♦ PRECISION INSTRUMENTS FOR TEST AND MEASUREMENT ♦

HARS-LX SERIES

Labratory Standard Decade Resistance Substituter

User and Service Manual

HARS-LXmanual/November, 2002

IET LABS, INC.
in the GenRad Tradition

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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.

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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 Laboratory Standard (HARS-LX) Series of resistance decade substituters (Figure 1.1) is a family of instruments providing a very broad choice of high performance resistance sources. Any number of decades from one to ten is available.

The HARS-LX substituter is a precision resistance source with excellent characteristics of accuracy, stability, temperature coefficient, and power coefficient. All these features serve to make it a laboratory resistance standard, exceeded in performance only by individual stand-alone standard resistors.

Hermetically sealed wirewound resistors are used for 1 Ω steps and over. These resistors are carefully conditioned under power and temperature in order to develop the best stability characteristics. Actual experience has shown them to exhibit a storage stability of better than 5 ppm/year, improving as they age. The low resistance resistors are constructed with resistance wire with a minimum of copper resistance in series to limit temperature coefficient effects.

The unit has a fixed minimum resistance of 10 mΩ. This is implemented by mechanically limiting the 10 mΩ decade from going below the “1” position. In this manner, no zero resistance subtractions have to be made, and the accuracy given is for the absolute reading.

The HARS-LX series employs completely enclosed dust-tight very low contact resistance switches. They feature solid silver alloy contacts and quadruple-leaf silver alloy wipers which keep switch contact resistance to under 1 mΩ per decade, and, more importantly, keep switch contact resistance *reproducible* insuring repeatable instrument performance.

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 HARS-LX is designed to allow very convenient maintenance of calibration over time. Most decades are calibratable without changing components or soldering of resistors. The decades for the 100 through 100 kΩ steps are calibrated with convenient trimmers. Trimming of the lower decades is also possible.

With a resolution as low as 1 mΩ and a maximum available resistance of over 12.2 MΩ, the HARS-LX Series may be employed for exacting precision measurement applications requiring high accuracy and stability. They can be used as components of dc and low frequency ac bridges, for calibration, as transfer standards, and as RTD simulators.

Figure 1.1: HARS-LX Series Laboratory Standard Decade Resistance Substituter

Chapter 2

SPECIFICATIONS

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

Resistor Type:
Resistance wire for 0.1 Ω steps and under; hermetically sealed, low inductance wirewound, for 1 Ω steps and over;

Minimum Resistance:
10 mΩ ± 0.5 mΩ; limited by the lowest settable position, "1", of the 10 mΩ/step decade.

Range
See Model information on next page.

Resolution
See Model information on next page.

Initial Accuracy:
±(20 ppm + 0.5 mΩ); at 23ºC, 4-terminal "true-ohm" measurement, 30-70% RH, absolute reading, **no zero subtraction required**, NIST traceable.

Initial Adjustment Accuracy:
±2.0 ppm for 100 Ω steps;
±1.5 ppm for 1 kΩ steps;
±1.0 ppm for 10 kΩ steps;
±1.5 ppm for 100 kΩ steps;
±3.0 ppm for 1 MΩ steps;
for increased accuracy, all individual resistors of the 1 Ω through 1 MΩ decades are user trimmable.

Stability:
<±(20 ppm + 0.5 mΩ)/year;
<±5 ppm/year, typical.

Max Power:
1 W/step up to 5 W total, or 2 A, or 1500 V, whichever applies first.

Resistance Repeatability:
<100 μΩ, short term, average value.

Leakage Resistance:
$>10^{10}$ Ω.

Resistance Temperature Coefficient:
<±20 ppm/ºC for 1 Ω steps and under;
<±15 ppm/ºC for 10 Ω steps;
<±3 ppm/ºC for 100 Ω steps and over;
<+50 μΩ/ºC for wiring and switch resistance, (to be considered whenever significant).

Resistance Power Coefficient:
<±1 ppm/mW for 0.1 Ω steps and under;
<±0.4 ppm/mW for 1 Ω steps;
<±0.3 ppm/mW for 10 Ω steps;
<±0.1 ppm/mW for 100 Ω steps and over;
<+50 μΩ/W total for wiring and switch resistance.

