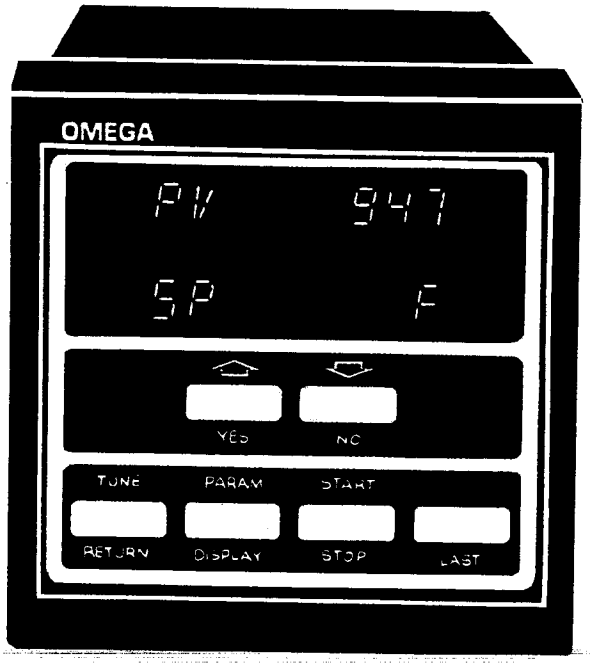
CN2001 and CN2002

Programmable Temperature Controllers



OMEGA®

An OMEGA Technologies Company

Operator's Manual

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CN-2000 SERIES
PROGRAMMABLE TEMPERATURE CONTROLLERS

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IMPORTANT

All CN2001 & 2 thermocouple models are shipped factory programmed to operate with Type "J" thermcouple, °F scaling. Users can re-program/re-scale these controllers to operate with other sensors by changing several digits in it's configuation code. Section 6 in this manual outlines how to implement this change.

SECTION 1 INTRODUCTION

1.1 GENERAL DESCRIPTION

The OMEGA® CN-2000 Series Programmable Controllers utilize the latest microprocessor technology to improve reliability, accuracy and control. Inputs can be either thermocouple or three wire RTD temperature sensors, or voltage or current signals from virtually any process variable. Output types are solid state relay, voltage or current signals, with either ON/OFF or proportioning control modes. These controllers provide proportional control of both heaters and coolers for stable automatic control of processes, or dual output control for separate control action.

The versatility of the CN-2000 makes it ideal for both laboratory and industrial use. The precision, fine tuning controls allow easy adjustment for accurate process control, and the bright alphanumeric display provides process variable and set point information from on demand, plus continuous alarm, output and operating mode status.

1.2 FEATURES

- Thermocouple, RTD, voltage or current inputs
- Current, voltage or solid state relay outputs
- ON/OFF or PID control
- Two independent process or deviation type alarms
- Timer option
- Remote Set Point available
- Digital Communications Options

1.3 AVAILABLE MODELS

MODEL NUMBER	DESCRIPTION	1 OUTPUT AND MODE	2 OUTPUT AND MODE (2002)
CN2001(*)	1 output	1A SSR, PID	1A SSR, on/off
CN2002(*)	2 output	1A SSR, PID	
CN2001(*)-A	1 output with alarms	1A, SSR, PID	1A SSR, on/off
CN2002(*)-A	2 output with alarms	1A, SSR, PID	
* Input Code			

INPUT CODE	INPUT TYPE
#J	Iron Constantan
#K	Chromega™-Alomega™
#T	Copper Constantan
#E	Chromega-Constantan
#R	Pt 13% Rh/Pt
#S	Pt 10% Rh/Pt
#B	Pt 30% Rh/Pt 6% Rh
#N	Omegalloy™(Nicrosil-Nisil)
#PLN	Platinel II
#G	W/W 26% Re
#C	W 5% Re/W 26% Re
#D	W 3% Re/W 25% Re
P1	Pt RTD, 100Ω *
P2	Pt RTD, 100Ω
MA	4 to 20 mA (from transmitter)
MV100	0 to 100mV DC
V5	0 to 5 VDC
V10	0 to 10 VDC

* refer to Handbook description of differences
# For T/C controllers, check that T/C type is correct (see Section 6)

OUTPUT OPTIONS

TYPE	FIRST OUTPUT (HEATING) SPECIFY:	SECOND OUTPUT (COOLING) SPECIFY
SSR, on/off	NF1	STD
SSR, PID	STD	PID2
4-20 mA &&	F1	F2
0-5VDC&&	DC1	DC2
Cooling	CL1	STD
Heating	STD	H2§
Auto/Manual	AM	N/A
Auto Tune	AT	N/A

§ N/A with PID2, F2 or DC2
&& Auto/Manual standard on these units

NOTES: SSR outputs are user configurable (refer to Section 6.2) for on/off and PID control.
Output 1 is user configurable for heat/cool.

ALARM OPTIONS

DESCRIPTION	ALARM 1 SPECIFY:	ALARM2 SPECIFY:
High Process	A11*	A21
Low Process	A12	A22*
High Deviation	A13	A23
Low Deviation	A14	A24
On Timer	A15	A25
Off Timer	A16	A26

* standard with CN2001A and CN2002A

COMMUNICATION OPTIONS

ORDERING SUFFIX	DESCRIPTION
D1	Remote Analog Setpoint (disables Alarm #2) (N/A with 2001A and 2002A)
D2	RS-232-C non isolated
D3	RS-232-C isolated
D4	RS-422-C non isolated
D5	RS-422-C isolated
D6	20 mA loop isolated
D7	Remote Start/Stop (disables alarm #2- uses terminals B & C)
D7DE	Remote Start/Stop (disables alarm #2- uses terminals D & E)

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 OMEGA Customer Service Department.

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 and carton in the event reshipment is necessary.

2.2 IDENTIFICATION

Refer to case mounted top label on each unit for proper identification of supply voltage, Output(s), Alarm/Timer and Sensor type before proceeding with the wiring.

MICROPROCESSOR BASED CONTROLLER OMEGA ENGINEERING, INC.

SENSOR INPUT	PRIMARY OUTPUT	SECONDARY OUTPUT
☐ T/C _____	☐ ON/OFF SSR	☐ NONE
☐ RTD _____	☐ PID SSR	☐ ON/OFF SSR
☐ mV _____	☐ 4-20 mA	☐ PID SSR
☐ mA _____	☐ 0-5 V DC	☐ 4-20 mA
☐ V _____	☐ _____	☐ 0-5 V dc
		☐ _____
POWER	**RELAY 1**	**COMMUNICATIONS**
☐ 120 V AC	☐ NONE	☐ NONE
☐ 220 V AC	☐ ALARM ____	☐ REM.S.P.
☐ 240 V AC	☐ TIMER_____	☐ RS232C
		☐ RS422
50/60 Hz	RELAY 2	☐ 20 mA
12 WATTS	☐ NONE	☐ NON ISOL
MAXIMUM	☐ ALARM_____	☐ ISOLATED
	☐ TIMER _____	☐ _____
1200-1450B		

2.3 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 digital communications is included, a ribbon cable connector must be pulled from the middle board before the assembly can be removed. 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 Series CN-2000 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.

The Series CN-2000 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.

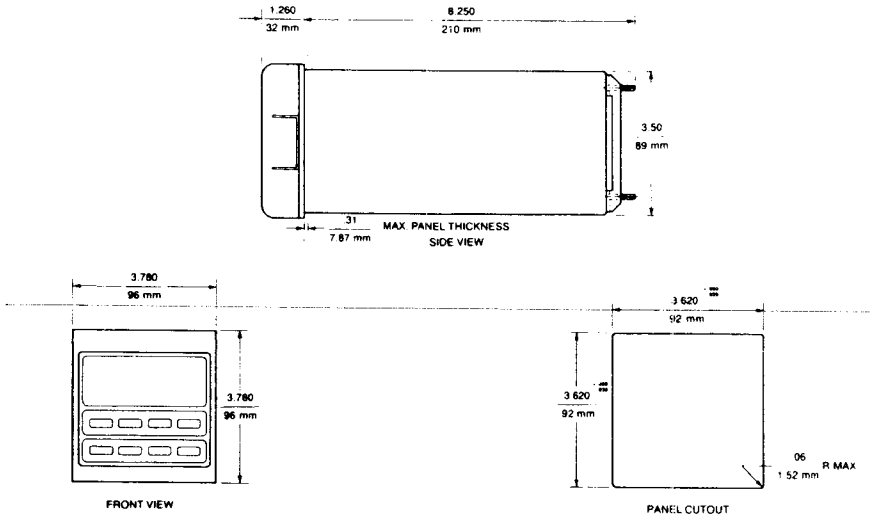


Figure 2-1. Cutout and Mounting Dimensions

2.4 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.

2.5 NOISE SUPPRESSION (Refer to Figure 2-2)

The primary source of electrical interference (noise) that can impact any digital device is inductors most commonly found as coils and windings in solenoids, 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.

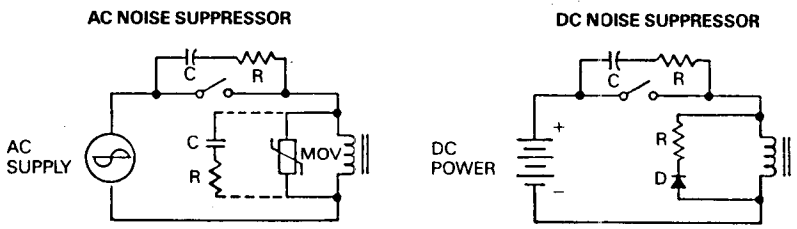


Figure 2-2. Noise Suppression

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

OMEGA P/N	DESCRIPTION
1821-101	Noise suppression kit includes one 0.1μF capacitor, one 220Ω resistor, one 47Ω resistor, one R-C snubber and one MOV rated for up to 130 VAC at 35 joules.

The use of twisted and shielded extension wire 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. Never run signal input leads in or near the same bundle as supply or load lines.

SNUBBER FOR NOISE SUPPRESSION

A resistor-capacitor snubber network is used to suppress transient noise generated by arcing across opening contacts or caused by collapsing fields of inductive coils. The noise generated by these may produce an undesirable response in an electronic instrument and the snubber helps to suppress this noise. The parts in this kit may be used across contacts or coils in circuits up to 240 VAC. The parts consist of the following: 1 220Ω resistor, 1 47Ω resistor, 1 0.1μF capacitor, and 1 MOV.

ACROSS COILS

The capacitor is connected in series with the 220Ω resistor (red-red-brown-gold) and the network is installed directly across the coil. The second resistor and the MOV in this kit are not used. Refer to Figure 2-3.

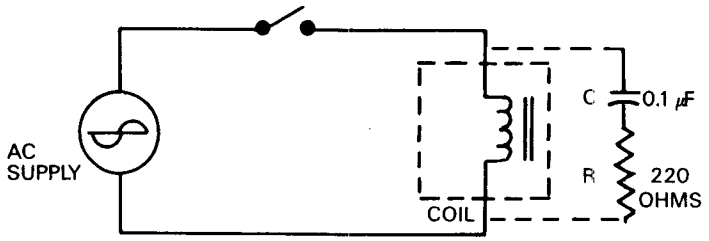


Figure 2-3. Coil Hookup

ACROSS CONTACTS

The capacitor is connected in series with the 47Ω resistor (yellow-violet-black-gold) and the network is installed directly across the contacts. The second resistor and the MOV in this kit are not used. Refer to Figure 2-4.

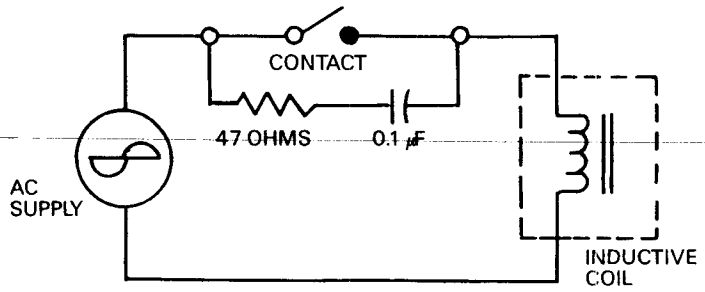


Figure 2-4. Contacts Hookup

MOV FOR NOISE SUPPRESSION

Metal oxide varistors (MOV's) are used to suppress transient noise surges that are caused by the collapsing fields of inductive coils. The MOV in this kit is rated at 35 Joules at 130 VAC maximum.

The MOV is connected directly across a coil or winding. Make sure that the voltage rating of the MOV is correct to match the supply voltage of the coil. Higher rated MOV's are available. The capacitor and resistors in this kit are not used. Refer to Figure 2-5.

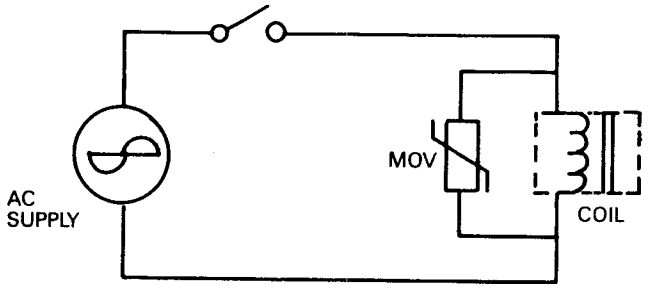


Figure 2-5. MOV Hookup

NOTE

FOR THE MOST EFFECTIVE SUPPRESSION, THE SNUBBER NETWORK OR MOV MUST BE MOUNTED AS CLOSE AS POSSIBLE TO THE CONTACTS OR COIL.

2.6 POWER CIRCUIT WIRING

The CN-2000 is normally wired for 120 V ac operation. Maximum input current at 120 V ac, 50/60 Hz is 115 mA ac. Connect the ac line power to rear terminals 6, 7 and 8 (see Figure 2-6). Terminal 6 is ac high; terminal 7 is ac low; terminal 8 is ground.

