



G A U G E S
T H E R M O M E T E R S
T R A N S M I T T E R S
R E C O R D E R S
C O N T R O L L E R S
L I Q U I D L E V E L S Y S T E M S
R T D S

ONE AND TWO PEN CIRCLE CHART RECORDING CONTROLLER

AJ-320

Installation, Wiring, Operation Manual



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Product Description 1.1

1.1.1 GENERAL

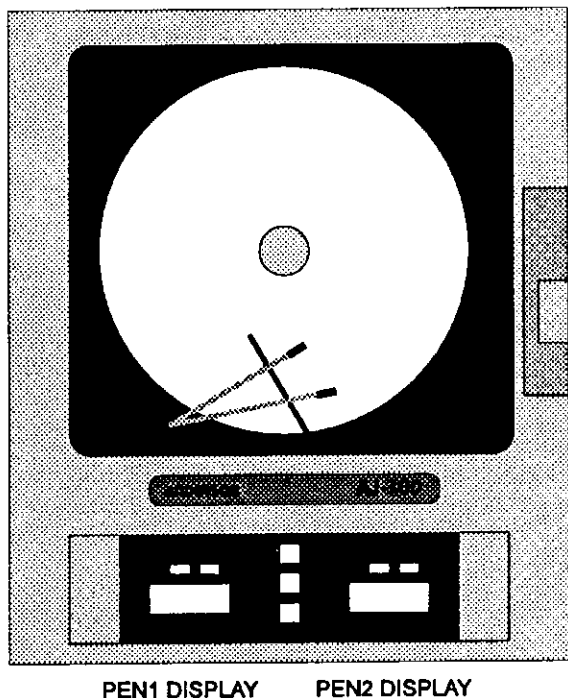
The instrument is a microprocessor based circular chart Recorder/Controller capable of measuring, displaying, recording and controlling from a variety of inputs. Applications include temperature, level, pressure, flow and others. The instruments can be specified as either a single or as a dual pen model.

Recording, control functions, alarm settings and other parameters are easily entered via the keypad. All user's data can be protected from unauthorized changes by the Enable mode security system, and is protected against memory loss, as a result of AC power outage, by battery back-up.

The process sensor input for each terminal block is user configurable to directly connect to either thermocouple, RTD, mVDC, VDC, or mA DC inputs. Changes in input type can easily be made by the user. Thermocouple and RTD linearization, as well as thermocouple cold junction compensation, are performed automatically. The instrument process variable inputs are isolated. An isolated 24 VDC regulated transmitter power supply can be provided in the instrument for use with up to two 4-20 mA DC process sensors.

The instrument can be ordered to operate on either 115 VAC or 230 VAC power at 50/60 Hz. The 230 VAC option includes a switch for selecting either 230 VAC or 115 VAC operation. The instrument is housed in a structural foam enclosure suitable for panel or surface mounting.

FIGURE 1-1



The number of keys and LED's will depend upon the configuration of individual unit.

1.1.2 RECORDING

The instrument records the selected process variable on a 12-inch circular chart. One box of standard charts is provided with each recorder. Charts are available in a wide selection of ranges. Chart rotation speed is programmable from 0.1 to 999.9 hours per revolution in 0.1 hour increments. The instrument can be ordered with one or two pens. Pen 1 is red and Pen 2 is green. Pens are the disposable fiber-tip type.

1.1.3 DISPLAYS

Each instrument is provided with a digital display and status indicator for each pen provided (See Figure 1-1). The display may be configured to display the Process Value, Process Value and Setpoint, or Setpoint only. During configuration the display(s) is/are used to show the enabled modes of operation and the parameter codes.

The display in the left corner is for Pen 1, the display in the right corner is for Pen 2 (if provided). The display includes status indicators for Manual mode operation, Output 1, Output 2, Alarm, degrees C, degrees F, engineering units, setpoint and minus sign. See Figure 1-2.

Display resolution is programmable for 0.1 or 1 degree for thermocouple and RTD inputs, and none, one, two or three decimal places for other input types.

1.1.4 CONTROL

The instrument can be provided with relay, or milliamp DC outputs. Instruments can be programmed for on-off, time proportioning, or current proportioning control depending upon the hardware present. Switching between the Control mode and the Manual mode of operation is easily accomplished with a dedicated key on the keypad. Switching is bumpless from the Control to the Manual mode, and while in manual, manipulation of proportional outputs is possible. Each pen of a dual pen recording controller is provided with its own AUTO/MANUAL key. Other standard control features include proportional control output limits, anti-reset windup and a unique Automatic Transfer function. If configured, the Automatic Transfer function allows manual control of the proportional output until the process reaches the setpoint at which time the instrument will go into the Control (automatic) mode of operation.

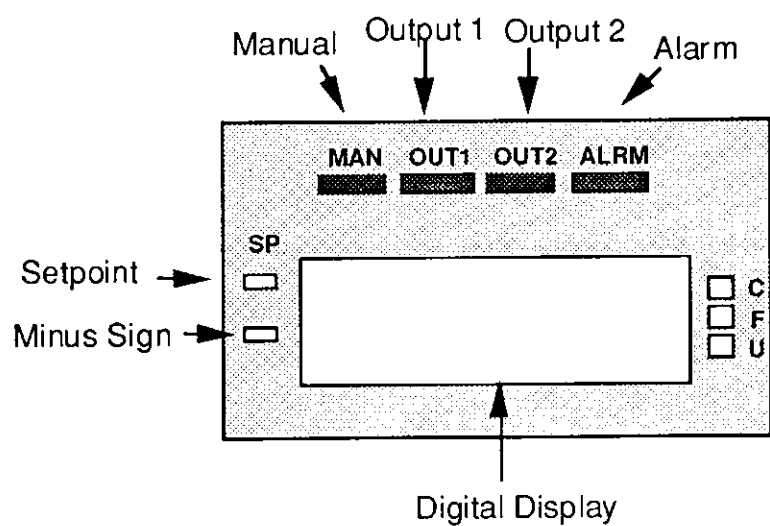
1.1.5 ALARM (Relays Optional)

An Alarm indicator is standard for each pen. Two alarm functions are provided for each pen and the alarm indicator will light if either alarm for that pen is on. Alarm settings are programmable two per pen. Alarm type may be selected as process direct or reverse (high or low).

1.1.6 PROCESS VALUE RE-TRANSMISSION OUTPUT

If an instrument is specified with mA/DC current output(s), any of the outputs may be programmed to operate as a process value re-transmission output. The output is scaleable but can not be used as a control output while assigned as a process value re-transmission output.

FIGURE 1-2



Installation and Wiring 2.1

Read these instructions carefully before proceeding with installation and operation. Electrical code requirements and safety standards should be observed. Installation should be performed by qualified personnel.

CAUTION: The Instrument AC power input is specified in the model number and on the wiring label affixed to the the top center of the platen. Verify the AC power input required by the instrument prior to proceeding with installation.

Unpacking 2.2

Remove the instrument from the carton and inspect for any damage due to shipment. If any damage is noticed due to transit, report and file a claim with the carrier. Write the model number and serial number of the instrument on the inside of the front cover of this Operation Manual for future reference.

Location 2.3

Locate the instrument away from excessive moisture, oil, dust, and vibration. Do not subject the instrument to operating temperatures outside of the 32°F to 131°F (0°C to 55°C) range.

Mounting 2.4

Figure 2-1 shows an installation view and physical dimensions for a panel mounted instrument. The panel where the instrument will be mounted must provide rigid support for the approximately 25 pound instrument. Adjacent instruments may be mounted within a minimum of 2 inches horizontally and 1 inch vertically, providing that proper panel support is supplied.

Panel Mounting Hardware Required: (not provided with instrument)
(4) #10 flat head bolts with nuts
(4) lock washers

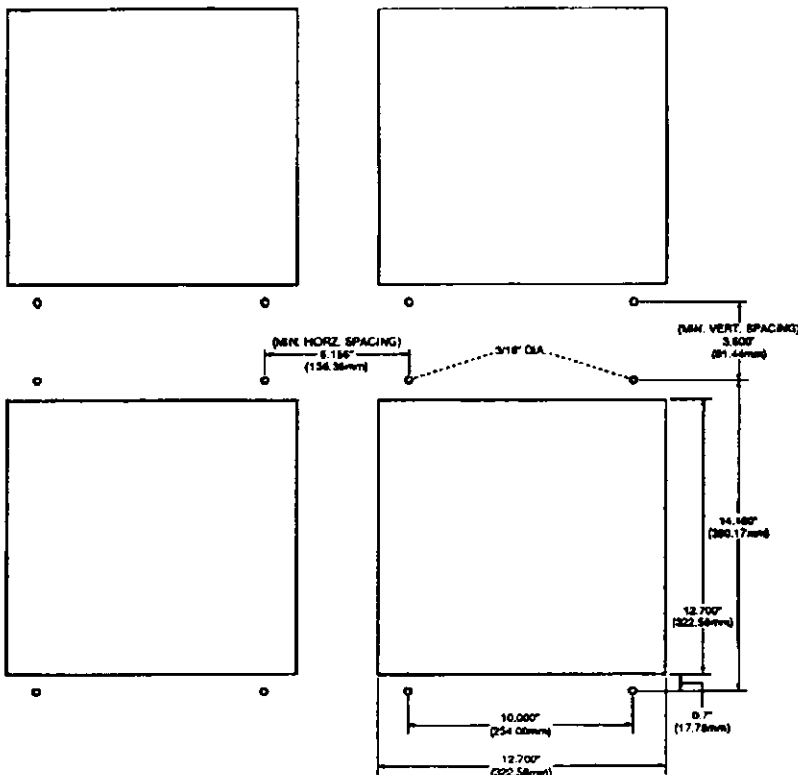
Panel Mounting:

1. Cut panel opening to the dimensions illustrated in **Figure 2-1**.
2. Pre-drill four 3/16 dia. holes for mounting or used the drill template molded into the case after inserting the instrument into the panel.
3. Insert the instrument in the panel opening. Firmly fasten the instrument to the panel using the nuts, bolts and lock washers.

Surface Mounting:

1. Install the mounting brackets, provided with the instrument, on the vertical sides of instrument housing. Use the brackets to fasten the instrument to the surface.

FIGURE 2-1



Preparations for Wiring 2.5

2.5.1 WIRING GUIDELINES

Electrical noise is a phenomenon typical of industrial environments. The following are guidelines that must be followed to minimize the effect of noise upon any instrumentation.

2.5.1.1 INSTALLATION CONSIDERATIONS

Listed below are some of the common sources of electrical noise in the industrial environment:

- Ignition Transformers
- Arc Welders
- Mechanical contact relay(s)
- Solenoids

Before using any instrument near the devices listed, the instructions below should be followed:

1. If the instrument is to be mounted in the same panel as any of the listed devices, separate them by the largest distance possible. For maximum electrical noise reduction, the noise generating devices should be mounted in a separate enclosure.

2. A separate isolation transformer to feed only instrumentation should be considered. The transformer can isolate the instrument from noise found on the AC power input.
3. If the instrument is being installed on existing equipment, the wiring in the area should be checked to insure that good wiring practices have been followed.

2.5.1.2 AC POWER WIRING

Earth Ground

The instrument includes noise suppression components that require an earth ground connection to function. To verify that a good earth ground is being attached, make a resistance check from the instrument chassis to the nearest metal water pipe or proven earth ground. This reading should not exceed 100 ohms. Each instrument should have a dedicated earth ground. Do not chain link multiple instrument ground wires.

Neutral (For 115VAC)

It is good practice to assure that the AC neutral is at or near ground potential. To verify this, a voltmeter check between neutral and ground should be done. On the AC range, the reading should not be more than 50 millivolts. If it is greater than this amount, the secondary of this AC transformer supplying the instrument should be checked by an electrician. A proper neutral will help ensure maximum performance from the instrument.

2.5.1.3 WIRE ISOLATION/SEGRATION

The instrument is designed to promote proper separation of the wiring groups that connect to the instrument. The AC power wire terminals are located near the top of the instrument boards. The analog signal terminals are located near the bottom of the instrument boards. Maintain this separation of the wires to insure the best protection from electrical noise. If the wires need to be run parallel with any other wiring type(s), maintain a minimum 6 inch space between the wires. If wires must cross each other, do so at 90 degrees to minimize the contact with each other and amount of cross talk. Cross talk is due to the EMF (Electro Magnetic Flux) emitted by a wire as current passes through it.

2.5.1.4 USE OF SHIELDED CABLE

Shielded cable helps eliminate electrical noise being induced on the wires. All analog signals should be run with shielded cable. Connection lead length should be kept as short as possible, keeping the wires protected by the shielding. The shield should be grounded at one end only. The preferred grounding location is at the sensor, transmitter or transducer.

2.5.1.5 NOISE SUPPRESSION AT THE SOURCE

Usually when good wiring practices are followed, no further noise protection is necessary. Sometimes in severe environments, the amount of noise is so great that it has to be suppressed at the source. Many manufacturers of relays, contactors, etc. supply "surge suppressors" which mount on the noise source.

For those devices that do not have surge suppressors supplied, RC (resistance-capacitance) networks and/or MOV (metal oxide varistors) may be added.

Inductive Coils - MOV's are recommended for transient suppression in inductive soils connected in parallel and as close as possible to the coil. See **Figure 2-2**. Additional protection may be provided by adding an RC network across the MOV.

Contacts - Arcing may occur across contacts when the contact opens and closes. This results in electrical noise as well as damage to the contacts. Connecting a RC network properly sized can eliminate this arc.

For circuits up to 3 amps, a combination of a 47 ohm resistor and 0.1 microfarad capacitor (1000 volts) is recommended. For circuits from 3 to 5 amps, connect 2 of these in parallel. See **Figure 2-3**.

FIGURE 2-2

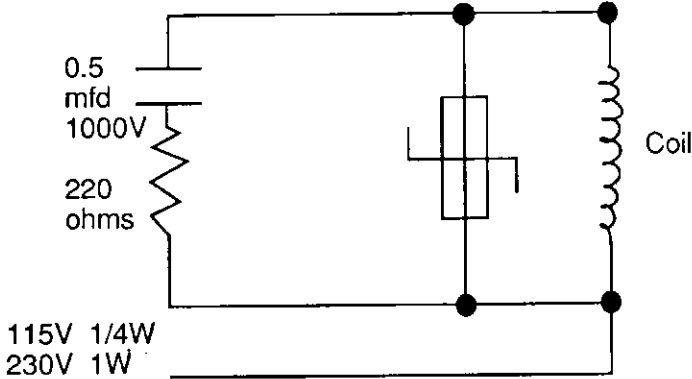
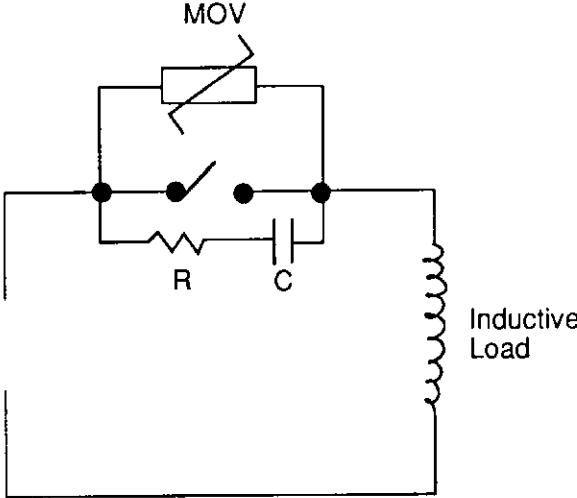


FIGURE 2-3



2.5.2 SENSOR PLACEMENT (Thermocouple or RTD)

If the temperature probe is to be subjected to corrosive or abrasive conditions, it should be protected by the appropriate thermowell. The probe should be positioned to reflect true process temperature:

- In liquid media - the most agitated area.
- In air - the best circulated area.

THEMOCOUPLER LEAD RESISTANCE

Thermocouple lead length can affect instrument accuracy, since the size (gauge) and the length of the wire affect lead resistance.

To determine the temperature error resulting from the lead length resistance, use the following equation:

$$T_{err} = TLe \cdot L \quad \text{where; } TLe = \text{value from appropriate Table}$$

$$L = \text{length of leadwire in thousands of feet.}$$

TABLE 1

Temperature error in °C per 1000 feet of Leadwire									
AWG No.	Thermocouple Type								
	J	K	T	R	S	E	B	N	C
10	.68	1.71	.76	2.05	2.12	1.15	14.00	2.94	2.53
12	1.08	2.68	1.21	3.30	3.29	1.82	22.00	4.68	4.07
14	1.74	4.29	1.95	5.34	5.29	2.92	35.00	7.44	6.37
16	2.74	6.76	3.08	8.30	8.35	4.60	55.50	11.82	10.11
18	4.44	11.00	5.00	13.52	13.65	7.47	88.50	18.80	16.26
20	7.14	17.24	7.84	21.59	21.76	11.78	141.00	29.88	25.82
24	17.56	43.82	19.82	54.32	54.59	29.67	356.50	75.59	65.27

TABLE 2

Temperature error in °F per 1000 feet of Leadwire									
AWG No.	Thermocouple Type								
	J	K	T	R	S	E	B	N	C
10	1.22	3.07	1.37	3.68	3.81	2.07	25.20	5.30	4.55
12	1.94	4.82	2.18	5.93	5.93	3.27	39.60	8.42	7.32
14	3.13	7.73	3.51	9.61	9.53	5.25	63.00	13.38	11.47
16	4.93	12.18	5.54	14.93	15.04	8.28	99.90	21.28	18.20
18	7.99	19.80	9.00	24.34	24.56	13.44	159.30	33.85	29.27
20	12.85	31.02	14.12	38.86	39.18	21.21	253.80	53.79	46.48
24	31.61	78.88	35.67	97.77	98.26	53.40	641.70	136.07	117.49

Example

A recorder is to be located in a control room 660 feet away from the process. Using 16 AWG, Type J thermocouple, how much error is induced?

$$T_{err} = TLe \cdot L = 4.93 \text{ (°F/1000 ft) from Table 2.}$$

$$T_{err} = 4.93 \text{ (°F/1000 ft)}$$

$$T_{err} = 3.3 \text{ °F}$$

RTD LEAD RESISTANCE

RTD lead length can affect instrument accuracy. Size (gauge) and length of the wire used affects lead length resistance.

