CLS200
User’s Guide
Safety Warnings, Cautions, and Notes

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

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

WARNING! To reduce the risk of fire or electric shock, install the CLS200 in a controlled environment, relatively free of contaminants.

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.

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

WARNING! During autotuning, the controller will set the output to 100% until the process variable rises near the setpoint. Set the setpoint within the safe operating limits of your system.

WARNING! Do not rely solely on the output override feature to shut down your process. Install external safety devices or over-temperature devices for emergency shutdowns.

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

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.

Physically separate high-voltage circuits from low-voltage circuits and from CLS200 hardware. If possible, install high-voltage ac power circuits in a separate panel.

CAUTION! Without proper grounding, the CLS200 may not operate properly or may be damaged.

CAUTION! To prevent damage from incorrect connections, do not turn on the ac power before testing the connections.

CAUTION! The EPROM and other components are sensitive to damage from electrostatic discharge (ESD). To prevent ESD damage, use an ESD wrist strap or another antistatic device.

NOTE! For indoor use only.

Avertissements, Attentions et Remarques

AVERTISSEMENT! Le régulateur peut s’avérer défaillant avec un régime de puissance de sortie à 0 % ou à 100 %. Pour éviter tout risque de décès, blessure personnelle, endommagements de l’équipement ou dégâts matériels, veuillez installer des équipements d’arrêt d’urgence externes. Si un décès ou un accident venait à se produire, vous devez installer des équipements d’arrêt d’urgence approuvés qui fonctionnent indépendamment du matériel de contrôle du processus.

AVERTISSEMENT! Risques de choc électrique. Coupez le courant de votre processus tout entier avant de commencer à installer le régulateur.

AVERTISSEMENT! Afin de minimiser les risques d’incendie ou de choc électrique, installez le CLS200 dans un environnement sous contrôle et relativement épargné par les contaminants.

AVERTISSEMENT! Afin de minimiser les risques de choc électrique, d’incendie, et de dégâts matériels, suivez tous les codes de l’électricité locaux et nationaux. Des diamètres de fils, des fusibles et des disjoncteurs magnéto-thermiques adaptés sont indispensables pour un fonctionnement sécurisé de cet équipement.

AVERTISSEMENT! Utilisez uniquement une alimentation électrique avec une note de rang 2. Une approbation UL® impose une alimentation électrique de rang 2.

AVERTISSEMENT! Pendant le réglage automatique, le régulateur définira la sortie sur 100 % jusqu’à ce que la variable du processus s’élève près de la valeur seuil. Définissez la valeur seuil dans les limites de fonctionnement sécurisées de votre système.

AVERTISSEMENT! Ne comptez pas uniquement sur la fonction de priorité de sortie pour arrêter le processus. Installez les dispositifs de sécurité externes ou de protection contre l’excès de température pour les arrêts d’urgence.

AVERTISSEMENT! Ne comptez pas uniquement sur l’alarme d’échec du capteur pour ajuster la sortie dans l’éventualité d’une défaillance du capteur. Si la boucle est en contrôle manuel lorsqu’une alarme d’échec du capteur se déclenche, la sortie n’est pas ajustée. Installez des dispositifs externes indépendants qui éteindront le système si une défaillance se produit.

ATTENTION! Ne faites jamais fonctionner des conducteurs d’entrée en faisceau avec des câbles à haute puissance ou près d’autres sources d’EMI. Cela pourrait lier par couplage inductif la tension sur les conducteurs d’entrée et endommager le régulateur, ou créer un bruit et être à l’origine de mauvaises mesures et de régulations erronées.

Séparez physiquement les circuits haute-tension des circuits basse-tension et du matériel CLS200. Si possible, installez des circuits électriques ca haute-tension dans un panneau séparé.
ATTENTION! Sans mise à la terre appropriée, il se peut que le CLS200 ne fonctionne pas correctement ou soit endommagé.

ATTENTION! Pour éviter tout dommage causé par des connexions incorrectes, n’allumez pas l’alimentation électrique en ca avant d’avoir testé les connexions.

ATTENTION! L’EPROM et les autres composants sont sensibles aux dégâts provoqués par les décharges électrostatiques (ESD). Pour éviter de tels dommages, utilisez un bracelet antistatique ou tout autre dispositif antistatique.

REMARQUE : Destiné à un usage intérieur uniquement.

Technical Assistance
If you encounter a problem with your Watlow® controller, review your configuration information to verify that your selections are consistent with your application: inputs, outputs, alarms, limits, etc. If the problem persists, you can get technical assistance from your local Watlow representative (see back cover), by e-mailing your questions to wintechsupport@watlow.com or by dialing +1 (507) 494-5656 between 7 a.m. and 5 p.m. Central Time USA & Canada. Ask for for an Applications Engineer. Please have the complete model number available when calling.

Return Material Authorization (RMA)
1. Call Watlow Customer Service, (507) 454-5300, for a Return Material Authorization (RMA) number before returning any failed product to Watlow. If you do not know why the product failed, contact an Application Engineer. All RMA's require:
   - Ship-to address
   - Bill-to address
   - Contact name
   - Phone number
   - Method of return shipment
   - Your P.O. number
   - Detailed description of the problem
   - Any special instructions
   - Name and phone number of person returning the product

2. Prior approval and an RMA number from the customer service department is required when returning any product. Make sure the RMA number is on the outside of the carton and on all paperwork returned. Ship on a freight prepaid basis.

3. After we receive your return, we will examine it to verify the reason for the product failure. Unless otherwise agreed to in writing, Watlow’s standard warranty provisions, which can be located at www.watlow.com/terms, will apply to any failed product.

4. In the event that the product is not subject to an applicable warranty, we will quote repair costs to you and request a purchase order from you prior to proceeding with the repair work.

5. Watlow reserves the right to charge for no trouble found (NTF) returns.

Contact Watlow
1241 Bundy Boulevard
Winona, Minnesota 55987 USA
Phone: +1 (507) 454-5300
Fax: +1 (507) 452-4507
http://www.watlow.com

Warranty
This product is warranted by Watlow for a period of 36 months in accordance with the terms and conditions set forth on Watlow’s website, which may be accessed at www.watlow.com/terms.

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Chapter 1: System Overview

Manual Contents
This manual describes how to install, set up, and operate CLS200 controllers. 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 CLS200 series controllers.
- **Chapter 2: Installation** provides detailed instructions on installing the CLS200 series controller and its peripherals.
- **Chapter 3: Using CLS200** provides an overview of operator displays used for system monitoring and job selection.
- **Chapter 4: Setup** provides detailed descriptions of all menus and parameters for controller setup.
- **Chapter 5: Enhanced Features** describes process variable retransmit, ratio, differential and cascade control features available with the enhanced features option.
- **Chapter 6: Ramp/Soak** explains how to set up and use the features of the ramp/soak option.
- **Chapter 7: Turning and Control** describes available control algorithms and provides suggestions for applications.
- **Chapter 8: Troubleshooting and Reconfiguring** includes troubleshooting, upgrading and reconfiguring procedures for technical personnel.
- **Chapter 9: Linear Scaling Examples** provides an example configuring a pressure sensor, a flow sensor, and an encoder using linear scaling.
- **Chapter 10: Specifications** lists detailed specifications of the controller and optional components.
Getting Started

The following sections provide information regarding product features, technical descriptions, safety requirements, and preparation for operation.

Safety Symbols

These symbols are used throughout this manual:

- **NOTE!** Marks a short message to alert you to an important detail.
- **CAUTION!** Information that is important for protecting your equipment and performance. Be especially careful to read and follow all cautions that apply to your application.
- **WARNING!** Safety alert appears with information that is important for protecting you, others and equipment from damage. Pay very close attention to all warnings that apply to your application.

Initial Inspection

Accessories may or may not be shipped in the same container as the CLS200, depending upon their size. Check the shipping invoice carefully against the contents received in all boxes.

Product Features

The CLS200 series controllers provide 4, 8 or 16 fully independent control loops. When used as a stand-alone controller, you may operate the CLS200 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 CLS200 can be locally or remotely controlled via an EIA/TIA-232 or EIA/TIA-485 serial communications interface.

The CLS200 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, process variable offset calibration to correct for sensor inaccuracies, detection of broken, shorted or reversed thermocouples, and a choice of Fahrenheit or Celsius display.

- **Accepts Resistive Temperature Detectors (RTDs):** Use 3-wire, 100Ω, platinum, 0.00385-curve sensors with two choices for range and precision of measurements. (To use this input, order a four-loop or eight-loop controller with scaling resistors.)

- **Automatic Scaling for Linear Analog Inputs:** The CLS200 series automatically scales linear inputs used with industrial process sensors. Enter two points, and all input values are automatically scaled in your units. Scaling resistors must be installed.

- **Dual Outputs:** The CLS200 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:** You can 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.

• **Control Outputs:** Set high/low deviation and high/low process limits to operate digital outputs as on/off control functions or alarms.

• **Flexible Alarm Outputs:** Independently set high/low process alarms and a high/low deviation band alarm 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:** When any alarm is triggered, the global alarm output is also triggered, and it stays on until you acknowledge it.

• **CPU Watchdog:** The CLS200 series CPU watchdog timer output notifies you of system failure. Use it to hold a relay closed while the controller is running, so you are notified if the microprocessor shuts down.

• **Front Panel or Computer Operation:** Set up and run the controller from the front panel or from a local or remote computer. Watlow® offers SpecView, a Windows® compatible Human Machine Interface (HMI) software package that includes data logging and graphing features in addition to process monitoring.

• **Modbus® RTU Protocol, EIA/TIA-232 and 485 Communications:** Connect to PLCs, operator interface terminals and third-party software packages using the widely supported Modbus® RTU protocol.

• **Multiple Job Storage:** Store up to eight jobs in memory, and access them locally by entering a single job number or remotely via digital inputs. Each job is a set of operating conditions, including setpoints and alarms.

• **Nonlinear Output Curves:** Select either of two non-linear output curves for each control output.

• **Autotuning:** Use the autotune feature to set up your system quickly and easily.

• **Pulse Counter Input:** Use the pulse counter input for precise control of motor or belt speed.

• **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.
CLS200 Parts List

You may have received one or more of the following components. See Table 1.1 – Ordering Options for configuration information.

- CLS200 series controller
- Controller mounting kit
- TB50 with 50-pin SCSI cable
- EIA/TIA-232 or EIA/TIA-485 communications cable
- Special input resistors (installed in CLS200)

Table 1.1 — Ordering Options

<table>
<thead>
<tr>
<th>CHARACTERISTIC</th>
<th>OPTIONS</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Loops</td>
<td>4 Loops</td>
<td>The number of analog inputs and control loops that can be controlled based on the feedback from the analog inputs. There is an additional control loop that uses feedback from the pulse input.</td>
</tr>
<tr>
<td></td>
<td>8 Loops</td>
<td></td>
</tr>
<tr>
<td></td>
<td>16 Loops</td>
<td></td>
</tr>
<tr>
<td>Firmware</td>
<td>Standard</td>
<td>Includes closed-loop, PID control, autotune, alarms, job memory and failed sensor detection</td>
</tr>
<tr>
<td></td>
<td>Ramp and Soak</td>
<td>Provides the features of the standard version plus the additional Ramp and Soak features</td>
</tr>
<tr>
<td></td>
<td>Enhanced Features</td>
<td>Provides the features of the standard version plus the additional Enhanced Features</td>
</tr>
<tr>
<td>Digital I/O Termination</td>
<td>Screw Terminals (TB18)</td>
<td>TB18 Terminal Block</td>
</tr>
<tr>
<td></td>
<td>Mass Termination (SCSI)</td>
<td>SCSI Connector</td>
</tr>
<tr>
<td>Digital I/O Termination Board Accessory</td>
<td>None</td>
<td>No external terminal board included</td>
</tr>
<tr>
<td></td>
<td>TB50 Terminal Board</td>
<td>TB50-SCSI (50 Pin terminal board)</td>
</tr>
<tr>
<td>Digital I/O Termination Cable Accessory</td>
<td>None</td>
<td>Accessory cable to connect digital I/O signals between the SCSI connector on the controller and the TB50 board</td>
</tr>
<tr>
<td></td>
<td>3-foot SCSI cable</td>
<td></td>
</tr>
<tr>
<td></td>
<td>6-foot SCSI cable</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3-foot SCSI cable with right angle connector</td>
<td></td>
</tr>
<tr>
<td>Serial Communication Jumper Settings</td>
<td>EIA/TIA-232</td>
<td>Application uses 232 communication or no communication</td>
</tr>
<tr>
<td></td>
<td>EIA/TIA-485, not terminated</td>
<td>Application uses 485 communication, this controller is not last in the network</td>
</tr>
<tr>
<td></td>
<td>EIA/TIA-485, terminated</td>
<td>Application uses 485 communication, this controller is last in the network</td>
</tr>
<tr>
<td>Serial Communication Cable</td>
<td>None</td>
<td>No communication cable</td>
</tr>
<tr>
<td></td>
<td>10 foot communication cable</td>
<td>Cable for 232 communication</td>
</tr>
<tr>
<td></td>
<td>(DB-9 female/bare wires)</td>
<td></td>
</tr>
<tr>
<td>Mounting Hardware</td>
<td>Plastic collar and screw clips</td>
<td>Standard mounting hardware</td>
</tr>
<tr>
<td></td>
<td>Low profile metal L-brackets and screws</td>
<td>Mounting hardware for legacy applications with tight fit</td>
</tr>
<tr>
<td>Customer Specific</td>
<td>None</td>
<td>Not applicable to standard product</td>
</tr>
<tr>
<td>CHARACTERISTIC</td>
<td>OPTIONS</td>
<td>DESCRIPTION</td>
</tr>
<tr>
<td>---------------</td>
<td>---------</td>
<td>-------------</td>
</tr>
</tbody>
</table>
| Analog Input 1 | Options for all units:  
  • Standard (Thermocouples and -10 to 60mV)  
  • Linear Current: 0-20mA DC / 4-20mA DC  
  • Linear Voltage: 0-5VDC  
  • Linear Voltage: 0-10VDC  
  Additional options for 4-loop and 8-loop units:  
  • 100 Ohm RTD Tenths Degree  
  • 100 Ohm RTD Whole Degree | Standard units accept thermocouples on all inputs. Controllers can be equipped with resistors to scale signals for various types of sensors. These resistors must be factory installed. Sixteen loop controllers cannot accept RTD sensors. |
| Analog Input 2 | | |
| Analog Input 3 | | |
| Analog Input 4 | | |
| Analog Input 5 | | |
| Analog Input 6 | | |
| Analog Input 7 | | |
| Analog Input 8 | | |
| Analog Input 9 | | |
| Analog Input 10 | | |
| Analog Input 11 | | |
| Analog Input 12 | | |
| Analog Input 13 | | |
| Analog Input 14 | | |
| Analog Input 15 | | |
| Analog Input 16 | | |

Technical Description

This section contains a technical description of each component of your CLS200 series controller.

CLS200

The CLS200 is housed in an 1/8-DIN panel mount package. It contains the CPU, RAM with a built-in battery, EPROM, serial communications, digital I/O, analog inputs, the screen and touch keypad.

Figure 1.1 — CLS200 Rear Views

The CLS200 has the following features:

- Keypad and 2-line, 16-character display.
- Screw terminals for the power and analog inputs and communications.
- Input power is 12 to 24VDC at 1 Amp.
- A 50-pin SCSI cable connects the digital inputs and outputs to the 50-terminal block (TB50). Four-loop and eight-loop models are available with an 18-terminal block (TB18) in place of the SCSI connector, as shown in Figure 1.2.
The firmware resides in an EPROM. See *Replacing the EPROM on page 150* for information on removing and replacing the EPROM.

The operating parameters are stored in battery-backed RAM. If there is a power loss the operating parameters are unchanged. The battery has a ten-year shelf life, and it is not used when the unit is on.

The microprocessor performs all calculations for input signal linearization, PID control, alarms and communications.

**Front Panel Description**

The display and touch keypad provide an intelligent way to operate the controller. The display has 16 alphanumeric or graphic characters per line. The 8-key keypad allows you to change the operating parameters, controller functions, and displays.

The information-packed displays show process variables, setpoints, and output levels for each loop. A bar graph display, single loop display, scanning display and an alarm display offer a real-time view of process conditions. Two access levels allow operator changes and supervisor changes.

![Figure 1.2 — CLS200 Front Panel](image)

**TB50**

The TB50 is an optional screw-terminal interface for control wiring which allows you to connect relays, encoders and discrete I/O devices to the CLS200. The screw terminal blocks accept wires as large as 18 AWG (0.75 mm²). A 50-pin SCSI cable connects the TB50 to the CLS200.

![Figure 1.3 — TB50](image)
CLS200 Cabling
Watlow offers optional cables to support installing your CLS200. A 50-pin SCSI cable connects the TB50 to the CLS200.

The optional cable used to connect the CLS200 to a computer using EIA/TIA-232 communications has a DB9 connector for the computer and bare wires for connecting to the CLS200.

Safety
Watlow 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 CLS200 controller may fail full-on (100% output power) or full-off (0% output power), or may remain full-on if an undetected sensor failure occurs. For more information about failed sensor alarms, see Failed Sensor Alarms on page 59.

Design your system to be safe even if the controller sends a 0% or 100% output power signal at any time. Install independent, external safety devices 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 a mechanical contactor. The limit controller monitors for a hazardous condition such as an undertemperature 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% or 100% power output state. To prevent death, personal injury, equipment damage or property damage, install external safety shutdown devices. If death or injury may occur, you must install approved 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, this controller can be programmed to reset the control outputs to off (this is the default). Typically, when power is re-started, the controller restarts to data stored in memory. If you have programmed the controller to restart with control outputs on, the memory-based restart might create an unsafe process condition for some installations. Therefore, you should only set the restart with outputs on if you are certain your system will safely restart. (See Process Power Digital Input on page 71.)

When using a computer or host device, you can program the software to automatically reload desired operating constants or process values on power-up. Keep in mind that these convenience features do not eliminate the need for independent safety devices.

Contact Watlow if you have any questions about system safety or system operation.
Chapter 2: Installation

This chapter describes how to install the CLS200 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 (EIA/TIA-232 or EIA/TIA-485)
- Output wiring

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

WARNING! The controller may fail in a 0% or 100% power output state. To prevent death, personal injury, equipment damage or property damage, install external safety shutdown devices. If failure may cause death or injury, you must install approved safety shutdown 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 Figures 2.2 to 2.11.)

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

Install the controller in a location free from excessive heat (below 50°C [122°F]), dust, and unauthorized handling. Electromagnetic and radio frequency interference can induce noise on sensor wiring. Select locations for the CLS200 and TB50 such that wiring can be routed clear of sources of interference such as high voltage wires, power switching devices and motors.

![Figure 2.1 — CLS200 System Components](image)

**NOTE!** For indoor use only.

**WARNING!** To reduce the risk of fire or electric shock, install the CLS200 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.
- 1/8-DIN rectangular punch 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 in. (3 mm) flathead screwdriver for wiring
- Multimeter

Mounting the Controller

Mount the controller before you mount the terminal block or do any wiring. The controller’s placement affects placement and wiring considerations for the other components of your system.

Ensure there is enough clearance for mounting brackets, terminal blocks, and cable and wire connections.

![Figure 2.2 — Clearance with TB18 Option](image1)

![Figure 2.3 — Clearance with Standard SCSI Cable](image2)
Figure 2.3a — Clearance with Right-Angle SCSI Cable

Figure 2.4 — Mounting Bracket Clearance

Figure 2.5 — Panel Thickness and Cutout Size
We recommend you mount the controller in a panel not more than 0.2 in. (5 mm) thick.

1. Choose a panel location free from excessive heat (below 50°C [122°F]), dust, and unauthorized handling. (Make sure there is adequate clearance for the mounting hardware, terminal blocks, and cables. The controller extends 7.00 in. (178 mm) behind the panel. Allow adequate room for wiring and cables beyond the connectors.)

2. Temporarily cover 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 1.80 in. (46 mm) by 3.63 in. (92 mm) as shown above. (Use caution; the dimensions given here have 0.02 in. (0.5 mm) 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.

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’s case.

8. Make sure the controller is seated properly. Tighten the installation screws firmly against the 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 you can mount the TB50: use the pre-installed DIN rail mounting brackets or use the plastic standoffs. Follow the corresponding procedure to mount the board.

*Figure 2.6 — 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 2.7.)

![Figure 2.7 — TB50 Mounted on a DIN Rail (Front)](image)

To remove the TB50 from the rail, use a flathead screwdriver to unsnap the bracket from the rail. (See Figure 2.8.)

![Figure 2.8 — TB50 Mounted on DIN Rail (Side)](image)

**Mounting with Standoffs**
1. Remove the DIN rail mounting brackets from the TB50.
2. Select 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.

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

Refer to the power supply manufacturer’s instructions for mounting information. Choose a Class 2 power supply that supplies an isolated regulated 12 to 24VDC at 1A.

**Mounting Environment**

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

**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 CLS200 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 mm²) 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 CLS200 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>
<thead>
<tr>
<th>FUNCTION</th>
<th>MFR. P/N</th>
<th>NO. OF WIRES</th>
<th>AWG</th>
<th>MM²</th>
<th>MAXIMUM LENGTH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Analog Inputs</td>
<td>Belden 9154</td>
<td>2</td>
<td>20</td>
<td>0.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Belden 8451</td>
<td>2</td>
<td>22</td>
<td>0.5</td>
<td></td>
</tr>
<tr>
<td>RTD Inputs</td>
<td>Belden 8772</td>
<td>3</td>
<td>20</td>
<td>0.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Belden 9770</td>
<td>3</td>
<td>22</td>
<td>0.5</td>
<td></td>
</tr>
<tr>
<td>Thermocouple Inputs</td>
<td>T/C Ext. Wire</td>
<td>2</td>
<td>20</td>
<td>0.5</td>
<td></td>
</tr>
<tr>
<td>Control Outputs</td>
<td>Belden 9539</td>
<td>9</td>
<td>24</td>
<td>0.2</td>
<td></td>
</tr>
<tr>
<td>and Digital I/O</td>
<td>Belden 9542</td>
<td>20</td>
<td>24</td>
<td>0.2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ribbon Cable</td>
<td>50</td>
<td>22 to 14</td>
<td>0.5 to 2.5</td>
<td></td>
</tr>
<tr>
<td>Analog Outputs</td>
<td>Belden 9154</td>
<td>2</td>
<td>20</td>
<td>0.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Belden 8451</td>
<td>2</td>
<td>22</td>
<td>0.5</td>
<td></td>
</tr>
<tr>
<td>Computer Communication:</td>
<td>Belden 9729</td>
<td>4</td>
<td>24</td>
<td>0.2</td>
<td>4,000 ft. (1,219 m)</td>
</tr>
<tr>
<td>EIA/TIA-232, 422</td>
<td>Belden 9730</td>
<td>6</td>
<td>24</td>
<td>0.2</td>
<td>4,000 ft. (1,219 m)</td>
</tr>
<tr>
<td>or 485, or 20mA</td>
<td>Belden 9842</td>
<td>4</td>
<td>24</td>
<td>0.2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Belden 9843</td>
<td>6</td>
<td>24</td>
<td>0.2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Belden 9184</td>
<td>4</td>
<td>22</td>
<td>0.5</td>
<td>6,000 ft. (1,829 m)</td>
</tr>
</tbody>
</table>

Noise Suppression

The CLS200’s 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 CLS200 case.
Symptoms of RFI/EMI
If your controller displays the following symptoms, suspect EMI:

- The controller’s display blanks out and then reenergizes as if power had been turned off for a moment.
- The process variable does not display correctly.

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

Avoiding RFI/EMI
To avoid or eliminate most RFI/EMI noise problems:

- Connect the CLS200 case to earth ground. The CLS200 system includes noise suppression circuitry. This circuitry requires proper grounding.
- Separate the 120 or 240VAC power leads from the low-level input and output leads connected to the CLS200 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, try to avoid mounting them in the same panel as the CLS200 series equipment.
- If you must use electromechanical relays and you must place them in a panel with CLS200 series equipment, use a 0.01 microfarad capacitor rated at 1000VAC (or higher) in series with a $47 \Omega$, 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 130VAC for 120VAC control circuits across the load, which limits the peak ac voltage to about 180VAC. 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
It is strongly recommended that you:

- 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.
- If you are using EIA/TIA-232 from a non-isolated host, either (1) do not connect any other power common point to earth ground, or (2) use an optical isolator in the communications line.
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 communications port.
- 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 each other or to earth ground:

- Power supply dc common
- TB1, terminals 5, 6, 11, 12 (analog common)
- TB1, terminal 17 (reference voltage common)
- TB1, terminals 23, 24 (communications common)
- TB2, terminal 2 (dc power common)

Special Precautions for the Sixteen-Loop Models

Sixteen-loop models have single-ended inputs. All the negative sensor leads are tied to the analog common. That means there is no sensor-to-sensor isolation. Proper grounding is critical for this unit. Take these additional precautions with a sixteen-loop controller:

- Use all ungrounded or all well-grounded thermocouples, not a mix.
- If using a mixture of thermocouples or low-voltage inputs (<500mV) and current inputs, connect the negative leads of the current transmitters to terminal 17 (Ref Com) on TB1.
- If using voltage transmitters, use only sourcing models or configuration. Sinking configurations will not work.
- Isolate the controller's communication port (if used) by using an optically isolated 232-to-485 converter.

Personal Computers and Ground Loops

Many PC communications ports connect the communications common to chassis ground. When such a PC is connected to the controller, this can provide a path to ground for current from the process that can enter the controller through a sensor (such as a thermocouple). This creates a ground loop that can affect communications and other controller functions. To eliminate a ground loop, either use an optically isolated communications adapter or take measures to ensure that sensors and all other connections to the controller are isolated and not conducting current into the unit.
Power Connections

This section covers making the power connections to the CLS200 and connecting the TB50.

Figure 2.10 – CLS200 Series Controller with TB18

Figure 2.11 – CLS200 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

<table>
<thead>
<tr>
<th>FUNCTION</th>
<th>POWER SUPPLY</th>
<th>CLS200 TB2</th>
</tr>
</thead>
<tbody>
<tr>
<td>DC Power (Controller)</td>
<td>+12 to 24VDC</td>
<td>+</td>
</tr>
<tr>
<td>DC Common</td>
<td>12 to 24VDC Common</td>
<td>–</td>
</tr>
<tr>
<td>Earth Ground</td>
<td>Ground</td>
<td></td>
</tr>
</tbody>
</table>

1. Connect the dc common terminal on the power supply to the dc common (-) terminal on CLS200 TB2.
2. Connect the positive terminal on the power supply to the dc positive (+) terminal on CLS200 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 CLS200 chassis and must be connected to earth ground.

5. Connect 120/240VAC 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 inch-pound (0.5 to 0.6 Nm).

**CAUTION!** Without proper grounding, the CLS200 may not operate properly or may be damaged.

**CAUTION!** To prevent damage from incorrect connections, do not turn on the ac power before testing the connections as explained in Testing Your System on page 31.

**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**
Connecting TB50 to CLS200
1. Connect the SCSI cable to the controller.
2. Connect the SCSI cable to the TB50.

Testing Your 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 CLS200. The display should read CALCULATING CHECKSUM then show the bar graph display. (See Figure 3.3.) If you do not see these displays, disconnect power and check wiring and power supply output.
2. Measure the +5VDC supply at the TB50 or TB18:
   a. Connect the voltmeter’s common lead to TB50 or TB18 terminal 3 or TB18 terminal 2.
   b. Connect the voltmeter’s positive lead to TB50 or TB18 screw terminal 1. The voltage should be +4.75 to +5.25VDC.

Digital Output Test
Use this procedure to test the controller’s outputs before loads are connected. If using it at another time for troubleshooting, disconnect loads from outputs before testing.
1. Connect a 500Ω to 100kΩ resistor between TB50 or TB18 screw terminal 1 and a digital output terminal. (See Table 2.7 TB18 Connections; Table 2.8 TB50 Connections for CLS204 and CLS208; or Table 2.9 TB50 Connections for CLS216.)
2. Connect the voltmeter’s positive lead to screw terminal 1.
3. Connect the common lead to the digital output terminal.
4. Use the digital output test in the MANUAL I/O TEST menu to turn the digital output on and off. (See Test Digital Output on page 94 and Digital Output Number on page 94.) When the output is ON, the output voltage should be less than 1V. When the output is OFF, the output voltage should be between 4.75 and 5.25V.

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% output. See Selecting the Control Status on page 56.

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 MANUAL I/O TEST menu. (See Digital Inputs on page 94.) This test shows whether the digital inputs are H (high, or open) or L (low, or closed).
3. Attach a wire to the terminal of the digital input you want to test. See Table 2.7 to Table 2.9 for connections.

   a. When the wire is connected only to the digital input terminal, the digital input test should show that the input is H (high, or 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 L (low, or closed).

Sensor Wiring

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

All inputs are connected to the terminals on TB1 on the back of the controller. The tables below list the connector locations.

