ANALYTICAL PROCESS CONTROL

7

LEARNING ACTIVITY PACKET

LOOP CONTROLLERS

AMATROL®

B33303-AB07AEN

LOOP CONTROLLERS

INTRODUCTION

A loop controller is the brain of the process control loop. It is the device that receives the feedback signal from the sensor and creates the output signal that maintains the process variable at the desired value. Controllers are an essential component in any control loop that requires a high level of accuracy.

This LAP covers the various functions of controllers. It also covers how to view and interpret different controller parameters.

ITEMS NEEDED

Amatrol Supplied

1 T5554 Analytical Process Control Learning System

1 T5554-C1-A Single-Loop PID Controller or
T5554-C2-A Dual-Loop PID Controller

School Supplied

1 Municipal Water Supply

1 Digital Multimeter

FIRST EDITION, LAP 7, REV. A

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SEGMENT 1

LOOP CONTROLLERS

OBJECTIVE 1 **DESCRIBE TWO CATEGORIES OF LOOP CONTROLLERS AND GIVE AN APPLICATION OF EACH**

Read This

Controllers are the decision-making devices in a control loop. They compare the information received from the process with the desired set point and correct the signal to the final control element to maintain the process at the setpoint.

There are two categories of process controllers:

• Pneumatic Controllers
• Electronic Controllers

Pneumatic Controllers

Pneumatic controllers, like the one in figure 1, use air inputs and outputs to sense the process variable and send error signals that correct for disturbances in the process.

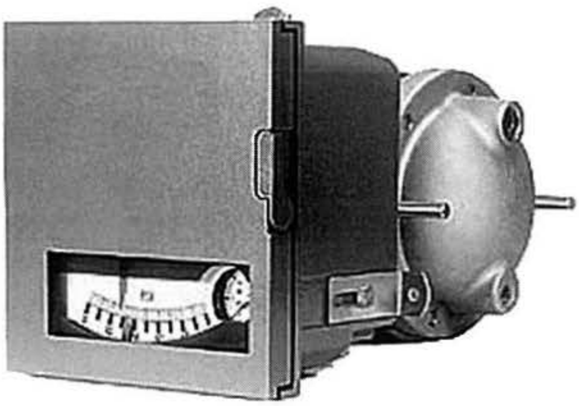


Figure 1. Pneumatic Controller

Figure 2 shows an example of the basic signal flow to and from a pneumatic controller. The controller corrects disturbances in the process according to the setpoint (SP) and feedback signal.

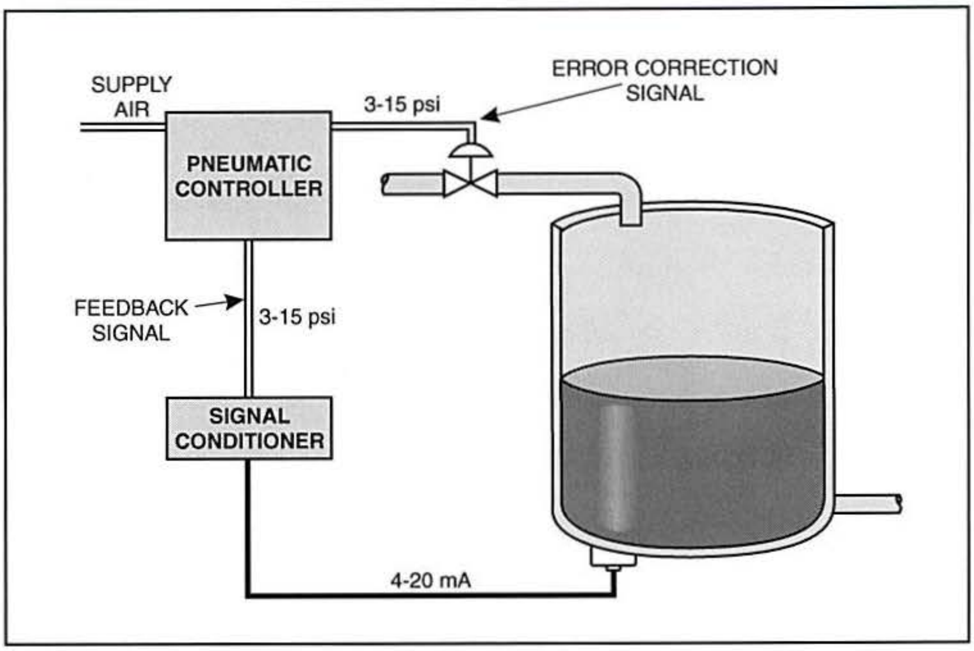


Figure 2. Basic Signal Flow for a Pneumatic Controller

The advantage of pneumatic controllers is that they are typically well suited for use in remote locations that do not have sufficient electrical power or in locations where the use of electricity could pose a danger. A painting process is an example of one of these locations.

Flammable vapors suspend in the air when paint is sprayed. An electronic controller could cause an electrical arc or spark that could result in a fire or explosion. Pneumatic controllers eliminate this hazard while providing control for the process.

Electronic Controllers

Electronic controllers, like the one in figure 3, use electrical inputs and outputs to sense the process variable and send error signals that correct for disturbances in the process.

Figure 3. Electronic Controller

Figure 4 shows an example of the basic signal flow to and from an electronic controller. Like a pneumatic controller, electronic controllers correct disturbances according to the setpoint (SP) and the input signal. However, the signals are electrical.

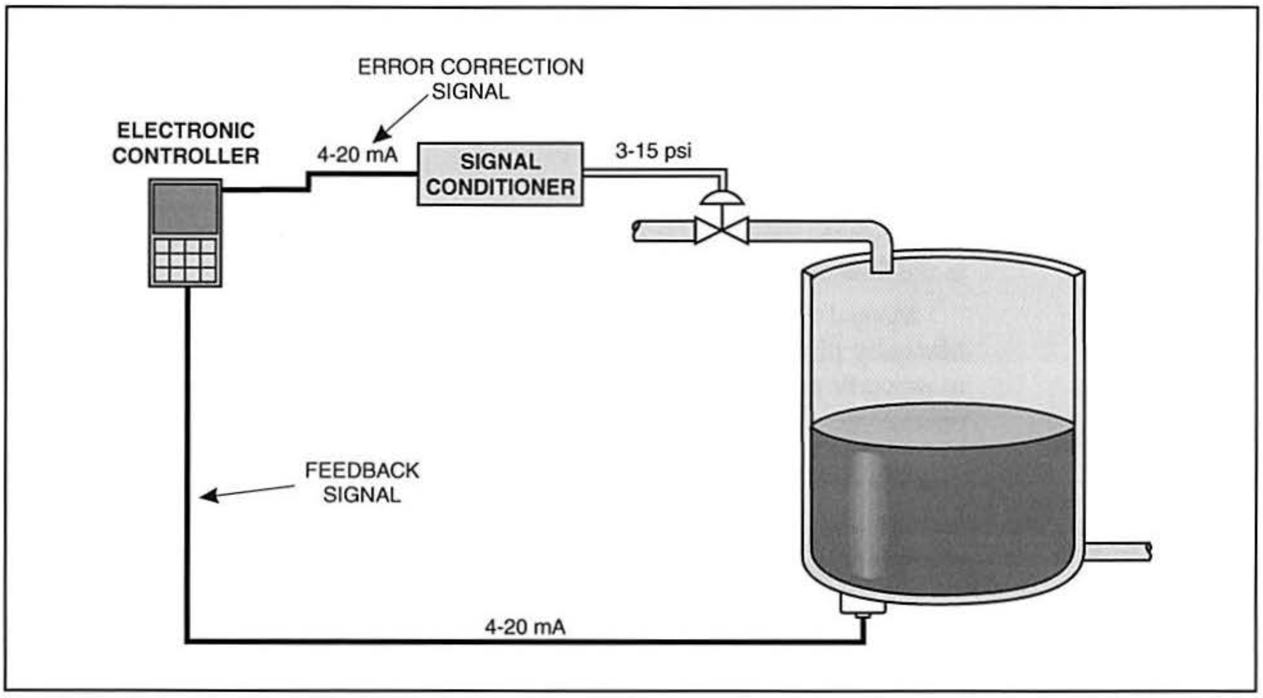


Figure 4. Basic Signal Flow for an Electronic Controller

Electronic controllers are the most widely used and diverse controllers available today. They are extremely accurate and can process information at a very fast rate. Electronic controllers are also highly reliable and easy to maintain and operate.

In addition, an operator or technician can easily configure an electronic controller using several methods such as using a PDA to program the controllers via an IR (infrared) port, using an external PC to program the controller via a network connection, or by using the built-in keys on the controller. These factors make them highly desirable for a number of applications, including heating and cooling systems, chemical mixing systems, and others.

Programmable Logic Controllers (PLCs) and computers are also included in the electronic controller category.

OBJECTIVE 2	DESCRIBE FOUR FUNCTIONS OF AN ELECTRONIC LOOP CONTROLLER

Read This

Most electronic loop controllers offer four common control functions:

- Manual Control
- On/Off Control
- Automatic Control
- Alarms

Manual Control

When the controller is in manual mode, the operator adjusts the output signal to the final control element manually, as figure 5 shows.

Manual control is very helpful when designing or troubleshooting a process. Manually placing demands on the system allows the operator to determine how to properly program the controller to respond to similar demands during normal operations.

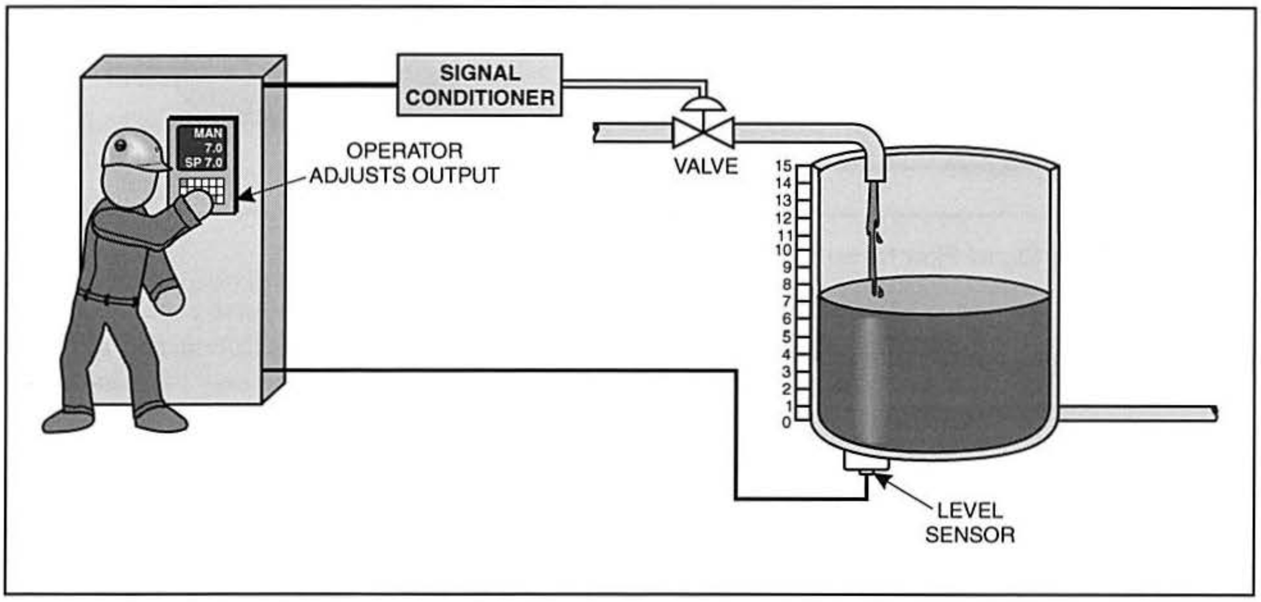


Figure 5. Manual Closed Loop Control System with an Electronic Controller

On/Off Control

Many electronic controllers have an on/off control mode for basic control of a process. In this mode, the controller uses built-in relay contacts wired to a final control element such as a solenoid valve, which is either on or off. The input sensor is an analog type but the controller turns the valve on or off based on predetermined sensor settings.

Figure 6 shows an example of an on/off level control system that uses an electronic controller. The high and low level limits are set in the controller. When the level is below the low limit, the controller opens the solenoid valve. When the level rises above the high limit, the controller closes the solenoid valve.

