

MODEL EC0X

ENVIRONMENTAL CHAMBER

USER AND REPAIR MANUAL

Covers EC0A, EC01, EC02 and EC03 Environmental Chambers

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INFORMATION ABOUT YOUR CHAMBER

MODEL _____ SERIAL NUMBER _____

OPTIONS INSTALLED:

COOLANT TYPE _____ Vac _____ Vdc _____ PRESSURE _____ psi

COOLING OPTIONS INSTALLED _____

OTHER OPTIONS INSTALLED: _____

POWER _____ watts

VOLTAGE _____ Vac , single phase _____ wire line cord.

PROBE TYPE: chamber _____

DEFAULT PID:

P= -1

I= -2

D= -1

FAIL-SAFE TYPE: Mechanical _____ Electronic _____

TESTED BY: _____ DATE: _____

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SECTION 1 GENERAL INFORMATION

INTRODUCTION

Thank you for your purchase of the EC0x Environmental Chamber!! Your new chamber was manufactured under stringent quality control procedures to insure trouble free operation for many years of service. If you should encounter difficulties with the use or operation of your chamber, contact Sun Systems "Customer Service Department" between the hours of 8:30AM and 5:00PM EST.

As with all Sun Systems products, we would appreciate any comments, suggestions or criticisms that you may have or develop regarding your evaluation of this equipment. Please address your comments to:

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LIMITED WARRANTY INFORMATION

EC0X Environmental Chamber

SUN ELECTRONIC SYSTEMS, INC. warrants this product to the original purchaser to be free from defects in material and workmanship and to operate within applicable specifications for a period of TWO (2) years from the date of shipment, provided it is used under normal operating conditions. This warranty does not apply to sealed assemblies which have been opened, or to any item which has been repaired or altered without SUN SYSTEMS authorization.

Risk of loss or damage to the product shall pass to the customer upon delivery, by SUN SYSTEMS, to the carrier at SUN SYSTEMS' premises.

We will repair or at our option replace, at no charge, any of our products which, in SUN SYSTEMS'S judgment, are found to be defective under the terms of this warranty. Except for such repair or replacement, SUN SYSTEMS will not be liable for any loss or damage to persons or property caused either directly or indirectly by use of this product or for any incidental damages or for any consequential damages. Before using, purchaser shall determine the suitability of this product via this document for his intended use and purchaser assumes all risk and liability whatsoever in connection therewith. No statement or recommendation not contained herein shall have any force or effect unless in agreement signed by an officer of SUN ELECTRONIC SYSTEMS, INC.

1.1 EC0X DESCRIPTION

The EC0X is a high performance environmental chamber that offers integral IEEE-488, RS-232 and Keyboard control interfaces as standard features. The EC0X was expressly designed to work with computer controlled test setups without the need for additional interface hardware. In addition, the EC0X may be used in a complete standalone configuration through the use of the front panel keyboard.

The EC0X features liquid carbon dioxide (LCO₂) or, optionally, liquid nitrogen (LN₂) expectorant cooling for fast cycling between temperatures. The microprocessor based temperature controller in the EC0X allows the operator to program up to 10 time and temperature segments from the keyboard in local mode. The automatic cycling feature of the EC0X allows for programmed time and temperature segments to be repeated from 1 to 1800 times or continuously.

When operated from a test system host computer through the IEEE-488 or RS-232 interfaces, an unlimited number of time and temperature segments are supported. The EC0X command set fully supports remote control operations with single temperature, scan temperature, control and special commands. The PID coefficients used by the controller's algorithm may be modified by the user for specific applications.

The EC0X includes safety features consisting of either a mechanical user adjustable failsafe thermostat or an electronic user adjustable failsafe as well as software upper temperature limit, short/open probe detection, a microprocessor hardware watchdog timer, and IEEE-488 bus time-outs.

1.2 EC0X SPECIFICATIONS

Table 1.2-1 Chamber Specifications

Model	EC0A	EC01	EC02	EC03
Mechanical				
Chamber Volume	.37 ft ³	.7 ft ³	2.2 ft ³	3.0 ft ³
	(0.010 m ³)	(0.020 m ³)	(0.062 m ³)	(0.085 m ³)
Test Chamber Dimensions [in (cm)]	10.0(25.4)W 8.0(20.3)H 8.0(20.3)D	12.0(30.5)W 9.75(24.75)H 10.25(26.0)D	20.0(50.8)W 12.0(30.5)H 16.0(40.6)D	20.0(50.8)W 12.0(30.5)H 22.0(55.9)D
Overall Dimensions [in (cm)]	17.5(44.5)W 13.25(33.7)H 20.0(50.8)D	21.0(53.3)W 16.0(40.6)H 24.0(61.0)D	30.0(76.2)W 19.5(49.5)H 30.0(76.2)D	30.0(76.2)W 19.5(49.5)H 36.0(91.4)D
Weight; Net/Shipping	38/55 lbs	49/68 lbs	80/100 lbs	98/115 lbs
Interior Construction	Stainless Steel	Stainless Steel	Stainless Steel	Stainless Steel
Electrical				
Power Option Current Requirement Plug / Receptacle				
100/115 VAC, 50/60 Hz, Single Ø, 3 Wire	15 amp 5266-C / 5261	15 amp 5266-C / 5261	20 amp 5266-C / 5261	N/A 5266-C / 5261
208/240 VAC, 50/60 Hz, Single Ø, 3 Wire	10 amp 5666-C / 5661	10 amp 5666-C / 5661	15 amp 5666-C / 5661	15 amp 5666-C / 5661
4 Wire	2411 / 2410	2411 / 2410	2411 / 2410	2411 / 2410
Power Requirement	1600 Watts	1800 Watts	2200 Watts	3000 Watts
Temperature Chamber Performance				
Max Empty Chamber Heat/Cool Rate of Change	0.5° C/sec (30° C/min)	0.5° C/sec (30° C/min)	0.25° C/sec (15° C/min)	0.25° C/sec (15° C/min)
Air-Flow(CFM, Vertical)	60 ft ³ /min	60 ft ³ /min	150 ft ³ /min	300 ft ³ /min

Table 1.2-2 Control Specifications

Control	
Temperature Setpoint Range	LC02 -73°C to + 300°C (LN2 Option: -184°C to + 300°C)
Time at Temperature Range	0.1 to 1800 minutes or continuous from IEEE-488 / RS232 Intf., 1 to 1800 mins. From keyboard, (hrs. optional)
Temperature Ramping Rate Control	Not Controlled Locally
Programmable	10 Programmable Set Temperatures and Times
Absolute Error (not including probe error)	±0.4°
Long Term Stability (per month)	±0.3°
Temperature Resolution	0.1°C or min from IEEE-488 / RS232 Intf., 1°C from Keyboard
Line Voltage Sensitivity (105-125 VAC)	±0.2°C @ 105-125VAC
Programmable Temperature Loop Control	1 to 1800 Cycles of Programmable Set Temperatures and Set Times or Continuous
Temperature Control Technique	PID Algorithm / Pulse Width Modulated
Local Operation	16 Key Keyboard / 4 Digit Display
Remote Operation	Built-In IEEE-488 / RS232 Interfaces
Additional I/O Capability	IEEE-488 to RS232 Transparent Mode, 2 Auxiliary Outputs, 1 Auxiliary Input, Failsafe Input
Safety Features	Open/Short Probe Detection, Adjustable Over Temperature Thermostat, Software Upper Temperature Limit, Hardware Watch-Dog Timer
Convenience Features	Heat and Cool Enable / Disable Switches
Input / Output Interfaces	
IEEE-488 Bus Interface Application	EC0x Remote Control
Protocol	Talker / Listener
Bus Address	0-30, Switch Settable
Interrupt Capability	SRQ / Serial Poll
RS-232 Serial Interface Application	EC0X Remote Control or IEEE Bi-Directional Transparent Operation
Protocol	ASCII Character Oriented
Data Rates	1200 – 9600 BAUD
Front Panel Interface Application	EC0x Local Control
Manual Parameter Input	16 Key Keyboard
Menu-Driven Visual Output	4 Digit Display
Visual Indicators	Cool, Heat, Time-out, REM, BOX TEMP
Audible Alarm	Time-Out Indication

1.3 EC0X OPTIONS

Power Options

Table 1.3-1 lists the plug and mating receptacle Hubbell, Inc. part numbers required for the different A.C. power combinations under the **Electrical** section. These options cannot be installed in the field.

Cooling Options

The standard EC0X without any options is intended to operate directly from liquid carbon dioxide. The carbon dioxide is to be provided from an industry standard 50 pound siphon type cylinder. The draw pressure from the cylinder is approximately 850 PSI at room temperature. A hose and fitting necessary to interface between the EC0X and LCO₂ cylinder is provided. No other valves or regulators are necessary. The lower temperature limit of LCO₂ is -73°C.

The capability for the delivery of low pressure LCO₂ from a 300 PSI Dewar vessel or bulk delivery system is an option. Extra Insulation is provided and a special nozzle assembly is used. Regular siphon cylinders should not be used with this option.

Chambers equipped with the LN₂ option are able to operate the chamber as low as -184°C in temperature. Liquid nitrogen is commonly supplied in either a Dewar vessel or a bulk delivery system. Delivery pressure for both systems vary. A bulk delivery normally runs a low pressure of 25psi. A dewar vessel could be set anywhere between 25psi to 230psi. A special solenoid valve and nozzle assembly is used based on the pressure you specify at the time of order. Due to the variation of hose requirements a standard hose is not supplied, but are available from Sun Systems as a separate item. Special injectors are available for various pressures, consult factory.

Time at Temperature Option

The EC0X can be set up for time in minutes or hours. The standard EC0X allows for a time at temperature range from .1 to 1800 **minutes** or continuous from the IEEE-488/RS-232 interfaces. For a time at temperature range from .1 to 1800 **hours** please see INIT command.

Port and Window Options

Access ports and window options are available. Access ports are normally located on the left side of EC0X and on the door. Common port sizes are 1", 2", 3" and 4" diameter ports with plug. Standard window sizes are 4"x6" on the EC01 and EC0A, 6"x8" on the EC02 and EC03. Sun Systems supports special options to our customer's specifications.

1.4 EC0X COMPONENT IDENTIFICATION

Take a moment to become familiar with the major components of your EC0X environmental chamber by reviewing the following figures. Refer to the Figures when performing adjustments, routine maintenance or removal and replacement procedures.

