FLUKE®

Calibration

9103

Dry-Well

User's Guide

2005 Rev. 1, 9/21

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Table of Contents

Introduction

The Fluke Calibration 9103 Dry-Well (the Product or the Calibrator) is a small portable instrument for quick on-site checks and calibration of thermocouple and RTD temperature probes. The Product is small enough to use in the field, and accurate enough to use in the lab. Calibrations can be done from -25 °C to 140 °C (-13 °F to 284 °F). Temperature display resolution is 0.1 °.

The Product features:

- Convenient handle
- RS-232 interface
- Universal ac input

Built-in programmable features include:

- Temperature scan rate control
- Temperature switch hold
- Eight set-point memory
- Adjustable readout in °C or °F

The Fluke Calibration hybrid analog/digital controller accurately controls the temperature. The controller uses a precision platinum RTD as a sensor and controls the well temperature with pulsed-driven Thermal Electric Devices (TED).

The LED front panel shows the current well temperature. Use the controller keypad to set temperature to any desired temperature within Product range. Multiple fault protection devices ensure user and Product safety and protection.

The Product is portable, low cost, and easy to operate. With proper use and maintenance, the Product provides continued accurate calibration of temperature sensors and devices. Read all safety guidelines and operating procedures of the calibrator as described in this manual and the *Safety Information* that ships with the Product.

Contact Fluke Calibration

Fluke Corporation operates worldwide. For local contact information, go to our website:
www.flukecal.com

To register your product, view, print, or download the latest User's Guide or manual supplement, go to our website.

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Safety Information

A **Warning** identifies conditions and procedures that are dangerous to the user. A **Caution** identifies conditions and procedures that can cause damage to the Product or the equipment under test.

General Safety Information is located in the printed *Safety Information* document that ships with the Product. It can also be found online at www.Flukecal.com. More specific safety information is listed where applicable.

Service Information

Contact an authorized Fluke Calibration Service Center if the Product needs calibration or repair during the warranty period. Please have Product information such as the purchase date and serial number ready when you schedule a repair.

Specifications and Environmental Conditions

Specifications

Specifications are in Table 1.

Table 1. Specifications

Range	-25 °C to 140 °C (-13 °F to 284 °F), at 23 °C ambient
Accuracy	±0.25 °C (±1.0°C in holes >6.4 mm (1/4 in))
Stability	±0.02 °C at –25 °C ±0.04 °C at 140 °C
Resolution	0.1 °C or °F
Well-to-Well Uniformity	±0.1 °C with similar probes
Thermal Electric Devices (TED)	150 W
Heating Time	18 minutes from ambient to 140 °C
Cooling Time	20 minutes from ambient to -25 °C
Stabilization Time	7 minutes
Immersion Depth	124 mm (4.875 in)
Power Requirements	115/230 V ac (±10 %), 50/60 Hz, 250 VA
Fuse Rating	F, 3 A, 250 V
Removable Inserts	A, B, C, or D See Figure 3.
Computer Interface	RS-232
Size (HxWxD)	261 mm x 143 mm x 245 mm (10.25 in x 5.63 in x 9.63 in)
Environmental Conditions **Ambient Temperature Range** **Ambient Relative Humidity** **Pressure** **Altitude**	 5 °C to 45 °C (41 °F to 113 °F) maximum 80 % for temperature <31 °C, decreasing linearly to 35 % at 40 °C 75 kPa to 106 kPa <2000 m
Weight	5.7 kg (12 lb)
Safety	General IEC 61010-1: Overvoltage Category II, Pollution Degree 2 Heating IEC 61010-2-010
Electromagnetic Compatibility (EMC)	International..... IEC 61326-1: Basic Electromagnetic Environment CISPR 11: Group 1, Class A *Group 1: Equipment has intentionally generated and/or uses conductively-coupled radio frequency energy that is necessary for the internal function of the equipment itself.* *Class A: Equipment is suitable for use in all establishments other than domestic and those directly connected to a low-voltage power supply network that supplies buildings used for domestic purposes. There may be potential difficulties in ensuring electromagnetic compatibility in other environments due to conducted and radiated disturbances.* *Caution: This equipment is not intended for use in residential environments and may not provide adequate protection to radio reception in such environments.* *Emissions that exceed the levels required by CISPR 11 can occur when the equipment is connected to a test object.* *The equipment may not meet the immunity requirements of this standard when test leads and/or test probes are connected.* Korea (KCC) ..... Class A Equipment (Industrial, Broadcasting, & Communication Equipment) *Class A: Equipment meets requirements for industrial electromagnetic wave equipment and the seller or user should take notice of it. This equipment is intended for use in business environments and not to be used in homes.* USA (FCC)..... 47 CFR 15 subpart B. This product is considered an exempt device per clause 15.103.

Environmental Conditions

Although the Product has been designed for optimum durability and trouble-free operation, handle the Product with care.

⚠Caution

To avoid damaging the Product:

- **Do not operate the Product in an excessively dusty or dirty environment.**
- **Minimize vibrations in the calibration environment.**
- **Use the Product indoors only.**

For Maintenance and cleaning recommendations, see *Maintenance*.

Quick Start

Unpacking

Unpack the Product carefully and inspect it for any damage that may have occurred during shipment. If there is shipping damage, notify the carrier immediately.

Verify that the following components are present:

- 9103 Dry-Well
- Insert for configuration ordered
- Mains power cable
- *9103 Safety Information*
- Insert Removal Tongs
- Serial cable

Setup

Place the Product on a flat surface with at least 15.24 cm (6 in) of free space around the Product. Plug the power cord into a grounded mains outlet. Observe that the nominal voltage corresponds to that indicated on the Product.

Power

See Table 1, for power details. Turn on the Product with the power switch located on the rear of the Product. The Product heats to the previously-programmed temperature set-point. The display indicates the actual Product temperature.

Once the Product is on, the fan begins to quietly blow air through the Product and the controller display illuminates after 3 seconds. After a brief self-test the Product begins normal operation. If the unit fails to operate, check the power connection.

Set the Temperature

Temperature Set-point explains in detail how to set the temperature set-point on the Product front panel. The procedure is summarized here:

1. Push **SET** twice to access the set-point value.
2. Push **UP** or **DOWN** to change the set-point value.
3. Push **SET** to program in the new set-point.
4. Push **EXIT** to return to the temperature display.

When you change the set-point temperature the controller switches the well TEDs on or off to raise or lower the temperature. The displayed well temperature gradually changes until it reaches the set-point temperature. The well can require 25 minutes to reach the set-point depending on the span. Another 6 minutes to 10 minutes is required to stabilize within ±0.1 °C of the set-point. Ultimate stability can take 20 minutes to 30 minutes more of stabilization time.

Parts and Controls

The user should become familiar with the Product and its parts (See Figure 1 and Figure 2).

Rear Panel

Mains power cable - The removable mains power cable attaches to the rear of the Product. The Cable plugs into an IEC grounded socket.

Power Switch - The power switch is on the power entry module (PEM). The PEM also houses the voltage selector and main fuses.

