

Operation Manual

*SE5000 Series
Temperature
Controller/
Power Supply*



Marlow Industries, Inc.



Description: SE5010-01		Lot Size: ONE		Kit no: 513648	
Part no.: 110-9034-001		Rev:		Approved: 9531	
				Serial No.: 2043	

Step	Operation	In	Out	Oper.	Date	Reference
050	BUILD HEATSINK ASSEMBLY	1	1	WM	5/25/95	135-9004-001
700	QC VERIFY TORQUE ON HARDWARE	1	1	WM	5/25/95	1023
100	BUILD CABLE ASSEMBLY	}	}	}	}	135-9017-001
101	BUILD CABLE ASSEMBLY	}	}	}	}	135-9018-001
102	BUILD CABLE ASSEMBLY	}	}	}	}	135-9019-001
200	BUILD SUB-CHASSIS ASSEMBLY NOTE: CONTROL BOARD ASSEMBLY WILL BE PROVIDED	}	}	}	}	135-9005-001 135-9003-001
300	BUILD FRONT PANEL ASSEMBLY NOTE: DISPLAY BOARD ASSEMBLY WILL BE PROVIDED	1	1	WM	5/25/95	135-9008-001 135-9002-001
400	BUILD CABLE ASSEMBLY	Σ	Σ	Σ	Σ	135-9021-001
450	OBTAIN SERIAL NUMBER OF SE5010. RECORD ON THIS TRAVELLER	1	1	WM	5/25/95	
500	RECORD SERIAL NUMBER OF EUROTHERM TEMPERATURE CONTROLLER MODULE S/N: <u>A51149-002-006-95-02</u>	1	1	WM	5/25/95	227-9003-001
550	BUILD SE5010 ASSEMBLY PER PRINT. LEAVE COVERS AND TRIM OFF FOR TEST AND INSPECTION	1	1	WM	5/25/95	110-9034
700	QC INSPECTION	1	1	TB	6/26	1023
600	ACCEPTANCE TEST RECORD DATA ON DATA SHEET	1	1	T.B	6/26	125-9008-001
700	QC INSPECTION	1	1	TB	6/26	1023
551	INSTALL COVERS AND TRIM	1	1	TB	6/26	110-9034
700	FINAL QC INSPECTION	1	1	TB	6/26	1023
900	DELIVER TO PACK USE SHIPPING CONTAINER P/N 490-9013-001	1	1	TB	6/24	

SIZE A	FSCM NO. 55686	DWG NO. 110-9034-XXX	REV K
SCALE N/A		CAD GENERATED DRAWING	SHEET 2 OF 9

ORIGINAL

POST BURN-IN DATA SHEET

MODEL NO.: SE 5010-01 PART NO.: 110-9034-001 DATE: 6-26-95

SERIAL NUMBER: 2043	APPROVED:	KIT NO.: 513648
PARAMETER	SPECIFICATION	ACTUAL
+ 5 VDC POWER	+5.00 (+4.75 TO +5.25)VDC	5.013 VDC
+ 12 VDC POWER	+12.00(+11.32 TO +12.68)VDC	12.258 VDC
- 12 VDC POWER	-12.00(-11.32 TO -12.68)VDC	-12.347 VDC
± 12 VDC BALANCE	0.25 VDC DIFF. (MAX)	0.089 VDC
DISPLAY AMPS ZERO	0.00(-0.01 TO 0.01)AMPS	0.00 AMPS
DISPLAY VOLTS ZERO	00.0(-00.1 TO 00.1)VOLTS	00.0 VOLTS
RIPPLE VOLTAGE (POS)	26.7 mV RMS (MAX)	4.50 mV RMS
RIPPLE VOLTAGE (NEG)	26.7 mV RMS (MAX)	4.56 mV RMS
REFERENCE VOLTAGE	1.0000 ±0.0005 VDC	1.0000 VDC
+ VOLTAGE ACCURACY	1% OF READING + 2 DIGITS	0 %
- VOLTAGE ACCURACY	1% OF READING + 2 DIGITS	0 %
+ CURRENT ACCURACY	1% OF READING + 2 DIGITS	0.016 %
- CURRENT ACCURACY	1% OF READING + 2 DIGITS	0.025 %
OUTPUT CURRENT BAL.	0.005 AMPS DIFF. (MAX)	0.005 AMPS
+ CURRENT LIMIT	0.01 AMPS DIFF. (MAX)	0.00 AMPS
THERMISTOR TH 1	4.5 (4.0 TO 5.0) °C	4.5 °C
THERMISTOR TH 1	-50.0 (-50.5 TO -49.5) °C	-50.2 °C
THERMISTOR TH 2	-27.2 (-27.7 TO -26.7) °C	-27.2 °C
THERMISTOR TH 3	25 (24.5 TO 25.5) °C	24.8 °C
THERMISTOR TH 4	25 (24.5 TO 25.5) °C	24.9 °C

ECN #9689

SIZE A	FSCM NO. 55686	DWG NO. 110-9034-XXX	REV X
SCALE N/A		CAD GENERATED DRAWING SHEET 3 OF 9	

Warranty Registration

SE5000, SE5010, and SE5020 Temperature Controller/ Power Supply

Marlow Industries, Inc., (MI) warrants for a period of one (1) year from date of sale the SE5000 Series Temperature Controller/Power Supply, including parts, not damaged or misused by the customer as determined by MI. The warranty form, completed with product serial numbers and date of sale, together with a proof of purchase, must be returned to MI, within 30 days of date of sale for validation. Unless customer is notified otherwise, any unit requiring warranty service will be returned to the customer within two (2) weeks of receipt by MI. The customer shall pay all shipping charges for return of the product to MI; if covered by the warranty, MI will pay the return shipping charge. Temporary replacement units are not furnished for use during the repair period. During the warranty period, MI agrees to repair or replace at its option a defective unit.

The foregoing warranty shall not apply to products including the Temperature Controller/Power Supply damaged by improper or inadequate maintenance, third party supplied software or interfacing, unauthorized modification or misuse, or operation in a manner or environment not specified for the product.

The above warranty is exhaustive and any further warranties, expressed, implied, or statutory are hereby expressly excluded. To validate warranty, print or type the information below, add your signature and date, and return this form in the enclosed envelope with a copy of the receipt or purchase order within 30 days of purchase to: Marlow Industries, Inc., 10451 Vista Park Road, Dallas, Texas 75238-1645 U.S.A.

☐ Mr. ☐ Ms.

Name: _____
First Middle Last

Company: _____

Address: _____

Date of Purchase: _____
Month Day Year

For Use Primarily in:

- | | |
|---|---|
| ☐ High-Gain Amplifiers | ☐ Liquid Cooling |
| ☐ Infrared Detectors | ☐ Air Cooling |
| ☐ Charged-Couple Devices | ☐ Cold Plates |
| ☐ Other _____ | ☐ Laser Diodes |

Model Number: _____ Serial Number: _____

Options and Accessories Purchased: (Please check all that apply.)

- | | |
|--|---|
| ☐ RS-232-C Computer Interface Option | ☐ tH 1 Bead Thermistor |
| ☐ RS-422-A Computer Interface Option | ☐ tH 2 Bead Thermistor |
| ☐ RS-232-C Interface Cable w/DE-9S connectors at both ends | ☐ tH 3 Bead Thermistor |
| ☐ RS-232-C Interface Cable w/DB-25S connector at computer end | ☐ tH 4 Chip Thermistor |
| ☐ RS-422-A Interface Cable | ☐ t tc Thermocouple |
| | ☐ Single Rack Mounting Kit |
| | ☐ Dual Rack Mounting Kit |

Condition of Carton and Contents upon Arrival:

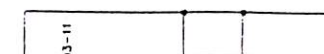
- ☐ Carton and Contents Both Satisfactory
☐ Carton Damaged but Contents Satisfactory
☐ Carton and Contents Both Damaged (Please explain.)

- ☐ Carton Satisfactory but Contents Damaged (Please explain.)

Signature: _____ Date: _____

DATE	APPROVED
7/28/88	BOS M
9/09/88	BOS M
10/05/88	M. GILLET
10/26/88	M. GILLET
2-1-89	BOS M
2/23/91	BOS M

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Operation Manual

SE5000 Series Temperature Controller/ Power Supply

SE5000, SE5010 & SE5020



marlow industries, inc.

Thermoelectric Innovation Through Research
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Warranty Policy

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The foregoing warranty shall not apply to products including the Temperature Controller/Power Supply damaged by improper or inadequate maintenance, third party supplied software or interfacing, unauthorized modification or misuse, or operation in a manner or environment not specified for the product.

The above warranty is exhaustive and any further warranties, expressed, implied, or statutory are hereby expressly excluded.

Operator Safety Precautions

Every precaution has been taken to ensure that this Operation Manual instructs the operator in the safe use of the SE5000 Series Temperature Controller/Power Supply. MI assumes no responsibility for errors or omissions not found to be the result of willful or gross negligence. Nor does MI, assume any liability for any damages that result from the use or misuse of the information contained in this *Operation Manual*.

All safety warnings and precautions in this manual must be complied with during all phases of operation of this instrument. Failure to comply with the warnings and precautions in this manual violates the product's design, manufacture, and intended use. Marlow Industries, Inc., assumes no liability for the operator's failure to comply with these precautions and warnings.

The SE5000 Series Temperature Controller/Power Supply must be connected to an electrical ground to minimize shock hazard. The instrument comes standard with a three-conductor AC power cable which must either be plugged into an approved three-contact electrical outlet or used with a three-contact to two-contact adapter. In the latter case, the grounding wire must be firmly connected to an electrical ground at the power outlet.

Do not operate the SE5000 Series Temperature Controller/Power Supply near water or other liquids. Never operate in a potentially explosive atmosphere, such as in the presence of flammable gases or fumes. Do not place the unit on an unstable cart, stand, or table, which may result in the unit falling, or in a manner which allows the cord to be walked on or otherwise damaged. Be sure the ventilation slots and openings in the cabinet are unobstructed. If the unit exhibits a distinct change in performance, indicating a need for service, turn off the power, disconnect the AC LINE connector from the power source, and return to MI for repair.

Do not attempt to calibrate, repair, service, install substitute parts, or perform any unauthorized modification to the instrument. These procedures are to be performed by MI personnel only.

Never remove the instrument covers or push any object through the ventilation slots as it may result in dangerous voltages or other risks even when the power cable has been removed. Never attempt to push any object through the cabinet, except when adjusting the current limit adjustment (See Section 3.4, *Front Panel Procedures*.) or when enabling the hardware configuration switch (W1) (See Section 4.0, *Configuration*.)

Unplug the unit from the wall outlet before cleaning. Do not use liquid or aerosol cleaners. (See Section, 6.1, *Maintenance*, for additional instructions.)

Operation Manual Part Number: 103-9005-001-11/89

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1.0 Introduction

This section provides a brief overview of this *Operation Manual* and your SE5000 Series Temperature Controller, including its features and accessories.

Prior to setting up your SE5000 Series Temperature Controller/Power Supply, check to be sure all items have arrived undamaged. If any items are missing or damaged, see Section 6.3, *Customer Service*. Your SE5000, SE5010, or SE5020 Temperature Controller/Power Supply comes standard with:

- AC Power Cord (7 ft, 2.13 m)
- DC Output Cable (8 ft, 2.34 m)
- ttc Type T Thermocouple (Copper/Constantan)
- Thermocouple Cable (8 ft, 2.34 m)
- Operation Manual

1.1 About this Manual

This *Operation Manual* contains information for the operation and configuration of the SE5000, SE5010, and SE5020 Temperature Controller/Power Supplies. It has been written as a guide to help you obtain optimal use of your Temperature Controller/Power Supply. To prevent damage to the instrument or your thermoelectric device, it is critical that you thoroughly read Section 2, *Installation*, and Section 3, *Operating Controls and Procedures*, before attempting to use the instrument.

Section 4, *Configuration*, will help you tailor your SE5000 Series instrument to your own needs. A *Tuning Tutorial*, Section 5, assists you in tuning your Temperature Controller/Power Supply to a specific load configuration. Section 6, *Troubleshooting*, helps you to quickly pinpoint a problem and find the correct solution.

Appendices include *Specifications* in Appendix A, computer interface *Communications Programs* in Appendix B, and *Accessories* in Appendix C.

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Do it Right Today, Better Tomorrow.

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Temperature Controller/Power Supply Operation Manual

Unless a more specific reference is made, the term "thermoelectric device" as used in this *Operation Manual*, refers to: thermoelectric cooling devices, coolers, modules, chip coolers, Peltier devices, heat pumps, cold plates, and thermoelectric assemblies.

The controls and indicators of both the temperature control and power supply modules of the Temperature Controller/Power Supply are referenced in this *Operation Manual* by capitalized, condensed, boldfaced type (e.g., **POWER**). Parameter list mnemonics, indicating which parameter has been selected and the value of each, appear on the Temperature Controller/Power Supply front panel green displays and are referenced in the *Operation Manual* as outlined type (e.g., *CHAL*).

1.2 General Information

The SE5000 Series Temperature Controller/Power Supplies are linear bipolar constant current power supplies interfaced with temperature control modules. The instruments are operable in both manual and automatic modes. In the manual mode, a constant output current level may be programmed with the measured temperature displayed and no temperature control action. In the automatic mode of operation both the setpoint and measured temperature are displayed and the bipolar power supply automatically provides the magnitude and polarity of current necessary to maintain the setpoint temperature.

1.3 Product Features

The SE5000 Series Temperature Controller/Power Supply provides the widest precision temperature control range for thermoelectric devices on the market--from -99.9°C to 150°C. Features of the fully-programmable, multi-option instrument include:

- Programmable PID (Proportional-Integral-Derivative)/ramp-to-setpoint control
- Four-digit LED and prompt displays
- Simultaneous display of measured temperature and temperature setpoint
- Digital readout of output voltage and output current
- Individual current limit adjustment for heating and cooling modes
- Red/green bargraph display for heat/cool modes
- User-selectable Celsius or Fahrenheit temperature units
- User selectable parameter configuration
- Parameter lockout by user
- Linear bipolar output
- Automatic cutback to prevent overshoot
- Operation with two different sensor types--thermistor or thermocouple
- Automatic shutdown for an open sensor or shorted thermistor
- High, low, and deviation limit alarms
- 115/230 VAC for worldwide operation
- Popular Electronic Industries Association (EIA) half rack size
- Tilt-up stand

Temperature Controller/Power Supply Operation Manual

1.4 Options & Accessories

The unit provides remote programming and readout when equipped with one of the communications options: RS-232-C or RS-422-A interfaces. Computer interface cables (9- or 25-pin for the RS-232-C and 9-pin for the RS-422-A) are furnished with each option. (See Appendix C.2, *Computer Interface Cables*.)

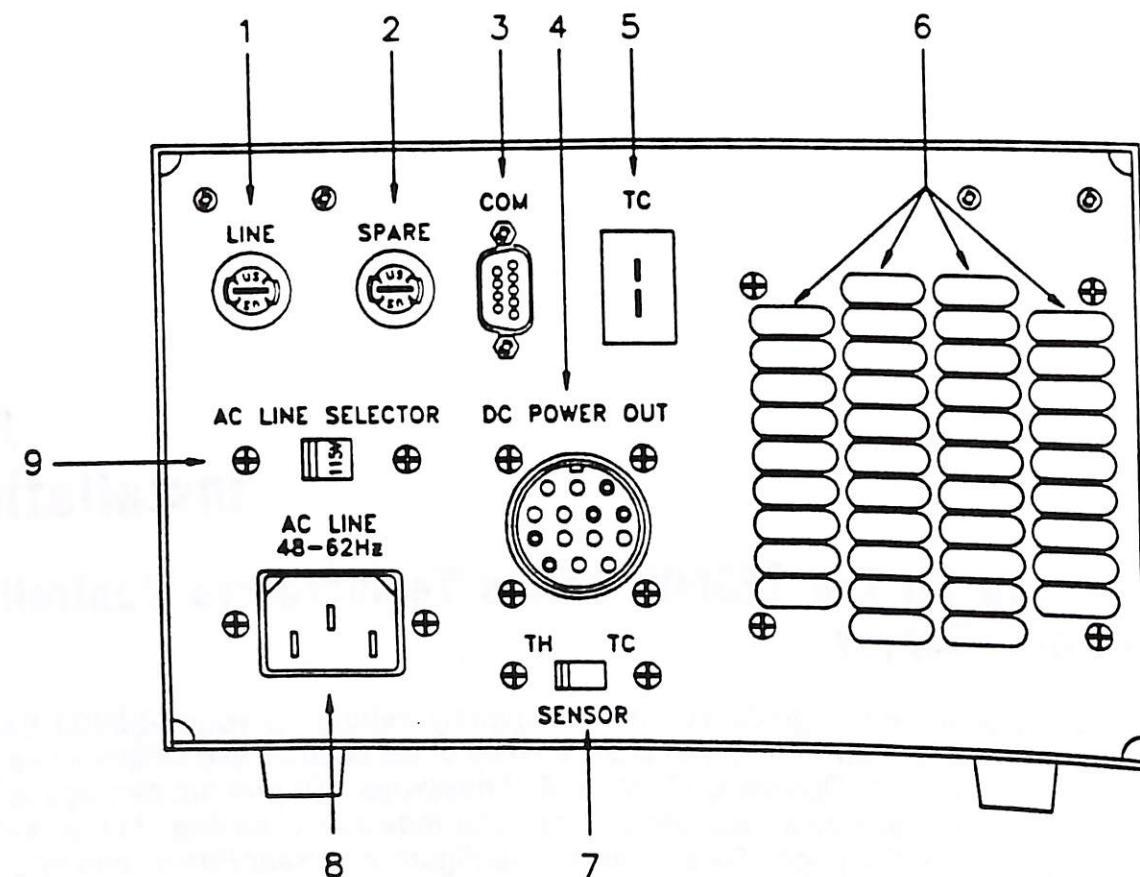
Additional accessories described in Appendix C include bead and chip thermistors, a type T (copper/constantan) thermocouple and single and dual rack mounting kits.

2.1 Setting Up the SE5000 Series Temperature Controller/ Power Supply

This section is designed to guide you in immediately setting up your SE5000 Series Temperature Controller/Power Supply to allow viewing of the controls and indicators as you work through Section 3.0, *Operating Controls & Procedures*. To prevent damage to the Temperature Controller/Power Supply or your thermoelectric device, follow safety precautions on back of title page. Be sure to refer to Figure 2.1, *Rear Panel*, and follow in sequence the precautions and procedures in this section.

The SE5000 Series Temperature Controller/Power Supply should be operated in a clean atmosphere that is free of dust and potentially explosive vapors or gases. The recommended ambient operating temperature range is 0° C (32° F) to 50° C (122° F). The environment should be such that no condensation forms on or in the instrument.

Figure 2.1 Rear Panel



- | | |
|----------------------------|---|
| 1 Line Fuse | 6 Ventilation Slots |
| 2 Spare Fuse | 7 Thermistor/Thermocouple Sensor Selector |
| 3 Communications Connector | 8 AC Line Connector |
| 4 DC Power Out Connector | 9 AC Line Selector |
| 5 Thermocouple Connector | |

Set-Up Procedures

STEP 1: Check the front panel to be sure that the **POWER** switch is off and that the **OPERATE/STANDBY** switch on the front panel is in **STANDBY**.

STEP 2: Be sure that the **AC LINE** Selector (115V/230V) switch located on the rear panel is in the position that corresponds to the **AC LINE** voltage. Connect the Temperature Controller's **AC LINE** power cord to an AC (50-60 Hz) power source.

STEP 3: Connect the DC power cable to the **DC POWER OUT** connector on the rear panel of the unit.

STEP 4: If not previously attached, bond the thermistor or thermocouple with a minimal amount of thermal epoxy to either the top ceramic of the thermoelectric heat

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pump or to the cold plate.

STEP 5: Connect the DC power leads (16 AWG) to the thermoelectric device leads, red to the positive lead and black to the negative lead.

