Operation Manual

For The

6622T Series

Automatic DCC Thermometry Bridges

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1. INTRODUCTION

1.1. SCOPE

This document describes the operation and maintenance of the 6622T Series of Automatic DCC Thermometry Bridges.

1.2. GENERAL DESCRIPTION

The 6622T 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 6622T with the software. Once the computer system is installed and connected to the IEEE-488 Interface of the 6622T Thermometry Bridge, full software control of the bridge is possible. The front panel controls and indicators of the 6622T 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.

6622T-B (Base model with measurement up to 100 kΩ)

6622T-XP (e**X**tended **P**recision model with measurement up to 100 kΩ, and higher accuracy)

The 6622T series bridges is installed with additional temperature functionality.

1.3. OVERVIEW

The 6622T 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 ppm. 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-based, 16 bit technology 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[1]. Remote access to the embedded microprocessor-controller, through a simple control language command set and GPIB communication interface allows the 6622T 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 6622T 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 Ω to 1 GΩ 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.

[1] 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 (Ix), set under control of the microprocessor, is passed through the variable turns of winding (Nx) of the comparator and through the unknown resistance (Rx). The isolated slave current (Is) is generated under microprocessor control, as a linear function of the number of turns (Nx) and is forced through the fixed slave windings (Ns) and the reference resistor (Rs). The currents (Is) and (Ix) flowing in the windings (Ns) and (Nx) respectively generate a net magnetic flux imbalance in the flux detector windings (Nd). This flux imbalance is proportional to the net ampere-turn error between the two windings [(Is) x (Ns)] and [(Ix) x (Nx)]. 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 (Is) to bring the (ampere-turn) error signal to zero. At balance, the ratio of the two currents (Ix and Is) flowing in the two windings is the same as the ratio of the turns set for each winding (Nx and Ns).

Complete electrical isolation between circuit currents is maintained throughout the 6622T 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 (Rx) and the reference resistance (Rs) and the nanovoltmeter detector provides the only connection between the two halves of the bridge. Power supply isolation techniques as recommended by Kibble[2] are used throughout to further isolate the bridge halves. The nanovolt detector is a high input impedance (>1 GΩ) 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 (Rs), the effective resistance potential imbalance and confirmation that ampere-turn balance is maintained, with the turns (Nx, Ns) and current (Ix, Is) settings, allows the unknown resistance value (Rx) to be calculated.

[2] Kibble, B.P. and Robinson, I.A., "An Isolated Mains Driven Power Supply", NPL Memorandum DES 54, September 1985.

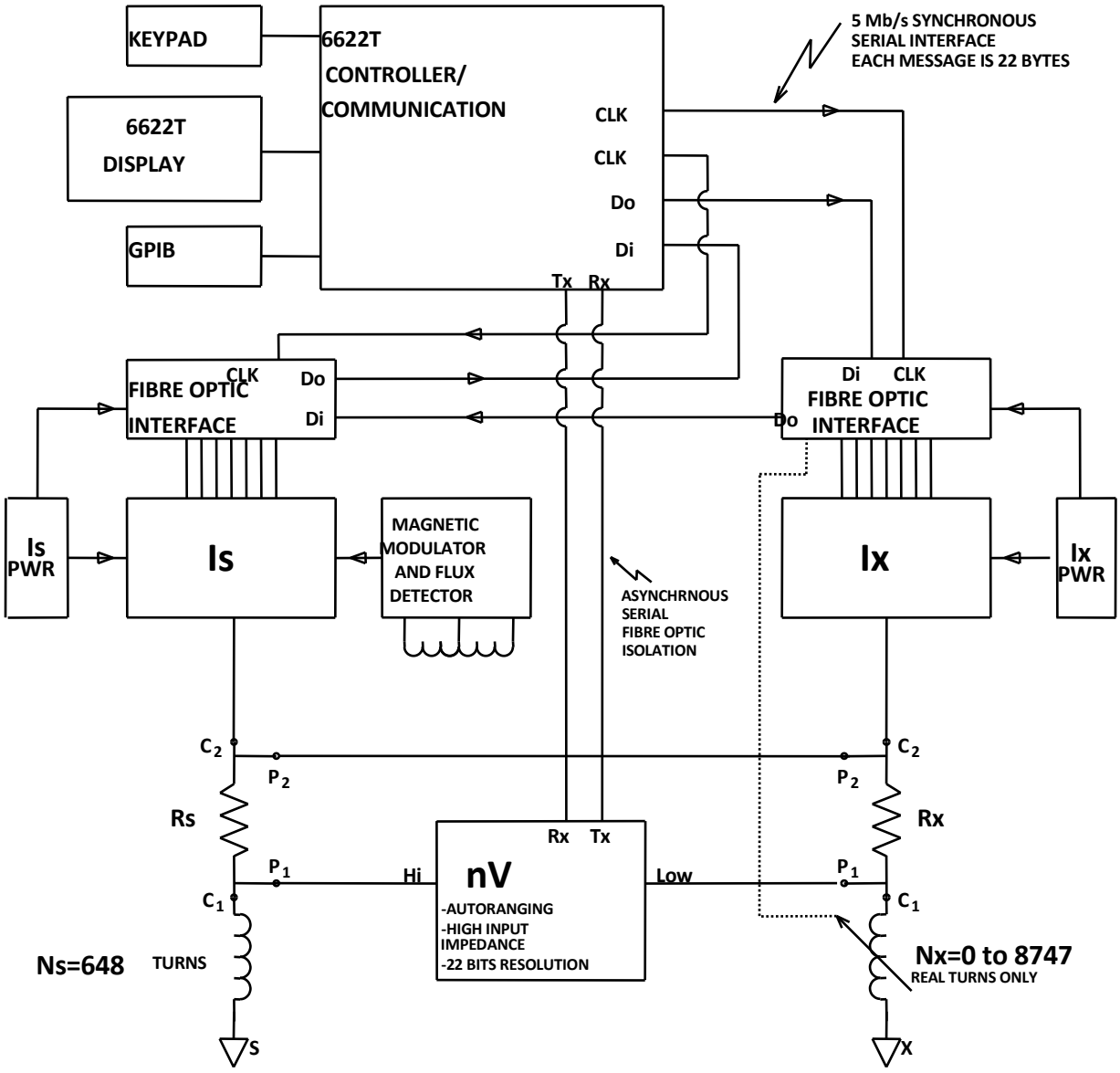


Figure 1-1 : Model 6622T Block Diagram

1.4.1.1. Low Ohm Measurement Mode

This mode can be used to make 4 terminal resistance measurements down to 0.1 μΩ against a 1 Ω. 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 mΩ ≤Rx≤ 100 kΩ. No external devices (except the two resistors) are required with the 6622T to make this measurement.

2. INSTALLATION

2.1. PRELIMINARIES

2.1.1. Unpacking

a. Remove the 6622T Automatic DCC Thermometry 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 (OM6622T)
   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 6622T Automatic DCC Thermometry 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 6622T 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, 6622T 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

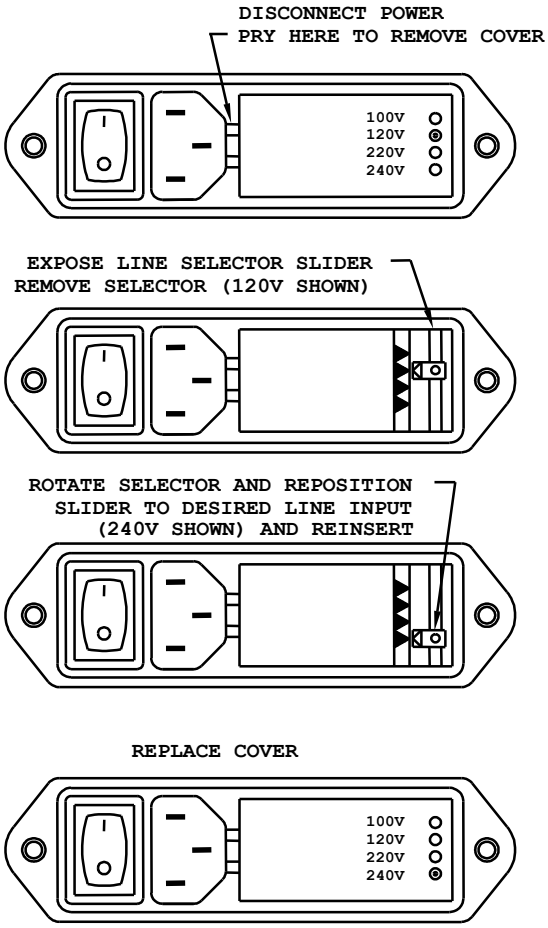


Figure 2-1 : Line Voltage Selector

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 6622T 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 6622T 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 kΩ 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 6622T Rx & Rs terminals as illustrated in figure 3-2

From the front panel of the model 6622T 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 6622T 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 kΩ 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 6622T'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. 6622T SERIES FRONT PANEL DISPLAY AND CONTROLS

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

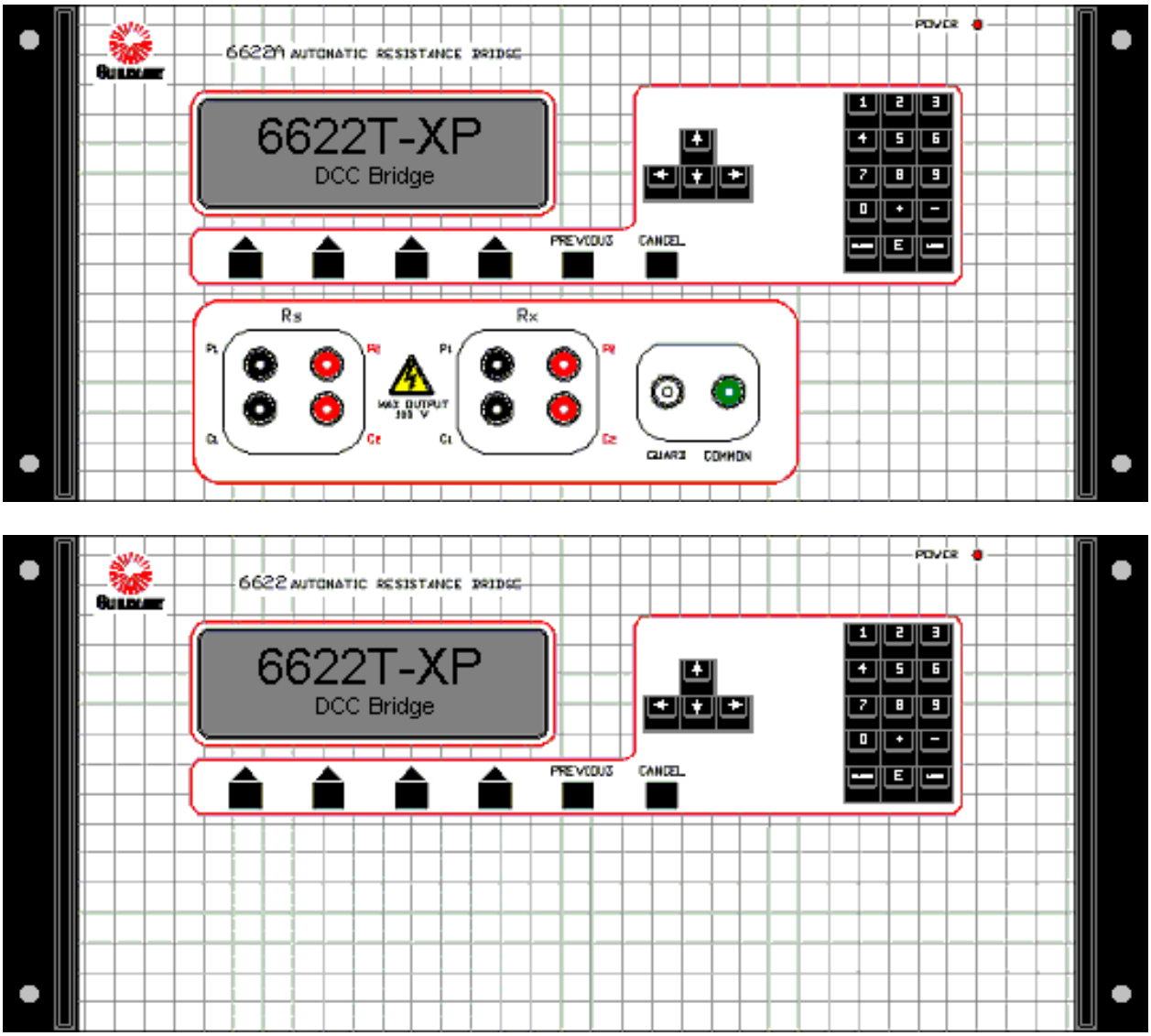


Figure 2-2 : 6622T Front View (Bench / Rack)

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 6622T. The active guard on the 6622T 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 6622T 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. 6622T SERIES REAR PANEL CONNECTORS AND CONTROLS

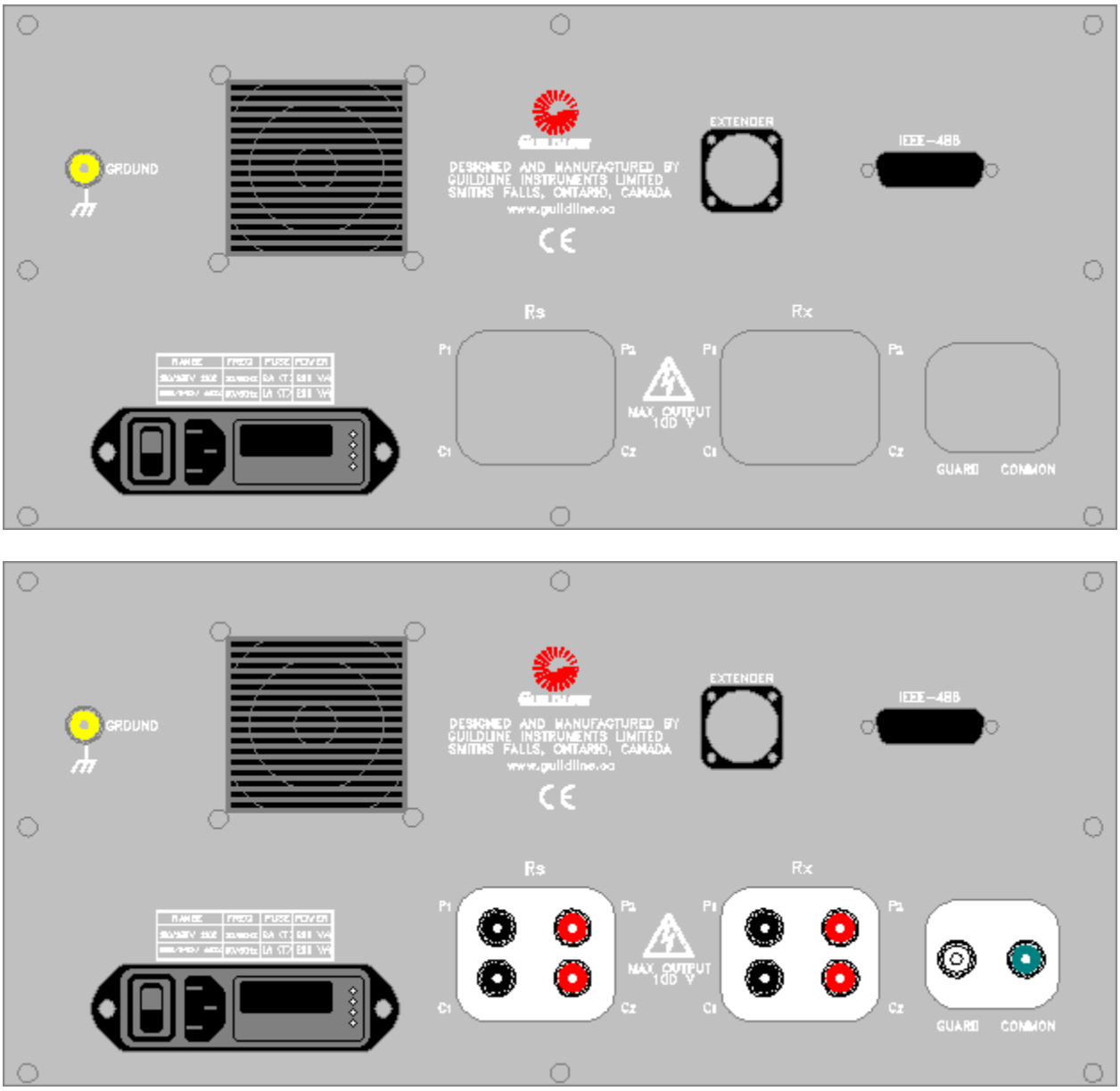


Figure 2-3 : 6622T Rear View (Bench / Rack)

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 6622T Series Automatic DCC Thermometry 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 the100/120 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 6622T. The active guard on the 6622T 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 6622T 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 6622T 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 6622T bridge. An operation guide for full automatic control of the 6622T 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.