To change the mains voltage selection, replace the fuses and place the voltage selector in the correct position.

1. Insert a small flat head screwdriver at the bottom of the PEM and lift the fuse holder cover from the PEM.
2. With the screwdriver, lift the fuse holder from the PEM.
3. Install the correct fuse:
   - 115 V or 250 V Fluke part number 109199. Fuse, 0.25x31.75 mm, 3 A, 250 V, fast blow.
4. Once installed, put the fuse holder back into the PEM. Make sure that the correct voltage shows on the closed fuse cover.

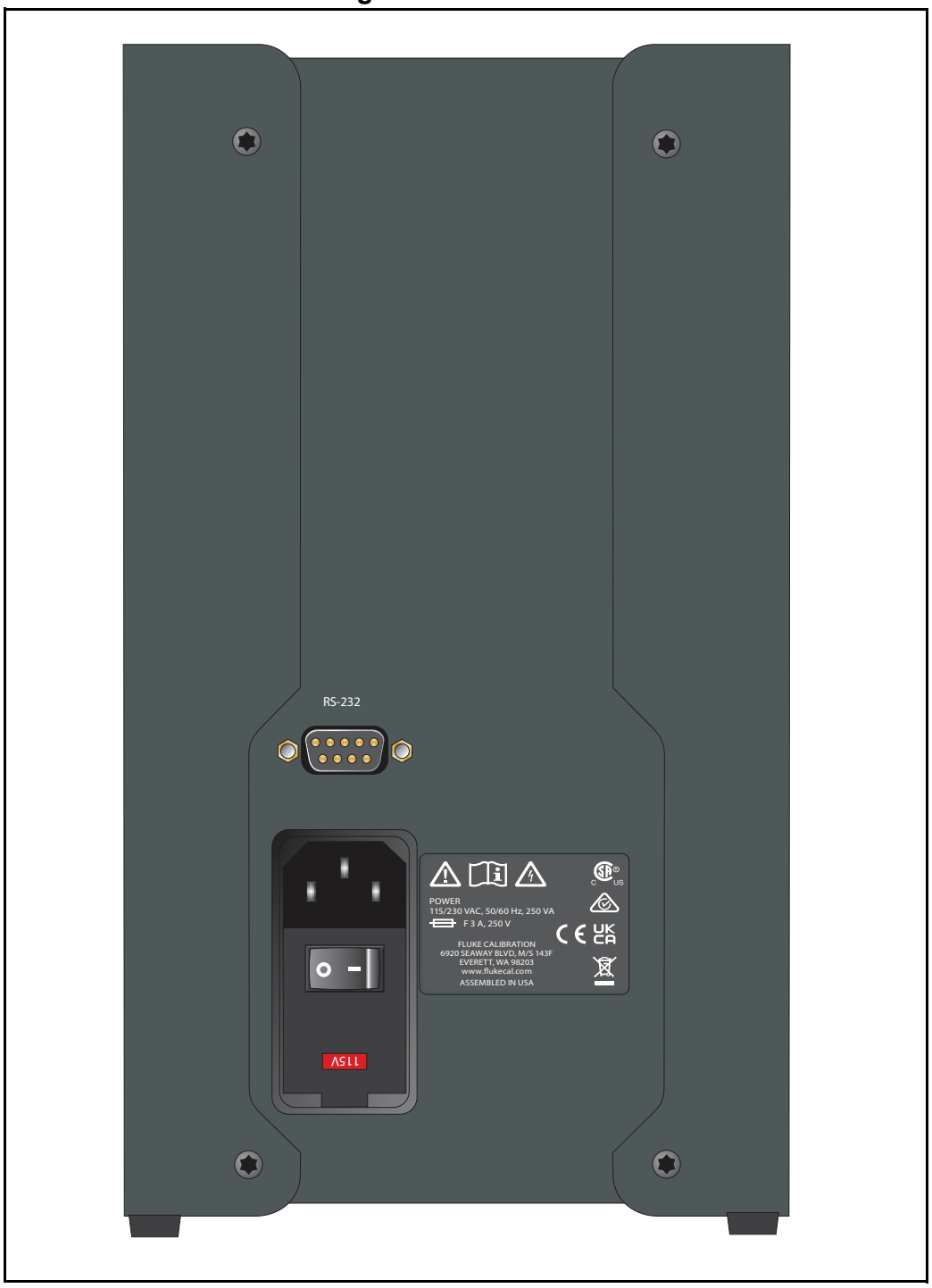
Serial Port - A DB-9 male connector connects the Product to a computer or terminal with serial RS-232 communications.

Fan - The fan inside the Product runs continuously as the Product operates and provides cooling for the Product. At high temperatures or during heating, the fan slows down. Slots at the top and around the two corners of the Product are provided for airflow. Keep the area around the calibrator clear to allow adequate ventilation. The airflow is directed up.

Thermal Electric Devices (TED)

The power of the Product is precisely controlled by the temperature controller to maintain a constant temperature. Power is controlled by periodically switching the TEDs on for a certain amount of time using power transistors.

Figure 1. Back Panel

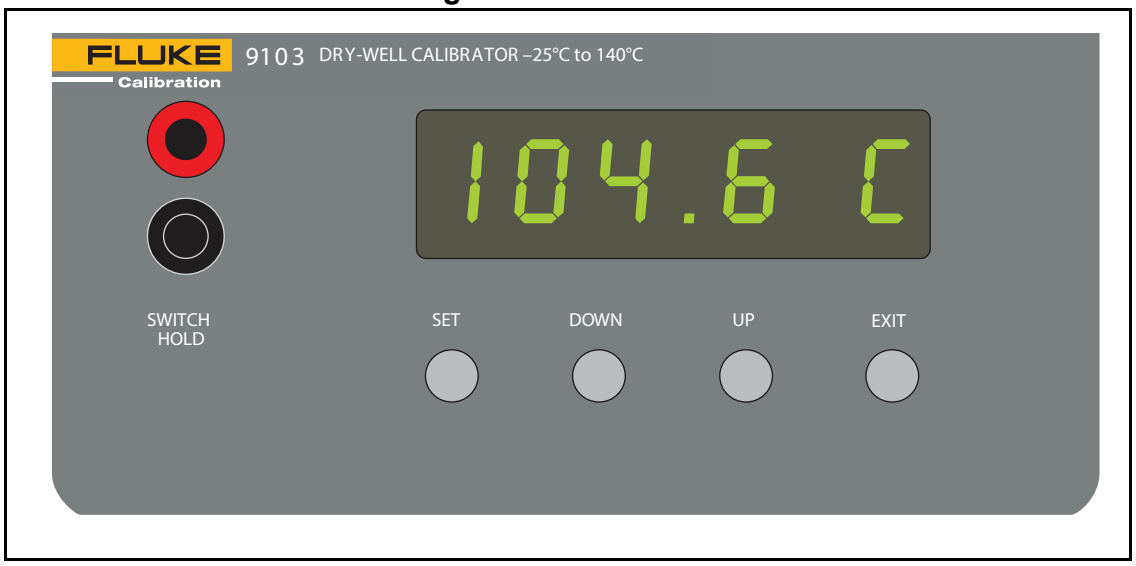


Front Panel

⚠Caution

Always leave enough clearance in front of the calibrator to allow for safe and easy installation and removal of probes.

