



REGULUS 4200 USER'S MANUAL

REGULUS 4200 DUAL-POWER TEMPERATURE CALIBRATOR

Operating Instructions

King Nutronics Part Number • 4200-001-001



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CURRENT REVISION

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CHAPTER

1

GENERAL INFORMATION

INTRODUCTION

This publication contains operation instructions for the King Nutronics Corporation Regulus 4200 Dual-Power Temperature Calibrator.

Figure 1-1 depicts the Regulus 4200 Dual-Power Temperature Calibrator. Table 1-1 lists the specifications for the unit.

MANUAL ORGANIZATION

Chapter 1 – General Information

Chapter 2 – Preparation for Use, Storage and Shipment

Chapter 3 – Setup and User Interface

Chapter 4 – Operation

Chapter 5 – Utilities

Chapter 6 – Maintenance

Chapter 7 – Replacement Parts

PRODUCT DESCRIPTION

The King Nutronics Regulus 4200 Dual-Power Temperature Calibrator is an innovative dry well temperature calibration system for field and laboratory use. Lightweight, portable and self-contained, the Regulus 4200 is fast and easy to operate. The Regulus 4200 can generate, measure and display temperature throughout the range of 95°F to 662°F (35°C to 350°C). Well temperature, stability and uniformity are maintained utilizing a unique dual-power technology. The operating efficiency of the Regulus 4200 is vastly superior compared to other instruments in its class.



Figure 1-1 Regulus 4200 Dual-Power Temperature Calibrator

SPECIFICATIONS

Table 1-1. Specifications

PERFORMANCE	
Temperature Range	95°F to 662°F (35°C to 350°C)
Accuracy	0.25°F (0.14°C) Full Range
Display Resolution	0.01°
Set Point Stability	0.05°F (0.027°C)
Average Heating Time*	10 minutes (to 662°F/350°C)
Average Cooling Time*	20 minutes from 662°F to 212°F (350°C to 100°C)
Uniformity (bottom 3" of the well)	0.25°F (0.14°C)

Table 1-1. Specifications (Continued)

GENERAL	
Ambient Operating Temperature	32°F to 120°F (0°C to 49°C)
Ambient Storage Temperature	-67°F to 167°F (-55°C to 75°)
Readout Units	°F, °C or K
Well Size	1" ID, 6" Depth (25.4 mm x 152.4 mm)
Dimensions	11" (W) x 7" (D) x 10" (H)
Weight	15 lb. (6.8 kg) with 4 adapter chucks
Voltage	120 VAC, 60 Hz
Current (max)	9 A
Fuse	10 A
Connectivity	USB-A, USB-B, RS-232

* Heating and cooling times are based on a starting temperature of 70°F (21°C) for heating and 662°F (350°C) for cooling.

EQUIPMENT OVERVIEW

Regulus Dual-Power Technology

The Regulus 4200 features a unique, patent-pending temperature well design utilizing an AC/DC dual-power system not available in other dry well calibrators. This enables the calibrator to heat the well and maintain well temperature more efficiently, with less power demand. This AC/DC dual-power technology is so efficient that the Regulus 4200 can be operated for hours from a portable, battery-powered DC to AC inverter, making the 4200 an ideal solution for field work when AC power is not readily available.

Safety and Thermal Efficiency

Most dry block calibrators exhaust heat from the top of the well, toward the operator and instrument under test. The REGULUS 4200 disperses its temperature well heat away from the operator and the device under test. There is no need for a heat shield or diverter to mitigate the risk of damage to the test instrument or injury to the operator. Additionally, the REGULUS 4200's insulated well design requires less power to reach and maintain temperatures, and there is less heat to exhaust, which all means no danger to the operator from external surfaces heated from hot exhaust air. For added safety, a red status LED alerts the operator whenever the temperature well is heated above 122°F (50°C).

Other LEDs indicate when power is applied to the well, and when the well temperature is stable at set temperatures.

Automated and Programmable Features

Among the many features of the Regulus 4200 are automated switch calibration, ramp and soak routines, and SCPI remote operation mode for automating test and calibration routines for hands-free operation, saving workload time and resources. The Regulus 4200 has RS-232, USB-A and USB-B interface connectivity and can create, store, print, extract and import data files such as test results, switch calibration results and standardization and calibration records. The Regulus 4200 can standardize and calibrate itself automatically using the RS-232 port when connected to compatible equipment.

Precision Adapter Chucks

The Regulus 4200 ships with four precision-ground and honed adapter chucks in the following sizes: 1/4", 3/8", 7/16" and 9/16". The adapter chucks are cylindrical sleeves that fit into the calibrator's temperature well. Each is precision machined to accept common diameters of test items such as thermocouples, resistance thermometers, liquid in glass thermometers (LiG), vapor and gas-filled thermometers and bimetallic thermometers. Custom, multi-hole chuck options are available. Refer to Chapter 7, "REPLACEMENT PARTS" on page 7-1.



Figure 1-2 Adapter Chucks

LIST OF ABBREVIATIONS

The following abbreviations are used in this manual:

Table 1-2. List of Abbreviations

TERM	MEANING
AC	Alternating Current
API	Application Protocol Interface
ADC	Analog to Digital

Table 1-2. List of Abbreviations (Continued)

DC	Direct Current
DMM	Digital Multimeter
LED	Light Emitting Diode
mm	Millimeter
PC	Personal Computer
PRT	Platinum Resistance Thermometer
UID	Unit Identification
USB	Universal Serial Bus
UUT	Unit Under Test
VFD	Vacuum Fluorescence Display
SCPI	Standard Commands for Programmable Instruments
SPRT	Standard Platinum Resistance Thermometer

CONTACT INFORMATION AND TECHNICAL SUPPORT

For technical support, contact:

King Nutronics Corporation
6421 Independence Avenue
Woodland Hills, California, 91367
USA

Phone: (818) 887-5460
FAX: (818) 887-2766
E-mail: support@kingnutronics.com
Website: www.kingnutronics.com

CHAPTER

2

PREPARATION FOR USE, STORAGE AND SHIPMENT

INTRODUCTION

This chapter includes information on initial inspection, safety information, storage and shipment of the Regulus 4200 Dual-Power Temperature Calibrator.

INITIAL INSPECTION

Carefully unpack the Regulus 4200 and inspect for any damage that may have occurred during shipping. If there is shipping damage, please notify the carrier as well as King Nutronics.

Confirm that the following accessories are present:

- Adapter Chucks (4 each)
- Chuck Tool
- Shoulder Strap
- Power Cord
- Pinch-Style Test Lead (1 set)
- RS-232 Cable
- Calibration Certificate
- USB Flash Drive

NOTE: When powered up, the Regulus 4200 serial number is displayed as its UID (Unit Identification) unless changed by the user. The serial number is also located in three places:

1. On the ID plate located on the back of the case.
2. On the calibration label located on the instrument panel.
3. In the adapter chuck storage area on the side of the chassis.

SAFETY INFORMATION

Operate the Regulus 4200 Dual-Power Temperature Calibrator only as outlined in this User's Manual and in accordance with the WARNING and CAUTION notices and procedures used throughout.



WARNING! Identifies conditions and actions that may pose a hazard to the operator.



CAUTION! Identifies conditions or actions that may cause damage to the Regulus 4200 or the instrument under test. Do not proceed beyond a CAUTION until the indicated conditions are fully understood and met.

GENERAL PRECAUTIONS

1. DO NOT use the unit in environments other than those listed in this User's Manual.
2. Inspect the unit for damage before each use. DO NOT use the unit if it appears damaged or operates abnormally.
3. Follow all safety guidelines listed in this User's Manual.
4. Calibration equipment should only be used by trained personnel.
5. Use of this equipment in a manner not specified by the manufacturer may defeat the safety features of the equipment.
6. This equipment was designed for temperature calibration. Any other use may cause unknown hazards to the operator.
7. Unattended operation is not recommended.
8. Overhead clearance is required. Always leave enough space for safe and easy insertion and removal of adapter chucks and test instruments.

BURN HAZARDS

1. DO NOT turn the unit upside down with adapter chucks in place. The adapter chucks will fall out.
2. DO NOT operate near flammable materials.
3. Use caution when operating the unit at high temperatures for extended periods of time.
4. DO NOT touch the inside of a hot temperature well.

5. The temperature of the well equals the actual display temperature.



WARNING! Probes and adapter chucks may be hot. Do not insert or remove a sensor until the temperature reads below 122°F (50°C).

6. DO NOT turn off the unit at temperatures above 212°F (100°C). Select a set point less than 212°F (100°C) and allow the instrument to cool before turning it off.
7. The unit can reach temperatures up to 662°F (350°C). Failure to observe safety precautions may result in fires and severe burns.

ELECTRICAL HAZARDS

You must follow these instructions to ensure proper operation of the unit's safety protections.

1. The Regulus 4200 must be plugged into a 120 VAC, 60 Hz AC-only electric outlet. The power cord has a three-pronged grounding plug for your protection against electrical shock and must be plugged directly into a properly grounded three-pronged receptacle. Alternately, a 1000W 10A AC-outlet battery pack can be used.
2. Always replace fuses with those of the same rating, type and voltage.
3. DO NOT apply any type of voltage to the switch test terminals.



WARNING! This equipment uses high voltage. SEVERE INJURY or DEATH may result if personnel fail to observe safety precautions. Before removing the unit from the case, turn the power off and disconnect the power cord.

SAFE OPERATING PARAMETERS

1. Always operate the unit at an ambient temperature between 32°F and 120°F (0°C to 49°C). Allow at least six inches (15cm) of clearance around the equipment for ventilation.
2. DO NOT use fluids to clean out the well. Fluids can leak into electronics and damage the unit.
3. Never introduce any foreign material into the probe bore of an adapter chuck.
4. DO NOT alter the values of the calibration coefficients. The correct values are critical for safe and proper unit operation.
5. DO NOT drop adapter chucks into the well. To avoid damage, use the chuck tool to lower the adapter chuck gently into the well. Remove the adapter chuck using the chuck tool.

6. The Regulus 4200 and any thermometer probes used with it are sensitive instruments that can be easily damaged. Always handle these devices with care. DO NOT allow them to be dropped, struck or overheated.
7. DO NOT operate this equipment in an excessively wet, oily, dusty or dirty environment. Always keep the well and adapter chucks clean and clear of foreign material.

The Regulus 4200 is a precision instrument. Although it has been designed for durability and trouble-free operation, it must be handled with care. **Always remove the adapter chuck from the well before transport, and place in the chuck rack to secure it.** Carry the Regulus 4200 in an upright position using the case handle or shoulder strap.

ENVIRONMENTAL CONDITIONS

Although the Regulus 4200 has been designed for optimum durability and trouble-free operation, it must be handled with care. The unit should not be operated in an excessively dusty or dirty environment, or unsheltered outdoor areas. The instrument operates safely under the following environmental conditions:

- Ambient temperature range: 32°F to 120°F (0°C to 49°C)
- Ambient relative humidity: 0% to 90%, non-condensing

If the Regulus 4200 will be stored outside the operating environment for an extended period of time, seal it in a plastic bag containing dry desiccant per Military Specification MIL-D-3464 or equivalent.

RETURN SHIPMENT

To return a Regulus 4200 to King Nutronics, contact Customer Support at support@kingnutronics.com to obtain a Returned Materials Authorization (RMA) number. Include the model and serial number. Include a return address, contact phone number and information regarding the issue experienced or service you require. Shipping instructions and fees will be quoted when you are issued an RMA number.

IMPORTANT: Prior to shipping the Regulus 4200, **remove any adapter chuck from the temperature well** and place all adapter chucks in the storage rack. Secure the power cord and test leads in the case cover using the straps provided. Tape the temperature well doors shut.

Pack and ship the Regulus 4200 in accordance with acceptable commercial practices for delicate instruments. Mark the container "FRAGILE". Please do not use Styrofoam packing peanuts.

RETURN SHIPMENT ADDRESS INFORMATION

To return a unit for calibration or service, contact:

King Nutronics Corporation
6421 Independence Avenue
Woodland Hills, California, 91367
USA

Phone: (818) 887-5460
FAX: (818) 887-2766
E-mail: support@kingnutronics.com
Website: www.kingnutronics.com

CHAPTER

3

SETUP AND USER INTERFACE

REGULUS 4200 SETUP

1. Remove the case lid. Place the Regulus 4200 on a flat surface with at least 6" (15cm) of free space around the instrument. Overhead clearance is required to allow safe and easy insertion and removal of adapter chucks and temperature probes.
2. If you plan to use the RS-232 port, remove the cover plate to access it. Connect the power cord to the Regulus 4200 and to a 120 VAC power source.
3. Open the temperature well insulating doors. Select an adapter chuck with the closest fitting bore to the test instrument's sensor or probe. Use the chuck tool to lift the adapter chuck from the chuck rack and carefully lower the adapter chuck into the temperature well.



Figure 3-1 Inserting an Adapter Chuck and a UUT

4. Insert the unit under test (UUT) probe or sensor into the bore of the adapter chuck. Close the well doors. Ensure that the sensing element or sensing portion of the test instrument sits 3" or deeper in the chuck bore.



CAUTION! Do not force the UUT probe or sensor into the adapter chuck bore. Damage to both the UUT and the adapter chuck may result.

NOTE: The inside diameter of the adapter chuck should be from 0.007" to 0.010" larger than the UUT probe or sensor diameter. The gap between the UUT probe or sensor and the adapter chuck bore affects calibration accuracy.

NOTE: The temperature well door insulation may need to be modified to accommodate UUT probes larger than 1/4" in diameter. Additional door insulation inserts are available from King Nutronics.

5. Power the Regulus 4200 on. The display startup screen shows the software/hardware version, then advances the operator through the setup screens.

USER INTERFACE

The Regulus 4200 is operated from the instrument panel. See Figure 3-2. Open the case lid to access the power cord connection, power switch, display and keypad. Behind the display, the USB-A, USB-B and RS-232 serial connections allow options for file management and remote operation. The user can also access the adapter chuck rack and the temperature well doors from here. The case lid can be removed by sliding it off its hinge pins.



Figure 3-2 Operator Controls

KEYPAD

The Regulus 4200 keypad contains numeric keys, function keys and indicator lights. The numeric and function keys are used to operate the unit and for menu navigation. Some keys have more than one function depending on the mode of operation. See "Function and Numeric Keys" on page 3-4.

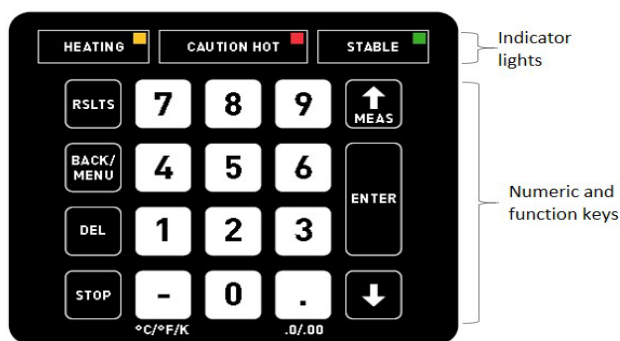


Figure 3-3 Keypad and Indicator Lights

Table 3-1. Function and Numeric Keys

KEY	OPERATION
RSLTS (Results)	Displays the MEASUREMENT REPORT screen of the previous procedure.
BACK/MENU	Returns to the previous screen. Continue pressing BACK/MENU to reach the MAIN MENU.
DEL (Delete)	Moves the cursor to the left, erasing one digit. In MANUAL MODE, pressing DEL will be followed with a confirmation screen to reset the current result summary.
STOP	Stops the heating operation in the temperature well and aborts any running procedure, followed by a confirmation screen. When STOP is confirmed, the screen returns to MANUAL MODE. The STOP key is also used to exit alphanumeric entry mode.
NUMBER, DASH AND DECIMAL POINT	Inputs numerical values. The dash and decimal point may not be operational in some numerical entry screens. In MANUAL MODE and SWITCH PROCEDURES the dash key is used to cycle across the available measurement units (°C, °F or K) and the decimal point is used to cycle between single and dual digit precision display (0.0 or 0.00).
UP/DOWN ARROWS	Navigates between menu options. Press to move the cursor up or down and to scroll through screens. · In text entry dialog screens, the arrows will activate the alphanumeric entry mode and cycle through available characters. · In numerical entry dialog screens, the up arrow will add the exponent sign for scientific notation (e.g., 1.23e-5). · In MANUAL MODE, before the green/STABLE light is lit, use the arrow keys to increment/decrement the set point. Once the green/STABLE light is lit, press the up arrow to display the MEASUREMENT ENTRY screen to enter the UUT's reading.
ENTER	Confirms menu selections and inputs.

INDICATOR LIGHTS

The Regulus 4200 features three indicator lights that show the activity and state of the temperature well. The HEATING, CAUTION-HOT and STABLE indicator lights are described below.

HEATING INDICATOR LIGHT

When the yellow/HEATING indicator light is off, all well electronics are off (idle state). When the yellow indicator light blinks slowly, AC power is being applied and the well temperature is increasing toward the set point. When the indicator light blinks quickly, the cooling process is active, and the well temperature is decreasing toward the set point. When the indicator light is solid yellow, DC

power is being applied and the well temperature is near or holding at the target set point.

