Measurements International

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AUTOMATED PRIMARY RESISTANCE BRIDGE

Model 6020

Operator Manual

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Operator Manual

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Approved by:
QA:
S/N:

Form MI 65, Rev. 3, Dated 21-03-02 (QAP 19, App. “M”)

This equipment may be sensitive to Electrostatic Sensitive Discharge (ESD). Failure to observe standard anti-static practices may result in degradation of performance or improper measurement results, even when an actual functional failure does not occur.

Do not touch the terminals during measurement and avoid any electrostatic discharge, namely when the measurement is running.

This equipment must be operated using the power cord supplied by the manufacturer (MIL) to ensure powerline pulse rejection compliance.

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1. Notices, Safety Warnings & Cautions

1.1 Copyright Notice

1.2 Sales and Technical Support

To contact Measurements International for sales inquiries or technical support, refer to the support links on the following Measurements International web pages:

- www.mintl.com
  For product-specific information and support, software, and documentation updates.
- sales@mintl.com
  For worldwide contact information for repair and service.

1.3 Results

Typical results and uncertainties will be shown, but these can and will vary.

Your results will be different! However, the results that we show are achievable and, in some cases, can easily be improved upon. We have attempted to include all reasonable considerations for our uncertainty budgets, but your uncertainty budgets should be re-assessed considering your environment, operating conditions, and metrological needs.

1.4 Safety Information

CAUTION

CAUTION notice signifies an operating procedure or practice that denotes a potential hazard and, if not correctly performed, could result in damage to the product or loss of important data. Ensure that the conditions are fully understood. If not, consult with Measurements International prior to proceeding.

WARNING

WARNING notice signifies an operating procedure or practice that denotes a potential hazard and, if not correctly performed, could result in personal injury or even death. Ensure that the conditions are fully understood. If not, consult with Measurements International prior to proceeding.

SAFETY

SAFETY notice signifies matters related to first aid or personal safety. Ensure that the conditions are fully understood. If not, consult with Measurements International prior to proceeding.

NOTE

NOTE signifies matters that the user must pay particular attention to. Do not proceed beyond a NOTE notice until the indicated conditions are fully understood and met.

1.4.1 Electrical Safety Symbols

The following symbols on the instrument and in the operating manuals indicate precautions that must be taken to maintain the safe operation of the instrument.

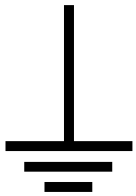


Figure 1.1: Digital Signal Ground. The reference point from which a digital logic signal is measured

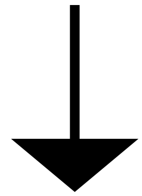


Figure 1.2: Analog Signal Ground. The reference point from which an analog signal is measured

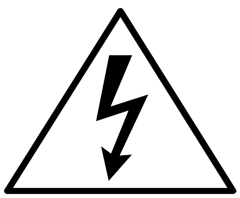


Figure 1.3: High Voltage - Risk of electric shock.

Figure 1.4: Caution information to avoid personal injury or damage to the product.

Figure 1.5: Protective Earth (PE) Ground. Indicates the wiring terminal must be connected to 'earth ground' before operating the equipment – for protection against electrical shock in case of a fault

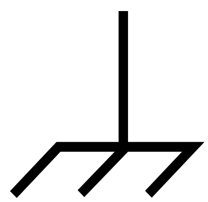


Figure 1.6: Frame (or chassis) ground terminal. It is typically connects to the equipment's metalwork frame

Figure 1.7: Direct Current (DC)

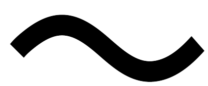


Figure 1.8: Alternating Current (AC)

1.4.2 Safety Considerations

Read the information below before using this instrument.

The following general safety precautions must be observed during all phases of operation, service, and repair of this instrument. Failure to comply with these precautions or specific warnings elsewhere in this manual violates safety standards for the instrument's design, manufacture, and intended use.

Measurements International assumes no liability for the customer's failure to comply with these requirements.

WARNING

Read all the safety information in this manual before using the product.

Use this product indoors only with an approved 3-conductor line cord.

Grounding the Instrument: For Safety Class 1 equipment (having a protective earth terminal), an uninterruptible safety earth ground must be provided from the mains power source to the product input wiring terminals or supplied power cable.

DO NOT operate the product in an explosive atmosphere or in the presence of flammable gases or fumes.

For continued protection against fire, replace the line fuse(s) only with fuse(s) of the same voltage and current rating and type. DO NOT use repaired fuses or short-circuited fuse holders.

Operating personnel must not remove equipment covers or shields. Procedures involving the removal of covers or shields are for use by service-trained personnel only. Under certain conditions, dangerous voltages may exist even with the equipment switched off. To avoid dangerous electrical shock, DO NOT perform cover or shield removal procedures unless you are qualified to do so.

DO NOT operate damaged equipment: Whenever the safety protection features built into this product may have been impaired, either through physical damage, excessive moisture, or any other reason, REMOVE POWER and do not use the product until safe operation can be verified by service-trained personnel. If necessary, return the product to Measurements International for service and repair to maintain safety features.

DO NOT service or adjust alone: DO NOT attempt any internal servicing (or adjustment) of the equipment unless another person is present, trained and capable of rendering first-aid and resuscitation.

DO NOT substitute parts or modify equipment: because of the danger of introducing additional hazards, DO NOT install substitute parts or perform any unauthorized modification to the product. Return the product to Measurements International for service and repair to ensure that safety features are maintained.

Measuring High Voltages can be hazardous: ALL input terminals must be considered hazardous whenever inputs greater than 60 V_{DC} are connected to ANY input terminal.

2. Introduction

This manual contains Installation instructions, local front panel operating instructions, software instructions for using the MI-6020 Software, and Service information for the Model 6020 Automated Primary Resistance Bridge.

2.1 Direct Current Comparator History

In the 1950's, new magnetic materials enabled increased accuracy in ratio measurements using transformers. The accuracy of the available calibration techniques was no longer sufficient, and a program of improvement was initiated. Studies of the three-winding current transformer indicated the possibility of obtaining stable and repeatable balances between the turns' ratio and the current ratio to a few parts in 10^4.

Conventional methods of comparing four-terminal resistors, e.g., the Kelvin Bridge or potentiometric comparison of resistors, pass the same current through both resistors, and the voltage drop over the resistors is compared to determine the resistance ratio. The following equations give the power generated in the resistors: index s denotes the standard resistor, and index x denotes the unknown resistor.

$$P_S = I^2 R_S; P_X = I^2 R_X \tag{2.1}$$

The ratio of the power is

$$\frac{P_S}{P_X} = \frac{I^2 R_S}{I^2 R_X} = \frac{R_S}{R_X} \tag{2.2}$$

The greatest power is dissipated in the largest resistance. In the Direct Current Comparator, different currents flow in the two resistors to produce the same voltage across both R_S and R_X. The power generated in each resistor is given by

$$P_S = \frac{E_S^2}{R_S}; P_X = \frac{E_X^2}{R_X} \tag{2.3}$$

The power ratio is given by

$$\frac{P_S}{P_X} = \frac{R_X}{R_S} \tag{2.4}$$

The greatest power is now dissipated in the smallest resistance.

In the potentiometric method, lead resistance is unimportant since no current flows in the measuring leads at balance. Here, resolution and accuracy are limited by current stability.

The Kelvin Bridge method is sensitive to the resistance of the measuring leads. Here, current stability is unimportant.

The Direct Current Comparator Bridge is not sensitive to measuring lead resistance, it does not require current stability, and the greatest power is dissipated in the smallest resistance.

The 6020 is a resistance ratio bridge based on the principle of the Direct Current comparator as developed by N. L. Kusters and other staff members of the National Research Council of Canada and further enhanced by Measurements International.

2.2 General Description

The Model 6020 is an automated precision DC resistance bridge employing the principle of the Direct Current Comparator. Measurements International has extended this technology into a bridge that will operate as a stand-alone device for measuring resistance ratio. As a remote-controlled automated system, the direct reading of the measured resistance and/or temperature is possible.

System resolution is 25 bits with an uncertainty of better than 0.04×10^{-6}. Self-calibration of the DCC can be carried out at any time, and the accuracy can be verified using the build-up technique for all ratios.

The 6020 uses three peripheral windings, which are selected automatically. The peripheral windings are configured to keep the ampere-turns as high as possible when performing 1:1 ratios and for ratios below 1.

This instrument provides an easy means of establishing resistor-to-resistor or resistor-to-resistance thermometer ratios. Measurement functions are selected by a touchscreen display or via the IEEE 488 bus. Measurement selections, results, and calibration data are displayed on the front panel. This information can also be transmitted over the IEEE-488 bus.

Two 4-terminal resistors can be connected to the rear panel inputs. These are designated R_S (standard) and R_X (unknown). The addition of Measurement International's Model 4220A Four Terminal Matrix Scanner can provide greater flexibility in resistor comparisons.

3. Specifications

4. Illustrations of 6020

4.1 Front View of Product

Pictures of the standard and thermometry front panels are shown in Figures 4.1 and 4.2. The touch screen is used to enter measurement values and select different functions.

Chapter 8 describes the Graphic User Interface (GUI) and its functionality.

A reset button is accessible on the front panel. Insert a thin, pointed object into the small hole to trigger a soft reset of the microcontroller.

Figure 4.1: Front View of the standard instruments

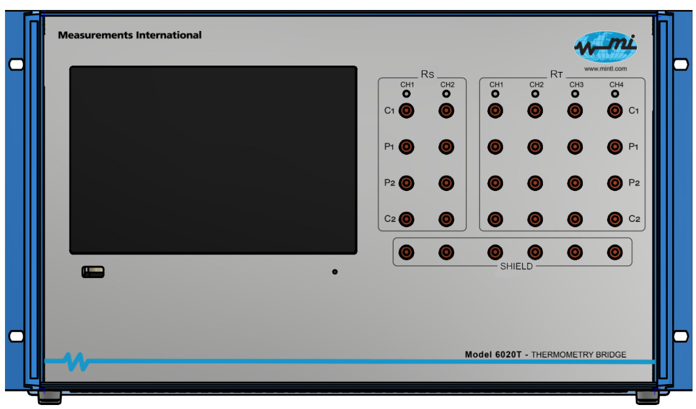


Figure 4.2: Front View of the Thermometry instruments

4.2 Rear View of the Product

Photo's of each back panel are shown in Figures 4.3, 4.4, and 4.5. The external connections to the bridge can be found on this panel, including the resistor and the external power supply terminals.

Chapter 6.3 describes the grounding terminals and Chapter 6.4 describes the resistor connections.

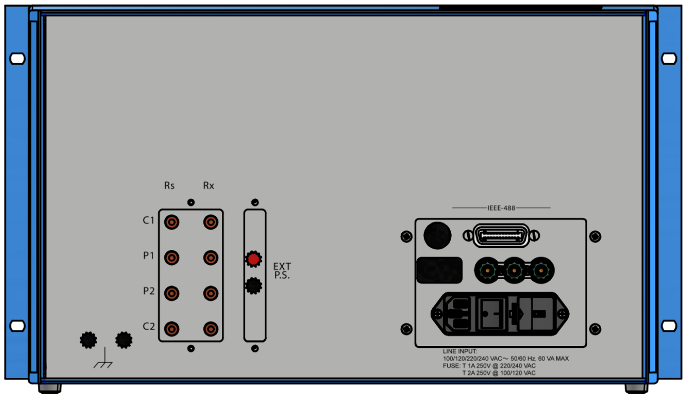


Figure 4.3: Rear View of 6020A

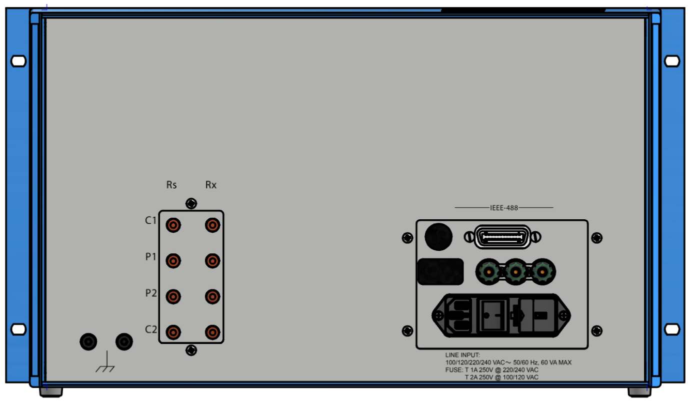


Figure 4.4: Rear View of 6020Q

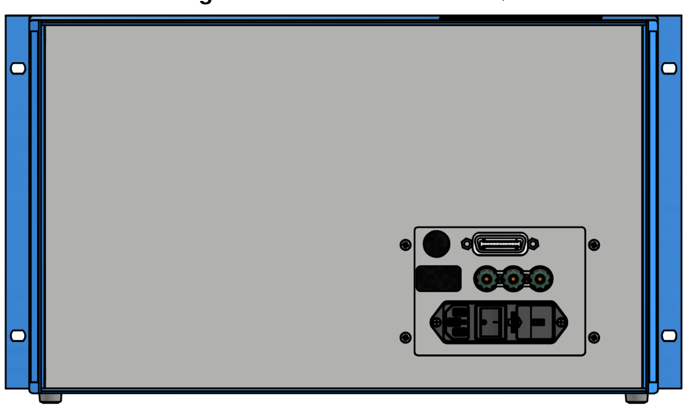


Figure 4.5: Rear View of 6020T

5. Inspection & Installation

5.1 Physical

The Model 6020 is thoroughly inspected and tested before shipment. However, damage could result from shipping. Do a visual check of the equipment and packaging materials, and both should be free of marks or dents.

The shipping case should be kept until the instrument can be thoroughly checked for mechanical and electrical damage. It is also recommended that the shipping case is saved for future use, such as sending the instrument for calibration or service.

5.1.1 Contents

Table 5.1: List of items included with the 6020 equipment

ITEM	QUANTITY
6020	1
Fuse (installed in instrument)	2
Operator Manual	1
Power Cord	1
4-conductor cable, 8 feet	2
6020 Software Installation (if purchased)	(1)
IEEE 488 computer cable (if purchased)	(1)
IEEE connection cable (if purchased)	(1)

5.2 Electrical

5.2.1 Line Voltage

With the power cord disconnected, visually check the line voltage selector on the power supply module. The switch should be set to the line voltage in your area.

WARNING

Check the system to ensure that the setting is correct

5.2.2 Input Voltage Selector

The power entry installed to the 6020 external power supply combines multi-function voltages and RFI filtering. Table 5.2 shows the available options.

Table 5.2: Voltage and current ratings

Voltage (V_{AC})	Fuse Rating
100	2 A, 250 V_{AC}
120	2 A, 250 V_{AC}
220	1 A, 250 V_{AC}
240	1 A, 250 V_{AC}

5.3 Installation

Connect the three-conductor power cord (supplied) to the power line connector on the back panel of the 6020 (Figure 4.3, 4.4, or 4.5), then connect the cable to a three-pin electrical outlet. When the switch situated on the power entry module is switched ON, the display on the 6020 will illuminate.

5.4 Power Line Requirement

The 6020 can be operated with single-phase 100 V_{AC} , 120 V_{AC}, 220 V_{AC}, 240 V_{AC} at 50/60 Hz as seen in 5.2. The power line can vary by 10%, not exceeding 250 V_{AC}. The maximum power consumption is 10 W.

5.5 Fuse Replacement and Voltage Selection

The power entry module houses the fuse and the voltage selector switch.

WARNING

Remove the power cord from the unit before attempting to change the fuses.

5.6 Fuse Inspection/Replacement

- Disconnect the power cord.
- Insert a screwdriver into the small slot to the left of the voltage switch. Apply some force and gently pry the fuse drawer.
- From the fuse drawer, shown in Figure 5.1, remove the two fuses and insert the new ones. See Table 5.2 for fuse requirements.
- Slide the drawer back in place and push it with some force until it clicks.

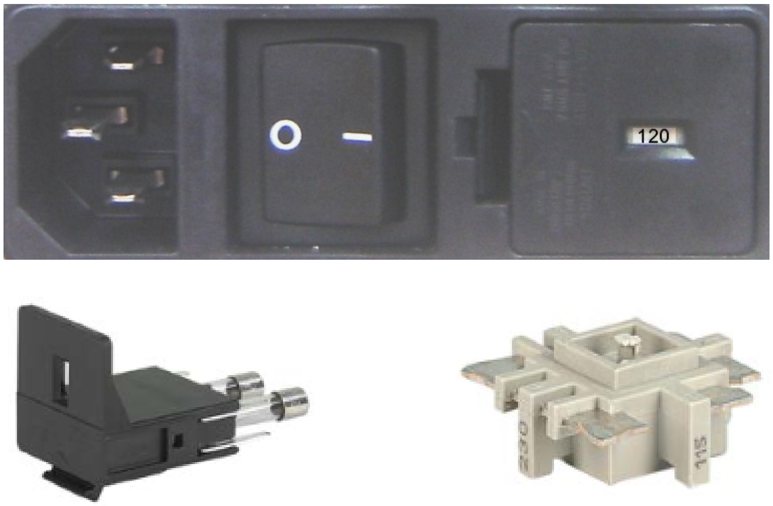


Figure 5.1: Power Module Entry Fuse Replacement

5.7 Service and Repair

If repair or service is required, please get in touch with the Measurements International sales office at sales@mintl.com.

6. Installation

6.1 Environmental

Although the unit has been designed for optimum durability and trouble-free operation, it is not recommended to operate the unit in an excessively dusty, dirty, or wet environment.

6.2 Location

The 6020 is best installed on a flat, clean surface (bench mount) or in a standard 19” instrument rack (optional rack mounting adapters are available).

The 6020 should be installed in a location that prevents the remote resistor leads from coming in contact with (or near) sources of electrical noise.

When mounting the 6020 in an instrument rack, install the bottom screws first; this will hold the unit while the other screws are being installed.

6.3 Grounding

The 6020 is supplied with a three-conductor AC cord plugging into the AC power module at the frame’s rear. To reduce the electrical shock hazard, always ensure that this cable is plugged into an approved three-contact grounded electrical outlet.

Three connections to the internal ground are located above the power entry module. The recommended configuration is all connected but may be connected individually if ground loop problems occur (Figure 6.1).

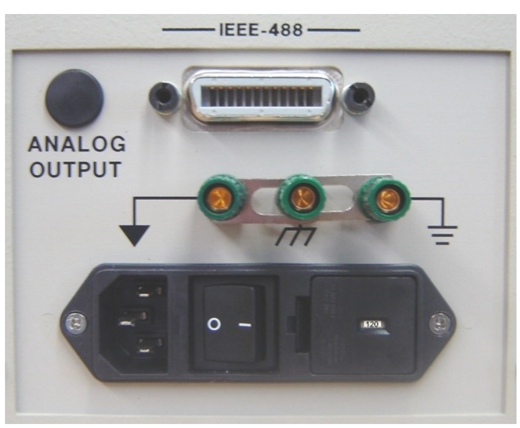


Figure 6.1: 6020 Ground terminals.

NOTE

Remove the digital logic link to earth ground when using the IEEE-488 interface.

6.4 Resistor Connections

Two 4-terminal resistors, designated R_S (standard) and R_X (resistor under test) can be connected to the 6020. The R_S or R_X resistor can be selected as the standard during operation.

The 6020 produces a current that flows to and from the resistors. Terminals designated $\mathbf{C_1}$ and $\mathbf{C_2}$ are for current. This current creates an electrical potential across the resistors, thus resulting in $\mathbf{P_1}$ and $\mathbf{P_2}$.

R_S is connected to the terminals designated $\mathbf{R_S}$ $\mathbf{C_1}$, $\mathbf{R_S}$ $\mathbf{P_1}$, $\mathbf{R_S}$ $\mathbf{P_2}$, $\mathbf{R_S}$ $\mathbf{C_2}$. R_X is connected to the terminals designated $\mathbf{R_X}$ $\mathbf{C_1}$, $\mathbf{R_X}$ $\mathbf{P_1}$, $\mathbf{R_X}$ $\mathbf{P_2}$, $\mathbf{R_X}$ $\mathbf{C_2}$ (Figure 6.2).

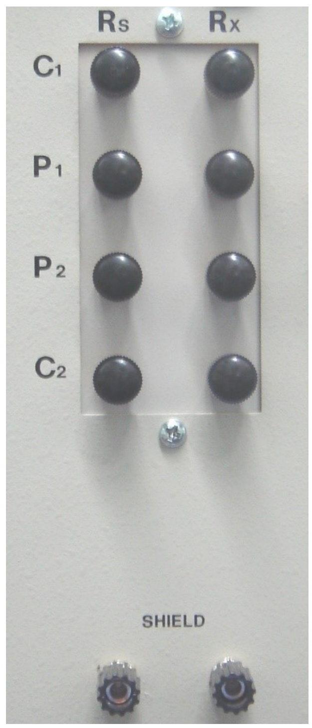


Figure 6.2: 6020 Resistors terminal.

NOTE

For optimum results, the resistors should be connected as described above with four-conductor solid wires such as Measurements International's SPSCW 4 twisted and shielded conductors. The shields should be connected to the shield terminals on the rear of the 6020. The leads should not exceed 3 meters in length.

6.5 Platinum Resistance Thermometer (PRT) Connections

These devices replace the R_X resistor and connect to the $\mathbf{R_X}$ $\mathbf{C_1}$, $\mathbf{R_X}$ $\mathbf{P_1}$, $\mathbf{R_X}$ $\mathbf{P_2}$, and $\mathbf{R_X}$ $\mathbf{C_2}$ terminals. PRT must have a corresponding value of $\mathbf{R_S}$, see Table 6.1.

Table 6.1: PRT equivalent R_S values

PRT ICE POINT	R
0.2	0.1
25	10
25	100
100	100

NOTE

Temperature equations and software are based on a paper by H. Preston-Thomas titled: *"The International Temperature Scale of 1990 (ITS-90)"*.

6.6 Interface Connections

Interface connection is made via a 24-pin D-type connector located on the rear panel (Figure 4.3, 4.4, or 4.5). One end of the IEEE-488 bus cable plugs into this, and the other into the interface connector on the remote-control computer.

6.7 Power Switch

The power on/off switch is in the power entry module on the back panel. See Figure 6.1. The illumination of the touch screen on the front panel is the power-on indication.

7. Measurements in Local Mode

After checking that the input voltage selector and fuse are correct, press the power module switch to turn the 6020 Bridge on and initiate the startup, during which the user will be greeted with an introduction screen.This screen shows a load bar and text telling the progress of the hardware initialization process (Figure 7.1).

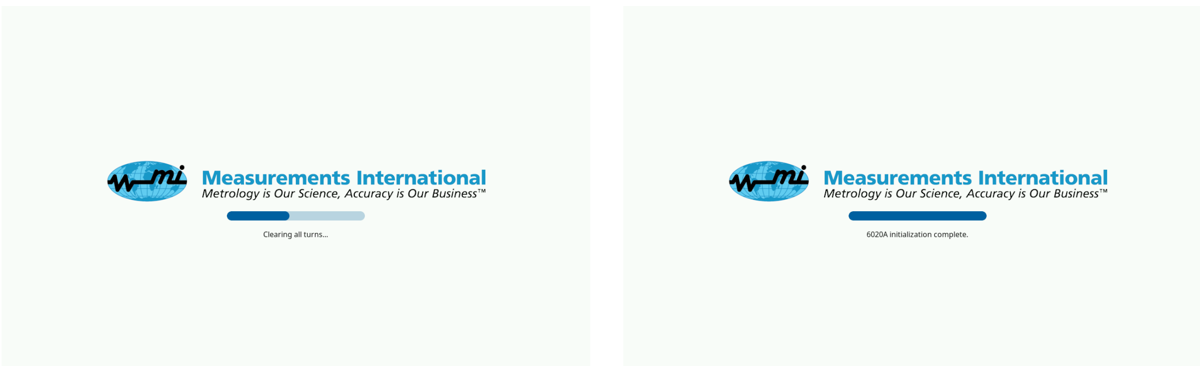


Figure 7.1: Startup and hardware initialization screen and initialization complete.