CAUTION: Be careful that the polarity of the leads to the thermoelectric device are correct. Reversed polarity will cause the measured temperature to diverge from the setpoint temperature, in either direction, cooling or heating, depending on the starting conditions.

STEP 6: Be sure that the thermoelectric device is properly attached to a heat sink.

STEP 7 A: If a thermistor is being used for the temperature sensor, connect the shielded 24 AWG twisted wire pair in the DC power cable to the thermistor at the thermoelectric device. Use a pair of approximately three-inch long, .003" dia. constantan wires (or other wire of low thermal conductivity) to jumper from the 24 AWG twisted wire pair to the thermistor leads. Polarity is unimportant. Leave the shield unconnected at the cable end to prevent a ground loop condition that may cause noise.

OR

STEP 7 B: If a type T (copper/constantan) thermocouple is being used for the temperature sensor, connect the thermocouple cable to the **TC** connector on the rear panel. Attach the thermocouple to the thermoelectric device and connect it to the 24 AWG thermocouple cable while observing proper polarity.

NOTE: Strain relief of wire is important to prevent wire from breaking.

STEP 8: Be sure that the **SENSOR** switch is set to the appropriate sensor type, **TH** for thermistor or **TC** for thermocouple.

STEP 9: Keeping the **OPERATE/STANDBY** switch in **STANDBY**, turn **POWER** on.

CAUTION: To prevent damage to the thermoelectric device, do not switch to **OPERATE** until you have thoroughly read Section 3.0, *Operating Controls and Procedures*, in this Operation Manual.

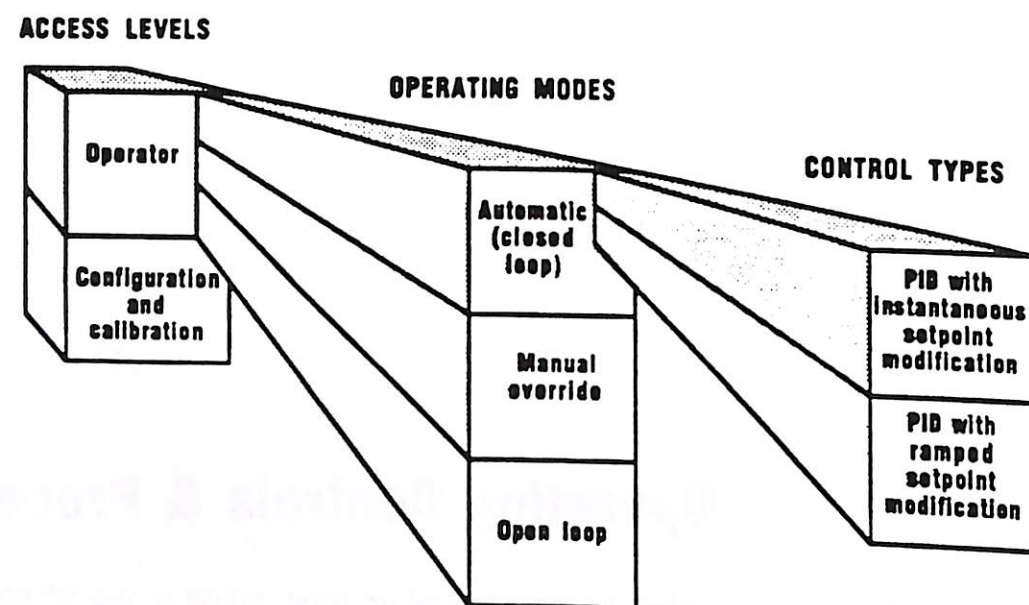
3.0 Operating Controls & Procedures

This section will assist you in obtaining a general understanding of the SE5000 Series Temperature Controller/Power Supply, its numerous controls and indicators, and basic operating procedures.

3.1 General Overview

The temperature control module features a two-level security system for operation in three modes: automatic, manual override, and open loop. In the automatic mode, two types of control are possible. Figure 3.1 shows how these access levels, operating modes, and control types are related. In addition, the controller may enter one of several abnormal conditions, such as an alarm condition, a sensor break, or a diagnostic condition. (See Section 3.7, *Alarm, Sensor Break, & Diagnostic Conditions*.)

Figure 3.1 Organization of Operator Environment



Access Levels

The configuration and calibration levels (See Fig. 3.1, *Organization of User Environment* above.) are separated from everyday operation through the use of a hardware configuration switch (W1) inside the unit. This switch is designed to prevent unintentional tampering while allowing you to enable these whenever necessary. (See Section 4.0, *Configuration*.)

Operator Level

The operator level protects the instrument from accidental modification of the calibration and configuration parameters. It also simplifies everyday, normal operation by suppressing infrequently modified parameters and shortening the parameter list presented to the operator. The operators' list is defined at the configuration and calibration level.

Configuration and Calibration Level

The more than 30 parameters maintained in the non-volatile memory determine the operation of the Temperature Controller/Power Supply. (See Section 4.0, *Configuration*.) You can modify these parameters from the as-delivered configuration to tailor the instrument to specific requirements through two procedures: selecting values for specific parameters and assigning an access level for each parameter in an abbreviated operators' parameter list.

CAUTION: Do not attempt calibration of the controller. The instrument must be returned to Marlow Industries, Inc., for proper recalibration. (See Section

6.3, Customer Service.)

Operating Modes

At the operator access level, you may operate the control module at three different operating modes:

Automatic Operating Mode (Closed-Loop)

This is the control module's routine operating mode and is the mode in which the unit is factory-set. In this mode, the measured value and the setpoint are in view in the dual displays, and you can modify the temperature setpoint and all alterable displayed parameters.

Manual Operating Mode

CAUTION: To prevent damage to your thermoelectric device or assembly, do not attempt to operate the Temperature Controller/Power Supply in the manual mode until you have thoroughly read, Section 3.0, *Operating Controls and Procedures*.

This mode is for manual adjustment of the output current level from the front panel. When selected, it overrides the output level required by the control action of the automatic mode. In this mode, the measured value and the output level (%) are in view in the dual displays. All alterable displayed parameters can be modified as in the automatic mode. Entrance to the manual mode can be inhibited at the configuration level. (See Section 4.0, *Configuration*.)

Open-Loop Operating Mode

This is an involuntary mode that occurs only upon detection of a broken input sensor. Depending on the degree of access determined by the configuration, the operator may modify the output level or by pushing the A/M button can enter the manual mode, or wait for a return to the automatic mode as soon as the input sensor is repaired. The manual light flashes to indicate this mode.

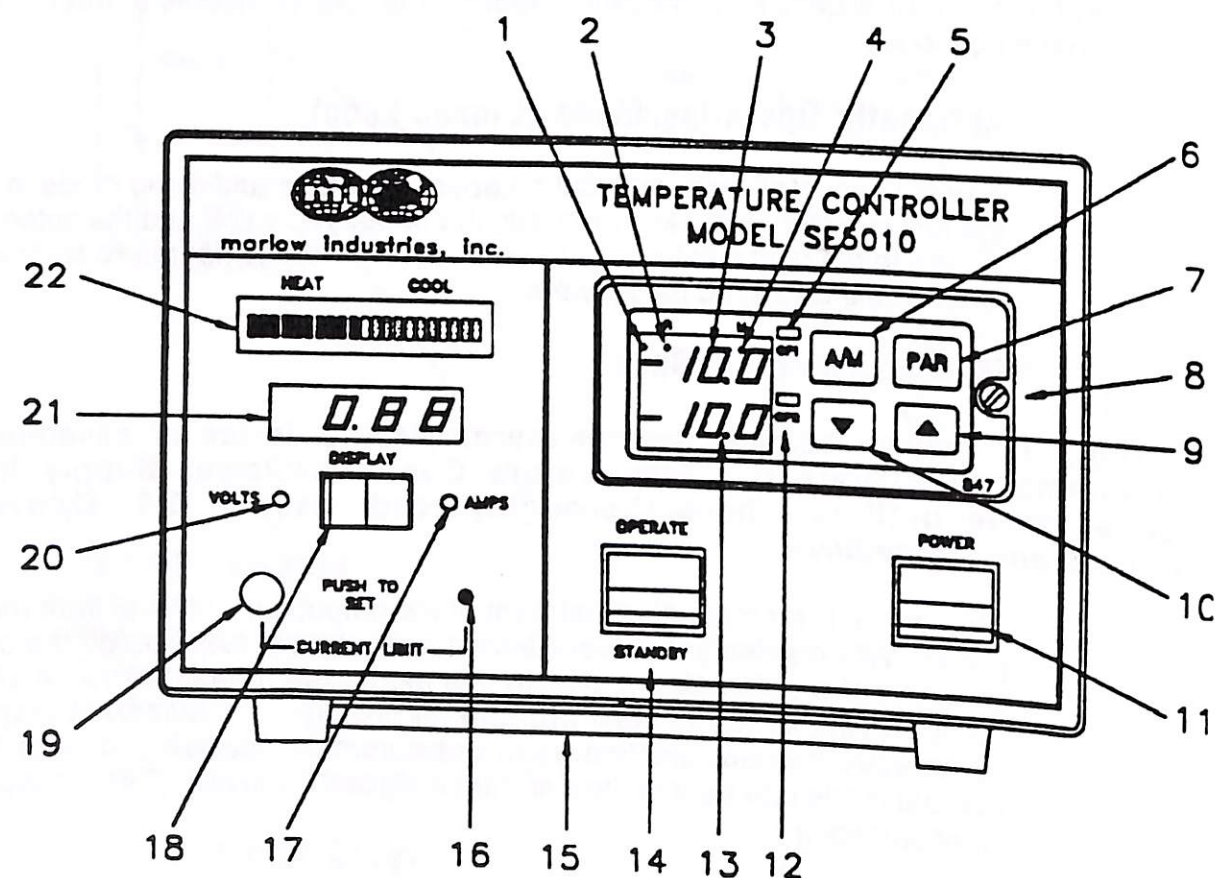
Control types

The control module can be configured to function with one of two control actions for use in the automatic mode: (See Section 3.4, *Front Panel Procedures*.)

- PID control with instantaneous setpoint modification
- PID control with ramped setpoint modification for controlling rate of temperature change.

3.2 Overview of Controls/Indicators

Figure 3.2 Front Panel Controls/Indicators



Controls/Indicators

For a complete explanation of each control or indicator, see Section 3.3, Functions of Front/Rear Panel Controls/Indicators.

- 1 Indicates communications transmission to host computer is in progress
- 2 Indicates "R" ramp-to-setpoint in progress
- 3 Upper green display of a measured value as selected on the parameter list or abnormal condition
- 4 Indicates "M" manual mode active
- 5 Output 1 energized light
- 6 Automatic/manual operation selection switch
- 7 Parameter scroll and alarm acknowledge pushbutton
- 8 Jack screw (used in configuring the instrument)
- 9 Up arrow for increasing value of parameter selected
- 10 Down arrow for decreasing value of parameter selected
- 11 Power switch

- 12 Output 2 light (not used)
- 13 Lower green display of temperature setpoint, output level setpoint, and parameter values or alarm condition
- 14 Operate/standby switch
- 15 Tilt-up stand
- 16 Current limit adjustment
- 17 Indicates amps selected for display
- 18 Volts/amps selection switch
- 19 Push to set current limit button
- 20 Indicates volts selected for display
- 21 Output voltage or current display
- 22 Heat/cool mode bargraph display indicating approximate percentage of current limit setting

Power Supply Controls/Indicators

NAME	FUNCTION AND RANGE
POWER	Applies AC Power
OPERATE/STANDBY	Selects Power Supply Operating Mode
VOLTS/AMPS	Indicates Units in Display
DISPLAY	Displays Output Voltage or Current
HEAT/COOL Bargraph	Red indicates HEATING as percentage of current limit Green indicates COOLING as percentage of current limit
PUSH TO SET--CURRENT LIMIT	Used to set current limit

Temperature Control Module Controls/Indicators

PAR	Parameter Selection: Mnemonics in Upper Green Display Value/mnemonics in Lower Green Display
-----	--

Parameter List:
Normal: Top Display--Measured Temperature
Lower Display--Setpoint (Output level in Manual)

MNEMONIC	FUNCTION
HIAL	High Alarm Setpoint: Range same as sensor
LoAL	Low Alarm Setpoint: Range same as sensor
d AL	Deviation Alarm Setpoint: 0.1 to 500.0°C (900.0°F)
Prop	Proportional Band: 0.1 to 500.0°C (900.0°F)
Int.t	Integration Time Constant: OFF, 1 to 8000 sec.

Temperature Controller/Power Supply Operation Manual

der.t
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SP L
H PL
C F
Sn

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bAud

Idno
Ctrl
SPrr
SP
OFSt

A/M
▽

△

OP1

OP2
R

M

SENSOR

Derivative Time Constant: OFF, 1 to 999 sec.
Setpoint High Limit: Range same as sensor
Setpoint Low Limit: Range same as sensor
Maximum Power Limit: 0.0 to 100.0%
°C/°F Selection

Sensor Selection: TH 1, TH 2, TH 3, TH 4,
or TC

Instrument Address: 0.0 to 9.9

Baud Rate: 300; 600; 1200; 4800; 9600; 19,200
(19.2)

Identification Number: 0 to 9999

Control Type: Pld or r SP

Setpoint Ramping Rate: 0.01 to 99.99%/min.

Setpoint Range: SP L to SP H

Calibration Offset: -9.99 to 99.99°

Auto or Manual Control Mode Selection

Down Arrow Decreases Value of Parameter
Selected

Up Arrow Increases Value of Parameter
Selected

Output 1 Light--Intensity varies directly with
magnitude of output signal, OFF for 0%
(maximum cooling) and maximum intensity for
100% (maximum heating)

Output 2 Light--Not Used

Dot under R is illuminated when ramp-to-setpoint
is in progress

Dot under M is illuminated when in the manual
mode

Selects sensor type TH (thermistor) or TC
(thermocouple) (located on rear panel)

NOTE: Addr, bAud, Idno, and OFSt are normally hidden from view. Addr, bAud, and Idno are accessible if equipped with either RS-232-C or RS-422-A communications option. OFSt can be made accessible by the user. (See Section 4.0, Configuration.) SPrr is accessible only when Ctrl is set to r SP (ramp-to-setpoint).

Two parameters--ACCS and CAL--can only be viewed with the hardware configuration switch (W1) closed. (See Section 4.0, Configuration.)

- ACCS (access) allows you to assign one of three security levels to each parameter. (See Section 4.3, Access Assignment.) Each parameter can be either:
 - (rAd) included in the operators' list with modification privileges,

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- (rAd) included in the operators' list with no modification privileges, or
- (Mde) excluded from the operators' list.

- CAL (calibration) enables the calibration procedure. This is performed either by reloading the permanently-stored factory calibration parameters (See Section 4.4, Offset Adjustment and Factory Calibration.), or by a complete recalibration.

CAUTION: Do not attempt calibration of the controller. The instrument must be returned to Marlow Industries, Inc., for proper recalibration. (See Section 6.3, Customer Service.)

3.3 Functions of Front/Rear Panel Controls/Indicators

Power Supply Controls

Switches

POWER (See Figure 3.2, Control #11)
The **POWER** switch applies AC power.

OPERATE/STANDBY (See Figure 3.2, Control #14)
The **OPERATE/STANDBY** switch selects the power supply operating mode. The output of the power supply is disconnected when the switch is set to **STANDBY** and is connected when set to **OPERATE**.

VOLTS/AMPS (See Figure 3.2, Control #18)
The **VOLTS/AMPS** switch allows you to select the read out mode: volts or amps.

PUSH TO SET--CURRENT LIMIT (See Figure 3.2, Controls #16 and #19)
The **PUSH TO SET--CURRENT LIMIT** button is used to set the current limit. When in **STANDBY** mode, the **PUSH TO SET** button is used to apply maximum input signal to the power supply to permit you to set the **CURRENT LIMIT** control to the desired current limit.

Indicators

DISPLAY (See Figure 3.2, Indicator #21)
The three and one-half digit red LED **DISPLAY** indicates either output voltage in volts or output current in amps dependent upon the position of the **VOLTS/AMPS** switch.

VOLTS (See Figure 3.2, Indicator #20)

The red LED **VOLTS** light indicates that volts is the unit of **DISPLAY**.

AMPS (See Figure 3.2, Indicator #17)

The red LED **AMPS** light indicates that amps is the unit of **DISPLAY**.

HEAT/COOL (See Figure 3.2, Indicator #22)

The **HEAT/COOL** bargraph indicates that the unit is in the heating or cooling mode. The red/green LED bargraph display indicates the approximate percentage of the **CURRENT LIMIT** setting. Each segment indicates approximately 10% of current limit setting. Red indicates heating (negative current polarity) and green indicates cooling (positive current polarity). The yellow middle segment LED illuminates to indicate less than 10% of current limit setting.

Temperature Control Module Indicators

Upper Green Display (See Figure 3.2, Indicator #3)

The upper green display indicates the measured value in the automatic or manual modes and mnemonics when viewing the parameter list with the **PAR** button, or when an abnormal condition exists.

Lower Green Display (See Figure 3.2, Indicator #13)

The lower green display indicates temperature setpoint in the automatic mode, output level setpoint (%) when in the manual mode, and parameter values when viewing the parameter list with the **PAR** button. If the measured value enters one or more alarm conditions, the appropriate mnemonic(s) (**HIAL**, **LoAL**, and **d AL**) alternate with the displayed setpoint.

Output Lights (OP1 and OP2) (See Figure 3.2, Indicators #5 and #12)

The intensity of lamp **OP1** varies directly with the magnitude of the output signal: off for maximum cooling, highest intensity for maximum heating. **OP2** is not used.

R Light (See Figure 3.2, Indicator #2)

The **R** light indicates ramp-to-setpoint in progress. Identified by the legend "R" above the upper display, this green LED dot is illuminated during the period when the controller is ramping from the actual measured value to the new setpoint. This lamp is only illuminated if ramp-to-setpoint operation has been enabled in the instrument configuration. When **PAR** is pressed during ramping, the lamp flashes as the operator inspects the instantaneous setpoint. (See Section 3.4, Subsection, *Ramp Mode Indicators*.)

M Light (See Figure 3.2, Indicator #4)

The **M** light indicates manual mode operation. The green LED dot—underneath the "M" above the upper-right corner of the upper display—is illuminated when the instrument is in the manual mode. A flashing manual light indicates the open-loop mode.

Additional Green Light (See Figure 3.2, Indicator #1)

An additional green LED light, located in the upper-left corner of the upper display (with no legend), is illuminated when the controller is receiving/transmitting information from/to the host computer. The light can be operative only if an optional communications board (RS-232-C or RS-422-A) is installed.

Temperature Control Module Switches

PAR (See Figure 3.2, Control #7)

The **PAR** parameter pushbutton function is used to advance to the next parameter when examining the parameter list.

△ & ▽ (See Figure 3.2, Controls #9 and #10)

The up and down value arrows are dedicated to increasing and decreasing the value of the parameter currently displayed. Most parameters have continuously variable numeric values; examples of these include setpoint, integral time constant. Others can be assigned only discrete values that are presented in a list in the Lower Green Display; these are mainly the configuration parameters, such as control type, sensor type.

For the numeric values, pressing the UP **△** (DOWN **▽**) button once increases (decreases) the displayed value by one digit. Holding a button down constantly causes the value to increase or decrease automatically as long as the button is depressed. The rate of change of the numeric value increases as long as the button is depressed to save the operator time in long range changes. The operation is identical for discrete values, except that each button push reveals the next value in the list.

A/M Button (See Figure 3.2, Control #6)

The **A/M** button selects automatic or manual mode operation. Pressing the **A/M** button when the controller is in the automatic mode places the controller in the manual mode. Pressing the button again returns the controller to automatic. The transition is transient-free: when transferring from automatic to manual, the output level in manual is determined by the most recent steady-state requirements in automatic; when switching from manual to automatic, the output level required to attain the desired setpoint is smoothly reached by integral action.