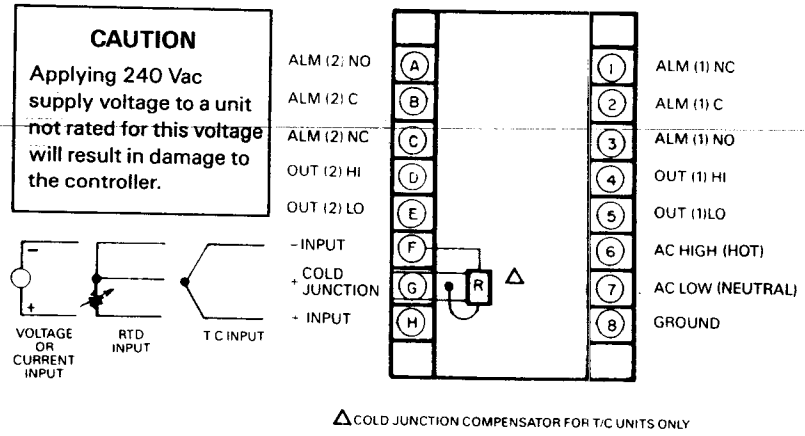


Figure 2-6. Rear Terminal Connections

2.7 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.

2.7.1 Thermocouple Input

NOTE

For thermocouple versions of the controller, check that the instrument has been programmed for the correct thermocouple type.

Before attaching the input leads, follow the instructions in Section 6 to check the thermocouple type and perform any reprogramming that may be necessary. The input leads should be clean and tight and the maximum loop resistance should not exceed 100 ohms.

Connect the red (−) thermocouple wire or extension lead to the rear panel terminal F (see Figure 2-6). Connect the color coded thermocouple lead to terminal H (+). No external connection is made to terminal G.

2.7.2 RTD Input

Connect the RTD sensor as shown in Figure 2-6 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.

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 ohms.

2.7.3 DC Voltage and DC Current Input

Connect the +dc input to terminal H, and connect the −dc input to terminal F (GND) (see Figure 2-6).

2.8 OUTPUT CIRCUIT WIRING

NOTE

Output options can not be added or changed in the field.

2.8.1 Solid State Relay—Primary and/or Secondary Output

Refer to Figure 2-7.

The Solid State Relay Output is a 1 ampere opto-isolated Triac output. Maximum voltage for SSR load is 240 V ac.

NOTE

Current limiting fuses are recommended to protect the 1 amp solid state relay.

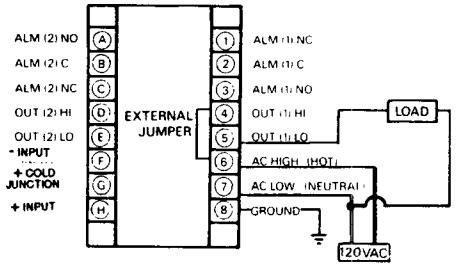


Figure 2-7a. Solid State Relay — Typical Primary Output Wiring

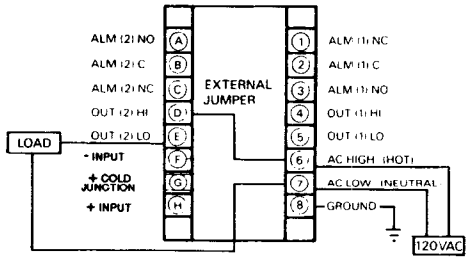


Figure 2-7b. Solid State Relay — Typical Secondary Output Wiring

NOTE

Power is not internally wired to relays. If the same power source is required to power the controller and the primary output, jumper terminal 6 (AC HI) to terminal 4 (OUT (1) HI). (For secondary output, jumper terminal 6 to terminal D (OUT (2) HI). Load is connected to terminal 5 (or E for secondary output). Power then goes through the relay to the load, and the other side of load is connected to AC LO to complete the circuit.

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

1. The leakage current in the 1 amp SSR may be sufficient to cause an external SSR to remain in the conducting state. A 2k ohm 8 watt power resistor across the external SSR will solve this problem.
2. The low power draw of the external SSR may cause the controller SSR to turn OFF due to insufficient holding current. Use of a loading resistor across the external SSR or relay terminals to increase the current will also solve this problem. Most loads are greater than 1 amp. It is recommended that external solid state relays such as SSR240A10 (nominal rating of 10 amps), SSR240A25 (nominal rating of 20 amps), or SSR240A45 (nominal rating of 35 amps), be used for larger loads.

2.8.2 Analog Output—Primary and/or Secondary Output (4-20 mA DC or 0-5 Vdc Output)

The solid state relay and analog output use the same terminals; therefore, only one type can be provided on each output (see Figure 2-8).

NOTE

Maximum Load Resistance = 1 K for 4-20 mA output.
Minimum Load Resistance = 1 K for 0-5 V dc output.

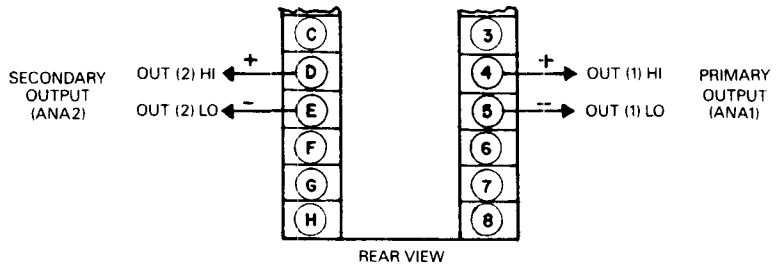


Figure 2-8. Current or Voltage Output—Primary and/or Secondary Output Wiring

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.

2.8.3 Alarm/Timer Wiring (Option)

Two independent alarms or timers (ALM 1 and ALM 2) use electromechanical relays with both NO and NC terminals with one common return (C) for each relay, available at the rear terminals.

The part number will specify if alarms or timers are provided and the type and action of alarm (PROCESS or DEVIATION, HI or LO acting) or timer. Relay contacts are rated 1 amp @ 240 V ac resistive load.

Terminal designations normally refer to the de-energized state, i.e., no power to the relays. To provide reliable alarm indication, the relays in this controller 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 and when the alarm(s) is ON, the relay terminal designations are as shown in Figure 2-9. During normal operation with no alarms ON, the relays are the reverse of that shown in Figure 2-9.

Special care should be taken, when wiring these relays to inductive devices such as coils and transformers. Noise suppressors as shown in Figure 2-9 are important to prevent electrical noise from being generated. See paragraph 2.5.

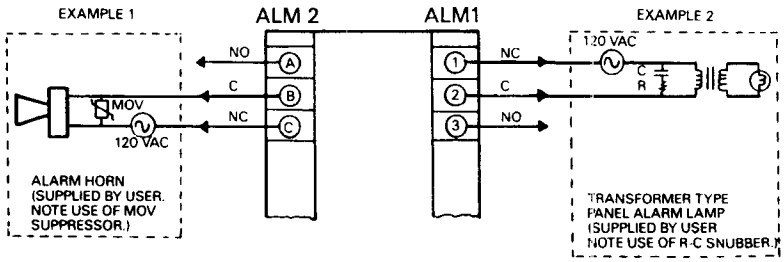


Figure 2-9. Alarm/Timer Wiring

2.9 REMOTE SETPOINT INPUT

A controller with REMOTE SETPOINT input option (D1) provides for remote linear analog current or voltage control of the primary set point. Although the standard set point input is calibrated for 0 to 5 Vdc, other voltages through 10 Vdc or currents through 100 mAdc may be supplied on special order. The remote input may be from an isolated stable current or voltage supply or, where the set point can be manually adjusted to the required value; it may use an internal controller supply with a remote potentiometer for a simplified source. All controllers supplied with remote set point input option have a part number whose second digit is a "1" (refer to paragraph 6.2).

NOTE

Controllers with remote set point input option can not have an ALARM/TIMER 2 option as these terminals are used for the remote set point input.

SPECIAL WIRING: The rear barrier terminal connections are changed as shown in Figure 2-10. All other connections are as described in the other paragraphs of Section 2.

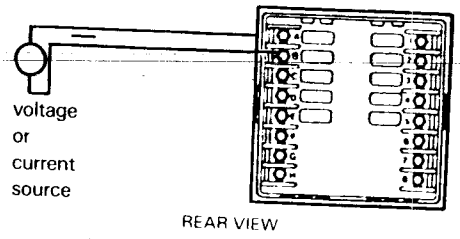


Figure 2-10. Remote SetPoint

2.10 DIGITAL COMMUNICATIONS WIRING

Controllers with digital communications option are provided with a special Type D (DB25) connector between the rear terminals (see Figure 2-11). Wiring to this connector is discussed in detail in Section 5.

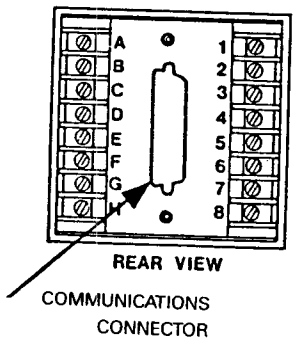


Figure 2-11. Communications Connector

SECTION 3 OPERATION

A LOOP is a series of items that appear on the controller display in a fixed sequence. The term MODE is used to define a keyboard setup that is required before a specific loop can be addressed. The CN-2000 is programmed to perform certain LOOPS only when in a specific MODE. For clarity, capital letters are used in this manual to denote names of LOOPS and MODES as well as for key names and functions.

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 i.e. 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 3.6. The TUNE mode is used for tuning and programming the controller prior to going on-line or during operation. Tuning is explained in detail in Section 4.

A third mode is used for calibration of the controller. This CAL mode is explained in detail in Section 6. The controller cannot operate while in the CAL mode.

Before putting the controller into operation please read the rest of this section, which explains the display and keypad functions.

3.3 DISPLAY INDICATIONS

The multicolor vacuum fluorescent provides all the communications to the operator. The central portion of the display is color coded blue and contains two rows of eight alphanumeric characters that display process measurement and set points, plus provide communications for tuning and operation. The display also has decimal point capability in the upper line of characters. Refer to Figure 3-1 and Table 3-1 for display indications.

Figure 3-1. Series CN-2000 Vacuum Fluorescent Display

TABLE 3-1

DISPLAY INDICATIONS

ITEM	INDICATION	FUNCTION
1	ALARM/TIMER indicators	The two alarm/timer indicators are color coded red and illuminate ALM with either a 1 or 2 or both, when one or both alarms or timers are active. The alarm/timer circuitry is active at all times and continue to function even when the controller is in the TUNE mode. The two independent alarms/ timers, ALM 1 and ALM 2, consist of electromechanical relays with both NO and NC contacts on the rear terminals. The alarm circuitry is active at all times. The alarms continue to function even when the controller is in the TUNE mode. Timer relay(s) begin timing when the START key is pushed. Their normal state is energized and are de-energized when the alarm/ timer indicators turn on signifying alarm/timer output.
2	OUTPUT indicators	The two output indicators included in the display appear in blue and illuminate the word OUT with either a 1 or 2 or both numbers when either or both outputs are on. (1 = primary output and 2 = secondary output). With ON/OFF and TPR (time proportional) control, the output indicator(s) will cycle on and off as the outputs cycle on and off.

TABLE 3-1 (cont'd)

ITEM	INDICATION	FUNCTION
2	OUTPUT indicators (cont'd)	With analog output control, the output indicator(s) will be ON when the output is ON and the measurement is outside the selected proportional band limits. When the measurement comes within the band limits, the numerical indicator will flash with an ON/OFF ratio proportional to the analog output.
3	MODE or status indicators	Color coded yellow and illuminate to show controller status:
a	TUN	The TUN indicator will illuminate when the CN-2000 is in the TUNE mode. In this mode, all tuning parameters can be viewed and set.
b	TUN (Flashing)	The TUN indicator will flash when the SELF TUNE program is in operation (units with Self Tune (AT) option only).
c	CAL	The CAL indicator illuminates when the controller is in the CALIBRATION mode. All control functions are inactive while in the CAL mode.
d	REM (Steady)	The REM indicator illuminates when the REMOTE SETPOINT option is included and in use. See paragraph 3.9. Also ON by computer command.
e	REM (Flashing)	The REM indicator will flash when a Digital Communications option is included and in use. See paragraph 3.10.
f	MAN (Steady)	The MAN indicator will illuminate when the controller outputs are under manual control. (CN2000 with Auto Manual (AM) option only)
g	MAN (Flashing)	The MAN indicator will flash when the control outputs are OFF as a warning that no action is taking place.

3.4 THE KEYPAD

The six key membrane type keypad on the front face of the controller requires only touch pressure to activate. All control and tuning can be performed through the keypad in conjunction with the alphanumeric display. Some keys are multifunction but they are non-ambiguous because for any specific display, each key has only one function (see Figures 3-2a & 3-2b and Table 3-2).

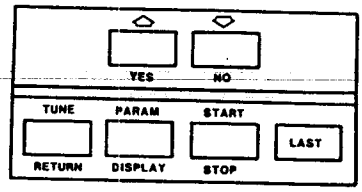


Figure 3-2a. Standard CN-2000 Keypad

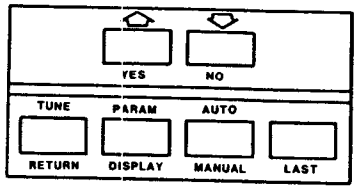


Figure 3-2b. Model CN-2000 with Auto Manual (Arn) AM option

TABLE 3-2

KEYPAD CONTROL KEYS

ITEM	KEY	FUNCTION
1	PARAM/DISPLAY key	Advances the displayed information one step at a time.
2	UP arrow key (also YES 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.
3	DOWN arrow key (also NO 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.