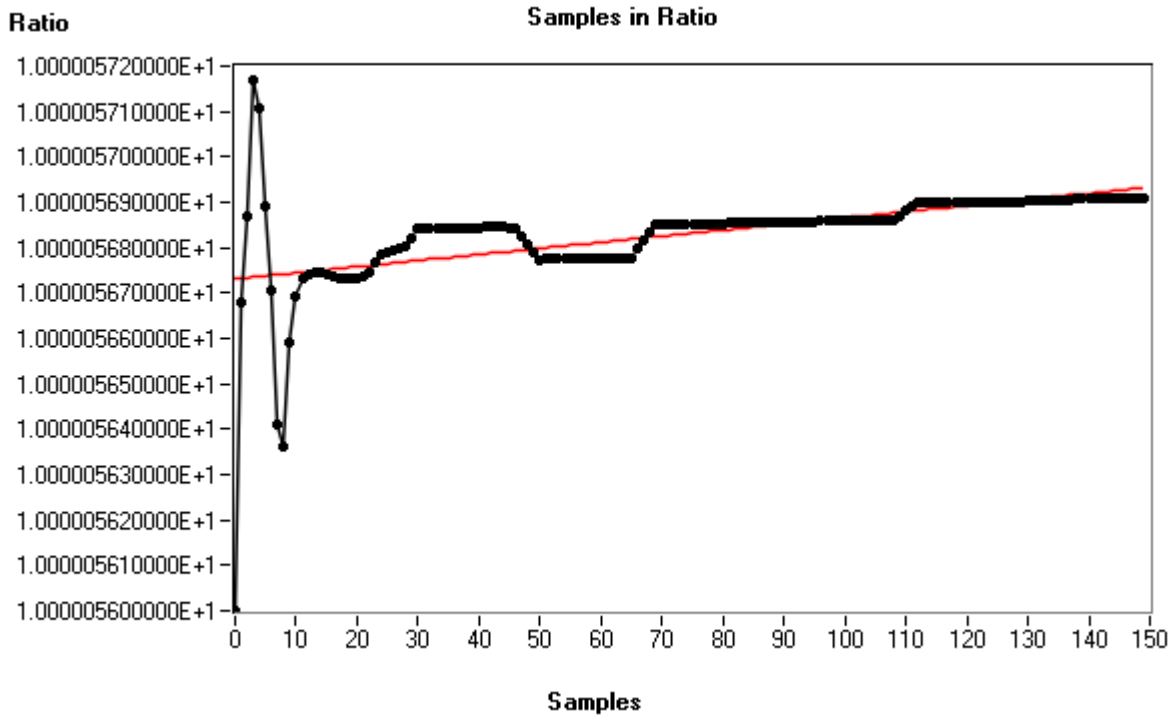


Figure 3-1 : Resistance Measurement Response Versus Test Sample

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 6622T Bridge.**

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

The 6622T 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.

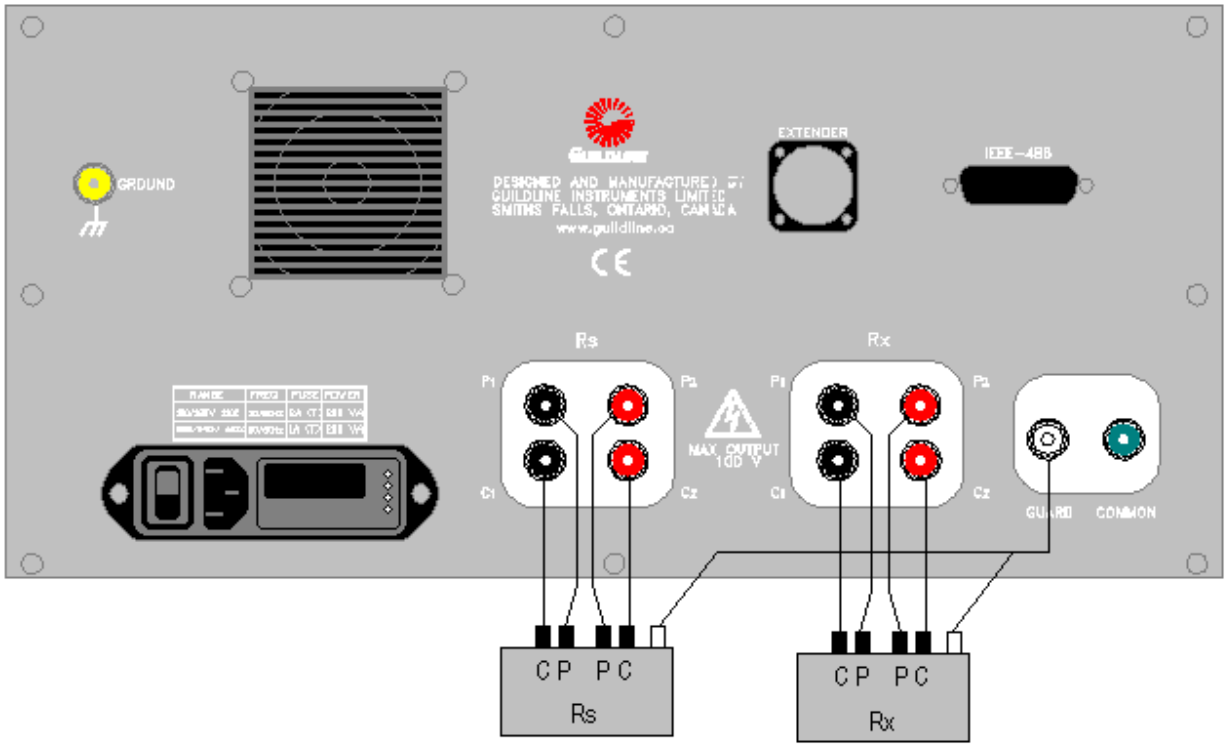


Figure 3-2 : Rear Panel Connections - Normal Ohm Mode

Step 1) Select the appropriate working standard resistor such that Rs:Rx 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 6622T 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:

Standard Resistor Current = Test Current x (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 6622T 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. (Ω)	U.U.T. (Ω)	Itest (mA)	Imax (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 6622T Models)

The 6622T 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 Ω reference is chosen.

Step 3) From the front panel of the model 6622T 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 6622T bridge and then the 'Meas Off ' sub-menu function key to start the measurement. The 6622T 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:

Standard Resistor Current = Test Current x (Rx/Rs)

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

$$Rs \geq \text{Ext. Ratio} \times Rx/2$$

Rs ≥ (Extender Ratio) x Rx

Ref. (Ω)	U.U.T. (Ω)	Itest (A)	Rs Current (mAmps)	Extender Ratio	Reversal Rate (sec)	Comment (1)
1	0.1	0.316	31.6	10:1	60	1 W test in Rx
1	0.01	10	100	100:1	60	1 W test in Rx
1	0.001	31.6	31.6	1000:1	60	1 W test in Rx
1	0.0001	100	100	1000:1	60	1 W test in Rx
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. (Ω)	U.U.T. (Ω)	Itest (A)	Rs 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 Rs
1	0.1	1	100	20:1 / 3A	60	Limit of 10 mW in Rs
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 Rs
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 Rs
100	0.1	10	10	200:1 / 15A	60	Limit of 10 mW in Rs
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 Rs
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.

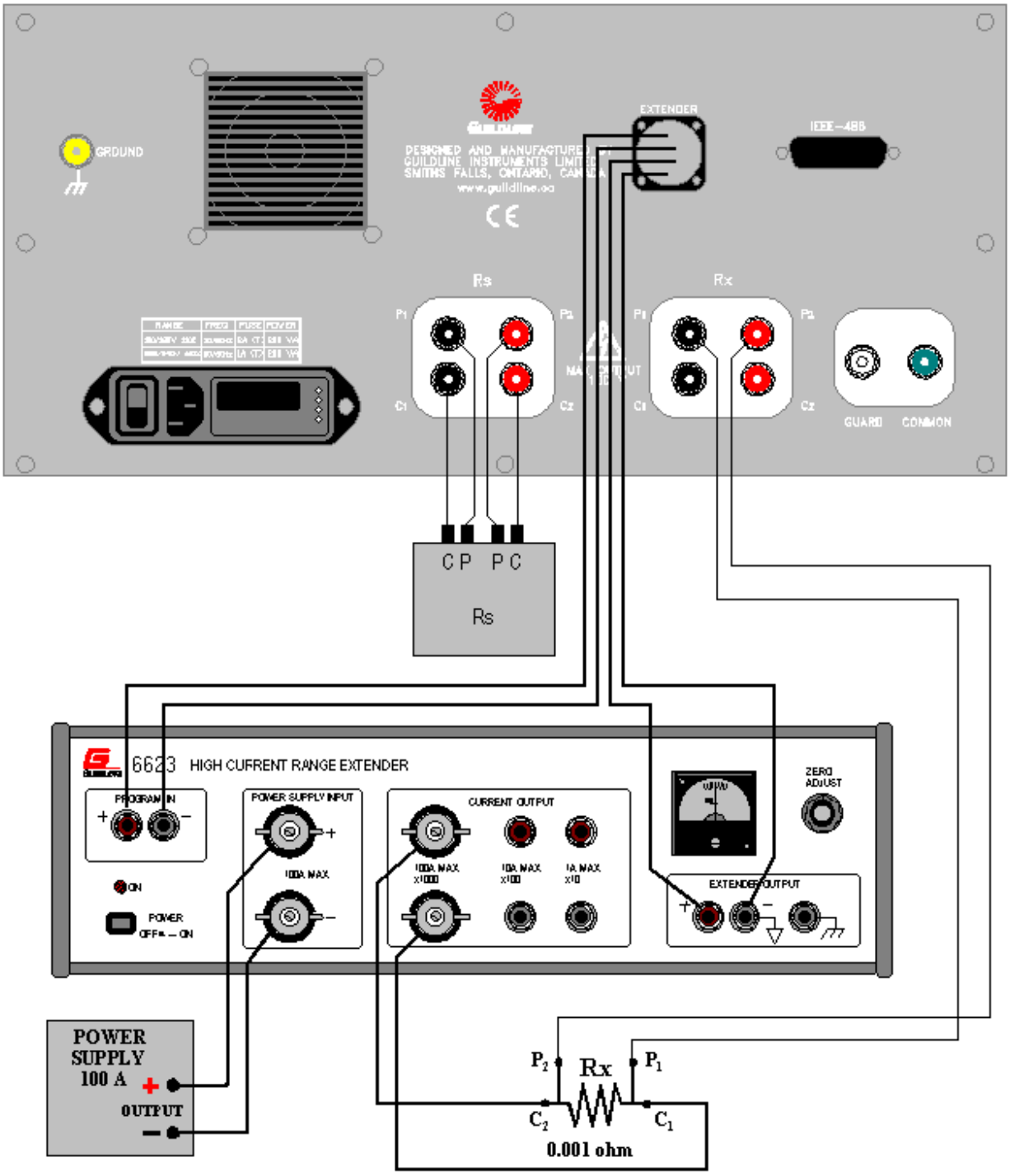


Figure 3-3 : Rear Panel Connections – Low Ohm Mode with 6623

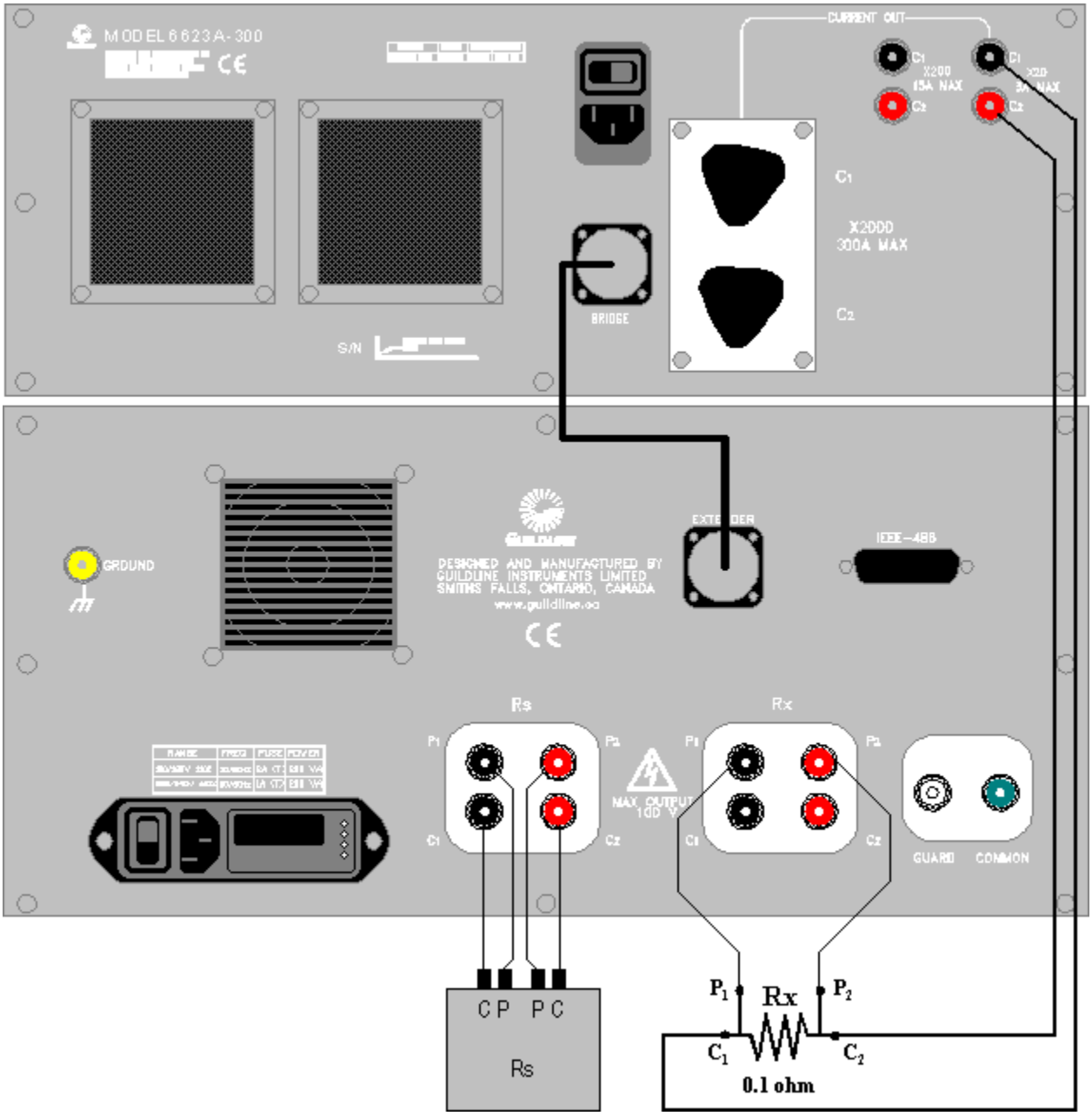


Figure 3-4 : Rear Panel Connections – Low Ohm Mode with 6623A-300

3.1.3. Thermometry Measurement Mode

The model 6622T in its Thermometry Measurement Mode is similar to Normal Ohm mode but is enables measurement of PRT and SPRT probes in the range of 1m ohm to 100k ohms. The following steps outline the general procedure for making Normal Ohm measurements. Figure 3-4 shows a typical rear panel connection for this measurement mode. The setup is the same as for the Normal mode described in the 6622T Operator's Manual OM6622T, except select the 'Probe' mode is enabled and the subsequent 'ITS-90', 'IPTS-68', or 'IEC-751' selection is made in step 4,

