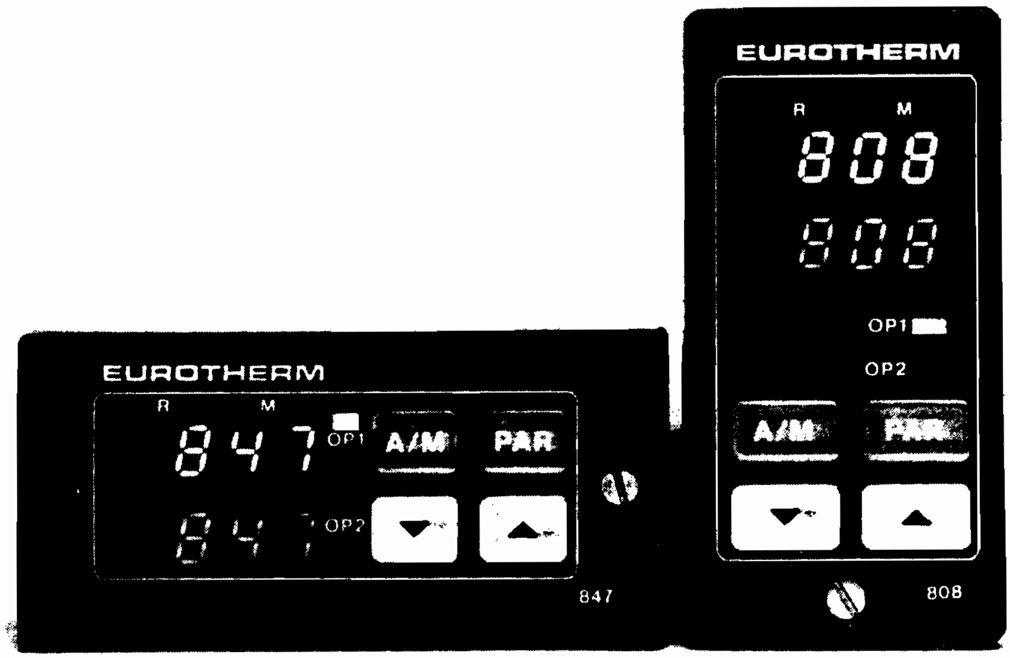
INSTALLATION AND OPERATION MANUAL

DOC. 1023-D

April 15, 1988

MODELS 808 AND 847 DIGITAL CONTROLLERS



EUROTHERM CORPORATION
A Eurotherm International Company
11485 Sunset Hills Road, Reston, Virginia 22090-5286

(703) 471-4870
Telex 89-9449
Facs (703) 437-3182

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MODEL 808/847 DIGITAL CONTROLLER

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Any significant modification since Revision C (November 30, 1987) is indicated by an arrow ⇨ in the margin.

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11485 Sunset Hills Road
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1. GENERAL

1.1 SCOPE

This manual contains information for the installation, operation, and configuration of the Models 808 and 847 Microprocessor-based Digital Controllers designed and manufactured in the USA by Eurotherm Corporation, 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) gasket kit for 1/8-DIN size instruments can be ordered separately. Order **KIT / 808NEMA3 / GASKET**.

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 forseen 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 808 or 847 Digital Temperature Controller
- Mounting hardware
- This manual

1.3.2 Product code

The Models 808 and 847 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 the appropriate table—Table 1.1, 1.2 or 1.3—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 **808** for vertical-profile controllers, or **847** 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 options **QL...**, 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: Temperature controller
(Additional option **QS** only)

Model	*HARDWARE CODE [1]* output 1	output 2	alarm	***options*** comms	additional options
808 or 847 /	/	/	/	/	/

CONFIGURATION CODE [1] config. type	sensor	setpoint range	display units	output 1	output 2	alarm output
(A						)/

HARDWARE CODE [1]

output 1 (heat) and output 2 (cool or alarm)

0	Not fitted	
D1	DC	*[2]*
L1	Logic	
R1	Relay	
T1	Triac	*[3]*

alarm

0	Not fitted
L1	Logic
R1	Relay

options

communications

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

additional options

0	None
QS	Self tuning

CONFIGURATION CODE [1]

configuration type [4]

A	Standard
@A	Non-standard

sensor input

Thermocouples		
J	Fe/SAMA constantan	*[5]*
K	Chromel™/Alumel™	
L	Fe/Konstantan (DIN)	*[5]*
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	

setpoint range [6]

	(°C)	(°F)	J	K	L	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					•	•		

display units [7]

C	Degrees Centigrade
F	Degrees Fahrenheit

output 1 (Heat)

1	Slow cycle	*[8]*
2	Fast cycle	*[9]*
3	0-20mA	*[10]*
4	4-20mA	*[10]*
5	ON/OFF	*[11]*

output 2 (Cool or Alarm)

0	OFF	
1	Water cooling	
2	Oil cooling	
3	Fan cooling	
4	Full scale low alarm	*[12]*
5	Full scale high alarm	*[12]*
6	Deviation band alarm	*[12]*

alarm output [13]

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

NOTES:

1. *The complete Product Code consists of both the Hardware and the Configuration Codes.*
2. *DC analog output module not available on Output 2.*
3. *Triac output module not available on Output 2 when used as second alarm output.*
4. *Standard: selections from this page. Non-standard: configurations requiring other parameter combinations or hardware modifications. Call your nearest Eurotherm sales and service representative.*
5. *Selection of setpoint range* **D** *with type J or L thermocouple invokes tenths' precision display.*
6. *These are preconfigured setpoint limits only; the input sensor is always linear over the entire range given in the Input Sensors table.*
7. *Units for all adjustable temperature parameters.*
8. *Available only with hardware modules* **L1**, **R1** *and* **T1**.
9. *Available only with hardware modules* **L1** *and* **T1**.
10. *Available only with hardware module* **D1**.
11. *Output 2 must be configured as Alarm 2 or OFF. Not available with hardware module* **D1**.
12. *Alarms are non-latching. Alarm state affirmed by energized output.*
13. *Alarms are non-latching. Alarm state affirmed by de-energized output.*

Table 1.2
Product Code: Programmer/controller
(Additional options **QP** and **QPS**)

HARDWARE CODE [1]

Model	*output 1*	*output 2*	*alarm*	*comms* (*options*)	*additional options* (*options*)
808 or 847 /	______ /	______ /	______ /	______ /	QP... /

CONFIGURATION CODE [1]

config. type	*sensor*	*setpoint range*	*display units*	*output 1*	*output 2*	*alarm output*
(A	______	______	______	______	______	______)/

HARDWARE CODE [1]

output 1 (heat) and output 2 (cool or alarm)

0	Not fitted	
D1	DC	[2]
L1	Logic	
R1	Relay	
T1	Triac	[3]

alarm

0	Not fitted
L1	Logic
R1	Relay

options

communications

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

additional options [4]

QP	Setpoint programming
QPS	Setpoint programming with self tuning

CONFIGURATION CODE [1]

configuration type [5]

A	Standard
@A	Non-standard

sensor input

Thermocouples		
J	Fe/SAMA constantan	[6]
K	Chromel™/Alumel™	
L	Fe/Konstantan (DIN)	[6]
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	

setpoint range [7]

	(°C)	(°F)	J	K	L	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					•	•		

display units [8]

C	Degrees Centigrade
F	Degrees Fahrenheit

output 1 (heat)

1	Slow cycle	[9]
2	Fast cycle	[10]
3	0-20mA	[11]
4	4-20mA	[11]

output 2 (cool or alarm)

0	None	
1	Water cooling	
2	Oil cooling	
3	Fan cooling	
4	Full-scale low alarm	[12]
5	Full-scale high alarm	[12]
6	Deviation band alarm	[12]

alarm output [13]

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

NOTES:

1. *The complete Product Code consists of both the Hardware and the Configuration Codes.*
2. *DC analog output module not available on Output 2.*
3. *Triac output module not available on Output 2 when used as second alarm output.*
4. *Minimum additional option of* **QP** *must be specified .*
5. *Standard: selections from this page. Non-standard: configurations requiring other parameter combinations or hardware modifications. Call your nearest Eurotherm sales and service representative.*
6. *Selection of setpoint range* **D** *with type J or L thermocouple invokes tenths' precision display.*
7. *These are preconfigured setpoint limits only; the input sensor is always linear over the entire range given in the Input Sensors table.*
8. *Units for all adjustable temperature parameters.*
9. *Available only with hardware modules* **L1**, **R1** *and* **T1**.
10. *Available only with hardware modules* **L1** *and* **T1**.
11. *Available only with hardware module* **D1**.
12. *Alarms are non-latching. Alarm state affirmed by energized output.*
13. *Alarms are non-latching. Alarm state affirmed by de-energized output.*

Table 1.3
Product Code: Controller or programmer/controller with linear inputs (Additional options **QL**, **QLP**, **QLS**, and **QLPS**)

HARDWARE CODE [1]

Model	*output 1*	*output 2*	*alarm*	*options: comms*	*options: input adapter*	*options: add'l options*
808 or 847	/	/	/	/	/	/ QL...

CONFIGURATION CODE [1]

config. type	*sensor*	*setpoint range*	*display units*	*output 1*	*output 2*	*alarm output*
/(A	X	X	X			)

CALIBRATION CODE [1]

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

HARDWARE CODE [1]

output 1 (heat) and output 2 (cool or alarm)

0	Not fitted	
D1	DC	[2]
L1	Logic	
R1	Relay	
T1	Triac	[3]

alarm

0	Not fitted
L1	Logic
R1	Relay

options

communications

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

input adapter [4]

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/8.33mV resolution
IAA02	-4 to +20mA/0.667µA resolution

additional options [5]

QL	Linear input
QLP	Linear input with setpoint programming
QLS	Linear input with self tuning
QLPS	Linear input, setpoint programming and self tuning

CONFIGURATION CODE [1]

configuration type [6]

A	Standard
@A	Non-standard

sensor input

X	Linear process or diff. temp. input

setpoint range

X	Linear process or diff. temp. input

display units

X	Linear process or diff. temp. input

output 1 (Heat)

1	Slow cycle	[7]
2	Fast cycle	[8]
3	0-20mA	[9]
4	4-20mA	[9]
5	ON/OFF	[10]

output 2 (Cool or Alarm)

0	None	
1	Water cooling	
2	Oil cooling	
3	Fan cooling	
4	Full scale low alarm	[11]
5	Full scale high alarm	[11]
6	Deviation band alarm	[11]

alarm output [12]

0	None
4	Full scale low alarm
5	Full scale high alarm
6	Deviation band alarm

CALIBRATION CODE [1]

input signal [13]

lower limit

upper limit

units

mV	Millivolts
V	Volts
mA	Milliamps

display range

lower limit [14]

upper limit [14]

units [15]

NOTES:

1. *The complete Product Code consists of the Hardware, Configuration, and Calibration Codes.*
2. *DC analog output module not available on Output 2.*
3. *Triac output module not available on Output 2 when used as second alarm output.*
4. *Dynamic range of input adapter must be greater than or equal to that of the input signal.*
5. *Minimum additional option of* **QL** *must be specified.*
6. *Standard: selections from this page. Non-standard: configurations requiring other parameter combinations or hardware modifications. Call your nearest Eurotherm sales and service representative.*

7. *Available only with hardware modules* **L1**, **R1** *and* **T1**.
8. *Available only with hardware modules* **L1** *and* **T1**.
9. *Available only with hardware module* **D1**.
10. *Output 2 must be configured as Alarm 2 or OFF. Not available with hardware module D1. Setpoint programming and ON/OFF control are mutually exclusive and cannot be configured or utilized together.*
11. *Alarms are non-latching. Alarm state affirmed by energized output.*
12. *Alarms are non-latching. Alarm state affirmed by de-energized output.*
13. *Lower and upper limits must be within the bounds of the selected input adapter and the units must agree. Specify up to 4 significant figures.*
14. *Display units must be within either –99.9 to 999.9 or –999 to 9999.*
15. *Write in display units. Use only the letters* **A** *to* **Z** *and* **a** *to* **z**. *For reference only; not displayed on front panel.*

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 Corporation 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 Corporation 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.

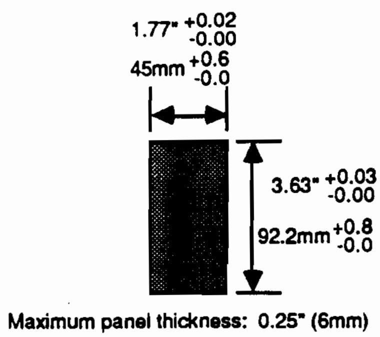


Figure 2.1. Panel cutout.

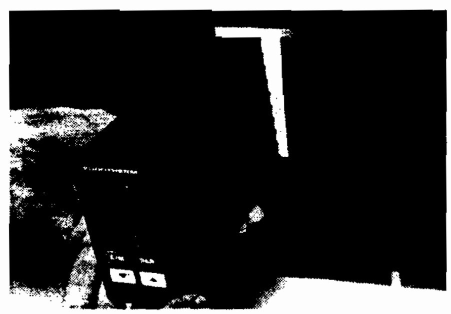


Figure 2.2. Installing instrument from front of panel into prepared cutout.

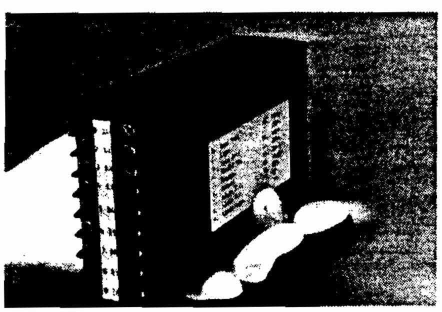


Figure 2.3. View from rear side of panel.

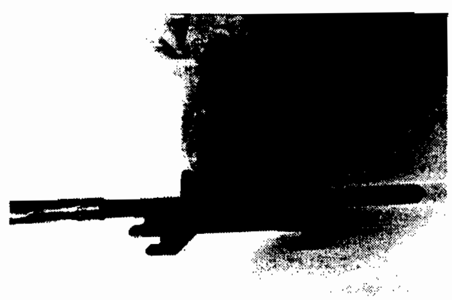


Figure 2.4. One of the 2 sleeve mounting brackets.

Figure 2.5. Installation of mounting bracket.

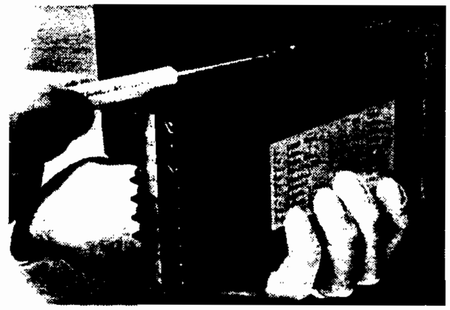


Figure 2.6. Tightening mounting bracket.

2.2 MULTIPLE INSTALLATIONS

The Models **808** and **847** 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 **847** cutouts to allow room for the mounting brackets.

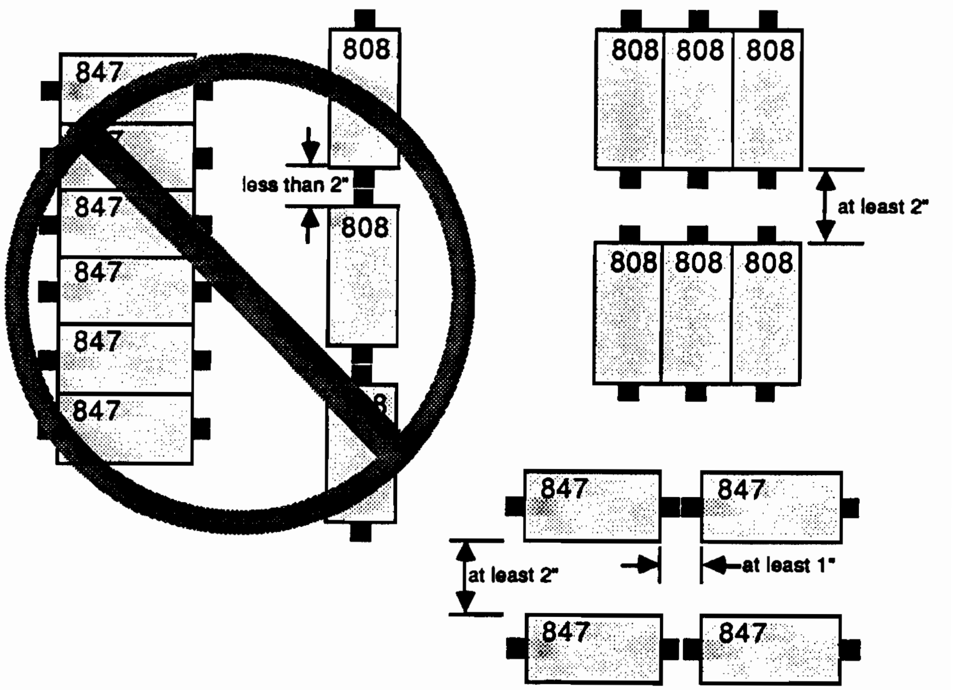


Figure 2.7. Multiple installation configurations to be discouraged (left), and suggested installation configurations (right).

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,**
- **Output 1 and output 2 power 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.

CAUTION! Damage to the instrument can result if output channels fitted with logic or DC output modules are wired as if they were fitted with triac or relay modules.

NOTE! Output 1 (terminals 1 and 2), Output 2 (terminals 3 and 4) and the 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 Tables 1.1 through 1.3.

- 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 3.6 for rear terminal designations and for wiring the power, outputs, and signal inputs.

- 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.