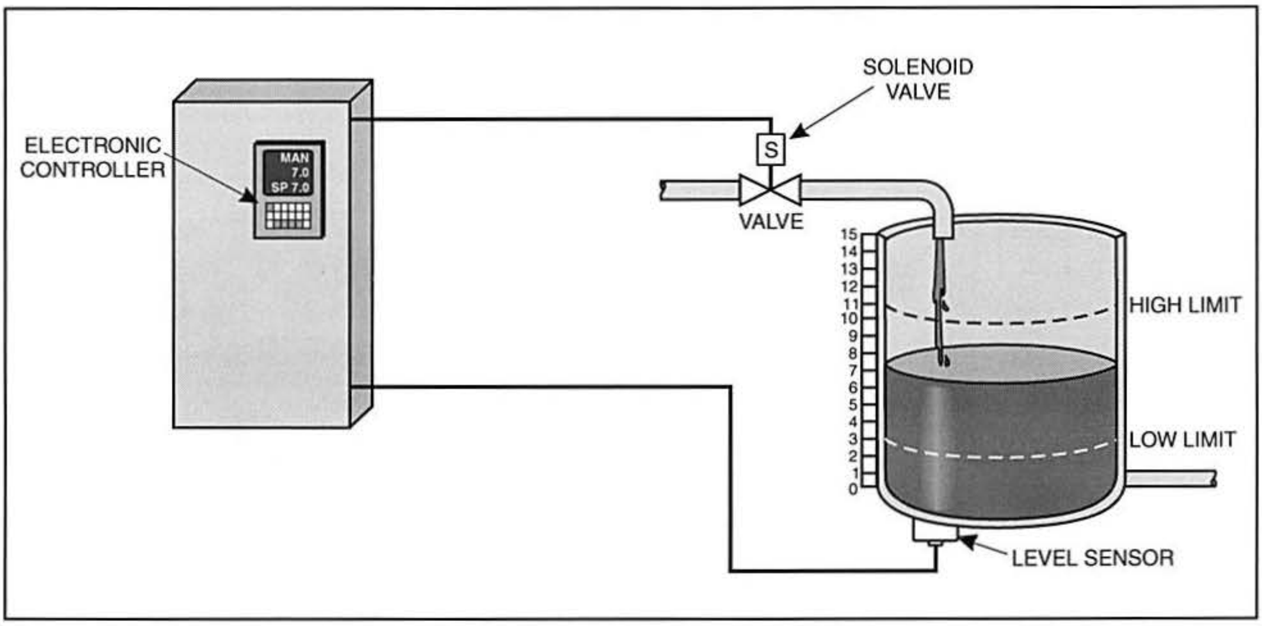


Figure 6. On/Off Level Control System using an Electronic Controller

Automatic Control

The most commonly used function of an electronic controller is automatic control. In this mode, controller parameters are programmed so that the controller automatically makes adjustments to the final control element (e.g. a valve) to maintain the setpoint. The controller increases or decreases the signal to the final control element to precisely control the process.

Figure 7 shows an example of an electronic controller being used in an automatic level control process. The controller monitors the level feedback from the level sensor and adjusts the output signal to the valve. This allows the controller to control the flow into the tank so that the level is maintained at the setpoint.

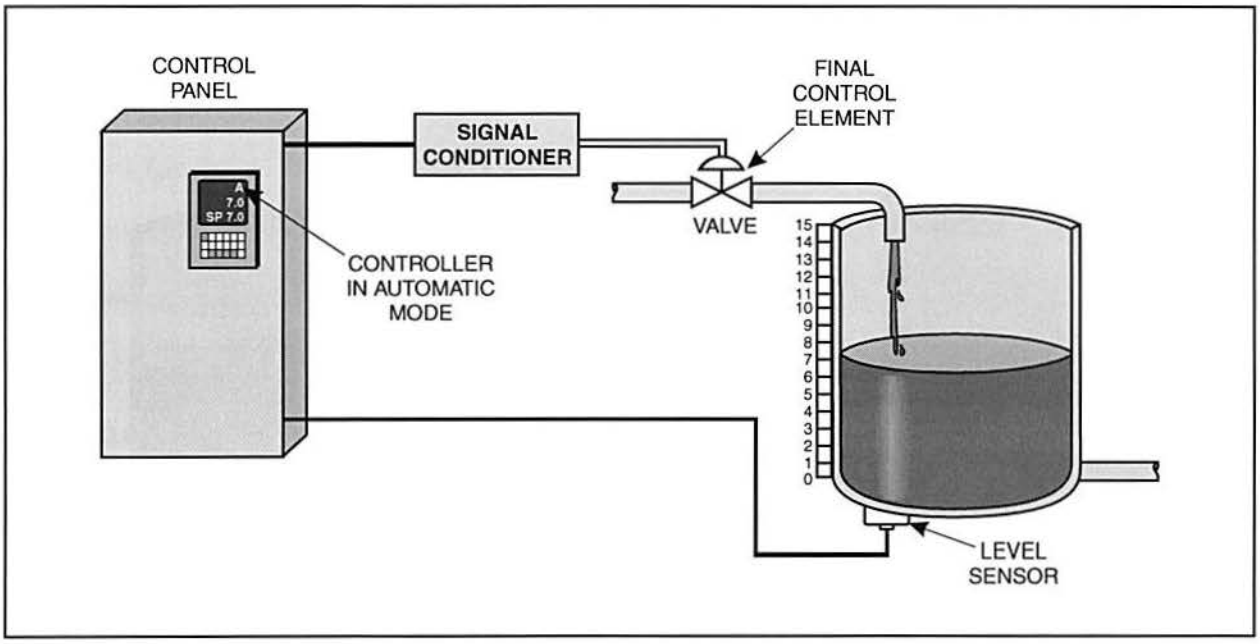


Figure 7. Automatic Level Control Process

Alarms

In addition to being used for control, the relay contacts in electronic controllers can also be used to control alarms. Alarms alert the operator to abnormal conditions in the process. For example, figure 8 shows a level control system that contains a high and low level alarm. The values of the high level and low level are programmed into the controller.

The alarm outputs can be connected to indicator lamps that signal an operator to adjust the input flow before the controller forces the valve to close. This decreases the frequency of oscillation in the system and prevents upsets in the process.

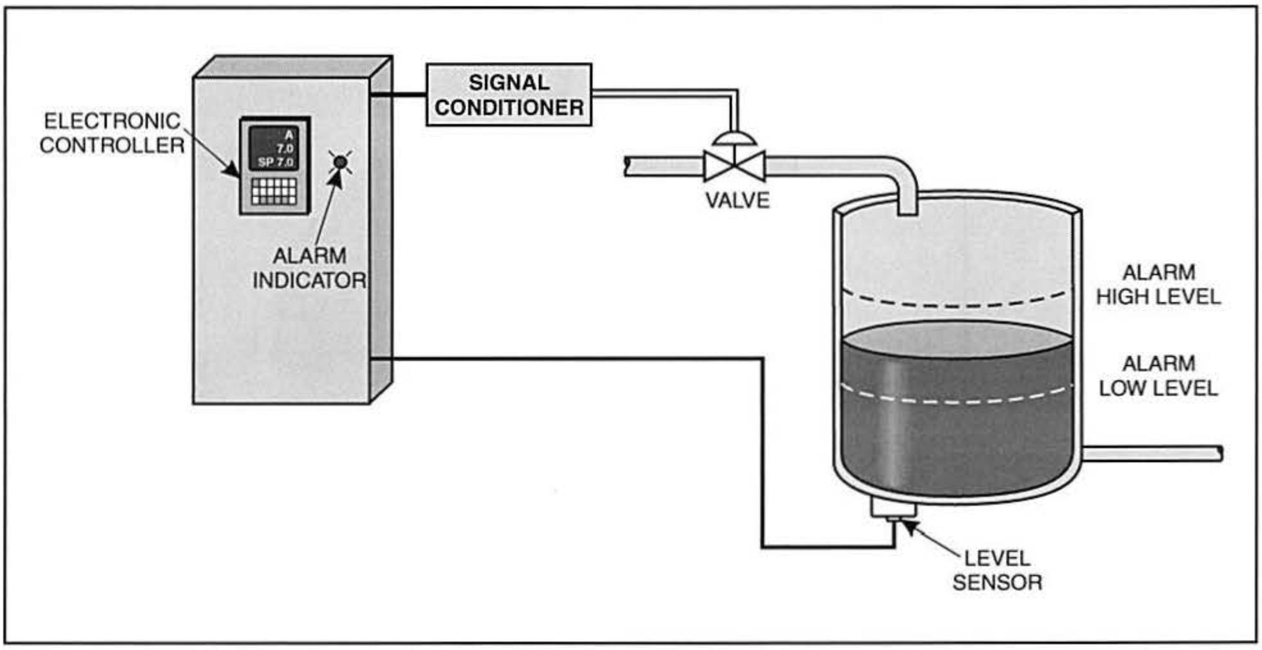


Figure 8. On/Off Level Control System with Alarms

OBJECTIVE 3 DESCRIBE THE CONSTRUCTION OF AN ELECTRONIC LOOP CONTROLLER

Read This

Most electronic controllers have four major components:

- Display Panel
- Control Panel
- Body
- Connection Terminals

Figure 9 shows an example of an industrial electronic loop controller, the Honeywell Model UDC 3500.

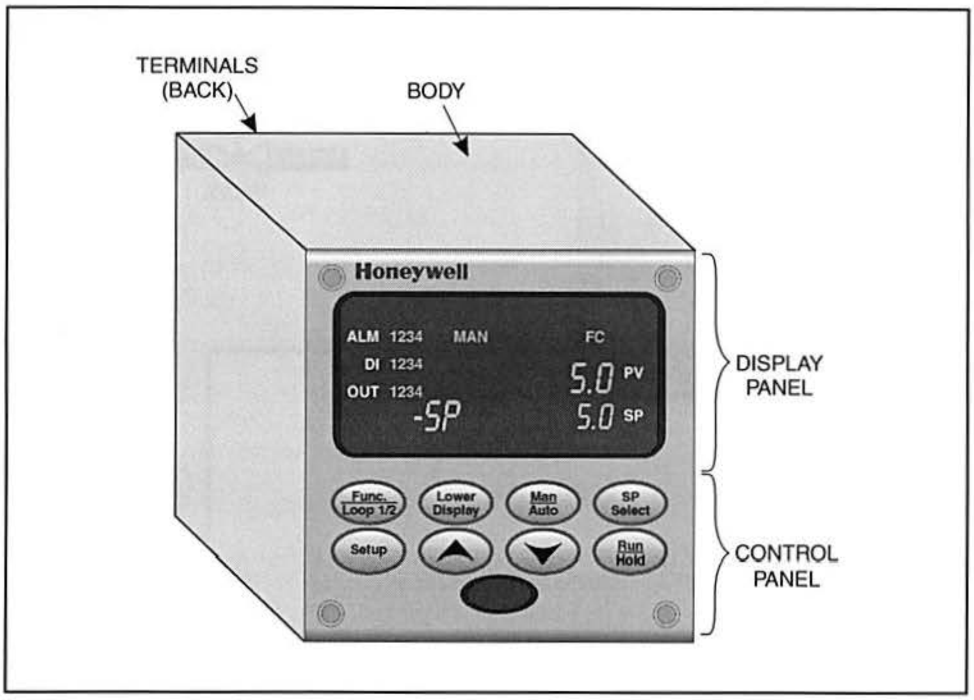


Figure 9. Construction of an Electronic Controller

Display Panel

The display of most electronic loop controllers, like the one in figure 10, can be divided into four common areas:

- **Functions Area -** This area displays the current status of the controllers operating functions such as active alarms, active digital inputs, and active output relays.
- **Process Variable/Setpoint Area -** This area displays the value of the process variable and the setpoint for the controller. Some controllers display the SP and PV at the same time while others require toggling between them. Other values such as output percentage and deviation (difference between SP and PV) may be displayed here as well.
- **Mode Area -** This area of the display panel indicates if the controller is in manual or automatic mode.
- **Units Area -** The units area is used to display the measurement units being used. For example, F indicates temperature measurement in degrees Fahrenheit and C indicates temperature measurement in degrees Celsius.

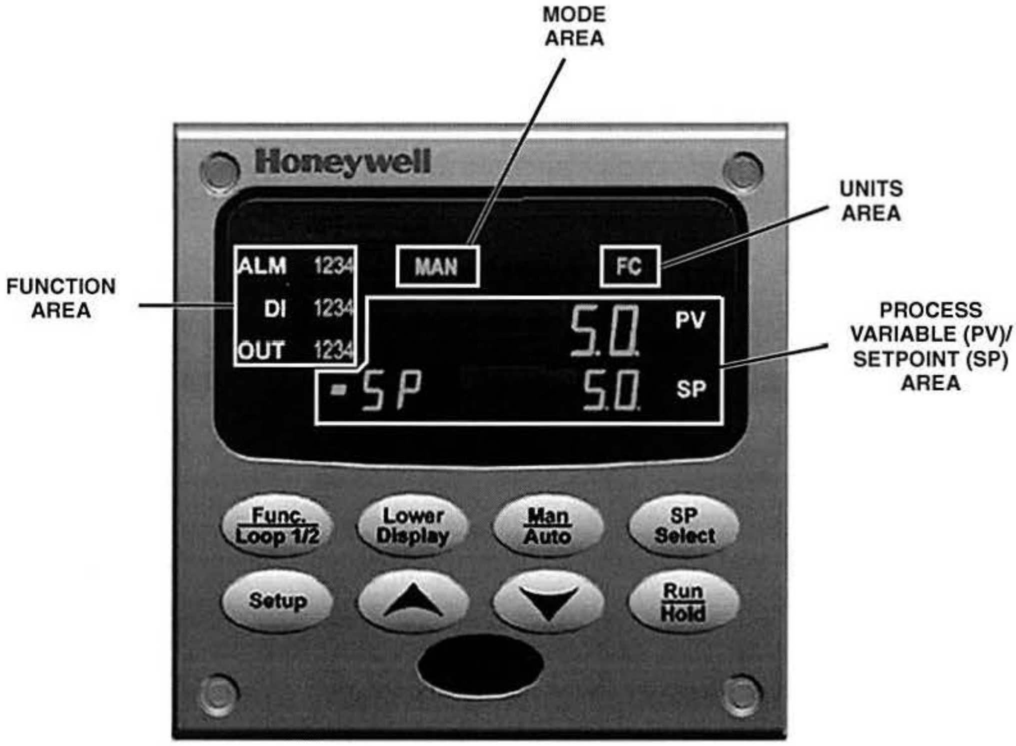


Figure 10. Electronic Loop Controller Display Areas

Control Panel

The control panel typically contains the keys necessary to navigate the different programming groups of the controller. The control panel may also include some type of communication port such as an infrared (IR) port. For example, the control panel of the Honeywell UDC 3500 controller shown in figure 11 consists of the following:

- **Setup Key** - Allows navigation through all of the programming groups within the setup menu.
- **Func Loop 1/2 Key** - Allows navigation through the different parameters within a selected programming group.
- **Lower Display Key** - Allows the operator to return the controller to normal display from the setup mode (programming). It also allows the operator to toggle the displayed value in the lower display.
- **Man/Auto Key** - Allows the operator to switch the controller between manual and automatic control modes.
- **SP Select Key** - Allows the user to choose between the different setpoints that have been programmed into the controller.
- **Run/Hold Key** - Allows the operator to start or hold a setpoint program. For example, the controller could be programmed to change from one setpoint to another over a certain period of time.
- **Up/Down ▲ ▼ Keys** - Allows the operator to change parameter values and scroll through some menus.
- **Communication Port** - An infrared port that allows the controller to be programmed remotely using a PDA or laptop computer equipped with an infrared port.

