FLUKE®
Calibration

9103

Dry-Well

User’s Guide

PN 2673813
March 2013

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Fluke Corporation
P.O. Box 9090
Everett, WA 98206-9090
U.S.A.

Fluke Europe B.V.
P.O. Box 1186
5602 BD Eindhoven
The Netherlands

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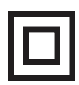
1 Before You Start

1.1 Symbols Used

Table 1 lists the International Electrical Symbols. Some or all of these symbols may be used on the instrument or in this manual.

Table 1 *International Electrical Symbols*

Symbol	Description
	AC (Alternating Current)
	AC-DC
	Battery
	CE Complies with European Union Directives
	DC
	Double Insulated
	Electric Shock
	Fuse
	PE Ground
	Hot Surface (Burn Hazard)
	Read the User's Manual (Important Information)
	Off
	On

Symbol	Description
	Canadian Standards Association
CAT II	OVERVOLTAGE (Installation) CATEGORY II, Pollution Degree 2 per IEC1010-1 refers to the level of Impulse Withstand Voltage protection provided. Equipment of OVERVOLTAGE CATEGORY II is energy-consuming equipment to be supplied from the fixed installation. Examples include household, office, and laboratory appliances.
	C-TIC Australian EMC Mark
	The European Waste Electrical and Electronic Equipment (WEEE) Directive (2002/96/EC) mark.

1.2 Safety Information

Use this instrument only as specified in this manual. Otherwise, the protection provided by the instrument may be impaired.

The following definitions apply to the terms "Warning" and "Caution".

- "Warning" identifies conditions and actions that may pose hazards to the user.
- "Caution" identifies conditions and actions that may damage the instrument being used.

1.2.1 ⚠ Warnings

To avoid personal injury, follow these guidelines.

BURN HAZARD – DO NOT touch the well access surface of the unit. The temperature of the well access is the same as the actual temperature shown on the display. If the instrument is set at 140°C and the display reads 140°C, the well is at 140°C.

DO NOT remove inserts at high temperatures. Inserts are the same temperature as the display temperature. Use extreme care when removing hot inserts.

DO NOT operate this unit without a properly grounded, properly polarized power cord.

DO NOT connect this unit to a non-grounded, non-polarized outlet.

HIGH VOLTAGE is used in the operation of this equipment. **SEVERE INJURY OR DEATH** may result if personnel fail to observe safety precautions. Before working inside the equipment, turn the power off and disconnect the power cord.

Always replace the fuse with one of the same rating, voltage, and type.

Overhead clearance is required. **DO NOT** place this instrument under a cabinet or other structure.

DO NOT use this unit for any application other than calibration work.

DO NOT use this unit in environments other than those listed in the user's guide.

DO NOT turn the unit upside down with the inserts in place; the inserts will fall out of the unit.

DO NOT operate near flammable materials.

Use of this instrument at **HIGH TEMPERATURES** for extended periods of time requires caution.

Completely **unattended high temperature operation** is not recommended for safety reasons.

Before initial use, after transport, and anytime the dry-well has not been energized for more than 10 days, the calibrator must be energized for a dry-out period of 1 to 2 hours before it can be assumed to meet all of the safety requirements of the IEC1010-1.

Follow all safety guidelines listed in the user's manual.

Calibration equipment should only be used by Trained Personnel.

1.2.2 ⚠ Cautions

To avoid possible damage to the instrument, follow these guidelines.

- Components and heater lifetime can be shortened by continuous high temperature operation.
- Allow for test probe expansion inside the well as the dry-well heats.
- **DO NOT** use fluids to clean out the well.
- Never introduce foreign material into the probe hole of the insert. Fluids, etc. can leak into the calibrator causing damage.
- **DO NOT** change the values of the calibration constants from the factory set values. The correct setting of these parameters is important to the safety and proper operation of the calibrator.
- **DO NOT** slam the probe stems into the well. This type of action can cause a shock to the sensor and affect the calibration.
- **DO** use a ground fault interrupt device.

1.3 Authorized Service Centers

Please contact one of the following authorized Service Centers to coordinate service on your Hart product:

Fluke Corporation, Hart Scientific Division

799 E. Utah Valley Drive

American Fork, UT 84003-9775
USA

Phone: +1.801.763.1600
Telefax: +1.801.763.1010
E-mail: support@hartscientific.com

Fluke Nederland B.V.
Customer Support Services
Science Park Eindhoven 5108
5692 EC Son
NETHERLANDS

Phone: +31-402-675300
Telefax: +31-402-675321
E-mail: ServiceDesk@fluke.nl

Fluke Int'l Corporation
Service Center - Instrimpex
Room 2301 Sciteck Tower
22 Jianguomenwai Dajie
Chao Yang District
Beijing 100004, PRC
CHINA

Phone: +86-10-6-512-3436
Telefax: +86-10-6-512-3437
E-mail: xingye.han@fluke.com.cn

Fluke South East Asia Pte Ltd.
Fluke ASEAN Regional Office
Service Center
60 Alexandra Terrace #03-16
The Comtech (Lobby D)
118502
SINGAPORE

Phone: +65 6799-5588

Telefax: +65 6799-5588

E-mail: antng@singa.fluke.com

When contacting these Service Centers for support, please have the following information available:

- Model Number
- Serial Number
- Voltage
- Complete description of the problem

2 Introduction

The Hart Scientific 9103 Dry-well may be used as a portable instrument or bench top temperature calibrator for calibration thermocouples and RTD temperature probes. The 9103 is small enough to use in the field and accurate enough to use in the lab. With an ambient temperature of 23°C (74°F), calibrations may be done over a range of –25°C to 140°C (–13°F to 284°F). The resolution of the 9103 temperature display is 0.1 degrees.