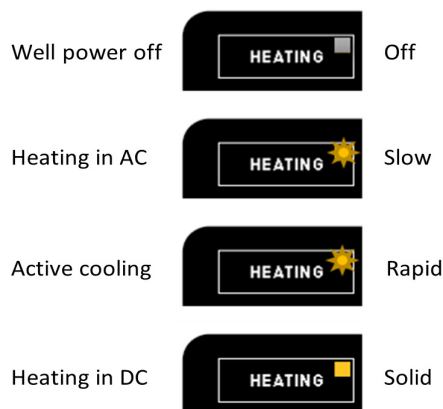


Figure 3-4 HEATING Indicator Light

CAUTION HOT INDICATOR LIGHT

For safe handling and storage, do not power down the unit when the red/CAUTION HOT indicator light is solid. Use caution when opening the temperature well doors and removing or inserting adapter chucks.



Figure 3-5 CAUTION HOT Indicator Light

STABLE INDICATOR LIGHT

When the green/STABLE indicator light is off, the well temperature is not stable or uniform. When the green indicator light blinks, the well temperature is within 0.1°F of the set point. When the indicator light is solid green the well temperature has stabilized and reached uniformity at the set point.

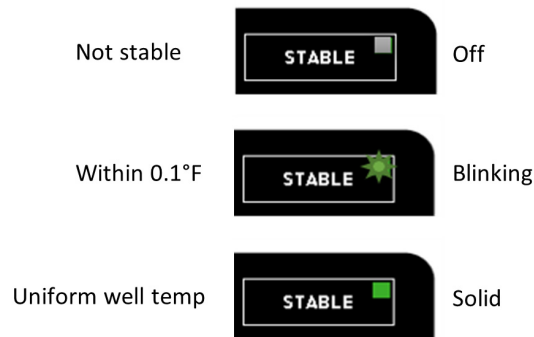


Figure 3-6 STABLE Indicator Light

DISPLAY

The Regulus 4200 has a graphical vacuum fluorescent display (VFD). The VFD is easy to read in bright sunlight as well as in dark conditions. The VFD brightness setup can be found in the SYSTEM INFORMATION menu.

The Regulus 4200 has five screen templates: Menu, Operational Mode, Value Entry, Confirmation and Quick Help.

OPERATIONAL SCREENS

Operational screens display the procedure name, power state of the well (on or off), the switch state (open or closed), the well temperature, the UUT temperature, the set point temperature, a soak timer and a scrolling message that indicates the key to use in the next step.

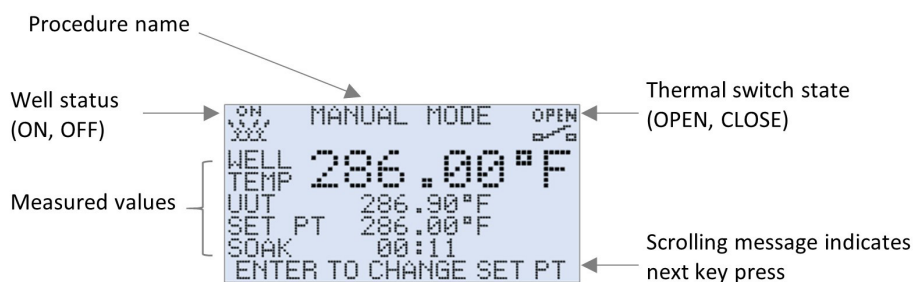


Figure 3-7 Operational Screen Example

VALUE ENTRY SCREENS

Value entry screens display the parameter name and icon, the parameter value (the default value will blink), the valid range for the parameter value and a message indicating the key to use in the next step.

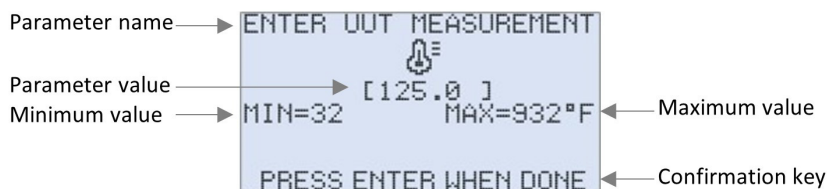


Figure 3-8 Value Entry Screen Example

NOTE: In text entry dialog screens, the up and down arrows will activate the alphanumeric entry mode to cycle through available characters. In numerical entry dialog screens, the up arrow will add the exponent sign for scientific notation (e.g., 1.23e-5).

CONFIRMATION SCREEN

In some cases, the user will be asked to confirm the selection. A confirmation screen is displayed showing the operation to be confirmed and the confirmation key. Any key other than the confirmation key will cancel the operation.



Figure 3-9 Confirmation Screen Example

QUICK HELP SCREEN

Pressing and holding any inactive key during an operational screen triggers a pop-up screen with a list of shortcut keys. The key name is listed on the left and its action is on the right. Release the key and press the shortcut key for the desired function. For example, to change temperature units press the dash (-) key.

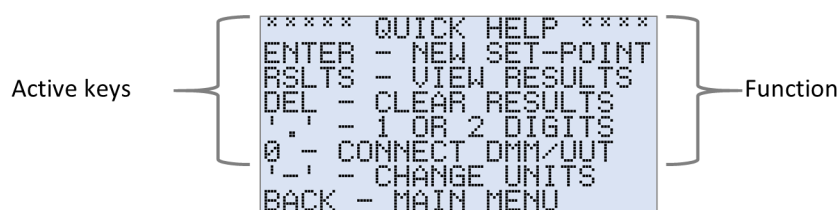


Figure 3-1 QUICK HELP Screen

DISPLAY THE MEASUREMENT UNITS AND DECIMAL PRECISION

The Regulus 4200 supports three types of temperature units, Fahrenheit (°F), Celsius (°C) and Kelvin (K) which can be cycled through by pressing the dash (-) key when in MANUAL MODE and SWITCH PROCEDURES.

Also supported is single or dual decimal digit display of the well temperature. To cycle between the two modes, press the decimal point (.). The feature is intended for display and reporting convenience only and does not affect the measurement accuracy of the unit.

Temperature units and decimal precision can also be changed in the UTILITIES MENU by selecting the TEMPERATURE or DISPLAY PREC options. See "TEMPERATURE UNITS" on page 5-10 and "DISPLAYED DECIMAL PRECISION" on page 5-11.

NOTE: The Regulus 4200 stores in memory the temperature unit (°F, °C or K) and display precision during navigation to the MAIN MENU. To change those parameters, press BACK/MENU to navigate to the MAIN MENU. These parameters can also be changed in the UTILITIES MENU by selecting the TEMPERATURE or DEC PRECISION options.

CHAPTER

4

OPERATING MODES

INTRODUCTION

The Regulus 4200 has four main operating modes: MANUAL, RAMP AND SOAK, SWITCH PROCEDURES and REMOTE OPERATION.

MANUAL MODE

Manual Mode prompts the user to input the desired well temperature set point. The unit then increases to the set temperature and stabilizes. After achieving the appropriate soak time, the user can input the temperature indicated by the unit under test (UUT). The Regulus 4200 calculates the temperature deviation between the indicated well temperature and the entered value. The deviation appears on the display and is stored in memory as a test report to review, save and export.

RAMP AND SOAK

Ramp and Soak is a user-programmable mode for setting a series of upscale and downscale routines for approaching temperature set points. At each user-defined set point (31 points maximum) the temperature stabilizes and is maintained for a user-defined “soak time” before advancing to the next set point. The user can also set the ramp rate for the temperature to reach the next set point. After the soak period, the operator can input the UUT temperature. The Regulus 4200 computes the deviation between the well temperature and the data entered. The user can configure the unit to repeat a program up to 10 cycles.

SWITCH PROCEDURES

The Regulus 4200 offers two procedures to assist in thermal switch adjustment and testing.

The switch adjustment procedure cycles between the high and low tripping points of the switch at a user-defined rate, and will calculate, display and log all switch parameters during the test. During the test, the user can adjust the switch's tripping points until it meets the specified parameters.

The switch testing procedure cycles between user-defined high and low temperature limits, detecting switch failures in addition to logging the tripping points and the type of the switch, normally open or normally closed.

In both the adjustment and testing modes, the user programs the parameters by entering the switch's identification information, upper and lower temperature limits, soak time, minimum ramp rate and number of desired test cycles. Pinch-style test leads (supplied) are connected between the Regulus 4200's banana plug connections and the UUT switch contacts to sample the switch's opening and closing. At the conclusion of the automated test, results are displayed with options to save the report to internal memory or export it to a removable flash drive.

REMOTE OPERATION

The Regulus 4200 can be controlled and monitored via a remote computer using SCPI over USB communication protocol. SCPI is the standard of choice for defining command sets of programmable instruments. An experienced user will be able to control the Regulus 4200 remotely or develop their own remote control application. See "SCPI COMMAND SET OVER RS232" on page 4-20.

MANUAL MODE

The Regulus 4200 starts in MANUAL MODE when first powered on. To select a different mode, press MENU/BACK to reach the MAIN MENU and select the mode from the list.

Perform a test in Manual Mode as follows. The procedure is also illustrated in screen flows, "Performing a Test in Manual Mode" on page 4-3.

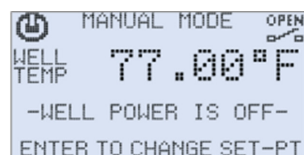
1. Perform the setup per "REGULUS 4200 SETUP" on page 3-1. The system starts in Manual Mode.
2. Press ENTER and input a target set point using the keypad. Confirm by pressing ENTER. The temperature well will heat up to the target set point.

NOTE: The set point value must be between 95°F and 662°F (35°C and 350°C) for the input to be accepted. Temperature values input outside this range cause an error tone.

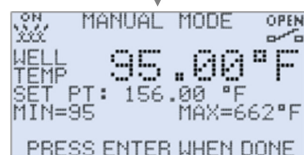
3. When the well temperature is stable, wait the UUT's required soak time and then press the up arrow/MEAS key to enter the UUT reading, followed by ENTER.

4. The temperature of the Regulus 4200, the entered UUT reading and the deviation between the two will appear on screen and be saved to the internal memory. Press BACK to navigate to the MANUAL MODE display.
5. Repeat steps 2 through 4 to test the UUT at additional set points.
6. To view test results during the test, press the RLSTS key and arrow down to RESULTS TABLE. To review, save and export the completed test results, see "VIEWING, SAVING AND EXPORTING MANUAL MODE AND RAMP AND SOAK TEST RESULTS" on page 4-4.

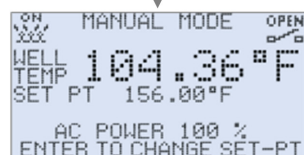
SCREEN FLOWS: PERFORMING A TEST IN MANUAL MODE



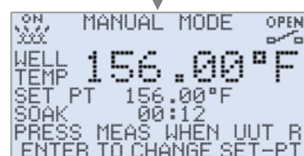
The Regulus 4200 automatically starts in MANUAL MODE when first powered on. Press ENTER to input a set point.



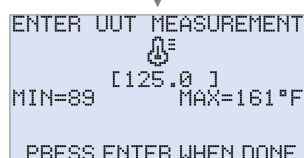
The SET PT prompt will blink. Input a set point and press ENTER. The range of valid values is 95° to 662°F (35° to 350°C).



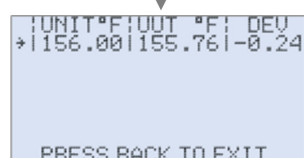
SET PT shows the entered set point (in this example 156.00°F). The WELL TEMP values change as the temperature well heats to the set point.



WELL TEMP shows a stable value of 156.00°F that matches the current set point. SOAK indicates the time the well temperature has been stable. Refer to the UUT's instructions for the required soak time at the stabilized temperature before capturing a reading.



Press the UP ARROW to enter the UUT reading. Press ENTER.



The deviation between the well temperature and the UUT is calculated, displayed and appended to the results table in the measurement report.

Figure 4-1 Performing a Test in Manual Mode

VIEWING, SAVING AND EXPORTING MANUAL MODE AND RAMP AND SOAK TEST RESULTS

Every test procedure generates a test report that is automatically saved to the unit's memory. If a procedure is terminated prematurely (by user abort, power failure or any malfunction), a temporary report named 'temp' will remain stored on the unit and can be accessed like any saved report.

The test results of measurements taken in MANUAL MODE and RAMP AND SOAK are accessed as described below, and are depicted in the screen flows, "Accessing a Saved Test Report" on page 4-5.

1. To view a test result during and after the test:
 - a) Press RSLTS to open the MEASUREMENT REPORT screen.
 - b) Select RESULTS TABLE to view the results of all measurements taken.
2. To save test results:
 - a) Press RSLTS to open the MEASUREMENT REPORT screen and select SAVE AS to open the FILE SAVE screen.
 - b) The file name prompt will blink with the current date. Press DEL to delete any placeholder text and enter a file name, which can be numbers, letters or a combination. Use the numeric keys to enter numbers. To enter text, use the arrows keys to access text entry and press ENTER after each selected letter. Press STOP to exit text entry. Press ENTER to save the file name and return to the MEASUREMENT REPORT screen.
3. To export test results:
 - a) Insert a USB drive in either of the slots.
 - b) Press RSLTS to open the MEASUREMENT REPORT screen.
 - c) Select EXPORT AS CSV to export the file to a spreadsheet format.
 - d) Select EXPORT AS JSON for use in backups and for programming purposes.
4. To view or export test results from the list of saved reports, follow the steps below, which are also depicted in screen flows in "Accessing a Saved Test Report" on page 4-5.
 - a) Press BACK/MENU to access the MAIN MENU. Select UTILITIES and press ENTER.
 - b) From the UTILITIES MENU, select VIEW REPORTS and press ENTER.
 - c) In the REPORTS VIEW MENU screen, select MEASUREMENTS and press ENTER.
 - d) Select the desired test report from the list and press ENTER to open the MEASUREMENT REPORT screen, where the file can be saved, exported or viewed. Or, to delete a report, select it and press DEL to open the DELETE FILE confirmation screen, and press DEL again to delete.

SCREEN FLOWS: ACCESSING A SAVED TEST REPORT

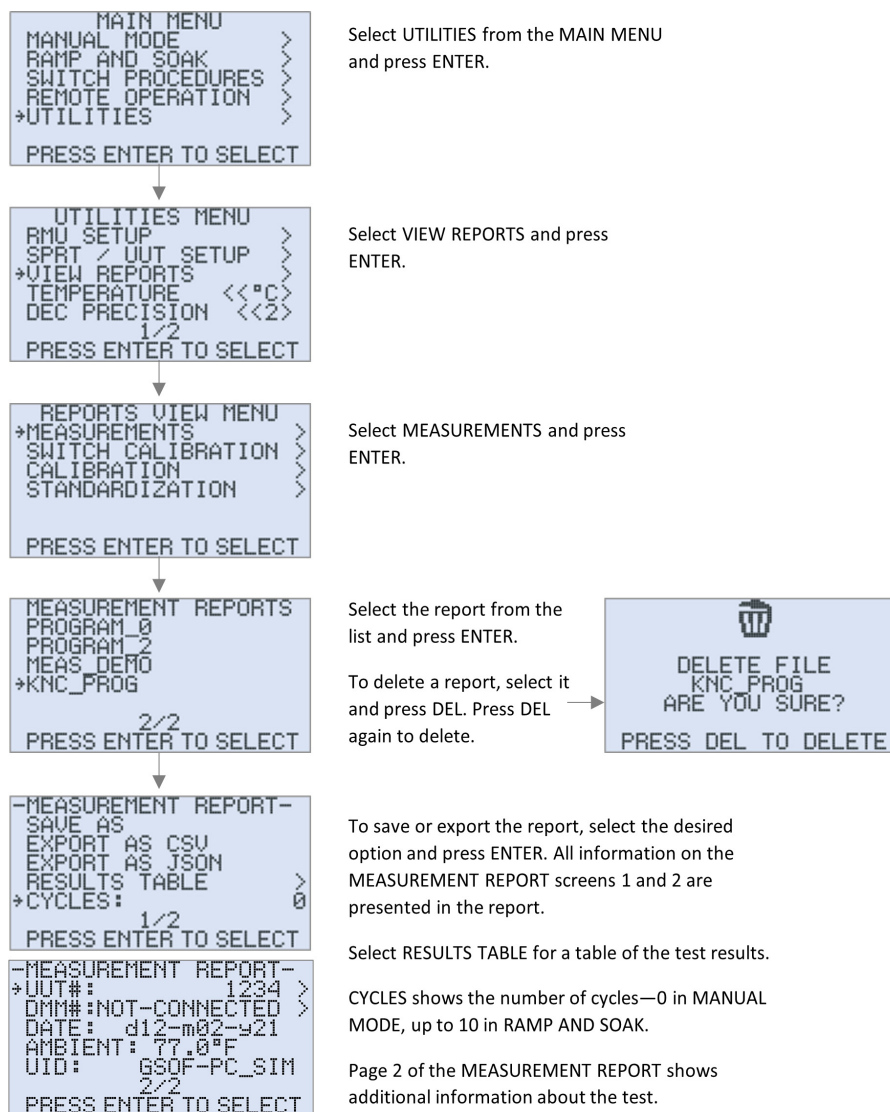


Figure 4-2 Accessing a Saved Test Report

RAMP AND SOAK

The RAMP AND SOAK mode provides for user-programmable input of well heating rates to specific temperature test points and control of soak times once the set point has stabilized. RAMP AND SOAK allows the user to create a custom temperature program that will run either manually or automatically, and can consist of up to 31 steps that define the target temperatures (set points), the rate (RAMP) at which the temperature transitions to each set point, and the amount of time to hold (SOAK) before acquiring a UUT reading and advancing to the next set point.

