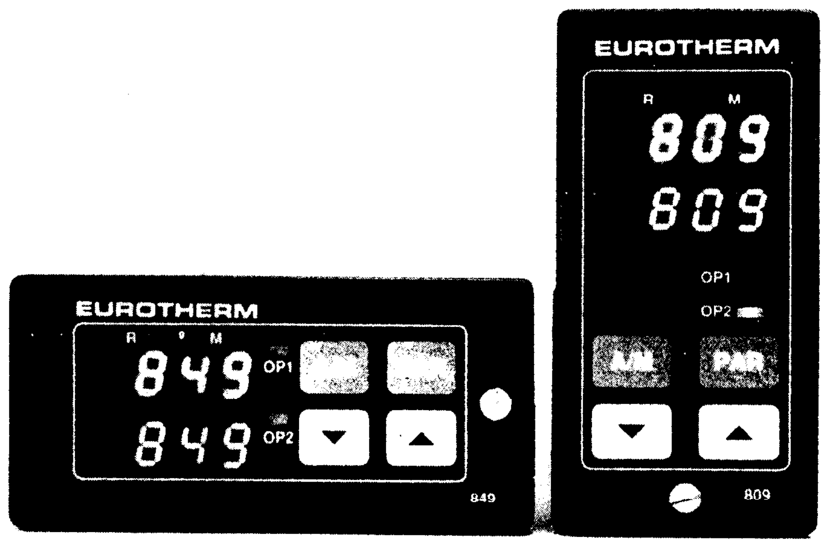
EUROTHERM CONTROLS

Installation and Operation Manual

MODELS 809 AND 849 VALVE POSITIONER CONTROLLERS

MODELS 809 AND 849 VALVE POSITIONER CONTROLLERS
WITH SETPOINT PROGRAMMING OPTION QP



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Issue 1

November 23, 1992

CAUTION!

Before installing, operating or servicing this unit supplied by Eurotherm Controls Inc, please read the following:

INSTRUCTIONS FOR SAFE USE OF EUROTHERM EQUIPMENT

(Note: These instructions represent good engineering principles and are applicable to all control equipment of the same type, whether from Eurotherm Controls Inc or any other supplier.)

ENCLOSURE OF LIVE PARTS

This unit should be installed inside a suitable grounded metal enclosure to prevent live parts being accessible to human hands and metal tools. It is recommended that rear terminal covers (available as an option) be fitted.

WIRING

It is important to connect the unit correctly in accordance with the installation data in this manual.
Wiring should conform to appropriate standards of good practice and local codes and regulations. Conductors should be commensurate with voltage and current ratings of the units.

OUT-OF-LIMITS ALARMS

In applications where excessive deviation of a controlled parameter due to equipment failure could cause damage to machinery or materials, or injury to personnel, it is strongly recommended that an additional separate unit with its own input sensor be used to give alarm indication or to shut down the process or both, as may be appropriate. (Note: The alarm function built into controllers may not give sufficient protection in these circumstances.) When the controller alarm function or separate alarm units are used they should be checked for correct operation at regular intervals.

CONFIGURATION

Many instrument functions are user selectable from the front panel. It is the user's responsibility to verify that the instrument configuration is correct. Personal injury, property loss and equipment damage could result from an improperly configured instrument.

Continued inside back cover...

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1. GENERAL

1.1 SCOPE

This manual contains information for the installation, operation, and configuration of the Models **809** and **849** microprocessor-based valve positioner controllers designed and manufactured in the USA by Eurotherm Controls Inc, Reston, Virginia.

1.2 ORDERING INFORMATION

1.2.1 General

This instrument is user-configurable. Hardware modifications (other than the choice of plug-in output boards or screw-on input adapters) are not required to obtain any of the possible configurations in the standard base product.

1.2.2 Shipping configuration

The instrument is shipped fully assembled ready for installation including the requested option(s). It will be pre-configured as ordered. Mounting hardware and installation instructions are included.

1.2.3 Accessories

The NEMA 3 (IP-54) gaskets for 1/8-DIN size instruments can be ordered separately. Order part numbers BO131932 and BO131943.

1.3 PRE-INSTALLATION

1.3.1 Receiving

1.3.1.1 Unpacking

- Exercise the normal precautions associated with unpacking and handling static-sensitive electronic equipment. Unpack all items from shipping container and visually check for any physical damage to the packing material. A detailed inspection should be made of the equipment surfaces that were adjacent to any damaged area.

CAUTION! Care should be taken to avoid electrostatic discharge (ESD) and thus reduce incidents of damage to the instrument. Keep the instrument in the conductive packing cocoon until panel installation. All work should be performed on a conductive surface with the personnel in contact with the surface by means of a grounded, metal or conductive plastic wrist strap with a 1MΩ series resistor. Synthetic and natural fibers that tend to harbor static electricity—nylon, wool, etc.—should not be worn.

- Retain the original conductive foamed polystyrene packaging material if reshipment is foreseen or required.

1.3.1.2 Inspection

- Inspect the equipment for damage incurred during shipment for bent or dented hardware or indicator lenses. Inventory the equipment against the packing list. If there is evidence of damage, or if a part is missing, report the discrepancy.

◦ The following items are included in the shipment:

- Model **809** or **849** Digital Temperature Controller
- Mounting hardware
- This manual

1.3.2 Product code

The Models **809** and **849** are versatile temperature controllers. As such, verify that the instrument is preset for the intended application.

◦ Compare the instrument *product code* against the information in Table 1.1 to verify that the *hardware code* includes the desired option(s) and that the *configuration* and *calibration codes* are as required for the application. The *product code* consists of 3 or 4 parts depending on the options selected:

- The *model number* is either **809** for vertical-profile controllers, or **849** for horizontal-profile controllers.
- The *hardware code* defines the type and location of the output modules, hardware options (communications board, input adapter for linear inputs), and the firmware options selected (self tuning, setpoint programming, linear inputs).
- The *configuration code* specifies the configuration and attributes which are not determined by hardware and which may be changed by the user. Any parameter or parameter value not affected by the choices in the *configuration code* is preset to the appropriate *standard value* listed in Table 5.2.
- The *calibration code*, used only with DC analog sensor inputs, defines the minimum and maximum values and units of the input signal, and the display range and units.

Note: The configuration code (in parentheses) and the calibration code [in brackets] apply to the instrument as it was shipped from the factory. Write down the complete product code in the space provided in Appendix D of this manual.

WARNING! The user is ultimately responsible for the proper configuration and calibration of the controller and selection of controller parameter values. Personal injury, property loss and equipment damage could result from an improperly configured instrument.

◦ First-time users are urged to read ALL instructions corresponding to their particular application.

Table 1.1
Product code

HARDWARE CODE [1]

Model	*output*	*alarm*	*comms*	*input adapter*	*additional options*
809 or 849 /	/	/	/	/	/

CONFIGURATION CODE [1]

config. type	*sensor*	*setpoint range*	*display units*	*alarm output*
(A				)/

CALIBRATION CODE [1]

input signal			**display range**		
lower limit	*upper limit*	*units*	*lower limit*	*upper limit*	*units*
[/	/	/	/	/	]

NOTES:

1. The complete Product Code consists of the Hardware, Configuration, and (in the case of linear inputs) Calibration Codes.

2. Dynamic range of input adapter must be greater than or equal to that of the input signal. The input adapter increases the panel depth of the controller to 7.105" (180.5mm).

3. Standard: Selections from this page. Non-standard: configurations requiring other parameter combinations or hardware modifications. Call your nearest Eurotherm Controls Sales and Service representative.

4. Selection of setpoint range D with types E, J, or L thermocouple invokes tenths' precision display.

5. Select for linear input. Requires completion of Calibration Code.

6. Units for all adjustable temperature parameters.

7. Alarms are non-latching. Alarm state affirmed by de-energized output.

8. Lower and upper limits must be within the bounds of the selected input adapter and units must agree. Specify up to 4 significant figures.

9. Display units must be within either -99.9 to 999.9 or -999 to 9999.

10. Write in display units. Use only the letters ***A*** *to* ***Z*** *and* ***a*** *to z. For reference only; not displayed on front panel.*

HARDWARE CODE [1]

output

0	Not fitted
VPR	Relay
VPT	Triac

alarm

0	Not fitted
L1	Logic
R1	Relay

communications

0	Not fitted
C2	EIA-232-D
C4	EIA-422-A

input adapter [2]

0	None (-10 to +50mV)/1.67µV resolut'n
IAV2	-40 to +200mV/6.67µV resolution
IA1V	-200 to 1000mV/33.3µV resolution
IA5V	-1 to +5V/0.167mV resolution
IA10V	-2 to +10V/0.333mV resolution
IA25V	-5 to +25V/0.833mV resolution
IAA02	-4 to +20mA/0.667µA resolution

additional options

0	None
QP	Setpoint programming

CONFIGURATION CODE [1]

configuration type [3]

A	Standard
@A	Non-standard

sensor input

Thermocouples		
B	Pt-30%Rh/Pt-6%Rh	
E	Chromel™/Adams constar	[4]
J	Fe/SAMA constantan	[4]
K	Chromel™/Alumel™	
L	Fe/DIN Konstantan	[4]
N	NiCroSil/NiSil	
P	Platinel II™	
R	Pt-13%Rh/Pt	
S	Pt-10%Rh/Pt	
T	Cu/Adams constantan	
Resistance temperature detector (RTD/3-wire)		
Z	DIN43760/BS1904/JIS C1602	
Linear input		
X	DC analog input	[5]

setpoint range [5]

	(°C)	(°F)	B	E	J	K	L	N	P	R	S	T	Z
A	-250+250	-400+500		•		•						•	
B	-100+100	-150+200		•		•						•	
C	-100+400	-100+750		•	•	•						•	
D	-75.0+400.0	-99.9+750.0		•	•		•						•
E	0-100	32-200		•	•	•	•	•	•	•	•	•	•
F	0-200	32-400		•	•	•	•	•	•	•	•	•	•
G	0-300	32-600		•	•	•	•	•	•	•	•	•	•
H	0-400	32-800		•	•	•	•	•	•	•	•		•
J	0-600	32-1200		•	•	•	•	•	•	•	•		
K	0-800	32-1400		•	•	•		•	•	•	•		
L	0-1000	32-1800		•	•	•		•	•	•	•		
M	0-1200	32-2100				•		•	•	•	•		
N	0-1600	32-2900								•	•		
P	200-1800	400-3200	•										
X	See Calibration Code (linear input only) [5]												

display units [6]

C	Degrees Centigrade
F	Degrees Fahrenheit
X	Blank (linear input only) [5]

alarm output [7]

0	OFF
4	Full scale low alarm
5	Full scale high alarm
6	Deviation band alarm

CALIBRATION CODE [1]

input signal [8]

lower limit

upper limit

units

mV	Millivolts
V	Volts
mA	Milliamps

display range

lower limit [9]

upper limit [9]

units [10]

1.3.3 Manufacturing revision levels

The instrument label indicates along with the product code and the serial number the *manufacturing revision level* under which the instrument was assembled.

There are 2 manufacturing revision level codes: the *software revision* and the *hardware revision*. If for any reason you need to contact Eurotherm Controls Inc concerning an instrument, be prepared to furnish these 2 numbers along with the product code. *Note these codes along with the product code and the serial number; Appendix D in the back of this manual is provided for this purpose.*

NOTE! **It is the customer's responsibility to maintain written documentation of the selected parameter values. Record values for the parameters in the schedule found in Appendix D.**

If an instrument must be returned to the factory for any reason, Eurotherm Controls Inc cannot guarantee that the customer settings will not be modified. When the instrument is returned to the customer, the parameter values and are taken from the Standard Value(s) column in Table 5.2 and will depend upon the output modules actually installed.

2. MECHANICAL INSTALLATION

2.1 PANEL MOUNTING OF INSTRUMENT SLEEVE

The instrument sleeve mounts into a 1.77x3.63" (45x92.2mm) cutout, and is secured from the rear with the 2 enclosed mounting brackets. Behind the panel provide for sufficient wiring space in order to properly separate the power and signal bundles.
The panel depth is 6.13" (156mm). With the linear input adapter **IA**, the panel depth increases to 7.11" (180mm).

Procedure

- Prepare the panel cutout according to Figure 2.1.
- Slide the instrument sleeve into the cutout from the front (Figures 2.2 and 2.3).
- Install the mounting brackets from the rear (Figures 2.4 and 2.5). Verify that the 4 tines of the brackets are firmly seated in the slots on the sleeve; correctly installed brackets will not fall out.
- Tighten the screws firmly. A torque limiter in each bracket prevents over-tightening.

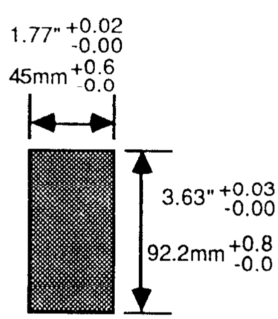


Figure 2.1. Panel cutout.

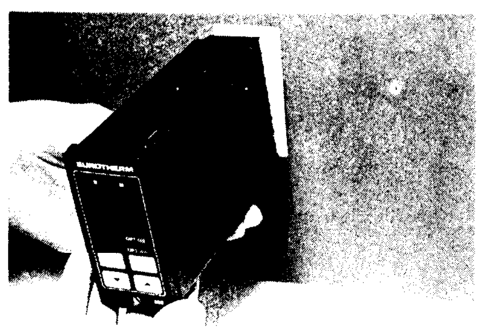


Figure 2.2. Installing instrument from front of panel into prepared cutout.

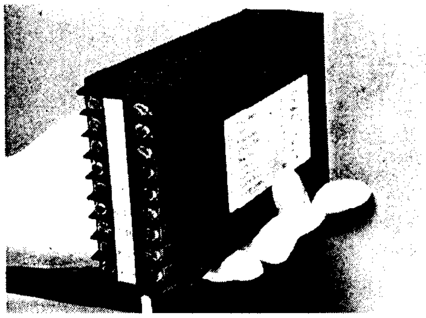


Figure 2.3. View from rear side of panel.

Figure 2.4. One of the 2 sleeve mounting brackets.

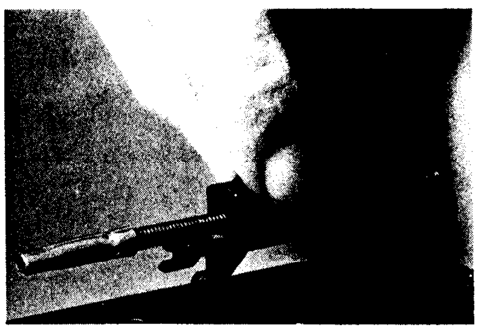


Figure 2.5. Installation of mounting bracket.

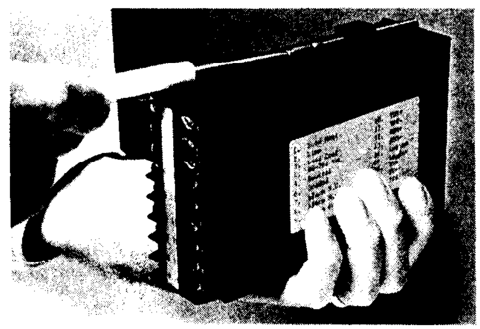


Figure 2.6. Tightening mounting bracket.

2.2 MULTIPLE INSTALLATIONS

The Models **809** and **849** controllers can be ganged in horizontal rows as shown in the right side of Figure 2.7. If more than one row is required, the rows should be separated be at least 2 inches vertically. Stacking the controllers vertically is discouraged.
At least 1 inch should be left horizontally between Model **849** cutouts to allow room for the mounting brackets.

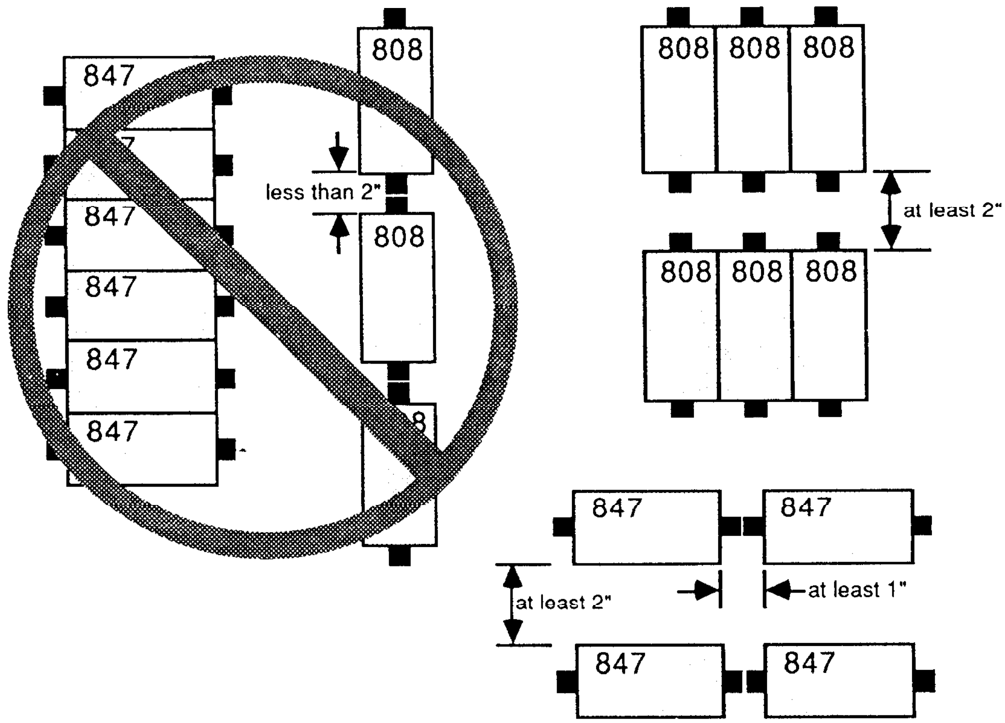


Figure 2.7. Multiple installation configurations to be discouraged (left), and suggested installation configurations (right).

3. ELECTRICAL INSTALLATION

3.1 GENERAL INFORMATION AND PRECAUTIONS

WARNING! When the controller is used to control a machine or process where personal injury or equipment damage might occur as a result of failure of any electronic or other controller function, you are urgently recommended to insist on installation of safeguards which would protect the operator and/or machine in the event of any unexpected operation of the machine or process.

WARNING! Electrical shock hazard that could cause injury or death can exist on the rear terminals of the instrument:

- Controller power supply at terminals 5 and 6,
- Open and close outputs at terminals 1 through 4,
- Alarm circuit power at terminals 8 through 10.
- Thermocouple input at terminals 19 and 20 if the thermocouple is at line voltage.

Even though voltage to controller power supply is OFF, do not neglect to remove all other potential shock hazards before touching the rear terminals. This is particularly important if the instrument is door mounted.

CAUTION! It is your responsibility to calculate the maximum possible current in each power and common wire. Do not exceed the rated current for any particular wire size permitted by the local electrical code. Overheated wires and damaged insulation may result from overloading.

NOTE! Open output (terminals 1 and 2), close output (terminals 3 and 4) and alarm outputs (terminals 8 and 10, and 9 and 10) are each fitted with an RC *suppression snubber* in parallel with the plug-in output module. When connected in a $120V_{ac}$ circuit, the snubber passes 1mA when the output triac or relay is OFF (open). In a $240V_{ac}$ circuit, the snubber passes 2mA.
When testing one of these outputs with a high input-impedance voltmeter and the output is *unloaded*, the voltmeter will read the line voltage even though the output is OFF. This does not indicate that the output channel is operating improperly.
The operation of these outputs should be tested only when they are appropriately loaded.

- Before wiring, verify the nameplate for correct model number and options. See Table 1.1.

- Power is always applied to the internal circuit when the instrument is connected to the AC supply (terminals 5 and 6).
- Make input and output terminations to instrument only with the power OFF.
- Refer to Figure 3.1 and to Tables 3.1 through 3.5 for rear terminal designations and for wiring the power, outputs, and signal inputs.

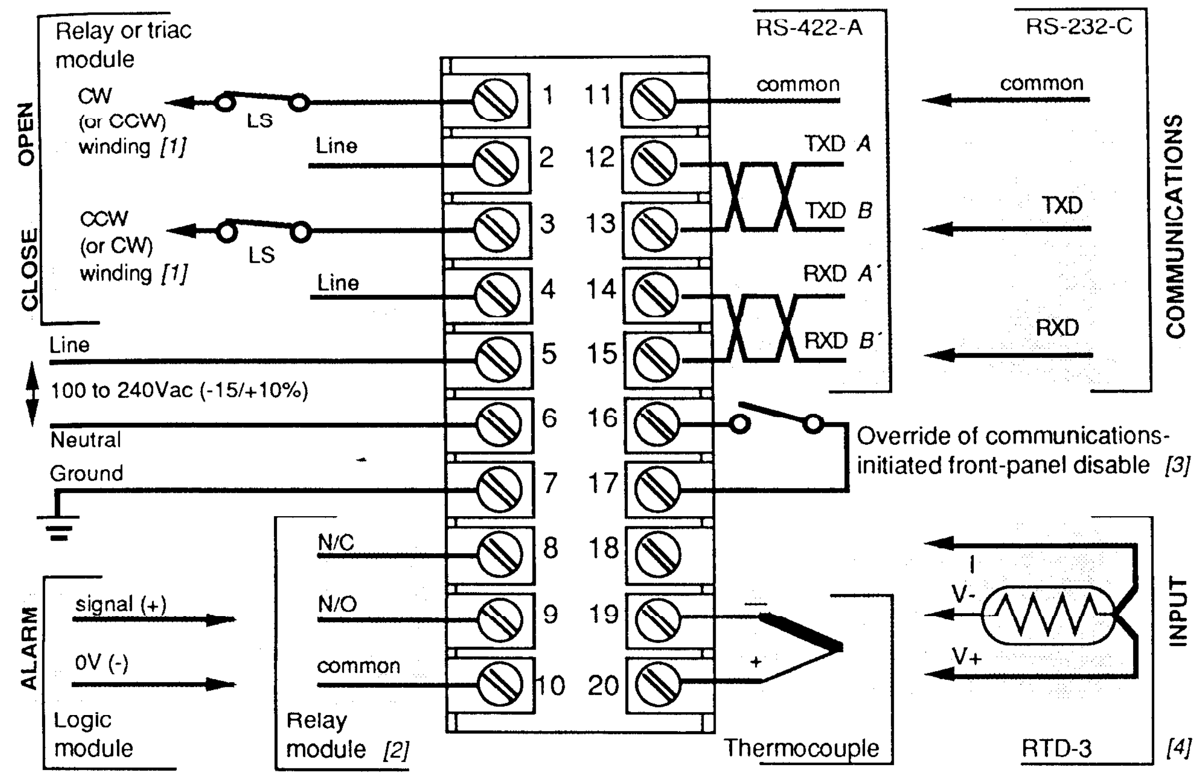


Figure 3.1. Models 809 and 849 external connections.

NOTES

1. When heat is required in heating applications (parameter **Act** *set to* **rev***), the open output is connected to the appropriate winding which opens the valve .*

2. N/C and N/O refer to the condition of the relay contacts when the relay is not energized: i.e. when the relay is in the alarm condition or when power is not applied to the controller.

3. The logic input is also used for the setpoint programming option if it is installed.

4. the linear input option may require the addition of an input adaptor.

- The rear screw terminals do not require the use of lugs for proper wire retention. If spade lugs are used they should have a self-retaining feature.

- Unused terminals should **not** be used as tie points as they may be internally connected.

- See also "INSTRUCTIONS FOR SAFE USE OF EUROTHERM EQUIPMENT" inside the cover of this manual.

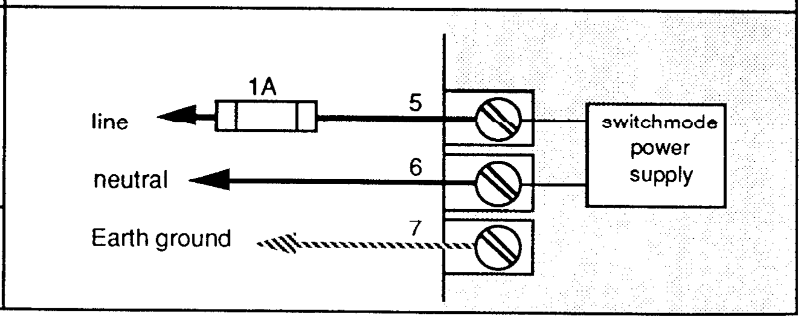
- Verify in the *Specifications* that the ratings of the controller output devices and the inputs are not exceeded.

3.2 POWER AND GROUND (terminals 5, 6, and 7)

The instrument may be powered from an AC voltage between 100 and 240V_{ac} (-10/+15%), 50 or 60 Hz.

- Connect the neutral to terminal 6. Connect the line to terminal 5; place a 1-Amp fuse in the line-side of the AC supply. Refer to Table 3.1. The power wiring bundle should be run separately from the signal wiring.
- The wire size should not be smaller than #18/AWG (0.5mm2); electrical codes and specifications may require, however, a larger wire size. The type of insulation must be in accordance with the electrical wiring codes (normally types THHN, THW or equivalent).