Figure 2. Front Panel



Display - The digital display shows set and actual temperatures and also indicates various Product functions, settings, and constants. The display shows temperatures in units according to the selected scale °C or °F.

Controller Keypad - The four-button keypad allows easy setting of the set-point temperature. Use the control buttons (**SET**, **DOWN**, **UP**, and **EXIT**) to set the Product temperature set-point, access, and set other operating parameters, and calibration parameters.

Set the control temperature directly in degrees of the current scale. Set the temperature to one-tenth of a degree Celsius or Fahrenheit.

The functions of the buttons are:

SET – Used to display the next parameter in the menu and to store parameters to the displayed value.

DOWN – Used to decrement the displayed value of parameters.

UP – Used to increment the displayed value.

EXIT – Used to exit a function and to skip to the next function. Any changes made to the displayed value are ignored. Hold **EXIT** for about a 1/2 a second to return control to the main display.

SWITCH HOLD – Use these terminals to connect and test external thermal switches and cutouts.

Constant Temperature Block Assembly

The *Block* is made of aluminum and provides a relatively constant and accurate temperature environment. Insert the sensor to be calibrated inside the block. The 1.25 in diameter well is used for sensors of that size or can be sleeved down with various sized multi-hole probe sleeves. TEDs surround the block assembly and provide even heat to the sensor. A high-temperature platinum RTD embedded at the base of the block assembly senses and controls the temperature of the block. The entire assembly is suspended in an air-cooled chamber thermally isolated from the chassis and electronics.

Probe Sleeves

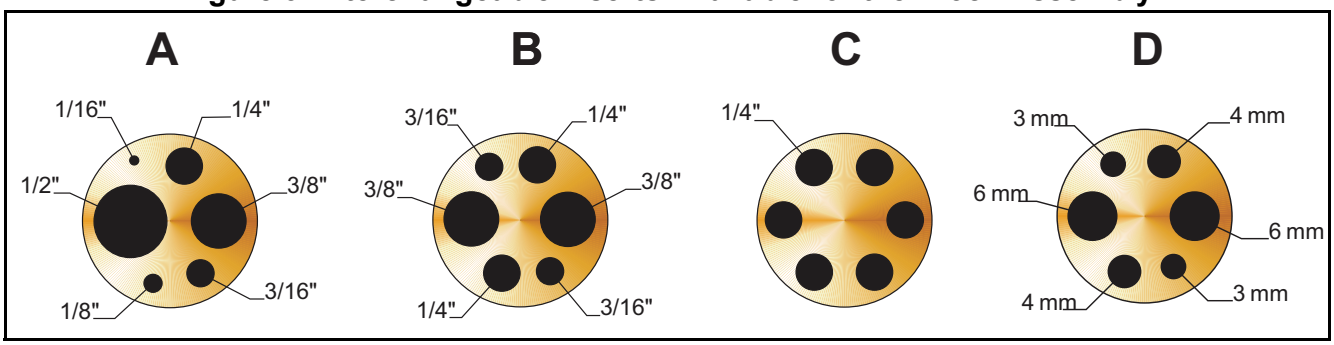
The probe sleeves are show in Figure 3.

The Product comes with a multiple-hole aluminum probe sleeve for insertion into the calibrator well and tongs for removing sleeves. Probe sleeves of various hole sizes are available and allow the probe to fit snugly into the well whatever the diameter of the probe.

One insert (whichever is ordered) is shipped with the unit. The insert types:

- Insert A (variety block): 1/2 in, 3/8 in, 1/4 in, 3/16 in, 1/8 in, and 1/16 in holes
- Insert B (comparison block): 2 each 3/8 in, 2 each 1/4 in, and 2 each 3/16 in holes
- Insert C (1/4 in comparison block): 6 each 1/4 in holes
- Insert D: 2 each 3 mm, 2 each 4 mm, and 2 each 6 mm holes

Figure 3. Interchangeable Inserts Available for the Block Assembly



General

Change the Display Units

The temperature units are factory defaulted to Celsius. To change to Fahrenheit or back to Celsius:

1. Push **SET** and **UP** simultaneously. The temperature display changes units.

or

1. Push **SET** three times from the temperature display to show

Un= C

2. Push **UP** or **DOWN** to change units.
3. Push **SET** to store the changes.

Controller Operation

Use the front panel to monitor the well temperature, adjust the set-point temperature in degrees C or F, monitor the heater output power, adjust the controller proportional band, operating parameters, serial interface configuration, and controller calibration parameters. Operation of the functions and parameters are shown in Figure 4. Copy this chart for reference.

In the subsequent discussion, the word **SET**, **UP**, **DOWN** or **EXIT** indicates the panel button, next to the display reading. Explanations of the button or display readings are to the right of each button or display value.

Well Temperature

The well temperature value normally shows on the display. The units of the temperature value (C or F) show at the right. For example,