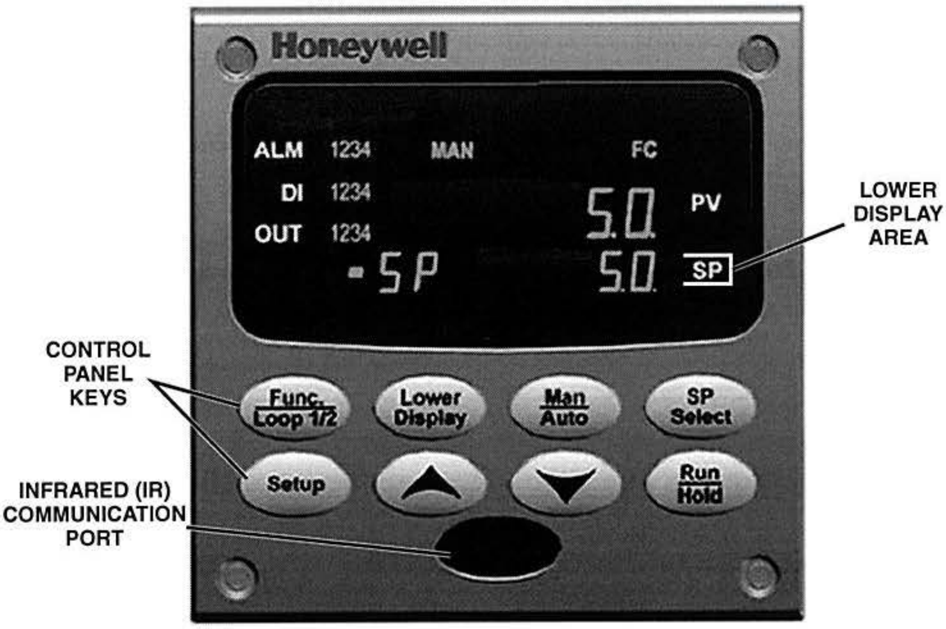


Figure 11. Control Panel Keys on a Honeywell Controller

Body

The body consists of a metal or plastic enclosure and the internal circuitry. The enclosure protects the controllers internal circuitry and allows the controller to be easily mounted to a panel.

The internal circuitry includes a processor, memory, solid-state relays, electro-mechanical relays, communication boards, and other devices, as shown in figure 12. The internal circuitry is very specific to the controller and depends on its types of functions and capabilities. All electronic controllers have power wiring as part of the internal circuitry and most include a printed circuit board that holds the processor and memory.

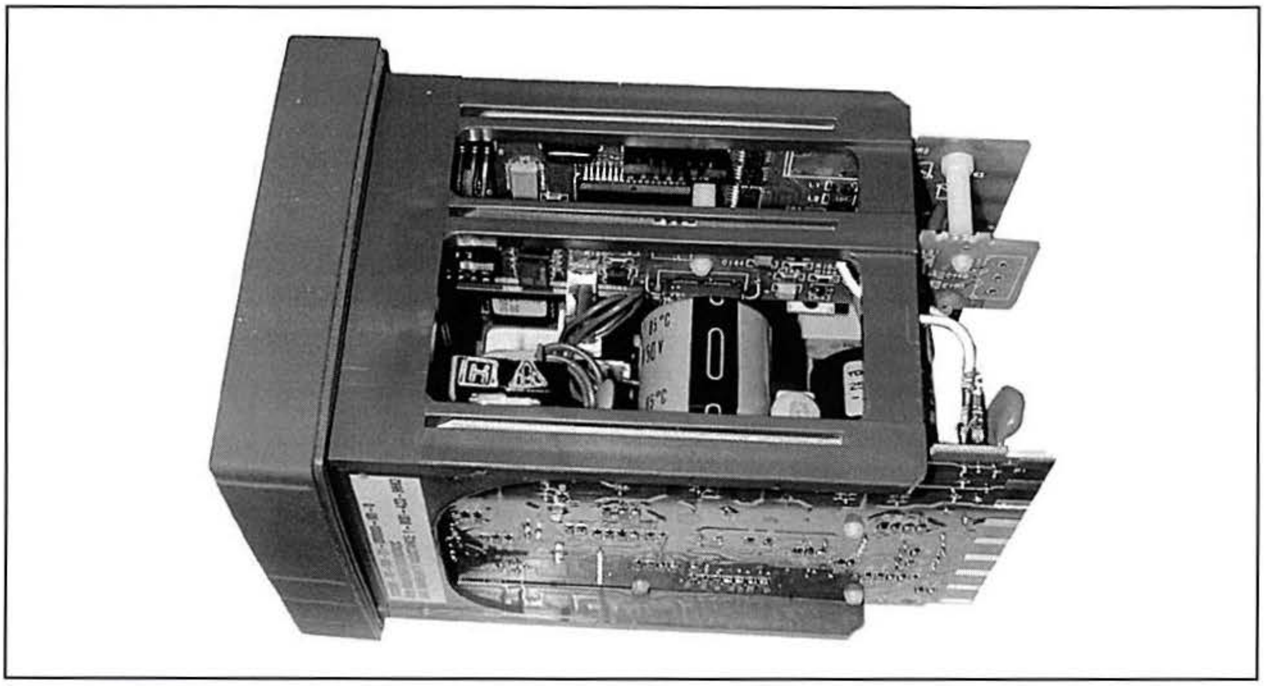


Figure 12. Internal Circuitry of an Electronic Controller

Connection Terminals

The connection terminals are located on the rear panel of the controller. These terminals include connections for power, input devices, communication devices, outputs to other devices, and analog and digital input signals. Figure 13 shows the connection terminals for a Honeywell UDC 3500 controller.

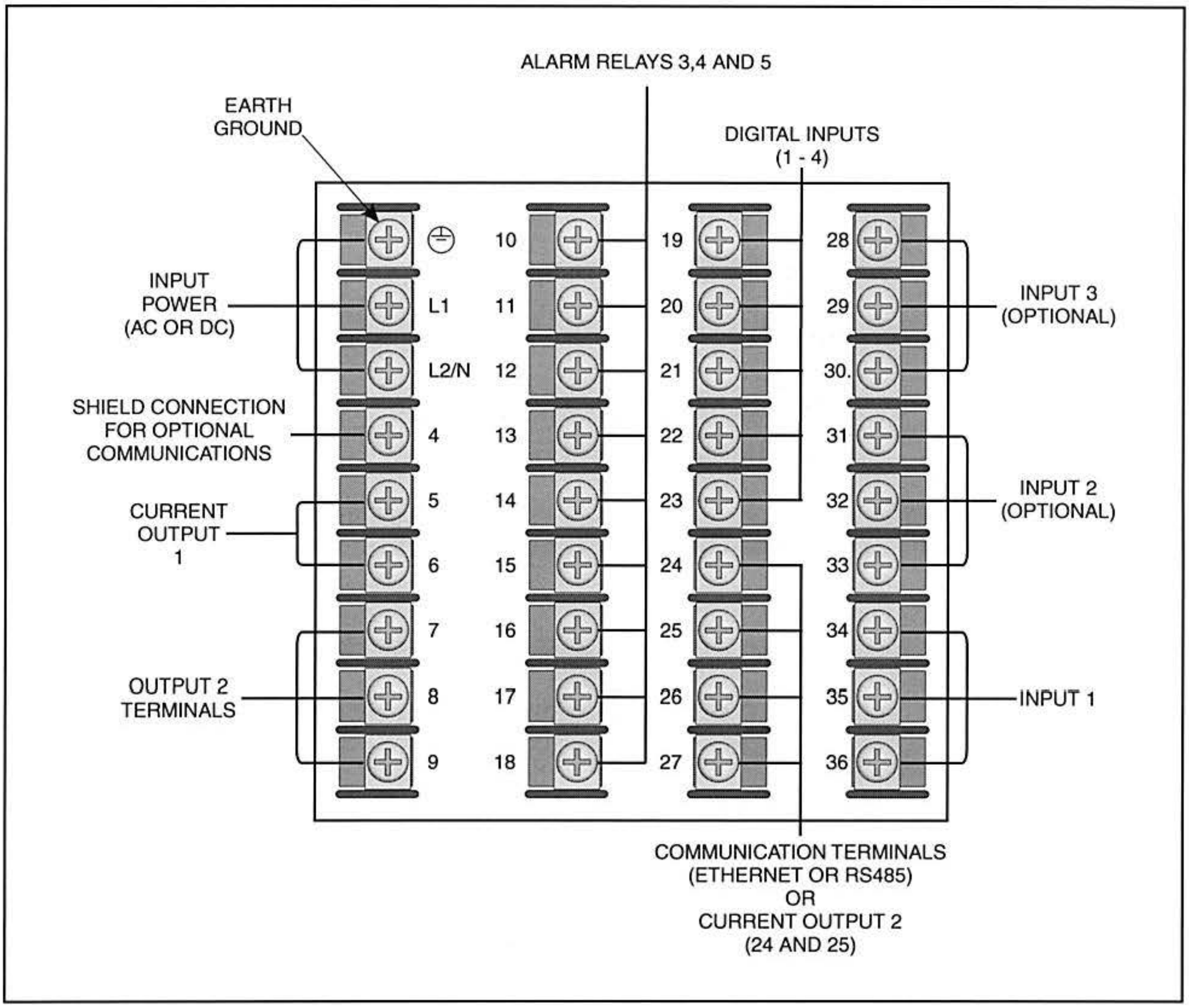


Figure 13. Configuration of Connection Terminals

Terminals 1-3 are used to connect input power to the controller. Terminal 1 is an earth ground connection. Terminals 2 and 3 have the appropriate input voltage, either AC or DC, connected to them. Common inputs voltages include 120 VAC or 24 VDC.

Terminal 4 is a shield connection that is used with the Ethernet or RS485 Communication Options. If the Communications Option is not used, terminal 4 is not used.

Terminals 5 and 6 are connections for Current Output 1. This output, typically 4-20 mA, is used to control the final control element in a process control loop.

Terminals 7-9 are the connections for Output 2. These terminals may be used several different ways, depending on the configuration of the controller. For example, figure 14 shows that Output 2 could be configured as a dual relay (Alarm relays 1 and 2), a single relay (Alarm relay 1), a solid state relay, an open-collector output, or an analog output (current).