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This button can be disabled when configuring the instrument, then the controller remains permanently in the automatic mode. Normal configuration is with the **A/M** button enabled.

TH/TC SENSOR (See Figure 2.1, Control #7)

Located on the rear panel, the **TH/TC SENSOR** slide switch sets the sensor type:

- In the **TH** (thermistor) position, a shunt resistor establishes the proper calibration for all thermistor types.
- In the **TC** (thermocouple) position, the resistor is switched out.

3.4 Front Panel Procedures

Every keystroke is accompanied immediately by visual feedback—a change in a parameter value or a change of state of a lamp. There are no double keystroke sequences.

If there is no response, verify that modification of all the parameters has not been locked out. If it has not, the control module may need maintenance.

Procedures Common to Automatic and Manual Mode

Modifying the Setpoint

The setpoint can be freely modified within the high and low limits. With the measured value in the upper display and the temperature setpoint in the lower display, use the **UP** $\triangle$ and **DOWN** ∇ pushbuttons to change the value.

In the manual mode, the percent of power output is the parameter modified by this same procedure; its upper limit may have a ceiling placed on it by **PL** (high power limit).

Locating and Modifying an Adjustable Parameter

STEP 1: With the instrument displaying the measured value and the setpoint, press **PAR** once to reveal the display units (**C** or **F**).

STEP 2: Press **PAR** once again to show the next enabled parameter and its current value on the display. Use the **UP** $\triangle$ and **DOWN** ∇ pushbuttons to modify the parameter value. To display the next parameter and its current value, press **PAR** again. Repeat as needed.

If the **PAR** button is untouched when viewing a particular parameter, the

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display returns to the measured value and the setpoint after 6 seconds. To override this 6-second timeout and permit viewing as long as desired, hold down **PAR**.

STEP 3: To modify a specific parameter, pressing **PAR** repeatedly until its mnemonic appears in the upper display, then modify the value with the **UP** $\triangle$ and **DOWN** ∇ pushbuttons.

These procedures are valid in either the automatic or manual modes, whether the measured value is in an alarm condition or not. (See Section 3.7, *Alarm, Sensor Break, & Diagnostic Conditions*.) Some parameter values may not respond to the **UP** $\triangle$ and **DOWN** ∇ buttons; these have been configured for viewing only at this level and not for operator modification. Others may be completely hidden from the operator. (See Section 4.0, *Configuration*.)

Setting Current Limits

CAUTION: To prevent damage to your thermoelectric device, be sure not to exceed the maximum rated current for the device as provided on its product specification sheet.

Be sure the **OPERATE/STANDBY** switch is in **STANDBY**. Press the **PUSH TO SET** button. To adjust the current limit: insert a small screwdriver through the front panel and turn the slotted shaft of the potentiometer while pressing the **PUSH TO SET** button and observing **DISPLAY** until **CURRENT LIMIT** is at desired setting. (See Figure 3.2, *Front Panel Controls/Indicators*.) Scroll to **PL** and set the % output level to limit the heating mode current limit to the desired value.

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Values of output level vs. output current are given in Table 3.1.
NOTE: Output Current is given as % of Current Limit.

TABLE 3.1
Output Level vs. Output Current

OUTPUT LEVEL(%)	OUTPUT CURRENT(%)
100.0	-100.0
90.0	- 80.0
80.0	- 60.0
70.0	- 40.0
60.0	- 20.0
50.0	0.0
40.0	20.0
30.0	40.0
20.0	60.0
10.0	80.0
0.0	100.0

The equation for the values in Table 3.1 is :

$$\text{Output Current(\%)} = -2 \times \text{Output Level(\%)} + 100$$

Example:

Current Limit set to 2 AMPS for cooling mode
 M PL set to 70.0%
 Then heating mode current limit is:
 $2 \text{ Amps} \times -0.40 = -0.8 \text{ AMPS}$

Additional Procedures for Manual Mode

CAUTION: When the Temperature Controller/Power Supply is in **OPERATE** mode and operating in the heating mode (negative current), exercise extreme caution to prevent overheating and destroying the thermoelectric device. Adjust current level very slowly by changing output level in single increments while observing measured temperature.

The manual mode may be activated by the **A/M** pushbutton and indicated by the green "M" LED dot. In the manual mode, the measured value appears in the upper display and the percent output level (0% = maximum positive current limit, 50% = OFF, and 100% = maximum negative current limit) in the lower display. (See Table 3.1.). When entering the manual mode from the automatic mode, the initial output level is the most recent calculated output level. Adjust the output level with the UP $\triangle$ and DOWN ∇ buttons to obtain the desired current output. Access to the

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manual mode can be inhibited in the configuration with the **AM** parameter.

Automatic Mode (with Ramp-to-Setpoint) Procedures

Ramping can be initiated in only 2 conditions: power-up and a change in setpoint. To perform ramp-to-setpoint operation, select **r SP** at the **Ctrl** parameter in the instrument configuration; this insures bumpless setpoint modification. The instantaneous setpoint follows a straight line joining the original measured value to the target setpoint. Select the rate at which ramping will progress (in °F/min or °C/min) with the **SPR** (setpoint ramping rate) parameter; it will remain constant for all ramps until **SPR** is changed.

Ramp Mode Indicators

During ramping, the upper display shows the measured value (as in normal automatic or manual operation); the lower display shows the target setpoint. During ramping segments the "R" lamp is illuminated. After the new target setpoint has been reached, the lamp goes out. To view the instantaneous setpoint during a ramping segment, depress the **PAR** button. The "R" lamp flashes to indicate that the value in the lower display is the current instantaneous setpoint. (The instantaneous setpoint display replaces the measured value units display [°C or °F] normally viewed after the first button push.)

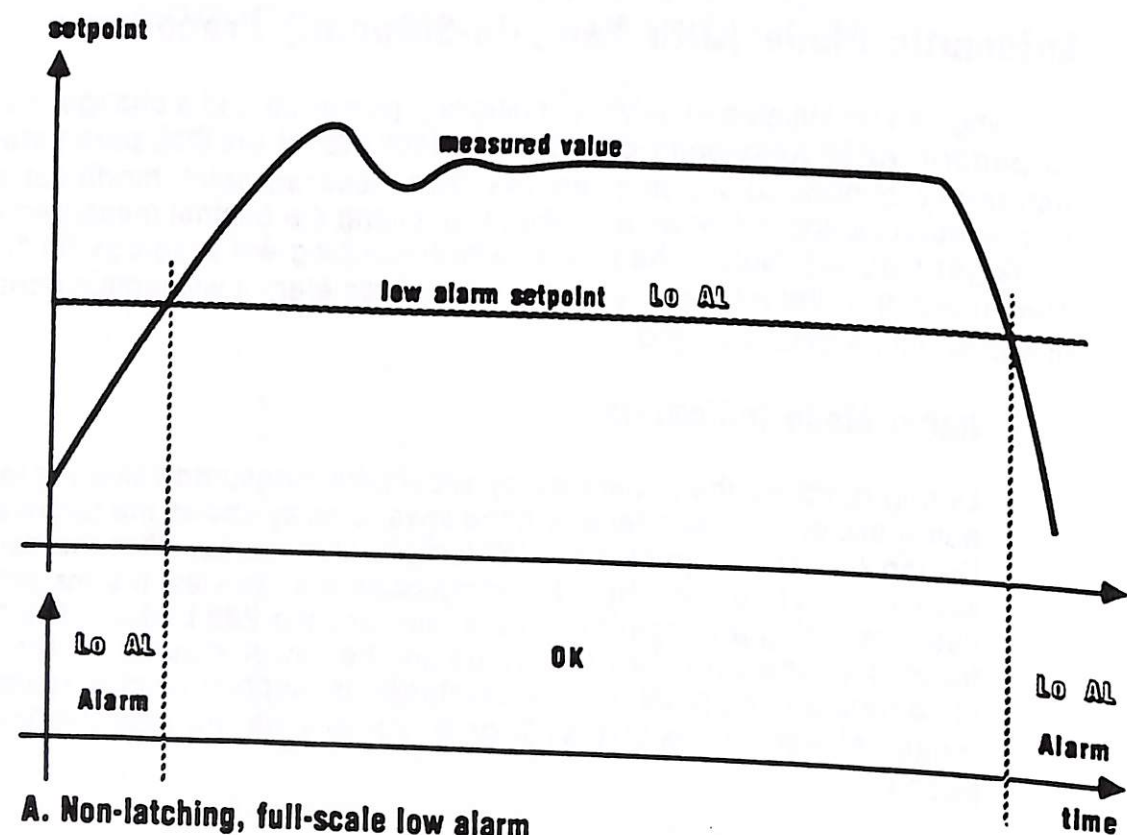
Ramping and Alarms

If the measured value follows a ramping setpoint through an alarm region, the alarms are detected and displayed as usual. As shown in Figure 3.3, two types of reactions are to be noted:

- **"Full scale" high and "full scale" low alarms.** (See Fig. 3.3 A.) The alarms are non-latching; therefore, crossing the alarm setpoints into the "safe" region turns off the alarm.
- **Deviation alarm.** (See Fig. 3.3 B.) The deviation alarm band follows the currently active setpoint. If the measured value cannot track the setpoint within the bounds of the deviation alarm, the alarm is turned on.

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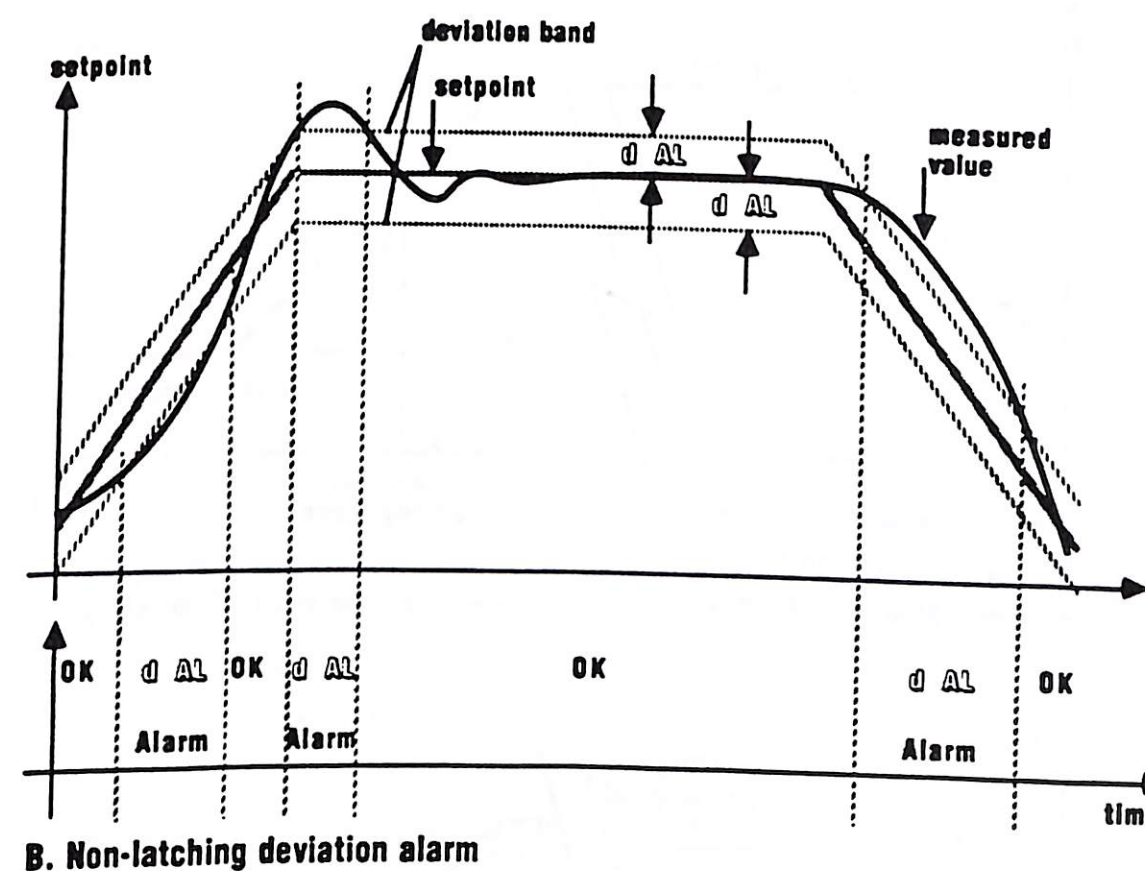
Figure 3.3. Ramp-to-Setpoint Operation and Alarms



A. Non-latching, full-scale low alarm

(continued on next page)

Figure 3.3. Ramp-to-Setpoint Operation and Alarms
(continued from previous page)



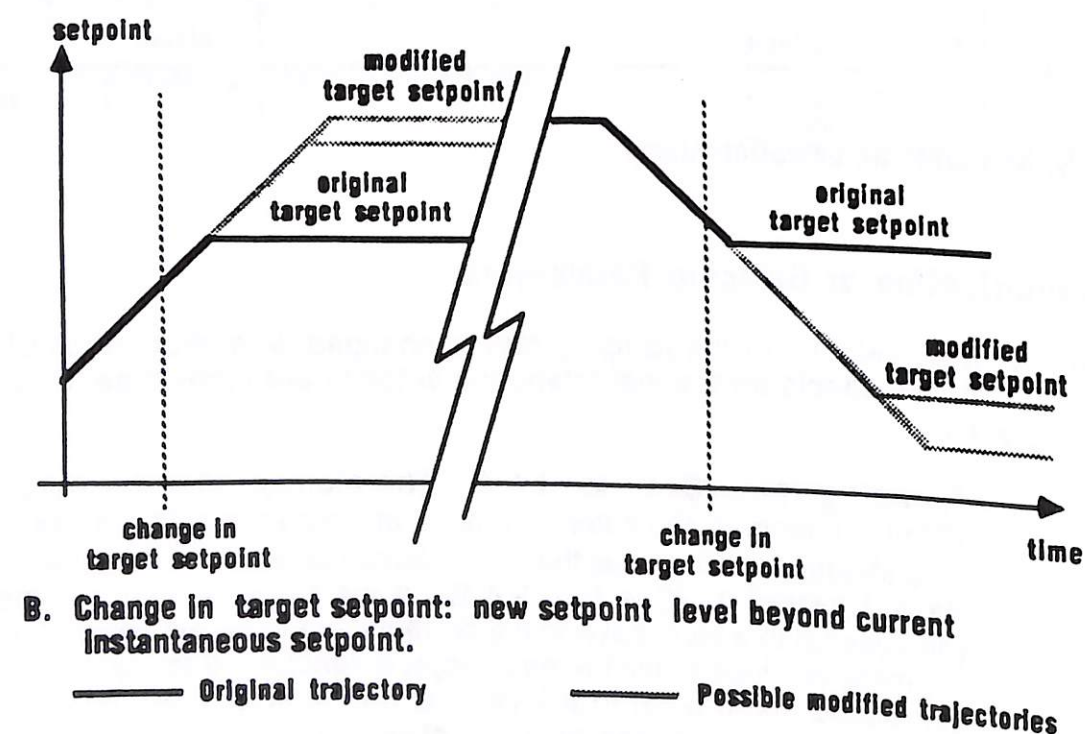
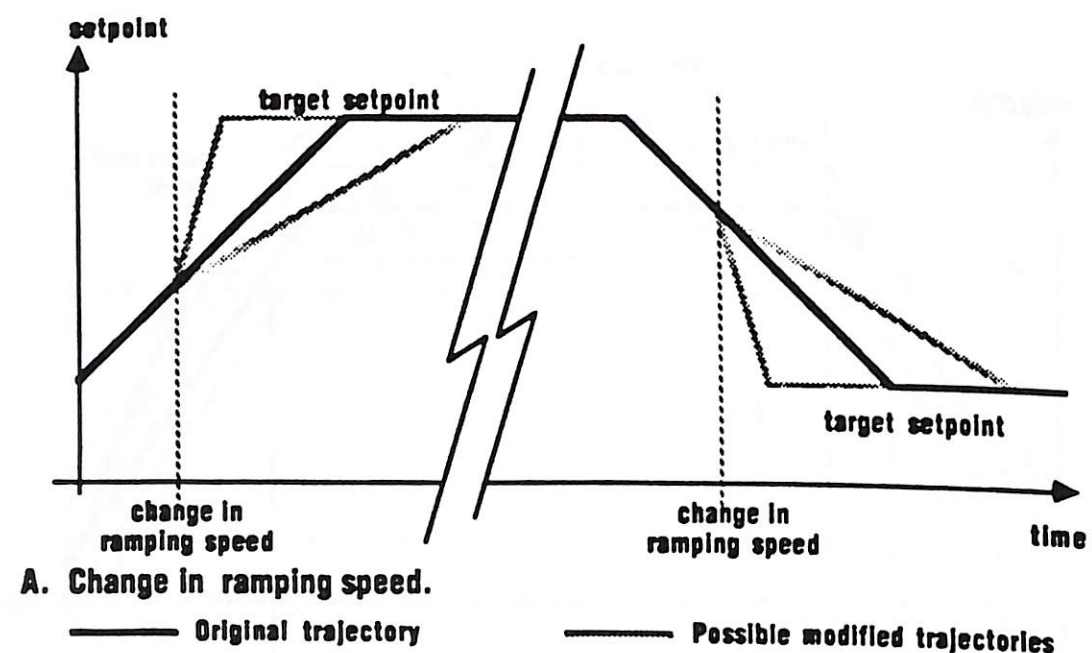
B. Non-latching deviation alarm

Modification of Ramping Parameters

If the target setpoint or the ramping rate is changed, in mid-progress of a ramp segment, the effects on the instantaneous setpoint are immediate, as shown in Figure 3.4.

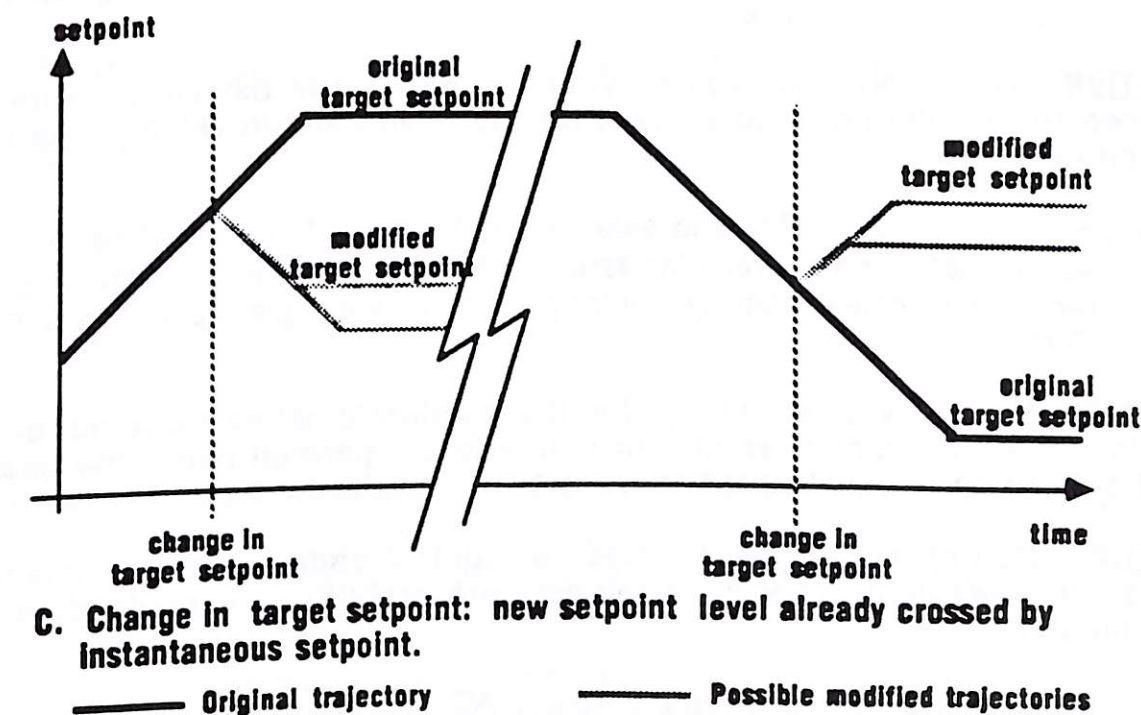
- **Ramping rate.** (See Fig. 3.4 A.) The moment that the ramping rate (SPT) is changed, the speed changes at which the setpoint rises or falls. This shortens or lengthens the time required to reach the target setpoint.
- **Target setpoint.** (See Fig. 3.4 B.) If the target setpoint is increased (decreased) to a level beyond the current instantaneous setpoint, the ramp segment continues until the new target is reached. If the target setpoint is decreased (increased) to a level that has already been crossed by the ramp, the slope changes sign (negative/positive) and the instantaneous setpoint ramps toward the new target setpoint.