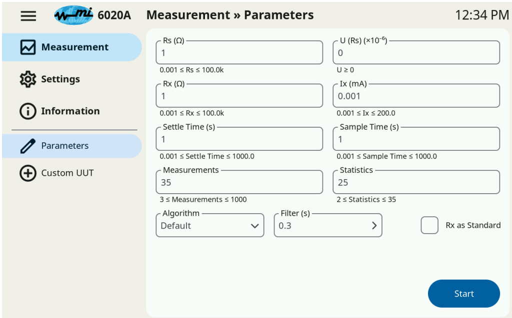
After the bridge's initialization process is completed, it will automatically switch to the main GUI interface (Figure 7.2). On the left of this screen is the navigation bar. It consists of menus and sub-menus. The submenus are displayed upon the selection of the main ones. The currently selected menu will be highlighted, and the title label will change correspondingly. At the top of the navigation bar is the expand/collapse button.

At this point, the instrument is ready for operation.

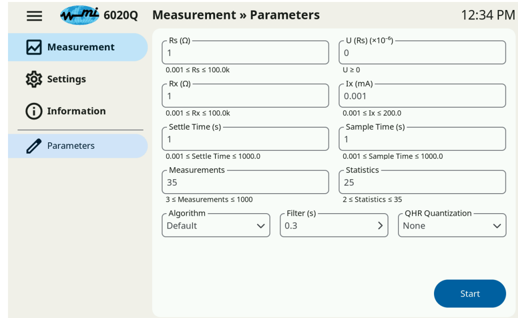
Although the direct current comparator bridges' primary objective is to measure the resistance of devices under test (Section 7.1), they can also measure temperature when a thermistor or platinum standard thermometer (PRT) is connected (see Section 7.2). Moreover, there are also models equipped with features to verify the quantization of the Quantum Hall effect (QHE) chips, as detailed in Section 7.3.

NOTE

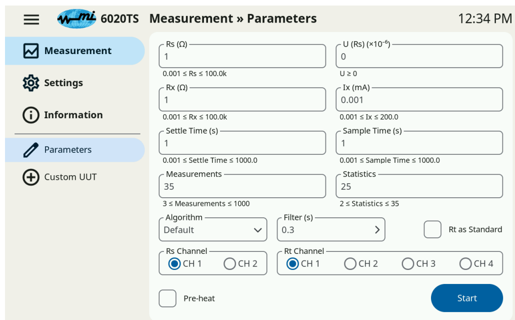
See Chapter 8 for details on the graphic user interface.



(a) 6020A Parameters window.



(b) 6020Q Parameters window.



(c) 6020T Parameters window.

Figure 7.2: Parameters windows, the default screen after initialization.

7.1 Resistance Measurement

7.1.1 UUT and Standard Connection

Connect two standard resistors, R_S and R_X, following the advice system setup of Section 6.4.

7.1.2 Measurement Settings

By default, the bridge loads the measurement parameters page after initialization, as shown in Figure 7.2. To enter values for the parameters, press on the box or the border of the field, then the label will change to blue to indicate that it has been selected. Once this happens, a number pad will pop up at the bottom of the screen.

Clicking anywhere on the GUI that isn't another field or the number pad will deselect the field, and the number pad will disappear. Pressing the enter button on the number pad will select the next field.

When selecting a field, a cursor will show the position. If the cursor is at the last position, begin typing to overwrite the value or press backspace to edit the value. If the cursor is not in the last position, it will always edit the value.

NOTE

See Table 7.1 for the recommended parameters.

7.1.3 Parameters

- **R_S (Ω)**: is the value of the standard resistor. It is not necessary to know the exact value of the standard resistor for R_S when performing Ratio measurements $r = R_X/R_S$
- **U(R_S)**: is the uncertainty of the standard given by a calibration.
- **R_X (Ω)**: is used to enter the nominal value of the measurand resistor R_X.
- **I_X (mA)**: is the current set in the measurand resistor.
- **Settle Time**: is the time, in seconds, the machine waits after setting the current (see Chapter 9).
- **Sample Time**: is the time, in seconds, dedicated to sampling with a sampling frequency $f_S = 1$*kS/s*
- **Measurements**: are the number of ratio measurements that the instrument performs.
- **Statistics**: the number of effective ratio measurements use to calculating the averaged and the standard deviation. These results are displayed on the LCD and reported to the application software when remotely controlled.
- **Algorithm**: is the type of steps that are performed in measurement (see Chapter 9)
- **Filter**: a parameter used to perform a moving average of a given number of ratios. (see Chapter 9)
- **R_X as Standard**: To swap the standard resistor to R_X, select the check box parameter. This option only affects the calculated resistance reported on the screen.

NOTE

The ratio is not affected by these options.

Table 7.1: 6020 measurement parameters recommended values.

R_S (Ω)	R_X (Ω)	I_X (mA)	I_{MAX} (mA)	t_{SETTLE} (s)	t_{SAMPLE} (s)	Filter (s)
0.001	0.01	15	20	6	2	0
0.01	0.1	15	20	6	2	0
0.1	0.1	150	150	6	2	0
0.1	1	15	15	6	2	0
1	1	50	100	6	2	0
1	10	5	10	6	3	0
10	10	30	50	6	3	0
10	100	3	5	6	4	0
100	100	10	10	6	4	0
100	1000	2	5	6	4	0
1,000	1,000	3	5	8	6	0
1,000	10,000	0.3	0.5	8	6	0
10,000	10,000	0.3	1.0	8	6	0
10,000	100,000	0.1	0.1	8	6	0

7.1.4 Start Measurement

Press the “Start” button to the bottom right of the parameter page, as shown in Figure 7.2. The navigation bar changes to display the different screen options that pertain to the measurement itself.

NOTE

The navigation bar menu is detailed and explained in Chapter 8.

Immediately after the measurement starts, the window changes to the measurement log view (Figure 7.3) where the measurement progress and status are displayed, such as the measurement parameter, the steps followed to balance the bridge, the measurement results, and any error that occurs.

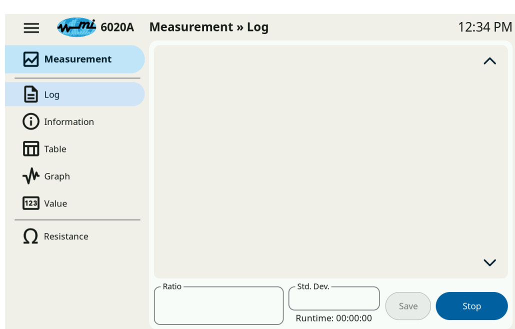
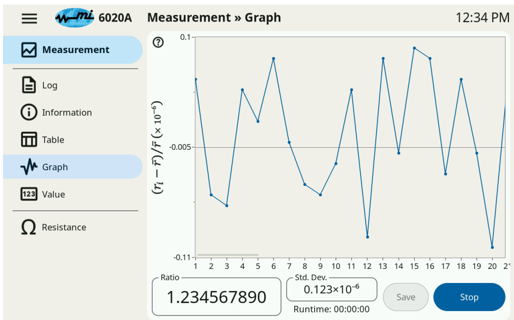


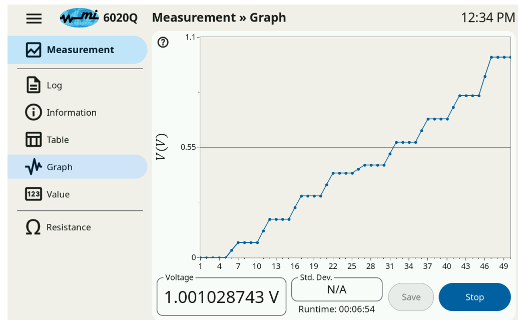
Figure 7.3: Measurement Log window, the default initial sequence window on all 6020 bridges.

After completing the second ratio measurement, the Ratio and Uncertainty fields at the bottom of the window will be filled in, and the window will change to the graph (Figure 7.4). When applicable, one can toggle from Ratio to Resistance or Temperature from this window.

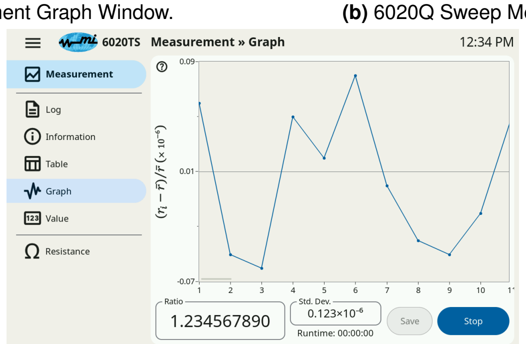
When pressed, the stop button at the bottom right of the windows interrupts the measurement.



(a) 6020A Ratio Measurement Graph Window.



(b) 6020Q Sweep Measurement Graph Window.



(c) 6020T Ratio Measurement Graph Window.

Figure 7.4: Measurement Sequence Graph Windows.

7.1.5 Uncertainty Calculation

The 6020 calculates and displays the average value and the uncertainty of measurements. The uncertainty box is the root-sum-square of the standard deviation of the mean of the measurement and the uncertainty of the standard $U(\mathrm{R_S})$. If the $U(\mathrm{R_S})$ is empty, the displayed uncertainty is the standard deviation of the mean of the measurement.

Following are the details of the calculation.

First, the measured ratio average r of the n observations is calculated.

$$\bar{r} = \frac{1}{n}\sum_{k=1}^{n} r_k \tag{7.1}$$

The experimental observation r_k differs in value due to random effect, so the variance σ^2 of the observation is given by

$$\sigma^2(r_k) = \frac{1}{(n-1)}\sum_{i=1}^{n}(r_i - \bar{r})^2 \tag{7.2}$$

The best estimation is the variance of the mean.

$$\sigma^2(\bar{r}) = \frac{\sigma^2(\bar{r_k})}{(n)} \tag{7.3}$$

The experimental standard deviation of the mean, also called Type A standard uncertainty $u(\bar{r})$ is then calculated as the square root of the experimental variance of the mean. The computed quantity represents how well $\bar{r}$ estimates the expected value μ_r of the quantity r.

Thus,

$$u(r) = \sigma_{\bar{r}} \frac{\sigma(\bar{r_k})}{\sqrt{n}} \tag{7.4}$$

Since the number of samples taken during a measurement is limited, its distribution is approximately normal. To account for the approximation, the bridge reports an expanded uncertainty. U_p from a Student's t distribution, as follows

$$\begin{aligned} U_p(r) &= k_p u(r) \\ &= t_p(\nu_{eff}) u(r) \end{aligned} \tag{7.5}$$

where k_p is a cover factor that corresponds to a specific level of confidence p, and ν_{eff} is the effective degree of freedom calculated from the Welch-Satterthwaite formula.

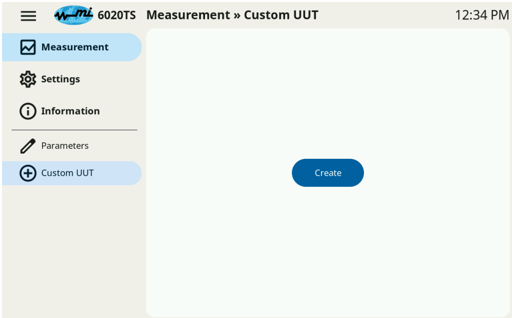
7.2 Temperature Measurement

NOTE

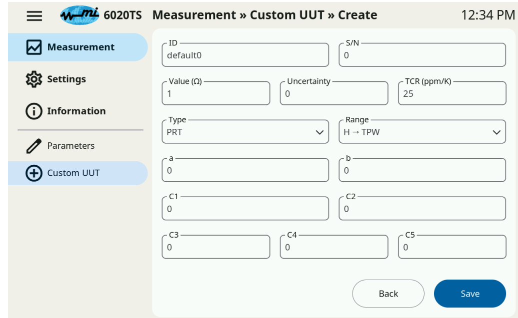
The feature described in this section are available only for some DC bridge models.

7.2.1 Custom UUT

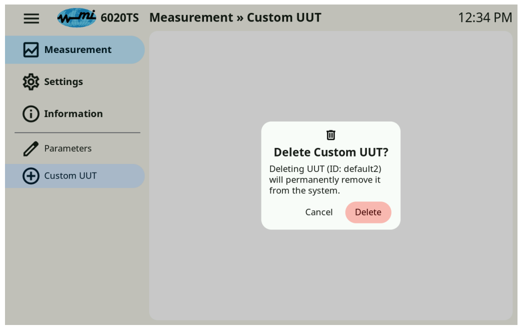
Thermometry Bridges support saving UUT configurations locally for convenience. In order to use the UUT feature navigate to the Measurement window and select the Custom UUT sub-menu (Figure 7.5). From here UUT's can be created, edited, or deleted at the user's convenience.



(a) Empty UUT window used to create new UUT's.



(b) UUT editing window.



(c) UUT deletion window.

Figure 7.5: UUT windows for temperature measurements.

7.2.2 Thermometry Connections

Connect a standard resistor to R_S and a temperature sensor to R_X or R_T.

The connections for the thermometry bridges are on the front panel. The equipped scanner has two inputs for resistance standard and four for thermometers as seen in Chapter 4.

7.3 QHR Quantization Verification

NOTE

The feature described in this section are available only for some DC bridge models.

The bridge is used to transfer values from a QHR device on step $i = 2$ to a 1 kΩ resistor with an accuracy of a few parts in 10^{-8}. However, in order to be confident in the accuracy of the measurements made with a QHR device, it is necessary to make a series of additional measurements of the device, over and above the comparison of R_{XY} to a 1 kΩ Standard Resistor.

In the order in which they might usually be carried out, the set of required measurements is:

- Field sweep of the Hall and longitudinal resistances (Figure 7.6).
- Three terminal measurements of the contact resistance (Figure 7.7).
- Precision checks on dissipation (Figure 7.8).

- Precision measurement of the Hall Resistance using two different sets of contacts in turn.

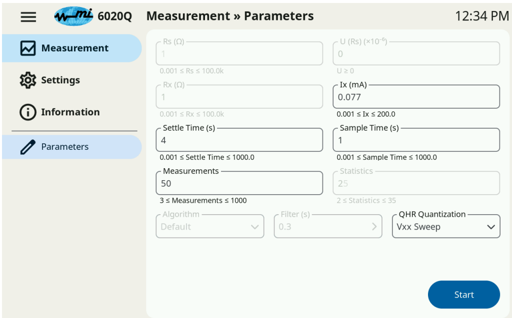


Figure 7.6: 6020Q V_{XX} Resistance Field Sweep Parameters.

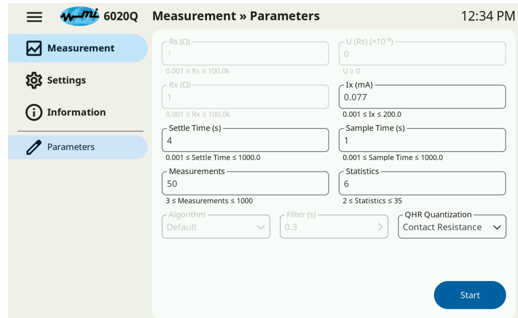


Figure 7.7: 6020Q Contact Resistance Parameters.

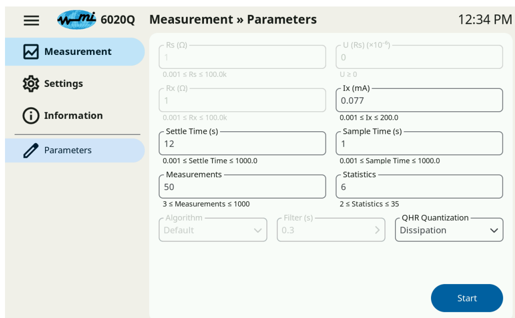


Figure 7.8: 6020Q Dissipation Check Parameters.

The connection diagrams for each of the measurements described above can be found in Appendix A.

8. Graphical User Interface (GUI)

This chapter describes the 6020 graphical user interface. Every menu is extensively explained to improve human-machine interaction.

8.1 Intro Screen

The introduction screen is shown upon powering the instrument on, as shown in Figure 8.1. The load bar below the logo shows the initialization progress. The progress bar is animated and increases as the hardware initialization advances. If some of the instrument's assemblies are malfunctioning, the instrument reboots and an error message is displayed in extreme cases where the hardware is damaged.

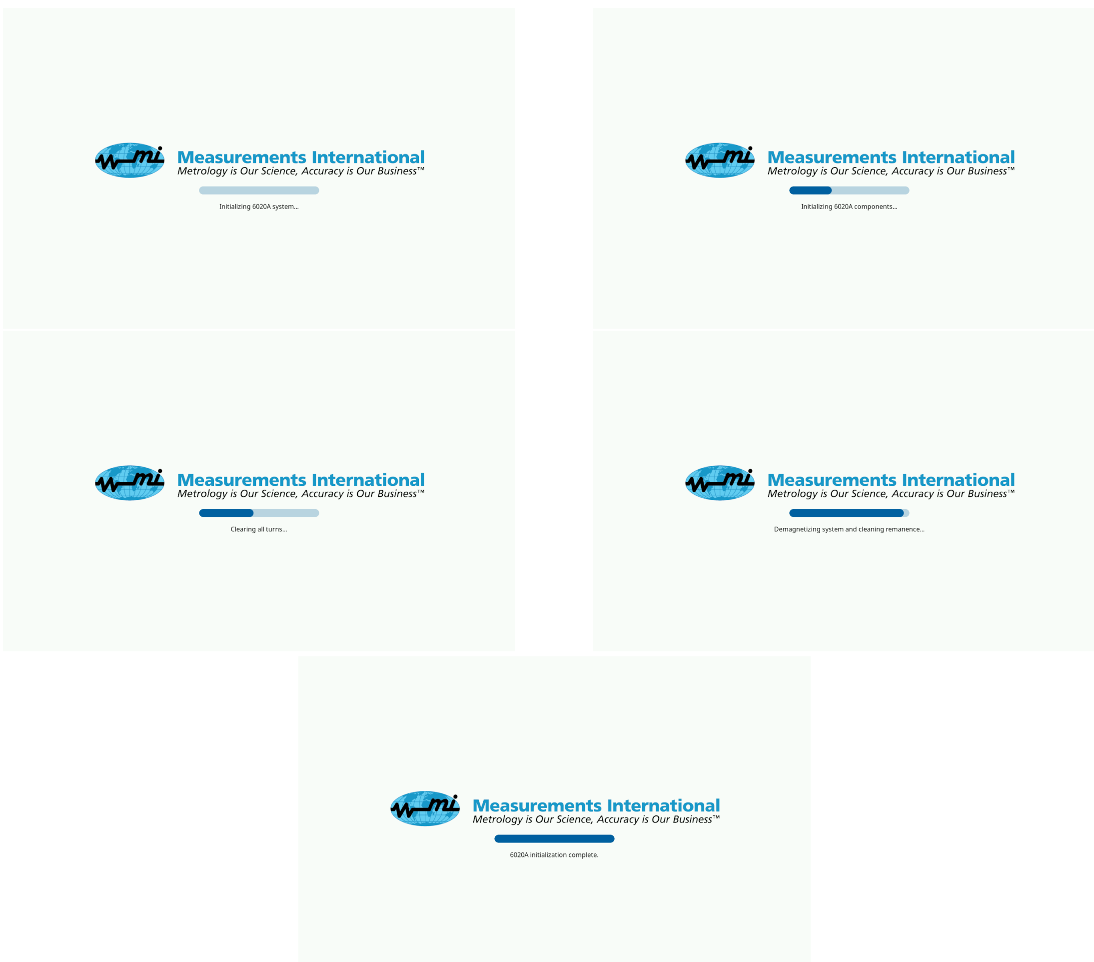


Figure 8.1: 6020 Startup sequence.

8.2 Main Screen Navigation

After the bridge completes its initialization process, it automatically switches to the main screen. On the left of this screen is the navigation bar, circled in blue in Figure 8.2. It consists of menus and sub-menus, and switching between menus will display a different set of sub-menus. The currently selected menu will be highlighted, and the “Title Label” will change accordingly. At the bottom of the navigation bar are the theme mode and expand/collapse buttons.

Each screen’s content area changes depending on whether the navigation bar is expanded or collapsed, as shown in Figure 8.3 and Figure 8.4.

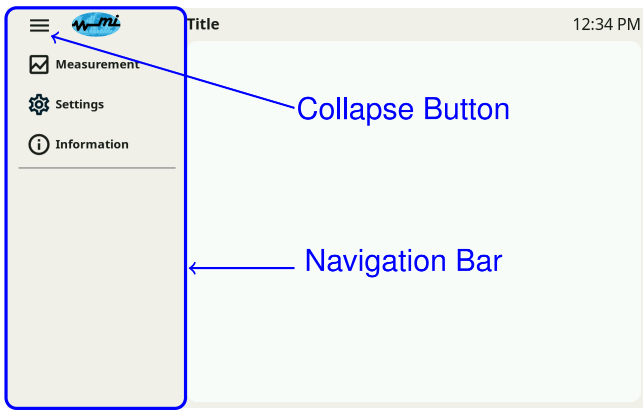


Figure 8.2: GUI Navigation Bar.

Figure 8.3: Navigation bar collapsed in light mode.

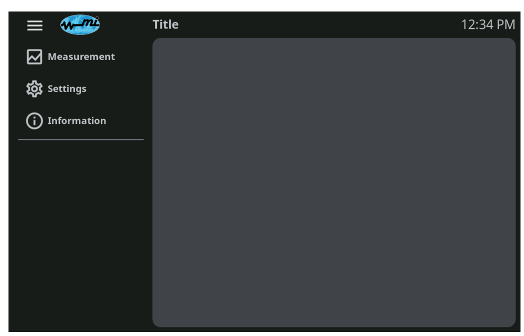


Figure 8.4: Navigation bar expanded in dark mode.

8.3 GUI Icons

The following are the icons and their descriptions of all the GUIs in the navigation menus.

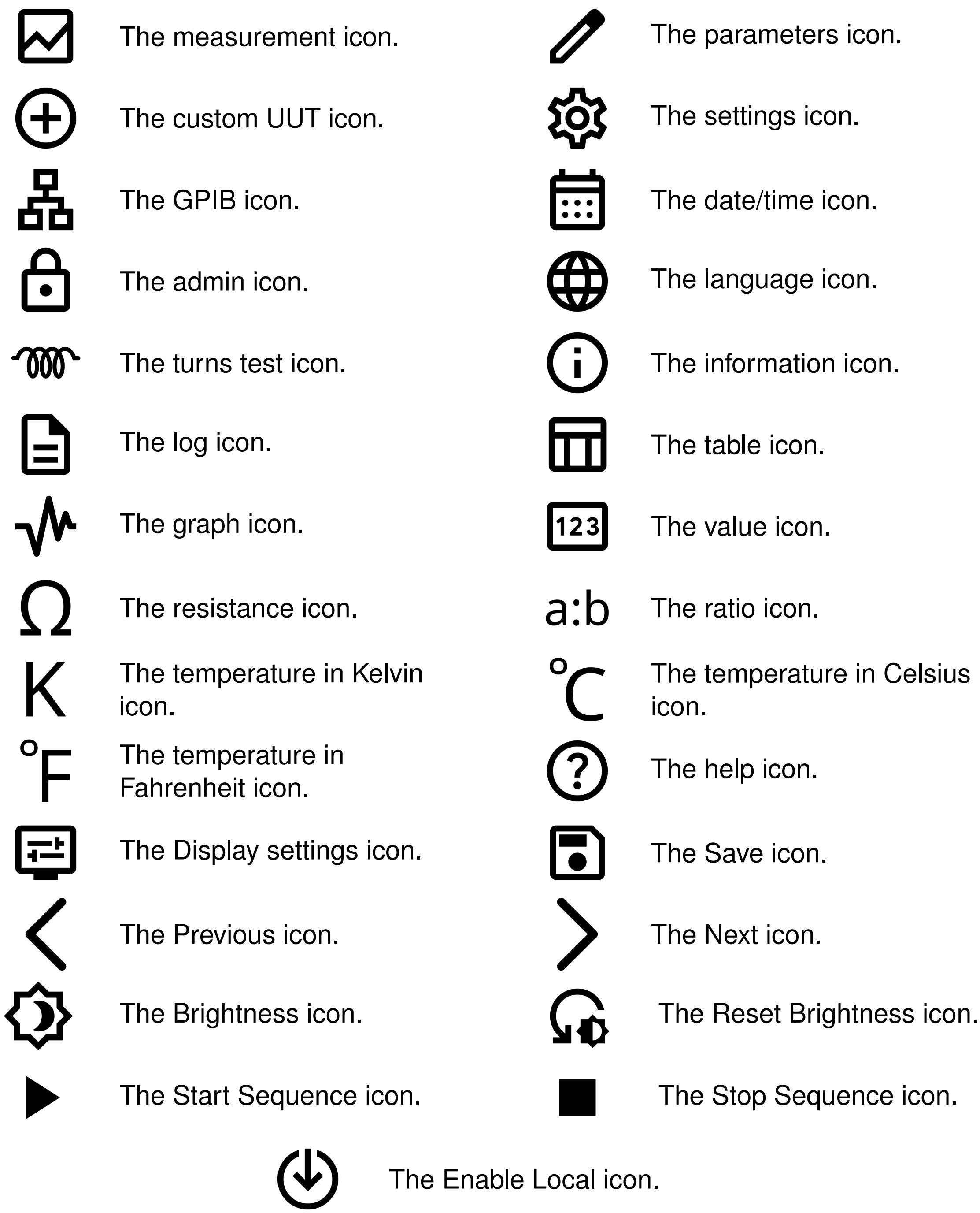


Figure 8.5: GUI Icons.