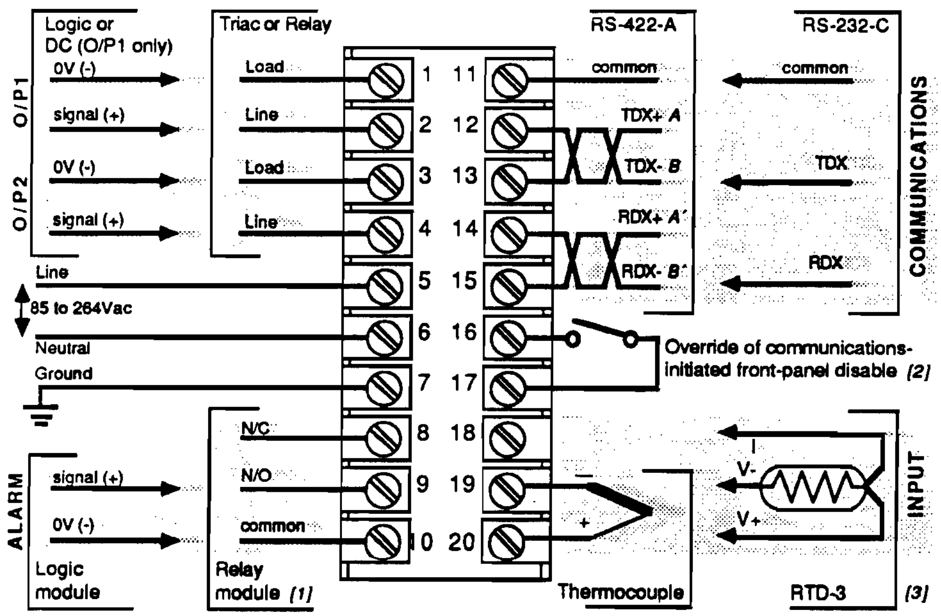


Figure 3.1. Models 808 and 847 external connections.

NOTES

1. *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.*
2. *The logic input is also used for the setpoint programming option if it is installed.*
3. *The linear input option may require the addition of an input adaptor.*

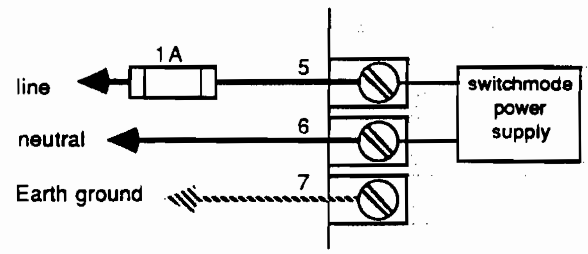
3.2 POWER AND GROUND (terminals 5, 6, and 7)

The instrument may be powered from an AC voltage between 85 and $264V_{ac}$, 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 (0.5mm^2); 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 85-264Vac 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).*

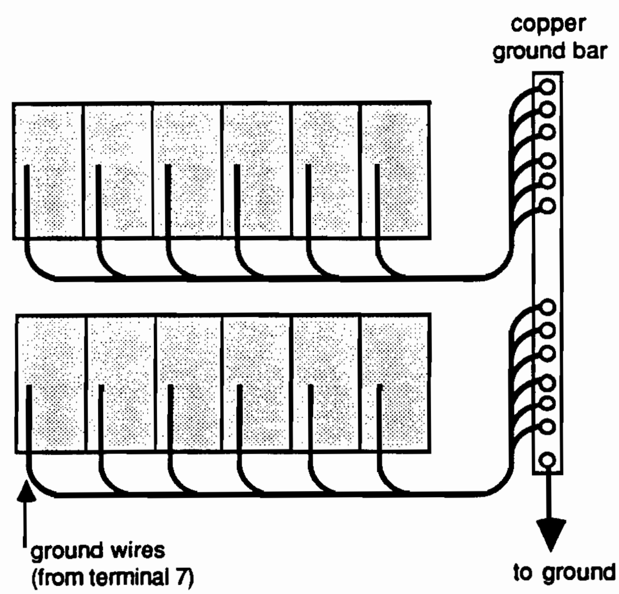


Figure 3.2. Recommended method of grounding multiple controller installations.

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):

- **logic output module [on O/P1 (terminals 1 and 2) and O/P2 (terminals 3 and 4)],**

- **DC output [on O/P1 (terminals 1 and 2)],**
- **thermocouple or RTD input (terminals 18 through 20),**
- **logic input (terminals 16 and 17).**

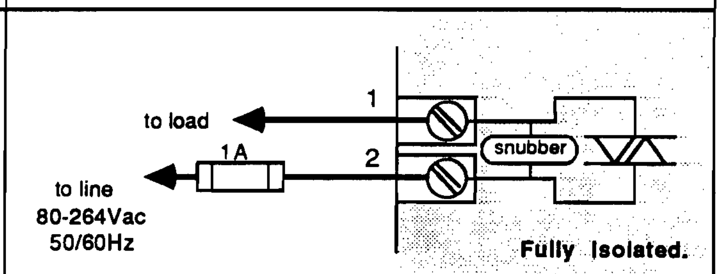
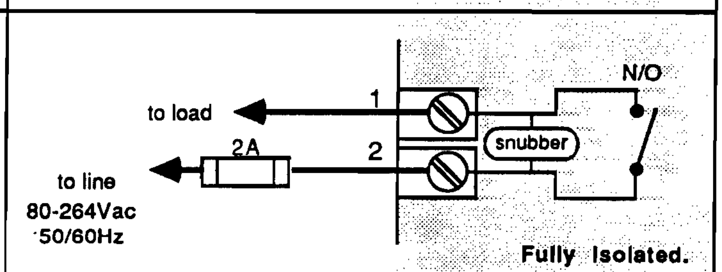
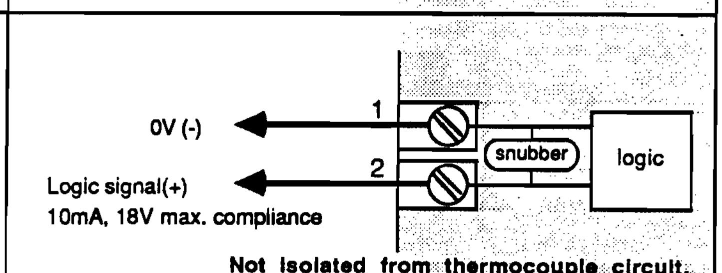
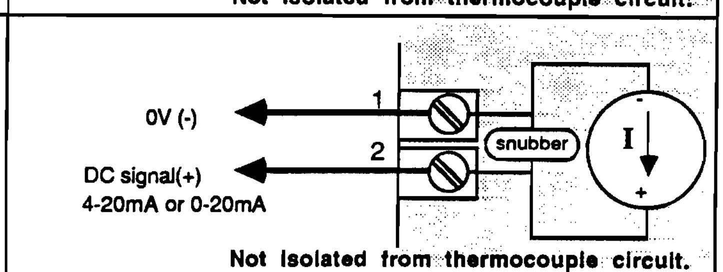
All input and output signals connected to these terminals must be isolated from one another. If any 2 of the above circuits become connected to each other externally to the controller, damage to the controller will result.

3.3 OUTPUT 1 (terminals 1 and 2)

Four different output module types can be fitted into the Output 1 channel: triac (T1), relay (R1), logic (L1), and DC (D1). Verify the "Output 1" code in the Hardware Code (Table 1.1, 1.2 or 1.3) and the label on the side of the instrument.

The external connections depend on what type of output module is installed. See Table 3.2 for connection details.

Table 3.2
Output 1 Wiring
Terminals 1 and 2

Function	External connections	Terminals	Internal device
Triac (T1) Internal connection between terminals is made during ON phase of output cycle (yellow OP1 lamp ON).			
Relay (R1) Relay contact is closed during ON phase of output cycle (yellow OP1 lamp ON).			
Logic (L1) Logic signal goes high during ON phase of output cycle (yellow OP1 lamp ON). Suitable for SSC inputs.			
DC (D1)			

3.4 OUTPUT 2 (terminals 3 and 4)

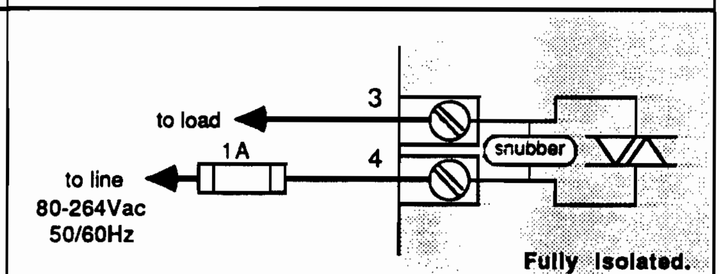
Three different output module types can be fitted into the Output 2 channel: triac (T1), relay (R1), and logic (L1). Verify the "Output 2" code in the Hardware Code (Table 1.1, 1.2 or 1.3) and the label on the side of the instrument.

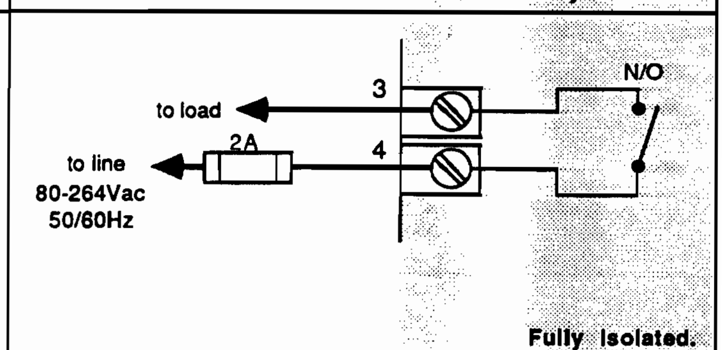
Output 2 is configurable as either the Cool channel or the Alarm 2 channel. If it is configured as an alarm channel (see the Configuration Code in Table 1.1, 1.2 or 1.3), the output module should not be a triac.

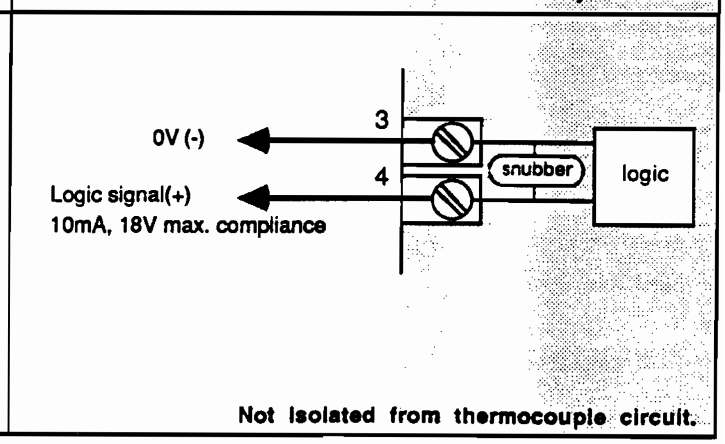
WARNING! Output 2 configured as an alarm channel is not failsafe: the output device is activated during the alarm condition. It is not intended to be used as the sole alarm device in a system. For failsafe operation, use the Alarm Output.

The external connections depend on what type of output module is installed. See Table 3.3 for connection details.

Table 3.3
Output 2 Wiring
Terminals 3 and 4

<table>
<tr><th>Function</th><th>External connections / Terminals / Internal device</th></tr>
<tr><td>Triac (T1)—Cool channel only.
Internal connection between terminals is made during ON phase of output cycle (yellow OP2 lamp ON).</td><td>
</td></tr>
<tr><td>Relay (R1)—Cool channel:
Relay contact is closed during ON phase of output cycle (yellow OP2 lamp ON).

Alarm 2 output:
Not failsafe—relay is energized (contact closed, yellow OP2 lamp ON) during alarm condition.</td><td>
</td></tr>
<tr><td>Logic (L1)—Cool channel
Logic signal goes high during ON phase of output cycle (yellow OP2 lamp ON). Suitable for SSC inputs.

Alarm 2 output:
Not failsafe—logic signal goes high during alarm condition (yellow OP2 lamp ON). Signal is low during non-alarm condition.</td><td>
</td></tr>
</table>

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

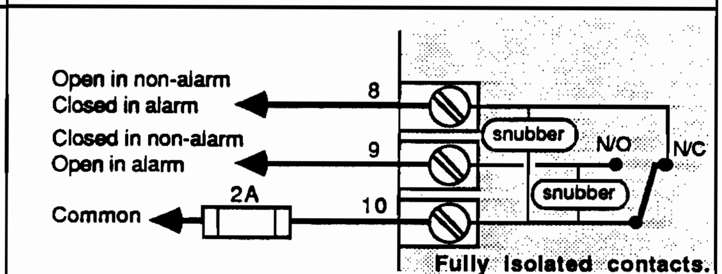
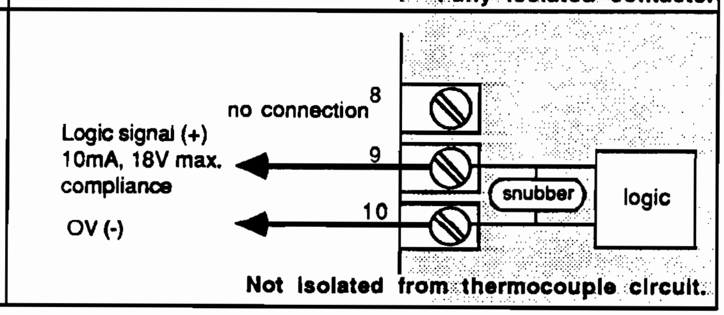
Two different module types can be fitted into the Alarm channel: relay (R1) and logic (L1). Verify the "Alarm" code in the Hardware Code (Table 1.1, 1.2 or 1.3) and the label on the side of the instrument. See Table 3.4.

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 never 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 Model 106 or equivalent and a separate input sensor.

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

Table 3.4
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.	

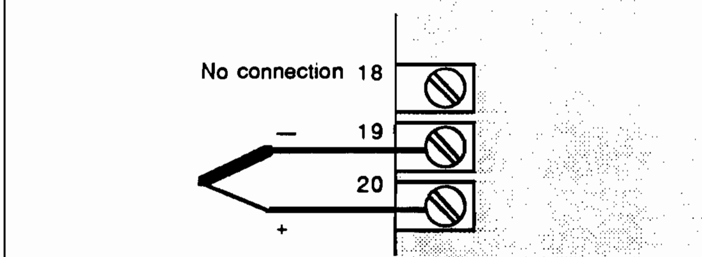
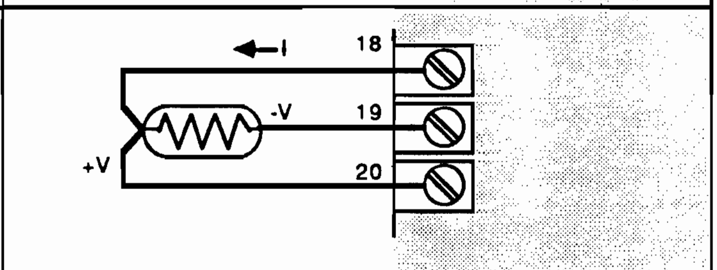
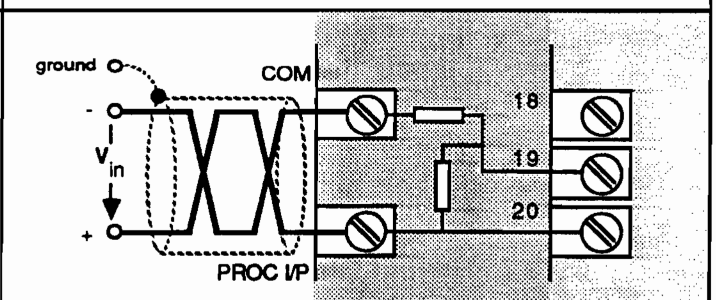
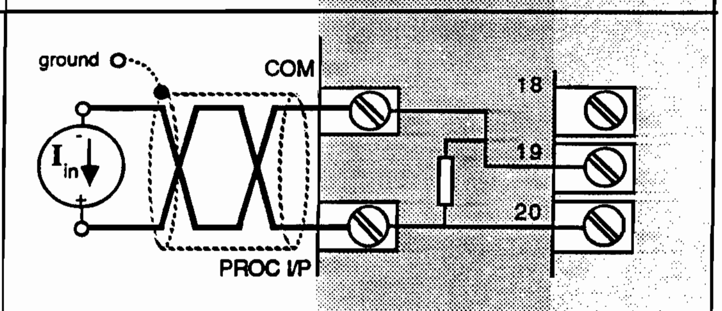
3.6 INPUT (terminals 18, 19, and 20)

The instrument accepts thermocouple and RTD inputs. With option **QL...** both low-level and linear process signals are accomodated. For the types and ranges of the input sensors, see the *Specifications.*

3.6.1 Thermocouple input

- Connect to terminals 19(-) and 20(+) as shown in Table 3.5.
- 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.

Table 3.5
Input Wiring
Terminals 18, 19, and 20

Sensor	External connections / Terminals
Thermocouple	
RTD, 3-wire connection	
Signal type (options QL... only)	**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	

3.6.2 RTD input

- Refer to Table 3.5 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.*

3.6.3 Linear input option QL...

3.6.3.1 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.

3.6.3.2 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.

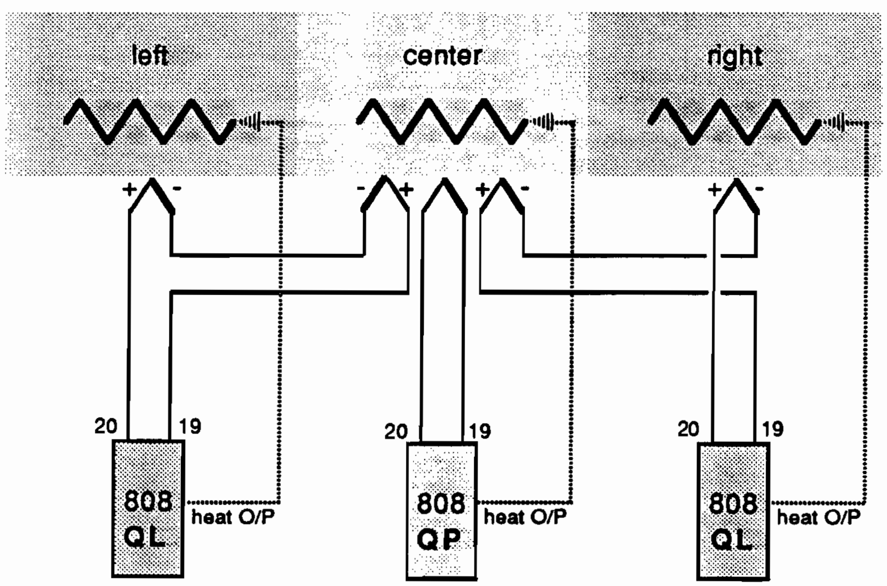


Figure 3.3. Input connections for differential temperature control (thermocouple bucking).

