

# 8LS

## User's Guide

### **Watlow Controls**

1241 Bundy Blvd.  
Winona, MN 55987

#### **Customer Service**

Phone: (800) 414-4299  
Fax: (800) 445-8992

#### **Technical Support**

Phone: (507) 494-5656  
Fax: (507) 452-4507  
Email: [wintechsupport@watlow.com](mailto:wintechsupport@watlow.com)

Part No. 10585-00. Revision 9.2  
July 1996

**Copyright © 1996**  
**Watlow Anafaze**

Information in this manual is subject to change without notice. No part of this publication may be reproduced, stored in a retrieval system, or transmitted in any form without written permission from Watlow Anafaze.

## Warranty

Watlow Anafaze, Incorporated warrants that the products furnished under this Agreement will be free from defects in material and workmanship for a period of three years from the date of shipment. The customer shall provide notice of any defect to Watlow Anafaze, Incorporated within one week after the Customer's discovery of such defect. The sole obligation and liability of Watlow Anafaze, Incorporated under this warranty shall be to repair or replace, at its option and without cost to the Customer, the defective product or part.

Upon request by Watlow Anafaze, Incorporated, the product or part claimed to be defective shall immediately be returned at the Customer's expense to Watlow Anafaze, Incorporated. Replaced or repaired products or parts will be shipped to the Customer at the expense of Watlow Anafaze, Incorporated.

There shall be no warranty or liability for any products or parts that have been subject to misuse, accident, negligence, failure of electric power or modification by the Customer without the written approval of Watlow Anafaze, Incorporated. Final determination of warranty eligibility shall be made by Watlow Anafaze, Incorporated. If a warranty claim is considered invalid for any reason, the Customer will be charged for services performed and expenses incurred by Watlow Anafaze, Incorporated in handling and shipping the returned unit.

If replacement parts are supplied or repairs made during the original warranty period, the warranty period for the replacement or repaired part shall terminate with the termination of the warranty period of the original product or part.

The foregoing warranty constitutes the sole liability of Watlow Anafaze, Incorporated and the customer's sole remedy with respect to the products. It is in lieu of all other warranties, liabilities, and remedies. Except as thus provided, Watlow Anafaze, Inc. disclaims all warranties, express or implied, including any warranty of merchantability or fitness for a particular purpose.

**Please Note:** External safety devices must be used with this equipment.

# Contents

<i>Overview</i>	<i>1</i>
System Diagram.....	2
Parts List .....	2
Safety .....	3
<i>Introduction</i>	<i>5</i>
Specifications.....	7
Analog Inputs.....	7
Control Capability.....	8
Digital Outputs.....	8
Digital Inputs .....	8
Pulse Counting Input .....	8
Serial Interface.....	8
Power Supply .....	8
<i>Installation</i>	<i>9</i>
Read This Before Installation .....	10
Mounting The 8LS.....	11
External Wiring.....	13
General Wiring Requirements .....	13
Cable Recommendations .....	15
Noise Suppression.....	16
Terminal Block And Connector Layout .....	18
RTB Connections.....	19
Analog Inputs.....	20
Input Scaling .....	21
Resistor Installation .....	22
Voltage Inputs.....	23
Milliamp Inputs.....	23
Thermocouple Inputs .....	23
RTD Inputs .....	24
Infrared Non-contact Temp. Sensors .....	24
Pulse Input .....	25
Carbon Probe Input.....	25
Control Outputs.....	27
PID Output Termination TB (Primary) or Flat Ribbon (Secondary).....	27

PID Control Relay Outputs .....	28
Primary Screw Terminal Outputs .....	28
Digital Outputs On The Screw Terminal Blocks .....	29
Primary Analog Outputs .....	29
Analog Output Dip Switch Setting for 0-5v/4-20mA .....	30
CPU Dip Switch.....	31
Secondary Outputs 50 Pin Ribbon Cable .....	31
Communications Set-up and Connections .....	33
RS-232 Connections.....	33
RS-485 Description And Connections.....	34

## *Using the 8LS* 37

Front Panel .....	37
Front Panel Keys.....	38
Displays .....	40
Bar Graph Display .....	40
Single Loop Display .....	41
Scanning Display .....	41
Alarm Display .....	41
Operator Menus .....	43
Changing the Setpoint.....	43
Selecting Status Mode .....	43
Autotune.....	44
Ramp/Soak.....	44

## *Setup* 45

How to enter the Setup menus? .....	45
How to edit a menu? .....	45
Setup Global Parameters Menu .....	47
Save as Job.....	48
Restore a Job.....	48
Set Alarm Delay.....	48
Set R/S Time Base .....	49
Lock Panel .....	49
Power Up Output Status .....	49
Controller Address.....	50
Communication Error Checking.....	50
Communication Baud Rate.....	51
Communication Protocol .....	51
AC Line Frequency.....	51
EPROM Version .....	52
Setup Inputs Menu .....	53

Input Type .....	54
Pulse Sample Time .....	55
Input Units .....	55
Linear Scaling Menus .....	56
Input Offset .....	58
Setup Control Menu .....	59
Heat/Cool PB .....	60
Heat/Cool TI .....	60
Heat/Cool TD .....	60
Heat/Cool Output Filter .....	60
Heat/Cool Spread .....	61
Setup Outputs Menu .....	62
Output Type .....	63
Cycle Time .....	63
Output Action .....	64
Output Limit .....	64
Output Limit Time .....	65
Nonlinear Output Curve .....	65
Heat Output .....	66
Setup Alarms .....	67
Alarm Types .....	68
High Process Alarm Setpoint .....	69
High Process Alarm Status .....	69
High Process Alarm Output Number .....	69
Deviation Band Alarm .....	70
Deviation Band Alarm Status .....	70
High Deviation Alarm Output Number .....	70
Low Deviation Alarm Output Number .....	71
Low Process Alarm Setpoint .....	71
Low Process Alarm Status .....	71
Low Process Alarm Output Number .....	72
Alarm Deadband .....	72
Alarm Delay .....	72
Test I/O .....	73
Digital Input Testing .....	73
Test Output .....	74
Digital Output Test .....	74

## *Tuning and Control* 75

Introduction .....	75
Control Modes .....	76
Control Outputs .....	78
Digital Output Control Forms .....	78

Setting Up and Tuning PID Loops .....	80
General PID Constants by Application.....	82
<i>Troubleshooting</i> .....	85
Stand Alone Systems .....	85
Checking Control Outputs .....	85
Checking Digital I/O.....	85
Computer Supervised Systems .....	86
Computer Problems .....	86
Computer Software .....	86
Communications Problems .....	87
Serial Interface .....	87
<i>Appendix A: Ramp Soak</i> .....	89
Introduction.....	89
R/S Features .....	89
Specifications.....	90
Configuring Ramp/Soak .....	90
Setting the R/S Time Base .....	91
Editing R/S Parameters .....	91
Choosing a Profile to Edit.....	91
Copying the Setup from Another Profile .....	92
Editing the Tolerance Alarm Time .....	92
Editing the Ready Setpoint .....	93
Editing the Ready Event States.....	93
Choosing an External Reset Input .....	94
Editing a Segment.....	94
Setting Segment Time.....	94
Setting a Segment Setpoint .....	95
Configuring Segment Events .....	95
Editing Event Outputs.....	96
Changing Event States .....	96
Editing Segment Triggers .....	96
Assigning an Input to a Trigger .....	97
Changing a Trigger's True State.....	97
Latching or Unlatching a Trigger .....	97
Setting Segment Tolerance .....	98
Ending a Profile .....	98
Repeating a Profile.....	98
Using Ramp/Soak .....	99
Assigning a Profile to a Loop.....	99
Running a Profile .....	100
Ramp/Soak Displays.....	101

Holding a Profile or Continuing from Hold.....	103
Resetting a Profile.....	104

*Appendix B: 8LS-CP* 105

Key Features .....	105
System Configuration .....	106
Specifications.....	108
Analog Inputs.....	108
Control Capability.....	108
CP Control .....	109
Trim Gas Temperature Alarm Output .....	109
Recommended CP Trim Gas Alarm for Continuous Applications .....	109
Recommended CP Trim Gas Alarm for Batch Applications	110
Carbon Probe .....	111
General Guidelines .....	111
Probe Burn Off.....	112
Carbon Probe Burn Off Requirements: .....	112
Burn Off Procedures .....	112
Burn Off Function.....	113
Setup Menus .....	114
Setup Inputs .....	114
Setup Carbon Burn Off.....	116
Setup Alarms.....	119
CP and DP Display .....	119

*Appendix C: 8LS Cascade* 121

Introduction.....	121
8LS Cascade Menus.....	121
Cascade Main Menu .....	121
Choosing the Primary Loop.....	122
Setting the High End of the Secondary Setpoint .....	122
Setting the Low End of the Secondary Setpoint .....	122

*Glossary* 123



# Overview

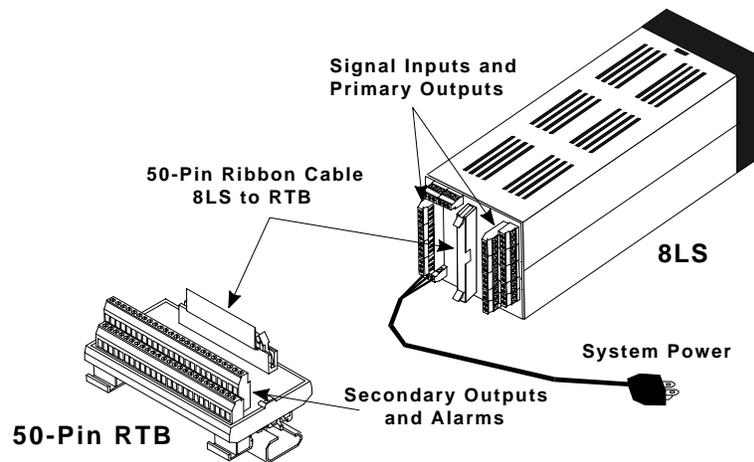
This manual describes how to install, setup, and operate an 8LS controller. Included are six chapters, Appendixes describing the 8LS-CP (Carbon Potential) and the 8LS-RS (Ramp/Soak), and a glossary of terms. Each chapter covers a different aspect of your control system and may apply to different users. The following describes the chapters and their purpose.

- **Introduction:** Gives a general description of the 8LS and its related specifications.
- **Installation:** Describes how to install the 8LS.
- **Using the 8LS:** Provides an overview of system displays and operator menus.
- **Setup:** Describes all the setup displays for the controller, and how to access them.
- **Tuning and Control:** Explains PID control and provides tips for tuning your system.
- **Troubleshooting:** Gives some basic guidelines for solving control problems.
- **Appendix A:** Describes the Ramp and Soak function in the 8LS controller.
- **Appendix B:** Describes the 8LS-CP controller—its function, features, and additional menus.

## System Diagram

---

The illustration below shows how the parts of the 8LS are connected. When unpacking your system, use the diagram and parts list below to ensure all parts have been shipped. Please don't hesitate to call Watlow Anafaze's Technical Service Department if you have problems with your shipment, or if the 8LS components are missing or damaged.



## Parts List

- 8LS controller
- Controller mount kit
- RTB
- 50 pin flat ribbon cable
- 8LS manual

## Safety

---

Watlow Anafaze has made efforts to ensure the reliability and safety of the 8LS™ controller and to recommend safe usage practices in systems applications. Please note that, in any application, failures can occur. These failures may result in full control outputs or other outputs which may cause damage to or unsafe conditions in the equipment or process connected to the 8LS controller.

Good engineering practices, electrical codes, and insurance regulations require that you use independent external safety devices to prevent potentially dangerous or unsafe conditions. Assume that the Watlow Anafaze 8LS controller can fail with outputs full on, outputs full off, or that other unexpected conditions can occur.

Install high or low temperature protection in systems where an overtemperature or undertemperature fault condition could present a fire hazard or other hazard. Failure to install temperature control protection where a potential hazard exists could result in damage to equipment and property, and injury to personnel.

The 8LS includes a reset circuit that sets the control outputs off or to the data stored in memory if the microprocessor resets—normally the result of a power failure and power return. If a memory-based restart will be unsafe for your process, program the 8LS controller to restart with outputs off. For additional safety, program the computer or other host device to automatically reload the desired operating constants or process values on return of operating power. However, these safety features do not eliminate the need for external, independent safety devices in potentially dangerous or unsafe conditions.

Watlow Anafaze also offers ANASOFT®, an optional software program for IBM-AT® or IBM-PC® compatible computers. In the event of a reset, ANASOFT will reload the 8LS controller with the current values in computer memory. The user must ensure that this reset will be safe for the process. Again, use of ANASOFT does not eliminate the need for appropriate external, independent, safety devices.

Contact Watlow Anafaze immediately if you have any questions about system safety or system operation.



# Introduction

The 8LS is a powerful 1/4 DIN controller that delivers 8 fully independent loops of PID control. It can function as a stand alone controller and as the key element in a computer supervised data acquisition and control system. An LED front panel display and a touch keypad are available for local entry of control and other operating parameters. The 8LS can also be supervised by a computer or programmable controller through the standard serial interface.

The 8LS features include:

**Direct Connection of Mixed Sensors:** Versatile analog inputs let you directly connect most industrial T/C sensors. Thermocouple inputs feature reference junction compensation, linearization, upscale break detection, and a choice of °F or °C display. Other analog inputs require scaling resistors on the 8LS inputs.

**Automatic Scaling:** All sensors can be automatically scaled by entering any two measurement points. For example, to scale a pressure sensor, enter two points such as 28% is 80 PSI, and 82% is 260 PSI. All subsequent values will be in PSI.

**Selectable Control Outputs:** Each PID primary control output can be selected as digital for on/off, time proportioning, or as analog for proportional 0-5vdc /4-20madc. The PID secondary output can be selected as digital for on/off, time proportioning, or distributed zero crossing. Each loop can be independently set for on/off, P, PI, or PID control with reverse acting [heat] or direct acting [cool] output.

**Complete Process Monitoring:** A unique alarm capability is included. You can set a deviation band alarm, and high and low process [fixed] alarms independently for each loop. In addition to global annunciator digital output, each alarm can include a single or grouped digital output. For example, the digital output from all the high process alarms can be directed to a single output for automatic process shutdown.

**Front Panel or Computer Operation:** You can set up and run the 8LS from the front panel or from a local or remote computer. We offer ANASOFT, an IBM PC or compatible menu driven program, to set the 8LS parameters. In addition, ANASOFT features graphic trend plotting, process overviews, printouts, and data archiving.

**Multiple Job Storage:** You can store up to 8 jobs in protected memory and access them by entering a single job number. Each job is a set of operating conditions, including setpoints and alarms. Thus if a single oven is producing multiple products, entry of the job number will setup all the loops.

**Dual Output Standard:** The 8LS includes dual control outputs for each loop with a second set of control constants for heating and cooling applications.

**Optional Ramp and Soak:** The 8LS is available with a built in powerful Ramp and Soak programmer for batch processing.

**Optional Extruder or Carbon Potential:** The 8LS is available with built in Extruder or Carbon Potential parameters for controlling these processes.

## Specifications

---

### Analog Inputs

Analog inputs	8, solid state, differential
Optical isolation	120 Vac between inputs; 175 Vac from input to ground
A/D converter	Integrating voltage to frequency
DC voltage range	-10 to 60 mV. You can change it with scaling resistors to any range from 0 to 25V
Resolution	0.02%, greater than 12 bits
Accuracy	0.05% at 25°C
Calibration	Automatic zero and full scale
Temperature coefficient	Less than 50 ppm/C, 0.005%/°C
Normal mode rejection	60 db at 60 Hz, full scale range maximum
Loop update time	2 times per second, every input
T/C burnout	Full upscale reading of input standard
DC milliamp inputs	4-20 mA, 10-50 mA, 0-50 mA, etc., with scaling resistors
Input Range	0-1V, 0-5V, 0-10V, 0-12V, up to 0-25 Vdc, with scaling resistors
Infrared inputs	Power supply included, with scaling resistors
Source impedance	Measurements are within specification with up to 500 ohms source resistance

### Thermocouple Ranges

J	-350 to 1400°F	-212 to 760°C
K	-450 to 2500°F	-268 to 1371°C
T	-450 to 750°F	-268 to 399°C
B	150 to 3200°F	66 to 1760°C
S	0 to 3200°F	-18 to 1760°C
R	0 to 3210°F	-18 to 1766°C
N	-450 to 2370°F	-268 to 1299°C

### RTD Ranges

RTD1	-148.0 to +572.0°F	-100 to 300°C	0.1°
RTD2	-184.0 to +1544.0°F	-120 to 840°C	0.2°

## Control Capability

Number of loops	8, dual output
Control outputs	Cycle Time Proportioning, Distributed Zero Crossing, On/Off or Analog; all independently selectable for each loop
Control action	Reverse [heat] or Direct [cool], independently selectable for each loop
Digital PID outputs	Nominal 5 Vdc at 20 mA to drive optically-isolated solid-state relays
Cycle time	Programmable for each loop, 1-255 seconds
Analog PID outputs	Selectable 0 to 5 Vdc at 20 mA maximum or 4 to 20 mAdc 500 ohm maximum load
Output resolution	12 bits

## Digital Outputs

Number	31
Configuration	1 Global Alarm (terminals) 30 for alarms or events (1-4 terminals, 5-30 RTB connector)

## Digital Inputs

Number	12
Configuration	12 for Ramp/Soak triggers (1-8 RTB connector, 9-12 terminals)

## Pulse Counting Input

Number	Selectable 1 per unit
Type	Open collector, 5 Vdc max.
Frequency	1 to 20 KHz

## Serial Interface

Type	RS-232 or RS-485 4 wire, jumper select
Isolation	RS-232: optical RS-485: To RS-485 Specification
Baud Rate	2400 or 9600, menu selectable
Protocol	Form of ANSI X3.28-1976, compatible with Allen Bradley PLC, full Duplex
Error check	BCC or CRC, menu selectable
No. of controllers	Each communications line: 32 with RS-485, 1 with RS-232

## Power Supply

Power input	85 to 132 Vac, .1A typical, 47 to 440 Hz
-------------	--

# Installation

This section explains how to install the 8LS. The instructions are written for nontechnical users. If you are technically proficient and they seem simple, at least skim all of the instructions, so you don't miss anything vital.

These symbols are used throughout this manual:



## DANGER

**This symbol warns you of a hazard to human life.**

---



## WARNING

**This symbol warns you of possible damage to property or equipment.**

---



## NOTE

**This symbol denotes information you must know in order to proceed.**

---

---

## Read This Before Installation

---



### DANGER

Shut off power to your process before you install the 8LS. High voltage may be present even when power is turned off! Reduce the danger of electric shock after installation--mount the 8LS in an enclosure that prevents personal contact with electrical components.

The 8LS measures input signals that are not normally referenced to ground, so the 8LS inputs and other signal lines can have high voltage present even when power is turned off. For example, if you inadvertently short a thermocouple to the AC power line.

---



### WARNING

During installation and wiring, place temporary covers over the housing slots and the rear of the 8LS so dirt and pieces of wire don't fall through the slots. When you are finished with installation, remove the covers.

Install the 8LS so the airflow to the slots in the housing is not restricted after installation. Make sure that other equipment does not block airflow to the housing slots.

Use #20 or #22 AWG wires and trim wire insulation to 1/4" (5 mm). Wire should fit inside the terminal with no bare wire exposed, to prevent contact between wires and the grounded case. Tin any stranded wire.

Support power, input and output cables to reduce strain on the terminals and to prevent wire removal.

---



### NOTE

Choose a panel location that leaves enough clearance to install and remove the 8LS and its components.

---

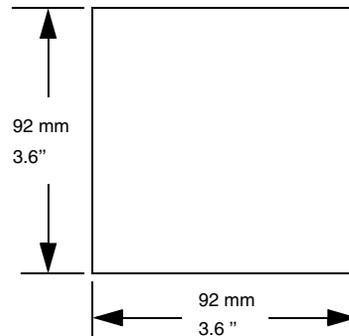
---

## Mounting The 8LS

The 8LS consists of a 1/4 DIN housing with a front plug in electronics module. The 8LS-OF (Open Frame) is suitable for sub-plate mounting inside an enclosure without a front panel. An 8LS-DK will supply the front panel keyboard with a 10-foot plug-in cable.

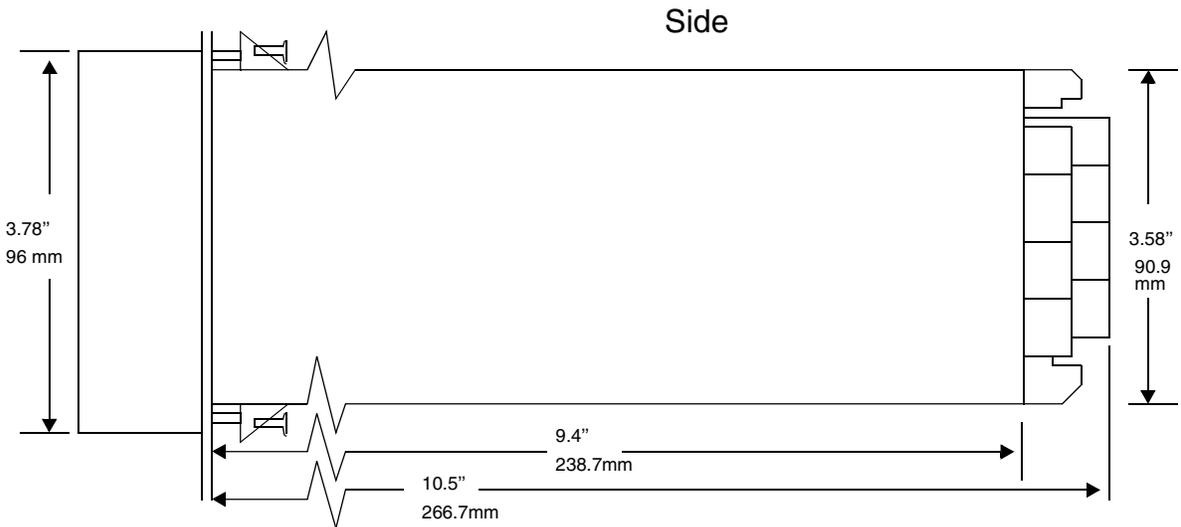
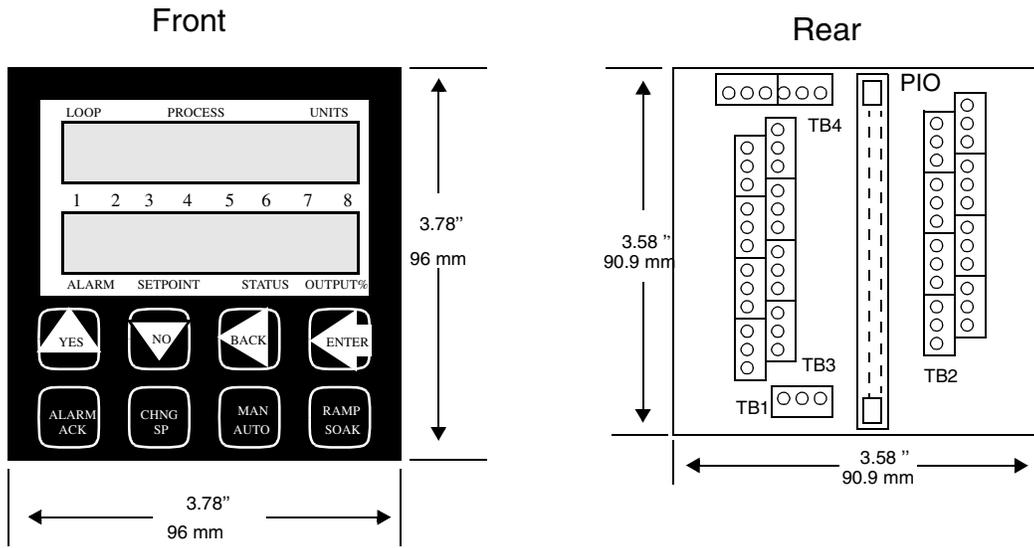
For optimum performance when directly connecting thermocouple inputs, the unit should be protected from thermal shocks whenever possible. This will minimize any temperature gradients across the terminal strips and ensure the highest accuracy.

1. Use the dimensions below to cut a hole in the panel.



Cut the hole carefully; the 1/4 DIN specification only allows a front panel of 96mm x 96mm [3.78in x 3.78in], so there's not a lot of room for error.

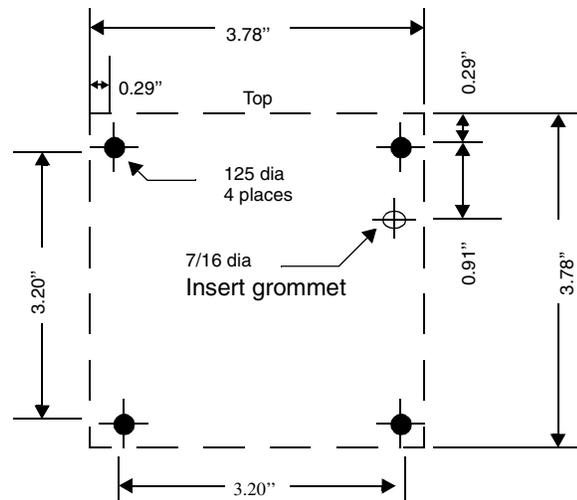
2. After the hole is cut, insert the 8LS through the front of the panel and screw the top and bottom clamps into place. If excessive vibration is anticipated a rear support may be required both for the 8LS and the interconnecting cables.



