Guildline

Volume II

TECHNICAL MANUAL
FOR ResCal™ 3.4
MODEL 6675/A

DATA ACQUISITION SOFTWARE

VOL II TM6675A-D-00
October 25, 2002

HAZARDS WARNING!

CURRENT COMPARATOR RESISTANCE BRIDGES AND SYSTEMS

READ THESE SAFETY PRECAUTIONS BEFORE SETTING UP OR USING THIS INSTRUMENT!

IMPROPER SETUP OR OPERATION OF THIS INSTRUMENT CAN RESULT IN PERSONAL INJURY, BURNS OR ELECTRICAL SHOCK!

Precautions, Safety and Preparation for Use

1. **Thoroughly read the set up and operating procedures in this manual before installing or using this instrument.**
2. Select the proper line voltage on the back panel and use only the proper fuse type and rating specified for this product.
3. The line power connection must have an earth ground conductor and must be connected to the instrument only with the line cord supplied or a proper line cord specified for the country of use.
   Operating this instrument without a proper grounded line connection can result in electrical shock hazard.
4. Observe all connector and terminal markings and ratings to avoid any possible shock, or other hazard to the user of this instrument.
5. Under no circumstances should unqualified personnel operate or service this instrument.
6. Do not connect the line power or operate this instrument with the covers removed.
7. Do not touch exposed terminal connections or make or break terminal connections with the instrument operating to avoid possible electrical shock hazard.
8. Operate this instrument only in a well ventilated and dry environment.
9. **Precaution is required to ensure HIGH CURRENT CONNECTIONS ARE NOT LOOSE or can possibly disconnect while current is flowing to avoid fire or equipment failure hazards.**

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1. MEASUREMENT OPERATION GUIDE

This section contains information regarding the measurement of low value resistors and low value resistance thermometers in the ranges of Rs equal to 10 mΩ to Rs equal to 10 kΩ as four terminal measuring devices. As well as a section on low resistance measurements (Rs = 1 Ω) is included, where use is made of the Guildline model 9923 and model 6623 range extenders. Lastly, a section on high value resistors in the ranges of Rs equal to 100 kΩ to Rs equal to 100 MΩ as two terminal measuring devices is also included.

1.1. Resistance Measurement Normal Ohms - 1 mΩ ≤ Rs ≤ 10 kΩ

The Model 6675/A bridge in its normal ohms mode enables measurement of resistance of values up to 10 kΩ : 10 kΩ (Rx : Rs). Several types of resistance thermometers, each involving a different resistance range, reference resistor and thermometer current can also be measured in this mode. Figure 1-1 shows a typical front panel connection for this measurement mode. A suggested guarding termination is shown in Figure 1-2

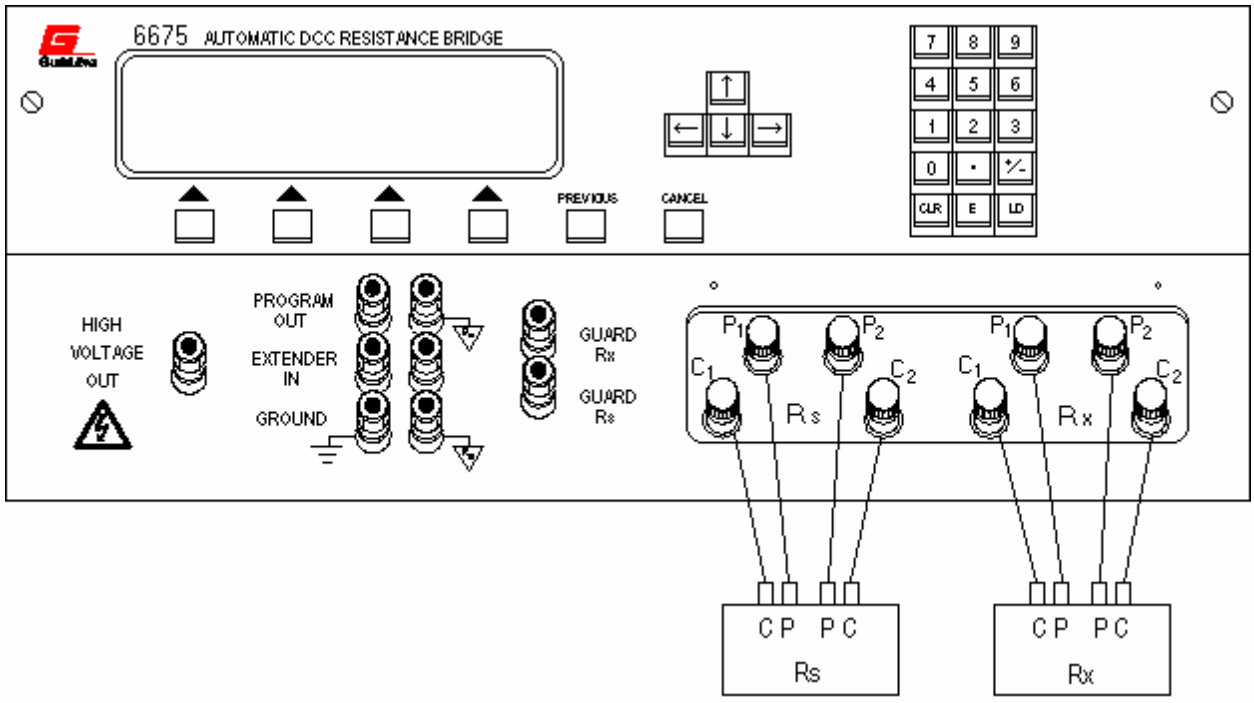


Figure 1-1 : Front Panel Connections - Normal Ohms

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.

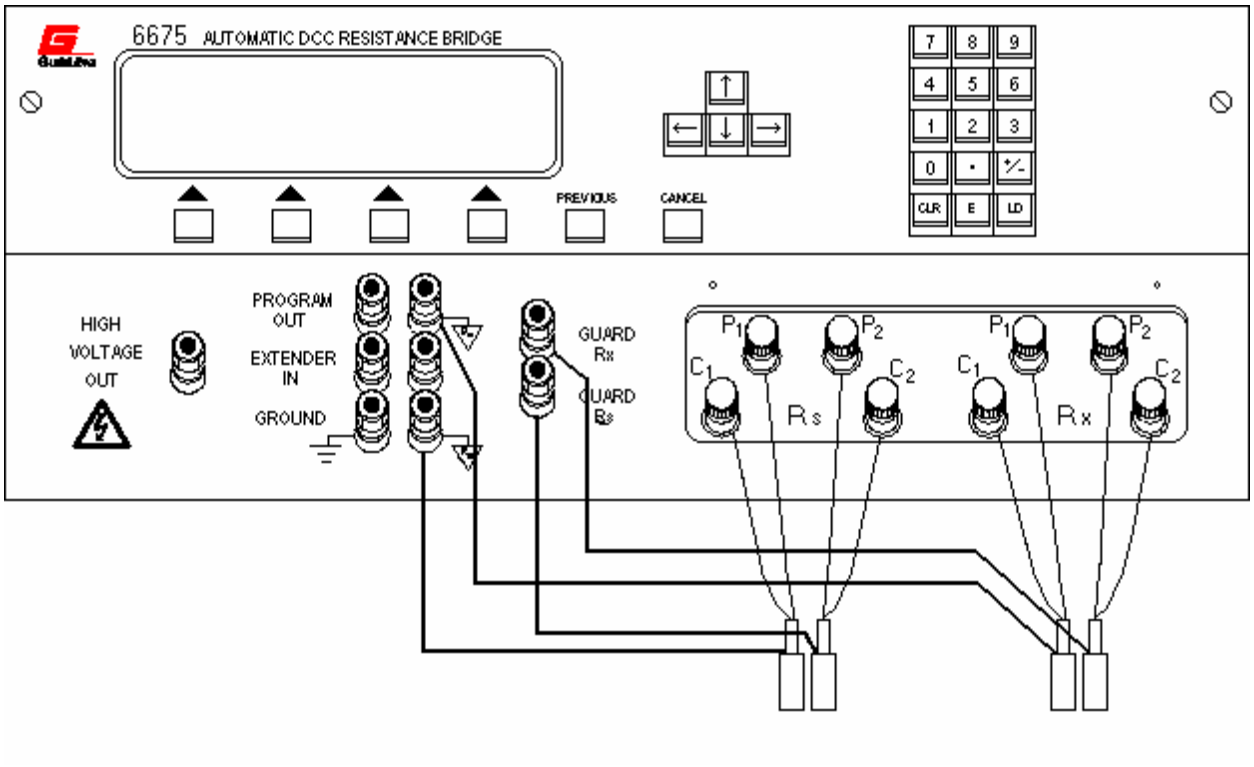


Figure 1-2 : Recommended Guarding for Normal Ohms

The following steps outline the general procedure for making a normal ohms measurement.

Step 1) Connect the IEEE-488.2 interface connector of the 6675/A to an IBM-PC compatible computer running Windows 95 and run the ResCal software.

Step 2) Connect the thermometer leads or the resistor to be measured on the four terminals labeled Rx on the front panel, where C_1P_1 identifies one current potential pair and C_2P_2 the other pair.

Step 3) Select a reference resistor and connect it to the four terminals labeled Rs, also on the front panel. Normally a value is chosen that will make the expected ratio lie between 1 : 1 and 13.4 : 1 (Rx : Rs). This ensures the best available precision.

Step 4) Click on the "Test" button on the ResCal panel.

Step 5) Click on the "Logging Temp./Res." switch to toggle between temperature or resistance measurement to select the correct measurement.

Step 6) Load the reference resistor parameters by clicking on "Load Rs" and selecting the appropriate resistor configuration file. If the configuration file does not already exist then create one by the following steps:

i) Click on the "Edit" button beside the "Load Rs" button.

ii) Enter all the pertinent information for the reference resistor in the Resistor Configuration window. The following parameters can be entered:

Serial Number	used to identify resistor in test file, test overview, and history file
R (ohms)	value in ohms of the resistor – required for Rs, optional for Rx
I test (mA)	test current applied when the resistor is attached to Rx during a four terminal measurement – must be a value between 0.0005 and 150 inclusive (typically resistance measurements are made at a 10 mW power level)
I max (mA)	maximum current that will be applied to the resistor when attached to Rs during a four terminal measurement – must be greater than or equal to I test and less than or equal to 150
V test (V)	test voltage applied when the resistor is attached to Rx during a two terminal measurement – must be a value between 15.7 and 990 inclusive (typically resistance measurements are made at a 10 mW power level)
V max (V)	maximum voltage that will be applied to the resistor when attached to Rs during a two terminal measurement – must be greater than or equal to V test and less than or equal to 990.
Uncertainty (ppm)	uncertainty of the resistance value in ppm of value – used to calculate the measurement uncertainty
Cal. Date	for reference only
Cal. Due	for reference only
Cal Temp (C)	for reference only

Temp. Coef. (ohm/C) for reference only

iii) Click on the "Save" button.

iv) Enter an appropriate name for the configuration file and click on the "Save" button in the Save Resistor File dialog box.

Step 7) Load the parameters for the resistor or thermometer to be measured by clicking on "Load Rx" and selecting the appropriate file. If the configuration file does not already exist then create one by the same procedure as in Step 6. The selection of temperature or resistance measurement in step 5 will determine whether a Probe Configuration (temperature) or a Resistor Configuration (resistor) file is required. A probe configuration file contains the following additional parameters:

RTPW (ohms)	the probe resistance in ohms at the probe temperature of the triple point of water for the ITS-90 scale, or the ice point of water for the IEC751 scale – this value is required for the temperature calculation
ITS-90/ IEC751	toggle switch to select the temperature scale
a b c d / A B C	coefficients required for calculating temperature from resistance (only those coefficients that are used for the selected temperature scale and temperature range need to be entered)
+ -	temperature ranges to be used by the ITS-90 temperature algorithm to convert resistance to temperature (not used for IEC751 scale)

Step 8) Set the reversal rate by entering the appropriate value in seconds in the Reversal Rate box. The recommended value for resistance measurement to specified accuracy is 60. For temperature measurement, a trade-off must be made between measurement uncertainty and response time.

Step 9) Be sure the Mode box is set to "Normal Ohms".

Step 10) If you do not wish to let the software optimize the reversal rate, set the Auto box to "Off". If you are measuring a varying resistance you will be able to track the changes better if the Auto box is set to "Track". If you want to use a shorter reversal rate but still maintain a certain accuracy, set the Auto box to "Stabilize". If the Auto box is not set to "Off", then enter a value in the Threshold (ppm) box to determine how much deviation will cause a change in the reversal rate.

Step 11) Set the Test Criteria for the number of samples to be taken. The criteria are as follows:

no. of Readings	the maximum number of samples that will be recorded after the Cutoff
Cutoff	the preliminary number of samples that are not saved
Deviation (ppm)	the maximum deviation of the last windowed number of samples before the measurement will be terminated. If the no of Readings criteria is reached before the Deviation criteria, the measurement is terminated.
Window	the latest number of samples that must meet the Deviation criteria in order to terminate the measurement

Step 12) You can describe the environment of the test facilities by clicking on the "Environment" button. This will open a Test Environment window where you can enter the pressure, temperature and humidity of the test facilities plus the location of the facilities and the operator's name. This information will be logged in the test data file.

Step 13) Select the desired update option by clicking on the "Update" control. The choices available are:

Update 1	the data is updated every 2 × reversal rate
Update 2	the data is updated every 1 × reversal rate
Update 4	the data is updated every ½ × reversal rate

Step 14) Save this test configuration by clicking on the "Save" button, entering an appropriate name for the configuration file and clicking on the "Save" button in the Save Sequence File dialog box.

Step 15) Click on the "Start" button. The measurement will now begin.

Step 16) You can change the scale being displayed by clicking on the Units control. The default unit for resistance is "Ratio" and for temperature is "Ohms". The units available are:

Ratio	the ratio of Rx : Rs
Ohms	Ratio × Rs
Delta (ppm)	the difference between Ratio and the nominal ratio expressed in ppm of nominal (the nominal ratio is determined from the Resistor Configuration files)

The following units are enabled for temperature only:

Kelvin	the calculated temperature expressed in kelvins
Celsius	the calculated temperature expressed in degrees Celsius
Fahrenheit	the calculated temperature expressed in degrees Fahrenheit

Note: - The displayed units do not affect the stored data. Test data is always stored in Ratio for resistance measurement and Celsius for temperature measurement.

Step 17) You can shorten the time required to reach a stable measurement value by clicking on the "Quick" control. This control will allow you to toggle the quick mode of operation on or off. This mode is primarily used when Rx is changing (such as when tracking temperature change or calibrating decade resistance boxes). Selecting quick reduces the resolution to 7 digits. This control is only available while not running an auto reversal rate function, as the auto-reversal rate optimizes this feature as well.

Step 18) You can double the power applied to Rx by clicking on the "Power" control. This control will allow you to toggle the power between ×1 and ×2. This control is useful for extrapolating to zero power resistance.

Step 19) You may terminate the measurement at any time by clicking on the Stop button.

Step 20) You may save the data file by selecting “File” on the menu bar then selecting “Save Data As”, entering an appropriate name for the configuration file and clicking on the “Save” button in the Save Data File dialog box.

1.2. Resistance Measurement Low Ohms - Rx ≤ 0.1 Ω

Typically Rs = 1 Ω, Rx ≤ 100 mΩ. This setup requires an external high current power supply and Guildline model 6623 Range Extender. A typical "Low Ohms" measurement configuration, using the model 6623 Range Extender is shown in Figure 1-3.

CAUTION:

If this is the first Low Ohms measurement in a sequence of measurements or if this is the first measurement since the 6675/A has been switched on, then start the measurement before applying the external current from the external power supply.

Ratio measurements made with the Guildline Range Extender should be made such that the condition:

$$\mathbf{Rs = (Rx) \times (EXTENDER\ RATIO)}$$

is maintained.

The steps for making a low ohms measurement are the same as those for making a normal ohms measurement with the following exceptions:

1) **In place of Step 2**: Connect Rx to the high current supply, and to the model 6623 Range Extender as shown in Figure 1-3.

2) **In place of Step 3**: Connect a 1 Ω reference resistor to the four Rs terminals.

3) **In place of Step 9**: Select the range extender ratio by clicking on the "Mode" box. The number to select is the number that corresponds to the current terminals on the Model 6623 range extender to which Rx is connected.

4) Proceed to make the measurement as you would in normal ohms.

NOTE:

In Extender mode there is a ±5 mA current source signal with 30 V compliance available at the PROGRAM OUT terminals, which is sufficient to drive a Guildline model 9606 High Current Reversing Switch or the "Program Input" terminals of the model 6623.

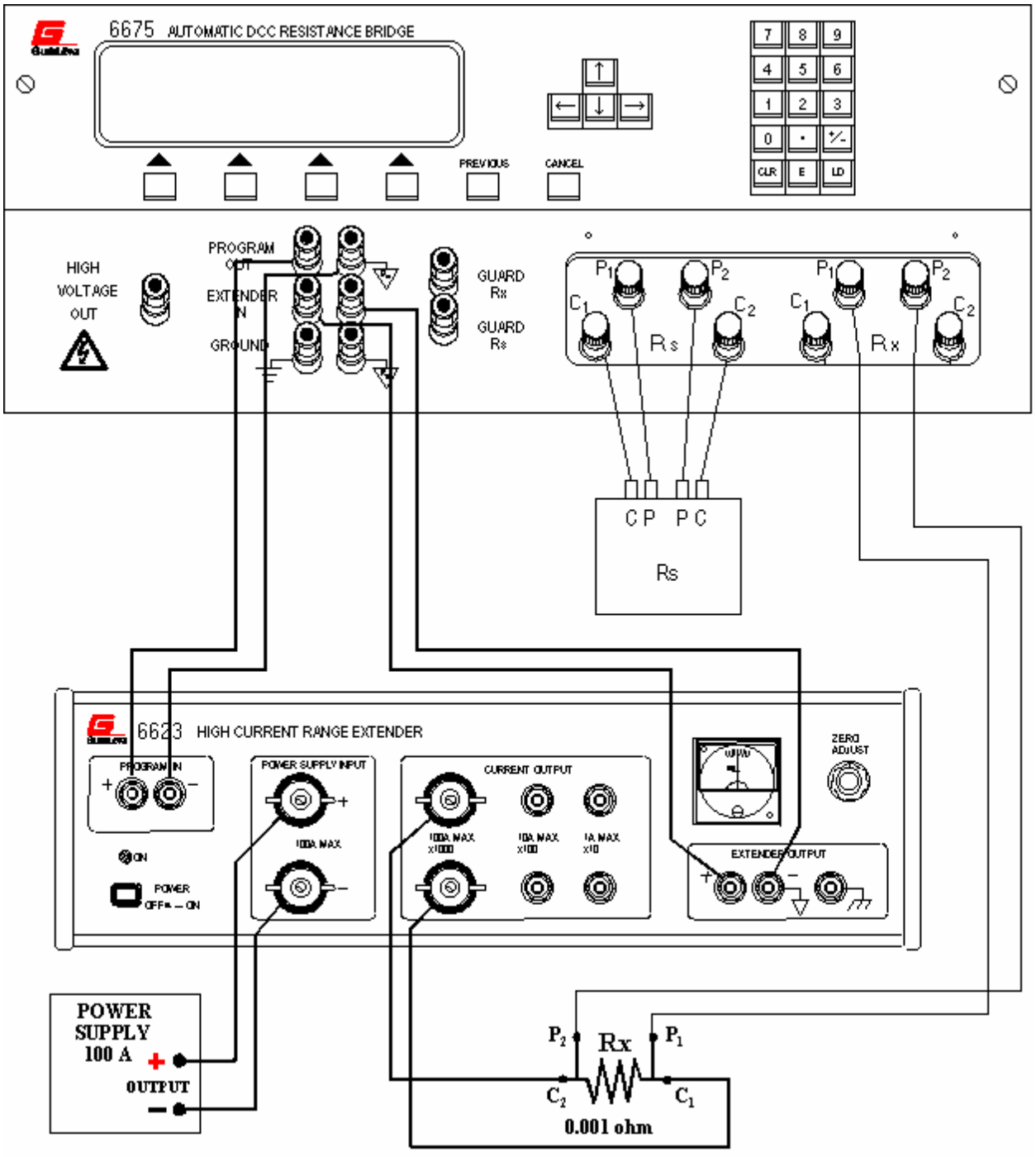


Figure 1-3: Front Panel Connections Low Ohms, 6623 Range Extender

1.3. Resistance Measurement - High Ohms - 100 kΩ ≤ Rs ≤ 100 MΩ; Rx ≤ 1 GΩ

The Model 6675/A in its High Ohms mode enables measurement of resistance values up to 1 GΩ:100 MΩ (Rx:Rs). This is a 2-terminal measurement. In this measurement mode there is a ±90 mA current source with a 30 volt compliance available on the Program Out terminals in order to drive a Model 9606 High Voltage Reversing Switch directly. Also in this measurement mode the test voltage set in the measurement setup is available at the High Voltage and terminal (referenced to ground Rx) once the measurement has been started.

