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SIGMA SYSTEMS
MODEL CC-3
PROGRAMMABLE TEMPERATURE CONTROLLER / INTERFACE

OPERATING & PROGRAMMING MANUAL

Firmware Revision 5.3

July 18, 1997

SIGMA SYSTEMS CORPORATION
3163 Adams Avenue
San Diego, California 92116 USA

TEL: (619) 283-3193 WWW.SigmaSystems.Com *FAX: (619/283-6526)*

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San Diego, California 92116 USA

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1. INTRODUCTION

This manual describes the operating procedures for the Sigma Systems Model CC-3 Controller, a microprocessor based controller and control communications interface for the family of Sigma Systems environmental chambers and platforms. Temperature control is available manually from the front panel, by use of user entered programs, or via remote control via either a RS-232 or IEEE 4888 GPIB. The controller has a precision temperature reading capability with a digital read-out. Two temperature probes can be connected to the controller allowing either probe to be the control probe while the other probe can be used to take measurements.

Two additional controlled device ports are available. They are intended for on/off control of a refrigeration compressor and an external load such as a device under test, or a main chamber or platform power relay. These ports normally are supplied as TTL level (low voltage) ports but are optionally available with solid state relays to control line voltage as in the case of units with mechanical refrigeration. The compressor control port may be toggled from the front panel at any time in the manual (LOCAL) mode. The compressor is not designed to cycle on and off with the temperature control function. Older CC-3 units (earlier than revision 12 EPROMs) were not supplied with front panel control of compressor port.

The controller operates in one of four modes: Local Mode, Program Mode, Remote Mode, and Setup Mode.

Using Local Mode, the operator can control the chamber or platform temperature using the keyboard and LED display on the front panel. In this mode, a set point is selected and the chamber or platform is controlled to that temperature.

Using Program Mode, the operator can enter up to 100 program steps via the front panel to be carried out when the START key is pressed. These programs are stored in non-volatile memory so they are retained even during power off conditions.

Using Remote Mode, control requirements are asserted by an external computer via either the RS-232 port or the IEEE-488 (GPIB) port. The IEEE-488 interface implementation is a TALKER/LISTENER with serial poll. Extended addressing and parallel poll capabilities are not supported. The RS-232 interface is fully configurable for baud rate, data bits, stop bits and parity.

Using Setup Mode, the user can configure the various parameters that define attached devices and determine how the controller will behave.

1.1 Custom Features / Interchangeability WARNING

Each Sigma Systems CC-3 Controller has been custom configured for the chamber or platform with which it was supplied or for which it was specified. Many units include special wiring for custom control applications, precision fail-safe additions, non-standard voltages, external unit power control, etc. **Units that may appear to be identical may be internally quite different. Do not interchange controllers between controlled devices (chambers and/or platforms) unless you are certain that the controllers have been identically constructed.**

Failure to heed this warning voids your warranty, may cause unpredictable controlled device behavior that could cause damage to persons or property, pose a risk of fire, or cause other problems. If you must move controllers between controlled devices, please contact the Sigma technical support department for assistance and advice.

1.2 Revision 5.3 Firmware

This manual is specifically written to cover the features of Release 5.3 firmware for the Sigma Systems Model CC-3 controller. While the features of 5.3 firmware are largely backward compatible with earlier firmware. The following firmware versions are earlier than Release 5.3:

Version 8, Version 10, Version 12, and Release 4.4

As Release 5.3 added a number of bug fixes and improved stability with systems operating with higher bus control speeds, Sigma highly recommends that all users update to the latest firmware release. Contact Sigma Technical Support. See Section 7.8.

2. PHYSICAL DESCRIPTION

The SIGMA SYSTEMS Model CC-3 Controller fits into an area 3.5" x 5.5" x 9.5" long. Connection to the chamber or platform is made through an umbilical cable with a 12 pin connector that is standard for all SIGMA chambers and thermal platforms. In addition, controllers destined for use with SIGMA thermal platforms have an additional 6 pin connector used for the sensor probe circuits.

2.1 Front Panel

The front panel consists of four major parts: the digital LED display, the LED indicators, the mode switch and the keyboard. The numbers in circles on the front panel guide the user through the steps for changing the temperature setting in the LOCAL (manual) mode of operation. See Section 3.

2.1.1 Digital LED Display

The Digital LED Display is a 7 digit display arranged in the following configuration:

*****.******

The display is used for showing probe temperatures, set points, program steps, fail-safe status and setup information.

2.1.2 LED Indicators

Below the Digital LED Display are four discrete LED Indicators. These indicators are arranged in the following order:



REFER indicator shows if power is applied to the refrigeration compressor control port (not all units are equipped with compressors).

COOL indicator lights when cooling is active, typically during the time the cryogenic valve is open on cryogenically cooled units.

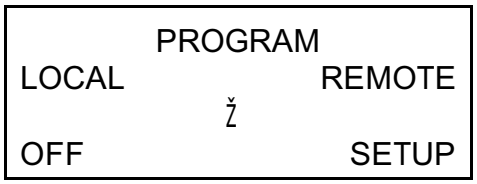
HEAT indicator is pulsed along with the on and off function of the heaters. These indicators are active in all modes of operation.

RUN indicator shows whether the chamber temperature is being controlled.

On older units the REFER button and REFER LED were not supplied.

2.1.3 Mode Switch

The Mode Switch is used to apply power to the chamber and to select the mode of operation. It is a 5 position rotary switch arranged as follows:



The OFF position removes the power from heating and cooling and compressor control circuits of both the controller and the chamber or thermal platform.

CAUTION: Placing the mode switch in the OFF position does not remove all power from either the controller or the chamber or thermal platform. Only the heating, cooling, and compressor control circuits are turned off. Full line voltage potential is still available in many places in both the controller and the chamber or platform. See servicing warnings and instructions in the appendix of this manual.

Moving the rotary switch changes the mode of operation of the chamber. The different modes are described in detail in separate sections of this manual. When the rotary mode switch is moved to a new position, other than OFF, the temperature control loop, if running, is turned off, heating and cooling are disabled but the chamber blowers will continue to run unless disabled via setup parameter 15. Likewise, at the end of a local or remotely controlled program, chamber blowers will continue to run, but heating and cooling will be disabled. Note that a chamber in this condition, with blowers running, will exhibit some heating due to blower air friction. This effect is exaggerated in units equipped with high velocity blowers. Moving the rotary switch between OFF and LOCAL will maintain the last used set point for next operation of the controller. See 6.3 for description of auto-start function.

2.1.4 Keyboard

The keyboard consists of 20 momentary contact keys. Certain keys are functional only in some of the modes of operation. With some keys, such as the Display Control, the function is different depending on the mode of operation. The Keyboard is arranged in the following configuration:

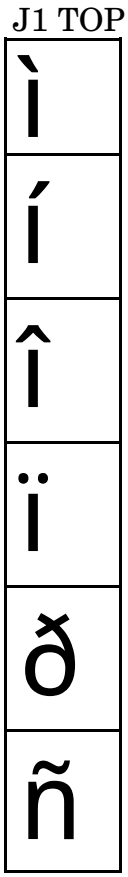
1	2	3	CLEAR PROG	START STOP
4	5	6	REFER	ENTER
7	8	9	ADV	DISP TEMP
.	0	+ -	CLEAR ENTRY	DISP CNTL

CLEAR PROG	Clear program from memory
START STOP	Start/Stop temperature control
REFER	Toggle refrigeration compressor on or off *
ENTER	Enter/finalize current keyboard entry
ADV	Advance to next program step
DISP TEMP	Display temperature
CLEAR ENTRY	Clear current keyboard/display entry
DISP CNTL	Display control set point

* = LOCAL MODE ONLY. Note that CC-3 Controllers built before the introduction of mechanical refrigeration to Sigma devices do not have this feature. Such units will not have either the REFER LED or the REFER key on the front panel.

2.2 Rear Panel Connections

At the rear panel of the controller, a cable is provided to connect to the power, cooling solenoid, mechanical refrigeration and heaters of the chamber. In addition, a six lug screw terminal block (J1) is provided for eyelet terminal connection of the temperature probes and for connection of one additional optional device such as the Sigma PFS-2 Precision Fail Safe.



Probe 1 (Black lead)

Probe 2 (Black lead)

Chassis Ground (Probe shield)
(Chamber or platform ground, etc.)

Probe 1 & 2 return (Red or White lead)

Auxiliary device ground

OPTIONAL Auxiliary device (control) power
(May be TTL or 12 VDC, switched or
unswitched, see below)

Please observe all standard anti-static procedures when making connections to these points!

An IEEE-488 connector, series 57 (metric threads), and an RS-232 connector, female DB-25, are provided for the remote modes of operation. Two TTL outputs are also available. (See Appendix 7.5)

2.3 Fail-safe System

The CC-3 is designed to sense the loss of control circuit power due to opening of a safety limit switch such as those supplied with all Sigma chambers and thermal platforms. If the controller is in the RUN mode and the fail-safe is tripped, the controller will stop controlling and display "FL. SAFE" on the digital LED display. It will also report the fail-safe tripped condition over the computer bus interface if in use. In order to re- establish normal operation, the failsafe system on Sigma chambers and thermal platforms requires that power be cycled off then on in addition to the out of range temperature condition subsiding. If the controller is to be used independently of a Sigma chamber or thermal platform, connect pins 10 & 11 of the 12-pin power plug to pin 3 for 120 volt operation. In the case of 208-240 volt operation connect pins 10 & 11 to pin 6 through a 56kS ½ watt resistor. See wiring diagram. Opening this connection will cause the above described failsafe condition.