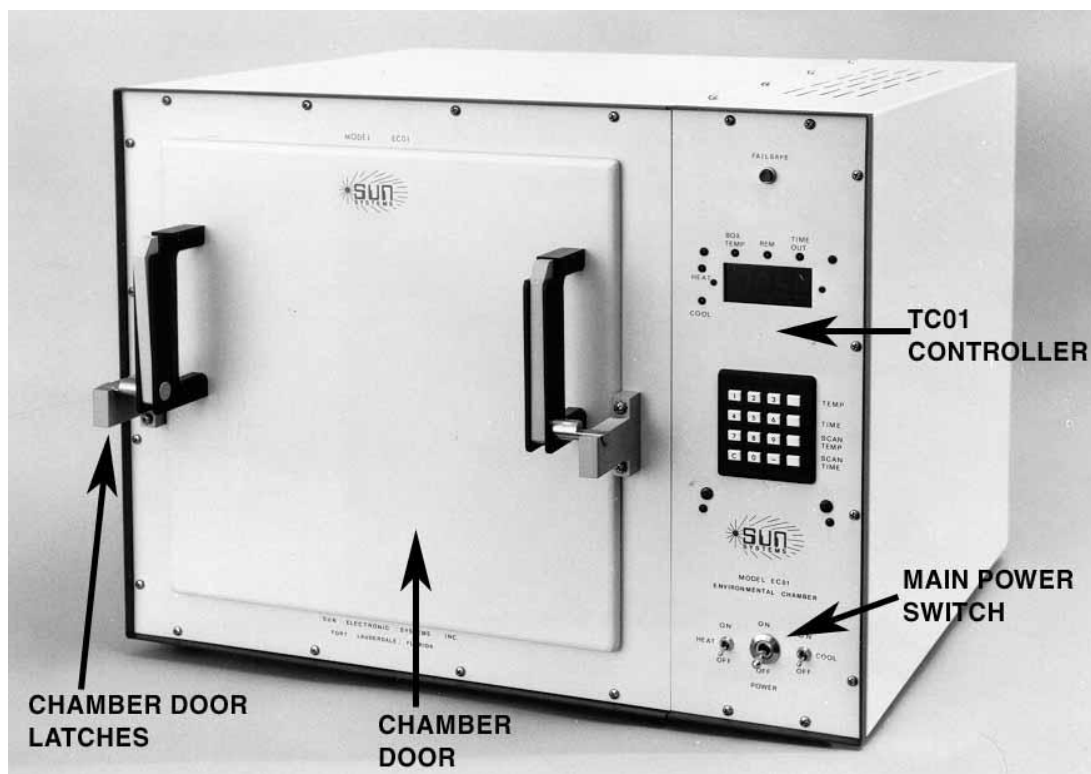


Fig. 1.4-1 Chamber Front View

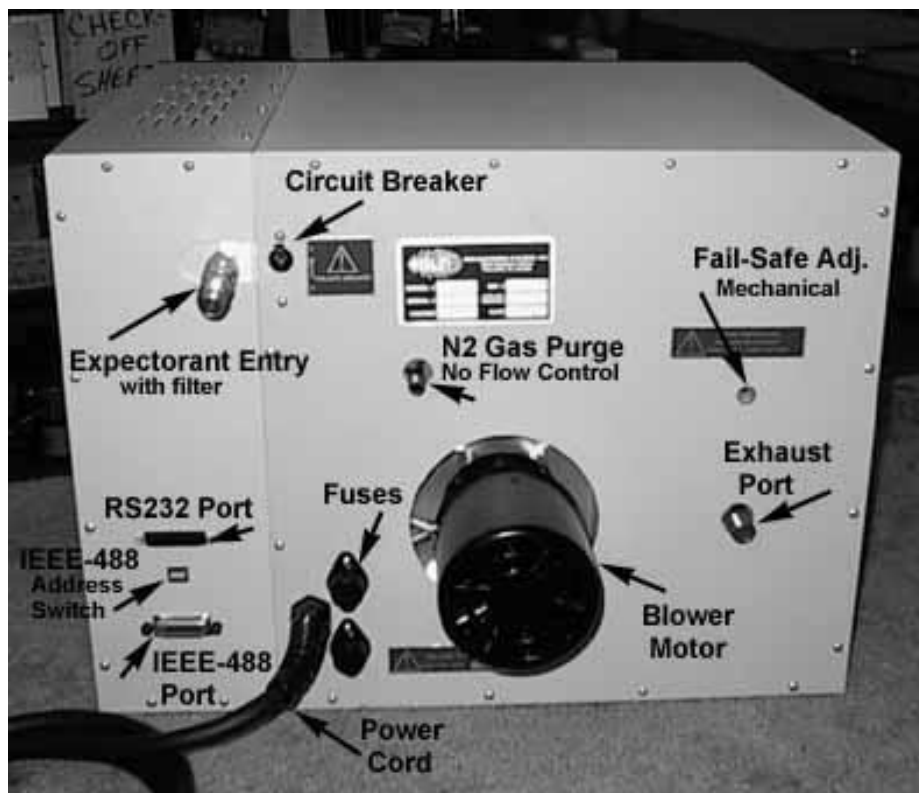


Fig. 1.4-2 Chamber Rear View with Mechanical Failsafe

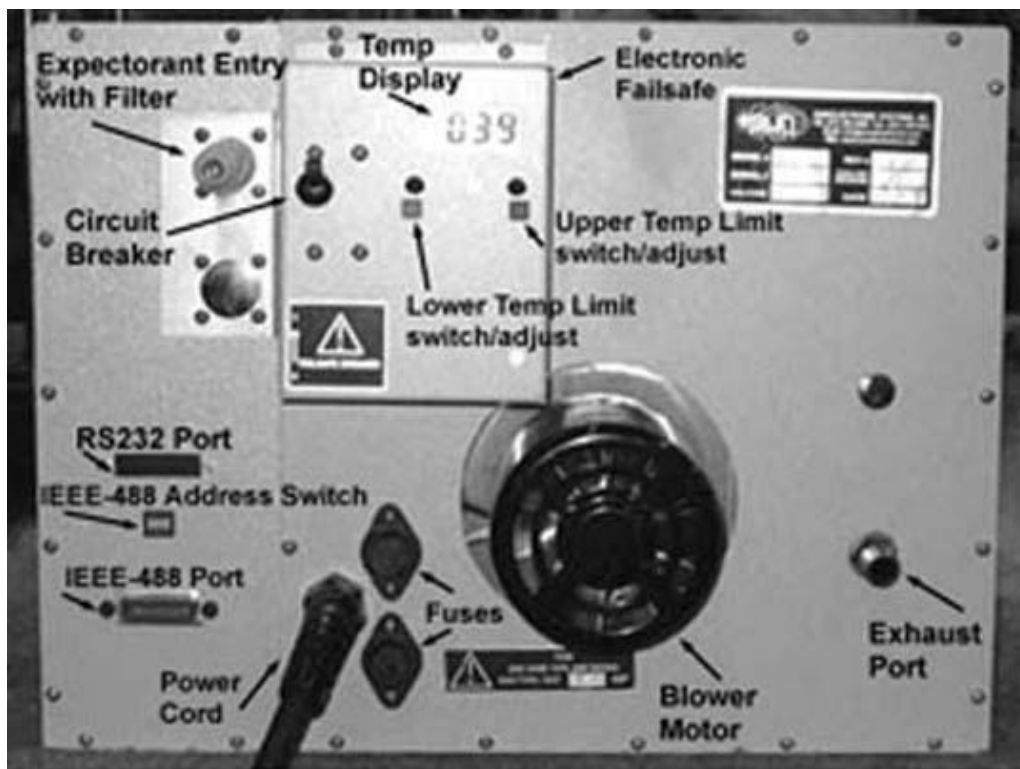


Fig. 1.4-3 Chamber Rear View with Electronic Failsafe

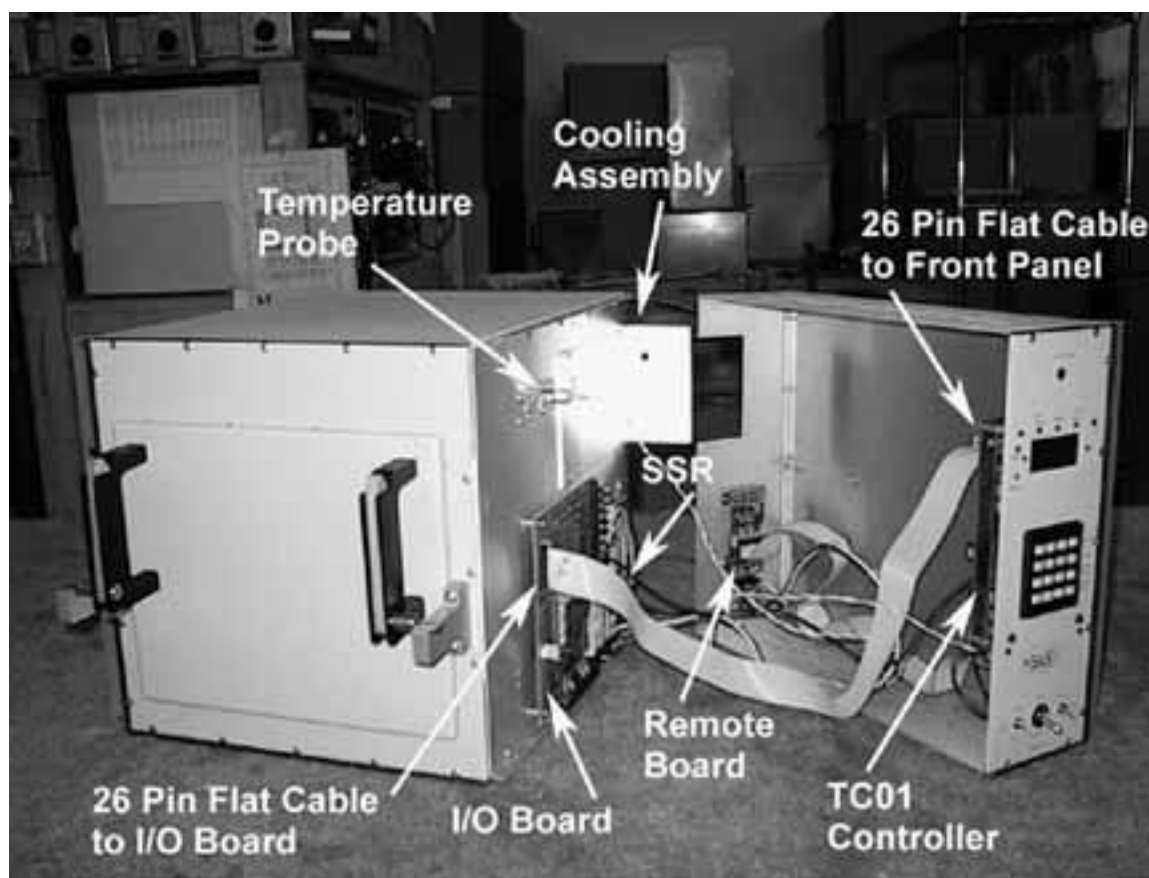


Fig. 1.4-4 EC0x Controller Section Separated Rev. F

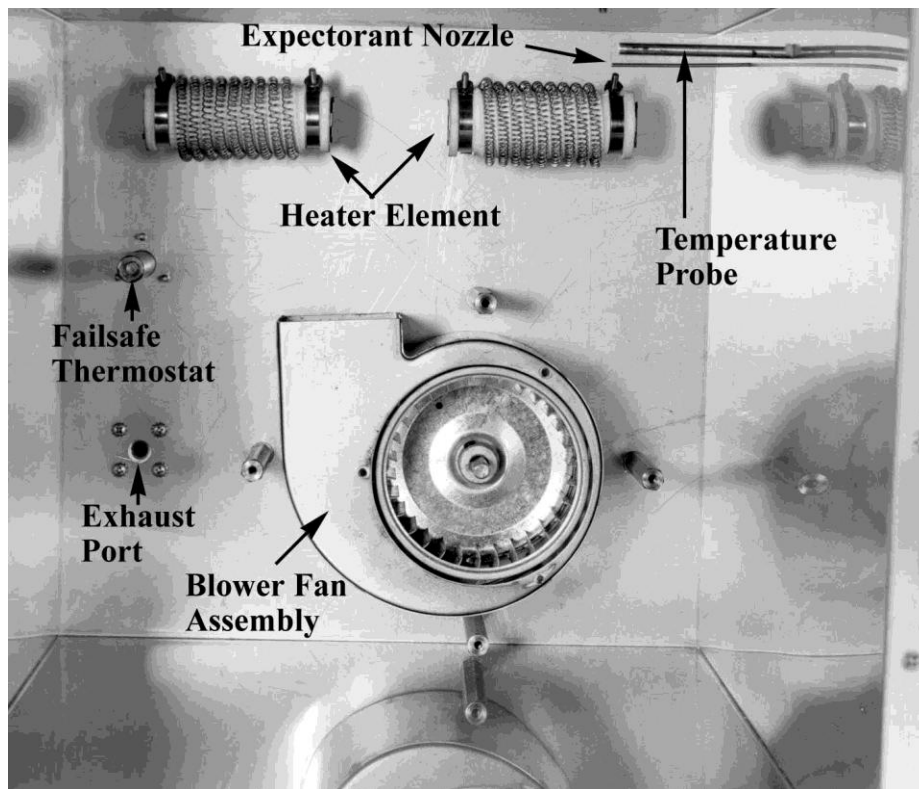


Fig. 1.4-5 Chamber with Baffle Removed

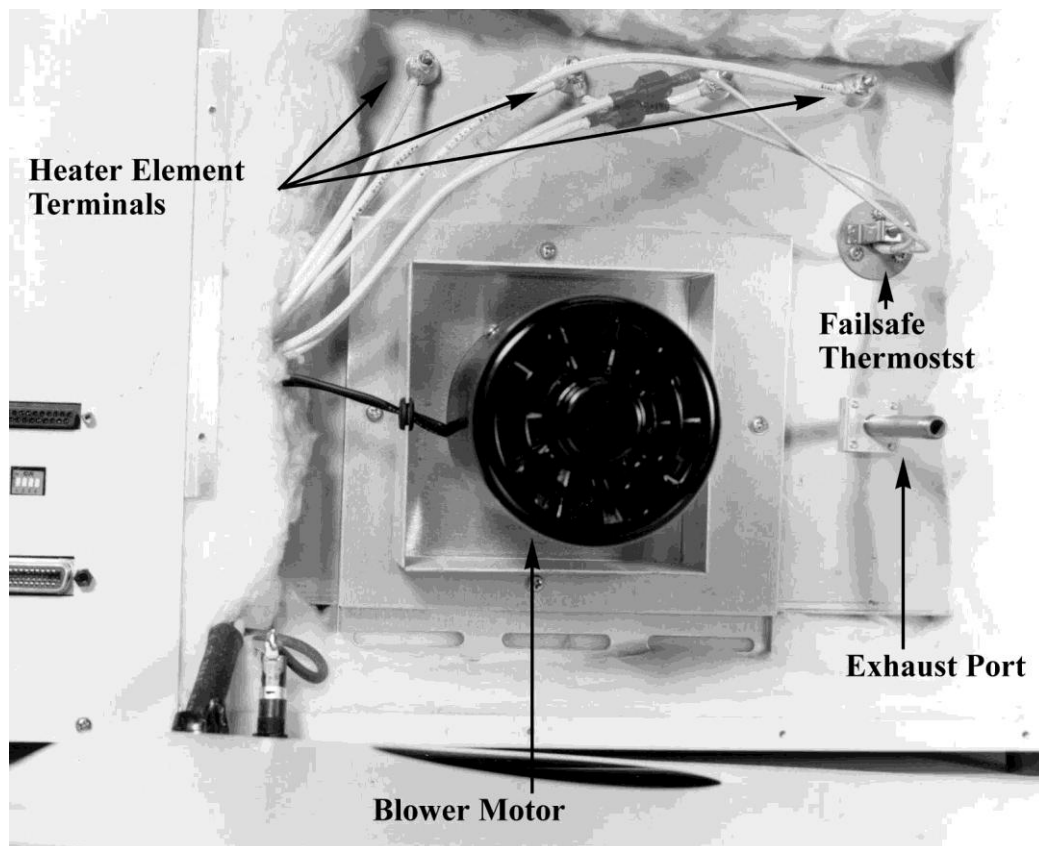


Fig. 1.4-6 Chamber Internal Rear View



Fig. 1.4-7 EC0x Controller Front Panel

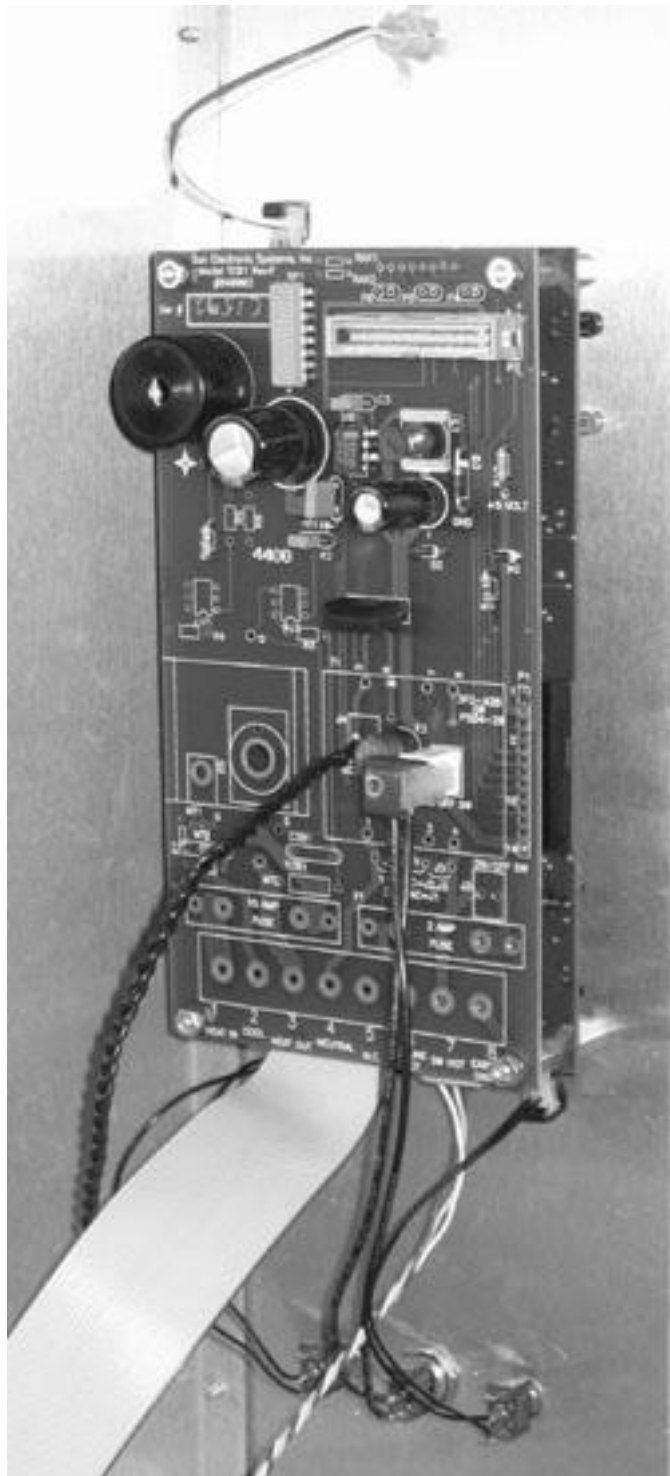


Fig. 1.4-8 EC0x Control Section Rev. F, Internal View, Two Board Stack



Fig. 1.4-9 EC0x Rev. F, CPU Board



Fig. 1.4-10 EC0x Rev. F, Power Supply Board

SECTION 2 RECEIVING, SAFETY AND INSTALLATION

2.1 INITIAL INSPECTION AND UNPACKING

Inspect the shipping container for obvious damage. If the shipping container is damaged, then a written note on the bill of lading describing the damage should be made while the delivery person is still on the premises. Unpack the EC0x and save all carton and cushioning material in case the unit needs to be returned. Verify the contents of the carton matches that of the items listed on the packing slip.

2.2 LOST OR DAMAGED EQUIPMENT

If you determine that the goods described on the packing slip are lost or damaged, first notify the transportation company to obtain the correct procedure for returning merchandise for repair or replacement. Then call Sun Systems for a return authorization number so that we may best handle the merchandise when it is returned.

2.3 SAFETY CONSIDERATIONS



Please take a moment to read the following safety precautions. If for any reason one does not fully understand the meaning of the cautions, please contact Sun Systems' customer service before proceeding.

CAUTION - Disconnect all electrical power sources before attempting any type of access or service to the interior of the chamber to prevent electrical shock. Turn off expectorant supplies and disconnect expectorant supply hoses before attempting any type of access or service to the interior of the chamber.

CAUTION - Always operate the chamber with the case grounded to earth ground. Verify that the power outlet to be used has an earth ground and meets your local electrical codes. Do not operate the chamber from an ungrounded outlet without first providing an earth ground to the chamber case.

CAUTION - Verify that the source of electrical power is compatible with the manufactured configuration of the chamber indicated on the rear of the unit.

CAUTION - Avoid personal contact with the interior portions of the test chamber area to prevent burns from heat or cold.

CAUTION - Use personal protective equipment such as gloves, goggles, face shields, etc., when working with or in any environment containing liquid carbon dioxide or liquid nitrogen.

CAUTION - Avoid any personal contact of the skin or eyes with liquid carbon dioxide or liquid nitrogen or supply lines and vessels carrying these liquids. Exposure to these liquids or the vessels which carry them can cause frostbite.

CAUTION - Operate the chamber in an environment with good ventilation to air. If the chamber is to be installed in any enclosed area, connect the chamber exhaust port to outside air. Never use the exhaust port for test access to the internal temperature chamber.

CAUTION - Always follow the safety precautions supplied by the vendor for your liquid carbon dioxide or liquid nitrogen storage cylinders and vessels.

CAUTION - Verify that the correct type of expectorant source is connected to the chamber before operating the chamber at low temperature.

CAUTION - Do not use Contaminated Expectorants. Test the expectorant for cleanliness by discharging a small amount through a clean filter. Inspect for quantities of ice, oil, rust or water for contamination.

CAUTION - Do not leave liquid nitrogen trapped in a supply line as high pressures will be developed when the liquid absorbs heat and is transformed from a liquid to gas. Bleed the supply hose when not in use.

CAUTION - When operating the chamber at low temperatures for extended periods of time, operate the chamber at 200°C for an hour to dry any moisture which may accumulate in the fiberglass insulation material surrounding the test area of the chamber.

CAUTION - Avoid oil contamination of the fiberglass insulation material surrounding the test area of the chamber. Liquid oxygen may be formed in the insulation material when operating at low temperature. Liquid oxygen mixed with oil can be explosive.

2.4 PREPARATION FOR USE

The EC0X is factory wired for AC sources delivering 110, 208, or 240 VAC, at 50 / 60 Hz. A tag located on the back panel of the chamber indicates the proper voltage to be applied. Insure that the current rating of the service is sufficient to provide the necessary amounts of power required by the chamber. Install the chamber on a surface which is flat, rigid and free from shock and vibration. Orient the chamber in such a manner that the control panel, door and coolant connection are readily accessible. Insure that 2 inches of free air space exists between the rear of the blower motor and any other objects.

2.5 LIQUID CARBON DIOXIDE DELIVERY SYSTEM

There are three common delivery systems available with the use of liquid carbon dioxide. They consist of a 50 pound, 850 PSI type K cylinder, a 350 pound, 300 PSI Dewar type vessel and 300 PSI bulk delivery systems. See pg. 7 for your chambers pressure (psi) setting.

Follow the recommendations of your LCO₂ supplier as to the correct methods to store and use your expectorant supply.

CAUTION - Use personal protective equipment such as gloves, goggles, face shields, etc., when working with or in an environment containing liquid carbon dioxide.

CAUTION - Avoid any personal contact of the skin or eyes with liquid carbon dioxide or supply lines and components carrying these liquids. Exposure to these liquids or the components which carry them can cause frostbite.

CAUTION - Operate the chamber in an environment with good ventilation to air. If the chamber is to be installed in an enclosed area, connect the chamber exhaust port to outside air. Never use the exhaust port for access to the internal temperature chamber for any means.

CAUTION - Always follow the safety precautions supplied by the vendor for your liquid carbon dioxide storage vessels.

CAUTION - Verify that the correct type of expectorant source is connected to the chamber before operating the chamber at low temperature.

CAUTION - Do not use contaminated expectorant. Test the expectorant for cleanliness by discharging a small amount through a clean filter. Inspect filter for quantities of ice, oil, rust or water.

2.5-1 LCO₂ Installation Procedure

1. Connect one end of the 6 foot hose supplied with the unit to the S.A.E. 37° flare male fitting located on the rear of the chamber.
2. Connect the loose end of the hose to the LCO₂ siphon cylinder, vessel or bulk delivery system.
3. Insure all fittings are secure. Turn on the LCO₂ supply and inspect for leaks at the fittings.

2.6 LIQUID NITROGEN DELIVERY SYSTEMS

Chambers equipped with liquid nitrogen for the cooling expectorant can operate as low as -184° C in temperature. Liquid nitrogen (LN₂) is commonly supplied in either a Dewar vessel or a bulk delivery system. Delivery pressure for both systems vary. A bulk delivery normally runs a low pressure of 25psi. A Dewar vessel could be set anywhere between 25psi to 230psi. See pg. 2 for your chambers pressure (psi) setting.

Caution - Use personal protective equipment such as gloves, goggles, face shields, etc., when working with or in an environment containing liquid nitrogen.

Caution - Avoid any personal contact of the skin or eyes with liquid nitrogen or supply lines and vessels carrying these liquids. Exposure to these liquids or the vessels which carry them can cause frostbite.

Caution - Operate the chamber in an environment with good ventilation to air. If the chamber is to be installed in an enclosed area, connect the chamber exhaust port to outside air. Never use the exhaust port for access to the internal temperature chamber for any means.

Caution - Always follow the safety precautions supplied by the vendor for your liquid nitrogen storage vessels.

Caution - Verify that the correct type of expectorant source is connected to the chamber before operating the chamber at low temperature.

Caution - Do not use contaminated expectorant. Test the expectorant for cleanliness by discharging a small amount through a clean filter. Inspect filter for quantities of ice, oil, rust or water.

Caution - Do not leave liquid nitrogen trapped in a supply line as high pressures will be developed when the liquid absorbs heat and is transformed from a liquid to a gas.

2.6-1 LN₂ Installation Procedure

1. The EC0X is equipped with a 3/8", SAE 45° flare male fitting (CGA 295) on the rear of the chamber. Connect the user supplied cryogenic supply hose to this fitting. A 3/8" I.D. supply hose should be used for best chamber operation.
2. Connect the other end of the cryogenic supply hose to the LN₂ supply.
3. Insure all fittings are secure. Turn on the LN₂ supply and check for leaks.

2.7 PRELIMINARY CHECKOUT OF EC0X CHAMBER

Refer to Section 3.1, PRELIMINARY CHECKOUT, for checkout of control functions.

SECTION 3 THEORY OF OPERATION

The EC0X is designed such that air flows vertically in the test chamber. The circulated air enters the blower in the lower rear of the chamber and is forced up and over heating elements. It then proceeds across the top interior of the chamber past the expectorant nozzle and the temperature probe used by the temperature controller. The front of the air baffle then redirects the air flow down to the interior of the chamber.

Heat and Cool operation is controlled by the TCO1 Temperature Controller (incorporated into the EC0X) from readings received from the temperature probe. This section of the manual fully describes the operation of the temperature controller.

3.1 PRELIMINARY CHECKOUT

The following procedure allows checking basic control function of the unit. Data entry is via the 16 key keyboard. At this time refer to the Command Summary, TABLE 3-4 and TABLE 3-5.

Enable the Heat and Cool toggle switches to the 'ON' position. Apply power to the system by switching the power switch to the 'ON' position. In TABLE 3-4 and TABLE 3-5, note the column "KEYBD/DISPLAY". This column summarizes keystroke entry for the various functions supported by the TC01. With TABLE 3-4 and TABLE 3-5 as a reference, input the following sequences and note the controller response. See Figures 3.5-1 and 3.5-2 for Chamber Keyboard Layouts.

<u>KEYSTROKE</u>		<u>CONTROLLER RESPONSE</u>
<u>Keyboard Layout 1</u>	<u>Keyboard Layout 2</u>	
C	*	Reset Controller (Clear) GPIB address is displayed for a few seconds Time is set to Infinity (1999) Temp is set to 25°C
50 TEMP	50 TEMP	Set Chamber to 50°C
5 TIME	5 TIME	Set Time at Temp = 5 minutes

At this point, Heat will be enabled and chamber temperature will rise. At any time, 'TEMP' or 'TIME' keys can be depressed to give status.

TEMP	TEMP	Chamber SET Temp Displayed
TIME **	TIME **	Remaining Time at 50°C
C	*	Reset Controller (Clear) Stop controlling temperature Display GPIB address Time = Infinity Temp = 25°C

** In 5 minutes, after reaching the set temp, the controller will "TIME-OUT" and sound the audible alarm. Depress "C" to clear the controller back to Time = Infinity and Temp = 25°C.

If the controller is operating properly, continue on for more detailed information.

3.2 LOCAL FRONT PANEL CONTROL

The Heat switch and Cool switch are located on either side of the main Power switch. The function of the Heat (Cool) switch is to disable application of power to the heaters (cooling solenoid) when in the "OFF" position. The TC01 microprocessor system continues to make heat or cool decisions independent of the switch settings but actual power is applied only if the Heat (Cool) switches are in the 'ON' position. This feature allows the operator to manually override the Heat (Cool) decisions of the TC01.

After power-up and/or after a "RESET" command, the Heat and Cool outputs are disabled. Setting the Single Mode 'SET TEMP' or starting the 'SCAN MODE' will enable the Heat and Cool outputs automatically. Control of Heat and Cool outputs is also provided by the 'ON' and 'OFF' commands via the RS232 port, or IEEE-488 bus.

The 3 1/2 digit numeric display indicates Temperature or Time depending upon previous keystrokes. The display will default to indicating Chamber temperature when no key is pressed and 3 seconds have elapsed. Set Temperature and Set Time are displayed when the "TEMP" key and "TIME" key are depressed, respectively.

Five LEDs offer status information on the TC01. The left side of the front panel contains the Heat and Cool LEDs. When power is going to the heater and the cooling circuit the LED will be on.