Refer to Figure 1-4 for internal High Voltage (HV) power supply connections and for external HV power supply connections. Figure 1-5 details a suggested guarding interconnection for the high resistance measurement mode.

CAUTION:

Dangerous voltages to 990 V DC can appear at the HIGH VOLTAGE OUTPUT front panel terminal during two-terminal, high resistance measurements. Also, when line power is first applied to the 6675 at power up, a momentary, high voltage pulse can appear at the HIGH VOLTAGE OUTPUT terminal.

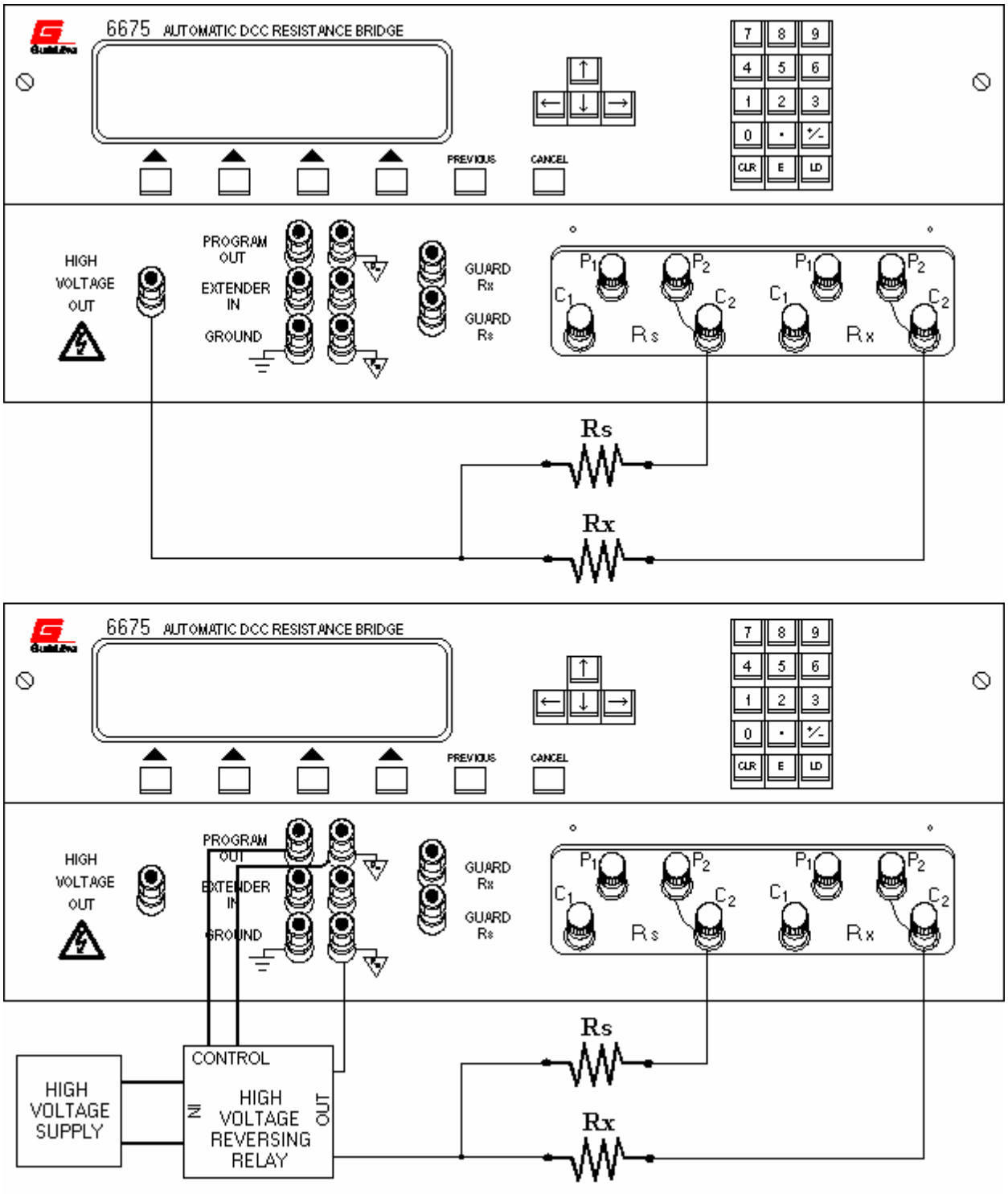


Figure 1-4 : Front Panel Connections - High Ohms

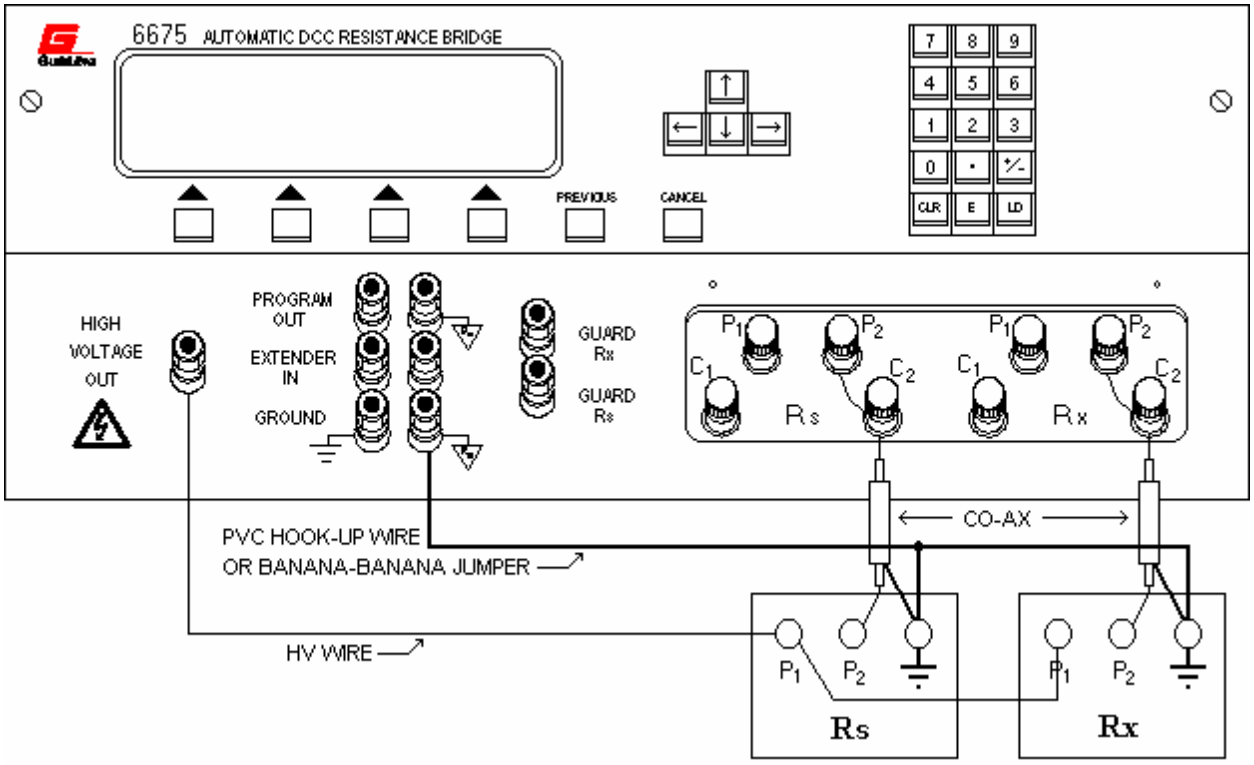


Figure 1-5 : Recommended Guarding for High Ohms

The steps for making a high ohms measurement are the same as those for making a normal ohms measurement with the following exceptions:

1) **In place of Step 2**: Connect Rx to the high voltage supply as shown in Figure 1-4.

2) **In place of Step 3**: Connect Rs to the high voltage supply as shown in Figure 1-4.

3) **In place of Step 9**: Select the "High Ohms" by clicking on the “Mode” box.

4) Proceed to make the measurement as you would in normal ohms.

NOTE:

To minimize errors in this 2-terminal measurement introduced by the wire interconnects, the wiring from the HV supply to the Rs and Rx resistors and the wiring from the Rs and Rx resistors to the front panel should be as short as possible.

1.4. Summary of Recommended Test Setups

a) Normal Ohm mode, 4-terminal measurements (10 mW on Rs)

Rs (Ω)	Rx (Ω)	Itest (mA)	Imax (mA)	Comment
0.1	0.1	141	150	2 mW tests due to output current limit of 150 mA on Rx and 250 mA on Rs
0.1	1	14.1	150	
1	1	100	150	
1	10	10	150	
10	10	31.6	100	
10	100	3.16	100	
100	100	10	31.6	
100	1 k	1	31.6	
1 k	1 k	3.16	10	
1 k	10 k	0.316	10	
10 k	10 k	1	3.16	
10 k	100 k	0.1	3.16	Reversal rate 90 seconds minimum

Table 1-1 : 4-Terminal Mode Test Setup

b) High Ohm mode, 2-terminal measurements (10 milliwatt on Rs), 90 second reversal rate.

Rs (Ω)	Rx (Ω)	Vtest (V)	Vmax (V)	Comment
100 k	100 k	31.6	100	
100 k	1 M	31.6	100	
1 M	1 M	100	316	
1 M	10 M	100	316	
10 M	10 M	316	1000	Output limit of voltage source
10 M	100 M	316	1000	Output limit of voltage source
100 M	100 M	990	1000	Output limit of voltage source
100 M	1 G	990	1000	Output limit of voltage source

Table 1-2 : 2-Terminal Mode Test Setup

c) Low Ohm mode, Current Range Extender measurements. These measurements have been standardized at 1 W dissipation in the current shunt.

Rs (Ω)	Rx (Ω)	Itest (A)	Extender Ratio	Comment
10	0.1	3.16	100:1	
1	0.1	0.316	10:1	Test at 10 mW
1	0.01	10.0	100:1	
1	0.001	31.6	1000:1	
1	0.0001	100	1000:1	

Table 1-3 : Low Ohm Mode Test Setup

2. GUILDLINE RESCAL 6675A DATA ACQUISITION SOFTWARE

ResCal is the accompanying control software for your 6675A Direct Current Comparator Resistance Bridge. The 6675A is designed to be run both independently or by the computer. Using the 6675A with the computer will increase the functionality of the instrument greatly from the stand alone unit. Before using the 6675A with the computer you should ensure that the operation of this software package is well understood. This software was designed with an interface that blends the most common features of a traditional front panel coupled with the familiarity of the Windows 95 interface. This document explains only the operation of the 6675/A with ResCal. For Stand alone operation please refer the Operators Manual Volume 1.

2.1. INSTALLATION AND SYSTEM CONFIGURATION

System Requirements

To properly install and execute ResCal you will need the following system configuration:

Hardware

- A Pentium class or greater IBM-PC compatible computer.
- Minimum 16 Megabytes of ram.
- Minimum 15 Megabytes of free hard drive space for the program files.
- A 256 colour VGA graphics card and monitor.
- Mouse supported by Windows.
- Printer supported by Windows (recommended).
- National Instruments GPIB controller interface card.
- CD ROM for installation purposes only.

Software

- Microsoft Windows 95/NT or newer operating system.
- National Instruments driver software for Windows.
- DCOM v1.1 or greater (recommended).

Installation

ResCal is supplied on a CD ROM. If your computer does not have a CD ROM, then contact Guildline Instruments Customer Service for a copy that can be supplied on 3 1/2" high density disks.

For your convenience the CD ROM will automatically start up the ResCal setup program after it has been placed in your CD ROM drive. For those who do not have Windows autoplay extender enabled or are installing from floppy disks, simply run the setup executable from the CD ROM or disk 1 through "Windows Explorer". The setup program will ask you if you wish to install and verify the install directory. Click on "Finish" and the setup will decompress all the files as well as create the appropriate directory structure. This setup will also update itself to the "Add/Remove Programs" list in your "Control Panel" for easy uninstallation.

To run ResCal there will be a shortcut created in your "Start Menu". This is found by clicking on "Start", then pointing to the sequence of sub-menus "Programs...Guildline Instruments...ResCal".

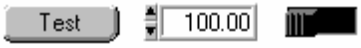
2.2. GENERAL

Throughout the various windows in ResCal you will see different indicators and controls. These are used to display, and retrieve information from you, as well as to control some of the features in ResCal. In some windows throughout ResCal you will also find menu bars that offer pertinent commands for that area of the program.

2.2.1. Indicators

Indicators are how ResCal displays information to you. The more common indicators are message indicators (text), numeric displays, and graphs. Indicator data cannot be changed directly by you. They are updated by ResCal as new information is available.

2.2.2. Controls



Controls are how you can input your information and choices into ResCal. The most common controls are buttons, switches, and numeric entry fields. These controls are, in most cases set to default values and can be changed as well as loaded with saved values to be edited or just viewed. Controls are activated by clicking on them and you will see a visual representation of the action of that control or activate an edit cursor for fields.

2.2.3. Fields

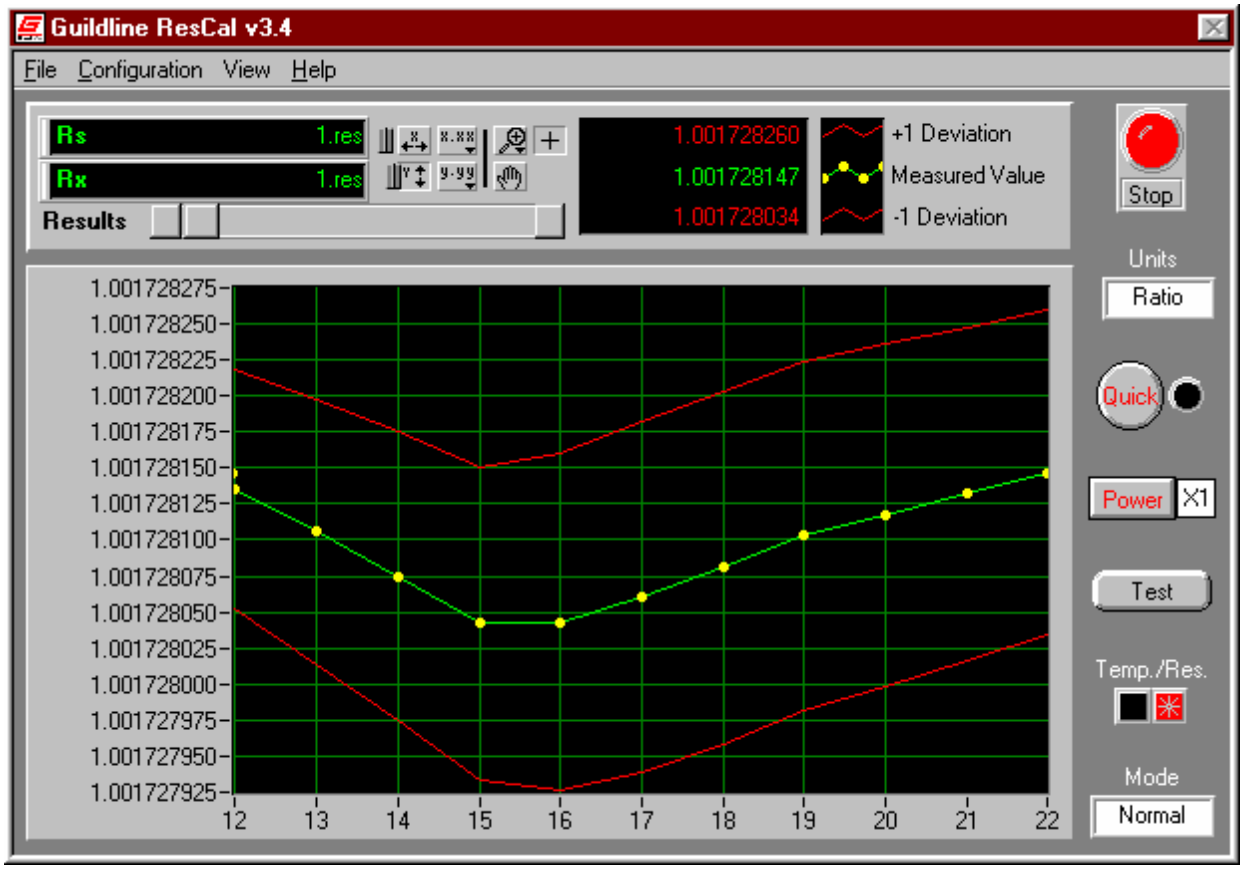
Fields are actually a type of control that requires a value or text entry through the keyboard. Being a type of control they will also in many cases be set to preset values and can be loaded with saved values as well as edited directly. This type of control is the most predominant type in all of the configuration windows. To edit the contents of a

field click with your mouse pointer inside the field and an editing cursor will appear. Enter in the desired information then click outside the field to keep the contents in the field.

2.2.4. Menu Bar

The other main way you have to navigate through ResCal is the menu bar. The menu bar has a series of commands within it that are relevant to that window. These commands usually consist of file management functions and program options rather than control of actual measurement. Some of the more common menu items also can be accessed by controls in the window or through quick key combinations known as hotkeys. All menu items can also be accessed by pressing the Alt key and using the arrow keys to navigate through the menus or by using the mouse.

2.3. MAIN WINDOW



In the main window there is a series of indicators and controls to setup and observe the measurement process. There is also a menu bar that you will need to use to access many of the functions and features of ResCal.

2.3.1. Stop Button

The "Stop" button located to the upper right is used to end a measurement in progress. When you start a measurement you will notice that the "Stop" button will turn red. It will remain red until the test has stopped. If you need to end a measurement early you can click on this control and the test will stop. The button will return to black when the test has successfully stopped.

2.3.2. Quick Control

The "Quick" control will allow you to toggle the 6675A's quick mode of operation. This mode is primarily used when there is large changes in your readings or for higher speed reversal rates. Selecting this will also reduce your accuracy to 7 digits. This control is only available while not running an auto reversal rate function. As the auto reversal rate optimizes this feature as well.

2.3.3. Power Control

The "Power" control allows you to step up your current to a value that is the square root of 2 times your configured current. You can also toggle back to your original value as set up in your test configuration.

2.3.4. Units Control

The "Units" control sets the units in which you wish to view the incoming data. Changing the units will not affect the data being stored. All data is stored in ratio for resistance and Celsius for temperature.

2.3.5. Temp./Res. Indicator

This indicator displays the type of data which you are logging. ResCal will log the degrees Celsius or ratio respectively. This is independent of how you have chosen to view the incoming data.

2.3.6. Test Button

The "Test" button opens up the Test Configuration window the same as the menu item Configuration...Test. This was placed for speed and simplicity in setting up your measurements.

2.3.7. Mode Indicator

The "Mode" indicator displays whether you have set ResCal to normal, high, or low ohms measurements. High ohms meaning when measuring with a 2-wire configuration, and low ohms is when you are using a 6623 range extender. In low ohms there are three ranges; x10, x100, and x1000.

2.3.8. File Indicators

Up to the top left of the main window there are two indicators displaying what two device files are being used for the test. They are especially useful when in multi-test situations where you can see which test is currently running.

2.3.9. Using The Graph

The graph on the main panel has a lot of features available for you to view your incoming data as you so choose. The main functions being that you can scroll back to view older samples at any time during the test using the scrollbar located above the graph and you can modify the x and y scales by the control buttons above the scrollbar. The x.xx and y.yy is a control for you to change the format and precision of each respective axis. The two buttons with the bi-directional arrows enables/disables the autoscaling feature of the graph. Autoscaling is a function that optimizes the scale of graph to display all the points, but maximizing the fixed amount of viewing space. This feature is enabled on the y axis by default therefore displaying the changes at the smallest possible scale that will still show all the information on the graph. There is also the zoom button which will change your mouse pointer to a magnifying glass to show that the feature is active. You can either click on a central point for the zoom or highlight an area to zoom into. And lastly by clicking on the hand you can arbitrarily drag the graph to the position you want. While in this mode your mouse pointer is in the shape of a hand. To return to normal from any of these states just click on the crosshair button, this is the default view mode. Clicking on the extremes of the x and y axis the number will highlight to allow you to change the scale.