100.0 C *Well temperature in degrees Celsius*

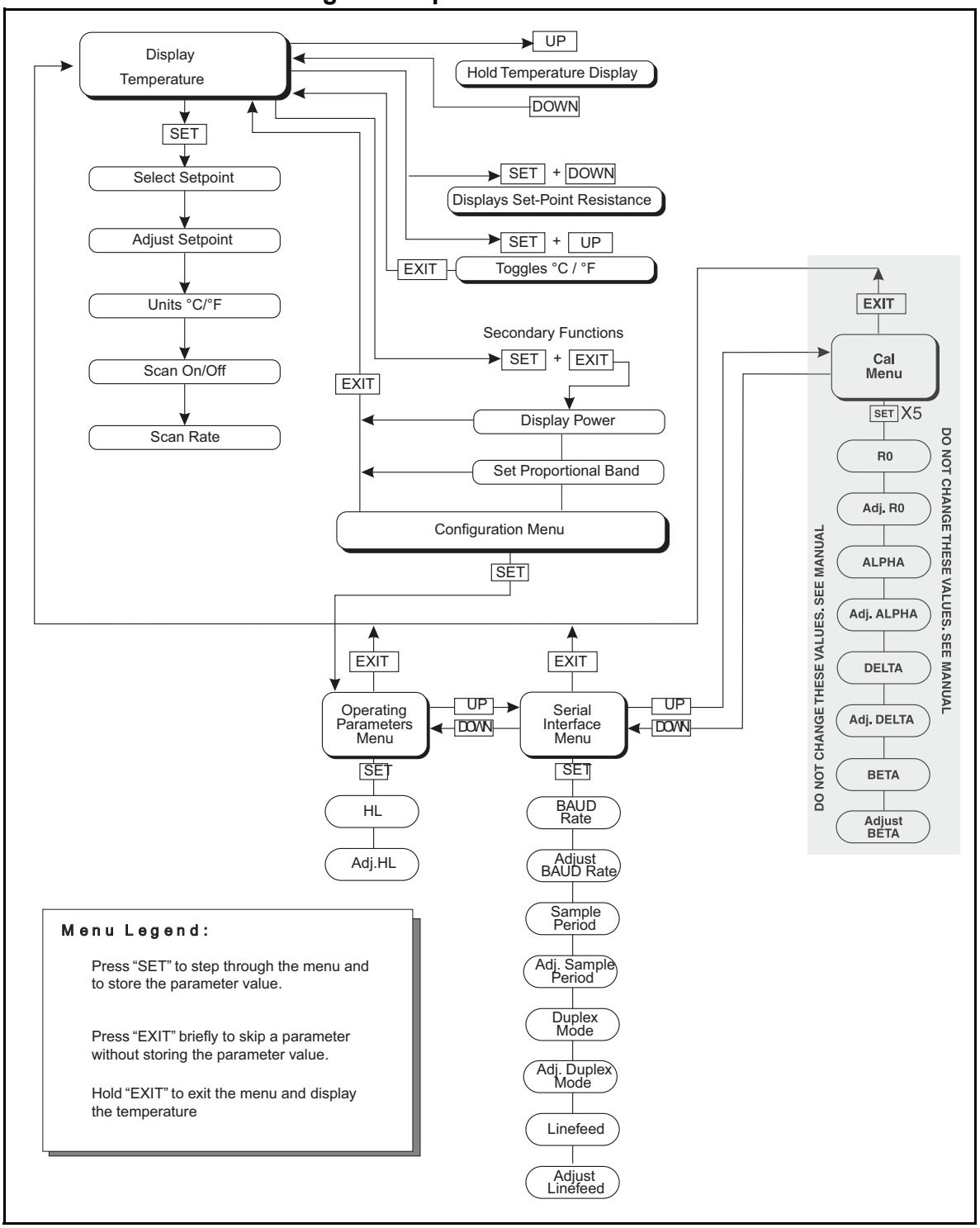
To access the temperature display from any other function, hold and release **EXIT**.

Temperature Set-point

The temperature set-point can be set to any value within the range and with resolution as given in the specifications. Be careful not to exceed the safe upper temperature limit of any device inserted into the well.

To set the temperature, select the set-point memory and adjust the set-point value.

Figure 4. Operational Flowchart



Programmable Set-points

The controller stores 8 set-point temperatures in memory. The set-points can be quickly recalled to conveniently set the Product to a previously-programmed temperature set-point.

To set the temperature, first select the set-point memory. Push **SET** from the temperature display function to access this function. The number of the set-point memory currently in use is shown at the left on the display followed by the current set-point value.

100.0 C	*Well temperature in degrees Celsius*
SET	*Access set-point memory*
1. 25	*Set-point memory 1, 25.0 °C currently used*

To change to another set-point memory location, push **UP** or **DOWN**.

4. 120	*New set-point memory 4, 120.0°C*

Push **SET** to accept the new selection and access the set-point value.

SET	*Accept selected set-point memory*

Set-point Value

Adjust the set-point after you select the set-point memory and push **SET**.

4 120	*Set-point value in °C*

If the set-point value is correct, hold **EXIT** to resume displaying the well temperature. Push **UP** or **DOWN** to adjust the set-point value.

125.0	*New set-point value*

When the desired set-point value is reached, push **SET** to accept the new value and access the temperature scale units. Push **EXIT** to ignore any set-point changes.

SET	*Accept new set-point value*

Temperature Scale Units

To change the display temperature units, see *Change the Display Units*.

Scan

Set and enable the scan rate so that when the set-point is changed the calibrator heats or cools at a specified rate (degrees per minute) until it reaches the new set-point. With the scan disabled, the calibrator heats or cools at the maximum possible rate.

Scan Control

The scan is controlled with the scan on/off function that appears in the main menu after the set-point function.

`Sc=OFF` *Scan function off*

Push **UP** or **DOWN** to toggle the scan on or off.

`Sc=On` *Scan function on*

Push **SET** to accept the present setting and continue.

SET *Accept scan setting*

Scan Rate

The scan rate can be set from .1 to 99.9 °C/minute. The maximum scan rate is actually limited by the natural heating or cooling rate of the Product. This rate is often <100 °C/minute, especially when cooling.

The scan rate function appears in the main menu after the scan control function. The scan rate units are in degrees C or F per minute, depending on the selected units.

`Sr=10.0` *Scan rate in °C/min*

Push **UP** or **DOWN** to toggle the scan on or off.

`Sr=2.0` *New scan rate*

Push **SET** to accept the new scan rate and continue.

SET *Accept scan rate*

Temperature Display Hold

The Product has a display hold function which allows an external switch to freeze the displayed temperature and stop the set-point from scanning. Use this function to test thermal switches and cutouts. This section explains the functions available to operate the temperature hold feature.

A subsequent example shows how to set up and use the hold feature to test a switch.

Enable the Hold Temperature Display

Push **UP** when the temperature shows to enable the Hold Temperature Display feature. The Hold Temperature Display shows the hold temperature on the right and the switch status on the left. The status **c** means the switch is closed and **o** means the switch is open. The status flashes when the switch is in its active position (opposite the normal position). The hold temperature display shows what the temperature of the well was when the switch changed from its normal position to its active position. While the switch is in the normal position the hold temperature will follow the well temperature.

If the Scan Control is OFF and the Hold Temperature Display is in use, the temperature at which the switch is activated does not affect the set-point temperature. However, if the Scan Control is ON and the Hold Temperature Display is being used, the temperature at which the switch is activated is stored as the new set-point temperature.

Operation of the hold temperature display is outlined below.

103.5C	*Well temperature display*
UP	*Access hold display*
c 103.5	*Switch status and hold temperature*

To return to the normal well temperature display, push **DOWN**.

Mode Setting

The Hold Temperature Display function is always in the automatic mode. In this mode the normal position is set to whatever the switch position is when the set-point is changed. For example, if the switch is currently open when the set-point is changed, the closed position then becomes the new active position.

The normal position is set automatically under any of these conditions:

- a new set-point number is selected
- the set-point value is changed
- a new set-point is set through the communications channels

Switch Wiring

The thermal switch or cutout is wired to the Product at the two terminals on the front of the calibrator labeled **SWITCH HOLD**. The switch wires can be connected to the terminals either way. Internally the black terminal connects to ground. The red terminal connects to +5 V through a 100 kΩ resistor. The calibrator measures the voltage at the red terminal and interprets +5 V as open and 0V as closed.

Switch Test Example

This section describes a possible application for the switch hold temperature display feature and how the instrument is set up and operated. Suppose you have a thermal switch which is supposed to open at about 75 °C and close at about 50 °C and you want to test the switch to see how accurate and repeatable it is. You can use the temperature hold feature and the scan function to test the switch. Measurements can be made by observing the display or, preferably, by collecting data using a computer connected to the RS-232 port.