The calibrator 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 temperature is accurately controlled by Hart's hybrid analog/digital controller. The controller uses a precision platinum RTD as a sensor and controls the well temperature with pulsed driven Thermal Electric Devices (TED).

The LED display panel continuously shows the current well temperature. The temperature may be easily set with the control buttons to any desired temperature within the specified range. The calibrator's multiple fault protection devices insure user and instrument safety and protection.

The 9103 Dry-well was designed for portability, low cost, and ease of operation. Through proper use, the instrument will continuously provide accurate calibration of temperature sensors and devices. The user should be familiar with the safety guidelines and operating procedures of the calibrator as described in this user manual.

3 Specifications and Environmental Conditions

3.1 Specifications

Operating Range	–25°C to 140°C (–13°F to 284°F), at 23°C ambient
Accuracy	±0.25°C (±1.0°C in holes > ¼” [6.4 mm])
Stability	±0.02°C at –25°C ±0.04°C at 140°C
Well-to-Well Uniformity	±0.1 with similar probes
Resolution	0.1°C or °F
Display Scale	°F or °C, switchable
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	4.875 inches (124 mm)
Power Requirements	115 VAC (±10%), 1.3 A or 230 VAC (±10%) 0.7 A, switchable, 50/60 Hz, 150W
Inserts	A, B, or C
Computer Interface	RS-232 included with free Interface-*it* Software (Model 9930)
Size	10.25” H x 5.63” W x 9.63” D (26.1 x 14.3 x 24.5 cm)
Weight	12 lb. (5.7 kg)

3.2 Environmental Conditions

Although the instrument has been designed for optimum durability and trouble-free operation, it must be handled with care. The instrument should not be operated in an excessively dusty or dirty environment. Maintenance and cleaning recommendations can be found in the Maintenance Section of this manual.

The instrument operates safely under the following conditions:

- temperature range: 5–45°C (41–113°F)
- ambient relative humidity: 15 - 50%
- pressure: 75kPa - 106kPa
- mains voltage within ± 10% of nominal
- vibrations in the calibration environment should be minimized
- altitude less than 2,000 meters

4 Quick Start

4.1 Unpacking

Unpack the instrument 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
- Power Cord
- Insert Removal Tongs
- 9930 Software
- Serial Cable
- Manual

4.2 Setup

Place the calibrator on a flat surface with at least 6 inches of free space around the instrument. Plug the power cord into a grounded mains outlet. Observe that the nominal voltage corresponds to that indicated on the back of the calibrator.

Turn on the power to the calibrator by toggling the switch on the power entry module. The fan should begin quietly blowing air through the instrument and the controller display should illuminate after 3 seconds. After a brief self-test the controller should begin normal operation. If the unit fails to operate please check the power connection.

The display will begin to show the well temperature and the Thermal Electric Devices will start operating to bring the temperature of the well to the set-point temperature.

4.3 Power

Plug the instrument power cord into a mains outlet of the proper voltage, frequency, and current capability. Refer to Section 3.1, Specifications, for power details. Turn the instrument on using the rear panel "POWER" switch. The instrument will turn on and begin to heat to the previously programmed temperature set-point. The front panel LED display will indicate the actual instrument temperature.

4.4 Setting the Temperature

Section 7.2 explains in detail how to set the temperature set-point on the calibrator using the front panel keys. The procedure is summarized here.

(1) Press "SET" **twice** to access the set-point value.

(2) Press "UP" or "DOWN" to change the set-point value.

(3) Press "SET" to program in the new set-point.

(4) Press "EXIT" to return to the temperature display.

When the set-point temperature is changed 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 may require 25 minutes to reach the set-point depending on the span. Another 6 to 10 minutes is required to stabilize within ±0.1°C of the set-point. Ultimate stability may take 20 to 30 minutes more of stabilization time.

5 Parts and Controls

The user should become familiar with the instrument and its parts as described below.

5.1 Back Panel

The back panel is shown in Figure 1 on page 14.

Power Cord – At the rear of the calibrator is the removable power cord inlet that plugs into an IEC grounded socket.

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

Serial Port – A DB-9 male connector is present for interfacing the calibrator to a computer or terminal with serial RS-232 communications.

Fan – The fan inside the calibrator runs continuously when the unit is being operated to provide cooling for the instrument. At high temperatures or during heating, the fan slows down. Slots at the top and around the two corners of the calibrator are provided for airflow. The area around the calibrator must be kept clear to allow adequate ventilation. The airflow is directed up.

5.2 Front Panel

The front panel is shown in Figure 2 on page 15.

