

ELT 171: Process Control Instrumentation

Lab 11: Temperature control loop

Objectives

- Assemble a simple process control loop for temperature control
- Program a PID controller for temperature control
- Observe how disturbances affect a process loop

Required Materials

- (1) CN96411TR autotune temperature controller
- (1) SCR19Z-12-040 power controller
- (1) CSS-404350/120V cartridge heater
- (1) RTD Probe, 100 ohm platinum, alpha 385, Sensor Tec Inc.

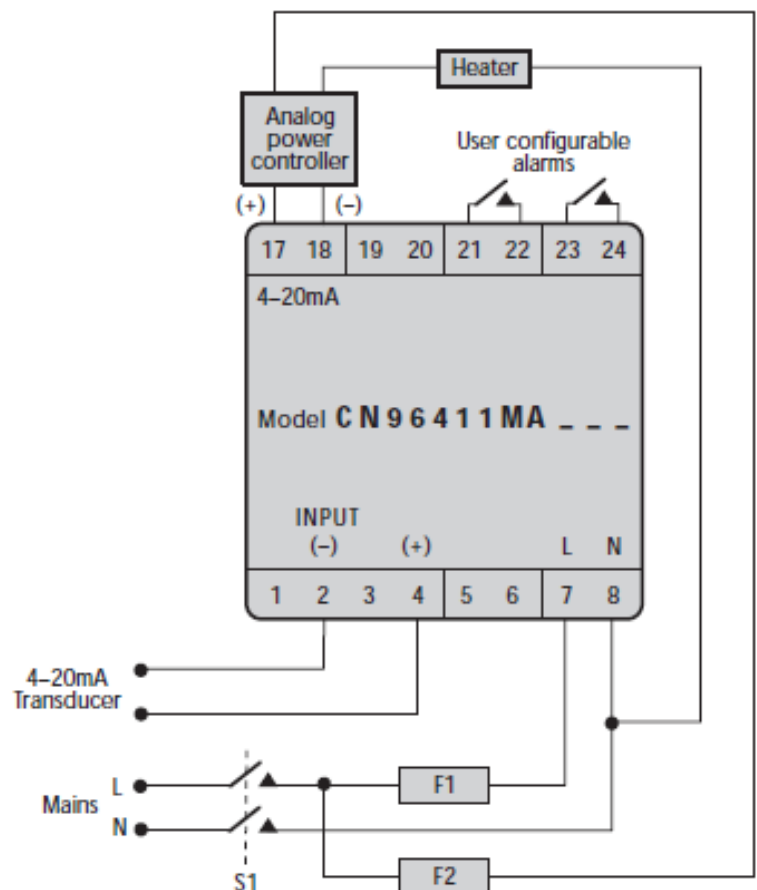


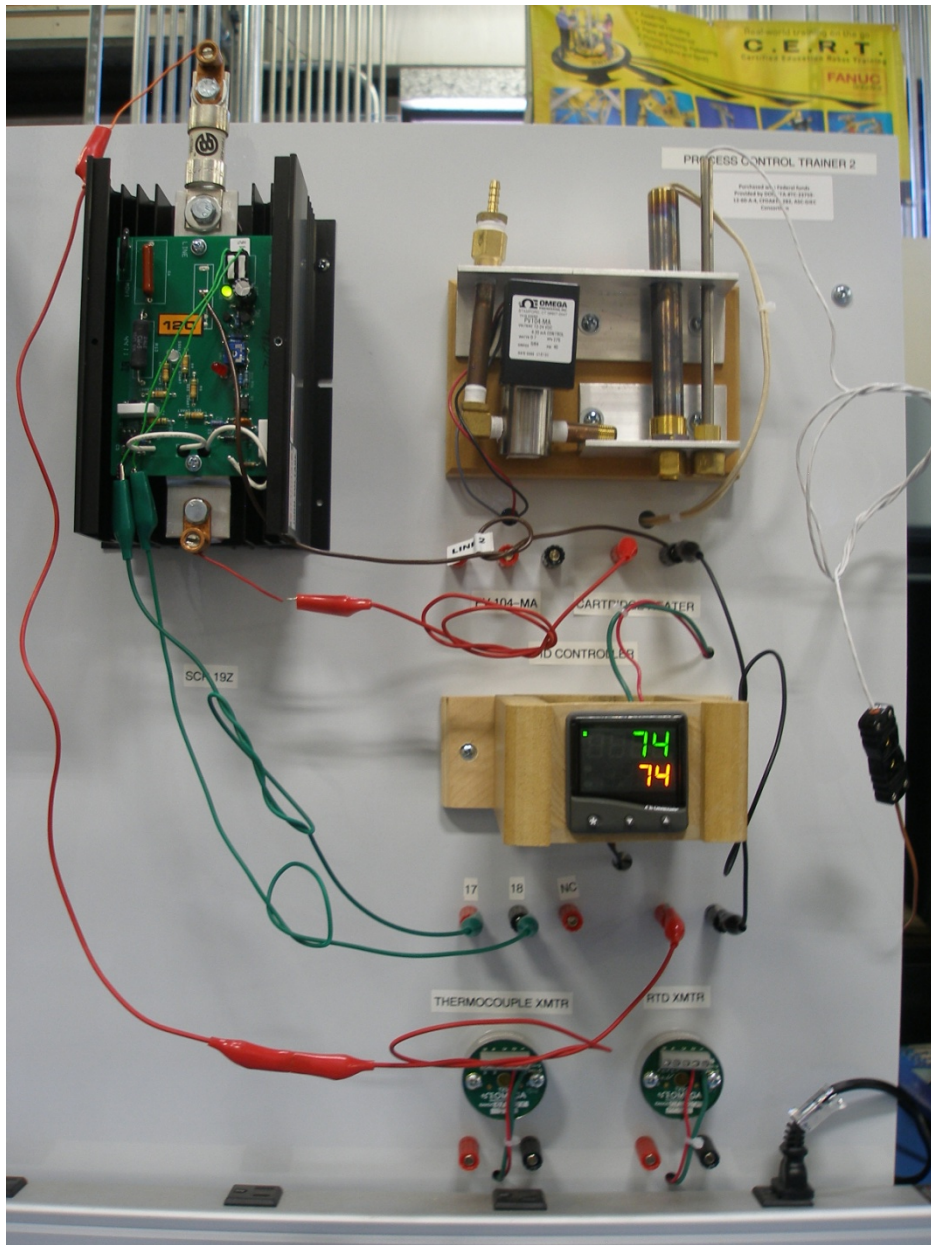
Introduction

The temperature control loop consists of a PID autotune temperature controller, an SCR power controller hooked up to a cartridge heater and monitored via a RTD. This is a 4-20mA control loop. The basic setup is shown at right. The 4-20mA transducer input is connected to the RTD. The analog power controller 4-20mA output is connected to the input to the SCR controller which sends a varying width pulse to the cartridge heater.

Note that in the illustration at right that the “analog power controller” is the SCR and that the 4-20mA transducer is the RTD. See the setup photo on the next page.

TYPICAL APPLICATION





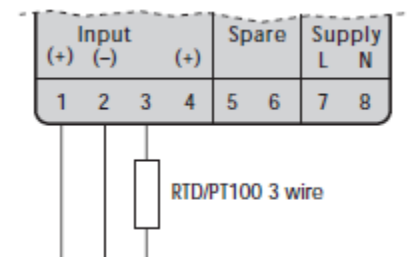
Procedure

On the process control trainer board, connect the circuit as shown. Note the following wiring:

- The brown wire on the SCR connects to black line power (hot).