To set up the test:

1. Connect the switch wires to the terminals on the front of the Product and place the switch in the well.
2. Enable set-point scanning by setting the scan to **ON** in the primary menu (see *Scan Control*).
3. Set the scan rate to a low value, say 1.0°C/min. (see *Scan Rate*). If the scan rate is too high you can lose accuracy because of transient temperature gradients. If the scan rate is too low the duration of the test may be longer than is necessary. Experiment to find the best scan rate.
4. Set the first program set-point to a value above the expected upper switch temperature, say 90°C.
5. Set the second program set-point to a value below the expected lower switch temperature, say 40°C, in the program menu.
6. Collect data on a computer connected to the RS-232 port. Refer to *Digital Communication Interface* for instructions on configuring the RS-232 communications interface.

Set-point Resistance

To display set-point resistance, push **SET** and **DOWN** simultaneously when the temperature appears. When **SET** and **DOWN** are released, the temperature appears again.

Temperature Scale Units

To toggle between °C and °F, push **SET** and **UP** simultaneously when the temperature appears.

Secondary Menu

Functions which are used less often are accessed within the secondary menu. To access the secondary menu, push **SET** and **EXIT** simultaneously and then release. The first function in the secondary menu is the heater power display (see Figure 4).

Thermal Electric Devices (TED)

The temperature controller controls the temperature of the well by pulsing the TED on and off. The total power being applied to the TED is determined by the duty cycle or the ratio of TED on time to the pulse cycle time. By knowing the amount of heating, the user can tell if the calibrator is heating up to the set-point, cooling down, or controlling at a constant temperature. Monitoring the percent heater power allows the user to know the stability of the well temperature. With good control stability the percent heating power should not fluctuate more than ±5 % within one minute.

The heater power display is accessed in the secondary menu. Push **SET** and **EXIT** simultaneously and release. The heater power displays as a percentage of full power.

100.0	*Well temperature*
SET+EXIT	*Access heater power in secondary menu*
SEC	*Flashes*
12.0P	*Heater power in percent*

To exit from the secondary menu, push **EXIT**. To continue on to the proportional band setting function, push **SET**.

Proportional Band

In a proportional controller such as this, the heater output power is proportional to the well temperature over a limited range of temperatures around the set-point. This range of temperature is called the proportional band. At the bottom of the proportional band, the heater output is 100 %. At the top of the proportional band, the heater output is 0. Thus, as the temperature rises the heater power is reduced, which consequently tends to lower the temperature back down. In this way the temperature is maintained at a constant level.

The temperature stability of the well and response time depend on the width of the proportional band. If the band is too wide, the well temperature deviates excessively from the set-point due to varying external conditions. This is because the power output changes very little with temperature and the controller cannot respond very well to changing conditions or noise in the system. If the proportional band is too narrow, the temperature may swing back and forth because the controller overreacts to temperature variations. For best control stability, the proportional band must be set for the optimum width.

The proportional band width is set at the factory as printed on the Report of Calibration. The proportional band width can be altered by the user if desired to optimize the control characteristics for a particular application.

The proportional band width is easily adjusted from the front panel. The width can be set to discrete values in degrees C or F depending on the selected units. The proportional band adjustment is accessed within the secondary menu. Push **SET** and **EXIT** to enter the secondary menu and show the heater power. Then push **SET** to access the proportional band.

SET+EXIT *Access heater power in secondary menu*

12.0 P *Heater power in percent*

SET *Access set-point voltage*

PrOP *Flashes PrOP and the setting*

15.0 *Proportional band setting*

To change the proportional band push **UP** or **DOWN**.

4.0 *New proportional band setting*

To store the new setting push **SET**. Push **EXIT** to continue without storing the new value.

SET *Accept the new proportional band setting*

Controller Configuration

The Product has a number of configuration and operating options and calibration parameters which are programmable from the front panel. These are accessed from the secondary menu after the proportional band function by pushing **SET**. push **SET** again to enter the first of three sets of configuration parameters — operating parameters, serial interface parameters, and calibration parameters. The menus are selected with **UP** and **DOWN** and then pushing **SET**. See Figure 4.

Operating Parameters

The operating parameters menu is indicated by:

PAr *Operating parameters menu*

The operating parameters menu contains the High Limit parameter.

The High Limit parameter adjusts the upper set-point temperature. The factory default and maximum are set to 140 °C (284 °F). For safety, a user can adjust the High Limit down so the maximum temperature set-point is restricted.

HL *Flashes HL and then displays the setting*

H=140 *Current HL setting*

Adjust the HL parameter with **UP** or **DOWN**.

H=90 *New High Limit setting*

To accept the new setting, push **SET**.

Serial Interface Parameters

The serial RS-232 interface parameters menu is indicated by:

SEr,AL *Serial RS-232 interface parameters menu*

The serial interface parameters menu contains parameters which determine the operation of the serial interface. The parameters in the menu are: BAUD rate, sample period, duplex mode, and linefeed.

Push **SET** to access the special parameters.

BAUD Rate

The BAUD rate is the first parameter in the menu. The BAUD rate setting determines the serial communications transmission rate.

The BAUD rate parameter is indicated by:

bAUd *Flashes bAUd and then displays the setting*

2400 b *Current BAUD rate*

The BAUD rate of the serial communications can be programmed to 300, 600, 1200, **2400** (default), 4800, or 9600 BAUD. Use **UP** or **DOWN** to change the BAUD rate value.

4800 b *New baud rate*

Push **SET** to set the BAUD rate to the new value or **EXIT** to abort the operation and skip to the next parameter in the menu.

Sample Period

The next parameter in the serial interface parameter menu is the sample period. The sample period is the time period in seconds between temperature measurements transmitted from the serial interface. If the sample rate is set to 5, the Product transmits the current measurement over the serial interface approximately every 5 seconds. The automatic sampling is disabled with a sample period of 0. The sample period is indicated by:

SPEr	*Flashes SPEr and then displays the setting*
SP=1	*Current sample period (seconds)*

Adjust the value with **UP** or **DOWN** and then **SET** to set the sample rate to the displayed value. **EXIT** does not store the new value.

SP=60	*New sample period*

Duplex Mode

The next parameter is the duplex mode. The duplex mode can be set to full duplex or half duplex. With full duplex any commands received by the Product through the serial interface are immediately echoed or transmitted back to the device of origin. With half duplex the commands are executed but not echoed. The duplex mode parameter is indicated by:

dUPL	*Flashes dUPL and then the displays the setting*
d=FULL	*Current duplex mode setting*

Change the mode with **UP** or **DOWN**.

d=HALF	*New duplex mode setting*

Linefeed

The final parameter in the serial interface menu is the linefeed mode. This parameter enables (on) or disables (off) transmission of a linefeed character (LF, ASCII 10) after transmission of any carriage-return. The linefeed parameter is indicated by:

LF	*Flashes LF and then displays the setting*
LF=On	*Current linefeed setting*

Change the mode with **UP** or **DOWN** then push **SET.**

LF=OFF	*New linefeed setting*

Calibration Parameters

The operator of the Product controller has access to a number of the calibration constants: R0, ALPHA, DELTA, and BETA. These values are set at the factory and must not be altered. The correct values are important to the accuracy and proper and safe operation of the Product. Access to these parameters is available to the user only so that in the event that the controller memory fails the user can restore these values to the factory settings. These constants and their settings are included on the calibration certificate that was included with the instrument.