3.7 COMMUNICATIONS OPTION (terminals 11 through 17)

Verify on the instrument label and the Hardware Code in the appropriate Table 1.1 through 1.3 if the EIA 232-C or the EIA 422-A communications board is installed.

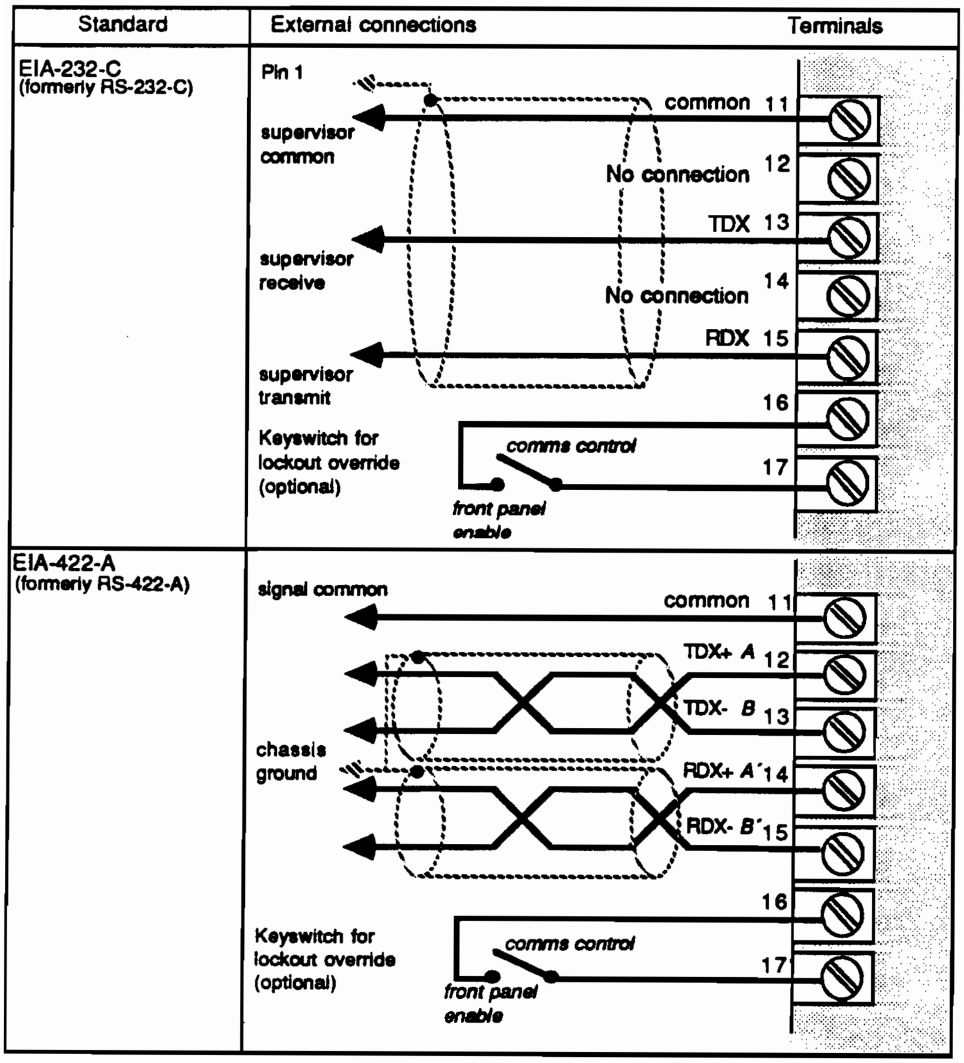
3.7.1 EIA-232-C

Refer to Table 3.6 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).

3.7.2 EIA 422-A

Refer to Table 3.6. Use Belden #8777 or similar (3 twisted pairs separately shielded, 22 gauge, stranded). Attach the shields to the chassis ground at the supervisor-end of the link. Limit cable length to 4000 feet (1200m).

Table 3.6
Communications Wiring
Terminals 11 through 17



3.7.3 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.

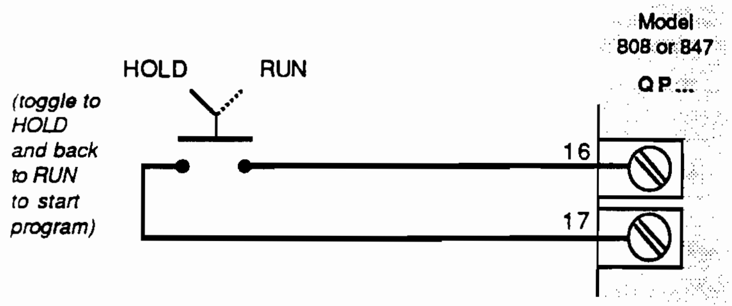
If either of the communications boards is not installed, then no connection need be made to terminals 16 and 17.

[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 section 3.8 for wiring these terminals in this case.]

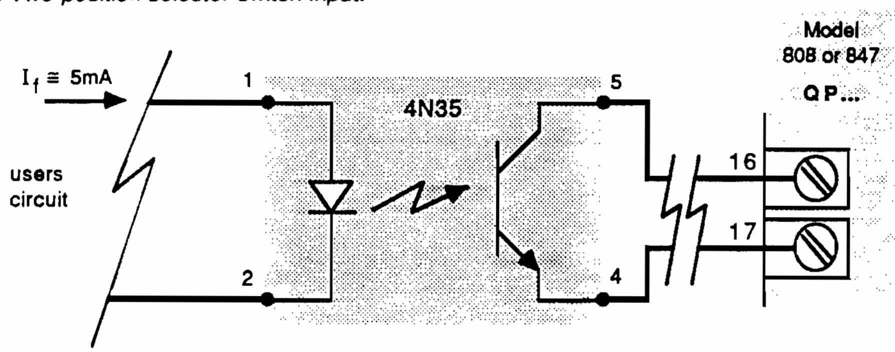
3.8 SETPOINT PROGRAMMING OPTION QP... (terminals 16 and 17)

Verify on the instrument label and the Hardware Code in the appropriate Table 1.1 through 1.3 if the setpoint programming option **QP...** is included among the firmware options.

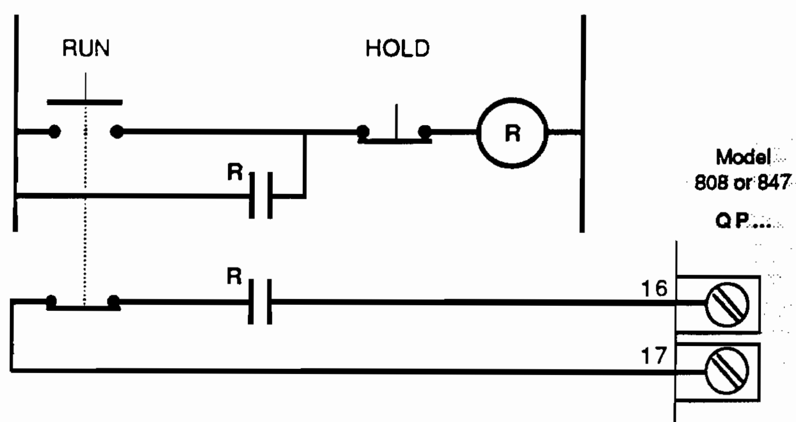
By means of making and breaking the external connection between terminals 16 and 17, the setpoint programmer can be placed into the RUN or HOLD state. There are several connections possible for interfacing to pushbuttons. selector switches, relay contacts or opto-couplers; these are shown in Figure 3.4.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

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.

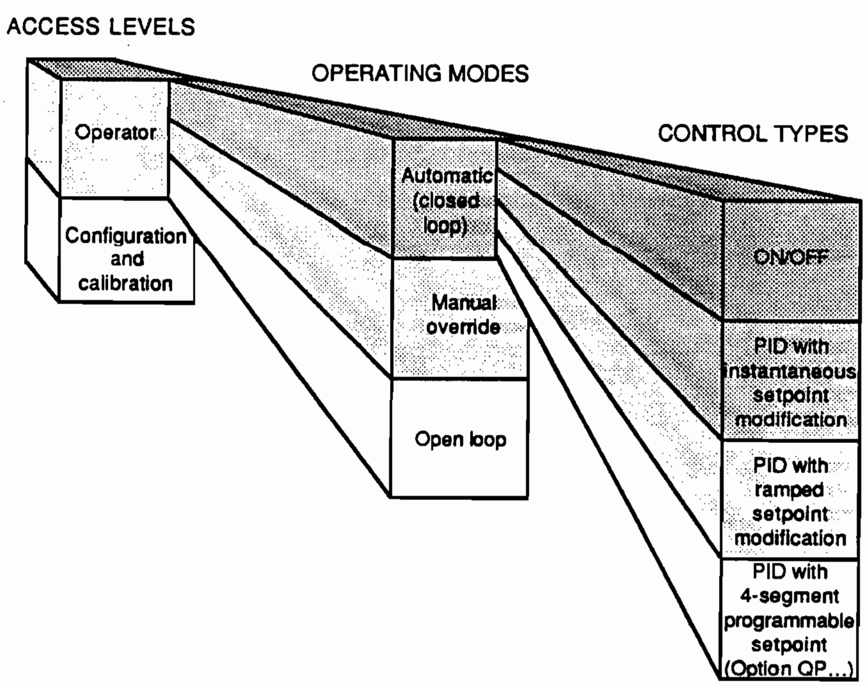


Figure 4.1. Organization of user environment.

◦ 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 (heat only).
- PID control with instantaneous setpoint modification
- PID control with ramped setpoint modification (rate limiting for loads sensitive to thermal shock)
- PID 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.

4.2.1.2 Output lights

◦ **OP1 and OP2**

• Each yellow LED is illuminated when the corresponding output channel is ON.

• When Output 1 is fitted with a DC output module, the intensity of lamp OP1 varies directly with the magnitude of the output signal.

Note! **When Output 1 is fitted with a DC output module and is configured for a 4-20mA output signal, the OP1 LED glows dimly as a 4mA signal is being supplied for a 0% output demand.**

• When Output 2 is configured as an alarm channel (AL2), lamp OP2 is illuminated when AL2 has switched into the alarm condition.

◦ **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.

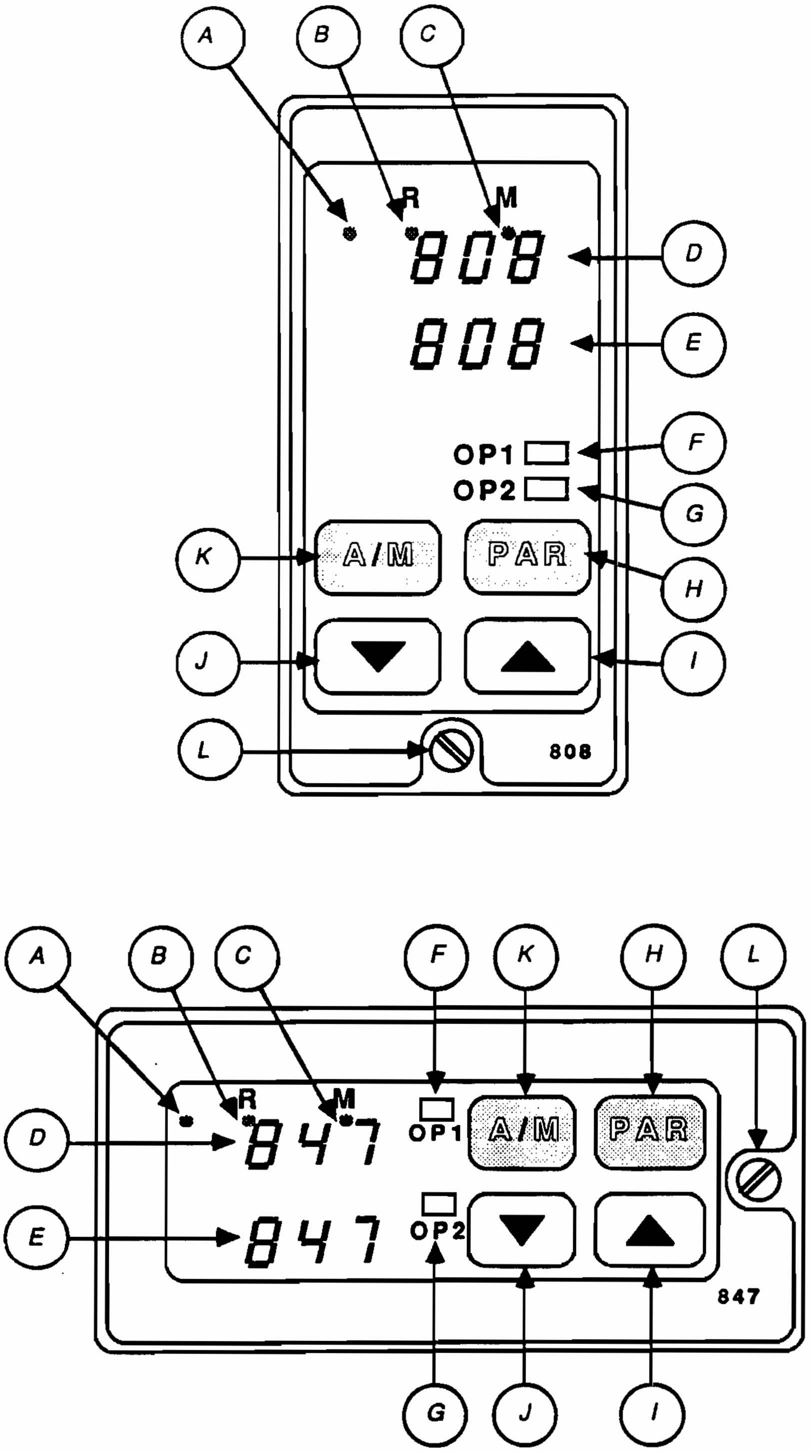


Figure 4.2. Front panels of models 808 and 847 temperature controllers.

A. Communications transmission in progress light.
B. Ramp-to-setpoint in progress light.
C. Manual mode active light.
D. Upper LED display.
E. Lower LED display.
F. Output 1 energized light.
G. Output 2 energized light.
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.

◦ **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.

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 percent power output is the parameter modified by this same procedure; its upper limit may have a ceiling placed on it by H PL (high power limit).

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 option QL... and 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.

4.3.2 Additional procedures for manual mode

With PID 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 percent output level in the lower display. When entering the manual mode from automatic, the initial output level is the most recent calculated output level. 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

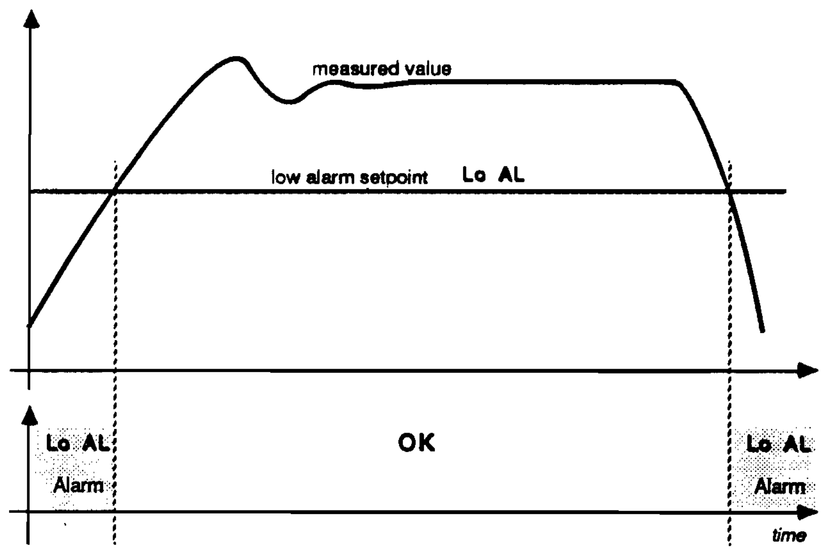
During ramping, the upper display shows the measured value (as in normal, automatic or manual operation); the lower display shows the target setpoint. During ramping segments the "R" lamp is illuminated. After the new target setpoint has been reached, the lamp goes out. To view the instantaneous setpoint 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

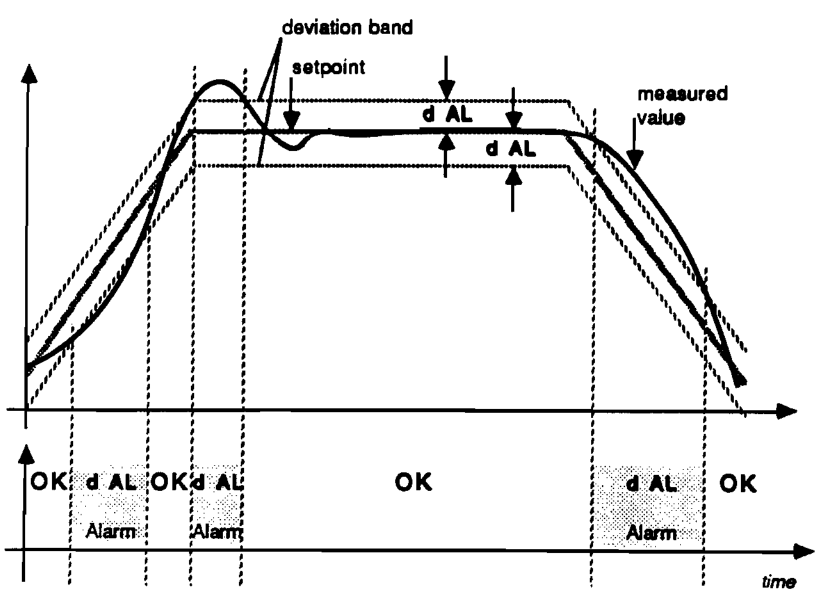
If the measured value follows a ramping setpoint through an alarm region, the alarms are detected, annunciated, and output as usual. As shown in Figure 4.3, two types of behavior are to be noted:

- **"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.