3. LOCAL MODE (Basic Operation)

The Local mode of operation the CC-3 provides simple control of the chamber or platform through the front panel controls. In this mode, a single set point is entered from the front panel and the controller will attempt to have the chamber or platform reach and hold that temperature. In local mode the compressor of mechanically refrigerated units can be turned on or off using the **<REFER>** button on the front panel.

The controller can be set to automatically start controlling at the last used temperature upon startup by setting the controller to the AutoStart mode. See AutoStart mode description, Section 6.4.

The circled numbers on the front panel guide the user through the sequence for the basic operation of changing the set point. The reasoning for each keystroke is as follows:

1. Display control set point temperature.

2. Clear the existing set point value.

3. Key-in control probe number (only if in 2 probe mode) & new set point.

4. Commit new set point entry.

5. Display current chamber temperature.

If controller RUN LED is not ON press **<START/STOP>** to begin controlling at set temperature.

3.1 Displaying Temperature

The temperature may be displayed at any time by pressing the **<DISP/TEMP>** key. The format of the display is:

pn - TTT.T

where ***n*** indicates from which probe the reading originates and the **-TTT.T** indicates the numeric temperature. In single probe mode, ***n*** is always 1. In two probe mode, n can be 1 or 2 as the temperature display toggles between probe 1 and probe 2 with each press of the Display Temperature **<DISP/TEMP>** key. The temperature is displayed to the nearest tenth of a degree C. although internal temperature values

are kept at a much higher precision. The value is rounded so that a display of 30.2 means a temperature between 30.150 and 30.249.

3.2 Displaying and Changing the Set Point

The set point may be displayed by pressing the Display Control key **<DISP/CNTL>**. The format of the display is:

sn -TTT.T

where ***n*** is the probe used for control. Upon entering the LOCAL mode from the PROGRAM REMOTE or SETUP mode, the control probe defaults to 1.

To change either the temperature or the control probe of a 2 probe configuration, use the following procedure:

1. First display the set point using **<DISP/CNTL>.**

2. Press **<CLEAR/ENTRY>** to clear the current value from the display. If single probe mode is in effect, **s1** will appear at the left of the display indicating the control probe must be 1. If two probe mode is in effect, the probe number is also cleared.

3. If the probe number is erased, (in two probe mode) enter the controlling probe desired, either 1 or 2. If in single probe mode, ignore this step.

4. Enter a set point temperature using the numeric, decimal point and sign keys. Numbers may be entered with a maximum of 1 decimal place. Pressing the sign **<+/->** key will toggle the value between positive and negative. Positive values will have no indication, negative values will show a minus (-) sign to the left of the temperature display.

5. Errors may be corrected by simply pressing **<CLEAR/ENTRY>** and re-keying the entry prior to pressing **<ENTER>**.

6. After the number is keyed in, press **<ENTER>** to commit the entry and store it as the new set point.

7. The controller will remain in the RUN mode if the rotary switch has not be changed and **<START/STOP>** has not been pressed.

TIP: It is not necessary to stop the controller from controlling the chamber or platform to change the set point. The set point may be changed at any time, even while the chamber or platform is being actively controlled.

3.3 Controlling to a Set Point

The controller will start to control to the specified set point when **<START/STOP>** is pressed. The RUN LED will light to indicate the control process is active. A subsequent press of **<START/STOP>** will cause the controller to stop controlling and the RUN LED will be extinguished. Unless disabled through setup, the chamber blowers will continue to run regardless of RUN status.

3.4 Compressor Control (mechanically refrigerated unit control only)

The compressor of a system employing mechanical refrigeration can be manually toggled at any time during local mode operation by pressing the **<REFER>** button. The REFER LED on the front panel indicates the state of the compressor control port. REFER control is shut off when controlling action is stopped by pressing the RUN/STOP button. If uncontrolled cooling is desired the user may start the compressor by pressing the REFER button when the RUN LED is not lit.

The controller can be configured to not respond to front panel **REFER** (compressor) ON/OFF commands. See SETUP mode, Section 6 - setup parameter F13.

4. PROGRAM MODE

The Program Mode allows more complicated front panel control than the Local Mode. The Program Mode allows a temperature control program to be entered into the controller memory for subsequent execution as required. Up to 100 program steps may be entered. Multiple programs may be entered and executed as long as the total number of steps in all programs does not exceed 100. Programs are stored in non-volatile memory retained by a Lithium battery even during power down of the controller. (See Appendix 7.1 for Sample Program.) Battery life is rated for 10 years.

4.1 Description of a Program Step

Each program step has five data parameters, called substeps. The program substeps are numbered 0-4. Except for special command steps (see Section 4.6), each substep has a dedicated function as follows:

Substep **0** is a set point temperature.

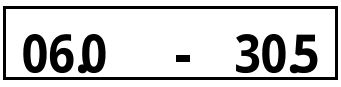
Substep **1** is the ramp time.

Substep **2** is the hold time.

Substep **3** is the next step to be executed. If this substep is specified as 100, the program will terminate after execution and the display will show "End".

Substep **4** is the probe used for control. It can be specified as 1 or 2 to select the probe to be used for temperature control, or 3 to 7 to effect special commands (see Section 4.6).

When displaying program steps on the LED display, the program step.substep is displayed at the left side of the display and the data associated with that program step.substep is displayed on the right as follows:



The example above shows step 6, substep 0 contains the temperature data -30.5

Each program step contains all five substeps, regardless of whether or not each step is used. Therefore, a complete program step is as follows:

FORMAT OF A STEP

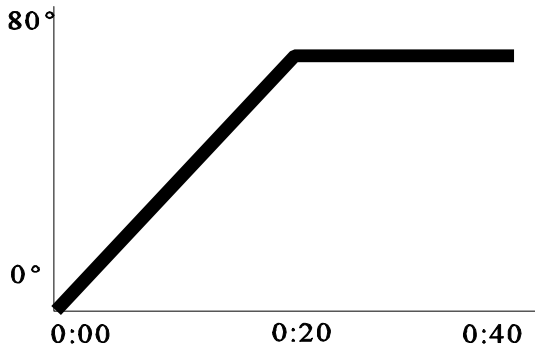
```
substep
   step          -----------data------------

          00.0  -TTT.T      - temp (set point)
          00.1   HH.MM      - ramp time
          00.2   HH.MM      - hold time
          00.3     NNN      - next step
          00.4        P     - control probe
```

where:

step	is the current program step number (00 - 99)	
substep	is the current program substep (0-4)	
TTT.T	is the set point temperature displayed to the nearest .1EC	
HH	is hour(s) (00 - 99)	for ramp or hold
MM	is minute(s) (00 - 59)	for ramp or hold
NNN	is the next program step number (00 - 100) to execute	
P	is the number of the probe (1 or 2) to use for control or...	
P	is the special command indicator (values of 3 thru 7) (See 4.6 for details)	

The simple graph at the right shows a typical ramp & hold scenario. In this example the user wants to ramp from 0E to 78E in 20 minutes and then hold 78E for the next 20 minutes. A single program step will accomplish both tasks.



The sample program step below will pass control to program step 6 when it has completed.

Program step.substep	Data	Effect/Purpose
05.0	78.0	Sets temp set point to 78E
05.1	00.20	Sets ramp time to 20 minutes
05.2	00.20	Sets hold time to 20 minutes
05.3	6	Sets step 6 as next step to execute
05.4	1	Selects probe 1 for active control

4.2 Clearing Program Memory (Reinitializing program steps)

When the controller is shipped from the factory, all program steps are initialized to their default values as shown below. To create a usable program for the controller to run, the user enters replacement values in those program steps to be used. All program steps are retained in memory even during power down of the controller. When it becomes necessary to clear all of the user programmed steps from memory, use the CLEAR PROGRAM **<CLEAR/PROG>** key on the keyboard. All program steps will be reinitialized to their default values. The procedure below will reinitialize all program steps to their default values.

To reinitialize all program steps to their default values, press **<CLEAR/PROG>** to display the **clr** warning message on the display, then press **<CLR/PROG>** again to return all program steps to their default values as shown below. If ever you accidentally press **<CLEAR/PROG>** and see the **clr** warning on the display, you may press any key except the **<CLEAR/PROG>** key abort the memory clearing process.

When the program memory is reinitialized, each of the 100 program steps is initialized to the following default values (null program steps):

Substep 0	30.0	(30 degrees C.)
Substep 1	00.00	(Ramp time zero)
Substep 2	00.00	(Hold time zero)
Substep 3	SS+1	(Next sequential step)
Substep 4	1	(Active Probe one)

4.3 Displaying Program Steps (not during execution)

To display the program steps, press the DISPLAY CONTROL key **<DISP/CNTL>**. Unless you are already in program mode and have just displayed a different program step, step 0, substep 0 (the set point for step zero) will be displayed. Each subsequent

press of the **<DISP/CNTL>** key will cause the display to increment to the next program substep.