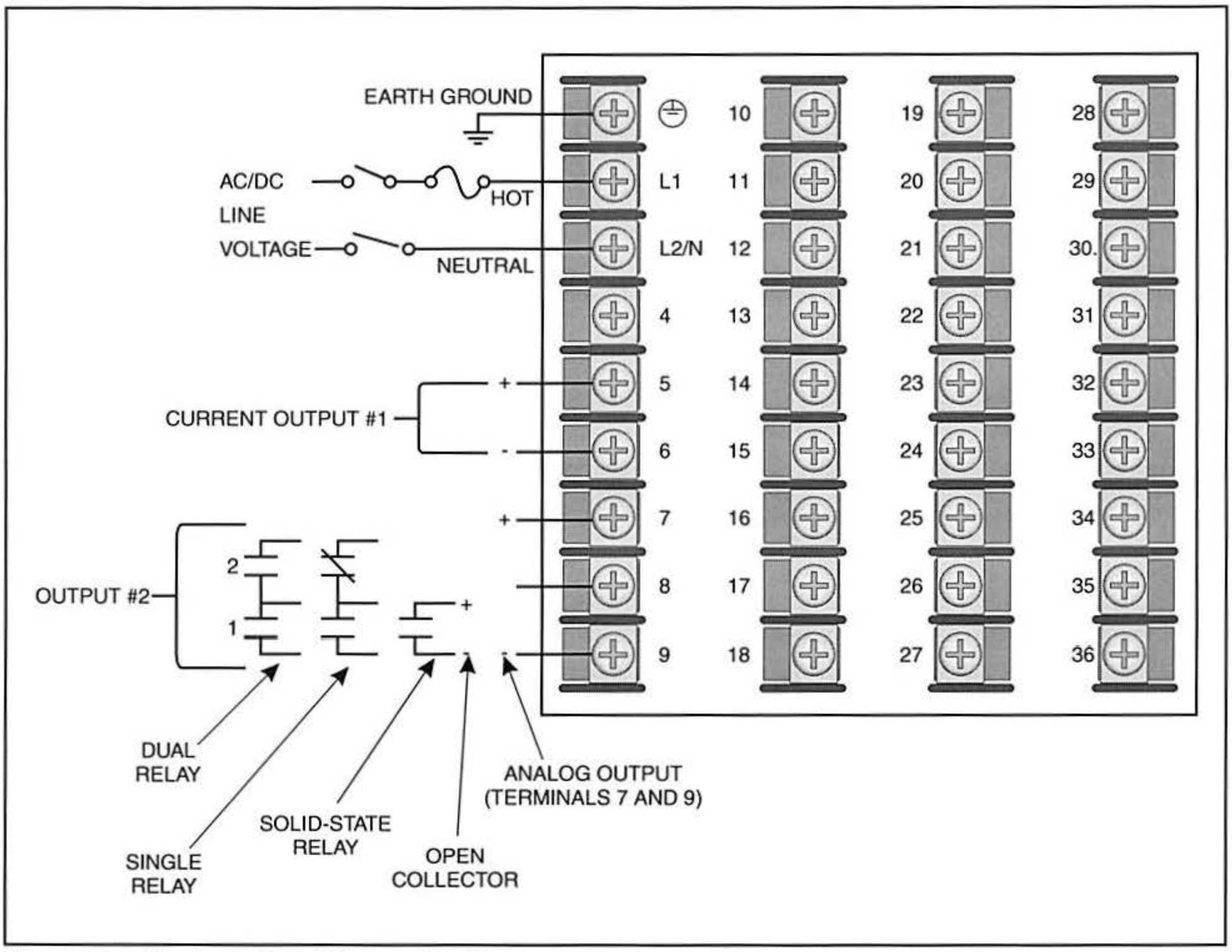


Figure 14. Configuration of Connection Terminals 1-9

Terminals 10-18 are used for alarm relays. Terminals 10-12 are used for alarm relay 3, terminals 13-15 for alarm relay 4, and terminals 16-18 for alarm relay 5.

Terminals 19-22 represent digital (discrete) inputs 1-4. Terminal 23 serves as a common for each input.

Terminals 24-27 are used for optional communications, either RS485 or Ethernet. If Ethernet is used, an Ethernet communication adaptor board is connected to terminals 24-27. Terminal 4 provides a shield connection for the communication options.

Terminals 28-36 represent inputs to the controller. Many different input signals can be connected to these input terminals including: a current signal (mA), a voltage signal (V or mV), or various types of temperature sensors such as thermocouples or RTDs (resistive temperature detectors). Terminals 34-36 are the connections for Input 1. Terminals 31-33 are for an optional Input 2. Terminals 28-30 are for an optional Input 3.

OBJECTIVE 4 DESCRIBE HOW TO POWER UP A HONEYWELL UDC 3500 CONTROLLER AND DETERMINE OPERATING STATUS

Read This

The controller can be powered up by applying electric power to it. The controller then runs a startup diagnostic test that consists of three different checks that are performed internally to determine if the controller is operating properly.

The first check is the RAM check. During this check, the controller checks the random access memory (RAM) to ensure that it is operating correctly. It does this by writing information to RAM and then reading it back. If the information that is read back is the same as the information that is sent out, the RAM is good.

After the RAM check, the next check is the configuration check. During this check, the controller reads information that is stored in its ROM and checks it against information stored inside the processor.

The last check is the calibration check, the controller checks the calibration of the inputs and outputs of the controller. This is done internally and has no affect on the process to which the controller is connected.

When the diagnostic test is completed, the message "TEST DONE" appears briefly on the display of the controller, as figure 15 shows.

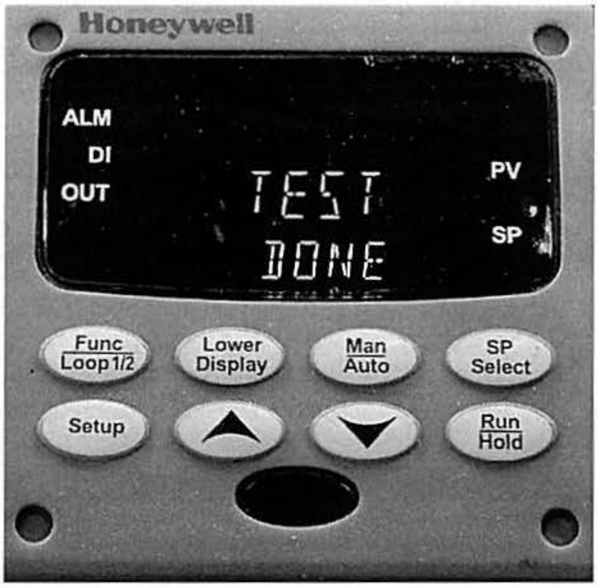


Figure 15. Test Done Message

If one or more of the checks fail during the diagnostic test, the controller enters the Failsafe Manual Mode. "FAILSAFE" flashes in the lower display, followed by any diagnostic messages associated with the failure. The cause of the failure must be determined and corrected before proceeding.

The table in figure 16 lists some of the common failure messages, along with their description. If a failure message appears on the display, the cause must be determined and corrected.

COMMON FAILURE MESSAGES FOR THE HONEYWELL UDC 3500	
DISPLAYED FAILURE MESSAGE	DESCRIPTION
RAM ERR	Ram check failed during startup diagnostic test.
CAL ERR	Calibration check failed during startup diagnostic test.
EE FAIL	Unable to write to non-volatile memory.
CFG ERR	Configuration check failed during startup diagnostic test. Configuration data is in error.
INP#RNG	Input is out of range. The # indicates the affected input number.
INP#FAIL	Two consecutive failures of the input or input value is outside the Out-of-Range limits. The # indicates the affected input number.
CONF ERR	Occurs for following conditions: PV low limit is > PV high limit SP low limit is > SP high limit Output low limit is > Output high limit
PV LIMIT	PV is out of prescribed range.
OUT#FAIL	Current output has failed (less than 3.5mA). The # indicates the affected output number.
BATT LOW	Battery voltage has fallen to unsafe level.
EUNPLGED	Ethernet adaptor board is unplugged, incorrectly connected, or the Ethernet network is not working.
EBRDFAIL	The Ethernet adaptor board has failed.

Figure 16. Common Failure Messages

OBJECTIVE 5 DESCRIBE HOW TO PERFORM A DISPLAY AND KEY TEST ON THE HONEYWELL UDC 3500 CONTROLLER

Read This

After the controller successfully completes the diagnostic test, it is possible to perform a display and key test. This test ensures that each element in the display can light up properly and that each key is working. This lets the operator know that the displays information is not the result of a bad display. You should perform these tests at initial startup. They should also be performed periodically during operation.

The display and key test is performed by pressing and holding the Setup and Func Loop 1/2 keys at the same time. The controller performs the display test by lighting up every element in the display, as shown in figure 17.

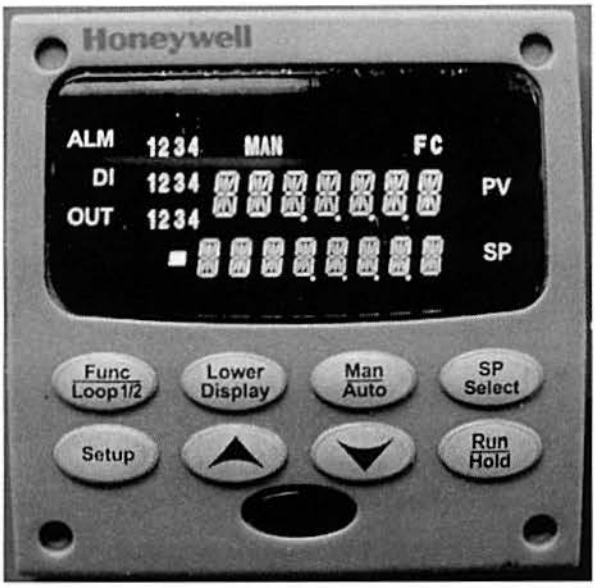
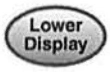


Figure 17. Display Test on the UDC 3500 Honeywell Controller

As the controller prepares for the key test, the upper portion of the display reads KEYS the lower portion of the display reads TRY ALL, as shown in figure 18.

Figure 18. Controller Preparing for Key Test

When each key on the control panel is pressed, the lower display of the control panel indicates the name of each key as it is pressed. The table below indicates the displayed result of pressing each key.

KEY	LOWER DISPLAY
	FUNCTION
	LWR DISP
	AUTO MAN
	SP SEL
	SETUP
	INCRMENT
	DECRMENT
	RUN HOLD

After seeing that all of the keys are working properly, wait approximately 5 seconds without pressing any keys. The controller automatically exits the display and key test and returns to normal operation.

SKILL 1 POWER UP A HONEYWELL UDC 3500 CONTROLLER AND PERFORM A DISPLAY AND KEY TEST

Procedure Overview

In this procedure, you will power up the Honeywell UDC 3500 controller and perform a display and key test.

☐ 1. Perform the following substeps to power up the controller and observe the display as the controller performs the startup diagnostic test.

During the diagnostic test, the controller performs memory and calibration checks to ensure it is functioning properly.

A. Make sure the main power cord is connected to the T5554.

B. Plug the main power cord into an available outlet.

C. Turn on the main circuit breaker on the T5554.

D. Observe the display of the controller as it performs the startup diagnostic test.

The diagnostic test should only take a few seconds. When the diagnostic test is complete, the display should indicate "TEST DONE", as shown in figure 19.

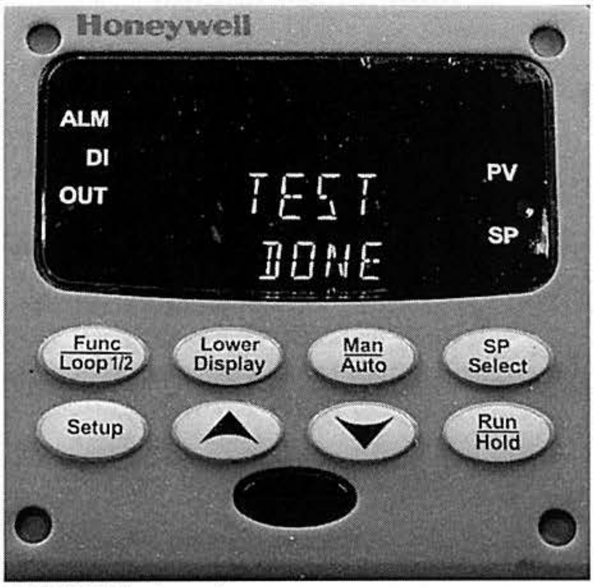


Figure 19. TEST DONE Displayed

NOTE

If any of the checks fail, the controller enters the Failsafe Manual Mode. If this occurs, "FAILSAFE" will begin blinking in the lower portion of the display, along with the associated failure message.

If a failsafe condition is indicated, notify your instructor for assistance.

- ❑ 2. Perform the following substeps to perform the display and key test.

  The display test ensures that all display elements light up properly. The key test ensures that all of the keys are functioning properly.

  A. Turn off the main circuit breaker on the T5554.

  B. Turn on the main circuit breaker again and wait for the TEST DONE display.

  C. When TEST DONE appears, press and hold the **Setup** key and the **Func Loop 1/2** key simultaneously.

  D. Release both keys.

  This causes the controller to run the display test. During the display test, all elements of the display light up, as figure 20 shows. If you miss the TEST DONE display, you will need to cycle power to the trainer and try again.

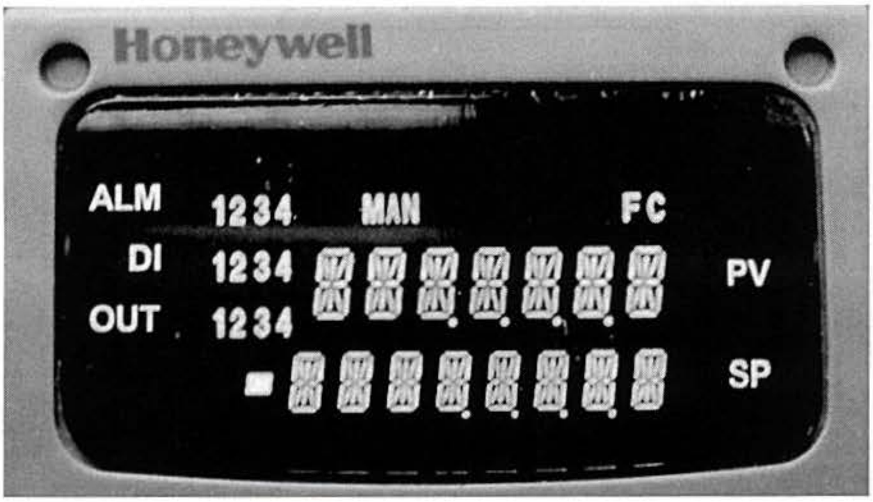


Figure 20. Display Test

Once the display test is complete, the upper and lower portions of the display will display the following message:

Upper Display: KEYS

Lower Display: TRY ALL

You can now perform the key test.