Ref. (Ω)	P.R.T. (Ω)	Itest (2) (mAmps)	Imax (mAmps)	Reversal Rate (sec)	Comment (1) Update 2 / Quick Measure
1	25	2 – 4	100	20	Limited by 10mW max in standard
1	100	1	100	20	Limited by 10mW max in standard
10	25	2 – 6.32	31.6	20	
10	100	1 – 3.16	31.6	20	
100	100	1 – 3.16	10	20	

Table 3-4 : Recommended Temperature Measurement Test Setup

NOTE: 1. It is recommended to use the "Quick" mode of operation for the model 6622T when making temperature measurements to remove all digital filtering and improve measurement latency. Also using "Update Mode 2" sets the sample timing to match the reversal rate. These settings are best suited for high speed, unfiltered data as required for most temperature applications.

2. Itest is based on a 100uW to 1mW power dissipation in the PRT at the triple point of water and maintaining less than 10mW in the standard.

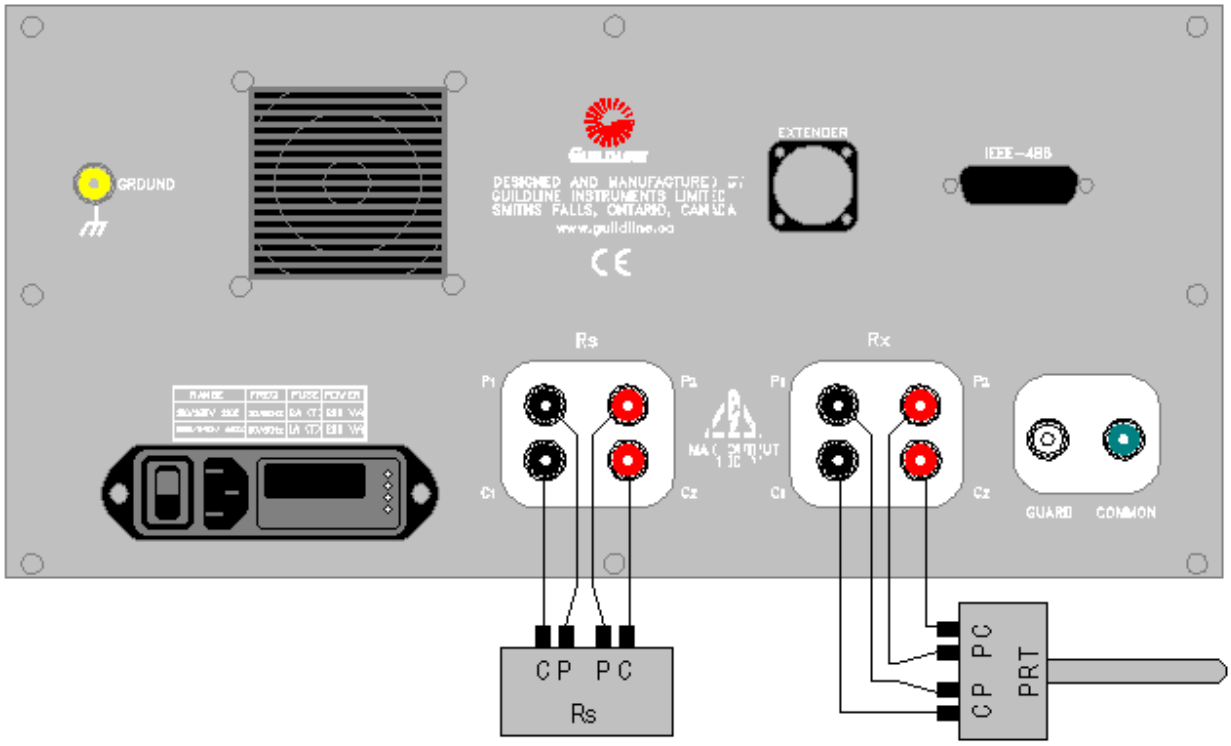


Figure 3-5 : Rear Panel Connections – PRT/SPRT

3.2. BRIDGEWORKS DATA ACQUISITION SOFTWARE

The BridgeWorks Data Acquisition Software is the control software for the 6622T Series Automatic DCC Thermometry Bridges. Using the 6622T 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 6622T Series bridges and software control will create a fully automated Resistance Measurement System. Before using the 6622T 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 6622T, 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 6622T 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 6622T Automatic DCC Thermometry Bridge via its computer system.

4.2. 6622T THERMOMETRY MEASUREMENT BRIDGE

The front panel of the 6622T 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 6622T bridge menu tree.

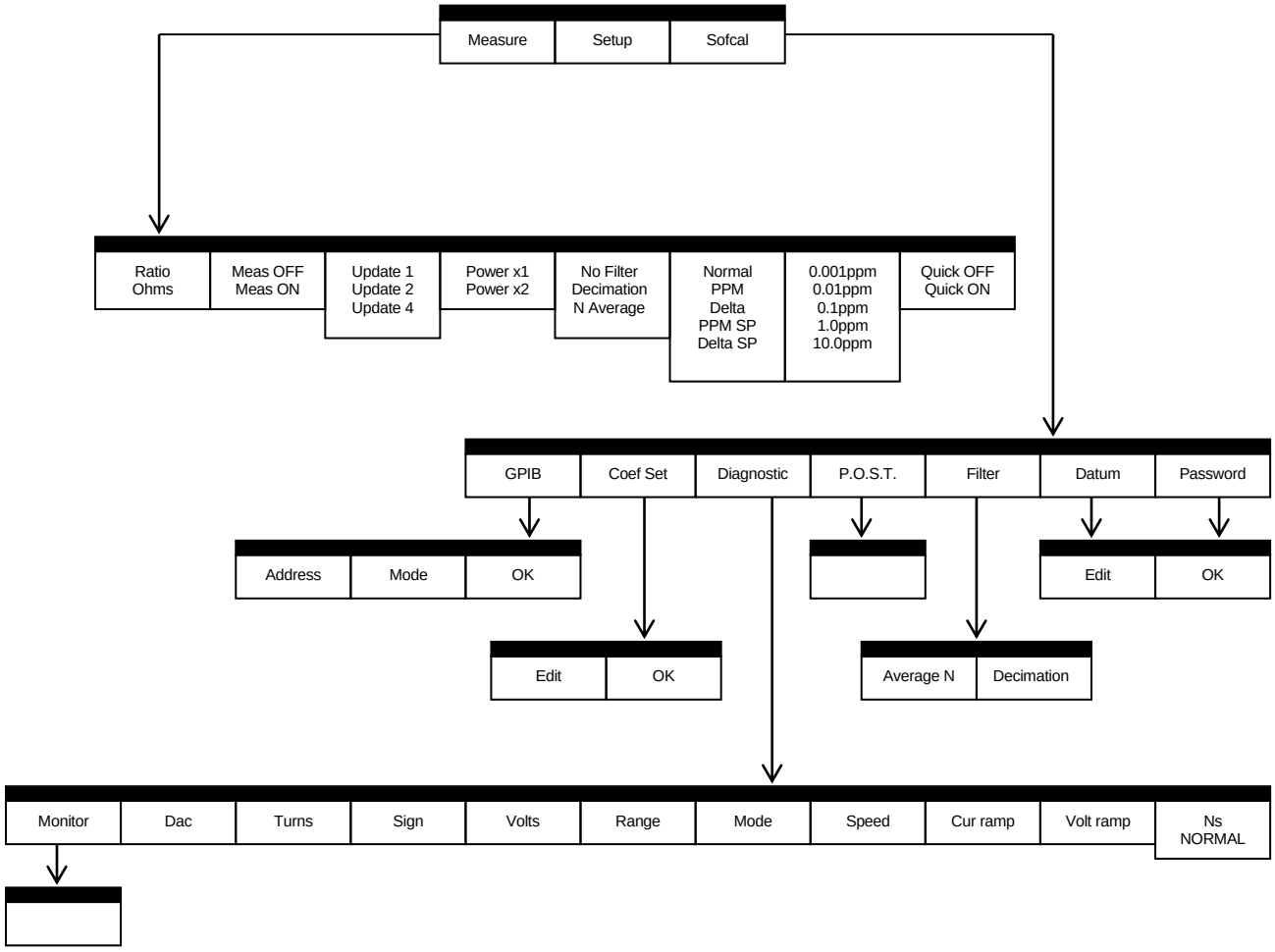


Figure 4-1 : Menu Tree – MEASURE/SOFCAL

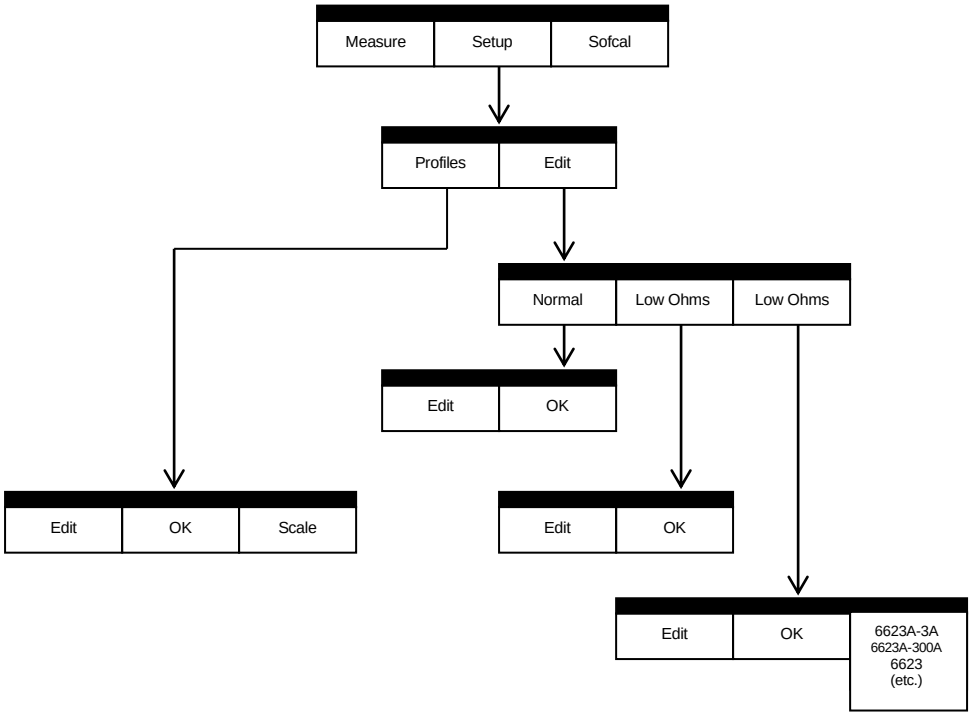


Figure 4-2 : Menu Tree – SETUP (Resistor)

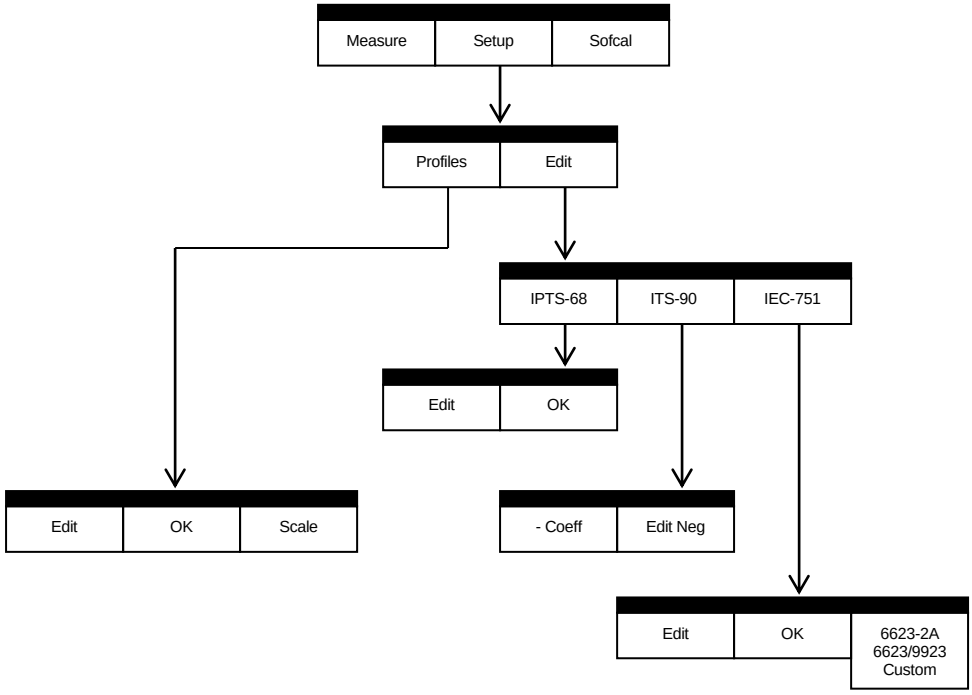


Figure 4-3 : Menu Tree – SETUP (Probe)