TABLE 3-2 (cont'd)

ITEM	KEY	FUNCTION
(see items 2 and 3)	YES and NO keys	Allow the operator to answer displayed questions.
4	TUNE/RETURN key	The TUNE key is used as part of the security code to enter the TUNE mode. The RETURN key is used to return the controller to the OPERATOR mode from any other mode.
5	START/STOP key	Turns the output(s) on or off. This key is not a power switch. The MAN indicator will flash when the output(s) are off.
6	AUTO/MANUAL key	The AUTO/MANUAL mode (units with AM option only) transfers control of the outputs to and from automatic control. The MAN indicator light is ON when the controller is in the manual mode.
7	LAST key	Allows the operator to recall the previous display at any time.

3.5 ALARM/TIMER OPTIONS

There are two alarm types available on the CN-2000 Controllers:

A 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.

A DEVIATION alarm is slaved to the controlling 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 degrees shown on the display as DF or DC.

DEVIATION BAND alarm is slaved to the set point, and is set plus and minus around the set point. Units are differential degrees for temperature.

The HI ACTING alarm activates (relay de-energized) when the measurement is equal to or above the alarm set point.

The LO ACTING alarm activates (relay de-energized) when the measurement is equal to or below the alarm set point.

ON TIMER relay is OFF during the timing period and goes ON at the completion of the period. The ALM lamp will light at the end of the period.

OFF TIMER relay is ON during the timing period and goes OFF at the completion of the period. The ALM lamp will be ON during the period and goes OFF at the end of the period.

The alarm/timer relays are energized when ALM indicator is OFF and de-energized when the ALM indicator is ON.

CAUTION

In any critical application where failure could cause expensive product loss or endanger personal safety, a second redundant limit controller is recommended.

3.6 OPERATOR LOOP

The OPERATOR loop is available to the operator at all times allowing the operator to read all operating parameters. Since the OPERATOR mode is the standard operating mode, there is no OPERATOR indicator light. See Figure 3-3, OPERATOR loop flow chart.

The PARAM/DISPLAY key is used to advance the displays within the loop. The LAST key may be used to review the previous display at any time. Pushing the PARAM/DISPLAY key will continuously repeat this loop.

The numerical value of any displayed value can be changed by pressing either the UP or DOWN arrow key. All possible displays are shown below. Your controller will only show displays appropriate to your application.

XX U SP XXX	This display shows measurement value with units and the set point value. The set point can be changed using the arrow keys.
XX U OUT1 XX%	This display shows measurement value and the primary output in % power output. Manual control (CN2000 units with Auto/Manual (Am) option only) of primary output is accomplished with this display.
XX U OUT2 XX%	This display shows measurement value and the secondary output in % power output, if included. Manual Control of the secondary output is accomplished with this display.
AUX SP X DF	This display shows the auxiliary set point (AUX SP) when OUTPUT 2 is on ON/OFF output. Units are differential (DF or DC) between the primary and secondary set point.

TIMER ? OVERRIDE	This display allows the operator to take manual control of TIMER 1 or TIMER 2 when they are included. Push YES key to activate next two displays when TIMER 1 and/or TIMER 2 are provided.
TIMER 1 ON/OFF TIMER 2 ON/OFF	These displays allow the operator to turn the TIMER relay(s) ON or OFF using the arrow keys when Timers are specified and enabled above. The ALM 1 and ALM 2 indicators will come ON when the TIMER relays are ON.
REMOTE SETPOINT	This display allows the operator to enable or disable the Remote Set Point option when provided, using the Yes/No keys. The REM indicator will come ON when Remote Set Point is active.
ENABLE ? COM LINK	This display allows the operator to enable or disable the Digital Communications option when provided, using the Yes/No keys. For complete details on the Digital Communications option, see Section 4. The REM indicator will flash when Digital Communications is active.

3.7 STOP/START CONTROL

The STOP/START key allows you to turn the control outputs ON and OFF. This is not a power switch. The controller electronic circuitry remains powered when the control outputs are turned OFF by this key.

The yellow MAN indicator will flash when the outputs are turned OFF.

3.8 AUTO/MANUAL CONTROL (Model CN2000 with AM option only)

The AUTO/MANUAL key allows you to take control and manually set the outputs from the keypad.

The OPERATOR loop includes two displays for manual control. These are OUT1 and OUT2 and show output as a % from 0 to 100% power.

With ON/OFF control the output is either fully ON or fully OFF. With time proportional control and analog control output, the output can be any value from 0 to 100% and can be adjusted to a particular value when in manual control. To prevent severe process transients when switching between manual and automatic control, an internal program is provided that starts the automatic control at the manual set point. This means that time proportional and analog controllers will drive to the correct output power at a controlled rate, not instantaneously. This action is called bumpless transfer and protects the process from severe transients during control transfer.

3.9 REMOTE SETPOINT

A second digit 1 (B for CN2000 units with Self Tune (AT) option) in the part number (refer to paragraph 6.2) indicates that the controller has been specified and manufactured to accept an analog remote set point from an externally mounted potentiometer or remote voltage or current source.

REMOTE ? SETPOINT	To enable this external input advance the display in the OPERATOR loop until this display appears. See Figure 3-3 OPERATOR loop flow chart.

Push the YES key to enable the remote set point input. The REM indicator will illuminate to confirm that control has been transferred from the internal set point to the external remote set point.

To disable this option, return to the REMOTE SETPOINT display, and push the NO key.

3.10 DIGITAL COMMUNICATIONS

A second digit 2 thru 6 (C thru G for CN2000 units with Self Tune (AT) option) in the part number (refer to paragraph 6.2) indicates that the controller has Digital Communications option.

ENABLE ? COM LINK	To enable Digital Communications, push the YES key at this display. See Figure 3-3 Operator Loop Flow Chart. To disable Digital Communications, push the NO key at this display.

The host cannot enable digital communications. This can only be accomplished by a key press on the front keypad of the controller. Even after communications is enabled, local control is still allowable.

During host-controlled operation, the front keypad remains active so that you can override the host and can take control if necessary.

The REM indicator light will flash when the communications is enabled. The REM indicator light will continue to flash until communications is disabled via the keypad. The host can also turn the REM indicator full on as part of the STATUS INPUT (PSW) command to inform you that the host is in control. Included in the host command structure is manual control of the controller output(s).

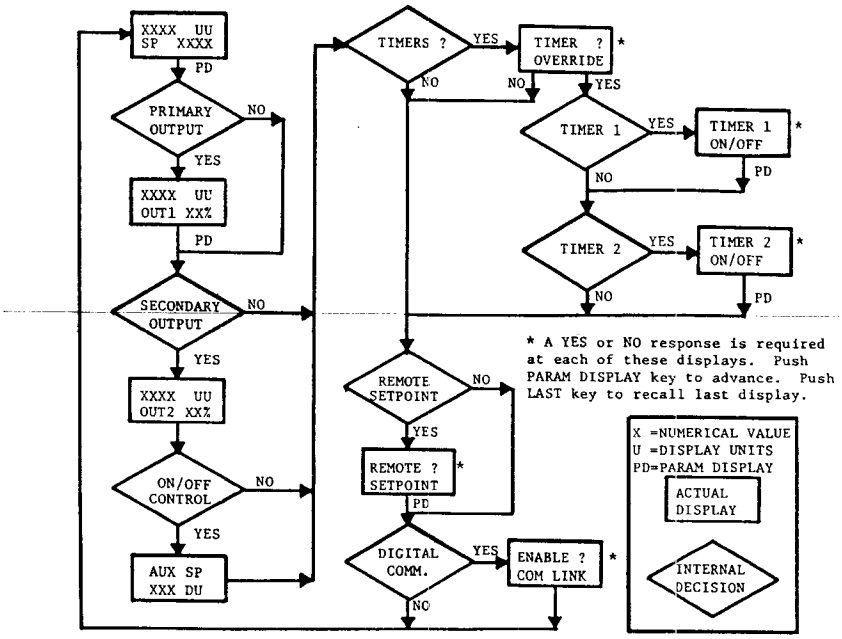


Figure 3-3. OPERATOR Loop Flow Chart

SECTION 4 TUNING

4.1 CONTROLLER TUNING FOR CN2000 CONTROLLERS WITHOUT SELF TUNE (AT) OPTION

This controller has been configured at the factory with input, output and alarm functions to meet your specific application. Arbitrary alarm and tuning values were used at the factory to allow complete controller checkout. It is necessary for you to TUNE this controller to your specific process or machine before going to automatic control. In the TUNE program the PARAM DISPLAY key advances the displays. The LAST key may be used to review the previous display at any time.

This section provides complete details on all tuning procedures.

4.1.1 TUNE Loop

The TUNE loop requires that a special tuning code be entered on the keyboard before any tuning information can be accessed. Press the following keys in sequence to enter the TUNE mode.

TUNE—LAST—YES

The yellow TUN indicator will illuminate on the display when the code is entered correctly. If the TUN indicator does not come ON, push the RETURN key and then push the code again. The PARAM/DISPLAY key advances the displays in the TUNE loop and the LAST key will back up the displays.

The TUNE displays shown below indicate all possible combinations. No specific application uses all of these displays. Your controller will only display those items appropriate to the part number of your controller. See Figure 4-1, TUNE Loop Flow Chart.

ALARM 1 XXX UU	or	TIMER 1 XXX:XX
ALARM 2 XXX UU		TIMER 2 XXX:XX

These two displays will appear when alarms or timers have been included. ALARMS can be process (F or C units) or deviation (DF or DC units). The UP or DOWN arrow keys are used to set in the desired alarm or timer values. Push the PARAM DISPLAY key to advance to the next display.

NOTE

If setting the alarm or timer relay(s) is the only function the operator wishes to perform in the TUNE Loop, push PARAM DISPLAY until END OF TUNE appears; then push the RETURN key to return to normal operation.

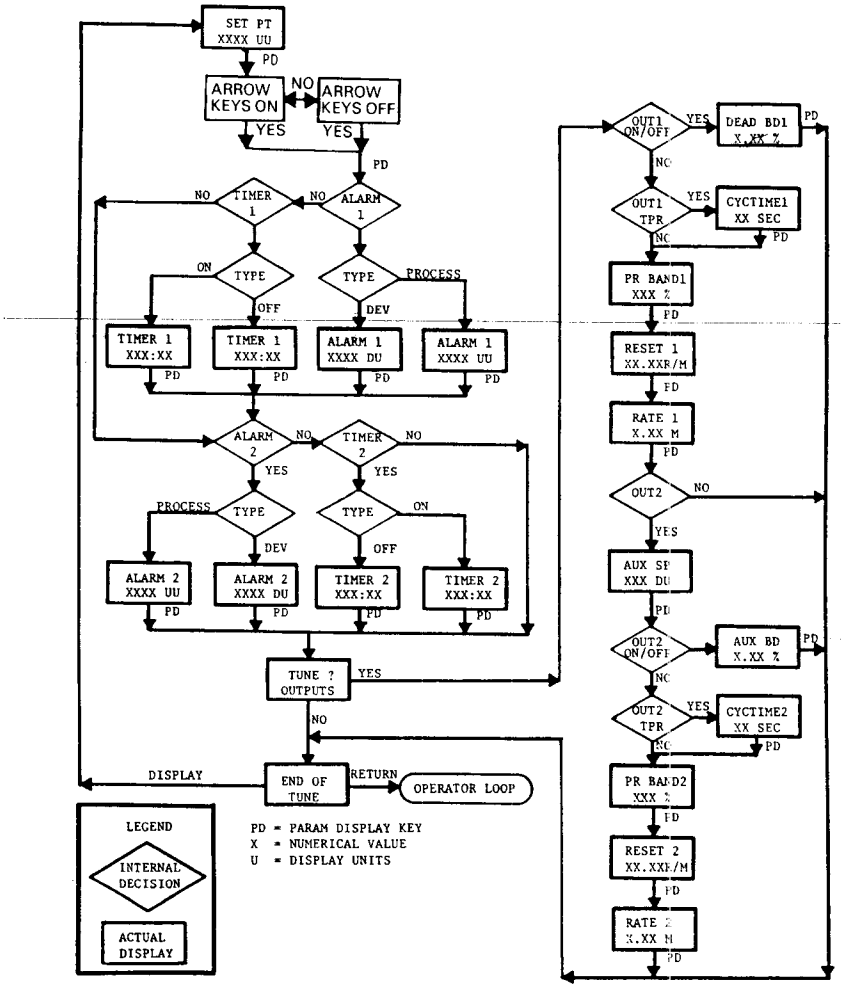


Figure 4-1. TUNE Loop Flow Chart (For CN2000 Units Without Self Tune (AT) Option)

TUNE ? OUTPUTS	At this display the operator must decide if he wishes to tune the outputs. A YES or NO answer using the appropriate key will allow the operator to tune each OUTPUT separately or to bypass this section. When a YES answer is entered, the outputs may be tuned using the following sequence of 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. Factory preset value is 0.25%. Push PARAM DISPLAY to advance.
CYCTIME1 XX SEC	This display appears when the primary output is specified as time proportioning control in the part number. A cycle time from 1 to 60 seconds can be selected. Factory preset is 15 seconds. Push PARAM DISPLAY to advance.
PR BAND1 XXX %	The following 3 displays appear when the PRIMARY OUTPUT is specified as time proportioning or voltage or current control. Set a proportional band (gain) of 1 to 200 percent using arrow keys. Factory preset value is 5%. Push PARAM DISPLAY key to advance to next display.
RESET 1 XX.XX R/M	RESET display indicates the RESET (integral) action. Reset from 0.01 to 20.00 repeats per minute (R/M) can be selected. Factory preset value is 0.25 R/M. A reset value of 0.00 turns the reset action off.
RATE 1 X.XX M	This display indicates the RATE (derivative) action. RATE from 0.01 to 5.00 minutes (M) can be selected. Factory preset value is 1.00 minutes. A rate value of 0.00 turns rate action off.
AUX SP XXX DF	This display appears only when a secondary output is provided. Auxiliary set point (AUX SP) defines the value of the secondary set point with respect to the primary set point. The units are differential degrees DF or DC. This set point can be set above (plus), equal to or below (minus) the primary set point using the arrow keys.