8.4 Measurement

This section describes the functions and parameters available in the Measurement Menu.

8.4.1 Parameters Screen

Figures 8.8, 8.9, and 8.10 shows the measurement parameter screen that loads after successfully completing the initialization process. Here, enter the parameters and start a measurement.

To enter values for the parameters, press on the box, the border of the field, and the label will change to blue to indicate that it has been selected. Then, a number pad (Figure 8.6) pops up from the bottom of the screen.

Clicking anywhere on the GUI that isn't another field or the number pad will deselect the field, and the number pad will disappear.

Pressing the enter button on the number pad will select the following field.

When selecting a field, a cursor will show the position. If the cursor is at the last position, begin typing to overwrite the value that is there or press backspace to edit the value. The cursor will always edit the value if it is not at the last position.

A special warning is displayed for uncertainty, as it has no upper bound to its range. Instead, values greater than 50 display a warning to indicate that high uncertainties may lead to undesirable results. The uncertainty field border, label, and range will also turn orange (Figure 8.7).

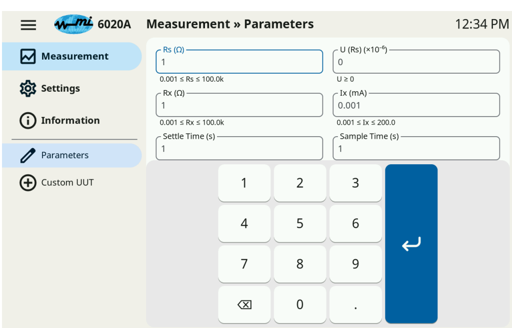


Figure 8.6: Parameters Screen Window with Keyboard.

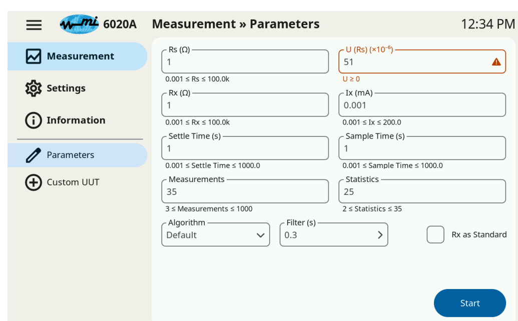


Figure 8.7: Parameter Entry Error Highlighted.

List of Parameters

WARNING

Each bridge will have the parameter range associated with the bridge specific minimums and maximums listed right under the respective parameters field.

R_S (Ω): This is the standard resistance connected to the R_S terminal of the back panel. It is the denominator coefficient for calculating the unit under test (UUT) resistance R_X from the measured ratio.

U(R$_S$)(×10^{-6}): This is the uncertainty associated with R$_S$ due to a calibration. This value is root-sum-squared with the Type A uncertainty that the instrument calculates.

NOTE

The R$_S$ uncertainties from calibration are entered for k=2

R$_X$ (Ω): This is the resistor under test connected to the R$_X$ terminals of the back panel. The displayed resistance value is calculated from the measured ratio and the R$_S$ value.

NOTE

R$_X$ may also be chosen from a pre-set created in the Custom UUT (Unit Under Test) screen.

Ix (mA): This is the milliampere current applied to the UUT. The current applied to R$_S$ is calculated based on the entered parameters.

Settle Time (s): This is the time the machine idles to allow the dissipation of any time constant resulting from the connection of the UUT to the current comparator after applying a current.
The range of this parameter is from 1 s to 1000 s.

Sample time (s): This is the time dedicated to sampling the signal of the nanovoltmeter. The analog-to-digital converter sampling frequency is fixed to $f_S = 1kHz$, thus sampling for 1 s results in 1000 samples.
The sample time can range from 1 ms to 1000 s.

Measurements: This is the number of repetitions of the measurement sequence that the instrument repeats.
The measurement must be a positive number greater than zero, with a maximum value of a thousand.

Statistics: This is the number of measurements used to calculate the arithmetic mean and the standard deviation.
This parameter can range from 1 to the number of measurements subtracted by one.

Algorithm: This dropdown menu allows the selection of a measurement algorithm. There are three choices: default, single, and double. See Chapter 9 for details.

NOTE

This feature might not be available

Filter: This dropdown menu allows the selection of a measurement filter. There are four choices: 0 s, 0.1 s, 1 s, and 3 s.
Besides the 0 s, which is the default setting, selecting a filter calculates the moving average with a buffer of 3, 10, or 30 ratios for the 0.1 s, 1 s, and 3 s, respectively.

6020A Parameters

R_X as Standard: This checkbox is used to change the R_X resistor to the standard for calculation and display purposes.

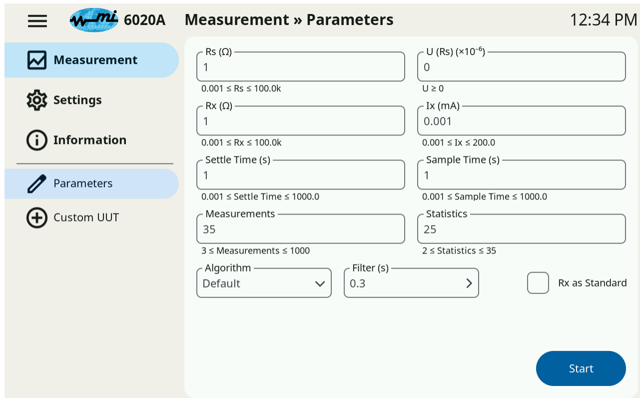


Figure 8.8: 6020A Parameters Screen Window.

6020Q Parameters

QHR Quantization: This dropdown menu allows the selection of the QHE quantization measurements described in Section 7.3 and 8.4.4.
There are four choices: None, Vxx Sweep, Contact Resistance, and Dissipation.

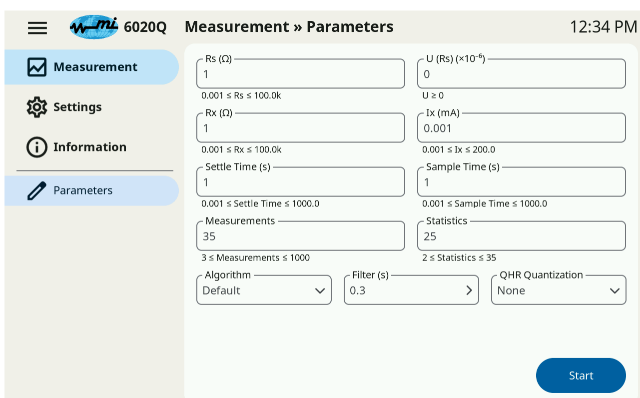


Figure 8.9: 6020Q Parameters Screen Window.

6020T Parameters

NOTE

The 6020T shares the **R_X as Standard** parameter from the 6020A, however it is called R_T as the unknown in thermometry bridges is typically a thermometer.

R_S Channel: This radial selection menu allows the user to select an R_S channel from the front panel mini-scanner to be used during the measurement sequence.
There are 2 channel options.

R_T Channel: This radial selection menu allows the user to select an R_T channel from the front panel mini-scanner to be used during the measurement sequence.
There are 4 channel options.

Pre-heat: This checkbox is used to enable or disable the resistor pre-heat option. This applies a 1 mA current across all resistors, except any selected channels during a measurement sequence, to ensure the stability of the temperature coefficient of the UUT's.

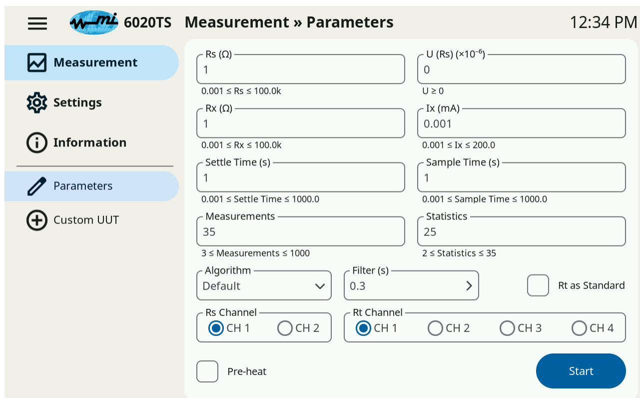


Figure 8.10: 6020T Parameters Screen Window.

8.4.2 Measurement: Custom UUT

> **NOTE**
>
> This feature is available only for some bridge models.

This window is dedicated to creating, selecting, editing, and deleting custom UUTs. If no UUTs are saved, the screen will display a button in the center of the screen, as shown in Figure 8.11.

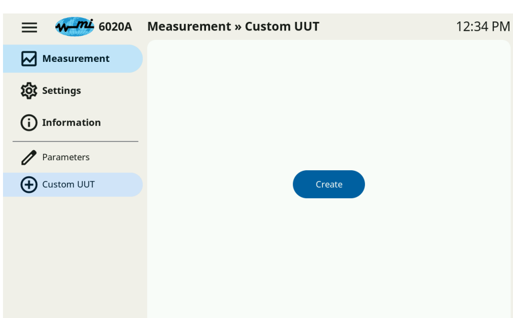


Figure 8.11: Custom UUT Create Window.

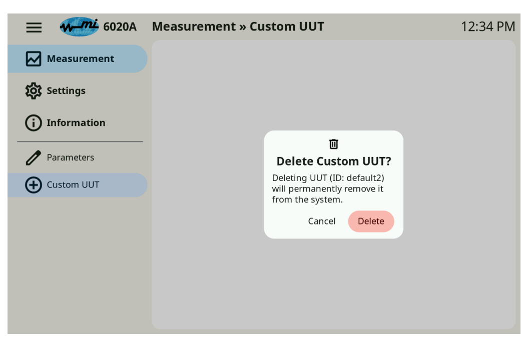


Figure 8.12: Custom UUT Delete Window.

As new pre-sets are created, the screen is filled out with cards, and the create button changes to be in the bottom right.

A default naming scheme is entered if an identifier is not given to the pre-set.

NOTE

The maximum number of custom UUT's allowed is 32.

The create button is disabled once the maximum allowed pre-sets are reached.

To select a custom UUT press anywhere on the card that isn't the delete or edit button. After selecting a custom UUT, the screen will return to the Measurement Parameters screen with the R_X field disabled (Figure 8.13).

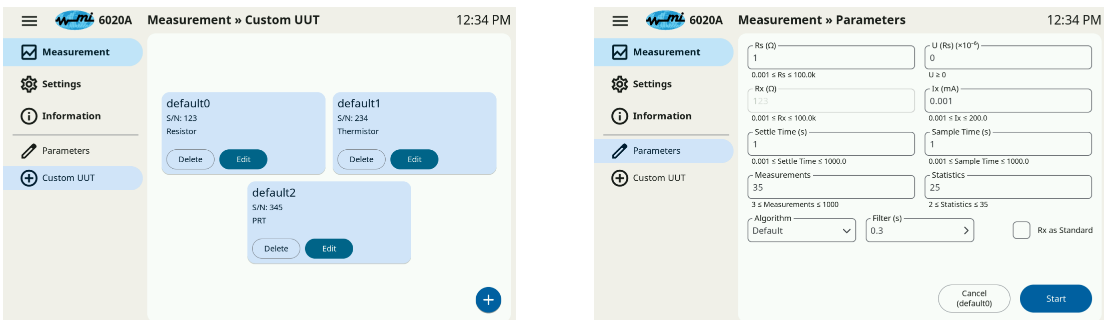


Figure 8.13: Custom UUT Cards and *default0* selected as R_X.

A cancel button also appears. It is the only way to deselect a custom UUT. Other custom UUTs can be selected even if there is already one set.

When the delete button is pushed, a popup confirms the wish to delete the selected custom UUT, as shown in Figure 8.12. When the popup appears, the cards are hidden, and all buttons are disabled until the popup is closed.

If cancel is pressed, the custom UUT is not deleted. If the delete button is pressed, the card is removed from the screen.

8.4.3 Measurement: Custom UUT: Create

This Custom UUT Create screen appears if the create button is pressed on the Custom UUT screen or the edit button on a card.

When the "ID" field is selected, a keyboard instead of a number pad will pop up.

A unique ID must be entered for the custom UUT. Otherwise, an error text appears, and the "Save" button will be disabled, as shown in Figure 8.14.

The value for the custom UUT must also fit within the expected ranges outlined in the measurement screen. An error text appears if the value is outside the range, as shown in Figure 8.14, and the "Save" button will be disabled.

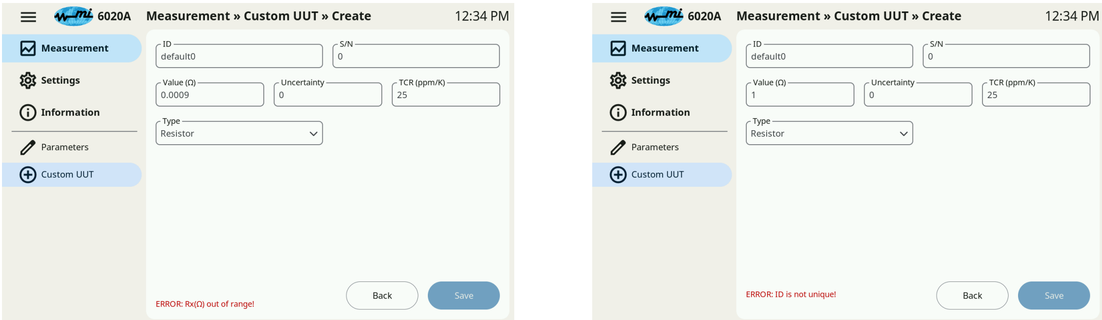


Figure 8.14: Custom UUT Error Messages: R_X is out of range, and ID is not Unique.

In the "Type" dropdown, three different types of sensors are selectable: resistor, thermistor, and standard platinum resistance thermometer (PRT).

Selecting a different type of sensor changes the parameters the user can enter, as shown in Figure 8.15.

When the "PRT" sensor type is selected, another dropdown is created for the different ranges. To view more information about the ranges, see Table 8.1.

All the fields are entered in the same way as the measurement screen. When the "Save" button is pressed, the Custom UUT is saved and returned to the Custom UUT screen.

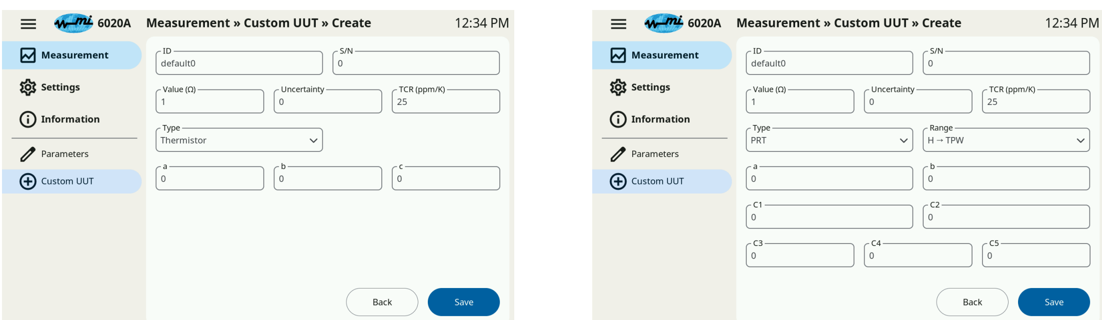


Figure 8.15: Custom UUT Type of Sensors.

8.4.4 Quantum Hall Resistance (QHR) Quantization Checks

> **NOTE**
>
> This feature is only available for the 6020Q and bridges enabled for QHR measurements.

One can access the QHR quantization check features (Figure 8.16) from the bottom right drop-down menu of the Measurement window.

There are four option available:

- None
- Sweep

Table 8.1: Custom PRT ITS90 Ranges and Coefficients.

Sub Range	Temperature (K)	Coefficient	ITS90 Range
Low Ranges			
1	13.8033 to 273.16	a_1, b_1, c_1-c_5	H $\rightarrow$TPW
2	24.5561 to 273.16	a_2, b_2, c_1-c_3	Ne $\rightarrow$TPW
3	54.3584 to 273.16	a_3, b_3, c_1	O $\rightarrow$TPW
4	83.8058 to 273.16	a_4, b_4	Ar $\rightarrow$TPW
5	234.3156 to 302.9146	a_5, b_5	Hg $\rightarrow$TPW
High Ranges			
6	273.15 to 1234.93	a_6, b_6, c_6, d	TPW $\rightarrow$Ag
7	273.15 to 933.473	a_7, b_7, c_7	TPW $\rightarrow$Al
8	273.15 to 692.677	a_8, b_8	TPW $\rightarrow$Zn
9	273.15 to 505.078	a_9, b_9	TPW $\rightarrow$Sn
10	273.15 to 429.7485	a_{10}	TPW $\rightarrow$In
11	273.15 to 302.9146	a_{11}	TPW $\rightarrow$Ga

- Contact Resistance
- Dissipation

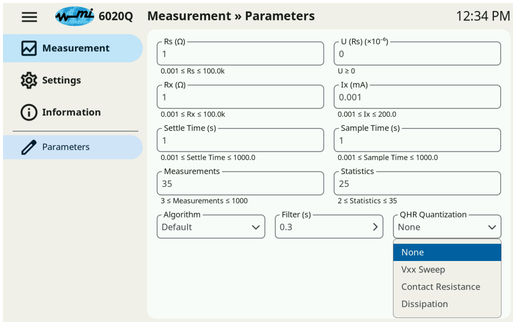


Figure 8.16: QHR drop down menu.

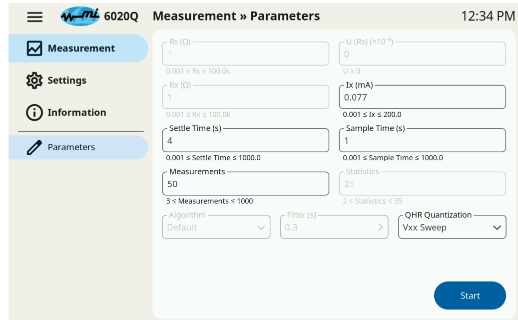


Figure 8.17: QHR Sweep Parameters.

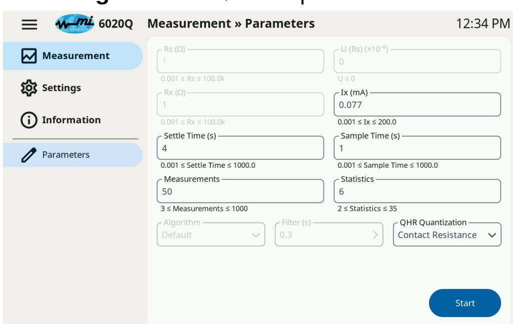


Figure 8.18: QHR Contact Resistance Parameters.

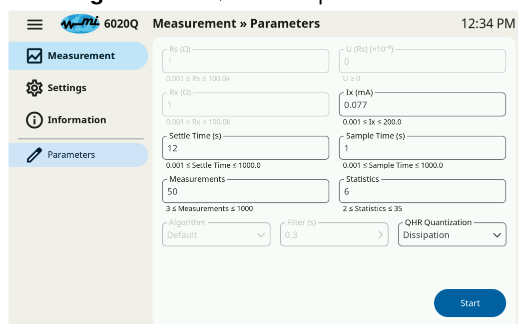


Figure 8.19: QHR Dissipation Parameters.

NOTE

For more information regarding QHR bridge connection read Appendix A

NOTE

The DC Bridge do not control superconductive magnet power supply. In case of sweeps the target magnetic field, rate and magnetic constant must be manually selected.

None

When None is selected, the QHR features are switched off, and the bridge is in normal resistance mode.

Sweep

The Sweep feature activates only the parameters necessary for V_{XX} and V_{XY} sweep check, as shown in Figure 8.17. I_X is the chip bias current, and its default value is 0.077 mA (this is the legacy value for the GaAs sample). By default, the settling time and sample time are 4 s and 1 s, respectively. The number of measurements is set to 50. However, it may be increased if a full sweep is performed.

Contact Resistance

Figure 8.18 shows the parameters active for the QHR contact resistance check. I_X is set to 0.077 mA, the settling time and sample time are 4 s and 1 s, respectively. The number of measurements is set to 50 and the statistics to 6.

Dissipation

Figure 8.19 shows the parameters active for the QHR contact resistance check, which are the same as per the contact resistance check. Double check the sample connection before starting a measurement.

8.4.5 Channel Selection

NOTE

This feature is only available for the DC Thermometry bridges.

The Channel selection feature controls the front panel scanner of the thermometry bridges. The inputs are subdivided into two R_S and four R_T (the UUT equivalent of R_X), as shown in Figure 8.20. By default, they are not selected. The radio button activates the channels. Select one of each R_S and R_T before starting the measurement.

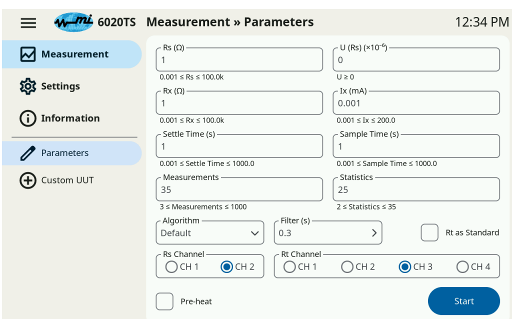


Figure 8.20: Channel Selections.

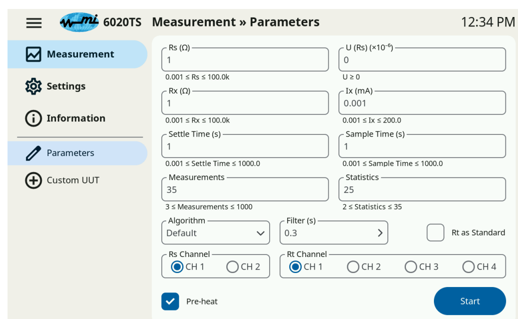


Figure 8.21: Pre-heat feature.

Another feature available from the thermometry bridges measurement window is the UUT's pre-heat (Figure 8.21). To activate it, click on the square beside the pre-heat label. When active, a warm-up current of 1 mA flows in all the R_T channels that are not selected.

WARNING

The pre-heat current might not be compatible with your thermometer. Caution must be taken when using this feature.

8.4.6 Measurement Sequence

The measure sequence screen, shown in Figure 8.22, appears immediately after starting a measurement. The navigation bar submenu changes to one dedicated to displaying the measurement information.

Figure 8.22 shows the persistent elements of the measurement sequence. The blank area will be filled in with the selected sub-menu.

