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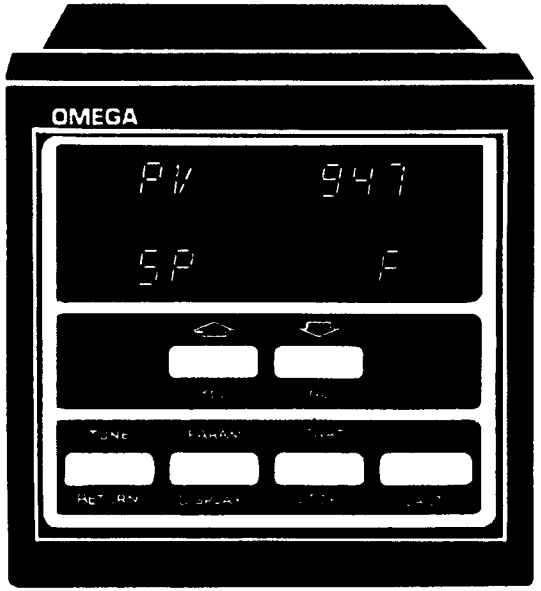
CN2041 & CN2042

Profile Controllers



OMEGA®
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Operator's Manual
M738/0692

WARRANTY

OMEGA warrants this unit to be free of defects in materials and workmanship and to give satisfactory service for a period of **13 months** from date of purchase. OMEGA Warranty adds an additional one (1) month grace period to the normal **one (1) year product warranty** to cover handling and shipping time. This ensures that our customers receive maximum coverage on each product. If the unit should malfunction, it must be returned to the factory for evaluation. Our Customer Service Department will issue an Authorized Return (AR) number immediately upon phone or written request. Upon examination by OMEGA, if the unit is found to be defective it will be repaired or replaced at no charge. However, this WARRANTY is VOID if the unit shows evidence of having been tampered with or shows evidence of being damaged as a result of excessive corrosion; or current, heat, moisture or vibration; improper specification; misapplication; misuse or other operating conditions outside of OMEGA's control. Components which wear or which are damaged by misuse are not warranted. These include contact points, fuses, and triacs.

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BEFORE RETURNING ANY PRODUCT(S) TO OMEGA, YOU MUST OBTAIN AN AUTHORIZED RETURN (AR) NUMBER FROM OUR CUSTOMER SERVICE DEPARTMENT (IN ORDER TO AVOID PROCESSING DELAYS). The assigned AR number should then be marked on the outside of the return package and on any correspondence. Please have the following information available BEFORE contacting OMEGA:

1. P.O. number under which the product was PURCHASED,
2. Model and serial number of the product, and
3. Repair instructions and/or specific problems you are having with the product.

OMEGA's policy is to make running changes, not model changes, whenever an improvement is possible. That way our customers get the latest in technology and engineering.

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SECTION 1 INTRODUCTION

1.1 GENERAL DESCRIPTION

The introduction of microprocessors into panel mounted ¼ DIN size controllers has resulted in control instruments with exceptional application flexibility. However, this broad capability can be very confusing to those not familiar with this new technology. This manual is written to take the user step by step through installation, set-up and operation of the OMEGA® CN2041 (single output) and CN2042 (dual output) Microprocessor-Based Profile Controllers.

The CN2041/2042 contains a unique alphanumeric display that actually shows keys words as well as numerical information. Sharing the front of the controller is an eight-key operator interface. When you push the appropriate key, the controller will scroll through a display routine to provide the information you need for complete tuning and proper operation.

The CN2041 and CN2042 are Profile Controllers that can store in memory up to 16 separate profiles and 256 individual control time segments. All profile programming is done through the front keypad in a very straight forward procedure expained in detail in Section 5. During profile control you can pause in place at any time or you can stop and shift to a new profile or segment.

Alarm/Event relay output(s) are also included that can be tied to the process variable or to the profile segments.

The Model CN2041 is a Single Output Profile Controller; the Model CN2042 is a Dual Output Profile Controller. Instructions in this manual apply to both models except where otherwise specified.

You can familiarize yourself with the controller prior to installation by attaching a 100 ohm resistor between input terminals F and H. The measurement on the display will be incorrect, but all routines and displays will function properly. As you read this manual you can follow the functions right on the controller.

You cannot harm the controller by pushing any keys. Special care is required, however, when in the calibration routine so as not to erase the factory set calibration. Follow the instructions carefully.

CAUTION

In any critical application where failure could cause product loss or endanger personnel, a second independent limit controller is recommended.

SECTION 2 INSTALLATION

2.1 UNPACKING

Remove the Packing List and verify that all equipment has been received. If there are any questions about the shipment, please call the OMEGA Customer Service Department at (203) 359-1660.

Upon receipt of shipment, inspect the container and equipment for any signs of damage. Take particular note of any evidence of rough handling in transit. Immediately report any damage to the shipping agent.

NOTE

The carrier will not honor any claims unless all shipping material is saved for their examination. After examining and removing contents, save packing material in the event reshipment is necessary.

2.2 MOUNTING

CAUTION

Insure that all power and measuring circuits are disconnected before installation is attempted.

In the normal course of installation and operation, there is no reason to remove the electronic assembly from the case. If the electronic assembly is removed, SPECIAL PRECAUTIONS MUST BE TAKEN IN HANDLING THE CMOS INTEGRATED CIRCUITS TO PREVENT STATIC DISCHARGES FROM CAUSING DEVICE FAILURE.

The entire electronic assembly can be removed from the case for servicing, without disturbing the rear terminal wiring, by pressing in the tabs on each side of the bezel and carefully pulling the assembly out of the case. When reinstalling the electronics assembly, make sure that the unit is inserted right side up and that all boards are firmly in their connectors.

The CN2041/2042 Controllers are designed for mounting in a control cabinet or rack where access to the rear terminals is enclosed and where supply and load wiring can be properly terminated and enclosed. Prepare a standard ¼ DIN panel cutout of 3.620" (92 mm) square and insert the instrument into the panel cutout. The U shaped mounting bracket, supplied with each unit, is installed from the rear of the controller and held in place by two threaded studs mounted on the rear of the case. Tighten the bracket with supplied hardware against the panel to insure a snug fit (see Figure 2-1).

Overtightening may cause the rear of the case to bow. To prevent this, a washer of the panel thickness may be used over the stud between the case and the bracket.

These controllers have been designed for panel mounting with natural convection cooling. When installing the unit, be sure that the case label and the rear vents are on the top side. Allow adequate clearance for proper air circulation.

NOTE

For panel mounting of two or more units, use a minimum horizontal spacing of 4.5" on center.

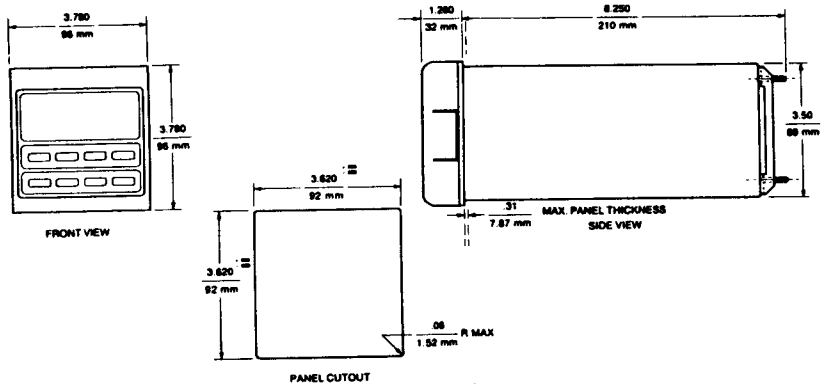


Figure 2-1. Cutout and Mounting Dimensions

2.3 WIRING

Successful operation begins with proper installation. Good installation requires not only that good wiring practices be followed, but also that reasonable protection be provided against external electrical influences that could interfere with controller operation. In addition, all wiring must conform to applicable local and national codes. The controller should be wired with an external power disconnect and fuse.

2.4 NOISE SUPPRESSION

The primary source of electrical interference (noise) that can impact any digital device is inductors most commonly found as coils and windings in solonoids, relays and transformers. It is important to suppress any potential for electrical noise at its source to ensure reliable controller operation. Specifically this means putting noise suppression devices across the terminals of all inductors in your system. Refer to Figure 2-2.

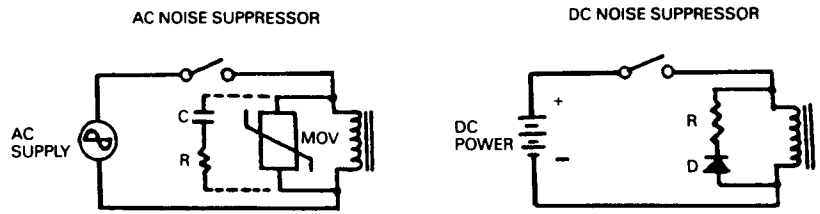


Figure 2-2. Noise Suppression

If you do not have the necessary components available, they may be purchased from OMEGA.

ITEM	MAX. AC	RATING	KIT
RC KIT	240 VAC	0.1μF/220 ohms	1821-100
MOV KIT	130 VAC	35 Joules	1821-98
MOV KIT	250 VAC	70	Joules 1821-99

When wiring to the controller, twisted pair with insulated shield is recommended for all signal leads. Make sure the shield is grounded ONLY at the controller. Be sure to protect against ground loops in signal leads, shields and all other input and output wiring.

Low level signal leads and high level power cables must not be run in the same conduit or cable trays. Care when wiring means better system reliability.

2.5 POWER CIRCUIT WIRING

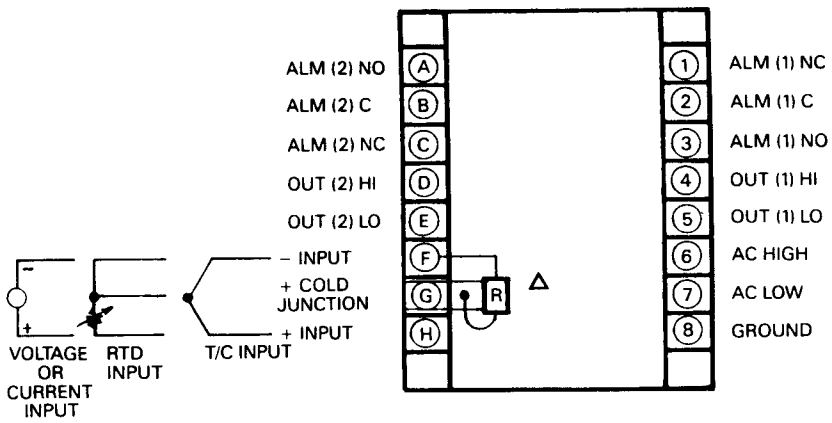
The CN2041/2042 is normally wired for 120 Vac operation. Maximum input current at 120 Vac, 50/60 Hz is 115 mAac. Connect the AC line power to rear terminals 6, 7 and 8 (see Figure 2-3). Terminal 6 is AC high; terminal 7 is AC low; terminal 8 is ground.

CAUTION

Applying 240 Vac supply voltage to a unit not rated for this voltage will result in damage to the controller.

NOTE

All wiring should conform to applicable local and national codes. Provision should be made so that the controller is wired with an external disconnect and fuse.



Δ COLD JUNCTION COMPENSATION FOR T/C UNITS ONLY

Figure 2-3. Rear Terminal Connections

2.6 INPUT CIRCUIT WIRING

NOTE

The use of twisted and shielded extension wire is recommended to minimize noise pick-up. Never run signal input leads in or near the same bundle as supply or load lines.

2.6.1 Thermocouple Input

It is important that the thermocouple extension leads are of the same type as specified in the controller part number, and that all connections are clean and tight. Maximum loop resistance of the T/C circuit should not exceed 100 ohms.

Connect the red (–) thermocouple wire or extension lead to the rear panel terminal F (see Figure 2-2). Connect the color-coded thermocouple lead to terminal H (+). No connection is made to terminal G.

2.6.2 RTD Input

Connect the RTD sensor as shown in Figures 2-3a and 2-3b for a three wire RTD input. If a two wire RTD is used, strap terminals F and G together and connect the RTD between this pair and terminal H. (For two wire RTDs, it is recommended to run three wires to the RTD and connect the F and G wires together as near the RTD as possible.) RTD leads can be extended with copper wire, provided the leads are of the same length and diameter and run in a common conduit. Maximum extension lead resistance should not exceed 10% of the normal RTD resistance at 0°C.

2.6.3 DC Voltage and DC Current Input

Connect the +dc input to terminal H, and connect the –dc input to terminal F (GND) (see Figure 2-3).

2.7 OUTPUT CIRCUIT WIRING

2.7.1 Solid State Relay—Primary and/or Secondary Output

The part number will specify which output(s) are included in each unit (CN2041 single output; CN2042, dual output). Since Solid State Relay and Analog Output use the same terminals, only one type can be provided on each output. Output type is not changeable in the field.

The Solid State Relay Output is a 1 ampere opto-isolated Triac output. An optional 50 mA Triac output may be supplied for either or both SSR outputs (SSR1 and SSR2) (see Figure 2-4). Maximum voltage for SSR load is 240 Vac.

NOTES

Current limiting fuses, such as Bussman KAA or KAB Series or Chase Shamut form 101 Amptrap (1 amp), are recommended to protect the 1 amp solid state relay.

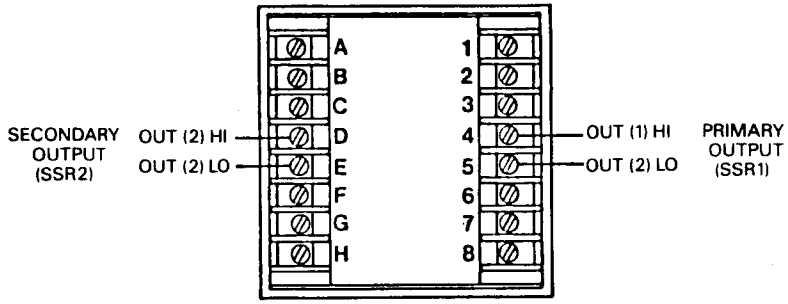


Figure 2-4. Solid State Relay—Primary and/or Secondary Output Wiring

APPLICATION NOTE: WHEN USING THE CONTROLLER SOLID STATE RELAY TO OPERATE AN EXTERNAL SOLID STATE RELAY TWO SITUATIONS MAY EXIST:

1. The leakage current of the controller SSR may be sufficient to cause an external SSR to remain in the conducting state. To prevent this the 50 mA SSR option is recommended.
2. The low power draw of the external SSR may cause the controller SSR to turn OFF due to insufficient holding current. The solution to this is also to use the 50 mA SSR option. An alternate approach is to use a loading resistor across the external SSR to increase the current.

2.7.2 Analog Output—Primary and/or Secondary Output (4-20 mAdc or 0-5 Vdc Output)

The solid state relay and the analog output use the same terminals; therefore, only one type can be provided on each output (see Figure 2-4). Output type is not changeable in the field.

NOTE

Maximum Load Resistance = 1 K for 4-20 mA output.
Minimum Load Resistance = 1 K for 0-5 Vdc output, or 2K for 0-10 Vdc.

Standard controllers with analog output(s) have a common connection between the input and output circuits. Grounding both input and output may cause controller damage and loss of control. Isolated input and/or outputs are available.

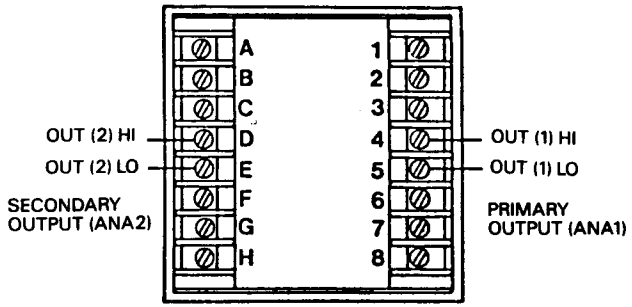


Figure 2-5. Current or Voltage Output—Primary and/or Secondary Output Wiring

2.7.3 Alarm/Event Relay Wiring

Two independent electromechanical alarm relays rated 1 amp at 240 Vac resistive load are included in the controller. Both normally open (NO) and normally closed (NC) terminals are available with one common return for each relay.

Terminal designations refer to the de-energized state, i.e., no power to the relays. To provide reliable alarm indication, the relays are energized during normal operation of the controller. When wiring to these relays, be sure to keep this in mind. Before power is applied to the controller the relay terminals are as shown in Figure 2-6. When the controller is powered, the terminal designations reverse. When an Alarm or Event relay turns ON, the terminal designations are as shown in Figure 2-6. Special care should be taken when wiring these relays to inductive devices such as coils and transformers. Noise suppressors as shown in Figure 2-6 are important to prevent electrical noise from being generated (see Paragraph 2-4).

