Series D8
User's Guide

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Part No. 0600-3120-2000 Rev. B

November 2008

Warranty

Watlow Anafaze, Incorporated warrants that the products furnished under this Agreement will be free from defects in material and workmanship for a period of three years from the date of shipment. The Customer shall provide notice of any defect to Watlow Anafaze, Incorporated within one week after the Customer's discovery of such defect. The sole obligation and liability of Watlow Anafaze, Incorporated under this warranty shall be to repair or replace, at its option and without cost to the Customer, the defective product or part.

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If replacement parts are supplied or repairs made during the original warranty period, the warranty period for the replacement or repaired part shall terminate with the termination of the warranty period of the original product or part.

The foregoing warranty constitutes the sole liability of Watlow Anafaze, Incorporated and the Customer's sole remedy with respect to the products. It is in lieu of all other warranties, liabilities, and remedies. Except as thus provided, Watlow Anafaze, Inc., disclaims all warranties, express or implied, including any warranty of merchantability or fitness for a particular purpose

Please Note: External safety devices must be used with this equipment.

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1

System Overview

Manual Contents

This manual describes how to install, set up, and operate a D8 series controller. Each chapter covers a different aspect of your control system and may apply to different users:

- **Chapter 1: System Overview** provides a component list and summary of features for the D8 series controllers.
- **Chapter 2: Installation** provides detailed instructions on installing the D8 series controller and its peripherals.
- **Chapter 3: Communicating via DeviceNet** explains how to add the D8 controller to a network and how to access controller data via DeviceNet.
- **Chapter 4: Operation and Setup** provides instructions about operating and setting up the D8.
- **Chapter 5: Tuning and Control** describes available control algorithms and provides suggestions for applications.
- **Chapter 6: Menu and Parameter Reference** provides detailed descriptions of all menus and parameters for controller setup.
- **Chapter 7: Troubleshooting and Reconfiguring** includes troubleshooting, upgrading and reconfiguring procedures for technical personnel.
- **Chapter 8: Specifications** lists detailed specifications of the controller and optional components.

Getting Started

Safety Symbols

These symbols are used throughout this manual:

WARNING! **_Indicates a potentially hazardous situation which, if not avoided, could result in death or serious injury._**

CAUTION! **_Indicates a potentially hazardous situation which, if not avoided, could result in minor or moderate injury or property damage._**

NOTE! **_Indicates pertinent information or an item that may be useful to document or label for later reference._**

Initial Inspection

Accessories may or may not be shipped in the same container as the D8, depending upon their size. Check the shipping invoice against the contents received in all boxes. If you are uncertain whether you have received all of the items you ordered, contact your vendor or Watlow Anafaze.

Product Features

D8 series controllers offer high-performance closed-loop control.

The D8 provides four or eight independent control loops with analog inputs — thermocouples, RTDs and process — and features DeviceNet communications.

When used as a stand-alone controller, you may operate the D8 via the two-line 16-character display and touch keypad. You can also use it as the key element in a computer-supervised data acquisition and control system. The D8 can be locally or remotely controlled via its DeviceNet communications interface.

D8 features include:

- **Direct Connection of Mixed Thermocouple Sensors:** Connect most thermocouples to the controller with no hardware modifications. Thermocouple inputs feature reference junction compensation, linearization, offset calibration to correct for sensor inaccuracies, detection of open, shorted or reversed thermocouples, and a choice of Fahrenheit or Celsius display.
- **Accepts Resistive Temperature Detectors (RTDs):** Use three-wire, 100 Ω, platinum, 0.00385-curve sensors. Special inputs must be installed.
- **Automatic Scaling for Process Analog Inputs:** The D8 series automatically scales process inputs used with industrial process sensors. Enter two points, and all input values are automatically scaled. Special inputs must be installed.
- **Dual Outputs:** The D8 series includes both heat and cool control outputs for each loop. Independent control parameters are provided for each output.
- **Independently Selectable Control and Output Modes:** Set each control output to on/off, time proportioning, Serial DAC (digital-to-analog converter) or distributed zero crossing mode. Set up to two outputs per loop for on/off, P, PI or PID control with reverse or direct action.
- **Boost Output Function:** Set digital outputs to function as boost on/off control in association with any alarm.
- **Flexible Alarms:** Independently set high and low alarms and high and low deviation alarms for each loop. Alarms can activate a digital output by themselves, or they can be grouped with other alarms to activate an output.
- **Global Alarm Output:** Any alarm event activates the global alarm output.
- **CPU Watchdog:** The CPU watchdog timer output notifies you of system failure.
- **Keypad or DeviceNet Operation:** Set up and run the controller from the keypad or via the DeviceNet interface.
- **DeviceNet Communications:** Connect software, programmable logic controllers and other master devices using the widely supported DeviceNet protocol. The D8 is compliant with both the ODVA DeviceNet specification and the Interface Guidelines for DeviceNet on Semiconductor Manufacturing Tools.
- **Multiple Job Storage:** Store up to eight jobs in the controller’s battery-backed memory. Load a job through the keypad, digital inputs or software. Each job is a set of operating conditions, including set points and alarm limits.

- **Nonlinear Output Curves:** Select either of two nonlinear output curves for each control output.
- **Autotuning:** Use the autotune feature to set up your system quickly and easily. The internal expert system table finds the correct PID parameters for your process.
- **Low Power Shutdown:** The controller shuts down and turns off all outputs when it detects the input voltage drop below the minimum safe operating level.
- **Process Variable Retransmit:** Scale a temperature or process and convert it to an analog output for external devices such as chart recorders.
- **Two-Zone Cascade Control:** Control thermal systems with long lag times, which cannot be accurately controlled with a single loop.
- **Ratio or Offset Control:** Control one process as a ratio or offset of another process.
- **Remote Analog Set Point:** Scale an external voltage or current source to provide a set point for a loop.

D8 Parts List

You may have received one or more of the following components. See Figure 2.1 on page 12 for D8 configuration information.

- D8 series controller with mounting collar and brackets
- TB50 with 50-pin SCSI cable
- Power supply with mounting bracket and screws
- Serial DAC (digital-to-analog converter)
- Special input resistors (installed in D8)
- User's guide

D8x0-0000-xx0x

Number of Loops
4 = 4-loop controller
8 = 8-loop controller

Digital I/O Termination
0 = TB18
1 = SCSI connector, no terminal board or cable
2 = SCSI connector, TB50 and 3-foot cable
3 = SCSI connector, TB50 and 6-foot cable
4 = SCSI connector, TB50 and 3-foot right angle cable
5 = SCSI connector, TB50 and 6-foot right angle cable

Power Supply
0 = No power supply
1 = CE Power Supply
2 = Wall mount power supply

Special Inputs
0 = Thermocouples and -10 to 60mV inputs only
X = Number of current, voltage and RTD inputs

Figure 1.1 D8 Standard Parts List

D8SI _ _ - _ _ - _ _

Special/Process Input Type
(Not required for thermocouple sensor inputs)
23 = RTD
43 = 0 to 10 mA dc
44 = 0 to 20 mA dc or 4 to 20 mA dc
50 = 0 to 100 mV dc
52 = 0 to 500 mV dc
53 = 0 to 1 Vdc
55 = 0 to 5 Vdc
56 = 0 to 10 Vdc
57 = 0 to 12 Vdc

Start Loop
XX = Loop number XX

End Loop
XX = Loop number XX

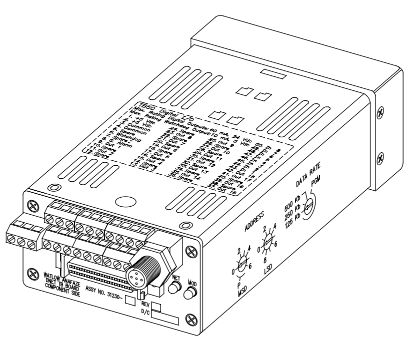
Figure 1.2 D8 Special Inputs Parts List

Technical Description

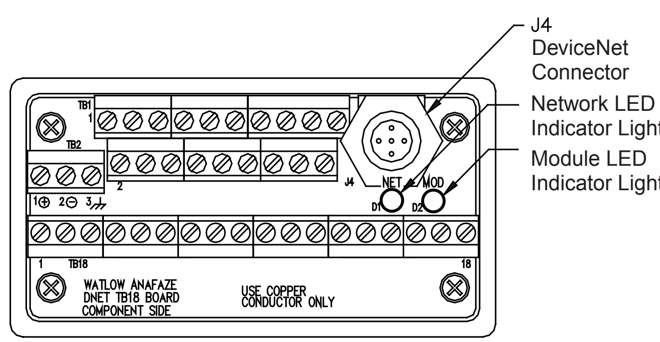
This section contains a technical description of each component of the D8 series controller.

D8

The D8 is housed in a 1/8-DIN panel mount package. It contains the central processing unit (CPU), random access memory (RAM) with a built-in battery, flash memory, communications, digital I/O, analog inputs, display and touch keypad.



Series D8 with SCSI Connector.



Series D8 with TB18 Connector.

Figure 1.3 D8 Rear Views

The D8 has the following features:

- Keypad and two-line, 16-character display.
- Screw terminals for the power and analog inputs.
- Micro-style connector for DeviceNet.
- Input power of 12 to 24 Vdc at 1 Amp.
- 50-pin SCSI cable to connect the digital inputs and outputs to the 50-terminal block (TB50). The D8 is available with an 18-terminal block (TB18) in place of the SCSI connector, as shown in Figure 1.3 on page 6.
- Nonvolatile flash memory for storage of firmware and programmable logic.
- Battery-backed storage of operating parameters. If a power loss occurs, the operating parameters are stored in memory. The battery has a ten-year shelf life, and it is not used when the controller is on.
- Microprocessor control of all calculations for input signal linearization, PID control, alarms, and communications.

Front Panel Description

The display and keypad provide an intelligent way to operate the controller. The display has 16 alphanumeric or graphic characters per line. The eight-key keypad allows you to change the operating parameters, controller functions and displays.

The displays show process variables, set points and output levels for each loop. A single-loop display, scanning display and alarm display offer a real-time view of process conditions.

For useful tips, help and menu information, press *i* from any screen.

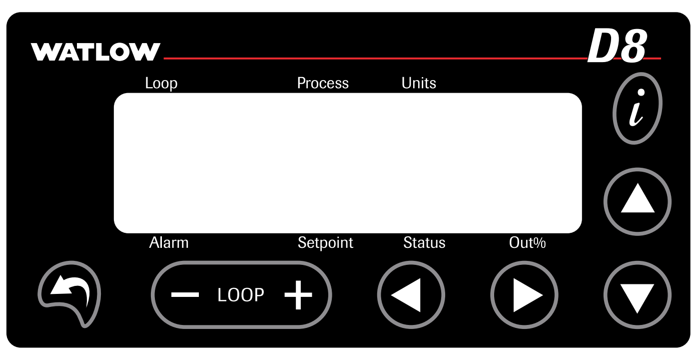


Figure 1.4 D8 Front Panel

TB50

The TB50 is a screw-terminal interface for control wiring. It allows you to connect power controllers and other discrete I/O devices to the D8. The screw terminal blocks accept wires as large as 18 AWG (0.75 mm^2). A 50-pin SCSI cable connects the TB50 to the D8.

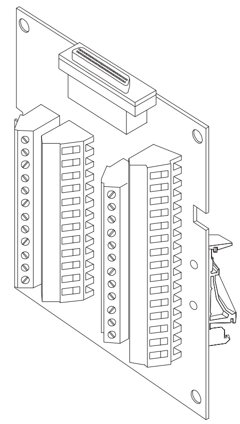


Figure 1.5 TB50

D8 Cabling

Watlow Anafaze provides cables required to install the D8. A 50-pin SCSI cable connects the TB50 to the D8.

Safety

Watlow Anafaze has made every effort to ensure the reliability and safety of this product. In addition, we have provided recommendations that will allow you to safely install and maintain this controller.

External Safety Devices

The D8 controller may fail full-on (100 percent output power) or full-off (0 percent output power), or may remain full-on if an undetected sensor failure occurs.

Design your system to be safe even if the controller sends a 0 percent or 100 percent output power signal at any timeInstall independent, external safety devices such as the Watlow Anafaze TLM-8 that will shut down the system if a failure occurs.

Typically, a shutdown device consists of an agency-approved high/low process limit controller that operates a shutdown device such as an mechanical contactor. The limit controller monitors for a hazardous condition such as an under-temperature or over-temperature fault. If a hazardous condition is detected, the limit controller sends a signal to open the contactor.

The safety shutdown device (limit controller and contactor) must be independent from the process control equipment.

WARNING! ***The controller may fail in a 0 percent or 100 percent output power state. To prevent death, personal injury, equipment damage or property damage, install external safety shutdown devices that operate independently from the process control equipment.***

With proper approval and installation, thermal fuses may be used in some processes.

Power-Fail Protection

In the occurrence of a sudden loss of power, the D8 controller can be programmed to reset the control outputs to off (this is the default). The controller can also be configured to restart to data stored in memory.

A memory-based restart might create an unsafe process condition for some installations. Use a memory-based restart only if you are certain your system will safely restart. See Power Up Loop Mode on page 128.

When using the controller with a computer or other master device, you can program the software to automatically reload desired operating constants or process values on powerup. These convenience features do *not* eliminate the need for independent safety devices.

Contact Watlow Anafaze immediately if you have any questions about system safety or system operation.

2

Installation

This chapter describes how to install the D8 series controller and its peripherals. Installation of the controller involves the following procedures:

- Determining the best location for the controller
- Mounting the controller and TB50
- Power connection
- Input wiring
- Communications wiring
- Output wiring

WARNING! ***Risk of electric shock. Shut off power to your entire process before you begin installing the controller.***

WARNING! ***The controller may fail in a 0 percent or 100 percent power output state. To prevent death, personal injury, equipment damage or property damage, install external safety shut-down devices that operate independently from the process control equipment.***

Typical Installation

Figure 2.1 shows typical installations of the controller with the TB50 and the TB18 terminal blocks. The type of terminal block you use greatly impacts the layout and wiring of your installation site. See Figure 2.2 to Figure 2.10 to determine potential space requirements.

We recommend that you read this entire chapter before beginning the installation procedure. This will help you to carefully plan and assess the installation.

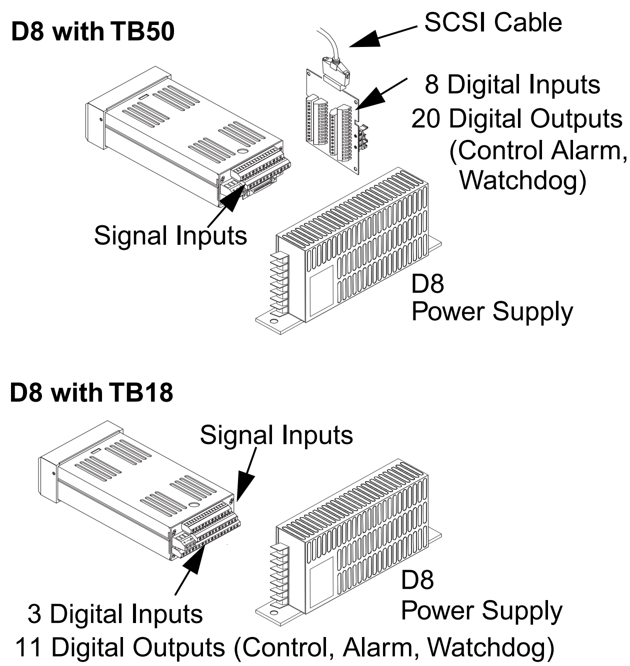


Figure 2.1 D8 System Components

Mounting Controller Components

Install the controller in a location free from excessive heat (>50º C), dust and unauthorized handling. Electromagnetic and radio frequency interference can induce noise on sensor wiring. Choose locations for the D8 and TB50 such that wiring can be routed clear of sources of interference such as high voltage wires, power switching devices and motors.

NOTE! ***For indoor use only.***

WARNING! ***To reduce the risk of fire or electric shock, install the D8 in a controlled environment, relatively free of contaminants.***

Recommended Tools

Use any of the following tools to cut a hole of the appropriate size in the panel.

- Jigsaw and metal file, for stainless steel and heavyweight panel doors.
- Greenlee 1/8-DIN rectangular punch (Greenlee part number 600-68), for most panel materials and thicknesses.
- Nibbler and metal file, for aluminum and lightweight panel doors.

You will also need these tools:

- Phillips head screwdriver
- 1/8-inch (3 mm) flathead screwdriver for wiring
- Multimeter

Mounting the Controller

Mount the controller before you mount the other components, such as the power supply or TB50, or do any wiring. The controller’s placement affects placement and wiring considerations for the other components of your system.

Ensure that there is enough clearance for mounting brackets, terminal blocks, and cable and wire connections. The controller extends 191 mm (7.5 inches) behind the panel face and the collar and brackets extend 7 mm (9/32 inches) on the sides and 12 mm (15/32 inches) above and below it. Allow an additional

41 mm (1.6 inches) for a right-angle DeviceNet connector and SCSI connector. Refer to Figure 2.2.

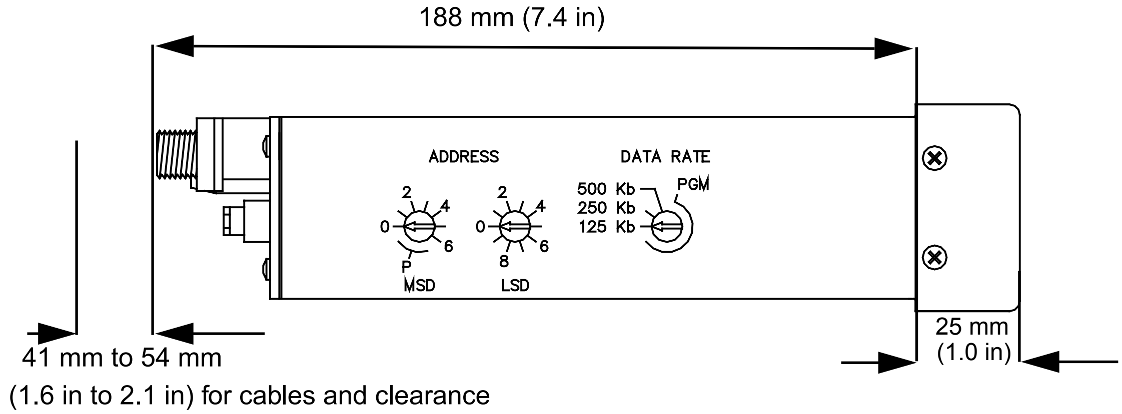


Figure 2.2 Module Dimensions and Clearance

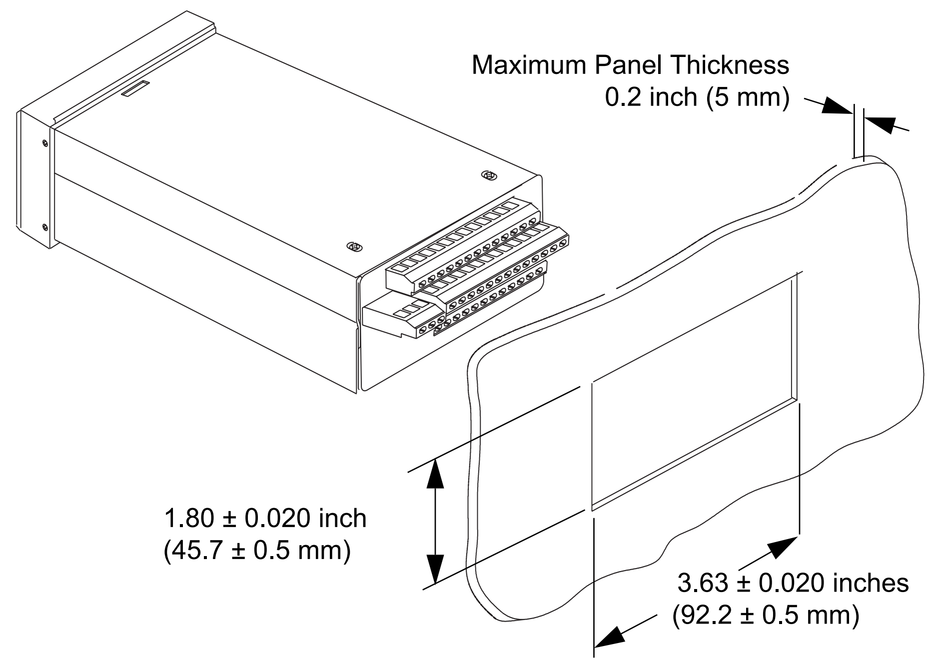


Figure 2.3 Wiring Clearances

We recommend you mount the controller in a panel not more than 0.2 inch (5 mm) thick.

1. Choose a panel location free from excessive heat (more than 50°C), dust, and unauthorized handling. (Make sure there is adequate clearance for the mounting hardware,

terminal blocks, and cables. The controller extends 188 mm (7.4 in.) behind the panel. Allow for an additional 41 to 54 mm (1.6 to 2.1 in.) beyond the connectors.

2. Temporarily cover any slots in the metal housing so that dirt, metal filings, and pieces of wire do not enter the housing and lodge in the electronics.
3. Cut a hole in the panel 46 mm (1.80 in.) by 92 mm (3.63 in.) as shown below. (This picture is NOT a template; it is for illustration only.) Use caution; the dimensions given here have 1 mm (0.02 in.) tolerances.
4. Remove the brackets and collar from the controller, if they are already in place.
5. Slide the controller into the panel cutout.
6. Slide the mounting collar over the back of the controller, making sure the mounting screw indentations face toward the back of the controller.

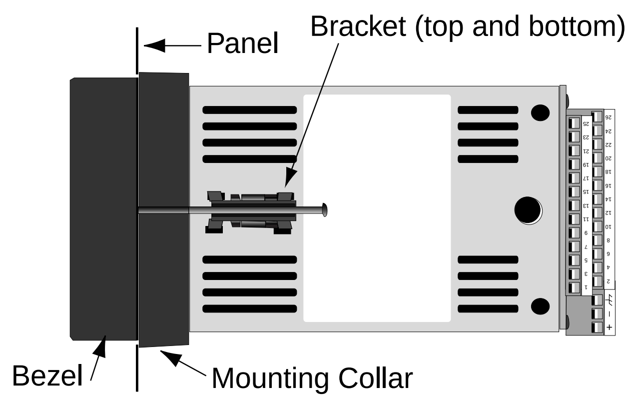


Figure 2.4 Mounting Bracket

7. Loosen the mounting bracket screws enough to allow for the mounting collar and panel thickness. Place each mounting bracket into the mounting slots (head of the screw facing the back of the controller). Push each bracket backward then to the side to secure it to the controller case.
8. Make sure the case is seated properly. Tighten the installation screws firmly against the mounting collar to secure the unit. Ensure that the end of the mounting screws fit into the indentations on the mounting collar.

Mounting the TB50

There are two ways to mount the TB50: Use the pre-installed DIN rail mounting brackets or use the plastic standoffs.

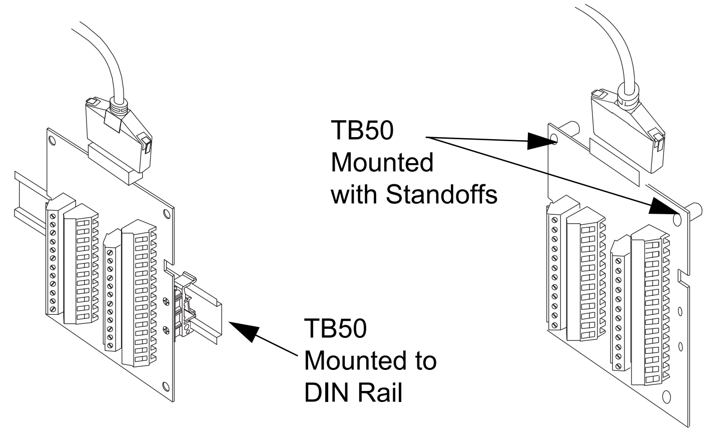


Figure 2.5 Mounting the TB50

DIN Rail Mounting

Snap the TB50 on to the DIN rail by placing the hook side on the rail first, then pushing the snap latch side in place. See Figure 2.6.

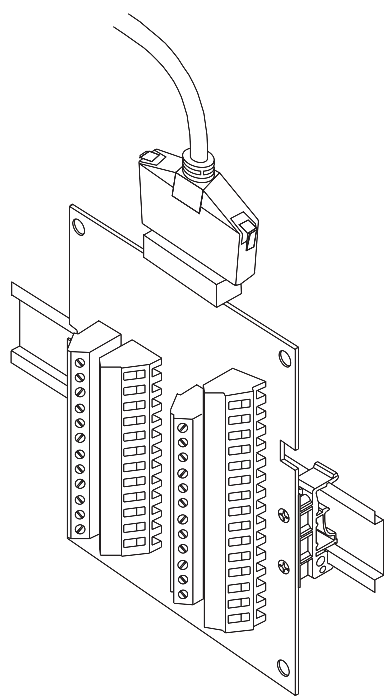


Figure 2.6 TB50 Mounted on a DIN Rail (Front)

To remove the TB50 from the rail, use a flathead screw driver to unsnap the bracket from the rail. See Figure 2.7.

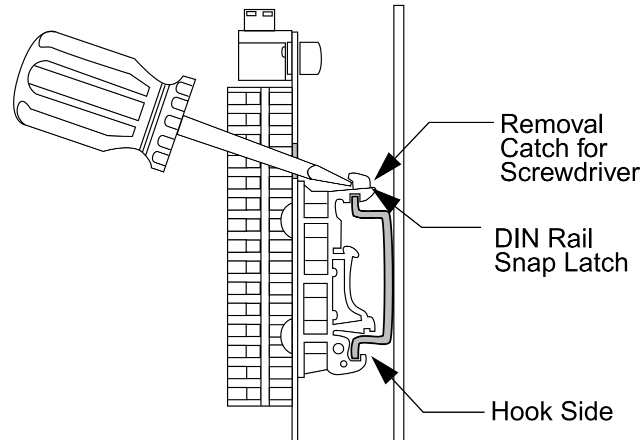


Figure 2.7 TB50 Mounted on DIN Rail (Side)

Mounting with Standoffs

1. Remove the DIN rail mounting brackets from the TB50.
2. Choose a location with enough clearance to remove the TB50, its SCSI cable and the controller itself.
3. Mark the four mounting holes.
4. Drill and tap four mounting holes for #6 (3.5 mm) screws or bolts.
5. Mount the TB50 with four screws or bolts.

There are four smaller holes on the terminal board. Use these holes to secure wiring to the terminal block with tie wraps.

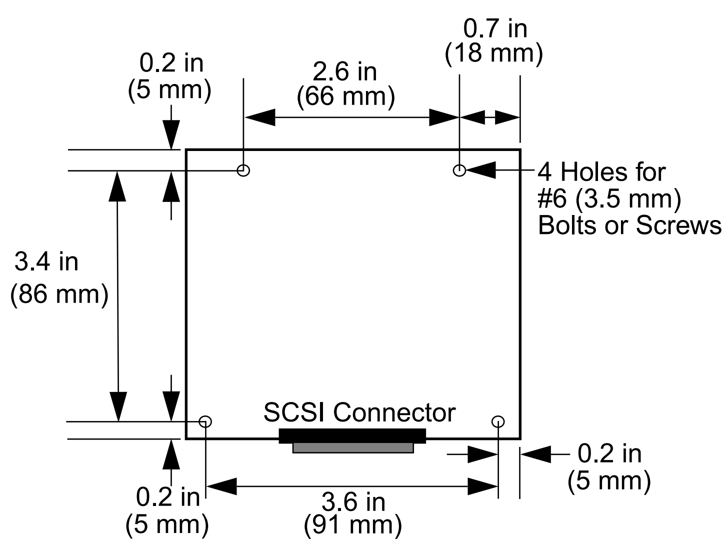


Figure 2.8 Mounting a TB50 with Standoffs

Mounting the Power Supply

If you use your own power supply for the D8, refer to the power supply manufacturer's instructions for mounting information. Choose a Class 2 power supply that supplies an isolated, regulated 12 to 24 Vdc at 1 A.

Mounting Environment

Leave enough clearance around the power supply so that it can be removed.

Mounting the Dual DAC or Serial DAC Module

This section describes how to mount the optional Dual DAC and Serial DAC digital-to-analog converters.

Mounting of the Dual DAC and Serial DAC is essentially the same, except that the dimensions differ.

Jumpers

The output signal range of the Dual DAC and Serial DAC modules is configured with jumpers. See Configuring Dual DAC Outputs on page 177 and Configuring Serial DAC Outputs on page 176 for information about setting these jumpers.

Mounting

1. Choose a location. The unit is designed for wall mounting. Install it as close to the controller as possible.
2. Mark and drill four holes for screw mounting. Holes accommodate #8 (3.5 mm) screws. See Figure 2.10 for screw locations. Install the unit with the four screws.

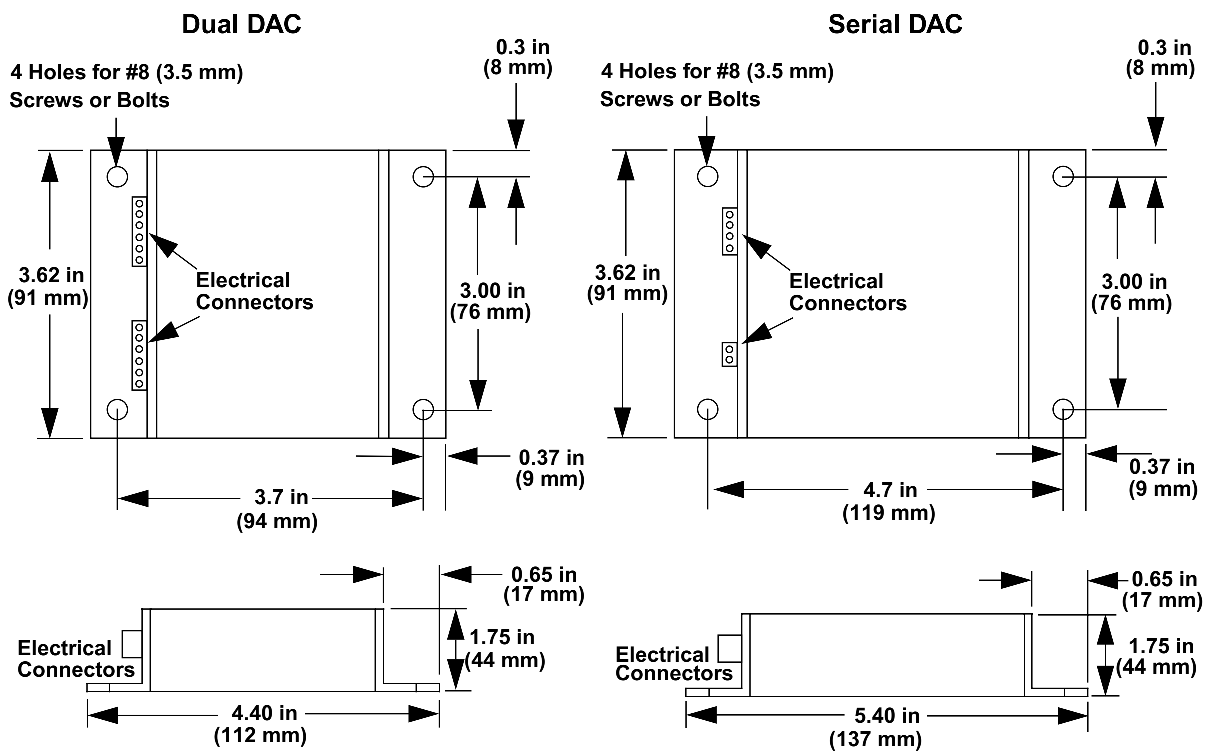


Figure 2.10 Dual DAC and Serial DAC Dimensions

System Wiring

Successful installation and operation of the control system can depend on placement of the components and on selection of the proper cables, sensors and peripheral components.

Routing and shielding of sensor wires and proper grounding of components can insure a robust control system. This section includes wiring recommendations, instructions for proper grounding and noise suppression, and considerations for avoiding ground loops.

WARNING! ***To reduce the risk of electrical shock, fire, and equipment damage, follow all local and national electrical codes. Correct wire sizes, fuses and thermal breakers are essential for safe operation of this equipment.***

CAUTION! ***Do not wire bundles of low-voltage signal and control circuits next to bundles of high-voltage ac wiring. High voltage may be inductively coupled onto the low-voltage circuits, which may damage the controller or induce noise and cause poor control.***

Physically separate high-voltage circuits from low-voltage circuits and from D8 hardware. If possible, install high-voltage ac power circuits in a separate panel.

Wiring Recommendations

Follow these guidelines for selecting wires and cables:

- Use stranded wire. (Solid wire can be used for fixed service; it makes intermittent connections when you move it for maintenance.)
- Use 20 AWG (0.5 mm^2) thermocouple extension wire. Larger or smaller sizes may be difficult to install, may break easily or may cause intermittent connections.
- Use shielded wire. The electrical shield protects the signals and the D8 from electrical noise. Connect one end of the input and output wiring shield to earth ground.
- Use copper wire for all connections other than thermocouple sensor inputs.

Table 2.1 Cable Recommendations

Function	Mfr. P/N	No. of Wires	AWG	mm^2
Analog Inputs	Belden 9154 Belden 8451	2 2	20 22	0.5 0.5
RTD Inputs	Belden 8772 Belden 9770	3 3	20 22	0.5 0.5
Thermocouple Inputs	thermocouple Ext. Wire	2	20	0.5
Control Outputs and Digital I/O	Belden 9539 Belden 9542 Ribbon Cable	9 20 50	24 24 22 to 14	0.2 0.2 0.5 to 2.5
Analog Outputs	Belden 9154 Belden 8451	2 2	20 22	0.5 0.5

Noise Suppression

The D8 outputs are typically used to drive solid state relays. These relays may in turn operate more inductive types of loads such as electromechanical relays, alarm horns and motor starters. Such devices may generate electromagnetic interference (EMI, or noise). If the controller is placed close to sources of EMI, it may not function correctly. Below are some tips on how to recognize and avoid problems with EMI.

For earth ground wire, use a large gauge and keep the length as short as possible. Additional shielding may be achieved by connecting a chassis ground strap from the panel to D8 case.

Symptoms of Noise

If your controller displays the following symptoms, suspect noise:

- The display screen blanks out and then reenergizes as if power had been turned off for a moment.
- The process variable value is incorrect on the controller display.

Noise may also damage the digital output circuit such that the digital outputs will not turn on. If the digital output circuit is damaged, return the controller to Watlow Anafaze for repair.

Avoiding Noise

To avoid or eliminate most RFI/EMI noise problems:

- Connect the D8 case to earth ground. The D8 system includes noise suppression circuitry. This circuitry requires proper grounding.
- Separate the 120 Vac and higher power leads from the low-level input and output leads connected to the D8 series controller. Do not run the digital I/O or control output leads in bundles with ac wires.
- Where possible, use solid state relays (SSRs) instead of electromechanical relays. If you must use electromechanical relays, avoid mounting them in the same panel as the D8 series equipment.
- If you must use electromechanical relays and you must place them in a panel with D8 series equipment, use a 0.01 microfarad capacitor rated at 1000 Vac (or higher) in series with a 47 Ω, 0.5 watt resistor across the normally-open contacts of the relay load. This is known as a snubber network and can reduce the amount of electrical noise.
- You can use other voltage suppression devices, but they are not usually required. For instance, you can place a metal oxide varistor (MOV) rated at 130 Vac for 120 Vac control circuits across the load, which limits the peak ac voltage to about 180 Vac (Watlow Anafaze part number 26-130210-00). You can also place a transorb (back-to-back zener diodes) across the digital output, which limits the digital output voltage.

Additional Recommendations for a Noise Immune System

We strongly recommended the following:

- Isolate outputs through solid state relays, where possible.
- Isolate RTDs or "bridge" type inputs from ground.
- Isolate digital inputs from ground through solid state relays. If this is not possible, then make sure the digital input is the only connection to earth ground other than the chassis ground.

Ground Loops

Ground loops occur when current passes from the process through the controller to ground. This can cause instrument errors or malfunctions.

A ground loop may follow one of these paths, among others:

- From one sensor to another.
- From a sensor to the dc power supply.

The best way to avoid ground loops is to minimize unnecessary connections to ground. Do **not** connect any of the following terminals to earth ground:

- Power supply dc common
- TB1 terminals 9, 10, 19 (analog common)
- TB2 terminal 2 (dc power common)

Do not connect the analog common terminals to the other terminals listed above.

Power Connections

This section explains how to make power connections to the D8 and the TB50.

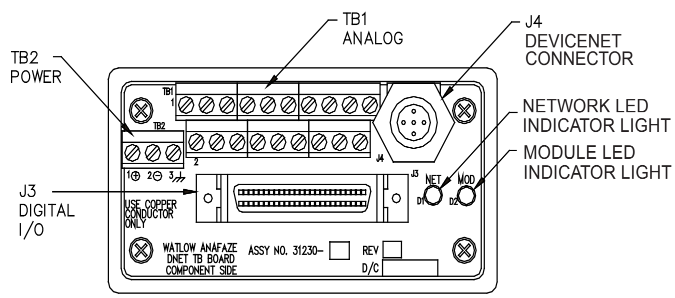


Figure 2.11 D8 Series Controller with TB50

Wiring the Power Supply

WARNING! ***Use a power supply with a Class 2 rating only. UL approval requires a Class 2 power supply.***

Connect power to the controller before any other connections, This allows you to ensure that the controller is working before any time is taken installing inputs and outputs.

Table 2.2 Power Connections

Function	Power Supply	D8 TB2
DC Power (Controller)	+12 to 24 Vdc	+
DC Common	12 to 24 Vdc Common	-
Earth Ground	Ground	⏚

1. Connect the dc common terminal on the power supply to the dc common (-) terminal on D8 TB2.
2. Connect the positive terminal on the power supply to the dc positive (+) terminal on D8 TB2.
3. If using an isolated dc output or another power supply to power the loads, connect the dc common of the supply powering the loads to the dc common of the supply powering the controller.
4. Use the ground connector on TB2 for chassis ground. This terminal is connected to the D8 chassis and must be connected to earth ground.
5. Connect 120/240 Vac power to the power supply.

NOTE! ***Connect the dc common of the power supply used for loads to the dc common of the supply powering the controller. If the supplies are not referenced to one another, the controller's outputs will not be able to switch the loads.***

NOTE! ***When making screw terminal connections, tighten to 4.5 to 5.4 in.-lb. (0.5 to 0.6 Nm).***

CAUTION! ***Without proper grounding, the D8 may not operate properly or may be damaged.***

CAUTION! ***To prevent damage from incorrect connections, do not turn on the heater power or other output power before testing the connections as explained in Testing the System on page 26.***

NOTE! ***Do not connect the controller's dc common (COM) to earth ground ⏚. Doing so will defeat the noise protection circuitry, making measurements less stable.***

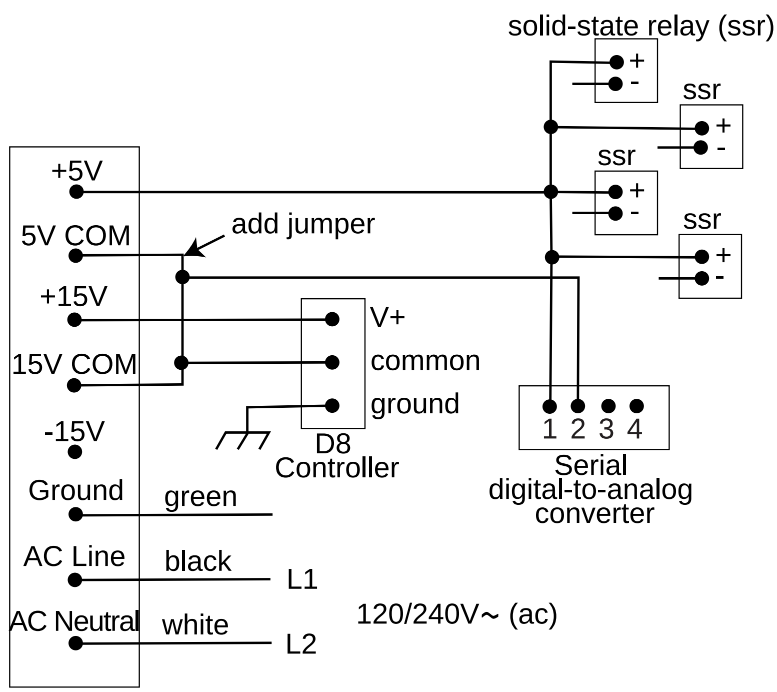


Figure 2.12 Power Connections with the D8 Power Supply

Connecting the TB50 to the D8

1. Connect the SCSI cable to the controller.
2. Connect the SCSI cable to the TB50.

Testing the System

This section explains how to test the controller after installation and prior to making field wiring connections.

TB50 or TB18 Test

Use this procedure to verify that the TB50 or TB18 is properly connected and supplied with power:

1. Turn on power to the D8. The display should first show *Calculating checksum*, and then show the single-loop display. If you do not see these displays, disconnect power and check wiring and power supply output.
2. Measure the +5 Vdc supply at the TB50 or TB18:
   a) Connect the voltmeter's common lead to TB50 terminal 3 or TB18 terminal 2.
   b) Connect the voltmeter's positive lead to TB50 or TB18 terminal 1. The voltage should be +4.75 to +5.25 Vdc.

Digital Output Test

Use this procedure to test the controller outputs before loads are connected. If using it at another time for troubleshooting, disconnect loads from outputs before testing.

1. Connect a 500 Ω to 100 k Ω resistor between TB50 or TB18 terminal 1 and a digital output terminal. See Table 2.6 on page 36 for TB18 connections or Table 2.7 on page 37 for TB 50 connections.
2. Connect the voltmeter's positive lead to terminal 1 on the TB50 or TB18.
3. Connect the voltmeter's common lead to the digital output terminal.
4. Use the digital output test in the *I/O tests* menu to turn the digital output on and off (see Test Digital Output 1 to 20 on page 153). When the output is off, the output voltage should be less than 1 V. When the output is on, the output voltage should be between 4.75 and 5.25 V.

NOTE! ***By default, heat outputs are enabled. Only disabled outputs may be turned on using the manual I/O test. To test heat outputs, set the corresponding loop to manual mode 100 percent output. See Changing the Control Mode and Output Power on page 85.***

Digital Input Test

Use the following procedure to test digital inputs before connecting to field devices:

1. Disconnect any system wiring from the input to be tested.
2. Go to the *Digital inputs* test in the *I/O tests* menu. This test shows whether the digital inputs are off (open) or on (closed).
3. Attach a wire to the terminal of the digital input you want to test. See Table 2.6 on page 36 for TB 18 connections or Table 2.7 on page 37 for TB50 connections.
   a) When the wire is connected only to the digital input terminal, the digital input test should show that the input is off (open).
   b) When you connect the other end of the wire to the controller common (TB50 terminal 3 or TB18 terminal 2), the digital input test should show that the input is on (closed).

Sensor Wiring

This section describes how to properly connect thermocouples, RTDs, current and voltage inputs to the controller. The controller can accept any mix of available input types. Some input types require that special scaling resistors be installed (generally done by Watlow Anafaze before the controller is delivered).

All inputs are installed at the "CH" input connectors (TB1) at the back of the controller. The illustrations below show the connector locations for all D8 series controllers.

CAUTION! ***Never run input leads in bundles with high power wires or near other sources of EMI. This could inductively couple voltage onto the input leads and damage the controller, or could induce noise and cause poor measurement and control.***

Table 2.3 TB1 Connections

Terminal Number	Label	Function
1	CH 1 IN+	Channel 1 positive input
2	CH 1 IN-	Channel 1 negative input
3	CH 2 IN+	Channel 2 positive input
4	CH 2 IN-	Channel 2 negative input
5	CH 3 IN+	Channel 3 positive input
6	CH 3 IN-	Channel 3 negative input
7	CH 4 IN+	Channel 4 positive input
8	CH 4 IN-	Channel 4 negative input
9	Com	Analog Common
10	Com	Analog Common
11	CH 5 IN+	Channel 5 positive input[1]
12	CH 5 IN-	Channel 5 negative input[1]
13	CH 6 IN+	Channel 6 positive input[1]
14	CH 6 IN-	Channel 6 negative input[1]
15	CH 7 IN+	Channel 7 positive input[1]
16	CH 7 IN-	Channel 7 negative input[1]
17	CH 8 IN+	Channel 8 positive input[1]
18	CH 8 IN-	Channel 8 negative input[1]
19	Com	Analog Common

NOTE! **[1] Terminals 11 to 18 are not used with a 4-channel controller.**

Input Wiring Recommendations

Use multicolored stranded shielded cable for analog inputs. Watlow Anafaze recommends that you use 20 AWG wire (0.5 mm^2). If the sensor manufacturer requires it, you can also use 24 or 22 AWG wiring (0.2 mm^2). Most inputs use a shielded twisted pair; some require a three-wire input.