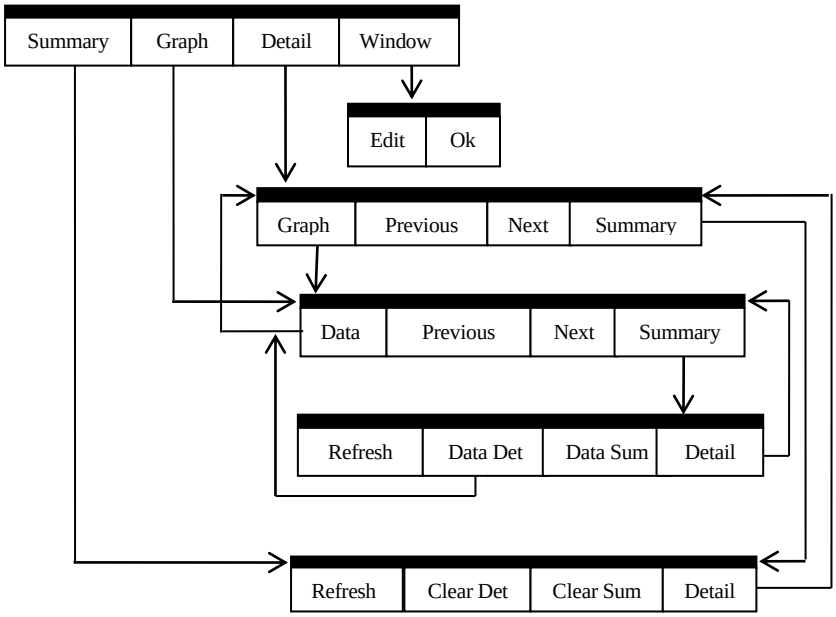
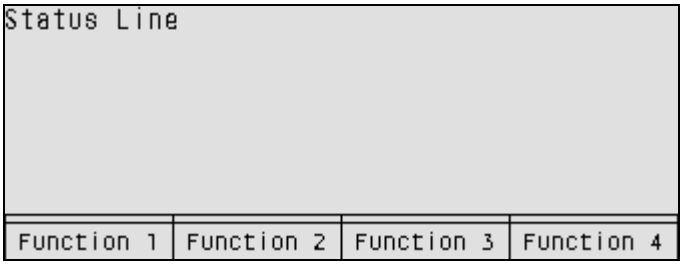


Figure 4-4 : Menu Tree – MEASURE-VIEW

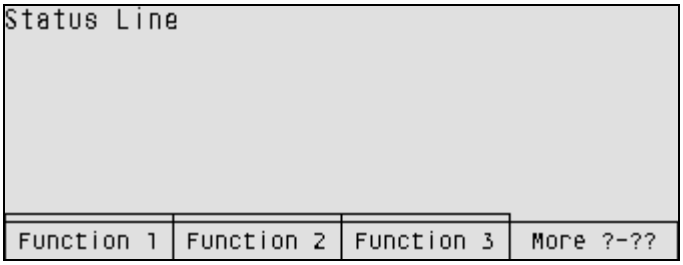
4.3. GENERAL KEY/DISPLAY OPERATIONS

4.3.1. Base menu

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



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.



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

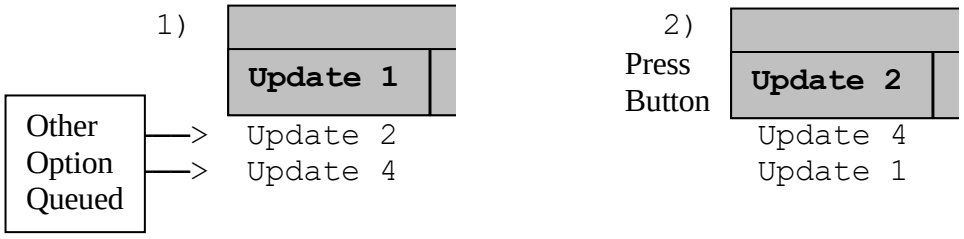
N represents the total number of available menu pages
n represents the current menu page

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.

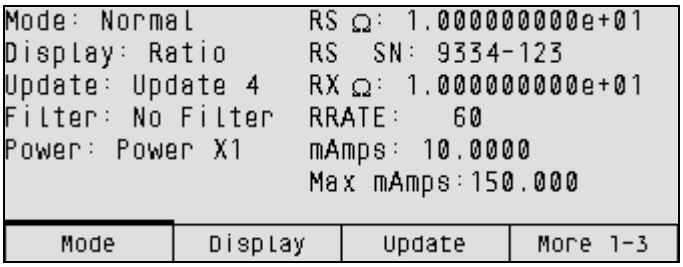
To return to the previous menu, (go up one menu level), press the <PREVIOUS> key that is located to the right of the screen.

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

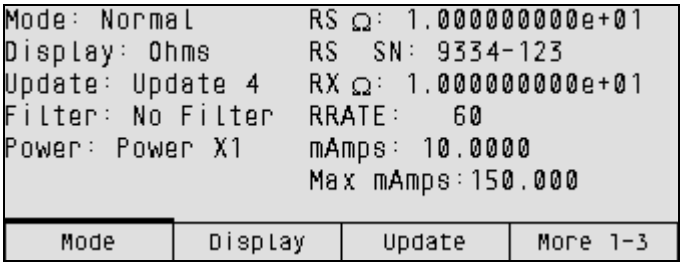
4.4.2. Menu Option - <any other menu but measure>

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



Example continued: Screen after pressing function key <Display>

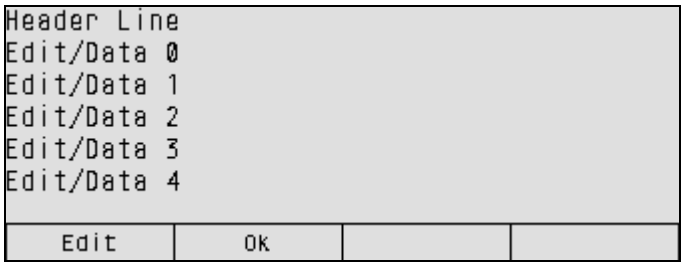


The alternate value "Ohms", associated with the function key <Display>, is toggled into the active screen area to replace the previous value "Ratio".

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.

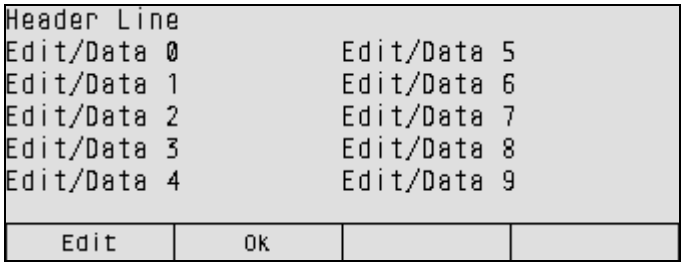
4.4.3. Base Edit/Select Menu - one column of data

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.



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.)



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.

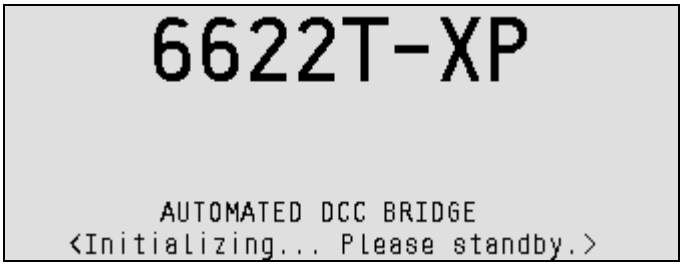
4.4.5.3. Function - <Ok>

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 6622T will start its internal power on self-test programming and display its opening banner. This banner will outline the 6622T's model configuration and the installed options. (i.e. -B, -XP, XPS, -XR, -XPR, -HV)

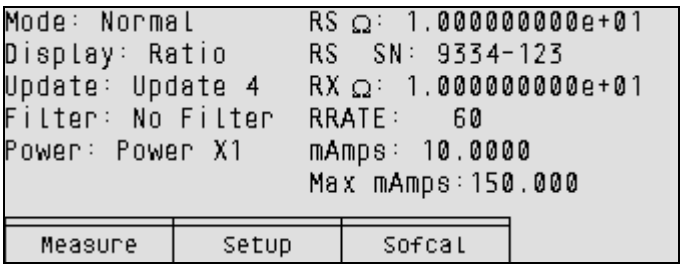


The REMOTE DISPLAY screen will appear only when the 6622T has been addressed by a remote communication device on the GPIB .



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



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

On power up the 6622T 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:

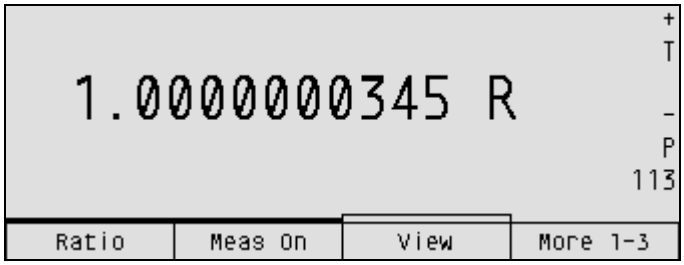
1. When entering another measurement mode using the <Setup> <Mode> menu.
   For example, when currently measuring a pair of NORMAL OHM resistors and then selecting LOW OHMS mode, the measurement cycle will be terminated and the 6622T will enter the <Measure off> mode.

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 6622T 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).

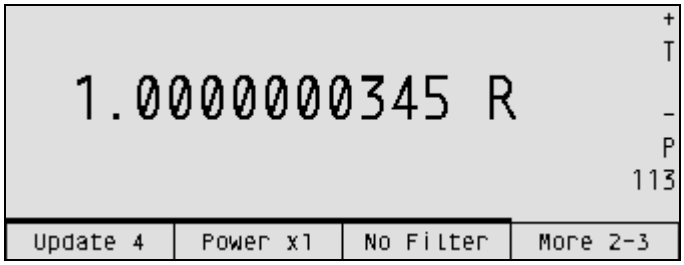
Function key <Fn-1> toggles through the set of available measurement units for the displayed result; the displayed result can have units of <Ratio> or <Ohms>. The active engineering units will be displayed in the <Fn-1> function key descriptor position.

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).

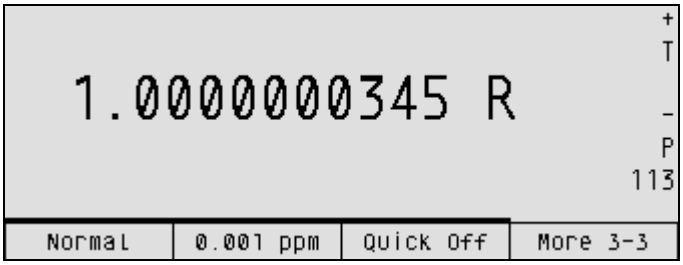
Function key <Fn-1> selects the screen measurement update rate as a function of the test current reversal rate. <Update 1> sets a screen update rate at twice the test current reversal rate; <Update 2> sets a screen update rate at the test current reversal rate; <Update 4> sets a screen update rate at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

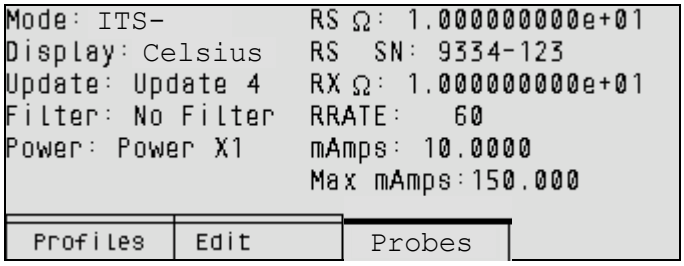
Function key <Fn-2> sets the display resolution in ppm of range. This affects Normal, Delta and Delta SP display modes only.

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.

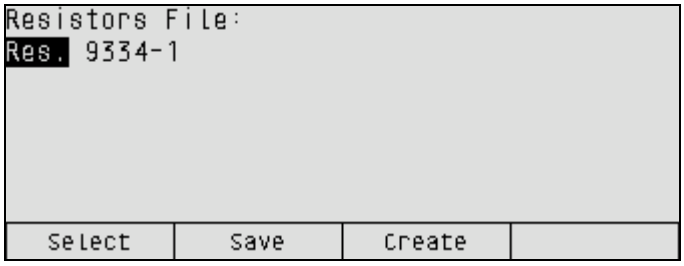
4.6.2. <Setup> MENU Fn-1 (Setup_MAIN)



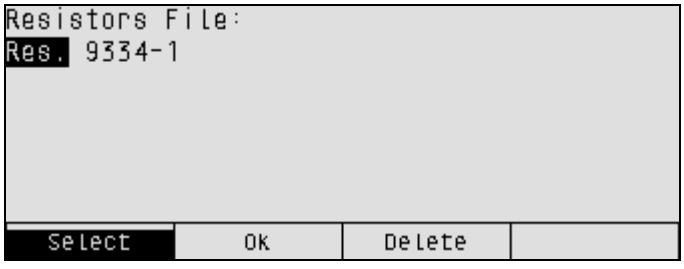
Function key <Fn-3>, <Probes>, allows you to toggle between "Resistors" and "Probes".

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

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



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

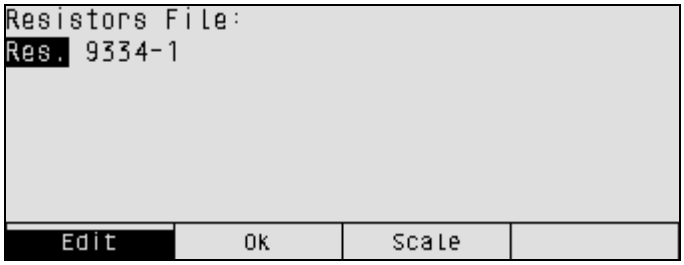


Function key <Fn-2>, <Ok>, selects the highlighted profile.

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.

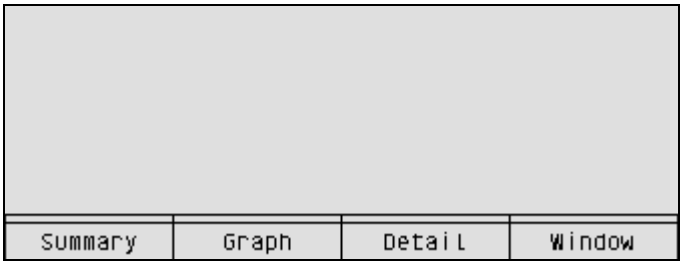


Function key <Fn-2>, <Ok>, creates a new profile with the name as entered in the text.

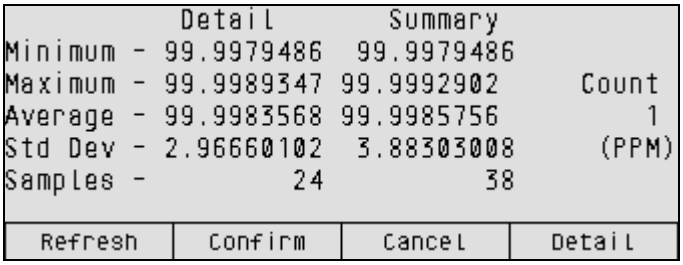
Function key <Fn-3>, <Scale>, allows insertion of special text for defining the resistor value. It toggles between m Ohms, Ohms, k Ohms, M Ohms.