⚠Caution

Do not change the values of the Product calibration constants from the factory set values. The correct setting of these parameters is important to the safety, proper operation, and performance of the Product.

The calibration parameters menu is indicated by:

CAL *Calibration parameters menu*

Push **SET** five times to enter the menu.

The calibration parameters R0, ALPHA, DELTA, and BETA characterize the resistance-temperature relationship of the platinum control sensor. These parameters can be adjusted to improve the accuracy of the Product

R0

This probe parameter refers to the resistance of the control probe at 0 °C. The value of this parameter is set at the factory for best Product accuracy.

ALPHA

This probe parameter refers to the average sensitivity of the probe between 0 and 100 °C. The value of this parameter is set at the factory for best instrument accuracy.

DELTA

This probe parameter characterizes the curvature of the resistance-temperature relationship of the sensor. The value of this parameter is set at the factory for best Product accuracy.

BETA

This probe parameter characterizes the low temperatures. The value of this parameter is set at the factory for best instrument accuracy.

Digital Communication Interface

This Product can communicate with and be controlled by other equipment through the digital serial interface.

With a digital interface, the Product can be connected to a computer or other equipment. This allows the user to set the set-point temperature, monitor the temperature, and access any of the other controller functions, all using remote communications equipment. Communications commands are summarized in Table 2.

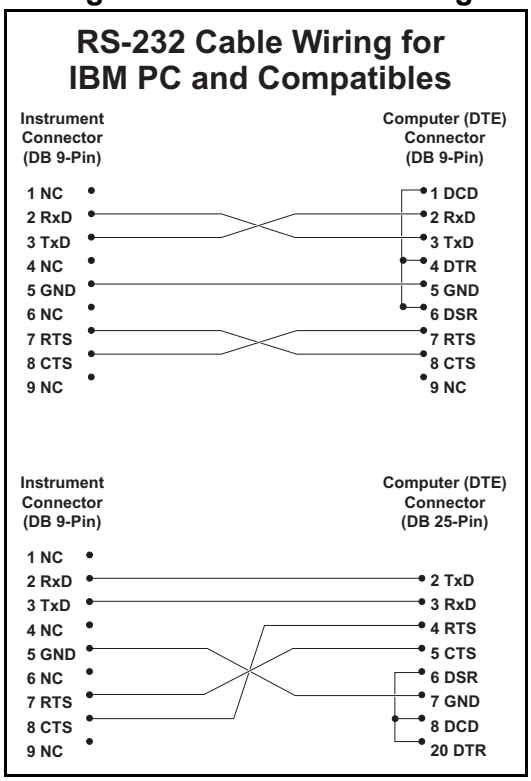
Serial Communications

The Product is installed with an RS-232 serial interface that allows serial digital communications over fairly long distances. With the serial interface the user can access any of the functions, parameters and settings discussed in *Controller Operation* with the exception of the BAUD rate setting.

Wiring

The serial communications cable attaches to the calibrator through the DB-9 connector at the back of the instrument. Figure 5 shows the pin-out of this connector and suggested cable wiring. To eliminate noise the serial cable should be shielded with low resistance between the connector (DB-9) and the shield. If the unit is used in a heavy industrial setting, the serial cable must be limited to ONE METER in length.

Figure 5. Serial Cable Wiring



Setup

Before operation the serial interface must first be set up by programming the BAUD rate and other configuration parameters. These parameters are programmed within the serial interface menu. The serial interface parameters menu is outlined in Figure 4.

To enter the serial parameter programming mode:

1. Push **EXIT** and **SET** then release to enter the secondary menu.
2. Push **SET** repeatedly until the display reads PAr.
3. Push **UP** until the serial interface menu is indicated with SErIAL.
4. Push **SET** to enter the serial parameter menu. In the serial interface parameters menu are the BAUD rate, the sample rate, the duplex mode, and the linefeed parameter.

BAUD Rate

The BAUD rate is the first parameter in the menu. The display prompts with the BAUD rate parameter by showing bAUd. Push **SET** to choose to set the BAUD rate. The current BAUD rate is displayed. The BAUD rate of the Product serial communications can be programmed to 300, 600, 1200, 2400, 4800, or 9600 baud. The BAUD rate is pre-programmed to 2400 BAUD. Use **UP** or **DOWN** to change the BAUD rate value. Push **SET** to set the BAUD rate to the new value or **EXIT** to abort the operation and skip to the next parameter in the menu.

Sample Period

The sample period is the next parameter in the menu and prompted with SPEr. The sample period is the time period in seconds between temperature measurements transmitted from the serial interface. If the sample rate is set to 5, the instrument transmits the current measurement over the serial interface approximately every 5 seconds. The automatic sampling is disabled with a sample period of 0. Push **SET** to choose to set the sample period. Adjust the period with **UP** or **DOWN** and then use **SET** to set the sample rate to the displayed value.

Duplex Mode

The next parameter is the duplex mode indicated with dUPL. The duplex mode can be set to half duplex (HALF) or full duplex (FULL). With full duplex any command received by the instrument via the serial interface is immediately echoed or transmitted back to the device of origin. With half duplex the commands are executed but not echoed. The default setting is full duplex. Change the mode with **UP** or **DOWN** and push **SET**.

Linefeed

The final parameter in the serial interface menu is the linefeed mode. This parameter enables (On) or disables (OFF) transmission of a linefeed character (LF, ASCII 10) after transmission of any carriage-return. The default setting is with linefeed on. Change the mode with **UP** or **DOWN** and push **SET**.

Serial Operation

Once the cable has been attached and the interface set up properly the controller immediately begins transmitting temperature readings at the programmed rate. The serial communications uses 8 data bits, one stop bit, and no parity. The set-point and other commands can be sent with the serial interface to set the temperature set-point and view or program the various parameters. The interface commands are discussed in *Interface Commands*. All commands are ASCII character strings terminated with a carriage-return character (CR, ASCII 13).

Interface Commands

The various commands to access the Product functions via the digital interfaces are listed in this section, see Table 2. These commands are used with the RS-232 serial interface. The commands are terminated with a carriage-return character. The interface makes no distinction between upper and lower case letters, so either can be used. Commands can be abbreviated to the minimum number of letters which determines a unique command. A command can be used to either set a parameter or to show a parameter depending on whether or not a value is sent with the command following a **=** character. For example, **s** returns the current set-point and **s=150.0** sets the set-point to 150.0 degrees.

In the list of commands in Table 2, characters or data within brackets, **[** and **]**, are optional for the command. A slash, */*, denotes alternate characters or data. Numeric data, denoted by **n**, can be entered in decimal or exponential notation. Characters are shown in lower case although upper case can be used. Spaces can be added within command strings and are simply ignored. Backspace (BS, ASCII 8) can be used to erase the previous character. A terminating CR is implied with all commands.