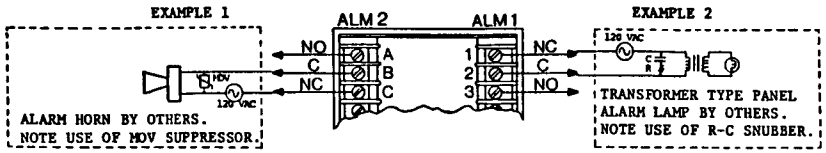


Figure 2-6. Alarm/Timer Wiring

SECTION 3 OPERATION

3.1 INITIAL POWER UP

CAUTION

Before proceeding, verify that the controller is correctly inserted in the case and not installed upside down. Rear vents should be at the top of the case. Front vents are at the bottom of the case.

After all connections have been made to the rear terminal connections and the correct wiring verified, power may be applied. The display should illuminate as soon as power is applied. If the multicolor vacuum fluorescent display does not illuminate immediately, disconnect the power and recheck the wiring. Allow at least five minutes for warm-up before starting operation.

3.2 MODES OF OPERATION

The controller can operate in one of two MODES, the OPERATOR mode or the TUNE mode. This distinction is made because different displays appear on the front of the controller for each mode and you can perform different functions in each mode.

The OPERATOR mode is the normal mode of operation. It is explained in detail in Paragraph 3.10. The TUNE mode is used for tuning the controller prior to going on-line or during operation. The TUNE mode is also used for manual control and for programming of the control profiles. The manual control and tuning portion of the TUNE mode is explained in detail in Section 4. Programming control profiles is explained in Section 5. The Digital Communications option is discussed in Section 6.

A third mode is used for recalibration of the controller. This CAL mode is expained in detail in Section 7.

Before putting the controller into operation, please read Paragraphs 3.3 through 3.7, which explain the display and keypad functions.

3.3 DISPLAY

The multicolor alphanumeric vacuum fluorescent display provides all the communications to the operator. The central portion of the display is blue and contains sixteen alphanumeric characters each. This display can actually show key words to prompt and inform you during all phases of operation. Refer to Figure 3-1.

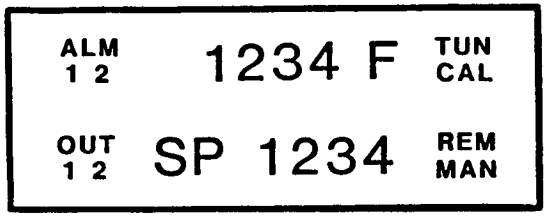


Figure 3-1. Vacuum Fluorescent Display

3.4 STATUS INDICATORS

Yellow MODE and STATUS indicators on the right side of the display illuminate to indicate specific controller status.

TUN	The TUN indicator illuminates when the controller is in the TUNE mode.
CAL	The CAL indicator illuminates when the controller is in the calibration mode. All control and alarm functions are inactive in the CAL mode.
REM	The REM indicator is flashing when a Digital Communications option is included and in use.
MAN (Steady)	The MAN indicator will illuminate when the controller outputs are under manual control.
MAN (Flashing)	The MAN indicator will flash when the control output(s) are OFF as a warning to the operator that no control is taking place.

3.5 ALARM INDICATORS

Red ALARM/EVENT relay indicators are included in the display in the upper left-hand corner. The letters ALM and either a 1 or 2 or both numbers illuminate when Relay 1 or 2 or both are de-energized (see Paragraph 2.7.3).

3.6 OUTPUT INDICATORS

Blue output indicators are included in the display in the lower left-hand corner. The letters OUT and either 1 or 2 or both numbers illuminate when Output 1 (Primary) or 2 (Second or Secondary, Model CN2042 only) are ON, i.e., relay is de-energized.

With ON/OFF and Time Proportional control action, the output indicator(s) cycle ON and OFF as the solid state relays cycle ON and OFF.

With analog output control, the output indicator(s) will be ON when the output is ON and the measurement is outside the proportional band. When the measurement is within the proportional band, the numerical indicator(s) will flash with an ON/OFF ratio proportional to the analog output.

3.7 KEYPAD

The eight key membrane type keypad on the front panel is the operator interface. Refer to Figure 3-2.

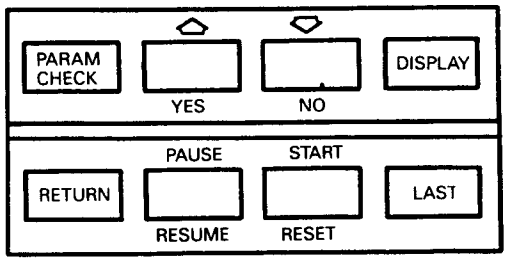


Figure 3-2. Controller Keypad

All control tuning and profile programming is performed with the keypad in conjunction with the display. There are no internal jumpers, switches or pots to set or adjust.

DISPLAY	The DISPLAY key advances the OPERATOR routine, allowing you to examine various system parameters.
PARAM CHECK	The PARAM CHECK key is the advance key for all other routines.
	The YES and NO keys allow the operator to answer a displayed question.
YES	The UP arrow key, when pressed, will INCREASE the numeric value of the parameter that is on the display. Holding the key in will increase the rate of change of the parameter.
NO	The DOWN arrow key, when pressed, will DECREASE the numeric value of the parameter that is on the display. Holding the key in will increase the rate of change of the parameter.
RETURN	The RETURN key returns the controller to the OPERATOR mode from any other mode.

PAUSE/RESUME — The PAUSE/RESUME key allows you to PAUSE the controller at any time during a profile and to RESUME profile control from the same point. Control is maintained at the then active set point during the PAUSE interval.

START/RESET — The START/RESET key allows you to RESET the controller at any time during a profile. You can shift to any other segment or even to a new profile and START control again. Pushing the RESET key turns OFF the outputs. Pushing the START key initiates control at the selected profile and segment.

LAST — The LAST key allows you to recall the previous display in any routine.

3.8 EVENT RELAY FUNCTIONS

Event relays are configured as ON or OFF event relays. An OFF event relay is energized during the normal operation (logic 0). When an event "ON" state occurs (logic 1), the relay de-energizes. An ON event relay is de-energized during normal operation (logic 0). When an event "OFF" state occurs (logic 1), the relay energizes. Event relays may be configured for non-latching or latching operation. A latching event relay will remain in its triggered (logic 1) state until reset using the RETURN key. Refer to Paragraphs 5.4 and 5.5 for setting instructions.

3.9 ALARM RELAY FUNCTIONS

To provide reliable alarm functioning, alarm relays are energized during normal operation and de-energized during an alarm state. Terminal designations for the electromechanical relays refer to the de-energized state. Alarms may be configured for non-latching or latching operation. A latching alarm will remain in its alarm state until reset using the RETURN key.

PROCESS alarm is an absolute value alarm that is independent of the set point and does not shift when the set point is changed. It can be either HI or LO acting.

DEVIATION alarm is slaved to the primary set point and can be set as a plus or minus value above, equal to, or below the set point. A deviation alarm shifts when the set point is changed. It can be HI or LO acting. Units are differential displayed units, i.e., DF or DC for temperature ranges.

DEVIATION BAND alarm is slaved to the primary set point, and can be set to a plus AND minus value on both sides of the set point value. The display is in differential displayed units.

HI ACTING alarm is activated when the measurement is equal to or above the alarm set point.

LO ACTING alarm is activated when the measurement is equal to or below the alarm set point.

3.10 OPERATING DISPLAYS

In the normal operating mode a series of displays are available to you. You can observe the controller action and can change some values as described below. Refer to Figure 3-3 OPERATOR Flow Chart. Refer to Paragraph 3.12 for the selection or changing of the profile letter and/or segment.

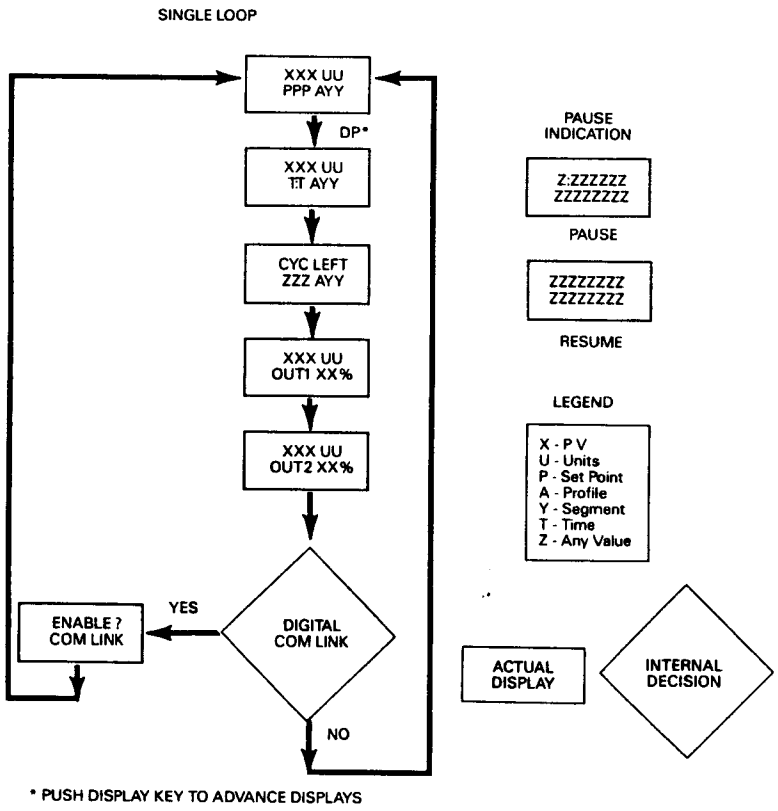


Figure 3-3. OPERATOR Loop Flow Chart

85 F 85 AO3

This is the basic display for the controller during normal operation. The top row shows the process variable with its units. The bottom row shows the set point, profile letter designator, and the active segment number. In normal operation, the arrow keys, unless turned OFF, allow you to change the active set point. Any change you make applies only to this segment, this time. The next time this profile is used, the set point reverts back to the value stored in permanent memory. During a RAMP segment, the SP shown is the end of segment set point. Advance the display by pushing the DISPLAY key.

85 F 0:15 AO3

If the DISPLAY key is pushed, the set point is replaced by a time remaining display. Segment Time is shown as a count down to zero display. You can change the time remaining using the arrow keys but any change you make applies only to this segment, this time. The next time this profile is used, it reverts back to the value stored in permanent memory.

A Time display of 00:00 while the controller is ON indicates an ASSURED SOAK hold. When the process variable comes within the present tolerance the timer resets and starts automatically.

CYC LEFT 2 AO3

The number of repeat cycles remaining is shown on this display. You can change the number of repeat cycles using the arrow keys but any change you make applies only to this profile, this time. The next time this profile is used the repeat cycles will revert back to the number stored in permanent memory.

85 F OUT1 0%

85 F OUT2 0%

These displays show the OUTPUT 1 and OUTPUT 2 (Model CN2042 only) percent power output. These are information displays only. No adjustment is available in this routine. Push the DISPLAY key to advance the display.

ENABLE ? COMM LINK

This display allows the operator to enable or disable the Digital Communications option when provided, using the YES/NO keys. The REM indicator will flash when Digital Communications is active. When the communications link is enabled, the host and the keypad are given equal priority by the controller. The controller acts on the latest information. For complete details on the Digital Communications option, see Section 6.

Two key functions PAUSE/RESUME and START/RESET provide useful control options that can be initiated while in the OPERATE or the TUNE mode. Refer to paragraphs 3.11 and 3.12.

3.11 PAUSE/RESUME

You can hold the profile control at any time by pushing the PAUSE key. The timer will stop, but the controller will remain active, holding control at the internal set point that was active when the key was pushed. Pushing the RESUME key restarts the timer and the profile continues from the point at which it was stopped.

:

A flashing colon appears in the upper left character position anytime the PAUSE key is pushed. The colon will appear with whatever display is visible when PAUSE is pushed.

3.12 START/RESET

You can STOP the profile control at any time by pushing the RESET key. Outputs go OFF and the timer stops.

85 F 85 AO3

This display automatically appears when you push the RESET key. This is the basic operator display with one difference. The Profile Designator letter will flash indicating that you can now change the Profile by using the arrow keys. If you push the DISPLAY key once, the Segment number will flash indicating that you can now change the segment number. There is no control or timer action taking place while you change profile and/or segment. When you push the START key, control begins at the profile and segment now displayed.

3.13 PROFILE REVIEW

You can examine the settings for the presently selected profile from the OPERATOR loop by pressing the PARAM CHECK key. In this review, the delay time, the set point and time for each segment, alarm settings, cycle, etc., are sequentially displayed in the same order and form as they are set (see Section 5). Only the relevant displays will appear. The PARAM CHECK key will scroll through the profile settings and pressing the DISPLAY key returns you to the normal operator displays. The profile settings may not be temporarily changed during one of the normal operator displays. To permanently change profile values, you must enter the TUNE loop (Section 4) and proceed as decribed in Section 5.

SECTION 4 TUNING

4.1 TUNING

This controller has been configured at the factory with input, output and Alarm/Event functions. Alarm and Tuning values have been preset to allow complete controller checkout at the factory. It is necessary that you tune this controller to your specific application.

All tuning is done in a security protected TUNE mode. A special series of displays in the TUNE mode actually displays key words at every step to prompt and inform you. Only those displays that apply to your controller part number will appear on the display. When you have scrolled through the complete TUNE program you can be confident that every Tune item has been addressed.

NOTE

The TUNE routine is the same for both models, except that the secondary output is available only in the Model CN2042.

The control profile programming, which is a part of the TUNE routine, is explained in detail in Section 5. All other Tuning functions are included in this section. Refer to Figure 4-1, TUNE Flow Chart.

4.2 ENTERING THE TUNE PROGRAM

A security key code protects the TUNE program. To enter the TUNE program push three keys, RETURN-LAST-YES in sequence (see Figure 4-2). A yellow TUN indicator light will illuminate. If it does not, push the RETURN key and then enter the key code again.

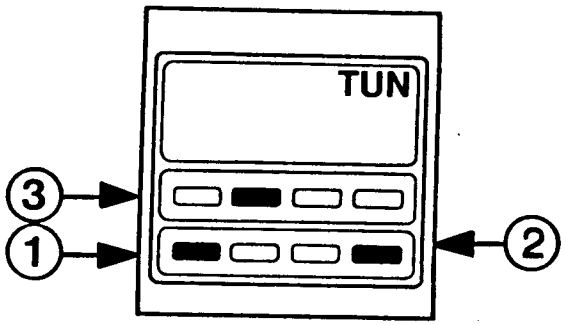


Figure 4-2. Entering the Tune Program

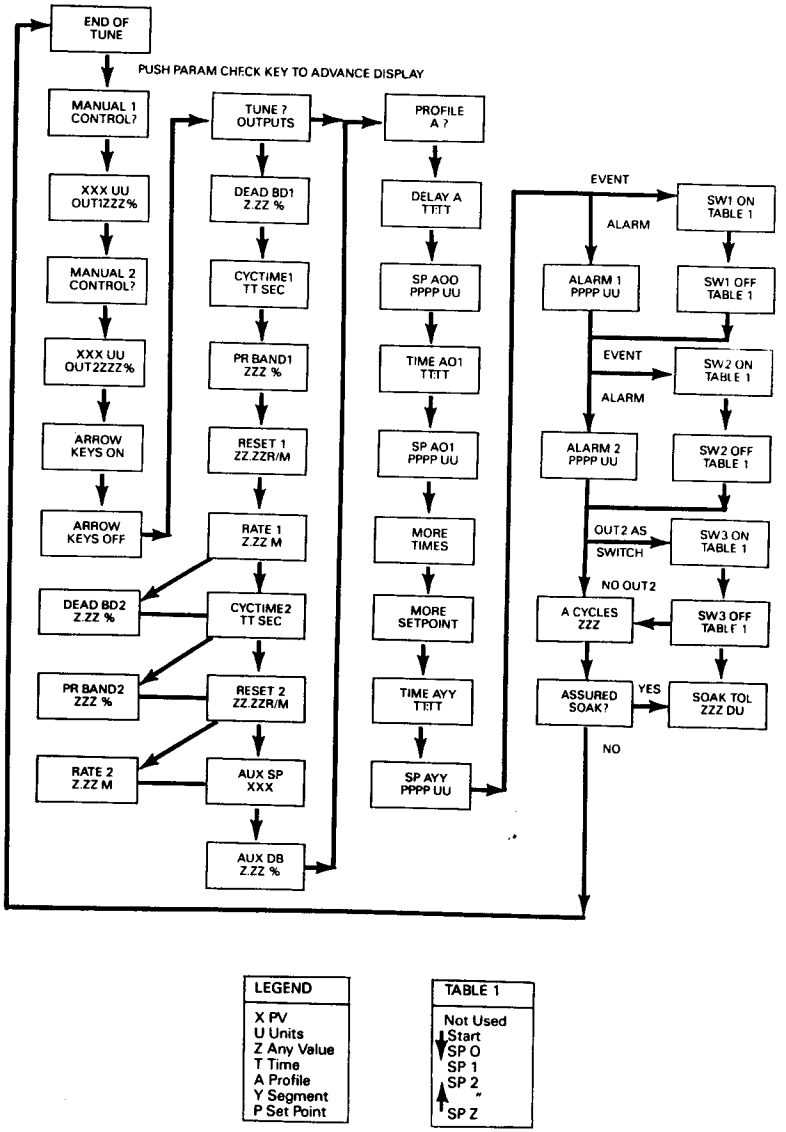
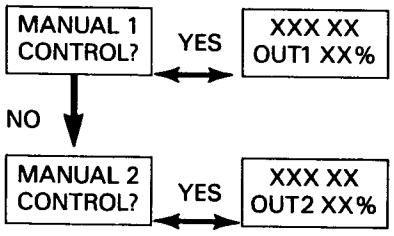


Figure 4-1. TUNE Loop Flow Chart

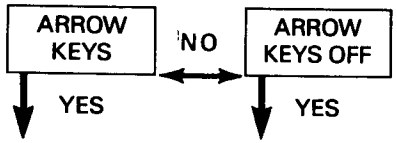
4.3 MANUAL CONTROL SELECTION



The first set of displays in the TUNE routine allow you to take MANUAL CONTROL of the output(s). The controller must be running in order to use the manual control function. Manual control is useful during system startup and testing. Pushing the NO or PARAM key advances the display by-passing manual control. Pushing the YES key calls up a display showing the process variable and the OUTPUT percent power. The yellow MAN indicator illuminates to indicate manual control and the arrow keys allow you to set the output at any desired percent power. Either or both outputs can be under manual control at any time. Push the PARAM key to advance to the next display.

