



## **Operation Manual**

**For The**

**6622A Series**

**Automatic DCC Resistance Bridges**

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## 1. INTRODUCTION

### 1.1. SCOPE

This document describes the operation and maintenance of the 6622A Series of Automatic DCC Resistance Bridges.

### 1.2. GENERAL DESCRIPTION

The 6622A series bridges can be controlled from the front panel or by a computer system through software. The BridgeWorks Software Users Manual describes the operation of the 6622A with the software. Once the computer system is installed and connected to the IEEE-488 Interface of the 6622A Resistance Bridge, full software control of the bridge is possible. The front panel controls and indicators of the 6622A Bridge, are shown in Figure 2-1. The corresponding rear panel controls and connectors are shown in Figure 2-2. The following models are described in this manual.

6622A-B (Base model with measurement up to 100 k $\Omega$ )

6622A-XP (eXtended Precision model with measurement up to 100 k $\Omega$ , and higher accuracy)

6622A-XPS (eXtended Special Accuracy model with measurement up to 100 k $\Omega$ )

6622A-XR (eXtended Range model with measurement up to 100 M $\Omega$ , at base accuracy)

6622A-XPR (eXtended Precision and Range model with measurement up to 100 M $\Omega$ , and higher accuracy)

6622A-HV (High Voltage model with measurement up to 1 G $\Omega$ , and the best accuracy)

The 6622A series bridges can also be installed with a T-Option adding additional temperature functionality. The description of T-Option and use of the 6622A bridge series in thermometry applications is outlined in the manual OM6622A/T.

## 1.3. OVERVIEW

The 6622A is a microprocessor-based, direct-current-comparator bridge designed for the automatic measurement and display of the ratio of two resistances to accuracies better than  $0.1 \mu\Omega/\Omega$ . The ratio of the two resistances is determined from a direct measurement of the voltage of the bridge imbalance while an ampere-turn balance is maintained. A microprocessor is used to control the direct-current-comparator, set the bridge measurement currents and measurement configuration, initiate the voltage measurement cycle and maintain the ampere-turn balance. This fully automated measurement process achieves optimum resistance ratio resolution and accuracy at the sub-ppm level.

The bridge is designed for flexibility and ease of use and is based on the manually operated direct-current-comparator bridge manufactured by Guildline Instruments (model 9975) and also on the original work of the National Research Council of Canada<sup>1</sup>. Remote access to the embedded microprocessor-controller, through a simple control language command set and GPIB communication interface allows the 6622A to fully exploit the capabilities of the direct-current-comparator to suit each user requirement while still maintaining optimum resistance ratio measurement accuracy at the sub-ppm level.

The design approach taken for the 6622A results in an effective bridge measurement accuracy of 27 bits (to a maximum of 32 bits depending on configuration), allowing the resistance ratio of resistances in the range  $0.001 \Omega$  to  $1 \text{ G}\Omega$  to be automatically measured.

The balance of the zero ampere-turn flux condition is maintained automatically using an electronic closed loop feedback network operating on the flux detector output to drive a slave power supply for the standard resistor current. The bridge balance (null voltage condition), is maintained automatically by adjusting the number of turns in series with the unknown resistor.

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<sup>1</sup> MacMartin, M.P. and Kusters, N.L., "A direct -current-comparator for four terminal resistance measurements", IEEE Trans. Instrumentation and Measurement, vol IM-15, pp.212-220, December 1966.

## 1.4. PRINCIPLE OF OPERATION

A simplified diagram of the automatic direct-current-comparator is shown in Figure 1-1. Two sets of four terminal connections hardware are provided, one set for the standard resistor and one set for the unknown resistance. A current ( $I_x$ ), set under control of the microprocessor, is passed through the variable turns of winding ( $N_x$ ) of the comparator and through the unknown resistance ( $R_x$ ). The isolated slave current ( $I_s$ ) is generated under microprocessor control, as a linear function of the number of turns ( $N_x$ ) and is forced through the fixed slave windings ( $N_s$ ) and the reference resistor ( $R_s$ ). The currents ( $I_s$ ) and ( $I_x$ ) flowing in the windings ( $N_s$ ) and ( $N_x$ ) respectively generate a net magnetic flux imbalance in the flux detector windings ( $N_d$ ). This flux imbalance is proportional to the net ampere-turn error between the two windings [ $I_s \times N_s$ ] and [ $I_x \times N_x$ ]. By sensing this imbalance with the sensitive flux detector winding and an electronic peak detector, a voltage signal is generated proportional to the sign and magnitude of the ampere-turn error. This voltage is used in a simple closed loop control configuration to adjust the slave current ( $I_s$ ) to bring the (ampere-turn) error signal to zero. At balance, the ratio of the two currents ( $I_x$  and  $I_s$ ) flowing in the two windings is the same as the ratio of the turns set for each winding ( $N_x$  and  $N_s$ ).

Complete electrical isolation between circuit currents is maintained throughout the 6622A by making full use of fiber optic technology. A fiber optic serial data communication link is used to transfer data between each functional component and the embedded microcontroller.

A link joining the two potential leads of the unknown resistance ( $R_x$ ) and the reference resistance ( $R_s$ ) and the nanovoltmeter detector provides the only connection between the two halves of the bridge. Power supply isolation techniques as recommended by Kibble<sup>2</sup> are used throughout to further isolate the bridge halves. The nanovolt detector is a high input impedance ( $>1 \text{ G}\Omega$ ) amplifier arrangement capable of resolving voltages at the nanovolt level with a typical linearity accuracy of 14 bits (to a maximum of 22 bits). In the automatic direct-current-comparator bridge arrangement this amplifier is used to measure the potential across the reference and unknown resistances.

Knowledge of the reference resistance value ( $R_s$ ), the effective resistance potential imbalance and confirmation that ampere-turn balance is maintained, with the turns ( $N_x$ ,  $N_s$ ) and current ( $I_x$ ,  $I_s$ ) settings, allows the unknown resistance value ( $R_x$ ) to be calculated.

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<sup>2</sup> Kibble, B.P. and Robinson, I.A., "An Isolated Mains Driven Power Supply", NPL Memorandum DES 54, September 1985.

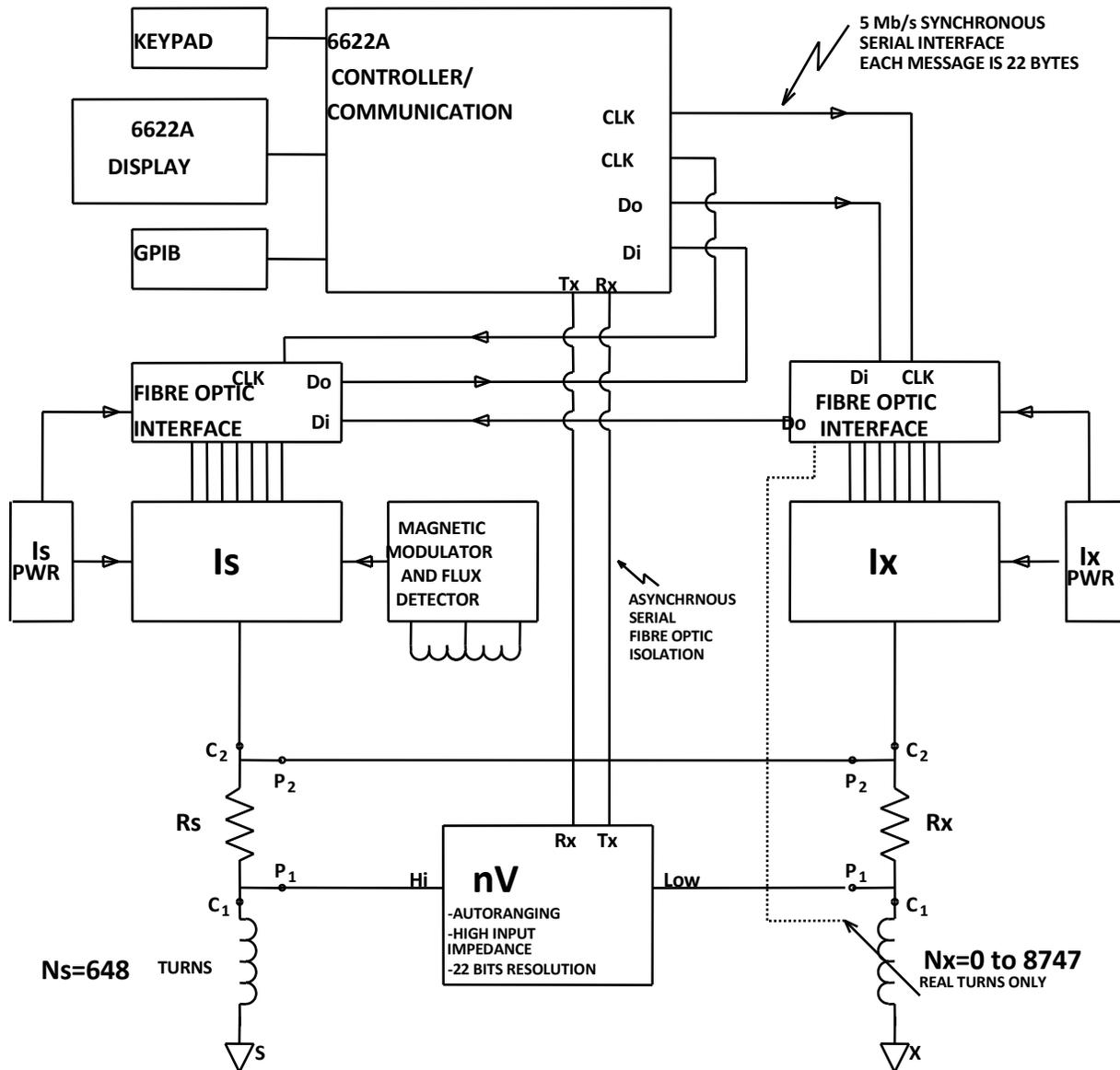


Figure 1-1 : Model 6622A Block Diagram

### **1.4.1.1. Low Ohm Measurement Mode**

This mode can be used to make 4 terminal resistance measurements down to  $0.1 \mu\Omega$  against a  $1 \Omega$ . In Low Ohm mode a high current range extender such as the model 6623A is used to improve the accuracy and allow for measurements below the normal Ohm range.

### **1.4.1.2. Normal Ohm Measurement Mode**

This mode allows a 4-terminal resistance measurement to be made from  $1 \text{ m}\Omega \leq R_x \leq 100 \text{ k}\Omega$ . No external devices (except the two resistors) are required with the 6622A to make this measurement.

### **1.4.1.3. High Ohm Measurement Mode**

This mode allows a 4-terminal resistance measurement to be made from  $100 \text{ k}\Omega \leq R_x \leq 1 \text{ G}\Omega$ , and is done with two internal voltage supplies in the 6622A. This mode is only available for eXtended Range and High Voltage models.

## 2. INSTALLATION

### 2.1. PRELIMINARIES

#### 2.1.1. Unpacking

- a. Remove the 6622A Automatic DCC Resistance Bridge and the other items from its shipping container in a suitable location.
- b. The following items are included with each new bridge
  - i. Operators Manual (OM6622A)
  - ii. Software Users Manual (SUM66XX)
  - iii. Spare Fuse 1 A Slo Blo (GPN# 099-21000)
  - iv. Spare Fuse 2 A Slo Blo (GPN# 099-22000)
  - v. Two 4-Wire Measurement Cables (GPN# 19591.01.02)
  - vi. AC Line Cord (GPN# 250-04030)
  - vii. Socket Screwkey, 5/64 (GPN# 950-61905)

#### 2.1.2. Power Voltage Selection

The 6622A Automatic DCC Resistance Bridges are shipped with the line input voltage set to 240 V and the line frequency requested at time of order. The line input selector must be set to the correct line voltage and the correct fuse must be installed before power is applied to the instrument. The 6622A has a voltage selection which must be set correctly. The settings available are 100 V, 120 V, 220 V, and 240 V. Figure 2-1 details the line input voltage selector setting.

The line frequency setting can be confirmed through front panel operation as outlined in Section 4.6.6.2. If the line input voltage is changed from that requested at time of order, 6622A may not be compatible with the new line input voltage and frequency. The ADC Beta value must agree with the value provided in the Bridge Coefficient Report supplied with the bridge.

Where the molded plug on the line cord supplied with the instrument does not match the local power outlet socket, the plug can be removed and replaced with one that does fit the local service. The plug should be re-wired as follows:

Brown wire	-	Line input
Blue wire	-	Neutral input
Green/Yellow	-	Ground (safety)

## 2.1.3. Fuse Replacement

Only fuses with specified current rating type should be used for replacement if necessary. See Table 2-1.

FUSES (TIME DELAY TYPE)			
100 V	120 V	220 V	240 V
2 A, 250 V, (T)	2 A, 250 V, (T)	1 A, 250 V, (T)	1 A, 250 V, (T)

Table 2-1 : Fuse Ratings

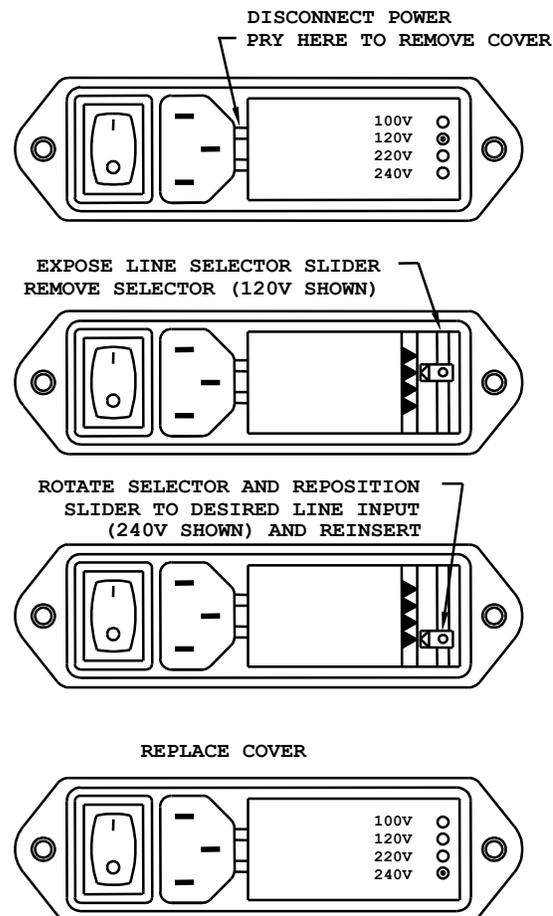


Figure 2-1 : Line Voltage Selector

### 2.1.4. Setup And Power On

- a. Verify that the power switch is off.
- b. Remove any excess packing material from around the front panel that is provided for shipping purposes only.
- c. Connect the computer system as applicable in accordance with the documentation provided. Connect a GPIB cable to the GPIB connector of the bridge and to the GPIB connector of the computer system.
- d. Set the line input selector to the correct line voltage and install the correct fuse before power is applied to the instrument as shown in Sections 2.1.2 and 2.2.
- e. Connect the input power cord from the 6622A bridge to a local AC power outlet.
- f. Turn on the power switch. You should see the opening banner indicating which model and options you have. Verify that no errors are displayed.
- g. Confirm the line frequency setting, as per section 2.1.2.
- h. If you are using software control open the BridgeWorks Data Acquisition Software in the computer. Refer to the BridgeWorks Software User's Manual.
- i. If BridgeWorks indicates that the 6622A bridge has not been found, then run the Rescan For Bridge utility in the File menu, to locate it. Note that you will also need to run the Rescan For Bridge utility, if the bridge was turned on after BridgeWorks was opened, has been replaced or the GPIB cables have been disconnected.

## 2.2. INCOMING INSPECTION

If no errors are displayed during power up, (see section 2.1.4 above) then proceed to measure two 10 k $\Omega$  standard resistors. Use the measurement set up procedure below. Note that any two resistance standards of equal nominal value may be used but the setup parameters will be different. Refer to Section 3.

- Step 1)** Connect the resistors to the 6622A Rx & Rs terminals as illustrated in figure 3-2
- From the front panel of the model 6622A select 'Setup' from the main menu functions.
- From the Setup menu, configure the measurement setup as follows:
- Select 'Normal' mode function key.
  - Select 'Edit' function key.
  - Enter 10000 on highlighted 'Resistance RS:' line on display by using the numeric key pad.
  - Select the down arrow key to highlight the next line on the display.
  - Leave standard resistor serial number under 'serial No. RS:' line blank.
  - Select the down arrow key to highlight the next line on the display.
  - Enter 10000 on highlighted 'Resistance RX:' line on display by using the numeric key pad.

- Select the down arrow key to highlight the next line on the display.
- Enter in 15 for the reversal rate for the measurement.
- Select the down arrow key to highlight the next line on the display.
- Enter 1 mA test current value for the test
- Select the down arrow key to highlight the next line on the display.
- Enter the maximum current value of 10 mA.
- Verify that all entered data is correct, and then press 'OK'.

**Step 2)** Press the 'Previous' function key twice to come back to the main menu.

**Step 3)** Press the 'Measure' function key and then the 'Meas Off ' sub-menu function key to start the measurement. The 6622A bridge will begin by showing the nominal value of the resistor to be measured, and then continue to go through a number of rough measurement cycles until a full resolution measurement value is displayed. The measurement may be stopped at any time by pressing the 'Meas On' menu key.

**Step 4)** The value displayed after about 15 minutes of measuring should read with in 100 ppm of the known ratio of the resistors.

**Step 5)** After completing of the test the 10 k $\Omega$  resistors should be removed.

**Note: The test should execute with no measurement errors indicated and should indicate a ratio within 100 ppm of the known ratio. This is not the 6622A's full rated accuracy but serves a functional test for the purposes of determining the instrument has been received in proper working order.**

## 2.3. 6622A SERIES FRONT PANEL DISPLAY AND CONTROLS

The displayed text for each control of the 6622A Series represents the current applicable state of the bridge.

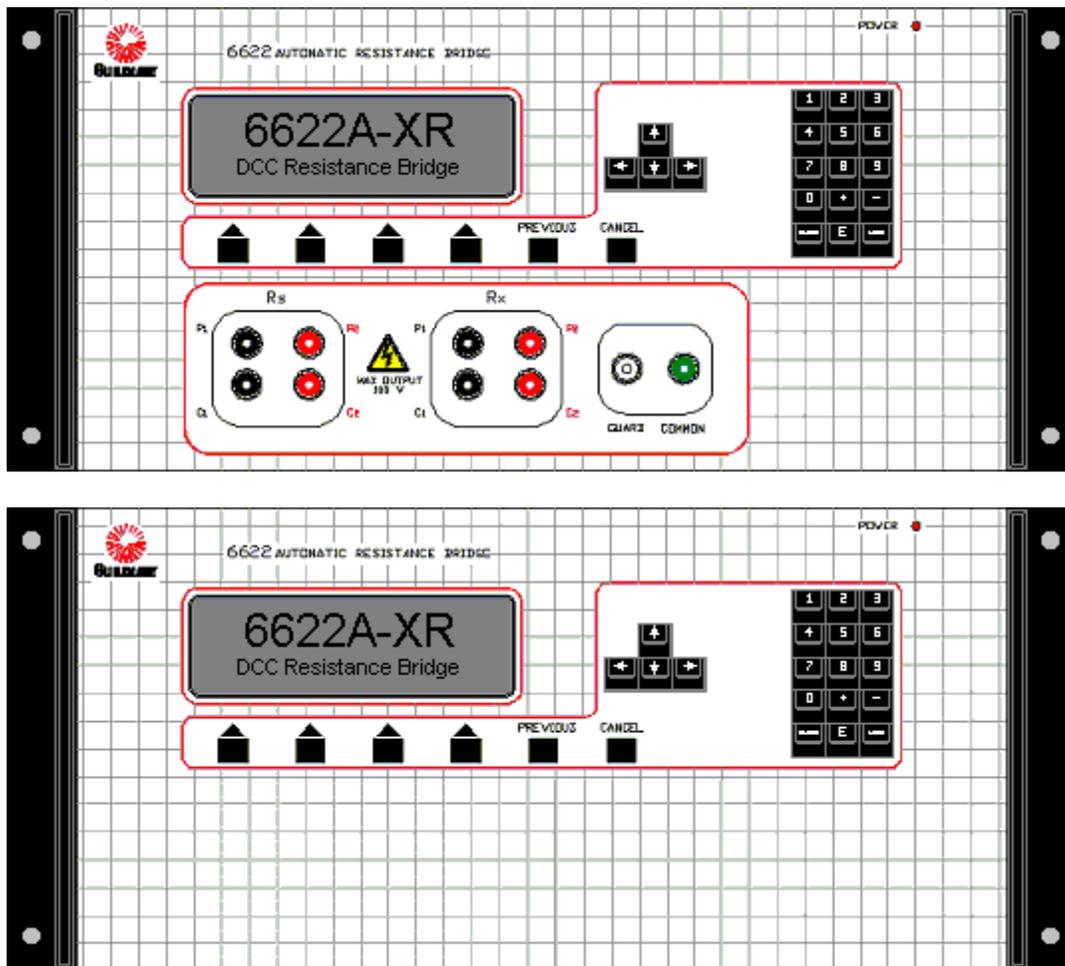


Figure 2-2 : 6622A Front View (Bench / Rack)

### 2.3.1. Standard Resistor Input Terminals (Bench Model Only)

The standard resistor input terminals consist of 4 low thermal binding posts. The binding posts have the 'Rs' label above the group of four posts. The posts are labeled clockwise from bottom left to right, 'C1', 'P1', 'P2', and 'C2'. These posts provide direct connection for your standard resistor. Switching between multiple resistances can be simplified and automated with the standard resistor input terminals connected to the Line A 'Rs C & P' output terminals of an optional model 16 Channel Scanner(s). These terminals are located on the front panel for bench top models.

### 2.3.2. Resistor Under Test Input Terminals (Bench Model Only)

The resistor under test input terminals consist of 4 low thermal binding posts. The binding posts have the 'Rx' label above the group of four posts. The posts are labeled clockwise from bottom left to right, 'C1', 'P1', 'P2', and 'C2'. These posts provide direct connection for your resistor under test. Switching between multiple resistances can be simplified and automated with the standard resistor input terminals connected to the Line B 'Rs C & P' output terminals of an optional model 16 Channel Scanner(s). These terminals are located on the front panel for bench top models.

### 2.3.3. Guard Terminal (Bench Model Only)

The guard terminal consists of a four way white binding post. The guard is an active circuit referenced to the signal low, C1, side of the four terminal Rx resistor. This terminal is located on the front panel for bench top models. Guard should never be connected to Ground as this will cause damage to the 6622A. The active guard on the 6622A should also never be connected to another device's guard that has an active guard such as a Fluke 5700A calibrator or damage may occur. This terminal is located on the front panel for bench top models.

### 2.3.4. Circuit Common Terminal (Bench Model Only)

The circuit common terminal consists of a four way black binding post. The circuit common terminal is connected to the circuit common internal to the model 6622A and is isolated from the chassis ground terminal. This terminal is located on the front panel for bench top models. This terminal is typically not used in measurement practice and is mainly used for diagnostics. This terminal is located on the front panel for bench top models.