The controller accepts the following inputs without any special scaling resistors:

- J, K, T, S, R, B and E thermocouples.
- Process inputs with ranges between -10 and 60 mV.

To avoid thermocouple open alarms on unused inputs, either set the *Input type* parameter to *skip* or jumper the input.

Thermocouple Connections

Connect the positive lead of the thermocouple to the IN+ terminal for one of the loops, and connect the negative lead to the corresponding IN- terminal.

Use 18 or 20 AWG (0.5 or 0.75 mm^2) for all thermocouple inputs. Most thermocouple wire is solid, unshielded wire. When using shielded wire, ground one end only.

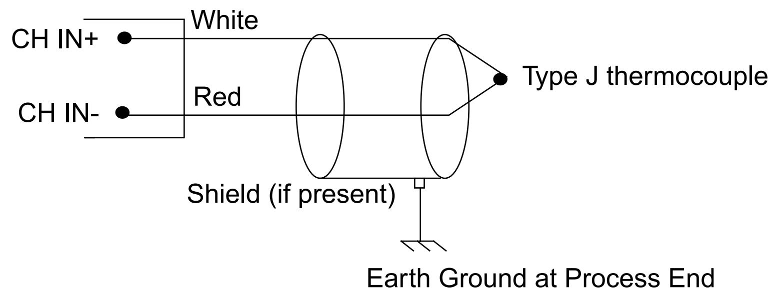


Figure 2.13 Thermocouple Connections

CAUTION! ***Ground loops and common mode noise can damage the controller or disrupt measurements. To minimize ground loops and common mode noise:***

• Do not mix grounded and ungrounded thermocouples. If any thermocouple connected to the controller is of grounded construction, all thermocouples should be of grounded construction and each should be connected to ground at the process end.

• Connect the earth ground terminal on TB2 to a good earth ground, but do not connect the analog common to earth ground. The D8 uses a floating analog common for sensor measurements. The noise protection circuits on the sensor inputs function correctly only if the controller is correctly installed. See Ground Loops on page 22.

RTD Input Connections

RTD inputs require accessory resistors. Watlow Anafaze recommends that you use a 100 Ω, three-wire platinum RTD to prevent reading errors due to cable resistance. If you use a two-wire RTD, jumper the negative input to common. If you must use a four-wire RTD, leave the fourth wire unconnected.

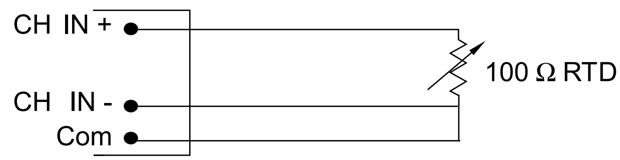


Figure 2.14 RTD Connections

Voltage Input Connections

Voltage inputs with ranges greater than -10 to 60 mV require accessory resistors. Special input resistors installed at Watlow Anafaze divide analog input voltages such that the controller sees a -10 to 60 mV signal on the loop.

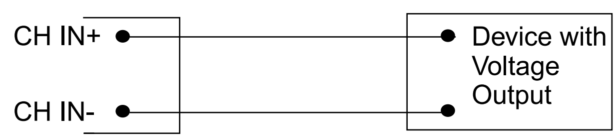


Figure 2.15 Voltage Signal Connections

Current Input Connections

Current inputs require accessory resistors. Special input resistors installed at Watlow Anafaze for analog current signals are such that the controller sees a -10 to 60 mV signal across its inputs for the loop.

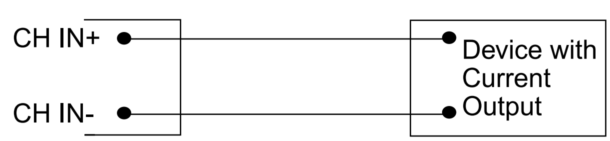


Figure 2.16 Current Signal Connections

Wiring Control and Digital I/O

This section describes how to wire and configure the control outputs for the D8 series controller. The D8 provides dual control outputs for each loop. These outputs can be enabled or disabled, and are connected through a TB50 or TB18.

NOTE! ***Control outputs are connected to controller common when the control output is on. If you connect external devices that may have a low side at a voltage other than controller ground, you may create ground loops. To prevent ground loops, use isolated solid state relays and isolate the control device inputs.***

Output Wiring Recommendations

When wiring output devices, use multicolored, stranded, shielded cable for analog outputs and digital outputs connected to panel-mounted solid state relays.

- Analog outputs usually use a twisted pair.
- Digital outputs usually have 9 to 20 conductors, depending on wiring technique.

Cable Tie Wraps

After you wire outputs to the TB50, install the cable tie wraps to reduce strain on the connectors. Each row of terminals has a cable tie wrap hole at one end. Thread the cable tie wrap through the cable tie wrap hole. Then, wrap the cable tie wrap around the wires attached to that terminal block.

Digital Outputs

The D8 provides dual control outputs for up to eight loops. By default, heat outputs are enabled and cool outputs are disabled. If the heat or cool output is disabled for a loop, then the output is available for alarms or programmable logic. The CPU watchdog timer output can be used to monitor the state of the controller; see CPU Watchdog Timer on page 34.

Table 2.4 Digital Output States and Values Stored in the Controller

State	Value[1]	Description
Off	0	Open circuit
On	1	Sinking current to controller common

[1] **Read and write these values through communications.**

All digital outputs sink current to controller common when on. The load may powered by the 5 Vdc supplied by the controller at the TB50, or by an external power supply. When using an external power supply, bear in mind:

- The D8 power supply available from Watlow Anafaze includes a 5 Vdc supply. When using it to supply output loads, connect the 5 Vdc common to the 15 Vdc common at the power supply.
- Do not exceed +24 volts.
- If you connect the external load to earth ground, or if you cannot connect it as shown in Figure 2.17, then use a solid state relay.

The outputs conduct current when they are on. The maximum current sink capability is 60 mA at 24 Vdc. The outputs cannot "source" current to a load.

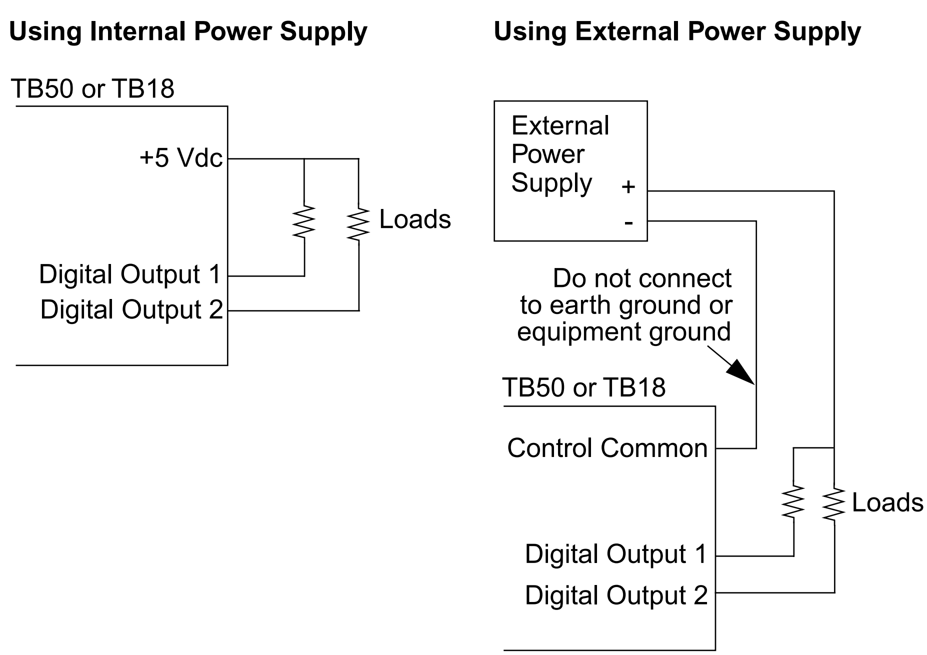


Figure 2.17 Digital Output Wiring

Configuring Outputs

As you choose outputs for control and alarms, bear in mind the following points:

- You can enable or disable the control outputs. By default, heat outputs are enabled and cool outputs are disabled.
- You can program each control output individually for on/off, time proportioning, distributed zero-crossing or Serial DAC control.
- You can individually program each control output for direct or reverse action.
- Alarm outputs other than the global alarm are non-latching. See Global Alarm on page 97.
- Alarms can be suppressed during process start up and for preprogrammed durations. See Power Up Alarm Delay on page 128.
- Alarm outputs can be configured, as a group, to sink to output during an alarm or stop current flow during an alarm. See Digital Output Alarm Polarity on page 129.

Control and Alarm Output Connections

Typically control and alarm outputs use external optically-isolated solid state relays (SSRs). SSRs accept a 3 to 32 Vdc input for control, and some can switch up to 100 Amps at 480 Vac. For larger currents, use silicon control rectifier (SCR) power controllers up to 1000 Amps at 120 to 600 Vac. You can also use SCRs and a Serial DAC for phase-angle fired control.

The control and alarm outputs are open collector outputs referenced in the D8's common. Each output sinks up to 60 mAdc to the controller common when on.

NOTE! ***Control outputs are sink outputs. They sink current when the output is on. Connect them to the negative side of solid state relays.***

Figure 2.18 shows sample heat, cool and alarm output connections.

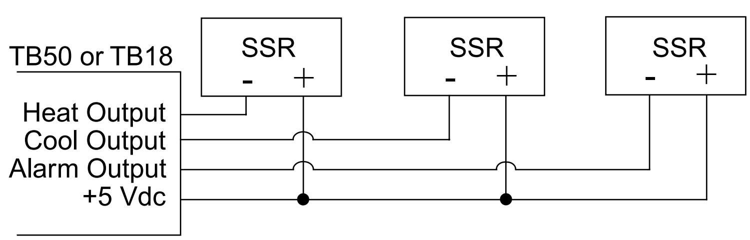


Figure 2.18 Sample Heat, Cool and Alarm Output Connections

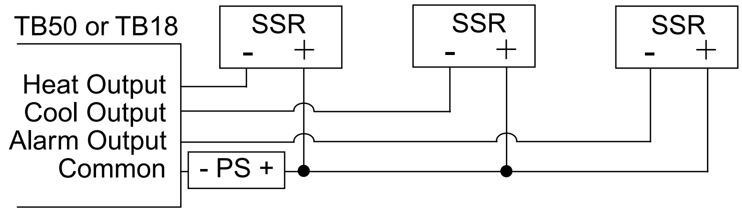


Figure 2.19 Output Connections Using External Power Supply

CPU Watchdog Timer

The CPU watchdog timer constantly monitors the microprocessor. It is a sink output located on TB50 terminal 6 or TB18 terminal 3. The output can be connected to an external circuit or device to monitor whether the controller is powered and operational. The output is on (low) when the microprocessor is operating; when it stops operating, the output goes off (high).

Figure 2.20 and Figure 2.21 show the recommended circuit for the watchdog timer output for the TB50 and the TB18.

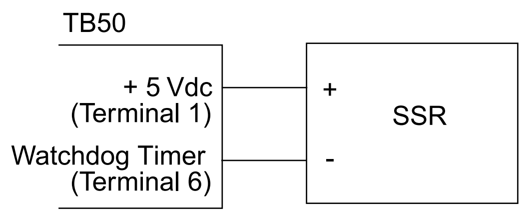


Figure 2.20 TB50 Watchdog Timer Output

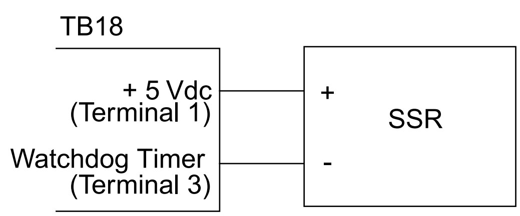


Figure 2.21 TB18 Watchdog Timer Output

Digital Inputs

All digital inputs are transistor-transistor logic (TTL) level inputs referenced to controller common and the internal +5 V power supply of the D8.

When an input is connected to the controller common, the input is considered on. Otherwise, the input is considered off. Most features that use the digital inputs can be user-configured to activate when an input is either on or off.

In the off state, internal 4.7 kΩ resistors pull the digital inputs high to 5 Vdc with respect to the controller common.

Table 2.5 Digital Input States and Values Stored in the Controller

State	Value[1]	Description
Off	0	Open circuit
On	1	Digital input connected to controller common

[1] Read and write these values through communications.

External Switching Device

To ensure that the inputs are reliably switched, use a switching device with the appropriate impedances in the on and off states and do not connect the inputs to external power sources.

When open, the switching device must provide an impedance of at least 14 kΩ to ensure that the voltage will rise to greater than 3.7 Vdc. When closed, the switch must provide not more than 1.7 kΩ impedance to ensure the voltage drops below 1.3 Vdc.

To install a switch as a digital input, connect one lead to the common terminal on the TB50 (terminals 3 and 4) or TB18 (terminal 2). Connect the other lead to the desired digital input terminal on the TB50 (terminals 43 to 50) or TB18 (terminals 16 to 18).

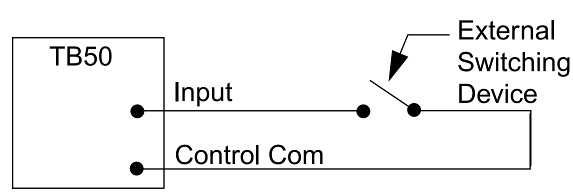


Figure 2.22 Wiring Digital Inputs

Functions Activated by Digital Inputs

Use digital inputs to activate the following functions:

- Load a job that is stored in controller memory. See BCD Job Load on page 126.
- Change all loops to manual mode at specified output levels. See Mode Override on page 127.
- Enable thermocouple short detection. See Thermocouple Short Alarm on page 129.
- Restore automatic control after a failed sensor has been repaired. See Restore Automatic Mode on page 138.

TB18 Connections

Table 2.6 TB18 Connections

		Control Output[1]	
Terminal	**Function**	**D84 _ - _ _ _ _ - _ _ _ _**	**D88 _ - _ _ _ _ - _ _ _ _**
1	+5 Vdc		
2	CTRL COM		
3	Watchdog timer		
4	Global alarm		
5	Output 1	Loop 1 heat	Loop 1 heat
6	Output 2	Loop 2 heat	Loop 2 heat
7	Output 3	Loop 3 heat	Loop 3 heat
8	Output 4	Loop 4 heat	Loop 4 heat
9	Output 5	Loop 1 cool	Loop 5 heat
10	Output 6	Loop 2 cool	Loop 6 heat
11	Output 7	Loop 3 cool	Loop 7 heat
12	Output 8	Loop 4 cool	Loop 8 heat
13	Output 9		Loop 1 cool
14	Output 10		Loop 2 cool
15	Output 18[2]	Serial DAC clock	Serial DAC clock
16	Input 1		
17	Input 2		
18	Input 3		

[1] The indicated outputs are dedicated for control when enabled in the loop setup. If one or both of the outputs are disabled for a loop, then the corresponding digital outputs become available for alarms.

[2] If you install a Watlow Anafaze Serial DAC, the D8 series controller uses digital output 18 (terminal 15) for a clock line. You cannot use output 18 for anything else if a Serial DAC is installed.

TB50 Connections

Table 2.7 TB50 Connections

		Control Output[1]				Control Output[1]	
Ter-minal	**Function**	**D88**	**D84**	**Ter-minal**	**Function**	**D88**	**D84**
1	+5 Vdc			2	+5 Vdc		
3	CTRL COM			4	CTRL COM		
5	Not used			6	Watchdog Timer		
7	Not used			8	Global Alarm		
9	Output 1	Loop 1 heat	Loop 1 heat	10	Not used		
11	Output 2	Loop 2 heat	Loop 2 heat	12	Not used		
13	Output 3	Loop 3 heat	Loop 3 heat	14	Not used		
15	Output 4	Loop 4 heat	Loop 4 heat	16	Not used		
17	Output 5	Loop 5 heat	Loop 1 cool	18	Not used		
19	Output 6	Loop 6 heat	Loop 2 cool	20	Not used		
21	Output 7	Loop 7 heat	Loop 3 cool	22	Not used		
23	Output 8	Loop 8 heat	Loop 4 cool	24	Not used		
25	Output 9	Loop 1 cool		26	Not used		
27	Output 10	Loop 2 cool		28	Not used		
29	Output 11	Loop 3 cool		30	Not used		
31	Output 12	Loop 4 cool		32	Not used		
33	Output 13	Loop 5 cool		34	Not used		
35	Output 14	Loop 6 cool		36	Not used		
37	Output 15	Loop 7 cool		38	Not used		
39	Output 16	Loop 8 cool		40	Not used		
41	Output 17			42	Output 18[2]	Serial DAC clock	
43	Input 1			44	Input 2		
45	Input 3			46	Input 4		
47	Input 5			48	Input 6		
49	Input 7			50	Input 8		

[1] The indicated outputs are dedicated for control when enabled in the loop setup. If one or both of a loop's outputs are disabled, the corresponding digital outputs become available for alarms or programmable logic.

[2] If you install a Watlow Anafaze Serial DAC, the D8 uses digital output 18 (terminal 42) for a clock line. You cannot use output 18 for anything else if a Serial DAC is installed.

Analog Outputs

Analog outputs can be provided by using a Dual DAC or Serial DAC module to convert the open collector outputs from the controller. Use multicolored stranded shielded cable for analog outputs. Analog outputs generally use a twisted pair wiring. The following sections describe how to connect the Dual DAC and Serial DAC modules to power the controller outputs and the load.

Wiring the Dual DAC

A Dual DAC module includes two identical circuits. Each can convert a distributed zero cross (DZC) signal from the controller to a voltage or current signal. Watlow Anafaze **strongly** recommends using a power supply separate from the controller supply to power the Dual DAC. Using a separate power supply isolates the controller's digital logic circuits and analog measurement circuits from the frequently noisy devices that take the analog signal from the Dual DAC.

Several Dual DAC modules may be powered by one power supply. Consult the Specifications chapter for the Dual DAC's power requirements. Also note in the specifications that the Dual DAC does not carry the same industry approvals as the Serial DAC.

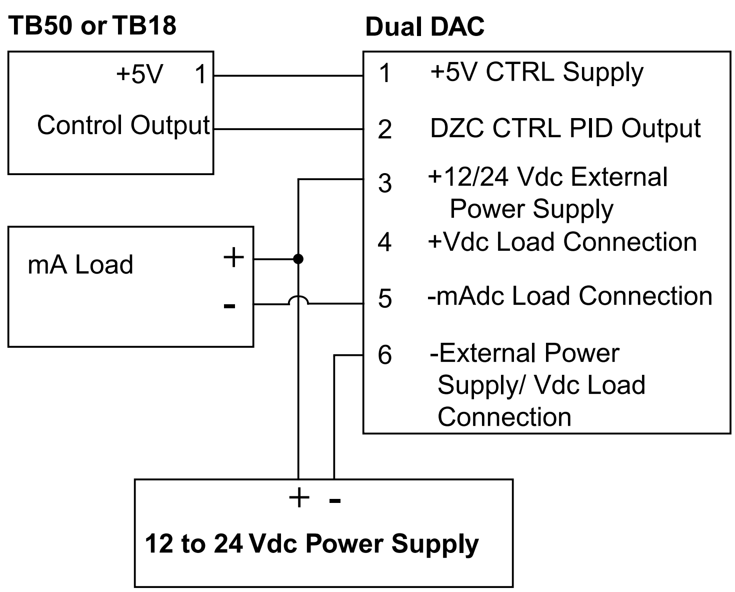


Figure 2.23 Dual DAC with Current Output

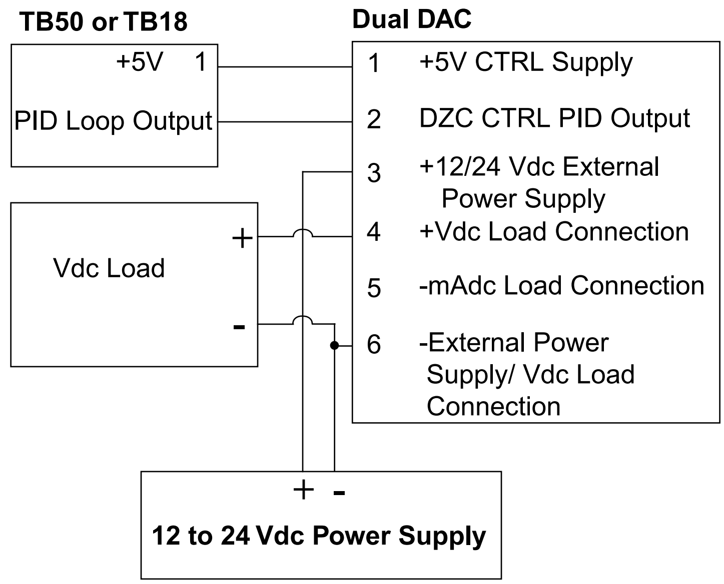


Figure 2.24 Dual DAC with Voltage Output

Wiring the Serial DAC

The Serial DAC provides a robust analog output signal. The module converts the proprietary Serial DAC signal from the controller's open collector output in conjunction with the clock signal to an analog current or voltage. See Figure 2.25 for wiring. The Serial DAC is user-configurable for voltage or current output through firmware configuration. See Configuring Serial DAC Outputs on page 176.

The Serial DAC optically isolates the controller's control output from the load. When a single Serial DAC is used, it may be powered by the 5 Vdc found on the TB50 or by an external power supply referenced to the controller's power supply. When using multiple Serial DACs, the controller cannot provide sufficient current; use the 5 Vdc output from the D8 power supply.

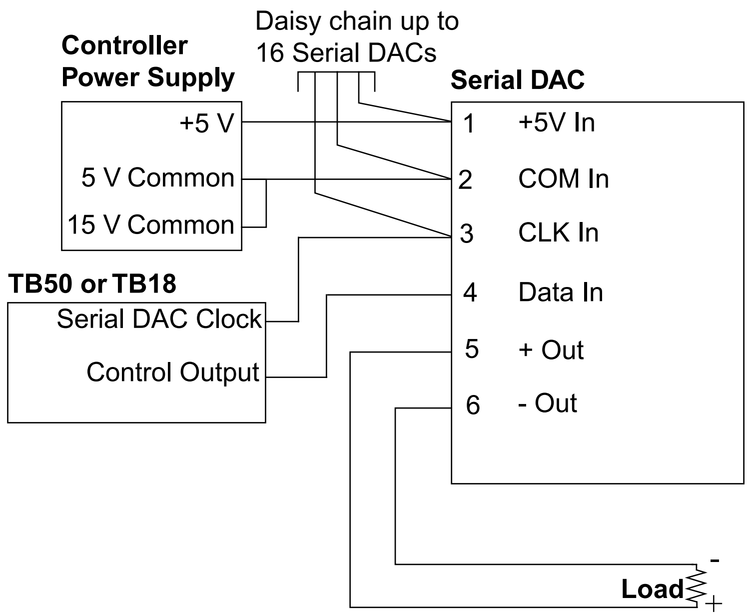


Figure 2.25 Single/Multiple Serial DACs

Connecting the D8 to a DeviceNet Network

Connector Type

Connect the D8 to the DeviceNet network using a female, sealed, micro-style, quick disconnect connector with five conductors. The DeviceNet connector is in the back of the controller.

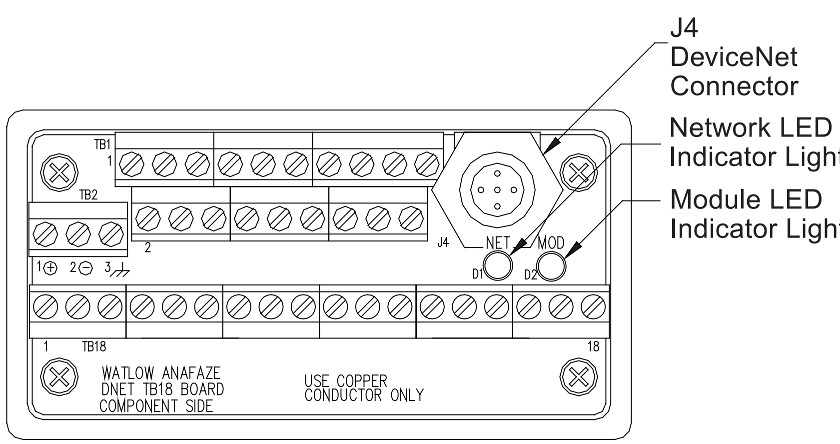


Figure 2.26 DeviceNet Connector

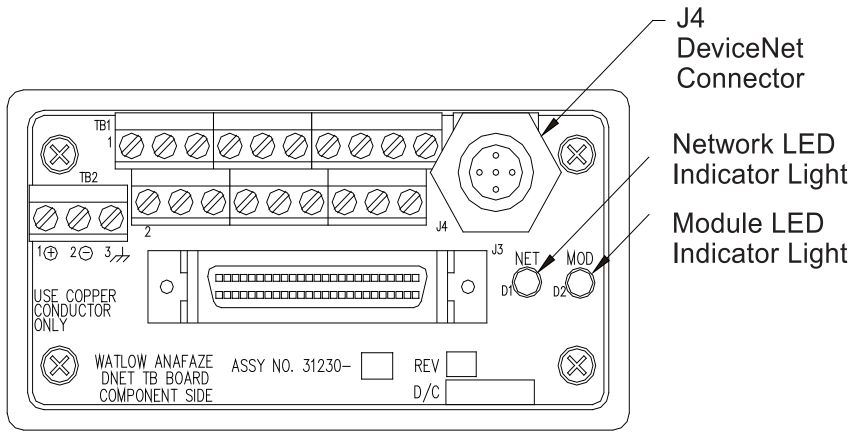


Figure 2.27 DeviceNet Connector

Pinout

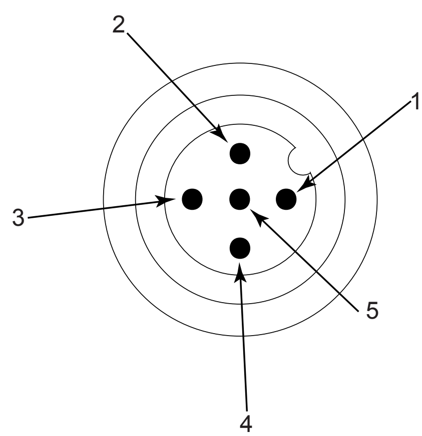


Figure 2.28 Pinout

Table 2.8 DeviceNet Connector

Pin	Signal	Function
1	Shield	Shield interconnect
2 V+		DeviceNet power
3	V-	DeviceNet power return
4	CAN+	Positive side of the DeviceNet bus
5	CAN-	Negative side of DeviceNet bus

Network Length

The network speed is limited by the end-to-end network distance. The longer the network, the slower the baud rate setting must be. See Table 2.9

Table 2.9 Maximum Network Speed

Distance	Baud Rate
100 m (328 ft)	500 Kbps
250 m (820 ft)	250 Kbps
500 m (1,640 ft)	125 Kbps

Baud Rate (Data Rate)

DeviceNet communications can use three different baud rates (data rates) 125k, 250k, and 500k baud. When the switch is set to the PGM position, the unit's baud rate is determined by a software setting. If the switch is set to PGM you must set the data rate using the controller's front panel or network-configuration software. As long as the switch is set to PGM, the controller will always come back up on the network with the last software-configured baud rate stored in the controller's memory.

As an example, assume the controller's baud rate switch is set to PGM, and it is programmed at 500k baud. Assume too, that the DeviceNet network experiences a power loss. When power is restored, the controller will come back up with a baud rate of 500k baud. If on the other hand, the baud rate switch was changed to 250k baud before the network power had been restored, the controller will attempt to come back on the network at 250k baud.

NOTE! ***When changing the baud rate via the software or by manually changing the switch position, you will need to cycle power on the network for the change to take effect.***

Node Address (MAC ID)

Valid node addresses on a DeviceNet network range from 0 to 63 decimal. When the switch is set to the PGM position, the unit's node address is determined by a software setting. If the switch is set to "PGM" you must set the node address using the controller's front panel or network-configuration software. As long as the switch setting remains set for software selection, the controller will always come back up on the network with the last software configured node address stored in the controller's memory.

Set the controller's MAC ID with the two rotary switches on the side of the case. Set the most significant digit (MSD) with the left switch and the least significant digit (LSD) with the right switch. For example, to set the address to 23, set the MSD to 2 and the LSD to 3.

NOTE! ***If the node address is changed with the switch, the D8 controller's power must be cycled before the change takes effect. If the node address is changed using software, the change takes effect immediately.***

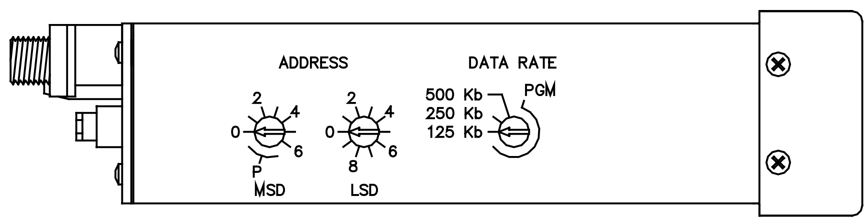


Figure 2.29 D8 Side with Rotary Switches

Status Indicators

The D8 controller has two indicator lights on the back, one labeled "NET" (Network) and the other labeled "MOD" (Module). On power-up the controller performs a self-test. The indicator light identified as "MOD" displays the result of this test as either pass (green) or fail (red). Also, under normal operation the indicator lights indicate the health of the module and the network. In the event that an indicator light should go from green to red either on power up or afterwards, consult tables Table 2.10 and Table 2.11 below for basic troubleshooting.

Table 2.10 Module Status Indicator Light

Indicator Light	Description
Off	No power is applied to the device.
Flashing Green-Red	The device is performing a Self-Test.
Green	The device is operating normally
Red	The device has detected an unrecoverable fault.

Table 2.11 Network Status Indicator Light

Indicator Light	Description
Off	**The device is not online.** The device has not completed the duplicate MAC ID test yet. The device may not be powered. Look at Table 2.10 ,Module Status Indicator Light.
Green	**The device is online and has connections in the established state.** For a Group 2 Only device it means that the device is allocated to a Master.
Red	**Failed communication device.** The device has detected an error that has rendered it incapable of communicating on the network (Duplicate MAC ID, or Bus-off).
Flashing Green	**The device is online, but no connection has been allocated or an explicit connection has timed out.**
Flashing Red	**A poll connection has timed out.**

3

Communicating by DeviceNet

This chapter explains how to add a D8 series controller to a DeviceNet network and how to access and manipulate the controller's data over a network using a Programmable Logic Controller or other device with a DeviceNet scanner. The chapter also includes descriptions of the D8's objects and attributes that are accessible via the DeviceNet protocol.

Accessing Data with a DeviceNet Master

Figure 3.12 to Figure 3.15 starting on page 65 illustrate the inputs and outputs in the D8 controller's polled I/O messages. These messages are typically used to get the controller's data in and out of a master on a DeviceNet network. To use this data in a Programmable Logic Controller (PLC) these parameters must be mapped through the master (scanner) to memory locations accessible to the PLC or other control devices.

When configuring the number of input bytes, it is important to note that the first input byte, the *Exception Status Byte* is not currently used. When configuring the D8 with DeviceNet network software such as RSNetWorx™, you must offset the polled input data by one byte. See the example in Mapping Polled I/O Data on page 50.

Software

More than one software package is available to configure devices such as the D8 on a DeviceNet network. This chapter provides step-by-step examples of configuring the D8 controller using Rockwell Software's RSNetWorx. The methodology used to accomplish this task will be different in other software, but the key steps and the end result, a valid stream of data from the D8 to the PLC or other device, will be the same.

About The Electronic Data Sheet (EDS)

Most, if not all, vendors supply an EDS file with their DeviceNet products. The EDS file allows for faster and easier configuration with the network software, but it is not required to make the device work. The examples cover commissioning the D8 on a network both with and without the EDS file. EDS files for the D8 are available on the Watlow web site and upon request from Watlow technical support.

NOTE! ***There are several versions of the EDS file. You must use the correct file for the number of loops in the controller (D84, 4-loop, or D88, 8-loop) and the controller firmware revision. This information is included in the file description on Watlow's web site.***

Configuring a D8 Using RSNetWorx

Complete the following steps prior to configuring the DeviceNet network software:

- The physical layer of the DeviceNet network is built.
- At least the D8 controller, a DeviceNet master, and a computer interface are connected to the network.
- Each device has a unique node addresses and the same baud rate setting.

Once all the devices are connected and power is applied to the network:

1. With RSLinx™ select and configure the appropriate communications driver for your hardware.
2. Open RSNetWorx and go online.

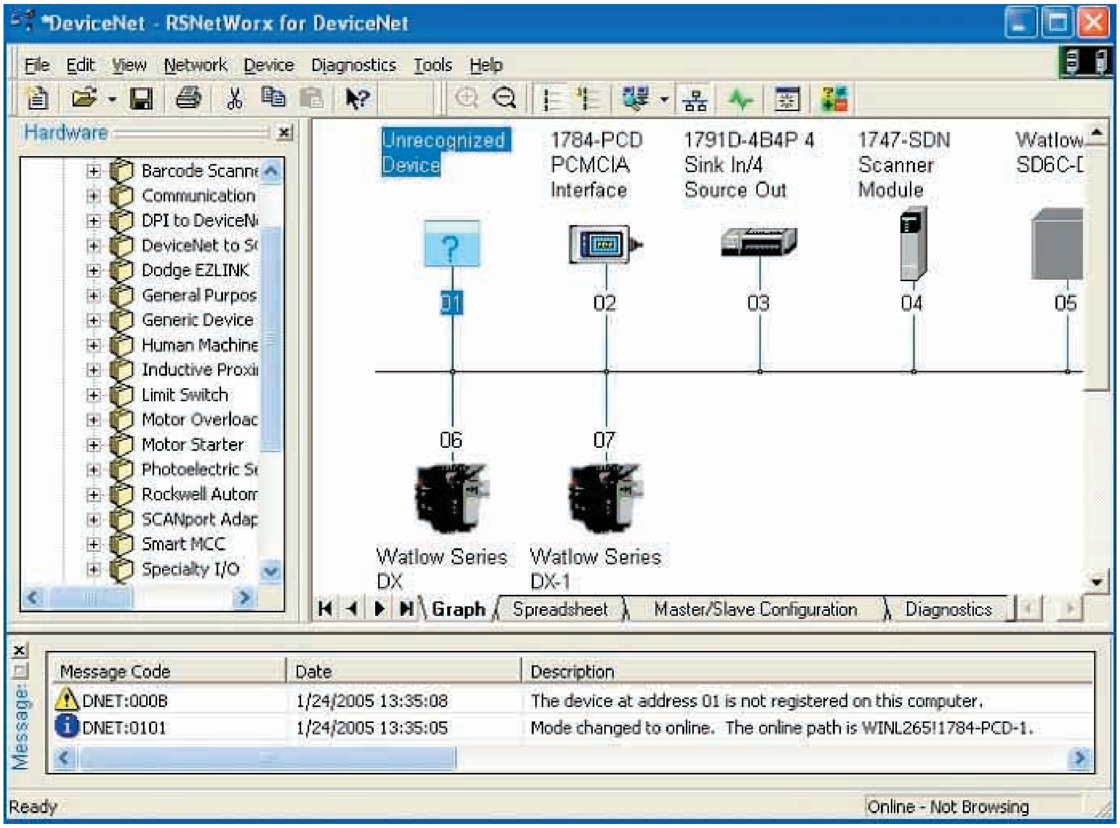


Figure 3.1 RSNetWorx On-line with Found Devices

Figure 3.1 shows node address 1 with a question mark on its icon, indicating that this device has not yet been registered in RSNetWorx. At this point the user may register an existing EDS file or create one. Both options are addressed in the following sections.

Registering the D8 without an EDS File

This section assumes the user does not have an EDS file from Watlow for the D8 controller but needs to get the unit up and running anyway.

To register the device without the Watlow EDS file:

1. Double-click the device with a question mark.
2. Proceed through the prompts to create an EDS file.
3. Select the polled method (Master/Slave) and then enter the number of input and output bytes. See Table 3.1.

Table 3.1 Number of Bytes

Controller	Input Bytes	Output Bytes
D84 (4-loop)	41	12
D88 (8-loop)	81	24

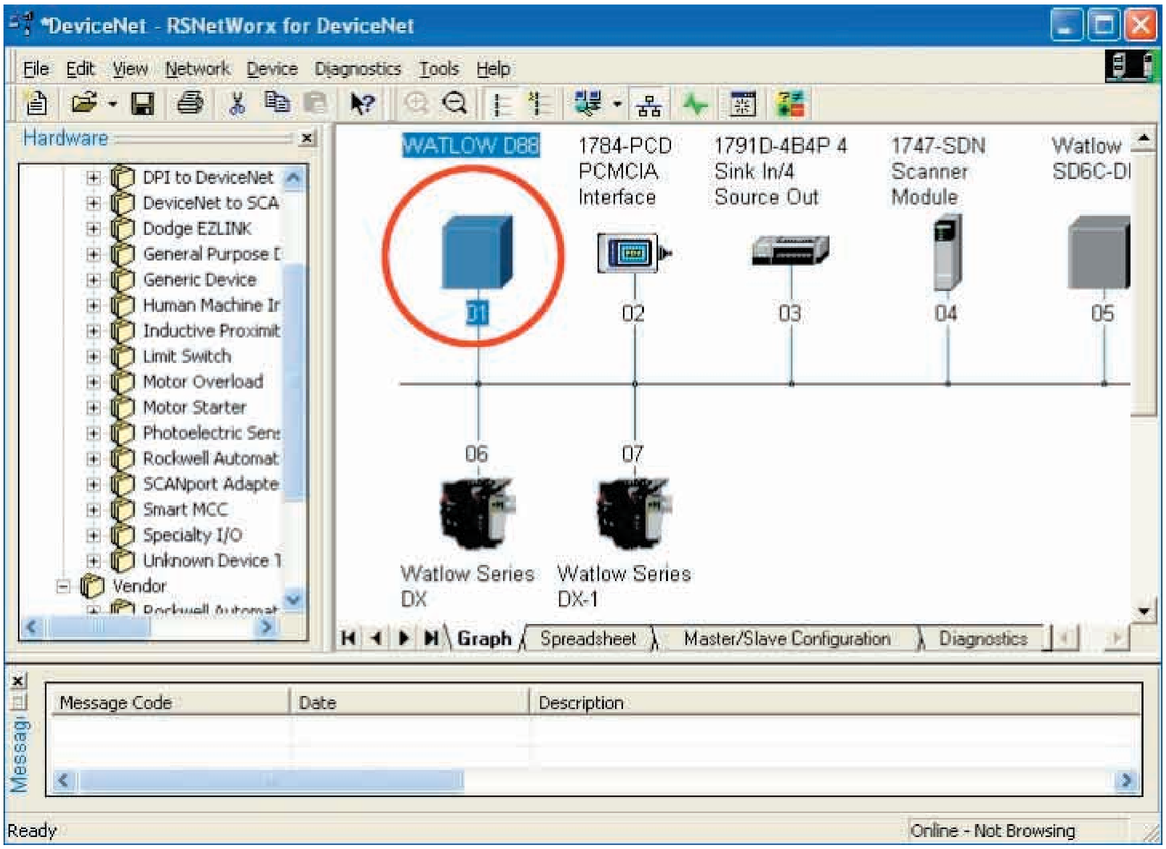
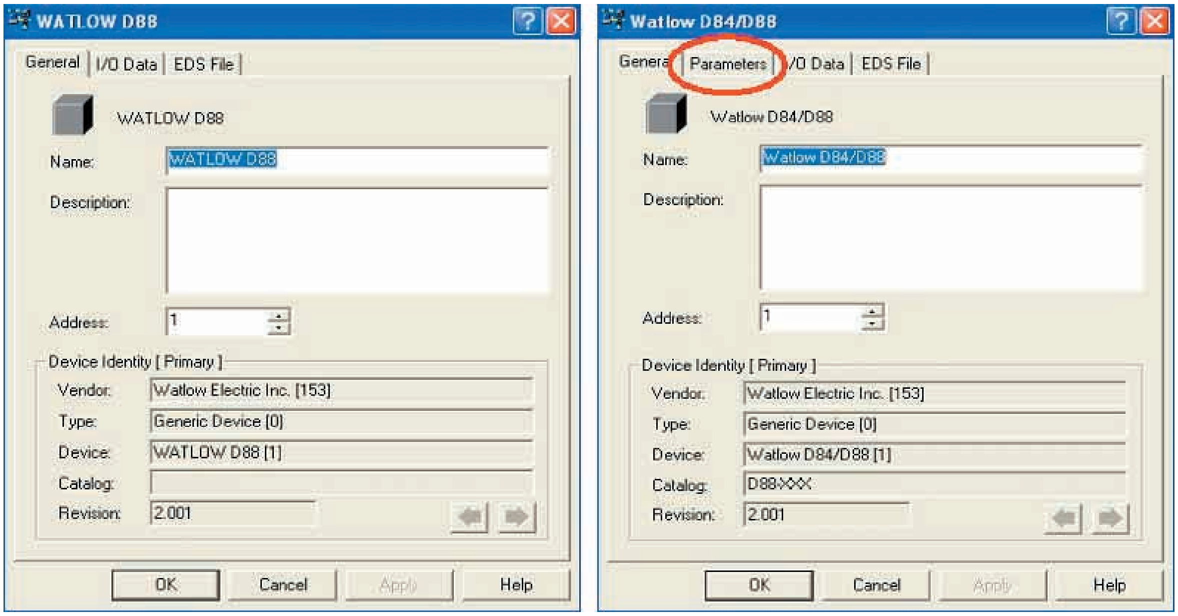


Figure 3.2 The D8 Registered in RSNetWorx

Registering the D8 with the Watlow EDS File

There are important differences between the results of registering the D8 controller with and without the Watlow-supplied EDS file, though these differences are not readily visible in Figure 3.2.

Double-clicking node address 1 (D8 controller) in the RSNetWorx graph of the network opens the dialog box shown at the left in Figure 3.3. When the controller is registered with the Watlow EDS, the same dialog box has an additional tab labeled *Parameters* as shown at the right in the figure.



A. Registered without the Watlow EDS **B. Registered with the Watlow EDS**

Figure 3.3 D8 Properties in RSNetWorx

The *Parameters* tab provides access to all of the D8 controller's parameters. See Figure 3.4. Some of these parameters have read-only access and some have read-and-write access. This tab can be a valuable tool for configuring the D8. Without the Watlow EDS file all configuration must be done through the front panel of the controller or via explicit messages initiated through a PLC or other device passed through a scanner (DeviceNet master).

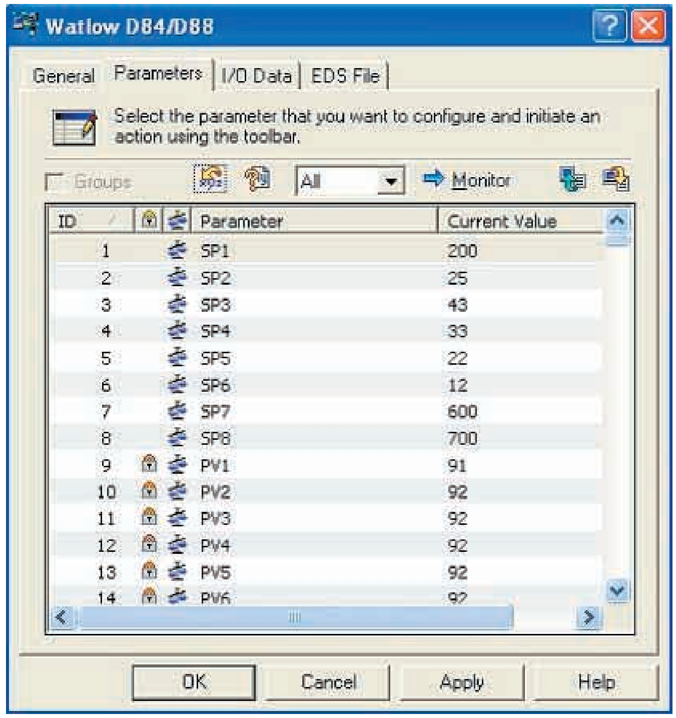


Figure 3.4 Parameters Tab

Mapping Polled I/O Data

Once the D8 controller is registered, the master must be configured to communicate with it. Once the master is configured it is possible to map the polled I/O data from the D8 to the PLC. The next sections address these steps.

Adding the D8 to the Master's Scanlist

This section describes configuring the DeviceNet scanner so that it will copy data between the scanner's memory and the D8 controller.

To add the D8 controller to the scanlist:

1. Double-click the 1747-SDN scanner (see Figure 3.2 on page 48) to open its properties dialog box. The properties dialog lists the *Available Devices* and displays the scanner's *Scanlist* (see Figure 3.5 on page 51). The Scanlist shows the devices that are mapped into the scanner's memory, the Available Devices list displays the devices that are on the network.
2. Uncheck the *Automap on Add* option. (When checked the software automatically assigns addresses to data from the

device starting at the next available byte in the PLC memory. When not checked the user controls how the bytes are arranged.)