Table 3.1
Power and Ground Wiring
Terminals 5, 6, and 7

Function	External connections Terminals
Power 100-240Vac (-15/+10%) 50/60Hz	
Ground	

- The instrument ground (terminal 7) should be directly connected to earth ground. *Do not pass by the ground terminal of other instruments ("daisy-chain" connection).*

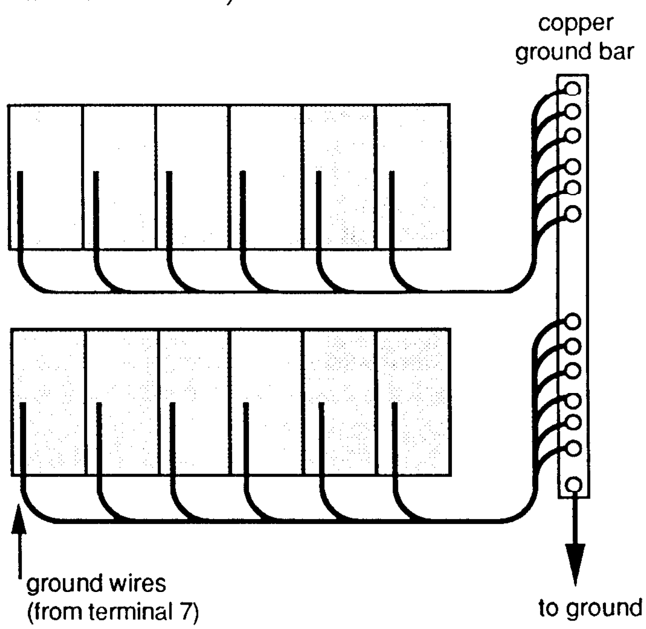


Figure 3.2. Recommended method of grounding multiple controller installations.

CAUTION! Observe proper wiring practices to eliminate the possibility of ground loops. Only ONE of the following inputs or outputs should be connected to the earth ground (terminal 7):

- **thermocouple or RTD input (terminals 18 through 20),**
- **logic input (terminals 16 and 17).**

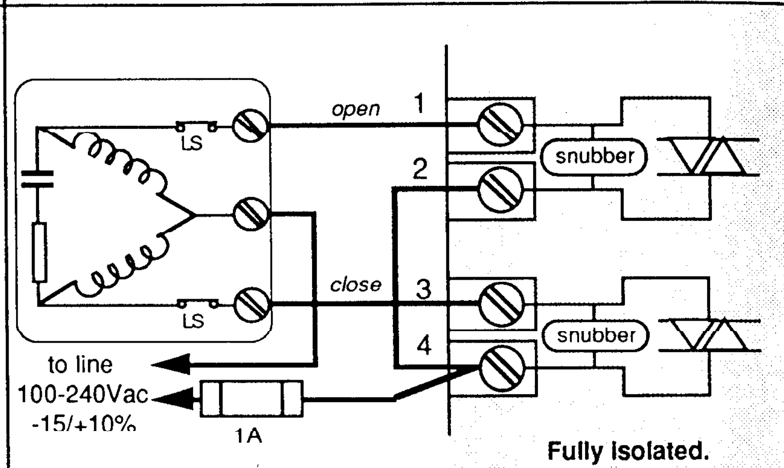
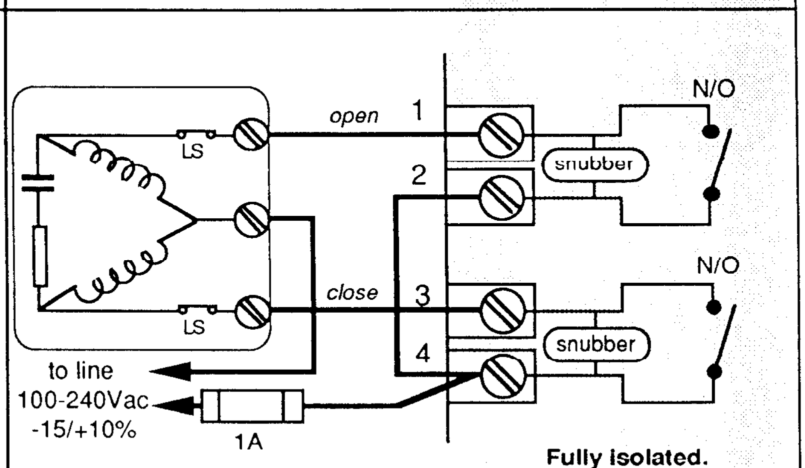
The input signals connected to these terminals must be isolated from one another. If either of the above circuits become connected to each other externally to the controller, damage to the controller will result.

3.3 OPEN AND CLOSE OUTPUTS (terminals 1 through 4)

Two different output module types can be fitted into the open and close channels: triac (**VPT**) and relay (**VPR**). Verify the "Output" code in the Hardware Code (Table 1.1) and the label on the side of the instrument.

The external connections are the same for both triacs or relays. See Table 3.2 for connection details.

Table 3.2
Output Wiring
Terminals 1 through 4

Function	External connections	Terminals	Internal device
Triac (VPT) Internal connection between terminals 1 and 2 is made during opening of valve (yellow OP1 lamp ON). Internal connection between terminals 3 and 4 is made during closing of valve (yellow OP2 lamp ON).			
Relay (VPR) Internal connection between terminals 1 and 2 is made during opening of valve (yellow OP1 lamp ON). Internal connection between terminals 3 and 4 is made during closing of valve (yellow OP2 lamp ON).			

NOTE: **The motor must be equipped with 2 cam-operated limit switches to prevent excess travel, one in series with each of the open and close windings of the motor.**

3.4 ALARM OUTPUT (terminals 8, 9, and 10)

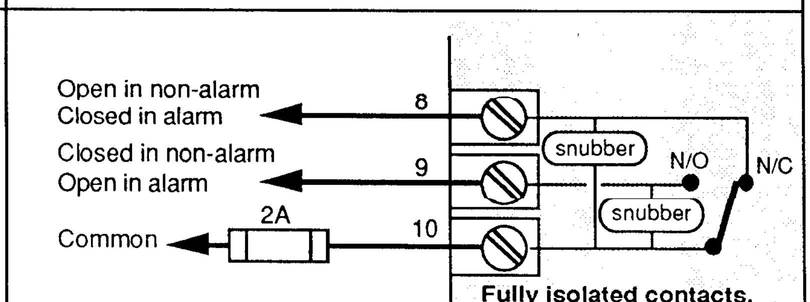
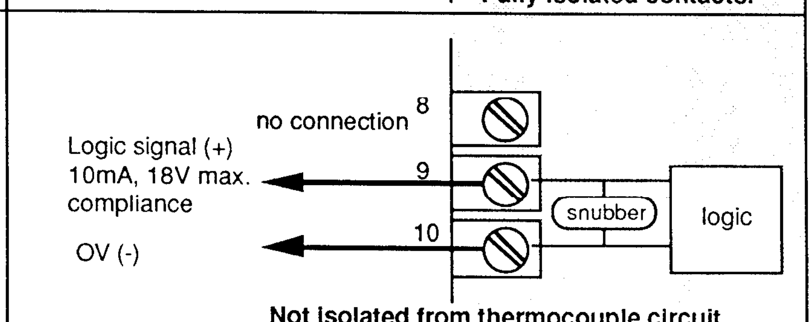
Two different module types can be fitted into the Alarm channel: relay (**R1**) and logic (**L1**). Verify the "Alarm" code in the Hardware Code (Table 1.1) and the label on the side of the instrument. See Table 3.3.

The Alarm output is **failsafe**: the output device is de-energized during the alarm condition or power down. The attached alarm circuit should be fused and designed to have failsafe operation even in the case of a blown fuse.

WARNING! **The alarm output channel should <u>never</u> be fitted with a triac output module. For critical alarm applications a redundant system should always be installed; use a separate alarm unit, e.g. Eurotherm Controls Model 92 or equivalent and a separate input sensor.**

The external connections depend on what type of output module is installed.

Table 3.3
Alarm Output Wiring
Terminals 8, 9, and 10

Function	External connections	Terminals	Internal device
Relay (R1) Failsafe operation—relay is in relaxed position during alarm.			
Logic (L1) Logic signal goes low during alarm condition;. Signal is active (high) during non-alarm condition.			

3.5 INPUT (terminals 18, 19, and 20)

The instrument accepts thermocouple,RTD, and linear inputs. For the types and ranges of the input sensors, see the *Specifications*.

3.5.1 Thermocouple input

- Connect to terminals 19(-) and 20(+) as shown in Table 3.4.

- Use appropriate compensating cable (thermocouple extension wire) having the same thermal emf as the thermocouple to which it is connected; verify that correct polarity is respected at both the thermocouple-end and instrument-end of the cable.

3.5.2 RTD input

- Refer to Table 3.4 for wiring. Only the 3-wire connection should be used. Connect the measurement leads to terminal 19 (-) and 20 (+). The excitation current is available at terminal 18.

- *Use the same gauge and length copper wire on all 3 terminals.*

3.5.3 Linear inputs

3.5.3.1 Millivolt-level signals

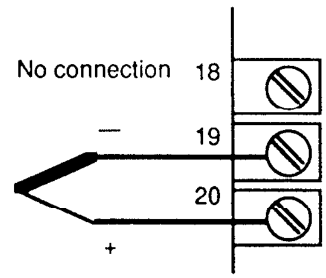
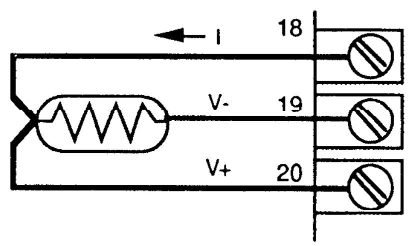
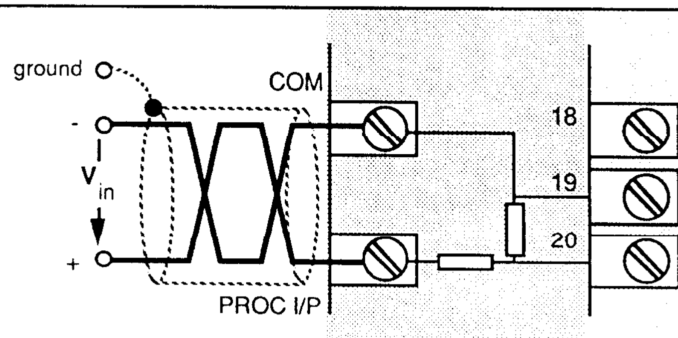
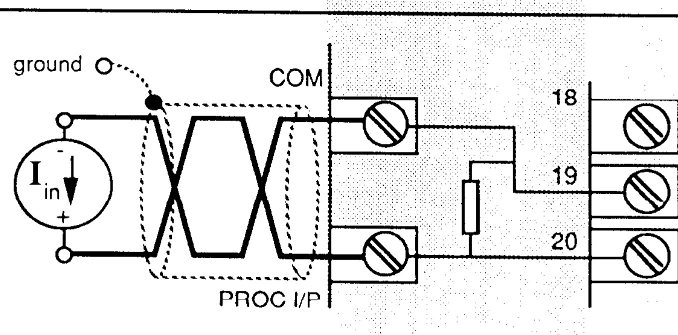
No input adapter is required for signals greater than -10mV and less than 50mV. The common (-) is connected to terminal 19 and the signal (+) is connected to terminal 20.

- Differential temperature control (thermocouple bucking). See Figure 3.3 for connections.
- Millivolt sources. Use a shielded twisted pair with the shield grounded at the signal source. If the signal wires pass through any screw terminals or connectors, make sure that the shield continuity is maintained and that it is grounded only at one end of the run.

3.5.3.2 Linear process signals

- Verify that the input adapter **IA...** corresponding to the input signal range and type (voltage or current) is installed onto rear terminals 18 through 20. [Terminal 18, the RTD excitation current, is not electrically connected to the input adapter; a lug is fitted there only for mechanical support.]
- Connect the input wires to the appropriate outer terminals of the input adapter: the wire carrying the signal to "PROC I/P" and the reference to "COM". Use a shielded twisted pair as described above.

Table 3.4
Input Wiring
Terminals 18, 19, and 20

Sensor	External connections / Terminals
Thermocouple	
RTD, 3-wire connection	
Signal type	**External connections / Input adapter terminals / Input adapter type IA... / Controller terminals**
Voltage **IA...** -10 to +50mV **NONE** -40 to +200mV **IAV2** -200 to +1000mV **IA1V** -1 to +5V **IA5V** -2 to +10V **IA10V** -5 to +25V **IA25V**	
Current **IA...** -4 to +20mA **IAA02**	

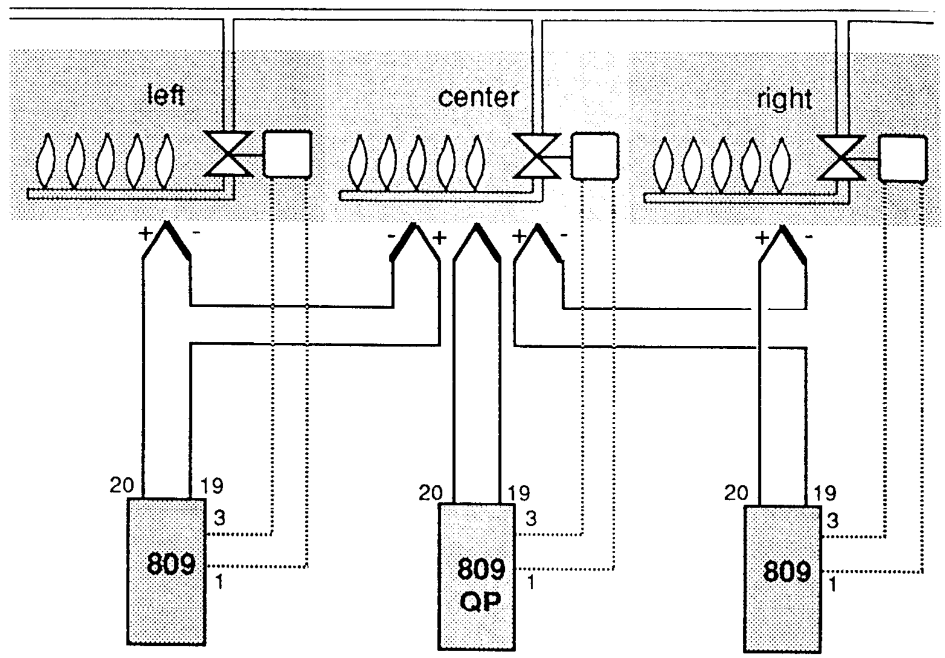


Figure 3.3. Input connections for differential temperature control (thermocouple bucking).

3.6 COMMUNICATIONS OPTION (terminals 11 through 17)

Verify on the instrument label and the Hardware Code in Table 1.1 if the EIA 232-D or the EIA 422-A communications board is installed.

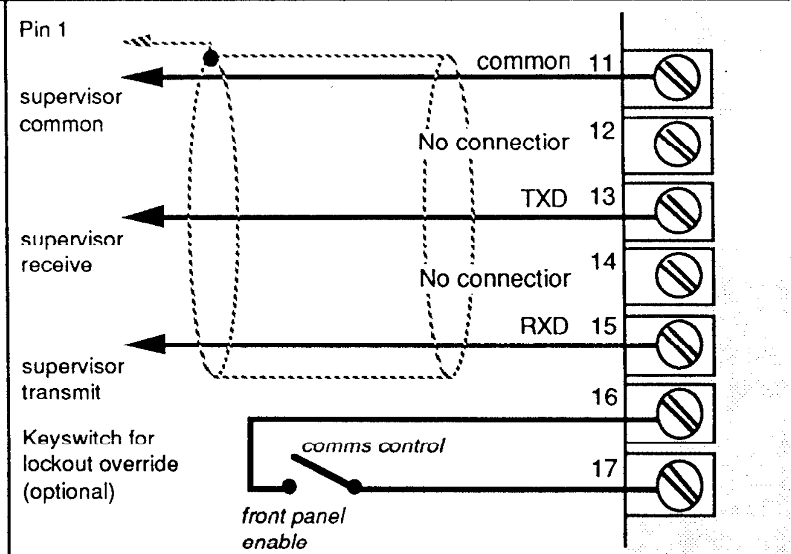
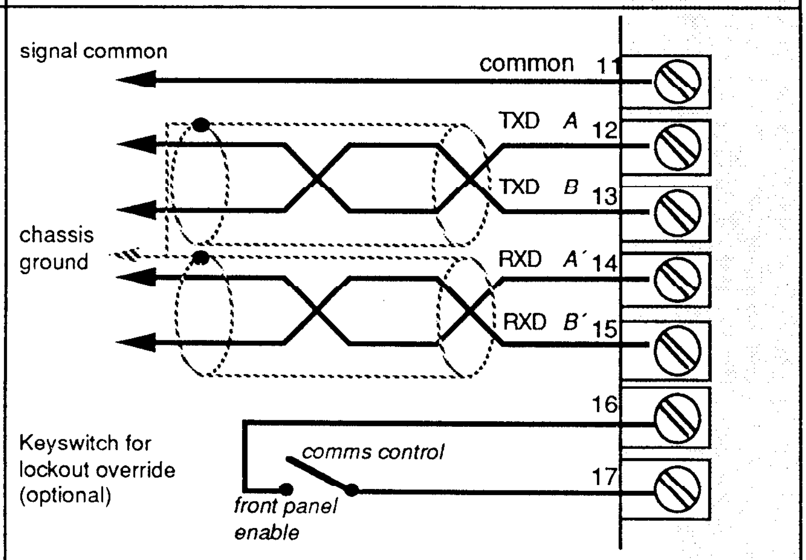
3.6.1 EIA-232-D

Refer to Table 3.5 for the proper hook-up. Use Belden #8771 or similar (3-conductor, 22 gauge, stranded, with shield). Attach the shield to pin 1 at the supervisor-end of the link. Limit cable length to 50 feet (15m).

3.6.2 EIA 422-A

Refer to Table 3.5. Use Belden #9843 or an equivalent low capacitance extended distance computer cable. Attach the shields to the chassis ground at the supervisor-end of the link. Limit cable length to 4000 feet (1200m).

Table 3.5
Communications Wiring
Terminals 11 through 17

<table>
<tr><th>Standard</th><th>External connections / Terminals</th></tr>
<tr><td>EIA-232-D</td><td>
</td></tr>
<tr><td>EIA-422-A
(formerly RS-422-A)</td><td>
</td></tr>
</table>

3.6.3 Lockout override switch

If a supervisory computer is programmed to lock out the front-panel pushbuttons, a 2-position keyswitch may be installed in the cabinet panel to locally enable the front-panel pushbuttons if they have been remotely disabled by the communications link. [An alternative method of regaining local control after a front-panel lockout by the communications link is to cycle the power to the controller OFF and ON again.]

The keyswitch key should be captive and the contacts closed in the "front-panel enable" position.

If local control is always desired, jumper terminals 16 and 17 together.

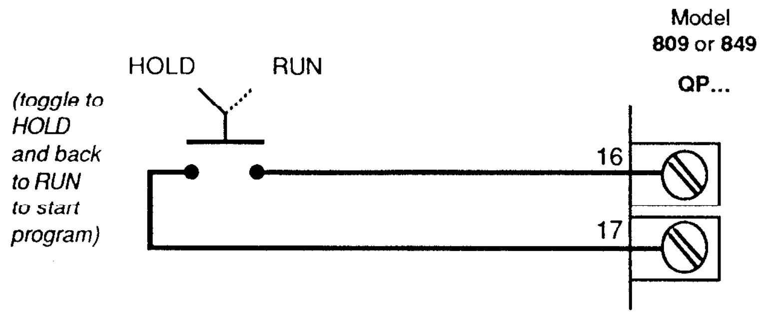
If either of the communications boards is not installed, then no connection need be made to terminals 16 and 17.

[Terminals 16 and 17 take on functions associated with the setpoint programming option if it is installed *and enabled by selecting* **Prog** *at* **Ctrl**. See §3.8 for wiring these terminals in this case.]

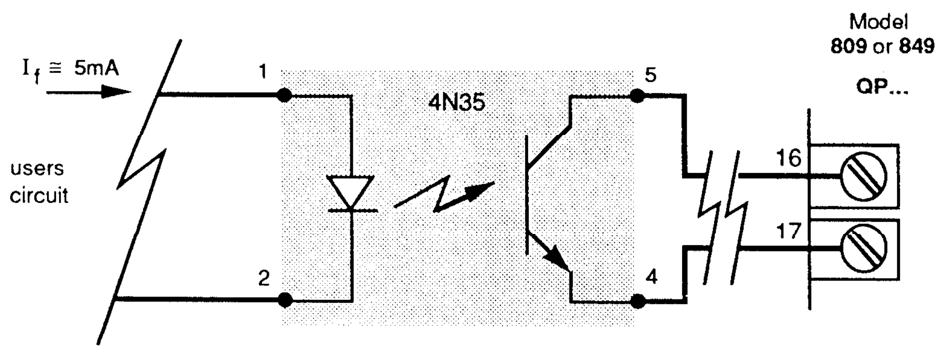
3.7 SETPOINT PROGRAMMING OPTION QP (terminals 16 and 17)

Verify on the instrument label and the Hardware Code in Table 1.1 if the setpoint programming option **QP** is included among the firmware options.

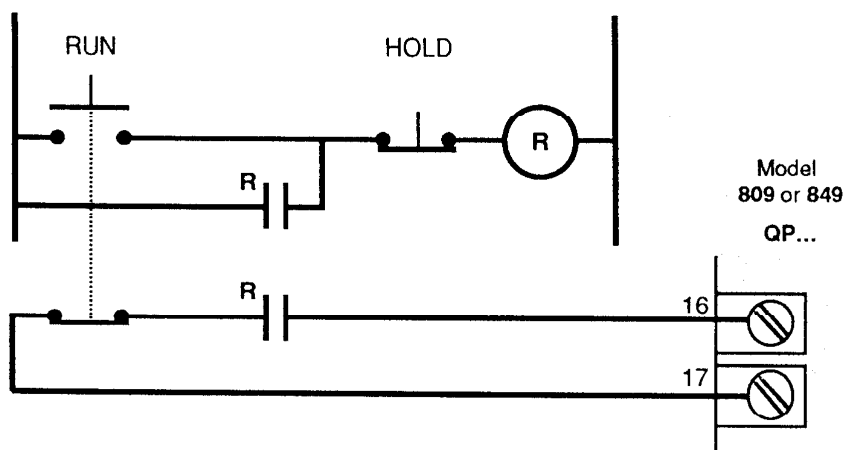
By means of making and breaking the external connection between terminals 16 and 17, the setpoint programmer can be placed into the RUN or HOLD state. There are several connections possible for interfacing to pushbuttons, selector switches, relay contacts or opto-couplers; these are shown in Figure 3.4. Operation of the setpoint programming option is discussed in §6.



A. Two-position selector switch input.



B. Example of opto-coupler input.



C. Two-pushbutton input.

Figure 3.4. Input connections for control of setpoint programming option.

4. OPERATION

4.1 GENERAL ORGANIZATION AND DEFINITIONS

The controller incorporates a 2-level security system, and functions in one of 3 operating modes. In the automatic mode, 3 or 4 types of control are possible. Figure 4.1 shows how these access levels, operating modes, and control types are related. In addition to this organization, the controller is always in one of several "conditions."

4.1.1 Access levels

Two access levels keep the configuration and calibration procedures separated from everyday, normal operation. A switch (**WB1**) inside the unit enables the configuration and calibration level (see §5.1).

4.1.1.1 Operator level

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

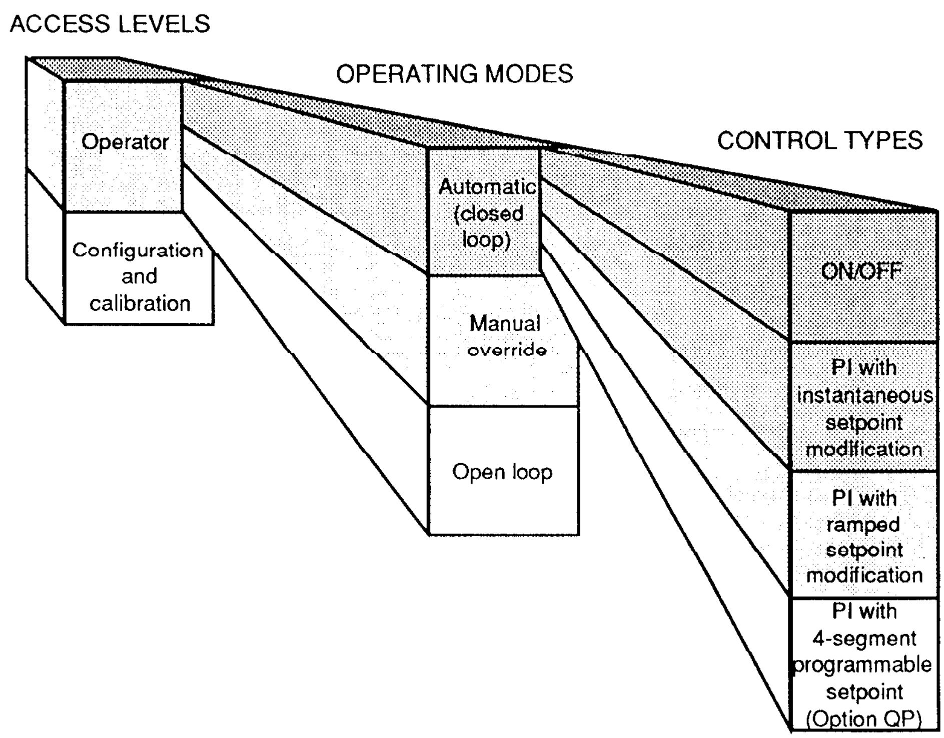


Figure 4.1. Organization of user environment.