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



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

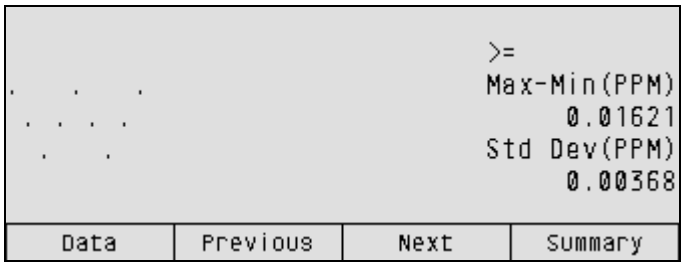
<Refresh> updates the detail and summary values.

<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.

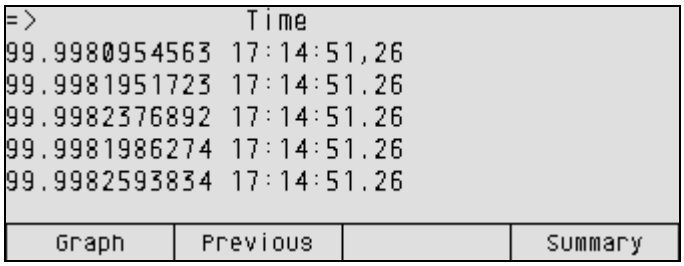
The Up arrow scrolls the trace buffer left by Up/Down Arrow Scroll Size.

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



<Graph> switches to the graph display.

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

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

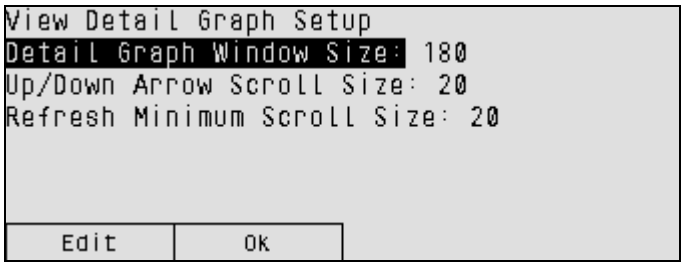
The Up arrow scrolls the trace buffer up by one (1) entry.

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



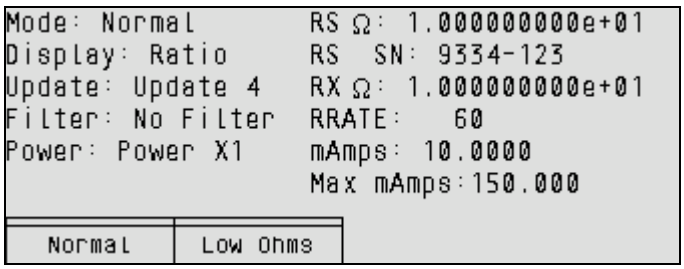
Detail Graph Window Size is the number of trace entries to display on the graph.

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)



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

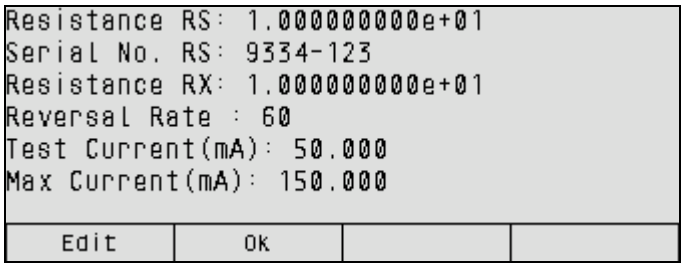
Function key <Fn-2>, <High Ohms>, will select the High Ohms measurement mode of operation.

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.



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:

[Test Current X (Rx/Rs)] >Max Current

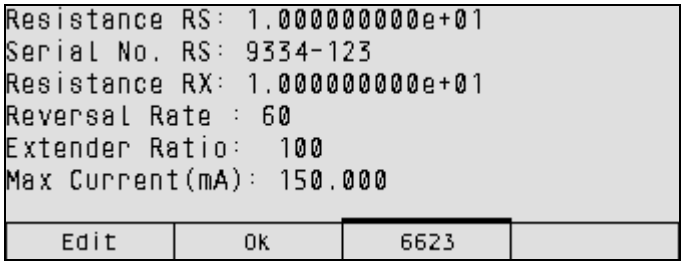
is satisfied, then the test is terminated, and an error message is displayed.

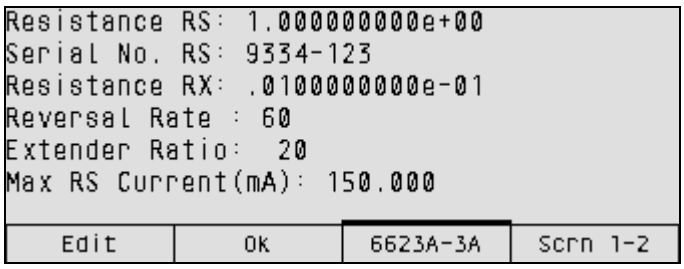
The Max Current is the maximum current that can be carried by the STANDARD RESISTOR (Rs).
Note that the highest Test Current value and Max Current value is 150 mA.

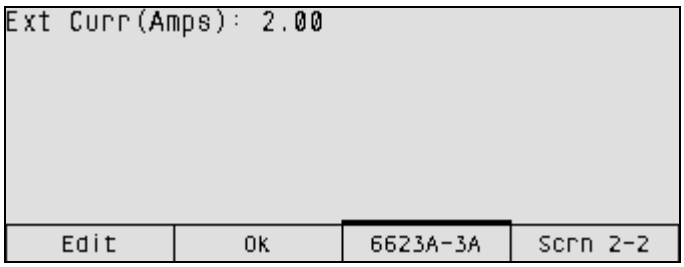
The reported ratio is (Rx/Rs).

4.6.5.2. <Low Ohms> MENU Fn-3 (Edit Ohms_MAIN)

Enter range extender configuration data.







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 Amps 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 mAmps.

If the condition:

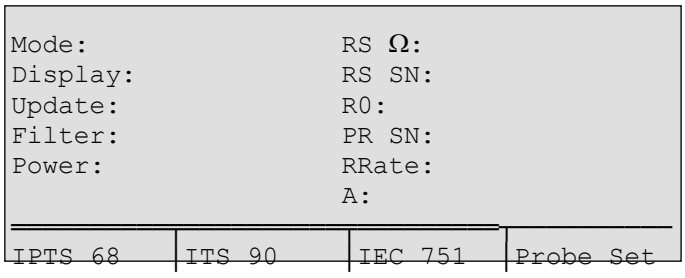
[Test Current X (Rx/Rs)] > Max Current

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. <Edit> MENU (Probe) Fn-2 (Edit MAIN)

The <Edit> menu will either be identical to the standard menu seen in the 6622T Series bridge, or be as described below dependent on the selection of the Resistors/Probes mode toggle key in the <Setup> menu.



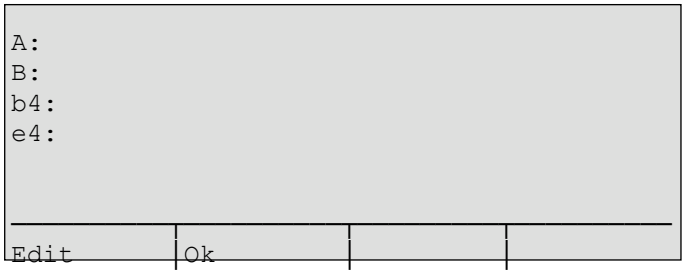
Function Key <Fn-1> ,<IPTS 68>, allows entry to the IPTS-68 measurement menu and enables the IPTS-68 coefficients for the probe to be viewed and or edited.

Function Key <Fn-2> ,<ITS 90>, allows entry to the ITS-90 measurement menu and enables the ITS-90 coefficients for the probe to be viewed and or edited.

Function Key <Fn-3> ,<IEC 751>, allows entry to the IEC-751 measurement menu and enables the IEC-751 coefficients for the probe to be viewed and or edited.

Function Key <Fn-4> ,<Probe Set>, allows entry to the Probe set menu and enables the test values for the probe to be viewed and or edited.

4.6.6.1. <IPTS 68> MENU Fn-1 (Edit MAIN)

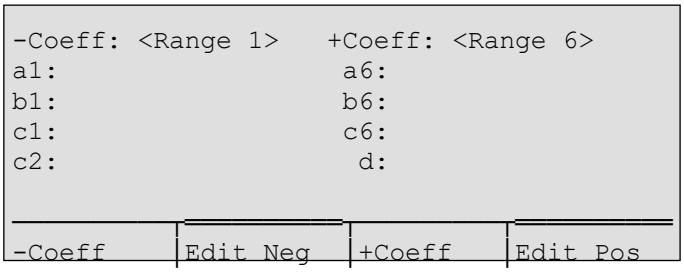


Press <Edit> and use arrow keys to move the highlight to the data line to be changed. Modify data and press <Ok>.

When <Edit> is pressed the PASSWORD CHECK display menu is activated.

Before the selected coefficient can be changed the correct password must be entered. If an incorrect password is entered, the error message "Invalid Password" will be displayed and the edit session will be terminated.

4.6.6.2. <ITS 90> MENU Fn-2 (Edit MAIN)



Function Key <Fn-1> ,<-Coeff>, selects from the ITS90 set of temperature ranges:

<Range 1> := <13.8 K to 273.16 K> : screen display '-259C to 0C'
<Range 2> := <24.5 K to 273.16 K> : screen display '-279C to 0C'
<Range 3> := <54.4 K to 273.16 K> : screen display '-219C to 0C'
<Range 4> := <83.8 K to 273.16 K> : screen display '-189C to 0C'
<Range 5> := <234.3 K to 302.91 K> : screen display '-39C to 30C'

When <Range 5> is selected for <-Coeff> the menu options <+Coeff> and <Edit Pos> are removed from the display screen along with the display of "+Coeff" values.

Function key <Fn-3>, <-Coeff>, selects from the ITS90 set of temperature ranges:

<Range 6> := <273.15 K to 1234.93 K> : screen display '0C to 962C'
<Range 7> := <273.15 K to 933.47 K> : screen display '0C to 660C'
<Range 8> := <273.15 K to 692.68 K> : screen display '0C to 420C'
<Range 9> := <273.15 K to 505.08 K> : screen display '0C to 232C'
<Range 10> := <273.15 K to 429.75 K> : screen display '0C to 157C'
<Range 11> := <273.15 K to 302.91 K> : screen display '0C to 30C'

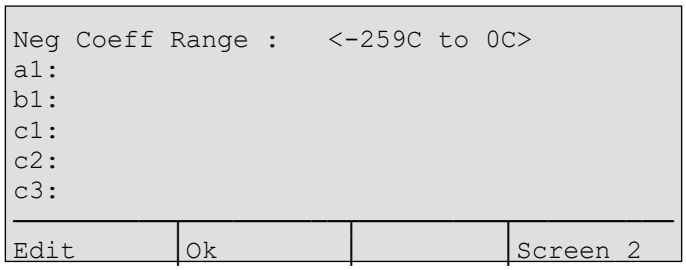
Function Key <Fn-2> ,<Edit Neg>, allows selection of the edit menu to enter and view the ITS90 probe (negative degree Celsius) temperature coefficients.
Function Key <Fn-4> ,<Edit Pos>, allows selection of the edit menu to enter and view the ITS90 probe (positive degree Celsius) temperature coefficients.

When either the <Edit Neg> or <Edit Pos> key is pressed the **PASSWORD CHECK** display menu is activated.

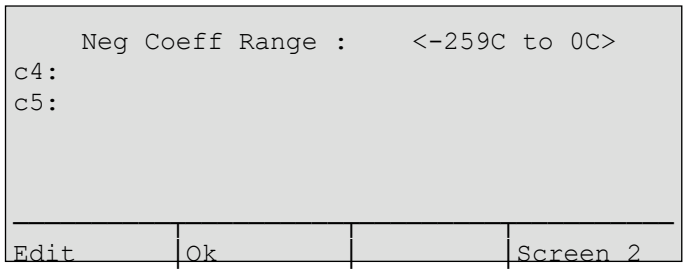
Before the selected set of coefficients can be changed the correct password must be entered.

If an incorrect password is entered, the error message "Invalid Password" will be displayed and the edit session will be terminated.

4.6.6.2.1. <Edit Neg> MENU Fn-2 (ITS90 Edit MAIN)

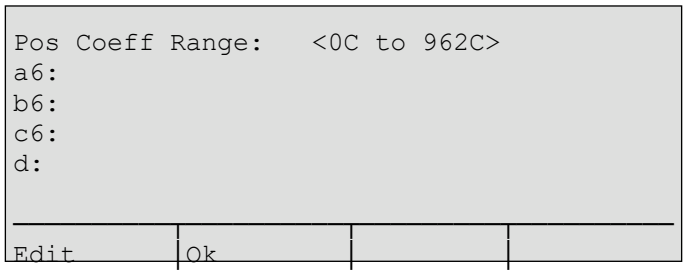


Press <Edit> and use arrow keys to move the highlight to the data line to be changed. Modify data and press <Ok>.



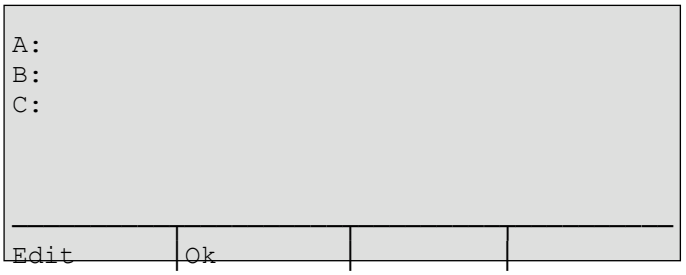
Press <Edit> and use arrow keys to move the highlight to the data line to be changed. Modify data and press <Ok>.

4.6.6.2.2. < Edit Pos> MENU Fn-4 (ITS90 Edit MAIN)



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

4.6.6.3. <IEC 751> MENU Fn-3 (Edit MAIN)

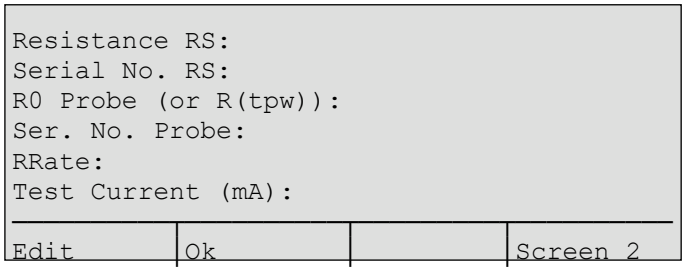


Press <Edit> and use arrow keys to move the highlight to the data line to be changed. Modify data and press <Ok>.

When <Edit> is pressed the PASSWORD CHECK display menu is activated.

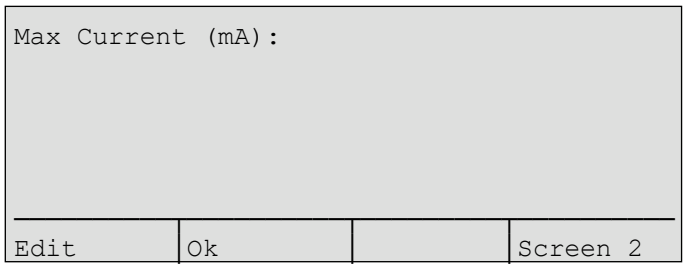
Before the selected coefficient can be changed the correct password must be entered. If an incorrect password is entered, the error message "Invalid Password" will be displayed and the edit session will be terminated.