3. Select *01 Watlow D84/D88* by clicking it in the *Available Devices* list.
4. Click the right-arrow button to put the D8 on the *Scanlist*.

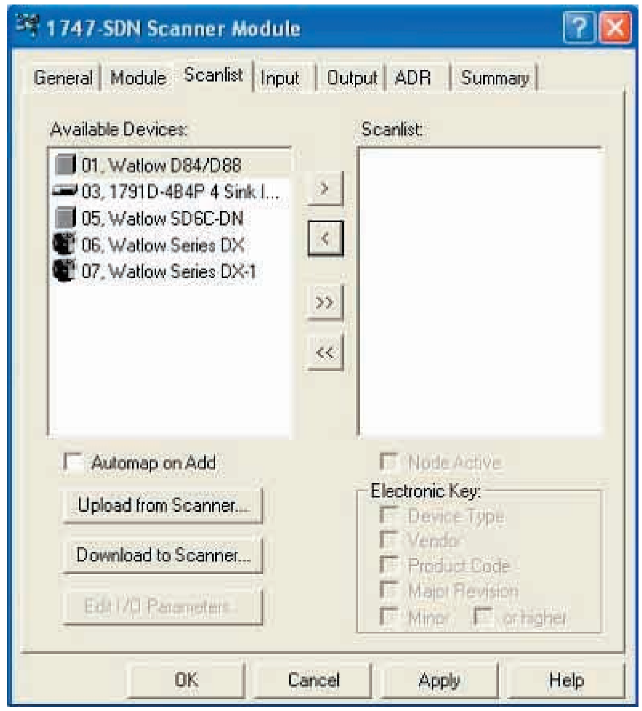


Figure 3.5 Adding the D8 to the Scanlist

Assigning PLC Addresses

Once the device has been added to the Scanlist, it is possible to map the polled bytes to any available contiguous memory location for both inputs and outputs.

The Allen-Bradley 1747-SDN scanner module in this example consumes the first 32 words of the input and output files corresponding to the slot in which it is inserted. For example, when the module is inserted in slot 3 of the PLC, the scanner uses addresses in the input file I:3.0 through I:3.31. This provides only 32 words of memory. Because the D88 controller supplies 81 bytes or 40.5 words of input, it is necessary to map the incoming polled data to the scanner's M1 file instead.

The following procedure maps the D88's input bytes to the scanner's M1 file. Actually only 40 words or 80 bytes of input data will be mapped because the Exception Status Byte, which is currently unused, is excluded.

The *Node* list in Figure 3.6 indicates that the scanner will communicate with the D8 via Polled messages. The scanner expects to find 81 bytes, but no data is currently mapped. The figure also shows four other devices on the network and their corresponding communications and data mapping configurations.

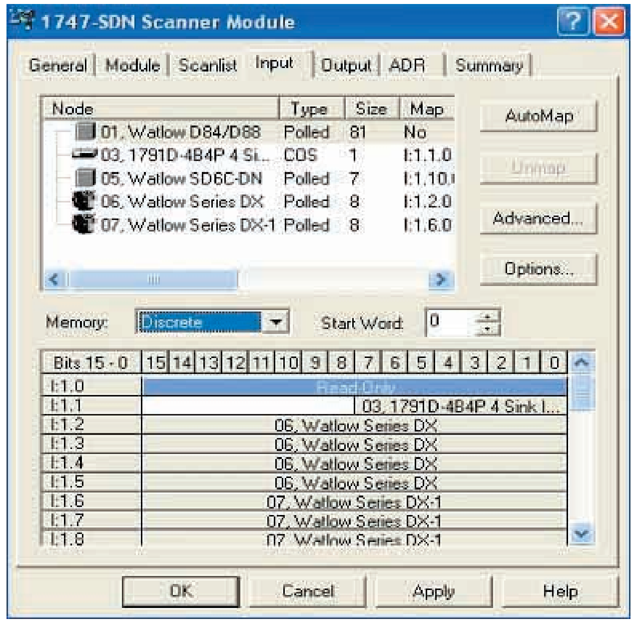


Figure 3.6 Scanner Input Properties

To map the D8's data:

1. Select the D8 by clicking *01, Watlow D84/D88* in the *Node* list on the *Input* tab.
2. Click the *Advanced* button to open the *Advanced Mapping* dialog box. See Figure 3.7 on page 53.
3. In the *Map From* group, for *Message*, select *Polled,* and set *Byte* to 1. (This excludes the first byte.)
4. In the *Map To* group, for *Memory*, select *M File*.
5. Set *Bit Length* to 640. (80 bytes times 8 bits per byte is 640 bits, the Exception Status Byte is excluded.)
6. Click *Apply Mapping*.

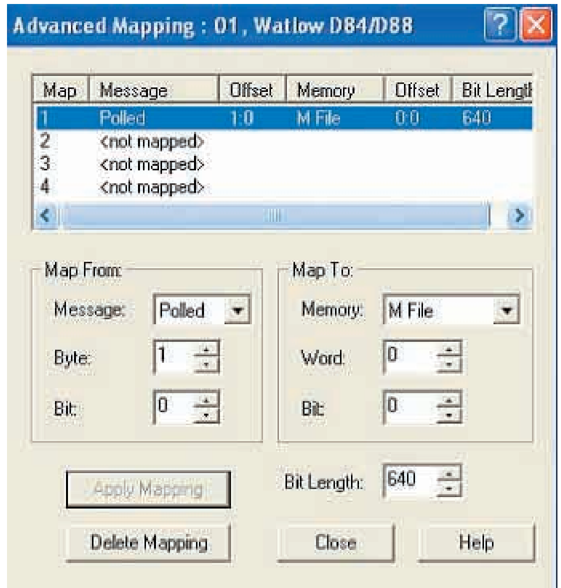


Figure 3.7 Advanced Mapping Dialog Box

The D8's polled input data is now mapped to the scanner's M1 file.

The scanner's M0 file may similarly be used to map the DeviceNet output data. The output data is easier to map because there is no Exception Status Byte to omit. See Poll Connection on page 64 for information on the output data.

Sample Ladder Logic

The following sections give examples of using information from the polled I/O and using explicit messages to read and write data between the D8 controller and a PLC.

Accessing Polled I/O Data

For a better understanding of the ladder logic examples in this section, refer to Figure 3.14 and Figure 3.15 starting on page 65. These figures illustrate the polled input and output messages. Because the first byte of the input data, the Exception Status Byte was excluded, the first word mapped is loop 1's Process Variable, and it is stored in the scanner's memory at M1:1.0. The Process Variables for subsequent loops are in the next seven memory locations (M1:1.1 to M1:1.7).

All ladder logic examples that follow were made using an Allen-Bradley SLC 5/04. Although there are different instructions from one PLC manufacturer to another, the same concepts apply.

NOTE! ***The contents of the scanner's M1 file cannot be monitored directly in RSLogix™, the logic-programming environment used in the following examples. For ease of demonstration and troubleshooting, the relevant registers are copied from the scanner's M1 file to the PLC's N14 file.***

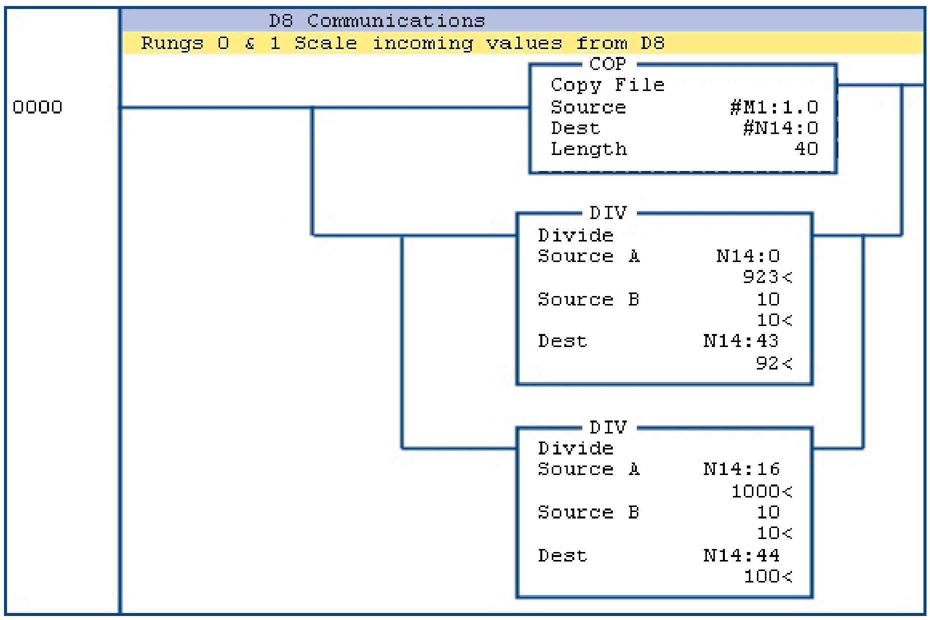


Figure 3.8 Using Scanned Data in Logic

For programming convenience the ladder program in Figure 3.8 copies the portion of the scanner's memory to which the D8's inputs are mapped into an integer file, N14:0. This information is automatically polled so it does not require special communication instructions to update values between the D8 and the PLC. During every PLC scan the DeviceNet scanner is queried for the latest values stored in its memory.

The D8 controller stores and communicates Process Variables and other parameters in tenths of a degree (see Decimal Placement for Numeric Values on page 59). In the logic a divide function scales the scanned value into whole degrees. The DIV function block divides the value in N14:0 (923) by 10 and places the temperature (92° F) into N14:43. This value can be used elsewhere in logic, and the programmer will know that the value is in degrees.

Figure 3.8 also shows the power level for loop 1 being scaled. The scanned value is also in tenths, so 1000 means 100% power (see Heat/Cool Output on page 122).

According to Figure 3.14 on page 65, M1:1.8 will hold the Set Point for loop 1. This value is copied by the ladder logic to N14:8. The 8 words after the set points, starting at M1:1.16 copied to N14:16 contain the Heat Output power for loops 1 to 8. Figure 3.9 shows the copied values for loop 1 to 8's Process Variables and Set Points and the Heat Outputs for loops 1 to 4.

N14:0	927	934	935	935	935	935	935	933	2000	250	N14:9
N14:10	430	330	220	120	6000	7000	1000	0	0	0	N14:20

Figure 3.9 Contents of the PLC Memory

Setting a Value with an Explicit Message

The Allen-Bradley 1747-SDN scanner module provides dedicated memory for explicit messages. In this model M0:1.224 is the first of 32 words that may be used for an explicit message (see Allen-Bradley Publication 1747-IN058C-EN-P - May 2002).

In the first rung of ladder logic in Figure 3.10 on page 56 when the *Enable Power Out Write* (B17:0/6) is on, the PLC writes to the scanner. At the first off-to-on transition of B17:0/6 the copy instruction (COP) sends an explicit message to the scanner. In this example, the message changes the Heat Output for loop 1 to the value specified in N14:56.

NOTE! ***The Heat Output can only be set via DeviceNet when the loop is in the Manual Mode. If the loop's Mode is Off, Tune or Auto, the controller sets the Heat Output.***

The copy instruction in the second rung of logic is executed only when a response to a previously sent explicit message is available to be read and interpreted by the ladder program (I:1/15). If communications is successful with the D8, the copy instruction returns an echo of N14:50 and places it in N14:60. If this echo occurs, the MVM instruction deletes the transaction from the response queue. If communications is not successful, an error code is returned via N14:60. For all error code definitions, see the Allen-Bradley publication mentioned above.

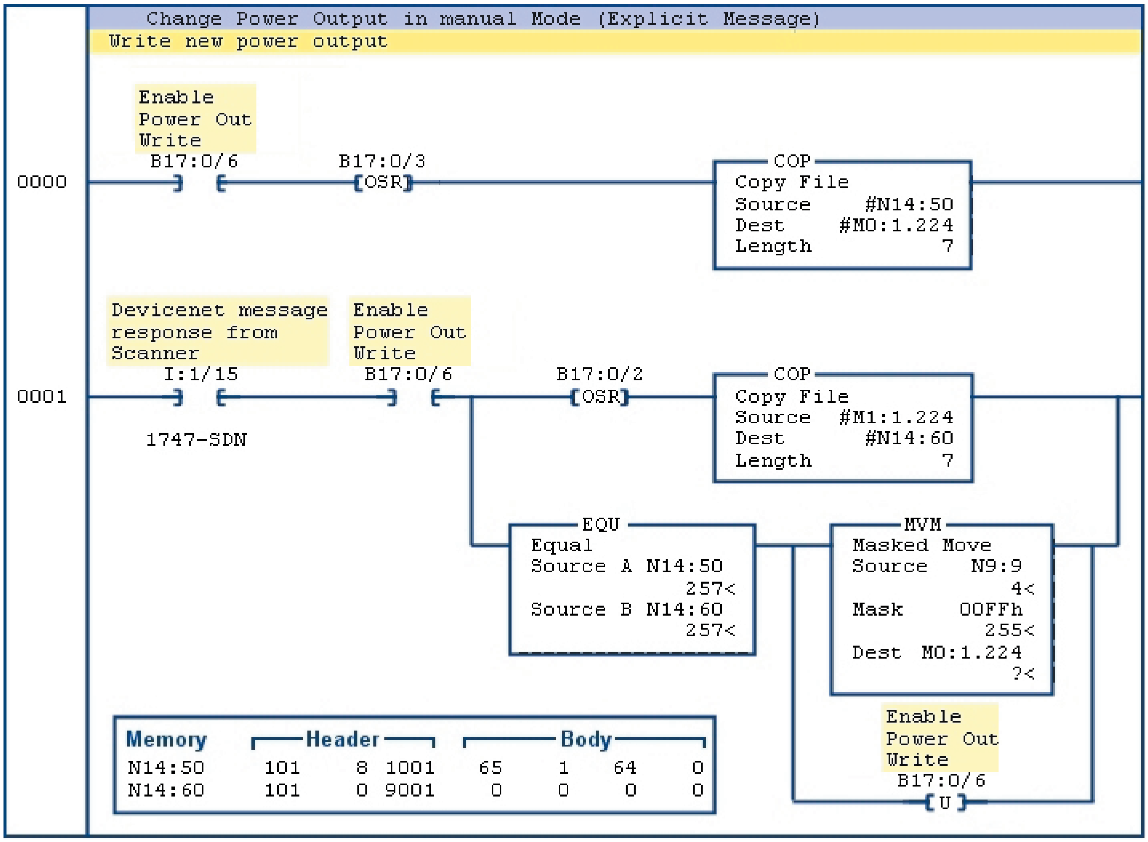


Figure 3.10 Explicit Write in Ladder

NOTE! ***The numbers shown above in N14:50 through N14:56 and N14:60 through N14:66 are in hexadecimal.***

The explicit messages in the example are 7 words long. The outbound transaction header is defined in the first 3 words of the copy instruction. In the figure the header for the first message is N14:50, 51, and 52. Table 3.2 lists and describes the parts of the message header.

Table 3.2 Outbound Transaction Header

Memory Location	Description	Example Value	Note
N14:50 MSB	Transaction ID (TXID)	1 hex	Unique number for message in the queue
N14:50 LSB	Command	1 hex	Execute the transmission block
N14:51 MSB	Port	0 hex	The DeviceNet port
N14:51 LSB	Data Size (in bytes)	8 hex	Size of the message body: 8 bytes or 4 words
N14:52 MSB	Service	10 hex	Get Attribute Single (See Table 3.21)
N14:52 LSB	MAC ID	1 hex	The D8's address

Up to 32 words are allocated for an explicit message in the scanner used in the example. The header used 3, leaving 29 for the message body. In this example only 4 words are used in the message body. The first 3 words of the body contain the class, instance and attribute to be accessed. The final word is the data, in this case the new power level sent to the D8. Table 3.3 lists and describes the parts of the message body.

Table 3.3 Explicit Message Body

Memory Location	Description	Example Value	Note
N14:53	Class	65 hex	Output Object (See Table 3.21)
N14:54	Instance	1 hex	Loop 1
N14:55	Attribute	64 hex	Heat Output (See Table 3.23)
N14:55	Data	0 hex	Sets the Heat Output to 0%

As another example, if you wanted to change the Heat Output for loop 6, the body of the message would be the same except that the *Instance* would be 6 hex.

Reading a Value with an Explicit Message

The logic in Figure 3.11 on page 58 initiates an explicit message from the PLC to the D8. This message specifies the Get Attribute Single service (0E hex) rather than the Set Attribute Single service (10 hex) used in the previous example.

With the class, instance and attribute specified, the PLC gets back the current setting for loop 1's Proportional Band. In this explicit read example you can see not much has changed in the ladder logic. In fact, the logic could be duplicated from the previous example with the only change being the contents of N14:92.

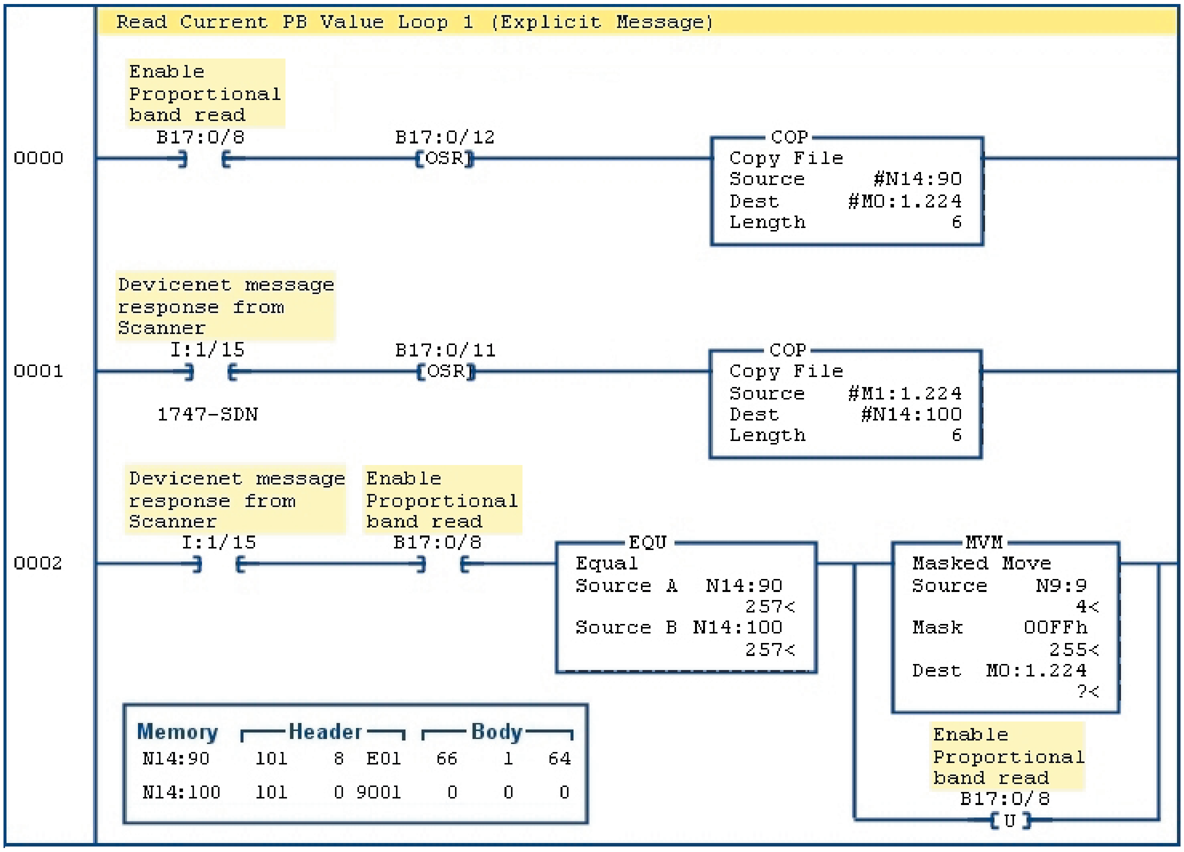


Figure 3.11 Explicit Read in Ladder

When I:1/15 comes on, indicating there is a response available to a previously sent message, the controller's loop 1 Proportional Band value is copied to N14:103. Again, if N14:100 comes back as an echo of N14:90 (transaction completed successfully) the MVM instruction deletes the transaction from the response queue.

Setting Parameters via DeviceNet

All values stored in the D8 are bits, integers or strings. Some integers represent settings that appear as text in the controller interface. Some integers represent numeric settings.

This section describes how to interpret values found in the DeviceNet objects.

Non-Numeric Settings

With the exceptions of the Loop Name and Units parameters, when the controller interface displays the setting as a word, a phrase and in some cases a number, see the parameter information in Chapter 6, Menu and Parameter Reference. The integer value appears in parentheses following each option. Use that integer value when you set or interpret the value of the parameter via DeviceNet.

Bit-Wise Values

Some settings, such as those that enable alarms, are stored as bits within words. To examine the value of just one bit, you can “and” the value with a mask word to extract the particular bit in which you are interested. To set or clear the bit, add or subtract the appropriate value to change the value of the word.

For example, to extract the fourth bit from a value in a bit-wise parameter, you would “and” it with a word that is all zeros except the fourth bit (0000000000001000, or 8 in decimal). To set the bit, add 8 to the value. To clear the bit, subtract 8 from the value.

NOTE! ***Throughout this manual, we refer to the least significant bit as the rightmost bit.***

Decimal Placement for Numeric Values

Numeric values that are in the loop’s engineering units are stored as integers. The number of decimal places that are assumed when a parameter value is stored in the controller depends upon the *Input type* and *Disp format* parameter values for the loop. See Table 3.4.

Table 3.4 Number of Decimal Places for Numeric Values via Logic

Input Type	Display Format	Decimal Places
Any thermocouple	-999 to 3000	1
RTD	-999.9 to 3000.0	1
Process	-999 to 3000	1
	-9999 to 30000	0
	-999.9 to 3000.0	1
	-99.99 to 300.00	2
	-9.999 to 30.000	3
	-0.9999 to 3.0000	4

To determine the integer value to set in the controller, move the decimal to the right the number of places specified.

For example:

- If a loop has a process input with a display format of -99.99 to 300.00, values are stored with two decimal places. If you read a value in the set point register of 2500, you should interpret that value as 25.00.
- If a loop has a thermocouple input and you want to set the *Alarm High SP* parameter to 355 through logic, you should set a value of 3550.

Decimal Placement for Percentage Values

Percentage values are stored internally in tenths of a percent, such that 1000 corresponds to 100.0 percent. Divide values by ten when reading, and multiply values by ten before writing.

D8 DeviceNet Overview

The D8 controller is configured as a Group 2 Only Slave device using the Predefined Master/Slave Connection Set.

The D8's DeviceNet interface includes objects in two main categories, DeviceNet Objects and Application Objects. DeviceNet objects handle what is necessary for networking and communications. Application Objects provide access to the D8 controller's parameters and data.

Master/Slave Connections

The D8 supports the*Predefined Master/Slave Connection Set,* which calls for the utilization of an Explicit Messaging Connection to manually create and configure Connection Objects within each connection end-point. These Connections are referred to collectively as the *Predefined Master/Slave Connection Set*.

The *master* is the device that gathers and distributes I/O data for the process controller. *Slaves* are the devices from which the master gathers I/O data and to which the master distributes I/O data. The master "owns" the slaves whose node addresses appear in its scan list. To determine which slaves it will communicate with, the master examines its scan list and sends commands accordingly. Except for the Duplicate MAC ID Check, a slave cannot initiate any communication before being told by the master to do so.

Addressing

All data is referenced using a four-part definition: Node (MAC ID) + Class + Instance + Attribute.

Table 3.5 Address Components

Address Component	Range
Node Address (MAC ID)	[0 to 63]
Class ID	[1 to 255]
Instance ID	[0 to 255]
Attribute ID	[1 to 255]

Data Types

The descriptions of attributes in the following sections include the data type for each. Table 3.6 lists and describes these data types.

Table 3.6 Elementary Data Types

Type	Description
BOOL	Logical Boolean (TRUE or FALSE)
BYTE	Bit string (8 bits)
EPATH	DeviceNet path segments
INT	Signed integer (16 bits)
SHORT_STRING	Character string (1 byte per character, 1 byte length indicator)
UDINT	Unsigned double integer (32 bits)
UINT	Unsigned integer (16 bits)
USINT	Unsigned short integer (8 bits)
WORD	Bit string (16 bits)

DeviceNet Objects

The following sections describe the standard DeviceNet objects and the D8-specific application objects. Tables in each section identify the class, available services, and the object's class and instance attributes.

Identity Object

The Identity object provides identification information for the device. This includes the device manufacturer, product name, product type, serial number and revision.

Table 3.7 Identity Class and Services

Class Code	01 hex
Class Services	None
Instance Services	01 hex Get Attribute All 05 hex Reset (O,1) 0E hex Get Attribute Single

Table 3.8 Identity Instance Attributes

Attribute	Access	Name	Type	Description
1 (1 hex)	Get	Vendor ID	UINT	Identification of each vendor by number. Watlow has vendor ID 153
2 (2 hex)	Get	Product Type	UINT	Identification of general type of product for vender. The D8 has type 0.
3 (3 hex)	Get	Product Code	UINT	Specific product code: D88 (1); D84 (2).
4 (4 hex)	Get	Revision	STRUCT of: 2 USINT	Revision of the item the Identity Object represents
5 (5 hex)	Get	Status	WORD	Summary status of device
6 (6 hex)	Get	Serial Number	UDINT	Serial number of device
7 (7 hex)	Get	Product Name	SHORT_ STRING	Human readable ID: "WATLOW D88" or "WATLOW D84"

Message Router Object

The Message Router object provides a messaging connection point through which a client may address a service to any object class or instance residing in the physical device.

Table 3.9 Message Router Class and Services

Class Code	02 hex
Class Services	None
Instance Services	04 hex Get Attribute Single

Table 3.10 Message Router Instance Attributes

Attribute	Access	Name	Type	Description
2 (2 hex)	Get	Number Available	UINT	Maximum number of connections supported. The D8 supports up to 3 connections.
3 (3 hex)	Get	Number Active	UINT	Number of connections currently used by the system components.

DeviceNet Object

The DeviceNet object is used to provide the configuration and status of a physical attachment to DeviceNet.

Table 3.11 DeviceNet Class and Services

Class Code	03 hex
Class Services	0E hex Get Attribute Single
Instance Services	10 hex Set Attribute Single 0E hex Get Attribute Single 08 hex Create 09 hex Delete

Table 3.12 DeviceNet Class Attributes

Attribute	Access	Name	Type	Description
1 (1 hex)	Get	Revision	UINT	Revision of this object

Table 3.13 DeviceNet Instance Attributes

Attribute	Access	Name	Type	Description
1 (1 hex)	Get/Set [1]	MAC ID	USINT	Node Address (0 to 63)
2 (2 hex)	Get/Set [2]	Baud Rate	USINT	Baud Rate (0 to 2)
4 (3 hex)	Get	Bus-Off Counter	USINT	Number of times CAN went to the bus-off state (0 to 255)
5 (4 hex)	Get	Allocation Info.	STRUCT of: BYTE USINT	Allocation Information Allocation Choice Byte MAC ID of Master (0 to 63, 255)

[1] If the Node Address (MAC ID) rotary switches are set to a value from 0 to 63, the MAC ID attribute has only Get access. If the rotary switches are set to the programmable mode, the MAC ID attribute has both Get and Set access.

[2] If the Baud Rate (data rate) rotary switch is set to 125, 250 or 500k baud, the Baud Rate attribute has only Get access. If the rotary switches are set to the software programmable mode, the Baud Rate has both Get and Set access.

Assembly Object

The Assembly object binds attributes of multiple objects, which allows data to or from each object to be sent or received over a single connection.

There are several instances of the Assembly object and each has an attribute 3 with controller parameter values for each loop concatenated. For example, an explicit get of instance 100, attribute 3 to a D84 controller returns the four set-point values in one message. This simplifies access to these frequently used parameters.

Table 3.14 Assembly Class and Services

Class Code	04 hex
Class Services	None
Instance Services	0E hex Get Attribute Single 10 hex Set Attribute Single

Table 3.15 Assembly Instance Attributes

Instance	Attribute	Access	Name	Type	Description
100 (64 hex)	3 (3 hex)	Get/Set	Set Points	array[1] of INTs	Set Point of each loop
101 (65 hex)	3 (3 hex)	Get/Set	Modes	array[1] of USINTs	Mode of each loop
102 (66 hex)	3 (3 hex)	Get	Process Variables	array[1] of INTs	Process Variable of each loop
103 (67 hex)	3 (3 hex)	Get	Heat Outputs	array[1] of UINTs	Heat Output of each loop
104 (68 hex)	3 (3 hex)	Get	Cool Outputs	array[1] of UINTs	Cool Output of each loop
105 (69 hex)	3 (3 hex)	Get	Alarm Status	array[1] of UINTs	Alarm status of each loop
106 (6A hex)	3 (3 hex)	Get/Set	Poll Out	array[1] of INTs+ array[1] of USINTs	Consumed Static Output
107 (6B hex)	3 (3 hex)	Get	Poll In	BYTE + array[2] of INTs + array[3] of UINTs	Consumed Static Input

[1] Array size is equal to the number of loops in the controller (4 in a D84 and 8 in a D88).
[2] Array size is equal to the two times the number of loops in the controller (8 in a D84 and 16 in a D88).
[3] Array size is equal to the three times the number of loops in the controller (12 in a D84 and 24 in a D88).

Poll Connection

The poll connection allows the master to write all set points and control modes in one connection. It also allows the reading of all process variables, set points, heat and cool outputs, and alarm status for all of the loops.

Figure 3.12 to Figure3.15 illustrate the contents of the polled I/O messages for the D84 (4-loop) and D88 (8-loop) controllers. The *Produced Static Input* message is produced by the controller as input to the DeviceNet bus. It is, therefore, output from the controller. The *Consumed Static Output* message is consumed by the controller. It is, therefore, input to the controller.

Byte	Byte	Byte	Byte	Byte	Byte	Byte	Byte
Exception Status 1 byte							
Loop 1 Process Variable INT (2 bytes)		Loop 2 Process Variable INT (2 bytes)		Loop 3 Process Variable INT (2 bytes)		Loop 4 Process Variable INT (2 bytes)	
Loop 1 Set Point INT (2 bytes)		Loop 2 Set Point INT (2 bytes)		Loop 3 Set Point INT (2 bytes)		Loop 4 Set Point INT (2 bytes)	
Loop 1 Heat Output UINT (2 bytes)		Loop 2 Heat Output UINT (2 bytes)		Loop 3 Heat Output UINT (2 bytes)		Loop 4 Heat Output UINT (2 bytes)	
Loop 1 Cool Output UINT (2 bytes)		Loop 2 Cool Output UINT (2 bytes)		Loop 3 Cool Output UINT (2 bytes)		Loop 4 Cool Output UINT (2 bytes)	
Loop 1 Alarm Status UINT (2 bytes)		Loop 2 Alarm Status UINT (2 bytes)		Loop 3 Alarm Status UINT (2 bytes)		Loop 4 Alarm Status UINT (2 bytes)	

Figure 3.12 D84 Produced Static Input

Byte	Byte	Byte	Byte	Byte	Byte	Byte	Byte
Loop 1 Set Point INT (2 bytes)		Loop 2 Set Point INT (2 bytes)		Loop 3 Set Point INT (2 bytes)		Loop 4 Set Point INT (2 bytes)	
Loop 1 Control Mode USINT (1 byte)	Loop 2 Control Mode USINT (1 byte)	Loop 3 Control Mode USINT (1 byte)	Loop 4 Control Mode USINT (1 byte)				

Figure 3.13 D84 Consumed Static Output

Byte	Byte	Byte	Byte	Byte	Byte	Byte	Byte
Exception Status 1 byte							
Loop 1 Process Variable INT (2 bytes)		Loop 2 Process Variable INT (2 bytes)		Loop 3 Process Variable INT (2 bytes)		Loop 4 Process Variable INT (2 bytes)	
Loop 5 Process Variable INT (2 bytes)		Loop 6 Process Variable INT (2 bytes)		Loop 7 Process Variable INT (2 bytes)		Loop 8 Process Variable INT (2 bytes)	
Loop 1 Set Point INT (2 bytes)		Loop 2 Set Point INT (2 bytes)		Loop 3 Set Point INT (2 bytes)		Loop 4 Set Point INT (2 bytes)	
Loop 5 Set Point INT (2 bytes)		Loop 6 Set Point INT (2 bytes)		Loop 7 Set Point INT (2 bytes)		Loop 8 Set Point INT (2 bytes)	
Loop 1 Heat Output UINT (2 bytes)		Loop 2 Heat Output UINT (2 bytes)		Loop 3 Heat Output UINT (2 bytes)		Loop 4 Heat Output UINT (2 bytes)	
Loop 5 Heat Output UINT (2 bytes)		Loop 6 Heat Output UINT (2 bytes)		Loop 7 Heat Output UINT (2 bytes)		Loop 8 Heat Output UINT (2 bytes)	
Loop 1 Cool Output UINT (2 bytes)		Loop 2 Cool Output UINT (2 bytes)		Loop 3 Cool Output UINT (2 bytes)		Loop 4 Cool Output UINT (2 bytes)	
Loop 5 Cool Output UINT (2 bytes)		Loop 6 Cool Output UINT (2 bytes)		Loop 7 Cool Output UINT (2 bytes)		Loop 8 Cool Output UINT (2 bytes)	
Loop 1 Alarm Status UINT (2 bytes)		Loop 2 Alarm Status UINT (2 bytes)		Loop 3 Alarm Status UINT (2 bytes)		Loop 4 Alarm Status UINT (2 bytes)	
Loop 5 Alarm Status UINT (2 bytes)		Loop 6 Alarm Status UINT (2 bytes)		Loop 7 Alarm Status UINT (2 bytes)		Loop 8 Alarm Status UINT (2 bytes)	

Figure 3.14 D88 Produced Static Input

Byte	Byte	Byte	Byte	Byte	Byte	Byte	Byte
Loop 1 Set Point INT (2 bytes)		Loop 2 Set Point INT (2 bytes)		Loop 3 Set Point INT (2 bytes)		Loop 4 Set Point INT (2 bytes)	
Loop 5 Set Point INT (2 bytes)		Loop 6 Set Point INT (2 bytes)		Loop 7 Set Point INT (2 bytes)		Loop 8 Set Point INT (2 bytes)	
Loop 1 Control Mode USINT (1 byte)	Loop 2 Control Mode USINT (1 byte)	Loop 3 Control Mode USINT (1 byte)	Loop 4 Control Mode USINT (1 byte)	Loop 5 Control Mode USINT (1 byte)	Loop 6 Control Mode USINT (1 byte)	Loop 7 Control Mode USINT (1 byte)	Loop 8 Control Mode USINT (1 byte)

Figure 3.15 D88 Consumed Static Output

Connection Object

The Connection Object allocates and manages the internal resources associated with both polled I/O and explicit messaging connections. The specific instance generated by the Connection Class is referred to as a Connection Instance or a Connection Object.

Table 3.16 Connection Class and Services

Class Code	05 hex
Class Services	None
Instance Services	0E hex Get Attribute Single 10 hex Set Attribute Single

Table 3.17 Connection Instance Attributes

Attribute	Access	Name	Type	Description
1 (1 hex)	Get	State	USINT	State of the object
2 (2 hex)	Get	Instance Type	USINT	Indicates either I/O or Messaging
3 (3 hex)	Get	Transport Class Trigger	BYTE	Defines behavior of the Connection
4 (4 hex)	Get	Produced Connection ID	UINT	Placed in CAN Identifier Field when the Connection transmits
5 (5 hex)	Get	Consumed Connection ID	UINT	CAN Identifier Field value that denotes message to be received
6 (6 hex)	Get	Initial Comm Characteristics	BYTE	Defines the Message Group(s) across which productions and consumption associated with this Connection when it occurs
7 (7 hex)	Get	Produced Connection Size	UINT	Maximum number of bytes transmitted across this Connection
8 (8 hex)	Get	Consumed Connection Size	UINT	Maximum number of bytes received across this Connection
9 (9 hex)	Get/Set	Expected Packet Rate	UINT	Defines timing associated with this Connection

Attribute	Access	Name	Type	Description
12 (C hex)	Get/Set	Watchdog Timeout Action	USINT	Defines how to handle inactivity or watchdog timeouts; Auto Delete (1), Deferred Delete (3)
13 (D hex)	Get	Produced Connection Path Length	UINT	Number of bytes in the Produced Connection Path Attribute
14 (E hex)	Get	Produced Connection Path	EPATH	Specifies the Application Object(s) whose data is to be produced by this Connection Object.
15 (F hex)	Get	Consumed Connection Path Length	UINT	Number of bytes in the Consumed Connection Path Length
16 (10 hex)	Get	Consumed Connection Path	EPATH	Specifies the Application Object(s) that are to receive data consumed by this Connection Object.

Input Object

The Input Object provides read/write access to all input parameters. Instance 0 of this object contains the class attributes listed in Table 3.19. The four-loop controller has four additional instances, and the eight-loop controller has eight additional instances, each containing the attributes listed in Table 3.20. Instance 1 corresponds to loop 1, instance 2 corresponds to loop 2, and so on.

Table 3.18 Input Class and Services

Class Code	64 hex
Class Services	0E hex Get Attribute Single
Instance Services	0E hex Get Attribute Single 10 hex Set Attribute Single

Table 3.19 Input Class Attributes (Instance 0)

Attribute	Access	Name	Type	Description
1 (1 hex)	Get	Revision	UINT	Revision of this object
2 (2 hex)	Get	Max Instance	UINT	Maximum instances of this object (8)
3 (3 hex)	Get	Number of Instances	UINT	Number of object instances

Table 3.20 Input Instance Attributes (Instances 1 to 4 or 8)

Attribute	Access	Name	Type	Description
100 (64 hex)	Get/Set	Set Point	INT	See page 122.
101 (65 hex)	Get	Process Variable	INT	See page 123.
102 (66 hex)	Get/Set	Input Type	SHORT_STRING	See page 131.
103 (67 hex)	Get/Set	Loop Name	SHORT_STRING	See page 132.
104 (68 hex)	Get/Set	Input Units	Array of 3 USINT	See page 132.
105 (69 hex)	Get/Set	Calibration Offset	INT	See page 132.
106 (6A hex)	Get/Set	Reverse Thermo-couple Detection	BOOL	See page 133.
107 (6B hex)	Get/Set	Display Format	USINT	See page 133.
108 (6C hex)	Get/Set	Input Range High	INT	See page 134.
109 (6D hex)	Get/Set	Input Range Low	INT	See page 135.
110 (6E hex)	Get/Set	Input High Signal	INT	See page 134.
111 (6F hex)	Get/Set	Input Low Signal	INT	See page 135.
112 (70 hex)	Get/Set	Input Filter	USINT	See page 135.

NOTE! ***All successful explicit message responses from a Set service will contain no data. The response will be a two-byte message containing the requester's node address and service code (with R/R bit set).***

Output Object

The Output Object provides read/write access to all output parameters. Instance 0 of this object contains the class attributes listed in Table 3.22. The four-loop controller has four additional instances, and the eight-loop controller has eight additional instances, each containing the attributes listed in Table 3.23. Instance 1 corresponds to loop 1, instance 2 corresponds to loop 2, and so on.

Table 3.21 Output Class and Services

Class Code	65 hex
Class Services	0E hex Get Attribute Single
Instance Services	0E hex Get Attribute Single 10 hex Set Attribute Single

Table 3.22 Output Class Attributes (Instance 0)

Attribute	Access	Name	Type	Description
1 (1 hex)	Get	Revision	UINT	Revision of this object
2 (2 hex)	Get	Max Instance	UINT	Maximum instances of this object (8)
3 (3 hex)	Get	Number of Instances	UINT	Number of object instances

Table 3.23 Output Instance Attributes (Instances 1 to 4 or 8)

Attribute	Access	Name	Type	Description
100 (64 hex)	Get/Set	Heat Output	UINT	See page 122.
101 (65 hex)	Get/Set	Cool Output	UINT	See page 122.
102 (66 hex)	Get/Set	Heat Output Type	USINT	See page 139.
103 (67 hex)	Get/Set	Cool Output Type	USINT	See page 139.
104 (68 hex)	Get/Set	Heat Action	BOOL	See page 141.
105 (69 hex)	Get/Set	Cool Action	BOOL	See page 141.
106 (6A hex)	Get/Set	Heat Cycle Time	USINT	See page 140.
107 (6B hex)	Get/Set	Cool Cycle Time	USINT	See page 140.
108 (6C hex)	Get/Set	Heat Power Limit	UINT	See page 141.
109 (6D hex)	Get/Set	Cool Power Limit	UINT	See page 141.
110 (6E hex)	Get/Set	Heat Power Limit Time	UINT	See page 141.
111 (6F hex)	Get/Set	Cool Power Limit Time	UINT	See page 141.
112 (70 hex)	Get/Set	Sensor Fail Heat Output	UINT	See page 142.
113 (71 hex)	Get/Set	Sensor Fail Cool Output	UINT	See page 142.
114 (72 hex)	Get/Set	Open Thermocouple Heat Output Average	BOOL	See page 142.
115 (73 hex)	Get/Set	Open Thermocouple Cool Output Average	BOOL	See page 142.
116 (74 hex)	Get/Set	Heat Output Curve	USINT	See page 143.
117 (75 hex)	Get/Set	Cool Output Curve	USINT	See page 143.
118 (76 hex)	Get/Set	Heat SDAC Signal	BOOL	See page 140.
119 (77 hex)	Get/Set	Cool SDAC Signal	BOOL	See page 140.
120 (78 hex)	Get/Set	Heat SDAC Low Signal	UINT	See page 140.
121 (79 hex)	Get/Set	Cool SDAC Low Signal	UINT	See page 140.
122 (7A hex)	Get/Set	Heat SDAC High Signal	UINT	See page 140.
123 (7B hex)	Get/Set	Cool SDAC High Signal	UINT	See page 140.
124 (7C hex)	Get/Set	Heat/Cool Output Action for Watchdog Inactivity Fault	BOOL	See page 156.

NOTE! ***All successful explicit message responses from a Set service will contain no data. The response will be a two-byte message containing the requester's node address and service code (with R/R bit set).***

Control Object

The Control Object provides read/write access to all control parameters. Instance 0 of this object contains the class attributes listed in Table 3.25. The four-loop controller has four additional instances, and the eight-loop controller has eight additional instances, each containing the attributes listed in Table 3.26. Instance 1 corresponds to loop 1, instance 2 corresponds to loop 2, and so on.

Table 3.24 Control Class and Services

Class Code	66 hex
Class Services	0E hex Get Attribute Single
Instance Services	0E hex Get Attribute Single 10 hex Set Attribute Single

Table 3.25 Control Class Attributes (Instance 0)

Attribute	Access	Name	Type	Description
1 (1 hex)	Get	Revision	UINT	Revision of this object
2 (2 hex)	Get	Max Instance	UINT	Maximum instances of this object (8)
3 (3 hex)	Get	Number of Instances	UINT	Number of object instances

Table 3.26 Control Instance Attributes (Instances 1 to 4 or 8)

Attribute	Access	Name	Type	Description
100 (64 hex)	Get/Set	Heat Proportional Band	UINT	See page 136.
101 (65 hex)	Get/Set	Cool Proportional Band	UINT	See page 136.
102 (66 hex)	Get/Set	Heat Integral	UINT	See page 137.
103 (67 hex)	Get/Set	Cool Integral	UINT	See page 137.
104 (68 hex)	Get/Set	Heat Derivative	USINT	See page 137.
105 (69 hex)	Get/Set	Cool Derivative	USINT	See page 137.
106 (6A hex)	Get/Set	Heat Manual Reset	UINT	See page 137.
107 (6B hex)	Get/Set	Cool Manual Reset	UINT	See page 137.
108 (6C hex)	Get/Set	Heat Filter	USINT	See page 137.

Attribute	Access	Name	Type	Description
109 (6D hex)	Get/Set	Cool Filter	USINT	See page 137.
110 (6E hex)	Get/Set	Hysteresis	UINT	See page 138.
111 (6F hex)	Get/Set	Restore Automatic Mode	USINT	See page 138.
112 (70 hex)	Get/Set	Mode	USINT	See page 122.

NOTE! ***All successful explicit message responses from a Set service will contain no data. The response will be a two-byte message containing the requester's node address and service code (with R/R bit set).***

Alarm Object

The Alarm Object provides read/write access to all alarm parameters. Instance 0 of this object contains the class attributes listed in Table 3.28. The four-loop controller has four additional instances, and the eight-loop controller has eight additional instances, each containing the attributes listed in Table 3.29. Instance 1 corresponds to loop 1, instance 2 corresponds to loop 2, and so on.