Also above the graph there is a legend for the graph. The three items are Measured Value, +1 Deviation, and -1 Deviation. The Measured value line (green) is the physical recorded value of that sample. The +/- deviation (red) plots draw out the displays how much the resistors have been moving in value from the start of the measurement up to, and including the current sample. These two deviation plots do not appear until after the first few measurements as the early values are usually not accurate enough to log as data and would cause mathematical errors.

2.3.10. File Menu

The menu functions located in the File menu are some of the programs basic utilities File management printing and some program setup utilities.

File...Save Data As (hotkey Ctrl+S)

This command will open a standard windows file dialog prompting you for a name in which to save the current test data. Once given a filename you can then click on OK to complete that task.

File...Update ResCal 2.0 File

Selecting this will open up a file converter option in ResCal v3.x that will rewrite ResCal v2.0 files in a format usable in this version.

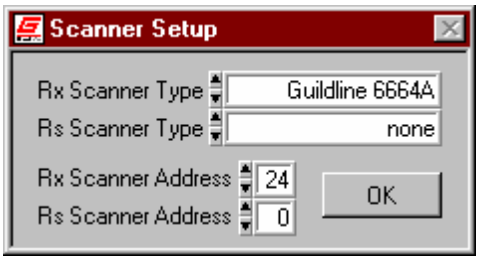
File...Printer Setup

This will call up your windows printer configuration editor so that you can prepare your printer for any documents you will need to print out of ResCal.

File...Print Window (hotkey Ctrl+P)

This menu item will print the contents of the main window through your windows default printer.

File...Set Scanner



Selecting this item will open the Scanner Configuration window in which you can assign the type and address of the scanner you will be using on both the Rs and Rx channel. This information will be saved in the 6675.ini file so that you will not have to set the scanners up again unless there has been a change. To assign the scanner, select the scanner type in the ring control of the "scanner type" and enter the GPIB address in the field associated with it. Do this for both the Rs side and Rx side of the 6675/A.

File...Rescan For 6675

This function when selected, will open a GPIB scanning utility that will query all 32 possible addresses for the 6675A Bridge. The address of the bridge that is found will be saved in the 6675.ini file so that ResCal will check that address first at startup

File...Reinitialize All To Default

This command will clear all of the stored data within the internal math functions and set all controls to their original state.

File...Exit (hotkey Ctrl+X)

This item, when selected, will exit you from ResCal.

2.3.11. Configuration Menu

The Configuration menu contains links to all the configuration windows used in creating device files and the test setup.

Configuration...Resistor

This menu item opens the Resistor Configuration window for you to create and edit "*.RES" or resistor files. One of these files is required on the Rs channel for all measurements and a second file will be needed on the Rx channel if the test is a resistance measurement.

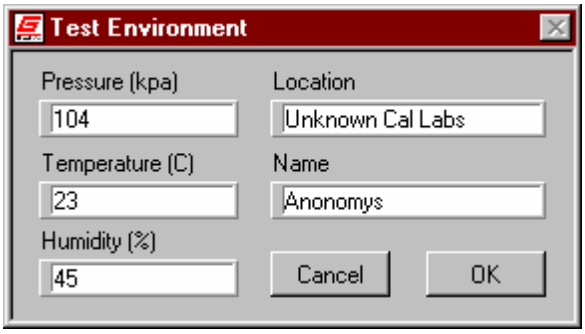
Configuration...Probe

Selecting this menu item opens the Probe Configuration window for you to create and edit "*.PRB" or probe files. One of these files is required on the Rx channel if the test is a temperature measurement.

Configuration...Test

This menu item opens the Test Configuration window for you to create and edit "*.SEQ" or test sequence files. From this window you also initiate the actual test. You start the test by clicking on "OK". If you do not wish to start the test then remember to click on "Cancel".

Configuration...Environment



Clicking on this option brings up a window where you can log the test variables external to the direct system. These items include pressure, room temperature, and humidity. You also have a place to log your name as the test operator and the company/lab name. These items will get logged into each test and shown in the Test Overview. All of these items will remain in active memory as log as the program is running with the exception of the company name that is also saved in the 6675.ini file so that it can be reloaded as a default value to this field next time the program is started.

2.3.12. View Menu

The View menu has all the features in it that are used to display test information. Most of these items are used with sample data.

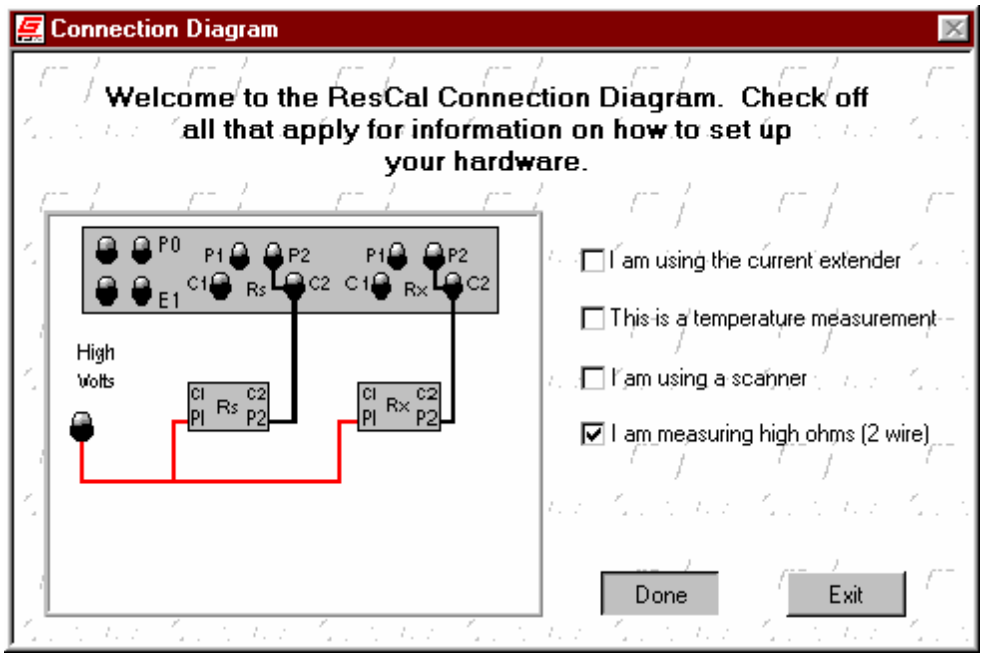
View...Test Overview

The Test Overview window will appear when you select this item. Inside the Test Overview is where you will be able to view your test along with the post test analysis completed by ResCal.

View...History Chart

Selecting this function will bring up a window quite similar to the Test Overview window. This window is called the History Chart. In here you will be able to group data from multiple tests for your analysis.

View...Connection Diagram



Clicking on this menu item will bring up the Connection Diagram window. This is the only test information window that is more for pre-test in that it used to serve as a guide on how to set up your hardware for your test. To use this guide you will need to select the checkboxes that describe your measurement and then click on the view button. The viewer window will then show a suggestion on how to set up the hardware.

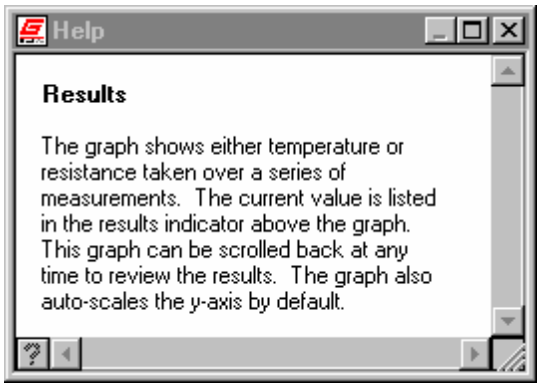
View...Load Data File In Excel

This feature prompts you to select a test file and then will load it into Excel for Microsoft Office. This will then allow you to apply your own custom data analysis to your tests.

2.3.13. Help Menu

In the Help menu you will find three selections that will assist you. They include information such on the operation of ResCal, and contact information for Guildline Support.

Help...Show Help (hotkey Ctrl+H)



This function will open a small window that will display a quick description of the control or indicator your mouse pointer is hovering over. This window will update itself as you hover over other controls and indicators throughout all of the windows in ResCal. This window will remain on top of all others until you click on the close button.

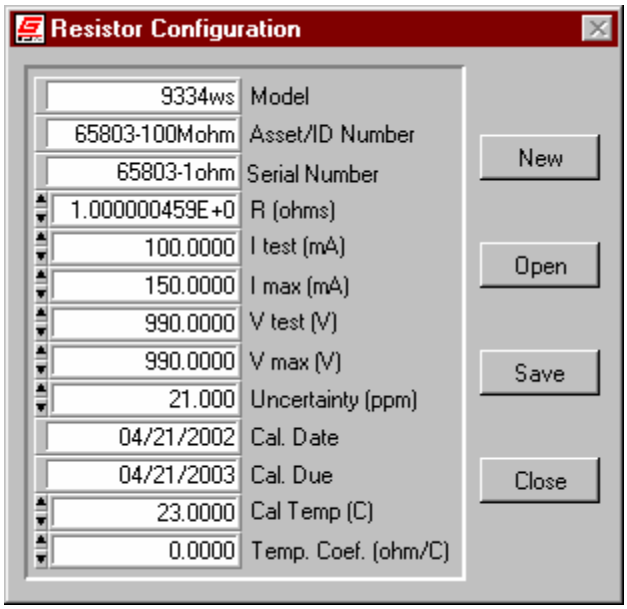
Help...Help

This menu selection will open up the windows help file which is your on-line reference guide. The help file can be navigated through hyperlinks and the search engine.

Help...About

Selecting this item will open a window that displays the program version number and how to contact Guildline Instruments. If you have an active connection to the internet you can click on the web address shown in the window to automatically open Internet Explorer and load our home page. Here you can access even more information about Guildline and our products.

2.4. RESISTOR CONFIGURATION WINDOW



The Resistor Configuration window is where you can create and edit "*.RES" or resistor files that are used by ResCal. These files serve as a profile for ResCal from which to make measurements using that resistor.

2.4.1. Creating a Resistor File

In the Resistor Configuration window there are several fields to be filled in. The "Serial Number", "Asset/ID Number", and "Model Number" fields will help you keep track of specific resistors, along with the "Cal. Date", "Cal. Due", "Cal. Temp. (C)" and "Temp. Coef. (ohm/C)". The "R(ohms)" field is where you enter the known or approximate value of the resistor. When this field has been entered for the first time the "Imax(mA)", "Itest(mA)", "Vmax(V)", and "Vtest(V)" fields will automatically be set to recommended values. These values can all be changed by selecting the corresponding field and typing in your own value. The "Imax(mA)" field is the maximum current you wish to allow through the resistor if it is connected to the Rs side of the 6675/A. The "Itest(mA)" sets the test current for the resistor if it is placed on the Rx side of the bridge. The "Vmax(V)" field is the maximum voltage you wish to apply to the resistor if it is connected to the Rs side of the 6675/A. The "Vtest(V)" sets the test voltage for the resistor if it is placed on the Rx side of the bridge. Always use caution when setting these values, as using wrong values will result in bad data or even failed tests. And lastly there is the "Uncertainty(ppm)" field where you can state any known inaccuracy of the resistor's value. Once you have all the information in place you must save the resistor file so that it can be used during the test.

2.4.2. Saving a Resistor File

To save the resistor configuration that is currently being displayed you click on the "Save" button. This will call up a Windows file dialog prompting you for a file name for

your resistor configuration. Type out the name you wish to call the configuration and click on save. The file extension ".RES" will automatically be added your saved Resistor Configuration.

2.4.3. Loading a Resistor File

To load a resistor configuration that has previously been saved, click on the "Open" button in the Resistor Configuration window. A standard Windows file dialog will prompt you to select a file with ".RES" extension. You then find and select the file of choice, highlight it, and then click on open.

2.4.4. Editing a Resistor File

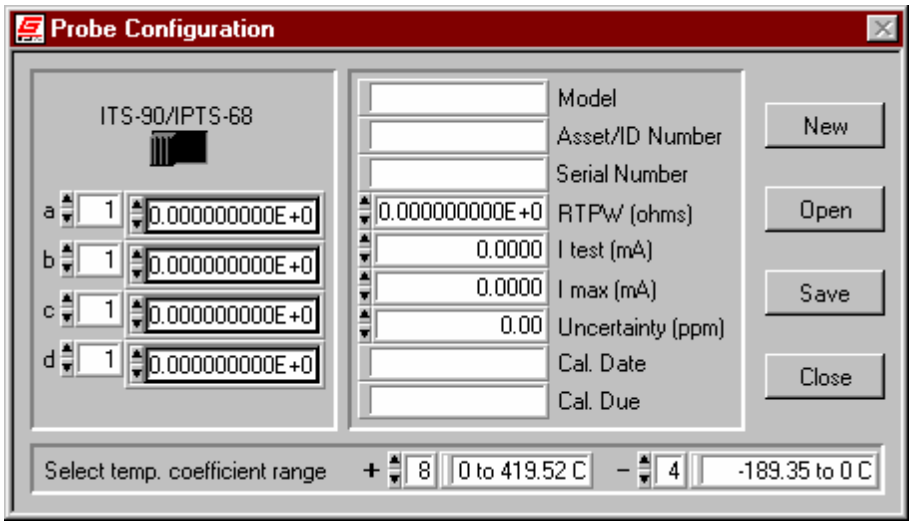
To edit an existing resistor file you need to open the file into the Resistor Configuration window. While the configuration is in the window you can change the fields to reflect the desired resistor configuration. When this is complete you merely save the new resistor configuration using the same name to overwrite the old file or a new name to keep both resistor configurations. You can then click on "Close" to close the Resistor Configuration window.

2.4.5. Resistor File Format

The resistor file consists of these twelve lines. The first acting as a header and the other eleven are read in as a configuration file. This file is stored as standard ASCII text and can be opened by any text editor. It is possible but not recommended that you edit these files outside the ResCal program.

```
[Resistor]
R=1.0000000E+1
Serial=34555
Itest=3.1306549E+1
Imax=1.0000000E+2
ppm=1.2000000E-1
Date=04/21/1999
Due=04/21/2000
Vtest=3.0000000E-1
Vmax=3.1622777E-1
caltemp=2.3000000E+1
coef=0.0000000E+0
```

2.5. PROBE CONFIGURATION WINDOW



The Probe Configuration window is where you can create and edit "*.PRB" or probe files that are used by ResCal. These files serve as a profile for ResCal from which to make measurements using that probe.

2.5.1. Creating a Probe File

In the Probe Configuration window there are many fields to be filled in. The "Serial Number", "Asset/ID Number", and "Model Number" fields will help you keep track of specific probes, along with the "Cal. Date" and "Cal. Due". The "RTPW(ohms)" field is where you enter the known triple-point of water resistance of the probe. When this field has been entered for the first time the "Imax(mA)" and "Itest(mA)" fields will automatically be set to recommended values. These values can all be changed by selecting the corresponding field and typing in your own value. The "Imax(mA)" field is the maximum current you wish to allow through the probe. The "Itest(mA)" sets the test current for the probe. Always use caution when setting these values, as using wrong values will result in bad data or even failed tests. And lastly there is the "Uncertainty(ppm)" field where you can state any known inaccuracy of the probe's value. Once you have all the information in place you must save the probe file so that it can be used during the test.

2.5.2. Setting Temperature Coefficients

Unlike resistor files, probes files also have coefficients that are used to mathematically to convert the probe resistance to temperature. There are two standardized sets of coefficients that ResCal will accept. They are the ITS-90 scale and the IPTS-68 scale for temperature conversion. You can enter the desired coefficient set by selecting the ITS-90/IPTS-68 switch. you will notice that the fields will change to suit each scale. You can in fact enter both sets of coefficients for any probe then merely select your scale of choice for the test. If you choose to use the IPTS-68 scale you must fill in at least those four coefficients for proper calculations. If the ITS-90 scale is the scale you will use you

need only to enter the coefficients that exist within the test's operating temperature range for the ITS-90 scale. However you can store all the coefficients for that probe in one file and merely select the ITS-90 range you wish to use before you start the test. You can select this range with the given controls for the positive and negative ranges at the bottom of the Probe Configuration window.

2.5.3. Saving a Probe File

To save the probe configuration that is currently being displayed you click on the "Save" button. This will call up a Windows file dialog prompting you for a file name for your probe configuration. Type out the name you wish to call the configuration and click on save. The file extension ".PRB" will automatically be added your saved Probe Configuration.

2.5.4. Loading a Probe File

To load a probe configuration that has previously been saved, click on the "Open" button in the Probe Configuration window. A standard Windows file dialog will prompt you to select a file with ".PRB" extension. You then find and select the file of choice, highlight it, and then click on open.

2.5.5. Editing a Probe File

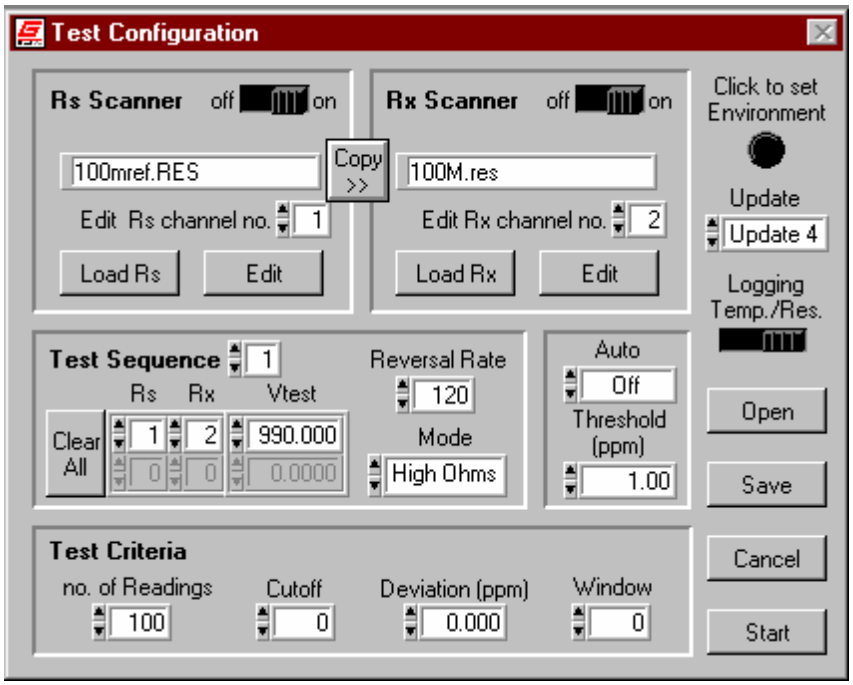
To edit an existing probe file you need to open the file into the Probe Configuration window. While the configuration is in the window you can change the fields to reflect the desired probe configuration. When this is complete you merely save the new probe configuration using the same name to overwrite the old file or a new name to keep both probe configurations. You can then click on "Close" to close the Probe Configuration window.

2.5.6. Probe File Format

The probe file consists of these fourty-three lines. The first acting as a header and the other fourty-two are read in as a configuration file. This file is stored as standard ASCII text and can be opened by any text editor. It is possible but not recommended that you edit these files outside the ResCal program.

```
[Probe]
R=1.0000000E+2
Itest=4.9500000E-1
Imax=1.0000000E+0
Serial=84785
ppm=5.0000000E+0
Posrange=7
Negrange=1
Scale=FALSE
a1=4.8539000E-7
a2=0.0000000E+0
a3=0.0000000E+0
a4=0.0000000E+0
a5=0.0000000E+0
a6=0.0000000E+0
a7=0.0000000E+0
a8=0.0000000E+0
a9=0.0000000E+0
a10=0.0000000E+0
a11=0.0000000E+0
b1=7.8652800E-7
b2=0.0000000E+0
b3=0.0000000E+0
b4=0.0000000E+0
b5=0.0000000E+0
b6=0.0000000E+0
b7=0.0000000E+0
b8=0.0000000E+0
b9=0.0000000E+0
c1=5.2165000E-8
c2=0.0000000E+0
c3=0.0000000E+0
c4=0.0000000E+0
c5=0.0000000E+0
c6=0.0000000E+0
c7=0.0000000E+0
d=7.5928400E-12
A=0.0000000E+0
B=0.0000000E+0
sB4=0.0000000E+0
E4=0.0000000E+0
Date=03/21/1999
Due=09/21/1999
```

2.6. TEST CONFIGURATION WINDOW



In the Test Configuration window you will be able to select which resistor and/or probe files you will need for your test(s). You can also control from this panel, the number of tests taken and their order, as well as the amount of samples within those tests. The controls for the Auto Reversal Rate feature can also be accessed on this panel.