### 2.3.5. Power

The power-on indicator is lighted when the AC power is applied to the unit and the power switch on the rear panel is "ON".

### 2.3.6. Display

The display is a combined green fluorescent vacuum consisting of 256 × 64 graphic display pixel and of 8 × 42-display character.

### 2.3.7. Numeric Keypad

The numeric keypad consists of the following cited 15 keys; <0>, <1>, <2>, <3>, <4>, <5>, <6>, <7>, <8>, <9>, <- >, <. >, <CLEAR>, <E>, <LOAD>.

### 2.3.8. Special Keys

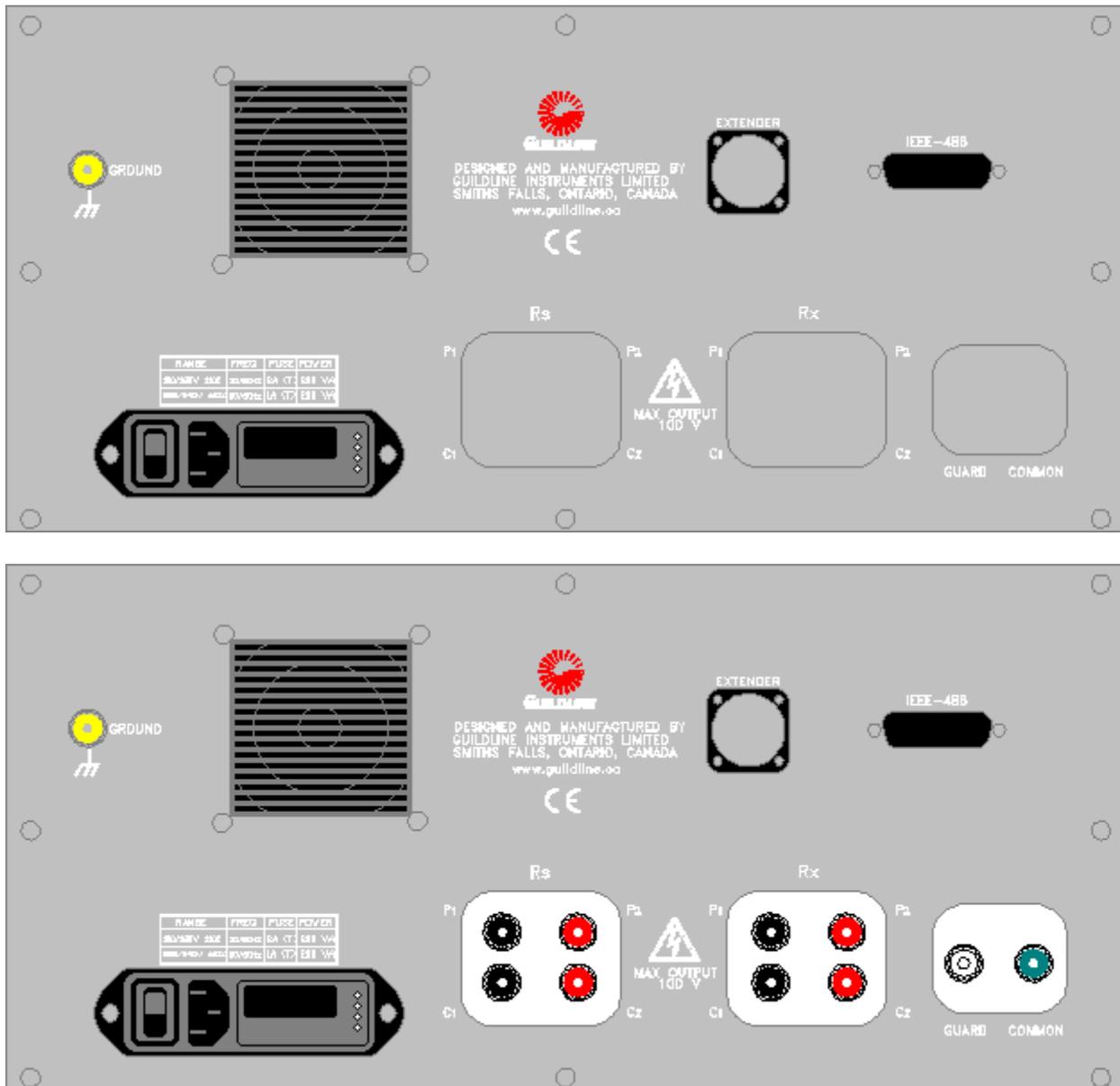
#### 2.3.8.1. Cursor Movement Keys

The 4 movement cursor keys are labeled as follow: <LEFT ARROW>, <UP ARROW>, <DOWN ARROW>, and <RIGHT ARROW>.

### 2.3.8.2. Function Keys

The four unlabelled keys located below the display are the function keys. Their functionality depends on the "soft" functions described in this manual Section 4. In addition to this, there are two fixed function keys: the <PREVIOUS> and the <CANCEL> keys. By pressing the <PREVIOUS> key within a selected menu, this action will return the control to the previous selected menu and by keying the <CANCEL> key; this action will undo any current keypad entries that have been entered.

## 2.4. 6622A SERIES REAR PANEL CONNECTORS AND CONTROLS



### 2.4.1. IEEE-488 Interface

The **IEEE-488** interface consists of the standard **IEEE-488** interface connector. The **IEEE-488** interface provides the means for the computer system to obtain complete computer control of the 6622A Series Automatic DCC Resistance Bridge.

### 2.4.2. Line Input Connector

The **Line Input Connector** is a combination of a 3-prong AC standard male connector, an ON/OFF switch and a fused input line voltage selector. The input line's voltage selector consists of a four-position selector and a fuse holder. The selector allows switching between the four possible tensions: 100 V, 120 V, 220 V and 240 V. A 2 A time delay fuse is provided for the 100/120 V operation and a 1 A time delay fuse is provided for the 220/240 V operation. The voltage selector and the fuse are set for the 240 V operation unless if it is requested otherwise.

### 2.4.3. Standard Resistor Input Terminals (Rack Model Only)

The reference resistor's input terminals consist of 4 low thermal binding posts. These binding posts have their '**Rs**' label inside a group of four posts. These posts are labeled clockwise from bottom left to right, 'C1', 'P1', 'P2', and 'C2'. These posts provide direct connection for your standard resistor. Switching between multiple standards can be simplified and automated with the standard resistor input terminals connected to the Line A 'Rs C & P' output terminals of an optional model 6664C 16 Channel Scanner(s). These terminals are located on the rear panel for rack mount models.

### 2.4.4. Resistor Under Test Input Terminals (Rack Model Only)

The resistor under test input terminals consist of 4 low thermal binding posts. The binding posts have the '**Rx**' label inside the group of four posts. The posts are labeled clockwise from bottom left to right, 'C1', 'P1', 'P2', and 'C2'. These posts provide direct connection for your resistor under test. Switching between multiple resistances can be simplified and automated with the standard resistor input terminals connected to the Line B 'Rs C & P' output terminals of an optional model 6664C 16 Channel Scanner(s). These terminals are located on the rear panel for rack mount models.

### 2.4.5. Guard Terminal (Rack Model Only)

The guard terminal consists of a four way white binding post. The guard is an active circuit referenced to the signal low, C1, side of the four terminal Rx resistor. This terminal is located on the rear panel for rack mount models. Guard should never be connected to Ground as this will cause damage to the 6622A. The active guard on the 6622A should also never be connected to another device's guard that has an active guard such as a Fluke 5700A calibrator or damage may occur). This terminal is located on the rear panel for rack mount models.

### 2.4.6. Circuit Common Terminal (Rack Model Only)

The circuit common terminal consists of a four way black binding post. The circuit common terminal is connected to the circuit common internal to the model 6622A and is isolated from the chassis ground terminal. This terminal is located on the rear panel for rack mount models. This terminal is typically not used in measurement practice and is mainly used for diagnostics. This terminal is located on the rear panel for rack mount models.

### **2.4.7. Ground Terminal**

The ground terminal consists of a four way green binding post. The ground terminal is bonded to the chassis of the 6622A Series and to power ground of the line input connector.

### **2.4.8. Extender Connector**

The Extender connector is a 6 pin circular connector which is used to connect the necessary signals to and from the 6623A Series or 6623 Range Extenders.

## 3. QUICK MEASUREMENT GUIDE

### 3.1. MEASUREMENT OPERATION GUIDE

This section contains information regarding the measurement of resistors in the range of 1m ohm to 1G ohms. This guide is provided for manual front panel control of the 6622A bridge. An operation guide for full automatic control of the 6622A bridge, through the terminal of the system computer, is provided in the BridgeWorks Software User’s Manual. A typical example of a resistance measurement response versus test sample is illustrated in Figure 3-1.

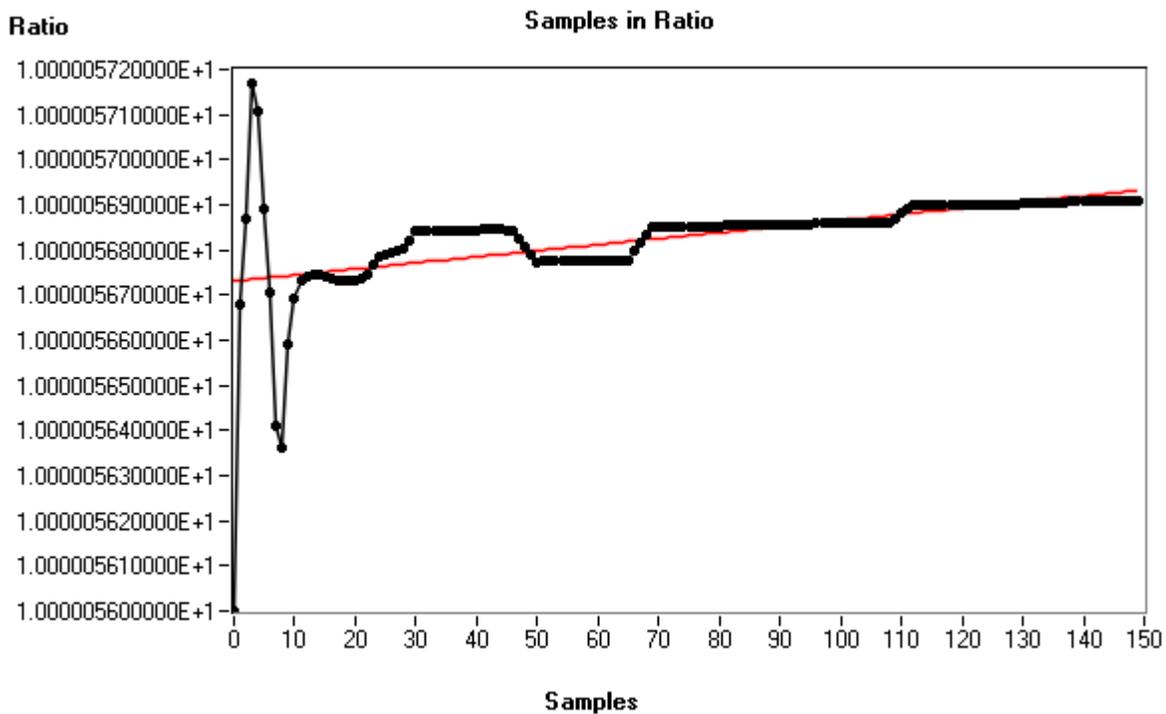


Figure 3-1 : Resistance Measurement Response Versus Test Sample

**NOTE:** The last 35 samples of a total of 150 measurement samples should be used to determine the mean measurement value and standard deviation of the sample set, to allow sufficient stabilization time to achieve the specified uncertainty for the model 6622A Bridge.

### 3.1.1. Normal Ohm Mode Resistance Measurement (All 6622A Models)

The 6622A in its Normal Ohm Mode enables measurement of resistors in the range of 1 mΩ to 100 kΩ. The following steps outline the general procedure for making Normal Ohm measurements. Figure 3-2 shows a typical rear panel connection for this measurement mode. Specifications are based on use of shielded wire connections throughout, with shields connected to the 'GUARD' terminal. Use of SCW cable from Guildline is most recommended.

**NOTE:**

**In this, as in all measurements, optimum results will be obtained if the environment is controlled. The recommendations in the Instrument Society of America (ISA) publication ISA RE52.1, especially in regards to relative humidity, should be observed.**

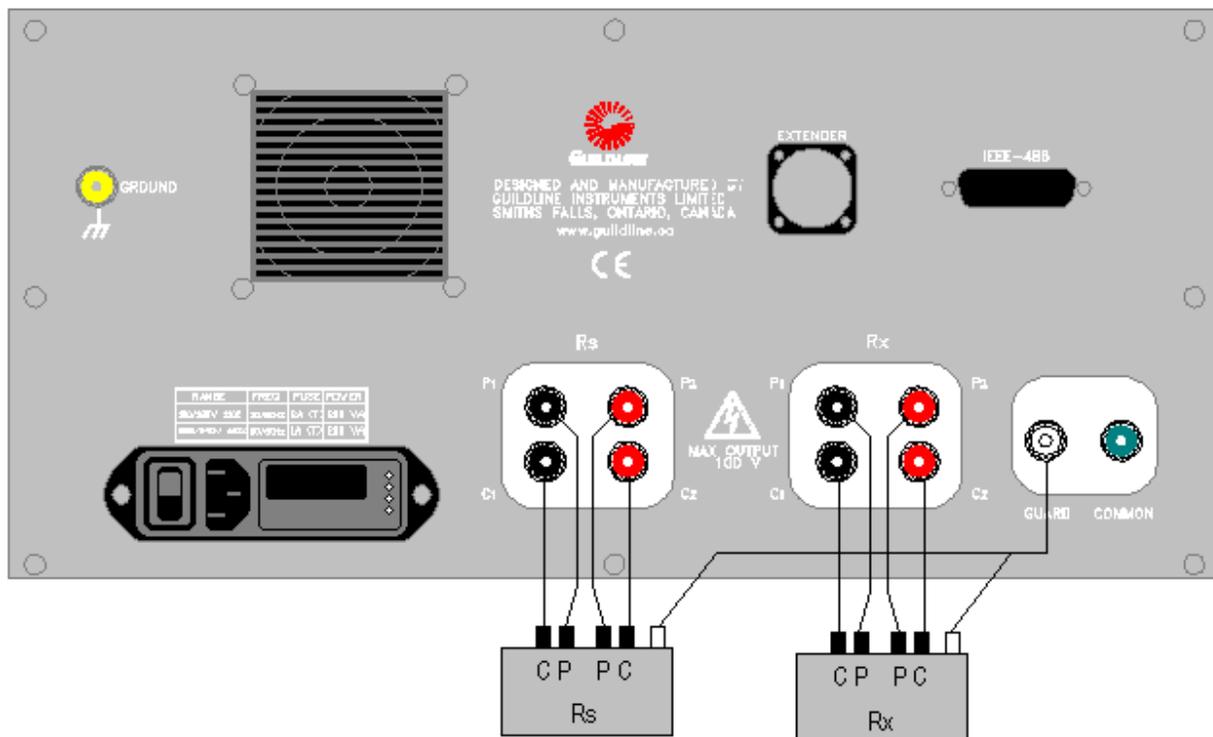


Figure 3-2 : Rear Panel Connections - Normal Ohm Mode

- Step 1)** Select the appropriate working standard resistor such that  $R_s:R_x$  is from 1:1 to 1:100, (see Table 3-1).

- Step 2)** Connect the Rs and Rx terminals to the terminals of the resistor to be measured. The four terminals are labeled as C1, P1, C2, and P2, and should be connected to the corresponding terminals of the 4 terminal resistor to be measured. For a 2 terminal resistor, connect the C1 and P1 pair shorted together at one terminal of the resistor and the C2 and P2 pair at the other terminal of the resistor.
- Step 3)** From the front panel of the model 6622A select 'Setup' from the main menu functions. See Section 4.6 for the menu descriptions and Table 3-1 for a summary of recommended test setups. From the Setup menu, configure the measurement setup as follows:
- Select 'Normal' mode function key.
  - Select 'Edit' function key.
  - Enter standard resistor value on highlighted 'Resistance RS:' line on display by using the numeric key pad.
  - Select the down arrow key to highlight the next line on the display.
  - Enter standard resistor serial number under 'serial No. RS:' line.
  - Select the down arrow key to highlight the next line on the display.
  - Enter the reversal rate for the measurement.
  - Select the down arrow key to highlight the next line on the display.
  - Enter the test current value for the resistor to be measured in mA.
  - Select the down arrow key to highlight the next line on the display.
  - Enter the maximum current value for the standard resistor in mA.
  - Verify that all entered data is correct, and then press 'OK'.

Note that the current in the standard resistor is controlled by the resistance of the resistor to be measured by the following formula:

$$\text{Standard Resistor Current} = \text{Test Current} \times (\text{Rx/Rs})$$

- Step 4)** Press the 'Previous' function key twice to come back to the main menu.
- Step 5)** Press the 'Measure' function key and then the 'Meas Off' sub-menu function key to start the measurement. The 6622A bridge will begin by showing the nominal value of the resistor to be measured, and then continue to go through a number of rough measurement cycles until a full resolution measurement value is displayed. The measurement may be stopped at any time by pressing the 'Meas On' menu key.

Ref. ( $\Omega$ )	U.U.T. ( $\Omega$ )	I <sub>test</sub> (mA)	I <sub>max</sub> (mA)	Reversal Rate (sec)	Comment (1)
1	0.1	150	150	60	Output current limited to 150 mA
1	1	100	150	20	
1	10	10	150	20	
1	100	1	150	60	
10	1	100	100	20	
10	10	31.6	31.6	20	
10	100	3.16	31.6	20	
10	1 k	0.316	31.6	60	
100	10	31.6	31.6	20	
100	100	10	10	20	
100	1 k	1	10	40	
100	10 k	0.1	10	90	
1 k	100	10	10	40	
1 k	1 k	3.16	3.16	40	
1 k	10 k	0.316	3.16	60	
1 k	100 k	0.032	3.2	90	
10 k	1 k	3.16	3.16	60	
10 k	10 k	1	1	60	
10 k	100 k	0.1	1	90	

Table 3-1 : Recommended Normal Ohm Mode Test Setups

**NOTE:** The last 35 measurement samples, of a total of 150, should be used, to allow for sufficient stabilization time to achieve the specified uncertainty.

### 3.1.2. Low Ohm Mode Resistance Measurement (All 6622A Models)

The 6622A in its Low Ohm Mode enables measurement of resistors below 1 ohm. When used with a 6623A series or 6623 range extender, measurement of low ohm resistors can be made with larger currents.

- Step 1)** Connect the bridge, the range extender, and external power supply (required only for 6623), the reference standard and the UUT resistor as shown below in the connection diagram, figure 3-3 or figure 3-4. Ensure you are using appropriate leads to carry the high current.
- Step 2)** Make sure the selection of working standard resistor is appropriate. For Measurement of low ohm UUT, usually a 1  $\Omega$  reference is chosen.
- Step 3)** From the front panel of the model 6622A select 'Setup' from the main menu functions. Tables 3-2 and 3-3 show a summary of recommended test setups. From the Setup menu, configure the measurement setup as follows:
- Select 'Low (ohm)' mode function key.
  - Options at this level are 'edit' (test setup information), 'ok' (to accept) or '6623A', or '6623'. Make sure the appropriate mode is selected. This can be done by pressing the softkey under displayed range extender model until the displayed value is changed to the desired model. The 6622(A) family of DCC bridges can work with the 6623A Series, or the 6623 of range extenders.
  - Select 'Edit' function key.
  - Enter standard resistor value on highlighted 'Resistance RS:' line on display by using the numeric key pad.
  - Select the down arrow key to highlight the next line on the display.
  - Enter standard resistor serial number under 'Serial No. RS:' line.
  - Select the down arrow key to highlight the next line on the display.
  - Enter the nominal value of Rx.
  - Enter the reversal rate for the measurement.
  - Select the down arrow key to highlight the next line on the display.
  - Enter the extender (transformation) ratio of 10 or 20, 100, or 1000. The ratio entered here should agree with the set of terminals used on the 6623 or 6623A. For example, if you are using the x1000 set of terminals on the 6623, enter ratio 1000 in the setup window here.
  - Select the down arrow key to highlight the next line on the display.
  - Enter the maximum current value for the (reference) standard resistor in mAmps. The max current needs to be slightly larger than the Rs current shown in Table 3-3 and is normally set at 150 mA.
  - Select the down arrow key to highlight the next line on the display.

- When a model 6623 and the external power supply are used, a user sets the test current on the external power supply, the bridge does not. When a model 6623A range extender is in use, enter the test current (for the resistor to be measured) in Amps.
- Verify that all entered data is correct, and then press 'OK'.

**Step 4)** Press the 'Previous' function key twice to come back to the main menu.

**Step 5)** On the current power supply, if being used, set the desired output current, but **DO NOT** enable the output yet. Press the 'Measure' function key on the 6622A bridge and then the 'Meas Off ' sub-menu function key to start the measurement. The 6622A bridge will begin by showing the nominal value of either the resistor or the ratio to be measured. At this time, the bridge is carrying out a measurement at 0 (zero) current. Now enable the current output of the power supply. Remember to always start the bridge measurement before the high current output of the current power supply is enabled. The bridge will continue to go through a number of measurement cycles until a full resolution measurement value is displayed. It may take a while to reach a stable measurement after the application of current. To stop a measurement, always disable the current of the power supply first. Then bridge measurement may be stopped by pressing the 'Meas On' menu key.