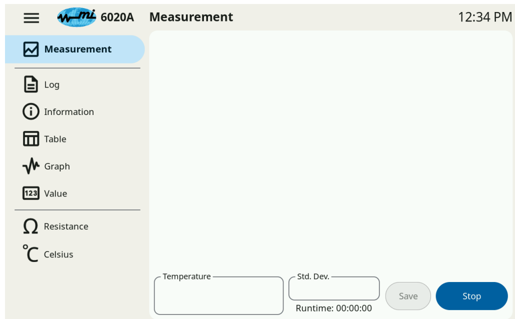


Figure 8.22: Measurement Sequence Window.

The controls are at the bottom of the navigation bar, which allows the display information to change from ratio to resistance and vice versa. If a custom UUT is selected for the measurement, there will also be an additional control to switch between temperatures.

8.4.7 Log View

By default, the log is the view displayed upon starting a measurement (Figure 8.23). This view will relay the current progress and status of the measurement.

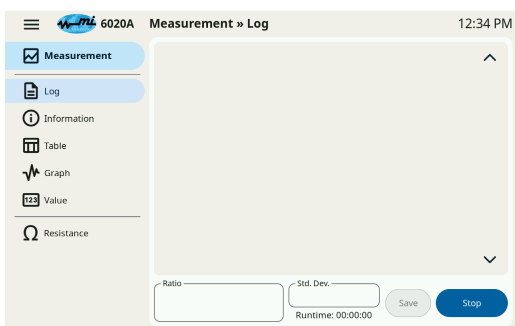


Figure 8.23: Measurement Log Window.

8.4.8 Measurement Information View

The measurement information view, shown in Figure 8.24, displays all the information regarding a measurement, primarily the parameters entered from the measurement screen.

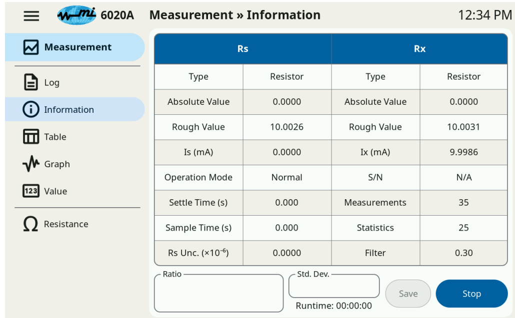


Figure 8.24: Measurement Information Window.

8.4.9 Table View

Figure 8.25 shows the table view where each measurement is displayed in a table. As a new measurement data point is ready, it is appended to the bottom of the table. Scroll the table by swiping up or down on it.

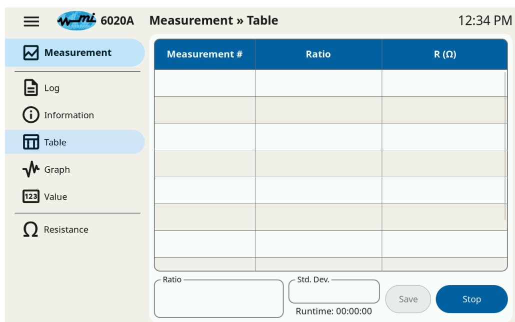


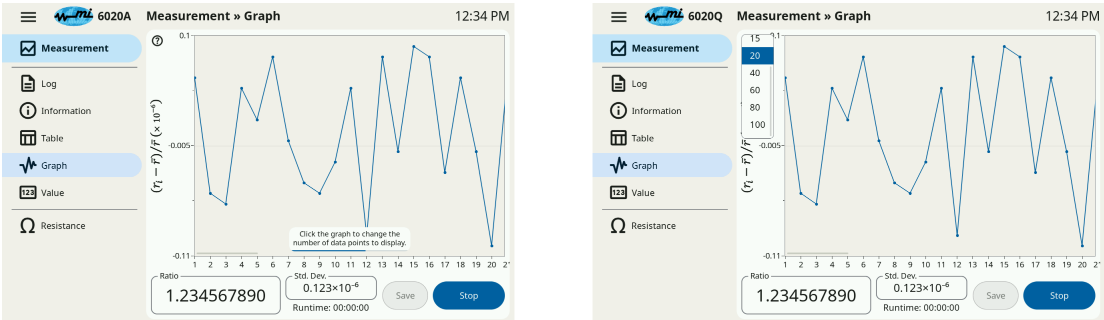
Figure 8.25: Table View.

8.4.10 Graph View

The graph view displays each measurement on a line graph (Figure 8.26). As a new data point is ready, it is added to the graph.

The graph screen introduces the ability to change how many data points to display. It is accessible by clicking on the graph. Press the tooltip in the top left to see instructions, as shown in Figure 8.26a.

Selecting to display more points than actual data points will only show how many points are available. It automatically adjusts until the target is reached. The graph is scrollable; off-screen points may be looked at by either swiping to the left or right.



(a) Tooltip view.

(b) Number of points selection.

Figure 8.26: Measurement Graph View.

8.5 Settings

Press the gear icon or the label to open the settings menu. The navigation bar will change to display the available sub-menu.
The menus and submenus are:

- GPIB (Section 8.5.1)
- Date / Time (Section 8.5.2)
- Admin (Section 8.5.3)
  - Corrections (Section 8.5.4)
- Language (Section 8.5.5)
- Turns Test (Section 8.5.6)
- Display (Section 8.5.7)

8.5.1 GPIB

The default window of the settings menu is the GPIB address setting, shown in Figure 8.27. Use the roller to the center of the window to change the current GPIB address. The default address is 15. To learn more about GPIB addressing, please refer to the IEEE-488 standard.

Use the roller until the desired address is highlighted to set a new address. Pressing "Save" will change the GPIB address. To confirm the change, see the number beside the current address label. The selection won't be confirmed if the save button is not pressed.

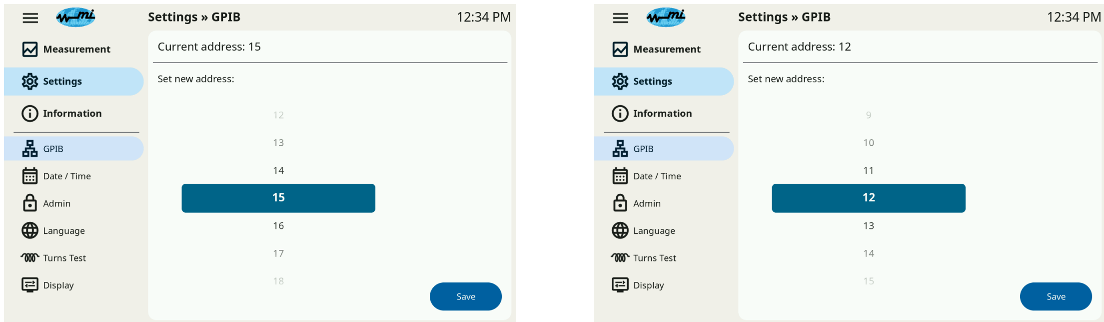


Figure 8.27: GPIB Address Setting Window.

8.5.2 Date & Time

The date and time settings, shown in Figure 8.28, provide the interface to change the system's date and time. None of the measurements are time-sensitive, but logging system events will timestamp the action.

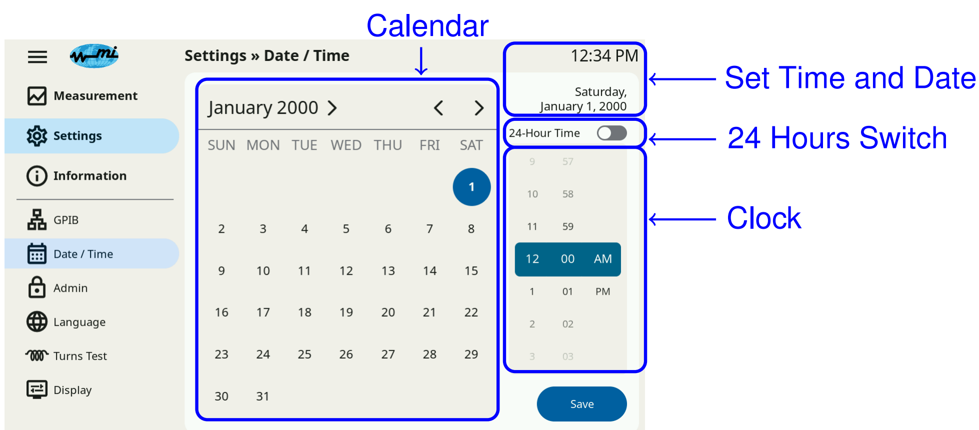


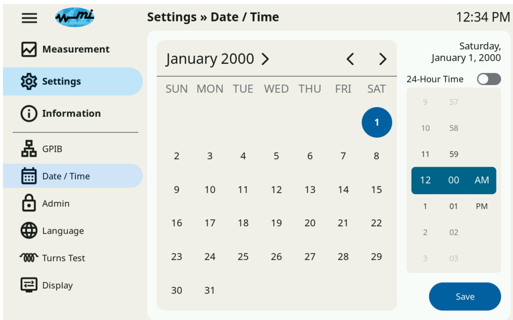
Figure 8.28: Date and Time Window.

To change the month, press the left or right arrows at the top right of the calendar, as shown in Figure 8.29a. These will change the calendar to display the previous or next month. To change the month or year quickly, press the month's name in the top left of the calendar. This will switch the calendar to display two rollers, one for the month and one for the year, as shown in Figure 8.29b. By pressing the month's name again, the calendar will display the last month and year set on the rollers and switch back to the main Date and Time window.

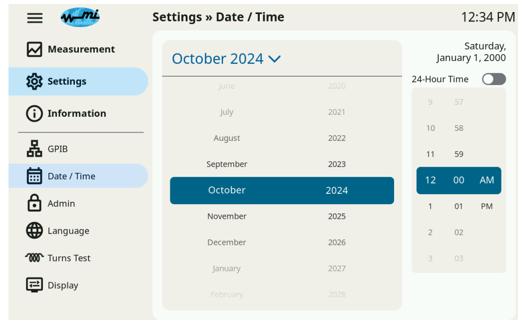
To select a date, press on the number that represents the date. To change the time, use the rollers to the calendar's right. To choose 24 or 12-hour time, press the switch above the time rollers, which automatically updates the display to the desired format. The selection is also updated along with the current date and time in the top right corner of the screen.

Once the desired date and time have been selected, press the "Save" button in the bottom right corner to set the system time. The chosen parameters are immediately updated in the display's top right corner.

The seconds are not selectable and are always set to 0. Therefore to best synchronize the system's time, it is suggested that the save button be pressed at the same time the minute changes on the clock reference.



(a) Month Browsing Button.



(b) Month and Year Rollers.

Figure 8.29: Calendar Setting.

8.5.3 Admin

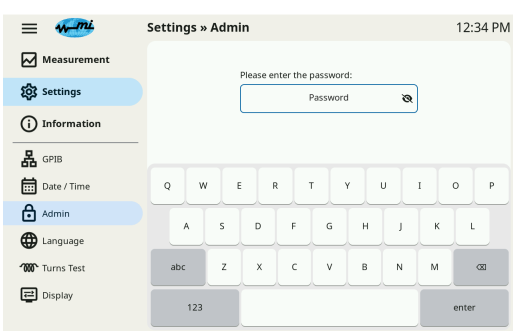
The admin menu is the window to access the correction tables and service menu.

The admin menu is a unique settings menu, it is password-protected. It will prompt the user to enter a password. Much like the other menus, a keyboard will pop up when the field is pressed. Figure 8.30a shows the windows status after the password filed is pressed.

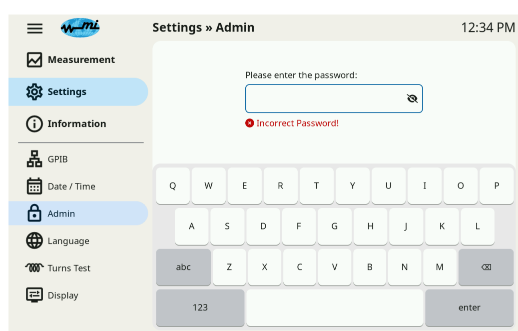
Entering an incorrect password will clear the input and warn that the password was entered incorrectly (Figure 8.30b).

NOTE

The password assigned to access the correction table is **111559111**



(a) Password Field and Keyboard.



(b) Wrong Passord Message.

Figure 8.30: Admin Window.

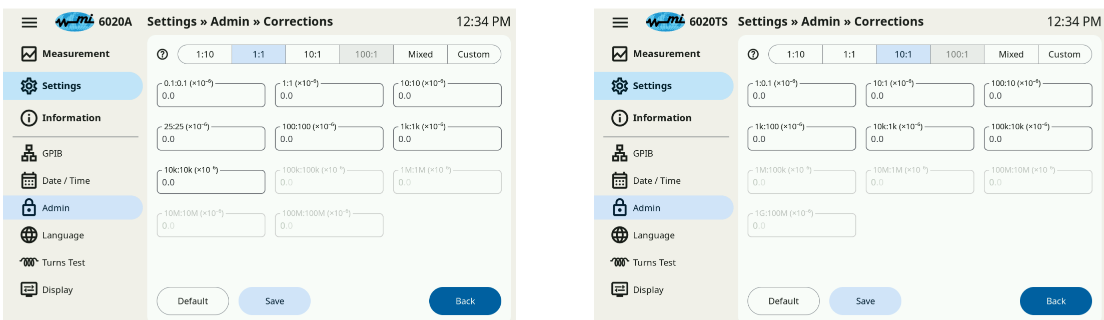
8.5.4 Corrections

The corrections are the parameters applied to the measured ratio to compensate for offset errors. Generally, they are determined by calibrating a more accurate system, such as a Cryogenic Current Comparator. They are added or subtracted from the ratios after each measurement loop (see Chapter 9).

NOTE

The active correction table and active ratio fields depends on the model of the bridge in use. The corrections are accessible only if the bridge allows those ratios

The corrections menu is accessed by correctly entering the password in the admin screen. Six correction tabs provide access to multiple ratio fields. Only the ratios compatible with the installed hardware are active. Figure 8.31 shows the active corrections for one of the DC bridges for the 1:1 (Figure 8.31a) and 10:1 ratios tabs(Figure 8.31a) ratios.



(a) 1:1 tab. **(b)** 10:1 tab.

Figure 8.31: Corrections Windows.

Corrections Tab - 1:10, 1:1, 10:1, 100:1

The 1:10, 1:1, 10:1, and 100:1 correction tabs are designed to allow up to 9, 11, 10, and 7 corrections respectively. To enter a correction tap the desired filed, a numpad board opens, type the value with sign. Press outside the numpad to close it.

Press the SAVE button to save the entered value for all ratios. A line of text will appear to show that the corrections have been saved.

Pressing the DEFAULT button will set the currently selected ratio to their default values.

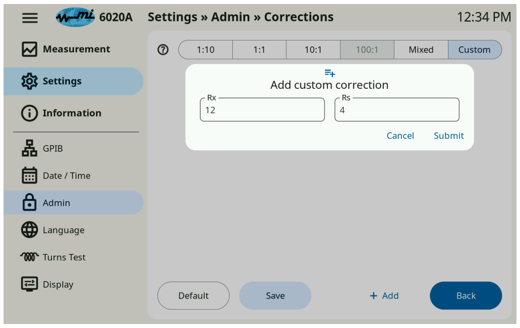
Pressing BACK will exit the menu without saving.

Mixed Correction Tab

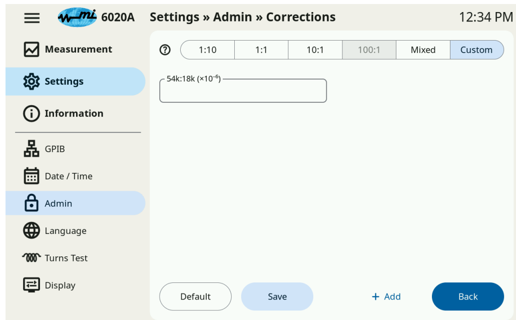
The mixed correction tab is designed to allow up to 8 'mixed' value corrections. Follow the instruction of Section 8.5.4 to enter data, save and exit without saving.

Custom Correction Tab

The custom correction tab allows to create ratio correction not available in other tables. When the ADD button is pressed a new popup windows open (Figure 8.32a). Enter the ratio in terms or R_X and R_S value in Ohm. Press CANCEL to disregard the modifications. Pressing SUBMIT a new ratio filed is created in the Custom Correction tab (Figure 8.32b).



(a) Add Ratio.

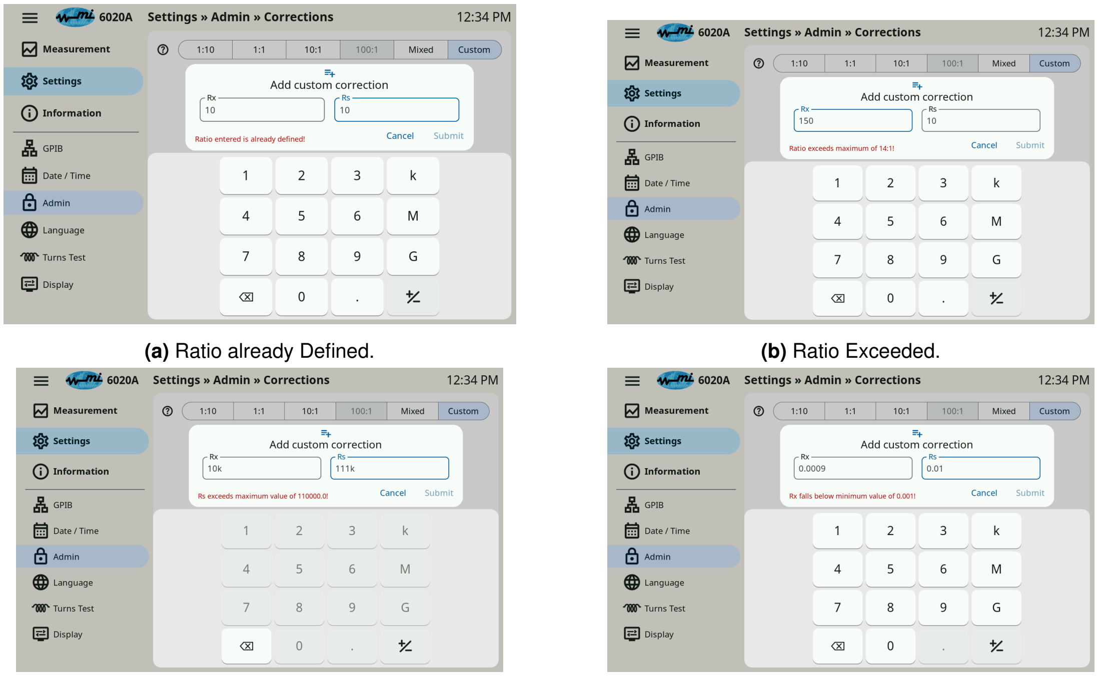


(b) Custom Corrections tab.

Figure 8.32: Custom Corrections Windows.

The bridge automatically check if the values of the resistances and the ratio entered comply with the hardware capability. There are 7 error checks:

- Ratio already defined (Figure 8.33a)
- Ratio exceeds maximum value (Figure 8.33b)
- Ratio falls below minimum value
- R_S exceeds maximum value (Figure 8.33c)
- R_S falls below minimum value
- R_X exceeds maximum value
- R_X falls below minimum value (Figure 8.33d)



(a) Ratio already Defined.

(b) Ratio Exceeded.

(c) R_S too Large.

(d) R_X too Small.

Figure 8.33: Custom Corrections Errors and Warnings.

If an error is detected, the SUBMIT button is not accessible. It becomes available as soon as the inspection criteria are met. After the new ratios are defined (Figure 8.32b) follow the instruction of Section 8.5.4 to enter the correction, save or exit without saving.

8.5.5 Language

From this screen it is possible to select system language. Figure 8.34, shows the window with the available languages. Pressing any of the buttons will change the language immediately.

NOTE

This feature is a work in progress. Screenshots do not currently reflect the languages supported or their correct translations.

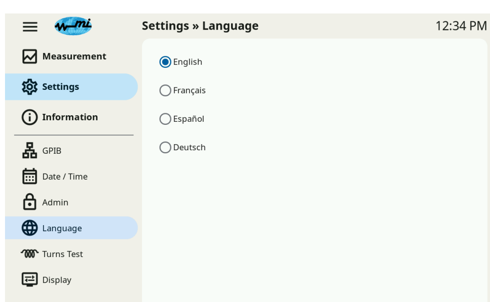


Figure 8.34: Language Window.

8.5.6 Turns Test

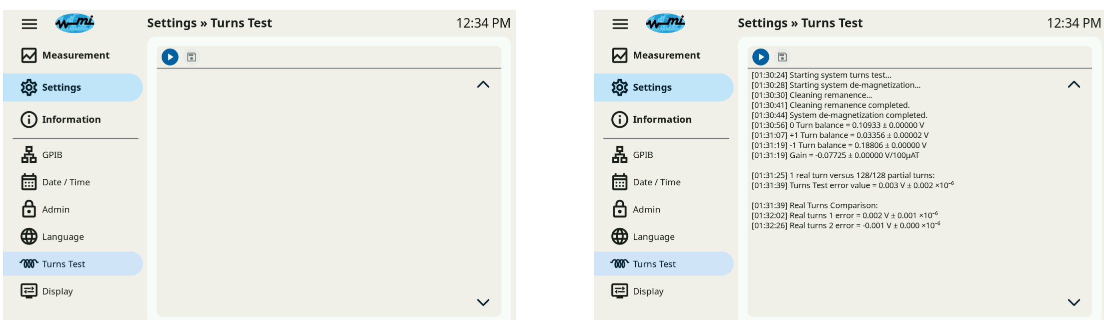
The DC bridges comparator is binary wound (1, 2, 4, 8. . . , 4096, 1024, 2048). The comparator consists of real turns, partial turns, and peripheral turns. An extra one-turn winding is present for testing purposes.

The turns test is used to verify the comparator's parameters, such as the control electronic offset, the sensitivity, and the error of the bridge windings. No external standards are required for this operation/

Figure 8.35 shows the Turns Test window. Press the start button to initiate the Turns Test procedure.

The initial testing is the measurement of the zero balance and the gain of the peak detector. The latter equals 100 mV for a 100 µAT offset in the comparator (100 µA through a one-turn winding). The offset or zero balance of the peak detector is removed by reversing the current and taking the average of the two readings (+1 and -1 turn balance).

Then, the turns test commences, first, with the one real turn vs. 128 partial turns. Thus, the real turns, made up of 1 through 4096 plus 1024 plus 2048 turns to give a ratio of 14:1, are measured. Lastly, the partial turns are compared. The configuration of the partial turns is also binary from 1 to 128, where 128 partial turns correspond to 1 real turn. The expected limits of the test are reported in Table 8.2.



(a) Log empty. **(b)** Log with data.

Figure 8.35: Turns Test Windows.

> **WARNING**
>
> Contact Measurement International if the real or partial turn error exceeds the maximum acceptable error.

Table 8.2: Turns Test Comparison Limits.

Peak Detector	
0 turn balance	50 mV
+1 turn balance	–100 mV ± 50 mV
-1 turn balance	100 mV ± 50 mV
Gain	100 mV ± 50 mV
Turns Comparison	
Turns	**Max Error (V)**
1 real vs 128 partial	0.01
Real Turns	
2	0.02
1	0.02
4	0.02
8	0.02
16	0.02
32	0.02
64	0.02
128	0.02
256	0.02
1024	0.02
2048	0.02
4096	0.02
1024	0.02
2048	0.02
Partial Turns	
1	0.02
2	0.02
4	0.02
8	0.02
16	0.02
32	0.02
64	0.02

8.5.7 Display

The Display menu, shown in Figure 8.36, define four LCD setting:

- Light/Dark Mode
- Brightness
- Screen Burn-in Fix
- Always On Display

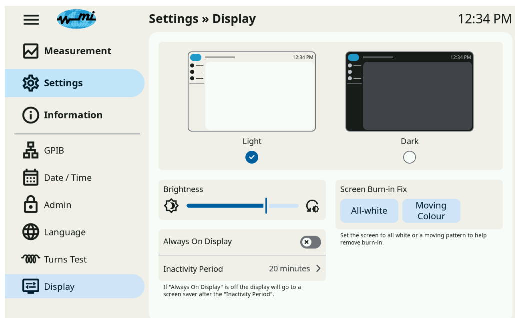


Figure 8.36: Display Window.