4.4 KEYPAD SECURITY

Additional security is available to prevent unauthorized controller adjustments.



With these displays you can disable the UP/DOWN arrow keys used to change set points when in the operator mode. All OPERATOR displays can still be viewed but no values can be changed while the arrow keys are turned OFF. The key codes do still function.

4.5 SETTING TUNING VALUES

A significant feature of this controller is the ease and precision of setting all tuning values. After the keypad security displays, the TUNE routine continues with the actual tuning displays.

The following presentation includes all possible tuning parameters. Your controller will only display those parameters appropriate to your controller part number.

TUNE ? OUTPUTS	Because you may be in the TUNE routine to do other functions such as setting a control profile, this display allows you to bypass the actual tuning display and to go immediately to the profile programming by pushing the NO key. Push the YES key for tuning the controller. At any display you can use the arrow keys to change the selected tuning value. Use the LAST key to review previous displays.
DEAD BD1 X.XX%	This display appears when the primary output is specified as ON/OFF control. A DEADBAND of 0.25, 0.50 or 1.00% of span can be selected. The controller is shipped with a preset DEADBAND of 0.25%.
CYCTIME1 XX SEC	This display appears when the primary output is specified as time proportioning control. A CYCLETIME from 1 to 60 seconds can be selected. The controller is shipped with a preset CYCLETIME of 15 seconds.

The following displays appear when the PRIMARY OUTPUT is specified as time proportioning or analog control. These are the PID tuning steps.

PR BAND1 XXX%	A PROPORTIONAL BAND (gain) from 1 to 200 percent can be selected. The controller is shipped with a preset PB value of 5%.
RESET 1 XX.XXR/M	This display indicates the RESET (integral) action. RESET from 0.01 to 20.00 repeats per minute (R/M) can be selected. A RESET value of 0.00 turns the reset action OFF. The controller is shipped with a preset value of 0.25 R/M.
RATE 1 XX.X M	This display indicates the RATE (derivative) action. RATE from 0.01 to 5.00 minutes (M) can be selected. A RATE value of 0.00 turns RATE action off. The controller is shipped with a preset RATE value of 1.00 minutes.

The following displays appear only when a secondary output is provided. Second output tuning values are completely independent of primary tuning values.

DEAD BD2 X.XX%	This display appears only when the second output is specified as ON/OFF control. A DEADBAND of 0.25, 0.50 or 1.00% of span can be selected. The controller is shipped with a preset DEADBAND of 0.25%.
CYCTIME2 XX SEC	This display appears only when a second output is provided and is specified as TPR control in the part number. A cycletime from 1 to 60 seconds can be selected. The controller is shipped with a preset cycletime of 15 seconds.

The following displays appear when the second output is specified as time proportional or analog control.

PR BAND2 XXX%	PROPORTIONAL BAND (gain) from 1 to 200% of span can be selected. The controller is shipped with a preset PB value of 5%.
RESET 2 XX.XXR/M	RESET (integral) action from 0.01 to 20.00 repeats per minute (R/M) can be selected. A RESET value of 0 turns the RESET action off. The controller is shipped with a preset RESET value of 0.25 R/M.
RATE 2 X.XX M	RATE (derivative) action from 0.01 to 5.00 minutes (M) can be selected. A RATE value of 0 turns the RATE action OFF. The controller is shipped with a preset RATE value of 1.00 minutes.
	Auxiliary Set Point (AUX SP) defines the value of the secondary set point with respect to the primary set point. The units are differential display units (DX).
AUX SP XXX DX	This secondary set point can be set above (plus), equal to, or below (minus) the primary set point, using the arrow keys. The controller is shipped with a preset AUX SP of 0. Auxiliary Set Point is only used in a Model CN2042 controller with dual output (HEAT/COOL) control.
AUX DB X.XX%	This display appears only when a secondary output specified as ON/OFF control is included. A DEADBAND of 0.25, 0.50 or 1.00% span can be selected. The controller is shipped with a preset DEADBAND of 0.25%.

Output tuning is now complete for the controller. The tune routine continues in Section 5 with Profile Programming, but first read Paragraph 4.6 on Pointers, which is a Tuning shortcut procedure.

4.6 POINTERS

To simplify tuning of the controller, special logic called POINTERS has been included that allows tuning personnel to jump back and forth between TUNE displays and OPERATOR displays quickly and efficiently.

To operate the tuning pointers, the controller must be in TUNE mode -i.e., TUN indicator light must be "ON". When in the TUNE mode the DISPLAY key will call up and display the OPERATOR displays in programmed order. The PARAM CHECK key will call up and display the TUNE displays in programmed order.

It is possible to jump back and forth between the TUNE and OPERATOR displays by using the PARAM CHECK key when at an OPERATOR display and the DISPLAY key when at a TUNE display.

For example: In the TUNE mode, the display can be advanced to RESET 1 using the PARAM CHECK key. Then by pressing the DISPLAY key, the OPERATOR display for OUT 1 can be put on the display. The PARAM CHECK key displays RESET 1 for tuning. The DISPLAY key displays OUT 1 to observe control action resulting from the change in RESET 1. The operator can go back and forth between these two displays at the touch of a key for quick and efficient tuning.

4.7 TUNING A THREE MODE (PID) CONTROLLER

The microprocessor controller is capable of exceptional control stability when properly tuned and used. The operator can achieve the fastest response time and smallest overshoot by following these instructions carefuly. The information for tuning this three mode controller may be different from other controller tuning procedures.

After the controller is installed and wired:

a. Apply power to the controller.
b. Disable the control outputs by pressing the STOP key. (The MAN indicator will flash when the output(s) have been disabled.)
c. Enter the TUNE Loop by pushing RETURN-LAST-YES keys in sequence. (The TUN indicator will illuminate.)
d. Press the PARAM CHECK key to advance through the TUNE Loop displays. When the question "TUNE OUTPUTS?" is displayed press the YES key.

The following list shows all of the displays used for PID tuning. Not all of these displays are applicable to every controller. The configuration number causes all of the useful displays to appear and suppresses the unnecessary displays. Other displays will appear for ON/OFF outputs.

Press the PARAM CHECK key to advance through the displays. Use the UP and DOWN keys to change each display to the value listed below:

CYCTIME 1 ----- 5 SEC (Only appears if the output is time proportional. A shorter cycletime may be required for systems with extremely fast response times.

PR BAND 1 ----- 5 %
RESET 1 ------- 0 R/M (0 turns reset OFF)
RATE 1 -------- 0 MIN (0 turns rate OFF)
CYCTIME 2 ----- 5 SEC
PR BAND 2 ----- 5 %
RESET 2 ------- 0 R/M (0 turns reset OFF)
RATE 2 -------- 0 MIN (0 turns rate OFF)
AUX SP -------- 0 DU (U represents display units such as F, C, etc.)

e. A single set point is needed in order to properly evaluate controller performance as changes are made in the tuning parameter settings. A profile which permits single point control can be programmed by following the instructions that follow:

Press the PARAM CHECK key until "PROFILE X ?" is displayed. The X represents the profile designators A through P. The following example uses profile A, but any available profile can be used. Press the YES key in response to this question.

Advance through the following displays by pressing the PARAM CHECK key and set each one to the value indicated below.

DELAY A SP A00	0:00	Chose a value of at least halfway between ambient and the maximum set point the system will reach in normal use (for tuning HEAT outputs).
TIME A01	CONT	Set the time to 0:00. Then press the DOWN ARROW key to select the CONTINUOUS setting.
SP A01 TIME A02	0:00	Set this value equal to SP A00.

ALARM 1		The ALARM displays may not appear.
ALARM 2		The ALARM SETPOINT has no effect on the control output performance. Select any value.
A CYCLES	1	
ASSURED SOAK ?		Press the NO key.
MORE PROFILES ?		Press the PARAM CHECK key.
END OF TUNE		Press the PARAM CHECK key until the "TUNE OUTPUTS ?" display appears, then press the YES key.

4.7.1 Tuning the Primary Output for Heating Control

1. Press the DISPLAY key until the process variable appears on the screen. It is not necessary to return to the OPERATOR mode while tuning the controller. See POINTERS in Paragraph 4.6. The DISPLAY key will advance the display through the OPERATOR Loop. The PARAM CHECK key advances the display through the TUNE Loop. The LAST key can be used to back up the display in either loop.

   Press the START key to enable the OUTPUTS and start the process. Note that when the controller is in the TUNE Loop, pressing the RESET key will stop control and return the controller to the OPERATOR Loop. Use the TUNE Loop key code sequence to return to the TUNE Loop if tuning is incomplete.

2. The process should run at a set point that will allow the process variable to stabilize with heat input required. The set point can be changed for the current profile run by pressing the UP or DOWN ARROW keys. The originally programmed set point will be restored the next time the profile is started.

3. With RATE and RESET turned off, the process variable will stabilize with a steady state deviation, or droop, between the set point and the actual process variable. Carefully note whether or not there are regular cycles or oscillations in the process level by observing the measurement on the display. (An oscillation may be as long as 30 minutes.)

   The tuning procedure is easier to follow if you use a chart recorder to monitor the process.

4. If there are no regular oscillations in the process, divide the PB by 2 (see Figure 4-3). Allow the process to stabilize and check for process variable oscillations. If there are still no oscillations, divide the PB by 2 again. Repeat until cycles or oscillations are obtained. Proceed to Step 5.

   If oscillations are observed immediately, multiply the PB by 2. Observe the resulting process variable for several minutes. If the oscillations continue, increase the PB by factors of 2 until the oscillations stop.

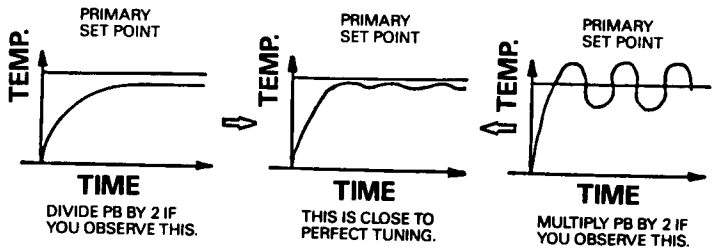


Figure 4-3. Temperature Oscillations

5. The PB is now very near its "CRITICAL" setting. Carefully increase or decrease the PB setting until cycles or oscillations JUST appear in the process recording.

   If no oscillations occur in the process even at the minimum proportional band setting of 1%, skip Steps 6 through 15 below and proceed to Section 4.7.2.

6. Read the steady-state deviation, or droop, between set point and actual process variable with the "CRITICAL" PB setting you have achieved. (Because the process is cycling a bit, use the average deviation.)

7. Measure the oscillation time, in minutes, between neighboring peaks or valleys (see Figure 4-4). This is most easily accomplished with a chart recorder, but a measurement can be read at 1 minute intervals to obtain the timing.

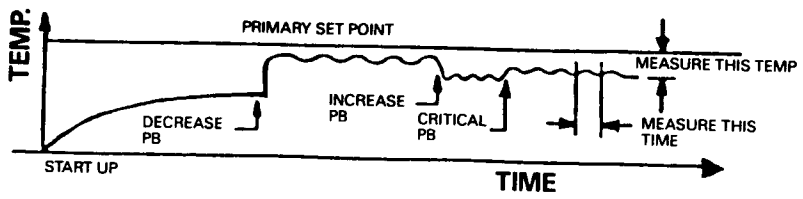


Figure 4-4. Oscillation Time

8. Now, increase the PB setting until these deviation, or droop, increase 65%.

   The desired final deviation can be calculated by multiplying the intial deviation achieved with the "CRITICAL" PB seting by 1.65 (see Figure 4-5) or by use of the convenient Nonogram I (see Figure 4-6). Try several trial-and-error settings of the PB control until the desired final deviation is achieved.

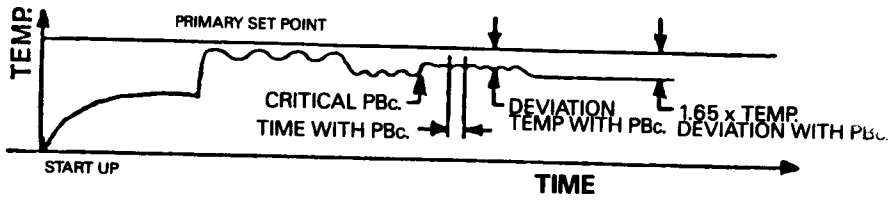


Figure 4-5. Calculating Final Temperature Deviation

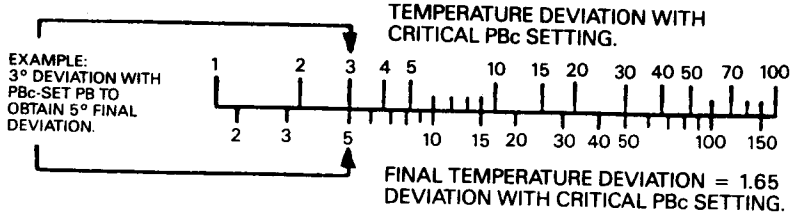


Figure 4-6. Nomogram I

9. You have now completed all the necessary measurements to obtain optimum performance from the controller. Only two more adjustments are required—RATE and RESET—and those will take less than two minutes.

10. Using the oscillation time measured in Step 7, calculate the value for RESET in repeats per minute as follows:

$$\text{RESET} = \frac{8}{5} \times \frac{1}{T_o} : \text{Where } T_o = \text{Oscillation Time in Minutes.}$$

OR Use Nomogram II (see Figure 4-7).

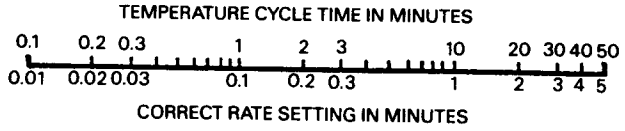


Figure 4-7. Nomogram II

Enter the value for RESET 1.

11. Again using the oscillation time measured in Step 7, calculate the value for RATE in minutes as follows:

$$\text{RATE} = \frac{T_o}{10} : \text{When } T_o = \text{Oscillation Time in Minutes.}$$

OR Use Nomogram III (see Figure 4-8).

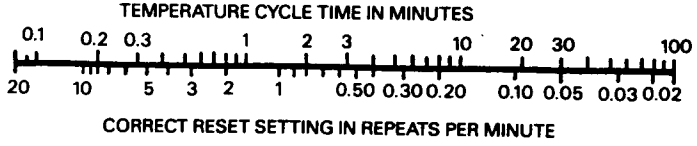


Figure 4-8. Nonogram III

12. If overshoot occurred, it can be eliminated by decreasing the RESET time. When changes are made in the RESET value, a corresponding change should also be made in the RATE adjustment so that the RATE value is equal to:

$$\text{RATE} = \frac{1}{6 \times \text{Reset Value}}$$; i.e., If reset = 2 R/M, then RATE = 0.08 min.