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 — Analog Input Connections on TB1 for Four-Loop and Eight-Loop Models |
|-----------------|-----------------|-----------------|
| INPUT           | + TERMINAL      | – TERMINAL      |
| Input 1         | 1               | 2               |
| Input 2         | 3               | 4               |
| Input 3         | 7               | 8               |
| Input 4         | 9               | 10              |
| Input 5         | 13              | 14              |
| Input 6         | 15              | 16              |
| Input 7         | 19              | 20              |
| Input 8         | 21              | 22              |

| Table 2.4 — Analog Input Connections on TB1 for Sixteen-Loop Models |
|-----------------|-----------------|-----------------|-----------------|
| INPUT           | + TERMINAL      | COMMON          | REFERENCE COMMON* |
| Input 1         | 1               | 5               | 17              |
| Input 2         | 3               | 5               | 17              |
| Input 3         | 7               | 5               | 17              |
| Input 4         | 9               | 5               | 17              |
| Input 5         | 13              | 11              | 17              |
| Input 6         | 15              | 11              | 17              |
| Input 7         | 19              | 11              | 17              |
| Input 8         | 21              | 11              | 17              |
### Input Wiring Recommendations

Use multicolored stranded shielded cable for analog inputs. Watlow recommends that you use 20 AWG wire (0.5 mm²). If the sensor manufacturer requires it, you can also use 24 or 22 AWG wiring (0.2 mm²). Most inputs use a shielded twisted pair; some require a 3-wire input.

Follow the instructions pertaining to the type(s) of input(s) you are installing.

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

- Linear inputs with ranges between -10 and 60mV.

Any unused inputs should be set to SKIP or jumpered to avoid thermocouple break alarms.

### Thermocouple Connections

Connect the positive lead of any of the supported thermocouple types to the IN+ terminal for one of the loops and the negative lead to the corresponding IN- terminal.

Use 18 or 20 AWG (0.5 or 0.75 mm²) for all the thermocouple inputs. Most thermocouple wire is solid, unshielded wire. When using shielded wire, ground one end only.

*For sixteen-loop controllers when mixing current inputs and low-voltage inputs (thermocouples or voltage inputs less than 1V), connect the current signal to the positive input and reference common (terminal TB1-17). If no low-voltage sensors are used, connect current inputs to the positive input and common terminals listed in the table above.

---

**INPUT** | + TERMINAL | COMMON | REFERENCE COMMON
---|---|---|---
Input 9 | 2 | 6 | 17
Input 10 | 4 | 6 | 17
Input 11 | 8 | 6 | 17
Input 12 | 10 | 6 | 17
Input 13 | 14 | 12 | 17
Input 14 | 16 | 12 | 17
Input 15 | 20 | 12 | 17
Input 16 | 22 | 12 | 17

---

*Figure 2.13 — Thermocouple Connections*
NOTE! When mixing current inputs with low-voltage inputs (thermocouples or voltage inputs less than 1V) to a sixteen-loop controller, connect the current inputs to the IN+ and Ref Com terminals. If no low-voltage sensors are used, connect current inputs to the IN+ and Com terminals on TB1. For all inputs to a four or eight-loop controller, connect the sensors to the IN+ and IN- terminals.

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

- With a sixteen-loop controller, use only ungrounded thermocouples with each thermocouple sheath electrically connected to earth ground. The negative sensor terminals on sixteen-loop controllers are tied to analog common.
- With a four-loop or eight-loop controller, 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 CLS200 uses a floating analog common for sensor measurements. The noise protection circuits on the sensor inputs function correctly only when the controller is correctly installed. See Ground Loops on page 28.

RTD Input Connections
This input type requires scaling resistors. Watlow recommends that you use a 100 W, 3-wire platinum RTD to prevent reading errors due to cable resistance. If you use a 2-wire RTD, jumper the negative input to common. If you must use a 4-wire RTD, leave the fourth wire unconnected.

Reference Voltage Terminals
The +5V Ref and Ref Com terminals are provided in order to power external bridge circuits for special sensors. Do not connect any other types of devices to these terminals.

Voltage Input Connections
This input type requires scaling resistors. Special input resistors installed at Watlow divide analog input voltages such that the controller sees a -10 to 60mV signal on the loop.
Current Input Connections

This input type requires scaling resistors. Special input resistors installed at Watlow for analog current signals are such that the controller sees a -10 to 60mV signal across its inputs for the loop.

Four-Loop or Eight-Loop Controller

Sixteen-Loop Controller

NOTE! When mixing current inputs with low-voltage inputs (thermocouples or voltage inputs less than 1V) to a sixteen-loop controller, connect the current inputs to the IN+ and Ref Com terminals. If no low-voltage sensors are used, connect current inputs to the IN+ and Com terminals on TB1.

Pulse Input Connections

The CLS200 can accept a pulse input of up to 2000Hz from a device such as an encoder. The frequency of this input is scaled with user-set parameters. See Setup Loop Input Menu on page 74 and Example 3: A Pulse Encoder on page 161. This scaled value is the process variable for loop 5 on a four-loop model, loop 9 on an eight-loop model or loop 17 on a sixteen-loop model.

The CLS200 can accommodate encoder signals up to 24VDC using a voltage divider or can power encoders with the 5VDC from the TB50 or TB18. The following figures illustrate connecting encoders. A pull-up resistor in the CLS200 allows open collector inputs to be used.
CLS200 and TB50 or TB18

Figure 2.17 — Encoder with 5VDC TTL Signal

For encoders with signals greater than 5VDC, use a voltage divider to drop the voltage to 5 volts at the input. Use appropriate values for R1 and R2 depending on the encoder excitation voltage. Be sure not to exceed the specific current load on the encoder.

Wiring Control and Digital I/O

This section describes how to wire and configure the control outputs for the CLS200 series controller.

NOTE! Control outputs are connected to the CLS200’s common when the control output is on (low). Be careful when you connect external devices that may have a low side at a voltage other than controller ground, since you may create ground loops.

If you expect grounding problems, use isolated solid state relays and isolate the control device inputs.

The CLS200 provides dual PID control outputs for each loop. These outputs can be enabled or disabled, and are connected via TB50 or TB18.

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

Once you have wired 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 CLS200 series provides dual control outputs for up to 16 loops. The controller’s default configuration has all heat outputs enabled and all cool outputs disabled. Disabling a heat output makes that output available to be used as a control or an alarm output. See Enable or Disable Heat or Cool Outputs on page 85. The CPU watchdog timer output can be used to monitor the state of the controller with an external circuit or device. See CPU Watchdog Timer on page 39.

<table>
<thead>
<tr>
<th>STATE</th>
<th>VALUE</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Off</td>
<td>High</td>
<td>Open circuit</td>
</tr>
<tr>
<td>On</td>
<td>Low</td>
<td>Sinking current to common</td>
</tr>
</tbody>
</table>

The digital outputs sink current from the load to the controller common. The load may powered by the 5VDC supplied by the controller at the TB50. Alternately, an external power supply may be used to drive loads.

Keep in mind the following points when using an external power supply:

- The CLS200 power supply available from Watlow includes a 5VDC supply. When using it to supply output loads, connect the 5VDC common to the 15VDC common at the power supply.
- Do not exceed +24 volts.
- If you tie the external load to earth ground, or if you cannot connect it as shown in (See Figure 2.21), then use a solid-state relay.

All digital outputs are sink outputs referenced to the CLS200 series controller common supply. These outputs are low (pulled to common) when they are on.

The outputs conduct current when they are low or on. The maximum current sink capability is 60mA at 24VDC. They cannot “source” current to a load.
Using Internal Power Supply

Using External Power Supply

**Figure 2.19 — Digital Output Wiring**

**Configuring Outputs**

Keep in mind the following points as you choose outputs for control and alarms:

- You can enable or disable the control outputs. The default setting is heat outputs enabled, cool outputs 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 nonlatching.
- Alarms can be suppressed during process start up and for preprogrammed durations. See **Alarm Delay on page 93**.
- Alarm outputs can be configured as a group as normally on (low) or normally off (high). See **Digital Output Polarity on Alarm on page 73**.

**Control and Alarm Output Connections**

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

The 34 control and alarm outputs are open collector outputs referenced to the CLS200’s common. Each output sinks up to 60mA DC to the controller common when on.
NOTE! Control outputs are SINK outputs. They are Low when the output is ON. Connect them to the negative side of solid state relays.

Figure 2.20 shows sample heat, cool and alarm output connections.

![Figure 2.20 — Sample Heat, Cool and Alarm Output Connections](image)

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 in order to determine if the controller is powered and operational. Do not exceed 5VDC, 10mA DC rating for the watchdog output. The output is low (on) when the microprocessor is operating; when it stops operating, the output goes high (off).

Figure 2.22 and Figure 2.23 show the recommended circuit for the watchdog timer output for the TB50 and the TB18.

![Figure 2.22 — TB50 Watchdog Timer Output](image)
Digital Inputs

All digital inputs are transistor-transistor logic (TTL) level inputs referenced to control common and the internal +5V power supply of the CLS200.

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 10k resistors pull the digital inputs high to 5VDC with respect to the controller common.

<table>
<thead>
<tr>
<th>STATE</th>
<th>VALUE</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Off</td>
<td>High</td>
<td>Open circuit</td>
</tr>
<tr>
<td>On</td>
<td>Low</td>
<td>Digital input connected to controller common</td>
</tr>
</tbody>
</table>

External Switching Devices

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 off, the switching device must provide an impedance of at least 11kΩ to ensure that the voltage will rise to greater than 3.7VDC. When on, the switch must provide not more than 1kΩ impedance to ensure the voltage drops below 1.3VDC.

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).

Functions Activated by Digital Inputs

Use digital inputs to activate the following functions:

- Load a job that is stored in controller memory. See Job Select Digital Inputs on page 68.
- Change all loops to manual mode at specified output levels. See Output Override Digital Input on page 70.
- Restore control automatically after a failed sensor has been repaired. See Restore PID Digital Input on page 83.
Figure 2.24 — Wiring Digital Inputs

### TB18 Connections

<table>
<thead>
<tr>
<th>TERMINAL</th>
<th>FUNCTION</th>
<th>CONTROL OUTPUT¹</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>FOUR-LOOP CONTROLER</td>
</tr>
<tr>
<td>1</td>
<td>+5VDC</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>CTRL COM</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Watchdog timer</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Global alarm</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Output 1</td>
<td>Loop 1 heat</td>
</tr>
<tr>
<td>6</td>
<td>Output 2</td>
<td>Loop 2 heat</td>
</tr>
<tr>
<td>7</td>
<td>Output 3</td>
<td>Loop 3 heat</td>
</tr>
<tr>
<td>8</td>
<td>Output 4</td>
<td>Loop 4 heat</td>
</tr>
<tr>
<td>9</td>
<td>Output 5</td>
<td>Pulse loop heat</td>
</tr>
<tr>
<td>10</td>
<td>Output 6</td>
<td>Loop 1 cool</td>
</tr>
<tr>
<td>11</td>
<td>Output 7</td>
<td>Loop 2 cool</td>
</tr>
<tr>
<td>12</td>
<td>Output 8</td>
<td>Loop 3 cool</td>
</tr>
<tr>
<td>13</td>
<td>Output 9</td>
<td>Loop 4 cool</td>
</tr>
<tr>
<td>14</td>
<td>Output 10</td>
<td>Pulse loop cool</td>
</tr>
<tr>
<td>15</td>
<td>Output 34²</td>
<td>Serial DAC clock</td>
</tr>
<tr>
<td>16</td>
<td>Input 1</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>Input 2</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>Input 3/Pulse input</td>
<td></td>
</tr>
</tbody>
</table>

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 ramp/soak events.

² For Watlow Serial DAC, the CLS200 series controller uses digital output 34 for a clock line. You cannot use output 34 for anything else when you have a control output configured for the SDAC.
## TB50 Connections

Table 2.8 – TB50 Connections for Four-Loop and Eight-Loop Controllers

<table>
<thead>
<tr>
<th>TERMINAL</th>
<th>FUNCTION</th>
<th>CONTROL OUTPUT¹</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>8-LOOP</td>
<td>4-LOOP</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>+5VDC</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>CTRL COM</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Not Used</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Pulse Input</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Output 1</td>
<td>Loop 1 heat</td>
<td>Loop 1 heat</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Output 2</td>
<td>Loop 2 heat</td>
<td>Loop 2 heat</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Output 3</td>
<td>Loop 3 heat</td>
<td>Loop 3 heat</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Output 4</td>
<td>Loop 4 heat</td>
<td>Loop 4 heat</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>Output 5</td>
<td>Loop 5 heat</td>
<td>Pulse loop heat</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>Output 6</td>
<td>Loop 6 heat</td>
<td>Loop 1 cool</td>
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<tr>
<td>21</td>
<td>Output 7</td>
<td>Loop 7 heat</td>
<td>Loop 2 cool</td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>Output 8</td>
<td>Loop 8 heat</td>
<td>Loop 3 cool</td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>Output 9</td>
<td>Pulse loop heat</td>
<td>Loop 4 cool</td>
<td></td>
</tr>
<tr>
<td>27</td>
<td>Output 10</td>
<td>Loop 1 cool</td>
<td>Pulse loop cool</td>
<td></td>
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<tr>
<td>29</td>
<td>Output 11</td>
<td>Loop 2 cool</td>
<td></td>
<td></td>
</tr>
<tr>
<td>31</td>
<td>Output 12</td>
<td>Loop 3 cool</td>
<td></td>
<td></td>
</tr>
<tr>
<td>33</td>
<td>Output 13</td>
<td>Loop 4 cool</td>
<td></td>
<td></td>
</tr>
<tr>
<td>35</td>
<td>Output 14</td>
<td>Loop 5 cool</td>
<td></td>
<td></td>
</tr>
<tr>
<td>37</td>
<td>Output 15</td>
<td>Loop 6 cool</td>
<td></td>
<td></td>
</tr>
<tr>
<td>39</td>
<td>Output 16</td>
<td>Loop 7 cool</td>
<td></td>
<td></td>
</tr>
<tr>
<td>41</td>
<td>Output 17</td>
<td>Loop 8 cool</td>
<td></td>
<td></td>
</tr>
<tr>
<td>43</td>
<td>Input 1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>45</td>
<td>Input 3</td>
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</tr>
<tr>
<td>49</td>
<td>Input 7</td>
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</table>

<table>
<thead>
<tr>
<th>TERMINAL</th>
<th>FUNCTION</th>
<th>CONTROL OUTPUT¹</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>8-LOOP</td>
<td>4-LOOP</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>+5VDC</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>CTRL COM</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Watchdog Timer</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Global Alarm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Output 34²</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Output 33</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Output 32</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>Output 31</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>Output 30</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>Output 29</td>
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<tr>
<td>22</td>
<td>Output 28</td>
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<td>24</td>
<td>Output 27</td>
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<td>26</td>
<td>Output 26</td>
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<tr>
<td>28</td>
<td>Output 25</td>
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</tr>
<tr>
<td>30</td>
<td>Output 24</td>
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<td></td>
</tr>
<tr>
<td>32</td>
<td>Output 23</td>
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<td></td>
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</tr>
<tr>
<td>34</td>
<td>Output 22</td>
<td></td>
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</tr>
<tr>
<td>36</td>
<td>Output 21</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>38</td>
<td>Output 20</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>40</td>
<td>Output 19</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>42</td>
<td>Output 18</td>
<td>Pulse loop cool</td>
<td></td>
<td></td>
</tr>
<tr>
<td>44</td>
<td>Input 2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>46</td>
<td>Input 4</td>
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<td>48</td>
<td>Input 6</td>
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<tr>
<td>50</td>
<td>Input 8</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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 ramp/soak events.
² For Watlow Serial DAC, the controller uses digital output 34 (terminal 10) for a clock line. You cannot use output 34 for anything else when you have a control output configured for the SDAC.
### Table 2.9 – TB50 Connections for Sixteen-Loop Controllers

<table>
<thead>
<tr>
<th>TERMINAL</th>
<th>FUNCTION</th>
<th>OUTPUT 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>+5VDC</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>CTRL COM</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Not Used</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Pulse Input</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Output 1</td>
<td>Loop 1 heat</td>
</tr>
<tr>
<td>11</td>
<td>Output 2</td>
<td>Loop 2 heat</td>
</tr>
<tr>
<td>13</td>
<td>Output 3</td>
<td>Loop 3 heat</td>
</tr>
<tr>
<td>15</td>
<td>Output 4</td>
<td>Loop 4 heat</td>
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<tr>
<td>17</td>
<td>Output 5</td>
<td>Loop 5 heat</td>
</tr>
<tr>
<td>19</td>
<td>Output 6</td>
<td>Loop 6 heat</td>
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<td>21</td>
<td>Output 7</td>
<td>Loop 7 heat</td>
</tr>
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<td>23</td>
<td>Output 8</td>
<td>Loop 8 heat</td>
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<tr>
<td>25</td>
<td>Output 9</td>
<td>Loop 9 heat</td>
</tr>
<tr>
<td>27</td>
<td>Output 10</td>
<td>Loop 10 heat</td>
</tr>
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<td>29</td>
<td>Output 11</td>
<td>Loop 11 heat</td>
</tr>
<tr>
<td>31</td>
<td>Output 12</td>
<td>Loop 12 heat</td>
</tr>
<tr>
<td>33</td>
<td>Output 13</td>
<td>Loop 13 heat</td>
</tr>
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<td>35</td>
<td>Output 14</td>
<td>Loop 14 heat</td>
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<td>37</td>
<td>Output 15</td>
<td>Loop 15 heat</td>
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<td>39</td>
<td>Output 16</td>
<td>Loop 16 heat</td>
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<td>41</td>
<td>Output 17</td>
<td>Pulse loop heat</td>
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<td>43</td>
<td>Input 1</td>
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<td>45</td>
<td>Input 3</td>
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<td>47</td>
<td>Input 5</td>
<td></td>
</tr>
<tr>
<td>49</td>
<td>Input 7</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>TERMINAL</th>
<th>FUNCTION</th>
<th>OUTPUT 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>+5VDC</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>CTRL COM</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Watchdog Timer</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Global Alarm</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Output 34²</td>
<td>Pulse loop cool</td>
</tr>
<tr>
<td>12</td>
<td>Output 33</td>
<td>Loop 16 cool</td>
</tr>
<tr>
<td>14</td>
<td>Output 32</td>
<td>Loop 15 cool</td>
</tr>
<tr>
<td>16</td>
<td>Output 31</td>
<td>Loop 14 cool</td>
</tr>
<tr>
<td>18</td>
<td>Output 30</td>
<td>Loop 13 cool</td>
</tr>
<tr>
<td>20</td>
<td>Output 29</td>
<td>Loop 12 cool</td>
</tr>
<tr>
<td>22</td>
<td>Output 28</td>
<td>Loop 11 cool</td>
</tr>
<tr>
<td>24</td>
<td>Output 27</td>
<td>Loop 10 cool</td>
</tr>
<tr>
<td>26</td>
<td>Output 26</td>
<td>Loop 9 cool</td>
</tr>
<tr>
<td>28</td>
<td>Output 25</td>
<td>Loop 8 cool</td>
</tr>
<tr>
<td>30</td>
<td>Output 24</td>
<td>Loop 7 cool</td>
</tr>
<tr>
<td>32</td>
<td>Output 23</td>
<td>Loop 6 cool</td>
</tr>
<tr>
<td>34</td>
<td>Output 22</td>
<td>Loop 5 cool</td>
</tr>
<tr>
<td>36</td>
<td>Output 21</td>
<td>Loop 4 cool</td>
</tr>
<tr>
<td>38</td>
<td>Output 20</td>
<td>Loop 3 cool</td>
</tr>
<tr>
<td>40</td>
<td>Output 19</td>
<td>Loop 2 cool</td>
</tr>
<tr>
<td>42</td>
<td>Output 18</td>
<td>Loop 1 cool</td>
</tr>
<tr>
<td>44</td>
<td>Input 2</td>
<td></td>
</tr>
<tr>
<td>46</td>
<td>Input 4</td>
<td></td>
</tr>
<tr>
<td>48</td>
<td>Input 6</td>
<td></td>
</tr>
<tr>
<td>50</td>
<td>Input 8</td>
<td></td>
</tr>
</tbody>
</table>

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 ramp/soak events.

² For Watlow Serial DAC, the controller uses digital output 34 (terminal 10) for a clock line. You cannot use output 34 for anything else when you have a control output configured or the SDAC.
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 the Dual DAC and Serial DAC modules.

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 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 Dual DAC's manual for power requirements. Also note that the Dual DAC does not carry the same industry approvals as the Serial DAC.

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. The Serial DAC is user-configurable for voltage or current output.

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 5VDC found on the TB50, or by an external supply referenced to the controller’s power supply. When using multiple Serial DACs, the controller cannot provide sufficient current; use the 5VDC output from the CLS200 power supply.

Serial Communications

The CLS200 series controllers are factory-configured for EIA/TIA-232 communications unless otherwise specified when purchased. However, the communications are jumper-selectable, so you can switch between EIA/TIA-232 and EIA/TIA-485. See Changing Communications on page 153.

EIA/TIA-232 Interface

EIA/TIA-232 provides communication to the serial port of a compatible computer. It is used for single controller installations where the cable length does not exceed 50 feet (15.2 m).

The EIA/TIA-232 interface is a standard three-wire interface. See the table below for connection information.

If you are using EIA/TIA-232 communications with grounded thermocouples, use an optical isolator between the controller and the computer to prevent ground loops.

Table 2.10 shows EIA/TIA-232 connections for 25-pin and 9-pin connectors.

EIA/TIA-232 may be used to connect a computer through a 232/485 converter, to an EIA/TIA-485 communications network with up to 32 CLS200 controllers.
### Table 2.10 — EIA/TIA-232 Connections

<table>
<thead>
<tr>
<th>WIRE COLOR</th>
<th>CLS200 TB1</th>
<th>DB 9 CONNECTOR</th>
<th>DB 25 CONNECTOR</th>
</tr>
</thead>
<tbody>
<tr>
<td>White</td>
<td>TX Pin 26</td>
<td>RX Pin 2</td>
<td>RX Pin 3</td>
</tr>
<tr>
<td>Red</td>
<td>RX Pin 25</td>
<td>TX Pin 3</td>
<td>TX Pin 2</td>
</tr>
<tr>
<td>Black</td>
<td>GND Pin 23</td>
<td>GND Pin 5</td>
<td>GND Pin 7</td>
</tr>
<tr>
<td>Green</td>
<td>GND Pin 24</td>
<td>N/U Pin 9</td>
<td>N/U Pin 22</td>
</tr>
<tr>
<td>Shield</td>
<td>N/C</td>
<td>GND Pin 5</td>
<td>GND Pin 7</td>
</tr>
</tbody>
</table>

### Jumers in EIA/TIA-232 Connectors

Some software programs and some operator interface terminals require a Clear to Send (CTS) signal in response to their Request to Send (RTS) signal, or a Data Set Ready (DSR) in response to their Data Terminal Ready (DTR). The CLS200 is not configured to receive or transmit these signals. To use such software with the CLS200, jumper the RTS to the CTS and the DTR to the DSR in the DB connector. Table 2.11 lists the standard pin assignments for DB-9 and DB-25 connectors.

### Table 2.11 — RTS/CTS Pins in DB-9 and DB-25 Connectors

<table>
<thead>
<tr>
<th></th>
<th>DB-9</th>
<th>DB-25</th>
</tr>
</thead>
<tbody>
<tr>
<td>RTS</td>
<td>7</td>
<td>4</td>
</tr>
<tr>
<td>CTS</td>
<td>8</td>
<td>5</td>
</tr>
<tr>
<td>DTR</td>
<td>4</td>
<td>20</td>
</tr>
<tr>
<td>DSR</td>
<td>6</td>
<td>6</td>
</tr>
</tbody>
</table>

Cables manufactured by Watlow for EIA/TIA-232 communications include these jumpers.

**Figure 2.25 — Connecting One CLS200 to a Computer Using EIA/TIA-232**
EIA/TIA-485 Interface

To communicate with more than one CLS200 series controller on a controller network, or to use communication cable lengths greater than 50 feet (15.2 m) from PC to controller, you must use EIA/TIA-485 communications.

When using EIA/TIA-485 communications, you must attach an optically isolated EIA/TIA-232 to EIA/TIA-485 converter to the computer.

Figure 2.26 and Figure 2.27 show the recommended system wiring. To avoid ground loops, use an optically isolated EIA/TIA-232 to EIA/TIA-485 converter between the computer and the EIA/TIA-485 network.

![EIA/TIA-485 Converter Diagram](image)

**Figure 2.26 — EIA/TIA-485 Wiring**

Cable Recommendations

Watlow recommends Belden 9843 cable or its equivalent. This cable includes three 24 AWG (0.2 mm²) shielded, twisted pairs. It should carry signals of up to 19.2k baud with no more than acceptable losses for up to 4,000 feet (1,220 m).

EIA/TIA-485 Network Connections

Watlow recommends that you use a single daisy chain configuration rather than spurs. Run a twisted-pair cable from the host or the converter to the first CLS200, and from that point run a second cable to the next CLS200, and so on. (See Figure 2.27.)

If necessary for servicing, instead of connecting each controller directly into the next, install a terminal strip or connector as close as possible to each CLS200, run a communications cable from one terminal strip to the next and connect the controllers to the bus with short lengths of cable.

To avoid unacceptable interference, use less than 10 feet (3 m) of cable from the terminal or connector to the CLS200 serial port.

Some systems may experience problems with sensor signal reading if the commons of multiple controllers are connected. See Signal Common on page 47.

Refer to Termination on page 47 for more on terminating resistors.

Connect the shield drain to earth ground only at computer or host end.
**Signal Common**

For usual installations, do not connect the dc commons of the controllers together or to the converter or host device. Use an optically isolating EIA/TIA-232-to-485 converter to prevent problems with sensor readings.

**Termination**

In order for EIA/TIA-485 signals to be transmitted properly, each pair must be properly terminated. The value of the termination resistor should be equal to the impedance of the communications cable used. Values are typically 150 to 200Ω.

The receive lines at the converter or host device should be terminated in the converter, the connector to the host device or the device itself. Typically the converter documentation provides instructions for termination.

Use a terminating resistor on the receive lines on the last controller on the 485 line. Set JU1 inside the CLS200 in position B to connect a 200Ω resistor across the receive lines. Refer to Changing Communications on page 153.

**EIA/TIA-485 Converters and Laptop Computers**

In order for an EIA/TIA-232-to-485 converter to optically isolate the computer from the 485 network, the 232 and 485 sides must be powered independently. Many 232-to-485 converters can be powered by the computer’s communications port. Some computers, laptops in particular, do not automatically provide the appropriate voltages. These computer/converter combinations can usually be used by connecting an external power supply to the 232 side of the converter. Not all converters have power inputs for the 232 side, however.
Chapter 3: Using CLS200

This chapter explains how to use the keypad and display to operate the controller. Figure 3.1 shows the operator menus and displays accessible from the front panel. To change global parameters, loop inputs, control parameters, outputs, and alarms using the setup menus, see Chapter 4: Setup.

Figure 3.1 — Operator Displays
Front Panel

The CLS200 front panel provides a convenient interface with the controller. You can use the front panel keys to program and operate the CLS200.

Figure 3.2 — CLS200 Front Panel

Front Panel Keys

- **YES** (up)
  - Press YES to:
    - Select a menu or parameter
    - Answer YES to the flashing ? prompts
    - Increase a value or choice when editing
    - Stop scanning mode

- **NO** (down)
  - Press NO to:
    - Skip a menu or parameter when the prompt is blinking
    - Answer NO to the flashing ? prompts
    - Decrease a value or choice when editing
    - Stop scanning mode
    - Perform a NO-key reset
NOTE! Pressing the NO key on power up performs a NO-key reset. This procedure clears the RAM and sets the controller’s parameters to their default values. See NO-Key Reset on page 150.

- **BACK**
  - Press BACK to:
    - Cancel editing
    - Return to a previous menu
    - Switch between bar graph, single loop and job displays
    - Stop scanning mode

- **ENTER**
  - Press ENTER to:
    - Store data or a parameter choice after editing and go to the next parameter
    - Start scanning mode (if pressed twice)

- **CHNG SP**
  - Press CHNG SP to change the loop setpoint

- **MAN AUTO**
  - Press MAN/AUTO to:
    - Toggle a loop between manual and automatic control
    - Adjust the output power level of manual loops
    - Automatically tune the loop

- **RAMP SOAK**
  - If your controller has the ramp/soak option, press RAMP/SOAK to:
    - Assign a ramp/soak profile to the current loop
    - Select the ramp/soak mode
    - See the status of a running profile

  Your controller may not have the ramp/soak option. If it does not, pressing the RAMP/SOAK key displays the message OPTION UNAVAILABLE.

- **ALARM ACK**
  - Press ALARM ACK to:
    - Acknowledge an alarm condition
    - Reset the global alarm output
Displays

This section discusses the controller’s main displays: bar graph, single loop and job.

Bar Graph Display

On power up, the controller displays general symbolic information for up to eight loops. This screen is called the bar graph display. The diagram below shows the symbols used in the bar graph display.

![Figure 3.3 — Bar Graph Display](image)

Table 3.1 explains the symbols you see on the top line of the bar graph display. These symbols appear when the controller is in dual output mode (heat and cool outputs enabled) and single output mode (heat or cool outputs enabled, but not both).