Controller Display - The digital display is an important part of the temperature controller because it not only displays set and actual temperatures but also displays various calibrator 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. The control buttons (SET, DOWN, UP, and EXIT) are used to set the calibrator temperature set-point and to access and set other operating parameters and calibration parameters.

Setting the control temperature is done directly in degrees of the current scale. It can be set to one-tenth of a degree Celsius or Fahrenheit.

The functions of the buttons are as follows:

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 or parameter.

UP – Used to increment the displayed value or parameter.

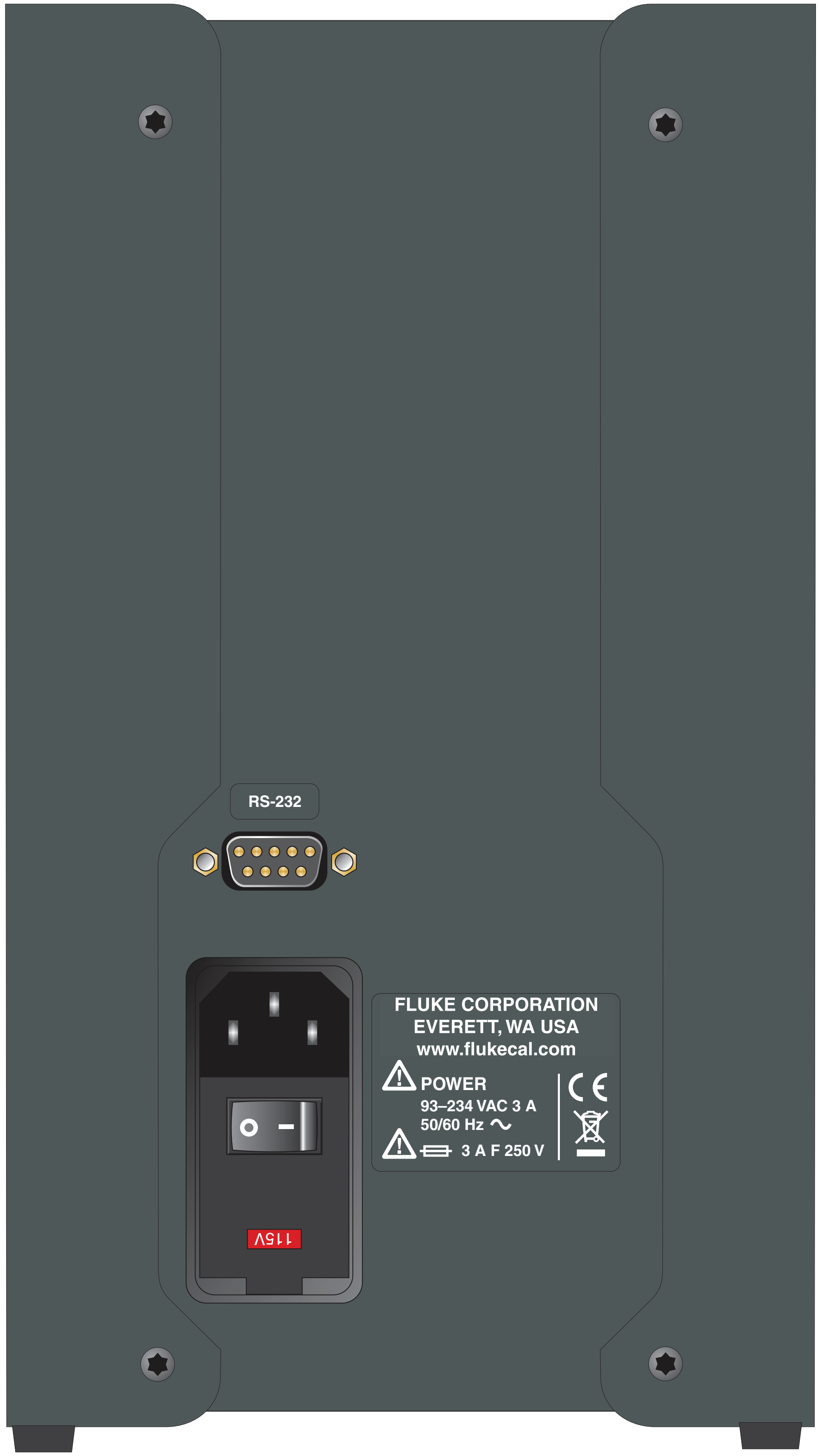


Figure 1 *9103 Back Panel*

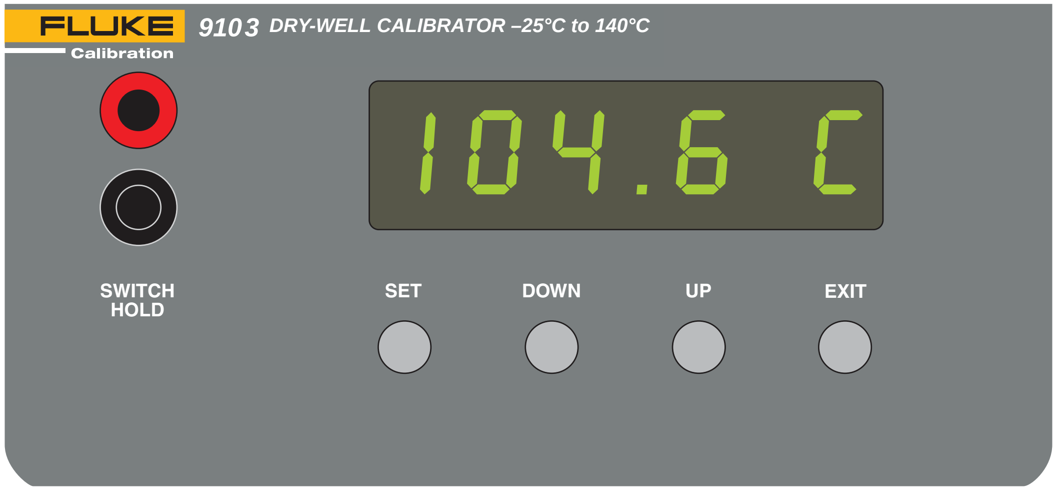


Figure 2 *9103 Front Panel*

EXIT – Used to exit a function and to skip to the next function. Any changes made to the displayed value are ignored. Holding “EXIT” for about ½ a second returns control to the main display.

Switch Hold – These terminals are for connecting and testing external thermal switches and cutouts.

5.3 Constant Temperature Block Assembly

The “Block” is made of aluminum and provides a relatively constant and accurate temperature environment in which the sensor that is to be calibrated is inserted. A 1.25 inch diameter well is provided that may be used for sensors of that size or may 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 is imbedded at the base of the block assembly to sense and control the temperature of the block. The entire assembly is suspended in an air cooled chamber thermally isolated from the chassis and electronics.

5.4 Probe Sleeves

The probe sleeves are show in Figure 3.

The calibrator is supplied 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 allowing the user’s probe to fit snugly into the well whatever the diameter of the probe.

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

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

or

- Insert D: 2 each 3 mm, 2 each 4 mm, and 2 each 6 mm holes

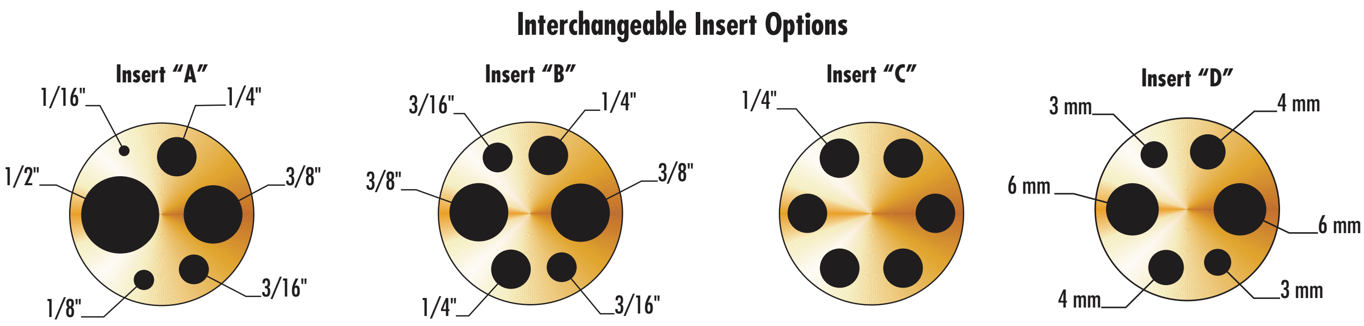


Figure 3 *Inserts Available for the 9103 Block Assembly*