Figure 3.4 Effect of Ramp Modification on a Ramp Segment In Progress



(continued on next page)

Figure 3.4 Effect of Ramp Modification on a Ramp Segment In Progress (continued from previous page)



3.5 Automatic Mode Operation

Units are factory-set in the automatic mode. This mode is indicated when the dot under the "M" in the upper display is unlit.

STEP 1: Be sure that the **OPERATE/STANDBY** switch is in **STANDBY**.

STEP 2: To select sensor type, press **PAR** repeatedly to scroll to Σ . Then use UP Δ / DOWN ∇ arrows to select sensor type that corresponds to sensor being used, i.e., TH 1, TH 2, TH 3, TH 4, or t_{tc}. Ensure that the **SENSOR** switch on the rear panel is set to the proper sensor type **TH** for a thermistor or **TC** for a thermocouple. (See Appendix, Section C.1, *Sensor Types*.)

CAUTION: The following sensor types should not be used: J_{tc}, CAtc, PL2, r_{tc}, S_{tc}, .Jtc, rtd3, L_{tc}, .Ltc, Lin, .Lin. Use of these sensors can result in temperature errors, loss of control, and damage to the thermoelectric device.

STEP 3: To adjust the temperature setpoint, use the UP Δ and DOWN ∇ buttons.

STEP 4: Press **PUSH TO SET** button and while observing **DISPLAY**, insert a small

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screwdriver through the front panel and turn the slotted shaft of the potentiometer to adjust the **CURRENT LIMIT** to the desired setting. (See Section 3.4, *Front Panel Procedures*.) Scroll to **PL** and set the % output to limit the heating mode current limit to the desired value.

CAUTION: To prevent damage to your thermoelectric device, be sure not to exceed the maximum rated current for the device as provided on its product specification sheet.

STEP 5: Scroll to **Ctrl** and select control mode, **Pid** or **r SP**. If **r SP** is selected, scroll to **SPrr** and set ramping rate. Set PID parameters **Prop**, **Int.t**, and **dEr.t** as required to achieve stability. Tuning procedures are explained in Section 5, *Tuning Tutorial*.

CAUTION: To achieve stability, the thermoelectric device should be in an enclosure which minimizes air currents and, if operated below the dew point, it should be in a dry atmosphere to prevent condensation and/or icing.

CAUTION: Do not use the **On.OF.** mode of control under any circumstances--to do so will result in very poor temperature stability and could damage the thermoelectric device.

STEP 6: Use **PAR** and **UP** Δ / **DOWN** ∇ arrows to scroll to and set/verify the following parameters: **HIAL**, **LoAL**, **d AL**, **Prop**, **Int.t**, **dEr.t**, **SP H**, **SP L**, **C F**, and, if equipped with an RS-232-C or RS-422-A interface option, **Addr**, **bAud**, and **Idnc**.

STEP 7: Ensure **A/M** is set to automatic mode. Set **VOLTS/AMPS** switch to desired position. Set the temperature setpoint to the desired value and set **OPERATE/STANDBY** switch to **OPERATE** to start controlling temperature.

3.6 Manual Mode Operation

Perform Steps 3.4.1 through 3.4.6 in the previous subsection, then set to manual mode through the **A/M** pushbutton. Entrance to the manual mode can be inhibited in the configuration.

Use **UP** Δ / **DOWN** ∇ arrows to set the % output to 50.0%. Set **VOLTS/AMPS** switch to **AMPS**, set **OPERATE/STANDBY** switch to **OPERATE**, and use **UP** Δ / **DOWN** ∇ arrows to set to desired current level. Read measured temperature in the upper display of the control module and % output in the lower display. Read output current in **DISPLAY**.

CAUTION: Do not exceed the maximum rated current of the thermoelectric device. Exercise extreme caution when operating in the heating mode

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(negative current) to prevent overheating and destroying the device. Adjust current level very slowly in single increments while observing measured temperature.

3.7 Alarm, Sensor Break, & Diagnostic Conditions

Alarm

When the lower display indicates **HIAL**, **LoAL**, and/or **d AL** alternating with the setpoint, the measured value has entered an alarm condition.

Sensor Break

Overrange Condition

- A broken thermistor/thermocouple or open input circuit is indicated by the mnemonic **Snb** (sensor break).
- The measured temperature value rises rapidly for a thermocouple (falls rapidly for a thermistor) before the overrange sensor break condition occurs.
- The controller then enters the open-loop mode and outputs the sensor break power selected by the **SnbP** parameter (normally 50.0% which indicates the unit is neither heating nor cooling).

Underrange Condition

- An incorrect thermocouple, reversed thermocouple connection, or shorted thermistor is indicated by the mnemonic **ur** (underrange).
- The measured temperature value rises rapidly for a shorted thermistor before the underrange sensor break condition occurs. However, for a reversed connection of a thermocouple or an incorrect thermocouple, the measured value falls.
- The controller then enters the open-loop mode and outputs the sensor break power selected by the **SnbP** parameter (normally 50.0% which indicates the unit is neither heating nor cooling).

Automatic Transfer to Open-Loop Mode

This mode is indicated by a flashing "**M**" light. When the faulty input condition is repaired, the controller reinstates automatic operation (if it is not placed into the manual mode by the operator).

CAUTION: Set **OPERATE/STANDBY** to **STANDBY** until fault is cleared.

There are two operating procedures depending on whether or not manual

operation has been previously authorized with the **A/M** parameter in the Instrument configuration:

- If manual operation has been used (normal), the operator can modify the sensor break power with the UP Δ and DOWN ∇ pushbuttons. By pushing on the **A/M** button, the operator can enter the manual mode. Transfer to the automatic mode is then possible only by pressing the **A/M** button again (dependent on whether the input fault has been corrected). If the controller remains in the open-loop mode and the input fault is repaired, it resumes automatic operation.
- If only automatic operation has been used, the UP Δ and DOWN ∇ and **A/M** buttons are disabled and the controller transfers from the open-loop mode to automatic as soon as the input condition is rectified. If only automatic operation is desired, the **A/M** parameter in the configuration list must be changed.

Diagnostic Condition

Checksum Error

The SE5000 Series Temperature Controller/Power Supply is self-diagnostic. If a checksum error is indicated by the message **CErr** in the lower display, close the hardware configuration switch (**W1**) (See Section 4.0, *Configuration*), push **PAR** and scroll and go to the bottom of the parameter list where the **CAch** and **EEch** parameters (and their values) are displayed. (**CAch** is the checksum value of the EPROM/ROM calculated by the microprocessor, and **EEch** is the correct checksum value stored in the EPROM. Note the values for **CAch** and **EEch** and the version number of the software; then call Marlow Industries, Inc. (See Section 6.3, *Customer Service*.) (The software version number is displayed in the lower display for 1 second after application of power to the instrument.)

CAUTION: If **CErr** appears, *something is wrong* with the instrument and it should not be used. Return it to Marlow Industries, Inc., for inspection and repair. (See Section 6.3, *Customer Service*.)

4.0 Configuration

There are more than 30 parameters maintained in non-volatile memory that determine the operation of the SE5000 Series Temperature Controller/Power Supply. These parameters can be modified from the "as-delivered" configuration to tailor the controller to specific requirements.

Two versions of the parameter list can be scrolled and viewed in the upper green display of the temperature control module: the complete version for configuration purposes and an abbreviated version with only user-designated parameters available to the operator for convenience and security during normal operation.

Configuration consists of two procedures:

- Selection of values for specific parameters
- Assignment of an access level for each parameter in the abbreviated operators' parameter list as required by the operator.

4.1 Full List Enable

CAUTION: Care should be taken to avoid electrostatic discharge (ESD). All work should be performed at a static-free work station. If a static-free work station is not available, avoid touching components on printed circuit boards while handling temperature control module out of its sleeve.

The complete parameter list is enabled by the hardware configuration switch (**W1**) located inside the instrument. To access the switch, proceed as follows:

STEP 1: Be sure the **OPERATE/STANDBY** switch is in **STANDBY**, then turn **POWER** off.

STEP 2: Remove the temperature control module from its sleeve by unscrewing the jack screw.

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STEP 3: Close the hardware configuration switch (W1) near the rear of the module on the left hand side.

STEP 4: Re-install the module in the sleeve and secure with the jack screw.

STEP 5: Turn **POWER** on.

NOTE: For normal operation, the switch should be left **OPEN**. Only during configuration should the switch be **CLOSED**.

4.2 Parameter Protection

Each parameter can be assigned one of three security levels to prevent accidental modification or tampering by unauthorized personnel. Procedures for assigning these levels follow Table 4.1. The three levels are:

- **ALTR.** The operator is at liberty to view and modify the value of the parameter.
- **READ.** The parameter and its value are presented on the operators' list, but modification of the parameter is inhibited. The parameter value can be changed only by entering the configuration and calibration access level.
- **HIDE.** The parameter is removed from the operators' list; viewing and modification of the parameter value is then only possible at the configuration and calibration access level.

CAUTION: Remove critical parameters from the operators' list to prevent inadvertent modification or tampering of configuration parameters or parameter values.

Front-panel access time to pertinent parameters is reduced by removing from the operators' list those parameters whose values are determined solely by the instrument application. Standard configuration is shown in Table 4.1. Other parameters may be hidden with **HIDE**.

Table 4.1
Standard Configuration
(continued on next page)

<u>MNEMONIC</u>	<u>PARAMETER</u>	<u>SETTING</u>	<u>ACCESS</u>
Hb***	Holdback band	500.0	HIDE
HIAL	High alarm setpoint	SP Hi Limit	ALTR
LoAL	Low alarm setpoint	SP Lo Limit	ALTR
dAL	Deviation alarm setpoint	30.0°C	ALTR
Prop	Proportional band	10.0°	ALTR
Int.t	Integral time constant	4s	ALTR
der.t	Derivative time constant	OFF	ALTR
SP L	Setpoint low limit	-99.9°C	ALTR

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Table 4.1
Standard Configuration
(continued from previous page)

<u>MNEMONIC</u>	<u>PARAMETER</u>	<u>SETTING</u>	<u>ACCESS</u>
SP H	Setpoint high limit	100.0°C	ALTR
H AO	High alarm output	OFF	HIDE
L AO	Low alarm output	OFF	HIDE
d AO	Deviation alarm output	OFF	HIDE
H PL	Maximum power limit	100.0%	ALTR
SubP	Sensor break power level	50.0%****	HIDE
OFSt	Calibration offset	0.00°	HIDE**
C F	°C/°F selection	C	ALTR
Sn	Sensor selection	tH 1	ALTR
Addr	Instrument address	0.0	HIDE*
bAud	Baud rate	9600	HIDE*
Idno	Identification number	0	HIDE*
Ctrl	Control type	PID	ALTR
SPrr***	Setpoint ramping rate	10.0°/min	ALTR
OP 1	Output 1 configuration	0-20	HIDE
OP 2	Output 2 configuration	OFF	HIDE
A H	Auto/manual enable	HAND	HIDE
CJC****	CJC reference selection	INT	HIDE
Pb d	Proportional band display	C-F	HIDE
Cb	Cutback operation	AUTO	HIDE
Act	Control action	REV	HIDE
ACCS	Parameter access assgmn.	(blank)	N/A
CAL	Calibration	----	N/A

- * ALTR if unit is equipped with either RS-232-C or RS-422-A communications option.
- ** May be set to ALTR by user.
- *** Mnemonic displays only when Ctrl is set to r SP.
- **** Indicates the unit is neither heating nor cooling. (See Section 3.8, Subsection *Sensor Break*.)
- ***** Mnemonic displays only when t to thermocouple is selected at Sn.

NOTE: Other mnemonics not in Table 4.1, *Standard Configuration*, above, are associated with the unused OP2 output channel which will appear (if OP2 is not set to Off) as you scroll through the access assignments. Ignore those not listed above.

4.3 Access Assignment

Use the following procedure to compose the operators' abbreviated parameter list. Only

those parameters that are shown as alterable (**ALt**) in Table 4.1 are to be used or altered from the standard configuration shown.

STEP 1: Enable the full parameter list with the hardware configuration switch (**W1**) using the procedures in Section, 4.1, *Full List Enable*.

STEP 2: Scroll down to **AGCS** by repeatedly pushing on the **PAR** button. The lower display will be blank.

STEP 3: Use UP Δ to display the first parameter in the lower display. (**PAR** terminates the procedure.)

STEP 4: Use DOWN ∇ to scroll through the possible selections visible in the upper display: **ALt**, **READ**, or **HIDE**. Press UP Δ after the desired access level appears to assign this level to the particular parameter, and view the next parameter in the lower display.

STEP 5: Continue this procedure until each parameter is assigned an access level. If no assignments are being made, after 5 seconds the display will automatically return to the condition and mode the unit was in when you began the procedure. Use **PAR** to leave this sub-scroll at any time remembering that the last parameter viewed is assigned the access currently visible in the upper display.

STEP 6: Be sure the **OPERATE/STANDBY** switch is in **STANDBY** and **POWER** is off. Remove the temperature control module from its sleeve again and reopen the hardware configuration switch (**W1**). Re-install the module in the sleeve and secure with the jack screw. Turn **POWER** on.

4.4 Offset Adjustment and Calibration

Determining if Recalibration is Advisable or Necessary

Final calibration of the temperature control module is performed at the factory after the unit has been burned-in and component values have stabilized to their life-long values. Under normal conditions, it should never require recalibration after leaving the factory.

CAUTION: Never attempt calibration of the controller other than thermistor calibration or restoration of original factory calibration for thermocouples. Recalibration can only be performed by Marlow Industries, Inc. (See Section 6.3, *Customer Service*.)

Most often it is the offset (**@fst**) that requires adjustment and not instrument calibration. There are normally three instances when offset adjustment is indicated:

- **Removal of sensor error.** If a sensor has been changed in a particular

control loop, the measured value reading with the new sensor might differ from the reading of the old one.

- **Compensation for thermal gradient.** This is the "classical" use of offset; there exists a known temperature difference between the thermistor/thermocouple location and the point of desired temperature measurement.
- **Display esthetics.** Sometimes exact numerical equivalence between two side-by-side digital displays on two instruments connected to two sensors is desired. Offset removes the difference between the displayed measured values due to differing zero offsets of each sensor and the thermal gradient between them.

Offset Adjustment

- **Operation.** The value of **@fst** is added algebraically to the measured value, e.g., an offset value of -2.00 applied to a measured value of 75.0 yields a display value of 73.0.
- **Rounding.** The **@fst** parameter has two significant digits to the right of the decimal point; the displayed measured value has only one (even though it has a much higher-precision storage format). The value of **@fst** is added to the measured value before rounding takes place. Normal, classical rounding procedures are used: if the digit to the right of the least significant display digit is greater than or equal to 5, the least significant display digit is increased 1 unit.

Offset Adjustment Procedures

STEP 1: If the calibration offset parameter (**@fst**) is not available on the operators' level, enable the full parameter list with the hardware configuration switch (**W1**) using the procedures in Section 4.1, *Full List Enable*.

STEP 2: The procedure for the addition of offset is identical to the adjustment of any parameter value: scroll to the parameter with the **PAR** button and adjust the parameter value with UP Δ and DOWN ∇ .

STEP 3: Be sure the **OPERATE/STANDBY** switch is in **STANDBY** and **POWER** is off. Remove the temperature control module from its sleeve again and reopen the hardware configuration switch (**W1**). Re-install the module in the sleeve and secure with the jack screw. Turn **POWER** on.

Calibration

If it is determined that offset adjustment will not cure the problem at hand, then there are two calibration procedures that the operator may perform that are dependent on the type of sensor that is being used. They are:

- Restoration of the original factory calibration for thermocouples
- Thermistor calibration

CAUTION: The thermistor calibration procedure may be performed independently of the restoration of original calibration for thermocouples; however, if the original calibration for thermocouples is restored, then the thermistor calibration procedure must be performed if the controller is to be operated with thermistors.

Restoration of Original Factory Calibration for Thermocouples

STEP 1: Be sure that **OPERATE/STANDBY** switch is in **STANDBY**.

STEP 2: Enable the full parameter list with the hardware configuration switch (**W1**) using the procedures in Section 4.1, *Full List Enable*.

STEP 3: Scroll down to **CAL** by repeatedly pressing the **PAR** button. The lower display will contain the sub-scroll header: ---

STEP 4: Use UP $\triangle$ or DOWN ∇ to display **FAC** in the lower display. (**PAR** terminates the procedure.)

STEP 5: Press **PAR** to affirm that **FAC** is indeed the desired calibration procedure. **FAC** now appears in the upper display, and **no** in the lower.

STEP 6: Use UP $\triangle$ and DOWN ∇ again to select **YES** or **no** in the lower display. **YES** continues the procedure; **no** terminates the procedure.

STEP 7: With **YES** in the lower display, depress **PAR** again to launch the selected calibration procedure. **FAC** will appear in both the upper and lower displays.

STEP 8: The procedure takes about 5 seconds after which **CAL** reappears in the upper display, and --- in the lower. If no assignments are being made, after 5 seconds the display will automatically return to the condition and mode the unit was in when you began the procedure.

STEP 9: Be sure that **POWER** is off. Remove the temperature control module from its sleeve again and reopen the hardware configuration switch (**W1**). Reinstall the module in the sleeve and secure with the jack screw. Turn **POWER** on and resume operation.

Thermistor Calibration Procedure

STEP 1: Be sure the **SENSOR** switch is set to **TH** and that both the DC Output Cable and Thermocouple Cable are disconnected.

STEP 2: Enable the full parameter list with the hardware configuration switch (**W1**) using the procedures in Section 4.1, *Full List Enable*.

STEP 3: Scroll down to **CAL** by repeatedly pressing the **PAR** button. The lower display will contain the calibration sub-scroll header: ---.

STEP 4: Use UP $\triangle$ or DOWN ∇ to display **rd** in the lower display. (**PAR** terminates the procedure.)

NOTE: Ignore any other mnemonics that may appear as you scroll to **rd**. These are used by authorized Marlow Industries, Inc., personnel only during factory calibration.

STEP 5: Press **PAR** to affirm that **rd** is indeed the desired calibration procedure. **rd** now appears in the upper display, and **no** in the lower.

STEP 6: Use UP $\triangle$ or DOWN ∇ again to select **YES** or **no** in the lower display. **YES** continues the procedure; **no** terminates the procedure.

STEP 7: With **YES** in the lower display, depress **PAR** again to launch the selected recalibration procedure. **rd** will appear in both the upper and lower displays.

STEP 8: The procedure takes about 5 seconds after which **CAL** reappears in the upper display, and --- in the lower. If no assignments are being made, after 5 seconds the display will automatically return to the condition and mode the unit was in when you began the procedure.

STEP 9: Be sure the **OPERATE/STANDBY** switch is in **STANDBY** and **POWER** is off. Remove the temperature control module from its sleeve again and reopen the hardware configuration switch (**W1**). Re-install the module in the sleeve and secure with the jack screw. Reconnect the DC Output Cable and the Thermocouple Cable and turn the **POWER** on.