From left to right, three red LEDs above the main display are labeled "BOX TEMP", "REM", and "TIME OUT" respectively. Activation of the "BOX TEMP" LED indicates that the numerals on the display are indicating Chamber Temperature. The "REM" LED will activate when the TC01 is in the Remote mode. Remote mode is current when information is being transferred via either the RS232 or IEEE-488 bus. The "TIME OUT" LED will activate when the Temperature Chamber has been at the Set Temperature for the required amount of time. Simultaneously, an audio indication will sound. The buzzer can be reset by depressing the "TIME" or "TEMP" or "C" (clear) key on the keyboard or by setting any controller TEMP/TIME function. (For any key to have effect, the keyboard must not have been "locked out" by an IEEE-488 lockout command. See Section 3.4-3, Command #10.)

Slightly below the 16 key keyboard are two holes with attending large panhead screws that are unlabeled. These holes provide access to calibration pots that are used to calibrate the TC01. Details are given in Section 4, USER ADJUSTMENTS.

LOCAL: SINGLE TEMP

The following commands are provided by the local keyboard, assuming the controller has not been instructed via an IEEE-488 interface command to 'lock out' local control. Any invalid data or any command error immediately causes the display to read '0.0' with no action taken by the controller.

CONVENTIONS:

1. "n" or "m" refers to any numeric key (a single keystroke)
2. "-" refers to the minus key - (Keyboard Layout 1)
"#" refers to the minus key # (Keyboard Layout 2)
3. Items enclosed in parentheses are optional. Thus n(n(n)) means that at least one numeric key has to be depressed. Two additional numeric keystrokes are optional.
4. "A => B" is read as "A is equal to or greater than B"
5. All temperatures referred to are in the units of "degrees Celsius".
6. Keystrokes are noted as a sequence of numbers and words that define each entry. "n(n(n)) TEMP" means "press 1,2, or 3 numeric keys, then press the TEMP key." "SCAN TEMP m" means "press the key marked 'SCAN TEMP' followed by a numeric entry."

3.2-1 Keyboard Commands: Single Temperature Mode

1. To SET the CHAMBER TEMPERATURE

(-) n(n(n)) TEMP where $-184 \leq (-)n(n(n)) \leq \text{UTL}$ (Keyboard Layout 1)

(#) n(n(n)) TEMP where $-184 \leq (\#)n(n(n)) \leq \text{UTL}$ (Keyboard Layout 2)

- A) If the controller was in the Scan Mode before this command, the Scan Mode is terminated and the Single Temp Mode is initiated.
- B) UTL is the user-settable limit temperature. UTL can only be set $\leq \text{PLIMIT}$. PLIMIT is the highest temperature allowed or 315°C.
- C) Fractional temperatures can be entered using the - key as a decimal point once a digit has been entered.
- D) Setting the temperature enables the Heat and Cool outputs with Heat/Cool switch override.
- E) A temperature < -184 or $> \text{UTL}$ is ignored and no action will be initiated by the controller.
- F) EXAMPLES:

Keyboard Layout 1:

50 TEMP	sets the chamber to +50°C
-38.5 TEMP	sets the chamber to -38.5°C
-200 TEMP	is ignored

Keyboard Layout 2:

50 TEMP	sets the chamber to +50°C
#38.5 TEMP	sets the chamber to -38.5°C
#200 TEMP	is ignored

2. To SET the TIME-AT-TEMPERATURE (Soak Time)

n(n(n(n))) TIME where $0 \leq n(n(n(n))) \leq 1999$

- A) A time < 0 or > 1999 is ignored and no action is taken by the controller.
- B) A time > 1800 and ≤ 1999 sets the time to infinity.
- C) Time is interpreted as Minutes unless changed to Hours using INIT Command
- D) EXAMPLES:

10 TIME	sets the soak time to 10 minutes
1981 TIME	sets the soak time to infinity
-10 TIME	is ignored (Keyboard Layout 1)
#10 TIME	is ignored (Keyboard Layout 2)

3. To DISPLAY the CHAMBER TEMPERATURE

No action is required to display the chamber temperature since the chamber temperature is normally displayed, unless the controller has been instructed to display another parameter. If so instructed, the controller will once again display the chamber temperature 3 seconds after the instruction.

4. To DISPLAY the SET TEMPERATURE

TEMP

The chamber set temperature will be displayed for 3 seconds.

5. To DISPLAY remaining time at temperature

TIME

The remaining Time-At-Temperature will be displayed for 3 second.

Time is interpreted as Minutes unless changed to Hours using INIT command

3.2-2 Keyboard Commands: Scan Mode

1. To SET/DELETE a SCAN TEMPERATURE

Keyboard Layout 1:

(-)n(n(n)) SCAN TEMP m where $-184 \leq (-)n(n(n)) \leq \text{UTL}$
and where $0 \leq m \leq 9$

Keyboard Layout 2:

(#)n(n(n)) SCAN TEMP m where $-184 \leq (\#)n(n(n)) \leq \text{UTL}$
and where $0 \leq m \leq 9$

- A) A temperature of < -184 or $> \text{UTL}$ is ignored and no action will be initiated by the controller.
- B) UTL is the user-settable limit temperature. UTL can only be set $\leq \text{PLIMIT}$. PLIMIT is the highest temperature allowed or 315°C .
- C) - SCAN TEMP m will delete Scan Temp and Scan Time m (Keyboard 1)
SCAN TEMP m will delete Scan Temp and Scan Time m (Keyboard 2)
- D) Fractional temperatures can be entered using the - key as a decimal point once a digit has been entered.
- E) Scan Temps can be assigned in any order. However, Scan Temps will be executed in ascending order.
- F) EXAMPLES:

Keyboard Layout 1:

-30 SCANTEMP 3	sets Scan Temp #3
50 SCANTEMP 0	sets Scan Temp #0
100 SCANTEMP 8	sets Scan Temp #8

The previous sequence will execute $+50^{\circ}\text{C}$ first, -30°C second, and 100°C third.

- SCANTEMP 3	deletes Scan Temp #3.
150 SCANTEMP 8	changes Scan Temp #8

Keyboard Layout 2:

#30 SCANTEMP 3	sets Scan Temp #3
50 SCANTEMP 0	sets Scan Temp #0
100 SCANTEMP 8	sets Scan Temp #8

The previous sequence will execute +50°C first, -30°C second, and 100°C third.

#SCANTEMP 3	deletes Scan Temp #3.
150 SCANTEMP 8	changes Scan Temp #8

G) A Scan Temp entered without a corresponding Scan Time is ignored at execution time.

2. To SET/DELETE a SCAN TIME

$n(n(n(n)))$ SCAN TIME m where $0 < n(n(n(n))) \leq 1999$

- A) A time < 0 or > 1999 is ignored and no action is initiated by the controller.
- B) A time > 1800 and ≤ 1999 sets the time to infinity.
- C) -SCAN TIME m will delete Scan Temp and Scan Time m. (Keyboard Layout 1)
#SCAN TIME m will delete Scan Temp and Scan Time m. (Keyboard Layout 2)
- D) Scan Times can be assigned in any order. They, along with their corresponding Scan Temp, will be executed in ascending order.
- E) Time is interpreted as Minutes unless changed to Hours using INIT Command
- F) EXAMPLES:

Keyboard Layout 1:

10 SCANTIME 3	sets Scan Time #3
82 SCANTIME 0	sets Scan Time #0
100 SCANTIME 8	sets Scan Time #8

The soak time at the first executed temperature will be 82 minutes, at the second temperature 10 minutes, and at the third temperature 100 minutes.

- SCANTIME 3	deletes Scan Time #3
55 SCANTIME 8	changes Scan Time #8

Keyboard Layout 2:

10 SCANTIME 3	sets Scan Time #3
82 SCANTIME 0	sets Scan Time #0
100 SCANTIME 8	sets Scan Time #8

The soak time at the first executed temperature will be 82 minutes, at the second temperature 10 minutes, and at the third temperature 100 minutes.

# SCANTIME 3	deletes Scan Time #3
55 SCANTIME 8	changes Scan Time #8

G) A Scan Time entered without a corresponding Scan Temp is ignored at execution time.

3. To SET the number of 'CYCLES' for the SCAN MODE

n(n(n(n))) SCAN TIME -	where $0 \leq n(n(n(n))) \leq 1999$ (Keyboard 1)
n(n(n(n))) SCAN TIME #	where $0 \leq n(n(n(n))) \leq 1999$ (Keyboard 2)

An input > 1800 and ≤ 1999 sets the number of cycles to infinity.

4. To DISPLAY a SCAN TEMPERATURE

SCAN TEMP m where $0 \leq m \leq 9$

Scan Temperature m will be displayed for 3 seconds.

5. To DISPLAY a SCAN TIME

SCAN TIME m

Scan Time m will be displayed for 3 seconds.

6. To DISPLAY the CURRENT CYCLE NUMBER

SCAN TIME –	(Keyboard Layout 1)
SCAN TIME #	(Keyboard Layout 2)

Note: '1' will be displayed during the first cycle or loop, '2' will be displayed during the second, etc. The scan will terminate automatically after the cycle where the current cycle number equals the number of cycles 'to do'. When the Scan Mode is terminated, the Heat and Cool outputs are disabled, the 'SET TEMP' is set for 25°C and the Time-At-Temperature is set to infinity, and the number of cycles "TO-DO" is set to infinity. If the Scan Mode hasn't started, or has been stopped (See command #11, this section) then this command displays the original number of cycles set.

7. To DISPLAY the CHAMBER TEMPERATURE

No action is required to display the chamber temperature since the chamber temperature is normally displayed, unless the controller has been instructed to display another parameter. If so instructed, the controller will once again display the chamber temperature 3 seconds after the instruction.

8. To DISPLAY the CURRENT SCAN TEMPERATURE

TEMP

The Set Temperature will be displayed for 3 seconds.

9. To DISPLAY REMAINING TIME at the CURRENT TEMPERATURE

TIME

The remaining Time-At-Temperature will be displayed for 3 seconds.

10. To START the SCAN MODE

SCAN TEMP SCAN TIME

Starting the Scan Mode without any valid Scan Temp/Scan Time data programmed will cause a 'COMMAND ERROR' response.

11. To STOP the SCAN MODE

SCAN TIME SCAN TEMP

Stopping the Scan Mode disables the Heat and Cool outputs, and disables the Time-Out function. Upon restarting, execution begins at the FIRST valid Scan Time/Temp of the "LOOP" or "CYCLE" in which it was stopped. Execution does NOT continue at the Scan Time/Temp at which the Scan was stopped.

3.2-3 Keyboard Commands: Control Group

To RESET (clear the CONTROLLER)

C (Keyboard Layout 1)
* (Keyboard Layout 2)

The controller is reset to power up conditions:

- 1) Single Temp mode
- 2) All Scan Temperatures and Time cleared
- 3) Set temperature equal to 25°C
- 4) Time-At-Temperature equal to infinity
- 5) # of Cycles equal to infinity
- 6) Compressor and Auxiliary outputs disabled
- 7) Heat/Cool outputs disabled
- 8) RS232-C Echo disabled
- 9) IEEE-488 address displayed for 3 seconds
- 10) Local control enabled
- 11) PID Coefficients returned to factory default PID=-1,-2,-1 (unless changed using INIT Command)
- 12) Scan Interrupts are disabled
- 13) UTL = PLIMIT
- 14) Deviation Limit Checking disabled

TIME-OUT INDICATIONS

SINGLE TEMPERATURE MODE

When the desired Soak Time (Time-At-Temperature) has been reached, the operator is alerted to this fact in two ways. First, the 'TIME-OUT' LED located on the front panel is turned 'ON'. Secondly, a continuous tone is emitted from a transducer located on the TC01 power supply board. The LED and audio indication will continue until a TIME or TEMP key is pressed. Alternately, the controller may be RESET by depressing the 'C' (clear) key. Note that when RESET, all SCAN Temps and Times are cleared and the Single Temp Mode is entered. See Section 3.2-3

SCAN MODE

The TC01 Scan Mode allows a maximum of 10 segments (0 through 9) to be programmed through the keyboard. Each segment is described by a Temperature and a Soak Time (Time-At-Temperature). One minute before any particular Soak Time is complete, an audible indication will start and continue for the remaining one minute. This Time-Out is distinguished from the Single Temp Mode Time-Out mentioned above in that the sound is 'ON' for 1 second and 'OFF' for 1 second. At the end of the 1 minute on/off period, the audible indication is automatically turned 'OFF'. The TC01 then moved on to the next Scan segment. This one minute "warning" can be used to alert an operator to start taking data or measurements during the final minute of the programmed soak time. If a number of cycles have been programmed, the above sequence is repeated for each cycle. At the end of the last soak time of the last cycle, a continuous tone is emitted until a TIME or TEMP key is pressed. Alternately, the controller can be RESET by depressing "C" (clear) on the keyboard. Note that when RESET, all Scan Temps and Times are cleared and the Single Temp Mode is entered. See Section 3.2-3

3.3 RS232-C REMOTE CONTROL

CONVENTIONS/COMMENTS:

1. "n" or "m" refers to any numeric character 0 through 9.
2. Items enclosed in parentheses "()" are optional. Thus n(n(n(n))) means that at least one numeric character has to be sent. One or two additional numeric characters to the left of a decimal and one character after a decimal is allowed.
3. All times referred to are in the unit of Minutes unless changed to Hours using INIT Command.
4. All temperatures referred to are in the unit of "degrees Celsius."
5. Commands sent to the controller and data sent from the controller are in the form of "ASCII character strings". Commands sent to the controller are masked to 7 bits and may contain space characters (blanks).
6. The RS232 encoding format used for Windows is: Baud Rate: 9600, Data: 8 Bits, Parity: None, Flow Control: None, Stop Bits: 1 (Note: Older equipment with serial numbers below C1508, Baud Rate = 2400)
7. Data sent from controller are followed by carriage return and line feed characters as line terminator.
8. See TABLE 3-1 for RS232-C CONTACT ASSIGNMENTS and WIRING DIAGRAM.
9. The command processor software ignores leading zero's and trailing digits on all numeric data received. For example, -0000025.32C will set the single mode temperature to -25.3°C.
10. BOLD type in the Terminal Examples indicate keystrokes required from the terminal keyboard.
11. When a 'dumb terminal' is used for the RS232 interface, any TC01 output will automatically be displayed on the terminal. When using a computer, any TC01 output must be read through some form of 'INPUT' or READ' statement, usually a part of an application program written in a language such as BASIC.
12. Computer examples are written in BASIC. In these BASIC statements, the variables X, Y, and A\$ are assumed to be defined somewhere else in the BASIC program and contain the proper values for desired results. The BASIC program statements: PRINT#1 and INPUT#1 are assumed to output RS232 data to the TC01 and input RS232 data from the TC01, respectively.

3.3-1 RS232 Commands: Single Temperature Mode

1. To SET the CHAMBER TEMPERATURE

$(-)\text{n}(\text{n}(\text{n}(\text{n})))\text{C}$ where $-184 \leq (-)\text{n}(\text{n}(\text{n}(\text{n}))) \leq \text{UTL}$

- A) If the controller was in the Scan Mode before this command, the Scan Mode is terminated and the Single Temp Mode is initiated.
- B) UTL is the user-settable limit temperature. UTL can only be set ≤ 315 .
- C) Setting the temperature enables the Heat and Cool outputs, with Heat/Cool switch override.
- D) A temperature < -184 or $> \text{UTL}$ is ignored and no action will be initiated by the controller.
- E) TERMINAL EXAMPLES:
50C sets the chamber to $+50.0^{\circ}\text{C}$
-38.2C sets the chamber to -38.2°C
-200C is ignored

F) COMPUTER EXAMPLES: PRINT#1,"-38.2C" or PRINT#1,X,"C"

2. To SET the TIME-AT-TEMPERATURE (Soak Time)

$\text{n}(\text{n}(\text{n}(\text{n})))\text{M}$ where $0 < \text{n}(\text{n}(\text{n}(\text{n}))) \leq 1999$

- A) A time < 0 or > 1999 is ignore and no action is initiated by the controller.
- B) A time between 1800 and 1999 sets the time to infinity.
- C) TERMINAL EXAMPLES:
10M sets the soak time to 10 minutes
1981M sets the soak time to infinity
-10M is ignored

D) COMPUTER EXAMPLES: PRINT#1,"10M" or PRINT#1,X"M"

3. To SET the DEVIATION LIMIT and ENABLE DEVIATION INTERRUPT

$\text{EDIn}(\text{n}(\text{n}(\text{n}(\text{n}))))$ where $0 \leq \text{n}(\text{n}(\text{n}(\text{n}(\text{n})))) \leq \text{UTL}$

- A) The allowed temperature deviation before generating a deviation interrupt is $\pm$ the set value around the target chamber set temperature.
- B) The deviation checking is automatically disabled during transitions between chamber temperature set points and begins once the chamber temperature is within the deviation limits of the set temperature.
- C) The deviation limit will be checked each time a new Heat/Cool period is calculated (once every 2 seconds, default).
- D) TERMINAL EXAMPLE: EDI5.3 enables interrupt and set limit to $\pm 5.3^{\circ}\text{C}$

E) COMPUTER EXAMPLE: PRINT#1,"EDI5.3" or PRINT#1,"EDI",X

4. To READ the CHAMBER TEMPERATURE

T

- A) The resolution of the temperature reading read over the interface is .1°
- B) The front panel LED display will display in increments of .1° up to 199.9°. At temperatures >200°, the display resolution is 1°.
- C) TERMINAL EXAMPLE: T chamber temp is displayed on terminal
- D) COMPUTER EXAMPLE: PRINT#1,"T" output command to TC01
INPUT#1,X read chamber temperature

5. To READ the SET TEMPERATURE

C

- A) The resolution of the temperature reading read over the interface is .1°
- B) The front panel LED display will display in increments of .1° up to 199.9°. At temperatures > 200°, the display resolution is 1°.
- C) TERMINAL EXAMPLE: C outputs Set Temp to terminal
- D) COMPUTER EXAMPLE: PRINT#1,"C" outputs command to TC01
INPUT#1,X read Set Temp

6. To READ the REMAINING TIME at the CURRENT TEMPERATURE

M

- A) Time is interpreted as Minutes unless changed to Hours using INIT Command. OPT Command can be used to determine Time setting.
- B) TERMINAL EXAMPLE: M outputs Time to terminal
- C) COMPUTER EXAMPLE: PRINT#1,"M" output command to TC01
INPUT#1,X read Time

3.3-2 RS232 Commands: Scan Mode

1. To SET/DELETE a SCAN TEMPERATURE

$(-)(n(n(n(n))))Am$ where $-184.0 \leq (-)(n(n(n(n)))) \leq \text{UTL}$ and $0 \leq m \leq 9$

- A) A temperature < -184 or $> \text{UTL}$ is ignored and no action is initiated by the controller.
- B) UTL is the user-settable limit temperature. UTL can only be set $\leq \text{PLIMIT}$. PLIMIT is the highest temperature allowed or 315°C .
- C) $-Am$ will delete Scan Temperature and Time m .
- D) Scan Temps can be assigned in any order. Scan Temps will be executed in ascending order.
- E) The resolution of the temperature set over the interface is $.1^{\circ}$. The LED display will display in increments of $.1^{\circ}$ up to 199.9° . At temperatures $>200^{\circ}$, the display resolution is 1° .
- F) TERMINAL EXAMPLES:
 - $-30A3$ sets Scan Temp #3 to -30°C
 - $50.2A0$ sets Scan Temp #0 to $+50.2^{\circ}\text{C}$
 - $100.5A8$ sets Scan Temp #8 to $+100.5^{\circ}\text{C}$

The above sequence will be executed $+50.2^{\circ}\text{C}$ first, -30.0°C second, and $+100.5^{\circ}\text{C}$ third. $-A3$ deletes Scan Temp #3. With Scan Temp #3 deleted, execution will start with $+50.2^{\circ}\text{C}$ and end with $+100.5^{\circ}\text{C}$. $150.5A8$ sets Scan Temp #8 to $+150.5^{\circ}\text{C}$. **Note** that the new Scan Temp of 150.5° writes over the old one of 100.5° .

- G) COMPUTER EXAMPLES: $\text{PRINT}\#1, "-30A3"$ or $\text{PRINT}\#1, X, "A", Y$

2. To SET/DELETE a SCAN TIME

$n(n(n)Bm$ where $0 \leq n \leq 1999$ and $0 \leq m \leq 9$

- A) A time < 0 or > 1999 is ignored and no action is initiated by the controller.
- B) A time between 1800 and 1999 sets the time to infinity.
- C) $-Bm$ will delete Scan Temperature and Time m .
- D) Scan Times can be assigned in any order. They, along with their corresponding Scan Temp, will be executed in ascending order.
- E) TERMINAL EXAMPLES:
 - $10B3$ sets Scan Time #3 to 10 minutes
 - $82B0$ sets Scan Time #0 to 82 minutes
 - $100B8$ sets Scan Time #8 to 100 minutes

The soak-time at the first executed temperature will be 82 minutes, at the second temperature, 10 minutes, and at the third temperature, 100 minutes.

