GUILD*LINE*
INSTRUMENTS

# TECHNICAL MANUAL

# FOR

# MODEL 5032

# VARIABLE TEMPERATURE AIR BATH

### NOTICE

**TM5032-J1-00**
**15 May, 2019**

# TABLE OF CONTENTS

# TABLE OF FIGURES

# LIST OF TABLES

# 1. INTRODUCTION

### 1.1. SCOPE
This manual contains technical specifications, a detailed description, maintenance information, and diagrams for the Guildline Instruments model 5032 Variable Temperature Air Bath.

### 1.2. GENERAL DESCRIPTION
The model 5032 Variable Temperature Air Bath is a bench top precision, programmable temperature bath. See Figure 1-1. It provides 82 litres (2.9 cu. ft.) of usable temperature controlled space. The internal temperature is maintained by a solid state control system. The regulated temperature can be selected from remote control or on the front control panel. The temperature range is from 15.00 °C to 50.00 °C with a set point resolution of 0.001 °C and ± 0.03 °C stability over 24 hours. The design assures minimal thermal gradients within the chamber.



**Figure 1-1:  Variable Temperature Air Bath**

The interior of the air bath chamber is of stainless steel construction. See Figure 1-2. This shielded enclosure is tied to earth ground through the power cord to reduce electromagnetic interference. The circulation fans, cooling units and heaters are separated from the air bath chamber to provide full and unimpeded access to the air bath chamber.

**Figure 1-2:  Air Bath Chamber**

The design of the bath employs a fixed rate of cooling from two thermoelectric modules to provide cooling capability. Precision heating temperature control balanced against this cooling is provided by rapidly switching off and on two incandescent lamps. This provides the required heating/cooling to balance the heat losses to ambient or the heat generated by apparatus within the chamber.  The thermoelectric modules are operated in reverse mode to act as booster heaters when changing from the present air bath chamber temperature to a higher set point temperature. The thermoelectric modules are only deactivated (i.e., not cooling or heating) when the temperature within the bath reaches the Cool Off variable, selected through the temperature control menu, with respect to the temperature set point (see section 3.6.9.6). An auxiliary probe is supplied with sufficient lead length to monitor any point within the chamber.

To protect the contents of the chamber from overheating due to a malfunction of the temperature control, there is an overriding over-temperature control that will disable the heating system if the temperature exceeds 55 °C ±4 °C.

Uses for the Variable Temperature Air Bath include:

• Maintaining a constant temperature environment for reference resistors such as the Guildline Instruments 9330 series resistors.
• Calibration of thermometers.
• Thermal cycling of materials or components.
• Calibration of temperature coefficients.

## 1.3.    FRONT PANEL CONNECTORS/CONTROLS

The 5032 front panel supports a simple 16 key keypad with a vacuum fluorescent (VF) display. The VF display is used to indicate the instrument status and temperature data statistics, as well as display the current temperature measurement. The display can be set to display the control point temperature or the temperature of the auxiliary probe provided with the air bath.

The 16 key keypad contains a numeric keypad (0-9, "." and "-") for data entry and 4 control keys. These control keys are for cursor movement and data entry control.

Figure 1-3 outlines the front panel features of the 5032 Variable Temperature  Air Bath.
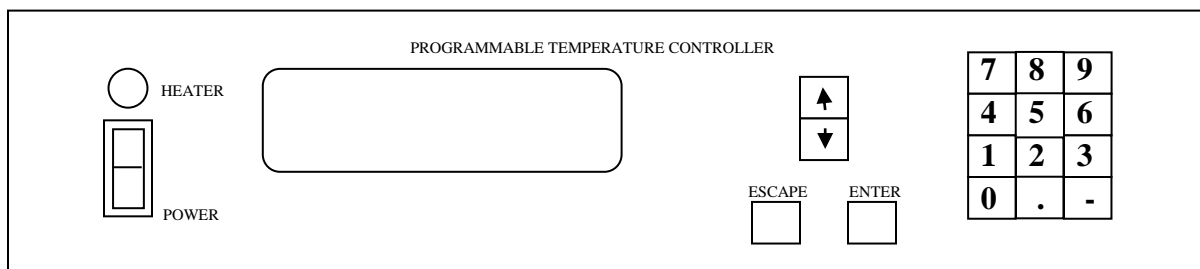


**Figure 1-3:  Control Panel**

### 1.3.1.  POWER SWITCH

The Power switch forms part of an integral line input / line filter / line voltage selector module mounted on the rear panel. In the on position, the power switch applies line power to the 5032. The 5032 will accept line input voltages in one of two ranges: 115 V ±10% or 230 V ±10%.

### 1.3.2.  NUMERIC KEYPAD

A set of momentary pushbutton keys arranged in a 4 row by 3 column matrix is provided for numeric data entry. The numeric keys are labeled "0", "1", "2", "3", "4", "5", "6", "7", "8", "9", with "." and "-" for decimal point and negative value entry. The numeric keypad is only active when an edit session is in process and acts as a single key type-over keypad.

### 1.3.3.  CURSOR MOVEMENT KEYS

The cursor movement keys are mounted beside the numeric keypad and can move the cursor "up", "down" one line at a time.

When the cursor is at one of the display boundaries and more information is to be displayed then pressing a cursor key will scroll the whole display by one line (up / down). During an edit session the "up" cursor key will enter the exponent "E".

### 1.3.4. VACUUM FLUORESCENT DISPLAY

The VF display module displays the menu text, system messages, and temperature data. The display will view up to 4 lines of 21 characters each line and is used to prompt the operator for data entry or to inform the operator of an intermediate (calculated) data value or action to be performed (help). The extreme right of the display shows the IEEE-488 (GPIB)/RS232 status (indicators SRQ, TALK, LISTEN and REMOTE).

### 1.3.5. HEATER INDICATOR

The Heater indicator is lit when the heater lamps are activated to heat the air bath chamber. It will flicker to indicate precision temperature regulation is occurring.

## 1.4. REAR PANEL CONNECTORS/CONTROLS

Figure 1-4 provides an outline of the 5032 rear panel controls and connectors.

### 1.4.1. IEEE-488 INTERFACE

A standard IEEE-488 connector is provided to allow control of the 5032 from a remote device attached to the interface. The remote commands are detailed in section 4 of this manual. The configuration of the interface is set from the front panel menu system.

### 1.4.2. RS232 INTERFACE

A standard RS232 25 pin "D-type" connector is provided to allow control of the 5032 from a remote device attached to the interface. The remote commands are detailed in section 4 of this manual. The configuration of the interface is set from the front panel menu system.

### 1.4.3. LINE INPUT CONNECTOR

A standard IEC 320 power inlet allows the attachment of international harmonized appliance connectors. Its associated Voltage Selection switch allows selection of either 115 VAC or 230 VAC power. The 5032 is normally supplied with a North American 3-pin cord set.
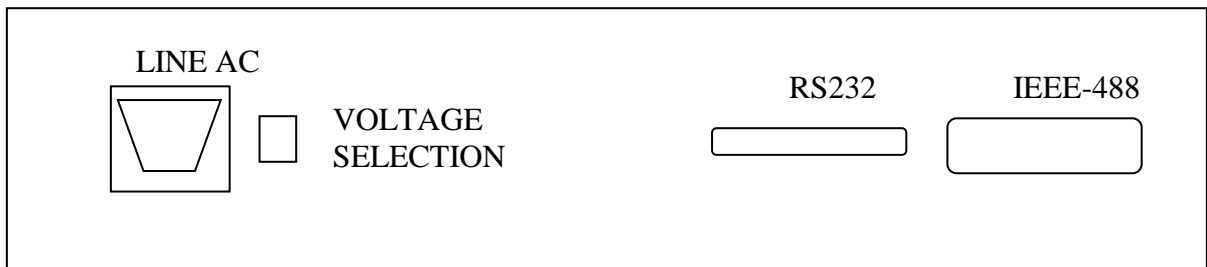


**Figure 1-4 : Rear Panel Layout**

## 1.5. AIR BATH CHAMBER CONNECTORS/SENSORS

The Channel "B" auxiliary thermistor probe is mounted on a bracket and connected to a wall socket at the rear of the air bath chamber. This thermistor probe provides the system temperature reading for recording the temperature in the air bath chamber of the 5032 Variable Temperature Air Bath. The thermistor probe is provided with sufficient cable to allow it to be moved to various positions throughout the air bath chamber.

The 5032 should not be operated with the thermistor probe mounted in the bracket on the back wall of the chamber. A sensor bracket has been provided in the Spare Parts Kit to allow the thermistor probe to be properly located in the center of the bath.  It is to be noted that there will be some significant temperature gradients near the outer walls of the chamber.

**Note: Calibration of the 5032 Variable Temperature Air Bath is done with the Channel "B" auxiliary thermistor probe in the center of the chamber.**
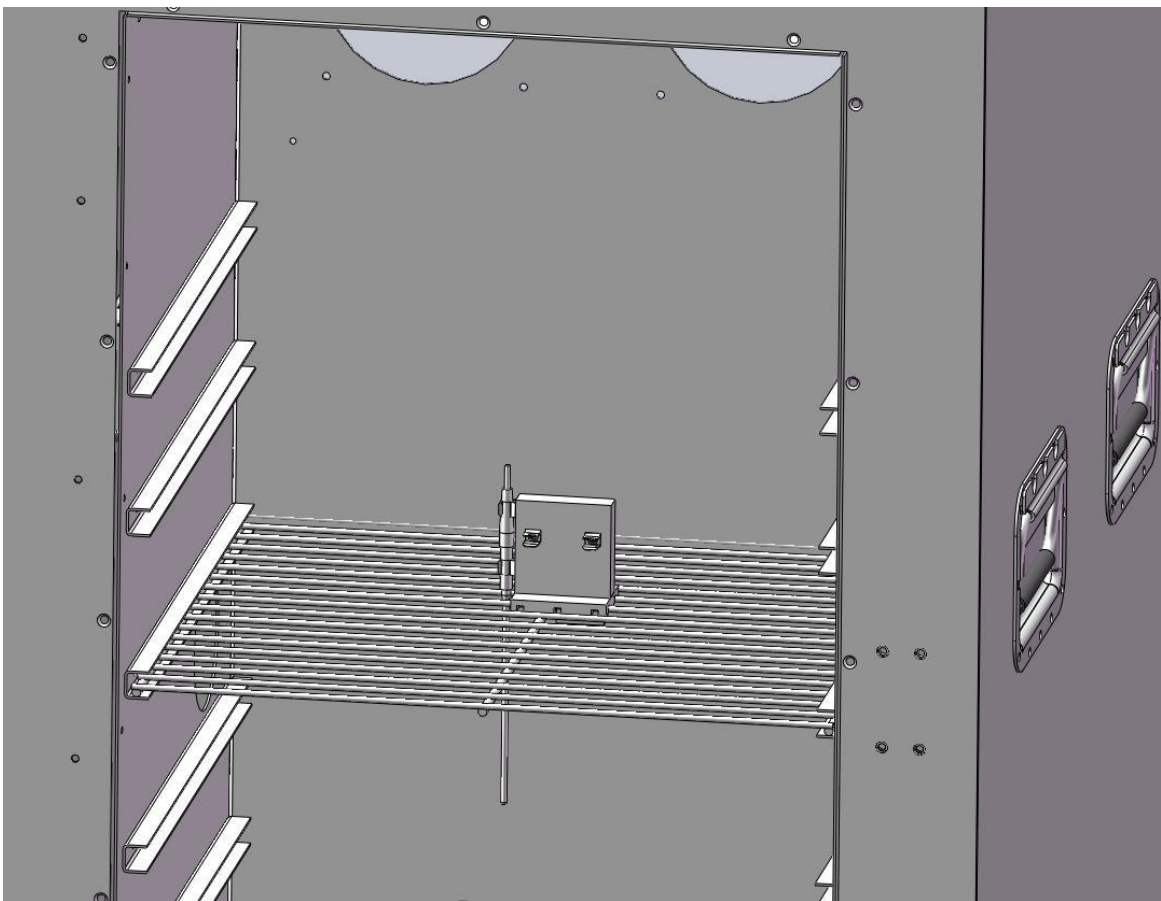


**Figure 1-5 : Suggested Thermistor Probe Position**

# 2. SPECIFICATIONS

## 2.1. GENERAL SPECIFICATIONS

| SPECIFICATIONS | 5032 | |
|---|---|---|
| Chamber Temperature Range | 15 °C to 50 °C, (Minimum to 6 °C below ambient) | |
| Temperature Set Point Accuracy | ± 0.06 °C over 1 year within ± 5°C of ambient<br>± 0.1 °C over 1 year outside ± 5°C of ambient<br>± 0.2 °C over 1 year set point over 40°C | |
| Set Point Resolution | 0.001 °C | |
| Temperature Stability | ± 0.015 °C over 24 hours within ± 2 °C ambient<br>± 0.03 °C over 24 hours within ± 5 °C ambient<br>± 0.06 °C over 24 hours outside ± 5 °C ambient<br>± 0.2 °C over 24 hours set point over 40°C | |
| Temperature Uniformity | ± 0.2 °C relative to chamber center, 5 cm minimum from walls for +15 °C to +40 °C | |
| Temperature Attenuation | ± 0.04 °C/°C of ambient temperature | |
| Heating Rate | 25 °C/hour | |
| Cooling Rate | 5 °C/hour, above ambient temperature<br>2 °C/hour, below ambient temperature | |
| Cold Power On Stabilization | 3 hours to within ±0.1 °C of set point | |
| Over Temperature Protection | Automatic shutdown if temperature exceeds 55 °C ± 4 °C | |
| Maximum Power Dissipation of unit under test (set point above ambient) | 5W maximum | |
| **MODEL 5032 ADDITIONAL SPECIFICATIONS** | | |
| Auxiliary PRT Temperature Monitor Accuracy (Bath Interior) | 0.01 °C at 23 °C ± 5 °C | |
| Menu Selections/Setups | 13 Selections including: Self Help, Measurement Display, Display Setup, Numerical Trend, Measurement History, Channel Setup, Calibration, Diagnostics, Temperature Control RS 232 Setup, GPIB Setup, Password Edit, Password Lockout | |
| Programmable Proportional Controller | Temperature Monitor Accuracy | ± 0.025 °C |
| | Temperature Monitor Resolution | 0.001 °C |
| | Programming | IEEE-488.2 RS232C |
| | Programming Language | SCPI (Standard Code Programmable Interchange) |

**Table 2-1: General Specifications**

**NOTES:**

1. These specifications are applicable with the air bath chamber empty.

2. The temperature set point shall be no more than 6 °C below the ambient temperature.

3. 24 hour set point accuracy and stability are defined as the deviation of the mean hourly value from the 24 hour mean for a single ambient temperature point at one point in the air bath chamber (typically the center). The peak to peak stability can be higher (±0.06 °C typical) depending on the temperature selected.

4. Temperature uniformity is relative to the center of the air bath chamber and at least 5 cm from the walls of the chamber for +15 °C to +40 °C.

# 3.  OPERATING INSTRUCTIONS

## 3.1.  INSTALLATION

This instrument was thoroughly tested and inspected before shipment and should be free from damage when received. Inspect it carefully, verify that all items on the packing list are present and check the instrument operation as soon as possible. Refer to the warranty card at the front of this manual if any damage or deficiencies are found.

The installation procedure is as follows:

1) Place the instrument on a stable bench capable of supporting the weight of the air bath.

> Ensure that air flow through the rear door is not obstructed. Allow at least 25 cm clearance.

### CAUTION

2) Ensure that the correct fuse has been installed – 2 A 250 V (T) should be used for a nominal line input of 115 V and 1 A 250 V (T) should be used for a nominal line input of 230 V.   Only fuses with the rated current and specified type should be used for replacement.