13. Several set point changes and consequent RESET and RATE time adjustments may be required to obtain the proper balance between "RESPONSE TIME" to a system upset and "SETTLING TIME". In general, fast response is accompanied by larger overshoot and consequently shorter time for the process to "SETTLE OUT". Conversely, if the response is slower, the process tends to slide into the final value with little or no overshoot. The requirements of the system dictate which action is desired.

14. When satisfactory tuning has been achieved, the cycle time should be increased to save contactor life (applies to units with time proportioning outputs only (TPR)). Increase the cycle time as much as possible without causing oscillations in the measurement due to load cycling.

15. Proceed to Paragraph 4.8

4.7.2 Tuning Procedure When No Oscillations are Observed

1. Measure the steady-state deviation, or droop, between the set point and the actual process value with minimum PB setting.

2. Increase the proportional band setting until the process deviation (droop) increases 65%. Nomogram I (refer to Figure 4-6) provides a convenient method of calculating the desired final process deviation.

3. Set RESET 1 to a high value (10 R/M). Set RATE 1 to corresponding value (.02 MIN.). At this point, the measurement should stabilize at the process set point due to the reset action.

4. Since we are not able to determine a "critical" oscillation time, the optimum of the rate and reset adjustments must be determined by trial and error. After the process has stabilized at set point, increase the set point value by 10 units. Observe the overshoot associated with the rise in the actual process value. Then return the set point to its original value and again observe the undershoot associated with the actual process change.

   Excessive overshoot implies that the RESET and/or RATE value are set too high. Overdamped response (no overshoot) implies that the RESET and/or RATE value are set too low. Refer to Figure 4-9. Where improved performance is required, change one tuning parameter at a time and observe its effect on performance when the set point is changed. Make incremental changes in the parameters until the performance is optimized.

5. When satisfactory tuning has been achieved, the cycle time should be increased to save contactor life (applies to units with time proportioning outputs only (TPR)). Increase the cycle time as much as possible without causing oscillations in the measurement due to load cycling.

RESET OR RATE TOO HIGH

RESET OR RATE TOO LOW.

Figure 4-9. Setting RESET and/or RATE

4.8 TUNING THE PRIMARY OR SECONDARY OUTPUT FOR COOLING CONTROL

A cooling output is tuned adapting the procedure used for heating outputs. The process should be run at a set point that requires cooling control for the process to stablize.

4.9 SIMPLIFIED TUNING PROCEDURE FOR PID CONTROLLERS

The following procedure is a graphical technique of analyzing a process response curve to a step input. It is much easier with a strip chart recorder reading the process variable (PV). Refer to Figure 4-10.

1. Starting from a cold start (PV at ambient), apply full power to the process without the controller in the loop, i.e., open loop. Record this starting time.
2. After some delay (for heat to reach the sensor), the PV will start to rise. After more of a delay, the PV will reach a maximum rate of change (slope). Record the time that this maximum slope occurs, and the PV at which it occurs. Record the maximum slope in degrees per minute. Turn OFF system power.

3. Draw a line from the point of maximum slope back to the ambient temperature axis to obtain the lumped system time delay Td (see Figure 4-10). The time delay may also be obtained by the equations:

   Td = time to max slope -(PV at max. slope - ambient)/max. slope

4. Apply the following equations to yield the PID parameters:

   Pr. Band = Td x max. slope x 100/span = % of span Reset = 0.4/Td = reset/minute Rate = 0.4 x Td = minutes

5. Bring the process to set point with the controller in the loop and observe response. If the response has too much overshoot, or is oscillating, then the PID parameters can be changed (slightly, one at a time, and observing process response) in the following directions:

   Widen the proportional band, lower the RESET value, and increase the RATE value.

   EXAMPLE: The chart recording in Figure 4-10 was obtained by applying full power to an oven. The chart scales are 10°F/cm, and 5 min/cm. The controller range is 100-600°F, for a span of 500°F.
   Maximum slope = 18°F/5 minutes = 3.6°F/minutes

   Time delay = Td = approximately 7 minutes

   Proportional Band = 7 minutes x 3.6°F/minutes x 100/500°F = 5%

   Reset = 0.4/7 minutes - 0.06 resets/minute

   Rate = 0.4 x 7 minutes = 2.8 minute

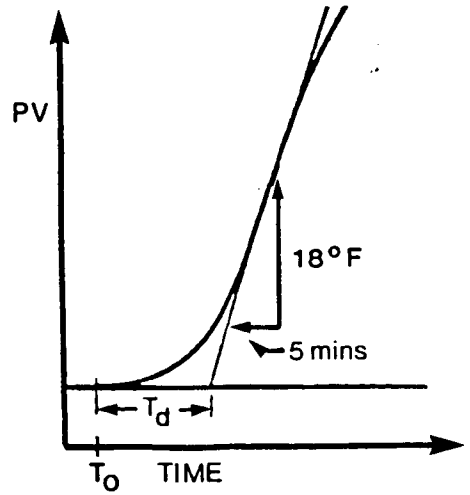


Figure 4-10. System Time Delay

SECTION 5 PROGRAMMING CONTROL PROFILES

5.1 CONTROL PROFILE

Control profiles are programmed in the TUNE mode immediately after the tuning displays in Section 4. Before putting a profile into memory, the profile should be written down.

With a completed profile worksheet in hand, proceed in the TUNE mode as follows.

5.2 PROFILE PROGRAM

PROFILE A ?	This is the first display in the profile programming routine. You can find this display while in the TUNE mode by pushing the PARAM key while in the TUNE mode, i.e., TUN indicator on. Depending on the controller configuration, up to 16 profiles designated by the letters A through P can be programmed into memory and used on demand. Push the NO or LAST key to scroll the display until you find the profile letter you want to use. Then push the YES key and proceed as follows:
DELAY A TT:TT	Using the arrow keys, set in the DELAY TIME from your work sheet. If no delay is desired, set in 00:00. Push PARAM key to proceed.
SP A00 XXX XX	Using the arrow keys, set in the starting set point. Starting set point can be ambient or any value within the span. When ASSURED SOAK is ON the controller will wait until this set point is reached before the profile will begin.
TIME A01 XX:XX	The entire profile can now be programmed in proper sequence using the arrow keys. All you program is the TIME for each segment and then the ending SET POINT for each segment. The PARAM key advances the display and the LAST key backs up the display. Note the information provided on the display. The top row shows either SP (set point) or TIME plus the Profile Designator letter and the Segment number. The bottom row shows either the end of segment SP value including Units or the Time remaining in the segment.

Each display automatically shows the profile letter designator and the segment being programmed as you advance through the profile. A SOAK segment has the same starting and ending set point. A RAMP segment has an ending set point higher or lower than the starting set point. The profile ends at any segment where you set in a TIME of 00:00. The profile programming then continues with the ALARM/EVENT instructions.

5.3 ALARM/EVENT PROGRAM

Your controller includes two electromechanical relays that can be used as ALARM or EVENT outputs. The PART NUMBER defines the type and action of the relays in your controller. Figure 5-1 illustrates how two relays specified as EVENT might be programmed.

Each EVENT relay can be turned ON once and OFF once during any profile. ON/OFF action takes place at Time = 00:00 which is the end of any designated segment.

5.4 RELAY 1

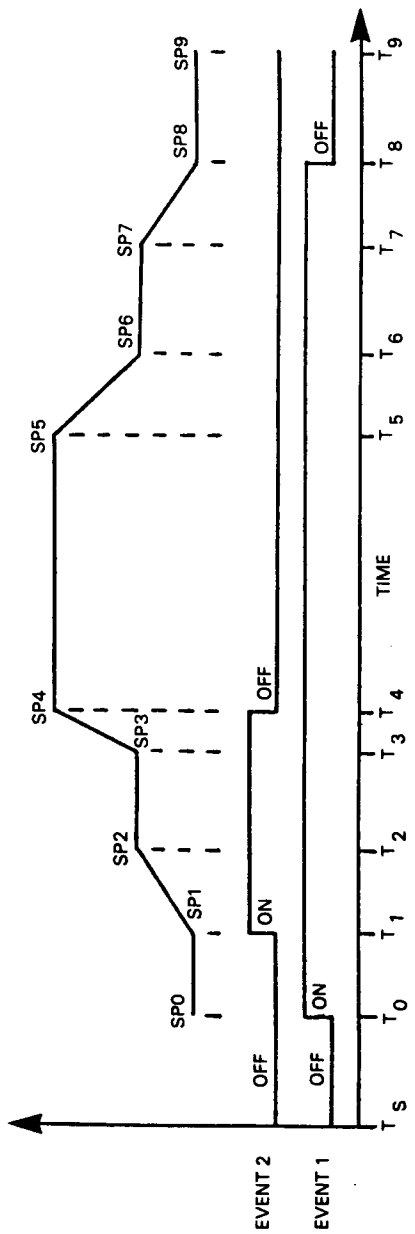
RELAY 1 can be configured from a large selection of Alarm and Event actions. However, once the RELAY 1 action decision is made and programmed as part of the factory calibration procedure, you can only use RELAY 1 as configured. This configuration can be changed if required for your application by following instructions in Section 7. Depending on the configuration specified, one of these displays will appear:

RELAY 1 AS AN ALARM	OR	RELAY 1 AS AN EVENT
ALM 1 XXX XX		SW1 ON XXX → push PARAM → SW1 OFF XXX
Use arrow keys to Set Alarm Value		Use arrow keys to program the segment for SW1 to go ON and then for SW1 to go OFF.

5.5 RELAY 2

RELAY 2 can be configured from a large selection of Alarm and Event functions. However, once the RELAY 2 function decision is made and programmed in the configuration calibration procedure, you can use RELAY 2 as configured.

RELAY 1 AS AN ALARM	OR	RELAY 1 AS AN EVENT
ALM 2 XXX		SW2 ON XXX → push PARAM → SW2 OFF XXX
Use arrow keys to set Alarm Value		Use arrow keys to program the segment for SW1 to go ON and then for SW1 to go OFF.



5.6 EVENT 3

A third EVENT switch may be available if OUTPUT 2 (SSR2) (Model CN2042 only) is not otherwise required. Once the decision is made and programmed in the configuration calibration procedure, all profiles can make use of Switch 3 using this display.

OUTPUT 2 AS AN EVENT (Switch 3)

SW3 ON XXX	push PARAM →	SW3 OFF XXX

Use arrow keys to program the segment for SW3 to go ON and then for SW3 to go OFF.

5.7 REPEAT CYCLES

X CYCLES XXX	The profile can automatically repeat up to 254 times, or can run continuously (CONT). Set repeats desired using arrow keys with one cycle shown as one repeat.

5.8 ASSURED SOAK

ASSURED SOAK ?	The ASSURED SOAK option, when activated by pushing the YES key, holds the timer at the end of any segment if the temperature is not within a preset tolerance. Push the YES to use ASSURED SOAK or push the NO to bypass this option.
SOAK TOL XXX	When ASSURED SOAK is selected, you program the allowable soak tolerance here using the arrow keys.

5.9 MORE PROFILES

MORE ? PROFILES	The selected profile programming is now complete. Push YES to proceed to program another profile. Push NO to end TUNE routine.
END OF TUNE	The tuning routine is now complete. You can review your programs by TUNE pushing the PARAM key or you can return to the normal operator control mode by pushing the RETURN key.

SECTION 6 DIGITAL COMMUNICATIONS OPTION

6.1 COMMUNICATION IDENTIFICATION

There are five types of communications interface options available for use with this controller. The options are:

D2 RS232C NON-ISOLATED
D3 RS232C ISOLATED
D4 RS422 NON-ISOLATED
D5 RS422 ISOLATED
D6 20 mA CURRENT LOOP ISOLATED

6.2 COMMUNICATIONS WIRING

The "D" type (DB25S) 25-pin digital communications connector located at the rear of the controller is a standard Electronic Industries Associates (EIA) interface for RS232C. RS422 and 20 mA current loop use the same connector.

Wiring to the controller is identical to that for any Data Terminal. Table 6-1 identifies each connector pin by function. Paragraphs 6.4 to 6.6 specify the specific wiring for the three available interfaces.

TABLE 6-1
CONNECTOR PIN DESIGNATIONS

PIN	MNEMONIC	SIGNAL	DESCRIPTION
1	GWG	Protective Ground	In the RS232C environment, this line provides a ground connection between devices. Although not required, may also be used for RS422 and 20 mA current loop configurations for the same purpose.
2	TX	Send Data	Transmits data within RS232C voltage levels (+12 V and −12 V) or RS422 voltage levels (0 and 5 V differential). Also used by the 20 mA current as 20 mA input (user supplied) for the transmit loop.
3	RX	Receive Data	Accepts data within RS232C or RS422 voltage levels or used by the 20 mA current loop as 20 mA input (user supplied) for the receive loop.

TABLE 6-1 (Cont'd)
CONNECTOR PIN DESIGNATIONS

PIN	MNEMONIC	SIGNAL	DESCRIPTION
4	RTS	Request to Send	This line is normally held inactive by the controller until a message is ready to be sent. Then the line is switched active and the controller waits for the clear to send.
5	CTS	Clear to Send	This line must be made active by the host in order for the controller to send data unless handshake lines are inactive (see switch settings, Paragraph 6.7).
6	DSR	Data Set Ready	Since the controller is a respond only device and does not initiate correspondence, the controller assumes that the host is ready to receive if the clear to send line is active, and does not monitor this line.
7	SG	Signal Ground	This line provides a common signal connection for the RS232C environment. It is also used as a ground reference for the power supplied by user for isolated configurations.
8	DTR−	Data Terminal Return	Return line for Data Terminal Ready signal (PIN 20) used with RS422 with handshake only.
9	+V	Positive Voltage	User must supply +12 Vdc on this pin if using RS232 isolated or +5 Vdc if using RS422 isolated configuration. No connection otherwise.
10	−V	Negative Voltage	User must supply −12 Vdc on this pin if using RS232C isolated configuration. No connection otherwise.

TABLE 6-1 (Cont'd)
CONNECTOR PIN DESIGNATIONS

PIN	MNEMONIC	SIGNAL	DESCRIPTION
11	CTS–	CTS Return	Return line for Clear to Send signal (PIN 5) used with RS422 with handshake only.
14	TX–	Send Data Return	Return line for Send Data signal (PIN 2) used with RS422. also 20 mA current loop return line for transmit loop.
16	RTS–	Request to Send Return	Return line for Request to Send signal (PIN 5) used only with RS422 handshake.
18	RX–	Receive Data Return	Return line for Receive Data signal (PIN 3) used with RS422 or 20 mA current loop on receive loop. Internally tied to Signal Ground (PIN 7) for RS232C operations.
20	DTR	Data Terminal Ready	When handshake lines are used, this line is always active telling the host to send data at any time. This line is in an undetermined state when handshake is not used.
25	DSR–	Data Set Read Return	Return line used for Data Set Ready signal (PIN 6) used with RS422 with handshake only.

NOTES

1. All signals are named with respect to the originating unit.
2. All undesignated pins are to be left open.
3. User must supply +12 Vdc @ 125 mA on PIN 9, –12 Vdc @ 50 mA on PIN 10 referenced to ground on PIN 7 for isolated RS232C operation. For isolated RS422 operation the user must supply +5 Vdc @ 150 mA on PIN 9 referenced to ground on PIN 7.

6.3 HANDSHAKE OPTION

The controller digital communications includes provision for the full handshake operation for use in RS232C and RS422 interfaces. Although handshaking signals are available on the controller, most systems do not require its use. It is recommended that unless the host system requires handshaking, S2 position 4 should be set in the OFF position to disable the handshake option. To enable handshake for these interfaces, set the S2 switch number 4 "ON" (see Paragraph 6.7). Four signal leads are used.

PIN 4	RTS	Request to Send
PIN 5	CTS	Clear to Send
PIN 6	DSR	Data Set Ready
PIN 20	DTR	Data Terminal Ready

The RS422 also requires return lines.

PIN 16	RTS	Request to Send Return
PIN 11	CTS	Clear to Send Return
PIN 25	DSR	Data Set Ready Return
PIN 8	DTR	Data Terminal Ready Return

The interface diagrams (Paragraphs 6.4 - 6.6) shown are suggestions ONLY. There are several alternate wiring configurations depending on the host. It is essential to compare the host or modem requirements with the PIN designations before connecting the system.