To determine the temperature error resulting from the lead length resistance, use the following equation:

$$T_{err} = TLe * L \quad \text{where; } TLe = \text{value from Table 3 if 3 wire or Table 4 is 2 wire.}$$

$$L = \text{length of leadwire in thousands of feet.}$$

TABLE 3 **3 Wire RTD**

AWG No.	Error °C	Error °F
10	+/-0.04	+/-0.07
12	+/-0.07	+/-0.11
14	+/-0.10	+/-0.18
16	+/-0.16	+/-0.29
18	+/-0.26	+/-0.46
20	+/-0.41	+/-0.73
24	+/-0.65	+/-1.17

TABLE 4 **2 Wire RTD**

AWG No.	Error °C	Error °F
10	+/-5.32	+/-9.31
12	+/-9.31	+/-14.6
14	+/-13.3	+/-23.9
16	+/-21.3	+/-38.6
18	+/-34.6	+/-61.2
20	+/-54.5	+/-97.1
24	+/-86.5	+/-155.6

Example

An application uses 2000 feet of 18 AWG copper lead wire for a 3-wire RTD sensor. What is the worst-case error due to this leadwire length?

$$T_{err} = TLe * L$$

$TLe = +/- .46 (°F/1000 \text{ ft})$ from Table 1

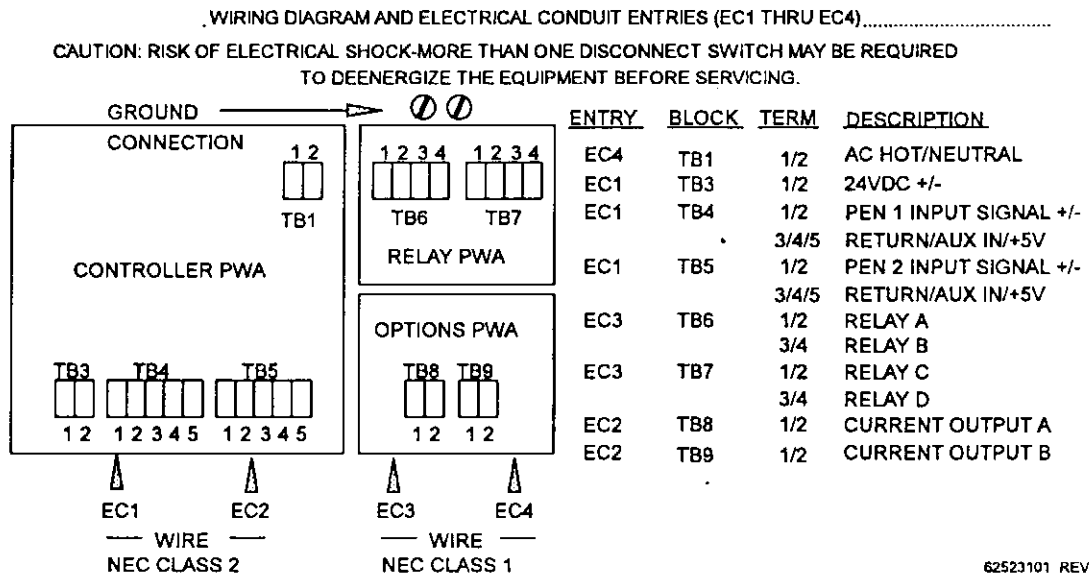
$$T_{err} = +/- .46 (°F/1000 \text{ ft}) * 2000 \text{ ft}$$

$$T_{err} = +/- 0.92 °F$$

Wiring Connections 2.6

All wiring connections are typically made to the instrument at the time of installation. Connections are made at the terminal boards provided, two 12 gauge wires maximum. Terminal boards are designated TB1 through TB9. See Figure 2-4 for the terminal board locations. The number of terminal boards present on the instrument depend upon the model number/hardware configuration.

FIGURE 2-4



2.6.1 ELECTRICAL CONDUIT OPENINGS

The instrument case will have conduit openings provided. To help minimize electrical noise that may adversely affect the operation of the instrument, AC power, sensor input, relay, and retransmission wires should be routed through separate conduit openings.

Unused conduit openings should be sealed.

WARNING: Avoid electrical shock. AC power wiring must not be connected at the source distribution panel until all wiring connections are completed.

FIGURE 2-5

AC Instrument Power Input

Connect the 115 VAC hot and neutral to terminals 1 and 2 respectively of TB1. See **Figure 2-4** for Terminal Board locations on the instrument. Connect the 230 VAC one leg to each terminal, be sure to check the position of the Voltage Selector switch provided with 230 VAC instruments. The switch position must match the voltage input to the instrument.

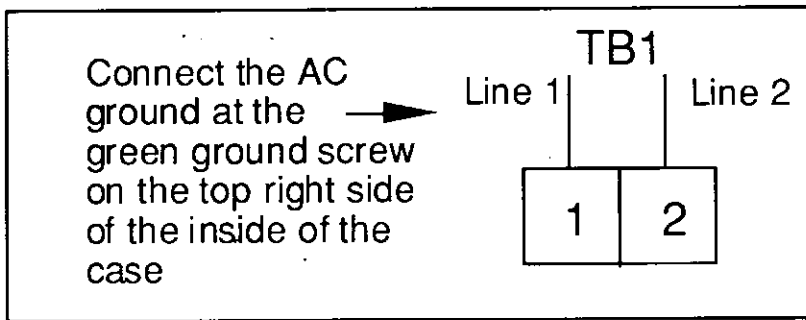


FIGURE 2-6

Thermocouple Inputs

Use TB4 for the Pen 1 input, and TB5 for the Pen 2 input. Connect the positive leg of the thermocouple to terminal 1, and the negative to terminal 2. Be sure that the input conditioning jumpers are properly positioned for a thermocouple input. See **Appendix A-1**.

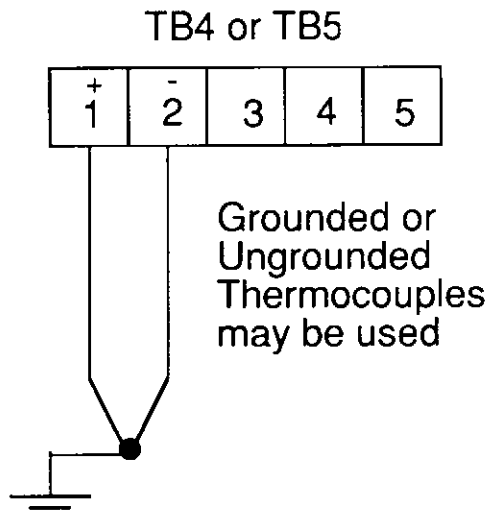


FIGURE 2-7

RTD Inputs

Use TB4 for the Pen 1, and TB5 for the Pen 2 input. Connections are shown for 3 wire and 2 wire RTD inputs. If a three wire device is used, install the common legs to terminals 2 and 3. If a two wire device is used, install a jumper between terminals 2 and 3. Be sure that the input conditioning jumpers are properly positioned for an RTD input. See **Appendix A-1**.

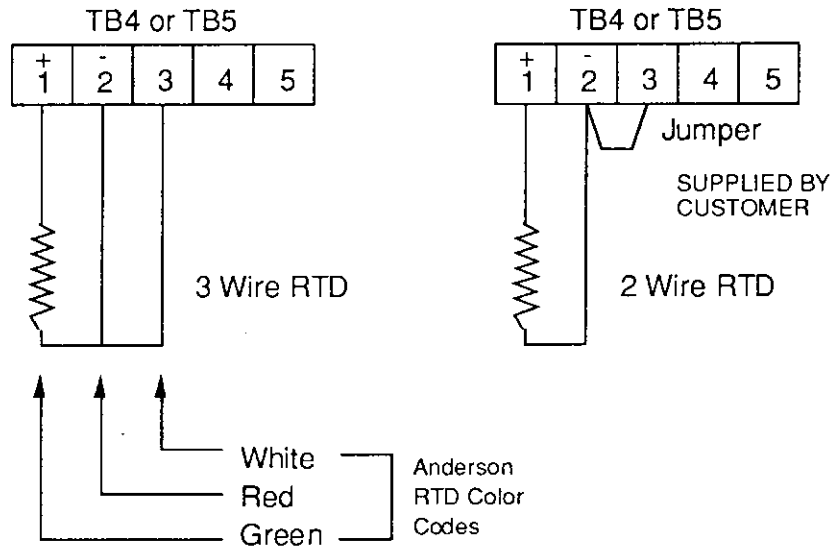


FIGURE 2-8

Volt, Millivolt and milliamp Input

Make the volt, millivolt and milliamp connections as shown below. Use TB4 for the Pen 1 input, and TB5 for the Pen 2 input. Terminal 1 is positive and terminal 2 is negative. The milliamp input requires the installation of an appropriate shunt resistor between terminals 1 and 2. A 250 ohm resistor is provided with the instrument (one per pen). Be sure that input conditioning jumpers are in the correct positions for the input being connected. See **Appendix A-1**.

Note: mA Input

1. Be sure 250 ohm shunt resistor is in place.
2. If un-powered input, you must wire to transmitter power supply also. See **Figure 2-13**.

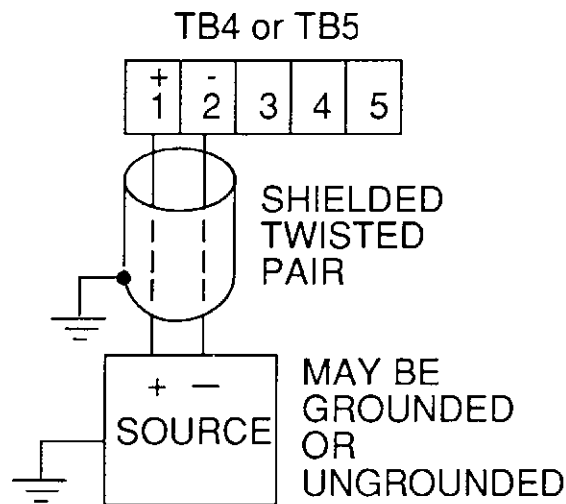
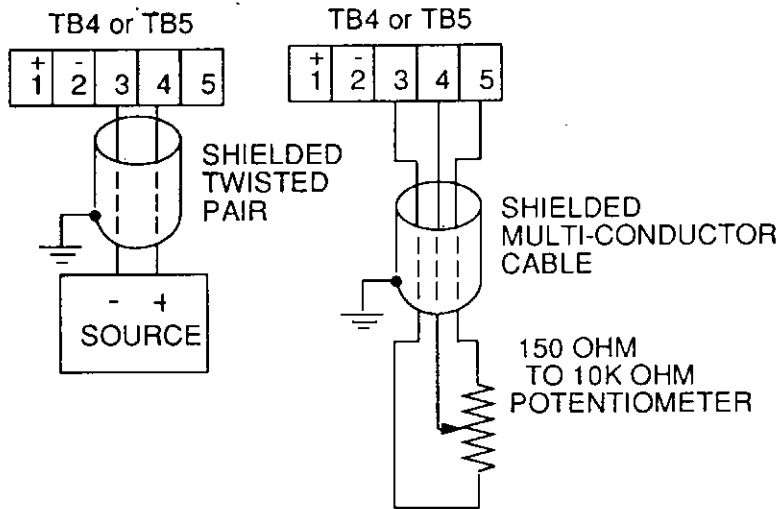


FIGURE 2-9

Remote Setpoint Input VDC , mADC

If Remote Setpoint option has been specified, make connections as shown. The remote setpoint input may be selected as either 0 to 5 VDC or 1 to 5 VDC input in the Program mode section. Make sure the configuration properly matches the input used. Use TB4 for Pen 1, and TB5 for Pen 2 if Pen 2 is provided and specified with the Remote Setpoint option. Connect the positive lead to terminal 4, and the negative lead to terminal 3 (Terminal 3 is the ground, terminal 4 is the input, terminal 5 is 5 VDC.) If a 4-20 mADC remote setpoint is to be used, the instrument remote setpoint input should be configured for 1 to 5VDC in the Program mode, and a 250 ohm resistor should be installed across terminals 4 and 3. A 250 ohm resistor is provided with the instrument, one per pen.



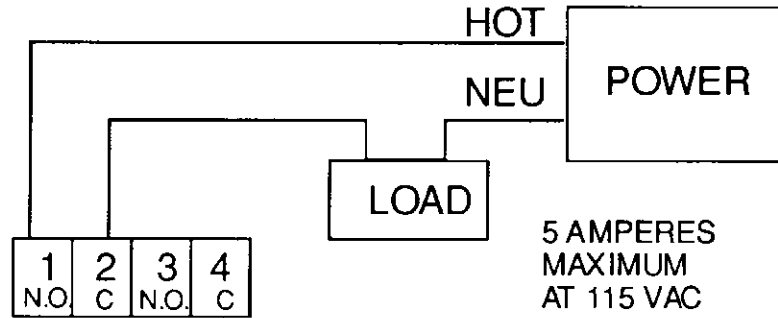
2.6.2 OUTPUT CONNECTIONS

Relay output(s), if provided in the instrument, may be assigned to control or alarm output functions for Pen 1 and/or Pen 2 (if present). Current outputs may be assigned to control and process value retransmission output for Pen 1 and/or Pen 2 (if present). The assignment of the output function (s) are/is accomplished in the Program mode. SPST relays are designated as Relay A through Relay D. Current outputs are designated as A and B.

FIGURE 2-10

SPST Relay Output

Connections are made to relays A through D as shown. Terminal connections are made using TB6 (Relay A, B), & TB7 (Relay C, D).

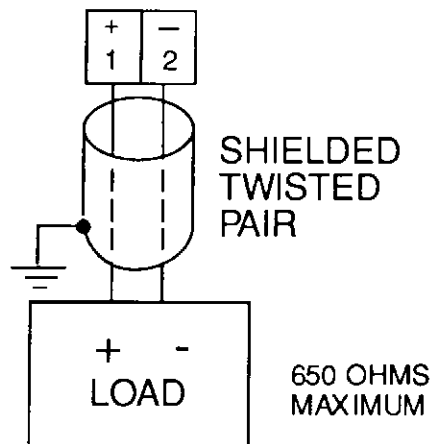


TB6 Relay A Terminals 1 & 2, Relay B Terminals 3 & 4
TB7 Relay C Terminals 1 & 2, Relay D Terminals 3 & 4

FIGURE 2-11

Current Output

Connections are made to current outputs A & B as shown. Each current output is programmable as either 4-20 mADC or 0-20 mADC. Each output must be assigned to the desired function in the Program mode. Terminal connections are made using TB8 and TB9 for current output A & B respectively. Connect positive lead (+) to terminal 1 and the negative lead (-) to terminal 2. Each current output will operate up to a 650 ohms maximum load.

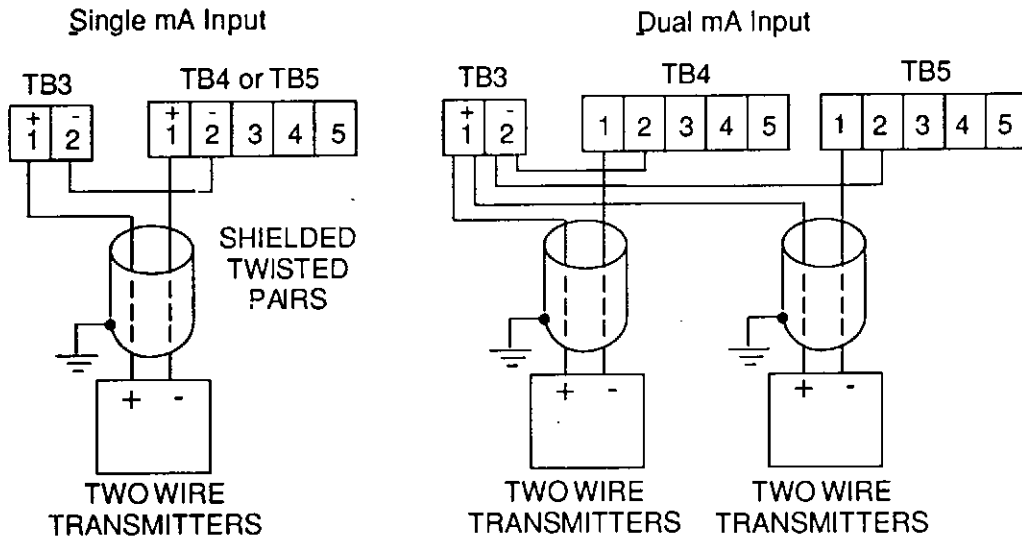


TB8 Current Output A
TB9 Current Output B

FIGURE 2-12

Transmitter Power Supply Input

If the isolated 24 VDC regulated transmitter power supply has been specified, the connections should be made as shown. Connections are made using TB3, terminal 1 is positive and terminal 2 is negative. The power supply is capable of providing the power needed by up to 2 transmitters (40 mADC maximum).

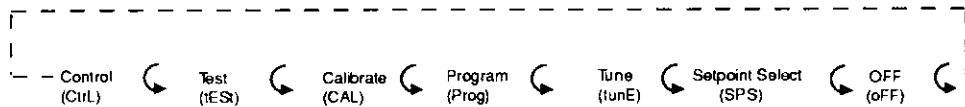


Configuration 3.1

After completing installation and wiring of the instrument, the configuration (set up) procedures must be performed to prepare the instrument for operation on the intended application. The procedures include selecting specific parameters, entering data and possible jumper positioning. Once properly configured the instrument will retain the user selections in memory so this procedure need not be repeated unless required by changes in the application.

Note: Your instrument may be provided factory set for your application - refer to documentation accompanying your order.

Parameter selections and data entry are made via the front keypad. To ease configuration and operation, user entered data has been divided up into several sections referred to as modes. Each mode contains a different type of data or may be used for specific operating functions. For two pen instruments, some modes are common to both pens. These modes are as follows:



Mode	Display Code	Function	Description
Off	oFF	Operation	Outputs and Alarms are Off Chart may stop rotating(selectable)
Control	Ctrl	Control	Outputs and Alarms are Active
Test	tES	Service	Tests Instrument Operation
Calibration	CAL	Service	Calibrates, Resets Instrument
Program	Prog	Configuration	Configure Operating Parameters
Tune	tunE	Configuration & Operation	Enter Tune and Alarm Settings
Setpoint Selection	SPS	Operation	Selects Remote or Local Setpoint Operation (Remote Setpoint Optional)
Enable	EnAb	Configuration	Mode security system, can lock out everything except Off and Control (See Appendix A-1 for hardware lockout information)

Note: Tune mode parameters may require adjustment to achieve proper control.

Associated with each mode is a series of unique displays that are accessed via the front keypad.

Calibration and Test modes are not used as part of the instrument configuration or operation. These are used for service and maintenance functions and are discussed in **Sections 5.4 & 5.5** of this manual.

Shipped Configuration/Jumper Positioning 3.2

If specified at time of order, the instrument will be pre-configured to the desired input. If not specified, refer to all tabulations labeled as "Default Parameters" to determine factory supplied settings. Instrument AC power input is as specified in the instrument model number and is shown on the ratings label. The 230 VAC option includes a switch in the instrument for selecting either 230 VAC or 115 VAC input power. If this feature is provided, verify AC input and switch position before applying power to the instrument.

3.2.1 JUMPER POSITIONING

Jumpers are used to condition the sensor inputs and to provide a security lockout feature. All jumpers are located on the instrument Processor board. The instrument board layout and jumper locations and functions are shown in **Appendix A-1**. Check the jumper positions in the instrument and verify that they are in the proper position for the intended application.

The sensor input jumpers JU4, JU5, JU6 and JU7 condition the sensor input signals and must be used in conjunction with input type selections made in the Program mode.

Operation Summary 3.3

3.3.1 MODE SELECTION

If the instrument is either in the Off mode or the Control mode, repeated pressing and releasing of the SCROLL key will cause the instrument to display the code corresponding to each mode that is enabled. To enter a mode while the code is displayed, press the DOWN key. If a mode does not appear, refer to the Enable mode section for information on how to determine if the mode is on.

Entry into any mode except the Control, Tune, Manual, Off and Enable modes, will cause the output(s) to turn off and any process re-transmission value output(s) to be 0 %. Entry into the Off mode will cause process re-transmission to remain active.

Start up Procedures 3.4

All configuration parameters are listed in **Tables 3-1** through **3-5**.