When a secondary COOLING or ON/OFF HEATING output is included in the controller, a second set of displays follows for tuning of this output.

AUX DB XX %	This display appears only when a secondary output is provided and is specified as ON/OFF control. A dead-band of 0.25, 0.50 or 1.00% of span can be selected. Factory preset at 0.25% of span.
CYCTIME2 XXX SEC	This display appears only when a secondary output is provided and is specified as TPR control in the part number. A cycle time from 1 to 60 seconds can be selected. Factory preset at 15 seconds.
PR BAND2 XXX %	PROPORTIONAL BAND (gain) from 1 to 200% of span can be selected. Refer to paragraphs 4.4 through 4.5 for instructions on proper tuning. Factory preset at 5%.
RESET 2 XX.XX R/M	RESET (integral) action from 0.01 to 20.00 repeats per minute (R/M) can be selected. Factory preset at 0.25 R/M. A reset value of 00.00 turns the RESET 2 OFF.
RATE 2 X.XX M	RATE (derivative) action from 0.01 to 5.00 minutes (M) can be selected. Factory preset value is 1.00 minutes. A RATE value of 0.00 turns the RATE action off.
END OF TUNE	This display is the final step in the TUNE loop. The LAST key will back up the display one step at a time within the TUNE loop. PARAM/DISPLAY key will repeat the TUNE loop from the top. RETURN key will exit the TUNE mode and return the display to the primary OPERATOR loop. This is the only display from which the TUNE Loop can be exited.

4.2 CONTROLLER TUNING FOR CN2000 CONTROLLERS WITH SELF TUNE (AT) OPTION

This controller has been configured at the factory with input, output and alarm functions to meet your specific application. Arbitrary alarm and tuning values were used at the factory to allow complete controller checkout. It is necessary for you to TUNE this controller to your specific process or machine before going to automatic control.

In this controller, a special program can automatically calculate the appropriate PID values during start-up and even during normal operation thereby eliminating the need for manual tuning. You initiate this SELF TUNE program from the front keypad by responding to a sequence of displayed questions. There are no internal switches, pots or jumpers to set or adjust. All tuning is accomplished through keypad inputs.

This controller is unique in that it not only automatically calculates the PID values but it will also show you those values on its alphanumeric display. You can use the calculated PID values or you can manually change any of them as circumstances require. For example: in a flow application you may want to turn the RATE action OFF.

NOTE

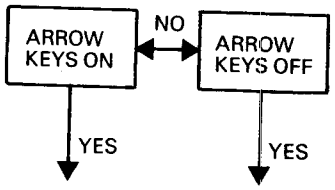
This SELF TUNE program ONLY applies to a primary HEAT acting output (OUT 1) and its PID values. For Time Proportional control (TPR) you must first select the CYCLETIME before self-tuning. If your controller has a secondary output (OUT2), you must also tune that output manually. Primary COOL acting control also must be manually tuned.

This section provides complete details on all Tuning procedures.

4.2.1 The Tune Loop and Keypad Security

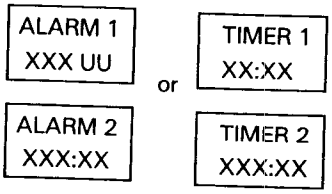
Access to the TUNE loop requires that a special key code be entered before any Tuning can be done. Press the keys TUNE-LAST-YES in sequence to enter the TUNE loop.

A yellow TUN indicator will illuminate on the display when the code is entered correctly. If the TUN indicator does not come ON, push the RETURN key and then push the code again. The PARAM DISPLAY key will advance the displays in the TUNE loop and the LAST key will back up the displays. A flow chart of the TUNE loop is shown in Figure 4-2 that shows all displays in the loop.



Additional security is available (on units shipped after Jan 1, 1989) 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.



When optional Alarm or Timer relay(s) are provided, one or two of these displays will appear in sequence. Set in the desired Alarm or Timer values using the arrow keys. Push the PARAM DISPLAY key to advance to next display.

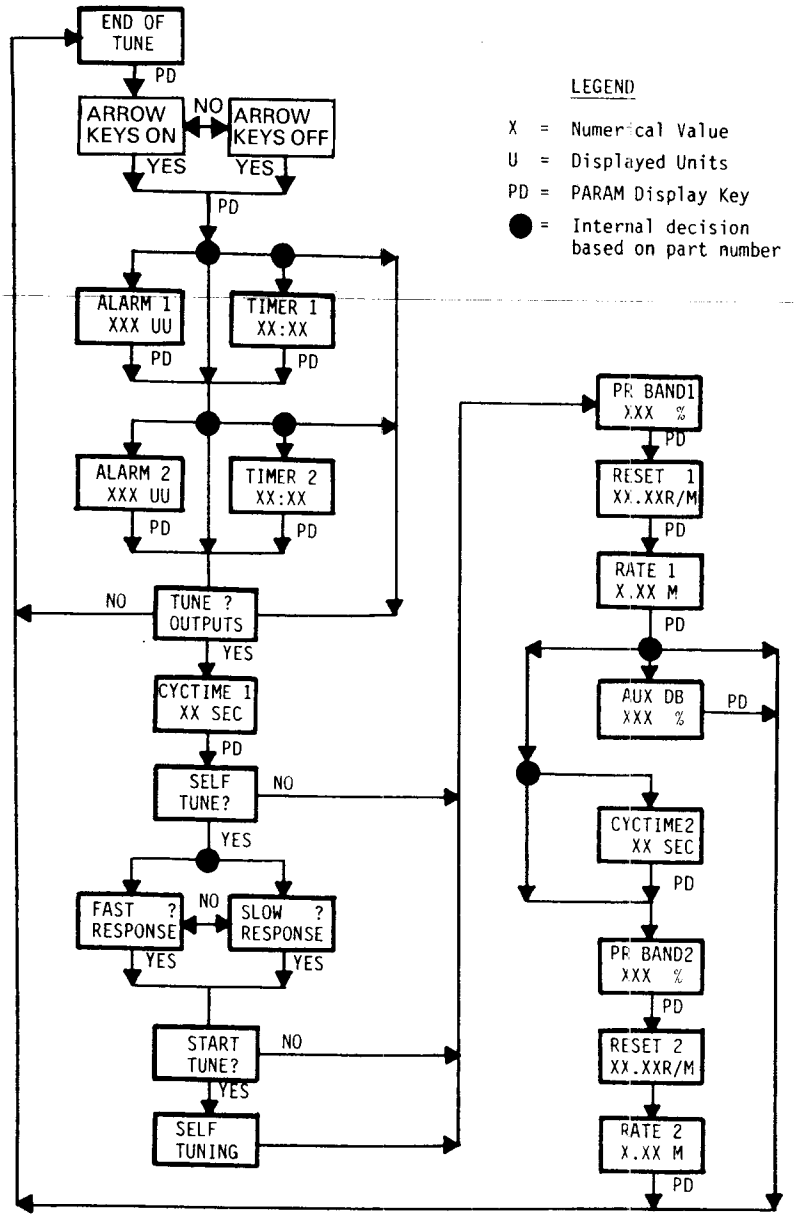


Figure 4-2. TUNE Loop for CN2000 Controllers, with Self Tune (AT) Option.

If setting the alarm relay(s) is the only function you wish to perform in the TUNE loop, push PARAM DISPLAY until END OF TUNE appears and then push the RETURN key to return to normal operation.

For actual Tuning, proceed by pushing the PARAM DISPLAY key.

TUNE ?
OUTPUTS

Push the YES key at this display to access all the Tuning programs. Tuning is required on all initial installations.

CYCTIME 1
XX SEC

This display appears ONLY when the primary output is specified as Time Proportional Control (TPR). Any CYCTIME from 1 to 60 seconds can be set using the arrow keys. The controller is shipped with a factory set value of 15 seconds.

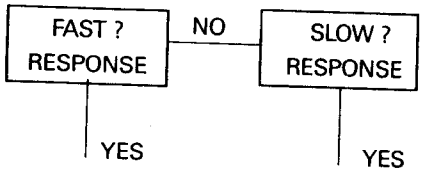
You must establish the correct CYCTIME for your application. The SELF TUNE program DOES NOT include determination of CYCTIME. When CYCTIME is set, push the PARAM DISPLAY key.

4.2.2 Self Tune Program

SELF
TUNE ?

This is the first display in the SELF TUNE program. Push YES key for SELF TUNE. Push NO key if manual tuning of the primary output is desired and proceed to Section 4.2.3.

You must next choose the desired closed loop response of the system: FAST or SLOW. Different tuning rules are applied by SELF TUNE according to your choice.



Indicate whether you want your system to be a FAST or SLOW responding system. Push the NO key to switch between these two displays. Push the YES key to select the desired response.

Select FAST RESPONSE for systems where a possible overshoot will not present a hazard. Select SLOW RESPONSE where potential overshoot is not acceptable. Your decision can be changed at any later time without retuning by returning to these displays in the TUNE loop and selecting the other response.

START TUNE ?

Push the NO key if you don't want to start the SELF TUNE procedure. The PID constants will then be calculated according to the last process model and your choice of response. This allows you to change your choice of FAST or SLOW tuning without repeating the self tuning program.

Push the YES key to initiate the SELF TUNE program.

SELF TUNING

The yellow TUN light will flash, and the display indicates that you are in SELF TUNE mode. After a short delay (15 secs), Output 1 will turn ON, and the controller will start to analyze the system.

4.2.3 Self Tune From A Cold Start

When you start your machine or process from a cold start, the SELF TUNE program begins with 100% output power until the temperature reaches approximately one-half way to set point (Figure 4-3). The set point must be at least 30 degrees F (17 degrees C) above ambient. If it isn't, the controller automatically goes to manual tuning displays. At the half-way point, the controller shuts off the output and monitors the process as it responds to the loss of heat. The controller calculates appropriate PID values and returns output power to quickly bring the temperature to set point under three mode control.

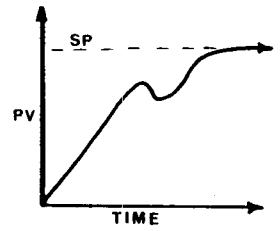


Figure 4-3. Self Tune From a Cold Start

4.2.4 Self Tune For Hot Restart and During Operation

NOTE

Controllers with analog inputs can only use SELF TUNE from a cold start. SELF TUNE from a hot start will yield erroneous results.

Anytime during operation, or after a pause in operation, the SELF TUNE program can be used when a thermocouple or RTD input is being used. If the process or machine is at or close to operating temperature, the controller will shut off the output to allow an approximate 20% drop in temperature (set point to ambient) while it calculates new PID values. The output is then turned ON to return the temperature to set point.

The 50% point for cold start and the 20% drop for hot retune are factory set but can be changed if either of these values causes process difficulties. Contact the factory for instruction on changing either value.

While the SELF TUNE is active, the yellow TUN indicator will flash and all keys but two are disabled. The RETURN key is active to allow you to observe the OPERATOR loop displays using the POINTER technique explained in paragraph 4.3. The STOP/START or AUTO/MANUAL (option AM) key is also active to allow you to stop the SELF TUNE program if required.

The SELF TUNE program will select the most appropriate PID values within fixed limits. Manual tuning allows broader tuning values as shown below.

	SELF TUNING	MANUAL TUNING
Proportional Band	1-50%	1-200%
RESET	0-10 R/M	0-20 R/M
RATE	0-3 M	0-5 M

When the SELF TUNE program is completed, the display automatically advances to show you the Proportional Band selected.

4.2.5 Manual Tuning

The following tuning displays are always available in the TUNE loop. When SELF TUNE is used, the first three displays will show the PID values selected by the SELF TUNE program. You can change these values if necessary. These same displays are used if you want to manually tune the primary output. Refer to Section 4.5 for a suggested tuning method.

PR BAND1 XXX%	Set a Proportional Band of 1 to 200% using arrow keys. Factory preset value is 5%. Push PARAM DISPLAY key to advance to the next display.
RESET XX:XXR/M	Set a RESET of 00.00 to 20.00 Repeats per Minute. Factory preset value is 0.25 R/M. Setting RESET to 00:00 turns RESET OFF.
RATE 1 X.XX M	Set a RATE of 0.00 to 5.00 Minutes. Factory preset value is 1.00 Minutes. Setting RATE to 0.00 turns RATE OFF.

When a secondary (COOLING) output is included in your controller, a second set of displays follows for manual tuning of this output.

AUX DB XX %	For ON/OFF secondary. Select a Deadband from 0.25, 0.50 and 1.00% of Span using the arrow keys. Factory set at 0.25% of Span.

CYCTIME 2 XXX SEC	For Time Proportional secondary. Select a CYCTIME of 1 to 60 seconds. Factory preset at 15 seconds.
PR BAND2 XXX%	Set a Proportional Band 2 of 1 to 200%. Factory preset at 5%.
RESET 2 XX:XX R/M	Set a RESET 2 of 00.00 to 20.00 Repeats per Minute. Factory preset at 0.25 R/M. Setting RESET 2 at 00.00 turns RESET 2 OFF.
RATE 2 X.XX M	Set a RATE 2 of 0.00 to 5.00 Minutes. Factory preset value is 1.00 Minutes. Setting RATE to 0.00 turns RATE OFF.
END OF TUNE	Tuning has been completed. At this display you have several key options.

LAST key will back up displays to review or change settings.
PARAM DISPLAY key will repeat TUNE loop from the top.
RETURN key will exit TUNE loop and return to Operator displays.

NOTE

You can only extinguish the TUN indicator by pushing the RETURN key while at the END OF TUNE display.

4.3 TUNING POINTERS

To simplify tuning of the Model CN-2000 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 the TUNE mode, i.e., TUN indicator ON. Pushing the RETURN key once, and then the PARAM DISPLAY, will allow the operator to review all of the OPERATOR loop displays. Push the RETURN key again to return to the TUNE loop displays. The PARAM DISPLAY key will now scroll through the TUNE displays. The operator can switch between loops simply by pushing the RETURN key.