NOTE

If no key is pressed within 5 seconds, the controller exits the key test mode and returns to the normal display.

E. Press and hold the **Func Loop 1/2** key.

FUNCTION should be displayed in the lower portion of the display. This tells you that the key is working properly.

F. Release the **Func Loop 1/2** key.

G. Repeat substeps E and F for the remaining keys shown in the table. The table in figure 21 indicates the proper results for each key.

KEY	LOWER DISPLAY
Func. Loop 1/2	FUNCTION
Lower Display	LWR DISP
Man Auto	AUTO MAN
SP Select	SP SEL
Setup	SETUP
▲	INCRMENT
▼	DECRMENT
Run Hold	RUN HOLD

Figure 21. Key Test Results

NOTE

If any of the keys fail the test, notify your instructor.

H. Wait approximately 5 seconds without pressing any keys.

The controller returns to the control mode display screen as shown in figure 22. Recall that in the control mode the display panel indicates whether the controller is in manual or automatic mode and displays the PV.

Figure 22. PID Controller's Control Mode Display Screen

❑ 3. Turn off the main circuit breaker to shut down the T5554.

OBJECTIVE 6 DESCRIBE THE TWO DISPLAY MODES OF THE HONEYWELL UDC 3500 CONTROLLER

The two display modes of the UDC 3500 Honeywell controller are the control display mode and the setup display mode. Figure 23 shows the controller in the control display mode. The controller enters this mode when it is first turned on and during normal operation.

The control display is active when the controller indicates the process variable (PV) in the upper display area. This is the only mode in which the controller indicates the PV on the display panel. The controller also indicates either the setpoint (SP), the output, or the deviation in the lower display area when the control display is active.

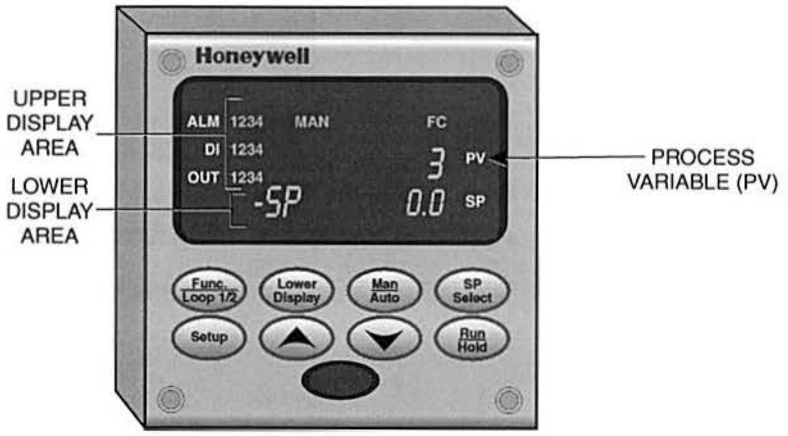


Figure 23. Honeywell Controller in the Control Display Mode

The controller enters the setup display mode when the Setup key is pressed. Figure 24 shows the controller display when it first enters the setup display mode (i.e. after the Setup key is pressed once). When the controller is in the setup display mode, the operator is able to view and change the controller setup parameters. However, the controller continues to operate under the settings that are already saved. If the controller has never been programmed, it operates according to the default settings.

Figure 24. Honeywell Controller in the Setup Mode

Do not confuse the display modes with the operating modes for the controller (i.e. automatic or manual). The controller operates in the manual or automatic operating mode (either can be set by pressing the Man/Auto key) regardless of the active display mode. The controller displays "MAN" in the upper left portion of the display when in manual mode and "A" when in automatic mode.

OBJECTIVE 7 DESCRIBE HOW TO NAVIGATE A HONEYWELL LOOP CONTROLLER MENU SYSTEM

Loop controllers have two basic menu systems: a control menu and a setup menu. The control display allows access to the control menu. The setup display allows access to the setup menu.

Control Menu Navigation

While in the control display menu, pressing the Lower Display key repeatedly scrolls through various display parameters in the lower display area. Common display parameters found in the lower display area include the setpoint (SP) value, the deviation (DEV) of the PV from the SP, and the output (OUT) of the controller. If the controller is a dual-loop controller, a second setpoint (2SP) also appears in the lower display. For example, figure 25 shows the controller indicating the output in the lower display area. Diagnostic messages also appear in the lower display area.

Figure 25. Honeywell Controller in the Control Display Mode

Also, pressing the SP Select key while in the control display menu switches from a local setpoint to a remote setpoint and pressing the Man/Auto key switches between the manual and automatic operating mode.

Setup Menu Navigation

The setup menu consists of the various setup parameter groups. Pressing the Setup key places the controller in the setup mode. Figure 26 shows a partial list of parameter groups for the Honeywell UDC 3500 controller.

COMMON PARAMETER GROUPS FOR HONEYWELL UDC 3500		
PARAMETER GROUP (Press Setup Key)	BASIC PARAMETERS (Press Func Loop 1/2 Key)	
LOOP TUNING	PROP BD or GAIN RATE MIN RSET MIN or RSET RPM MAN RSET SECURITY	LOCKOUT AUTO MAN RUN HOLD SP SEL
SP RAMP	SP RAMP TIME MIN FINAL SP	HOT START SP RATE SP PROG
ACCUTUNE	FUZZY ACCUTUNE DUPLEX SP CHANGE	
ALGORITHM	CONT ALG PIDLOOPS OUT OVRD TIMER	PERIOD START RESET INCREMENT
OUTPUT	OUT ALG OUT RNG C1 RANGE RLYSTATE	RLY TYPE CUR OUT1 LOW VAL HIGH VAL
INPUT	IN TYPE XMITTER IN HIGH IN LOW RATIO	BIAS IN FILTER BURNOUT EMISSIV
CONTROL	PV SOURC PID SETS LSP'S RSP SRC SP TRACK PWR MODE SP HiLIM SP LoLIM ACTION	OUTHiLIM OUTLoLIM I Hi LIM I Lo LIM DROPOFF FAILMODE FAILSAFE PBorGAIN MINorRPM
COM	Com ADDR ComSTATE IR ENABLE BAUD TX DELAY	WSFLOAT SHEDENAB UNITS CSP RATIO CSP BIAS
ALARMS	A1S1TYPE A1S1 VAL A1S2TYPE A1S2 VAL BLOCK ALRM MSG	A2S1TYPE A2S1 VAL A2S2TYPE A2S2 VAL DIAGNOST
DISPLAY	DECIMAL PWR FREQ IDNUMBER	TEMPUNIT LANGUAGE

Figure 26. Partial Setup Menu Parameter Groups for the Honeywell UDC 3500 Controller

The following steps show how to enter the setup mode and navigate through the setup menu:

Step 1: Enter the Setup Menu - Use the Setup key to enter the setup menu. Pressing the Setup key repeatedly allows you to scroll through all of the setup groups. The up ▲ and down ▼ keys may also be used to scroll through the groups so that you can scroll in both directions.

Step 2: Scroll through parameters in a selected group - Use the Func Loop 1/2 key to scroll through all of the parameters in a group.

Step 3: Adjust the value of selected parameters - Pressing the up ▲ and down ▼ keys adjusts the value of a parameter.

Step 4: Return to the Control Display Mode - Pressing the Lower Display key returns to the control display mode.

SKILL 2 NAVIGATE A HONEYWELL LOOP CONTROLLER MENU SYSTEM

Procedure Overview

In this procedure, you will power up a Honeywell loop controller and navigate through the different menus and displays.

- ❑ 1. Turn on the main circuit breaker on the T5554 Analytical Process Control System.
- ❑ 2. Observe the controller as it displays "TEST DONE" and enters the control display mode.

NOTE

If the diagnostic test fails, notify your instructor before proceeding.

- ❑ 3. If necessary, press the **Man/Auto** key until "MAN" appears in the upper left portion of the display, indicating that the controller is in manual mode, as shown in figure 27.

  If the controller is already in the manual mode, proceed to the next step.

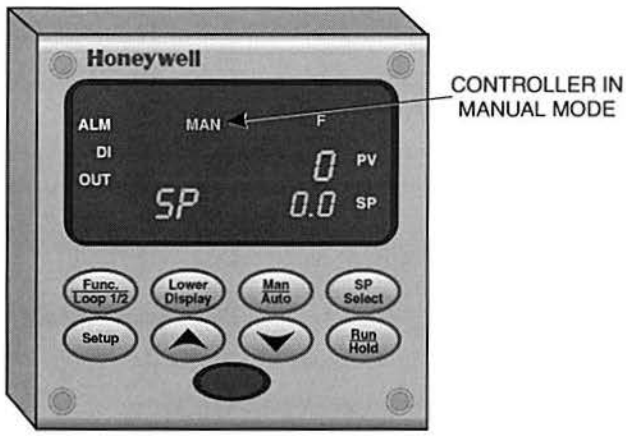


Figure 27. Controller in Manual Mode

❑ 4. Press the **Lower Display** key repeatedly to scroll through the lower display menu.

You should find that pressing the Lower Display key allows you to display the following options:

DISPLAYED NAME	NAME	FUNCTION
OUT	Output	Displays the output from the controller as a percentage of the maximum output (1 - 100%)
DEV	Deviation	Displays the difference between the set-point and the process variable
SP	Setpoint	Displays the current setpoint

Notice This

NOTE

If your T5554 uses a dual-loop controller, 2SP may also appear in the lower display if the second control loop is enabled.

❑ 5. Perform the following substeps to navigate the setup menu of the Honeywell PID controller.

A. Press the **Setup** key on the controller.

The controller should enter the setup menu and display the first setup group, "TUNING," as shown in figure 28.

Figure 28. PID Controller Displaying Tuning Setup Group

B. Press the **Setup** key again to move to the next setup group.

The controller should display the second setup group, "SP RAMP," as shown in figure 29.

Figure 29. PID Controller Displaying SP Ramp Setup Group

C. Continue pressing the **Setup** key repeatedly to scroll through the remaining setup groups shown in the following table.

SETUP GROUP DISPLAYED	SETUP GROUP NAME
TUNING	TUNING
*TUNING L2	TUNING LOOP 2
SP RAMP	SETPOINT RAMP
ACCUTUNE	ACCUTUNE
ALGORTHM	ALGORITHM
*MATH	MATH FUNCTIONS
*LOGIC	LOGIC FUNCTIONS
OUT ALG	OUTPUT ANALOG
INPUT 1	INPUT 1
*INPUT 2	INPUT 2
CONTROL	CONTROL
*CONTROL 2	CONTROL 2
OPTIONS	OPTIONS
COM	COMMUNICATIONS
ALARMS	ALARMS
DISPLAY	DISPLAY
READ STATUS	READ STATUS

*ONLY PRESENT FOR DUAL-LOOP CONTROLLER

NOTE

You can also use the up ▲ and down ▼ keys to scroll through the setup groups.

D. Press the **Lower Display** key to return to the control mode display screen.

❑ 6. Turn off the main circuit breaker to shutdown the T5554.

SEGMENT 1

SELF REVIEW

1. ____________ controllers use air inputs and outputs to sense the process variable and control the process.

2. When a loop controller is in the ___________ mode, the operator controls its output.

3. The _____________ of an electronic loop controller consists of an enclosure and the internal circuitry.

4. The __________ area of the display is used to indicate the measurement units.

5. The two basic menus of a controller are the control menu and the ________ menu.

6. The two display modes of the UDC 3500 Honeywell loop controller are the setup display mode and the _________ display mode.

7. __________ controllers use electrical inputs and outputs to sense the process variable and control the process.

8. The _______ test ensures that each element in the display lights up properly and that each key is working.

9. For the Honeywell UDC 3500, connection terminals ___________ are used for optional communications, either RS485 or Ethernet.

10. After powerup, the Honeywell UDC 3500 runs a startup ____________ that consists of three different checks.

SEGMENT 2

LOOP CONTROLLER PARAMETERS

OBJECTIVE 8 DESCRIBE FIVE COMMON TYPES OF LOOP CONTROLLER PARAMETER GROUPS

Parameters are specific values programmed into the controller to allow proper control of the process. The controller cannot control the process unless the parameters are correctly entered. Most loop controllers group parameters according to type or function. Figure 30 shows a sample flow chart of how the information in a process controller can be arranged.