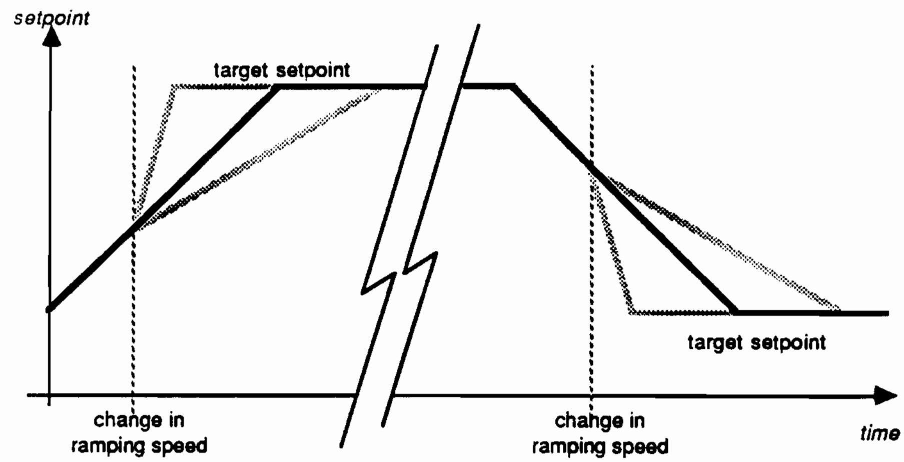
Figure 4.3. Ramp-to-setpoint operation and alarms.

4.3.3.3 Modification of ramping parameters

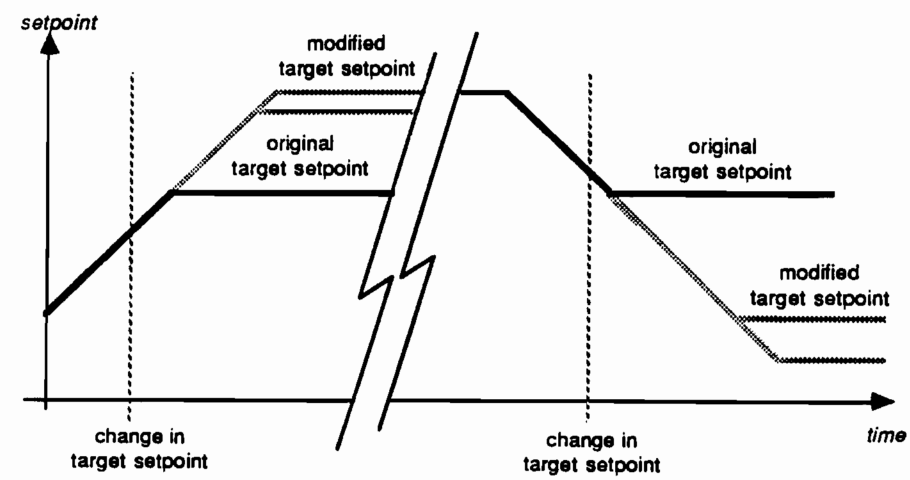
If the target setpoint or the ramping speed are changed in mid-progress of a ramp segment, the effects on the instantaneous setpoint are immediate as shown in Figure 4.4.

- **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.



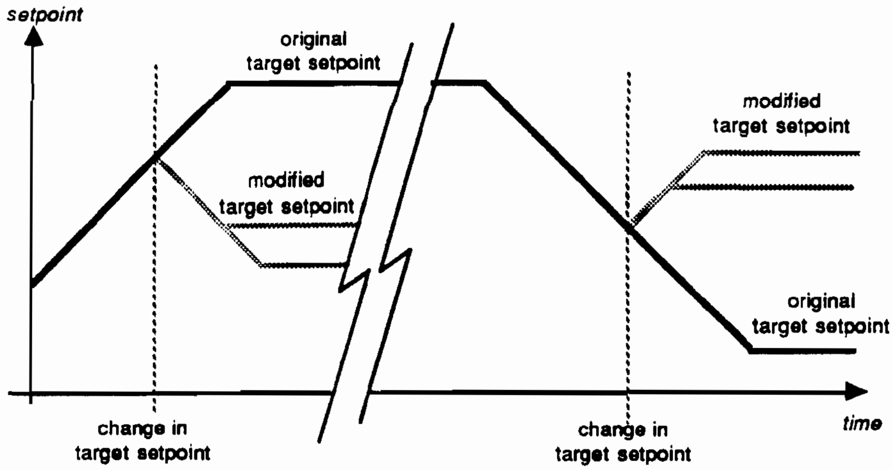
A. Change in ramping speed.



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

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

Original trajectory *Possible modified trajectories*



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

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

Original trajectory — *Possible modified trajectories*

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, <u>and</u> 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 <u>not</u> flash.]
- When AL2 annunciates an alarm condition, the yellow OP2 lamp is illuminated.

Alarm 1

Upper display flashes

if

LAt *or* nLat is selected at H AO, L AO *and/or* d AO

and if

an alarm condition exists on the measured value input.

Alarm 2

Output light OP2 is lit

if

L Hi, n Hi, L Lo, n Lo, L dA *or* n dA is selected at OP2

and if

an alarm condition exists on the measured value input.

A. Annunciation of Alarm 1 and Alarm 2 output conditions.

Alarm 1 and Alarm 2

Lower display alternately flashes

Hi AL

Lo AL

and/or

d AL

with setpoint display

If

the measured value crosses at least one threshold set at

Hi AL

Lo AL

and/or

d AL

B. Annunciation of alarm input condition.

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.

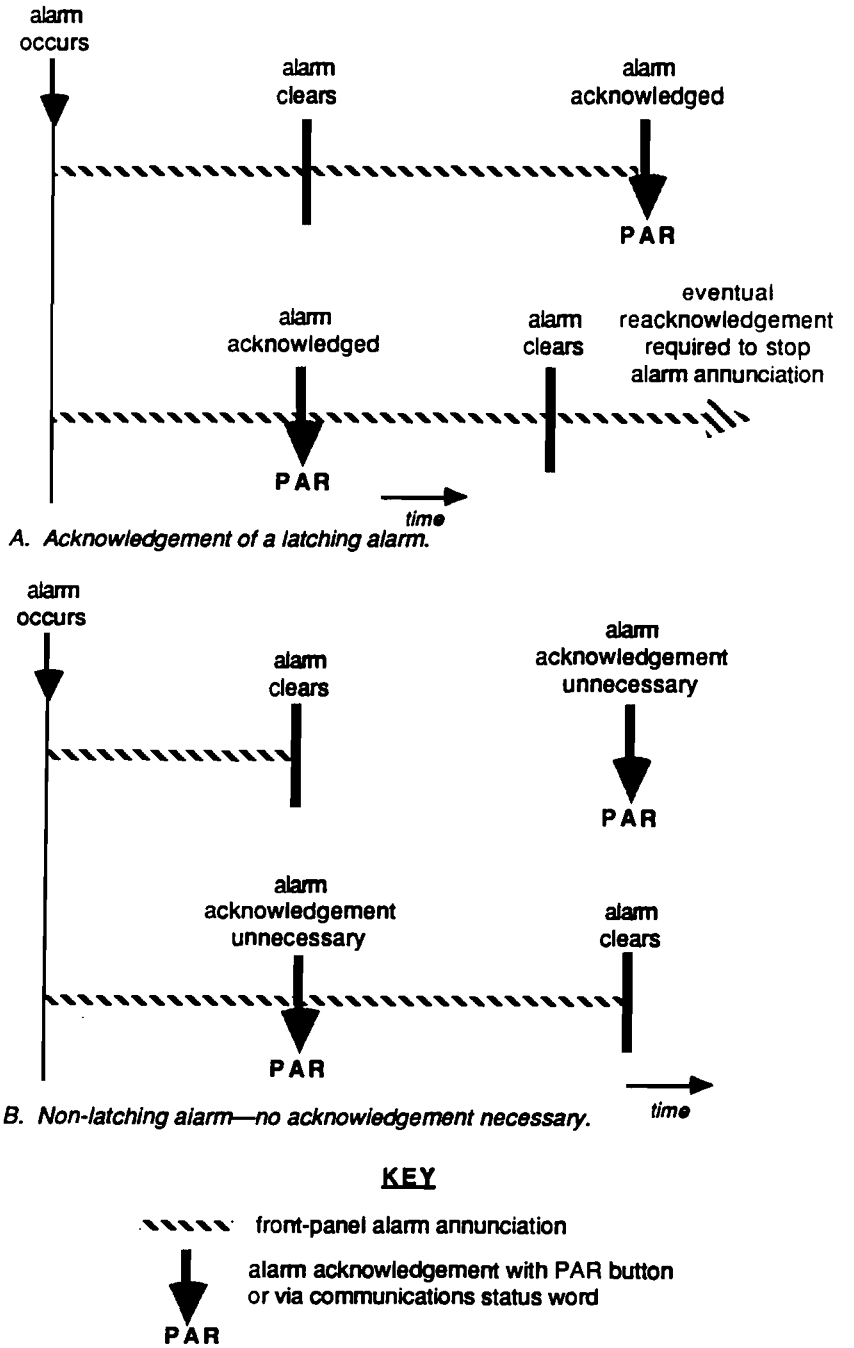


Figure 4.6. Alarm acknowledgement scenarios: latching and non-latching alarms

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 u r (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 Corporation for repair and inspection.

5. CONFIGURATION AND CALIBRATION

There are over 30 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. Synthetic and natural fibers that tend to harbor static electricity—nylon, wool, etc.—should not be worn.

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.

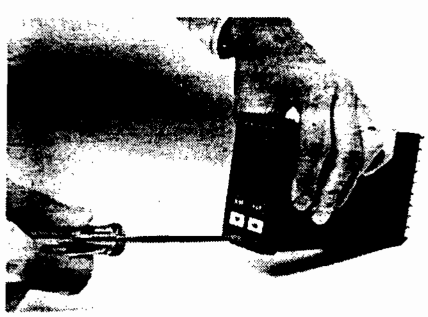


Figure 5.1. Removal of instrument from sleeve.

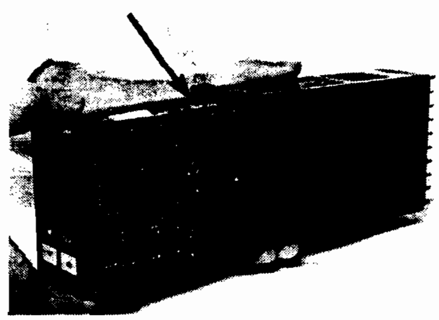


Figure 5.2. Location of configuration switch.

5.2 CONFIGURATION PROCEDURE

5.2.1 Verification of hardware/configuration parameter compatibility

Not all the signal types generated by the controller can drive any output module, and not all output modules are suited for all applications. Refer to Table 5.1 to see what combinations of configuration parameters are possible for a particular set of output modules.

Table 5.1
Configuration/Output Module Compatibility

	CRITICAL CONFIGURATION PARAMETERS					
	OUTPUTS					ALARM 1
	OP 1		OP 2			
	Time proportioned	DC output	Cool	Alarm 2	Digital	H AO L AO d AO
	tP Ptb	4-20 0-20	FAn OIL H2O 0.5	L Hi n Hi L Lo n Lo L dA n dA	On	
OUTPUT MODULES						
Triac (T1)	●		●		●	
Logic (L1)	●		●	●	●	●
Relay (R1) (If H c.t & C c.t ≥ 5s)	●		●	●	●	●
DC (D1)		●				

● = permissible combination of configuration parameter and output module

5.2.2 Configuration parameters

All parameters are presented in Table 5.2 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. C c.t (cool cycle time) disappears if there is no cool channel selected. Other parameters appear only if firmware options **QL...**, **QP...** or **QS** have 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.

NOTE! **Complete reconfiguration of the instrument is facilitated if selections are made first for sensor type Sn, control type Ctrl, output 1 OP1, and output 2 OP2. Fixing these values from the beginning determines the presence or absence of the remaining parameters in the scroll list.**

Table 5.2
Complete Parameter List: Part 1

Normal display
Setpoint programming option **QP...**
Self-tuning option **QS**

Mnemonic	Parameter	Adjustable range	Standard Value(s)	Comments
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".
none	Output level setpoint	-99.9 to +100.0% (heat/cool) 0.0 to 100.0% (heat only)		Displayed only in manual without mnemonic. ("M" dot is lit.)
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 appear only if "Prog" is selected at "Ctrl".
The "tune" mnemonic appears only with the self-tuning option "QS."

Mnemonic	Parameter	Adjustable range	Standard Value(s)	Comments
Prog	Programmer state select and status annunciation	Program in standby **idle** Program running **run** Program in hold **hold**	idle	
SP	Base setpoint	Upper limit: "SP H" Lower limit: "SP L"	70°F (25°C)	
tunE **	Tune on demand	**OFF** **on**	OFF	Appears only if option "QS" installed.
LC	Loop counter	1-200 plus "cont" (continuous) *	1	
r1	1st ramp rate	0.01-99.99 units/min.	10.00°/min.	
L1	1st dwell level	Input sensor range	70°F (25°C)	
d1	1st dwell time	0-9999min.	1min.	
r2	2nd ramp rate	0.01-99.99 units/min.	10.00°/min.	
L2	2nd dwell level	Input sensor range	70°F (25°C)	
d2	2nd dwell time	0-9999min.	1min.	
Hb *	Holdback band (units' precision)	1-9999 (units' precision) 1 to 3600°F 1 to 9999 units	100° or units	Appears if "Prog" or "r SP" is selected.
	Holdback band (tenths' precision)	0.1 to 500.0°C 0.1 to 900.0°F 0.1 to 999.9 units		

Table 5.2
Complete Parameter List: Part 2

Alarm setpoints
Control Parameters

Mnemonic	Parameter	Adjustable range	Standard Value(s)	Comments
ALARM SETPOINTS				
Hi Al	High alarm setpoint	Input sensor range	setpoint high limit	
Lo Al	Low alarm setpoint	Input sensor range	setpoint low limit	
d Al	Deviation alarm setpoint (units' precision)	1 to 2000°C 1 to 3600°F 1 to 9999 units	30°C (50°F)	
	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%)	40°C (60°F) for "Pid", "r SP" and "Prog" 3°C (5°F) hysteresis for "On.Off"	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.
	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	OFF plus 1 to 8000s	360s	Disappears if "On.Of" selected at "Ctrl".
dEr.t	Derivative time constant	OFF plus 1 to 999s	60s	Disappears if "On.Of" selected at "Ctrl".
rEL.C	Relative cool gain	0.1 to 10.0	0.5 (water cooling) 1.0 (oil cooling) 2.0 (fan cooling)	Disappears if "OFF" or any alarm selected at "OP 2", or if "On.Of" selected at "Ctrl". Parameter is output-module dependent.
H c.t	Heat cycle time	0.3 to 80.0s	20.0s (slow cycle) 0.3s (fast cycle)	Disappears if "0-20" or "4-20" selected at "OP1", or if "On.Of" selected at "Ctrl". Parameter is output-module dependent.
C c.t	Cool cycle time	0.3 to 80.0s	20.0s	Disappears if "OFF" or any alarm selected at "OP 2", or if "On.Of" selected at "Ctrl". Parameter is output-module dependent.
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".
	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".

Table 5.2
Complete Parameter List: Part 3

Setpoint limits
Alarm 1 output
Output power limits
Measured value attributes

Mnemonic	Parameter	Adjustable range		Standard Value(s)	Comments
SETPOINT LIMITS					
SP L	Setpoint low limit	Input sensor range			Must be > "SP L"
SP H	Setpoint high limit	Input sensor range			Must be < "SP H"
ALARM 1 OUTPUT					
H AO	High alarm output	Latched Non-latched Off	LAt nLAt OFF		Parameter is output-module dependent.
L AO	Low alarm output	Latched Non-latched Off	LAt nLAt OFF		Parameter is output-module dependent.
d AO	Deviation alarm output	Latched Non-latched Off	LAt nLAt OFF		Parameter is output-module dependent.
OUTPUT POWER LIMITS					
H PL	Maximum power limit	0.0 to 100.0%		100.0%	
SnbP	Sensor break power level	-99.9 to +100.0% (heat/cool) 0.0 to 100.0% (heat only)		0.0%	
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	
C F	°C/°F selection	Degrees centigrade Degrees Fahrenheit	C F		Affects all temperature-dependent parameters.

Table 5.2
Complete Parameter List: Part 4

Input sensor selection
Communications configuration
General configuration

Mnemonic	Parameter	Adjustable range		Standard Value(s)	Comments
INPUT SENSOR SELECTION					
Sn	Sensor selection	J thermocouple	**J tc**		
		K thermocouple	**CAtc**		
		PL2 thermocouple	**PL2**		
		R thermocouple	**r tc**		
		S thermocouple	**S tc**		
		T thermocouple	**t tc**		
		J T/C (10ths' precision)	**.Jtc**		
		RTD, 100Ω, Pt	**rtd3**		
		L thermocouple	**L tc** **		
		L T/C (10ths' precision)	**.Ltc** **		
		Linear process	**Lin** *		Available only if option "QL" installed.
		Linear process (10ths')	**.Lin** *		Available only if option "QL" installed.

COMMUNICATIONS CONFIGURATION

Parameters appear even though communications board may not be installed.

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

GENERAL CONFIGURATION

Mnemonic	Parameter	Adjustable range		Standard Value(s)	Comments
Idno	Identification number	0 to 9999		0	Provided for customer use only; not a part of any control function.
Ctrl	Control type	ON/OFF	**On.Of**	PID	
		PID	**Pid**		
		PID w/ ramp-to-setpoint	**r SP**		
		PID w/ SP programming	**Prog**		Available only if option "QP..." installed.
SPrr	Setpoint ramping speed	0.01 to 99.99 units/min		10.00°/min	Appears only if "SPrr" selected at "Ctrl".