> The 5032 has been shipped with the line input voltage selector set to 230 V and the fuse removed.  The line input selector must be set to the correct line voltage and proper rated fuse installed before power is applied to the instrument.  The settings available are 115 V and 230 V. Remove the warning label positioned across the power line input socket after setting the correct operating voltage and installing the correct fuse.

3) Plug the supplied moulded line cord into the 3-pin power receptacle on the rear panel of the instrument.  Ensure that the other end of the line cord is plugged into a wall socket or extension cord that has a protective or safety ground.  Where 3-contact power supply outputs are not available, a suitable protective ground connection must be made before switching the instrument power on.  Any interruption of the protective ground may possibly render the instrument unsafe.

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

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

5) Set the POWER switch to the ON position and observe that the screen displays 5032 and that no warning messages appear before or after.
6) In the event of a non-volatile memory failure, you will need to verify and possibly re-enter you calibration data for the control and auxiliary thermistors. Refer to section 3.6.7.
7) Upon reaching the main menu go to the measurement display sub-screen and enter your set point value.
8) When the inner chamber reaches its operating temperature, the HEATER lamps will indicate periodic cycling. Due to the thermal lagging, it will take up to 3 hours to change the inner chamber to be within ±0.05 °C of the set point temperature. The bath should be allowed sufficient time to stabilize at the set point temperature accordingly. The auxiliary channel displays the air bath chamber to allow the user to make this determination.

## 3.2.    MAIN MENU OPERATING PROCEDURES
The front panel of the 5032 consists of a keypad and display areas. The keypad consists of:

- one set of numeric keys <0,1,2,3,4,5,6,7,8,9> for numeric data entry;
- one minus sign key <->;
- one decimal point key <.>;
- A set of two cursor movement keys are also provided, in the form of the <up arrow> and <down arrow>;
- Two control keys are positioned beneath the arrow keys. These keys take on the function as <Enter> and <Escape>;
- A vacuum fluorescent graphical display is mounted to the left of the keypad. This display is used to provide data information and user function feedback to the operator.

## 3.3.    GENERAL KEY/DISPLAY OPERATIONS
The following information describes typical displays and corresponding menu descriptions for associated function keys.

### 3.3.1. BASE MENU

Typically consists of a header line, a cursor column, a data window, and the GPIB status.

```
Header Line:            ▌
↑Menu option 3          ▌
█Menu option 4          ▌
↓Menu option 5          ▌
```
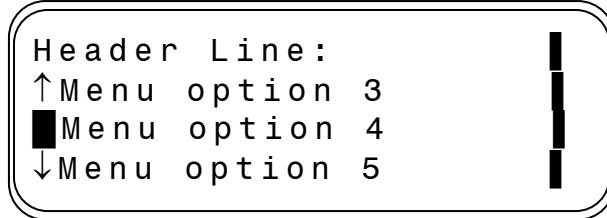
### 3.3.2. BASE MENU DISPLAY

The cursor is a reverse video single character field, positioned in the cursor column. When there are more than three option items in the data window an up arrow symbol (↑) or down arrow symbol (↓) is displayed in the cursor column to indicate that more data selection options are available outside the existing data display window.

Pressing the <down arrow> or the <up arrow> key can scroll the data window down or up respectively, one line for each key press.

```
Main:
↑Menu option 3
█Menu option 4
↓Menu option 5
```
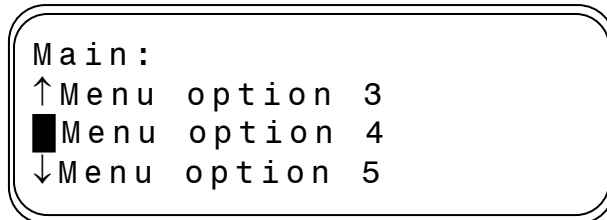
In the above screen pressing the <down arrow> key when the cursor is on the last line will scroll the display data window down one line to remove "Menu option 3" and add "Menu option 6" to the last line of the window as shown in the example window below.

The cursor must be in row 1 for the menu data window to scroll up one row when the up arrow is pressed. The cursor must be in row 3 for the menu data window to scroll down one row when the down arrow is pressed.

**3.4.    BASIC MENU OPERATIONS**

**3.4.1.  MENU SELECTION EXAMPLE - Main**

```
Main:
↑Menu option 3
█Menu option 4
↓Menu option 5
```

In the menu option "Main", pressing the <Enter> key passes control to the selected option at the current cursor position. In the screen example, pressing the <Enter> key will pass control to the "Menu option 4" sub menu. Pressing <Escape> will initialize the cursor at the topmost menu option available at the "Main" menu level (HOME position).

**3.4.2.  SUBMENU OPTIONS**

If at a submenu selection there are a defined set of alternate values, pressing the <Enter> key, will cause one of the alternate values to be selected and displayed in the associated active area of the display screen.

Example: Current Screen

```
┌─────────────────────────────────┐
│ Header Line:                    │
│ █Menu item:DISABLED             │
│  Menu item:Data Value           │
│ ↓Menu item:                     │
└─────────────────────────────────┘
```

Example continued: Screen after pressing <Enter>

```
┌─────────────────────────────────┐
│ Header Line:                    │
│ █Menu item:ENABLED              │
│  Menu item:Data Value           │
│ ↓Menu item:                     │
└─────────────────────────────────┘
```

The alternate value "ENABLED", associated with the annotation at the current cursor location, is toggled in the active screen area to replace the previous value "DISABLED".

### 3.4.3.  BASE EDIT MENU

When the stored value of an internal coefficient or system parameter needs to be changed, the <Enter> key must be invoked at the sub menu level "Sub Menu Header", in which the parameter is viewed. When the edit menu function is active for the sub menu selected, the data field at the current cursor location is enabled for editing.

Use the cursor movement arrow keys to position the cursor to the parameter line of interest as shown below. Pressing the <Enter> key, will move the cursor to the first digit/character of the data value. All data fields are numeric and the new value can be entered, replacing the previous value, using the numeric keypad.

If the data field is entered in exponent notation, pressing the <up arrow> key will enter the character "E" for exponent.

When the data value is acceptable it can be saved to system memory by pressing <Enter>. The cursor will return to the first column leaving the new value in the display window. Only valid data values will be accepted for the new data value. If the new value is outside the range of acceptable values the previous value is returned unchanged.

If the <Escape> key is pressed at any time before pressing <Enter> the previous value is returned to the displayed "data value".

Example edit screen to change the entry at "Data value".

```
Header Line:
  Menu item: ENABLED
  Menu item: New Data█
↓Menu item:
```

When the changed parameter is acceptable the new sub menu screen is updated with the changed parameter showing in the data display window.

### 3.4.4. PASSWORD PROTECTION

Several parameters used by the system firmware are password protected. If an attempt is made to change or edit a protected parameter the password window will appear.

```
Enter Password:
█Password:
  Enter Password
  to continue.
```

Pressing the <Escape> key aborts the operation and passes control back to the previous menu.

To continue the edit session the following sequence must be followed:

1)  Press <Enter> to enter the password.
2)  When the cursor moves to the password entry position, key in the password and press the <Enter> key.
3)  Press the <Escape> key to continue the edit session to change the value of the protected parameter.

If at step 3 above, the wrong password is entered, the following window will appear:

```
Wrong Password:
█
 Wrong Password
 Operation aborted.
```
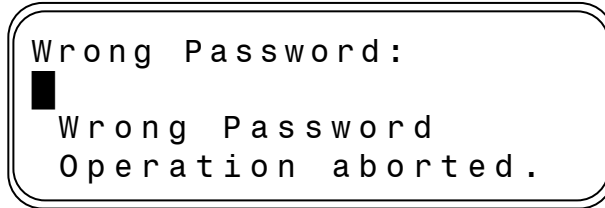
Press the <Escape> key to return to the previous menu.

## 3.5.    TITLE SCREEN

At power ON the 5032 will start its internal self-test programming and display its opening banner:

```
     G u i l d l i n e

        5032
```
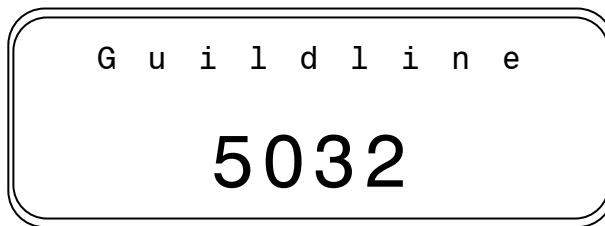
The opening banner will be automatically removed at the termination of the self-test routines and passes control to the "Measurement Display" window.  If the <Escape> key is pressed the display will show the main menu function "Main Menu" and position the cursor at the HOME position.

### 3.5.1.  REMOTE DISPLAY

The REMOTE DISPLAY will appear on the right side of the display only when the 5032 has been addressed by a remote communication device on the IEEE-488 (GPIB) or RS232 port, as in the example below.

```
Sub Menu:              █  SRQ
↑Menu selection:       █  TALK
█Menu selection:       █  LISTEN
↓Menu selection:       █  REMOTE
```
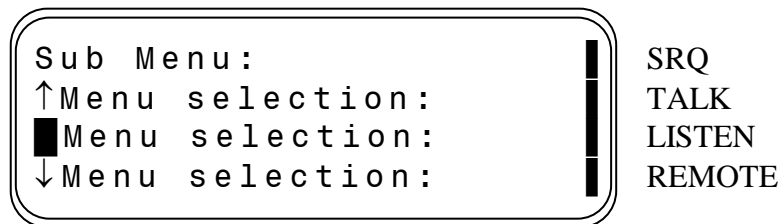
The REMOTE DISPLAY indicators are as follows, and are applicable to both the IEEE-488 (GPIB) and RS232 ports, unless otherwise indicated:

SRQ – The Service ReQuest indicator is lit when the 5032 is requesting service. It is applicable to the IEEE-488 (GPIB) only.

TALK – The TALK indicator is lit when the 5032 is transmitting data and commands.

LISTEN – The LISTEN indicator is lit when the 5032 is receiving data and commands.

REMOTE – The REMOTE indicator is lit when the 5032 is under remote control.

The only active key that will work when in REMOTE mode is the <Escape> key. When <Escape> is pressed the 5032 returns to local front panel mode of operation. The exception is when local lockout has been enabled. In this case, none of the keys on the front panel will be enabled.

### 3.6.    MAIN MENU

The main menu is the starting point for all 5032 configuration options. The HOME position for the cursor is as shown in the example below.

```
Main Menu:
█Help
 Measurement Display
↓Display Setup
```
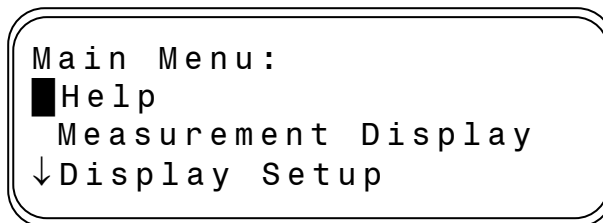
A <↓> character will appear in row 3 of the cursor column to indicate that other menu options are available. Pressing the <down arrow> key will scroll the data window to show the available options.

The menu options available at the "Main Menu" level are:

- Help
- Measurement Display
- Display Setup
- Numerical Trend
- Measurement History
- Channel Setup
- Calibration
- Diagnostics
- Temperature Control
- RS232 Setup
- GPIB Setup
- Edit Password
- Password Lockout

Pressing <Escape> will initialize the data window to position the cursor to the HOME position in the "Main Menu" menu level.

### 3.6.1. HELP
A HELP menu function is available on-line to the casual user of the 5032. With use, the menu system can be perused with little difficulty. The help function can be used as a guide for the occasional user.

Pressing the <Enter> key with the cursor located at the Help line option in the "Main Menu" will pass control to the Help information display window.

#### 3.6.1.1. Menu Navigation
Describes how to use the cursor keys to move about the menu system and to do edits.

#### 3.6.1.2. Change variable
Describes how to perform changes to variables saved in the 5032 memory.

### 3.6.2. MEASUREMENT DISPLAY
With the cursor positioned at the Measurement Display selection pressing <Enter> will display the temperature measurement in the main data window.

Pressing the <Escape> key will return control to the main menu level.

```
Main Menu:
 Help
█Measurement Display
↓Display Setup
```

### 3.6.2.1.    Measurement

The Measurement can be displayed in Celsius, Kelvin, Fahrenheit, or even ohms. The measurement display value can be either channel directly, a comparison to set point, or inter-comparison between channels.

```
Aux
█Set Point: 23.00
      22.89 °C
```

### 3.6.2.2.    Set Point

The Set Point can be entered in the Measurement Display menu.  The Set Point is entered in the displayed units of the measurement.  Pressing the <Escape> key will return control to the main menu level.  Pressing the <Enter> key will permit changing the Set Point parameter (any value in the range 15.00 °C through 50.00 °C).

### 3.6.3.  DISPLAY SETUP

With the cursor positioned at the Display Setup selection, pressing <Enter> will pass control to the Display Setup menu where the data display format for both input data channels can be selected.

```
Main Menu:
↑Measurement Display
█Display Setup
↓Numerical Trend
```

Pressing the <Escape> key will return control to the main menu level.

Pressing the <Enter> key will permit changing the value or optional state of the selected parameter.

```
Display Mode:
█Mode    Aux
 Units             °C
↓Aux Filter      ON
```
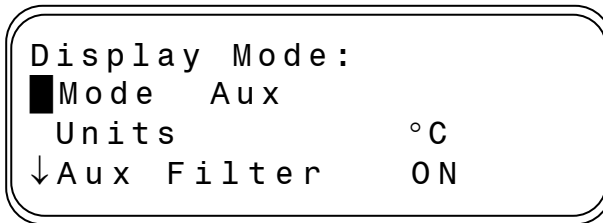
### 3.6.3.1.  Mode

This menu option allows the user to set the Measurement Display to one of "Ctl", "Aux", "Aux – Ctl", or "Ctl - Setpoint".

- **Ctl**            The currently displayed data value for the Control Channel.
- **Aux**            The currently displayed data value for the Auxiliary Channel.
- **Aux - Ctl**      The difference between the currently displayed data value for the Auxiliary Channel and the currently displayed data value for the Control Channel.
- **Ctl – Set Point** The difference between the currently displayed data value for the Control Channel and the set point.

### 3.6.3.2.  Units

This menu option allows the user to set the engineering units of operation, from one of temperature as (K), (°C) or (°F) or directly in resistance (Ω).

### 3.6.3.3.  Aux Filter

This menu option allows the user to turn the filter function for the auxiliary channel ON or OFF.

### 3.6.3.4.  Sample Size

This menu option allows setting of the sample size (any value in the range 3 through 50) for the filter used for the reported data.

### 3.6.3.5.  Resolution

This menu option allows setting of the temperature display resolution (any value in the range 1 through 3) for the resolution sets how many digits after the decimal place are displayed.

### 3.6.4.  NUMERICAL TREND

With the cursor positioned at the Numerical Trend selection, pressing <Enter> will pass control to the Trend menu where the trend data for both input data channels will be displayed in the main data window.

```
 ╭─────────────────────────────────╮
 │ Main Menu:                      │
 │ ↑Display Setup                  │
 │ ■Numerical Trend                │
 │ ↓Measurement History            │
 ╰─────────────────────────────────╯
```

Pressing the <Escape> key will return control to the main menu level.

Pressing the <Enter> key will permit changing the value or optional state of the selected parameter.

Data displayed in the Trend display data window are:

- **Max**       Display the maximum value attained by the Ctl Channel (since the last Ctl Channel reset) and the Aux Channel ((since the last Aux Channel reset).
- **Min**       Display the minimum value attained by the Ctl Channel ((since the last Ctl Channel reset) and the Aux Channel ((since the last Aux Channel reset).
- **Spread**    Display the difference between the Max. value and the Min. value for the Ctl Channel and the Aux Channel.
- **Std Dev**   Display the standard deviation of the displayed data set for the Ctl Channel and the Aux Channel. The standard deviation is based on the previous n samples where n is the value of "sample size" entered in the "Display Mode" menu. (After a channel reset for the Ctl Channel or Aux Channel has been pressed, the value n increases from 1 to "sample size" for that channel as each new sample is taken.)
- **Drift**       Display the rate of change of the previous n samples of displayed data for the Ctl Channel and the Aux Channel in units per hour (n is defined as above).