Table 3.27 Alarm Class and Services

Class Code	67 hex
Class Services	0E hex Get Attribute Single
Instance Services	0E hex Get Attribute Single 10 hex Set Attribute Single

Table 3.28 Alarm Class Attributes (Instance 0)

Attribute	Access	Name	Type	Description
1 (1 hex)	Get	Revision	UINT	Revision of this object
2 (2 hex)	Get	Max Instance	UINT	Maximum instances of this object (8)
3 (3 hex)	Get	Number of Instances	UINT	Number of object instances

Table 3.29 Alarm Instance Attributes (Instances 1 to 4 or 8)

Attribute	Access	Name	Type	Description
100 (64 hex)	Get/Set	Alarm High Set Point	INT	See page 143.
101 (65 hex)	Get/Set	Alarm Low Set Point	INT	See page 146.
102 (66 hex)	Get/Set	High Deviation Value	UINT	See page 145.
103 (67 hex)	Get/Set	Low Deviation Value	UINT	See page 145.

Attribute	Access	Name	Type	Description
104 (68 hex)	Get/Set	Alarm Hysteresis	UINT	See page 147.
105 (69 hex)	Get/Set	Alarm High Output	USINT	See page 144.
106 (6A hex)	Get/Set	Alarm Low Output	USINT	See page 146.
107 (6B hex)	Get/Set	High Deviation Output	USINT	See page 145.
108 (6C hex)	Get/Set	Low Deviation Output	USINT	See page 146.
109 (6D hex)	Get/Set	Alarm Delay	UINT	See page 147.
110 (6E hex)	Get	Alarm Status	UINT	See page 154.
111 (6F hex)	Get/Set	Alarm Enable	UINT	See page 153.
112 (70 hex)	Get/Set	Alarm Function	UINT	See page 154.
113 (71 hex)	Get/Set	Alarm Acknowledge	UINT	See page 153.

NOTE! ***All successful explicit message responses from a Set service will contain no data. the response will be a two-byte message containing the requester's node address and service code (with R/R bit set).***

PV Retransmit Object

The PV Retransmit Object provides read/write access to all process variable retransmit parameters. Instance 0 of this object contains the class attributes listed in Table3.31. The four-loop controller has four additional instances, and the eight-loop controller has eight additional instances, each containing the attributes listed in Table 3.32. Instance 1 corresponds to loop 1, instance 2 corresponds to loop 2, and so on.

Table 3.30 PV Retransmit Class and Services

Class Code	68 hex
Class Services	0E hex Get Attribute Single
Instance Services	0E hex Get Attribute Single 10 hex Set Attribute Single

Table 3.31 PV Retransmit Class Attributes (Instance 0)

Attribute	Access	Name	Type	Description
1 (1 hex)	Get	Revision	UINT	Revision of this object
2 (2 hex)	Get	Max Instance	UINT	Maximum instances of this object (8)
3 (3 hex)	Get	Number of Instances	UINT	Number of object instances

Table 3.32 PV Retransmit Instance Attributes (Instances 1 to 4 or 8)

Attribute	Access	Name	Type	Description
100 (64 hex)	Get/Set	Heat Output Retransmit	USINT	See page 148.
101 (65 hex)	Get/Set	Cool Output Retransmit	USINT	See page 148.
102 (66 hex)	Get/Set	Heat Retransmit Low Process Variable	INT	See page 148.
103 (67 hex)	Get/Set	Cool Retransmit Low Process Variable	INT	See page 148.
104 (68 hex)	Get/Set	Heat Retransmit High Process Variable	INT	See page 148.
105 (69 hex)	Get/Set	Cool Retransmit High Process Variable	INT	See page 148.

NOTE! ***All successful explicit message responses from a Set service will contain no data. The response will be a two-byte message containing the requester's node address and service code (with R/R bit set).***

Ratio Object

The Ratio Object provides read/write access to all ratio parameters. Instance 0 of this object contains the class attributes listed in Table 3.34. The four-loop controller has four additional instances, and the eight-loop controller has eight additional instances, each containing the attributes listed in Table 3.35. Instance 1 corresponds to loop 1, instance 2 corresponds to loop 2, and so on.

Table 3.33 Ratio Class and Services

Class Code	69 hex
Class Services	0E hex Get Attribute Single
Instance Services	0E hex Get Attribute Single 10 hex Set Attribute Single

Table 3.34 Ratio Class Attributes (Instance 0)

Attribute	Access	Name	Type	Description
1 (1 hex)	Get	Revision	UINT	Revision of this object
2 (2 hex)	Get	Max Instance	UINT	Maximum instances of this object (8)
3 (3 hex)	Get	Number of Instances	UINT	Number of object instances

Table 3.35 Ratio Instance Attributes (Instances 1 to 4 or 8)

Attribute	Access	Name	Type	Description
100 (64 hex)	Get/Set	Ratio Master Loop	USINT	See page 150.
101 (65 hex)	Get/Set	Ratio Low Set Point	INT	See page 150.
102 (66 hex)	Get/Set	Ratio High Set Point	INT	See page 151.
103 (67 hex)	Get/Set	Control Ratio	UINT	See page 151.
104 (68 hex)	Get/Set	Ratio Set Point Differential	INT	See page 151.

NOTE! ***All successful explicit message responses from a Set service will contain no data. The response will be a two-byte message containing the requester's node address and service code (with R/R bit set).***

Cascade Object

The Cascade Object provides read/write access to all cascade parameters. Instance 0 of this object contains the class attributes listed in Table 3.37. The four-loop controller has four additional instances, and the eight-loop controller has eight additional instances, each containing the attributes listed in Table 3.38. Instance 1 corresponds to loop 1, instance 2 corresponds to loop 2, and so on.

Table 3.36 Cascade Class and Services

Class Code	6A hex
Class Services	0E hex Get Attribute Single
Instance Services	0E hex Get Attribute Single 10 hex Set Attribute Single

Table 3.37 Cascade Class Attributes (Instance 0)

Attribute	Access	Name	Type	Description
1 (1 hex)	Get	Revision	UINT	Revision of this object
2 (2 hex)	Get	Max Instance	UINT	Maximum instances of this object (8)
3 (3 hex)	Get	Number of Instances	UINT	Number of object instances

Table 3.38 Cascade Instance Attributes (Instances 1 to 4 or 8)

Attribute	Access	Name	Type	Description
100 (64 hex)	Get/Set	Cascade Primary Loop	USINT	See page 149.
101 (65 hex)	Get/Set	Cascade Low Set Point	INT	See page 149.
102 (66 hex)	Get/Set	Cascade High Set Point	INT	See page 149.

NOTE! ***All successful explicit message responses from a Set service will contain no data. The response will be a two-byte message containing the requester's node address and service code (with R/R bit set).***

Global Object

The Global Object provides read/write access to all global parameters. Instance 0 contains the class attributes listed in Table 3.40. Instance 1 contains the attributes listed in Table 3.41.

Table 3.39 Global Class and Services

Class Code	6B hex
Class Services	0E hex Get Attribute Single
Instance Services	0E hex Get Attribute Single 10 hex Set Attribute Single

Table 3.40 Global Class Attributes (Instance 0)

Attribute	Access	Name	Type	Description
1 (1 hex)	Get	Revision	UINT	Revision of this object
2 (2 hex)	Get	Max Instance	UINT	Maximum instances of this object (1)
3 (3 hex)	Get	Number of Instances	UINT	Number of object instances (1)

Table 3.41 Global Instance Attributes (Instance 1)

Attribute	Access	Name	Type	Description
100 (64 hex)	Get/Set	Load Setup From Job	USINT	See page 125.
101 (65 hex)	Get/Set	Save Setup As Job	USINT	See page 125.
102 (66 hex)	Get/Set	BCD Job Load	USINT	See page 126.
103 (67 hex)	Get/Set	BCD Job Load Logic	BOOL	See page 126.
104 (68 hex)	Get/Set	Mode Override	USINT	See page 127.
105 (69 hex)	Get/Set	Mode Override Digital Input Active	BOOL	See page 128.
106 (6A hex)	Get/Set	Power Up Alarm Delay	USINT	See page 128.
107 (6B hex)	Get/Set	Power Up Loop Mode	BOOL	See page 128.
108 (6C hex)	Get/Set	Keypad Lock	BOOL	See page 129.
109 (6D hex)	Get/Set	Thermocouple Short Alarm	USINT	See page 129.
110 (6E hex)	Get/Set	AC Line Frequency	BOOL	See page 129.
111 (6F hex)	Get/Set	Digital Output Alarm Polarity	BOOL	See page 129.
112 (70 hex)	Get	Digital Inputs 1 (LSB) to 8 (MSB)*	USINT	See page 152.
113 (71 hex)	Get/Set	Digital Outputs 1 (LSB) to 8 (MSB)	USINT	See page 153.
114 (72 hex)	Get/Set	Digital Outputs 9 (LSB) to 16 (MSB)	USINT	See page 153.
115 (73 hex)	Get/Set	Digital Outputs 17 (LSB) to 18	USINT	See page 153.
116 (74 hex)	Get	Ambient Sensor	INT	See page 155.
117 (75 hex)	Get	Battery Status	BOOL	OK = 0; Fault = 1
118 (76 hex)	Get	HW Ambient Status	BOOL	OK = 0; Fault = 1
119 (77 hex)	Get	HW Offset Status	BOOL	OK = 0; Fault = 1
120 (78 hex)	Get	HW Gain Status	BOOL	OK = 0; Fault = 1

* Least significant bit (LSB) is digital input 1, most significant bit (MSB) is digital input 8.

NOTE! ***All successful explicit message responses from a Set service will contain no data. The response will be a two-byte message containing the requester's node address and service code (with R/R bit set).***

4

Operation and Setup

This chapter explains how to use the keypad and display to operate the controller. This chapter also explains the basic concepts that you need to understand to set up and operate the controller.

General Navigation Map

The normal display on the D8 is the loop display. Figure 4.1 shows how to navigate from the loop display to other displays, menus and parameters.

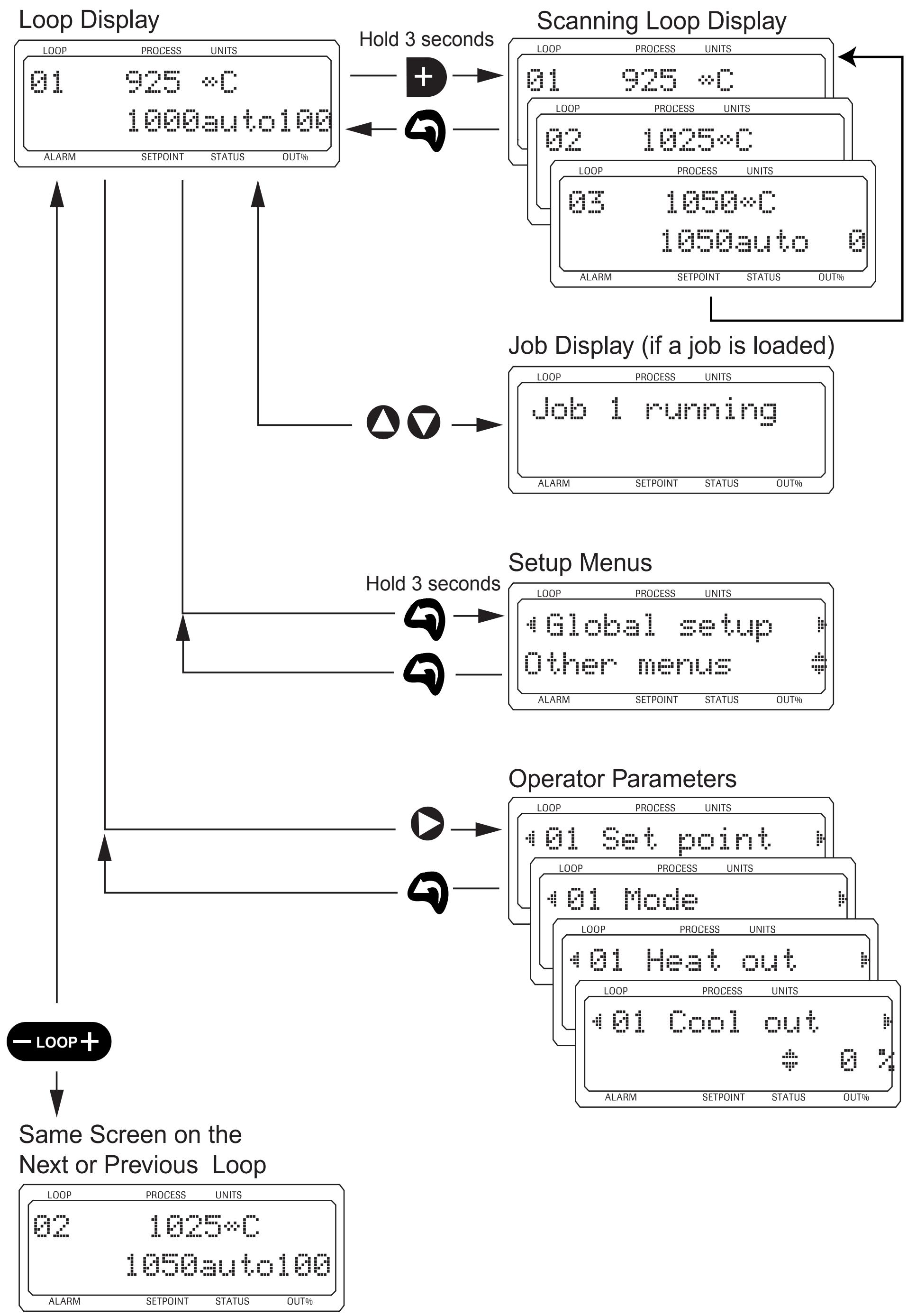
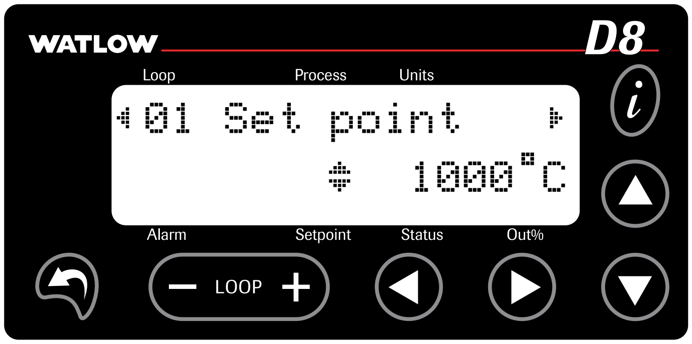


Figure 4.1 General Navigation Map

Keypad



Key	Description
	Access the setup menus (press and hold for 3 seconds). Cancel a change without saving. Escape from a parameter to a top-level setup menu. Escape from a setup menu to the loop display or job display. Acknowledge an alarm.
	Toggle between the loop display and job display (if a job is loaded). Edit a parameter value. Scroll through the top-level setup menus.
	Toggle between the loop display and job display (if a job is loaded). Edit a parameter value. Scroll through the top-level setup menus. Clear RAM and set all parameters to defaults (hold during power up).
	Save a change and go to the previous parameter.
	Access the operator parameters (from the loop display). Save a change and go to the next parameter.
−LOOP+	Go to a different loop. Save a change and go to a different loop. Go to the scanning loop display (hold + for 3 seconds).
	Get more information about the current screen.

Figure 4.2 Keypad Navigation

Displays

Loop Display

The loop display shows detailed information about a loop.

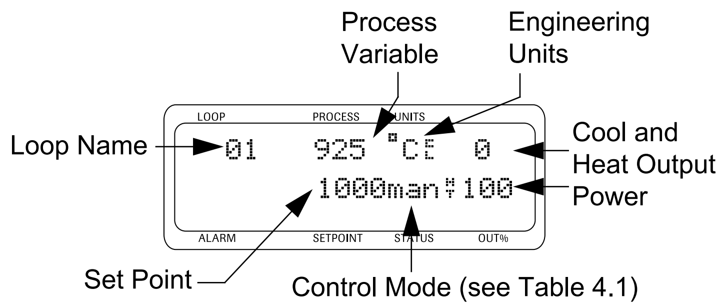


Figure 4.3 Loop Display

The control modes are described in Table 4.1.

Table 4.1 Control Modes

Control Mode	Description
off	The loop is set to off. One or both outputs are enabled but both outputs are at 0%.
man	The loop is in manual control. One or both outputs are enabled.
auto	The loop is in automatic control. Only one output (heat or cool) is enabled.
heat	The heat and cool outputs are enabled. The loop is in automatic control and heating.
cool	The heat and cool outputs are enabled. Loop is in automatic control and cooling.
tun	The loop is in autotune mode.
(blank)	The heat and cool outputs are both disabled.

NOTE! ***If the input type for a loop is set to "skip," the loop display will be blank for that loop.***

The scanning loop display sequentially displays the information for each loop. The data for each loop displays for one second. To activate the scanning loop display, go to the loop display, then press and hold the + side of the −LOOP+ key for three seconds. To exit the scanning mode, press any key.

Alarm Displays

If an alarm condition occurs, the controller displays an alarm code or alarm message.

Two-Character Alarm Codes

If a process, deviation, ambient warning or failed sensor alarm occurs, a two-character alarm code appears in the lower left corner of the loop display.

The alarm code blinks and you cannot change the display until the alarm has been acknowledged. After the alarm is acknowledged, the alarm code stops blinking. The alarm code remains on the display until the condition that caused the alarm is corrected.

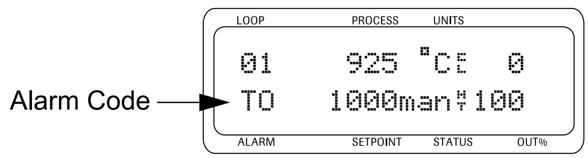


Figure 4.4 Loop Display with Alarm Code

For more information about alarms, see Setting Up Alarms on page 93 and Process Alarms on page 95.

Failed Sensor Alarm Messages

If the alarm is for a failed sensor, an alarm message appears in the first line of the loop display, as shown in Figure 4.5.

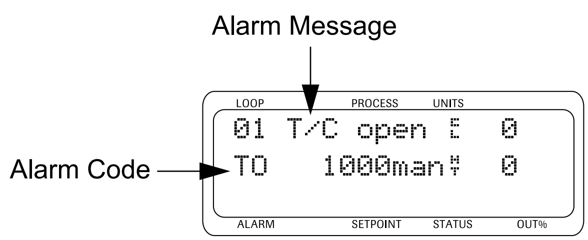


Figure 4.5 Display for Failed Sensor Alarm

Table 4.2 describes the alarm codes and messages for process alarms and failed sensor alarms.

Table 4.2 Alarm Codes and Messages for Process and Failed Sensor Alarms

Alarm Code	Alarm Message	Description
AH	(No message)	Alarm high. See Alarm High and Alarm Low on page 96.
AL	(No message)	Alarm low. See Alarm High and Alarm Low on page 96.
HD	(No message)	High deviation alarm. See Deviation Alarms on page 96.
LD	(No message)	Low deviation alarm. See Deviation Alarms on page 96.
AW	(No message)	Ambient Warning: The controller is within 5°C of its operating temperature limits. See Ambient Warning on page 160.
TO	T/C open	Thermocouple open. See Thermocouple Open Alarm on page 94.
TR	T/C reversed	Thermocouple reversed. See Thermocouple Reversed Alarm on page 94.
TS	T/C shorted	Thermocouple shorted. See Thermocouple Short Alarm on page 94.
RO	RTD open	RTD open. See RTD Open and RTD Fail Alarms on page 94.
RF	RTD fail	RTD open or shorted. See RTD Open and RTD Fail Alarms on page 94.

For details about the condition that causes each alarm, see Setting Up Alarms on page 93.

How to Acknowledge an Alarm

To acknowledge a process alarm, failed sensor alarm or system alarm, press . If there are other loops with alarm conditions, the alarm display switches to the next loop that has an alarm. Acknowledge all alarms to clear the global alarm digital output.

The keypad and display will not work for anything else until you acknowledge each alarm. The alarm code or message persists as long as the alarm condition exists.

System Alarm Messages

If a system alarm occurs, the alarm message replaces the entire display. The message persists until the condition is corrected and the alarm is acknowledged.

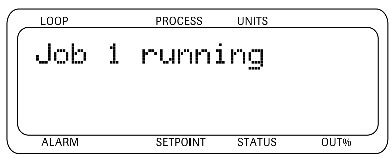
Table 4.3 describes system alarm messages. For more information, see the Troubleshooting and Reconfiguring chapter.

Table 4.3 System Alarm Messages

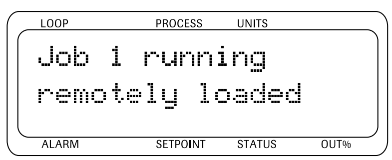
Message	Description
Low power	The power supply has failed. See Low Power on page 163.
Battery dead	The RAM battery in the D8 is not functioning correctly, and stored data has been corrupted. See Battery Dead on page 163.
H/W error: Ambient	The temperature around the controller is outside of the acceptable range of -5 to 55°C. See H/W Error: Ambient on page 165.
H/W error: Gain	Hardware failed because of excessive voltage on inputs. See H/W Error: Gain or Offset on page 164.
H/W error: Offset	

Job Display

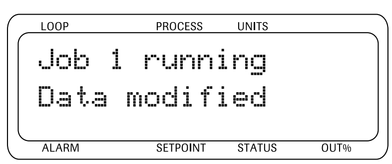
The job display appears if you load a job from memory. If you load a job using the *Load setup from job* parameter, the job display shows the following screen:



If the job was loaded using digital inputs, the display shows this screen:



If parameters are modified while the job is running, the display shows this screen:



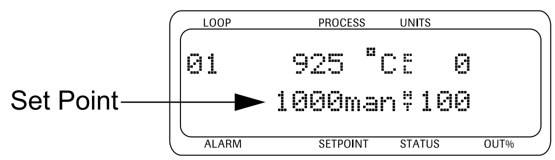
To toggle between the job display and the loop display, press ▲ or ▼.

Changing the Set Point

How to Manually Change the Set Point

Start at the loop display and follow these steps:

1. Press −LOOP+ to choose the appropriate loop.
2. Press ▶. The *Set point* parameter should appear. If nothing happens, the keypad may be locked; see Keypad Lock on page 129. Also, the *Set point* parameter is not available if cascade control or ratio control is enabled on the loop.
3. Press ▲ or ▼ to adjust the set point value.
4. Press ◀ to save the value and return to the loop display, *or* press −LOOP+ to save the value and switch to the set point for another loop, *or* press ↶ to cancel changes.
5. On the loop display, the new set point value is shown on the second line.



Other Methods of Changing the Set Point

You can use other methods to change the set point:

- **Cascade Control:** Use the output of one loop to adjust the set point of another loop. See Setting Up Cascade Control on page 100.
- **Ratio Control:** Use the process variable of one loop, multiplied by a ratio, as the set point of another loop. See Setting Up Ratio Control on page 104.
- **Differential Control:** Use the process variable of one loop, plus an offset value, as the set point of another loop. See Setting Up Differential Control on page 106.
- **Remote Analog Set Point:** Use an external device such as a PLC to control the set point. See Setting Up Remote Analog Set Point on page 107.
- **Communications:** Use a computer program or operator interface panel to change the set point. See Chapter 3: Communicating by DeviceNet.

Changing the Control Mode and Output Power

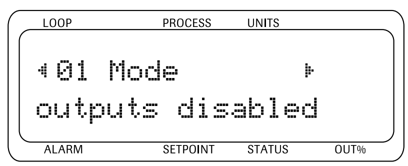
The D8 has four control modes:

- **Off:** Outputs are at 0%.
- **Automatic:** The controller automatically adjusts the output power according to the set point, process variables and other control parameters.
- **Manual:** You set the output power level.
- **Autotune:** The controller calculates the best PID settings for optimum control. For more information, see Autotuning on page 91.

To change the control mode and output power level, start at the loop display and do the following:

1. Press to choose the appropriate loop.
2. Press twice. The *Mode* parameter should appear. (If nothing happens, the keypad may be locked; see Keypad Lock on page 129).

NOTE! ***If the heat and cool outputs are disabled on this loop, the Mode parameter is not available. Instead, this message appears:***



3. Press or to choose a control mode. If you make a change and want to cancel it, press .
4. Press to save the new value.
5. If you chose manual mode, then the next parameter is the *Heat output* or *Cool output* parameter. Use these parameters to set the heat and cool output power levels, then press to save.
6. You should be back at the loop display. The control mode is shown on the second line of the loop display; see Table 4.1 on page 80.

Accessing and Navigating the Setup Menus

Use the setup menus to configure the controller. For a list of all setup menus and parameters, refer to Figure 6.2 on page 124.

How to Access the Setup Menus

To access the setup menus, press and hold for three seconds, until the *Global setup* menu appears.

To prevent unauthorized personnel from accessing setup parameters, the controller reverts to the regular display if you do not press any keys for three minutes.

How to Edit a Setup Parameter

To edit a setup parameter, go to the appropriate setup menu, go to the parameter, then edit the value:

1. Press and hold for three seconds to access the setup menus.
2. Press to go to the appropriate a menu.
3. If applicable, press LOOP to choose the loop that you want to edit.
4. Press to go to the parameter that you want to edit.
5. To edit a parameter:
   - Press or to choose a value.
   - Press to save the new value and go to the next parameter.
   - Press to cancel a change without saving.
6. Repeat from step 4 to edit another parameter in the current menu.
7. Press to return to the top-level menus.
8. Repeat from step 2 to go to another menu, or press to exit the setup menus.

For information about setting parameters through communications, see Appendix A, DeviceNet Interface.

Setting Up Closed-Loop Control

Closed-loop control is used to control an output based on feedback from a sensor or other signal.

Feedback

The controller receives electrical signals, or feedback, from a sensor or other device. The input parameters determine how the controller interprets the signal. The controller interprets or scales the input signal in engineering units such as °C or °F.

Control Algorithm

When the controller is in automatic control mode and a set point is supplied, the controller determines the appropriate output signal.

The controller calculates the output signal based on the feedback and the control algorithm. Each loop may use either on/off control or any combination of proportional, integral and derivative (PID) control. See the Tuning and Control chapter for information about these control modes.

Control Output Signal Forms

The output level calculated by the controller is represented by a percentage (0 to 100 percent) of power to be applied. That value is applied on a digital or analog output according to the user-selected output type. See Heat/Cool Output Type on page 139 for more information about the output types available.

Heat and Cool Outputs

In some applications, two outputs may be controlled according to one input. For example, a loop with both heat and cooling water flow might be controlled according to feedback from one thermocouple.

In such systems, the control algorithm includes provisions to avoid switching too frequently between the heat and cool outputs. The on/off algorithm uses a hysteresis parameter. The PID algorithms use both a hysteresis parameter and the PID parameters to determine when control switches between heating and cooling.

How to Set Up Closed-Loop Control

To set up closed-loop control:

- Use the *Input* menu to specify the type of input signal and, if necessary, how to scale that signal.
- Use the *Control* menu to specify PID parameters and the control hysteresis.
- Use the *Output* menu to enable the heat and cool outputs and to specify other output parameters.
- Provide a set point:
    - To use cascade control to adjust the set point of the loop, set up the *Cascade* menu.
    - To use ratio control, differential control, or remote analog set point, set up the *Ratio* menu.
    - To manually adjust the set point of the loop, use the *Set point* parameter to enter the set point. See Changing the Set Point on page 84.
- Put the controller in automatic mode. See Changing the Control Mode and Output Power on page 85.

For more information about the setup menus and parameters, see the Menu and Parameter Reference chapter.

Setting Up a Process Input

If you use a process input signal, you must set up scaling parameters in the *Input* menu to scale the raw input signals to the engineering units of the process.

Input Scaling

To scale the input, you enter values that represent two points on a conversion line. Each point indicates an input signal level and the corresponding process value.

The input signal is expressed as percent of full range. For example, for a 0 to 20 mA process input, 0 mA is 0 percent, 10 mA is 50 percent, and so on.

The conversion line scales the input signal to the engineering units of the process. For example, in Figure 4.6, a 20 percent input signal corresponds to 8 pounds per square inch (PSI), and a 100 percent signal corresponds to 28 PSI.

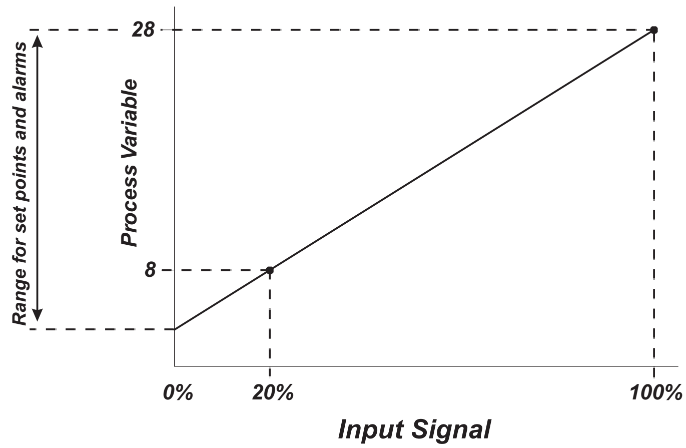


Figure 4.6 Input Scaling

The range for set points and alarms is bound by the process variables that correspond to the 0 percent and 100 percent input signals. Bear in mind that the range for set points and alarms is *not* bound by the low and high process variable ranges that you enter in the scaling parameters.

Input Scaling Example: 4 to 20 mA Sensor

Situation

Suppose the controller has a 0 to 20 mA process input that is connected to a pressure sensor. The pressure sensor has a range of 4 to 20 mA, representing 0.0 to 50.0 pounds per square inch (PSI).

Setup

Set the scaling parameters in the *Input* menu as follows:

- For the *Input type* parameter, choose *process*.
- For the *Disp format* parameter, choose *-999.9to 3000.0*, because the sensor measures PSI in tenths.
- For the *Input signal low* and *Input signal high* parameters, use the minimum and maximum range of the sensor. In this case, the sensor range is 4 to 20 mA. The range must be expressed in percent of full scale. To determine the percentages, divide the minimum and maximum sensor range (4 mA and 20 mA) by the maximum signal that the controller can accept (20 mA):
    - *Input signal low* = 4 mA/20 mA = 0.2 = 20%

    - *Input signal high* = 20 mA/20 mA = 1.0 = 100%
- For the *Input range low* and *Input range high* parameters, enter the process values that correspond to the low and high signals. In this case, a 20 percent (4 mA) signal represents 0.0 PSI. A 100 percent (20 mA) signal represents 50.0 PSI.

Table 4.4 Input Readings

Process Variable Displayed	Sensor Input	Reading in Percent of Full Scale
50.0 PSI	20 mA	100%
.0 PSI	4 mA	100% x (4 mA/20 mA) = 20%

Table 4.5 Scaling Values

Parameter	Value
Input range high	50.0 PSI
Input high signal	100.0%
Input range low	.0 PSI
Input low signal	20.0%

Input Scaling Example: 0 to 5 Vdc Sensor

Situation

A flow sensor connected to the controller measures the flow in a pipe. The sensor generates a 0 to 5 Vdc signal. Independent calibration measurements of the flow in the pipe indicate that the sensor generates 0.5 V at 3 gallons per minute (GPM) and 4.75 V at 65 GPM. The calibration instrument is accurate ±1 GPM.

Setup

For the *Disp format* parameter in the *Input* menu, choose *-999to 3000*, because the calibrating instrument is precise to ±1 GPM.

The tables below show the minimum and maximum input signals and their corresponding process variables, and the resulting values for the scaling parameters.

Table 4.6 Input Readings and Calculations

Process Variable Displayed	Sensor Input	Reading in Percent of Full Scale
65 GPM	4.75 V	(4.75 V / 5.00 V) x 100% = 95%
3 GPM	0.5 V	(0.5 V / 5.00 V) x 100% = 10%

Table 4.7 Scaling Values

Parameter	Value
Input range high	65 GPM
Input high signal	95.0%
Input range low	3 GPM
Input low signal	10.0%

Autotuning

Autotuning is a process by which a controller calculates the correct PID parameters for optimum control. Only the heat output of a loop may be autotuned.

How Does Autotuning Work?

Autotuning is performed at the maximum allowed output. If an output limit has been set, then autotuning occurs at that value. Otherwise, the control output is set to 100 percent.

The PID constants are calculated according to process response to the output. The loop need not reach or cross the set point to successfully determine the PID parameters.

The controller looks at the delay between when power is applied and when the system responds and uses this information to determine the proportional band. The controller then looks for the slope of the rising temperature to become constant to determine the integral term. The controller mathematically derives the derivative term from the integral term.

When the controller finishes autotuning a loop, it switches the loop to automatic mode. If the process reaches 80 percent of the set point or the autotuning time exceeds 30 minutes, the controller switches the loop to automatic mode and applies the PID constants it has calculated up to that point.

Autotuning is started at ambient temperature or at a temperature above ambient. However, the temperature must be*stable* and there must be sufficient time for the controller to determine the new PID parameters.

Prerequisites

Before autotuning, the controller must be installed with control and sensor circuitry and the thermal load in place. It must be safe to operate the thermal system, and the approximate desired operating temperature (set point) must be known.

The technician or engineer performing the autotune should know how to use the controller keypad or HMI software interface to do the following:

- Select a loop.
- Change the set point.
- Change the control mode (manual, automatic, off or tune).
- Read and change the setup parameters.

How to Autotune a Loop

NOTE! ***The loop must be stable at a temperature well below the set point in order to successfully autotune. The controller will not complete tuning if the temperature exceeds 80 percent of set point before the new parameters are found.***

To autotune a loop:

1. Go to the loop display (see Loop Display on page 80) and press −LOOP+ to choose the loop to autotune.
2. Verify that process is stable.
3. Put the loop into manual control mode (see page 85).
4. Enter a set point value as near the normal operating temperature as is safe for the system (see page 84).

WARNING! ***During autotuning, the controller sets the output to 100 percent until the process variable rises to 80 percent of set point. Enter a set point that is within the safe operating limits of your system.***

5. Access the setup menus (see page 86). Go to the *Input filter* parameter in the *Input* menu. Write down the value, and then change it to *0 scans*. Press ⏵ to save the new setting.
6. Press ↶ twice to return to the loop display.
7. Set the *Mode* parameter to *tune* (see page 85).
8. The controller will automatically return to the loop display. The word *tun* flashes throughout the tuning process. When tuning is complete, the control mode indicator changes to *auto*.
9. Adjust the set point to the desired operating temperature (see page 84).
10. Restore the *Input filter* parameter to its original value.

Setting Up Alarms

The D8 has three main types of alarms:

- Failed sensor alarms
- Process alarms
- System alarms

Failed Sensor Alarms

Failed sensor alarms alert you if one of the following conditions occurs:

- Thermocouple open
- Thermocouple shorted (must be enabled)
- Thermocouple reversed (enabled by default)
- RTD open positive input or open negative input
- RTD short between the positive and negative inputs

What Happens if a Failed Sensor Alarm Occurs?

If a failed sensor alarm occurs:

- The controller switches to manual mode at the output power indicated by the *Sensor fail heat output* and *Sensor fail cool output* parameters in the *Output* menu. (The output power may be different for a thermocouple open alarm; see Thermocouple Open Alarm below.)
- The controller displays an alarm code and alarm message on the display. See Alarm Displays on page 81.
- The global alarm output is activated.

Thermocouple Open Alarm

The thermocouple open alarm occurs if the controller detects a break in a thermocouple or its leads.

If a thermocouple open alarm occurs, the controller switches to manual mode. The output level is determined as follows:

- If the *Open T/C ht/cl out average* parameter in the *Output* menu is set to *on*, then the controller sets the output power to an average of the recent output.
- If the *Open T/C ht/cl out average* parameter is set to *off*, then the controller sets the output to the level indicated by the *Sensor fail heat/cool output* parameter in the *Output* menu.

Thermocouple Reversed Alarm

The thermocouple reversed alarm occurs if the temperature goes in the opposite direction and to the opposite side of ambient temperature than expected—for example, a loop is heating and the measured temperature drops below the ambient temperature.

The thermocouple reversed alarm is enabled by default. If false alarms occur in your application, you can disable the alarm by setting the *Reversed T/C detect* parameter to *off*. See Reversed Thermocouple Detection on page 133.

Thermocouple Short Alarm

The thermocouple short alarm occurs if the process power is on and the temperature does not rise or fall as expected. To enable the thermocouple short alarm, you must do the following:

- Choose a digital input for the *TC short alarm* parameter in the *Global setup* menu.
- Connect the digital input to a device that connects the input to controller common when the process power is on.

RTD Open and RTD Fail Alarms

The RTD open alarm occurs if the controller detects that the positive RTD lead is broken or disconnected.

The RTD fail alarm occurs if the controller detects any of the following conditions:

- negative lead is broken or disconnected
- common lead is broken or disconnected
- positive and negative leads are shorted
- positive and common leads are shorted
- positive, negative and common leads are shorted

The RTD alarms are enabled on any channel with Input Type set to RTD.

Restore Automatic Control After a Sensor Failure

This feature returns a loop to automatic control after a failed sensor is repaired. To enable this feature:

- Choose a digital input for the *RestoreAuto* parameter in the *Control* menu.
- Connect the digital input to the dc common terminal on the controller.

Process Alarms

The D8 has four process alarms, each of which you can configure separately for each loop:

- Alarm low
- Alarm high
- Low deviation alarm
- High deviation alarm

What Happens if a Process Alarm Occurs?

If a process alarm occurs, the controller does the following:

- Shows an alarm code on the display. See Alarm Displays on page 81.
- Activates the global alarm output. See Global Alarm on page 97.
- Activates the digital output that is assigned to the process alarm (if applicable). The digital output remains active until the process variable returns within the corresponding limit and hysteresis. The alarm output deactivates when the process returns to normal.

Process Alarm Outputs

Any digital output that is not used as a control output can be assigned to one or more process alarms.

The controller activates the output if any alarm assigned to the output is active. Process alarm outputs are non-latching—that is, the output is deactivated when the process returns to normal, whether or not the alarm has been acknowledged.

Specify the active state of process alarm outputs at the *D/O alarm polarity* setting in the *Global setup* menu.

Alarm Function: Standard Alarm or Boost Output

You can configure each process alarm as either a standard alarm or a boost alarm:

- A standard alarm provides traditional alarm functionality: The operator must acknowledge the alarm message on the controller display, a latching global alarm is activated, and the alarm can activate a user-specified non-latching alarm output.
- A boost alarm provides on/off control output using the alarm set points. For example, you could configure a high deviation alarm to turn on a fan. The alarm activates a user-specified non-latching output. Alarm messages do not have to be acknowledged, and the global alarm is not activated.

Alarm High and Alarm Low

An alarm high occurs if the process variable rises above a user-specified value. An alarm low occurs if the process variable drops below a separate user-specified value. See Figure 4.7

Enter the alarm high and low set points at the *Alarm high SP* and *Alarm low SP* parameters in the *Alarms* menu.

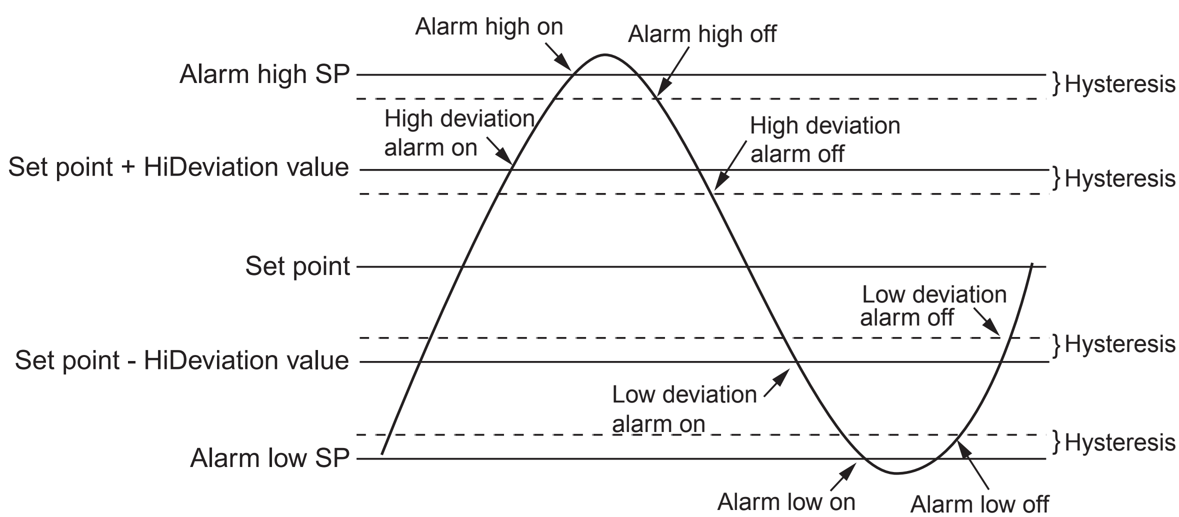


Figure 4.7 Activation and Deactivation of Process Alarms

Deviation Alarms

A deviation alarm occurs if the process deviates from set point by more than a user-specified amount; see Figure 4.7. You can set separate high and low deviation values at the*HiDeviation value* and *LoDeviation value* parameters in the *Alarms* menu.

Upon power up or when the set point changes, the behavior of the deviation alarms depends upon the alarm function:

- If the alarm function parameter is set to *standard*, then deviation alarms do not activate until the after the process variable has first come within the deviation alarm band. This prevents nuisance alarms.
- If the alarm function parameter is set to *boost*, then the deviation output switches on whenever the set point and process variable differ by more than the deviation setting, regardless of whether the process variable has been within the deviation band. This allows you to use boost control upon power up and set point changes.

Global Alarm

The D8 comes equipped with a global alarm output. The global output is activated if one or more of the following conditions occurs:

- A system alarm occurs, or
- A failed sensor alarm occurs and is unacknowledged, or
- A process alarm occurs and is unacknowledged. The global alarm occurs only if the alarm function is set to *standard* in the *Alarms* menu. (The global alarm does *not* occur if the alarm function is set to *boost*.)

The global alarm output stays active until all alarms have been acknowledged.

When the global alarm output is active, it conducts current to the controller's dc common. When the global alarm output is not active, it does not conduct current.

NOTE! ***You cannot configure any parameters for the global alarm. The active state of the global alarm output is NOT affected by the*** **D/O alarm polarity** ***parameter in the*** **Global setup** ***menu.***

Setting Up Process Variable Retransmit

The process variable retransmit feature retransmits the process variable of one loop (primary) via the control output of another loop (secondary). This signal is linear and proportional to the engineering units of the primary loop input.

Typical uses include data logging to analog recording systems, and long distance transmission of the primary signal to avoid signal degradation. The retransmitted signal can also be used as an input to other types of control systems such as a PLC.

Any available heat or cool output may be used as a retransmit output. Any process variable may be retransmitted, including the input from the same loop.

To get a 4 to 20 mA or 0 to 5 Vdc signal, the controller output signal must be connected to a Serial DAC.

How to Set Up Process Variable Retransmit

1. Configure all of the setup parameters for the primary loop (the loop whose input signal will be retransmitted).
2. Choose an unused control output to retransmit the input signal. This output may be on the primary loop or on a different loop.
3. On the secondary loop (the loop whose output will retransmit the signal):
   - Set up the parameters in the *PV retrans* menu. See Process Variable Retransmit Menu on page 148.
   - Enable the loop's output and configure it to meet the requirements of the application.
4. If the signal is being retransmitted to another controller, configure the input of that controller to accept the linear output signal produced by the retransmit output.

Process Variable Retransmit Example: Data Logging

The D8 controls the temperature of a furnace. The thermocouple in one of the zones is connected to the controller and is used for closed-loop PID control. An analog recorder data logging system is also in place, and a recording of the process temperature is required. The recorder requires a linear 4 to 20 mA input signal, which represents a process variable range of 0 to 1000° F.

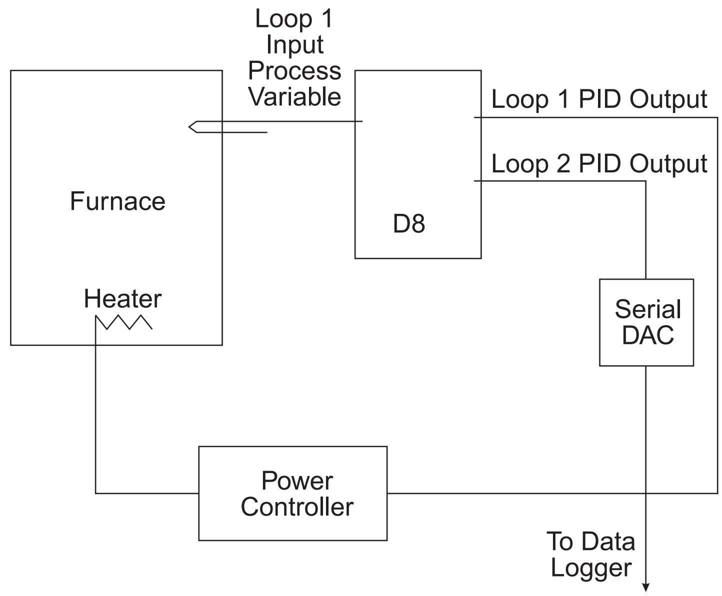


Figure 4.8 Application Using Process Variable Retransmit

Table 4.8 shows the parameter setup for this example.