See Tables 3-2 and 3-3 for the recommended test setups. Note that the current in the standard resistor is controlled by the resistance of the resistor to be measured and the extender current by the following formula:

$$\text{Standard Resistor Current} = \text{Test Current} \times (\text{Rx/Rs})$$

Also note that measurements made in Low Ohm mode should be made such that the following conditions are maintained:

$$R_s \geq \text{Ext. Ratio} \times R_x/2$$

$$R_s \geq (\text{Extender Ratio}) \times R_x$$

Ref. ( $\Omega$ )	U.U.T. ( $\Omega$ )	I <sub>test</sub> (A)	R <sub>s</sub> Current (mAmps)	Extender Ratio	Reversal Rate (sec)	Comment (1)
1	0.1	0.316	31.6	10:1	60	1 W test in R <sub>x</sub>
1	0.01	10	100	100:1	60	1 W test in R <sub>x</sub>
1	0.001	31.6	31.6	1000:1	60	1 W test in R <sub>x</sub>
1	0.0001	100	100	1000:1	60	1 W test in R <sub>x</sub>
1	0.00001	100	100	1000:1	60	Limit of Current Source
1	0.000001	100	100	1000:1	60	Limit of Current Source

Table 3-2 : 6623 Recommended Low Ohm Mode Test Setup

**NOTE: The last 35 measurement samples, of a total of 150, should be used, to allow for sufficient stabilization time to achieve the specified uncertainty.**

Ref. ( $\Omega$ )	U.U.T. ( $\Omega$ )	I <sub>test</sub> (A)	R <sub>s</sub> Current (mA)	Extender Ratio/Range	Reversal Rate (sec)	Comment (1)
1	0.01	3	30	20:1 / 3A	60	Limit of x 20, 3A Range
1	0.05	2	100	20:1 / 3A	60	Limit of 10 mW in R <sub>s</sub>
1	0.1	1	100	20:1 / 3A	60	Limit of 10 mW in R <sub>s</sub>
10	0.1	3	30	20:1 / 3A	60	Limit of x 20, 3A Range
100	0.5	3	15	20:1 / 3A	60	Limit of x 20, 3A Range
1000	10	0.8	8	20:1 / 3A	60	Limit of Voltage Compliance
1	0.001	15	15	200:1 / 15A	60	Limit of x 200/15A Range
1	0.005	15	75	200:1 / 15A	60	Limit of x 200/15A Range
1	0.01	10	100	200:1 / 15A	60	Limit of 10 mW in R <sub>s</sub>
10	0.01	15	15	200:1 / 15A	60	Limit of x 200/15A Range
10	0.05	6.32	31.6	200:1 / 15A	60	Limit of 10 mW in R <sub>s</sub>
100	0.1	10	10	200:1 / 15A	60	Limit of 10 mW in R <sub>s</sub>
1	1u	300	0.3	2000:1 / 300A	90	Limit of x2000/300A Range
1	10u	300	3	2000:1 / 300A	90	Limit of x2000/300A Range
1	50u	300	15	2000:1 / 300A	90	Limit of x2000/300A Range
1	100u	300	30	2000:1 / 300A	90	Limit of x2000/300A Range
1	0.0005	200	100	2000:1 / 300A	90	Limit of 10 mW in R <sub>s</sub>
10	0.0005	300	15	2000:1 / 300A	90	Limit of x2000/300A Range
10	0.001	300	30	2000:1 / 300A	90	Limit of x2000/300A Range

Table 3-3 : 6623A-300 Recommended Low Ohm Mode Test Setup

- NOTE: 1. The last 35 measurement samples, of a total of 150, should be used, to allow for sufficient stabilization time to achieve the specified uncertainty.**
- 2. Refer to the specific Range Extender Operation Manual for test parameters of other Range Extender models.**

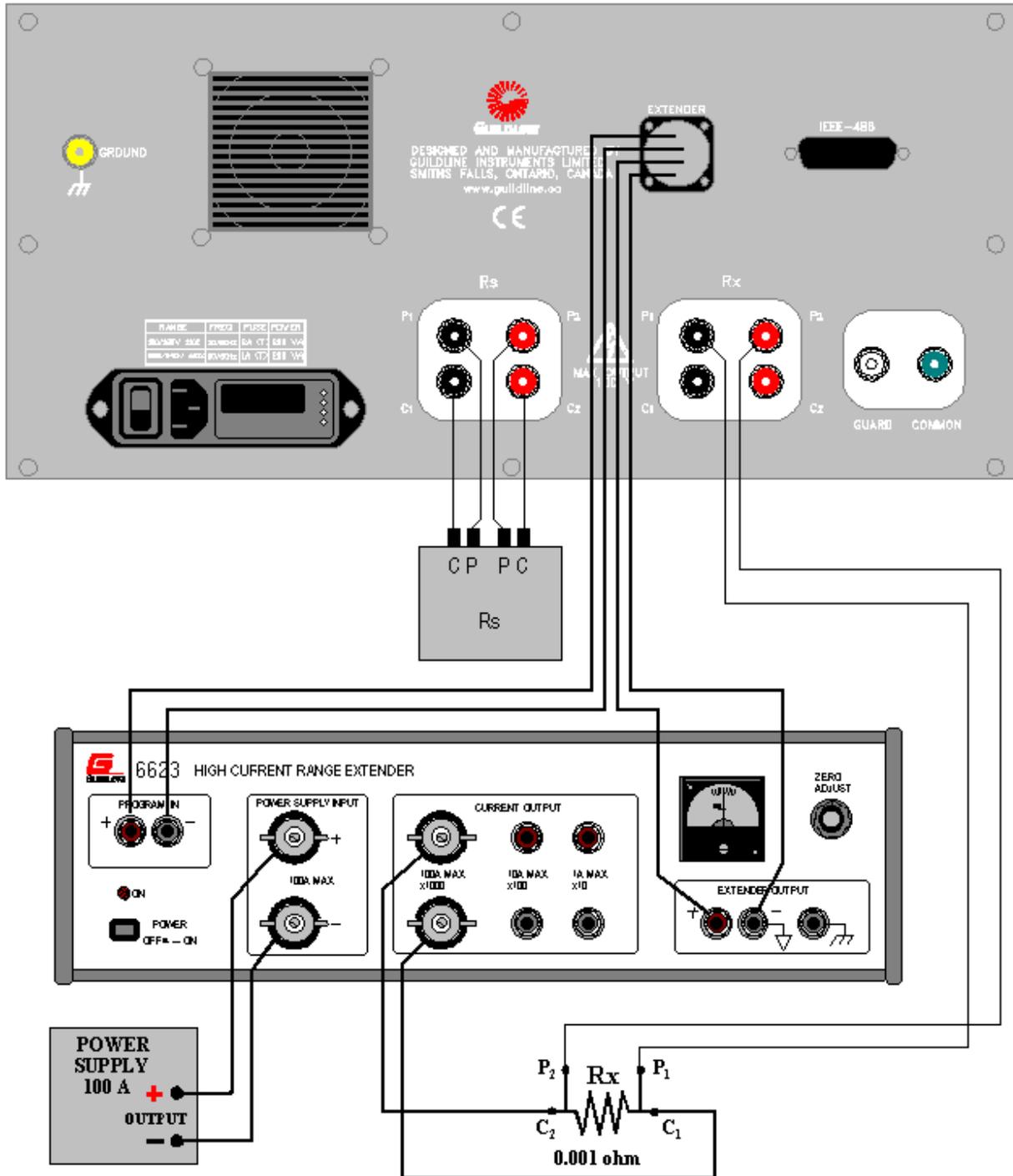


Figure 3-3 : Rear Panel Connections – Low Ohm Mode with 6623

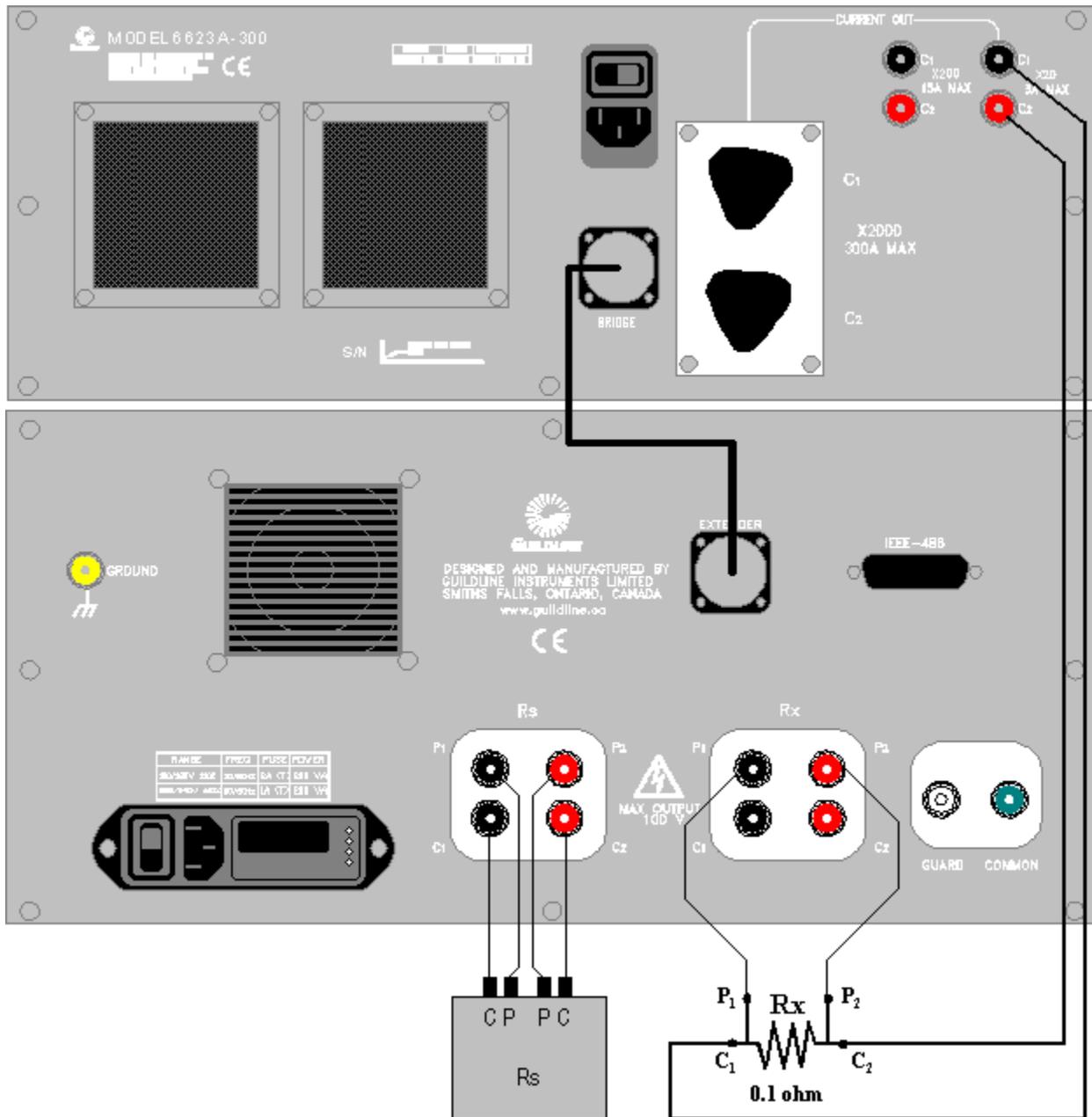


Figure 3-4 : Rear Panel Connections – Low Ohm Mode with 6623A-300

### 3.1.3. High Ohm Mode Resistance Measurement (6622A-XR and 6622A-XPR)

The 6622A in its High Ohm mode enables measurement of resistors in the range of 100 k $\Omega$  to 100 M $\Omega$ . The setup is the same as for the Normal mode described in section 3.1.1, except select the 'High Ohm' mode function key in step 4, and enter a 'Test Voltage' and 'Max Voltage' in place of currents. Figure 3-5 shows a typical rear panel connection for four terminal resistors. Specifications are based on use of shielded wire connections throughout, with shields connected to the 'GUARD' terminal. Use of SCW cable from Guildline is most recommended.

**WARNING:**

**The 6622A bridge can produce dangerous voltages of up to 100 V for the XR and XPR models. Exercise caution when setting output voltages as to avoid injury or equipment damage.**

In High Ohm Mode, the 6622A uses the internal voltage source to make the measurement. See Table 3-4 for the recommended test setups up to 100 V. Note that in High Ohm mode, the test voltages are equal on both the Rx and Rs resistors. The Rs:Rx ratio should be such that Rs:Rx is from 1:1 to 1:100.

Ref. ( $\Omega$ )	U.U.T. ( $\Omega$ )	V <sub>test</sub> (V)	V <sub>max</sub> (V)	Reversal Rate (sec)	Comment (1)
10 k	1 M	10	32	90	
100 k	100 k	31.6	32	90	
100 k	1 M	31.6	32	90	
1 M	1 M	100	100	90	Output limit of voltage source
1 M	10 M	100	100	120	Output limit of voltage source
1 M	100 M	100	100	120	Output limit of voltage source
10 M	10 M	100	100	120	Output limit of voltage source
10 M	100 M	100	100	120	Output limit of voltage source

Table 3-4 : Recommended 100 V High Ohm Mode Test Setup

**NOTE: The last 35 measurement samples, of a total of 150, should be used, to allow for sufficient stabilization time to achieve the specified uncertainty.**

### 3.1.4. High Ohm Mode Resistance Measurement (6622A-HV)

The 6622A-HV in its High Ohm mode enables measurement of resistors in the range of 100 k $\Omega$  to 1 G $\Omega$ . The setup is the same as for the 6622A-XR and 6622A-XPR with the difference being that there is 1000 V available. Figure 3-5 shows a typical rear panel connection for four terminal resistors. Specifications are based on use of shielded wire connections throughout, with shields connected to the 'GUARD' terminal. Use of SCW cable from Guildline is most recommended.

**WARNING:**

**The 6622A bridge can produce dangerous voltages of up to 1000 V for the HV model. Exercise caution when setting output voltages as to avoid injury or equipment damage.**

In High Ohm mode, the 6622A uses the internal voltage source to make the measurement. See Table 3-5 for the recommended test setups at 1000 V. Note that in High Ohm mode, the test voltages are equal on both the Rx and Rs resistors. The Rs:Rx ratio should be such that Rs:Rx is from 1:1 to 1:100.

Ref. ( $\Omega$ )	U.U.T. ( $\Omega$ )	V <sub>test</sub> (V)	V <sub>max</sub> (V)	Reversal Rate (sec)	Comment (1)
10 k	1 M	10	32	90	
100 k	100 k	31.6	32	90	
100 k	1 M	31.6	32	90	
1 M	1 M	100	100	90	
1 M	10 M	100	100	120	
1 M	100 M	100	320	120	
10 M	100 M	316	320	120	
100 M	100 M	1000	1000	150	
100 M	1 G	1000	1000	150	

Table 3-5 : Recommended 1000 V High Ohm Mode Test Setup

**NOTE: The last 35 measurement samples, of a total of 150, should be used, to allow for sufficient stabilization time to achieve the specified uncertainty.**

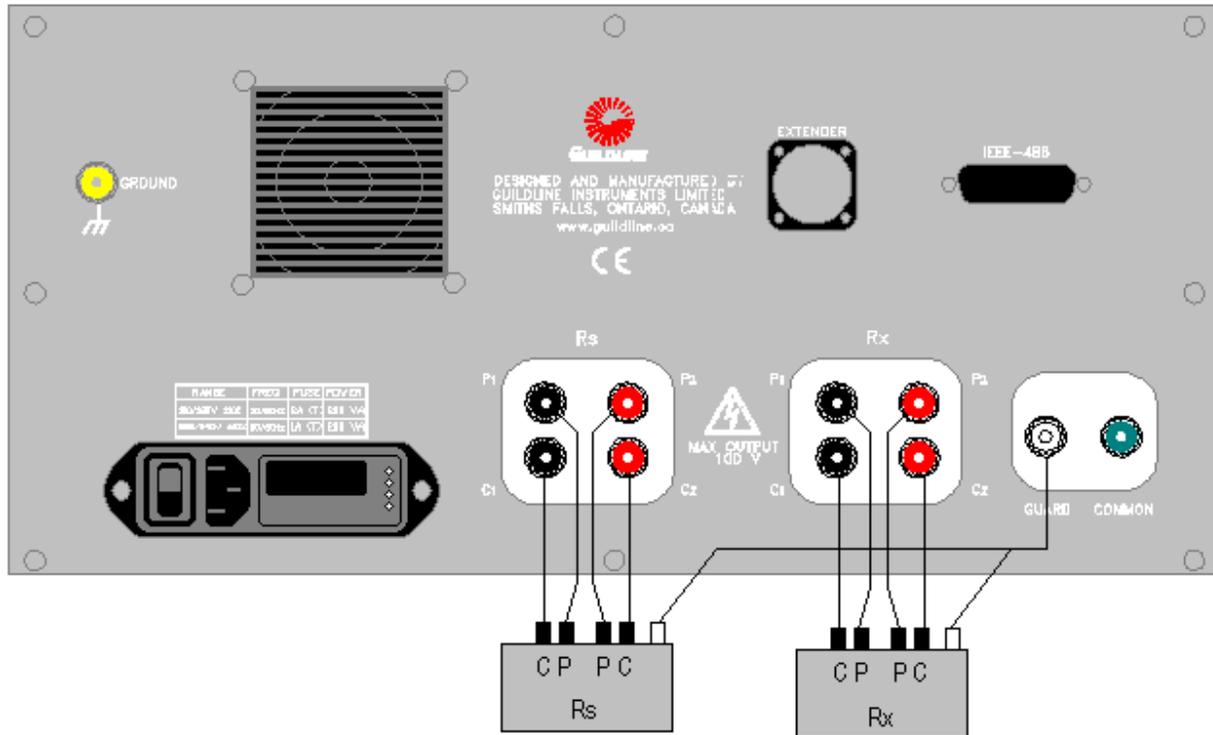


Figure 3-5 : Rear Panel Connections – High Ohm Mode

### 3.2. BRIDGEWORKS DATA ACQUISITION SOFTWARE

The BridgeWorks Data Acquisition Software is the control software for the 6622A Series Automatic DCC Resistance Bridges. Using the 6622A with the BridgeWorks Data Acquisition Software will increase the functionality and the productivity of the bridge. Adding optional 6664C Scanner(s) to work along with 6622A Series bridges and software control will create a fully automated Resistance Measurement System. Before using the 6622A with the computer, ensure that the operation of the software package is well understood. The computer controls the system through the IEEE-488 Interface (GPIB) of the 6622A, and optionally, the model 6664C.

**Warning: It is strongly advised that you do not attempt to change any parameters manually while under software control. If manual intervention is viewed as necessary, it should only occur while the software is either closed or displaying an error message.**

Refer to the BridgeWorks Software User's Manual for a description of the software functions and automatic operation of the system under software control.

## 4. INSTRUMENT OPERATION

### 4.1. FRONT PANEL OPERATING PROCEDURE

The 6622A Bridges is manually operable from the front panel. The BridgeWorks Software User's Manual contains the operating instructions for fully automatic software control of the 6622A Automatic DCC Resistance Bridge via its computer system.

### 4.2. 6622A RESISTANCE MEASUREMENT BRIDGE

The front panel of the 6622A consists of a keypad and display area. The keypad consists of:

- one set of numeric keys <0,1,2,3,4,5,6,7,8,9> for numeric data entry;
- one change sign key <->;
- one enter exponent key <E>;
- one <CLEAR> data value key;
- one <LOAD> data value key.

A set of four cursor movement keys are also provided, in the form of the <up arrow>, <down arrow>, <left arrow> and <right arrow>.

Four software programmable keys are positioned beneath the display area. These keys take on the function as displayed in the display area immediately above the key.

The <PREVIOUS> key is provided to move backward to the last menu level through the menu software and the <CANCEL> key is provided to cancel the last data entry.

The display is used to provide data information and user function feedback to the operator. The display is divided into three main areas:

1. status line area; for display of system status information;
2. function key area; for description of function key operation;
3. data area; for display of result data and configuration data.

The following information describes typical displays and corresponding menu descriptions for associated function keys. Figures 4-1 and 4-2 illustrate the 6622A bridge menu tree.