- The LINE output of the SCR (with fuse) connects to the black line power (hot).
- The LOAD connection goes to the cartridge heater.
- The other cartridge heater lead connects to the white power line (neutral).

On the PID controller:

- The white (neutral) line connects to terminal 8.
- The black (hot) line connects to terminal 7.



- The RTD positive lead (red) connects to terminal 3.
- The RTD negative lead connects to terminal 2.
- Install a jumper between terminals 1 and 2.
- The 4-20mA lines to the SCR are as follows:
 - Positive to terminal 17
 - Negative to terminal 18

INSTRUMENT PANEL FEATURES

! This page can be photocopied and used as a visual aid and bookmark when working in other parts of the manual.



ADJUSTMENTS

To enter or exit **program mode:**

To scroll through **functions:**

To change **levels** or **options:**

To view setpoint units:

To increase setpoint:

To decrease setpoint:

To reset latched alarm or tune fail:

To run or Hold a program:

Press ▲ ▼ together for 3 seconds

Press ▲ or ▼

Press * ▲ together or * ▼ together

Press *

Press * ▲ together

Press * ▼ together

Press ▲ ▼ together briefly

Press * ▼ together for 3 seconds

Notes: If in difficulty by becoming "lost" in program mode, press ▲ and ▼ together for 3 seconds to return to display mode, check the INSTRUMENT ADJUSTMENTS above and try again.