4.6.6.4. <Probe Set> MENU Fn-4 (Edit MAIN)



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

A resistance value >0 for the ice point resistance (R0) or triple point of water resistance (Rtpw), MUST be entered for the probe before a measurement can take place.



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

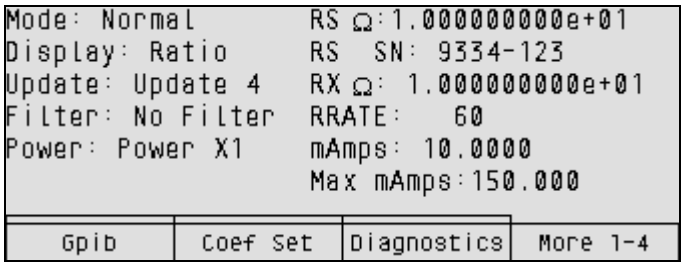
4.6.7. <Sofcal> MENU Fn-3 (MAIN)

The menu options available through this function allow configuration setup and general modes of operation of the 6622T. 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 6622T bridge.

Sofcal menu page 1 of 4.

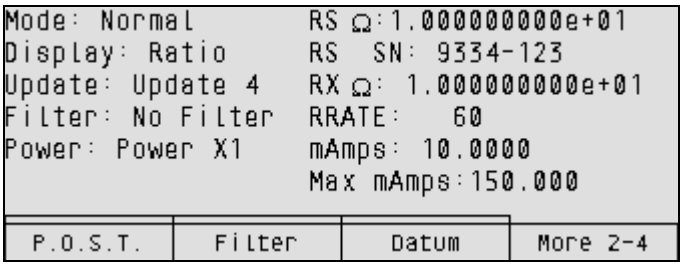


Function Key <Fn-1>, <GPIB>, allows selection of the device GPIB parameters including address and mode.

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 6622T.

Sofcal menu selection menu page 2 of 4.

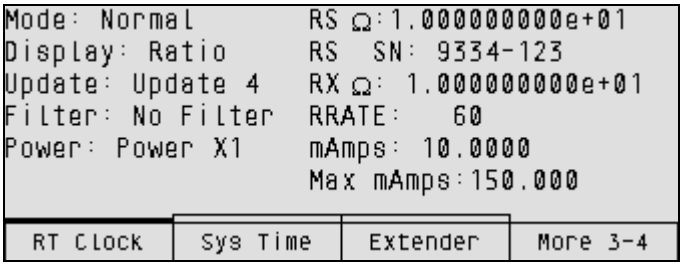


Function Key <Fn-1>, <P.O.S.T.>, displays the result of the power on self test and the revision level of the installed software.

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.

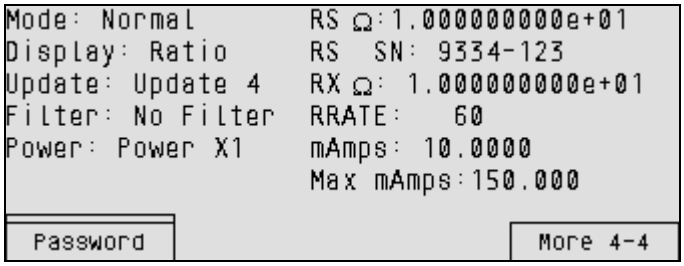


Function key <Fn-3> toggles the trace time mode <RT Clock> and <Relative>.

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

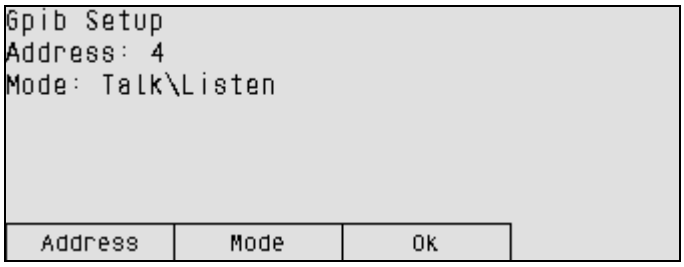
Function Key <Fn-3>, <Extender>, allows creation and editing of low ohms extenders.

Sofcal menu selection menu page 4 of 4.



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

4.6.7.1. <GPIB>MENU Fn-1 (Sofcal_MAIN)

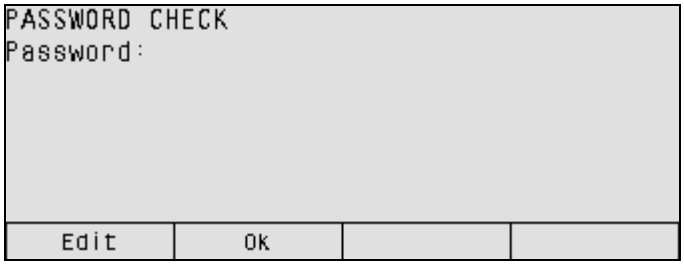


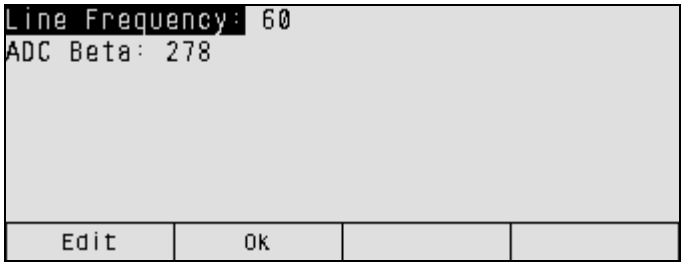
<Address> function key Fn-1 sets the GPIB address.
<Mode> function key Fn-2 selects from the options <Talk/Listen>, <Talk Only>, <Disabled>.

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

4.6.7.2. <Coef Set> MENU Fn-2 (Sofcal_MAIN)

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



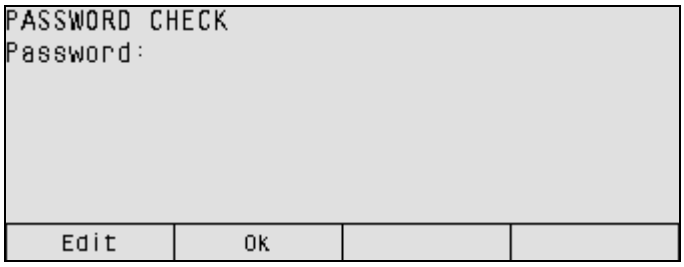


Line Frequency is either 60 Hz or 50 Hz.

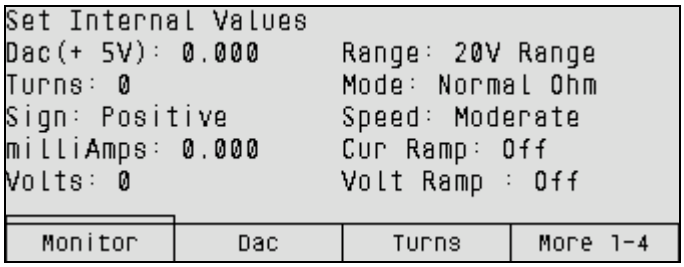
ADC Beta must be between 225 and 330. This is a factory setting.

4.6.7.3. <Diagnostic> MENU Fn-3 (Sofcal_MAIN)

To enter the Diagnostics window a password must be supplied.



Diagnostic menu selection page 1 of 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.

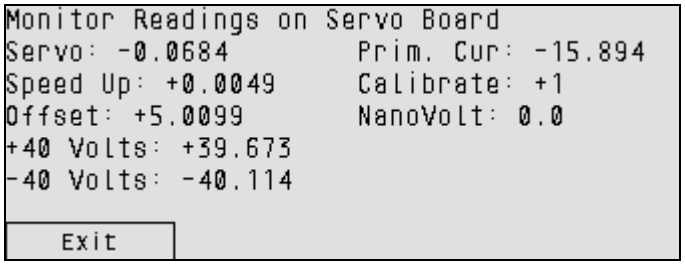
Function Key <Fn-2>, <Dac> selects the values for a 12-bit digital to analog converter on the servo card assembly.

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.

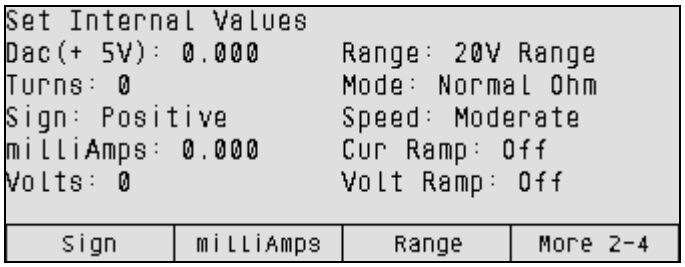
4.6.7.3.1. <Monitor> MENU Fn-1 (Diagnostic_Sofcal_MAIN)

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



4.6.7.3.2. <Diagnostic> MENU Fn-1 (Sofcal_MAIN)

Diagnostic menu selection page 2 of 4.



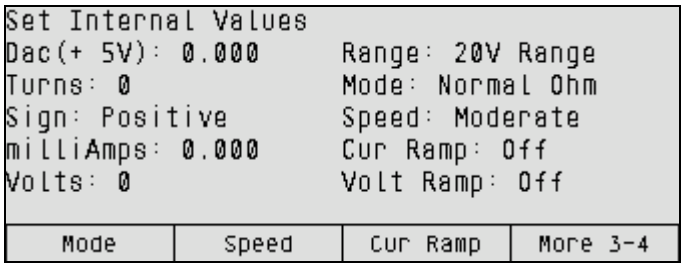
Function key <Fn-1>, <Sign> enables sets the direction of current flow and the polarity of the voltage outputs.

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.

Function key <Fn-3>, <Range> selects the measurement voltage range for the built-in voltmeter from: <20V>, <2V>, <200mV>, <20mV>, <2mV>.

Diagnostic menu selection page 3 of 4.

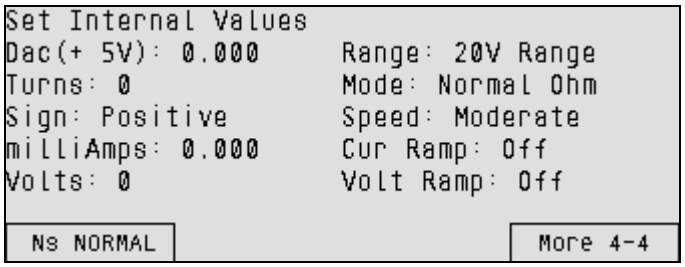


Function key <Fn-1>, <Mode> sets the measurement mode from the choice of <Normal> and <Low>.

Function key <Fn-2>, <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.

Function key <Fn-3>, 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.

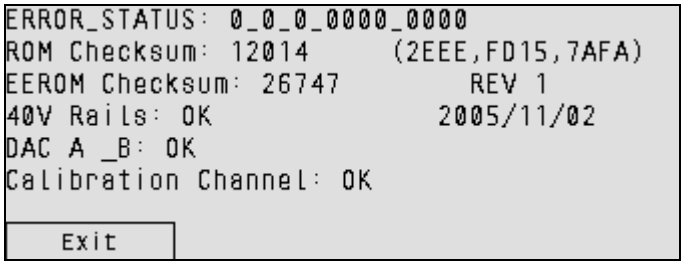
Diagnostic menu selection page 4 of 4.



Function key <Fn-1>, 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 6622T. Pressing key <Fn-3> will update the state of the 6622T.

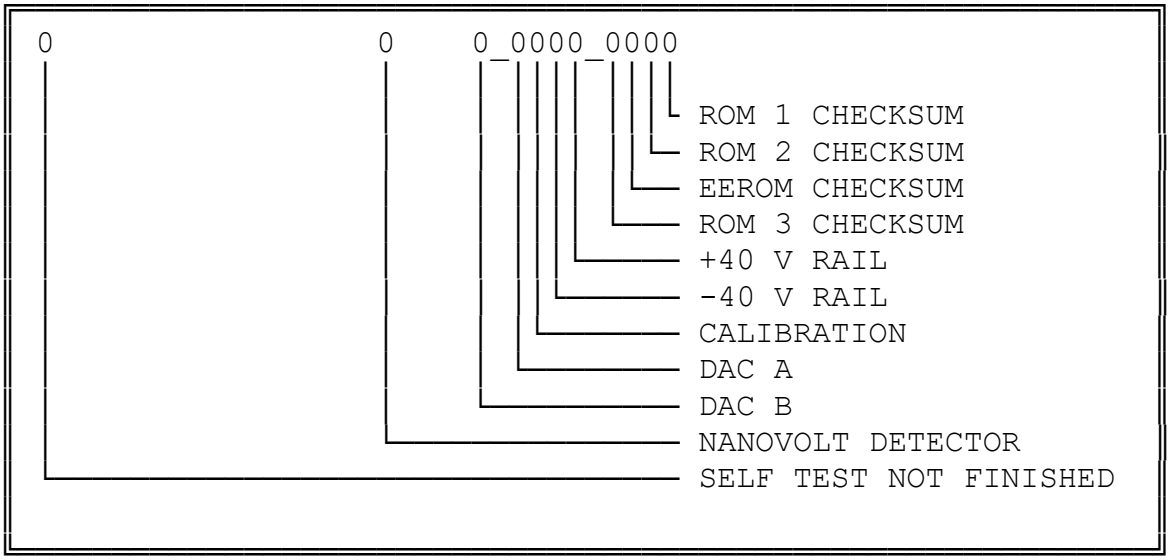
4.6.7.4. <P.O.S.T.> MENU Fn-1 (Sofcal_MAIN)

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



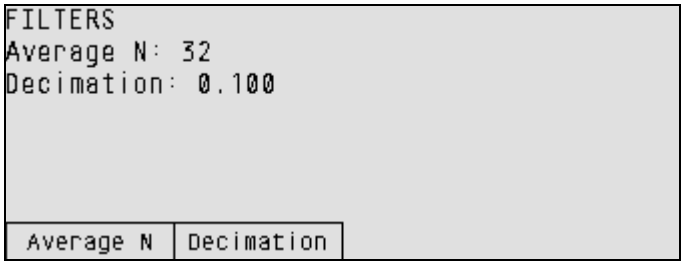
NOTE:
A restricted access password system has been implemented for certain Sofcal functions. If the password is changed it can be reset to the factory default password by entering this menu and pressing in order: Left Arrow, Right Arrow, Up Arrow, Down Arrow.

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.

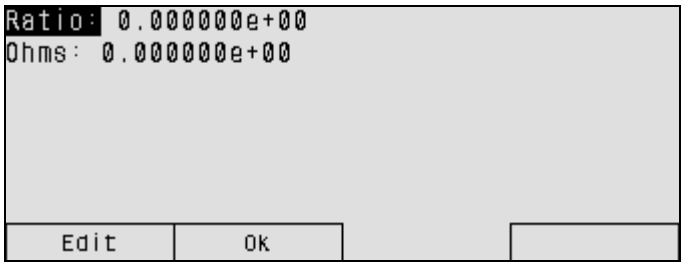
4.6.7.5. <Filter> MENU Fn-2 (Sofcal_MAIN)



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>.