If handshake is not required or if these signals are not compatible with the host computer, the S2 switch number 4 MUST be "OFF". Handshaking cannot be used for any 20 mA current loop interface or for drop line RS422 configurations.

6.4 RS232C INTERFACE (See Figures 6-1 and 6-2)

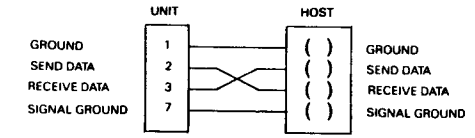


Figure 6-1. RS232C Half/Full Duplex Without Handshake

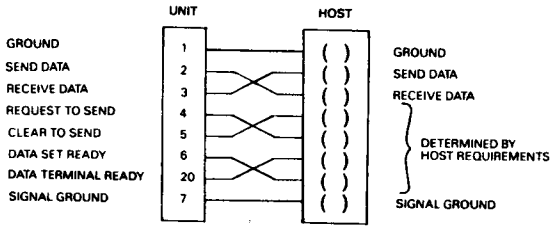


Figure 6-2. RS232C Half/Full Duplex With Handshake

6.5 RS422 INTERFACE (See Figures 6-3 and 6-4)

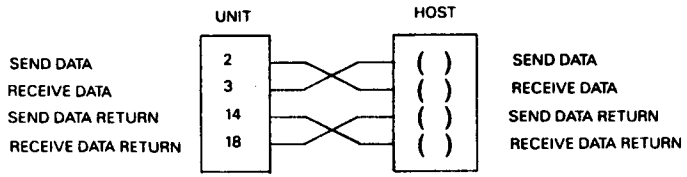


Figure 6-3. RS422 Half/Full Duplex Without Handshake

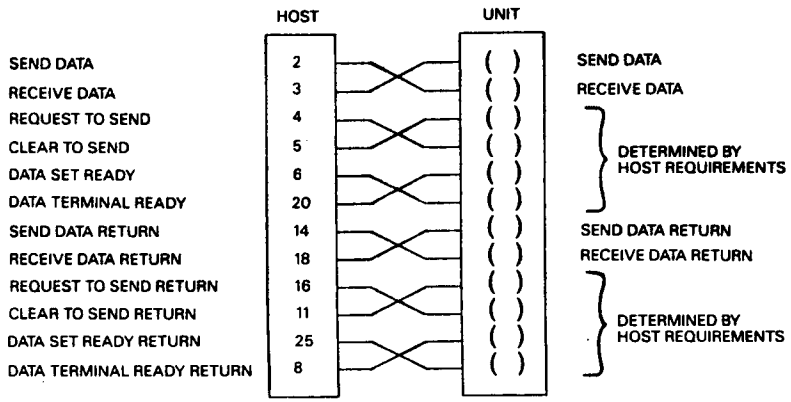


Figure 6-4. RS422 Half/Full Duplex With Handshake

The RS422 driver is shown in Figure 6-5. Be sure the Host RS422 driver conforms or it will be necessary to swap connections between all signals and their respective return lines to correct polarity, i.e., PINS 2 and 14, PINS 3 and 18, etc.

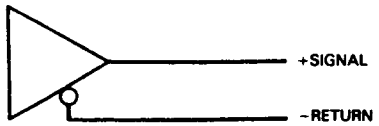


Figure 6-5. RS422 Driver

RS422 may be DROP LINE configured to enable the host to talk to several controllers through one port as shown in Figure 6-6.

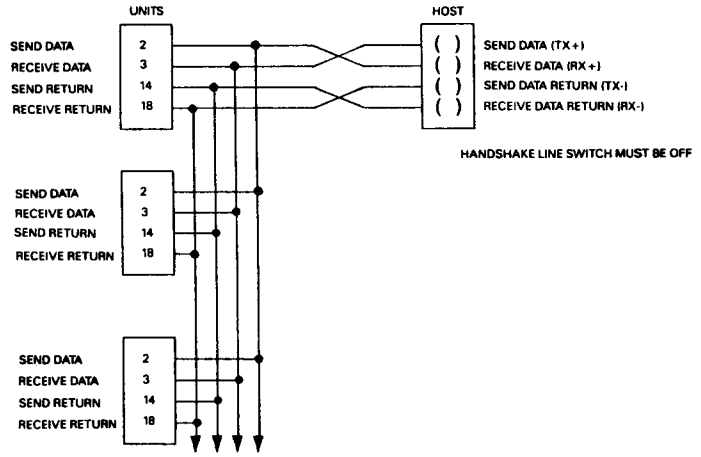


Figure 6-6. Several CN2041/2042 Controllers in Conjunction With One Host

6.6 20 mA CURRENT LOOP INTERFACE (See Figures 6-7 through 6-10)

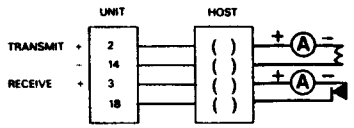


Figure 6-7. Full Duplex 4-Wire Connections

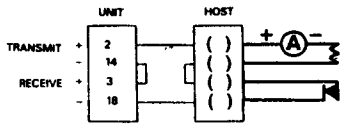


Figure 6-8. Half Duplex 2-Wire Connections

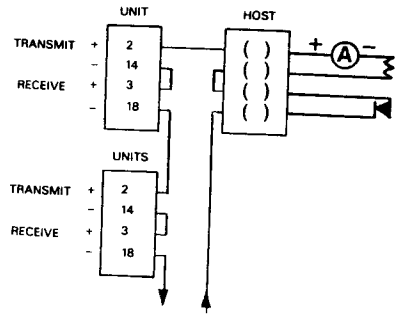


Figure 6-9. Half Duplex 2-Wire Chaining of Several Controllers

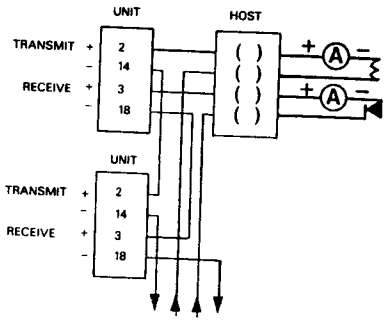


Figure 6-10. Full Duplex 4-Wire Chaining of Several Controllers

NOTES

1. Symbol A indicates 20 mA current source provided by others.
2. Less than 2.3 V (Transmit) and 1.0 V (Receive) drop across contacts while marking.
3. Maximum voltage that can be applied across Transmitter or Receiver Terminals is 24 V. Maximum current is 30 mA.

6.7 FORMAT SELECTION SWITCHES

Format selector switches mounted on the communications circuit board inside the controller allow the user to select Parity, Baud Rate and Unit Address to fit the application (see Figure 6-11). The switch options are:

PARITY:	Even, odd or no parity (factory set at NO PARITY)
BAUD RATE:	300, 600, 1200 or 2400 (factory set at 1200)
UNIT ADDRESS:	0 to 63 (factory set at ADDRESS 0000)
Handshake:	YES or NO (factory set at NO HANDSHAKE)

To access these switches, turn power to the controller OFF. Press in the tabs on each side of the front bezel and pull the electronic assembly forward enough to expose the switches. DO NOT REMOVE the assembly from the case.

Carefully note the type of switch action. Rocker switch action is PUSH IN to activate. Slider switch action is slide UP or DOWN to activate. Follow the markings on the switch for the correct switch position for ON (CLOSED, HI, 1) or OFF (OPEN, LO, 0). Use a pencil, pen tip or bent paper clip to set desired switch position.

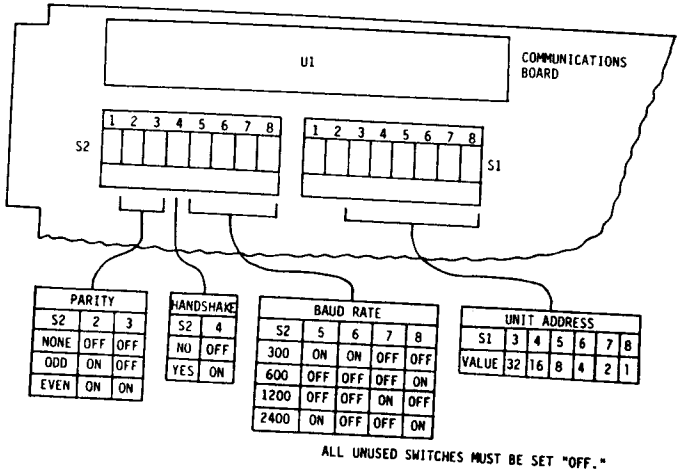


Figure 6-11. Format Selection Switches

6.8 ASYNCHRONOUS SERIAL DATA FORMAT

The DATA WORD consists of one ASCII character, i.e., two hexadecimal characters plus one start bit and two stop bits. The number of incoming stop bits is not critical. The controller can accept any number of stop bits. The controller will always respond with two stop bits. The MSB of the data bits is the parity bit. When parity is not used, the MSB must be OFF. (See Figure 6-12.)

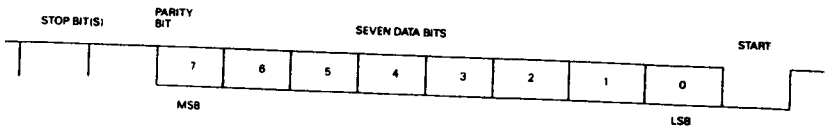


Figure 6-12. Serial Data Format

6.9 PROTOCOL

6.9.1 Data Protocol

The controller is always the passive listener in this protocol. Transmission is always initiated by the host computer. The host sends a command or a command and data to the controller. The controller responds within 200 ms either with system status or with system status and data.

The COMMAND sent by the host must be all upper case letters in the following format except that CKSUM is optional with the host. The controller will ignore a lack of CKSUM if none is provided by the host computer. The controller will always respond with a CKSUM even if the host does not send one. See Paragraphs 6.9.4 and 6.9.5. The controller will not accept lower case letters.

TO READ DATA:

* UNIT# : R PARAMETER : CKSUM CR

TO WRITE DATA:

* UNIT# : W PARAMETER / DATA : CKSUM CR

NOTE

The controller will ignore LF if transmitted after CR.

The controller will respond within 200 ms in the following format:

RESPONSE TO READ COMMAND:

$ STATUS : DATA : CKSUM CR LF

RESPONSE TO WRITE COMMAND:

$ STATUS :: CKSUM CR LF

NOTE

Spacing is included above purely for clarity. Actual data transmission must not include spacings. NULL characters HEX "00" may be sent within the context of the message to the host from the controller and should be ignored, but must not be sent to the controller.

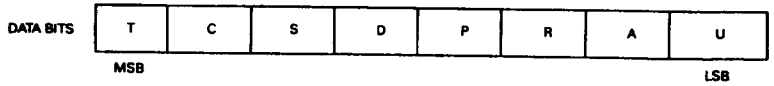
6.9.2 Data Protocol Definitions

*	Standard ASCII character used by the host computer to initiate a command
:	Standard ASCII character used as a field separator
/	Standard ASCII character used as a separator between the PARAMETER mnemonic and the data in the WRITE command
$	Standard ASCII character used by the controller as the first character in a response

UNIT #	ASCII 0 to 63. The controller will ignore leading zeros. The unit address identification is by means of binary weighted internal switches on the controller communications board. The unit address can be omitted in transmissions when addressing unit 0. Refer to Paragraph 6.13.4 for the General Broadcast feature.
R	READ command
W	WRITE command
PARAMETER	Controller variable shown as an ASCII mnemonic. ONLY UPPER CASE CHARACTERS MAY BE USED
CKSUM	TWO ASCII hexadecimal characters representing an eight-bit checksum formed by adding each byte of the string preceding the checksum into an eight-bit accumulator and ignoring any overflow. The resulting eight-bit sum is sent as two hexadecimal characters. The high order four bits are the first characters and the low order four bits are the last character. CKSUM is optional with the user.
CR	Carriage Return
LF	Line Feed
STATUS	Two ASCII coded hexadecimal characters defining the system status
DATA	A string of ASCII digits, including minus sign where appropriate, representing the numerical value of the PARAMETER specified. Decimal points are not sent to or from the controller.

6.9.3 Status Response

Every command from the host computer causes the controller to generate to two ASCII HEX character status report as part of its response. Normal state (0) is assumed to be normal controller operation. Refer to Figure 6-13.

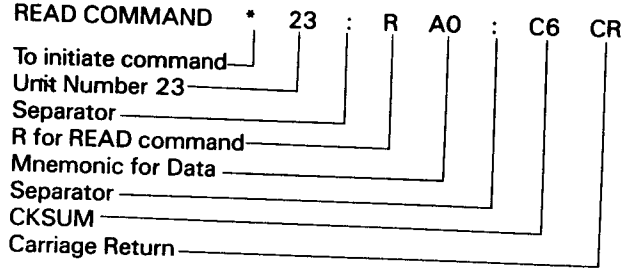


BIT	ABNORMAL CONDITION "1"
T	Transmission Error
C	CKSUM Error on Received Data
S	Syntax Error or Illegal Input
D	Communications Turned OFF
P	Parity Error on Received Data
R	INPUT OPEN
A	Alarm Condition (Relay 1 and/or Relay 2)
U	Reserved

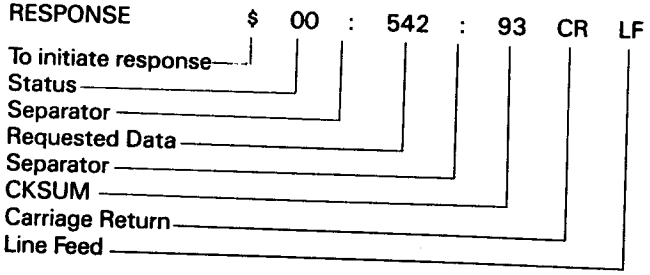
Figure 6-13. Status Report

6.9.4 Protocol Example—Read

A command to READ the measurement of Unit Number 23 would be:



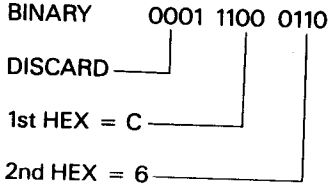
The controller response to the READ command if the measurement were 542 degrees would be:

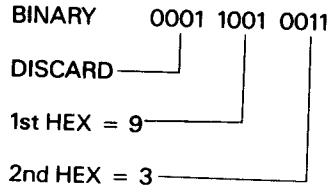


CKSUM COMPUTATION IS AS FOLLOWS (for example in this section)

READ COMMAND CHAR	HEX
*	2A
2	32
3	33
:	3A
R	52
A	41
0	30
:	3A
TOTAL	1C6

RESPONSE REPLY CHAR	HEX
$	24
0	30
0	30
:	3A
5	35
4	34
2	32
:	3A
TOTAL	193



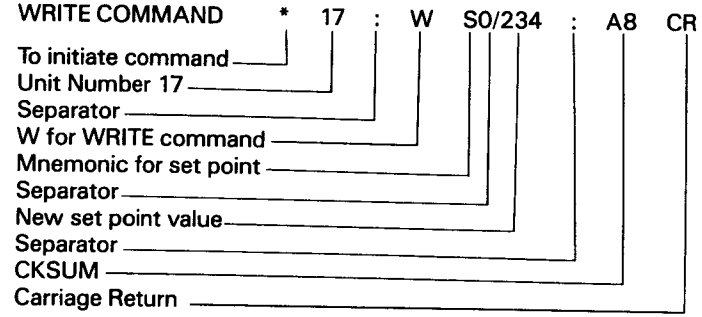


NOTE

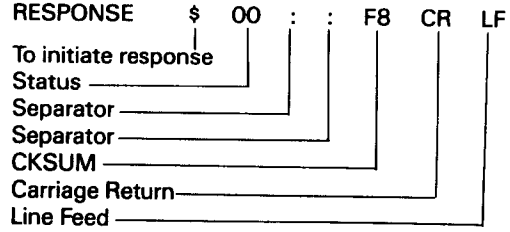
Parity bits are not include in the CKSUM.

6.9.5 Protocol Example—Write

A command to WRITE (enter new data) into Unit Number 17 to make set point 0 = 234° would be:



The controller response to the WRITE command would be:



NOTE

The beginning of data and end of data (field) separators (:) will both be present even if status only (NO DATA) is being transmitted.

6.10 MNEMONICS

6.10.1 Definition of Mnemonics

Mnemonics are used in this protocol to specify the various parameters of interest. Leading zeros are ignored and can be omitted.

The mnemonics will be described in groups according to their uses. Many of the mnemonics listed in this manual are followed by one or more coded characters enclosed in parenthesis. These characters indicate which special considerations apply to these mnemonics and are not part of the mnemonic they refer to.

