

## HARS-LX Series

### Laboratory Standard Decade Resistance Substituter

### User and Service Manual



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HARS-LX series im/May 2012



**IET LABS, INC.**  
534 Main Street, Westbury, NY 11590

[www.ietlabs.com](http://www.ietlabs.com)  
TEL: (516) 334-5959 • (800) 899-8438 • FAX: (516) 334-5988

◆ 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 HARS-LX Laboratory Standard Decade Resistance Substituter provides a high-performance resistance source.

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 stand-alone standard resistors.

The resistors are constructed with resistance wire with a minimum of copper resistance in series to limit temperature coefficient effects.

The unit usually has a fixed minimum resistance of 10 m $\Omega$ . This is implemented by mechanically limiting the 10 m $\Omega$  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 m $\Omega$  per decade, and more importantly, keep switch contact resistance *reproducible*, insuring repeatable instrument performance.

High quality gold plated tellurium copper binding posts 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 contribute to thermal emf problems.

The HARS-LX series can start with a resolution as low as 1 m $\Omega$  and go up over 12.2 M $\Omega$ . It may be employed for exacting precision measurement applications requiring high accuracy and stability. The series can be used as components of dc and low frequency ac bridges, for calibration, as transfer standards, and as RTD simulators.



Figure 1-1: Sample HARS-LX unit

## 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.

### 2.1 Specifications

Resistance per step	Total decade resistance	Max current	Max power	Temperature coefficient ( $\pm$ ppm/ $^{\circ}$ C)	Power coefficient ( $\pm$ ppm/mW)	Stability ( $\pm$ ppm/yr)	Decade positions	Resistor type
		whichever applies first						
1 m $\Omega$	10 m $\Omega$	2 A	NA	20	1	20 ppm+0.5 m $\Omega$	11 positions "0"-10"	Resistance wire
10 m $\Omega$	100 m $\Omega$	2 A	NA	20	1		10 positions "1"-10" (10 m $\Omega$ minimum reading)	
100 m $\Omega$	1 $\Omega$	2 A	NA	20	1			
1 $\Omega$	10 $\Omega$	1 A	5 W	20	0.4			Wirewound hermetically sealed low-inductance
10 $\Omega$	100 $\Omega$	0.33 A	5 W	10	0.3			
100 $\Omega$	1 k $\Omega$	0.1 A	5 W	3	0.1			
1 k $\Omega$	10 k $\Omega$	33 mA	5 W	3	0.1	10 ppm ( $<$ 5 ppm typical)		
10 k $\Omega$	100 k $\Omega$	10 mA	5 W	3	0.1			
100 k $\Omega$	1 M $\Omega$	3 mA	2,000 V peak	3	0.1			
1 M $\Omega$	10 M $\Omega$	1 mA	2,000 V peak	3	0.1			Metal oxide
10 M $\Omega$	100 M $\Omega$	2,000 V peak		15	0.2			
Wiring and switch resistance		NA		50 $\mu\Omega$ / $^{\circ}$ C	0.2 $\mu\Omega$ /W	NA		

\*Last decade has 12 positions from "0" to "11."

#### Accuracy:

**For 1 m $\Omega$  through 1 M $\Omega$ :**  $\pm$ (20 ppm+0.5 m $\Omega$ )

**For 10 M $\Omega$ :**  $\pm$ 0.02%

At 23 $^{\circ}$ C "true ohm" measurement, 30-70% RH, absolute reading, case grounded, SI traceable

No zero subtraction required

#### Minimum resistance:

For models with 10 m $\Omega$  or lower the minimum is 10 m $\Omega$   $\pm$  0.5 m $\Omega$ ; determined by the lowest settable position, "1", of the 10 m $\Omega$ /step decade.

For models with lowest steps of 100 m $\Omega$  or higher, the minimum resistance is determined by the first position of the lowest decade.

#### Resistance repeatability:

Better than 100  $\mu\Omega$ , short-term, average value

#### Leakage Resistance:

$>$ 10 G $\Omega$

#### Switch Type:

Multiple solid silver contacts; dust-tight diallyl-phthalate body.

To allow continuous rotation, a blank position is added on most decades.

#### Environmental Conditions:

**Operating Temperature:** 0 $^{\circ}$ C to 55 $^{\circ}$ C

**Storage Temperature:** -40 $^{\circ}$ C to 70 $^{\circ}$ C

**For Best Performance:**

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

**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 case for shielding. Rear outputs are available as an option.

**Mechanical information:**

Model	Dimensions	Weight
1 decade	7.7 cm W x 7.7 cm H x 8.4 cm D (3" W x 3" H x 3.3" D)	0.45 kg (1.0 lb)
2-5 decades	37.5 cm W x 8.9 cm H x 10.2 cm D (14.8" W x 3.5" H x 4" D)	2.0 kg (4.3 lb)
6-7 decades	43.9 cm W x 8.9 cm H x 10.2 cm D (17.3" W x 3.5" H x 4.0" D)	2.2 kg (4.8 lb)
8-10 decades	48.3 cm W x 17.8 cm H x 19.7 cm D (19" W x 7" H x 7.8" D)	5.1 kg (11 lb)
11 decades	48.3 cm W x 31 cm H x 19.7 cm D (19" W x 12.3" H x 7.8" D)	6.6 kg (14 lb)