### 3.6.4.1.    Channel
Pressing the <Enter> key at the "Channel" menu item, will toggle the trend display between the Ctl Channel and the Aux Channel.

### 3.6.4.2.    Reset Ctl
Pressing the <Enter> key at the "Reset Ctl" menu item, will clear the trend variables for the Ctl Channel and set the Min and Max to the current value.

### 3.6.4.3.    Reset Aux
Pressing the <Enter> key at the "Reset Aux" menu item, will clear the trend variables for the Aux Channel and set the Min and Max to the current value.

### 3.6.5.  MEASUREMENT HISTORY
With the cursor positioned at the Measurement History selection, pressing <Enter> will pass control to the Measurement History menu where the data acquisition function of the 5032 can be configured.

```
Main Menu:
↑Numerical Trend
█Measurement History
↓Channel Setup
```

Pressing the <Escape> key will return control to the main menu level.

```
History Menu:
█Channel  Ctl
 Display History...
↓Clear Data
```

### 3.6.5.1.    Channel
With the cursor key positioned at the Channel option, pressing the <Enter> key selects the data values saved for either Ctl or Aux channels.

### 3.6.5.2.    Display History
With the cursor key positioned at the Display History option, pressing <Enter> displays the data values saved for either Control Channel or Auxiliary Channel in the Display History menu window. The most recent data is displayed in ascending chronological order.

Pressing <Escape> will return control to the previous menu level.

Pressing <Enter> jumps to the end of the history buffer (a sample may not be present until the history buffer is full).

Use the cursor keys to scroll forward or backward through the archived data.

```
History Aux  Channel
█08:28:07    21.98 °C
 08:30:07    21.99 °C
↓08:32:07    22.00 °C
```

### 3.6.5.3. Clear Data

With the cursor key positioned at the Clear Data option, pressing the <Enter> key clears the data values saved for channels A and B.

### 3.6.5.4. Sample Interval

With the cursor key positioned at the Sample Interval option pressing the <Enter> key enables entry of the desired data sample interval as a value in the range 1 through 2000 samples, i.e. 1.2 seconds to 2400 seconds.

**NOTE: the value stored is the average of all measurement samples over the sample interval.**

### 3.6.5.5. Sample

With the cursor key positioned at the Sample option, pressing the <Enter> key enables the saving of data at channels A and B. The option for this switch is ON or OFF.

### 3.6.5.6. Sample Mode

With the cursor key positioned at the Sample Mode option, pressing the <Enter> key sets the sampling of data at channels A and B for a single sweep mode of operation or as a continuous sweep. In single sweep mode, the sample data stops being saved when the history buffer is filled. In the continuous mode, once the history buffer is filled, the new sample data overwrites the oldest sample data.

### 3.6.5.7. Dump

The Dump option is enabled by pressing the <Enter> key while the cursor is at the "Dump" menu option. This option formats the sampled history data collected for channels A and B for output. The history data is sent to the Talk Only port of the 5032. The format of the data is identical to the format of the FETCh:HISTory? response (see section 4.7.16.3).

**NOTE: this data dump requires significant time to execute and will cause problems at slow baud rates on the RS232 port. To ensure a successful data dump, use 9600 baud or higher.**

## 3.6.6. CHANNEL SETUP

With the cursor positioned at the Channel Setup selection, pressing <Enter> will pass control to the Channel setup menu. This menu option allows the operator to select, from a list of 16 thermistors, the serial number of the thermistor that is attached to that input channel (Ctl or Aux). The corresponding coefficients of the selected thermistor become active and any calculation/linearization that is made to the resistance data for that channel will use the selected coefficients.

```
┌─────────────────────────────────┐
│ Main Menu:                      │
│ ↑Measurement History            │
│ ■Channel Setup                  │
│ ↓Calibration                    │
└─────────────────────────────────┘
```

Pressing the <Escape> key will return control to the main menu level.

Pressing the <Enter> key will permit changing the value or optional state of the selected parameter.

```
┌─────────────────────────────────┐
│ Connect Channel:                │
│  Ctl:   S/N XXXXXXXX            │
│ ■Aux:   S/N XXXXXXXX            │
│ ↓Init Ctl                       │
└─────────────────────────────────┘
```

### 3.6.6.1. Ctl Channel thermistor selection

With the cursor positioned at the prompt "Ctl: S/N", pressing <Enter> will select the next serial number from a list of 16 thermistor serial numbers that can be attached to the Ctl Channel input.

### 3.6.6.2. Aux Channel thermistor selection

With the cursor positioned at the prompt "Aux: S/N", pressing <Enter> will select the next serial number from the same list as above of 16 thermistor serial numbers that can be attached to the Aux Channel input.

### 3.6.6.3. Initialize Ctl Channel

With the cursor positioned at the prompt "Init Ctl", pressing <Enter> will apply the correct calibration coefficients for the thermistor selected for the Ctl Channel input.

### 3.6.6.4. Initialize Aux Channel

With the cursor positioned at the prompt "Init Aux", pressing <Enter> will apply the correct calibration coefficients for the thermistor selected for the Aux Channel input.

### 3.6.7. CALIBRATION

With the cursor positioned at the Calibration selection, pressing <Enter> will pass control to the Calibration menu. This menu option assists in the calibration of the 5032 subsystems and the attached thermistor calibration data.

```
Main Menu:
↑Channel Setup
█Calibration
↓Diagnostics
```

Pressing the <Escape> key will return control to the main menu level.

Pressing the <Enter> key will permit changing the value or optional state of the selected parameter.

```
Calibration:
█Thermistors
 Ctl Channel Set Coef
↓Ctl Channel Set Ohms
```

### 3.6.7.1.    Thermistors

With the cursor positioned at the Thermistors selection, pressing <Enter> will pass control to the Thermistors menu. This menu option assists in the entry of each thermistor calibration coefficients and calibration of the 5032 subsystems.

```
Thermistors:
█Thermistor 1:……
 Thermistor 2:……
↓Thermistor 3:……
```

This menu level selects the thermistor to be configured. Calibration coefficients for up to 16 thermistors can be entered and saved in the 5032 memory.

#### 3.6.7.1.1.    Thermistor 1

Enter the calibration parameters for the first thermistor.

```
Thermistor 1: ……
█Serial # ……
 Coefficients
```

- **Serial #**    enter a unique thermistor serial number to a maximum of 11 characters.

- **Coefficients - Thermistor**       this sub-menu level allows selection and entry of coefficients for the Steinhart-Hart equation for thermistors.

```
Thermistor Coef
█A:     1.471700E-03
 B:     2.375830E-04
 C:     1.049340E-07
```

### 3.6.7.1.2.  Thermistor 2 through Thermistor 16

Enter the calibration parameters for the second thermistor to thermistor 16 in a similar manner to that described for thermistor 1.

**Note:   The factory default setting of the 16 thermistor is:**

> **serial number of Thermistor n = n**
> **Coefficients:**
> > **Thermistor**
> > > **A = 1.471700E-03,**
> > > **B = 2.375830E-04,**
> > > **C = 1.049340E-07.**

### 3.6.7.2.    Ctl Channel Set Coef

This sub-menu allows the operator to view or enter the Ctl Channel coefficients to convert the raw A/D converter value to resistance in ohms.

```
Set Ctl Coef
█C0: 0.000000
 C1: 9.830000E-04
 C2: 0.000000
```

With the cursor positioned at the Ctl Channel Set Coefficients selection, pressing <Enter> will display for editing the resistance coefficients $C_0$, $C_1$ and $C_2$. The coefficients convert the raw A/D value $X$ to resistance $R$ in ohms according to the equation:

$$R = C_0 + C_1 \times X + C_2 \times X^2$$

### 3.6.7.3. Ctl Channel Set Ohms

This sub-menu permits an auto calibration procedure to take place using three external reference resistors.

With the cursor positioned at the Ctl Channel Set Ohms selection, pressing <Enter> will pass control to the Ctl Channel Range Sub-menu. With the cursor positioned at the desired resistance range, pressing <Enter> will pass control to the auto-calibration sub-menu.

```
Set Ctl Ohms
█Low (2252.0,0.00)
 Med (4504.0,0.00)
 High (6756.0,0.00)
```

With the cursor positioned at the desired reference resistor, pressing <Enter> will display for editing the reference resistor value in ohms.

```
Set Ctl Ohms
█Test Ohms 2.252E+03
```

Pressing the <Escape> key will initiate a one minute sampling of the reference resistor. Upon completion of this self calibration, the auto calibration sub-menu is displayed with the updated values in parenthesis. The resistance coefficients are updated when the auto-calibration sub-menu is exited, only if all three reference resistors have been self calibrated.

### 3.6.7.4. Aux Channel Set Coefficients

The Aux Channel coefficients may be viewed or modified in an identical manner as the Ctl Channel coefficients.

### 3.6.7.5. Aux Channel Ohms

The Aux Channel auto calibration is performed in an identical manner as the Ctl Channel auto calibration.

### 3.6.8. DIAGNOSTICS

With the cursor positioned at the Diagnostics selection, pressing <Enter> will pass control to the Diagnostics menu where there some functional 5032 system tests can be executed.

```
Main Menu:
↑Calibration
█Diagnostics
↓Temperature Control
```

Pressing the <Escape> key will return control to the main menu level.

Pressing the <Enter> key will permit changing the value or optional state of the selected parameter.

```
Diagnostics:
█Keyboard Test
 Dump
```

#### 3.6.8.1.    Keyboard test

With the cursor positioned at the Keyboard Test option, pressing <Enter> will report the label of the next key pressed.

```
Keyboard Test:
█Press Enter 5
 times to exit
 Key:  Times:0
```

Pressing <Enter> 5 times will return control to the previous menu level.

#### 3.6.8.2.    Calibration Data Dump

With the cursor positioned at the Dump option, pressing <Enter> sends calibration coefficients for the 16 thermistors and for the two channels to the Talk Only port. The data is presented in a self –explanatory format.

### 3.6.9. TEMPERATURE CONTROL

With the cursor positioned at the Temperature Control selection, pressing <Enter> will pass control to the Temperature Control menu where the 5032 temperature control variables can be modified.

```
Main Menu:
↑Diagnostics
█Temperature Control
↓RS232 Setup
```

Pressing the <Escape> key will return control to the main menu level.

Pressing the <Enter> key will permit changing the value or optional state of the selected parameter.

```
Temperature Control:
█Window: 0.006
 Threshold: 40.00
↓Kp: 10.00
```

#### 3.6.9.1.    Window

This menu option allows setting of the Window value (any value in the range 0.00 through 1.00). Window is the temperature either side of the set point temperature, within which only integral servo control is employed.

#### 3.6.9.2.    Threshold

This menu option allows setting of the Threshold value (any value in the range 15.00 °C through 50.00 °C). The Threshold sets the temperature above which the cooling module should no longer be used.

#### 3.6.9.3.    Kp

This menu option allows setting of the Kp value (any value in the range 0.00 through 100.00).

#### 3.6.9.4.    Ki

This menu option allows setting of the Ki value (any value in the range 0.00 through 0.10).

### 3.6.9.5. Cooling On
This menu option allows setting of the Cool On value (any value in the range 0.00 °C through 35.00 °C). The Cooling On sets the temperature error threshold, above which the cooling module is turned on.

### 3.6.9.6. Cooling Off
This menu option allows setting of the Cool Off value (any value in the range 0.05 °C through 35.00 °C). The Cooling Off sets the temperature error threshold, below which the cooling module is turned off.

### 3.6.9.7. Heat Delay
This menu option allows setting of the Heat Delay value (any value in the range 0.00 through 50.00 seconds). The Heat Delay sets how long after the cooling module has been turned off that the Heat Lamps may be turned on.

### 3.6.9.8. Booster On
This menu option allows setting of the Booster On value (any value in the range 0.25 °C through 35.00 °C). The Boost On sets the temperature error threshold, below which the booster heater is used to speed up reaching the set point.

### 3.6.9.9. Booster Off
This menu option allows setting of the Booster Off value (any value in the range 0.20 °C through 35.00 °C). The Boost Off sets the temperature error threshold, above which the booster heater is turned off while approaching the set point.

Note: The temperature error is Set Point temperature minus actual temperature.

### 3.6.10. RS232 SETUP
With the cursor positioned at the RS232 Setup selection, pressing <Enter> key will pass control to the RS232 setup menu where the RS232 communication output of the 5032 can be configured.
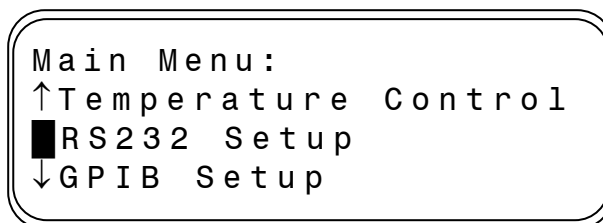
```
Main Menu:
↑Temperature Control
█RS232 Setup
↓GPIB Setup
```

Pressing the <Escape> key will return control to the main menu level.

Pressing the <Enter> key will permit changing the value or optional state of the selected parameter.

```
┌─────────────────────────────────┐
│                                 │
│  RS232  Setup:                  │
│  ■Mode  DISABLED                │
│   Baud  Rate  9600              │
│  ↓Data  Bits  8                 │
│                                 │
└─────────────────────────────────┘
```

### 3.6.10.1.  Mode

With the cursor key positioned at the Mode option, pressing the <Enter> key permits the mode of operation for the RS232 communication port to be set. The mode of operation of this function can be set to one of:

- DISABLED
- TALK ONLY
- TALK/LISTEN

### 3.6.10.2.  Baud rate

With the cursor key positioned at the Baud Rate option, pressing the <Enter> key permits the baud rate for the RS232 communication port to be set. The speed of communication can be selected from one of the standard asynchronous baud rates from 75 through 38400 baud.

### 3.6.10.3.  Data bits

With the cursor key positioned at the Data bits option, pressing the <Enter> key permits the number of data bits for the RS232 communication port to be set. The number of data bits in the serial data word can be selected as either 7 or 8.

### 3.6.10.4.  Stop bits

With the cursor key positioned at the Stop bits option, pressing the <Enter> key permits the number of stop bits for the RS232 communication port to be set. The number of stop bits in the serial data word can be selected as either 1 or 2.

### 3.6.10.5.  Parity

With the cursor key positioned at the Parity option, pressing the <Enter> key permits the type of parity bit used to be set. The type of parity bit used in the serial data word can be selected from one of:

- NONE
- ODD
- EVEN

#### 3.6.10.6. Flow control

With the cursor key positioned at the Flow Control option, pressing the <Enter> key permits the type of handshaking used when communicating with slower devices over the serial interface, to be set from one of:

- NONE
- XON/XOFF
- RTS/CTS

#### 3.6.10.7. Echo

With the cursor key positioned at the Echo option, pressing the <Enter> key enables or disables the 5032 from returning (echoing) all characters received over the serial interface. This option can be set to either ON or OFF.

#### 3.6.10.8. Initialize

Pressing <Enter> key at the "Initialize" menu item will configure the RS232 communication port to the parameters currently displayed. If "Initialize" is not executed, the new configuration does not become effective until after a power on reset.

### 3.6.11. GPIB SETUP

With the cursor positioned at the GPIB Setup selection, pressing the <Enter> key will pass control to the GPIB setup menu where the GPIB/IEEE-488 communication port of the 5032 can be configured.

```
Main Menu:
↑RS232 Setup
█GPIB Setup
↓Edit Password
```

Pressing the <Escape> key will return control to the main menu level.