* Available only with software revision 02.00 or greater

** Available only with software revision 03.00 or greater

Table 5.2
Complete Parameter List: Part 5

General configuration (continued)

Mnemonic	Parameter	Adjustable range		Standard Value(s)	Comments
GENERAL	**CONFIGURATION (continued)**				
OP 1	Output 1 configuration	time proportioning	**tP**		Parameter is output-module dependent.
		0-20mA	**0-20**		
		4-20mA	**4-20**		
		t.p. w/ power feedback	**PFb** *		
OP2	Output 2 configuration: selection of cooling algorithm,	OFF	**OFF**		Parameter is output-module dependent.
		fan cooling	**FAn**		
		oil cooling	**OIL**		
		water cooling	**H2O**		
		5% min. CT cooling	**0.05**		
	Alarm 2 (AL2),	latched high alarm	**L Hi**		AL2 is not failsafe and is not intended to be configured as the sole alarm in a *critical* installation.
		non-latched high alarm	**n Hi**		
		latched low alarm	**L Lo**		
		non-latched low alarm	**n Lo**		
		latched dev. alarm	**L dA**		
		non-latched dev. alarm	**n dA**		
	or digital	ON	**on** *		
A H	Auto/manual enable	automatic mode only	**Auto**	Automatic mode only	
		manual mode enabled	**HAnd**		
CJC	CJC reference selection	Internal reference	**Int**	Internal reference	
		0°C reference	**0C**		
		45°C reference	**45C**		
		50°C reference	**50C**		
Pb d	Proportional band display	°C or °F	**C-F**	°C or °F	Disappears if "Lin" or ".Lin" selected at "Sn"
		Linear input units	**Lin**		Appears if "Lin" or ".Lin" selected at "Sn"
		Percent	**Pct**		
PH-L	Prop.band scale factor (units' precision)	10 to 1500°C		Setpoint range from Product Code.	Parameter appears only if "Pct" is chosen for "Pb d". Scale factor range is dependent on choice of I/P sensor precision and temperature units.
		18 to 2700°F			
		1 to 9999 units			
	Prop.band scale factor (tenths' precision)	50.0 to 999.9°C			
		90.0 to 999.9°F			
		0.1 to 999.9 units			

* Available only with software revision 02.00 or greater

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Table 5.2
Complete Parameter List: Part 6

General configuration (continued)
Linear process input option **QL...**
Limited-access functions

Mnemonic	Parameter	Adjustable range		Standard Value(s)	Comments
GENERAL CONFIGURATION (continued)					
t SU **	Tune on startup	Enable Disable	**YES** **no**	Enable	Available only option "QS" installed.
Cb O *	Cutback operation	automatic (3 x Xp) manual	**Auto** **HAnd**	Automatic	

LINEAR PROCESS INPUTS (option QL...) *

These parameters appear only if "Lin" or ".Lin" is selected at "Sn", except "Act" which always appears if this option is installed.

Mnemonic	Parameter	Adjustable range		Standard Value(s)	Comments
Act	Control action	Reverse action control Direct action control	**rEv** **dIr**	Reverse action	
HI L	High sensor break point	-999 to 9999 (units precision) -99.9 to 999.9 (10ths' precision)			
Lo L	Low sensor break point	-999 to 9999 (units precision) -99.9 to 999.9 (10ths' precision)			
FII	Input filter constant	0.01 to 99.99° or units		1.00 unit	
Proc	Process scaling	1st setup point 2nd setup point	**P1** **P2**		

LIMITED-ACCESS FUNCTIONS

Viewable only in configuration and calibration access level.

Mnemonic	Parameter	Adjustable range		Standard Value(s)	Comments
ACCS	Parameter access assignment	Hidden Read only Alterable	**Hide** **rEAd** **Altr**		
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**		

* Available only with software revision 02.00 or greater

** Available only with software revision 03.00 or greater

5.2.3 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 5.3 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 5.3
Installation-dependent parameters: Part 1

Control parameters
Alarm 1 output
Output power limits
Measured value attributes
Input sensor selection
Communications configuration

Mnemonic	Parameter	Suggested values or uses	Comments, recommendations and examples
CONTROL PARAMETERS			
rEL.C	Relative cool gain	0.2 Water cooling 1.0 Oil cooling 2.0 Fan cooling 1.0 Pulsed CO_2 cooling	Starting values only—may need to be adjusted during tuning.
H c.t	Heat cycle time	20s Mechanical contactor 5s Mercury contactor 0.3s Solid-state contactor	
C c.t	Cool cycle time	10s Water cooling solenoid 10s Oil cooling solenoid 20s Fan cooling 10s Pulsed CO_2 cooling	
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 alwsys be installed.**
L AO	Low alarm output		
d AO	Deviation alarm output		
OUTPUT POWER LIMITS			
H PL	Maximum power limit	Maximum allowed level of operation	Not to be used in lieu of an alarm or fuses. Provide a redundant protection system if damage may result from overpowering the load.
SnbP	Sensor break power level	Safe level of operation	May require modification depending on particular job.
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 5.3
Installation-dependent parameters: Part 2

General configuration

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, etc.
		PID	Standard PID	Most conventional loads
		r SP	PID with starting ramp	Ramp-to-setpoint for loads not tolerating thermal shock.
SPrr	Setpoint ramping speed	A safe dT/dt for the load		Only if "r SP" chosen for "Ctrl"
OP1	Output 1 configuration	**Pfb**	O/P devices with t.p. I/Ps; V-squared power feedback	Recommended time proportioning output for electrically heated loads controlled by solid-state or mechanical contactor. Load must be on same phase as controller.
		tP	O/P devices with time proportioning inputs	Solid-state contactors, solenoids, relays, etc.—applications where load is not electrically heated or on same phase as controller.
		0-20	O/P devices with DC I/Ps	SCR units (phase angle or fast cycle O/P)
		4-20	O/P devices with DC I/Ps	SCR units (phase angle or fast cycle O/P)
OP2	Output 2 configuration: selection of cooling algorithm,	**Off**	OP1 only (no cooling)	
		FAn	Forced-air cooling	Linear algorithm, 500ms minimum ON time
		OIL	Non-evaporative cooling	Linear algorithm, any pulsed, non-evaporative cooling medium; 35ms minimum ON time
		H2O	Evaporative cooling	Non-linear algorithm, pulsed evaporative water cooling only, 35ms minimum ON time **H2O algorithm must be used on water-cooled systems where the water temperature rises above 100°C.**
		0.05	Pulsed CO2 cooling	Minimum ON time = 5% of cycle time
	Alarm 2 (AL2),	**L HI**		For annunciation, interlock and indication only; not intended for shutdown or critical applications.
		n HI		
		L Lo		
		n Lo		
		L dA		**AL2 is not failsafe and is not intended to be configured as the sole alarm in a critical installation.**
		n dA		
	or digital	**ON**		For commutation of OP2 via communications link.
A H	Auto/manual enable	**Auto**	Automatic mode only	"Hand" should be selected only if the operating personnel have a requirement for manual override.

Table 5.3
Installation-dependent parameters: Part 3

General configuration (continued)
Linear process inputs (option **QL...**)
Limited-access functions

Mnemonic	Parameter	Suggested values or uses		Comments, recommendations and examples
GENERAL CONFIGURATION (continued)				
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** **HAnd**	Automatic (3 x Xp) Manual	"Auto" is preferred except if zone requires cutback point adjustments for enhanced overshoot suppression.
LINEAR PROCESS INPUTS (option QL...)				
Act	Control action	**rEv** **dIr**	Heat load on O/P1 Cool load on O/P1	
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	**P1** **P2**	As required As required	I/P signals for scaling should be as close as possible to min. and max. of I/P range.
LIMITED-ACCESS FUNCTIONS				
ACCS	Parameter access assignment	**HIdE** **rEAd** **Altr**	Hidden Read-only 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.

5.3 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.
- 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.

DO:	SEE:
1. Enable the full parameter list with configuration switch WB1.	
2. Depress PAR until :	A C C S
3. Depress UP to advance to first parameter:	A l t r H i A l
4. Depress DOWN to scroll through selection of 3 security levels until desired level appears.	H i d E H i A l r E A d H i A l A l t r H i A l
5. Depress UP to advance to next parameter. Continue for other parameters.	A l t r L o A l

Figure 5.3. Access assignment procedure.

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.

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 808/847 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 is 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 aesthetics.** 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 Bureau of Standards 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 NBS 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; OP1 and OP2 are momentarily disabled during this procedure.

5.4.3.1 Characteristics

- The NBS-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.

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.

- 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**.

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 5.4 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 5.4!

Table 5.4
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. 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.)
- ○ 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**.

DO:	**SEE:**
1. Enable the full parameter list with configuration switch WB1. Connect calibration source to input terminals before preceeding.	
2. Depress PAR until :	C A L — — — —
3. Depress UP or DOWN to advance to:	C A L 2 0 . 0
4. Depress PAR.	2 0 . 0 n o
5. Depress UP or DOWN to affirm.	2 0 . 0 Y E S
6. Depress PAR to launch procedure.	2 0 . 0 2 0 . 0
7. 5 seconds later the reference is calibrated. Repeat procedure for other references requiring calibration.	C A L — — — —

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

6. SETPOINT PROGRAMMING OPTION QP...

6.1 INTRODUCTION

6.1.1 Programmer/controller

The Models **808** and **847** 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.

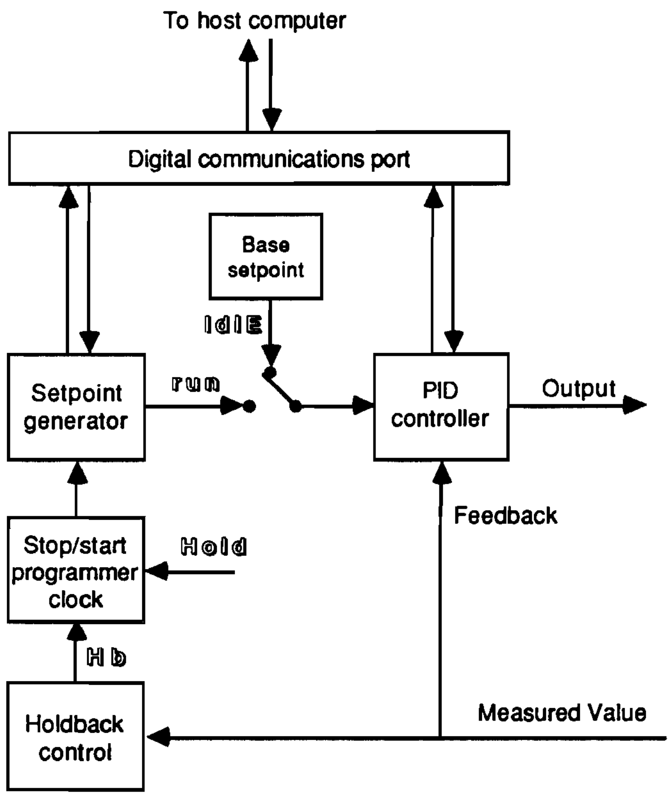


Figure 6.1. Conceptual block diagram of a programmer/controller.

6.1.2 Program segments

The **808/847** 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.

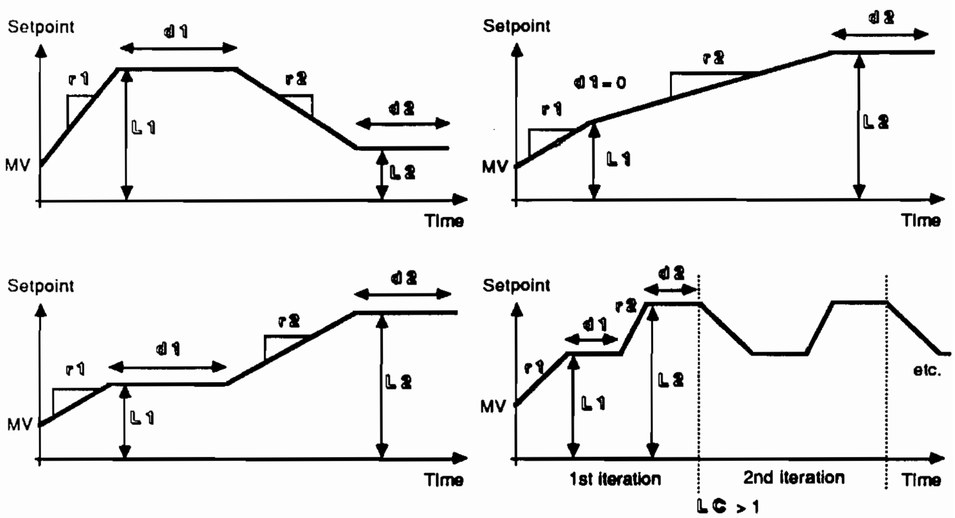


Figure 6.2. Examples of 4-segment programs (2 ramp/dwell pairs).

6.1.3 Programmer states

The Model **808/847** 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.

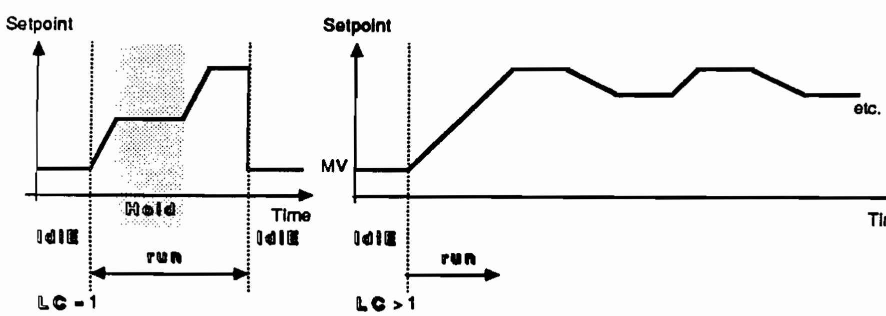


Figure 6.3. Programmer states.

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.

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. (Not available in Release 1.11 software).

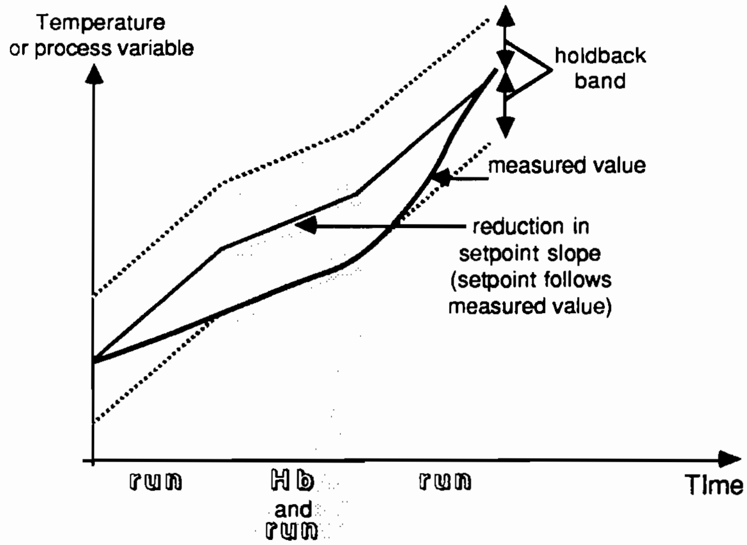
6.1.4 Program control methods

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.

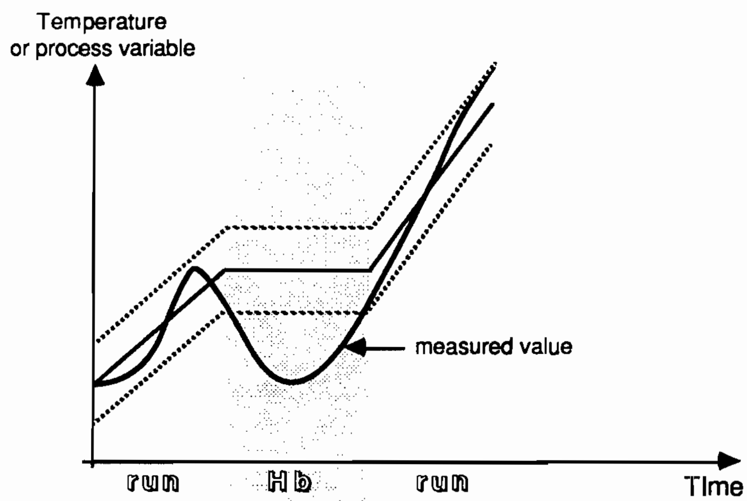
NOTE! **If the programmer remains in Hold and does not run, verify that rear terminals 16 and 17 are connected together. If rear-terminal control is not to be used in the installation, these 2 terminals should be shorted.**

6.1.4.1 Front-panel pushbuttons

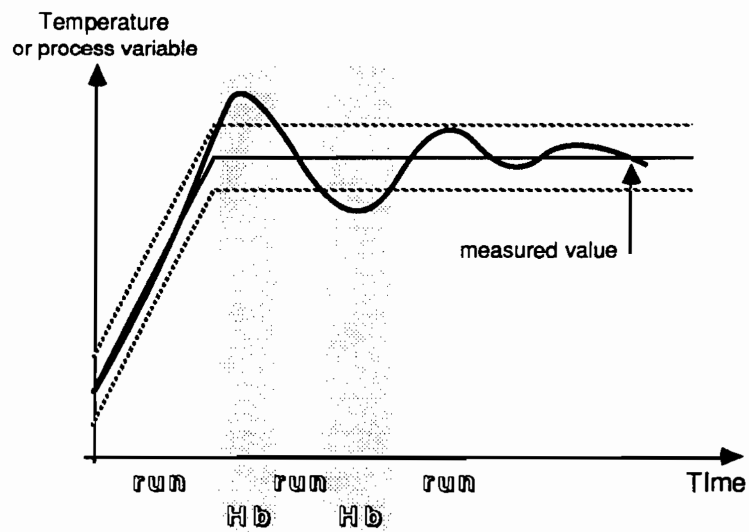
The program can be placed in run, Hold or IdlE by scrolling to Prog and selecting the appropriate setting. Note that if the



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.



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

Figure 6.4. Holdback examples.

programmer is in IdlE, placing it into Hold causes the unit to first enter run but it is placed immediately into Hold.

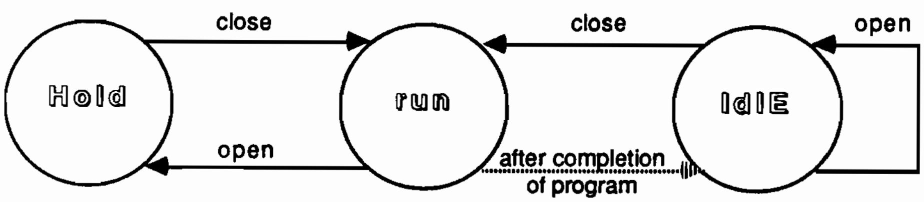
6.1.4.2 Rear-terminal connections (terminals 16 and 17)

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.