NOTE

The TUN indicator can only be turned off and the TUNE Loop can only be terminated when at the "END OF TUNE" display. Pushing the RETURN key when at this display cancels the TUNE program and turns TUN off.

For example: In the TUNE mode (TUN indicator ON) the display can be advanced to RESET 1 using the PARAM/DISPLAY key. Then, after pressing the RETURN key to call up the OPERATOR Loop, the display can be advanced to OUT 1 using the PARAM/DISPLAY key. Push RETURN to see and set RESET 1 and then push RETURN again to observe OUT 1 response to that change. The operator can go back and forth between these two displays at the touch of a key for quick and efficient tuning.

4.4 TUNING A PID (THREE MODE) CONTROLLER

The Series CN-2000 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 carefully. The information for tuning this three mode controller may be different from other controller tuning procedures. Normally the SELF TUNE feature (units with AT option) will eliminate the necessity to use this manual tuning procedure for the primary output, however, adjustments to the SELF TUNE values may be made if desired.

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.)

   With CN2000 units with AM (Auto/Manual) option, the operator must go to manual control, push MANUAL key, and turn the outputs OFF using the DOWN arrow key.

c. Enter the TUNE loop by pushing TUNE-LAST-YES keys in sequence. (The TUN indicator will illuminate).

d. Press PARAM/DISPLAY key to advance the TUNE program to TUNE OUTPUTS

e. Press YES key. For time proportional primary output, CYCTIME 1 will appear. Enter the following value:

   CYC TIME 1 ——— 5 SEC (Only appears if output is TPR output, a smaller cycle time may be required for systems with an extremely fast response time).

f. Press PARAM DISPLAY and sequentially enter the following values. (For CN2000 with the SELF TUNE (AT) option, press PARAM DISPLAY and answer NO to the SELF TUNE display. Then press PARAM DISPLAY again and sequentially enter the following values.)

PR BAND 1 – – – – – 5% (PB)

RESET 1 – – – – 0 R/M (TURNS OFF RESET FUNCTION)

RESET 2 – – – – 0 R/M

RATE 1 – – – – 0 MIN (TURNS OFF RATE FUNCTION)

RATE 2 – – – – 0 MIN

NOTE

On units with dual three mode outputs the primary and secondary tuning parameters are independently set and must be tuned separately. The procedure used in this section is for a HEATING primary output. A similar procedure may be used for a primary COOLING output or a secondary COOLING output.

4.4.1 Tuning Outputs for Heating Control

1. Press the RETURN key so that the measurement appears on the screen. It is not necessary to return to OPERATOR mode while tuning the controller (POINTERS).

   Press START key (or AUTO key, for CN2000 with AM option) to enable the OUTPUT(S) and start the process.

2. The process should be run at a set point that will allow the temperature to stabilize with heat input required.

3. With RATE and RESET turned OFF, the temperature will stabilize with a steady state deviation, or droop, between the set point and the actual temperature. Carefully note whether or not there are regular cycles or oscillations in this temperature 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 recorder to monitor the process temperature.

4. If there are no regular oscillations in the temperature, divide the PB by 2 (see Figure 4-4). Allow the process to stabilize and check for temperature 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 temperature for several minutes. If the oscillations continue, increase the PB by factors of 2 until the oscillations stop.

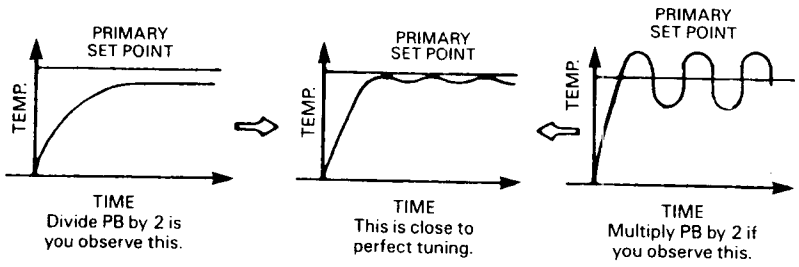


Figure 4-4. Temperature Oscillations

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 temperature recording.

   If no oscillations occur in the process temperature even at the minimum PB setting of 1%, skip Steps 6 through 11 below and proceed to paragraph 4.4.2.

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

7. Measure the oscillation time, in minutes, between neighboring peaks or valleys (see Figure 4-5). This is most easily accomplished with a chart recorder, but a measurement can be read at one minute intervals to obtain the timing.

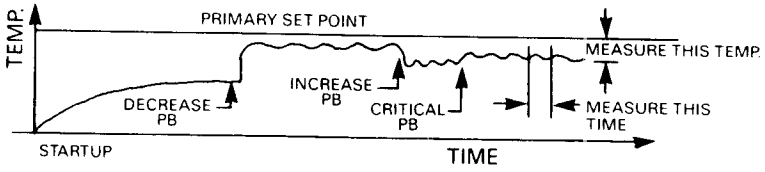


Figure 4-5. Oscillation Time

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

   The desired final temperature deviation can be calculated by multiplying the initial temperature deviation achieved with the CRITICAL PB setting by 1.65 (see Figure 4-6) or by use of the convenient Nomogram I (see Figure 4-7). Try several trial-and-error settings of the PB control until the desired final temperature deviation is achieved.

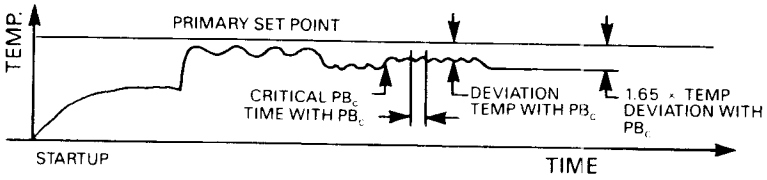
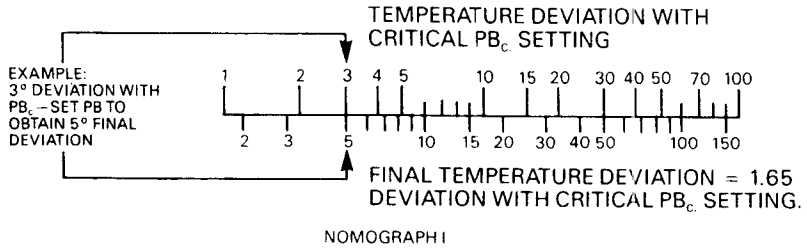


Figure 4-6. Calculating Final Temperature Deviation



NOMOGRAPH I

Figure 4-7. Nomogram I

9. You have now completed all the necessary measurements to obtain optimum performance from the CN-2000 Controller. Only two more adjustments are required—RATE and RESET.

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

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

OR Use Nomogram II (See Figure 4-8):

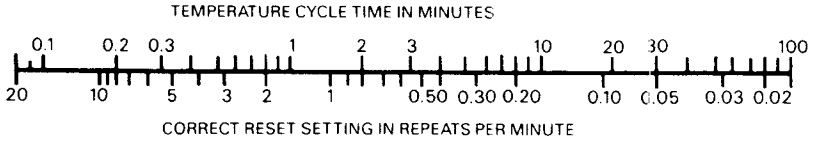


Figure 4-8. Nomogram II

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:

$$\text{RATE} = \frac{To}{10;}$$ Where to = Oscillation Time

OR Use Nomogram III (See Figure 4-9)

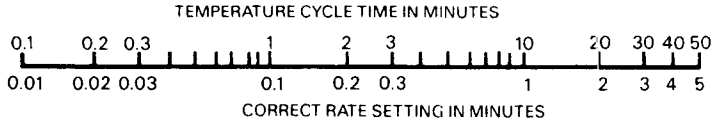


Figure 4-9. Nomogram III

Enter this value for Rate 1.

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, the 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 (TPRI)). Increase the cycle time as much as possible without causing oscillations in the measurement due to load cycling.

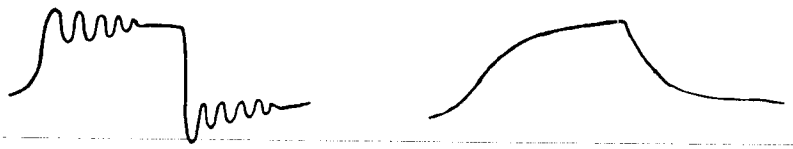
15. Proceed to Paragraph 4.4.3.

4.4.2 Tuning Procedure When No Oscillations Are Observed

1. Measure the steady-state deviation, or droop, between set point and actual temperature with minimum PB setting.
2. Increase the PB setting until the temperature deviation (droop) increases 65%. Nomogram I (see Figure 4-7) provides a convenient method of calculating the desired final temperature deviation.
3. Set the RESET 1 to a high value (10 R/M). Set the RATE 1 to a corresponding value (0.02 MIN). At this point, the measurement should stabilize at the set point temperature due to reset action.
4. Since we were not able to determine a critical oscillation time, the optimum settings of the reset and rate adjustments must be determined by trial and error. After the temperature has stabilized at set point, increase the set point temperature setting by 10 degrees. Observe the overshoot associated with the rise in actual temperature. Then return the set point setting to its original value and again observe the overshoot associated with the actual temperature 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 4-10. 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 (TPRI)). 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 4-10. Setting RESET and/or RATE

4.4.3 Tuning the Primary Output for Cooling Control

The same procedure is used as defined for heating. The process should be run at a set point that requires cooling control before the temperature will stabilize.

4.5 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).

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 4-11). The time delay may also be obtained by the equation:

   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 × max. slope × 100/span = % of span
   Reset = 0.4 / Td = resets/minute
   Rate = 0.4 × Td = minutes

5. Restart the system and 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 4-11 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, or 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 × 3.6°F/minutes × 100/500°F = 5%.

Reset = 0.4/7 minutes = 0.06 resets/minute

Rate = 0.4 × 7 minutes = 2.8 minute

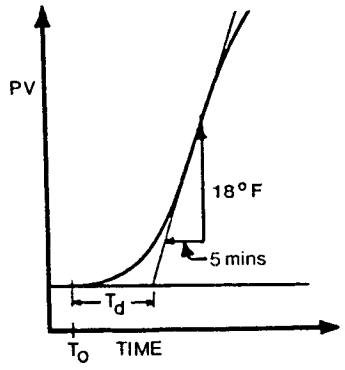


Figure 4-11. System Time Delay

The host cannot initiate communications enable. This can only be accomplished by a key press on the front keypad of the controller. See paragraph 3.8. Even after communications is enabled, local control is allowable.

During host-controlled operation, the front keypad is still active so that the operator can override the host and can take direct control if necessary.

The REM indicator light will flash when the communications is enabled. The host can also turn the REM indicator full on as part of the STATUS INPUT (PSW) command to inform the operator that the host is in control.

5.1 INSTRUMENT IDENTIFICATION

The specific type of digital communications circuitry provided in a Model CN-2000 Controller is indicated by the PART NUMBER.

- DO = No digital communications
- D1 = Analog remote set point (disables alarm #2)
- D2 = Non-isolated RS232C communications
- D3 = Isolated RS232C communications
- D4 = Non-isolated RS422 communications
- D5 = Isolated RS422 communications
- D6 = Isolated 20 mA current loop communications

For for CN2000 Controllers With Self Tune (AT) Option:

- EA = No communications
- EB = Remote analog set point
- EC = RS232C non-isolated
- ED = RS232C isolated
- EE = RS422 non-isolated
- EF = RS422 isolated
- EG = 20 mA current (isolated)

The communications circuitry is located on the middle circuit board of the electronic assembly. This board plugs into the front bezel assembly and connects to the rear "D" connector by means of a flexible flat ribbon cable that plugs into the bottom edge of the communications circuit board.

5.2 COMMUNICATIONS WIRING

The "D" Type (DB25S) 25-PIN digital communications connector located at the rear of the CN-2000 case is a standard Electronic Industries Associates (EIA) interface for RS232C. RS422 and 20 mA current loop use the same connector.

Wiring to the Model CN-2000 is identical to that for any Data Terminal. Table 5-1 identifies each PIN by function. Sections 5.4, 5.5 and 5.6 provide the specific wiring for the three available interfaces.

TABLE 5-1
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 loop 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.
4	RTS	Request to Send	This line is normally held inactive by the CN-2000 until a message is ready to be sent. Then the line is switched active and the CN-2000 waits for the Clear To Send.
5	CTS	Clear to Send	This line must be made active by the host in order for the CN-2000 to send data unless handshake lines are inactive (see switch settings, paragraph 5.7).
6	DSR	Data Set Ready	Since the CN-2000 is a respond only device and does not initiate correspondence, the CN-2000 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.

TABLE 5-1 (cont'd)
CONNECTOR PIN DESIGNATIONS

PIN	MNEMONIC	SIGNAL	DESCRIPTION
8	DTR	DTR Return	Return line for Data Terminal Ready signal (PIN 20) used with RS422 with handshake only.
9	+V	Positive Voltage	User must supply +12 V dc on this PIN if using RS232C isolated configuration or +5 V dc if using RS422 isolated configuration. No connection otherwise.
10	−V	Negative Voltage	User must supply −12 V dc on this PIN if using RS232C isolated configuration. No connection otherwise.
11	CTS	CTS Return	Return line for Clear To Send signal (PIN 5) used with RS422. Also 20 mA current Loop return line for transmit loop.
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 for Request To Send signal (PIN 4) used only with RS422 with 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 operatons.
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 Ready 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.

5.3 HANDSHAKE OPTION

The Model CN-2000 digital communications includes provision for the full handshake selection for use in RS232C and RS422 interfaces. To enable handshake for these interfaces, set the S2 switch number 4 "ON". (Refer to paragraph 5.7.) 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 12	CTS	Clear to Send Return
PIN 25	DSR	Data Set Ready Return
PIN 8	DTR	Data (Terminal) Ready Return

Interface diagrams (Sections 5.5 and 5.6) shown are suggestion **only.** There are several alternate wiring configurations depending on the host. It is essential to compare the host or modem requirements with the CN-2000 pin designations (Section 5.3) 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.