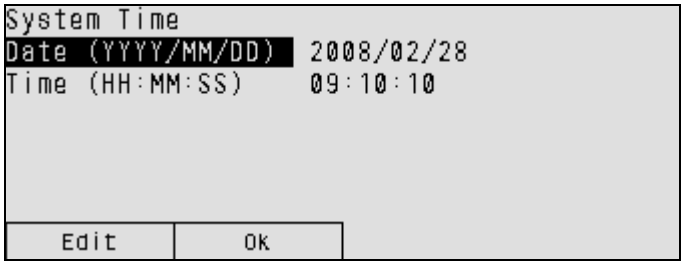
4.6.7.6. <Datum> MENU Fn-3 (Sofcal_MAIN)



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

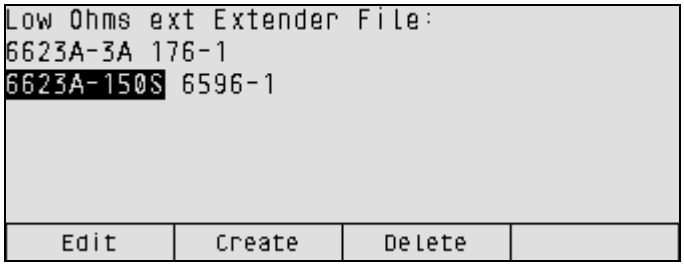
The datum function is applied to the <Measure> menu.

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



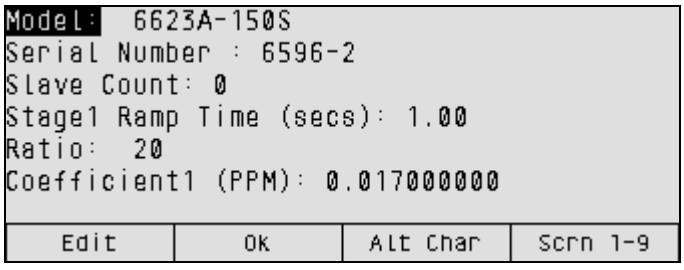
This allows the updating of the system date and time. The time is entered in 24 hour format.

4.6.7.8. <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.

4.6.7.8.1. Extender



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.

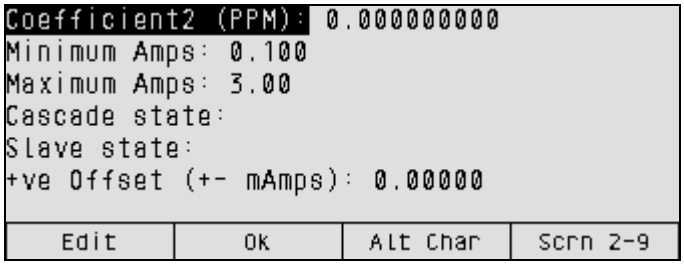
<Alt Char> allows the insertion of <A>, <B>, <C>, and <S> into the text.

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 6622T 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 ± PPM and is used when this stage is active.



Coefficient 2 is ± PPM 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.

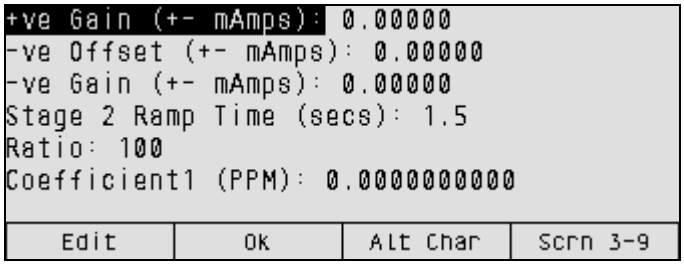
Maximum Amps is used to specify the minimum current for this stage. For a standard Guildline product this is 3.0 A.

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 milliampere correction. This is applied when positive current is sent by the 6622T. 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 positive current is sent by the 6622T. For a standard Guildline product this is 0.

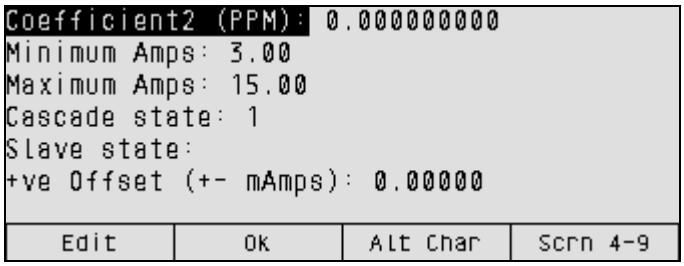
-ve Offset is used to offset the current with a milliampere correction. This is applied when negative current is sent by the 6622T. For a standard Guildline product this is 0.

-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 6622T. 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 6622T 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 6622T 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).

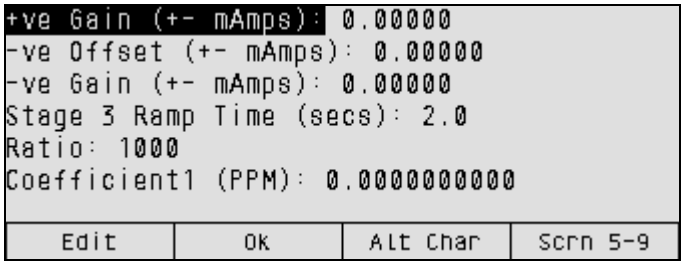


Minimum Amps is used to specify the minimum current for this stage. For a standard Guildline product this is 3.0 A.

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

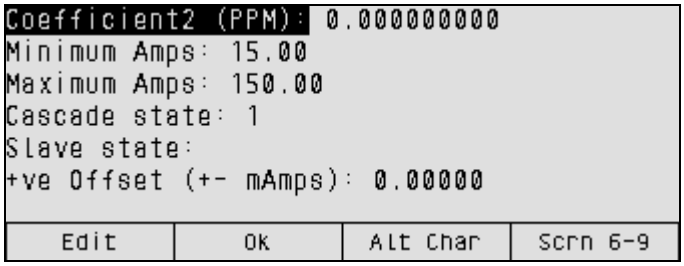
Cascade state is used to select the stage.
For a standard Guildline product this is 1.

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



Stage 3 Ramp Time is the ramp time in seconds for current. The 6622T 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).

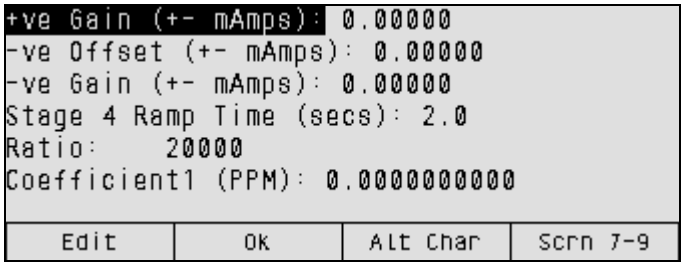


Minimum Amps is used to specify the minimum current for this stage. For a standard Guildline product this is 15.0 A.

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)

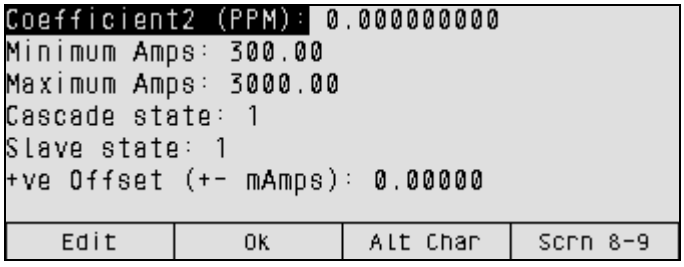
Cascade state is used to select the stage.
For a standard Guildline product this is 1.

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



Stage 4 Ramp Time is the ramp time in seconds for current. The 6622T 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.

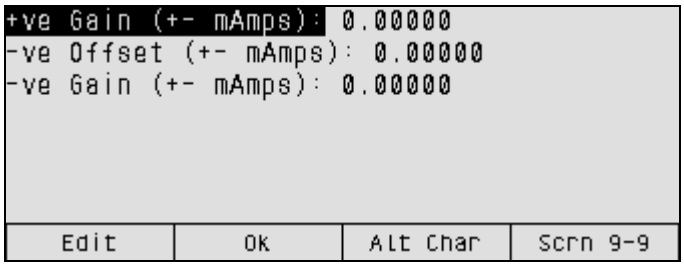


Minimum Amps is used to specify the minimum current for this stage. For a Guildline 6623A-3000 this is 150.0 A.

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

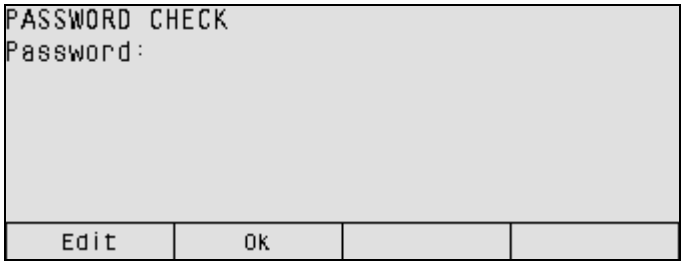
Cascade state is used to select the stage.
For a standard Guildline product this is 1.

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.

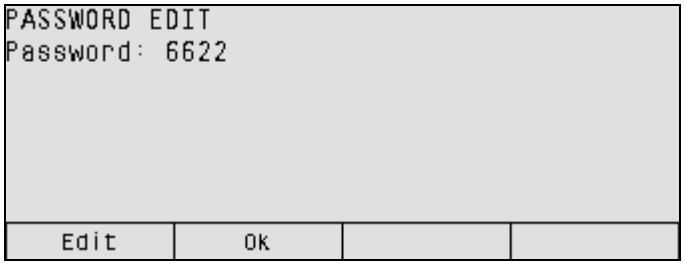


4.6.6.9 PASSWORD> MENU Fn-1 (Sofcal_MAIN)

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



In 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.



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 4.6.7.4 <P.O.S.T.>, to allow recovery of the factory default password setting.

5. VERIFICATION AND CALIBRATION

5.1. RESISTANCE RATIO ACCURACY VERIFICATION

This procedure covers the ratio accuracy verification of the 6622T Automatic DCC Thermometry 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 6622T is connected through a 6664C scanner.

5.1.1. Purpose

The purpose of this procedure is to assure that the 6622T Automatic DCC Thermometry 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 6622T is performing within the manufacturer's specifications relative to its last calibration.

5.1.2. Equipment Required

The following equipment is required for all 6622T 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 Ω standard resistor, stable to ±0.01 ppm over a 24 hour period (x2)
- 10 Ω standard resistor, stable to ±0.01 ppm over a 24 hour period
- 100 Ω standard resistor, stable to ±0.01 ppm over a 24 hour period (x2)
- 1 kΩ standard resistor, stable to ±0.01 ppm over a 24 hour period
- 10 kΩ standard resistor, stable to ±0.01 ppm over a 24 hour period (x2)

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 6622T Thermometry Bridge is switched on and have the following resistors ready for connection to the 6622T 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_X Resistor	R_s Resistor	Excitation Current	Reversal Rate	Meas. Mode	Closure Method
Tests 1 – 12 for all 6622T bridges.						
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	

2. 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:

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

3. The maximum allowable interchange closure errors (ppm) for the following resistor pairs are:

Resistor	Resistor	Interchange Closure Error	
		-B	-XP
1 Ω	1 Ω	0.1	0.05
100 Ω	100 Ω	0.1	0.05
10 kΩ	10 kΩ	0.1	0.05

4. 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

5. The maximum allowable ladder up errors (ppm) for the following resistor sets are:

Resistor	Resistor	Resistor	Interchange Closure Error	
			-B	-XP
1 Ω	10 Ω	100 Ω	0.100	0.067
100 Ω	1 kΩ	10 kΩ	0.167	0.133

5.2. TEMPERATURE RATIO VERIFICATION

This section outlines the recommended thermometry based ratio verification requirements for the model 6622T.

5.2.1. Purpose

The purpose of the procedure in this section is to assure that the model 6622T Series Bridge functions properly and meets the manufacturer's additional specifications for Temperature Measurement. It is recommended that these procedures be performed after any corrective maintenance activity, or if the operator perceives a problem.

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

5.2.1. Equipment Required

The following equipment is required for this procedure.

- 10 ohm standard resistor, stable to ±0.01 ppm over a 24 hour period (x2)
- 100 ohm standard resistor, stable to ±0.01 ppm over a 24 hour period (x2)
- 1k ohm standard resistor, stable to ±0.01 ppm over a 24 hour period (x2)
- 25 ohm standard resistor, stable to ±0.01 ppm over a 24 hour period
- 300 ohm standard resistor, stable to ±0.2 ppm over a 24 hour period
- Temperature controlled environment sufficient to maintain the reference and working standard resistors to their specified uncertainties

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.

5.2.2. Set Up

1. Ensure that the 6622T Thermometry Bridge is switched on and have the following resistors ready for connection to the 6622T 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.

5.2.3. 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_X Resistor	R_s Resistor	Excitation Current	Reversal Rate	Meas. Mode
Tests 1 – 13 for all 6622T T-Option bridges.					
1	10Ω	10Ω	3.16mA	20s	Normal
2	10Ω	10Ω	3.16mA	20s	Normal
3	100Ω	100Ω	1.0mA	20s	Normal
4	100Ω	100Ω	1.0mA	20s	Normal
5	1kΩ	1kΩ	1.0mA	20s	Normal
6	1kΩ	1kΩ	1.0mA	20s	Normal
7	25Ω	10Ω	2.0mA	20s	Normal
8	100Ω	25Ω	0.5mA	20s	Normal
9	100Ω	10Ω	0.5mA	20s	Normal
10	300Ω	100Ω	0.5mA	20s	Normal
11	1kΩ	300Ω	0.2mA	20s	Normal
12	1kΩ	100Ω	0.2mA	20s	Normal

2. 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:

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

3. The maximum allowable interchange closure errors (ppm) for the following resistor pairs are:

Resistor	Resistor	Interchange Closure Error	
		-B	-XP
10Ω	10Ω	0.1	0.05
100Ω	100Ω	0.1	0.05
1kΩ	1kΩ	0.1	0.05

4. 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

5. The maximum allowable ladder up errors (ppm) for the following resistor sets are:

Resistor	Resistor	Resistor	Interchange Closure Error	
			-B	-XP
10Ω	25Ω	100Ω	0.2	0.1
100Ω	300Ω	1kΩ	0.2	0.1
10Ω	100Ω	1kΩ	0.2	0.1

6. TROUBLESHOOTING AND MAINTENANCE

6.1. INTRODUCTION

This section covers troubleshooting, repair and verification of the 6622T Automatic DCC Thermometry Bridge.

6.1.1. Error Messages

The 6622T Automatic DCC Thermometry Bridge will display error messages either on the front panel display of the 6622T Thermometry 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 6622T 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	-**None**, 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	-**None**, fatal error (try power switch)

Table 6-1 : Model 6622T 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 6622T 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 6622T 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 6622T bridge to reflect these coefficients. This will return the bridge's alignment to the 'as shipped' settings.