Table 4.8 Parameters Settings for Process Variable Retransmit Example

Menu	Parameter	Value	Comment
PV retrans	Ht output retrans	PV 1	Choose to retransmit the loop 1 process variable.
PV retrans	Ht retrans LowPV	0°F	This is the input value represented by a 0 percent output signal. The recorder input is a linear 4 to 20 mA signal representing a range of 0° F to 1000° F, so we will use a 0 percent output signal to represent 0° F.
PV retrans	Ht retrans HighPV	1000°F	This is the input value represented by a 100 percent output signal. The recorder input is a linear 4 to 20 mA signal representing a range of 0° F to 1000° F, so we will use a 100 percent output signal to represent 1000° F.
PV retrans	Cl output retrans	none	Not using the cool output of loop 2 to retransmit a process variable.

To complete this configuration, the output for loop 2 must be configured to provide the 4 to 20 mA analog signal (via the Serial DAC) that is required by the data logger.

When setup is completed, the controller will produce an output on loop 2 which is linear and proportional to the loop 1 process variable.

Setting Up Cascade Control

Cascade control is used to control thermal systems with long lag times, which cannot be as accurately controlled with a single control loop. The output of the first (primary) loop is used to adjust the set point of the second (secondary) loop. The secondary loop normally executes the actual control.

Some applications, such as aluminum casting, use two-zone cascade control where the primary output is used for the primary heat control and the cascaded output is used for boost heat. You can use the primary heat output for both control *and* for determining the set point of the secondary loop.

How the Secondary Set Point is Determined

The set point of the secondary loop is determined according to the heat and cool output values from the primary loop and user-specified cascade parameters:

- If the primary loop has both heat and cool outputs, then the set point of the secondary loop is equal to the *Cascade low SP* parameter when the cool output is at 100 percent, and is equal to the *Cascade high SP* when the heat output is at 100 percent. See Figure 4.9.
- If the primary loop has only a heat output, then the set point of the secondary loop is equal to the *Cascade low SP* parameter when the heat output is at 0 percent, and is equal to the *Cascade high SP* parameter when the heat output is at 100 percent. See Figure 4.10.
- If the primary loop has only a cool output, then the set point of the secondary loop is equal to the *Cascade low SP* parameter when the cool output is at 100 percent, and is equal to the *Cascade high SP* parameter when the cool output is at 0 percent.

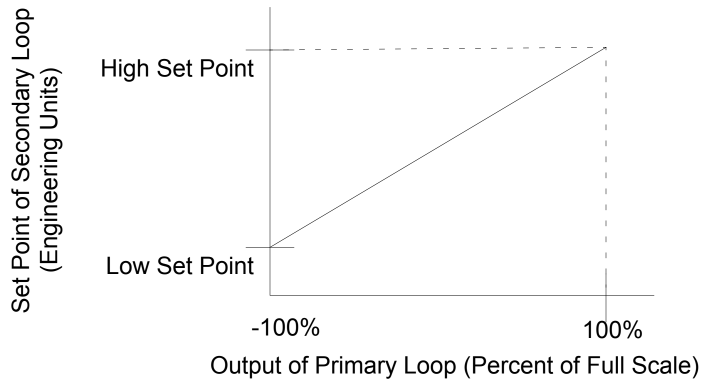


Figure 4.9 Secondary Set Point When Primary Loop Has Heat and Cool Outputs

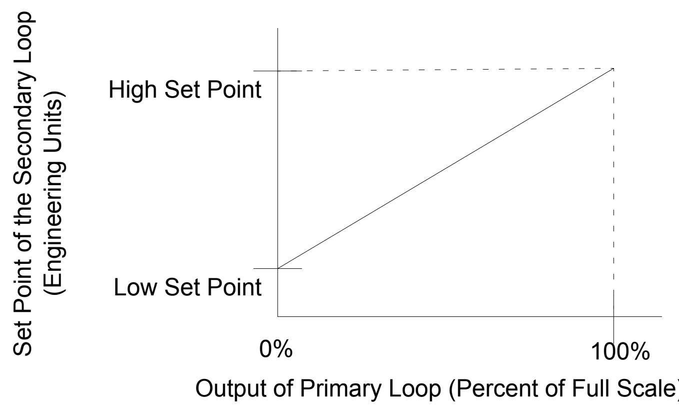


Figure 4.10 Secondary Set Point When Primary Loop Has Heat Output Only

Proportional-Only Control on the Primary Loop

The PID parameters of the primary loop must be tuned to produce the desired effect on the set point of the secondary loop. The primary loop typically uses proportional-only control. Disabling the integral and derivative components of PID makes the secondary set point a predictable function of the primary loop's process variable.

The proportional band is selected so that the set point of the secondary loop has the desired relationship to the process variable of the primary loop. For an example, see Cascade Control Example: Water Tank on page 102.

How To Set Up Cascade Control

1. For the primary cascade loop:
   - Configure proportional-only control. For an example, see Cascade Control Example: Water Tank on page 102.
   - Enter the desired set point. See Changing the Set Point on page 84.
2. For the secondary cascade loop:
   - Set up PID control as you would for a standard closed-loop application.
   - Set up the parameters in the *Cascade* menu. See Cascade Menu on page 149.

NOTE! ***Cascade control cannot be used on the same control loop as ratio control.***

Cascade Control Example: Water Tank

A tank of water has an inner and outer thermocouple. The outer thermocouple is located in the center of the water. The inner thermocouple is located near the heating element. The desired temperature of the water is 150° F, which is measured at the outer thermocouple.

Using cascade control, the outer thermocouple is used on the primary loop (in this example, loop 1), and the inner thermocouple is used on the secondary loop (loop 2). The heater is controlled by loop 2.

As the temperature of the outer thermocouple drops from 150° F to 140° F, the set point of the secondary loop should rise from 150 to 190° F.

Table 4.9 and Table 4.10 show the setup for this application.

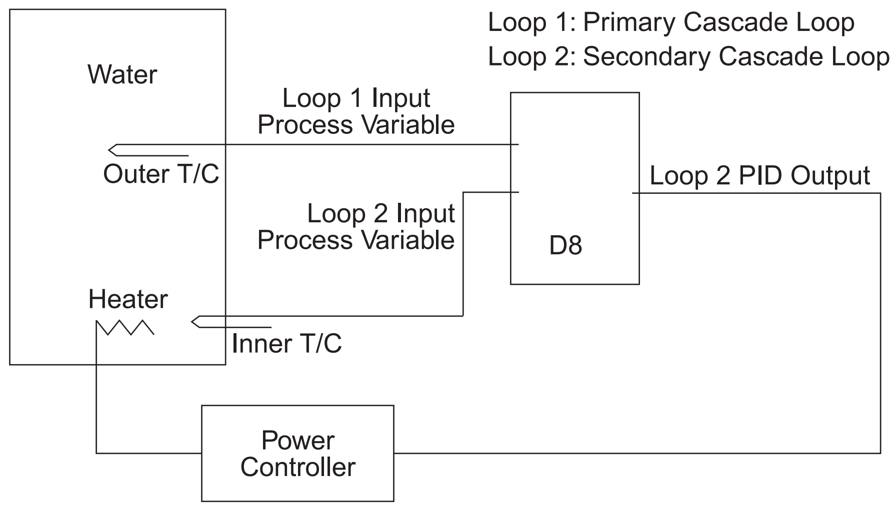


Figure 4.11 Example Application Using Cascade Control

Table 4.9 Parameter Settings for the Primary Loop in the Cascade Example

Menu	Parameter	Value	Comment
(none)	`Set point`	`150°F`	Desired temperature at the inner thermocouple.
`Control`	`Ht prop band`	`10`	As the input drops 10° F, the output increases to 100 percent.
`Control`	`Ht integral`	`0`	Only proportional control is used.
`Control`	`Ht derivative`	`0`	Only proportional control is used.

Table 4.10 Parameter Settings for the Secondary Loop in the Cascade Example

Menu	Parameter	Value	Comment
`Cascade`	`Cascade prim loop`	`1`	Loop 1 is the primary loop.
`Cascade`	`Cascade low SP`	`150°F`	When the primary loop's output is 0 percent, the secondary loop's set point is 150° F.
`Cascade`	`Cascade high SP`	`190°F`	When the primary loop output is 100 percent, the secondary channel set point is 190° F.

As the temperature in the middle of the tank (loop 1) drops, the output goes up proportionally and the set point of loop 2 goes up proportionally. Thus heat is added to the system at the element even though the temperature near the element may have been at the desired temperature.

With proportional control, when loop 1 is at set point, its output is 0 percent, and the set point of loop 2 is equal to the desired temperature 150º F. If the temperature of the loop 1 drops below 149º F, the deviation results in a proportional output of 10 percent. This results in an increase to the set point for loop 2 equal to 10 percent of the set point range. In this case the range is 40º F (190º F - 150º F = 40º F), and 10 percent of 40º F is 4º F.

So when the temperature at loop 1 drops 1º F, the set point of loop 2 increases by 4º F until the output of loop 1 is 100 percent and the set point of loop 2 is 190º F. At this point, further decreases of the loop 1 process variable have no additional affect on loop 2. Figure 4.12 illustrates this relationship.

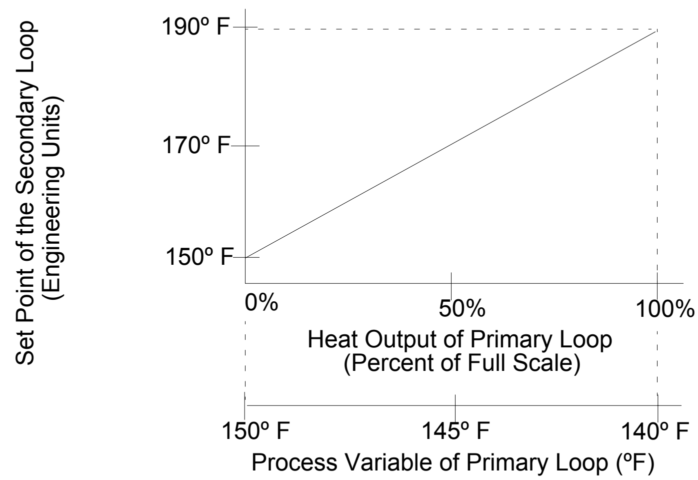


Figure 4.12 Relationship of Secondary Loop Set Point to Primary Loop Process Variable in Cascade Example

Setting Up Ratio Control

Ratio control allows the process variable of one loop (master loop), multiplied by a ratio, to be the set point of another loop (ratio loop). You can assign any process variable to determine the set point of a ratio loop.

By adjusting the ratio control parameters, you can adjust the influence that the master loop process variable has on the set point of the ratio loop.

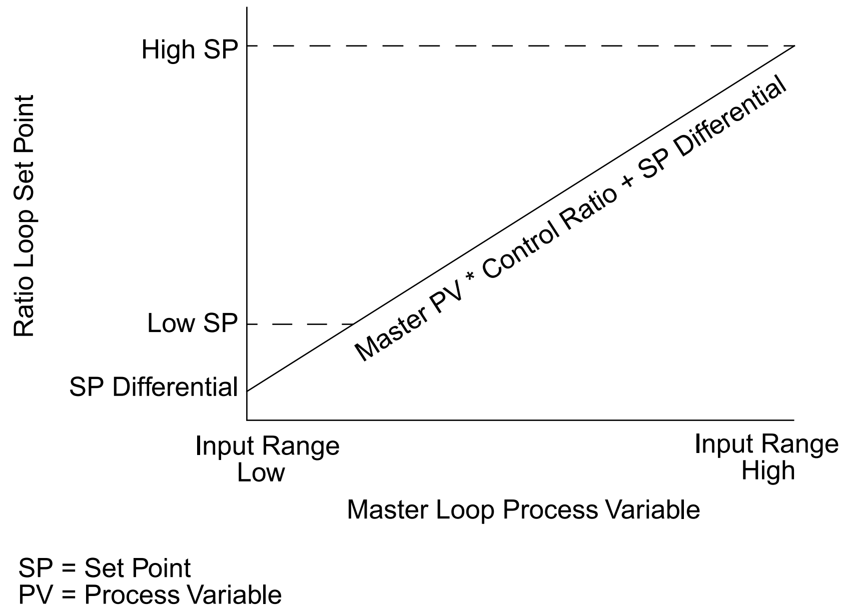


Figure 4.13 Relationship Between the Process Variable on the Master Loop and the Set Point of the Ratio Loop

NOTE! ***Ratio control cannot be used on the same control loop as cascade control.***

How to Set Up Ratio Control

1. Adjust and tune the master loop for optimal performance before implementing the ratio setup.
2. For the ratio loop, set the parameters in the *Ratio* menu.
3. Configure both the master loop and the ratio loop for inputs, outputs, and alarms

Ratio Control Example: Diluting KOH

A chemical process requires a formula of two parts water (H_2O) to one part potassium hydroxide (KOH) to produce diluted potassium hydroxide. The desired flow of H_2O is 10 gallons per second (gps), so the KOH should flow at 5 gps.

Separate pipes for each chemical feed a common pipe. The flow rate of each feeder pipe is measured by a D8, with H_2O flow measured on loop 1 and KOH flow measured on loop 2. The outputs of loops 1 and 2 adjust motorized valves.

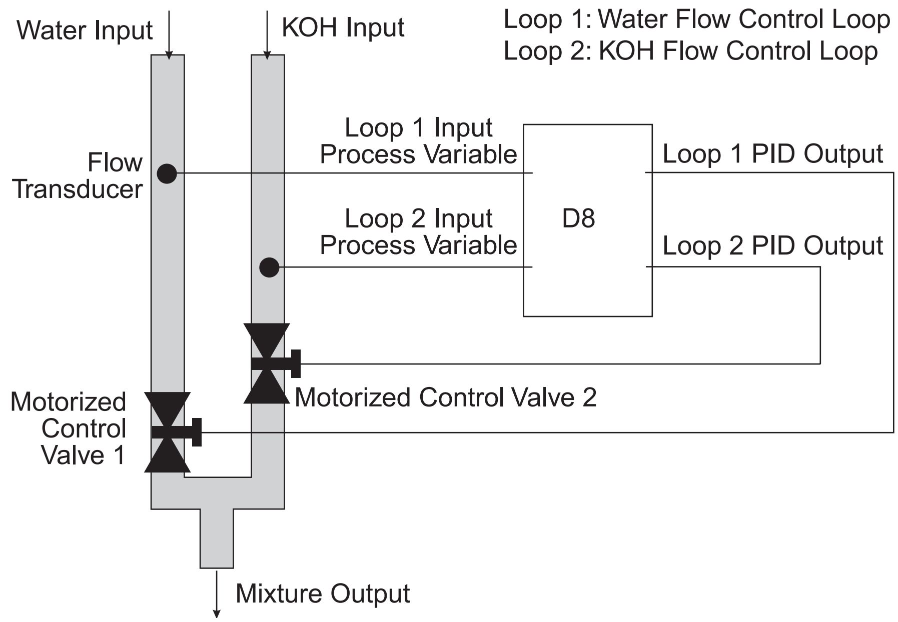


Figure 4.14 Application Using Ratio Control

Table 4.11 Ratio Control Settings for the Ratio Loop (Loop 2) in the Example

Menu	Parameter	Value	Comment
Ratio	Ratio master loop	01	Loop 1 is the master loop.
Ratio	Ratio low SP	0.0	The minimum ratio loop set point is 0.0 gallons per second (gps).
Ratio	Ratio high SP	7.0	The maximum ratio loop set point is 7.0 gps.
Ratio	Control ratio	0.5	The H_20 flow rate (10 gps) is multiplied by 0.5 to obtain the KOH flow rate (5 gps).
Ratio	Ratio SP diff	0	For this example, there is no set point differential.

Setting Up Differential Control

Differential control is a simple application of ratio control, used to control one process (ratio loop) at a differential, or offset, to another process (master loop).

How to Set Up Differential Control

Set up differential control as you would set up ratio control. Set the *Control ratio* parameter to 1.0, and enter the desired set point differential (offset) at the *Ratio SP diff* parameter.

Differential Control Example: Thermoforming

A thermal forming application requires that the outer heaters operate at temperature 50º F hotter than the center heaters. The center heaters use infrared (IR) sensors for temperature feedback. The outer heaters use thermocouples for feedback.

We can use differential control to control the outer heaters at a 50º F differential to the central heaters. For example, if the set point for the center heaters is 325º F, the set point of the outer heaters will be 375º F.

In this application, the center heaters will be controlled by the master loop (on loop 1), and the outer heaters will be controlled by the ratio loop (on loop 2).

To set up this application, first set up the master loop (loop 1) for PID control with a set point of 325º F. Then, for the ratio loop (loop 2), set the parameters in the *Ratio* menu as shown in Table 4.12.

Table 4.12 Parameter Settings for the Ratio Loop (Loop 2) for the Example

Menu	Parameter	Value	Comment
Ratio	Ratio master loop	01	Loop 1 is the master loop.
Ratio	Ratio low SP	300.0°F	The lowest allowable set point for the ratio loop. For this example, we'll use 300.0.
Ratio	Ratio high SP	400.0°F	The highest allowable set point for the ratio loop. For this example, we'll use 400.0.
Ratio	Control ratio	1.0	For differential control, always set this parameter to 1.0.
Ratio	Ratio SP diff	50°F	The set point differential, or offset.

To complete the differential control setup, loop 1 and loop 2 must be configured for inputs, outputs and alarms.

Setting Up Remote Analog Set Point

Remote analog set point allows external equipment, such as a PLC or other control system, to change the set point of a loop.

Typically, a voltage or current source is connected to an analog input on the controller, and this input is configured as the master loop for ratio control.

Proper scaling resistors must be installed on the input to allow it to accept the analog input signal.

How to Set Up a Remote Analog Set Point

1. For the master loop (the loop that accepts the input signal from the external device), set the parameters in the *Input* menu.
2. For the ratio loop (the one whose set point is controlled by the external device), set the parameters in the *Ratio* menu. Specify the loop that accepts the input signal as the master loop.

Remote Analog Set Point Example: Changing a Set Point with a PLC

A PLC provides a 0 to 5 Vdc signal representing 0 to 300° F as a remote set point input to the D8. The input signal is received on loop 1, and control is performed on loop 2. The D8 is equipped with the proper scaling resistors to allow it to accept a 0 to 5 Vdc input.

Table 4.13 and Table 4.14 show the parameter settings for this application.

Table 4.13 Parameters Settings for the Master Loop (Loop 1) in the Example

Menu	Parameter	Value	Comment
Input	Input type	process	A 0 to 5 Vdc input signal is a process input.
Input	Input range high	300°F	The 5 Vdc input signal represents 300° F.
Input	Input high signal	100.0%	The controller is equipped with a 0 to 5 Vdc input, and the input signal is 0 to 5 Vdc, so the signal covers the full scale of 0 to 100 percent.
Input	Input range low	0°F	The 0 Vdc input signal represents 0° F.
Input	Input low signal	0.0%	The controller is equipped with a 0 to 5 Vdc input, and the input signal is 0 to 5 Vdc, so the signal covers the full scale of 0 to 100 percent.

Table 4.14 Parameter Settings for the Ratio Loop (Loop 2) in the Example

Menu	Parameter	Value	Comment
Ratio	Ratio master loop	01	Loop 1 is the master loop (receives the input signal from the external device).
Ratio	Ratio low SP	0°F	For this example, we will assume that the process can be set safely over the entire range of 0 to 300° F. If desired, we could set a more restrictive range for the ratio loop.
Ratio	Ratio high SP	300°F	
Ratio	Control ratio	1.0	For this example, we want to retain the original input value, so we will multiply it times 1.0.
Ratio	Ratio SP diff	0	For this example, we want to retain the original value, so we will add 0.

To complete the setup, loop 2 must be configured for inputs, outputs, and alarms. In addition, loop 1 may be configured for outputs and alarms.

5

Tuning and Control

This chapter describes the different methods of control available with the D8. This chapter covers control algorithms, control methods, PID control, starting PID values and tuning instructions to help appropriately set control parameters in the D8 system.

For more information about PID control, consult the *Watlow Anafaze Practical Guide to PID*.

Control Algorithms

This section explains the algorithms available for controlling a loop.

The control algorithm dictates how the controller responds to an input signal. Do not confuse control algorithms with control output signals (for example, analog or pulsed dc voltage). There are several control algorithms available:

- On/off
- Proportional (P)
- Proportional and integral (PI)
- Proportional with derivative (PD)
- Proportional with integral and derivative (PID)

P, PI or PID control is necessary when process variable cycling is unacceptable or if the load or set point varies.

NOTE! ***For any of these control algorithms to function, the loop must be in automatic mode.***

On/Off Control

On/off control is the simplest way to control a process. The controller turns an output on or off when the process variable reaches limits around the desired set point. This limit is adjustable.

For example, if the set point is 1000° F and the control hysteresis is 20° F, the heat output switches on when the process variable drops below 980° F and off when the process rises above 1000° F. A process using on/off control cycles around the set point. Figure 5.1 illustrates this example.

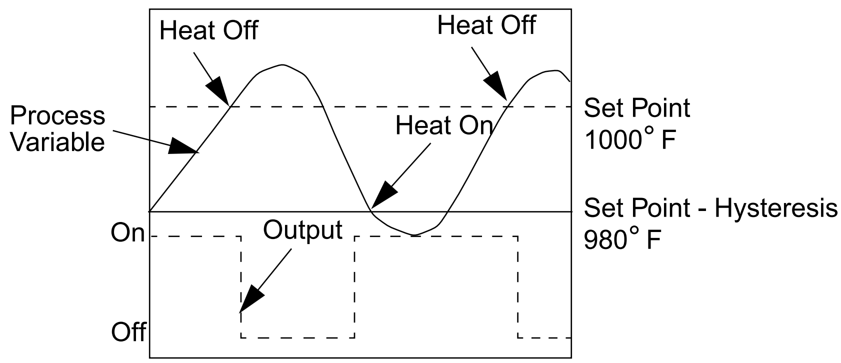


Figure 5.1 On/Off Control

Proportional Control (P)

Proportional control eliminates cycling by increasing or decreasing the output proportionally with the process variable's deviation from the set point.

The magnitude of proportional response is defined by the proportional band. Outside this band, the output is either 100 percent or 0 percent. Within the proportional band the output power is proportional to the process variable's deviation from the set point.

For example, if the set point is 1000° F and the proportional band is 20° F, the output power is as follows:

- 0 percent when the process variable is 1000° F or above
- 50 percent when the process variable is 990° F
- 75 percent when the process variable is 985° F
- 100 percent when the process variable is 980° F or below

However, a process that uses only proportional control settles at a point above or below the set point; it never reaches the set point. This behavior is known as *offset* or *droop*. When using proportional control, configure the manual reset parameter for the power level required to maintain set point.

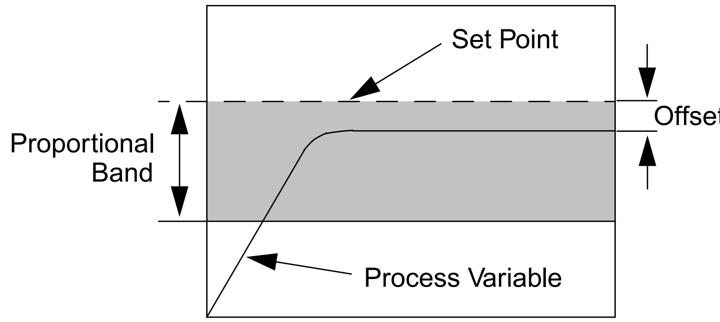


Figure 5.2 Proportional Control

Proportional and Integral Control (PI)

With proportional and integral control, the integral term corrects for offset by repeating the proportional band’s error correction until there is no error. For example, if a process tends to settle about 5° F below the set point, appropriate integral control brings it to the desired setting by gradually increasing the output until there is no deviation.

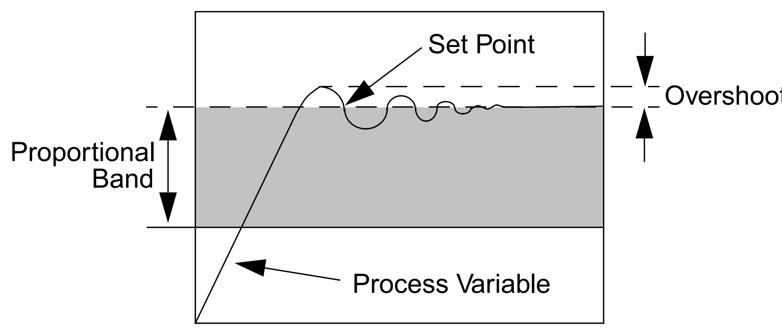


Figure 5.3 Proportional and Integral Control

Proportional and integral action working together can bring a process to set point and stabilize it. However, with some processes the user may be faced with choosing between parameters that make the process very slow to reach set point and parameters that make the controller respond quickly, but introduce some transient oscillations when the set point or load changes. The extent to which these oscillations cause the process variable to exceed the set point is called *overshoot*.

Proportional, Integral and Derivative Control (PID)

Derivative control corrects for overshoot by anticipating the behavior of the process variable and adjusting the output appropriately. For example, if the process variable is rapidly approaching the set point from below, derivative control reduces the output, anticipating that the process variable will reach set point. Use derivative control to reduce the overshoot and oscillation of the process variable that is common to PI control. Figure 5.4 shows a process under full PID control.

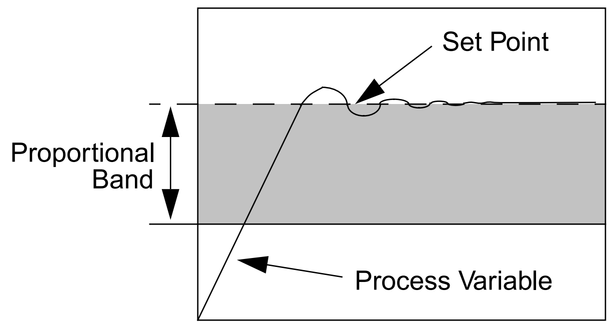


Figure 5.4 Proportional, Integral and Derivative Control

Heat and Cool Outputs

Each loop may have one or two outputs. Often a heater is controlled according to the feedback from a thermocouple, in which case only one output is needed.

In other applications, two outputs may be used for control according to one input. For example, a system with a heater and a proportional valve that controls cooling water flow can be controlled according to feedback from one thermocouple.

In such systems, the control algorithm avoids switching too frequently between heat and cool outputs. The on/off algorithm uses the control hysteresis parameter to prevent such oscillations (see Hysteresis on page 138). When PID control is used for one or both loop outputs, both the hysteresis parameter and PID parameters determine when control switches between heating and cooling.

Setting Up and Tuning PID Loops

After installing your control system, tune each control loop and then set the loop to automatic control. When tuning a loop, choose PID parameters that will best control the process. This section gives PID values for a variety of heating and cooling applications.

NOTE! ***Tuning is a slow process. After adjusting a loop, allow about 20 minutes for the change to take effect.***

Proportional Band Settings

Table 5.1 shows proportional band settings for various temperatures in degrees Fahrenheit or Celsius.

Table 5.1 Proportional Band Settings

Temperature Set Point	PB	Temperature Set Point	PB	Temperature Set Point	PB
-100 to 99	20	1100 to 1199	75	2200 to 2299	135
100 to 199	20	1200 to 1299	80	2300 to 2399	140
200 to 299	30	1300 to 1399	85	2400 to 2499	145
300 to 399	35	1400 to 1499	90	2500 to 2599	150
400 to 499	40	1500 to 1599	95	2600 to 2699	155
500 to 599	45	1600 to 1699	100	2700 to 2799	160
600 to 699	50	1700 to 1799	105	2800 to 2899	165
700 to 799	55	1800 to 1899	110	2900 to 2999	170
800 to 899	60	1900 to 1999	120	3000 to 3099	175
900 to 999	65	2000 to 2099	125	3100 to 3199	180
1000 to 1099	70	2100 to 2199	130	3200 to 3299	185

As a general rule, set the proportional band to ten percent of the set point below 1000° and five percent of the set point above 1000°. This setting is useful as a starting value.

Integral Settings

The controller's integral parameter is set in seconds per repeat. Some other products use an integral term called reset, in units of repeats per minute. Table 5.2 shows integral settings versus reset settings.

Table 5.2 Integral Term and Reset Settings

Integral (Seconds/Repeat)	Reset (Repeats/Minute)	Integral (Seconds/Repeat)	Reset (Repeats/Minute)
30	2.0	210	0.28
45	1.3	240	0.25
60	1.0	270	0.22
90	0.66	300	0.20
120	0.50	400	0.15
150	0.40	500	0.12
180	0.33	600	0.10

As a general rule, use 60, 120, 180 or 240 as a starting value for the integral.

Derivative Settings

The controller's derivative parameter is programmed in seconds. Some other products use a derivative term called rate programmed in minutes. Use the table or the formula to convert parameters from one form to the other. Table 5.3 shows derivative versus rate. Rate = Derivative/60.

Table 5.3 Derivative Term Versus Rate

Derivative (seconds)	Rate (minutes)	Derivative (seconds)	Rate (minutes)
5	0.08	35	0.58
10	0.16	40	0.66
15	0.25	45	0.75
20	0.33	50	0.83
25	0.41	55	0.91
30	0.50	60	1.0

As a general rule, set the derivative to 15 percent of integral as a starting value.

NOTE! ***While the basic PID algorithm is well defined and widely recognized, various controllers implement it differently. Parameters may not be taken from one controller and applied to another with optimum results even if the above unit conversions are performed.***

General PID Constants by Application

This section gives PID values for many applications. They are useful as control values or as *starting* points for PID tuning.

Proportional Band Only (P)

Set the proportional band to seven percent of the set point. (Example: Set point = 450, proportional band = 31).

Proportional with Integral (PI)

- Set the proportional band to ten percent of set point. (Example: Set point = 450, proportional band = 45).
- Set integral to 60.
- Set derivative off.
- Set the output filter to 2.

Proportional and Integral with Derivative (PID)

- Set the proportional band to ten percent of the set point. (Example: Set point = 450, proportional band = 45).
- Set the integral to 60.
- Set the derivative to 15 percent of the integral. (Example: Integral = 60, derivative = 9).
- Set the output filter to 2.

Table 5.4 shows general PID constants by application.

Table 5.4 General PID Constants

Application	Proportional Band	Integral	Derivative	Filter	Output Type	Cycle Time	Action
Electrical heat with solid state relays	50°	60	15	4	DZC	-	Reverse
Electrical heat with electromechanical relays	50°	60	15	6	TP	20	Reverse
Cool with solenoid valve	70°	500	90	4	TP	10	Direct
Cool with fans	10°	Off	10	4	TP	10	Direct
Electric heat with open heat coils	30°	20	Off	4	DZC	-	Reverse
Gas heat with motorized valves	60°	120	25	8	Analog	-	Reverse
Set Point>1200	100°	240	40				

Control Outputs

The controller provides open collector outputs for control. These outputs normally control the process using solid state relays.

Open collector outputs can be configured to drive a serial digital-to-analog converter (Serial DAC) which, in turn, can provide 0 to 5 Vdc, 0 to 10 Vdc or 4 to 20 mA control signals to operate field output devices.

Output Control Signals

The following sections explain the different control output signals available.

On/Off

When on/off control is used, the output is on or off depending on the difference between the set point and the process variable. PID algorithms are not used with on/off control. The output variable is always off or on (0 or 100 percent).

Time Proportioning (TP)

With time proportioning outputs, the PID algorithm calculates an output between 0 and 100 percent, which is represented by turning on an output for that percent of a fixed, user-selected time base or cycle time.

The cycle time is the time over which the output is proportioned, and it can be any value from 1 to 255 seconds. For example, if the output is 30 percent and the cycle time is ten seconds, then the output will be on for three seconds and off for seven seconds. Figure 5.5 shows examples of time proportioning and distributed zero crossing (DZC) waveforms.

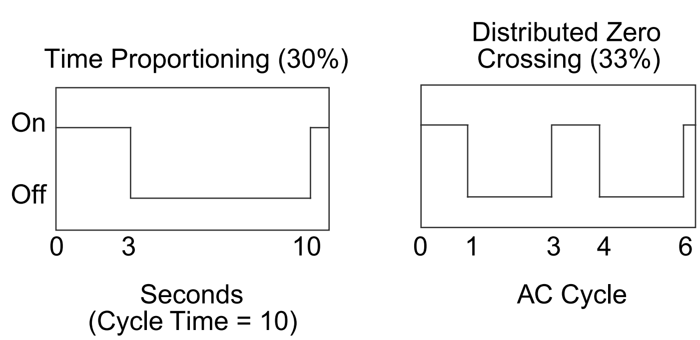


Figure 5.5 Time Proportioning and Distributed Zero Crossing Waveforms

Distributed Zero Crossing (DZC)

With DZC outputs, the PID algorithm calculates an output between 0 and 100 percent, but the output is distributed on a variable time base. For each ac line cycle, the controller decides whether the power should be on or off. There is no fixed cycle time since the decision is made for each line cycle. When used in conjunction with a zero crossing device, such as a solid state relay (SSR), switching is done only at the zero crossing of the ac line, which helps reduce electrical noise.

Using a DZC output should extend the life of heaters. Since the time period for 60 Hz power is 16.6 ms, the switching interval is very short and the power is applied uniformly. DZC should be used with SSRs. Do not use DZC output for electromechanical relays.

The combination of DZC output and a solid state relay can inexpensively approach the effect of analog, phase-angle fired control. Note, however, DZC switching does not limit the current and voltage applied to the heater as phase-angle firing does.

Three-Phase Distributed Zero Crossing (3P DZC)

This output type performs exactly the same as DZC except that the minimum switching time is three ac line cycles. This may be advantageous in some applications using three-phase heaters and three-phase power switching.

Analog Outputs

For analog outputs, the PID algorithm calculates an output between 0 and 100 percent. This percentage of the analog output range can be applied to an output device via a Dual DAC or a Serial DAC.

Output Filter

The output filter digitally smooths PID control output signals. It has a range of 0 to 255 scans, which gives a time constant of 0 to 85 seconds for a CPC408 or 0 to 43 seconds for a CPC404. Use the output filter if you need to filter out erratic output swings due to extremely sensitive input signals, like a turbine flow signal or an open air thermocouple in a dry air gas oven.

The output filter can also enhance PID control. Some processes are very sensitive and would otherwise require a large proportional band, making normal control methods ineffective. Using the output filter allows a smaller proportional band to be used, achieving better control.

Also, use the filter to reduce the process output swings and output noise when a large derivative is necessary, or to make badly tuned PID loops and poorly designed processes behave properly.

Reverse and Direct Action

With reverse action an increase in the process variable causes a decrease in the output. Conversely, with direct action an increase in the process variable causes an increase in the output. Heating applications normally use reverse action and cooling applications usually use direct action.

6

Menu and Parameter Reference

The D8 has operator and setup parameters that let you change the configuration of the controller. This section contains the following information for each operator and setup parameter:

- Description
- Values
- Default value
- Information for addressing controller parameters via DeviceNet.

For information about how to access the operator and setup parameters, see the Operation and Setup chapter.

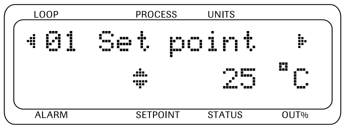
Operator Parameters

Use the operator parameters to change the set point, control mode or output power level.

	Access the operator parameters (from the loop display). Save a value and go to the next parameter.
	Edit parameter values.
	Save a value and go to the previous parameter.
–LOOP+	Save a value and go to the next or previous loop.
	Cancel a change without saving. Escape to the loop display.

Figure 6.1 Operator Parameter Navigation

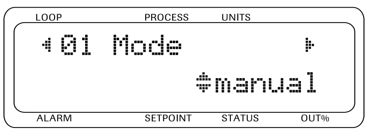
Set Point



Enter the desired value for the process variable. The new set point will take effect immediately when you save the new value. The *Set point* parameter is not available if ratio control or cascade control is enabled for the loop.

Values: For thermocouples and RTD inputs, same as the input range (see Table 6.7). For process and pulse inputs, any value between the *Input range low* and *Input range high* parameters in the *Input* menu.
Default: 25
Decimal Placement for DeviceNet: See Decimal Placement for Numeric Values on page 59.
DeviceNet Object: Assembly (04 hex), Input (64 hex)

Mode



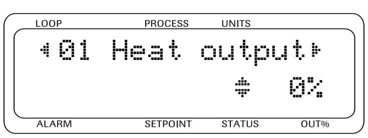
Choose the control mode for this loop.

Values: See Table 6.1
Default: off (3)
DeviceNet Object: Assembly (04 hex), Control (66 hex)

Table 6.1 Control Modes

Display Value	DeviceNet Value	Description
manual	0	The operator manually sets the output power for the loop.
auto	1	The controller automatically controls the outputs according to the controller configuration.
tune	2	The controller calculates PID parameters for the loop. After tuning, the controller switches to automatic mode.
Off	3	Outputs are at 0%

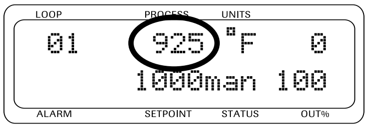
Heat/Cool Output



Choose the manual output power level for this loop. This parameter is available only for the manual control mode.

Values: 0 to 100% (0 to 1000). Values in parentheses are for communications.
Default: 0% (0)
Decimal Placement for DeviceNet: See Decimal Placement for Percentage Values on page 60.
DeviceNet Object: Assembly (04 hex), Output (65 hex)

Process Variable



Indicates the value measured by the sensor after filtering and scaling. This parameter is read-only.

Values: For thermocouples and RTD inputs, same as the input range (see Table 6.7 on page 131). For process and pulse inputs, any value between the *Input range low* and *Input range high* parameters in the *Input* menu.
Decimal Placement for DeviceNet: See Decimal Placement for Numeric Values on page 59.
DeviceNet Object: Assembly (04 hex), Input (64 hex)

Overview of the Setup Menus

The D8 has nine setup menus. Table 6.2 provides a brief description of each menu. Figure 6.2 lists all of the menus and parameters in the same order that they appear in the controller.

Table 6.2 D8 Setup Menus

Menu	Description	Page Number
Global setup	Configure global settings, which affect all loops.	125
Input	Configure the input for each loop.	131
Control	Configure PID control for each loop.	136
Output	Configure heat and cool outputs for each loop.	139
Alarms	Configure alarms for each loop.	143
PV retrans	Configure process variable retransmit.	148
Cascade	Configure cascade control.	149
Ratio	Configure ratio control.	150
I/O test	Perform tests of the digital inputs, digital outputs and keypad.	151

Navigation for the Setup Menus

⟲	Access the setup menus (press and hold for 3 seconds) Cancel a change without saving. Escape from a parameter to a menu. Escape from a menu to the loop display.
▲▼	Go to the next or previous menu. Edit a parameter value.
◀▶	Save a value and go to the next or previous parameter.
−LOOP+	Save a value and go to the next or previous loop.

Global setup
- Load setup from job
- Save setup as job
- BCD job load
- BCD job load logic
- Mode override
- Mode override D/I active
- Power up alarm delay
- Power up loop mode
- Keypad lock
- TC short alarm
- AC line freq
- D/O alarm polarity
- MAC ID
- Baud rate
- Module LED
- Network LED
- Bus off count
- WATLOW D8x Vx.xx cs=xxxx

Input
- Input type
- Loop name
- Input units
- Input pulse sample
- Calibration offset
- Reversed T/C detect
- Disp format
- Input range high
- Input high signal
- Input range low
- Input low signal
- Input filter

Control
- Heat prop band
- Heat integral
- Heat derivative
- Heat manual reset
- Heat filter
- Cool prop band
- Cool integral
- Cool derivative
- Cool manual reset
- Cool filter
- Hysteresis
- RestoreAuto

Output
- Heat output type
- Heat cycle time
- Heat SDAC signal
- Ht SDAC low signal
- Ht SDAC hi signal
- Heat action
- Heat power limit
- HtPwr limit time
- Sensor fail heat output
- Open T/C ht out average
- Heat output curve
- Cool output type
- Cool cycle time
- Cool SDAC signal
- Cl SDAC low signal
- Cl SDAC hi signal
- Cool action
- Cool power limit
- ClPwr limit time
- Sensor fail cool output
- Open T/C cl out average
- Cool output curve

Alarms
- Alarm high SP
- Alarm high func
- Alarm high output
- HiDeviation value
- HiDeviation func
- HiDeviation output
- LoDeviation value
- LoDeviation func
- LoDeviation output
- Alarm low SP
- Alarm low func
- Alarm low output
- Alarm hysteresis
- Alarm delay

PV retrans
- Heat output retrans PV
- Ht retrans LowPV
- Ht retrans HighPV
- Cool output retrans PV
- Cl retrans LowPV
- Cl retrans HighPV

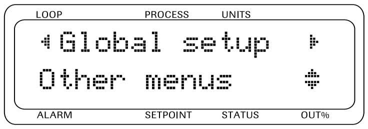
Cascade
- Cascade prim loop
- Cascade low SP
- Cascade hi SP

Ratio
- Ratio master loop
- Ratio low SP
- Ratio high SP
- Control ratio
- Ratio SP diff

I/O tests
- Digital inputs
- Keypad test
- Display test
- Test D/O 1
- ...
- Test D/O 20

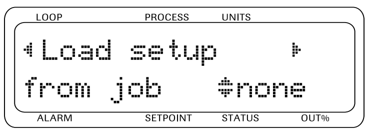
Figure 6.2 Setup Menus and Parameters

Global Setup Menu



Use the *Global setup* menu to set parameters that affect all loops.

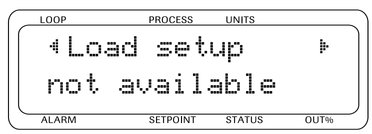
Load Setup From Job



Load one of the jobs stored in battery-backed RAM. The following parameters are loaded for each loop as part of a job:

- PID constants, filter settings, set points and hysteresis.
- Control mode (automatic or manual) and output power levels (if the loop is in manual control)
- Alarm functions, set points, hysteresis and delay settings.

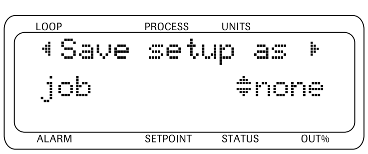
If you have enabled remote job selection (see BCD Job Load on page 126), you will see the message below, and you will not be able to use the controller keypad to load a job.



NOTE! ***Current settings are overwritten when you select a job from memory. Save your current settings to another job number if you want to keep them.***

Values: 1 to 8 (1 to 8) or *none* (0). Values in parentheses are for communications.
Default: *none* (0)
DeviceNet Object: Global (6B hex)

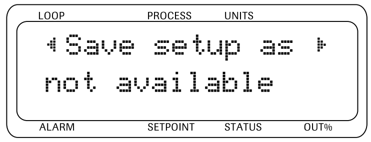
Save Setup As Job



Save the current settings as one of eight jobs in the battery-backed RAM. The following parameters are saved for each loop as part of a job:

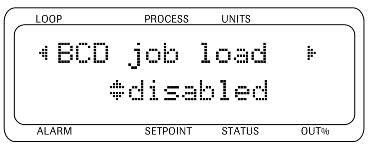
- PID constants, filter settings, set points and hysteresis.
- Control mode (automatic, tune, off or manual) and output power levels (if the loop is in manual control)
- Alarm functions, set points, hysteresis and delay settings.

If you have enabled remote job selection (see BCD Job Load on page 126), you will see the message below, and you will not be able to use the controller keypad to save a job.



Values: 1 to 8 (1 to 8) or *none* (0). Values in parentheses are for communications.
Default: *none* (0)
DeviceNet Object: Global (6B hex)

BCD Job Load



Choose the digital input(s) to use for remote job selection. The controller uses the states of the selected inputs as a binary code that specifies which job number to run (see Table 6.3).

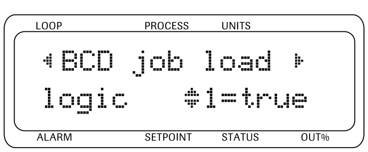
To save jobs into memory, use the *Save setup as job* parameter.

Values: See Table 6.3
Default: *disabled* (0)
DeviceNet Object: Global (6B hex)

Table 6.3 Values for BCD Job Load

Display Value	DeviceNet Value	Description
use D/I 1	1	Use digital input 1 for remote selection of jobs 1 and 2.
use D/I 1-2	2	Use digital inputs 1 and 2 for remote selection of jobs 1 to 4.
use D/I 1-3	3	Use digital inputs 1 to 3 for remote selection of jobs 1 to 8.
disabled	0	Disable remote job selection

BCD Job Load Logic



Choose which state is considered "true" for the digital inputs that are used for remote job selection.

- If *1=true* is selected, then an input is true if connected to controller common, and false for an open circuit.
- If *0=true* is selected, then an input is true for an open circuit, and false if connected to controller common.

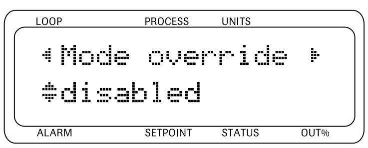
Table 6.4 shows which combinations of input states are required to load each job.