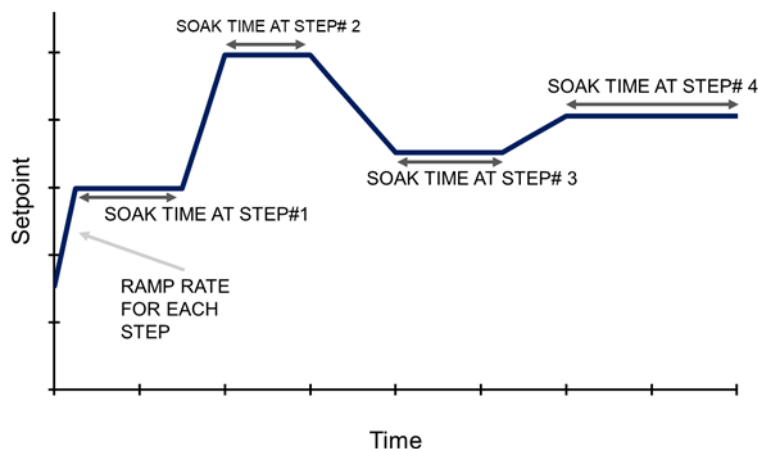


Figure 4-3 Ramp and Soak Profile

CREATE OR MODIFY A RAMP AND SOAK PROGRAM

To create or modify a RAMP AND SOAK program, follow the instructions below. See also the screen flows, "SCREEN FLOWS: CREATE OR MODIFY A RAMP AND SOAK PROGRAM" on page 4-8.

1. Select RAMP AND SOAK from the MAIN MENU and press ENTER to open the PROGRAM LIST screen.
2. From the PROGRAM LIST screen, create a new program or select an existing program from the list, and press ENTER. A program can also be deleted from this screen by selecting it, pressing the DEL key, and pressing DEL again to confirm. To cancel the deletion press ENTER or BACK/MENU.
3. The PROGRAM screen displays either NEW PROGRAM if "Add new program" was selected, or the name of the existing program selected. There are five options that define the parameters of the program: MEASUREMENT, CYCLES, SEQUENCE, TRANSITION RATE, TARGET TEMPERATURE, and SOAK TIME.
 - a) MEASUREMENT – Press ENTER to choose between AUTO and MANUAL, and arrow down to the next option. The unit performs as follows:
 - i) MANUAL: The unit will prompt the user to manually enter a UUT measurement before advancing to the next step.
 - ii) AUTO with a connected DMM: The unit will automatically sample the UUT and transition to the next step.
 - iii) AUTO without DMM connected: The unit will prompt the user to press the up arrow to run in FREE mode without data logging, meaning the program runs automatically but there are no measurements taken or results gener-

ated. This option is useful for exercising the UUT before performing a test.

- b) CYCLES – Press ENTER to open the NUMBER OF CYCLES screen. Enter the number of times the sequence of steps should repeat, up to 10 repetitions, and press ENTER.
- c) SEQUENCE -- Displays the number of steps in the program. Select SEQUENCE and press ENTER to create, edit, insert or delete steps of the sequence.
 - i) To create a sequence step, select INSERT NEW STEP and press ENTER. If this is the first sequence step, the TRANSITION RATE screen will open. If a sequence step already exists, the STEP INDEX screen will open and show the next sequential step number. Press ENTER to accept the step number and open the TRANSITION RATE screen.
 - ii) At the RAMP RATE screen, enter the ramp rate, i.e., the rate in temperature units per minute at which the temperature should increase or decrease to reach the set point. Press ENTER.
 - iii) At the TARGET TEMPERATURE screen, enter the target set point and press ENTER.
 - iv) At the SOAK TIME screen, enter the amount of time the unit should hold the temperature before measuring the UUT and advancing to the next step. Press ENTER.
 - v) Select INSERT NEW STEP and press ENTER. The STEP INDEX screen will display the sequential number of the next step. Repeat the actions above until the required sequences are added. Press BACK/MENU to return to the PROGRAM screen.

NOTE: To insert a step between existing steps, at the STEP INDEX screen enter the desired step number and press ENTER. Other previously added steps will be shifted down in the sequence to accommodate the new step. A step can be edited by selecting it. A step can be deleted by selecting it, pressing DEL, and confirming the deletion by pressing DEL again.

- d) SAVE – To save the program, select SAVE and press ENTER to open the ENTER FILE NAME screen. Enter the program name, which can be numbers, letters or a combination. For letters, press the up arrow to access text entry and scroll to the desired letter. Press ENTER to insert the desired letter. Press STOP to exit text entry. When the program name entry is complete, or to use the existing program name, press ENTER.

SCREEN FLOWS: CREATE OR MODIFY A RAMP AND SOAK PROGRAM

Select RAMP AND SOAK and press ENTER.

```

MAIN MENU
MANUAL MODE      >
→RAMP AND SOAK   >
SWITCH PROCEDURES >
REMOTE OPERATION >
UTILITIES        >
PRESS ENTER TO SELECT
  
```

To create a new program, select NEW PROGRAM and press ENTER.

```

PROGRAM LIST
→NEW PROGRAM
PRESS ENTER TO SELECT
  
```

OR

If programs exist, select "Add new program" and press ENTER.

```

PROGRAM LIST
PROGRAM_0_25
PROGRAM_0_11
PROGRAM_0
→KNC_PROG
Add new program 3/3
PRESS ENTER TO SELECT
  
```

```

PROGRAM LIST
PROGRAM_0_25
PROGRAM_0_11
PROGRAM_0
→KNC_PROG
Add new program 3/3
PRESS ENTER TO SELECT
  
```

Select an existing program to modify or view. Press ENTER.

```

DELETED FILE
KNC_PROG
ARE YOU SURE?
PRESS DEL TO DELETE
  
```

Press the DEL key to delete a selected program. Press DEL again to confirm. Press MENU/BACK or ENTER to cancel the deletion.

Select MEASUREMENT. Press ENTER to choose MANUAL or AUTO.

```

NEW PROGRAM
→MEASUREMENT: AUTO
CYCLES: 1
SEQUENCE: 4
SAVE
RUN      <<01:29h>
PRESS ENTER TO SELECT
  
```

MANUAL: The user will enter the UUT measurement to advance to the next step.

AUTO with DMM: With a DMM connected, the program runs automatically.

AUTO without DMM: If a DMM is not connected, the program runs automatically in FREE mode without data logging, meaning it does not measure or log results.

Select CYCLES. Press ENTER to input the number of times the sequence of steps should repeat, up to 10.

```

NEW PROGRAM
MEASUREMENT: AUTO
→CYCLES: 1
SEQUENCE: 21
SAVE
RUN      <<00:40h>
PRESS ENTER TO SELECT
  
```

SCREEN FLOWS: CREATE OR MODIFY A RAMP AND SOAK PROGRAM, continued

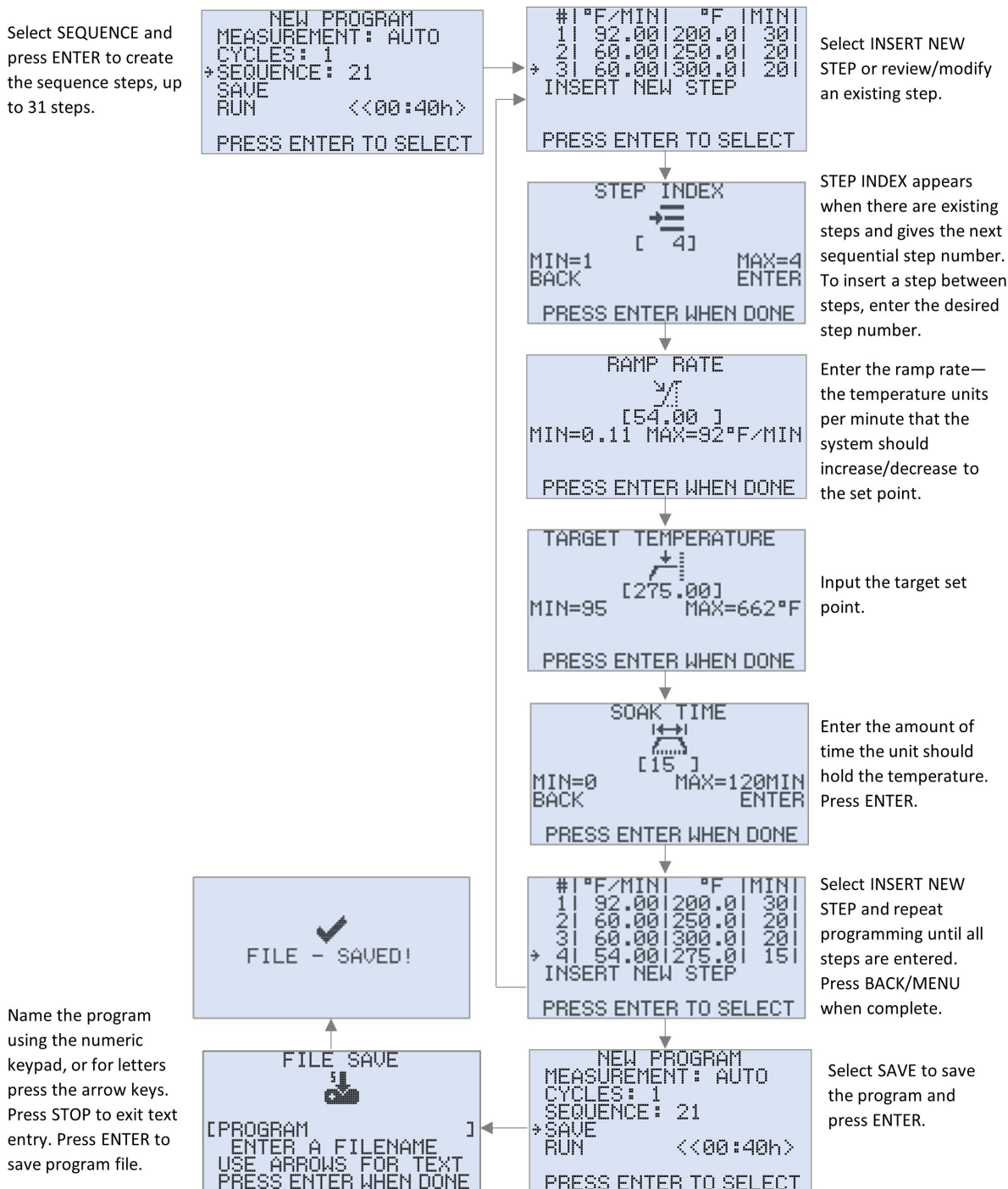


Figure 4-4 Create or Modify a Ramp and Soak Program

RUN A RAMP AND SOAK PROGRAM

Select RUN to start the RAMP AND SOAK program.

If MEASUREMENT is set to MANUAL, the well temperature reaches the set point and holds for the user-defined soak time, then prompts the user to enter the UUT temperature. The next screen shows the well temperature, the UUT temperature and the deviation between them. Press BACK/MENU to advance to the next set point.

If AUTO is selected with a connected DMM, the unit will run through the program automatically without user input. The user can check the test results during the test by pressing the RSLTS key and arrowing down to RESULTS TABLE.

NOTE: If AUTO is selected without a DMM connected, a screen asks the user to confirm that the program will run in FREE mode without data logging. This means no measurements are taken and no reports are generated. Therefore, this is not a test, but useful for exercising a UUT before performing a test.

While a program is running, the screen will display the program name, measurement MODE (MANUAL, AUTO or FREE), the well temperature, current set point and soak time remaining. The current step and cycle are displayed at the bottom of the screen.

SAVE, EXPORT AND REVIEW THE TEST REPORT

The RAMP AND SOAK test report has the same structure as the MANUAL MODE test report. Refer to "VIEWING, SAVING AND EXPORTING MANUAL MODE AND RAMP AND SOAK TEST RESULTS" on page 4-4.

SWITCH PROCEDURES

The Regulus 4200 can be used to adjust, calibrate and test a variety of thermal switches and thermostats using either the SWITCH ADJUSTMENT or AUTOMATIC SWITCH TEST procedure described below.

For each procedure, the user can follow the switch measurements while the test is running by selecting the report view screen. A temporary file is also saved at each event. At the end of the procedure, a final report is generated and saved. The switch parameters covered by the report are:

- Type of switch – Whether the switch is open or closed above its average tripping temperature.
- Tripping points – The low and high temperature points when the switch's state changes.
- Average and differential (hysteresis) temperatures.



WARNING! Do not connect the switch continuity test leads to a voltage source when connected to the Regulus 4200.

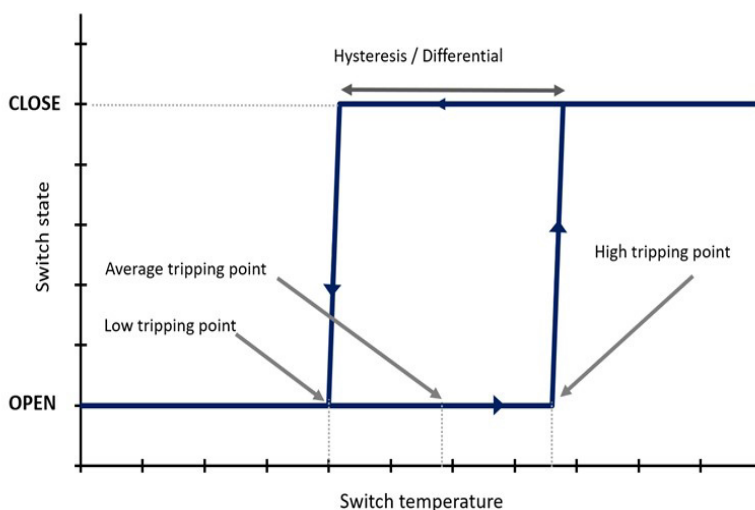


Figure 4-5 State Transition Curve of a Switch

SWITCH SETUP

Before starting a SWITCH ADJUSTMENT or AUTOMATIC SWITCH TEST procedure, set up the Regulus 4200 and the switch to be tested as follows:

1. Using the supplied test leads, connect the switch to the switch test terminals on the Regulus 4200.
2. Insert the switch's thermal sensing element or bulb into the temperature well.
3. Navigate from the MAIN MENU to SWITCH PROCEDURES, select SWITCH# and input the switch's serial number or identification. This information will appear on the final test report.

NOTE: If the switch serial number or identification requires the use of letters, press the up arrow. Three beeps signal that the user is now in text entry. Arrow up or down to reach the desired letter. Press ENTER after each letter desired. Press STOP to exit text entry and return to the SWITCH INPUT screen. Press ENTER to save the switch information.

SCREEN FLOWS: SWITCH SETUP

Select SWITCH PROCEDURES from the MAIN MENU and press ENTER.

```

MAIN MENU
MANUAL MODE >
*SWITCH PROCEDURES >
RAMP AND SOAK >
REMOTE OPERATION >
UTILITIES >
PRESS ENTER TO SELECT
  
```

Select SWITCH# and press ENTER. Input the serial or ID number for the switch and press ENTER. Use the arrow keys to select letters.

```

SWITCH PROCEDURES
*SWITCH#: 1701
SWITCH ADJUSTMENT
AUTOMATIC TEST
PRESS ENTER TO SELECT
  
```

```

INPUT SWITCH#
  A
[1701 ]
MUST ENTER A VALUE
USE ARROWS FOR TEXT
PRESS ENTER WHEN DONE
  
```

Figure 4-6 Switch Setup

SWITCH ADJUSTMENT

The SWITCH ADJUSTMENT procedure identifies the switch's type and tripping points, and facilitates adjustment by providing real-time feedback as the temperature oscillates the switch between its tripping points.

In setting up the SWITCH ADJUSTMENT procedure, the user can define the safe operating range for switch activation, the minimum ramp rate at which the unit should oscillate the switch to its transition points (open or closed), and the number of cycles for the transition between the two switch states. The first cycle starts at the highest ramp rate of 27°F/minute. At the end of each cycle the ramp rate is reduced by one third (or a factor of three) until it reaches the user-defined minimum ramp rate. As the procedure advances through the cycles, the tripping point measurements will become more accurate, and the cycle period will become longer. Refer to "Switch Adjustment Temperature Profile" on page 4-13 for a graphical representation of the SWITCH ADJUSTMENT temperature profile.

NOTE: Because of thermodynamics, the switch's temperature will lag behind the indicated well temperature, causing measurements for low and high tripping points to be lower and higher, respectively, than the actual temperatures on the switch. Lowering the ramp rate will increase the measurement accuracy.