For a single pen instrument, parameters for each mode are displayed in the left display. If the instrument being configured is a two pen model, a sequence of applicable parameters will be displayed in the Pen 2 display after the Pen 1 parameters have been reviewed and configured. After the Pen 2 parameters have been completed, parameters common to both pens will be configured and displayed in the Pen 1 display.

The instrument is provided with a time out feature. If the instrument is in any mode (except while executing a calibration or test procedure) and no keypad activity takes place for 240 seconds, the instrument will time out and exit the mode automatically. The display will become the code for the respective mode. If a mode code is displayed for 5 seconds with no keypad activity, then the time out will cause the instrument to proceed to either the Control or Off mode, depending upon whether the mode entered was an operational mode (Tune, Manual, Enable) or non operational mode (Test, Program, Cal).

3.4.1 POWER UP PROCEDURE

- A. Verify that all electrical connections have been properly made before applying power to the instrument.
- B. Upon **power up**, a brief flash on all displays (left and, if equipped, right) will occur to show the instrument is active. Then **3XXX** will be displayed (X representing digits), then **XXXX**, then **XXXX**, identifying the twelve digit model number as defined in the order matrix. Next, the EPROM part number will be indicated **P-XX**. After the EPROM part number, the software revision level will be displayed in the format **rX.XX** followed by **P.dn** (if **Pen Action on Power Up, PAPu**, in Program Mode is set to **0**, pens go to "HOME" position at power up). During this display, the decimal point after the "P" will blink to show the mode is active. Upon successful completion of this routine, **Ctrl** or **oFF** will be displayed for about three seconds. The mode displayed will be the mode that the instrument was in when the power was turned off. During this time the operator may select another mode (**Tune**, **Manual**, **Enable**) or non-operational mode (**Test**, **Program**, **Cal**).
- C. If any error messages are displayed, refer to **Section 5.6** for a definition of the error message and the required action.

Front Panel Operation 3.5

3.5.1 DIGITAL DISPLAY AND STATUS LED'S

The digital display provided for each pen has 4 digits and a decimal point. Each digit has seven segments and is capable of producing numeric characters from 0-9 and certain alpha characters. The digital display is used to provide indication of process variable as well as displaying codes used for configuration and operation of the instrument. The display includes the following Status Indicator LED's;

Label	Color	Function
MAN	Amber	Lights when the Manual StbY mode is on.
OUT1	Red	Lights when Output 1 is on or mADC output selected.
OUT 2	Amber	Lights when Output 2 is on or mADC output selected..
ALRM	Red	Lights when either Alarm is on.
C	Red	Lights to indicate that the process value is in degrees C (Celsius).
F	Red	Lights to indicate that the process value is in degrees F (Fahrenheit).
U	Red	Lights to indicate that the process value is in terms of Engineering units.
SP	Green	Indicates that the value displayed is the setpoint.
-	Red	Lights to indicate a negative displayed value.

Refer to **Figure 1-2** for the display features illustration.

3.5.2 KEYPAD CONTROLS

The keys on the keypad functions include:

- SCROLL:** Used to :
1. Display the enabled modes.
 2. While in a mode, used to sequence the parameter codes and values.
 3. Exit some Test and Calibration functions

4. Work in conjunction with other keys:
 - a. With the UP key to display proportional output %
 - b. With the DOWN Key;
 - 1) On power up to alter model #
 - 2) Enter Cal/Test functions

UP: Used to:

1. Exit a mode.
2. Turn a mode On in the Enable mode
3. Increase a parameter numerical value
4. View the setpoint for Pen 1 (Press release)
5. Increase the setpoint value (Press hold)
6. Work in conjunction with other keys:
 - a. With the SCROLL key to display proportional output %
 - b. With the DOWN key;
 - 1) Lamp test (Press release)
 - 2) Enter the Enable mode (Press and hold for 11 seconds)

DOWN: Used to:

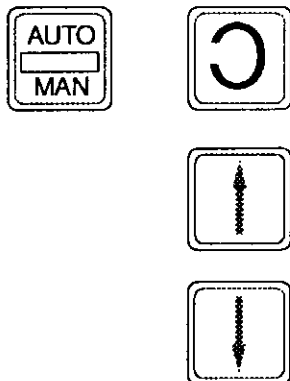
1. Enter a mode
2. Turn a mode Off in the Enable mode
3. Decrease a parameter numerical value
4. View the setpoint for Pen 2 (if provided).
5. Decrease the setpoint value (Press hold)
6. Step display through parameter codes in a mode
7. Work in conjunction with other keys:
 - a. With the SCROLL key;
 - 1) On power up to alter the model number displayed
 - 2) Enter Cal/Test functions
 - b. With the UP key;
 - 1) Lamp test (Press release)
 - 2) Enter the Enable mode (Press and hold for 11 seconds)

AUTO/MAN: Used to:

The upper key is for Pen 1, the lower key is for Pen 2 (if provided)

1. In the Control mode to enter the Manual mode if proportional output(s) selected
2. In the Manual mode to enter the Control mode if proportional output(s) selected

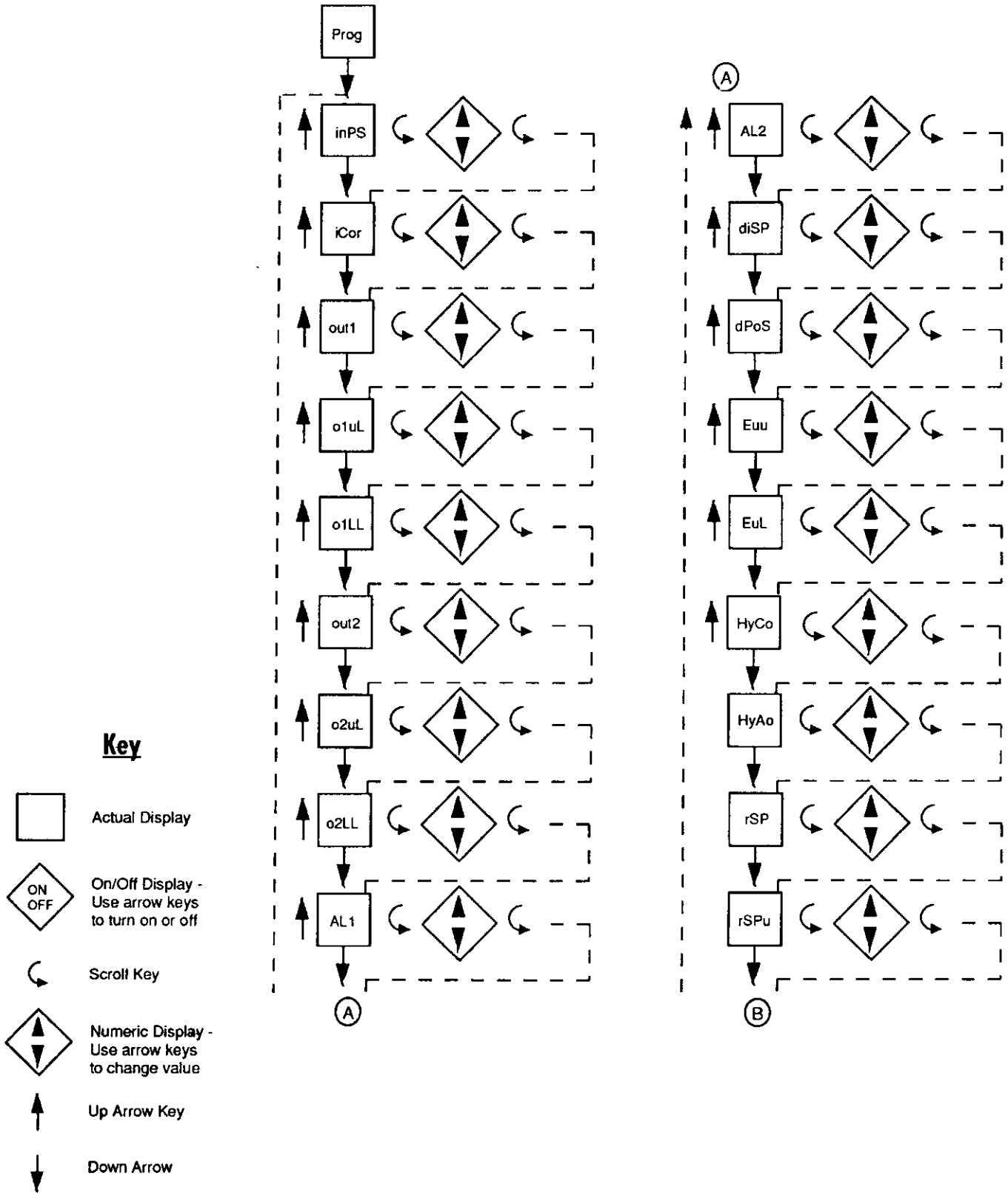
FIGURE 3-1

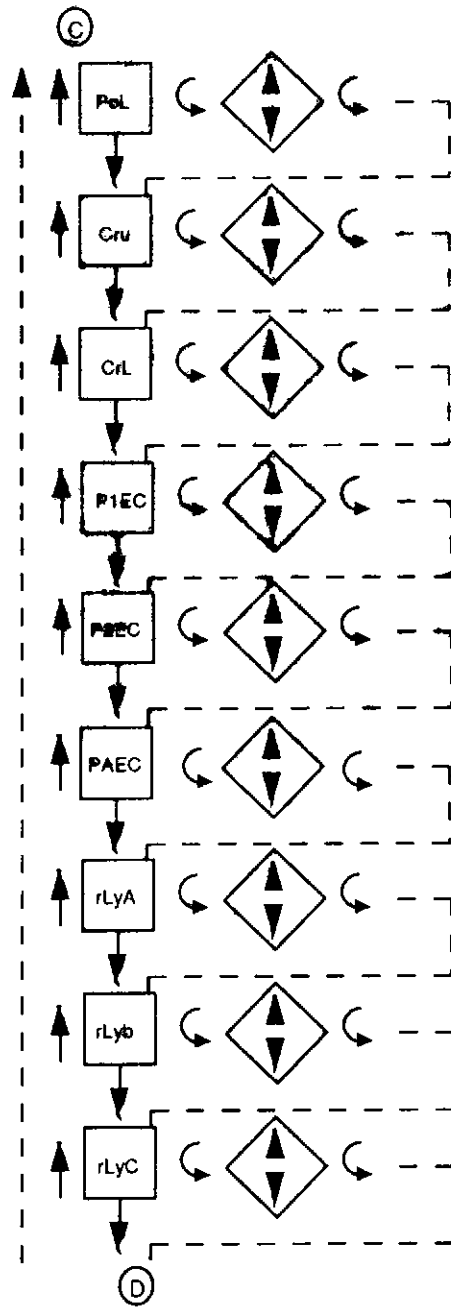
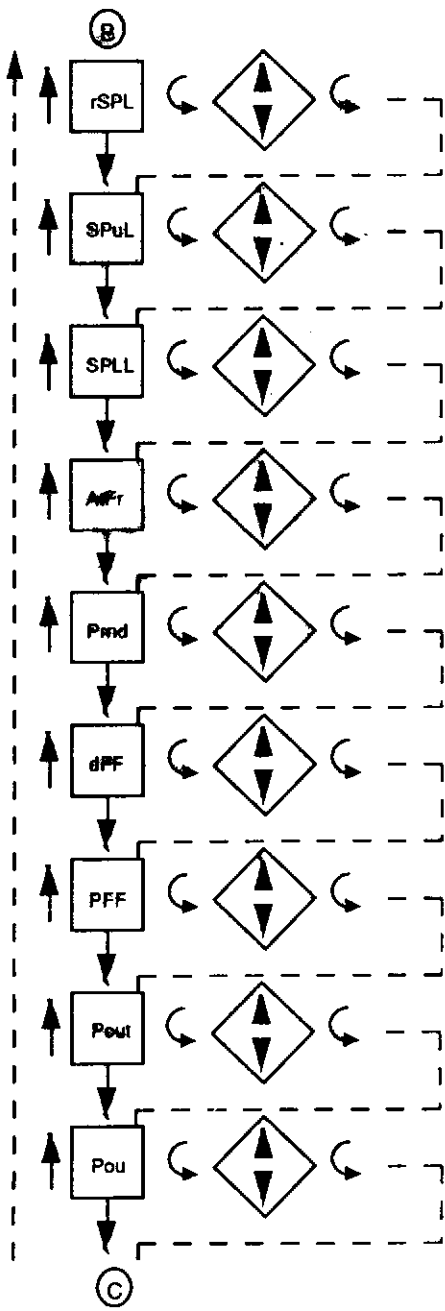


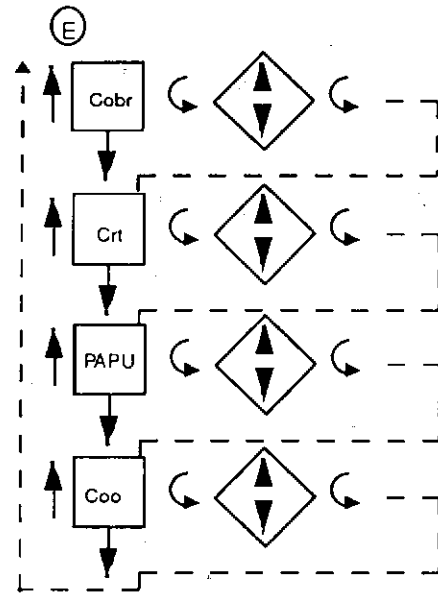
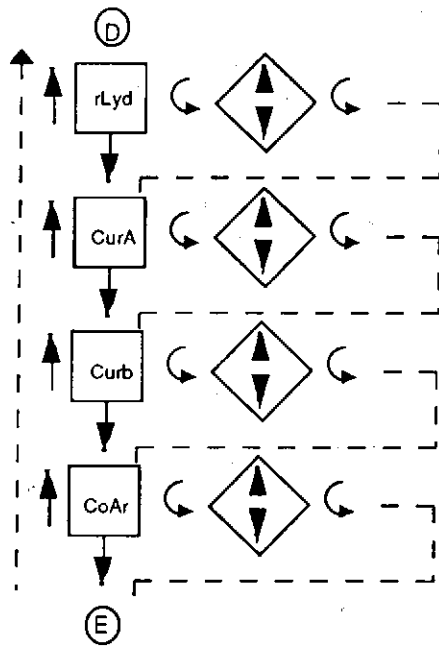
Lamp Test

From the Off or Control modes, all display and status LEDs can be illuminated simultaneously by depressing the UP and DOWN keys at the same time. Any defective LEDs will not light.


PROGRAM MODE FLOW CHART










Key

 Actual Display

 On/Off Display -
Use arrow keys
to turn on or off

 Scroll Key

 Numeric Display -
Use arrow keys
to change value

 Up Arrow Key

 Down Arrow

TABLE 3-1 PROGRAM MODE CONFIGURATION PROCEDURE

Press the SCROLL key until **Prog** is displayed. Press the DOWN key to enter the Program mode. Pen 1 will be displayed in the left display. To enter the Pen 1 parameter, press the DOWN key. To enter the Pen 2 parameter, if provided, press the SCROLL key, then the DOWN key. To enter the unit parameter, press the SCROLL key with either Pen 1 or Pen 2 displayed until unit is displayed, then press the DOWN key. Press the SCROLL key to advance the display through the parameter codes and their values. Use the UP and DOWN keys to adjust the values. After adjusting a parameter, press the SCROLL key to proceed to the next parameter. After all selections have been made, press the UP key with a parameter in the display (not a setting) to exit the mode. For two pen instruments the parameters and values which are applicable to Pen 1 will appear in the left display, then the parameters and values which are applicable to Pen 2 will appear in the right display. Then the unit parameters and values will appear in the left display.

For illustration purposes all available Program mode parameters have been listed. The parameters that will appear on the specific instrument will depend upon the model number (hardware configuration) of the instrument and on the parameter selections previously made.

For future reference, record the parameter selections for the application in the "Your Setting" column and on the Software Reference Sheet in **Appendix E**. Use the Software Reference Sheet to program the instrument.

To prevent unauthorized changes to the Program mode, the mode can be disabled (turned off) in the Enable mode.

STEP	DESCRIPTION	DISPLAY CODE	AVAILABLE SETTINGS	FACTORY SETTING	YOUR SETTING
1	Input Select	InPS	0=J T/C degrees C 1=J T/C degrees F 2=K T/C degrees C 3=K T/C degrees F 4=T T/C degrees C 5=T T/C degrees F 6=R T/C degrees C 7=R T/C degrees F 8=S T/C degrees C 9=S T/C degrees F 10=E T/ C degrees C 11=E T/C degrees F 12=B T/ C degrees C 13=B T/C degrees F 14=N T/ C degrees C 15=N T/C degrees F 16=C T/ C degrees C 17=C T/C degrees F 20=RTD degrees C 21=RTD degrees F 30=0 to 5 VDC 31=1 to 5 VDC 32=0 to 50 mVDC 33=10 to 50 mVDC 34=0 to 25 mVDC	7	
2	Input Correction	ICor	-300 to 300 degrees/units	0	
3	Output 1	out1	0 = None 1=On-Off- Direct 2=On-Off- Reverse 3=Time Proportioning- Direct 4=Time Proportioning -Reverse 5=Current Proportioning -Direct 6=Current Proportioning -Reverse	0	

STEP	DESCRIPTION	DISPLAY CODE	AVAILABLE SETTINGS	FACTORY SETTING	YOU SETTI
4	Output 1 Percent Upper Limit (o1uL and o1LL will not be seen if out1 = 0,1,2)	o1uL	0 to 100 percent	100	
5	Output 1 Percent Lower Limit	o1LL	0 to 100 percent	0	
6	Output 2	out2	0 = None 1=On-Off- Direct 2=On-Off- Reverse 3=Time Proportioning- Direct 4=Time Proportioning-Reverse 5=Current Proportioning- Direct 6=Current Proportioning -Reverse	0	
7	Output 2 Percent Upper Limit (o2uL and o2LL will not be seen if out2 = 0,1,2)	o2uL	0 to 100 percent	100	
8	Output 2 Percent Lower Limit	o2LL	0 to 100 percent	0	
9	Alarm 1 the Alarm Point is selected in the Tune mode	AL1	0 to 2 0 = None 1=Process Alarm-Direct 2=Process Alarm-Reverse	0	
10	Alarm 2	AL2	Same selections as Alarm 1	0	
11	Display Select	diSP	1=Process value only 2=Process value/setpoint 5=Setpoint only	1	
12	Decimal Position	dPoS	0 to 3 0=None 1=One decimal place 2=Two decimal places 3=Three decimal places RTD and thermocouple inputs are limited to either 0 or 1 decimal positions	0	
13	Engineering Units Upper Value (Euu and EuL will be seen if the pen input select = 30,31,32,33,34)	Euu	-9999 to 9999	1000	
14	Engineering Units Lower Value	EuL	-9999 to 9999	0	
15	Hysteresis for Control Outputs	HyCo	0 to 300 Width of Hysteresis Band (See page 66 for definition)	3	
16	Hysteresis for Alarm Outputs	HyAo	0 to 300 Width of Hysteresis Band	3	