Pressing the <Enter> key will permit changing the value or optional state of the selected parameter.

```
GPIB Setup:
█Address 1
 Mode DISABLED
↓Initialize
```

### 3.6.11.1. Address

With the cursor key positioned at the Address option, pressing <Enter> permits the GPIB address for the 5032 to be set to an address in the range 1 through 30.

### 3.6.11.2. Mode

With the cursor key positioned at the Mode option, pressing <Enter> permits the mode of operation for the GPIB communication port to be set to one of:

- DISABLED
- TALK ONLY
- TALK/LISTEN

### 3.6.11.3. Initialize

Pressing <Enter> key at the "Initialize" menu item, will configure the GPIB communication port to the parameters currently displayed. If "Initialize" is not executed, the new configuration does not become effective until after a power on reset.

## 3.6.12. EDIT PASSWORD

This menu option can be used to change the existing password.

```
Main Menu:
↑GPIB Setup
█Edit Password
 Password Lockout
```

This is itself a protected data item so the correct password must be entered prior to any attempt to change the password. The following edit window will appear when this option is selected.

```
Edit Password:
█Password XXXX
```

Follow these steps to change the password:

1) Press <Enter> to change the password.

2)  When the cursor moves to the password entry position, key in the new password on the keypad to a maximum of 8 characters and press the <Enter> key.

3)  Press the <Escape> key to accept the new password and continue back to the main menu.

### 3.6.13. PASSWORD LOCKOUT

This menu option can be used to lock the keypad and data entry functions.

```
Main Menu:
↑GPIB Setup
 Edit Password
█Password Lockout
```

The following edit window will appear when this option is selected.

```
Password Lockout:
█Press Enter to Exit.
```
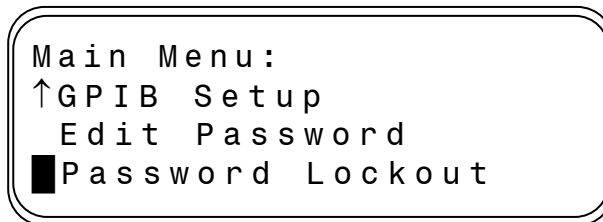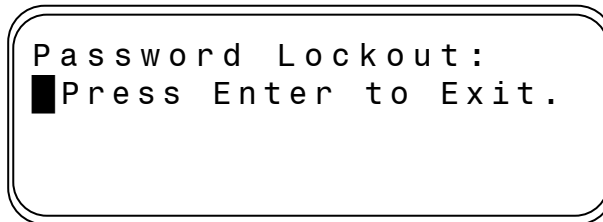
To unlock the keypad the correct password must first be entered.

When successful, control will return to the main menu with the cursor at the home position.

---

*NOTE:*

*The factory default password is:*

**5032**

*To reset the password back to the factory default, the following key sequence must be entered at the keypad: Escape, Up, Enter, Down*

---

# 4.   REMOTE CONTROL

The 5032 precision thermometer operates directly from the front panel or under remote control of an instrument controller, computer or terminal. Remote control can be interactive, with the user controlling each step from a terminal, or under the control of a computer running the 5032 in an automated system. It is also possible to connect a printer to the remote interface of the 5032 and have the 5032 output some or all of the measurements taken to the printer for a permanent record.

This chapter describes the interfaces and the commands to which the 5032 will respond. The setting of the IEEE-488 address and mode is described in section 3.6.11.

## 4.1.   INTERFACES
The model 5032 has two interfacing standards available:

- A parallel interface conforming to IEEE-488.2.
- A serial interface conforming to RS-232C.

The IEEE-488 connector is mounted to the rear panel. The IEEE-488 address defaults to a factory setting of 01. This setting can be viewed and set to a valid address using the front panel controls. Setting up the IEEE-488 address from the front panel is explained in section 3.6.11.

The RS-232C connector is mounted on the rear panel but it has to be configured from the front panel as explained in section 3.6.10.

The 5032 can be operated in a system where both RS-232C and IEEE-488 interfaces are being used. It can be controlled with an IEEE-488 bus and a printer connected to the RS-232C output for permanent records of measurements.

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

## 4.2.   IEEE-488 (GPIB) INTERFACE
The 5032 is fully programmable for use on the IEEE standard 488.1 interface bus (also known as the General Purpose Interface Bus (GPIB). The interface is also designed in compliance with the supplemental standard IEEE-488.2. Devices connected to the bus in a system are designated as talkers, listeners, talker/listeners, or controllers. The 5032 can be operated on the IEEE-488 bus as a talker or under the control of an instrument controller as a talker/listener.

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

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

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

### 4.2.1. CONTROLLER

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

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

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

### 4.2.2. IEEE-488 RESPONSES

The reply to any IEEE-488 query command will be a sequence of ASCII characters followed by a line-feed character (0x0A). The line-feed character may also be expressed as $0A_{16}$ or $10_{10}$ or $12_8$ or Ctrl-J. Throughout this manual we will use the "C" programming language notation for expressing numbers in base 16, specifically 0x0A indicates that 0A is to be interpreted in base 16 (hex).

### 4.2.3. INTERCONNECTING CABLE AND IEEE-488 CONNECTOR

The interconnecting cable of IEEE-488 1978 consists of 24 conductors, 16 conductors are for carrying signals and 8 for grounding. An individual cable assembly may be up to 4 meters long and should have both a plug and a receptacle connector type at each end of the cable. Each connector assembly is fitted with a pair of captive locking screws.

### 4.2.4. TYPICAL SYSTEM

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

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

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

### 4.2.5.  ADDRESS AND TALK/LISTEN SELECTION
The IEEE-488 Address and Talk/Listen status can be set using the front panel controls as directed by the operator menuing system.

If there is no controller and the 5032 is hooked up to a printer for hard copy then Talk Only mode should be selected as the preferred mode of operation.

### 4.2.6.  IEEE-488 ELECTRICAL INTERFACE
The 5032 meets the subsets of the IEEE-488 interface specification IEEE-488.1 shown in Table 4-1. The pin connections on the IEEE-488 interface connector are shown in Table 4-2.

| Source Handshake | SH1 | complete source handshake capabilities. |
|---|---|---|
| Acceptor Handshake | AH1 | complete acceptor handshake capabilities. |
| Talker | T5 | has a talker capability with a single primary address in the range 0 to 30. Extended addressing is not implemented. Talk only. |
| Listener | L4 | supports basic listener with unaddressed if MTA(My Talk Address) is received. The talk and listen addresses will always be the same. Does not support extended listen addresses. Does not support Listen Only. |
| Service Request | SR1 | complete service request generation capabilities. |
| Remote Local | RL1 | all functions on the front panel can be locked out by the IEEE-488 controller. |
| Parallel Poll | PP0 | no parallel poll capabilities. |
| Device Clear | DC1 | full device clear capabilities. |
| Device Trigger | DT0 | no device trigger capabilities. |
| Controller | C0 | can never become the bus controller. |
| Electrical Interface | E2 | all required electrical interface capability. |

**Table 4-1 : IEEE-488 Device Capabilities**

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

**Table 4-2 : IEEE-488 Pin Designations**

### 4.2.7. IEEE-488 INPUT BUFFERING

The IEEE-488 input buffer is 256 bytes long. The input full bit is set when the buffer is above 75% full (64 bytes remaining), hence if the programmer limits messages sent to the 5032 to 32 bytes and checks the IFL bit in the status register before sending each message, then under normal operating conditions the buffer should never overflow. If the buffer is full and the programmer sends more data, the 5032 will perform the necessary handshaking as per usual, but the data will be lost, this is done for two reasons:

If the buffer is full, the fault must have originated with the controller, since the 5032 interprets most commands in fewer than 15 milliseconds. This prevents the 5032 from locking up the IEEE-488 bus.

### 4.2.8. IEEE-488 OUTPUT BUFFERING

Output from query commands are placed into a 256 byte output buffer. When the controller reads data from the 5032 the responses will come from the output buffer in, first-in first-out order. If for some reason the controller does not read the responses from its query commands the output buffer will overflow, in this case the first data into the buffer will still be valid and the later data will be lost. When output data is lost the query error bit in the status register will be set. When the output buffer is not empty then the message available (MAV) bit will be set in the status register.

### 4.2.9. IEEE-488 DEADLOCK

If the controller demands a byte of data from the 5032 and the buffer is empty, the 5032 will set the Query Error flag in the Event Status Register.

## 4.3. RS-232C INTERFACE

The 5032 has an RS-232C interface which can be connected to a controller or to a simple printer. The controller (which can be almost any computer with an RS-232C interface) can control the 5032 through a variety of commands which allow setting the instruments operating parameters, and analyzing the measurements made by the 5032. The simple printer interface can be used to log any or all of the measurements taken by the 5032 during normal operation.

When using the RS-232C port to remotely control the 5032, either interactively with a terminal or under computer control, operation is the same as using an IEEE-488 controller connected to the IEEE-488 port for control, with the following exceptions:

1. The program message terminator is Carriage Return (0x0D).
2. There is no SRQ capability when using serial remote control. The status registers still behave as described in this chapter, but the 5032 serial interface does not have a way to perform the SRQ function.
3. There is no direct way to perform IEEE-488 hardware interface functions such as DCL (Device Clear) or SDC (Selected Device Clear).

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

**Table 4-3 : RS232 Pin Designations**

The 5032 Variable Temperature Air Bath is a data communication equipment (DCE) so TxD is an input (the data which the modem is to transmit).

### 4.3.1.  RS-232C RESPONSES

The reply to any RS-232C query command will be a sequence of ASCII characters followed by a Carriage-Return character (0x0D) and then a Line-Feed character (0x0A). The Line-Feed character may also be expressed as $0A_{16}$ or $10_{10}$ or $12_8$ or Ctrl-J. Throughout this document we will use the "C" programming language notation for expressing numbers in base 16, specifically 0x0A indicates that 0A is to be interpreted in base 16 (hex).

## 4.4.    COMMAND LANGUAGE

The commands for IEEE-488 and RS-232C mainly correspond to the labels assigned to the front panel menus. Throughout this document when examples are given they apply to commands through the RS-232C interface or through the IEEE-488 interface. The examples will not show the termination characters since these differ for each of the interfaces (See sections 4.2.2 and 4.3.1).

### 4.4.1.  GENERAL SYNTAX FOR COMMANDS

The 5032 uses a sophisticated command parser which can usually determine which command was desired, even if the command is entered incorrectly. Some care should be taken when sending commands such as SYSTem:VERBose and SYSTem:VERSion? Since the parser may not be able to decide which command was desired in the event of a gross misspelling (such as using VERBion instead of VERSion).

No command used in the 5032 has an embedded space in its name. Spaces (0x20) are used only to separate command names from their parameters.

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

Throughout this manual some of the command names will have an UPPER case portion and a lower case portion. The command may be shortened such that only the portion of the command name which was presented in UPPER case characters is present. The command parser of the 5032 is case insensitive (i.e. the letter case of commands sent to the 5032 does not matter), both UPPER case letters and lower case letters may be used.

### 4.4.2. GENERAL SYNTAX FOR NUMBERS

Numeric parameters may have up to 30 characters, and although the 5032 will accept numeric parameters in the range $\pm$2.2E-308 through $\pm$1.8E308, the useful range of numbers is between $\pm$1.0E-8 and $\pm$1.0E5.

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

- 123.4
- 123.4e00
- 0.1234E3
- 1234e-1
- 0000123.4

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

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

Multipliers (such a $\mu$, m, k, and M) are not permitted on commands, all numbers must be entered in the base units, for example 100 mV can be expressed as 100e-3 or 0.100. Expressions (for example 7 + 20 X 3) are not allowed as parameters.

## 4.5.    REMOTE AND LOCAL OPERATION

The 5032 can be operated using the front panel keys or it can be operated remotely using a remote controller. In addition the 5032 can be placed in a local lockout condition at any time by a command from the controller. When combined, the local, remote, and lockout conditions yield four possible operating states:

### 4.5.1.  LOCAL

The 5032 responds to local and remote commands. This is also called "Front Panel Operation". Only remote commands that do not affect the state of the 5032 are allowed to execute. (For example the command FETCh? A is allowed to operate but the command MEASure:SENSor A,1 which would change the instrument state (use sensor number 1 for the Ctl Channel input) is not allowed.) If the controller sends a command which would affect the instrument state while in local, the command will be ignored, and an Execution Error indication will be given.

### 4.5.2.  LOCAL WITH LOCKOUT

Local with lockout is identical to Local except that the 5032 will go into remote with lockout instead of the remote state when the 5032 receives a remote command. The local with lockout state is entered by sending an IEEE-488 LLO+REN command from the controller, or by sending the RS232 LOCKOUT command to the 5032.

### 4.5.3.  REMOTE

When the Remote Enable (REN) line is asserted and the controller addresses the 5032 as a listener, the 5032 enters the remote state.

Front panel operation is restricted to the use of the <Escape> key. Pressing the <Escape> key or sending the GTL (Go To Local) interface message returns the 5032 to the local state.

### 4.5.4.  REMOTE WITH LOCKOUT

The remote with lockout state can be entered from remote or local with lockout, but not directly from local. Remote with lockout is similar to the remote state but restricted: the <Escape> key will not return to the local state. To return the 5032 to the local with lockout state the controller must send a GTL interface command. To return the 5032 to the local state the controller must unassert the REN control line. Table 4-4 summarizes the possible Remote/Local state transitions.

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

**Table 4-4 : Remote/Local State Transitions**

## 4.6.    PROGRAMMING COMMAND SUMMARY

A brief description of each of the possible remote RS232 and IEEE-488 commands and their syntax in BNF (Backus Naur Form) follows:

- words inside angle brackets (i.e. <digit> ) are defined items
- :== means "is defined to be"
- {|} means "or"
- words inside square brackets (i.e. [+]) means optional
- Required letters are shown in upper case but may be upper or lower case

| | | |
|---|---|---|
| <d> | :== {0\|1\|2\|3\|4\|5\|6\|7\|8\|9} | |
| <l> | :== {A\|B\|C\|...\|Z\|a\|b\|c\|...\|z} | |
| <s> | :== {<l> \| <l><s>} | |
| <b> | :== {0\|1} | |
| <u> | :== {<d> \| <d><u>} | |
| <n> | :== [{+\|-}]<u> | |
| <f> | :== <n>[.[<u>]][E<n>] | |
| <?> | :== {<l> \| <d>} | |
| <*> | :== {<?> \| <?><*>} | (not to be confused with  *) |
| <DD> | :== <u> | (limited to range 1...31) |
| <MM> | :== <u> | (limited to range 1...12) |
| <YYYY> | :== <u> | (limited to ranges 0...38, 70..99 and 1970..2038) |
| <hh> | :== <u> | (limited to range 0...23) |
| <mm> | :== <u> | (limited to range 0...59) |
| <ss> | :== <u> | (limited to range 0...59) |

| COMMAND | COMMENT |
|---|---|
| *CLS | clear event status register, empty input queue |
| *ESE <u> | set event status enable |
| *ESE? | report event status enable |
| *ESR? | report event status register |
| *IDN? | report identity of unit |
| *OPC | set operation complete bit in event status register |
| *OPC? | report operation complete |
| *OPT? | report any reportable options |
| *RST | reset the instrument to a known defined state |
| *SRE <u> | set the service request mask |
| *SRE? | report service request mask |
| *STB? | report serial poll status byte |
| *TST? | report results of self test |
| *WAI | wait for pending operations to complete |
| CONFigure: | |
|   BOOSter? | report the Booster module status |
|   COOLing? | report the Cooling module status |
|   HEATer? | report the Heater power |
|   WINDow <f> | set the Window variable for temperature control |
|   WINDow? | report the Window variable for temperature control |
|   SETPoint <f> | setup the Setpoint |
|   SETPoint? | report the Setpoint |
|   SETUp <f>,<f>,<f>,<f>,<f>,<f>,<f>,<f> | set the variables for the temperature control algorithm |
|   SETUp? | report the variables for the temperature control algorithm |
| FETCh? {A\|B} | fetch most recent data value for the given channel |
| FETCh: | |
|   DIFFerence? | fetch the most recent difference data value |
|   HISTory? | fetch the history data |
| MEASure: | |
|   CALCulation <u> | select difference calculation mode |
|   CALCulation? | report difference calculation mode |
|   FILTer <b>,0,<u> | set the digital filter state, type and size |
|   FILTer? | report the filter setup |
|   HISTory <b>,<u>,<b> | set measurement history state, rate and mode |
|   HISTory? | report measurement history configuration |
|   HISTory: | |
|     CLEAr | clear measurement history buffer |
|   SENSor {A\|B},<u> | assign a thermistor (0…15) to the given input channel |
|   SENSor? {A\|B} | report the thermistor assigned to the given input channel |
|   TRENd {A\|B} | reset trend data for given channel |
|   TRENd? {A\|B} | report trend data for given channel |
|   UNIT {O\|C\|F\|K} | select the units of measurement |
|   UNIT? | report the units of measurement |

| COMMAND | COMMENT |
|---|---|
| SOFCAL: | |
|    CHANnel {A\|B},<u>,<f>,<f>,<f> | set linearization coefficients for given channel and range |
|    CHANnel? {A\|B},<u> | report linearization coefficients for given channel and range |
|    DATE <YYYY>,<MM>,<DD> | set date of calibration |
|    DATE? | report date of calibration |
|    SENSor <u>,… | program parameters for given thermistor |
|    SENSor? <u> | report given thermistor parameters |
| SYSTem: | |
|    COMMunicate: | |
|       GPIB <u>,<u> | setup GPIB communications to given address and mode |
|       GPIB? | report GPIB set up |
|       SERial <u>,<u>,<u>,<u>,<u>,<b>,<u> | setup RS232 communications to given baud rate, data bits, parity, stop bits, flow control, echo, and mode |
|       SERial? | report RS232 set up |
|    DATE <YYYY>,<MM>,<DD> | enter the current calendar date |
|    DATE? | report the current calendar date |
|    DIAGnostic: | |
|       ROMChecksum? | report ROM checksum |
|       SerialNUMber <u> | assign serial number |
|       SerialNUMber? | report unit serial number |
|       TEST? <u> | perform internal test of given type and report result |
|    KEY? | report last key pressed |
|    LOCAL | enter the local state (RS232 only) |
|    LOCKOUT | enter the local lockout state (RS232 only) |
|    REMOTE | enter the remote state (RS232 only) |
|    TERSe | respond to commands with a minimum data set |
|    TIME <hh>,<mm>,<ss> | enter the current time of day |
|    TIME? | report the current time of day |
|    VERBose | respond to commands with maximum data set |
|    VERSion? | report the installed software version |
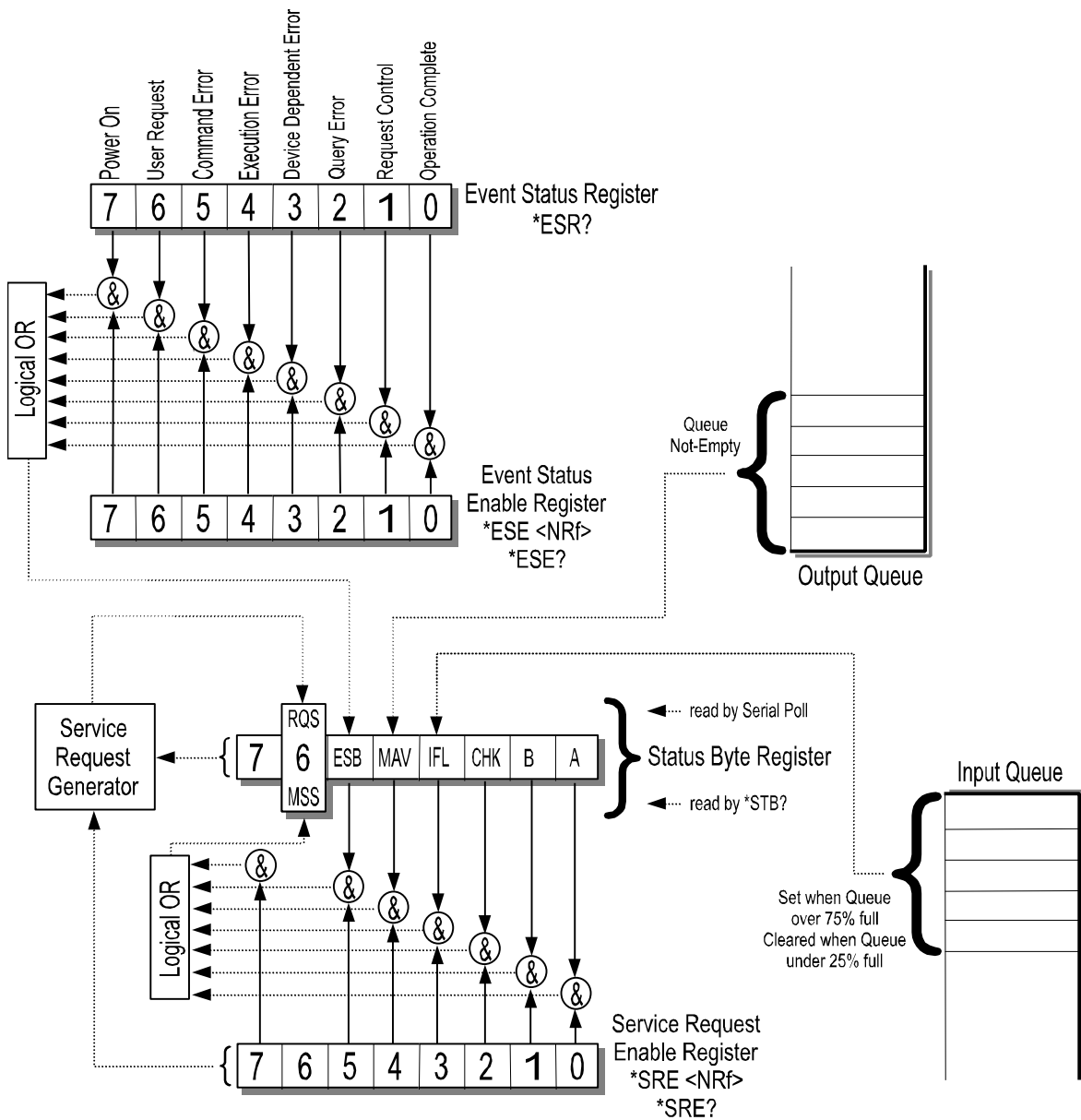
**Figure 4-1 : Event Status Bit Operation**

**4.7.    REMOTE COMMANDS**

This section details all the valid commands which may be sent over either the IEEE-488 or the RS-232C interface port. The responses listed below are the verbose response.

If the numeric parameter to the command is missing or unrecognizable the CME (CoMmand Error) bit in the Event Status Register (see Table 4-5) will be set. If the unrecognizable command was sent over the RS-232C interface, the 5032 will respond with "Unrecognized Command".

If the numeric value is out of range then the EXE (EXecution Error) bit will be set for a program data element out of range error. If the out of range value was sent over the RS-232C interface, the 5032 will respond with "Invalid Parameter".

Unless otherwise indicated, the terse response is that portion of the response printed in bold.

### 4.7.1.  *CLS - CLEAR STATUS COMMAND
This command clears all Event Status Registers summarized in the status byte register. All queues, except the Output Queue, that are summarized in the status byte register are emptied. The 5032 is forced into the Operation Complete Idle State and the Operation Complete Query Idle state.

### 4.7.2.  *ESE <u> - SET EVENT STATUS ENABLE REGISTER
This command sets the standard event status enable register bits. When the bits in the Event Status Enable (ESE) register are "ANDed" with the bits in the Event Status Register (ESR) if the result is non-zero then the Event Status Bit (ESB) in the Status Byte (STB) register is set.

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

### 4.7.3.  *ESE? - EVENT STATUS ENABLE QUERY
This command reports the current value of the Event Status Enable Register. The value returned will be between 0 and 255.

### 4.7.4.  *ESR? - EVENT STATUS REGISTER QUERY
This query allows the programmer to determine the current contents of the event status register. Reading the Event Status Register clears it.

| Bit Location | | Name | Description |
|---|---|---|---|
| 0 | LSB | OPC | OPeration Complete. This event bit is generated in response to the *OPC or *OPC? command. It indicates that the 5032 has completed any pending operations and that the parser is ready to accept more program messages. |
| 1 | | RQC | ReQuest Control. This event bit indicates to the GPIB controller that the 5032 is requesting permission to become the controller in charge. The 5032 will never set this bit. |
| 2 | | QYE | QuerY Error. This bit indicates that an attempt is being made to read data from the output queue when no output is either present or pending, or that data in the output queue has been lost (queue over-flow). See also GPIB Deadlock. |
| 3 | | DDE | Device Dependent Error. Not Used. |
| 4 | | EXE | EXecution Error. Set when (1)a program data element is evaluated to be outside the legal input range or is inconsistent with the 5032's capabilities, (2)a valid program message could not be properly processed. |
| 5 | | CME | CoMmand Error. Set when (l)a syntax error has been detected by the parser, (2)a semantic error has occurred indicating that an unrecognized header has been received, (3)A Group Execute Trigger was entered into the input buffer inside a program message. |
| 6 | | URG | User Request. Set when any key is depressed on the 5032 keyboard. |
| 7 | MSB | PON | Power ON. This bit is set after the 5032 is powered up. |

**Table 4-5 : Event Status Register**

### 4.7.5. *IDN? - IDENTIFICATION QUERY

This command causes the 5032 to reply with an identification string. The identification string is built up of four (4) fields delimited by commas (,). The first field is the manufacturer (i.e. Guildline Instruments), the second field is the model (i.e. 5032), the third field is the serial number (i.e. 55065), and the final field is the firmware revision (i.e. E). A typical response might read:

**Guildline Instruments, 5032, 55065, E**

### 4.7.6. *OPC - OPERATION COMPLETE

This command will cause the 5032 to set the Operation Complete bit (bit 0) in the Event Status Register. Since the 5032 processes all commands sequentially, the operation complete bit will be set as soon as the command is parsed.

### 4.7.7. *OPC? - OPERATION COMPLETE QUERY

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

### 4.7.8. *OPT? - REPORT AVAILABLE OPTIONS

This query command reports the presence or absence of various options. The format of the reply is a series of arbitrary ASCII response fields separated by commas. The 5032 will always report the value 0.

### 4.7.9. *RST - DEVICE RESET

This command is intended to return the 5032 to a known state, specifically a return to terse mode. This command will not affect the following:

1. The output queue.
2. The state of the IEEE-488 interface.
3. The selected address of the 5032.
4. The *SRE setting.
5. The *ESE setting.
6. Calibration data that affects device specifications.

The *RST command will perform the following actions:
Clear the key-press buffer.
Make remote responses terse.
Set the measurement units to degrees Celsius.
Set the measurement display to the Aux Channel.

*RST is a MANDATORY IEEE-488.2 command.

### 4.7.10. *SRE <u> - SERVICE REQUEST ENABLE COMMAND

The service request enable command allows the 5032 to generate a service request on the IEEE-488 interface under a limited set of conditions. The limitations on the conditions are defined by the numeric parameter following the *SRE command. The numeric parameter is a decimal integer in the range 0-255. The numeric parameter when expressed in base 2 (binary) represents the bit values of the Service Request Enable Register. For all bits (except bit 6) a bit value of one (1) indicates an enabled condition and a bit value of zero (0) represents a disabled condition. *SRE? Is the companion query command.

### 4.7.11. *SRE? - SERVICE REQUEST ENABLE QUERY

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

### 4.7.12. *STB? - STATUS BYTE QUERY

This command allows the programmer to read the status byte and master summary bits (shown in Table 4-6).

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

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

This Register can be read by Serial Poll or by the *STB? command.

### 4.7.13. *TST? - QUERY RESULTS OF SELF TEST

This command is intended to report the status of any self-tests performed by the 5032. If the 5032 passes all of its self-tests then the reply will be 0.
The possible failure codes are the sum of:

1   Non-volatile memory failure
2   ROM checksum failure
4   Power supply failure

### 4.7.14. *WAI - WAIT-TO- CONTINUE COMMAND

This command is intended to suspend the execution of any further commands until all pending operations have been completed. Since the 5032 does not implement a new command until the last operation has been completed, this command has no effect. It is included in the list of remote commands because it is a mandatory IEEEE-488.2 command.

| LOCATION | | NAME | DESCRIPTION |
|---|---|---|---|
| 0 | LSB | A | Set when the Ctl Channel measurement is completed. Cleared by the "FETCH? A" query. |
| 1 | | B | Set when the Aux Channel measurement is completed. Cleared by the "FETCH? B" query. |
| 2 | | CHK | CHecKsum computation complete. This bit is set once, after instrument power on and the completion of the computation of the ROM checksum is cleared by the :SYST:DIAG:ROMC?" query . |
| 3 | | IFL | Input FuLl. This bit is set when the input queue is over 75% full and cleared when the queue drops below 25% full. |
| 4 | | MAV | Message AVailable. This bit is set when the output queue is not empty. |
| 5 | | ESB | Event Summary Bit. This bit is set when the result of a bitwise AND of the Event Status Enable register is not zero. |
| 6 | | RQS | ReQuest for Service. This bit is set when the result of a bit-wise AND of the Status Byte Register and the Service Request Enable register is not zero. |
| 7 | MSB | unused | Always zero. |

**Table 4-6 : Status Byte Register**

### 4.7.15. CONFigure: - SET OPERATING CONFIGURATION

This command allows a system programmer to configure the operating parameters for the instrument. The form of the configure command sequences are as follows:

    CONFigure: BOOSter?
        display the booster heater status
    CONFigure: COOLing?
        display the cooling module status
    CONFigure: HEATer?
        display the heater power
    CONFigure:WINDow <window>
        setup the control window (<window>:== <f>)
    CONFigure: WINDow?
        display the control window setup
    CONFigure:SETPoint <setpoint>
        setup the temperature setpoint (<setpoint>:== <f>)
    CONFigure: SETPoint?
        display the temperature setpoint
    CONFigure:SETUp <thr>, <kp>, <ki>, <Coff>, <Con>, <delay>, <Bon>, <Boff>
        set the temperature control operating parameters (<thr>:== <f>; <kp>:== <f>; <ki>:== <f>; <Coff>:== <f>; <Con>:== <f>; <delay>:== <f>; <Bon>:== <f>; <Boff>:== <f>)
    CONFigure: SETUp?
        display temperature control operating parameters

### 4.7.15.1.   CONFigure:BOOSter?

This query command requests the current booster heater status used for the temperature control.  The response from the 5032 will be:

Booster Power **100.000** %

### 4.7.15.2.   CONFigure:COOLing?

This query command requests the current cooling module status used for the temperature control.  The response from the 5032 will be:

Cooling **1**

### 4.7.15.3.   CONFigure:HEATer?

This query command requests the current heater power used for the temperature control.  The response from the 5032 will be:

Heater Power **39.499** %

### 4.7.15.4.   CONFigure:WINDow <window>

The window command sets the window for the temperature control algorithm.

<window>:== <f>          This parameter sets the Window variable for the temperature control algorithm. The valid range is from 0.000 to 1.000.

### 4.7.15.5.   CONFigure:WINDow?

This query command requests the current window used for the temperature control. The response from the 5032 will be:

Window **0.006**

### 4.7.15.6.   CONFigure:SETPoint <setpoint>

The setpoint command allows you to enter the desired temperature setpoint for the air bath.  The set point is entered in the currently displayed units.

<setpoint>:== <f>          This parameter will allow setting of the temperature set point.  The valid range is from 15.000 to 50.000.