To display a specific program step, enter a one or two digit step number directly after any press of the **<DISP/CNTL>** key and then press the **<DISP/CNTL>** key again to display the entered step.substep 0.

4.4 Entering or Changing a Program Step

There is no difference between entering a program step and modifying an existing one.
To change any part of the program, first display the current step by pressing **<DISP/CNTL>**. If you wish to make changes to a step other than the current step, enter the 1 or 2 digits for the step number (0-99) and press **<DISP/CNTL>** again. Substep 0 of the desired step will now be displayed.

For each substep displayed, you may change the current value or accept the current value. To accept the current value and display the next substep, press **<DISP/CNTL>**.

To change the current value, press **<CLEAR/ENTRY>** to clear the old value then enter the desired new value. Pressing the **<ENTER>** key stores the new substep value and advances the display to the next substep. Only valid changes are allowed. Subsequent and steps and substeps may be altered in the same manner by pressing **<DISP/CNTL>** until the desired step is displayed.

Note: The program may only be changed when the program is not executing (run LED is off) and the controller is in the program mode (Mode swith set to PROGRAM).

Appendix 7.3 contains a template form for writing programs.

4.5 Running (Executing) a Program

To start program execution, the beginning program step of the program to be run must be on the display. Displaying a specific program step is covered in Section 4.3.

With the first step of a program shown on the display, press **START/STOP>** to begin program execution at that step. The program will continue to execute until it reaches program step 100 where it will display "End" and wait for action from the operator.

Running programs may also be stopped at any time by pressing **<START/STOP>**. After a program has been stopped in this manner, pressing **<START/STOP>** again will cause the program to continue executing from the beginning of the step it was

executing when it was stopped. Important: If the refrigeration compressor was on when the program execution was interrupted in this way, it will not be restarted when program execution is restarted. The compressor port will remain off until the program reaches a CO command.

At the end of a program, the controller will not turn on further heat or cool, however, the chamber blowers will remain on unless Blower Shutoff Mode has been enabled(see Section 6.6). The blowers can be turned off manually by an operator using the front panel mode switch. Set the switch to OFF to turn off the blowers.

IMPORTANT: If you are controlling an chamber or platform with optional solid state relay power control, including units with compressor control, please read Section 4.6.5 at this time.

CAUTION: Chamber temperatures can exceed 70EC, without heaters energized, if high velocity blowers have been installed. If this presents a problem, be sure the test load is removed promptly at the end of the program run, or enable Blower Shutoff Mode (see Section 6.6) to have blowers not run on at the end of a program execution.

4.5.1 Program Run Time Information/Considerations

When a program is running, the display shows the currently executing program step number on the left and the total amount of remaining run time for that step on the right. The time displayed is the sum of any remaining ramp time and/or hold time. The temperature may be displayed by pressing **<DISP/TEMP>** while the program is running. Pressing **<DISP/CNTL>** will restore the display of the current step number and the time left in the step.

Programs may be designed to run continuously by specifying the next step to be any previous step of the program. In this way, step 100, the end, is never reached. The program must then be stopped by the operator pressing the **<START/STOP>** key. Controlled looping is also possible. See 4.6.2.

Multiple programs may be stored in memory since a program may be started from any step and terminates with any step specifying 100 as its next program step. It is the operator's responsibility to keep a record of the beginning program step number for each program in memory.

4.6 Special Commands

There are six instances of special commands that use the substep data within a step for different purposes than normal. These commands can be categorized into three groups: (4.6.1) Maximizing ramp speed, (4.6.2) Creating controlled loops, and (4.6.3-6) External port controls. In each case only some of the substeps are used. To enhance program readability, we suggest that you set any unused substep values to zero.

4.6.1 Maximizing Ramp Speed & Other Ramp Considerations

When a ramp time is specified in a program step, the controller attempts, within the limits of system capability, to achieve a linear temperature change rate such that the set point is achieved precisely at the end of the ramp period. If an insufficient ramp time is specified, some of the hold time will be "borrowed" to allow the ramp to setpoint to complete.

To achieve the **maximum ramp rate**, set the ramp time (substep 1) to 00.00 and the hold time (substep 2) to 99.00. A program step with a ramp time of 00.00 and a hold time (substep 2) of 99.00 will cause the controller to achieve the setpoint as quickly as possible then immediately execute the next step. If a specific hold time following ramping at maximum ramp rate is required, then use two steps. Both steps should specify the same set point. The first step should have a ramp time of 00.00 and a hold time of 99.00. The second step should have a ramp time of 00.00 and the desired hold time.

Note that a program step with specified ramp and hold times will terminate at the end of the specified time (ramp time + hold time), regardless of whether the controller was able to achieve the setpoint. On the other hand, a maximum speed ramp step (substep 1 = 00.00 & substep 2 = 99.00) will not advance to the next step until and unless the setpoint is achieved. If the unit under test generates or absorbs heat in a manner than prevents the test environment from ever becoming stable at the setpoint, the program will "hang" on such a step as it will not advance to the next step unless it can stabilize the platform or chamber at the setpoint.

A program step with a ramp time of 00.00, a hold time of 00.00, and a probe number of either 1 or 2 is a **null program step**. A null program step has no effect on the temperature set point of the chamber. It is used to fill an unneeded step in an existing program.

4.6.2 Controlled Program Looping

The program may be placed into a controlled loop by the use of the PROGRAM LOOP special command. When the Probe is specified as 3, the Set Point value is used as a loop count. This value must be specified as an integer. Each time the Loop Command is reached in the program, the loop count is decremented by one. As long as the loop count is greater than zero, the program will execute the step indicated in the Next-Step-Number substep of the Program Loop step. When the loop count (substep 0) value finally becomes zero, the step following the Program Loop step is executed.

Example:

Step & substep	Value	
07.0	5	Loop count
07.1	0000	(not used)
07.2	0000	(not used)
07.3	1	Loop start step
07.4	3	Identifies this step as a PROGRAM LOOP command

This will loop 5 times from step 1 to step 7 decrementing the loop counter by 1 for each loop. When the loop counter has reached 0 the program will continue with step 8.

Note: Nested program loops not supported. They may appear to work if you try to use them, but the loop will never complete and further results are not predictable.

4.6.3 External Compressor On

When the Probe (substep 4) is specified as 4, the program step turns the refrigeration compressor control port on. Substeps 0 - 2 are ignored and substep 3 may not = 100 in this step. Upon power up, start and stop of program execution, and changing of the mode switch, this port will be off. The REFER LED on the front panel will indicate when this port is on or off.

4.6.4 External Compressor Off

When the Probe (substep 4) is specified as 5, the program step turns the refrigeration compressor control port off. Substeps 0 - 2 are ignored and substep 3 may not = 100 in this step. Off is the default mode for this port upon power up, start and stop of

program and changing the rotary switch. The REFER LED on the front panel will indicate when this port is on or off.

4.6.5 Optional Aux/Power Control Port On

When the Probe (substep 4) is specified as 6, the program step turns the optional aux/power control port on. Substeps 0 - 2 are ignored and substep 3 may not = 100 in this step. Upon power up and changing of the mode switch, this port will be on. At start and end of program execution, this port will be automatically set to off.

For special order chambers or platforms equipped with optional solid state relay to control main power, this command must be used once at the beginning of a program in order to turn the chamber or platform on. Note that because this control will disable all power to an chamber with solid state relay chamber power control, the normal continuous running of the air circulation fans is disabled regardless of the state of the Blower Shutoff Mode setup parameter.

4.6.6 Optional Aux/Power Control Port Off

When the Probe (substep 4) is specified as 7, the program step turns the optional load control port off. Substeps 0 - 2 are ignored and also substep 3 may not = 100 in this step. Upon power up and changing the rotary switch this port will be on. At start and end of program execution, this port will be automatically set to off.

4.7 Common Programming Issues

4.7.1 Step Numbering

Remember that the first step or substep is 0 instead of 1.

4.7.2 Changing Substep Values

When changing a substep value on the right half of the display, you must use the **CLEAR/ENTRY** key to clear the previous entry from the display before entering a new value, then press ENTER to store that new value.

4.7.3 Control Ports

Refrigeration compressor and optional aux/power control ports will return to their default values of On (HI) and Off (LO) respectively upon changing the setting of the rotary switch. However before the start and after the end of a program they will both be LO.

5. REMOTE MODE

Remote mode provides for control of the CC-3 from a remote computer or terminal using either standard RS-232 serial communication or Instrumentation Standard IEEE-488 (GPIB) communication. Selection of the type of interface is made from the setup mode, see Section 6.

NOTE: The IEEE-488.2 requirement for lockout of front panel control during IEEE-488 control is not enabled in this controller. The front panel mode switch remains active during remote control.

In remote mode, the CC-3 is controlled externally by sending a 2 character ASCII command over the bus followed by an optional set of parameters, and ending with a terminator. For both IEEE-488 and RS-232 communication, the terminator is Carriage Return & Line Feed (13,10 decimal) (0Dh 0Ah). For IEEE-488 command structure, see Appendix 7.4.