### Remote Panel Mounting Dimensions

#### Notes:

1. Dashed line indicates panel outline.
2. Drill holes as indicated.
3. Install grommet and feed wire through grommet.
4. Attach panel using 4 #4 screws (from behind).



### External Wiring

During wiring, it is recommended that the 8LS electronics be removed or that temporary covers be put over the housing slots to ensure pieces of wire do not enter the housing and lodge in the electronics. Always ensure that the housing is clean when the electronics is plugged in.

A successful installation of an 8LS control system depends on selecting the proper equipment and using correct installation techniques with appropriate material. One area of concern is the wiring type and placement of the wiring.

The wiring is selected according to the function of the wire, the installation requirements, and the possible mechanical electrical problems that may occur.

The function of the wire is divided into two basic categories: **Inputs** and **Outputs**. The process control requirements will dictate the **type** of inputs and the outputs along with the mechanical electrical requirements of the individual installation.

The term AC power is applied to the 120 VAC control supply. High power is applied to 240 VAC or higher, primarily used for control loads.

### General Wiring Requirements

1. Use stranded wire. Solid wire is recommended for fixed service and tends to make intermittent connections when moving the field wiring around for maintenance.

2. Use 20 or 22 AWG size wire. The use of 16,18,20,22, or 24 AWG is permissible also. The power requirement is not a factor in the wire size. Only the mechanical strength and the ohmage of the wire may be factors to consider. Smaller or larger sizes are not easily installed, may be easily broken and/or cause intermittent connections.
3. Use shielded wire. The electrical shield is used primarily to protect from unwanted electrical noise.

Normal use of the **input wiring shield** is to connect one end only to the 120 VAC panel ground at the 8LS panel location. Another method is to connect it at the sensor site ground and to the Analog Ground terminal of the 8LS.

Normal use of the **output wiring shield** would be to connect one end only to the 120 VAC panel ground in the panel that the 8LS is mounted in. Actual use of the shields will be determined by the installation requirement.

For additional noise suppression measures see NOISE SUPPRESSION FOR Digital Outputs.

4. Use Thermocouple Extension Wire for all thermocouple (T/C) inputs. Most T/C Ext. Wire is solid wire unshielded. When using such, the shield function cannot be utilized and only 16, 18, or 20 AWG should be used. Install all T/C wiring in its own conduit away from AC Power and High Power wiring. Depending on type and wire size up to 400-500 feet in length may be used to be within stated accuracy and source impedance.
5. Use multiconductor stranded shielded cable for analog inputs. Most inputs will use a shielded twisted pair, but some may require a 3 wire input. Run all analog input wiring in its own conduit away from AC Power and High Power wiring. Wire sizes of 20, 22, or 24 AWG may be used.
6. Use multiconductor stranded shielded cable for analog outputs and PID digital outputs connected to panel mount SSR's. The analog output will normally use a twisted pair while the digital outputs will be up to 9 or 20 conductors depending on wiring techniques. All cables will be shielded. The wiring size will normally be 24 AWG. The maximum length for the digital outputs should not exceed 25 feet. The maximum length for the analog outputs should not exceed 400 feet. All wiring must be in a separate conduit away from AC Power and High Power wiring.

When using the 50 conductor flat ribbon cable for the I/O, use of the 50-pin connector is recommended for both ends of the cable. The wire is too small to withstand much flexing when connected to a screw terminal. The cable length should not exceed 15 feet.
7. When installing communications wiring, by pulling in an extra pair, a sound power phone system could be used for communications between the 8LS and the computer. This could be used for maintenance, checking calibration and many other functions. A David Clark #H5030 sound powered system has been used successfully in systems requiring this function.
8. When installing any I/O wiring to the 8LS inside a panel, it should never be run in the same bundle as AC power wiring.

Wiring bundles of low power Watlow Anafaze circuits next to bundles of high power AC wiring should never be done. The physical separation of the high power circuits from the controllers should be of prime importance. In fact, most AC voltage high power circuits are installed in a separate panel.

## Cable Recommendations

Use these cables or their equivalent.

Function	MFR P/N	# of Wires	AWG
Analog Inputs	Belden #9154	2	20
	Belden #8451	2	22
RTD Inputs	Belden #8772	3	20
	Belden #9770	3	22
T/C Inputs	T/C Ext. Wire	2	
Carbon Probe Input	Belden #88760	2	18
Digital PID Outputs and Digital I/O	Belden #9539	9	24
	Belden #9542	20	24
	Ribbon Cable	50	
Analog Outputs	Belden #9154	2	20
	Belden #8451	2	22
Computer Communication: RS232, RS422, RS485, or 20 mA	Belden #9729	4	24
	Belden #9730	6	24
	Belden #9842	4	24
	Belden #9843	6	24

## Noise Suppression

When using the digital outputs from Watlow Anafaze multiloop controllers to energize dry contact electrical-mechanical relays with inductive loads, generation of RFI may become a problem.

This may cause the 8LS display to blank out and then re-energize as if power had been momentarily turned off. It may also cause the CPU in the equipment to reset, losing the PID output levels. It may also damage the digital output IC circuit, thus not being able to energize the digital outputs. If the IC circuit is damaged, factory repair will be required.

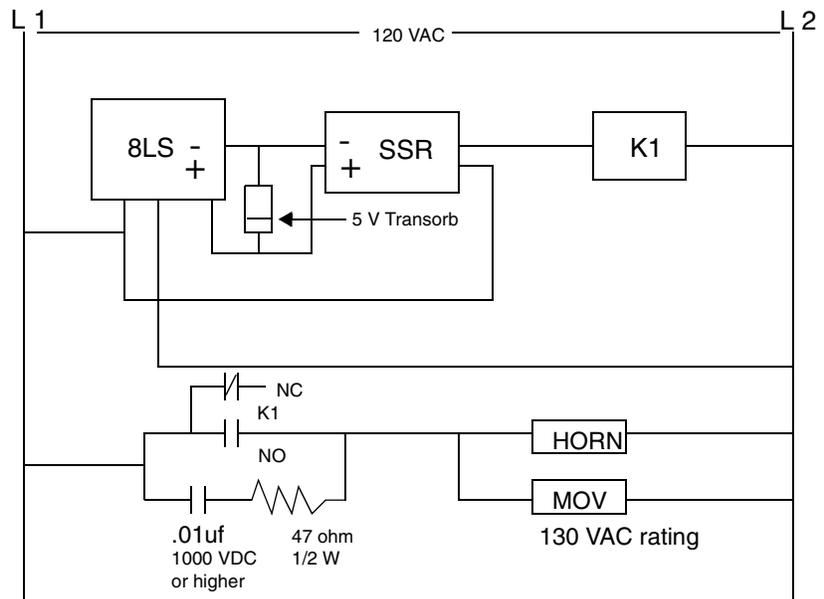
The type of loads that may cause a problem are motor starters, alarm horns, etc. The RFI is generated upon opening of the metallic relay contacts.

To correct the problem of RFI noise problems:

1. Use Solid State Relays (SSR) wherever possible in place of electrical-mechanical relays (E-M relays).
2. When using E-M relays, if possible do not mount them in the same panel as the Watlow Anafaze equipment.
3. Separate the 120 vac power leads from the low level input and outputs leads from the Watlow Anafaze. Do not run the digital outputs or PID control outputs leads in the same wire bundle as any 120 vac wires. Inputs leads should never be run in the same bundle with any high power leads.
4. If E-M relays are required and must be in the same panel as the Watlow Anafaze equipment, use a .01 uF at 1000 vdc or higher vdc disk capacitor in series with a 47 ohm 1/2 W resistor across the NO contacts of the relay load contacts. This is the most important step in suppressing RFI from relay contacts. This network is known as arc suppressor or snubber networks.
5. Use of other voltage suppressing devices may also be used, but are not normally required. A device known as a MOV rated at 130 vac for 120 vac control circuits may be placed across the load. This will limit the peak ac voltage to about 180 vac. A device known as a transorb (back to back zeners) may be used across the digital output. The rating of 5 vdc should be used. This will limit the dc voltage to 5 vdc on the digital output loop.

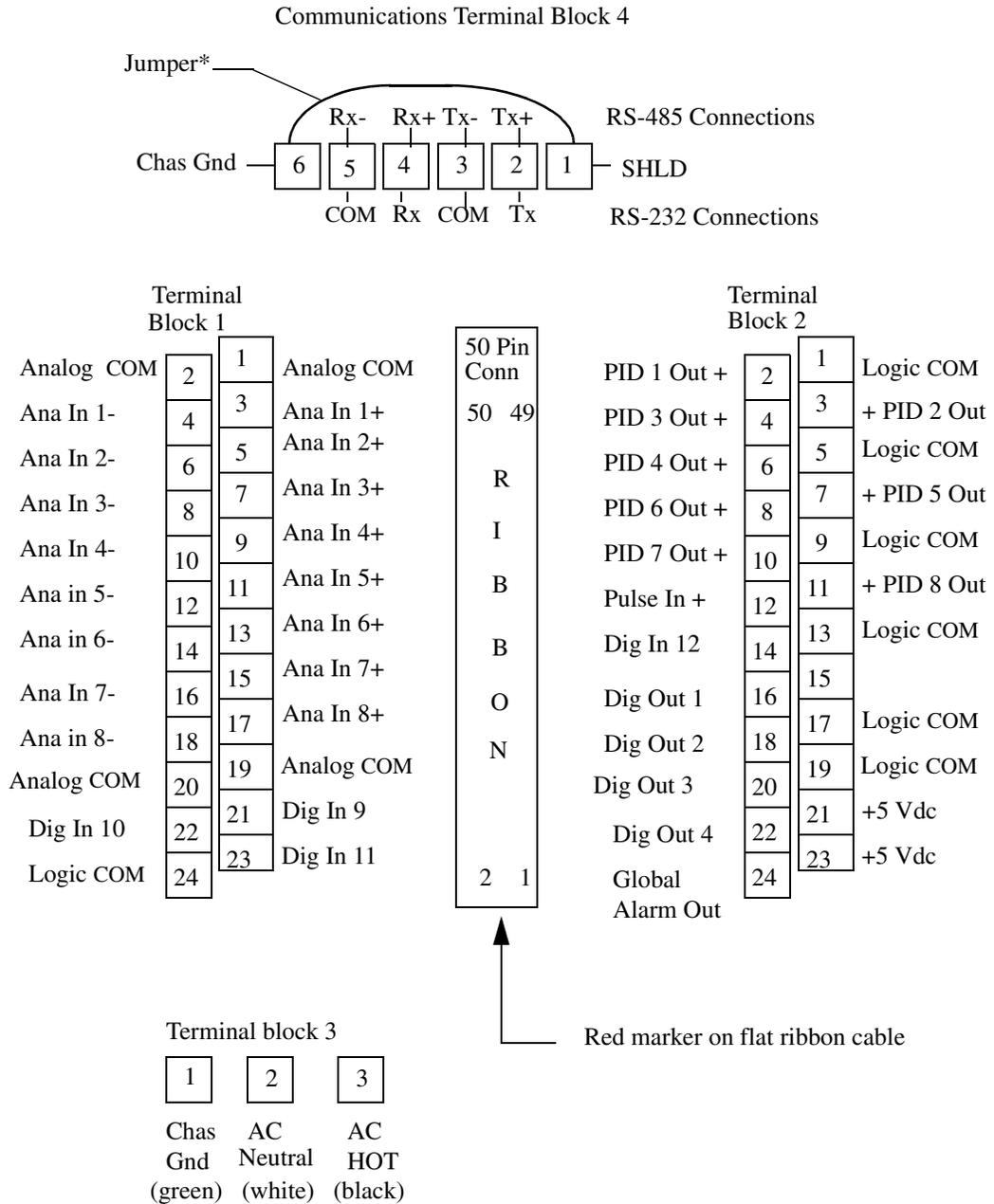
See diagrams for proper placement of the above devices. The parts for RFI suppression are available from Watlow Anafaze.

The above steps should eliminate any noise problems that might be present with using E-M relays. If, problems persists and/or any questions about the above steps arises, please call **Watlow Anafaze Technical Service Department** at **(408) 724 3800**.



## Terminal Block And Connector Layout

The 8LS terminal blocks and connectors are assigned according to the following two pages. Subsequent sections provide detailed connection descriptions.



\* It is suggested with noisy electrical environments, a heavy gauge jumper wire be connected between the chassis ground and shield terminals on the rear terminal block as shown.

## RTB Connections

The RTB provides the control outputs and additional digital inputs and outputs as follows:

Terminal	Function	Terminal	Function
1	+5 Vdc	2	+5 Vdc
3	Logic COM	4	Logic COM
5	Spare	6	Spare
7	Spare	8	Spare
9	PID 1 Out	10	Dig 30 Out
11	PID 2 Out	12	Dig 29 Out
13	PID 3 Out	14	Dig 28 Out
15	PID 4 Out	16	Dig 27 Out
17	PID 5 Out	18	Dig 26 Out
19	PID 6 Out	20	Dig 25 Out
21	PID 7 Out	22	Dig 24 Out
23	PID 8 Out	24	Dig 23 Out
25	Dig 5 Out	26	Dig 22 Out
27	Dig 6 Out	28	Dig 21 Out
29	Dig 7 Out	30	Dig 20 Out
31	Dig 8 Out	32	Dig 19 Out
33	Dig 9 Out	34	Dig 18 Out
35	Dig 10 Out	36	Dig 17 Out
37	Dig 11 Out	38	Dig 16 Out
39	Dig 12 Out	40	Dig 15 Out
41	Dig 13 Out	42	Dig 14 Out
43	Dig 1 In	44	Dig 2 In
45	Dig 3 In	46	Dig 4 In
47	Dig 5 In	48	Dig 6 In
49	Dig 7 In	50	Dig 8 In

All digital outputs and the PID outputs on this ribbon connection are Sink Outputs. They are in reference to the 5Vdc supply. The outputs will be low when they are on.

All digital inputs are TTL level inputs and may be selected from software if they will be high/false or low/true inputs.



---

#### NOTE

**When using the RTB, proper polarity of the flat ribbon cable is necessary for correct pin terminations. Install the red marker indicating pin #1 to the left when terminal #1 of the RTB is to the left. The flat ribbon cable should have the red marker down when installing it on the back of the 8LS. To confirm proper polarity, check that pin #1 is +5vdc with respect to pin #3.**

---

## Analog Inputs

Connecting analog signals to the 8LS is normally straightforward. Most thermocouples can be directly connected and mixed in any order. Other types of analog signals such as RTD's or mAdc or Vdc require scaling resistors installed on the 8LS inputs. Some problems may occur that could reduce accuracy and possibly damage the unit. Below are some of the potential areas for concern.

### *Common Mode Voltage*

Common mode voltage is the voltage between the ground at the sensor and the ground at the 8LS. It can be an AC or DC voltage and appears equally at the high and low input terminals. Frequently it is caused by large currents flowing in the ground path between the 8LS and the sensors. Use isolated sensors or ungrounded thermocouples and locate the 8LS as close as possible to the sensors in order to minimize the effects. Do not exceed the maximum common mode voltage of 175 Vac.

### *Normal Mode Voltage*

Normal mode voltage appears across the terminals of the input and is the signal from the sensor plus any undesirable noise. The major cause of this noise is AC power line pick-up. The effects are reduced by the 8LS capacity to integrate the signal over a multiple of the power line frequency. Further reduction can be achieved by locating the 8LS near the sensors and by using twisted and shielded sensor wires.

To ensure accurate readings, the maximum of normal mode plus signal should not exceed -10mv to +60mv.

### *Grounding*

For best accuracy, observe the grounding recommendations for connecting each input and output signal. The analog signal grounds should be connected to the analog ground terminals. The communication and control outputs should be connected to their respective grounds. Do not mix the grounds or connect them together. If possible, route the analog signal cables separately from the communication, control and power cables.

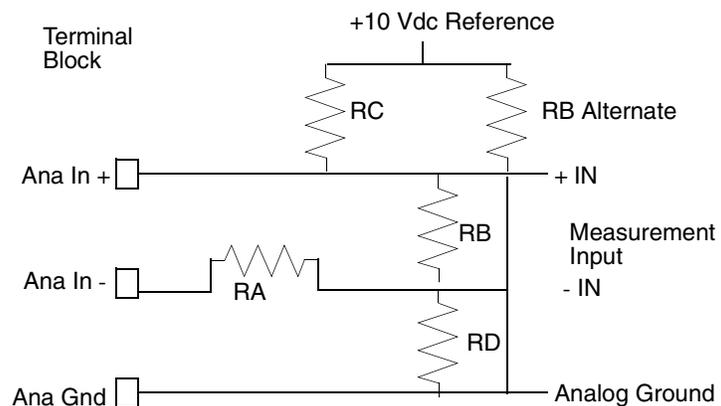
### Source Impedance

Each sensor has a certain output impedance which is effectively connected across the 8LS input amplifier when a measurement is made. To reach the rated accuracy, the maximum source impedance should not exceed 500 ohms. Consult Watlow Anafaze for operation with higher source impedance.

## Input Scaling

The 8LS contains an area that can be used to install resistors to scale input voltages and convert milliamp inputs to match the -10 to 60mv (-16.7% to 100%) input range. The input circuit is designed to enable connection of current inputs (such as 4 to 20ma), voltage inputs, and 3-Wire RTD. Watlow Anafaze will supply input scaling as needed -- order option 8LS-SI-XX. The input circuit is shown below:

Ana In + = Analog signal + input  
 Ana In - = Analog signal - input  
 Ana Gnd = Analog signal ground

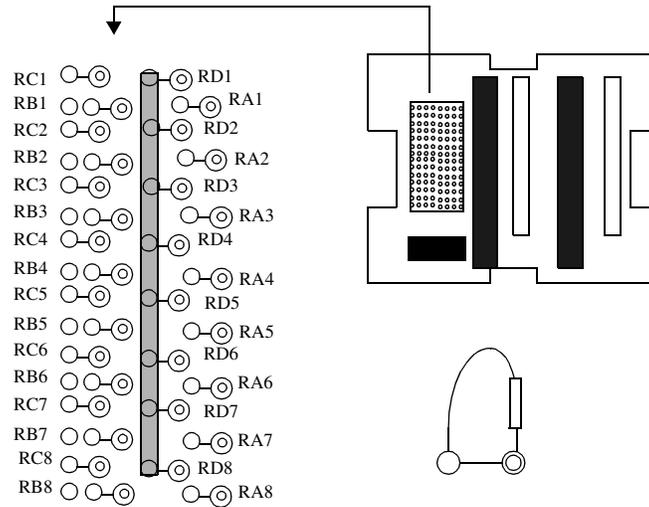


RA is shorted by a jumper on the PC board, REMOVE THIS JUMPER TO INSTALL RA.

Resistors should be 0.1% metal film, 1/4 watt. Note that the resistors must be stood on end due to the compact size of the unit. Other components such as capacitors can be installed for signal conditioning. Please consult Watlow Anafaze. The PC board silk screen shows the resistor locations.

## Resistor Installation

For scaling resistors the body of the resistor goes vertically into the hole with the white silk screen. The lead on the top then goes into the adjacent indicated hole. The resistor positions are highlighted.



## Voltage Inputs

DC Voltage inputs should be connected with the positive side to the **High** terminal and the negative side to the **Low** terminal. The input range is -10 to +60 mV. Signals greater than 60 mv must be scaled with resistors to match the input full scale to 60 mv. The scaling resistor RA is selected as the voltage dropping and/or current limiting resistor. RB is selected for the 60 mv full scale dropping resistor. It should normally be less than 300Ω and no greater than 1000Ω. Any value above 1000Ω for RB will cause error due to the upscale burnout circuit.

This table shows scaling resistors values.

Output Voltage Range	RA	RB	Accuracy
0-100 mV	499 Ω	750 Ω	+ .1 %
0-500 mV	5.49 KΩ	750 Ω	+ .1 %
0-1 V	6.91 KΩ	442 Ω	+ .2 %
0-5 V	39.2 KΩ	475 Ω	- .2 %
0-10 V	49.9 KΩ	301 Ω	- .1 %

The above values are .1% standard metal film resistor values and will give an accuracy of ±0.25%. The above values at .1% are our factory stock. Any possible error due to resistor tolerance error may be corrected by using the built in linear scaling. Remove the jumper in the RA location to install RA.

## Milliamp Inputs

Current inputs from transmitters are accommodated by placing resistors in the input section to convert the current input into a voltage. Different current input ranges are accommodated by selecting the proper resistor values.

A single 0.1% resistor is used as follows:

4 to 20 ma	0 to 10 ma
RB = 3.000 Ω	RB = 6.000 Ω

## Thermocouple Inputs

All thermocouple types may be directly connected to the Watlow Anafaze 8LS. Types J, K, T, R, S, B, and N linearization and cold junction compensation are provided standard in the Watlow Anafaze 8LS. For other thermocouple types, optional input ranges are required. Thermocouples should be connected with the positive lead to **Ana In +** terminal and the negative lead to **Ana In-** terminal of TB1. RA is the only resistor used for T/C inputs and it is a jumper.

## RTD Inputs

The standard industrial RTD is a 100 ohm Platinum three wire assembly. We highly recommend using the 3-wire RTD. The 8LS will be configured for the standard three wire RTD input.

Watlow Anafaze offers two standard DIN 385 Curve RTD input ranges, as shown in the table below:

RTD Type	Input Range	Display Resolution
RTD1	-100.0 to +300.0 °C -148.0 to +572.0 °F	0.1°
RTD2	-120.0 to 840.0 °C -184.0 to +1544.0 °F	0.2°

RTD Range resistors are Watlow Anafaze factory stock in .05% tolerance.

Range	RA	RB Alternate	RC
RTD1	80 Ω	22 KΩ	22 KΩ
RTD2	100 Ω	48 KΩ	48 KΩ

## Infrared Non-contact Temp. Sensors

The IRSM (infrared sensing module) is ideally suited for many infrared non-contact temperature applications. It can be supplied by Watlow Anafaze as a fully integrated system with the 8LS configured to provide power for up to four IRSM modules and for direct connection of the IRSM output. The following connections are required if the IRSM internal ambient sensor is not used:

8LS Signal	IRSM Wires		
	Pin	Color	Function
Analog In +	A	Orange	Signal Out (0-10 mAdc)
Analog In -	B	White	Signal Ground
Analog Gnd	K		Shield
+5 Vdc	E	Red	+5 Vdc supply
Logic Gnd	C	Black	Power Ground
Logic Gnd	J	Brown	No Peak Hold
No Connection	D	Green	+15 Vdc supply
No Connection	F	Blue	Ambient Sensor
No Connection	H	Yellow	Track and Hold

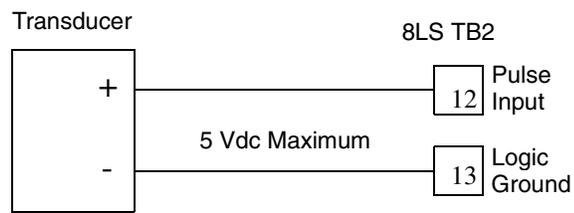
The range of the standard IRSM is 0-1000 degrees F with an output of 0-10ma dc. The input of the Watlow Anafaze 8LS is configured for a 0-10madc input.

To use more than four IRSM's with the 8LS, use an external power supply of 8-15vdc.

If desired, a second input may be used to monitor the internal IRSM ambient temperature. Consult Watlow Anafaze for more information.

## Pulse Input

The single pulse input is used when a speed or flow input is available as a Open Collector signal of 5Vdc maximum from the transducer. The frequency range of the input is from 1Hz to 20KHz. The sample time period is adjustable from 1 to 20 seconds. To enable the pulse input, select PLS for the input type of the loop that is to be used for the pulse input. Do not use the analog input terminals. Connect the transducers output using shielded wiring to the pulse input pin 12 of TB2 as shown:



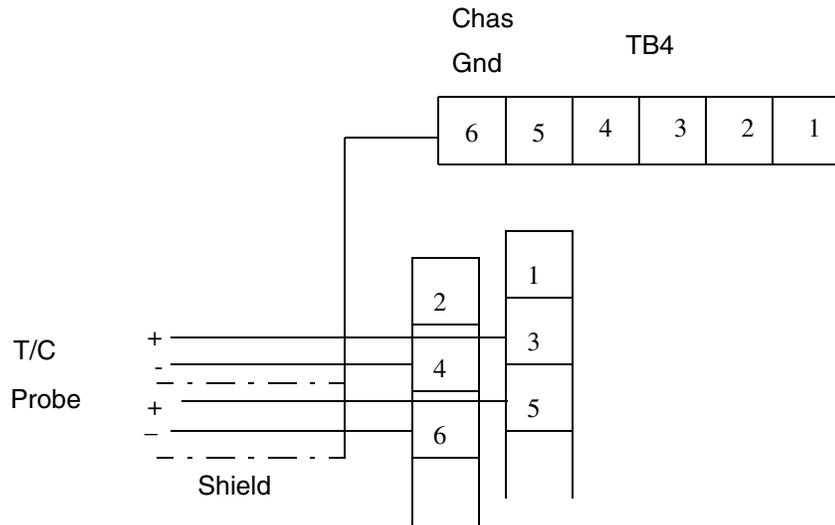
## Carbon Probe Input

The standard zirconia carbon probe as used by the metal treating industry will have two outputs.