4.1.1.2 Configuration and calibration level

Two parameters at the end of the parameter list—**ACCS** and **CAL**—can only be viewed with the hardware switch closed. They are discussed in §5.

◦ **ACCS** (access) allows the user to assign one of 3 security levels to each parameter. Each parameter can be either:

- included in the operators list with modification privileges (**Altr**),
- included in the operators list with no modification privileges (**rEAd**), or
- excluded from the operator's list (**Hide**).

◦ **CAL** (calibration) enables the calibration procedure. This can be either a reloading of the permanently-stored factory calibration parameters, or a complete recalibration. Complete recalibration should only be executed in a laboratory environment.

4.1.2 Operating modes

When at the operator access level, the controller can be in only one of 3 operating modes:

4.1.2.1 Automatic operating mode (closed-loop)

This is the controller's "normal" operating mode: the measured value and the setpoint are in view in the dual displays. Direct use of the **UP** and **DOWN** buttons adjusts the temperature setpoint. Entering or leaving automatic is through the **A/M** pushbutton. The user can modify all alterable displayed parameters.

4.1.2.2 Manual operating mode

This mode is for manual adjustment of the output level from the front panel and when selected, overrides the output level demanded by the control action of the automatic mode. The measured value and the output level (%) are in view in the dual displays. Direct use of the **UP** and **DOWN** buttons adjusts the output level setpoint. Entering or leaving manual is through the **A/M** pushbutton, however, entering the manual mode can be inhibited in the configuration. The user can modify all alterable displayed parameters as in the automatic mode. The manual light is illuminated.

4.1.2.3 Open-loop operating mode

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

4.1.3 Control types

The controller can be configured to function with one of several control actions for use in the automatic mode:

- ON/OFF control. Output available on terminals 1 and 2 only. For use with spring return valves and solenoids only.
- PI control with instantaneous setpoint modification
- PI control with ramped setpoint modification (rate limiting for loads sensitive to thermal shock)
- PI control with 4-segment setpoint programming (option **QP**: see §6).

4.2 FRONT PANEL IDENTIFICATION

Refer to Figure 4.2 for identification of the displays, lights and pushbuttons.

4.2.1 Indications

4.2.1.1 Displays

- **Upper display functions**
- Measured value when in the automatic or manual modes;
- Parameter mnemonics when viewing the parameter list with the **PAR** button.

- The measured value displayed flashes if the controller enters the alarm condition and if the AL1 output has switched into the alarm state. [If the controller enters the alarm condition and **H AO**, **L AO**, and **d AO** have been set to OFF, the measured value display does not flash.]

- **Lower display functions**
- Temperature setpoint when in the automatic mode;
- Output level setpoint (%) when in the manual mode;
- Parameter value when viewing the parameter list with the **PAR** button.

- If the measured value enters one or more alarm conditions, the appropriate mnemonic(s) (**HiAL**, **LoAL**, and **d AL**) alternate with the displayed setpoint. If the self-tuning algorithm is active then **tunE** flashes in the lower display. See §8.

4.2.1.2 Output lights

- **OP1 and OP2**

Each yellow LED is illuminated when the corresponding output channel is ON, i.e. when the valve is moving. When the parameter

Act is set to **rev** and the outputs are wired as shown in Table 3.2, then OP1 lights when the valve is opening and OP2 lights when the valve is closing.

◦ **Communications transmission in progress**
Located in the upper-left corner of the upper display (with no legend), this green LED dot is illuminated when the controller is transmitting information to the host computer. The light can be operative only if a communications board (option **C2** or **C4**) is installed.

◦ **Ramp-to-setpoint in progress**
Identified by the legend "R" in the upper display, this green LED dot is illuminated during the period when the controller is ramping from the actual measured value to the new setpoint. This lamp can only be seen illuminated if ramp-to-setpoint operation has been enabled in the instrument configuration. The lamp flashes during inspection of the instantaneous setpoint during ramping when **PAR** is depressed. See also §4.3.3.

◦ **Manual mode**
The manual light—underneath the "M" in the upper-right corner of the upper display—is illuminated when the instrument is in the manual mode. A flashing manual light indicates the open-loop mode—see §4.4.3.

4.2.2 Pushbuttons

There are 4 front-panel pushbuttons:

4.2.2.1 PAR (= parameter)

The PARAMETER pushbutton has 2 functions:

- To advance to the next parameter when examining the parameter list;
- To acknowledge an alarm with a latched output when the controller is annunciating an alarm.

4.2.2.2 UP and DOWN arrows

The **UP** and **DOWN** arrows have the sole functions of increasing and decreasing, respectively, the value of the parameter currently displayed. Most parameters have continuously variable numeric values; examples of these include setpoint, integral time constant, etc. Others can be assigned only discrete values that are presented in a list; these are mainly the configuration parameters: Control type, output configuration, etc.

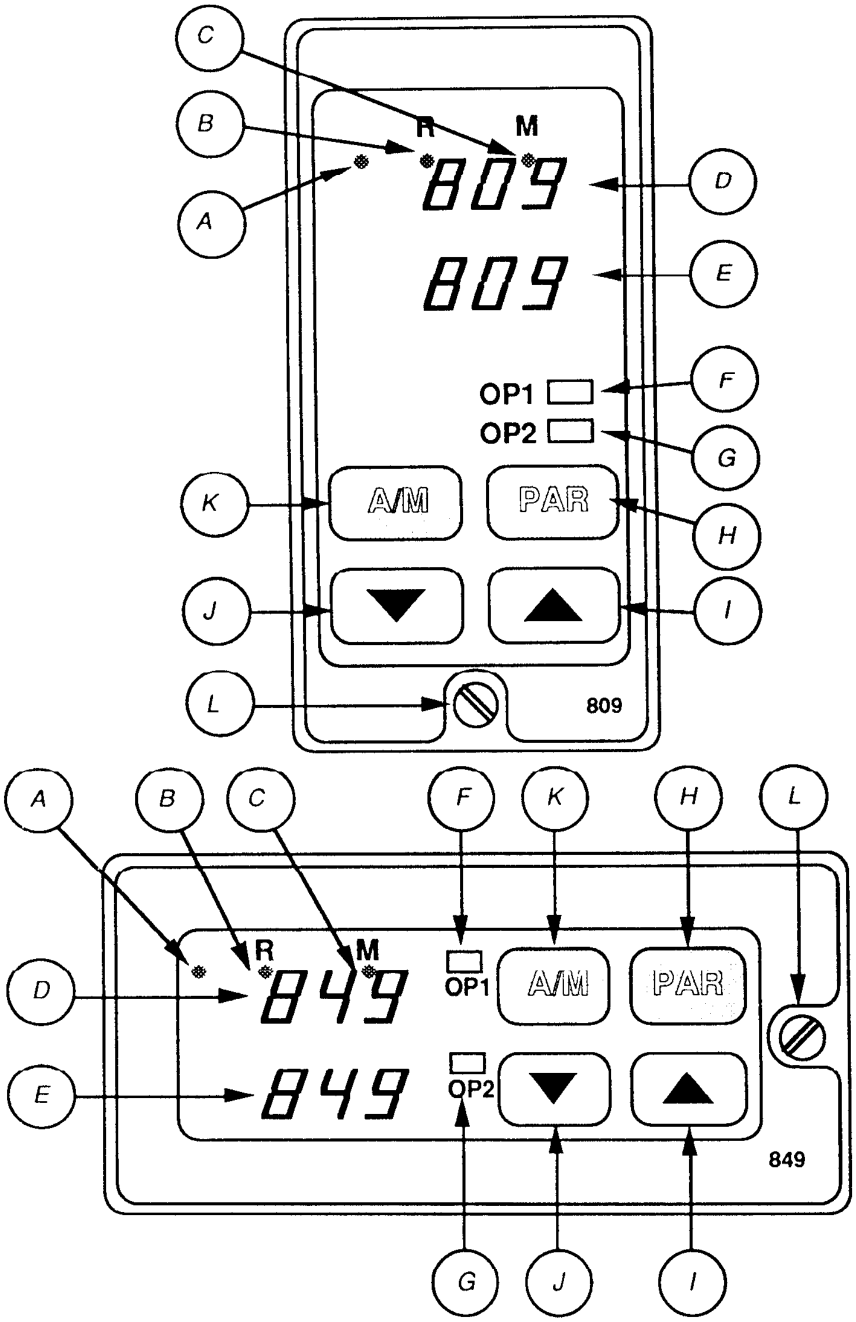


Figure 4.2. Front panels of Models 809 and 849 temperature controllers.
A. *Communications transmission in progress light.* ***B***. *Ramp-to-setpoint light.* ***C***. *Manual mode active light.* ***D***. *Upper LED display.* ***E***. *Lower LED display.* ***F***. *Valve opening light (Act = rev).* ***G***. *Valve closing light (Act = rev).* ***H***. *Parameter scroll and alarm acknowledge pushbutton.* ***I***. *Increase parameter value pushbutton.* ***J***. *Decrease parameter value pushbutton.* ***K***. *Auto/manual operation selection pushbutton.* ***L***. *Jacking screw.*

For the numeric values, depressing the **UP** (**DOWN**) button once increases (decreases) the displayed value by 1 least significant digit. Holding a button down momentarily causes the value to increase or decrease automatically as long as the button is depressed. The operation is identical for discrete values, except that each button push reveals the next value in the list.

4.2.2.3 A/M (= automatic/manual operation selection)

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

This button can be disabled when configuring the instrument; the controller remains permanently in the automatic mode unless the configuration parameter is changed.

4.3 FRONT PANEL PROCEDURES

Each and every keystroke is accompanied immediately by some sort of visual feedback—a change in a parameter value or a change of state of a lamp. There are no double keystroke sequences.

Verify that the front panel has not been disabled remotely by the communications link, or that modification of all the parameters has not been locked out if there is no response.

4.3.1 Procedures common to automatic and manual modes

4.3.1.1 Modifying the setpoint

The setpoint can be freely modified within the limits of the setpoint high and low limits.

With the measured value in the upper display and the temperature setpoint in the lower display, use the **UP** and **DOWN** pushbuttons to change the setpoint value.

In the manual mode, the inferred valve position is the parameter modified by this same procedure.

4.3.1.2 Locating and modifying an adjustable parameter

With the instrument displaying the measured value and the setpoint, depressing **PAR** once reveals the display units (**C** or **F**).

NOTE! **With Lin or .Lin selected under Sn (input sensor selection), there is no indication of the units display when PAR is depressed.**

With option QP and Prog selected under Ctrl, the mnemonic for the current program segment shares the display with C or F if the program status is run, hold or Hb.

Depressing **PAR** once again shows the next enabled parameter and its current value on the display. The parameter value can either be modified with the **UP** and **DOWN** pushbuttons, or left unmodified. Pressing **PAR** again displays the next parameter and its current value and so on.

If the **PAR** button is untouched when viewing a particular parameter, the display returns to the measured value and the setpoint after 6 seconds. Holding down on **PAR** overrides this 6-second timeout and permits viewing as long as desired.

To modify a certain parameter, continue pressing **PAR** until its mnemonic appears in the upper display, then modify the value with the **UP** and **DOWN** pushbuttons.

These procedures are valid in either the automatic or manual modes; or if the measured value is in an alarm condition or not.

Some parameter values may not respond to the **UP** and **DOWN** buttons; these have been configured for viewing only and not for operator modification. Others may be completely hidden from the operator. See §5.3.

4.3.2 Additional procedures for manual mode

With PI control, the manual mode is activated by the **A/M** pushbutton (see §4.2.2.3) and indicated by the green "M" LED dot. In the manual mode, the measured value appears in the upper display and the inferred valve position in the lower display. When entering the manual mode from automatic, the initial valve position is the most recent calculated valve position. Adjust the output level with the **UP** and **DOWN** buttons.

The **A/M** pushbutton operates in a similar fashion with ON/OFF control, except for the adjustment of the output with the **UP** and **DOWN** buttons. Here, the OFF output state is selected by the **DOWN** pushbutton (0.0% in the display), and the ON output state the **UP** pushbutton (100.0% in the display).

Access to the manual mode can be inhibited in the configuration with the **A H** parameter.

4.3.3 Automatic mode (with ramp-to-setpoint) procedures

Ramp-to-setpoint operation is selected with **r SP** at the **Ctrl** parameter in the instrument configuration; it insures bumpless setpoint modification. Ramping is initiated only by one of 2 conditions: power-up and a change in setpoint. The instantaneous setpoint follows a straight line joining the original measured value to the target setpoint. The speed at which the ramping progresses (in °F/min or °C/min) is selectable by the **SPrr** (setpoint ramp rate) parameter and remains constant for all ramps until **SPrr** is changed.

See §6.2.3 and Figure 6.4 (parts A and B) for the operation of the holdback feature (parameter **Hb**) during ramping.

4.3.3.1 Annunciation

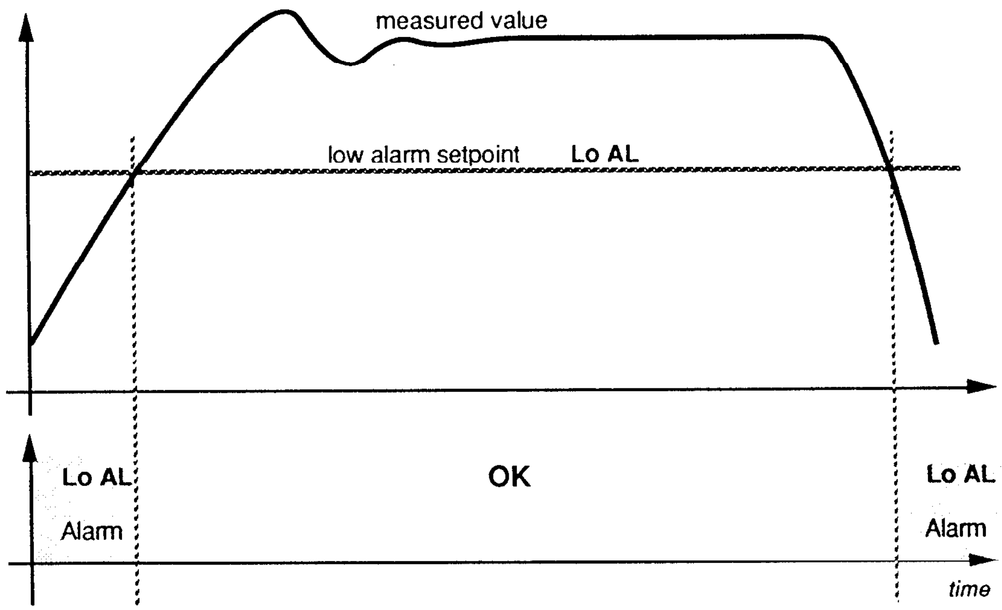
During ramping, the upper display shows the measured value (as in normal, automatic or manual operation); the lower display shows the target setpoint. During ramping segments the "R" lamp is illuminated. After the new target setpoint has been reached, the lamp goes out. To view the instantaneous setpoint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

4.3.3.2 Ramping and alarms

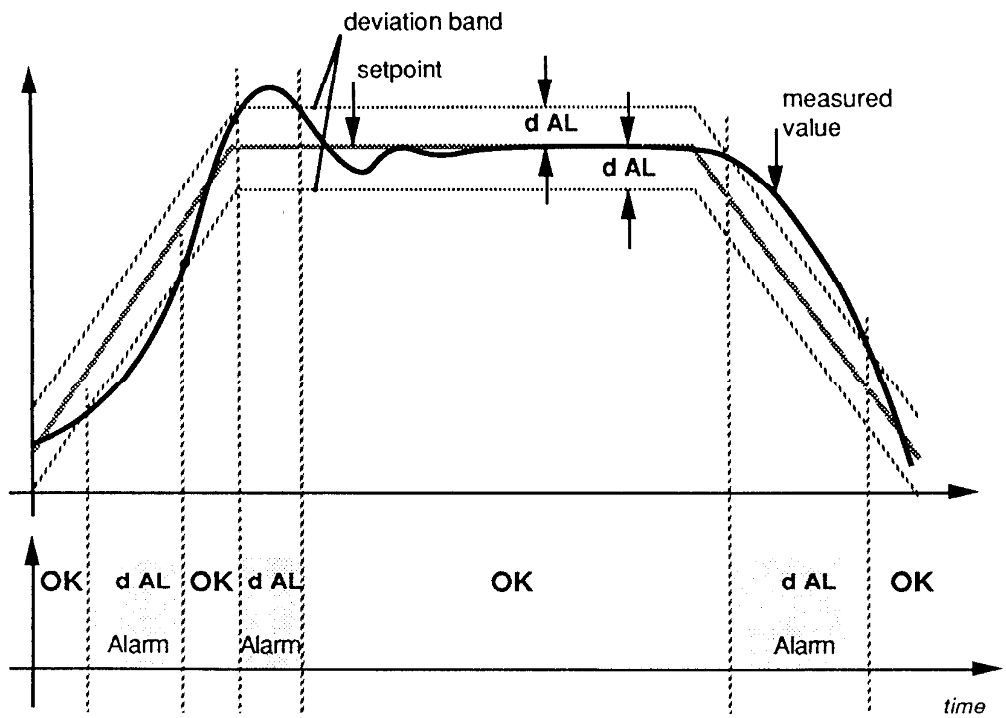
If the measured value follows a ramping setpoint through an alarm region, the alarms are detected, annunciated, and output as usual. As shown in Figure 4.3, two types of behavior are to be noted:

- **"Full scale" high and "full scale" low alarms.** If the alarms are non-latching, crossing the alarm setpoints into the "safe" region ends the alarm condition.

- **Deviation alarm.** The deviation alarm band follows the currently active setpoint. If the measured value cannot track the setpoint within the bounds of the deviation alarm, an alarm condition is generated.



A. Behavior of non-latching full-scale low alarm.



B. Behavior of non-latching deviation alarm.

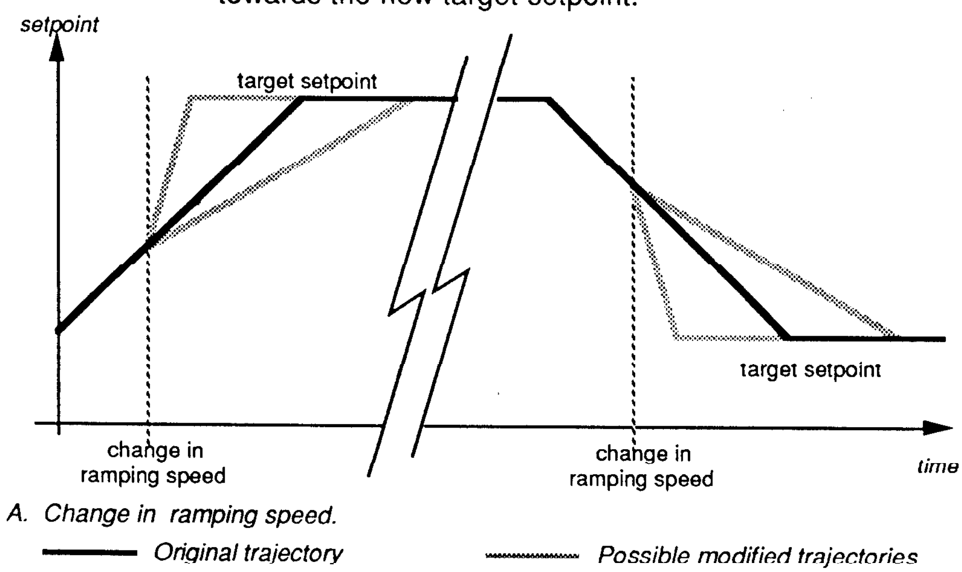
Figure 4.3. Ramp-to-setpoint operation and alarms.

4.3.3.3 Modification of ramping parameters

If the target setpoint or the ramping speed are changed in mid-progress of a ramp segment, the effects on the instantaneous setpoint are immediate as shown in Figure 4.4.

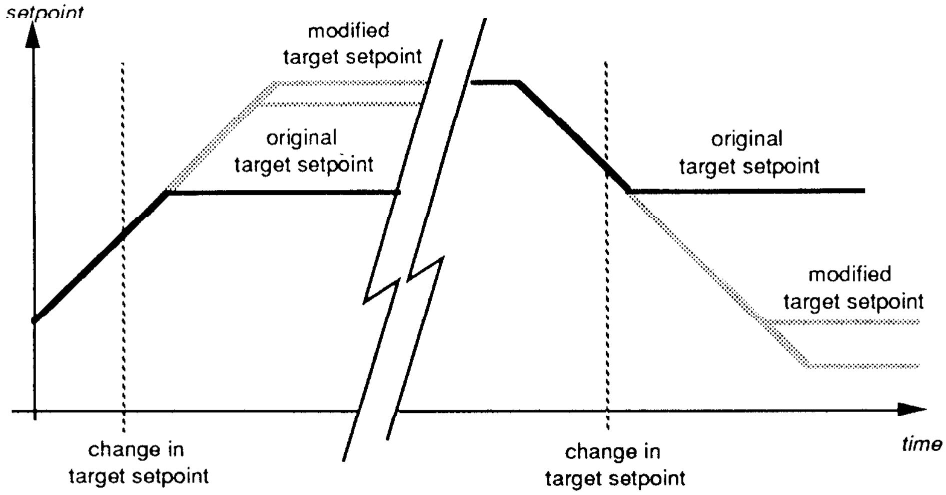
- **Ramping speed.** The moment that the ramping speed (**SPrr**) is changed the speed at which the setpoint rises or falls changes. This accordingly shortens or lengthens the time required to reach the target setpoint.

- **Target setpoint.** If the target setpoint is increased (decreased) to a level beyond the current instantaneous setpoint, the ramp segment continues until the new target is reached. If the target setpoint is decreased (increased) to a level that has already been crossed by the ramp, the slope changes sign and the instantaneous setpoint ramps towards the new target setpoint.

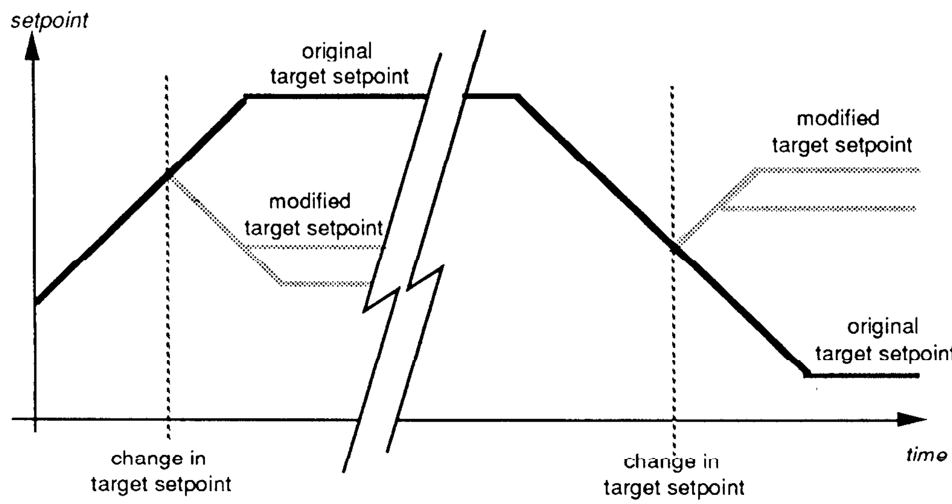


A. Change in ramping speed.

Figure 4.4. Effect of ramp parameter modification on a ramp segment in progress. (continued on next page).



B. Change in target setpoint: new setpoint level beyond curent instantaneous setpoint.



C. Change in target setpoint: new setpoint level already crossed by instantaneous setpoint.

Original trajectory — *Possible modified trajectories*

Figure 4.4. Effect of ramp parameter modification on a ramp segment in progress. (continued from previous page).

4.4 CONDITIONS

4.4.1 Normal

The normal condition is the absence of an alarm, sensor break, or diagnostic condition.

4.4.2 Alarm

4.4.2.1 Annunciation

There are 2 levels of alarm annunciation (Figure 4.5):

- Lower display indicates **HiAL**, **LoAL**, and/or **d AL** alternating with the setpoint: the measured value has entered an alarm condition
- Upper display flashes the measured value: AL1 has been configured to respond to at least one of the 3 alarm setpoints, *and* AL1 has switched into an alarm state. [It is possible to configure the controller so that the alarms are simply annunciated by the display and that no action is taken by AL1. In this case the measured value display does *not* flash.]

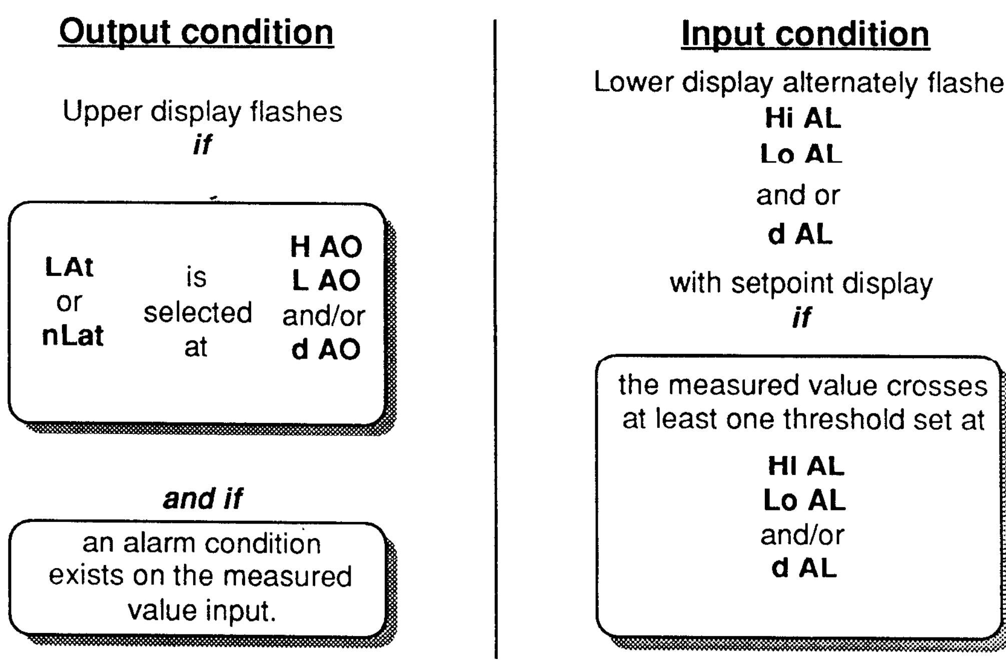


Figure 4.5. Front-panel alarm annunciation.