Most mnemonics can be written to and read. Those followed by an (R) in the description in this manual are "READ ONLY" mnemonics. An (R!) indicates that a write statement will be accepted by the controller, but should not be sent. THIS MAY RESULT IN AN UNDESIRABLE CONTROL RESPONSE! A (U) denotes that an unstructured response will be sent by the controller. DATA STRUCTURE is described under SPECIAL USER FEATURES in Paragraph 6.13.2.

To the right of each mnemonic is a list of the allowable values for the mnemonic and/or a brief description.

6.10.2 Configuration and Calibration Mnemonics

This section consists entirely of "READ ONLY" parameters. All configuration and calibration parameters are described in detail in Section 7, Calibration. Table 6-2 tells how to interpret data as well as what limits apply to data values. The numeric value assigned to each of these mnemonics can be read by the computer, but can only be changed directly through the controller keypad.

TABLE 6-2
CONFIGURATION AND CALIBRATION MNEMONICS

FUNCTION	MNEMONIC		DEFINITION
CONFIGURATION #	A1	(R,U)	Defines controller capability
LO SPAN	A3	(R)	Alarm and set point low limit
HI SPAN	A4	(R)	Alarm and set point hi limit
LO VAL	A6	(R)	Number displayed when the LO reference signal is sensed
HI VAL	A7	(R)	Number displayed when the HI reference signal is sensed
TIME BASE	E11	(R)	0 = HRS./MIN. 1 = MIN./SEC.
UNITS	A2	(R,U)	Response is 2 ASCII digits
DECIMAL PLACES	A5	(R)	Select 0 to 3

NOTE

No computer access is allowed to the reference calibration procedure described in Section 7, Calibration.

6.10.3 Tuning Parameter Mnemonics

The TUNING parameters are described in Section 4, Tuning. The CONFIGURATION NUMBER A1 defines which parameters are applicable to each particular installation. Refer to Table 6-3.

TABLE 6-3
TUNING PARAMETER MNEMONICS

FUNCTION	MNEMONIC	LIMITS
PRIMARY DEAD BAND	C2	25, 50, or 100 represents a dead band of .25%, .50% or 1.00% of span. For ON/OFF outputs only.
PRIMARY CYCLETIME	D2	1 to 60 seconds in one second steps. For ANALOG and TPR outputs.
PRIMARY PB %	D3	1 to 200 percent in 1% steps. For ANALOG and TPR outputs.
PRIMARY RESET	D4	1 to 2000 or 0 = OFF represents 0 to 20.00 Repeats per Minute for ANALOG and TPR outputs.
PRIMARY RATE	D5	1 to 500 or 0 = OFF represents 0 to 5.00 Minutes for ANALOG and TPR outputs.
AUXILIARY SET POINT	E0	Set as differential units from the primary (profile) set point. The process unit value (primary = aux. differential) must be $\leq$ = +50% and/or $\geq$ = −50% of the total SPAN.
SECONDARY DEAD BAND	C3	25, 50 or 100 represents dead band of .25%, .50% or 1.00% of span for ON/OFF outputs only.
SECONDARY CYCLETIME	D6	1 to 60 seconds. For TPR outputs.
SECONDARY PB %	D7	1 to 200 percent. For ANALOG and TPR outputs.
SECONDARY RESET	D8	1 to 2000 or 0 = OFF represents 0 to 20.00 Repeats per Minute. For ANALOG and TPR outputs.
SECONDARY RATE	D9	1 to 500 or 0 = OFF represents 0 to 5.00 Minutes. For ANALOG and TPR outputs.

6.11 PROFILE PROGRAMMING

6.11.1 Profile Mnemonics

Certain parameters are used to program and operate "Ramp and Soak" profiles. They are described in Section 4, Tuning. The CONFIGURATION NUMBER A1 specifies the quantity and length of profiles that can be programmed.

6.11.2 Ramp and Soak Profiles

A "Ramp and Soak" profile is used to map out a path for the control set point (and process variable) to follow over a period of time. Set points are milestones which define the end of a segment. Set points are set in the units of the process variable. Segments are timed intervals between set points. The length of each segment is defined in the units of time indicated by the TIME BASE E11. The time units can be Hours:Minutes or Minutes:Seconds. See Figure 6-14.

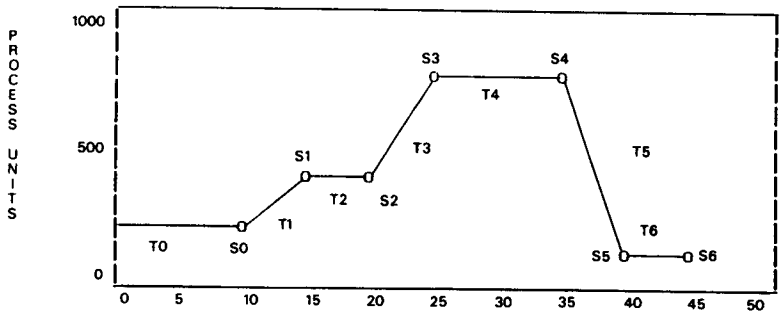


Figure 6-14. Ramp and Soak Profiles

6.11.3 Profile Programming Procedure and Mnemonics

1. Select the profile to be programmed by writing the desired profile letter to the PROFILE SELECTOR E8. For example, to select profile A for unit #1, send *1:WE8/A: to the controller.
2. Select the starting DELAY TIME TO. A delay is sometimes used to allow for loading or unloading material in batch processes.
3. The initial set point is SO. In temperature applications, SO might be set to room temperature, i.e. 80 F. If unit #1 is set for Fahrenheit, SO can be set by sending *1:WSO/80: to it.

4. The first segment, T1, defines the time the process should take to reach set point 1, S1, from SO. If the TIME BASE E11 indicates a setting of hours and minutes, a time of 1 hour and 35 minutes can be written for segment 1 by sending *1:WT1/0135: to unit #1. Leading zeros may be omitted.
5. Now that SO and T1 have been esablished, S1 can be set. S1 will be followed by T2, S2, T3, S3, T4, S4, etc. until the desired profile is complete.

   Setting a segment time to 0 indicates that the preceding set point was the endpoint for the profile. The controller will ignore all subsequent set points and segments.
6. The CYCLES FOR PROFILE mnemonic E4 is used to establish the number of times the profile will be repeated. A number from 1 to 254 can be selected or 255 can be selected for continuous operation.

TABLE 6-4
PROFILE PROGRAMMING MNEMONICS

FUNCTION	MNEMONIC	DEFINITION
PROFILE SELECTOR	E8 (U)	Selects a profile to be programmed or run. The profiles are designated by the letters A through P. The CONFIGURATION NUMBER A1 indicates which profiles are available. Writing a profile letter to this mnemonic will cause the controller to run the specified profile WHEN CONTROL IS STARTED BY THE HOST. (REFER TO PROFILE CONTROL C8 values 3, 4, 6 and 7 described in Paragraph 6.12.2.)
SEGMENT TIME X	Tx	To access a segment time in a profile, set PROFILE SELECTOR E8 for the desired profile and address Tx (x = segment #). The CONFIGURATION NUMBER A1 indicates the number of segments available. TO is used for the delay time. The possible values for Tx are 0000 to 9959 for HHMM or MMSS or −0001 = CONTINUOUS.

TABLE 6-4 (Cont'd)
PROFILE PROGRAMMING MNEMONICS

FUNCTION	MNEMONIC	DEFINITION
PROFILE SET POINT X	Sx	To access a set point in a profile, set PROFILE SELECTOR E8 for the desired profile and address Sx (x = set point #). The CONFIGURATION NUMBER A1 indicates the number of set points available. The process unit value for Sx must be ≤ = HI SPAN and ≥ = LO SPAN.
CYCLES FOR PROFILE	E4	The number of times the profile should be repeated each time it is started, i.e. 1 to 254 or 255 = CONTINUOUS.

6.11.4 Assured Soak

ASSURED SOAK is used when necessary for the PROCESS VARIABLE to be within a specified tolerance of a profile set point before starting the clock for the subsequent segment. Using this feature may result in longer profile run times. The tolerance is checked at the end of each segment, but not between set points. Writing a 0 to E7 turns ASSURED SOAK off. An ASSURED SOAK tolerance of 1 to 200 process units can be selected. Refer to Table 6-5.

TABLE 6-5
ASSURED SOAK MNEMONIC

FUNCTION	MNEMONIC	DEFINITION
ASSURED SOAK	E7	The assured soak tolerance of the profile indicated by E8. Select 1 to 200 or 0 = OFF.

6.11.5 Alarms and Event Relays

Alarms, where present, must be set for each individual profile. Determine which types of alarms are available in the unit by examining the CONFIGURATION NUMBER A1.

Alarms designated as HI alarms will activate when the PROCESS VARIABLE goes below the alarm set point. A PROCESS ALARM is set to a fixed process unit value for the entire profile. A DEVIATION ALARM is set to a fixed differential unit value either above (+) or below (−) the set point. Its process unit value changes as the set point varies during a profile run. A DEVIATION BAND ALARM is set as a fixed differential unit value which is simultaneously effective both above and below the set point. PROCESS, DEVIATION, and DEVIATION BAND ALARMS are all triggered by the displayed PROCESS VARIABLE. Refer to Table 6-6.

TABLE 6-6
ALARM MNEMONICS

FUNCTION	MNEMONIC	DEFINITION
ALARM 1 SET POINT ALARM 2 SET POINT	E5 E6	Set point for each alarm in the profile indicated by E8. The set point unit value must be ≤ = HI SPAN and ≥ = LO SPAN. For a deviation alarm, the value may not exceed ±50% of the Span.

When the CONFIGURATION NUMBER indicates that an alarm or output is configured as an EVENT RELAY, it is programmed to trigger at the end of a specified segment during the profile. If ALARM 1 is an event relay, sending *1:WE12/2: will turn the ALM 1 display indicator on and de-energize relay 1 (SWITCH 1) at SET POINT 2, S2. Sending *1:WE13/5: will turn the indicator off at SET POINT 5 and energize the relay coil. SWITCH 2 is ALARM 2 and SWITCH 3 is OUTPUT 2. Each event relay may be turned on once and off once during each profile. Refer to Table 6-7.

TABLE 6-7
EVENT RELAY MNEMONICS

FUNCTION	MNEMONIC	DEFINITION
SWITCH 1 TURNED ON	E12	Each switch must be set within its profile. A value from −2 through the highest programmed segment number may be entered. −2 = switch not used in profile. −1 = turn to indicated condition at the start of the profile. 0 through the highest programmed segment number will turn the switch to the condition indicated by the mnemonic at the specifed set point number. Any event relay may be actuated ON/OFF or OFF/ON only once in a given profile segment.
SWITCH 1 TURNED OFF	E13	
SWITCH 2 TURNED ON	E14	
SWITCH 2 TURNED OFF	E15	
SWITCH 3 TURNED ON	E16	
SWITCH 3 TURNED OFF	E17	

6.12 OPERATION

6.12.1 Operating and Status Mnemonics

These mnemonics are used to direct the controller once the profiles have been established. Some provide for the assignment of the profile to be run, where in the profile the controller should start, and whether automatic or manual control is desired. Others give the operator information on the status of the controller and the process.

6.12.2 Starting the Controller

For CN2041/2042 Controllers, write a profile letter to the PROFILE SELECTOR E8 which was described in the PROFILE MNEMONICS. If the profile should be started at a set point part way through the profile (using C8 values 4 or 7) the SEGMENT SELECTOR must be set to the desired set point number.

The controller is almost ready to be started. It is recommended at this point that the PROCESS STATUS WORD C0 be read to be sure that another profile is not in progress and that system conditions are normal.

Writing a correct value to the PROFILE CONTROL C8 will start the profile running. The PROFILE CONTROL is also used to change between automatic and manual control once the profile has been started or to pause at any point in the profile.

TABLE 6-8
MNEMONICS FOR STARTING THE CONTROLLER

FUNCTION	MNEMONIC		DEFINITION
SEGMENT SELECTOR	E9		Sets segment for C8-4 or C8-7. The value may be a number from 0 to the maximum segment number.
PROCESS STATUS WORD	C0	(R!)	BIT# (MSB) 7 6 5 4 3 2 1 0 (LSB))

#	0 STATUS	1 STATUS
7	stopped	started
6	manual	automatic
5	normal	input open
4	normal	reserved
3	REM flashing	REM on
2	ALM 2 off	ALM 2 on
1	ALM 1 off	ALM 1 on
0	reserved	reserved

TABLE 6-8 (Cont'd)
MNEMONICS FOR STARTING THE CONTROLLER

FUNCTION	MNEMONIC	DEFINITION
PROFILE CONTROL	C8	Used to START or STOP control.

WRITTEN VALUE = CONTROL ACTION

0 = stop
1 = pause in automatic
2 = pause in manual
3 = begin automatic control at the beginning of selected profile
4 = begin automatic control at the beginning of selected segment
5 = resume automatic control
6 = begin manual control at the beginning of selected profile
7 = begin manual control at the beginning of selected segment
8 = resume manual control

READ VALUE = CONTROL ACTION

0 = stopped
1 = paused in automatic
2 = paused in manual
3 = running in automatic
6 = running in manual 4, 5, 7 & 8 are unused

6.12.3 Operating and Monitoring the Controller

The mnemonics in this section (see Table 6-9) and in the previous section (6.12.2) provide the user with comprehensive information and control of the process. The PROCESS VARIABLE A0 indicates the current measurement. The CONTROLLING SET POINT E10 indicates the instantaneous set point which the controller is working to maintain.

TABLE 6-9
MNEMONICS FOR OPERATING AND MONITORING THE CONTROLLER

FUNCTION	MNEMONIC		DEFINITION
PROCESS VARIABLE	A0	(R)	Current process variable measurement.
CONTROLLING SET POINT	E10	(R!)	The instantaneous primary set point value the controller is using.

6.12.4 Status Indicators

Mnemonics B0 through B3 (refer to Table 6-10) are status indicators. INPUT OPEN, B0, indicates a broken sensor or "out-of-range" condition with a value of "1". The REM INDICATOR B1 reflects the condition of the REM light on the controller display. ALARM 1 (B2) and ALARM 2 (B3) indicate the status of the alarm relays. All of these mnemonics are found as individual bits within the PROCESS STATUS WORD C0 which was described in Table 6-8.

TABLE 6-10
STATUS INDICATORS

FUNCTION	MNEMONIC		DEFINITION
INPUT OPEN	B0	(R)	0 = normal 1 = out of range or open input
REM INDICATOR	B1		0 = flashing 1 = on steady
ALARM 1	B2	(R!**)	
ALARM 2	B3		0 = off 1 = on ** writing a 0 is used to reset a "LATCHING ALARM. DO NOT WRITE TO NON-LATCHING ALARMS!

The mnemonics in Table 6-11 indicate where the controller is working within the profile.

TABLE 6-11
MNEMONICS INDICATING WHERE THE CONTROLLER IS WITHIN THE PROFILE

FUNCTION	MNEMONIC		DEFINITION
PROCESS PROFILE	A8	(R,U)	Current or last run profile.
PROCESS SEGMENT	A9	(R)	Current segment for currently running profile.
ENDING SET POINT	E1		Value of the set point at the end of the current segment. The ENDING SET POINT must be ≤ = HI SPAN and ≥ = LO SPAN.
TIME LEFT	E2		Time left in current segment 0000 to 9959 for HHMM or MMSS.
CYCLES LEFT	E3		How many more times the currently running profile will be rerun before it stops. 0 to 254 or 255 = CONTINUOUS.

6.12.5 Manual Control of Proportional Outputs

Manual control of proportional outputs is accomplished by using the PROFILE CONTROL C8 along with the OUTPUT % mnemonics. The output % can be read at any time. Whenever the controller is running and in manual control, the OUTPUT % can be changed through a write command. The SECONDARY OUTPUT % C11 is used with the Model CN2042 Controllers that use OUT2 as a secondary proportional output.

TABLE 6-12
OUTPUT % MNEMONICS

FUNCTION	MNEMONIC	DEFINITION
PRIMARY OUTPUT %	C10	0 to 100 represents output power in percent.
SECONDARY OUTPUT %	C11	

6.12.6 Manual Control of ON/OFF Outputs

Manual control of ON/OFF outputs is accomplished using the mnemonics in Table 6-13:

TABLE 6-13
MANUAL CONTROL OF ON/OFF OUTPUTS

FUNCTION	MNEMONIC	DEFINITION
OUT1 STATUS	B4	0 = OFF or 0% output
OUT2 STATUS	B5	1 = ON or 100% output
ALM1 STATUS	B2	
ALM2 STATUS	B3	

6.13 SPECIAL USER FEATURES

6.13.1 The User Display

A special COM LINK DISPLAY appears in the OPERATOR LOOP following the ENABLE COM LINK display when the com link is enabled. Two lines of 8 characters are available for custom messages to be sent from the host computer. The following rules must be observed.