Table 2. Controller Communications Commands

Command Description	Command Format	Command Example	Returned	Returned Example	Acceptable Values
Display Temperature					
Read current set-point	s[etpoint]	s	set: 999.99 {C or F}	set: 100.00 C	
Set current set-point to n	s[etpoint]=n	s=200.0			Instrument Range
Read temperature	t[emperature]	t	t: 999.9 {C or F}	t: 55.6 C	
Read temperature units	u[nits]	u	u: x	u: C	
Set temperature units:	**u[nits]=c/f**				C or F
Set temperature units to Celsius	u[nits]=c	u=c			
Set temperature units to Fahrenheit	u[nits]=f	u=f			
Read scan mode	sc[an]	sc	sc: {ON or OFF}	sc: ON	
Set scan mode	sc[an]=on/off	sc=on			ON or OFF
Read scan rate	sr[ate]	sr	srat: 99.9 {C or F}/ min	srat:12.4 C/min	
Set scan rate	sr[ate]=n	sr=1.1			0.1 to 99.9
Read hold	ho[ld]	ho	hld: open/closed, 99.9 {C or F}	hold: open, 30.5 C	
Secondary Menu					
Read proportional band setting	pr[op-band]	pr	pb: 999.9	pb: 15.9	
Set proportional band to *n*	pr[op-band]=n	pr=8.83			Depends on Configuration
Read heater power (duty cycle)	po[wer]	po	po: 999.9	po: 1.0	

Command Description	Command Format	Command Example	Returned	Returned Example	Acceptable Values
Configuration Menu					
Operating Parameters Menu					
Read High Limit	hl	hl	hl: 999	hl: 140	
Set High Limit	hl=n	hl=90			0-140
Serial Interface Menu					
Read serial sample setting	sa[mple]	sa	sa: 9	sa: 1	
Set serial sampling setting to *n* seconds	sa[mple]=n	sa=0			0 to 999
Set serial duplex mode:	**du[plex]=f[ull]/ h[alf]**				FULL or HALF
Set serial duplex mode to full	du[plex]=f[ull]	du=f			
Set serial duplex mode to half	du[plex]=h[alf]	du=h			
Set serial linefeed mode:	**lf[eed]=on/of[f]**				ON or OFF
Set serial linefeed mode to on	lf[eed]=on	lf=on			
Set serial linefeed mode to off	lf[eed]=of[f]	lf=of			
Calibration Menu					
Read R0 calibration parameter	r[0]	r	r0: 999.999	r0: 100.578	
Set R0 calibration parameter to *n*	r[0]=n	r=100.324			90 to 110
Read ALPHA calibration parameter	al[pha]	al	al: 9.9999999	al: 0.0038573	
Set ALPHA calibration parameter to *n*	al[pha]=n	al=0.0038433			.002 to .005
Read DELTA calibration parameter	de[lta]	de	de: 9.99999	de: 1.507	
Set DELTA calibration parameter	de[lta]=n	de=1.3742			0–3.0
Read BETA calibration parameter	be[ta]	be	be:9.999	be:0.342	
Set BETA calibration parameter	be[ta]=n	be=0.342			-100.0 to 100.0
Functions not on menu					
Read firmware version number	*ver[sion]	*ver	ver.9999,9.99	ver.9103,2.00	
Read structure of all commands	h[elp]	h	list of commands		
Read all operating parameters	all	all	list of parameters		

Legend: [] Optional command data
{} Returns either information
n Numeric data supplied by user
9 Numeric data returned to user
x Character data returned to user

Note: When DUPLEX is set to FULL and a command is sent to READ, the command is returned followed by a carriage return and linefeed. Then the value is returned as indicated in the RETURNED column.

Test Probe Calibration

For optimum accuracy and stability, allow the Product to warm up for 25 minutes after power-up and then allow adequate stabilization time after reaching the set-point temperature. After completing operation of the calibrator, allow the well to cool by setting the temperature to 25 °C for one-half hour before turning off the power.

Calibrate a Single Probe

Insert the probe to be calibrated into the well of the Product. Best results are obtained with the probe inserted to the full depth of the well. Once the probe is inserted into the well, allow adequate stabilization time to allow the test probe temperature to settle as described above. Once the probe has settled to the temperature of the well, it may be compared to the calibrator display temperature. The display temperature should be stable to within 0.1 °C degree for best results. Never introduce any foreign material into the well.

Stabilization and Accuracy

The stabilization time of the Product depends on the conditions and temperatures involved. Typically the test well will be stable to 0.1 °C within 6 minutes of reaching the set-point temperature. Ultimate stability will be achieved 30 minutes after reaching the set temperature.

Inserting a cold probe into a well requires another period of stabilizing depending on the magnitude of the disturbance and the required accuracy. For example, inserting a .25 inch diameter room temperature probe at 125 °C takes 5 minutes to be within 0.1 °C of its settled point and takes 6 minutes to achieve maximum stability.

Speeding up the calibration process can be accomplished by knowing how soon to make the measurement. Typical measurements should be made at the desired temperatures with the desired test probes to establish these times.

Calibration and Adjustment Procedure

Sometimes the user may want to calibrate the Product to improve the temperature set-point accuracy. Calibration is done by adjusting the controller probe calibration constants R0, ALPHA, DELTA, and BETA so that the temperature of the calibrator as measured with a standard thermometer agrees more closely with the set-point. The thermometer used must be able to measure the well temperature with higher accuracy than the desired accuracy of the Product. By using a good thermometer and following this procedure the Product can be calibrated to an accuracy of better than 0.5 °C up to 140 °C.

Calibration Points

When calibrating the Product, R0, ALPHA, DELTA, and BETA are adjusted to minimize the set-point error at each of four different temperatures. Any four reasonably-separated temperatures can be used for the calibration. Improved results can be obtained for shorter ranges when using temperatures that are just within the most useful operating range of the Product. The farther apart the calibration temperatures, the larger will be the calibrated temperature range but the calibration error will also be greater over the range. For example, -20.0 °C to 100 °C is chosen as the calibration range, the Product may achieve an accuracy of, say ±0.3 °C over the range -20 °C to 100 °C. Choosing a range of 50 °C to 90 °C may allow the Product to have a better accuracy of maybe ±0.2 °C over the range but outside that range the accuracy may be only ±1.5 °C.

Calibration Procedure

1. Choose four set-points to use in the calibration of the R0, ALPHA, DELTA, and BETA parameters. These set-points are generally –25 °C, 0 °C, 75°C, and 140 °C but other set-points can be used if desired or necessary.
2. Set the Product to the low set-point. When the Product reaches the set-point and the display is stable, wait at least 15 minutes and then take a reading. Sample the set-point resistance by holding down **SET** and pushing **DOWN**. Write these values down as T1 and R1 respectively.
3. Repeat step 2 for the other set-points recording them as T1, R1, T2, R2, T3, R3, T4 and R4 respectively.
4. If adjustment is needed, use the recorded results to calculate new values for the R0, ALPHA, DELTA, and BETA.