5.4 RS232C INTERFACE (See Figures 5-1 and 5-2)

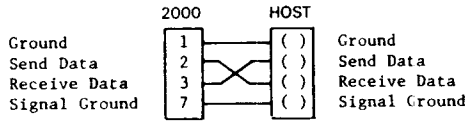


Figure 5-1. RS232C Half/Full Duplex Without Handshake

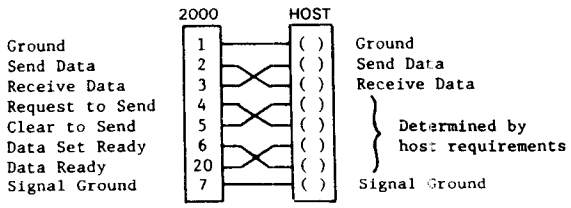


Figure 5-2. RS232C Half/Full Duplex With Handshake

.5 RS422 INTERFACE (See Figures 5-3 and 5-4.)

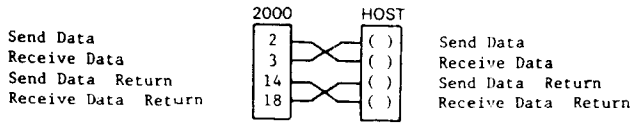


Figure 5-3. RS422 Half/Full Duplex Without Handshake

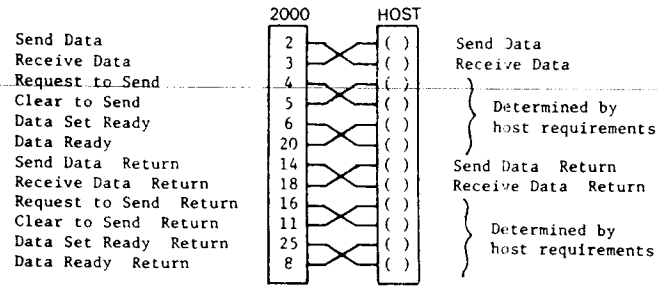


Figure 5-4. RS422 Half/Full Duplex With Handshake

The RS422 driver is shown in Figure 5-5. 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 5-5. RS422 Driver

RS422 may be drop line configured to enable the host to talk to several CN-2000 units through one port as shown in Figure 5-6.

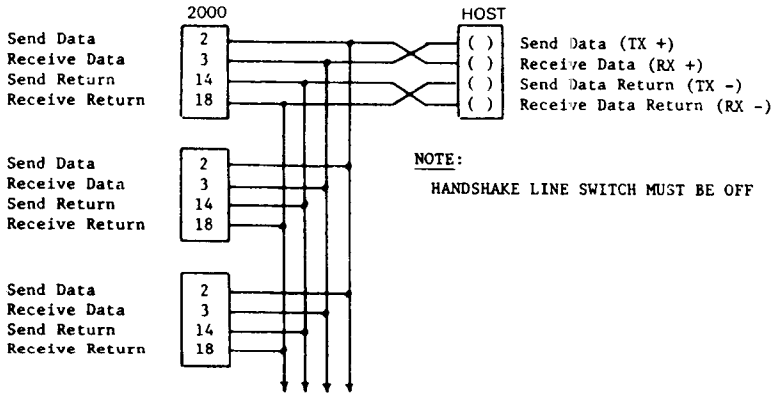


Figure 5-6. Several CN-2000 Units in Conjunction With One Host

5.6 20 mA CURRENT LOOP INTERFACE (See Figures 5-7 through 5-10)

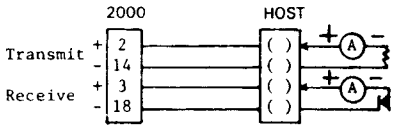


Figure 5-7. Full Duplex 4-Wire Connections

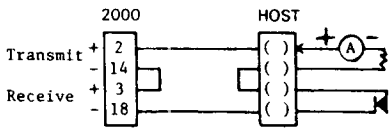


Figure 5-8. Half Duplex 2-Wire Connections

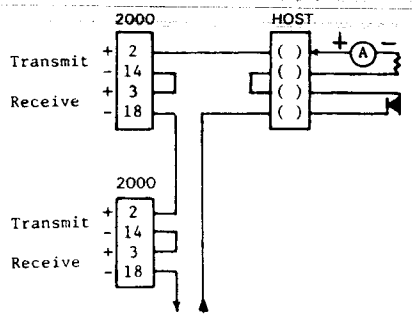


Figure 5-9. Half Duplex 2-Wire Chaining of Several CN-2000 Controllers

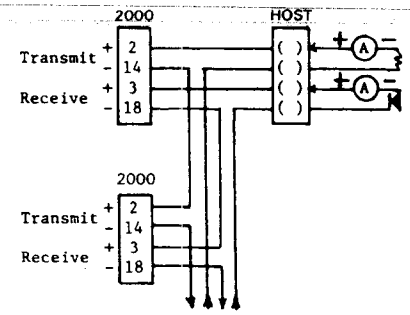


Figure 5-10. Full Duplex 4-Wire Chaining of Several CN-2000 Controllers

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.

5.7 FORMAT SELECTION SWITCHES

Format selector switches mounted on the communications circuit board inside the Model CN-2000 Controller allow the user to select Parity, Baud Rate and Unit Address to fit the application (see Figure 5-11). The switch options are:

PARITY: Even, odd or no parity (factory set at NO PARITY)

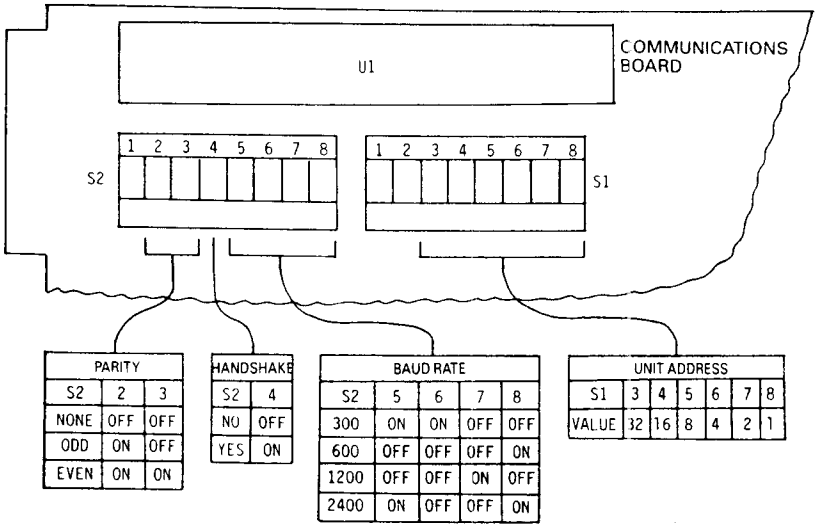
BAUD RATE: 300, 600, 1200 or 2400 (factory set at 1200)

UNIT ADDRESS: 0 to 63 (factory set at ADDRESS 00)

HANDSHAKE: YES or NO (factory set at NO HANDSHAKE)

To access these switches, turn power to the Model CN-2000 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 slid 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 or pen tip to set desired switch position. Each unused switch **MUST** be in the OFF position.



PARITY		
S2	2	3
NONE	OFF	OFF
ODD	ON	OFF
EVEN	ON	ON

HANDSHAKE	
S2	4
NO	OFF
YES	ON

BAUD RATE				
S2	5	6	7	8
300	ON	ON	OFF	OFF
600	OFF	OFF	OFF	ON
1200	OFF	OFF	ON	OFF
2400	ON	OFF	OFF	ON

UNIT ADDRESS						
S1	3	4	5	6	7	8
VALUE	32	16	8	4	2	1

ALL UNUSED SWITCHES MUST BE SET "OFF"

Figure 5-11. Format Selection Switches

5.8 PROGRAMMING

5.8.1 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 CN-2000 can accept any number of stop bits. The CN-2000 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 5-12.)

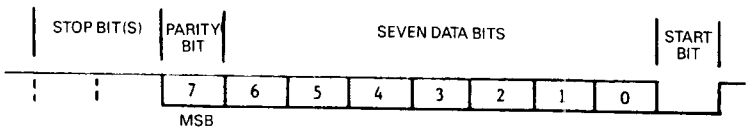


Figure 5-12. Serial Data Format

5.8.2 Data Protocol

The Model CN-2000 Controller is always the passive (listener) link in this protocol. Transmission is always initiated by the host computer. The host sends a command or a command and data to the Model CN-2000 Controller. The Model CN-2000 responds within 100 ms. either with system status or with system status and data.

The COMMAND sent by the host must be in the following format except that CKSUM is optional with the host. The CN-2000 will ignore a lack of CKSUM if none is provided by the host computer. The CN-2000 will always respond with a CKSUM even if it is not used. See examples on Page 41 and 42.

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 Model CN-2000 will RESPOND within 100 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 CN-2000 and should be ignored, but must not be sent to the CN-2000.

5.8.3 Data Protocol Definitions

See examples in Section 5.8.8 and 5.8.10 of this manual.

*	– 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 a WRITE COMMAND.
$	– Standard ASCII character used by the Model CN-2000 as the first character in a response.
UNIT #	– ASCII 0 to 63. The unit address ID is established via binary weighted internal switches on the Model CN-2000 communications board. The unit address can be omitted in transmissions when only one unit is involved and address switches are set to all zeros.
R	– READ command
W	– WRITE command
PARAMETER	– Controller variable shown as a three-character ASCII mnemonic. See Section 5.8.4. ONLY UPPER CASE CHARACTERS MAY BE USED.
CKSUM	– **Two** ASCII coded 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 character 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. See paragraphs 5.8.5 and 5.8.6.
DATA	– A string of ASCII digits, including minus sign where appropriate, representing the numerical value of the PARAMETER specified. Limited to four character spaces.

5.8.4 Parameter Designations

Function	MNEMONIC	Definition	LIMITS: All values must be set in as whole numbers. See Notes below.
Operator Functions	PV0	Process Variable	DO NOT WRITE PROCESS VARIABLE.
	CSP	Control Set Point	MUST BE WITHIN SYSTEM SPAN LIMITS.
	OP1	Output 1, PRImary Output	READ only, see Note [1]
	OP2	Output 2, SECondary Output	READ only, see Note [1]
Primary Control	DB1	Dead Band 1	25, 50 or 100 for % of SPAN[3]
	CT1	Cycle Time 1	1 to 60 for seconds of Cycle Time
	PB1	Proportional Band 1	1 to 200 for % of SPAN
OUTPUT 1	RE1	Reset 1	1 to 2000 for R/M or 0 for RESET OFF[3]
	RA1	Rate 1	1 to 500 for Minutes or 0 for Rate OFF[3]
Secondary Control	ASP	AUXiliary Set Point	Secondary set point must be within SPAN.
	DB2	Dead Band 2 (AUX DB)	25, 50 or 100 for % of SPAN[3]
	CT2	Cycle Time 2	1 to 60 for seconds of Cycle Time
	PB2	Proportional Band 2	1 to 200 for % of SPAN
OUTPUT 2	RE2	Reset 2	1 to 2000 for R/M or 0 for RESET OFF[3]
	RA2	Rate 2	1 to 500 for Minutes or 0 for Rate OFF[3]
Alarms (Option)	AL1	Alarm 1 Set Point	Must be within system span limits
	AL2	Alarm 2 Set Point	Must be within system span limits
Timers* (Option)	R1H	Relay 1 Hours	0 to 999 for hours
	R1M	Relay 1 Minutes	0 to 59 for minutes (see Note 2)
	R2H	Relay 2 Hours	0 to 999 for hours
	R2M	Relay 2 Minutes	0 to 59 for minutes
Status	PSW	Process Status	
	CSW	Control Status	

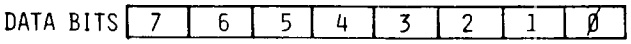
*Timers can be set to operate in Hours/Minutes or Minutes/Seconds at time of initial calibration. For Minutes/Seconds operation R1H and R2H will read in minutes and R1M and R2M will read in seconds.

NOTES

1. Output power level is communicated as a digital value from 0 to 4095. To read % output, divide transmitted value by 40.95.
2. Set in hours and minutes without colon, i.e., 9959 for 99:59.
3. Set desired value as a whole number. The CN-2000 internal logic will multiply your number by 0.01 to yield correct decimal value.

5.8.5 Control Commands–Process Status (PSW)

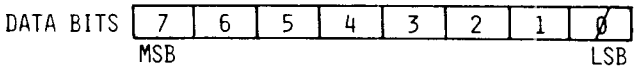
The USER may READ or WRITE the Process Status (mnemonic PSW) as two ASCII HEX characters. Before WRITING a new command, you must first read the existing command data bits. All data bits you do not wish to change **MUST** be repeated in the new command including bits designated RESERVED.



BIT	0 STATUS	1 STATUS
7	Stop	Start
6	Manual	Auto Control
5	Normal	Input Open (READ only)
4	Normal	Data Lost (READ only)
3	"REM" flashing	"REM" full on
2	Reserved	Reserved
1	ALM/Timer 1 OFF	ALM/Timer 1 ON
Ø	Reserved	Reserved

5.8.6 Control Commands–Control Status (CSW)

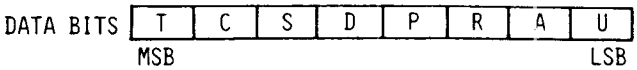
The USER may READ or WRITE the Control Status (mnemonic CSW) as two ASCII HEX characters. Before WRITING a new command, you must first read the existing command data bits. All data bits you do not wish to change **MUST** be repeated in the new command including bits designated RESERVED.