When in program mode, after 60 seconds of key inactivity the display will revert to either *inPt : nonE* or, if the initial configuration has been completed, the measured value. Any settings already completed will be retained. During Program Configuration it is recommended that this feature is inhibited. Select *ProG StAY* in Level 4.

INPUT SENSOR SELECTION

Temperature sensors

Getting started

After power-up the controller requires programming with the following information:

Type of Sensor (See list at right)

Operating unit °C °F bAr P*S*i Ph rh SEt

Allocation of Output Device to SP1/SP2 (Relay / SSd) or analog. SP3 is always relay.

Setpoint

Thermocouples	Description	Sensor range	Linearity
tC b	Pt-30%Rh/Pt-6%Rh	0 to 1800 °C	2.0 *
tC E	Chromel/Con	0 to 600 °C	0.5
tC J	Iron/Constantan	0 to 800 °C	0.5
tC K	Chromel/Alumel	-50 to 1200 °C	0.25*
tC L	Fe/Konst	0 to 800 °C	0.5
tC n	NiCrosil/NiSil	-50 to 1200 °C	0.25*
tC r	Pt-13%Rh/Pt	0 to 1600 °C	2.0*
tC s	Pt-10%Rh/Pt	0 to 1600 °C	2.0*
tC t	Copper/Con	-200 / 250 °C	0.25*
Resistance thermometer rtd 2/3 wire	Pt100/RTD-2/3	-200 / 400 °C	0.25*

When the above information has been programmed into the controller it will be operational with factory PID settings.

Initial set-up

On power-up the controller will display the self test sequence followed by the initial display inPt : none

1. Select input sensor

Press and hold the ▲ or ▼ buttons at the same time. Press ▼ to scroll back through options until “Level” is displayed. Press * and ▲ to reach “Level 2.” Press ▲ ten times to reach “Input.”

Press * and ▲ or ▼ to scroll through options for “RTD.”

LINEAR INPUT

When Linear Input is selected, the display resolution of the setpoint and many other functions will be changed from the setting previously made at di.SP in Level 2, to that set at dECP in Level A.

It is therefore recommended that on completion of the Initial Set-up the Linear Input settings in Level A be completed before moving on to configure Levels 1, 2 and 3.

2. Select operating unit

Press and hold * and use the ▲ or ▼ buttons to scroll through the unit selection list until the correct unit is displayed. Release the buttons. The display will read selected unit e.g. unit: °C Press ▲ once the display will now read SP1.d: none

3. Select SP1 (Main setpoint output device)

Press and hold * and use the ▲ or ▼ buttons to select from the choices **Rly**, **SSd** or

AnLG depending on the model supplied. SP2 and SP3 outputs will be automatically allocated. (See output options table below).

Output Options Table

Model	SP1 Output	SP2 Output	SP3 Output
CN96111	<i>RLY</i>	<i>RLY</i>	<i>RLY</i>
CN96211	<i>SSd</i> <i>RLY</i>	<i>RLY</i> <i>SSd</i>	<i>RLY</i> <i>RLY</i>
CN96221	<i>SSd</i>	<i>SSd</i>	<i>RLY</i>
CN96(*)11	<i>AnLG</i> <i>RLY</i>	<i>RLY</i> <i>AnLG</i>	<i>RLY</i> <i>RLY</i>
CN96(*)21	<i>AnLG</i> <i>SSd</i>	<i>SSd</i> <i>AnLG</i>	<i>RLY</i> <i>RLY</i>

4. To enter initial configuration into controller memory

Press and hold both ▲ and ▼ buttons for 3 seconds. The display will now read **PArK** and measured variable (e.g. ambient temperature 23°). **PArK** is displayed because a setpoint has not yet been entered.

To display setpoint units

Press and hold * The displays will now read **unit** (eg. °C) and **0**.

To enter setpoint

Press and hold * and use ▲ button to increase or ▼ button to decrease the reading and scroll to required setpoint value. (The digit roll-over rate increases with time).

THE CONTROLLER IS NOW OPERATIONAL WITH THE FOLLOWING FACTORY SETTINGS AS FOLLOWS:

Proportional band/Gain 10°C/18°F/100 units

Integral time/Reset 5 mins

Derivative time/Rate 25 secs

Proportional cycle-time 20 secs

(Typical setting for relay output)

DAC Derivative approach control 1.5

(Average setting for minimum overshoot)

Note: For more precise control or for non temperature applications where a **Linear input** transducer is being used, the controller may need to be tuned to the process.