Compute DELTA

$$A = T_4 - T_3$$

$$B = T_3 - T_2$$

$$C = \left[\frac{T_4}{100}\right]\left[1 - \frac{T_4}{100}\right] - \left[\frac{T_3}{100}\right]\left[1 - \frac{T_3}{100}\right]$$

$$D = \left[\frac{T_3}{100}\right]\left[1 - \frac{T_3}{100}\right] - \left[\frac{T_2}{100}\right]\left[1 - \frac{T_2}{100}\right]$$

$$E = R_3 - R_2$$

$$F = R_2 - R_1$$

$$delta = \frac{AF - BE}{DE - CF}$$

$T_{1\text{-}4}$ - Measured temperature using the reference thermometer.

$R_{1\text{-}4}$ - Value of R display. (Push **SET** and **DOWN** at the same time.)

where

T_1 and **R_1** are the measured temperature and resistance at -25 °C

T_2 and **R_2** are the measured temperature and resistance at 0 °C

T_3 and **R_3** are the measured temperature and resistance at 75 °C

T_4 and **R_4** are the measured temperature and resistance at 140 °C

Compute R0 and ALPHA

$$a_1 = T_2 + delta\left[\frac{T_2}{100}\right]\left[1 - \frac{T_2}{100}\right]$$

$$a_3 = T_4 + delta\left[\frac{T_4}{100}\right]\left[1 - \frac{T_4}{100}\right]$$

$$rzero = \frac{R_4 a_1 - R_2 a_3}{a_1 - a_3}$$

$$alpha = \frac{R_2 - R_4}{R_4 a_1 - R_2 a_3}$$

delta is the new value of DELTA computed above.

Compute BETA

$$x = \left[\frac{T_1}{100}\right] - 1$$

$$y = \left[\frac{T_1}{100}\right]$$

$$beta = \frac{1}{(alpha)(x)(y^3)} + \frac{T_1}{(x)(y^3)} - \frac{delta}{y^2} - \frac{\frac{R_1}{rzero}}{(alpha)(x)(y^3)}$$

Where T_1 and R_1 are the measured temperature and resistance at –25.00 °C and **alpha**, **rzero**, and **delta** are the new values of ALPHA, R0, and DELTA calculated above.

To program the new values for DELTA (delta), R0 (rzero), ALPHA (alpha), BETA (beta) into the Product:

1. See *Calibration Parameters* to display R0.
2. Push **SET** then use **UP** or **DOWN** until the correct numerical setting is displayed. Push **SET** to accept the new value.
3. Repeat step 2 for ALPHA and DELTA.

Accuracy and Repeatability

Check the accuracy of the Product at various points over the calibrated range. If the Product does not pass specification at all set-points, repeat the Calibration Procedure.

Maintenance

For proper maintenance of the Product, follow these guidelines:

- Ice will build up over a period of time if the unit is operated at sub-zero temperatures, allowing water to pool in the well at temperatures above 0.0 °C. The user needs to drain the water build up after every use. Two methods are available for draining the water:
  - Remove the insert from the well and tip the unit upside down draining all water.
  - Take the unit above 100 °C for 1 hour causing the water to evaporate.
- If the outside of the Product becomes soiled, wipe it clean with a damp cloth and mild detergent. Do not use harsh chemicals on the surface which can damage the paint.
- Be sure that the well of the calibrator is kept clean and clear of any foreign matter.
- Do not use fluids to clean out the well.
- Handle the Product with care. Avoid knocking or dropping the Product.
- If a hazardous material is spilled on or inside the Product, the user is responsible for taking the appropriate decontamination steps as outlined by the national safety council with respect to the material.
- If the mains supply cable becomes damaged, replace it with a cord with the appropriate gauge wire for the current of the Product. If there are any questions, call an Authorized Service Center (see *Contact Fluke Calibration*) for more information.
- Before using any cleaning or decontamination method except those recommended by Fluke Calibration, users should check with an Authorized Service Center to be sure that the proposed method will not damage the equipment.

Troubleshooting Problems, Possible Causes, and Solutions

This section contains information on troubleshooting.

In the event that the Product appears to function abnormally, this section can help to find and solve the problem. Several possible problem conditions are described along with likely causes and solutions. If a problem arises, read Table 3 carefully and attempt to understand and solve the problem. If the problem cannot otherwise be solved, contact an Authorized Service Center (see *Contact Fluke Calibration* for assistance. Be sure to have the model number, serial number, voltage, and problem description available.

Table 3. Troubleshooting

Problem	Possible Causes and Solutions
Incorrect temperature reading	**Incorrect Calibration parameters.** Incorrect R0, ALPHA, DELTA, and BETA parameters. Find the value for R0, ALPHA, DELTA, and BETA on the Report of Calibration that was shipped with the Product. Reprogram the parameters into the instrument (see *Calibration Parameters*). Allow the Product to stabilize and verify the accuracy of the temperature reading. **Controller locked up.** The controller may have locked up due to a power surge or other aberration. Initialize the system by performing the Factory Reset Sequence. **Factory Reset Sequence.** Hold **SET** and **EXIT** down simultaneously while powering up the Product. The Product display shows '-init-', the model number, and the firmware version. Each of the controller parameters and calibration constants must be reprogrammed. The values can be found on the Report of Calibration (see *Calibration Parameters*).
The Product heats or cools too quickly or too slowly	**Incorrect scan and scan rate settings.** The scan and scan rate settings may be set to unwanted values. Check the Scan and Scan Rate settings. The scan may be off (if the unit seems to be responding too quickly). The scan may be on with the Scan Rate set low (if unit seems to be responding too slowly).
An **o** shows at the left of the display	**External switch test is open**. The displayed temperature is frozen keeping the set-point from scanning. Push **DOWN** to turn the switch test off.
The display shows an error code	**Controller problem.** The error messages signify problems with the controller. Err 1 - a RAM error Err 2 - a NVRAM error Err 3 - a Structure error Err 4 - an ADC setup error Err 5 - an ADC ready error Initialize the system by performing the Factory Reset Sequence described above.

Table 3. Troubleshooting

Problem	Possible Causes and Solutions
The display shows Err 6 and flashes SEnSor	**Defective control sensor**. The control sensor may be shorted, open or otherwise damaged. Perform the Factory Reset Sequence described above. If this does not fix the problem, contact Fluke Calibration.
The display shows Err 7	**Heater control error**. Perform the Factory Reset Sequence as described above to initialize the Product. If the Product repeats the error code, turn the Product off and allow the unit to sit at least one-half hour. Turn the Product back on. If the Product repeats the error code, turn off the Product and contact Fluke Calibration for a return authorization and for instructions on returning the unit.
Temperature readout is not the actual temperature of the well	**May need calibration**. With the Product stable, slowly rotate the unit. If no change occurs, the unit may need to be calibrated. Contact Fluke Calibration. **RF energy emissions**. If the display changes more than twice the normal display deviation, another unit in the area could be emitting RF energy. Move the Product to a different location and rotate the Product again. If the temperature is correct in this new area or deviates differently than the first are, RF energy is present in the room. If a user must perform the test in the affected area, use the comparison test to eliminate any possible errors.