BIT	0 STATUS	1 STATUS
7	Reserved	Reserved
6	Reserved	Reserved
5	Reserved	Reserved
4	Normal	Timer override (event alarm only)
3	Reserved	Reserved
2	Reserved	Reserved
1	Reserved	Reserved
Ø	Reserved	Reserved

5.8.7 Status Response

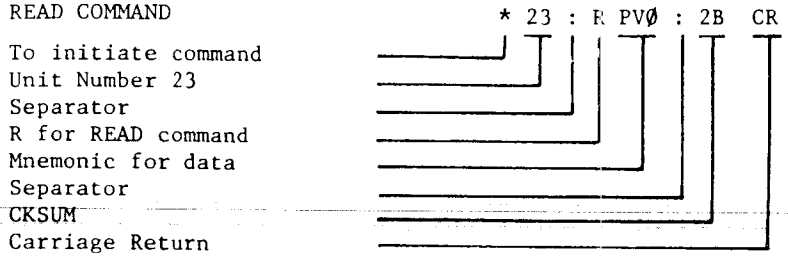
Every command from the host computer causes the Model CN-2000 to generate a two ASCII HEX character status report as part of its response. Normal state (0) is assumed to be normal controller operation.



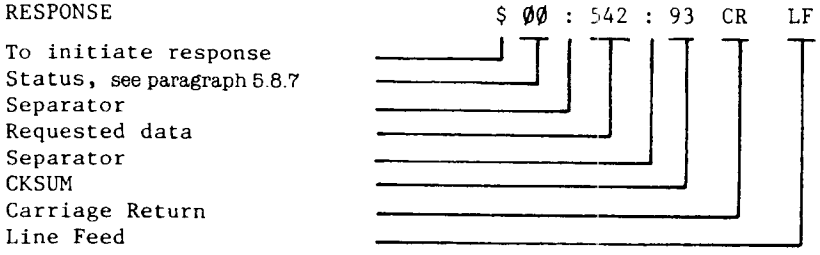
BIT	ABNORMAL CONDITION "1"
T	Transmission Error
C	CKSUM Error on received Data
S	Syntax Error or Illegal Input
D	Communications Turned OFF
P	Parity Error on received Data
R	INPUT OPEN
A	Alarm Condition (Relay 1)
U	Reserved

5.8.8 Protocol Example–Read

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

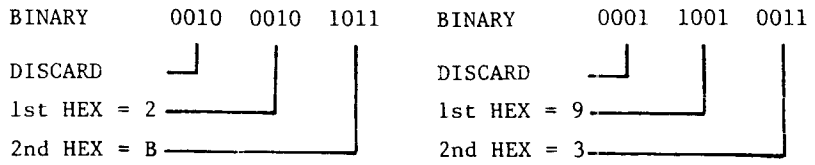


The Model CN-2000 response to the READ command if the measurement were 542 degrees would be:



CKSUM Computation is as follows (for example in this section):

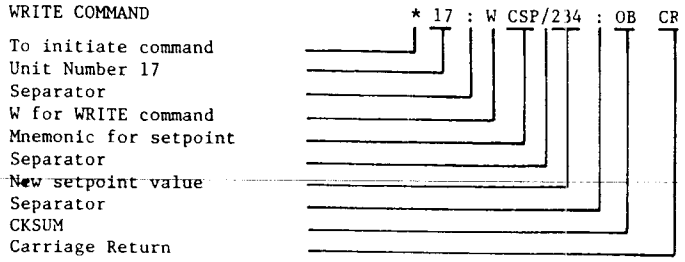
READ COMMAND		RESPONSE REPLY	
CHAR	HEX	CHAR	HEX
*	2A	$	24
2	32	Ø	3Ø
3	33	Ø	3Ø
:	3A	:	3A
R	52	5	35
P	5Ø	4	34
V	56	2	32
Ø	3Ø	:	3A
:	3A		
TOTAL	22B	TOTAL	193



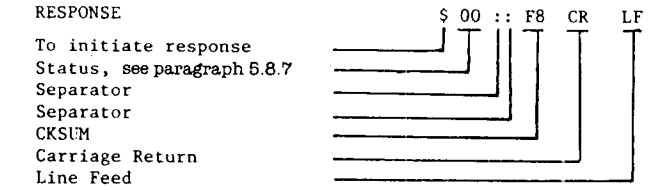
Note: Parity bits are not included in the CKSUM

5.8.9 Protocol Example–Write

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



The Model CN-2000 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.

5.8.10 ASCII Table

	LSB	0000	0001	0010	0011	0100	0101	0110	0111	1000	1001	1010	1011	1100	1101	1110	1111
MSB		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 6 CALIBRATION

The CN2000 Series 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 operating standards or to recover from extraordinary circumstances such as DATA LOST/PLEASE CAL.

The calibration procedure for the CN2000 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 Calibration Loop, Figure 6-1.) The REFERENCE procedure is the more traditional calibration using an external reference source. A structural program also exists for this calibration (see Calibration Loop, Figure 6-1). 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 a properly protected (cover exposed terminals) ac power source and an appropriate input is necessary. If input is not convenient, a jumper between Terminals F and H is adequate for CONFIGURATION calibration. REFERENCE calibration requires a precise calibration source for the input signal.

CAUTION

COMPUTER DEVICES ARE NON-FORGIVING. KEY SEQUENCES AND INSTRUCTIONS MUST BE FOLLOWED PRECISELY. DO NOT SKIP ANY STEP.

6.1 ENTERING CALIBRATION PROGRAM

A security code protects the calibration procedure. To enter the calibration mode push the three keys as indicated in Figure 6-2 simultaneously. Note that on the CN2000 Series the upper left key is not shown on the keypad but it does exist under the front panel. A front display "CAL" indicator will illuminate. If it does not, push the RETURN key and then push the 3 key code again.

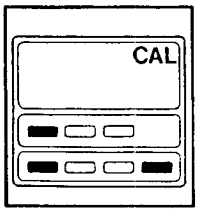


Figure 6-2. Entering Calibration Loop

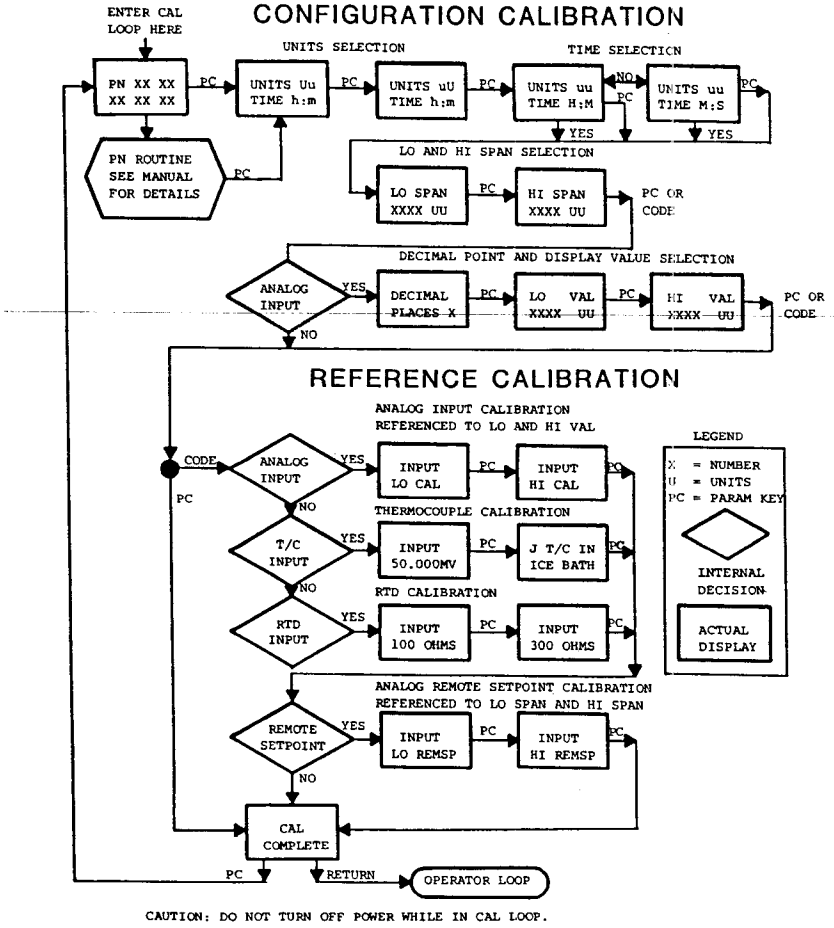
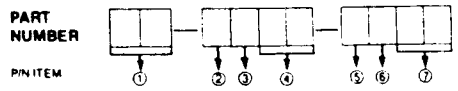


Figure 6-1. Calibration Loop

6.2 PART NUMBER

PN 11 23
44 56 77

The PART NUMBER is the first CAL loop display. If this display does not appear, push the LAST key until it is on the display. This 10 digit PART NUMBER fully defines the controller.



1 Model

E0	2000	No communications
E1	2000	Remote Analog Setpoint
E2	2000	RS232C non-isolated
E3	2000	RS232C isolated
E4	2000	RS422 non-isolated
E5	2000	RS422 isolated
E6	2000	20 mA Current (isolated)
EA	2000*	No communications
EB	2000*	Remote Analog Setpoint
EC	2000*	RS232C non-isolated
ED	2000*	RS232C isolated
EE	2000*	RS422 non-isolated
EF	2000*	RS422 isolated
EG	2000*	20 mA Current (isolated)

* With AT (SELF TUNE) option.

2 Primary Output

0	NO PRIMARY
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 4-20 mA DC
6	PRI. COOL 4-20 mA DC
7	PRI. HEAT 0-5 VDC
8	PRI. COOL 0-5 VDC

3 Secondary Output

0	NO SECONDARY
1	SEC. HEAT SSR ON/OFF
2	SEC. COOL SSR ON/OFF
4	SEC. COOL SSR PROP.
6	SEC. COOL 4-20 mA DC
7	SEC. COOL 0-5 V DC

Note: Units with "Auto/Manual" option (replacing the "Start/Stop" option) have code "Z" (instead of code "E") in the part number. .

4 Input

00	J thermocouple
01	K thermocouple
02	R thermocouple
03	S thermocouple
04	T thermocouple
06	E thermocouple
07	B thermocouple
08	PLATINEL II T/C
09	Ni/Ni 18% Moly T/C
10	W5%Re/W26%Re T/C
11	W3%Re/W25%Re T/C
12	W/W26%Re T/C
20	RTD 100 ohm pt.
21	RTD 100 ohm pt. (0.1 res)
40	0-5 volts DC
60	4-20 mA DC

5 Alarm/Timer 1

0	no alarm
1	HI process
2	LO process
3	HI deviation
4	LO deviation
5	ON Timer
6	OFF Timer

6 Alarm/Timer 2

0	no alarm
1	HI process
2	LO process
3	HI deviation
4	LO deviation
5	ON Timer
6	OFF Timer

7 Options

00	No options
XX	Any special

The CN2000 Controllers have been manufactured with specific hardware that determines input and output capability. The PART NUMBER defines this capability. The PART NUMBER also defines some items that can be changed by a keypad instruction without any hardware change. For example: In a controller provided with thermocouple input, the type of thermocouple can be changed by a keypad instruction. However an input cannot be changed to an RTD or process input unless a hardware change is also made. CONFIGURATION calibration deals specifically with those items that can be changed strictly by a keypad instruction.

6.3 PART NUMBER CHANGES

DIGIT 1: Any number change requires a hardware change.

DIGIT 2: Numbers 1, 2, 3, 4 are interchangeable by keypad instructions only.
Number 5 and 6 are interchangeable by keypad instructions only.
Number 7 and 8 are interchangeable by keypad instructions only.
Any other change requires a hardware change too.

DIGIT 3: Numbers 1, 2 and 4 are interchangeable by keypad instructions only. Any other change requires a hardware change too.

DIGIT 4: Numbers 00 thru 12 are interchangeable by keypad instructions only. Any other change requires a hardware change too.

DIGIT 5: All numbers except 0 are interchangeable by keypad instruction only.

DIGIT 6: All numbers except 0 are interchangeable by keypad instruction only.

DIGIT 7: This number has no effect on the microprocessor commands. It is used to identify specials and should only be changed by authorized personnel.

Most recalibration requirements will use the original part number found on the instrument labels. If you make a change in the PART NUMBER, be sure you write the new number down on the back cover of this manual for future reference.

If you do not need to reset or change the part number, push the PARAM DISPLAY key to advance the display and proceed to paragraph 6.5

If you do want to change the part number, proceed with paragraph 6.4.

6.4 SETTING THE PART NUMBER

An additional security code protects the part number. To change the part number push the two keys indicated in Figure 6.3 simultaneously.

A flashing digit will appear at the first digit position. The digit that is flashing can be changed by using the arrow keys. The PARAM DISPLAY key advances the flashing digit and the LAST key backs up the digit. You can change any of the part numbers within the rules stated in paragraph 6.3. Be very careful not to enter an illegal part number.

If you are recovering from the DATA LOST mode be sure to enter the complete part number. When the part number is correct push the PARAM DISPLAY key until the next display appears.

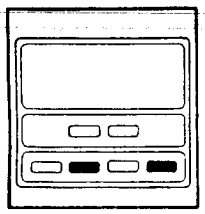


Figure 6-3. Setting the Part Number

6.5 SETTING THE DISPLAYED UNITS (ALSO CONVERTING FROM °C TO °F)

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 UU
TIME H:M

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. UNITS setting starts with the left hand digit. Push the PARAM DISPLAY 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. The left hand position can be a blank. Push PARAM DISPLAY key when units are correct.

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.

In order to convert from °C (centigrade) to °F (fahrenheit), follow the directions to get into the CAL loop.

1. In the CAL loop when the part number is displayed, press the PARAM CHECK key.
2. Controller then displays UNITS _C
   TIME H:M
3. The temperature units of measure are two digits long, where the first digit is blank. The first digit is always to be left blank. Press PARAM CHECK key to move to the second digit in order to change the letter.
4. Press the UP arrow three times until F is displayed.
5. Press the PARM CHECK key until display reads CAL COMPLETE.
6. Press RETURN key.
7. The CN2000 unit is now converted from °C to °F.