When working in this window use caution as clicking on the "Start" will execute the test configuration as displayed. Be sure to click on "Cancel" if you do not wish to execute the test but wish to close this window.

2.6.1. Rs/Rx Scanner Switch

When you have opened up the Test Configuration window you can choose to enable scanners on both the Rs and Rx channels. Turning the scanner switch "on" will set up the use of a scanner on that channel and make a control appear allowing you to edit the contents of any channel on the scanner.

2.6.2. Load Rs/Rx Buttons

Clicking on the "Load Rs" or "Load Rx" button will bring up a Windows dialog box searching for the resistor file that will be loaded for the respective channel. If you are in temperature mode the Rx channel will load probe files instead of resistor files. Loading a channel with a scanner enabled on it will instead load the chosen file to the scanner channel number and will then need to be accessed by selecting the scanner channel number in the test sequence.

2.6.3. Edit Button

The "Edit" button will call up the Resistor or Probe Configuration window whichever is pertinent. This will allow you to edit an existing file or create a new one without having to exit from the Test Configuration window. When you have completed your editing closing the window will NOT load the file you are editing into your test configuration as that file may already be loaded.

2.6.4. Copy Button

The "Copy" button will copy the resistor profiles loaded on the Rs scanner to the Rx scanner to remove the need for repetitive work when configuring both scanners the same or using a shared scanner.

2.6.5. Mode

The Mode control allows you to set ResCal up to use the 6623 range extender for low ohms measurements or 2-wire high ohm measurements. For low ohms you select the desired range on which you will be using the extender. By leaving the control in the off position to you will be set for normal ohms measurements.

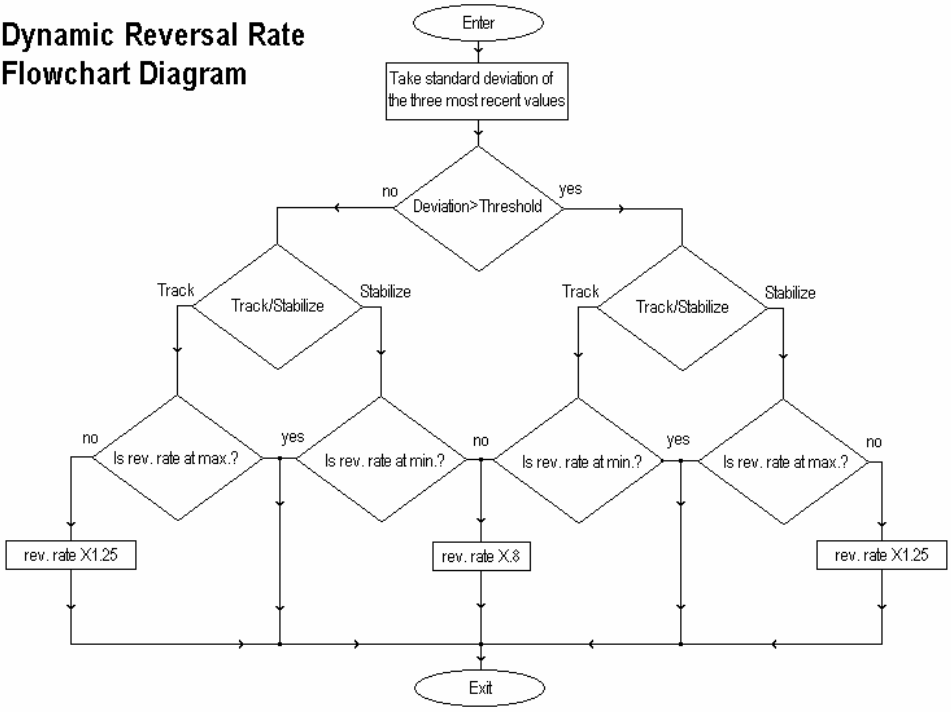
2.6.6. Reversal Rate

The reversal rate control has three functions on the Test Configuration window. That function is determined by Auto Reversal Rate mode. When that mode is set to off, the reversal rate entered is the reversal rate for the test. In the tracking mode the entered value is the upper limit of the changing reversal rate. Inversely in stabilization mode the entered value is the lower limit of the changing reversal rate.

2.6.7. Auto Reversal Rate

Auto Reversal Rate is a feature in ResCal that lets the computer locate the optimum reversal rate based upon your criteria for drift and accuracy. The Auto Reversal Rate obtains the criteria needed for this decision process from a combination of user set "Threshold" control, the deviation of the three most recent values, and measurement type (tracking or stabilization). This is a real time process during the measurement cycle that dynamically updates the reversal rate to accommodate for any changes encountered. To enable any of the Auto Reversal Rate modes you can click on the ring control labeled "Auto" in the Test Configuration window.

Dynamic Reversal Rate Flowchart Diagram



2.6.8. Threshold Control

The Threshold control is where you can establish the guideline that the Auto Reversal Rate will follow. The threshold is defined as, "at which magnitude of standard deviation will the Auto Reversal Rate choose to increase or decrease the reversal rate." While taking a resistance measurement this can be thought of as the ceiling for how much noise or drift (in ppm) you will allow before ResCal will slow down the reversal rate to gain more stable readings. If you are taking a temperature measurement this value will determine (also in ppm) at which magnitude of slope that it is felt that the temperature is moving and will speed up the reversal rate to track it.

2.6.9. Test Sequence

Setting the Test Sequence is where you get to choose the order of events as to which channel of the scanner(s) will be enabled for each test. This meaning that your resistors and probes that you have assigned to a scanner channel now can be accessed in any order you desire. You simply click your mouse into the first Rs field and choose the scanner channel that contains the resistor you wish to use. Then do the same for the Rx channel. You will need to specify the test current value in the space provided beside the channel numbers. If you are not using a scanner for either Rs or Rx, then leave that side at the default of 0 for the scanner channel number. Using the control above the scanner channel entry fields you can scroll down to access more fields to add to your sequence. Note that the number in the scroll control is the number of the test or scanner setting for the top line in the Test Sequence.

2.6.10. No. of Readings

The "No. of Readings" control allows you to select how many samples you wish to log of the test(s) you execute. ResCal will use this number to know when to stop the current test and carry out the next test if there is more than one test in the sequence.

2.6.11. Cutoff

The cutoff control is where you select how many rough readings at the beginning of a test you would like to take before logging or using the data. This will not change how many values are recorded, but adjust the overall length of the test.

2.6.12. Deviation

The deviation control is where you define what is an acceptable amount of deviation to satisfy your criteria and carry on to the next test. If this field or the "Window" field is left at zero ResCal does not enable deviation as a test criteria.

2.6.13. Window

Window is a control that lets you vary the sample size of the standard deviation calculation. This allows you to specify over how many readings you require a given standard deviation. If this field or the Deviation field is left at zero ResCal does not enable deviation as a test criteria. When deviation is used as a test criteria the test will continue until the standard deviation of the last "Window" sample size falls within the "Deviation" limit or until the "no. of Readings" has been reached.

2.6.14. Logging

The logging control allows you to select the type of test that is being recorded. You may choose to have the test values logged in ratio (resistance test), or in Celsius (temperature test). The type of logging relates to how the test viewer will display the data.

2.6.15. Update Control

The "Update" control allows you to set the update rate in which you receive a reading from your 6675A. Update 4 is the fastest returning a value at every reversal. Update 2 returns a value at every second reversal and Update 1 every 4 reversals. In all cases a reading is still taken every reversal. The slower modes, however, are returning an average of all the readings within that period.

2.6.16. Setting the Environment

Environmental settings is where you can log the conditions under which the test is being executed. Here you enter in the values for test area temperature, humidity, and pressure. As well as the company/lab name and test conductor. To set the environment click on the indicator for the environment on the Test Configuration window. This action will bring up the window with the fields to edit these settings. Click on "OK" to accept the changes and the window will close and update the new information. The indicator will also display that the environment log has been set.

2.6.17. Saving a Test Configuration

To save the test configuration that is currently being displayed you click on the "Save" button. This will call up a Windows file dialog prompting you for a file name for your test configuration. Type out the name you wish to call the configuration and click on save. The file extension ".SEQ" will automatically be added to your saved Test Configuration.

2.6.18. Loading a Test Configuration

To load a test configuration that has previously been saved, click on the "Open" button in the Test Configuration window. A standard Windows file dialog will prompt you to select a file with ".SEQ" extension. You then find and select the file of choice, highlight it, and then click on open.

2.6.19. Editing a Test Configuration

To edit an existing test configuration you need to open the file into the Test Configuration window. While the configuration is in the window you can change the fields to reflect the desired test configuration. When this is complete you merely save the new test configuration using the same name to overwrite the old file or a new name to keep both test configurations. You can then click on "OK" to execute the test or "Cancel" to close the window and not start the test.

2.6.20. Test Configuration File Format

The test configuration file consists of these seventeen lines. The first acting as a header and the other sixteen are read in as a configuration file. This file is stored as standard ASCII text and can be opened by any text editor. It is possible but not recommended that you edit these files outside the ResCal program.

```
[Sequence]
Threshold=80.000000000
Auto=1
Revrate=30
Mode=0
Window=0
Devi=0.000000000
Update=2
Cutoff=5
Readings=200
R/T=FALSE
ScanRs=FALSE
ScanRx=FALSE
SequenceRs=25-
60538A.RES\09\09\09\09\09\09\09\09\09\09\09\09\09\09\09\09\09\09\09\09\09\09\0
9\09\09\09\09\09\09\09\09\0D\0A
```

SequenceRx=162ce-
1603.PRB\09\09\09\09\09\09\09\09\09\09\09\09\09\09\09\09\09\09\09\09\09\09\09\09\09\09\09\09\09\09\09\09\0D\0A
Itest=""
TestSequence=""

2.7. DATA LOGGING

As with any data acquisition software the primary purpose is to retrieve and store data. If the configuration is set for a single measurement you will need to save your test before starting the next one. While configured to take multiple measurements, ResCal will automatically save to a self generated filename, so that it can proceed to the next test in the sequence.

2.7.1. Saving a Data File

To save the data file that is currently being displayed on the main window you can go to the menu bar and select "File...Save Data As" or use hotkey "Ctrl+S". You will then see a Windows file dialog prompting you to save the information in a *.TST file. This file can then be recalled by the Test Overview window for review. If you have chosen to save a file that has the same name and path as another file you will get a warning message. In this message you are given the choice to cancel the saving operation or replace the other file with the one you are trying to save.

2.7.2. Saving Multiple Files

Saving multiple files is used when there is a scanner enabled on either one or both of the channels. There is actually nothing you need to do, as the user to set up the files that are saved, other than you should be aware of how the file names are generated. ResCal will use the file names of the units under test on the Rs and Rx channels.

As an example:

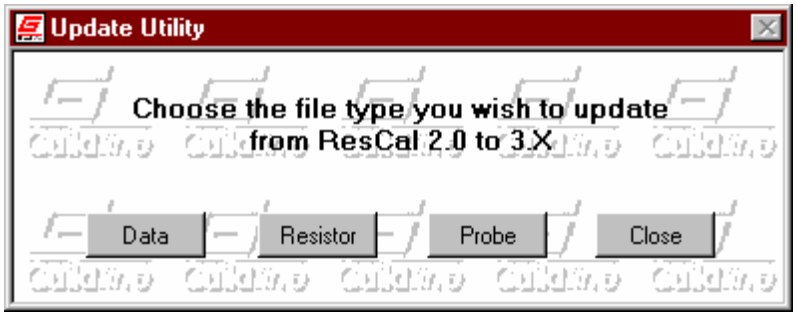
```
standard.RES vs. measured.RES.TST
```

or

```
standard.RES vs. measured.PRB.TST
```

The format as can be seen above, (Rs channel) vs. (Rx channel).TST, is used to automatically generate the test filename. Knowing this will be important for you to keep track of your data and prevent any conflicts in your file system.

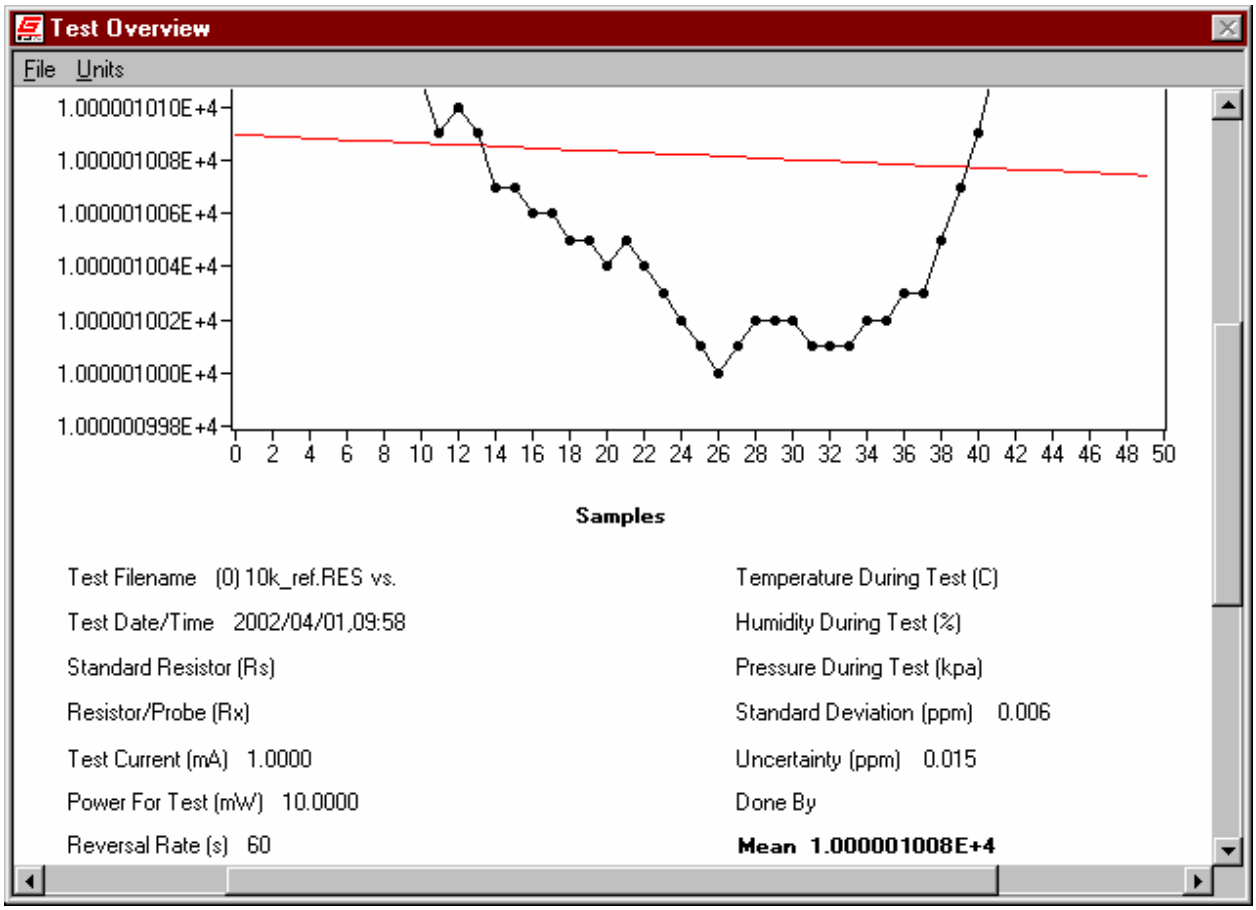
2.7.3. Updating ResCal v2.0 Files



To update your previous data files that were created in ResCal v2.0 go to the menu bar on the Main window and select "File...Update ResCal 2.0 File". This will open a window with some utilities for you to convert your old data and device files to the format used in ResCal v3.x. You are given three different file type options. "Data" will open a Windows file dialog that is looking for a "*.DAT file". When you have selected the file you wish to convert the utility will bring up another file dialog. This dialog will wait for you to enter the name for the converted file and then add the extension "*.TST" to that name. The next option "Resistor" will take you through the same procedure but for a resistor file. But remember to exercise caution with resistor files as both versions of ResCal use the same extension *.RES. Lastly there is the "Probe" option which will convert a ResCal v2.0 "*.PRT" file to a ResCal "*.PRB" file in the same manner as the resistor and data files.

There are some files which are used in ResCal v2.0 that can not be updated. These files are "*.DEV" files which define the scanners that you would use with the 6675A. These are no longer needed with ResCal as the scanner control drivers are embedded into the program itself. The other type that cannot be updated is the "*.MEA" file which in most respect is the functional equivalent of "*.SEQ" file used by ResCal. They are both test configuration files but the information from one type to the next is inconclusive due to the differences in how ResCal v3.x operates from v2.0.

2.8. TEST OVERVIEW WINDOW



The Test Overview window is where you can load and edit saved test data. This window will complete a data analysis of the loaded test to give a graph with the best fit curve as well as mean, standard deviation and uncertainty calculations. These are all displayed in a clean organized report format which can be printed out.

2.8.1. Viewing a Test

To open a previously made test file to be viewed select "File...Open" from the menu bar or use hotkey "Ctrl+O". This will bring up a standard Windows file dialog that is looking for "*.TST" files. Highlight the file of choice and click on open.

2.8.2. Saving a Test Overview

When test files are initially created there was no opportunity to add your own notes. For this reason you can save a currently loaded test file from the viewer. While in the viewer you can alter the "notes" to place any additional information that is not represented in the given information by the viewer. You can save the file by selecting "File...Save" or by using hotkey "Ctrl+S". In the file dialog that comes from selecting the save function you can choose a new name for the file or use the same name to overwrite the updated file. If you choose to overwrite or your new name already exists you will get a warning message

asking if you wish to replace the older file or cancel the operation. Click on replace if you are sure that you do not need the older copy.

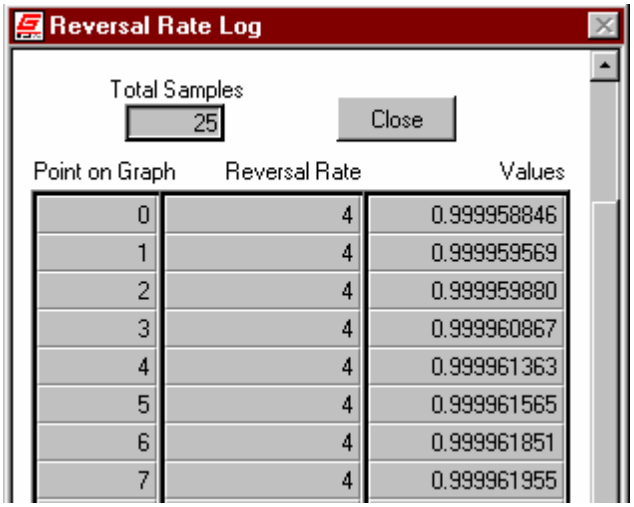
2.8.3. Selecting Units

In the test file viewer you have the option to view your data in the most common units used for the data being displayed. All resistance measurements can be viewed as a ratio (default) or in Ohms. As for temperature the units available are Kelvin (default), Celsius, and Fahrenheit. You can change the displayed units after loading the file and the viewer will convert the units for you and update the graph. This function is accessed through the menu bar under "Units". The current unit will be checked off and unavailable selections will be disabled. To change the unit just select the one you want from the available options in that drop menu.

2.8.4. Crop Tool

The crop tool is a utility to allow you to remove unwanted extra data from the test in which you are viewing. When you select the crop tool a small window will open with a start and a go to field. Here you select the range of points you wish to keep. Click on the OK button and your data will be updated. The crop tool does not permanently affect your saved data. To keep the changes made by the crop tool you must resave your data.

2.8.5. Viewing the Reversal Rate Log



In ResCal data is not stored based on a timeline, samples are based on an incrementing sample number. This is because using the dynamic reversal rate removes the measurement time as a constant variable. For those instances where the timeframe is necessary information, the reversal rate for each measurement is logged. This log can be accessed from the menu bar by selecting "File...View Reversal Log". The Reversal Log will pop up in a scroll window displaying the total number of samples and each sample's reversal rate and value. When you are finished with the reversal log click on the "Close" button.