6 General

6.1 Changing Display Units

The instrument can display temperature in Celsius or Fahrenheit. The instruments are shipped from the factory set to Celsius. To change to Fahrenheit or back to Celsius there are two ways:

1. Press “SET” and “UP” simultaneously. This will change the display units.

or

1. Press the “SET” key three times from the temperature display to show

```
Un = C
```

2. Press the “UP” or “DOWN” key to change units.
3. Press “SET” to store changes.

6.2 Thermal Electric Devices (TED)

The power of the instrument 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.

7 Controller Operation

This section discusses in detail how to operate the calibrator temperature controller using the front control panel. By using the front panel key-switches and LED display, the user may 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 the flowchart in Figure 4 on page 20. This chart may be copied for reference.

In the following discussion a button with the word SET, UP, DOWN, or EXIT inside indicates the panel button while the dotted box indicates the display reading. Explanation of the button or display reading are to the right of each button or display value.

7.1 Well Temperature

The digital LED display on the front panel allows direct viewing of the actual well temperature. This temperature value is what is normally shown on the display. The units, C or F, of the temperature value are displayed at the right. For example,

100.0 C	*Well temperature in degrees Celsius*

The temperature display function may be accessed from any other function by pressing the "EXIT" button.

7.2 Temperature Set-point

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

Setting the temperature involves selecting one of the eight (8) set-points in memory and then adjusting the set-point value.

7.2.1 Programmable Set-points

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

To set the temperature, first select the set-point memory. This function is accessed from the temperature display function by pressing "SET". The number of the set-point memory currently being used is shown at the left on the display followed by the current set-point value.