5.1 Remote Commands

5.1.1 SI - Select Immediate Mode

This command selects the immediate mode of operation. In immediate mode, a command is executed immediately when it is received over the interface. If a previous command is executing, it is canceled. Status commands such as Read Temperature, Read Status, or Read Error do not cancel outstanding commands.

5.1.2 SP - Select Program Mode

This command selects the program mode of operation. In program mode, commands are executed in the order they are sent. The commands are stored in a command buffer until such time as the controller can execute them. Program mode (SP) is the default upon entering the Remote mode of operation. Note that the command buffer is limited in size. Each time a command is sent to the CC-3 in program mode, the status and error bytes should be checked for buffer full condition. The command will not be partially stored. If any of the error bits related to command acceptance (bits 2, 4, 5, or 6) are set, the command has not been accepted.

5.1.3 ES - Enable SRQ (Status Request Mode)

For the IEEE-488 interface, SRQ is sent with the binary status. The status in both cases is not cleared until read with an RS command.

This command enables the SRQ function. SRQ is sent on all status or error changes. For the RS-232 interface, SRQ is sent as the ASCII string:

SQ "binary status byte" <CR> <LF>

5.1.4 DS - Disable the SRQ

This command disables the SRQ function (default is DS).

5.1.5 TO - Turn Aux/Power Control On

This and the following commands are standardly implemented as TTL outputs available at points on the CC-3B circuit board or (if specially ordered) on lug 6 of terminal strip J1 at rear of controller. (See appendix 7.5.) The command is used to control an optional remote (chamber or platform) power switch. The default setting when entering Remote mode is on.

5.1.6 TF - Turn Aux/Power Control Off

This command is used to turn off an optional remote chamber power switch (default is on).

5.1.7 CO - Turn the Compressor On

This command is available to remotely turn on a compressor. If the unit was originally sold in a system without a compressor this command may be used as an auxiliary output discrete. The default setting upon entering Remote mode is off. The REFER LED on the front panel will display the status of this control port.

5.1.8 CF - Turn the Compressor Off

This command is available to remotely turn off a compressor or auxiliary device (default is off). The REFER LED on the front panel will display the status of this control port.

5.1.9 RS - Request Status Information

This command instructs the chamber controller to send the status byte. If the interface is RS-232 the response is an ASCII string as follows:

RS "status byte" <CR> <LF>

For IEEE-488, the status byte is sent when the interface is addressed as a talker. The status byte is cleared following the transmission of this command. Note: No <CR> <LF> are sent.

5.1.10 RE - Request Error Information

This command instructs the chamber controller to send the error byte. If the interface is RS-232 the response is an ASCII string as follows:

RE "error byte" <CR> <LF>

For IEEE-488, the error byte is sent when the interface is addressed as a talker. The error byte is cleared following the transmission of this command. Note: No <CR> <LF> are sent.

5.1.11 GT -TTT.T - Go To Temperature

This command instructs the chamber to control to the set point specified in the command. A status bit is set, if the SRQ has been enabled, when the chamber has stabilized within .1 degrees of the set point for 15 seconds. (See Section 7.4 for examples.)

5.1.12 DL HH,MM - Delay

This command causes the chamber to stay at a set point for a specified period of time before executing the next command. (See Section 7.4 for examples.)

5.1.13 RA -TTT.T,HH,MM - Ramp to Temperature

This command executes a ramping function. The operands of the command include a ramp temperature and a ramp time. When executed, the chamber executes a linear ramp from the current temperature to the specified temperature over the specified time period. (See Section 7.4 for example.)

5.1.14 PNn - Select Active Probe

This command selects the probe that will be used for remote control of the chamber. The default when entering the Remote mode of operation is probe 1. For single probe systems, this command is never used although all units are sold capable of utilizing two probes. Valid probe numbers here are 1 and 2 only. (See Section 7.4 for example.)

5.1.15 PTn - Read Temperature

This command is used to read the specified probe temperature. a 200 ms. delay after issuing this command is required for proper operation (See Section 7.4 for example.) For the RS-232 interface, the response is:

Pn -TTT.T <CR> <LF>
wait 200

where n is the probe number (1 or 2).

See Appendix 7.4 for additional IEEE Commands.

5.2 RS-232 Interface

The controller may communicate remotely through an RS-232 interface. To use RS-232 communication, the interface must be selected for RS-232 remote communication in Setup mode. Additionally, the interface must be software selected for proper baud rate, parity, data bits and stop bits. These are also set through the keypad in Setup mode and become stored in the non- volatile memory. To initialize RS-232 parameters turn unit to SETUP then back to REMOTE for proper operation (Section 6.0, Setup Mode.)

A female DB-25 connector is provided on the rear panel. The interface is set up as a DCE with DTR and CTS set always true.

5.3 IEEE-488 Interface

The IEEE-488 interface is implemented as a Talker/Listener without extended addressing or parallel poll capability. The primary address is selected through the keypad in Setup mode. A standard IEEE-488 connector is provided on the rear panel. (See sample commands in Appendix 7.4.)

5.4 Command Summary

COMMAND	ACTION	PARAMETER USAGE
SI	Select immediate mode	
SP	Select program mode (default)	
ES	Enable the SRQ	
DS	Disable the SRQ (default)	
TO	Turn the Aux/Power port on (default)	
TF	Turn the Aux/Power port off	
CO	Turn the Compressor port on	
CF	Turn the Compressor port off (default)	
RS	Request status byte	
RE	Request error byte	
GT	Go to new temperature	GT -TTT.T
DL	Delay for Hr., Min.	DL HH,MM
RA	Ramp time Hr., Min.	RA -TTT.T,HH,MM
PNn	Select active probe (default #1)	
PTn	Read temperature from probe n	

The CC-3 can be commanded to STOP controlling the temperature by issuing IEEE-488 standard I/O statements ABORTIO, Bus Clear, or Selected Device Clear. (See Section 7.3.)

The intricacies of using the IEEE-488 bus for control are covered in detail in troubleshooting section, 7.7.6. It is strongly recommended that the user read that entire section before writing any control programs.

5.5 Status Information

The Status Byte has the following bit meanings:

BIT	RS-232 INTERFACE	IEEE-488 INTERFACE
7	Interval complete	Error
6	Error	SRQ set
5	Control probe #	Control probe #
4	Set point reached	Set point reached
3	Interval complete	Interval complete
2	Compressor status (0 off/1 on)	
1	Chamber status (0 off/1 on)	
0	SRQ enabled (1), disabled (0)	

The RS-232 interface leaves interval complete in bit 7 for backward compatibility, but duplicates it in bit 3 for 7 bit ASCII communication.

5.6 Error Information

The error byte has the following meanings:

BIT	INFORMATION
7	Time-out error -- chamber did not reach temperature in 20 minutes unless instructed otherwise. (Only set with GT command.)
6	Input buffer full (exceeded 256 chars)
5	Undefined command (any command other than those in 5.4)
4	Input error -- too many characters
3	Fail-safe tripped
2	Illegal argument string
1	Ramp time/temperature combination error
0	Door open (active with optional door switch).

Note: The error byte is cleared after it is read.

If the user should send a command string(s) such that the 256 character input ring buffer is full, an SRQ error (if SRQ is enabled) will be generated. It will continue to generate errors with each new character transmitted until the buffer empties enough to accept the next command.

5.7 Noise Immunity

Noise can show up as lost or incorrect data sent over the bus. In extreme cases this noise can disrupt controller operation regardless of whether computer bus is in control or not. The following modification has been found to solve many computer bus related noise problems. It will provide static ground to the backshell of the IEEE 488 bus connector as well as pin 1 of the RS-232 connector, bypassing any path through the digital circuitry. It is not done at the factory because in some cases it actually degrades noise immunity by creating a ground loop.

Bus static ground connection is made as follows: Solder a short green 22g. wire to the A-Board static ground eyelet located below the IEEE-488 connector (see board layout). Hook the other end of the wire to a horseshoe lug and connect it to the main terminal strip J1, lug #3. (green).

6. SETUP MODE

The Setup mode is entered by placing the mode switch in the right most position. Setup mode is used to modify operational parameters of the chamber. When first entering Setup mode, the digital display should display:

f-0 n (n = 1 to 10)

This first display indicates the setting for field 0. There are sixteen parameter fields which can be modified. Table 6.1 shows the meaning of each field and the values each field can be assigned.