2.8.6. Printing a File

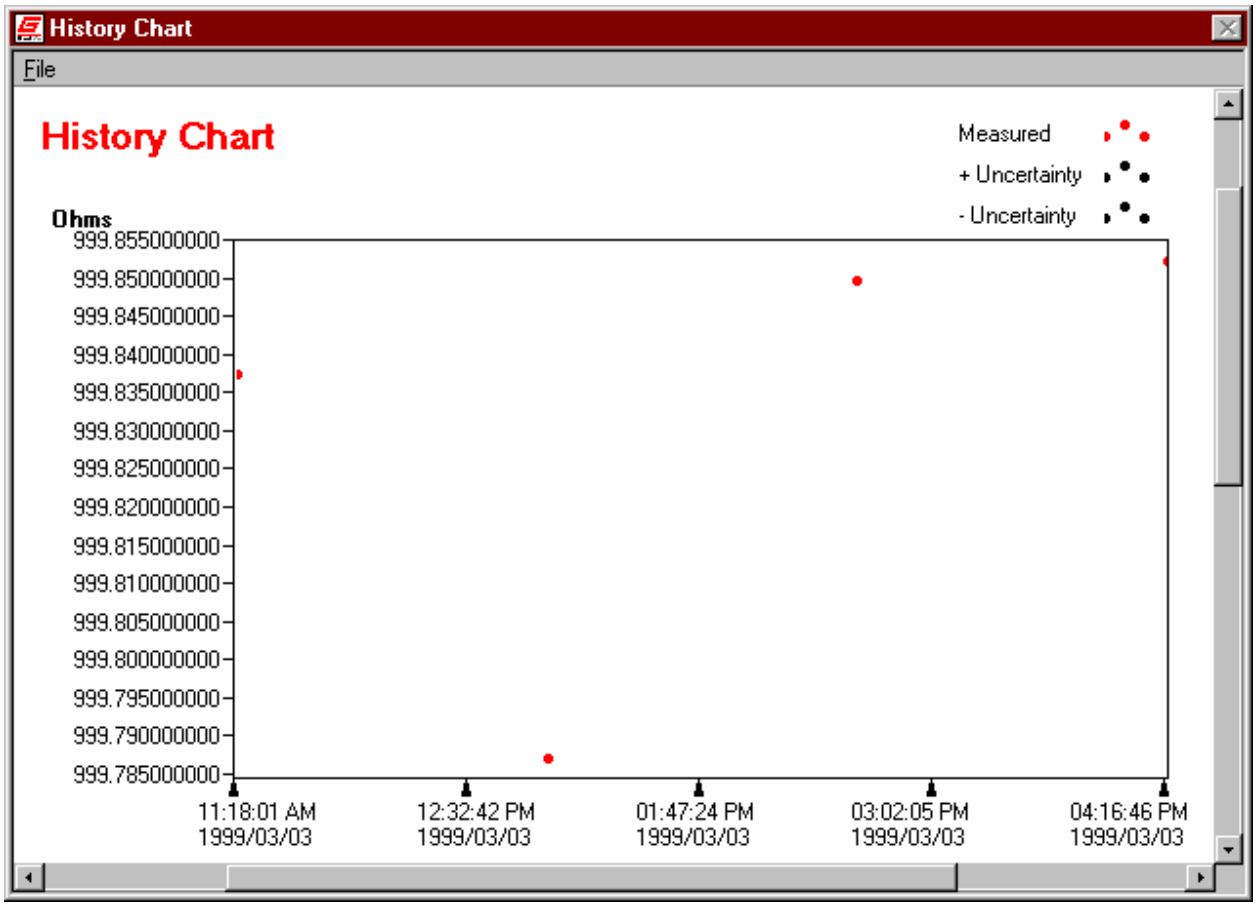
To print the information currently being displayed to you go to "File...Print Window" or use hotkey "Ctrl+P". This function will print out a one page document that will have the same layout as the contents of the display window.

2.8.7. Test File Format

The test file consists of a minimum of sixteen lines. The first fourteen are read in as a configuration file and all other lines are the stored data and reversal rate information. This file is stored as standard ASCII text and can be opened by any text editor. It is possible but not recommended that you edit these files outside the ResCal program.

```
Rs=25.000000000
Ro=25.550462000
uncertainty=0.050000000
STDserial=60538A
TSTserial=
Time=1999/03/03,14:26:19
Itest=0.9900
Power=0.0250
Humidity=
Pressure=
Temp=
Name=
Place=
Notes=
39.993714300    39.993742115    39.993745344    39.993757513…
30.000000000    30.000000000    30.000000000    30.000000000…
```

2.9. HISTORY CHART WINDOW

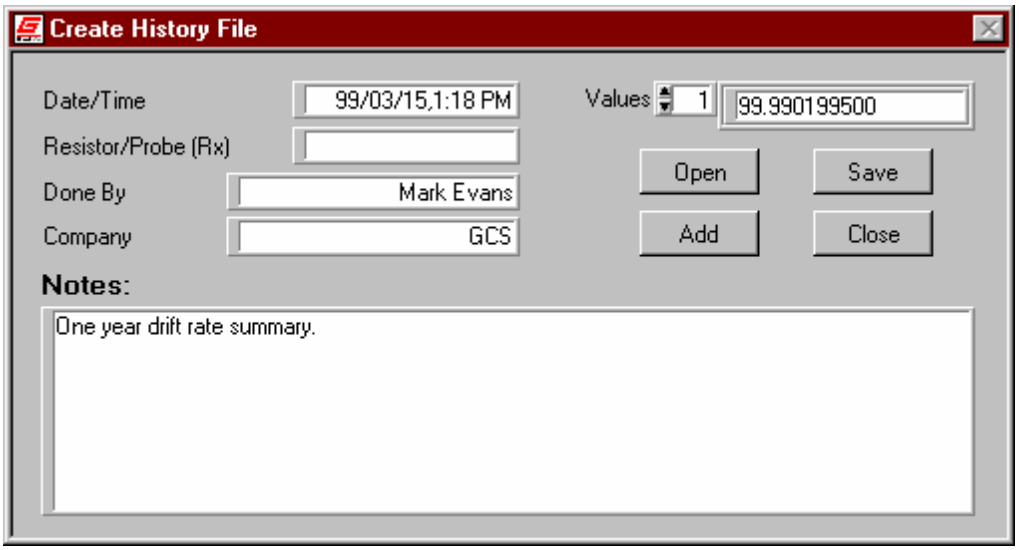


The History Chart window is similar to the Test Overview window except that the viewer is made to open and create "*.HIS" or history files. History files are cumulated test "*.TST" file data grouped into one file for the purpose of analyzing many measurements on the same resistor.

2.9.1. Viewing a History File

To open a previously made history file to be viewed select "File...View" from the menu bar or use hotkey "Ctrl+V". This will bring up a standard Windows file dialog that is looking for "*.HIS" files. Highlight the file of choice and click on open.

2.9.2. Creating a History File



History files are created from concatenated data of more than one test file. This is geared for tracking the long term data of the resistor under test. This is done by going to the menu bar and selecting "File...Editor" or hotkey "Ctrl+E". A file editing window will appear asking the you to enter your name as the file's creator, and the company name. From this window you click on the "Add" button and choose the first file you wish to use. You will notice that the "Date" and "Rx" test serial number fields have been updated. You can view the actual data in the "Values" array indicator in the file creation window. You then repeat this process for all the files you wish to group. When you have all your data in place you should then enter your name, company, as well as any additional notes you wish to store with the document.

You can also click on the "Open" button to load an existing history file to update in this manner.

2.9.3. Printing a History File

To print the information currently being displayed to you go to "File...Print Window" or use hotkey "Ctrl+P". This function will print out a one page document that will have the same layout as the contents of the display window .

2.9.4. History File Format

The history file consists of eight lines. The first five are read in as a configuration file and all other lines are the stored data. The sixth line is time (number of seconds since midnight Jan. 1, 1904). The seventh line is the mean value in ohms. The eighth line is the uncertainty in ppm. This file is stored as standard ASCII text and can be opened by any text editor. It is possible but not recommended that you edit these files outside the ResCal program.

```
TSTserial=
Time=3/9/99,9:21 AM
Name= John Doe
Place= Guildline Calibration Services
Notes=
3003329503      3003325447      3003322681      3003340606
999.837404403   999.786986295   999.849730807   999.852198273
0.002581        0.056895        0.009123        0.013972
```

2.10. ERROR MESSAGES

While using ResCal if problem occurs, error messages will pop up to guide you towards a solution. Below is a list of the error messages placed into ResCal and there associated number as referred to by the 6675A.

Error 0: Test canceled... There has been a detector communication failure. Restart the 6675A and retry your test. If this problem persists please contact your local Guildline representative, or technical support.

Error 1: Test canceled... Invalid test setup. Please check your settings and retry.

Error 2: Test canceled...
The servo has railed. Check your hardware setup and also be sure the ratio is not too high. If this problem persists please contact your local Guildline representative, or technical support.

Error 3: Test canceled...
The nanovoltmeter is not responding. Restart the 6675A and retry your test. If this problem persists please contact your local Guildline representative, or technical support.

Error 4: Test canceled...
The null has gone out of range. Check your test settings and retry. If this problem persists please contact your local Guildline representative, or technical support.

Error 5: Test canceled...
The maximum test has been exceeded. Please check your settings and retry.

Error 6: Test canceled...
The EEPROM has failed, all values will be reset to default. Please retry your test.

Error 7: Test canceled...
No serial number specified. Enter in the serial number in the device file (*.RES, *.PRB) and retry.

Error 8: Test canceled...
The nanovoltmeter has gone out of range. Please check your setting and retry. If this problem persists please contact your local Guildline representative, or technical support.

Error 9: Test canceled...
The self test had failed. Restart the 6675A and retry your test. If this problem persists please contact your local Guildline representative, or technical support.

Error 10: Test canceled...
Invalid Password.
Retype the password and try again.

3. REMOTE CONTROL

The 6675A Automatic direct-current-comparator resistance bridge operates directly from the front panel or under remote control of an instrument controller, computer or terminal. Remote control can be interactive, with the user controlling each step from a terminal, or under the control of a computer running the 6675A in an automated system. It is also possible to connect a printer to the remote interface of the 6675A and have the 6675A output some or all of the measurements taken to the printer for a permanent record.

This chapter describes the interfaces and the commands to which the 6675A will respond. The setting of the IEEE-488 address and mode is described in Volume I.

3.1. INTERFACES

The model 6675A has two interfacing standards available:

1. An IEEE-488 interface conforming to IEEE-488.2.

2. A serial interface conforming to RS-232C.

The IEEE-488 connector is mounted to the rear panel. The IEEE-488 address defaults to a factory setting of 04. This setting can be viewed and set to a valid address using the front panel controls. Setting up the IEEE-488 address from the front panel is explained in Volume I Section 3.7.4.4.1.

The RS-232C connector is on the rear but it has to be configured from the front panel as explained in Volume I Section 4.2.

The 6675A can be operated in a system where both RS-232C and IEEE-488 interfaces are being used. It can be controlled with an IEEE-488 bus and a printer connected to the RS-232C output for permanent records of measurements.

In a system containing more than one controller, only one controller can exercise control while the other stays in dormant state until control is transferred.

3.2. IEEE-488 (GPIB) INTERFACE

The 6675A is fully programmable for use on the IEEE standard 488.1 interface bus (also known as the General Purpose Interface Bus GPIB). The interface is also 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 6675A can be operated on the IEEE-488 bus under the control of an instrument controller as a talker/listener.

This manual assumes that the user is familiar with the basics of the IEEE-488 interface bus.

The IEEE-488 interfacing standard applies to interface of instrumentation systems or portions of them, in which the:

- Data exchanged among the interconnected apparatus is digital.
- Number of devices that may be interconnected by one contiguous bus does not exceed 15.
- Total transmission path lengths over interconnecting cables does not exceed the lesser of either 20 metres or 2 metres times the number of devices on the bus.
- Data rate across the interface on any signal line does not exceed 1 megabit per second.

3.2.1. 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)[1] and/or optionally, the controller should assert the EOI data byte control signal to terminate the query command sequence.

3.2.2. 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).

3.2.3. Interconnecting Cable and IEEE-488 Connector.

The interconnecting cable of IEEE-488 consists of 24 conductors, 16 conductors are for carrying signals and 8 for grounding. Individual cable assembly should be up to 4 metres long and should have both a plug and a receptacle connector type at each end of the cable. Each connector assembly is fitted with a pair of captive locking screws.

3.2.4. Typical System.

Data Input/Output Lines - The 8 data I/O 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 bidirectional manner.

[1] The line-feed character may also be expressed as $0A_{16}$ or 10_{10} or 12_8 or control-J. Throughout this manual we will use the "C" programming language notation for expressing numbers in base 16, specifically 0x0A indicates that 0A is to be interpreted in base 16 (hex).

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)

3.2.5. 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 menuing system. If there is no controller and the 6675A is hooked up to a printer for hard copy then Talk Only mode should be selected as the preferred mode of operation.

3.2.6. IEEE-488 Electrical Interface.

The 6675A meets the subsets of the IEEE-488 interface specification IEEE-488.1 shown in Table 2.2. The pin connections on the IEEE-488 interface connector are shown in Table 2.1.

SH1 The 6675A has complete source handshake capabilities.

AH1 The 6675A has complete acceptor handshake capabilities.

T6 The 6675A has talker capabilities with a single primary address in the range 0 to 30. Extended addressing is not implemented. The 6675A does not support talk only.

L4 The 6675A supports basic listener with unaddress if MTA (My Talk Address) is received. The talk and listen addresses will always be the same. The 6675A does not support extended listen addresses. The 6675A does not support listen only.

SR1 The 6675A has complete service request generation capabilities.

RL1 All functions (except Remote) on the front panel of the 6675A can be locked out by the IEEE-488 controller.

PP0 The 6675A has no parallel poll capabilities.

DC1 The 6675A has full device clear capabilities.

DT0 The 6675A has no device trigger capabilities.
C0 The 6675A can never become the bus controller.
E2 The 6675A has all required electrical interface capability.

PIN	NAME	DESCRIPTION
1	DIO1	Data Input Output Line1
2	DIO2	Data Input Output Line2
3	DIO3	Data Input Output Line3
4	DIO4	Data Input Output Line4
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 safety ground)
13	DIO5	Data Input Output Line5
14	DI06	Data Input Output Line6
15	DIO7	Data Input Output Line7
16	DIO8	Data Input Output Line8
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 3-4: IEEE-488.1 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 3-5: IEEE-488 Device Capabilities

3.2.7. 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), hence if the programmer limits messages sent to the 6675A to 32 bytes and checks the IFL bit in the status register before sending each message, then under normal operating conditions the buffer should never overflow. If the buffer is full and the programmer sends more data, the 6675A will perform the necessary handshaking as per usual, but the data will be lost, this is done for two reasons:

1. If the buffer is full, the system programmer is probably in error since the 6675A should never become full (the 6675A interprets most commands in under 150 milliseconds).

2. The 6675A will never lock up the IEEE-488 bus.

3.2.8. IEEE-488 Output Buffering

Output from query commands are placed into a 256 byte output buffer. When the controller reads data from the 6675A the responses will come from the output buffer in, first in first out order. 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.

3.2.9. IEEE-488 Deadlock

If the controller demands a byte of data from the 6675A and the buffer is empty, the 6675A will set the Query Error flag in the Event Status Register.

3.3. RS-232C INTERFACE

The 6675A has an RS-232C interface which can be connected to a controller or to a simple printer. The controller (which can be almost any computer with an RS-232C interface) can control the 6675A through a variety of commands which allow setting the instruments operating parameters, and analyzing the measurements made by the 6675A. The simple printer interface can be used to log any or all of the measurements taken by the 6675A during normal operation.

When using the RS-232C port to remotely control the 6675A, either interactively with a terminal or under computer control, operation is the same as using an IEEE-488 controller connected to the IEEE-488 port for control, with the following exceptions:

1. The end of line input terminator is Carriage Return (0x0D).

2. There is no SRQ capability when using serial remote control. The status registers still behave as described in this chapter, but the 6675A serial interface does not have a way to perform the SRQ function.

3. There is no direct way to perform IEEE-488 hardware interface functions such as DCL (Device CLear) or SDC (Selected Device Clear).

3.3.1. RS-232C - Pin Designations.

Pin	Signal	Function	Direction
1	CHG	Chassis Ground	IN/OUT
2	TxD	Transmit Data	IN
3	RxD	Receive Data	OUT
4	RTS	Request To Send	IN
5	CTS	Clear To Send	OUT
6	DSR	Data Set Ready	OUT
7	GND	Signal Ground	IN/OUT
8	DCD	Data Carrier Detect	OUT
20	DTR	Data Terminal Ready	IN
All other pins not used or connected.			

Table 3-6: RS-232C Pin Designations

The 6675A Automatic direct-current-comparator resistance bridge is a data communication equipment (DCE) so TxD is an input (the data which the modem is to transmit).

3.3.2. RS-232C Responses.

The reply to any RS-232C query command will be a sequence of ASCII characters followed by a Carriage-Return character (0x0D) and then a Line-Feed character (0x0A). The Line-Feed character may also be expressed as 0A16 or 1010 or 128 or control-J. Throughout this document we will use the "C" programming language notation for expressing numbers in base 16, specifically 0x0A indicates that 0A is to be interpreted in base 16 (hex).

3.4. COMMAND LANGUAGE

The commands for IEEE-488 and RS-232C mainly correspond to the labels assigned to the front panel menus. Throughout this document when examples are given they apply to commands through the RS-232C interface or through the IEEE-488 interface. The examples will not show the termination characters since these differ for each of the interfaces (See sections 2.2.2 and 2.3.2).

3.4.1. General Syntax for Commands

The 6675A uses a sophisticated command parser which can usually determine which command was desired, even if the command is entered incorrectly. Some care should be taken when sending commands such as SYSTem:VERBose and SYSTem:VERSion? since the parser may not be able to decide which command was desired in the event of a gross misspelling (such as using VERBion instead of VERSion).

No command used in the 6675A 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..

Throughout this manual some of the command names will have an UPPER case portion and a lower case portion. The command may be shortened such that only the portion of the command name which was presented in UPPER case characters is present. The command parser of the 6675A is case insensitive (i.e. the letter case of commands sent to the 6675A does not matter), both UPPER case letters and lower case letters may be used.

3.4.2. General Syntax for Numbers

Numeric parameters may have up to 30 characters, and although the 6675A 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.

The portion of the command parser which interprets numeric input will correctly recognize most common forms of numeric input, for example the following are all valid methods of expressing the number 123.4:

123.4
123.4e00

0.1234E3
1234e-1
0000123.4

The following are examples of invalid forms of expressing a number:

123.4 e00	space between mantissa and exponent letter
1234D-1	exponent not e or E
n123.4	letter in front of the first digit
e34	missing mantissa

Multipliers (such a µ, m, k, and M) are not permitted on commands, all numbers must be entered in the base units, for example 100 mV can be expressed as 100e-3 or 0.100.

Expressions (for example 7 + 20 X 3) are not allowed as parameters.

3.5. REMOTE AND LOCAL OPERATION.

The 6675A can be operated using the front panel keys or it can be operated remotely using a remote controller. In addition the 6675A 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:

3.5.1. Local.

The 6675A responds to local and remote commands. This is also called "Front Panel Operation". Only remote commands that do not affect the state of the 6675A are allowed to execute. If the controller sends a command which would affect the instrument state while in local, the command will be ignored, and an Execution Error indication will be given.

3.5.2. Local With Lockout.

Local with lockout is identical to Local except that the 6675A will go into remote with lockout instead of the remote state when the 6675A receives a remote command. The local with lockout state is entered by sending an IEEE-488 LLO+REN command from the controller, or by sending the RS232 LOCKOUT command to the 6675A.

3.5.3. Remote.

When the Remote Enable (REN) line is asserted and the controller addresses the 6675A as a listener, the 6675A enters the remote state.

Front panel operation is restricted to the use of the Remote pushbutton. Pressing the Remote key or sending the GTL (Go To Local) interface message returns the 6675A to the local state.

3.5.4. Remote With Lockout.

The remote with lockout state can be entered from remote or local with lockout, but not directly from local. Remote with lockout is similar to the remote state but restricted: the Remote key will not return to the local state. To return the 6675A to the local with lockout state the controller must send a GTL interface command. To return the 6675A to the local state the controller must unassert the REN control line.

Table 2.4 summarizes the possible Remote/Local state transitions.

From	To	IEEE-488 Interface Command	RS-232C Interface Command
Local	Remote	MLA+REN	REMOTE
	Local/Lockout	LLO+REN	LOCKOUT
Remote	Local	GTL	LOCAL
	Remote/Lockout	LLO+REN	LOCKOUT
Local/Lockout	Remote/Lockout	MLA+REN	REMOTE
Remote/Lockout	Local	Not (REN)	LOCAL
	Local/ Lockout	GTL	None

Table 3-7: Remote/Local State Transitions

3.6. REMOTE COMMANDS

3.6.1. *ESE <unsigned> - Set Event Status Enable Register.