- F) COMPUTER EXAMPLES: $\text{PRINT}\#1, "10B3"$ or $\text{PRINT}\#1, X, "B", Y$

3. TO SET THE NUMBER OF 'CYCLES' OR 'LOOPS' FOR THE SCAN MODE

$n(n(n(n)))B-$ where $1 \leq n(n(n(n))) \leq 1999$

- A) An input >1800 and ≤ 1999 sets the number of cycles to infinity.
- B) The number of cycles that have been set can only be displayed before the Scan sequence has started. (see command #7 below) or, once the Scan sequence has been started, by stopping the Scan sequence and executing command #7 below. See command #12, this section.

C) TERMINAL EXAMPLES: 124B- sets the number of cycles to 124

D) COMPUTER EXAMPLES: PRINT#1,"125B-" or PRINT#1,X,"B-"

4. To SET the DEVIATION LIMIT and ENABLE DEVIATION INTERRUPTS

$EDIn(n(n(n(n))))$ where $0 \leq n(n(n(n(n)))) \leq UTL$

- A) The allowed temperature deviation before generating a deviation interrupt is +/- the set value around the target chamber set temperature.
- B) The deviation checking is automatically disabled during transitions between chamber temperature set points and begins once the chamber temperature is within the deviation limits of the Set Temperature.
- C) The deviation limit will be checking each time a new Heat/Cool period is calculated (once every 2 seconds, default).

D) TERMINAL EXAMPLES: EDI5.3 enables interrupt and sets limit to +/- 5.3°C

E) COMPUTER EXAMPLES: PRINT#1,"EDI5.3" or PRINT#1,EDI",X

5. To READ a SCAN TEMPERATURE

Am where $0 \leq m \leq 9$

- A) The resolution of the temperature measurement over the interface is .1°. The LED display will display in increments of .1° up to 199.9°. At temperatures $> 200^\circ$, the display resolution is 1°.

B) TERMINAL EXAMPLES : A3 causes TC01 to output Scan Temp #3

C) COMPUTER EXAMPLES:
PRINT#1,"A3" outputs command to TC01
INPUT#1,X reads Scan Temp #3 or PRINT#1,"B",Y INPUT#1,X

6. To READ a SCAN TIME

Bm where $0 \leq m \leq 9$

A) Time is interpreted as Minutes unless changed to Hours using INIT Command

7. TO READ THE CURRENT CYCLE NUMBER

B-

A) '1' will be displayed during the first cycle or loop, '2' will be displayed during the second, etc. The scan will terminate automatically after the cycle where the current cycle number equals the number of cycles 'to do'. When the Scan Mode is terminated, the Heat and Cool outputs are disabled, the 'SET TEMP' is set for 25°, the Time-At-Temperature is set to infinity, and the number of cycles 'to do' is set to infinity. If the Scan Mode hasn't started, or has been stopped (see Command #11, this section), then this command displays the original number of cycles set.

B) TERMINAL EXAMPLES: B- reads current cycle number

C) COMPUTER EXAMPLES: PRINT#1,"B-"
INPUT#1,X

8. To READ the CURRENT CHAMBER TEMPERATURE

T

A) The resolution of the temperature measurement over the interface is .1°. The LED display will display in increments of .1° up to 199.9°. At temperatures > 200°, the display resolution is 1°.

B) TERMINAL EXAMPLES: T causes TC01 output current Temp

C) COMPUTER EXAMPLES: PRINT#1,"T"
INPUT#1,X

9. To READ the CURRENT SCAN TEMPERATURE

C

A) See Command #8 A) above

B) TERMINAL EXAMPLES: C causes TC01 to output current Scan Temp

C) COMPUTER EXAMPLES: PRINT#1,"C"
INPUT#1,X

10. To READ REMAINING TIME at CURRENT TEMPERATURE

M

- A) Time is interpreted as Minutes unless Hours was selected using the INIT Command
- B) TERMINAL EXAMPLES: C causes TC01 to output remaining time
- C) COMPUTER EXAMPLES: PRINT#1,"M" outputs commands to TC01
INPUT#1,X reads Time

11. To START the SCAN MODE

AB

- A) Starting the Scan Mode without any valid Scan Temp/Scan Time data programmed will cause a 'COMMAND ERROR' response.
- B) TERMINAL EXAMPLES: AB starts Scan Mode
- C) COMPUTER EXAMPLES: PRINT#1,"AB" starts Scan Mode or PRINT#1,A\$

12. To STOP the SCAN MODE

BA

- A) Heat and Cool outputs are disabled; the Time-Outs function is turned off. Upon restarting, execution beings at the FIRST valid Scan Temp/Time data of the 'LOOP' or 'CYCLE' in which it was stopped. It does NOT continue at the Scan Data at which the Scan was stopped.
- B) TERMINAL EXAMPLES: BA stops Scan Mode
- C) COMPUTER EXAMPLES: PRINT#1,"BA" stops Scan Mode

3.3-3 RS232 Commands: Control Group

1. To RESET (clear) the CONTROLLER

R

The controller is rest to power up conditions:

- 1) Single Temp Mode
- 2) All Scan Temperatures and Times cleared
- 3) Set Temperature equal to 25°C
- 4) Time-At-Temperature equal to infinity
- 5) # of Cycles equal to infinity
- 6) Compressor and Auxiliary outputs disabled
- 7) Heat/Cool Outputs disabled
- 8) RS232-C Echo disabled
- 9) IEEE-488 Address displayed for 3 seconds

- 10) Local Control enabled
- 11) PID Coefficients returned to factory default PID=-1,-2,-1
(unless changed using INIT Command)
- 12) Scan Interrupts are disabled
- 13) UTL =PLIMIT
- 14) Deviation Limit Checking disabled

2. To ENABLE LOCAL CONTROL of the CONTROLLER

Pressing a local keyboard key returns the controller to Local Mode. There is no local lockout function supported for the RS232-C bus.

3. To ENABLE REMOTE CONTROL

The controller is automatically set in the Remote Mode whenever it receives a character over the RS232-C bus.

4. To ENABLE RS232 ECHO mode

H

- A) The default mode is 'NO ECHO' of characters that come in the RS232 port.
- B) This command sets the controller in the 'ECHO MODE' which causes any character input to the RS232 port to be echoed back out to the RS232 port.
- C) To re-enter the 'NO ECHO' mode, the controller must be RESET. Note that RESET will clear all SCAN Times and Temps and controller will enter Single Temp Mode.
- D) TERMINAL EXAMPLES: H enables RS232 Echo
- E) COMPUTER EXAMPLES: PRINT#1,"H" enables RS232 Echo

5. To ENABLE the HEAT and COOL OUTPUTS

ON

- A) Setting the Single Mode 'SET TEMP' or starting the 'SCAN MODE' also automatically enables the Heat and Cool outputs.
- B) TERMINAL EXAMPLES: ON enables Heat/Cool outputs
- C) COMPUTER EXAMPLES: PRINT#1,"ON" or PRINT#1,A\$

6. To ENABLE the AUXILIARY #1 OUTPUT

OUT1ON

- A) This Auxiliary Output is typically used for compressor control in mechanically cooled temperature chambers. At power up, the TC01 sets a status bit that instructs it to use the AUX #1 output for compressor control. The TC01 will automatically turn the compressor ON when one of the following conditions are met:
- 1) When the SET temperature $\leq 40^{\circ}\text{C}$ and Heat/Cool outputs enabled.
 - 2) When the TC01 is in the Scan Mode and the next Scan Set Temperature is less than the current Scan Set Temp and the time remaining at the current Set Temp is < 1 minute and Heat/Cool outputs enabled.
 - 3) Whenever cooling is required (and has been required for >1 minute) regardless of the current Set Temp value and Heat/Cool outputs enabled.
 - 4) If a new Set Temp $<$ the current Set Temp in the Single Temp Mode.
- B) The TC01 will automatically turn the compressor OFF when:
- 1) The SET temperature $> 40^{\circ}\text{C}$ and cooling has not been required for a period of 1 minute and not in the last minute of a Scan Temp point.
 - 2) The TC01 has received an OFF command or whenever the Heat/Cool outputs are disabled.

The TC01 will always perform the above automatic compressor control unless it receives an "OUT1ON" or an "OUT1OFF" command. Once it receives either, the automatic compressor control is disabled until the TC01 is RESET. Once disabled, the user can enable or disable this output (via "OUT1ON" or "OUT1OFF") at will to control whatever external event desired, including any compressor. The Auxiliary Output consists of an open collector output plus a 5 volt/270 ohm current source which can be used to drive opto coupler circuits. See Section 6.8 WIRING DIAGRAMS for the Auxiliary Output interface.

C) TERMINAL EXAMPLES: OUT1ON enables Aux#1 output

D) COMPUTER EXAMPLES: PRINT#1,"OUT1ON" or PRINT#1,A\$

7. To ENABLE the AUXILIARY #2 OUTPUT

OUT2ON

- A) This auxiliary output is not used by any TC01 internal function. The default condition is off.
- B) TERMINAL EXAMPLES: OUT2ON enables Aux#2 output
- C) COMPUTER EXAMPLES: PRINT#1,"OUT2ON" or PRINT#1,A\$

8. To ENABLE SCAN MODE INTERRUPTS

ESI

A) While the RS232 port does not experience or deliver 'INTERRUPTS' as such, this command allows the TC01 to output the various characters that signify End-Of-Soak-Times as discussed in Section 3.3-5.

B) TERMINAL EXAMPLES: ESI enables Scan Mode Interrupts

C) COMPUTER EXAMPLES: PRINT#1,"ESI" or PRINT#1,A\$

9. To ENABLE DEVIATION INTERRUPTS

See above

10. To DISABLE LOCAL KEYBOARD CONTROL

There is no command to disable local control from the RS232 port.
See IEEE-488 command on local lockout.

11. to DISABLE RS232 ECHO

R

A) Note that this is a RESET Command which will also reset most other controller parameters. See Command # 1 of this section.

B) TERMINAL EXAMPLES: R will disable Echo and Reset TC01

C) COMPUTER EXAMPLES: PRINT#1,"R" or PRINT#1,A\$

12. To DISABLE the HEAT and COOL OUTPUTS

OFF

A) TERMINAL EXAMPLES: OFF disables Heat/Cool outputs

B) COMPUTER EXAMPLES: PRINT#1,"OFF" or PRINT#1,A\$

13. To DISABLE THE AUXILIARY #1 OUTPUT

OUT1OFF

A) See discussion at command #6 of this section

B) TERMINAL EXAMPLES: OUT1OFF disables Aux#1 output

C) COMPUTER EXAMPLES: PRINT#1,"OUT1OFF" or PRINT#1,A\$

14. To DISABLE the AUXILIARY #2 OUTPUT

OUT2OFF

- A) TERMINAL EXAMPLE : OUT2OFF disables Aux #2 output
- B) COMPUTER EXAMPLE : PRINT#1,"OUT2OFF" or PRINT#1,A\$

15. To DISABLE SCAN MODE INTERRUPTS

DSI

- A) See discussion at command #8 of this section
- B) TERMINAL EXAMPLE: DSI disables Scan Mode Interrupts
- C) COMPUTER EXAMPLE: PRINT#1,"DSI" or PRINT#1,A\$

16. To DISABLE the DEVIATION INTERRUPT

DDI

- A) See discussion at Section 3.3-2 command #4.
- B) TERMINAL EXAMPLE : DDI disables deviation interrupts
- C) COMPUTER EXAMPLE : PRINT#1,"DDI" or PRINT#1,A\$

3.3-4 RS232 Special Group

1. PID COEFFICIENT CHANGE

Modification of the PID coefficients used in the TC01 algorithm is not generally recommended for the casual user. The standard TC01 PID coefficients have been chosen to provide a good compromise between fast settling time and good overshoot characteristics. However, for those who wish to optimize the TC01 transient or steady state response for their particular application, an engineering note (Tuning the PID Coefficients) has been written to assist in the PID coefficient changes. It is available as a download from our website www.sunelectronics.com.

The TC01 controller calculates the amount of heating or cooling required to maintain the chamber temperature at the set temperature using a 3 mode proportional, integral, derivative servo equation. There is a weighing coefficient for each of the three components of the control equation. At power up, the TC01 reads the default PID coefficients from its EEPROM memory and will use these coefficients unless they are changed, by the user, using this "PID=" command. Once changed, the TC01 will continue to use the new coefficients until changed by another command or until the TC01 is powered off, they are not stored in the EEPROM. Therefore, if other than the default coefficients are to be used, they must be set each time the TC01 is powered on. Beginning with the controllers Revision F, a new command "INIT" has been added to allow the user to make permanent changes to the PID coefficients. See Command #5 INIT TC01 OPERATING MODES, found further in this section. Permanent coefficient modifications for controllers prior to Revision F must be programmed in ROM by factory.

To SET PID WEIGHING COEFFICIENTS

PID= (-)n, (-)n, (-)n where $0 < n < 9$ (Note: Default values PID=-1,-2,-1)

- A) The above values of 'n' are interpreted as exponents of 2. Therefore each multiplier has a range of $2^{(-9)}$ to $2^{(+9)}$.
- B) The first value is the 'Proportional coef.' multiplier. The second value is the 'Integral coefficient' multiplier. The third value is the 'Derivative coefficient multiplier'.

C) **TERMINAL EXAMPLE:**

PID=0,-3,4 sets the Proportional coefficient to one
since $2^{(0)} = 1$

sets the Integral coef. to $2^{(-3)} = .125$

sets the Derivative coef. to $2^{(4)} = 16$

D) **COMPUTER EXAMPLE:**

```
PRINT#1,"PID=0,-3,4"  
PRINT#1,"PID=",X," ",Y," ",Z
```

To READ the CURRENT PID COEFFICIENTS

PID?

- A) The three multipliers will be sent, each followed by CR LF
- B) **TERMINAL EXAMPLE:** PID?
- C) **COMPUTER EXAMPLE:** PRINT#1"PID?"
INPUT#1,P\$
INPUT#1,I\$
INPUT#1,D\$

2. OUTPUT THE INSTALLED OPTIONS

OPT

The OPT command allows the user to determine the type of unit that he is talking to, the type of probe, and the units of time that have been selected. Upon receiving the OPT command the TC01 will send an ASCII string containing "TC01, probe type, time units ". The substring TC01 informs the user that he is talking to a TC01. The probe type substring provides info on the type of temperature sensor that the TC01 is configured for. The substring time units will be MIN when minutes selected or HRS for hours time selection.

3. OUPUT AUXILIARY INPUT STATE

IN1

- A) The value returned is 0 if the input is a TTL logic low, and 1 if the input is a logic high.
- B) See Section 6.8 for the AUXIN wiring.
- C) **TERMINAL EXAMPLE :** IN1 causes TC01 to output State
- D) **COMPUTER EXAMPLE :** PRINT#1,"IN1" or PRINT#1,A\$

3.3-5 RS232: Time-Outs/Problem Indications

TIME-OUT INDICATIONS — SINGLE TEMPERATURE MODE

When the desired soak time (Time-At-Temperature) has been reached, the operator is alerted to this fact in three ways. Firstly, the 'TIME-OUT' LED located on the front panel is turned 'ON'. Secondly, a continuous tone is emitted from a transducer located on the TC01 power supply board. Thirdly, an ASCII 'I' is sent by the TC01 to the host RS232 device. The LED and audio indication will continue until a TIME or TEMP key is pressed. Alternately, the controller may be RESET by sending a RESET command (see Section 3.3-3) or by depressing the "C" key on the TC01 keyboard. Note that all SCAN Temps are cleared by the RESET command.

TIME-OUT INDICATIONS — SCAN MODE

Time-Out bus and port indications may be ENABLED or DISABLED per commands in Section 3.3-3. The default condition is that Time-Out Indications are DISABLED. Audio (buzzer) and visual (LED) indicators are always enabled and may never be disabled.

The TC01 SCAN Mode allows a maximum of 10 segments to be programmed through the RS232 port. Each segment is described by a Temperature and a Soak-Time (Time-At-Temperature). Additionally, the Scan Mode sequence chosen by the user can be programmed to be automatically repeated any number of times up to a total of 1800 'CYCLES'. Thus we may define several types of "TIME-OUTS" that would be useful to the user.

The first to consider is a Time-Out Indication at the end of each Soak Time point within the Temperature Scan sequence. Another type would be a Time-Out Indication signifying completion of the last Soak Time in a Scan sequence. Since the Scan sequence can be cycled, yet another Time-Out Indication would be to alert that all cycles programmed have been completed.

The TC01 outputs three different ASCII characters for each of the three distinct Time-Outs (assuming Time-Out Indications are ENABLED). The table below describes said characters. The characters are sent out 1 minute before completion of Time-Out.

<u>TIME-OUT TYPE</u>	<u>ASCII CHARACTER SENT</u>
SOAK TIME COMPLETE	P
CYCLE ('LOOP') COMPLETED	L
END OF TOTAL RUN	E

PROBLEM INDICATORS

Three problem indicators have been incorporated into the TC01.

<u>PROBLEM TYPE</u>	<u>ASCII CHARACTER SENT</u>
Deviation Limit Exceeded (when enabled)	D
Chamber Temp Exceeds UTL (automatically disables heat/cool)	O
Command Error	CMD ERROR!!

TABLE 3-1 RS232-C Contact Assignments & Wiring Diagram

CONTACT		SIGNAL LINE
1	'	GROUND
2	'	TRANSMIT DATA
3	'	RECEIVE DATA
7	'	SIGNAL GROUND
20	'	DATA TERMINAL READY

To communicate over the RS232 bus, a cable constructed with a male DB25 connector on the EC0x controller and a female DB9 connector on PC end and wired as follows is required:

EC0x CONTROLLER (DB25 Male)	COMPUTER (DB9 Female)
Pin#	Pin#
(2) TxD	RxD (2)
(3) RxD	TxD (3)
(7) GND	GND (5)

For EC0x Chambers with serial number C1508 or later, use the following settings to communicate through Windows:

Connect using desired COM port
 Bits per second: 9600
 Data bits: 8
 Parity: NONE
 Stop bits: 1
 Flow Control: NONE
 CAPS LOCK "ON" FOR TC01

**** Note:** If you are running Windows and operating an EC0x chamber with a serial number prior to C1508, you will need to use the following settings:

Connect using desired COM port
 Bits per second: 2400
 Data bits: 8
 Parity: NONE
 Stop bits: 1
 Flow Control: NONE
 CAPS LOCK "ON" FOR TCO1

If your computer is using a DB25 Male connector instead of the DB9, the wiring connections are as follows.

EC0x CONTROLLER (DB25 Male)	COMPUTER (DB25 Female)
Pin#	Pin#
(2) TxD	RxD (3)
(3) RxD	TxD (2)
(7) GND	GND (7)

3.4 IEEE-488 REMOTE CONTROL

CONVENTIONS:

- 1) "n" or "m" refers to any numeric character 0 through 9
- 2) Items enclosed in parentheses "()" are optional. Thus n(n(n(.n))) means that at least one numeric character has to be sent. Optionally, one or two additional characters to the left of a decimal are allowed and one character after the decimal is allowed.
- 3) The sample 9825 commands assume that the calculator's IEEE-488 interface card is set to select code 7; and that the temperature controller's address has been set to binary 3.
- 4) Blanks, or space char, are ignored.
- 5) "X" and "Y" are variables assumed to be defined elsewhere in the controlling program.
- 6) See Table 3-2 for IEEE-488 CONTACT ASSIGNMENTS
- 7) See Table 3-3 for IEEE-488 BUS ADDRESS SWITCH SETTINGS
- 8) The command processor software ignores leading zero's and trailing digits on all numeric data received. For example: -000025.321000C will set the Signal Mode Temperature to -25.3°C.