T A B L E 6.1

Field #	Field Purpose	Permitted Field Values	Factory Setting
0	PID controller, Proportional term Controller gain, P term, number=EC from set point where controller will use full on control	1 - 10	5 - 7
1	Number of Probes installed	1 - 2	1
2	Remote communication port select 0 = RS-232 1 = IEEE-488	0 - 1	1
3	RS-232 port baud rate 1=300 2=600 3=1200 4=2400 5=4800 6=9600	1 - 6	6
4	RS-232 port data bits	7 - 8	8
5	RS-232 port stop bits	1 - 2	1
6	RS-232 port parity enable 0=disabled 1=enabled	0 - 1	0
7	RS-232 port parity type 0=even 1=odd	0 - 1	0
8	RS-232 port echo 0=disabled 1=enabled	0 - 1	1
9	IEEE-488 port primary address	0 - 30	1
10	PID controller, Integral term Tens of seconds required for I term effect equal to P term effect	Adjustment not normally required	5 - 7

11	PID controller, Differential term Seconds required for D term effect to equal P term effect	Adjustment not normally required	5 - 7
12	PID controller, integral wind-up limiter term	Adjustment not required	7
13	Refrigeration compressor front panel control 1=yes 0=no	0 - 1	0
14	Autostart in Local Mode 1=yes 0=no	0 - 1	0
15	Blower shut-off mode 0=disable 1=enable	0 - 1	0

Note: The setup field parameters are stored in non-volatile memory that is retained even during power down.

6.1 Displaying the Field Values

The contents of field 0 is displayed upon entering the Setup mode. To display the next field, press the **<DISP/CNTL>** key. Pressing **<DISP/CNTL>** after field 15 will cause field 0 to be re-displayed.

6.2 Changing the Value of a Setup Field

A field may be changed with the following procedure:

1. Display the field to be changed using the **<DISP/CNTL>** key as detailed in 6.1.
2. Repeatedly press **<ADV>** until the desired field value appears on the display.
3. Press **<ENTER>** to replace the old value with the new value

The old value is not replaced until the **<ENTER>** key is pressed. Therefore, a change may be canceled simply by pressing **<DISP/CNTL>** before the **<ENTER>** has been pressed. The new parameters go into effect upon leaving the Setup mode.

While in setup mode, the temperature may still be displayed by pressing the **<DISP/TEMP>** key. Pressing **<DISP/CNTL>** after displaying temperature will resume the setup field parameter display.

The local control set point is returned to 30.0 after leaving the setup mode and the controller will be in the idle (not controlling) mode.

6.3 Two Probe Mode (Setup field 1)

This controller will control or display from either probe input. The behavior of the controller, and selection of the probe which controls it, is by program command in both program mode and remote control mode. In local mode, the setup parameter for field 1(# of active probes) must be set to 2 before the two probe mode can be used as described in Section 3.

It is very important to use only 500S platinum RTD probes from Sigma. Sigma probes are specially calibrated and matched to the internal controller data sets of the CC-3. Use of other probes will likely cause significant loss of accuracy.

6.4 Auto-start Mode (Setup field 14)

The controller may be set up to automatically begin controlling at the last used LOCAL mode temperature by setting the Auto-start setup field (14) to 1. When Autostart is enabled, moving the mode from OFF to LOCAL will cause the controller to begin controlling to the last set local mode set point without the necessity of pressing **<START/STOP>**. If the system includes mechanical refrigeration, and the last local control session had the compressor turn on, it will be turned on for the Autostart session as well. The compressor may still be manually turned on and off at any time in the LOCAL mode by pressing the REFER button.

6.5 Blower Shut-off Mode (Setup field 15)

Normally at the end of a program execution, or in the event of a Fail-Safe shutdown condition, the blowers in an chamber will continue to run. If this is not desired, the blowers can be set to shut off under these conditions by enabling the Blower Shut-off mode by setting the value of setup up field 15 to 1.

6.6 Temperature Control Terms (PID) (Setup fields 0, 10, 11, 12)

The PID control terms that the CC-3 uses for temperature control are available in setup fields 0, 10, and 11. Do not change field 12. If you are not familiar with PID terms and their effects, a non-theoretical discussion can be found in Section 7.7.7 in the troubleshooting appendix of this manual.

7. APPENDIX

7.1 Programming Examples & Notes

7.1.1 Simple Local Program Example

The following temperature test routine uses basic temperature control commands including controlled and maximum rate ramping and temperature hold (dwell):

Using Probe 1 for control...
Use 5 minutes to ramp from ambient to 45.2°C
Hold 45.2 for 2 minutes
Use 2 minutes to ramp to 32.3°C
Hold 32.3°C for 6 minutes
Go to 50.1°C as quickly as possible
Go to -10°C as quickly as possible
Hold -10°C for 3 minutes
End program

The following is the exact key sequence for entering this routine as a program into CC-3 program memory:

Set the CC-3 to Program mode by setting the rotary MODE switch to the PROGRAM position.

If you wish to erase any programs already in memory and start with "clear" reinitialized program memory, press **CLEAR/PROG CLEAR/PROG**

The table which follows shows how to enter all of the data for this program. There are shortcuts that can be used to save some time when entering program data. The shortcuts are shown in the next table. If you are not familiar with CC-3 programming, be sure your understand all of the entries in the first table before attempting to use the shortcut method.

Step Number	Displayed Step . Substep	Keys to press	Description of entry
0	00.0	CLEAR/ENTRY 45.2 ENTER	Go to 45.2°C
	00.1	CLEAR/ENTRY 5 ENTER	Use 5 minute ramp time
	00.2	CLEAR/ENTRY 2 ENTER	Hold temperature for 2 minutes
	00.3	CLEAR/ENTRY 1 ENTER	Execute step 1 next
	00.4	CLEAR/ENTRY 1 ENTER	Use probe 1
1	01.0	CLEAR/ENTRY 32.3 ENTER	Go to 32.3°C
	01.1	CLEAR/ENTRY 2 ENTER	Use 2 minute ramp time
	01.2	CLEAR/ENTRY 6 ENTER	Hold 32.3°C for 6 minutes
	01.3	CLEAR/ENTRY 2 ENTER	Execute step 2 next
	01.4	CLEAR/ENTRY 1 ENTER	Use probe 1
2	02.0	CLEAR/ENTRY 50.1 ENTER	Go to 50.1°C
	02.1	CLEAR/ENTRY 0 ENTER	Ramp as quickly as possible
	02.2	CLEAR/ENTRY 9900 ENTER	Do not hold at this temperature Execute next step immediately
	02.3	CLEAR/ENTRY 3 ENTER	Execute step 3 next
	02.4	CLEAR/ENTRY 1 ENTER	Use probe 1
3	03.0	CLEAR/ENTRY -10.0 ENTER	Go to -10°C
	03.1	CLEAR/ENTRY 0 ENTER	Ramp as quickly as possible
	03.2	CLEAR/ENTRY 3 ENTER	Hold -10°C for 3 minutes
	03.3	CLEAR/ENTRY 100 ENTER	End program Turn off heat & cool
	03.4	CLEAR/ENTRY 1 ENTER	Use probe 1

7.1.2 Using shortcuts to shorten program entry time

Shortcuts can make program entry easier and faster if the program step memory to be used for the new program contains the values that you need. Default reinitialization values are stored in every program step when program memory is "cleared" by pressing **CLEAR/PROG CLEAR/PROG** to reinitialize program memory. These default values are often what you need.

If a program is already in memory, a new program can be entered into either the steps that the existing program occupies or into steps that remain unused since the last reinitialization. In either case, some of the existing data in the steps to be used may be the same as the new program data. If the is the case, the old data can be retained more easily than it can be re-entered.

The "shortcut" is simply a one keystroke method of retaining the existing value in a step when that value is the value you need. For instance, a reinitialized program step always has a substep 4 (probe #) value of 1. If you are going to use probe 1 in a step in your program, you can simply retain that value instead of rekeying the value.

When entering a program, you display substeps sequentially by pressing **DISP/CNTL**. When you have displayed a substep that contains and displays a value that is the same as the value you need for that substep, you can simply retain that value. To retain an existing value in a substep and go on to the next substep, press **DISP/CNTL** when the step.substep and value are displayed.

Thus the program entry sequence from the table above could be changed to the following, more efficient, entry sequence. (This sequence presumes that you have just reinitialized program memory by pressing **CLEAR/PROG CLEAR/PROG**)

Step Number	Displayed Step . Substep	Keys to press	Description of entry
0	00.0	CLEAR/ENTRY 45.2 ENTER	Go to 45.2°C
	00.1	CLEAR/ENTRY 5 ENTER	Use 5 minute ramp time
	00.2	CLEAR/ENTRY 2 ENTER	Hold temperature for 2 minutes
	00.3	DISP/CNTL	Accept default value of 1 Execute step 1 next
	00.4	DISP/CNTL	Accept default value of 1 Use probe 1
1	01.0	CLEAR/ENTRY 32.3 ENTER	Go to 32.3°C
	01.1	CLEAR/ENTRY 2 ENTER	Use 2 minute ramp time
	01.2	CLEAR/ENTRY 6 ENTER	Hold 32.3°C for 6 minutes
	01.3	DISP/CNTL	Accept default value of 2 Execute step 2 next
	01.4	DISP/CNTL	Accept default value of 1 Use probe 1
2	02.0	CLEAR/ENTRY 50.1 ENTER	Go to 50.1°C
	02.1	DISP/CNTL	Accept default value of 0 Ramp as quickly as possible
	02.2	CLEAR/ENTRY 9900 ENTER	Do not hold at this temperature Execute next step immediately
	02.3	DISP/CNTL	Accept default value of 3 Execute step 3 next
	02.4	DISP/CNTL	Accept default value of 1
3	03.0	CLEAR/ENTRY -10.0 ENTER	Go to -10°C
	03.1	DISP/CNTL	Accept default value of 0 Ramp as quickly as possible
	03.2	CLEAR/ENTRY 3 ENTER	Hold -10°C for 3 minutes
	03.3	CLEAR/ENTRY 100 ENTER	End program Turn off heat & cool
	03.4	DISP/CNTL	Accept default value of 1 Use probe 1