4.4.2.2 Acknowledgement

The alarm outputs can be configured as *latching* or *non-latching*. Latching outputs require acknowledgement to clear the display of the alarm indications. (Non-latching outputs do not—as soon as the alarm condition has cleared, the display and output return to the normal, non-alarm condition.) Alarm scenarios are illustrated in Figure 4.6.

To acknowledge a latching alarm, depress the **PAR** pushbutton after the alarm condition has cleared.

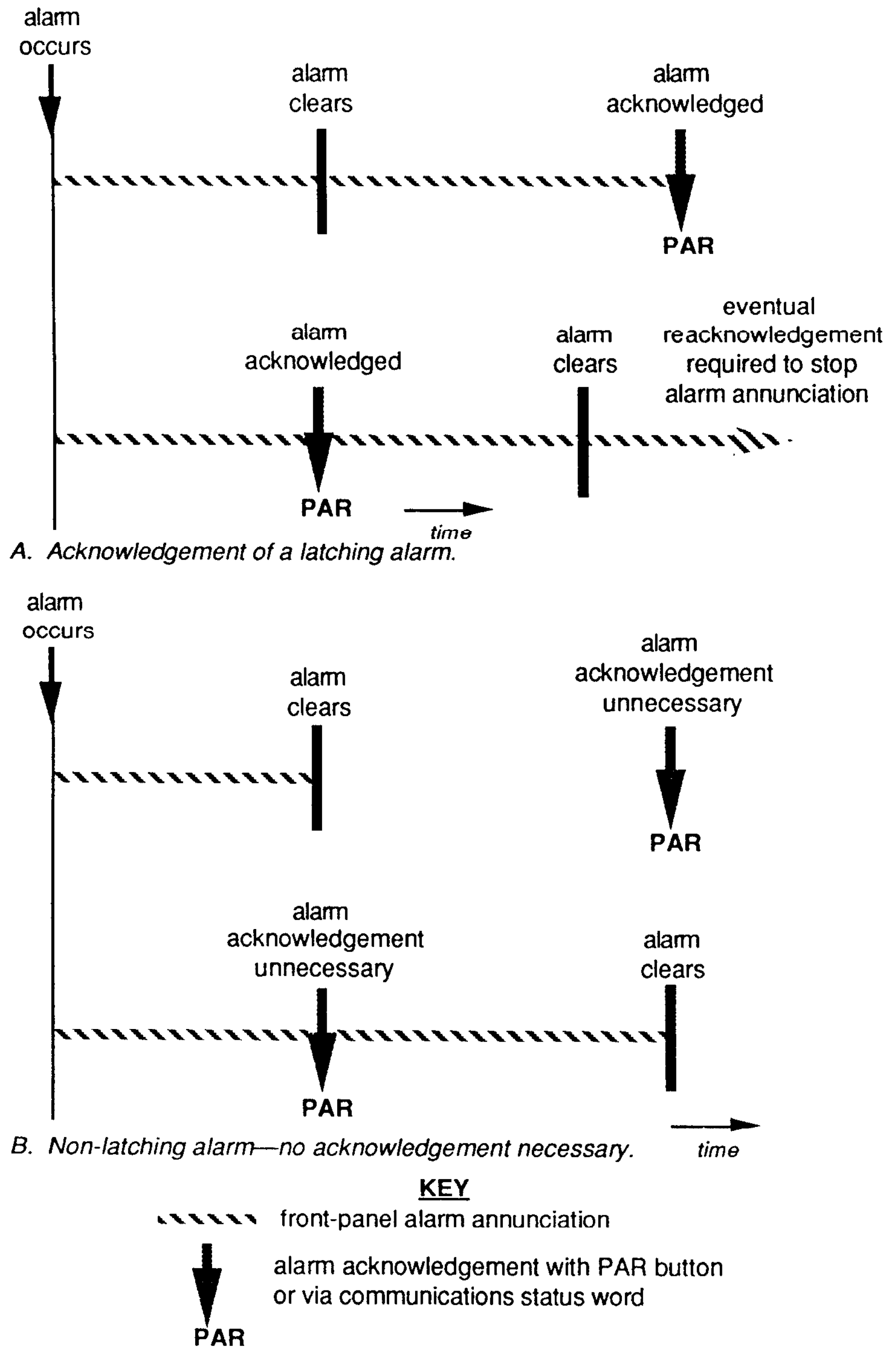


Figure 4.6. Alarm acknowledgement scenarios: latching and non-latching alarms.

4.4.3 Sensor break

4.4.3.1 Annunciation

◦ **Overrange condition**

• A broken thermocouple or open input circuit is indicated by the mnemonic **Sn b** (sensor break).

• The measured value rises rapidly before the sensor break indication occurs. The open input circuit is detected by an overrange input signal exceeding the maximum of the linearization table.

• The controller then enters the open-loop mode and outputs the sensor break power selected by the **SnbP** parameter.

◦ **Underrange condition**

• A condition in which the input falls below the minimum of the linearization table will cause the display **ur** (underrange) to appear. Examples of such situations include: incorrect thermocouple, reversed connection, etc.

• The controller then enters the open-loop mode and outputs the sensor break power selected by the **SnbP** parameter.

4.4.3.2 Automatic transfer to open-loop mode

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

There are 2 operating procedures depending on whether or not manual operation has been previously authorized with the **A H** parameter in the instrument configuration:

◦ If manual operation has been authorized, the operator can modify the sensor break power with the **UP** and **DOWN** pushbuttons. By pushing on the **A/M** button, the operator can enter definitively the manual mode. Transfer to the automatic mode is then possible only by depressing the **A/M** button again (dependant on if the input fault has been corrected). If the controller remains in the open-loop mode and the input fault is repaired, it resumes automatic operation.

◦ If only automatic operation has been authorized, the **UP**, **DOWN**, and **A/M** buttons are disabled and the controller transfers from the open-loop mode to automatic as soon as the input condition is rectified. If normal manual operation is desired, the **A H** parameter in the configuration list must be changed.

4.4.4 Self-diagnostic

4.4.4.1 Checksum error

A checksum error is indicated by the message **CErr** in the lower display, the user should close the configuration link (**WB1**) and go to the bottom of the parameter list where the **CAch** and **EEch** parameters (and their values) are displayed. [**CAch** is the checksum value of the EPROM/ROM calculated by the microprocessor, and **EEch** is the correct checksum value stored in the EEPROM.]

The user should note the values for **CAch** and **EEch** and the version number of the software; then he should call Eurotherm Corporation. [The software version number is displayed in the lower display for 1 second after application of power to the instrument.]

If **CErr** appears, *something is wrong* with the instrument and it should not be used. Return it to Eurotherm Controls Inc for repair and inspection.

5. CONFIGURATION AND CALIBRATION

There are over 40 parameters maintained in non-volatile memory that determine the operation of the instrument. These parameters can be modified from the "as-delivered" configuration specified by the *Product Code* on the external label to tailor the controller to specific requirements.

The parameter list is presented in 2 different versions in the instrument: the complete, full list for configuration purposes (the configuration and calibration level); and an abbreviated version with only user-designated parameters available to the operator for convenience and security during normal operation (the operator level).

Configuration consists of 2 procedures: selection of values for specific parameters, and assignment of an *access level* for each parameter in the abbreviated operator's parameter list.

5.1 FULL LIST ENABLE

The complete parameter list is enabled by the hardware configuration switch (**WB1**) located inside the instrument. To access this switch, refer to Figures 5.1 and 5.2.

CAUTION! Care should be taken to avoid electrostatic discharge (ESD) and thus reduce incidents of damage to the instrument. All work should be performed on a conductive surface with the personnel in contact with the surface by means of a grounded, metal or conductive plastic wrist strap with a 1MΩ series resistor.

For normal instrument operation, the switch should be OPEN. Only during configuration (and calibration) should the switch be CLOSED. Even though operation seems similar to that at the operator level, the hardware switch should never be left closed outside of calibration and configuration sessions.

Figure 5.1. Removal of instrument from sleeve.

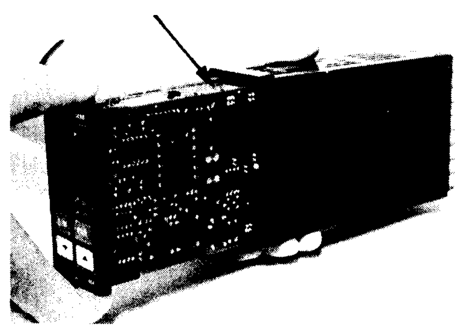


Figure 5.2. Location of configuration switch.

5.2 CONFIGURATION PROCEDURE

5.2.1 Configuration parameters

All parameters are presented in Table 5.1 in the order that they are viewed in the display. Only parameters relevant to the instrument's current configuration are displayed as not all parameters are used in any single configuration. Some parameters cause the appearance or disappearance of others: e.g. **Fil** (input filter constant) appears only if **Lin** or **.Lin** is selected at **Sn**. Other parameters appear only if firmware option **QP** has been selected upon ordering.

The first column, *Mnemonic*, contains the abbreviation that is seen in the upper display for the parameter in the *Parameter* column. For those parameters having continuously adjustable parameters, the *Adjustable Range* column shows the minimum and maximum values, and for those parameters having only discrete values, the possible selections are given.

Standard values are those loaded into the instrument memory during manufacture. If more than one value appears in the *Standard value* column, the selection is determined by the Configuration Coding portion of the Product Code. The *Comments* column points out any particular traits that the specific parameter may have. The column *Bisync* cross references the communications mnemonics to the front-panel (user) mnemonics.

NOTE! **Complete reconfiguration of the instrument is facilitated if selections are made first for sensor type Sn and control type Ctrl. Fixing these values from the beginning determines the presence or absence of the remaining parameters in the scroll list.**

Table 5.1
Complete Parameter List: Part 1

Mnemonic	Parameter	Adjustable range	Standard Value(s)	Comments	Bisync
SP	Setpoint	Upper limit: "SP H" Lower limit: "SP L" *(only the base setpoint is adjustable here)*	70°F (25°C)	Displayed in auto without mnemonic. Mnemonic displayed only in manual. Becomes present program setpoint if "Prog" selected at "Ctrl" and programmer status is "run", "hold" or "Hb".	SP
none	Inferred valve position	0.0 to 100.0%		Displayed only in manual without mnemonic. ("M" dot is lit.)	OP
C or F (plus appropriate prog. segment)	Display units	Annunciation only	'	No units displayed for linear inputs. Program segment annunciation only if status is "run", "hold" or "Hb".	---

SETPOINT PROGRAMMING (option QP) *These parameters (except "Hb") appear only if "Prog" is selected at "Ctrl".*

Mnemonic	Parameter	Adjustable range	Standard Value(s)	Comments	Bisync
Prog	Programmer state select and status annunciation	Program in standby **idle** Program running **run** Program in hold **hold**	idle		OS
SP	Base setpoint	Upper limit: "SP H" Lower limit: "SP L"	70°F (25°C)		SP
tunE	Tune on demand	**OFF** **on**	OFF		XS
LC	Loop counter	1-200 plus "cont" (continuous)	1		Lc
r1	1st ramp rate	0.01-99.99 units/min.	10.00°/min.		r1
L1	1st dwell level	Input sensor range	70°F (25°C) For B T/C: 400°F (200°C) For linear I/P: setpoint		l1
d1	1st dwell time	0-9999min.	1min.		t1
r2	2nd ramp rate	0.01-99.99 units/min.	10.00°/min.		r2
L2	2nd dwell level	Input sensor range	70°F (25°C) For B T/C: 400°F (200°C) For linear I/P: setpoint		l2
d2	2nd dwell time	0-9999min.	1min.		t2
Hb	Holdback band (units' precision)	1-2000°C 1 to 3600°F 1 to 9999 units	100° or units	Appears if "Prog" or "r SP" is selected at "CtrL".	Hb
	Holdback band (tenths' precision)	0.1 to 500.0°C 0.1 to 900.0°F 0.1 to 999.9 units			

Table 5.1
Complete Parameter List: Part 2

Mnemonic	Parameter	Adjustable range	Standard Value(s)	Comments	Bisync
ALARM SETPOINTS					
Hi Al	High alarm setpoint	Input sensor range	setpoint high limit		HA
Lo Al	Low alarm setpoint	Input sensor range	setpoint low limit		LA
d Al	Deviation alarm setpoint (units' precision)	1 to 2000°C 1 to 3600°F 1 to 9999 units	30°C (50°F) If "d AO" set to "Off", setpoint high limit - setpoint low limit		DA
	Deviation alarm setpoint (tenths' precision)	0.1 to 500.0°C 0.1 to 900.0°F 0.1 to 999.9 units			
CONTROL PARAMETERS					
ProP	Proportional band (units' precision)	1 to 4500°C (1 to 300%) 1 to 8100°F (1 to 300%) 1 to 9999 units (1 to 810%)	Approx. 10% of setpoint range	Becomes hysteresis with "On.Of" selected at "Ctrl". Follows units selection made at "Pb d". Decimal point in lower display indicates degrees or linear units selected. No decimal point indicates % selected.	XP
	Proportional band (tenths' precision)	0.1 to 500.0°C (1 to 450%) 0.1 to 900.0°F (1 to 810%) 0.1 to 999.9 units (1 to 810%)			
Int.t	Integral time constant	1 to 8000s	360s	Must be > "tt".	TI
tt	Motor travel time	0.1 to 240.0s	30.0s		TT
bISh	Mechanical backlash	0.0 to 20.0% of range of motion	0.00%		BK
ct	Cycle time at 50% velocity	0.1 to 240.0s	0.3s		TM
lnrt	Motor inertia time	0.000 to 1.000s	0.000s		TN
H cb	High cutback (units' precision)	1 to 2000°C 1 to 3600°F 1 to 9999 units	120°C (180°F)	Appears only if "HAnd" selected at "Cb O".	HB
	High cutback (tenths' precision)	0.1 to 500.0°C 0.1 to 900.0°F 0.1 to 999.9 units			
L cb	Low cutback	same selection as "H cb"	120°C (180°F)	Appears only if "HAnd" selected at "Cb O".	LB

Table 5.1
Complete Parameter List: Part 3

Mnemonic	Parameter	Adjustable range	Standard Value(s)	Comments	Bisync
SETPOINT LIMITS					
SP H	Setpoint high limit	Input sensor range		Must be > "SP L"	HS
SP L	Setpoint low limit	Input sensor range		Must be < "SP H"	LS
ALARM 1 OUTPUT					
H AO	High alarm output	Latched **LAt** Non-latched **nLAt** Off **OFF**			#1
L AO	Low alarm output	Latched **LAt** Non-latched **nLAt** Off **OFF**			#2
d AO	Deviation alarm output	Latched **LAt** Non-latched **nLAt** Off **OFF**			#3
OUTPUT LIMIT					
SnbP	Sensor break motor velocity	-99.9 to +100.0%	-99.9%		BP
MEASURED VALUE ATTRIBUTES			*These parameters disappear if "Lin" or ".Lin" is selected at "Sn".*		
OFSt	Calibration offset	-9.99 to 99.99°	0.00°C or °F		#6
C F	°C/°F selection	Degrees centigrade **C** Degrees Fahrenheit **F**		Affects all temperature-dependent parameters.	#7

Table 5.1
Complete Parameter List: Part 4

Mnemonic	Parameter	Adjustable range		Standard Value(s)	Comments	Bisync
INPUT SENSOR SELECTION						
Sn	Sensor selection	J thermocouple K thermocouple PL2 thermocouple R thermocouple S thermocouple T thermocouple J T/C (10ths' precision) RTD, 100Ω, Pt L thermocouple L T/C (10ths' precision) Linear process Linear process (10ths') B thermocouple E thermocouple N-14AWG thermocouple E T/C (10ths' precision) N-14AWG T/C (10ths')	J tc CAtc PL2 r tc S tc t tc .Jtc rtd3 L tc .Ltc Lin .Lin b E n .E .n			#8

COMMUNICATIONS CONFIGURATION

Parameters appear even though communications board may not be installed.

Mnemonic	Parameter	Adjustable range		Standard Value(s)	Comments	Bisync
Addr	Instrument address	0.0 to 9.9 (group & unit)		0.0		GU (or #9)
bAud	Baud rate	300 baud 600 baud 1200 baud 4800 baud 9600 baud 19,200 baud	300 600 1200 4800 9600 19.2	9600		BR (or #4)

Table 5.1
Complete Parameter List: Part 5

Mnemonic	Parameter	Adjustable range		Standard Value(s)	Comments	Bisync
GENERAL CONFIGURATION						
idno	Identification number	0 to 9999		0	Provided for customer use only; not a part of any control function.	#B
Ctrl	Control type	ON/OFF Valve positioner Valve positioner w/ ramp-to-setpoint Valve positioner w/ SP programming	On.Of vALv r SP Prog	Valve positioner	Available only if option "QP" installed.	#C
SPrr	Setpoint ramping speed	0.01 to 99.99 units/min		1.00°/min	Appears only if "SPrr" selected at "Ctrl".	SR
A H	Auto/manual enable	automatic mode only manual mode enabled	Auto HAnd	Automatic mode only		#F
CJC	CJC reference selection	Internal reference 0°C reference 45°C reference 50°C reference	Int 0C 45C 50C	Internal reference		#G
Pb d	Proportional band display	°C or °F Linear input units Percent	C-F Lin Pct	°C or °F	Disappears if "Lin" or ".Lin" selected at 'Sn" Appears if "Lin" or ".Lin" selected at "Sn"	#4
PH-L	Prop.band scale factor (units' precision)	10 to 1500°C 18 to 2700°F 1 to 9999 units		Setpoint range from Product Code, i.e. setpoint high limit - setpoint low limit	Parameter appears only if "Pct" is chosen for "Pb d". Scale factor range is dependent on choice of input sensor precision and temperature units.	#5
	Prop.band scale factor (tenths' precision)	50.0 to 999.9°C 90.0 to 999.9°F 0.1 to 999.9 units				
t SU	Tune on startup	Enable Disable	YES no	Disable		#O
Cb O	Cutback operation	automatic (3 x Xp) manual	Auto HAnd	Automatic		#J

Table 5.1
Complete Parameter List: Part 6

Mnemonic	Parameter	Adjustable range		Standard Value(s)	Comments	Bisync
LINEAR PROCESS INPUTS				*These parameters appear only if "Lin" or ".Lin" is selected at "Sn", except "Act" which always appears if this option is installed.*		
Act	Control action	Reverse action control Direct action control	**rEv** **dir**	Reverse action		#N
HI L	High sensor break point	-999 to 9999 (units precision) -99.9 to 999.9 (10ths' precision)		Upper display limit +5%		1H
Lo L	Low sensor break point	-999 to 9999 (units precision) -99.9 to 999.9 (10ths' precision)		Lower display limit -5%		1L
Fil	Input filter constant	0.01 to 99.99° or units		1.00 unit		#K
Proc	Process scaling	1st setup point 2nd setup point	**P1** **P2**	•		#L #M
LIMITED-ACCESS FUNCTIONS				*Viewable only in configuration and calibration access level.*		
ACCS	Parameter access assignment	Hidden Read only Alterable	**Hide** **rEAd** **Altr**			#H
CAL	Calibration procedure	Sub-scroll header 20mV reference cal. 50mV reference cal. CJC reference cal. RTD reverence cal. Retrieve original factory calibration values	**- - - -** **20.0** **50.0** **cJc** **rtd** **FAC**			#I

5.2.2 Pre-installation setup

There are a certain number of parameters that are installation-dependent, and as such normally need to be adjusted only once. These can be configured at a bench before panel installation. For convenience and safety, these parameters can be removed from the operator's parameter list with the **HidE** access assignment—see §5.3.2 for this procedure.

Table 5.2 lists safe and proper values for parameters which should be configured *before* installation of the instrument in the panel. This list contains common settings for the most frequently seen installations; it is not all inclusive, nor does it pretend to be a complete applications guide.

Note the values for all parameters in the schedule in Appendix D or on the reference card.

WARNING! Do not configure the instrument while it is controlling any process.

WARNING! You are responsible for the proper configuration of the controller and selection of controller parameter values. Personal injury, property loss and equipment damage could result from an improperly configured instrument.

WARNING! Caution should be observed if parameters are modified remotely via the communications link.

Table 5.2
Installation-dependent parameters: Part 1

Mnemonic	Parameter	Suggested values or uses	Comments, recommendations and examples
CONTROL PARAMETERS			
tt	Motor travel time	Use value from motor data sheet.	
blSh	Mechanical backlash	Set to correspond as closely as possible to the actual backlash in the linkage. See §5.2.3.	Backlash compensation is performed only when in automatic mode.
ct	Cycle time at 50%	0.1s For triac outputs directly driving motor windings. >0.1s For relay outputs or triac outputs driving contactors.	0.1s is usually the optimal setting for triac outputs. Make long enough to minimize contactor wear, but less than 5% of "tt".
Inrt	Motor inertia time	Follow procedure in §5.2.3.	
ALARM 1 OUTPUT			
H AO	High alarm output	LAt System shutdown conditions nLAt Indication, annunciation or interlock	Latching alarms should be used in installations where operator intervention is required to verify system security before restarting. Non-latching alarms can be used when an out-of-range signal is used as part of the process control; e.g. system warm-up. **An independent alarm system should always be installed.**
L AO	Low alarm output		
d AO	Deviation alarm output		
OUTPUT POWER LIMITS			
SnbP	Sensor break motor velocity	Safe level of operation.	Usually set to -99.9% for fastest valve closure.
MEASURED VALUE ATTRIBUTES			
C F	°C/°F selection	Plant standard	Confusion is avoided if all instruments are set to same display units.
INPUT SENSOR SELECTION			
Sn	Sensor selection	Connected sensor type	Input sensor type should not be changed after range-dependent parameters have been entered.
COMMUNICATIONS CONFIGURATION			
Addr	Instrument address	Commensurate with communications system	Be sure that no 2 units have the same address.
bAud	Baud rate		

Table 5.2
Installation-dependent parameters: Part 2

Mnemonic	Parameter	Suggested values or uses	Comments, recommendations and examples
GENERAL CONFIGURATION			
Idno	Identification number	According to user's numbering scheme	Loop no., zone no., panel no., date of commissioning, date of next certification, etc.
Ctrl	Control type	**On.Of** ON/OFF	Blowers, level control, compressors, spring-return or solenoid valves. Output available on terminals 1 and 2. Not for standard valves.
		vALv Standard valve positioner	Most conventional symmetrical valves.
		r SP Valve positioner with ramping	Ramp-to-setpoint for loads not tolerating thermal shock.
		Prog Valve postioner with setpoint programming	
SPrr	Setpoint ramping speed	A safe dT/dt for the load	Only if "r SP" chosen for "Ctrl"
A H	Auto/manual enable	**Auto** Automatic mode only	"Hand" should be selected only if the operating personnel have a requirement for manual override.
CJC	CJC reference selection	**Int** Internal CJC reference	"Int" is sufficient for most applications. For those applications where an external ice point or oven has been chosen for CJC, use the appropriate external reference selection.
Pb d	Proportional band display	**C-F** Degrees	Direct setting in degrees simplifies adjustment.
PH-L	Proportional band scale factor	Normally the assumed span of the instrument	Used only for proportional band display in percent.
Cb O	Cutback operation	**Auto** Automatic (3 x Xp) **HAnd** Manual	"Auto" is preferred except if zone requires cutback point adjustments for enhanced overshoot suppression.
LINEAR PROCESS INPUTS			
Act	Control action	**rEv** Control of heating applications: gas, steam, hot water, etc. **dIr** Control of cooling applications: refrigerants, chilled water, etc.	The heating and cooling indications here apply when valve opening winding is connected to terminals 1 and 2 as shown in Table 3.2.
Hi L	High sensor break point	105% usable upper range value	5% margin allows for operation to both high and low input signal limits without tripping over- or underrange detection.
Lo L	Low sensor break point	-5% usable lower range value	
FIl	Input filter constant	1.00 unit	Noisy I/P signals may require an increase in this value.
Proc	Process scaling	**P 1** As required **P 2** As required	Input signals for scaling should be as close as possible to minimum and maximum of input range.
LIMITED-ACCESS FUNCTIONS			
ACCS	Parameter access assignment	**HidE** Hidden **rEAd** Read-only **Altr** Alterable	Removing the maximum number of parameters from the operator's scroll list with "HidE" reduces the likelihood of accidental modification and reduces the access time to the important remaining parameters.