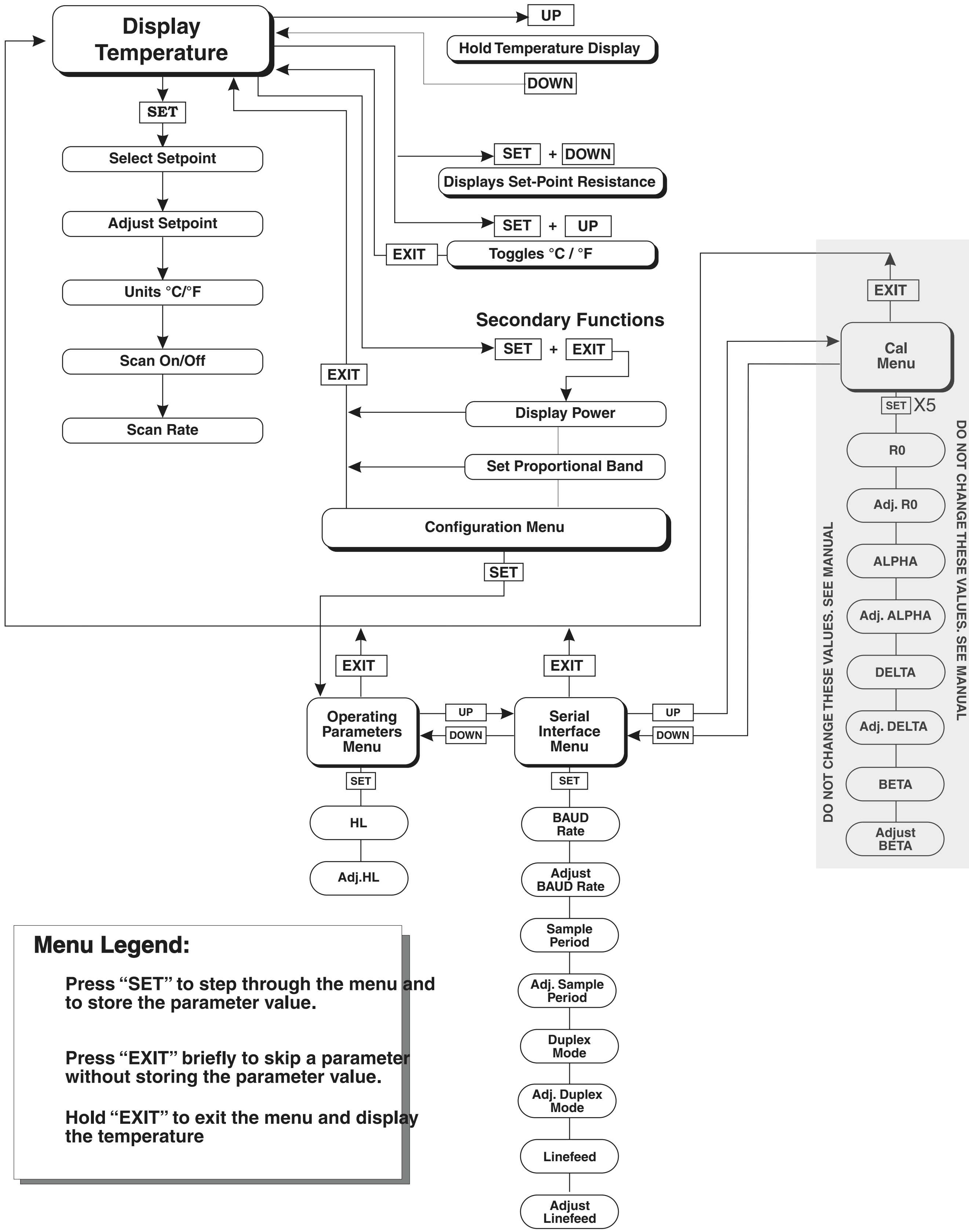


Figure 4 *Controller Operation Flowchart*

`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 the set-point memory press “UP” or “DOWN”.

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

Press “SET” to accept the new selection and access the set-point value.

[SET] *Accept selected set-point memory*

7.2.2 Set-point Value

The set-point value may be adjusted after selecting the set-point memory and pressing “SET”.

`4 120` *Set-point value in °C*

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

`125.0` *New set-point value*

When the desired set-point value is reached press “SET” to accept the new value and to access the temperature scale units. If “EXIT” is pressed, any changes made to the set-point are ignored.

[SET] *Accept new set-point value*

7.2.3 Temperature Scale Units

The temperature scale units of the controller can be set by the user to degrees Celsius (°C) or Fahrenheit (°F). The units are used in displaying the well temperature, set-point, and proportional band.

Press “SET” after adjusting the set-point value to change display units.

`Un= C` *Scale units currently selected*

Press “UP” or “DOWN” to change the units.

`Un= F` *New units selected*

7.3 Scan

The scan rate can be set and enabled 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.

7.3.1 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*

Press "UP" or "DOWN" to toggle the scan on or off.

`Sc=On` *Scan function on*

Press "SET" to accept the present setting and continue.

[SET] *Accept scan setting*

7.3.2 Scan Rate

The next function in the main menu is the scan rate. The scan rate can be set from .1 to 99.9°C/minute. The maximum scan rate however is actually limited by the natural heating or cooling rate of the instrument. This rate is often less than 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 per minute, degrees C or F depending on the selected units.