If neither offset adjustment nor Thermistor Calibration has alleviated the problem, return the unit to Marlow Industries, Inc., for recalibration. (See Section 6.3, *Customer Service*.)

5.0 Tuning Tutorial

5.1 Introduction

This section will assist you in determining the values of the Proportional/Integral/Derivative (PID) terms and other related control parameters in the Temperature Controller/Power Supply for a specific application. Proper tuning of a controller is essential to its correct operation.

The tuning procedure is normally performed on system start-up, or if the thermoelectric device type is changed, or if the mechanics of the system are altered appreciably. In this latter instance, the associated controller must be "re-tuned" to ensure optimal performance. Anytime a controller is replaced in an existing system that is properly tuned, the parameters of the new instrument must be set to the same values as those of the old instrument.

Tuning the controller module involves setting values for the following parameters:

- Proportional band $ProP$, integral time constant $Int.t$, and derivative time constant $der.t$.
- Automatic cutback operation ($Cb @$ set to $Auto$) is utilized. No adjustment to the cutback points is necessary; they are automatically set by the controller to three times the value of $ProP$.

The choice of PID parameters determines the behavior of the controller at setpoint (small-signal response). The automatic cutback parameters govern the performance due to major changes in setpoint during start-up (large-signal response).

Tuning may be performed with the procedures outlined in this section. Temperature values in this section's examples can be either in Fahrenheit or Celsius. The operator selects the desired temperature measuring unit on the front panel. (See Section 3.2, *Overview of Controls/Indicators*.)

NOTE: The examples given are for a thermoelectric device with a relatively small time

constant. The integral and derivative times will be longer for devices with larger time constants, such as cold plates. Conversely, shorter integral and derivative times will be used for thermoelectric devices with smaller time constants such as fast transient thermoelectric heat pumps.

5.2 PID Control Parameters

Proportional Band (Gain) $Prop$

Proportional Band (PB), or gain, amplifies the error between setpoint and measured value to establish an output level. Proportional band is the temperature range over which the output level is continuously adjustable in a linear fashion from 0% (maximum cooling) to 100% (maximum heating). Below the proportional band, the output level is 100%, above the proportional band, 0%, as shown in Figure 5.1.

The width of the proportional band determines the magnitude of the response to the error. If the proportional band is too narrow, meaning high gain, the system oscillates by over- and under-shooting the target temperature. Devices with fast response times will require lower gain (wider proportional band) than slow devices. Also, a given device operating in the heating mode will require a lower gain than when operating in the cooling mode.

A wide proportional band, low gain, could lead to control "wander," i.e., erratic stray from the setpoint, because of a lack of responsiveness. The ideal situation is achieved when the proportional band is as narrow as possible without causing oscillation.

Figure 5.1 Proportional Band with Full PID Control

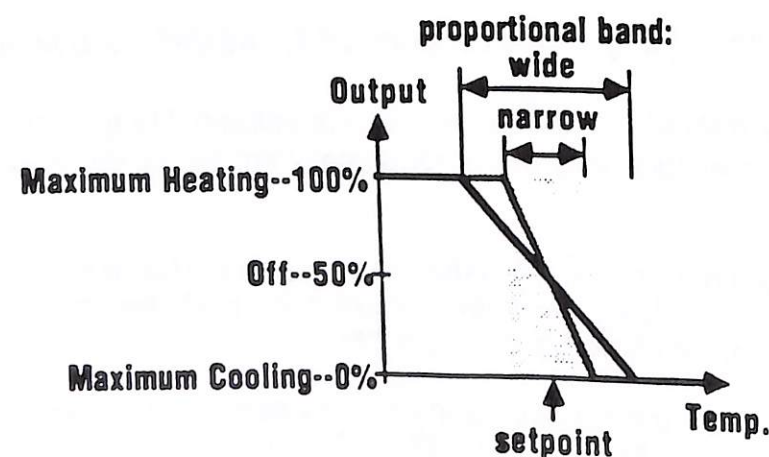


Figure 5.2 Proportional-Only Control

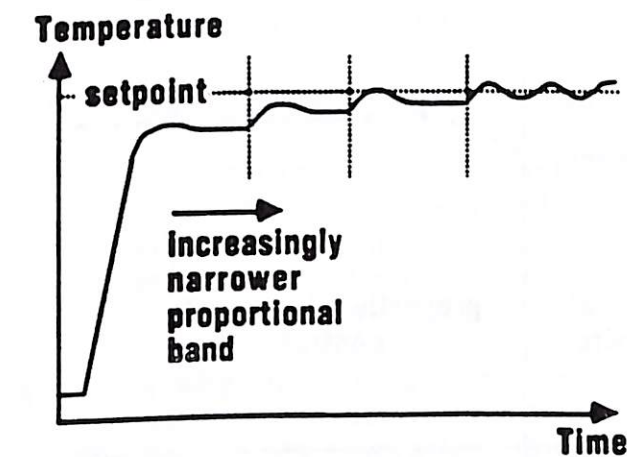


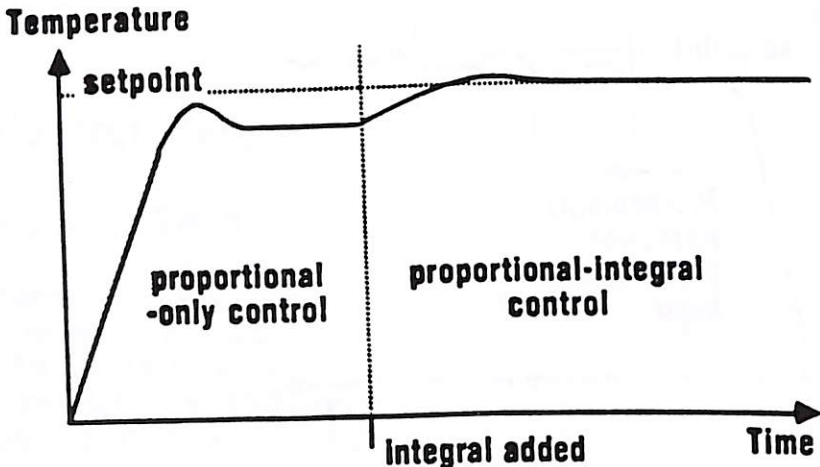
Figure 5.2 shows the effect of narrowing the proportional band to the point of oscillation. This control zone comes up to temperature with a proportional band 50° wide. This results in an appreciable initial error between setpoint and actual temperature. As the proportional band is narrowed, the temperature comes closer to setpoint until finally, at a setting of 10° , the system becomes unstable.

Integral Time Constant (Reset) $Int.t$

Integral action, or *automatic reset*, is probably the most important factor governing control at setpoint. The integral term slowly shifts the output level as a result of an error between setpoint and measured value. If the measured value is below setpoint the integral action gradually increases the output level in an attempt to correct this error.

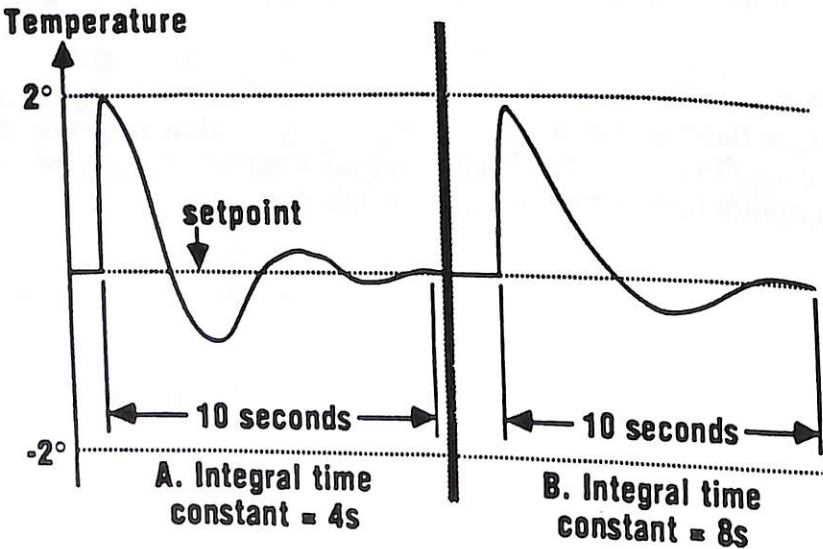
Figure 5.3 demonstrates the result of introducing integral action. Again the temperature rises and levels out at a point just below setpoint. A 20° proportional band is used. Once the temperature settles, integral action is introduced. Notice that the temperature rises further until it is at setpoint.

Figure 5.3 Adding Integral Action



The units of adjustment of the integral time constant are measured in seconds. If the integral term is set to a short time, the output level could be shifted too quickly. This would cause oscillation, since the controller is trying to work faster than the load can change. The longer the integral time constant, the more slowly the output level is shifted; an integral time constant which is too long results in very sluggish control.

Figure 5.4 A & B Widening Integral Time Constant



In Figure 5.4.A, a proportional band of 20° and an integral time constant of 4 seconds provide stable control at setpoint. A positive 2° perturbation results in some overshoot before settling. Figure 5.4.B shows the result of a similar perturbation but

with an 8-second integral time constant. Lengthening the integral time constant results in the markedly slower response shown; however, the overshoot caused by the positive 2° perturbation is markedly reduced.

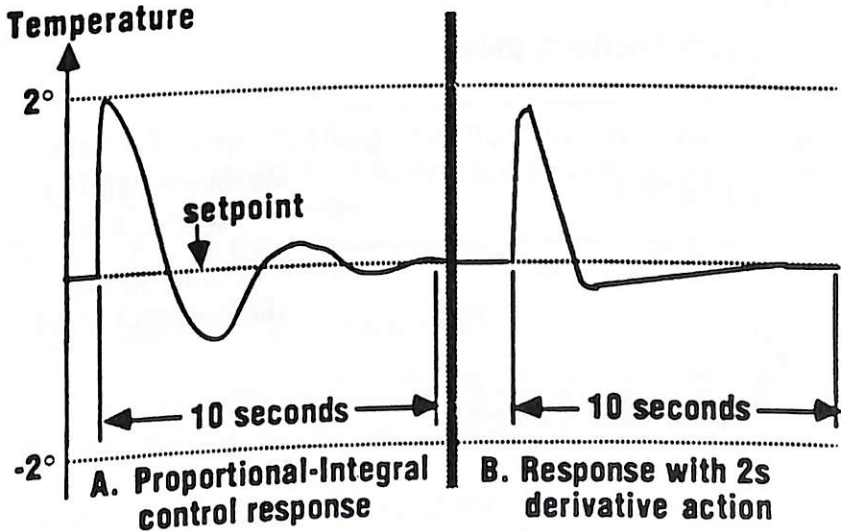
Derivative Time Constant (Rate Action) $dEr.t$

Derivative action, or *rate*, provides a sudden shift in output level as a result of a rapid change in measured value. If the measured value drops quickly the derivative term provides a large change in output level in an attempt to correct the perturbation before it goes too far. It is most beneficial in recovering from small perturbations and should be introduced after reaching the setpoint.

CAUTION: Derivative should *not* be used to curb overshoot on start-up. To effectively use derivative to prevent overshoot on start-up, the steady-state performance must be greatly degraded. Overshoot inhibition is best left to the automatic cutback operation.

The oscillatory response to a perturbation shown in Figure 5.5.A is virtually eliminated by derivative action as shown in Figure 5.5.B. Here a 2-second derivative term is added to the 20° proportional band and 4-second integral time constant. As with the other two tuning parameters, there is a way of improperly setting this term: *derivative oscillation* is typically a cyclic wandering away from setpoint caused by too much derivative action.

Figure 5.5 A & B Adding Derivative Action



Derivative action, when used, is often mistakenly associated with overshoot inhibition rather than transient response.

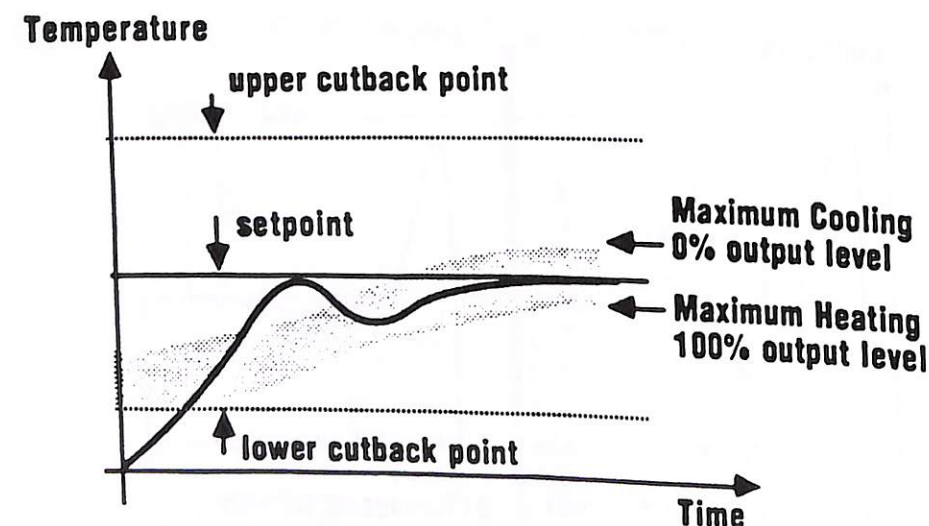
5.3 Automatic Cutback Parameters

The Temperature Controller/Power Supply contains two parameters which are automatically adjusted to prevent overshoot: high- and low-cutback levels. These parameters are independent of the other three tuning values. By using the cutback parameters, the system can be set up for optimum steady-state response (with the PID parameters) and the overshoot is limited.

Cutback operation involves moving the proportional band towards the *cutback point* nearest the measured value whenever the latter is outside the proportional band and the power is saturated, i.e., at 0% or 100%. Integral action is inhibited when the measured value is outside the cutback region (e.g., on start-up). The proportional band moves downscale to the lower cutback point, waits for the measured value to enter it, and then escorts the temperature with full PID control to the setpoint (See Figure 5.6). This process is reversed for falling temperature. In the great majority of applications, this process leads to overshoot-free start-up and decreases the time needed to bring equipment into operation.

With parameter Cb 0 set to Auto (standard configuration), the high- and low- cutback points are automatically determined by the controller and set to a value three times the proportional band.

Figure 5.6 Cutback Operation



5.4 Procedures for Tuning

The Closed-Loop Cycling Method

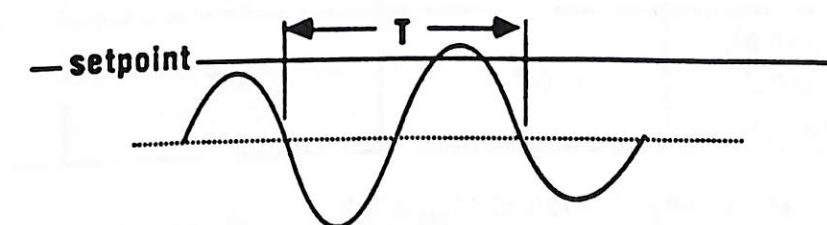
There are several established techniques for tuning control loops. The one

described here is the *closed-loop cycling* method first formally described in an article by J.G. Zeigler and N.B. Nichols¹.

Tuning with the Zeigler-Nichols method requires forcing the system to oscillate. By placing a proportional-only controller (no integral or derivative terms) in oscillation through the setting of the proportional band to a very small value, the control loop cycles with a characteristic frequency (Figure 5.7). This characteristic frequency is a very accurate representation of the system's responsiveness and is used to derive the controller time constants.

It should be understood that "optimal tuning," as defined by Ziegler and Nichols, is achieved when the system responds to a perturbation with a 4:1 decay ratio, i.e., given an initial perturbation of +40°, the controller's subsequent response would yield an undershoot of -10° followed by an overshoot of +2.5°. This definition of "optimal tuning" may not suit every application.

Figure 5.7 Determining Period of Oscillation, T, with Closed-Loop Cycling Method



CAUTION: The closed-loop cycling method is *not* recommended for those systems that cannot be made to oscillate conveniently or safely.

Procedures for Tuning

STEP 1: Set Int.t = OFF and dEr.t = OFF.

STEP 2: Reduce the value of ProP until the measured value oscillates. Measure the period of oscillation T as shown in Figure 5.7.

STEP 3: Widen the proportional band (increase the value of ProP) until the process is just slightly unstable. This value is called the point of *ultimate sensitivity* (P).

STEP 4: Refer to Table 5.1 for the values of ProP, Int.t, and dEr.t.

NOTE: Most thermoelectric devices can be stabilized without use of dEr.t. In any

¹ Optimum settings for automatic controllers, J.G. Ziegler and N.B. Nichols, *Transactions of the A.S.M.E.*, November 1942, pp. 759-767.

event $dEr.t$ should not be used during start-up. If needed, it should be introduced after reaching the setpoint.

Table 5.1
Closed-Loop Cycling Tuning Constants—4:1 Decay Ratio

CONTROLLER	PARAMETER		
	Proportional band Prop	Integral time constant Int.t	Derivative time constant dEr.t
Proportional only (P)	2 P	N.A.	N.A.
Proportional and integral (PI)	2.2 P	0.8 T	N.A.
Proportional, integral and derivative (PID)	1.67 P	0.5 T	0.12 T

P=ultimate sensitivity T=period of oscillation

Again, the settings given in Table 5.1 establish control with a 4:1 decay ratio which may give too much overshoot for some processes. Tuning objectives may be better fulfilled with the responses shown in Figure 5.8. Table 5.2 gives guidelines for altering these values.

Figure 5.8 Typical Response Curves

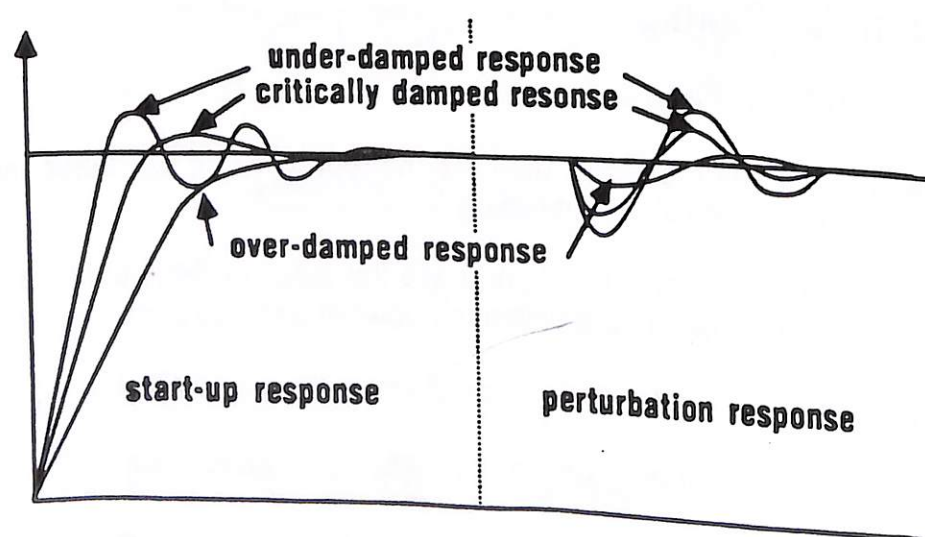


Table 5.2
Variable Response Tuning Constants

RESPONSE	PARAMETER		
	Proportional band Prop	Integral time constant Int.t	Derivative time constant dEr.t
Under-damped	P	0.5 T	0.125 T
Critically damped	1.5 P	T	0.167 T
Over damped	2 P	1.5 T	0.167 T

P=ultimate sensitivity T=period of oscillation

5.5 Troubleshooting PID Tuning

In many instances a control loop is slightly unstable and may oscillate a few degrees. This can be due to the fact that the loop was never properly tuned or that the tuning procedures outlined above were not quite appropriate for the load. In these cases, it may not be desirable to repeat the somewhat extensive tuning procedures outlined above. To quickly "repair" the tuning of the control loop, two procedures may be tried:

- First, compare the period of oscillation (Figure 5.7) to the integral time constant setting; the integral time constant should be at least as long as the period of oscillation. If the integral time constant is shorter than the period of oscillation, increase the integral time constant to at least that value. If the loop continues to oscillate with the appropriate integral term, the proportional band should be increased until the oscillation is eliminated.
- Some control zones have certain physical configurations which prevent them from being tuned with derivative action. Even though derivative action is a stabilizing factor in most loads, some loads have *transport lags* which cannot stabilize if derivative is used. This would occur, for example, in a system where heat is transported to the load by moving air. If adjusting the integral action and proportional band as stated above does not stabilize a controller, try reducing or removing the derivative action.