Breakdown Voltage:
1500 V peak to case.

Operating Temperature:
0ºC to 55ºC.

Storage Temperature:
-40ºC to 70ºC.

Switch Type:
11 position "0"-"10" (12 position, "0"-"11" for highest decade); multiple solid silver contacts; dust tight diallyl phthalate body. To allow continuous rotation, a blank position is added on most decades.

Terminals:
Four, 5 way, gold plated tellurium copper binding posts with low thermal emf and low resistance, for four terminal Kelvin measurements, plus one binding post connected to the case for shielding. Rear outputs are available as an option.

Dimensions:
Rack model: 48.3 cm W x 17.8 cm H x 19.7 cm D (19.0" x 7.0" x 7.75")

Weight:
5.1 kg (13 lb)

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MODEL INFORMATION

Model (Select L or LX accuracy grade)	Total Resistance (Ω)	No. of Decades	Resolution (Ω)
HARS-L(LX)-1-0.001	0.01	1	0.001
HARS-L(LX)-1-0.01	0.1	1	0.01
HARS-L(LX)-1-0.1	1	1	0.1
HARS-L(LX)-1-1	10	1	1
HARS-L(LX)-1-10	100	1	10
HARS-L(LX)-1-100	1 k	1	100
HARS-L(LX)-1-1K	10 k	1	1 k
HARS-L(LX)-1-10K	100 k	1	10 k
HARS-L(LX)-1-100K	1 M	1	100 k
HARS-L(LX)-1-1M	10 M	1	1 M
HARS-L(LX)-2-0.001	0.11	2	0.001
HARS-L(LX)-2-0.01	1.1	2	0.01
HARS-L(LX)-2-0.1	11	2	0.1
HARS-L(LX)-2-1	110	2	1
HARS-L(LX)-2-10	1.1 k	2	10
HARS-L(LX)-2-100	11 k	2	100
HARS-L(LX)-2-1K	110 k	2	1 k
HARS-L(LX)-2-10K	1.1 MΩ	2	10 k
HARS-L(LX)-2-100K	11 MΩ	2	100 k
HARS-L(LX)-3-0.001	1.11	3	0.001
HARS-L(LX)-3-0.01	11.1	3	0.01
HARS-L(LX)-3-0.1	111	3	0.1
HARS-L(LX)-3-1	1.11 k	3	1
HARS-L(LX)-3-10	11.1 k	3	10
HARS-L(LX)-3-100	111 k	3	100
HARS-L(LX)-3-1K	1.11 M	3	1 k
HARS-L(LX)-3-10K	11.1 M	3	10 k

OPTIONS
- **RH** 10 mΩ rheostat for lowest decades, 20 µΩ resolution.
- **RO** Rear output binding posts

Model (Select L or LX accuracy grade)	Total Resistance (Ω)	No. of Decades	Resolution (Ω)
HARS-L(LX)-4-0.001	11.11	4	0.001
HARS-L(LX)-4-0.01	111.1	4	0.01
HARS-L(LX)-4-0.1	1.111 k	4	0.1
HARS-L(LX)-4-1	11.11 k	4	1
HARS-L(LX)-4-10	111.1 k	4	10
HARS-L(LX)-4-100	1.111 M	4	100
HARS-L(LX)-4-1K	11.11 M	4	1 k
HARS-L(LX)-5-0.001	111.11	5	0.001
HARS-L(LX)-5-0.01	1.111 1 k	5	0.01
HARS-L(LX)-5-0.1	11.111 k	5	0.1
HARS-L(LX)-5-1	111.11 k	5	1
HARS-L(LX)-5-10	1.111 1 M	5	10
HARS-L(LX)-5-100	11.111 M	5	100
HARS-L(LX)-6-0.001	1.111 11 k	6	0.001
HARS-L(LX)-6-0.01	11.1111 k	6	0.01
HARS-L(LX)-6-0.1	11.111 k	6	0.1
HARS-L(LX)-6-1	1.111 11 M	6	1
HARS-L(LX)-6-10	11.111 1 M	6	10
HARS-L(LX)-7-0.001	11.111 11 k	7	0.001
HARS-L(LX)-7-0.01	111.111 1 k	7	0.01
HARS-L(LX)-7-0.1	1.111 111 M	7	0.1
HARS-L(LX)-7-1	11.111 11 M	7	1
HARS-L(LX)-8-0.001	111.111 11 k	8	0.001
HARS-L(LX)-8-0.01	1.211 111 1 M	8	0.01
HARS-L(LX)-8-0.1	1.211 111 M	8	0.1
HARS-L(LX)-9-0.001	1.211 111 11 M	9	0.001
HARS-L(LX)-9-K-RM	1.211 111 11 M	9	0.001
HARS-L(LX)-9-0.01	12.111 111 1 M	9	0.01
HARS-L(LX)-10-0.001	12.111 111 11 M	10	0.001
HARS-L(LX)-11-0.001	121.111 111 11 M	11	0.001