8.5.8 Light/Dark Mode

Light and dark modes refer to color themes used in graphical user interface to enhance readability and user comfort. To select the desired setting, which will be applied to all the windows, click on the radio button below the window depicting the theme (Figure 8.37). The selection is automatically saved.

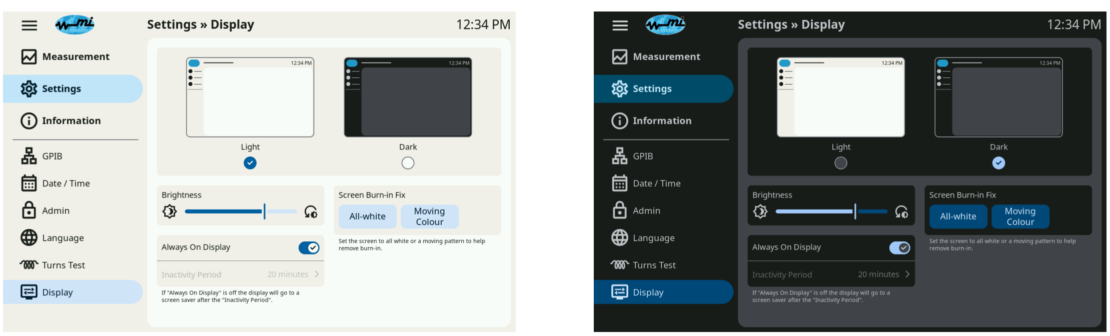


Figure 8.37: Light and Dark Mode Setting.

8.5.9 Brightness

The brightness slider changes the intensity of the backlight. To reduce the setting, slide it to the left (Figure 8.38) or the right to increase it. The selection is automatically saved.

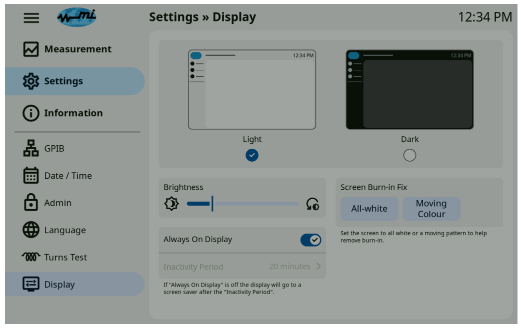


Figure 8.38: Brightness Setting Reduced.

8.5.10 Screen Burn-in Fix

Under some circumstances, there could be screen burn-in, especially when switching to the dark theme after using the light theme for quite some time. To help reduce this effect, select one of the two options, ”All-white” or ”Moving Colour”, by clicking on the buttons in the Screen Burn-in Fix decorator (Figure 8.37).

Both are as effective to help mitigate screen burn-in.

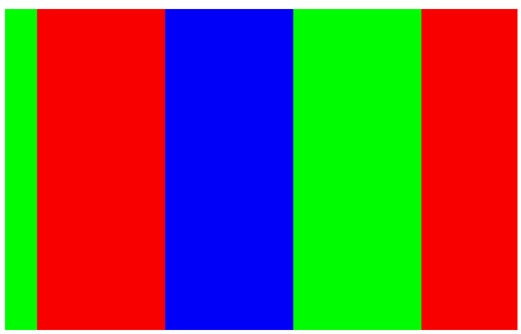


Figure 8.39: Moving Colours Feature.

The “All-white” option changes the screen to display all white, and the “Moving Colour” (Figure 8.39) option has a set pattern of red, green, and blue moving around on the screen. Pressing the screen after an option has been selected returns to the menu.

WARNING

Fast-changing colors can trigger seizures in people with photosensitive epilepsy.

8.5.11 Always On Display

The always-on-display feature is designed to enable/disable the screen saver.

If the slider is set to on, the screen is lit up. Otherwise, when off, it will set up a screen saver after the inactivity period expires. To change the inactivity period, click the time beside the label. A drop-down menu with nine items opens, then select the desired option. The maximum span is 2 hours.

When activated, an MI bouncing logo screensaver that changes color appears (Figure 8.40). Touch the screen to go back to the last active window.

Figure 8.40: Screen Saver In Action.

8.6 Information

The information screen is where the company and system information are stored (Figure 8.41). A contact email and toll-free phone number are provided along with a QR code that, if scanned, links to the Measurements International website.

The firmware version and bridge build are stored here as well.

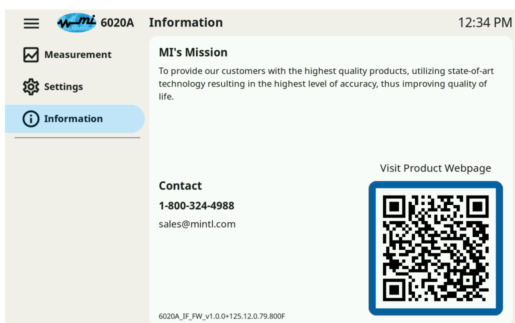
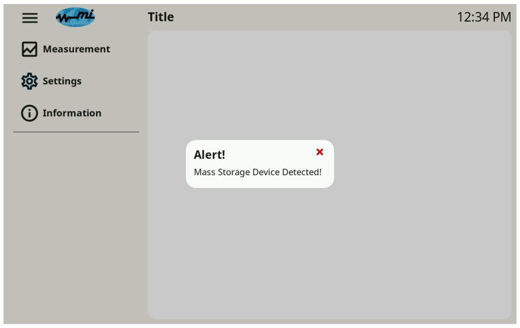


Figure 8.41: Information Window.

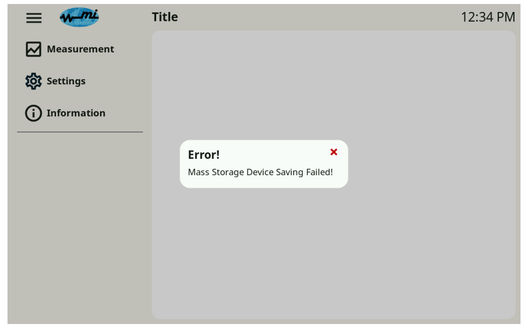
8.7 Mass Storage Devices

One can connect a USB mass storage device (MSD) from the front panel. Upon connection, a popup window opens to notify the user that the system has detected the MSD (Figure 8.42a).

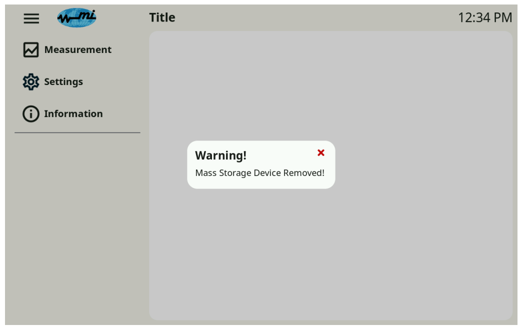
When an MSD is available, the save button in the lower part of the measurement window (see Chapter 9) and the save icon at the top of the turns test windows (see Figure 8.35) are activated. At the end of a measurement, click the save button to store the sequence log data to the MSD. In case of problems in saving to the MSD, the system notifies the user, creating an error message popup window (Figure 8.42b).



(a) MSD Connected.



(b) MSD Failed.



(c) MSD Removed.

Figure 8.42: Mass Storage Device Notification Windows.

Upon saving, if it is not already in existence, the machine creates three directories:

- Measurement
- Turns Test
- Service

The first two folders are saved in the selected language, while the latter is stored only in English. The file is saved in the proper folder; therefore, the measurement data are stored in the Measurement directory and the turns test in the Turns test directory. The file name is automatically created, and its format is as follows:

`Measurement_YYYY_MM_DD_HH_mm_SS.log`

Where YYYY is the year, MM is the month, DD is the day, HH is the hour, mm is the minute and SS is the second. The content of the file is stored in text format so that it can be opened with any standard text editor application.

A last popup message is created upon disconnecting the MSD from the USB port (Figure 8.42c).

9. Measurement Sequence and Algorithms

This section explains the details of the measurement sequence and the differences between the three available algorithms.

Although the algorithms have some commonalities, such as the current reversal, the definition of the settle time, and the sample time, their execution is specific to each algorithm.

The measurement sequence starts with a process identical to each algorithm, the rough measurement. With this function, the bridge verifies the connection of the resistors, R_X and R_S, and their value. It adjusts the current in each bridge branch and selects the gain of the nano-volt amplifier. If some parameters entered are not confirmed during the rough measurement, the instrument will report a *Check Connection error*.

Completed the rough measurement, the instrument commences the selected algorithm execution.

NOTE

Some of the feature illustrated in this chapters might not be available.

9.1 Default Algorithms

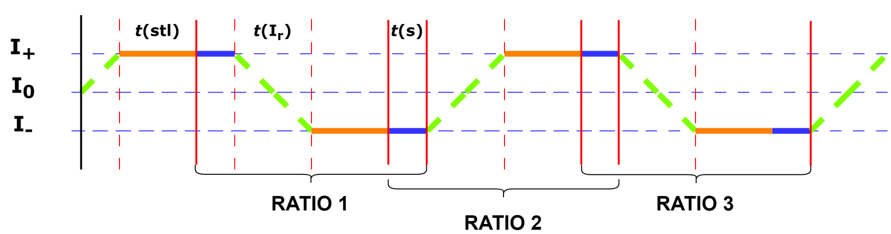


Figure 9.1: Default Algorithm Timing Diagram. The signal t(stl), in orange, is the settling time, $t(I_r)$, in green, is the current reversal time, and t(s), in blue, is the sample time.

The default algorithm is the legacy process provided with the DC ratio bridges since the first model was developed at MI, which time diagram is shown in Figure 9.1.

After the turn selection, the algorithm ensures that the current polarity is set correctly. Then, it settles for the time (***t*(stl)**) selected from the front panel. As soon as the waiting time is exhausted, the machine samples the nano-voltmeter signal for as long as specified in the sample time field and averages the data.

Then, the current is inverted, which takes 500 ms. Then, the machine settles the samples for the time allocated and averages the samples.

The ratio is calculated based on the averaged positive and negative samples. This process is repeated N times, where N is the number of measurements entered in the front panel. If the number of ratios is more significant than one, the ratio's average and the standard deviation (see Chapter 7) are calculated and displayed.

9.2 Single

The *Single* and *Double* algorithms are developed to improve the *default* one. Although the default algorithm has faster execution, it is affected by autocorrelation since one of the previous data sets is reused to calculate the following ratio.

The name Single refers to a single current reversal for each ratio. The algorithm is similar to the default; however, no data set is reused to calculate the ratios. Moreover, to optimize the runtime, after a current reversal, the instrument sample for twice ***t*(s)**, where half of the data are used to calculate the current ratio and the second are for the second ratio (Figure 9.2).

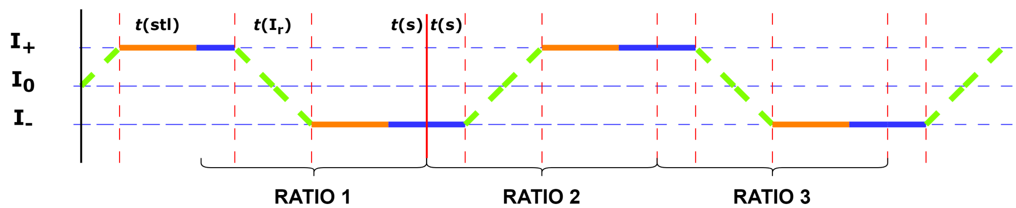


Figure 9.2: Single Current Reversal Algorithm. The peculiarity of this procedure is the double sampling after reversal.

9.3 Double

The *Double* has twice current reversal for each ratio measurement. This algorithm is developed to compensate for any short time during a ratio measurement. The positive current data are acquired at the beginning and at the end of the measurement sequence for a total of twice ***t*(s)**. Whereas, for the negative current, the sample, also twice ***I*(s)**, is sampled continuously (Figure 9.3).

The execution time is twofold the time for the single algorithm.

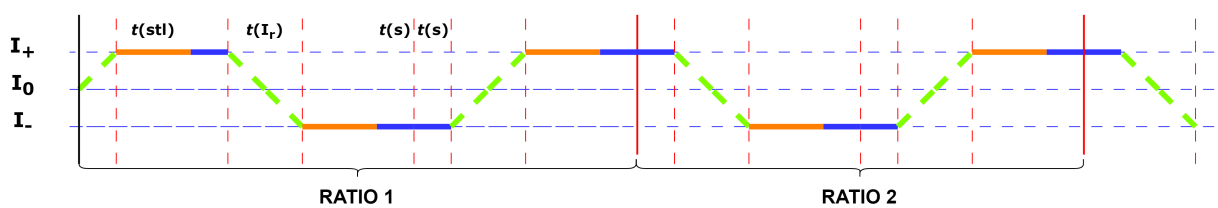


Figure 9.3: Double current reversal algorithm. Compared to the other algorithms, each ratio is calculated with twice the data sample.

10. Remote Control

The 6020 also operates via the IEEE-488 (GPIB) bus under the control of a remote computer with Measurements International's software. The software will send all the measurement parameters to the bridge through GPIB, automatically starting the measurement sequence

The bridge then displays the remote-control popup, as in Figure 10.1 before switching to the measurement sequence log page.

If a PRT or thermometry measurement is selected, the screen will display the temperature and the "°C", "°F", or "K" sidebar buttons that allow the users to change the actively displayed value.

The system status bar will also show a blinking "Remote Control" label near the top right of the screen.

Refer to Chapter 11 for a description of commands, error messages, reports, and error numbers that are accepted and handled by the 6020.

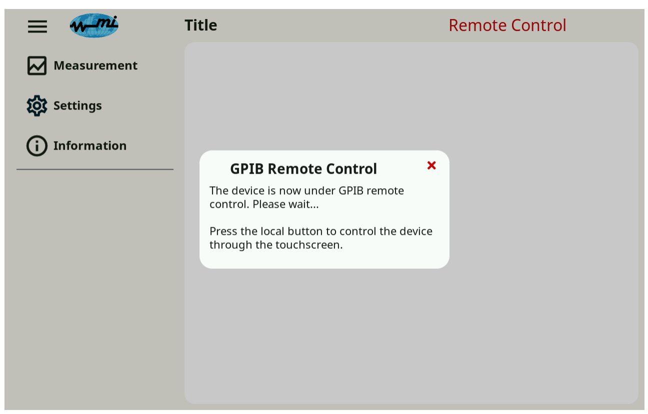


Figure 10.1: Remote Control Address Selection Menu

10.1 IEEE-488 Control

The IEEE-488 interface enables the instrument's remote-control capabilities through the IEEE-488.1 and IEEE-488.2 interface compliance criteria. The 6020 specifically meets the IEEE-488.1 SH1, AH1, T6, L4, SR1, RL1, PP0, DC1, DT0, C0, and E2 compliance, and supports the IEEE-488.2 Status Reporting commands. See Chapter 11 for the complete list of command descriptions. ‘’

10.2 IEEE-488 Commands

The single-character commands tabulated in Chapter 11 are accepted and handled by the 6020 when received over the GPIB interface.

Upon receiving a command, the 6020 responds with an ANSWER or ERROR message. The ANSWER reply is the 3-character reply sent in response to the Query (Q) command (see table in Chapter 11).

The ERROR reply consists of the character “E”, then the first character of the received command, and finally, a one or two-digit error number that describes the reason for the error (see Error Number Table in Chapter 14).

If a command received by the 6020 is illegal during active sequences, an error message is sent as a reply, ensuring that only valid commands and values are received. The error message syntax is described in Chapter 11.

10.3 Device Address

There are two ways to change the GPIB address of the device.

One, the user can navigate to GPIB under the Settings menu, shown in Figure 10.2, to manually select the device’s address and can confirm the change using this menu, as the “Current Address” label will reflect any changes.

Two, the user can also send the `SYS:ADR <NR1>` command, with `<NR1>` lying inside the valid GPIB address range of [1 - 31]. This change can be verified by rescanning for devices inside of the NI MAX software under the GPIB-USB devices or by changing the device address within the MI 6020 software settings and getting a response to the `*IDN?` query within the Diagnostic Tools. If the value given to the device is outside of the valid range, the system won’t change its value.

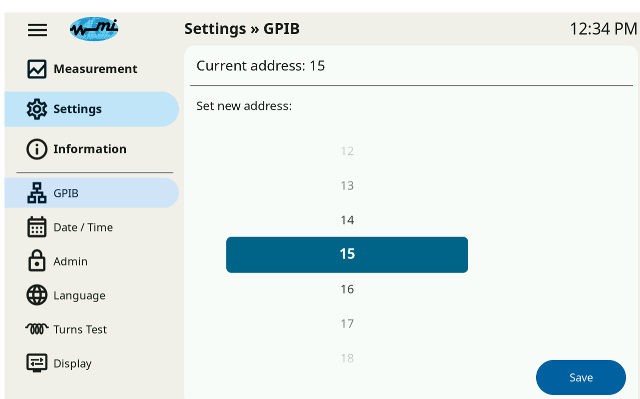


Figure 10.2: Remote Control Popup

10.4 Status Byte Registers

At system startup, the GPIB system is designed to load the last known state of the status byte registers. The default behavior can be changed to clear the registers through the *PSC command/query as defined by IEEE-488.2. While this bit is high, the system will automatically set the registers to their default state of:

`*STB - 000 | *SRE - 255 | *ESR - 000 | *ESRE - 128`

Inside each of the status registers, in Figure 10.3, the user may set the associated "enable" register control bits to select the style of error handling and status reporting they may prefer to use.

It is also worth noting that, during a remote measurement sequence or a remote turns test, the MAV bit is temporarily used as part of the proprietary codes listed within Chapter 13, as the number of unique messages during the sequences requires at least 5 bits. Once the sequences are complete, the status registers return to their default use cases.

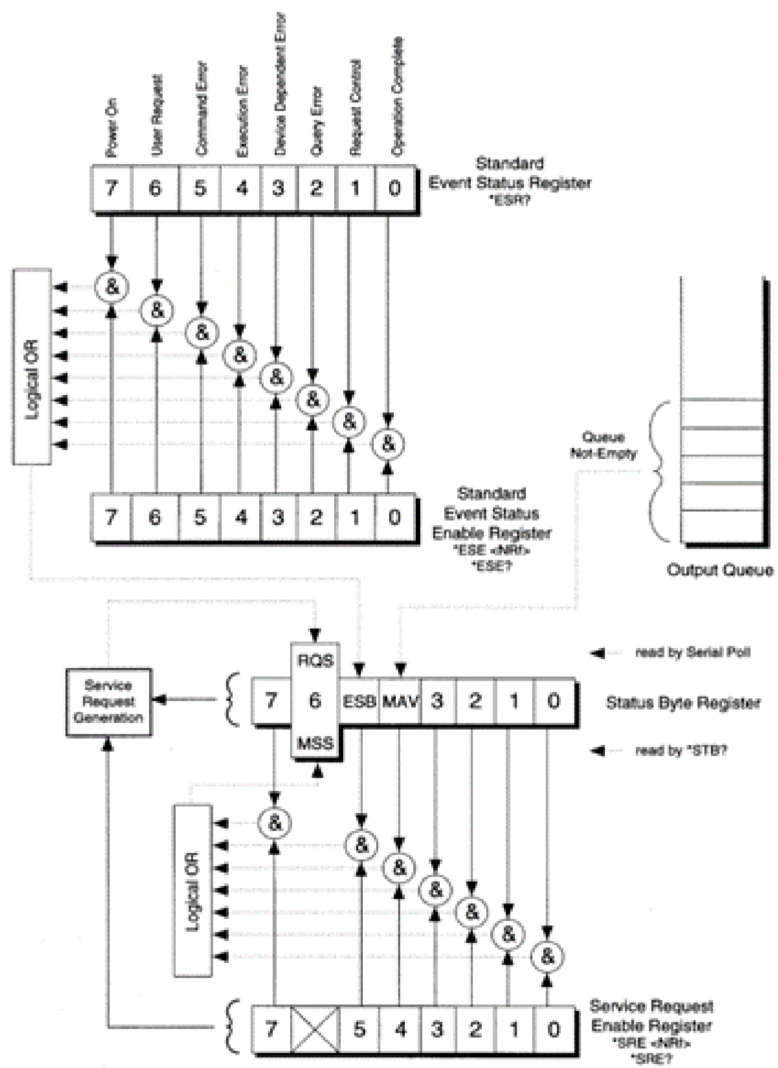


Figure 10.3: GPIB Status Registers and Required Status Capabilities

10.5 Identification Response

The command response to *IDN? has been made to handle the NI MAX 35ms query during the “Scan for Hardware” routine. The response is formatted to follow the IEEE-488.2 require standard response:

`<Manufacturer>,<Model>,<SerialNumber>,<FirmwareRevision>`

This response auto-populates within the NI MAX software’s device information page and lists the model under the instrument name under the GPIB controller menu.

10.6 6020 Software Reports

The reports tabulated in Chapter 13 are all sent over the GPIB interface by the 6020 software during either a measurement sequence or turns-test sequence. The 6020 software sends reports over the GPIB interface using the following steps:

- The 6020 asserts the GPIB control line `SRQ`. This command tells the GPIB controller that a device has made a serial request. The 6020 writes the serial request value that describes the pending report to its GPIB serial port register. These “serial request values” are tabulated in Chapter 13.
- The 6020 waits until the `SRQ` line is de-asserted through serial polling of the BCR register of the GPIB controller. The 6020 responds to this serial poll with the contents of its serial poll register (the “serial request value”), and then the register is cleared.
- The 6020 sends the report message over the GPIB interface in the format tabulated in Chapter 13.

10.7 Error Numbers Sent by the 6020

The tables in Chapter 14 error numbers sent as part of error reports and replies. Note that error numbers 11 to 25 are used by the 6020 Bridge to indicate an error during measurement. If there is an error during measurement, the measurement is stopped, standby is switched on, and the system returns to an idle state for the following sequence.

11. List of Commands

11.1 GPIB Generic Commands

This section describes the GPIB commands required by the IEEE-488.2 standard.

*CLS (no query form)

	This command clears all GPIB event registers and queues.
Group	Status
Syntax	*CLS
Related Commands	***ESR?** ***STB?**

*ESE

	Sets and queries the bits in the Standard Event Status Enable Register (ESE). The ESE is an 8-bit mask register that determines which bits in the Standard Event Status Register (ESR) will set the Event Status Bit (ESB) in the Status Byte Register (STB).
Group	Status
Syntax	*ESE <NR1> *ESE?
Related Commands	***CLS** ***ESR?**
Arguments	<NR1> where <NR1> is an integer value in the range of 0 – 255. The binary bits of the ESE are set according to this value. The power-on default for the ESE is 0 if *PSC is 1. If *PSC is 0 the ESE maintains its value through a power cycles.

Continued on next page...

*ESE *(continued)*

Returns	<*NR1*>, a decimal value of the contents of the ESE in the range of 0 – 255.
Example	**ESE* 148 sets the ESE to binary 10010100 which enables PON, EXE, and QRY bits. **ESE?* might return the integer string 48, showing that the ESE contains the binary value 00110000

*ESR? (query only)

	Returns the contents of the Standard Event Status Register (ESR).
Group	Status
Syntax	**ESR?*
Related Commands	***CLS** ***OPC** ***SRE**
Returns	<*NR1*>, a decimal value of the contents of the ESR in the range of 0 – 255.
Example	**ESR?* might return the integer string 48, showing that the ESR contains the binary value 00110000.

*IDN? (query only)

	Returns the device identification code in IEEE-488.2 notation listed in Section 10.5.
Group	Status
Syntax	**IDN?*
Returns	A string that includes: <Measurements International>, <Model>,<SerialNumber>,<FirmwareRevision>
Example	**IDN?* might return the following response for the instrument: *Measurements International, model, 1234567, 1.0.0*

*OPC

This configures the instrument to generate an operation complete message by setting the Operation bit of the Standard Event Status Register (ESR) when all pending commands that use OPC flags are completed.

The query places an ASCII character ”1” into the output queue when all such OPC commands are complete.