One is the T/C output. A type K, N, R, or S is used. This output will use standard T/C Extension Wire connecting it to the 8LS.

The second output is the carbon probe output. This output requires using a special cable due to the electrical and temperature requirements of the probe and its environment. The cable requirements are two wire with shield with a high ambient temperature rating of at least 150° C.

The Belden cable part number 88760 is highly recommended for the connection of the carbon probe to the 8LS. An equivalent cable may be used.



Probe Cable Belden #88760.  
Connect Shield to TB4-6 Chassis Ground.

No. of CP Loops	T/C input Loop Number	Carbon Probe Input Loop No.
CP-1	1	2
CP-2	3	4
CP-3	5	6
CP-4	7	8

---

## Control Outputs

---



### WARNING

**Control outputs are connected to the 8LS logic ground. Be careful when you connect external devices that may have a low side at voltage other than controller ground, since you may create ground loops.**

**If you expect grounding problems, use isolated solid state relays and isolate the control device inputs.**

---

### PID Output Termination TB (Primary) or Flat Ribbon (Secondary)

The 8LS PID control outputs are Dual Outputs for each loop. For identification these are called primary and secondary control outputs. Therefore, each loop has control of two outputs, a primary and a secondary. These are set by factory default to be for Heat/Cool applications whether or not they will be used for heat/cool operation.

Primary simply means that it is physically implemented on the terminal block instead of the 50 pin ribbon cable. This is because many applications use only one output, and a user will not have to buy a remote terminal block to use the primary output. Also, the primary outputs are the only ones which can be programmed to analog. Primary outputs cannot be programmed for DZC outputs.

The default output assignment is for the heat output to be on the primary terminal outputs and the cool output to be on the secondary 50 pin ribbon outputs. This can be changed, however, on an individual channel basis by assigning the heat output to the ribbon cable. The primary and secondary outputs do not have to be used for heat/cool since:

1. Each output may be individually programmed as a different type: ON/OFF, TP (both outputs), DZC (secondary only) and ANALOG (primary only).
2. Each output can be individually programmed to be direct or reverse acting [both outputs can be the same].
3. There may be a deadband programmed for heat/cool, and in that deadband both outputs will be off.

## Pid Control Relay Outputs

Typical ON/OFF, TP, DZC control outputs utilize external optically-isolated solid-state relays. These relays use a 3 to 32vdc input for control and can be sized to switch up to 100amps at 480vac. For larger currents these relays can be used to drive contactors.

## Primary Screw Terminal Outputs

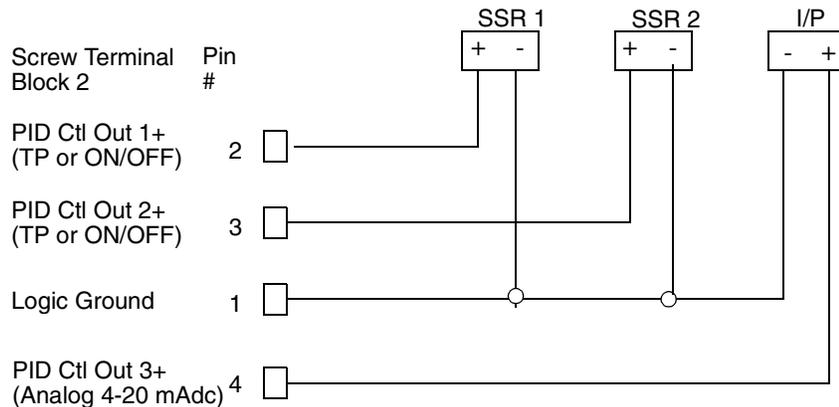
The primary PID positive output for each loop is located on the screw terminal blocks and labeled **Ctl Out 1+** through **Ctl Out 8+**. The negative side of the output is Logic Ground.



### NOTE

**Primary control outputs are a source supplying 5vdc when the output is On. They should be connected to the positive (+) side of SSRs. Analog outputs are positive with respect to logic ground.**

Connections are made as follows:



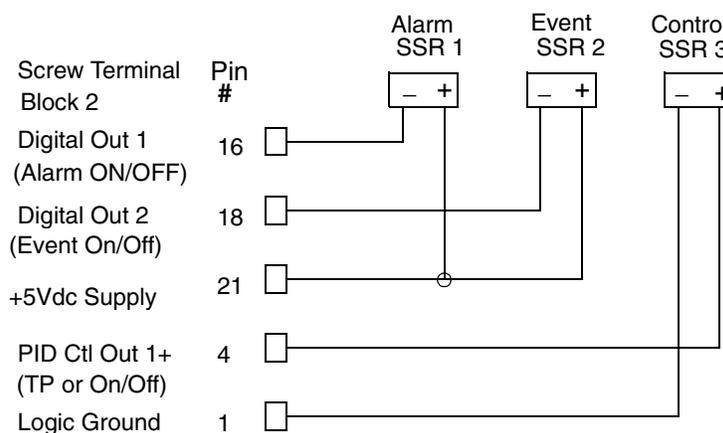
## Digital Outputs On The Screw Terminal Blocks



### NOTE

**Alarms and events outputs are sinking +5vdc to ground when the output is ON. They should be connected to the minus (-) side of SSRs.**

Connections are made as follows:



See Terminal Block and Connector Layout.

## Primary Analog Outputs

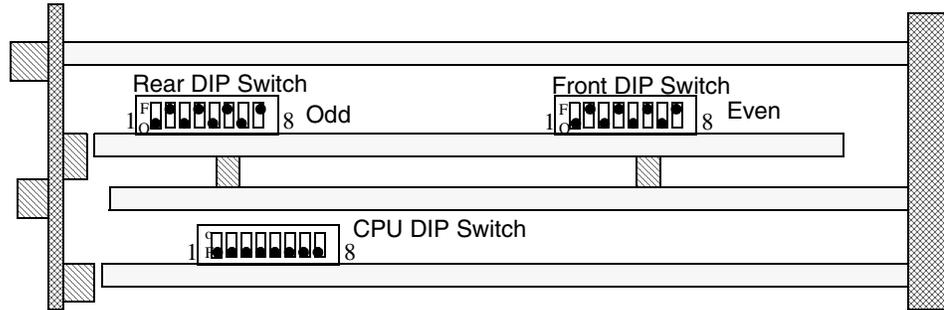
The 8LS provides either 4 to 20mA with 500 ohms maximum load or 0-5vdc at 5mA maximum. Selection is made on internal dip switches.

The control outputs are shipped as voltage outputs, and can be converted from voltage to current by changing the dip switch settings on the control output card. If you are using the output as a digital mode, such as TPV, you should leave the output in voltage mode. These switches are accessible from the top of the electronics assembly after it has been removed from the housing.

There are two dip switch packages on the Output Card, each with 8 switches. Each channel requires two switches. The dip switch package near the rear panel controls the odd numbered outputs, while the dip switch package near the front panel controls the the even channels. When the unit is viewed from the top, with the rear panels to the left, the channels are in ascending order from left to right [See silk screen on the printed circuit board].

For each channel, a switch pair will have the switches set in complementary states. If the first switch of the pair is down and the second is up, the output is in voltage mode. If the first is up and the

second is down, the output is in current mode. Thus if switch 3 is down and 4 is up on the dip switch package near the rear panel, then channel 3 is set for voltage.



Output switches are set to voltage mode; in CPU switch all special features are set to Off.

### Analog Output Dip Switch Setting for 0-5v/4-20mA

Loop	Switch	Position	0-5 Vdc	4-20 mA
1	Rear	1	O	F
1	Rear	2	F	O
3	Rear	3	O	F
3	Rear	4	F	O
5	Rear	5	O	F
5	Rear	6	F	O
7	Rear	7	O	F
7	Rear	8	F	O
2	Front	1	O	F
2	Front	2	F	O
4	Front	3	O	F
4	Front	4	F	O
6	Front	5	O	F
6	Front	6	F	O
8	Front	7	O	F
8	Front	8	F	O

**O** indicates an On switch, **F** indicates an Off switch.

## CPU Dip Switch



---

**WARNING**

**Normal mode of operation is for all positions to be Off. Positions that are On will effect the 8LS normal operation mode.**

---

Position 1 ON--Clears the battery backed RAM and re-initializes the factory default values into the RAM.

1. Turn off power.
2. Set DIP switch position 1 ON.
3. Turn on power for 10 seconds, and then turn it off.
4. Set DIP switch position 1 OFF.
5. Turn on power.

Positions 2 to 8 are not used for normal 8LS operations. All positions must be OFF.



---

**NOTE**

**Turn off the power before you set any DIP switch. After the new settings, turn on the power to energize the new DIP switch settings.**

---

## Secondary Outputs 50 Pin Ribbon Cable



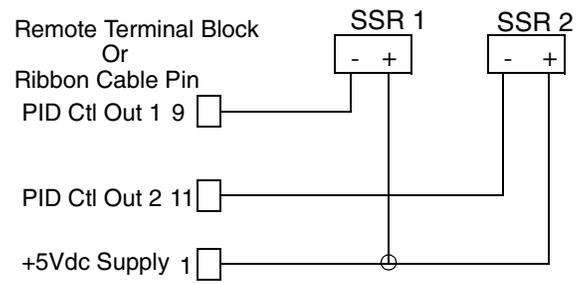
---

**NOTE**

**Secondary control outputs are sinking +5vdc to ground when the output is on. Connect them to the minus (-) side of SSRs.**

---

Connections are made as follows:



## Communications Set-up and Connections

The 8LS offers two types of serial communications: RS-232 and RS-485. Up to 32 addresses can be set in the 8LS for one communication line. RS-232 can not be used for more than 1 controller.

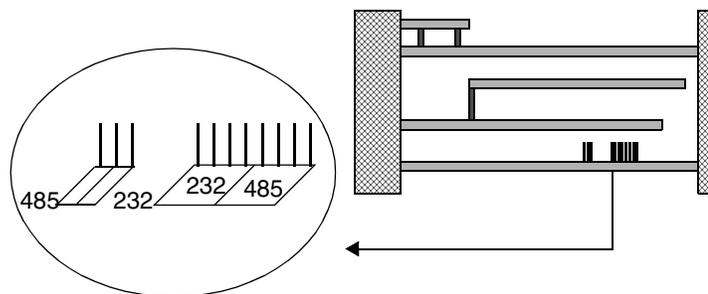
Unless otherwise specified in the purchase order, units are shipped configured for RS-232. They may be easily modified to RS-485 by moving a cable and a jumper plug. These may both be reached from the bottom of the electronics assembly after it has been removed from the chassis. The cable has a 4 pin connector which plugs into 4 pins on an 8 pin header on the processor card. RS-232 is on the 4 pins closest to the front panel, while RS-485 is on the 4 pins nearest to the rear panel. The connector is always installed with the red lead nearest the front panel. The jumper plug is located near the cable connector. The position closest to the rear panel is for RS-232, while the position nearest the front panel is for RS-485.

### RS-232 Connections

The optically-isolated RS-232 interface is connected using the Communications terminal block 1. See table below for connections.

Computer Connector		8LS	Watlow Anafaze
DB 25	DB 9	TB 4 Pin No.	Cable
RX Pin 3	RX Pin 2	TX Pin 2	White
TX Pin 2	TX Pin 3	RX Pin 4	Red
GND Pin 7	GND Pin 5	GND Pin 5	Black

The computer pins are for the normal 25 pin RS-232 connector [DB25] and the normal 9 pin connector [DB9]. On some computers transmit TX and receive RX may be reversed. Please check your computer manual for details.



## RS-485 Description And Connections

The RS-485 is a voltage balanced long distance multi-point transmission interface. It may use 2 or 4 lines depending on system requirements. The 8LS uses four lines [two lines can be accommodated on special order -- contact Watlow Anafaze].

### *RS-485 Description*

The EIA Standard RS-485 specifies only the electrical characteristics of generators (transmitters) and receivers for use in digital multi-point systems. The specification of transmission lines, signaling rates, protocols, etc. is left entirely up to the user. The transmitters and receivers selected by Watlow Anafaze also meet the requirements of RS-422.

The following information is intended to make recommendations for the application of the RS-485 interface to Watlow Anafaze equipment.

The maximum signaling rate used by the Watlow Anafaze 8LS and associated equipment is 9600 baud. Since this is far below the maximum signaling rate covered by the specification, satisfactory performance may be expected without strict adherence to all of the design rules. Watlow Anafaze has presented conservative recommendations to insure reliable operation. If deviations are necessary, please contact Watlow Anafaze.

### *Cable Recommendations*

We recommend twisted shielded pairs for the RS-485 cables. The transmitters and receivers specified in RS-485 are very tolerant of cable characteristics, and some leeway is possible unless distances and signaling rates push the specification limits.

One requirement is very important, as it impacts performance even down to low frequency operation. The loop resistance of the transmission line [wire only -- not terminating resistor] must not exceed  $200\Omega$  for a properly terminated line with a reasonable margin for noise. Thus the following recommendations for distance and wire gauge should be observed:

Distance	Wire Gauge	Recommended Cable
4000 ft.	24 AWG	Belden # 9729/9842
6000 ft.	22 AWG	Belden # 9184

The use of a shield depends on the noise environment and grounding considerations. The above cables are shielded.

### *RS-485 Connections*

Connection of Watlow Anafaze controllers to a system computer requires an interface at the computer to convert RS-232 levels to RS-485. Watlow Anafaze recommends two options:

- B&B Electronics 485OIC with 485PS2 or 485OISPR with 485PS.
- Black Box Model LD485A. The LD485A should be configured for DCE operation, with the RTS/CTS delay jumper in the "on" position. Watlow Anafaze can supply this converter configured and checked out with the system on request.

Jumper setup for the B&B Electronics:

1. JP1 Off
2. JP2 Installed

Normal Operation LD485A installation setup:

1. DCE operation (Dip shunt in XW1A socket)
2. Normal operation (Front panel switch out)
3. Full Duplex operation (Jumper W8 on Full)
4. RTS/CTS Delay set to ON (Jumper W9 to ON)
5. Unterminated operation (Switch S2 to Unterm)
6. No jumper at position W7

The RS-485 specification is for "balanced line" operation, and is not true differential. Thus a common connection is required between all stations on the communication line. This can be accomplished by either a 5th wire (which could be shield) or a common ground connection.

The Watlow Anafaze system more conveniently supports the common ground connection, although 5th wire can be supported if required due to common mode voltages generated in a given installation. The 3rd wire connection would be required only if the "common mode" voltage between stations exceeds the RS-485 specification of 7 volts peak.

To make sure the communication system works, the controller chassis must be electrically tied to Earth ground, and the host computer communication must be tied to Earth ground. If the host computer RS-232 communication is not referenced to Earth ground, install the 100 $\Omega$  resistor in W7 as recommended by Black Box.

The following diagram shows the recommended system hookup. The transmitter from the host computer connects in parallel to the controller receivers, and the host computer receiver connects in parallel to the controller transmitters. A single "daisy chain" is recommended. Octopus connections or "spurs" are discouraged.

A termination resistor is required at each end of the transmission line. This is accomplished by applying a 200Ω resistor across the line at the farthest point from the computer transmitter. Check with Watlow Anafaze for setting the Black Box SW2 to the "term" position to terminate the computer receive line.

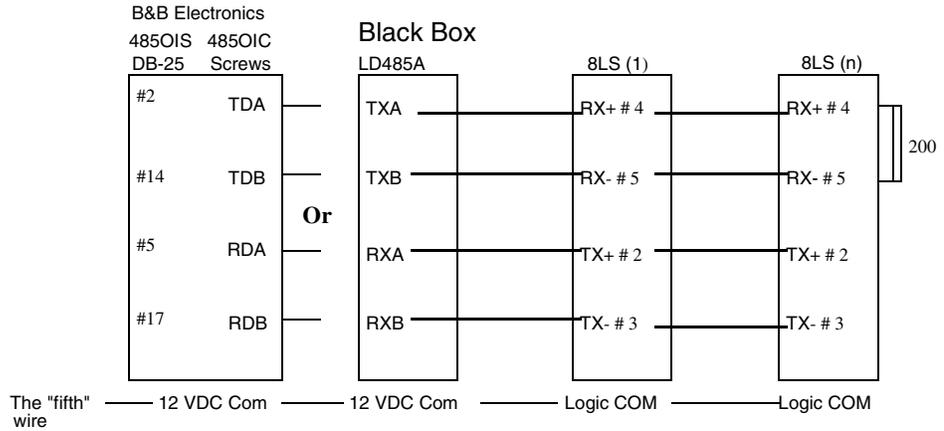
The fifth wire for RS-485 communications is recommended for noisy environment.



**NOTE**

**Connect the cable shields to equipment ground only at the 8LS controller sites. Do not connect the shield at the computer site to Ground. Connect a 200 ohm terminating resistor between RX- and RX+ at the 8LS.**

For multiple units connect the system in parallel as follows:

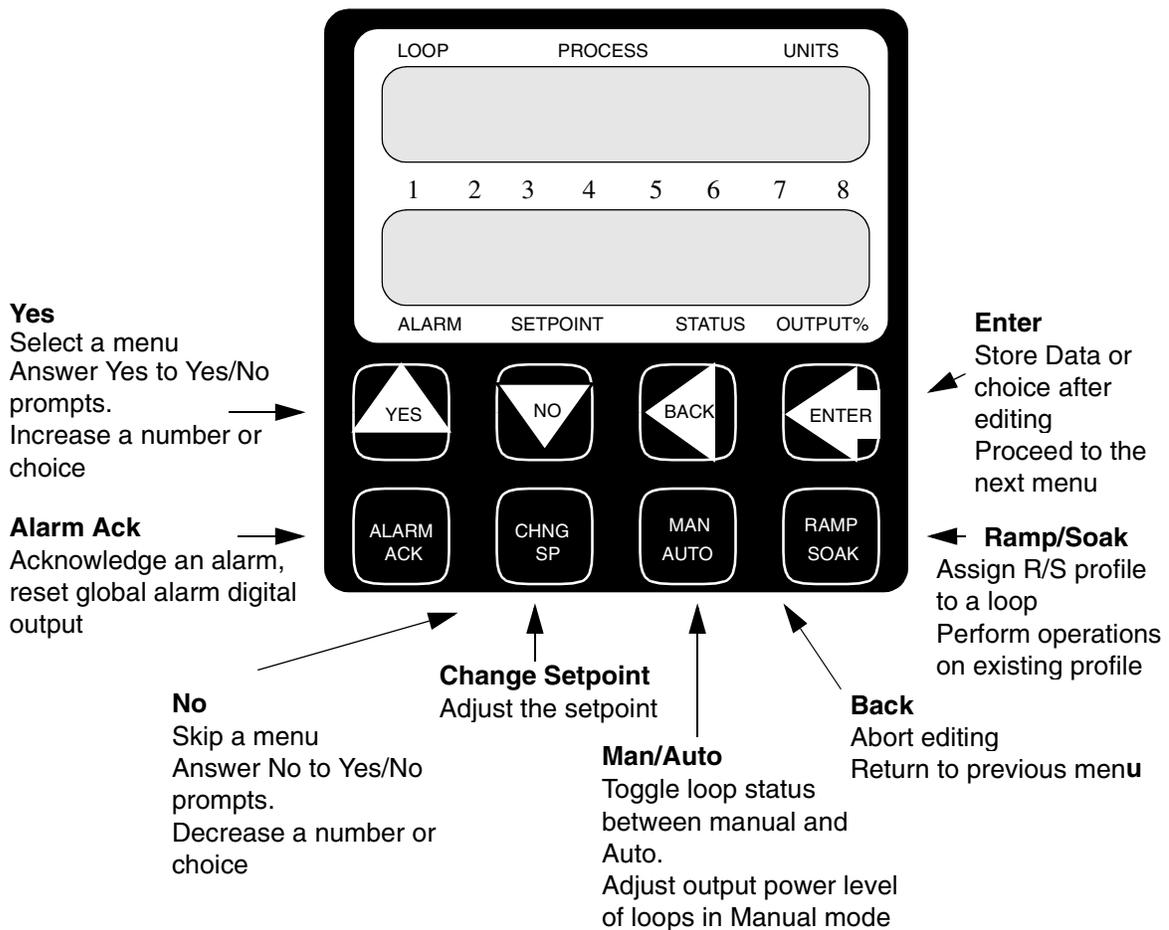


# Using the 8LS

This Chapter will show you how to use the 8LS from the front panel.

## Front Panel

The 8LS front panel provides a convenient interface with the controller for both viewing the process conditions and operating the controller. You can program and operate the 8LS with the front panel keys shown below, or you can use ANASOFT, a program designed specifically for Watlow Anafaze controllers.



## Front Panel Keys



### *Yes/Up*

Press Yes to

- Select a menu when prompt is blinking
- Answer Yes to Yes/No prompts
- Increase a number or choice you are editing



### *No/Down*

Press No to

- Skip a menu when prompt is blinking
- Answer No to Yes/No prompts
- Decrease a number or choice you are editing



### *Back*

Press Back to

- Abort editing
- Return to a previous menu



### *Enter*

Press Enter to

- Store data or menu choice after editing
- Proceed to the next menu



### *Alarm Ack*

Press Alarm Ack to

- Acknowledge an alarm condition, reset global alarm digital output



### *Chng SP*

Press Chng SP to

- Adjust the setpoint on displayed loop



### *Man/Auto*

Press Man/Auto to

- Toggle loop status between Manual and Auto
- Adjust output power level of loops in Manual mode



### *Ramp/Soak*

Press Ramp/Soak to

- Assign a Ramp/Soak profile to selected loop
- Perform operations on profile you have assigned



---

#### NOTE

**If the Ramp/Soak function is not installed, this key has no function.**

---

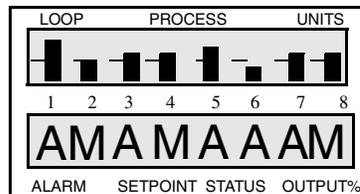
## Displays

The next section discusses the 8LS displays:

- Bar Graph display
- Single Loop display
- Scanning display
- Alarm display

### Bar Graph Display

This is the default display on power-up. It provides a system overview by displaying a deviation bar graph for each loop. Loop status including acknowledged alarms, manual or auto are also displayed.



The upper display shows the Bar Graph for each loop.

The highest and lowest level of the Bar Graph display are the upper and lower deviation alarms. If deviation alarms are Off, the display range is  $\pm 5\%$  of setpoint. The intermediate levels are linearly spaced between the upper and lower limits.

The lower display shows each loop's status. The table below shows the loop status symbols.

Loop Status Symbol		
Loop Function	Loop Display	Description
AUTO	A	Single output loop is in automatic control mode. The output power percentage displayed is for the heat output.
HEAT	H T	Dual output loop is in automatic control and the heat output is active. The output power percentage displayed is for the heat output.
COOL	C L	Dual output loop is in automatic control and the cool output is active. The output power percentage displayed is for the cool output.
MANUAL	M	Loop is in manual control mode. Output power percentage displayed is for the heat output.

The table below shows the status symbols for the Ramp and Soak option.

Loop Status Symbol		Description
Loop Function	Loop Display	
START	S	Ramp/Soak profile loaded, ready to start
RUN	R	Ramp/Soak profile is running
HOLD	H	Ramp/Soak profile is in hold
WAIT	W	Ramp/Soak loop is waiting for a trigger state to be satisfied
TOLERANCE ERROR	T	Ramp/Soak loop is out of tolerance and loop is in hold

If an acknowledged alarm exists, the Bar Graph is replaced by an alarm symbol.

Press **Back** to see the Single Loop display.

## Single Loop Display

This display shows the detailed information for one loop at a time.

Press the **Back** key to return to the Bar Graph display.

LOOP	PROCESS	UNITS
8	76	°F
1	2	3
4	5	6
7	8	
▲	130	A100
ALARM	SETPOINT	STATUS OUTPUT%

## Scanning Display

Pressing both **Yes** and **No** arrow keys when you're in Single Loop display, activates the Scanning display.

In this mode, the controller will automatically step through the active channels, showing the Single Loop display for each, for about a second.

Press any arrow key to return to the Single Loop display.

## Alarm Display

The Alarm display is the same as the Single Loop display except the alarm status is flashing.

The table below shows the alarm symbols.

Alarm	Symbol
High process	▲▲
High deviation	▲
Low deviation	▼
Low process	▼▼
Tolerance error	T

The Alarm display interrupts any system display. If more than one alarm is present, the first one is shown.

When you press the Alarm Ack key, the flashing stops but the alarm indicator remains as long as the alarm condition exists.

