure 5.1 to find the problem. In a clean environment, and using gloves, disassemble the unit as described below, and examine the parts in question to determine the necessary repair or replacement.

Figure 5.1: Schematic Diagram for HRRS-10kV Series

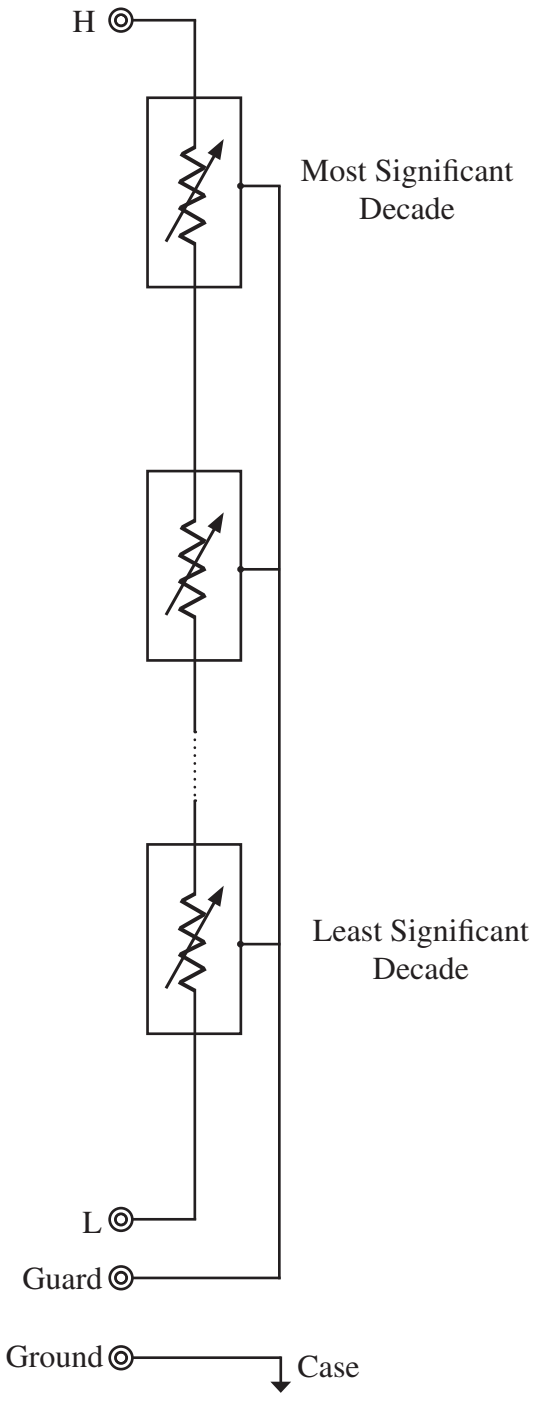

Table 5.2: Replacement List

Model Ref	IET Pt No	Description
1	HRRS-5kV-1100	Kel-F Plate
Not Shown	HRRS-5kV-1200	G-10 Plate (behind switch)
2	HRRS-0.01MΩ-10kV-SW	Switch Assembly, 10 kΩ steps
2	HRRS-0.1MΩ-10kV-SW	Switch Assembly, 100 kΩ steps
2	HRRS-1MΩ-10kV-SW	Switch Assembly, 1 MΩ steps
2	HRRS-10MΩ-10kV-SW	Swithc Assembly, 10 MΩ steps
2	HRRS-100MΩ-10kV-SW	Switch Assembly, 100 MΩ steps
2	HRRS-1GΩ-10kV-SW	Switch Assembly, 1 GΩ steps
2	HRRS-10GΩ-10kV-SW	Switch Assembly, 10 GΩ steps
2	HRRS-100GΩ-10kV-SW	Switch Assembly, 100 GΩ steps
2	HRRS-1TΩ-10kV-SW	Switch Assembly, 1 TΩ steps
2	26-36-613	Knob
2	30-36-103	Knob Cap
2	46-36-010BV422	Figure Dial
2	47-36-023	Stator
3	01-1033-8-0312	Binding Post, Red
3	01-1033-8-0310	Binding Post, Black
3	320051	Binding Post, Green
3	01-1008-1-0310	Binding Post, Gold

Figure 5.2: HRRS-10kV Unit

5.6 Disassembly, Component Replacement, and Reassembly

The assembly of the unit should only be done by qualified personnel.

5.6.1 Disassembly

Refer to Figure 5.2 to locate part numbers and proceed as follows:

1. Work in a clean environment, and use gloves to handle any components.

2. Place the instrument on a flat surface and remove the housing screws from the instrument. The housing may now be removed.

5.6.2 Component Replacement

Determine and locate any faulty component that requires replacement as described in the Section 5.5: Troubleshooting.

To remove a decade switch assembly (HRRS-*-10kV-SW), proceed as follows:

1. Unsolder the bus wire connecting the switch assembly.

2. Pry off the cap from the knob and remove the nut under it.

3. Pull off the knob and remove the nut under it.

4. The decade switch assembly may now be removed.

5. Replace the assembly by reversing the above steps.

6. Replace the knob and cap, making certain that the figure dial and the stator are properly aligned for the particular switch setting.

5.6.3 Reassembly

1. Tighten the four (4) standoffs if applicable (some units may no longer have them).

2. Replace the housing, match the holes, and attach the housing screws.

3. Recalibrate the unit. Refer to Section 5.3: General Considerations for Calibration for instructions.

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