STEP	DESCRIPTION	DISPLAY CODE	AVAILABLE SETTINGS	FACTORY SETTING	YOUR SETTING
17	Remote Setpoint If rSP is set to zero then rSPu and rSPL are not seen	rSP	0 to 2 0=Not Used 1=1 to 5 VDC 2=0 to 5 VDC	0	
18	Remote Setpoint Upper Value	rSPu	-9999 to 9999	1400	
19	Remote Setpoint Lower Value	rSPL	-9999 to 9999	0	
20	Setpoint Upper Limit	SPuL	-9999 to 9999	1400	
21	Setpoint Lower Limit	SPLL	-9999 to 9999	0	
22	Automatic Transfer	AtFr	0 to 2 0 = No Automatic Transfer 1=Transfers when the process value goes below the setpoint 2=Transfers when the process value goes above the setpoint	0	
23	Process Rounding of Display Value	Prnd	0 to 100 0 = No rounding	0	
24	Display Filter Factor	dFF	1 to 20 1= no filtering (number of values averaged)	1	
25	Process Filter Factor	PFF	Same selection as dFF	1	
26	Process Value Output Retransmission (If Pout =0 then Pou and PoL will not be displayed)	Pout	0=Not selected 1=Selected	0	
27	Process Output Upper Value	Pou	-9999 to 9999	2000	
28	Process Output Lower Value	PoL	-9999 to 9999	0	
29	Chart Range Upper Value	Cru	-9999 to 9999	200	
30	Chart Range Lower Value	CrL	-9999 to 9999	0	
31	Proportional Output 1 Action on Error Condition (If out1 = 0,1,2 then P1EC will not be displayed)	P1EC	0 to 100%	0	
32	Proportional Output 2 Action on Error Condition (If out2 = 0,1,2 then P2EC will not be displayed)	P2EC	0 to 100%	0	

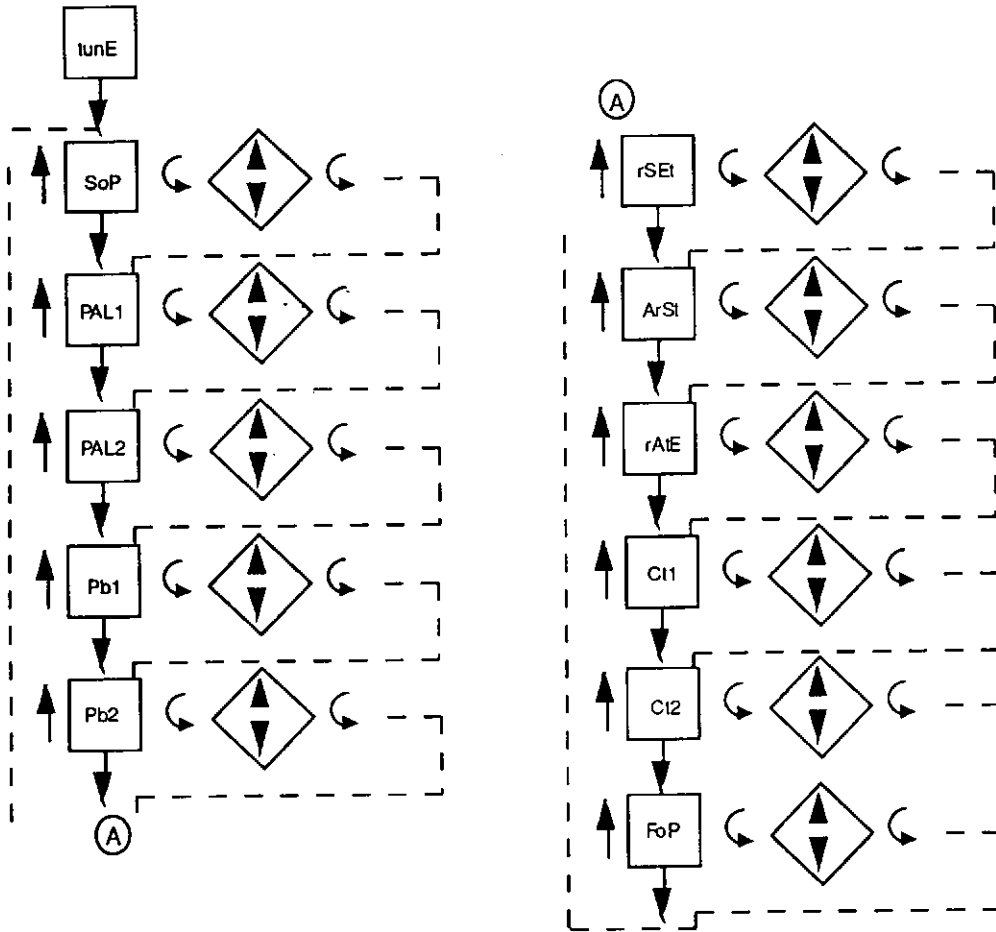
STEP	DESCRIPTION	DISPLAY CODE	AVAILABLE SETTINGS	FACTORY SETTING	YOU SETTING
33	Pen Action on Error Condition	PAEC	0 or 1 0 = Pen goes to 0 % of chart 1 = Pen goes to 100 % of chart	1	

Pressing the SCROLL key with the **PAEC** parameter value displayed in the Pen 1 window will advance the display of a single pen instrument to the unit parameters. Pressing the SCROLL key with the **PAEC** parameter displayed in the Pen 1 window of a two pen instrument will advance the display to be **PENs** in the Pen 2 window. The Pen 2 Program mode parameter selections can be made now. Pressing the SCROLL key with the **PAEC** parameter value displayed in the Pen 2 window will cause the display to advance to the unit parameters displayed in the Pen 1 window.

Unit Parameters

34	Relay A Assignment	rLyA	0 to 8 1=Assigned to Alarm 1-Pen 1 2=Assigned to Alarm 2-Pen 1 3=Assigned to Alarm 1-Pen 2 4=Assigned to Alarm 2-Pen 2 5=Assigned to Output 1-Pen 1 6=Assigned to Output 2-Pen 1 7=Assigned to Output 1-Pen 2 8=Assigned to Output 2-Pen 2	0	
35	Relay B Assignment	rLyb	Same selection as rLyA	0	
36	Relay C Assignment	rLyC	Same selection as rLyA	0	
37	Relay D Assignment	rLyd	Same selection as rLyA	0	
38	Current Output A Assignment	CurA	0 to 6 0=Not Assigned 1=Assigned to Process Value Output-Pen 1 2=Assigned to Process Value Output-Pen 2 3=Assigned to Output 1-Pen 1 4=Assigned to Output 2-Pen 1 5=Assigned to Output 1-Pen 2 6=Assigned to Output 2-Pen 2	0	
39	Current Output B Assignment	Curb	Same selection as CurA	0	
40	Current Output A Range	CoAr	0 to 1 0=0-20 mA 1=4-20 mA	1	
41	Current Output B Range	Cobr	Same selection as CoAr	1	
42	Chart Rotation Time	Crt	0.1 to 999.9 hours per rotation	1.0	
43	Pen Action at Power Up	PAPU	0 = Pen(s) go to the "Home" position (toward chart center) 1 = Pen(s) remain in last position prior to power down.	0	
44	Chart Operation in Off Mode	Coo	0 to 1 0=Chart continues rotating in the Off mode 1=Chart stops rotating while in the Off mode	0	

TUNE MODE FLOW CHART



Key







-  Actual Display
-  On/Off Display - Use arrow keys to turn on or off
-  Scroll Key
-  Numeric Display - Use arrow keys to change value
-  Up Arrow Key
-  Down Arrow

TABLE 3-2 TUNE MODE CONFIGURATION PROCEDURE

The Tune mode allows the entry, review or altering of the process control Tune adjustments and alarm setting(s).

To enter the Tune mode, press and release the SCROLL key until **tunE** is displayed, then press the DOWN key. Press the SCROLL key to advance the display through the parameters and their values. Use the UP and DOWN keys to select (adjust) the values. Each time the DOWN key is pressed while a parameter code is being displayed, such as **SoP**, the next parameter code in the sequence will be displayed (**PAL1**).

After selecting a parameter, press the SCROLL key to proceed to the next parameter. Pen 1 selections will appear in the Pen 1 window and the Pen 2 (if provided) selections will appear in the Pen 2 window after the Pen 1 parameters have been displayed. After all selections have been made, press the UP key with a parameter in the display (not a setting) to exit the mode.

For illustration purposes, all available Tune mode parameters have been listed. The parameters that will appear on the specific instrument will depend upon the parameter selections previously made in the Program mode.

For future reference, record the parameter selections for the application in the "Your Setting" column and on the Software Reference Sheet in **Appendix E**. Use the Software Reference Sheet to program the instrument.

To prevent unauthorized changes to the Tune mode, the mode can be disabled (turned off) in the Enable mode.

The Tune mode is adjusted on-line. The instrument will react to changes as they are made.

STEP	DESCRIPTION	DISPLAY CODE	AVAILABLE SETTINGS	FACTORY SETTING	YOU SETTI
1	Second Output Position (Will not be seen if out2=0)	SoP	-1000 to 1000 units	0	
2	Process Alarm 1 (The Alarm setting seen will depend upon the Alarm selected in the Program mode)	PAL1	-9999 to 9999 units	0	
3	Process Alarm 2	PAL2	-9999 to 9999 units	0	
4	Proportional Band Output 1 (Will only be seen if out1=3,4,5,6,7)	Pb1	1 to 3000 units	100	
5	Proportional Band Output 2 (Will only be seen if out2=3,4,5,6)	Pb2	1 to 3000 units	100	
6	Manual Reset (Will only be seen if Pb1/Pb2 were shown)	rSEt	-1500 to 1500 units	0	
7	Automatic Reset Output 1 - Integration (Will be seen if Pb1 was shown)	ArSt	0.0 to 100.0 repeats per minute	0.0	
8	Rate Output 1 Derivative (Will be seen if Pb1 was seen)	rAtE	0.0 to 10.0 minutes	0.0	

STEP	DESCRIPTION	DISPLAY CODE	AVAILABLE SETTINGS	FACTORY SETTING	YOUR SETTING
9	Cycle Time Output 1 (Will be seen if out1=3,4)	Ct1	1 to 240 seconds	30	
10	Cycle Time Output 2 (Will be seen if out2=3,4)	Ct2	1 to 240 seconds	30	
11	First Output Position	FoP	-1000 to 1000 units	0	

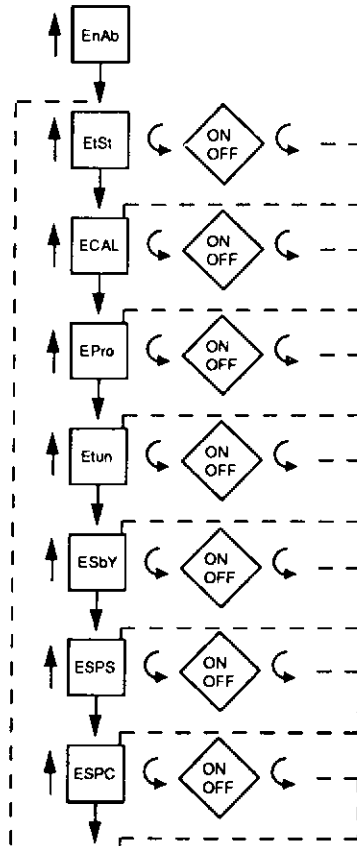
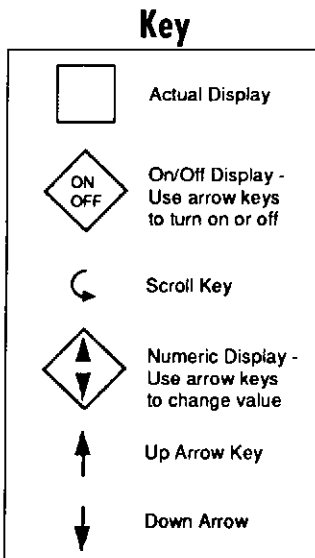
TABLE 3-3 ENABLE MODE CONFIGURATION PROCEDURE

To enter the Enable mode, press the UP and DOWN keys while in **Ctrl** or **oFF** modes. All the display lamps will light. After 2 seconds, the display will show **Cchg** and the pen(s) will move to and remain at a point above the top graduation on the chart. Continue pressing the UP and DOWN keys, after 2 additional seconds, the display will show **P dn** and the pen(s) are driven below the bottom graduation on the chart. After 6 more seconds, the display will show **EnAb**. Release the keys and the display will change to **EtSt**. Press and release the DOWN key and each mode to be enabled/disabled will be displayed. With the enable mode prompt for the desired mode displayed press the SCROLL key to verify that the displayed mode is either **on** (enabled) or **oFF** (disabled). Press the DOWN key to turn off the mode, press the UP key to turn on the mode or press the SCROLL key to advance the display to the next enable mode prompt. Use the "Your Setting" column in the table to record your settings.

A hardware jumper located on the Processor Board (See **Appendix A-1**) can be used to lock/unlock the Enable mode. When the jumper is moved to the locked position, entry into the Enable mode is not possible until the jumper is moved to the unlocked position.

STEP	DESCRIPTION	DISPLAY CODE	AVAILABLE SETTINGS	FACTORY SETTING	YOUR SETTING
1	Test Mode	EtSt	on or oFF	oFF	
2	Calibration Mode	ECAL	on or oFF	oFF	
3	Program Mode	EPro	on or oFF	on	
4	Tune Mode	Etun	on or oFF	on	
5	Manual (Stby) Mode	ESby	on or oFF	on	
6	Setpoint Select mode (Optional)	ESPS	on or oFF	on	
7	Setpoint Change	ESPC	on or oFF	on	

ENABLE MODE FLOW CHART



Operation 4.1

4.1.1 OFF MODE

In the Off mode, the instrument control, and alarm function(s) are turned off. Process Re-transmission signal(s) remain active. The chart rotation can be selected in the Program mode to stop or continue to rotate when the instrument is in the Off mode. The pen(s) will remain active. The Off mode can be entered by pressing and releasing the SCROLL key until the display reads **oFF**, then pressing the DOWN key. The display will read **oFF** and then current process variable at two second intervals. Entering the Off mode of a dual pen instrument will cause both pens to enter the Off mode. The second pen display will be blank as the left display reads **oFF** and displays the process value for the second pen at the same time as the upper display. To exit off mode, press DOWN key while Cntrl prompt is displayed.

4.1.2 CONTROL MODE

In the Control mode, the instrument control function(s) and alarm(s) are actively responding to the process variable as selected in the Program and Tune modes and the chart will be rotating at the rate selected. The Control mode allows setpoint changes from either local setpoint (standard) adjustment by an operator at the front keypad or from a remote setpoint source (optional). Other operations in the Control mode include a lamp test and proportional output display.

4.1.2.1 LOCAL SETPOINT OPERATION

Single Pen Instruments: The instrument must be in the Control mode to allow setpoint value to be displayed and adjusted. In the Control mode, to view the setpoint, press and release the **UP** or **DOWN** key. The green LED under the SP label will light to indicate that the displayed value is the setpoint. To change the setpoint value press and hold the appropriate key. Press and hold the **UP** key to increase the setpoint or press and hold the **DOWN** key to decrease the setpoint. The setpoint will change slowly at first then faster as the key is held. If the setpoint will not increase, check the Program mode to see that you are not trying to increase the setpoint above the setpoint upper limit **SPuL**. If the setpoint will not decrease check the Program mode to see that you are not trying to decrease the setpoint below the setpoint lower limit **SPLl**. If the setpoint will not increase or decrease, check that the Setpoint Change mode is on in the Enable mode.

Dual Pen Instruments: The setpoint of each instrument can be reviewed separately. **PEN 1:** To review and change the local setpoint for Pen 1 press the **UP** key. The green LED in the left display will light indicating that the setpoint value is displayed. The setpoint can now be raised by pressing and holding the **UP** key or decreased by pressing the **DOWN** key. **PEN 2:** The setpoint for Pen 2 is viewed and changed in the same manner, except the **DOWN** key must be pressed to access the Pen 2 setpoint. The setpoint will change slowly at first then faster as the key is held. If the setpoint will not increase, check the Program mode to see that you are not trying to increase the setpoint above the setpoint upper limit **SPuL**. If the setpoint will not decrease, check the Program mode to see that you are not trying to decrease the setpoint below the setpoint lower limit **SPLl**. If the setpoint will not increase or decrease, check that the Setpoint Change mode is on in the Enable mode.

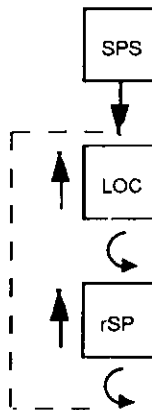
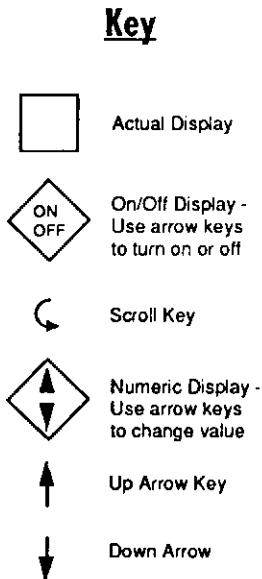
4.1.2.2 REMOTE SETPOINT OPERATION

Single Pen Instruments: If the instrument is specified and provided with Remote Setpoint capability (auxiliary input of 0-5 VDC or 1-5 VDC), and the Remote Setpoint has been properly configured in the Program mode, the Setpoint Select mode will be accessible, if enabled. Press and release the SCROLL key until **SPS** appears in the display, then press the DOWN key. The display will show **Loc** if the local (keypad entered) setpoint is being used or **rSP** if the remote setpoint is in use. Press the SCROLL key to select the setpoint mode that will be used by the instrument. Press the UP key to exit the Setpoint Select mode.

Dual Pen Instruments: If the instrument is specified and provided with the Remote Setpoint capability for either or both pens and the Remote Setpoint has been properly configured in the Program mode for either or both pens, the Setpoint Select mode will be accessible, if enabled. Press and release the SCROLL key until **SPS** appears in the display, then press the DOWN key. The left display will light and the right display will blank if pen 1 is selected for a remote setpoint. If only pen 2 is selected as a remote setpoint then the right display will blank and the right display will light. If both pens are selected for remote setpoint, the right display is accessed by pressing the DOWN key while the left display shows the setpoint mode selected for that pen. The display(s) will show **Loc** if the local (keypad entered) setpoint is being used or **rSP** if the remote setpoint is in use. Press the SCROLL key to select the setpoint mode that will be used by the instrument. Press the UP key to exit the Setpoint Select mode. If a problem develops with the remote setpoint signal for either pen, the left display will show **rSEr**, the remote setpoint error code.

Note: When switching from **rSP** back to **Loc** setpoint, the **rSP** becomes the **Loc** setpoint.

SETPOINT SELECT FLOW CHART



4.1.2.3 ON-OFF CONTROL

On-Off control can only be implemented on controllers provided with SPST relay. On-Off operation can be assigned to either or both output 1 and 2 for each pen. The On-Off control can be selected as direct or reverse acting. Direct action is typically used in cooling applications. The output device will turn on when the process value is greater than the setpoint. Reverse action is typically a heating application. The output device will turn on if the process value is below the setpoint. A hysteresis adjustment is provided for On-Off outputs on each pen. This adjustment is in terms of degrees/engineering units and defines the width of the hysteresis band about the setpoint. This parameter may also be referred to as a dead band. Relay chatter can be eliminated by proper adjustment of this parameter. When operating in On-Off control, the control algorithm will turn the output on or off depending upon the setpoint, the relative position of the process value, and the hysteresis adjustment. The respective OUT 1 or OUT2 indicator for the respective pen will illuminate to indicate that the output device is on.