The asterisk (*), slash (/), and colon (:) are used in the comm link protocol and can not be sent as characters to this display. To display an asterisk, send an ASCII left bracket ([). To display a slash, send an ASCII percent sign (%). A comma will appear as a colon between any two of the first 7 characters. When placed between the 7th and 8th characters, it appears as a point at the top left of the 8th character and as a decimal point after the 8th character.

The period (.) and comma (,) are special function characters. A period will appear as a decimal point between any two of the first 7 character positions. When placed between the 7th and 8th characters, it appears as a point at the top left of the 8th character. A percent (%) sign can be displayed in the 8th position by sending an ASCII percent sign in the 8th character preceded by a comma.

The position between the 1st and 2nd characters on the upper line is special. A blinking colon appears there when the controller is in a PAUSE condition and will occur no matter what else is displayed.

UPPER USER DISPLAY	C6	Accepts 8 characters plus
LOWER USER DISPLAY	C7	special function characters.

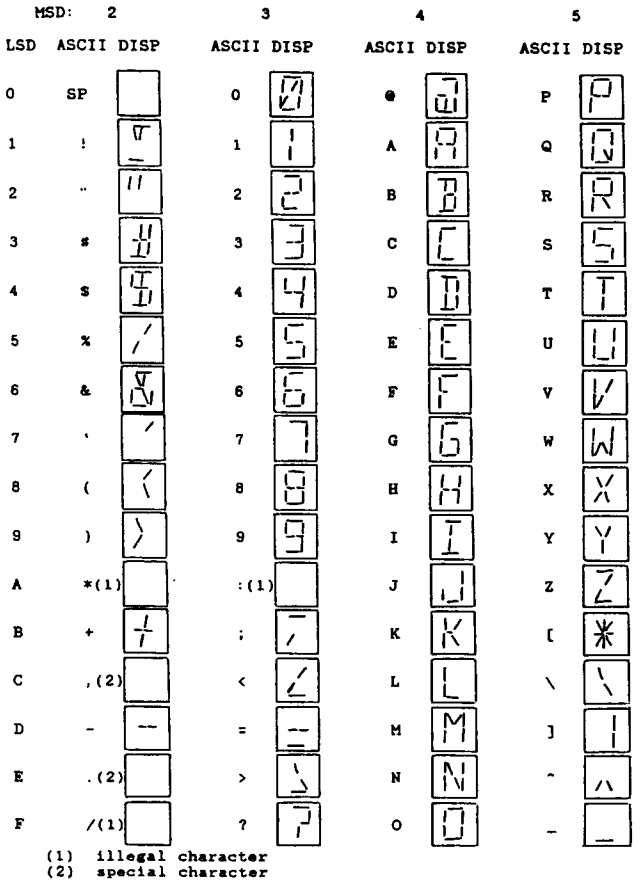


Figure 6-15. The User Display

6.13.2 Data Structure

There are 5 structures available for data sent from the controller to the host computer.

STRUCTURE 0: This structure sends a variable number of bytes. It uses leading zero suppression. Since an error causes the data to be suppressed, no data bytes are sent between the colons in the response.

STRUCTURE 1: This structure sends the data as 5 bytes.

An error response will be sent as:

byte	
1	null
2	null
3	null
4	null
5	null

A decimal value will be sent as:

byte	
1	null for positive, ASCII - for negative
2	ASCII number
3	ASCII number
4	ASCII number
5	ASCII number

A hexadecimal value will be sent as:

byte	
1	null
2	null
3	null
4	ASCII hex
5	ASCII hex

A time value will be sent as:

For Hours and Minutes:

byte	
1	null
2	ASCII number for hrs.
3	ASCII number for hrs.
4	ASCII number for min.
5	ASCII number for min.

For Minutes and Seconds:

byte	
1	null
2	ASCII number for min.
3	ASCII number for min.
4	ASCII number for sec.
5	ASCII number for sec.

STRUCTURE 2: This structure is the same as Structure 1 except that spaces are sent instead of nulls.

STRUCTURE 3: This structure sends the data as 6 bytes. An error response will be sent as:

byte	
1	null
2	null
3	null
4	null
5	null
6	null

A decimal value will be sent as:

byte	
1	null for positive, ASCII for negative
2	ASCII number
3	ASCII number
4	ASCII number
5	ASCII number
6	ASCII number

A hexadecimal value will be sent as:

byte	
1	null
2	null
3	null
4	null
5	ASCII hex
6	ASCII hex

A time value will be sent as:

For Hours and Minutes:

byte	
1	null
2	zero
3	ASCII number for hrs.
4	ASCII number for hrs.
5	ASCII number for min.
6	ASCII number for min.

For Minutes and Seconds:

byte	
1	null
2	zero
3	ASCII number for min.
4	ASCII number for min.
5	ASCII number for sec.
6	ASCII number for sec.

STRUCTURE 4: This structure is the same as Structure 3 except that spaces are sent instead of nulls.

TABLE 6-14
DATA STRUCTURE MNEMONIC

FUNCTION	MNEMONIC	DEFINITION
DATA STRUCTURE	D15	Select 0 to 4.

The DATA STRUCTURE will be Structure 1 unless it is changed by the user. On power up, error messages will be sent from the controller in Structure 1 until the controller correctly receives a valid command. It will then respond in the selected structure. If a structure is selected that cannot accommodate the data to be sent, the format will be changed temporarily by the controller. For example, if the data to be sent is 1000 and Structure 2 is selected, the structure will be changed temporarily to Structure 4. Some mnemonics do not send structured data. These are A1, A2, A8, C6, C7, and E8.

6.13.3 User Memory

Two mnemonics have been provided to allow a number to be stored in the controller memory (see Table 6-15). This can be used to identify a specific controller, a cluster of controllers, controller function, etc. This mnemonic is not used by the controller in any internal function.

TABLE 6-15
USER MEMORY MNEMONICS

FUNCTION	MNEMONIC	DEFINITION
SAVED USER MEMORY	D16	−32767 to +32767 can be stored and read. The value will be saved on a power down. It is reset to zero during a DATA LOST condition.
USER MEMORY	D17	−32767 to +32767 can be stored and read. The value resets to 0 after a power down.

6.13.4 General Broadcast

This feature allows a WRITE command, such as START, STOP, or PROFILE PROGRAMMING command, to be accepted by all CN2041/2042 Controllers on the communications loop. This is accomplished by addressing the WRITE command to UNIT NUMBER 99. For example, sending the command, *99:WC8/3:, will START all controllers on the communications loop at the beginning of their selected profiles at the same time. The controller will not send a response to the host in the case of a general broadcast command. It is recommended that the HOST individually verify that each controller received the command.

6.14 ASCII TABLE

MSB	LSB	0000	0001	0010	0011	0100	0101	0110	0111	1000	1001	1010	1011	1100	1101	1110	1111
		0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
0000	0	NUL	SOH	STX	ETX	EOT	ENQ	ACK	BEL	BS	HT	LF	VT	FF	CR	SO	SI
0001	1	DLE	DC1	DC2	DC3	DC4	NAK	SYN	ETB	CAN	EM	SUB	ESC	FS	GS	RS	US
0010	2	SP	!	"	#	$	%	&	'	(	)	*	+	,	-	.	/
0011	3	0	1	2	3	4	5	6	7	8	9	:	;	<	=	>	?
0100	4	@	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
0101	5	P	Q	R	S	T	U	V	W	X	Y	Z	[	\	]	^	_
0110	6	`	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o
0111	7	p	q	r	s	t	u	v	w	x	y	z	{	|	}	~	DEL

BINARY — HEX — ASCII

SECTION 7 CALIBRATION

7.1 RECALIBRATION

The Controllers are delivered fully calibrated and ready to use. Recalibration is not normally required or recommended but it may be necessary in order to meet plant standards or to recover from extraordinary circumstances such as the DATA LOST/PLEASE CAL mode.

The calibration procedure for the CN2041/2042 Controllers include both a CONFIGURATION procedure and a REFERENCE procedure. The CONFIGURATION procedure refers to those steps that must be performed to tell the microprocessor details of the application including input, output, control action, alarms, display units, span and time base. These details are to be keyed through the front keypad in a structured sequence (refer to the Calibration Loop, Figure 7-1). The REFERENCE procedure is the more traditional calibration using an external reference source. A structural program also exists for this calibration . Please note that a type J thermocouple is required for the thermocouple reference calibration.

Controller CONFIGURATION calibration can be performed at the normal controller installation or on a bench. Only AC power and an appropriate input is necessary. If an input is not convenient, a jumper between terminals F and H is adequate for the CONFIGURATION calibration. REFERENCE calibration requires a precise calibration source for the input signal.

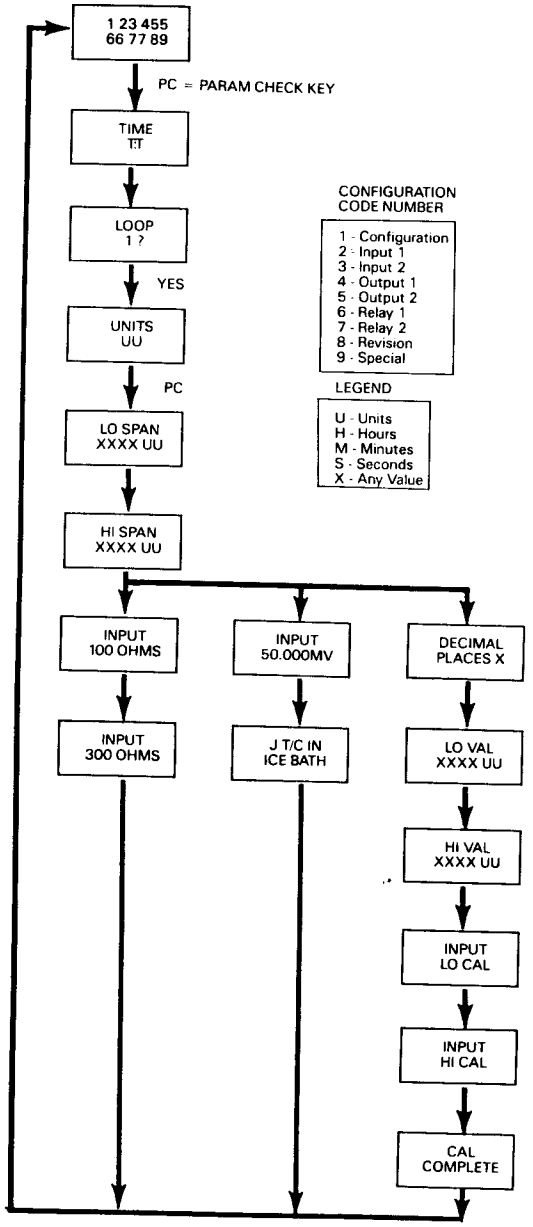


Figure 7-1. CALIBRATION Loop Flow Chart

CAUTIONS

COMPUTER DEVICES ARE NON-FORGIVING. TO FUNCTION PROPERLY, THE INSTRUCTIONS MUST NOT ONLY BE CORRECT BUT MUST ALSO BE KEYED IN THE CORRECT ORDER. PLEASE FOLLOW THE INSTRUCTIONS IN THIS SECTION PRECISELY.

DO NOT ALLOW THE AC POWER TO BE TURNED OFF WHILE IN THE CALIBRATION MODE.

7.2 CONFIGURATION CALIBRATION

The first portion of the calibration procedure involves instructing the software within the controller on the appropriate controller configuration for the specific application. Instructions and data are input to the controller through the front keypad. The controller has been manufactured with specific hardware that determines its input and output capability. For recalibration you will be keeping the same configuration number, but if your application requirements change, certain software changes are permissible as detailed in Paragraph 7.4.

For example: In a controller provided with a thermocouple input, the type of thermocouple input can be changed purely by a software change. However, the input cannot be changed to an RTD or PROCESS input unless a hardware change is also made. Changing HEAT acting to COOL acting control is a software change, but changing a SOLID STATE RELAY output to a PROCESS output requires a hardware change. CONFIGURATION calibration deals strictly with allowable software changes.

A security code protects the calibration procedures. To enter the calibration mode, push the three keys indicated in Figure 7-2 simultaneously. A front panel display "CAL" indicator will illuminate. If it does not, push the RETURN key and then push the 3 key code again.

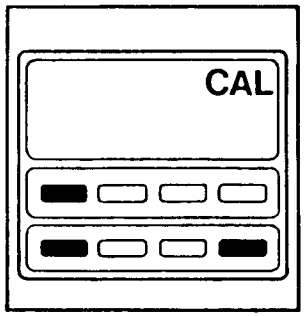


Figure 7-2. Entering the Calibration Loop

7.3 CONTROLLER CONFIGURATION NUMBER

1	23	455
66	77	89

The CONFIGURATION NUMBER is the first display in the CAL mode. If this display does not appear, push the LAST key until it is on the display. The number shown is the controller configuration number that defines all operating functions for the controller.

CONTROLLER CONFIGURATION NUMBER ① ②③ ④⑤⑤ ⑥⑥ ⑦⑦ ⑧⑨

① Configuration

0	2 Profiles, 99 Segments; Without Communications Option
1	4 Profiles, 64 Segments; Without Communications Option
2	8 Profiles, 32 Segments; Without Communications Option
3	16 Profiles, 16 Segments; Without Communications Option
8	2 Profiles, 99 Segments; With Communications Option
9	4 Profiles, 64 Segments; With Communications Option
A	8 Profiles, 32 Segments; With Communications Option
B	16 Profiles, 16 Segments; With Communications Option

② First Input

0	J Thermocouple
1	K Thermocouple
2	R Thermocouple
3	S Thermocouple
4	T Thermocouple
6	E Thermocouple
7	B Thermocouple
8	Platinel II T/C
K	100 ohm PT RTD 3850 PPM (1I)
L	100 ohm PT RTD 3850 PPM (0.1I)
R	Process Input
Z	No Input

③ Second Input

Same numbering as first input. Some limitations apply. Contact factory for details.

④ First Output (OUT 1)

0	No Output
1	Pri. Heat SSR On/Off
2	Pri. Cool SSR On/Off
3	Pri. Heat SSR Prop.
4	Pri. Cool SSR Prop.
5	Pri. Heat Analog
6	Pri. Cool Analog

⑤ Second Output (OUT 2)

00	No Output
11	Sec. Heat SSR On/Off
12	Sec. Cool SSR On/Off
14	Sec. Cool SSR Prop.
16	Sec. Cool Analog
17	Event Relay
18	Retransmit PV 1
19	Retransmit SP 1

⑥ Alarm/Event 1

00	No Alarm/Event Relay 1
01	Latching, Power Failure
11	Non-Latching, Hi Process
12	Non-Latching, Lo Process
13	Non-Latching, Hi Deviation
14	Non-Latching, Lo Deviation
15	Non-Latching, Deviation Band
17	Non-Latching, Event Relay
18	Heat Aux. Output
19	Cool Aux. Output
31	Latching, Hi Process
32	Latching, Lo Process
33	Latching, Hi Deviation
34	Latching, Lo Deviation
35	Latching, Deviation Band

⑦ Alarm/Event Relay 2

00	No Alarm/Event Relay 2
01	Non-Latching, Error Alarm
11	Non-Latching, Hi Process
12	Non-Latching, Lo Process
13	Non-Latching, Hi Deviation
14	Non-Latching, Lo Deviation
15	Non-Latching, Deviation Band
17	Non-Latching, Event Relay
31	Latching, Hi Process
32	Latching, Lo Process
33	Latching, Hi Deviation
34	Latching, Lo Deviation
35	Latching, Deviation Band

⑧ Revision Code

Assigned by factory. No user Selection.

⑨ Special Options

Assigned by factory. Contact Factory for details.

NOTE

It is advisable to record the full configuration number of the controller for future reference.

7.4 RULES FOR CHANGING CONFIGURATION NUMBER

1 23 455 66 77 89	CONFIGURATION NUMBERS

Digit marked 1: 0,1,2 and 3 are interchangeable
4,5,6 and 7 are interchangeable

Digit marked 2: 0 through 9 are interchangeable

Digit marked 3: 0 through 9 are interchangeable

Digit marked 4: 1,2,3 and 4 are interchangeable
5 and 6 are interchangeable
7 and 8 are interchangeable

Digits marked 55: 11,12,14 and 17 are interchangeable
18 and 19 are interchangeable
21,22,23,24 and 27 are interchangeable
25 and 26 are interchangeable
28 and 29 are interchangeable

Digits marked 66 and 77: All numbers are interchangeable

Digits marked 8 and 9: No effect on software.
Only used to indicate specials.
DO NOT CHANGE THESE NUMBERS

If you do not need to reset or change the configuration number, push the PARAM key to advance the display and proceed to Paragraph 7.6.