5.2.3 Adjustment of load-sensitive parameters

Values for certain control parameters can be adjusted only with the controller connected to the load. First assign values to the parameters concerned with the valve motor and linkage. After that either use the self tuning feature or perform a manual tune to determine the values of **ProP** and **Int.t**.

◦ Valve motor and linkage parameters

• **tt**, motor travel time. Use the value from the manufacturer's data sheet. [On the occasion that loading the motor lengthens the travel time, measure the travel time.]

• **blSh**, mechanical backlash. This is the angle the shaft turns before moving the valve, and is expressed as a percentage of the total range of motion. **blSh** can be determined either by time or angle measurements. Use either one of these ratios to get a value for **blSh**:

$$\frac{\text{time shaft turns before moving valve x 100\%}}{\text{total travel time}}$$

or

$$\frac{\text{angle shaft turns before moving valve x 100\%}}{\text{total travel angle}}$$

• **ct**, Cycle time at 50%. The best performance for systems with triac outputs (**VPT**) directly driving the motor windings is obtained by setting **ct** to 0.1s. If the controller is fitted with relay outputs (**VPR**), or if the controller is fitted with triac outputs that drive contactors, **ct** should be increased to minimize contactor wear. Do not exceed 5% of the value of **tt**.

• **inrt**, motor inertia time. **inrt** compensates for the effect of inertia in the motor causing overrun each time the output switches OFF. Use this procedure to empirically determine the value:

1. Set **tt**, **blSh**, and **ct** to their correct values.
2. Set **A H** to **HAnd**.
3. With the **A/M** pushbutton place the controller in manual mode (the **M** indicator should be lit).
4. Press the **DOWN** pushbutton and hold it until the valve is stopped at its minimum posisiton *and* the display indicates zero position, then release it.
5. Press the **UP** pushbutton and hold it until the valve stops at its maximum position, then release it. Note carefully that the displayed position reaches 100% at the *same* instant that the valve reaches its maximum position. If is does not then the motor travel time (**tt**) was incorrectly set.
6. Repeat step 5 using the **DOWN** pushbutton to move the valve to its minimum position.

7. Repeat steps 5 and 6, but this time, instead of holding the button, press and release the button repeatedly to pulse the output. If the position indication lags behind the actual position, the motor is showing the effect of inertia. Increase the value of **Inrt** and re-test, repeating this until the indication is satisfactory.

° Cutback, proportional band, and integral time constant

• If the control setpoint is far from the ambient temperature, set **Cb O** to **HAnd**; the self-tuning algorithm calculates the values of **H cb** and **L cb** in this case.

If the control setpoint is near the ambient temperature, set **Cb O** to **Auto**. This automatically assigns a value of 3 x **ProP** to the cutback parameters **H cb** and **L cb** since the self-tuning algorithm does not calculate the values of **H cb** and **L cb** in this case.

• Follow the procedure for using the self tuning feature as outlined in §8, or manually tune the loop as described in Appendix C.

5.3 PARAMETER ACCESS ASSIGNMENT

5.3.1 Parameter protection

Each parameter can be assigned one of 3 security levels to prevent accidental modification or tampering by unauthorized personnel. These 3 tiers are: -

- **Altr**. The operator is at liberty to view and modify the value of the parameter.
- **rEAd**. The parameter and its value are presented on the operator's list but modification of the parameter is inhibited. The parameter value can be changed only by entering the configuration and calibration access level. The parameter value is dimmed to indicate that it cannot be modified.
- **HidE**. The parameter is removed from the operator's list; viewing and modification of the parameter value is then only possible at the configuration and calibration access level.

CAUTION! Remove critical parameters from the operator's list to prevent inadvertant modification or tampering of configuration parameters or parameter values.

Front-panel access time to pertinent parameters is reduced by removing from the operator's list those parameters whose values are determined solely by the instrument application. Many parameters in Table 5.3 can be hidden with **HidE** before panel installation, and almost all of them after commissioning the system.

DO:	SEE:
1. Enable the full parameter list with configuration switch WB1.	
2. Depress **PAR** until :	ACCS
3. Depress **UP** to advance to first parameter:	Altr HiAl
4. Depress **DOWN** to scroll through selection of 3 security levels until desired level appears.	HidE HiAl rEAd HiAl Altr HiAl
5. Depress **UP** to advance to next parameter. Continue for other parameters.	Altr LoAl

Figure 5.3. Access assignment procedure.

5.3.2 Access assignment procedure

To compose the operator's abbreviated parameter list refer to Figure 5.3.

- Enable the full parameter list with configuration switch **WB1** (see §5.1).
- Scroll down to **ACCS** by repeatedly pushing on the **PAR** button. On arrival the lower display is blank.
- Use **UP** to display the first parameter in the lower display. (**PAR** terminates the procedure.)
- Use **DOWN** to scroll through the possible selections visible in the upper display: **Altr**, **rEAd**, or **HidE**. Press **UP** after the desired access level appears to assign this level to the particular parameter, and view the next parameter in the lower display.
- Continue this procedure until each parameter is assigned an access level. The display times out in 5 seconds if no buttons are touched. Use **PAR** to leave this sub-scroll at any time remembering that the last parameter viewed is assigned the access currently visible in the upper display.

5.4 CALIBRATION AND OFFSET ADJUSTMENT

5.4.1 Determination if recalibration is advisable or necessary

The inherently drift-free design of the Model **809/849** means that under normal conditions it should never require recalibration after leaving the factory. Final calibration at the factory is performed after the unit has been burnt-in and component values have stabilized to their life-long values. [Recalibration may be necessary, however, if certain components in the analog input stage have been changed.] Generally one should consider 2 preparatory steps before a full recalibration of the controller be attempted.

- **Offset adjustment.** Most often it is the OFFSET that requires adjustment and not the instrument calibration. There are normally 3 instances when offset adjustment is indicated and *not* recalibration:
  - **Removal of thermocouple zero error.** If a thermocouple assembly has been changed in a particular control loop, the measured value reading with the new assembly might differ from the reading of the old one.
  - **Compensation for thermal gradient.** This is the "classical" use of offset; there exists a known temperature difference between the thermocouple location and the point of desired temperature measurement.
  - **Display æsthetics.** Sometimes exact numerical equivalence between 2 side-by-side digital displays on 2 instruments connected to 2 thermocouples is desired. Offset removes the difference between the displayed measured values

due to differing zero offsets of each thermocouple and the thermal gradient between the 2 probes.

Recalibrating the instrument for any of the preceeding reasons is *not* a viable solution for any of these problems. See §5.4.2 for specifics concerning offset adjustment.

◦ **Return to factory calibration.** The controller maintains in non-volatile memory the values of the factory calibration parameters which can be retrieved at any time. This backup is provided in case of a faulty recalibration in the field. If it is suspected that the controller seems to be operating improperly because of a bad calibration, implementing the **FAC** parameter in the **CAL** sub-scroll list restores the original calibration tracable to the National Institute of Standards and Technology (NIST) of the U.S. Government. See §5.4.3 for this procedure.

◦ **Field recalibration.** This should be attempted only if the controller is to be calibrated to an NIST-tracable thermocouple, or for instrument recertification by trained and qualified personnel. See §5.4.4 for the procedure.

5.4.2 Offset adjustment

5.4.2.1 Behavior of the offset adjustment

◦ **Operation.** The value of **Ofst** is added *algebraically* to the measured value e.g., an offset value of -2.00 applied to a measured value of 500. yields a display value of 498.

◦ **Rounding.** The **Ofst** parameter has 2 significant digits to the right of the decimal point; the displayed measured value has none or only 1 (even though it has a much higher-precision storage format). The value of **Ofst** is added to the measured value *before* rounding takes place. Normal, classical rounding procedures are used: if the digit to the right of the least significant display digit is greater than or equal to 5, the least significant display digit is increased 1 unit.

5.4.2.2 Offset adjustment procedure

◦ If the calibration offset parameter (**Ofst**) is not available on the operator's level, enable the full parameter list with configuration switch **WB1** (see §5.1).

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

◦ Return the instrument to the operator's level by opening switch **WB1**.

5.4.3 Original factory calibration retrieval

WARNING! Do not perform the procedure of retrieving the original factory calibration while the instrument is controlling a process as the outputs are momentarily disabled during this procedure.

5.4.3.1 Characteristics

- The NIST-traceable calibration can be retrieved with the instrument installed in the panel. No change in the rear connections is required.
- The procedure requires about 5 seconds to complete.

5.4.3.2 Procedure for retrieving the factory calibration parameters

- Refer to Figure 5.4.
- Enable the full parameter list with configuration switch **WB1** (see §5.1).
- Scroll down to **CAL** by repeatedly pushing on the **PAR** button. On arrival the lower display contains the calibration sub-scroll header: ----.
- Use **UP** or **DOWN** to display **FAC** in the lower display. (**PAR** terminates the procedure.)
- Depress **PAR** to affirm that **FAC** is indeed the desired calibration procedure. **FAC** now appears in the upper display, and **no** in the lower.
- Use **UP** or **DOWN** again to select **YES** or **no** in the lower display. **YES** continues the procedure; **no** terminates the procedure.
- With **YES** in the lower display, depress **PAR** again to launch the selected recalibration procedure.
- The procedure lasts about 5 seconds after which **CAL** reappears in the upper display, and ---- in the lower. This display eventually times out and the controller then displays the measured value and the setpoint.
- Return the instrument to the operator's level by opening switch **WB1**.

DO:	SEE:
1. Enable the full parameter list with configuration switch WB1.	
2. Depress PAR until :	CAL ----
3. Depress UP or DOWN to advance to:	CAL FAC
4. Depress PAR.	FAC no
5. Depress UP or DOWN to affirm.	FAC YES
6. Depress PAR to launch procedure.	FAC FAC
7. 5 seconds later the procedure is completed.	CAL ----

Figure 5.4. Procedure to retrieve original factory calibration.

5.4.4 Field recalibration

CAUTION! Attempt recalibration only if you have thoroughly read this section and if you have adequate equipment and a suitable location in which to perform the procedure.

WARNING! Any maintenance performed with power ON and the instrument removed from the panel subjects the operator to electrical shock hazards that could cause injury or death. Such maintenance should be performed only by trained and qualified personnel who are aware of the existing hazards.

5.4.4.1 Equipment and preparation

Proper laboratory procedures are to be observed when calibrating this instrument. The precision and accuracy of the calibration equipment used should be at least twice the instrument specifications. Suggested equipment includes:

- **DC millivolt source with cold junction compensation for type J thermocouples:** To simulate thermocouple inputs. 0.1% accuracy. Eurotherm Model 239 or equivalent.
- **Type J thermocouple compensation cable.**
- **Decade resistance box:** For simulation of RTD input—General Radio GR 1433T or equivalent (5 decades in 0.01Ω steps, 0.02% precision).

Recalibration of any instrument is a bench-top laboratory procedure. It should not be attempted with the instrument installed in a panel.

CAUTION! Care should be taken to avoid electrostatic discharge (ESD) and thus reduce incidents of damage to the instrument. All work should be performed on a conductive surface with the personnel in contact with the surface by means of a grounded, metal or conductive plastic wrist strap with a 1MΩ series resistor. Synthetic and natural fibers that tend to harbor static electricity—nylon, wool, etc.—should not be worn

If the recalibration procedure is not successful, the factory-installed values can always be reloaded with the procedure in §5.4.3.

5.4.4.2 References requiring calibration

The instrument contains 4 references; Table 5.3 shows which of these need to be calibrated depending on the intended application.

NOTE! The recalibration of the references must be performed in the order given in Table 5.3!

Table 5.3
References Requiring Calibration

		INPUT TYPE		
REFERENCE	MNEMONIC	All thermocouples	RTD	Linear signals
20.000mV	**20.0**	●	●	●
50.000mV	**50.0**	●	●	●
CJC	**cJc**	●		
RTD	**rtd**		●	

● = required calibration

5.4.4.3 Procedure for recalibration

- ◦ Remove the instrument from the panel and place on laboratory bench with the necessary equipment. Refer to Figure 5.5.
- ◦ Enable the full parameter list with configuration switch **WB1** (see §5.1).
- ◦ Apply power to the instrument and let it warm up for at least 30 minutes.
- ◦ Prepare the input connections for the reference to be calibrated:
- • **20.000mV:** uncompensated millivolts with copper connections.
- • **50.000mV:** uncompensated millivolts with copper connections.
- • **cJc:** compensated millivolts equivalent to type J thermocouple at 0°C. Use thermocouple extension wire.
- • **rtd:** 3-wire copper connection to reference resistance (100.00Ω). All 3 wires must be of identical length.
- ◦ Scroll down to **CAL** by repeatedly pushing on the **PAR** button. On arrival the lower display contains the calibration sub-scroll header: ----. (Depressing **PAR** again terminates the procedure.)

DO:	SEE:
1. Enable the full parameter list with configuration switch WB1. Connect calibration source to input terminals before proceeding.	
2. Depress PAR until :	CAL ————
3. Depress UP or DOWN to advance to:	CAL 20.0
4. Depress PAR.	20.0 no
5. Depress UP or DOWN to affirm.	20.0 YES
6. Depress PAR to launch procedure.	20.0 20.0
7. 5 seconds later the reference is calibrated. Repeat procedure for other references requiring calibration.	CAL ————

Figure 5.5. Recalibration procedure (20.000mV as an example).

- Use **UP** or **DOWN** to display the desired reference in the lower display: **20.0, 50.0, cJc**, or **rtd**.
- Depress **PAR** to affirm the selection of references for calibration procedure. The selection now appears in the upper display, and **no** in the lower.
- Use **UP** or **DOWN** again to select **YES**or **no** in the lower display. **YES** continues the procedure; **no** terminates the procedure.
- With **YES** in the lower display, depress **PAR** again to launch the selected recalibration procedure.
- The procedure lasts about 5 seconds after which **CAL** reappears in the upper display, and ---- in the lower. This display eventually times out and the controller then displays the measured value and the setpoint.
- Change the input for the next reference to be calibrated and repeat the procedure.
- After all the references have been calibrated, return the instrument to the operator's level by opening switch **WB1**.

6. SETPOINT PROGRAMMING OPTION QP

6.1 INTRODUCTION

6.1.1 Programmer/controller

The Models **809** and **849** with option **QP** contain a firmware *setpoint generator* in addition to the controller function. The setpoint generator or *programmer* outputs to the controller setpoint input a series of straight-line *segments* that are adjustable in duration and slope. The controller ensures that the measured value respects this profile as closely as possible. Figure 6.1 shows how the setpoint generator is incorporated into the programmer/controller.

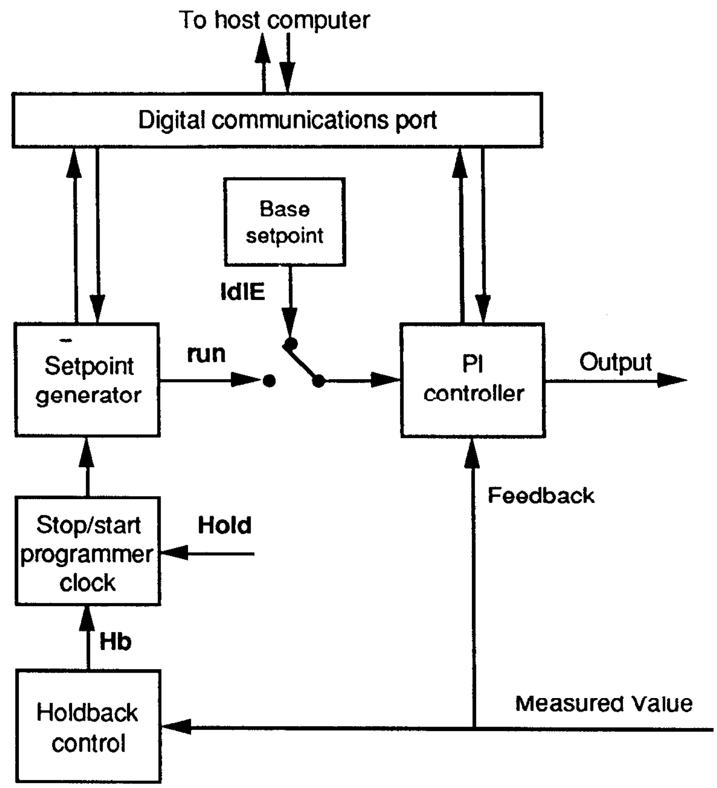


Figure 6.1. Conceptual block diagram of a programmer/controller.

6.1.2 Program segments

The **809/849** programmer/controller generates a fixed-format, 4-segment program: ramp, dwell, ramp, dwell. The 4 segments are executed in succession; when the first is finished, the second is automatically started and so on until the fourth segment is executed. The program can be executed between 1 and 200 times or continuously.

Examples of various programs following this format are given in Figure 6.2.

6.1.2.1 Ramp segments

The setpoint for the temperature or process variable increases or decreases at a linear *ramping rate* until a specified *target level* is reached. The target level can be either above or below the current measured value; the relative positions of the two determine if the slope of the ramp is positive or negative. The ramping rate is expressed in units/minute.

6.1.2.2 Dwell segments

The programmer setpoint does not move during dwell segments; it rests at the assigned value until the *dwell time* has expired.

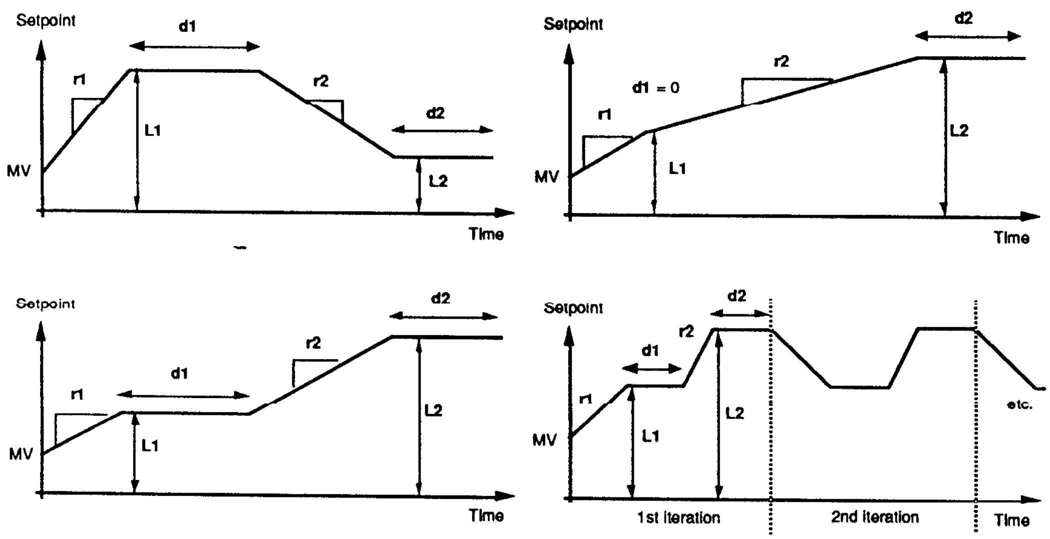


Figure 6.2. Examples of 4-segment programs (2 ramp/dwell pairs).

6.1.3 Programmer states

The Model **809/849** programmer is a 3-state programmer. In each of these states the controller and the programmer operate independently of one another. Figure 6.3 shows examples of these states. The programmer state selection is available under the **Prog** parameter in the scroll list.

6.1.3.1 Idle

When the programmer is placed into **idLE**, it behaves as a standard controller with the control setpoint determined by the value shown on the bottom display (the *base setpoint*). After completion of a program i.e. the

end of the fourth segment, the programmer automatically places itself into **idLE**. Launching a program from **idLE** starts the program from the beginning.
A program may be terminated during running by selecting **idLE**.

6.1.3.2 Run

The program has been started and is moving through its various segments. When the programmer is in **run**, it must be in one of the 4 program segments.
Affirming **run** when in **idLE** always launches a program at the beginning. After completion the controller returns to **idLE**.

6.1.3.3 Hold

If **Hold** is selected during a program the time base is stopped and the setpoint remains unchanged until the **Hold** is released. Putting the programmer into **Hold** effectively lengthens the total run time of the program.

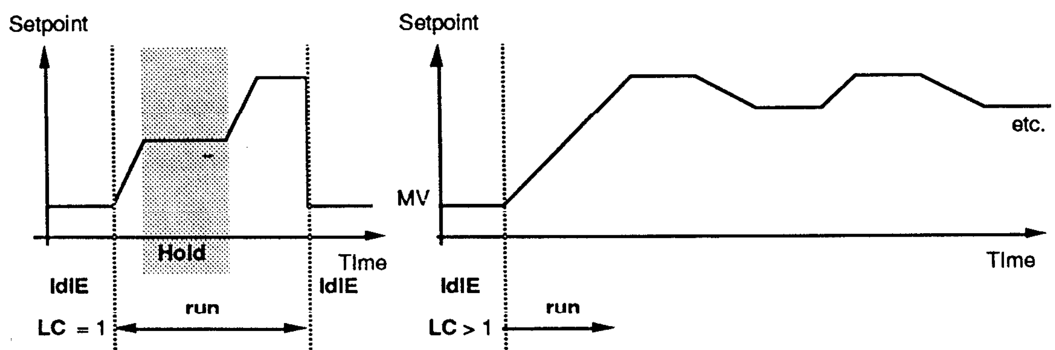
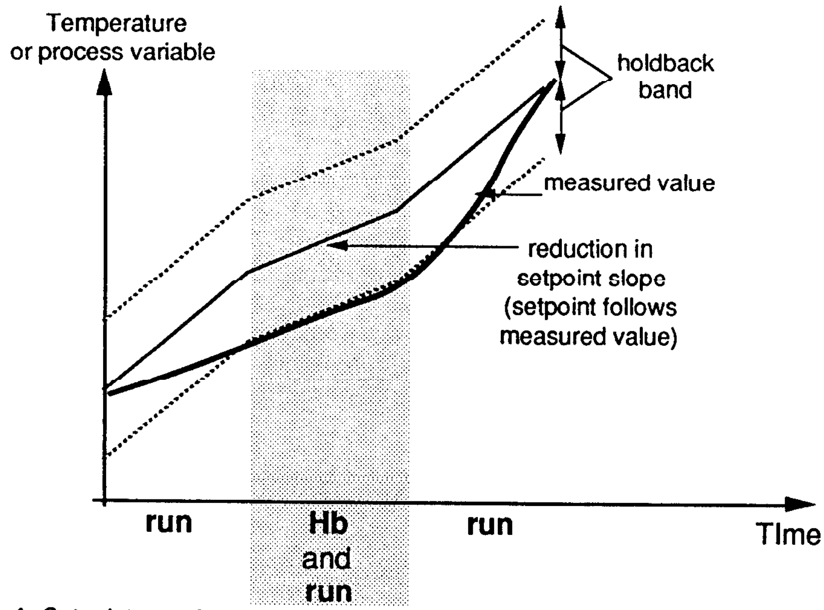


Figure 6.3. Programmer states.

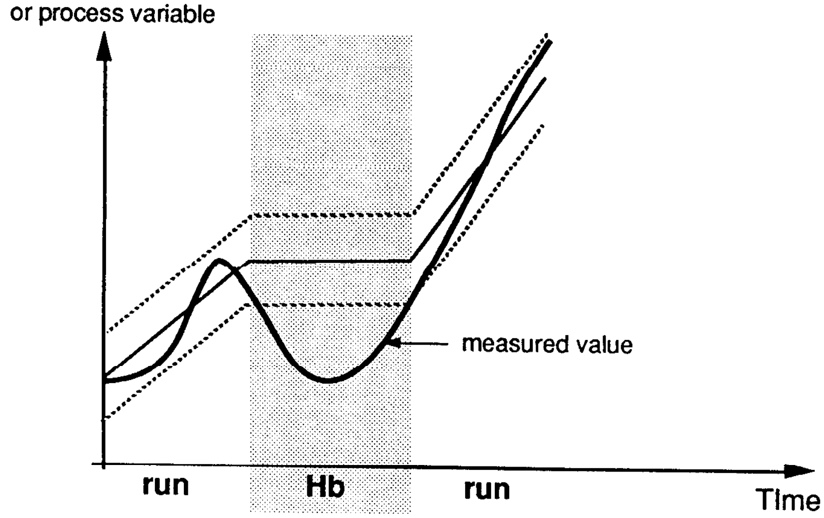
6.1.3.4 Holdback

Holdback (**Hb**) is a special case of **Hold** and the programmer behaves as if it were in **Hold** with one major exception: it cannot be selected by the user—only the programmer can place itself into holdback. While running a program, if the absolute value of the difference between the programmer setpoint and the measured value exceeds the *holdback band* (mnemonic **Hb**), the programmer enters holdback. By stopping the programmer clock, the measured value has a chance to “catch up” to the programmed setpoint. Figure 6.4 shows how holdback operation influences the program profile. During a ramp segment, holdback can have the effect of flattening out the slope of the ramp. During a dwell segment holdback guarantees a minimum soak time by stopping the clock if the measured value deviates outside of the holdback band. The program returns to **run** once the deviation has reduced as long as **Hold** is not selected.

The mnemonic **Hb** is strictly an indication and is not a selection under the **Prog** parameter. [Available only with software revision 02.00 or greater.]