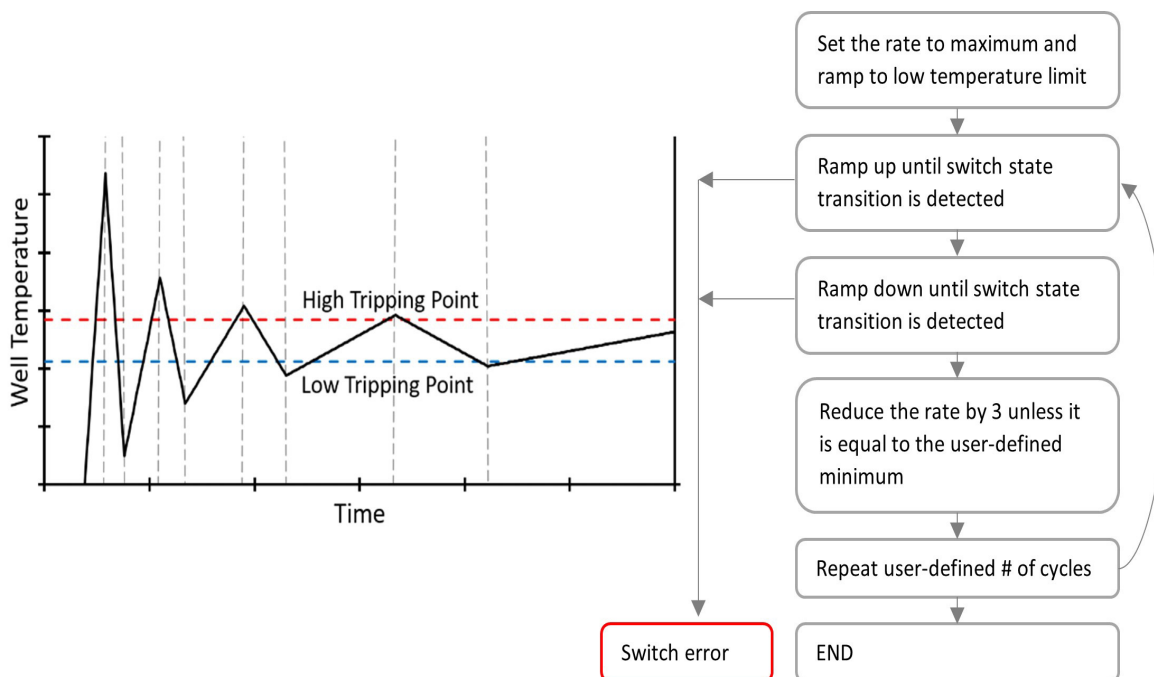


Figure 4-7 Switch Adjustment Temperature Profile

SWITCH ADJUSTMENT PROCEDURE

Perform a switch adjustment as follows:

1. Prepare the Regulus 4200 for operation per "REGULUS 4200 SETUP" on page 3-1 and follow the instructions for "SWITCH SETUP" on page 4-11.
2. From the SWITCH PROCEDURES screen select SWITCH ADJUSTMENT. The SWITCH ADJUSTMENT menu contains four options: RANGE, MIN RATE, MAX CYCLES and RUN.
3. Select RANGE and press ENTER to input the lower and upper temperature limits for the test. Press ENTER.
4. Select MIN RATE and press ENTER to open the RAMP RATE screen. Input the minimum ramp rate at which the temperature will change while searching for the switch tripping points. Press ENTER.
5. Select MAX CYCLES to input the number of times to repeat the test, 10 through 50 in increments of 10. Press ENTER to increment by 10 cycles.
6. Select RUN and press ENTER to start the test.
7. View the in-process or completed switch adjustment test by pressing RSLTS to open the SWITCH REPORT, which has 4 screens containing the test data. On screen 4/4 of the SWITCH REPORT, the user can export or save the test. Press BACK/MENU to return the SWITCH ADJUSTMENT test.
8. To save, export or view a previously saved switch adjustment test, navigate to the MAIN MENU, select UTILITIES and press ENTER. Select VIEW REPORTS and press ENTER. Select SWITCH CALIBRATION to open the

SWITCH REPORTS list. Select the desired report and press ENTER to open the SWITCH REPORT, which has 4 screens containing the test data. On screen 4/4 of the SWITCH REPORT, the user can export or save the test.

SCREEN FLOWS: SWITCH ADJUSTMENT PROCEDURE

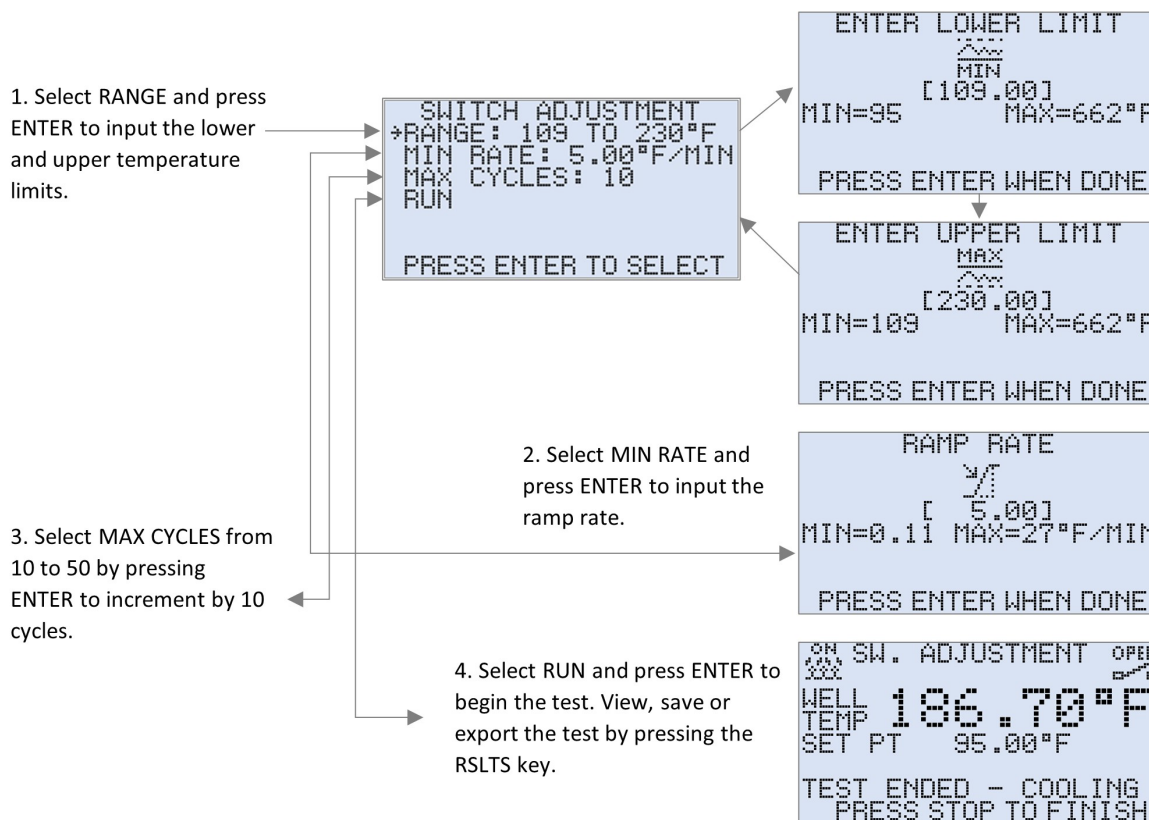


Figure 4-8 Switch Adjustment Procedure

AUTOMATIC SWITCH TESTING

The AUTOMATIC TEST procedure is used to intensively test the thermal switch or thermostat using an automated user-defined program. The test identifies the switch type, tripping points and incorrect switch state events over the test's temperature range. When the Regulus 4200 registers the first occurrence of switch state transition during a ramp up in temperature, the unit continues to ramp to the upper limit of the temperature range in order to test the reliability of the switch by verifying that the switch does not change its state again while still ramping up. If not, then after the soak period, the unit begins the ramp down. Refer to "Automatic Switch Test Temperature Profile" on page 4-15 for a graphical representation of the Automatic Switch Test temperature profile.

During the AUTOMATIC SWITCH TEST test cycle, the Regulus 4200 performs five steps:

1. Ramp to the user-defined low temperature limit at the highest ramp rate, and hold for the defined soak time.
2. Search for the high trip point temperature of the switch while ramping up the well temperature at the user-defined rate.
3. Ramp to the user-defined high temperature limit at the highest ramp rate, and hold for the user-defined soak rate.
4. Search for the lower trip point temperature of the switch while ramping down at the user-defined rate.
5. Perform a new test cycle, starting from step one, until all the user-defined cycles are complete.

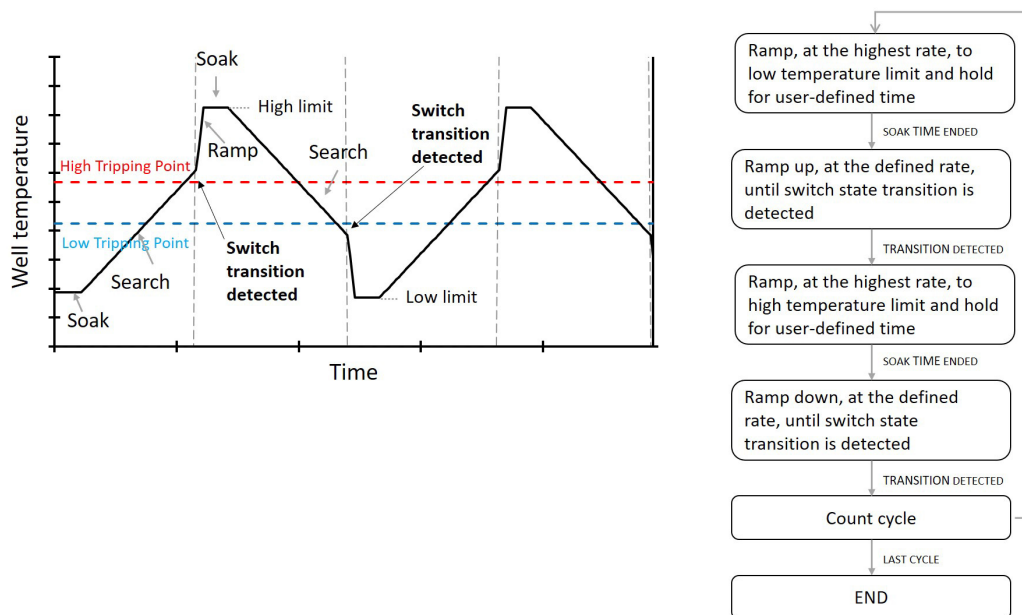


Figure 4-9 Automatic Switch Test Temperature Profile

CREATE AN AUTOMATIC SWITCH TEST PROGRAM

To create an automatic switch test, do the following. See "Create an Automatic Switch Test Program" on page 4-17 for the screen flows.



CAUTION! Do not exceed the switch's maximum temperature, as specified by the manufacturer.

1. Prepare the Regulus 4200 for operation per "REGULUS 4200 SETUP" on page 3-1. Follow the instructions for "SWITCH SETUP" on page 4-11 .
2. Choose SWITCH PROCEDURES from the MAIN MENU and press ENTER. Select AUTOMATIC TEST and press ENTER.
3. The SW. TESTS LIST screen will open, allowing the user to create a new switch test program, open an existing program or delete an existing program. Select "Add new test" and press ENTER to open the switch test review screen, which will display NEW SWITCH TEST at the top of the screen.
4. In the switch test review screen, enter the parameters for the program: Select RANGE to input the values, select CYCLE to input the number of times to repeat the test, select RATE to input the ramp rate, and select SOAK TIME to input the time to hold the temperature. Press ENTER after each parameter to return to the switch test review screen.

NOTE: A typical ramp rate is 1.8°F/minute (1.0°C/minute).

5. Press MENU/BACK to input the file name for the new test. Use the arrow keys to input letters. Press ENTER to return to the SW. TEST LIST screen. The newly created test appears in the list.

NOTE: If the file name requires the use of letters, press the up arrow. Three beeps signal that the user is now in alphanumeric entry. Arrow up or down to advance to the desired letter. Press ENTER to progress to the next letter or number. Press STOP to exit alphanumeric entry and return to the SWITCH TEST screen. Press ENTER to save the switch information and continue to the next step.

SCREEN FLOWS: CREATE AN AUTOMATIC SWITCH TEST PROGRAM

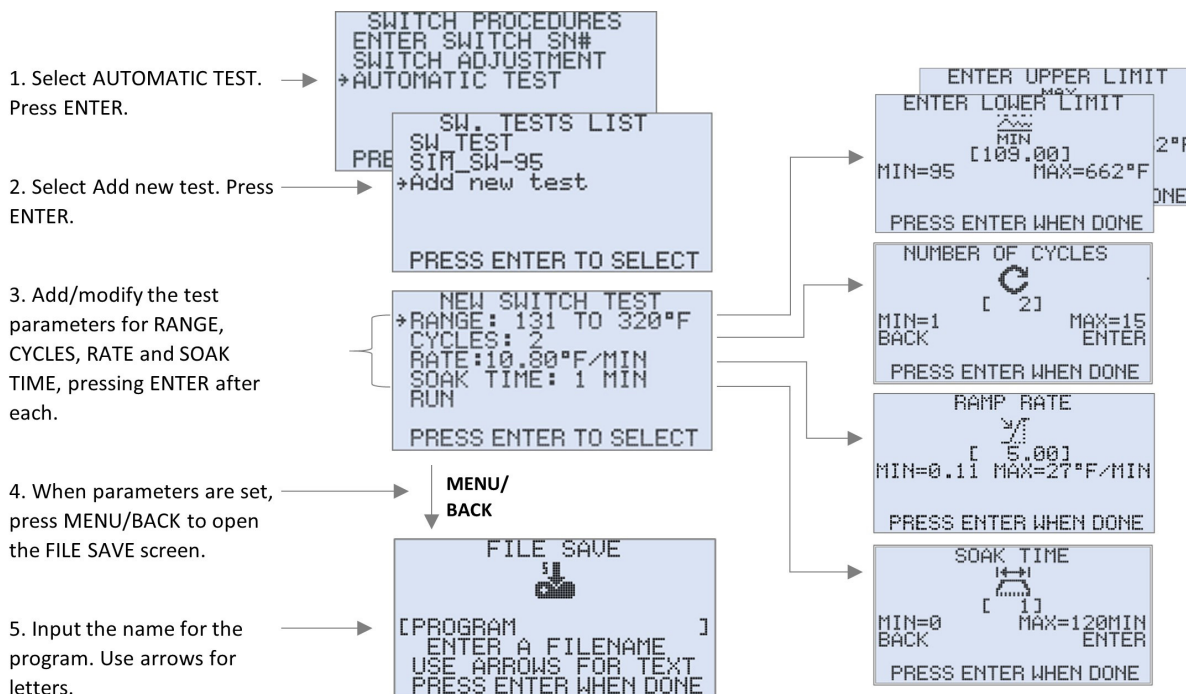


Figure 4-10 Create an Automatic Switch Test Program

RUN AN AUTOMATIC SWITCH TEST PROGRAM

To run an Automatic Switch Test, do the following:

1. Prepare the Regulus 4200 for operation per "REGULUS 4200 SETUP" on page 3-1, and follow the instructions for "SWITCH SETUP" on page 4-11.
2. Choose SWITCH PROCEDURES from the MAIN MENU and press ENTER. Select AUTOMATIC TEST and press ENTER.
3. The SW. TESTS LIST screen will open. Select the desired test and press ENTER to open the switch test review screen. The name of the test appears at the top of the screen, followed by the parameters of the test. These parameters can be changed from this screen if desired. To begin the test, select RUN and press ENTER.
4. View the in-process or completed AUTOMATIC SWITCH TEST by pressing RSLTS to open the SWITCH REPORT, which has 4 screens containing the test data. On screen 4/4 of the SWITCH REPORT, the user can export or save the test. Press BACK/MENU to return the AUTOMATIC SWITCH TEST.
5. To save, export or view a previously saved AUTOMATIC SWITCH TEST, navigate to the MAIN MENU, select UTILITIES and press ENTER. Select VIEW REPORTS and press ENTER. Select SWITCH CALIBRATION to open the SWITCH REPORTS list. Select the desired report and press ENTER to open the SWITCH REPORT, which has 4 screens containing the test data. On screen 4/4 of the SWITCH REPORT, the user can export or save the test.

DELETE AN AUTOMATIC SWITCH PROGRAM

To delete an Automatic Switch Test, do the following:

1. Choose SWITCH PROCEDURES from the MAIN MENU and press ENTER. Select AUTOMATIC TEST and press ENTER.
2. The SW. TESTS LIST screen will open. Select the test to be deleted and press DEL. A DELETE FILE screen will open. To confirm the deletion, press DEL. To cancel the deletion press ENTER or BACK.

REMOTE OPERATION

The Regulus 4200 can be controlled remotely via a host computer running an automated script or by the user via application. The unit responds to control commands such as set point changes and activation or deactivation of the well's power, and will also reply to inquiry requests regarding the well temperature, UUT reading, switch state and heaters power. In the REMOTE OPERATION menus there are two options: SCPI COMMAND MODE and PC BYPASS MODE. Only the SCPI COMMAND MODE is covered in this user manual. The PC BYPASS MODE is for future use.

