Allen-Bradley

User Manual

Temperature Control Module

(Cat. No. 1771-TCM Series D)
(Cat. No. 1771-TCMR Series B)

Important User Information

Because of the variety of uses for the products described in this publication, those responsible for the application and use of this control equipment must satisfy themselves that all necessary steps have been taken to assure that each application and use meets all performance and safety requirements, including any applicable laws, regulations, codes and standards.

The illustrations, charts, sample programs and layout examples shown in this guide are intended solely for purposes of example. Since there are many variables and requirements associated with any particular installation, Allen-Bradley does not assume responsibility or liability (to include intellectual property liability) for actual use based upon the examples shown in this publication.

Allen-Bradley publication SGI-1.1, *Safety Guidelines for the Application, Installation, and Maintenance of Solid-State Control* (available from your local Allen-Bradley office), describes some important differences between solid-state equipment and electromechanical devices that should be taken into consideration when applying products such as those described in this publication.

Throughout this manual we use notes to make you aware of safety considerations:

ATTENTION: Identifies information about practices or circumstances that can lead to personal injury or death, property damage or economic loss.

Attention statements help you to:

- identify a hazard
- avoid the hazard
- recognize the consequences

Important: Identifies information that is critical for successful application and understanding of the product.

Summary of Changes

Modules Covered by this Manual

This manual now covers three versions of the temperature control modules that are nearly identical, except for the type of temperature sensor:

- 1771-TCM series B, C and D (firmware revision 3.3) for thermocouples
- 1771-TCMR (new release) for resistance type sensors

Summary of Changes for 1771-TCM Firmware Revision 3.3

We made these changes to this manual:

- Added a lowpass filter to the temperature input
  – enabled (1) disabled (0) by Configuration Block word 2, bit 13
  – time constant (0–9.9 sec) stored in Configuration word 25
- To accelerate reaching the initial setpoint, added an auto-tune startup aggressiveness parameter stored in Configuration word 14.
- Added a setpoint ramp-hold bit for use when ramping to a setpoint.
  – enabled (1) holds the setpoint at the current value
  – disabled (0) restores ramping to the selected setpoint
  Enabled in the Dynamic block for each loop.
- Added a selectable display mode that displays temperature in 1° increments and creates a ± 1° deadband at the setpoint.
  Enabled in the Dynamic block for all loops or none.
- Added a status bit to indicate the direction of ramping for each loop.
  Indicated in the System Status block for each loop.
- Changed the initialization rung of the communication program:
  – to clear the TPO bits (for block and single transfer)
  – to write valid Configuration and Auto-tune Blocks to the module
  – to avoid clearing the gains block on first scan

We improved module performance with these firmware adjustments:

- After auto-tune, errors are reported as warnings rather than faults.
- The anti-repeat windup (integral action) is faster and more active.
- When downloading an auto-tune or gains block to the module controlling in automatic mode, the integral sum is scaled by the ratio of old-to-new gains to minimize the bump.
- The Heat PID gains generated by auto-tune have been moderated for more stable control.
- Heat/Cool now uses split-range control with the same I term for both to provide smoother transitions between heating and cooling.

Important: If replacing an earlier module in heat/cool mode, you must auto tune the module to establish valid PID values.

Important: Either module now includes configuration software with accompanying manual (publication 1771-6.4.5) and a communication ladder program. They simplify the procedures to configure and program the module. We describe the communication program in appendix C.

Important: The communication program and configuration software are also available from the Internet. Access them from our website:
www.ab.com/plclogic/prodinfo/io/I_O/tcmsw/index.html

You must have INTERCHANGE™ software to use the configuration software. You must have a programming software to download the communication program to your PLC processor.

Standardized Terminology (throughout manual)

Our terminology is generally consistent with customer usage, but inconsistent with ISA/IEEE. This table should clarify some definitions.

Existing A-B Term:	ISA/IEEE Term:	Meaning:
Control Variable (V or CV) Controller Output (CO)	Manipulated Variable (M)	what the controller applies to the control system
Process Variable (PV)	Controlled Variable (C)	in a control loop, that which is directly measured or controlled
n/a	Process Variable (PV)	any variable of the process, including the manipulated variable and the controlled variable
Proportional Gain (K_p)	Controller Gain (K_c)	Overall gain for the loop with *dependent* PID action (affects integral and derivative terms as well)

We also changed the term "system" status to "module" status because that is what the module returns to the processor.

About the 1771-TCMR Module

This module can use any of these resistance-type sensors:

- 100 ohm platinum (USA)
- 100 ohm platinum (Euro)
- 120 ohm nickel
- 10 ohm copper

Input connections to the module are routed through the 1771-RTP4 remote termination panel. Installation, programming, power requirements, and module specifications are otherwise identical to the 1771-TCM module.

Using This Manual

This manual shows you how to use your Temperature Control Module in an Allen-Bradley PLC system for barrel temperature control and other injection molding or extrusion-related temperature control applications. The modules covered in this manual are:

- cat. no. 1771-TCM, Series B, C or Series D with firmware release 3.3
- cat. no. 1771-TCMR, Series A, for resistance-type sensors

This manual helps you install, program, calibrate, and troubleshoot your TCM or TCMR module. TemperatureControl™ configuration software is included with either module. For information on using TemperatureControl configuration software, see manual 1771-6.4.5.