HARS-LX SERIES OPERATING GUIDE

CONSULT INSTRUCTION MANUAL FOR PROPER INSTRUMENT OPERATION

Resistor Type: Resistance wire for 0.1 Ω steps and under; hermetically sealed, wirewound, low inductance, for 1 Ω steps and over.

Range and Resolution: 10 mΩ minimum to 12,211,111.11 Ω, in 10 decade, with 1 mΩ resolution.

Minimum Resistance: 10 mΩ ±0.5 mΩ; determined by lowest settable position, "1", of the 10 mΩ decade switch.

Initial Accuracy: ±(20 ppm + 1.0 mΩ) at 23°C, absolute reading, no zero subtraction required, NIST traceable.

Temperature Coefficient: <±20 ppm/°C for 1 Ω steps and under;
<±15 ppm/°C for 10 Ω steps;
<±3 ppm/°C for 100 Ω steps and over;
<+50 µΩ/°C for wiring and switch resistance, (to be considered wherever significant).

Maximum Power: 1 W per step up to 5 W total or 2 A maximum.

Stability: <±(20 ppm + 0.5 mΩ)/year;
<±5 ppm/year, typical.

Power Coefficient: <±1000 ppm/W for 0.1 Ω steps and under;
<±400 ppm/W for 1 Ω steps;
<±300 ppm/W for 10 Ω steps;
<±100 ppm/W for 100 Ω steps and over.
<+50 µΩ/W for wiring and switch resistance.

Maximum Applied Voltage: 1500 V peak to case.

Switch Type: 11 position, 0-10 (12 position, 0-11 for 100 kΩ decade); multiple solid silver contacts; dust tight diallyl phthalate body. To allow continuous rotation, a blank position is added on most decades.

Switch Operation: Whenever the unit has been idle, turn each switch 7-10 times both ways before using. This switch "break-in" procedure is standard metrology procedure required for best accuracy to remove any silver oxide film on the contact surfaces, typically <1 mΩ.

MODEL: HARS-LX-10-.001 SN: D1-0031111

WARNING

Observe all safety rules when working with high voltages or line voltages. Connect the (GND) 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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HARSLXLBL/p2/HARS-LX-10-.001/07-00

Figure 2.1: Typical OPERATING GUIDE Affixed to Unit

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 then 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.

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

3.2 Installation

For a rack mounted 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 is recommended.

For bench models, no installation as such is required, because this instrument series is not powered. Since it is a high accuracy instrument, it is recommended that a bench space be provided that would not expose it to abuse and keep it protected from temperature extremes and contaminants.

3.3 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 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 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

OPERATION

4.1 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.

4.2 Connection

4.2.1 General Considerations

Four insulated low thermal emf binding posts labeled **CRNT HI**, **CRNT LO**, **SENSE HI**, and **SENSE LO** provide two current and two potential terminals, respectively, for four terminal measurement. Two terminal measurements may be made by shorting **CRNT HI** to **SENSE HI**, and **CRNT LO** to **SENSE LO**, preferably with shorting links or other substantial means. The four terminal connection is important of course for low resistances.

A fifth metal binding post labeled **GND** (Ground) is connected to the case and may be used accordingly as a guard or shield terminal. It may also be connected using a shorting link to either terminal to implement a two-terminal as opposed to a three-terminal measurement.