**HARS-LX-5-0.001-K OPERATING GUIDE**  
CONSULT INSTRUCTION MANUAL FOR PROPER INSTRUMENT OPERATION

Resistance per step	Total decade resistance	Max current whichever applies first	Max power	Temperature coefficient (±ppm/°C)	Power coefficient (±ppm/mW)	Stability (±ppm/yr)	Decade positions	Resistor type
1 mΩ	10 mΩ	2 A	NA	20	1	20 ppm+0.5 mΩ	11 positions "0"-*10"	Resistance wire  Wirewound hermetically sealed low-inductance
10 mΩ	100 mΩ	2 A	NA	20	1		10 positions "1"-*10" (10 mΩ minimum reading)	
100 mΩ	1 Ω	2 A	NA	20	1		11 positions "0"-*10"	
1 Ω	10 Ω	1 A	5 W	20	0.4			
10 Ω	100 Ω	0.33 A	5 W	10	0.3			
Wiring and switch resistance		NA		50 µΩ/°C	0.2 µΩ/W	NA		

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

**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 case for shielding. Rear outputs are available as an option.

**MODEL:** HARS-LX-5-0.001-K **SN:** D3-1146544

**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.

**IET LABS, INC.**  
CAGE CODE: 62015

• 534 Main Street, Westbury, NY 11590  
• Tel: (516) 334-5959 • 800-899-8438 • Fax: (516) 334-5988

[www.ietlabs.com](http://www.ietlabs.com)

HARS-LX-5-0.001 8/03-07-2012

Figure 2-1: Sample 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 in 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 there is no required installation.

Since this is a high accuracy instrument, it is recommended that a space be provided that would not expose it to mechanical abuse and keep it maintained at laboratory standard temperatures near 23°C.

### 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

Four insulated low-thermal-emf binding posts labeled **CURRENT HI**, **CURRENT LO**, **SENSE HI**, and **SENSE LO** provide two current and two potential terminals, respectively, for 4-terminal measurement. 2-terminal measurements may be made by shorting **CURRENT HI** to **SENSE HI**, and **CURRENT 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 as a guard or shield terminal. It may also be connected using the shorting link to either terminal to implement a 2-terminal as opposed to a 3-terminal measurement.

### 4.3 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, to keep contact resistance to a minimum, 4-terminal connections should be employed, and 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 not considered significant for the task being performed.

### 4.4 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 HARS-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 manifest 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 appear as a false component of the dc resistance measurement, and can be the order of milliohms.

#### 4.5 Dial Setting

The resistance setting may be read directly from the dial settings. 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 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.

#### 4.6 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.

#### 4.7 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 four hours after any significant temperature variation.

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

#### 4.8 Switch Conditioning

The switch wipers employed in this unit are self cleaning. They have solid silver alloy contacts. After being 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.

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

#### 4.9 Meter Shunt Applications

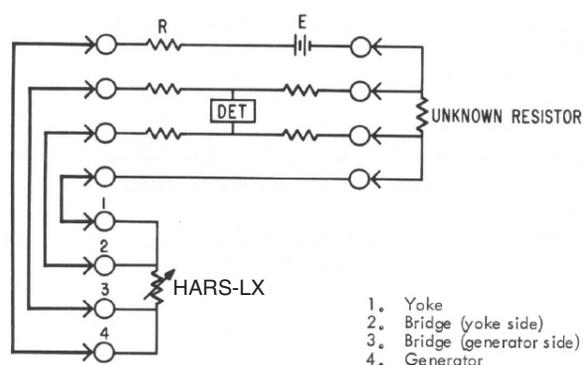
To measure the current in a 4-terminal resistor:

1. Measure the voltage drop between the two terminals of the resistor not connected to the current source.
2. Determine the current by the ratio of the measured voltage to the known resistance.

Using the 4-terminal technique helps avoid errors caused by the voltage drops in the current-carrying leads and contacts. Errors caused by lead and contact resistances in the voltage measuring circuit are negligible if the current in this circuit is small.

## 4.10 Kelvin Bridge Applications

Use 4-terminal resistance standard for all Kelvin bridge measurements. When connected as shown in Figure 4-1, errors caused by lead and contact resistances can be made negligible because they appear as part of the generator or yoke resistance, or in series with high resistance bridge arms.



**Figure 4-1: Kelvin Bridge Connections**

For maximum protection and accuracy, limit power input to HARS-LX to 1 Watt. This may be accomplished by placing a resistor in series with the bridge generator or battery.