This command sets the standard event status enable register bits. When the bits in the Event Status Enable (ESE) register are "ANDed" with the bits in the Event Status Register (ESR) if the result is non-zero then the Event Status Bit (ESB) in the Status Byte (STB) register is set.

The values accepted for the *ESE command are between 0 and 255, all other values are considered to be an error. The default value for The Event Status Enable (ESE) register at power on is zero (0).

3.6.2. *ESE? - Event Status Enable Query

This command reports the current value of the Event Status Enable Register. The value returned will be between 0 and 255.

3.6.3. *ESR? - Event Status Register Query

This query allows the programmer to determine the current contents of the event status register. Reading the Event Status Register clears it.

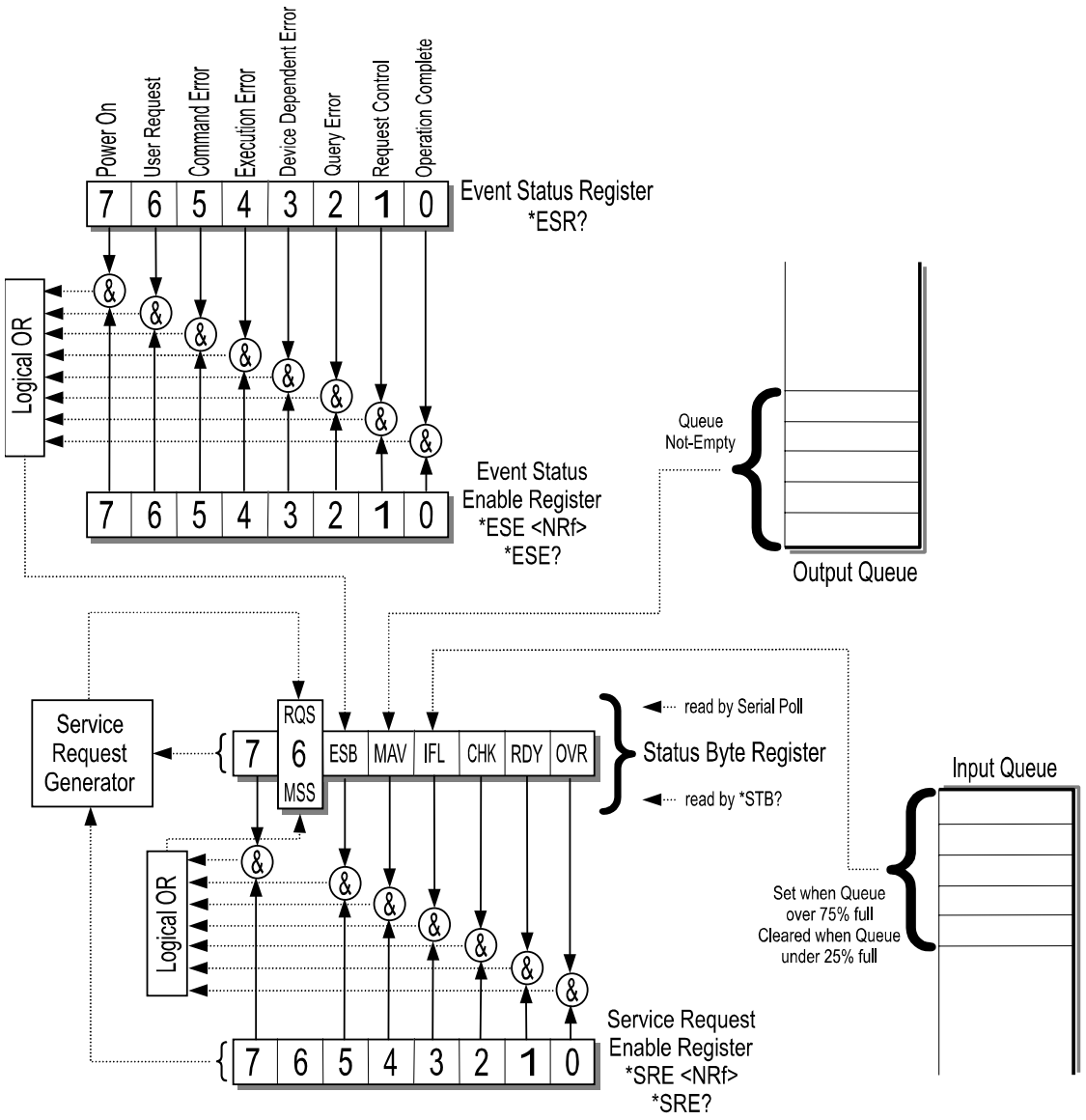


Figure 3-1 Event Status Bit Operation

3.6.4. *IDN? - Identification Query

This command causes the 6675A to reply with an identification string. The identification string is built up of four (4) fields delimited by commas (,). The first field is the manufacturer (i.e. Guildline Instruments), the second field is the model (i.e. 6675A), the third field is the serial number (i.e. 55065), and the final field is the firmware revision (i.e. A). A typical response might read:

```
Guildline Instruments, 6675A, 55065, A
```

The reply string will be shorter than 73 characters.

3.6.5. *OPC - Operation Complete

This command will cause the 6675A to set the Operation Complete bit (bit 0) in the Event Status Register. Since the 6675A processes all commands sequentially, the operation complete bit will be set as soon as the command is parsed.

3.6.6. *OPC? - Operation Complete Query

This query will place a numeric 1 in the output buffer indicating that all pending operations are complete.

3.6.7. *OPT? - Report Available Options

This query command reports the presence or absence of various options. The format of the reply is a series of arbitrary ASCII response fields seperated by commas. The first field reports the frequency of the power line (50 Hz or 60 Hz). The 6675A does not currently report any other options. The reply will be either:

60

or

50

3.6.8. *RST - Device Reset

This command is intended to return the 6675A to a known state, specifically a return to terse mode. This command will not affect the following:

1. The output queue.
2. The state of the IEEE-488 interface.
3. The selected address of the 6675A.
4. The *SRE setting.
5. The *ESE setting.
6. Calibration data that affects device specifications.

The *RST command will perform the following actions:

1. Select last used configuration.
2. Display data consistent with last used configuration.
3. The chart recorder output will be set to zero.
4. The Sync. output will be reset.
5. The key-press buffer will be cleared.

*RST is a MANDATORY IEEE-488.2 command.

Bit Location		Name	Description
0	LSB	OPC	OPeration Complete. This event bit generated in response to the *OPC *OPC? command. It indicates that the 6675A has completed any pending operations and that the parser is ready to accept more program messages.
1		RQC	ReQuest Control. This event bit indicates to the IEEE-488 controller that the 6675A is requesting permission to become the controller in charge. The 6675A will never set this bit.
2		QYE	QuerY Error. This bit indicates that an attempt is being made to read data from the output queue when no output is either present or pending, or that data in the output queue has been lost (queue over- flow). See also GPIB Deadlock.
3		DDE	Device Dependent Error. Not used.
4		EXE	EXecution Error. Set when 1) a program data element is evaluated to be outside the legal input range or is inconsistent with the 6675A's capabilities, 2) a valid program message could not be properly processed.
5		CME	CoMmand Error. Set when l) a syntax error has been detected by the parser, 2) a semantic error has occurred indicating that an unrecognized header has been received, 3) a Group Execute Trigger was entered into the input buffer inside a program message.
6		URG	User Request. Set when any key is depressed on the 6675A keyboard.
7	MSB	PON	Power ON. This bit is set after the 6675A is powered up.

Table 3-8: Event Status Register

3.6.9. *SRE <unsigned> -Service Request Enable Command

The service request enable command allows the 6675A to generate a service request on the IEEE-488 interface under a limited set of conditions. The limitations on the conditions are defined by the numeric parameter following the *SRE command. The numeric parameter is a decimal integer in the range 0-255. The numeric parameter when expressed in base 2 (binary) represents the bit values of the Service Request Enable Register. For all bits (except bit 6) a bit value of one (1) indicates an enabled condition and a bit value of zero (0) represents a disabled condition. *SRE? is the companion query command.

3.6.10. *SRE? - Service Request Enable Query

This command allows a programmer to determine the current contents of the Service Request Enable Register. A decimal number between 0 and 63 or between 128 and 191 will be returned.

3.6.11. *STB? - Read Status Byte Query

This command allows the programmer to read the status byte and master summary bits (shown in Table 2.6.).

The response from this command is a decimal integer in the range 0-255. This decimal integer when expressed in base 2 (binary) represents the bit values in the Status Byte Register. Note that the Master Summary Status bit and Not RSQ is reported in bit 6.

The Status Byte Register can also be read with the Read Serial Poll hardware command on the IEEE-488 interface.

3.6.12. *TST? - Query Results of Self Test

This command is intended to report the status of any self-tests performed by the 6675A. If the 6675A passes all of its self-tests then the reply will be:

0

If any failures are detected then the result will be an integer number (between -32768 and 32767) indicating which test failed.

LOCATION		NAME	DESCRIPTION
0	LSB	OVR	OVer Range. Set on over range, cleared to zero when input returns within range
1		RDY	ReaDY. Set when the unit has a stable reading.
2		CHK	CHecKsum computation complete. This bit is set once, after instrument power on and the completion of the computation of the ROM checksum is cleared by the RomChecksum? command.
3		IFL	Input FuLl. This bit is set when the input queue is over 75% full and cleared when the queue drops below 25% full.
4		MAV	Message AVailable. This bit is set when the output queue is not empty.
5		ESB	Event Summary Bit. This bit is set when the result of a bitwise AND of the Event Status Enable register is not zero.
6		RQS	ReQuest for Service. This bit is set when the result of a bit-wise AND of the Status Byte Register and the Service Request Enable register is not zero.
7	MSB	unused	Always zero.

Table 3-9: Status Byte Register

3.6.13. MEASure - Set/Display The Measurement Parameters

This command allows a system programmer to set/display the settings for the current measurement. The form of the measure command sequences is as follows:

MEASure <state>	select the measurement state <state> :== 0|1 type <boolean> 0 :== OFF 1 :== ON
MEASure?	query, display the measurement state of the instrument
MEASure:UNIT <unit>	select the units of measurement and instrument operation <unit> :== R|O|C|F|K|V type <letter> R :== Ratio O :== Ohms C :== Celsius F :== Fahrenheit K :== Kelvin V :== Volt
MEASure:UNIT?	query, display the units of measurement
MEASure:FILTer <function>	set up 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 method of reporting the difference data

MEASure:CHARt <state> — set the state of the chart recorder
<state> :== 0|1 type <boolean>
0 :== measure
1 :== calibrate

MEASure:CHARt? — query, display the state of the chart recorder

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

MEASure:VOLT <state> — set the state of the nanovoltmeter to measure input voltages at the potential terminals
<state> :== 0|1 type <boolean>
0 :== OFF
1 :== ON

MEASure:VOLT? — query nanovoltmeter status

If the numeric parameter to the command is missing or unrecognizable the CME (CoMmand Error) bit in the Event Status Register will be set. If the numeric value is out of range then the EXE (EXecution Error) error bit will be set for a program data element out of range error.

3.6.13.1. MEASure <state> - Start/stop the measurement cycle

This command initiates the start of a measurement cycle. If a measurement cycle is in progress and "MEAS 0" is sent, the measurement will be terminated imediately.

<state> :== 0|1 type <boolean>

Where:

0 :== OFF
1 :== ON

3.6.13.2. MEASure? - Query the measurement cycle status

This query command requests information regarding the state of the measurement cycle. The verbose response from the 6675A is as follows:

```
Measurement ON
```

to indicate that a measurement cycle is in process. The corresponding terse response is:

```
1
```

3.6.13.3. MEASure:UNIT <unit> - Set units of operation

This command selects the engineering units of measure to be used for all calculations performed by the 6675A. The units set by this command act globally and needs to be set only once.

<unit> :== R|0|C|F|K|V type <letter>

Where:

R :== resistance ratio
0 :== resistance ohms
C :== temperature degrees Celsius
F :== temperature degrees Fahrenheit
K :== temperature kelvin
V :== volts

3.6.13.4. MEASure:UNIT? - Query the Engineering units in use
This query command requests the Engineering units used. The verbose response from the 6675A is as follows:

```
Units Resistance Ratio
```

to indicate that the results displayed have no units but are the result of a ratiometric resistance measurement. The corresponding terse response is:

```
R
```

3.6.13.5. MEASure:FILTer <function> - Set the digital filter factors
This command turns on the digital filter algorithm used in the 6675A. A simple decimation or moving average digital filter can be selected by this command. The digital decimation filter calculates the average of the last M% readings; while the moving average filter calculates the average of the last N readings where M and N is some positive <unsigned> integers greater than 1. The filtered result is indicated in the display window.

<function> :== 0|1|2 type <digit>

Where:
0 :== Filter OFF
1 :== Decimation
2 :== Simple average

3.6.13.6. MEASure:FILTer? - Query filter settings
This query command displays the value of the currently selected filter factor. The verbose response from the 6675A is as follows:

```
Filter, Decimation,7
```

to indicate that the filter is a decimation type with a factor of 0.07 (x100). The corresponding terse response is:

```
1,7
```

3.6.13.7. MEASure:UPDAte <rate> - Set the number of screen updates
This command sets the number of screen updates for each measurement cycle.

<rate> :== 0|1|2 type <digit>

Where:
0 :== 1 update for each cycle
1 :== 2 updates for each cycle
2 :== 4 updates for each cycle

3.6.13.8. MEASure:UPDAte? - Query update settings

This query command displays the value of the currently selected screen update rate. The verbose response from the 6675A is as follows:

```
Update rate 2 each cycle
```

to indicate that the screen update rate is 2 per measurement cycle. The corresponding terse response is:

```
1
```

3.6.13.9. MEASure:DEVIation <diff> - Set the method of reporting differences

This command sets the method of reporting difference information for each measurement cycle.

<diff> :== 0|1|2|3|4 type <digit>

Where:

0 :== disable difference reporting, normal operations
1 :== report differences in parts per million from setpoint
2 :== report differences as a delta change from setpoint
3 :== report differences from datum in parts per million
4 :== report differences from datum as a delta change

3.6.13.10. MEASure:DEVIation? - Query difference settings

This query command displays the value of the currently selected method of reporting differences. The verbose response from the 6675A is as follows:

```
Parts per million from setpoint
```

to indicate that the method of reporting differences is parts per million from setpoint reading. The corresponding terse response is:

```
1
```

3.6.13.11.MEASure:CHARt <state> - Set the state of the chart recorder output

This command sets the chart recorder state.

<state>:== 0|1 type <boolean>

Where:

0:== place chart recorder into measurement mode to allow chart recorder output to follow measured parameter

1:== place chart recorder into calibrate mode to allow the chart recorder output to respond to the configuration setup of the chart recorder <CONF:CHARt> function.

3.6.13.12.MEASure:CHARt? - Query chart recorder output status

This query command displays the value of the chart recorder output state. The verbose response from the 6675A is as follows:

```
Chart recorder output Chart Cal
```

to indicate that the chart recorder output is in the calibrate mode. The corresponding terse response is:

```
1
```

3.6.13.13.MEASure:QUICk <state> - Enable quick measurement

This command selects quick measurement mode. Quick measurement reports the measured value with a minimum delay. The resolution of the value will vary with the roughness of the balance. The maximum resolution with quick measure on, is 7 significant digits.

<state> :== 0|1 type <boolean>

Where:

0 :== OFF

1 :== ON

3.6.13.14. MEASure:QUICk? - Query the quick measurement status

This query command requests information regarding the state of the quick measurement mode. The verbose response from the 6675A is as follows:

```
Quick ON
```

to indicate that quick measurement mode is active. The corresponding terse response is:

```
1
```

3.6.13.15. MEASure:VOLT <state> - Set the state of the nanovoltmeter
This command sets the state of the nanovoltmeter to measure voltages.

<state> :== 0|1 type <boolean>

Where:
0 :== disable voltmeter function
1 :== enable voltmeter function

3.6.13.16. MEASure:VOLT? - Query nanovoltmeter state
This query command displays the state of the nanovoltmeter function. The verbose response from the 6675A is as follows:

```
Nanovoltmeter function ON
```

to indicate that the nanovoltmeter function is turned ON. The corresponding terse response is:

```
1
```

3.6.14. CONFigure - Set Operating Configuration
This command allows a system programmer to configure the operating parameters for the instrument. The form of the configure command is as follows:

CONFigure <function>	setup the configuration <function> :== 0|1 type <boolean> 0 :== resistor config 1 :== probe config
CONFigure?	query, display the active configuration
CONFigure:CHARt <state>	setup the chart recorder <state> :== 0|1|2|3|4 type <digit> 0:== Cal step 1:== plus full scale 2:== zero 3:== minus full scale 4:== Chart datum
CONFigure:CHARt?	query, display the chart recorder setup

CONFigure:CHARt:SCALe <scale>, <factor>
set the chart recorder scale factor

<scale>:==0|1|2|3|4 type <digit>
0:== scale ppm/volt
1:== scale ohms/volt
2:== scale degrees/volt
3:== scale volts/volt
4:== scale volts
<factor>:==<nr3>

CONFigure:CHARt:SCALe? query, display the active chart recorder scale factor

CONFigure:DATUm <unit>, <value> initialise the datum to be used as the setpoint 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>

CONFigure:DATUm? query, display the datum used as the setpoint in all difference calculations

CONFigure:FILTer <size1>, <size2> set the filter sizes
<size1> :== <unsigned>
<size2> :== <unsigned>
size1 sets the decimation filter coefficient
size2 sets the N average filter coefficient

CONFigure:FILTer? query, display the active filter coefficients

CONFigure:SAVE:RESIstor <file> save the active unit configuration to the resistor memory data <file> area
<file>:== <unsigned>
number of resistor files
limited to range 00 thru 14

NOTE:
FOR THE PREVIOUS COMMAND TO BE SUCCESSFUL A CONF:SAVE:RESI? QUERY MUST BE SENT BEFORE THIS COMMAND.

CONFigure:SAVE:RESIstor?	query, display the list of unoccupied resistor configuration slots available in resistor memory area
CONFigure:SAVE:PROBe <file>	save the active unit configuration to the probe memory data <file> area <file>:== <unsigned> number of probe files limited to range 00 thru 04

NOTE:
FOR THE PREVIOUS COMMAND TO BE SUCCESSFUL A CONF:SAVE:PROB? QUERY MUST BE SENT BEFORE THIS COMMAND

CONFigure:SAVE:PROBe?	query, display the list of unoccupied probe configuration slots available in probe memory area
CONFigure:LOAD:RESIstor <file>	restore resistor <file> configuration to the active memory area <file>:== <unsigned> number of resistor files limited to range 00 thru 14
CONFigure:LOAD:RESIstor?	query, display the list of occupied resistor configuration slots available in resistor memory area
CONFigure:LOAD:PROBe <file>	restore probe <file> configuration to the active memory area <file>:== <unsigned> number of probe files limited to range 00 thru 04
CONFigure:LOAD:PROBe?	query, display the list of unoccupied probe configuration slots available in probe memory area SAME AS "SAVE"

CONFigure:RESIstor <md>, <RS>, <RS_Sn>, <RX>, <R_R>, <Tst_Val>, <Tst_Max>
set the active resistor measurement configuration
<md> :== 0|1|2 type <digit>
0 :== 4-wire mode
1 :== 2 wire mode
2 :== range extender mode
<RS> :== <nr3> - ref. resistor value
<RS_Sn> :== <string> - ref. resistor serial #
<RX> :== <nr3> - approx. Rx value
<R_R> :== <nr3> - current reversal rate
<Tst_Val> :== <nr3> - test current/volts or extender ratio
<Tst_Max> :== <nr3> - max current(Is)/volts for ref resistor

CONFigure:RESIstor? query, display active resistor configuration information

CONFigure:PROBe <RS>, <RS_Sn>, <R0>, <PR_Sn>, <R_R>, <Tst_Val>, <Tst_Max>
set the active probe measurement configuration
<RS> :== <nr3> - ref. resistor value
<RS_Sn> :== <string> - ref. resistor serial #
<R0> :== <nr3> - probe resistance at ice point (IPTS68) or triple point (ITS90)
<PR_Sn> :== <string> - probe serial #
<R_R> :== <nr3> - current reversal rate
<Tst_Val> :== <nr3> - test current (Ix)
<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:RESIstor:DISPlay <unit>, <rate>, <filter>, <size>, <power>

set the active display parameters for resistor measurements

<unit> :== R|O type <letter>
R :== Ratio
O :== Ohms

<rate> :== 0|1|2 type <digit>
0 :== 1 updates/cycle
1 :== 2 updates/cycle
2 :== 4 updates/cycle

<filter> :== 0|1|2 type <digit>
0 :== none
1 :== decimation
2 :== simple average

<size> :== <unsigned>
size = % for decimation
and sample size for simple average

<power> :== 0|1|2 type <digit>
0 :== power normal X1
1 :== power X2
2 :== power X0.5

CONFigure:RESIstor:DISPlay? query, display the active display setup

CONFigure:PROBe:DISPlay <unit>, <rate>, <filter>, <size>, <power>
set the active display parameters for a probe
<unit> :== R|O|C|F|K type <letter>
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
and 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 <equ_#>, <coeff_00>, <coeff_01>, .., <coeff_n>
set the active probe conversion coefficients
<equ_#> :== <unsigned> - equ_# takes on a value in the range 00 through 11 for the temperature calibration range of the probe
<coeff_00> :== <nr3> - <coeff_xx> are coefficients 01 through n for the probe ITS90 conversion algorithm.
When <equ_#> :== 00 then <coeff_xx> are the IPTS68 coefficients.