SCPI COMMAND MODE

SCPI (Standard Commands for Programmable Instruments) is the standard of choice for defining command sets of programmable instruments. Supported by all major manufacturers, SCPI provides customers with faster and less expensive installation, development and support by giving their technicians and programmers a consistent command language across all types of programmable instruments. The SCPI interface gives an experienced user immediate familiarity when controlling the Regulus 4200 remotely or developing a remote-control application.

REMOTE SETUP AND ACTIVATION

From the MAIN MENU select REMOTE OPERATION and press ENTER. From the REMOTE OPERATION screen, select SCPI COMMAND MODE. The available communication parameters are listed in "SCPI RS232 Communication Parameters" on page 4-19. The default baud rate is 115200 bps. Selecting any of the parameters will cycle through the supported values. From the SCPI COMMAND MODE screen select CONNECT. The display will continue to show the most updated well temperature, well power status and switch state.

Table 4-1 SCPI RS232 Communication Parameters

PARAMETERS	
Baud rate	300, 600, 1200, 2400, 4800, 9600, 19200, 38400, 57600, 115200*
Parity	none*, odd, even
Data bits	7,8*

* Default values.

SCREEN FLOWS: ACTIVATING SCPI COMMAND MODE

From the MAIN MENU select REMOTE OPERATION and press ENTER.

```

MAIN MENU
MANUAL MODE      >
SWITCH PROCEDURES >
RAMP AND SOAK    >
*REMOTE OPERATION >
UTILITIES        >

PRESS ENTER TO SELECT
    
```

Select SCPI COMMAND MODE and press ENTER.

```

REMOTE OPERATION
*SCPI COMMAND MODE >
PC BYPASS MODE     >

PRESS ENTER TO SELECT
    
```

Define the communications parameters by selecting and entering the BAUD, PARITY and DATA BITS per Table 4-1.

Select CONNECT and press ENTER.

```

SCPI COMMAND MODE
*CONNECT
BAUD: 115200
PARITY: NONE
DATA BITS: 8

PRESS ENTER TO SELECT
    
```

The display show real time temperature, well power and switch state status.

```

⏻ SCPI MODE OPEN
WELL TEMP 25.00°C
-WELL POWER IS OFF-
PRESS STOP TO ABORT
    
```

Figure 4-11 Activating SCPI Command Mode

SCPI COMMAND SET OVER RS232

See the table below for applicable commands.

Table 4-2 SCPI Command Set Over RS232

COMMAND	ACTION	SEND COMMAND	RESPONSE EXAMPLE
*IDN?	Read the product information (Manufacturer, Model Number, Serial Number, and Firmware version).	*IDN?	KNC,4200,A123,1.20
INP:SWIT:CLOS?	Read the switch input state, open (0) or closed (1).	INP:SWIT:CLOS?	0
OUTP:STAT? OUTP:STAT [n]	Read or set the Main Heat output enable, off (0) or on (1).	OUTP:STAT? OUTP:STAT 1	0 No response
OUTP:DATA? <P, S>	Read the primary (bottom) or secondary (top) heater output power in percent	OUTP:DATA? P OUTP:DATA? S	18.0 18.5
OUTP:PRI?	Read the primary (bottom) heater output power in percent	OUTP:PRI?	18.0
OUTP:SEC?	Read the secondary (top) heater output power in percent	OUTP:SEC?	18.0
MEAS:DMM?	Read the reference sensor resistance (in ohms).	MEAS:RES?	264.262
MEAS:UUT?	Read the reference sensor temperature.	MEAS:TEMP? 1CEL	164.5
SENS1:DATA?	Read the reference input resistance.	SENS1:DATA?	199.9366
SENS2:DATA?	Read the UUT input. The returned value units will be according to function: PRT/RTD will be in resistance; TC will be in mV; 4-20 will be in mA.	SENS2:DATA?	230.9366
SOUR:SENS:RES?	Read the control sensor resistance (in ohms).	SOUR:SENS:RES?	
SOUR:SENS:TEMP?	Read the control sensor resistance or temperature (CEL, FAR or KEL).	SOUR:SENS:TEMP? 1FAR	87.65
SOUR:SPO? SOUR:SPO [n]	Set the control set-point, C or F, where "n" is a real value with acceptance limits.	SOUR:SPO? 1CEL SOUR:SPO 250.0 FAR	50.00 No response

Table 4-2 SCPI Command Set Over RS232 (Continued)

COMMAND	ACTION	SEND COMMAND	RESPONSE EXAMPLE
SOUR:STAB:TEST?	Read the temperature stability test results. Stable = 1; Unstable = 0	SOUR:STAB:TEST? A value of 0 is returned if the controller is not stable at the current set-point. Otherwise, a value of 1 is returned if the controller is stable at the current set-point.	0
SYST:BEEP:IMM	Beep the system beeper	SYST:BEEP:IMM	The system beeper makes an audible sound
SYST:DATE[?] [<DMY, MDY, YMD>, <val>, <val>, <val>]	Read or set the system's date using numbers separated by commas	SYST:DATE? YMD SYST:DATE YMD,	YMD, 2020,02,24 YMD, 2020,01,31
SOUR:RATE <min> <units>, <max> <units>	Set the ramp rates of the unit. where <units> is "CPM" or "FPM". <min> is a negative value for cooling rate. <max> is a positive value for heating rate.	SOUR:RATE -10.0 FPM, 40.0 FPM	No response

CHAPTER

5

UTILITIES

INTRODUCTION

The UTILITIES menu, accessible from the MAIN MENU, enables the user to access additional setup and user interface parameters. The various utilities options include:

1. DMM SETUP—Configure a DMM to perform a variety of tests and have the DMM information appear in reports.
2. UUT/SPRT SETUP—Configure a UUT or SPRT reference sensor to perform a variety of tests and have the UUT or SPRT information appear in the reports.
3. VIEW REPORTS—Access all saved test results.
4. TEMPERATURE—Select temperature units of F°, C° or K.
5. DEC PRECISION—Choose displaying 1 or 2 decimals.
6. DATE—Select the date and date format.
7. SYSTEM INFO—Software version, error log, and adjustment of the display brightness, maximum cooling blower power and mute/unmute the unit's internal speaker.
8. MAINTENANCE—See Chapter 6 for MAINTENANCE options:
 - a) Advanced functions such as CALIBRATION, STANDARDIZATION and MANUAL COEFFICIENT ENTRY.
 - b) Assign the unit a unique ID for use in reports (in lieu of the serial number assigned at the factory).
 - c) FILE MANAGEMENT to back up the unit's configuration to a flash drive, restore it from a flash drive, manage files through the FILE EXPLORER, perform a factory reset and update the unit's software.

NOTE: The MAINTENANCE selection in the UTILITIES menu is accessed only by entering the code **1234**. The purpose of this code is to confirm that the user is accessing the advanced features in the MAINTENANCE menu intentionally. The MAINTENANCE menu features, including CALIBRATION and STANDARDIZATION, are discussed in Chapter 6, MAINTENANCE .

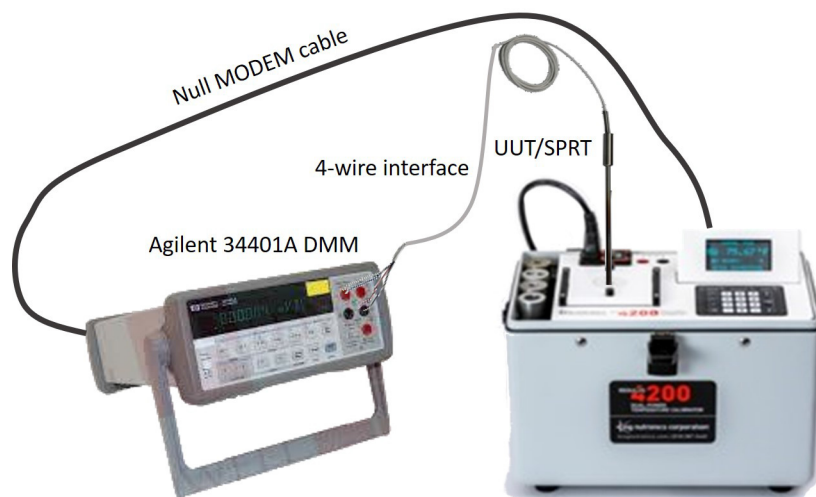


Figure 5-1 DMM and UUT/SPRT Setup Connections

DMM SETUP

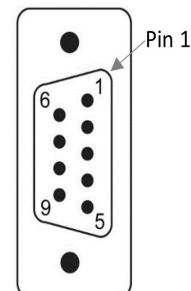
In automatic testing and calibration, the DMM is the Agilent Digital Multimeter Model 34401A or device with a compatible SCPI command set. It acts as the interface between the Regulus 4200 and the SPRT.

NOTE: For ease of use, the Regulus 4200 remembers the last action taken. For example, the most recent DMM created or selected will appear at the top of DMM LIST menu the next time it is accessed. Likewise, the unit remembers file names and will suggest the last name chosen, so that if the new file name is similar, the user need only enter the needed digits or text. To create an entirely new file name, the user will use the DEL key to delete the existing characters and enter a new name.

Connect the DMM, using the Null MODEM Cable (with crossed RX, TX signals), to the serial connector on the Regulus 4200. The unit's RS232 connector is a DB9 male connector and follows the DTE pinout as show in "DB9 Pinout for DMM Setup" on page 5-3.

Table 5-1. DB9 Pinout for DMM Setup

PIN NUMBER	FUNCTION	DIRECTION
1	NC	
2	RX	Input
3	TX	Output
4	DTR	Output
5	Ground	
6	RTS	Output
7	CTS	Input
8	NC	
9	NC	



Set up the DMM as follows. See also the screen flows:

1. Select UTILITIES from the MAIN MENU and press ENTER to open the UTILITES MENU.
2. Select DMM SETUP and press ENTER to open the DMM LIST.
3. Select “Add new device” and press ENTER. This opens a series of screens:
 - a) DMM MANUFACTURER – Enter the manufacture name or other identification. Use arrows for text, ENTER to advance to the next letter, and STOP to exit text entry. Press ENTER.
 - b) DMM MODEL – Enter the model name, number or other identification. Use arrows for text. Press ENTER.
 - c) INPUT DMM SN# - Enter the DMM serial number and press ENTER.
 - d) CAL EXPIRATION DATE – Enter the DMM’s calibration expiration date and press ENTER.
 - e) DMM COMMUNICATION – Verify that the communication type, BAUD rate, parity and data bits match the parameters on the DMM. These can be modified by selecting a parameter and pressing ENTER.
 - f) When complete, select DONE and press ENTER to open the ENTER FILE NAME screen.
 - g) Enter a unique file name or accept the name suggested by the unit. Press ENTER to save. The screen will display the DMM information entered, which can be modified by selecting any of the lines.
4. When the DMM information is correct, select CONNECT and press ENTER. The screen heading will read DMM DETECTED and will display the DMM ID and measured resistance. Verify that the resistance readings are in the correct range. If resistance readings are not in the correct range, check the connections to the DMM and UUT/SPRT.
5. Press BACK/MENU to return to the UTILITIES MENU.

SCREEN FLOWS: DMM SETUP

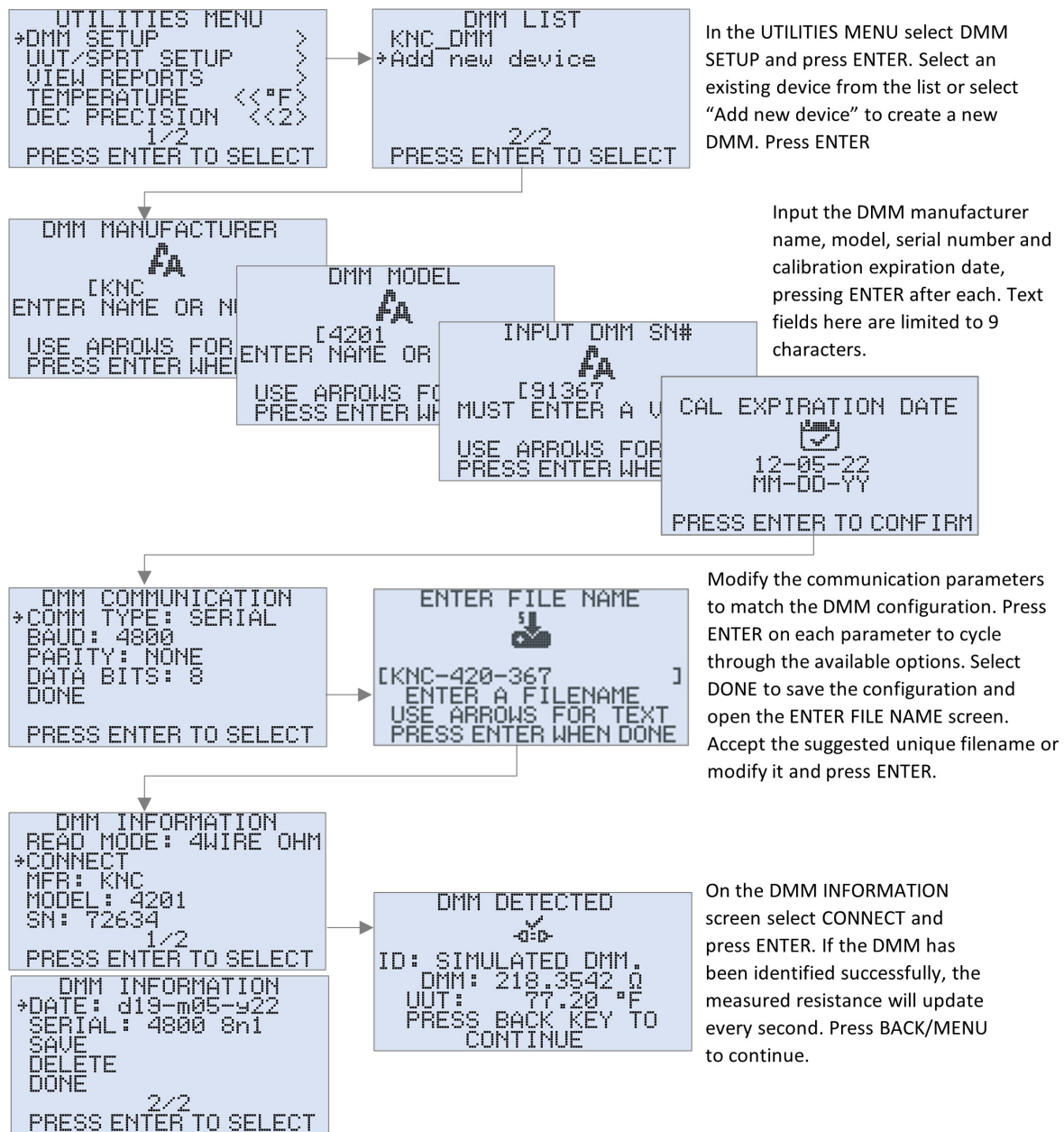


Figure 5-2 DMM Setup

UUT/SPRT SETUP

When performing a test in MANUAL MODE or RAMP AND SOAK manually, the UUT or SPRT information will appear in the MEASUREMENT REPORT only if it is first set up and selected.

NOTE: For ease of use, the Regulus 4200 remembers the last action taken. For example, the most recent UUT/SPRT selected will appear at the top of UUT/SPRT LIST menu the next time it is accessed. Likewise, the unit remembers file names and will suggest the last name chosen, so that if the new file name is similar, only enter the needed digits or text. To create an entirely new file name, use the DEL key to delete the existing characters and enter a new name.

Set up the UUT/SPRT as follows. To interface with a DMM, connect the 4-wire interface of the UUT/SPRT to the connectors on the DMM.

1. From the UTILITIES MENU select UUT/SPRT SETUP and press ENTER to open the SPRT LIST screen.
2. Select “Add new device” and press ENTER. This opens a series of screens:
 - a) DEVICE MANUFACTURER – Delete any unwanted characters by pressing the DEL key. Enter the manufacture name or other identification. Use arrows for text, ENTER to advance to the next letter, and STOP to exit text entry. Press ENTER.
 - b) DEVICE MODEL – Delete any unwanted characters by pressing the DEL key. Enter the model name, number or other identification. Use arrows for text. Press ENTER.
 - c) INPUT DEVICE SN# - Enter the UUT/SPRT serial number and press ENTER.
 - d) CAL EXPIRATION DATE – Enter the UUT/SPRT’s calibration expiration date and press ENTER.
 - e) COEFFICIENTS – Reference the “Results for Nominal Current Calibration” table found in the UUT/SPRT’s current calibration certificate for the coefficients needed for UUT/SPRT setup. If the UUT/SPRT was calibrated using the ITS-90 temperature accuracy scale, select ITS90 from the TYPE option in the COEFFICIENTS screen. If the UUT/SPRT was calibrated using the IPTS-68 temperature accuracy scale, select IPTS68.