<table>
<thead>
<tr>
<th>SYMBOL</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;</td>
<td>Loop is in low process or low deviation alarm.</td>
</tr>
<tr>
<td>&gt;</td>
<td>Loop is in high process or high deviation alarm.</td>
</tr>
<tr>
<td>▼</td>
<td>Loop is above setpoint. If you enable the high or low deviation alarm, this symbol is scaled to it. If you do not enable these alarms, these symbols are scaled to the setpoint ±5% of the sensor’s range.</td>
</tr>
<tr>
<td>▲</td>
<td>Loop is at setpoint. If you enable the high or low deviation alarm, this symbol is scaled to it. If you do not enable these alarms, these symbols are scaled to the setpoint ±5% of the sensor’s range.</td>
</tr>
<tr>
<td>☢</td>
<td>Loop is below setpoint. If you enable the high or low deviation alarm, this symbol is scaled to it. If you do not enable these alarms, these symbols are scaled to the setpoint ±5% of the sensor’s range.</td>
</tr>
<tr>
<td>(blank)</td>
<td>Loop’s input type is set to SKIP.</td>
</tr>
<tr>
<td>F</td>
<td>Open thermocouple (T/C), shorted T/C, reversed T/C, open RTD or shorted RTD.</td>
</tr>
</tbody>
</table>
Table 3.2 explains the control status symbols on the bottom line of bar graph display. Additional symbols may appear with the ramp/soak option. (See Bar Graph Display on page 126.)

Table 3.2 — Control Status Symbols on the Bar Graph and Single Loop Displays

<table>
<thead>
<tr>
<th>BAR GRAPH DISPLAY SYMBOL</th>
<th>SINGLE LOOP DISPLAY SYMBOL</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>M</td>
<td>MAN</td>
<td>One or both outputs are enabled. Loop is in manual control.</td>
</tr>
<tr>
<td>A</td>
<td>AUTO</td>
<td>Only one output (heat or cool) is enabled. Loop is in automatic control.</td>
</tr>
<tr>
<td>T</td>
<td>TUNE</td>
<td>The loop is in autotune mode.</td>
</tr>
<tr>
<td>H</td>
<td>HEAT</td>
<td>Both heat and cool outputs are enabled. Loop is in automatic control and heating.</td>
</tr>
<tr>
<td>C</td>
<td>COOL</td>
<td>Both heat and cool outputs are enabled. Loop is in automatic control and cooling.</td>
</tr>
<tr>
<td>(blank)</td>
<td>(blank)</td>
<td>Both outputs disabled, or input type is set to SKIP.</td>
</tr>
</tbody>
</table>

Navigating in Bar Graph Display

When the bar graph display is visible:

- Press the YES (up) or NO (down) key to see a new group of loops.
- Press ENTER twice to scan all groups of loops. The groups will display sequentially for three seconds each. This is called scanning mode.
- Press any key to stop scanning.
- Press BACK once to go to the job display, if enabled, or the single loop display.

Single Loop Display

The single loop display shows detailed information for one loop at a time.

![Single Loop Display](image)

Figure 3.4 — Single Loop Display

The control status indicator shows MAN, AUTO or TUNE modes.

If both control outputs for a loop are enabled and the loop is in automatic control, then the single loop display shows HEAT or COOL as the control status:
Navigating the Single Loop Display

In the single loop display:

- Press **YES** to go to the next loop.
- Press **NO** to go to the previous loop.
- Press **BACK** once to go to the job display (if enabled) or bar graph display.
- Press **ENTER** twice to start the single loop scanning display. The single loop scanning display shows information for each loop in sequence. Data for each loop displays for one second.
- Press any key to stop scanning.

Alarm Displays

If a process, deviation, failed or system sensor alarm occurs, the controller switches from any Single Loop display or Bar Graph display to the Single Loop display for the loop with the alarm. The global alarm output turns on and a two-character alarm code appears in the lower left corner of the Single Loop display.

If the alarm is for a failed sensor, a short message appears in place of the process variable and units. Control outputs associated with failed sensors are set to the value of the **SENSOR FAIL HT/CL OUTPUT %** parameter (default, 0%).

The alarm code blinks and displays cannot be changed until the alarm has been acknowledged. Once the alarm is acknowledged, the alarm code stops blinking. When the condition that caused the alarm is corrected, the alarm messages disappear.
Alarms that still exist but have been acknowledged are displayed on the Bar Graph display. A letter or symbol indicates the alarm condition. See Table 3.3 for a full list of alarm codes, failed sensor messages and alarm symbols.

Table 3.3 shows the symbols used in each form of the alarm display.

**Table 3.3 — Alarm Type and Symbols**

<table>
<thead>
<tr>
<th>ALARM CODE</th>
<th>BAR GRAPH SYMBOL</th>
<th>ALARM MESSAGE</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>FS</td>
<td>F</td>
<td>T/C BREAK</td>
<td>Failed Sensor: Break detected in thermocouple circuit.</td>
</tr>
<tr>
<td>RO</td>
<td>F</td>
<td>RTD OPEN</td>
<td>RTD Open: Break detected in RTD circuit.</td>
</tr>
<tr>
<td>RS</td>
<td>F</td>
<td>RTD SHORTED</td>
<td>RTD Short: Short detected in RTD circuit.</td>
</tr>
<tr>
<td>RT</td>
<td>F</td>
<td>REVERSED TC</td>
<td>Reversed Thermocouple: Reversed polarity detected in thermocouple circuit.</td>
</tr>
<tr>
<td>ST</td>
<td>F</td>
<td>T/C SHORTED</td>
<td>Shorted Thermocouple: Short detected in thermocouple circuit.</td>
</tr>
<tr>
<td>HP</td>
<td>&gt;</td>
<td>No message</td>
<td>High Process Alarm: Process variable has risen above the high alarm set point.</td>
</tr>
<tr>
<td>HD</td>
<td>&gt;</td>
<td>No message</td>
<td>High Deviation Alarm: Process variable has risen above the setpoint plus the deviation alarm value.</td>
</tr>
<tr>
<td>LP</td>
<td>&lt;</td>
<td>No message</td>
<td>Low Process Alarm: Process variable has dropped below the low alarm set point.</td>
</tr>
<tr>
<td>LD</td>
<td>&lt;</td>
<td>No message</td>
<td>Low Deviation Alarm: Process variable has dropped below the setpoint minus the deviation alarm value.</td>
</tr>
<tr>
<td>AM</td>
<td>*</td>
<td>No message</td>
<td>Ambient Warning: Controller’s ambient temperature has exceeded operating limits by 5°C.</td>
</tr>
</tbody>
</table>
Acknowledging an Alarm

Press ALARM ACK to acknowledge the alarm. If there are other loops with alarm conditions, the Alarm display switches to the next loop in alarm. Acknowledge all alarms to clear the global alarm digital output (the keypad and display won’t work for anything else until you acknowledge each alarm). The alarm symbols are displayed as long as the alarm condition is valid.

System Alarms

When a system alarm occurs, the global alarm output turns on and an alarm message appears on the display. The message continues to be displayed until the error condition is removed and the alarm is acknowledged. The CLS200 can display the following system alarms:

- **BATTERY DEAD**
  See Battery Dead on page 143.

- **LOW POWER**
  See Low Power on page 143.

- **AW**
  See Ambient Warning on page 144.

- **H/W FAILURE: AMBIENT**
  See H/W Ambient Failure on page 144.

- **H/W FAILURE: GAIN**
  See H/W Gain or Offset Failure on page 145.

- **H/W FAILURE: OFFSET**
  See H/W Gain or Offset Failure on page 145.

Job Display

The job display appears only if:

- You have enabled JOB SELECT DIG INPUTS. (See Job Select Digital Inputs on page 68.)
- or —
- You have selected a job from the job load menu.

After loading a job using the LOAD SETUP FROM JOB menu, the job display shows you the following screen:

If parameters are modified while the job is running, this screen will display:
If the job was loaded using digital inputs, the display shows:

![Display showing job status](image)

**Changing the Setpoint**

Select the single loop display for the loop you want to change. Press CHNG SP. This display appears:

![Setpoint display](image)

- Press YES to change the setpoint.
- Press the up or down keys (YES or NO) to increase or decrease the setpoint value.
- Press ENTER to save your changes and return to single loop display.
  - or –
  Press NO or BACK (without pressing ENTER) to return to single loop display without saving the new setpoint.

**Selecting the Control Status**

If you set the control status to AUTO, the controller automatically controls the process according to the configuration information you give it.

If you set the control status to MAN, you need to set the output level.

If you set the control status to TUNE, the controller performs an autotune and chooses PID parameters.

**NOTE!** If the loop outputs are disabled, you cannot toggle between manual and automatic control. If you try it, the screen shows an error message telling you that the outputs are disabled, as shown below. Use the SETUP LOOPS OUTPUT menu to enable the outputs. See Setup Loop Outputs Menu on page 84.
Manual and Automatic Control

1. Switch to the single loop display for the loop.
2. Press MAN/AUT0.
3. Press YES to change the mode
   – or –
   if the mode is MAN, press NO to set the output power. Go to the next subsection, Manual Output Levels.
   – or –
   press NO if in AUT0 to cancel and remain in AUT0 mode.
4. Select a mode by pressing the up or down key (YES or NO) to scroll through the modes.
5. Press ENTER to make the mode change
   – or –
   press BACK to return to the single loop display without saving the new mode setting.
6. If you set the loop to manual, you are prompted for the output power. Go to Manual Output Levels below.

Manual Output Levels

If the loop to is set to manual control, the controller prompts for output levels for the enabled control outputs. Use this menu to set the manual heat and cool output levels. You should see a display like this:

1. Press YES to change the output power level. (If the heat output is enabled, you will be able to change the heat output power level. If only the cool output is enabled, you will be able to change only the cool output power level.)
   – or –
   Press NO to go to the cool output, if available, and then press YES to change the cool output.
2. Press up or down (YES or NO) to select a new output power level.
3. Press ENTER to store your changes
   – or –
   press BACK to discard your changes and return to single loop display.
4. Repeat from Step 1 for the cool output, if available.
5. Press BACK at any time to discard your changes and return to single loop display.

Autotuning a Loop

Autotuning is a process by which a controller determines the correct PID parameters for optimum control. This section explains how to autotune the CLS200.
Prerequisites

Before autotuning the controller, it 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 (setpoint) must be known.

The technician or engineer performing the autotune should know how to use the controller front panel or MMI software interface to do the following:

1. Select a loop to operate and monitor.
2. Set a loop’s setpoint.
3. Change a loop’s control status (MAN, TUNE, AUTO).
4. Read and change the controller’s global and loop setup parameters.

Background

Autotuning is performed at the maximum allowed output. If you have set an output limit, autotuning occurs at that value. Otherwise, the control output is set to 100% during the autotune. Only the heat output (output 1) of a loop may be autotuned.

The PID constants are calculated according to process’s response to the output. The loop need not reach or cross setpoint to successfully determine the PID parameters. While autotuning the controller looks at the delay between when power is applied and when the system responds in order to determine the integral term (TI). The controller then looks for the slope of the rising temperature to become constant in order to determine the proportional band (PB). The derivative term (TD) is derived mathematically from the TI.

When the controller has finished autotuning, the loop’s control status switches to AUTO. If the process reaches 75% of the setpoint or the autotuning time exceeds 30 minutes, the controller switches to AUTO and applies the PID constants it has calculated up to that point.

The autotune 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.

Performing an Autotune

NOTE! A loop must be stable at a temperature well below the setpoint in order to successfully autotune. The controller will not complete tuning if the temperature exceeds 75% of setpoint before the new parameters are found.

The following procedure explains how to autotune a loop:

1. Select the single loop display of the loop to be tuned.
2. Ensure the loop’s process variable is stable and the loop is in MAN control status.
3. Set the setpoint to a value as near the normal operating temperature as is safe for the system.

WARNING! During autotuning, the controller will set the output to 100% until the process variable rises near the setpoint. Set the setpoint within the safe operating limits of your system.
4. Use the three-key sequence (ENTER, ALARM ACK, CHNG SP) to access the setup menus. In the SETUP LOOP INPUT menu, locate the INPUT FILTER parameter. Note the setting and then change it to 0 SCANS.

5. Press the BACK key until the single loop display appears.

6. Press the MAN/AUTO key.

7. Press the YES key to toggle to the TUNE mode.

8. Press the ENTER key to begin tuning the loop. TUNE flashes throughout the tuning process. When tuning is completed the control status indicator changes to AUTO.

9. Adjust the setpoint to the desired temperature.

10. Restore the INPUT FILTER parameter to its original value.

Using Alarms

The CLS200 has three main types of alarms:

- Failed sensor alarms
- Process alarms
- System alarms

Alarm Delay

You can set the controller to delay normal alarm detection and alarm reporting. There are two kinds of alarm delay:

- Start-up alarm delay delays process alarms (including deviation alarms but not failed sensor alarms) for all loops for a time period you set at the STARTUP ALARM DELAY parameter in the SETUP GLOBAL PARAMETERS menu.

- Loop alarm delay delays failed sensor alarms and process alarms (including deviation alarms) for one loop until the alarm condition is continuously present for longer than the loop alarm delay time you set.

Failed sensor alarms are affected by the loop alarm delay even during the start-up alarm delay time period.

Failed Sensor Alarms

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

- Thermocouple open
- Thermocouple shorted (must be enabled)
- Thermocouple reversed (must be enabled)
- 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 set with the SENSOR FAIL HT OUTPUT and SENSOR FAIL CL OUTPUT parameters in the SETUP LOOP OUTPUTS menu. (The output power may be different for a thermocouple open alarm. See Thermocouple Open Alarm on page 60.)
- The controller displays an alarm code and alarm message on the display. See Alarm Displays on page 53.
- 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 HEAT/COOL T/C BRK OUT parameter in the SETUP LOOP OUTPUTS menu is set to ON, then the controller sets the output power to an average of the recent output.
- If the HEAT/COOL T/C BRK OUT AVG parameter is set to OFF, then the controller sets the output to the level set with the SENSOR FAIL HT/CL OUTPUT parameter in the SETUP LOOP OUTPUTS 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 disabled by default. To enable this alarm, set the REVERSED T/C DETECT parameter in the SETUP LOOP INPUTS menu to ON. It may be disabled if false alarms occur in your application.

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 PROCESS POWER DIGIN parameter in the SETUP GLOBAL PARAMETERS menu.
- Connect the digital input to a device that connects the input to controller common when the process power is on.

RTD Open or RTD Shorted Alarm

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

The RTD shorted alarm occurs if the controller detects that the positive and negative RTD leads are shorted.

You do not have to set any parameters for the RTD alarms.
**Restore Automatic Control After a Sensor Failure**

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

- Choose a digital input for the RESTORE PID DIGIN parameter in the SETUP LOOP CONTROL PARAMS menu.
- Connect the digital input to the dc common terminal on the controller.

**Process Alarms**

The CLS200 has four process alarms, each of which you can configure separately for each loop:

- Low process alarm
- High process alarm
- Low deviation alarm
- High deviation alarm

**Setting Up Alarms**

To set up an alarm:

- Set the alarm setpoint
- Set the alarm type
- Choose an output, if desired
- Set the alarm deadband
- Set an alarm delay, if desired

The setpoints, deviation alarm values, and deadband all use the same decimal format as the loop’s process variable.

**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 53.)
- Activates the global alarm output. (See Global Alarm on page 63.)
- 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 deadband; 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 DIG OUT POLARITY ON ALARM setting in the SETUP GLOBAL PARAMETERS.
**Alarm Type: Control or Alarm**

You can configure each process alarm as either a control or alarm.

- Alarm configuration 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.

- Control configuration provides on/off control output using the alarm setpoint. 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.

**High and Low Process Alarms**

A high process alarm occurs if the process variable rises above a user-specified value. A low process alarm occurs if the process variable drops below a separate user-specified value. See Figure 3.9.

Enter the alarm high and low process setpoints at the HI PROC ALARM SETPT and LO PROC ALARM SETPT parameters in the SETUP LOOP ALARMS menu.

![Figure 3.9 — Activation and Deactivation of Process Alarms](image)

**Deviation Alarms**

A deviation alarm occurs if the process deviates from setpoint by more than a user-specified amount. (See Figure 3.9.) Set the deviation with the DEV ALARM VALUE parameter in the SETUP LOOP ALARMS menu.

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

- If the alarm type parameter is set to ALARM, 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 type parameter is set to CONTROL, then the deviation output switches on whenever the setpoint 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 setpoint changes.
Global Alarm

The CLS200 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 type is set to ALARM in the SETUP LOOP ALARMS menu. (The global alarm does not occur if the alarm type is set to CONTROL.)

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 DIG OUT POLARITY ON ALARM polarity parameter in the SETUP GLOBAL PARAMETERS menu.

Ramp/Soak

If you have a controller without the Ramp/Soak option, pressing the RAMP/SOAK key has no effect. If you have a controller with this option installed, see Chapter 6: Ramp/Soak on page 115.
Chapter 4: Setup

The setup menus let you change detailed configuration information. This section describes how to set up the controller using the built-in keypad and display. The following information is included in this chapter:

- Accessing the setup menus
- Changing parameter settings
- Description of controller parameters

If you have not set up a CLS200 series controller before, or if you do not know what values to enter, please read Chapter 7: Tuning and Control, which contains PID tuning constants and useful starting values.

How to Access the Setup Menus

Use the **three-key sequence** to enter the setup menus:

1. Select the single loop display for the loop you wish to edit.
2. Press **ENTER then ALARM ACK then CHNG SP** to access the setup menus. Do not press these keys at the same time; press them one at a time.

3. The first setup menu appears.

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

How to Change a Parameter

To change a parameter, first select the appropriate menu, then the parameter.

When you enter the setup menus, the first menu is **SETUP GLOBAL PARAMETERS**. Refer to Figure 4.1 for a listing of all top level menus and their related parameters.

1. Select the single loop display for the loop to set up.
2. Enter the three-key sequence. The first menu is displayed: **SETUP GLOBAL PARAMETERS**.
3. To select the appropriate menu:
   a. Press NO to move from one menu to the next. The menus wrap around; pressing NO continuously advances through the top level menus.
   b. Press YES to enter the displayed menu.

4. To select the parameter to be edited:
   a. Press NO to advance from one parameter to the next. Parameters do not wrap around.
   b. Press YES to edit the displayed parameter.

5. To edit the parameter setting:
   a. Press up or down (YES or NO) to scroll to the value or choice you want to select.
   b. Press ENTER to accept the change
      - or -
      press BACK to cancel the change without saving.

6. Select another parameter and repeat from step 4, or press BACK to return to the top level menu.

7. Select another menu and repeat from step 3,
   - or -
   press BACK to exit the setup menus.

The following sections tell more about the parameters for each of the six top level menus. Each display illustration contains the default value for that specific parameter.
Standard Menus

Figure 4.1 shows the top level menus accessible from the single loop display. If the enhanced features option or ramp/soak feature is installed, refer to Chapter 5: Enhanced Features on page 96 or Chapter 6: Ramp/Soak on page 115 for additional menus.

![CLS200 Menu Tree](image)

Figure 4.1 — CLS200 Menu Tree
Setup Global Parameters Menu

Table 4.1 shows the parameters available in this menu.

Table 4.1 — Global Parameters

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>DEFAULT VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>LOAD SETUP FROM JOB?</td>
<td>1</td>
</tr>
<tr>
<td>SAVE SETUP TO JOB?</td>
<td>1</td>
</tr>
<tr>
<td>JOB SELECT DIG INPUTS?</td>
<td>NONE</td>
</tr>
<tr>
<td>JOB SEL DIG INS ACTIVE?</td>
<td>LOW</td>
</tr>
<tr>
<td>OUTPUT OVERRIDE DIG INPUT?</td>
<td>NONE</td>
</tr>
<tr>
<td>OVERRIDE DIG IN ACTIVE?</td>
<td>LOW</td>
</tr>
<tr>
<td>STARTUP ALARM DELAY?</td>
<td>0 MINS</td>
</tr>
<tr>
<td>RAMP/SOAK TIME BASE?*</td>
<td>HOURS/MIN</td>
</tr>
<tr>
<td>KEYBOARD LOCK STATUS?</td>
<td>OFF</td>
</tr>
<tr>
<td>POWER UP OUTPUT STATUS?</td>
<td>OFF</td>
</tr>
<tr>
<td>PROCESS POWER DIGIN?</td>
<td>NONE</td>
</tr>
<tr>
<td>CONTROLLER ADDRESS?</td>
<td>1</td>
</tr>
<tr>
<td>COMMUNICATIONS BAUD RATE?</td>
<td>19200</td>
</tr>
<tr>
<td>COMMUNICATIONS PROTOCOL?</td>
<td>MOD</td>
</tr>
<tr>
<td>COMMUNICATIONS ERR CHECK?</td>
<td>BCC</td>
</tr>
<tr>
<td>AC LINE FREQ?</td>
<td>60 HERTZ</td>
</tr>
<tr>
<td>DIG OUT POLARITY ON ALARM?</td>
<td>LOW</td>
</tr>
<tr>
<td>CLS200 [model no., firmware rev.]</td>
<td></td>
</tr>
</tbody>
</table>

* The RAMP/SOAK TIME BASE parameter appears only if the ramp/soak feature is installed.

Load Setup From 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.

Load any one of eight jobs saved in battery-backed RAM.
Chapter 4: Setup

Selectable values: 1 to 8

The following parameters are loaded for each loop as part of a job:

- PID constants, filter settings, setpoints and spread values.
- Loop control status (automatic or manual) and output values (if the loop is in manual control).
- Alarm function (off, alarm control) setpoints, high/low process setpoints, high/low deviation setpoints and deadband settings, and loop alarm delay.

If you have enabled the remote job select function (see Job Select Digital Inputs below), you will not be able to load a job. If you try, you will see this message:

Save Setup to Job

Save the job information for every loop to one of eight jobs in the battery-backed RAM.

Selectable values: 1 to 8

If you have enabled the remote job select function (see Job Select Digital Inputs below), you will not be able to save a job. If you try, you will see this message:

Job Select Digital Inputs

Set the number of job select inputs. The controller uses these inputs as a binary code that specifies the job number to run. The number of inputs you choose in this parameter controls the number of jobs you can select remotely.

If you select NONE, digital inputs do not affect job selection. Jobs may be loaded and saved using the LOAD SETUP FROM JOB and SAVE SETUP TO JOB parameters.
Selectable values: 1, 2 or 3 inputs, or NONE. These choices have the following effect:

**Table 4.2 — Job Select Inputs**

<table>
<thead>
<tr>
<th>SETTING</th>
<th>ENABLES</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Jobs 1-2</td>
</tr>
<tr>
<td>2</td>
<td>Jobs 1-4</td>
</tr>
<tr>
<td>3</td>
<td>Jobs 1-8</td>
</tr>
<tr>
<td>NONE</td>
<td>Disables remote selection</td>
</tr>
</tbody>
</table>

Table 4.3 shows which input states select which jobs. When nothing is connected, the inputs are all false and job 1 is selected.

**Table 4.3 — Job Selected for Various Input States**

<table>
<thead>
<tr>
<th>DIGITAL INPUT 3</th>
<th>DIGITAL INPUT 2</th>
<th>DIGITAL INPUT 2</th>
<th>JOB NO.</th>
</tr>
</thead>
<tbody>
<tr>
<td>F</td>
<td>F</td>
<td>F</td>
<td>1</td>
</tr>
<tr>
<td>F</td>
<td>F</td>
<td>T</td>
<td>2</td>
</tr>
<tr>
<td>F</td>
<td>T</td>
<td>F</td>
<td>3</td>
</tr>
<tr>
<td>F</td>
<td>T</td>
<td>T</td>
<td>4</td>
</tr>
<tr>
<td>T</td>
<td>F</td>
<td>F</td>
<td>5</td>
</tr>
<tr>
<td>T</td>
<td>F</td>
<td>T</td>
<td>6</td>
</tr>
<tr>
<td>T</td>
<td>T</td>
<td>F</td>
<td>7</td>
</tr>
<tr>
<td>T</td>
<td>T</td>
<td>T</td>
<td>8</td>
</tr>
</tbody>
</table>

**Job Select Digital Inputs Active**

Specify which state is considered “true” for the digital inputs used for job selection. Default is LOW, meaning that an input must be pulled low to be considered true. If HIGH is selected, an input will be considered true unless it is pulled low.

Selectable values: HIGH or LOW.

Changing this setting has the effect of reversing the order of the jobs in Table 4.3.
Output Override Digital Input

To enable the output override feature, select a digital input. When the specified input is activated, the controller sets all loops to manual mode at the output levels specified at the SENSOR FAIL HT OUTPUT and SENSOR FAIL CL OUTPUT parameters in the SETUP LOOP OUTPUTS menu.

**Selectable values:** NONE or input number 1 to 8.

Use the next parameter, OVERRIDE DIG IN ACTIVE, to set the signal state that activates the output override feature.

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

Override Digital Input Active

Specify whether a low or high signal activates the output override feature (see OUTPUT OVERRIDE DIG INPUT above).

**Selectable values:** HIGH or LOW.

You can set the input to be active when low or active when high. When the input selected for OUTPUT OVERRIDE DIG INPUT changes to the specified state, all the loop’s outputs are set to their sensor fail levels.

Startup Alarm Delay

Set a startup delay for process and deviation alarms for all loops. The controller does not report these alarm conditions for the specified number of minutes after the controller powers up. This feature does not delay failed sensor alarms.

**Selectable values:** 0 to 60 minutes.
Keyboard Lock Status
Set this parameter to ON to disable the CHNG SP, MAN/AUTO, and RAMP/SOAK keys on the keypad. If the keys are disabled, pressing them has no effect. If you want to use these functions, turn off the keyboard lock.

Selectable values: ON or OFF.

Power Up Output Status

WARNING! Do not set the controller to start from memory if it may be unsafe for your process to have outputs on upon power-up.

Set the initial power-up state of the control outputs. If you choose OFF, all loops are initially set to manual mode at 0% output. If you choose MEMORY, the loops are restored to the control status and output value prior to powering down.

See In Case of a Power Failure on page 130 for information about how this feature affects ramp/soak profiles.

Selectable values: OFF or MEMORY.

Process Power Digital Input
To enable the thermocouple short detection feature, select a digital input (1 to 8). Connect the specified input to a device that pulls the input low when the process power is on. A short is indicated when the process power is on and the temperature does not rise as expected.

If the controller determines that there is a thermocouple short, it sets the loop to manual mode at the power level set for the SENSOR FAIL HT OUTPUT or SENSOR FAIL CL OUTPUT parameter in the SETUP LOOP OUTPUTS menu.

Selectable values: 1 to 8, or NONE.
Controller Address
Set the communications address for the controller. On an EIA/TIA-485 communication network, each controller must have a unique address. Begin with address 1 for the first controller and assign each subsequent controller the next higher address.

Selectable values: 1 to 247.

Communications Baud Rate
Set the communications baud rate.

Selectable values: 9600, 2400 or 19200.

NOTE! Set the baud rate to the same speed in both the controller and the HMI software or panel.

Communications Protocol
Set the communications protocol. Choose the correct protocol for the software or device with which the controller will communicate. You must switch power to the controller off, then back on, to make a change to this parameter take effect.

Selectable values: MOD (Modbus® RTU), ANA (Anafaze), AB (Allen Bradley).

Communications Error Checking
If you selected the ANA or AB communications protocol, set the data check algorithm for CLS200 communications.

CRC (Cyclic Redundancy Check) is a more secure error checking algorithm than BCC, but it requires more calculation time and slows communications. BCC (Block Check Character) ensures a high degree of communications integrity. We recommend BCC unless your application requires CRC.
Selectable values: BCC or CRC.

**AC Line Frequency**

Specify the ac line frequency. Since the controller reduces the effect of power line noise on the analog measurement by integrating the signal over the period of the ac line frequency, the controller must know the frequency of power in use.

You must switch power to the controller off, then back on, to make a change to this parameter take effect.

Selectable values: 50 Hertz or 60 Hertz.

**Digital Output Polarity on Alarm**

Set the polarity of all digital outputs used for alarms. If LOW is selected, if an alarm occurs the outputs sink to analog common. If HIGH is selected, the outputs sink to common when no alarm is active and go high when an alarm occurs.

Selectable values: HIGH or LOW.

This parameter does not affect the Global Alarm output or the Watchdog Alarm output.

**EPROM Information**

The display shows the controller type, firmware options, the firmware version and the EPROM checksum. Table 4.4 lists the available firmware options.
Table 4.4 — Firmware Option Codes

<table>
<thead>
<tr>
<th>FIRMWARE OPTION</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>(none)</td>
<td>Standard Firmware</td>
</tr>
<tr>
<td>-EF</td>
<td>Enhanced Features Option</td>
</tr>
<tr>
<td>-RS</td>
<td>Ramp/Soak Option</td>
</tr>
</tbody>
</table>

**NOTE!** If the EPROM information does not match this description, the EPROM probably contains a custom program. Custom programs may not work as described in this manual. If that is the case, contact your dealer for more information about the firmware.