Group	Synchronization
Syntax	**OPC* **OPC?*
Related Commands	***WAI**
Returns	<*NR1*>, a boolean value indicating if the pending operations are completed or not. 0 - Busy; 1 - Complete
Example	**OPC?* might return 1 to indicate all pending operations are complete.

*PSC

Sets and queries the power-on status flag that controls the power-on state of SRE and ESE. When *PSC is true, the SRE and ESE are cleared at power-on. When *PSC is false, the current values are preserved in EEPROM.

Group	Source
Syntax	**PSC <NR1>* **PSC?*
Related Commands	***RST** ***OPC**
Arguments	<NR1> where <*NR1*> = 0 sets the power-on status clear flag to false, disables the power-on clear, and allows the device to assert service request (SRQ) after power on.
Returns	<*NR1*>, which is a boolean indicating if the pending operations are complete or not. 0 – load user status; 1 – load default status.

Continued on next page...

*PSC *(continued)*

Example	**PSC 0* sets the power-on status clear flag to false. **PSC?* might return 1, indicating power-on status flag is set true.

*RST (no query form)

This command is used to set the device back to a default state, place into local mode, and display the main menu without purging any stored settings.

The *RST command does not change any of the following:
• State of the GPIB interface
• Data stored in EEPROM
• Current GPIB address
• Output queue
• SRE settings
• ESE settings
• Power-On Status Clear flag setting

Group	Status
Syntax	***RST*
Related Commands	***PSC**

*SRE

This command is used to set and query the bits in the Service Request Enable Register (SRE).

Group	Status
Syntax	**SRE<NR1>* **SRE?*
Related Commands	***ESR?** ***PSC**

Continued on next page...

*SRE *(continued)*

Arguments	<NR1> where <*NR1*> is an integer value in the range from 0 – 255. The binary bits of the SRE are set according to this value. Using an out-of-range value causes an execution error. The power-on default for SRE is 0 if *PSC is 1. If *PSC is 0, the SRE maintains its last known value.
Returns	<*NR2*>, which is a decimal value of the contents of the SRE in the range of 0 - 255.
Example	**SRE 48* sets the bits in the SRER to 00110000 binary. **SRE?* might return a value of 32, indicating the bits in SRE are configured as 00100000 binary.

*STB? (query only)

	The byte query returns the contents of the Status Byte Register (STB). This register contains the Service Request (RQS) bit which can be used as an interrupt trigger for more automated STB queries.
Group	Status
Syntax	**STB?*
Related Commands	***CLS** ***PSC**
Returns	<*NR1*>, which is a decimal value of the contents of the STB in the range of 0 – 255.
Example	**STB?* might return the string 48, showing that the STB contains the binary value 00110000.

*TST? (query only)

	Initiates a simple self-test and reports any errors.
Group	Diagnostic
Syntax	**TST?*

Continued on next page...

*TST? *(continued)*

Returns	<*NR1*>, where <*NR1*> = 0 indicates the self-test completed with no errors. <*NR1*> *not equal to* 0 indicates the self-test detected an error.

*WAI (no query form)

	This command prevents the instrument from executing further commands or queries until all pending commands are complete.
Group	Synchronization
Syntax	**WAI*
Related Commands	***OPC**

11.2 MI Custom Commands

This section describes the MI custom commands that are valid for each bridge.

A (no query form)

	Sets the global R_S parameter used during a measurement sequence.
Group	Measurement
Syntax	*A<NR1>*
Related Commands	**B, D, G, I, J, M, S, T, Y, r, s, t, x**
Arguments	*<NR1>* where *<NR1>* is a floating-point value in the range of 0.001 – *Supported Bridge Max*. The value can be sent as either the literal floating-point value or as the scientific notation equivalent: <f.ffff>or <f.ffEf> The R_S parameter is set according to this value. If the value passed is out of range, the device will not run the measurement sequence.
Example	A10.0002465 or A1.00002465E+1 sets the R_S parameter to 10.0002465.

B (no query form)

	Sets the type of R_X measurement parameter, defining the measurement as either standard resistor, thermistor, or PRT.
Group	Measurement
Syntax	*B<STR1>*
Related Commands	**A, D, G, I, J, M, T, Y, a, b, c, d, e, f, g, h, i, r, s, t, x**

Continued on next page...

B *(continued)*

Arguments	*<STR1>* where <STR1> is one of three valid strings: • “Resistor” • “PRT” • “Thermistor”
Example	*BThermistor* sets the R_X Type parameter to run a measurement for a thermistor.

C (no query form)

	Start the system turns test routine that reports descriptions, turns numbers, turns error values, turns error uncertainties, zero balance values, and zero balance uncertainties back to the software for logging. Can be stopped using the standby command “S”
Group	Turns Test
Syntax	*C*
Related Commands	**S**

G (no query form)

	Sets the filter factor parameter used during a measurement sequence to specify the number of ratios to average within the filter.
Group	Measurement
Syntax	*G<NR1>*
Related Commands	**A, B, D, I, J, M, T, Y, r, s, t, x**

Continued on next page...

G *(continued)*

Arguments	*<NR1>* where *<NR1>* is one of four valid numbers: • 0 – zero filter, does not average any ratios • 1 – 0.3 filter, averages 3 ratios • 2 – 1.0 filter, averages 10 ratios • 3 – 3.0 filter, averages 30 ratios If the number passed is invalid, the device will not run the measurement sequence.
Example	*G1* sets the filter factor to 0.3, averaging 3 ratios for each point on the graph.

I (no query form)

Sets the global Ix parameter, in mA, used during a measurement sequence.

Group	Measurement
Syntax	*I<NR1>*
Related Commands	**A, B, D, G, J, M, T, Y, r, s, t, x**
Arguments	*<NR1>* where *<NR1>* is a floating-point value in the range of 0.001 – *Supported Bridge Max*. The value can be sent as either the literal floating-point value or as the scientific notation equivalent: <f.ffff>or <f.ffEf> If the number passed is invalid, the device will not run the measurement sequence.
Example	*I0.102* or *I1.02E-1* sets the Ix parameter to 0.102 mA.

J (no query form)

Sets the global number of statistics parameter used during a measurement sequence.

Continued on next page...

J *(continued)*

Group	Measurement
Syntax	*J<NR1>*
Related Commands	**A, B, D, G, I, M, T, Y, r, s, t, x**
Arguments	<*NR1*> where <*NR1*> is an integer value in the range of 2 - <*number of measurements*>. This value sets the statistics parameter. If the value passed is out of range, the device will not run the measurement sequence.
Example	*J25* sets the number of statistics parameter to 25, signalling to the bridge to only use the last 25 ratios in the calculations.

M (no query form)

Sets the global number of measurements parameter used during a measurement sequence.

Group	Measurement
Syntax	*M<NR1>*
Related Commands	**A, B, D, G, I, M, T, Y, r, s, t, x**
Arguments	<*NR1*> where <*NR1*> is an integer value in the range of 3 – 1000. The number of measurement parameter is set according to this value. If the value passed is out of range, the device will not run the measurement sequence.
Example	*M35* sets the number of measurements parameter to 35, signalling to the bridge to measure a total of 35 ratios.

O (no query only)

	Sets the global algorithm parameter used during a measurement sequence.
Group	Measurement
Syntax	*O<NR1>*
Arguments	*<NR1>* where *<NR1>* is an integer value in the range of 1-3: • 1 – Default • 2 – Single • 3 – Double The measurements parameter is set according to this value. If the value passed is out of range, the device will default to the Default algorithm.
Related Commands	**A, B, G, I, J, M, r, t, z**
Example	*O2* sets the algorithm to Single for the next measurement sequence.

Q? (query only)

	Queries the 6020 for a 3-character reply that describes the current system status and its active remote capabilities.
Group	Diagnostic
Syntax	*Q?*
Related Commands	**E, S, W, Y**
Returns	*<STR1>* where *<STR1>* contains 3 characters detailing the system status: • R or L – remote or local • S or s – Standby ON or Standby OFF • Q or q – Local Lockout ON or Local Lockout OFF.

Continued on next page...

Q? *(continued)*

Example	*Q?* might return "Rsq" to signify that the 6020 is idle but the remote capabilities are active.

S (no query form)

	Sets the global stop flag to high, signalling to the bridge to stop any sequence it is currently running and return to a known idle state.
Group	System
Syntax	*S*
Related Commands	**E, Q, W, Y**

T (no query form)

	Sets the global settle time parameter, in seconds, used during a measurement sequence.
Group	Measurement
Syntax	*T<NR1>*
Related Commands	**A, B, D, G, I, J, M, Y, r, s, t, x**
Arguments	*<NR1>* where *<NR1>* is an integer value in the range of 1s – 1000s. The settle time parameter is set according to this value. If the value passed is out of range, the device will not run the measurement sequence.
Example	*T16* sets the current settle time parameter to 16 seconds.

r (no query form)

	Sets the global R_X parameter used during a measurement sequence.
Group	Measurement
Syntax	*r<NR1>*
Related Commands	**A, B, D, G, I, J, M, T, Y, s, t, x**
Arguments	*<NR1>* where *<NR1>* is a floating-point value in the range of 0.001 – *Supported Bridge Max*. The value can be sent as either the literal floating-point value or as the scientific notation equivalent: <f.ffff>or <f.ffEf> The R_X parameter is set according to this value. If the value passed is out of range, the device will not run the measurement sequence
Example	*A10.0002465* or *A1.00002465E+1* sets the R_X parameter to 10.0002465.

t (no query form)

	Sets the global sample time parameter used during a measurement sequence.
Group	Measurement
Syntax	*t<NR1>*
Related Commands	**A, B, D, G, I, J, M, T, Y, r, s, x**

Continued on next page...

t *(continued)*

Arguments	<*NR1*> where <*NR1*> is a floating-point value in the range of 0.001s - 1000s. The value can be sent as either the literal floating-point value or as the scientific notation equivalent: <f.ffff>or <f.ffEf> The sample time parameter is set according to this value. If the value passed is out of range, the device will not run the measurement sequence
Example	*t10.246* or *t1.0246E+1* sets the sample time parameter to 10.246 which corresponds to 10,246 Delta samples.

z (no query form)

	Signals the start of the measurement sequence. This command should be executed after all parameters have been sent to ensure all measurement parameter data has been accurately set for the current sequence. However, if the command is sent before all the parameters have been updated, the sequence will begin with the last set or default valid data.
Group	Measurement
Syntax	*z*
Related Commands	**A, B, D, G, I, J, M, T, Y, r, s, x**

11.3 MI 6020A Custom Commands

D (no query form)

	Sets one of the ITS-90 sub-ranges when initializing the PRT based measurement sequence.
Group	Measurement
Syntax	*D<STR1>*
Related Commands	**B, a, b, c, d, e, f, g, h, i**
Arguments	*<STR1>* where *<STR1>* is one of twelve valid strings: • "None" • "HtoZero" • "NetoZero" • "OtoZero" • "ArtoZero" • "ZerotoAg" • "ZerotoAl" • "ZerotoZn" • "ZerotoSn" • "ZerotoIn" • "ZerotoGa" • "HgtoGa" If the string passed is invalid, the device will not run the measurement sequence
Example	*DZerotoAg* sets the Thermometer Type parameter to calculate the temperature values for a PRT in the range of 0 ℃ to the freezing point of Silver (ITS-90 3.3.2). *DNone* sets the Thermometer Type parameter to calculate the temperature values for thermistor.

E (no query form)

	Sets the extender present system control flag for remote measurement sequences that use a current extender in tandem with the 6020A. This allows the bridge to work remotely with the external device.
Group	System

Continued on next page...

E *(continued)*

Syntax	*E*
Related Commands	**H, S, W, Y, j**

H (no query form)

Clears the extender ready system control flag for remote measurement sequences that use a current extender in tandem with the 6020A.

Group	System
Syntax	*H*
Related Commands	**E, S, W, Y, j**

W (no query form)

When an extender (6011 or 6012) is in the system, the bridge must often wait until the extender is ready. This command will set the global extender ready flag high to allow the system to continue operation.

Also informs the bridge that the rough resistor measurement will be at full current (when the extender current is less than 1 A).

Group	System
Syntax	*W*
Related Commands	**E, H, S, Y, j**

Y (no query form)

	Sets the global extender error parameter, in ppm, used to correct for any known device error during a measurement sequence.
Group	System
Syntax	*Y*
Related Commands	**E, H, S, W, j**

a (no query form)

	Sets the thermistor coefficient parameter “a” for a thermistor or PRT based measurement sequence.
Group	Measurement
Syntax	*a<NR1>*
Related Commands	**B, D, b, c, d, e, f, g, h, i**
Arguments	<*NR1*> where <*NR1*> is a floating-point value. The value can be sent as either the literal floating-point value or as the scientific notation equivalent: <f.ffff>or <f.ffEf> The thermistor coefficient parameter “a” is set according to this value. If the value passed is out of range, the device will not run the measurement sequence.

b (no query form)

	Sets the thermistor coefficient parameter “b” for a thermistor or PRT based measurement sequence.
Group	Measurement

Continued on next page...

b *(continued)*

Syntax	*b<NR1>*
Related Commands	**B, D, a, c, d, e, f, g, h, i**
Arguments	<*NR1*> where <*NR1*> is a floating-point value. The value can be sent as either the literal floating-point value or as the scientific notation equivalent: <f.ffff>or <f.ffEf> The thermistor coefficient parameter “b” is set according to this value. If the value passed is out of range, the device will not run the measurement sequence.

c (no query form)

Sets the thermistor coefficient parameter “c” for a thermistor or PRT based measurement sequence.

Group	Measurement
Syntax	*c<NR1>*
Related Commands	**B, D, a, b, d, e, f, g, h, i**
Arguments	<*NR1*> where <*NR1*> is a floating-point value. The value can be sent as either the literal floating-point value or as the scientific notation equivalent: <f.ffff>or <f.ffEf> The thermistor coefficient parameter “c” is set according to this value. If the value passed is out of range, the device will not run the measurement sequence.

d (no query form)

Sets the thermistor coefficient parameter “d” for a thermistor or PRT based measurement sequence.

Group	Measurement
Syntax	*d<NR1>*
Related Commands	**B, D, a, b, c, e, f, g, h, i**
Arguments	*<NR1>* where *<NR1>* is a floating-point value. The value can be sent as either the literal floating-point value or as the scientific notation equivalent: <f.ffff>or <f.ffEf> The thermistor coefficient parameter “d” is set according to this value. If the value passed is out of range, the device will not run the measurement sequence.

e (no query form)

Sets the thermistor coefficient parameter “c1” for a thermistor or PRT based measurement sequence.

Group	Measurement
Syntax	*e<NR1>*
Related Commands	**B, D, a, b, c, d, f, g, h, i**
Arguments	*<NR1>* where *<NR1>* is a floating-point value. The value can be sent as either the literal floating-point value or as the scientific notation equivalent: <f.ffff>or <f.ffEf> The thermistor coefficient parameter “c1” is set according to this value. If the value passed is out of range, the device will not run the measurement sequence.

f (no query form)

	Sets the thermistor coefficient parameter "c2" for a thermistor or PRT based measurement sequence.
Group	Measurement
Syntax	*f<NR1>*
Related Commands	**B, D, a, b, c, d, e, g, h, i**
Arguments	<*NR1*> where <*NR1*> is a floating-point value. The value can be sent as either the literal floating-point value or as the scientific notation equivalent: <f.ffff> or <f.ffEf>. The thermistor coefficient parameter "c2" is set according to this value. If the value passed is out of range, the device will not run the measurement sequence.

g (no query form)

	Sets the thermistor coefficient parameter "c3" for a thermistor or PRT based measurement sequence.
Group	Measurement
Syntax	*g<NR1>*
Related Commands	**B, D, a, b, c, d, e, f, h, i**
Arguments	<*NR1*> where <*NR1*> is a floating-point value. The value can be sent as either the literal floating-point value or as the scientific notation equivalent: <f.ffff>or <f.ffEf> The thermistor coefficient parameter "c3" is set according to this value. If the value passed is out of range, the device will not run the measurement sequence.

h (no query form)

Sets the thermistor coefficient parameter “c4” for a thermistor or PRT based measurement sequence.

Group	Measurement
Syntax	*h<NR1>*
Related Commands	**B, D, a, b, c, d, e, f, g, i**
Arguments	*<NR1>* where *<NR1>* is a floating-point value. The value can be sent as either the literal floating-point value or as the scientific notation equivalent: <f.ffff>or <f.ffEf> The thermistor coefficient parameter “c4” is set according to this value. If the value passed is out of range, the device will not run the measurement sequence.

i (no query form)

Sets the thermistor coefficient parameter “c5” for a thermistor or PRT based measurement sequence.

Group	Measurement
Syntax	*i<NR1>*
Related Commands	**B, D, a, b, c, d, e, f, g, h**
Arguments	*<NR1>* where *<NR1>* is a floating-point value. The value can be sent as either the literal floating-point value or as the scientific notation equivalent: <f.ffff>or <f.ffEf> The thermistor coefficient parameter “c5” is set according to this value. If the value passed is out of range, the device will not run the measurement sequence.

j (no query form)

Sets the extender Ix range factor variable, used to calculate and display the correct ratio data to the screen during extender measurements.

NOTE: The current, Ix, must be set first since the final extender range is equal to present Ix / extender Ix

Group	Measurement
Syntax	*j<NR1>*
Related Commands	**E, H, S, W, Y**
Arguments	*<NR1>* where *<NR1>* is a floating-point value. The value must be sent as the equivalent extender Ix so that the range can be calculated for displaying ratios.
Example	*j1200* sets the extender Ix variable to 1200 mA and divides by the set Ix variable (1.2 mA) to calculate the associated extender range (x1000). This range is then used to manipulate the display array data to ensure the right values are displayed to the screen.

s (no query form)

Clears the R_X as standard flag used during the measurement sequence to false. This ensures that the system runs the measurement sequence as though R_S is the standard resistor.

Group	Measurement
Syntax	*s*
Related Commands	**A, B, D, G, I, J, M, T, Y, r, t, x**

x (no query form)

Sets the R_X as standard flag used during the measurement sequence to true. This ensures that the system runs the measurement sequence as though R_X is the standard resistor.

Group	Measurement
Syntax	*x*
Related Commands	**A, B, D, G, I, J, M, T, Y, r, s, t**

11.4 MI 6020Q Custom Commands

F (no query form)

	Sets the bridge to run a "normal" measurement sequence, rather than one of the QHR sweep or contact measurements.
Group	Measurement
Syntax	*F*
Related Commands	**A, B, G, I, J, M, O, T, r, t, y, z**

y (no query form)

	Sets the bridge to run one of the QHR specific measurement sequences.
Group	Measurement
Syntax	*y<STR1>*
Related Commands	**A, B, F, G, I, J, M, O, T, r, t, z**
Arguments	*<STR1>* where <STR1> is one of 3 valid characters to set the specific QHR measurement: • "c" • "m" • "n" The QHR measurement parameter is set according to this value. If the value passed is out of range, the device will not run the measurement sequence
Example	*ym* sets the measurement sequence to run a sweep instead of the standard measurement sequence.

11.5 MI 6020T Custom Commands

The 6020T shares the following commands with the 6020A.

- D - see 11.26
- a - see 11.31
- b - see 11.32
- c - see 11.33
- d - see 11.34
- e - see 11.35
- f - see 11.36
- g - see 11.37
- h - see 11.38
- i - see 11.39
- s - see 11.41
- x - see 11.42

m (no query form)

	Set the Mini-Scanner R_S channel that will be used during the measurement sequence.
Group	Measurement
Syntax	*m<NR1>*
Related Commands	**n, q, z**
Arguments	*<NR1>* where *<NR1>* is an integer value representing the desired R_S channel to be set: • “1” for channel 1 • “2” for channel 2 The Mini-Scanner channel parameter is set according to this value. If the value passed is out of range, the device will clear the channel and fail the measurement sequence.

Continued on next page...

m *(continued)*

Example	*m1* sets R_S channel 1.

n (no query form)

	Set the Mini-Scanner R_T channel that will be used during the measurement sequence.
Group	Measurement
Syntax	*n*<*NR1*>
Related Commands	**m, q, z**
Arguments	<*NR1*> where <*NR1*> is an integer value representing the desired R_X channel to be set: • "1" for channel 1 • "2" for channel 2 • "3" for channel 3 • "4" for channel 4 The Mini-Scanner channel parameter is set according to this value. If the value passed is out of range, the device will clear the channel and fail the measurement sequence.
Example	*m4* sets R_T channel 4.

q (no query form)

	Set the Mini-Scanner pre-heat function that is used to enable or disable the constant thermal load across all the resistor channels. **NOTE:** The pre-heat function, when enabled, is active on all channels of the Mini-Scanner except for the selected channels during a measurement. This is to prevent any additional current from leaking across the selected resistors during the measurement sequence. Once the sequence is complete, all resistors will return to the pre-heat state.

Continued on next page...

q *(continued)*

Group	Measurement
Syntax	*q<NR1>*
Related Commands	**m, n, z**
Arguments	*<NR1>* where *<NR1>* is a Boolean value representing the desired pre-heat state to be set, ON or OFF (1 or 0).
Example	*q1* sets pre-heat ON.

12. Error Message Format

The received command cannot be handled at this time for the reason described by the error number, see the Error Code Table in Chapter 14 for a description of error numbers. This error message is sent instead of an expected response.

Syntax	*E<STR1><NR1>*
Arguments	*<STR1>* where <STR1> is the command/location description that generated the error code. *<NR1>* where <NR1> is a 2-digit integer value in the range of 11-25 that describes the specific error that took place.

13. Software Reports

Measurement Description

This message describes the total number of measurements to be taken and reported during the upcoming measurement sequence.

The associated serial request value (STB) is SRQ + 1.

Syntax	*D<STR1>*
Arguments	*<STR1>* where *<STR1>* is a string of up to 25 characters.

Measurement Error Report

This message contains an error report generated by the 6020 during the measurement sequence. The error itself can be one of many errors, listed in Chapter 14. Once the error has been generated, the 6020 will return to idle to prepare for the next measurement sequence.

The associated serial request value (STB) is SRQ + ErrCode.

Syntax	*E<STR1><NR1>*
Arguments	*<STR1>* where *<STR1>* is the command/location description that generated the error code. i.e. “M” would indicate an error was generated during the measurement sequence, while “A” would indicate an error from the “A” command. *<NR1>* where *<NR1>* is an integer value of up to 2 digits that describe the error that took place. All the values can be found in Chapter 14

Measurement Number

This message contains the measurement number associated with the upcoming ratio data from the current measurement sequence. The valid value range is from 0 – 1000.

The associated serial request value (STB) is SRQ + 3.

Syntax	*#<NR1>*
Arguments	<*NR1*> where <*NR1*> is an integer value of up to 4 decimal places.

Measurement Ratio

This message contains the last measured ratio during the current measurement sequence, associated with the current measurement number.

The associated serial request value (STB) is SRQ + 4.

Syntax	*&<NR1>*
Arguments	<*NR1*> where <*NR1*> is floating-point value of up to 15 decimal places.

Measurement Rough R_S

This message contains the measured rough R_S value associated with the upcoming measurement sequence.

The associated serial request value (STB) is SRQ + 17.

Syntax	*S<NR1>*
Arguments	<*NR1*> where <*NR1*> is a floating-point value of up to 4 decimal places.

Measurement Rough R_X

This message contains the measured rough R_X value associated with the upcoming measurement sequence.

The associated serial request value (STB) is SRQ + 16.

Syntax	*R<NR1>*
Arguments	*<NR1>* where *<NR1>* is a floating-point value of up to 4 decimal places.

Turns Test Description

This message describes the subset of results reported during the upcoming turns test routine.

The associated serial request value (STB) is SRQ + 1.

Syntax	*D<STR1>*
Arguments	*<STR1>* where *<STR1>* is a string of up to 25 characters.

Turns Test Error Uncertainty

This message contains the uncertainty in the turns test error values reported during the turns test routine.

The associated serial request value (STB) is SRQ + 7.

Syntax	*@<NR1>*
Arguments	*<NR1>* where *<NR1>* is a floating-point value of up to 4 decimal places.