Audience

You must be able to program and operate Allen-Bradley programmable controllers to make efficient use of these modules. In particular, you must know how to program block-transfers. If not, refer to applicable PLC® programming manuals before attempting to write programs.

Terminology

In this manual, we refer to the:

- temperature control module as the "module"
  Where there are differences, we designate TCM or TCMR
- programmable controller, as the "PLC processor" or the "processor"
- thermocouple as a "TC"
- resistance–type sensor as a resistance temperature device "RTD"
- time-proportioned output as "TPO"
- tuning-assisted process as "TAP"
- proportional-integral-derivative terms as "PID" terms

Related Publications

For a list of publications with information on Allen-Bradley programmable controller products, consult publication index SD499.

If you are going to use:	Refer to:
TemperatureControl™ Configuration Software	• Temperature Control Module Programming Manual (publication 1771-6.4.5)
Pro-Set™ 700 Software	• Pro-Set 700 Reference Manual (publication 6500-6.4.3) • Pro-Set 700 User Manual (publication 6500-6.5.18) • Pro-Set 700 Systems Job-Setting Guide (publication 6500-6.9.3)
PanelView™, RSView™ or other man-machine interface	• PanelBuilder 900 Configuration Software (publication 2711-815) • other publications that accompanied the product

Notes:

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Overview of TCM and TCMR Temperature Control Modules

This chapter gives you information on:

- module features
- temperature control in a PLC system
- how the module communicates with the PLC processor
- restriction of use in an I/O chassis
- compatible replacement of a series B or series C TCM module
- standard terminology

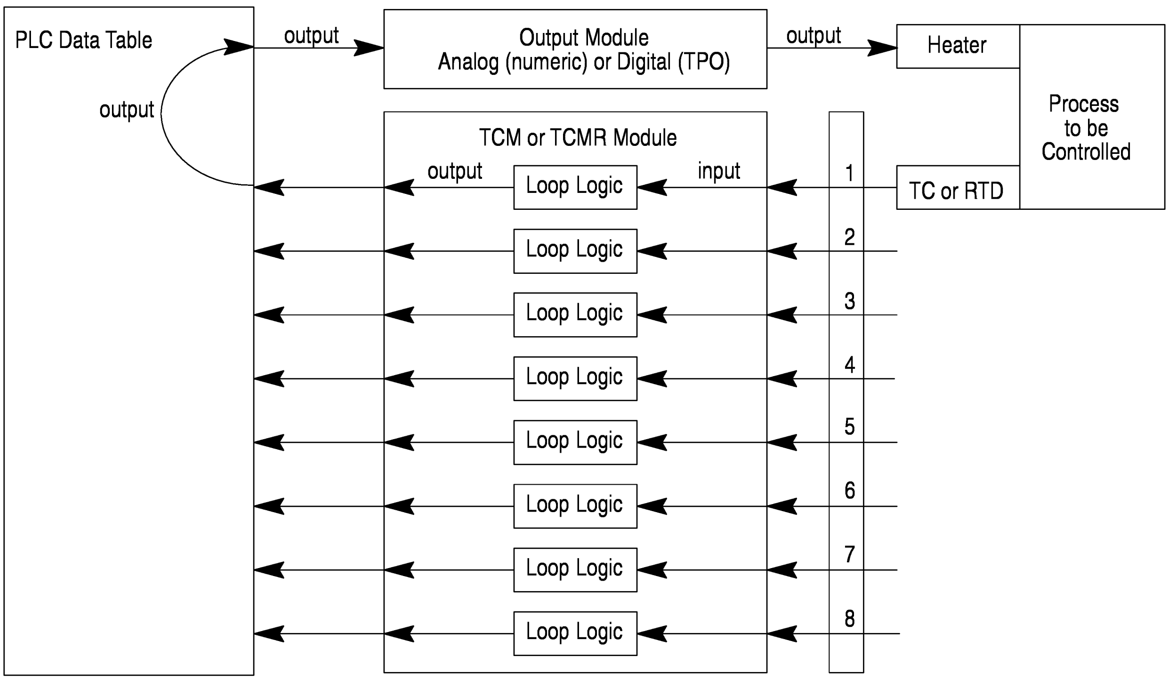
Module Features

TCM or TCMR modules provide:

- 8 independent heat/cool temperature control loops
- auto-tuning of PID loops (one loop or any combination of loops can be auto-tuned while other loops are running) and a unique start-up algorithm
- for TCM modules, an isolated TC input (types B, E, J, K, R, S, T) or (±100mV) for each PID loop
- for TCMR modules, a 100 ohm platinum, 120 ohm nickel, or 10 ohm copper resistance-type (RTD) sensor for each PID loop
- 16-bit analog-to-digital converter resolution (0.1° resolution)
- heat signal (PID loop output) to the data table as a numeric % value for each temperature loop
- cool signal (PID loop output) to the data table as a numeric % value for each temperature loop
- a heat signal (for each PID loop) to the data table as a TPO bit
- a cool signal (for each PID loop) to the data table as a TPO bit
- temperature values in °C or °F
- self-calibration (external reference required)
- user-selectable high and low alarms with dead band for hysteresis
- input open-circuit detection