Setup Loop Input Menu

The SETUP LOOP INPUT menu includes parameters related to the loop input:

- Input type
- Input units
- Input scaling and calibration
- Input filtering

Table 4.5 — Setup Loop Input

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>DEFAULT VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>INPUT TYPE?</td>
<td>J</td>
</tr>
<tr>
<td>LOOP NAME?</td>
<td>01</td>
</tr>
<tr>
<td>INPUT UNITS?</td>
<td>°F</td>
</tr>
<tr>
<td>INPUT READING OFFSET?</td>
<td>0°F</td>
</tr>
<tr>
<td>REVERSED T/C DETECT?</td>
<td>OFF</td>
</tr>
<tr>
<td>INPUT PULSE SAMPLE TIME?</td>
<td>1</td>
</tr>
<tr>
<td>DISP FORMAT?²</td>
<td>-999 to 3000</td>
</tr>
<tr>
<td>INPUT SCALING HI PV?²</td>
<td>1000</td>
</tr>
<tr>
<td>INPUT SCALING HI RDG?²</td>
<td>100.0% FS</td>
</tr>
<tr>
<td>INPUT SCALING LO PV?²</td>
<td>0</td>
</tr>
<tr>
<td>INPUT SCALING LO RDG?²</td>
<td>0.0% FS</td>
</tr>
<tr>
<td>INPUT FILTER?</td>
<td>3 SCANS</td>
</tr>
</tbody>
</table>
1 This parameter is available only for the pulse loop (loop 5 on four-channel controller, loop 9 on an eight-channel controller and loop 17 on a sixteen-channel controller).

2 These parameters are available only if LINEAR is selected for INPUT TYPE.

3 These parameter is available only if INPUT TYPE is set to one of the thermocouple or RTD options.

**Input Type**

Specify the type of input sensor used on this loop:

- Thermocouple type J, K, T, S, R, B or E.
- RTD 1 or RTD 2.
- Linear input.
- Skip (an input type available for unused loops). Alarms are not detected, and the scanning display does not show loops that are set to SKIP.
- Pulse input (available only for loop 5 on a four-channel controller, loop 9 on an eight-channel controller or loop 17 on a sixteen-channel controller).

**Table 4.6 — CLS200 Input Types and Ranges**

<table>
<thead>
<tr>
<th>INPUT TYPE</th>
<th>INPUT RANGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>J T/C</td>
<td>-350 to 1,400°F (-212 to 760°C)</td>
</tr>
<tr>
<td>K T/C</td>
<td>-450 to 2,500°F (-268 to 1,371°C)</td>
</tr>
<tr>
<td>T T/C</td>
<td>-450 to 750°F (-268 to 399°C)</td>
</tr>
<tr>
<td>S T/C</td>
<td>0 to 3,200°F (-18 to 1,760°C)</td>
</tr>
<tr>
<td>R T/C</td>
<td>0 to 3,210°F (-18 to 1,766°C)</td>
</tr>
<tr>
<td>B T/C</td>
<td>150 to 3,200°F (+66 to 1,760°C)</td>
</tr>
<tr>
<td>E T/C</td>
<td>150 to 3,200°F (+66 to 1,760°C)</td>
</tr>
<tr>
<td>RTD1</td>
<td>-148.0 to 572.0°F (-100.0 to 275.0°C)</td>
</tr>
<tr>
<td>RTD2</td>
<td>-184 to 1,544°F (-120 to 840°C)</td>
</tr>
<tr>
<td>PULSE</td>
<td>0 to 2kHz</td>
</tr>
<tr>
<td>SKIP</td>
<td>Loop not used.</td>
</tr>
<tr>
<td>LINEAR</td>
<td>See Linear Scaling Parameters on page 77.</td>
</tr>
</tbody>
</table>
Loop Name
Assign a two-character name to the loop. This name is shown on the single loop display in place of the loop number.

```
01 LOOP
NAME ? 01
```

Selectable values: 0 to 9, A to Z, %, /, ° (degree symbol).

Input Units
For loops with temperature sensor input types, choose a temperature scale: Fahrenheit or Celsius. For a linear or pulse loop, choose a three-character description of the loop’s engineering units.

```
01 INPUT
UNITS ? °F
```

Selectable values: The table below shows the character set for input units.

<table>
<thead>
<tr>
<th>INPUT</th>
<th>CHARACTER SETS FOR UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermocouple or RTD</td>
<td>° F or ° C</td>
</tr>
<tr>
<td>LINEAR or PULSE</td>
<td>0 to 9, A to Z, %, /, °, space</td>
</tr>
</tbody>
</table>

Input Reading Offset
If the input type is a thermocouple or RTD, specify the offset to correct for signal inaccuracy at a given point. For example, at temperatures below 400°F, a type J thermocouple may be inaccurate or “offset” by several degrees. Use an independent thermocouple or your own calibration equipment to find the offset for your equipment.

A positive value increases the reading and a negative value decreases it.

```
01 INPUT READING
OFFSET ? 0°F
```

Selectable values: See Table 4.8.
### Table 4.8 — Input Reading Offset

<table>
<thead>
<tr>
<th>TYPE OF SENSOR</th>
<th>OFFSET RANGE</th>
<th>°F</th>
<th>°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>RTD2 J</td>
<td>-300 to +300</td>
<td>-300 to +300</td>
<td></td>
</tr>
<tr>
<td>RTD2 K</td>
<td>-300 to +300</td>
<td>-300 to +300</td>
<td></td>
</tr>
<tr>
<td>RTD2 T</td>
<td>-300 to +300</td>
<td>-300 to +300</td>
<td></td>
</tr>
<tr>
<td>RTD1</td>
<td>-300.0 to +300.0</td>
<td>-300.0 to +300.0</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>-300 to +76</td>
<td>-300 to +300</td>
<td></td>
</tr>
<tr>
<td>S</td>
<td>-300 to +76</td>
<td>-300 to +300</td>
<td></td>
</tr>
<tr>
<td>R</td>
<td>-300 to +66</td>
<td>-300 to +300</td>
<td></td>
</tr>
</tbody>
</table>

### Reversed T/C Detection
Set this parameter to ON to enable polarity checking for thermocouples. If a reversed thermocouple is detected, the controller sets the loop to manual control at the SENSOR FAIL HT OUTPUT or SENSOR FAIL CL OUTPUT power level and displays the alarm.

**Selectable values:** ON or OFF.

### Input Pulse Sample Time
You can connect a digital pulse signal of up to 2kHz to the pulse input. Use this parameter to set the time over which pulses are counted. The controller counts pulses for the amount of time you set here before calculating the frequency. The controller scales this frequency and uses the resulting value as the process variable for the pulse loop. Generally, the longer the pulse sample time, the more stable the process variable, but the slower the response of the pulse loop.

This parameter is available only for loop 5 on a four-loop model, loop 9 on an eight-loop model or loop 17 on a sixteen-loop model.

**Selectable values:** 1 to 20 seconds.

### Linear Scaling Parameters
The following parameters are only available if the input type is LINEAR or PULSE. These parameters let you scale the raw input readings (in millivolts or Hertz) to the engineering units of the process variable.

For linear inputs, the input reading is in percent (0 to 100%) representing the 0 to 60mV input range of the controller. For pulse inputs, the input reading is in Hertz (cycles per second.)
The scaling function is defined by two points on a conversion line. This line relates the process variable (PV) to the input signal. The engineering units of the process variable can be any units—the graph in Figure 4.2 shows PSI as an example.

Before you enter the values determining the two points for the conversion line, you must choose an appropriate display format. The controller has six characters available for process display; select the setting with the desired number of decimal places. Use a display format that matches the range of the process variable and resolution of the sensor. The display format you choose is used for the process variable setpoint, alarms limits, deadband, spread and proportional band.

The process variable range for the scaled input is between the process variable values that correspond to the 0% and 100% input readings. For the pulse input, it is between the 0Hz and 2000Hz readings. The process variable range defines the limits for the setpoint and alarms. See Figure 4.3.
**Display Format**

Select a display format for a linear or pulse input. Choose a format appropriate for the input range and sensor accuracy.

```
ALARM 01 DISP FORMAT ?
-999 TO 3000
```

**Selectable values:** The controller has several available display formats, as shown in Table 4.9. The table also shows the maximum and minimum process variable for each display format.

<table>
<thead>
<tr>
<th>DISPLAY FORMAT</th>
<th>MAXIMUM PROCESS VARIABLE</th>
<th>MINIMUM PROCESS VARIABLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>-9999 TO +30000</td>
<td>30,000</td>
<td>-9,999</td>
</tr>
<tr>
<td>-999 TO +3000</td>
<td>3,000</td>
<td>-999</td>
</tr>
<tr>
<td>-999.9 TO +3000.0</td>
<td>3,000.0</td>
<td>-999.9</td>
</tr>
<tr>
<td>-99.99 TO +300.00</td>
<td>300.00</td>
<td>-99.99</td>
</tr>
<tr>
<td>-9,999 TO +30,000</td>
<td>30,000</td>
<td>-9,999</td>
</tr>
<tr>
<td>-9999 TO +3.0000</td>
<td>3.0000</td>
<td>-0.9999</td>
</tr>
</tbody>
</table>

**High Process Variable**

Set a high process variable for input scaling purposes. The high process variable and the high reading (HI RDG) together define one of the points on the linear scaling function’s conversion line. Set HI PV to the value you want displayed when the signal is at the level set for the HI RDG.

```
ALARM 01 INPUT SCALING
HI PV ? 1000
```

**Selectable values:** Any value between the low process variable (LO PV) and the maximum process variable for the selected display format. See Table 4.9.

**High Reading**

Enter the input signal level that corresponds to the high process variable (HI PV) you entered in the previous parameter.

```
ALARM 01 INPUT SCALING
HI RDG? 100.0%FS
```

**Selectable values:** For linear inputs, any value between -99.9% and 999.9% of full scale, where 100% corresponds to 60mV and 0% corresponds to 0mV. For pulse inputs, any value between 0 and 2000HZ. The high reading must be greater than the low reading (LO RDG).
**Low Process Variable**

Set a low process variable for input scaling purposes. The low process variable and the low reading (LO RDG) together define one of the points on the linear scaling function’s conversion line. Set L0 PV to the value you want displayed when the signal is at the level set for the low reading (LO RDG).

**Selectable values:** Any value between the minimum process variable and the high process variable for the selected display format. See Table 4.9 on the previous page.

**Low Reading**

Enter the input signal level that corresponds to the low process variable (L0 PV) you entered in the previous parameter.

**Selectable values:** For linear inputs, any value between -99.9% and 999.9% percent of full scale, where 100% corresponds to 60mV and 0% corresponds to 0mV. For pulse inputs, any value between 0 and 2000 HZ. The low reading must be less than the high reading (HI RDG).

**Input Filter**

The controller has two types of input filtering:

- The rejection filter ignores sensor readings outside the acceptance band when subsequent readings are within the band. For temperature sensors, the band is ±5° about the last accepted reading. For linear inputs the band is ±0.5% of the input range. This filter is not adjustable.

- A simulated resistor-capacitor (RC) filter damps the input response if inputs change unrealistically or change faster than the system can respond. If the input filter is enabled, the process variable responds to a step change by going to 2/3 of the actual value within the number of scans you set.

**Selectable values:** 0 to 255 scans. 0 disables the filter.
Setup Loop Control Parameters Menu

Use the SETUP LOOP CONTROL PARAMS menu to adjust heat and cool control parameters, including:

- Proportional band (PB, or gain), integral (TI or reset), and derivative (TD, or rate) settings
- Output filter
- Spread between heat and cool outputs

The controller has separate PID and filter settings for heat and cool outputs. The screens used to set these parameters are nearly identical. In this section, only the heat screens are shown and explained. The heat and cool parameters appear only if the corresponding output is enabled.

See Setup Loop Outputs Menu on page 84 for help enabling and disabling heat and cool outputs.

Table 4.10 shows the parameters available in the SETUP LOOP CONTROL PARAMS menu.

**Table 4.10 – Setup Loop Control Parameters**

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>DEFAULT VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>HEAT CONTROL PB?</td>
<td>Depends upon the INPUT TYPE setting; 50 for J-type thermocouple.</td>
</tr>
<tr>
<td>HEAT CONTROL TI?</td>
<td>Depends upon the INPUT TYPE setting; 180 SEC/R for J-type thermocouple.</td>
</tr>
<tr>
<td>HEAT CONTROL TD?</td>
<td>0</td>
</tr>
<tr>
<td>HEAT CONTROL FILTER?</td>
<td>3</td>
</tr>
<tr>
<td>COOL CONTROL PB?</td>
<td>50</td>
</tr>
<tr>
<td>COOL CONTROL TI?</td>
<td>Depends upon the INPUT TYPE setting; 60 SEC/R for J-type thermocouple.</td>
</tr>
<tr>
<td>COOL CONTROL TD?</td>
<td>Depends upon the INPUT TYPE setting; 0 SECONDS for J-type thermocouple.</td>
</tr>
<tr>
<td>COOL CONTROL FILTER?</td>
<td>3</td>
</tr>
<tr>
<td>SPREAD?</td>
<td>5</td>
</tr>
<tr>
<td>RESTORE PID DIGIN?</td>
<td>NONE</td>
</tr>
</tbody>
</table>
Heat or Cool Control PB
Set the proportional band (also known as gain). A larger value yields less proportional action for a given deviation from setpoint.

Selectable values: Dependent upon sensor type.

The controller internally represents the proportional band (PB) as a gain value. When you edit the proportional band, you will see the values change in predefined steps; small steps for narrow proportional band values and large steps for wide proportional band values.

The controller calculates the default proportional band for each input type according to the following equation:

\[
\text{Default PB} = \frac{\text{High Range} - \text{Low Range}}{\text{Gain}}
\]

Heat or Cool Control TI
Set the integral term (also known as reset). A larger value yields less integral action.

Selectable values: 0 (off) to 6000 seconds.

Heat or Cool Control TD
Set the derivative constant. A larger value yields greater derivative action.

Selectable values: 0 to 255 seconds.
Heat or Cool Output Filter
Dampen the response of the heat or cool output. The output responds to a step change by going to approximately 2/3 of its final value within the number of scans you set here. A larger value results in a slower, or more dampened, response to changes in the process variable.

Selectable values: 0 to 255.0 disables the output filter.

Spread
For a loop using on/off control, the spread is the control hysteresis. This determines the difference between the point at which a heat output turns off as the temperature rises, and the point at which it turns back on as the temperature falls.

For a loop using PID control, the spread determines how far the process variable must be from the setpoint before the controller can switch from heating to cooling. A loop will not switch from heat to cool or vice versa unless the process variable deviates from setpoint by more than the spread.

When the loop is using PID control and the spread is set to 0, the PID calculation alone determines when the heat or cool output should be on.

Selectable values: 0 to 255, 25.5, 2.55, .255, or .0255, depending upon the DISP FORMAT setting.

Restore PID Digital Input
To enable the sensor failure recovery feature, select a digital input at this parameter. If the specified input is held low when a thermocouple fails, the loop returns to automatic control after the thermocouple is repaired.

Selectable range: NONE (disable the sensor failure recovery feature), 1 to 8.
Setup Loop Outputs Menu

Use the SETUP LOOP OUTPUTS menu to:

- Enable or disable outputs
- Set output type
- Set cycle time for time proportioning outputs
- Enter Serial DAC parameters (for Serial DAC outputs)
- Select control action
- Set output level limit and limit time
- Select sensor fail output (output override)
- Select a nonlinear output curve

Table 4.11 shows the parameters available in the SETUP LOOP OUTPUTS menu. Both heat and cool outputs have the same parameters; only one of each parameter is shown.

Table 4.11 – Setup Loop Outputs

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>DEFAULT VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>HEAT CONTROL OUTPUT?</td>
<td>ENABLED</td>
</tr>
<tr>
<td>HEAT OUTPUT TYPE?</td>
<td>TP</td>
</tr>
<tr>
<td>HEAT OUTPUT CYCLE TIME?</td>
<td>10s</td>
</tr>
<tr>
<td>SDAC MODE?*</td>
<td>VOLTAGE</td>
</tr>
<tr>
<td>SDAC LO VALUE?*</td>
<td>0.00 VDC</td>
</tr>
<tr>
<td>SDAC HI VALUE?*</td>
<td>10.00 VDC</td>
</tr>
<tr>
<td>HEAT OUTPUT ACTION?</td>
<td>REVERSE</td>
</tr>
<tr>
<td>HEAT OUTPUT LIMIT?</td>
<td>100%</td>
</tr>
<tr>
<td>HEAT OUTPUT LIMIT TIME?</td>
<td>CONT</td>
</tr>
<tr>
<td>SENSOR FAIL HT OUTPUT?</td>
<td>0%</td>
</tr>
<tr>
<td>HEAT T/C BRK OUT AVG?</td>
<td>OFF</td>
</tr>
<tr>
<td>HEAT OUTPUT?</td>
<td>LINEAR</td>
</tr>
<tr>
<td>COOL CONTROL OUTPUT?</td>
<td>DISABLED</td>
</tr>
</tbody>
</table>

*The SDAC parameters are available only if you select SDAC as the output type. Use these parameters to configure the Serial DAC signal output.
Enable or Disable Heat or Cool Outputs

Enable or disable the heat or cool output for the loop. If you want the loop to have a control output, you must enable at least one output. You can also disable a heat or cool control output and use the output for something else, such as an alarm.

Selectable values: ENABLED or DISABLED.

Heat or Cool Output Type

Select the output type.

Selectable values: TP, DZC, SDAC, ON/OFF, 3P DZC. See Table 4.12 for a description of the output types.

NOTE! The controller assigns digital output 34 as a clock line for the Serial DAC. You will not be able to assign another function to output 34 if any loop’s output is set to SDAC.

Table 4.12 — Heat / Cool Output Types

<table>
<thead>
<tr>
<th>OPTION</th>
<th>OUTPUT TYPE</th>
<th>DEFAULT VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>TP</td>
<td>Time Proportioning</td>
<td>Percent output converted to a percent duty cycle over the user-selected, fixed time base.</td>
</tr>
<tr>
<td>DZC</td>
<td>Distributed Zero Crossing</td>
<td>Output on/off state calculated for every ac line cycle. Use with solid state relay or Dual DAC.</td>
</tr>
<tr>
<td>SDAC</td>
<td>Serial DAC</td>
<td>Use with Serial DAC.</td>
</tr>
<tr>
<td>ON/OFF</td>
<td>On/Off</td>
<td>Output either full on or full off.</td>
</tr>
<tr>
<td>3P DZC</td>
<td>3-Phase Distributed Zero Crossing</td>
<td>Use with 3-phase heaters when wired in delta configuration. (For grounded Y configuration, use DZC instead.)</td>
</tr>
</tbody>
</table>

For an expanded description of these output types, see Chapter 8, Tuning and Control.
Heat or Cool Cycle Time

Set the cycle time for time proportioning outputs.

This parameter appears only if the heat or cool output type for the loop is set to time proportioning (TP).

Selectable values: 1 to 255 seconds.

SDAC Mode

Select the Serial DAC output signal.

Selectable values: CURRENT or VOLTAGE.

SDAC Low Value

Set the low output signal level for the Serial DAC. The Serial DAC converts 0% output from the controller to the value set here.

Set the high and low values to match the input range of the output device. For instance, if the output device has a 0.00 - 10.00 V range, set the SDAC LO VALUE to 0.00 VDC and set the SDAC HI VALUE to 10.00 VDC.

Selectable values: 0.00 to 9.00 VDC or 0.0 to 19.90 MA. This value must be less than the SDAC HI VALUE.

SDAC High Value

Set the high output signal level for the Serial DAC. The Serial DAC converts 100% output from the controller to the value set here.

Set the high and low values to match the range of the output device. For instance, if the output device has a 4 to 20mA range, set the SDAC HI VALUE to 20.00 MA and the SDAC LO VALUE to 4.00 MA.
Selectable values: 0.10 to 10.00 VDC or 0.10 to 20.00 MA. This value must be greater than the SDAC LO VALUE.

Heat or Cool Output Action
Select the control action for the output. Normally, heat outputs are set to reverse action and cool outputs are set to direct action. When output action is set to REVERSE, the output goes up when the process variable goes down. When set to DIRECT, the output goes up when the process variable goes up.

Selectable values: REVERSE or DIRECT.

Heat or Cool Output Limit
This parameter limits the maximum PID control output for a loop’s heat or cool output. This limit may be continuous, or it or it may be in effect for a specified number of seconds (see the next parameter). If you choose a timed limit, the output limit time restarts when the controller powers up and whenever the loop goes from manual to automatic control. The output limit only affects loops under automatic control. It does not affect loops under manual control.

Selectable values: 0 to 100%.

Heat or Cool Output Limit Time
Set a time limit for the output limit set at the previous parameter.

Selectable values: 1 to 999 seconds, or to CONT (continuous).
Sensor Fail Heat or Cool Output

When a sensor fail alarm occurs or when the OUTPUT OVERRIDE DIG INPUT becomes active on a loop that is in automatic control, that loop goes to manual control at the percent power output set here.

![Sensor Fail Heat or Cool Output](image)

**Selectable values:** 0 to 100%.

**NOTE!** When a sensor fails or the override input is detected, both the heat and cool outputs are set to their fail settings. In most applications, SENSOR FAIL HT OUTPUT and SENSOR FAIL CL OUTPUT should be set to 0%.

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

Heat or Cool Thermocouple Break Output Average

If you set this parameter to ON and a thermocouple break occurs, a loop set to automatic control status will go to manual mode at a percentage equal to the average output prior to the break.

![Heat or Cool Thermocouple Break Output Average](image)

**Selectable range:** ON or OFF.

Heat or Cool Linearity

Select an output curve. For a nonlinear process, select CURVE 1 or CURVE 2.

![Heat or Cool Linearity](image)

**Selectable values:** CURVE 1, CURVE 2, or LINEAR. Refer to Figure 4.4.
Figure 4.4 — Linear and Nonlinear Outputs

If curve 1 or 2 is selected, a PID calculation results in a lower actual output level than the linear output requires. One of the nonlinear curves may be used when the response of the system to the output device is nonlinear.

Setup Loop Alarms Menu

Use the SETUP LOOP ALARMS menu to set:

- High and low process and deviation alarms
- Alarm outputs
- Alarm/control behavior
- Alarm deadband
- Alarm delay

Table 4.13 shows the parameters available in the SETUP LOOP ALARMS menu.
Table 4.13 — Setup Loop Alarms

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>DEFAULT VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>HI PROC ALARM SETPT?</td>
<td>1000</td>
</tr>
<tr>
<td>HI PROC ALARM TYPE?</td>
<td>OFF</td>
</tr>
<tr>
<td>HI PROC ALARM OUTPUT?</td>
<td>NONE</td>
</tr>
<tr>
<td>DEV ALARM VALUE?</td>
<td>5</td>
</tr>
<tr>
<td>HI DEV ALARM TYPE?</td>
<td>OFF</td>
</tr>
<tr>
<td>HI DEV ALARM OUTPUT?</td>
<td>NONE</td>
</tr>
<tr>
<td>LO DEV ALARM TYPE?</td>
<td>OFF</td>
</tr>
<tr>
<td>LO DEV ALARM OUTPUT?</td>
<td>NONE</td>
</tr>
<tr>
<td>LO PROC ALARM SETPT?</td>
<td>0</td>
</tr>
<tr>
<td>LO PROC ALARM TYPE?</td>
<td>OFF</td>
</tr>
<tr>
<td>LO PROC ALARM OUTPUT?</td>
<td>NONE</td>
</tr>
<tr>
<td>ALARM DEADBAND?</td>
<td>2</td>
</tr>
<tr>
<td>ALARM DELAY?</td>
<td>0 SECONDS</td>
</tr>
</tbody>
</table>

High Process Alarm Setpoint
Set the value at which the high process alarm activates.

Selectable values: Any point within the scaled sensor range.

High Process Alarm Type
Select an alarm type for the high process alarm.

Selectable values: OFF, ALARM, or CONTROL.

High Process Alarm Output Number
Choose a digital output to activate when the high process alarm occurs, if desired.
Selectable values: NONE, or any output from 1 to 34 not enabled for closed-loop control or for the Serial DAC clock.

Deviation Alarm Value
Set the deviation from setpoint at which the high and low deviation alarms occur.

Choose a digital output to activate when the high deviation alarm occurs, if desired.

Selectable values: 0 to 255, 25.5, 2.55, .255 or .0255, depending on the INPUT TYPE and DISP FORMAT settings.

High Deviation Alarm Type
Select an alarm type for the high deviation alarm.

Choose a digital output to activate when the high deviation alarm occurs, if desired.

Selectable values: ALARM, CONTROL or OFF.

Low Deviation Alarm Type
Select an alarm type for the low deviation alarm.

Selectable values: ALARM, CONTROL or OFF.
Low Deviation Alarm Output Number
Choose a digital output to activate when the low deviation alarm occurs, if desired.

Selectable values: NONE, or any output from 1 to 34 not enabled for closed-loop control or for the Serial DAC clock.

Low Process Alarm Setpoint
Set a low process alarm setpoint. See Process Alarms on page 61.

Selectable values: Any value within the input sensor’s range.

Low Process Alarm Type
Select an alarm type for the low process alarm.

Selectable values: ALARM, CONTROL or OFF.

Low Process Alarm Output Number
Choose a digital output to activate when the low process alarm occurs, if desired.

Selectable values: NONE, or any output from 1 to 34 not enabled for closed-loop control or for the Serial DAC clock.

Alarm Deadband
Set an alarm deadband. This deadband value applies to the high process, low process, high deviation and low deviation alarms for the loop. Use the alarm deadband to avoid repeated alarms as the process variable cycles around an alarm value.
**Alarm Delay**

Set a loop alarm delay. This parameter delays failed sensor, process and deviation alarms until the alarm condition has been continuously present for longer than the alarm delay time.

Selectable range: 0 to 255 seconds.

**Manual I/O Test**

This menu facilitates testing of:

- Digital inputs
- Digital outputs
- The keypad buttons

**Table 4.14** shows the screens available in the **MANUAL I/O TEST** menu.

**Table 4.14** — Manual I/O Test

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>DEFAULT VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>DIGITAL INPUTS</td>
<td>HHHHHHHHH</td>
</tr>
<tr>
<td>TEST DIGITAL OUTPUT?</td>
<td>1: IN USE</td>
</tr>
<tr>
<td>DIGITAL OUTPUT NUMBER XX?</td>
<td>OFF</td>
</tr>
<tr>
<td>KEYPAD TEST</td>
<td>N/A</td>
</tr>
<tr>
<td>DISPLAY TEST</td>
<td>N/A</td>
</tr>
</tbody>
</table>

**NOTE!** The DIGITAL OUTPUT NUMBER screen appears only if an unassigned output has been selected in the TEST DIGITAL OUTPUT screen.
Digital Inputs

View the logic state of the eight digital inputs as H (high) meaning the input is not pulled low, or L (low) meaning the input is connected to the controller common.

This screen shows the state of inputs 1 to 8 from left to right. See Figure 4.5. Since inputs are pulled high when they are not connected, test an input by shorting it to controller common and making sure this screen shows the correct state for that input.

![Digital Inputs Screen](image)

Figure 4.5 — Digital Inputs Screen

When you are done testing digital inputs, press YES or NO to advance to the next screen, or press BACK to return to the MANUAL I/O TEST menu.

Test Digital Output

Select one of the digital alarm outputs to test. You will test the output on the next screen.

You cannot force the state of an output enabled for control.

![Test Digital Output Screen](image)

Selectable values: Any output from 1 to 34 that is not enabled for closed-loop control or for the Serial DAC clock and GA, the global alarm output.

Digital Output Number

This screen appears only if you selected an output that is not in use for control at the TEST DIGITAL OUTPUT screen.

Use this parameter to manually toggle a digital output on or off to test it. Toggling an output ON sinks current from the output to the controller common. Toggling the output OFF stops current flow. All tested outputs are set to OFF when you exit the MANUAL I/O TEST menu.

You cannot toggle outputs enabled for control. To test a control loop output, first disable it using the SETUP LOOP OUTPUTS menu.

![Digital Output Number Screen](image)

Selectable values: ON or OFF.
Keypad Test
Test the keypad. The test begins automatically when the screen appears.

- Press any key to test the keypad. The controller will display the name of the key you have pressed.
- Press NO twice to end the test and return to the top of the MANUAL I/O TEST menu.

Display Test
Use this function to test the display.

- Press YES to display the pixel test pattern.
- Press YES to toggle the pixel pattern.
- Press NO to end the test and return to the top of the MANUAL I/O TEST menu.
Chapter 5: Enhanced Features

This chapter explains five additional features for the CLS200 controller when enabled with enhanced features option firmware:

- Process variable retransmit
- Cascade control
- Ratio control
- Remote analog setpoint
- Differential control
Enhanced Features Menus

**Figure 5.1 — Enhanced Features Option Menus**
Process Variable Retransmit

The process variable retransmit feature retransmits the process signal 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 degradation of the primary signal. The signal can also be used as an input to other types of control systems such as a PLC.

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

The controller output signal must be connected to a Dual DAC or Serial DAC converter to get a 4 to 20mA DC or 0 to 5VDC signal. The choice of converter depends on application requirements.

The process variable retransmit feature is included in both the ramp/soak and enhanced features options.

**NOTE!** If an output is defined as a process variable retransmit, it cannot be used for PID control.

Process Variable Retransmit Menu

The setup parameters for the process variable retransmit feature appear in the **SETUP LOOP PV RETRANSMIT** menu.