To run this program, set the program pointer to the first program step (00) and then start the program using the following key sequence:

00 DISP/CNTL START/STOP

7.1.3 Local Program Example Using the Special Commands

The following temperature test routine uses program looping commands and the special port control commands:

Turn chamber or platform (or auxiliary load) on
Do the following loop 5 times
    Using probe 2 for control...
    Turn compressor on
    Use 15 minutes to ramp from ambient to 11.5°C
    Hold 11.5 for 20 minutes
    Use 1 hour to ramp to -32.3°C
    Hold -32.3°C for 1 hour
    Turn compressor off
    Go to 50°C as quickly as possible
    Hold 50°C for 2 ½ hours
Turn chamber or platform (or auxiliary load) off
End program

The following is the exact key sequence for entering this program into the CC-3 program step memory:

Set the CC-3 to Program mode by setting the rotary MODE switch to the PROGRAM position. Press **<DISP/CNTL>**, then:

Step Number	Displayed Step . Substep	Keys to press	Description of entry
0	00.0	DISP/CNTL	Accept default value Value not used
	00.1	DISP/CNTL	Accept default value Value not used
	00.2	DISP/CNTL	Accept default value Value not used
	00.3	DISP/CNTL	Accept default value of 1 Execute step 1 next
	00.4	CLEAR/ENTRY 6 ENTER	Turn aux/power control port on
1	01.0	DISP/CNTL	Accept default value Value not used
	01.1	DISP/CNTL	Accept default value Value not used
	01.2	DISP/CNTL	Accept default value Value not used
	01.3	DISP/CNTL	Accept default value of 2 Execute step 2 next
	01.4	CLEAR/ENTRY 4 ENTER	Turn compressor port on

Step Number	Displayed Step . Substep	Keys to press	Description of entry
2	02.0	CLEAR/ENTRY 11.5 ENTER	Go to 11.5°C
	02.1	CLEAR/ENTRY 15 ENTER	Use 15 minute ramp time
	02.2	CLEAR/ENTRY 20 ENTER	Hold temperature for 20 minutes
	02.3	DISP/CNTL	Accept default value of 3 Execute step 3 next
	02.4	CLEAR/ENTRY 2 ENTER	Use probe 2
3	03.0	CLEAR/ENTRY -32.3 ENTER	Go to 32.3°C
	03.1	CLEAR/ENTRY 100 ENTER	Use 1 hour ramp time
	03.2	CLEAR/ENTRY 100 ENTER	Hold -32.3°C for 1hour
	03.3	DISP/CNTL	Accept default value of 4 Execute step 4 next
	03.4	CLEAR/ENTRY 2 ENTER	Use probe 2
4	04.0	DISP/CNTL	Go to 50.1°C
	04.1	DISP/CNTL	Accept default value of 0 Ramp as quickly as possible
	04.2	CLEAR/ENTRY 9900 ENTER	Do not hold at this temperature Execute next step immediately
	04.3	DISP/CNTL	Accept default value of 3 Execute step 3 next
	04.4	CLEAR/ENTRY 5 ENTER	Turn compressor port off
5	05.0	CLEAR/ENTRY 50.0 ENTER	Go to 50°C
	05.1	DISP/CNTL	Accept default value of 0 Ramp as quickly as possible
	05.2	CLEAR/ENTRY 230 ENTER	Hold 50°C for 2 hours & 30 minutes
	05.3	DISP/CNTL	Accept default value of 6 Execute step 6 next
	05.4	CLEAR/ENTRY 2 ENTER	Use probe 2
6	06.0	CLEAR/ENTRY 5 ENTER	Set loop count to 5
	06.1	DISP/CNTL	Accept default value Value not used
	06.2	DISP/CNTL	Accept default value Value not used
	06.3	DISP/CNTL 1 ENTER	Step number of first step in loop routine
	06.4	CLEAR/ENTRY 3 ENTER	Loop command

Step Number	Displayed Step . Substep	Keys to press	Description of entry
7	07.0	DISP/CNTL	Accept default value Value not used
	07.1	DISP/CNTL	Accept default value Value not used
	07.2	DISP/CNTL	Accept default value Value not used
	07.3	DISP/CNTL	Accept default value of 8 Execute step 8 next
	07.4	CLEAR/ENTRY 7 ENTER	Turn aux/power control port off
8	08.0	DISP/CNTL	Accept default value Value not used
	08.1	DISP/CNTL	Accept default value Value not used - Null step
	08.2	DISP/CNTL	Accept default value Value not used - Null step
	08.3	CLEAR/ENTRY 100 ENTER	End program Turn off heat and cool
	08.4	DISP/CNTL	Accept default value Value not used (must be 1 or 2)

Sample program notes:

AUX/POWER CONTROL PORT ON/OFF commands are only necessary when using special order options such as an external relay to control chamber or platform power or an active load under test. COMPRESSOR PORT ON/OFF commands similarly depend on the equipment being controlled having a refrigeration compressor. If the chamber or platform being controlled does not require their use, either of these ports can be configured to control user equipment. Call our technical support department for information.

Step 8 is required because End of Program (substep 3 (next step) = 100) cannot be used in the same step as any of the special commands which use probe numbers 3 and higher.

7.2 Keeping More than One Program in Memory

Programs can be installed and run anywhere there is room within the 100 step (00-99) memory allocation. To install programs at step number **xx**, press

DISP/CNTL xx DISP/CNTL.

Example: **DISP/CNTL 18 DISP/CNTL** will set the program pointer to step 18, substep 0.

Once you have set the program pointer to a step, you can enter new program information by following the procedure in Section 4.4 or run a program that begins at that step as detailed in Section 4.5.

IMPORTANT: When placing more than one program in memory, all programs except the last one must end with SUBSTEP 3 = 100, or a non terminating loop, in order to prevent separate successive programs from automatically running successively. It is good programming practice to place an End of Program (SUBSTEP 3 = 100) command at the end of every program. This will assure that program data that may be entered into higher step numbers at a later time will not have unexpected results when the initial program is run.

7.3 Sigma Systems CC-3 Programming Worksheet

(O.K. to copy)

Date:	Program Name:	Page _____of _____

Step	Sub-Step	Substep Data	Notes/Comments
	.0		
	.1		
	.2		
	.3		
	.4		

Step	Sub-Step	Substep Data	Notes/Comments
	.0		
	.1		
	.2		
	.3		
	.4		

	.0		
	.1		
	.2		
	.3		
	.4		

	.0		
	.1		
	.2		
	.3		
	.4		

	.0		
	.1		
	.2		
	.3		
	.4		

	.0		
	.1		
	.2		
	.3		
	.4		

	.0		
	.1		
	.2		
	.3		
	.4		

	.0		
	.1		
	.2		
	.3		
	.4		

7.4 Sample Command Structure for IEEE-488 Operation

All sample commands are written in BASIC for a Hewlett Packard 85F computer and are representative of the required structure for proper operation of the CC-3's IEEE-488 interface.

Assumptions: CC-3 address is set to 1.
All options have been implemented.

SI - Select Immediate Mode
OUTPUT 701 "SI"

SP - Select Program Mode
OUTPUT 701 "SP"

ES - Enable the SRQ
OUTPUT 701 "ES"

DS - Disable the SRQ
OUTPUT 701 "DS"

TO - Turn Chamber On
OUTPUT 701 "TO"

TF - Turn Chamber Off
OUTPUT 701 "TF"

CO - Turn Compressor On
OUTPUT 701 "CO"

CF - Turn Compressor Off
OUTPUT 701 "CF"

RS - Request Status Information
OUTPUT 701 "RS"
To receive the status byte, use the following:
Enter 701 using "%,%B";A
DISP A

RE - Request Error Information
OUTPUT 701 "RE"
To receive error byte, use the following:
Enter 701 using "%,%B";A
DISP A

GT - Go To Temperature

OUTPUT 701 "GT 85.0" or
OUTPUT 701 "GT 85" or
OUTPUT 701 "GT85"

DL - Delay

OUTPUT 701 "DL 00,25"
OUTPUT 701 "DL00,25"

RA - Ramp to Temperature

OUTPUT 701 "RA 85.5,00,25"

PNn - Select Active Probe

OUTPUT 701 "PN 2"

PTn - Read Temperature

OUTPUT 701 "PT1"
To receive temperature, use the following:
WAIT 200 (this is required)
ENTER 701;A$
DISP A$

The CC-3 responds only to the following standard I-O statements:

ABORTIO 7	(Aborts all bus activity and resets the CC-3)
CLEAR 7	(Aborts all bus activity and resets the CC-3)
CLEAR 701	(Selected device clear, resets the CC-3)
SPOLL (701)	(Polls device #1 for status register contents) The SRQ must be enabled, using "ES", and the SRQ line must be activated before the CC-3 will respond to a serial poll request.