6.0 Prevention & Handling of Problems

This section addresses routine maintenance and provides a Troubleshooting Chart and a section on customer service information.

6.1 Maintenance

Disconnect the **AC LINE** Connector from the power source before cleaning. Do not use liquid or aerosol cleaners. The outer case may be cleaned with a clean, soft cloth dampened (not dripping) in mild detergent dissolved in water. Do not use a hard brush or cloth or a solvent, as it may damage the finish.

6.2 Troubleshooting Chart

The following chart is designed to help you quickly pinpoint solutions to common problems:

<u>SYMPTOMS</u>	<u>POSSIBLE CAUSE</u>	<u>REMEDY</u>
• Sn b in upper green display. • 50.0 in lower green display. • dot flashing under "M." • alarm indications: LoAL & d AL for thermistor. HIAL & d AL for thermo- couple alternately flashing with the 50.0 in the lower display.	• Broken or disconnected sensor lead(s).	• Repair or connect sensor lead(s).

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SYMPTOMS

- $\overline{M}$ in upper green display.
- 50.0 in lower green display.
- dot flashing under "M."
- alarm indications:
HIAL & dAL
alternately flashing
with the 50.0 in the lower
display.

POSSIBLE CAUSE

- Shorted thermistor
leads or reversed
thermocouple leads.

REMEDY

- Repair or properly
connect sensor
lead(s).

- Measured temperature
diverges from setpoint
temperature.

- Reversed polarity to
thermoelectric device
or reversed thermo-
couple leads.

- Connect leads to
thermoelectric device
or thermocouple
with proper polarity.

- Measured temperature
is relatively stable but
different from setpoint
temperature and output
current is less than
current limit.

- $\overline{I}$ (integral time
constant) is set to off.

- Set in appropriate
amount of $\overline{I}$
to achieve stability
at the setpoint.

- Measured temperature
is relatively stable but
different from setpoint
temperature and output
current is equal to the
current limit.

- Current limit is set
too low to achieve
the setpoint.

- Increase the current
limit to maximum
for the device.

- The thermoelectric
device is not capable
of driving the heat
load to the setpoint
temperature.

- Check for improper
heatsinking of the
device, improper
size heatload, or
a damaged device.

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SYMPTOMS

- Measured temperature
is unstable (oscillating)
about the setpoint
temperature.

POSSIBLE CAUSE

- Tuning of Pid para-
meters is not
optimum.
- Condensation on the
thermoelectric device
causing "detuning."
- Erratic air currents
blowing across
the device.

REMEDY

- Set Prop, Int.t, and
dEr.t. (See Section
5.0, *Tuning Tutorial*.)
- Operate in dry
atmosphere
or above dew point.
- Operate in draft-
free environment.

- Excessive overshoot
(or undershoot) from
setpoint #1 to setpoint #2.

- Tuning of Pid para-
meters is not optimum.
- Improper current limits
for heating mode and/or
cooling mode.

- Set Prop, Int.t, and
dEr.t. (See Section
5.0, *Tuning Tutorial*.)
or use rSP (ramp
to setpoint) Ctrl
(control) mode and
set SP π (setpoint
ramping rate) to de-
sired rate. (See Note,
below.)

NOTE:

- If overshoot occurred when going from a low to a higher setpoint, reduce the heating mode current limit by reducing $\overline{HPL}$ (maximum power limit). (See Section 3.4, *Front Panel Procedures*.)
- If undershoot occurred when going from a low to a higher setpoint, increase the heating mode current limit by increasing $\overline{HPL}$ (maximum power limit). (See Section 3.4, *Front Panel Procedures*.)
- If overshoot occurred when going from a high to a lower setpoint, reduce the cooling mode current limit by reducing the **CURRENT LIMIT**. (See Section 3.4, *Front Panel Procedures*.)
- If undershoot occurred when going from a high to a lower setpoint, increase the cooling mode current limit by increasing the **CURRENT LIMIT**. (See Section 3.4, *Front Panel Procedures*.)

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SYMPTOMS

- Measured temperature does not change.
- POWER** is on, unit is in the **OPERATE** mode, and **DISPLAY** indicates $\pm 0.0X$ AMPS and $\pm XX.X$ VOLTS (where X is any value from 1 to 9.)

POSSIBLE CAUSE

- CURRENT LIMIT** set to "zero" (fully counter-clockwise).
- DC power lead(s) not connected to thermoelectric device.
- Damaged thermoelectric device.

REMEDY

- Set **CURRENT LIMIT** to proper value.
- Connect DC power leads to thermoelectric device.
- Inspect thermoelectric device for damage (open circuit); replace if required.

- Measured temperature does not change when unit **POWER** is on and unit is in the **OPERATE** mode and **DISPLAY** indicates $\pm X.XX$ AMPS and $\pm 00.X$ VOLTS. (Where $\pm X.XX$ is equal to the **CURRENT LIMIT** and is any value from 1 to 9.)

- DC power leads are shorted together or the thermoelectric device is shorted.

- Inspect and repair DC power leads or thermoelectric device as required.

- HIAL** (high alarm)
- d AL** (deviation alarm) alternately flashing with setpoint in lower display with measured temperature stable and equal to setpoint.

- Alarm limits improperly set.

- Check alarm limits for proper settings.

- LoAL** (low alarm)
- d AL** (deviation alarm) alternately flashing with setpoint in lower display with measured temperature stable and equal to setpoint.

- Alarm limits improperly set.

- Check alarm limits for proper settings.

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SYMPTOMS

- Cannot adjust setpoint temperature above (or below) some value to reach desired setpoint.

POSSIBLE CAUSE

- SP H** (setpoint high limit) and/or **SP L** (setpoint low limit) improperly set.

REMEDY

- Check setpoint limits for proper settings.

- When using a thermocouple sensor, the measured temperature is stable and equal to the setpoint; however, there is a temperature offset at the thermoelectric device detected by some other means of measuring temperature.

- A material other than copper or constantan has been introduced in the thermocouple leads connecting the unit to the thermoelectric device. (If wires pass through connectors, the connectors should have copper and constantan pins for the thermocouple wires.) This material is creating additional thermocouple junctions introducing thermal emfs

- Check thermocouple wiring to make sure the lead up to and including the thermocouple junction at the thermoelectric device is all copper and the other is all constantan.

(electromotive forces) or

"voltage" which vary with the temperature at these junctions, creating errors and drift in the measured temperature.

- LED displays dimmed or not working.

- Power cord disconnected.

- Reconnect broken connection.

- Incorrect **AC LINE** selection

- Check **AC LINE** selection.

- Blown line fuse on rear panel.

- Replace line fuse with spare fuse. If spare fuse blows, return unit to Marlow Industries, Inc., for service. (See Section 6.3, Customer Service.)

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6.3 Customer Service

To order additional units, options and/or accessories or to replace or repair products, contact Marlow Industries, Inc.; Marlow Industries U.K.; or your representative:

Customer Service Department
Marlow Industries, Inc.
10451 Vista Park Road
Dallas, TX 75238-1645 USA
TEL: 214-340-4900
FAX: 214-341-5212

Marlow Industries UK
7 Laura House
Jengers Mead
Billingshurst West Sussex
England
(44)-403-784-849
(44)-403-782-901

Representatives

(Country codes in parentheses)

Denmark

Radio Parts A/S
Glentevej 57
DK 2400 Copenhagen NV
Denmark
TEL: (45)-38 33 33 11
TELEX: 19613
FAX: (45)-31 34 22 32

Holland & Belgium

Rodelco
P.O. Box 6824
4802 HV Breda
Holland
TEL: (31)-76-784911
TELEX: 54195
FAX: (31)-76-710029

France

Equipements Scientifiques S.A.
127 Rue de Buzenal
B.P. No 26-92380
Garches
France
TEL: (33) 1 47 95 9900
TLX: 20 4004 F
FAX (33) 1 47 01 1622

India & Subcontinent

Regal International, Inc.
273 Closter Dock Road
Closter NJ 07624
USA
TEL: 201-784-9428
TLX: 642250
FAX: 201-784-1805

Germany

Nucletron Vertriebs GmbH
Geräte + Systeme
Gaertnerstrasse 60
8000 München 50
Germany
TEL: (49) 089-149002 20
TLX: 5215297
FAX: (49) 089-149002 11

Israel

Landseas Ltd.
P.O. Box 676
3 Yehonathan Nethanyahu St.
Or-Yehuda 60256
Israel
TEL: (972)-3-533 3033
FAX: (972)-3-533 3052

Italy

Eurelettronica SPA
Via E Fermi 8
20094 Assaso
Milano, Italy
TEL: (39)-2-45-7841
FAX: (39)-2-48-80275

Japan

RASA Industries, LTD.
1-1, Kyo bashi 1-Chome
Chuo-Ku, Tokyo 104
(Yaesu Dai Bldg.)
Japan
TEL: (81) 3-3278-3916
TLX: 225318
FAX: (81) 3-3281-6697

Spain

Cidete
c/J. Anselmo Clave, 96-98
08800 Vilanova i la Geltru
Barcelona
Spain
TEL: (34)-3-815-1471
FAX: (34)-3-815-7980

Sweden

Kaitech Trade AB
S-161 69 Bromma
Sweden
TEL (46) 08-764-5455
FAX (46) 08-98-8130

Appendix A Specifications

A.1 Specifications for Model SE5000

Output Power	18W max
Output Current (Io)	0 to ± 2 Amps
Output Voltage (Vo) Compliance	0 to ± 9 V dc at 2 Amps
Control Stability	$\pm 0.1^\circ\text{C}$ (Typical)
Temperature Control Range	-99.9°C to 150.0°C
Ramp Rate Range	$0.01^\circ/\text{min.}$ to $99.99^\circ/\text{min.}$
Control Mode	PID and PID with Ramp-to-Setpoint
Temperature Sensors	See Appendix C, <i>Accessories</i>
Temperature Accuracy	Depends on Sensor Tolerance
Linearization Accuracy	0.1°C for Thermistor, 0.2°C for Thermocouple
Calibration Accuracy	0.5°C
Power Supply Output Stage	Linear Bipolar
Ripple and Noise	Less than 10 mA rms
Operating/Storage Temperature	0°C to 50°C / -10°C to 50°C
AC Input Power	104-125/208-250 V ac 48-62 Hz
AC Input Current	0.6 Amp max for 115 V ac 0.3 Amp max for 230 V ac
Voltage (Vo) Readout F.S. Range	± 199.9 V dc
Current (Io) Readout F.S. Range	± 19.99 Amps
Readout Accuracy (Vo & Io)	1% of reading + 2 digits
Dimensions (EIA Half Rack)	5.22" H x 8.38" W x 10.6" D (13.26 cm H x 21.29 cm W x 26.92 cm D)
Weight	10 lbs. (4.55 kg)
Line Fuse Rating	1 Amp, 250 V ac

Specifications subject to change without notice.

A.2 Specifications for Model SE5010

Output Power	96W max
Output Current (Io)	0 to ± 6 A dc
Output Voltage (Vo) Compliance	0 to ± 16 V dc at 6 Amps, to ± 21 V dc at 1 Amps
Control Stability	$\pm 0.1^\circ\text{C}$ (Typical)
Temperature Control Range	-99.9°C to 150.0°C
Ramp Rate Range	0.01°/min. to 99.99°/min.
Control Mode	PID and PID with Ramp-to-Setpoint
Temperature Sensors	See Appendix C, <i>Accessories</i>
Temperature Accuracy	Depends on Sensor Tolerance
Linearization Accuracy	0.1°C for Thermistor, 0.2°C for Thermocouple
Calibration Accuracy	0.5°C
Power Supply Output Stage	Linear Bipolar
Ripple and Noise	Less than 10 mA rms
Operating/Storage Temperature	0° C to 50° C / -10°C to 50°C
AC Input Power	104-125/208-250 VAC, 48-62 Hz
AC Input Current	2.4 Amps max for 115 V ac 1.2 Amps max for 230 V ac
Voltage (Vo) Readout F.S. Range	± 199.9 V dc
Current (Io) Readout F.S. Range	± 19.99 Amps
Readout Accuracy (Vo & Io)	1% of reading + 2 digits
Dimensions (EIA Half Rack)	5.22" H x 8.38" W x 16.0" D (13.26 cm H x 21.29 cm W x 40.64 cm D)
Weight	20 lbs. (9.09 kg)
Line Fuse Rating	3 Amps, 250 V ac

Specifications subject to change without notice.

A.3 Specifications for Model SE5020

Output Power	192W max
Output Current (Io)	0 to ± 12 Amps
Output Voltage (Vo) Compliance	0 to ± 16 V dc at 12 Amps, to ± 21 V dc at 1 Amps
Control Stability	$\pm 0.1^\circ\text{C}$ (Typical)
Temperature Control Range	-99.9°C to 150.0°C
Ramp Rate Range	0.01°/min. to 99.99°/min.
Control Mode	PID and PID with Ramp-to-Setpoint
Temperature Sensors	See Appendix C, <i>Accessories</i>
Temperature Accuracy	Depends on Sensor Tolerance
Linearization Accuracy	0.1°C for Thermistor, 0.2°C for Thermocouple
Calibration Accuracy	0.5°C
Power Supply Output Stage	Linear Bipolar
Ripple and Noise	Less than 10 mA rms
Operating/Storage Temperature	0° C to 50° C / -10°C to 50°C
AC Input Power	104-125/208-250 VAC, 48-62 Hz
AC Input Current	4.8 Amps max for 115 V ac 2.4 Amps max for 230 V ac
Voltage (Vo) Readout F.S. Range	± 199.9 V dc
Current (Io) Readout F.S. Range	± 19.99 Amps
Readout Accuracy (Vo & Io)	1% of reading + 2 digits
Dimensions, EIA Half Rack	5.22" H x 8.38" W x 16.0" D (13.26 cm H x 21.29 cm W x 40.64 cm D)
Weight	30 lbs. (13.64 kg)
Line Fuse Rating	6.25 Amps, 250 V ac

Specifications subject to change without notice.

Appendix B Communications Programs

Marlow Industries, Inc., SE5000 Series Temperature Controller/Power Supplies, in accordance with RS-422-A specification, can provide two-way asynchronous serial communication with a computer; the protocol used corresponds to ASCII X3.28 rev. '76 subcategories 2.5 and A4. This protocol defines the necessary procedures to perform the communication functions of establishing connection, message transference, and termination of the connection. Messages consist of ASCII characters including non-printing "control" characters and can be classified in two sequences, one to read information from the Temperature Controller/Power Supply and one to send data to it. This information is valid for SE5000, SE5010, and SE5020 units and Sections (B.1 to B.5) apply to all of them.

B.1 Formal Specification

Multi Drop Supervisory Link

Transmission Standard	:RS-422-A (bi-directional)
Protocol	:ANSI-X3.28-2.5-A4
Data Rates	:300; 600; 1200; 2400; 4800; 9600; 19,200
Character Format	:ASCII+1 start, 1 parity, and 1 stop bit.
Parity	:Even

Single Serial Link

Transmission Standard	:RS-232-C (bi-directional)
Protocol	:ANSI-X3.28-2.5-A4
Data Rates	:300; 600; 1200; 2400; 4800; 9600; 19,200
Character Format	:ASCII+1 start, 1 parity, and 1 stop bit.
Parity	:Even

Digital Communication

Table B.1 Digital Communication

	RS-232-C	RS-422-A
Electrical Connections	3-wire single ended	4-wire differential
No. of drivers and receivers allowed per line	1 driver 1 receiver	1 driver 10 receivers
maximum cable length	50 ft (15 m)	4000 ft (1200 m)

Computer Interface Cables

Two 12-ft. (3.05 m) computer interface cables are available:

RS-232-C (DE-9S connectors on both ends or with DE-9S connector at unit end and DB-25S at computer end)

RS-422-A (DE-9S connector at unit end and DB-25P connector at computer end)

(See Appendix C, *Accessories*, for ordering information.) Table B.2 provides wiring information.

Table B.2 Computer Interface Cable Wiring

The cables connect to the **COM** connector on the rear panel of the Temperature Controller/Power Supply (TC/PS).

RS-232-C Cable

Signal	TC/PS	Computer	
	DE-9S Pin No.	DB-25S Pin No.	DE-9S Pin No.
TX	2	2	2
RX	3	3	3
COM	5	7	5

RS-422-A Cable

Signal	TC/PS	Computer
	DE-9S Pin No.	DB-25P Pin No.
RX +	1	3
RX -	2	16
TX +	8	12
TX -	9	13
COM	7	7

B.2 Explanation of Terms

Mnemonics

Information is exchanged with a Temperature Controller/Power Supply using mnemonics of two characters to specify the actual parameter, for example;

PV is the process variable
XP is the proportional band, etc.

(See Table B.5, *Mnemonics of Parameters Accessible via Communications Link*, in Section B.3, *Communications Mnemonics*, for a full table of accessible mnemonics.)

Control Characters

Six non-printing ASCII control characters are used to control the messages:

ASCII-HEX	
02	(STX) Start of Text
03	(ETX) End of Text
04	(EOT) End of Transmission
05	(ENQ) Enquiry
06	(ACK) Positive Acknowledge
15	(NAK) Negative Acknowledge

Data Formats

Associated with each mnemonic is a value for which there are two possible data formats: Free and Fixed.

Free Format

This is the format normally used. There are five characters used in the Temperature Controller/Power Supply which include the number and if necessary the decimal point and minus sign. Leading or trailing zeros or leading spaces may be used to pad out the data, e.g.:

13.9 may be sent as 013.9, 13.9, etc.

The minus sign must precede the value, e.g.:

-2 may be sent as -2, -002, -0002, etc.

The decimal point and the minus sign are treated as one complete character. When returning the data, the Temperature Controller/Power Supply will always place the decimal point (or the minus sign) in the same place as it appears on the display of the controller, and it will pad it out with spaces up to the five characters.

Fixed Format

This corresponds to the TCS ASCII Protocol. Spaces are not permitted and the data string is always five characters in length including the decimal point. For negative numbers, the minus sign replaces the decimal point, e.g.:

+5.3 5.300, 05.30, 005.3, etc.
-5.3 5-300, 05-30, 005-3, etc.

Again, when returning values, the Temperature Controller/Power Supply will always place the decimal point (or minus sign) in the same position as the instrument display and will pad out to five characters with zeros.

The choice of Free/Fixed is made by clearing/setting a "flag" or bit in a special parameter called the Status Word (SW).

Status Words

These enable the computer to check or alter various functions at the controller, e.g.:

- Check state of alarms
- Auto/manual selection
- Remote/local selection
- Disable front panel keys
- Free or fixed data format selection, etc.

ASCII Codes

Before a character is transmitted, it is turned into an ASCII code. This is a universal code. Full lists are shown in Tables B.3 *ASCII Codes* and B.4 *Complete List of HEX-ASCII's* in this section. The ASCII code is 7 bits and to this the start, parity, and stop bit have to be added as shown in Figure B.1. Marlow Industries, Inc., protocol requires even parity and a single stop bit. This has to be programmed as part of the software related to the communications output port of the computer.