- **Retransmit Process Variable**
  Enter the number of the loop that provides the process variable for the retransmit calculation.
  
  If you set this parameter to **NONE** and press **NO**, the controller skips to the **COOL OUTPUT RETRANS PV** screen. The **COOL** parameter is set up the same way as the **HEAT** parameter.

  **Selectable values:** Any loop or **NONE**.
**Minimum Input**

Enter the lowest value of the process variable to be retransmitted. This value is expressed in the same engineering units as the input loop.

If the process variable falls below the minimum, the output will stay at the minimum value.

![Minimum Input Diagram](image)

**Selectable values:** Any value in the input loop’s range.

**Minimum Output**

Enter the output value (0 to 100%) that corresponds to the minimum input.

If you select a minimum output value other than 0%, the output will never drop below MIN OUT, even if the process variable drops below the MIN INP that you specified.

![Minimum Output Diagram](image)

**Selectable values:** 0 to 100%.

**Maximum Input**

Enter the highest value of the process variable to be retransmitted. This value is expressed in the same engineering units as the input loop.

If the process variable goes above the maximum, the output will stay at the maximum value.

![Maximum Input Diagram](image)

**Selectable values:** Any value in the input loop’s range.

By adjusting the maximum and minimum inputs, you can scale the output appropriately. See Figure 5.2.
Maximum Output

Enter the output value (0 to 100%) which corresponds to the maximum input.

The output will never go above this maximum output percentage, regardless of how high the process variable goes.

Selectable values: 0 to 100%.

Process Variable Retransmit Example: Data Logging

The CLS200 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 input is a linear 4 to 20mA DC signal representing a process variable range of 0 to 1000°F.
To set up this application, you would do the following:

1. First, set up the standard control loop parameters according to the furnace application, in this case on loop 1.

2. Select another unused PID output for retransmitting the thermocouple value (for example, loop 2 heat output).

3. Change the display to loop 2, and then enter the three-key sequence (ENTER, then ALARM ACK, then CHNG SP) and go to the first screen in Table 5.1.

4. Follow the steps in Table 5.1 to configure the process variable retransmit option.

5. After following the steps in Table 5.1, press BACK several times until the normal loop display appears. The controller will now produce an output on loop 2 which is linear and proportional to the loop 1 process variable.

### Table 5.1 — Application Example: Setting Up Process Variable Retransmit

<table>
<thead>
<tr>
<th>DISPLAY</th>
<th>USER INPUT</th>
</tr>
</thead>
<tbody>
<tr>
<td>PRESS SETUP LOOP 02 PV RETRANSMIT</td>
<td>Press YES.</td>
</tr>
<tr>
<td>ENTER 02 HEAT OUTPUT RETRANS PV? 01</td>
<td>Enter 01 for loop 1 process variable. Press ENTER.</td>
</tr>
</tbody>
</table>
## Display

<table>
<thead>
<tr>
<th>Loop</th>
<th>Process</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>02 Heat Retrans</td>
<td>MIN INP?</td>
<td>0</td>
</tr>
</tbody>
</table>

**User Input:** Enter the minimum input value, which corresponds to the minimum output percentage. For a range of 0 to 1000˚ F, set the minimum input value to 0˚ F. Press **ENTER**.

<table>
<thead>
<tr>
<th>Loop</th>
<th>Process</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>02 Heat Retrans</td>
<td>MIN OUT%?</td>
<td>0</td>
</tr>
</tbody>
</table>

**User Input:** Enter the minimum output percentage, from 0 to 100%. For this example we will assume a full span with a minimum of 0%. Press **ENTER**.

<table>
<thead>
<tr>
<th>Loop</th>
<th>Process</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>02 Heat Retrans</td>
<td>MAX INP?</td>
<td>1000</td>
</tr>
</tbody>
</table>

**User Input:** Enter the maximum input value, which corresponds to the maximum output percentage. For a range of 0 to 1000˚ F, set the maximum input value to 1000˚ F. Press **ENTER**.

<table>
<thead>
<tr>
<th>Loop</th>
<th>Process</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>02 Heat Retrans</td>
<td>MAX OUT%?</td>
<td>100</td>
</tr>
</tbody>
</table>

**User Input:** Enter the maximum output percentage, from 0 to 100%. For this example we will assume a full span with a maximum of 100%. Press **ENTER**.

<table>
<thead>
<tr>
<th>Loop</th>
<th>Process</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>02 Cool Output</td>
<td>RETRANS PV?</td>
<td>NONE</td>
</tr>
</tbody>
</table>

**User Input:** The process variable retransmit section of the controller programming is now completed. We are not using the cool output of loop 2 to retransmit a process variable, so choose **NONE**. Press **ENTER**.

### Notes about this application:

- This is not a thermocouple curve type of signal and requires a linear input range in the recorder.
- To complete this configuration, the loop 2 output must be enabled and tailored to meet the requirements of the data application. In this example, the data logger requires an analog input of 4 to 20mA.
- The CLS200 Series controllers must be used with a Watlow Serial DAC.

Consult Chapter 4: Setup for information on setting up the other options of the controller.

**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 setpoint of the second (secondary) loop. The secondary loop normally executes the actual control.

The cascade control feature allows the output percentage of one control loop to determine the setpoint of a second control loop. By adjusting the setpoint (SP) parameters, the user can adjust the influence that the primary loop has on the setpoint of the secondary loop. See Figure 5.4.
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. The CLS200 allows you to use the primary heat output for both control and for determining the setpoint of the secondary loop.

![Diagram showing secondary loop setpoint calculation]

Calculation of new secondary loop setpoint:

\[
SP_2 = \text{Base SP} + |\text{Cool Output Power}| \times \text{Cool Span} + |\text{Heat Output Power}| \times \text{Heat Span}
\]

**Figure 5.4 — Relationship Between the Primary Loop’s Output and the Secondary Loop’s Setpoint**

**NOTE!** Cascade control cannot be used on the same control loop as ratio control. However, both features may be used in the same multiloop controller.

**Setup Loop Cascade Menu**

The setup parameters for cascade control appear under the **SETUP LOOP CASCADE** menu.

Press **YES** to set up the cascade parameters. The loop currently displayed (loop 02 in this case) will be the secondary control loop, which performs the actual control.

**Primary Loop**

Enter the primary loop number. The output percentage of this loop will control the setpoint of the secondary loop.

**Selectable values:** Any loop except the secondary loop.
**Base Setpoint**

Enter the setpoint that corresponds to 0% (heat and cool) output from the primary loop (PRIM. LOOP). This value is expressed in the same engineering units as the secondary loop’s process variable.

Selectable values: Any value from the secondary loop’s minimum process variable to its maximum process variable.

**Minimum Setpoint**

Enter the lowest value of the secondary loop setpoint. This minimum setpoint overrides any calculation caused by the primary loop calling for a lower setpoint. This value is expressed in the same engineering units as the secondary loop’s process variable.

Selective values: Any value from the secondary loop’s minimum process variable to its maximum process variable.

**Maximum Setpoint**

Enter the highest value of the secondary loop setpoint. This maximum setpoint overrides any calculation caused by the primary loop calling for a higher setpoint. This value is expressed in the same engineering units as the secondary loop’s process variable.

Selective values: Any value from the secondary loop’s minimum process variable to its maximum process variable.

**Heat Span**

Enter the multiplier to apply to the primary loop heat output percentage.

Selective values: -9999 to +9999.
Cool Span
Enter the multiplier to apply to the primary loop cool output percentage.

Selectable values: -9999 to +9999.

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 with a setpoint range of 150 to 190°F.

To set up this application, you would do the following:

1. Change the display to loop 2, which will be the secondary loop, and then enter the three-key sequence (ENTER, then ALARM ACK, then CHNG SP) and go to the first screen in Table 5.2.
2. Follow the steps in Table 5.2 to configure cascade control.
Table 5.2 – Application Example: Setting Up Cascade Control

<table>
<thead>
<tr>
<th>DISPLAY</th>
<th>USER INPUT</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>DISPLAY</strong></td>
<td><strong>USER INPUT</strong></td>
</tr>
<tr>
<td><img src="image" alt="Setup Loop 02 Cascade?" /></td>
<td>Press <strong>YES</strong> to set up the cascade parameters with loop 2 as the secondary loop.</td>
</tr>
<tr>
<td><img src="image" alt="Loop 02 Cascade Prim. Loop? 01" /></td>
<td>Enter 01 for loop 1 process variable. Press <strong>ENTER</strong>.</td>
</tr>
<tr>
<td><img src="image" alt="Loop 02 Cascade Base SP? 150" /></td>
<td>The base setpoint corresponds to the 0% level output of the primary loop. Enter the base setpoint of the secondary loop. For this example, we will assume a base setpoint of 150°F, which is the desired water temperature. Press <strong>ENTER</strong>.</td>
</tr>
<tr>
<td><img src="image" alt="Loop 02 Cascade Min SP? -350" /></td>
<td>Enter the minimum setpoint of the secondary loop. For this example, we will use a minimum setpoint of -350°F. Press <strong>ENTER</strong>.</td>
</tr>
<tr>
<td><img src="image" alt="Loop 02 Cascade Max SP? 1400" /></td>
<td>Enter the maximum setpoint of the secondary loop. For this example, we will use a maximum setpoint of 1400°F. Press <strong>ENTER</strong>.</td>
</tr>
<tr>
<td><img src="image" alt="Loop 02 Cascade HT SPAN? 40" /></td>
<td>Enter the heat span of the secondary loop. This is the span over which the primary output from 0 to 100% is used to change the setpoint. The desired setpoint range is 150 to 190°F. We will assume a linear rise in setpoint, so the heat span is 40°F. Press <strong>ENTER</strong>.</td>
</tr>
<tr>
<td><img src="image" alt="Loop 02 Cascade CL SPAN? 0" /></td>
<td>Enter the cool span of the secondary loop. For this example we will assume no low-side adjustment to the setpoint, so the cool span is 0°F. Press <strong>ENTER</strong>.</td>
</tr>
</tbody>
</table>

3. Press **BACK** several times until the normal loop display appears. The output percentage of loop 1 will now control the setpoint of loop 2.

To verify that cascade is working as expected, you would follow these steps:

1. Set loop 1 to **MANUAL** and the **OUTPUT** to 0%. Loop 2 setpoint should equal 150 (BASE SP).
2. Adjust loop 1 **MANUAL OUTPUT** to 50%. Loop 2 setpoint should equal 170 (BASE SP + 50% of HT SPAN)
3. Adjust loop 1 **MANUAL OUTPUT** to 100%. Loop 2 setpoint should equal 190 (BASE SP + HT SPAN).
4. To complete the cascade setup, both loop 1 and loop 2 must be configured for inputs, outputs, and alarms.

In addition, the PID parameters of loop 1 must be tuned to produce the desired effect for the application on the setpoint of loop 2. For a cascade control application that uses the secondary loop for PID control, loop 1 typically uses only proportional mode. This must be set for the amount of change in the process variable to cause a 100% change in the output level.

The proportional band is selected so the setpoint of the secondary loop has the desired relationship to the process variable of the primary loop. In this application, the proportional band (PB) of the primary loop is set to 10°F and the integral and derivative are turned off.

![Figure 5.6 — Secondary Loop Setpoint Related to Primary Loop Output](image)

As the temperature of loop 1 drops, the output of loop 1 goes up proportionally and the setpoint 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 setpoint (150°F).

With proportional control, when loop 1 is at setpoint, its output is 0%, and the setpoint of loop 2 is equal to the base setpoint (150°F). If the temperature of loop 1 drops to 149°F, the deviation results in a proportional output of 10%. This times the span of 40°F results in an increase in setpoint for loop 2 of 4°F. The loop 2 setpoint increases to 154°F. For every degree that loop 1 drops, loop 2 increases by 4°F until the output of loop 1 is 100% and the loop 2 setpoint is 190°F. Any further drop in the loop 1 process variable does not affect loop 2.

The PID parameters of loop 2 must be tuned to perform efficient control.

For two-zone cascade control systems, the PID settings for both loops, the primary plus the secondary, must be optimized for good temperature control.

See Chapter 4: Setup for information on tuning PID loops.
Ratio Control

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

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

![Diagram showing the relationship between the master loop's process variable and the ratio loop's setpoint.]

**Figure 5.7 — Relationship Between the Master Loop’s Process Variable and the Ratio Loop’s Setpoint**

### NOTE!
Ratio control cannot be used on the same control loop as cascade control. However, both features may be used in the same multiloop controller.

Setup Loop Ratio Control Menu

The ratio control parameters appear in the **SETUP LOOP RATIO CONTROL** menu.

Press **YES** to set up the ratio control parameters with loop number 2 as the ratio loop.
**Master Loop**

Enter the master loop which will provide the output to the internal controller setpoint calculation for the ratio loop setpoint.

Selectable values: Any loop except the loop currently selected (in this case, loop 02). Choose NONE for no ratio control.

**Minimum Setpoint**

Enter the lowest allowable setpoint for the ratio loop. This minimum setpoint overrides any ratio calculation calling for a lower setpoint. This value is expressed in the same engineering units as the ratio loop’s process variable.

Selectable values: Any value from the minimum value of the ratio loop’s process variable to its maximum value.

**Maximum Setpoint**

Enter the highest allowable setpoint for the ratio loop. This maximum setpoint overrides any ratio calculation calling for a higher setpoint. This value is expressed in the same engineering units as the ratio loop’s process variable.

Selectable values: Any value from the minimum value of the ratio loop’s process variable to its maximum value.

**Control Ratio**

Enter the multiplier to apply to the master loop’s process variable.

Selectable values: 0.1 to 999.9.
**Setpoint Differential**

Enter the value to add or subtract from the ratio loop setpoint calculation before using it as the setpoint. This value is expressed in the same engineering units as the ratio loop’s process variable.

<table>
<thead>
<tr>
<th>SP DIFF</th>
<th>0</th>
</tr>
</thead>
</table>

**Selectable values:** -9999 to 9999 with the decimal placement determined by the DISP FORMAT setting for the ratio loop.

**Ratio Control Example: Diluting KOH**

A chemical process requires a formula of two parts water (H₂O) to one part potassium hydroxide (KOH) to produce diluted potassium hydroxide. The desired flow of H₂O 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 CLS200, with H₂O flow as process variable 1 and KOH flow as process variable 2. The outputs of loops 1 and 2 adjust motorized valves.

1. Adjust and tune loop 1 (H₂O) for optimal performance before implementing the ratio setup.
2. Switch the controller to display loop 2 (KOH), and then enter the three-key sequence (ENTER, then ALARM ACK, then CHNG SP) and go to the first screen in Table 5.3.
3. Follow the steps in Table 5.3 to configure ratio control.
### Table 5.3 – Application Example: Setting Up Ratio Control

<table>
<thead>
<tr>
<th>DISPLAY</th>
<th>USER INPUT</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image" alt="Setup Loop 02 Ratio Control?" /></td>
<td>Press <strong>YES</strong> to set up the ratio control parameters or loop 02.</td>
</tr>
<tr>
<td><img src="image" alt="Loop 02 Ratio Control Mstr Loop? 01" /></td>
<td>Assign loop 01 as the master loop. Press <strong>ENTER</strong>.</td>
</tr>
<tr>
<td><img src="image" alt="Loop 02 Ratio Control Min Sp? 0.0" /></td>
<td>Enter the minimum ratio loop setpoint. For this example, we will use 0.0 gallons per second as a minimum. Press <strong>ENTER</strong>.</td>
</tr>
<tr>
<td><img src="image" alt="Loop 02 Ratio Control Max Sp? 7.0" /></td>
<td>Enter the maximum ratio loop setpoint. For this example, we will use 7.0 gallons per second as a maximum. Press <strong>ENTER</strong>.</td>
</tr>
<tr>
<td><img src="image" alt="Loop 02 Ratio Control Ctrl Ratio? 0.5" /></td>
<td>Enter the control ratio, which is the multiple applied to the master. The H₂O flow rate is multiplied by 0.5 to obtain the KOH flow rate setpoint. Press <strong>ENTER</strong>.</td>
</tr>
<tr>
<td><img src="image" alt="Loop 02 Ratio Control Sp Diff.? 0" /></td>
<td>Enter the setpoint differential (or offset). For this example we have no offset requirement and will use 0. Press <strong>ENTER</strong>.</td>
</tr>
</tbody>
</table>

4. Press **BACK** several times until the normal loop display appears. The setpoint of loop 2 will now be equal to one half of the process variable of loop 2.

5. To complete the ratio setup, configure both loops 1 and 2 for inputs, outputs, and alarms. See Chapter 4: Setup for information on loop setup.
Remote Analog Setpoint

The remote analog setpoint is set up identically to ratio control. To provide a setpoint remotely, typically a voltage or current source is connected to an analog input on the controller. This input is configured as a linear input type and the master loop for ratio control. All other input types are also usable as remote analog setpoint inputs.

Specify the loop to which the analog input is connected as the master loop and setup the rest of the ratio control parameters as outlined in Setup Loop Ratio Control Menu on page 108.

Remote Analog Setpoint Example: Setting a Setpoint with a PLC

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

Both the remote analog setpoint feature and the process variable retransmit feature can be used with PLC systems as the link between multiloop PID control systems and PLC systems.

For example, a 0 to 5VDC signal representing 0 to 300°F will be used as a remote setpoint input to the CLS200. The input signal will be received on loop 1 with the control being performed on loop 2. Note that proper scaling resistors must be installed on the input of loop 1 to allow it to accept a 0 to 5VDC input.

To set up this application, you would do the following:

1. In the loop 1 SETUP LOOP INPUT menu, set the INPUT TYPE to LINEAR, set HI PV to 300, set LO PV to 0, set HI RDG to 100.0% and set LO RDG to 0.0%.
2. Change the display to loop 2, and then enter the setup parameters. Go to the first screen in Table 5.4.
3. Follow the steps in Table 5.4 to configure the process variable retransmit option.

Table 5.4 — Application Example: Setting Up Remote Setpoint

<table>
<thead>
<tr>
<th>DISPLAY</th>
<th>USER INPUT</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image" alt="loop process units" /></td>
<td>Press <strong>YES</strong> to set up the cascade parameters with loop 2.</td>
</tr>
<tr>
<td><img src="image" alt="loop process units" /></td>
<td>Assign loop 01 to be the master loop. Press <strong>ENTER</strong>.</td>
</tr>
<tr>
<td><img src="image" alt="loop process units" /></td>
<td>Enter the minimum ratio loop setpoint. For this example, we will use 0°F. Press <strong>ENTER</strong>.</td>
</tr>
</tbody>
</table>
4. Press BACK several times until the normal loop display appears. The setpoint of loop 2 will now be equal to the process variable of loop 1.

5. To complete the remote analog setpoint setup, loop 1 may be configured for outputs and alarms. Likewise, loop 2 must be configured for inputs, outputs, and alarms. See Chapter 4: Setup for information on loop setup.

**Differential Control**

Differential control is a simple application of the ratio control option, used to control one process (ratio loop) at a differential, or offset, to another (master loop). To use differential control, set the ratio value to 1.0 and enter the desired offset with the SP DIFF parameter.

**Differential Control Example: Thermoforming**

A thermal forming application requires that the outside heaters operate at a higher temperature than the center heaters. The differential control point is determined by the master loop which is using infrared (IR) sensors for temperature feedback. Secondary loops use thermocouples for feedback.

The loop using the IR sensor as an input is assigned to the master loop in the SETUP LOOP RATIO CONTROL menu. The secondary loop is the differential control loop. Setting the setpoint differential (SP DIFF) to the desired offset will produce the desired offset between the secondary and master loops.

For example, the master loop can be controlled at 325°F and the secondary loop at 375°F by using a differential of 50°F.

Loop 1 must be set up for PID control of the setpoint at 325°F.
To set up this application, you would do the following:

1. Change the display to loop 2, and then enter the setup parameters. Go to the first screen in Table 5.5.
2. Follow the steps in Table 5.5 to configure the process variable retransmit option.

Table 5.5 - Application Example: Setting Up Differential Control

<table>
<thead>
<tr>
<th>DISPLAY</th>
<th>USER INPUT</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SETUP LOOP Q2 RATIO CONTROL?</strong></td>
<td>Press <strong>YES</strong> to set up the cascade parameters with loop 2.</td>
</tr>
<tr>
<td><strong>O2 RATIO CONTROL MSTR LOOP? 01</strong></td>
<td>Assign loop 01 as the master loop. Press <strong>ENTER</strong>.</td>
</tr>
<tr>
<td><strong>MIN SP? 300.0</strong></td>
<td>Enter the minimum ratio loop setpoint. For this example, we will use <strong>300.0° F</strong>. Press <strong>ENTER</strong>.</td>
</tr>
<tr>
<td><strong>MAX SP? 400.0</strong></td>
<td>Enter the maximum ratio loop setpoint. For this example, we will use <strong>400.0° F</strong>. Press <strong>ENTER</strong>.</td>
</tr>
<tr>
<td><strong>CTRL RATIO? 1.0</strong></td>
<td>Enter the control ratio, which is the multiple applied to the master process variable. In this example the ratio is <strong>1.0</strong>. Press <strong>ENTER</strong>.</td>
</tr>
<tr>
<td><strong>SP DIFF.? 50</strong></td>
<td>Enter the setpoint differential (or offset). For this example, we have an offset of +50. Press <strong>ENTER</strong>.</td>
</tr>
</tbody>
</table>

3. Press **BACK** several times until the normal loop display appears. The setpoint of loop 2 will now be equal to process variable of loop 1 plus 50°F.
4. To complete the differential control setup, loop 1 and loop 2 must be configured for inputs, outputs, and alarms. See Chapter 4: Setup for information on loop setup.
Chapter 6: Ramp/Soak

This chapter covers setup and operation of ramp/soak profiles in CLS200 series controllers. These features are available in controllers that have the optional ramp/soak firmware installed. The ramp/soak feature turns your controller into a powerful and flexible batch controller. Ramp/soak lets you program the controller to change a process setpoint in a preset pattern over time. This preset pattern, or temperature profile, consists of several segments. During a segment, the temperature goes from the previous segment’s setpoint to the current segment’s setpoint.

- If the current segment’s setpoint is higher or lower than the previous segment’s setpoint, it is called a ramp segment.
- If the current segment’s setpoint is the same as the previous segment’s setpoint, it is called a soak segment.

![Figure 6.1 — Sample Ramp/Soak Profile](image-url)
Features

Ramp/soak in the CLS200 includes the following features:

- **Ready segment sets loop up for profile**: Ready segment can control at setpoint until profile needs to run. Ready segment events set all available event outputs to desired states before profile starts.

- **Up to 20 segments per profile**: The controller can store up to 17 profiles, each with up to 20 segments.

- **Multiple profiles run independently**: Each loop can run a different profile or the same profile can be run independently on more than one loop.

- **Up to two triggers per segment**: Triggers are digital inputs that can be programmed to start and hold segments based on the trigger’s digital state. You can use any one of the eight digital inputs for triggers. You can also use the same trigger for more than one segment or more than one profile.

- **Up to four events per segment**: Digital outputs controlled by the ramp/soak profile. Events outputs are set at the end of a segment. You can use any of the digital outputs that are not used for control or for the Serial DAC clock.

- **Tolerance hold ensures time at temperature**: Set a limit on how far the process variable can vary above or below setpoint. The profile clock only runs when the process variable is within the limit.

- **Tolerance alarm indicates process not tracking setpoint**: Set a maximum amount of time for the tolerance hold to wait for a process deviation before notifying the operator. The operator can acknowledge the alarm and proceed if desired.

- **User-configurable time base**: Program profiles to run for hours and minutes or for minutes and seconds.

- **Repeatable profiles**: Set any profile to repeat from 1 to 99 times or continuously.

- **Fast setup for similar profiles**: Set up one profile, then copy it and alter it to set up the rest.

- **External reset**: Select a digital input you can use to hold a profile in the “start” state and restart it.

*Table 6.1* summarizes the ramp/soak features of the CLS200.

<table>
<thead>
<tr>
<th>Table 6.1 — Ramp/Soak Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of possible profiles</td>
</tr>
<tr>
<td>Number of times to repeat a profile</td>
</tr>
<tr>
<td>Number of segments per profile</td>
</tr>
<tr>
<td>Number of triggers per segment</td>
</tr>
<tr>
<td>Type of triggers</td>
</tr>
<tr>
<td>Number of possible inputs for triggers</td>
</tr>
<tr>
<td>Number of events per segment</td>
</tr>
<tr>
<td>Number of possible outputs for events (At least one of these outputs must be used for control)</td>
</tr>
</tbody>
</table>
Ramp/Soak Menus

The SETUP R/S PROFILES menu appears between the SETUP LOOP ALARMS and MANUAL I/O TEST menus. Figure 6.2 shows the ramp/soak setup menu tree. *See Process Variable Retransmit on page 98.

Figure 6.2 — Setup Ramp/Soak Profiles Menu
Setup Global Parameters Menu

With the Ramp and Soak option, an additional menu appears on the SETUP GLOBAL PARAMETERS menu.

Ramp/Soak Time Base

The RAMP/SOAK TIME BASE parameter is in the SETUP GLOBAL PARAMETERS menu.

Use this parameter to set the time base in all your ramp/soak profiles. When set to HOURS/MINS, the setpoint is updated once every minute. When set to MINS/SECS, the setpoint is updated once every second.

Selectable values: HOURS/MINS (hours/minutes) or MINS/SECS (minutes/seconds).

Setup Ramp/Soak Profile Menu

The SETUP RAMP/SOAK PROFILE menu is located between the SETUP LOOP ALARMS and the MANUAL I/O TEST menus if the ramp/soak option is installed.

Press YES to set up or edit ramp/soak profiles.

Edit Ramp/Soak Profile

Choose a profile to set up or edit.

Selectable values: A to Q (17 profiles).

Copy Setup From Profile

Set up similar profiles quickly by copying the setup of an existing profile.

Selectable values: A to Q.
**Tolerance Alarm Time**

Set a limit on how long the process variable can be outside the tolerance set for the segment before the tolerance alarm occurs. If the process variable does not return within the tolerance, the tolerance alarm will recur after the tolerance alarm time elapses again.

If the alarm persists, you may want to reset the profile.

```
A OUT-OF-TOLRANCE
ALARM TIME? 1:00
```

**Selectable values:** 0:00 to 99:59 (minutes or hours, depending on the time base setting).

**Ready Segment Setpoint**

When you assign a profile to a loop, the profile does not start immediately. Instead, it goes to the ready segment (segment 0) and stays there until you put the profile in run mode.

You can set a setpoint, assign events, and set event states for the ready segment. Use this parameter to set the ready segment setpoint. Setting the setpoint to OFF ensures that control outputs for the loop running the profile will not come on.

```
A READY SEGMENT
SETPOINT? OFF
```

**Selectable values:** -999 to 9999, or OFF. See Setpoints and Tolerances for Various Input Types on page 124.

**Ready Segment Edit Events**

Press YES to set or edit the ready state for all outputs that are not used for control or for the Serial DAC clock. When you assign a profile, the controller starts the ready segment: it goes to the setpoint and puts all the outputs in the state you set here. The outputs stay in the states they are set to until their states are changed at the end of subsequent segments.

```
A READY SEGMENT
EDIT EVENTS ?
```

Press NO to advance to EXTERNAL RESET INPUT NUMBER.
Ready Event Output
Press NO to increment the output number. Press YES to set the event state to ON or OFF. This parameter appears only if you answered YES to READY SEGMENT EDIT EVENTS?

Selectable values: ON or OFF.
When you are done, press BACK to return to READY SEGMENT EDIT EVENTS, then press NO to go to the next parameter.

External Reset Input Number
Select one of the eight digital inputs as an external reset. When the reset input is on, the profile is set to RUN mode at the beginning of the first segment. As long as the reset input is on, the profile is held at the beginning of the first segment. Once the reset input turns off the profile begins to run.

Selectable values: 1 to 8, or N (for no external reset).

Edit Segment Number
Each profile is made up of several segments (up to 20). Choose the segment to edit.

Selectable values: 1 to 20.
The first time you use this parameter, it defaults to segment 1. When you finish editing a segment, the controller goes to the next segment. This loop continues until you make a segment the last segment of a profile.

Segment Time
Enter the duration of the segment.

Selectable values: 0:00 to 999:59 (hours and minutes or minutes and seconds, depending on the selected time base).
**Segment Setpoint**

Enter the ending setpoint for the segment you are editing. For a ramp, the setpoint changes steadily over the segment time from the end setpoint of the previous segment to the value set here. For a soak, set the value here equal to the end setpoint of the previous segment.

Selectable values: -999 to 3276, or OFF (no output during segment). See Setpoints and Tolerances for Various Input Types on page 124.

**Edit Segment Events**

You can assign up to four digital outputs, or events, to each segment. When the segment ends, the outputs you select are set to the state you specify. Press YES to select outputs and specify their states.

Press NO to advance to the EDIT SEG TRGGRS parameter.

**NOTE!** Events are set at the end of segments. If you want a segment to start with an event, program the event in the previous segment. You can also create a segment with zero time preceding the segment during which you want the event on.

**Segment Event Output**

Select a digital output for the event. Use a digital output that is not being used for PID control or for Serial DAC clock.