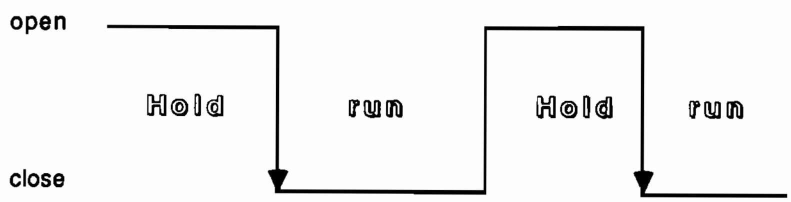
If the programmer is in IdlE or Hold, shorting the terminals places the programmer into run. If the terminals are already shorted (as is the case after the completion of a program) and it is desired to repeat the program, the terminals must be opened and shorted to launch the program again.

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.

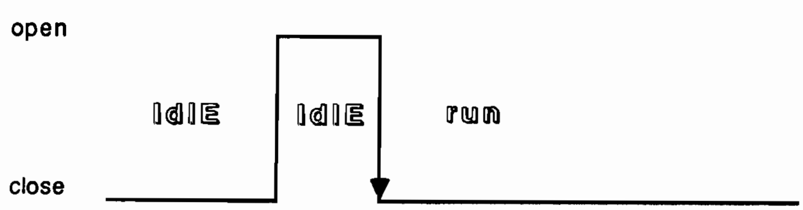
If the program is currently running, opening the rear terminals places the programmer into Hold.



A. Programmer states available by opening and closing link between rear terminals.



B. RUN/HOLD control sequence.



C. Starting program from IDLE after completion of previous program.

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

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 §3.8 for wiring connections for rear-terminal programmer control.

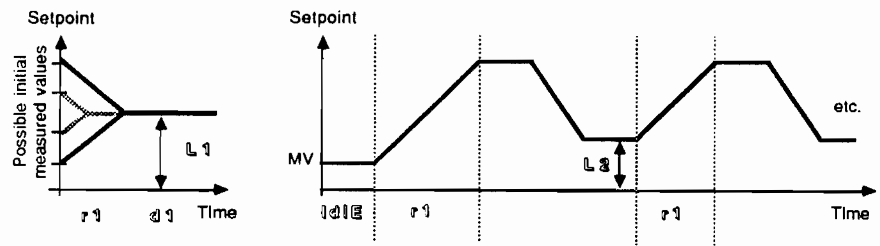
6.1.4.3 Communications interface

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. [Available only with software revision 02.00 or greater.]

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.

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 IdlE), 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 5.2 for the order and positioning of the program control parameters in the scroll list.

When Prog is selected and the programmer state is not IdlE the base setpoint is available for view and modification under the mnemonic 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 IdlE 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 IdlE appears in the lower display.

• Either press **PAR** or let the display time out to enter the IdlE 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.

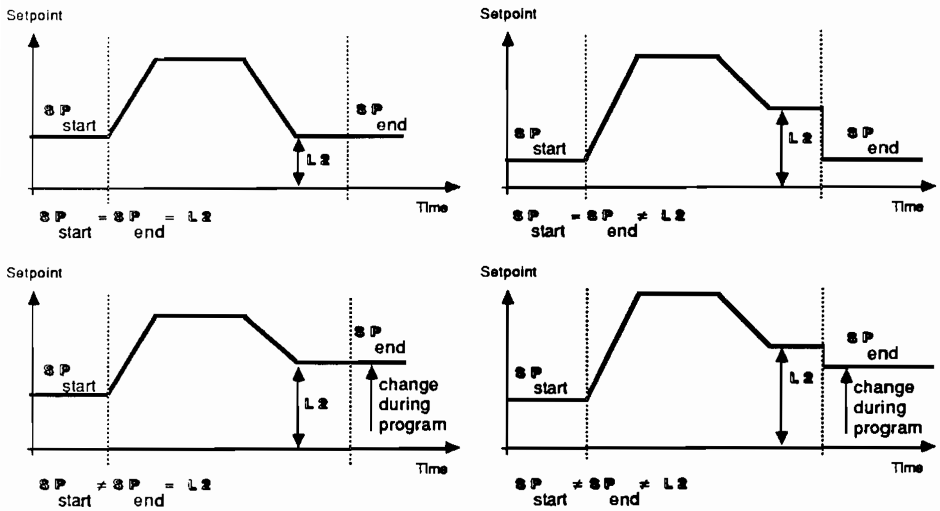


Figure 6.7. Methods of ending programs.

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.

6.4.7 Changing program parameters

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

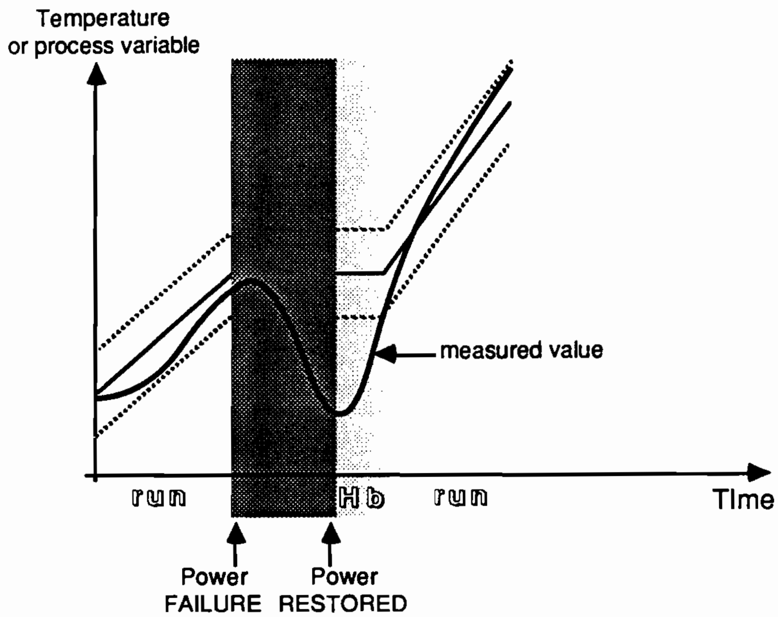
- Any changes made to these parameters while in IdLE are *permanent.*

- Any changes made to these parameters while in HoLd cause a *temporary* change valid only during the particular iteration of the program loop.

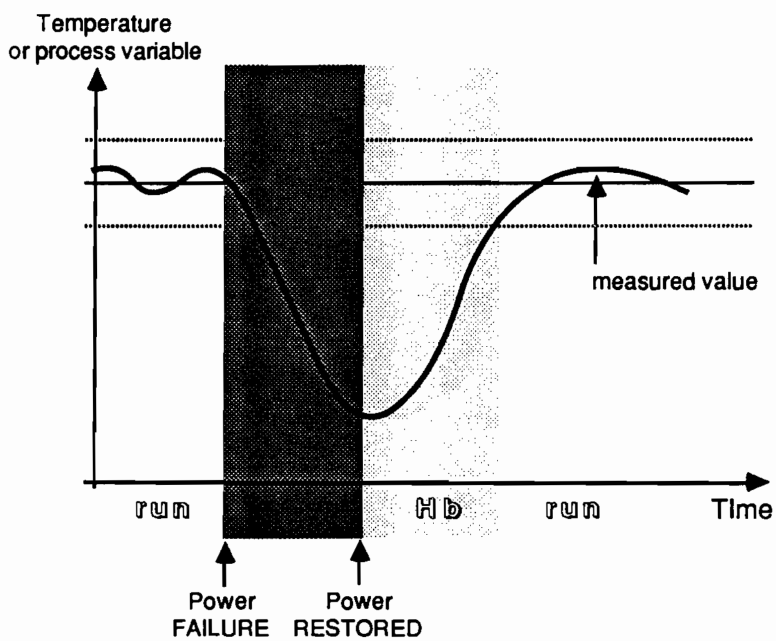
- The programmer does not permit any changes to be made to these parameters during run. The base setpoint SP, along with holdback band Hb and the other non-program parameters can still be freely and permanently modified during run.

6.4.8 Alarms

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



A. Effect on ramp segment.



B. Effect on dwell segment.

Figure 6.8. Loss of power during program RUN.

7. LINEAR INPUT OPTION QL...

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 1.3.

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

7.1.2 Wiring

Refer to §3.6.3 for the connection and wiring of the input signal.

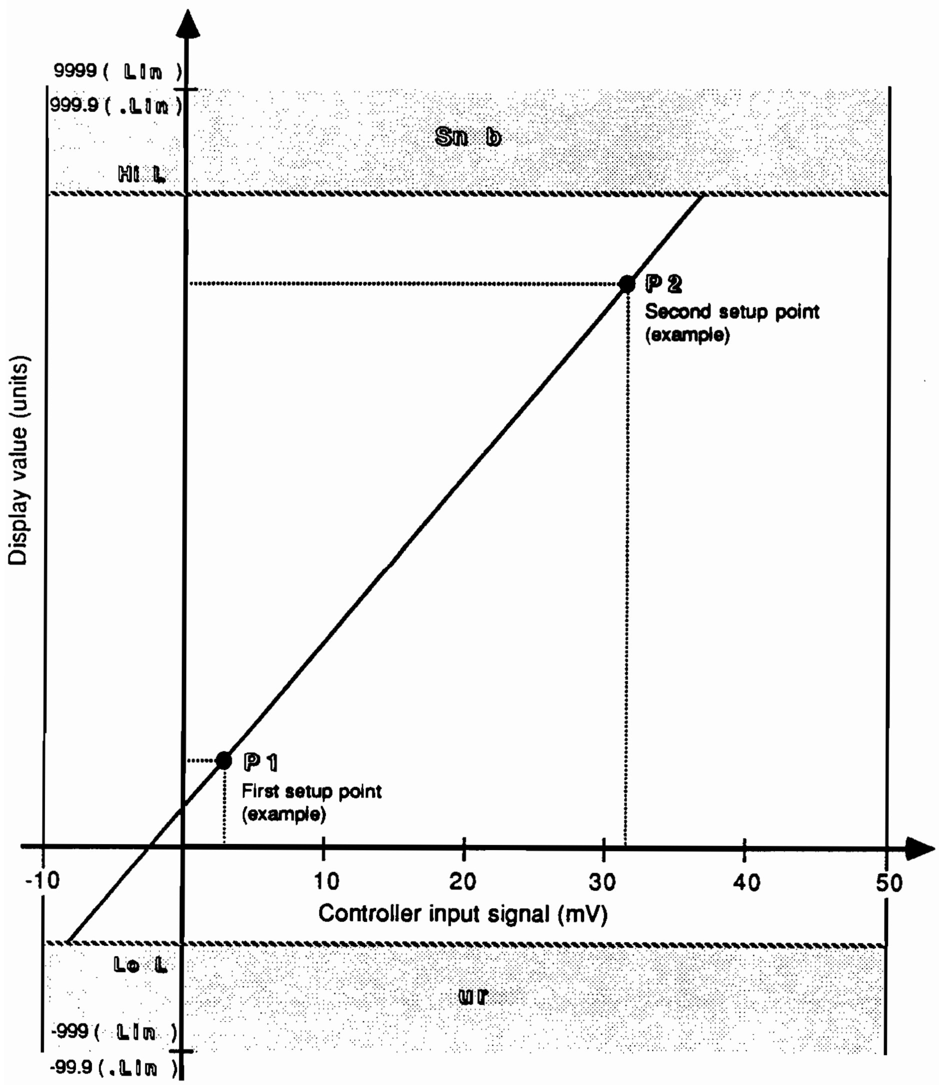


Figure 7.1 Linear input set-up and configuration.

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 5.2, Part 5).

◦ Select control action Act to be either rev (reverse) for a negative controller gain or dir (direct) for a positive controller gain. [Act always appears on the scroll list if option **QL...** is installed.]

- rev provides a decreasing output as the measured value increases. rev should be selected for temperature control loops with the heat output on the Output 1 channel.
- dir provides an increasing output as the measured value increases.

◦ 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.

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.

7.4 FILTER VALUE

The Models **808** and **847** 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°.

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 P 1
4. Depress PAR again: The number in the lower display will be the value (after adjustment) assigned to the injected input signal.	P 1 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.	P 1 2500
6. Depress PAR:	2500 no
7. Depress UP to affirm	2500 YES
8. Depress PAR	P 1 P 1
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.

8. SELF TUNING OPTION QS

8.1 INTRODUCTION

8.1.1 Types of self tuning

The Models **808** and **847** 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 PID parameters:

- ProP proportional band
- Int.t integral time constant
- der.t derivative 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 tthe edge.

NOTE! Revision level 3.20 of the self-tuning software does not calculate the value of the relative cool gain, rEl.C, but assumes that the setting selected by the user is correct.
When tuning a load which is principally cooled, as in cryogenic or exothermic applications, the cool channel proportional band is established by the algorithm. The value of the relative cool gain is used to calculate the heat channel proportional band. This implies that, under these conditions, if the the value of rEL.C is not set correctly, the unit may not control properly in heating.

CAUTION! On water-cooled evaporative systems tuned with the self-tuning algorithm, damage can result to the system if OP2 is improperly set to FAN, OIL or 0.05.
Be sure that H2O is selected for OP2 in this case.

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 PID selection: Pid, r SP or Prog
- Control action = reverse (rEv)—option **QL...** only.

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.

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

- PID 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 808/847 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 5.2 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 PID 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.]

The value of relative cool gain, rEL.C, assigned by the operator before starting the self-tune operation, is assumed to be correct and is *not* adjusted. See Table 5.3 for suggested starting values of rEL.C.

If the cool channel output is configured for non-linear evaporative cooling (OP2 set to H2O), 20% cooling is used to invoke the oscillations as opposed to 100% cooling (which is used for non-evaporative cooling).

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

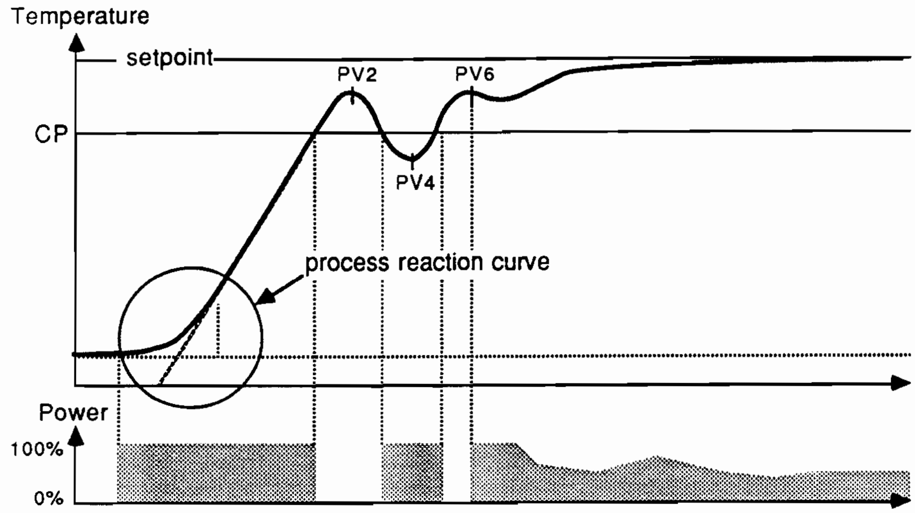


Figure 8.1. Start-up tune—heat-up

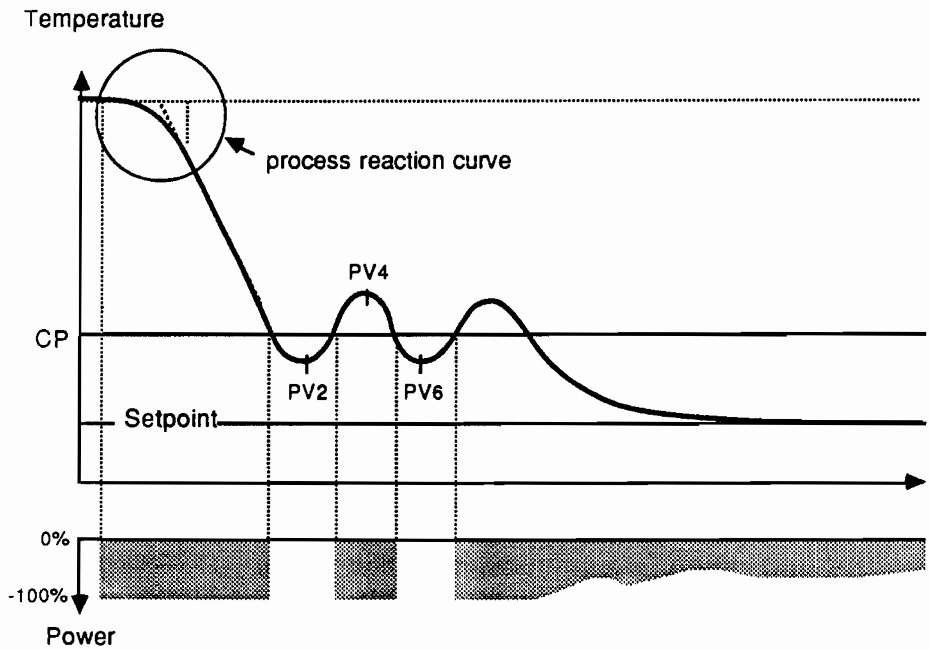


Figure 8.2. Start-up tune—cool down.

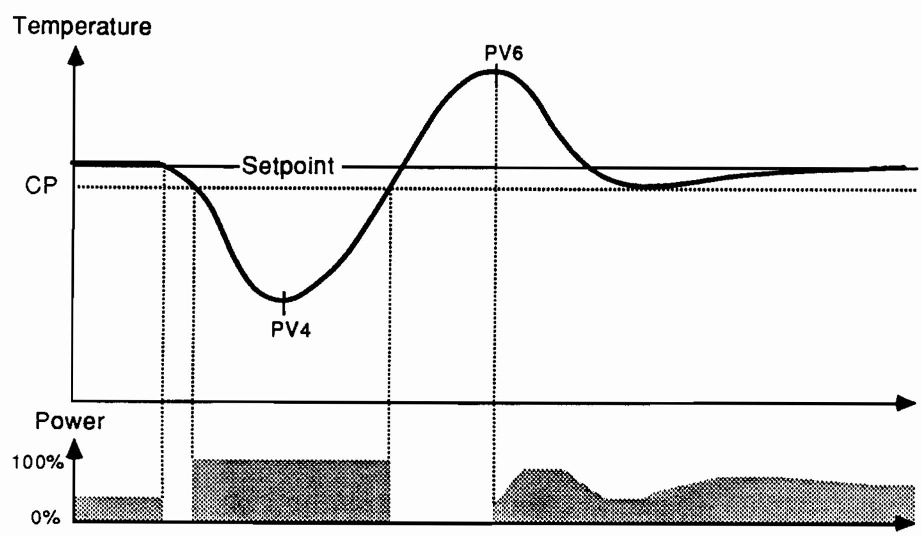


Figure 8.3. Tune at setpoint—endothermic process.