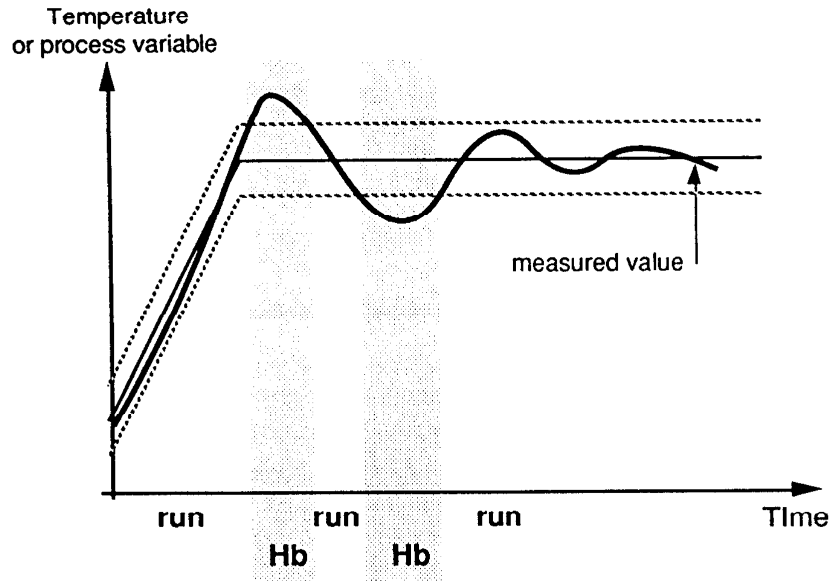


A. Setpoint ramping rate limited by system response. Programmer alternating between HOLDBACK and RUN reduces effective slope.



B. "Catastrophic" incident halts ramping until measured value re-enters holdback band.

Figure 6.4. Holdback examples. (continued on next page.)



C. Holdback action during dwell period stops clock when measured value exceeds holdback band.

Figure 6.4. Holdback examples. (continued from previous page.)

6.1.4 Program control methods

Program control consists of changing the *state* of the programmer. This is accomplished by way of the front panel pushbuttons, the rear terminals or the communications interface. The instrument obeys the last command issued by any of the 3 sources. An overriding exception to this is if the rear terminals 16 and 17 are open circuit, the programmer remains in **Hold**, no matter what other commands are issued through the communications link or the front panel.

NOTE! **If the programmer remains in Hold and does not run, verify that rear terminals 16 and 17 are connected together. If rear-terminal control is not to be used in the installation, these 2 terminals should be shorted.**

6.1.4.1 Front-panel pushbuttons

The program can be placed in **run**, **Hold** or **IdlE** by scrolling to **Prog** and selecting the appropriate setting. Note that if the programmer is in **IdlE**, placing it into **Hold** causes the unit to first enter **run** but it is placed immediately into **Hold**.

6.1.4.2 Rear-terminal connections (terminals 16 and 17)

If **Ctrl** is set to **Prog**, rear terminals 16 and 17 are used for program control. The relationships between the programmer states and the switching conditions are illustrated in Figure 6.5. Note that it is not possible to enter **IdlE** through use of the rear terminals.

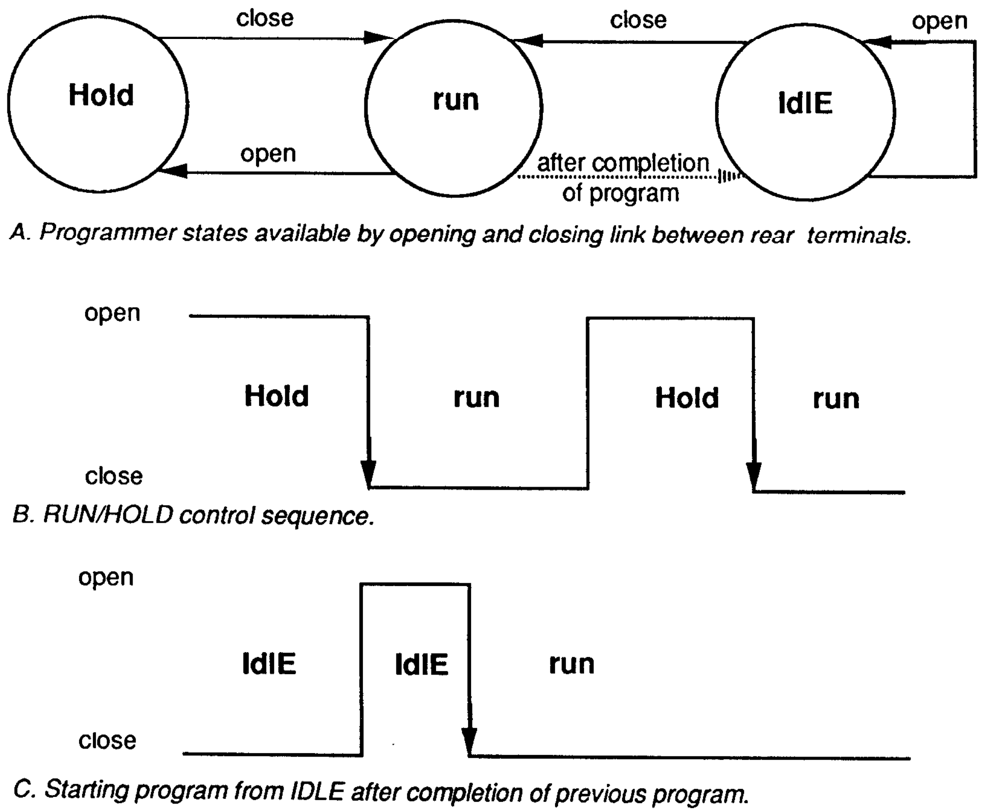


Figure 6.5. Use of rear-terminal connections 16 and 17 for programmer control.

If the programmer is in **IdlE** or **Hold**, shorting the terminals places the programmer into **run**. If the terminals are already shorted (as is the case after the completion of a program) and it is desired to repeat the program, the terminals must be opened and shorted to launch the program again.

If the rear terminals are open circuit the programmer cannot enter **run**. It will remain in **IdlE** until **run** is attempted at which time it will be placed immediately into **Hold**.

If the program is currently running, opening the rear terminals places the programmer into **Hold**.

When **Ctrl** is set to **Prog**, terminals 16 and 17 no longer function as the local override of the front-panel disable (§3.7.3). If the front panel is disabled through the communications link and communications with the host is lost, power to the instrument must be cycled OFF and ON again to enable the front-panel pushbuttons.

See §3.7 for wiring connections for rear-terminal programmer control.

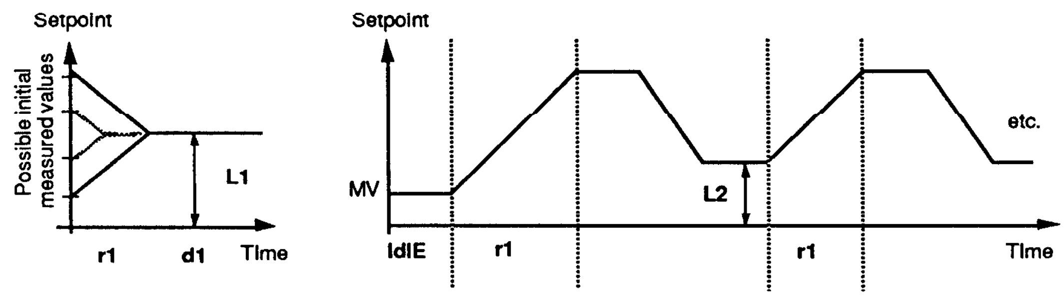
6.1.4.3 Communications interface

All aspects of the programming feature can be accessed and controlled through the digital communications port.

6.2 PROGRAM PARAMETERS

6.2.1 Segment parameters

- **r1** = ramp 1. The rate at which the setpoint ramps to the first target level. Adjustable from 0.01 to 99.99 display units per minute. **r1** always starts from the measured value (*servo start*). Servo start is illustrated in Figure 6.6.



A. Possible servo starts from various initial measured values.

B. Difference between ramp 1 segments in multiple-loop program when the initial measured value does not equal target level 2.

Figure 6.6. Servo start on ramp 1 segment.

- **L1** = target level 1. The target value to which the setpoint ramps when the programmer has been placed into **run**. Adjustable over the entire range of the input sensor. Note that the adjustment range of this level is *not* bound by the setpoint limit parameters **SP H** and **SP L.**

- **d1** = dwell time 1. The length of time the setpoint remains at **L1** after completing the **r1** and before beginning the **r2**. Adjustable from 0 to 9999 minutes. [The value of this parameter indicates the time remaining in the dwell segment *if* the value is viewed while the program is currently in this particular dwell segment. The segment is skipped if **d1** is set to zero minutes.]

- **r2** = ramp 2. The rate at which the setpoint ramps from **L1** to **L2** after completion of **L1**. Adjustable from 0.01 to 99.99 display units per minute.

- **L2** = target level 2. The target value to which the setpoint ramps after completion of **d1**. Adjustable over the entire range of the input sensor. Note that the adjustment range of this level is *not* bound by the setpoint limit parameters **SP H** and **SP L.**

- **d2** = dwell time 2. The length of time the setpoint remains at **L2** after completing **r2** and before either ending or repeating the program. Adjustable from 0 to 9999 minutes. [Note that this value indicates the time remaining in the dwell segment *if* the value is viewed while the program is currently in this particular dwell segment. The segment is skipped if **d2** is set to zero minutes.]

6.2.2 Loop counter

LC = loop counter. This parameter determines the number of iterations of the program. The value may be adjusted between 1 and 200 repetitions plus a selection, **Cont**, for continuous program cycling. [Continuous program cycling is available only with software revision 02.00 or greater.] Note that when a program is running, the value indicated will reflect the number of iterations *remaining including the current iteration* before the programmer reverts to **IdlE**.

6.2.3 Holdback

Hb = holdback band. The allowable deviation between the programmed setpoint and measured value during a program. If the deviation between the programmed setpoint and measured value exceeds **Hb** the program is automatically placed into **Hold** (clock stops) until the deviation reduces to an acceptable level; the program then resumes operation (clock starts). **Hb** is adjustable over the entire range of the input sensor and is always enabled. So that holdback has no effect on the program, set **Hb** to an extremely large value.

6.3 PROGRAM ANNUNCIATORS

6.3.1 Programmer state

6.3.1.1 State lamp "R"

The LED immediately below the **R** legend on the fascia indicates the state of the program:

- OFF = **IdlE**
- ON = **run**
- FLASHING = **Hold** or **Hb**

NOTE! **The "R" lamp also indicates ramp-to-setpoint in progress if r SP (and not Prog) has been selected under Ctrl.**

6.3.1.2 Programmer state display

The parameter **Prog** reflects the current state of the program as listed in §6.1.3.

6.3.2 Program segment

If the program is in either **run, Hb** or **Hold**, pressing **PAR** once causes the lower display to annunciate the current segment of the program **r1, d1, r2, d2** or **Hb** along with the units.
[Signals indicating the current program segment can be derived only through the communications link.]

6.3.3 Remaining time

If the program is currently executing either **d1** or **d2**, the value shown below these parameter mnemonics reflects the time remaining in the segment as opposed to the total time for that particular segment.

6.3.4 Setpoints

While the program is in **run, Hold**, or **Hb**, the setpoint shown on the bottom display is the current working setpoint. The base setpoint used at the end of the program (in **IdIE**), can be viewed by scrolling through the parameter list to **SP**.

6.4 OPERATION

All of these procedures can also be performed through the digital communications link (option **C2** or **C4**). Some are possible by opening or shorting rear terminals 16 and 17.

6.4.1 Enabling setpoint programming

To enable setpoint programming set **Ctrl** to **Prog.** This causes all of the program control parameters to appear in the scroll list unless they have been removed with **HidE** (§5.3). See Table 5.1 for the order and positioning of the program control parameters in the scroll list.

When **Prog** is selected and the programmer state is not **IdIE** the base setpoint is available for view and modification under the mnenomic **SP**.

6.4.1 Running (starting) a program

6.4.1.1 Procedures

- Verify that all program and controller parameters have been assigned the desired values. Then follow one of these 3 procedures:

- From the front panel:

- Verify that terminals 16 and 17 are shorted.
- Scroll down the parameter list with **PAR** until **Prog** appears.
- Depress either **UP** or **DOWN** until the program state parameter **run** appears in the lower display.

• Either press **PAR** or let the display time out to enter the **run** program state.

◦ From the rear terminals:

• If terminals 16 and 17 are open circuit, short them together. If the terminals are shorted together, open circuit them and then short them together.

◦ Through the external communications port:

• This requires modification of the optional status parameter OS using the external communications protocol.

◦ In all cases the state lamp "R" illuminates to indicate that the programmer is in **run**.

6.4.1.2 RUN characteristics

◦ If the programmer is in **run**, the parameters **LC**, **r1**, **L1**, **d1**, **r2**, **L2**, and **d2** cannot be adjusted from either the front panel or the external communciations port. Any other parmeter that is accessable is adjustable.

◦ A modification to the value of the holdback band **Hb** during **run** is permanent.

◦ If a dwell segment is selected for display during **run** and the programmer is currently in that segment, it is the time remaining and *not* the total dwell time that is displayed. The same holds true if the programmer is interrogated through the external communications port.

◦ Observation of loop counter **LC** in a multiple iteration program (**LC** ≠ 1) during **run** yields the number of iterations remaining including the current iteration.

6.4.3 Holding a program

6.4.3.1 Procedures

◦ Follow one of these 3 procedures:

◦ From the front panel:

• Scroll down the parameter list with **PAR** until **Prog** appears.

• Depress either **UP** or **DOWN** until the program state parameter **Hold** appears in the lower display.

• Either press **PAR** or let the display time out to enter the **Hold** program state.

◦ From the rear terminals:

• Open circuit terminals 16 and 17

◦ Through the external communications port:

• This requires modification of the optional status parameter OS using the external communications protocol.

◦ In all cases the state lamp "R" flashes to indicate that the programmer is in **Hold**.

6.4.3.2 HOLD characteristics

◦ When the programmer is in **Hold**, the programmer clock is stopped. The time elapsed that the programmer is in **Hold** effectively lengthens the total run time of the program.

◦ Changes made to parameters **LC**, **r1**, **L1**, **d1**, **r2**, **L2**, and **d2** during **Hold** are valid only during the current iteration of the program.

NOTE! **It is possible for the programmer to be in Hold and Hb simultaneously. To resume the evolution of the program, run must be selected and the holdback condition must be cleared.**

NOTE! **Hold is not at all the same as the manual operating mode (HAnd):**
Hold stops the time base of the programmer and permits temporary adjustment of the parameters; the controller remains in automatic closed-loop operation and the measured value controls at the setpoint.
HAnd affects the controller (see §4.1.2.2). The programmer clock continues to run during manual operation; the controller output level is adjustable thus influencing the measured value. If, however, the difference between the measured value and the programmed setpoint exceeds the holdback band, the programmer places itself into Hb.

6.4.4 Resetting a program

6.4.4.1 Procedures

◦ A program can be placed into **IdIE** from the front panel or through the external communications port. The rear terminals do not provide this option. Two procedures follow:

◦ From the front panel:

• Scroll down the parameter list with **PAR** until **Prog** appears.

• Depress either **UP** or **DOWN** until the program state parameter **IdIE** appears in the lower display.

• Either press **PAR** or let the display time out to enter the **IdIE** program state.

◦ Through the external communications port:

• This requires modification of the optional status parameter os using the external communications protocol.

◦ In both cases the state lamp "R" extinguishes to indicate that the programmer is in **IdlE**.

6.4.4.2 IDLE characteristics

◦ Modifications made to *all* parameters in **IdlE** are permanent.

6.4.5 Ending a program

Four options are available to the user at the end of a program as shown in Figure 6.7.

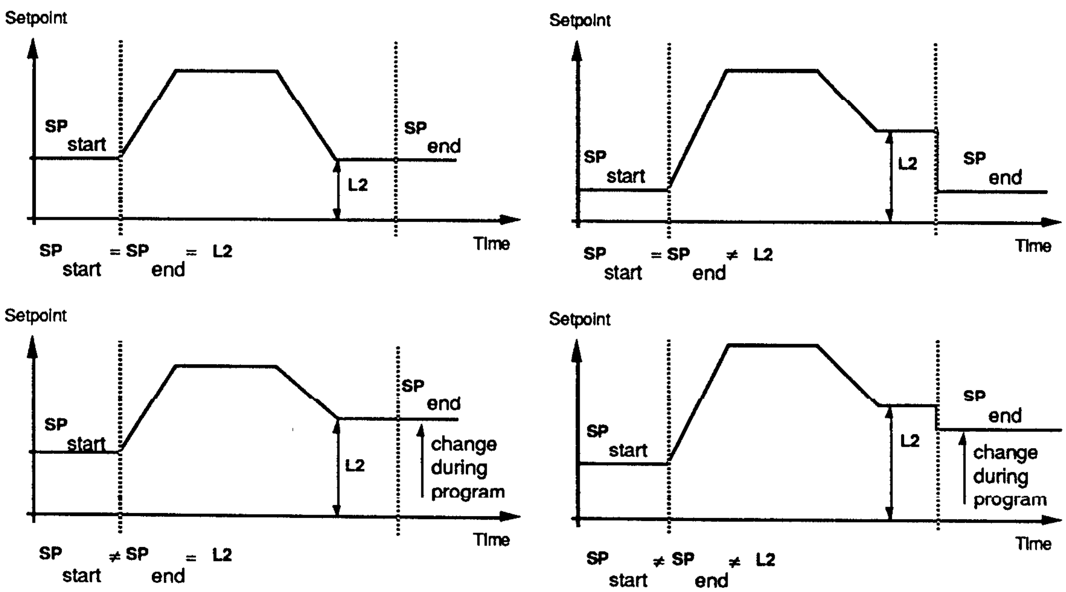
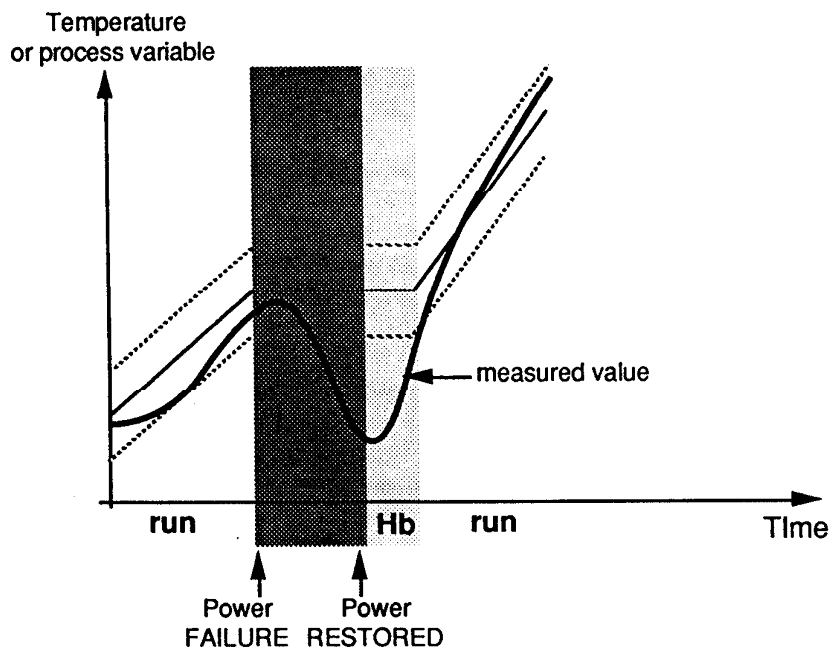


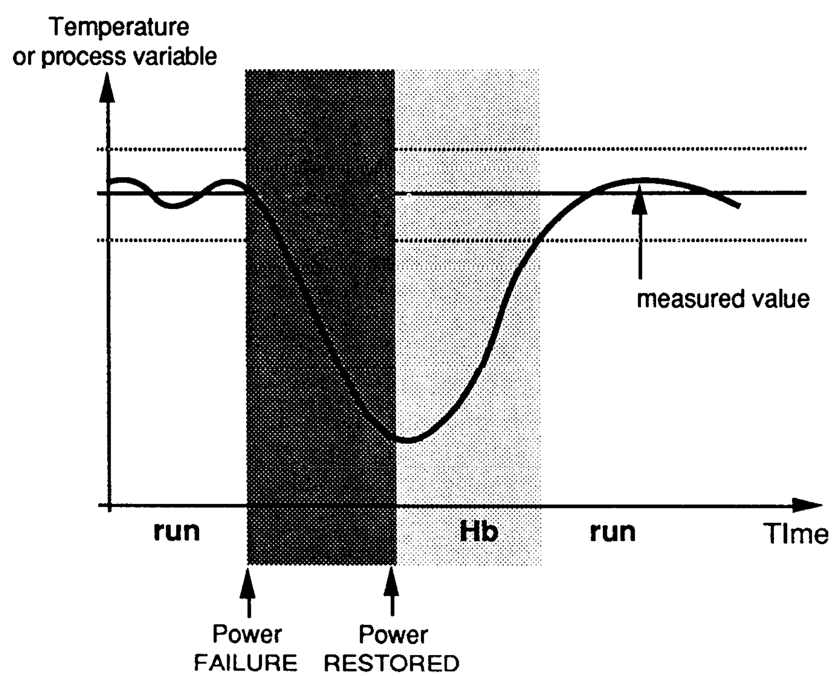
Figure 6.7. Methods of ending programs.

6.4.6 Loss of power during a program

Figure 6.8 shows the effect of a power outage during program **run**. When power is lost, the values of all the parameters are saved in non-volatile memory. When power is restored, the clock resumes counting in the same segment as soon as the measured value re-enters the holdback band.



A. Effect on ramp segment.



B. Effect on dwell segment.

Figure 6.8. Loss of power during program RUN.

6.4.7 Changing program parameters

Parameters **LC**, **r1**, **L1**, **d1**, **r2**, **L2**, and **d2** can be modified while the programmer is either in **IdIE** or **Hold**.

- Any changes made to these parameters while in **IdIE** are *permanent*.
- Any changes made to these parameters while in **Hold** cause a *temporary* change valid only during the particular iteration of the program loop.
- The programmer does not permit any changes to be made to these parameters during **run**. The base setpoint **SP**, along with holdback band **Hb** and the other non-program parameters can still be freely and permanently modified during **run**.

6.4.8 Alarms

See §4.3.3.2 for a discussion of alarms with time-varying setpoints.

7. LINEAR INPUTS

7.1 HARDWARE

7.1.1 Input adapter

Verify that the input adapter model **IA...** is appropriately sized for the anticipated input signal: large enough that the input adapter range just encompasses the input signal swing but small enough that resolution does not suffer. The nominal ranges of the input adapters already have a 20% overdrive factor designed into them (on the positive side only) so that an **IA10V** can be safely used for a signal with a +10V maximum. A list of available input adapters is found in Table 1.1.

NOTE! The input adapter increases the panel depth of the controller to 7.105" (180.5mm).

7.1.2 Wiring

Refer to §3.5.3 for the connection and wiring of the input signal.

7.2 SET-UP AND CONFIGURATION

◦ Set the sensor selection parameter **Sn** to **Lin** (units' display precision) or to **.Lin** (tenths' display precision). Selecting **Lin** or **.Lin** reveals other linear process input parameters (Table 5.1, Part 6).

◦ Select control action **Act** to be either **rev** (reverse) for a negative controller gain or **dir** (direct) for a positive controller gain.
• **rev** provides a decreasing output as the measured value increases. **rev** should be selected for heating temperature control loops with the valve open winding connected to terminals 1 and 2.
• **dir** provides an increasing output as the measured value increases. **dir** should be selected for cooling temperature control loops with the valve open winding connected to terminals 1 and 2.

◦ Set **Hi L** to the point desired to be the sensor overrange point or the sensor upper break point (in display units). If the input signal causes the display value to exceed this threshold, the controller enters the sensor break condition (see §4.4.3). **Hi L** is normally set to 105% of the maximum useful sensor output signal level to allow for operation up to maximum without entering the sensor break condition.

◦ Set **Lo L** to the point desired to be the sensor underrange point or the sensor lower break point (in display units). If the input signal causes the display value to fall below this threshold, the controller enters the sensor break condition (see §4.4.3). **Lo L** is normally set to -5% of the minimum useful sensor output signal level to allow for operation down to minimum without entering the sensor break condition.