Five common types of loop controller parameter groups are:

- Tuning Group
- Control Group
- Input Group
- Alarm Group
- Options Group

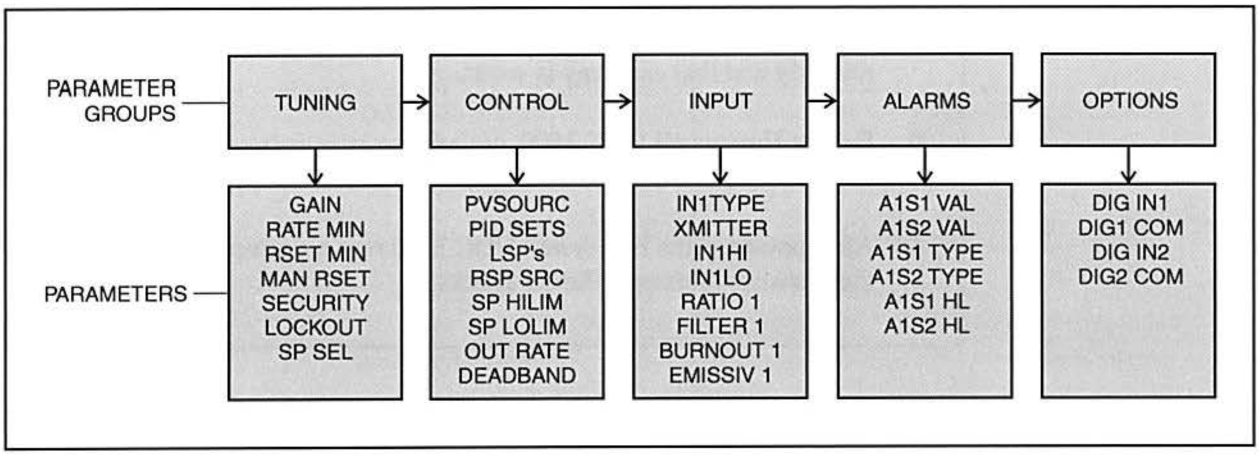


Figure 30. Sample Parameter Grouping for a Loop Controller

Tuning Group

Tuning parameters include values that determine the specific type of control being used (i.e. proportional, derivative, integral), cycle time recording, and some security options (i.e. disabling some of the keys to prevent someone from changing the parameters).

Input Group

Input parameters include values and information about the input devices and signals to the controller. Examples include the type of input (RTD, thermocouple, 4-20 mA, 1-5 V, etc.), the type of transmitter (linear, square root, analytic, etc.), and the range of the input values.

Control Group

Control parameters include values that determine how the controller controls the process loop. These parameters include setpoint limits, deadband, process variable source, and the output rate.

Alarm Group

Many loop controllers have relays to activate alarm signals. Alarm parameters control these relays. These parameters include the value for which the alarm turns on and what aspect of the process the alarm represents (e.g. process variable, a particular input, deviation, etc.).

Options Group

Many loop controllers have optional components or modules that can be added to expand the capabilities of the controller. The options parameters include parameters that allow the controller to be configured to use the options. These parameters include settings for digital inputs and extra analog outputs.

OBJECTIVE 9 DESCRIBE HOW TO VIEW AND INTERPRET CONTROLLER PROCESS VARIABLES

Read This

The process variable (PV), setpoint (SP), and deviation of the PV from the SP are three commonly viewed loop controller display parameters. Many controllers allow the operator to view at least two of these parameters at the same time. Viewing these parameters gives an indication of the current state of the process. However, to interpret the parameters, the PV is usually compared to the SP.

The Honeywell UDC 3500 controller, shown in figure 31, always displays the PV when in the control display mode. In the manual mode, the controller indicates the output value in the lower display in addition to the PV, as figure 31 also shows.

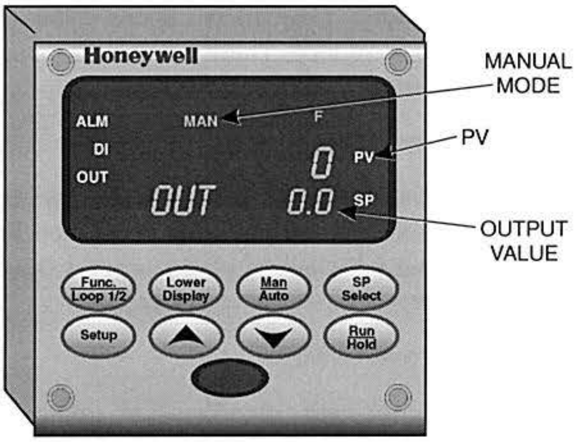


Figure 31. Honeywell Controller Displaying the PV and Controller Output in Manual Mode

The analog output from the Honeywell UDC 3500 Honeywell controller is a 4-20 mA signal. The controller displays the output as a percentage. For example, in figure 31 the output value is 0%. Therefore, the controller output is at its minimum value (4 mA). If the displayed output is 50%, the signal output is 12 mA (i.e. halfway between 4 and 20 mA).

However, if the controller is in the automatic mode ("A" in the upper left portion of the display), the display panel indicates the SP in the lower display in addition to the PV, as shown in figure 32.

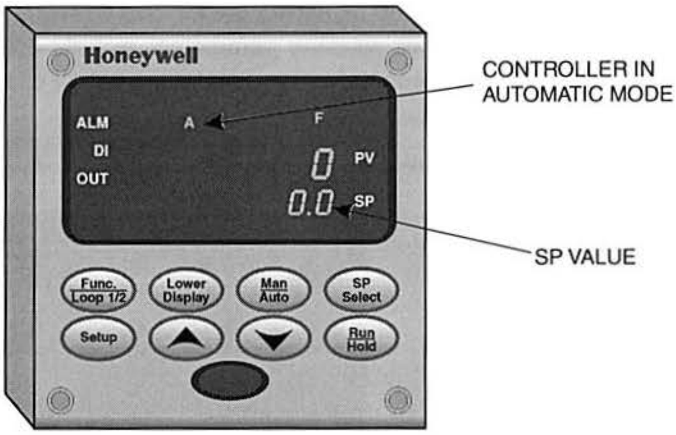


Figure 32. Honeywell Controller Displaying the PV and SP in Automatic Mode

Pressing the Lower Display key while in either operating mode (manual or automatic) allows scrolling between the SP, output, or the deviation.

The Honeywell controller calculates and displays the difference between the PV and the SP in a value called the deviation (DEV) parameter. This parameter indicates if the output from the controller must increase or decrease to reduce the error to zero.

The deviation parameter is viewable by pressing the Lower Display key until DEV appears in the lower display, as shown in figure 33. For example, the deviation shown in figure 33 is 0.04. Therefore, the PV would have to increase by 0.04 to equal the SP.

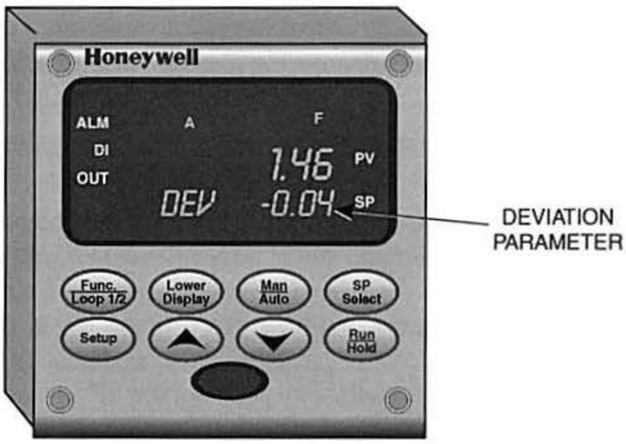


Figure 33. Deviation Parameter Displayed

OBJECTIVE 10 DESCRIBE HOW TO ENTER A LOOP CONTROLLER PARAMETER USING THE CONTROL PANEL KEYS

Read This

Loop controller parameters may be entered using the keypad on the control panel. Figure 34 shows the keypad on the Honeywell UDC 3500 controller. Other methods of entering parameters include using a PDA to transfer parameters via an IR communication port or using a PC to transfer parameters via a network connection.

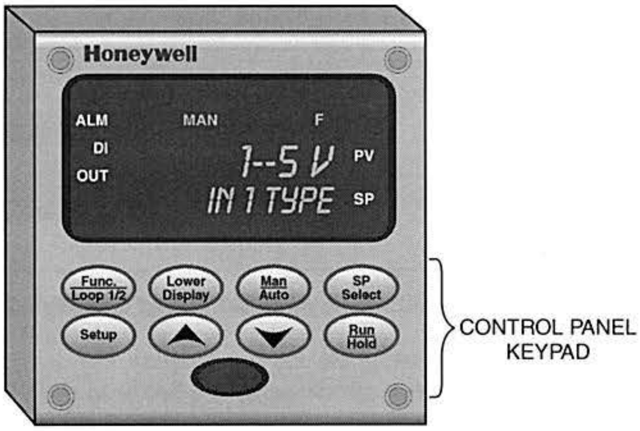


Figure 34. Keypad on the Honeywell UDC 3500 Controller

The following steps describe how to enter or change a parameter in the Honeywell UDC 3500 loop controller using the keypad::

Step 1: Enter the Setup Menu - Using the Setup key to enter the setup menu and scroll through the setup groups.

Step 2: Scroll through parameters in a selected group - Using the Func Loop 1/2 key to scroll through the parameters within a setup group.

Step 3: Adjust the value of selected parameters - Using the up ▲ and down ▼ keys to change the display value of selected parameters.

Step 4: Return to the control display mode - When all required parameters are programmed, pressing the Lower Display key returns to the control display mode.

Some parameters can be viewed and changed without entering the setup mode. For example, the setpoint is viewed and changed while the controller is in the control display mode by pressing the Lower Display key until the SP appears on the display and then pressing the up ▲ and down ▼ keys to change the value. Also, changing from a local to a remote setpoint (if a remote setpoint is being used) is accomplished by pressing the SP Select key while in the control display mode.

SKILL 3 CHANGE HONEYWELL UDC 3500 LOOP CONTROLLER PARAMETERS

Procedure Overview

In this procedure, you are going to change a number of the Honeywell controller's parameters in several of the parameter groups.

❑ 1. Turn on the main circuit breaker and observe the controller as it displays "TEST DONE" and enters the control display mode.

NOTE

If the diagnostic test fails, notify your instructor before proceeding.

Recall that in the control display mode, the PV is indicated on the display.

❑ 2. Press the **Setup** key to enter the setup menu.

❑ 3. Perform the following substeps to change parameters in the "INPUT 1" parameter group.

A. Press the **Setup** key repeatedly to scroll through the parameter groups until you come to the "INPUT 1" parameter group.

The parameter groups appear in the lower portion of the display.

B. Press the **Func Loop 1/2** key.

The controller should display the first parameter in the "INPUT 1" parameter group, "IN1 TYPE", as shown in figure 35. This parameter describes the type of input signal.

The parameter name appears in the lower portion of the display and the parameter value appears in the upper portion of the display.

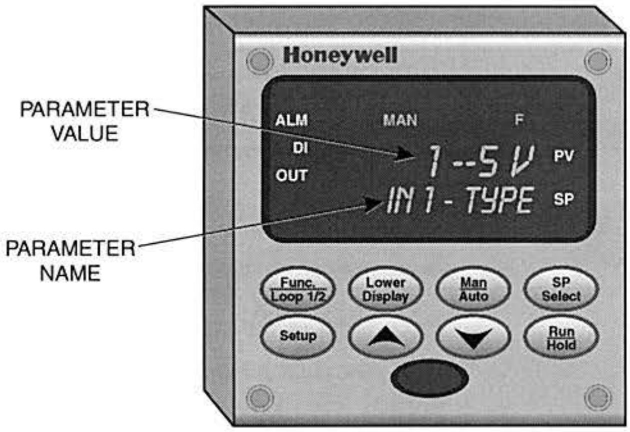


Figure 35. IN1 TYPE Parameter

C. Press the up ▲ and down▼ keys to scroll through all of the possible settings for the parameter so you can see all of the input signals the controller accepts.

D. Once the settings return to the beginning (1-5 V), use the up ▲ and down ▼ keys to change the setting to **4-20 mA**.

E. Press the **Func Loop 1/2** key to move to the next parameter in the group, "XMITTER1," as shown in figure 36.

This parameter describes the type of transmitter. It should be set to LINEAR, as also shown in figure 36. This indicates that the sensor output varies linearly with the input.

F. Press the up ▲ and down ▼ keys to scroll through all of the possible settings for the parameter until the settings return to the beginning (LINEAR).

G. Use the up ▲ and down ▼ keys to change the setting to **SQROOT**.

Figure 36. XMITTER Parameter Set to LINEAR

H. Press the **Func Loop 1/2** key to move to the next parameter, "IN1 HIGH".

I. Use the up ▲ and down ▼ keys to change the setting to **25**.

J. Press the **Func Loop 1/2** key to move to the next parameter, "IN1 LOW".

K. Use the up ▲ and down▼ keys to change the setting to 8.

❑ 4. Perform the following substeps to change parameters in the "CONTROL" parameter group.

A. Press the **Setup** key to scroll through the setup parameter groups until you reach the "CONTROL" group.

B. Press the **Func Loop 1/2** key to view the first parameter in the group. You should find that the first parameter is "PV SOURC".

C. Use the **Func Loop 1/2** key to navigate through the menu until you come to the "SP HiLIM" parameter.

This parameter sets the high limit for the setpoint.

D. Use the up ▲ and down ▼ keys to change the setting to **24**.

E. Press the **Func Loop 1/2** key to move to the next parameter, SP LoLIM.

This parameter sets the low limit for the setpoint.

F. Use the up ▲ and down▼keys to change the setting to **10**.

❑ 5. Press the **Lower Display** key to exit the setup menu and return to the control display.

❑ 6. Continue to press the **Lower Display** key until "SP" appears in the lower part of the display screen, as shown in figure 37.