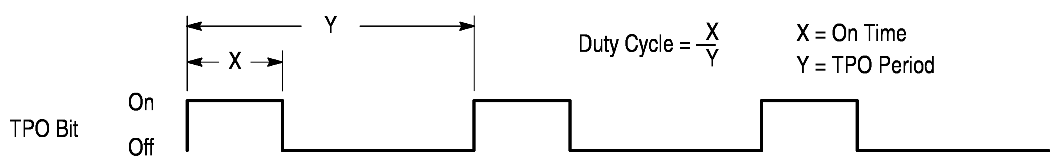
Temperature Control in a PLC System

The TCM and TCMR modules are intelligent I/O modules that provide a maximum of 8 PID loops for temperature control. Either module has 8 analog inputs: the TCM module is designed for thermocouple (TC) inputs, the TCMR module is designed for resistance type device (RTD) inputs. The module performs the PID algorithm and tuning-assisted-process (TAP) algorithm for each loop. The output of each loop is sent from the module to the PLC data table. Your application ladder logic must access the loop output in the data table and send it to an output module to close the loop.



The output of each loop is sent from the module to the PLC data table as both an analog (numeric) value and as the duty cycle of a bit that is cycled at a regular period. We call this duty-cycle bit a time-proportioned output (TPO) bit.

Your ladder logic can monitor the analog (numeric) value and send it to an analog output module to generate the output signal to an analog temperature control actuator. Or, your ladder logic can send the TPO signal to a digital output module to generate the TPO output signal to an on/off temperature control actuator.



How the Module Communicates with the PLC Processor

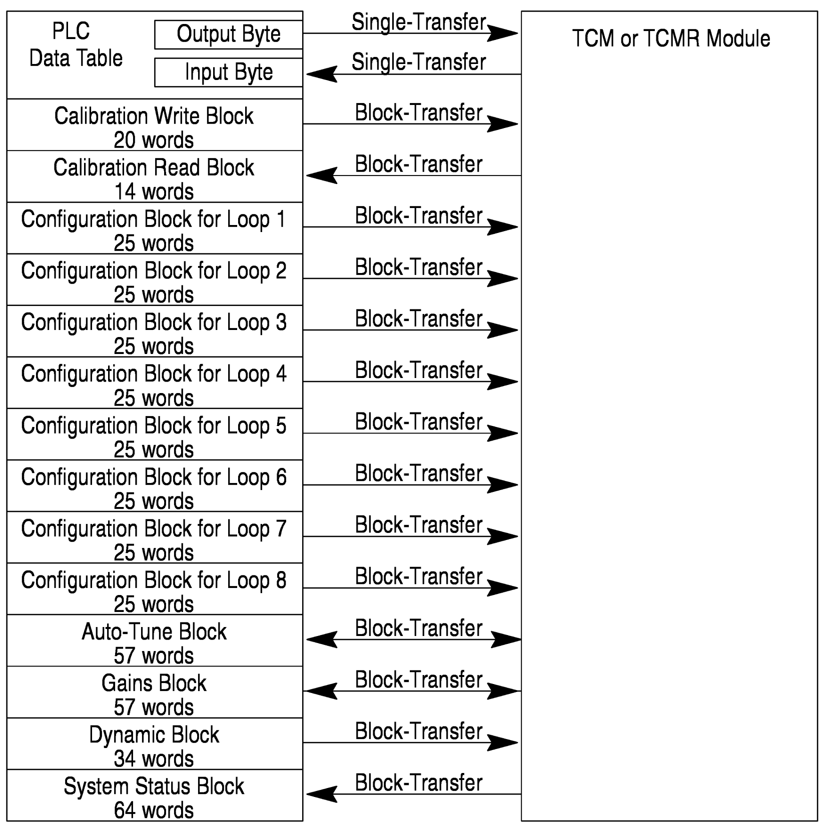
TCM and TCMR modules communicate with the PLC processor by both block-transfer and single-transfer. Your application ladder logic must include block-transfer write instructions to send the following data blocks to the module:

- a configuration block for each (8 max) PID loop (chapter 4)
- auto-tune block (chapter 5)
- gains block (chapter 6)
- dynamic block (chapter 7)
- calibration block (not required for normal operation)(chapter 9)

Your ladder logic must include block-transfer read instructions to get the following data blocks from the module:

- auto-tune block (chapter 5)
- gains block (chapter 6)
- system status (chapter 8)
- calibration block (not required for normal operation)(chapter 9)

Unless the module is located in an I/O chassis (with a 1771-ASB I/O adapter) on a universal remote I/O link providing heat/cool control, you can use the high-speed TPO signals by including instructions in the ladder logic for examining an input image byte which is single-transferred from the module. This byte contains the output of each loop as the duty cycle of a TPO bit that is cycled at a regular period. Each bit corresponds to one of the 8 PID loops.



Restriction of Use in a Remote I/O Chassis

TCM and TCMR modules provide TPO signals thru both the block-transfer and single-transfer of I/O data. Single-transfer of TPO signals provide a faster output update to the temperature control actuator.

When a very fast cut-off is required in an operation controlling both heat *and* cooling, place the module in a *local* chassis and use the single-transferred TPO signal. For heat-only or cool-only operation, the effective period for updating the single-transferred TPO bits is approximately 10ms. If you alternately examine heat and cool TPO bits, the effective period for updating the single-transferred TPO bits is approximately 20ms.