`Sr= 10.0` *Scan rate in °C/min.*

Press "UP" or "DOWN" to change the scan rate.

`Sr= 2.0` *New scan rate*

Press "SET" to accept the new scan rate and continue.

[SET] *Accept scan rate*

7.4 Temperature Display Hold

The calibrator has a display hold function which allows action of an external switch to freeze the displayed temperature and stop the set-point from scanning. This function is useful for testing thermal switches and cutouts. This section explains the functions available for operating the temperature hold feature. An example follows showing how to set up and use the hold feature to test a switch.

7.4.1 Enabling the Hold Temperature Display

Pressing the "UP" button when the temperature is displayed enables 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 being used, 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 press "DOWN".

7.4.2 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 will be set automatically under any of the following conditions, (1) a new set-point number is selected, (2) the set-point value is changed, (3) a new set-point is set through the communications channels.

7.4.3 Switch Wiring

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

7.4.4 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, follow the steps below.

1. Connect the switch wires to the terminals on the front of the calibrator and place the switch in the well.
2. Enable set-point scanning by setting the scan to "ON" in the primary menu (see Section 7.3.1).
3. Set the scan rate to a low value, say 1.0°C/min. (see Section 7.3.2). If the scan rate is too high you may 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. You may need to 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 Section 8 for instructions on configuring the RS-232 communications interface.

7.5 Set-point Resistance

To display the Set-point Resistance, press the "SET" and "DOWN" keys simultaneously when the temperature is displayed. When the "SET" and "DOWN" keys are released the temperature is again displayed.

7.6 Temperature Scale Units

To toggle between °C and °F, press the "SET" and "UP" keys simultaneously when the temperature is displayed.

7.7 Secondary Menu

Functions which are used less often are accessed within the secondary menu. Pressing "SET" and "EXIT" simultaneously and then releasing accesses the secondary menu. The first function in the secondary menu is the heater power display. (See Figure 4 on page 20.)

7.8 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 lets the user know how stable the well temperature is. 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. Press “SET” and ”EXIT” simultaneously and release. The heater power is displayed as a percentage of full power.

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

To exit out of the secondary menu press and hold “EXIT”. To continue on to the proportional band setting function press “EXIT” momentarily or “SET”.

7.9 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 fairly constant temperature.

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 deviation 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 to about 15.0°C. The proportional band width may be altered by the user if he desires to optimize the control characteristics for a particular application.

The proportional band width is easily adjusted from the front panel. The width may be set to discrete values in degrees C or F depending on the selected units. The proportional band adjustment can be accessed within the secondary menu. Press "SET" and "EXIT" to enter the secondary menu and show the heater power. Then press "SET" twice 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 press "UP" and "DOWN".

4.0 — *New proportional band setting*

To store the new setting press "SET". Press "EXIT" to continue without storing the new value.

SET — *Accept the new proportional band setting*

7.10 Controller Configuration

The controller has a number of configuration and operating options and calibration parameters that are programmable via the front panel. These are accessed from the secondary menu after the proportional band function by pressing "SET". Pressing "SET" again enters the first of three groups of configuration parameters—operating parameters, serial interface parameters and calibration parameters. **The groups are selected using the "UP" and "DOWN" keys and then pressing "SET".** (See Figure 4 on page 20.)

7.11 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 126 °C. For safety, a user can adjust the High Limit parameter down so the maximum temperature set-point is restricted.

Press “SET” to enable adjustment of the High Limit parameter.

HL	*Flashes “HL” and then displays the setting*
H=126	*Current HL setting*

Adjust the HL parameter using “UP” or “DOWN”.

H=90	*New High Limit setting*

Press “SET” to accept the new High Limit parameter.

7.12 Serial Interface Parameters

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

SErIAL	*Serial RS-232 interface parameters menu*

The serial interface parameters menu contains parameters which determine the operation of the serial interface. These controls only apply to instruments fitted with the serial interface. The parameters in the menu are: BAUD rate, sample period, duplex mode, and linefeed.

Press “SET” to access the serial parameters.

7.12.1 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 may be programmed to 300 600, 1200, **2400**, 4800, or 9600 BAUD. 2400 BAUD is the default setting. Use “UP” or “DOWN” to change the BAUD rate value.

4800 b	*New BAUD rate*

Press "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.

7.12.2 Sample Period

The sample period is the next parameter in the serial interface parameter menu. 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 five 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 use "SET" to set the sample rate to the displayed value. "EXIT" does not store the new value.

SP=60	*New sample period*

7.12.3 Duplex Mode

The next parameter is the duplex mode. The duplex mode may be set to full duplex or half duplex. With full duplex any commands received by the calibrator via 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 displays the setting*

d=FULL	*Current duplex mode setting*

The mode may be changed using "UP" or DOWN" and pressing "SET".

d=HALF	*New duplex mode setting*

7.12.4 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*

The mode may be changed using "UP" or "DOWN" and pressing "SET".