4.2.2 Electrical Considerations

In order to make proper use of the full performance capabilities of the HARS-LX unit, especially if low resistance or low resistance increments are important, care must be taken in connecting to the terminals of the decade box.

In particular, in order to keep contact resistance to a minimum, four terminal connections should be employed, and also, the most substantial and secure connection to the binding posts should be made. They 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 would not be considered significant for the task being performed.

4.2.3 Thermal emf Considerations

The highest quality low emf components are used in the HARS-LX Series. In particular, the terminals are made of gold plated tellurium copper, which exhibits low emf and low resistance. There nevertheless may be some minute thermal emf generated at the user's test leads where they contact the FIARS-LX banana jacks. This will depend on the test lead material. Whenever this is critical, brass and iron materials should be avoided.

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. This can be of the order of milliohms.

4.3 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.

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 if any. It adds about 11 % to the nominal total decade resistance. The most significant decade also has an “11” position to extend the resistance range to over 1.2 MΩ. The 10 mΩ decade, however, does not go below the “ 1 “ position in order to maintain a precise and constant minimum resistance of 10 mΩ, so that no subtraction of zero resistance is required.

To determine the resistance obtained when any one or more “10” or “11” settings are used, simply add 1 to the next higher decade. For example, a setting of “10-11-10-10-10-10-1-10” becomes:

10	1 0 0 0 0 0. 0 0 0
11	1 1 0 0 0. 0 0 0
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
1	. 0 1 0
10	. 0 1 0
Total	1 1 2 1 1 1. 0 2 0

In order to obtain a zero in the 10 mΩ position, set the 10 mΩ decade to the “10” position, i.e. 100 mΩ, and take the 100 mΩ setting, in the next decade, into consideration. To get 1.000 Ω, for example, the switches should be set to show “0.-9-10-0”.

Since the highest decade has an additional “11” position, resistance values of over 1.2 times can be obtained.

4.4 Power Considerations

To maintain the maximum possible accuracy and precision, power applied to the HARS-LX should be kept as low as possible, preferably below 0.1 W. For best protection of the instrument, it is advisable to limit the input power to 1 W. This may be implemented with a series resistor or fuse.

4.5 Environmental Conditions

For optimal accuracy, the decade box should be used in an environment of 23ºC. It should be allowed to stabilize at that temperature for at least four hours after any significant temperature variation.

Humidity should be maintained at laboratory conditions of 30% to 70% RH.

4.6 Switch Conditioning

The switch wipers employed in this unit are self cleaning constructed of solid silver alloy with solid silver alloy contacts. Whenever left idle, the wipers and contacts must be conditioned or “broken in” again to remove the film of silver oxide that develops over time. This is standard metrology practice when high accuracy is required. This effect is of the order of less than 1 mΩ, so it may be ignored whenever measurements of that magnitude are not important.

To perform this “breaking in,” simply rotate each switch seven to ten times in each direction.

Chapter 5

MAINTENANCE

5.1 Reliability, Maintainability, and EMI Rationale

The closed design and the sealed switches and resistors make for a reliable design of the Model HARS-LX. Coupled with six trimmable decades, this makes maintainability possible indefinitely.

A complete metal enclosure makes the unit resistant to electromagnetic interference (EMI).

5.2 Preventive Maintenance

The Model HARS-LX is packaged in a closed case which will limit the entry of contaminants and dust to the inside of the instrument. If it is maintained in a generally clean or air conditioned environment, cleaning will be seldom required. In a contaminated atmosphere, cleaning may be required.

Should cleaning be needed, open the instrument as described below and remove any dust from the internal components. Use compressed air or clean brushes. **Do not** handle any of the resistors or circuit boards with bare hands. If handling is required clean gloves should be worn.

The front panel should be periodically cleaned to eliminate any leakage paths from near or around the binding posts. Alcohol may be used with lint-free cloth.

To clean the inside of the unit, open the case 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 4 housing screws from the rear of the instrument. The housing may now be removed.
3. Use optical grade dry compressed air or a clean brush to remove any dust or debris.
4. Replace the housing, match the holes, and attach the 4 housing screws.

5.3 Verification of Performance and Calibration

The Model FIARS-LX may be employed as a stand alone instrument or as an integral component of another system. If it is the latter, then it should be verified or calibrated as part of the overall system where the combined results may be matched to the complete system and provide a superior calibration.