Please refer to the following section on AUTOTUNE.

AUTOTUNE

This is a single shot procedure to match the controller to the process. Select either **Tune** or **Tune at Setpoint** from the criteria given below.

The **Tune** program should be used for applications other than those listed under **Tune at Setpoint** below. The procedure will apply disturbances when the temperature or process reaches 75% of the setpoint value, causing overshoot which is monitored in order to adjust the **DAC** overshoot inhibit feature. Care should be taken to ensure that any overshoot is safe for the process.

The **Tune at Setpoint** program is recommended when:

- The process is already at setpoint and control is poor
- The setpoint is less than 100°C in a temperature application
- Re-tuning after a large setpoint change
- Tuning multi-zone and/or heat-cool applications.

Notes: **DAC** is not re-adjusted by Tune at setpoint. **Proportional Cycle Time** can be preselected before running the Autotune program. (see page 5).

TUNE OR TUNE AT SETPOINT PROGRAM

Enter program (▲ and ▼) and from the display **tunE : oFF** press and hold * and press ▲ to display **tunE : on** or **tunE : At.SP** Exit program mode (▲ and ▼).

The **TUNE** program will now start. The display will show **tunE** as the process variable climbs to setpoint.

Note: Avoid tuning while running a program as SP1 may be different from the target setpoint.

When the **TUNE** or **TUNE AT SETPOINT** program is complete the PID values are entered automatically. The process will rise to setpoint and control should be stable. If not, this may be because optimum cycle time is not automatically implemented. To set the cycle time, see **PROPORTIONAL CYCLE-TIME** below.

PROPORTIONAL CYCLE-TIME

The choice of cycle-time is influenced by the external switching device or load. eg. contactor, SSR, valve. A setting that is too long for the process will cause oscillation and a setting that is too short will cause unnecessary wear to an electro-mechanical switching device.

Factory set

To use the 20 sec factory set cycle-time no action is needed whether autotune is used or not.

To Manually Select AUTOTUNE Calculated CYCLE-TIME

When AUTOTUNE is completed, enter program (▲ and ▼) and select **CYC.t** in **Level 1**. The display will read **CYC.t : 20** (the factory setting).

To view the new calculated optimum value, press and hold both * and ▼ buttons until indexing stops. The calculated value will be displayed eg. **A16**. If acceptable, exit program (▲ and ▼) to implement this setting.

To Pre-select Automatic Acceptance of AUTOTUNE Calculated CYCLE-TIME

Before AUTOTUNE is initiated select **CYC.t** in **Level1**, press and hold both * and ▼ buttons until indexing stops at **A --** . Exit program (▲ and ▼) to accept calculated value automatically.

To Manually Pre-select Preferred CYCLE-TIME

Before AUTOTUNE is initiated select **CYC.t** in **Level 1**, press and hold both * and ▲ or ▼ buttons until indexing stops at preferred value then exit program (▲ and ▼) to accept.

CYCLE-TIME RECOMMENDATIONS

Output Device	Factory Setting	Recommended Minimum
Internal relays	20 seconds	10 seconds
Solid state drives	20 seconds	0.1 seconds

Programming

For users with previous experience of configuring programmers, the Function List and Functions Map respectively will be reasonably self explanatory.

The Functions and their Settings are grouped to maximize speed of Programming. New users should take a short time to study the following before starting to configure the first program, and may wish to take on board the following tips and suggestions.

Program Mode Exit switch (ProG/Auto) Program Level 4.

This standard feature of the Model CN9600 causes automatic exit from program mode after sixty seconds of Key inactivity. It is highly recommended that this setting be disabled and changed to ProG/StAy to ensure that adequate time is available for making unfamiliar adjustments.. It may also be useful at this point to consider the setting also on,Level 4, SEt.L that enable the Programmer menu entry point to be changed from its default position to the point of last exit.

Program Parameter List

Listing the required Program Settings and Parameter Values segment by segment beside each Setting/Segment Number, and Program Display Mnemonic will reduce the risk of programming mistakes during the learning period.

Memorize Basic Key Functions

Use the Function Map on pages 14 and 15 to become familiar with the following Menu

Navigation principles

Hold both (▲ and ▼) for three seconds to enter or exit Program Mode.