6.6 SETTING THE TIME BASE

A time base must be selected when a TIMER alarm is included.

UNITS UU TIME H:M

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

6.7 SETTING THE SPAN

LO SPAN XXXX UU

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 UU

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 for thermocouple and RTD inputs. For certain thermocouples higher limits may be included. Push the UP arrow key to read the maximum programmed limit.

Process type inputs are limited to any span between −3200 and +3200 units. You can assign any display value to the LO SPAN and HI SPAN within these limits and the controller will automatically linearize all values in between. Use the UP and DOWN arrow keys to change values. Advance from LO to HI SPAN using the PARAM DISPLAY key. The LAST Key will back up from HI to LO SPAN. Both direct and reverse spans are allowable.

CONFIGURATION calibration for controllers with thermocouple or RTD input is now complete. If you have this type of controller proceed to paragraph 6.10.

If you have a process input controller, three more displays are available. Push the PARAM DISPLAY key and proceed to paragraph 6.8.

6.8 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 DISPLAY key to advance to the next display.

6.9 SETTING THE DISPLAY RANGE

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

HI VAL XXXX UU	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 reference calibration is required. You can change the displayed range purely through the keypad when a process signal such as 4-20 mA is the input.

6.10 REFERENCE CALIBRATION

At this point in the calibration program the CONFIGURATION calibration has been completed. Three situations may exist.

a) You have completed what you need to do and wish to return the controller to use. Push the PARAM DISPLAY key and proceed to paragraph 6.15.

b) The controller will not advance when you push the PARAM DISPLAY key. Proceed with the following instructions. This occurs usually when calibrating after a DATA LOST/PLEASE CAL.

c) You wish to perform a REFERENCE calibration. Proceed with the following instructions.

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 UU	or	HI VAL XXX UU

If you are not at one of these displays and wish to do a REFERENCE calibration push the PARAM DISPLAY 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 6-4 simultaneously.

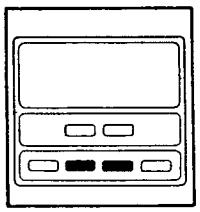


Figure 6-4. Entering the Reference Calibration

CAUTION

ALLOW AT LEAST A 20 MINUTE WARMUP BEFORE ANY REFERENCE CALIBRATION IS ATTEMPTED.

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

6.11 Thermocouple Input Calibration
6.12 RTD Input Calibration
6.13 Process Input Calibration

6.11 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 2 minute interval for the source input to stabilize with the +50.000 mV applied and then push the PARAM DISPLAY 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 stabilize and then push the PARAM DISPLAY key. Proceed to paragraph 6.15.

6.12 RTD CALIBRATION

RTD input controllers should be 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 2 minute interval for the source to stabilize and then push the PARAM DISPLAY key.
INPUT 300 OHMS	Set the RTD calibrator for 300.00 ±.05 ohms. Allow a 2 minute interval for the source to stabilize and then push the PARAM DISPLAY key. For controllers with 0.1 RTD resolution, different inputs may be specified. Follow the instructions provided on the display. Push PARAM DISPLAY key and proceed to paragraph 6.15.

6.13 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 DISPLAY 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 DISPLAY key. Proceed to paragraph 6.15.

6.14 REMOTE SETPOINT CALIBRATION

REMOTE SETPOINT Input can be used in any controller that has been provided with this option. Perform all other calibrations proceeding with this calibration.

To calibrate the REMOTE SETPOINT Input enter the reference calibration program as described in paragraph 6.10 and advance to the following using the PARAM DISPLAY key.

INPUT LO REMSP	Connect the remote voltage or current source to terminals B (+) and F (−) or use the internal +2.45 VDC across terminals C and F to power a remote 10K ohm potentiometer with arm connected to terminal B.

Set the input source to the LO INPUT value that is to correspond to the LO SPAN value previously established. Wait 2 minutes for the system to stabilize and then push the PARAM DISPLAY key.

INPUT HI REMSP	Set the input source to the HI INPUT value that is to correspond to the HI SPAN value previously established. Wait 2 minutes for the system to stabilize and then push the PARAM DISPLAY key. Proceed to paragraph 6.15.

6.15 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 references 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 7 SERVICE INFORMATION & TROUBLESHOOTING

7.1 MAINTENANCE

Some simple preventative steps will help assure optimum performance:

- Keep controller fairly clean and protected from dirt, oil and corrosion.
- Periodically recheck all electrical connections.
- Allow at least 5 minutes for warm-up before starting operation.
- Clean keypad and display with a soft, damp cloth. Solvents or chemcal cleaners should not be used.

If you experience difficulty with a controller, first check all wiring. Also pull the electronic assembly foward 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 sequence has been used and that the set points and tuning values set into the controller are appropriate to the application.

7.2 DIAGNOSTIC DISPLAYS

The controller contains several self-diagnosis programs that will display an appropriate warning when necessary. When any of these displays appear the control output(s) go OFF and the alarm(s) 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 voltage to the controller drops below specification to a low voltage level. Check the AC voltage level and correct if necessary.

RTC FAILURE

RAM FAILURE

If either of these displays appear, try switching the AC power ON or OFF to the controller. If the indication stays the same, the controller must be serviced by authorized personnel.

DATA LOST

PLEASE CAL

This flashing display indicates 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 its internal memory. When this display appears the controller shuts down. Recalibration is a quick and easy procedure which is fully explained in Section 6.

7.3 TROUBLESHOOTING

The troubleshooting information in Table 7-1 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 7-1
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 P.B. adjustment until load cycling is eliminated.

TABLE 7-1 (cont'd)

SYMPTOM	PROBABLE CAUSE	CORRECTIVE ACTION
	Rate time is too short.	Increase rate time adjustment.
4. Controller operating but temperature not at set point and calling for 100% power.	Controller not warmed up.	Wait five minutes for controller to stabilize.
	Improper sizing of heater to load.	Higher wattage heaters are required.
5. Display shows input open.	Thermocouple or input circuit open.	Check thermocouple and extension wire for open circuits.
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 outlined previously, the rate and reset adjustments are set to zero (turned off).
	Cycle time is set too long.	Reduce cycle time.
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 overshoot 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 8 REMOTE START/STOP

The following information pertains to the Remote Start/Stop option for the CN2000 Series Controller. This option is available in two (2) formats: D7 (using terminals B and C, and disables alarm 2) or D7DE (using terminals D and E, and disables output 2).

The remote/start option provides for start/stop control of the unit from a remote location. The start/stop key pad on the CN2000 Series unit remains active and this function may be controlled either from the front panel or the remote location. Units may be alternatively configured for remote actuation from a dry circuit contact closure.

8.1 WIRING

The connections for remote start/stop are through terminals D & E or B & C on the rear terminal strip. Refer to Figure 2-6. Polarity is not important for dry circuit contact closure. The dry circuit contacts are assumed to either a normally open push button or a normally open relay contact suitable for low voltage operation.

8.2 OPERATION

Operation of the remote start/stop circuit is actuated by a contact closure as shown in Figure 8-1. A momentary contact across Terminals B and C (for option D7) or D and E (for option D7DE) is all that is required. The contact must remain closed for a minimum duration of 100 milliseconds to ensure that the controller will recognize the input signal to change state between start and stop.

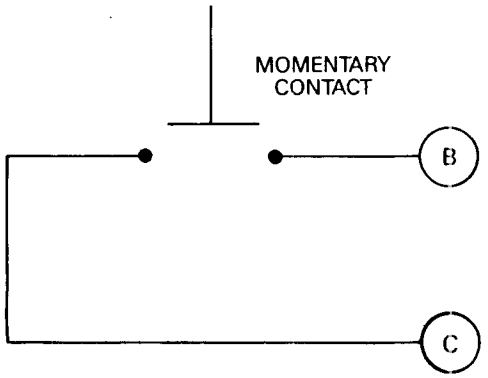


Figure 8-1. Remote Start/Stop Wiring Diagram

SECTION 9 SPECIFICATIONS

INPUTS

LINE VOLTAGE:	117 V ac (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 Ω Platinum (α = .00385)
CURRENT:	4-20 mA
VOLTAGE:	0-5 V dc, 0-10 V dc, 0-100 mV
POWER CONSUMPTION:	8 watts typical
RANGES AND ACCURACY:	See Table 9-1
REPEATABILITY:	±0.5°F
TEMPERATURE STABILITY:	3 μ V/°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 1 AND 2:	Independent, process or deviation, SPDT relay, 1.0 amp @ 120/240 V ac

ADJUSTMENTS

CYCLE TIME:	Adjustable, from 1 to 60 seconds
RATE (DERIVATIVE):	Adjustable, from 0.02 to 5 min. Independent primary and secondary rates
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 primary and secondary bands
ANTI RESET 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

SPECIFICATIONS (cont'd)

OUTPUTS

PRIMARY AND SECONDARY:	Independent
CURRENT:	4 to 20 mA proportional, into 1 kΩ max load
VOLTAGE:	0 to 5 V dc proportional, into min. load at 1 kΩ
SOLID STATE RELAY:	Optically isolated, SPST, normally open at 120/240 V ac
ALARMS:	2 independent, process or deviation type, SPDT relay, normally open, rated 1 amp @ 120/240 V ac
MEMORY:	Non-volatile storage of input linearizations, control and alarm types and actions, and all routines and instructions for all display. Battery protected memory storage of set points,

TABLE 9-1
MEASUREMENT RANGES AND ACCURACY

TC TYPE	SPAN	MAX. ERROR	TC TYPE	SPAN	MAX. ERROR
J	−299/−250°F	±4°F	B	+32/+212°F	−0,+180°F
	−250/+1402°F	±3°F		+121/+590°F	−52,+9°F
				+590/−950°F	±8°F
	−184/−152°C	±2°C		+950/+3259°F	−3,+4°F
	−152/+761°C	±2°C			
K	−341/−100°F	±13°F		0/+100°C	−0/+100°C
	−100/+2482°F	±3°F		+100/+310°C	−27,±6°C
	−207/−73°C	±7°C		+310/+510°C	±5°C
	−73/+1361°C	±2°C		+510/+1793°C	±2°C
R	+32/200°F	−10,+3°F	PLATINEL II	−115/+85°F	±8°F
	+200/+490°F	−5,+3°F		+85/+2500°F	±3°F
	+490/+3199°F	±3°F			
	0/+93°C	−6,+2°C		−82/+29°C	±5°C
	+93/+254°C	−3,+2°C		+29/+1375°C	±2°C
	+254/+1759°C	±2°C	Ni/Ni 18% Mo N	0/+110°F	±4°F
S	+32/+185°F	−8,+3°F		+225/+2390°F	±3°F
	+185/+450°F	−5,+3°F		−15/+1310°C	±2°C
	+450/+3181°F	±3°F	W5%Re/W26%RE °C	+32/+3260°F	±4°F
	0/+85°C	−8,+3°C		0/+2315°C	±2°C
	+85/+232°C	−3,+2°C	W3%Re/W25%Re D	+32/+225°F	−10,+4°F
	+232/+1750°C	±2°C		+225/3260°F	±4°F
T	−380/−300°F	−8,+5°F			
	−300/+741°F	±3°F		+32/+107°C	−6,+2°C
				+107/+2240°C	±2°C
	−230/−184°C	−5,+3°C		+2240/+2371°C	
	−184/+394°C	±2°C			
N	−200/−50°F	±8°F	W/W26%Re G	+32/+220°F	−0,+110°F
	−50/+2300°F	±3°F		+220/+480°F	±15°F
				+480/3260°F	±5°F
	−130/−46°C	±5°C			
	−46/+1260°C	±2°C		0/+104°C	−0,+60°C
				+104/+249°C	±8°C
E	−179/+1610°F	±3°F		+249/+2315°C	±3°C
	−117/+870°C	±2°C			

RTD TYPE	SPAN	MAX. ERROR	RTD TYPE	SPAN	MAX. ERROR
1 DEGREE RES.	−300/−240°F	±4°F	0.1 DEGREE RESOLUTION	−148.0/999.9°F	±.4°F
	−240/+1500°F	±3°F			
	−180/+800°C	±2°C		−100.0/+540.0°C	±.3°C

MAXIMUM LINE RESISTANCE: 1Ω PER LEG

CURRENT AND VOLTAGE RANGES: Nominal Span (−)10 to +65 mV—Typical Burden: +50 mV Full Scale ±2 Counts Maximum Error (−3200 Counts to +3200 Counts Max. Reading Span)

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 OMEGA's customers receive maximum coverage on each product. If the unit should malfunction, it must be returned to the factory for evaluation. OMEGA's 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.

OMEGA is glad to offer suggestions on the use of its various products. Nevertheless, OMEGA only warrants that the parts manufactured by it will be as specified and free of defects.

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SPECIAL CONDITION: Should this equipment be used in or with any nuclear installation or activity, purchaser will indemnify OMEGA and hold OMEGA harmless from any liability or damage whatsoever arising out of the use of the equipment in such a manner.

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Direct all warranty and repair requests/inquiries to the OMEGA ENGINEERING Customer Service Department. BEFORE RETURNING ANY PRODUCT(S) TO OMEGA, PURCHASER MUST OBTAIN AN AUTHORIZED RETURN (AR) NUMBER FROM OMEGA'S 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.

FOR **WARRANTY** RETURNS, 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 under warranty, and
3. Repair instructions and/or specific problems relative to the product.

FOR **NON-WARRANTY** REPAIRS OR **CALIBRATION**, consult OMEGA for current repair/calibration charges. Have the following information available BEFORE contacting OMEGA:

1. P.O. number to cover the COST of the repair/calibration,
2. Model and serial number of product, and
3. Repair instructions and/or specific problems relative to the product.

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