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 PID 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.

8.4 ABORT CONDITIONS

8.4.1 Start-up tune abort—heat-only

If the temperature does not crest at **PV2** and return to the the control point **CP** (Figure 8.1) but is held up by some external influence (Figure 8.5) the self-tune routine aborts. The algorithm waits for a time before aborting; this time is variable and depends on many factors. Data gathered from the process reaction curve are used as the source for determining the PID parameters in lieu of data from the oscillations. This form of abort could occur in a multi-zone application where an adjacent zone is adding heat which elevates the temperature of the zone being tuned.

8.4.2 Start-up tune abort—heat/cool

For a heat-cool controller, if the temperature does not crest at **PV2** and return to the the control point **CP** (Figure 8.1) but is held up by some external influence (Figure 8.6), the self-tune routine then applies cooling to cause the temperature to drop to **CP**. At this point, oscillations are forced as shown and the PID terms are calculated based on critical points of the oscillations. If the temperature cannot be brought down to **CP** even by the application of cooling, the PID terms are calculated from data acquired from the process reaction curve.

8.4.3 Tune at setpoint abort

Similar abort sequences are followed for tuning at setpoint if the oscillations are unsuccessful. If, however, there is a heat-cool abort no calculations will be performed.

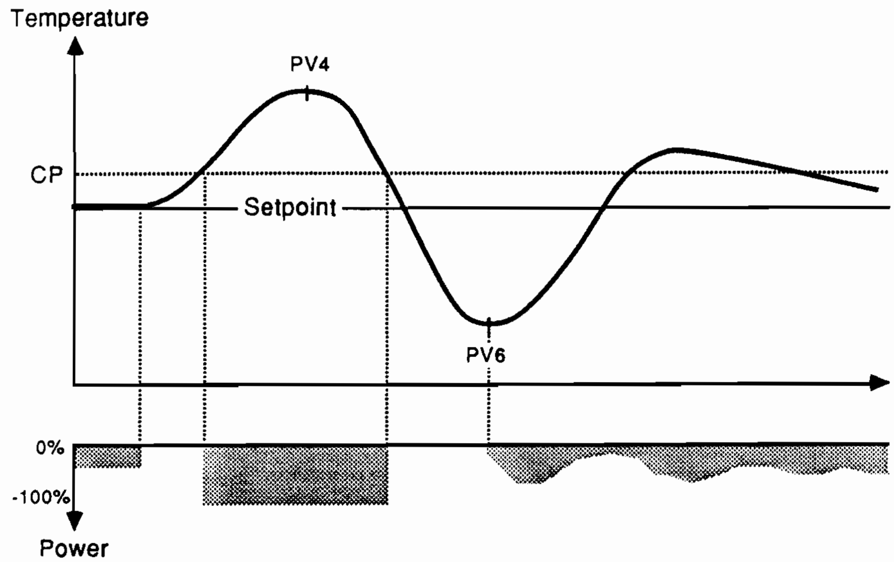


Figure 8.4. Tune at setpoint—exothermic process.

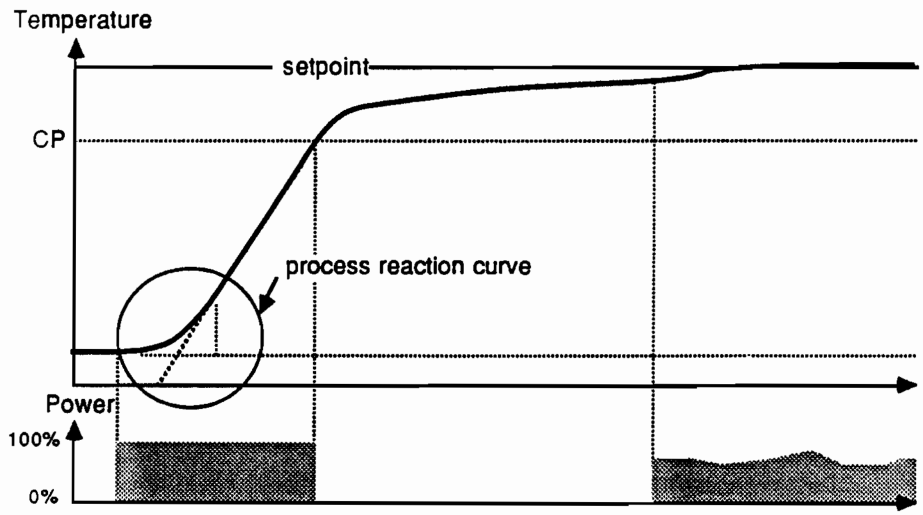


Figure 8.5. Start-up tune abort—heat only

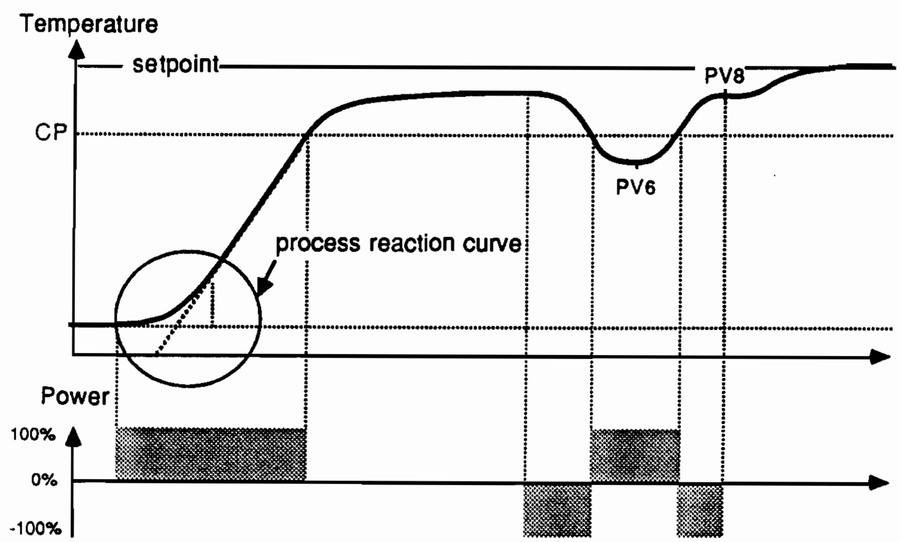


Figure 8.6. Start-up tune abort—heat/cool.

APPENDIX A. SPECIFICATIONS

ABSOLUTE MAXIMUM RATINGS

Supply voltage	85-264$V_{ac\ rms}$
Voltage between any 2 terminals	264$V_{ac\ rms}$
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	264$V_{ac\ rms}$ (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	6 (J, K, L, R, S, PL2, 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 (option QL...)

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	8.33mV

Current input adapter

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

2. OUTPUT DEVICES (see also Table 5.1)

2.1 Triac module (isolated from all other circuits)

Maximum load current (resistive load)	$1A_{rms}$
Minimum load current (resistive load)	$50mA_{rms}$
Off-state current	3mA @ $264V_{ac}$
Load voltage range	80-$264V_{ac}$ @ 50/60Hz
Line fuse	2AG, 1A, 250V (Littelfuse 225001)
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 Relay module (isolated from all other circuits)

Output contacts	
O/P 1 and O/P 2 channels	Form A, isolated
Alarm 1 channel	Form C, isolated
Maximum load voltage	$264V_{ac}$
Minimum load voltage	$10V_{peak}$
Maximum load current (resistive load)	$2A_{rms}$

2.4 DC module (not isolated from thermocouple circuit)

Current output ranges	0-20mA and 4-20mA
Compliance	18V
Resolution	0.009%
Ripple current	<$0.01mA_{peak\text{-}to\text{-}peak}$
Linearity	±0.5%
Accuracy	
0-20mA OUTPUT RANGE	
Minimum output level	0.0±0.1mA
Maximum output level	20.0+1.0/-0.0mA
4-20mA OUTPUT RANGE	
Minimum output level	4.0+0.0/-0.5mA
Maximum output level	20.0+1.0/-0.0mA
Low-pass filter break-point frequency	3.4Hz

3. CONTROL CHARACTERISTICS

3.1 General

3.1.1 Automatic operation

Control types	ON/OFF, or PID with or without ramp-to-setpoint operation, or PID 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 and OFF
Derivative time constant range	1-999s and OFF
Overshoot suppression	adjustable high and low "cutbacks"

3.1.2 Manual operation

Auto/manual selection	bumpless changeover
Power level adjustment range	-99.9 to 100.0% (0.0 to 100.0% for heat-only output)
Power setpoint resolution	0.1%
Power setpoint limit	high limit

3.2 Output 1 (Heat)

Signal type	time proportioned or continuously variable
Cycle time range (time proportioned)	0.3-80s
Power feedback compensation range	±15% of nominal supply voltage

3.3 Output 2 (Cool or Alarm 2)

3.3.1 Cool

Signal type	time proportioned
Cycle time ranges	0.3-80s
Cool gain multiplier (relative to heat channel)	0.1-10.0

Modes:

Cooling Type	Min. ON time	Algorithm
Water	35ms	non-linear
Air	500ms	linear
Oil	35ms	linear
5%	5% of CT	linear
Cooling OFF	—	—

3.3.2 Alarm 2 (see §4)

4. ALARMS

Number of alarm output channels	2 independent alarm outputs: AL1 and AL2 (AL2 occupies Output 2 channel)
Number of alarms	3 independent alarm functions:"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
Alarm action	
Alarm 1	Failsafe (alarm state affirmed by de-energized output)
Alarm 2	Alarm state affirmed by energized output
Number of setpoints assignable to output channel	
Alarm 1	3
Alarm 2	1

5. COMMUNICATIONS

Transmission standard	EIA-232-C or EIA-422
Transmission rate selection	300, 600, 1200, 2400, 4800, 9600, or 19200 baud
Number of stop bits	1
Parity	Even
Protocol subcatagories	ANSI X3.28 (1976 version, 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	85-264$V_{ac\ rms}$
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 gasket kit

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 (option QS)

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

Table A.1
Input Sensors

THERMOCOUPLES			RANGE				PRE-CISION
TYPE	COMPOSITION		°F		°C		
	POSITIVE MATERIAL	NEGATIVE MATERIAL	MIN.	MAX.	MIN.	MAX.	°F or °C
J	Iron	SAMA constantan (Cu-45%Ni)	-211	1832	-135	1000	1
K	Chromel™ (Ni-10%Cr)	Alumel™ (Ni-2%Al-2%Mn-1%Si)	-418	2543	-250	1395	1
L	Iron	DIN Konstantan	-148	1652	-100	900	1
PL2	Platinel II™ (alloy #5355)	Platinel II™ (alloy #7674)	32	2543	0	1395	1
R	Platinum-13%Rhodium	Platinum	32	2912	0	1600	1
S	Platinum-10%Rhodium	Platinum	32	2912	0	1600	1
T	Copper	Adams constantan (Cu-45%Ni)	-418	752	-250	400	1
J	Iron	SAMA constantan (Cu-45%Ni)	-99.9	752.0	-75.0	400.0	0.1
L	Iron	DIN Konstantan	-99.9	752.0	-99.9	400.0	0.1
RTD-3	(DIN 43760 / BS 1904)		-99.9	752.0	-99.9	400.0	0.1

Chromel and Alumel are registered trademarks of Hoskins Manufacturing Company, Detroit, Michigan.
Platinel II is a registered trademark of Engelhard Minerals and Chemicals Corporation, Carteret, New Jersey.

APPENDIX B. INSTALLATION OF FRONT-PANEL GASKETS

If a Model **808** or **847** is to be mounted into an electrical enclosure that must meet the NEMA 3 rating (IEC IP-54), then the gasket kit **KIT / 808NEMA3 / GASKET** is required.

This kit is composed of 2 parts:

- O-ring gasket fitting between the rear shoulder of the controller bezel and the panel, and
- Strip gasket sealing the controller front panel to the controller sleeve.

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.

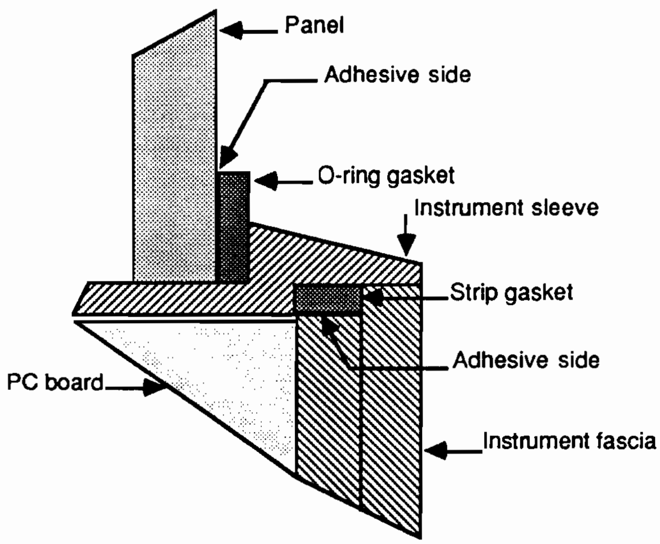


Figure B.1. Location of front-panel gaskets—section view.

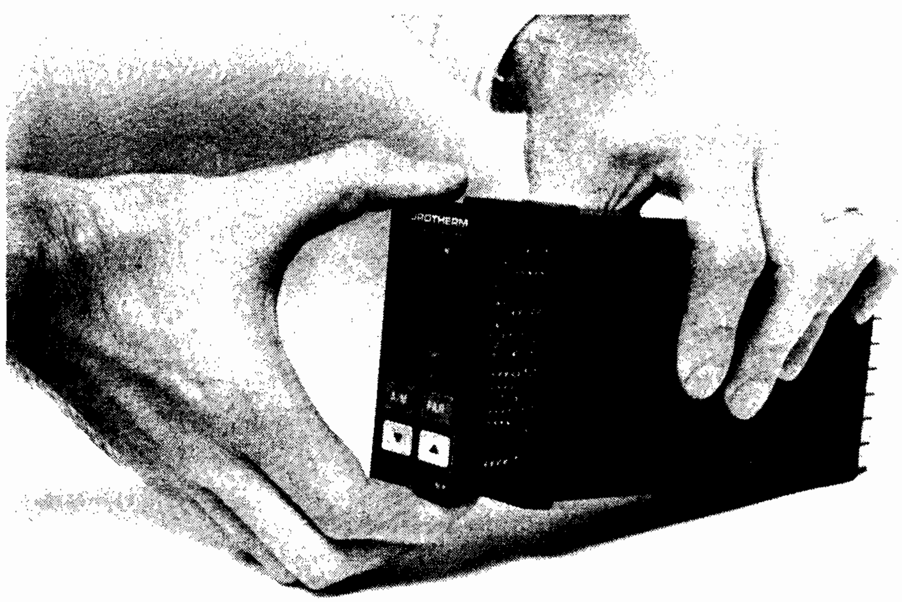


Figure B.2. Open the instrument by turning the front jacking screw and slide the instrument partially out of the sleeve.

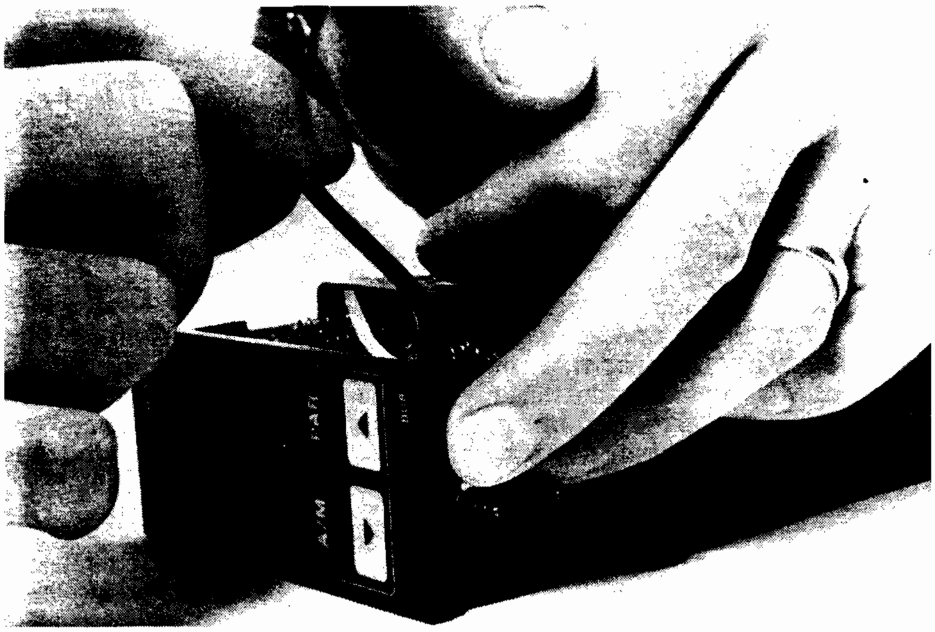


Figure B.3. Carefully peel off a few inches of the backing paper from the adhesive backing of the strip gasket, and starting underneath the jacking screw, apply the gasket around the inner shoulder of the fascia plate. Do not stretch the neoprene.

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 PID controller is the systematic procedure for determining the values of the PID terms 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 PID 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 **808** and **847** involves setting values for the following parameters:

- For heat-only PID systems (see §C.4.2): Proportional band ProP, integral time constant Int.t and, derivative time constant dEr.t.

- For heat/cool PID systems (see §C.4.4): Relative cool gain rEL.C is added to the above list.

- For both, 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 PID 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 option **QS** is installed on the controller.

C.2 PID CONTROL PARAMETERS

C.2.1 Proportional band (gain) ProP

Proportional band (PB), or gain, amplifies the error between setpoint and measured value to establish an output level. Proportional band is the temperature range over which the output level is continuously adjustable in a linear fashion from 0% 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.