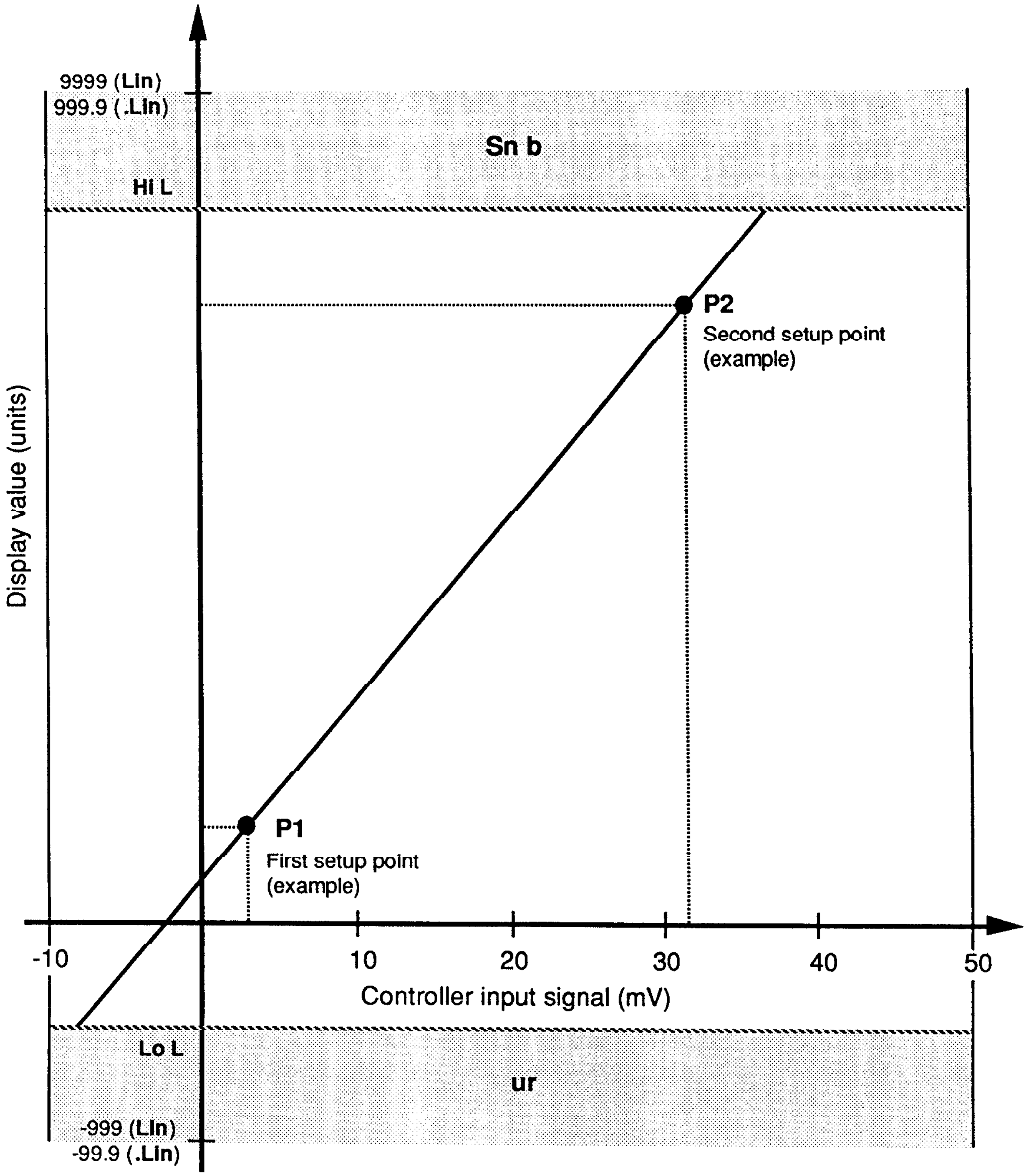


Figure 7.1. Linear input set-up and configuration.

CAUTION! Hi L and Lo L are not alarms and do not provide electrical signal outputs. Use the alarm output or a separate redundant alarm system to alert of a critical condition.

- Set the variable digital filter, **Fil**, to 1.00 as an initial value.

7.3 SCALING PROCEDURE

The scaling procedure entails adjusting 2 setup points, **P1** and **P2**, that link known-value input signals to specific display values.These 2 scaling values are used to define a straight line and are *not* interactive (Figure 7.1). Scale the input for display by using the **Proc** parameter and this procedure (outined in Figure 7.2).

- Connect the controller to some form of signal generator which can reproduce the sensor output, or to the sensor itself if the sensor can be induced to supply various signal levels.

The input to the *controller* must be between -10mV and 50mV. Voltage signals which exceed this range must be attenuated with an appropriately sized input adapter **IA....** Current signals are converted to the -10 to 50mV range with a shunt input adapter.

Apply a signal to the controller equal to some known low value. This is the first setup point **P1**. The input signal value used does not have to be exactly at the zero point but should be as near zero as possible.

- Scroll through to the **Proc** parameter and press **UP. P1** appears in the lower display.

- Press **PAR** again; **P1** appears in the upper display and a number appears in the lower display.

- Adjust the number with **UP** or **DOWN** until the display value corresponds to the signal presently applied to the input of the instrument.

- Press the **PAR** pushbutton. The number which was entered appears in the upper display and **no** appears in the lower display.

- Press **UP. YES** appears in the lower display.

- Press **PAR. P1** appears in both displays while the controller is storing the low scaling point.

- After several seconds, **Proc** appears in the upper display to signal completion.

- Apply a signal to the controller equal to some known high value. This is the second setup point **P2**. The input signal value used does not have to be exactly at the span point but should be as near span as possible. Repeat the above procedure substituting **P2** and the display value corresponding to the second input signal.

- Establish all remaining parameters for the controller based on the requirements of the application.

DO:	SEE:
1. Connect source (from signal generator or sensor) to input terminals before proceeding. Apply a signal equal to a known low value for the first setup point (P1).	
2. Depress PAR until :	Proc ----
3. Depress UP until :	Proc P1
4. Depress PAR again: The number in the lower display will be the value (after adjustment) assigned to the injected input signal.	P1 1500
5. Depress UP or DOWN to adjust the number in the lower display until it corresponds to the value represented by the injected input signal.	P1 2500

Figure 7.2. Linear input scaling procedure. *(continued on next page.)*

6. Depress PAR:	2500 no
7. Depress UP to affirm	2500 YES
8. Depress PAR	P1 P1
9. After 5 seconds the scaling of the first setup point is completed. Repeat procedure for the second setup point (P2).	Proc ----

Figure 7.2. Linear input scaling procedure. (continued from previous page.)

7.4 FILTER VALUE

The Models **809** and **849** incorporate a digital input filter having an adjustable coefficient found under **Fil** in the scroll list. This value, in display units, marks a gradual cutoff between what should be considered real changes in the measured value and background noise.

When the value is set to 1.00, perturbations or step changes in the measured value greater than 1.00 input unit are given more significance than changes less than 1.00 input unit.

Increasing or decreasing the value of **Fil** moves the cutoff point up or down. For temperature controllers, **Fil** is set to 1.00°.

8. SELF TUNING

8.1 INTRODUCTION

8.1.1 Types of self tuning

The Models **809** and **849** feature 2 types of self tuning:

8.1.1.1 Tune from ambient

A self-tune procedure from ambient is performed if the measured value is not near the control setpoint. This can apply to a "normal" heat-up condition or tuning a load which operates predominantly in cooling, i.e. the setpoint is well below ambient.

8.1.1.2 Tune from setpoint

A self-tune procedure from setpoint is performed if the measured value is near the control setpoint. This can apply to either an endothermic or an exothermic process or a process which must be cooled to maintain control point.

8.1.2 Parameters calculated

Both types of self tuning calculate values for the PI parameters:

- **ProP** proportional band
- **Int.t** integral time constant

In addition, the tune-from-ambient operation calculates the cutback levels:

- **H cb** high cutback
- **L cb** low cutback.

The tune-from-setpoint verifies that the cutback values are not within the proportional band. Cutback values lying within the proportional band are moved out to the edge.

8.1.3 Conditions for self tuning

Self-tuning operates under the following conditions (refer to Figure 4.1):

- Access level = operator
- Operating mode = automatic (**Auto**)
- Control type = any PI selection: **vALv**, **r SP** or **Prog**
- Control action = reverse (**rEv**).

The following overrides and exclusions prevail:

- Manual operating mode. Tuning is temporarily halted when the controller is placed into manual (**HAnd**).Switching from manual to automatic with tuning ON restarts self-tuning from the begining—it does not resume from where it left off.

◦ Power failure. A power failure causes the **tunE** parameter to revert back to **no**. If tuning is a result of the the **t Su** being set to **YES**, tuning restarts after a power failure.

◦ PI control with setpoint programming (option QP). Self-tuning does not run while a 4-segment program is running. The program must be placed into **IdIE** or **Hold** before intiating self-tuning.

◦ PI control with ramped setpoint modification. Self-tuning overrides ramping if the unit is set for **r SP**.

CAUTION! If the unit is configured in this way for the reason of preventing shock to the load, self-tuning should not be used as the 809/849 self-tuning algorithm purposely shocks the system.

8.2 PARAMETERS AND ANNUNCIATION

Two different parameters can be used to launch a tune operation. Both determine to perform a tune from ambient or tune from setpoint, whichever is appropriate. See Table 5.1 for the position of these parameters in the scroll list.

8.2.1 Tune on demand

◦ **tunE**. This parameter has two possible settings. It is used both as a request to perform a tune operation at any time and as an annunciation of the tuning status.

- **OFF**. As an annunciation, the unit is not presently self-tuning; this means that a tuning operation was never launched, or that it has successfully or unsuccessfully terminated a tuning operation.
As a command, it terminates a tuning operation in progress. The values currently assigned to the PI and cutback parameters in the scroll list are used for the control.
- **on**. As an annunciation, this indicates that the controller is presently in tuning operation.
As a command, the unit begins tuning the control loop.

8.2.2 Tune on start-up

◦ **t Su** = tune on start-up. This parameter has two possible settings. It is used both as a request to perform a tune operation upon start-up and as an annunciation of a successful tuning operation.

- **no**. As an annunciation, this indicates that a successful tune operation was performed upon start-up, and that when power is applied to the unit in the future, no tuning will be attempted.
As a command, select **no** so that the unit does not perform a tune operation upon application of power.

- **YES.** As an annunciation, this means that no *successful* tune operation has ever been performed upon start-up and that the next time power is applied to the unit, a self-tuning operation will be launched.
  As a command, select **YES** to enable a tune operation upon the next application of power.

8.3 OPERATION

Possible senarios of self-tuning operations are presented here. During the operation, **tunE** flashes in the lower display. Do not make any adjustments to the controller parameters during this period. The self-tuning is finished when **tunE** no longer flashes in the lower display. [If there are alarm annunciations (**Hi AL**, **Lo AL** or **d AL**) during self-tuning, they flash alternantly with **tunE**.]

8.3.1 Start-up tune

Figure 8.1 illustrates the heat-up case for a start-up tune, and Figure 8.2 the cool-down case.

The outputs from the controller are turned OFF and the temperature is monitored for 1 minute.

Heat (or cooling) is applied and the start-up process reaction curve is evaluated. The appropriate values are stored for later use.

A switch-off point, **CP**, is calculated. Once the temperature has reached **CP** power is set to 0%. Oscillations through **PV4** and **PV6** are forced as shown.

Values for the PI terms and the high and low cutback levels are calculated from the various critical points of the oscillation.

8.3.2 Tune at setpoint

Figure 8.3 illustrates self-tuning of an endothermic process, and Figure 8.4 an exothermic process.

Upon initiating a tune at setpoint the output power is fixed for one minute.

Both outputs are turned off and the direction of the response noted. When the temperature drops (or rises), oscillations are induced around the control point **CP** by addition of heating (or cooling).

Values for the PI terms are calculated from the various critical points of the oscillation. The high and low cutback levels are not calculated but are checked to insure that they are not inside the proportional band.

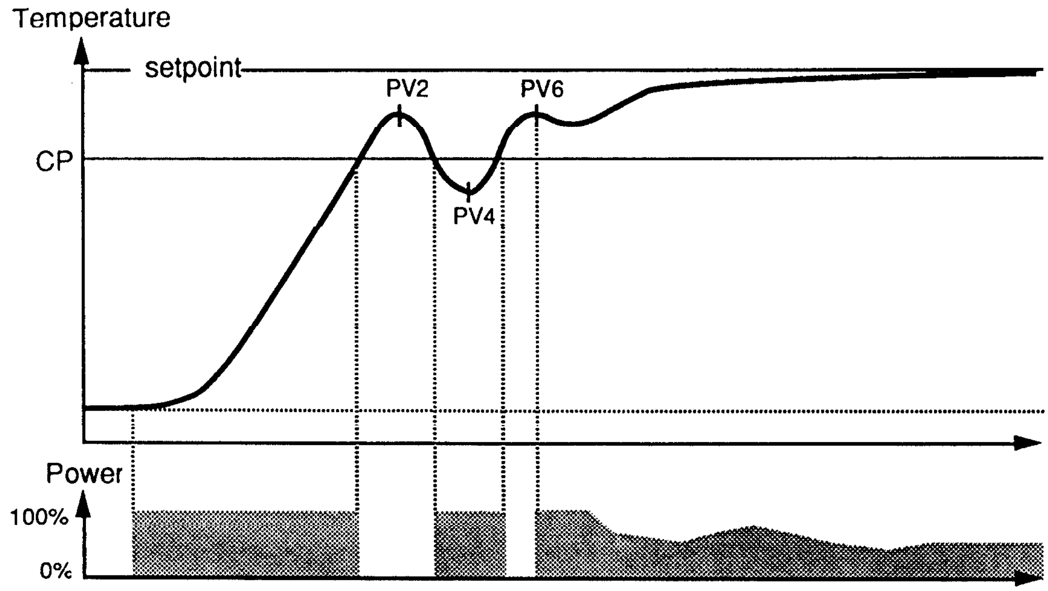


Figure 8.1. Start-up tune—heat-up.

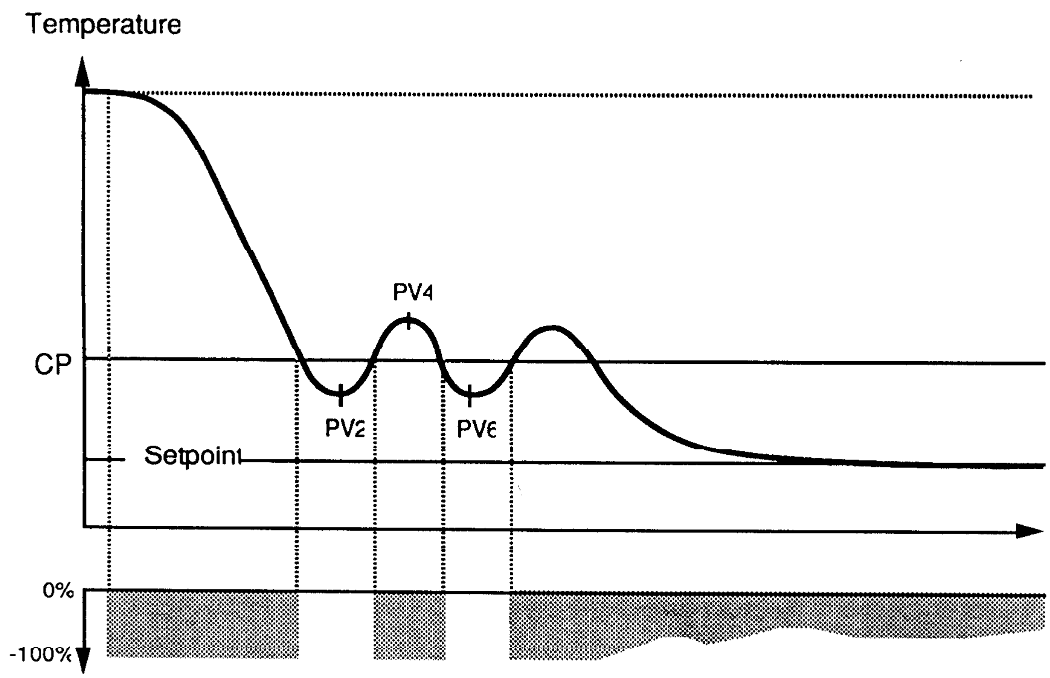


Figure 8.2. Start-up tune—cool down.

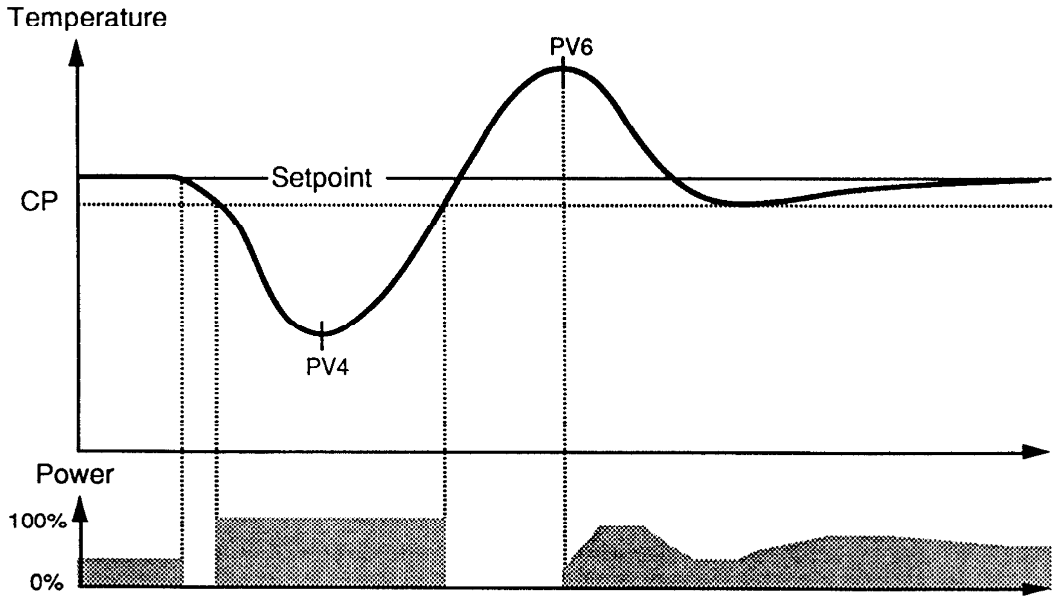


Figure 8.3. Tune at setpoint—endothermic process.

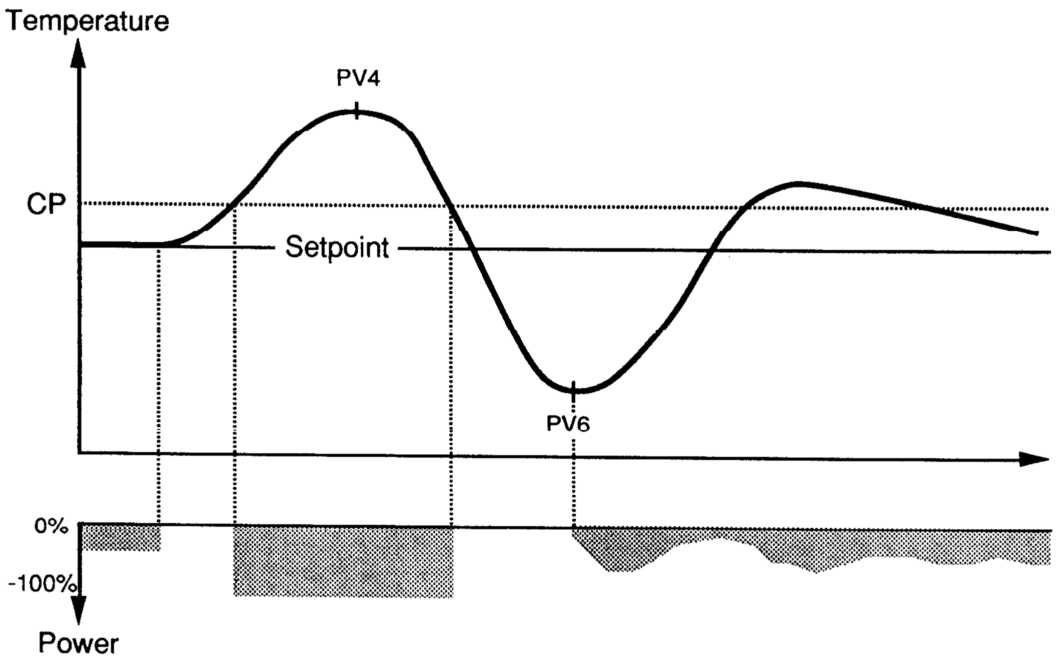


Figure 8.4. Tune at setpoint—exothermic process.

8.3.3 After tuning

Note for future reference the values of the various parameters that the self tuner has calculated.

In the event that the controller does not seem to be controlling properly, then the self-tuning operation may not have been successful; manual tuning is probably required. See Appendix C.

APPENDIX A. SPECIFICATIONS

ABSOLUTE MAXIMUM RATINGS

Supply voltage	$240V_{ac\ rms}$ nominal plus 10%
Voltage between any 2 terminals	$264V_{ac\ rms}$
Input voltage (thermocouple, RTD or logic input)	$10V_{dc}$
Ambient temperature	-10 to 50°C

1. INPUTS (see also Table A.1)

1.1 All inputs

Calibration accuracy	0.15% of reading +12µV ±1/2 l.s.d. (typ.)
Sampling frequency	8Hz
Maximum sensor break reaction time	30s
Sensor break power level adjustment range	-99.9 to 100.0%
Maximum common-mode voltage @ 50/60Hz	$264V_{ac\ rms}$ (with respect to neutral)
Common mode rejection @ 50/60 Hz	≥120dB
Series mode rejection @ 50/60 Hz	≥60dB

1.2 Thermocouples

Number of thermocouple types	10 (B, E, J, K, L, N, PL2, R, S, T)
Thermocouple linearization accuracy	0.2°C
Maximum thermocouple loop resistance	1000Ω
Cold junction compensation rejection ratio	20:1 (internal detector) ±0.5°C
External cold junction reference selections	0, 45 or 50°C

1.3 Resistance temperature detector

Sensor type	100Ω Pt (DIN 43760/BS 1904)
Resistance @ 0 °C	100.0Ω
Resistance @ 100 °C	138.5Ω
Connection	3-wire
Excitation current	184µA
Maximum lead resistance	10Ω/wire
Linearization accuracy	0.1°C

1.4 Linear process input

Voltage input adapters

RANGE	R_{input}	RESOLUTION
-10 to +50mV (no adapter req'd)	500kΩ	1.67µV
-40 to +200mV	1kΩ	6.67µV
-200 to +1000mV	5.2kΩ	33.3µV
-1 to +5V	27kΩ	0.167mV
-2 to +10V	56kΩ	0.333mV
-5 to +25V	56kΩ	0.833mV

Current input adapter

RANGE	R_{input}	RESOLUTION
-4 to +20mA	2.5Ω	0.667µA

2. OUTPUT DEVICES

2.1 VPT Triac module (isolated from all other circuits)

Maximum load current (resistive load)	$1A_{rms}$
Minimum load current (resistive load) or power	greater of $50mA_{rms}$ or 5VA
Off-state current	3mA @ $264V_{ac}$
Load voltage range	21.8-$264V_{ac}$ @ 50/60Hz
Isolation technology	zero-crossing opto-coupler

2.2 Logic module (not isolated from thermocouple circuit)

Output	10mA, $18V_{dc}$ max. compliance
Maximum short-circuit current	20mA (typ.)

2.3 VPR and R1 Relay modules (isolated from all other circuits)

Output contacts	
VPR	Form A, isolated
R1	Form C, isolated
Maximum load voltage	$264V_{ac}$
Minimum load voltage	$10V_{peak}$
Maximum load current (resistive load)	$2A_{rms}$

3. CONTROL CHARACTERISTICS

3.1 General

3.1.1 Automatic operation

Control types	ON/OFF, or PI with or without ramp-to-setpoint operation, or PI with setpoint programming (option **QP**)
Setpoint limits	low and high secureable limits
Proportional band range	1-4500°C (1-8100°F); 1-9999 units or equivalent in %
Integral time constant range	1-8000s
Overshoot suppression	adjustable high and low “cutbacks”

3.1.2 Manual operation

Auto/manual selection	bumpless changeover
Valve position adjustment range	0.0 to 100.0%

4. ALARM

Number of simultaneous alarm functions	3: "Full-scale" high, "Full-scale" low, and deviation band, each with its own setpoint
Annunciation memory	Latching (memorized until acknowledgement) or non-latching (disappears when alarm clears). Memory for each of the 3 alarm functions can be independently selected.
Hysteresis	1°C standard
Alarm action	Failsafe (alarm state affirmed by de-energized output)

5. COMMUNICATIONS

Transmission standard	EIA-232-D or EIA-422
Transmission rate selection	300, 600, 1200, 2400, 4800, 9600, or 19200 baud
Character format	Start bit, 7 data bits, even parity bit, stop bit
Protocol	ANSI X3.28 (1976 version, subcatagories 2.5 and A4)
Address range (group and unit number)	100 instruments (addresses 0.0 to 9.9)

6 GENERAL

6.1 Physical

Dimensions	
Overall	3.78" x 1.89" x 6.5" deep (96 x 48 x 165 mm)
Panel depth w/o input adapter	6.13" (156mm)
Panel depth w/ input adapter	7.11" (180mm)
Panel cutout	3.62" x 1.77" (92 x 45 mm)
Weight	1 lb. (455g)
Enclosure materials	
Sleeve and terminal block	Novadur L-FR flame-retardant ABS
Bezel	Lexan 940™ polycarbonate
Connections	
External	20-screw barrier terminal strip
Internal	Plug-in boards with blade connectors

6.2 Power supply

Line voltage range	100-240V$_{ac\ rms}$ (-15/+10%)
Line frequency range	48-62Hz
Line fuse	2AG, 1A, 250V (Littelfuse 225001)
Power supply type	Switch mode
Isolation technology	Transformer
Power dissipation	5W (typ.)

6.3 Front panel

6.3.1 Displays

Technology	7-segment green LED
Number of significant digits	4
Character height	0.3" (7.62mm)
Functions	
Display 1 (upper)	Measured value, parameter mnemonics, special indications
Display 2 (lower)	Parameter values

6.3.2 Indicators

Outputs	2 yellow LEDs
Alarms	Display 1 flashes, message on Display 2
Open input	**Sn b** on Display 1
Temperature units	**F** or **C** on Display 2 at beginning of scroll (The temperature-dependent display parameters are automatically converted when units are changed.)
Special indications	By illuminated dots in Display 1: • Ramp-to-setpoint in progress or programmer in run state • Communications transmission • Manual mode.