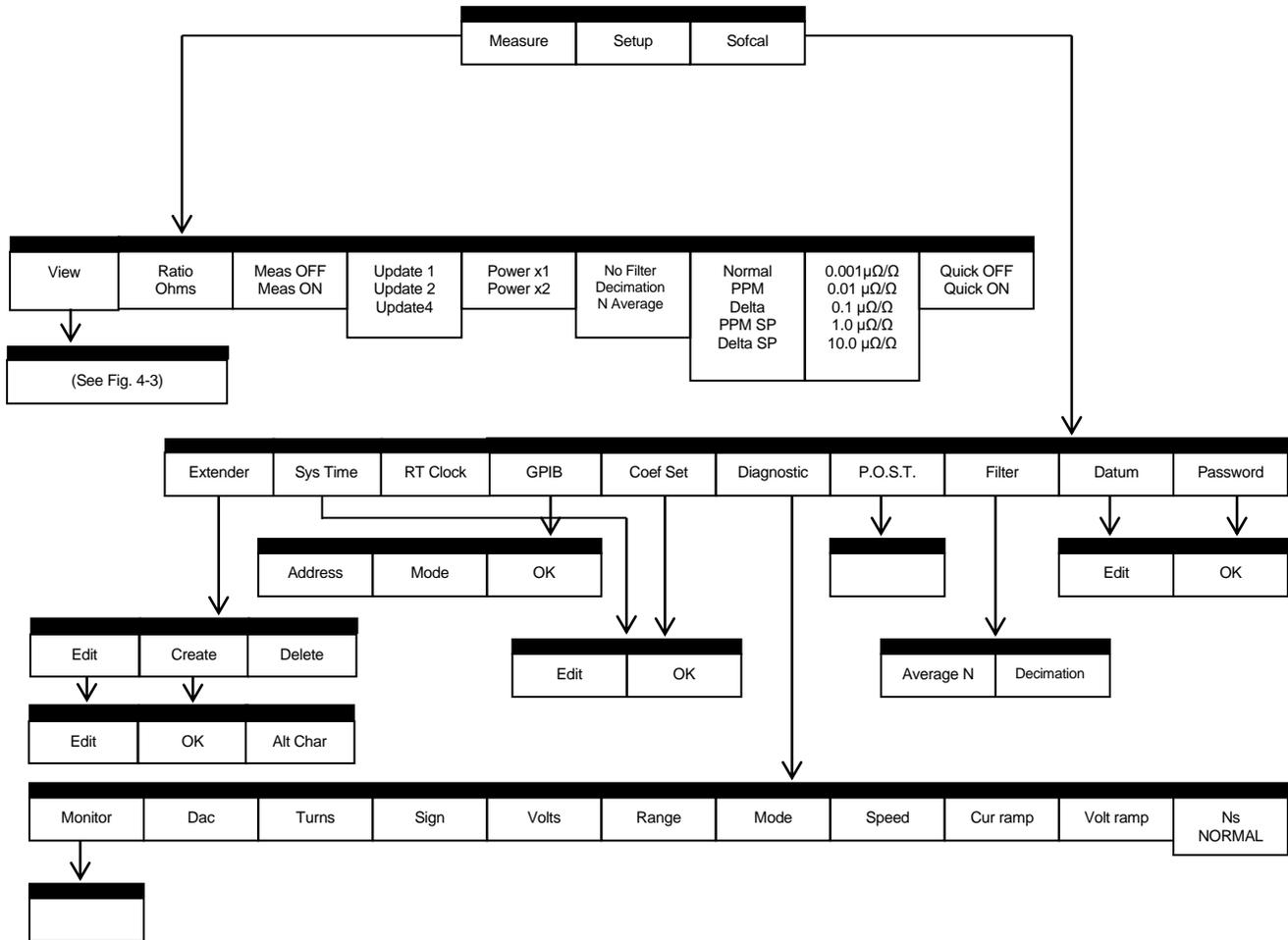


Figure 4-1 : Menu Tree – MEASURE/SOFCAL

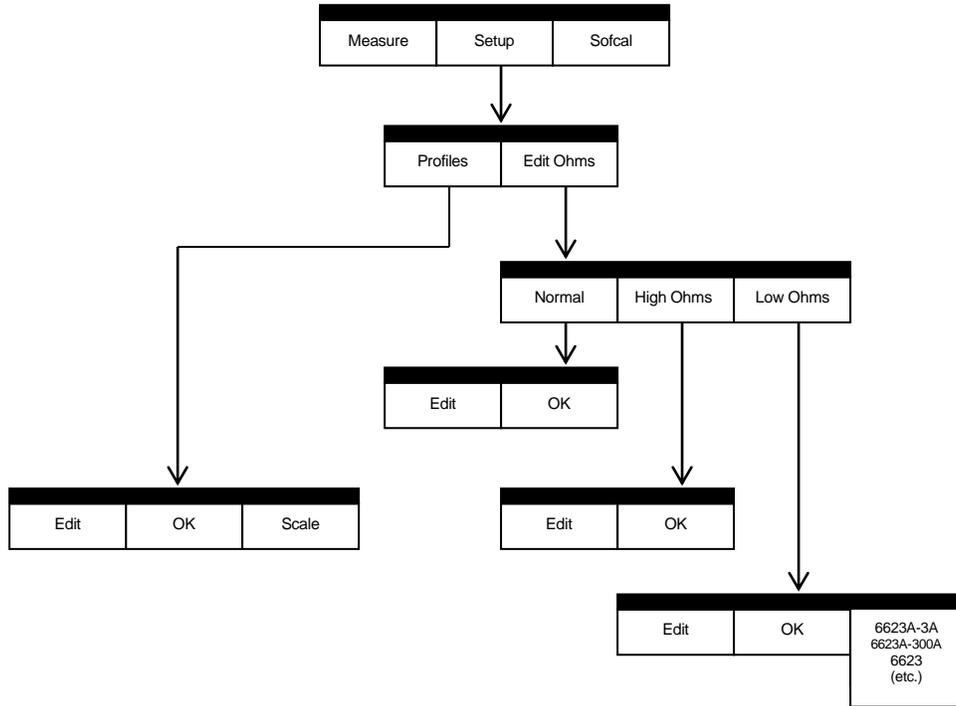


Figure 4-2 : Menu Tree – SETUP

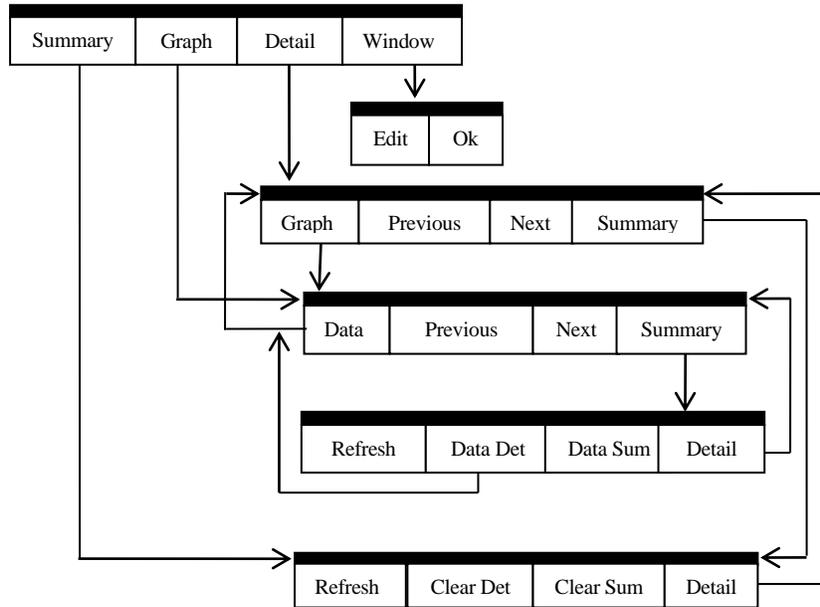


Figure 4-3 : Menu Tree – MEASURE-VIEW

## 4.3. GENERAL KEY/DISPLAY OPERATIONS

### 4.3.1. Base menu

Typically consists of four function key (or less) description areas, and a status line.

Status Line			
Function 1	Function 2	Function 3	Function 4

When there are more than four functions for a given menu level a <Scrn n-N> function key will appear. Pressing this menu option will display the remaining set of operations available at the current menu level.

Status Line			
Function 1	Function 2	Function 3	More ?-??

Where, in the function key - <Scrn n-N>

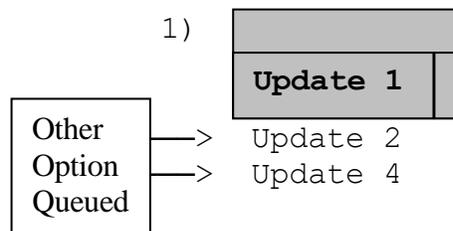
- N** represents the total number of available menu pages
- n** represents the current menu page

## 4.4. BASIC MENU OPERATIONS

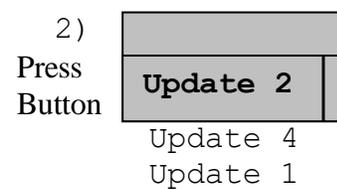
### 4.4.1. Menu Option-<MEASURE>

In the menu option <MEASURE>, several function keys are defined where each key can cause one of several actions. If the function key <Fn> has multiple states, pressing the key beneath the displayed function will cause it to toggle between the valid states. The displayed name of the key will be updated to reflect the newly assigned state.

#### Example: Current key option



#### Option after key press



If the displayed option leads to another menu level then the functions available at the next (lower) level menu will be displayed on the screen.

To return to the previous menu, (go up one menu level), press the <PREVIOUS> key that is located to the right of the screen.

Continually pressing the <PREVIOUS> key will return control to the Main Menu.

### 4.4.2. Menu Option - <any other menu but measure>

In all other menu options if a function key has a defined set of alternate values, pressing that function key will cause one of the alternate values to be selected and displayed in the associated active area of the display screen.

**Example: Current Screen**

Mode: Normal	RS Ω: 1.000000000e+01
Display: Ratio	RS SN: 9334-123
Update: Update 4	RX Ω: 1.000000000e+01
Filter: No Filter	RRATE: 60
Power: Power X1	mAmps: 10.0000
	Max mAmps: 150.000
Mode	Display
Update	More 1-3

**Example continued: Screen after pressing function key <Display>**

Mode: Normal	RS Ω: 1.000000000e+01
Display: Ohms	RS SN: 9334-123
Update: Update 4	RX Ω: 1.000000000e+01
Filter: No Filter	RRATE: 60
Power: Power X1	mAmps: 10.0000
	Max mAmps: 150.000
Mode	Display
Update	More 1-3

The alternate value "Ohms", associated with the function key <Display>, is toggled into the active screen area to replace the previous value "Ratio".

**NOTE:**

**When a function key box is drawn with two lines in the display window pressing that function key will select a set of lower level menu options. In the previous example, the function key <Mode> will move to a second lower level in the menu system.**

### 4.4.3. Base Edit/Select Menu - one column of data

An optional header line can appear at the top of a screen display to prompt or inform the user with "details" of the present menu level. If a header line is displayed the number of selections are restricted to 5 or less. If there is no header line then the number of selections can be 6 or less.

Header Line			
Edit/Data 0			
Edit/Data 1			
Edit/Data 2			
Edit/Data 3			
Edit/Data 4			
Edit	OK		

### 4.4.4. Base Edit/Select Menu - two columns of data

If there is a header line then the number of selections displayed is limited to a maximum of 10. Without the header, line up to 12 selections can be displayed. (Header line is optional.)

Header Line			
Edit/Data 0		Edit/Data 5	
Edit/Data 1		Edit/Data 6	
Edit/Data 2		Edit/Data 7	
Edit/Data 3		Edit/Data 8	
Edit/Data 4		Edit/Data 9	
Edit	OK		

### 4.4.5. Operation of Select/Edit Data Menus

#### 4.4.5.1. Function - <Scrn n-N>

If more than one screen of display information is available for selection as current at a menu level, then a <Scrn n-N> software function key will appear above the fourth function key <Fn-4>. The numeric "N" represents the total number of screens available for view. Pressing the <Scrn n-N> function key will cause the display to move to the next sequential screen. Pressing the key on the last screen will cause the display to move back to the first screen.

#### 4.4.5.2. Function - <Edit>

Pressing the <Edit> key will cause one of the currently selected items or the first item in a list to be highlighted. The cursor arrow keys can then be used to move the highlight from selection to selection on the screen.

If the screen type is a selection screen, for example the <Resistor select menu function>, the highlighted item will be selected active, only when the soft function key <Ok> is pressed.

While in an <Edit screen function>, the highlighted item can be modified by using direct entry from the numeric key pad. If the cursor movement <left/right arrow> keys, or <CLEAR> key have not been pressed then any numeric entry will clear the current line and display the pressed key at the cursor position. Pressing any one of the cursor movement keys will cause the current character under the cursor to be replaced with the next numeric key pressed.

The <CLEAR> key, when editing data will clear the current data.

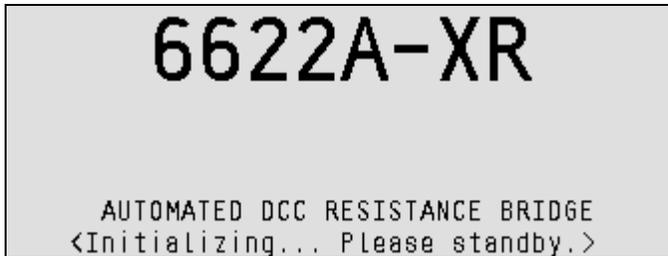
#### 4.4.5.3. Function - <Ok>

Pressing the soft function <Ok> key will either load the item selected or accept all the changes that have been made in the current menu (including the screens not currently displayed if there are multiple screens).

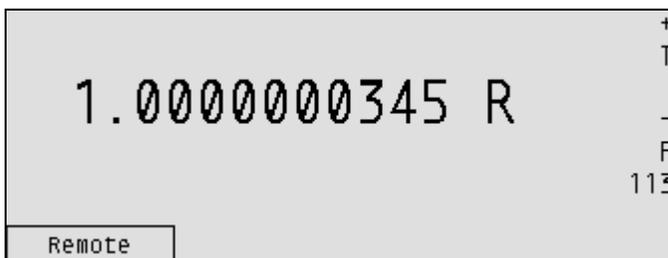
At any time before pressing the <Ok> key, the <CANCEL> key can be pressed to undo all changes that have been made.

## 4.5. TITLE SCREEN

At power ON the 6622A will start its internal power on self-test programming and display its opening banner. This banner will outline the 6622A's model configuration and the installed options. (i.e. -B, -XP, XPS, -XR, -XPR, -HV)



The REMOTE DISPLAY screen will appear only when the 6622A has been addressed by a remote communication device on the GPIB .



The only active soft function key that will work when in Remote mode is the function key <Fn-1>, <Remote>. The exception is when local lockout has been enabled; in this case none of the keys on the front panel will be enabled.

## 4.6. MAIN MENU

Mode: Normal	RS Ω: 1.000000000e+01
Display: Ratio	RS SN: 9334-123
Update: Update 4	RX Ω: 1.000000000e+01
Filter: No Filter	RRATE: 60
Power: Power X1	mAmps: 10.0000
	Max mAmps: 150.000
Measure	Setup Sofcal

The main menu, on power up will display a null measurement configuration where all parameters have been initialized to zero.

On power up the 6622A Bridge will default to a standby condition with the measurement cycle of operations OFF i.e. <Measure off>.

During instrument operation, the operator can return to the main menu from any previously selected lower menu level. When at the Main Menu level, pressing the <CANCEL> key will automatically stop the measurement cycle and cause a return to the <Measure off> mode.

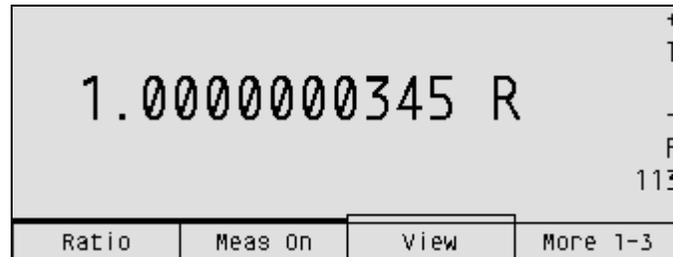
There are two other menu sequences that will also turn <Measure off> automatically:

1. When entering another measurement mode using the <Setup> <Mode> menu. For example, when currently measuring a pair of NORMAL OHM resistors and then selecting LOW OHMS mode, the measurement cycle will be terminated and the 6622A will enter the <Measure off> mode.
2. When entering the <Sofcal> <Diagnostic> menu.

### 4.6.1. <Measure> MENU Fn-1 (Main)

Function key <Fn-1>, <Measure> will select the Measure sub-functions menu to control the measurement functions of the bridge.

## 4.6.1.1. <Measure> MENU Fn-1 (MAIN) Page 1 of 3



The <STATUS LINE> will only appear if the 6622A is currently making a measurement. The information displayed in the <STATUS LINE> depends on the options selected.

1. if <PPM>, <PPM SP>, <DELTA>, or <DELTA SP> is the current selection then the <STATUS LINE> will contain the Datum of proceeding numbers.
2. if <N AVERAGE> is selected the standard deviation will be displayed, on the <STATUS LINE>, for the raw unfiltered values.
3. if the current measurement mode is <LOW OHMS> then the extender ratio will also be displayed on the <STATUS LINE>.

Available functions (menu page 1 of 3).

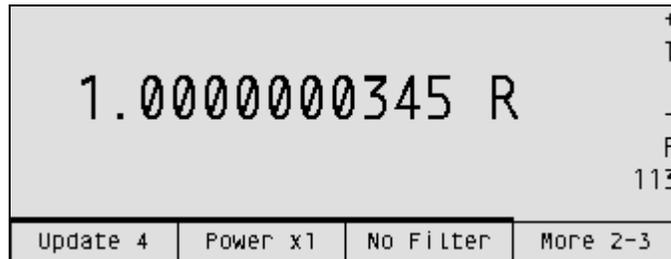
Function key <Fn-1> toggles through the set of available measurement units for the displayed result; the displayed result can have units of <Ratio> or <Ohms>. The active engineering units will be displayed in the <Fn-1> function key descriptor position.

Function key <Fn-2> enables or disables the measurement cycle by turning <Measure ON> or <Measure OFF>. The state of the measurement cycle is displayed in the <Fn-2> function key window.

Function key <Fn-3> selects the View sub-system.

Function key <Fn-4> selects the next menu page of available functions.

## 4.6.1.2. <Measure> MENU Fn-1 (MAIN) Page 2 of 3



Available functions (menu page 2 of 3).

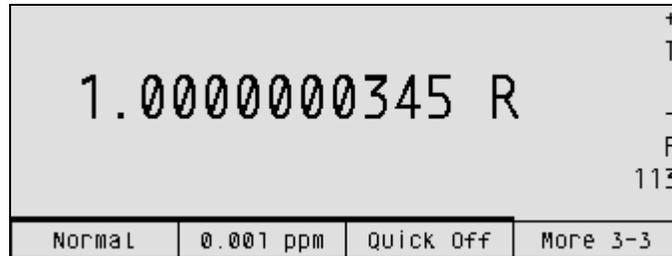
Function key <Fn-1> selects the screen measurement update rate as a function of the test current reversal rate. <Update 1> sets a screen update rate at twice the test current reversal rate; <Update 2> sets a screen update rate at the test current reversal rate; <Update 4> sets a screen update rate at half the test current reversal rate.

Function key <Fn-2> selects twice the rated power.

Function key <Fn-3> turns on the filter function to operate on the measurement data. Select from <No Filter>, <Decimation> and <N Average> where the sample size N can be entered from the keypad through the <Softcal> <Filter> menu.

Function key <Fn-4> displays next menu page of available functions.

### 4.6.1.3. <Measure> MENU Fn-1 (MAIN) Page 3 of 3



Available functions (menu page 3 of 3), last menu page.

Function key <Fn-1> selects the mode of displaying the measurement data as <Normal>; parts per million <PPM> (i.e.  $\mu\Omega/\Omega$ ); change <Delta>; change ppm from a set point <PPM SP>; and change from a set point <Delta SP>. When this function is enabled, the datum value will be displayed on the STATUS LINE of the display.

Function key <Fn-2> sets the display resolution in ppm of range. This affects Normal, Delta and Delta SP display modes only.

Available resolutions are; <0.001 ppm>, <0.01 ppm>, <0.1 ppm>, <1.0 ppm>, <10 ppm>.

Function key <Fn-3> toggles the quick measure mode on <Quick ON> and off <Quick OFF>. The quick measure function disables the internal software filters that are invoked for the four cycle precision measurements and are used in the calculation of resistance ratio. Disabling the software filter function decreases the time required to calculate and report the measured ratio. However, the data are now noisier, and so two least significant digits of available resolution are removed from the display when quick measure is turned on.

Function key <Fn-4> returns to menu page 1 of 3.

### 4.6.2. <Setup> MENU Fn-1 (Setup\_MAIN)

Mode: Normal	RS Ω: 1.000000000e+01
Display: Ratio	RS SN: 9334-123
Update: Update 4	RX Ω: 1.000000000e+01
Filter: No Filter	RRATE: 60
Power: Power X1	mAmps: 10.0000
	Max mAmps: 150.000
Profiles	Edit Ohms

### 4.6.3. <Profiles> MENU Fn-1 (Profiles MAIN)

Profiles allow the user to save resistor configuration files. 15 profiles are available.

Resistors File:			
Res. 9334-1			
Select	Save	Create	

Function key <Fn-1>, <Select>, allows the selection and deletion of profiles.

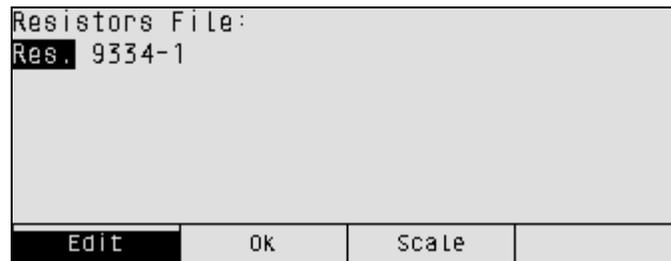
Resistors File:			
Res. 9334-1			
Select	OK	Delete	

Function key <Fn-2>, <Ok>, selects the highlighted profile.

Function key <Fn-3>, <Delete>, deletes the currently selected profile.

Function key <Fn-2>, <Save>, saves the Edit Ohms resistor configuration in the current profile.

Function key <Fn-3>, <Create>, allows the creation of a new profile.

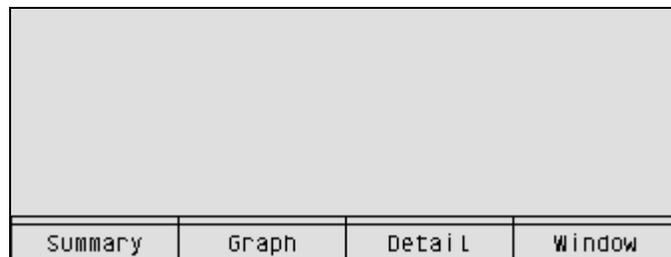


Function key <Fn-2>, <Ok>, creates a new profile with the name as entered in the text.

Function key <Fn-3>, <Scale>, allows insertion of special text for defining the resistor value. It toggles between m Ohms, Ohms, k Ohms, M Ohms.

#### 4.6.4. View

The **View Menu** allows the user to view the trace data in graphical and text format. The last 500 entries are kept in memory and the individual entries can be viewed. A summarization of the data is kept from the last <Clear Sum> point. A graphical summary is also maintained by averaging all samples within a 180 point array.



##### 4.6.4.1. Summary

	Detail	Summary	
Minimum -	99.9979486	99.9979486	
Maximum -	99.9989347	99.9992902	Count
Average -	99.9983568	99.9985756	1
Std Dev -	2.96660102	3.88303008	(PPM)
Samples -	24	38	
Refresh	Confirm	Cancel	Detail

The **Count** entry indicates how many actual values have been averaged within the summary graph.

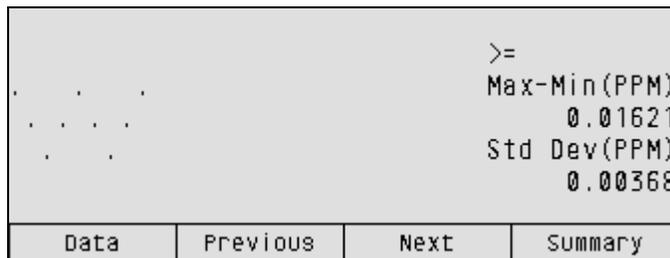
<Refresh> updates the detail and summary values.

<**Detail**> switches to the Detail display.

<**Clear Det**> clears the trace buffer. It requires a confirmation to prevent accidental clearing.

<**Clear Sum**> clears the summary buffer

### 4.6.4.2. Detail Graph



<**Data**> switches to the detail display.

<**Previous**> (if present) scrolls the trace buffer window left.

<**Next**> (if present) scrolls the trace buffer window right.

<**Summary**> switches to the summary display.

The Up arrow scrolls the trace buffer left by Up/Down Arrow Scroll Size.

The Down arrow scrolls the trace buffer right by Up/Down Arrow Scroll Size.

The Left Arrow scrolls to the beginning of the trace buffer.

The Right Arrow scrolls the end of the buffer and sets the trace in automatic update mode. The >= symbol in the display indicates that the auto update mode is enabled.

### 4.6.4.3.Detail

E>	Time		
99.9980954563	17:14:51,26		
99.9981951723	17:14:51.26		
99.9982376892	17:14:51.26		
99.9981986274	17:14:51.26		
99.9982593834	17:14:51.26		
Graph	Previous		Summary

<Graph> switches to the graph display.

<Previous> (if present) scrolls back by 5 entries.

<Next> (if present) scrolls forward by 5 entries.

The Up arrow scrolls the trace buffer up by one (1) entry.

The Down arrow scrolls the trace buffer down by one (1) entry.

The Left Arrow scrolls to the beginning of the trace buffer.

The Right Arrow scrolls the end of the buffer and sets the trace in automatic update mode.

### 4.6.4.4.Window

View Detail Graph Setup	
Detail Graph Window Size:	180
Up/Down Arrow Scroll Size:	20
Refresh Minimum Scroll Size:	20
Edit	OK

Detail Graph Window Size is the number of trace entries to display on the graph.

Up/Down Arrow Scroll Size is the number of trace entries to scroll by during Up/Down arrow selection in the detail graph.

Refresh Minimum Scroll Size is the number of entries to leave available for update when the detail graph which is currently being viewed reaches the Detail Graph

Window Size. This prevents the screen from doing a complete refresh on each new entry once the window size is less than the number of trace entries.

### 4.6.5. <Edit Ohms> MENU Fn-2 (Edit\_Ohms MAIN)

Mode: Normal	RS Ω: 1.000000000e+01
Display: Ratio	RS SN: 9334-123
Update: Update 4	RX Ω: 1.000000000e+01
Filter: No Filter	RRATE: 60
Power: Power X1	mAmps: 10.0000
	Max mAmps: 150.000
Normal	High Ohms
	Low Ohms

Function key <Fn-1>, <Normal>, will select the Normal Ohm measurement mode of operation.