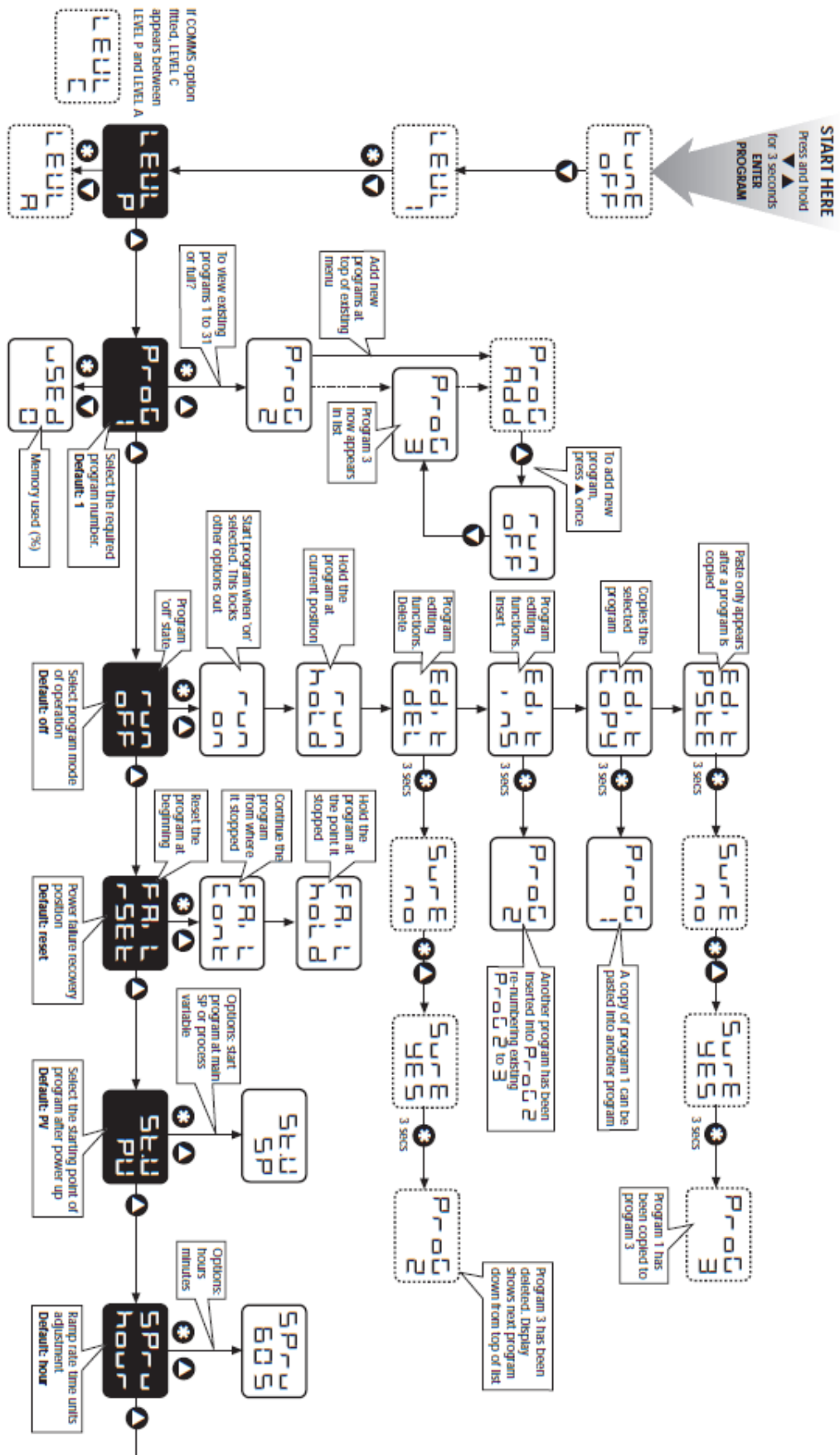
Key either *▲ or *▼ to view Functions (follow horizontal arrows).

Key either ▲ and ▼ to view or change settings (follow vertical arrows).

Key * and hold for three seconds to confirm Edit Functions.

Note: Factory Settings appear in the lower display in each of the Functions illustrated in the Function Map.

PROGRAMMER FUNCTION MAP



Testing the loop

1. Adjust your setpoint to 95 degrees,
2. Set the PID controller to tune.
3. Observe the controller as it comes up to temperature.
4. Once stable, disconnect the RTD and describe what happens.

5. Get a piece of ice and hold it against the RTD and describe what happens.

6. Remove the ice from the RTD and describe what happens.

7. What would happen if you blew hot air on the RTD? How would the loop react?

*** end of lab 11 ***