3.4-1 GPIB Commands: Single Temperature Mode

1. to SET the CHAMBER TEMPERATURE

(-)n(n(n(.n)))C where -184.0 <= (-)n(n(n(.n))) <= UTL

- A) If the controller was in the Scan Mode before this command, the Scan Mode is terminated and the Single Temp Mode is initiated.
- B) UTL is the user-settable limit temperature. UTL can only be set <= PLIMIT. PLIMIT is the highest temperature allowed for the TC01 and is 315°C.
- C) Setting the temperature enables the Heat and Cool outputs with heat cool switch override.
- D) A temperature < -184 or > UTL is ignored and no action will be initiated by the controller.
- E) Sample GPIB commands write 703,"50.2C"
 assume controller id=7
 TC01 device address = 03
 string="50.2C"
 sets the chamber temperature to +50.2°C

2. to SET the TIME-AT-TEMPERATURE (Soak Time)

n(n(n(n)))M where 0 <= n(n(n(n))) <= 1999\

- A) A time < 0 or > 1999 is ignored and no action is initiated by the controller.
- B) A time between 1800 and 1999 sets the time to infinity.
- C) Time is interpreted as Minutes unless the Hours was selected using INIT Command

3. to SET the DEVIATION LIMIT and ENABLE DEVIATION INTERRUPT

EDIn(n(n(.n))) where $0 \leq n(n(n(.n))) \leq \text{UTL}$

- A) The allowed temperature deviation before generating a deviation interrupt is +/- the set value around the target chamber set temperature.
- B) The deviation checking is automatically disabled during transitions between chamber temperature set points and begins once the chamber temperature is within the deviation limits of the set temperature.
- C) The deviation limits will be checked each time a new Heat/Cool period is calculated (once every 2 seconds, default).

4. to READ the CHAMBER TEMPERATURE

T

- A) The resolution of the temperature reading read over the bus is $.1^{\circ}$.
- B) The LED display will display in increments of $.1^{\circ}$ up to 199.0° . At temperatures $>200^{\circ}$ the display resolution is 1° .

5. to READ the SET TEMPERATURE

C

- A) The resolution of the temperature reading read over the bus is $.1^{\circ}$.

6. to READ the REMAINING TIME at the CURRENT TEMPERATURE

M

- A) Time is interpreted as Minutes unless Hours was selected using INIT Command

3.4-2 GPIB Commands: Scan Mode

1. to SET/DELETE a SCAN TEMPERATURE

(-) (n(n(n(.n)))Am where $-184.0 \leq (-)n(n(n(.n))) \leq \text{UTL}$

- A) A temperature <-184 or $> \text{UTL}$ is ignored and no action is initiated by the controller.
- B) UTL is the user-settable limit temperature. UTL can only be set $\leq \text{PLIMIT}$. PLIMIT is the highest temperature allowed for the TC01 and is 315°C .
- C) -Am will delete Scan Temperature and Time m
- D) Scan Temps can be assigned in any order. However, Scan Temps will be executed in ascending order of 'm'.
- E) The resolution of the temperature set over the interface is $.1^{\circ}$. The LED display will display in increments of $.1^{\circ}$ up to 199.9 . At temps $>200^{\circ}$, the display resolution is 1° .

2. to SET/DELETE a SCAN TIME

$n(n(n)Bm$ where $0 \leq n \leq 1999$ and $0 \leq m \leq 9$

- A) A time < 0 or > 1999 is ignored and no action is initiated by the controller.
- B) A time between 1800 and 1999 sets the time to infinity.
- C) $-Bm$ will delete Scan Temperature and Time m
- D) Scan Times can be assigned in any order. They, along with their corresponding Scan Temp, will be executed in ascending order.
- E) Time is interpreted as Minutes unless Hours was selected using INIT Command

3. to SET the number of CYCLES for the SCAN MODE

$n(n(n))B-$ where $1 \leq n(n(n)) \leq 1999$

- A) An input >1800 and ≤ 1999 sets the number of cycles to infinity.
- B) The number of cycles that have been set can only be displayed before the Scan sequence has begun (see command #7 below) or, once the Scan sequence has started, by stopping the Scan sequence and executing command #7 below.

See command #12 of this section.

4. to SET the DEVIATION LIMIT and ENABLE DEVIATION INTERRUPTS

$EDIn(n(n(.n))))$ where $0 \leq n(n(n(.n)))) \leq UTL$

- A) The allowed temperature deviation before generating a deviation interrupt is $\pm$ the set value around the target chamber set temperature.
- B) The deviation checking is automatically disabled during transitions between chamber temperature set points and begins once the chamber temperature is within the deviation limits of the set temperature.
- C) The deviation limit will be checked each time a new heat/cool period is calculated (once every 2 seconds, default)

5. to READ a SCAN TEMPERATURE

Am where $0 \leq m \leq 9$

- A) The resolution of the temperature measurement over the interface is $.1^\circ$. The LED display will display in increments of $.1^\circ$ up to 199.9° . At temperatures $>200^\circ$, the display resolution is 1° .

6. to READ a SCAN TIME

Bm where $0 \leq m \leq 9$

- A) Time is interpreted as Minutes unless Hours was selected using the INIT Command

7. to READ the CURRENT CYCLE NUMBER

B-

- A) '1' will be displayed during the first cycle or loop, '2' will be displayed during the second, etc. The Scan will terminate automatically after the cycle where the current cycle number equals the number of cycles "TO DO". When the Scan Mode is terminated, the Heat and Cool outputs are disabled, the 'SET TEMP' is set for 25°C and the Time-At-Temperature is set to infinity, and the number of cycles "TO DO" is set to infinity. If the Scan Mode has not started, or has been stopped (see command #12 of this section) then this command displays the original number of cycles set.

8. to READ the CURRENT CHAMBER TEMPERATURE

T

- A) The resolution of the temperature reading read over the bus is .1°. The LED display will display in increments of .1° up to 199.9°. At temperatures >200, the display resolution is 1°.

9. to READ the CURRENT SCAN TEMPERATURE

C

- A) See command 8 A) above

10. to READ the REMAINING TIME at CURRENT TEMPERATURE

M

- A) Time is interpreted as Minutes unless Hours was selected using INIT Command

11. TO START THE SCAN MODE

AB

- A) Starting the Scan Mode without any valid Scan Temp/Scan Time data programmed will cause a 'COMMAND ERROR' response.

12. to STOP the SCAN MODE

BA

- A) Heat and Cool outputs are disabled, the time-out function is turned off. Upon restarting, execution begins at the FIRST valid Scan Temp/Time data of the "LOOP" or 'CYCLE' in which it was stopped. It does NOT continue at the Scan Data at which the Scan was stopped.

3.4-3 GPIB Commands: Control Group

1. to RESET the CONTROLLER

R

- A) The controller is reset to power up conditions:
 - 1) Single Temp Mode
 - 2) All Scan Temperatures and Times cleared
 - 3) Set Temperature equal to 25°C
 - 4) Time-At-Temperature equal to infinity
 - 5) # of Cycles equal to infinity
 - 6) Compressor and Auxiliary Outputs disabled
 - 7) Heat/Cool Outputs disabled
 - 8) RS232-C Echo disabled
 - 9) IEEE-488 Address displayed for 3 seconds
 - 10) Local Controls enabled
 - 11) PID Coefficients returned to factory default PID=-1,-2,-1
 - 12) (unless changed using INIT Command)
 - 13) Scan Interrupts are disabled
 - 14) UTL = PLIMIT
 - 15) Deviation Limit Checking disabled

2. to ENABLE LOCAL CONTROL

See IEEE std 488-1975

- A) Sample GPIB command

lcl 7 (see your GPIB system documentation for its command)
- B) After the return to local command is received, pressing the RESET key (the 'C' key) on the local keyboard is necessary to return the controller to local control.

3. to ENABLE REMOTE CONTROL

See IEEE std 488-1975

- A) Sample GPIB command

rem 703 (see your GPIB system documentation for its command)
- B) The controller is also set in Remote Mode whenever it is selected during a bus transfer.

4. to ENABLE RS232 ECHO MODE

H

- A) The default mode is 'NO ECHO' of characters that come in the RS232 port.
- B) This command sets the controller in the 'ECHO MODE' which causes any character put to the RS232 port to be echoed back out the RS232 port.

- C) To re-enter the 'NO ECHO' mode, the controller must be RESET. Note that RESET will clear all SCAN Times and Temps and the controller will enter the Single Temp Mode. See command #1 above.

5. to ENABLE the HEAT and COOL OUTPUTS

ON

- A) Setting the Single mode 'SET TEMP' or starting the 'SCAN MODE' also automatically enables the Heat and Cool outputs.

6. to ENABLE the AUXILIARY #1 OUTPUT

OUT1ON

- A) This Auxiliary Output is typically used for compressor control in mechanically cooled temperature chambers. At power up, the TC01 sets a status bit that instructs it to use the AUX #1 output for compressor control. The TC01 will automatically turn the compressor ON when one of the following conditions is met:

- 1) When the SET temperature $\leq 40^{\circ}\text{C}$ and Heat/Cool outputs enabled.
- 2) When the TC01 is in the Scan Mode and the next Scan Set Temperature is less than the current Scan Set Temp and the time remaining at the current point is < 1 minute and Heat/Cool outputs enabled.
- 3) Whenever cooling is required (and has been required continuously for > 1 minute) regardless of the current set temperature value and Heat/Cool outputs enabled.
- 4) If a new Set Temp $<$ current Set Temp in the Single Temp Mode.

- B) The TC01 will automatically turn the compressor OFF when:

- 1) The SET temperature $> 40^{\circ}\text{C}$ and cooling has not been required for a period of 1 minute and not in the last minute of a Scan Temp point.
- 2) The TC01 has received an OFF command or whenever the Heat/Cool outputs are disabled.

The TC01 will always perform the above automatic compressor control unless it receives an "OUT1ON" or an "OUT1OFF" command. Once it receives either, the automatic compressor control is disabled until the TC01 is RESET or turned OFF then ON again. Once disabled, the user can then enable or disable this output (via "OUT1ON" or "OUT1OFF") at will to control whatever external event desired, including any compressor. The Auxiliary Output consists of an open collector output plus a 5 volt/270 ohm current source which can be used to drive opto coupler circuits. See Section 6.8 WIRING DIAGRAMS for Auxiliary Output interface.

7. to ENABLE the AUXILIARY #2 OUTPUT

OUT2ON

- A) This auxiliary output is not used by internal TC01 functions. The default condition is DISABLED.

8. to ENABLE SCAN MODE INTERRUPTS

ESI

- A) This command allows the TC01 to output the various characters that signify End-Of-Soak-Times as discussed in Section 3. 4-5.

9. to ENABLE DEVIATION INTERRUPT

Deviation Interrupts are automatically enabled by setting the deviation limit. The interrupt character output by the TC01 is discussed in Section 3.6

10. to DISABLE LOCAL CONTROL

See IEEE-488 standard 488-1975 or above

11. to DISABLE RS232 ECHO

R

- A) Note that this is a RESET command which will also reset most other controller parameters. See command #1 of this section.

12. to DISABLE the HEAT and COOL OUTPUTS

OFF

13. to DISABLE the AUXILIARY #1 OUTPUT

OUT1OFF

See discussion at command #6.

14. to DISABLE the AUXILIARY #2 OUTPUT

OUT2OFF

15. to DISABLE SCAN MODE INTERRUPTS

DSI

- A) See discussion at command #8.

16. to DISABLE the DEVIATION INTERRUPT

DDI

- A) See discussion at command #9.

3.4-4 GPIB Commands: Special

1. to INPUT CHARACTER STRING from SYSTEM CONTROLLER & OUTPUT SAID STRING to RS232-C INTERFACE

!ssss...sss where ssss...sss is an ASCII character string

- A) This command allows direct control of custom circuitry by the GPIB System Controller. Any custom circuitry with an RS232 interface can be controlled by this command, and interrogated with the use of the next command. Thus an unlimited number of events and status thereof can be incorporated as part of the automated test facility. For example, one may wish to test, say, 100 component (resistors, thermistors, etc.) in an automated setup. One way to accomplish this would be to build the necessary switching circuitry with an RS232 interface. Then, the GPIB System Controller would direct the proper switching sequence via the TC01 controller. Similarly, Command #2 below could be used to ascertain status information from the switching circuitry.

2. TO INPUT CHARACTER STRING FROM RS232 INTERFACE TO IEEE-488 SYSTEM CONTROLLER

S

System controller reads a line of characters that are sent to the TC01 via the RS232 port. A carriage return or line feed terminates the sequence.

3. PID COEFFICIENT CHANGE

Modification of the PID coefficients used in the TC01 algorithm is not generally recommended for the casual user. The standard TC01 PID coefficients have been chosen to provide a good compromise between fast settling time and good overshoot characteristics. However, for those who wish to optimize the TC01 transient or steady state response for their particular application, an engineering note (Tuning the PID Coefficients) has been written to assist in the PID coefficient changes. It is available as a download from our website www.sunelectronics.com.

The TC01 controller calculates the amount of heating or cooling required to maintain the chamber temperature at the set temperature using a 3 mode proportional, integral, derivative servo equation. There is a weighing coefficient for each of the three components of the control equation. At power up, the TC01 reads the default PID coefficients from its EEPROM memory and will use these coefficients unless they are changed, by the user, using this "PID=" command. Once changed, the TC01 will continue to use the new coefficients until changed by another command or until the TC01 is powered off, they are not stored in the EEPROM. Therefore, if another command or default coefficients are to be used, they must be set each time the TC01 is powered on. Beginning with the controllers Revision F, a new "INIT" command has been added to allow the user to make permanent changes to the PID coefficients. See Command #8 INIT TCO1 OPERATING MODES, found further in this section. Permanent coefficient modifications for controllers prior to Revision F must be programmed in ROM by factory.

to SET PID WEIGHING COEFFICIENTS

PID=(-)n,(-)n,(-)n where $0 < n < 9$ (Note: Default values, PID=-1,-2,-1)

- A) The above values of 'n' are interpreted as exponents of 2. Therefore each multiplier has a range of $2^{(-9)}$ to $2^{(+9)}$.

- B) The first value is the 'Proportional coef.' multiplier. The second value is the 'Integral coefficient' multiplier. The third value is the 'Derivative coefficient' multiplier.

to read PID WEIGHING COEFFICIENTS

PID?

- A) The three multipliers will be sent, each followed by CR LF

4. OUTPUT THE INSTALLED OPTIONS

OPT

The OPT command allows the user to determine the type of unit that he is talking to, the type of probe, and the units of time that have been selected. Upon receiving the OPT command the TC01 will send an ASCII string containing "TC01, probe type, time units ". The substring TC01 informs the user that he is talking to a TC01. The probe type substring provides info on the type of temperature sensor that the TC01 is configured for. The substring time units will be MIN when minutes selected or HRS for hours time selection.

5. OUTPUT AUXILIARY INPUT STATE

IN1

- A) The value returned is 0 if the input is a TTL logic low, and 1 if the input is at logic high.
B) See Section 6.8 for wiring information.

6. to SET UPPER TEMPERATURE LIMIT (UTL)

(-)n(n(n(n(.n))))UTL where $-184 \leq (-)n(n(n(n(.n)))) \leq \text{PLIMIT}$

- A) UTL may be set to any value between -184 and PLIMIT inclusive. The value of PLIMIT is 315°C.
B) UTL is set equal to PLIMIT at power up.

7. to OUTPUT CURRENT TEMPERATURE LIMIT (UTL)

UTL

8. INIT TC01 OPERATING MODES

INITn,p,i,d,M or H,C

The INIT command allows the user to change most TC01 modes. The INIT command is a remote only command. The parameters that it changes are stored in EEPROM such that the information is saved with power off.

n is a digit between 1 and 7 and selects the temperature probe type as follows;

1= RTD 3 wire 100 ohm .385 alpha

2= RTD 3 wire 100 ohm .392 alpha

3= J thermocouple

4= K thermocouple

5= T thermocouple

, data separator

p allows permanent change to the PID P coefficient

, data separator

i allows permanent change to the PID I coefficient

, data separator

d allows permanent change to the PID D coefficient

, data separator

M to set time units to minutes or H for hours units

, data separator

Finally always send C character

3.4-5 GPIB TIME-OUT/PROBLEM INDICATIONS

TIME-OUT INDICATIONS — SINGLE TEMPERATURE MODE

When the desired Soak Time (Time-At-Temperature) has been reached, the operator is alerted to this fact in three ways. Firstly, the "TIME-OUT" LED located on the front panel is turned 'ON'. Secondly, a continuous tone is emitted from a transducer located on the TC01 power supply board. Thirdly, a 'service request' is made by activating the SRQ line on the GPIB bus. When the GPIB system controller subsequently polls the TC01 that requested service, the timed-out TC01 responds with a HEX 41. Any TC01 that has not timed-out will respond to the polling with a HEX 00. The LED and audio indication will continue until the controller is sent a RESET command via the GPIB bus, or is reset manually (if local lockout not enabled) by depressing the "C" (clear) key on the TC01 keyboard. Setting or reading TIME or TEMP will also clear the buzzer and LED.

TIME-OUT INDICATIONS — SCAN MODE

Time-out indications may be ENABLED or DISABLED per commands in Section 3.4-3. The default condition is that Time-Out indications are DISABLED.

The TC01 SCAN mode allows a maximum of 10 segments to be programmed through the IEEE-488 bus. Each segment is described by a Temperature and a Soak-Time (Time-At-Temperature). Additionally, the Scan Mode sequence chosen by the user can be programmed to be automatically repeated any number of times up to a total of 1800 'cycles'. Thus we may define several types of 'TIME-OUTS' that would be useful to the user.

The first to consider is a Time-Out Indication at the end soak time point within the temperature scan sequence. Another type would be a Time-Out Indication signifying completion of the last soak time in a scan sequence. Since the scan sequence can be cycled, yet another Time-Out Indication would be to alert the user that all cycles programmed have been completed.

The TC01 outputs three different interrupt characters, one for each of the three distinct Time-Outs (assuming time-out indications are ENABLED). The table below describes said characters. The characters are sent out 1 minute before completion of Time-Out.

<u>TIME-OUT TYPE</u>	<u> GPIB INTERRUPT CHARACTER SENT (HEX)</u>
SOAK TIME COMPLETE	43
CYCLE ('LOOP') COMPLETED	44
END OF TOTAL RUN	45

PROBLEM INDICATORS

Four problem indicators have been incorporated into the TC01.

<u>PROBLEM TYPE</u>	<u> INTERRUPT CHARACTER SENT (HEX)</u>
Deviation Limit Exceeded (when enabled)	46
Chamber Temp exceeds UTL	47
Command Error	42
IEEE-488 Bus lock-up time-out	4F

3.5 REMOTE ADDRESS SELECT SWITCH

Figure 1.4-2 and 1.4-3 in Section 1, shows the location of the RS232-C connector, the IEEE-488 connector, and the address select switch on the back panel of the EC0x Chambers control section.

The talk/listen address for the IEEE-488 interface is set using the four position switch located on the I/O panel. The switches are such that a "ZERO" is set having the switch "ON" and a "ONE" is set with the switch "OFF". If there is any doubt about which address is encoded, the display will show the GPIB address for three seconds immediately upon power-up or upon given a RESET (clear) command.

TABLE 3-2 lists the contact pin assignments for the IEEE-488 connector.

TABLE 3-3 lists the 16 possible addresses as determined by the switch settings.