However, do not use single-transferred TPO signals to control both heating *and* cooling elements if the module is in an I/O chassis (with a 1771-ASB adapter) on a universal remote I/O link. If multiplexed between heat and cool, this single-transfer TPO signal may be unreliable if the module is in an I/O chassis on a universal remote I/O link. Therefore, this module can be used in a chassis on a remote I/O link only in heat-only applications, cool-only applications, or applications that don't call for high-speed cut-off of the TPO signal.

ATTENTION: The module can be used in an I/O chassis (with 1771-ASB adapter) on a universal remote I/O link only in applications that do NOT call for high-speed cut-off of TPO heat *and* cool signals. The module provides TPO signals thru the block-transfer and single-transfer of I/O data. Single transfer provides faster updates of outputs to temperature control actuators. However, do not use single-transferred TPO signals to control both heat *and* cool actuators if the module is in an I/O chassis (with 1771-ASB adapter) on a universal remote I/O link because under these conditions TPO signals may be unreliable.

When using the module for heating/cooling in an I/O chassis on a remote I/O link, use the block-transferred TPO bits. These bits are updated fast enough for most temperature control applications. The module's period for updating the heat and cool bits it makes available thru block-transfer is approximately 100ms.

Use of Data Table

Communication between module and processor is bi-directional. The module uses a byte in the output image table and a byte in the input image table for addressing block transfers. It also requires an area in the data table to store the block-transfer read and write data. The processor also single-transfers output data thru a second byte in the output image table to the module and single-transfers input data from the module thru a second byte in the input image table. These modules use 16 bits of I/O image table and require 1/2-slot or restricted 1-slot addressing. Data table use and address restrictions are as follows:

Catalog Number	Use of Data Table				Compatibility		
	Input Image Bits	Output Image Bits	Read-Block Words	Write-Block Words	Type of Addressing		
					1/2-slot	1-slot	2-slot
1771-TCM or -TCMR	16	16	192	342 max	Yes	R	No

Yes = Compatible without restriction
R = Restricted compatibility; it cannot be in the same even/odd pair of slots with a 32-bit module
No = Not compatible

You can place the module in any I/O slot of the I/O chassis. However, do not put the module into the same even/odd module-slot pair as a 32-bit-density module unless you are using 1/2-slot addressing.

Processor Compatibility

If using TemperatureControl configuration software, you must use a PLC-5 processor. If not using configuration software, the module is compatible with PLC-3®, PLC-5®, and PLC-5/250™ processors. The module is not compatible with PLC-2® processors because these processors cannot process integer values in natural binary format.

Compatible Replacement for Series B or C TCM Modules

The TCM series D module is a compatible replacement for a series A or B modules. The only differences between them are:

- series C and D TCM modules draw more backplane current from the power supply (see chapter 2 and in appendix A)
- the series D TCM module has UL/CSA and CE certification; the series C TCM module has the CE mark, and is only approved for installation within the European Union and EEA regions. The series B module does not have the CE mark or UL/CSA.
- series C and D TCM modules (and series B updated to firmware release 3.3) expect two additional words in the configuration block to configure the non-barrel auto-tune disturbance size.
- heat and cool mode requires that you run Auto-tune to establish vali PID values.

Standard Terminology

The avoid the confusion of referring to the same parameter with two different terms (when comparing this manual with the Configuration Software manual, publication 1771-6.4.5) we have changed several terms in this manual to comply with standard ISA/IEEE terminology:

Terms previously used in this manual:	ISA/IEEE Terms now used in this manual:	Meaning:
Control Variable (V or CV) Controller Output (CO)	Manipulated Variable (M)	what the controller applies to the control system
Process Variable (PV)	Controlled Variable (C)	in a control loop, that which is directly measured or controlled
n/a	Process Variable (PV)	any variable of the process, including the manipulated variable and the controlled variable
Proportional Gain (K_p)	Controller Gain (K_c)	Overall gain for the loop with *dependent* PID action (affects integral and derivative terms as well)

Installing the Module

This chapter gives you information on:

- compliance with European Union directives
- protecting from electrostatic damage
- installing the 1771-TCM module, including:
  - calculating backplane current load
  - determining I/O chassis addressing mode
  - choosing module location in the I/O chassis
  - keying the I/O chassis slot for the module
  - planning for sufficient depth of I/O enclosure
  - installing the remote terminalion panel
  - installing the cables
  - connecting inputs to the remote termination panel
  - grounding the shields
- observing installation precautions
- interpreting indicator lights

Compliance with European Union Directives

If this product has the CE mark it is approved for installation within the European Union and EEA regions. It has been designed and tested to meet the following directives.

EMC Directive

This product is tested to meet Council Directive 89/336/EEC Electromagnetic Compatibility (EMC) and the following standards, in whole or in part, documented in a technical construction file:

- EN 50081-2
  EMC – Generic Emission Standard, Part 2 – Industrial Environment
- EN 50082-2
  EMC – Generic Immunity Standard, Part 2 – Industrial Environment

This product is intended for use in an industrial environment.

Low Voltage Directive

This product is tested to meet Council Directive 73/23/EEC Low Voltage, by applying the safety requirements of EN 61131–2 Programmable Controllers, Part 2 – Equipment Requirements and Tests.