7.5 Installation and Use of TTL Outputs and Input

The CC-3 has incorporated in it the ability to receive one TTL signal and send two TTL signals. Throughout the manual, the outputs are referred to as AUX/POWER CONTROL PORT and COMPRESSOR PORT. The input is referred to as the DOOR SWITCH. These signals are available on the "B" board, J-4 (dip socket). The pin-outs are as follows:

PIN 10	Aux/Power Control (Normally high - See 5.1.5 & 5.1.6)
PIN 11	Compressor Control (Normally low - See 5.1.7 & 5.1.8)
PIN 6	Door Switch (N.0. - value in error byte - See 5.6)

If only one of the output controls is required, terminal block J-1 lug 6 can be used as a tie point and the REQUIRED GROUND IS AVAILABLE ON LUG 5. See Section 2.2.

The required ground for the TTL outputs and the 5v supply for the TTL input is available on the “B” circuit board at approximately the top center of the board. Both are large round solder pads. The ground is labeled “COM” and the 5 volt supply is labeled “5V”.

These ports are TTL level and will require proper isolation and drive capability considerations when interfacing to other devices. **Damage to the CC-3 from improper connection or use of these board level facilities is not covered under your Sigma Systems warranty.**

If the controller is equipped with internal solid state relay to control the compressor, the output of the solid state relay is through pin 8 of P1, the 12 pin power cable to the controller.

At the end of running a program from the front panel, the chamber control port and the compressor control port will return to their original default positions of high and low, respectively.

7.6 Field Calibration of Model CC-3 Controller

WARNING: Sigma Systems CC-3 Controllers obtain power from the chamber or platform to which they are connected. The controllers do not have protective side covers on the chassis. It is imperative to disconnect the power to both the chamber or platform and the controller (if separate) from the power source before removing the controller. Look for an optional separate power cord going to the controller. If the controller is equipped with a separate power cord, disconnect that cord also before removing the controller. FAILURE TO HEED THIS WARNING WILL LIKELY RESULT IN SEVERE DAMAGE TO THE CONTROLLER AND DANGER OF HIGH VOLTAGE ELECTRICAL SHOCK TO THE USER.

Equipment Required:

Digital volt meter capable of four digits accuracy.
Decade resistance box capable of 0.1 ohm resolution.

Procedure:

1. Remove power from the unit. Access the controller chassis by removing the screws at the four corners of the controller front panel.

2. Remove probe connections at the controller's rear terminal strip, J1-1 and J1-4.

3. Locate test points TP1 and TP2 and adjustments R29 and R32 in the upper rear area of the right hand circuit board (B- board see fig.).

4. Apply power to unit and turn power switch on.

5. * With nothing hooked to the probe inputs of the controller, adjust R29 until the voltage at TP1 reads 7.100 volts +\- 0.005 . and adjust R32 until the voltage at TP2 reads 1.70 volts +\- 0.05.

6. Securely connect the resistance box across the probe-1 inputs, (J1-1 and J1-4) set the resistance box to 500.0 ohms. Adjust R32 slightly until the controller front panel reads exactly P1 0.0 (no minus sign). Value should already be within +/- 5 degrees C.

7. With the resistance box still across the probe-1 inputs, (J1-1 and J1-4) set the resistance box to 695.0 ohms. Adjust R29 slightly until the controller front panel reads exactly P1 100.0.

8. Recheck that the controller still reads 0.0 with 500.0 ohms at input. If it takes more than 3 iterations of these adjustments to calibrate the controller, the controller is in need of repair work.

9. Remove power from unit, reinstall controller into unit.

10. Controller response rate can be adjusted as follows. With the rotary switch in the SETUP mode, press ADV until F0 = 4 to 6, then press ENTER. Higher numbers represent larger proportional term and thus a slower controller response (lower gain) and lower numbers represent faster response (higher gain).

* This step may be omitted if calibration error is less than +/- 5.0 degrees C.

7.7 Troubleshooting

7.7.1 Servicing Considerations - Service WARNINGS

WARNING: Sigma Systems CC-3 Controllers obtain power from the chamber or platform to which they are connected. The controllers do not have protective side covers on the chassis. It is imperative to disconnect the power to both the chamber or platform and the controller (if separate) from the power source before removing the controller. Look for an optional separate power cord going to the controller. If the controller is equipped with a separate power cord, disconnect that cord also before removing the controller. FAILURE TO HEED THIS WARNING WILL LIKELY RESULT IN SEVERE DAMAGE TO THE CONTROLLER AND DANGER OF HIGH VOLTAGE ELECTRICAL SHOCK TO THE USER.

7.7.2 Before you go any further...

Make sure you have the most recent firmware for your CC-3. A number of problems for each of the areas discussed in this troubleshooting section have been addressed with firmware upgrades over the years. To check the firmware version number, disconnect all power from the controller and remove it from it's mount. Remember to use proper anti static procedures when handling the controller separate from it's mount. Turn the controller over and look for the three EPROMS with labels on them. The version number is on those labels and can be read without disassembling the controller.

As of the date of this manual, the current firmware version is 5.3. Any other version is older, including versions 10 and 12. If you have other than the current firmware, contact Sigma technical support to obtain the latest version for a nominal charge. Firmware revisions have especially dealt with bus speed, bus fault tolerance, and issues relating to systems hangups when dealing with faster controlling bus devices.

7.7.3 Diagnosing and Solving Hardware Problems

Most hardware related problems are best left to the technicians at Sigma Systems.

If you are having problems with the controller stopping or locking up at unexpected times, check the ground connections for the power source. Also review Section 5.7 in this manual for some tips on noise immunity. If the problem persists, you may be able to obtain a noise suppression kit from Sigma that will help. If your controller uses power from the chamber or platform, it is possible to install an optional separate power cord for the controller so that it may have it's own clean power source.

If the problem relates to the display getting scrambled, the cause is likely static discharges in or near the front panel. Especially if the environment is carpeted, train your users to use their finger to discharge the static potential they may have accumulated on something other than the CC-3 front panel.

7.7.4 Diagnosing and Solving Local Mode Problems

Controller starts immediately in Local Mode

If the system improperly begins controlling to the setpoint when you turn the controller from OFF to LOCAL Mode, before you press **<START/STOP>**, the Autostart setup parameter (F14) is set to enable Autostart. Resetting this setup parameter to 0 will disable the automatic starting feature.

7.7.5 Diagnosing and Solving Program Mode Problems

Illegal parameters

Local programming does not allow the entry of illegal parameters except in one case. Remember that the special commands that use probe numbers 3 through 7 to do something special such as loop, turn on an external device, etc. may not be the last command and point to step 100 to end the program.

Hard Loops

Also note that hard loops will execute forever. Standard loops, using the loop command, do not allow nesting. Only one loop may be active at a time. If you have a nested loop, it may appear to function properly, but it will probably never complete.

Explicit Program End

If you are observing behavior that indicates that the controller is continuing to control beyond the end of the steps you have in your program, check to be certain that you have a step at the end of your program that points to step 100 to end the process. Otherwise, if there are some unused steps further up in program memory, they may be getting executed in error. Be sure that any unused steps that are in the middle of your program have been changed to null steps (ramp and hold time both = 0).

Blowers Misbehaving

If the blowers seem to behave differently than you expect, check the Blower Shutoff Mode setup parameter (F15).

Program hangs on Ramp as Quickly as Possible step

Note that a program step with specified ramp and hold times will terminate at the end of the specified time (ramp time + hold time), regardless of whether the controller was able to achieve the setpoint. On the other hand, a maximum speed ramp step (substep 1 = 00.00 & substep 2 = 99.00) will not advance to the next step until and unless the setpoint is achieved. If the unit under test generates or absorbs heat in a manner than prevents the test environment from ever becoming stable at the setpoint, the program will "hang" on such a step as it will not advance to the next step unless it can stabilize the platform or chamber at the setpoint.

7.7.6 Diagnosing and Solving IEEE-488 (GPIB) and RS-232 Problems

General Considerations

Bus communication problems often involve command syntax errors. The Sigma CC-3 is case sensitive. The command "GT" is not satisfied by "Gt", "gT", or "gt". Each command line must be properly terminated with both a CR (ODh) and LF (10h). The CC-3 ignores EOI.

If you are having no success with bus communications, check to be certain that the correct bus (RS-232 or GPIB IEEE-488) is selected using setup parameter F2.

SI (Immediate Mode) or the default SP (Program Mode) are typically issued at the beginning of a program sequence. However they may be issued at any point. If the CC-3 receives a SI command and there is a command executing and/or commands in the command buffer, the executing command is interrupted and the command buffer is cleared.

The Aux/Power ON (TO) and Aux/Power OFF (TF) commands control the auxiliary power control port. This port is normally used to control power to the chamber or platform or an optional device. It is not necessary to use these commands to enable and disable temperature control.