6.1.2. Model 6622T Setup Warnings

The model 6622T Thermometry 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 6622T 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 6622T. 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 6622T'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 6622T 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 6622T as identified by the 6622T 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 6622T Automatic DCC Thermometry Bridge. The following procedure is can be automated in using a test sequence BridgeWorks Data Acquisition Software if the 6622T is connected through a 6664C scanner.

6.2.1. Purpose

The purpose of this procedure is to assure that the 6622T Automatic DCC Thermometry 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 6622T 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 6622T 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 6622T.

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

6.2.2. Equipment Required

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

- 1 Ω resistor, stable to ±10 ppm over a 24 hour period (x2)
- 10 Ω resistor, stable to ±10 ppm over a 24 hour period
- 100 Ω resistor, stable to ±10 ppm over a 24 hour period

6.2.3. Set Up

Ensure that the 6622T Thermometry Bridge is switched on and have the following resistors ready for connection to the 6622T 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_X Resistor	R_s Resistor	Excitation Current	Reversal Rate	Meas. Mode	Closure Method
Tests 1 – 5 for 6622T and 6622T-XP bridges.						
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	

2. For the 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:

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

3. The maximum allowable interchange closure errors (ppm) for the resistor pairs are ±100 ppm.

4. 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_a is the 100:1 ratio
R_b is the 100:10 ratio
R_c is the 10:1 ratio

5. The maximum allowable ladder up errors (ppm) for the resistor sets are ±100 ppm.

7. REMOTE CONTROL

The model 6622T Automatic DCC Thermometry 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 6622T 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 6622T 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 6622T, 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 6622T system has an external IEEE-488 interface.

The IEEE-488 connector is mounted on the rear panel of the model 6622T 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 6622T is fully programmable for use on the IEEE 488 interface bus (also known as the General Purpose Interface Bus (GPIB)). The model 6622T 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 6622T 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.

Instrument	IEEE-488 Address Setting	Remote/Local Setting	Controller Type Setting
Model 6622T 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 6622T 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 $0A_{16}$ or 10_{10} or 12_8 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 INDENTIFY) 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 6622T 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 6622T 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 6622T 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 6622T and the buffer is empty, the model 6622T 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 6622T 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 6622T 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 6622T will accept numeric parameters in the range ±2.2E-308 through ±1.8E308, the useful range of numbers is between ±1.0E-8 and 1.0E5.

7.4. MODEL 6622T REMOTE AND LOCAL OPERATION

The model 6622T can be operated locally using the front panel keys, or it can be operated remotely using a remote controller. In addition, the model 6622T 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 6622T 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 6622T are allowed to execute.

Local With Lockout:

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

Remote:

When the Remote Enable (REN) line is asserted and the controller addresses the model 6622T as a listener, the model 6622T 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 6622T to the local state. While the BridgeWorks Data Acquisition Software is open, the model 6622T 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 6622T 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 6622T to the local with lockout state, the controller must send a GTL interface command. To return the model 6622T to the local state, the controller must unassert the REN control line.

7.5. MODEL 6622T 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

COMMAND	COMMENT
MEASure:UNIT <unit>	select the units of measurement and instrument operation <unit> :== R|O|C|F|K|V type <letter> R:==Ratio O:==Ohms C:==Celsius F:==Fahrenheit K:==Kelvin V:==Volts
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 :== ppm from datum 4 :== delta from datum
MEASure:DEVIation?	query, display the method of reporting the difference

COMMAND	COMMENT
	data
MEASure:RESOlution <prec>	select the precision of reporting the data <prec>:==0|1|2|3|4 type <digit> 0 :== 0.001 ppm 1 :== 0.01 ppm 2 :== 0.1 ppm 3 :== 1.0 ppm 4 :== 10.0 ppm
MEASure:RESOlution?	query, display the precision of reporting the data
MEASure:VOLT <state>	set the state of the nanovoltmeter to measure input voltages at the potential terminals 0:== OFF 1:== ON
MEASure:VOLT?	query nanovoltmeter status
MEASure:QUICk <state>	select the quick measurement state <state>:== 0|1 type <boolean> 0 :== OFF 1 :== ON
MEASure:QUICk?	query, display the quick measurement state of the instrument

CONFigure - configure instrument operating parameters

CONFigure:DATUm <unit>, <value>	initialize the datum to be used as the set point in all difference calculations <unit> :== R|O|C|F|K|V type <letter> R:==Ratio O:==Ohms C:==Celsius F:==Fahrenheit K:==Kelvin V:==Volts <value>:==<nr3>

COMMAND	COMMENT
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>, <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 information
CONFigure:RESIstor:DISPlay <unit>, <rate>, <filter>, <size>, <power>	set the active display parameters for resistor measurements

COMMAND	COMMENT
	<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 resistor display setup
CONFigure:PROBe <RS>, <RS_SN>, <R0>, <PRT_SN>, <Rev_Rate>, <Tst_Val>, <Tst_Max>	set the active probe measurement configuration <RS>:==<nr3>

COMMAND	COMMENT
	ref. resistor value <RS_SN>:==<string> ref. resistor serial # <R0>:==<nr3> Probe resistance at ice point (IPTS68) Or triple point of water (ITS90) <PRT_SN>:==<string> probe resistor serial # <Rev_rate>:==<nr3> test current reversal rate <Tst_Val>:==<nr3> test current/volts <Tst_Max>:==<nr3> max current(Is) for ref resistor
CONFigure:PROBe?	query, display active probe configuration Information; response includes all associated coefficients see CONF:PROB:PCOE? and CONF:PROB:NCOE?
CONFigure:PROBe:DISPlay <unit>, <rate>, <filter>, <size>, <power>	set the active display parameters for probe measurements <unit>:== R|O|C|F|K type <letter>

COMMAND	COMMENT
	R:==Ratio O:==Ohms C:==Celsius F:==Fahrenheit K:==Kelvin <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 2 :== power X0.5
CONFigure:PROBe:DISPlay?	query, display the active probe display setup
CONFigure:PROBe:COEFficient <equation_#>, <coeff_00>, <coeff_01>, .., <coeff_n>	set the active probe conversion coefficients measurements <equation_#>:== <unsigned>: equation_# takes on a value in the range 00 through 11 for the temperature calibration range of the probe

COMMAND	COMMENT
	<coeff_00>:==<nr3> <coeff_xx> are coefficients 01 through n for the probe ITS90 conversion algorithm. When <equation>:==00 the IPTS68 coefficients can be set.
CONFigure:PROBe:PositiveCOEfficient?	query, display the active probe positive temperature coefficients
CONFigure:PROBe:NegativeCOEfficient?	query, display the active probe negative temperature coefficients

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
1:== 2V range
2:== 200mV range
3:== 20mV range
4:== 2mV range

SYSTem - set the unit system settings

SYSTem:COMMunicate:GPIB <address>, <mode>
setup GPIB communications
<address>:== <unsigned>
<mode>:== 0|1|2
type <digit>

COMMAND	COMMENT
	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

SOFCAL - set the unit calibration details

SOFCAL:COEF <ratio>, <range>, <corr>, <uncert>	<ratio>: == 0|1|2|3|4|5 0:==0.1:1 ratio 1:==1:1 ratio 2:==1:1 ratio (648 turns) 3:==10:1 ratio (648 turns)

COMMAND	COMMENT
	4:==10:1 ratio (81 turns) 5:==100:1 ratio type<digit> <range>: == 0|1|2|3|4|5|6|7|8 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 5:==100k ohm Rs range 6:==1M ohm Rs range 7:==10M ohm Rs range 8:==100M ohm Rs range <corr>:==<nr3> correction coefficient (ppm of ratio) <uncert>:==<nr3> uncertainty (ppm of ratio)
SOFCAL:COEF? <ratio>, <range>	query, display ratio correction coefficient <ratio>: == 0|1|2|3|4|5 0:==0.1:1 ratio 1:==1:1 ratio 2:==1:1 ratio (648 turns) 3:==10:1 ratio (648 turns) 4:==10:1 ratio (81 turns) 5:==100:1 ratio type<digit>

COMMAND	COMMENT
	<range>: == 0|1|2|3|4|5|6|7|8 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 5:==100k ohm Rs range 6:==1M ohm Rs range 7:==10M ohm Rs range 8:==100M ohm Rs range
SOFCAL <beta>	set adc beta <beta>: == <unsigned> 200 <= beta < 300
SOFCAL?	query, display adc beta for the nanovolt detector
SOFCAL:GET	Calculate adc beta for the nanovolt detector
SOFCAL: FREQuency <Hz>	set the line frequency option <Hz>: = = 011 type <digit> 0 : = = 60 Hz 1 : = = 50 Hz
SOFCAL:DATE SOFCAL:DATE<YYYY>,<MM>,<DD	query, display the calibration date set the calibration date <YYYY> calibration year <MM> calibration month <DD> calibration day
SOFCAL:PRIM SOFCAL:PRIM<state>	query, display the primary turns lock set the primary turns lock <state> 0|1|2 type<boolean> 0:== unlocked 1:== locked to 81 turns 2:== locked to 648 turns

COMMAND	COMMENT
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 <status>:==0|1 type <boolean> 0:== OFF 1:== ON
IXTurns?	query, display relay turns setting
IXTurns <turns>	set relay turns <turns>:==<unsigned> 0≤turns≤8747
ISDAC <value>	set dac setting <value>:==<nr1> value == ±5 Volts
ISMux?	query, display the multiplexer channel
ISMux <channel>	set the multiplexer channel <channel>:==0|1|2|3|4|5|7 type <digit> 0:== servo 1:== speedup 2:== offset

COMMAND	COMMENT
	3:== +40 Volts 4:== -40 Volts 5:== primary current 7:== calibrate
ISResolution?	query, display the resolution setting
ISResolution <resolution>	set the resolution <resolution>:==0|1|2 type <digit> 0 :== high 1 :== medium 2 :== low
ISSpeed?	query, display the speed setting
ISSpeed <speed>	set the speed <speed>:==0|1|2|3 type <digit> 0 :== reset 1 :== slow 2 :== moderate 3 :== fast
OHmmode?	Query, display the ohm mode
OHmmode <mode>	set the ohm mode <mode>:==0|1|2 type <digit> 0 :== normal 2 :== low ohms
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
Voltage?	query, display the nanovoltmeter measurement
RESET	reset instrument to power on reset state

8. APPENDICES

8.1. GENERAL SPECIFICATIONS (continued)

6622T Series General Specifications				
Linearity		± 0.01 ppm 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 ppm/ºC 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 ppm ± 10 µA		
Test voltage (for measurement above 100 kΩ)	V_{DC} 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 +25 °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 8-1 : General Specifications (continued)

8.2. RESISTANCE MEASUREMENT SPECIFICATION

The following tables show the uncertainty contribution of the model 6622T Bridges to the total measurement. Because of the wide range of Rx/Rs ratios available, it is possible to measure UUT's with a variety of Rs standards. For example, a 100Ω UUT could be measured with a 1 Ω, 10 Ω or 100 Ω reference standard (Rs). To determine the bridge's contribution to measurement uncertainty, simply look at the Rs you are using, and go to the appropriate UUT range. The base model 6622T Bridge has a best uncertainty of 0.1 ppm, that is equivalent to ±25 µK for a 25.5Ω SPRT at 0 °C measured against a 25Ω reference resistor. The 6622T-XP Bridge has a best uncertainty of 0.05 ppm/±13 µK.

Rs 1 Ω	Rx/Rs Measurement Uncertainty (3 Years)				24 Hour Stability
	0.08Ω ► R_x ◄ 0.8Ω	0.8 Ω ► R_x ◄ 6.3Ω	6.3 Ω ► R_x ◄ 13.4Ω	13.4Ω ► R_x ◄ 107.5Ω	
Base Model	± 0.4 ppm	± 0.1 ppm	± 0.1 ppm	± 0.2 ppm	< ± 0.04 ppm
XP Model	± 0.3 ppm	± 0.05 ppm	± 0.05 ppm	± 0.1 ppm	< ± 0.04 ppm

Rs 10 Ω	Rx/Rs Measurement Uncertainty (3 Years)				24 Hour Stability
	0.08Ω ► R_x ◄ 0.8Ω	0.8Ω ► R_x ◄ 6.3Ω	6.3Ω ► R_x ◄ 13.4Ω	13.4Ω ► R_x ◄ 107.5Ω	
Base Model	± 0.4 ppm	± 0.1 ppm	± 0.1 ppm	± 0.2 ppm	< ± 0.04 ppm
XP Model	± 0.3 ppm	± 0.05 ppm	± 0.05 ppm	± 0.1 ppm	< ± 0.04 ppm

Rs 25 Ω	Rx/Rs Measurement Uncertainty (3 Years)				24 Hour Stability
	2.5Ω ► R_x ◄ 20Ω	20Ω ► R_x ◄ 157.5Ω	157.5Ω ► R_x ◄ 335Ω	335Ω ► R_x ◄ 2687Ω	
Base Model	± 0.4 ppm	± 0.1 ppm	± 0.1 ppm	± 0.2 ppm	< ± 0.04 ppm
XP Model	± 0.3 ppm	± 0.05 ppm	± 0.05 ppm	± 0.1 ppm	< ± 0.04 ppm

Rs 100 Ω	Rx/Rs Measurement Uncertainty (3 Years)				24 Hour Stability
	10Ω ► R_x ◄ 80Ω	80Ω ► R_x ◄ 630Ω	630Ω ► R_x ◄ 1340Ω	1.34kΩ ► R_x ◄ 10.75kΩ	
Base Model	± 0.4 ppm	± 0.1 ppm	± 0.1 ppm	± 0.4 ppm	< ± 0.04 ppm
XP Model	± 0.3 ppm	± 0.05 ppm	± 0.05 ppm	± 0.2 ppm	< ± 0.04 ppm

Rs 1 kΩ	Rx/Rs Measurement Uncertainty (3 Years)				24 Hour Stability
	100Ω ► R_x ◄ 800Ω	800Ω ► R_x ◄ 6.3 kΩ	6.3kΩ ► R_x ◄ 13.4kΩ	13.4kΩ ► R_x ◄ 107.5kΩ	
Base Model	± 0.4 ppm	± 0.1 ppm	± 0.1 ppm	± 1.0 ppm	< ± 0.04 ppm
XP Model	± 0.3 ppm	± 0.1 ppm	± 0.1 ppm	± 1.0 ppm	< ± 0.04 ppm

Rs 10 kΩ	Rx/Rs Measurement Uncertainty (3 Years)				24 Hour Stability
	1kΩ ► R_x ◄ 8kΩ	8kΩ ► R_x ◄ 63kΩ	63kΩ ► R_x ◄ 134kΩ	Optional	
Base Model	± 0.4 ppm	± 0.1 ppm	± 0.3 ppm	Optional	< ± 0.04 ppm
XP Model	± 0.3 ppm	± 0.1 ppm	± 0.3 ppm	Optional	< ± 0.06 ppm

1 - Specifications are based on 20 second reversal rate, 100 µW power dissipation in R_x and environment temperature of 23°C ±2°C.
2 - Lowest possible R_x is defined as $R_{x(low)} = R_s \times .08$ and Maximum possible R_x is determined by $R_{x(high)} = R_s \times 107.5$.

Table 8-2 : Resistance Measurement Specification (All 6622T Models)