## Operator Menus

---

You can perform these tasks from Single Loop display.

### Changing the Setpoint

Press CHNG SP from the loop you want to change. This display appears:

LOOP	PROCESS	UNITS
5		
1	2	3
4	5	6
7	8	
SP ?		25
ALARM	SETPOINT	STATUS OUTPUT%

- Press **Yes** to change the setpoint.
- Press **Yes** or **No** to change the setpoint value.
- Press **Enter** to save your changes and return to Single Loop display.
- Press **No** or **Back** to return to Single Loop display without saving the new setpoint.

### Selecting Status Mode

- Press **Man/Auto** from the loop you want to change. This display appears:

LOOP	PROCESS	UNITS
6 = AUTO		
1	2	3
4	5	6
7	8	
SET? TUNE		
ALARM	SETPOINT	STATUS OUTPUT%

- Press **No** to switch between Auto, Manual, and Tune.
- Press **Yes** and then **Enter** to store your choice.
- Press **Back** if you want to go back to Single Loop display without changing the mode.

If you have set the current loop to Manual control, this display appears after you press **Enter**:

LOOP		PROCESS				UNITS	
6		SET				MAN	
1	2	3	4	5	6	7	8
OUT		H T		?		0	
ALARM	SETPOINT	STATUS	OUTPUT%				

- Press **Yes** to change the output power.
- Press **Yes** or **No** to select a new power output level.
- Press **Enter** to store your choice and go back to Single Loop display

## Autotune

If you set the current loop control status to Tune and press Enter, the controller automatically sets the loop to manual control, 100% output. The autotune function then calculates the appropriate PID constants for the loop and puts the loop in automatic control with the calculated PID values.

### The Autotune function will abort if:

- Process variable goes over 75% of the setpoint.
- PID constants were not calculated after 10 seconds (a failure of some sort).

## Ramp/Soak

Use the Ramp/Soak key only if the optional Ramp/soak package is included in the controller. Information pertaining to programming and operation of ramp and soak profiles is included in the Ramp/Soak section.

# Setup

The Setup menus let you change the 8LS detailed configuration information.

If you have not set up a modular system before, or if you don't know what values to enter, please read the next section first, *Tuning and Control*, which contains PID tuning constants and useful starting values.

## How to enter the Setup menus?

1. In Single Loop display, select the loop you wish to edit.
2. Enter this pass sequence: **Enter**, **Alarm Ack**, and **Chng SP**.



3. The first Setup menu appears.

## How to edit a menu?

- Press **Yes** to select this menu or **No** to advance to the next menu. (When you select a menu, the blinking question mark changes to an equal sign.)
- Press **Yes** (up) or **No** (down) to toggle between the options.
- Press **Enter** to store the value you have selected, or **Back** to stop editing and return to the main menu.

The Setup section contains detailed information about the submenus of the main menus.

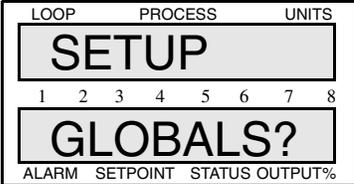
The next page shows a diagram of the six main menus (plus the Ramp/Soak main menu if the option's installed) and all their submenus.

Setup Globals?	Setup Input?	Setup control?	Setup Outputs?	Setup Alarms?	Setup R/S Pro?	Test I/O ?
Save as job# ?	Input type?	Control PB $\frac{H}{T}$ ?	Outputs Typ $\frac{H}{T}/\frac{C}{L}$ ?	Alarms HP?	R/S pro Prof ?	INS = 1 1 1 1 1 1 1 1 1 1
Restore Job# ?	Input smplt? (only Pulse)	Control TI $\frac{H}{T}$ ?	Outputs CT $\frac{H}{T}/\frac{C}{L}$ ?	Hi pro outpn?	R/S pro Copy ?	Test out NR ?
Alarm delay?	Input unit?	Control TD $\frac{H}{T}$ ?	Outputs Act $\frac{H}{T}/\frac{C}{L}$ ?	Alarms Dev?	Outtol T ?	Dig out NR01 ?
R/S time base?	Hi PV? (only Linear & Pulse)	Control FIL $\frac{H}{T}$ ?	Outputs Lim $\frac{H}{T}/\frac{C}{L}$ ?	Hi dev Outpn?	Ready SP ?	
Panel lock?	Hi RDG? (only Linear & Pulse)	Control PB $\frac{C}{L}$ ?	Outputs Ltm $\frac{H}{T}/\frac{C}{L}$ ?	Lo dev Outpn?	Ready Events ?	
Power up outs?	Lo PV? (only Linear & Pulse)	Control TI $\frac{C}{L}$ ?	Outputs NLO $\frac{H}{T}/\frac{C}{L}$ ?	Alarms LP?	Extrst In NR ?	
Contrllr addr?	Lo RDG? (only Linear & Pulse)	Control TD $\frac{C}{L}$ ?	$\frac{H}{T}/\frac{C}{L}$ out?	Lo pro Outpn?	Edit Seg ?	
Comm err chk?	Offset? (T/C & RTDs)	Control FIL $\frac{C}{L}$ ?		Alarms Dbd?	Seg T ?	
Comm baud?		Control spr?		Alarm Dly?	Seg SP ?	
Comm ptcl?					Seg Events ?	
AC line?					Seg Triggs ?	
PROM info					Seg Tol ?	
					Seg Last ?	
					Edit Seg ?	

The R/S menu appears only if the Ramp and Soak option is installed in your 8LS. If it's not, the **Test I/O** display appears right after the **Setup Alarms** display.

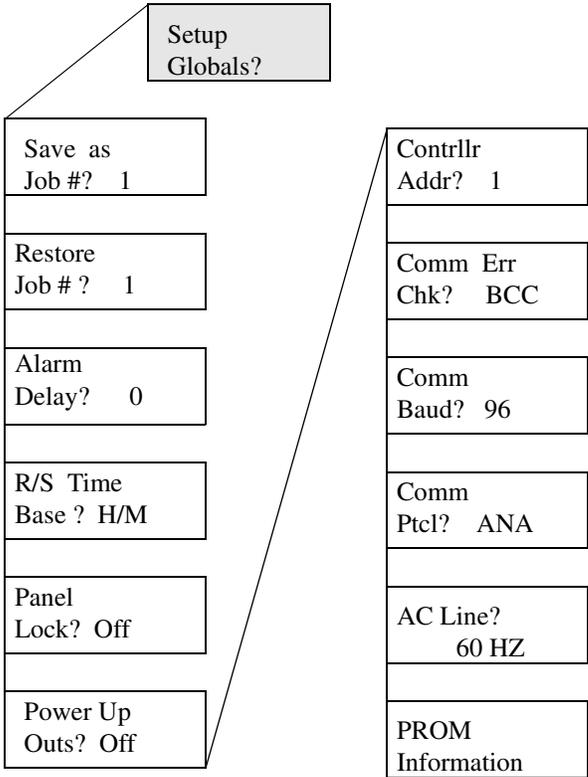
# Setup Global Parameters Menu

The Setup global parameters menu looks like this:



Answering Yes to this prompt gets you into the globals submenus.

Below is the setup global parameters menu tree. Notice the default values inside the boxes.



## Save as Job

Use this menu to save the job information for every loop to one of eight jobs in the battery-backed memory.

LOOP	PROCESS	UNITS
SAVE AS		
1	2	3 4 5 6 7 8
JOB #? 1		
ALARM	SETPOINT	STATUS OUTPUT%

**Selectable Range:** 1-8.

## Restore a Job

Use this menu to load a job from the memory .

LOOP	PROCESS	UNITS
RESTORE		
1	2	3 4 5 6 7 8
JOB # ? 1		
ALARM	SETPOINT	STATUS OUTPUT%

**Selectable Range:** The last job number or job 1.

## Set Alarm Delay

Use this menu to set a startup delay for all system alarms. Alarm checking will be delayed for the number of minutes you enter. This is used to avoid nuisance alarms when starting up a system.

LOOP	PROCESS	UNITS
ALARM		
1	2	3 4 5 6 7 8
DELAY ? 0		
ALARM	SETPOINT	STATUS OUTPUT%

**Selectable Range:** 0-60 minutes.

## Set R/S Time Base

Use This menu to set the global ramp and soak time base to units of hours and minutes or minutes and seconds. All time entries in r/s profiles will assume the units you set here.

LOOP	PROCESS	UNITS					
R/S TIME							
1	2	3	4	5	6	7	8
BASE?H/M							
ALARM	SETPOINT	STATUS	OUTPUT%				

**Selectable values:** Hours and minutes or minutes and seconds.



### NOTE

**This prompt appears only if your 8LS has the Ramp and Soak option installed.**

## Lock Panel

Use this menu to disable the front panel keys **Chng SP**, **Man/Auto**, and **Ramp/Soak**.

LOOP	PROCESS	UNITS					
PANEL							
1	2	3	4	5	6	7	8
LOCK?OFF							
ALARM	SETPOINT	STATUS	OUTPUT%				

**Selectable values:** On or Off.

## Power Up Output Status

Use this menu to configure the initial power-up state of the control outputs. If you choose Off, all control outputs are initially set to Manual mode at 0% output level. If you choose Mem, the outputs are restored to their condition when power was removed.

LOOP	PROCESS	UNITS					
POWER UP							
1	2	3	4	5	6	7	8
OUTS?OFF							
ALARM	SETPOINT	STATUS	OUTPUT%				

**Selectable values:** Off and Mem.




---

**WARNING**

**Set safe start up conditions. Do not use memory startup if there is any chance the process could start in an unsafe state.**

---

## Controller Address

Use this menu to set the 8LS controller address. This address is used for communications and each 8LS in a system must have a different address. Begin with address 1 for the first controller and assign each subsequent controller the next higher address.

LOOP	PROCESS	UNITS
<b>CONTRLLR</b>		
1	2	3
4	5	6
7	8	
<b>ADDR?</b>		<b>1</b>
ALARM	SETPOINT	STATUS OUTPUT%

**Selectable range:** 1 to 32.

## Communication Error Checking

Use this menu to set the data check algorithm used in the Watlow-Anafaze communications protocol.

LOOP	PROCESS	UNITS
<b>COMM ERR</b>		
1	2	3
4	5	6
7	8	
<b>CHK? BCC</b>		
ALARM	SETPOINT	STATUS OUTPUT%

**Selectable values:** BCC (Block Check Character) or CRC (Cyclic Redundancy Check).




---

**NOTE**

**If you are using ANASOFT, be sure to set ANAIN-STL to the same error checking method you set in this menu.**

---

## Communication Baud Rate

Use this menu to set the communications baud rate.

LOOP	PROCESS	UNITS
COMM		
1	2	3 4 5 6 7 8
BAUD? 96		
ALARM	SETPOINT	STATUS OUTPUT%

Selectable values: 2400 or 9600.



### NOTE

If you are using ANASOFT, be sure to set ANAIN-STL to the same baud rate you set in this menu.

## Communication Protocol

Use this menu to set the protocol type to either Allen Bradley or ANAFAZE.

LOOP	PROCESS	UNITS
COMM		
1	2	3 4 5 6 7 8
PTCL? ANA		
ALARM	SETPOINT	STATUS OUTPUT%

Selectable values: ANA (ANAFAZE) or A/B (Allen Bradley).

## AC Line Frequency

Use this menu to configure the controller to match the AC line frequency. Since the controller reduces the effect of normal mode noise by integrating the signal over the period of the AC line frequency, that accuracy will be reduced if this is not set correctly.

LOOP	PROCESS	UNITS
AC LINE?		
1	2	3 4 5 6 7 8
60 HZ		
ALARM	SETPOINT	STATUS OUTPUT%

Selectable values: 60 Hz or 50 Hz.

## EPROM Version

Use this menu to see the controller's EPROM version and checksum.

LOOP	PROCESS	UNITS					
8LS-RS							
1	2	3	4	5	6	7	8
V3.20							
ALARM	SETPOINT	STATUS	OUTPUT%				

## Setup Inputs Menu

The Setup input main menu lets you access menus which change loop input parameters:

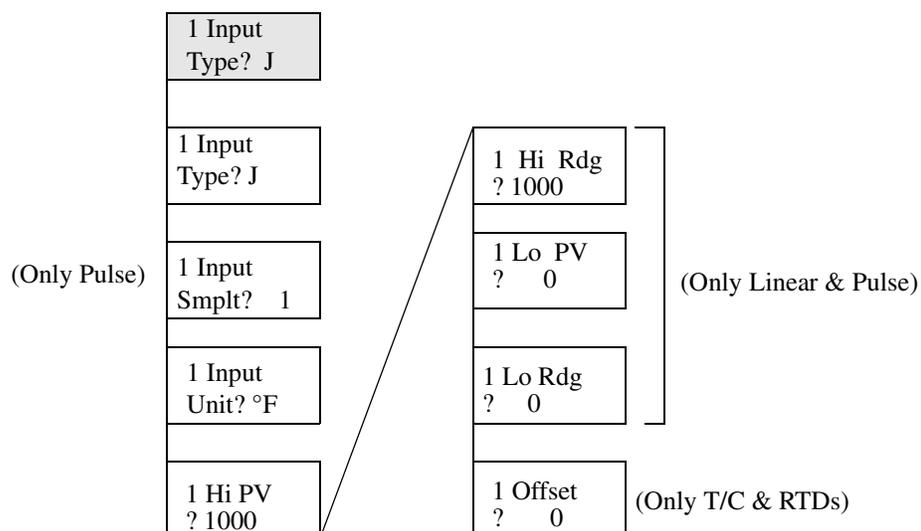
- Input type
- Engineering units
- Scaling

The Setup inputs menu looks like this:

LOOP	PROCESS	UNITS
1	SETUP	
1	2	3
4	5	6
7	8	
INPUT?		
ALARM	SETPOINT	STATUS OUTPUT%

Answering Yes to this prompt, gets you into the Inputs submenus.

Below is the setup inputs menu tree. Notice the default values inside the boxes.



## Input Type

Use this menu to configure the input sensor for each loop as one of these input types:

- Thermocouple types (J, K, T, S, R, B, and N)
- RTD. Two ranges: RTD1 (Platinum class A: DIN 43760-1980, Alpha=.00385), and RTD2 (Platinum class B: DIN 43760-1980, Alpha=.00385).
- Linear and Pulse inputs.
- Skip. Scanning display doesn't show loops you set to Skip.

LOOP	PROCESS	UNITS
1	INPUT	
1	2	3
4	5	6
7	8	
TYPE? J		
ALARM	SETPOINT	STATUS OUTPUT%

**Selectable range:** See the table below for the input types and ranges available for the 8LS.

Input Type	Fahrenheit Range	Celsius Range
J	-350 to +1400	-212 to +760
K	-450 to +2500	-268 to +1371
T	-450 to +750	-268 to +399
S	0 to +3200	-18 to +1760
R	0 to +3210	-18 to +1766
B	+150 to +3200	+66 to +1760
N	-450 to +2370	-268 to +1299
RTD1	-148.0 to +572.0	-100.0 to +300.0
RTD2	-184 to +1544	-120 to +840
Pulse	0-20 KHz	
Skip	Loop is not scanned or displayed	
Linear	See <i>Linear scaling</i> section in this chapter	

## Pulse Sample Time

You can connect a digital pulse signal of 20 KHz to the controller's pulse input. Use this menu to specify the pulse sample period. Every sample period, the number of pulses the controller receives is divided by the sample time. The controller scales this number and uses it as the pulse loop's PV.

LOOP	PROCESS	UNITS
1	INPUT	
1	2	3
4	5	6
7	8	
SMPLT? 1		
ALARM	SETPOINT	STATUS OUTPUT%

**Selectable range:** 1-20 seconds.

## Input Units

Use this menu to choose a description for the loop's engineering units.

LOOP	PROCESS	UNITS
1	INPUT	
1	2	3
4	5	6
7	8	
UNIT = °F		
ALARM	SETPOINT	STATUS OUTPUT%

**Selectable range:** The table below shows the character set for input units.

Input	Character Set
T/C & RTDs	°F or °C
Linear & Pulse	0-9, A-Z, %, degrees, /, space

When entering three-character description (for Linear and Pulse), the editing proceeds left to right, one character at a time. After you enter the third character, the display advances to the next menu.

## Linear Scaling Menus



### NOTE

**The next four menus appear only for Linear or Pulse loops.**

For all inputs automatic scaling is provided. To set the scaling enter a high process variable in engineering units and a corresponding high reading. Then enter a low process variable in engineering units and a corresponding reading. Using points as near as possible to zero and full scale is best. After these entries the process variable, the setpoint and alarms will all be in engineering units.

### High PV Display

LOOP	PROCESS	UNITS
1	HI PV	
1	2	3
4	5	6
7	8	
? 1000		
ALARM	SETPOINT	STATUS OUTPUT%

**Selectable range:** 0-9999.

### High RDG Display

LOOP	PROCESS	UNITS
1	HI RDG	
1	2	3
4	5	6
7	8	
? 1000		
ALARM	SETPOINT	STATUS OUTPUT%

**Selectable range:** 0-9999.

The high input reading is referenced to 60mV and is calculated using this equation:

$$\text{HIGH RDG} = (1000) * \frac{(\text{Sensor output @ High PV})}{60 \text{ mV}}$$

### Low PV Display

LOOP	PROCESS	UNITS
1	LO PV	
1	2	3
4	5	6
7	8	
? 0		
ALARM	SETPOINT	STATUS OUTPUT%

**Selectable range:** 0-9999.

*Low RDG Display*

LOOP		PROCESS				UNITS	
1 LO RDG							
1	2	3	4	5	6	7	8
? 0							
ALARM		SETPOINT		STATUS		OUTPUT%	

**Selectable range:** 0-9999.

The low input reading is referenced to 60mV and is calculated using this equation:

$$\text{LOW RDG} = (1000) * \frac{(\text{Sensor output @ Low PV})}{60 \text{ mV}}$$

*Linear Input Scaling Example:***Problem:**

You want to connect a pressure sensor to be able to read pressure directly in PSI. The sensor has an output of 4-20mA over a range of 100-400PSI. The 4-20mA is converted to 12-60mV. How will you set the input scaling?

**Solution:**

1. Set the High PV to 400 and enter the units as P, S, and I.
2. Calculate the High RDG and enter it:

$$\text{High RDG} = 1000 * \frac{(60 \text{ mV}) \leftarrow \text{Sensor output @ high PV}}{(60 \text{ mV}) \leftarrow \text{Full scale 8LS input}}$$

$$=1000$$

3. Set the Low PV to 100 and enter the units as P, S, and I.
4. Calculate the Low RDG and enter it:

$$\text{Low RDG} = 1000 * \frac{(12 \text{ mV}) \leftarrow \text{Sensor output @ low PV}}{(60 \text{ mV}) \leftarrow \text{Full scale 8LS input}}$$

$$=200$$

## Input Offset



---

### NOTE

**The next menu appears only for Thermocouple or RTD loops.**

---

Use this menu to make up for the input signal's inaccuracy. For example, at temperatures below 400°F, a type J thermocouple may be inaccurate ("offset") by several degrees. To correct for offset errors, change the factory default setting to a positive or negative value for the loop you are editing. A positive value increases the reading and a negative value decreases it.

LOOP	PROCESS	UNITS					
1	OFFSET						
1	2	3	4	5	6	7	8
?	0	°	F				
ALARM	SETPOINT	STATUS	OUTPUT%				

**Selectable range:** -300 to +300.

## Setup Control Menu

The Setup Control menu allows you to set control parameters for both heat and cool outputs of the selected loop.

These are the parameters you can edit.

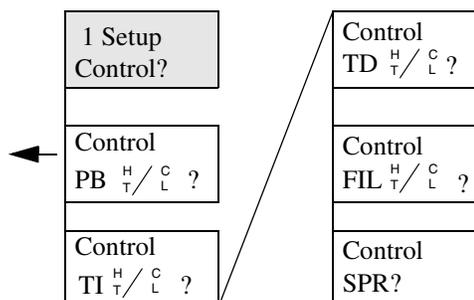
- Proportional Band
- Integral
- Rate
- Output Filter
- Spread between heat and cool outputs

The Setup Control menu looks like this:

LOOP	PROCESS	UNITS
1	SETUP	
1	2	3
4	5	6
7	8	
CONTROL ?		
ALARM	SETPOINT	STATUS OUTPUT%

Answering Yes to this prompt gets you into the control submenus. Below is the setup control menu tree. Notice the default values inside the boxes.

The letters  $\begin{matrix} H \\ T \\ C \\ L \end{matrix}$  for Heat or Cool do not appear together on the display. There are four displays for Heat and four displays for Cool.



### NOTE

**If you set the Cool output PB to Off, the loop becomes a single output channel and will no longer function as a heat/cool loop. Further programming of Cool output parameters is skipped and the display returns to the Setup Control prompt.**

### Heat/Cool PB

Use this menu to set the Proportional Band.

LOOP	PROCESS	UNITS
1 CONTROL		
1	2	3 4 5 6 7 8
PB	$\frac{H}{T}$ ?	50
ALARM	SETPOINT	STATUS OUTPUT%

### Heat/Cool TI

Use this menu to set the Integral Term.

LOOP	PROCESS	UNITS
1 CONTROL		
1	2	3 4 5 6 7 8
TI	$\frac{H}{T}$ ?	180
ALARM	SETPOINT	STATUS OUTPUT%

Selectable range: 0-5000 seconds.

### Heat/Cool TD

Use this menu to set the Derivative constant.

LOOP	PROCESS	UNITS
1 CONTROL		
1	2	3 4 5 6 7 8
TD	$\frac{H}{T}$ ?	0
ALARM	SETPOINT	STATUS OUTPUT%

Selectable range: 0-255 seconds.

### Heat/Cool Output Filter

Use This menu to dampen the heat or cool output's response. The output responds to a step change by going to approximately 2/3 of its final value within the number of scans you set here.

LOOP	PROCESS	UNITS
1 CONTROL		
1	2	3 4 5 6 7 8
FIL	$\frac{H}{T}$ ?	2
ALARM	SETPOINT	STATUS OUTPUT%

Selectable range: 0-255.

## Heat/Cool Spread

Use this menu to set the spread between the heat and cool output and the spread of the On/Off control action.

LOOP	PROCESS	UNITS					
1 CONTROL							
1	2	3	4	5	6	7	8
SPR?		10					
ALARM	SETPOINT	STATUS	OUTPUT%				

**Selectable range:** 0-255 engineering units.

## Setup Outputs Menu

The Setup Outputs Menu allows you to edit output parameters such as:

- Output type
- Cycle time
- Control action
- Output level limit
- Output limit duration
- Heat/Cool nonlinear output curve
- Terminal Block or Ribbon

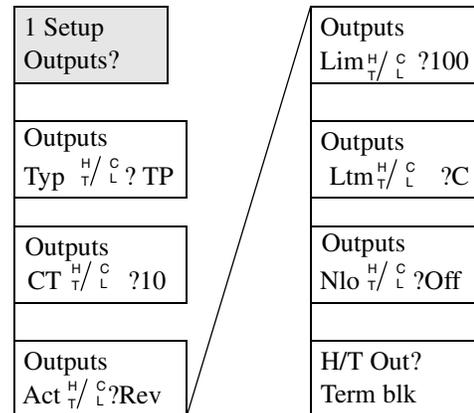
The Setup Outputs Menu looks like this:

LOOP	PROCESS	UNITS
1 SETUP		
1	2	3 4 5 6 7 8
OUTPUTS?		
ALARM	SETPOINT	STATUS OUTPUT%

Answering Yes to this prompt gets you into the Setup Outputs submenus. Below is the setup outputs menu tree. Notice the default values inside the boxes.

The letters  $\frac{H}{T}$  for Heat and  $\frac{C}{L}$  for Cool are displayed depending on whether you set the heat or cool control.

The heat output parameters are programmed first, and then the same parameters for the cool output.



### NOTE

**If the channel is operating as a single output loop, all prompts for the Cool output data are suppressed. When the last Heat output variable is programmed, the display returns to the Setup Outputs prompt.**

## Output Type

Use this menu to to set the output type.

LOOP	PROCESS	UNITS
1 OUTPUTS		
1	2	3 4 5 6 7 8
TYP <sup>H</sup> ? TP		
ALARM	SETPOINT	STATUS OUTPUT%

**Selectable values:** The next table shows the available output types.

Display Code	Output Type	Definition
TP	Time Proportioning	Percent output is converted to a percent duty cycle over the programmed cycle time.
DZC	Distributed Zero Crossing. Available only on secondary (50 pin Ribbon output).	Output On/Off state calculated for every AC line cycle.
O/F	On/Off	Output either full On or full Off.
ANA	Analog 0-5 Vdc or 4-20 mAdc. Available only on primary (terminal).	Output is proportional over the range of the voltage or current output selected by Dip switch setting.

## Cycle Time

Use this menu to set the Cycle Time for the TP outputs.

LOOP	PROCESS	UNITS
1 OUTPUTS		
1	2	3 4 5 6 7 8
CT <sup>H</sup> ? 10		
ALARM	SETPOINT	STATUS OUTPUT%

**Selectable values:** 1-255 seconds.



### NOTE

**This menu appears only if you set the output type to TP.**

## Output Action

Use this menu to select the control action for the current output loop. The default is Reverse for heat outputs and Direct for cool outputs.