RS-232 Problems

RS-232 issues are usually communications interface related. The CC-3 is configured as DCE (Data Communications Equipment). Therefore, it is not appropriate to use a crossover or "null modem" cable. Use a straight-through cable that does not have pins 2 and 3 reversed. The CC-3 does no hardware or software handshaking. DTR and CTS are constantly asserted by the CC-3 for compatibility with devices that need these signals. Hardware handshaking from the controlling device is ignored. Software handshaking will be parsed as data by the CC-3 and will reliably result in failure.

Important: The RS-232 port is reinitialized when the mode switch is turned first to SETUP and then back to REMOTE. Moving the switch directly from some other position to REMOTE may leave the port in an unstable state. Always move the switch to SETUP first unless you want to avoid port reinitialization for some reason.

When a status or error byte is requested the requested byte is returned in the following string:

Status: RS*b*<CR><LF>
Error: RE*b*<CR><LF>

where RS or RE are ASCII characters, *b* is the binary status or error byte, and <CR> and <LF> are the standard line terminators.

GPIB IEEE-488 Problems

GPIB IEEE-488 issues typically are either timing or syntax related. Commands that generate a response by the CC-3 must be given sufficient time for the response to be generated and sent. Requests for temperature (PTn) require a 200 ms delay between the request and the reading of the response. It is a good precautionary measure to allow 50 ms for other responses, such as those for RE or RS commands. Note that timing issues can seem to "appear out of nowhere" when control code is modified, recompiled by a compiler that does better code optimization, or if the controlling program is moved to a faster computer. Any of these events can result in operational speed increases that no longer allow the CC-3 time to return a request. Sigma recommends using specific delays in control programs, whether needed or not, so that timing related problems will not mysteriously appear in the future when seemingly unrelated changes are made in the system hardware or software.

Timing is also an issue with Selected Device Clear commands. If the CC-3 receives a Selected Device Clear while it is still processing a recent previous Selected Device Clear, the CC-3 may hang (lockup). Avoid frequently repeated Selected Device Clear commands. There is no advantage to rapid repeated assertion of this command. Note also that the Bus Clear command and Selected Device Clear command are processed identically by the CC-3.

CC-3 status requests are available either via the manual RS (read status) command or by enabling SRQ with the ES command and then using serial poll to obtain the status byte. The serial poll method will only return the status byte after SRQ is enabled with an ES command. The following bits in the status byte are reset after the byte is read by either serial poll or by the RS command:

Bit	Use
3	Interval complete
4	Set point reached
6	SRQ set
7	Error

Note that bit 4, Set Point Reached, is an event triggered flag that is set only once each time the set point is reached and settled upon by the CC-3. After this bit has been set and then subsequently read, it is cleared. Subsequent additional reads of the status byte will not have this bit set, even though the controller is continuing to operate at setpoint, unless a new setpoint has been established and reached in the interim.

The error byte is completely cleared when read. Note that bit 0, the Door Switch Open indicator, is an event triggered flag that is set once when the door switch loop is closed and reset once when the loop is opened.

7.7.7 Diagnosing and Solving Temperature Control (PID) Problems

The Sigma CC-3 controller uses a classic PID control algorithm. Users who are familiar with PID control will find this section somewhat simplistic and generalized as it is written for use by support personnel who are competent installers and mechanics, but who may not know, or need to know, the theory and intricacies of PID control.

There are three user adjustable control "terms" that the CC-3 uses to control temperature. They are:

Proportional term	Setup field 0
Integral term	Setup field 10
Differential term	Setup field 11

Note that you will also find the in setup section of this manual a reference to the Integral Wind-up Limiter Term (Setup field 12). Do not alter this field. It is set once at the factory for the CC-3 model controller and never requires adjustment.

Adjusting for changing needs.

When you CC-3 was shipped from the factory, it was optimized, or "tuned", for normal operation of the chamber or platform to which it was attached, or for which it was intended. It was presumed that the load that you would test would not have great mass, that some overshoot of the setpoint was acceptable when going to a new temperature, and that the cryogenic coolant available (if used) would be delivered from a supply source that indeed delivered liquid, not just compressed gas.

Your needs may not match the original settings, or your controller may have had it's settings changed for other reasons. If the controller is settling a little short of the setpoint, or is oscillating, you can probably make a few changes in the PID settings and improve things considerably.

You need to be aware that very precise control requires a stable environment. The CC-3 is an excellent and accurate controller. However, it is not magic. For example, if you tune your CC-3 to provide fast ramps with conservative approaches to setpoints with liquid nitrogen cooling a static load, and then run the unit using a nitrogen source that delivers gas instead of liquid a good part of the time, and then you add a substantial live load as well, your system performance will not be what you expected. Before you start the tuning process, we suggest that you do what you can to be sure that you are tuning for the actual loads that you will be testing using the coolant that will be available at test time.

If you are using cryogenic coolant, be certain that the coolant delivery is consistent. It is not possible to provide a stable environment in your chamber or on your platform if the supplied coolant's ability to absorb heat keeps drastically changing as the supply vacillates between liquid and gas. Likewise, if you will have live loads that turn on and off during the test, optimize the performance of the system with the load at the point that is most critical to you. If the live loading is small, it should make little difference. However, if the live load is substantial, the performance of the system will be adversely affected when it is operating with a load substantially different than the load for which it was tuned.

Before you change any of the PID terms in your CC-3, write down the existing values. It is not hard for inexperienced users to make enough changes that things get much worse. If this happens to you, you will want to have a list of the original settings so you can at least go back to what you had easily. If you forget to write the setting down, or if your controller was way off to begin with, we suggest that you start with the default settings as shown in Section 6, Setup Mode.

The Proportional Term

The Proportional term (Setup field 0) is the most often adjusted term. The proportional term is the number of degrees from the setpoint at which the CC-3 will begin to decrease the applied heating or cooling. If the proportional term = 10, then, within the last 10 degrees of reaching the setpoint, the heating or cooling will be cut by 10% for each degree closer to the setpoint the chamber or platform gets. If the proporational term = 5, then, within the last 5 degrees of reaching the setpoint, the heating or cooling will be cut by 20% for each degree closer to the setpoint the chamber or platform gets.

Decreasing the proportional term value will cause the CC-3 to apply full heating or cooling to the chamber or platform for a longer time (slows closer to the setpoint). Increasing the proportional term will begin the ramp slowdown sooner.

Decreased proportional term value will allow faster ramping at the expense of more overshoot. Increasing the value will reduce overshoot at the expense of a long settle time.

The proportional term is very necessary to slow the heating or cooling to prevent wild overshoot of the setpoint. However, because the slowing increases as the setpoint is approached, there is a point at which the applied heating or cooling is not sufficient to continue the progress to achieve the setpoint. The Integral term compensates for this shortcoming of the proportional term effect.

The Integral Term

The Integral term (Setup field 10) provides a time buffer for the slowing of the ramp caused by the proportional term. This causes the slowing from the proportional term to be delayed just a bit so that the setpoint is achieved. If the integral term is too small, the setpoint may never be reached. If it is too large, there will be an oscillation of the temperature about the setpoint. Increase the integral term value if the temperature never quite gets to the setpoint. Lower this value if the temperature oscillates about the setpoint.

There will always be some oscillation, but a proper setting of the integral term will keep these oscillations very minor and within the range of established control accuracy. When the CC-3 is shipped from the factory, the integral term is set such that it will work well for most applications. Small adjustments to the proportional term rarely require adjustment of the integral term. Change this setting in small amounts only after careful demonstration of the need.

The Differential Term

The Differential term (Setup field 11) is the least often changed term. It's effects on the other terms are subtle and illusive to most users. Don't change this term unless you are thoroughly convinced of the necessity for doing so. The differential term supplies an anticipatory response that can be helpful with slow processes (large loads). It helps to compensate for the effects of thermal inertia at it's extremes. If the term is too small, anticipation may be inadequate for slow responding systems and the setpoint may be illusive. If the differential term is too large, the system may over anticipate and begin excessive oscillation. The differential term changes the period of any temperature oscillations. This can be helpful in the rare event that a change in the proportional or integral term has set up an oscillation that seems "hard to break". If this term is excessive, the oscillations that develop are typically more rapid than those associated with an excessive integral term value. Note that this term has such profound effects on the other two that there is a strong possibility that if you change this value, you will have to adjust one or both of the other term values as well.

7.8 Technical Support, Repairs & Returns

Sigma's Technical Support department can be reached by email, fax, or telephone:

Email:	TechSupport@SigmaSystems.Com
Fax:	*619/283-6526*
Telephone:	619/283-3193

Normal business hours are 8:00 AM to 5:00 PM, normal business weekdays, Pacific time.

Also you can access our FTP and Web sites at:

FTP	FTP.SigmaSystems.Com
WWW	WWW.SigmaSystems.Com

If you wish to send us a controller for repair or updating, please contact technical support before shipping to obtain a return authorization number. When contacting technical support it is often very helpful if you know the serial number of the unit under discussion. Out of warranty repairs can be charged on either VISA or Mastercard, or can be billed if you have an account with us. Please obtain purchase authorization from your buying department before returning items to us for servicing. Pre-authorized and credit card based repairs are typically returned to you much faster that repairs that must wait for purchase authorizations during the time, or after, repairs are made.

8 Schematics and Component Layout

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