Values: *1=true* (0) or *0=true* (1). Values in parentheses are for communications.
Default: *1=true* (0)
DeviceNet Object: Global (6B hex)

Table 6.4 Digital Input States Required to Load Each Job

Job	Digital Input		
	1	**2**	**3**
1	F	F	F
2	T	F	F
3	F	T	F
4	T	T	F
5	F	F	T
6	T	F	T
7	F	T	T
8	T	T	T

Mode Override



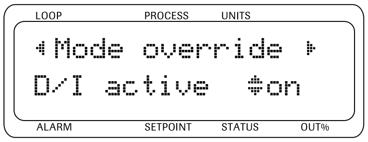
Choose the digital input to use for the mode override feature. When the input is activated, the controller sets all loops to manual mode at the output levels specified at the *Sensor fail heat output* and *Sensor fail cool output* parameters in the *Output* menu.

Use the *Mode override D/I active* parameter to choose which signal state activates the mode override feature.

Values: *enabled by D/I1* to *enabled by D/I8* (1 to 8) or *disabled* (0). Values in parentheses are for communications.
Default: *disabled* (0)
DeviceNet Object: Global (6B hex)

WARNING! ***Do not rely solely on the mode override feature to shut down your process. Install external safety devices or overtemperature devices for emergency shutdowns.***

Mode Override Digital Input Active

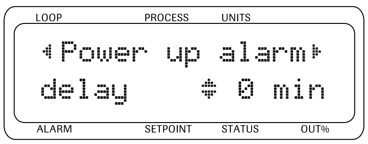


Choose whether the on state (connected to controller common) or off state (open circuit) activates the mode override feature.

Use the *Mode override* parameter to enable the mode override feature and select the digital input.

Values: *on* (0) or *off* (1). Values in parentheses are for communications.
Default: *on* (0)
DeviceNet Object: Global (6B hex)

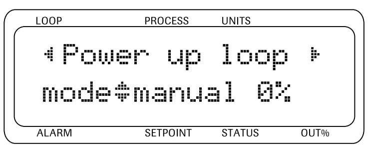
Power Up Alarm Delay



Specify how long to delay high, low and deviation alarms on all loops during powerup. This feature does not delay failed sensor alarms.

Values: 0 to 60 minutes
Default: 0
DeviceNet Object: Global (6B hex)

Power Up Loop Mode



Choose the power-up state of the control outputs.

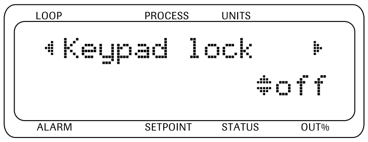
Values: See Table 6.5 on page 128.
Default: *off* (0)
DeviceNet Object: Global (6B hex)

WARNING! ***Do not set the controller to start from memory if it might be unsafe for the control outputs to be on upon power up.***

Table 6.5 Power Up Loop Modes

Display Value	DeviceNet Value	Description
off	0	Upon powerup, all loops are set to manual mode at 0 percent output.
from memory	1	Upon powerup, all loops are restored to the previous control mode and output power level.

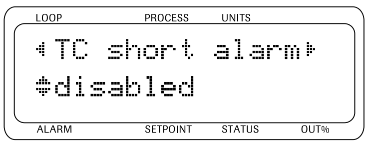
Keypad Lock



Set this parameter to *on* to disable the ▶ key on the keypad. This restricts access to the operator parameters from the controller keypad.

Values: *on* (1) or *off* (0). Values in parentheses are for communications, and are stored as the second bit of the system command word, so set or read only that bit.
Default: *off* (0)
DeviceNet Object: Global (6B hex)

Thermocouple Short Alarm

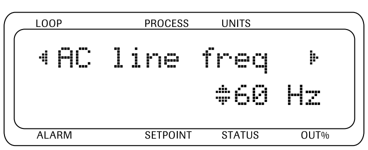


Choose a digital input to enable for thermocouple short detection. Install a device that connects the input to controller common when the process power is on. A thermocouple short is detected if the process power is on but the temperature does not rise as expected.

If a thermocouple short is detected, the controller puts the loop in manual mode at the output power level specified by the *Sensor fail heat output* or *Sensor fail cool output* parameter in the *Output* menu.

Values: *enabled by D/I1* to *enabled by D/I8* (1 to 8) or *disabled* (0). Values in parentheses are for communications.
Default: *disabled* (0)
DeviceNet Object: Global (6B hex)

AC Line Frequency

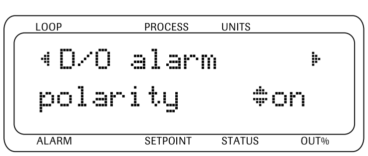


Specify the ac line frequency. The controller uses this information for correct timing of distributed zero-crossing (DZC) output signals and for optimum filtering of analog inputs.

If you edit this parameter, you must switch power to the controller off, then back on, in order for the change take effect.

Values: 50 (1) or 60 (0) Hz. Values in parentheses are for communications.
Default: 60 Hz (0)
DeviceNet Object: Global (6B hex)

Digital Output Alarm Polarity



Choose the polarity of all digital outputs used for alarms.

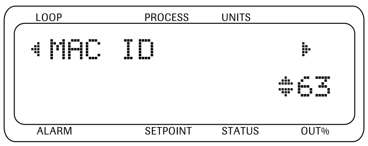
This setting does *not* apply to the global alarm output or the CPU watchdog output.

Values: See Table 6.6.
Default: *on* (0)
DeviceNet Object: Global (6B hex)

Table 6.6 Digital Output Alarm Polarity

Display Value	DeviceNet Value	Description
on	0	Digital alarm outputs sink current to analog common when an alarm occurs.
off	1	Digital alarm outputs stop sinking current to analog common when an alarm occurs.

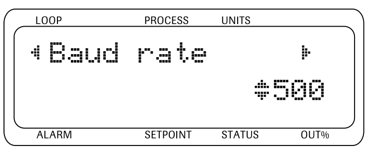
MAC ID



The node address for the controller. This value is set with the Address rotary switches. See Connecting the D8 to a DeviceNet Network on page 40.

Values: 00 to 63
DeviceNet Object: DeviceNet (03 hex)

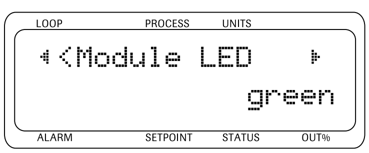
Baud Rate



Indicates the baud rate for communications. This value is set with the Data Rate rotary switch. See Connecting the D8 to a DeviceNet Network on page 40.

Values: 125, 250, 500K
DeviceNet Object: DeviceNet (03 hex)

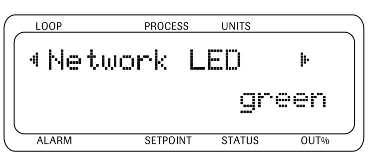
Module LED



Indicates the status of the Module LED

Values: off, green, red, flashing red, flashing green (see Module Status Indicator Light on page 44).
DeviceNet Object: N/A

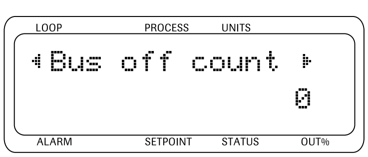
Network LED



Indicates the status of the Network LED

Values: off, flashing green, green, flashing red, red, (see Network Status Indicator Light on page 44).
DeviceNet Object: N/A

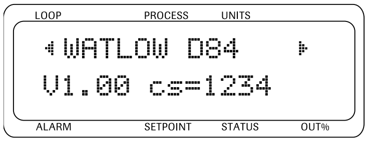
Bus Off Count



Indicates the number of times the controller has gone to the bus-off state.

Values: 0 (indicates the controller has not had a bus off error since the last power cycle) or 1 (indicates the controller has gone bus off since the last power cycle)
DeviceNet Object: DeviceNet (03 hex)

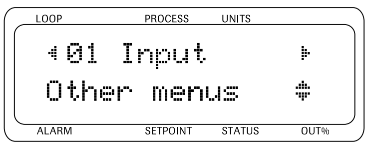
Model and Firmware Version



The last parameter in the *Global setup* menu shows the controller model (WATLOW D84 or WATLOW D88), the firmware version (Vxx.xx), and the flash-memory checksum (CS=xxxx).

DeviceNet Objects: Model: Identity (01 hex), Firmware Version: N/A, Checksum: N/A.

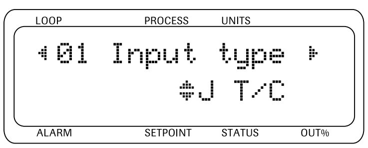
Input Menu



Use the *Input* menu to configure the process input:

- Input type
- Engineering units
- Scaling, calibration and filtering.

Input Type



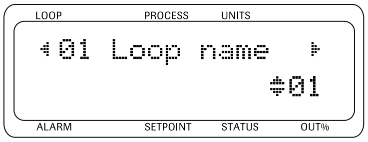
Choose the type of sensor that is connected to the analog input.

Values: See Table 6.7.
Default: *J thermocouple* (1)
DeviceNet Object: Input (64 hex)

Table 6.7 Input Types and Ranges

Display Value	DeviceNet Value	Description	Input Range
J t/c	1	Type J thermocouple	-350 to 1400°F (-212 to 760°C)
K t/c	2	Type K thermocouple	-450 to 2500° F (-268 to 1371°C)
T t/c	3	Type T thermocouple	-450 to 750°F (-268 to 399°C)
S v	4	Type S thermocouple	0 to 3200°F (-18 to 1760°C)
R t/c	5	Type R thermocouple	0 to 3210°F (-18 to 1766°C)
B t/c	6	Type B thermocouple	150 to 3200°F (66 to 1760°C)
E t/c	20	Type E thermocouple	-328 to 1448°F (-200 to 787°C)
RTD	8	RTD	-328.0 to 1150.0°F (-200.0 to 621.1°C)
process	0	Voltage or current signal, depending upon the hardware configuration. See Figure 1.2 on page 6.	User defined. See Setting Up Process Variable Retransmit on page 97.
skip	10	Loop is not used for control, does not report alarms, and is not shown on the scanning display.	(none)

Loop Name



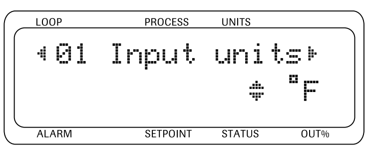
Enter a two-character name for the loop. This name is shown on the controller display in place of the loop number.

Values: See Table 6.8.
Default: The loop number (*01*, *02*, *03*, and so on.)
DeviceNet Object: Input (64 hex)

Table 6.8 Characters for the Loop Name and Input Units Parameters

Character	Display Values	ASCII Values
A to Z	A to Z	65 to 90
0 to 9	0 to 9	48 to 57
Degree symbol	°	223
Percent sign	%	37
Forward slash	/	47
Space	▪	32
Pound sign	#	35

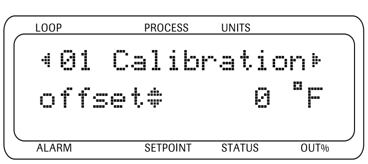
Input Units



For a thermocouple or RTD input, choose the temperature scale. For a process input, enter a three-character description of the engineering units.

Values: For a process input, see Table 6.8. For a thermocouple or RTD input, *˚F* or *˚C*. When setting the units for a thermocouple or RTD input through communications, you must set the first character as a space (32), the second character as the degree symbol (223) and the third character as "C" (67) or "F" (70).
Default: *˚C* for a thermocouple or RTD input, three spaces for a process input
DeviceNet Object: Input (64 hex)

Calibration Offset



For a thermocouple or RTD input, enter the offset to correct for signal inaccuracy. A positive value increases the reading and a negative value decreases it. Use an independent sensor or your own calibration equipment to find the offset for your system.

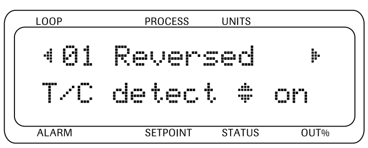
Values: See Table 6.9
Default: 0 or 0.0

Decimal Placement for DeviceNet: See Decimal Placement for Numeric Values on page 59.
DeviceNet Object: Input (64 hex)

Table 6.9 Calibration Offset Ranges

Type of Sensor	Offset Range	
	˚F	˚C
RTD	-300.0 to 300.0	-300.0 to 300.0
J Thermocouple K Thermocouple T Thermocouple	-300 to 300	-300 to 300
B Thermocouple S Thermocouple	-300 to 76	-300 to 300
R Thermocouple	-300 to 66	-300 to 300

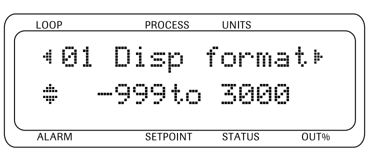
Reversed Thermocouple Detection



Choose whether to enable polarity checking for thermocouples. If the controller detects a reversed thermocouple, it activates an alarm and sets the loop to manual mode at the power level indicated by the *Sensor fail heat output* or *Sensor fail cool output* parameter in the *Output* menu.

Values: *on* (1) or *off* (0). Values in parentheses are for communications.
Default: *on* (1)
DeviceNet Object: Input (64 hex)

Display Format



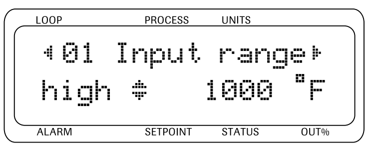
For a process input, choose the range and the number of decimal places for the process variable and related parameters. Choose a precision appropriate for the range and accuracy of the sensor.

Values: See Table 6.10 on page 134
Default: *-999 to 3000* for a process input.
DeviceNet Object: Input (64 hex)

Table 6.10 Display Formats

Display Value	DeviceNet Value	Minimum Process Variable	Maximum Process Variable
-999 to 3000	255	-999	3000
-9999 to 30000	0	-9999	30000
-999.9 to 3000.0	1	-999.9	3000.0
-99.99 to 300.00	2	-99.99	300.00
-9.999 to 30.000	3	-9.999	30.000
-.9999 to 3.0000	4	-0.9999	3.0000

Input Range High

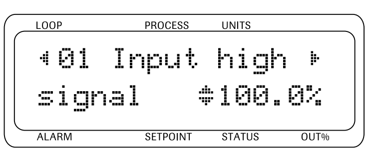


For a process input, enter the high process variable for input scaling purposes. This value will be displayed when the input signal is at the level set for *Input high signal*.

This parameter and the *Input high signal* parameter together define a point on the conversion line for the scaling function. See Setting Up a Process Input on page 88.

Values: Any value between *Input range low* and the maximum process variable for the selected display format (see Table 6.10).
Default: 1000. Decimal placement depends upon the value of the *Disp format* parameter.
Decimal Placement for DeviceNet: See Decimal Placement for Numeric Values on page 59.
DeviceNet Object: Input (64 hex)

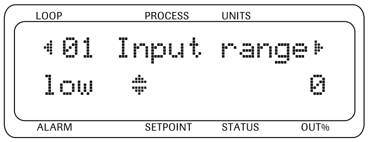
Input High Signal



For a process input, enter the input signal level that corresponds to the value for the *Input range high* parameter. The high signal is a percentage of the full scale input range.

Values: -99.8 to 999.9 (-998 to 9999) percent of full scale. This value must be greater than the value for *Input low signal*. Values in parentheses are for communications.
Default: 100.0% (1000)
Decimal Placement for DeviceNet: See Decimal Placement for Percentage Values on page 60.
DeviceNet Object: Input (64 hex)

Input Range Low

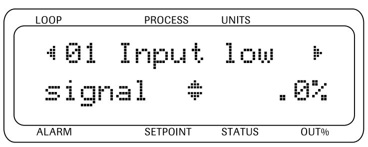


For a process input, enter the low process variable for input scaling purposes. This value will be displayed when the input signal is at the level set for *Input low signal*.

This value and the value for *Input low signal* together define one of the points on the scaling function's conversion line. See Setting Up a Process Input on page 88.

Values: Any value between the minimum process variable for the selected display format (see Table 6.10 on page 134) and the value for *Input range high*.
Default: 0
Decimal Placement for DeviceNet: See Decimal Placement for Numeric Values on page 59.
DeviceNet Object: Input (64 hex)

Input Low Signal

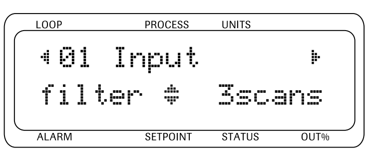


For a process input, enter the input signal level that corresponds to the low process variable you entered for the *Input range low* parameter. The low signal is a percentage of the full scale input range.

Values: -99.9 to 999.8 (-999 to 9998) percent of full scale. This value must be less than the value for *Input high signal*. Values in parenthesis are for communications.
Default: 0
Decimal Placement for DeviceNet : See Decimal Placement for Percentage Values on page 60.

DeviceNet Object: Input (64 hex)

Input Filter

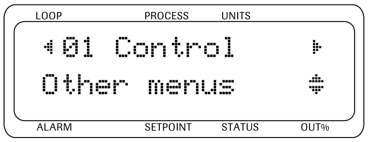


Choose the amount of filtering to apply to the process variable before the value is logged, displayed or used in the control calculation. The input filter simulates a resistor-capacitor (RC) filter. Use it to keep the process variable from varying unrealistically.

When enabled, the process variable responds to a step change by going to two-thirds of the actual value within the specified number of scans. One scan is 0.17 seconds for a four-loop controller and 0.33 seconds for a eight-loop controller.

Values: 0 (off) to 255
Default: 3
DeviceNet Object: Input (64 hex)

Control Menu



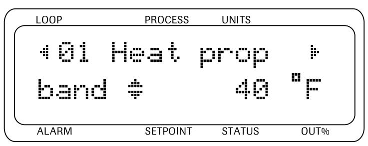
Use the *Control* menu to adjust heat and cool control parameters, including:

- Proportional band, integral and derivative
- Output filter
- Control hysteresis

The controller has separate PID and filter settings for heat and cool outputs. In this section, only the heat screens are shown, but the explanations apply to both the heat and cool parameters.

If you have not set up a Series D8 controller before, or if you do not know which values to enter, read the Tuning and Control chapter, which contains PID tuning constants and useful starting values.

Heat/Cool Proportional Band



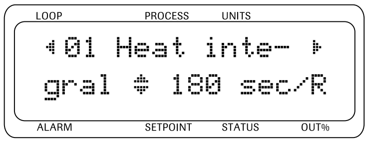
Enter the proportional band. A larger value yields less proportional action for a given deviation from set point.

Values: For a thermocouple or RTD input, see Table 6.11. For a process input, 1 to the span of the input range (*Input range high* - *Input range low*).
Default: 50 for a thermocouple, RTD or process input.
Decimal Placement for DeviceNet: See Decimal Placement for Numeric Values on page 59.
DeviceNet Object: Control (66 hex)

Table 6.11 Proportional Band Values

Type of Sensor	Values in ˚F	Values in ˚C
J Thermocouple	1 to 1750	1 to 972
K Thermocouple	1 to 2950	1 to 1639
T Thermocouple	1 to 1200	1 to 667
S Thermocouple	1 to 3200	1 to 1778
R Thermocouple	1 to 3210	1 to 1784
B Thermocouple	1 to 3350	1 to 1694
E Thermocouple	1 to 1776	1 to 987
RTD	0.1 to 1478.0	0.1 to 821.1

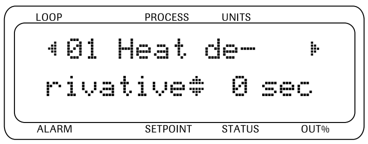
Heat/Cool Integral



Enter the integral constant. A larger value yields less integral action.

Values: 0 (off) to 6000 seconds per repeat
Default: For the *Heat integral* parameter, 180. For the *Cool integral* parameter, 60.
DeviceNet Object: Control (66 hex)

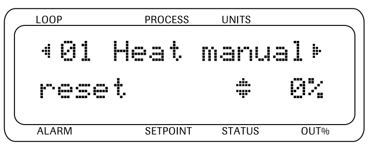
Heat/Cool Derivative



Enter the derivative constant. A larger value yields greater derivative action.

Values: 0 to 255 seconds
Default: 0
DeviceNet Object: Control (66 hex)

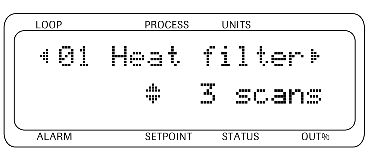
Heat/Cool Manual Reset



A process that uses only proportional control settles at a point above or below the set point; it never reaches the set point. This is known as *offset* or *droop*. At this parameter, enter the power level required to maintain set point to compensate for this offset.

Values: 0 to 100% (0 to 1000). Values in parentheses are for communications.
Default: 0% (0)
Decimal Placement for DeviceNet: See Decimal Placement for Percentage Values on page 60.
DeviceNet Object: Control (66 hex)

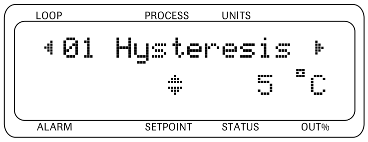
Heat/Cool Filter



Use this parameter to dampen the response of the heat or cool output. The output responds to a change by going to approximately two-thirds of its final value within the specified number of scans. A larger value results in a slower response to changes in the process variable.

Values: 0 (off) to 255
Default: 3
DeviceNet Object: Control (66 hex)

Hysteresis



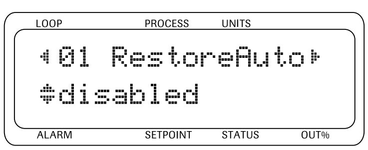
Specify how much the process variable must deviate from set point before the output can switch between on and off (for on/off control) or switch between heating and cooling (for heat/cool control).

Values: See Table 6.12 for values and decimal placement. For communications the value is always 0 to 5000, see Table 6.12 for implied decimal location.
Default: See Table 6.12
DeviceNet Object: Control (66 hex)

Table 6.12 Values for the Control Hysteresis and Deviation Alarm Parameters

Input Type	Display Format	Values	Default
Thermocouple	n/a	0 to 500	5
RTD	n/a	0 to 500.0	5.0
Process	-999 to 3000	0 to 500	5
	-9999 to 30000	0 to 5000	50
	-999.9 to 3000.0	0.0 to 500.0	5.0
	-99.99 to 300.00	0.00 to 50.00	0.50
	-9.999 to 30.000	0.000 to 5.000	0.050
	-0.9999 to 3.0000	0.0000 to 0.5000	0.0050

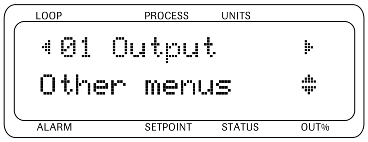
Restore Automatic Mode



Choose a digital input. If the input is connected to controller common, the loop returns to automatic control mode after a failed sensor is repaired (if it was in automatic mode when the sensor failure occurred).

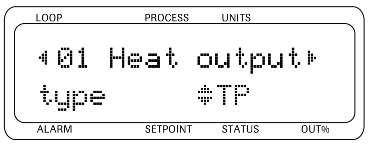
Values: *enabled by D/I1* to *enabled by D/I8* (1 to 8) or *disabled* (0). Values in parentheses are for communications.
Default: *disabled* (0)
DeviceNet Object: Control (66 hex)

Output Menu



Use the *Output* menu to enable and configure heat and cool outputs.

Heat/Cool Output Type



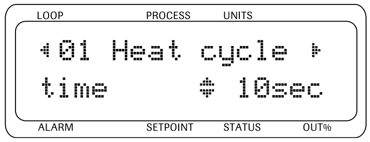
Choose the output type, or disable the heat or cool output. For more information about each output type, see the Tuning and Control chapter. (If an output is used for process variable retransmit, the *disabled* option is not available. To disable the output, first disable process variable retransmit for the output. See Heat/Cool Output Retransmit on page 148.)

Values: See Table 6.13
Default: *TP* (2) for heat, *disabled* (0) for cool
DeviceNet Object: Output (65 hex)

Table 6.13 Heat and Cool Output Types

Output Type	Display Value	DeviceNet Value	Description
Time Proportioning	TP	2	The output is switched on and off once during a user-selected cycle time. Within each cycle, the duration of on versus off time is proportional to the percent output power.
On/Off	on/off	1	The output is either full on or full off.
None	disabled	0	The output is not used for control and is available for another use, such as an alarm output.
Three-Phase Distributed Zero Crossing	3P DZC	5	Same as *DZC*, but for three-phase heaters wired in delta configuration. For grounded Y configuration, use DZC instead.
Serial DAC	SDAC	4	Use this option if a Serial DAC is connected to the output. If you set the output type to *SDAC*, the controller assigns digital output 34 as a clock line for the Serial DAC.
Distributed Zero Crossing	DZC	3	The output on/off state is calculated for every ac line cycle, which means that the output turns on and off multiple times per second. Use *DZC* with solid state output devices or a Dual DAC. Not recommended for use with electromechanical relays.

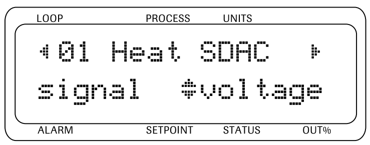
Heat/Cool Cycle Time



For a time-proportioning output, enter the cycle time in seconds. For more information about cycle time, see Time Proportioning (TP) on page 118.

Values: 1 to 255 seconds
Default: 10
DeviceNet Object: Output (65 hex)

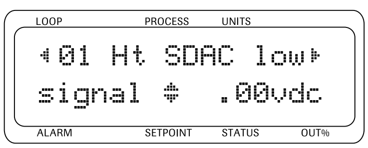
Heat/Cool SDAC Signal



For a Serial DAC output, choose the type of output signal that the Serial DAC will provide.

Values: *voltage* (0) or *current* (1). Values in parentheses are for communications.
Default: *voltage* (0)
DeviceNet Object: Output (65 hex)

Heat/Cool SDAC Low Signal

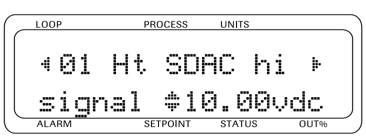


For a Serial DAC output, enter the low output signal level for the Serial DAC. The Serial DAC converts 0 percent output from the controller to this value.

Enter high and low values that match the input range of the output device. For instance, if the output device has a 0 to 10 Vdc input range, then set *SDAC low signal* to *.00 Vdc* and set *SDAC hi signal* to *10.00 Vdc*.

Values: .00 to 9.90 Vdc (0 to 990) or 0.00 to 19.90 mA (0 to 1990). This value must be less than the value of *SDAC hi signal*. Values in parentheses are for communications.
Default: .00 Vdc (0) or 4.00 mA (400)
DeviceNet Object: Output (65 hex)

Heat/Cool SDAC High Signal

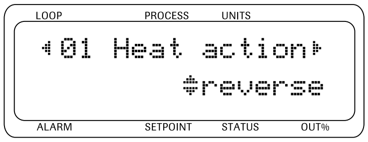


For a Serial DAC output, enter the high output signal level for the Serial DAC. The Serial DAC converts 100 percent output from the controller to the value set here.

Enter the high and low values that match the input range of the output device. For instance, if the output device has a 4 to 20 mA input range, then set *SDAC hi signal* to *20 mA* and set *SDAC low signal* to *4 mA*.

Values: 0.10 to 10.00 Vdc (10 to 1000) or 0.10 to 20.00 mA (10 to 2000) This value must be greater than the value of *SDAC low signal*. Values in parentheses are for communications.
Default: 10.00 Vdc (1000) or 20.00 mA (2000)
DeviceNet Object: Output (65 hex)

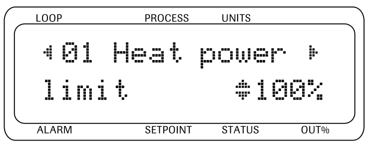
Heat/Cool Action



Choose the control action for the output. When the action is set to *reverse*, the output goes up when the process variable goes down. When the action is set to *direct*, the output goes down when the process variable goes down. Normally, heat outputs are set to reverse action and cool outputs are set to direct action.

Values: *reverse* (0) or *direct* (1). Values in parentheses are for communications.
Default: *reverse* (0) for heat outputs, *direct* (1) for cool outputs
DeviceNet Object: Output (65 hex)

Heat/Cool Power Limit

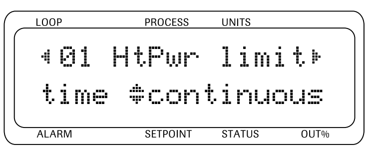


Use this parameter to limit the output power for a heat or cool output. This limit may be continuous, or it may be in effect for the number of minutes specified at the next parameter.

The power limit only affects loops in automatic mode. It does not affect loops in manual mode.

Values: 0 to 100% (0 to 1000). Values in parentheses are for communications.
Default: 100% (1000)
Decimal Placement for DeviceNet: See Decimal Placement for Percentage Values on page 60.
DeviceNet Object: Output (65 hex)

Heat/Cool Power Limit Time

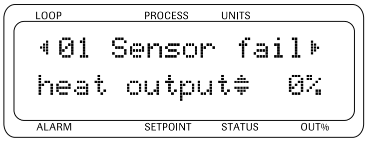


Enter the duration of the power limit set at the previous parameter, or choose *continuous* to keep the limit in effect at all times.

If you choose a timed limit, the limit timer restarts whenever the controller powers up and whenever the loop switches from manual to automatic mode.

Values: 1 to 999 minutes (1 to 999) or *continuous* (0). Values in parentheses are for communications.
Default: *continuous* (0)
DeviceNet Object: Output (65 hex)

Sensor Fail Heat/Cool Output



A loop will switch to manual mode at the specified output power if one of the following conditions occurs while in automatic mode:

- A failed sensor alarm occurs, or
- The mode override input becomes active (see Mode Override on page 127).
- DeviceNet connection becomes inactive unexpectedly.

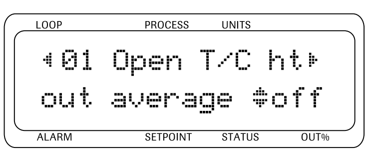
For most applications, this parameter should be set to 0% for both heat and cool outputs.

Values: 0 to 100% (0 to 1000). Values in parentheses are for communications.
Default: 0% (0)
Decimal Placement for DeviceNet: See Decimal Placement for Percentage Values on page 60.

DeviceNet Object: Output (65 hex)

WARNING! ***Do not rely solely on the failed sensor alarm to adjust the output in the event of a sensor failure. If the loop is in manual mode when a failed sensor alarm occurs, the output is not adjusted. Install independent external safety devices to shut down the system if a failure occurs.***

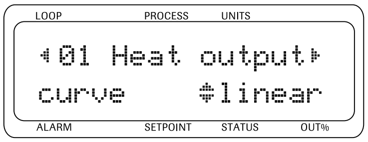
Open Thermocouple Heat/Cool Output Average



If you set this parameter to *on* and a thermocouple open alarm occurs, a loop set to automatic control mode will switch to manual mode at the average output prior to the alarm.

Values: *on* (1) or *off* (0). Values in parentheses are for communications.
DeviceNet Object: Output (65 hex)

Heat/Cool Output Curve



Choose an output curve. If curve 1 or 2 is selected, a PID calculation results in a lower actual output level than the linear output requires. Use curve 1 or 2 if the system has a nonlinear response to the output device.

Values: *linear* (0), curve *1* (1) or curve *2* (2). Values in parentheses are for communications.
Default: *linear* (0)
DeviceNet Object: Output (65 hex)

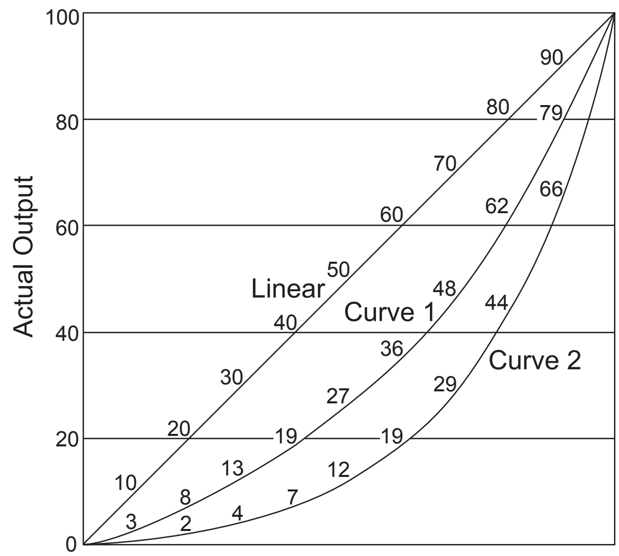
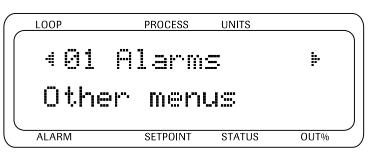


Figure 6.3 Linear and Nonlinear Outputs

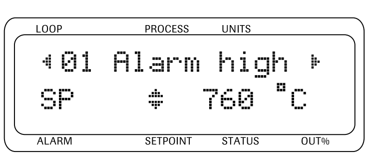
Alarms Menu



Use the *Alarms* menu to configure high alarms, low alarms, and deviation alarms, including:

- Alarm set points
- Alarm outputs
- Alarm behavior
- Alarm hysteresis
- Alarm delay

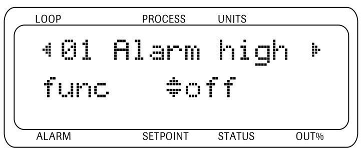
Alarm High Set Point



Enter the set point at which the high alarm activates. The high alarm activates if the process variable rises above this value. For more information about the high alarm, see Alarm High and Alarm Low on page 96.

Values: For a thermocouple or RTD input, any value within the input range (see Table 6.7). For a process or pulse input, any value between the *Input range low* and *Input range high* parameters.
Default: 760. Decimal placement depends upon the *Input type* and *Disp format* settings.
Decimal Placement for DeviceNet: See Decimal Placement for Numeric Values on page 59.
DeviceNet Object: Alarm (67 hex)

Alarm High Function



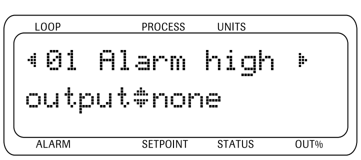
Choose whether the high alarm functions as an alarm or as a boost output, or disable the alarm.

Values: See Table 6.14 on page 144.
Default: *off*
DeviceNet Object: See Alarm Acknowledge on page 153 and Alarm Function on page 154.

Table 6.14 Alarm Functions

Value	Description
off	No alarm function.
standard	Alarm is indicated and logged. Latching global alarm is activated. Alarm must be acknowledged to clear. Optional non-latching alarm output is activated.
boost	Alarm message on controller display only. Alarm does not require acknowledgement. Non-latching alarm output is activated. Use the alarm set points to control this output for boost control.

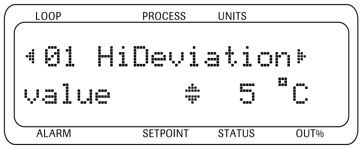
Alarm High Output



Choose a digital output to activate when the high alarm occurs. You cannot choose an output that is in use for closed-loop control or for the Serial DAC clock.

Values: *none* (0) or output 1 to 18 (1 to 18). Values in parentheses are for communications.
Default: *none* (0)
DeviceNet Object: Alarm (67 hex)

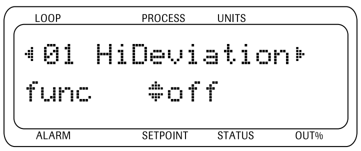
High Deviation Value



Enter the amount by which the process variable must rise above the set point for the high deviation alarm to occur. For more information, see Deviation Alarms on page 96.

Values: See Table 6.12 on page 138 for values and decimal placement.
Default: See Table 6.12 .
DeviceNet Object: Alarm (67 hex)

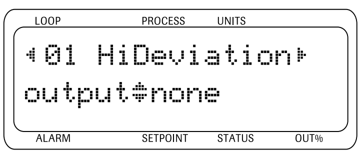
High Deviation Function



Choose whether the alarm functions as an alarm or as a boost output, or disable the alarm.

Values: See Table 6.14 on page 144.
Default: *off*
DeviceNet Object: See Alarm Enable on page 153 and Alarm Function on page 154.

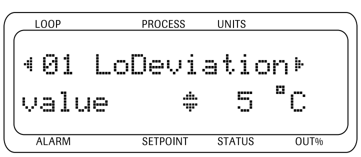
High Deviation Output



Choose a digital output to activate when the high deviation alarm occurs. You cannot choose an output that is in use for closed-loop control or for the Serial DAC clock.

Values: *none* (0) or output 1 to 18 (1 to 18). Values in parentheses are for communications.
Default: *none* (0)
DeviceNet Object: Alarm (67 hex)

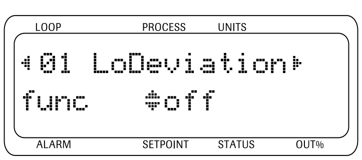
Low Deviation Value



Enter the amount by which the process variable must fall below the set point for the low deviation alarm to occur. For more information, see Process Alarms on page 95.

Values: See Table 6.12 on page 138 for values and decimal placement.
Default: Table 6.12
DeviceNet Object: Alarm (67 hex)

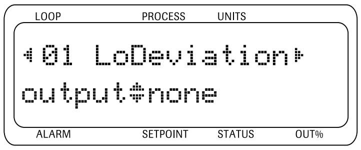
Low Deviation Function



Choose whether the alarm functions as an alarm or as a boost output, or disable the alarm.

Values: See Table 6.14 on page 144.
Default: *off*
DeviceNet Object: See Alarm Enable on page 153 and Alarm Function on page 154.

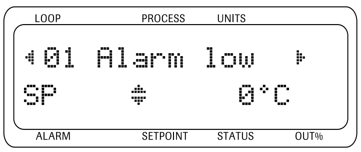
Low Deviation Output



Choose a digital output to activate when the low deviation alarm occurs. You cannot choose an output that is in use for closed-loop control or for the Serial DAC clock.

Values: *none* (0) or output 1 to 18 (1 to 18). Values in parentheses are for communications.
Default: *none* (0)
DeviceNet Object: Alarm (67 hex)

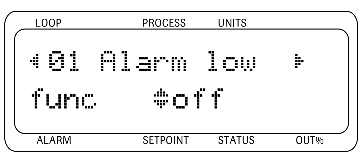
Alarm Low Set Point



Enter the set point at which the low alarm activates. The low alarm activates if the process variable drops below this value. For more information, see Process Alarms on page 95.

Values: For a thermocouple or RTD input, any value within the input range (see Table 6.7 on page 131). For a process or pulse input, any value between the *Input range low* and *Input range high* parameters.
Default: 0
Decimal Placement for DeviceNet: See Decimal Placement for Numeric Values on page 59.
DeviceNet Object: Alarm (67 hex)

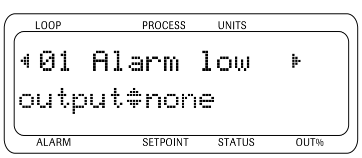
Alarm Low Function



Choose whether the alarm functions as an alarm or as a boost output, or disable the alarm.

Values: See Table 6.14 .
Default: *off*
DeviceNet Object: See Alarm Acknowledge on page 153 and Alarm Function on page 154.

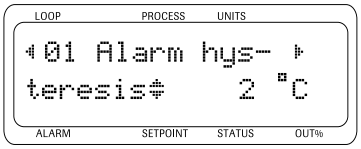
Alarm Low Output



Choose a digital output to activate when the low alarm occurs. You cannot choose an output that is in use for closed-loop control or for the Serial DAC clock.

Values: *none* (0) or output 1 to 18 (1 to 18). Values in parentheses are for communications.
Default: *none* (0)
DeviceNet Object: Alarm (67 hex)

Alarm Hysteresis



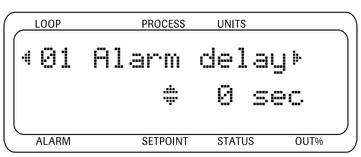
Enter the amount by which the process variable must return within the alarm limit before a high alarm, low alarm or deviation alarm clears. Use the alarm hysteresis to prevent repeated alarms as the process variable cycles around an alarm limit.

Values: See Table 6.15 on page 147 for values and decimal placement. For communications the value is always 0 to 5000.
Default: See Table 6.15.
DeviceNet Object: Alarm (67 hex)

Table 6.15 Values for Alarm Hysteresis

Input Type	Display Format	Values	Values via Communications	Default
Thermocouple	n/a	0 to 500	0 to 5000	2
RTD	n/a	0 to 500.0	0 to 5000	2.0
Process	-999 to 3000	0 to 500	0 to 5000	2
	-9999 to 30000	0 to 5000	0 to 5000	20
	-999.9 to 3000.0	0.0 to 500.0	0 to 5000	2.0
	-99.99 to 300.00	0.00 to 50.00	0 to 5000	0.20
	-9.999 to 30.000	0.000 to 5.000	0 to 5000	0.020
	-0.9999 to 3.0000	0.0000 to 0.5000	0 to 5000	0.0020

Alarm Delay

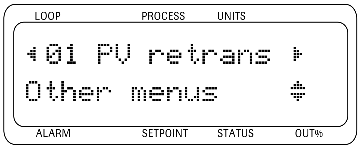


Use this parameter to delay a failed sensor or process alarm until the alarm condition has been continuously present for longer than the delay time.

To delay alarms on powerup only, see Power Up Alarm Delay on page 128.

Values: 0 to 255 seconds.
Default: 0
DeviceNet Object: Alarm (67 hex)

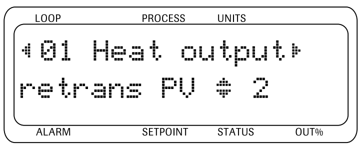
Process Variable Retransmit Menu



Use the *PV retrans* menu to configure an output so that it will retransmit the process variable from another loop. For details, see Setting Up Process Variable Retransmit on page 97.

This menu contains parameters for both heat and cool outputs. The sample screens in this section show the heat parameters, but the descriptions apply to both the heat and cool parameters.

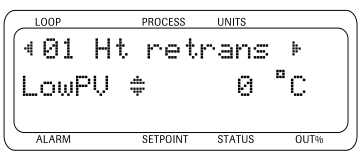
Heat/Cool Output Retransmit



Choose the loop that provides the process variable to be retransmitted. For example, in the sample display at left, the heat output from loop 1 (01) will retransmit the process variable from loop 2.

Values: *none* (0), or loop 1 to 4 (1 to 4) for a four-loop controller or loop 1 to 8 (1 to 8) for an eight-loop controller. Values in parentheses are for communications.
Default: *none* (0)
DeviceNet Object: Retransmit (68 hex)

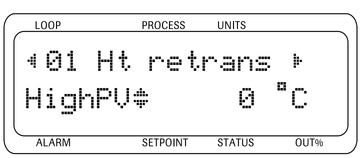
Heat/Cool Retransmit Low Process Variable



Enter the value of the process variable to retransmit as a 0 percent output signal. If the process variable falls below this value, the output will stay at 0 percent.

Values: Any value within the input sensor range; see Table 6.7 .
Default: The minimum value in the input sensor range
Decimal Placement for DeviceNet: See Decimal Placement for Numeric Values on page 59.
DeviceNet Object: Retransmit (68 hex)

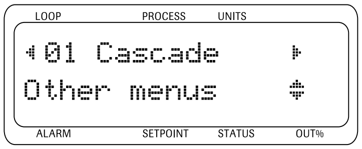
Heat/Cool Retransmit High Process Variable



Enter the value of the process variable to retransmit as a 100 percent output signal. If the process variable rises above this value, the output will stay at 100 percent.

Values: Any value within the input sensor range; see Table 6.7 .
Default: The maximum value in the input sensor range
Decimal Placement for DeviceNet: See Decimal Placement for Numeric Values on page 59.
DeviceNet Object: Retransmit (68 hex).

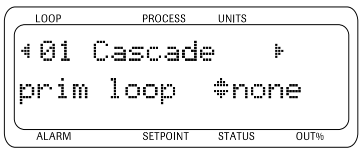
Cascade Menu



Use the cascade menu to configure cascade control. Use cascade control to calculate the set point of the current loop (the secondary, or outer, loop) based upon the output of another loop (the primary, or inner, loop).

For more information about cascade control, see Setting Up Cascade Control on page 100.

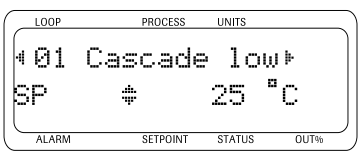
Cascade Primary Loop



Choose the primary loop. The controller uses the output of the primary loop to calculate the set point of the current loop.

Values: *none* (0), or loop 1 to 4 (1 to 4) for a four loop-controller or 1 to 8 (1 to 8) for an eight-loop controller. You cannot choose the current loop. Values in parentheses are for communications.
Default: *none* (0)
DeviceNet Object: Cascade (6A hex)

Cascade Low Set Point

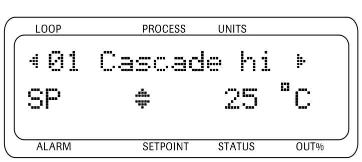


Enter the set point to use for the current loop when the output of the primary loop is at its minimum value. The set point will never drop below this value.