For specific information required by EN 61131-2, see the appropriate sections in this publication, as well as these Allen-Bradley publications:

- Industrial Automation Wiring and Grounding Guidelines For Noise Immunity, publication 1770-4.1
- Automation Systems Catalog

This equipment is classified as open equipment and must be mounted in an enclosure during operation to provide safety protection.

Protecting from Electrostatic Damage

Electrostatic discharge can damage semiconductor devices inside this module if you touch backplane connector pins. Observing the following:

ATTENTION: Electrostatic discharge can degrade performance or cause permanent damage. Handle the module as stated below.

- Wear an approved wrist-strap grounding device.
- Handle the module from the front, away from the backplane connector. Do not touch backplane connector pins.
- Keep the module in its static-shield box when not in use.

Installing the 1771-TCM Module

Follow the steps below to install your module.

1. Calculate Backplane Current Load

The module receives its power through the 1771 I/O chassis backplane from the chassis power supply. The maximum current loads are:

For This Module:	The Max Load Current Is:
1771-TCM, series D	steady state = 1.1A, surge = 1.5A
1771-TCMR series B	steady state = 1.3A, surge = 1.5A

Add this load to the loads of all other modules in the I/O chassis. The total load must not exceed the load specification for either the chassis backplane or backplane power supply . For the 1771-P7 and -PS7 power supplies, use the surge current rating. For other power supplies, use the steady state rating.

2. Determine I/O Chassis Addressing Mode

Because either module has a 16-I/O-bit density, you cannot use it in an I/O chassis set for 2-slot addressing. The module is compatible with either 1-slot or ½-slot addressing.

3. Determine Module Location in the I/O Chassis

The extreme left slot of an I/O chassis is not an I/O module slot; it is reserved for a processor or I/O adapter module.

- If you are using ½-slot addressing, you can place your module into any I/O module slot of the I/O chassis.
- If you are using 1-slot addressing, do not place the module into the same even/odd module-slot pair as a 32-bit-density module. The 32-bit module uses 2 bytes in the input image table and 2 bytes in the output image table.
- Thermocouples provide very low-level analog signals. To minimize electrical noise interference, group analog and low-voltage dc digital modules away from ac modules or high voltage dc digital modules.
- If your application requires high-speed cut-off of heat *and* cool TPO signal, do not install either module in an I/O chassis (with a 1771-ASB I/O adapter) on a universal remote I/O link.

4. Key the I/O Chassis Slot for the Module

Use the plastic keying clips shipped with each I/O chassis, for keying the I/O slot to accept only this type of module.

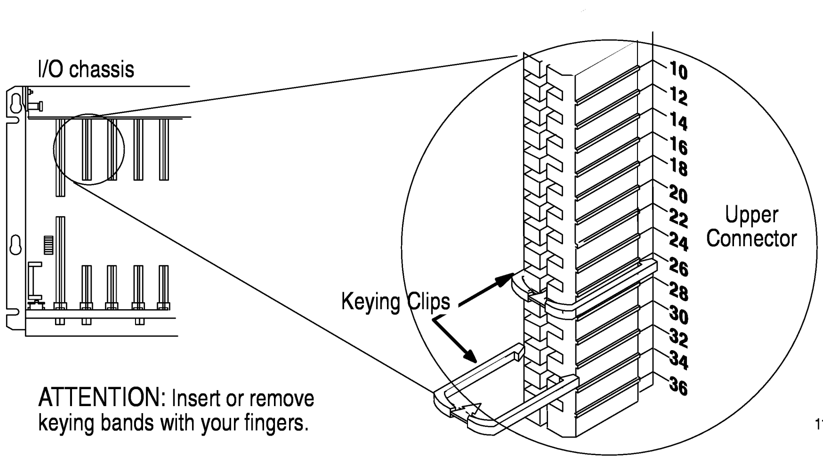
ATTENTION: Observe the following precautions when inserting or removing keying clips:

- insert or remove keying clips with your fingers
- make sure that keying placement is correct

Incorrect keying or the use of a tool can result in damage to the backplane connector and possible system faults.

I/O modules are slotted in two places on the rear edge of the circuit board. The position of the keys on the backplane connector must correspond to these slots to allow insertion of the module. Place key clips between these numbers labeled on the upper backplane connector.

Keying Positions
Between 26 and 28
Between 32 and 34



You can change the position of these keys if subsequent system design and rewiring makes insertion of a different type of module necessary.

5. Plan for Sufficient Depth of I/O Enclosure

Cable connectors extend beyond the front of the module. Your I/O enclosure must provide room for a total of 215 mm (8.5 inches) from the backplane panel to the front of the cable connector installed on the module.