This parameter appears only if you answered YES to EDIT SEG EVENTS?

Selectable values: Any digital output from 1 to 34, except those in use, or NONE (no event).

When you are done setting segment events, press BACK to return to EDIT SEG EVENTS, then press NO to go to the next parameter.
**Segment Events Output States**

Assign a state to the event. At the end of the segment, the output goes to the state you assign here. This parameter appears only if you answered **YES** to **EDIT SEG EVENTS**?

- **Selectable values:** **OFF** (high) or **ON** (low).

**Edit Segment Triggers**

Each segment may have up to two triggers (digital inputs). Both triggers must be true in order for the segment to run. If a trigger is not true, the profile goes into the trigger wait state.

- **Press** **YES** to edit triggers for the current segment, or **NO** to advance to the **SEGMENT TOLERANCE** parameter.

**Trigger Input Number**

Assign a digital input to a segment trigger. You can assign any digital input to any trigger. You can also assign the same digital input as a trigger in more than one segment and more than one profile.

This parameter appears only if you answered **YES** to **EDIT SEG TRGGRS**?

- **Selectable values:** Any digital input from 1 to 8, or **NONE** (disable trigger).

When you are done editing segment triggers, press **BACK** to return to **EDIT SEG TRGGRS**.

**Trigger Active State**

Choose the state that will satisfy the trigger condition. A trigger input is **ON** when pulled low by an external device. A trigger input is **OFF** when the digital input is high.

This parameter appears only if you answered **YES** to **EDIT SEG TRGGRS**?

- **Selectable values:** **OFF** or **ON**.
**Trigger Latch Status**

Choose whether the trigger is latched or unlatched.

- A latched trigger is checked once, at the beginning of a segment.
- An unlatched trigger is checked constantly while a segment is running. If an unlatched trigger becomes false, the segment timer stops and the loop goes into trigger wait state.

When using two triggers with a segment, the following logic applies:

**Table 6.2 — Trigger Latch Logic**

<table>
<thead>
<tr>
<th>TRIGGER SETTINGS</th>
<th>TRIGGER LOGIC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Both Triggers Latched</td>
<td>ORed Trigger starts a segment</td>
</tr>
<tr>
<td>Both Triggers Unlatched</td>
<td>ANDed Triggers start/continue a segment</td>
</tr>
<tr>
<td>One Trigger Latched, One Trigger Unlatched</td>
<td>• The unlatched trigger starts/continues a segment. • The latched trigger has no effect.</td>
</tr>
</tbody>
</table>

This parameter appears only if you answered **YES** to EDIT SEG TRGGRS?

**Selectable values:** LATCHED or UNLATCHED.

**Segment Tolerance**

Set a positive or negative tolerance value for each segment. Tolerance works as shown in **Figure 6.3**.

![Figure 6.3 — Positive and Negative Tolerances](image)

If you enter a positive tolerance, the process is out of tolerance when the process variable goes above the setpoint plus the tolerance.

If you enter a negative tolerance, the process goes out of tolerance when the process variable goes below the setpoint minus the tolerance.

**Selectable values:** -99 to 99, or OFF (no tolerance limit). See Setpoints and Tolerances for Various Input Types on page 124.
Last Segment
Specify whether the current segment is the last one in the profile.

Selectable values: NO or YES.

Repeat Cycles
Set the number of times you want a profile to repeat or cycle.

The profile returns to START mode after completing the number of cycles specified here.

Selectable values: 1 to 99, or C (continuous cycling).

Setpoints and Tolerances for Various Input Types
Setpoints and tolerances are set in segments before the profile is assigned to a particular loop. When the profile is used with a loop, the INPUT TYPE and DISP FORMATS settings are applied to the following parameters:

- Ready setpoint
- Segment setpoint
- Segment tolerance

Refer to Table 6.3 to determine how these parameters are affected for the various INPUT TYPE and DISP FORMAT settings.

Table 6.3 — Display Formats

<table>
<thead>
<tr>
<th>INPUT TYPE</th>
<th>DISPLAY FORMAT</th>
<th>YOU ENTER IN THE PROFILE</th>
<th>RESULTING VALUE WHEN PROFILE IS ASSIGNED TO A LOOP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermocouples and RTDs</td>
<td>N/A</td>
<td>300</td>
<td>300.0</td>
</tr>
<tr>
<td>Linear</td>
<td>-999 to 3000</td>
<td>300</td>
<td>300.0</td>
</tr>
<tr>
<td></td>
<td>-9999 to 30000</td>
<td>300</td>
<td>300.0</td>
</tr>
<tr>
<td></td>
<td>-999.9 to 3000.0</td>
<td>300</td>
<td>300.0</td>
</tr>
<tr>
<td></td>
<td>-99.99 to 300.0</td>
<td>300</td>
<td>300.0</td>
</tr>
<tr>
<td></td>
<td>-9.999 to 30.000</td>
<td>300</td>
<td>3.000</td>
</tr>
<tr>
<td></td>
<td>-9999 to 3.0000</td>
<td>300</td>
<td>0.3000</td>
</tr>
</tbody>
</table>
Using Ramp/Soak

This section explains how to assign a profile to a loop, how to put a profile in RUN or HOLD mode, how to reset a profile, and how to display profile statistics. Figure 6.4 shows the ramp/soak screens.

Figure 6.4 — Ramp/Soak Screens

Ramp/Soak Displays

The single loop and bar graph displays show additional codes when ramp/soak firmware is installed.

Single Loop Display

When the controller is running a profile, the single loop display shows the ramp/soak mode where it would usually show MAN or AUTO. Table 6.4 describes the modes.

Table 6.4 — Ramp/Soak Single Loop Display

<table>
<thead>
<tr>
<th>RAMP/SOAK MODE</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>STRT</td>
<td>The profile is in the ready segment.</td>
</tr>
<tr>
<td>RUN</td>
<td>The profile is running.</td>
</tr>
<tr>
<td>HOLD</td>
<td>The user has put the profile in hold mode.</td>
</tr>
<tr>
<td>TOHO</td>
<td>The profile is in tolerance hold.</td>
</tr>
<tr>
<td>WAIT</td>
<td>The profile is in trigger wait state.</td>
</tr>
</tbody>
</table>
This is the single loop display when a profile is running. If a tolerance alarm occurs, the controller displays a flashing T in the alarm symbol position.

### Bar Graph Display

The ramp/soak mode is also displayed on the bar graph display. Table 6.5 describes the control status symbols used for loops with ramp/soak profiles assigned.

<table>
<thead>
<tr>
<th>RAMP/SOAK SYMBOL</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>R</td>
<td>A profile is running</td>
</tr>
<tr>
<td>H</td>
<td>A profile is holding.</td>
</tr>
<tr>
<td>S</td>
<td>A profile is in ready state/start mode.</td>
</tr>
<tr>
<td>O</td>
<td>A profile is in tolerance hold.</td>
</tr>
<tr>
<td>W</td>
<td>A profile is in trigger wait.</td>
</tr>
</tbody>
</table>

### Time Remaining Display

From the single loop display, press the RAMP/SOAK key once.

This screen shows how much time remains to complete the profile. All screens that are accessed by pressing RAMP/SOAK key have the same information on the top line.
Cycle Number Display
From the single loop display, press the RAMP/SOAK key twice. This screen displays the number of times the profile has run out of the total number of cycles. In this example, the ramp/soak profile is on the 10th of 15 cycles to be performed.

Set Mode Display
From the single loop display, press the RAMP/SOAK key three times. The SET MODE parameter allows you to change the ramp/soak mode.

Assigning a Profile to a Loop
Use this parameter to assign a profile to a loop.

Selective Values: A to Q or NONE

Assigning a Profile the First Time
To assign a profile to a loop that does not have a profile currently assigned:
1. In the single loop display, switch to the loop you want to assign a profile to.
2. Press the RAMP/SOAK key. The ASSIGN R/S PROFILE parameter appears.
3. Choose one of the available profiles and press ENTER
   - or -
   press BACK to return to single loop display without sending profile data to the controller.

Assigning, Changing and Unassigning a Profile
To assign a new profile to a loop that already has one assigned:
1. In the single loop display, switch to the loop in which you want to change or unassign the profile.
2. Press the RAMP/SOAK key three times.
3. Press the NO key. You will see the RESET PROFILE parameter. See Resetting a Profile on page 130.

4. Press YES then ENTER to reset the profile. You will see the ASSIGN PROFILE parameter. See Assigning a Profile to a Loop on page 127.

5. Choose one of the available profiles or NONE (to unassign) and press ENTER.

6. To return to the single loop display without changing the profile assignments, press BACK.

Running a Profile

When you assign a profile, it does not start running immediately. Instead, the loop is in the START mode and the READY segment (segment 0). Use the SET MODE parameter to start a profile (put it in RUN mode).

Starting a Profile

You can start a profile only when it is in the READY segment.

1. In the single loop display, switch to the loop you want to start.

2. Press the RAMP/SOAK key three times. The SET MODE parameter appears.

3. Press YES and ENTER to start the profile. While the profile is in START mode, the only mode available is the RUN mode.

Running Several Profiles Simultaneously

To run several profiles simultaneously, follow these steps:

1. Set up the profiles so that segment 1 of each profile has the same latched trigger.

2. Assign the profiles to the appropriate loops. The loops will go to the READY segment of each profile.

3. Set each profile to RUN mode.

4. Trip the trigger.

Editing a Profile While It Is Running

You can edit a profile while it is running. Changes made to segments after the current segment will take effect when the segment is reached. Changes made to the segments that have already been completed will take effect the next time the profile is run. Do not edit the current segment. Changes to the current segment can have unexpected consequences.

Holding a Profile or Continuing from Hold

Use the SET MODE parameter to select the ramp/soak profile mode. Table 6.6 shows the available modes.
Table 6.6 — Ramp/Soak Profile Modes

<table>
<thead>
<tr>
<th>CURRENT MODE</th>
<th>AVAILABLE MODE</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>STRT</td>
<td>RUN</td>
<td>Begin running the assigned profile.</td>
</tr>
<tr>
<td>HOLD</td>
<td>CONT</td>
<td>Continue from user-selected hold. The profile runs from the point when you put the profile in HOLD mode. (You cannot continue from a tolerance hold or a trigger wait.) After you choose this mode, the controller switches back to RUN mode.</td>
</tr>
<tr>
<td>RUN</td>
<td>HOLD</td>
<td>Hold the profile.</td>
</tr>
</tbody>
</table>

**Holding a Profile**

In HOLD mode, all loop parameters stay at their current settings until you change the mode or reset the profile. To put a profile into HOLD mode, follow these steps:

1. In the single loop display, switch to the loop you want to hold.
2. Press the RAMP/SOAK key three times to see the SET MODE parameter:

   ![Image of SET MODE parameter]

3. Press YES to set the mode. While the profile is running, the only mode you will be able select is HOLD.
4. Press ENTER to hold the profile.

**Continuing a Profile**

To resume or continue a profile that is holding:

1. In the single loop display, switch to the loop you want to run.
2. Press the RAMP/SOAK key three times. The SET MODE parameter appears.
3. Press YES to set the mode. While the profile is holding, the only mode you will be able select is CONT (continue).
4. Press ENTER to run the profile.

**Responding to a Tolerance Alarm**

A tolerance can be set for each segment. The following occurs when the process variable goes outside this tolerance:

- The profile goes into tolerance hold
- The segment timer holds
- The loop’s single loop display shows T0H0
- The tolerance alarm timer starts
If the process variable returns within the segment tolerance before the tolerance alarm time elapses, the profile returns to RUN mode and the tolerance alarm timer resets.

The following occurs if the profile remains out of tolerance for longer than the tolerance alarm time:

- The controller displays the single loop display with the tolerance alarm (a flashing T)
- The global alarm output turns on

Press ALARM ACK to:

- Turn off the global alarm output
- Reset the tolerance alarm timer
- Clear the tolerance alarm

If the process variable does not return within the tolerance, the tolerance alarm will recur after the tolerance alarm time elapses again.

If the alarm persists you may want to reset the profile.

**Resetting a Profile**

To reset a profile, follow these steps:

1. In the single loop display, switch to the loop you want to reset.
2. Press the RAMP/SOAK key three times to see the SET MODE parameter.
3. Press the NO key. The following screen will display:

   ![Screen Display](image.png)

4. Press YES to reset the profile, and then ENTER to confirm your choice.

When you reset a profile, the following happens:

- The profile returns to the ready segment. The setpoint goes to the ready setpoint, and the event outputs go to the states you specified for the READY EVENT OUTPUT parameter in the READY SEGMENT EDIT EVENTS submenu (See Ready Segment Edit Events on page 119.)
- The controller shows you the ASSIGN R/S PROFILE screen in case you would like to assign a different profile to the loop or select NONE to unassign the profile.

**In Case of a Power Failure**

If the power fails or the controller is otherwise powered down while running a ramp/soak profile, by default the profile is set to the START mode when power is restored.

If the POWER UP OUTPUT STATUS parameter in the SETUP GLOBAL PARAMETERS menu is set to MEMORY, then after a power failure the profile will resume operation at the elapsed time of the segment that was active when the power failure occurred.
Chapter 7: Turning and Control

This chapter describes the different methods of control available with the CLS200. This chapter covers control algorithms, control methods, PID control, starting PID values and tuning instructions to help appropriately set control parameters in the CLS200 system. For more information on PID control, consult the Watlow 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 setpoint varies.

NOTE! For any of these control statuses 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 setpoint. This limit is adjustable; Watlow controllers use an adjustable spread.

For example, if the setpoint is 1,000°F and the spread is 20°F, the heat output switches on when the process variable drops below 980°F and off when the process rises above 1,000°F. A process using on/off control cycles around the setpoint. Figure 7.1 illustrates this example.
Proportional Control

Proportional control eliminates cycling by increasing or decreasing the output proportionally with the process variable’s deviation from the setpoint.

The magnitude of proportional response is defined by the proportional band. Outside this band, the output is either 100% or 0%. Within the proportional band the output power is proportional to the process variable’s deviation from the setpoint.

For example, if the setpoint is 1,000°F and the proportional band is 20°F, the output is:

- 0% when the process variable is 1,000°F or above
- 50% when the process variable is 990°F
- 75% when the process variable is 985°F
- 100% when the process variable is 980°F or below

However, a process which uses only proportional control settles at a point above or below the setpoint; it never reaches the setpoint by itself. This behavior is known as offset or droop.
Proportional and Integral Control

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 setpoint, appropriate integral control brings it to the desired setting by gradually increasing the output until there is no deviation.

![Figure 7.3 — Proportional and Integral Control](image)

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

Proportional, Integral and Derivative Control

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 setpoint from below, derivative control reduces the output, anticipating that the process variable will reach setpoint. Use it to reduce overshoot and oscillation of the process variable common to PID control. **Figure 7.4** shows a process under full PID control.

![Figure 7.4 — Proportional, Integral and Derivative Control](image)
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 SPREAD parameter to prevent such oscillations. See Spread on page 83. When PID control is used for one or both loop outputs, both the SPREAD parameter and PID parameters determine when control switches between heating and cooling.

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 5VDC, 0 to 10VDC or 4 to 20mA 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 setpoint and the process variable. PID algorithms are not used with on/off control. The output variable is always off or on (0% or 100%).

Time Proportioning (TP)

With time proportioning outputs, the PID algorithm calculates an output between 0 and 100%, 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% and the cycle time is 10 seconds, then the output will be on for 3 seconds and off for 7 seconds. Figure 7.5 shows examples of time proportioning and distributed zero crossing (DZC) waveforms.

![Figure 7.5 — Time Proportioning and Distributed Zero Crossing Waveforms](image-url)
**Distributed Zero Crossing (DZC)**

With DZC outputs, the PID algorithm calculates an output between 0 and 100%, 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 60Hz power is 16.6ms, 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%. 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 170 seconds for a sixteen-loop controller, 0 to 85 seconds for an eight-loop controller or 0 to 43 seconds for a four-loop controller. 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.
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 (PB) Settings

Table 7.1 shows proportional band settings for various temperatures in degrees Fahrenheit or Celsius.

Table 7.1 — Proportional Band Settings

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

As a general rule, set the proportional band to 10% of the setpoint below 1000° and 5% of the setpoint above 1000°. This setting is useful as a starting value.

Integral Settings

The controller’s integral parameter (TI) is set in seconds per repeat. Some other products use an integral term called reset, in units of repeats per minute. Table 7.2 shows integral settings versus reset settings.
Table 7.2 – Integral Term and Reset Settings

<table>
<thead>
<tr>
<th>INTEGRAL (SECONDS/REPEAT)</th>
<th>RESET (REPEATS/MINUTE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>2.0</td>
</tr>
<tr>
<td>45</td>
<td>1.3</td>
</tr>
<tr>
<td>60</td>
<td>1.0</td>
</tr>
<tr>
<td>90</td>
<td>0.66</td>
</tr>
<tr>
<td>120</td>
<td>0.50</td>
</tr>
<tr>
<td>150</td>
<td>0.40</td>
</tr>
<tr>
<td>180</td>
<td>0.33</td>
</tr>
<tr>
<td>210</td>
<td>0.28</td>
</tr>
<tr>
<td>240</td>
<td>0.25</td>
</tr>
<tr>
<td>270</td>
<td>0.22</td>
</tr>
<tr>
<td>300</td>
<td>0.20</td>
</tr>
<tr>
<td>400</td>
<td>0.15</td>
</tr>
<tr>
<td>500</td>
<td>0.12</td>
</tr>
<tr>
<td>600</td>
<td>0.10</td>
</tr>
</tbody>
</table>

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

Derivative Settings

The controller’s derivative parameter (TD) 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 7.3 shows derivative versus rate. Rate = Derivative/60.

Table 7.3 – Derivative Term Versus Rate

<table>
<thead>
<tr>
<th>DERIVATIVE (SECONDS)</th>
<th>RATE (MINUTES)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>0.08</td>
</tr>
<tr>
<td>10</td>
<td>0.16</td>
</tr>
<tr>
<td>15</td>
<td>0.25</td>
</tr>
<tr>
<td>20</td>
<td>0.33</td>
</tr>
<tr>
<td>25</td>
<td>0.41</td>
</tr>
<tr>
<td>30</td>
<td>0.50</td>
</tr>
<tr>
<td>35</td>
<td>0.58</td>
</tr>
<tr>
<td>40</td>
<td>0.66</td>
</tr>
<tr>
<td>45</td>
<td>0.75</td>
</tr>
<tr>
<td>50</td>
<td>0.83</td>
</tr>
<tr>
<td>55</td>
<td>0.91</td>
</tr>
<tr>
<td>60</td>
<td>1.0</td>
</tr>
</tbody>
</table>

As a general rule, set the derivative to 15% 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 7% of the setpoint. (Example: Setpoint set to 450, proportional band set to 31).

Proportional with Integral (PI)

- Set the proportional band to 10% of setpoint. (Example: Setpoint set to 450, proportional band set to 45).
- Set integral to 60.
- Set derivative to Off.
- Set the output filter to 2.

PI with Derivative (PID)

- Set the proportional band to 10% of the setpoint. (Example: Setpoint set to 450, proportional band set to 45).
- Set the integral to 60.
- Set the derivative to 15% of the integral. (Example: Integral set to 60, derivative set to 9).
- Set the output filter to 2.

Table 7.4 shows general PID constants by application.

Table 7.4 — General PID Constants

<table>
<thead>
<tr>
<th>APPLICATION</th>
<th>PROPORTIONAL BAND</th>
<th>INTEGRAL</th>
<th>DERIVATIVE</th>
<th>FILTER</th>
<th>OUTPUT TYPE</th>
<th>CYCLE TIME</th>
<th>ACTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electrical heat with solid state relays</td>
<td>50°</td>
<td>60</td>
<td>15</td>
<td>4</td>
<td>DZC</td>
<td>–</td>
<td>Reverse</td>
</tr>
<tr>
<td>Electrical heat with electro-mechanical relays</td>
<td>50°</td>
<td>60</td>
<td>15</td>
<td>6</td>
<td>TP</td>
<td>20</td>
<td>Reverse</td>
</tr>
<tr>
<td>Cool with solenoid valve</td>
<td>70°</td>
<td>500</td>
<td>90</td>
<td>4</td>
<td>TP</td>
<td>10</td>
<td>Direct</td>
</tr>
<tr>
<td>Cool with fans</td>
<td>10°</td>
<td>Off</td>
<td>10</td>
<td>4</td>
<td>TP</td>
<td>10</td>
<td>Direct</td>
</tr>
<tr>
<td>Electric heat with open heat coils</td>
<td>30°</td>
<td>20</td>
<td>Off</td>
<td>4</td>
<td>DZC</td>
<td>–</td>
<td>Reverse</td>
</tr>
<tr>
<td>Gas heat with motorized valves</td>
<td>60°</td>
<td>120</td>
<td>25</td>
<td>8</td>
<td>Analog</td>
<td>–</td>
<td>Reverse</td>
</tr>
<tr>
<td>Gas heat with motorized valves Setpoint &gt; 1200</td>
<td>100°</td>
<td>240</td>
<td>40</td>
<td>8</td>
<td>Analog</td>
<td>–</td>
<td>Reverse</td>
</tr>
</tbody>
</table>
Chapter 8: Troubleshooting and Reconfiguring

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:

- Controller is installed correctly. (See Chapter 2: Installation for help.)
- 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 Application Engineering for additional troubleshooting help. If you need to return the unit to Watlow for testing and repair, Customer Service will issue you an RMA number. See Return Material Authorization (RMA) on page 3.

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.
Troubleshooting Controllers

A problem may be indicated by one or more of several types of symptoms:

- A process or deviation 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 and Deviation Alarms

When a process or deviation alarm occurs, the controller switches to the single loop display for the loop with the alarm and displays the alarm code on the screen.

<table>
<thead>
<tr>
<th>CODE</th>
<th>ALARM</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>HP</td>
<td>High Process</td>
<td>Process variable has risen above the high process alarm setpoint.</td>
</tr>
<tr>
<td>HD</td>
<td>High Deviation</td>
<td>Process variable has risen above the setpoint by more than the deviation alarm value.</td>
</tr>
<tr>
<td>LD</td>
<td>Low Deviation</td>
<td>Process variable has dropped below the setpoint by more than the deviation alarm value.</td>
</tr>
<tr>
<td>LP</td>
<td>Low Process</td>
<td>Process variable has dropped below the low process alarm setpoint.</td>
</tr>
</tbody>
</table>

Responding to Process and Deviation Alarms

In a heating application, a low process 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 status is set to manual instead of automatic.
- The heaters are not working due to a hardware failure.
- The sensor is not placed correctly and is not measuring the load's temperature.
- The deviation limit is too narrow.
- The system is so poorly tuned that the temperature is cycling about setpoint by more than the alarm setpoint.

NOTE! In cooling applications, similar issues cause high process and high deviation alarms.
In a heating application, a high process alarm setpoint or high deviation alarm may indicate one of the following:

- The setpoint and high process alarm setpoint have been lowered and the system has not had time to cool to within the new alarm limit.
- The control status is set to manual and the heat output is greater than 0%.
- The load has decreased such that the temperature has risen.
- The heater is full-on due to a hardware failure.
- The system is so poorly tuned that the temperature is cycling about setpoint by more than the alarm setpoint limit.

**Resetting a Process or Deviation Alarm**

Your response to an alarm depends upon the alarm type setting, as explained in Table 8.2 below.

<table>
<thead>
<tr>
<th>ALARM TYPE</th>
<th>OPERATOR RESPONSE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>The operator does not need to do anything. The alarm clears automatically when the process variable returns within the alarm setpoint.</td>
</tr>
<tr>
<td>Alarm</td>
<td>Acknowledge the alarm by pressing ALARM ACK on the controller or by using software. The alarm clears after the process variable returns within the alarm setpoints and the operator has acknowledged it.</td>
</tr>
</tbody>
</table>

**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 on the screen.

<table>
<thead>
<tr>
<th>CODE</th>
<th>ALARM Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>FS</td>
<td>Open thermocouple.</td>
</tr>
<tr>
<td>RT</td>
<td>Temperature changed in the opposite direction than expected.</td>
</tr>
<tr>
<td>ST</td>
<td>Temperature failed to change as expected.</td>
</tr>
<tr>
<td>RO</td>
<td>Positive or negative lead is broken or disconnected.</td>
</tr>
<tr>
<td>RS</td>
<td>Positive and negative leads are shorted.</td>
</tr>
</tbody>
</table>

A failed sensor alarm clears once it has been acknowledged and the sensor is repaired.
System Alarms
If the controller detects a hardware problem, it displays a message. The message persists until the condition is corrected.

Table 8.4 — Hardware Error Messages

<table>
<thead>
<tr>
<th>MESSAGE</th>
<th>POSSIBLE CAUSE</th>
<th>RECOMMENDED ACTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>LOW POWER</td>
<td>Power supply failed</td>
<td>See Low Power on page 143.</td>
</tr>
<tr>
<td>BATTERY DEAD</td>
<td>RAM battery is dead</td>
<td>See Battery Dead on page 143.</td>
</tr>
<tr>
<td>AW</td>
<td>Ambient warning. Ambient temperature exceeds operating limits by less than 5°C (9°F).</td>
<td>See Ambient Warning on page 144.</td>
</tr>
<tr>
<td>H/W AMBIENT FAILURE</td>
<td>Ambient temperature exceeds operating limits by 5°C (9°F). Reference voltage (5VDC) shorted to common. Hardware failed due to excessive voltage on inputs.</td>
<td>See H/W Ambient Failure on page 144.</td>
</tr>
<tr>
<td>H/W GAIN FAILURE</td>
<td>Hardware failed due to excessive voltage on inputs.</td>
<td>See H/W Gain or Offset Failure on page 145.</td>
</tr>
<tr>
<td>H/W OFFSET FAILURE</td>
<td>Hardware failed due to excessive voltage on inputs.</td>
<td>See H/W Gain or Offset Failure on page 145.</td>
</tr>
</tbody>
</table>

Other Behaviors
The following table indicates potential problems with the system or controller and recommends corrective actions.

Table 8.5 — Other Symptoms

<table>
<thead>
<tr>
<th>SYMPTOM</th>
<th>POSSIBLE CAUSES</th>
<th>RECOMMENDED ACTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indicated temperature not as expected</td>
<td>Controller not communicating</td>
<td>See Checking Analog Inputs on page 145.</td>
</tr>
<tr>
<td></td>
<td>Sensor wiring incorrect</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Noise</td>
<td></td>
</tr>
<tr>
<td>CLS200 display is not lit</td>
<td>Power connection incorrect</td>
<td>Check wiring and service. See Wiring the Power Supply on page 29.</td>
</tr>
<tr>
<td></td>
<td>No EPROM or bad EPROM</td>
<td>Replace the EPROM. See Replacing the EPROM on page 150.</td>
</tr>
<tr>
<td></td>
<td>CLS200 damaged or failed</td>
<td>Return the CLS200 for repair. See Return Material Authorization (RMA) on page 3.</td>
</tr>
<tr>
<td>CLS200 display is lit, but keys do not work</td>
<td>Keypad is locked</td>
<td>See Keys Do Not Respond on page 145.</td>
</tr>
<tr>
<td></td>
<td>CLS200 damaged or failed</td>
<td>Return the CLS200 for repair. See Return Material Authorization (RMA) on page 3.</td>
</tr>
<tr>
<td>SYMPTOM</td>
<td>POSSIBLE CAUSES</td>
<td>RECOMMENDED ACTION</td>
</tr>
<tr>
<td>------------------------------------------------------------------------</td>
<td>---------------------------------------------------</td>
<td>-----------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Control status of one or more loops changes from automatic to manual</td>
<td>Failed sensor</td>
<td>Check the display or software for a failed sensor message</td>
</tr>
<tr>
<td>Digital job select feature is enabled and has changed jobs</td>
<td>Failed sensor</td>
<td>Check the display or software for a failed sensor message</td>
</tr>
<tr>
<td>All loops are set to manual 0%</td>
<td>Power is intermittent</td>
<td>Check wiring and service. See Wiring the Power Supply on page 29. Provide backup power (UPS). Set POWER UP OUTPUT STATUS to MEMORY. See Power Up Output Status on page 71.</td>
</tr>
<tr>
<td>Analog reference voltage is overloaded</td>
<td>Disconnect wiring from the +5V Ref connection on TB1.</td>
<td></td>
</tr>
<tr>
<td>Hardware failure</td>
<td>Check the controller front panel for a hardware alarm. See System Alarms on page 142.</td>
<td></td>
</tr>
<tr>
<td>Controller does not behave as expected</td>
<td>Corrupt or incorrect values in RAM</td>
<td>Perform a NO-key reset. See NO-Key Reset on page 150.</td>
</tr>
</tbody>
</table>

**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. Acknowledge the alarm.
2. If the error message remains, turn the power to the controller off, then on again.
3. If the error message returns, check that the power supplied to the controller is at least 12.0VDC @ 1A. See Wiring the Power Supply on page 29.
4. If the error message returns again, make a record of the settings. Then, perform a NO-key reset. See NO-Key Reset on page 150.
5. If the error is not cleared, contact your supplier for further troubleshooting guidance. See Return Material Authorization (RMA) on page 3.