LOOP	PROCESS	UNITS
1 OUTPUTS		
1	2	3 4 5 6 7 8
ACT <sup>H</sup> ?REV <sub>T</sub>		
ALARM	SETPOINT	STATUS OUTPUT%

**Selectable values:** Reverse or Direct.

## Output Limit

The output from each loop's dual heat/cool output may be limited to a value less than 100%. This level may not be exceeded by the PID control action. This limit on the control output may be limited by a period of time and then returned to full 100% output or it may be a continuous limit until changed by the programming keys. The limit time delay is restarted whenever you:

- Enter a new time period
- Switch a loop's mode from Manual to Auto
- Power up the controller

The time period is adjustable from 1 to 999 seconds for a maximum period of time of over 16 minutes. A time of 0 seconds will be displayed as C, the same as for Continuous.

The output limiting is disabled by setting the value to 100%. The control mode of ON/OFF has no output limiting available.

You may use the output limiting for "Soft Start" type of requirements of different processes, or to restrict the energy into a process, tailoring the controller output to the process needs.

Use this menu to limit the maximum PID control output for a loop's heat and cool outputs. This may be a constant limit or a temporary one subject to the output limit delay.

LOOP	PROCESS	UNITS
1 OUTPUTS		
1	2	3 4 5 6 7 8
LIM <sup>H</sup> ? 100 <sub>T</sub>		
ALARM	SETPOINT	STATUS OUTPUT%

**Selectable range:** 0-100%.

## Output Limit Time

Use this menu to set the time limit for the output limit.

LOOP	PROCESS	UNITS
1 OUTPUTS		
1	2	3
4	5	6
7	8	
LTM $\frac{H}{T}$ ? C		
ALARM	SETPOINT	STATUS OUTPUT%

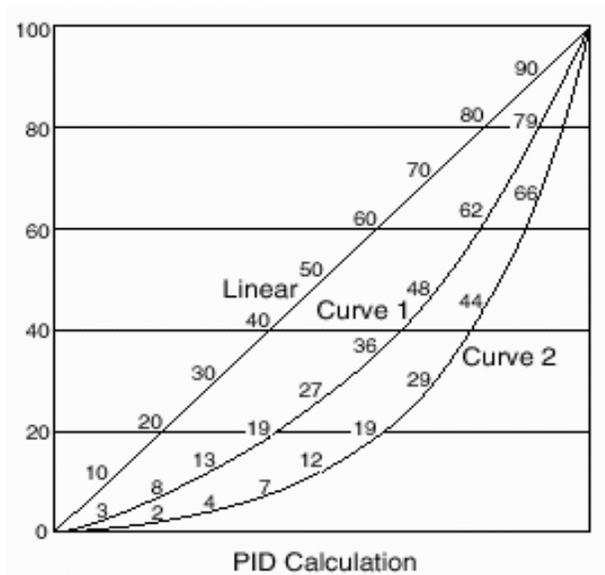
**Selectable values:** 1-999 seconds or C (Continuous).

## Nonlinear Output Curve

Use this menu to select one of two nonlinear output curves for nonlinear processes.

LOOP	PROCESS	UNITS
1 OUTPUTS		
1	2	3
4	5	6
7	8	
NLO $\frac{H}{T}$ ?OFF		
ALARM	SETPOINT	STATUS OUTPUT%

**Selectable values:** 1 (curve 1), 2 (curve 2), or Off (linear/no curve). The linear curves are shown below.



## Heat Output

Use this menu to select the Terminal Block or the Flat Ribbon for the heat output termination. The heat output is usually defaulted to the screw terminals of TB2, while the cool output is on the 50 pin flat ribbon connections of P10. However, you can switch the outputs, so heat is switched to the flat ribbon output, and cool--to the screw terminals of TB2.

LOOP	PROCESS	UNITS
1	HT	OUT?
1	2	3 4 5 6 7 8
TERM BLK		
ALARM	SETPOINT	STATUS OUTPUT%

**Selectable values:** Term Blk or Flat Rib.



---

### NOTE

**The analog output is not available on the ribbon cable, and the DZC is not available on the screw terminals.**

---

## Setup Alarms

The Setup Alarms main menu lets you access menus which change the alarm functions for the selected loop.

You can edit these parameters:

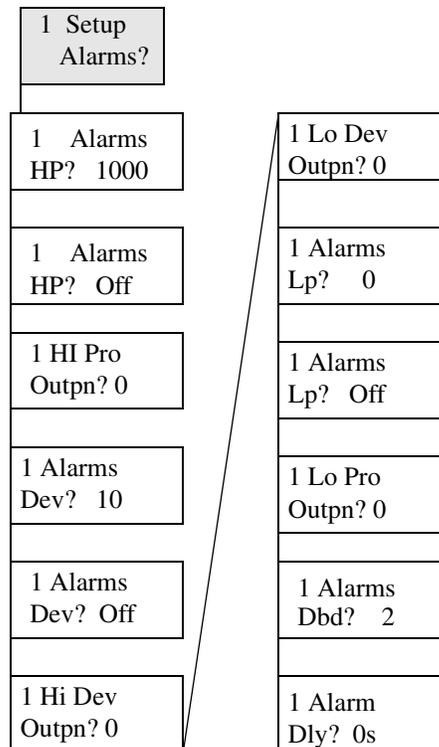
- High process alarm
- Deviation band alarm
- Low process alarm
- Alarm Deadband

The Setup Alarms main menu looks like this:

LOOP	PROCESS	UNITS
1	SETUP	
1	2	3
4	5	6
7	8	
ALARMS?		
ALARM	SETPOINT	STATUS OUTPUT%

Answering Yes to this prompt, gets you into the Alarms submenus.

Below is the setup alarms menu tree. Notice the default values inside the boxes.



## Alarm Types

### Global Alarms

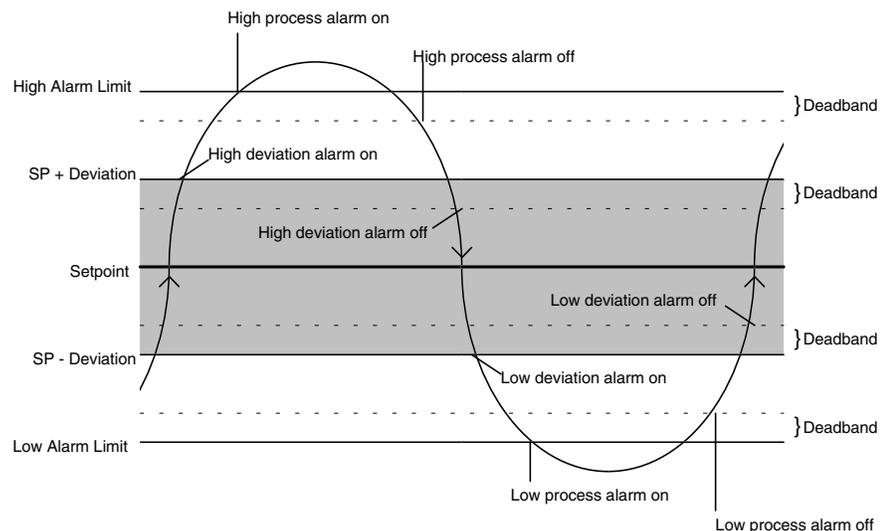
Global alarms occur when a loop alarm, set to Alarm, is unacknowledged, or when there are any unacknowledged failed sensor alarms. (If an alarm occurs, the 8LS front panel displays an appropriate alarm code). Even if the alarm condition goes away, the global alarm stays on until you use the **Alarm Ack** key (or ANASOFT) to acknowledge it.

### Process Alarms

Process alarms include high and low deviation and high and low process alarms. You can set each of these alarms to Off (no alarm function) or On (Standard alarm function).

- High process and high deviation alarms activate when the process variable goes above a value you set. They remain active until the process variable goes below that value minus the deadband. (See diagram below.)
- If you don't use a digital output for PID control, you can assign it to one or more process variable alarms. The output is active if any of its alarms are active. All alarm outputs are active Low or active High, depending on the global alarm output polarity setting.
- Low process and low deviation alarms activate when the process variable goes below a value you set. They remain active until the process variable goes above that value plus the deadband. (The diagram below shows these alarms.)

When the controller powers up or the setpoint changes, deviation alarms do not activate until the process goes inside the deviation alarm band--preventing deviation alarms during a cold start. (High and low process alarms are always enabled.)



## High Process Alarm Setpoint

Use this menu to select the setpoint at which the high process alarm activates. The high process alarm activates when the process variable (PV) goes above the high process setpoint. It deactivates when the PV goes below the high process setpoint minus the deadband value, if you have set one.

LOOP	PROCESS	UNITS
1	ALARMS	
1	2	3
4	5	6
7	8	
HP?	1000	
ALARM	SETPOINT	STATUS OUTPUT%

**Selectable values:** Any point within the scaled sensor range.

## High Process Alarm Status

Use this menu to enable or disable the high process alarm.

LOOP	PROCESS	UNITS
1	ALARMS	
1	2	3
4	5	6
7	8	
HP?	OFF	
ALARM	SETPOINT	STATUS OUTPUT%

**Selectable values:** On, Off.

## High Process Alarm Output Number

Use this menu to assign the digital output that activates when the loop is in high process alarm.

LOOP	PROCESS	UNITS
1	HI PRO	
1	2	3
4	5	6
7	8	
OUTPN =	0	
ALARM	SETPOINT	STATUS OUTPUT%

**Selectable values:** 0-30.

## Deviation Band Alarm

Use this menu to set the deviation bandwidth, a positive and negative alarm point relative to the setpoint. If the setpoint changes, the alarm points also changes. You can assign a separate digital output to the high and low deviation alarm setpoints. (For example, the high deviation alarm turns on a fan, and a low deviation alarm turns on a heater.)

LOOP	PROCESS	UNITS
1 ALARMS		
1	2	3 4 5 6 7 8
DEV ?		10
ALARM	SETPOINT	STATUS OUTPUT%

Selectable values: 0-255.

## Deviation Band Alarm Status

Use this menu to set the deviation alarm status. You can enable or disable the alarm function.

LOOP	PROCESS	UNITS
1 ALARMS		
1	2	3 4 5 6 7 8
DEV ?		OFF
ALARM	SETPOINT	STATUS OUTPUT%

Selectable values: On , Off.

## High Deviation Alarm Output Number

Use this menu to assign a digital output which activates when the loop is in high deviation alarm.

LOOP	PROCESS	UNITS
1 HI DEV		
1	2	3 4 5 6 7 8
OUTPN? 0		
ALARM	SETPOINT	STATUS OUTPUT%

Selectable values: 0-30.




---

### NOTE

All digital outputs are "OR'ed" together (combined). Therefore, you can assign more than one alarm to the same output number, and that output will be On if any of those alarms is On.

---

## Low Deviation Alarm Output Number

Use this menu to assign a digital output which activates when the loop is in low deviation alarm.

LOOP	PROCESS	UNITS
1	LO	DEV
1	2	3
4	5	6
7	8	
ALARM	SETPOINT	STATUS OUTPUT%
OUTPN	? 0	

**Selectable values:** 0-30.

## Low Process Alarm Setpoint

Use this menu to set a low process alarm setpoint. The low process alarm activates when the process variable (PV) goes below the low process alarm setpoint. It deactivates when the PV goes above the low process alarm setpoint plus the deadband.

LOOP	PROCESS	UNITS
1	ALARMS	
1	2	3
4	5	6
7	8	
ALARM	SETPOINT	STATUS OUTPUT%
LP?		0

**Selectable values:** Any value within the input sensor's range.

## Low Process Alarm Status

Use this menu to enable or disable the low process alarm.

LOOP	PROCESS	UNITS
1	ALARMS	
1	2	3
4	5	6
7	8	
ALARM	SETPOINT	STATUS OUTPUT%
LP?		OFF

**Selectable values:** On, Off.

## Low Process Alarm Output Number

Use this menu to assign the digital output that activates when the loop is in low process alarm.

LOOP	PROCESS	UNITS
1	LO	PRO
1	2	3
4	5	6
7	8	
OUTPN?		0
ALARM	SETPOINT	STATUS OUTPUT%

**Selectable values:** 0-30.

## Alarm Deadband

Use this menu to set an alarm deadband. This deadband value applies to the high process, low process, high deviation, and low deviation alarms for the loop you are editing. Use the alarm deadband to avoid repeated alarms, as the PV cycles slightly around an alarm value.

LOOP	PROCESS	UNITS
1	ALARMS	
1	2	3
4	5	6
7	8	
DBD?		2
ALARM	SETPOINT	STATUS OUTPUT%

**Selectable values:** 0-255.

## Alarm Delay

Use this menu to set a loop alarm delay. This delay is set separately for each loop. It delays failed sensor and process alarms until the alarm condition has been continuously present for longer than the alarm delay time you set.

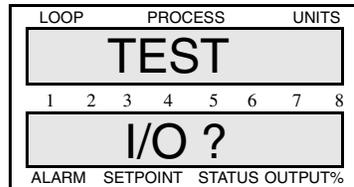
LOOP	PROCESS	UNITS
1	ALARM	
1	2	3
4	5	6
7	8	
DLY?		0S
ALARM	SETPOINT	STATUS OUTPUT%

**Selectable values:** 0-255 seconds.

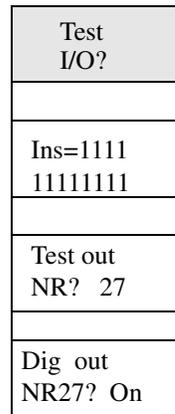
## Test I/O

The Test I/O main menu lets you view menus which can help you test the digital inputs and the digital outputs.

The main menu looks like this:

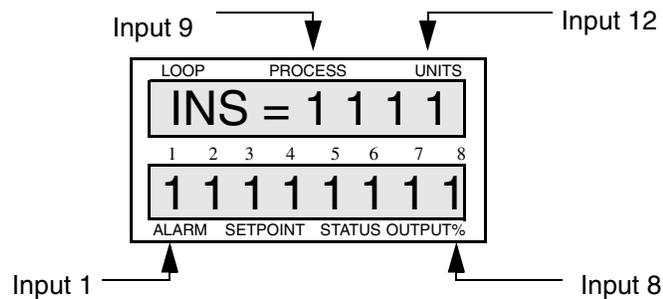


Answering Yes to this prompt gets you into the I/O test submenus. Below is the menu tree. Notice the default values in the boxes.



## Digital Input Testing

Use this view-only menu to see the logic state of the 12 digital inputs as 1's (High) or 0's (Low). the menu displays inputs 1 through 12.



## Test Output

Use this menu to select one of the 30 digital outputs for manual operation.

LOOP	PROCESS	UNITS
TEST OUT		
1	2	3 4 5 6 7 8
NR = 1		
ALARM	SETPOINT	STATUS OUTPUT%

**Selectable values:** 1-30.

## Digital Output Test

Use this menu to toggle the state of a digital output between On and Off.

LOOP	PROCESS	UNITS
DIG OUT		
1	2	3 4 5 6 7 8
NR01? OFF		
ALARM	SETPOINT	STATUS OUTPUT%

**Selectable values:** On, Off.



---

### NOTE

**Before leaving this menu, turn Off all the outputs you have turned On.**

---

# Tuning and Control

---

## Introduction

This chapter explains PID control and supplies some starting PID values and tuning instructions, so that you can use control parameters appropriate for your system. If you would like more information on PID control, consult the Watlow Anafaze *Practical Guide to PID*.

The control mode dictates how the controller responds to an input signal. The control mode is different from the type of control output signal (like analog or pulsed DC voltage). There are several control modes available: On/Off, Proportional (P), Proportional and Integral (PI), Proportional with Derivative, and Proportional with Integral and Derivative (PID). P, PI, or PID control are necessary when process variable (PV) cycling is unacceptable or if the process or setpoint (SP) is variable.



---

### NOTE

**For any of these control modes to function, the loop must be in automatic mode.**

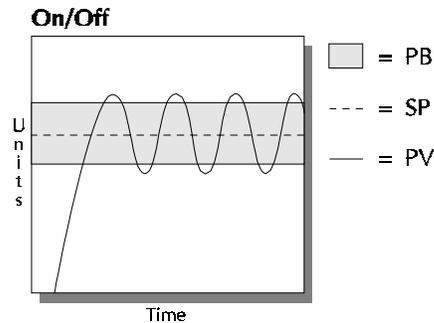
---

## Control Modes

The next sections explain the different modes you can use to control a loop.

### *On/Off Control*

On/Off control is the simplest way to control a process; a controller using On/Off control turns an output on or off when the process variable reaches a certain limit above or below the desired setpoint. You can adjust this limit, since Watlow Anafaze controllers use an adjustable spread. For example, if your setpoint is 1000°F, and your limit (spread) is 20°F, the output switches On when the process variable goes below 980°F and Off when the process goes above 1000°F. (The next diagram shows a process under On/Off control.)



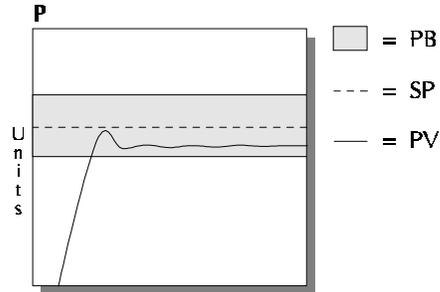
### *Proportional Control*

A process using On/Off control frequently cycles around the setpoint. When process variable cycling is unacceptable or the process or setpoint are variable, use proportional control. Proportional control, or Gain, eliminates cycling by increasing or decreasing the output proportional to the process variable's distance from the setpoint.

The limits of proportional control are defined by the Proportional Band (PB); outside this band of control, the output is either 100% or 0%. For example--using the same values from the example above and a PB of 20°--the output is:

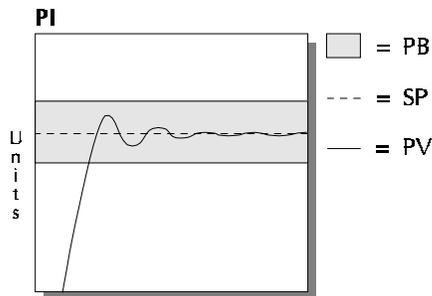
- 50% when the process variable is 990°F
- 75% when the process variable is 985°F
- 100% when the process variable is 980°F or below.

However, a process which uses only Proportional control may settle at a point above or below the setpoint; it may never reach the setpoint at all. This behavior is known as “offset” or “droop”. (This diagram shows a process under proportional control only.)



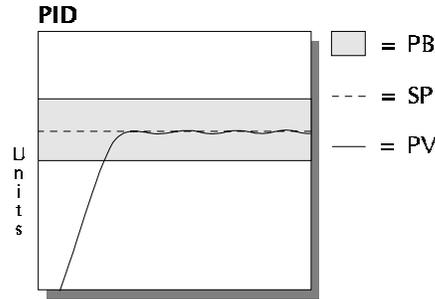
### *Proportional and Integral Control*

For Proportional and Integral control, use the Integral term, or Reset, with Proportional control. The Integral term corrects for offset by repeating the Proportional band's error correction until there is no error. For example, if a process tends to settle about 5°F below the setpoint, use Integral control to bring it to the desired setting. (The next diagram shows a process under proportional and integral control.)



### Proportional, Integral and Derivative Control

For an improved level of control, use Derivative control with Proportional or Proportional and Integral control. Derivative control corrects for overshoot by anticipating the behavior of the process variable and adjusting the output appropriately. For example, if the process variable is rapidly approaching the setpoint, Derivative control reduces the output, anticipating that the process variable will reach setpoint. Use it to eliminate the process variable overshoot common to PI control. (This figure shows a process under full PID control).



### Control Outputs

The 8LS provides a 5 Vdc digital output signal for PID control outputs. These outputs normally control the process using relays.

### Digital Output Control Forms

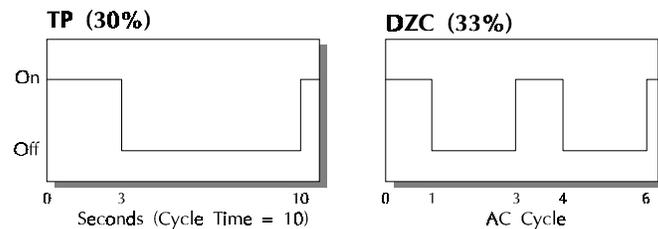
The next section explains different modes for control outputs.

#### On/Off

On/Off output is very simple: it turns the output on or off according to the control signal of the On/Off control.

#### Time Proportioning (TP)

Time Proportioning attempts to digitally simulate an analog output percentage by turning the output on or off for each time step so that the cumulative average of the output is the desired setting. You must enter a cycle time for TP outputs. The cycle time is the time over which the output is proportioned, and it can be any value from 1 to 255 seconds. For example, if the output is 30% and the Cycle Time is 10 seconds, then the output will be on for 3 seconds and off for seven seconds. The figure below shows typical TP and DZC graphs.



### *Distributed Zero Crossing (DZC)*

DZC output is essentially a Time Proportioning output. However, for each AC line cycle the controller decides whether the power should be On or Off. There is no Cycle Time since the decision is made for each line cycle. Since the time period for 60 Hz power is 16.6 ms, the switching interval is very short and the power is applied uniformly. Switching is done only at the zero crossing of the AC line, which helps reduce electrical “noise”.

DZC output is primarily used for very fast acting electrical heating loads using Solid State Relays (SSRs). For instance, the open air heater coil is an example of a fast acting load. Do not use DZC output for electromechanical relays.

The combination of DZC output and a solid state relay can inexpensively approach the effect of analog phase angle fired control, and can increase heater life.

### *Output Digital Filter*

The output filter digitally filters the PID control output signal. It has a range of 0-255 levels, which gives a time constant of 0-127.5 seconds. Use the output filter if you need to filter out erratic output swings due to extremely sensitive input signals, like a turbine flow signal or an open air thermocouple in a dry air gas oven.

The output filter can also enhance PID control. Some processes are very sensitive and require a high PB, so normal control methods are ineffective. You can use a smaller PB- and get better control- if you use the digital filter to reduce the high and low process output swings.

You can also use the filter to reduce output noise when a large derivative is necessary, or to make badly tuned PID loops and poorly designed processes behave properly.

### *Reverse and Direct Action*

Reverse action is an output control action in which an increase in the process variable causes a decrease in the output. Direct action is an output control action in which an increase in the process variable causes an increase in the output. Heating applications normally use reverse action and cooling applications usually use direct action.

## Setting Up and Tuning PID Loops

After you have installed your control system, tune each control loop and then set the loop to automatic control. (When you tune a loop, you choose PID parameters that will best control the process.) If you don't mind minor process fluctuations, you can tune the loop in automatic control mode. This section gives PID values for a variety of heating and cooling applications.

Tuning is a slow process. After you have adjusted a loop, allow about 20 minutes for the change to take effect.

### *Proportional Band (PB) Settings*

The table below shows PB settings for various temperatures in degrees F.

Temperature Setpoint	PB	Temperature Setpoint	PB	Temperature Setpoint	PB
-100 to 99	20	1100 to 1199	75	2200 to 2299	135
100 to 199	20	1200 to 1299	80	2300 to 2399	140
200 to 299	30	1300 to 1399	85	2400 to 2499	145
300 to 399	35	1400 to 1499	90	2500 to 2599	150
400 to 499	40	1500 to 1599	95	2600 to 2699	155
500 to 599	45	1600 to 1699	100	2700 to 2799	160
600 to 699	50	1700 to 1799	105	2800 to 2899	165
700 to 799	55	1800 to 1899	110	2900 to 2999	170
800 to 899	60	1900 to 1999	120	3000 to 3099	175
900 to 999	65	2000 to 2099	125	3100 to 3199	180
1000 to 1099	70	2100 to 2199	130	3200 to 3299	185

As a general rule, set the PB to 10% of the setpoint below 1000° and 5% of the setpoint above 1000°. This setting is useful as a starting value.

*Integral Term (TI) Settings*

This table shows TI settings vs. Reset settings.

<b>TI (secs./repeat)</b>	<b>Reset (repeats/min)</b>	<b>TI (secs./repeat)</b>	<b>Reset (repeats/min)</b>
30	2.0	210	0.28
45	1.3	240	.25
60	1.0	270	.22
90	.66	300	.20
120	.50	400	.15
150	.40	500	.12
180	.33	600	.10

As a general rule, use 60, 120, 180, or 240 as a starting value for the TI.

*Derivative Term (TD) Settings*

This table shows Derivative term (TD) versus Rate Minutes (RM);  
Rate=TD/60.

<b>TD (secs./repeat)</b>	<b>Rate (repeats/min)</b>	<b>TD (secs./repeat)</b>	<b>Rate (repeats/min)</b>
5	.08	35	.58
10	.16	40	.66
15	.25	45	.75
20	.33	50	.83
25	.41	55	.91
30	.50	60	1.0

As a general rule, set the TD to 15% of TI as a starting value.

## General PID Constants by Application

This section gives PID values for many applications. They are useful as control values or as starting points for PID tuning.