6.3.3 Pushbuttons

Technology	Dome membrane with tactile feedback
Functions:	
A/M	Auto/manual selection
PAR	Parameter scroll, alarm acknowledge
Up arrow	Increase parameter value
Down arrow	Decrease parameter value

6.4 Environmental

Operating temperature range	0-50°C
Relative humidity	5-95%, non-condensing
Vibration specification	Mil Std 810D, method 516-I
Facia seal rating	NEMA 3 (IP-54) with optional gaskets

7. PROGRAMMER (option QP)

7.1 Program size and format

Number of segments/program	4
Program format	2 ramp/dwell pairs
Number of programs in memory	1
Maximum number of program repetitions	200 (with possibility of continuous program repetition)
Ramp rates	0.01 to 99.99° or units/minute
Dwell times	0 to 9999 minutes

7.2 Program control

Control means	Front panel pushbuttons, rear-terminal connections, or communications port
Number of programmer states	3 (RUN, HOLD, IDLE)
Holdback band	1 to 999° or units
Starting method	Servo start from measured value
Ending method	Return to front-panel (base) setpoint

8. SELF-TUNING

Self-tune initiation means	On demand or on startup
Parameters determined	
Tune from ambient	PI terms, high and low cutback levels
Tune from setpoint	PI terms

Table A.1
Input Sensors

Sensor Type	Scroll Mnemonic	Thermocouples		Range			
		Positive material	Negative material	°F min.	°F max.	°C min.	°C max.
J	J tc	Iron	SAMA Constantan (Cu-45%Ni)	-211	1832	-135	1000
K	CAtc	Chromel™ (Ni-10%Cr)	Alumel™ (Ni-2%Al-2%Mn-1%Si)	-427	2501	-255	1372
Platinel II	PL2	Platinel II™ (alloy #5355)	Platinel II™ (alloy #7674)	-436	2543	-260	1395
R	r tc	Platinum-13% Rhodium	Platinum	-58	3213	-50	1767
S	S tc	Platinum-10% Rhodium	Platinum	-58	3213	-15	1767
T	t tc	Copper	Adams Constantan (Cu-45%Ni)	-436	752	-260	400
J	.J tc	Iron	SAMA Constantan (Cu-45%Ni)	-99.9	999.9	-99.9	999.9
RTD-3	rtd	DIN 43760/BS1904/JIS1602		-99.9	999.9	-99.9	850.0
L	L tc	Iron	DIN Konstantan	-148	1652	-100	900
L	.L tc	Iron	DIN Konstantan	-99.9	999.9	-99.9	900
Linear	Lin			-999	9999	-999	9999
Linear	.Lin			-99.9	999.9	-99.9	999.9
B	b tc	Platinum-30% Rhodium	Platinum-6% Rhodium	32	3308	0	1820
E	E tc	Chromel™ (Ni-10%Cr)	Adams Constantan (Cu-45%Ni)	-148	1472	-100	800
N	n tc	NiCroSil	NiSil	32	2372	0	1300
E	.E tc	Chromel™ (Ni-10%Cr)	Adams Constantan (Cu-45%Ni)	-99.9	999.9	-99.9	800.0
N	.n tc	NiCroSil	NiSil	32.0	999.9	0	999.9

APPENDIX B. INSTALLATION OF FRONT-PANEL GASKETS

If a Model **809** or **849** is to be mounted into an electrical enclosure that must meet the NEMA 3 rating (IEC IP-54), then 2 gaskets are required:

- Part nº BO131942 — strip gasket sealing the controller front panel to the controller sleeve.
- Part nº BO131943 — rectangular gasket fitting between the rear shoulder of the controller bezel and the panel,

Both gaskets are made of neoprene and have a self-adhesive backing. Figure B.1 shows how the 2 gaskets seal the instrument fascia to the instrument sleeve, and the sleeve to the panel.

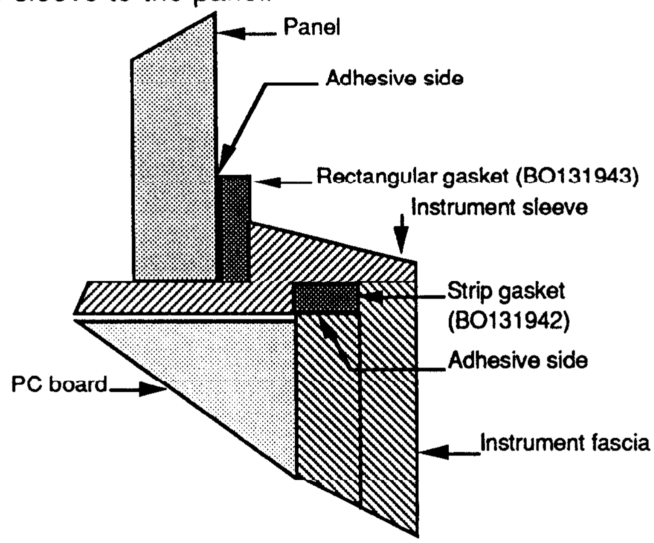


Figure B.1. Location of front-panel gaskets—section view.

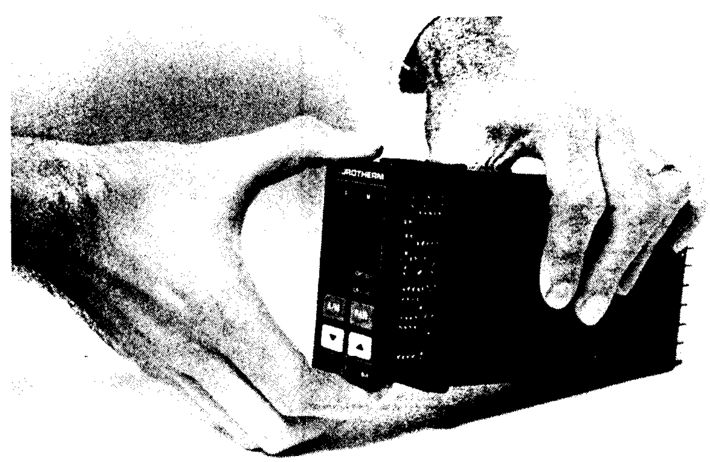


Figure B.2. Open the instrument by turning the front jacking screw and slide the instrument partially out of the sleeve.

Figure B.3. Carefully peel off a few inches of the backing paper from the adhesive backing of the strip gasket, and starting underneath the jacking screw, apply the gasket around the inner shoulder of the fascia plate. Do not stretch the neoprene.

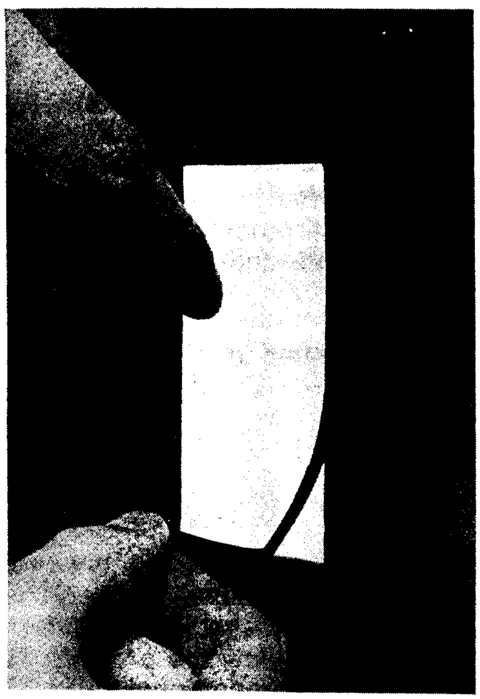


Figure B.4. Remove the backing from the O-ring seal. Apply the seal around the panel cutout on the outside of the panel.

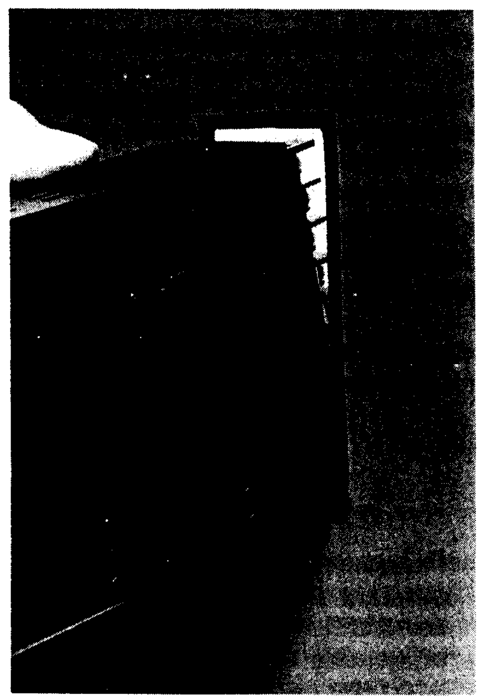


Figure B.5. Insert the controller from the front of the panel and install according to the instructions in §2.

APPENDIX C. TUNING TUTORIAL

C.1 INTRODUCTION

Tuning a PI valve positioner controller is the systematic procedure for determining the values of the PI terms (proportional band and integral time constant) and other related control parameters of a controller for a specific installation. Proper tuning of a controller is not only essential to its correct operation but also greatly improves product quality, reduces scrap, shortens down-time and saves money.

Procedures for tuning PI valve positioner controllers are well established and simple to perform. The tuning procedure is normally performed on system start-up, or if heaters are changed or if the mechanics of the system are altered appreciably. In this latter instance the associated controller must be "re-tuned" to insure optimal performance. Anytime a controller is replaced into an existing system that is properly tuned, the parameters of the new instrument must be set to the same values as on the old instrument.

Tuning the Models **809** and **849** involves setting values for the following parameters:

- Proportional band **ProP** and integral time constant **Int.t**
- If cutback operation **Cb O** is *not* set to **Auto** (see §C.4.5): High cutback **H cb** and low cutback **L cb** must be set.

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

Tuning can be performed with the procedures outlined in this section or automatically if the self-tune feature is used (see §8).

C.2 PI CONTROL PARAMETERS

C.2.1 Proportional band (gain) ProP

Proportional band (PB or X_p), or gain, amplifies the error between setpoint and measured value to establish an output level. Proportional band is the temperature range over which the output level is continuously adjustable in a linear fashion from 0% to 100%. Below the proportional band the output level is full ON (100%), above the proportional band, full OFF (0%) as shown in Figure C.1.

The width of the proportional band determines the magnitude of the response to the error. If the proportional band is too narrow, meaning high gain, the system oscillates by being over-responsive.

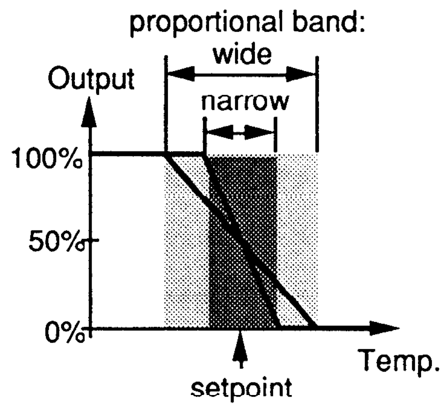


Figure C.1. Proportional band with PI control.

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

Figure C.2 shows the effect of narrowing the proportional band to the point of oscillation. This control zone comes up to temperature with a proportional band 150° wide. This results in an appreciable initial error between setpoint and actual temperature. As the proportional band is narrowed, the temperature comes closer to setpoint until finally, at a setting of 9° the system becomes unstable.

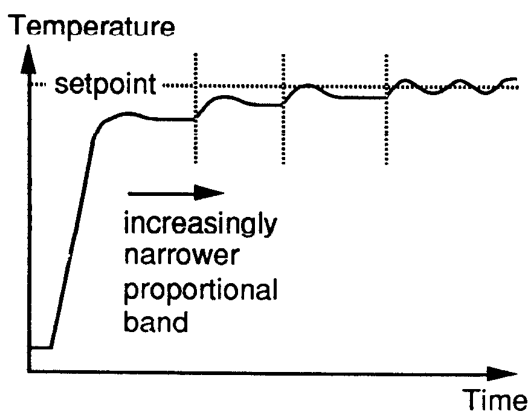


Figure C.2. Proportional-only control.

C.2.2 Integral time constant (reset) Int.t

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

Figure C.3 demonstrates the result of introducing integral action. Again the temperature rises and levels out at a point just below setpoint. A 36° proportional band is used. Once the temperature settles, integral action is introduced. Notice that the temperature rises further until it is at setpoint.

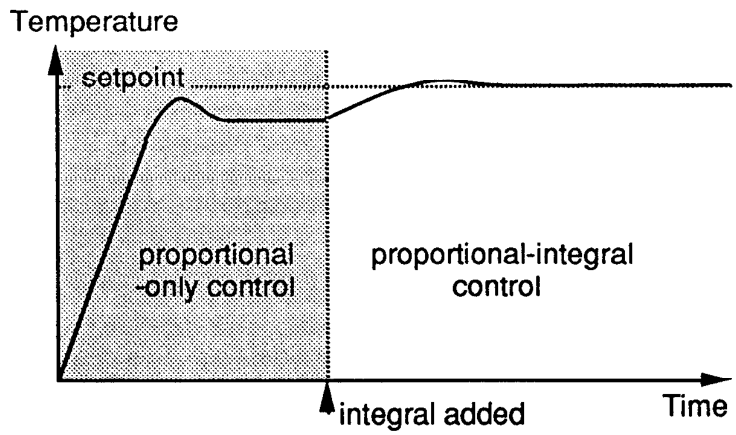


Figure C.3. Adding integral action.

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

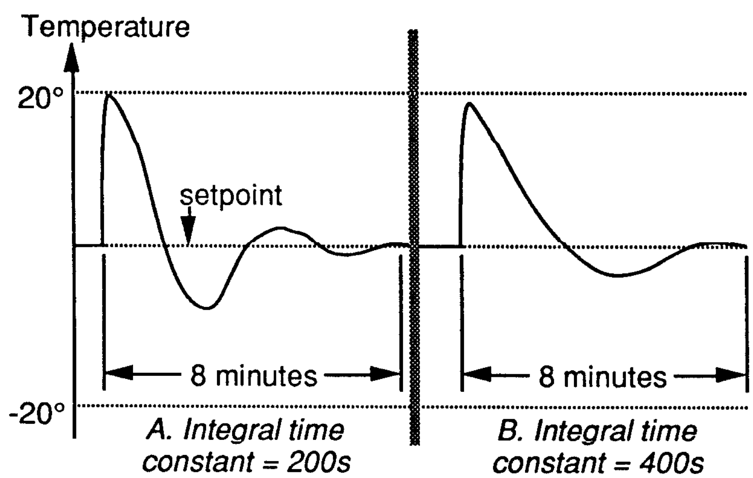


Figure C.4. Widening the integral time constant.

In Figure C.4.A, a proportional band of 36° and an integral time constant of 200 seconds provide stable control at setpoint. A positive 20 degree perturbation results in some overshoot before settling. Figure C.4.B shows the result of a similar perturbation but with a 400-second integral time constant. Lengthening the integral time constant results in the markedly slower response shown.

C.3 APPROACH CONTROL PARAMETERS H cb AND L cb

The Models **809** and **849** controllers contain 2 parameters which can be adjusted to prevent overshoot: *high-* and *low cutback levels.* These parameters are independent of the proportional band and the integral time constant. By using the cutback parameters, the system can be set up for optimum steady-state response (with the PI parameters) *and* the overshoot can be limited as desired.

Cutback operation involves moving the proportional band towards the *cutback point* nearest the measured value whenever the latter is outside the proportional band and the power is saturated, i.e. at 0 or 100%. Integral action is inhibited when the measured value is outside the cutback region (e.g. on start-up). The proportional band moves downscale to the lower cutback point, waits for the measured value to enter it, and then escorts the temperature with full PI control to the setpoint (Figure C.5). This process is reversed for falling temperature. In the great majority of applications this process leads to overshoot-free start-up and decreases the time needed to bring equipment into operation.

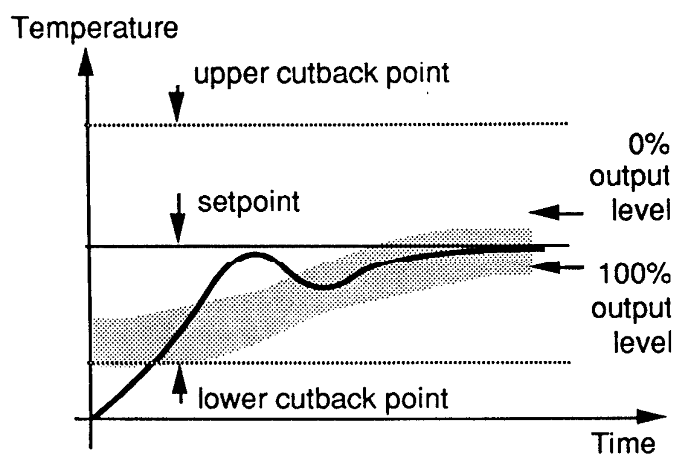


Figure C.5. Cutback operation.

If the parameter **Cb O** (cutback operation) is set to **Auto**, the high- and low cutback points are automatically determined by the **809** or **849** and set to a value three times the proportional band. If **Cb O** is set to **HAnd** (manual), the 2 cutback points can be freely and independently adjusted.

C.4 PROCEDURES

C.4.1 The closed-loop cycling method

There are several established techniques for tuning control loops. The one described here is the *closed-loop cycling* method first formally described in an article by J.G. Zeigler and N.B. Nichols[1].

Tuning with the Zeigler-Nicholls method requires forcing the system to oscillate. By placing a proportional-only controller (no integral term) in oscillation by setting the proportional band to a very small value, the control loop cycles with a characteristic frequency (Figure C.6). This characteristic frequency is a very accurate representation of the system's responsiveness and is used to derive the integral time constant.

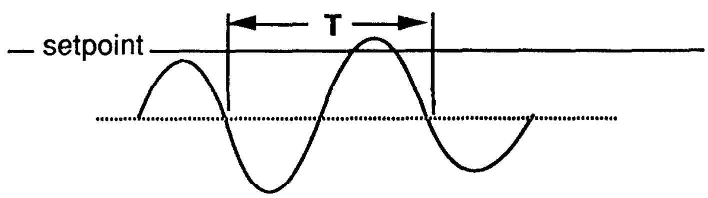


Figure C.6. Determining the period of oscillation, T, with the closed-loop cycling method.

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

The closed-loop cycling method is *not* recommended for those systems that cannot be made to oscillate conveniently or safely. For example, the cooling time of a well insulated oven may be several orders of magnitude greater than the heating time. Other systems simply cannot support wide thermal oscillations.

Before tuning a loop values should be assigned to the installation-dependent parameters listed in Table 5.2.

---

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

C.4.2 Procedure for tuning heat-only systems

- Set **Int.t** to maximum (8000 seconds).

- Reduce the value of **ProP** until the measured value oscillates. Measure the period of oscillation **T** as shown in Figure C.6.
- Widen the proportional band (increase the value of **ProP**) until the process is just slightly unstable. This value of **ProP** is called the point of *ultimate sensitivity* (**P**).

- Refer to Table C.1 for the values of **ProP** and **Int.t** to set into the controller. The value of **Int.t** must be greater than or equal to the value of **tt**.

Table C.1
Closed-loop Cycling Tuning Constants—4:1 decay ratio

	Proportional band **ProP**	Integral time constant **Int.t**
Proportional only (P)	2P	not applicable
Proportional and integral (PI)	2.2P	0.8T

C.4.3 Adjusting the cutback points

The cutback parameters are adjusted after the preceeding tuning procedure(s) have been performed. Note that low cutback affects the system only on start-up from cold and that high cutback comes into play only when there are major negative setpoint changes.

C.4.3.1 Use of automatic cutback

Automatic cutback operation (**Cb O** set to **Auto**) is recommended. No adjustment to the cutback points is necessary; they are automatically set by the controller to 3 times the value of **ProP**.

C.4.3.2 Manual adjustment of cutback parameters

Adjustment of cutback points **H cb** and **L cb** away from the pre-determined values may be indicated in some instances: well insulated heating zones (must widen cutback) and zones with high ambient cooling (must narrow cutback). For further details concerning cutback adjustment consult *Applications Note AN-PLAS-5: Control of overshoot in plastics-extruder barrel zones.* If these procedures do not work for a particular application, contact your nearest Eurotherm sales and service representative.

C.5 TROUBLESHOOTING PI TUNING

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

The first thing to do is to compare the period of oscillation (Figure C.6) to the integral time constant setting; the integral time constant should be at least as long as the period of oscillation. If the integral time constant is shorter than the period of oscillation, it should be increased to at least that value. If the loop continues to oscillate with the appropriate integral term, the proportional band should be increased to eliminate the oscillation.

APPENDIX D. INSTRUMENT REGISTER

This space is provided for recording of pertinant data about your Model **809/849** digital valve positioner controller. This information may be required when contacting Eurotherm Controls Inc concerning this instrument.

D.1 PRODUCT CODE

HARDWARE CODE

Model	*output*	*alarm*	*comms*	*input adapter*	*additional options*
/	/	/	/	/	/

CONFIGURATION CODE

config. type	*sensor*	*setpoint range*	*display units*	*alarm output*
(				)/

CALIBRATION CODE

input signal			***display range***		
lower limit	*upper limit*	*units*	*lower limit*	*upper limit*	*units*
[/	/	/	/	/	]

D.2 SERIAL NUMBER

order number	*line item number*	*incremental number*	*year*	*month*
-	-	-	-	

D.3 MANUFACTURING REVISION LEVEL

MANUFACTURING REVISION LEVEL

software	*hardware*

D.4 INSTALLATION INFORMATION

Date of installation ....

Location ....

....

D.5 INSTRUMENT CONFIGURATION AND PARAMETER SETUP

The following schedule is for archiving values assigned to the various instrument parameters.

Mnemonic	Parameter				
S P	Setpoint				
none	Inferred valve position				
C or F	Display units				

SETPOINT PROGRAMMING (OPTION QP)

Prog	Programmer state select and status annunciation				
S P	Base setpoint				
tunE	Tune on demand				
LC	Loop counter				
r1	1st ramp rate				
L1	1st dwell level				
d1	1st dwell time				
r2	2nd ramp rate				
L2	2nd dwell level				
d2	2nd dwell time				
Hb	Holdback band				

ALARM SETPOINTS

Hi Al	High alarm setpoint				
Lo Al	Low alarm setpoint				
d Al	Deviation alarm setpoint				

Mnemonic	Parameter				
CONTROL PARAMETERS					
ProP	Proportional band				
Int.t	Integral time constant				
tt	Motor travel time				
blSh	Mechanical backlash				
ct	Cycle time at 50% velocity				
inrt	Motor inertia time				
H cb	High cutback				
L cb	Low cutback				
SETPOINT LIMITS					
SP H	Setpoint high limit				
SP L	Setpoint low limit				
ALARM 1 OUTPUT					
H AO	High alarm output				
L AO	Low alarm output				
d AO	Deviation alarm output				
OUTPUT LIMIT					
SnbP	Sensor break motor velocity				
MEASURED VALUE ATTRIBUTES					
OFST	Calibration offset				
C F	°C/°F selection				

Mnemonic	Parameter				

INPUT SENSOR SELECTION

Sn	Sensor selection				

COMMUNICATIONS CONFIGURATION

Addr	Instrument address				
bAUd	Baud rate				

GENERAL CONFIGURATION

Idno	Identification number				
Ctrl	Control type				
SPrr	Setpoint ramping speed				
A H	Auto/manual enable				
CJC	CJC reference selection				
Pb d	Proportional band display				
PH-L	Proportional band scale factor				
t SU	Tune on start up				
Cb O	Cutback operation				

LINEAR PROCESS INPUTS

Act	Control action				
Hi L	High sensor break point				
Lo L	Low sensor break point				
Fil	Input filter constant				
Proc	Process scaling				

Continued from inside front cover.

GROUNDING

This instrument has internal circuits which are isolated or "floating." This is necessary to prevent the occurrence of a "ground loop" in signal circuits. To avoid possible shock hazards in the event of an internal fault causing breakdown of insulation, it is recommended that all equipment connected to this unit be enclosed in a grounded metal enclosure. Sheaths of thermocouples (or other sensors) should be properly grounded by a separate conductor (instead of being dependent on grounding via the machine framework).

ESD PRECAUTIONS

This instrument contains static sensitive components. Care should be taken to avoid electrostatic discharge (ESD) and thus reduce incidents of damage to the instrument when removed from its sleeve. Any manipulation of the instrument printed circuit boards should be performed on a conductive surface with the personnel in contact with the surface by means of a grounded, metal or conductive plastic wrist strap with a 1MΩ series resistor.

SUPPLY ISOLATORS

Every electrical system should be provided with means for isolating the system from the AC supply to allow safe working during repair and maintenance. SCRs and triacs are not adequate means of isolating the supply, and should always be backed by a suitable mechanical disconnect switch.

HAZARDOUS ATMOSPHERES

This unit is not suitable for use in areas subject to hazardous atmospheres. No Eurotherm product should be connected to a circuit which passes into or through a hazardous area unless appropriate precautions are taken (even though the instrument itself may be located in a safe area). Such an installation should conform to the requirements of the relevant Authority. (In the USA: Factory Mutual Research Corporation and Underwriters' Laboratories, Inc.).

PROCEDURE IN THE EVENT OF TROUBLE

Before beginning any investigation of a fault, the electrical supplies to all equipment concerned should be switched off and isolated. Units suspected of being faulty should be disconnected and removed to a properly equipped workshop for testing.