`LF=OFF` *New linefeed setting*

7.13 Calibration Parameters

The operator of the calibrator controller has access to a number of the calibration constants namely 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 calibrator. Access to these parameters is available to the user only so that in the event that the controller memory fails the user may 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 calibrator calibration constants from the factory set values. The correct setting of these parameters is important to the safety and proper operation of the calibrator.*

The calibration parameters menu is indicated by,

`CAL` *Calibration parameters menu*

Press "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 may be adjusted by an experienced user to improve the accuracy of the calibrator.

Note: The calibration procedure is explained in Section 10.

7.13.1 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 instrument accuracy.

7.13.2 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.

7.13.3 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 instrument accuracy.

7.13.4 BETA

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

8 Digital Communication Interface

The calibrator is capable of communicating with and being controlled by other equipment through the digital serial interface.

With a digital interface the instrument may 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 on page 34.

8.1 Serial Communications

The calibrator is installed with an RS-232 serial interface that allows serial digital communications over fairly long distances. With the serial interface the user may access any of the functions, parameters and settings discussed in Section 7 with the exception of the BAUD rate setting.

8.1.1 Wiring

The serial communications cable attaches to the calibrator through the DB-9 connector at the back of the instrument. Figure 5 on page 31 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.

8.1.2 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

Figure 5 *Serial Cable Wiring*

interface menu. The serial interface parameters menu is outlined in Figure 4 on page 20.

To enter the serial parameter programming mode first press "EXIT" while pressing "SET" and release to enter the secondary menu. Press "SET" repeatedly until the display reads "PAr". Press "UP" until the serial interface menu is indicated with "SErIAL". Finally press "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.

8.1.2.1 BAUD Rate

The BAUD rate is the first parameter in the menu. The display prompts with the BAUD rate parameter by showing "bAUd". Press "SET" to choose to set the BAUD rate. The current BAUD rate is displayed. The BAUD rate of the 9103 serial communications may 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. Press "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.

8.1.2.2 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 five seconds. The automatic sampling is disabled with a sample period of 0. Press "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.

8.1.2.3 Duplex Mode

The next parameter is the duplex mode indicated with "dUPL". The duplex mode may 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. The mode may be changed using "UP" or "DOWN" and pressing "SET".

8.1.2.4 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. The mode may be changed using "UP" or "DOWN" and pressing "SET".

8.1.3 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 may be sent via the serial interface to set the temperature set-point and view or program the various parameters. The interface commands are discussed in Section 8.2 . All commands are ASCII character strings terminated with a carriage-return character (CR, ASCII 13).

8.2 Interface Commands

The various commands for accessing the calibrator 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, hence either may be used. Commands may be abbreviated to the minimum number of letters that determines a unique command. A command may be used to either set a parameter or display 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 following list of commands, characters or data within brackets, "[" and "]", are optional for the command. A slash, "/", denotes alternate characters or data. Numeric data, denoted by "n", may be entered in decimal or exponential notation. Characters are shown in lower case although upper case may be used. Spaces may be added within command strings and will simply be ignored. Backspace (BS, ASCII 8) may be used to erase the previous character. A terminating CR is implied with all commands.

Table 2 *9103 Controller Communications Commands*

Command Description	Command Format	Command Example	Returned	Returned Example	Acceptable Values
Display Temperature					
Read current set-point	s[etpoint]	s	set: 999.9 {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	scan: {ON or OFF}	scan: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:12.4C/min	
Set scan rate	sr[ate]=n	sr=1.1			.1 to 99.9
Read hold	ho[ld]	ho	hold: open/closed, 99.9 {C or F}	hold: open, 30.5 C	
Secondary Menu					
Read proportional band setting	pr[opband]	pr	pb: 999.9	pb: 15.9	
Set proportional band to *n*	pr[opband]=n	pr=8.83			Depends on Configuration
Read heater power (duty cycle)	po[wer]	po	po: 999.9	po: 1.0	
Configuration Menu					
Operating Parameters Menu					
Read high limit	hl	hl	hl:999	hl:126	
Set high limit	hl=n	hl=90			0–126
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					

Table 2 *9103 Controller Communications Commands continued*

Command Description	Command Format	Command Example	Returned	Returned Example	Acceptable Values
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.				

9 Test Probe Calibration

For optimum accuracy and stability, allow the calibrator 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 switching the power off.

9.1 Calibrating a Single Probe

Insert the probe to be calibrated into the well of the calibrator. 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.**

9.2 Stabilization and Accuracy

The stabilization time of the calibrator 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.

10 Calibration Procedure

Sometimes the user may want to calibrate the instrument 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 calibrator. By using a good thermometer and following this procedure the instrument can be calibrated to an accuracy of better than 0.5°C up to 140°C.

10.1 Calibration Points

In calibrating the instrument, R0, ALPHA, DELTA, and BETA, are adjusted to minimize the set-point error at each of three different temperatures. Any three reasonably separated temperatures may 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 instrument. 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. If, for instance, –20°C to 100°C is chosen as the calibration range, the calibrator may achieve an accuracy of say ±0.3°C over the range –20 to 100°C. Choosing a range of 50°C to 90°C may allow the calibrator to have a better accuracy of maybe ±0.2°C over that range but outside that range the accuracy may be only ±1.5°C.