6. Install the Remote Termination Panel

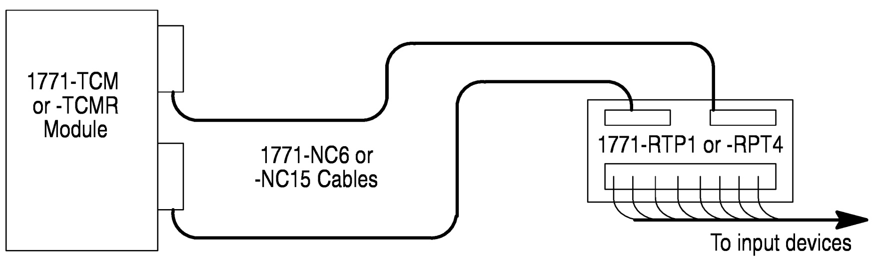
The remote termination panel provides for input connections to the module. You select the correct panel according to the type of input:

For this type of input:	With this module:	Use this panel:
thermocouple	1771-TCM	1771-RPT1*
resistance bulb	1771-TCMR	1771-RTP4

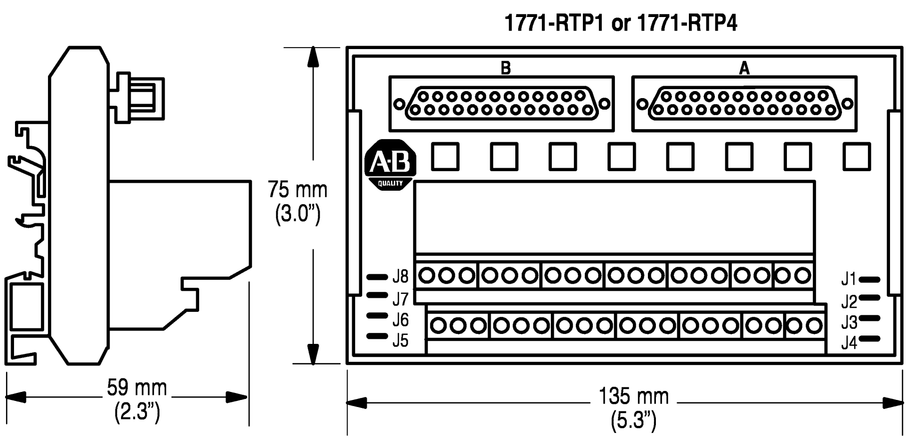
* contains cold-junction temperature compensation

Mount the panel in a location that provides a constant temperature close to ambient. Place the panel sufficiently close to the module so the distance is within the length of the interconnect cable you choose.

- length of 1771-NC6 cable is 6 feet (1.8m)
- length of 1771-NC15 cable is 15 feet (4.6m)



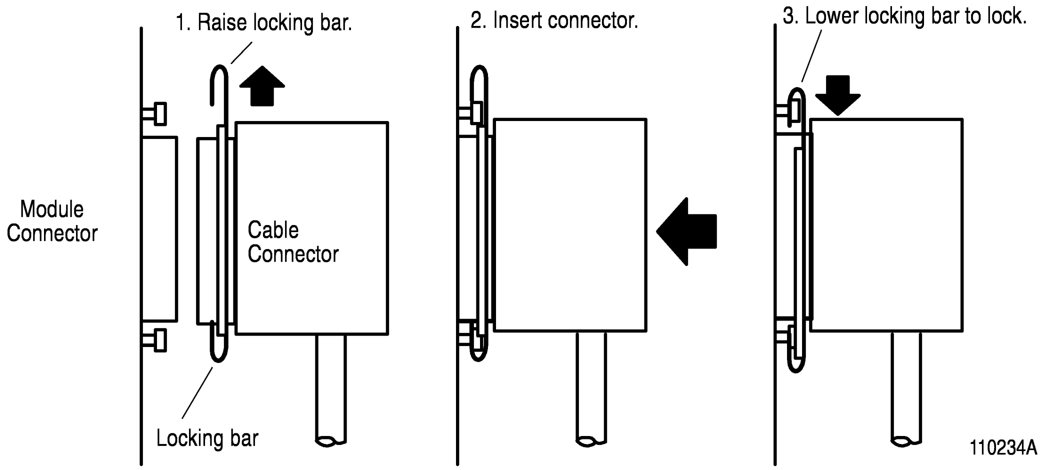
The panels are designed for mounting on standard DIN 1 or DIN 3 mounting rails. Mounting dimension are shown in the figure.



7. Install the Cables

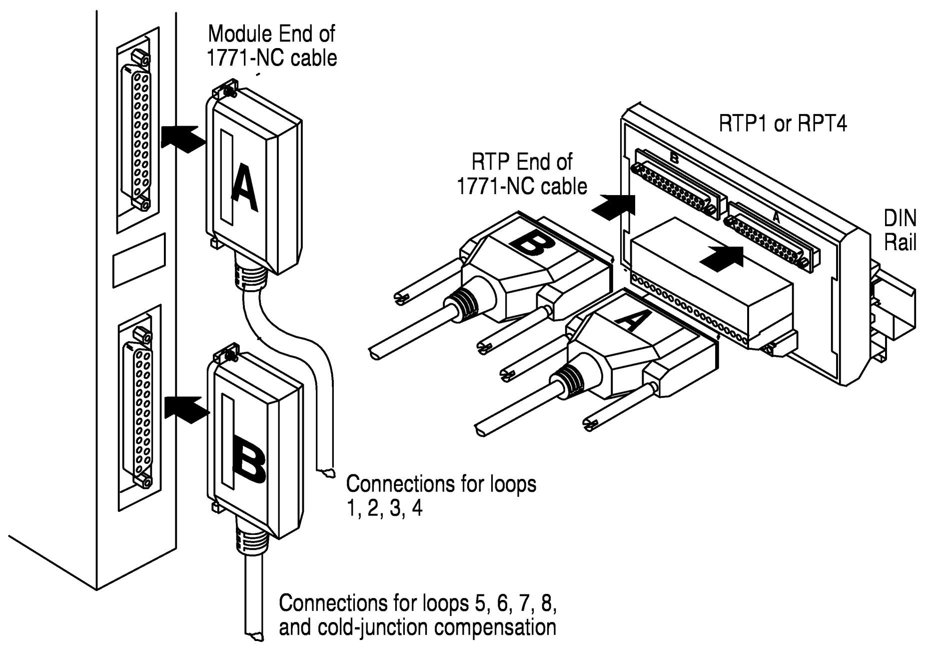
Connect the 1771-NC6 or -NC15 cable to the module as shown:

1. Slide the locking bar up.
2. Insert the cable connector into the mating connector on module.
3. Lower the locking bar over the mating pins to lock the connector.