In order to vary a proportional output value, press and release the SCROLL key until the display code for the output is displayed **Po1** or **Po2**. Press the SCROLL key again to see the percentage of output value. Press the UP key to increase the output percentage value. Press the DOWN key to decrease the output percentage value.

If no keys are pressed, the display will sequence through the following displays:

Po1 if output 1 is 3,4,5,6,7 then the output 1 percentage of output value.

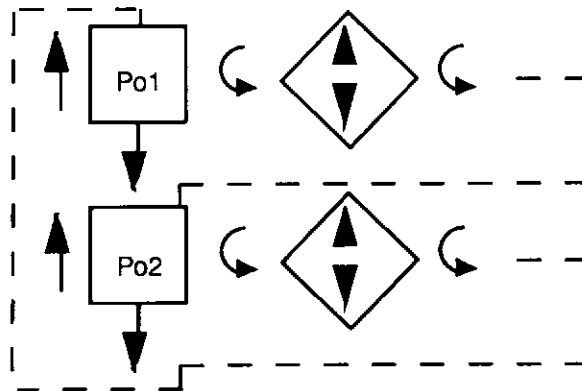
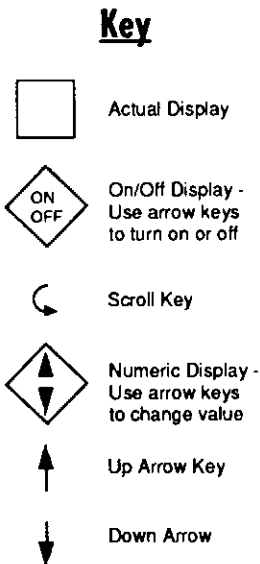
Po2 if output 2 is 3,4,5,6 then the output 2 percentage of output value.

Proc will be displayed then current process value for that pen.

In order to change a proportional value once the cyclic display begins, press and release the UP or DOWN key then press the SCROLL key until the display code for the output is displayed **Po1** or **Po2**. Press the SCROLL key again to see the percentage of output value. Press the UP key to increase the output percentage value. Press the DOWN key to decrease the output percentage value.

To return to the Control mode of operation from the Manual mode, press the specified **AUTO/ MAN** key. If the Automatic Transfer feature is selected in the Program mode, the instrument will switch from Manual mode to the Control mode when process value reaches the setpoint value.

STANDBY MODE FLOW CHART



Alarm Operation 4.2

There are two alarms available per pen. The type of alarm is selected in the Program mode as follows.

1. Process Alarm Direct - the alarm will be on if the process value is greater than the process value selected.
2. Process Alarm Reverse - the alarm will be on if the process value is less than the process value selected.

The alarms will be active while the instrument is in the Control mode. Relay can be assigned to provide output capability for the alarm functions.

The alarm value is selected in the Tune mode.

Alarm output chatter can be reduced by using the hysteresis for the alarm outputs adjustable in the Program mode to create a deadband around the alarm point.

Tune Mode Operation 4.3

Proportional output controllers may require the adjustment (tuning) of the PID and other related parameters. This provides a means for the instrument's control algorithm to be adjusted to meet specific application requirements.

4.3.1 SYSTEMATIC TUNING METHOD

1. Changes in tuning parameters should be made one at a time.
2. After making any changes in tuning parameters, a disturbance should be introduced into the process so that the process reaction may be observed. This process reaction, or recovery, will tell whether the tuning parameters provide the desired control. It is usually easiest to make a step change in setpoint to introduce this disturbance.
3. The change in setpoint or disturbance, referenced above should be large enough to cause an observable deviation of process from setpoint. However, this change should not be so large that it will cause the controller output to proceed to either extreme limit.
4. Controller tuning for optimal control is not hard and fast, BE PATIENT: The process will take a certain amount of time to react to the setpoint changes during tuning. The amount of time depends upon the specific process, however, a period of 8 to 12 minutes should be allowed between changes. The important point to remember is to allow the process to react completely, do not rush through tuning of the controller. If the complete process reaction is not observed, optimum control may never be achieved.
5. Time Proportioning control output(s) require the cycle time be adjusted for the application. Short cycle times typically result in the most accurate process control, but will cause the quickest "wear out" of any mechanical components.
6. Leave all other tuning parameters (except for the alarm settings) at the factory default settings. Obtain the best possible process reaction by adjusting the Proportional Band width parameter. The setting that achieves the best response for the process should be left in the controller programming, and should be noted on the Software Reference Sheet in **Appendix E**.

7. If there are to be no setpoint or load changes in the process, the Proportional Band adjustment may be all that is necessary for proper control. If an offset still exists (the process does not settle out at setpoint with the best possible proportional band adjustment) Manual Reset may be added to eliminate this offset.
8. Auto Reset may be added to eliminate process offsets with respect to setpoint. Increase Auto Reset from 0 in 0.2 increments. Start with a small amount. Increase this increment if there is no apparent reaction. Remember to allow the process 8 to 12 minutes to react to any changes.
9. If necessary, Rate may be added. Rate is a dynamic tuning parameter. Rate may be required to compensate for load changes or to inhibit process oscillations that may occur when a large amount of auto reset (4 or 5 repeats / minute) is being used.
10. Controller tuning is not hard and fast. It may be necessary to adjust the tuning parameters over a period of time to obtain optimal control of the process.

4.3.2 ZIEGLER NICHOLS TUNING METHOD

This procedure has been determined empirically to yield ideal 1/4 amplitude decay tuning parameters that are determined by watching the system in a sustained oscillation (curve C page 44, the ultimate proportional band and ultimate time period) and then using these values from this sustained oscillation to calculate ideal parameters.

To aid in determining the process oscillation, the instrument configuration parameters can be adjusted. By reducing the chart upper value **CrU** and increasing the chart lower value **CrL** the resolution of the oscillation can be better observed. Also the chart rotation time **Crt** can be reduced to improve the observation of the oscillation cycle times.

Determining Ultimate Proportional Band and Ultimate Time Period

1. Set Manual Reset **rSet** to 0.0, **ArSt** 0.0 and set **raTE** to 0.0.
2. Enter the Control mode of operation, observe the process reaction.
3. Set the Proportional Band (**PB**) at 100 and upset the process and observe the response. One easy method for imposing the upset is to move the setpoint for a few seconds and then return it to its original value.
4. Achieve a response curve similar to the sustained oscillation (curve C), this is the Ultimate Proportional Band (**UPB**) and Ultimate Time Period (**UTP**).
 - a) If the response curve from step 3 does not damp out, as in curve A from drawing, the **PB** is too low. The **PB** should be increased and step 3 repeated.
 - b) If the response in step 3 damps out, the **PB** is too high. The **PB** should be decreased and step 3 repeated.

These values obtained for Ultimate Proportional Band (UPB) and Ultimate Time Period (UTP) are used to calculate ideal P, PI, PD, PID tuning parameters using the following Ziegler-Nichols equations:

Proportional only control (P) -

$$P (\text{Pb}) = 2 \times \text{UPB (degrees or units)}$$

Proportional plus automatic reset (PI) -

$$P (\text{Pb}) = 2.2 \times \text{UPB (degrees or units)}$$
$$I (\text{ArSt}) = 1.2 / \text{UTP (repeats per minute)}$$

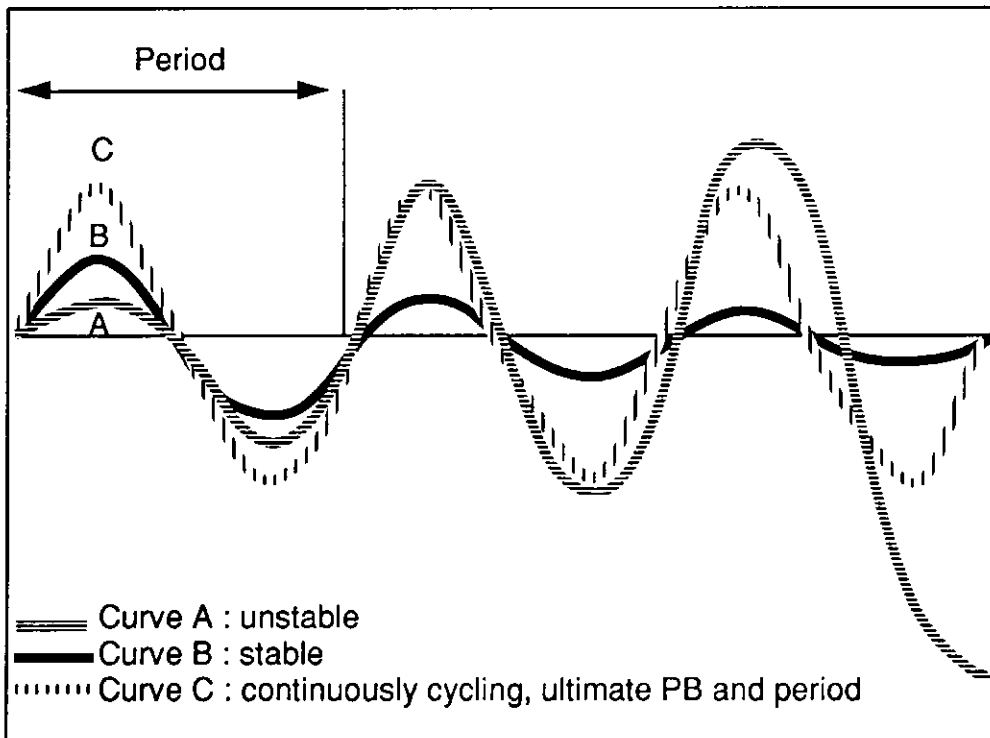
Proportional-plus-derivative (or rate) (PD) -

$$P (\text{Pb}) = 1.7 \times \text{UPB (degrees or units)}$$
$$D (\text{rAtE}) = \text{UTP} / 8 \text{ (minutes)}$$

Proportional-plus automatic reset-plus derivative (PID) -

$$P (\text{Pb}) = 1.7 \times \text{UPB (degrees or units)}$$
$$I (\text{ArSt}) = 2 / \text{UTP (repeats per minute)}$$
$$D (\text{rAtE}) = \text{UTP} / 8 \text{ (minutes)}$$

If an overdamped response is desired, multiply the proportional band by two.



Service 5.1

This section contains information regarding calibration and test procedures that can be performed in the field as well as items concerning the normal maintenance of the instrument.

Changing Charts 5.2

Chart changes may be done while in the normal operating mode.

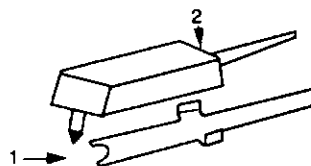
CAUTION: The chart flange assembly pin is sharp to perforate the chart. Use caution while installing the chart to avoid coming into contact with the pin.

1. **DEPRESS** and **HOLD** the UP and DOWN keys for between 2 and 3 seconds. Immediately after depressing the keys, the unit will do a Lamp Test with all LED segments and indicators lighted on the display(s). Do not let go of the keys.
2. After 2-3 seconds, the display will show **Cchg**, the pen(s) will move to and remain at a point above the top graduation on the chart and the chart will stop rotating. All other functions remain active (Control, Display, etc.)
3. Open the instrument door. Raise the pen(s) using pen lifter, and remove old chart.
4. With the pen(s) held up, install new chart. Be sure to line up the chart time line so that the current time is aligned with the time setting mark on the chart platen.
5. Push pen lifter to return pen(s) to active position and close instrument door.
6. **DEPRESS** and **HOLD** the UP and DOWN keys for between 2 and 3 seconds. Immediately after depressing the keys, the unit will do a Lamp Test with all LED segments and indicators lighted on the display(s). Do not let go of the keys.
7. After 2-3 seconds, the display will show **Cchg** momentarily, then the pen(s) position and chart rotation will be restored.

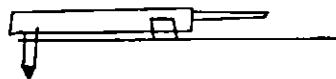
Changing Pens 5.3

1. Open the instrument door. Refer to **Figure 5-1** for pen changing procedure. This procedure is also provided on a label on the instrument chart platen. Be sure to replace the pen cartridge with the same type (color) that was removed. Be careful not to bend the pen arm while changing the pen.

FIGURE 5-1
Changing Pens



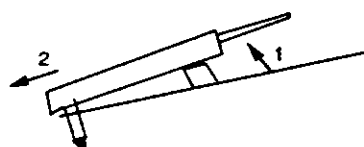
To install pen, slide pen into holder (1) and push down (2) as shown by arrows



To remove pen for replacement, pull up at back end (1) and push out.

For five replacement pen cartridges order:

- Green #60500401
- Red #60500402



Calibration 5.4

CAUTION: Do not attempt any calibrations without the proper test equipment that meets or exceeds the factory recommended specifications.

Press and release the SCROLL key until **CAL** appears on the display, then press the DOWN key to enter the mode. The display will change to be **CAL1**. Press the SCROLL key to advance the display to the other calibration modes available. For two pen units, **CAL2** and **CAL 3** will need to be performed on TB 4 to calibrate Pen 1 and Pen 2 inputs. Both TB 4 and TB 5 inputs must be calibrated for thermocouple inputs. **Table 5-1** provides a listing of field calibration routines. All instruments are calibrated prior to shipment from factory.

CALIBRATION FLOW CHART

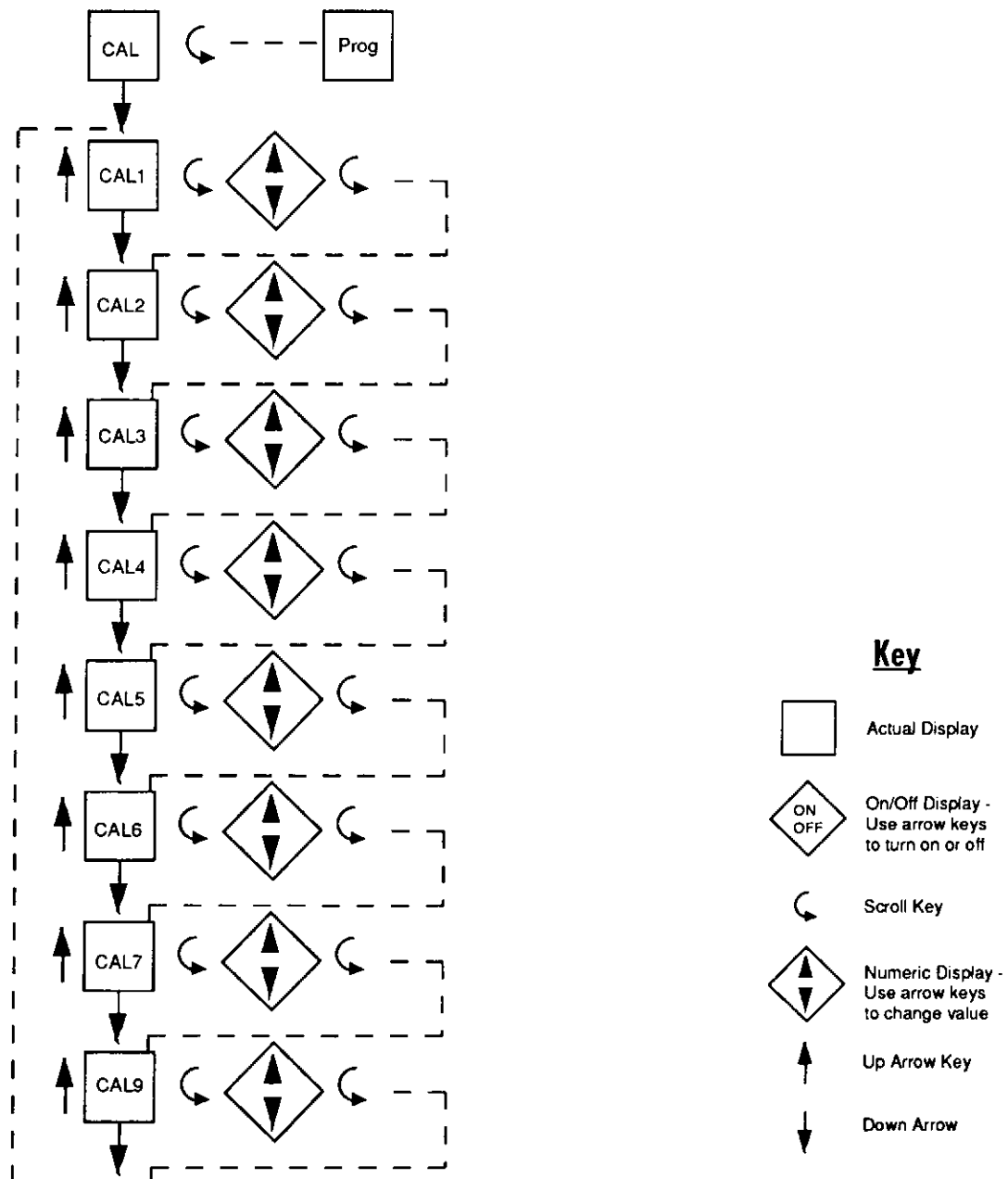


TABLE 5-1 CALIBRATION PROCEDURES

Calibration Procedure	Description
CAL 1	Reinitialization of program and tuning values.
CAL 2	Main calibration necessary for all input types.
CAL 3	Cold Junction Compensation calibration used to correct for component variation in the CJC circuit. Necessary for thermocouple inputs.
CAL 4	Cold Junction Utility, displays temperature the cold junction compensator is sensing. No adjustment is made with this procedure.
CAL 5	RTD input calibration. Necessary to be performed on both terminal boards.
CAL 6	Cold Junction Compensation on/off. Used for validating thermocouple inputs with a millivolt source (Non-temperature compensating) and RH checks on 2 pen units.
CAL 7 & CAL 8	Factory use only
CAL 9	Pen position calibration used to calibrate pens to chart.

5.4.1 CAL 1 PARAMETER RE-INITIALIZATION

This routine is used to clear all information in the Program and Tune modes. All parameters will be reset to default values. **Before performing this procedure make sure that the Program and Tune values are written down so that they can be re-entered after Calibration 1 is completed. No test equipment required.**

With **CAL 1** displayed, press and hold the DOWN key, then press the SCROLL key. The display will momentarily blank; Release the keys. Upon completion of the routine, **CAL 1** will reappear on the display.

5.4.2 CAL 2 MAIN CALIBRATION

This routine determines and saves calibration values which correct for component variations relating to the basic measuring function of the unit. A 50.00 mVDC +/- .01mVDC source is required for testing. **Make sure that the Processor board jumpers JU4 and JU5 are in the non-volt positions. See Appendix A-1 for proper positioning. After completing CAL2, be sure to reposition these jumpers to the appropriate position for your input.**

With **CAL 2** displayed, press and hold the DOWN key, then press the SCROLL key. Release the keys when the instrument displays **hLd1**. Short the input terminals or apply 0.00, +/- .01 mVDC to TB 4 terminals 1 and 2. Press the DOWN key and **dELy** will appear for 10 seconds, then **SCAn** will appear for 10 seconds. A calibration reference number will then appear, this should be 0 +/- 50. If this number falls outside these limits, press the SCROLL key and **CAL 2** will be displayed. Perform the calibration again. Repeat the calibration until the number falls within the tolerance limits. If the number remains outside the limits, check the connections and try the calibration again. If the number does not approach the tolerance limits contact the nearest representative or the factory for assistance. With an acceptable reference number on the display, remove the short and connect a 50.00, +/- .01 mVDC source to the TB 4 terminals 1 and 2. Be sure to observe the proper polarity when connecting the source. Terminal 1 is positive and terminal 2 is negative. Press the DOWN key, **dELy** will be displayed for 10 seconds and then **SCAn** for 10 seconds. When the calibration is complete **CAL 2** will reappear.