### 4.7.15.7.   CONFigure:SETPoint?

This query command requests the current set point used for the air bath. The response from the 5032 will be:

Setpoint **23.000** C

**4.7.15.8. CONFigure:SETUp <thr>,<kp>,<ki>,<Coff>,<Con>,<delay>,<Bon>,<Boff >**
This command sets up the operating configuration for the temperature control algorithm of the 5032.

| | |
|---|---|
| <thr>:== <f> | This parameter sets the Threshold variable for the temperature control algorithm. The valid range is from 15.000 to 50.000. |
| <kp>:== <f> | This parameter sets the Kp variable for the temperature control algorithm. The valid range is from 0.000 to 100.000. |
| <ki>:== <f> | This parameter sets the Ki variable for the temperature control algorithm. The valid range is from 0.000 to 0.100. |
| <Coff>:== <f> | This parameter sets the Cooling Off variable for the temperature control algorithm. The valid range is from 0.050 to 35.000. |
| <Con>:== <f> | This parameter sets the Cooling On variable for the temperature control algorithm. The valid range is from 0.000 to 35.000. |
| <delay>:== <f> | This parameter sets the Heat Delay variable for the temperature control algorithm. The valid range is from 0.000 to 50.000. |
| <Bon>:== <f> | This parameter sets the Booster On variable for the temperature control algorithm. The valid range is from 0.250 to 35.000. |
| <Boff>:== <f> | This parameter sets the Booster Off variable for the temperature control algorithm. The valid range is from 0.200 to 35.000. |

**4.7.15.9. CONFigure:SETUp?**
This query command requests the current operating configuration for the temperature control algorithm. The response from the 5032 will be:

Setup **50.000, 10.000, 0.010, 0.050, 0.000, 0.100, 0.250, 0.200**

**4.7.16. FETCh - MEASUREMENT DATA QUERY**
This query command retrieves the measurement data. The form of the fetch command sequences are as follows:

FETCh? <channel>
    display data value for the requested channel (<channel >:== {A|B})
FETCh:DIFFerence?
    display the value of the selected difference calculation

FETCh:HISTory?

    display the block of saved data for the current history channel

### 4.7.16.1.   FETCh? <channel>

This query command requests from the 5032 the most recent data value. The response is in the displayed units.

    <channel>:== {A|B}    This parameter selects the thermistor input channel measurement to be displayed.

The 5032 response will be:

    Channel A temperature **24.006** deg. C

Or

    Channel A resistance **109.2836** ohms

### 4.7.16.2.   FETCh:DIFFerence?

This query command responds with the value which would be displayed in the "Measurement Difference" window of the VF display. The response to this query command is:

    DDD: **xxx.xxx** U

| DDD is one of: | |
|---|---|
| | Ctl |
| | Aux |
| | Aux – Ctl |
| | Ctl - Setpoint |
| . | Difference value |

| U is one of: | |
|---|---|
| | deg. C |
| | deg. F |
| | ohms |
| | K |

### 4.7.16.3.   FETCh:HISTory?

The response to this query command is a block of data of a maximum of 499 pairs of saved data. The verbose format of the response is:

Date/Time Wed Feb 01 10:45:11 1995, Ctl Ch aaaaaaaaaaa, Aux Ch bbbbbbbbbbb, Sample Off, Interval 1, Sample Mode Continuous, Units C, Readings 499; xxx.xxx, yyy.yyy;...; xxx.xxx, yyy.yyy

| Date/Time : | time of the last sample in the list |
|---|---|
| aaaaaaaaaaa: | serial number of the thermistor assigned to the Ctl Channel |

| | |
|---|---|
| bbbbbbbbbb: | serial number of the thermistor assigned to the Aux Channel |
| Sample: | 0 = Off; 1 = On |
| Interval: | 1 to 2000 |
| Sample Mode: | 0 = Continuous; 1 = Single sweep |
| Units: | C\|F\|O\|K |
| Readings: | number of data pairs to follow |
| xxx.xxx: | Ctl Channel value in units indicated |
| yyy.yyy: | Aux Channel value in units indicated |

The terse format of the above response is:

Wed Feb 01 10:45:11 1995, "aaaaaaaaaaa", "bbbbbbbbbb", 0, 1, 0, C, 499; xxx.xxx, yyy.yyy;...; xxx.xxx, yyy.yyy

## 4.7.17. MEASure - SET/DISPLAY THE MEASUREMENT PARAMETERS

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

MEASure:CALCulation <mode>
    select difference calculation mode (<mode>:== {0|1|2|3})
MEASure:CALCulation?
    display the difference calculation mode
MEASure:FILTer <state>,<function>,<size>
    setup the digital filter and select a filter size for the Aux Channel data (<state>:== {0|1}; <function>:== 0; <size>:== {3|4|…|50})
MEASure:FILTer?
    display the filter setup
MEASure:HISTory <state>,<rate>,<mode>
    set measurement history configuration (<state>:== {0|1}; <rate>:== {1|2|…|2000}; <mode>:== {0|1})
MEASure:HISTory?
    display the measurement history configuration
MEASure:HISTory:CLEAr
    clear measurement history buffer
MEASure:SENSor <channel>,<sensor>
    assign an input (<channel>:== {A|B}) to a thermistor number (<sensor>:== {0|1|…|15}
MEASure:SENSor? <channel>
    display the thermistor number assigned to the input (<channel>:== {A|B})
MEASure:TRENd <channel>
    reset trend data (<channel>:== {A|B})

MEASure:TRENd? <channel>
> display the trend data (<channel>:== {A|B})

MEASure:UNIT <unit>
> select the units of measurement and instrument operation
> (<unit>:== {O|C|F|K})

MEASure:UNIT?
> display the units of measurement

### 4.7.17.1.   MEASure:CALCulation <mode>

This command selects the difference calculation to be one of:

> 0   current Control Channel value
> 1   current Auxiliary Channel value
> 2   current Auxiliary Channel value minus current Control Channel value
> 3   current Control Channel value minus Setpoint value

### 4.7.17.2.   MEASure:CALCulation?

This query command responds with the difference calculation mode. The verbose response is:

> Difference Mode DDD

Where DDD is one of:

> Ctl
> Aux
> Aux – Ctl
> Ctl - Setpoint

The terse response is the number described above.

### 4.7.17.3.   MEASure:FILTer <state>,<function>,<size>

This command turns on the digital filter algorithm used in the 5032. A simple moving average (<function> = 0) digital filter is selected by this command. The digital filter calculates the average of the last N readings where N is the value, between 3 and 50, assigned to <size>. To turn the filter function off, <state> should be set to 0. This function operates on both input data channels.

### 4.7.17.4.   MEASure:FILTer?

This query command requests the value of the currently selected filter factor.

The response from the 5032 will be:

Filter **1,0,25**

Indicating that the filter is ON (1), and 25 readings are the assigned number of samples to be used by the simple average filter algorithm.

### 4.7.17.5.  MEASure:HISTory <state>,<rate>,<mode>

This command sets the following parameters for the storing of measurement data:

| | | |
|---|---|---|
| <state> | :== 0 | OFF (storage suspended) |
| | :== 1 | ON (storage enabled) |
| <rate> | :== <u> | the number of measurement samples averaged together and stored as one value (1 to 2000) |
| <mode> | :== 0 | Continuous (oldest data is overwritten by new data) |
| | :== 1 | Single sweep (storage stops when buffer full) |

### 4.7.17.6.  MEASure:HISTory?

This query command responds with the configuration of the history function. The verbose response is:

Sample Off, Interval 50, Sample Mode Continuous

The equivalent terse response is:

**0, 50, 0**

### 4.7.17.7.  MEASure:HISTory:CLEAr

This command clears the stored measurement data from the history buffer.

### 4.7.17.8.  MEASure:SENsor <channel>,<sensor>

This command controls the assignment of a thermistor and its associated coefficients to an input channel of the 5032.

| | | |
|---|---|---|
| <channel> | :== {A|B} | This parameter assigns the associated 5032 thermistor input channel. |
| <sensor> | :== {0|1|…|15} | This parameter selects the thermistor number assigned from the SOFCAL:SENSor setup procedure. Coefficients for up to sixteen thermistors can be saved in the non-volatile memory of the 5032. The selected thermistor number can be one of 0 through 15. |

This command is valid only when in the REMOTE state.

### 4.7.17.9.   MEASure:SENsor? <channel>

This query command requests the current assignment of a thermistor number to an input channel of the 5032.

<channel> :== {A|B}        This parameter assigns the associated 5032 thermistor input channel.

The response from the 5032 will be:

Aux Channel thermistor **3**

Indicating that thermistor data set #3 is assigned to input Aux Channel.

### 4.7.17.10.  MEASure:TRENd <channel>

This command sets the trend data for the specified channel to the following:

Min        last displayed value
Max        last displayed value
Range      0
Std Dev    0
Drift      0

### 4.7.17.11.  MEASure:TRENd? <channel>

This query command responds with the trend data for the specified channel. The response is:

Channel A**,** Mode **C,** Min **24.107,** Max **24.218,** Spread **0.111,** Std **0.013,** Drift **0.001**

Indicating that this is the trend data for the Control Channel, displayed in degrees Celsius. The data are listed in order:

minimum value since last reset
maximum value since last reset
spread between maximum and minimum values
standard deviation of last n samples
rate of change (units/second) of last n samples (n is the filter sample size)

### 4.7.17.12.  MEASure:UNIT <unit>

This command selects the engineering units of measure to be used for all calculations performed by the 5032. The accepted units of temperature are C|CEL for degrees Celsius; F|FAR for degrees Fahrenheit; K|KEL for kelvins. For direct reading in ohms, the accepted command is O|OHM.

The units set by this command act globally and can be set once in any instrument setup operation.

The selected unit of operation for the 5032 is saved in non-volatile memory.

### 4.7.17.13. MEASure:UNIT?

This query command requests a report of the current setting of the engineering units of measure used for all calculations performed by the 5032. The response from the 5032 will be:

Units **CEL**

Indicating that CELSIUS degrees are the assigned units of measure.

### 4.7.18. SOFCAL - SET 5032 CALIBRATION COEFFICIENTS

This series of commands allow a system programmer to set the operating calibration coefficients for the instrument.

## WARNING

*Great care should be taken when using this command since the 5032 cannot check that the values of the parameters are correct.*

The form of the SOFCAL command sequences are as follows:

SOFCAL:CHANnel<channel>,<C0>,<C1>,<C2>
      set linearization coefficients (<channel>:== {A|B}; <C0>:== <f>; <C1>:== <f>; <C2>:== <f>)
SOFCAL:CHANnel?<channel>
      query linearization coefficients (<channel>:== {A|B})
SOFCAL:DATE <YYYY>,<MM>,<DD>
      set date of calibration
SOFCAL:DATE?
      display date of calibration
SOFCAL:SENSor<sensor>,<argument>
      program sensor parameters (<sensor>:== {0|1|...|15}; <argument> see below)
SOFCAL:SENSor?<sensor>
      query sensor parameters (<sensor>:== {0|1|...|15}

#### 4.7.18.1.   SOFCAL:CHANnel<channel>,<C0>,<C1>,<C2>

This command allows remote entry of the calibration coefficients for the two 5032 input channels A and B. When using this command the entries are as follows:

| | | |
|---|---|---|
| <channel> :== {A\|B} | | This parameter assigns the associated 5032 thermistor input channel. |
| <C0> | :== <f> | linearization coefficient 0 |
| <C1> | :== <f> | linearization coefficient 1 |
| <C2> | :== <f> | linearization coefficient 2 |

#### 4.7.18.2.   SOFCAL:CHANnel? <channel>

The SOFCAL query command allows the programmer to review the current values stored for instrument calibration of the selected thermistor input channel.
      <channel> :== {A|B}      as above

The 5032 response will be:

Channel A coefficients: **0.000, 9.83000E-04, 0.000**

### 4.7.18.3.   SOFCAL:DATE <YYYY>,<MM>,<DD>

This command is used to set the date of calibration of the 5032.

| | | |
|---|---|---|
| <DD> | :== <u> | day of month (limited to range 1...31) |
| <MM> | :== <u> | month of year (limited to range 1...12) |
| <YYYY> | :== <u> | year (limited to ranges 00…38, 70...99 and 1970...2038) |

The range limits of the date of calibration are January 1, 1970 to January 19, 2038.

### 4.7.18.4.   SOFCAL:DATE?

This query command requests the date of calibration of the 5032. The response will be:

Calibration date **1999,04,30**

### 4.7.18.5.   SOFCAL:SENSor <sensor>,"s", S, a, b...

This SOFCAL command programs one of the 16 saved sensor configurations. The symbols for the argument passed are defined as follows:

| | | |
|---|---|---|
| <sensor> | :== <u> | thermistor number (0 through 15) |
| s | :== <string> | thermistor serial number (max 11 characters) |
| S | :== {0\|1\|2\|3\|4} | temperature scale, defined as: |
| | | 4        Thermistor |
| a, b… | :== <f> | calibration coefficients, where the order and number of the coefficients depends on the temperature scale as follows: |
| | | Thermistor     A, B, C |

### 4.7.18.6.   SOFCAL:SENSor? <sensor>

This query command requests the current configuration settings for the thermistor associated with the data set <sensor>.

| | | |
|---|---|---|
| <sensor>:== <u> | | thermistor number (0 through 15) |

The verbose response is:

Thermistor n, SN "s", <S> Coefficients a, b, c

The terse response is:

n, "s", S, a, b, c

Where:

n    thermistor number (1 through 16)
s    thermistor serial number
S    temperature scale description as listed above

## 4.7.19. SYSTem: - SET THE 5032 OPERATING PARAMETERS

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

SYSTem:COMMunicate:GPIB <address>,<mode>
    setup GPIB communications (<address>:== {1|2|…|30}; <mode>:== {0|1|2})
SYSTem:COMMunicate:GPIB?
    display the GPIB set up
SYSTem:COMMunicate:SERial <bd>,<dt>,<pr>,<st>,<pc>,<ch>,<md>
    setup RS232 communications to the following:
        <bd>:== <u>        baud rate
        <dt>:== {7|8}        data bits
        <pr>:== {0|1|2}        parity
        <st>:== {1|2}        stop bits
        <pc>:== {0|1|2}        flow control
        <ch> :== <b>        echo
        <md>:== {0|1|2}        mode
SYSTem:COMMunicate:SERial?
    display RS232 set up
SYSTem:DATE <YYYY>,<MM>,<DD>
    set the current date
SYSTem:DATE?
    display the current date
SYSTem:DIAGnostic:ROMChecksum?
    display ROM checksum
SYSTem:DIAGnostic:SerialNUMber <number>
    assign unit serial number
SYSTem:DIAGnostic:SerialNUMber?
    display unit serial number
SYSTem:DIAGnostic:TEST? <number>
    perform internal test and report result
SYSTem:KEY?
    query last key pressed
SYSTem:LOCAL
    enter the local state (RS232 command only)
SYSTem:LOCKOUT
    enter the local lockout state (RS232 command only)
SYSTem:REMOTE
    enter the remote state (RS232 command only)
SYSTem:TERSe
    respond to commands with a minimum data set

SYSTem:TIME <hh>,<mm>,<ss>
    set the current time
SYSTem:TIME?
    display the current time
SYSTem:VERBose
    respond to commands with a  maximum data set
SYSTem:VERSion?
    display the installed software version

### 4.7.19.1.   SYSTem:COMMunicate:GPIB <address>,<mode>

This command sets the operating address and mode of operation of the IEEE-488 communication interface.

| | |
|---|---|
| <address>:== <u> | this parameter assigns the bus address and can take on any value in the range 1 to 30. |
| <mode>:== {0\|1\|2} | this parameter sets the mode of operation of the communication interface to one of: |

        0     disable the IEEE-488 interface
        1     enables TALK ONLY operation
        2     enable TALK/LISTEN capabilities

This command does not become effective until the 5032 has been initialized by a power on reset.