**Battery Dead**

The dead battery alarm indicates that the CLS200 battery is not functioning correctly or has low power or no power. If this alarm occurs, parameters have reset to the factory default settings.

**NOTE!** The controller will retain its settings when powered. The battery is required to keep the settings in memory only when the controller is powered down.
If the controller displays **BATTERY DEAD**:

1. Acknowledge the alarm.
2. If the error message remains, make a record of the settings, turn the power to the controller off, then on again.
3. If the error message returns when power is restored, perform a NO-key reset. See **NO-Key Reset on page 150**.
4. If the error is not cleared, contact your supplier for further troubleshooting guidelines. See **Removing or Replacing the Battery on page 152**.

**Ambient Warning**

The ambient warning alarm indicates that the ambient temperature of the controller is too hot or too cold. Ambient warning occurs when the controller’s temperature is in the range of 23 to 32°F or 122 to 131°F (-5 to 0°C or 50 to 55°C). The operating limits are 32 to 122°F (0 to 50°C).

If the controller displays **AW** in the lower left corner of the display:

1. Acknowledge the alarm.
2. If the error message remains, check the ambient air temperature near the controller. Adjust ventilation, cooling or heating to ensure that the temperature around the controller is 32 to 122°F (0 to 50°C). If the unit is functioning correctly, the error will clear when the ambient temperature is within range and the alarm has been acknowledged.
3. If the ambient temperature is within range and the error persists:
   a. Turn the power to the controller off.
   b. Remove the boards from the CLS200 housing. See **Replacing the EPROM on page 150**.
   c. Reseat the boards and turn the power on.
4. If the error persists, make a record of the settings then perform a NO-key reset. See **NO-Key Reset on page 150**.
5. If the error is not cleared, contact your supplier for further troubleshooting guidelines. See **Return Material Authorization (RMA) on page 3**.

**H/W Ambient Failure**

The hardware ambient failure alarm indicates that the ambient sensor in the CLS200 is reporting that the temperature around the controller is outside of the acceptable range of 0 to 50°C. This error can also occur when there is a hardware failure.

If the controller displays **H/W AMBIENT FAILURE**:

1. Acknowledge the alarm.
2. If the error message remains, check the ambient air temperature near the controller. Adjust ventilation, cooling or heating to ensure that the temperature around the controller is 0 to 50°C. If the unit is functioning correctly, the error will clear automatically when the ambient temperature is within range and the alarm has been acknowledged.
3. Remove any connections to the 5VDC reference (TB1-18) on the back of the controller. If this corrects the problem, there was an error in the wiring. You may need to consult technical
support to determine the correct wiring.

4. If the ambient temperature is within range and the error persists:
   a. Turn the power to the controller off.
   b. Remove the boards from the CLS200 housing.
   c. Reseat the boards and turn power on.

5. If the error persists, make a record of the settings, then perform a NO-key reset. See NO-Key Reset on page 150.

6. If the error is not cleared, contact your supplier for further troubleshooting guidelines. See Return Material Authorization (RMA) on page 3.

   **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 Gain or Offset Failure**

If the controller displays **H/W GAIN FAILURE** or **H/W OFFSET FAILURE**:

1. Acknowledge the alarm.

2. If the error message remains, turn the power to the controller off, then on again.

3. If the H/W Gain error is reported, remove any connections to the 5VDC reference (TB1-18) on the back of the controller. If this corrects the problem, there was an error in the wiring. You may need to consult technical support to determine the correct wiring.

4. If the error persists, make a record of the settings, then perform a NO-key reset. See NO-Key Reset on page 150.

5. If the error is not cleared, contact your supplier for further troubleshooting guidelines. See Return Material Authorization (RMA) on page 3.

   **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 Respond**

If the CLS200 seems to function but the **MAN/AUTO**, **CHNG SP**, **ALARM ACK**, and **RAMP/SOAK** keys do not respond when you press them, the keypad is probably locked. Unlock the keypad according to the instructions in Keyboard Lock Status on page 71.

**Checking Analog Inputs**

If the process variable displayed on the controller is not as expected:

1. If the values displayed in software and on the controller do not agree, verify that the controller is communicating.
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.

   **NOTE!** Noise in excess of 1VAC should be eliminated by correctly grounding the CLS200. See *Wiring the Power Supply* on page 29.

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 20Ω is normal. Readings in excess of 200Ω indicate a problem with the sensor.
   - For RTDs, measure between the IN+ and IN- terminals of TB1. RTD inputs should read between 20 and 250Ω.

5. To verify that the controller hardware is working correctly, check any input (except the pulse input or an RTD) as follows:
   a. Disconnect the sensor wiring.
   b. Set the INPUT TYPE to J T/C in the SETUP LOOP INPUT menu.
   c. Place a short across the input. The controller should indicate the ambient temperature on the loop you are testing.

**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 above 2VAC is observed, 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 2VAC may indicate problems with the ac ground circuit.

- Check for ac voltage on thermocouples with the heater power on. 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 2VAC may indicate the ground lead is not connected to the CLS200 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 is set accordingly.
• For an RTD or linear voltage or current input, check that the correct input scaling resistors are installed (see Scaling Resistors on page 154) and check the input scaling parameter settings (see Linear Scaling Parameters on page 77).
• If readings are erratic, look for sources of electrical noise. See Noise Suppression on page 26.
• Eliminate possible ground loops. See Ground Loops on page 28.
• Contact your supplier for further troubleshooting guidance.

Checking Control Outputs
To check control outputs:
• Set the loop you want to check to manual mode.
• Set the output power percentage to the desired level.
• Set the output type to ON/OFF or TP (see Chapter 4: Setup).

If the control output is not connected to an output device like an SSR, connect an LED in series with a 1 kW resistor from +5V to the output. (Tie the anode of the LED to +5V.) The LED should be off when the output is 0% and on when the output is 100%.

Testing Control Output Devices
Connect the solid state relay (SSR) control terminals to the CLS200 control output and connect a light bulb (or other load that can easily be verified) to the output terminals on the SSR. Put the loop in manual mode and set the output to 100%. The ac load should turn on.

Do not attempt to measure ac voltage at the SSR's output terminals. Without a load connected, the SSR's 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 +5VDC supply at the TB18 or TB50. The voltage should be +4.75 to +5.25VDC:
   a. Connect the voltmeter’s common lead to the TB18 screw terminal 2 or TB50 screw terminal 3.
   b. Connect the voltmeter’s positive lead to the TB18 or TB50 screw terminal 1.

Testing Control and Digital Outputs
1. Turn off power to the controller.
2. Disconnect any process output wiring on the output to be tested.
3. Connect a 500Ω to 100kΩ resistor between the +5V terminal (TB18 or TB50 screw 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 PID control output, use the MAN/AUTO key to turn the output on (100%) and off (0%). When the output is off, the output voltage should be less than 1V. When the output is on, the output voltage should be between +3.75 and +5.25V.

7. If you are testing a digital output not used for control, use the MANUAL I/O TEST menu to turn the output on and off. See Manual I/O Test on page 93.

Testing Digital Inputs

1. Turn 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 MANUAL I/O TEST menu. This parameter shows whether the digital inputs are H (high, or open) or L (low, or closed).
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 H (high). 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 L (low).

Additional Troubleshooting for Computer Supervised Systems

These four elements must work properly in a computer-supervised system:

- The controller
- The computer and its EIA/TIA-232 or EIA/TIA-485 serial interface
- The EIA/TIA-232 or EIA/TIA-485 communication lines
- The computer software

For troubleshooting, disconnect the communications line from the computer and follow the troubleshooting steps in the first section of this chapter. The next few sections explain troubleshooting for the other elements of computer supervised systems.

Computer Problems

If you are having computer or serial interface problems, check the following:

- Check your software manual and make sure your computer meets the software and system requirements.
- Check the communications interface, cables, and connections. Make sure the serial interface is set according to the manufacturer’s instructions.
- To test an EIA/TIA-232 interface, purchase an EIA/TIA-232 tester with LED indicators. Attach the tester between the controller and the computer. When the computer sends data to the controller, the tester’s TX LED should blink. When the computer receives data from the controller, the RX LED should blink.
You can also connect an oscilloscope to the transmit or receive line to see whether data is being sent or received. If the serial port does not appear to be working, the software setup may need to be modified or the hardware may need to be repaired or replaced.

Communications
Most communications problems are due to incorrect wiring or incorrectly set communications parameters. Therefore, when there is a problem, check the wiring and communications settings first. Verify the following:

- **Communications port:** Software must be configured to use the communications port to which the controller is connected.
- **Software protocol:** Set the correct protocol for the software MOD for Modbus® or ANA for Anafaze.
- **Controller address:** Configure software to look for the controller at the correct address. In a multiple-controller installation, each controller must have a unique address.
- **Baud rate:** Software and controller must be set the same.
- **Error checking (ANA protocol only):** Software and controller must be set the same (CRC or BCC).
- **Hardware protocol:** PC and controller must use the same protocol, or a converter must be used. The controller is typically configured for EIA/TIA-232 when it is shipped. See Changing Communications on page 153 on to change between EIA/TIA-232 and EIA/TIA-485. To communicate with more than one controller, or when more than 50 feet of cable is required, use EIA/TIA-485. Even for a single controller, you may use EIA/TIA-485 and an optically isolating converter to eliminate ground loops.
- **Converter:** Make sure that the EIA/TIA-232-to-485 converter is powered, configured and wired correctly.
- **Cables:** Check continuity by placing a resistor across each pair of wires and measuring the resistance with an ohmmeter at the other end.

Ground Loops
Many PC communications ports have their common wires connected to chassis ground. Once connected to the controller, this can provide a path to ground for current from the process that can enter the controller through a sensor (such as a thermocouple). This creates a ground loop that can affect communications and other controller functions. To eliminate a ground loop, either use an optically isolated communications adapter or take measures to ensure that sensors and all other connections to the controller are isolated and not conducting current into the unit.

Software Problems
If the controller and serial communications connections seem to be working correctly, but you are still not getting the result you expect, consult the resources you have available for the software program you are using.
User-Written Software
You can request a communications specification from Watlow if you want to write your own software. Watlow will answer technical questions that arise during your software development process, but does not otherwise support user-developed or third-party software in any way.

NO-Key Reset
Performing a NO-key reset returns all controller settings to their defaults. All recipes are also cleared.
To perform a NO-key reset:
1. Make a record of the controller’s settings.
2. Turn off power to the unit.
3. Press and hold the NO key on the keypad.
4. Turn on power to the controller still holding the NO key.
5. When prompted RESET WITH DEFAULTS?, release the NO key and press the YES key.
6. If you do not see the RESET WITH DEFAULTS? prompt or do not get a chance to press YES, repeat the procedure.
7. Restore the controller settings.

Replacing the EPROM
Replacing the EPROM involves minor mechanical disassembly and reassembly of the controller. You will need a Phillips screwdriver and an IC extraction tool or a small, standard, jeweler’s screwdriver.

CAUTION! The EPROM 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 EPROM with another version results in full erasure of RAM. Make a record of all parameters before changing the EPROM.

1. Make a record of the controller’s settings.
2. Power down the controller.
3. Remove the four screws from the sides of the controller front panel.
4. Remove the electronics assembly from the case, as shown in Figure 8.1.
5. Unplug the front panel overlay ribbon cable from the connector on the processor board (the bottom one in the stack of two boards).

6. Pull back the arms that latch the two boards in the carrier at side with the ribbon cable and rotate the boards out of the carrier as shown in Figure 8.3

7. Remove the two plastic standoffs that connect the analog (top) board to the processor (bottom) board and lift the analog board off the processor board.
8. Locate the EPROM on the processor board. The EPROM is a 32-pin socketed chip that is labeled with the model, version and checksum.

![Figure 8.5 — EPROM Location](image)

9. Remove the existing EPROM from its socket with an IC extraction tool or a jeweler’s flathead screwdriver.

![Figure 8.6 — Remove EPROM](image)

10. Carefully insert the new EPROM into the socket. Make sure that the chip is oriented so that its notch fits in the corresponding corner of the socket.

11. Reverse steps 3 through 7 to reassemble the unit. However, at step 6 insert the two-board assembly straight in to the carrier making sure all four arms latch on the boards.

12. Power up the controller.

13. Re-enter the controller settings, if necessary.

**Removing or Replacing the Battery**

The lithium battery in the battery-backed RAM module on the processor board should be removed and disposed of properly if decommissioning the controller. It may also be replaced, if needed during the life of the controller.

To remove the battery:

1. Follow steps 1 to 7 of the procedure *Replacing the EPROM on page 150* to access the processor board.

2. Locate the battery backed RAM module. See *Figure 8.10 — Single-Ended Input Circuit in Sixteen-Loop Controllers on page 157*.

3. Insert a small flat blade screwdriver vertically into the slot on one side of the RMA module.

4. Angle the screwdriver handle toward the center of the RAM chip gently until the side with the
slot unlatches and the battery holder comes off the module.

5. Remove the battery from the holder.

6. Follow local applicable recycling requirements for Coin Cell Lithium type BR-1632 Battery.

![Battery-Backed RAM Module on the Processor Board](image)

*Figure 8.7 — Battery-Backed RAM Module on the Processor Board*

To replace the battery, if desired:

1. Align the contact springs on the battery holder with the contacts on the RAM module.

2. Hook the battery holder flange under the RAM module’s base board.

3. Fit the alignment ribs on the battery holder into the alignment notches in the RAM module’s base board.

4. Push down and forward and latch the battery holder on the module.

5. To reassemble the unit reverse steps 3 through 7 of the procedure Replacing the EPROM on page 150. However, at step 6 insert the two-board assembly straight in to the carrier making sure all four arms latch on the boards.

6. Power up the controller.

7. Re-enter the controller settings, if necessary.

**Changing Communications**

To switch between EIA/TIA-232 and EIA/TIA-485, change the jumpers as shown in *Figure 8.8*.

![Jumper Configurations](image)

*Figure 8.8 — Jumper Configurations*

You will need tweezers and a Phillips head screwdriver to switch between EIA/TIA-232 and
EIA/TIA-485. Follow these steps:

1. Power down the unit.
2. Remove the controller’s metal casing. See Replacing the EPROM on page 150 for step-by-step instructions.
3. On the top board find the four-jumper block on JU2, JU3, JU4 and JU5.
4. Use tweezers to carefully slide the jumper block off the pins.
5. Use tweezers to gently slide the four-jumper block onto the correct pins (see Figure 8.8).
6. If you are configuring the controller as the last device on an EIA/TIA-485 network, move JU1 to the B position.
7. Reassemble the controller.

Scaling Resistors

Resistors are installed for all inputs on the CLS200. Inputs with signal ranges between -10 and +60mV use 0Ω resistors in the RC position only. All other input signals require special input scaling resistors.

The following sections describe the scaling resistors to help you determine how a unit is configured.

**NOTE!** Scaling resistors cannot be changed in the field. For input types other than thermocouples, the controller must be ordered with and factory configured with scaling resistors.

Four-Loop and Eight-Loop Input Circuit

Four-loop and eight-loop controllers can accept differential thermocouple, mV DC, VDC, mADC and RTD inputs. Unless ordered with special inputs these controller accept only signals within the standard range -10 to 60mVDC. 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.

![Figure 8.9 — Differential Input Circuit in Four-Loop and Eight-Loop Controllers](image-url)
Figure 8.9 shows the input circuit for one differential, analog input. See Current Inputs to Four-Loop and Eight-Loop Controllers on page 155 through RTDs and Thermistor Inputs to Four-Loop and Eight-Loop Controllers on page 156 for resistor values for voltage, current and RTD inputs.

**Current Inputs to Four-Loop and Eight-Loop Controllers**

Each current input has a 3.0Ω resistor in the resistor pack (RP) location for the input. Resistor pack locations have three through holes. Resistors are installed as shown in the illustration below.

**Table 8.6** – Resistor Values for Current Inputs to Four-Loop and Eight-Loop Controllers

<table>
<thead>
<tr>
<th>INPUT RANGE</th>
<th>RESISTOR VALUE RD</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 to 20mA</td>
<td>3.0Ω</td>
</tr>
</tbody>
</table>

Resistor tolerance: ±0.1%

**Table 8.7** – Resistor Locations for Current Inputs to Four-Loop and Eight-Loop Controllers

<table>
<thead>
<tr>
<th>LOOP</th>
<th>RESISTOR LOCATION RD</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>RP1</td>
</tr>
<tr>
<td>2</td>
<td>RP2</td>
</tr>
<tr>
<td>3</td>
<td>RP3</td>
</tr>
<tr>
<td>4</td>
<td>RP4</td>
</tr>
<tr>
<td>5</td>
<td>RP5</td>
</tr>
<tr>
<td>6</td>
<td>RP6</td>
</tr>
<tr>
<td>7</td>
<td>RP7</td>
</tr>
<tr>
<td>8</td>
<td>RP8</td>
</tr>
</tbody>
</table>

**Voltage Inputs to Four-Loop and Eight-Loop Controllers**

Each voltage input uses two scaling resistors one at the resistor pack (RP) and one at RC for the input. The values of the resistors determines the input range. Resistor pack locations have three pads. Resistors are installed as shown in the illustration below.

**Table 8.8** – Resistor Values for Voltage Inputs to Four-Loop and Eight-Loop Controllers

<table>
<thead>
<tr>
<th>INPUT RANGE</th>
<th>RESISTOR VALUES</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>RC</td>
</tr>
<tr>
<td>0 to 5VDC</td>
<td>39.2Ω</td>
</tr>
<tr>
<td>0 to 10VDC</td>
<td>49.9Ω</td>
</tr>
</tbody>
</table>

Resistor tolerance: ±0.1%
Table 8.9 — Resistor Locations for Voltage Inputs to Four-Loop and Eight-Loop Controllers

<table>
<thead>
<tr>
<th>LOOP</th>
<th>RESISTOR LOCATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>RC: R58, RD: RP1</td>
</tr>
<tr>
<td>2</td>
<td>RC: R56, RD: RP2</td>
</tr>
<tr>
<td>3</td>
<td>RC: R54, RD: RP3</td>
</tr>
<tr>
<td>4</td>
<td>RC: R52, RD: RP4</td>
</tr>
<tr>
<td>5</td>
<td>RC: R50, RD: RP5</td>
</tr>
<tr>
<td>6</td>
<td>RC: R48, RD: RP6</td>
</tr>
<tr>
<td>7</td>
<td>RC: R46, RD: RP7</td>
</tr>
<tr>
<td>8</td>
<td>RC: R44, RD: RP8</td>
</tr>
</tbody>
</table>

RTDs and Thermistor Inputs to Four-Loop and Eight-Loop Controllers
Each RTD or thermistor input has three scaling resistors installed: one each at RA, RB and RC for the input. The values of the resistors determines the input range. RA and RB are a matched pair of resistors installed in the resistor pack (RP) location as shown in the illustration below.

Table 8.10 — Resistor Values for RTD and Thermistor Inputs to Four-Loop and Eight-Loop Controllers

<table>
<thead>
<tr>
<th>INPUT RANGE</th>
<th>RESISTOR VALUES</th>
</tr>
</thead>
<tbody>
<tr>
<td>RTD1</td>
<td>RA/RB: 10.0kΩ, RC: 80Ω</td>
</tr>
<tr>
<td>RTD2</td>
<td>RA/RB: 25.0kΩ, RC: 100Ω</td>
</tr>
</tbody>
</table>

Resistor tolerances: RA/RB 0.1% (10 ppm/°C) matched to 0.02% (2 ppm/°C) RC 0.05%.

Table 8.11 — Resistor Locations for RTD and Thermistor Inputs to Four-Loop and Eight-Loop Controllers

<table>
<thead>
<tr>
<th>LOOP</th>
<th>RESISTOR LOCATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>RA/RB: RP1, RC: R57</td>
</tr>
<tr>
<td>2</td>
<td>RA/RB: RP2, RC: R55</td>
</tr>
<tr>
<td>3</td>
<td>RA/RB: RP3, RC: R53</td>
</tr>
<tr>
<td>4</td>
<td>RA/RB: RP4, RC: R51</td>
</tr>
<tr>
<td>5</td>
<td>RA/RB: RP5, RC: R49</td>
</tr>
<tr>
<td>6</td>
<td>RA/RB: RP6, RC: R47</td>
</tr>
<tr>
<td>7</td>
<td>RA/RB: RP7, RC: R45</td>
</tr>
<tr>
<td>8</td>
<td>RA/RB: RP8, RC: R43</td>
</tr>
</tbody>
</table>
Sixteen-Loop Input Circuit

Sixteen-loop controllers can accept single-ended thermocouple, mVDC, VDC and mA DC inputs. Unless ordered with special inputs, the controller accepts only signals within the standard range of -10 to 60mVDC.

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 milliamp current signals or voltage signals outside the standard range, resistors are added or replaced to scale the signals to the standard range.

Figure 8.10 shows the schematic for one single-ended sensor input to sixteen-loop controller. See Current Inputs to Sixteen-Loop Controllers on page 157 and Voltage Inputs to Sixteen-Loop Controllers on page 158 for specific instructions and resistor values for voltage and current inputs.

![Figure 8.10 - Single-Ended Input Circuit in Sixteen-Loop Controllers](image)

### Current Inputs to Sixteen-Loop Controllers

Each current input has a 3.0Ω resistor in the RD location for the input.

<table>
<thead>
<tr>
<th>Input Range</th>
<th>Resistor Value RD</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 to 20mA</td>
<td>3.0Ω</td>
</tr>
</tbody>
</table>

Resistor tolerance: ±0.1%

### Table 8.12 – Resistor Locations for Current Inputs to Sixteen-Loop Controllers

<table>
<thead>
<tr>
<th>Loop</th>
<th>Resistor Location RD</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>R42</td>
</tr>
<tr>
<td>2</td>
<td>R40</td>
</tr>
<tr>
<td>3</td>
<td>R38</td>
</tr>
<tr>
<td>4</td>
<td>R36</td>
</tr>
<tr>
<td>5</td>
<td>R34</td>
</tr>
<tr>
<td>6</td>
<td>R32</td>
</tr>
<tr>
<td>7</td>
<td>R30</td>
</tr>
<tr>
<td>8</td>
<td>R28</td>
</tr>
</tbody>
</table>
Voltage Inputs to Sixteen-Loop Controllers

Each voltage input has two scaling resistors installed: one at RC and one at RD for the input. The values of the resistors determines the input range.

Table 8.14 — Resistor Values for Voltage Inputs to Sixteen-Loop Controllers

<table>
<thead>
<tr>
<th>INPUT RANGE</th>
<th>RESISTOR VALUES</th>
</tr>
</thead>
<tbody>
<tr>
<td>RC</td>
<td>RD</td>
</tr>
<tr>
<td>0 to 5VDC</td>
<td>39.2Ω</td>
</tr>
<tr>
<td>0 to 10VDC</td>
<td>49.9Ω</td>
</tr>
</tbody>
</table>

Resistor tolerance: ±0.1%

Table 8.15 — Resistor Locations for Voltage Inputs to Sixteen-Loop Controllers

<table>
<thead>
<tr>
<th>LOOP</th>
<th>RC LOCATIONS</th>
<th>RD LOCATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>R58</td>
<td>R42</td>
</tr>
<tr>
<td>2</td>
<td>R56</td>
<td>R40</td>
</tr>
<tr>
<td>3</td>
<td>R54</td>
<td>R38</td>
</tr>
<tr>
<td>4</td>
<td>R52</td>
<td>R36</td>
</tr>
<tr>
<td>5</td>
<td>R50</td>
<td>R34</td>
</tr>
<tr>
<td>6</td>
<td>R48</td>
<td>R32</td>
</tr>
<tr>
<td>7</td>
<td>R46</td>
<td>R30</td>
</tr>
<tr>
<td>8</td>
<td>R44</td>
<td>R28</td>
</tr>
<tr>
<td>9</td>
<td>R57</td>
<td>R41</td>
</tr>
<tr>
<td>10</td>
<td>R55</td>
<td>R39</td>
</tr>
<tr>
<td>11</td>
<td>R53</td>
<td>R37</td>
</tr>
<tr>
<td>12</td>
<td>R51</td>
<td>R35</td>
</tr>
<tr>
<td>13</td>
<td>R49</td>
<td>R33</td>
</tr>
<tr>
<td>14</td>
<td>R47</td>
<td>R31</td>
</tr>
<tr>
<td>15</td>
<td>R45</td>
<td>R29</td>
</tr>
<tr>
<td>16</td>
<td>R43</td>
<td>R27</td>
</tr>
</tbody>
</table>

Scaling and Calibration

The controller provides offset calibration for thermocouple, RTD, and other fixed ranges, and offset and span (gain) calibration for linear and pulse inputs. In order to scale linear input signals, you must:

1. Have appropriate scaling resistors installed.
2. Select the display format. The smallest possible range is -.9999 to 3.0000; the largest possible range is -9,999 to 30,000.
3. Enter the appropriate scaling values for your process.
Chapter 9: Linear Scaling Examples

This chapter provides three linear scaling examples. The examples describe:

- A pressure sensor generating a 4 to 20mA signal
- A flow sensor generating a 0 to 5V signal
- A pulse encoder generating 900 pulses per inch of movement

Example 1: A 4-to-20mA Sensor

Situation
A pressure sensor that generates a 4 to 20mA signal is connected to the controller. The specifications of the sensor state it generates 4mA at 0.0 pounds per square inch (PSI) and 20mA at 50.0 PSI.

Setup
The sensor is connected to a loop input set up with a resistorscaling network producing 60mV at 20mA.

The INPUT TYPE for the loop is set to LINEAR. The sensor measures PSI in tenths, so the DISP FORMAT is set to -999.9 to 3000.0.

Table 9.1 — Input Readings

<table>
<thead>
<tr>
<th>PROCESS VARIABLE DISPLAYED</th>
<th>SENSOR INPUT</th>
<th>READING, PERCENT OF FULL SCALE (%FS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>50.0 PSI</td>
<td>20mA</td>
<td>100%FS</td>
</tr>
<tr>
<td>0.0 PSI</td>
<td>4mA</td>
<td>100% x (4mA/20mA) = 20%FS</td>
</tr>
</tbody>
</table>

The scaling values setup in the SETUP LOOP INPUT menu are shown in Table 9.2.

Table 9.2 — Scaling Values

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>PROMPT</th>
<th>VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Process Variable</td>
<td>HIGH PV</td>
<td>50.0 PSI</td>
</tr>
<tr>
<td>High Sensor Reading</td>
<td>HIGH RDG</td>
<td>100.0%FS</td>
</tr>
<tr>
<td>Low Process Variable</td>
<td>LOW PV</td>
<td>0.0 PSI</td>
</tr>
<tr>
<td>Low Sensor Reading</td>
<td>LOW RDG</td>
<td>20.0%FS</td>
</tr>
</tbody>
</table>
Example 2: A 0-to-5VDC Sensor

Situation
A flow sensor connected to the controller measures the flow in a pipe. The sensor generates a 0 to 5V signal. The sensor's output depends on its installation. Independent calibration measurements of the flow in the pipe indicate that the sensor generates 0.5V at three gallons per minute (GPM) and 4.75V at 65 GPM. The calibration instruments are accurate to within 1 gallon per minute.

Setup
The sensor is connected to a loop input set up with a resistor voltage divider network producing 60mV at 5V. The INPUT TYPE for the loop is set to LINEAR. The calibrating instrument is precise to ±1 GPM, so the DISP FORMAT is set to -999 to 3000.

This table shows the input readings and the percentage calculation from the 60mV full scale input.

<table>
<thead>
<tr>
<th>PROCESS VARIABLE DISPLAYED</th>
<th>SENSOR INPUT</th>
<th>READING, PERCENT OF FULL SCALE (%FS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>65 GPM</td>
<td>4.75</td>
<td>$(4.75V / 5.00V) \times 100% = 95%FS$</td>
</tr>
<tr>
<td>3 GPM</td>
<td>0.5</td>
<td>$(0.5V / 5.00V) \times 100% = 10%FS$</td>
</tr>
</tbody>
</table>

Table 9.4 – Scaling Values

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>PROMPT</th>
<th>VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Process Variable</td>
<td>HIGH PV</td>
<td>65 GPM</td>
</tr>
<tr>
<td>High Sensor Reading</td>
<td>HIGH RDG</td>
<td>95.0%FS</td>
</tr>
<tr>
<td>Low Process Variable</td>
<td>LOW PV</td>
<td>0.0 PSI</td>
</tr>
<tr>
<td>Low Sensor Reading</td>
<td>LOW RDG</td>
<td>10.0%FS</td>
</tr>
</tbody>
</table>
Example 3: A Pulse Encoder

Situation
A pulse encoder which measures the movement of a conveyor is connected to the controller. The encoder generates 900 pulses for every inch the conveyor moves. You want to measure conveyor speed in feet per minute (FPM).

Setup
The encoder input is connected to the controller’s pulse input. The INPUT TYPE for the loop is set to PULSE. A one second sample time gives adequate resolution of the conveyor’s speed. The resolution is:

\[
\frac{1 \text{ pulse}}{1 \text{ second}} \times \frac{60 \text{ seconds}}{1 \text{ minute}} \times \frac{1 \text{ inch}}{900 \text{ pulses}} \times \frac{1 \text{ foot}}{12 \text{ inches}} = 1.11 \text{ FPM}
\]

A DISP FORMAT of -99.99 to 300.00 is appropriate.