The value of this resistance can be calculated from the following formula:

$$R = \frac{E^2}{4}$$

where:

R = value of the power-limiting resistor

E = open circuit voltage of the generator

The protective resistor should have a power rating of 4 W or more. Input power should be limited to 1/10 W or less for most accurate measurements.

# Chapter 5

## MAINTENANCE

### 5.1 Maintainability and Reliability

It is possible to maintain Model HARS-LX indefinitely. It is reliable due to its closed design and sealed switches and resistors. It is possible to adjust the unit, if necessary. The unit is resistant to electromagnetic interference (EMI) because of its metal enclosure.

### 5.2 Preventive Maintenance

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

The Model HARS-LX is packaged in a closed case and uses completely sealed switches. This limits the entry of contaminants and dust to the inside of the switches. If it is maintained in a clean or air-conditioned environment, cleaning will seldom be required.

Should cleaning be needed:

1. Remove the 4 housing screws from the side of the instrument, and remove the housing.
2. Remove any dust or debris using optical grade dry compressed air or a clean brush.
3. Replace the housing and reattach the 4 housing screws.

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.

### 5.3 Calibration

The Model HARS-LX may be employed as a stand-alone instrument or as an integral component of a system. If used as part of a system, it should be calibrated as part of the overall system to provide an optimum system calibration.

If the HARS-LX is employed as a stand alone device, the following should be observed:

- Calibration Interval
- General Considerations
- Required Equipment
- Calibration Procedure

#### 5.3.1 Calibration Interval

The recommended HARS-LX Series calibration interval is twelve (12) months.

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

### 5.3.2 Calibration Considerations

Before starting the calibration procedure, you need to consider the following:

- Calibration environment should be 23°C and less than 50% relative humidity.
- Test instruments should be sufficiently more accurate than the HARS-LX unit, and/or the uncertainty of the measurement instrumentation has to be considered in the calibration Test Uncertainty Ratio (TUR).
- The testing equipment and the HARS-LX unit should stabilize at laboratory conditions for at least 24 hours.
- Kelvin type 4-wire test leads should be used to obtain accurate low resistance measurements.
- Steps should be taken to minimize thermal emf effects, such as using a meter with “True Ohm” capacity.
- Accepted metrology practices should be followed.

### 5.3.3 Required Equipment

Many combinations of standards, transfer standards, meters, and bridges may be used to calibrate this instrument. The following are some possible choices:

- Resistance Standards for 0.001  $\Omega$ . IET options include the SRL Series.
- Precision resistance measurement bridge or multimeter, with a transfer accuracy of  $\pm 1$  ppm. Options include:
  - Guildline Model 9975
  - Measurements International Model 6000A
  - ESI model 242, 242A, 242C, or 242D
  - A high-precision, high-stability digital multimeter (e.g. Fluke 8508A) along with a set of resistance standards for ratio mode.

### 5.3.4 Calibration Procedure

To calibrate the HARS-LX unit, proceed as follows:

1. Set up the calibration equipment in the resistance measurement mode and exercise the switches 10 times in each direction.
2. Allow the switches to cool for 15 minutes.
3. Confirm the minimum resistance of the unit.
 

*Allow a confidence band for the uncertainty of the measuring instrument and setup.*
4. Determine the allowable upper and lower limits for each resistance setting of each decade based on the specified accuracy and the confidence band.
 

*For the HARS-LX series, the limits for any resistance “R” are:  
[R $\pm$ (20 ppm+0.5 m $\Omega$ )].*
5. Confirm that the resistances fall within these limits.
6. If any resistances fall outside these limits, the associated switch assembly may require service or replacement.

### 5.4 Replaceable Parts List

Model Ref	IET Pt No	Description
1	32-21	Binding Post, Red
2	32-20	Binding Post, Black
3	32-19	Binding Post, Gold
4	HARS-LX-4300-KNB	Knob Assembly
Not Shown	HARS-LX-3100	Foot
Not Shown	HARS-4000-LX-.001	1 mΩ/step Decade Switch Assembly
Not Shown	HARS-4000-LX-0.01	10 mΩ/step Decade Switch Assembly
Not Shown	HARS-4000-LX-0.1	100 mΩ/step Decade Switch Assembly
Not Shown	HARS-4000-LX-1	1 Ω/step Decade Switch Assembly
Not Shown	HARS-4000-LX-10	10 Ω/step Decade Switch Assembly
Not Shown	HARS-4000-LX-100	100 Ω/step Decade Switch Assembly
Not Shown	HARS-4000-LX-1k	1 kΩ/step Decade Switch Assembly
Not Shown	HARS-4000-LX-10k	10 kΩ/step Decade Switch Assembly
Not Shown	HARS-4000-LX-100k	100 kΩ/step Decade Switch Assembly
Not Shown	HARS-4000-LX-1M	1 MΩ/step Decade Switch Assembly
Not Shown	HARS-4000-LX-10M	10 MΩ/step Decade Switch Assembly

**Table 5-1: Replaceable Parts List**



**Figure 5-1: HARS-LX Replaceable Parts**