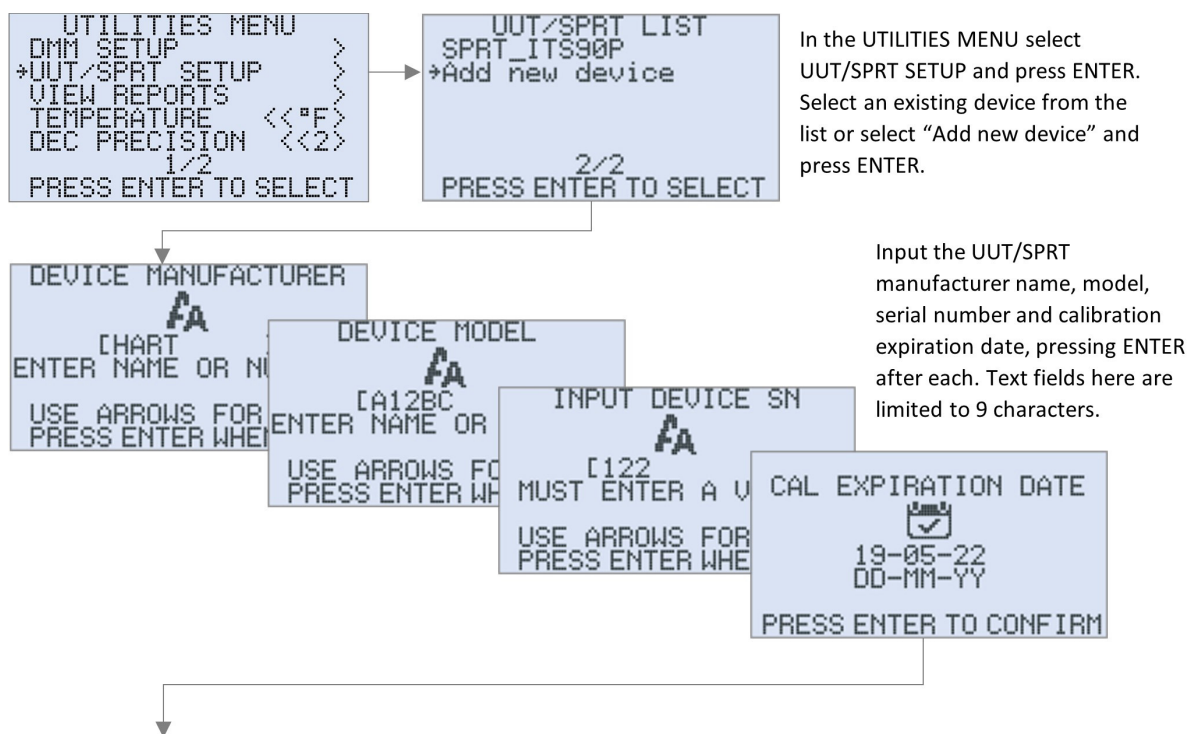
NOTE: The Regulus 4200 accepts calibration coefficients in two standard temperature accuracy scales: ITS-90, and the older IPTS-68. Coefficients that are saved under ITS-90 can be converted to IPTS-68 by changing the TYPE selection in the COEFFICIENTS screen from ITS90 to IPTS68.

Coefficients can be input in scientific notation (e.g, 1.23e-4) by pressing the up arrow to add the ‘e’ symbol. Coefficient values can be negative (-) numbers. Ensure that numbers are input accurately.

- f) Enter the following coefficients from the UUT/SPRT's "Results for Nominal Current Calibration" table:
 - i) For ITS-90 enter the RPTW, a7, b7 and c7 coefficients. Coefficients for a4 and b4 are always 0.0000000e+00.
 - ii) For IPTS-68 enter the R0, α , and δ coefficients.
 - iii) When complete, select DONE and press ENTER.
- g) When all information is correct, select DONE and press ENTER. The UUT/SPRT LIST screen will open and show the name of the UUT or SPRT entered.

NOTE: Selecting DONE from the DEVICE INFORMATION screen selects the UUT or SPRT for reporting purposes. For example, in MANUAL MODE or when performing RAMP AND SOAK manually, the UUT/SPRT information will appear on the test results report only if the UUT/SPRT was previously set up and DONE was selected.

SCREEN FLOWS: UUT/SPRT SETUP



SCREEN FLOWS: UUT/SPRT SETUP, continued

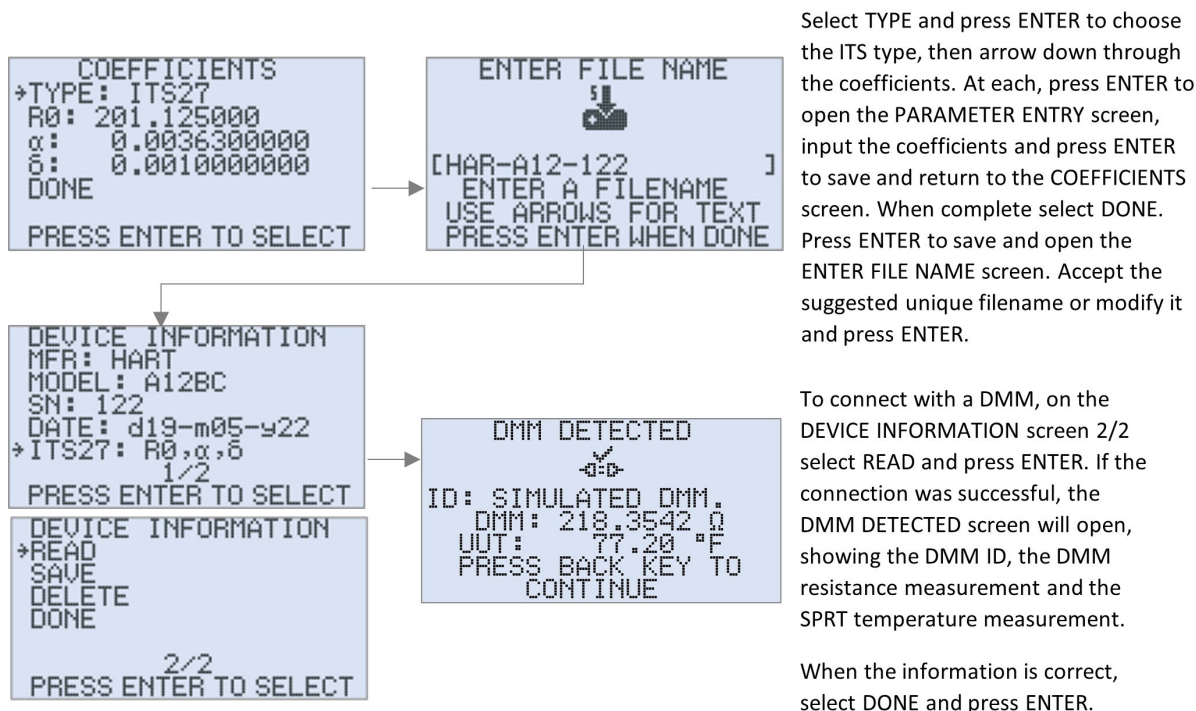


Figure 5-3 UUT/SPRT Setup

VIEW REPORTS

The Regulus 4200 generates test result reports that can be viewed during the test, or reviewed, saved and exported when the test is complete. In-process reports are accessed and saved by pressing the RSLTS key. Saved reports are accessed from the UTILITIES MENU.

There are four categories of reports: MEASUREMENTS for use with tests performed in MANUAL MODE and RAMP AND SOAK, SWITCH CALIBRATION for switch adjustment and switch test reports, and for system maintenance, CALIBRATION reports are covered in "ACCESSING THE CALIBRATION REPORT" on page 6-6 . For STANDARDIZATION reports see "ACCESSING THE STANDARDIZATION REPORT" on page 6-9.

MEASUREMENT REPORTS

MEASUREMENT REPORTS are used with tests performed in MANUAL MODE and in RAMP AND SOAK. The user can view, save and export a current test by pressing the RSLTS key to access the MEASUREMENT REPORTS screen. The user can access a saved test through the UTILITIES menu.

For the UUT or SPRT information to appear on the measurement report, it must first be set up and selected through the UTILITIES MENU. See "UUT/SPRT SETUP" on page 5-4.

Review or export a saved MANUAL MODE or RAMP AND SOAK test report as follows:

3. From the MAIN MENU select UTILITIES and press ENTER to open the UTILITIES MENU.
1. Select VIEW REPORTS and press ENTER to open the VIEW REPORTS MENU.
2. Select MEASUREMENTS and press ENTER to open the MEASUREMENT REPORTS screen.
3. Select the desired report and press ENTER. The MEASUREMENT REPORT will display on the screen as follows:
 - a) SAVE AS – Accept the suggested file name or delete unwanted characters and enter a new name for the test.
 - b) EXPORT AS CSV – Export the test report to a flash drive in CSV format. Automatically included is a .pcl file, which can be converted into a formatted .pdf report using a .pcl converter application. A .pcl conversion app is included on the King Nutronics flash drive.
 - c) EXPORT AS JSON – Export the test report to a flash drive in JSON format. Automatically included is a .pcl file, which can be converted into a .pdf report using a .pcl converter application. A .pcl conversion app is included on the King Nutronics flash drive.

NOTE: A .pcl conversion app is loaded on the flash drive included with the Regulus 4200 accessories. Download the app and then drag the .pcl file to the app icon. A .pdf file will appear in the same folder as the .pcl file.

- d) RESULTS TABLE – View the results at each test point: unit's temperature, the UUT temperature reading and the deviations between them.
- e) CYCLES – The number of automated procedure repetitions. Not applicable in MANUAL MODE.
- f) UUT # - Select and press ENTER to view the UUT manufacturer, model, serial number and calibration due date.
- g) DMM # - Select and press ENTER to view the DMM manufacturer, model, serial number and calibration due date.
- h) DATE – Date of the test.
- i) AMBIENT – The average temperature inside the case during the test.
- j) UID – Factory serial number or the name/identification the end-user has given to the unit.

SCREEN FLOWS: VIEW, SAVE AND EXPORT A MANUAL MODE OR RAMP AND SOAK REPORT

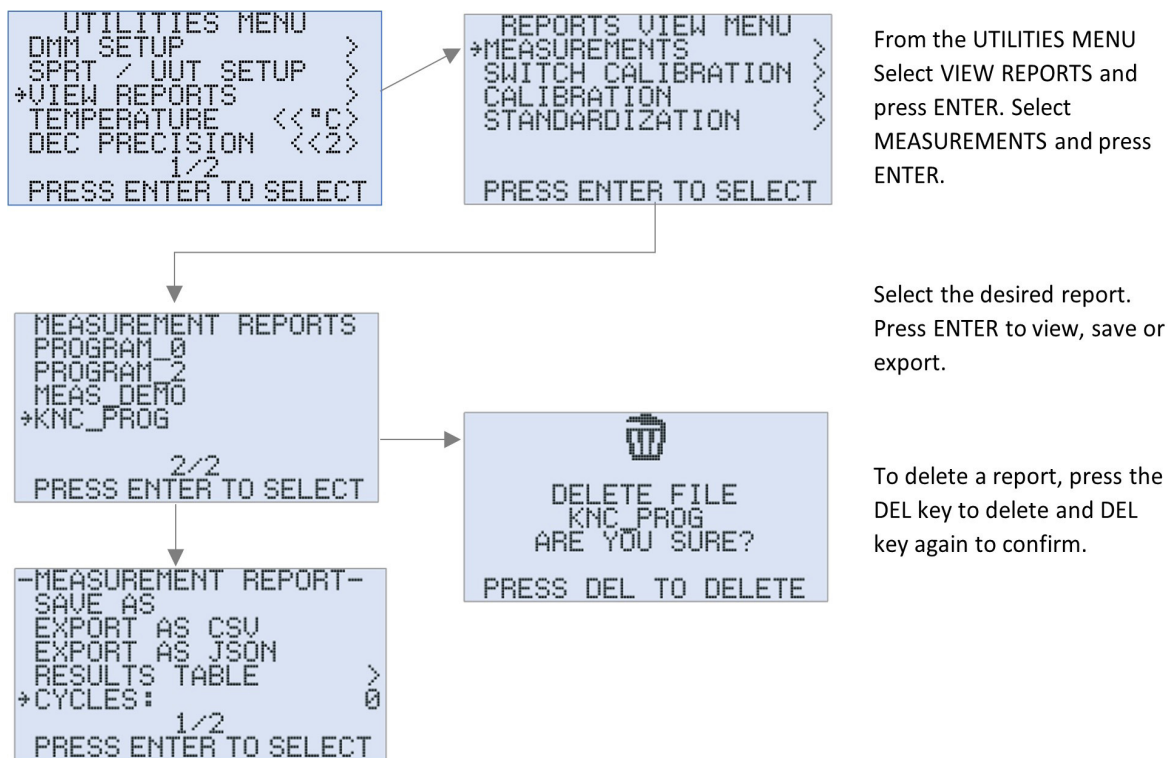


Figure 5-4 View, Save and Export a MANUAL MODE or RAMP AND SOAK Report

SWITCH CALIBRATION REPORTS

SWITCH CALIBRATION REPORTS are generated with SWITCH ADJUSTMENT and SWITCH TEST procedures. The user can view, save and export a current test by pressing the RSLTS key to access the SWITCH REPORT screen. The user can access a saved test through the UTILITIES menu.

Review or export a saved SWITCH ADJUSTMENT or SWITCH TEST report as follows:

1. From the MAIN MENU select UTILITIES and press ENTER to open the UTILITIES MENU.
2. Select VIEW REPORTS and press ENTER to open the VIEW REPORTS MENU.
3. Select SWITCH CALIBRATION and press ENTER to open the SWITCH REPORTS screen.

4. Select the desired report and press ENTER. The SWITCH REPORT will display on the screen as follows:
 - a) SWITCH #—Select and press ENTER to view the switch manufacturer, model, serial number and calibration expiration date.
 - b) REF #—Select and press ENTER to view the reference information on the Regulus 4200.
 - c) DMM #—If connected, select and press ENTER to view the DMM manufacturer, model, serial number and calibration due date.
 - d) DATE—The date of the test.
 - e) TYPE—The type of switch, whether open or closed at a given temperature.
 - f) OPEN TEMP—Temperature at which the switch is open.
 - g) CLOSE TEMP—Temperature at which the switch is closed.
 - h) AVG TEMP—The average temperature during the test.
 - i) DIFFERENTIAL—The average difference between the high to low trip points.
 - j) TRIP POINTS—Temperatures at which the switch state changed.
 - k) RATE—The rate of increase/decrease in units per minute.
 - l) LIMITS—Parameters set for the test.
 - m) AMBIENT—Ambient temperature.
 - n) EXPORT AS CSV—Export the test report to a flash drive in CSV format. A .pcl file is automatically included for conversion to a formatted .pdf report if desired.
 - o) EXPORT AS JSON—Export the test report to a flash drive in JSON format. A .pcl file is automatically included for conversion to a formatted .pdf report if desired.
 - p) SAVE AS—Accept the suggested file name or create a new name for the test.

CALIBRATION REPORTS

See Chapter 6, Maintenance for details.

STANDARDIZATION REPORTS

See Chapter 6, Maintenance for details.

TEMPERATURE UNITS

The Regulus 4200 supports three types of temperature units: Fahrenheit, Celsius and Kelvin. The units type selected will show on the display and in exported report values. The units type selected is saved in memory and will be the new default for all operating modes each time the unit is powered on.

From the UTILITIES MENU arrow to TEMPERATURE and press ENTER to cycle to the desired value.

DISPLAYED DECIMAL PRECISION

The Regulus 4200 supports one or two decimal digits to display the indicated well's temperature. This is for the display purposes only and does not affect accuracy. Reports are viewed and exported using two decimal digits. The selected setting is saved to memory and will be the default for all operating modes.

From the UTILITIES MENU select DEC PRECISION. Press ENTER to cycle between 1 and 2 digits.

DATE

To update the date and/or time, select DATE from the UTILITIES MENU and press ENTER to open the date and time screens. The user can also switch between two date display formats: <MM/DD/YY> or <DD/MM/YY>.

SYSTEM INFO

From the UTILITIES MENU, select the SYSTEM INFO and press ENTER to open the SYSTEM INFORMATION menu. The user can view or change settings in the Regulus 4200 as follows:

1. VER—Shows the current software version.
2. BRIGHTNESS—Press ENTER to cycle through the display brightness values.
3. MAX BLOWER PWR—Press ENTER to cycle through the blower power values.
4. SPEAKER—Press ENTER to make the speaker ACTIVE or MUTE. Key press will produce an audio “beep” in ACTIVE or MUTE mode.
5. VIEW ERROR LOG—Press ENTER to view and save the error log.
6. SYSTEM HEALTH—Press ENTER to view live statistics on the unit as follows and press STOP to exit.
 - a) Internal voltages – should be 5V, 24V and 48V. The V115 will always show 0.0.
 - b) Heaters resistance – Acceptable value between 20 to 30 ohm.
 - c) Display response – Acceptable value below 2000 uSec.
 - d) Keypad response – Each key press should generate different value.
 - e) Real-time clock accuracy – Acceptable drift is 1 sec for every minute.
 - f) Case temperature – Should be close to the current ambient temperature.