Function key <Fn-2>, <High Ohms>, will select the High Ohms measurement mode of operation.

Function key <Fn-3>, <Low Ohms>, will select operation using the high current range extender for low value resistance measurements.

**NOTE:**

**The measurement mode is affected immediately when the function key is pressed. If a measurement is in progress when a different mode is selected, then the measurement will stop. If the measurement is re-started, then it will operate in the new mode.**

#### 4.6.5.1. <Normal> MENU Fn-1 (Edit Ohms MAIN)

Enter configuration for Normal Ohm mode measurement to be made.

Resistance RS: 1.000000000e+01	
Serial No. RS: 9334-123	
Resistance RX: 1.000000000e+01	
Reversal Rate : 60	
Test Current(mA): 50.000	
Max Current(mA): 150.000	
Edit	OK

Press <Edit> and use arrow keys to move the highlight to the data line to be changed. Modify data and press <Ok>. Check resistance limits for Rs and Rx. Check also power limits set by test current.

The Test Current value sets the current in the UNKNOWN RESISTOR (Rx).

If the condition:

$$[\text{Test Current} \times (\text{Rx}/\text{Rs})] > \text{Max Current}$$

is satisfied, then the test is terminated, and an error message is displayed.

The Max Current is the maximum current that can be carried by the STANDARD RESISTOR (Rs).

Note that the highest Test Current value and Max Current value is 150 mA.

The reported ratio is (Rx/Rs).

#### 4.6.5.2. <High Ohms> MENU Fn-2 (Edit Ohms\_MAIN)

Resistance RS: 1.000000000e+06			
Serial No. RS: 9334-456			
Resistance RX: 1.000000000e+07			
Reversal Rate : 120			
Test Voltage(V): 100.000			
Max Voltage(V): 100.000			
Edit	OK		

Press <Edit> and use arrow keys to move the highlight to the data line to be changed. Modify data and press <Ok>.

Where:

**Test Voltage(V)** is the common terminal voltage providing current for Rs and Rx.

and

**Max Voltage(V)** is the maximum voltage rating for Rs or Rx. Enter the lower of the two maximum voltage ratings.

### 4.6.5.3. <Low Ohms> MENU Fn-3 (Edit Ohms\_MAIN)

Enter range extender configuration data.

Resistance RS: 1.000000000e+01			
Serial No. RS: 9334-123			
Resistance RX: 1.000000000e+01			
Reversal Rate : 60			
Extender Ratio: 100			
Max Current(mA): 150.000			
Edit	OK	6623	

Resistance RS: 1.000000000e+00			
Serial No. RS: 9334-123			
Resistance RX: .0100000000e-01			
Reversal Rate : 60			
Extender Ratio: 20			
Max RS Current(mA): 150.000			
Edit	OK	6623A-3A	Scrn 1-2

Ext Curr(Amps): 2.00			
Edit	OK	6623A-3A	Scrn 2-2

Press <Edit> and use arrow keys to move the highlight to the data line to be changed. Modify data and press <Ok>. Check resistance limits for Rx and Rs.

Function key <Fn-3> will select the different available current range extender modes such as <6623A-3A>, <6623A-300>,<6623A-3000, and <6623>.

Check also power limits set by Test Current.

The Test Current value sets the current in the UNKNOWN RESISTOR (Rx) and can be selected up to 3 Amps with the 6623A-3A and 3000 A with the 6623A-3000. With the 6623 the drive current is not entered and is determined by an external power supply.

The Max RS Current value is the maximum current that can be carried by the STANDARD RESISTOR (Rs) and is limited to 150 mA.

If the condition:

$$[\text{Test Current} \times (\text{Rx}/\text{Rs})] > \text{Max Current}$$

is satisfied, then the test is terminated and an error message is displayed.

Note that the highest Test Current value is 3000 A for a 6623A-3000 but each stage has different defined limits (see Sofcal Extender) and the highest Max RS Current value is 150 mA.

#### 4.6.6. <Sofcal> MENU Fn-3 (MAIN)

The menu options available through this function allow configuration setup and general modes of operation of the 6622A. Three pages of menu options are available for this Sofcal selection.

#### WARNING:

**The Sofcal menu has direct control of the hardware in your bridge. Improper use of these functions can result in permanent damage to your 6622A bridge.**

Sofcal menu page 1 of 4.

Mode: Normal	RS Ω: 1.000000000e+01		
Display: Ratio	RS SN: 9334-123		
Update: Update 4	RX Ω: 1.000000000e+01		
Filter: No Filter	RRATE: 60		
Power: Power X1	mAmps: 10.0000		
	Max mAmps: 150.000		
Gpib	Coef Set	Diagnostics	More 1-4

Function Key <Fn-1>, <GPIB>, allows selection of the device GPIB parameters including address and mode.

Function Key <Fn-2>, <Coef Set>, allows updates to the Line Frequency and ADC Beta.

Function Key <Fn-3>, <Diagnostic>, allows selection of functions that control the hardware. This function is useful when diagnosing problems with the 6622A.

Sofcal menu selection menu page 2 of 4.

Mode: Normal		RS Ω: 1.000000000e+01	
Display: Ratio		RS SN: 9334-123	
Update: Update 4		RX Ω: 1.000000000e+01	
Filter: No Filter		RRATE: 60	
Power: Power X1		mAmps: 10.0000	
		Max mAmps: 150.000	
P.O.S.T.	Filter	Datum	More 2-4

Function Key <Fn-1>, <P.O.S.T.>, displays the result of the power on self test and the revision level of the installed software.

Function Key <Fn-2>, <Filter>, allows setting of the filter constants for the AVERAGE and DECIMATION filters.

Function Key <Fn-3>, <Datum>, allows setting of reference/datum values for measurement display changes.

Sofcal menu selection menu page 3 of 4.

Mode: Normal		RS Ω: 1.000000000e+01	
Display: Ratio		RS SN: 9334-123	
Update: Update 4		RX Ω: 1.000000000e+01	
Filter: No Filter		RRATE: 60	
Power: Power X1		mAmps: 10.0000	
		Max mAmps: 150.000	
RT Clock	Sys Time	Extender	More 3-4

Function key <Fn-3> toggles the trace time mode <RT Clock> and <Relative>.

Function Key <Fn-2>, <Sys Time>, allows setting of the date and time.

Function Key <Fn-3>, <Extender>, allows creation and editing of low ohms extenders.

Sofcal menu selection menu page 4 of 4.

Mode: Normal	RS $\Omega$ : 1.000000000e+01
Display: Ratio	RS SN: 9334-123
Update: Update 4	RX $\Omega$ : 1.000000000e+01
Filter: No Filter	RRATE: 60
Power: Power X1	mAmps: 10.0000
	Max mAmps: 150.000
Password	More 4-4

Function Key <Fn-1>, <PASSWORD>, allows setting of the unit password feature.  
By default the password is “6622”

### 4.6.6.1. <GPIB>MENU Fn-1 (Sofcal\_MAIN)

Gpib Setup			
Address: 4			
Mode: Talk\Listen			
Address	Mode	Ok	

<Address> function key Fn-1 sets the GPIB address.

<Mode> function key Fn-2 selects from the options <Talk/Listen>, <Talk Only>, <Disabled>.

No GPIB settings will be saved or acted upon until <FN-3> the <Ok>. key has been pressed.

### 4.6.6.2. <Coef Set> MENU Fn-2 (Sofcal\_MAIN)

To enter the Coef Set Edit window a password must be supplied.

PASSWORD CHECK			
Password:			
Edit	Ok		

Line Frequency: 60			
ADC Beta: 278			
Edit	Ok		

Line Frequency is either 60 Hz or 50 Hz.

ADC Beta must be between 225 and 330. This is a factory setting.

### 4.6.6.3. <Diagnostic> MENU Fn-3 (Sofcal\_MAIN)

To enter the Diagnostics window a password must be supplied.

PASSWORD CHECK			
Password:			
Edit	OK		

Diagnostic menu selection page 1 of 4.

Set Internal Values			
Dac(+ 5V): 0.000		Range: 20V Range	
Turns: 0		Mode: Normal Ohm	
Sign: Positive		Speed: Moderate	
milliAmps: 0.000		Cur Ramp: Off	
Volts: 0		Volt Ramp : Off	
Monitor	Dac	Turns	More 1-4

Function Key <Fn-1>, <Monitor> selects the monitor menu level and displays the value of the internal channels reported from the servo card assembly.

Function Key <Fn-2>, <Dac> selects the values for a 12-bit digital to analog converter on the servo card assembly.

Function key <Fn-3>, <Turns> allows the number of turns to be entered for the RX side, from 0 → 8747 turns.

**CAUTION:**

**Do not enter a number larger than 8747.**

#### 4.6.6.3.1. <Monitor> MENU Fn-1 (Diagnostic\_Sofcal\_MAIN)

This diagnostic menu allows monitoring of the signals on the servo board.

```

Monitor Readings on Servo Board
Servo: -0.0684      Prim. Cur: -15.894
Speed Up: +0.0049  Calibrate: +1
Offset: +5.0099    NanoVolt: 0.0
+40 Volts: +39.673
-40 Volts: -40.114

Exit
  
```

### 4.6.6.3.2. <Diagnostic> MENU Fn-1 (Sofcal\_MAIN)

Diagnostic menu selection page 2 of 4.

```

Set Internal Values
Dac(+ 5V): 0.000    Range: 20V Range
Turns: 0            Mode: Normal Ohm
Sign: Positive      Speed: Moderate
milliAmps: 0.000   Cur Ramp: Off
Volts: 0            Volt Ramp: Off

Sign  milliAmps  Volts  More 2-4
  
```

Function key <Fn-1>, <Sign> enables sets the direction of current flow and the polarity of the voltage outputs.

Function key <Fn-2>, <milliamps> sets the magnitude of the current output. For the current to flow to the Rs and Rx terminals <Mode> must be set to <Normal Ohm>. The current range is from 0 to 150 mA. This function is disabled when <High Ohms> is selected.

When <Mode> is set to <Low Ohms> the current range extender is activated and allowable current range is from 0 to 150 mA is used to drive the range extender. Set the <milliamps> between 0 to 100. The range extender then multiplies the current going through the unknown resistor.

**WARNING:**

The 6622A bridge can produce dangerous voltages of up to 1000 V for the HV model and 100 V for the XR and XPR models. Exercise caution when setting output voltages as to avoid injury or equipment damage.

Function key <Fn-3>, <Volts> sets magnitude of the voltage output. For the voltage to be set onto RS and RX terminals <Mode> must be set to <High Ohms>. The voltage range is from 0 V to 100 V in steps of 1V for the 6622A-XR and 6622A-XPR models. The voltage range is from 0 V to 1000 V in steps of 4 V for the 6622A-HV model. Voltage is not available in 6622A and 6622A-XP models. This function is disabled except when <High Ohms> is selected.

Diagnostic menu selection page 3 of 4.

Set Internal Values			
Dac(+ 5V): 0.000	Range: 20V Range		
Turns: 0	Mode: Normal Ohm		
Sign: Positive	Speed: Moderate		
milliAmps: 0.000	Cur Ramp: Off		
Volts: 0	Volt Ramp: Off		
Range	Mode	Speed	More 3-4

Function key <Fn-1>, <Range> selects the measurement voltage range for the built-in voltmeter from: <20V>, <2V>, <200mV>, <20mV>, <2mV>.

Function key <Fn-2>, <Mode> sets the measurement mode from the choice of <Normal> and <Low>.

Function key <Fn-3>, <Speed> sets the servo-loop speed from the choice of <Slowest>, <Slow>, <Moderate> and <Fast>. The servo loop is used for balancing the flux in the core.

Diagnostic menu selection page 4 of 4.

Set Internal Values			
Dac(+ 5V): 0.000	Range: 20V Range		
Turns: 0	Mode: Normal Ohm		
Sign: Positive	Speed: Moderate		
milliAmps: 0.000	Cur Ramp: Off		
Volts: 0	Volt Ramp: Off		
Cur Ramp	Volt Ramp	Ns NORMAL	More 4-4

Function key <Fn-1>, enables or disables the automatic ramping feature for the Current. For current to flow to the Rs and Rx terminals, the <Mode> must be set to NORMAL.

Function key <Fn-2>, enables or disables the automatic ramping feature for Voltage. For the voltage to be set onto Rs and Rx terminals, the <Mode> must be set to <High Ohms>. This function is only available on voltage models (6622A-X, 6622A-XPR, and 6622A-HV)

Function key <Fn-3>, selects servo (Rs) toroid turns to 648 (Ns NORMAL) or 81 (Ns 100:1). The displayed information does not necessarily indicate the present state of the 6622A. Pressing key <Fn-3> will update the state of the 6622A.

#### 4.6.6.4. <P.O.S.T.> MENU Fn-1 (Sofcal\_MAIN)

This Sofcal menu selection displays the results of the internal self-test performed by the 6622A.

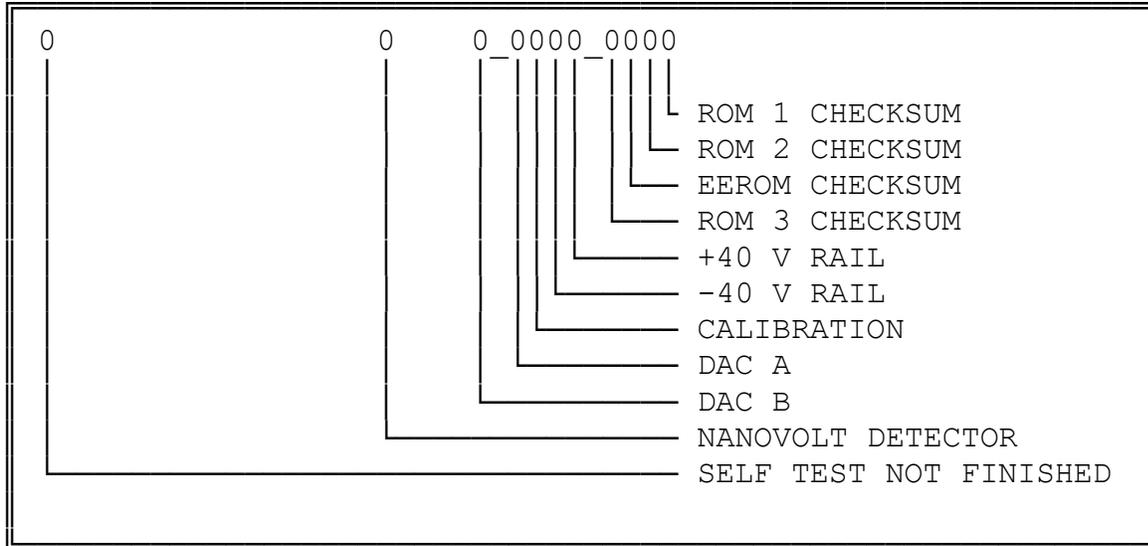
```

ERROR_STATUS: 0_0_0_0000_0000
ROM Checksum: 12014      (2EEE,FD15,7AFA)
EEROM Checksum: 26747      REV 1
40V Rails: OK           2005/11/02
DAC A_B: OK
Calibration Channel: OK
Exit
  
```

**NOTE:**

A restricted access password system has been implemented for certain Sofcal functions. If the password is changed it can be reset to the factory default password by entering this menu and pressing in order: **Left Arrow, Right Arrow, Up Arrow, Down Arrow.**

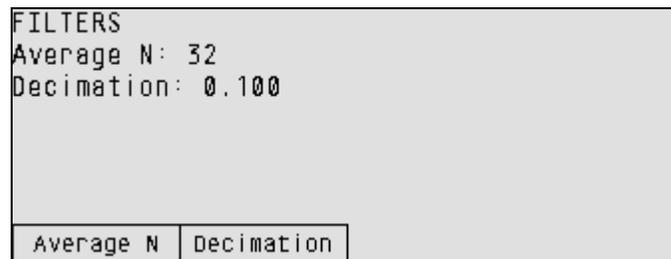
ERROR STATUS displays the error bits in hexadecimal notation.



**NOTE:** 0 = Success, 1 = Failure

**ROM CHECKSUM** is the sum of the CRC's of both PROMS. **EEROM CHECKSUM** is the CHECKSUM for the battery backed RAM.

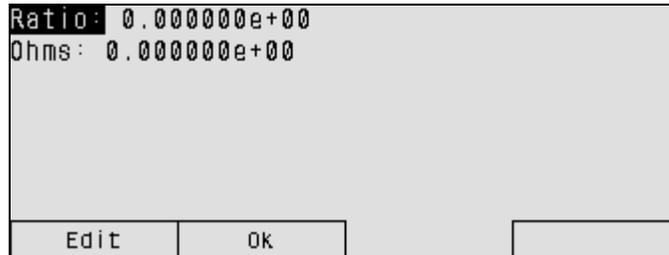
#### 4.6.6.5. <Filter> MENU Fn-2 (Sofcal\_MAIN)



Function key Fn-1 <Average N> allows the number of data samples to be set for the simple averaging filter <1, 2, 4, 8, 16, 32, 64, and 128>.

Function key Fn-2 <Decimation> allows the setting of the decimation filter factor <0.001 through 0.500>.

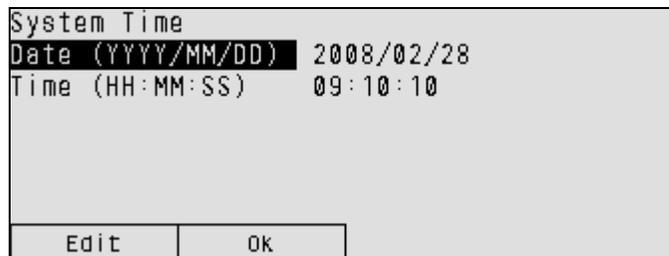
### 4.6.6.6. <Datum> MENU Fn-3 (Sofcal\_MAIN)



The values displayed in this menu are used as datum values when the 6622A is measuring ratio or resistance.

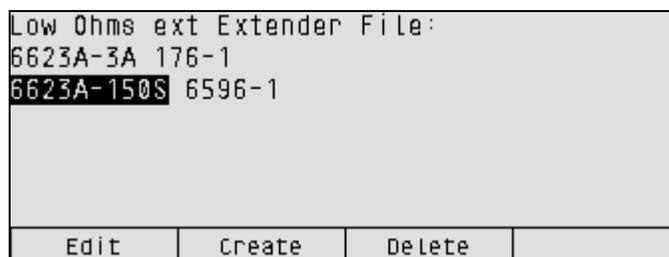
The datum function is applied to the <Measure> menu.

### 4.6.6.7. <Sys Time>MENU Fn-2 (Sofcal MAIN)



This allows the updating of the system date and time. The time is entered in 24 hour format.

### 4.6.6.8. <Extender>MENU Fn-3 (SofcalMENU)



This allows creation, deletion and editing of extenders.

Existing extenders are selected with <UP> and <DOWN> arrows and the edit or delete acts on the highlighted extender.

### 4.6.6.8.1. Extender

Model: 6623A-150S			
Serial Number : 6596-2			
Slave Count: 0			
Stage1 Ramp Time (secs): 1.00			
Ratio: 20			
Coefficient1 (PPM): 0.017000000			
Edit	OK	Alt Char	Scrn 1-9

**Model** is usually 6623A- ...

- 3 – 3 A
- 150 – 150 A
- 300 – 300 A
- 600 – 600 A
- 1000 – 1000 A
- 3000 – 3000 A
- 6000 – 6000A
- 10,000 – 10,000 A

However custom extenders can be created also.

<Alt Char> allows the insertion of <A>, <B>, <C>, and <S> into the text.

**Serial Number** is the serial number as indicated on the extender which is being created or edited.

**Slave Count** is used to specify the number of 150 A modules when more than one module is present. i.e. 6623A-3000 has a slave count of twenty (20).

**Stage 1 Ramp Time** is the ramp time in seconds for current. The 6622A always sets current to zero (0) and then sets the specified current during state changes. (turns or polarity) For a standard Guildline Product the setting for this stage is 1 second.

**Ratio** is the extender ratio for this stage. For a standard Guildline product this is twenty (20).

**Coefficient 1** is  $\pm \mu\Omega/\Omega$  and is used when this stage is active.

Coefficient2 (PPM): 0.0000000000			
Minimum Amps: 0.100			
Maximum Amps: 3.00			
Cascade state:			
Slave state:			
+ve Offset (+- mAmps): 0.000000			
Edit	OK	ALT Char	Scrn 2-9

**Coefficient 2** is  $\pm \mu\Omega/\Omega$  and is used when this stage is active.

**Minimum Amps** is used to specify the minimum current for this stage. For a standard Guildline product this is 0.1 A.

**Maximum Amps** is used to specify the minimum current for this stage. For a standard Guildline product this is 3.0 A.

**Cascade state** is used to select the stage. For a standard Guildline product this is 0 or blank.

**Slave state** is used to select the stage. For a standard Guildline product this is 0 or blank.

**+ve Offset** is used to offset the current with a milliamper correction. This is applied when positive current is sent by the 6622A. For a standard Guildline product this is 0.

+ve Gain (+- mAmps): 0.000000			
-ve Offset (+- mAmps): 0.000000			
-ve Gain (+- mAmps): 0.000000			
Stage 2 Ramp Time (secs): 1.5			
Ratio: 100			
Coefficient1 (PPM): 0.0000000000			
Edit	OK	ALT Char	Scrn 3-9

**+ve Gain** is used to adjust the current with a milliamper correction. The gain is multiplied by the requested current and then added to the requested current. This is applied when positive current is sent by the 6622A. For a standard Guildline product this is 0.

**-ve Offset** is used to offset the current with a milliamper correction. This is applied when negative current is sent by the 6622A. For a standard Guildline product this is 0.

**-ve Gain** is used to adjust the current with a milliampere correction. The gain is multiplied by the requested current and then added to the requested current. This is applied when negative current is sent by the 6622A. For a standard Guildline product this is 0.

**If the extender is only one stage (6623A-3) then the remaining fields are not required. Except when the 6622A bridge is using Rev. Z Firmware. This firmware requires you to set the “Cascade” to 1 on the second stage, which is otherwise unused.**

**Stage 2 Ramp Time** is the ramp time in seconds for current. The 6622A always sets current to zero (0) and then sets the specified current during state changes. (turns or polarity) For a standard Guildline Product the setting for this stage is 1.5 seconds.