Figure B.1 ASCII Code Composition

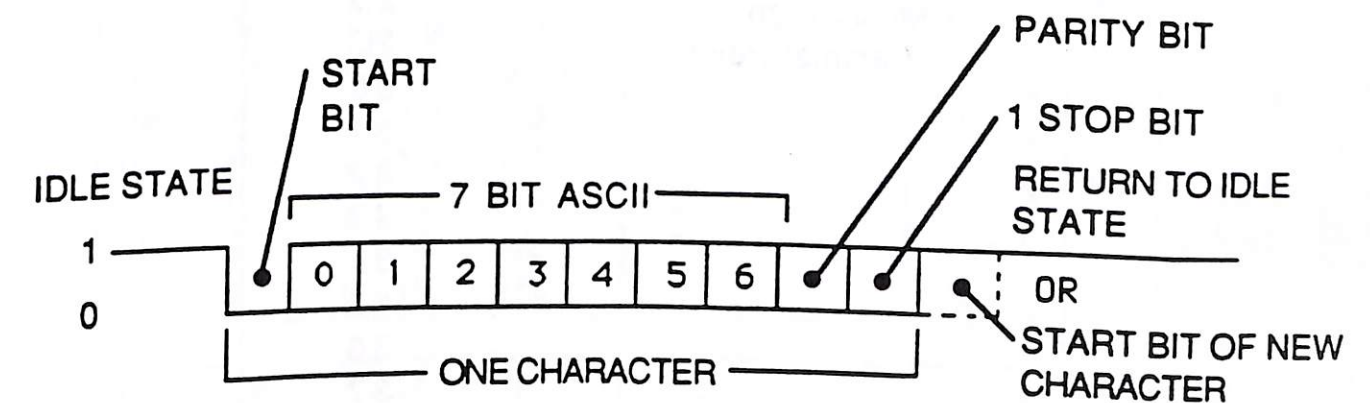


Table B.3 provides a short list of ASCII codes with the character (or code) in the left column a hexadecimal (HEX) code in the right column.

Table B.3 ASCII Codes

ASCII Codes	ASCII-HEX
STX - Start of Text	02
ETX - End of Text	03
EOT - End of Transmission	04
ENQ - Enquiry	05
ACK - Positive Acknowledge	06
NAK - Negative Acknowledge	15
- Space	20
- Minus Sign	2D
- Decimal Point	2E
0	30
1	31
2	32
3	33
4	34
5	35
6	36
7	37
8	38
9	39
>(greater)	3E

Table B.4 provides a complete list of HEX-ASCIIs with the HEX code in the left column and the corresponding character (or code) in the right column.

Table B.4 Complete List of HEX-ASCIIs

00 NUL	10 DLE	20 space	30 0
01 SOH	11 DC1	21 !	31 1
02 STX	12 DC2	22 "	32 2
03 ETX	13 DC3	23 £	33 3
04 EOT	14 DC4	24 \$	34 4
05 ENQ	15 NAK	25 %	35 5
06 ACK	16 SYN	26 &	36 6
07 BEL	17 ETB	27 ' ,	37 7
08 BS	18 CAN	28 (	38 8
09 HT	19 EM	29)	39 9
0A LF	1A SUB	2A *	3A :
0B VT	1B ESC	2B +	3B ;
0C FF	1C FS	2C ' ,	3C <
0D CR	1D GS	2D -	3D =
0E SO	1E RS	2E .	3E >
0F SI	1F US	2F /	3F ?

40 @	50 P	60 `	70 p
41 A	51 Q	61 a	71 q
42 B	52 R	62 b	72 r
43 C	53 S	63 c	73 s
44 D	54 T	64 d	74 t
45 E	55 U	65 e	75 u
46 F	56 V	66 f	76 v
47 G	57 W	67 g	77 w
48 H	58 X	68 h	78 x
49 I	59 Y	69 i	79 y
4A J	5A Z	6A j	7A z
4B K	5B [	6B k	7B {
4C L	5C \	6C l	7C
4D M	5D]	6D m	7D }
4E N	5E ^	6E n	7E ~
4F O	5F _	6F o	7F DEL

B.3 Communications Mnemonics

Table B.5 provides a complete list of all parameters accessible via the communications link (RS-232-C or RS-422-A). The parameter names and corresponding ASCII/HEX code and mnemonics are listed for each parameter.

Table B.5 Mnemonics of Parameters Accessible via Communications Link

ASCII/HEX	MNEMONICS	PARAMETER
48 53	HS	Setpoint high limit
4C 53	LS	Setpoint low limit
50 56	PV	Last measured value
4F 50	OP	Output power in auto read only
53 57	SW	Status Word Hexadecimal
53 4C	SL	Local Setpoint
48 41	HA	High alarm setpoint
4C 41	LA	Low alarm setpoint
44 41	DA	Deviation alarm setpoint
58 50	XP	Proportional band
54 49	TI	Integral time constant
54 44	TD	Derivative time constant
42 50	BP	Sensor break power
48 4F	HO	Heat output limit
53 52	SR	Ramp-to-setpoint ramp rate

B.4 Status Word

The status word is made up of 16 bits, each one of which represents a particular function on the controller as detailed below. These are Read/Only (R/O), Read/Write (R/W) or Read/Clear (R/C) addressable.

The 16 bits are sent as four hexadecimal numbers preceded by ">" to warn the computer that the data is hexadecimal. The format is thus SW = >ABCD. These digits are still transmitted in ASCII code.

Table B.6 Status Word Bit Functions

TYPE	DIGIT	BIT	FUNCTION	ATTRIBUTE	CLEAR/SET
Reserved	D	0	Data Format	R/W	Free/Fixed
	D	1	Sensor Break	R/O	No/Yes
	D	2	Key Disable	R/W	No/yes
	D	3	Spare	-	-
Alarm 3 and key handling	C	4	Spare	-	-
	C	5	Parameter Change via keys	R/W	No/Yes
	C	6	Dev. Alm State	R/O	Off/On
	C	7	Dev. Alm Cause	R/O	Absent/Present
Alarms 1 and 2	B	8	Low Alm State	R/O	Off/On
	B	9	Low Alm Cause	R/O	Absent/Present
	B	10	High Alm State	R/O	Off/On
	B	11	High Alm Cause	R/O	Absent/Present
Command	A	12	Alarm Acknowledge	R/C	ACK/Alarm
	A	13	Spare	-	-
	A	14	Spare	-	-
	A	15	Auto/Manual	R/W	Auto/Manual

NOTES:

Alarm State

Indicates whether the Temperature Controller/Power Supply has identified and flagged an alarm condition.

Alarm Cause

Identifies if alarm condition is still present.

Alarm ACK

Writing a logical bit "0" into this bit location will cancel the state of any of the alarms, but it will not clear the cause of any of the alarms.

Parameter Change

Indicates that a parameter has been changed via the front keys. This bit can only be cleared by writing a logical bit "0" into this bit location.

Sensor Break

Indicates either a sensor break condition (over range) or a sensor under range condition exists.

B.5 Example Programs (written in IBM Basic)

Program: READ - CONTROLLER

This program will read all of the parameters of the Temperature Controller/Power Supply and display them on the computer screen.

The program communicates via COM1 at 9600 baud. If either of these need to be changed, then alter the statement in line 640. Changing COM1 to COM2 will communicate via the second RS-232-C port if fitted.

```

10 REM READ-CONTROLLER PROGRAM
20 REM -----
30 REM DATE      : JUNE 21, 1989
40 REM -----
50 REM INITIALIZE SCREEN
60 REM -----
70 CLS                                'CLEAR SCREEN FOR THE FIRST TIME ONLY
80 CYCLE=0                            'COUNTS HOW MANY CYCLES WE DO
90 GOSUB 340                          'SETUP GLOBAL DEFINITIONS
100 GOSUB 610                         'SETUP COMMUNICATIONS PORT
110 LOCATE 2,29
120 PRINT "MI READ - CONTROLLER DEMO PROGRAM"
130 REM -----
140 REM MAIN LOOP
150 REM -----
160 CYCLE = CYCLE + 1                  'NEXT CYCLE
170 LOCATE 4,32
180 PRINT "CYCLE  :";CYCLE;
190 LNUMB=6
200 FOR PN=1 TO LASTPARAM
210 PARAMETER$=PNAME$(PN)
220 LOCATE LNUMB, 31
230 PRINT ">";
240 GOSUB 670
250 GOSUB 720                          'BUILD PACKET
260 LOCATE LNUMB, 32                'SEND PACKET AND WAIT FOR UNIT TO REPLY
270 PRINT PNAME$(PN), " = ";RX$;    'POSITION CURSOR TO NEXT LINE ON DISPLAY
280 LOCATE LNUMB,31
290 PRINT " ";
300 LNUMB = LNUMB + 1
310 NEXT PN                          'MOVE TO NEXT LINE
320 IF CYCLE > 1000 THEN CYCLE = 0  'RESET AFTER DOING THIS MANY
330 GOTO 160                        'REPEAT MAIN LOOP
340 REM -----
350 REM INITIALIZE PARAMETERS
360 REM -----

```

'X.Y ADDRESS OF UNIT TO BE INTERROGATED

'DEFINE PARAMETER MNEMONIC

```

370 ADDRESS$ = "0000"
380 STX$ = CHR$(&H2)
390 ETX$ = CHR$(&H3)
400 EOT$ = CHR$(&H4)
410 ENQ$ = CHR$(&H5)
420 ACK$ = CHR$(&H6)
430 NAK$ = CHR$(&H15)
440 LASTPARAM = 14
450 DIM PNAME$(LASTPARAM)
460 PNAME$(1) = "PV"
470 PNAME$(2) = "SL"
480 PNAME$(3) = "HS"
490 PNAME$(4) = "LS"
500 PNAME$(5) = "OP"
510 PNAME$(6) = "HA"
520 PNAME$(7) = "LA"
530 PNAME$(8) = "DA"
540 PNAME$(9) = "XP"
550 PNAME$(10) = "TI"
560 PNAME$(11) = "TD"
570 PNAME$(12) = "BP"
572 PNAME$(13) = "HO"
574 PNAME$(14) = "SR"
580 TRUE = 0
590 FALSE = -1
600 RETURN
610 REM -----
620 REM SETUP COMMUNICATIONS PORT
630 REM -----
640 COMFIL$ = "COM1 :9600,E,7,1,RS,CSO,DSO,CDO"
    'SET BAUD RATE HERE

650 OPEN COMFIL$ AS #1
660 RETURN
670 REM -----
680 REM BUILD PACKET TO SEND
690 REM -----
700 PACKET$ = EOT$ + ADDRESS$ + PARAMETER$ + ENQ$
710 RETURN
720 REM -----
730 REM SEND PACKET
740 REM -----
750 IF NOT EOF(1) THEN RX$ = INPUT$(LOC(1), #1)
760 RX$ = ""
770 IN$ = ""
780 PRINT #1,PACKET$;
790 INTERVAL = 1000
800 TIM = 0
810 TIMEOUT = FALSE
820 RXEND = FALSE

```

'HOW LONG TO WAIT BEFORE WE TIMEOUT

'CLEAR TIMEOUT FLAG
'CLEAR RECEIVE COMPLETED FLAG

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```

830 WHILE (RXEND = FALSE) AND (TIMEOUT=FALSE)
      TERMINATE ON RXEND OR TIMEOUT
840 WHILE NOT EOF(1)
      IF COMMS BUFFER CONTAINS DATA THEN GET IT
850 IN$=INPUT$(1, #1)
      READ NEXT CHARACTER FROM COMMS BUFFER
860 RX$ = RX$ + IN$
      APPEND TO RECEIVED DATA STRING
870 IF (IN$=ETX$) OR (IN$=ACK$) OR (IN$=NAK$) THEN RXEND = TRUE
      RESET TIMEOUT IF SOMETHING WAS RECEIVED
880 TIM=0
      BUFFER EMPTY
890 WEND
      MAY HAVE TO TIMEOUT IF WE DONT GET IT
900 TIM= TIM +1
      SOON

910 IF (TIM > INTERVAL) THEN TIMEOUT + TRUE
920 WEND
      RXEND OR TIMEOUT
930 IF LEN(RX$) <= 1 THEN 1060
940 BCCERROR = FALSE
950 BCC =0
960 FOR X =2 TO (LEN (RX$) -1)
970 BCC =BCC XOR ASC (MID$(RX$,X,1))
980 NEXT X
990 IF CHR$(BCC) <> IN$ THEN BCCERROR = TRUE
      LAST CHARACTER IN IN$ WAS BCC

1000 IF BCCERROR = TRUE THEN RX$ = "BCC ERROR" : GOTO 1090
1010 SOD = INSTR(RX$, STX$) + 3
      FIND FIRST DATA CHARACTER
1020 EOD = INSTR(RX$, ETX$)
      FIND LAST DATA CHARACTER
1030 LOD = EOD - SOD
1040 RX$ = MID$(RX$, SOD, LOD)
1050 GOTO 1090
1060 TIMEOUT = TRUE THEN RX$ = "TIMEOUT"
1070 IF RX$ = ACK$ THEN RX$ = "ACK"
1080 IF RX$ = NAK$ THEN RX$ = "NAK"
1090 RETURN

```

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Program: WRITE - CONTROLLER

This program will allow the operator to change any of the addressable parameters. The user is prompted for a parameter, which must be in the appropriate two-digit mnemonic. The user is then prompted for a new value for this parameter. The data is constructed into a string and sent to the unit. The mnemonic data, and reply string are shown on the computer screen.

The baud rate can be changed by altering the command in line 550.

```

10 REM WRITE - CONTROLLER PROGRAM
20 REM -----
30 REM DATE      : JUNE 21, 1989
40 REM -----
50 REM INITIALIZE VARIABLES
60 REM -----
70 GOSUB 420
      SETUP GLOBAL DEFINITIONS
80 GOSUB 550
      SETUP COMMUNICATIONS PORT
90 REM -----
100 REM DRAW MAIN SCREEN
110 REM -----
120 CLS
130 LOCATE 2,24
      DISPLAY PROGRAM TITLE AT TOP
140 PRINT "MI WRITE-CONTROLLER DEMO PROGRAM"
      PARAMETER MNEMONIC
150 LOCATE 12,28
      VALUE
160 PRINT "PARAMETER"
      RESPONSES
170 LOCATE 13,28
      VALUE
180 PRINT "VALUE"
      RESPONSES
190 LOCATE 14,28
      VALUE
200 PRINT "MESSAGE RECIEVED"
      RESPONSES
210 REM -----
220 REM MAIN LOOP
230 REM -----
240 PROMPT$ = "ENTER PARAMETER"
      PROMPT FOR PARAMETER NAME

250 GOSUB 610
260 IF LEN(USERENTRY$) <> 2 THEN 240
      IGNORE BLANK ENTRIES

270 CMD$ = USERENTRY$
280 PROMPT$ = "ENTER NEW VALUE"
      GET USER TO ENTER NEW VALUE

290 GOSUB 610
300 IF LEN(USERENTRY$) = 0 THEN 240
      IGNORE BLANK ENTRIES
      SAVE NEW VALUE
      REPORT NEW VALUE ON SCREEN

310 VALUE$ = USERENTRY$
320 LOCATE 12,48
      VALUE
330 PRINT CMD$
      VALUE
340 LOCATE 13,48
      VALUE
350 PRINT VALUE$
      VALUE

```


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```

360 GOSUB 710
370 GOTO 240
380 STOP
390 REM -----
400 REM SETUP GLOBALS
410 REM -----
420 ADDRESS$ = "0000"           'X.Y ADDRESS TO BE INTERROGATED
430 STX$ = CHR$(&H2)
440 EXT$ = CHR$(&H3)
450 EOT$ = CHR$(&H4)
460 ENQ$ = CHR$(&H5)
470 ACK$ = CHR$(&H6)
480 NAK$ = CHR$(&H15)
490 TRUE = 0
500 FALSE = -1
510 RETURN
520 REM -----
530 REM SETUP COMMS PORT
540 REM -----
550 COMFIL$ = "COM1 :9600,E,7,1,RS,CSO,DSO,CDO"
    'SET BAUD RATE HERE

560 OPEN COMFIL$ AS #1
570 RETURN
580 REM -----
590 REM USER ENTRY
600 REM -----
610 LOCATE 23,1
620 FOR I=1 TO 79 : PRINT " ";: NEXT I
    'POSITION FOR PROMPT/ENTRY

630 LOCATE 23,1
640 PRINT PROMPT$;
650 INPUT " : ", USERENTRY$
    'CLEAR ANY PREVIOUS PROMPT FIRST
    'NOW READY TO DISPLAY PROMPT
    'DISPLAY IT
    'WAIT FOR USER INPUT.
660 IF LEN(USERENTRY$) = 0 THEN PRINT CHR$(7);
    'SOUND BELL IF NONE ENTERED.

670 RETURN
680 REM -----
690 REM MODIFY PARAMETER
700 REM -----
710 PACKET$ = STX$ + CMD$ + VALUE$ + ETX$
    'CONSTRUCT SEND PACKET
    'CALCULATE BCC

720 BCC$ = PACKET$
730 GOSUB 1340
740 PACKET$ = EOT$ + ADDRESS$ + PACKET$ + CHR$(BCC)
    'PACKET COMPLETE
    'THEN PACKET

750 MESSAGE$ = PACKET$
760 GOSUB 1110
770 GOSUB 820
780 RETURN
790 REM -----
    'CATCH AND REPORT ANY RECEIVED DATA

```

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```

800 REM RECIEVE DATA FROM UNIT
810 REM -----
820 CHECKBCC = FALSE           'SET TRUE IF WE NEED TO CHECK BCC
830 TIMEOUT = FALSE           'INITIALIZE RECIEVE STATUS FLAGS
840 RXEND = FALSE              'BREAK LOOP IF EITHER OF FLAGS GO TRUE
850 TIM = 0                    'INITIALIZE TIMEOUT COUNTER
860 RX$ = ""                   'CLEAR RECIEVED DATA STRING
870 IN$ = ""                   'CLEAR LAST CHARACTER READ
880 WHILE (RXEND=FALSE) AND (TIMEOUT=FALSE)
    'TERMINATE ON RXEND OR TIMEOUT
    'IF COMMS BUFFER CONTAINS DATA, GET IT
    890 WHILE NOT EOF(1)
        900 IN$=INPUT$(1,#1)
        'READ NEXT CHARACTER FROM COMMS BUFFER
        910 RX$=RX$+IN$
        'APPEND TO RECEIVED DATA
        920 TIM=0
        'RESET TIMEOUT WHEN WE RECEIVE SOMETHING

    930 IF (IN$=ETX$) THEN CHECKBCC = TRUE
        'BCC SHOULD BE NEXT SO CHECK IT

    940 IF (IN$=ETX$) OR (IN$=ACK$) OR (IN$=NAK$) OR (IN$=EOT$) THEN RXEND = TRUE
        'BUFFER EMPTY
        'UPDATE TIMEOUT COUNTER

    950 WEND
    960 TIM=TIM+1
    970 IF (TIM > 100) THEN TIMEOUT=TRUE
        'TIMEOUT AFTER COUNT REACHES THIS
        'TIMEOUT OR RECEIVE COMPLETE

    980 WEND
    990 IF CHECKBCC=FALSE THEN 1040
    1000 BCC$=MID$(RX$,1,(LEN(RX$)-1)) 'STRIP OFF BCC CHARACTER FIRST
    1010 GOSUB 1340
    1020 IF CHR$(BCC) <> IN$ THEN RX$="BCC ERROR"
        'SAY WE HAVE AN ERROR

    1030 GOTO 1050
    1040 IF LEN(RX$)=0 THEN RX$="NONE RECEIVED"
        'NOTHING RECEIVED SO SAY SO
        'DISPLAY RECEIVED DATA STRING