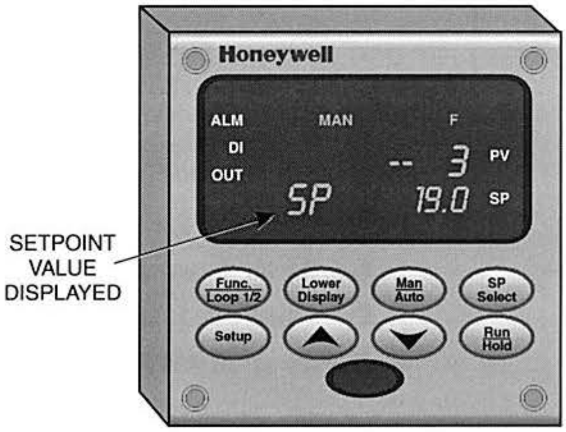


Figure 37. Lower Display Showing the Setpoint Value

❑ 7. Use the up ▲ and down ▼ keys to change the SP value to **15**.

The SP is a parameter that is frequently changed during operation to meet production needs.

❑ 8. Turn off the main circuit breaker to shutdown the T5554.

OBJECTIVE 11 DESCRIBE HOW TO RESTORE FACTORY SETTINGS FOR THE HONEYWELL UDC 3500 CONTROLLER

Read This

There are times when it is necessary to return the Honeywell UDC 3500 controller parameters to the default factory settings. It is good practice to do this the first time the controller is programmed or when the current parameter settings are not known.

Restoring the factory settings overwrites the current parameters in the controller and replaces them with factory default settings. The Honeywell controller user manual lists the factory default settings for all of the parameters. This provides known parameter settings with which to start.

Figure 38. Honeywell UDC 3500 Controller Factory Reset Initialized

The following steps describe how to restore factory settings for the Honeywell UDC 3500 controller using the keypad:

Step 1: Power up the Controller - The restoration process is initiated during power up. If the controller is already powered up, power it down and back up.

Step 2: Initiate the Restoration during Power Up Sequence - Simultaneously pressing the Func Loop 1/2 and up ▲ arrow keys while "TEST DONE" appears on the display places the controller in the restoration mode. The upper display should show "UDC" and the lower display should show "UPDATE", as figure 38 shows.

Step 3: Select the Config Restore option - Pressing the Func Loop 1/2 key causes the restore menu to appear. "DIS" should appear in the upper display and "RESTORE" should appear in the lower display. Pressing the up arrow▲ key moves to the next menu item, Configuration Restore. "CFG" should appear in the upper display and "RESTORE" should appear in the lower display, as figure 39 shows.

Figure 39. Configuration Restore Menu Display

Step 4: Initiate the Restoration - Pressing the Func Loop 1/2 key initiates the restoration of the configuration to the factory defaults. During the restoration process, "DOING" appears in the upper display and "RESTORE" appears in the lower display, as figure 40 shows.

Once the restoration process is complete, the controller returns to the control display mode. All parameters are now reset to factory defaults.

Figure 40. Doing Restore Display

SKILL 4 RESTORE FACTORY SETTINGS FOR THE HONEYWELL UDC 3500 CONTROLLER

Procedure Overview

In this procedure, you will restore the settings for the Honeywell UDC 3500 controller back to factory defaults. This will overwrite the current settings in the controller.

- ❑ 1. Turn on the main circuit breaker and observe the display of the controller.
- ❑ 2. While "TEST DONE" appears on the display, simultaneously press the **Func Loop 1/2** and up arrow▲ keys to initiate the restore function.

NOTE

If you do not press the keys before "TEST DONE" disappears, you must power down the controller and repeat steps 1 and 2.

The controller should now be in the restore mode. The upper display should show "UDC" and the lower display should show "UPDATE", as shown in figure 41.

Figure 41. Factory Restore Initialized

- ❑ 3. Press the **Func Loop 1/2** key.

The upper display should now indicate "DIS" and the lower display should indicate "RESTORE". Display restore is the first restore menu item.

❑ 4. Press the up arrow ▲ key to advance to the next restore menu item.

The upper display should now indicate "CFG" and the lower display should indicate "RESTORE", as shown in figure 42.

Figure 42. Configuration Restore Menu Display

❑ 5. Press the **Func Loop 1/2** key to restore the configuration to the factory default settings.

As the restoration process is occurring, the upper display indicates "DOING" and the lower display indicates "RESTORE", as shown in figure 43.

Figure 43. Doing Restore Display

When the restoration is complete, the controller returns to the control display mode. All parameters are now reset to factory default settings.

❑ 6. Turn off the main circuit breaker on the T5554.

SEGMENT 2

SELF REVIEW

1. __________ are specific values programmed into the controller to allow proper control of the process.

2. Many controllers have relays to activate __________ signals.

3. Values that determine the specific type of control being used are called ________ parameters.

4. Five types of common loop controller parameters are options, input, tuning, control, and ________ parameters.

5. The Honeywell UDC 3500 controller always displays the __________ when in the control display mode.

6. Pressing the ____________ key on the Honeywell UDC 3500 controller allows scrolling between the SP, output, and deviation in the lower display area.

7. One method to enter parameters into a loop controller is to use the __________ on the control panel of the controller.

8. To initiate the restoration during power up, simultaneously press the Func Loop 1/2 and _______ keys.

9. Restoring the factory settings _______ the current parameters.

SEGMENT 3

MANUAL OPERATION

OBJECTIVE 12 DESCRIBE THE OPERATION OF AN ELECTRONIC LOOP CONTROLLER IN MANUAL MODE

Read This

A process system that uses an electronic loop controller in manual mode generally behaves as an open loop system. However, the operator can make output adjustments to control the process if necessary. Figure 44 shows an example of a manual open loop level control process using an electronic controller. Because the system is open loop, there is no automatic feedback element. However, the operator can monitor the level using the scale on the side of the tank.

In this system, the operator does not have to program any particular parameters. The operator simply places the controller in manual mode and adjusts the output based upon the change in level. Essentially, the controller acts like a hand valve that is able to make very small adjustments.

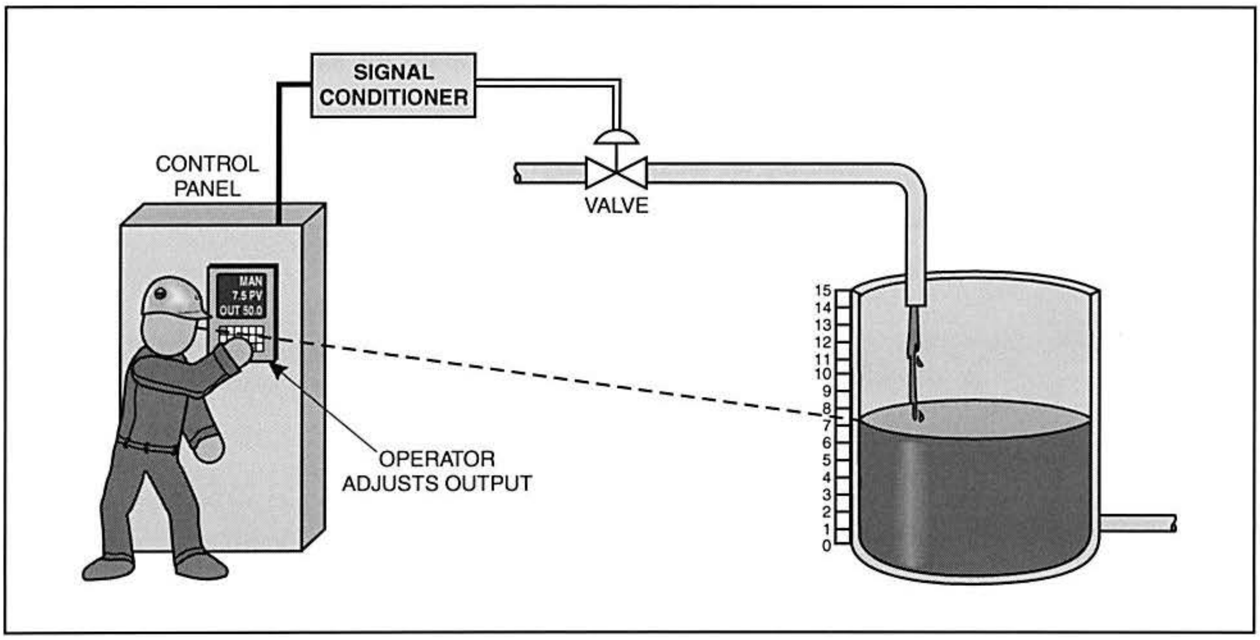


Figure 44. Open Loop Level Control Process with Controller in Manual Mode

OBJECTIVE 13 DESCRIBE HOW TO CONNECT A LOOP CONTROLLER TO A FINAL CONTROL ELEMENT

Read This

The Honeywell UDC 3500 controller, like many electronic controllers, has at least one 4-20 mA analog output. The output from a controller is used to control an electrical valve or an output load device that usually controls a pneumatic valve (final control element). If the load device accepts a 4-20 mA signal, the controllers analog output terminals can be wired directly to the input terminals of the load, as shown in figure 45.

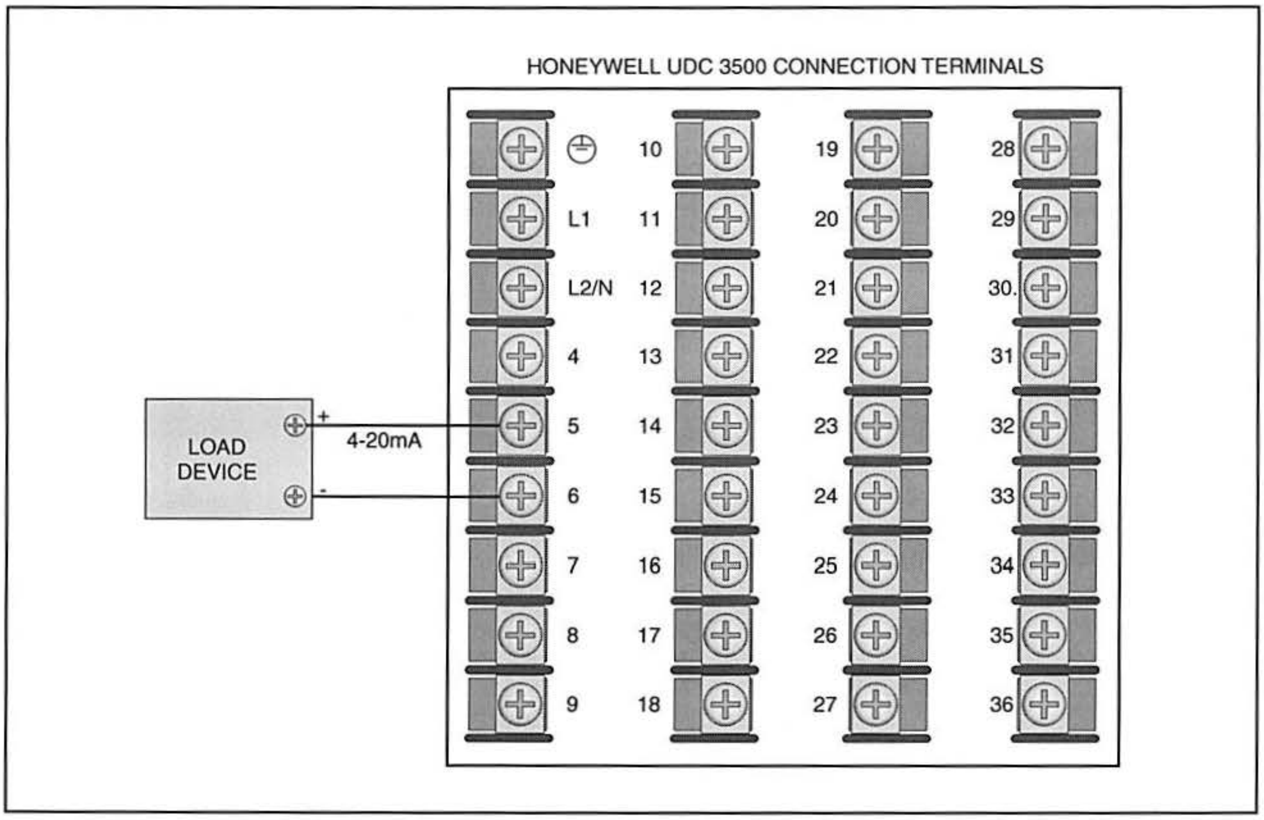


Figure 45. Honeywell Controller Output Wired to a Load Device that Accepts a Current Input

If the device requires a voltage input, you can place a resistor across the input terminals of the load device to change the signal from a current to a voltage, as shown in figure 46, as long as it does not adversely affect the input impedance of the device. The size of the resistor determines the voltage signal value according to Ohms Law (E = IR). For example, a 250-ohm resistor changes the 4-20 mA signal to a 1-5V signal.

$0.004 \times 250 = 1V$

$0.20 \times 250 = 5V$

This is a common technique used when the output of the controller is current but the load device requires voltage.