TABLE 3-2 IEEE-488 CONTACT ASSIGNMENTS

CONTACT	SIGNAL LINE		CONTACT	SIGNAL LINE
1	DIO 1		13	DIO 5
2	DIO 2		14	DIO 6
3	DIO 3		15	DIO 7
4	DIO 4		16	DIO 8
5	EOI		17	REN
6	DAU		18	GND
7	NRFD		19	GND
8	NDAC		20	GND
9	IFC		21	GND
10	SRQ		22	GND
11	ATN		23	GND
12	SHIELD		24	GND, LOGIC

TABLE 3-3 IEEE-488 Bus Address Switch Setting

ADDRESS SWITCH 1 2 3 4	TALK ADDRESS CHARACTER	LISTEN ADDRESS CHARACTER	DECIMAL VALUE
0 0 0 0	@	SP	0
1 0 0 0	A	!	1
0 1 0 0	B	"	2
1 1 0 0	C	#	3
0 0 1 0	D	\$	4
1 0 1 0	E	%	5
0 1 1 0	F	&	6
1 1 1 0	G	' (single quote)	7
0 0 0 1	H	(	8
1 0 0 1	I	)	9
0 1 0 1	J	*	10
1 1 0 1	K	+	11
0 0 1 1	L	, (comma)	12
1 0 1 1	M	- (dash)	13
0 1 1 1	N	. (period)	14
1 1 1 1	O	/	15

0 = switch "on"
1 = switch "off"

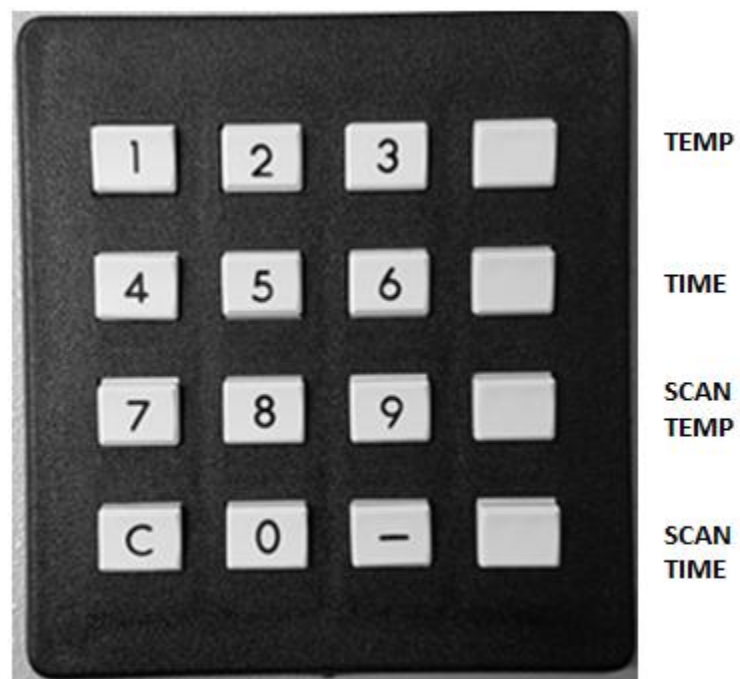


Fig. 3.5-1 Chamber Keyboard Layout 1 (Before 2017)

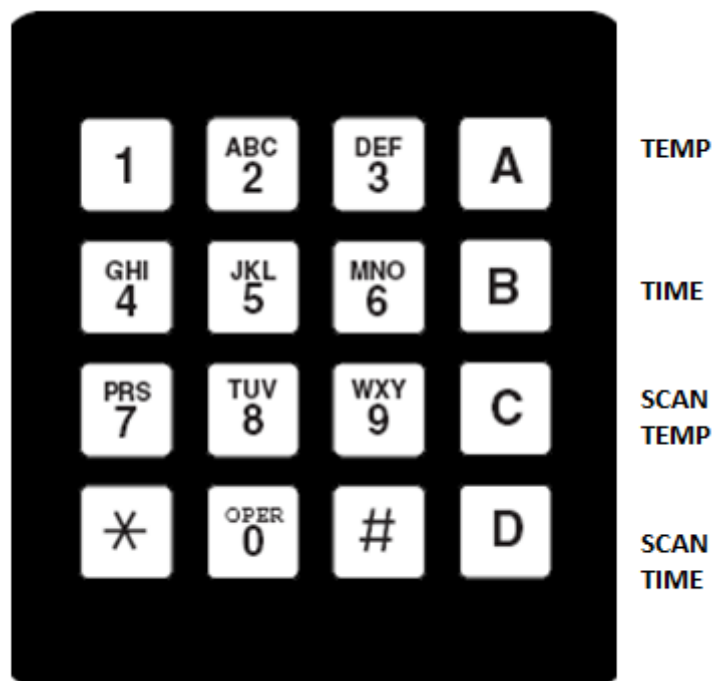


Fig. 3.5-2 Chamber Keyboard Layout 2 (2017)

3.6 COMMAND SUMMARY

TABLE 3-4 Command Summary/Examples for Keyboard Layout 1

FUNCTION	KEYBD/DISPLAY*	RS232*	IEEE-488*
<u>SINGLE TEMP MODE</u>			
SET Chamber Temp	50 TEMP	50.0C	50.0C
SET Time-at-Temp	5 TIME	5M	5M
SET Deviation Limit	(n/a)	EDI10	EDI10
OUTPUT Chamber Temp	automatic	T	T
OUTPUT Current Set Temp	TEMP	C	C
OUTPUT remaining Time at Current Temp	TIME	M	M
<u>SCAN MODE</u>			
SET Scan Temp m	50 SCANTEMP 0	50.0A0	50.0A0
SET Scan Time m	5 SCANTIME 0	5B0	5B0
SET # of Cycles	10 SCANTIME -	10B-	10B-
SET Deviation Limit	(n/a)	EDI10	EDI10
OUTPUT Scan Temp m	SCANTEMP 0	A0	A0
OUTPUT Scan Time m	SCANTIME 0	B0	B0
OUTPUT Current Cycle #	SCANTIME -	B-	B-
OUTPUT Chamber Temp	automatic	T	T
OUTPUT Current			
SET Scan Temp	TEMP	C	C
OUTPUT Current			
remaining Scan Time	TIME	M	M
DELETE Scan Temp m	- SCANTEMP 0	-A0	-A0
DELETE Scan Time m	-SCANTIME 0	-B0	-B0
START Scan Mode	SCANTEMP SCANTIME	AB	AB
STOP Scan Mode	SCANTIME SCANTEMP	BA	BA

*For the Single Temperature Mode, the commands assume a desired temperature of 50°C, and a soak time of 5 minutes. A 10° deviation limit is required. For the SCAN mode, the commands assume that the first allowed segment (m=0) is being set to a temperature of 50°C for 5 minutes. Additionally, 10 cycles of the scan sequence are desired along with a 10°deviation alarm.

+ Denotes new command/feature since last manual update

TABLE 3-4 Command Summary/Examples for Keyboard Layout 1 (Cont'd)

<u>FUNCTION</u>	<u>KEYBD/DISPLAY*</u>	<u>RS232*</u>	<u>IEEE-488*</u>
<u>CONTROL GROUP</u>			
Reset (Clear)	C	R	R
ENABLE Local Control	(n/a)	Press Key	lcl 7 **
ENABLE Remote Control	(n/a)	automatic	rem703**
ENABLE RS232 Echo	(n/a)	H	H
ENABLE HEAT/COOL Out	H/C switches ON	ON	ON
ENABLE Auxiliary #1 Out	(n/a)	OUT1ON	OUT1ON
ENABLE Auxiliary #2 Out	(n/a)	OUT2ON	OUT2ON
ENABLE Scan Interrupts	(n/a)	ESI	ESI
ENABLE Deviation In'rpt	(n/a)	EDI10	EDI10
DISABLE Local Control	(n/a)	(n/a)	llo 7 **
DISABLE RS232 Echo	(n/a)	R	R
DISABLE Heat/Cool Out	H/C switches OFF	OFF	OFF
DISABLE Auxiliary #1 Out	(n/a)	OUT1OFF	OUT1OFF
DISABLE Auxiliary #2 Out	(n/a)	OUT2OFF	OUT2OFF
DISABLE Scan Interrupts	(n/a)	DSI	DSI
DISABLE Deviation In'rpt	(n/a)	DDI	DDI
<u>SPECIAL</u>			
TRANSFER GPIB to RS232	(n/a)	(n/a)	!sss
TRANSFER RS232 to GPIB	(n/a)	(n/a)	S
PID COEFFICIENTS CHANGE	(n/a)	refer to manual	
+ OUTPUT probe option	(n/a)	OPT	OPT
OUTPUT Aux Input State	(n/a)	IN1	IN1
SET UTL	(n/a)	180UTL	180UTL
OUTPUT UTL	(n/a)	UTL	UTL
+ INIT	(n/a)	INITn,...	INITn,...

* See Previous page for * details

** These commands are for an HP 9825 System Controller

+ Denotes new command/feature since last manual update

TABLE 3-5 Command Summary/Examples for Keyboard Layout 2

FUNCTION	KEYBD/DISPLAY**	RS232**	IEEE-488**
<u>SINGLE TEMP MODE</u>			
SET Chamber Temp	50 TEMP	50.0C	50.0C
SET Time-at-Temp	5 TIME	5M	5M
SET Deviation Limit	(n/a)	EDI10	EDI10
OUTPUT Chamber Temp	automatic	T	T
OUTPUT Current Set Temp	TEMP	C	C
OUTPUT remaining Time at Current Temp	TIME	M	M
<u>SCAN MODE</u>			
SET Scan Temp m	50 SCANTEMP 0	50.0A0	50.0A0
SET Scan Time m	5 SCANTIME 0	5B0	5B0
SET # of Cycles	10 SCANTIME #	10B-	10B-
SET Deviation Limit	(n/a)	EDI10	EDI10
OUTPUT Scan Temp m	SCANTEMP 0	A0	A0
OUTPUT Scan Time m	SCANTIME 0	B0	B0
OUTPUT Current Cycle #	SCANTIME #	B-	B-
OUTPUT Chamber Temp	automatic	T	T
OUTPUT Current			
SET Scan Temp	TEMP	C	C
OUTPUT Current			
remaining Scan Time	TIME	M	M
DELETE Scan Temp m	# SCANTEMP 0	-A0	-A0
DELETE Scan Time m	# SCANTIME 0	-B0	-B0
START Scan Mode	SCANTEMP SCANTIME	AB	AB
STOP Scan Mode	SCANTIME SCANTEMP	BA	BA

**For the Single Temperature Mode, the commands assume a desired temperature of 50°C, and a soak time of 5 minutes. A 10° deviation limit is required. For the SCAN mode, the commands assume that the first allowed segment (m=0) is being set to a temperature of 50°C for 5 minutes. Additionally, 10 cycles of the scan sequence are desired along with a 10° deviation alarm.

+ Denotes new command/feature since last manual update

TABLE 3-5 Command Summary/Examples for Keyboard Layout 2 (Cont'd)

<u>FUNCTION</u>	<u>KEYBD/DISPLAY**</u>	<u>RS232**</u>	<u>IEEE-488**</u>
<u>CONTROL GROUP</u>			
Reset (Clear)	*	R	R
ENABLE Local Control	(n/a)	Press Key	lcl 7 ***
ENABLE Remote Control	(n/a)	automatic	rem703***
ENABLE RS232 Echo	(n/a)	H	H
ENABLE HEAT/COOL Out	H/C switches ON	ON	ON
ENABLE Auxiliary #1 Out	(n/a)	OUT1ON	OUT1ON
ENABLE Auxiliary #2 Out	(n/a)	OUT2ON	OUT2ON
ENABLE Scan Interrupts	(n/a)	ESI	ESI
ENABLE Deviation In'rpt	(n/a)	EDI10	EDI10
DISABLE Local Control	(n/a)	(n/a)	llo 7 ***
DISABLE RS232 Echo	(n/a)	R	R
DISABLE Heat/Cool Out	H/C switches OFF	OFF	OFF
DISABLE Auxiliary #1 Out	(n/a)	OUT1OFF	OUT1OFF
DISABLE Auxiliary #2 Out	(n/a)	OUT2OFF	OUT2OFF
DISABLE Scan Interrupts	(n/a)	DSI	DSI
DISABLE Deviation In'rpt	(n/a)	DDI	DDI
<u>SPECIAL</u>			
TRANSFER GPIB to RS232	(n/a)	(n/a)	!sss
TRANSFER RS232 to GPIB	(n/a)	(n/a)	S
PID COEFFICIENTS CHANGE	(n/a)	refer to manual	
+ OUTPUT probe option	(n/a)	OPT	OPT
OUTPUT Aux Input State	(n/a)	IN1	IN1
SET UTL	(n/a)	180UTL	180UTL
OUTPUT UTL	(n/a)	UTL	UTL
+ INIT	(n/a)	INITn,...	INITn,...

** See Previous page for * details

*** These commands are for an HP 9825 System Controller

+ Denotes new command/feature since last manual update

3.7 INTERRUPTS

<u>Condition</u>	<u>RS232 (ASCII)</u>	<u>IEEE-488 (HEX)</u>
No interrupt	(n/a)	00
Single Temp Mode time-out	I	41
Command Error	CMD ERROR!!	42
SCAN Temp Point time-out	P	43
SCAN Temp Cycle time-out	L	44
SCAN Temp End of Run	E	45
DEVIATION Alarm	D	46
Chamber Temp > UTL	O	47
GPIB lock-up time-out	(n/a)	4F

SECTION 4 USER ADJUSTMENTS

The EC0X supports user adjustments for the setting of the IEEE - 488 Bus Interface Address, RS-232 Baud Rate Select, Temperature Controller Calibration, PID Coefficient Modification and Mechanical or Electronic Failsafe Thermostat Adjustment. The temperature probe type and minutes/hours time units are covered in RS232 and GPIB command section see INIT command.

4.1 IEEE-488 INTERFACE ADDRESS SELECT

The IEEE-488 address switch is located on the rear panel of the EC0X. Consult "REMOTE ADDRESS SELECT SWITCH" in Section 3.5,

4.2 RS-232 INTERFACE BAUD RATE SELECT

The baud rate of the RS232 port is factory set at 9600 baud. The baud rate is field changeable by 2 jumpers on the CPU board. The jumpers are located below the uP socket on the CPU board. Proceed as follows:

The controller will need to be taken out of the chamber for the baud rate change.

CAUTION: BE SURE THAT THE CHAMBER IS UNPLUGGED!

1. The CPU board is the board that contains the LED display. To gain access to the CPU board, remove 4 front panel screws that hold the board stack to the front panel sheet metal.
2. Install jumpers in location BAUD-0 and BAUD-1 as given below. The two jumpers are located just below the square uP socket.
3. If the cool polarity or failsafe polarity need to be changed do them now see below.
4. Replace board stack and reinstall TC01 controller.

jumper BAUD-0	jumper BAUD-1	baud rate
out	out	9600
in	out	4800
out	in	2400
in	in	1200

4.3 TEMPERATURE PROBE CALIBRATION

Calibration for the EC0x is accomplished by adjusting two calibration pots; one for "0°C " calibration point and one for a "100°C " calibration point. The calibration pots are below the keyboard. Two panhead screws are installed in the calibration holes to protect the pots. As one looks at the front panel, the "0°" calibration pot is accessed through the hole on the right while the "100° " pot is accessed through the left hole. A small-bladed screwdriver will be needed for the adjustment. Note: The temperature probe type is covered in the RS232 and GPIB command sections. See the INIT command in either Section 3.3-4 RS232 SPECIAL GROUP or Section 3.4-4 GPIB COMMANDS: SPECIAL

4.3-1 Probe Calibration

The controller is calibrated by adjusting the 0° pot for a 0° reading on the TC01 display with the probe held at a 0° C. Similarly, the 100° pot is adjusted for a 100° reading with the probe held at 100° C. The calibration procedure can be accomplished with the probe in the chamber while using another standard temperature meter to monitor the chamber or the freezing and boiling points of distilled water can be used as the two calibration points. For this latter method, carefully remove the temperature probe from the chamber so that it may be placed in contact with the hot or cold water. Sun also manufactures a dual well temperature probe calibrator that provides the 0° and 100° C temperatures. Note: The temperature probe type is covered in the RS232 and GPIB command sections. See the INIT command in either Section 3.3-4 RS232 SPECIAL GROUP or Section 3.4-4 GPIB COMMANDS: SPECIAL

4.4 PID COEFFICIENT MODIFICATIONS

PID coefficients may only be modified from the IEEE-488 or RS-232 interfaces using the "PID=" command. These are temporary modifications, they are not saved when the power is removed from the EC0x. Beginning with controllers Revision F, a new command "INIT" has been added to allow the user to make permanent changes to the PID coefficients. Permanent coefficient modifications for controllers prior to Revision F must be programmed in ROM by Sun Systems. Consult Section 3.3-4 RS232 SPECIAL GROUP for systems using the RS-232 interface and Section 3.4-4 GPIB COMMANDS: SPECIAL for systems using the IEEE-488 interface.

4.5 MECHANICAL FAILSAFE ADJUSTMENT

The mechanical failsafe provided with the chamber is a safety device to prevent the chamber from inadvertently overheating. You will need to determine the maximum temperature that you can allow the chamber to reach. This temperature is set to +155°C from the factory. To change this temperature, perform the procedure listed below. If this maximum temperature is ever reached in your chamber, the failsafe light on the front of the chamber will light and the circuit breaker on the rear of the chamber will trip, thus removing power from the heaters.

STEP 1: Locate the failsafe adjusting hole on the rear of the EC0X and displace any insulation material which may block access to the failsafe adjusting screw.

STEP 2: If the desired trip point is higher than +155°C, the failsafe adjusting screw must be turned counterclockwise until it stops. This sets the failsafe at the highest value available and will not trip the circuit breaker. If the desired trip point is lower than +155°C, it is not necessary to adjust the screw at this time.

STEP 3: Set the chamber temperature to the desired trip point temperature and set the wait time to 10 minutes. For example, if the desired trip point is +155°C, the following keystrokes from the front panel would be necessary:

```
155 TEMP
10 TIME
```

To set the trip point for a temperature other than +155°C, replace the 155 with the desired trip point.

STEP 4: After the chamber is at the set point for 10 minutes, the buzzer will sound and the Time Out LED will light on the front panel. The failsafe can now be set.

STEP 5: Using a small blade screwdriver, slowly adjust the screw clockwise to lower the failsafe trip point until the heater circuit breaker on the rear of the unit trips. The failsafe lamp on the front panel will illuminate. When this occurs, stop turning the screw clockwise and turn the screw 1/4 of a turn counterclockwise and reset the heater circuit breaker to restore normal operation. If the circuit breaker does not reset, adjust the failsafe slightly more in the counterclockwise direction until the circuit breaker remains on and the chamber functions normally.

4.6 ELECTRONIC FAILSAFE ADJUSTMENT

The electronic fail-safe provided with the chamber is a safety module to protect the chamber from a number of possible conditions. The Temperature Limit Module detects the following conditions and causes the dual pole circuit breaker to open;

1. If the chamber temperature exceeds the Upper Temp Limit (UTL) setting of the module.
2. If the chamber temperature goes below the Lower Temp Limit (LTL) setting of the module.
3. If the module's thermocouple should fail as an open circuit.
4. If the module's power supply should fail. Such as its fuse blowing.
5. If a current of 2 amps or more is detected to the chamber chassis earth ground. This condition can occur, for example, if a heater element fails in such a way that the heater element wire breaks and comes in contact with the inner chamber wall.

When the 2 pole breaker opens all line power is removed from the heater circuitry. Opening of the breaker also causes a signal to be sent to the chamber main controller electronics. The main controller, upon indication of the breaker open state, then turns off all fans and valves and turns on the FAIL-SAFE LED. Once the breaker is tripped open, it will stay in the open tripped state until manually reset by moving the handle to the up position. Before resetting the breaker it is necessary to correct the cause of the breaker trip, else it will trip again within a few seconds. Never hold the breaker lever in the up position, just push it up and release the lever.

The breaker and Limit Module are located on the rear of the chamber. There is a 3 1/2 digit LCD display that normally display's the chamber temperature as sensed by the Limit Module. Note that the Limit Module's temperature accuracy is much less than the temperatures displayed on the front panel (see temperature table that follows). There are two push keys and two screws that can be removed to access the UTL and LTL adjustment pots. To view the current UTL setting, push and hold the RED key. To adjust the UTL setting, remove the screw above the red key then while holding the red key use a small flat tipped screw driver and adjust the UTL setting. The LTL setting is done in a like manner using the BLUE key and its adjustment pot that is located above the blue key.

The following table gives approximate module temperature readings relative to the actual temperature. The module was designed to be a simple analog circuit to provide reliable chamber protection. Its temperature accuracy was not a design goal. For example, to cause the trip at 300°C actual chamber temperature you may need to set the module UTL to 303°C or so.

ACTUAL TEMP °C	MODULE READOUT °C
-200	-146
-100	-88
-60	-55
-20	-19
0	0
100	100
200	202
300	303
400	415

SECTION 5 MAINTENANCE

The EC0X was designed to be virtually trouble and maintenance free. However, to prolong your chambers useful product life and to maintain it at its optimum working condition, Sun Systems recommends performing routine maintenance to the blower motor and expectorant filter on a semiannual basis.

5.1 BLOWER MOTOR INSPECTION AND CLEANING PROCEDURE

This procedure is to insure proper air flow is received by the blower motor assembly.

STEP 1 - Position the chamber such that access is allowed to the rear of the chamber.

STEP 2 - Clean the intake of the blower motor with a brush or vacuum/brush combination.

STEP 3 - Reposition the chamber insuring that at least 2 inches of free air space exists between the rear of the blower motor and any other objects.

5.2 EXPECTORANT FILTER CLEANING AND INSPECTION

This procedure is necessary to insure proper working order of the cooling system.

STEP 1 - Position the chamber such that access to rear of the unit is possible.