Turns Test Error Value

This message describes the subset of results reported during the upcoming turns test routine.

The associated serial request value (STB) is SRQ + 5.

Syntax	**<*NR1*>
Arguments	<*NR1*> where <*NR1*> is a floating-point value of up to 4 decimal places.

Turns Test Turn Number

This message contains the real or partial turns value associated with the upcoming data from the current turns test.
The valid value range is from 0 - *Supported Bridge Max*.

The associated serial request value (STB) is SRQ + 3.

Syntax	*#*<*NR1*>
Arguments	<*NR1*> where <*NR1*> is an integer value of up to 4 digits.

Turns Test Zero Balance

This message contains the measure balance value at zero turns during the turns test routine.

The associated serial request value (STB) is SRQ + 6.

Syntax	*(*<*NR1*>
Arguments	<*NR1*> where <*NR1*> is a floating-point value of up to 4 decimal places.

Turns Test Zero Uncertainty

This message contains the uncertainty in the turns test balance values at zero turns during the turns test routine.

The associated serial request value (STB) is SRQ + 8.

Syntax	*$<NR1>*
Arguments	*<NR1>* where *<NR1>* is a floating-point value of up to 4 decimal places.

14. MI Error Code Table

Table 14.1: 6020 Error Code Lookup Table

Error Name	Value	Meaning
Need Standby OFF	11 + 64[1]	A GPIB command was received that cannot be performed while standby state is active.
Ix is Not Set	12 + 64[1]	The 6020 tried to perform an action that cannot be performed while the system has no primary current.
Check Connections	13 + 64[1]	During any part of the measurement sequence, a failure has occurred that is likely caused by loose/intermittent connections.
Voltage Too Low	14 + 64[1]	During a measurement, the voltage across the resistor network is too low, likely caused by too low of a primary current setting.
Turns out of Range	15 + 64[1]	During a measurement, a failure has occurred where the calculated turns ratio exceeds the specifications of the 6020, likely caused by the resistor ratio.
R_S out of Range	21 + 64[1]	During a measurement, the measured value of R_S exceeds 10% of the entered value, likely caused by user error or loose/intermittent connections.
Unknown Error	25 + 64[1]	An error was reported that is none of the above set.

NOTE

The bridges may report other warnings locally during measurements and turns tests. These are typically due to an event that is not currently supported by the software report, and that *may* be useful when experiencing unexpected results.

[1] RQS bit – used to indicate a service request.

15. IEEE-488.2 Error Code Table

Table 15.1: IEEE-488 Error Code Lookup Table

Register	Bit	Decimal	Error
ESR	0	1	**Operation Complete Flag** L – Operation/s not completed or even invoked H – Operation/s completed
	1	2	Not Implemented (C0)
	2	4	**Querry Error** Problem processing and formatting a query
	3	8	Not Implemented (internal error checking)
	4	16	**Execution Error** Problem during parse or receive/send over GPIB
	5	32	**Command Error** User entered incorrect command syntax
	6	64	Not Implemented (PP0)
	7	128	**Power-On Clear flag** L – Store current stats byte configuration in memory and load on boot H – Clear status byte configuration and load default values
STB	0	1	See Chapter 14 for device error codes
	1	2	See Chapter 14 for device error codes
	2	4	See Chapter 14 for device error codes
	3	8	See Chapter 14 for device error codes

Continued on next page...

(continued)

	4	16	**Message Available** H – When data is still available in output queue to be read by user L – When output queue is empty See Chapter 14 for device error codes during sequence operations
	5	32	**Event Status bit** H – Any of the 8 flags in ESR is set high L – All of the 8 flags in ESR is set low
	6	64	**Service Request** H – Any of the other 7 flags in STB is set high L – All of the other 7 flags in STB is set low
	7	128	Not Implemented

H = bit High (1), L = bit Low (0)

16. Application Software

16.1 Opening Menu Screen

The **Opening Menu Screen** is displayed upon entering the 6020 software program (refer to Figure 16.1). This screen allows the user to load previously saved files for system settings.

> **NOTE**
>
> Software Version 1.1.1 is shown in Figure 16.1, Figure 16.2, and Figure 16.3 may be changed by updating programs; for the current version, please see the running software display on the computer.

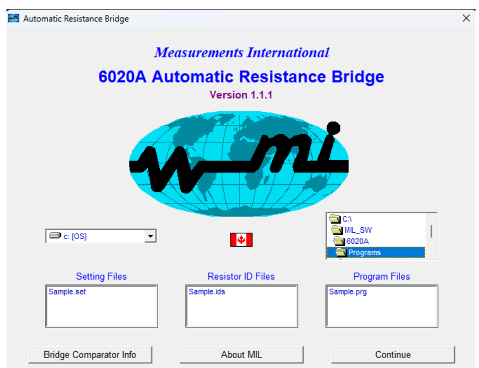


Figure 16.1: Application Opening Menu Screen.

The lower half of the screen contains lists of all resistor files (*.ids), setup files (*.set), and program files (*.prg) in the 6020's 'Program' directory. It is also possible to change the working drive and/or directory by using the appropriate boxes. To select the initial settings, highlight the appropriate files using the mouse as shown in Figure 16.1. Some sample files were included when the 6020 software was installed. Sample files for the 'Settings', 'Resistor IDs', and 'Program Files' are provided to show the information for each file type

16.2 Bridge Comparator Info

Selecting the 'Bridge Comparator Info' button displays information about the comparator turns of the bridge the software is intended for (See Figure 16.2).

16.3 About MIL

Selecting the About MIL button (see Figure 16.3) gives the user information on Measurements International and the 6020 software.

Any problems or inquiries about the software can be addressed by contacting Measurements International using the phone number or e-mail address (micustomer.service@mintl.com).

The software version is also shown here. Please refer to this revision number when contacting Measurements International regarding software problems.

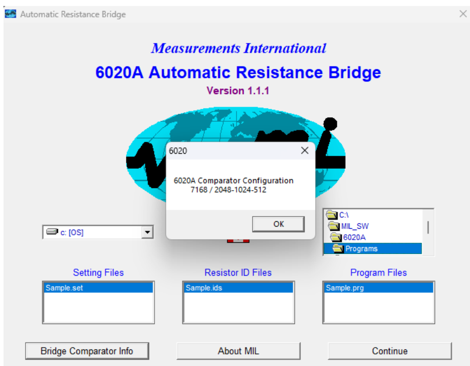


Figure 16.2: Bridge Comparator Information.

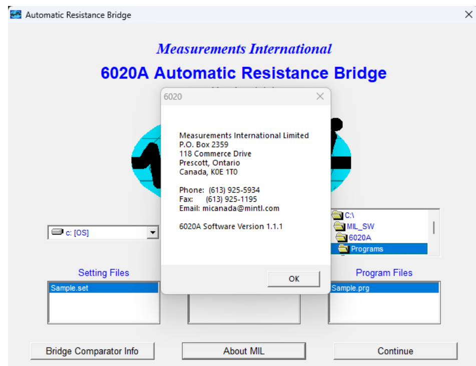


Figure 16.3: MIL 6020 Software Information.

16.4 Continue

The Continue button loads and opens the highlighted setting, resistor, and program files. Selecting the Continue button opens the Main Menu Screen, see Figure 16.4.

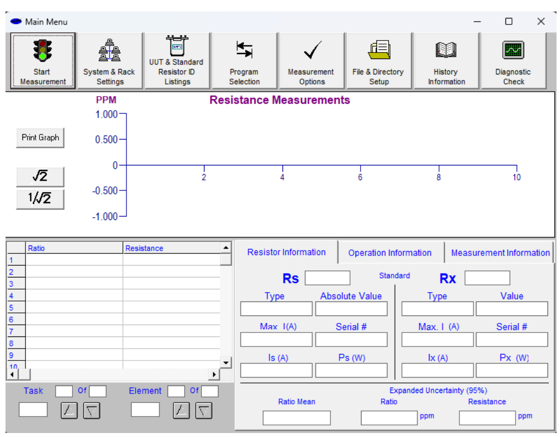


Figure 16.4: Main Menu Screen.

16.5 Main Menu

The Main Menu Screen (Figure 16.4) contains a group of menu keys located at the top of the screen, which may be selected to perform a complete measurement. The following gives a very brief description of the functions of the menu keys in the Main Menu Screen. The functions of these keys are described in more detail in later sections.

- Start / Stop Measurement - starts or stops a measurement run
- System and Rack Settings - contains hardware configuration.
- Resistor ID Listings - contains resistor / PRT / thermistor information.
- Program Selection - creates, edits, or selects a measurement program.
- Measurement Options - includes various measurement options.
- File and Directory Setup - displays present file paths.
- History Information - displays summary information on resistors.
- Diagnostic Check - includes 6020 calibration.

Measurement values are displayed in the table in the lower left portion of the screen while the values are plotted in a graph in the center of the screen.

The 'Resistor Information' tab displays the R_S and R_X properties as well as the mean, standard deviation, and uncertainties for measurements. The 'Operation Information' tab allows the operator access to the graph options and the IEEE command display. The 'Measurement Information' tab displays the program, task, and measurement settings.

Refer to Chapter 7 for information on how these functions are used during a measurement run.

16.5.1 System & Rack Settings

This screen is used to enter the information pertaining to the instruments being used in the 6020 system. Enter the 6020's uncertainty, uncertainty degrees of freedom (infinite), serial number and GPIB address at the top left of the screen. The bridge's uncertainty will be used in uncertainty calculations.

Scanners Settings

The default setting for the number of scanners being used is zero. One or two scanners can be enabled by selecting the 'In System' boxes. The model, serial number and GPIB address are also entered here. If you are using a 4220-1R, check the appropriate box. This enables the serial number entry and the ability to run a program for calibrating a type 1010 or 1060 transfer standard. Figure 16.5.

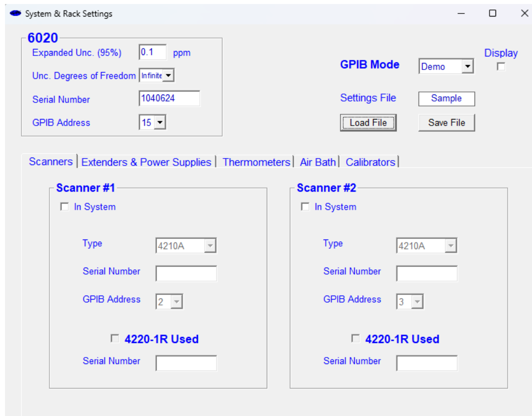


Figure 16.5: System & Rack - Scanner Set-Up Screen.

Extender & Power Supply Settings

The use of extenders and power supplies in the system is enabled by selecting the "Extenders & Power Supplies" tab and entering respective serial numbers, uncertainty information and GPIB addresses (Figure 16.6). The GPIB can be configured into two modes: Demo or National Instruments. Commands and Serial Polls can be displayed on the main screen on the 'Operations Information' tab by checking the 'Display' box located next to the GPIB Mode selector.

NOTE

This feature is not recommended for regular operation because it slows down the measurement timing.

Never divide the Current by 10 for Rough Measurements

This routine is built into the software to protect the resistors that are being measured. If the rough values measured do not agree with the selected values, the program will shut down. This routine should never be selected for currents below 10% of the rated power supply current.

6011 Extender and 6100 Power Supply Settings

The Extender and Power Supply setup can be configured in several different ways depending on the hardware that is available.

With the Extender selected in this menu, the software can also be set for measuring the transimpedance of DC Transformers instead of an unknown resistance. Selecting the option "DC Transformers" instead of "Resistors" in the frame "Units Under Test" (Figure 16.7 to Figure 16.10) will change the forms of "Resistor ID Listings" (Figure 16.13), and "Program Selection" (Figure 16.15).

Below is the setup screen for using the 6011 Range Extender and 6100 Power supply. Refer to the 6011 Operating Manual for connection drawings.

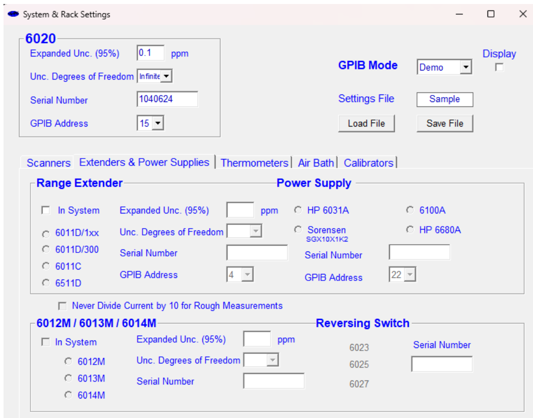


Figure 16.6: System & Rack - Extender & Power Supply Screen.

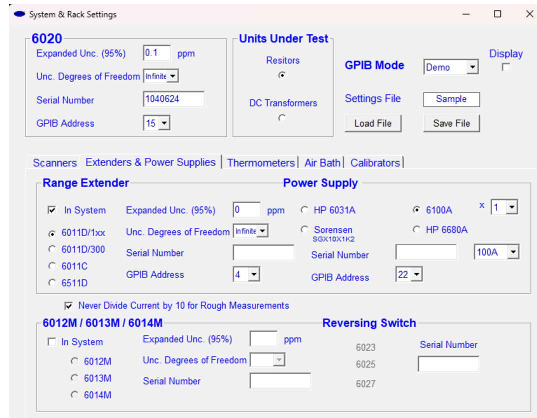


Figure 16.7: System & Rack - 6011/6100 Set Up Screen.

6011/300 Extender and 6100 Power Supply Settings

The Extender and Power Supply setup can be configured in several different ways depending on the hardware that is available. Below is the setup screen for using the 6011/300 Range Extender and 6150 Power supplies. Refer to the 6011 Operating Manual for connection drawings.

6011/400 Extender and 6680 Power Supply Settings

The Extender and Power Supply setup can be configured in several different ways depending on the hardware that is available. Below is the setup screen for using the 6011 with the 6013 Range Extender and 6680 Power supplies for current measurements up to 400A. Refer to the 6011 Operating Manual for connection drawings.

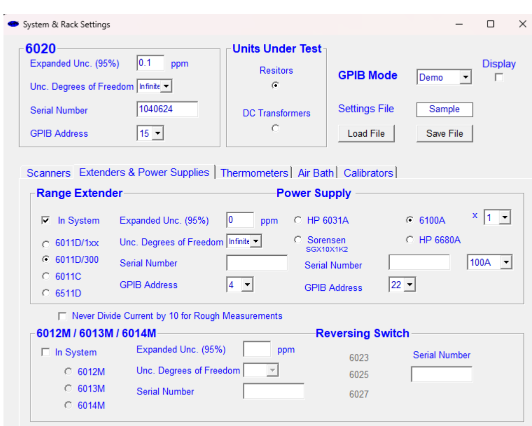


Figure 16.8: System & Rack - 6011/300 Set Up Screen.

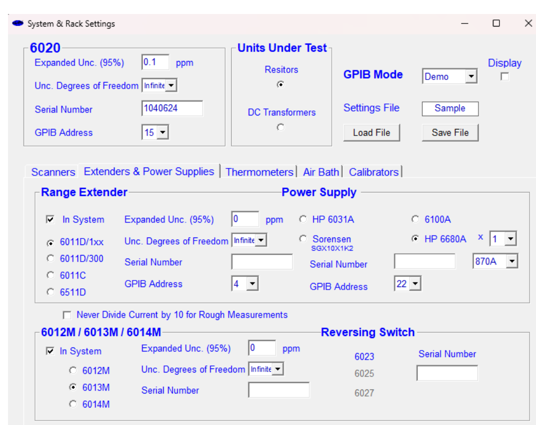


Figure 16.9: System & Rack - 6011/400 Set Up Screen.

6011/2000 Extender and 6680 Power Supply Settings

The Extender and Power Supply setup can be configured in several different ways depending on the hardware that is available. Below is the setup screen for using the 6011/2000 Amp with the 6012 Range Extender and 6680 Power supplies for current measurements up to 2000A. Refer to the 6011 Operating Manual for connection drawings.

6011/3000 Extender and 6680 Power Supply Settings

The Extender and Power Supply setup can be configured in several different ways depending on the hardware that is available. Below is the setup screen for using the 6011/3000 Amp with the 6014 Range Extender and 6680 Power supplies for current measurements up to 3000A. Refer to the 6011 Operating Manual for connection drawings.

NOTE

Many different settings files may be created. It may be advantageous to save the information under the name of the customer. In time, when resistors require recalibration, the settings file can be loaded with all the pertinent data.

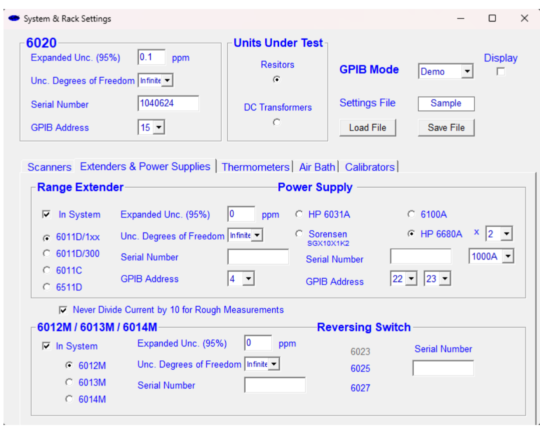


Figure 16.10: System & Rack - 6011/2000 Set Up Screen.

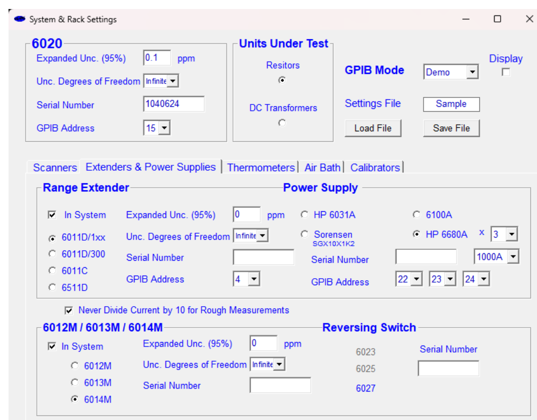


Figure 16.11: System & Rack - 6011/3000 Set Up Screen.

Chub Selection

Selecting the “Chub-E4” tab allows for up to four external thermometers to be used to monitor the temperature of resistors and shunts during measurements. Checking the “In System” box enables the Chub-E4 in the system (refer to Figure 16.12).

The temperature of any oil baths used in the system can also be measured by using the Chub-E4 Standards Thermometer.

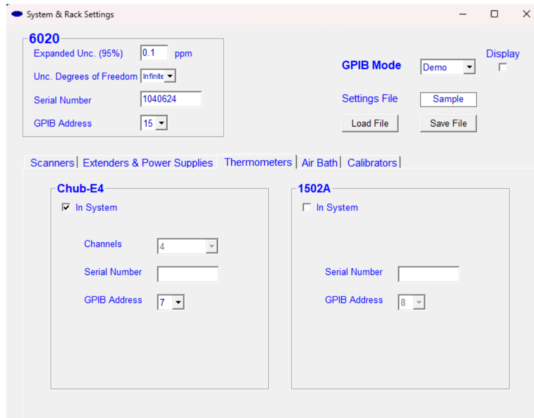


Figure 16.12: System & Rack - Chub-E4 Screen.

16.5.2 Resistor ID Listings

An example of the Resistor ID Listings Menu is displayed in Figure 16.13. There are two types of resistor banks available to be used: Standard and Measurand. The Standard resistors are stored in a file with the name Standard.res. Several 'Measurand Resistor' files can be stored in the resistor bank (all of them will have the file extension .ids) as shown in Figure 16.13. The two banks can be selected by clicking the option buttons above the resistor information table as seen in Figure 16.13. Additional information about the standard resistors such as calibrated value, calibration date and drift/month in ppm is also entered here.

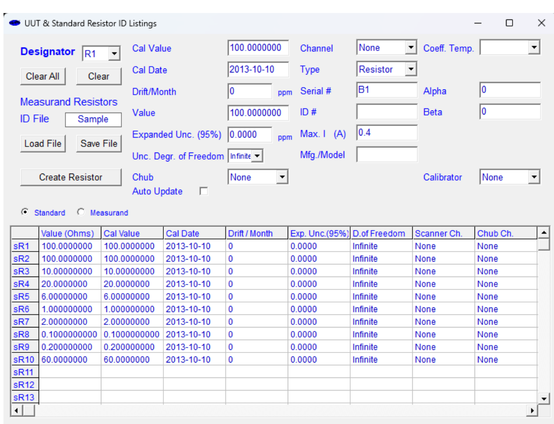


Figure 16.13: Resistor ID Standards Listings Menu Screen.

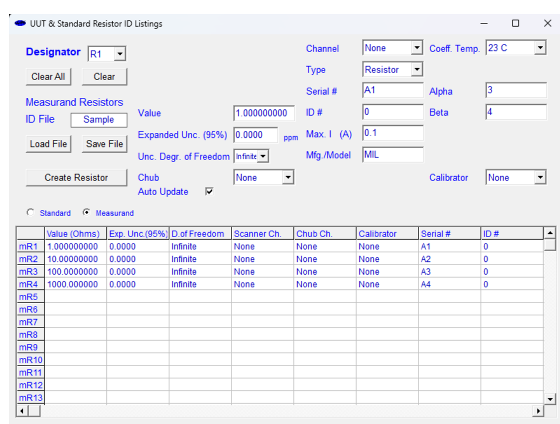


Figure 16.14: Resistor ID Measurand and Listings Menu Screen.

Resistors can be selected from the grid by using the 'Designator' combo box located in the top left corner, or by double-clicking on the corresponding row on the grid. A single resistor or all resistors can be cleared by using the clear buttons.

To create a resistor, fill in the information for the resistor at the top of the screen (some information may have default values assigned to them). Select the destination row from the grid, and then click the 'Create Resistor' button.

NOTE

The information in the 'Channel' or the 'Chub' combo box is only present when scanners or a Chub-E4 is enabled in the system. Refer to section 16.5.1 System & Rack Settings.

To use or edit the information from an existing resistor, double-click its row on the grid and the data will be copied to the resistor creation fields. Make any necessary changes and re-enter it in the ID file as described above.

A resistor can be one of three types - a Resistor, a PRT, or a Thermistor. This determination can be made using the 'Type' combo box. For different types, there are different types of coefficients. Coefficient values are especially important for PRT's and Thermistor. This is because the coefficients are used to calculate the temperature readings.

NOTE

Many different Resistor ID Listing files may be created. It may be advantageous to save the information under the name of the customer. In time, when resistors require recalibration, the ID Listing file can be loaded with all the pertinent data. This will also allow the user to track the history of the resistors.

Checking the "Auto Update" function (refer to Figure 16.13 or Figure 16.14) automatically updates 3 fields for R_X once the measurement has been completed.

- Value
- Expanded Uncertainty (95%)
- Uncertainty degrees of freedom (number of values used for statistics -1)

16.5.3 Program Selection

The Programs that run 6020 measurements are set up with the following structure: The base component for a Program is an Element. An Element can be one of three types: a Measurement, a Wait State, or a User Function.

A Measurement consists of the two resistors being measured, a current value, a reversal rate, a filter setting, the number of measurements being taken, and the number of readings to use when calculating statistics.

Wait States are used to create a delay between other Elements. They are either waiting for a specified amount of time or waiting until a specified computer system time.

User Functions are modules that must be created in Microsoft Visual Basic 6 (see Section 16.5.2). These could range from file and data manipulation to controlling other units.

Once Elements have been created, they can then be combined into Tasks. Tasks are a sequence of Elements that run to perform a certain job. These Tasks can in turn be combined to create a Program that can be run from the main screen.

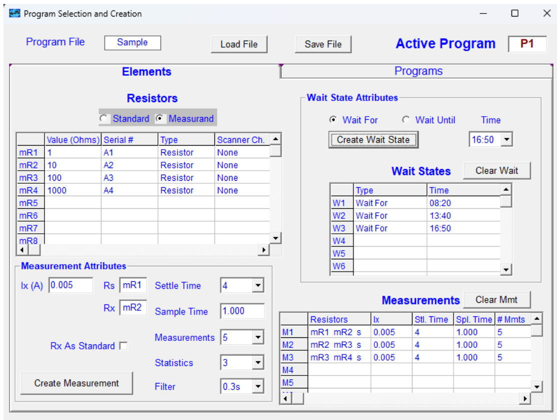


Figure 16.15: Creating & Editing a Measurement Program Menu Screen.