**Ratio** is the extender ratio for this stage. For a standard Guildline product this is one hundred(100).

Coefficient2 (PPM): 0.000000000			
Minimum Amps: 3.00			
Maximum Amps: 15.00			
Cascade state: 1			
Slave state:			
+ve Offset (+- mAmps): 0.00000			
Edit	OK	ALT Char	Scrn 4-9

**Minimum Amps** is used to specify the minimum current for this stage. For a standard Guildline product this is 3.0 A.

**Maximum Amps** is used to specify the minimum current for this stage. For a standard Guildline product this is 15.0 A

**Cascade state** is used to select the stage. For a standard Guildline product this is 1.

**Slave state** is used to select the stage. For a standard Guildline product this is 0 or blank.

```

+ve Gain (+- mAmps): 0.00000
-ve Offset (+- mAmps): 0.00000
-ve Gain (+- mAmps): 0.00000
Stage 3 Ramp Time (secs): 2.0
Ratio: 1000
Coefficient1 (PPM): 0.0000000000

```

Edit	OK	ALT Char	Scrn 5-9
------	----	----------	----------

**Stage 3 Ramp Time** is the ramp time in seconds for current. The 6622A always sets current to zero (0) and then sets the specified current during state changes. (turns or polarity) For a standard Guildline Product the setting for this stage is 2.0 seconds.

**Ratio** is the extender ratio for this stage. For a standard Guildline product this is one thousand (1000).

```

Coefficient2 (PPM): 0.0000000000
Minimum Amps: 15.00
Maximum Amps: 150.00
Cascade state: 1
Slave state:
+ve Offset (+- mAmps): 0.00000

```

Edit	OK	ALT Char	Scrn 6-9
------	----	----------	----------

**Minimum Amps** is used to specify the minimum current for this stage. For a standard Guildline product this is 15.0 A.

**Maximum Amps** is used to specify the maximum current for this stage. For a standard Guildline product this is 150.0 A (Model 6623A-150).

**Cascade state** is used to select the stage. For a standard Guildline product this is 1.

**Slave state** is used to select the stage. For a standard Guildline product this is 0 or blank.

```
+ve Gain (+- mAmps): 0.00000
-ve Offset (+- mAmps): 0.00000
-ve Gain (+- mAmps): 0.00000
Stage 4 Ramp Time (secs): 2.0
Ratio: 20000
Coefficient1 (PPM): 0.0000000000
```

Edit	OK	Alt Char	Scrn 7-9
------	----	----------	----------

**Stage 4 Ramp Time** is the ramp time in seconds for current. The 6622A always sets current to zero (0) and then sets the specified current during state changes. (turns or polarity) For a standard Guildline Product the setting for this stage is 2.0 seconds.

**Ratio** is the extender ratio for this stage.

```
Coefficient2 (PPM): 0.0000000000
Minimum Amps: 300.00
Maximum Amps: 3000.00
Cascade state: 1
Slave state: 1
+ve Offset (+- mAmps): 0.00000
```

Edit	OK	Alt Char	Scrn 8-9
------	----	----------	----------

**Minimum Amps** is used to specify the minimum current for this stage. For a Guildline 6623A-3000 this is 150.0 A.

**Maximum Amps** is used to specify the maximum current for this stage. For a Guildline 6623A-3000 this is 3000.0 A.

**Cascade state** is used to select the stage. For a standard Guildline product this is 1.

**Slave state** is used to select the stage. For a standard Guildline product this is 1. For a Guildline 6623A-3000 the slave count is set to 20.

```
+ve Gain (+- mAmps): 0.00000
-ve Offset (+- mAmps): 0.00000
-ve Gain (+- mAmps): 0.00000
```

Edit	OK	Alt Char	Scrn 9-9
------	----	----------	----------

## 4.6.6.9 PASSWORD> MENU Fn-1 (Sofcal\_MAIN)

In order to obtain access to change the system password the current password must be supplied.

PASSWORD CHECK			
Password:			
Edit	OK		

To enter the current password, first press the <Edit> key, enter the current password and press <OK>. An invalid password will not allow access. When the <Edit> key is pressed again, the active password will be displayed.

PASSWORD EDIT			
Password: 6622			
Edit	OK		

The password can be changed using the keypad numeric keys. A string of up to nine (9) characters can be entered for the password. Function key <Ok> will accept the new password as entered.

**NOTE:**

**The factory default password is: 6622**

**If the password has been changed and subsequently misplaced, see Section 4.6.6.4 <P.O.S.T.>, to allow recovery of the factory default password setting.**

## 5. VERIFICATION AND CALIBRATION

### 5.1. RATIO ACCURACY VERIFICATION

This procedure covers the ratio accuracy verification of the 6622A Automatic DCC Resistance Bridge. This procedure is not a self-calibration but an intermediary check on whether the bridge is operating within its specifications relative to its last calibration. The following procedure can be automated in using a test sequence Bridgeworks Data Acquisition Software if the 6622A is connected through a 6664C scanner.

#### 5.1.1. Purpose

The purpose of this procedure is to assure that the 6622A Automatic DCC Resistance Bridge meets the manufacturer's specifications. It is recommended that these procedures be performed after any corrective maintenance activity, or if the operator perceives a problem with respect to ratio accuracy.

It is recommended that all of these procedures be performed on an annual basis to verify that the 6622A is performing within the manufacturer's specifications relative to its last calibration.

### 5.1.2. Equipment Required

The following equipment is required for all 6622A bridge models to execute the procedure outlined in this section.

- Temperature controlled environment sufficient to maintain the reference and working standard resistors to their specified uncertainties
- 1  $\Omega$  standard resistor, stable to  $\pm 0.01 \mu\Omega/\Omega$  over a 24 hour period (x2)
- 10  $\Omega$  standard resistor, stable to  $\pm 0.01 \mu\Omega/\Omega$  over a 24 hour period
- 100  $\Omega$  standard resistor, stable to  $\pm 0.01 \mu\Omega/\Omega$  over a 24 hour period (x2)
- 1 k $\Omega$  standard resistor, stable to  $\pm 0.01 \mu\Omega/\Omega$  over a 24 hour period
- 10 k $\Omega$  standard resistor, stable to  $\pm 0.01 \mu\Omega/\Omega$  over a 24 hour period (x2)

The following equipment is required for the 6622A-XR, 6622A-XPR and 6622A-HV bridge models to execute the procedure outlined in this section.

- 100 k $\Omega$  standard resistor, stable to  $\pm 0.02 \mu\Omega/\Omega$  over a 24 hour period
- 1 M $\Omega$  standard resistor, stable to  $\pm 0.04 \mu\Omega/\Omega$  over a 24 hour period (x2)
- 10 M $\Omega$  standard resistor, stable to  $\pm 0.2 \mu\Omega/\Omega$  over a 24 hour period
- 100 M $\Omega$  standard resistor, stable to  $\pm 0.5 \mu\Omega/\Omega$  over a 24 hour period

The following equipment is required for only the 6622A-HV bridge models to execute the procedure outlined in this section.

- An additional 100 M $\Omega$  standard resistor, stable to  $\pm 0.5 \mu\Omega/\Omega$  over a 24 hour period

**Note: Ten of these standard resistors are available in the optional model 6634A Resistance Standard and up to four reference resistors are available in the portable Guildline Instruments model 6634TS Resistance Standard.**

### 5.1.3. Set Up

1. Ensure that the 6622A Resistance Bridge is switched on and have the following resistors ready for connection to the 6622A or pre-connected to scanner channel leads from the optional 6664C scanner as defined above.
2. Set these standard resistors into the controlled temperature environment and allow time for them to stabilize. The Guildline model 6634A offers up to 10 of these resistors in a temperature stabilized rack mountable chamber. Open the BridgeWorks Data Acquisition Software in the computer.

## 5.1.4. Verification

1. Use the “Test Sequence” function of the “Configuration” menu of the BridgeWorks Data Acquisition Software to measure the resistance ratio of each resistor pair with the corresponding excitation current and reversal rate listed below. See the BridgeWorks Software User’s Manual for the particulars of running a test sequence. These measurements can also be made manually. If they are made manually, allow sufficient time for the measurement to settle (1 – 2 hours) and ensure that all measurements made that are related to a given closure are within 24 hour of each other.

Meas. No.	R <sub>X</sub> Resistor	R <sub>S</sub> Resistor	Excitation Current	Reversal Rate	Meas. Mode	Closure Method
<i>Tests 1 – 12 for all 6622A bridges.</i>						
1	1 Ω	1 Ω	100 mA	20 s	Normal	Interchange
2	1 Ω	1 Ω	100 mA	20 s	Normal	
3	100 Ω	100 Ω	10 mA	20 s	Normal	Interchange
4	100 Ω	100 Ω	10 mA	20 s	Normal	
5	10 kΩ	10 kΩ	1 mA	60 s	Normal	Interchange
6	10 kΩ	10 kΩ	1 mA	60 s	Normal	
7	10 Ω	1 Ω	10 mA	20 s	Normal	Ladder
8	100 Ω	10 Ω	1.0 mA	20 s	Normal	
9	100 Ω	1 Ω	1.0 mA	20 s	Normal	
10	1 kΩ	100 Ω	1.0 mA	40 s	Normal	Ladder
11	10 kΩ	1 kΩ	0.1 mA	60 s	Normal	
12	10 kΩ	100 Ω	0.10 mA	90 s	Normal	
<i>Additional tests 13 – 20 for 6622A-XR, 6622A-XPR, and 6622A-HV</i>						
13	1 MΩ	1 MΩ	100 V	90 s	High Ohms	Interchange
14	1 MΩ	1 MΩ	100 V	90 s	High Ohms	
15	100 kΩ	10 kΩ	0.10 mA	90 s	Normal	Ladder
16	1 MΩ	100 kΩ	10 V	90 s	High Ohms	
17	1 MΩ	10 kΩ	10 V	90 s	High Ohms	
18	10 MΩ	1 MΩ	100 V	90 s	High Ohms	Ladder
19	100 MΩ	10 MΩ	100 V	120 s	High Ohms	
20	100 MΩ	1 MΩ	100 V	120 s	High Ohms	
<i>Additional tests 21 and 22 for 6622A-HV only</i>						
21	100 MΩ	100 MΩ	1000 V	150 s	High Ohms	Interchange
22	100 MΩ	100 MΩ	1000 V	150 s	High Ohms	

- For each resistor pair, calculate and report the interchange closure error. For example, if the Rx:Rs ratio of the first measurement is  $R_a$  and the Rx:Rs ratio of the second measurement, where the two resistors are exchanged with one another, is  $R_b$ , then the interchange error  $e_i$  in ppm of the nominal ratio is:

$$e_i = (1/2) \times |(R_a \times R_b) - 1| \times 10^6$$

- The maximum allowable interchange closure errors ( $\mu\Omega/\Omega$ ) for the following resistor pairs are:

Resistor	Resistor	Interchange Closure Error					
		-B	-XP	-XPS	-XR	-XPR	-HV
1 $\Omega$	1 $\Omega$	0.1	0.05	0.02	0.1	0.05	0.04
100 $\Omega$	100 $\Omega$	0.1	0.05	0.02	0.1	0.05	0.04
10 k $\Omega$	10 k $\Omega$	0.1	0.05	0.05	0.1	0.05	0.05
1 M $\Omega$	1 M $\Omega$				0.6	0.4	0.4
100 M $\Omega$	100 M $\Omega$						3.5

- For the 100:1 ladder up closure errors, the 100:1 ratio must agree to within the specification of the nominal ratio for either directly measuring the 100:1 ratio, or calculating the ratio from the product of the 100:10 ratio and the 10:1 ratio, as follows:

$$e_i = (1/3) \times |R_a - (R_b \times R_c)| / R_a \times 10^6$$

Where:

- $R_a$  is the 100:1 ratio
- $R_b$  is the 100:10 ratio
- $R_c$  is the 10:1 ratio

- The maximum allowable ladder up errors ( $\mu\Omega/\Omega$ ) for the following resistor sets are:

Resistor	Resistor	Resistor	Interchange Closure Error					
			-B	-XP	-XPS	-XR	-XPR	-HV
1 $\Omega$	10 $\Omega$	100 $\Omega$	0.100	0.067	0.053	0.100	0.067	0.060
100 $\Omega$	1 k $\Omega$	10 k $\Omega$	0.167	0.133	0.120	0.167	0.133	0.127
10 k $\Omega$	100 k $\Omega$	1 M $\Omega$				1.233	1.150	1.150
1 M $\Omega$	10 M $\Omega$	100 M $\Omega$				5.600	4.200	3.533

## 6. TROUBLESHOOTING AND MAINTENANCE

### 6.1. INTRODUCTION

This section covers troubleshooting, repair and verification of the 6622A Automatic DCC Resistance Bridge.

#### 6.1.1. Error Messages

The 6622A Automatic DCC Resistance Bridge will display error messages either on the front panel display of the 6622A Resistance Bridge in manual mode or on the computer monitor when using the BridgeWorks Data Acquisition Software. The error messages and their corrective measures are summarized in Table 6-1. See also of the BridgeWorks Software User's Manual. The 6622A will display the error messages until the next GPIB or keyboard event. The BridgeWorks Data Acquisition Software will display the error messages until acknowledged by the user.

Error Number	Error	Corrective Measures
0	nV Detector Communication Failure	- <b>None</b> , fatal hardware error (try power switch)
1	Invalid Test Setup	-Resistors not wired to Rx and Rs terminals properly, improper test setup
2	Servo Railed	-No current path on Rx or Rs terminals
3	Nano Zero, nVoltmeter not responding	-Cycle power switch, else fatal hardware error
4	Null out of Range	-Autoranger having problems, so enter in approx. ratio
5	Max Test Exceeded	-Exceeded max current or Rs resistor
6	EEROM Failure, Resetting all values to default	- Corrupted or lost stored configuration data. You will need to reset your GPIB address to 4 (refer to Sections 4.6.6.1 and 6.1.3) then run the 'Coefficients' utility located in the 'Utilities' menu of the BridgeWorks Data Acquisition Software.
7	No Serial Number Specified, File not saved	-Rs Serial number left blank in setup, put one in
8	Nano Railed, Out of Nanovoltmeter range	-Resistors not wired to Rx and Rs terminals properly, invalid Test setup
9	Failed Self Test	- <b>None</b> , fatal error (try power switch)

Table 6-1 : Model 6622A Error Messages

**Note:** The 'Coefficient' utility described for error 6 is a dedicated program that can read in the stored ratio correction coefficients as well as load them into the 6622A DCC Bridge. It can also store and load these values in a file as well as print them out. If error number 6 occurs, you should use this utility to verify that your 6622A has the proper coefficients loaded, by cross referencing them to the coefficient printout supplied with your system. If they are wrong, re-enter the correct values and update your 6622A bridge to reflect these coefficients. This will return the bridge's alignment to the 'as shipped' settings.

### 6.1.2. Model 6622A Setup Warnings

The model 6622A Resistance Bridge provides limit checks for variables that can be setup during the configuration of a measurement. Below is a listing of the warnings that may appear on its display in manual operation or on the computer monitor when the BridgeWorks Data Acquisition Software is used. Corrective measures can be made as appropriate before the measurement or other function is initiated. See also the BridgeWorks Software User's Manual. The model 6622A will display the warning messages until the next GPIB or keyboard event. The BridgeWorks Data Acquisition Software will display the warning messages until acknowledged by the user.

- Reversal Rate too low or not set!! Minimum reversal rate is 4 seconds!!
- Rs value has not been set!!
- Extender Ratio not set
- Test Value not set
- Max Test Value has not been set
- Test Value EXCEEDS Max Test Value
- Test Value Exceeds Maximum Current Output!!
- Test Value is below minimum current output!!!
- Maximum Current Value exceeds Maximum Current output!!!
- Set internal Values. This menu allows full control of the model 6622A. Great care should be taken when using these functions
- Self test not completed

### 6.1.3. Bridge Coefficients

1. Run the BridgeWorks Data Acquisition Software in the computer.
2. From BridgeWorks Software User's Manual SUM66XX for the particulars of running this test.

Warning: This utility has the potential to modify your 6622A's software coefficients. Improper use of this program can uncalibrate your hardware. In particular, do not press the "Update" button.

3. Press the 'Display' button in the Coefficients window. Once all of the coefficients have been downloaded from the 6622A and displayed in the window, press the 'Print' button in the window to print a copy of the Bridge Coefficient Report. Verify that the coefficients in this report are identical to those in the previous Bridge Coefficient Report for the same 6622A as identified by the 6622A serial number.
4. Press the 'Close' button in the Coefficients window to close the Coefficients utility.

## 6.2. QUICK RATIO CHECK

This procedure covers the quick ratio check of the 6622A Automatic DCC Resistance Bridge. The following procedure can be automated in using a test sequence BridgeWorks Data Acquisition Software if the 6622A is connected through a 6664C scanner.

### 6.2.1. Purpose

The purpose of this procedure is to assure that the 6622A Automatic DCC Resistance Bridge is fully operational by testing all ratio ranges and basic measurement modes. It is not a test for full rated accuracy. To test the 6622A to full rated accuracy see Section 5 for verification and calibration. It is recommended that these procedures be performed if the operator perceives a problem with the operation of the 6622A or a reported error or warning appears on the display. It is also recommended that these procedures be performed after any corrective maintenance activity to confirm the operation of the 6622A.

It is recommended that all of these procedures be performed on an annual basis to verify performance of the 6622A for its recertification.

### 6.2.2. Equipment Required

The following equipment is required for all 6622A bridge models to execute the procedure outlined in this section.

- 1  $\Omega$  resistor, stable to  $\pm 10 \mu\Omega/\Omega$  over a 24 hour period (x2)
- 10  $\Omega$  resistor, stable to  $\pm 10 \mu\Omega/\Omega$  over a 24 hour period
- 100  $\Omega$  resistor, stable to  $\pm 10 \mu\Omega/\Omega$  over a 24 hour period

The following equipment is required for the 6622A-XR, 6622A-XPR and 6622A-HV bridge models to execute the procedure outlined in this section.

- 10 k $\Omega$  resistor, stable to  $\pm 10 \mu\Omega/\Omega$  over a 24 hour period (x2)
- 100 k $\Omega$  resistor, stable to  $\pm 10 \mu\Omega/\Omega$  over a 24 hour period
- 1 M $\Omega$  resistor, stable to  $\pm 10 \mu\Omega/\Omega$  over a 24 hour period

### 6.2.3. Set Up

Ensure that the 6622A Resistance Bridge is switched on and have the following resistors ready for connection to the 6622A or pre-connected to scanner channel leads from the optional 6664C scanner as defined above.

### 6.2.4. Check Procedure

1. Use the “Test Sequence” function of the “Configuration” menu of the BridgeWorks Data Acquisition Software to measure the resistance ratio of each resistor pair with the corresponding excitation current and reversal rate listed below. See the BridgeWorks Software User’s Manual for the particulars of running a test sequence. These measurements can also be made manually. If they are made manually, allow sufficient

time for the measurement to settle (5-10 minutes) and ensure that all measurements made that are related to a given closure are within 4 hours of each other.

Meas. No.	R <sub>X</sub> Resistor	R <sub>S</sub> Resistor	Excitation Current	Reversal Rate	Meas. Mode	Closure Method
<i>Tests 1 – 5 for 6622A and 6622A-XP bridges.</i>						
1	1 Ω	1 Ω	100 mA	15 s	Normal	Interchange
2	1 Ω	1 Ω	100 mA	15 s	Normal	
3	10 Ω	1 Ω	10 mA	15 s	Normal	Ladder
4	100 Ω	10 Ω	3.16 mA	15 s	Normal	
5	100 Ω	1 Ω	1.0 mA	15 s	Normal	
<i>Tests 6 – 10 for 6622A-XR, 6622A-XPR, and 6622A-HV</i>						
6	10 kΩ	10 kΩ	1 mA	15 s	Normal	Interchange
7	10 kΩ	10 kΩ	1 mA	15 s	Normal	
8	100 kΩ	10 kΩ	0.10 mA	30 s	Normal	Ladder
9	1 MΩ	100 kΩ	32 V	30 s	High Ohms	
10	1 MΩ	10 kΩ	10 V	30 s	High Ohms	

- For the resistor pair, calculate and report the interchange closure error. For example, if the R<sub>X</sub>:R<sub>S</sub> ratio of the first measurement is R<sub>a</sub> and the R<sub>X</sub>:R<sub>S</sub> ratio of the second measurement, where the two resistors are exchanged with one another, is R<sub>b</sub>, then the interchange error e<sub>i</sub> in ppm of the nominal ratio is:

$$e_i = (1/2) \times |R_a \times R_b - 1| \times 10^6$$

- The maximum allowable interchange closure errors (ppm) for the resistor pairs are  $\pm 100 \mu\Omega/\Omega$ .
- For the 100:1 ladder up closure errors, the 100:1 ratio must agree to within the specification of the nominal ratio for either directly measuring the 100:1 ratio, or calculating the ratio from the product of the 100:10 ratio and the 10:1 ratio, as follows:

$$e_i = (1/3) \times |R_a - R_b \times R_c| / 100 \times 10^6$$

Where:

R<sub>a</sub> is the 100:1 ratio  
R<sub>b</sub> is the 100:10 ratio  
R<sub>c</sub> is the 10:1 ratio

- The maximum allowable ladder up errors (ppm) for the resistor sets are  $\pm 100 \mu\Omega/\Omega$ .

# 7. REMOTE CONTROL

The model 6622A Automatic DCC Resistance Bridge series operates directly from the front panels or under remote control of the computer supplied with the system. Remote control can be interactive, with the user controlling each step from a terminal (not supplied with the system), or under the control of the computer running the model 6622A as an automated system with the use of the BridgeWorks Data Acquisition Software.

This chapter describes the IEEE-488 interfaces and the commands to which the model 6622A will respond. A detailed description of the remote control command set is included in Section 5.5 of this manual.

**WARNING: In general, local control from the front panels should be performed only when remote control is inactive. This occurs when the BridgeWorks Data Acquisition Software is either closed or displaying an error message. During remote control, the front panel controls, particularly those of the model 6622A, may appear to be inactive, due to the frequency of communication by the computer system, which acts as the GPIB controller.**

## 7.1. INTERFACES

The model 6622A system has an external IEEE-488 interface.

The IEEE-488 connector is mounted on the rear panel of the model 6622A bridge. This connector can optionally be daisy chained together to other components such as the 6664A and 6664A-2A Scanners as well as to connect to the IEEE-488 connector of the computer system.

The factory settings for the IEEE interface are shown in the Table 5-1. The factory setting also includes a set bus speed for the controller of 2 usec.

## 7.2. IEEE-488 (GPIB) INTERFACE

The model 6622A is fully programmable for use on the IEEE 488 interface bus (also known as the General Purpose Interface Bus (GPIB)). The model 6622A interface is designed in compliance with the supplemental standard IEEE-488.2. Devices connected to the bus in a system are designated as talkers, listeners, talker/listeners, or controllers. The model 6622A is operated on the IEEE-488 bus as a talker/listener. This manual assumes that the user is familiar with the basics of the IEEE-488 interface bus.

<u>Instrument</u>	<u>IEEE-488 Address Setting</u>	<u>Remote/Local Setting</u>	<u>Controller Type Setting</u>
Model 6622A Bridge	4	N/A	N/A

Table 7-1 : Factory Setting-GPIB

### 7.2.1. Controller

There can be only one designated controller in charge on the IEEE-488 bus. This device exercises overall bus control and is capable of both receiving and sending data. The rest of the devices can be designated as listener, talker or talker/listener.

The controller can address other devices and command them to listen, address one device to talk and wait till the data is sent. Data routes are set by the controller but it need not take part in the data interchange.