### *Proportional Band Only (P)*

PB: Set the PB to 7% of the setpoint (SP) (Example: Setpoint = 450, so Proportional Band = 31).

### *Proportional with Integral (PI)*

PB: Set the PB to 10% of SP (Example: Setpoint = 450, so PB = 45).

Set TI to 60.  
Set TD to Off.  
Set the Output Filter to 2.

### *PI with Derivative (PID)*

PB: Set the PB to 10% of the SP (Example: Setpoint = 450, so PB = 45).

Set the TI to 60.  
Set the TD to 15% of the TI (Example: TI = 60, so TD = 9).  
Set the Output Filter to 2.

The next table shows general PID constants by application.

Application	PB	TI	TD	Filter	Output Type	Cycle Time	Action
Electrical heat w/ Mechanical relays	50°	60	15	6	TP	20	Reverse
Gas heat with motor- ized valves	60°	120	25	8	ANA	NA	
Cool w/ solenoid valve	10°	Off	Off	4	TP	20	Direct
Cool w/ fans	10°	off	Off	4	TP	60	Direct





# Troubleshooting



---

## NOTE

**If you need to return the 8LS to Watlow-Anafaze, please call first for a Returned Materials Authorization (RMA) number. This number helps us track your equipment and return it to you as soon as possible.**

---

---

## Stand Alone Systems

If the unit has no display, check the 120vac power supply.

If you insert a spare unit, enter the values from the original unit. You can store and enter these values using a standard IBM PC or compatible computer and ANASOFT software.

## Checking Control Outputs

To check control outputs:

1. Set the loop you want to check to Manual mode.
2. Set the output power percentage to the desired level.
3. Set the output type to On, Off or TP.

A very simple test is to use a LED with a series 1K resistor connected across a TP or DZC output to see if it's pulsing. You can also use a voltmeter to check the outputs.

## Checking Digital I/O

Check the digital I/O from the Test I/O menu. You can also use a LED with a series 1k resistor to see the outputs turn On and Off.

---

## Computer Supervised Systems

These four items must work together to operate the 8LS:

1. The 8LS
2. The computer including the RS-232 or other serial interface
3. The communications link
4. The computer software

If the system does not work on initial startup, check the 8LS, the computer, and the serial link. First, check the 8LS in the stand alone mode. If there's a problem, return the 8LS to Watlow-Anafaze for service. The serial link must be RS485 when using more than one 8LS.

If ANASOFT is running in the system, when a unit is replaced, ANASOFT will detect a controller reset [indicated on initial power up] and automatically reload the current parameters in ANASOFT.

If the system includes multiple Watlow-Anafaze 8LS controllers, the address must be set correctly. This should be done using a spare housing before plugging the unit into the system housing. If the address is not changed the unit will probably have the default address 1. If the address must be changed while the system is up and on line, ANASOFT will indicate communication errors as it will probably get responses from two controllers at once. The address should be set as quickly as possible, and the current job reloaded to ensure the correct parameters are at each controller.

### Computer Problems

To check the computer, run standard programs that use the display and the printer. The serial interface must be functioning. This is harder to test since most programs do not use the serial interface. Check any computer problems with the computer supplier.

### Computer Software

This can be divided into: ANASOFT and user written software:

#### *User Written Software*

If you don't want to use ANASOFT as your software interface to the 8LS, you are responsible for the correct operation of the software you buy or write. You can request the Watlow-Anafaze **Communications Specification** if you want to write your own software. Watlow-Anafaze will answer any technical questions that arise during your software development process, but Watlow-Anafaze does not otherwise support user software in any way.

If you write your own software, first write a routine that sends and receives display commands to and from the 8LS. The protocol includes all characters, so the display should show the hexadecimal values of the data sent in both directions. If you have problems with the software you write, you can use this program to test your communications.

### *ANASOFT*

If ANASOFT is not working, check these things first:

1. ANAINSTL (the ANASOFT installation program) has the correct path for the program and data files.
2. All the necessary files exist in the directory specified by the path.
3. Your computer has enough memory. ANASOFT requires up to 640K of free memory to run. to maximize the amount of free memory available, use a memory manager (like HIMEM from DOS 5.0).
4. Your computer is not running memory-resident programs. Check your AUTOEXEC.BAT file to make sure that no memory-resident programs automatically run on startup; they may interfere with ANASOFT.
5. The software key is properly installed on the printer port. It should be plugged into the printer port with the female end toward the computer and the male end toward the printer. Do not remove the screws on the software key to connect it.

If, after you check these things , ANASOFT still does not work correctly, consult the *ANASOFT User's Guide* for more troubleshooting information.

## Communications Problems

If the computer is functioning properly, check the communication interface, cables and connections. A number of problems have been traced to bad cables or connections.

### Serial Interface

The serial interface must be correctly installed in the computer and set according to the manufacturers directions. ANASOFT communicates using Comm Port 1. Some multi-function interface cards allow setting of the comm port -- this should be done correctly. In addition, make sure only one communications channel is set as comm port 1. If necessary, you can change the communications port in the install program.

When the communications interface is correctly installed, you can use a scope to check the transmit line to insure characters are being sent to the 8LS.



# Appendix A: Ramp Soak

---

## Introduction

This Appendix will teach you how to set up and use Ramp/Soak profiles in 8LS controllers.

The Ramp/Soak feature turns your 8LS into a powerful and flexible batch controller. The Ramp/Soak feature lets you program the controller to change a process setpoint in a preset pattern over time. This preset pattern, or temperature **profile**, consists of several **segments**. During a segment, the temperature goes from the previous segment's setpoint to the current segment's setpoint.

- If the current segment's setpoint is larger or smaller than the previous segment's setpoint, it is called a **ramp** segment.
- If the current segment's setpoint is the same as the previous segment's setpoint, it is called a **soak** segment.

Each segment can have up to two **triggers**. At least one must be true before the segment can start. While the input is not true, the profile waits (this wait state is called **trigger wait**).

You can use any one of the eight digital inputs for triggers. You can also use the same trigger for more than one segment or more than one profile.

Each segment can also have up to four **events** (external signals connected to the digital outputs). Events occur at the end of a segment. You can use any of the digital outputs for events.

## R/S Features

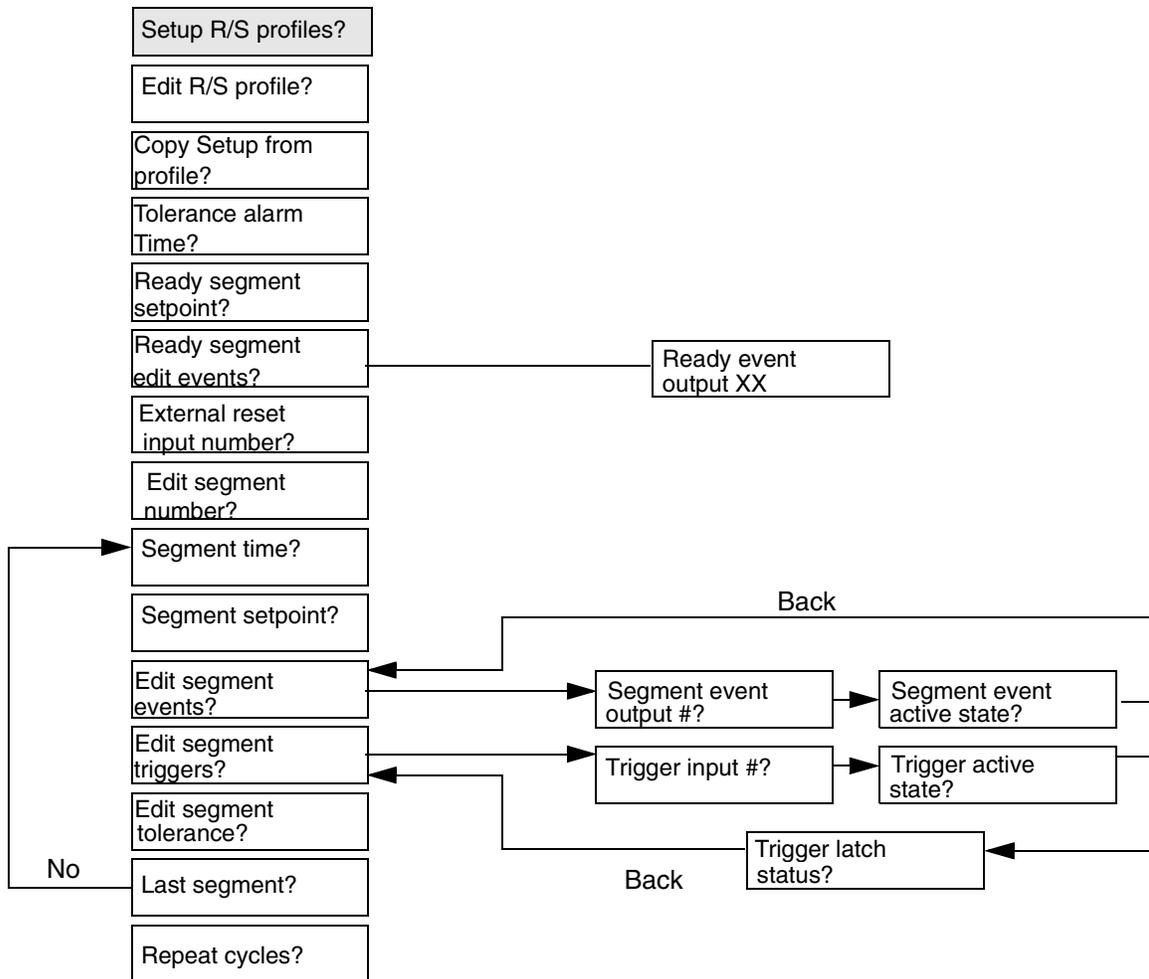
- **User-configurable time base:** Watlow Anafaze's Ramp/Soak lets you set your profiles to run for hours and minutes or for minutes and seconds—Whichever is appropriate for your application.
- **Repeatable profiles:** You can set any profile to repeat from 1 to 99 times or continuously.
- **Fast setup for similar profiles:** You can set up one profile, then copy it and alter it to set up the rest.
- **External reset:** Use the 8LS external reset menu to configure a digital input you can use to reset a profile to the Ready state.

## Specifications

Number of possible profiles	8
Number of times to repeat a profile	1-99 or continuous
Number of segments per profile	1-20
Number of triggers per segment	Up to 2
Type of triggers	Latched/ Unlatched
Number of possible inputs for triggers	8
Number of events per segment	4
Number of possible outputs for events (At least one of these outputs must be used for control)	30

## Configuring Ramp/Soak

This section will teach you how to set up R/S profiles. The following diagram shows the R/S configuration menu tree.



## Setting the R/S Time Base

The R/S time base menu is in the Setup Globals main menu.

Use this menu to set the time base in all your R/S profiles.

LOOP	PROCESS	UNITS
R/S TIME		
1	2	3
4	5	6
7	8	
BASE? H/M		
ALARM	SETPOINT	STATUS OUTPUT%

**Selectable Values:** H/M (Hours/Mins) or M/S (Mins/Secs).

## Editing R/S Parameters

You can reach the rest of the menus in this section from the Setup Ramp/Soak profile main menu. This menu is located between the Setup Loop Alarms main menu and the Manual I/O Test main menu.

LOOP	PROCESS	UNITS
SETUP		
1	2	3
4	5	6
7	8	
R/S PRO?		
ALARM	SETPOINT	STATUS OUTPUT%

Answering Yes to this prompt allows you to setup or edit R/S profiles.

## Choosing a Profile to Edit

Use this menu to choose a profile to set up or edit.

LOOP	PROCESS	UNITS
R/S PRO		
1	2	3
4	5	6
7	8	
PROF? A		
ALARM	SETPOINT	STATUS OUTPUT%

**Selectable Values:** A to H (8 profiles).

## Copying the Setup from Another Profile

Use this menu to setup similar profiles quickly, by copying a profile to another one.

LOOP	PROCESS	UNITS					
R/S PRO							
1	2	3	4	5	6	7	8
COPY? H							
ALARM	SETPOINT	STATUS	OUTPUT%				

**Selectable Values:** A to H.

## Editing the Tolerance Alarm Time

Use this menu to set a tolerance time that applies to the entire profile.

LOOP	PROCESS	UNITS					
A OUTTOL							
1	2	3	4	5	6	7	8
T? 1:00							
ALARM	SETPOINT	STATUS	OUTPUT%				

When the segment goes out of tolerance,

- The segment goes into tolerance hold.
- The segment timer holds.
- The loop's single loop display shows TOHO (Tolerance Hold).

When the segment has been out of tolerance for more than the tolerance alarm time,

- The controller goes into tolerance alarm.
- The tolerance timer resets.

You must acknowledge the tolerance alarm by pressing the ALARM ACK key before you can do any other editing.

**Selectable Values:** 0:00 to 99:59 (minutes or hours, depending on the time base setting).

## Editing the Ready Setpoint

When you assign a profile to a loop, the profile doesn't start immediately; instead, it goes to the ready segment (segment 0) and stays there until you put the profile in Start mode.

You can set a setpoint, assign events, and set event states for the ready segment. Use this menu to set the ready segment setpoint.

LOOP	PROCESS	UNITS
A READY		
1	2	3 4 5 6 7 8
SP? OFF		
ALARM	SETPOINT	STATUS OUTPUT%

**Selectable Values:** -999 to 9999, or Off.

## Editing the Ready Event States

Use this menu to set the ready state for all outputs that are not used for control. When you assign a profile, the controller starts the ready segment: it goes to the ready setpoint and puts all the outputs in the ready state you set here. The outputs stay in the ready state until the end of segment 1, when segment 1's events become active.

LOOP	PROCESS	UNITS
A READY		
1	2	3 4 5 6 7 8
EVENTS?		
ALARM	SETPOINT	STATUS OUTPUT%

When you press NO, you will advance to the next menu. If you press YES, this menu appears:

LOOP	PROCESS	UNITS
A READY		
1	2	3 4 5 6 7 8
DO01?OFF		
ALARM	SETPOINT	STATUS OUTPUT%

**Selectable Values:** On or Off.

## Choosing an External Reset Input

Use this menu to select an external reset input. Toggle the input to reset a profile to Ready state when it is in Run, Hold, or Wait mode. You can make any of the eight digital inputs the external reset input.

LOOP	PROCESS	UNITS
A EXTRST		
1	2	3 4 5 6 7 8
IN NR? 0		
ALARM	SETPOINT	STATUS OUTPUT%

**Selectable Values:** 0-12.

## Editing a Segment

Each profile is made up of several segments (up to 20). Use this menu to choose the segment to edit.

LOOP	PROCESS	UNITS
A EDIT		
1	2	3 4 5 6 7 8
SEG? 1		
ALARM	SETPOINT	STATUS OUTPUT%

**Selectable Values:** 1-20.

The first time you use this menu, it defaults to segment 1. when you have finished editing a segment, the controller returns you to this menu and goes to the next segment. This loop continues until you make a segment the last segment of a profile.

## Setting Segment Time

Use this menu to change the segment's time.

LOOP	PROCESS	UNITS
A SEG 01		
1	2	3 4 5 6 7 8
T? 0:00		
ALARM	SETPOINT	STATUS OUTPUT%

**Selectable Values:** 000:00-999:59 (minutes or seconds, depending on the selected time base).

## Setting a Segment Setpoint

Use this menu to set a setpoint for the segment you are editing. The process will go to this setpoint by the end of the segment time.

LOOP	PROCESS	UNITS
A SEG 01		
1	2	3 4 5 6 7 8
SP? OFF		
ALARM	SETPOINT	STATUS OUTPUT%

**Selectable Values:** -999 to 9999, or Off (no segment setpoint).

## Configuring Segment Events

You can assign up to four digital outputs—**Events**—to each segment. When the segment ends, the events you select go to the output state you specify. Use this menu to select events and specify their output states.

LOOP	PROCESS	UNITS
A SEG 01		
1	2	3 4 5 6 7 8
EVENTS?		
ALARM	SETPOINT	STATUS OUTPUT%

**Selectable Values:** YES or NO.

### *Starting a segment with an event*

If you want a segment to start with an event (usually events happen at the end of the segment), program the previous segment for the event. You can also use this trick:

1. Setup the segments that come before the first segment.
2. Setup an extra segment with time 000:00 and with the events for the first segment.
3. Setup the first segment.

If you also want to have events at the end of the segment, or you want the event to go off at the end of the segment, setup the first segment with the desired event number and event output state.

## Editing Event Outputs

This menu appears only if you answered YES to the previous menu. Use it to assign a digital output to each event. Assign digital outputs that are not being used for PID control.

LOOP	PROCESS	UNITS
A S01EV1		
1	2	3 4 5 6 7 8
DOUT?NO		
ALARM	SETPOINT	STATUS OUTPUT%

**Selectable Values:** 1-30, except those IN USE, or No (no event).

## Changing Event States

Use this menu to assign an output state to each event: On (High) or Off (Low). When the event occurs, the output goes to the state you assign here.

LOOP	PROCESS	UNITS
A S01EV1		
1	2	3 4 5 6 7 8
DO01?OFF		
ALARM	SETPOINT	STATUS OUTPUT%

**Selectable Values:** Off (Low) or On (High).

## Editing Segment Triggers

Each segment has two triggers (digital inputs). One of these triggers must be true before the segment can begin. If a segment times out and at least one of the next segment's triggers is not true, the profile goes into trigger wait state.

Use this menu to edit triggers for the current segment.

LOOP	PROCESS	UNITS
A SEG 01		
1	2	3 4 5 6 7 8
TRIGGRS?		
ALARM	SETPOINT	STATUS OUTPUT%

**Selectable Values:** YES (to edit triggers of current segment), or NO (to advance to the Edit Segment Tolerance menu).

## Assigning an Input to a Trigger

This menu appears only if you answered YES to the Edit Segment Triggers menu. Use it to assign one of the controller's eight digital inputs to a segment trigger. You can assign any digital input to any trigger. You can also assign the same digital input to multiple triggers.

LOOP	PROCESS	UNITS
A S01TR1		
1	2	3 4 5 6 7 8
DIN? NO		
ALARM	SETPOINT	STATUS OUTPUT%

**Selectable Values:** 1-12, or No (no input assigned). Setting a trigger to No disables it.

## Changing a Trigger's True State

Use this menu to toggle a trigger's true state between On and Off. This menu appears only if you answered YES to the Edit Segment triggers menu.

LOOP	PROCESS	UNITS
A S01TR1		
1	2	3 4 5 6 7 8
DI03? OFF		
ALARM	SETPOINT	STATUS OUTPUT%

**Selectable Values:** Off or On.

## Latching or Unlatching a Trigger

Use this menu to make a trigger latched or unlatched.

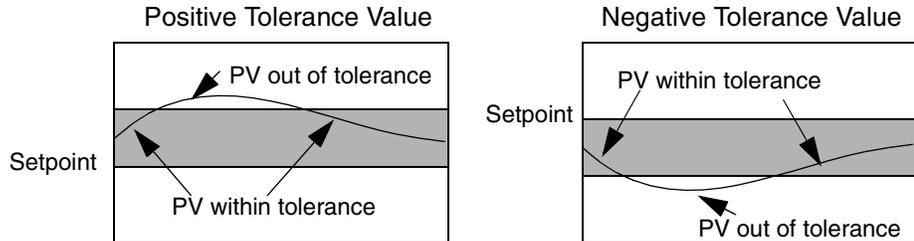
- A latched trigger is checked once, at the beginning of a segment.
- An unlatched trigger is checked constantly while a segment is running. If an unlatched trigger becomes false, the segment timer stops and the loop goes into trigger wait state.

LOOP	PROCESS	UNITS
A S01TR1		
1	2	3 4 5 6 7 8
LATCH? N		
ALARM	SETPOINT	STATUS OUTPUT%

**Selectable Values:** N (No: unlatched), Y (Yes: latched).

## Setting Segment Tolerance

Use this menu to set a positive or negative tolerance value for each segment. this value is displayed in the engineering units of the process and is a deviation from the setpoint.



- If you enter a positive tolerance, the process is out of tolerance when the PV goes above the setpoint plus the tolerance.
- If you enter a negative tolerance, the process goes out of tolerance when the PV goes below the setpoint minus the tolerance.

LOOP	PROCESS	UNITS
A SEG 01		
1	2	3 4 5 6 7 8
TOL? OFF		
ALARM	SETPOINT	STATUS OUTPUT%

**Selectable Values:** -99 to +99, or Off (no tolerance).

## Ending a Profile

Use this menu to make a segment the last one in the profile.

LOOP	PROCESS	UNITS
A SEG 01		
1	2	3 4 5 6 7 8
LAST? NO		
ALARM	SETPOINT	STATUS OUTPUT%

**Selectable Values:** No or Yes.

## Repeating a Profile

Use this menu to set the number of times you want a profile to repeat or cycle.

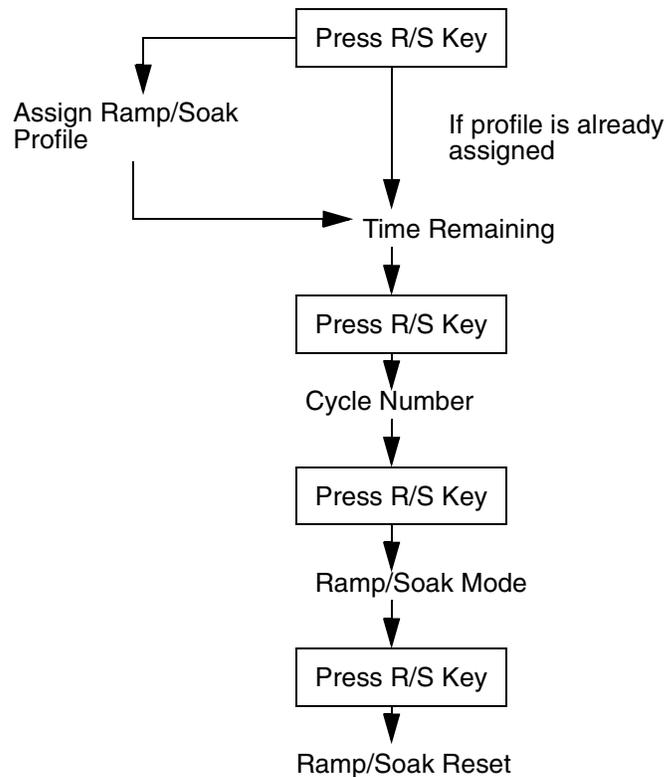
LOOP	PROCESS	UNITS
A		
1	2	3 4 5 6 7 8
CYCLE? 1		
ALARM	SETPOINT	STATUS OUTPUT%

**Selectable Values:** 1-99, or C (continuous cycling).

## Using Ramp/Soak

This section explains how to assign a profile to a loop, how to put a profile in Run, Continue, or Hold mode, how to reset a profile, and how to display profile statistics.

The next figure shows the Ramp/Soak key menus.



From the Ramp/Soak Reset display:

- Press NO to return to Single Loop display.
- Press BACK to return to the Time Remaining display.

### Assigning a profile to a loop

Use this menu to assign a profile to a loop.

LOOP	PROCESS	UNITS					
1	SELECT						
1	2	3	4	5	6	7	8
PROF? 0							
ALARM	SETPOINT	STATUS	OUTPUT%				

**Selectable Values:** A-H, or 0.

### *Assigning a profile the first time*

To assign a profile to a loop that doesn't have a profile, follow these steps:

1. In Single Loop display, switch to the loop you want to edit.
2. Press the RAMP/SOAK key. The assigning menu appears. (See menu in previous page)
3. Choose one of the available profiles and press ENTER.
4. Press BACK if you wish to return to Single Loop display without saving any changes.

### *Assigning a different profile*

To assign a new profile to a loop that already has one assigned, follow these steps:

1. Press the RAMP/SOAK key three times.
2. Press the NO key. You will see the Reset Profile menu.
3. Press YES, then ENTER, to reset the profile. You will see the Assign Profile menu. (See previous page.)
4. Choose one of the available profiles and press ENTER.
5. Press BACK if you wish to return to Single Loop display without saving any changes.

## Running a Profile

When you assign a profile, it does not start running immediately; instead, the loop enters the Ready segment (segment 0). Use this menu to start a profile (put it in Start mode).



### *Starting a profile*

You can start a profile only when it's in the Ready segment.

1. Press the RAMP/SOAK key repeatedly until you see the Ramp/Soak mode menu.
2. While the profile is in Ready segment, the only mode available is the Run mode.
3. Press YES to start the profile, and then ENTER to advance to the next menu.

### Running several profiles simultaneously

To run several profiles simultaneously, follow these steps:

1. Setup the profiles so that segment 1 of each profile has the same latched trigger.
2. Assign the profiles to the appropriate loops. The loops will go to the Ready segment of each profile.
3. Set each profile to Run mode.
4. Trip the trigger.

### Editing a profile while it is running

You can edit a profile while it is running, but the changes you have made will not take effect until the next time it runs.