If you do want to change the configuration number, proceed with Paragraph 7.5.

7.5 SETTING THE CONFIGURATION NUMBER

A security code protects the configuration number. To change the configuration number, push the two keys indicated in Figure 7-3 simultaneously (PAUSE/RESUME and LAST).

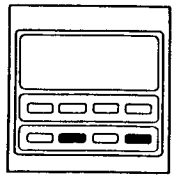


Figure 7-3. Setting the Configuration Number

A flashing cursor will appear at the first digit position. The digit that is flashing can be changed by using the arrow keys. The PARAM key advances the flashing cursor and the LAST key backs up the cursor. You can change any of the configuration digits within the rules stated in Paragraph 7.4. Be very careful not to enter an illegal configuration number.

If you are recovering from the DATA LOST mode, be sure to enter the complete configuration number. When the configuration number is correct, push the PARAM key.

7.6 SETTING THE TIME BASE

One time base must be selected for profile control.

TIME XX:XX	You can select Hours:Minutes (H:M) or Minutes:Seconds (M:S) for the profile time base. Push the NO key to change the selection. When the time base is correct, push the PARAM key to advance the next display.

7.7 SETTING THE DISPLAYED UNITS

The controller will accept any 2 alphanumeric characters for displayed units. The only limitation is that the temperature F or C units MUST be in the right-hand position.

UNITS XX	The best way to see how units are set is to push the arrow key while watching the display. All numbers and letters are available in both positions. Start with the left-hand digit and then push PARAM key to move to the right-hand digit. LAST key will back up right to left, if needed. The DOWN key will scroll the digit reverse to the UP key. A blank is available in the sequence for single character units.

IMPORTANT NOTE: Changing units between F and C does not change the numerical values of any set points, alarms, or span limits. Each set point, alarm and span limit must be individually changed to correspond to the new units of measurement. When no units are specified, the controller uses the degree C linearization table for thermocouple or RTD input.

7.8 SETTING THE SPAN

LO SPAN XXXX XX	The next two displays are LO and HI SPAN. SPAN is the LO and HI limits outside of which the system is not to operate. The controller automatically limits all set points and alarms to be within this SPAN.

HI SPAN XXXX XX

The controller stores in permanent memory the maximum allowable spans for all listed Thermocouple and RTD inputs. Unless ordered otherwise, the maximum span will appear on these displays. You can select any span up to the stored limits. Use the UP and DOWN arrow keys to change values. Advance from LO to HI SPAN using the PARAM key. The LAST key will back up from HI to LO SPAN. Note that two parameters, i.e., proportional band and deadband are tuned as a percent of this span.

Configuration calibration for controllers with thermocouple or RTD input is now complete. If you have this type of controller, push the PARAM key and proceed to Paragraph 7.11.

Spans for process type inputs are limited to any span between −3200 and +3200 units. If you have a process input controller, three more displays apply. Push the PARAM key to continue the configuration calibration with Paragraph 7.9.

7.9 SETTING THE DECIMAL POINT

DECIMAL PLACES X

This display allows the selection of decimal point position from zero (no decimal point) to third position from the right (i.e., 0.783). Use the UP or DOWN arrow keys to select decimal point position. When decimal position is correct, push the PARAM CHECK key to advance to the next display.

7.10 SETTING THE DISPLAY RANGE

LO VAL XXXX XX

This display is used to program the desired display indication at minimum input. For example: LO VAL can be set to indicate 0 for 4 mA input level. After setting the desired reading using the arrow keys, press the PARAM CHECK key.

HI VAL XXXX XX

This display is used to program the desired display indication at maximum input. For example: HI VAL can be set to indicate 2000 for a 20 mA input level.

The LO VAL/HI VAL procedure is the electronic equivalent of changing the scale in an analog panel meter. No input recalibration is required. You can change the displayed range purely through the keypad when a process signal such as 4-20 mA is the input.

7.11 REFERENCE CALIBRATION

CAUTION

ENTRY INTO THE REFERENCE CALIBRATION ROUTINE WITHOUT PROPER CALIBRATION EQUIPMENT MAY ERASE THE FACTORY CALIBRATION. DO NOT PROCEED WITH THESE INSTRUCTIONS UNTIL YOU ARE PROPERLY PREPARED.

REFERENCE calibration refers to the procedure for calibrating the controller to an external input reference source. Before starting a REFERENCE calibration you must be at one of these displays:

HI SPAN XXX XX

OR

HI VAL XXX XX

If you are not at one of these displays and wish to do a REFERENCE calibration, push the PARAM CHECK key until "CAL COMPLETE" appears. Then push the LAST key once.

A security code protects the REFERENCE calibration procedures. To enter the REFERENCE calibration mode, push the two keys indicated in Figure 7-4 simultaneously.

CAUTION

ALLOW AT LEAST A 20 MINUTE WARM-UP BEFORE ANY REFERENCE CALIBRATION IS ATTEMPTED.

There are three stored calibration routines. The controller will automatically display the correct instructions for your application.

7.12 Thermocouple Input Calibration
7.13 RTD Input Calibration
7.14 Process Input Calibration

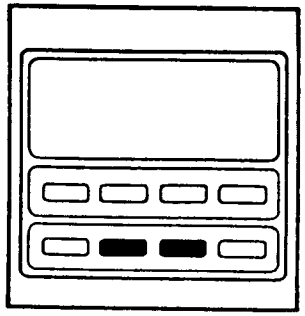


Figure 7-4. Entering the Reference Calibration

7.12 THERMOCOUPLE CALIBRATION

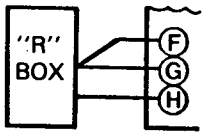
All thermocouple input controllers are calibrated in the same manner. A 50.000±.005 mV source, and a type J thermocouple in an Ice Bath or equivalent simulator are required.

IMPORTANT NOTE: A cold-junction compensator resistor is provided at the rear terminals of each thermocouple input controller. Calibration of thermocouple units MUST be done with the specific compensator to be used in the final installation. All thermocouple input controllers are calibrated with a type J thermocouple.

INPUT 50.000 mV	This display indicates that a stable, precision, distortion-free 50.000 mV DC calibration source be connected to rear case terminals F (−) and H (+). Allow a two minute interval for the source input to stabilize with the 50.000 mV applied and then push the PARAM CHECK key.

J T/C IN ICE BATH	Without removing the AC power, change the input to a J T/C in Ice Bath or to its equivalent from a calibration device. Allow a 2 minute interval for the input to stablize and then push the PARAM CHECK key. Proceed to Paragraph 7.15.

7.13 RTD CALIBRATION



All RTD input controllers are calibrated using a precision decade resistance box. Be sure to use short, low resistance leads and good tight connections. Three wire connections to the input are required to minimize lead resistance errors. All wires must be the same gauge and length.

INPUT 100 OHMS	This display is the first step for RTD calibration. Connect the RTD calibrator and set for 100.00±.05 ohms. Allow a 30 second interval for the source to stabilize and then push the PARAM CHECK key.

INPUT 300 OHMS	Set the RTD calibrator for 300.00±.05 ohms. Allow a 30 second interval for the source to stabilize and then push the PARAM CHECK key. For controllers with 0.1 RTD resolution, different inputs may be specified. Follow the instructions provided on the display, then proceed to Paragraph 7.15.

7.14 PROCESS CALIBRATION

An appropriate voltage or current source is required for process input calibration.

INPUT LO CAL	This display is the first step for process input calibration. Connect the calibrator and set its output to the LO calibration value. With a 4-20 mA input the LO CAL would be 4 mA. Allow a 2 minute interval for the source to stabilize and then push the PARAM CHECK key.

INPUT HI CAL	Adjust the calibrator to output the HI calibration value. With a 4-20 mA input the HI CAL would be 20 mA. Allow a 2 minute interval for the source to stabilize and then push the PARAM CHECK key. Proceed to Paragraph 7.15.

7.15 CALIBRATION COMPLETE

CAL COMPLETE	This is the final display in the calibration program. When at this display, you must push the return key to enter and store all calibration data. THIS STEP IS CRITICAL. All the changes and reference calibration are not valid until this step is completed. When you push the RETURN key the controller returns to the OPERATOR mode and the CAL indicator goes out.

You can now remove the calibrator and return the controller to its normal installation.

SECTION 8 SERVICE INFORMATION

8.1 GENERAL

If you experience difficulty with a controller, first check all wiring. Also pull the electronic assembly forward out of the case enough to check that all circuit boards and plug-in components are snugly in their connectors.

Check that the correct key sequences have been used and that the set point and tuning values set into the controller are appropriate for the application. Make sure that the housing is properly mounted in the panel. Forward vents are on the bottom of the case and the rear vents must be on the top of the case.

8.2 DIAGNOSTIC DISPLAYS

The controller contains several self-diagnostic programs that will display an appropriate warning when necessary. When any of these displays appear, the control output(s) go OFF and the alarms go ON.

INPUT OPEN	This display indicates that the input is an open circuit, and must be corrected before proceeding.
POWER FAILURE	This display will appear if the AC supply voltage to the controller drops to a low voltage level below specification. Check the AC voltage level and correct if necessary.
RTC FAILURE RAM FAILURE	If either of these displays appear, try switching the AC supply voltage to the controller OFF and ON. If the indication stays the same, the controller must be serviced by authorized personnel.

8.3 DATA LOST

DATA LOST PLEASE CAL	These alternating flashing displays indicate that, for some reason, the controller calibration has been lost. This is an error alarm that prevents the controller from continuing to operate after an error is detected in the internal memory. When these displays appear, the controller shuts down.

Recalibration is a quick and easy procedure which is fully explained in Section 7. You can recalibrate the controller by following the instructions supplied or you contact the OMEGA Customer Service Department at (203) 359-1660.

8.4 TROUBLESHOOTING

The troubleshooting information in Table 8-1 is included to serve as a guide to enable equipment repair. It is a guide only, and cannot cover all possible contingencies that may occur.

TABLE 8-1
TROUBLESHOOTING GUIDE

SYMPTOM	PROBABLE CAUSE	CORRECTIVE ACTION
1. Power applied, display does not light and controller does not operate	No power applied to controller	Check power wiring and fusing.
	Controller not engaged properly in housing	Check if controller is properly engaged in housing.
2. No power to load. Measurement indicates temperature below set point. Output indicator is on continuously.	Open connection to load	Check load wiring fuses, and connections.
3. Erratic control	Cycle time is too long	Reduce cycle time. When using electromechanical relay or contactor, set cycle time at value just below point where load cycling occurs.
	Proportional band is too narrow	Widen PB adjustment until load cycling is eliminated.
	Rate time is too short	Increase rate time adjustment.
4. Controller operating but temperature not at set point and calling for 100% power	System dynamics requires more time	Wait for process to reach set point.
	Improper sizing of source to load	Larger source is required.
5. Display shows input open	Thermocouple, RTD, or input circuit open	Check sensor and extension wire in circuits for opens.
6. Inability to tune controller properly	On controllers with dual three mode outputs, resets and rates for both outputs must be set to zero before beginning the tuning procedure.	In tuning procedure outline previously, the rate and reset adjustments are set to zero (turned off).
	Cycle time is set too long	Reduce cycle time.

TABLE 8-1 (Cont'd)
TROUBLESHOOTING GUIDE

SYMPTOM	PROBABLE CAUSE	CORRECTIVE ACTION
7. Slow response to set point or load change with tuned controller.	Reset time is too short	Increase the resets/minute (R/M) and recheck response by making a small set point change.
8. Large over-shoot on SP or load change	Reset time is set too long	Decrease the reset (R/M) and recheck response by making a small set point change.
9. Stepwise response to set point or load changes	Rate time is set too long	Decrease rate time setting and recheck response by making a small set point change.

SECTION 9 SPECIFICATIONS

INPUTS

LINE VOLTAGE:	117 Vac (220 or 240 Vac optional)
SENSOR:	Thermocouple: Types J, K, T, E, R, S, B, Pt II, N, G, C, D; RTD, 3-wire, 100 ohm platinum (a = .00385)
CURRENT:	4-20 mA
VOLTAGE:	0-5 Vdc, 0-10 Vdc, 0-100 mV
POWER CONSUMPTION:	8 watts typical
RANGES AND ACCURACY:	See Table 8-1
REPEATABILITY:	±0.5°F
TEMPERATURE STABILITY:	3 μV/°C
OPERATING AMBIENT:	5° to 55°C
COMMON MODE NOISE REJECTION:	140 dB
SENSOR BREAK PROTECTION:	Upscale standard, alarms triggered
DISPLAY:	2 rows of 8 alphanumeric characters
ALARMS:	SPDT relay, 1.0 amp @ 120/240 Vac

ADJUSTMENTS

CYCLE TIME:	Adjustable, from 1 to 60 seconds
RATE (DERIVATIVE):	Adjustable, from 0.02 to 5 min.; independent primary and secondary rates

SPECIFICATIONS (Cont'd)

RESET (INTEGRAL):	Adjustable, from 0.01 to 20 repeats per min.; independent for primary and secondary outputs
PROPORTIONAL BAND (GAIN):	Adjustable from 0 to 200% of span; independent for primary and secondary bands
ANTIRESET WINDUP:	(Standard) Inhibits reset when process variable is outside of the proportional band
ON/OFF OUTPUT DEADBAND:	Selectable at 0.25, 0.50 or 1.00% of span
AUTO MANUAL:	Bumpless Transfer

OUTPUTS

PRIMARY AND SECONDARY:	Independent
CURRENT:	4 to 20 mA proportional, into 1 kohm max. load
VOLTAGE:	0 to 5 dc proportional, into min. load at 1 kohm
SOLID STATE RELAY:	Optically isolated, SPST, normally open at 120/240 Vac
ALARMS:	User selectable for: high/low, process/deviation/event relay/ deviation band, latching/nonlatching

PROGRAMMED ADJUSTMENTS

PROFILES:	User-select between: 2 profiles of 99 segments each, 4 profiles of 64 segments each, 8 profiles of 32 segments each, or 16 profiles of 16 segments each; each segment can be defined as a ramp (change in set point over time) or soak (constant set point over time)
MEMORY:	Non-volatile storage of input linearizations, control and alarm types and actions, and all routines and instructions for all displays. Battery protected memory storage of set points, tuning parameters and measurement data.

SPECIFICATIONS (Cont'd)

INPUT CODE	TYPE	MAX. RANGE, °F	MAX. RANGE, °C	RESOL	ACC.
J	Iron Constantan	-300 to 1400°F	-180 to 760°C	1°	±3°F, 2°C
K	Chromel Alumel	-340 to 2480°F	-207 to 1360°C	1°	±6°C,3°F
T	Copper Constantan	-380 to 740°F	-230 to 390°C	1°	±2°F,1°C
E	Chromel Constantan	-180 to 1610°F	-115 to 870°C	1°	±4°F,2°C
R	Pt13% Rh/Pt	32 to 3200°F	0 to 1760°C	1°	±6°F,4°C
S	Pt10% Rh/Pt	32 to 3180°F	0 to 1750°C	1°	±6°F,4°C
B	Pt30% Rh/Pt 6%Rh	600 to 3250°F	310 to 1790°C	1°	±5°F,3°C
N	Omegalloy™	-200 to 2300°F	-130 to 1260°C	1°	±5°F,3°C
PLN	Platinel II	-140 to 2500°F	-95 to 1375°C	1°	±5°F,3°C
G	W/W26% Re	200 to 3260°F	94 to 2315°C	1°	±6°F,4°C
C	W5% Re/W 26% RE	32 to 3260°F	0 to 2315°C	1°	±7°F,5°C
D	W3%Re/W 25% Re	32 to 3260°F	0 to 2315°C	1°	±7°F,5°C
P1	Pt RTD, 100 ohms	-300 to 1500°F	-180 to 800°C	1°	±4°F,2°C
P2	Pt RTD, 100 ohms	-145.0 to 999.9°F	-100.0 to 540.0°C	0.1°	±2.3°F,1.3°C
MA	4 to 20 mA	0 to 100.0%*		1%	±0.03 mA
MV100	0 to 100 mVdc	0 to 100.0%*		1%	±0.2mV
V5	0 to 5 Vdc	0 to 100.0%*		1%	±0.01 V
V10	0 to 10 Vdc	0 to 1000%*		1%	0.02V

* Voltage and current input models are fully scaleable for zero and span. Maximum display is ±3200 counts with adjustable decimal point.