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 volmeter 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

If the numeric parameter to the command is missing or unrecognizable the CME (CoMmand Error) bit in the Event Status Register will be set. If the numeric value is out of range (i.e. not 0 - 99) then the EXE (EXecution Error) bit will be set for a program data element out of range error.

3.6.14.1. CONFigure <function> - Set the configuration of the 6675A

This command sets the configuration of the 6675A and takes on the following format:

<function> :== 0|1 type <boolean>

Where:
0 :== resistor configuration
1 :== probe configuration

3.6.14.2. CONFigure? - Query 6675A configuration that is active

This query command displays the active configuration of the 6675A. The verbose response from the 6675A is as follows:

```
Resistor configuration
```

to indicate that the active configuration is for resistors. The corresponding terse response is:

```
0
```

3.6.14.3. CONFigure:CHARt <function> - Set the configuration of the 6675A chart recorder output

This command allows setting of the chart recorder output configuration. The command function is as follows:

<state> :== 0|1|2|3|4 type <digit>

Where:

0:== set chart output to measured value plus calibration step
1:== set output to plus full scale
2:== set output to zero
3:== set output to minus full scale
4:== set chart datum to present measured value

3.6.14.4. CONFigure:CHARt? - Query chart recorder configuration.

This query command displays the configuration of the chart recorder. The verbose response from the 6675A is as follows:

```
Chart recorder Cal Step
```

to indicate that the chart recorder is configured for calibration step operation. The corresponding terse response is:

```
0
```

3.6.14.5. CONFigure:CHARt:SCALe <scale>, <factor> - Set the chart recorder scale factors.

This command allows setting of the active configuration of the chart recorder scale factors.

<scale>:==0|1|2|3|4 type <digit>

Where:

0:== scale ppm/volt
1:== scale ohms/volt
2:== scale degrees/volt
3:== scale volts/volt
4:== scale volts

<factor>:==<nr3>

3.6.14.6. CONFigure:CHARt:SCALe? - Query chart recorder scale configuration.

This query command displays the configuration of the chart recorder scale factor. The verbose response from the 6675A is a list as follows:

```
Chart recorder scales
1.000000 PPM,
0.000010 Ohms,
1.000000 Deg,
1.000000 Volts,
3.000000 Cal
```

to indicate that the chart recorder output is configured for operation at :

1ppm/volt, 0.000010 ohms/volt, 1 degree/volt,1 volt/volt and 2 volt (step calibration).

The corresponding terse response is:

```
1.000000,0.000010,1.000000,1.000000,3.000000
```

3.6.14.7.CONFigure:DATUm <unit>, <value> - Initialise the difference datum point.

This command allows setting of the active configuration of the initial point to be used in all difference calculations.

<unit> :== R|O|C|F|K|V type <letter>

Where:

R :== Ratio
O :== Ohms
C :== Celsius
F :== Fahrenheit
K :== kelvin
V :== Volts

<value>:==<nr3>

3.6.14.8. CONFigure:DATUm? - Query datum setting.

This query command displays the setting of the datum used in all difference calculations. The verbose response from the 6675A is as follows:

```
Datum 200.000 ohms
```

to indicate that the datum is configured for operation at 200.000 ohms. The corresponding terse response is:

```
O,200.000
```

3.6.14.9. CONFigure:FILTer <size1>, <size2> - Set the filter coefficients

This command allows setting of the active filter coefficients for the display measurements.

<size1> :== <nr3> sets the decimation filter coefficient (in the range 0 to 0.5)
<size2> :== <unsigned> sets the N average filter coefficient (unsigned integer).

3.6.14.10. CONFigure:FILTer? - Query filter coefficient setting.

This query command displays the setting of the filter coefficients used. The verbose response from the 6675A is as follows:

```
Decimation 0.080%,
Average 38
```

to indicate that the decimation filter coefficient is 0.08 and that the N average filter coefficient is 38. The corresponding terse response is:

```
0.080000,38
```

3.6.14.11.CONFigure:SAVE:RESIstor <file> - Save a resistor file
This command allows saving to nonvolatile memory, the active configuration of a resistor.

NOTE:
FOR THIS COMMAND TO BE SUCCESSFUL A CONF:SAVE:RESI? QUERY MUST BE SENT BEFORE THIS COMMAND

<file> :== <unsigned> file handle; number of resistor files limited to range 00 thru 14

3.6.14.12. CONFigure:SAVE:RESIStor? - Query list of resistor files.
This query command displays the list of unoccupied resistor file handles available in memory . The verbose response from the 6675A is as follows:

```
Resistor files available 00,13,14
```

to indicate that file handles available for use are 00,13,14. All other file handles contain resistor information. The corresponding terse response is:

```
00,13,14
```

3.6.14.13.CONFigure:SAVE:PROBe <file> - Save a probe file.
This command allows saving to nonvolatile memory, the active configuration of a temperature probe.

NOTE:
FOR THIS COMMAND TO BE SUCCESSFUL A CONF:SAVE:PROB? QUERY MUST BE SENT BEFORE THIS COMMAND

<file>:== <unsigned> file handle; number of temperature probe files limited to range 00 thru 04

3.6.14.14.CONFigure:SAVE:PROBe? - Query list of probe files.
This query command displays the list of unoccupied probe file handles available in memory. The verbose response from the 6675A is as follows:

```
Probe files available 03,04
```

to indicate that probe file handles available for use are 03,04. All other file handles contain probe information. The corresponding terse response is:

```
03,04
```

3.6.14.15. CONFigure:LOAD:RESIstor <file> - Load a resistor file.
This command restores to active memory a previously saved resistor file from nonvolatile memory.

<file>:== <unsigned> file handle; number of resistor files limited to range 00 thru 14

3.6.14.16.CONFigure:LOAD:RESIstor? - Query list of resistor files.
This query command displays the list of occupied resistor file handles in memory. The verbose response from the 6675A is as follows:

```
Resistor files not available 00,13,14
```

to indicate that file handles used are 00,13,14. The corresponding terse response is:

```
00,13,14
```

3.6.14.17.CONFigure:LOAD:PROBe <file> - Load a probe file.
This command restores a previously saved temperature probe file from nonvolatile memory.

<file>:== <unsigned> file handle; number of temperature probe files limited to range 00 thru 04

3.6.14.18.CONFigure:LOAD:PROBe? - Query list of probe files.
This query command displays the list of unoccupied probe file handles available in memory. The verbose response from the 6675A is as follows:

```
Probe files available 03,04
```

to indicate that probe file handles available for use are 03,04. All other file handles contain probe information. The corresponding terse response is:

```
03,04
```

3.6.14.19.CONFigure:RESIstor <mode>, <RS>, <RS_Sn>, <RX>, <Rev_Rate>, <Tst_Val>, <Tst_Max> - Configure a resistor measurement configuration.

This command allows the setup of a measurement configuration for a test resistor.

<mode> :== 0|2 type <digit>

Where:

0 :== 4-wire mode
2 :== range extender 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 or extender ratio
<Tst_Max>:==<nr3> max current (Is)/volts for ref resistor

3.6.14.20. CONFigure:RESIstor? - Query active resistor measurement configuration.

This query command displays the currently active resistor measurement configuration. The verbose response from the 6675A is as follows:

```
04 terminal; Rs= 1000.000 ohms;Rs serial number=  121212AA; RX=
100.000; 30 seconds reversal rate; 30.000mA test current;
100.000mA max Is
```

to indicate that a 4-terminal resistor measurement is set up with a standard resistor of 1000.000 ohms, serial number 121212aa and approximate Rx value of 10.000 ohms. A reversal rate of 30 seconds is set with a test Ix current of 30mA; Is max is set to 100mA. The corresponding terse response is:

```
0, 1000.000, 121212AA, 100.000, 30, 30.000, 100.000
```

3.6.14.21. CONFigure:PROBe <RS>, <RS_Sn>, <R0>, <PR_Sn>, <Rev_Rate>, <Tst_Val>, <Tst_Max>- Configure a probe measurement configuration.

This command allows the setup of a measurement configuration for a test temperature probe.

<RS> :== <nr3>	ref. resistor value
<RS_Sn> :== <string>	ref. resistor serial #
<R0> :== <nr3>	probe resistance at ice point (IPTS68) or triple point (ITS90)
<Pr_Sn>:==<string>	probe serial #
<Rev_rate>:==<nr3>	test current reversal rate
<Tst_Val>:==<nr3>	test current (Ix) value
<Tst_Max>:==<nr3>	max current (Is) for ref resistor

3.6.14.22. CONFigure:PROBe? - Query active probe measurement configuration.

This query command displays the currently active probe measurement configuration. See query CONF:PROB:PCOE? Also see query CONF:PROB:NCOE?

3.6.14.23.CONFigure:RESIstor:DISPlay <unit>, <rate>, <filter>, <size>, <power> - Set the active display parameters for resistor measurements

<unit> :== R|O type <letter>
Where:
R :== Ratio
O :== Ohms
<rate> :== 0|1|2 type <digit>
Where:
0 :== 1 updates/cycle
1 :== 2 updates/cycle
2 :== 4 updates/cycle
<filter> :== 0|1|2 type <digit>
Where:
0 :== none
1 :== decimation
2 :== simple average
<size> :== <unsigned>
size = % for decimation
size = sample size for simple average
<power> :== 0|1|2 type <digit>
Where:
0 :== power normal X1
1 :== power X2
2 :== power X0.5

3.6.14.24.CONFigure:RESIstor:DISPlay?

Query, display the active display setup. Note that the integer displayed for the decimation filter is 100X the decimation coefficient.

3.6.14.25.CONFigure:PROBe:DISPlay <unit>, <rate>, <filter>, <size>, <power> -Set the active display parameters for a probe

<unit> :== R|O|C|F|K type <letter>
Where:
R:==Ratio
O:==Ohms
C:==Celsius
F:==Fahrenheit
K:==kelvin
<rate> :== 0|1|2 type <digit>
Where:
0 :== 1 updates/cycle
1 :== 2 updates/cycle
2 :== 4 updates/cycle
<filter> :== 0|1|2 type <digit>
Where:
0 :== none
1 :== decimation
2 :== simple average
<size>:==<unsigned>
size = % for decimation
size = sample size for simple average
<power> :== 0|1|2 type <digit>
Where:
0 :== power normal X1
1 :== power X2
2 :== power X0.5

3.6.14.26.CONFigure:PROBe:DISPlay?

Query, display the active probe display setup

3.6.14.27.CONFigure:PROBe:COEFficient <equ_#>, <coeff_00>, <coeff_01>, .., <coeff_n> - Set the active probe conversion coefficients

<equ_#> :== <unsigned> equ_# takes on a value in the range 00 through 11 for the temperature calibration range of the probe
<coeff_00> :== <nr3> <coeff_xx> are coefficients 01 through n for the probe ITS90 conversion algorithm.

When <equ_#> :== 00 the IPTS68 coefficients can be set.

3.6.14.28. CONFigure:PROBe:PositiveCOEfficient?

Query, display the active probe positive temperature coefficients

3.6.14.29. CONFigure:PROBe:NegativeCOEfficient?

Query, display the active probe negative temperature coefficients

3.6.14.30. CONFigure:VOLTmeter <range>, <zero>, <high>, <ref> - Set the voltmeter calibration coefficients

<range> :== 0|1|2|3|4 type <digit>
Where:
0 :== 20V range
1 :== 2V range
2 :== 200mV range
3 :== 20mV range
4 :== 2mV range
<zero> :== <unsigned>
<high> :== <unsigned>
<ref> :== <nr1>

3.6.14.31. CONFigure:VOLTmeter? <range> - Query, display the volmeter calibration setup

<range>:== 0|1|2|3|4 type <digit>
Where:
0 :== 20V range
1 :== 2V range
2 :== 200mV range
3 :== 20mV range
4 :== 2mV range

3.6.15. SYSTem - Set 6675A Operating Parameters

This command allows a system programmer to set the operating parameters for the instrument. The form of the system command is as follows:

SYSTem:COMMunicate:GPIB <address>, <mode> setup GPIB communications
<address> :== <unsigned>
<mode> :== 0|1|2 type <digit>
0 :== disable
1 :== talk only
2 :== talk/listen

SYSTem:COMMunicate:GPIB? query, display GPIB set up

SYSTem:COMMunicate:SERial <bd>, <data>, <parity>, <stop>, <pace>, <echo>, <md>
setup RS232 communications
<bd> :== <unsigned>
<data> :== <unsigned>
<parity> :== 0|1|2|3|4 type <digit>
0 :== none
1 :== odd
2 :== even
3 :== mark
4 :== space
<stop>:== <unsigned>
<pace>:== 0|1|2|3 type <digit>
0 :== none
1 :== XON/XOFF
2 :== RTS/CTS
3 :== ACK/NACK
<echo> :== 0|1 type <boolean>
0 :== OFF
1 :== ON
<md>:== 0|1|2 type <digit>
0 :== disable
1 :== talk only
2 :== talk/listen

SYSTem:COMMunicate:SERial? query, display RS232 set up

SYSTem:LOCAL enter the local state
RS232 command only

SYSTem:LOCKOUT enter the local lockout state
RS232 command only

SYSTem:REMOTE enter the remote state
RS232 command only

SYSTem:TERSe respond to commands with a minimum data set

SYSTem:VERBose respond to commands with maximum 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>

3.6.15.1. SYSTem:COMMunicate:GPIB <address>, <mode> - Setup GPIB communications

<address> :== <unsigned>
<mode> :== 0|1|2 type <digit>
Where:
0 :== disable
1 :== talk only
2 :== talk/listen

3.6.15.2. SYSTem:COMMunicate:GPIB? - Query The GPIB Mode Setup

This command reports the setting of the GPIB communication port of the 6675A. The IEEE-488 address and mode settings are returned in response to this query.

3.6.15.3.. SYSTem:COMMunicate:SERial <baud>, <data>, <parity>, <stop>, <pace>, <echo>, <mode> - Setup RS232 communications

<baud> :== <unsigned> Set baud rate to closest 'standard' value.
<data> :== <unsigned> 7|8 Set the number of data bits in the serial word.
<parity> :==0|1|2|3|4 type <digit>
0 :== none
1 :== odd
2 :== even
3 :== mark
4 :== space
<stop> :== <unsigned> 1|1.5|2 Set the number of stop bits.
<space> :== 0|1|2|3 type <digit>
0 :== none
1 :== XON/XOFF
2 :== RTS/CTS
3 :== ACK/NACK
<echo> :== 0|1 type <boolean>
0:== OFF
1:== ON
<mode> :== 0|1|2 type <digit>
0 :== disable
1 :== talk only
2 :== talk/listen

3.6.15.4.SYSTem:COMMunicate:SERial? - Query The RS232 Mode Setup.
This query command reports the setting of the RS232 serial communication port of the 6675A. The settings set by the SYSTEM:COMMunicate:SERial command are returned in response to this query.

3.6.15.5.SYSTem:LOCAL - Enter The Local State
This command will place the 6675A into the local state. This command duplicates the IEEE-488 GTL (Go To Local) message. Normally this command is only sent from an RS232C controller, if this command is received from an IEEE-488 controller it will be ignored. There are no parameters for the LOCAL command. For example the command:

SYST:LOCAL

will enter the local state (See section 2.5).

3.6.15.6.SYSTem:LOCKOUT - Enter The Local Lockout State
This command will place the 6675A into the local lockout state. This command duplicates the IEEE-488 LLO (Local Lock Out) message. Normally this command is only sent from an RS232C controller, if this command is received from an IEEE-488 controller it will be ignored. There are no parameters for the LOCKOUT command. For example the command:

SYST:LOCKOUT

will enter the lockout state (See section 2.5).

3.6.15.7.SYSTem:REMOTE - Enter The Remote State.
This command will place the 6675A into the remote state. This command duplicates the IEEE-488 REN (Remote ENable) message. Normally this command is only sent from an RS232C controller, if this command is received from an IEEE-488 controller it will be ignored. There are no parameters for the REMOTE command. For example the command:

SYST:REMOTE

will enter the remote state (see section 2.5).

3.6.15.8.SYSTem:TERse - Disable Verbose Mode
This is the default mode for the 6675A after reset. Typically query commands will return very little extraneous information in terse mode.

3.6.15.9. SYSTem:VERBose - Set Verbose Mode

The verbose command causes the output of all subsequent commands to contain additional information. This mode should be used for determining problems with programs and when the instrument is being used interactively.

3.6.15.10. SYSTem:VERSion? - Query The 6675A Software Version

This command is used when the instrument software version needs to be verified. This command can be used instead of the *IDN? command to report only the software version.

3.6.15.11. SYSTem:DIAGnostic: - Enter The Diagnostic Mode

These sub-commands can be used to assist in the location of a failed subsystem in the unlikely event that the instrument fails.

3.6.15.11.1. SYSTem:DIAGnostic:ROMChecksum? - Query ROM Checksum

This command will return the checksum of the installed instrument read only memory. Since the checksum algorithm is quite involved, the 6675A microprocessor will compute the checksum in its "spare" time. Depending on bus activity, it can take up to 30 seconds to receive a response from this command.

In order to determine if the computation of the checksum is complete the programmer may either poll the checksum until the value is no longer -1 or wait for the CHK bit in the STATUS BYTE register to be set to one (1). It should be noted that the CHK bit will only be set once after the 6675A is powered on, hence simply waiting for the CHK bit to become set may not always work if the ROM checksum has been previously read.

3.6.15.11.2. SYSTem:DIAGnostic:SERialNumber <unsigned>

This command accepts an integer in the range -200 000 to +200 000, this number will be reported in the serial number field of the *IDN? command.

3.6.16. FETCh?

This command allows a system programmer to retrieve the most recent data from the 6675A.

3.7. REMOTE PROGRAMMING HINTS

The following is a brief note on how to configure a National Instruments GPIB-PC controller card when used with the 6675A. Two program outlines are provided that collect data using the National Instruments GPIB-PC interface.

Assuming that National Instrument drivers have been installed with all the default names. The device name for ADDRESS 4 will be "DEV4", and could be used to control the 6675A.