If however, the HARS-LX is employed as a stand alone device, the following considerations and procedures should be followed.

5.3.1 Calibration Interval

The HARS-IX 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.

It should be noted that if the instrument is to be used to transfer resistance values only, recalibration is not actually required assuming that there has been no drastic change in the deviations of any individual resistors.

5.3.2 General Considerations

It is important, whenever calibrating or certifying the HARS-LX Series, to be very aware of the capabilities and limitations of the test instruments used. A bridge may be employed, and there are some direct reading resistance meters or digital multimeters available that can be used in conjunction with standards to verify the accuracy of these units.

Such calibration systems would have to be **significantly** more accurate than the specified initial accuracy of the HARS-LX if an initial calibration is required, or sufficient for a ±20 ppm calibration, the long term accuracy, if only a verification of performance is required.

It is important to allow both the testing instrument and- the HARS-LX to stabilize for a number of hours (or days if necessary for any of the calibration components) at the nominal operating temperature of 23ºC, and at nominal laboratory conditions of humidity. There should be no temperature gradients across the unit under test.

Substantial Kelvin type 4-wire test leads should be used to obtain accurate low resistance measurements. Steps should be taken to minimize thermal emf effects, by maintaining an even temperature, and by using only low emf connectors. Using meters with a "true ohm" function is recommended.

Proper metrology practices should be followed in performing this verification or calibration.

5.3.3 Required Equipment

As described above, many combinations of standards, transfer standards and bridges may be utilized to perform a verification or a calibration of this instrument. The following are some possible choices:

1. Resistance Transfer Standards for 1 Ω, 10 Ω, 100 Ω, 1 kΩ, 10 kΩ, 100 kΩ, 1 MΩ, and 10 MΩ per step, calibrated to ±10 ppm; IET Labs. HATS-LR, HATS-Y, or SRL Series or equivalent. (The 1 Ω, and 10 Ω transfer standards are optional, and are only used to take advantage, if desired of the trimmability of these two decades.)
2. Precision Resistance Measurement Bridge or Automatic System, with a transfer accuracy of ±l ppm; Guildline Model 9975, or Measurements International Model 6000A, or ESI model 242, 242A, 242C, or 242D, or equivalent. Or a high precision, high stability digital multimeter along with a set of resistance standards for

5.3.4 Verification Procedure

1 Determine the allowable upper and lower limits for each resistance setting of each decade following the specified accuracy. For the HARS-LX Series, these limits, in Ω, for any resistance R are [R ±(20 x 10^{-6}R + 0.001 Ω)]. These are the limits for accuracy within one year of operation.

2. Set up and employ the required calibration equipment in the resistance measurement mode. For the particular equipment chosen, follow the appropriate instructions for making transfer measurements of resistance.
3. Confirm that all the resistances fall within these limits.
4. If array resistances fall outside these limits, or to bring any of the trimmableable decades, 1 Ω through 10 MΩ, within precise adjustment, proceed as described below.

5.4 Calibration

If any individual resistance, requires calibration, this may be performed by simply trimming the associated resistor network. This applies for 1 Ω steps and over. There is a resistance trimming network provided for each resistance in these ranges. These may be accessed by removing the housing and accessing the particular decade PC board.

Whereas it is possible to calibrate any one resistance step, note that the nth step of a decade is the sum of resistances 1 through n, so that errors are cumulative. It is therefore recommended that whenever any resistance of a particular decade is trimmed, that all the resistors of that decade be tested and trimmed if required.

This procedure should be performed in an environment as free as possible from electrical noise. The front panel should of course be connected to the test instrument guard point.

Nothing should be handled with bare hands. If it should become necessary to handle any internal component, gloves should be worn.

If any non-trimmable decades, i.e. 0.1Ω steps, 0.010 Ω steps, or 0.001Ω steps, are out of calibration, the associated switch assembly must be either serviced or replaced. Consult IET Labs.

To confirm that a proper calibration was performed, all the readings for any decade should be obtained again without adjusting any of the trimming potentiometers. They should be within specifications. If they are not, the calibration must be repeated.