### 4.7.19.2.   SYSTem:COMMunicate:GPIB?

This query command requests the setting of the IEEE-488 communication port of the 5032. The IEEE-488 address and mode setting are returned in response to this query. The response will be:

    GPIB **8, 1**

Indicating that the communication bus address is set to 08 and the mode of operation is TALK ONLY.

### 4.7.19.3.   SYSTem:COMMunicate:SERial<bd>,<dt>,<pr>,<st>,<pc>,<ch>,<md>

This command configures the RS232 serial communication interface of the 5032.

| | |
|---|---|
| <bd>:== <u> | this parameter allows setting of the communication data rate. Valid baud rates in the range 75 to 38400 are permitted. |
| <dt>:== {7\|8} | this parameter sets the number of data bits in the data word. |

| | | |
|---|---|---|
| &lt;pr&gt;:== {0\|1\|2} | this parameter sets the operation of the parity bit to one of: | |
| | 0 | NO parity |
| | 1 | ODD parity |
| | 2 | EVEN parity |
| &lt;st&gt;:== {1\|2} | this parameter sets the number of stop bits in the data word. | |
| &lt;pc&gt;:== {0\|1\|2} | this parameter sets the mode of pacing the data transmit and receive functions to one of: | |
| | 0 | no handshake |
| | 1 | XON/XOFF handshaking |
| | 2 | RTS/CTS hardware handshaking |
| &lt;echo&gt;:== {0\|1} | this parameter controls echo responses from the 5032. | |
| &lt;mode&gt;:== {0\|1\|2} | this parameter sets the mode of operation of the RS232 communication interface to one of: | |
| | 0 | disable the RS232 interface |
| | 1 | enables TALK ONLY operation |
| | 2 | enable TALK/LISTEN operation |

### 4.7.19.4.   SYSTem:COMMunicate:SERial?

This query command requests the setup of the serial RS232 communication interface of the 5032.

The verbose response from the 5032 will be:

```
RS232 Baud   19600,
       Bits    8,
       Parity  0,
       Stop    1,
       Pace    1,
       Echo    0,
       Mode    1
```

The terse response from the 5032 will be:
    19600,8,0,1,1,0,1

### 4.7.19.5.  SYSTem:DATE <YYYY>,<MM>,<DD>
This command is used to set the current run-time date of the 5032.

| | |
|---|---|
| <DD>:== <u> | day of month (limited to range 1...31) |
| <MM>:== <u> | month of year (limited to range 1...12) |
| <YYYY>:== <u> | year (limited to ranges 00…38, 70...99 and 1970...2038) |

 The range limits of the date are January 1, 1970 to January 19, 2038.

### 4.7.19.6.  SYSTem:DATE?
This query command requests the date of calibration of the 5032. The response will be:

Date **1999, 04, 30**

### 4.7.19.7.  SYSTem:DIAGnostic:ROMChecksum?
This query command requests the checksum of the installed instrument read only memory. Since the checksum algorithm is quite involved, the 5032 microprocessor will compute the checksum in its "spare" time. Depending on bus activity, it can take up to 30 seconds to receive a response from this command.

In order to determine if the computation of the checksum is complete the programmer must wait for the CHK bit in the STATUS BYTE register to be set to one (1). It should be noted that the CHK bit will only be set once after the 5032 is powered on; hence simply waiting for the CHK bit to become set may not always work if the ROM checksum has been previously read. The response will be:

ROM checksum **72304**

### 4.7.19.8.  SYSTem:DIAGnostic:SerialNUMber <number>
This command accepts an integer in the range 0 to 1 000 000, this number will be reported in the serial number field of the *IDN? command.

### 4.7.19.9.  SYSTem:DIAGnostic:SerialNUMber?
This query command requests the unit serial number. This is the same number as is reported in the serial number field of the *IDN? command. The 5032 will respond:

Instrument Serial Number **12345**

### 4.7.19.10.  SYSTem:DIAGnostic:TEST? <number>

This command will perform the requested internal self-test and report 0 if the test was a success (test result is within allowable limits). A non zero result determines the source of the failure.

    <number>:== 0        memory test
        The memory test results are the sum of:
0     Pass
1     U202 ROM checksum failure
2     U203 ROM checksum failure
4     U201 NVRAM checksum failure

### 4.7.19.11.  SYSTem:KEY?

This query command will report the value of the key most recently pressed on the front panel keyboard. In terse mode the response will be one of:

    0, 1, 2, 3, 4, 5, 6, 7, 8, 9, ., -, A, B, C, D, t, u, v, w,?

Where ? indicates that no keys have been pressed since the 5032 was last reset. The verbose mode reply will be preceded with "KEY". The meanings of the various key characters are shown in Table 5-7.

| Character | Key Name |
| --- | --- |
| 0 - 9 | Numeric digits |
| . | Decimal point |
| - | Negative sign |
| t | ↓ Down arrow |
| u | ↑ Up arrow |
| v | Escape |
| w | Enter |

**Table 4-7 : Keyboard Character Names**

### 4.7.19.12.  SYSTem:LOCAL

This command will place the 5032 into the local state. This command duplicates the IEEE-488 GTL message (See section 4.5). This command can only be sent from an RS-232C controller. There are no parameters for the LOCAL command.

### 4.7.19.13.  SYSTem:LOCKOUT

This command will place the 5032 into the local lockout state. This command duplicates the IEEE-488 LLO message (See section 4.5). This command can only be sent from an RS-232C controller. There are no parameters for the LOCKOUT command.

### 4.7.19.14. SYSTem:REMOTE

This command will place the 5032 into the remote state. This command duplicates the IEEE-488 REN message (See section 4.5). This command can only be sent from an RS-232C controller. There are no parameters for the REMOTE command.

### 4.7.19.15. SYSTem:TERSe

This is the default mode for the 5032 after reset. Typically query commands will return very little extraneous information in terse mode. There are no parameters for the TERSE command.

### 4.7.19.16. SYSTem:TIME <hh>,<mm>,<ss>

This command is used to set the current run-time of the 5032.

| | |
|---|---|
| <hh>:== <u> | hour of day (limited to range 0...23) |
| <mm>:== <u> | minute of hour(limited to range 0...59) |
| <ss>:== <u> | second of minute (limited to range 0…59) |

### 4.7.19.17. SYSTem:TIME?

This query command requests the time of the 5032. The response will be:

Time **18,27,06**

### 4.7.19.18. SYSTem:VERBose

The verbose command causes the output of all subsequent commands to contain additional information. This mode should be used for determining problems with programs and when the instrument is being used interactively. There are no parameters for the VERBOSE command.

### 4.7.19.19. SYSTem:VERSion?

This query command requests the instrument software version. This command can be used instead of the *IDN? command to report only the software version. The response from the 5032 might be:

**E**

# 5.  MAINTENANCE

## 5.1.  PREVENTIVE MAINTENANCE

### 5.1.1.  CLEANING
The instrument requires very little maintenance other than periodic dusting of the outside and inside of the enclosure. Remove accumulated dust from the air filter on the rear door.

### 5.1.2.  TEMPERATURE CHECK
Insert a thermometer in through the side access hole, place it at the same location as the auxiliary channel thermometer and make a direct measurement of the air temperature within the chamber. Compare this temperature to the selected temperature set point and the auxiliary channel temperature as indicated on the front panel display. Although the auxiliary thermometer is normally mounted on a clip at the rear of the air bath chamber, the best location for comparison to the set point temperature is at the center of the bath.

Care should be exercised to ensure that the thermometer probe being used, other than the one supplied, has a low self heating effect in air otherwise false temperatures will be measured.

## 5.2.  CORRECTIVE MAINTENANCE
Symptoms appear at the beginning of each of the following paragraphs as a guide to detailed fault location. Refer to section 6 of this manual for the THEORY OF OPERATION.

### 5.2.1.  PRELIMINARY CHECKS
Check POWER – The graphical display should be displaying information when the instrument is connected to the AC line and the POWER switch is set to "ON". If not, check that the circulation fans inside at the rear of the air bath chamber are running. If they are not, then a general loss of power is indicated. Check the line input fuse at the rear.

Note that the 5032 has an auto-reset over-temperature cut-off switch inside the heating-cooling control space at the back of the chamber. If the 5032 does not power up this cut-off switch may have tripped or it may be defective. The switch is accessible by removing the back panel of the chamber.

Check the HEATER indicator - It should indicate the cycling on and off of the heater.

### 5.2.2.  TEMPERATURE CONTROL
If the temperature remains too low and the HEATER indicator is lit, check the continuity and resistance of the heater circuit.

### 5.2.3.  OVER-TEMPERATURE

If the temperature within the chamber significantly exceeds 52 °C nominal, then the thermal breaker will trip and shut down the entire 5032. Allow the enclosure to cool to less than 50 °C. The over-temperature cut-off switch will reset automatically once the chamber temperature has cooled down sufficiently. After the 5032 is switched on again, if the HEATER indicator does not indicate heater cycling when the temperature approaches the set point, then check the operation of the control circuit.

### 5.2.4.  HEATER LAMPS

Poor temperature stability may be the result of one of the two heater lamps being defective. For optimal reliability, both lamps should be replaced at the same time. Use identical lamps of the same 50 watt rating. The operation of the two lamps may be observed from the front of the chamber by looking into the air outlet holes at the bottom of the chamber. You should see light on both sides at the back of the space at the underside of the bottom plate.

## 5.3.    CALIBRATION

The procedure outlined here is intended to calibrate the 5032 Air bath resistance scale as well as the temperature scale for the Control and Auxiliary thermistor probes.

### 5.3.1.  RESISTANCE CALIBRATION

Calibrate the resistance scale by measuring reference resistors and aligning the 5032 A/D output to these resistance values through firmware calibration coefficients.

1)    Connect probe simulators into the PROBE port on the rear of the Programmable Temperature Controller module. A four wire connection is required. Set both Control and Auxiliary simulators to 2250 Ω.

2)    Toggle the 5032 POWER switch to ON.

3)    Set AUX FILTER to ON and SAMPLE SIZE to 20:

  a)    From the Main Menu, **Select** "Display Setup".
  b)    From the Display Mode menu, **Select** "Aux Filter" to toggle the filter to ON.
  c)    From the Display Mode menu, **Edit** "Sample Size" to a value of 20.

NOTE: Before performing any calibration, the 5032 must have been operating for a minimum of 30 minutes.

4)      Perform the resistance calibration process:

a)      From the Main Menu, **Select** "Calibration".
b)      From the Calibration menu, **Select** "Ctl Channel Set Ohms".
c)      From the Set Ctl Ohms menu, **Select** "Low".
d)      **Edit** "Test Ohms" to the actual resistance value for the probe simulator setting.
e)      When satisfied that the 5032 is making a stable measurement of the Low Ohms resistor, press **<Escape>**. (The measurement process will take one minute.)
f)      Once the Set Ctl Ohms menu is being displayed again, set the decade resistance box to 4500 Ω and wait for the measurement to stabilise.
g)      From the Set Ctl Ohms menu, **Select** "Med", **Edit** "Test Ohms" to the actual resistance value for the probe simulator setting, and press **<Escape>**.
h)      Repeat steps f and g with the probe simulator set to 6750 Ω and "High" selected.
i)      **Exit** from the Set Ctl Ohms menu. Enter the password "5032".

NOTE: The above resistance values are nominal values for each calibration point; however the actual resistance value must be known and entered to an accuracy of **3 ppm**.

5)      Repeat the above resistance calibration for Aux Channel.

6)      Record the calibration coefficients that have been automatically saved by this calibration procedure:

a)      From the Main Menu, **Select** "Calibration".
b)      From the Calibration menu, **Select** "Ctl Channel Set Coef".
c)      Record the calibration coefficients that are displayed.
d)      Press **<Escape>** to return to the Calibration menu.
e)      Repeat the above for Aux Channel.

## 5.3.2. AUXILIARY PROBE TEMPERATURE CALIBRATION

Calibrate the Auxiliary Temperature scale by comparison to a reference thermometer and fitting resistance versus temperature data to the Hart-Steinhart equation. This procedure requires the use of the fluid bath. The fluid bath must be preheated to 18 ℃ and allowed to stabilise at this temperature. The temperature of the bath must be monitored using the resistance ratio bridge with a primary standard PRT. Before performing any calibration, the 5032 must have been operating for a minimum of 30 minutes.

1) Connect the thermistor probe and the control thermistor to the probe input. Toggle the 5032 POWER switch to ON.

2) Prepare the constant temperature fluid bath to regulate at 18 °C.

3) Set the 5032 display to AUXILIARY channel, UNITS to OHMS, AUX FILTER to ON and SAMPLE SIZE to 20:

   a) From the Main Menu, **Select** "Display Setup".
   b) From the Display Mode menu, **Edit** "Mode" to toggle the mode to "Aux Channel".
   c) From the Display Mode menu, **Edit** "Units" to toggle the units to Ω.
   d) From the Display Mode menu, **Edit** "Aux Filter" to toggle the filter to ON.
   e) From the Display Mode menu, **Edit** "Sample Size" to a value of 20.

4) Insert the Standard PRT and the thermistor probe into the Isothermal Block in the bath regulating at 18 °C. Allow time for the probes to stabilize in the 18 °C bath.

5) Record the resistance of the thermistor probe from the 5032 display, and the temperature of the Standard PRT from the Temperature Measurement System.

6) Raise the temperature of the bath to 30 °C and allow time for the probes to stabilize in the 30 °C bath. Record the resistance of the thermistor probe and the temperature of the Standard PRT.

7) Raise the temperature of the bath to 42 °C and allow time for the probes to stabilize in the 42 °C bath. Record the resistance of the thermistor probe and the temperature of the Standard PRT.

8) Compute the thermistor coefficients for the probe with the use of the Hart-Steinhart equation.

9)      Enter the calibration coefficients for the thermistor probe into the 5032:

     a)      From the Main Menu, **Select** "Calibration".
     b)      From the Calibration menu, **Select** "Thermistors".
     c)      From the Thermistors menu, **Select** "Thermistor 2:".
     d)      From the Thermistor 2 menu, **Edit** "Serial #" to 2.
     e)      With the cursor on "Coefficients" press **<Enter>**.
     f)      With the cursor on "Thermistor" press **<Enter>**.
     g)      **Edit** each calibration coefficient to the correct value from the thermistor coefficients computation.
     h)      **Exit** from the Coefficients menu. Enter the password "5032".
     i)      **Exit** from the Thermistor 2 menu.

## 5.3.3. CONTROL PANEL TEMPERATURE CALIBRATION

Calibrate the Control Temperature scale by comparison to a reference thermometer and fitting resistance versus temperature data to the Hart-Steinhart equation.

1)      Fix the location of the Reference Thermometer Probe in the centre of the Air Bath chamber.

2)      Set the 5032 display to UNITS of "°C".

3)      In the "Measurement Display" menu, **Edit** the Set Point temperature to 18 °C.

4)      After the bath has reached the set-point temperature as indicated by the Reference Thermometer display, wait a further one hour for the temperature to stabilize.

5)      Observe the HEATER light. If the light is cycling on and off at regular intervals, then proceed to the next step. If the light is cycling at irregular intervals, then trim the "Temperature Control" coefficients:

     a)      From the Main Menu, **Select** "Display Setup".
     b)      From the Display Mode menu, **Edit** "Mode" to toggle the mode to "Ctl Channel".
     c)      From the main menu, **Select** "Temperature Control".
     d)      **Edit** "Window" coefficient to 0.
     e)      **Edit** "Ki" coefficient to 0.
     f)      **Edit** "Kp" coefficient to the value which causes a minimum peak to peak variation in the Ctl temperature display.
     g)      **Edit** "Ki" coefficient to the value which causes the Ctl temperature display to match the "Set Point" value.

   h)    If the peak to peak variation in the Ctl temperature display is large, **Edit** "Window" to a value close to the peak to peak variation.

   i)    Set the display Mode back to "Aux Channel".