- If the primary loop has only the heat output enabled, then this value is the set point when the heat output of the primary loop is 0 percent.
- If the primary loop has only the cool output enabled or has the heat and cool outputs enabled, then this value is the set point when the cool output is 100 percent.

Values: For a thermocouple or RTD input, any value within the input range (see Table6.7). For a process input, any value between the *Input range low* and *Input range high* parameters. This value must be less than the *Cascade hi SP* parameter.
Default: 25 for a thermocouple, RTD or process input.
Decimal Placement for DeviceNet: See Decimal Placement for Numeric Values on page 59.
DeviceNet Object: Cascade (6A hex)

Cascade High Set Point

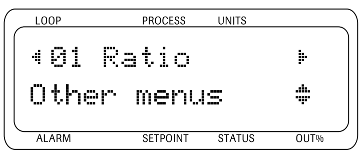


Enter the set point to use for the current loop when the output of primary loop is at its maximum value. The set point will never exceed this value.

- If the primary loop has only the heat output enabled, or has the heat and cool outputs enabled, this value is the set point when the output of the primary loop is 100 percent.
- If the primary loop has only the cool output enabled, then this value is the set point when the output of the primary loop is 0 percent.

Values: For a thermocouple or RTD input, any value within the input range (see Table 6.7 on page 131). For a process input, any value between the *Input range low* and *Input range high* parameters. This value must be greater than the*Cascade low SP* parameter.
Default: 25 for a thermocouple, RTD or process input.
Decimal Placement for DeviceNet: See Decimal Placement for Numeric Values on page 59.
DeviceNet Object: Cascade (6A hex)

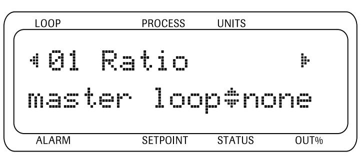
Ratio Menu



Use the ratio menu to configure ratio control, differential control or remote analog set point. Use these control methods to calculate the set point of the current loop (the ratio loop) based upon the process variable of another loop (the master loop).

For more information about ratio control, see Setting Up Ratio Control on page 104, Setting Up Differential Control on page 106 and Setting Up Remote Analog Set Point on page 107.

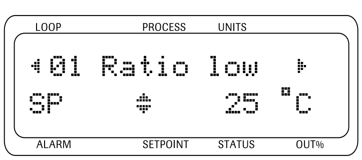
Ratio Master Loop



Choose the master loop. The controller uses the process variable of the master loop to calculate the set point of the current loop.

Values: *none* (0), or loop 1 to 4 (1 to 4) for a four-loop controller or 1 to 8 (1 to 8) for an eight-loop controller. You cannot choose the current loop.
Default: *none* (0)
DeviceNet Object: Ratio (69 hex)

Ratio Low Set Point

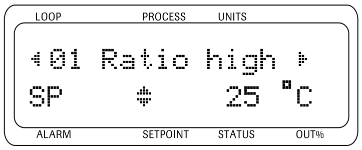


Enter the lowest allowable set point for the current loop. The set point will never drop below this value, regardless of the result of the ratio calculation.

Values: For a thermocouple or RTD input, any value within the input range (see Table 6.7). For a process, any value between the *Input range low* and *Input range high* parameters. This value must be less than the *Ratio high SP* parameter.
Default: 25

Decimal Placement for DeviceNet: See Decimal Placement for Numeric Values on page 59.
DeviceNet Object: Ratio (69 hex)

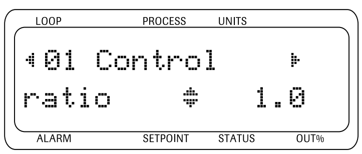
Ratio High Set Point



Enter the highest allowable set point for the current loop. The set point will never exceed this value, regardless of the result of the ratio calculation.

Values: For a thermocouple or RTD input, any value in the input sensor range; see Table 6.7 on page 131. For a process input, any value from *Input range low* to *Input range high*. This value must be greater than the *Ratio low SP* parameter.
Default: 25
Decimal Placement for DeviceNet: See Decimal Placement for Numeric Values on page 59.
DeviceNet Object: Ratio (69 hex)

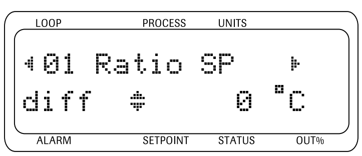
Control Ratio



Enter the factor by which to multiply the process variable of the master loop to calculate the set point of the ratio loop.

Values: .1 to 999.9 (1 to 9999). Values in parentheses are for communications (values are in tenths).
Default: 1.0 (10) for a thermocouple, RTD or process input.
DeviceNet Object: Ratio (69 hex)

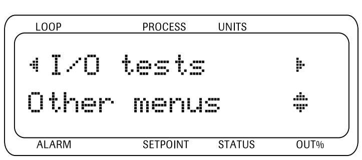
Ratio Set Point Differential



Enter the value to add to the ratio calculation before using it as the set point.

Values: -9999 to 9999. Decimal placement depends upon the *Input type* and *Disp format* values in the *Input* menu.
Default: 0
Decimal Placement for DeviceNet: See Decimal Placement for Numeric Values on page 59.
DeviceNet Object: Ratio (69 hex)

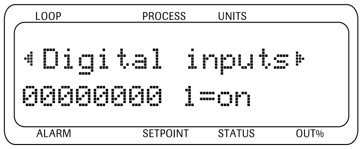
I/O Tests Menu



Use the *I/O tests* menu to test the following:

- Digital inputs
- Digital outputs
- Keypad

Digital Inputs



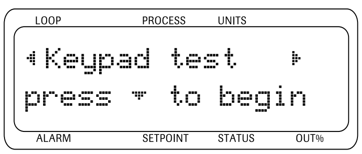
This parameter indicates the states of the eight digital inputs. A *1* indicates that the input is connected to controller common (on). A *0* indicates an open circuit (off).

To test an input, short it to controller common. When the input is shorted, its input state should be *1*. For detailed instructions, see Digital Input Test on page 27.

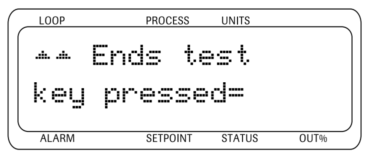
The controller display shows the states of digital inputs 1 to 8 from left to right.

Values: 0 if the input is off, 1 if the input is on
DeviceNet Object: Global (6B hex)

Keypad Test



To test the keypad, press ▼. This screen will appear:

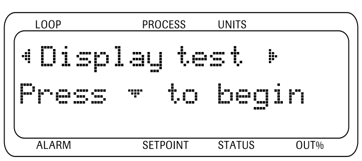


To test a key, press it. If the key is working properly, an icon for that key appears.

When you are done testing the keypad, press ▲▲ to return to the *Keypad test* parameter.

DeviceNet Object: None

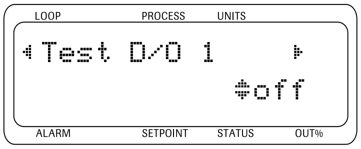
Display Test



Displays two screens with alternate pixels lit. Press ▼ to enter test, press ▲ or ▼ to switch pattern. Press ↵ to end the test.

DeviceNet Object: None

Test Digital Output 1 to 20



Use the *Test D/O* parameter to manually toggle a digital output on and off. Choose *on* to sink the current from the output to the controller common. Choose*off* to stop the current flow. For instructions, see Digital Output Test on page 26. You cannot toggle an output that is enabled for control.

Values: *off* (0) or *on* (1)
Default: *off* (0)
DeviceNet Object: Global (6B hex)

NOTE! ***When you exit the* I/O tests *menu, all outputs that were forced on are turned off.***

Parameters Only Available via Communications

These parameters are available only via communications. They are not accessible through the controller keypad.

Alarm Acknowledge

Indicates whether an alarm has been acknowledged. To acknowledge an alarm, clear the bit for that alarm. Table 6.17 on page 155 shows which bit corresponds to each alarm.

This parameter is available only via communications.

Values: Unacknowledged (1) or acknowledged (0)
DeviceNet Object: Alarm (67 hex)

Alarm Enable

Enable or disable an alarm. Table 6.16 on page 154 shows the bit to set or read for each alarm. This parameter is available only via communications.

Values: Disabled (0) or enabled (1)
Default: Disabled (0)
DeviceNet Object: Alarm (67 hex)

Table 6.16 Bit Positions for Alarm Enable and Alarm Function

Alarm	Bit
Low Deviation Alarm	Third
High Deviation Alarm	Fourth
Alarm Low	Fifth
Alarm High	Sixth

NOTE! ***All other bits, 1, 2, and 7 to 16 are always 0. You must transmit a complete 2-byte word to set any alarm parameter for a channel. You may want to read the alarm settings before constructing the word to set an alarm parameter.***

NOTE! ***The least significant bit is considered the first bit and the most significant is considered the sixteenth bit. See Bit-Wise Values on page 59.***

Alarm Function

Choose whether an alarm behaves as a standard alarm or as a boost output. For descriptions of the standard and boost functions, see Table 6.14 on page 144. Table 6.16 on page 154 shows the bit to read for each alarm.

This parameter is available only via communications.

Values: Standard alarm (0) or boost output (1)
Default: Standard alarm (0)
DeviceNet Object: Alarm (67 hex)

Alarm Status

Indicates whether an alarm is active. Table6.17 shows the bit to read for each alarm. This parameter is available only via communications.

Values: Not active (0) or active (1)
DeviceNet Object: Alarm (67 hex)

Table 6.17 Bit Positions for Alarm Status and Alarm Acknowledge

Alarm	Bit
Low Deviation Alarm	Third
High Deviation Alarm	Fourth
Alarm Low	Fifth
Alarm High	Sixth
Thermocouple Reversed	Seventh
Thermocouple Shorted	Eighth
Thermocouple Open	Ninth
RTD Open	Tenth
RTD Fail	Eleventh

Ambient Sensor Reading

This read-only parameter indicates the temperature measured by the cold-junction compensation sensor located near the analog input terminal block.

This parameter is available only for communications programs.

Values: Temperature in tenths of a degree Fahrenheit. To convert to Celsius, use the formula °C = 5/9 (°F - 32).
DeviceNet Object: Global (6 hex)

Table 6.18 System Status Bits

Parameter	Description	Values	DeviceNet Object
Battery Status	Indicates whether the values in RAM have been corrupted while the power has been off.	0: No corruption detected 1: Data corrupted	Global (6)
Hardware Ambient Status	Indicates whether the ambient temperature is within the controller's operating range. If the ambient is out of range, the controller sets all loops to manual mode at 0 percent power.	0: Within range 1: Outside of range	Global (6)
Hardware Offset Status	Indicates whether the zero self-calibration measurement falls within acceptable limits.	0: In calibration 1: Out of calibration	Global (6)
Hardware Gain Status	Indicates whether the full scale self-calibration measurement falls within acceptable limits.	0: In calibration 1: Out of calibration	Global (6)

Heat/Cool Output Action for Watchdog Inactivity Fault

Action on heat and cool outputs when a DeviceNet Watchdog Inactivity Timeout is detected.

Values: See Table 6.19 on page 156
Default: 0
DeviceNet Object: Output (65 hex)

Table 6.19 DeviceNet Value for Watchdog Inactivity Fault

DeviceNet Value	Description
0	If not in Manual Mode will then put in Manual Mode, with output set to value in Sensor Fail Heat and Cool Output.
1	Do Nothing (continue operating output).

7

Troubleshooting and Reconfiguring

This chapter explains how to troubleshoot and reconfigure the controller.

When There is a Problem

The controller is only one part of your control system. Often, what appears to be a problem with the controller is really a problem with other equipment, so check these things first:

- The controller is installed correctly. (See the Installation chapter.)
- Sensors, such as thermocouples and RTDs, are installed correctly and working.

NOTE! ***If you suspect your controller has been damaged, do not attempt to repair it yourself, or you may void the warranty.***

If the troubleshooting procedures in this chapter do not solve your system's problems, call Watlow technical support (see page 1). If you need to return the unit to Watlow Anafaze for testing and repair, Customer Service will issue you an RMA number (see Returning a Unit on page 158).

CAUTION! ***Before trying to troubleshoot a problem by replacing your controller with another one, first check the installation. If you have shorted sensor inputs to high voltage lines or a transformer is shorted out, and you replace the controller, you will risk damage to the new controller.***

If you are certain the installation is correct, you can try replacing the controller. If the second unit works correctly, then the problem is specific to the controller you replaced.

Returning a Unit

Before returning a controller, contact your supplier or call Watlow (see page 1) for technical support.

Controllers purchased as part of a piece of equipment must be serviced or returned through the equipment manufacturer. Equipment manufacturers and authorized distributors should call customer service at Watlow to obtain a return materials authorization (RMA) number. Shipments without an RMA will not be accepted. Other users should contact their suppliers for instructions on returning products for repair.

Troubleshooting the Controller

A problem may be indicated by one or more of several types of symptoms:

- A process alarm
- A failed sensor alarm
- A system alarm
- Unexpected or undesired behavior

The following sections list symptoms in each of these categories and suggest possible causes and corrective actions.

Process Alarms

When a process alarm occurs, the controller switches to the single-loop display for the loop with the alarm and displays the alarm code (see Alarm Displays on page 81).

Possible Causes of a Process Alarm

In a heating application, a low alarm or low deviation alarm may indicate one of the following:

- The heater has not had time to raise the temperature.
- The load has increased and the temperature has fallen.
- The control mode is set to manual instead of automatic.
- The heaters are not working because of a hardware failure.
- The sensor is not placed correctly and is not measuring the load's temperature.
- The alarm settings are too tight. The process variable varies by more than the alarm limits because of load changes, lag or other system conditions.
- The system is so poorly tuned that the temperature is cycling about set point by more than the alarm set point.

NOTE! ***In cooling applications, similar issues cause high alarms.***

In a heating application, a high alarm or high deviation alarm may indicate one of the following:

- The process set point and high alarm set point have been lowered and the system has not had time to cool to within the new alarm setting.
- The controller is in manual mode and the heat output is greater than 0 percent.
- The load has decreased such that the temperature has risen.
- The heater is full-on because of a hardware failure.
- The system is so poorly tuned that the temperature is cycling about set point by more than the alarm set point.

NOTE! ***In cooling applications, similar issues cause low alarms.***

Responding to a Process Alarm

Your response to an alarm depends upon the alarm function setting, as explained in Table 7.1.

Table 7.1 Operator Response to Process Alarms

Alarm Function	Operator Response
Boost	The operator does not need to acknowledge the alarm. The alarm clears automatically when the process variable returns within limits.
Standard	Acknowledge the alarm by pressing ↻ on the keypad or via communications. The alarm clears after the operator acknowledges it *and* the process variable returns within the limits.

Ambient Warning

The Ambient Warning indicates that the controller is within 5°C of its operating temperature limits. If an Ambient Warning occurs, the alarm code AW (flashing) is displayed, and the global alarm output is turned on. Acknowledging the alarm turns off the global alarm output. The error clears when the condition no longer exists and the alarm has been acknowledged.

If the controller displays the AW alarm code:

1. Acknowledge the alarm.
2. Adjust the ambient temperature to a more appropriate level.

Failed Sensor Alarms

When a failed sensor alarm occurs, the controller switches to the single loop display for the loop with the alarm and displays an alarm code (see Alarm Displays on page 81).

A failed sensor alarm clears once it has been acknowledged and the sensor is repaired. For more information about the causes of failed sensor alarms, see Failed Sensor Alarms on page 93.

System Alarms

If the controller detects a hardware problem, it displays an alarm message, and with the exception of the Low Power alarm, turns on the global alarm output. The global alarm remains on until the alarm is acknowledged. The message persists until the condition is corrected and the alarm is acknowledged.

The D8 displays the following system alarm messages:

- *Low power*: See Low Power on page 163.
- *Battery dead*: See Battery Dead on page 163.
- *H/W error: Ambient*: See H/W Error: Ambient on page 165.
- *H/W error: Gain*: H/W Error: Gain or Offset on page 164.
- *H/W error: Offset*: See H/W Error: Gain or Offset on page 164.

Other Behaviors

Table 7.2 indicates potential problems with the system or controller and recommends corrective actions.

Table 7.2 Other Symptoms

Symptom	Possible Causes	Recommended Action
Indicated temperature not as expected	Controller not communicating Sensor wiring incorrect Noise	See Checking Analog Inputs on page 166.
D8 display is not lit	Power connection incorrect	Check wiring and service. See Wiring the Power Supply on page 23.
	Failed flash memory chip	Replace the flash memory chip. See Replacing the Flash Memory Chip on page 170.
	D8 damaged or failed	Return the D8 for repair. See Returning a Unit on page 158.
D8 display is lit, but keys do not work	Keypad locked	See Keys Do Not Work on page 166.
	Unacknowledged alarm	An alarm condition exists and has not been acknowledged. See How to Acknowledge an Alarm on page 82.
	D8 damaged or failed	Return the D8 for repair. See Returning a Unit on page 158.

Symptom	Possible Causes	Recommended Action
Control mode of one or more loops changes from automatic to manual	Failed sensor	Check the display or HMI software for a failed sensor message.
	BCD job selection feature loaded a different job	Check whether the new job was supposed to be loaded. If not, check the BCD job load setup: Check the settings of the BCD job load parameters in the *Global setup* menu. Use the *Digital inputs* parameter in the *I/O tests* menu to test the BCD job load input(s). Check the device that is used to activate job selection.
All loops are in manual mode at 0 percent power	Intermittent power	Check wiring and service. See Wiring the Power Supply on page 23. Use a separate dc supply for the controller. Provide backup power (uninterruptible power system). In the *Global* menu, set the *Power up loop mode* parameter to *from memory* if safe for your application. See Power Up Loop Mode on page 128.
	Hardware failure	Check the controller display for a hardware alarm. See System Alarms on page 160.
Controller does not behave as expected	Corrupt or incorrect values in RAM	Clear the RAM. See Clearing the RAM on page 169.

Reading the DeviceNet Indicator Lights

The Module Status Indicator Light indicates whether or not the device has power and is operating properly. The following chart is the definition of valid states available to this indicator:

Table 7.3 Module Status Indicator States and Descriptions

Device State	Indicator Light State	Description
Power Off	Off	No power applied to device.
Device Self-Test	Flashing Green-Red	Device is in Self-Test.
Device Operational	Green	Device is operating normally.
Unrecoverable Fault	Red	Device has detected an unrecoverable fault. All module level faults are considered unrecoverable.

Table 7.4 Network Status Indicator Light

Indicator Light	Description
Off	**The device is not online.** The device has not completed the duplicate MAC ID test yet. The device may not be powered. Look at Table 2.10, Module Status Indicator Light.
Green	**The device is online and has connections in the established state.** For a Group 2 Only device it means that the device is allocated to a Master.
Red	**Failed communication device.** The device has detected an error that has rendered it incapable of communicating on the network (Duplicate MAC ID, or Bus-off).
Flashing Green	**The device is online, but no connection has been allocated or an explicit connection has timed out.**
Flashing Red	**A poll connection has timed out.**

Corrective and Diagnostic Procedures

The following sections detail procedures you may use to diagnose and correct problems with the controller.

Low Power

If the controller displays *Low power* or the display is not lit:

1. Turn the power to the controller off, then on again.
2. If the *Low power* alarm message returns, check that the power supplied to the controller is at least 12.0 Vdc at 1 A. See Wiring the Power Supply on page 23.
3. If power is correct and the alarm message persists, make a record of all controller settings. Then, clear the RAM. See Clearing the RAM on page 169.
4. If the alarm is not cleared, contact your supplier for further troubleshooting guidance. See Returning a Unit on page 158.

Battery Dead

The Battery dead alarm indicates that the battery is not functioning correctly. This alarm occurs upon powerup only. The alarm indicates that values stored in memory may have been corrupted because of battery failure and should be restored to factory defaults.

If the Battery Dead alarm occurs, the controller displays an alarm message and the global alarm output turns on. Acknowledging the alarm restores all settings to factory defaults and turns off the global alarm output.

CAUTION! ***Acknowledging this alarm restores all setting to factory defaults.***

NOTE! ***The controller retains its settings when powered. The battery is required to keep the settings in memory only while the controller is not powered.***

If a replacement controller is available:

1. Replace the controller.
2. Enter the parameter settings into the new controller.

If you must use the controller with the failed battery:

1. Acknowledge the Battery Dead alarm. This restores all setting to factory defaults.
2. Using your record of controller settings, re-enter your settings.

H/W Error: Gain or Offset

Gain and Offset alarms indicate that a hardware error is preventing accurate measurements. If a Gain or Offset alarm occurs, the control outputs are turned off, an alarm message is displayed and the global alarm output turns on. Acknowledging the alarm turns off the global alarm output. The error clears when the condition no longer exists and the alarm has been acknowledged.

If the controller displays *H/W error: Gain* or *H/W error: Offset*:

1. Switch the power to the controller off, then on again.
2. If the alarm persists, make a record of all controller settings, then clear the RAM. See Clearing the RAM on page 169.
3. If the alarm is not cleared, contact your supplier for further troubleshooting guidelines. See Returning a Unit on page 158.

NOTE! ***If the controller has failed, it is likely that it was damaged by excessive voltage or noise. Before replacing the controller, troubleshoot for noise and ground loops.***

H/W Error: Ambient

The *H/W error: Ambient* alarm indicates that the ambient sensor in the D8 is reporting that the temperature around the controller is outside of the acceptable range of 0 to 50° C. This alarm can also occur if there is a hardware failure.

If an H/W Error: Ambient alarm occurs, the control outputs are turned off, an alarm message is displayed with the ambient temperature and the global alarm output turns on. Acknowledging the alarm turns off the global alarm output. The error clears when the condition no longer exists and the alarm has been acknowledged.

If the controller displays *H/W error: Ambient*:

1. Acknowledge the alarm and check the ambient air temperature near the controller. Adjust ventilation, cooling or heating so that the temperature around the controller is 0 to 50° C. If the unit is functioning correctly, the alarm will clear automatically when the ambient temperature is within range.
2. If the ambient temperature is within range and the alarm persists, reseat the board assembly:
   a) Switch off power to the controller.
   b) Remove the board assembly from the D8 housing. See Replacing the Flash Memory Chip on page 170, steps 2 to 5.
   c) Reseat the board assembly and reassemble the controller. Reverse the steps refered to above to reseat.
   d) Switch on power to the controller.
3. If the alarm persists, make a record of all controller settings, then clear the RAM. See Clearing the RAM on page 169.
4. If the alarm is not cleared, contact your supplier for further troubleshooting guidelines. See Returning a Unit on page 158.

NOTE! ***If the controller has failed, it is likely that it was damaged by excessive voltage or noise. Before replacing the controller, troubleshoot for noise and ground loops.***

Keys Do Not Work

If the D8 seems to function but one or more keys do not work, check the following:

- If the ▶ key does not work, but other keys work, then the keypad is probably locked. Unlock the keypad according to the instructions in Keypad Lock on page 129.
- Check whether there is an unacknowledged alarm. The keys will not work for anything else until all alarms are acknowledged. To acknowledge an alarm, press ↩.

Checking Analog Inputs

1. If the process variable read via communications does not agree with the process variable on the controller display, verify that the controller is communicating. See Reading the DeviceNet LEDs on page 148.
2. If the process variable indicated on the controller display is incorrect:
   a) Verify that you have selected the correct input type for the affected loops.
   b) Verify that sensors are properly connected.
3. If the sensors are correctly connected, with power on to the heaters check for high common mode voltage:
   a) Set a voltmeter to measure volts ac.
   b) Connect the negative lead to a good earth ground.
   c) One by one, check each input for ac voltage by connecting the positive lead on the voltmeter to the positive and negative sensor input connections. The process variable should indicate ambient temperature. If it does not, contact your supplier to return the unit for repair. See Returning a Unit on page 158.

NOTE! ***Noise in excess of 1 Vac should be eliminated by correctly grounding the D8. See Wiring the Power Supply on page 23.***

4. Verify the sensors:

- For thermocouples, remove the thermocouple leads and use a digital voltmeter to measure the resistance between the positive and negative thermocouple leads. A value of 2 to 20 Ω is normal. Readings in excess of 200 Ω indicate a problem with the sensor.
- For RTDs, measure between the IN+ and IN- terminals of TB1. RTD inputs should read between 20 and 250 Ω.

5. To verify that the controller hardware is working correctly, check any input (except an RTD) as follows:
   a) Disconnect the sensor wiring.
   b) In the *Input* menu, set the *Input type* parameter to *J thermocouple*.
   c) Place a short across the input. On the loop that you are testing, the controller should indicate the ambient temperature.

Earth Grounding

If you suspect a problem with the ac ground or a ground loop:

- Measure for ac voltage between ac neutral and panel chassis ground. If ac voltage is above 2 Vac, then there may be a problem with the ac power wiring. This should be corrected per local electrical codes.
- With ac power on, measure for ac voltage that may be present between control panels’ chassis grounds. Any ac voltage above 2 Vac may indicate problems with the ac ground circuit.
- With the heater power on, check for ac voltage on thermocouples. A control output providing power to the heaters will increase the ac voltage if there is heater leakage and an improper grounding circuit. Measure from either positive or negative thermocouple lead to ac ground. AC voltage above 2 Vac may indicate the ground lead is not connected to the D8 TB2 ground terminal.

If the above tests indicate proper ac grounding but the controller is indicating incorrect temperatures or process readings:

- Verify which type of sensor is installed and that the *Input type* parameter in the *Input* menu is set accordingly.
- For an RTD or process input, check that the correct input scaling resistors are installed (see Installing Scaling Resistors on page 172) and check the input scaling parameter settings (see Setting Up a Process Input on page 88).
- If readings are erratic, look for sources of electrical noise. See Noise Suppression on page 21.

- Eliminate possible ground loops. See Ground Loops on page 22.
- Contact your supplier for further troubleshooting guidance.

Testing Control Output Devices

Connect the solid-state relay (SSR) control terminals to the D8 control output and connect a light bulb (or other load that can easily be verified) to be switched by the SSR's outputs. Put the loop in manual mode and set the output to 100 percent. The ac load should turn on.

Do not attempt to measure ac voltage at the output terminals of the SSR. Without a load connected, the SSR output terminals do not turn off. This makes it difficult to determine whether the SSR is actually working. Measure the voltage across a load or use a load that can be visually verified, such as a light bulb.

Testing the TB18 and TB50

1. Turn on power to the controller.
2. Measure the +5 Vdc supply at the TB18 or TB50. The voltage should be +4.75 to +5.25 Vdc:
    a) Connect the voltmeter's common lead to TB18 terminal 2 or TB50 terminal 3.
    b) Connect the voltmeter's positive lead to the TB18 or TB50 terminal 1.

Testing Control and Digital Outputs

1. Switch off power to the controller.
2. Disconnect any output wiring on the output to be tested.
3. Connect a 500 Ω to 100 kΩ resistor between the +5V terminal (TB18 or TB50 terminal 1) and the output terminal you want to test.
4. Connect the voltmeter's common lead to the output terminal, and connect the voltmeter's positive lead to the +5V terminal.
5. Restore power to the controller.
6. If you are testing a control output, turn the output on and off by setting the loop to 100 percent and 0 percent output power (see Changing the Control Mode and Output Power on page 85). When the output is off (0 percent), the output voltage should be less than 1V. When the out-

put is on (100 percent), the output voltage should be between +4.75 and +5.25V.

7. If you are testing a digital output not used for control, use the *I/O tests* menu to turn the output on and off. See Test Digital Output 1 to 20 on page 153.

Testing Digital Inputs

1. Switch off power to the controller.
2. Disconnect any system wiring from the input to be tested.
3. Restore power to the controller.
4. Go to the *Digital inputs* parameter in the *I/O tests* menu.
5. Attach a wire to the terminal of the digital input to test. When the wire is connected only to the digital input terminal, the *Digital inputs* parameter should show that the input is off (*0*). When you connect the other end of the wire to controller common (TB50 terminal 3), the *Digital inputs* parameter should show that the input is on (*1*).

Clearing the RAM

Clearing the random access memory (RAM) returns all controller settings to their defaults. All stored jobs are also cleared from controller memory.

To clear the RAM:

1. Make a record of all controller settings.
2. Switch off power to the controller.
3. Press and hold ▼.
4. Switch on power to the controller while still holding ▼.
5. When you see the prompt *Clear RAM?*, release ▼ and press ▶.
6. Restore the controller settings.

NOTE! ***If your controller does not have a keypad and display, you can clear the RAM by powering the controller up with pins 1 and 6 on the keypad header (J3 on the bottom circuit card) shorted. After clearing the RAM, power down the controller and remove the jumper wire from the keypad header before putting the controller back in service.***

Replacing the Flash Memory Chip

This procedure requires a 32-pin PLCC IC extraction tool.

CAUTION! ***The flash memory chip and other components are sensitive to damage from electrostatic discharge (ESD). To prevent ESD damage, use an ESD wrist strap or other antistatic device.***

NOTE! ***Replacing the flash memory chip results in full erasure of RAM. Make a record of all parameters before changing the flash memory chip.***

1. Make a record of controller parameters.
2. Switch off power to the controller.
3. Disconnect input power to the controller.
4. Remove the four screws from the sides of the controller front bezel.
5. Remove the electronics assembly from the case, as shown in Figure 7.1.

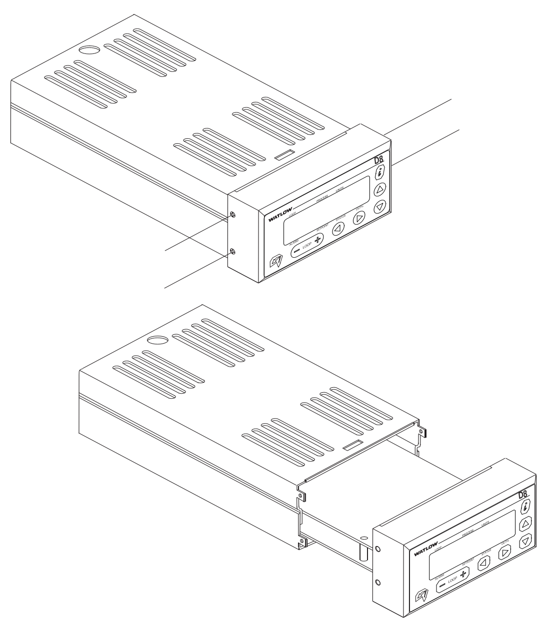


Figure 7.1 Removal of Electronics Assembly from Case

6. Unscrew the four screws at the corners of the top board and carefully unplug this board to access the bottom board. Figure 7.2 shows the screws to remove:

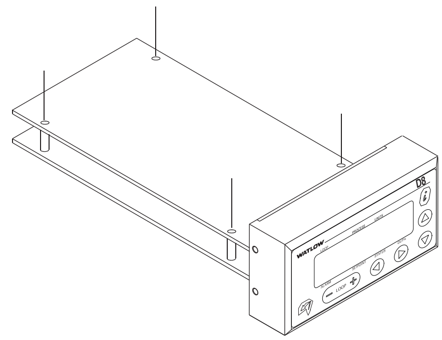


Figure 7.2 Screw Locations on PC Board

7. Locate the flash memory chip on the circuit board. The flash memory chip is a 32-pin socketed chip that is labeled with the model, version and checksum.

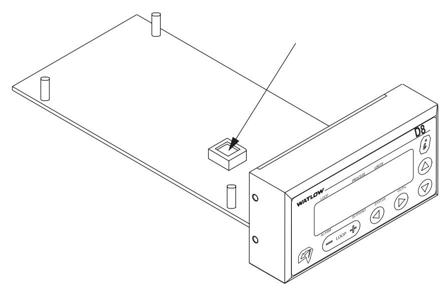


Figure 7.3 Location of Flash Memory Chip

8. Remove the existing flash memory chip from its socket with an IC extraction tool.
9. Carefully insert the new flash memory chip into the socket. Make sure that the chip is oriented so that its notch fits in the corresponding corner of the socket.
10. Reverse steps 2 through 6 to reassemble the unit.
11. Power up the controller.
12. Re-enter parameters.

Installing Scaling Resistors

Resistors are installed for all inputs on the D8. Inputs with signal ranges between -10 and +60 mV use 0 Ω resistors in the RC position only. All other input signals require special input scaling resistors.

CAUTION! ***Scaling resistors are soldered to the circuit board. Only qualified technicians should attempt to install or remove these components. Improper techniques, tools or materials can result in damage to the controller that is not covered by the warranty.***

Input Circuit

The D8 can accept thermocouple, mVdc, Vdc, mAdc and RTD inputs. Unless ordered with special inputs these controller accept only signals within the standard range -10 to 60 mVdc.

To accommodate other signals, the input circuit must be modified. When configured for thermocouple inputs, 0Ω resistors are installed in all RC locations. To accommodate voltage signals outside the standard range, milliamp current signals or RTDs, resistors are added or replaced to scale the signals to the standard range. These resistor can be installed by Watlow Anafaze or by a qualified electronics technician using scaling resistors supplied by Watlow Anafaze.

Figure 7.4 shows the input circuit for one differential analog input. See Current Inputs on page 173 through RTD Inputs on page 175 for specific instructions and resistor values for voltage, current and RTD inputs.

NOTE! ***When adding your own scaling resistors to the controller, for voltage and RTD inputs you will have to carefully remove one of the RC resistors in order to install the resistor listed in the table.***

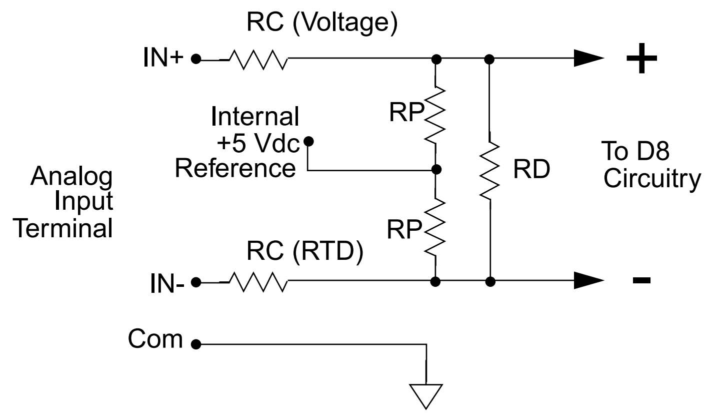


Figure 7.4 Input Circuit

Current Inputs

For each current input, you must install a resistor. The value of the resistor must be correct for the expected input range. Install the resistor in the listed resistor pack (RP) location. Note the resistor pack locations have three through-holes. Install the resistor as shown in the illustration below.

Table 7.5 Resistor Values for Current Inputs

Input Range	Resistor Value RD
0 to 10 mA	6.0 Ω
0 to 20 mA	3.0 Ω

Resistor tolerance: ±0.1%

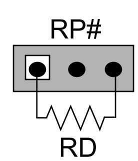


Table 7.6 Resistor Locations for Current Inputs

Loop	Resistor Location RD	Loop	Resistor Location RD
1	RP1	5	RP5
2	RP2	6	RP6
3	RP3	7	RP7
4	RP4	8	RP8

Voltage Inputs

For each voltage input, you must install two resistors. The resistances must be correct for the expected input range. Note the resistor pack (RP) locations have three through-holes. Install the RD resistor as indicated in the illustration below.

Table 7.7 Resistor Values for Voltage Inputs

Input Range	Resistor Values	
	RC	RD
0 to 100 mVdc	499 Ω	750 Ω
0 to 500 mVdc	5.49 kΩ	750 Ω
0 to 1 Vdc	6.91 kΩ	442.0 Ω
0 to 5 Vdc	39.2 kΩ	475.0 Ω
0 to 10 Vdc	49.9 kΩ	301.0 Ω
0 to 12 Vdc	84.5 kΩ	422.0 Ω

Resistor tolerance: ±0.1%

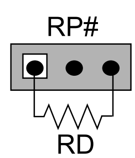


Table 7.8 Resistor Locations for Voltage Inputs

Loop	Resistor Locations	
	RC	RD
1	R58	RP1
2	R56	RP2
3	R54	RP3
4	R52	RP4
5	R50	RP5
6	R48	RP6
7	R46	RP7
8	R44	RP8

RTD Inputs

For each RTD input, you must install three resistors: RA, RB, and RC. The resistance must be correct for the expected input range. RA and RB are a matched pair of resistors. Install them in the resistor pack (RP) locations as shown in the illustration below.

Resistor values:

- RA/RB: 25 kΩ
- RC: 18.2 Ω

Resistor tolerances:

- RA/RB: Matched to 0.02% (±5 ppm/°C) with absolute tolerance of 0.1% (±25 ppm/°C)
- RC: Accurate to 0.05% (±5ppm/°C)

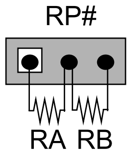


Table 7.9 Resistor Locations for RTD Inputs

Loop	Resistor Values	
	RA/RB	RC
1	RP1	R57
2	RP2	R55
3	RP3	R53
4	RP3	R51
5	RP4	R49
6	RP5	R47
7	RP6	R45
8	RP7	R43

Scaling and Calibration

The controller provides offset calibration for thermocouple, RTD, and other fixed ranges, and offset and span (gain) calibration for process inputs. In order to scale the input signal, you must:

1. Install appropriate scaling resistors.
2. Enter the input range at the *Disp format* parameter in the *Input* menu. The smallest possible range is -.9999 to 3.0000; the largest possible range is -9999 to 30000.
3. Enter the appropriate scaling values for your process. See Setting Up a Process Input on page 88.

Configuring Serial DAC Outputs

On the Serial DAC, the voltage and current output is jumper-selectable. Refer to Figure 7.5. Configure the jumpers as indicated on the Serial DAC label.

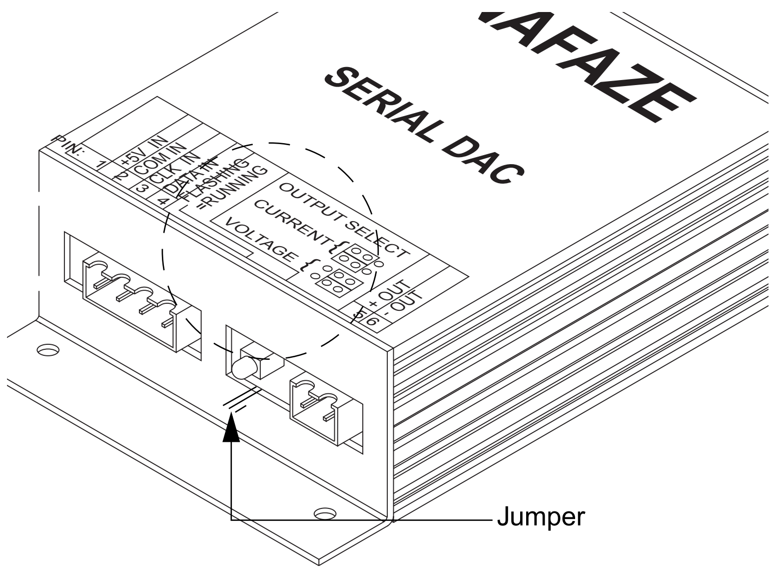


Figure 7.5 Serial DAC Voltage and Current Jumper Positions

Configuring Dual DAC Outputs

Dual DAC modules ship with both of the outputs configured for the signal type and span that were ordered. The module contains two independent circuits (DAC1 and DAC2). These circuits can be configured for different output types. Remove the board from the housing and set the jumpers. The odd-numbered jumpers determine the signal from DAC 1; the even-numbered jumpers determine the output from DAC 2.

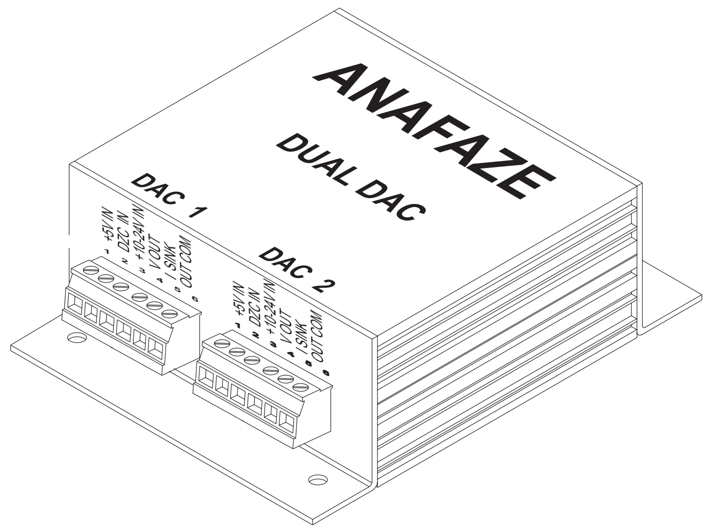


Figure 7.6 Dual DAC

Table 7.10 Dual DAC Jumper Settings

Output Type	Jumper Settings						
	1/2	3/4	5/6	7/8	9/10	11/12	13/14
0 to 5 Vdc	B	A	A	O	B	A	O
0 to 10 Vdc	B	A	A	O	B	O	O
4 to 20 mA	O	A	B	A	A	O	A
A = Load jumper in the “A” position, or load jumper if header has only two pins. B = Load jumper in the “B” position. O = Open. Do not load jumper.							

1. Power down the system (if the Dual DAC is already installed and wired).
2. Ensure the DAC 1 and DAC 2 terminal blocks or associated wires are labeled such that you will know which terminal block connects to which side of the board if the module is already installed and wired.
3. Unplug the two terminal blocks.
4. Depending on the installation, you may need to unmount the Dual DAC module before proceeding. Remove the four screws from the end plate on the opposite side of the module from the terminal blocks.
5. If necessary, remove the two mounting screws holding the loosened end plate in place.
6. Slide the board out of the housing.
7. Set the jumpers for the two outputs as desired. See Table 7.10.
8. Replace the board such that the connectors extend through the opposite end plate. The board fits in the third slot from the bottom.
9. Reconnect the two terminal blocks to the DAC 1 and DAC 2 connectors.
10. Replace the end plate, end plate screws and, if necessary, mounting screws.
11. Check the wire connections to the DAC 1 and DAC 2 terminal blocks.
12. If necessary, change the wiring connections to the correct configuration for the new output type. See Wiring the Dual DAC on page 38.
13. Restore system power.

8

Specifications

This chapter contains specifications for the D8 series controllers, TB50 terminal board, Dual DAC module, Serial DAC module and the D8 power supply.

System Specifications

This section contains D8 series controller specifications for environmental specifications and physical dimensions, inputs, outputs, the serial interface and system power requirements.

The controller consists of a processor module with a 50-terminal block (TB50) or a processor module with an 18-terminal block (TB18).

Table 8.1 Agency Approvals / Compliance

CE Directive	Electromagnetic Compatibility (EMC) Directive 89/336/EEC
UL and C-UL	UL 916, Standard for Energy Management Equipment File E177240
ODVA	DeviceNet and Semiconductor SIG

Physical Specifications

Table 8.2 Environmental Specifications

Storage Temperature	-20 to 60° C
Operating Temperature	0 to 50° C
Humidity	10 to 95% non-condensing
Environment	The controller is for indoor use only

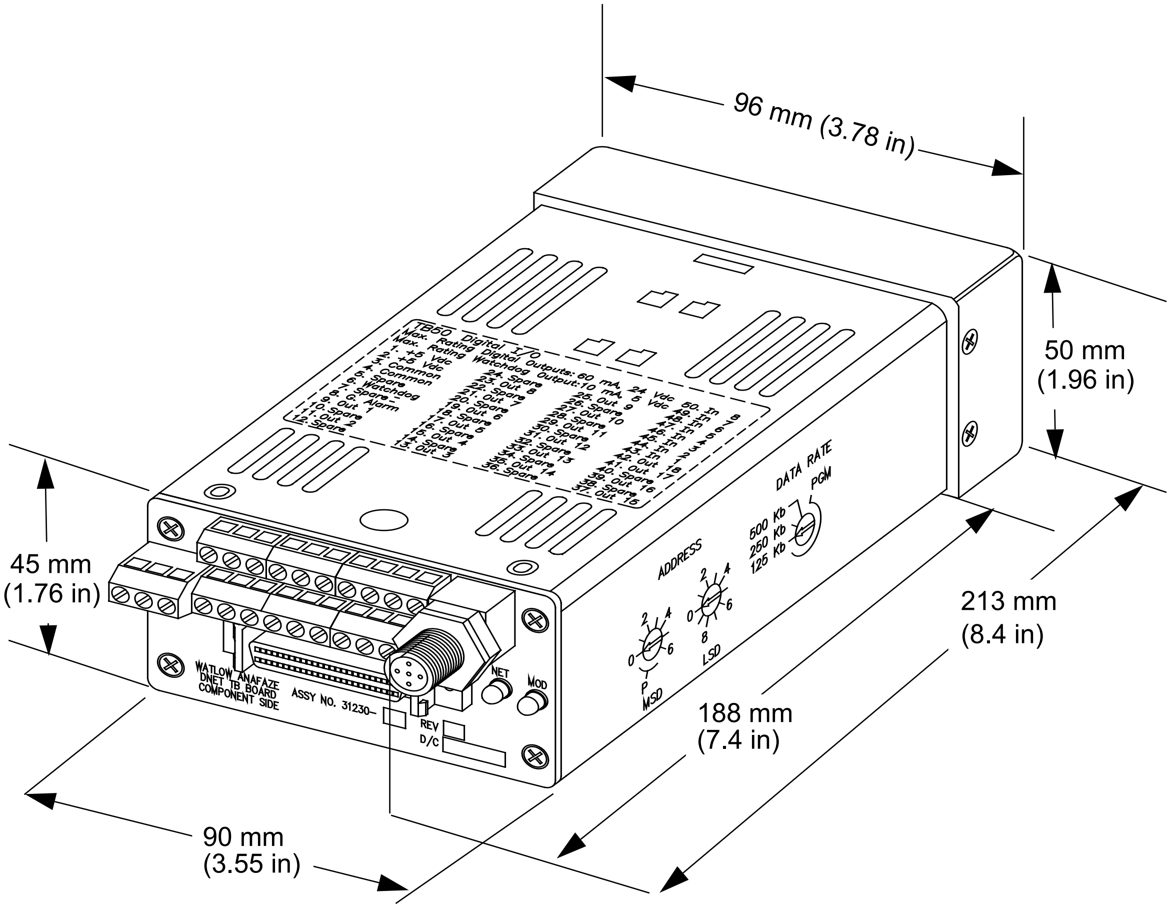


Figure 8.1 D8 Module Dimensions

Table 8.3 D8 with Straight SCSI

Length*	10.0 to 10.5 in.	254 to 267 mm
Width	3.78 inches	96 mm
Height	1.96 inches	50 mm

*Exact requirement depends on usage and choice of cables.