Error recovery:

See Section 5.6 for details. Insure that the millivolt source is connected correctly and functioning properly.

The calibration can be exited when **hLd1** or the calibration reference number is displayed by pressing the SCROLL key.

CAL2 QUICK CALIBRATION

This routine will allow the operator to execute a rough calibration on their unit via the keypad with no other equipment or disturbance to established wiring. It is intended to provide a partial recovery from a calibration corruption where the necessary equipment indicated may not be available. It should be noted that this is not intended as a substitution to the main calibration procedure described earlier and may deter considerably from the accuracy of the instrument.

With CAL2 displayed, press and hold the DOWN ARROW key, then press the SCROLL key. Release both keys and the instrument will display hLd1. Press and hold the UP ARROW key, then press the SCROLL key. The display will momentarily blank and then CAL1 will be displayed. Release both keys and depress the UP ARROW key. CAL will be displayed.

5.4.3 CAL 3 COLD JUNCTION COMPENSATION

This routine determines and saves calibration values which correct for component variations relating to the cold junction compensation. This calibration must be preceded by CAL 2, the main calibration, to properly calibrate the instrument. These two calibrations are all that is needed for proper operation with thermocouple inputs.

Test equipment: 1-type J thermocouple
1-mercury thermometer +/- .25 degrees F or equivalent

Allow 30 minutes of warm up time for the instrument with the thermocouple connected before proceeding with calibration.

Operation:

With CAL 3 displayed, depress and hold the DOWN key. Then press the SCROLL key and the unit will display hoLd. Release both keys. Press the DOWN key and deLy will be displayed for ten seconds, then SCAn for ten seconds. If SCAn remains in the display for much longer than ten seconds, refer to the note below. The instrument will compute and display the cold junction temperature to the nearest tenth of a degree C. Compare reading with thermometer and use the UP and DOWN keys to correct the reading, if necessary. To end the procedure, press the SCROLL key and CAL3 will be displayed again.

NOTE: If the instrument continues to display in SCAn, proceed as follows. With SCAn displayed, press the SCROLL key. CAL3 should be displayed. With CAL3 displayed, while pressing the DOWN key, press the SCROLL key. The instrument will display hoLd. Press the UP key. The instrument will begin the calibration procedure with a default value and proceed to deLy. Complete calibration as described above.

Error recovery:

See Section 5.6 for details on specific errors. The calibration can be exited if hoLd or the CJC temperature is displayed by pressing the SCROLL Key.

5.4.4 CAL 4 COLD JUNCTION UTILITY

This procedure displays the temperature the cold junction compensator is sensing. No test equipment is required.

With CAL 4 displayed press and hold the DOWN key, then press the SCROLL key. Release both keys and SCAn will be displayed for 10 seconds while the instrument senses the CJC temperature. The result will then be displayed to a tenth of a degree C. The input terminals must be shorted. CAL 3 must first be performed. ***The displayed temperature is not the ambient temperature. It is the temperature of the CJC.*** To exit, press the SCROLL key and CAL 4 will be displayed.

5.4.5 CAL 5 RTD INPUT

This procedure determines and saves calibration values relating to RTD inputs. This calibration must be preceded by CAL 2 to properly calibrate the instrument. Both RTD inputs must be calibrated and both inputs must have valid inputs during the calibration. Decade resistance substitution box with .01% resolution or equivalent are required. ***Make sure that the Processor board jumpers JU4, JU6 and JU5, JU7 are in the proper positions. See Appendix A-1.***

With **CAL 5** displayed, press and hold the DOWN key and then press the SCROLL key. The display will now be **PEn1** to indicate that the instrument is set to calibrate the RTD input on TB 4. Press the DOWN key to change the display to **PEn2** to calibrate the RTD input at TB 5. Choose the input TB to be calibrated and press the SCROLL key, **hLd1** will then be displayed. Connect the decade box at 100 ohm setting across the input terminals 1 and 2 and a jumper wire from terminal 2 to 3. Press the DOWN key and **dELy** will be displayed for 10 seconds, then **SCAn** for ten seconds. When **hLd2** is displayed, change the decade box setting to 277 ohms to the input terminals (do not disturb the wiring) and press the DOWN key. The display will change to **dELy** for 10 seconds, followed by **SCAn** for ten more seconds. **CAL 5** will be displayed after the calibration is completed.

Error recovery:

See **Section 5.6** for details on specific errors.

The calibration can be exited when the instrument displays **hLd1** by pressing the SCROLL key.

5.4.6 CAL 6 COLD JUNCTION UTILITY

This routine provides selection of operating modes for the cold junction compensation used for thermocouple inputs.

With **CAL 6** displayed, press and hold the DOWN key, then press the SCROLL key. The instrument will display **C6** and the number of the mode in effect. Press the UP or DOWN key to change the mode selection (indicated by number to the right of the C6). Pressing the SCROLL key will exit the calibration with the last mode number displayed in effect.

The selected mode will remain in effect if power is interrupted. To return the instrument to normal operation, **CAL 6** must be exited, with mode zero selected, or **CAL 1** must be executed to initialize all parameters.

Mode 0: Normal operating mode.

Mode 1: Cold Junction Compensation temperature will be internally fixed at 0 degrees C by the software to facilitate linearization testing when using an uncompensated millivolt source to simulate the thermocouple millivolt input signal.

5.4.7 CAL 9 PEN CALIBRATION

This procedure is used to calibrate the pen(s). No special test equipment is required.

With **CAL9** displayed, push and hold the DOWN key, then press the SCROLL key. Release both keys and the display will indicate **PEn1**. For 2 Pen instruments press the DOWN key to toggle the display between pen 1 and pen 2. With the desired pen displayed press the SCROLL key.

P.dn will be displayed while the selected pen is moved to its HOME position (toward the chart hub) with the decimal point flashing to indicate this mode. Once Pen Home is found, the pen will move to the inner ring and **PEnL** will be displayed. At this point, one of two adjustments may be made; Pen Arc or Zero and Span:

Pen Arc - To adjust the pen arc, the UP and DOWN keys are pressed simultaneously to draw an arc for visual reference. The display will show **P uP** while the selected pen moves upscale to the top stop position. The pen then moves back downscale to nominally place the pen at the outer ring (100%) of the chart. The display will now display **ArC**. The pen arm may be loosened and the length adjusted to a position and angle to place the pen tip near the outer ring then retighten the pen arm. Press any key and the pen will drive to HOME, then back to the inner ring (0%) and **PEnL** will be displayed.

Zero and Span - To begin a pen zero, with **PEnL** in the display, the UP or DOWN key may be pressed to move the pen to the low end of the chart span (0%). When adjusted, press the SCROLL key and **P uP** is displayed while the pen is moved to the outer edge (100%) of the chart, then **PEnH** is displayed. To adjust pen span, use the UP and DOWN keys to adjust the pen for the high end (100%) of the chart. When adjusted, press the SCROLL key and **P dn** will be displayed for about 5 seconds while the pen is moved to the 50% point on the chart, then **PEn1** is displayed.

The calibration may now be performed again to verify the accuracy, or press the UP key twice to exit back to the CAL mode.

Test Mode Procedures 5.5

To enter the Test mode, press and release the SCROLL key until **tESt** appears on the display, then press the DOWN key. **tSt1** will be displayed, press and release the SCROLL key to advance the display to the desired test. Tests 1, 2 and 3 are performed as a unit so the display will advance directly to **tSt4** from **tSt1**. Listed below in **Table 5-2** are the test procedures available. Test 1, 2 and 3 are performed on start up, periodically during operation, and on entry into the Test mode. Test 4 is executed on entry into and periodically during the Operation mode. These tests can be used as a trouble shooting aid.

TEST MODE FLOW CHART

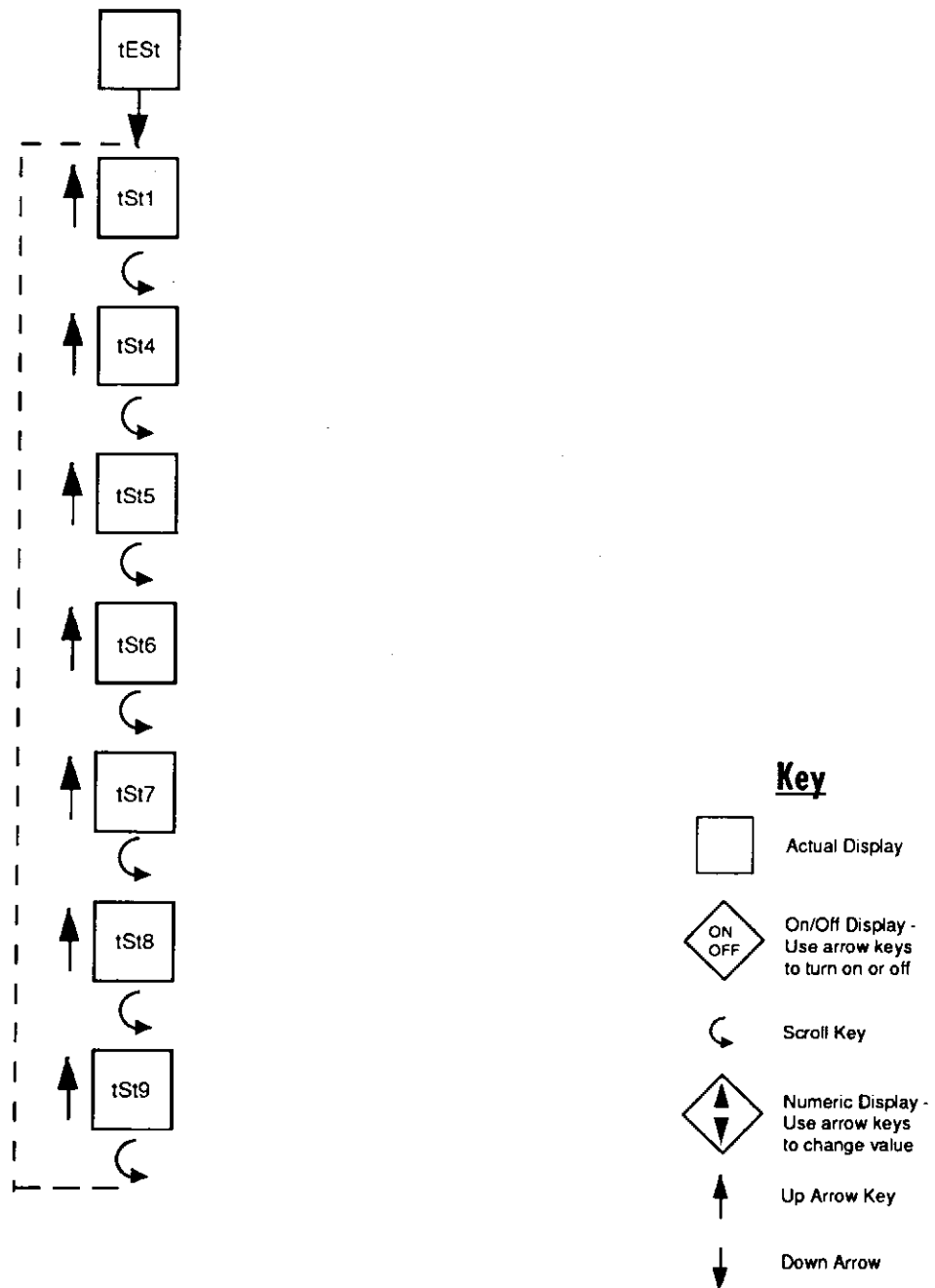


TABLE 5-2 TEST PROCEDURES AND DESCRIPTION

<u>Test</u>	<u>Description</u>
Test 1	Microprocessor internal RAM test. Used to check the processor RAM to make sure it is functioning correctly.
Test 2	External RAM test, used to test the RAM chip for proper function.
Test 3	EPROM checksum test, used to check that the EPROM program is correct.
Test 4	External RAM checksum test; instrument test and identifies how many times Errors 16 or 17 have occurred.
Test 5	Verifies that all keys are functional and all LEDs are working.
Test 6	Used to verify that all relays and solid state relay driver outputs are working correctly.
Test 7	This procedure will allow operator to adjust the current output value to check the output and to test the operation of the external device.
Test 8	Pen and chart motor operational check.
Test 9	Verifies that the auxiliary inputs are functioning properly.

5.5.1 TEST 1 INTERNAL RAM TEST

Tests the Random Access Memory internal to the microprocessor. No special test equipment is required.

With **tSt1** displayed, press and hold the DOWN key, then press the SCROLL key. **tSt1** will be displayed momentarily while the test is in progress. Upon successful completion, the instrument will proceed to Test 2.

5.5.2 TEST 2 EXTERNAL RAM TEST

Tests the battery backed-up RAM external to the microcomputer. No special test equipment is required.

After completion of Test 1, **tSt2** will be displayed momentarily while the test is in progress. Upon successful completion, the instrument will proceed to Test 3.

5.5.3 TEST 3 PROGRAM EPROM TEST

This is a checksum test to verify data integrity of the stored program. No special test equipment is required.

After completion of Test 2, **tSt3** will be displayed momentarily while the test is in progress. Upon successful completion of Test 3 **tst1** will be displayed.

5.5.4 TEST 4 EXTERNAL RAM CHECKSUM TEST

This is a checksum test to verify the integrity of data stored in RAM and indicate the number of times the instrument has had an Error 16 or 17. The unit may have automatically recovered from these errors. No special test equipment is required.

With **tst4** displayed, press and hold the DOWN key then press the SCROLL key. The display will blank momentarily, then momentarily display two numbers, and then **tst4** will be displayed. These numbers indicate the number of times Error 16 and 17 have occurred respectively. Test 4 can be executed again, or another test may be selected.

5.5.5 TEST 5 KEYPAD/DISPLAY TEST

This test allows the operator to verify that the keys work and that all display elements can be lighted. No special test equipment is required.

With **tSt5** displayed press and hold the DOWN key, then press the SCROLL key and then release both keys. The display will go blank. The following code will be displayed while the corresponding key is pressed:

Key	Display
SCROLL	SCrL
UP	uAro
DOWN	dAro
AUTO/MAN (Pen 1)	Autu
AUTO/MAN (Pen 2)	AutL
UP and DOWN	(All LED's and segments lit)
SCROLL and UP	(exit)

To exit, press the SCROLL and UP keys simultaneously, **tSt5** will be displayed.

5.5.6 TEST 6 RELAY/RELAY DRIVER OUTPUT TEST

Allows the operator to verify that the Relay output(s) are working. A volt/ohm meter will be required to test the output.

With **tSt6** displayed, press and hold the DOWN key, then press the SCROLL key. **oFF** will be displayed. For SPST Relay outputs, connect the meter across the relay output in the ohm scale. Press and release the DOWN key to advance through the following sequence:

DISPLAY	RELAY ON SPST
rLYA	A
rLYb	B
rLYC	C
rLYd	D
oFF	None

To exit, press the SCROLL key and **tSt6** will be displayed. **The existence of Relay output(s) is dependent upon the hardware configuration.**

5.5.7 TEST 7 CURRENT OUTPUT TEST

This test allows the operator to verify that the current output(s) are functioning properly or will allow the selection of an output value for testing of associated equipment. A milliamp meter is required for testing.

With **tSt7** displayed, press and hold the DOWN key, then press the SCROLL key. The display will indicate **CurA**, for the first current output. By pressing the DOWN key, the instrument will display **Curb**, and then back to **CurA**. Choose the desired output to be tested and connect the milliamp meter across the terminals of the output being tested. Be sure to observe the proper polarity when connecting the meter. Terminal 1 is positive and terminal 2 is negative. Press the SCROLL key and the display will indicate 4 milliamps. Use the UP and/or DOWN key to increase or decrease the current output in 1 mADC steps from 0 to 20 mADC. The current output reading should be ± 0.1 mADC at any output value. A $\pm 5\%$ of span adjustment for the current output(s) is provided by using the potentiometer adjacent to the current output on the Current Output board. See **Appendix A-4**.

To exit the test, press the SCROLL key and **tSt7** will be displayed. **The existence of a mADC current output is dependent upon the hardware configuration.**

5.5.8 TEST 8 PEN/CHART MOTOR TEST

This test allows the operator to verify that pen and chart motors are functioning properly. No special test equipment is required.

With **tSt8** displayed, press and hold the DOWN key, then press the SCROLL key. The display will show **ALL** while the test is in progress. This test functions automatically. The chart speed will be at maximum, 72 seconds per revolution. Starting at the current pen position, pen 1 will move (sweep) upscale for 5 seconds, then downscale for 5 seconds. Pen 2 (if provided) will sweep in the opposite direction. The pens will continue to cycle until the test is exited. To exit, press the SCROLL key. The display will show **tSt8**.

5.5.9 TEST 9 AUXILLIARY INPUT TEST

This test allows the operator to verify that the auxiliary input(s), if specified, are functioning properly. Auxiliary inputs are the remote setpoint and position proportioning options.

With **tSt9** displayed, press and hold the DOWN key, then press the SCROLL key. The display will show **Ai1**, Auxiliary Input 1. By pressing the DOWN key the instrument will sequence through the selections for testing: **Ai2** then back to **Ai1** (Ai=Auxiliary Input). With the desired input function selected, press the SCROLL key. The corresponding value will be displayed. The Auxiliary input voltage will be displayed to the nearest hundredth of a volt. To terminate the test, press the SCROLL key. The display will show **tSt9**.

Trouble-shooting and Diagnostics 5.6

The Trouble-shooting Guidelines Section consists of two columns. The first column is a list of some possible instrument conditions. The second column is a list of steps that should improve the condition. The steps should be performed in order until the condition improves or all the steps have been completed. If the instrument condition has not improved, contact the nearest representative or the factory for assistance.

Trouble-shooting should be performed by qualified personnel using the proper equipment and following all safety precautions. Whenever possible the trouble-shooting should be accomplished with the electrical power disconnected. The instrument contains static sensitive components so care should be taken to observe anti-static procedures.

Condition

Correction Steps

Display(s) Is/are blank

1. Verify that the correct instrument power, as indicated on the wiring label on the platen, is supplied to TB 1 terminals 1 & 2. Check the position of the power select switch, on 230 VAC models, correctly indicates the power that is connected to the instrument. If the switch does not indicate the correct voltage, reposition as necessary. If the voltage is not correct check the power source.
2. Turn off the instrument power. Wait about 5 seconds then turn the power on again.
3. Turn off the instrument power, open the cover, loosen the platen hold down screw, and swing the platen out of the way. Inspect the instrument ensuring all wiring / ribbon cables are properly connected / seated.
 - a. The white ribbon cables that connect the Processor board (**Appendix A-1**) to the interconnect board must be properly aligned and seated in the sockets.
 - b. The display board(s) white ribbon cable(s) pins should be properly aligned and seated in the sockets.
 - c. Inspect the PROM, RAM and microprocessor chips to see that the legs are properly seated in the sockets on the Processor Board.
 - d. Close the platen and tighten the hold down screw. Close the cover and turn on the power to see if the display(s) will now light.
4. Turn off the instrument power. Press and hold the UP and DOWN keys. Turn on the power. Hold the keys pressed for about 10 seconds. If the display(s) light the model number, Program and Tune mode parameters will need to be re-entered.