CHAPTER

6

CALIBRATION AND SYSTEM MAINTENANCE

INTRODUCTION

Calibration and system maintenance functions in the Regulus 4200 are accessed by selecting MAINTENANCE from the UTILITIES MENU. Upon pressing ENTER, the system requires the user to enter a code, **1234**, and press ENTER to open the MAINTENANCE MENU. This ensures that actions performed in the MAINTENANCE MENU are done intentionally. The MAINTENANCE MENU contains the following options:

CALIBRATION—Verify the accuracy of the Regulus 4200 by confirming that the indicated temperature is within the specified tolerance.

STANDARDIZATION—Align the unit's indicated temperature readings to match a reference standard scale, e.g., ITS-68 or ITS-90.

MANUAL COEF ENTRY—Review or modify the current coefficients type, values and the standardization/calibration date.

CHANGE UID—Rename the unit's unique identifier. This value can be set by the user. The UID is added to all reports generated by the unit.

NOTE: The Regulus 4200 comes with its serial number as its UID (unit identification). If the UID is changed, the unit's serial number can be found on the ID plate located on the back of the case, on the calibration label located on the instrument panel, and in the adapter chuck storage area on the side of the chassis.

FILE MANAGEMENT—Operations to backup and restore the system configuration and files, basic file explorer to export or delete individual files and reset to factory

defaults.

SCREEN FLOWS: ACCESSING THE MAINTENANCE MENU

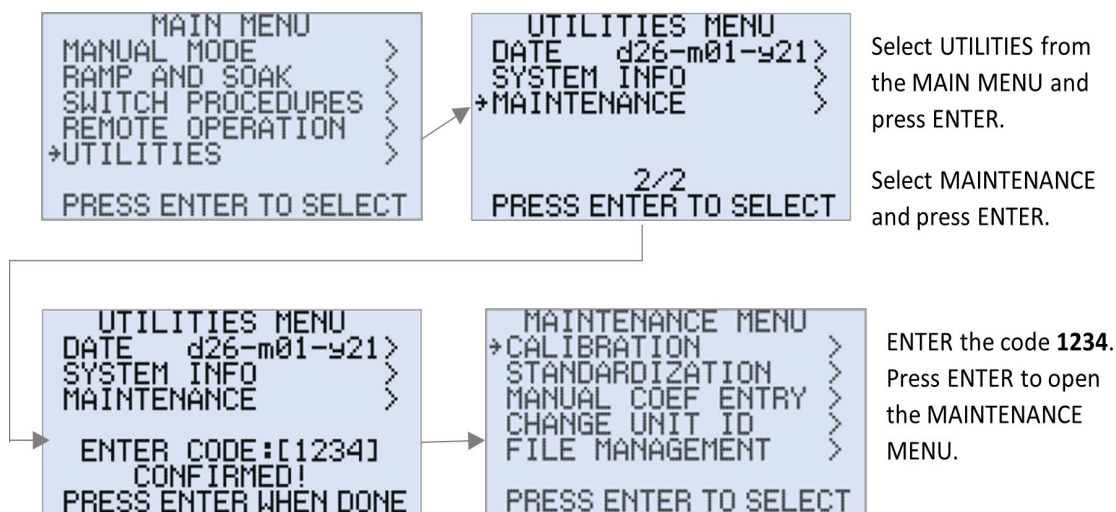


Figure 6-1 Accessing the Maintenance Menu

CALIBRATION

The Regulus 4200 is shipped from the factory calibrated, along with a document package that includes its King Nutronics calibration certificate. A label on the instrument panel indicates the calibration date, calibration expiration date and the unit's serial number.

King Nutronics recommends calibration of the Regulus 4200 at 12-month intervals or after any significant repairs. Calibration can be performed by King Nutronics to ISO/IEC 17025 calibration standards. The user can also calibrate the Regulus 4200 as described below. System calibration should be done per the user's Quality Management Systems guidelines.

Calibration is the process of verifying the accuracy of the Regulus 4200 by comparing its indicated temperature reading to a calibrated reference standard (typically a SPRT sensor) at defined temperature points. If the difference between the two readings is shown to be out of tolerance, then realignment of the Regulus 4200 is required. This realignment is referred to as standardization. In the standardization process, new coefficients are generated which realign the Regulus 4200's temperature accuracy to within system specifications. After standardization, the Regulus 4200 is then calibrated to verify that its accuracy is within specifications of 0.25.°F (0.14°C) Full Range.

CALIBRATION PROCEDURE SETUP

The Regulus 4200 can be calibrated automatically using an Agilent Model 34401A Multimeter or equivalent accuracy DMM that supports the SCPI command set for communications, or manually using a calibrated SPRT with a readout to provide the sensor reference readings. With either method, the user chooses between using three or seven factory-determined set points that cover the range of the unit, as time and quality requirements allow. In automatic calibration, the Regulus 4200 runs through the set points and displays the results automatically. In manual calibration, the unit will automatically ramp to and soak at each set point, prompting the user to input the indicated temperature of the reference sensor before continuing to the next set point.

When calibration is complete, the results are automatically saved, and the data can be accessed and exported and viewed from the UTILITIES MENU / VIEW REPORTS / CALIBRATION.

To prepare for calibration, the user will gather the appropriate equipment, set up the DMM if used, set up the SPRT or reference probe, choose between three or seven set points, and determine whether the calibration will be performed automatically or manually. This data will appear on the calibration report. The process is as follows below.

EQUIPMENT REQUIRED

The following equipment is required for calibration:

Automatic calibration:

1. Calibrated Agilent Model 34401A Multimeter or equivalent accuracy DMM that supports the SCPI command set for communications.
2. Calibrated SPRT, e.g., Rosemount 162CE, Hart Scientific 5628 or Fluke 5698.
3. RS-232 Interface cable (NULL MODEM type).
4. Adapter chuck sized for the chosen SPRT probe.

Manual calibration:

1. Calibrated SPRT with readout e.g., Rosemount 162CE, Hart Scientific 5628 or Fluke 5698.
2. Adapter chuck sized for the chosen SPRT probe.

DMM AND SPRT SETUP

Whether performing a calibration in automatic or manual mode, identification information for the DMM and SPRT are required for the calibration report.

Automatic calibration: Set up the DMM per "DMM SETUP" on page 5-2. Set up the SPRT per "UUT/SPRT SETUP" on page 5-4. Also refer to "DMM and UUT/SPRT Setup Connections" on page 5-2.

Manual calibration: No DMM setup is required. Set up the SPRT per "UUT/SPRT SETUP" on page 5-4. Also refer to "DMM and UUT/SPRT Setup Connections" on page 5-2.

PERFORMING A CALIBRATION

The operator can choose to calibrate the unit using three or seven test points across the operational range of the Regulus 4200. Using three test points is usually sufficient to calibrate the Regulus 4200, and is quicker than a seven test point calibration. However, if the Regulus 4200 is suspected to be out of tolerance or is operating erratically at certain temperature ranges, the seven test point may help the user understand any operational anomalies and may assist in troubleshooting operational issues.

The calibration points are 122°F (50°C), 392°F (200°C), and 662°F (150°C), for the three-point calibration, and 122°F (50°C), 212°F (100°C), 302°F (150°C), 392°F (200°C), 482°F (250°C), 572°F (300°C) and 662°F (350°C), for the seven-point calibration.

To proceed with calibration, do the following:

1. From the MAIN MENU select UTILITIES and press ENTER.
2. From the UTILITIES MENU select MAINTENANCE and press ENTER. Input the code **1234** and press ENTER to open the MAINTENANCE MENU.

NOTE: The user must enter the code **1234** to access the MAINTENANCE MENU. This is to ensure that actions taken in this menu are intentional.

3. From the MAINTENANCE MENU, select CALIBRATION and press ENTER to open the DMM LIST screen.
4. In the DMM list, selection depends whether the calibration will be done automatically or manually.

For automatic calibration:

- a) Select a DMM from the DMM LIST menu or create a new one by selecting "Add new device" and following the instructions in "DMM SETUP" on page 5-2. Press ENTER to open the DMM INFORMATION screen.
- b) Verify the information on the DMM INFORMATION screen. Any line can be edited by selecting it and pressing ENTER.
- c) In the DMM INFORMATION screen, select CONNECT and press ENTER. The screen should display DMM DETECTED. Press BACK/MENU to return to the DMM INFORMATION screen.

NOTE: Selecting CONNECT tells the Regulus 4200 to run an automatic calibration. The DMM must be connected for the unit to be calibrated automatically.

- d) In the DMM INFORMATION screen, arrow down to DONE and press ENTER to open the UUT/SPRT LIST screen.
- e) Proceed to Step 5, below.

For manual calibration:

In manual calibration, a DMM will not be connected to the Regulus 4200. Follow steps a) through c) below. Ensure that the DMM INFORMATION screen indicates "CONNECT TO DMM."

- a) From the DMM LIST screen select NONE and press ENTER to open the DMM INFORMATION screen.
 - b) If the second line option is DISCONNECT FROM DMM, select it and press ENTER. If the option is CONNECT TO DMM, no action is necessary.
 - c) In the DMM INFORMATION screen, arrow down to DONE and press ENTER to open the UUT/SPRT LIST screen.
5. The process for choosing an SPRT is the same for automatic and manual calibration.
- a) In the UUT/SPRT LIST, select an SPRT or create a new SPRT configuration per the instructions in "UUT/SPRT SETUP" on page 5-4. Press ENTER to open the DEVICE INFORMATION screen.
 - b) Verify that the information in the DEVICE INFORMATION screen is correct. Arrow down to READ and press ENTER. In automatic calibration mode, the screen will read DMM DETECTED. In manual calibration mode, the screen will indicate DMM NOT DETECTED. Press ENTER to return to the DEVICE INFORMATION screen.
 - c) Arrow down to DONE and press ENTER to open the CALIBRATION screen.
6. The CALIBRATION screen displays all the parameters of the calibration:
- a) **MODE:** If a DMM was selected and connected, the display reads MODE: AUTO. If the DMM selected was NONE and it was disconnected, the display reads MODE: MANUAL.
 - b) **POINTS:** Press ENTER to choose between 3 or 7 test points.
 - c) **SOAK TIME:** Press ENTER to modify the soak time at the test points. A soak time of 30 minutes is recommended.
 - d) **RUN:** Displays the estimated run time of the procedure based on the soak time and calibration points.
 - e) **SPRT#:** Displays the selected SPRT.
 - f) **DMM#:** Displays the selected DMM, or empty if the DMM selection was NONE.

7. In the CALIBRATION screen select RUN and press ENTER. The calibration procedure will start. During the test, the display shows the current state (ramp or soak) and the set point temperature.
 - a) In automatic mode calibration, the Regulus 4200 executes the steps automatically.
 - b) In manual mode calibration, at the end of the soak time for each point, the unit will prompt the user to input the temperature of the reference sensor.
 - c) When the program has ended, the screen displays PROGRAM ENDED – POWER IS OFF. Press the RSLTS key to view, export and save the report. For details, see "ACCESSING THE CALIBRATION REPORT" on page 6-6.

ACCESSING THE CALIBRATION REPORT

When the calibration procedure is complete, press the RSLTS key to view the calibration report. The CALIBRATION REPORT screen states whether the calibration passed or failed, the date, the parameters of the test and a table showing the deviation of the unit's temperature from the reference sensor for each calibration point. Arrow down to save and export the report as a .csv or .json file to a flash drive, or select SAVE AS to save it to the system. Accept the filename or change/create a new one, and press ENTER. A saved calibration report can be accessed from the UTILITIES MENU by selecting VIEW REPORTS and then CALIBRATION.

When a .csv or .json file is exported to a flash drive, a .pcl file is also included. This file contains a formatted report that, using a pcl-to-pdf converter application, can be easily converted to a pdf file. A PCL to PDF conversion application is included on the King Nutronics thumb drive supplied with the Regulus 4200. Download the app and drag the .pcl file to it to generate a .pdf in the same directory as the .pcl file.

STANDARDIZATION

The Regulus 4200 has a Platinum Resistance Thermometer (PRT) embedded in its temperature well. The accuracy of this PRT requires periodic calibration and in some instances re-alignment. To maintain the accuracy of the Regulus 4200, annual standardization and calibration is recommended.

In standardization, the Regulus 4200 is taken to three temperature points and compared to a calibrated Standard Platinum Resistance Thermometer (SPRT). The embedded PRT sensor's resistance at each point is used to generate corrected coefficients that define the temperature curve of the Regulus 4200 according to ITS-90. This process can be done automatically with the Regulus 4200 reading the SPRT temperature, or manually with a technician inputting the SPRT temperature at each standardization test point: 122°F (50°C), 374°F (190°C) and 626°F (330°C). With either automatic or manual standardization, the corrected coefficients generated by the standardization are automatically saved to the Regulus 4200, replacing the previous coefficients.

STANDARDIZATION PROCEDURE SETUP

The Regulus 4200 can be standardized automatically using an Agilent Model 34401A Multimeter or equivalent accuracy DMM that supports the SCPI command set for communications, or manually using a calibrated SPRT with a readout for the sensor reference readings. In automatic standardization, the Regulus 4200 runs through the set points and displays the results automatically. In manual standardization, the unit will automatically ramp to and soak to each set point, prompting the user to input the indicated temperature of the reference sensor before continuing to the next set point.

When standardization is complete, the result is automatically saved, and the data can be accessed and exported from the UTILITIES MENU, VIEW REPORTS, STANDARDIZATION.

To prepare for standardization, the user will gather the appropriate equipment, determine whether the calibration will be performed automatically or manually, set up the DMM accordingly if used and set up the SPRT. This data will appear on the standardization report. The process is as follows:

EQUIPMENT REQUIRED

The following equipment is required for standardization:

Automatic standardization:

1. Calibrated Agilent Model 34401A Multimeter or equivalent accuracy DMM that supports the SCPI command set for communications.
2. Calibrated SPRT e.g., Rosemount 162CE, Hart Scientific 5628 or Fluke 5698.
3. RS-232 Interface cable (NULL MODEM type).
4. Adapter chuck sized for the chosen SPRT probe.

Manual standardization:

1. Calibrated SPRT with readout e.g., Rosemount 162CE, Hart Scientific 5628 or Fluke 5698.
2. Adapter chuck sized for the chosen SPRT probe.

DMM AND SPRT SETUP

Whether performing a standardization in automatic or manual mode, identification information for the DMM and SPRT are required for the standardization report.

Automatic standardization: Set up the DMM per "DMM SETUP" on page 5-2 . Ensure the DMM is connected. Set up the SPRT per "UUT/SPRT SETUP" on page 5-4. Also refer to "DMM and UUT/SPRT Setup Connections" on page 5-2 .

Manual standardization: No DMM setup is required. Set up the SPRT per "UUT/SPRT SETUP" on page 5-4. Also refer to "DMM and UUT/SPRT Setup Connections" on page 5-2.

PERFORMING A STANDARDIZATION PROCEDURE

To proceed with standardization, do the following:

1. From the MAIN MENU select UTILITIES and press ENTER.
2. From the UTILITIES MENU select MAINTENANCE and press ENTER. Input the code **1234** and press ENTER to open the MAINTENANCE MENU.

NOTE: The user must enter the code **1234** to access the MAINTENANCE MENU. This is to ensure that actions taken in this menu are intentional.

3. From the MAINTENANCE MENU, select STANDARDIZATION and press ENTER to open the DMM LIST screen.
4. In the DMM list, selection depends on whether the standardization will be done automatically or manually.

Automatic standardization:

- a) Select a DMM from the DMM LIST menu or create a new one by selecting "Add new device" and following the instructions in "DMM SETUP" on page 5-2. Press ENTER to open the DMM INFORMATION screen.
- b) Verify the information on the DMM INFORMATION screen. Any line can be edited by selecting it and pressing ENTER.
- c) In the DMM INFORMATION screen, select CONNECT and press ENTER. The screen will display DMM DETECTED. Press BACK/MENU to return to the DMM INFORMATION screen.

NOTE: Selecting CONNECT tells the Regulus 4200 to run an automatic standardization. The DMM must be connected for the unit to be standardized automatically.

- d) In the DMM INFORMATION screen, arrow down to DONE and press ENTER to open the UUT/SPRT LIST screen.

Manual standardization:

In manual standardization, a DMM will not be connected to the Regulus 4200. Follow steps a) through c) below. Ensure that the DMM INFORMATION screen indicates "CONNECT TO DMM."

- a) From the DMM LIST screen select NONE and press ENTER to open the DMM INFORMATION screen.
- b) The second line option is either CONNECT TO DMM or DISCONNECT FROM DMM. If the option is DISCONNECT FROM DMM,

- Manual standardization:** At the end of the soak time for each point, the unit will prompt the user to input the temperature of the reference sensor.

temperature deviation between the unit's temperature from the reference sensor for each standardization point. Arrow down to save and export the report as a .csv or .json file to a flash drive, or select SAVE AS to save it to the unit. Accept the filename or change/create a new one, and press ENTER. A saved standardization report can be accessed from the UTILITIES MENU by selecting VIEW REPORTS and then STANDARDIZATION.

When a .csv or .json file is exported to a flash drive, a .pcl file is also included. This file contains a formatted report that, using a pcl-to-pdf converter application, can be easily converted to a pdf file. A pcl-to-pdf converter application is included on the King Nutronics flash drive supplied with the unit. Download the app and drag the .pcl file to it to generate a .pdf in the same directory as the .pcl file.