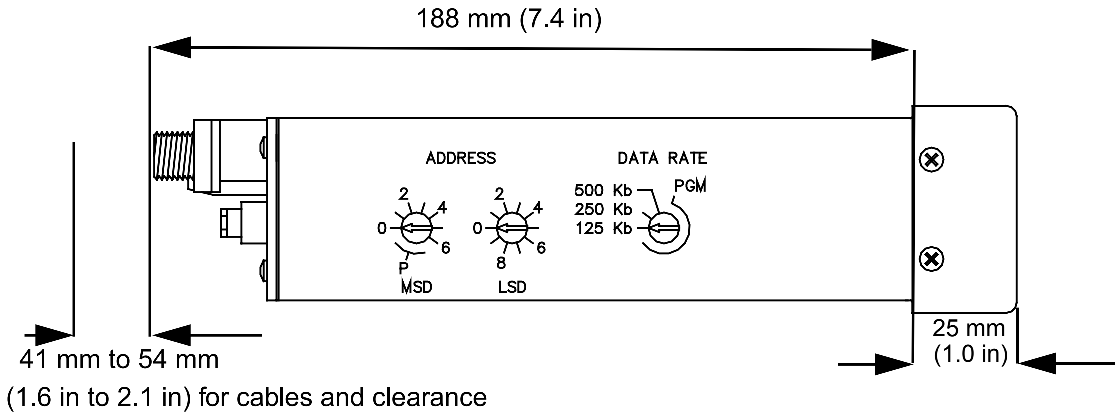


Figure 8.2 Module Dimensions and Clearance

Table 8.4 D8 Connections

Power Terminals (TB2)	Captive screw cage clamp
Power Wire Gauge (TB2)	22 to 18 AWG (0.5 to 0.75 mm^2)
Power Terminal Torque (TB2)	4.4 to 5.3 in.-lb. (0.5 to 0.6 Nm)
Sensor Terminals (TB1)	Captive screw cage clamp
Sensor Wire Gauge (TB1)	Thermocouple: 20 AWG (0.5 mm^2) Process: 22 to 20 AWG (0.5 mm^2) Communications: 24 AWG (0.2 mm^2)
Sensor Terminal Torque (TB1)	4.4 to 5.3 in.-lb. (0.5 to 0.6 Nm)
Output Terminals (TB18)	Captive screw cage clamp
Output Wire Gauge (TB18)	Multiconductor cables: 24 AWG (0.2 mm^2) Single-wire: 22 to 18 AWG (0.5 to 0.75 mm^2)
Output Terminal Torque (TB18)	4.4 to 5.3 in.-lb. (0.5 to 0.6 Nm)
SCSI Connector	SCSI-2 female
DeviceNet Connector	Male, sealed, micro-style, quick disconnect DeviceNet connector

Table 8.5 TB50 Physical Dimensions

Weight	0.32 lb.	0.15 kg
Length	4.1 inches	104 mm
Width	4.0 inches	102 mm
Height	1.5 inches	37 mm

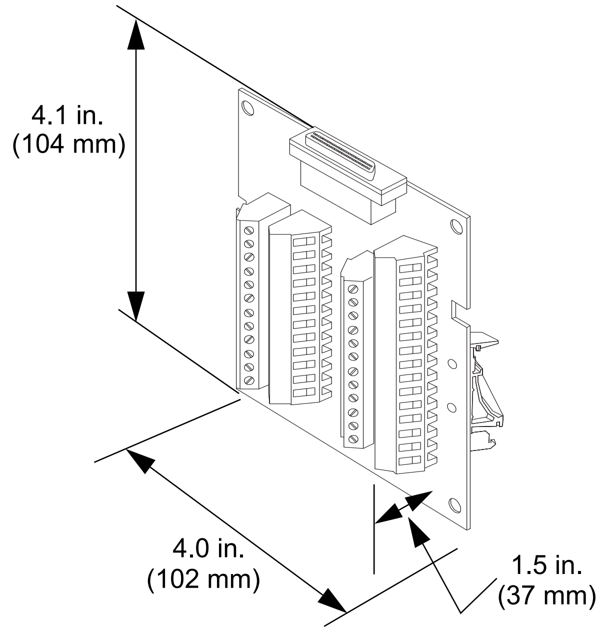


Figure 8.3 TB50 Dimensions

Table 8.6 TB50 Connections

Screw Terminal Torque	4.4 to 5.3 in.-lb. (0.5 to 0.6 Nm)
SCSI Connector on Board	SCSI-2 female
Output Terminals	Captive screw cage clamp
Output Wire Gauge	Multiconductor cables: 24 AWG (0.2 mm^2) Single-wire: 22 to 18 AWG (0.5 to 0.75 mm^2)
Output Terminal Torque	4.4 to 5.3 in.-lb. (0.5 to 0.6 Nm)

Table 8.7 TB50 with Straight SCSI

Length	6.4 inches	163 mm
Width	4.0 inches	102 mm
Height	1.5 inches	37 mm

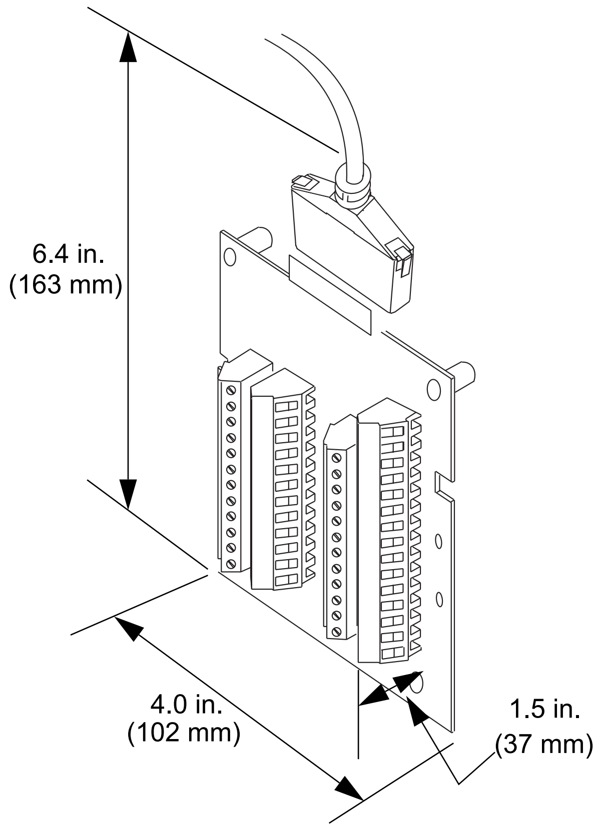


Figure 8.4 TB50 Dimensions with Straight SCSI Cable

Table 8.8 TB50 with Right Angle SCSI

Length	5.4 inches	137 mm
Width	4.0 inches	102 mm
Height	1.5 inches	37 mm

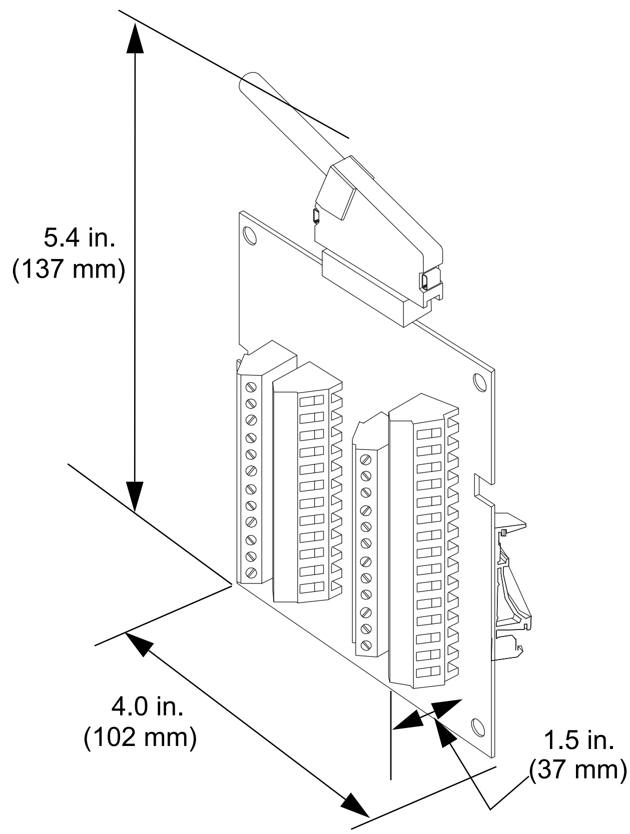


Figure 8.5 TB50 Dimensions with Right-Angle SCSI Cable

Inputs

The controller accepts analog sensor inputs which are measured and may be used as feedback for control loops. It also accepts digital (TTL) inputs which may be used to trigger certain firmware features.

Table 8.9 Analog Inputs

Number of Control Loops	D84_- _ _ _ _ - _ _ _ _ : 4 loops D88_- _ _ _ _ - _ _ _ _ : 8 loops
Number of Analog Inputs	D84_- _ _ _ _ - _ _ _ _: 4 loops with full range of input types D88_- _ _ _ _ - _ _ _ _: 8 loops with full range of input types
Input Switching	Differential, solid-state multiplexer
Input Sampling Rate	D84_- _ _ _ _ - _ _ _ _: 6 Hz (167 ms) at 60 Hz; 5 Hz (200 ms) at 50 Hz D88_- _ _ _ _ - _ _ _ _: 3 Hz (333 ms) at 60 Hz; 2.5 Hz (400 ms) at 50 Hz
Milliampere Inputs	0 to 20 mA (3 Ω resistance) or 0 to 10 mA (6 Ω resistance), with scaling resistors
Voltage Input Ranges Available	0 to 12 V, 0 to 10 V, 0 to 5 V, 0 to 1 V, 0 to 500 mV, 0 to 100 mV with scaling resistors
Source Impedance	For 60 mV thermocouple, measurements are within specification with up to 500 Ω source resistance For other types of analog signals, the maximum source impedance is 5000 Ω
Input Range	-10 to +60 mV, or 0 to 25 V with scaling resistors
Resolution	0.006%, greater than 14 bits (internal)
Accuracy	0.03% of full scale (60 mV) at 25° C
	0.08% of full scale (60 mV) at 0 to 50° C
Analog Over Voltage Protection	±20 V referenced to digital ground.
Maximum Common Mode Voltage	5 V input to input or input to analog common
Common Mode Rejection (CMR)	For inputs that do not exceed ±5 V, >60 dB dc to 1 kHz, and 120 dB at selected line frequency.
Calibration	Automatic zero and full scale
Analog Ground to Frame Ground Maximum	40 V
DC Common to Frame Ground Maximum Potential	40 V
Open Thermocouple Detection	Pulse type for upscale break detection

Table 8.10 Thermocouple Range and Resolution

Thermocouple Type	Range in ˚F	Range in ˚C	Accuracy* at 25˚C Ambient		Accuracy* at 0 to 50˚C Ambient	
			˚F	˚C	˚F	˚C
J	-350 to 1400	-212 to 760	±2.2	±1.2	±3.3	±1.8
K	-450 to 2500	-268 to 1371	±2.4	±1.3	±3.8	±2.1
T	-450 to 750	-268 to 399	±2.9	±1.6	±5.8	±3.2
S	0 to 3200	-18 to 1760	±5.0	±2.8	±8.8	±4.9
R	0 to 3210	-18 to 1766	±5.0	±2.8	±8.8	±4.9
B	150 to 3200	66 to 1760	±7.2	±4.0	±22.1	±12.3
E	-328 to 1448	-200 to 787	±1.8	±1.0	±2.9	±1.6

* True for 10 percent to 100 percent of span except type B, which is specified for 800° F to 3200° F.

Table 8.11 RTD Range and Resolution

Range in ˚F	Range in ˚C	Resolution in ˚C	Measurement Temperature in ˚C	Accuracy at 25˚C Ambient		Accuracy at 0 to 50˚C Ambient	
				˚F	˚C	˚F	˚C
-328.0 to 1150.0	-200.0 to 621.1	0.07	25	0.9	0.5	1.2	0.5
			400	2.7	1.5	4.1	2.2

Table 8.12 Input Resistance for Voltage Inputs

Range	Input Resistance
0 to 12 V	85 kΩ
0 to 10 V	50 kΩ
0 to 5 V	40 kΩ
0 to 1 V	7.4 kΩ
0 to 500 mV	6.2 kΩ
0 to 100 mV	1.2 kΩ

Table 8.13 Digital Inputs

Number	With TB50: 8 With TB18: 3
Function	Selectable for output override or remote job selection
Input Voltage Protection	Diodes to supply and common. Source must limit current to 10 mA for override conditions
Voltage Levels	<1.3 V = Low >3.7 V = High (TTL) 5 V maximum, 0 V minimum
Maximum Switch Resistance to Pull Input Low	1.7 kΩ
Minimum Switch Off Resistance	1.4 kΩ
Response Time	50 ms (AC line frequency set to 60 Hz) 60 ms (AC line frequency set to 50 Hz)

Outputs

The controller directly accommodates switched dc and open-collector outputs only. These outputs can be used to control a wide variety of loads. They are typically used to control solid state relays or other power switching devices which, in turn, control devices such as heaters. They may also be used to signal another device of an alarm condition in the controller.

Analog outputs may be accomplished by using Dual DAC or Serial DAC modules in conjunction with one of the control outputs.

An open-collector CPU watchdog output is also provided so that an external device can monitor the CPU state.

Analog Outputs

No direct analog outputs are provided.

The digital outputs may be used in conjunction with Dual DAC or Serial DAC modules to provide analog signals. See Dual DAC Specifications on page 191 and Serial DAC Specifications on page 193.

Digital Outputs

Table 8.14 Digital Outputs Control / Alarm

Number	20 with TB50 option or 13 with TB18 option
Operation	Open collector output; ON state sinks to logic common
Function	1 Global alarm output 1 CPU watchdog output Balance selectable as closed-loop control or alarms
Number of Control Outputs per PID Loop	2 (maximum)
Control Output Types	Time proportioning, distributed zero crossing, Serial DAC or on/off. All independently selectable for each output. Heat and cool control outputs can be individually disabled for use as alarm outputs
Time Proportioning Cycle Time	1 to 255 seconds, programmable for each output
Control Action	Reverse (heat) or direct (cool), independently selectable for each output
Off State Leakage Current	<0.01 mA to dc common
Maximum Current	60 mA for each output. 5V power supply (from the processor module) can supply up to 350 mA total to all outputs
Maximum Voltage Switched	24 Vdc

Table 8.15 5 Vdc Output (Power to Operate Solid-State Relays)

Voltage	5 Vdc
Maximum Current	350 mA

Table 8.16 Communications

Minimum Time Between Polled I/O Requests	20 ms

Table 8.17 D8 Power Requirements

Voltage	15 to 24 +/-3 Vdc
Maximum Current	1 A

Power Supply

Specifications for the D8 power supply are available at www.watlow.com. See the links on the D8 page.

Dual DAC Specifications

The Watlow Anafaze Dual DAC (digital-to-analog converter) is an optional module for the D8 series controller. The Dual DAC converts a distributed zero crossing (DZC) output signal to an analog process control signal. Watlow Anafaze provides the following version of the Dual DAC:

- 4 to 20 mAdc
- 0 to 5 Vdc
- 0 to 10 Vdc

Table 8.23 Dual DAC Environmental Specifications

Storage Temperature	-20 to 60° C
Operating Temperature	0 to 50° C
Humidity	10 to 95% non-condensing

Table 8.24 Dual DAC Physical Specifications

Weight	0.42 lb.	0.19 kg
Length	4.4 inches	112 mm
Width	3.6 inches	91 mm
Height	1.8 inches	44 mm

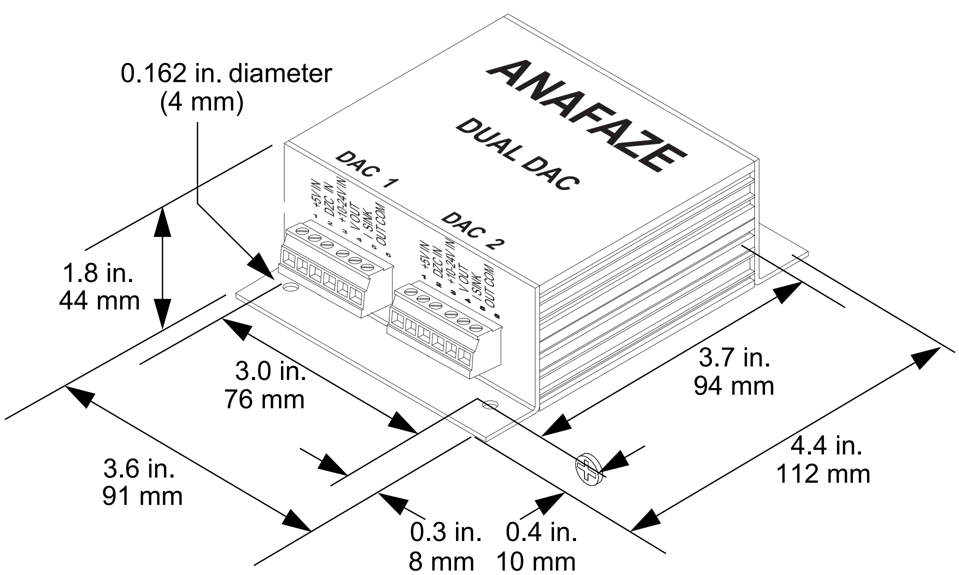


Figure 8.7 Dual DAC Dimensions

Dual DAC Inputs

The Dual DAC accepts an open-collector signal from the D8 controller and the power from an external power supply. See Table 8.25 .

Table 8.25 Dual DAC Power Requirements

Parameter	Description
Voltage	12 to 24 Vdc
Current	100 mA @ 15 Vdc

Dual DAC Analog Outputs

Table 8.26 Dual DAC Specifications by Output Range

Version	4 to 20 mA	0 to 5 V	0 to 10 V	Units
Gain Accuracy	± 6	± 6	± 6	percent
Output Offset	± 0.75	± 0.75	± 0.75	percent of full scale range
Ripple	1.6	1.6	1.6	percent of full scale range
Time Constant	2	2	2	seconds
Maximum Current Output	20	10	10	mAdc
Load Resistance (12 V)	250 maximum	500 minimum	1000 minimum	Ohms
Load Resistance (24 V)	850 maximum	n/a	n/a	Ohms

Serial DAC Specifications

Watlow Anafaze offers a Serial DAC for precision open-loop analog outputs. The Serial DAC is jumper-selectable for a 0 to 10 Vdc or 4 to 20 mA output. Multiple Serial DAC modules can be used with one D8. The Serial DAC carries a CE mark.

Table 8.27 Serial DAC Environmental Specifications

Storage Temperature	-20 to 60° C
Operating Temperature	0 to 50° C
Humidity	10 to 95% non-condensing

Table 8.28 Serial DAC Physical Specifications

Weight	0.76 lb.	0.34 kg
Length	5.4 inches	137 mm
Width	3.6 inches	91 mm
Height	1.8 inches	44 mm

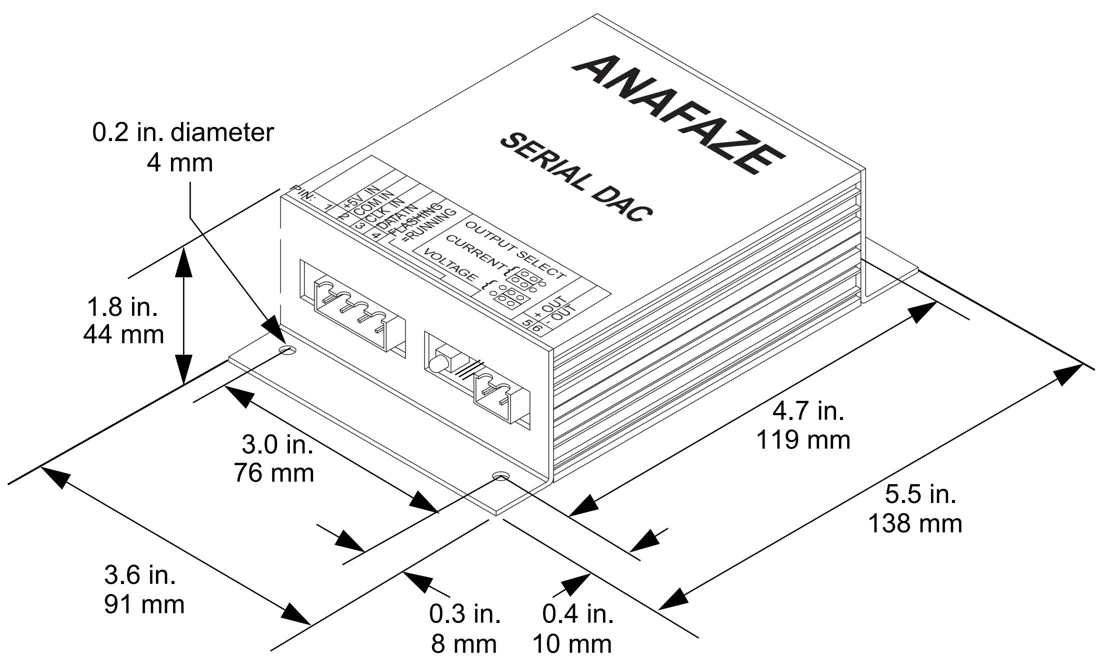


Figure 8.8 Serial DAC Dimensions

Table 8.29 Serial DAC Agency Approvals / Compliance

CE Directive	Electromagnetic Compatibility (EMC) directive 89/336/EEC
UL and C-UL	UL 916 Standard for Energy Management Equipment File E177240

Serial DAC Inputs

The Serial DAC requires a proprietary serial data signal and the clock signal from the D8 via the TB50. Any control output can be configured to provide the data signal. The Serial DAC also requires a 5 Vdc power input.

Table 8.30 Serial DAC Inputs

Data	4 mA maximum to DC COM Open collector or HC CMOS logic levels
Clock	0.5 mA maximum to DC COM Open collector or HC CMOS logic levels

Table 8.31 Serial DAC Power Requirements

Voltage	4.75 to 5.25 Vdc @ 300 mA maximum

Serial DAC Analog Outputs

Table 8.32 Serial DAC Analog Output Specifications

Absolute Maximum Common Mode Voltage	Measured between output terminals and controller common: 1000 V
Resolution	15 bits (plus polarity bit for voltage outputs) (0.305 mV for 10 V output range) (0.00061 mA for 20 mA output range)
Accuracy (Calibrated for Voltage Output)	For voltage output: ± 0.005 V (0.05% at full scale) For current output: ± 0.1 mA (0.5% at full scale)
Temperature coefficient	440 ppm/ °C typical
Isolation Breakdown Voltage	1000 V between input power and signals
Current	0 to 20 mA with 10 V minimum compliance (500 Ω load)
Voltage	0 to 10 Vdc with 10 mA source capability
Output Response Time	1 ms typical
Update Rate	Once per controller A/D cycle nominal. Twice per second maximum for 60 Hz clock rate. Output changes are step changes due to the fast time constant. All Serial DAC loop outputs are updated at the same time.

Declaration of Conformity

D8 Series

WATLOW ANAFAZE
314 Westridge Drive
Watsonville, California 95076 USA

Declares that the following product: **English**

Designation:	*D8 Series*
Model Number(s):	*D8(4 or 8)(any digit or letter)-(any 4 digits or letters)-(any 4 digits or letters)*
Classification:	*Installation Category II, Pollution Degree II*
Rated Voltage:	*12 to 24 VDC*
Rated Current:	*610mA maximum*

Meets the essential requirements of the following European Union Directive(s) using the relevant section(s) of the normalized standards and related documents shown:

89/336/EEC Electromagnetic Compatibility Directive

EN 61326:	**1997**	**Electrical equipment for measurement, control and laboratory use - EMC requirements (Class A)**
EN 61000-4-2:	*1995*	*Electrostatic discharge*
EN 61000-4-3:	*1997*	*Radiated immunity*
EN 61000-4-4:	*1995*	*Electrical fast transients*
EN 61000-4-5:	*1995*	*Surge immunity*
EN 61000-4-6:	*1994*	*Conducted immunity*
EN 61000-4-11:	*1994*	*Voltage dips, short interruptions and voltage variations immunity*

Déclare que le produit suivant : **Français**

Désignation :	*Série D8*
Numéro(s) de modèle(s):	*D8(4 ou 8)(Tout caractère ou lettre)-(tout groupe de 4 caractères ou lettres)-(tout groupe de 4 caractères ou lettres)*
Classification :	*Installation catégorie II, degré de pollution II*
Tension nominale :	*12 à 24V c.c.*
Courant nominal :	*610 mA maximum*

Conforme aux exigences de la (ou des) directive(s) suivante(s) de l'Union Européenne figurant aux sections correspondantes des normes et documents associés ci-dessous :

89/336/EEC Directive de compatibilité électromagnétique

EN 61326:	**1995**	**Appareillage électrique pour la mesure, la commande et l'usage de laboratoire –– Prescriptions relatives à la Compatilité Electro Magnétique (Classe A)**
EN 61000-4-2 :	*1995*	*Décharge électrostatique*
EN 61000-4-3:	*1997*	*Insensibilité à l'énergie rayonnée*
EN 61000-4-4 :	*1995*	*Courants électriques transitoires rapides*
EN 61000-4-5 :	*1995*	*Insensibilité aux surtensions*
EN 61000-4-6:	*1996*	*Insensibilité à l'énergie par conduction*
EN 61000-4-11 :	*1994*	*Insensibilité aux chutes subites, aux courtes interruptions et aux variations de tension*

Erklärt, daß das folgende Produkt: **Deutsch**

Beschreibung:	*Serie D8*
Modellnummer(n):	*D8(4 oder 8)(jede Zahl oder Buchstabe)*-(4 beliebige Buchstaben oder Ziffern)-(4 beliebige Buchstaben oder Ziffern)
Klassifikation:	*Installationskategorie II, Emissionsgrad II*
Nennspannung:	*12 bis 24 Vdc*
Nominaler Stromverbrauch:	*max. 610 mA*

Erfüllt die wichtigsten Normen der folgenden Anweisung(en) der Europäischen Union unter Verwendung des wichtigsten Abschnitts bzw. der wichtigsten Abschnitte der normalisierten Spezifikationen und der untenstehenden einschlägigen Dokumente:

89/336/EEC Elektromagnetische Übereinstimmungsanweisung

EN 61326:	**1997**	**Elektrogeräte zur Messung, Regelung und zum Laboreinsatz EMC - Richtlinien (Klasse A)**
EN 61000-4-2:	*1995*	*Elektrostatische Entladung*
EN 61000-4-3:	*1997*	*Strahlungsimmunität*
EN 61000-4-4:	*1995*	*Elektrische schnelle Stöße*
EN 61000-4-5:	*1995*	*Spannungsstoßimmunität*
EN 61000-4-6:	*1994*	*Störimmunität*
EN 61000-4-11:	*1994*	*Immunität gegen Spannungsgefälle, kurze Unterbrechungen und Spannungsabweichungen*

Declara que el producto siguiente: **Español**

Designación:	*Serie D8*
Números de modelo:	*D8(4 ó 8)(qualquier citra ó letra)-(cualquier 4 citras ó letras)-(cualquier 4 citras ó letras)*
Clasificación:	*Categoría de instalación II, grado de contaminación ambiental II*
Tensión nominal:	*12 a 24Vcc*
Consumo nominal de energía:	*610 mA máximo*

Cumple con los requisitos esenciales de las siguientes Directivas de la Unión Europea, usando las secciones pertinentes de las reglas normalizadas y los documentos relacionados que se muestran:

89/336/EEC - Directiva de Compatibilidad Electromagnética

EN 61326:	**1997**	**Equipo elétrico para medición control y uso en laboratorios - Requisitos de compatibilidad electromagnética (Clase A)**
EN 61000-4-2:	*1995*	*Descarga electrostática*
EN 61000-4-3:	*1997*	*Inmunidad radiada*
EN 61000-4-4:	*1995*	*Perturbaciones transitorias eléctricas rápidas*
EN 61000-4-5:	*1995*	*Sobretensión*
EN 61000-4-6:	*1994*	*Inmunidad conducida*
EN 61000-4-11:	*1994*	*Caídas de tensión, interrupciones breves y variaciones de tensión*

Dean Hoffman	Watsonville, California. USA
Name of Authorized Representative	Place of Issue
Controls Product Group Leader	September 12, 2002
Title of Authorized Representative	Date of Issue

Signature of Authorized Representative

Glossary

A

AC
See Alternating Current.

AC Line Frequency
The frequency of the ac line power measured in Hertz (Hz), usually 50 or 60 Hz.

Accuracy
Closeness between the value indicated by a measuring instrument and a physical constant or kno wn standards.

Action
The response of an output when the process v ariable is changed. See also Direct Action, Reverse Action.

Address
A numerical identifier for a controller when used i computer communications.

Alarm
A signal that indicates that the process has e xceeded or fallen below a certain range around the set point. For example, an alarm may indicate that a process is too hot or too cold. See also Failed Sensor Alarm, Global Alarm, High De viation Alarm, High Alarm, Loop Alarm, Low Deviation Alarm, Low Alarm.

Alarm Delay
The lag time before an alarm is activated.

Alternating Current (AC)
An electric current that re verses at re gular intervals, and alternates positive and negative values.

Ambient Temperature
The temperature of the air or other medium that surrounds the components of a thermal system.

American Wire Gauge (AWG)
A standard of the dimensional characteristics of wire used to conduct electrical current or signals. AWG is identical to the Brown and Sharpe (B&S) wire gauge.

Ammeter
An instrument that measures the magnitude of an electric current.

Ampere (Amp, A)
A unit that defines the rate of f w of electricity (current) in the circuit. Units are one coulomb (6.25 x 1018 electrons) per second.

Analog Output
A continuously v ariable signal that is used to represent a v alue, such as the process v alue or set point value. Typical hardw are configurations are 0 t 20mA, 4 to 20mA or 0 to 5 Vdc.

Automatic Mode
A feature in which the controller sets PID control outputs in response to the process v ariable and the set point.

Automatic Reset
The integral function of a PI or PID temperature controller that adjusts the process temperature to the set point after the system stabilizes. The inverse of integral.

Autotune
A feature that automatically sets temperature control PID values to match a particular thermal system.

AWG
See American Wire Gauge.

B

Baud Rate
The rate of information transfer in serial communications, measured in bits per second.

BCD
Binary coded decimal. F or BCD job loading, the binary states of three digital inputs are decoded as decimal numbers 1 to 8.

Bumpless Transfer
A smooth transition from automatic (closed loop) to manual (open loop) operation. The control output does not change during the transfer.

C

Calibration
The comparison of a measuring de vice (an unknown) against an equal or better standard.

Celsius
A temperature scale in which water freezes at 0° C and boils at 100° C at standard atmospheric pressure. The formula for conversion to the Fahrenheit scale is °F = (1.8 x °C) + 32. Formerly known as Centigrade.

Central Processing Unit (CPU)
The unit of a computing system that includes the circuits controlling the interpretation of instructions and their execution.

Circuit
Any closed path for electrical current. A configuratio of electrically or electromagnetically-connected components or devices.

Class
The model for a software object. Objects of a class are similar to one another. DeviceNet classes define wha attributes and services objects of that type have. Class services are used to examine and change class attributes.

Closed Loop
A control system that uses a sensor to measure a process variable and makes decisions based on that feedback.

Cold Junction
Connection point between thermocouple metals and the electronic instrument.

Common Mode Rejection Ratio
The ability of an instrument to reject electrical noise, with relation to ground, from a common voltage. Usually expressed in decibels (dB).

Communications
The use of digital computer messages to link components. See also Serial Communications, Baud Rate.

Control Action
The response of the PID control output relative to the difference between the process variable and the set point. See also Direct Action, Reverse Action.

Current
The rate of flw of electricity. The unit of measure is the Ampere (A). 1 Ampere = 1 coulomb per second.

Cycle Time
The time required for a controller to complete one on-off-on cycle. It is usually expressed in seconds.

Cyclic Redundancy Check (CRC)
An error checking method in communications that provides a high level of data security.

D

DAC
See Digital-to-Analog Converter.

Data Logging
A method of recording a process variable over a period of time. Used to review process performance.

DC
See Direct Current.

Default Parameters
The programmed instructions that are permanently stored in the microprocessor software.

Derivative Control (D)
The last term in the PID algorithm. Action that anticipates the rate of change of the process and compensates to minimize overshoot and undershoot. Derivative control is an instantaneous change of the control output in the same direction as the proportional error. This is caused by a change in the process variable that decreases over the time of the derivative. The derivative is expressed in seconds.

Deutsche Industrial Norms (DIN)
A set of technical, scientific and dimensional standards developed in Germany. Many DIN standards have worldwide recognition.

Deviation Alarm
See High Deviation Alarm, Low Deviation Alarm.

DeviceNet
DeviceNet is a network that connects industrial devices. DeviceNet is designed to provide a cost-effective and robust solution to device networking. DeviceNet is designed to transport control-oriented information associated with low-level devices and other information related to the system being controlled, such as configuration parameters

Digital-to-Analog Converter (DAC)
A device that converts a numerical input signal to a signal that is proportional to the input in some way.

DIN
See Deutsche Industrial Norms.

Direct Action
An output control action in which an increase in the process variable causes an increase in the output. Usually used with cooling applications.

Direct Current (DC)
An electric current that fl ws in one direction.

Distributed Zero Crossing (DZC)
A form of digital output control in which the output on/off state is calculated for e very ac line c ycle. Power is switched at the zero cross, which reduces electrical noise. See also Zero Cross.

DZC
See Distributed Zero Crossing.

E

Earth Ground
A metal rod, usually copper , that pro vides an electrical path to the earth, to pre vent or reduce the risk of electrical shock.

EIA/TIA
Electronic Industries Alliance (EIA) and Telecommunications Industry Association (TIA). See also Serial Communications.

EIA/TIA-232 — A standard for interface between data terminal equipment and data communications equipment for serial binary data interchange. This is usually for communications over a short distance (50 feet [15 m] or less) and to a single device.

EIA/TIA-485 — A standard for electrical characteristics of generators and recei vers for use in balanced digital multipoint systems. This is usually used to communicate with multiple de vices over a common cable or where distances o ver 50 feet (15 m) are required.

Electrical Noise
See Noise.

Electromagnetic Interference (EMI)
Electrical and magnetic noise imposed on a system. There are many possible causes, such as switching ac power inside the sine w ave. EMI can interfere with the operation of controllers and other devices.

Electrical-Mechanical Relays
See Relay, Electromechanical.

Emissivity
The ratio of radiation emitted from a surf ace compared to radiation emitted from a blackbody at the same temperature.

Engineering Units
Selectable units of measure, such as de grees Celsius or F ahrenheit, pounds per square inch, ne wtons per meter, gallons per minute, liters per minute, cubic feet per minute or cubic meters per minute.

F

Fahrenheit
The temperature scale that sets the freezing point of water at 32° F and its boiling point at 212° F at standard atmospheric pressure. The formula for con version to Celsius is °C = 5/9 (°F - 32).

Failed Sensor Alarm
Warns that an input sensor no longer produces a v alid signal.

Filter
Filters are used to handle v arious electrical noise problems.

Digital Filter — A filter that sl ws the response of a system when inputs change unrealistically or too fast. Equi valent to a standard resistor -capacitor (RC) filte

Digital Adaptive Filter — A filter that reject high frequency input signal noise (noise spikes).

Heat/Cool Filter — A filter that sl ws the change in the response of the heat or cool output. The output responds to a step change by going to approximately 2/3 its final alue within the numbers of scans that are set.

Frequency
The number of cycles over a specified period of time usually measured in c ycles per second. Also referred to as Hertz (Hz).

G

Gain
The amount of amplification used in an electrical ci -cuit. Gain can also refer to the proportional (P) mode of PID.

Global Alarm
Warns that one or more alarm conditions exist by activating a digital output.

Ground
An electrical line with the same electrical potential as the surrounding earth. Electrical systems are usually grounded to protect people and equipment from shocks due to malfunctions. Also referred to as "safety ground."

H

Hertz (Hz)
Frequency, measured in cycles per second.

High Deviation Alarm
Warns that the process has risen more than a certain amount above set point. It can be used as either an alarm or control function.

High Power
(As defined by Watlow Anafaze) Any voltage above 24 Vac or Vdc and any current level above 50 mAac or mAdc.

High Alarm
A signal that is associated with a set maximum value that can be used as either an alarm or boost control function.

HMI
Human-machine interface.

Hysteresis

Control Hysteresis — The range through which a variation of the input produces no noticeable change in the output. In the hysteresis, specific conditions can be placed on control output actions. Operators select the hysteresis. It is usually above the heating proportional band and below the cooling proportional band.

Process Hysteresis — In heat/cool applications, the +/- difference between heat and cool. Also known as process deadband.

I

Input

Analog Input — An input that accepts process variable information.

Digital Input — An input that accepts on and off signals.

Input Scaling
The converting of input signals to the engineering units of the process variable.

Input Type
The signal type that is connected to an input, such as thermocouple, RTD or process.

Instance
An object that is an occurance of a class. Each instance of a DeviceNet object can have unique values for its attributes and can be examined or changed using the instance services. Class services are used to examine and change class attributes, which affect all instances. Instance services are used to examine and change instance attributes which affect only that particular instance.

Integral Control (I)
Control action that automatically eliminates offset, or droop, between set point and actual process temperature.

J

Job
A set of operating conditions for a process that can be stored and recalled in a controller's memory. Also called a *recipe*.

Junction
The point where two dissimilar metal conductors join to form a thermocouple.

K

Keypad Lock
A feature that prevents operation of the keypad by unauthorized people.

L

Lag
The delay between the output of a signal and the response of the instrument to which the signal is sent.

Linearity
The deviation in response from an expected or theoretical straight line value for instruments and transducers. Also called *linearity error.*

Load
The electrical demand of a process, expressed in power (Watts), current (Amps) or resistance (Ohms).

The item or substance that is to be heated or cooled.

Low Deviation Alarm
Warns that the process has dropped more than a certain amount below set point. It can be used as either an alarm or control function.

Low Alarm
A signal that is associated with a set minimum value that can be used as either an alarm or boost control function.

M

Manual Mode
A selectable mode that has no automatic control aspects. The operator sets output levels.

Manual Reset
A parameter that allows the user to eliminate offset or droop between set point and actual process temperature. See also Integral.

Milliampere (mA)
One thousandth of an ampere.

N

Noise
Unwanted electrical signals that usually produce signal interference in sensors and sensor circuits. See also Electromagnetic Interference.

Noise Suppression
The use of components to reduce electrical interference that is caused by making or breaking electrical contact, or by inductors.

O

Object
An object is a software programming concept in which data and functionality are associated with virtual objects. DeviceNet objects consists of data called attributes and functions called services. Services are used to examine or change attribute values.

Offset
The difference between the set point and the actual value of the process variable. Offset is the error in the process variable that is typical of proportional-only control.

On/Off Control
A method of control that turns the output full on until set point is reached, and then off until the process differs from the set point by more than the hysteresis.

Open Loop
A control system with no sensory feedback.

Optical Isolation
Two electronic networks that are connected through an LED (Light Emitting Diode) and a photoelectric receiver. There is no electrical continuity between the two networks.

Output
Control signal action in response to the difference between set point and process variable.

Output Type
The form of control output, such as time proportioning, distributed zero crossing, Serial DAC or analog. Also the description of the electrical hardware that makes up the output.

Overshoot
The amount by which a process variable exceeds the set point before it stabilizes.

P

PID
Proportional, Integral, Derivative. A control mode with three functions: Proportional action dampens the system response, integral corrects for droops, and derivative prevents overshoot and undershoot.

Polarity
The electrical quality of having two opposite poles, one positive and one negative. Polarity determines the direction in which a current tends to flow.

Process Input
A voltage or current input that represents a straight line function.

Process Variable (PV)
The parameter that is controlled or measured. Typical examples are temperature, relative humidity, pressure, flow, fluid level, events, etc.

Proportional (P)
Output effort proportional to the error from set point. For example, if the proportional band is 20° and the process is 10° below the set point, the heat proportioned effort is 50 percent. The lower the PB value, the higher the gain.

Proportional Band (PB)
A range in which the proportioning function of the control is active. Expressed in units, degrees or percent of span. See also PID.

Proportional Control
A control using only the P (proportional) value of PID control.

Pulse Input
Digital pulse signals from devices, such as optical encoders.

PV
See Process Variable.

R

Ramp
A programmed increase in the temperature of a set point system.

Range
The area between two limits in which a quantity or value is measured. It is usually described in terms of lower and upper limits.

Recipe
See Job.

Relay

A switching device.

Electromechanical Relay — A power switching device that completes or interrupts a circuit by physically moving electrical contacts into contact with each other. Not recommended for PID control.

Solid State Relay (SSR) — A switching device with no moving parts that completes or interrupts a circuit electrically.

Reset
See Automatic Reset, Manual Reset.

Resistance
Opposition to the flow of electric current, measured in Ohms.

Resistance Temperature Detector (RTD)
A sensor that uses the resistance temperature characteristic to measure temperature. There are two basic types of RTDs: the wire RTD, which is usually made of platinum, and the thermistor, which is made of a semiconductor material. The wire RTD is a positive temperature coefficient sensor only, while the thermistor can have either a negative or positive temperature coefficient

Reverse Action
An output control action in which an increase in the process variable causes a decrease in the output. Heating applications usually use reverse action.

RTD
See Resistance Temperature Detector.

S

Serial Communications
A method of transmitting information between devices by sending all bits serially over a single communication channel.

Set Point (SP)
The desired value of the process variable. For example, the temperature at which a system is to be maintained.

Shield
A metallic foil or braided wire layer surrounding conductors that is designed to prevent electrostatic or electromagnetic interference from external sources.

Signal
Any electrical transmittance that conveys information.

Solid State Relay (SSR)
See Relay, Solid State.

Span
The difference between the lower and upper limits of a range expressed in the same units as the range.

Stability
The ability of a device to maintain a constant output with the application of a constant input.

T

Thermistor
A temperature-sensing device made of semiconductor material that exhibits a large change in resistance for a small change in temperature. Thermistors usually have negative temperature coefficients, although they are also available with positive temperature coefficients.

Thermocouple (T/C)
A temperature sensing device made by joining two dissimilar metals. This junction produces an electrical voltage in proportion to the difference in temperature between the hot junction (sensing junction) and the lead wire connection to the instrument (cold junction).

Thermocouple Extension Wire
A grade of wire used between the measuring junction and the reference junction of a thermocouple. Extension wire and thermocouple wire have similar properties, but extension wire is less costly.

Transmitter
A device that transmits temperature data from either a thermocouple or RTD by way of a two-wire loop. The loop has an external power supply. The transmitter acts as a variable resistor with respect to its input signal. Transmitters are desirable when long lead or extension wires produce unacceptable signal degradation.

U

Undershoot
The amount by which a process variable falls below the set point before it stabilizes.

V

Volt (V)
The unit of measure for electrical potential, voltage or electromotive force (EMF). See also Voltage.

Voltage (V)
The difference in electrical potential between two points in a circuit. It is the push or pressure behind current flow through a circuit. One volt (V) is the difference in potential required to move one coulomb of charge between two points in a circuit, consuming one joule of energy. In other words, one volt (V) is equal to one ampere of current (I) flowing through one ohm of resistance (R), or V = IR.

Z

Zero Cross
Action that provides output switching only at or near the zero-voltage crossing points of the ac sine wave.

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Menu Structure