Model Number Displayed during power up is incorrect

1. Turn off the instrument power, wait 5 seconds then re-apply the power. Verify that the number displayed during the power up sequence is the same as indicated on the label affixed to the platen. If the number displayed is incorrect, perform the following steps:
 - a. Turn off the power to the instrument. Press and hold the UP and DOWN keys. Turn on the power and keep the keys pressed until the model number displayed resets to **32X0-0000-0021**, where the digit "X" is determined by the firmware installed. Release the keys and turn off the power.
 - b. To enter the correct model number press and hold the SCROLL and DOWN keys and turn on the instrument power. **32X0** should be displayed. Wait about 5 seconds and release the keys. The display should stay **32X0**. Use the UP/DOWN keys as necessary to change the displayed number to match the first 4 digits of the model number as indicated on the label on the platen. After adjusting the first 4 digits to the proper values, press the SCROLL key and the display will change to **0000**. Use the UP/DOWN keys to set the next 4 digits of the model number to the correct values. Press the Scroll key and the display will be **0021**. Use the UP/DOWN keys as necessary to adjust the last 4 digits of the number. Press the SCROLL key and the power up sequence will be complete. The Program and Tune mode parameters will need to be re-entered.

Relay Malfunction

1. Verify that the Program and Tune mode parameters are correctly set.
2. Turn off the power to the instrument. Wait about 5 seconds and turn the power on again. Confirm that the model number displayed during the power up sequence indicates that the output(s) is/are present in the instrument. See **Appendix C** for the model number explanation/decoding. This number should match the number on the label affixed to the platen.
3. Turn off the power to the instrument. Open the cover. Loosen the platen hold down screw and swing the platen open. Inspect the instrument Relay Driver board (See Fig. 2-4) for the presence of the output device(s). A relay output will appear to be a cube. Inspect that the output terminal connections are present and firmly attached.

4. Check the output(s) operation by performing Test 6 as described in the Test section. If the output(s) function in the Test mode, re-examine the Program and Tune mode parameters settings.
5. If the output appears not to turn off, remove the power to the instrument. Open the cover and loosen the platen hold down screw. Swing the platen open. Clip the resistor located on the Relay Board adjacent to the output(s) that seem to stay on (See Appendix A-2). A .01 microfarad, 1 KV should be connected from the terminal listed below, for the output where the resistor indicated was removed, to the AC ground.

Relay A	R1	TB 6	Terminal 1
Relay B	R2	TB 6	Terminal 3
Relay C	R3	TB 7	Terminal 1
Relay D	R4	TB 7	Terminal 3

Close the platen and tighten the hold down screw. Close the cover and turn the power on to the instrument. Check the operation of the output(s).

**mADC Output(s)
Malfunction**

1. Verify that the Program mode parameters are correctly set.
2. Turn Off the power to the instrument. Wait about 5 seconds and turn the power on again. Confirm that the model number displayed during the power up sequence indicates that the output(s) is/are present in the instrument. See Appendix C for the model number explanation/decoding. This number should match the number on the label affixed to the platen.
3. Turn off the power to the instrument. Open the cover. Loosen the platen hold down screw and swing the platen open. Inspect the instrument Current Output board (See Fig. 2-4) for the presence of the output device(s). The output will not work if the hardware is not present. Inspect that the output terminal connections are present and firmly attached. Close the platen and tighten the hold down screw. Close the cover and turn on the power.
4. Refer to the Test section and carry out the procedure for the Current Output(s) Test 7. If the current output operates properly in the Test mode recheck the Program mode parameters.

Pen(s) do not operate	<ol style="list-style-type: none"> 1. Verify that the Program mode parameters are properly set. 2. If the process value in the display exceeds the chart upper or the chart lower values selected in the Program mode, the pen will appear stuck at the chart upper or lower edge respectively. Reconfigure values as needed by the application (May require a new chart). 3. Perform Test 8 as described in the Test section of the manual. If the pen(s) operate in Test 8, perform the pen calibration, Cal 9, as described in the Calibration section of the manual. Return the instrument to the oPEr and check the operation of the pen(s).
Error Code Displayed	
SnSr - Sensor Break or Over Range	<ol style="list-style-type: none"> 1. Inspect the sensor for proper operation and connection to the instrument. Acceptable sensor ranges for the instrument are listed in the Specifications section, Appendix D. 2. Verify that the Program mode input selection matches the sensor input connected. 3. Check that the input conditioning jumpers on the Processor board (Appendix A-1) are in the proper position for the sensor input. Check that the jumpers are in the proper position for the Terminal Board where the sensor is connected. 4. Perform the calibration procedure(s), as described in the Calibration section, for the sensor input type.
Hi - Input more than 10% Over Span	<ol style="list-style-type: none"> 1. Perform the steps listed for the SnSr Error Condition.
Lo - Input more than 10% Under Span	<ol style="list-style-type: none"> 1. Perform the steps listed for the SnSr Error Condition.
rSEr - Remote Setpoint	<ol style="list-style-type: none"> 1. Check the Program mode to see that the correct remote setpoint Error voltage has been selected. 2. Check the voltage at the remote setpoint terminals 3 and 5 for the proper voltage.

6 - display overranged
(the "broken 6" appears at the left segment of the display)

1. If this error code is displayed as a Program or Tune mode parameter, perform the Cal 1 procedure as described in the Calibration section of the manual.
2. If this error code appears as part of the model number during the power up sequence follow, the steps listed for the "**Model Number is not correct**" condition.
3. If this error appears, check the Program mode parameter **dPos**, if set to 1 change to 0 and see if the error clears.

Er 1 - Microprocessor RAM Failure

1. Turn off the power to the instrument. Wait 5 seconds, and turn the power on.
2. Turn off the power to the instrument. Open the cover, and loosen the platen hold down screw. Swing open the platen and inspect that the microprocessor chip (U5) is properly seated in the socket located on the Processor board (**Appendix A-1**). Close the platen and tighten the screw. Close the cover and turn on the power.

Er 2 - External RAM Failure

1. Turn off the power to the instrument. Wait 5 seconds, and turn the power on.

Er 3 - PROM Checksum

1. Perform the steps listed for **Er 1** except that the Failure PROM (U7) on Processor board (**Appendix A-1**) should be inspected.

Er 4 - RTD Mismatch Error

1. Check the connections to the instrument for the RTD Input Calibration (CAL5) are as described in the Calibration section. Repeat the RTD Input Calibration.

Er 5 - No Zero Crossings Detected

1. Turn off the power to the instrument. Wait 5 seconds, and turn the power on.
2. Connect the instrument to another AC power source.

Er 6 - AC line below 43 HZ

1. Turn off the power to the instrument. Wait 5 seconds, and turn the power on.
2. Connect the instrument to another AC power source.

Er 7 - AC line over 64 HZ

1. Turn off the power to the instrument. Wait 5 seconds, and turn the power on.
2. Connect the instrument to another AC power source.

Er 8 - Cal 2 Volt Input Error	<ol style="list-style-type: none">1. Check that 50 mVDC is properly connected to the instrument and is within the tolerance limits as indicated in the CAL2 procedure of the Calibration section.2. Turn off the power to the instrument and open the cover. Loosen the platen hold down screw and swing the platen open. Inspect the Processor board (Appendix A-1) to insure that the input conditioning jumper JU4 is in the non-volt position. The jumper must be in the non-volt position to perform the CAL 2 procedure. Close the platen and tighten the hold down screw. Close the cover and turn on the power to the instrument.3. Perform the CAL2 procedure as described in the Calibration section.
Er 9 - ADC Reference Number Error	<ol style="list-style-type: none">1. Perform the CAL2 procedure as described in the Calibration section.
Er10 - ADC Reference Voltage Error	<ol style="list-style-type: none">1. Perform the CAL2 procedure as described in the Calibration section.
Er11 - Cold Junction Compensation Error	<ol style="list-style-type: none">1. Perform the CAL3 procedure as described in the Calibration section.
Er12 - CAL2 Voltage Error	<ol style="list-style-type: none">1. Check that 50 mVDC is properly connected to the instrument and is within the tolerance limits as indicated in the CAL2 procedure of the Calibration section.2. Turn off the power to the instrument and open the cover. Loosen the platen hold down screw and swing the platen open. Inspect the Processor board (Appendix A-1) to insure that the input conditioning jumper JU4 is in the non-volt position.3. Perform the CAL2 procedure as described in the Calibration section.
Er13 - RTD CAL5 Input Error	<ol style="list-style-type: none">1. Check that the resistance device is of the correct value and properly connected to the instrument and is within the tolerance limits as indicated in the CAL5 procedure of the Calibration section.2. Turn off the power to the instrument and open the cover. Loosen the platen hold down screw and swing the platen open. Inspect the Processor board (Appendix A-1) to insure that the input conditioning jumpers are in the correct position for the RTD input for the Terminal Board being calibrated. For TB 4, JU4 should be in the non-volt position and JU6 in the RTD position. For TB 5, JU5 should be in the non-volt position and JU7 in the RTD position.3. Perform the CAL5 procedure as described in the Calibration section.

Er14 - Cold Junction Compensation Error	1. Perform the CAL3 procedure as described in the Calibration section.
Er15 - Ground Reference Tolerance Error	1. Perform the CAL2 procedure as described in the Calibration section.
Er16 - Program/Tune Mode Checksum Error	1. Record all Program and Tune mode parameters. Perform the CAL1 procedure as described in the Calibration section. Re-enter the Program and Tune mode parameters.
Er17 - Calibration Checksum Error	1. Perform the calibration procedures that are needed for the input sensors that will be used.
Er20 - Setpoint Error	<ol style="list-style-type: none"> 1. Press the UP or DOWN key to change the setpoint to a different value, then restore the needed setpoint. 2. Perform the CAL1 procedure as described in the calibration section.
Er36 - Incorrect Crystal For Digital Communications	1. Turn off the power to the instrument, wait 5 seconds then turn the power on.
Er37 - Incorrect Micro. For Digital Communications	1. Turn off the power to the instrument, wait 5 seconds then turn the power on.
Er38 - Incorrect RAM for profiles	<ol style="list-style-type: none"> 1. Turn off power, wait 5 seconds and turn power on. 2. Reconfigure to non-profile model #.
Momentary Er70 - Controller unable to respond within 250 milliseconds	1. Tried to communicate while unit was in a non-control mode.
Momentary Er71 - Byte received before the response was transmitted	1. The unit received a request before proper amount of time has elapsed since last request.
Momentary Er72 - Incorrect Block check character was received	1. Data received not valid, possible corruption on the comm link. Possible noise.
Momentary Er73 - Byte received with incorrect parity	<ol style="list-style-type: none"> 1. Improper parity selection on the transmitting terminal. 2. Incorrect baud rate. 3. Noise

Appendix A Board Layouts

FIGURE A-1 • Processor Board

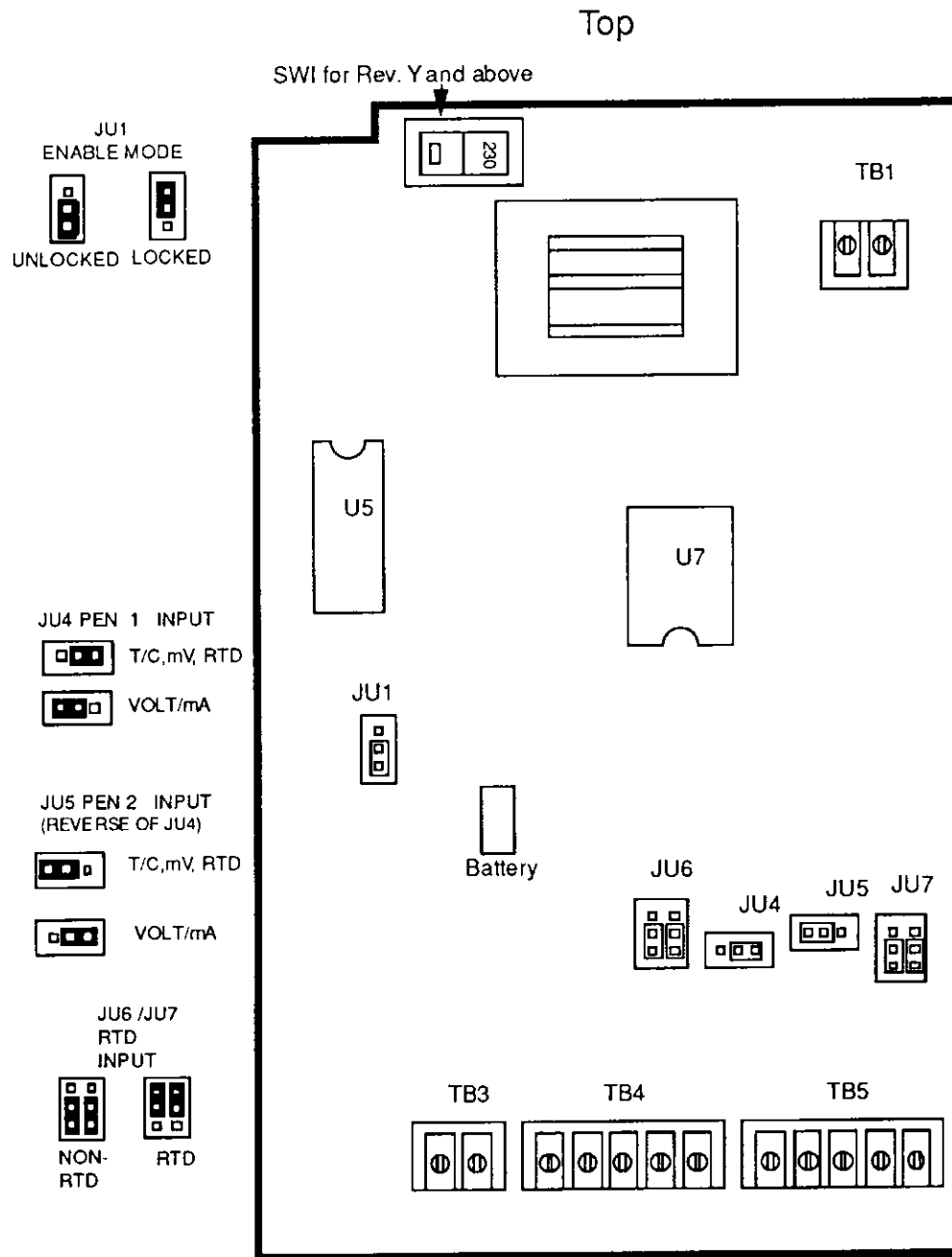
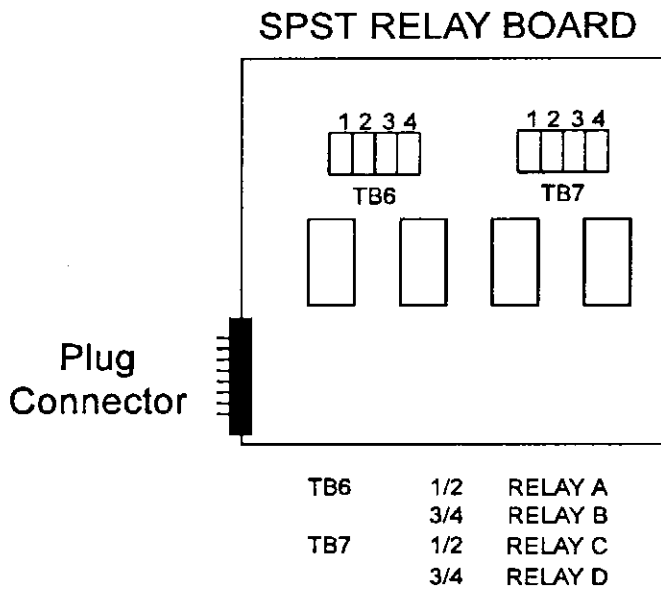


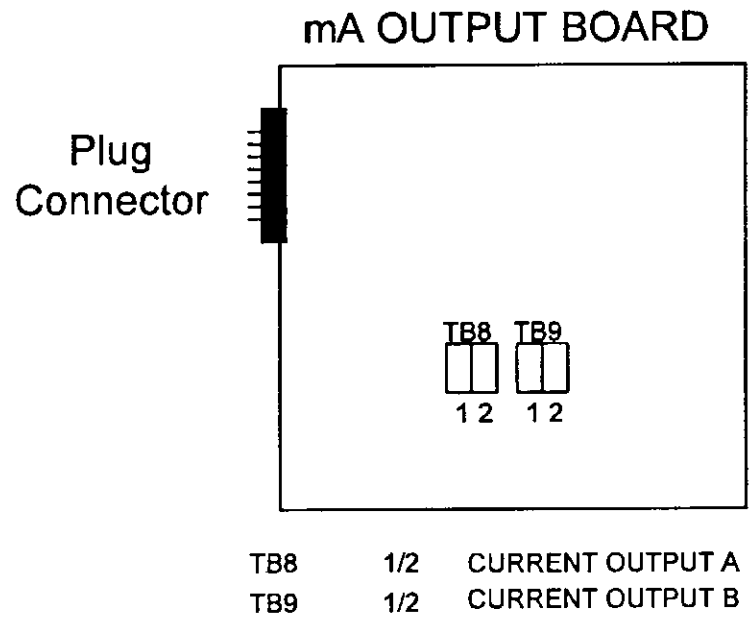
FIGURE A-2 - SPST Relay/Output Board



If the relay is connected to a high impedance AC device, the snubber network used to protect the relay contact may cause the output to appear to be activated when the relay is off. To cure the problem, cut the snubber resistor for the output that is being affected.

<u>Resistor</u>	<u>Relay</u>
R1	Relay A
R2	Relay B
R3	Relay C
R4	Relay D

FIGURE A-4 - Current Output Board



Appendix B

Glossary

Automatic Reset (Integral)

This parameter is used so that the instrument will compensate for process variable deviations from setpoint that occur when the process load characteristics change. Instructions for determining the automatic reset settings are given in **Table 3.2**. Factory default is 0.0. Display code **ArS1**, **ArS2**.

Automatic Transfer

This feature, if configured, allows manual control of the process until setpoint is reached, at which point the controller automatically transfers from manual to automatic control. Factory default value is 0 = no auto transfer. Display code **AtFr**.

Bumpless Transfer

This feature prevents step changes in proportional outputs when changing from automatic to manual control only.

Cycle Time

This Tune mode parameter is used to select the on/off cycle time for time proportioning outputs (**Ct1** for Output 1 and/or **Ct2** for Output 2).

When using the Position Proportioning option, **Ct1** must be selected for the stroke time of the motor.

Display Filter Factor

This parameter is adjustable from 1 to 20 which represents the number of scans per second of the process variable that are averaged together before updating the displayed and recorded value. The factory default value is 1 = no filtering. Display code **dFF**.

Engineering Units Upper and Engineering Units Lower

These Program mode parameters are used with volt, millivolt, and milliamp inputs. The Engineering Units Upper **Euu** should be selected as the value to be displayed when the input is at maximum. The Engineering Units Lower **EuL** should be selected as the value to be displayed when the input is at minimum.

First Output Position

This parameter is adjustable from -1000 to 1000 units and represents a shift or offset of the on-off actuation points or proportional band for the first output relative to the normal position. For example, a negative value could be used to offset an expected overshoot. First Output Position also shifts the proportional band with respect to the process value range outside of which integral action is inhibited. Factory default is 0. Display code **FoP**.