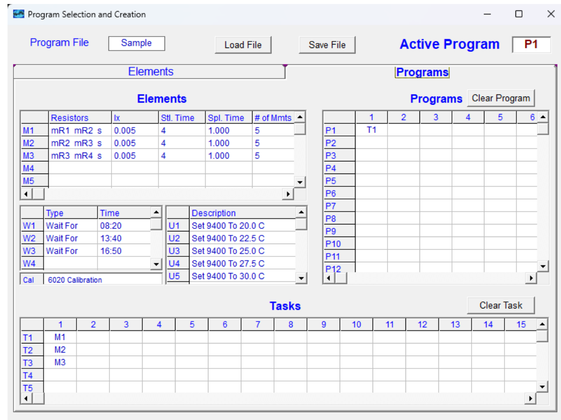


Figure 16.16: Creating & Editing Tasks and Programs Screen.

16.5.4 Elements Tab

A Measurement element is created by using the 'Resistors' grid and entering values into the 'Measurement Attributes' fields. Select a resistor by dragging the desired resistor from the 'Resistors' grid to the R_S and R_X resistor fields.

The IX current value must be entered, and the desired reversal rate and filter settings must be selected from the pull-down boxes along with the desired number of measurements and statistics. Select the destination row in the 'Measurements' grid and click on the 'Create Measurement' button to finish creating the Measurement elements M1, M2 and so on (see Figure 16.15).

16.5.5 Wait States

Create a Wait State by selecting its type ('Wait For' or 'Wait Until'), then select the desired time from the combo box. Refer to Figure 16.8. 6011/400 Set Up Screen. The times for the Wait States are given in 24-hour clock format. The 'Wait For' states will delay the Task for a specified time.

The 'Wait Until' states will delay until the system clock reaches the selected time. Select a destination row and then click on the 'Create Wait State' button to move the Wait State to the grid.

16.5.6 User Functions

User Functions must be created in Microsoft Visual Basic 6 and made into a .dll (Dynamically Linked Library) file. Up to 20 User Functions can be created (U1-U20). To do this, the function code must be modified. This is done by following instructions 1-9.

1. Start Visual Basic 6.
2. In the **File** Menu, choose **Open Project**.

3. Locate the folder where the 6020 software is installed and open **fn6020X C.vbp**, where X is any bridge model.

4. In the Project Explorer Window, open the folder **Class Modules**, highlight **FnCode (FnCode.cls)** and choose View, Code from the Visual Basic File Menu. (If the Project Explorer Window is not visible, select **View, Project Explorer**.)

5. The code contains 60 functions called **Public Function FunctionXDescription**, where **X** is an integer between 1 and 60.
Functions 21-40 are used with the NI GPIB driver.
Functions 41-60 are used with the DEMO MODE.
The name of the function must be entered between the ”” (empty string).
Example: **Function9Description** = ”name of the function”.
If e.g., function 9 is added, then **Function9Description**, **Function29Description** and **Function49Description** must be modified accordingly. When all the steps have been completed, these function names will appear in the Program Table (refer to Figure 16.16)

6. The code contains 60 functions called **Public Function User FunctionX** where **X** is an integer between 1 and 60. This is where the User's own code must be entered.
If e.g. function 9 is added then **UserFunction9**, **UserFunction29** and **UserFunction49** must be modified accordingly.

7. When finished, save the modified User Function code by choosing **File**, **Save Project** from the File Menu.

8. The file must now be converted into a .dll file. This is done by selecting **File**, **Make Fn6020X C.dll** from the File Menu, where X is any bridge model.

9. Replace the old Fn6020X C.dll file (which is located in the system folder, e.g. `C:\ WINDOWS\ SYSTEM32\`) with the new Fn6020X C.dll file, where X is any bridge model.

Once the 6020 software is started, click the Program Selection button accessible from the Main Screen to open the Program Tab and the new User Functions, U1-U20, which can be dragged as tasks to the 'Tasks Grid'. However, if a function description remains “” (empty string, see step 5), the corresponding user function cannot be dragged to the tasks grid.

16.5.7 Programs Tab

The 'Programs' tab allows the operator to create Tasks by combining Measurements, Wait States, and User Functions that were created in the 'Elements' tab. Elements can be combined into Tasks by dragging the desired Measurement, Wait State, or User Function from the appropriate grid and dropping it into one of the rows of the 'Tasks' grid. Drag a Task from the 'Tasks' grid to the desired 'Programs' grid row in order to create a Program.

NOTE

Elements cannot be dragged directly into the 'Programs' grid. They must be combined into a Task first.

To select a program to run from the main screen, double-click the desired row in the ’Programs’ grid, and the program designator will appear in the ’Active Program’ window. Refer to Figure 16.16.

The file containing the Programs is saved in the ’Program Files’ directory as specified in the ’File & Directory Setup’ screen

16.5.8 Measurement Options

This screen is used to set conditions for the measurement run. Select the ’Save Measurements’ box to save the results to a file after a measurement. See Figure 16.17.

NOTE

Type in the filename WITHOUT an extension (the extension is already set to .mea).

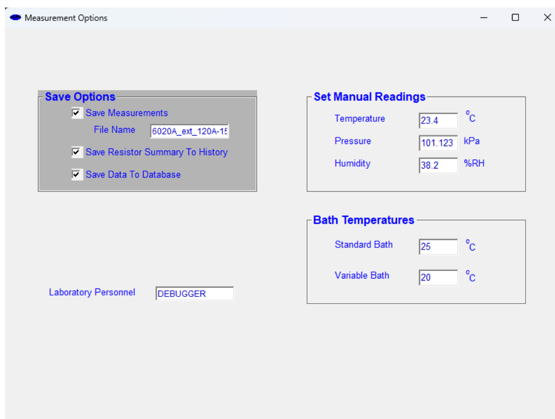


Figure 16.17: Measurement Options.

This check box also tells the software to save the data from an infinite run. The only difference in this case is that the data file will be saved into infinite

Select the ’Save Resistor Summary To History’ box to save a summary of the run to a file with the resistor’s serial number and extension .his as its filename ([S/N].his). This file is used by the ’History Information’ to display a resistor’s history graph. The output files are saved in the ’Data Files’ directory specified in the ’File & Directory Setup’ screen

To manually input environmental conditions, enter corresponding values into the fields in the Temperature, Pressure, and Humidity section. These values will be displayed on the main screen and written to the saved measurements file.

Select the ’Save Data To Database’ box in order to save a summary of the run to a file that will have a default name depending on the date and time when it is being created.

For example, in the default file name **D4083011.09** the first digit 4 means 2004, 08 means August, 30 means the 30th (of August), and 11.09 is the time (hours and minutes) the file was created. However, the file can have any other name chosen by the operator.

If the file path selected for the database file in the ”File & Directory Setup” (Section 16.5.9) ends with a folder name, e.g. " `C:\Program Files\6020X\Data\`", where X is any bridge model, then the file will have a default name.

Otherwise, if for example the file path is "`C:\Program Files\6020X\Data\New.txt`", where X is any bridge model, the file will have the name "`New.txt`".

The following pieces of information are stored to a database file:

- The standard resistor value ("1e1" for example, means 10 Ω).
- The date and time when the program started to run.
- The time when the database file was created, i.e. the time when the program was ended. If the box 'Save Data To Database' is not selected, the database file can still be created afterwards from the File and Directory Setup (Chapter 16.5.9). However, in that case, the time when the database was created is not the exact time when the program ended.
- The current flowing through the standard resistor.
- The value of Settle Time in seconds.
- The serial number of the standard resistor and it's resistor value ("1e1" for example, means 10 Ω).
- The serial number of the measured resistor.
- The final average value of the ratio.
- The standard deviation of the final average value of the ratio in ppm.
- The number of measurements/the number for statistics.
- The final average value of the measured resistor.
- The software revision number..
- The ratio and the range of a current extender (if a current extender was used)
- The current flowing through R_X and the Scanner Channel of R_X (if scanner is used).
- The current flowing through R_S and the Scanner Channel of R_S (if scanner is used)
- The identification number of R_X.
- The Chub-E4 temperature.
- The Chub-E4 temperature uncertainty in ppm.

An example of a 6020A database file is shown below:

```
2.00e+0|01-31-2025 13:20:51|13:26:32|8 (s)|12812=1.000000000e+00|12813|
1.999714060|0.0042|30/25|1.999717099|0|Revision 1.1.1|1 :  1|
Ix = 50.000 mA Channel 11|Is = 100.000 mA Channel 17|6020 - 0|
MI 6020A Process|Standard Resistor|
```

16.5.9 File & Directory Setup

There are two ways to change the paths in the 'System Drives & Paths' section. The first is to type in the desired path manually. The second is to locate the path by using the windows on the right side of the screen. Then drag and drop the path from the 'Files' box into the appropriate field in the 'System Drives & Paths' section. This will copy the currently displayed path. Use this to ensure that the 'System Drives & Paths' section has all the correct 'Program Files', 'Data Files', 'WordPad', 'Database Files', and 'Excel' paths. Refer to Figure 16.18.

The 'Save Present Measurements' section is used to save the information displayed on the main screen to a file. Check the desired boxes and click the 'Save Measurement Information' button to save the data. To open a measurement file in WordPad, click on the 'Open Saved Measurement File In WordPad' button to get a listing of files.

The box 'Owner's e-mail' contents are saved to a database file with other information described in the Measurement Options (Section 16.5.8).

Select the 'Save Data To Database' box and then click the 'Save Measurement Information' button. Clicking the 'Open Excel File' button launches the 6020 Data Extraction Macro in Excel where e.g. measurement and calibration reports can be loaded. The resistor's temperature coefficients, Alpha and Beta, are calculated here.

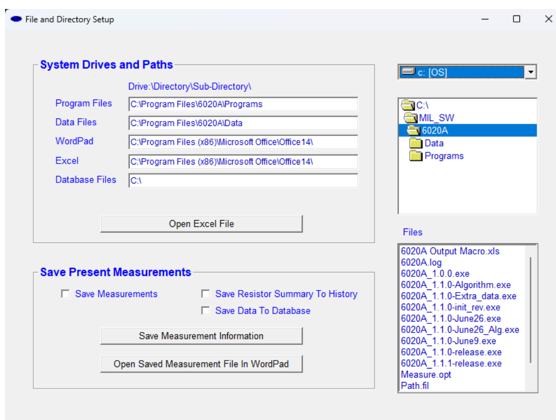


Figure 16.18: File & Directory Setup Screen.

16.5.10 History Information

Click on the 'Load History File' button to view a resistor's saved history data (Figure 16.19). A new window will open where the desired file can be selected. Check the 'Show Projection' box to display a projected value for a resistor. The software will use regression analysis on the loaded data to project a value for the resistor. The date that the computer is set at is used as default, but any date can be chosen. The projected value is displayed as an orange box. The standard deviation and a trend line (linear, logarithmic, or polynomial) can also be displayed by selecting the appropriate boxes. The graph can be printed by clicking the 'Print Graph' button next to the graph area's lower left corner (Figure 16.19). A history file can be opened in WordPad by clicking the 'Open Saved History File In WordPad' button.

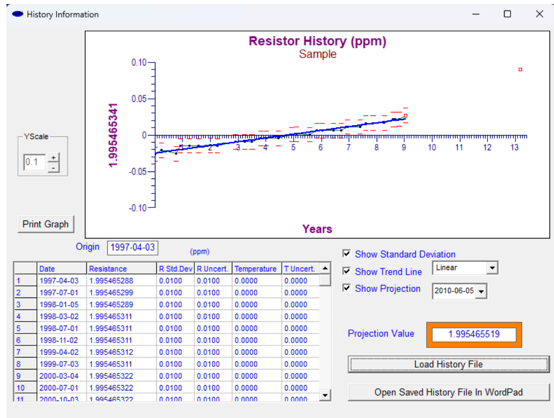


Figure 16.19: History Screen.

16.5.11 Diagnostic Check

The remote calibration routine starts by clicking the 'Start Calibration' button. The data will be saved to a file if the 'Save Calibration Results' box is checked. See Figure 16.20. The filename should not have an extension (already set to .cal), and the output file should be saved in the 'Data Files' directory specified on the 'File & Directory Setup' screen. Click the 'Open Saved Calibration File in WordPad' button to access previously saved calibration files. Refer to Section 8 Calibration for recommended values, detailed information about the calibration sequence, and Chapter 8 SERVICE INFORMATION for eventual adjustment.

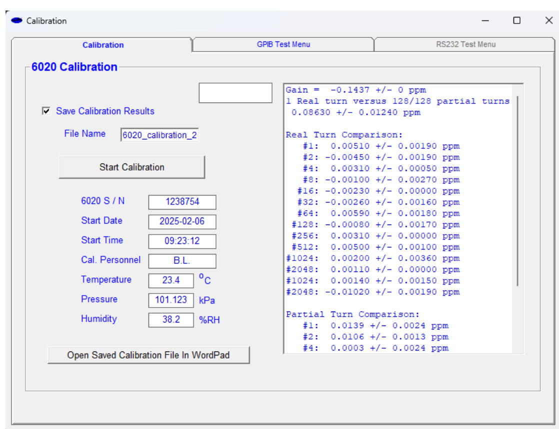


Figure 16.20: Calibration Screen.

16.5.12 GPIB Test Menu and RS232 Test Menu

These menus are shown in Figure 16.21 and Figure 16.22. They can be accessed by clicking the corresponding tabs of the Diagnostic Menu. The purpose of these menus is to allow the operator to test individual units if it is suspected that one of them is not responding on the GPIB bus or serial port. It should be noted that these screens only allow one unit to be tested at a time. The list of available remote commands for each unit can be found in their respective manuals. Some example commands for each unit are also displayed in these menus. Select the unit for test by clicking on the corresponding radio button located on the left hand side of the unit type box. The unit name and its GPIB address (or Serial Port Number) will turn orange when that unit has been selected.

A remote command can then be entered in the Type Command to be Sent box (or Command Sent box) at the bottom of the screen. Once the command has been entered, the Send button must be selected in order to actually send the command to the unit.

The unit will not respond by returning value unless the Get button is pressed. It should be noted that not all send commands will return a value. However, some units respond to any command, and in that case the button Send and Get can be used (Figure 16.22). Check that the GPIB (or serial) cable is connected and the GPIB address (COMM port number) setting of the unit matches the value shown on the test screen.

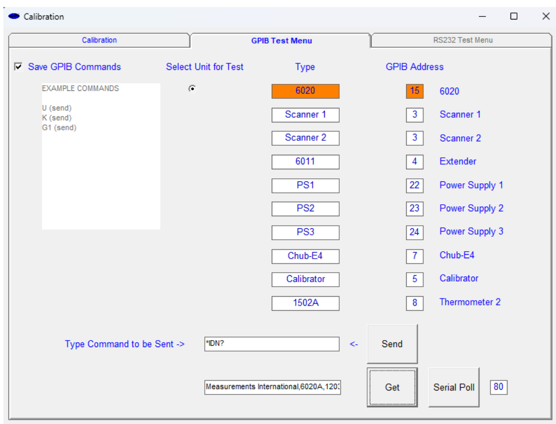


Figure 16.21: GPIB Test Menu with a Bridge Selected.

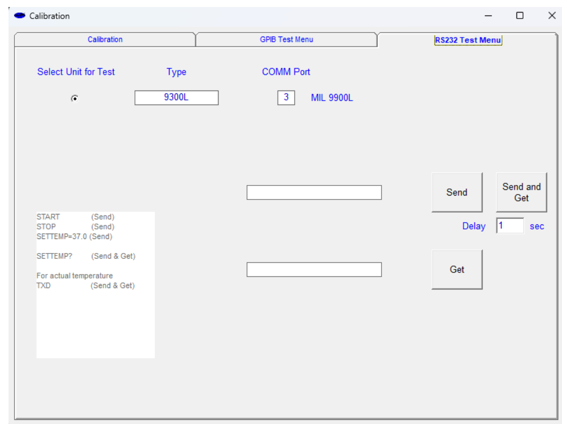


Figure 16.22: RS232 Test Menu with a bath selected.

A. Quantum Hall Resistance Connections

This appendix describes the QHR chip connection to perform quantization check.

WARNING

Refer to your QHR system user manual before performing measurements.

NOTE

For detail regarding the quantization check measurement see your QHR system user manual.

NOTE

The information reported here assumes the use of a six-contact chip, two of which are the source of the device's drain, and the other four are the resistor contacts as shown in Figure A.1.

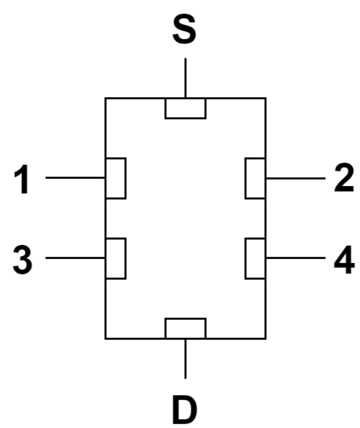


Figure A.1: QHR Sample.

A.1 Sweep Check Connections

Connect the chip accordingly to Figure A.2 and Figure A.3 to perform the longitudinal and Hall resistance sweep check.

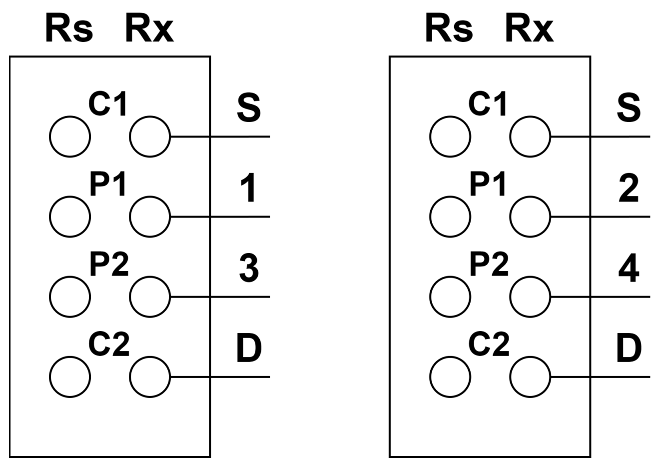


Figure A.2: Seep check for Longitudinal Resistance - Vxx.

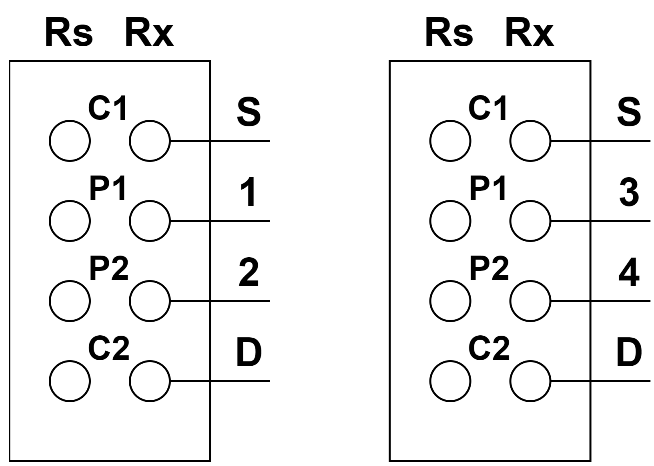


Figure A.3: Seep check for Hall Resistance - Vxy.

A.2 Contact Resistance Connections

Connect the chip accordingly to Figure A.4 to perform the contact resistance checks.

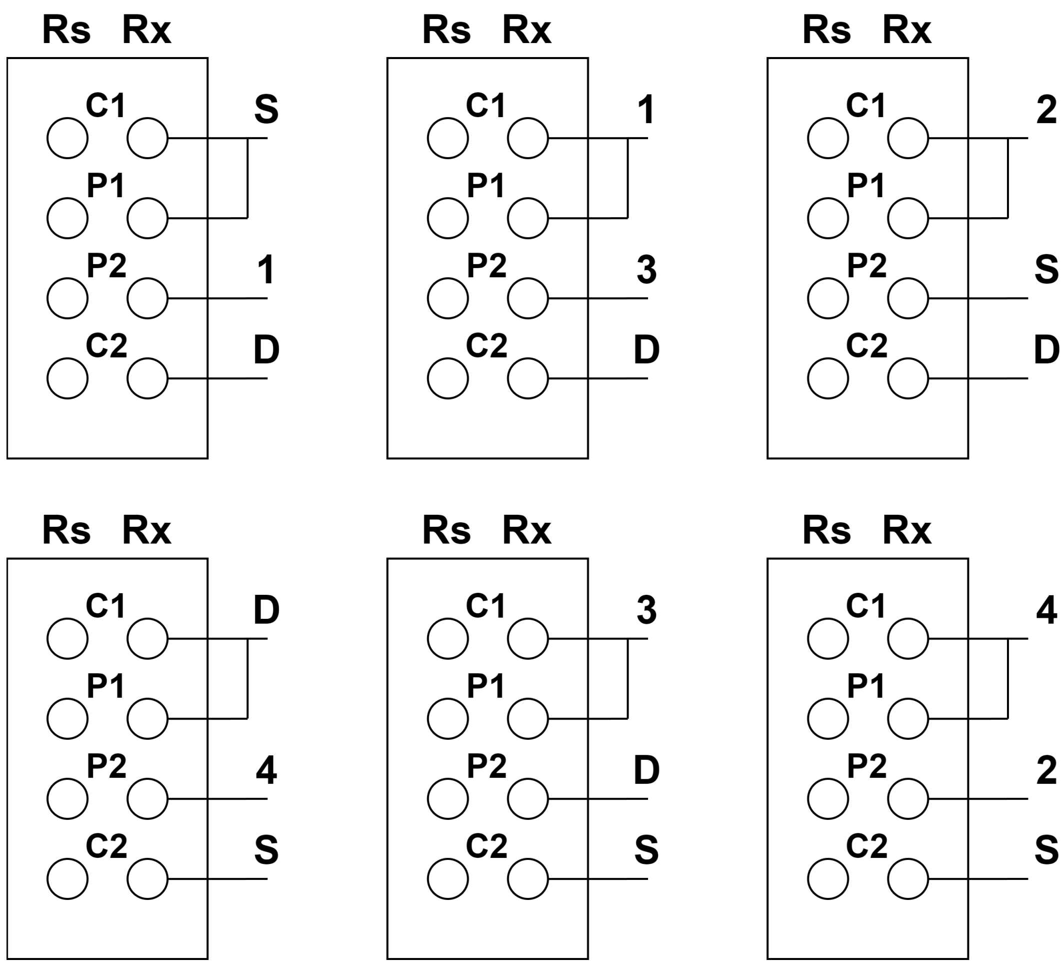


Figure A.4: Contac Resistance Check.

A.3 Dissipation Connections

Connect the chip accordingly to Figure A.5 to perform the dissipation checks.

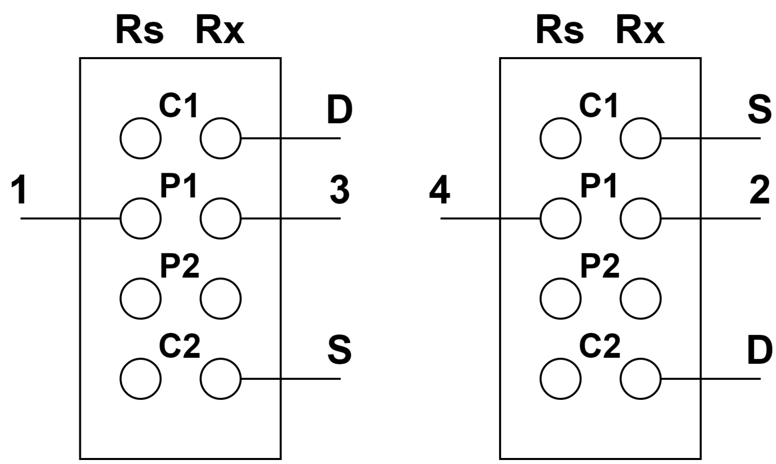


Figure A.5: Dissipation Check.

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