STEP 2 - Turn off the expectorant supply and remove the expectorant supply hose from the rear of the chamber. The hose connects to the filter assembly.

STEP 3 - Remove the filter back section and then the filter itself.

STEP 4 - Remove any contamination from the filter. If need be, tap the filter lightly as not to damage the filter.

STEP 5 - Replace the filter and filter back section.

STEP 6 - Reconnect the expectorant supply hose and turn on the expectorant supply. Check for leaks around the fittings.

SECTION 6 FAULT ANALYSIS AND REPAIR

The EC0X was designed and built to provide years of service with a minimum amount of systems down time. Should the chamber malfunction, attempt to isolate the fault using the fault isolation tables in Section 6.1. Follow the recommended repair procedures included in the tables. If return for repair of the chamber or any subassemblies is indicated, please follow the return material authorization procedure outlined in Section 6.2. In some cases, repair can be facilitated on site using the repair procedures detailed in Sections 6.3 and on. In any case, call Sun Systems and we will gladly assist you in the correction of the malfunction.

6.1 FAULT ANALYSIS CHARTS

The following fault isolation charts are included to assist the user to identify common problems which may occur with the EC0X chamber. Some of the faults can be corrected quickly and easily by following the corrective measures illustrated in the charts. If, however, the problem persists, call Sun Systems for assistance.

Table 6.1-1 Fault Isolation

FAULT SYMPTOM	PROBABLE CAUSE	CORRECTIVE MEASURE
No Response when Main Power Switched On	Failsafe Breaker in OFF Position	Check AC Outlet and Circuit Breaker
	Main Power Fuse Blown	Remove Fuse and Inspect
		Replace if Blown
Chamber Blows Fuse Upon Power On	Broken Heater Element Making Contact with Case	Replace Heater Element
Controller Displays a Temperature Of +321°C	Probe Disconnected	Reconnect Probe
	Open Temperature Probe	Replace Probe
Controller Displays a Temperature Of -103°C	Shorted Temperature Probe	Replace Probe
Chamber Does Not Heat	Controller Heat Switch Not in ON (Up) Position	Turn Heat Switch ON
	Fuse F2 Blown On TC01 Power Supply Board	Inspect Fuse & Replace
	Controller Failure	Return for Repair
	Heater Element Failure	Replace Heater Element
Chamber Slow to Heat	Single Element Open	Replace Heater Element
Blower Fails to Operate	Failsafe Thermostat Has Tripped	Adjust For Proper Operation
	Defective Main Power	Replace Relay
	Faulty Blower Motor	Replace Blower Motor
Chamber Fails to Cool (With No Audible Sound From The Cool Solenoid)	Controller Cool Switch Not in the ON (Up) Position	Turn Switch ON
	Fuse F1 Blown on TC01 Controller	Inspect And Replace Fuse
	TC01 Controller Failure	Return for Repair
	Cool Solenoid Faulty	Replace Solenoid
Chamber Fails to Cool or Cools Slowly (With Audible Sound from the Cool Solenoid Opening and Closing)	Expectorant Delivery System Faulty	Check Expectorant Filter
		Verify Expectorant Delivery Pressure
		Wrong Expectorant Delivery System for Option Ordered
		Improper Connection to Delivery System. Requires Liquid to Chamber.

6.2 RETURN MATERIAL AUTHORIZATION PROCEDURE

In the event the chamber or a module within the chamber is in need of repair, call Sun Systems at (321) 383-9400 for a Return Material Authorization (RMA) number and an estimate for the turnaround time for the repair. The RMA number is valid for 30 days and must be indicated on the outside shipping label. It is also helpful if a brief explanation of the problem accompanies the unit. After securing the RMA number, ship the unit, freight prepaid, to:

Attn: RMA #
Sun Electronic Systems, Inc.
1845 Shepard Drive
Titusville, Florida 32780

Equipment in transit is the sole responsibility of the rightful owner. After repair, and unless otherwise specified, units will be returned FOB via owner designated carrier.

6.3 TEMPERATURE CONTROLLER SECTION REMOVAL AND REPLACEMENT

The temperature controller section (TCO1) is located on the right side of the chamber when viewed from the front. See photo Section 1. Follow the procedure outlined below for the removal and replacement of the TCO1 controller section.

STEP 1 - Remove all electrical power from the chamber, i.e., unplug the chamber from the line voltage. Turn off the expectorant supply and disconnect expectorant supply hose from the chamber. Ensure that all of the components of the chamber have reached ambient temperature.

CONTROLLER SECTION ACCESS

STEP 2 - Position the chamber on its left side as viewed from the front. Remove the 6-32 screws located on the exposed bottom of the chamber / control section intersection. Return the chamber to its normal position.

STEP 3 - Remove the 6-32 screws located on the top of the chamber.

STEP 4 - Carefully separate the controller chassis from the chamber section being careful not to stress the wiring or probe connections.

TEMPERATURE PROBE REMOVAL

STEP 5 - If probe is to stay with controller then remove probe from chamber section. If probe is to stay with chamber then remove probe connector from controller main PC board.

STEP 6 - Disconnect the 26 pin flat cable from the I/O board that is mounted on the chamber section wall and also unplug the twisted 2 wire power input cable from the I/O board.

REPLACEMENT - Reverse steps 1-6.

6.4 HEATER ELEMENT REMOVAL AND REPLACEMENT

The heating elements are located behind the air baffle located inside the test chamber area. Follow the procedure below for removal and replacement of a heating element.

STEP 1 - Remove all electrical power from the chamber, i.e., unplug the chamber from the line voltage. Turn off the expectorant supply and disconnect expectorant supply hose from the chamber. Insure that the heating elements and the interior of the chamber have had time to reach ambient temperature.

REMOVE AIR BAFFLE

STEP 2 - Remove the 6-32 screws and the 8-32 screws located around the blower air intake on the rear wall of the interior of the test chamber.

STEP 3 - Remove the 6-32 screws located on the ceiling of the test chamber. Remove air baffle.

REMOVE CHAMBER BACK PLATE

STEP 4 - Remove the #6 screws located on the perimeter of the chamber back plate and carefully pivot back plate away without stress to the line or fuse wiring.

HEATER ELEMENT REMOVAL

STEP 5 - Carefully remove the fiberglass insulation from the heater mounting area. Remove the 6-32 nut and flat washer from each side of the heater element. Remove the wired ring terminals from the heater element mounts.

STEP 6 - Remove the next 6-32 nut and beveled washer from both mounting sides.

NOTE: When reinstalling, always place the wide part of the bevel washer towards the ceramic insulator. Tighten the nut finger tight plus 3/4 of a turn or use 4 inch pounds of torque.

STEP 7 - Stand to the side of the chamber. While supporting the two ceramic insulators from falling with one hand, reach inside and grasp the heater element and pull towards the front of the chamber.

HEATER ELEMENT REPLACEMENT

In reverse order, follow steps 2 through 7 to reinstall new ceramic insulators and heater element.

6.4-1 Heater Element Replacement Table

The following is a guide to the number and type of heater elements used in each chamber. Chambers using both wattages, the upper elements on each side are 800w and lower are 600w.

<u>Model #</u>	<u>PN# 980201 (600 watt)</u>	<u>PN# 980205 (800 watt)</u>
EC0A, EC01	2	
EC02		2
EC03	4	

6.5 COOLING MODULE ASSEMBLY REMOVAL AND REPLACEMENT

The cooling module consists of the nozzle, cool solenoids and associated plumbing necessary to deliver the expectorant to the test chamber.

STEP 1 - Remove all electrical power from the chamber, i.e., unplug the chamber from the line

voltage. Turn off the expectorant supply and disconnect expectorant supply hose from the chamber. Insure that the components which carry the expectorant have had time to reach ambient temperature.

CONTROLLER SECTION ACCESS

STEP 2 - Follow the steps required to gain access to the controller section as outlined in Section 6.3.

COOLING SOLENOID VOLTAGE DISCONNECT

STEP 3 - Locate and follow the wires attached to the cool module and disconnect the wires from the I/O board terminal block. Write down positions that the wires are connected so that you reconnect the wires in the same fashion.

COOLING MODULE REMOVAL

STEP 4 - The cooling assembly has a 6" nozzle which protrudes into the top of the test chamber area. Carefully remove the screws which hold the cooling assembly on to the mounting plate and pull the module off the mounting plate in a perpendicular fashion.

REPLACEMENT - Reverse steps 2 through 4

6.6 Mechanical FAILSAFE THERMOSTAT REMOVAL AND REPLACEMENT

If your chamber was manufactured with a mechanical failsafe, the thermostat is located internally on the rear of the chamber. If replacement of the thermostat is deemed necessary, follow the procedure below.

STEP 1 - Remove all electrical power from the chamber, i.e., unplug the chamber from the line voltage. Turn off the expectorant supply and disconnect expectorant supply hose from the chamber. Insure that the heating elements and the interior of the chamber have had time to reach ambient temperature.

REMOVE CHAMBER BACK PLATE

STEP 2 - Remove the (ie. 14) #6 screws located on the perimeter of the chamber back plate and carefully pivot back plate away without stress to the line voltage and fuse wiring.

STEP 3 - Carefully remove the strip of fiberglass insulation which covers the local of the failsafe thermostat. Locate the thermostat and disconnect the (2) wires attached in line to the thermostat utilizing quick disconnect terminals.

STEP 4 - Remove the (3) #6 screws which hold the thermostat to the rear wall of the test chamber and remove the thermostat.

REPLACEMENT - Reverse steps 2 through 4. Calibrate the thermostat under the procedures described in "Section 4.5 MECHANICAL FAILSAFE ADJUSTMENT".

6.7 BLOWER MOTOR REMOVAL AND REPLACEMENT

If a faulty blower has been determined, perform the following procedure for removal and replacement.

STEP 1 - Remove all electrical power from the chamber, i.e., unplug the chamber from the line voltage. Turn off the expectorant supply and disconnect expectorant supply hose from the chamber. Insure that the heating and cooling elements and the interior of the chamber have had time to reach ambient temperature.

STEP 2 - Follow the steps required to gain access to the controller section as outlined in Section 6.3., Temperature Controller Removal and Replacement.

REMOVE AIR BAFFLE

STEP 3 - Remove the (3) 6-32 screws and the (4) 8-32 screws located around the blower air intake on the rear wall of the interior of the test chamber

STEP 4 - Remove the (2) 6-32 screws located on the ceiling of the test chamber and remove air baffle.

REMOVE CHAMBER BACK PLATE

STEP 5 - Remove the (14) or (18) #6 screws located on the perimeter of the chamber backplate and carefully pivot back plate away without stress to the line voltage and fuse wiring.

BLOWER MOTOR REMOVAL

STEP 6 - From inside the test chamber, remove the blower wheel by loosening the set screw which holds the wheel to the motor shaft.

STEP 7 - Locate and follow the two wires connected to the blower motor back to the I/O board terminal block located in the controller section and disconnect. Feed wires through access hole in chamber side plate and let hang near blower motor.

STEP 8 - Remove the (4) 8-32 screws which secure the blower motor adapting plate and remove the blower motor in a perpendicular fashion.

REPLACEMENT - Reverse steps 2 through 8.

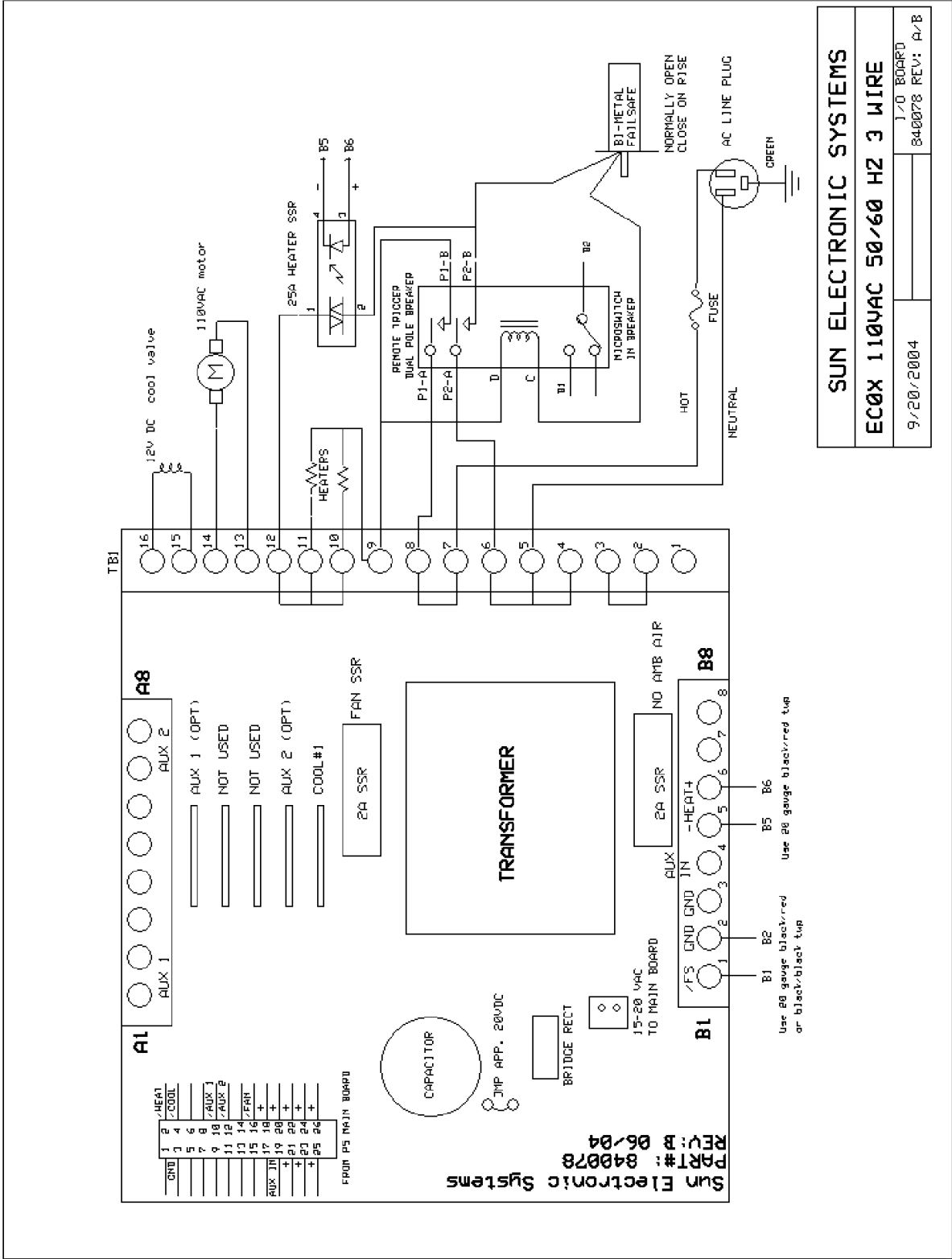
6.8 EC0X WIRING DIAGRAMS

The following figures illustrate the three different configurations of electrical wiring in the EC0X environmental chamber. Changes to the electrical wiring of the EC0X should be made at the factory.

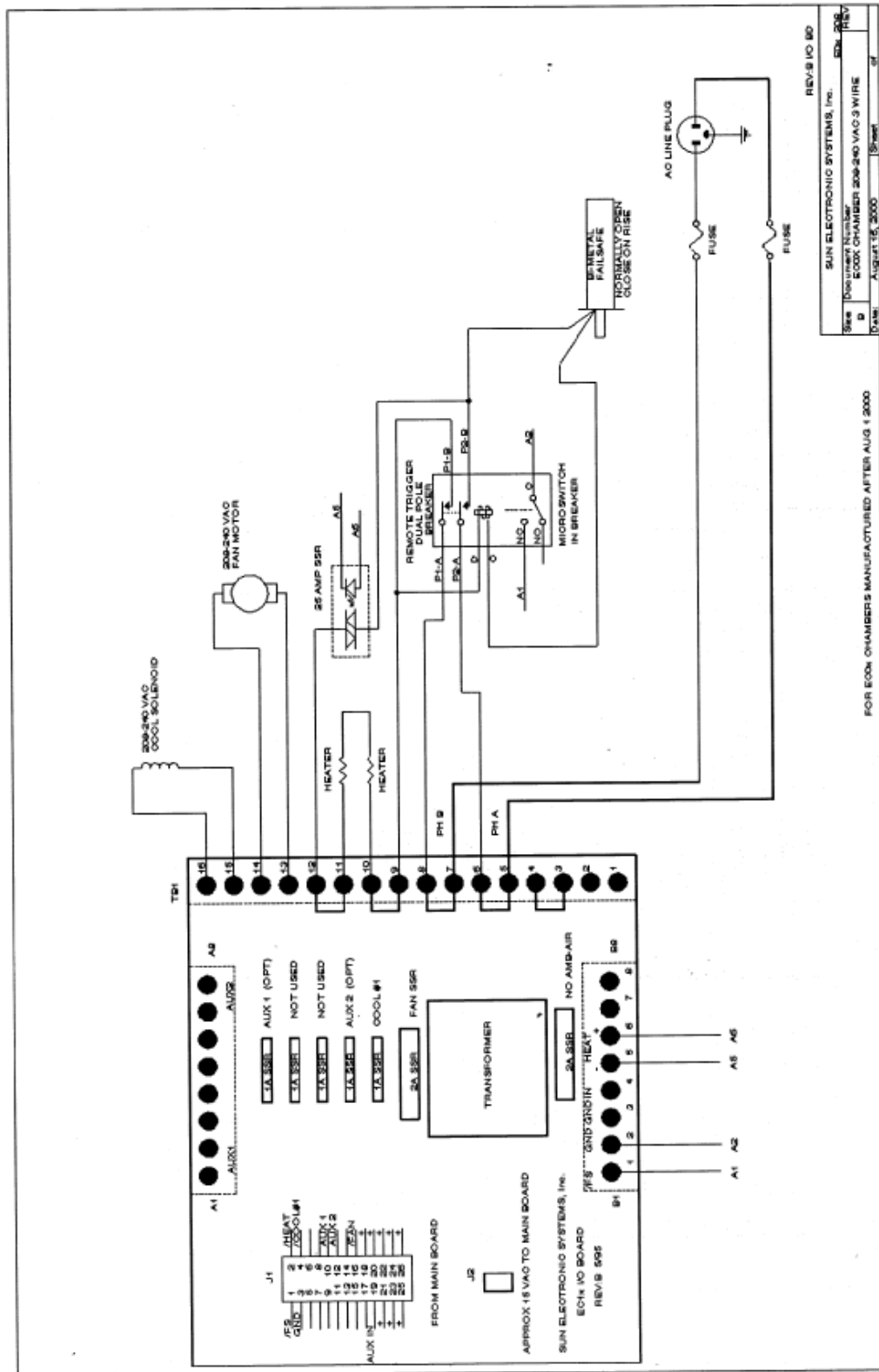
The diagram illustrates the electrical connections for the 501x NO BOARD. Key components and their connections are as follows:

- Transformer (J2):** A 12VAC transformer connected to the main board.
- Terminal Block J1:**
 - HEAT 100 POLAR: 1 (AUX 1), 2 (AUX 2), 3 (AUX 1), 4 (AUX 2), 5 (AUX 1), 6 (AUX 2), 7 (AUX 1), 8 (AUX 2), 9 (AUX 1), 10 (AUX 2), 11 (AUX 1), 12 (AUX 2), 13 (AUX 1), 14 (AUX 2), 15 (AUX 1), 16 (AUX 2), 17 (AUX 1), 18 (AUX 2), 19 (AUX 1), 20 (AUX 2), 21 (AUX 1), 22 (AUX 2), 23 (AUX 1), 24 (AUX 2), 25 (AUX 1), 26 (AUX 2).
 - AUX 1, AUX 2, and HEAT 100 POLAR are connected to the main board.
- Terminal Block TB1:**
 - 15: 110VAC COOL SOLENOID COOL #1
 - 14: 110VAC FAN MOTOR
 - 13: 28 AMP SSR
 - 12: HEATER
 - 11: HEATER
 - 10: HEATER
 - 9: HEATER
 - 8: REMOTE TRIGGER DUAL POLE BREAKER
 - 7: REMOTE TRIGGER DUAL POLE BREAKER
 - 6: REMOTE TRIGGER DUAL POLE BREAKER
 - 5: REMOTE TRIGGER DUAL POLE BREAKER
 - 4: REMOTE TRIGGER DUAL POLE BREAKER
 - 3: REMOTE TRIGGER DUAL POLE BREAKER
 - 2: REMOTE TRIGGER DUAL POLE BREAKER
 - 1: REMOTE TRIGGER DUAL POLE BREAKER
- Breaker Assembly:**
 - Includes a REMOTE TRIGGER DUAL POLE BREAKER with terminals P1-A, P1-B, P2-A, P2-B, and P1-C.
 - A MICROSWITCH IN BREAKER is connected to the breaker assembly.
 - A THERMAL FAILSAFE is connected to the breaker assembly, labeled "THERMAL FAILSAFE NORMALLY OPEN CLOSE ON RISE".
- Wiring Details:**
 - 110VAC COOL SOLENOID COOL #1 is connected to TB1 15.
 - 110VAC FAN MOTOR is connected to TB1 14.
 - 28 AMP SSR is connected to TB1 13.
 - HEATER is connected to TB1 12, 11, 10, and 9.
 - REMOTE TRIGGER DUAL POLE BREAKER is connected to TB1 8, 7, 6, 5, 4, 3, 2, and 1.
 - MICROSWITCH IN BREAKER is connected to TB1 4.
 - THERMAL FAILSAFE is connected to TB1 4.