CALIBRATE AFTER STANDARDIZATION

After standardization, calibrate the Regulus 4200 per "CALIBRATION" on page 6-2 to verify that the accuracy of the unit is within specifications of 0.25.°F (0.14°C) Full Range.

ITS-90 AND IPTS-68 COEFFICIENTS MANUAL ENTRY

ITS-90 and IPTS-68 coefficients for the Regulus 4200 can be input manually if needed to restore a previous set of coefficients. The user will need access to data provided on the most recent calibration or standardization report. If neither of these reports are available, contact King Nutronics for support.



WARNING! Improper coefficients can lead to system malfunction and dangerous well temperatures that can harm the unit and the operator. Coefficients should only be modified by an experienced technician.

Manually input the coefficient values as follows:

1. From the MAIN MENU select UTILITIES and press ENTER.
2. From the UTILITIES MENU select MAINTENANCE and input the verification code **1234** and press ENTER.

3. From the MAINTENANCE MENU select MANUAL COEF ENTRY and press ENTER. The UNITS STD PARAMETERS screen will open and display the following menu:
 - a) EXP DATE: The expiration date on the most recent calibration or standardization report.
 - b) AMBIENT: The average ambient temperature measured inside the case, as shown on the most recent calibration or standardization report.
 - c) ITS COEFFICIENTS: Select and press ENTER to open the COEFFICIENTS screen and choose or input the following data:
 - i) TYPE: Press ENTER to choose between ITS90 and IPTS68 per the most recent calibration or standardization report. Arrow down to the next selection, RTPW.
 - ii) For ITS-90 enter the RTPW, a7, b7 and c7 coefficients. Coefficients for a4 and B4 are always 0.0000000e+00.
 - iii) For IPTS-68 enter the R0, α , and δ coefficients.
 - iv) When complete, select DONE and press ENTER.

NOTE: If, due to a loss of valid coefficient values, the unit cannot standardize, select TYPE as IPTS68, and enter the coefficients as follows:

R0: 200

Alpha: 0.00363

Delta: 1.5

These standard values will be sufficient for the user to standardize the unit, after which the corrected coefficients will be automatically saved to the system. Always calibrate the unit after standardization to verify that the accuracy is within specifications of 0.25.°F (0.14°C) Full Range.

4. Perform a standardization per "PERFORMING A STANDARDIZATION PROCEDURE" on page 6-8.
5. Perform a calibration per "PERFORMING A CALIBRATION" on page 6-4 to verify that the unit's accuracy is within specifications of 0.25.°F (0.14°C) Full Range.

UNIT IDENTIFICATION (UID) AND NAME CHANGE

The CHANGE UNIT UID selection from the MAINTENANCE MENU allows the user to identify a specific unit by name or number (up to 9 characters) other than the serial number. The UID name is displayed on the top row during each power up in the date confirmation screen, and appears on every report generated by the unit.

To change the UID:

1. From the MAIN MENU select UTILITIES and press ENTER.
2. From the UTILITIES MENU select MAINTENANCE and input the verification code **1234** and press ENTER.
3. From the MAINTENANCE MENU select CHANGE UNIT ID and press ENTER.
4. The VERIFY UNIT ID screen will appear. Enter the desired name/number up to 9 characters and press ENTER.

NOTE: The Regulus 4200 comes configured with its unique King Nutronics serial number as the UID by default. Since the UID appears on each report, any new UID name should always be unique to the unit and not belong to any other unit(s) in the laboratory.

FILE MANAGEMENT

The Regulus 4200 stores every device configuration, program or report as a JSON file in the FILE MANAGEMENT menu. Different from the VIEW REPORTS menu found in the UTILITIES MENU, where individual files can be exported or deleted, the FILE MANAGEMENT selection allows wholesale copying, deleting and restoring of the system configuration and multiple programs and reports.

The available file-related maintenance operations are as follows:

- **BACKUP TO DRIVE** - Copies all configuration, program and report files to the connected flash drive.
- **RESTORE FROM DRIVE** - Overwrites all stored configuration, programs and report files with a copy found in the connected flash drive.
- **FILE EXPLORER** – Allows the user to navigate through the folders and export or delete individual files.
- **FACTORY RESET** - Erases the unit's memory and keeps the main configuration file.
- **SOFTWARE UPDATE** - Updates the unit's software.

BACKUP TO DRIVE

The BACKUP TO DRIVE operation copies all the configuration files, programs and reports from the unit's memory to a connected flash drive. The BACKUP TO

DRIVE operation works in concert with the FACTORY RESET and RESTORE TO DRIVE functions, and is useful for:

- Having a backup of the unit's configuration, programs and reports.
- Transferring many files in .json format to a PC for further examination. These files can be edited/deleted on a PC so that only the desired files are reinstalled on the Regulus 4200.
- Copying complicated programs to other units. If, for example, there is a long Ramp and Soak program that the user would like to implement across other Regulus 4200 units, the BACKUP TO DRIVE allows the user to copy all the files to a PC, delete everything but the desired program(s), and install the program(s) on other Regulus 4200s.
- Protecting programs and reports from unwanted access. If, for example, the unit is being transferred to another location that should not have access to certain programs or reports, they can be saved using the BACKUP TO DRIVE selection, erased using the FACTORY RESET selection, and reinstalled using the RESTORE FROM DRIVE selection.



CAUTION! BACKUP TO DRIVE **will overwrite** any existing files on the flash drive. Using an empty flash drive is recommended.

To initiate a BACKUP TO DRIVE operation:

1. Insert an empty flash drive (1 MB minimum) in the USB port.
2. From the MAIN MENU select UTILITIES and press ENTER.
3. From the UTILITIES MENU select MAINTENANCE and input the verification code **1234** and press ENTER.
4. From the MAINTENANCE MENU select FILE MANAGEMENT and press ENTER.
5. From the FILE MANAGEMENT screen select BACKUP TO DRIVE and press ENTER. The unit will recognize the flash drive and backup will begin. The screen will display STORAGE DETECTED COPYING FOLDER while scrolling through the folders of files being copied. The unit returns to the FILE MANAGEMENT screen when the backup is complete.



Figure 6-2 Backup Screen

RESTORE FROM DRIVE

The RESTORE FROM DRIVE operation replaces Regulus 4200 files with files found in the connected flash drive. Files that exist in the unit's memory but do not exist on the flash drive will not be affected or deleted.

The RESTORE TO DRIVE operation is used for restoring files after a factory reset, memory repair or replacement, or for duplicating the same configuration files, programs or reports on other Regulus 4200s. Flash drive files can be selectively edited on a PC so that only the desired files remain on the flash drive for restoration.



CAUTION! Deleting a file or a folder is irreversible. Deleting the configuration file <sysFull.json> (located in the root directory) will cause the unit to lose its configuration and calibration with the most recent ITS parameters. Before deleting or restoring files, always back up the Regulus 4200 using the BACKUP TO DRIVE operation.

To initiate a RESTORE TO DRIVE operation:

1. Insert a flash drive containing the files to be downloaded to the unit in the USB port. The flash drive should have at least 1MB of free space.
2. From the MAIN MENU select UTILITIES and press ENTER.
3. From the UTILITIES MENU select MAINTENANCE and input the verification code **1234** and press ENTER.
4. From the MAINTENANCE MENU select FILE MANAGEMENT and press ENTER.

5. From the FILE MANAGEMENT screen select RESTORE FROM DRIVE and press ENTER.
 - a) The screen will warn that this procedure overwrites existing files. To continue press the UP ARROW. To cancel press BACK/MENU or ENTER.
 - b) The screen will display STORAGE DETECTED COPYING FOLDER while scrolling through the folders of files being copied.
 - c) The screen will read CONFIGURATION RESTORE COMPLETED! REBOOT THE UNIT NOW. Power the unit off and on. The unit will power up with the restored files.

SCREEN FLOWS: RESTORE CONFIGURATION



Figure 6-3 Restore Configuration Screens

FILE EXPLORER

The FILE EXPLORER menu selection allows users to navigate through the entire file system tree of the Regulus 4200's memory to view all existing files and to export or delete any of them. These files are stored in folders according to their classification as follows:

Table 6-1. File Explorer Menu

FOLDER NAME	DESCRIPTION
dmm	DMM device configuration
sprt	UUT and reference sensor (SPRT) device configurations
rampsoak	Ramp and Soak Programs
swcal	Thermal switch testing programs
reports	Test results reports
errorLog	Unit's error logs (if saved by the user)
sysFull.json	Contains the complete Regulus 4200 configuration including the UID, calibration date, ITS coefficients and date format

To access the FILE EXPLORER:

1. From the MAIN MENU select UTILITIES and press ENTER.
2. From the UTILITIES MENU select MAINTENANCE and input the verification code **1234** and press ENTER.
3. From the MAINTENANCE MENU select FILE MANAGEMENT and press ENTER.
4. From the FILE MANAGEMENT screen select FILE EXPLORER and press ENTER to view the FILE EXPLORER directory.
 - a) Press ENTER to view the files in a folder.
 - b) Select a folder to view the files it contains and press ENTER.
 - c) Select the desired file. Press the DASH key '-' to copy the files to a flash drive. Press the DEL key to delete the file, and at the prompt press DEL again to confirm.
 - d) Select. '..' located at the top row and press ENTER to return to the FILE EXPLORER directory.

FACTORY RESET

The FACTORY RESET selection erases the unit's memory including configurations, programs and reports. The unit's calibration will void, and the ITS coefficients will be replaced with the default values.

FACTORY RESET is useful when the user wants to delete a significant number of programs or reports for the purposes of file organization, or when the user wishes to remove programs or reports from the memory to prevent unwanted access and reinstall them later.



CAUTION! Always perform the BACKUP TO DRIVE for <sysFull.json> before attempting a FACTORY RESET to maintain the unit's calibration and settings. Otherwise the unit must be calibrated, standardized and recalibrated to confirm accuracy.

To perform a FACTORY RESET:

1. From the MAIN MENU select UTILITIES and press ENTER.
2. From the UTILITIES MENU select MAINTENANCE and input the verification code **1234** and press ENTER.
3. From the MAINTENANCE MENU select FILE MANAGEMENT and press ENTER.

4. From the FILE MANAGEMENT screen select FACTORY RESET and press ENTER.
 - a) The screen will caution that FACTORY RESET erases the unit's calibration, reports and programs. To continue press the UP ARROW. To cancel press the BACK/MENU key or ENTER.
 - b) The screen will display STORAGE DETECTED COPYING FOLDER while scrolling through the folders of files being copied.
 - c) The screen displays FACTORY RESET COMPLETED! REBOOT THE UNIT NOW. Power the unit off and on.
 - d) Once the unit is powered up, enter the date and time. The next screen displays SYSTEM ERROR LOG. Select CONFIG FILE MISSING and press ENTER to open the MAIN MENU.
 - e) From the MAIN MENU select UTILITIES, then MAINTENANCE and enter the code **1234**.
 - f) From the MAINTENANCE MENU select FILE MANAGEMENT and press ENTER.
 - g) Select RESTORE FROM DRIVE and press ENTER.
 - i) The screen will warn that this procedure overwrites existing files. To continue press the UP ARROW. To cancel press BACK/MENU or ENTER.
 - ii) The screen will display STORAGE DETECTED COPYING FOLDER while scrolling through the folders of files being copied.
 - iii) The screen will read CONFIGURATION RESTORE COMPLETED! REBOOT THE UNIT NOW. Power the unit off and on. The unit will power up with the restored files.

UPDATE SOFTWARE

The Regulus 4200 software can be easily updated by copying the <firmware.img> file from King Nutronics to a flash drive.

To update the Regulus 4200 from the flash drive do the following:

1. Insert a flash drive containing the <firmware.img> file into USB.
2. From the MAIN MENU select UTILITIES and press ENTER.
3. From the UTILITIES MENU select MAINTENANCE and input the verification code **1234** and press ENTER.
4. From the MAINTENANCE MENU select FILE MANAGEMENT and press ENTER.
5. From the FILE MANAGEMENT screen select UPDATE SOFTWARE and press ENTER.
 - a) To enter UPDATE MODE press and hold the MEAS key while powering the unit off and then on.
 - b) The unit will detect the USB. Press and hold the ENTER key to delete the line of arrows (>>>>).
 - c) The update will commence and, when complete, will alert the user to restart the unit.

SCREEN FLOWS: UPDATE THE SOFTWARE

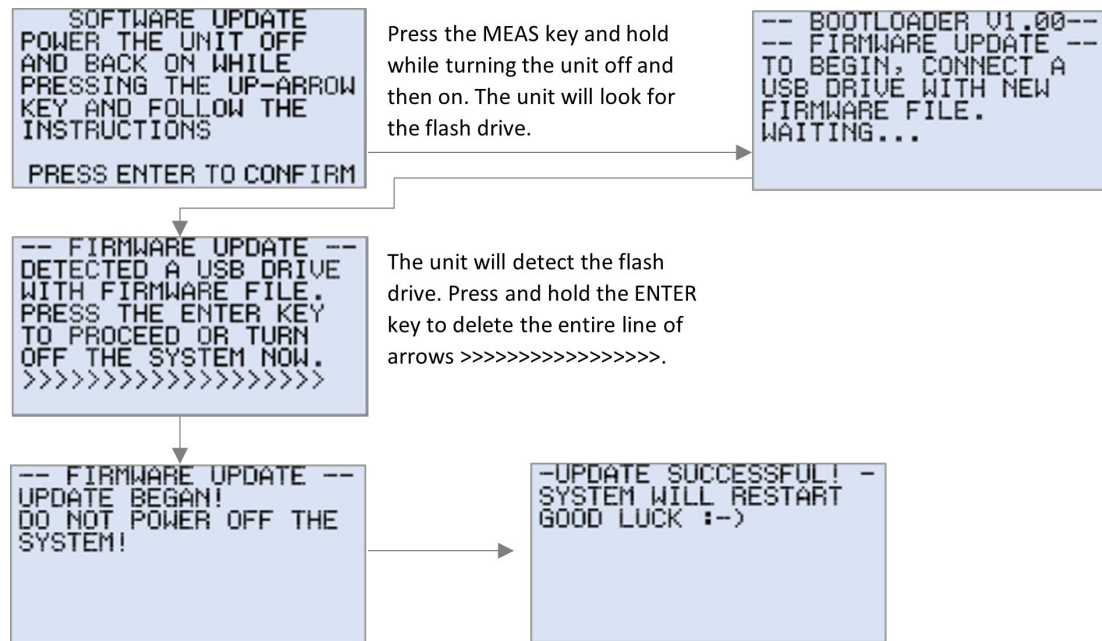


Figure 6-4 Update Software

CHAPTER

7

REPLACEMENT PARTS

Replacement parts can be ordered from King Nutronics Corporation.

Table 7-1 Replacement Parts

KING NUTRONICS PART NUMBER	DESCRIPTION	UoM
3605-41-9	Adapter Chuck, #1, Bore Diameter 0.145 (9/64")*	Each
3605-28-250	Adapter Chuck, #2, Bore Diameter 0.250 (1/4")**	Each
3605-41-15	Adapter Chuck, #3, Bore Diameter 0.280 (9/32")*	Each
3605-41-7	Adapter Chuck, #4, Bore Diameter 0.353 (23/64")*	Each
3605-28-375	Adapter Chuck, Bore Diameter 0.375 (3/8")**	Each
3605-41-1	Adapter Chuck, #5, Bore Diameter 0.380-A (3/8")†	Each
3605-41-3	Adapter Chuck, #6, Bore Diameter 0.380-B (3/8")†	Each
3605-41-11	Adapter Chuck, #7, Bore Diameter 0.380-C (3/8")†	Each
3605-41-13	Adapter Chuck, #8, Bore Diameter 0.470 (15/32")*	Each
3605-28-437	Adapter Chuck, Bore Diameter 0.437 (7/16")**	Each
3605-28-500	Adapter Chuck, #9, Bore Diameter 0.500 (1/2")*	Each
3605-28-562	Adapter Chuck, Bore Diameter 0.562" (9/16")**	Each
3605-28-625	Adapter Chuck, #10, Bore Diameter 0.625 (5/8")*	Each
3605-41-17	Adapter Chuck, #11, Bore Diameter 0.692 (11/16")*	Each
3605-28-937	Adapter Chuck, #12, Bore Diameter 0.937 (15/16")*	Each
4200-014-006	Carrying strap	Each

Table 7-1 Replacement Parts (Continued)

KING NUTRONICS PART NUMBER	DESCRIPTION	UoM
3729-12-37	Safety Fuse, 120V 10A	Each
4200-104-001	Thermal Switch Lead Cables	Each
4200-018-002	King Nutronics Logo Flash Drive	Each
4200-103-001	Null MODEM Cable for Agilent DMM Connection	Each
3603-12-1	Temperature Well Door Inserts	Pair
3603-36-1	Adapter Chuck Tool	Each

*Available for purchase. Not included with the Regulus 4200.

**Standard adapter chucks included with the Regulus 4200.

†Adapter chucks with counterbore. Available for purchase. Not included with the Regulus 4200.



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