All controller query and command sequences should be terminated with the line-feed character (0x0A) and or optionally, the controller should assert the EOI data byte control signal to terminate the query command sequence.

The controller of the model 6622A is the computer system, which the user controls through the BridgeWorks Data Acquisition Software.

### 7.2.2. IEEE-488 Responses

The reply to any IEEE-488 query command will be a sequence of ASCII characters followed by a line-feed character (0x0A). The line-feed character may also be expressed as 0A<sub>16</sub> or 10<sub>10</sub> or 12<sub>8</sub> or control-J. Throughout this manual, the "C" programming language notation is used for expressing numbers in base 16. Specifically, 0x0A indicates that 0A is to be interpreted in base 16 (hex).

### 7.2.3. Interconnecting Cable And IEEE-488 Connector

The interconnecting cable of IEEE-488 1978 consists of 24 conductors; of which 16 conductors are for carrying signals and 8 conductors are for grounding. The individual cable assembly could be up to 4 meters long. The cable should be double shielded and should have both a shielded plug and a receptacle connector type at each end of the cable. Guildline Instruments Part Number 996-23006 is a suitable IEEE-488 cable assembly of length 2 meters. Each connector assembly is fitted with a pair of captive locking screws.

### 7.2.4. Typical System

The 8-Data Input/Output Lines form the data bus over which data between the various devices is transmitted under the supervision of the controller. The message bytes are carried on Data I/O signal lines in a bit parallel byte serial form, asynchronously and generally in a bi-directional manner.

Handshake or Data Byte Control - The three interface signals are used to effect the transfer of each byte of data on the DIO signal lines from a talker or controller or one or more listeners.

1. DAV (DATA VALID) is used to indicate the condition of (availability and validity) information on the DIO signal lines.
2. NDAC (NOT DATA ACCEPTED)
3. NRFD (NOT READY FOR DATA) is used to indicate the condition of readiness of devices to accept data.
4. SRQ (SERVICE REQUEST) is used by a device to indicate the need for attention and to request an interruption of the current sequence of events.
5. REN (REMOTE ENABLE) is used (by a controller) in conjunction with other messages to select between two alternate sources of device programming data.
6. EOI (END OR IDENTIFY) is used (by a talker) to indicate the end of a multiple byte transfer sequence or in conjunction with ATN (by a controller) to execute a polling sequence.
7. ATN (ATTENTION)
8. IFC (INTERFACE CLEAR)

### **7.2.5. Address And Talk/Listen Selection**

The IEEE-488 Address and Talk/Listen status can be set using the front panel controls as directed by the operator menu system.

If there is no controller and the model 6622A is hooked up to a printer for hard copy, then Talk Only mode should be selected as the preferred mode of operation.

### **7.2.6. IEEE-488 Electrical Interface**

The model 6622A meets the subsets of the IEEE-488 interface specification IEEE-488.1 shown in Table 5-3. The pin connections on the IEEE-488 interface connector are shown in Table 5-2.

### **7.2.7. IEEE-488 Input Buffering**

The IEEE-488 input buffer is 256 bytes long. The input full bit is set when the buffer is above 75% full, 64 bytes remaining.

PIN	NAME	DESCRIPTION
1	DIO1	Data Input Output Line 1
2	DIO2	Data Input Output Line 2
3	DIO3	Data Input Output Line 3
4	DIO4	Data Input Output Line 4
5	EIO	End or Identify
6	DAV	Data Valid
7	NRFD	Not Ready for Data
8	NDAC	Not Data Accepted
9	IFC	Interface Clear
10	SRQ	Service Request
11	ATN	Attention
12	SHIELD	Screening on Cable (connected to ground)
13	DIO5	Data Input Output Line 5
14	DI06	Data Input Output Line 6
15	DIO7	Data Input Output Line 7
16	DIO8	Data Input Output Line 8
17	REN	Remote Enable
18	GND6	Ground wire of twisted pair with DAV
19	GND7	Ground wire of twisted pair with NRFD
20	GND8	Ground wire of twisted pair with NDAC
21	GND9	Ground wire of twisted pair with IFC
22	GND10	Ground wire of twisted pair with SRQ
23	GND11	Ground wire of twisted pair with ATN
24	GND	Logic Ground

Table 7-2 : IEEE-488 Connector Pin Designations

Source Handshake	SH1
Acceptor Handshake	AH1
Talker	T6
Listener	L4
Service Request	SR1
Remote Local	RL1
Parallel Poll	PP0
Device Clear	DC1
Device Trigger	DT0
Controller	C0
Electrical Interface	E2

Table 7-3 : Model 6622A IEEE-488 Device Capabilities

### 7.2.8. IEEE-488 Output Buffering

Output from query commands are placed into a 256 byte output buffer. If for some reason the controller does not read the responses from its query commands the output buffer will overflow, in this case the first data into the buffer will still be valid and the later data will be lost. When output data is lost the query error bit in the status register will be set. When the output buffer is not empty then the message available (MAV) bit will be set in the status register.

### 7.2.9. IEEE-488 Deadlock

If the controller demands a byte of data from the model 6622A and the buffer is empty, the model 6622A will set the Query Error flag in the Event Status Register.

### 7.3. COMMAND LANGUAGE

The commands for IEEE-488 mainly correspond to the labels assigned to the front panel menus. The examples will not show the termination character.

#### 7.3.1. General Syntax For Commands

The model 6622A uses a sophisticated command parser which can usually determine which command was desired, even if the command is entered incorrectly.

No command used in the model 6622A has an embedded space in its name, spaces (0x20) are used only to separate command names from their parameters.

The comma "," must delimit all multiple arguments used in a command sequence.

#### 7.3.2. General Syntax For Numbers

Numeric parameters may have up to 30 characters, and although the 6622A will accept numeric parameters in the range  $\pm 2.2E-308$  through  $\pm 1.8E308$ , the useful range of numbers is between  $\pm 1.0E-8$  and  $1.0E5$ .

### 7.4. MODEL 6622A REMOTE AND LOCAL OPERATION

The model 6622A can be operated locally using the front panel keys, or it can be operated remotely using a remote controller. In addition, the model 6622A can be placed in a local lockout condition at any time by a command from the controller. When combined; the local, remote and lockout conditions yield four possible operating states:

#### **Local:**

The model 6622A responds to local and remote commands. This is also called "Front Panel Operation". Only remote commands that do not affect the state of the model 6622A are allowed to execute.

#### **Local With Lockout:**

Local with lockout is identical to Local, except that the model 6622A will go into remote with lockout instead of the remote state when the model 6622A receives a remote command.

## Remote:

When the Remote Enable (REN) line is asserted and the controller addresses the model 6622A as a listener, the model 6622A enters the remote state. Front panel operation is restricted to the use of the Remote softkey/pushbutton. Pressing the Remote softkey or sending the GTL (Go To Local) interface message returns the model 6622A to the local state. While the BridgeWorks Data Acquisition Software is open, the model 6622A is in the remote state most of the time, due to the frequency of communication.

## Remote With Lockout:

The remote with lockout state can be entered from remote or local with lockout, but not directly from local. To enter the remote with lockout state, the controller must send the commands UNL, MLA and LLO in that order, and then a valid data message must be sent while REN is true. As long as REN remains true and the command GTL is not received, the model 6622A will remain in the remote with lockout state. Remote with lockout is similar to the remote state but restricted: The Remote softkey will not return to the local state. To return the model 6622A to the local with lockout state, the controller must send a GTL interface command. To return the model 6622A to the local state, the controller must unassert the REN control line.

## 7.5. MODEL 6622A PROGRAMMING COMMAND SUMMARY

A brief description of each of the possible remote IEEE-488 commands and their syntax in BNF (Backus Naur Form) follows:

- words inside angle brackets (ie. < and > ) are defined items
  - ::= means "is defined to be"
  - | means "or"
  - [] means optional
  - required letters are shown in upper case but may be upper or lower case.
- <digit> ::= 0|1|2|3|4|5|6|7|8|9  
 <letter> ::= A|B|C|...|Z|a|b|c|...|z  
 <string> ::= <letter> | <letter><string>  
 <boolean> ::= 0|1  
 <unsigned> ::= <digit> | <digit><unsigned>  
 <nr1> ::= [+|-]<unsigned>  
 <nr3> ::= <nr1>[.<unsigned>][E<nr1>]  
 <?> ::= <letter> | <digit>  
 <\*> ::= <?> | [<\*>] :not to be confused with \*  
 <DD> ::= <unsigned> : limited to range 1...31  
 <MM> ::= <unsigned> : limited to range 1...12  
 <YYYY> ::= <unsigned> : limited to ranges 1999 and up

The STB Bits are as follows:

bit 7 = (unused)

bit 6 = SRQ (service request)

; set when (SRQ\_mask|GPIB\_STAT\_PORT) != 0

- bit 5 = ESB (event summary)
  - ; set when bitwise AND of ESE, register is not zero
- bit 4 = MAV (message available)
  - ; set when GPIB Tx buffer has data available
  - ; cleared when the buffer is empty
- bit 3 = IFL (input buffer full)
  - ; set when input buffer is over 80% full
  - ; cleared when input buffer drops under 20% full
  
- bit 2 = CHK (Checksum calculation complete)
- bit 1 = RDY (ready)
  - ; set when unit has a stable reading
  - ; cleared when unit is working
- bit 0 = OVR (over range)
  - ; set when over range detected (in ISR)
  - ; cleared when over range cleared

## COMMAND

## COMMENT

*CLS	clear status register
*ESR?	query, display event status register
*ESE?	query, display event status enable
*ESE <unsigned>	set event status enable
*IDN?	query, display identity of unit
*OPT?	query, display any reportable options
*OPC?	query, operation complete
*OPC	set operation complete bit in event status register
*RST	reset the instrument to a known defined state
*STB?	query, display serial poll status byte
*SRE?	query, display service request mask
*SRE <unsigned>	set the service request mask
*TST?	query, display results of self test
FETCh?	fetch the most recent data value
	MEASure - set the measurement parameters
MEASure <state>	select the measurement state
	<state> ::= 0 1
	type <boolean>
	0 ::= OFF
	1 ::= ON
MEASure?	query, display the measurement state of the instrument
MEASure:UNIT <unit>	select the units of measurement and instrument operation
	<unit> ::= R O V

COMMAND	COMMENT
	type <letter> R:==Ratio O:==Ohms V:==Volt
MEASure:UNIT?	query, display the units of measurement
MEASure:FILTer <function>	setup the digital filter for the display data <function>:== 0 1 2 type <digit> 0 :== Filter OFF 1 :== Decimation 2 :== Simple average
MEASure:FILTer?	query, display the filter setup
MEASure:UPDAtE <rate>	set the number of screen updates for each measurement cycle <rate>:== 0 1 2 type <digit> 0:==1 updates/cycle 1:==2 updates/cycle 2:==4 updates/cycle
MEASure:UPDAtE?	query, display the screen update rate setting
MEASure:DEVIation <diff>	select the method of reporting the difference data <diff>:==0 1 2 3 4 type <digit> 0 :== disable/normal 1 :== parts per million 2 :== delta change 3 :== $\mu\Omega/\Omega$ (ppm) from datum 4 :== delta from datum
MEASure:DEVIation?	query, display the method of reporting the difference data
MEASure:RESOLution <prec>	select the precision of reporting the data <prec>:==0 1 2 3 4 type <digit> 0 :== 0.001 $\mu\Omega/\Omega$ 1 :== 0.01 $\mu\Omega/\Omega$ 2 :== 0.1 $\mu\Omega/\Omega$ 3 :== 1.0 $\mu\Omega/\Omega$ 4 :== 10.0 $\mu\Omega/\Omega$
MEASure:DEVIation?	query, display the precision of reporting the data type <boolean>  0:== OFF

COMMAND	COMMENT
MEASure:VOLT?	1:== ON query nanovoltmeter status
MEASure:SELF<state>	CONFigure - configure instrument operating parameters
CONFigure:DATUm <unit>, <value>	initiate or terminate the internal self test process initialize the datum to be used as the set point in all difference calculations <unit> ::= R O V type <letter> R:==Ratio O:==Ohms V:==Volts <value>::=<nr3>
CONFigure:DATUm?	query, display the datum used as the set point in all difference calculations
CONFigure:FILTer <size1>,<size2>	initialize the filter coefficients <size1> ::= <nr3> decimation filter coefficient <size2> ::= <unsigned> N average filter coefficient
CONFigure:FILTer?	query the filter coefficients
CONFigure:RESIstor <md>, <RS>, <SN>, <RX>, <Rev_Rate>, <Tst_Val>, <Tst_Max>	set the active resistor measurement configuration <mode>::= 0 1 2  type <digit> 0:==normal mode 1:==high ohms mode 2:==low ohms mode <RS>::=<nr3> ref. resistor value <RS_Sn>::=<string> ref. resistor serial # <RX>::=<nr3> approximate value Rx <Rev_rate>::=<nr3> test current reversal rate <Tst_Val>::=<nr3> test current/volts <Tst_Max>::=<nr3> max current(Is)/volts for ref resistor
CONFigure:RESIstor?	query, display active resistor configuration

COMMAND	COMMENT
CONFigure:RESIstor:DISPlay <unit>, <rate>, <filter>, <size>, <power>	information set the active display parameters for resistor measurements <unit>::= R O type <letter> R::=Ratio O::=Ohms <rate>::= 0 1 2 type <digit> 0::=1 updates/cycle 1::=2 updates/cycle 2::=4 updates/cycle <filter>::= 0 1 2 type <digit> 0::= none 1::= decimation 2::= simple average <size>::=<unsigned> size = % for decimation = sample size for simple average <power>::= 0 1 2 type <digit> 0::= power normal X1 1::= power X2
CONFigure:RESIstor:DISPlay?	query, display the active display setup
CONFigure:VOLTmeter <range>, <zero>, <high>, <ref>	set the voltmeter calibration coefficients <range>::= 0 1 2 3 4 type <digit> 0::= 20V range 1::= 2V range 2::= 200mV range 3::= 20mV range 4::= 2mV range <zero>::=<unsigned> <high>::=<unsigned> <ref>::=<nr1>
CONFigure:VOLTmeter? <Range>	query, display the voltmeter calibration setup <range>::= 0 1 2 3 4 type <digit> 0::= 20V range

COMMAND	COMMENT
	1:== 2V range
	2:== 200mV range
	3:== 20mV range
	4:== 2mV range
	SYSTem – set the unit operating conditions
SYSTem:COMMunicate:GPIB <address>, <mode>	setup GPIB communications <address>:== <unsigned> <mode>:== 0 1 2 type <digit> 0 :== disable 1 :== talk only 2 :== talk/listen
SYSTem:COMMunicate:GPIB?	query, display GPIB set up
SYSTem:TERSe	respond to commands with a minimum data set
SYSTem:VERBoSe	respond to commands with a minimum data set
SYSTem:VERSion?	query, display the installed software version
SYSTem:DIAGnostic:ROMChecksum?	query, display rom checksum
SYSTem:DIAGnostic:SERialNumber <number>	assign serial number <number>:==<unsigned> Diagnostic Command Set
SYSTem:CHECK	invoke the internal self check
SYSTem:RESULT?	query, display the results from the last self check
ADconvRead?	query, display adc reading in engineering units
ADconvB?	query, display adc in raw binary units
Filter?	query, display the nano voltmeter filter setting
Filter <function>	set the nano voltmeter filter <function>:==0 1 type <boolean> 0:== OFF 1:== ON
Highres?	query, display the high resolution mode setting
Highres <resolution>	set the high resolution mode <resolution>:==0 1 type <boolean> 0:== OFF 1:== ON
HardWareFilter?	query, display the hardware filter status
HardWareFilter <status>	set the hardware filter status

COMMAND	COMMENT
	<status>::=0 1 type <boolean> 0::= OFF 1::= ON
IXTurns? IXTurns <turns>	query, display relay turns setting set relay turns <turns>::=<unsigned> 0≤turns≤8747
ISDAC <value>	set dac setting <value>::=<nr1> value == ± 5 Volts
ISMux? ISMux <channel>	query, display the multiplexer channel set the multiplexer channel <channel>::=0 1 2 3 4 5 7 type <digit> 0::= servo 1::= speedup 2::= offset 3::= +40 Volts 4::= -40 Volts 5::= primary current 7::= calibrate
ISResolution? ISResolution <resolution>	query, display the resolution setting set the resolution <resolution>::=0 1 2 type <digit> 0 :::= high 1 :::= medium 2 :::= low
ISSpeed? ISSpeed <speed>	query, display the speed setting set the speed <speed>::=0 1 2 3 type <digit> 0 :::= reset 1 :::= slow 2 :::= moderate 3 :::= fast
OHmode? OHmode <mode>	Query, display the ohm mode set the ohm mode <mode>::=0 1 2 type <digit>  0 :::= normal

COMMAND	COMMENT
RESET	2 ::= low ohms reset instrument to power on reset state
Range?	query, display the selected range
Range <range>	set the nanovoltmeter range <range> ::= <unsigned> range any one of 0.002, 0.02, 0.2, 2.0, 20.0
SOFCAL:COEF? <ratio>, <range>	query, display ratio correction coefficient <ratio>: == 0 1 2 3 4 type<digit> 0 ::= 0.1:1 ratio 1 ::= 1:1 ratio 2 ::= 10:1 ratio (648 turns) 3 ::= 10:1 ratio (81 turns) 4 ::= 100:1 ratio <range>: == 0 1 2 3 4 5 6 7 type<digit> 0 ::= 1 ohm Rs range 1 ::= 10 ohm Rs range 2 ::= 100 ohm Rs range 3 ::= 1k ohm Rs range 4 ::= 10k ohm Rs range
SOFCAL:COEF <ratio>, <range>, <corr>, <uncert>	set ratio correction coefficient <ratio>: == 0 1 2 3 4 type<digit> 0 ::= 0.1:1 ratio 1 ::= 1:1 ratio 2 ::= 10:1 ratio (648 turns) 3 ::= 10:1 ratio (81 turns) 4 ::= 100:1 ratio <range>: == 0 1 2 3 4 5 6 7 type<digit> 0 ::= 1 ohm Rs range 1 ::= 10 ohm Rs range 2 ::= 100 ohm Rs range 3 ::= 1k ohm Rs range 4 ::= 10k ohm Rs range <corr> ::= <nr3> correction coefficient (ppm of ratio) <uncert> ::= <nr3>  uncertainty (parts in 10 <sup>6</sup> of ratio)

COMMAND	COMMENT
SOFCAL <beta>	set adc beta <beta>: == <unsigned> 200 ≤ beta ≤ 300
SOFCAL <beta> ?	query, display adc beta for the nanovolt detector
SOFCAL: FREQuency <Hz>	set the line frequency option <Hz>: == 0 1 type <digit> 0 : == 60 Hz 1 : == 50 Hz
SOFCAL:GET?	Calculate adc beta for the nanovolt detector
SOFCAL:DATE?	query, display the calibration date
SOFCAL:DATE<YYYY>,<MM>,<DD>	set the calibration date <YYYY> calibration year <MM> calibration month <DD> calibration day
SOFCAL:PRIM?	query, display the 81 primary turns lock
SOFCAL:PRIM<state>	set the 81 primary turns lock <state> 0 1 type<boolean> 0:== unlocked 1:== locked to 81 turns
Voltage?	query, display the nano voltmeter measurement

## 8. APPENDICES

### 8.1. GENERAL SPECIFICATIONS

6622A Series Automatic DCC Resistance Bridge General Specifications		
Operating Temperature to Full Specification	+23 ± +3	°C
	+73.4 ± +5.4	°F
Operating Temperature Maximum Range <50% RH	+18 to +28	°C
	+64.4 to +82.4	°F
Storage Temperature Maximum Range	-20 to +60	°C
	-4 to +140	°F
Operating Humidity	20 to 50	% RH
Storage Humidity	15 to 80	% RH
Power Requirements (Maximum):	200	VA
Voltage Requirements (1)	100, 120, 220 or 240 ±10 %	VAC
Line Frequency (1)	50 ± 5 % or 60 ± 5 %	Hz
Weight (Nominal)	58	lbs
	27	kg
Dimensions (Bench Unit):	D 441 , W 525 , H 230	mm
	D 17.36 , W 20.67 , H 9.06	in
Dimensions (Rack Unit):	D 467 , W 525 , H 222	mm
	D 18.36 , W 20.67 , H 8.75	in

Table 8-1 : General Specifications

- NOTE: 1. The 6622A Series bridges are always configured for 240 VAC. It is configured to other customer requirements for line frequency at the time of order.**
- 2. The voltage setting at the power entry on the back of the instrument must be set for the correct line voltage and the correct fuse must be installed by the customer.**

## 8.2. GENERAL SPECIFICATIONS (continued)

6622A Series General Specifications			
Linearity		± 0.01 μΩ/Ω of full scale (Full scale defined as 13.4:1 and 100:1)	
Display resolution (ppm)		Selectable (Programmable) from 0.0001 ppm to 10 ppm	
Temperature Coefficient		0.01 μΩ/Ω /°C of reading	
Automatic current reversal rate (in seconds) s		4 s to 1637 s programmable, increment of 1second	
Communication		IEEE 488.2 (SCPI Based Language Instructions)	
Test current (for measurement to 100 kΩ)	Usable range (±30 V) compliance) (A)	10 μA ~ 150 mA (extension to 10,000 A available)	
	Resolution (μA)	1 μA	
	Accuracy [error(ppm) + offset(A)]	±100 μΩ/Ω ± 10 μA	
Test voltage (for measurement above 100 kΩ)	V <sub>DC</sub> Range (±1mA compliance)	0 ~ 100 Vdc (XR and XPR models). HV Model has 0 ~ 1000 Vdc	
	Resolution (V)	1 V for Bridges with 100 Volt Module, 256 bit for 1000 Volt Model (≈4V)	
	Accuracy error (%)	± 0.2 % of full scale voltage output	
Bridge Operating Temperature to Full Specifications		23 °C ± 3 °C	73.4 °F ± 5.4 °F
Bridge Maximum Operating Range (<50 % RH)		+18 °C to +28 °C	+64.4 °F to +82.4 °F
Bridge Temperature Storage Range		-20 °C to +60 °C	-4 °F to +140 °F
Power Requirements		VAC: 100 V, 120 V, 220 V and 240 V ± 10 % / 50 or 60 Hz ± 5 %, 200 VA	
Dimensions (Width x Height x Depth)			Weight
440 mm x 200 mm x 465 mm		17.3" x 7.8" x 18.3"	27 kg 59.5 lbs

Table 8-2 : General Specifications (continued)

## 8.3. RESISTANCE MEASUREMENT SPECIFICATION

**Note:** The 6622A-Base, 6622A-XP and 6622A-XPS models are limited to a maximum of 100 kΩ with a maximum Rs (Resistance Standard) of 10 kΩ. Because of the unique variable ratios available on all models, it is possible to measure UUT's with a variety of Rs Standards. For example, a 10 kΩ UUT could be measured with a 100 Ω, 1 kΩ and 10 kΩ Resistance Standard (Rs). To determine the measurement uncertainty due to the bridge, simply look at the Rs you are using, and then go to the appropriate UUT Sub range.