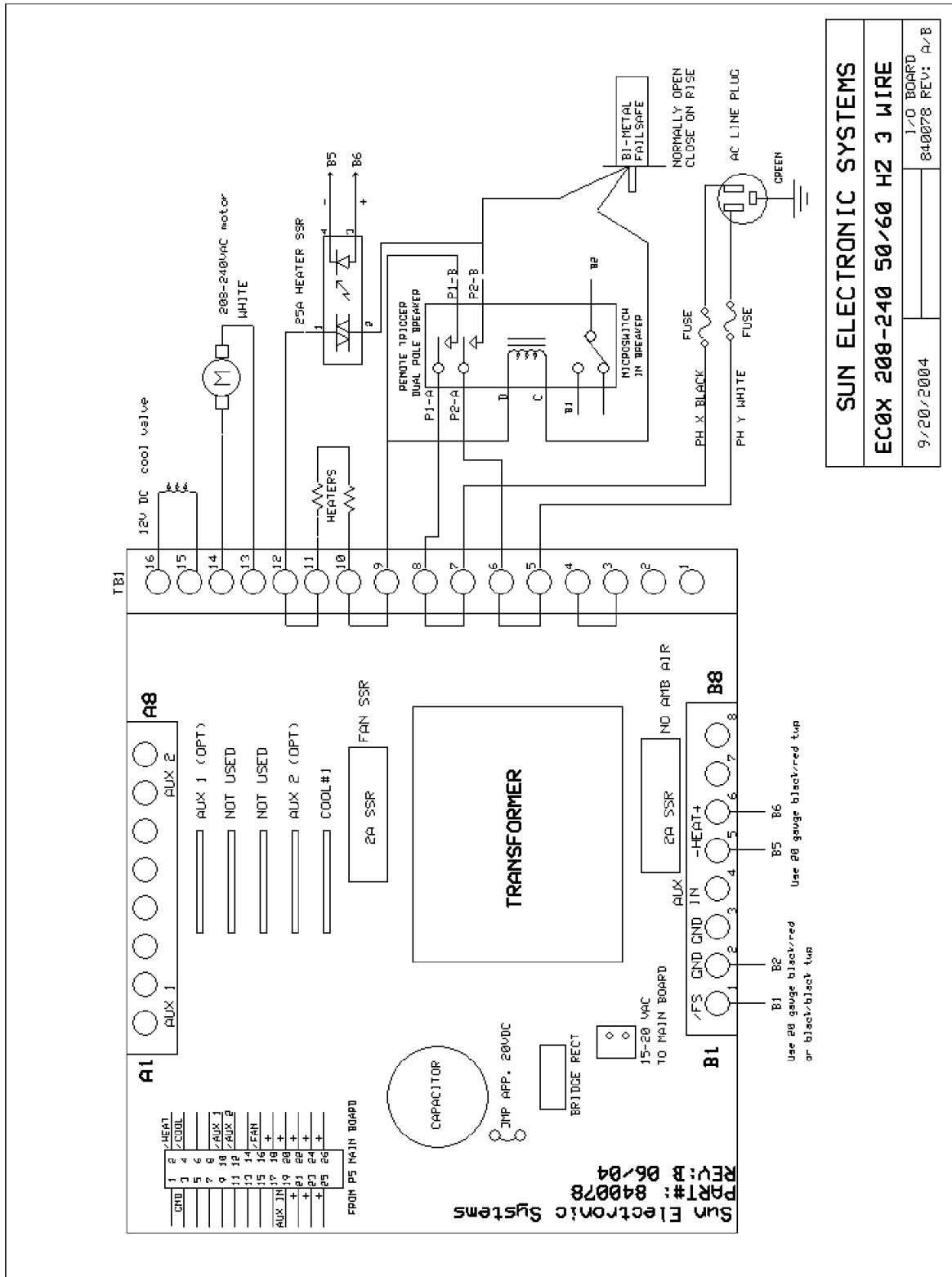
110 V_{ac} 3 WIRE SCHEMATIC WITH V_{dc} COOL VALVE



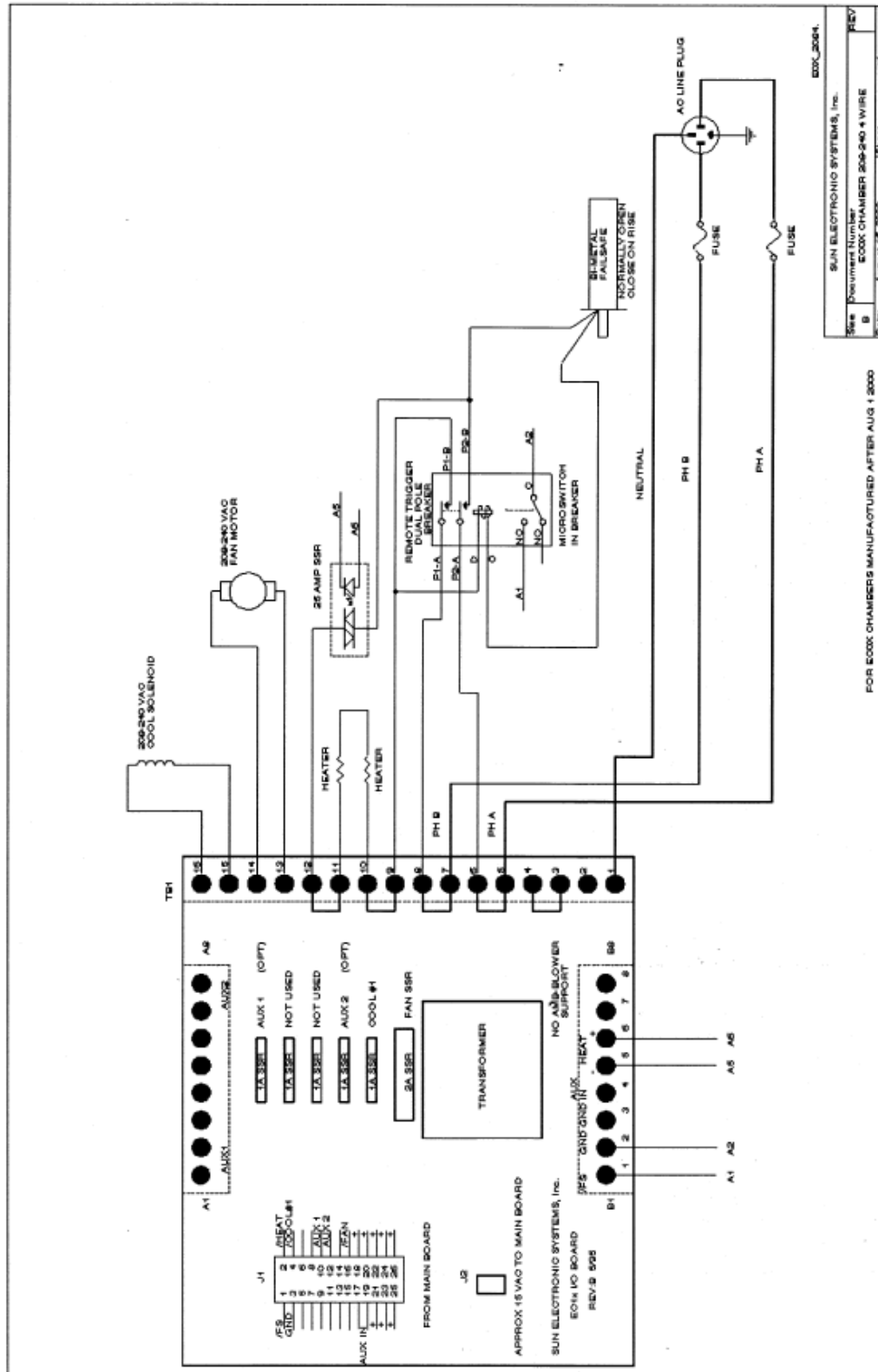
208 - 240 V_{ac} 3 WIRE SCHEMATIC WITH V_{ac} COOL VALVE



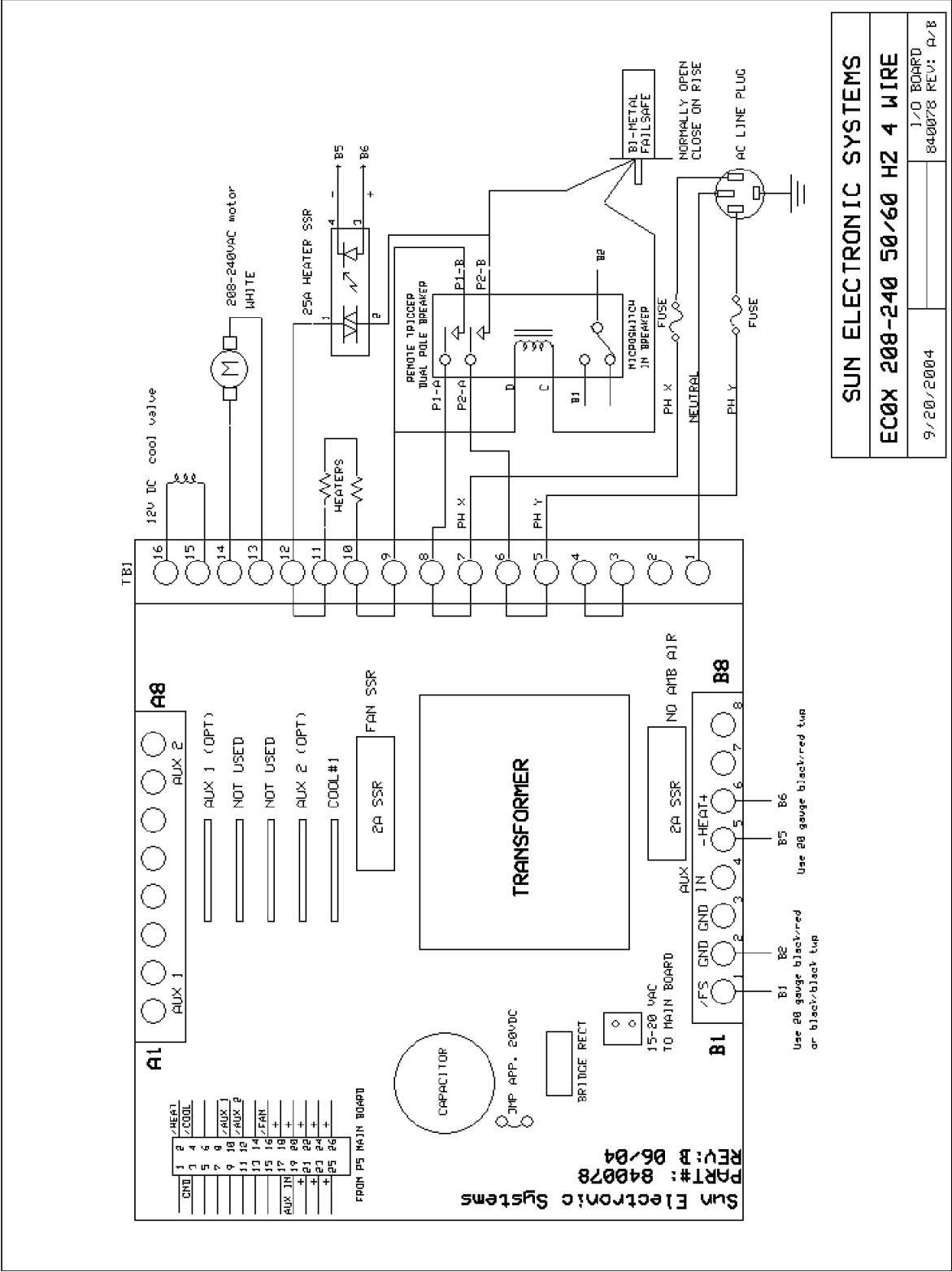
208 V_{ac} 3 wire schematic WITH V_{dc} COOL VALVE



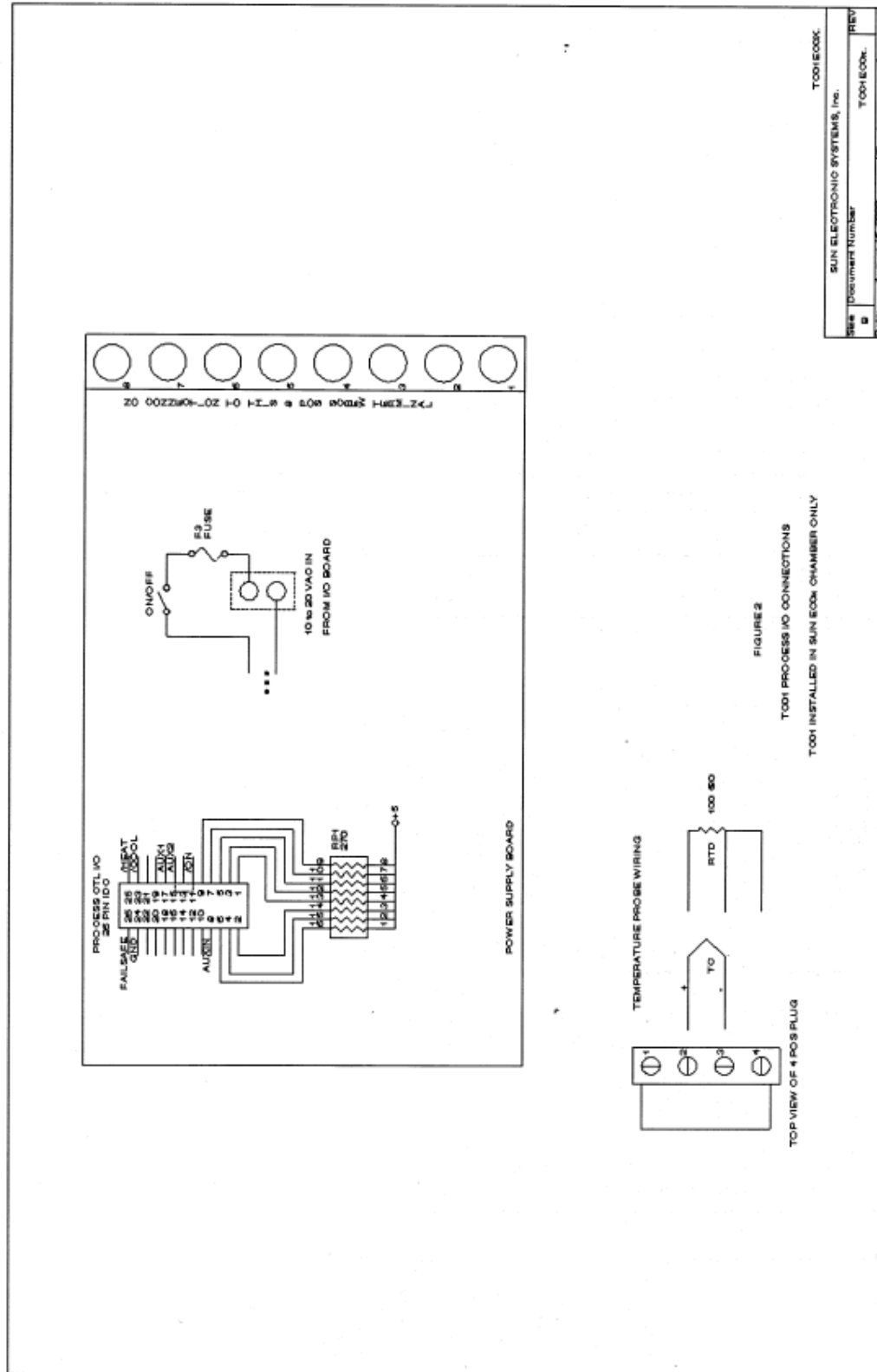
208-240 V_{ac} 4 WIRE SCHEMATIC WITH V_{ac} COOL VALVE



208-240 V_{ac} 4 WIRE SCHEMATIC WITH V_{dc} COOL VALVE



EC0X PROCESS I/O CONNECTIONS



SECTION 7 REPLACEMENT PARTS

COOL ASSEMBLY	850 PSI LCO ₂ 110 VAC (CH1V1T)
COOL ASSEMBLY	850 PSI LCO ₂ 208 -240 VAC (CH2V1T)
COOL ASSEMBLY	850 PSI LCO ₂ VDC (CHDC1T)
COOL ASSEMBLY	300 PSI LCO ₂ 110 VAC (CL1V1T)
COOL ASSEMBLY	300 PSI LCO ₂ 208-240 VAC (CL2V1T)
COOL ASSEMBLY	300 PSI LCO ₂ VDC (CLDCWLNv)
COOL ASSEMBLY	LN2 110 VAC (LN1V1T) specify Hi or Low PSI
COOL ASSEMBLY	LN2 208-240 VAC (LN2V1T) specify Hi or Low PSI
COOL ASSEMBLY	LN2 VDC (LNDC1T) specify Hi or Low PSI

BIMETAL FAIL-SAFE, NORMALLY OPEN (800008)
EC0A, EC01 BLOWER WHEEL (490002)
EC02 BLOWER WHEEL (490003)
EC03 BLOWER WHEEL (490010)

TC01 RTD PROBE ASSEMBLY (980101)

ASSEMBLED I/O BOARD, 120 VAC (980036)
ASSEMBLED I/O BOARD, 220 VAC (980036-VAC)
ASSEMBLED I/O BOARD, VDC (981046)
HEATER 25 AMP SSR (800003)
EXPECTORANT FILTER ASSEMBLY LCO₂ (980240)
EXPECTORANT FILTER ASSEMBLY LN₂ (980241)

600 WATT HEATER ELEMENT (980201)
800 WATT HEATER ELEMENT (980205)

LEFT DOOR HANDLE ASSEMBLY (980501)
RIGHT DOOR HANDLE ASSEMBLY (980502)
DOOR POST EC0A/01 (910031)
DOOR POST EC02/03 (910005)
DOOR GASKET EC0A (980518)
DOOR GASKET EC01 (980512)
DOOR GASKET EC02/03 (980516)

6 FT STAINLESS LCO₂ HOSE (WITHOUT FITTINGS) (570002)
LN₂ HOSE, 6 FT (570020)
LCO₂ TANK ADAPTOR (980239)
2 POLE PLATE BREAKERS (650010)

EXTRA EC0x MANUAL (MANEC0X)

SECTION 8 ERROR CODES

E0 FOREGROUND PROGRAM ERROR

The E0 error code indicates that the controller has encountered a problem during program execution. Toggle the power switch off then on. Once the chamber is on, press C (Keyboard Layout 1) or * (Keyboard Layout 2).

E1 PROBE INT ERROR

The E1 error code indicates that the temperature probe is faulty. Switch temperature probe with another probe of the same type (i.e. RTD, J Thermocouple, K Thermocouple, etc.).

E2 ILLEGAL OP CODE

The E2 error code indicates the controller is crashing (due to illegal opcode). However, this error can be caused by a short in remote panel or GPIB cable/card data line. Unplug the chamber and disconnect the remote ribbon cable from the bottom of the control stack. Plug the chamber back in and power up. If error code is present even with the remote panel ribbon cable disconnected the control stack is faulty and should be sent in for repair.

If the error code goes away, then there is a problem with either the remote panel/ribbon cable (short) or possibly a faulty GPIB cable/card. Unplug the chamber and disconnect the GPIB cable. Reconnect the remote panel ribbon cable, plug the chamber back in, and power up. If error appears, then remote panel ribbon cable is faulty. If problem appears only when GPIB cable is plugged in, then the GPIB cable/card is faulty.

E3 FAILSAFE ACTIVE MODE

The E3 error code indicates that the circuit breaker has tripped. Flip the circuit breaker switch up.