10.2 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, 60°C, and 125°C but other set-points may be used if desired or necessary.
2. Set the instrument to the low set-point. When the instrument reaches the set-point and the display is stable, wait 15 minutes or so and then take a reading. Sample the set-point resistance by holding down the "SET" key and pressing the "DOWN" key. Write these values down as T_1 and R_1 respectively.
3. Repeat step 2 for the other three set-points recording them as T_1, R_1, T_2, R_2, T_3, R_3, T_4 and R_4 respectively.
4. Using the recorded data, calculate new values for R0, ALPHA, DELTA, and BETA parameters using the equations given below.

10.2.1 Compute DELTA

$$A = T_4 - T_3$$

$$B = T_3 - T_2$$

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

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

$$E = R_4 - R_3$$

$$F = R_3 - R_2$$

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

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

$\mathbf{R_{1\text{-}4}}$ - Value of R from display of 9103 (Press SET and DOWN at the same time.)

where

$\mathbf{T_1}$ and $\mathbf{R_1}$ are the measured temperature and resistance at –25°C

$\mathbf{T_2}$ and $\mathbf{R_2}$ are the measured temperature and resistance at 0°C

$\mathbf{T_3}$ and $\mathbf{R_3}$ are the measured temperature and resistance at 60°C

$\mathbf{T_4}$ and $\mathbf{R_4}$ are the measured temperature and resistance at 125°C

10.2.2 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.

10.2.3 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.

Program the new values for DELTA (delta), R0 (rzero), ALPHA (alpha), BETA (beta) into the instrument with the following steps.

1. Reference Section 7.13 to display R_0.
2. Press “SET” then use the “UP” or “DOWN” keys until the correct numerical setting is displayed. Press “SET” to accept the new value.
3. Repeat step 2 for ALPHA and DELTA.

10.2.4 Accuracy and Repeatability

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

11 Maintenance

- The instrument has been designed with the utmost care. Ease of operation and simplicity of maintenance have been a central theme in the product development. Therefore, with proper care the instrument should require very little maintenance. Avoid operating the instrument in an oily, wet, dirty, or dusty environment.
- 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: 1) Remove the insert from the well and tip the unit upside down draining all water. 2) Take the unit above 100°C for a period of one hour causing the water to evaporate.
- If the outside of the instrument becomes soiled, it may be wiped clean with a damp cloth and mild detergent. Do not use harsh chemicals on the surface which may 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.
- The instrument should be handled with care. Avoid knocking or dropping the instrument.
- If a hazardous material is spilt on or inside the instrument, 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 cord becomes damaged, replace it with a cord of the appropriate gauge wire for the current of the instrument. If there are any questions, call an Authorized Service Center for more information.
- Before using any cleaning or decontamination method except those recommended by Hart, users should check with an Authorized Service Center to be sure that the proposed method will not damage the equipment.
- If the instrument is used in a manner not in accordance with the equipment design, the operation of the calibrator may be impaired or safety hazards may arise.

12 Trouble Shooting

If problems arise while operating the instrument, this section provides some suggestions that may help you solve the problem. A wiring diagram is also included.

12.1 Troubleshooting

In the event that the instrument appears to function abnormally, this section may help to find and solve the problem. Several possible problem conditions are described along with likely causes and solutions. If a problem arises, please read this section carefully and attempt to understand and solve the problem. If the problem cannot otherwise be solved, contact an Authorized Service Center (see Section 1.3 on page 3) for assistance. Be sure to have the model number and serial number of your instrument available.

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 instrument. Reprogram the parameters into the instrument (see Section 7.13, Calibration Parameters). Allow the instrument 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 the SET and EXIT buttons down at the same time while powering up the instrument. The instrument displays 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 Test that was shipped with the instrument.
The instrument 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" is displayed at the left of the display	**External switch test is open.** The displayed temperature is frozen keeping the set-point from scanning. Turn the switch test off by pressing the "DOWN" button of the front panel.
The display shows any of the following: Err 1. Err 2. Err 3. Err 4. or Err 5	**Controller problem.** The error messages signify the following 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 describe above.

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 a Hart Scientific Authorized Service Center.
The display shows Err 7	**Heater control error.** Initialize the unit by performing the Factory Reset Sequence as described above. If the unit repeats the error code, turn the unit off and allow the unit to sit at least one-half hour. Turn the unit back on. If the unit repeats the error code, turn off the unit and contact contact a Hart Scientific Authorized Service Center 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 unit stable, slowly rotate the unit. If no change occurs, the unit may need to be calibrated. Contact contact a Hart Scientific Authorized Service Center. **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 unit to a different location and rotate the unit 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 you have to perform the test in the effected area, use the comparison test to eliminate any possible errors.

12.2 CE Comments

12.2.1 EMC Directive

Hart Scientific's equipment has been tested to meet the European Electromagnetic Compatibility Directive (EMC Directive, 89/336/EEC). The Declaration of Conformity for your instrument lists the specific standards to which the unit was tested.

12.2.2 Low Voltage Directive (Safety)

In order to comply with the European Low Voltage Directive (73/23/EED), Hart Scientific equipment has been designed to meet the IEC 1010-1 (EN 61010-1) and IEC 1010-2-010 (EN 61010-2-010) standards.