The "DEV4" should be configured as follows:

- Default device name: DEV4
- GPIB address (fixed): 4
- Secondary address: none
- Timeout setting: 3 seconds
- Serial poll timeout: 3 seconds
- Terminate read on EOS: YES
- Set EOI with EOS on write: YES
- Type of compare on EOS: 7 bit
- EOS byte: 0A hex
- Send EOI at end of writes: YES
- Enable repeat addressing: YES

3.7.1. Programming Note 1 : BASIC

Sample Bus Control Program Using Basic And National Instruments GPIB-PC Controller

```
100 REM BASIC Example Program - for Guildline Model 6675A Resistance
101 REM 6675/A
105 REM
112 REM You MUST merge this code with DECL.BAS.
115 REM
120 REM Assign a unique identifier to device and
125 REM store in variable DEV%.
130 REM
135   BDNAME$ = "DEV4"
140   CALL IBFIND (BDNAME$, DEV%)
145 REM
150 REM Check for error on IBFIND call.
155 REM
160   IF DEV% < 0 THEN GOSUB 2000
170 REM
180 REM Clear the device.
190   CALL IBCLR (DEV%)
195 REM
200 REM Check for an error on each GPIB call to be
210 REM safe.
215 REM
220   IF IBSTA% < 0 THEN GOSUB 3000
230 REM
240 REM Ensure that the 6675A Resistance Bridge is not in MEASURE mode.
250 REM
260   WRT$ = "MEAS 0"
265   CALL IBWRT (DEV%, WRT$)
270   IF IBSTA% <0 THEN GOSUB 3000
280 REM
290 REM Set up resistance ratio measurement for 10 Ohm to 10 Ohm
292 REM
294   WRT$= "CONF:RESI 0,10,10OHM,10,30,31.6,100"
296   CALL IBWRT (DEV%,WRT$)
298   IF IBSTA% <0 THEN GOSUB 3000
300 REM
320 REM
330 REM Tell the 6675A Resistance Bridge to measure resistance
340 REM
350   WRT$ = "MEAS 1"
355   CALL IBWRT (DEV%,WRT$)
360   IF IBSTA% < 0 THEN GOSUB 3000
380 REM
390 REM Loop on reading the status byte until
400 REM the 6675A says that the reading is complete
410 REM Check that the 6675A is still measuring.
412 REM If not measuring then an error has occurred
420   WRT$ = "MEAS?"
422   CALL IBWRT (DEV%,WRT$)
430   IF IBSTA% < 0 THEN GOSUB 3000
434   RD$ = SPACE$(48)
435   CALL IBRD (DEV%,RD$)
436   IF IBSTA% < 0 THEN GOSUB 3000
```

```
438   IF VAL(RD$) <> 1 THEN GOTO 4000
440 REM
450 REM Now test the status byte (STB).
460 REM If STB has bit 2 set then the 6675A Resistance Bridge
470 REM has finally finished its reading otherwise
475 REM loop around
480 REM
490   WRT$="*STB?" : CALL IBWRT (DEV%,WRT$)
492   IF IBSTA% < 0 THEN GOSUB 3000
494   RD$ = SPACE$(48) : CALL IBRD (DEV%,RD$)
496   IF IBSTA% < 0 THEN GOSUB 3000
498   IF VAL(RD$) AND &H02 THEN GOTO 500
499   GOTO 420
500 REM
510 REM Ask the 6675A Resistance Bridge to give us the next
515 REM measurement
520 REM
525   WRT$ = "FETC?" : CALL IBWRT (DEV%,WRT$)
526   IF IBSTA% < 0 THEN GOSUB 3000
530   RD$ = SPACE$(48) : CALL IBRD (DEV%,RD$)
540   IF IBSTA% < 0 THEN GOSUB 3000
550 REM
560 REM Print out the reading and loop around to catch
570 REM the next reading
580 REM
585   PRINT RD$
590   GOTO 420
2000 REM A routine at this location would notify
2010 REM you that the IBFIND call failed, and
2020 REM refer you to the handler software
2030 REM configuration procedures.
2040  PRINT "IBFIND ERROR" : RETURN
3000 REM An error checking routine at this
3010 REM location would, among other things,
3020 REM check IBERR to determine the exact
3030 REM cause of the error condition and then
3040 REM take action appropriate to the
3050 REM application. For errors during data
3060 REM transfers, IBCNT may be examined to
3070 REM determine the actual number of bytes
3080 REM transferred.
3090  PRINT "GPIB ERROR" : RETURN
4000 REM An error routine to tell you that the measurement
4010 REM terminated prematurely
4020  PRINT "ERROR, TEST TERMINATED PREMATURELY."
4030 REM
5000  END
```

3.7.2. Programming Note 2 : Psuedo C

Program example

```
Begin {
      "MEAS 0"
      (int)md = MODE;
      (double)Rs = RS_OHM;
      (char*)SN = RS_Serial_Number;
      (double)Rx = RX_OHM;                \\ optional - should be set to
                                          approximate value
      (int)R_R = REVERSAL_RATE;
      (double)Tx = TEST_mAMPS_VOLTS;
      (double)Tmax = MAX_mAMPS_VOLTS;
      "CONF:RESI md, Rs, SN, Rx, R_R, Tx, Tmax"
      "CONF:RESI:DISP O, 2, 0, 0, 0"      \\ display ohms fastest update
      EXIT = 0;   \\ some condition for terminating test
      do{
            while (("MEAS?"==1)&&(("*STB?"&0x02)!=0x02));
            if("MEAS?"==1){
                  (double)value = "FETCH?"

\\ Do something with value
            }

\\ Evaluate exit condition

      }while(("MEAS?"==1)&&(!EXIT));

      if("MEAS?"==0)

\\ERROR     test terminated prematurely go on to next test

      else
            "MEAS 0"                      \\*turn measure off go on to
                                          next test

} END
```

NOTE:

1) All strings in quotes are commands sent to 6675A across the GPIB.
2) All quotes ending in ? have to be followed by a read from GPIB and converted to proper number or format.

3.8. MODEL 6675A 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
<YY>         :== <unsigned>              : limited to ranges 00..99 and 1970..2038
<HH>         :== <unsigned>              : limited to range 0...23
<mm>         :== <unsigned>              : limited to range 0...59
<SS>         :== <unsigned>              : limited to range 0...59
```

The STB Bits are as follows:

```
bit 7 = (unused)
bit 6 = SRQ (service request)
        ; set when (SRQ_mask|GPIB_STAT_PORT) != 0
bit 5 = ESB (event summary)
        ; set when bitwise AND of ESE, register is not zero
bit 4 = MAV (message available)
        ; set when GPIB Tx buffer has data available, cleared when the buffer is empty
bit 3 = IFL (input buffer full)
        ; set when input buffer is over 80% full
        ; cleared when input buffer drops under 20% full
bit 2 = CHK (Checksum calculation complete)
bit 1 = RDY (ready)
        ; set when unit has a stable reading, cleared when unit is working
bit 0 = OVR (over range)
        ; set when over range detected (in ISR), cleared when over range cleared
COMMAND                         COMMENT
```

*CLS	clear status register
*ESR?	query, display event status register
*ESE?	query, display event status enable
*ESE <unsigned>	set event status enable
*IDN?	query, display identity of unit
*OPT?	query, display any reportable options
*OPC?	query, operation complete
*OPC	set operation complete bit in event status register
*RST	reset the instrument to a known defined state
*STB?	query, display serial poll status byte
*SRE?	query, display service request mask
*SRE <unsigned>	set the service request mask
*TST?	query, display results of self test
FETCh?	fetch the most recent data value

MEASure - set the measurement parameters

MEASure <state>	select the measurement state <state>:== 0|1 type <boolean> 0 :== OFF 1 :== ON
MEASure?	query, display the measurement state of the instrument
MEASure:UNIT <unit>	select the units of measurement and instrument operation <unit> :== R|O|C|F|K|V type <letter> R:==Ratio O:==Ohms C:==Celsius F:==Fahrenheit K:==kelvin V:==Volt
MEASure:UNIT?	query, display the units of measurement
COMMAND	COMMENT
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 data
MEASure:CHARt <state>	set the state of the chart recorder <state> :== 0|1 type <boolean> 0 :== measure 1 :== calibrate
MEASure:CHARt?	query, display the state of the chart recorder
MEASure:QUICk <state>	select the quick measurement state <state> :== 0|1 type <boolean> 0 :== OFF 1 :== ON

COMMAND	COMMENT
MEASure:QUICk?	query, display the quick measurement state of the instrument
MEASure:VOLT <state>	set the state of the nanovoltmeter to measure input voltages at the potential terminals <state>:== 0|1 type <boolean> 0:== OFF 1:== ON
MEASure:VOLT?	query nanovoltmeter status

CONFigure - configure instrument operating parameters

CONFigure <function>	setup the configuration <function>:==0|1 type <boolean> 0 :== resistor config 1 :== probe config
CONFigure?	query, display the active configuration
CONFigure:CHARt <state>	setup the chart recorder <state> :== 0|1|2|3|4 type <digit> 0:== Cal step 1:== plus full scale 2:== zero 3:== minus full scale 4:== Chart datum
CONFigure:CHARt?	query, display the chart recorder setup
CONFigure:CHARt:SCALe <scale>, <factor>	set the chart recorder scale factor <scale>:==0|1|2|3|4 type <digit> 0:== scale ppm/volt 1:== scale ohms/volt 2:== scale degrees/volt 3:== scale volts/volt 4:== scale volts <factor>:==<nr3>
CONFigure:CHARt:SCALe?	query, display the active chart recorder scale factor

COMMAND	COMMENT
CONFigure:DATUm <unit>, <value>	initialise the datum to be used as the setpoint 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>
CONFigure:DATUm?	query, display the datum used as the setpoint in all difference calculations
CONFigure:FILTer <size1>,<size2>	initialise the filter coefficients <size1> :== <nr3> decimation filter coefficient <size2> :== <unsigned> N average filter coefficient
CONFigure:FILTer?	query the filter coefficients
CONFigure:SAVE:RESIstor <file>	save the active unit configuration to the resistor memory data <file> area <file>:== <unsigned> number of resistor files limited to range 00 thru 14
CONFigure:SAVE:RESIstor?	query, display the list of unoccupied resistor configuration slots available in resistor memory area
CONFigure:SAVE:PROBe <file>	save the active unit configuration to the probe memory data <file> area <file>:== <unsigned> number of probe files limited to range 00 thru 04
CONFigure:SAVE:PROBe?	query, display the list of unoccupied probe configuration slots available in probe memory area

COMMAND	COMMENT
CONFigure:LOAD:RESIstor <file>	restore resistor <file> configuration to the active memory area <file>:== <unsigned> number of resistor files limited to range 00 thru 14
CONFigure:LOAD:RESIstor?	query, display the list of occupied resistor configuration slots available in resistor memory area
CONFigure:LOAD:PROBe <file>	restore probe <file> configuration to the active memory area <file>:== <unsigned> number of probe files limited to range 00 thru 04
CONFigure:LOAD:PROBe?	query, display the list of unoccupied probe configuration slots available in probe memory area SAME AS "SAVE"
CONFigure:RESIstor <md>, <RS>, <SN>, <RX>, <Rev_Rate>, <Tst_Val>, <Tst_Max>	set the active resistor measurement configuration <md>:== 0|2| type <digit> 0:==set 4-wire mode 2:==range extender mode <RS>:==<nr3> ; ref. resistor value <SN>:==<string> ref. resistor serial # <RX>:==<nr3> approximate value Rx <Rev_rate>:==<nr3> test current reversal rate <Tst_Val>:==<nr3> test current/volts or extender ratio <Tst_Max>:==<nr3> max current(Is)/volts for ref resistor
CONFigure:RESIstor?	query, display active resistor configuration information

COMMAND	COMMENT
CONFigure:PROBe <RS>, <RS_Sn>, <R0>, <PR_Sn>, <R_R>, <Tst_Val>, <Tst_Max>	set the active probe measurement configuration <RS>:==<nr3> ref. resistor value <RS_Sn>:==<string> ref. resistor serial # <R0>:==<nr3> probe resistance at ice point (IPTS68) or triple point (ITS90) <Pr_Sn>:==<string> probe serial # <Rev_rate>:==<nr3> test current reversal rate <Tst_Val>:==<nr3> test current (Ix) value <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?

COMMAND	COMMENT
CONFigure:RESIstor:DISPlay <unit>, <rate>, <filter>, <size>, <power>	set the active display parameters for resistor measurements <unit> :== R|O type <letter> R :== Ratio O :== Ohms <rate> :== 0|1|2 type <digit> 0 :== 1 updates/cycle 1 :== 2 updates/cycle 2 :== 4 updates/cycle <filter> :== 0|1|2 type <digit> 0 :== none 1 :== decimation 2 :== simple average <size> :== <unsigned> size = % for decimation and sample size for simple average <power> :== 0|1|2 type <digit> 0 :== power normal X1 1 :== power X2 2 :== power X0.5
CONFigure:RESIstor:DISPlay?	query, display the active display setup

COMMAND	COMMENT
CONFigure:PROBe:DISPlay <unit>, <rate>, <filter>, <size>, <power>	set the active display parameters for a probe <unit> :== R|O|C|F|K type <letter> 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 and 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

COMMAND COMMENT

CONFigure:PROBe:COEFficient <equation_#>, <coeff_00>, <coeff_01>, .., <coeff_n>
set the active probe conversion coefficients
<equation_#>:== <unsigned>
equation_# takes on a value in the range 00 through 11 for the temperature calibration range of the probe
<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 volmeter 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

COMMAND COMMENT

SYSTem - set the unit operating conditions

SYSTem:COMMunicate:GPIB <address>, <mode>
setup GPIB communications
<address>:== <unsigned>
<mode>:== 0|1|2
type <digit>
0 :== disable
1 :== talk only
2 :== talk/listen

SYSTem:COMMunicate:GPIB? query, display GPIB set up

SYSTem:COMMunicate:SERial <bd>, <data>, <parity>, <stop>, <pace>, <echo>, <md>
setup RS232 communications
<bd> :== <unsigned>
<data> :== <unsigned>
<parity> :== 0|1|2|3|4 type <digit>
0 :== none
1 :== odd
2 :== even
3 :== mark
4 :== space
<stop>:== <unsigned>
<pace>:== 0|1|2|3 type <digit>
0 :== none
1 :== XON/XOFF
2 :== RTS/CTS
3 :== ACK/NACK
<echo> :== 0|1 type <boolean>
0 :== OFF
1 :== ON
<md>:== 0|1|2 type <digit>
0 :== disable
1 :== talk only
2 :== talk/listen

SYSTem:COMMunicate:SERial? query, display RS232 set up

SYSTem:LOCAL enter the local state
RS232 command only

COMMAND	COMMENT
SYSTem:LOCKOUT	enter the local lockout state RS232 command only
SYSTem:REMOTE	enter the remote state RS232 command only
SYSTem:TERSe	respond to commands with a minimum data set
SYSTem:VERBose	respond to commands with maximum 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>

Model 6670 remote command set

ADconvRead?	query, display adc reading in engineering units
ADconvB?	query, display adc in raw binary units
Filter?	query, display the filter setting
Filter <function>	set the 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
IXCurrent?	query, display Ix test current in microamps
IXCurrent <value>	set Ix test current in microamps <value>:==<nr3>
IXSign?	query, display Ix test current sign

COMMAND	COMMENT
IXSign <sign>	set Ix test current sign <sign>:==0|1 type <boolean> 0 :== positive 1 :== negative
IXTurns?	query, display relay turns setting
IXTurns <turns>	set relay turns <turns>:==<unsigned> 0 to 8747
ISDAC <channel>, <value>	set quad DAC setting <channel>:==0|1|2|3 type <digit> <value>:==<unsigned> 0 to 4095 for channels 0|1 0 = -10 Volts 4095 = +10 Volts for channels 2|3 0 = 0 Volts 4095 = +10 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 3:== +40 Volts 4:== -40 Volts 5:== primary current 7:== calibrate
OHmmode?	query, display the ohm mode
OHmmode <mode>	set the ohm mode <mode>:==0|2 type <digit> 0 :== 4-wire 2 :== range extender

COMMAND	COMMENT
REMOTE	enter remote mode
Range?	query, display the selected range
Range <range>	set the nanovoltmeter range <range>:==<unsigned> 0 = 20 V range 1 = 2 V range 2 = 200 mV range 3 = 20 mV range 4 = 2 mV range
SOFCAL?	query, display adc beta for nanovolt detector
SOFCAL <beta>	set adc beta <beta>:==<unsigned> 200 to 300
TErse	turn off verbose mode
UPdate	update Rs and Rx
VERbose	set verbose mode

4. Appendix of Formulas

4.1. Temperature Calculations

In all of the following temperature calculations, these variables have the same meaning:

R0 probe resistance at the ice point (triple point of water for ITS90)
Rt probe resistance at the temperature being measured
W ratio of Rt/R0
t temperature in degrees Celsius
T temperature in kelvins (T = t + 273.15)
All other variables are coefficients specific to that temperature scale

4.1.1. ITS90

The ITS90 temperature is calculated using the following fixed coefficients:

B0 =	0.183324722	D0 =	439.932854
B1 =	0.240975303	D1 =	472.418020
B2 =	0.209108771	D2 =	37.684494
B3 =	0.190439972	D3 =	7.472018
B4 =	0.142648498	D4 =	2.920828
B5 =	0.077993465	D5 =	0.005184
B6 =	0.012475611	D6 =	-0.963864
B7 =	-0.032267127	D7 =	-0.188732
B8 =	-0.075291522	D8 =	0.191203
B9 =	-0.056470670	D9 =	0.049025
B10 =	0.076201285		
B11 =	0.123893204		
B12 =	-0.029201193		
B13 =	-0.091173542		
B14 =	0.001317696		
B15 =	0.026025526		

This calculation also uses the coefficients as, bs, c1, c2, c3, c4, c5, cs and d which are unique to that specific probe over the sub-range (s) to which it was calibrated.

If the ratio W is less than 1

$$T = 273.16\sum_{j=0}^{15} B_j \left(\frac{W_r^{1/6} - 0.65}{0.35} \right)^j$$

Otherwise

$$t = \sum_{j=0}^{9} D_j \left(\frac{W_r - 2.64}{1.64} \right)^j$$

In either case Wr is defined as follows:

If the ratio W is less than 1

$$W_r = W - a_s(W-1) - b_s(W-1)^2 - \sum_{j=1}^{5} c_j \left(\ln(W)\right)^{j+n}$$

Where the following applies for the particular sub-range:

s=1 (-259.3467°C to 0.01°C)	n=2
s=2 (-248.5939°C to 0.01°C)	n=0; c4=c5=0
s=3 (-218.7916°C to 0.01°C)	n=1; c2=c3=c4=c5=0
s=5 (-38.8344°C to 29.7646°C)	n=0; c1=c2=c3=c4=c5=0

An exception is sub-range 4 (-189.3442°C to 0.01°C) where:

$$W_r = W - a_4(W-1) - b_4(W-1)\ln(W)$$

If the ratio W is not less than 1

$$W_r = W - a_s(W-1) - b_s(W-1)^2 - c_s(W-1)^3 - d(W - W_{Al})^2$$

Where the following applies for the particular sub-range:

s=5 (-38.8344°C to 29.7646°C)	c5=d=0
s=6 (0.01°C to 961.78°C)	if W<WAl then d=0

s=7 (0.01°C to 660.323°C)	d=0
s=8 (0.01°C to 419.527°C)	c8=d=0
s=9 (0.01°C to 231.928°C)	c9=d=0
s=10 (0.01°C to 156.5985°C)	b10=c10=d=0
s=11 (0.01°C to 29.7646°C)	b11=c11=d=0

(Note: WAl is the value of W at t=660.323°C. This value is calculated using a6, b6 and c6 and setting d=0)

4.1.2. IPTS68

This calculation uses the coefficients A, B, b4 and e4 which are unique to that specific probe.

If the ratio W is less than 1 the temperature must be determined by an itterative process using the following fixed coefficients:

a0 =	38.59276	a7 =	77.35767	a14 =	179.54782
a1 =	43.44837	a8 =	-95.75103	a15 =	700.42832
a2 =	39.10887	a9 =	-223.52892	a16 =	29.48666
a3 =	38.69352	a10 =	239.50285	a17 =	-335.24378
a4 =	32.56883	a11 =	524.64944	a18 =	-77.25660
a5 =	24.70158	a12 =	-319.79981	a19 =	66.76292
a6 =	53.03828	a13 =	-787.60686	a20 =	24.44911

A first approximation is made as:

$$t = \frac{W - 1}{A}$$

Next, the following calculation is repeated until the new value of t differs from the old value by less than 0.0001°C.

$$t = \sum_{j=0}^{20} a_j \left(\frac{\ln\left(W - b_4 t - e_4 (t - 100) t^3\right) + 3.28}{3.28} \right)^j - 273.15$$

Otherwise if the ratio W is not less than 1 the temperature is calculated as:

$$t = t' + 0.045 \left(\frac{t'}{100} \right) \left(\frac{t'}{100} - 1 \right) \left(\frac{t'}{419.58} - 1 \right) \left(\frac{t'}{630.74} - 1 \right)$$

Where:

$$t' = \frac{\sqrt{A^2 + 4B(W-1)} - A}{2B}$$

4.2. Statistical and Analysis Calculations

4.2.1. Standard Deviation

The Standard deviation is computed using the following formula:

$$\sigma_x = \sqrt{\frac{1}{n}\sum_{i=0}^{n-1}(x_i - \mu)^2} \quad ,$$

where $\mu = \frac{1}{n}\sum_{i=0}^{n-1} x_i$, and n is the number of elements in X.

4.2.2. Uncertainty

The uncertainty is computed using the following formula:

$$U = \sqrt{(2\sigma_x)^2 + \sum_{i=0}^{n-1} x_i^{\,2}} \quad ,$$

where X_i are known uncertainties.