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.

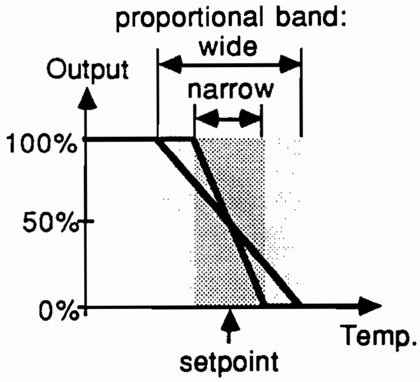


Figure C.1. Proportional band (with full PID control).

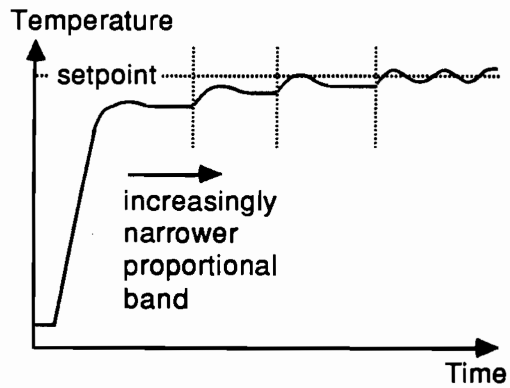


Figure C.2. Proportional-only control.

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.

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.

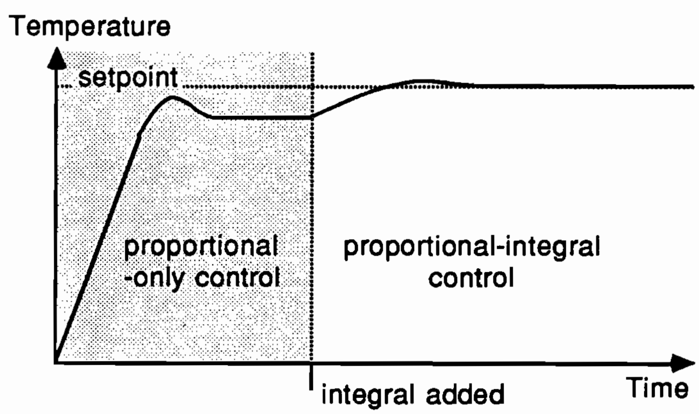


Figure C.3. Adding integral action.

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.

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.

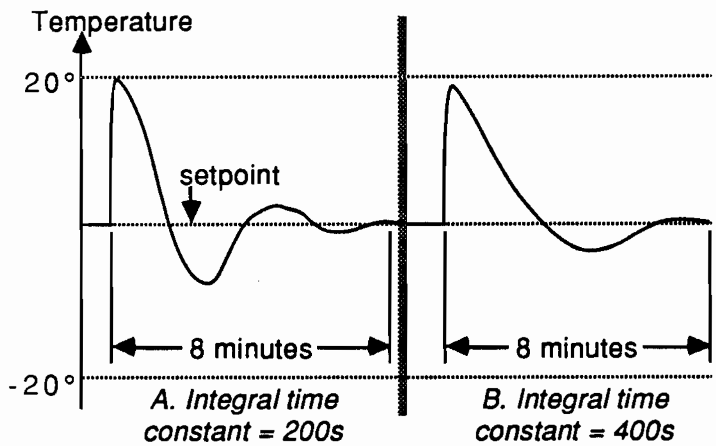


Figure C.4. Widening integral time constant.

C.2.3 Derivative time constant (rate action) dEr.t

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

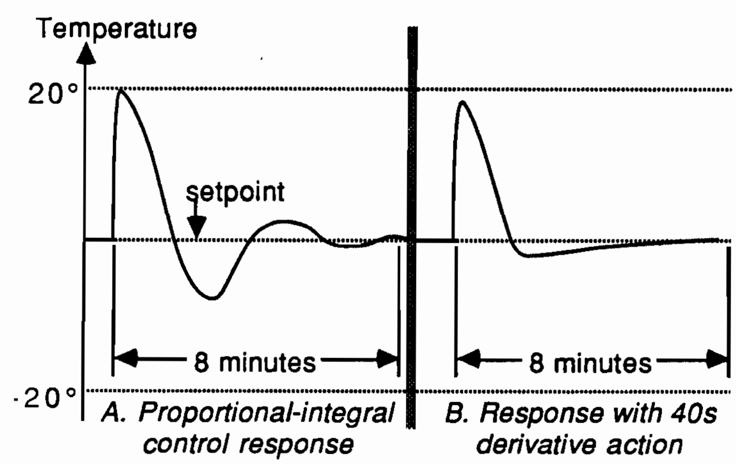


Figure C.5. Adding derivative action.

The oscillatory response to a perturbation shown in Figure C.5.A is virtually eliminated by derivative action as shown in Figure C.5.B where a 40-second derivative term is added to the 36° proportional band and 200-second integral time constant. As with the other two tuning parameters, there is a way of improperly setting this term: *derivative oscillation* is typically a cyclic wandering away from setpoint caused by too much derivative action.

Derivative action, when used, is often mistakenly associated with overshoot inhibition rather than transient response. In fact, derivative should *not* be used to curb overshoot on start-up. To effectively use derivative to prevent overshoot on start-up, the steady-state performance must be greatly degraded. Overshoot inhibition is best left to the approach-control parameters, high- and low cutback.

C.3 APPROACH CONTROL PARAMETERS H cb AND L cb

The Models **808** and **847** controllers contain 2 parameters which can be adjusted to prevent overshoot: *high-* and *low cutback levels.* These parameters are independent of the other three tuning values. By using the cutback parameters, the system can be set up for optimum steady-state response (with the PID parameters) *and* the overshoot 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 PID control to the setpoint (Figure C.6). This process is reversed for falling temperature. In the great majority of applications this process leads to overshoot-free start-up and decreases the time needed to bring equipment into operation.

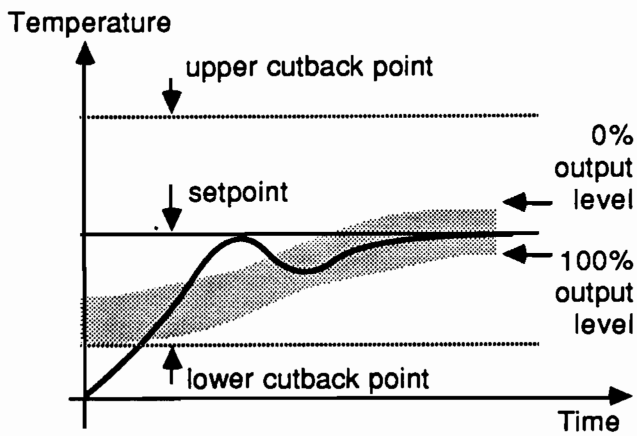


Figure C.6. Cutback operation.

If the parameter Cb o is set to Auto, the high- and low cutback points are automatically determined by the **808** or **847** 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. Nicholls[1].

Tuning with the Zeigler-Nicholls method requires forcing the system to oscillate. By placing a proportional-only controller (no integral or

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.

derivative terms) in oscillation by setting the proportional band to a very small value, the control loop cycles with a characteristic frequency (Figure C.7). This characteristic frequency is a very accurate representation of the system's responsiveness and is used to derive the controller time constants.

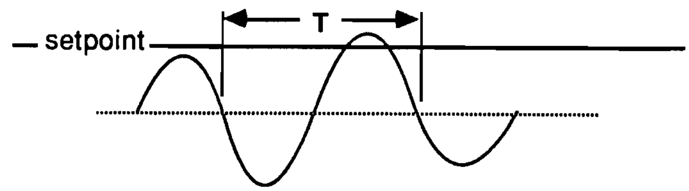


Figure C.7. Determining period of oscillation, T, with closed-loop cycling method.

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, so the trade-offs must be understood. Tuning objectives may be better fulfilled with the responses shown in Figure C.8.

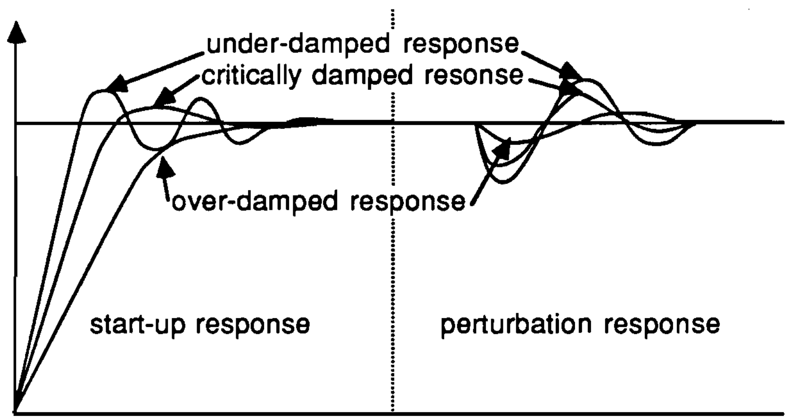


Figure C.8. Typical response curves.

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, such as calenders.

Before tuning a loop values should be assigned to the installation-dependent parameters listed in Table 5.3.

C.4.2 Procedure for tuning heat-only systems

- Set Int.t = OFF and dEr.t = OFF.

- Reduce the value of ProP until the measured value oscillates. Measure the period of oscillation **T** as shown in Figure C.7.
- Widen the proportional band (increase the value of ProP) until the process is just slightly unstable. This value is called the point of *ultimate sensitivity* (**P**).

- Refer to Table C.1 for the values of ProP, Int.t and dEr.t.

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

CONTROLLER	PARAMETER Proportional band **ProP**	Integral time constant **Int.t**	Derivative time constant **dEr.t**
Proportional only (P)	**2P**	not applicable	not applicable
Proportional and integral (PI)	**2.2P**	**0.8T**	not applicable
Proportional, integral and derivative (PID)	**1.67P**	**0.5T**	**0.12T**

Again, the settings given in Table C.1 establish control with a 4:1 decay ratio which may give too much overshoot for some processes. Table C.2 gives guidelines for altering these values; responses are shown in Figure C.8.

Table C.2
Variable Response Tuning Constants

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

C.4.3 Systems with cooling

As the cooling action is separate and distinct from the heating action, it has a very different effect and magnitude in most cases. That is to say that if there is 10kW of heating available, there may be 20kW of cooling available. If the controller is tuned for proper heating action it will have an incorrect gain setting for the cooling action. Since cooling action is typically applied at the same location as the heating action, the load time constants are the same but since the magnitude is different then the gain is incorrect. The Models **808** and **847** controllers offer a *relative cool gain* adjustment (rEL.C) to compensate for this possible imbalance. It is a multiplier for the proportional band that is used when the controller is delivering cooling power.

If there is not enough cooling action (relative cool gain is too small) the temperature remains above setpoint for a prolonged period of time and is very sluggish in dropping back to setpoint (assuming the controller is requesting cooling output.) In this instance, the relative cool gain should be increased.

A relative cool gain setting that is too high results in *cooling oscillation*. Cooling oscillation has a particular characteristic and is very easily diagnosed. As shown in Figure C.9, the temperature slowly rises above setpoint as the power demand from the controller decreases gradually. Eventually, the cooling action causes a rapid drop in temperature resulting in a sharp increase in power demand back into the heating region. The classic cycling between heating and cooling with this sawtooth waveform characteristic is reduced by lowering the relative cool gain adjustment.

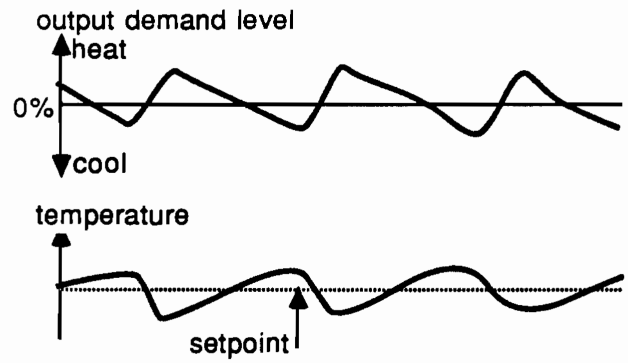


Figure C.9. Cooling oscillation.

C.4.4 Tuning heat/cool systems

In addition to the procedure in §C.4.1, the cool gain parameter rEL.C must be set for these systems.

- Start with the standard cool gain values listed in Table 5.3. [The appropriate cooling algorithm must be implemented under mnenomic OP2—see Table 5.3.]

- As the controller is required to add cooling it may oscillate as cooling is applied. If this occurs, decrease the value of rEL.C until the loop stabilizes.

- If the measured value remains above setpoint, however, increase the value of cool gain.

C.4.5 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.4.5.1 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.4.5.2 Manual adjustment of cutback parameters

Adjustment of cutback points H cb and L cb away from the predetermined 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 PID 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.7) to the integral time constant setting; the integral time constant should be at least as long as the period of oscillation. If the integral time constant is shorter than the period of oscillation, 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. Make sure the zone is not in cooling oscillation (Figure C.9).

Some control zones have certain physical configurations which prevent them from being tuned with derivative action. Even though derivative action is a stabilizing factor in most heated loads, some loads have *transport lags* which cannot stabilize if derivative is used. This would occur, for example, in a system where heat is transported to the load by flowing air. If adjusting the integral action and proportional band as stated above does not stabilize a controller, try reducing or removing the derivative action.

C.6 ADJUSTING ON/OFF CONTROL

The hysteresis band (represented by ProP) should be set as small as possible to minimize output ripple but large enough to reduce wear on devices such as mechanical contactors.

APPENDIX D. INSTRUMENT REGISTER

This space is provided for recording of pertinant data about your Model **808/847** digital controller. This information may be required when contacting Eurotherm Corporation concerning this instrument.

D.1 PRODUCT CODE

	HARDWARE CODE			options		
Model	*output 1*	*output 2*	*alarm*	*comms*	*input adapter*	*add'l options*
/	/	/	/	/	/	

CONFIGURATION CODE

config. type	*sensor*	*setpoint range*	*display units*	*output 1*	*output 2*	*alarm output*
/(A						)

CALIBRATION CODE (OPTION QL... ONLY)

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	Output level setpoint (in manual only)				
C or F	Display units (display only)				

SETPOINT PROGRAMMING (option QP...)

Prog	Programmer state select and status annunciation				
S P	Base setpoint				
tunE **	Tune on demand				
L C	Loop counter				
r 1	1st ramp rate				
L 1	1st dwell level				
d 1	1st dwell time				
r2	2nd ramp rate				
L 2	2nd dwell level				
d 2	2nd dwell time				
Hb *	Holdback band				

ALARM SETPOINTS

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

CONTROL PARAMETERS

ProP	Proportional band				
Int.t	Integral time constant				
dEr.t	Derivative time constant				
rEL.C	Relative cool gain				
H c.t	Heat cycle time				
C c.t	Cool cycle time				
H cb	High cutback point				
L cb	Low cutback point				

SETPOINT LIMITS

SP L	Setpoint low limit				
SP H	Setpoint high limit				

Mnemonic	Parameter				
ALARM 1 OUTPUT					
H AO	High alarm output				
L AO	Low alarm output				
d AO	Deviation alarm output				
OUTPUT POWER LIMITS					
H PL	Maximum power limit				
SnbP	Sensor break power level				
MEASURED VALUE ATTRIBUTES					
OFSt	Calibration offset				
C F	°C/°F selection				
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				
OP 1	Output 1 configuration				
OP2	Output 2 configuration				
A H	Auto/manual enable				
CJC	CJC reference selection				
Pb d	Proportional band display				
PH-L	Prop.band scale factor				
t SU **	Tune on startup				
Cb O *	Cutback operation				
LINEAR PROCESS INPUTS (option QL...) *					
Act	Control action				
Hi L	High sensor break point				
Lo L	Low sensor break point				
FiI	Input filter constant				

* Starting with software revision 02.00 ** Starting with software revision 03.00

CAUTION

Before installing, operating or servicing equipment supplied by Eurotherm Corporation, 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 or any other supplier.)

OVERCURRENT PROTECTION

It is recommended that AC power supplies to Eurotherm instruments be protected by fuses or automatic circuit breakers rated at not more than 2 Ampères.

VOLTAGE RATINGS

Care must be taken to ensure that maximum voltage ratings are not exceeded.

Unless otherwise stated in the specification of any particular unit, the maximum voltage which may be applied between any two isolated circuits, or between any isolated circuit and ground, is limited to the highest rated supply voltage for that unit.

ENCLOSURE OF LIVE PARTS

Some metal parts of certain types of Eurotherm equipment can become electrically "live" in some conditions of normal operation.

Unless clearly intended to be panel mounted and accessible during normal operation, all units 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 on most Eurotherm units) be fitted wherever possible.

WIRING

It is important to connect all equipment correctly in accordance with the installation data provided for each type of unit.

Unlabelled terminals must not be used as "tie points" for other wires (unless the installation instructions mention that this is permissible). Such unlabelled terminals may be internally connected. Any questions concerning the correct wiring of a Eurotherm unit should be directed to the nearest Eurotherm Sales and Service representative.

Most connections to Eurotherm equipment require correct polarity to be maintained, and due attention must be given to ensure this.

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 recommended that an additional separate unit be used to give alarm indication or to shut down the process or both, as may be appropriate. (Note: "Alarm boards" fitted inside controllers may not give sufficient protection in these circumstances). When "alarm units" or "alarm boards" are used they should be checked for correct operation and calibration at regular intervals.

(CONTINUED INSIDE BACK COVER)

(CONTINUED FROM INSIDE FRONT COVER)

GROUNDING

All "ground" terminals must be securely connected to ground by conductors appropriate to the current ratings of the units.
Most Eurotherm instruments have 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 any Eurotherm 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).

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.

TEMPERATURE SENSOR FAILURE

In the event of sensor failure (i.e., thermocouple break or open input circuit) the instrument might display erroneous readings before indicating the input fault condition. For example, upon thermocouple break, the display reading rises rapidly before an indication occurs.

HAZARDOUS ATMOSPHERES

Unless otherwise stated in the published specification of any particular unit, Eurotherm products are 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. Any attempt to troubleshoot while installed could be hazardous to personnel and equipment.

IF IN DOUBT, ASK !

If you have any questions regarding any aspect of installing, operating or servicing your Eurotherm equipment, please contact your nearest Eurotherm Sales and Service Representative.