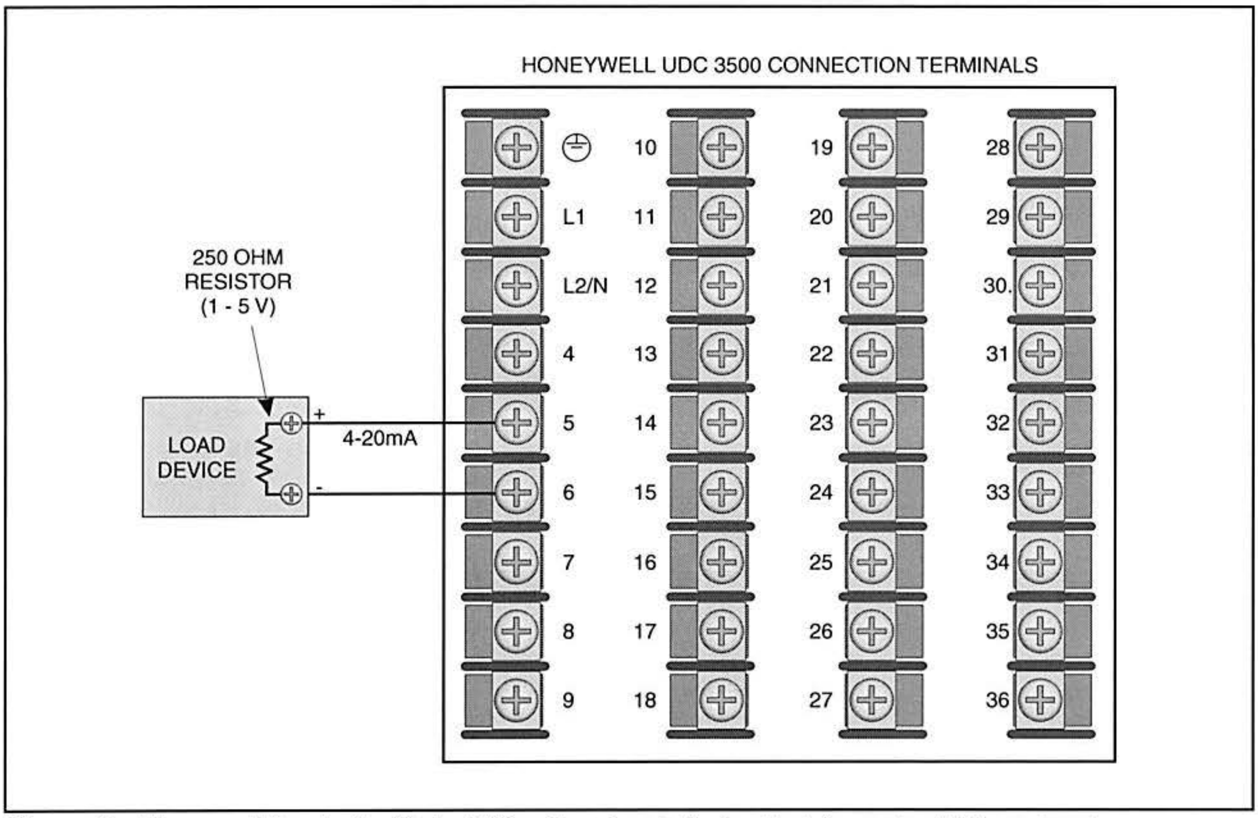


Figure 46. Honeywell Controller Output Wired to a Load Device that Accepts a Voltage Input

OBJECTIVE 14 DESCRIBE HOW TO OPERATE A LOOP CONTROLLER IN MANUAL OPEN LOOP MODE

Read This

The Honeywell UDC 3500 controller is operated in manual open loop mode using the following steps:

Step 1: Place the controller in the manual mode - Pressing the Man/Auto key places the controller in manual mode.

Step 2: Display the controller output - Pressing the Lower Display key displays the controller output. The Honeywell controller displays the output as a percentage from 0 - 100%, where 4 mA equals 0% and 20 mA equals 100%.

Step 3: Adjust the output as necessary - Pressing the up ▲ and down▼ keys adjusts the output.

Step 4: Toggle between output, setpoint, and deviation to view output status - The controller normally indicates the output in the lower display when in manual mode. Pressing the Lower Display key toggles between the setpoint, deviation value, or output.

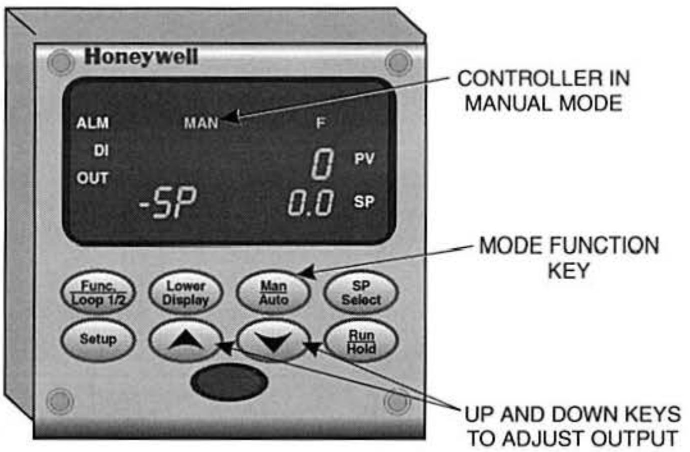


Figure 47. Manual/Auto Key on a Loop Controller

Procedure Overview

In this procedure, you will connect the output of the Honeywell UDC3500 controller to a multimeter and measure the output current (4-20mA) as you manually adjust the output of the controller.

- ❑ 1. Perform a lockout/tagout.
- ❑ 2. Locate a digital multimeter and connected it to measure the output of the controller, similar to figure 48.

  Make sure to use the proper jacks on the meter for measuring current (i.e. 200mA and COM).

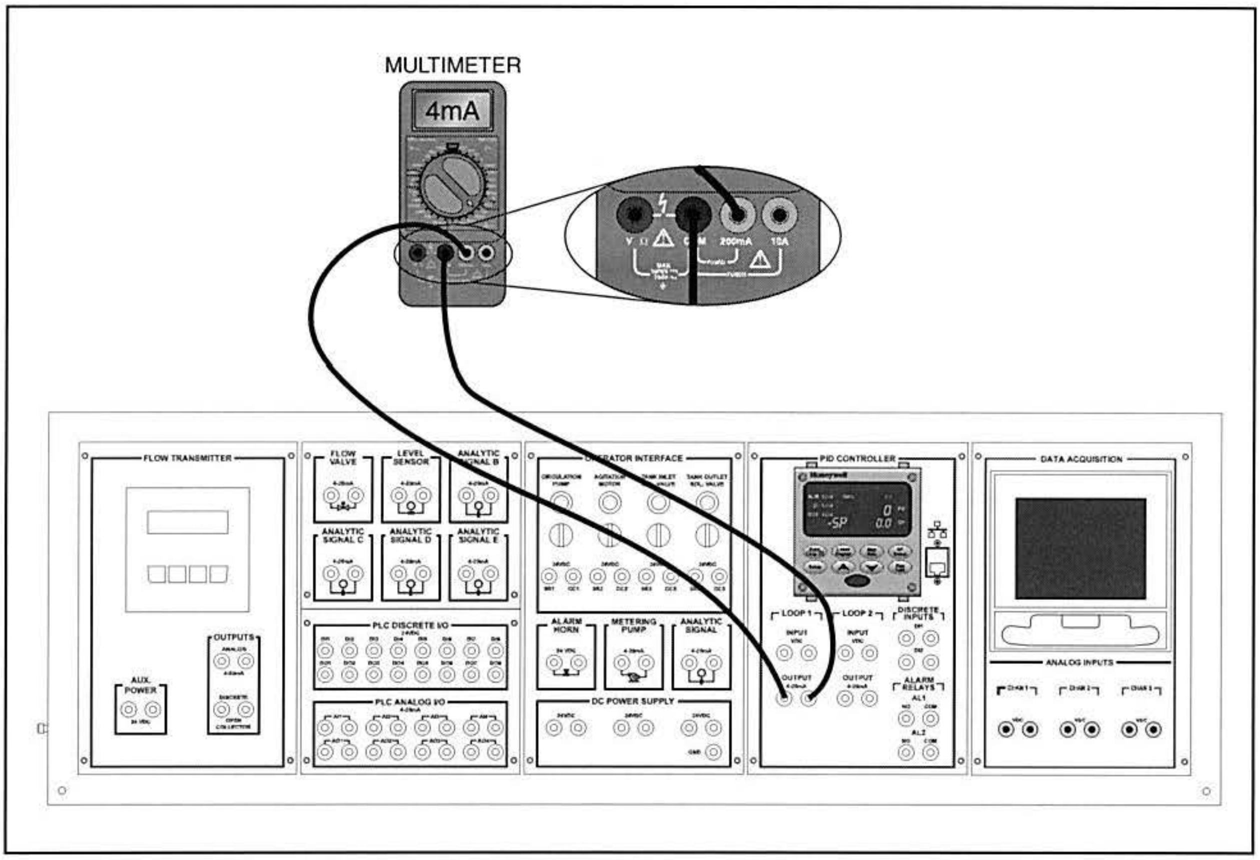


Figure 48. Digital Meter Connected to Measure Output of Controller

- ❑ 3. Set the multimeter to measure DC milliamps.
- ❑ 4. Remove the lockout/tagout and turn on the main circuit breaker.

❑ 5. After the controller completes the startup diagnostic test, observe the display and determine if the controller is in the manual mode (MAN).

❑ 6. If the controller is not in the manual mode, press the **Man/Auto** key to place the controller in the manual mode, as figure 49 shows.

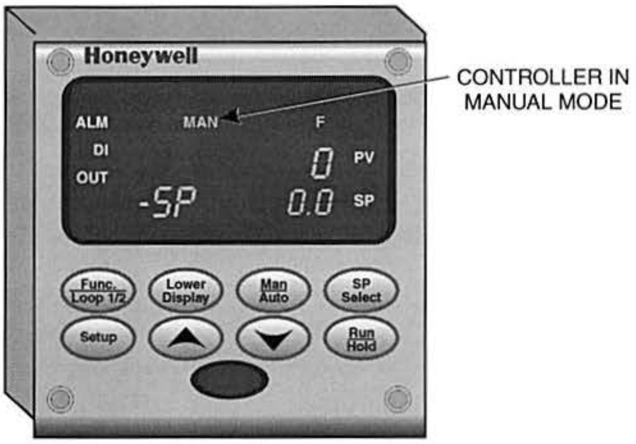


Figure 49. Manual/Auto Key on a Loop Controller

❑ 7. Observe the display and determine if the output parameter (OUT) is displayed in the lower portion of the display.

❑ 8. If the output parameter is not displayed, press the **Lower Display** key repeatedly until the output parameter is displayed.

This is indicated by "OUT" at the bottom of the display. At this point, the output parameter should indicate 0.0. The output is displayed as a percentage of the maximum output, which is 20mA. An indication of 0% represents an output of 4mA.

❑ 9. Observe the display of the multimeter and record the reading, similar to figure 50.

Output Reading ________________________________ (mA)

Figure 50. Display of Multimeter Indicates 4mA

The measured output current for an indicated output of 0% is 4mA.

❑ 10. Use the up ▲ and down ▼ keys to manually increase the output of the controller to **50%**.

❑ 11. Observe the display of the multimeter and record the reading.

Output Reading ________________________________ (mA)

The measured output current for an indicated output of 50% is 12mA.

❑ 12. Use the up▲ and down ▼ keys to manually increase the output of the controller to **100%**.

❑ 13. Observe the display of the multimeter and record the reading.

Output Reading ________________________________ (mA)

The measured output current for an indicated output of 100% is 20mA.

❑ 14. Use the up ▲ and down ▼ keys to manually decrease the output of the controller to **75%**.

❑ 15. Observe the display of the multimeter and record the reading.

Output Reading ________________________________ (mA)

The measured output current for an indicated output of 75% is 16mA.

❑ 16. Use the up ▲ and down ▼ keys to manually decrease the output of the controller to **25%**.

❑17. Observe the display of the multimeter and record the reading.

Output Reading _______________________________________ (mA)

The measured output current for an indicated output of 25% is 8mA.

❑18. Use the up ▲ and down ▼ keys to manually decrease the output of the controller to 0%.

❑19. Observe the display of the multimeter and record the reading.

Output Reading _______________________________________ (mA)

The output current should return to 4mA.

Manually adjusting the output parameter changes the output of the controller accordingly. Making manual adjustments is sometimes required to bring an out of control process back under control or to test/calibrate control components.

❑20. Turn off the main circuit breaker.

❑21. Disconnect the multimeter, turn it off, and return it to the proper storage area.

SEGMENT 3

SELF REVIEW

1. A system that uses an electronic controller in manual mode is a(n) __________ loop system.

2. Once the controller is in __________ mode, the operator can adjust the controller's output.

3. A Honeywell UDC 3500 controller normally indicates the __________ in the lower display area when it is in manual mode.

4. Most electronic controllers have a __________ mA output.

5. If a load device accepts a 4-20 mA signal, the controller's __________ terminals can be wired directly to the input terminals of the load device.

6. If a load device requires a voltage input, a _________ is placed across the input terminals of the load device to change the signal from a current to a voltage.

7. Using a 250-ohm resistor changes a 4-20 mA signal to a _________ V signal.