The input readings are as follows:
- At 0Hz, the input reading will be 0.00 FPM.
- At the maximum pulse rate of the CLS200 (2000Hz):

\[
\frac{2000 \text{ pulses}}{1 \text{ second}} \times \frac{60 \text{ seconds}}{1 \text{ minute}} \times \frac{1 \text{ inch}}{900 \text{ pulses}} \times \frac{1 \text{ foot}}{12 \text{ inches}} = 11.11 \text{ FPM}
\]

Table 9.5 — Scaling Values

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>PROMPT</th>
<th>VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Process Variable</td>
<td>HIGH PV</td>
<td>11.11 FPM</td>
</tr>
<tr>
<td>High Sensor Reading</td>
<td>HIGH RDG</td>
<td>2000Hz</td>
</tr>
<tr>
<td>Low Process Variable</td>
<td>LO PV</td>
<td>0 FPM</td>
</tr>
<tr>
<td>Low Sensor Reading</td>
<td>LO RDG</td>
<td>0Hz</td>
</tr>
</tbody>
</table>
Chapter 10: Specifications

This chapter contains specifications for the CLS200 series controllers and the TB50 terminal board.

CLS200 System Specifications

This section contains CLS200 series controller specifications for environmental specifications and physical dimensions, inputs, outputs, the serial interface and system power requirements.

Table 10.1 – Agency Approvals / Compliance

<table>
<thead>
<tr>
<th>CE Directive</th>
<th>See Declaration of Conformity</th>
</tr>
</thead>
<tbody>
<tr>
<td>UL® and C-UL</td>
<td><strong>UL® 61010-1 Safety requirements for measurement,</strong></td>
</tr>
<tr>
<td></td>
<td><strong>control and laboratory equipment File E185611</strong></td>
</tr>
</tbody>
</table>

CLS200 Processor Physical Specifications

Table 10.2 – Environmental Specifications

<table>
<thead>
<tr>
<th>Specifications</th>
<th>-20 to 60°C</th>
<th>0 to 50°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Storage Temperature</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operating Temperature</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Humidity</td>
<td>10 to 95% non-condensing</td>
<td></td>
</tr>
<tr>
<td>Environment</td>
<td>The controller is for indoor use only</td>
<td></td>
</tr>
</tbody>
</table>

Table 10.3 – Physical Dimensions

<table>
<thead>
<tr>
<th>Dimensions</th>
<th>Weight</th>
<th>Length*</th>
<th>Width</th>
<th>Height</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1.98 lbs</td>
<td>8.0 inches</td>
<td>3.80 inches</td>
<td>1.98 inches</td>
</tr>
<tr>
<td></td>
<td>0.9kg</td>
<td>203 mm</td>
<td>96 mm</td>
<td>50 mm</td>
</tr>
</tbody>
</table>

* Without SCSI cable or with TB18 option.
**Figure 10.1** — CLS200 Processor Module Dimensions

**Table 10.4** — Processor with Standard SCSI Cable

<table>
<thead>
<tr>
<th></th>
<th>Length</th>
<th>Width</th>
<th>Height</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>10.0 inches</td>
<td>3.80 inches</td>
<td>1.98 inches</td>
</tr>
<tr>
<td></td>
<td>254 mm</td>
<td>96 mm</td>
<td>50 mm</td>
</tr>
</tbody>
</table>

**Figure 10.2** — CLS200 Clearances with Straight SCSI Cable

**Table 10.5** — Processor with Right Angle SCSI Cable

<table>
<thead>
<tr>
<th></th>
<th>Length</th>
<th>Width</th>
<th>Height</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>9.0 inches</td>
<td>3.80 inches</td>
<td>1.98 inches</td>
</tr>
<tr>
<td></td>
<td>229 mm</td>
<td>96 mm</td>
<td>50 mm</td>
</tr>
</tbody>
</table>
Figure 10.3 — CLS200 Clearances with Right-Angle SCSI Cable

Table 10.6 — Processor Connections

<table>
<thead>
<tr>
<th>Power Terminals (TB2)</th>
<th>Captive screw cage clamp</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power Wire Gauge (TB2)</td>
<td>22 to 18 AWG (0.5 to 0.75 mm²)</td>
</tr>
<tr>
<td>Power Terminal Torque (TB2)</td>
<td>4.4 to 5.3 in-lb. (0.5 to 0.6Nm)</td>
</tr>
<tr>
<td>Sensor Terminals (TB1)</td>
<td>Captive screw cage clamp</td>
</tr>
</tbody>
</table>
| Sensor Wire Gauge (TB1) | Thermocouples: 20 AWG (0.5 mm²)  
 Linear: 22 to 20 AWG (0.5 mm²)  
 Communications: 24 AWG (0.2 mm²) |
| Sensor Terminal Torque (TB1) | 4.4 to 5.3 in-lb. (0.5 to 0.6Nm) |
| Output Terminals (TB18) | Captive screw cage clamp |
| Output Wire Gauge (TB18) | Multiconductor cables: 24 AWG (0.2 mm²)  
 Single-wire: 22 to 18 AWG (0.5 to 0.75 mm²) |
| Output Terminal Torque (TB18) | 4.4 to 5.3 in-lb. (0.5 to 0.6Nm) |
| SCSI Connector | SCSI-2 female |

TB50 Physical Specifications

Table 10.7 — TB50 Physical Dimensions

| Weight | 0.32 lbs | 0.15kg |
| Length* | 4.1 inches | 104 mm |
| Width | 4.0 inches | 102 mm |
| Height DIN Rail Mounted | 1.5 inches | 37 mm |
| Height Off Panel (DIN Brackets Removed) | 0.92 Inches | 23 mm |
**Figure 10.4 — TB50 Dimensions**

**Table 10.8 — TB50 Connections**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>SCSI Connector on Board</td>
<td>SCSI-2 female</td>
</tr>
<tr>
<td>Output Terminals</td>
<td>Captive screw cage clamp</td>
</tr>
<tr>
<td>Output Wire Gauge</td>
<td>Multiconductor cables: 24 AWG (0.2 mm$^2$) Single-wire: 22 to 18 AWG (0.5 to 0.75 mm$^2$)</td>
</tr>
<tr>
<td>Screw Terminal Torque</td>
<td>4.4 to 5.3 in-lb. (0.5 to 0.6Nm)</td>
</tr>
</tbody>
</table>

**Table 10.9 — TB50 with Straight SCSI Cable**

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Length</td>
<td>6.4 inches</td>
<td>163 mm</td>
</tr>
<tr>
<td>Width</td>
<td>4.0 inches</td>
<td>102 mm</td>
</tr>
<tr>
<td>Height DIN Rail Mounted</td>
<td>1.5 inches</td>
<td>37 mm</td>
</tr>
</tbody>
</table>

**Figure 10.5 — TB50 Dimensions with Standard SCSI Cable**
Table 10.10 — TB50 with Right Angle SCSI Cable

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Length</th>
<th>Width</th>
<th>Height DIN Rail Mounted</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.4 inches</td>
<td>137 mm</td>
<td>102 mm</td>
<td>37 mm</td>
</tr>
</tbody>
</table>

Figure 10.6 — 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 10.11 — Analog Inputs

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Analog Inputs</td>
<td>4 with full range of input types, plus one pulse OR 8 with full range of input types, plus one pulse OR 16 with full range of input types, plus one pulse</td>
</tr>
<tr>
<td>Input Switching</td>
<td>4-Loop and 8-Loop: Differential solid state multiplexer 16-Loop: Single-ended, solid state multiplexer</td>
</tr>
<tr>
<td>Input Sampling Rate</td>
<td>4-Loop: 6Hz (167 ms) at 60Hz; 5Hz (200 ms) at 50Hz 8-Loop: 3Hz (333 ms) at 60Hz; 2.5Hz (400 ms) at 50Hz 16-Loop: 1.5Hz (667 ms) at 60Hz; 1.25Hz (800 ms) at 50Hz</td>
</tr>
<tr>
<td>Analog Over Voltage Protection</td>
<td>±20V referenced to digital ground</td>
</tr>
<tr>
<td>Maximum Common Mode Voltage</td>
<td>5V input to input or input to analog common (four-loop and eight-loop models)</td>
</tr>
<tr>
<td>Common Mode Rejection (CMR)</td>
<td>For inputs that do not exceed ±5V, &gt;60dB dc to 1kHz, and 120dB at selected line frequency</td>
</tr>
<tr>
<td>A/D Converter</td>
<td>Integrates voltage to frequency</td>
</tr>
<tr>
<td>Input Range</td>
<td>-10 to +60mV, or 0 to 25V with scaling resistors</td>
</tr>
<tr>
<td>Resolution</td>
<td>0.006%, greater than 14 bits (internal)</td>
</tr>
</tbody>
</table>
### Table 10.12 – Pulse Inputs

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number</td>
<td>1</td>
</tr>
<tr>
<td>Frequency Range</td>
<td>0 to 2,000Hz</td>
</tr>
<tr>
<td>Input Voltage Protection</td>
<td>Diodes to supply and common</td>
</tr>
<tr>
<td>Voltage Levels</td>
<td>&lt;1.3V: Low</td>
</tr>
<tr>
<td></td>
<td>&gt;3.7V: High (TTL)</td>
</tr>
<tr>
<td>Maximum Switch Resistance to</td>
<td>2kΩ</td>
</tr>
<tr>
<td>Pull Input Low</td>
<td></td>
</tr>
<tr>
<td>Minimum Switch Off Resistance</td>
<td>30kΩ</td>
</tr>
</tbody>
</table>

### Table 10.13 – Thermocouple Range and Resolution

<table>
<thead>
<tr>
<th>THERMOCOUPLE TYPE</th>
<th>RANGE IN °F</th>
<th>RANGE IN °C</th>
<th>ACCURACY* AT 25°C AMBIENT °F</th>
<th>ACCURACY* AT 0 TO 50°C AMBIENT °F</th>
</tr>
</thead>
<tbody>
<tr>
<td>J</td>
<td>-350 to 1,400</td>
<td>-212 to 760</td>
<td>±2.2 ±1.2</td>
<td>±3.3 ±1.8</td>
</tr>
<tr>
<td>K</td>
<td>-450 to 2,500</td>
<td>-268 to 1,371</td>
<td>±2.4 ±1.3</td>
<td>±3.8 ±2.1</td>
</tr>
<tr>
<td>T</td>
<td>-450 to 750</td>
<td>-268 to 399</td>
<td>±2.9 ±1.6</td>
<td>±5.8 ±3.2</td>
</tr>
<tr>
<td>S</td>
<td>0 to 3,200</td>
<td>-18 to 1,760</td>
<td>±5.0 ±2.8</td>
<td>±8.8 ±4.9</td>
</tr>
<tr>
<td>R</td>
<td>0 to 3,210</td>
<td>-18 to 1,766</td>
<td>±5.0 ±2.8</td>
<td>±8.8 ±4.9</td>
</tr>
<tr>
<td>B</td>
<td>150 to 3,200</td>
<td>66 to 1,760</td>
<td>±7.2 ±4.0</td>
<td>±22.1 ±12.3</td>
</tr>
<tr>
<td>E</td>
<td>-328 to 1,448</td>
<td>-200 to 787</td>
<td>±1.8 ±1.0</td>
<td>±2.9 ±1.6</td>
</tr>
</tbody>
</table>

* True for 10% to 100% of span except type B, which is specified for 800°F to 3200°F.
Table 10.14 — RTD Range and Resolution

<table>
<thead>
<tr>
<th>NAME</th>
<th>RANGE IN °F</th>
<th>RANGE IN °C</th>
<th>RESOLUTION IN °C</th>
<th>MEASUREMENT TEMPERATURE IN °C</th>
<th>ACCURACY* AT 25°C AMBIENT</th>
<th>ACCURACY* AT 0 TO 50°C AMBIENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>RTD1</td>
<td>-148.0 to 527.0</td>
<td>-100.0 to 275.0</td>
<td>0.023</td>
<td>25 °F</td>
<td>±0.7 °F; ±0.4 °C</td>
<td>±1.0 °F; ±0.6 °C</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>275 °F</td>
<td>±1.9 °F; ±1.1 °C</td>
<td>±2.8 °F; ±1.6 °C</td>
</tr>
<tr>
<td>RTD2</td>
<td>-184 to 1544</td>
<td>-120 to 840</td>
<td>0.023</td>
<td>25 °F</td>
<td>±2.5 °F; ±1.4 °C</td>
<td>±5.9 °F; ±3.3 °C</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>840 °F</td>
<td>±2.9 °F; ±1.6 °C</td>
<td>±8.6 °F; ±4.8 °C</td>
</tr>
</tbody>
</table>

Table 10.15 — Input Resistance for Voltage Inputs

<table>
<thead>
<tr>
<th>RANGE</th>
<th>INPUT RESISTANCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 to 10V</td>
<td>50kΩ</td>
</tr>
<tr>
<td>0 to 5V</td>
<td>40kΩ</td>
</tr>
</tbody>
</table>

Table 10.16 — Digital Inputs

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number</td>
<td>8</td>
</tr>
<tr>
<td>Configuration</td>
<td>8 selectable for output override, remote job selection</td>
</tr>
<tr>
<td>Input Voltage Protection</td>
<td>Diodes to supply and common. Source must limit current to 10mA for override conditions</td>
</tr>
<tr>
<td>Voltage Levels</td>
<td>&lt;1.3V: Low &gt;3.7V: High (TTL) 5V maximum, 0V minimum</td>
</tr>
<tr>
<td>Maximum Switch Resistance to Pull Input Low</td>
<td>1kΩ</td>
</tr>
<tr>
<td>Minimum Switch Off Resistance</td>
<td>11kΩ</td>
</tr>
<tr>
<td>Update Rate</td>
<td>6Hz</td>
</tr>
</tbody>
</table>

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 SSRs or other power switching devices which in turn control, for example, heaters. They may also be used to signal another device of an alarm condition in the controller.

An open-collector CPU watchdog output is also provided so that an external device may monitor the CPU state.
**Analog Outputs**

Analog outputs may be accomplished by using Dual DAC or Serial DAC modules in conjunction with the digital outputs. Contact your supplier or Watlow for more information on these accessory products.

**Digital Outputs**

**Table 10.17 — Digital Outputs Control / Alarm**

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number</td>
<td>35 via TB50 and/or SCSI option, 13 via TB18</td>
</tr>
<tr>
<td>Operation</td>
<td>Open collector output, ON state sinks to logic common</td>
</tr>
<tr>
<td>Function</td>
<td>34 Outputs selectable as closed-loop control or alarm/control. 1 global alarm output</td>
</tr>
<tr>
<td>Number of Control Outputs per PID Loop</td>
<td>2 (maximum)</td>
</tr>
<tr>
<td>Control Output Types</td>
<td>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.</td>
</tr>
<tr>
<td>Time Proportioning Cycle Time</td>
<td>1 to 255 seconds, programmable for each output.</td>
</tr>
<tr>
<td>Control Action</td>
<td>Reverse (heat) or direct (cool), independently selectable for each output</td>
</tr>
<tr>
<td>Off State Leakage Current</td>
<td>&lt;0.01mA to dc common</td>
</tr>
<tr>
<td>Maximum Current</td>
<td>60mA for each output. 5V power supply (from the processor module) can supply up to 350mA total to all outputs.</td>
</tr>
<tr>
<td>Maximum Voltage Switched</td>
<td>24VDC</td>
</tr>
</tbody>
</table>

**Table 10.18 — CPU Watchdog Output**

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number</td>
<td>1</td>
</tr>
<tr>
<td>Operation</td>
<td>Open collector output, ON state sinks to logic common</td>
</tr>
<tr>
<td>Function</td>
<td>Monitors the processor module microprocessor</td>
</tr>
<tr>
<td>Maximum Current</td>
<td>10mA (5V power supply in the processor module can supply up to 350mA total to all outputs)</td>
</tr>
<tr>
<td>Maximum Voltage Switched</td>
<td>5VDC</td>
</tr>
</tbody>
</table>

**Table 10.19 — 5VDC Output (Power to Operate Solid-State Relays)**

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voltage</td>
<td>5VDC</td>
</tr>
<tr>
<td>Maximum Current</td>
<td>350mA</td>
</tr>
</tbody>
</table>
### Table 10.20 — Reference Voltage Output (Power to Operate Bridge Circuit Sensors)

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voltage</td>
<td>5VDC</td>
</tr>
<tr>
<td>Maximum Current</td>
<td>10mA</td>
</tr>
</tbody>
</table>

### Table 10.21 — Serial Communication

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>EIA/TIA-232 3-wire or EIA/TIA-485 4-wire</td>
</tr>
<tr>
<td>Isolation</td>
<td>None</td>
</tr>
<tr>
<td>Baud Rate</td>
<td>2,400, 9,600 or 19,200 user selectable</td>
</tr>
<tr>
<td>Error Check</td>
<td>BCC or CRC, user selectable</td>
</tr>
<tr>
<td>Number of Controllers</td>
<td>1 with EIA/TIA-232 communications; up to 32 with EIA/TIA-485 communications, depending upon protocol</td>
</tr>
<tr>
<td>Protocol</td>
<td>Form of ANSI X3.28-1976 (D1, F1), compatible with Allen Bradley PLC/2, full duplex or Modbus® RTU</td>
</tr>
</tbody>
</table>

### Table 10.22 — Power Requirements

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voltage</td>
<td>15 to 24VDC ±3VDC</td>
</tr>
<tr>
<td>Current (Maximum Load)</td>
<td>1A</td>
</tr>
</tbody>
</table>
Glossary

A

AC
See Alternating Current.

AC Line Frequency
The frequency of the AC power line measured in Hertz (Hz), usually 50 or 60Hz.

Accuracy
Closeness between the value indicated by a measuring instrument and a physical constant or known standards.

Action
The response of an output when the process variable is changed. See also Direct Action, Reverse Action.

Address
A numerical identifier for a controller when used in computer communications.

Alarm
A signal that indicates that the process has exceeded or fallen below a certain range around the setpoint. For example, an alarm may indicate that a process is too hot or too cold. See also:
- Deviation Alarm
- Failed Sensor Alarm
- Global Alarm
- High Deviation Alarm
- High Process Alarm
- Loop Alarm
- Low Deviation Alarm
- Low Process Alarm

Alarm Delay
The lag time before an alarm is activated.

Alternating Current (AC)
An electric current that reverses at regular 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 unit that defines the rate of flow of electricity (current) in the circuit. Units are one coulomb (6.25 x 10^18 electrons) per second.

Analog Output
A continuously variable signal that is used to represent a value, such as the process value or setpoint value. Typical hardware configurations are 0 to 20mA, 4 to 20mA or 0 to 5VDC.

Automatic Mode
A feature that allows the controller to set PID control outputs in response to the Process Variable (PV) and the setpoint.
**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.

**Block Check Character (BCC)**
A serial communications error checking method. See also *Cyclic Redundancy Check*.

**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 device (an unknown) against an equal or better standard.

**Celsius (Centigrade)**
Formerly known as Centigrade. 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:

\[ ^\circ F = (1.8 \times ^\circ C) + 32 \]

**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 configuration of electrically or electromagnetically connected components or devices.

**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 error between the process variable and the setpoint. For reverse action (usually heating), as the process decreases below the setpoint the output increases. For direct action (usually cooling), as the process increases above the setpoint, the output increases.

**Control Status**
The type of action that a controller uses. For example, on/off, time proportioning, PID, automatic or manual, and combinations of these.

**Current**
The rate of flow 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. It provides a high level of data security but is more difficult to implement than Block Check Character (BCC). See also Block Check Character.
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.

Deadband
The range through which a variation of the input produces no noticeable change in the output. In the deadband, specific conditions can be placed on control output actions. Operators select the deadband. It is usually above the heating proportional band and below the cooling proportional band.

Default Parameter Settings
The values that the user adjustable parameters have when a controller ships from Watlow or after the user programmed setting are cleared.

Derivative Control (D)
The last term in the PID algorithm. Action that anticipated 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 (PV) that decreases over the time of the derivative (TD). The TD is in units of seconds.

Deutsche Industrial Norms (DIN)
A set of technical, scientific and dimensional standards developed in Germany. Many DIN standards have worldwide recognition.

Deviation Alarm
Warns that a process has exceeded or fallen below a certain range around the setpoint.

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.

Direct Action
An output control action in which an increase in the process variable, causes an increase in the output. Cooling applications usually use direct action.

Direct Current (DC)
An electric current that flows in one direction.

Distributed Zero Crossing (DZC)
A form of digital output control in which the output on/off state is calculated for every ac line cycle. Power is switched at the zero cross, which reduces electrical noise. See also Zero Cross.

Earth Ground
A metal rod, usually copper, that provides an electrical path to the earth, to prevent or reduce the risk of electrical shock.

EIA/TIA
See Serial Communications.

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 on inside the sine wave. EMI can interfere with the operation of controls and other devices.

Electrical-Mechanical Relays
See Relay, Electromechanical.

Emissivity
The ratio of radiation emitted from a surface compared to radiation emitted from a blackbody at the same temperature.

Engineering Units
Selectable units of measure, such as degrees Celsius and Fahrenheit, pounds per square inch, newtons per meter, gallons per minute, liters per minute, cubic feet per minute or cubic meters per minute.
EPROM
Erasable Programmable, Read-Only Memory inside the controller.

Error
The difference between the correct or desired value and the actual value.

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 conversion to Celsius:

\[ ^\circ C = \frac{5}{9} (^\circ F - 32) \]

Failed Sensor Alarm
Warns that an input sensor no longer produces a valid signal. For example, when there are thermocouple breaks, infrared problems or resistance temperature detector (RTD) open or short failures.

Filter
Filters are used to handle various electrical noise problems.

Digital Filter (DF)
A filter that slows the response of a system when inputs change unrealistically or too fast. Equivalent to a standard resistor-capacitor (RC) filter.

Digital Adaptive Filter
A filter that rejects high frequency input signal noise (noise spikes).

Heat/Cool Output Filter
A filter that slows 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 value within the numbers of scans that are set.

Frequency
The number of cycles over a specified period of time, usually measured in cycles per second. Also referred to as Hertz (Hz). The reciprocal is called the period.

Gain
The amount of amplification used in an electrical circuit. Gain can also refer to the Proportional (P) mode of PID.

Global Alarm
Alarm associated with a global digital output that is cleared directly from a controller or through a user interface.

Global Digital Outputs
A digital output that alerts the operator when an alarm occurs.

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 a “safety ground”.

Hertz (Hz)
Frequency, measured in cycles per second.

High Deviation Alarm
Warns that the process is above setpoint, but below the high process alarm setpoint. It can be used as either an alarm or control function.

High Power
(Relative to the CLS200 power.) Any voltage above 24VAC or VDC and any current level above 50mA AC or mA DC.

High Process Alarm
Indicates that a process value has risen above the high process alarm setpoint. It can be used as either an alarm or control function.

High Process Variable
See Process Variable (PV).

High Reading
An input level that corresponds to the high process value. For linear inputs, the high reading is a percentage of the full scale input range. For pulse inputs, the high reading is expressed in cycles per second (Hz).
I

Infrared (IR)
A region of the electromagnetic spectrum with wavelengths ranging from one to 1,000 microns. These wavelengths are suited for radiant heating and infrared (noncontact) temperature sensing.

Input
Process variable information that is supplied to the instrument.

Input Scaling
The ability to scale input readings (readings in percent of full scale) to the engineering units of the process variable.

Input Type
The signal type that is connected to an input, such as thermocouple, RTD, linear or process.

Integral Control (I)
Control action that automatically eliminates offset, or droop, between setpoint 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.

L

Lag
The delay between the output of a signal and the response of the instrument to which the signal is sent.

Linear Input
A process input that represents a straight line function.

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.

Loop Alarm
Any alarm system that includes high and low process, deviation band, deadband, digital outputs, and auxiliary control outputs.

Low Deviation Alarm
Warns that the process is below the setpoint, but above the low process alarm setpoint. It can be used as either an alarm or control function.

Low Process Alarm
Indicates that a process value has dropped below the low process alarm setpoint. It can be used as either an alarm or control function.

Low Reading
An input level corresponding to the low process value. For linear inputs, the low reading is a percentage of the full scale input range. For pulse inputs, the low reading is expressed in cycles per second (Hz).

M

Manual Mode
A selectable mode that has no automatic control aspects. The operator sets output levels.

Manual Reset
See Reset.

Milliampere (mA)
One thousandth of an ampere.

MMI
Man-machine interface.
NO-Key Reset
A method for resetting the controller’s memory.

Noise
Unwanted electrical signals that may 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.

Nonlinear
A firmware feature that reduces the actual output signal from the automatically calculated level. Often used with cool outputs.

Offset
The difference in temperature between the setpoint and the actual process temperature. 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 setpoint is reached, and then off until the process error exceeds the hysteresis.

Open Loop
A control system with no sensory feedback.

Operator Menus
The menus accessible from the front panel of a controller. These menus allow operators to set or change various control actions or features.

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 setpoint and process variable.

Output Type
The form of PID 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 setpoint before it stabilizes.

Panel Lock
A feature that prevents operation of the front panel by unauthorized people.

PID
Proportional, Integral, Derivative. A control status 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 Variable (PV)
The parameter that is controlled or measured. Typical examples are temperature, relative humidity, pressure, flow, fluid level, events, etc. The high process variable is the highest value of the process range, expressed in engineering units. The low process variable is the lowest value of the process range.

Proportional (P)
Output effort proportional to the error from setpoint. For example, if the proportional band is 20° and the process is 10° below the setpoint, the heat proportioned effort is 50%. 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.

R
Ramp
A programmed change in the temperature of a setpoint 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.

Reflection Compensation Mode
A control feature that automatically corrects the reading from a sensor.

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
Control action that automatically eliminates offset or droop between setpoint and actual process temperature. See also Integral Control.

Automatic Reset
The integral function of a PI or PID temperature controller that adjusts the process temperature to the setpoint after the system stabilizes. The inverse of integral.

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.

EIA/TIA-232
An Electronics Industries of America (EIA) 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
An Electronics Industries of America (EIA) standard for electrical characteristics of generators and receivers for use in balanced digital multipoint systems. This is usually used to communicate with multiple devices over a common cable or where distances over 50 feet (15 m) are required.
Setpoint (SP)
The desired value programmed into a controller. 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.

Spread
In heat/cool applications, the +/- difference between heat and cool. Also known as process deadband. See also Deadband.

Stability
The ability of a device to maintain a constant output with the application of a constant input.

T

T/C 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.

TD (Timed Derivative)
The derivative function.

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).

TI (Timed Integral)
The Integral term.

Transmitter
A device that converts temperature or other process data from a sensor to an analog voltage or current. Transmitters are desirable when long lead or extension wires produce unacceptable signal degradation.

U

Upscale Break Protection
A form of break detection for burned-out thermocouples. Signals the operator that the thermocouple has burned out.

Undershoot
The amount by which a process variable falls below the setpoint 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’s 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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REPEAT CYCLES
Declaration of Conformity

CLS200 Multi-Loop Temperature Controller

WATLOW Electric Manufacturing Company
1241 Bundy Blvd.
Winona, MN 55987 USA

Declares that the following products:
Designation: CLS200
Classification: Temperature Control, Installation Category II, Pollution degree 2, IP20
Rated Supply: 15 to 24 V== (dc) 610 mA maximum

Meets the essential requirements of the following European Union Directives by using the relevant standards show below to indicate compliance.

**2014/30/EU Electromagnetic Compatibility Directive**

EN 61326-1: 2013 Electrical equipment for measurement, control and laboratory use – EMC requirements (Industrial Immunity, Class A Emissions)
CAUTION: This equipment not intended for use in residential environments and may not provide adequate protection to radio reception in such environments

IEC 61000-4-2:2008 Electrostatic Discharge Immunity Test
IEC 61000-4-3:2007 Radiated Radio-frequency, Electromagnetic Field Immunity 10V/m 80 MHz-
+ A1/2008, A2/2010 1GHz, 3V/m 1.4GHz-2.7GHz
IEC 61000-4-4:2012 Electrical Fast-Transient / Burst Immunity Test
IEC 61000-4-5:2014 Surge Immunity Tests
+ A1/2017
IEC 61000-4-6:2013 + Corrigendum 2015 Immunity to conducted disturbances induced by radio-frequency fields.
EN 61000-3-2:2018 Limits for harmonic current emissions ≤ 16A per phase.
EN 61000-3-3:2013 + A1/2017 Limitations of Voltage changes, Fluctuations and Flicker ≤ 16A per phase.
SEMI F47:0812 Specification for Semiconductor Sag Immunity Figure R1-1

**2014/35/EU Low-Voltage Directive**

EN 61010-1:2010 Safety Requirements of electrical equipment for measurement, control and laboratory use. Part 1: General requirements

Per 2012/19/EU WEEE Directive Please Recycle Properly

RoHS compliant to 2011/65/EU Directive.

Models contain a type BR1632 lithium coin cell battery embedded within Maxim Semiconductor DS1230Y / DS9034 RAM which shall be recycled at end of life per 2006/66/EC Battery Directive as amended by 2013/56/EU Directive.

Doug Kuchta
Name of Authorized Representative
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