<h1>6622A-BASE</h1> <p>XP Range: 1 mΩ ◀ ▶ 100 kΩ</p>		Low Ohms Ratios <sup>1</sup>			
		R <sub>s</sub> 1 Ω ▶	± 0.8 μΩ/Ω	± 0.7 μΩ/Ω	
		NOMINAL RATIO ▶	<b>0.001:1</b>	<b>0.01:1</b>	
		ACTUAL RATIO ▶	0.8m > Rx < 0.008	0.008 > Rx < 0.08	
INTERCHANGE <sup>1</sup> SPECIFICATION	RESISTANCE STANDARD	3 YEAR RATIO SPECIFICATIONS <sup>2</sup>			
0.8 > Rx < 6.3	◀ ACTUAL RATIO ▶	0.08 > Rx < 0.8	0.8 > Rx < 6.3	6.3 > Rx < 13.4	13.4 > Rx < 107.5
<b>1:1</b>	◀ NOMINAL RATIO ▶	<b>0.1:1</b>	<b>1:1</b>	<b>10:1</b>	<b>100:1</b>
± 0.03 μΩ/Ω	◀ 1 Ω ▶	± 0.6 μΩ/Ω	± 0.1 μΩ/Ω	± 0.1 μΩ/Ω	± 0.1 μΩ/Ω
± 0.03 μΩ/Ω	◀ 10 Ω ▶	± 0.6 μΩ/Ω	± 0.1 μΩ/Ω	± 0.1 μΩ/Ω	± 0.1 μΩ/Ω
± 0.03 μΩ/Ω	◀ 100 Ω ▶	± 0.6 μΩ/Ω	± 0.1 μΩ/Ω	± 0.1 μΩ/Ω	± 0.3 μΩ/Ω
± 0.03 μΩ/Ω	◀ 1 kΩ ▶	± 0.6 μΩ/Ω	± 0.1 μΩ/Ω	± 0.1 μΩ/Ω	± 0.8 μΩ/Ω
± 0.05 μΩ/Ω	◀ 10 kΩ ▶	± 0.6 μΩ/Ω	± 0.1 μΩ/Ω	± 0.2 μΩ/Ω	[XR MODEL]

<h1>6622A-XR</h1> <p>Base Range: 1 mΩ ◀ ▶ 100 MΩ</p>		Low Ohms Ratios <sup>1</sup>			
		R <sub>s</sub> 1 Ω ▶	± 0.8 μΩ/Ω	± 0.7 μΩ/Ω	
		NOMINAL RATIO ▶	<b>0.001:1</b>	<b>0.01:1</b>	
		ACTUAL RATIO ▶	0.8m > Rx < 0.008	0.008 > Rx < 0.08	
INTERCHANGE <sup>1</sup> SPECIFICATION	RESISTANCE STANDARD	3 YEAR RATIO SPECIFICATIONS <sup>2</sup>			
0.8 > Rx < 6.3	◀ ACTUAL RATIO ▶	0.08 > Rx < 0.8	0.8 > Rx < 6.3	6.3 > Rx < 13.4	13.4 > Rx < 107.5
<b>1:1</b>	◀ NOMINAL RATIO ▶	<b>0.1:1</b>	<b>1:1</b>	<b>10:1</b>	<b>100:1</b>
± 0.03 μΩ/Ω	◀ 1 Ω ▶	± 0.6 μΩ/Ω	± 0.1 μΩ/Ω	± 0.1 μΩ/Ω	± 0.1 μΩ/Ω
± 0.03 μΩ/Ω	◀ 10 Ω ▶	± 0.6 μΩ/Ω	± 0.1 μΩ/Ω	± 0.1 μΩ/Ω	± 0.1 μΩ/Ω
± 0.03 μΩ/Ω	◀ 100 Ω ▶	± 0.6 μΩ/Ω	± 0.1 μΩ/Ω	± 0.1 μΩ/Ω	± 0.3 μΩ/Ω
± 0.03 μΩ/Ω	◀ 1 kΩ ▶	± 0.6 μΩ/Ω	± 0.1 μΩ/Ω	± 0.1 μΩ/Ω	± 0.8 ppm
± 0.05 μΩ/Ω	◀ 10 kΩ ▶	± 0.6 μΩ/Ω	± 0.1 μΩ/Ω	± 0.2 μΩ/Ω	± 3 μΩ/Ω
± 0.15 μΩ/Ω	◀ 100 kΩ ▶	± 1 μΩ/Ω	± 0.3 μΩ/Ω	± 0.5 μΩ/Ω	± 6 μΩ/Ω
± 0.25 μΩ/Ω	◀ 1 MΩ ▶	± 2.5 μΩ/Ω	± 0.6 μΩ/Ω	± 0.8 μΩ/Ω	± 8 μΩ/Ω
± 2.0 μΩ/Ω	◀ 10 MΩ ▶	± 8 μΩ/Ω	± 4 μΩ/Ω	± 8 μΩ/Ω	[HV MODEL]

<h2>6622A-XP</h2> <p>XP Range: 1 mΩ ◀ ▶ 100 kΩ</p>		Low Ohms Ratios <sup>1</sup>			
		$R_s$ 1 Ω ▶	± 0.7 μΩ/Ω	± 0.6 μΩ/Ω	
		NOMINAL RATIO ▶	<b>0.001:1</b>	<b>0.01:1</b>	
		ACTUAL RATIO ▶	0.8m > Rx < 0.008	0.008 > Rx < 0.08	
INTERCHANGE <sup>1</sup> SPECIFICATION	RESISTANCE STANDARD	3 YEAR RATIO SPECIFICATIONS <sup>2</sup>			
0.8 > Rx < 6.3	◀ ACTUAL RATIO ▶	0.08 > Rx < 0.8	0.8 > Rx < 6.3	6.3 > Rx < 13.4	13.4 > Rx < 107.5
<b>1:1</b>	◀ NOMINAL RATIO ▶	<b>0.1:1</b>	<b>1:1</b>	<b>10:1</b>	<b>100:1</b>
± 0.02 ppm	◀ 1 Ω ▶	± 0.4 μΩ/Ω	± 0.05 μΩ/Ω	± 0.05 μΩ/Ω	± 0.1 μΩ/Ω
± 0.02 ppm	◀ 10 Ω ▶	± 0.4 μΩ/Ω	± 0.05 μΩ/Ω	± 0.05 μΩ/Ω	± 0.1 μΩ/Ω
± 0.02 ppm	◀ 100 Ω ▶	± 0.4 μΩ/Ω	± 0.05 μΩ/Ω	± 0.05 μΩ/Ω	± 0.3 μΩ/Ω
± 0.02 ppm	◀ 1 kΩ ▶	± 0.4 μΩ/Ω	± 0.05 μΩ/Ω	± 0.05 μΩ/Ω	± 0.8 μΩ/Ω
± 0.03 ppm	◀ 10 kΩ ▶	± 0.4 μΩ/Ω	± 0.05 μΩ/Ω	± 0.15 μΩ/Ω	[XPR MODEL]

<h2>6622A-XPR</h2> <p>XPR Range: 1 mΩ ◀ ▶ 100 MΩ</p>		Low Ohms Ratios <sup>1</sup>			
		$R_s$ 1 Ω ▶	± 0.7 μΩ/Ω	± 0.6 μΩ/Ω	
		NOMINAL RATIO ▶	<b>0.001:1</b>	<b>0.01:1</b>	
		ACTUAL RATIO ▶	0.8m > Rx < 0.008	0.008 > Rx < 0.08	
INTERCHANGE <sup>1</sup> SPECIFICATION	RESISTANCE STANDARD	3 YEAR RATIO SPECIFICATIONS <sup>2</sup>			
0.8 > Rx < 6.3	◀ ACTUAL RATIO ▶	0.08 > Rx < 0.8	0.8 > Rx < 6.3	6.3 > Rx < 13.4	13.4 > Rx < 107.5
<b>1:1</b>	◀ NOMINAL RATIO ▶	<b>0.1:1</b>	<b>1:1</b>	<b>10:1</b>	<b>100:1</b>
± 0.02 μΩ/Ω	◀ 1 Ω ▶	± 0.4 μΩ/Ω	± 0.05 μΩ/Ω	± 0.05 μΩ/Ω	± 0.1 μΩ/Ω
± 0.02 μΩ/Ω	◀ 10 Ω ▶	± 0.4 μΩ/Ω	± 0.05 μΩ/Ω	± 0.05 μΩ/Ω	± 0.1 μΩ/Ω
± 0.02 μΩ/Ω	◀ 100 Ω ▶	± 0.4 μΩ/Ω	± 0.05 μΩ/Ω	± 0.05 μΩ/Ω	± 0.3 μΩ/Ω
± 0.02 μΩ/Ω	◀ 1 kΩ ▶	± 0.4 μΩ/Ω	± 0.05 μΩ/Ω	± 0.05 μΩ/Ω	± 0.8 μΩ/Ω
± 0.03 μΩ/Ω	◀ 10 kΩ ▶	± 0.4 μΩ/Ω	± 0.05 μΩ/Ω	± 0.15 μΩ/Ω	± 3 μΩ/Ω
± 0.1 μΩ/Ω	◀ 100 kΩ ▶	± 0.7 μΩ/Ω	± 0.2 μΩ/Ω	± 0.3 μΩ/Ω	± 6 μΩ/Ω
± 0.2 μΩ/Ω	◀ 1 MΩ ▶	± 1.5 μΩ/Ω	± 0.4 μΩ/Ω	± 0.6 μΩ/Ω	± 8 μΩ/Ω
± 1.5 μΩ/Ω	◀ 10 MΩ ▶	± 8 μΩ/Ω	± 2.5 μΩ/Ω	± 4 μΩ/Ω	[HV MODEL]

<h2>6622A-XPS</h2> <p>XPS Range: 1 mΩ ◀▶ 100 kΩ</p>		Low Ohms Ratios <sup>1</sup>			
		R <sub>s</sub> 1 Ω ▶	± 0.7 μΩ/Ω	± 0.6 μΩ/Ω	
		NOMINAL RATIO ▶	<b>0.001:1</b>	<b>0.01:1</b>	
		ACTUAL RATIO ▶	0.8m > Rx < 0.008	0.008 > Rx < 0.08	
INTERCHANGE <sup>1</sup> SPECIFICATION	RESISTANCE STANDARD	3 YEAR RATIO SPECIFICATIONS <sup>2</sup>			
0.8 > Rx < 6.3	◀ ACTUAL RATIO ▶	0.08 > Rx < 0.8	0.8 > Rx < 6.3	6.3 > Rx < 13.4	13.4 > Rx < 107.5
<b>1 : 1</b>	◀ NOMINAL RATIO ▶	<b>0.1 : 1</b>	<b>1 : 1</b>	<b>10 : 1</b>	<b>100 : 1</b>
± 0.015 μΩ/Ω	◀ 1 Ω ▶	± 0.4 μΩ/Ω	± 0.02 μΩ/Ω	± 0.03 μΩ/Ω	± 0.1 μΩ/Ω
± 0.015 μΩ/Ω	◀ 10 Ω ▶	± 0.4 μΩ/Ω	± 0.02 μΩ/Ω	± 0.03 μΩ/Ω	± 0.1 μΩ/Ω
± 0.015 μΩ/Ω	◀ 100 Ω ▶	± 0.4 μΩ/Ω	± 0.02 μΩ/Ω	± 0.03 μΩ/Ω	± 0.3 μΩ/Ω
± 0.015 μΩ/Ω	◀ 1 kΩ ▶	± 0.4 μΩ/Ω	± 0.02 μΩ/Ω	± 0.03 μΩ/Ω	± 0.8 μΩ/Ω
± 0.03 μΩ/Ω	◀ 10 kΩ ▶	± 0.4 μΩ/Ω	± 0.05 μΩ/Ω	± 0.15 μΩ/Ω	[HV MODEL]

<h2>6622A-HV</h2> <p>HV Range: 1 mΩ ◀▶ 1 GΩ</p>		Low Ohms Ratios <sup>1</sup>			
		R <sub>s</sub> 1 Ω ▶	± 0.7 μΩ/Ω	± 0.6 μΩ/Ω	
		NOMINAL RATIO ▶	<b>0.001:1</b>	<b>0.01:1</b>	
		ACTUAL RATIO ▶	0.8m > Rx < 0.008	0.008 > Rx < 0.08	
INTERCHANGE <sup>1</sup> SPECIFICATION	RESISTANCE STANDARD	3 YEAR RATIO SPECIFICATIONS <sup>2</sup>			
0.8 > Rx < 6.3	◀ ACTUAL RATIO ▶	0.08 > Rx < 0.8	0.8 > Rx < 6.3	6.3 > Rx < 13.4	13.4 > Rx < 107.5
<b>1 : 1</b>	◀ NOMINAL RATIO ▶	<b>0.1 : 1</b>	<b>1 : 1</b>	<b>10 : 1</b>	<b>100 : 1</b>
± 0.02 μΩ/Ω	◀ 1 Ω ▶	± 0.4 μΩ/Ω	± 0.04 μΩ/Ω	± 0.04 μΩ/Ω	± 0.1 μΩ/Ω
± 0.02 μΩ/Ω	◀ 10 Ω ▶	± 0.4 μΩ/Ω	± 0.04 μΩ/Ω	± 0.04 μΩ/Ω	± 0.1 μΩ/Ω
± 0.02 μΩ/Ω	◀ 100 Ω ▶	± 0.4 μΩ/Ω	± 0.04 μΩ/Ω	± 0.04 μΩ/Ω	± 0.3 μΩ/Ω
± 0.02 μΩ/Ω	◀ 1 kΩ ▶	± 0.4 μΩ/Ω	± 0.04 μΩ/Ω	± 0.04 μΩ/Ω	± 0.8 μΩ/Ω
± 0.03 μΩ/Ω	◀ 10 kΩ ▶	± 0.4 μΩ/Ω	± 0.05 μΩ/Ω	± 0.15 μΩ/Ω	± 3 μΩ/Ω
± 0.1 μΩ/Ω	◀ 100 kΩ ▶	± 0.7 μΩ/Ω	± 0.2 μΩ/Ω	± 0.3 μΩ/Ω	± 6 μΩ/Ω
± 0.2 μΩ/Ω	◀ 1 MΩ ▶	± 1.5 μΩ/Ω	± 0.4 μΩ/Ω	± 0.6 μΩ/Ω	± 8 μΩ/Ω
± 0.7 μΩ/Ω	◀ 10 MΩ ▶	± 4 μΩ/Ω	± 1.0 μΩ/Ω	± 2 μΩ/Ω	[MODEL 6530]
± 2.5 μΩ/Ω	◀ 100 MΩ ▶	± 8 μΩ/Ω	± 3.5 μΩ/Ω	± 6 μΩ/Ω	[MODEL 6530]

1 - Interchange specification (i.e. sometimes referred to as a self-calibration) and Low Ohms Ratio specifications - refer to 6622A Manual for additional information about Low Ohms and Interchange specifications.

2 - 3 Year Calibration interval with annual performance verification (automated).

3 - Specifications are based on 10 mW R<sub>s</sub> power dissipation or the maximum current in R<sub>s</sub> or the limit of 6622A output and temperature of 23°C ±3°C.

4 - Ratio uncertainties Less than 0.08 :1 for R<sub>s</sub> 10 Ohm and below are calculated using 6623A Range Extender Series with the 6622A Series Bridge.

5 - Lowest possible R<sub>x</sub> Ratio is defined as R<sub>xlow</sub> = R<sub>s</sub> x .08 and Maximum possible R<sub>x</sub> Ratio is determined by R<sub>xhigh</sub> = R<sub>s</sub> x 107.5.

6 - Maximum Upper Range is limited to 134 kΩ for 6622A, 6622A-XP and 6622A-XPS with the maximum R<sub>s</sub> allowed as 10 kΩ.

7 - Maximum Upper Range is limited to 134 MΩ for 6622A-XR and 6622A-XPR with the maximum R<sub>s</sub> allowed as 10 MΩ.

8 - Maximum Upper Range is limited to 1.34 GΩ for 6622A-HV with the maximum R<sub>s</sub> allowed as 100MΩ based on 1000 V.

**Table 8-3 : Resistance Measurement Specification (All 6622A Models)**

3 Year Specification Includes Specified Bridge(s) Specifications, Patented Internal Precision Current Source, Internal Switching, System Scanner and Wiring. Coverage Factor k=2 (95%), Temperature Environment of 23°C ±3°C.

<b>6623A-3</b>	x20 – 3A 1 mΩ ~ 50mΩ	x20 – 3A 50mΩ ~ 10 Ω				
6622A Base, 6622- XR	± 0.8 μΩ/Ω	± 0.7 μΩ/Ω				
6622A-XP, XPR. & HV Models	± 0.7 μΩ/Ω	± 0.6 μΩ/Ω				
<b>6623A-10</b>	x100 – 10A 0.1mΩ ~ 0.5mΩ	x100 – 10A 0.5mΩ ~ 0.01Ω	x20 – 3A 1mΩ ~ 50mΩ	x20 – 3A 50mΩ ~ 10 Ω		
6622A Base, 6622- XR	± 3.5 μΩ/Ω	± 0.9 μΩ/Ω	± 0.8 μΩ/Ω	± 0.7 μΩ/Ω		
6622A-XP, XPR. & HV Models	± 3 μΩ/Ω	± 0.8 μΩ/Ω	± 0.7 μΩ/Ω	± 0.6 μΩ/Ω		
<b>6623A-150</b>	X1000 – 150A 1 μΩ ~ 10 μΩ	X1000 – 150A 10 μΩ ~ 0.1mΩ	X1000 – 150A 0.1mΩ ~ 0.5mΩ	x1000 – 150A 0.5mΩ ~ 0.01Ω	x100 – 15A 1mΩ ~ 50mΩ	x20 – 3A 50mΩ ~ 10 Ω
6622A Base, 6622- XR	± 20 μΩ/Ω	± 10 μΩ/Ω	± 3 μΩ/Ω	± 0.8 μΩ/Ω	± 0.7 μΩ/Ω	± 0.7 μΩ/Ω
6622A-XP, XPR. & HV Models	± 18 μΩ/Ω	± 9 μΩ/Ω	± 2.5 μΩ/Ω	± 0.7 μΩ/Ω	± 0.6 μΩ/Ω	± 0.6 μΩ/Ω
<b>6623A-300</b>	x2000 – 300A 1 μΩ ~ 10 μΩ	x2000 – 300A 10 μΩ ~ 0.1mΩ	x2000 – 300A 0.1mΩ ~ 0.5mΩ	x2000 – 300A 0.5mΩ ~ 0.01Ω	x200 – 15A 1mΩ ~ 50mΩ	x20 – 3A 50mΩ ~ 10 Ω
6622A Base, 6622- XR	± 15 μΩ/Ω	± 8 μΩ/Ω	± 2 μΩ/Ω	± 0.8 μΩ/Ω	± 0.7 μΩ/Ω	± 0.7 μΩ/Ω
6622A-XP, XPR. & HV Models	± 12 μΩ/Ω	± 7 μΩ/Ω	± 1.5 μΩ/Ω	± 0.7 μΩ/Ω	± 0.6 μΩ/Ω	± 0.6 μΩ/Ω
<b>6623A-450A/600</b>	x4000 – 600A 1 μΩ ~ 10 μΩ	x4000 – 600A 10 μΩ ~ 0.1mΩ	x4000 – 600A 0.1mΩ ~ 0.5mΩ	x4000 – 600A 0.5mΩ ~ 0.01Ω	x400 – 30A 1mΩ ~ 50mΩ	x20 – 3A 50mΩ ~ 10 Ω
6622A Base, 6622- XR	± 15 μΩ/Ω	± 8 μΩ/Ω	± 2 μΩ/Ω	± 0.8 μΩ/Ω	± 0.7 μΩ/Ω	± 0.7 μΩ/Ω
6622A-XP, XPR. & HV Models	± 12 μΩ/Ω	± 7 μΩ/Ω	± 1.5 μΩ/Ω	± 0.7 μΩ/Ω	± 0.6 μΩ/Ω	± 0.6 μΩ/Ω
<b>6623A-1k/2k/3k</b>	x20000 – FSA 0.1 μΩ ~ 1 μΩ	x20000 – FSA 1 μΩ ~ 10 μΩ	x20000 – FSA 10 μΩ ~ 0.1mΩ	x20000 – FSA 0.1mΩ ~ 0.5mΩ	x2000 – 150A 0.5mΩ ~ 0.01Ω	x200 – 15A 1mΩ ~ 0.1Ω
6622A Base, 6622- XR	± 18 μΩ/Ω	± 12 μΩ/Ω	± 8 μΩ/Ω	± 2 μΩ/Ω	± 0.8 μΩ/Ω	± 0.7 μΩ/Ω
6622A-XP, XPR. & HV Models	± 16 p μΩ/Ω	± 10 μΩ/Ω	± 7 μΩ/Ω	± 1.5 μΩ/Ω	± 0.7 μΩ/Ω	± 0.6 μΩ/Ω
<b>6623A-4k/5k/6k</b>	x40000 – FSA 0.1 μΩ ~ 1 μΩ	x40000 – FSA 1 μΩ ~ 10 μΩ	x40000 – FSA 10 μΩ ~ 0.1mΩ	x40000 – FSA 0.1mΩ ~ 0.5mΩ	x4000 – 300A 0.5mΩ ~ 0.01Ω	x400 – 30A 1mΩ ~ 0.1Ω
6622A Base, 6622- XR	± 16 μΩ/Ω	± 10 μΩ/Ω	± 6 μΩ/Ω	± 1.8 μΩ/Ω	± 0.8 μΩ/Ω	± 0.7 μΩ/Ω
6622A-XP, XPR. & HV Models	± 14 μΩ/Ω	± 8 μΩ/Ω	± 5 μΩ/Ω	± 1.4 μΩ/Ω	± 0.7 μΩ/Ω	± 0.6 μΩ/Ω
<b>6623A-7k/8k/9k/10k</b>	x100 k – FSA 0.1 μΩ ~ 1 μΩ	x100 k – FSA 1 μΩ ~ 10 μΩ	x100 k – FSA 10 μΩ ~ 0.1mΩ	x100 k – FSA 0.1mΩ ~ 0.5mΩ	x10000 – 300A 0.5mΩ ~ 0.01Ω	x1000 – 30 A 1mΩ ~ 0.1Ω*
6622A Base, 6622- XR	± 14 μΩ/Ω	± 8 μΩ/Ω	± 5 μΩ/Ω	± 1.6 μΩ/Ω	± 0.8 μΩ/Ω	± 0.7 μΩ/Ω
6622A-XP, XPR. & HV Models	± 12 μΩ/Ω	± 6 μΩ/Ω	± 4 μΩ/Ω	± 1.2 μΩ/Ω	± 0.7 μΩ/Ω	± 0.6 μΩ/Ω

**Table 8-4 : Resistance Measurement Specification (All 6623A Models)**