Hysteresis

This parameter is adjustable from 0 to 300 units representing the width of the band (half above and half below setpoint). Used with ON/OFF or Alarm outputs to reduce cycling. For instance, with a value of 4 and a setpoint of 70 the output will turn ON when the process variable drops to 68 and stay ON until 72 is reached, then turn OFF the output. Factory default = 3. Display code **HyAo** for Alarm outputs. Display code **HyCo** for ON/OFF Control outputs.

Input Correction

This parameter is adjustable from -300 to 300 units and is used as a method to compensate for a linear sensor error. Factory default is 0 = no correction. Display code **iCi1**, **iCi2**.

Manual Reset

This parameter is adjustable from -1500 to 1500 units representing a manual shift of proportional band(s) relative to the normal position which is an even straddle of the setpoint. Manual reset is intended to be used when automatic reset is not used to allow compensation for deviations from setpoint which remain after the process has stabilized. Factory default is 0. Increasing the value increases the process variable, i.e. if the process variable stabilizes too

low, increase the manual set. Integral action, and conversely reset-windup inhibit apply over the same process value range regardless of the manual reset value. Display code **rSEt**.

Platen

The flat surface in the instrument upon which the chart rotates.

Pen Action on Power Up

This parameter specifies whether the pen, on a power-up, will drive to the HOME position (center of chart), then return to it's correct position. This is done as a cal check. Settings are 0 = go to HOME and 1 = remain in last position prior to power down. Default is 0.

Position Proportioning Sensitivity

A percentage of the first output proportional band width (Pb1).

Process Filter Factor

This parameter is adjustable from 1 to 20 which represents the number of scans per second of the process variable that are averaged together before updating the process value used for control purposes. The factory default value is 1 = no filtering. Display code **PFf**.

Process Retransmission Output

Allows re-transmission of the process variable. Factory default is 0 = not selected. Display code **PouT**. If selected, must be assigned to a current output and scaled using Process Output upper and lower values.

Process Output Upper and Lower Values (Used in conjunction with process retransmission output)

These parameters specify the process value range over which the assigned current output will vary in a linear manner from 100% to 0%. If the process value is greater than **Pou** the output will be 100%. If the process value is less than **PoL** the output will be 0%. Factory default values are 2000 for the upper value and 0 for the lower value. Display codes **Pou** (upper) and **PoL** (lower).

Process Rounding

This parameter is adjustable from 0 to 100 units and is used to round the process value to the nearest value specified. This is for display only and does not affect the recorded value or control action. Intended for use where the engineering units span is large, to reduce display fluctuation. Factory default is 0 = no rounding. Display code **Prnd**. (e.g. Prnd = 3, Process Value = -6, -3, 0, 3, 6, 9....)

Proportional Band (PB)

This parameter is adjustable from 1 to 3000 units (not Percent of span) and represents the process value range where the proportional output is at a percentage of the full output. Instructions for determining Pb are given in **Section 4.3**. Factory default is 100 units. Display code **Pb1** and **Pb2**.

Rate (Derivative)

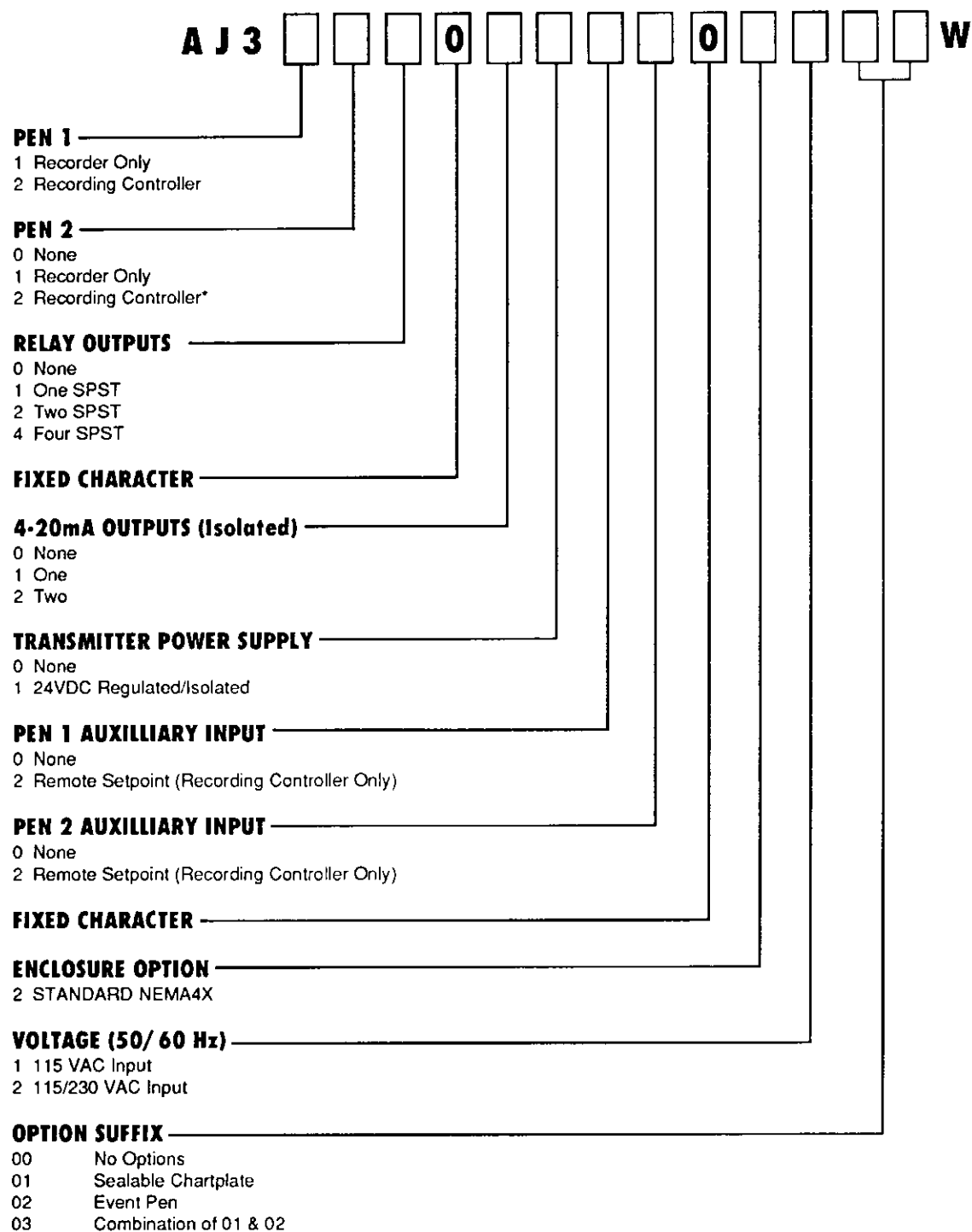
This parameter is adjustable from 0.0 to 10.0 minutes and specifies how the control action responds to the rate of change in the process variable. For example, if the process variable is rising rapidly to setpoint, power is turned off sooner than it would be if the rise were slow. In effect, derivative action anticipates lags within the system and shifts the proportioning band by an amount determined by the rate of change of the input sensor.

Magnitude of the shift is determined by a derivative time constant. If the time constant is, say, .1 minute (6 seconds), for every unit per second rate of change of the process variable at the sensor, the proportioning band is moved 7 units in the direction that helps control. Likewise, if the time constant is 1 minute (60 seconds), for every unit per second rate of change of the process variable at the sensor, the proportioning band is moved 60 units in the direction that helps control. Factory default is 0.0 Display code **rAtE**.

Second Output Position (SoP)

This parameter is adjustable from -1000 to 1000 units and represents a shift or offset of the on-off actuation points or proportional band for the second output relative to the normal position. A positive value creates a gap where no control outputs are on, a negative value creates an overlap of control outputs (if the first output position is at the normal position). Second Output Position also shifts the proportional band with respect to the process value range outside of which integral action is highlighted (reset-windup inhibit). Factory default is 0. Display code **SoP**.

Appendix C Order Matrix



* Pen 2 available as Rec./Contr. only if Pen 1 is Rec./Contr.

Note: 4-20mA inputs are accommodated using the 1-5V input and a 250 ohm Shunt Resistor (provided with the unit).

Appendix D Product Specifications

Measurement Error Limit	<ul style="list-style-type: none">• Type J,K,T,E,N,C T/C's and RTD $\pm 0.25\%$ of reading plus 1 degree @ 25 degrees C• Type R,S, B T/C's $\pm 0.25\%$ of span @ 25 degrees C• mA, mV and VDC $\pm 0.25\%$ of scaled span plus 1 Whole Digit @ 25 degrees C
Ambient Temperature Error	0.01% of span per degree C deviation from 25 degrees C
Scan Rate	1 scan/second
Display Decimal Positions	One, two or three decimal places (0.1 or 1 degrees for T/C or RTD)
Noise Rejection	Normal mode, 85dB minimum at 60 Hz or greater. Common mode, 90dB minimum, 115 VAC maximum.
Line Voltage	115/230VAC $\pm 10\%$ 50/60 Hz
Power Consumption	25VA maximum
Operating Temperature	32 to 131° F 0 to 55° C (ambient)
Storage Temperature	-40 to 149° F -40 to 65° C
Humidity	0 to 90% RH, noncondensing
Dimensions	16.77 H x 14.12 W x 7.75 Deep
Weight	25 pounds maximum
Enclosure	NEMA 4X
Sensor Fault Detection	Displays SnSr for sensor or transmitter break. Outputs go off. PV Out to 100%. Fault detection is not functional for 0-5V or 0-20mA inputs
Agency Approvals	UL and CSA pending
Transmitter Power Supply	Provides up to 40mA of current at 24 VDC
Warranty	3 years, see inside back cover for details.

Input Specifications

THERMOCOUPLE

TYPE	RANGE	TYPE	RANGE
J	0 to 760C 0 to 1400F	E	0 to 750C 0 to 1400F
K	0 to 1360C 0 to 2500F	B	200 to 1800C 400 to 3300F
T	-220 to 400C -330 to 750F	N	0 to 1300C 0 to 2370F
R	200 to 1650C 400 to 3000F	C	200 to 2300C 390 to 4170F
S	200 to 1650C 400 to 3000F		

MILLIAMPS	MILLIVOLTS	RTD
4-20 mADC (with resistor)	0 TO 25 mV 0 to 50 mV 10 to 50 mV	100 OHM (.00385 OHMS/OHM/C) -140 to 400C

VOLTS	REMOTE SETPOINT
0 to 5 VDC 1 to 5 VDC	0 to 5 VDC 1 to 5 VDC

CONTROL ADJUSTMENTS

Proportional Band	1 to 3000 units
Manual Reset	-1500 to 1500 units
Auto Reset (Integral)	0.0 to 100.0 repeats per minute
Rate (Derivative)	0.0 to 10.0 minutes
Cycle Time	1 to 240 seconds
On/Off Hysteresis (width of hysteresis band)	0 to 300 units
First Output Position	-1000 to 1000 units
Second Output Position	-1000 to 1000 units
Automatic Transfer Function	User selectable to transfer from manual to automatic control when setpoint is reached Can be disabled.
Auto/Manual	Bumpless transfer from automatic to manual.
Manual Output	0 to 100%

ALARM ADJUSTMENTS

Process Alarm	-9999 to 9999 units
Hysteresis	0 to 300 units

CONTROL OUTPUTS

Relay SPST	115 VAC: 5.0A Resistive, 1/8HP or 250VA 230 VAC: 2.5A Resistive, 1/8HP or 250VA
mADC Current	4-20 or 0-20 mADC into 650 ohms maximum load

DISPLAY

Digital Display	Two possible; one per installed pen. Red LED's 0.56" high.
Status Indicators	LED indicators for Output 1, Output 2, Manual Operation, Alarm, Setpoint, minus sign and process value units (°C, °F, or E).

RECORD

Chart	12 in circular chart; 100 charts furnished with each instrument if standard range
Chart Range	-9999 to 9999 %/ units
Chart Drive	DC stepper motor
Chart Rotation	User configurable from 0.1 to 999.9 hours per revolution
Pen Type	Disposable Fiber-tip
Pen Color	Pen 1-Red Pen 2-Green
Pen Response Time	< 9 seconds over chart span
Chart Accuracy	±1.0% of chart span from displayed value

Appendix E Software Reference/ Record Sheet

PROGRAM MODE			
	Pen 1	Pen 2	unit
inPS			rLyA
iCor			rLyb
out1			rLyC
o1uL			rLyd
o1LL			CurA
out2			Curb
o2uL			CoAr
o2LL			Cobr
AL1			Crt
AL2			PAPU
diSP			Coo
dPoS			
Euu			
EuL			
HyCo			
HyAo			
rSP			
SPuL			
SPLL			
AtFr			
Prnd			
dFF			
PFF			
Pout			
Pou			
PoL			
Cru			
CrL			
P1EC			
P2EC			
PAEC			

TLNEMODE		
	Pen 1	Pen 2
SoP		
PAL1		
dAL1		
bAL1		
PAL2		
dAL2		
bAL2		
Pb1		
Pb2		
rSEt		
ArSt		
rAtE		
Ct1		
Ct2		
FoP		

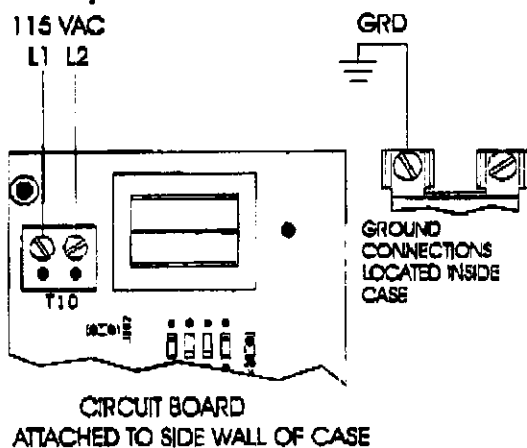
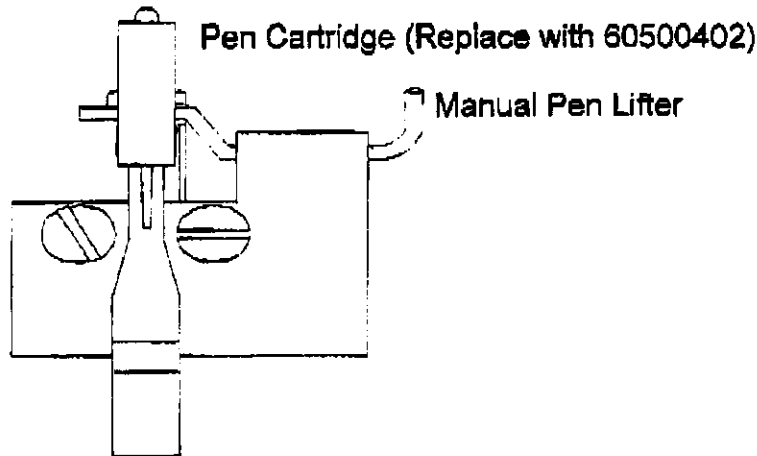
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EtSt	
ECAL	
EPro	
Etun	
ESby	
ESPS	
ESPC	



TECHNICAL BULLETIN

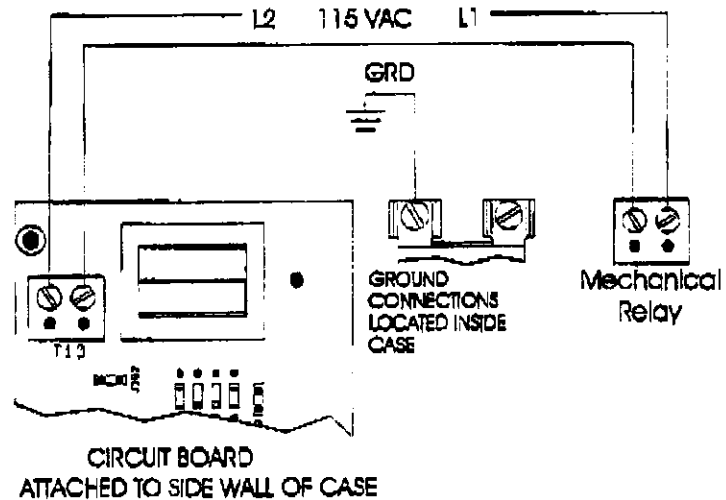
AJ-300 Series Circular Chart Recorder Event Pen Operation and Wiring

The information below illustrates operation and wiring procedures for AJ-300 Series Circular Chart Recorders equipped with an Event Pen Option. As always, be sure to disconnect all source of AC power wired to the instrument prior to performing service.



Externally Triggered

The diagram above illustrates proper wiring for 110 VAC actuated externally triggered event pen input. It is recommended that a 1/4 amp fuse be placed in line with hot leg (L1) to protect the circuitry in the event of a short.



Internally Triggered

The diagram above illustrates proper wiring for 110 VAC actuated internally triggered event pen input. It is recommended that a 1/4 amp fuse be placed in line with hot leg (L1) to protect the circuitry in the event of a short. For internal wiring, the recorder MUST have a SPST relay available. The desired setpoint for actuation of the pen set via the keypad interface, and is in accordance with the relay chosen (R1, R2, R3 or R4). Please consult the operations manual supplied with the recorder for additional information about the optional *Rel Interface Card* or programming of the *Alarm Value*.

Warranty and Return Statement

These products are sold by The Anderson Instrument Company (Anderson) under the warranties set forth in the following paragraphs. Such warranties are extended only with respect to a purchase of these products, as new merchandise, directly from Anderson or from an Anderson distributor, representative or reseller, and are extended only to the first buyer thereof who purchases them other than for the purpose of resale.

Warranty

These products are warranted to be free from functional defects in materials and workmanship at the time the products leave the Anderson factory and to conform at that time to the specifications set forth in the relevant Anderson instruction manual or manuals, sheet or sheets, for such products for a period of three years.

THERE ARE NO EXPRESSED OR IMPLIED WARRANTIES WHICH EXTEND BEYOND THE WARRANTIES HEREIN AND ABOVE SET FORTH. ANDERSON MAKES NO WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE WITH RESPECT TO THE PRODUCTS.

Limitations

Anderson shall not be liable for any incidental damages, consequential damages, special damages, or any other damages, costs or expenses excepting only the cost or expense of repair or replacement as described above.

Products must be installed and maintained in accordance with Anderson instructions. Users are responsible for the suitability of the products to their application. There is no warranty against damage resulting from corrosion, misapplication, improper specifications or other operating condition beyond our control. Claims against carriers for damage in transit must be filed by the buyer.

This warranty is void if the purchaser uses non-factory approved replacement parts and supplies or if the purchaser attempts to repair the product themselves or through a third party without Anderson authorization.

Returns

Anderson's sole and exclusive obligation and buyer's sole and exclusive remedy under the above warranty is limited to repairing or replacing (at Anderson's option), free of charge, the products which are reported in writing to Anderson at its main office indicated below.

Anderson is to be advised of return requests during normal business hours and such returns are to include a statement of the observed deficiency. The buyer shall pre-pay shipping charges for products returned and Anderson or its representative shall pay for the return of the products to the buyer.

Approved returns should be sent to: ANDERSON INSTRUMENT COMPANY INC.
156 AURIESVILLE ROAD
FULTONVILLE, NY 12072 USA

ATT: REPAIR DEPARTMENT

Note: Must be marked with Return Authorization Number (RMA). Obtainable from Anderson Customer Service, or local distributor.