    1050 DISPLAY$=RX$
    1060 GOSUB 1160
    1070 RETURN
    1080 REM -----
    1090 REM SEND MESSAGE
    1100 REM -----
    1110 PRINT #1,MESSAGE$;
    1120 RETURN
    1130 REM -----
    1140 REM PRINT MESSAGE
    1150 REM -----
        'SCREEN POSITION TO PRINT
    1160 LOCATE 14,48
    1170 FOR X=1 TO LEN(DISPLAY$)
        1180 CH$=MID$(DISPLAY$,X,1)
        'LOOK AT NEXT CHARACTER TO DISPLAY
        1190 IF (LEN(DISPLAY$)>1) AND (X=LEN(DISPLAY$)) THEN CH$="<BCC>":GOTO 1270
        1200 IF CH$=STX$ THEN CH$="<STX>":GOTO 1270
        1210 IF CH$=ETX$ THEN CH$="<ETX>":GOTO 1270
        1220 IF CH$=EOT$ THEN CH$="<EOT>":GOTO 1270

```


Temperature Controller/Power Supply Operation Manual

```

1230 IF CH$=ENQ$ THEN CH$="<ENQ>":GOTO 1270
1240 IF CH$=ACK$ THEN CH$="<ACK>":GOTO 1270
1250 IF CH$=NAK$ THEN CH$="<NAK>":GOTO 1270
1260 IF CH$ < " " OR CH$ > "~" THEN CH$="<#>"+ASC(CH$)+">"
1270 PRINT CH$;
1280 NEXT X                ' DO EACH CHARACTER
1290 PRINT "
1300 RETURN
1310 REM -----
1320 GENERATE BLOCK CHECK DIGIT
1330 REM -----
1340 BCC=0
1350 FOR X=2 TO LEN(BCC$)    'FROM AFTER STX UP TO AND INCLUDING ETX
1360 BCC=BCC XOR ASC(MID$(BCC$,X,1))
1370 NEXT X
1380 RETURN

```

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Appendix C Accessories

The following accessories are available from Marlow Industries, Inc., for use with the SE5000 Series Temperature Controller/Power Supply. To order, contact Marlow Industries, Inc.; Marlow Industries U.K.; or your representative. (See Section 6.3, *Customer Service*.)

C.1 Sensor Types

Mnemonic	Description	Range (°C)
TH 1	Bead Thermistor Bead, .022" dia x .100" l (.56 mm dia x 2.5 mm l) Bead wire, .002" dia x 1" l (5 microns dia x 25 mm l) 4.7K @ 25°C resistance Top-of-the-line thermistor for use when accuracy and interchangeability are critical. Can be used on all Marlow Industries, Inc., thermoelectric cooling devices and cold plates.	-99.9 to 100.0
TH 2	Bead Thermistor Bead, .014" dia (.36 mm dia) Bead wire, .001" dia x .3" l (25 microns dia x 8 mm l) 1.25K ±5% @ 25°C resistance Versatile thermistor offering good accuracy when used to stabilize at 25°C, but poor accuracy at extreme temperatures. Small lead wires minimize conductive heat loads but require special handling care.	-99.9 to 100.0
TH 3	Bead Thermistor Bead, .095" dia (2.4 mm dia) Bead wire, .008 dia x 1.5" l (.2 mm dia x 38 mm l)	-70.0 to 150.0

10K @ 25°C resistance
Low-cost thermistor with high accuracy and interchangeability. Large bead and leads allow easier handling but limit use to large thermoelectric cooling devices and cold plates.

TH 4

Chip Thermistor

.049" w x .1" l x .022" h
(1.24 mm w x 2.5 mm l x .56 mm h)

10K ±5% @ 25°C resistance

Low-cost thermistor for use when moderate accuracy and interchangeability are needed. Large size limits use on small thermoelectric cooling devices. Lead wires are not attached.

-55.0 to 150.0

t tc

Type T Thermocouple--(Copper-Constantan)

.003" dia x 12" l, uninsulated

(76 microns dia x 2.54 cm l)

Low-cost thermocouple offering high accuracy, uninsulated leads. Requires thermocouple extension wire and isothermal connector block if third metal conductor is used in either lead.

-99.9 to 150.0

Table C.1 Sensor Accuracy Specifications

Mnemonic	Temp. Interval	Accuracy
TH 1	-100 to -80 °C	± 1.5 °C
	-80 to 100 °C	± 1.0 °C
TH 2	-100 to -25 °C	± 6.5 °C
	-25 to 50 °C	± 3.5 °C
	@ 25 °C	± 1.5 °C
	50 to 100 °C	± 6.7 °C
TH 3	-70 to -30 °C	± 1.0 °C
	-30 to 110 °C	± 0.5 °C
	110 to 150 °C	± 1.0 °C
TH 4	-55 to 40 °C	± 1.8 °C
	@ 25 °C	± 1.3 °C
	40 to 80 °C	± 3.6 °C
	80 to 150 °C	± 7.8 °C
t tc	-100 to -66 °C	± 1.5 °C
	-66 to 130 °C	± 1.0 °C
	130 to 150 °C	± 1.1 °C

Table C.2. t H 1 Thermistor R vs T Table

°C	RESISTANCE (ohms)									
	0	1	2	3	4	5	6	7	8	9
-100	3684742	3413114	3162644	2931628	2718499	2521821	2340273	2172641	2017812	1874765
-90	1742560	1620337	1507303	1402732	1305957	1216366	1133394	1056527	985288	919240
-80	857983	801147	748394	699412	653912	611632	572329	535777	501773	470124
-70	440657	413211	387637	363797	341565	320825	301469	283397	266518	250747
-60	236004	222218	209321	197252	185953	175370	165455	156162	147447	139273
-50	131603	124403	117641	111289	105319	99707	94428	89462	84788	80387
-40	76243	72337	68656	65186	61912	58823	55908	53155	50555	48099
-30	45777	43581	41505	39540	37681	35921	34253	32674	31177	29758
-20	28413	27136	25925	24775	23684	22647	21662	20726	19836	18990
-10	18185	17419	16690	15996	15335	14706	14106	13534	12989	12469
0	11973	11500	11048	10617	10206	9812	9436	9077	8734	8406
10	8092	7791	7504	7229	6965	6713	6472	6240	6018	5806
20	5602	5406	5218	5039	4866	4700	4541	4388	4241	4100
30	3964	3834	3709	3588	3473	3361	3254	3151	3051	2956
40	2864	2775	2689	2607	2528	2451	2377	2306	2238	2171
50	2108	2046	1986	1929	1874	1820	1768	1718	1670	1623
60	1578	1535	1493	1452	1412	1374	1337	1301	1267	1233
70	1201	1170	1139	1110	1081	1054	1027	1001	976	951
80	928	905	882	861	840	819	800	780	762	744
90	726	709	693	676	661	646	631	617	603	589
100	576									

Table C.3. tH 2 Thermistor R vs T Table

°C	RESISTANCE (ohms)									
	0	1	2	3	4	5	6	7	8	9
-100	914553	845210	781523	723003	669206	619729	574203	532294	493696	458131
-90	425345	395107	367205	341446	317655	295670	275345	256546	239149	223043
-80	208125	194299	181481	169591	158557	148312	138796	129952	121729	114080
-70	106961	100334	94160	88407	83043	78040	73371	69012	64941	61136
-60	57580	54254	51142	48229	45502	42946	40551	38305	36199	34222
-50	32366	30623	28985	27446	25999	24637	23356	22150	21013	19943
-40	18934	17983	17086	16239	15440	14686	13973	13299	12663	12060
-30	11491	10952	10442	9958	9501	9067	8656	8266	7896	7545
-20	7212	6896	6596	6310	6039	5781	5536	5303	5081	4870
-10	4669	4477	4294	4121	3955	3797	3646	3502	3365	3234
0	3108	2989	2875	2765	2661	2561	2466	2375	2287	2204
10	2124	2047	1974	1903	1836	1771	1709	1650	1593	1538
20	1486	1435	1387	1340	1296	1253	1212	1172	1134	1097
30	1062	1028	996	964	934	905	877	850	824	799
40	775	751	729	707	686	666	647	628	610	592
50	575	559	543	528	513	499	485	472	459	447
60	435	423	412	401	390	380	370	360	351	342
70	333	325	317	309	301	294	286	279	272	266
80	259	253	247	241	236	230	225	219	214	209
90	205	200	195	191	187	183	178	175	171	167
100	163									

Table C.4. tH 3 Thermistor R vs T Table *Ref. 2228-05*

°C	RESISTANCE (ohms)									
	0	1	2	3	4	5	6	7	8	9
- 70	3117494	2873695	2650430	2445856	2258308	2086275	1928389	1783409	1650209	1527768
- 60	1415156	1311531	1216126	1128242	1047246	972559	903654	840053	781317	727046
- 50	676878	630477	587541	547792	510975	476857	445226	415886	388659	363381
- 40	339901	318081	297795	278926	261368	245021	229797	215610	202386	190053
- 30	178546	167806	157776	148407	139650	131463	123805	116639	109931	103649
- 20	97764	92248	87076	82225	77673	73400	69388	65619	62077	58747
- 10	55615	52669	49896	47286	44827	42511	40328	38270	36329	34497
0	32769	31137	29596	28140	26764	25464	24234	23070	21969	20927
10	19941	19006	18121	17282	16486	15732	15016	14337	13693	13081
20	12500	11948	11423	10925	10451	10000	9571	9163	8775	8405
30	8053	7717	7397	7093	6802	6525	6261	6009	5768	5539
40	5320	5110	4910	4719	4536	4362	4195	4035	3883	3736
50	3597	3463	3334	3212	3094	2981	2873	2770	2671	2576
60	2484	2397	2313	2232	2155	2080	2009	1940	1874	1811
70	1750	1692	1635	1581	1529	1479	1431	1385	1340	1297
80	1256	1216	1178	1141	1105	1071	1038	1006	975	945
90	917	889	862	837	812	788	765	742	721	700
100	680	660	641	623	605	588	572	556	541	526
110	511	497	484	471	458	446	434	422	411	400
120	390	380	370	360	351	342	333	325	317	309
130	301	294	286	279	273	266	259	253	247	241
140	235	230	224	219	214	209	204	199	195	190
150	186									

Table C.5. tH 4 Thermistor R vs T Table

°C	RESISTANCE (ohms)									
	0	1	2	3	4	5	6	7	8	9
- 55	533999	501134	470490	441907	415233	390265	36635	34365	321482	299817
- 50	390331	367073	345343	325030	306035	288265	271635	256065	241482	227817
- 40	215008	202997	191729	181155	171227	161904	153144	144911	137170	129889
- 30	123038	116589	110517	104798	99408	94328	89538	85020	80756	76732
- 20	72932	69342	65951	62745	59715	56848	54136	51569	49139	46838
- 10	44657	42592	40633	38776	37015	35344	33758	32253	30823	29465
0	28174	26948	25782	24673	23618	22614	21659	20749	19883	19057
10	18271	17522	16807	16126	15476	14856	14264	13700	13160	12645
20	12153	11683	11233	10804	10393	10000	9624	9264	8920	8590
30	8275	7972	7683	7405	7139	6884	6639	6405	6180	5964
40	5757	5558	5367	5183	5007	4838	4675	4519	4369	4224
50	4085	3952	3823	3699	3580	3466	3355	3249	3147	3048
60	2953	2862	2773	2688	2606	2527	2451	2377	2306	2237
70	2171	2107	2046	1986	1929	1873	1819	1767	1717	1669
80	1622	1577	1533	1490	1449	1410	1371	1334	1298	1263
90	1229	1197	1165	1134	1105	1076	1048	1021	995	969
100	945	921	897	875	853	832	811	791	772	753
110	735	717	700	683	667	651	636	621	607	592
120	579	565	552	540	528	516	504	493	482	471
130	461	451	441	431	422	413	404	395	387	379
140	371	363	355	348	341	334	327	320	314	307
150	301									

C.2 Computer Interface Cables

Two 12-ft. (3.05 m) computer interface cables are available:

- RS-232-C (DE-9S connectors on both ends or with DE-9S connector at Temperature Controller/ Power Supply (TC/PS) end and DB-25S at computer end)
- RS-422-A (DE-9S connector at TC/PS end and DB-25P connector at computer end)

RS-232-C Cable

Signal	TC/PS	Computer	
	DE-9S Pin No.	DB-25S Pin No.	DE-9S Pin No.
TX	2	2	2
RX	3	3	3
COM	5	7	5

RS-422-A Cable

Signal	TC/PS	Computer
	DE-9S Pin No.	DB-25P Pin No.
RX +	1	3
RX -	2	16
TX +	8	12
TX -	9	13
COM	7	7

C.3 Rack Mounting Kits

Single and dual rack mount kits for mounting alone or in a pair into a standard Electronic Industries Association (EIA) 19" cabinet. Kits include brackets, mounting hardware, and instructions.

Warranty Registration

SE5000, SE5010, and SE5020 Temperature Controller/ Power Supply

Marlow Industries, Inc., (MI) warrants for a period of one (1) year from date of sale the SE5000 Series Temperature Controller/Power Supply, including parts, not damaged or misused by the customer as determined by MI. The warranty form, completed with product serial numbers and date of sale, together with a proof of purchase, must be returned to MI, within 30 days of date of sale for validation. Unless customer is notified otherwise, any unit requiring warranty service will be returned to the customer within two (2) weeks of receipt by MI. The customer shall pay all shipping charges for return of the product to MI; if covered by the warranty, MI will pay the return shipping charge. Temporary replacement units are not furnished for use during the repair period. During the warranty period, MI agrees to repair or replace at its option a defective unit.

The foregoing warranty shall not apply to products including the Temperature Controller/Power Supply damaged by improper or inadequate maintenance, third party supplied software or interfacing, unauthorized modification or misuse, or operation in a manner or environment not specified for the product.

The above warranty is exhaustive and any further warranties, expressed, implied, or statutory are hereby expressly excluded. To validate warranty, print or type the information below, add your signature and date, and return this form in the enclosed envelope with a copy of the receipt or purchase order within 30 days of purchase to: Marlow Industries, Inc., 10451 Vista Park Road, Dallas, Texas 75238-1645 U.S.A.

☐ Mr. ☐ Ms.

Name: _____
First Middle Last

Company: _____

Address: _____

Date of Purchase: _____
Month Day Year

For Use Primarily in:

- ☐ High-Gain Amplifiers
- ☐ Infrared Detectors
- ☐ Charged-Couple Devices
- ☐ Other _____

- ☐ Liquid Cooling
- ☐ Air Cooling
- ☐ Cold Plates
- ☐ Laser Diodes

DATE	APPROVED
7/25/83	BDB M
7/25/83	BDB M
7/25/83	BDB M
7/25/83	BDB M
7/25/83	BDB M
7/25/83	BDB M
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7/25/83	BDB M

103-14

TOKER QIT
J-03

203-11

17

18

15V

203907

09

0113

100V SERIES COMPONENTS ARE ON DISPLAY BOARD
100V SERIES COMPONENTS ARE ON CHASSIS
100V SERIES COMPONENTS ARE ON FRONT PANEL OF REAR PANEL

Model Number: _____ Serial Number: _____

Options and Accessories Purchased: (Please check all that apply.)

- | | |
|--|---|
| ☐ RS-232-C Computer Interface Option | ☐ tH 1 Bead Thermistor |
| ☐ RS-422-A Computer Interface Option | ☐ tH 2 Bead Thermistor |
| ☐ RS-232-C Interface Cable w/DE-9S connectors at both ends | ☐ tH 3 Bead Thermistor |
| ☐ RS-232-C Interface Cable w/DB-25S connector at computer end | ☐ tH 4 Chip Thermistor |
| ☐ RS-422-A Interface Cable | ☐ ttc Thermocouple |
| | ☐ Single Rack Mounting Kit |
| | ☐ Dual Rack Mounting Kit |

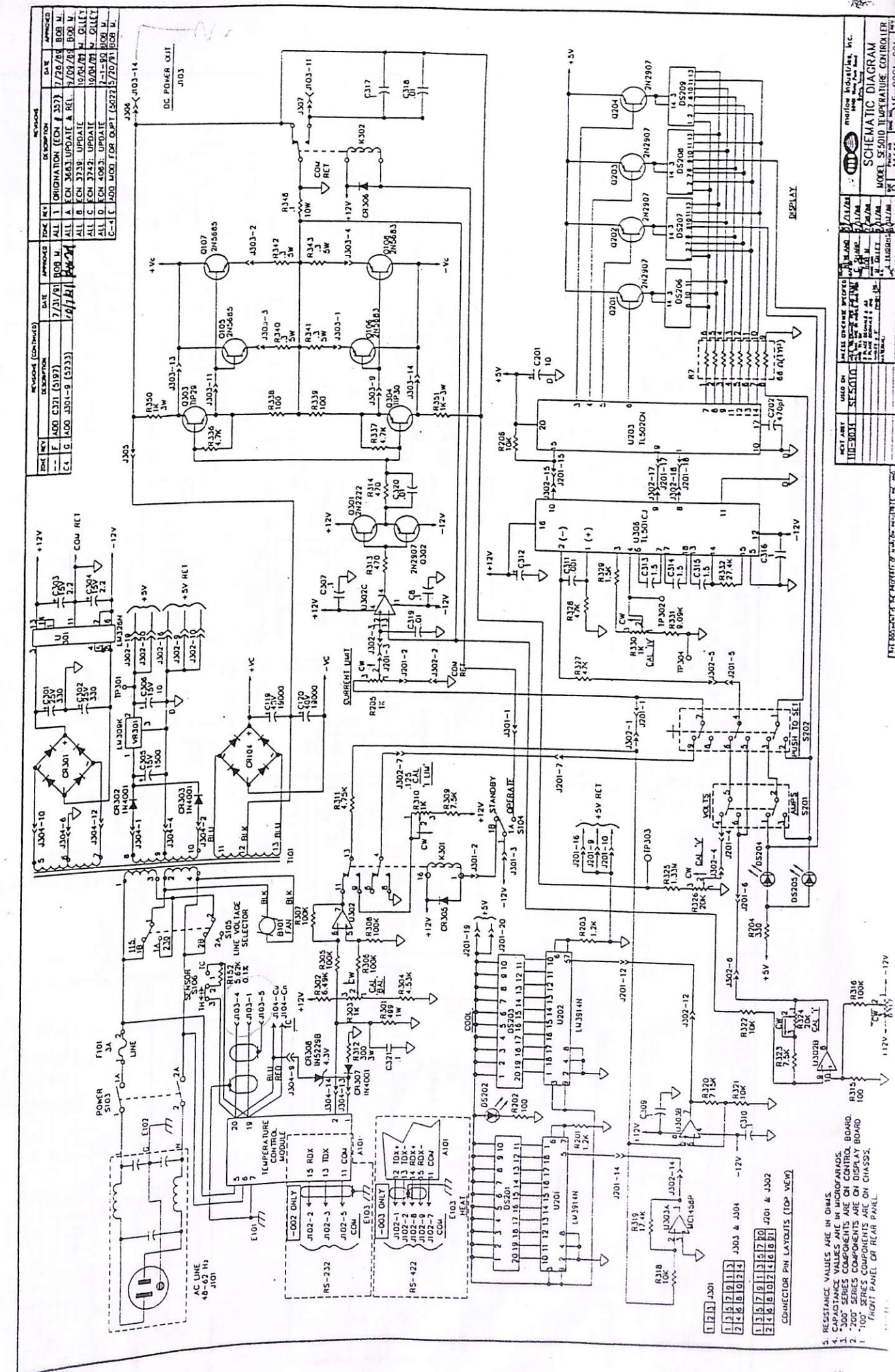
Condition of Carton and Contents upon Arrival:

- ☐ Carton and Contents Both Satisfactory
- ☐ Carton Damaged but Contents Satisfactory
- ☐ Carton and Contents Both Damaged (Please explain.)

- ☐ Carton Satisfactory but Contents Damaged (Please explain.)

Signature: _____ Date: _____

Equipments Scientifiques S.A.
127, rue de Buzenval BP 26
92380 GARCHES
Tél. 47 95 99 00



TEL 47 95 99 00

[illegible]
$$\frac{1}{1-x^2} = \frac{1}{1-x} \cdot \frac{1}{1+x}$$

(AMP) max 3A

the AL has
to be -70

SPL m7 @
SPL ~~m7 @~~

HPL has CF C

Inlet 20
desert OFF

SMTH3
~~SMTH3~~

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