6)   Record the actual bath temperature from the Reference Thermometer display. Set the display Units to "Ω. Record the set-point resistance from the "Set Point" value displayed in the "Measurement Display" menu.

7)   Set the 5032 display to UNITS of "°C". In the "Measurement Display" menu, set the "Set Point" temperature to 30 °C. Repeat step 3 through step 6.

8)   Repeat step 7 with a set-point temperature of 42 °C.

9)   Compute the thermistor coefficients for the control thermistor as in 5.3.2. Step 8.

10)  Enter the calibration coefficients for the control thermistor into the 5032:

   a)    From the Main Menu, **Select** "Calibration".
   b)    From the Calibration menu, **Select** "Thermistors".
   c)    From the Thermistors menu, **Select** "Thermistor 1:".
   d)    From the Thermistor 1 menu, **Edit** "Serial #" to 1.
   e)    With the cursor on "Coefficients" press **<Enter>**.
   f)    With the cursor on "Thermistor" press **<Enter>**.
   g)    **Edit** each calibration coefficient to the correct value from the thermistor coefficients computation.
   h)    **Exit** from the Coefficients menu. Enter the password "5032".
   i)    **Exit** from the Thermistor 1 menu.

11)  Set up a communications link and set the calibration date by sending the string:

"SOFCAL:DATE <YYYY>,<MM>,<DD>"

## 5.4. TEMPERATURE VERIFICATION
The procedure outlined here is intended to verify the 5032 Air bath temperature performance.

NOTE:   Appropriate consideration must be maintained in addressing the self heating effects of probes when used in air.

### 5.4.1. TEMPERATURE ACCURACY/STABILITY
This set of tests confirms the temperature performance of the 5032.

1)    Fix the location of the Auxiliary Thermistor Probe and the Reference Thermometer probe in the centre of the Air Bath chamber.

2)    Set up a communications link and configure the RS232 Mode to "TALK ONLY". Set up to log the Reference Thermometer temperature.

3)    Set the bath set-point to 25 °C. After the bath has been regulating at the set-point for 1 hour, start capturing the RS-232 data to file. Start logging the Reference Thermometer temperature.

4)    Let the bath run at this set-point for 24 hours.

5)    Stop capturing the RS-232 data and the Reference Thermometer temperature data.

6)    Print a line chart of the Aux temperature data:

a)    Open the data file in MS Excel in comma delimited format (the file will be too large, but accept what is loaded).
b)    Insert a line chart (without markers) of column C (Aux channel data) into a new sheet.
c)    Print the chart.

The peak to peak temperature deviation, after the bath has stabilized, must be less than 0.06 °C.

7)    Record the mean Aux temperature and Reference Thermometer temperature. The maximum error between the Reference Thermometer temperature and the Aux temperature must be less than ±0.01 °C. The maximum error – after the bath has stabilized – between the Reference Thermometer temperature and the set-point must be less than ±0.06 °C.

8)    Start capturing the RS-232 data to file. Set the bath set-point to 17 °C. Let the bath run at this set-point for 24 hours plus the initial time required (2.5 hours maximum) to achieve a stable bath temperature at the new set-point.

9) Stop capturing the data. Record the mean Aux temperature and Reference Thermometer temperature. The maximum error between the Reference Thermometer temperature and the Aux temperature must be less than ±0.01 °C. The maximum error – after the bath has stabilized – between the Reference Thermometer temperature and the set-point must be less than ±0.06 °C. Print a line chart of the Aux temperature data. The time for the temperature step change shall be less than 2.5 hours (7500 samples). The peak to peak temperature deviation, after the bath has stabilized, must be less than 0.06 °C.

10) Repeat steps 8 and 9 with a set-point temperature of 50 °C. The time for the temperature step change shall be less than 1 hour (3000 samples).

### 5.4.2. OVER-TEMPERATURE

This test ensures the over temperature protection device is operating correctly. It is to be noted that this test may affect the set point accuracy so should only be performed if it is suspected that there is a malfunction with the over-temperature protection sensor.

1) Fix the location of the Reference Thermometer Probe in the centre of the Air Bath chamber.

2) Assign Thermistor 2 coefficients to the control channel:

   a) From the Main Menu, **Select** "Channel Setup".
   b) From the Channel Setup menu, **Edit** "Ctl" to toggle to thermistor serial number "2".
   c) With the cursor on "Init Ctl" press <**Enter**>.

3) Set the set-point temperature to 50:

   a) From the Main Menu, **Select** "Display Setup".
   b) From the Display Mode menu, **Edit** "Units" to toggle the units to "°C".
   c) From the Main Menu, **Select** "Measurement Display".
   d) With the cursor on "Set Point", **Edit** the set-point to 50.

4) Monitor the Reference Thermometer temperature.

5) Record the temperature at which the air bath shuts off. This over-temperature limit must be 55 ±4 °C.

6) The 5032 bath over-temperature cut-off switch will re-set itself after the chamber temperature cools sufficiently below 50 °C.

7) Restore the control channel thermistor coefficients to those of thermistor serial number "1":

   a) From the Main Menu, **Select** "Channel Setup".
   b) From the Channel Setup menu, **Edit** "Ctl" to toggle to thermistor serial number "1".
   c) With the cursor on "Init Ctl" press <**Enter**>.

# 6. THEORY OF OPERATION

## 6.1. INTRODUCTION

The temperature control circuit in the model 5032 consists of the following functional blocks.

a) Temperature Control -   consisting of a sensor, analog to digital converter, keyboard, CPU based control logic, precision incandescent lamp heater (two lamps) and thermoelectric cooler/booster heater (two modules).

b) Temperature Monitor -   consisting of a sensor, analog to digital converter, CPU based display logic and a display.

c) Over-Temperature Circuit -   cuts off power to entire 5032 if air bath chamber exceeds 55 °C nominal.

d) Power Supply -   provides power for all circuits, continuously drives two air circulation fans at the rear of air bath chamber and the air circulation fan at the rear of the enclosure.
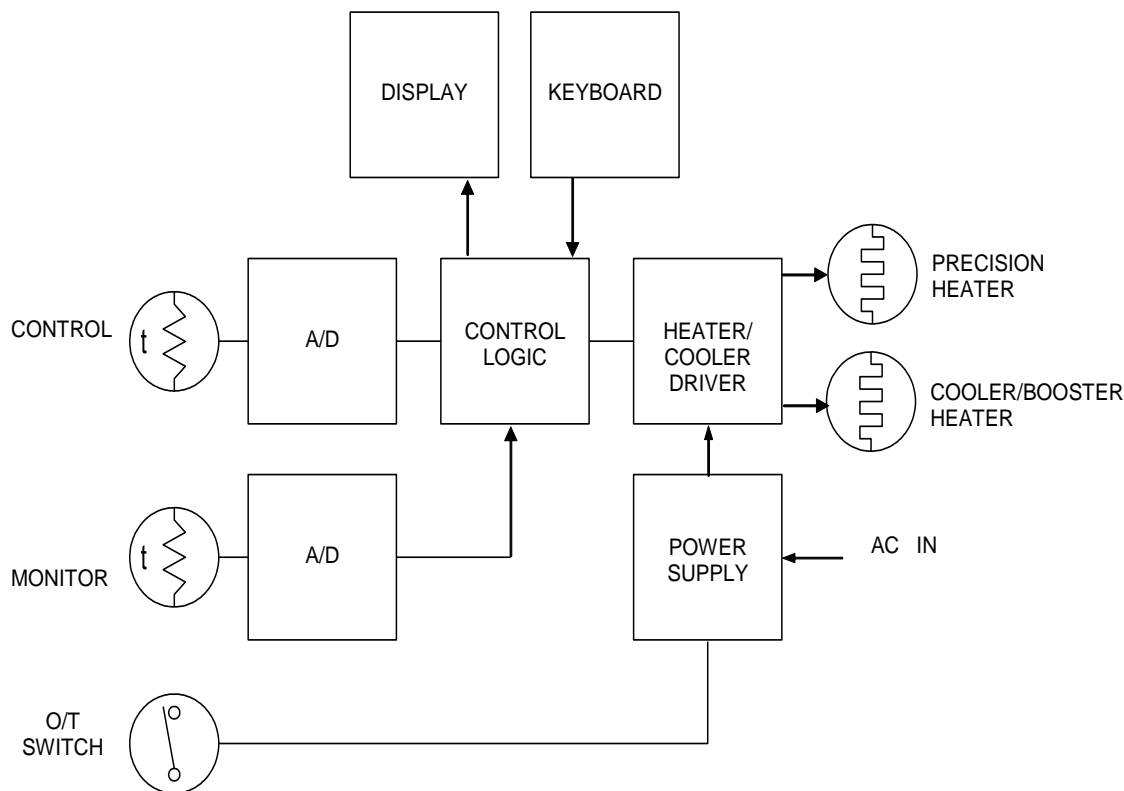


**Figure 6-1: HEATER CONTROL UNIT**

## 6.2. GENERAL DESCRIPTION OF THE INTERNAL CIRCUITS

The 5032 contains three functional printed circuit board assemblies.

The first assembly is the main Temperature Controller PCB assembly. This assembly contains the electronics that converts the measured change in resistance from two thermistors to digital values for scaling by a microprocessor based computer to units of temperature (or direct display of resistance).

The second assembly is the front panel Keyboard PCB assembly. This assembly contains the matrix of momentary front panel keys. It is connected to the CPU assembly by a ribbon cable and connector assembly.

The third assembly is the front panel Vacuum Fluorescent graphical display module. It is connected to the CPU assembly by a ribbon cable and connector assembly.

## 6.3. CIRCUIT DESCRIPTION TEMPERATURE CONTROLLER PCB

Figure 7-1 details the main functional sections of the Temperature Controller PCB assembly.

### 6.3.1. POWER SUPPLY
The analogue circuitry is driven from +8 volts. The logic circuitry is driven exclusively from +5 volts.

The circuit is designed such that supply voltages need not be critical. As such, conventional three terminal regulators are quite adequate in all supplies.

### 6.3.2. FRONT END AMPLIFIER
The current through the sensor is set to a value required to keep the effective self-heating in the attached temperature thermistor to a minimum. Each thermistor current is determined by a separate current mirror, which is a ratio of the A/D converter reference. There are two thermistor input channels. Channel "A" is connected to a thermistor located near the bottom of the air temperature regulation chamber behind the air bath chamber. The nominal resistance of this thermistor at 25 °C is 2000 Ω. This thermistor provides the system temperature reading for maintaining the Variable Temperature Air Bath. The Channel "B" auxiliary thermistor sensor is mounted on a bracket and connected to a wall socket at the rear of the air bath chamber. The nominal resistance of the thermistor at 25 °C is 2252 Ω. This thermistor provides the system temperature reading for recording the temperature in the air bath chamber. The thermistor is provided with sufficient cable to allow it to be moved to various positions throughout the air bath chamber.

### 6.3.3.  CLOCK CIRCUITS

The oscillator, which provides the clock source for the entire instrument, is based on a 14.7456 MHz crystal. The microprocessor is clocked directly from the oscillator output while the A/D converter (U403), UART (U300) and GPIB (U304) are driven from the processor clock, PCLK (4.9152 MHz).

### 6.3.4.  ANALOGUE TO DIGITAL CONVERSION

The analogue to digital converter (U403) is a dual channel 24-bit sigma delta converter linear to ±15 ppm of full scale. The conversion time is 100 ms. The settling time in switching between Ctl Channel and the Aux Channel slows the cycle time down to 1.2 seconds.

As is customary in high performance quantization circuitry, the analogue and digital grounds have been kept separate except at a single point. Throughout the front end amplifier section the analogue ground is set up as a star ground (i.e. returning to a single point) to keep ground noise problems to a minimum. This star ground is centered at the analogue ground pin of the A/D converter.

### 6.3.5.  MICROPROCESSOR CIRCUIT

For each input channel scanned, the digital output of the A/D converter is the quantified representation of the resistance of the associated thermistor. Linearization and conversion of the equivalent resistance is performed using the microprocessor circuit, an INTEL 80C188 (U100) device.

All input output devices on the main CPU PCB are mapped directly to the peripheral chip select signals of the microprocessor U100. Devices U101, U102, U103 provide buffered drive capability to the data and address control signals.

Memory devices U200 - U203 provide all the memory requirements to execute the 5032 program and store all program and calibration variables in a combination of volatile and non-volatile memory.

The A/D converter U403 is free running. DRDY (data ready) interrupts the microprocessor when a conversion is complete. The microprocessor enables TFS (Transmit Frame Synchronization) to transfer the data from U403 into the serial to parallel shift registers U405, U406 and U407. The microprocessor then reads the 3 bytes from the shift registers.

A/D converter commands are written to the shift registers by the microprocessor. Then the microprocessor enables RFS (Receive Frame Synchronization) to transfer data from the parallel to serial shift registers U407, U406 and U405 to U403.

A power monitor integrated circuit U105 keeps the reset pin low while Vcc is brought high on power up. This permits the external logic to stabilize before the microprocessor assumes control. U105 also performs a watchdog function that, if not activated periodically, will reset the microprocessor.

### 6.3.6. FRONT PANEL INTERFACE
The front panel interface is handled as a direct peripheral device to the 80C188 microprocessor. Connector J101 connects the buffered data /address and control signals to the vacuum fluorescent display module.

### 6.3.7. KEYBOARD INTERFACE
The keyboard is serviced as a four column by eight row matrix. The columns are driven low one at a time by U302 port C and the rows are read by U302 port A. The keyboard is attached to J300.

### 6.3.8. IEEE-488 INTERFACE
The interface to the instrumentation bus is carried out by a Texas Instrument general purpose interface bus integrated circuit (U304). In tandem with the bus transceivers (U305, U306), the GPIB chip performs the basic talker/listener functions via the back panel adapter. This connector conforms to the IEEE-488 1978 standard.

### 6.3.9. RS232 SERIAL INTERFACE
The serial RS232 interface is implemented by U300 (16C552) and the level translator device U301 (LT1134).

## 6.4. CIRCUIT DESCRIPTION FRONT PANEL DISPLAY ASSEMBLY

The front panel display assembly consists of two PCB assemblies mounted to the front panel.

### 6.4.1. VACUUM FLUORESCENT DISPLAY MODULE
The VF display assembly contains the main graphical display module that mounts to the rear of the front panel with standoffs. It is electrically connected to the Temperature Controller PCB at connector J101.

### 6.4.2. KEYBOARD PCB
The keyboard PCB contains the matrix of momentary front panel keys. It is mounted on the rear of the front panel with the key switches protruding through.  It is electrically connected to the Temperature Controller PCB at connector J300.

## 6.5. TEMPERATURE CALCULATION

The microprocessor converts the raw A/D converter value to resistance using the channel calibration coefficients. There are separate coefficients for each channel and are calculated by:

$$R = C_0 + C_1X + C_2X^2$$

The microprocessor then converts the calculated resistance to temperature using the following algorithm. The particular algorithm used depends on the calibration assigned to the thermistor attached to that specific channel.

In the following equation, these variables have the meaning:
$R_t$  thermistor resistance at the temperature being measured
$t$  temperature in degrees Celsius
$T$  temperature in kelvins ($T = t + 273.15$)
   All other variables are coefficients specific to that temperature scale.

### 6.5.1. THERMISTOR

This temperature calculation uses absolute resistance rather than resistance ratio. This calculation uses the coefficients $A$, $B$, and $C$ which are unique to that specific thermistor. The nominal values of these coefficients for a 2252 $\Omega$ thermistor are:

$A =$  1.47170E-03
$B =$  2.37583E-04
$C =$  1.04934E-07

The temperature in kelvins is calculated as:
$$T = \left[A + B\ln(R_t) + C(\ln(R_t))^3\right]^{-1}$$