## Ramp/Soak Displays

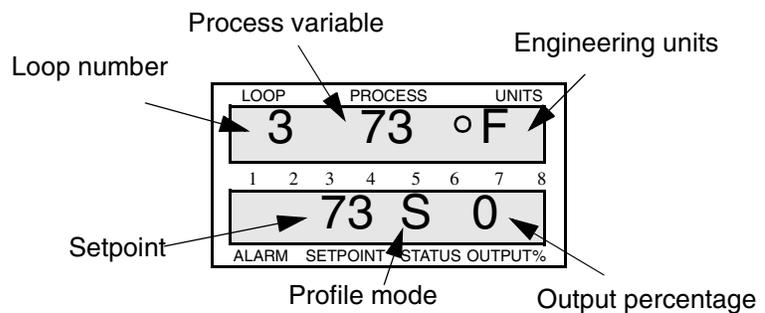
The Single loop and Bar Graph displays show additional codes for R/S controllers.

### Single loop display

When the controller is running a profile, the Single Loop display shows the profile mode where it would usually show MAN or AUTO. The next table shows the available codes and their meaning.

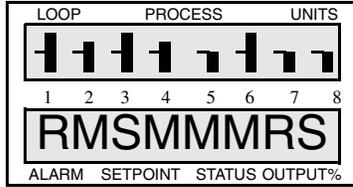
Code	Mode
STRT	The profile is in the Ready segment.
RUN	The profile is running.
HOLD	The user has put the profile in Hold mode.
TOHO	The profile is in tolerance hold.
WAIT	The profile is in trigger wait state.

This is the Single Loop display when a profile is running.



### Bar graph display

Loops that are running R/S profiles have different Bar Graph display codes. For these loops, you will see the first letter of each mode where the controller would normally display M (for Manual control) or A (for Automatic control).



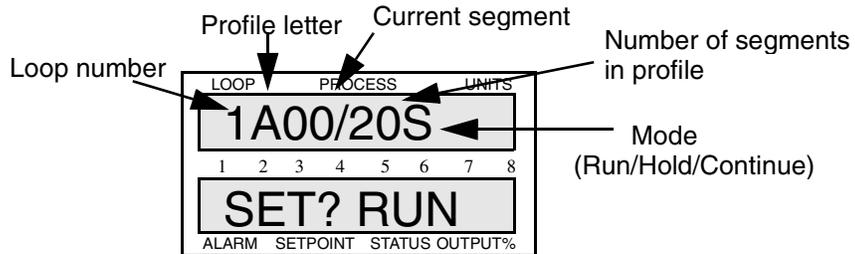
The next table shows the codes you would see in loops running R/S profiles.

Code	Meaning
R	A profile is running.
H	A profile is holding.
S	A profile is in Ready state.
O	A profile is in tolerance hold.

### Ramp/Soak Key Displays

Use the RAMP/SOAK key to see the time left in the current profile, the profile's status, or the number of times the profile has cycled.

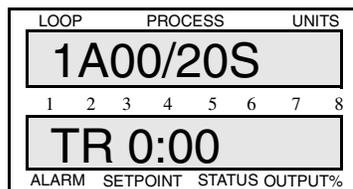
All the menus you can reach from the RAMP/SOAK key have the same information on the top line.



### How long has the profile run?

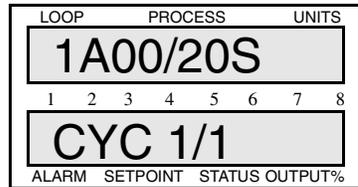
From Single Loop display, press the RAMP/SOAK key **once**.

The next menu appears only if you have already assigned a profile to the loop.



*How many times has it cycled?*

From Single Loop display, press the RAMP/SOAK key **twice**. The next menu will appear. This menu displays the number of times the profile has run out of the total number of cycles.



**Holding a Profile or Continuing from Hold**

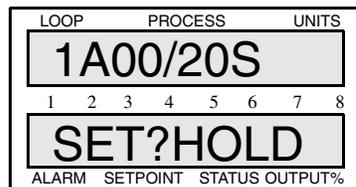
Use the profile mode menu to hold a profile or continue from Hold. The next table shows the available modes.

Current Mode	Available Mode	Description
Start	Run	Begin running the assigned profile.
Hold	Cont	Continue from user-selected hold. Profile runs from the point when you put the profile in Hold mode. (You cannot continue from a tolerance hold or a trigger wait.) After you choose this mode, the controller switches back to Run mode.
Run	Hold	Hold the profile.

*Holding a profile*

In Hold mode, all loop parameters stay at their current settings until you change the mode or reset the profile. To put a profile in hold, follow these steps:

- Press RAMP/SOAK key repeatedly until you see the R/S mode menu.



- While the profile is running, the only mode you will be able select is Hold.
- Press YES to hold the profile, and then ENTER to advance to the next menu.

### Continuing a profile

If a profile is holding and you want it to run, you can put it in Continue mode.

- Press RAMP/SOAK key repeatedly until you see the R/S mode menu
- While the profile is holding, the only mode you will be able select is Cont (Continue).
- Press YES to continue the profile, and then ENTER to advance to the next menu.

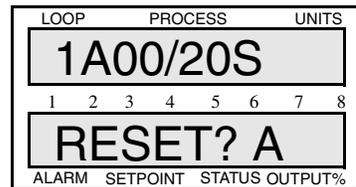
### Resetting a profile

Use this menu to reset a profile. When you reset a profile, the following happens:

- The profile returns to the ready segment. The PV goes to the ready setpoint, and the ready segment events go to the state you specified in the Edit Ready Event State menu.
- The controller shows you the Assign Profile menu in case you would like to assign a different profile to the loop.

To reset a profile, follow these steps:

1. Press RAMP/SOAK key repeatedly until you see the R/S mode menu
2. Press the NO key. You should see the menu below.
3. Press YES to reset the profile, and then ENTER to confirm your choice.



# Appendix B: 8LS-CP

The 8LS-CP controller with a Zirconia Carbon Probe assembly can control and record the Dew point of atmosphere generators or the percentage of Carbon Potential of hardening and sintering furnaces.

The 8LS-CP can accept direct connection of one to four Zirconia carbon probes without any special external signal conditioning amplifiers. The high impedance amplifier with the proper filter components mounted in the 8LS-CP provide a correct reading of the probe millivolt output without using an external probe amplifier. Direct connection of the probe reference type N, K, R, or S thermocouple is standard.

Loops that are not used for carbon input may be used as standard inputs for PID control and recording of other process parameters such as temperature zones.

## Key Features

- Selectable direct reading and control of Dew Point (DP), percentage of Carbon Potential (CP), or probe Millivolts (mV).
- Automatic indication of probe out of range conditions as to high/low temperature or high/low probe millivolt.
- Easily adjustable CO+CO<sub>2</sub> and Hydrogen percentage levels for correct atmosphere reading.
- Easily adjustable process variable offset corrects for thermocouple or probe sensor irregularities.
- Automatic probe Burn Off function with selectable contact or interval timer start.
- Trim Gas temperature warning alarm 1400-2400°F output per probe input.
- Independent Ramp/Soak temperature carbon programmer for boost carbon control.

## System Configuration

The 8LS-CP uses a modified input with discreet components per carbon input. Each CP input requires two loops. The 8LS-CP is factory configured to contain between 1 to 4 CP loops. The unit must be ordered for the number of CP inputs required per 8LS. Loops not used for the CP input may be used as standard inputs.

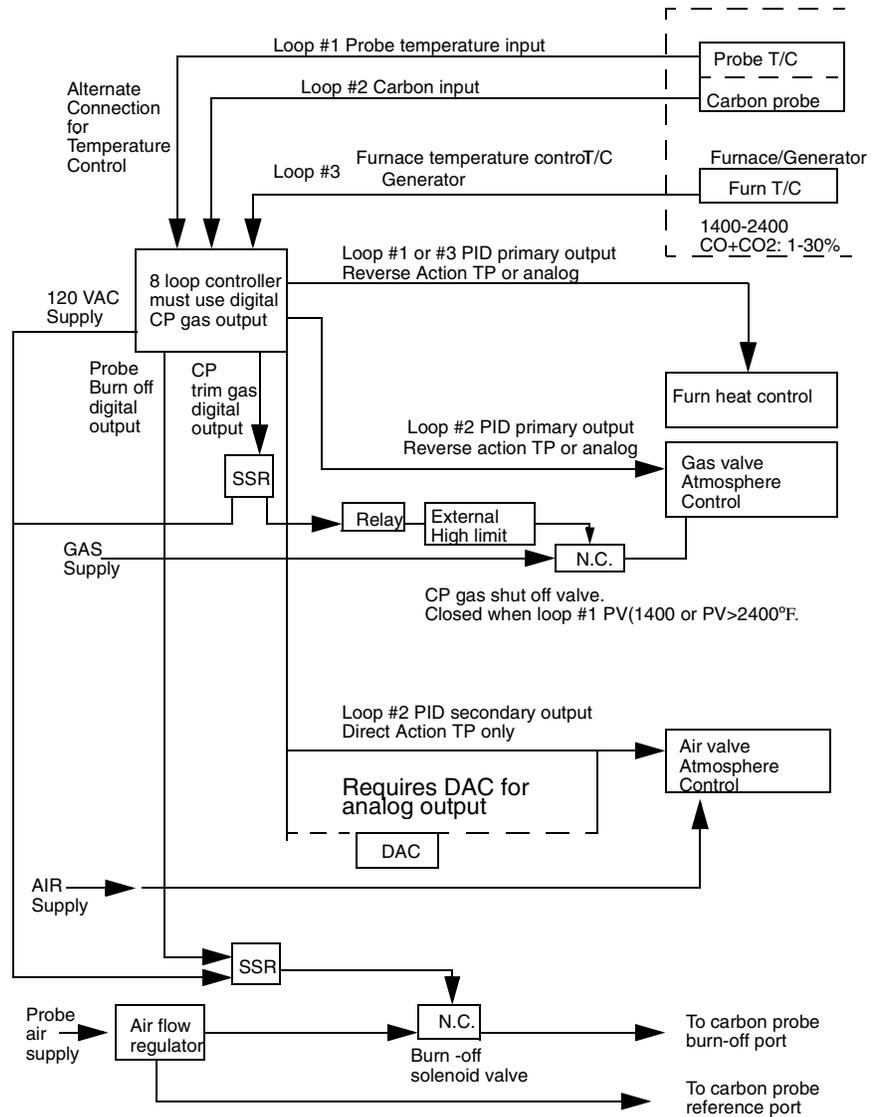
The analog output of loops 7 and 8 can be used for recording analog process signal representing the PV of loops 2 and 4 (carbon probe inputs). This function is selected through the DIP Switch setting on the CPU board. Position #4 must be On in order to use the PV recording function.

Model Number	Loop #	Loop Function
8LS-CP-1	1 2 3, 4, 5, 6, 8 7	Ref. T/C for loop #2 probe temp Carbon Probe input Standard PID loops Recording analog process signal representing the PV of loop 2.
8LS-CP-2	1 2 3 4 5, 6 7 8	Ref. T/C for loop #2 probe temp Carbon Probe input Ref. T/C for loop #4 probe temp Carbon Probe input Standard PID loops Recording analog process signal representing the PV of loop 2. Recording analog process signal representing the PV of loop 4.
8LS-CP-3	1 2 3 4 5 6 7-8	Ref. T/C for loop #2 probe temp Carbon Probe input Ref. T/C for loop #4 probe temp Carbon Probe input Ref. T/C for loop #6 probe temp Carbon Probe input Standard PID loops
8LS-CP-4	1 2 3 4 5 6 7 8	Ref. T/C for loop #2 probe temp Carbon Probe input Ref. T/C for loop #4 probe temp Carbon Probe input Ref. T/C for loop #6 probe temp Carbon Probe input Ref. T/C for loop #8 probe temp Carbon Probe input

The 8LS-CP is not only ordered for the number of carbon input loops desired, but the CPU DIP Switch on the CPU board must be set correctly to reflect the number of carbon inputs.

Number of Carbon Loops	CPU DIP Switch	
	#7	#8
CP-1	Off	Off
CP-2	Off	On
CP-3	On	Off
CP-4	On	On

The figure below presents a typical 8LS-CP control system.



---

## Specifications

The standard specifications listed in the **Introduction** section of this manual apply to the 8LS-CP with the following additions:

### Analog Inputs

#### *Each CP Input:*

- 1 Loop Selectable Type N, K, R, or S T/C Reference Temperature for CP
- 1 Loop Selectable % Carbon Potential (CP), Dew point (DP), or DC MV
- Carbon probe input

#### *Carbon Probe Input Range:*

- mV Range: 960 to 1275 mVdc
- CP Range: .10 to 1.40% Carbon
- Adjustable CO+CO<sub>2</sub> Range: 1-30%
- DP Range: -40 to 300° F/C
- Adjustable Hydrogen Range: 1-100%

### Control Capability

#### *CP PID Control*

T/C Loop has standard PID control.

Carbon Probe Loop PID control is reference to T/C Loop: output is available for control when T/C Loop is between 1400 to 2400°F.

#### *CP Trim Gas*

A separate output is available for each CP input.

Selectable Digital Output 1-30 will be On when T/C Loop PV is between 1400 to 2400°F and Off when PV is outside those limits.

#### *Carbon Burn Off*

Selectable Digital Output 1-30 with adjustable interval timer or contact start and burn off period timer. A separate output is available for each CP input.

- Interval timer range: 1 to 255 hours.
- Contact Start: Selectable Digital Input 1-12.
- Burn Off Period range: 1-45 minutes.
- Maximum Allowable Temperature: 1900 or 2100°F

---

## CP Control

The temperature control may be accomplished by using a standard Analog Input/Output loop or it may be installed so that the T/C Reference Loop of the CP input is the temperature control for the system. A standard PID control and output function is available from the T/C Reference Loop.

When using the Carbon Burn Off function, the T/C Reference Loop should not be used for temperature control.

The carbon probe input loop has a dual closed loop PID output for the control of the atmosphere. The control may use trim gas or air as control variables. The reverse action output is connected to the enriching gas supply valve, and the direct action output is connected to the air supply valve. The CP Loop PID control outputs are only available when the T/C Reference Loop is between 1400 to 2400°F. Temperatures outside these limits will set the PID outputs to zero percent output.

---

## Trim Gas Temperature Alarm Output

The 8LS-CP has a digital output, available for each CP input, that is called the CP Gas Alarm. This output is selectable from the alarm menu of the CP loop as one of the 1-30 digital outputs available. It will be On when the temperature of the T/C Reference Loop is between 1400 to 2400°F. Below or above these limits, the CP gas alarm output is Off.

For batch type furnaces, where the temperature will drop below the 1400°F limit of the CP gas alarm, a latching CP gas alarm function is required. This special latching alarm function is accomplished by setting a setpoint on the low process alarm of the probe reference temperature loop. Setting a low alarm setpoint keeps the CP gas alarm On below 1400°F.

The process temperature must first go above 1400°F to turn On the CP gas alarm output, and it will not turn Off until the actual temperature has gone below the low process alarm setpoint. The lowest setting of the low process alarm for this feature is 900°F. To use this feature, after selecting a digital output for the CP gas alarm output, select the same digital output for the reference temperature loop low process alarm output and set the setpoint of the low process alarm for the desired alarm warning.

This output could be used to power a Normally Closed solenoid valve installed in the enriching gas supply line to the trim gas control valve. **As always, an external temperature safety device should be used in series with the CP gas alarm output.**

## Recommended CP Trim Gas Alarm for Continuous Applications

When using the 8LS-CP for controlling the gas atmosphere, it is required to prevent gas from being introduced by the control system until the temperature is above 1400°F (760°C). The 8LS-CP has a digital output for each carbon input that will be On or Low whenever the PV of the reference T/C input is between 1400 to 2400°F. When the PV is below 1400°F or above 2400°F, the digital output will be Off or High.

This output—known as the CP Gas Output—is selectable as one of the 30 digital outputs that are available on the 8LS. There could be more than one output (up to 4)—depending on the number of CP inputs. The setpoint of this output is not adjustable in the field.

To use this output correctly, it must be wired in series with a safety shutdown temperature device to provide for redundant limit/warning of the carbonizing gas control system.

## Recommended CP Trim Gas Alarm for Batch Applications

When using the 8LS-CP for controlling the gas atmosphere in a batch furnace, it is required to prevent gas from being introduced by the control system until the temperature is above 1400°F (760°C) and to still be able to maintain the atmosphere when temperature goes below 1400°F. This requires that the CP gas alarm output will be maintained below the 1400°F limit.

The 8LS-CP gas output of the carbon loop alarm function will be On or Low whenever the PV of the reference T/C input is between 1400 to 2400°F. Use the CP gas digital output also for the reference T/C loop low process alarm digital output. After the PV reaches 1400°F, it allows the CP gas output to stay On below 1400°F, and until the SP of the low process alarm is exceeded, it will stay On. The lowest setting of the low process alarm is 900°F.

If the low process alarm setpoint is exceeded (PV goes below SP), the CP gas output will turn Off and stay Off until the temperature on the reference T/C goes above 1400°F.

## Carbon Probe

---

In general practice, follow the probe manufacturer's recommendations as to installation and maintenance schedule.

### General Guidelines

1. The probe must be exposed to the same atmosphere as the work load.
2. Be sure of the physical location as to length so the work load will not hit the probe and—for free atmosphere—flow around the probe.
3. Reference air flow should be in the range of .2-1.0 SCFH. Air flow below .2 SCFH will cause incorrect readings.
4. Useful service life of 12 months is normal. Probes should routinely be rebuilt by the probe manufacturer.
5. Furnace temperature should be 300°F or less when installing the Zirconia probe.
6. Do not install probes in new or rebricked furnaces until they have been dried out for at least 8 hours at 1700°F with a reducing atmosphere.

The use of the Zirconia probe in carburizing applications is trouble free except for two common problems:

- Zirconia probes are sensitive to thermal shock. rapid temperatures changes will cause the Zirconia probe to crack.  
To minimize thermal shock to the probe:
  - a. When inserting the probe, the recommended rate of insertion is 1"/minute. Too slow is better than too fast.
  - b. To avoid thermal shock upon opening the furnace door to ambient air, correct placement of the probe inside the furnace is a must.
- Carbon build-up on the probe is a very common problem and is one of the reasons for the probe to measure the oxygen level incorrectly.

To minimize carbon build-up:

- a. Avoid high carbon sooting if at all possible.
- b. Clean off the carbon on the probe with a carbon burn-off.

## Probe Burn Off

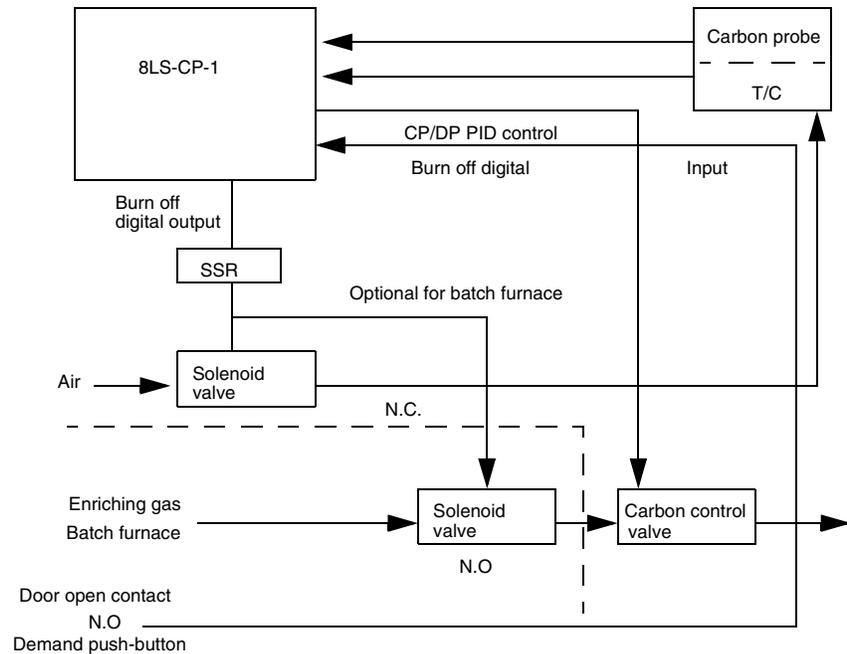
### Carbon Probe Burn Off Requirements:

1. To burn off carbon, excess fresh air is supplied to the end of the probe.
2. The excess fresh air burning off the carbon will cause the temperature of the probe to increase. The temperature must be monitored from the probe internal T/C, so that the maximum temperature of the probe is not exceeded.
3. The excess fresh air flow requirement is 1 to 2 SCFH.
4. The frequency and length of the burn off may be controlled from a timer or from a contact.
5. The frequency is normally measured in hours and the amount of time for the burn off is in minutes.
6. The CP controller PID output must be maintained, so that there is no change of the enriching gas, due to the misreading of the CP probe during burn-off.
7. The level of the PID control signal must be maintained following the burn off cycle to allow the probe to recover before automatic control is restored.
8. The method of burn-off is determined by the type of furnace.

### Burn off Procedures

	<b>Continuous Furnace (In time mode)</b>	<b>Batch Furnace (in input mode)</b>
<b>Recommended air flow</b>	2 SCFH	1 SCFH
<b>Purge period</b>	5 minutes set by operator	Time set by operator
<b>Burn off cycle</b>	3 hours set by operator	Cycles with open door
<b>Method of operation</b>	<ol style="list-style-type: none"> <li>1. Hold enrichment gas at current level during purge cycle.</li> <li>2. Monitor carbon probe temperature with the built in T/C.</li> </ol>	<ol style="list-style-type: none"> <li>1. Disable enrichment gas during cycle.</li> <li>2. Monitor carbon probe temperature with the built in T/C.</li> </ol>
<b>Set the SP for maximum probe temperature of either 1900 or 2100°F. The carbon burn off cycle will stop if temperature exceeds the limit. The burn off will continue when temperature goes below the limit.</b>		

The figure below describes the typical installation of a carbon burn off system.



## Burn Off Function

The carbon probe burn off function of the 8LS-CP is designed to supply excess fresh reference air to the outside of the probe assembly. When the excess air is exited at the end of the probe assembly, it supplies excess oxygen for the burning off of the built up carbon on the end of the probe.

The burn off selectable digital output of 1-30 will use an interval timer with a range setting of 1-255 hours or a selectable digital input of 1-12 for a contact closure to start the burn off procedure. The burn off period timer range is 1-45 minutes.

While in the burn off function, the Time mode selection for a continuous furnace, or Input mode for a batch furnace, will determine the control action of the PID output of the CP Loop.

- In the Time mode, the interval timer will start the burn off and hold the CP PID control output to the value it was at when the burn off was started.
- In the Input mode, a contact on a digital input generated by a door opening, or a switch closure, for instance, can start the burn off. The CP PID output will be held at the value it was at when the burn off started.

If you want to disable the enrichment gas during the burn off period, a Normally Open solenoid valve should be installed in the enriching gas line and powered from the same SSR that is supplying power to the burn off air solenoid valve.

In both modes, the control output signal will be held an additional two minutes after the burn off period to allow the probe to stabilize before resuming automatic control.

The burn off function digital output will be turned Off if the probe T/C exceeds the maximum allowable probe temperature of a selectable 1900 or 2100°F. It will remain off until the temperature falls at least 100°F below the selectable limit.

## Setup Menus

This section describes the additional editing parameters for the CP functions.

### Setup Inputs

#### *Input Type*

For the **Reference Temperature** Loop input, there are only four selectable T/C types available: K, R, S, N.

LOOP	PROCESS	UNITS
1 INPUTS		
1	2	3
4	5	6
7	8	
TYPE? K		
ALARM	SETPOINT	STATUS OUTPUT%

**Selectable Values:** K, R, S, N.

For the **Carbon Probe** Loop input, three engineering functions types are available: Carbon Potential(CP), Dewpoint (DP), or Millivolt(MV). Upon selecting either CP or DP another menu item becomes available: CO+CO2% and % of Hydrogen. The mV selection is not referenced to the temperature loop and is a direct reading of the probe millivolts.

LOOP	PROCESS	UNITS
2 INPUTS		
1	2	3
4	5	6
7	8	
TYPE? CP		
ALARM	SETPOINT	STATUS OUTPUT%

**Selectable values:** CP, DP, or MV.

### CO+CO2% and % of Hydrogen

Upon selecting CP as the input type, the following menu is available. Use it to adjust the amount of CO+CO2% in the atmosphere.

LOOP	PROCESS	UNITS
2	CO%	
1	2	3 4 5 6 7 8
?20		
ALARM	SETPOINT	STATUS OUTPUT%

**Selectable Range:** 1-30%.

Upon selecting DP as the input type, the following menu is available. Use it to adjust the amount of Hydrogen in the atmosphere.

LOOP	PROCESS	UNITS
2	H%	
1	2	3 4 5 6 7 8
? 40		
ALARM	SETPOINT	STATUS OUTPUT%

**Selectable Range:** 1-100%.

### Engineering Units

The engineering units of the carbon loop can be edited only for the Dewpoint type. The engineering units for CP and MV are fixed: "%CP" for CP and "MV" for MV.

Upon selecting the DP type and following the Hydrogen menu, the next menu is available. Use it to select if the reading is in °F or °C.

LOOP	PROCESS	UNITS
2	INPUTS	
1	2	3 4 5 6 7 8
UNIT? °F		
ALARM	SETPOINT	STATUS OUTPUT%

**Selectable Values:** F or C.

### Offset Calibration

If the carbon probe input type is set to CP or DP, a menu is available for editing an offset calibration of the probe input in the engineering units of the process variable.

The MV input is in direct reading of the millivolt output of the carbon probe with no offset adjustable available.

LOOP	PROCESS	UNITS
2 OFFSET		
1	2	3
4	5	6
7	8	
? 0 °F		
ALARM	SETPOINT	STATUS OUTPUT%

#### Selectable Range:

Input Type	Offset Range
CP	-.99 to +9.99% of Carbon
DP	-300 to +300°F/C



#### WARNING

**Incorrect setting of these values may cause incorrect operation of the 8LS-CP.**

### Setup Carbon Burn Off

Use the following menus to edit the carbon burn off function of the 8LS-CP.

LOOP	PROCESS	UNITS
2 CP		
1	2	3
4	5	6
7	8	
BURNOFF?		
ALARM	SETPOINT	STATUS OUTPUT%

#### Burn Off Start Mode

This menu allows you to edit the burn off start mode. Setting it to **Off** will deactivate the burn off. Selecting **Time** means the burn off procedure will be started periodically based on a time interval. This is

typically used in continuous furnace applications. Setting the start mode to **Input** means the burn off procedure will be started based on a digital input signal. This is typically used in batch furnace applications.

LOOP	PROCESS	UNITS
2BO STRT		
1	2	3
4	5	6
7	8	
MD? OFF		
ALARM	SETPOINT	STATUS OUTPUT%

**Selectable Values:** Off, Time, Input.

### *Burn Off Time Interval*

This menu is displayed if the start mode is set to Time. Use it to edit the time interval between the burn off function.

LOOP	PROCESS	UNITS
2BO INTR		
1	2	3
4	5	6
7	8	
HRS? 3		
ALARM	SETPOINT	STATUS OUTPUT%

**Selectable Range:** 1-255.

### *Burn Off start Input*

This menu is displayed if the start mode is set to Input. Use it to edit the digital input number which will initiate the burn off procedure. When the input is set to 0, the procedure will not start from any digital input and the burn off function will be deactivated.

LOOP	PROCESS	UNITS
2BO STRT		
1	2	3
4	5	6
7	8	
INPUT? 0		
ALARM	SETPOINT	STATUS OUTPUT%

**Selectable Range:** 1-12, or 0.

### *Burn Off Time Period*

This menu is displayed if the start mode is set to either Input or Time. Use it to edit the time period of the burn off. This is the time that the burn off air flow output will be set On to allow air flow to the probe burn off port.

LOOP	PROCESS	UNITS					
2BO TIME							
1	2	3	4	5	6	7	8
MINS? 5							
ALARM	SETPOINT	STATUS	OUTPUT%				

**Selectable Range:** 1-45.

### *Maximum Allowable Probe Temperature*

This menu is displayed if the start mode is set to either Input or Time. Use it to edit the maximum allowable probe temperature during the burn off procedure. When this temperature exceeds the burn off air flow, digital output is set Off until the probe temperature is 100°F below the Maximum Allowable Probe Temperature Setpoint. When the output is Off, the air flow to the probe should stop, allowing the probe to cool down.

LOOP	PROCESS	UNITS					
2BO TEMP							
1	2	3	4	5	6	7	8
MAX? 1900							
ALARM	SETPOINT	STATUS	OUTPUT%				

**Selectable Range:** 1900°F or 2100°F (1038°C or 1149°C).

### *Burn Off Air Flow Output Number*

This menu is displayed if the start mode is set to either Input or Time. Use it to edit the digital output number that controls the burn off air flow. Setting the number to 0 means the air flow digital output will not be activated.

LOOP	PROCESS	UNITS					
2BO AIR							
1	2	3	4	5	6	7	8
OUTPT? 0							
ALARM	SETPOINT	STATUS	OUTPUT%				

**Selectable Range:** 1-30 or 0.

## Setup Alarms

### CP Gas Alarm

This menu is available from the Setup Alarms main menu. Use it to set the digital output number for the CP trim gas alarm output. This output is On when the temperature of the T/C Reference Loop is between 1400 to 2400°F and Off when the temperature is outside these limits. When setting it to 0, the CP GAS output is disabled.

LOOP	PROCESS	UNITS
2CP GAS		
1	2	3
4	5	6
7	8	
OUTPN? 0		
ALARM	SETPOINT	STATUS OUTPUT%

**Selectable Range:** 1-30, or 0.

### CP and DP Display

The display of the carbon probe loop process variable depends upon the input values of the T/C Reference Loop and the probe millivolt level.

In order to display the engineering values of the input, both the T/C and probe loops must be within limits of the carbon probe variables for correct reading of the probe.

LOOP	PROCESS	UNITS
2 HIT %CP		
1	2	3
4	5	6
7	8	
.25 M 0		
ALARM	SETPOINT	STATUS OUTPUT%

- If the CP loop is in automatic mode, an out of range reading will set both CP control outputs to 0.
- If the control is in manual mode, it will not effect the outputs.

The next table shows the CP loop out of range indications.

Process condition	Indication
Reference T/C is below 1400°F	LOT
Reference T/C is above 2400°F	HIT
Probe MV is below 960 MVDC	LOV
Probe MV is above 1275 MVDC	HIV



# Appendix C: 8LS Cascade

## Introduction

---

The Cascade control feature allows the output percentage of one control loop to be used as the setpoint of a second control loop. The loop providing the output is called the Master or Primary loop. The loop that is using the output is called the Slave or Secondary loop.

In Watlow Anafaze multiloop controllers, the Master loop output can supply more than one secondary setpoint loop with a cascade setpoint.

The cascade control provides an adjustable range of the Secondary setpoint on a per loop basis.

The 0% level of the Primary loop control output sets the low end of the Secondary setpoint. The 100% level of the Primary loop control output sets the high end of the Secondary setpoint.

Selection of Cascade control is done on a per loop basis.

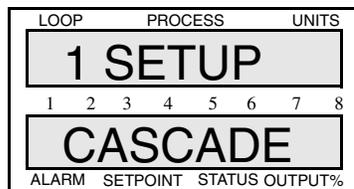
## 8LS Cascade Menus

---

### Cascade Main Menu

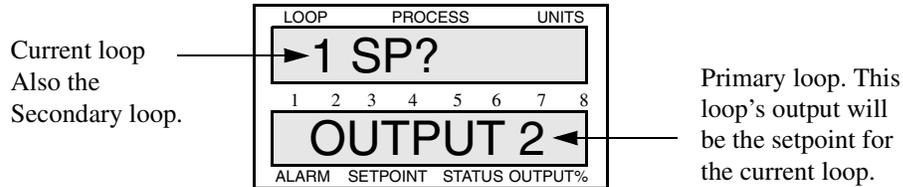
The following is the cascade main menu. It appears after the Setup Outputs main menu.

Press **Yes** if you wish to edit Cascade parameters. If you press **No**, the Setup Alarms main menu appears.



## Choosing the Primary Loop

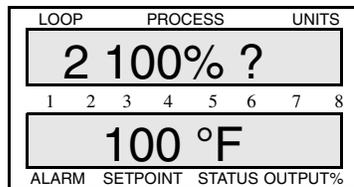
Use this selection to choose the primary loop for cascade control. This loop provides the output for the Secondary loop, which is the current loop as it appears on the upper line of the display.



## Setting the High End of the Secondary Setpoint

Use this selection to set the high end of the secondary loop setpoint.

This setting determines the high end setpoint of the Secondary loop (in this case loop 2) when the Primary loop's output reaches 100%.

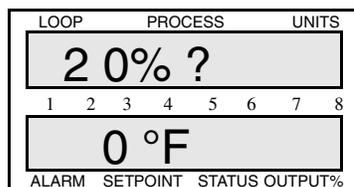


**Selectable Range:** The range of the input type selected on the secondary loop.

## Setting the Low End of the Secondary Setpoint

Use this menu to set the low end of the secondary loop's setpoint.

This setting determines the low end setpoint of the Secondary loop (in this case loop 2) when the Primary loop's output reaches 0%.



**Selectable Range:** The range of the input type selected on the secondary loop.

# Glossary

## A

### AC

See Alternating Current.

### AC Line Frequency

The frequency of the AC power line measured in Hertz (Hz), usually 50 or 60 Hz.

### Accuracy

Closeness between the value indicated by a measuring instrument and a physical constant or known standards.

### Action

The response of an output when the process variable is changed. See also Direct action, Reverse action.

### Address

A numerical identifier for a controller when used in computer communications.

### Alarm

A signal that indicates that the process has exceeded or fallen below a certain range around the setpoint. For example, an alarm may indicate that a process is too hot or too cold. See also:

- Deviation Alarm
- Failed Sensor Alarm
- Global Alarm
- High Deviation Alarm
- High Process Alarm
- Loop Alarm
- Low Deviation Alarm
- Low Process Alarm

### Alarm Delay

The lag time before an alarm is activated.

### Alternating Current (AC)

An electric current that reverses at regular intervals, and alternates positive and negative values.

### Ambient Temperature

The temperature of the air or other medium that surrounds the components of a thermal system.

### American Wire Gauge (AWG)

A standard of the dimensional characteristics of wire used to conduct electrical current or signals. AWG is identical to the Brown and Sharpe (B&S) wire gauge.

### Ammeter

An instrument that measures the magnitude of an electric current.

### Ampere (Amp)

A unit that defines the rate of flow of electricity (current) in the circuit. Units are one coulomb (6.25 x 10<sup>18</sup> electrons) per second.

### Analog Output

A continuously variable signal that is used to represent a value, such as the process value or setpoint value. Typical hardware configurations are 0-20mA, 4-20mA or 0-5 Vdc.

### Automatic Mode

A feature that allows the controller to set PID control outputs in response to the Process Variable (PV) and the setpoint.

### Autotune

A feature that automatically sets temperature control PID values to match a particular thermal system.

## B

### Bandwidth

A symmetrical region above and below the setpoint in which proportional control occurs.

### Baud Rate

The rate of information transfer in serial communications, measured in bits per second.

### Block Check Character (BCC)

A serial communications error checking method. An acceptable method for most applications, BCC is the default method. See CRC.

**Bumpless Transfer**

A smooth transition from Auto (closed loop) to Manual (open loop) operation. The control output does not change during the transfer.

**C**

**Calibration**

The comparison of a measuring device (an unknown) against an equal or better standard.

**Celsius (Centigrade)**

Formerly known as Centigrade. A temperature scale in which water freezes at 0°C and boils at 100°C at standard atmospheric pressure. The formula for conversion to the Fahrenheit scale is: °F=(1.8x°C)+32.

**Central Processing Unit (CPU)**

The unit of a computing system that includes the circuits controlling the interpretation of instructions and their execution.

**Circuit**

Any closed path for electrical current. A configuration of electrically or electromagnetically-connected components or devices.

**Closed Loop**

A control system that uses a sensor to measure a process variable and makes decisions based on that feedback.

**Cold Junction**

Connection point between thermocouple metals and the electronic instrument.

**Common Mode Rejection Ratio**

The ability of an instrument to reject electrical noise, with relation to ground, from a common voltage. Usually expressed in decibels (dB).

**Communications**

The use of digital computer messages to link components.  
See Serial Communications.  
See Baud Rate.

**Control Action**

The response of the PID control output relative to the error between the process variable and the setpoint. For reverse action (usually heating), as the process decreases below the setpoint the output increases. For direct action (usually cooling), as the process increases above the setpoint, the output increases.

**Control Mode**

The type of action that a controller uses. For example, On/Off, time proportioning, PID, Automatic or manual, and combinations of these.

**Current**

The rate of flow of electricity. The unit of measure is the ampere (A).  
1 ampere = 1 coulomb per second.

**Cycle Time**

The time required for a controller to complete one on-off-on cycle. It is usually expressed in seconds.

**Cyclic Redundancy Check (CRC)**

An error checking method in communications. It provides a high level of data security but is more difficult to implement than Block Check Character (BCC).  
See Block Check Character.

**D**

**Data Logging**

A method of recording a process variable over a period of time. Used to review process performance.

**Deadband**

The range through which a variation of the input produces no noticeable change in the output. In the deadband, specific conditions can be placed on control output actions. Operators select the deadband. It is usually above the heating proportional band and below the cooling proportional band.

**Default Parameters**

The programmed instructions that are permanently stored in the microprocessor software.

**Derivative Control (D)**

The last term in the PID algorithm. Action that anticipated the rate of change of the process, and compensates to minimize overshoot and undershoot. Derivative control is an instantaneous change of the control output in the same direction as the proportional error. This is caused by a change in the process variable (PV) that decreases over the time of the derivative (TD). The TD is in units of seconds.

**Deutsche Industrial Norms (DIN)**

A set of technical, scientific and dimensional standards developed in Germany. Many DIN standards have worldwide recognition.

**Deviation Alarm**

Warns that a process has exceeded or fallen below a certain range around the setpoint.

**Digital to Analog Converter (DAC)**

A device that converts a numerical input signal to a signal that is proportional to the input in some way.

**Direct Action**

An output control action in which an increase in the process variable, causes an increase in the output. Cooling applications usually use direct action.

**Direct Current (DC)**

An electric current that flows in one direction.

**Distributed Zero Crossing (DZC)**

A form of digital output control. Similar to burst fire.

**E****Earth Ground**

A metal rod, usually copper, that provides an electrical path to the earth, to prevent or reduce the risk of electrical shock.

**Electrical Noise**

See Noise.

**Electromagnetic Interference (EMI)**

Electrical and magnetic noise imposed on a system. There are many possible causes, such as switching ac power on inside the sine wave. EMI can interfere with the operation of controls and other devices.

**Electrical-Mechanical Relays**

See Relay, electromechanical.

**Emissivity**

The ratio of radiation emitted from a surface compared to radiation emitted from a blackbody at the same temperature.

**Engineering Units**

Selectable units of measure, such as degrees Celsius and Fahrenheit, pounds per square inch, newtons per meter, gallons per minute, liters per minute, cubic feet per minute or cubic meters per minute.

**EPROM**

Erasable Programmable, Read-Only Memory inside the controller.

**Error**

The difference between the correct or desired value and the actual value.

**F****Fahrenheit**

The temperature scale that sets the freezing point of water at 32°F and its boiling point at 212°F at standard atmospheric pressure. The formula for conversion to Celsius is: °C=5/9 (°F-32°F).

**Failed Sensor Alarm**

Warns that an input sensor no longer produces a valid signal. For example, when there are thermocouple breaks, infrared problems or resistance temperature detector (RTD) open or short failures.

## Filter

Filters are used to handle various electrical noise problems.

**Digital Filter (DF)** — A filter that allows the response of a system when inputs change unrealistically or too fast. Equivalent to a standard resistor-capacitor (RC) filter

**Digital Adaptive Filter** — A filter that rejects high frequency input signal noise (noise spikes).

**Heat/Cool Output Filter** — A filter that slows the change in the response of the heat or cool output. The output responds to a step change by going to approximately 2/3 its final value within the numbers of scans that are set.

## Frequency

The number of cycles over a specified period of time, usually measured in cycles per second. Also referred to as Hertz (Hz). The reciprocal is called the period.

## G

### Gain

The amount of amplification used in an electrical circuit. Gain can also refer to the Proportional (P) mode of PID.

### Global Alarm

Alarm associated with a global digital output that is cleared directly from a controller or through a user interface.

### Global Digital Outputs

A pre-selected digital output for each specific alarm that alerts the operator to shut down critical processes when an alarm condition occurs.

### Ground

An electrical line with the same electrical potential as the surrounding earth. Electrical systems are usually grounded to protect people and equipment from shocks due to malfunctions. Also referred to a "safety ground".

## H

### Hertz(Hz)

Frequency, measured in cycles per second.

### High Deviation Alarm

Warns that the process is above setpoint, but below the high process variable. It can be used as either an alarm or control function.

### High Power

Any voltage above 24 VAC or Vdc and any current level above 50 mAac or mAdc.

### High Process Alarm

A signal that is tied to a set maximum value that can be used as either an alarm or control function.

### High Process Variable (PV)

See Process Variable (PV).

### High Reading

An input level that corresponds to the high process value. For linear inputs, the high reading is a percentage of the full scale input range. For pulse inputs, the high reading is expressed in cycles per second (Hz).

## I

### Infrared

A region of the electromagnetic spectrum with wavelengths ranging from one to 1,000 microns. These wavelengths are most suited for radiant heating and infrared (noncontact) temperature sensing.

### Input

Process variable information that is supplied to the instrument.

### Input Scaling

The ability to scale input readings (readings in percent of full scale) to the engineering units of the process variable.

### Input Type

The signal type that is connected to an input, such as thermocouple, RTD, linear or process.

**Integral Control (I)**

Control action that automatically eliminates offset, or droop, between setpoint and actual process temperature.

See Auto-reset.

**J****Job**

A set of operating conditions for a process that can be stored and recalled in a controller's memory. also called a Recipe.

**Junction**

The point where two dissimilar metal conductors join to form a thermocouple.

**L****Lag**

The delay between the output of a signal and the response of the instrument to which the signal is sent.

**Linear Input**

A process input that represents a straight line function.

**Linearity**

The deviation in response from an expected or theoretical straight line value for instruments and transducers. also called Linearity Error.

**Liquid Crystal Display (LCD)**

A type of digital display made of a material that changes reflectance or transmittance when an electrical field is applied to it.

**Load**

The electrical demand of a process, expressed in power (watts), current (amps), or resistance (ohms). The item or substance that is to be heated or cooled.

**Loop Alarm**

Any alarm system that includes high and low process, deviation band, deadband, digital outputs, and auxiliary control outputs.

**Low Deviation Alarm**

Warns that the process is below the setpoint, but above the low process variable. It can be used as either an alarm or control function.

**Low Process Alarm**

A signal that is tied to a set minimum value that can be used as either an alarm or control function.

**Low Reading**

An input level corresponding to the low process value. For linear inputs, the low reading is a percentage of the full scale input range. For pulse inputs, the low reading is expressed in cycles per second (Hz).

**M****Manual Mode**

A selectable mode that has no automatic control aspects. The operator sets output levels.

**Manual Reset**

See Reset.

**Milliampere (mA)**

One thousandth of an ampere.

**N****No Key Reset**

A method for resetting the controller's memory (for instance, after an EPROM change).

**Noise**

Unwanted electrical signals that usually produce signal interference in sensors and sensor circuits. See Electromagnetic Interference.

**Noise Suppression**

The use of components to reduce electrical interference that is caused by making or breaking electrical contact, or by inductors.

**Non Linear**

Through Watlow-Anafaze software, the Non Linear field sets the system to linear control, or to one of two non linear control options. Input 0 for Linear, 1 or 2 for non linear.

## O

### Offset

The difference in temperature between the setpoint and the actual process temperature. Offset is the error in the process variable that is typical of proportional-only control.

### On/Off Control

A method of control that turns the output full on until setpoint is reached, and then off until the process error exceeds the hysteresis.

### Open Loop

A control system with no sensory feedback.

### Operator Menus

The menus accessible from the front panel of a controller. These menus allow operators to set or change various control actions or features.

### Optical Isolation

Two electronic networks that are connected through an LED (Light Emitting Diode) and a photoelectric receiver. There is no electrical continuity between the two networks.

### Output

Control signal action in response to the difference between setpoint and process variable.

### Output Type

The form of PID control output, such as Time Proportioning, Distributed Zero Crossing, SDAC, or Analog. Also the description of the electrical hardware that makes up the output.

### Overshoot

The amount by which a process variable exceeds the setpoint before it stabilizes.

## P

### Panel Lock

A feature that prevents operation of the front panel by unauthorized people.

## PID

Proportional, Integral, Derivative. A control mode with three functions:

Proportional action dampens the system response, Integral corrects for droops, and Derivative prevents overshoot and undershoot.

### Polarity

The electrical quality of having two opposite poles, one positive and one negative. Polarity determines the direction in which a current tends to flow.

### Process Variable

The parameter that is controlled or measured. Typical examples are temperature, relative humidity, pressure, flow, fluid level, events, etc. The high process variable is the highest value of the process range, expressed in engineering units. The low process variable is the lowest value of the process range.

### Proportional (P)

Output effort proportional to the error from setpoint. For example, if the proportional band is 20° and the process is 10° below the setpoint, the heat proportioned effort is 50%. The lower the PB value, the higher the gain.

### Proportional Band (PB)

A range in which the proportioning function of the control is active. Expressed in units, degrees or percent of span.  
See PID.

### Proportional Control

A control using only the P (proportional) value of PID control.

### Pulse Input

Digital pulse signals from devices, such as optical encoders.

## R

### Ramp

A programmed increase in the temperature of a setpoint system.

**Range**

The area between two limits in which a quantity or value is measured. It is usually described in terms of lower and upper limits.

**Recipe**

See Job.

**Reflection Compensation Mode**

A control feature that automatically corrects the reading from a sensor.

**Relay**

A switching device.

**Electromechanical Relay** — A power switching device that completes or interrupts a circuit by physically moving electrical contacts into contact with each other. Not recommended for PID control.

**Solid State Relay (SSR)** — A switching device with no moving parts that completes or interrupts a circuit electrically.

**Reset**

Control action that automatically eliminates offset or droop between setpoint and actual process temperature.

See also Integral.

**Automatic Reset** — The integral function of a PI or PID temperature controller that adjusts the process temperature to the setpoint after the system stabilizes. The inverse of integral.

**Automatic Power Reset** — A feature in latching limit controls that

**Resistance**

Opposition to the flow of electric current, measured in ohms.

**Resistance Temperature Detector (RTD)**

A sensor that uses the resistance temperature characteristic to measure temperature. There are two basic types of RTDs: the wire RTD, which is usually made of platinum, and the thermistor which is made of a semiconductor material. The wire RTD is a positive temperature coefficient sensor only, while the thermistor can have either a negative or positive temperature coefficient.

**Reverse Action**

An output control action in which an increase in the process variable causes a decrease in the output. Heating applications usually use reverse action.

**RTD**

See Resistance Temperature Detector.

**S****Serial Communications**

A method of transmitting information between devices by sending all bits serially over a single communication channel.

**RS-232**—An Electronics Industries of America (EIA) standard for interface between data terminal equipment and data communications equipment for serial binary data interchange. This is usually for communications over a short distance (50 feet or less) and to a single device.

**RS-485**—An Electronics Industries of America (EIA) standard for electrical characteristics of generators and receivers for use in balanced digital multipoint systems. This is usually used to communicate with multiple devices over a common cable or where distances over 50 feet are required.

**Setpoint (SP)**

The desired value programmed into a controller. For example, the temperature at which a system is to be maintained.

**Shield**

A metallic foil or braided wire layer surrounding conductors that is designed to prevent electrostatic or electromagnetic interference from external sources.

**Signal**

Any electrical transmittance that conveys information.

**Solid State Relay (SSR)**

See Relay, Solid State.

**Span**

The difference between the lower and upper limits of a range expressed in the same units as the range.

**Spread**

In heat/cool applications, the +/- difference between heat and cool. Also known as process deadband.

See deadband.

**Stability**

The ability of a device to maintain a constant output with the application of a constant input.

**T**

**T/C Extension Wire**

A grade of wire used between the measuring junction and the reference junction of a thermocouple. Extension wire and thermocouple wire have similar properties, but extension wire is less costly.

**TD (Timed Derivative)**

The derivative function.

**Thermistor**

A temperature-sensing device made of semiconductor material that exhibits a large change in resistance for a small change in temperature. Thermistors usually have negative temperature coefficients, although they are also available with positive temperature coefficients.

**Thermocouple (T/C)**

A temperature sensing device made by joining two dissimilar metals. This junction produces an electrical voltage in proportion to the difference in temperature between the hot junction (sensing junction) and the lead wire connection to the instrument (cold junction).

**TI (Timed Integral)**

The Integral term.

**Transmitter**

A device that transmits temperature data from either a thermocouple or RTD by way of a two-wire loop. The loop has an external power supply.

The transmitter acts as a variable resistor with respect to its input signal. Transmitters are desirable when long lead or extension wires produce unacceptable signal degradation.

**U**

**Upscale Break Protection**

A form of break detection for burned-out thermocouples. Signals the operator that the thermocouple has burned out.

**Undershoot**

The amount by which a process variable falls below the setpoint before it stabilizes.

**V**

**Volt (V)**

The unit of measure for electrical potential, voltage or electromotive force (EMF).

See Voltage.

**Voltage (V)**

The difference in electrical potential between two points in a circuit. It's the push or pressure behind current flow through a circuit. One volt (V) is the difference in potential required to move one coulomb of charge between two points in a circuit, consuming one joule of energy. In other words, one volt (V) is equal to one ampere of current (I) flowing through one ohm of resistance (R), or  $V=IR$ .

**Z**

**Zero Cross**

Action that provides output switching only at or near the zero-voltage crossing points of the ac sine wave