Connect the other end of each cable to the remote termination panel.

Important: You need two cables per module. Connect cable A from the *top* connecter to the *right-hand* connector on the panel. Connect cable B from the *bottom* connector on the *left-hand* connector on the panel. Use thumb screws to lock the connectors to the panel.



Important: For thermocouple inputs: if using only 4 loops, use cable B (loops 5-8) because you must provide for cold-junction compensation.

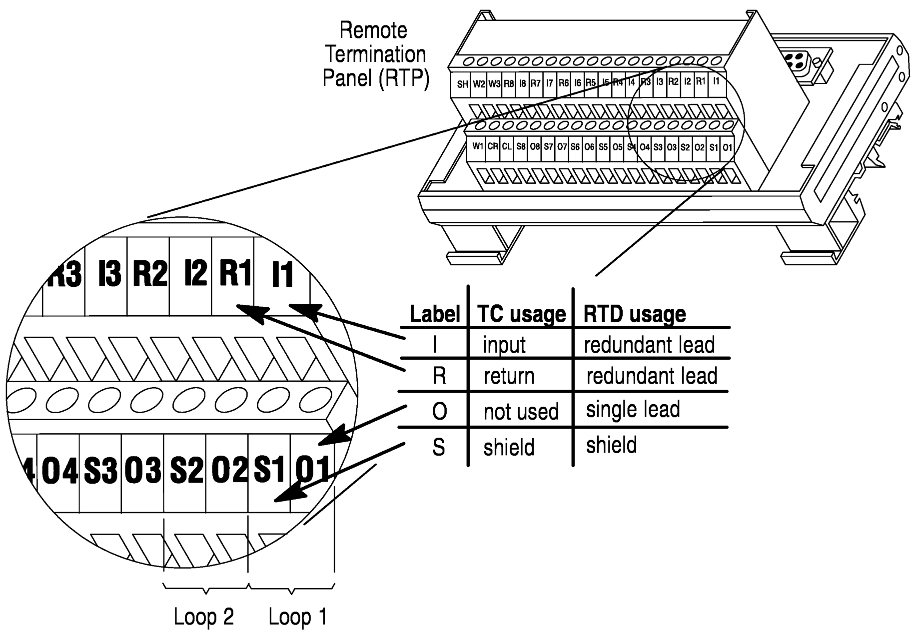
4. Connect Inputs to the Remote Termination Panel

The panel has a set of 4 screw terminals for each temperature control loop input. With thermocouples, one terminal per loop is not used.

Cable	Loop	Terminal Label	Connect to:	Cable	Loop	Terminal Label	Connect to:
A	1	I1	+Input 1 (+)	B	5	I5	Input 5 (+)
		R1	–Return 1 (–)			R5	Return 5 (–)
		S1	Shield 1 *			S5	Shield 5 *
		O1	RTD single lead**			O5	RTD single lead**
	2	I2	Input 2 (+)		6	I6	Input 6 (+)
		R2	Return 2 (–)			R6	Return 6 (–)
		S2	Shield 2 *			S6	Shield 6 *
		O2	RTD single lead**			O6	RTD single lead**
	3	I3	Input 3 (+)		7	I7	Input 7 (+)
		R3	Return 3 (–)			R7	Return 7 (–)
		S3	Shield 3 *			S7	Shield 7 *
		O3	RTD single lead**			O7	RTD single lead**
	4	I4	Input 4 (+)		8	I8	Input 8 (+)
		R4	Return 4 (–)			R8	Return 8 (–)
		S4	Shield 4 *			S8	Shield 8 *
		O4	RTD single lead**			O8	RTD single lead**

* Ground each shield at one end, and only one end of the cable.
** Not used for Thermocouples.

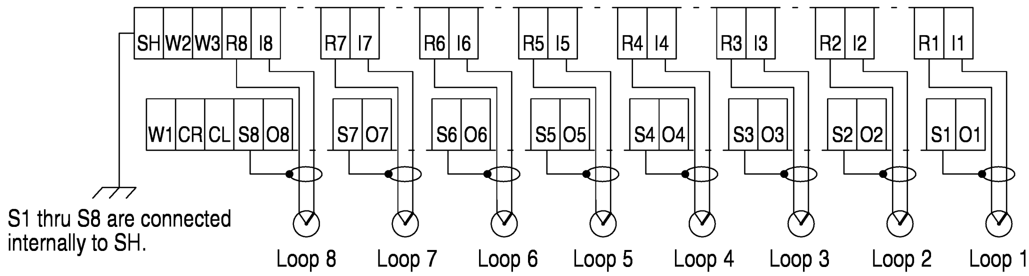
We show the terminal labels:



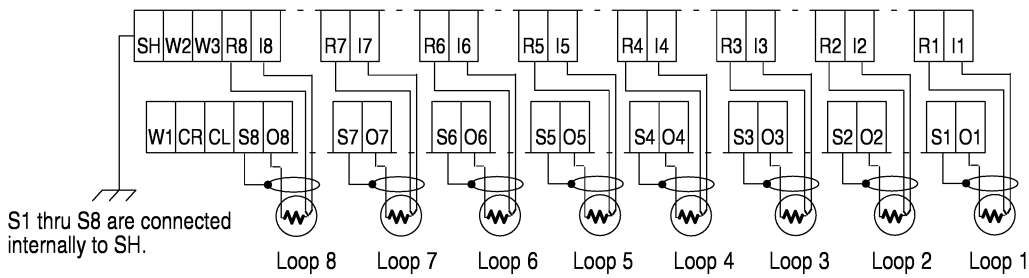
To connect input wiring (22-12 AWG) to the panel:

1. Strip 9 mm (3/8 inch) of insulation from the wire.
2. Insert the wire into the open connector slot.
3. Tighten the screw to clamp the wire.

Thermocouple (TC) Connections



Resistance-type Device (RTD) Connections

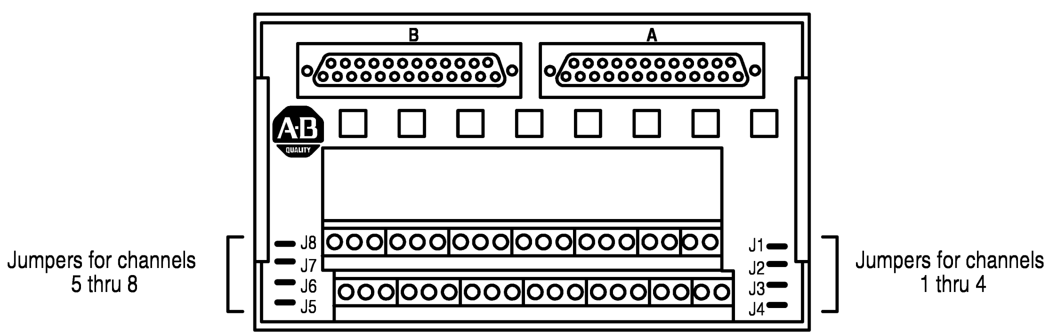


Refer to appendix D for additional information on input connections.

4. Ground the Shields

When using shielded cable or shielded thermocouple extension wire, ground the shield at only one end of the cable. We recommend that you connect the shield drain wire to the "**S**" connection on the panel for each loop. All shield connections are connected together inside the panel. You can ground the entire panel by connecting a single wire from the "**SH**" connection to the nearest ground bus.

If you **do not** want to ground a particular shield at the panel, you can remove the jumper for that particular channel. This will allow the shield to float at the panel end. To remove a jumper, you must cut it out, as close to the circuit board as possible at both ends. **Once you remove a jumper it cannot be replaced.** Jumpers are labeled J1-J8, corresponding to channels 1-8 respectively.



Observing Installion Precautions

When installing the module in an I/O chassis:

1. Turn off power to the I/O chassis:

ATTENTION: Remove power from the 1771 I/O chassis backplane and disconnect the cable from the module before removing or installing an I/O module.

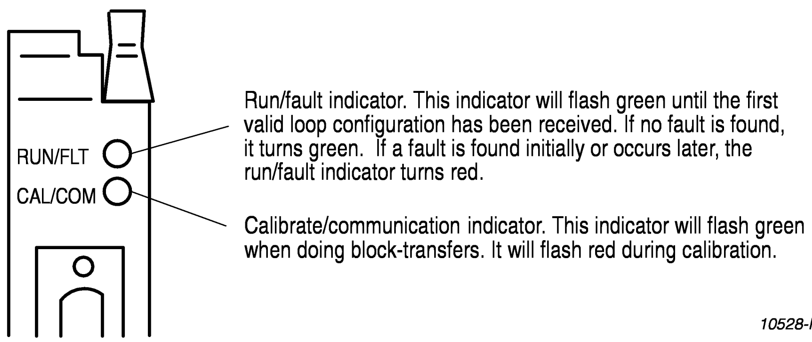
Failure to remove power from the backplane could cause injury or equipment damage due to possible unexpected operation.

Failure to remove power from the backplane could cause module damage, degradation of performance, or injury.

2. Place the module in the plastic tracks on the top and bottom of the slot that guides the module into position.
3. Do not force the module into its backplane connector. Apply firm even pressure on the module to seat it properly.
4. Snap the chassis latch over the top of the module to secure it.

Interpreting Indicator Lights

The front panel of the analog module contains two bi-color indicators: a red/green RUN/FLT (run/fault) indicator and a red/green CAL/COM (calibrate/communication) indicator.



At power-up, the module performs an initial self check. If/when found OK, the module starts the run/fault indicator to flash green. It will continue to flash green until the first valid loop configuration has been received. If/when the module detects a fault, this indicator turns red.

Possible causes of module faults and corrective action are discussed in Chapter 10, "Troubleshooting."

Module Communication

In this chapter, we describe:

- I/O image
- single-transfer programming
- communication sequence
- block-transfer programming
- module update period

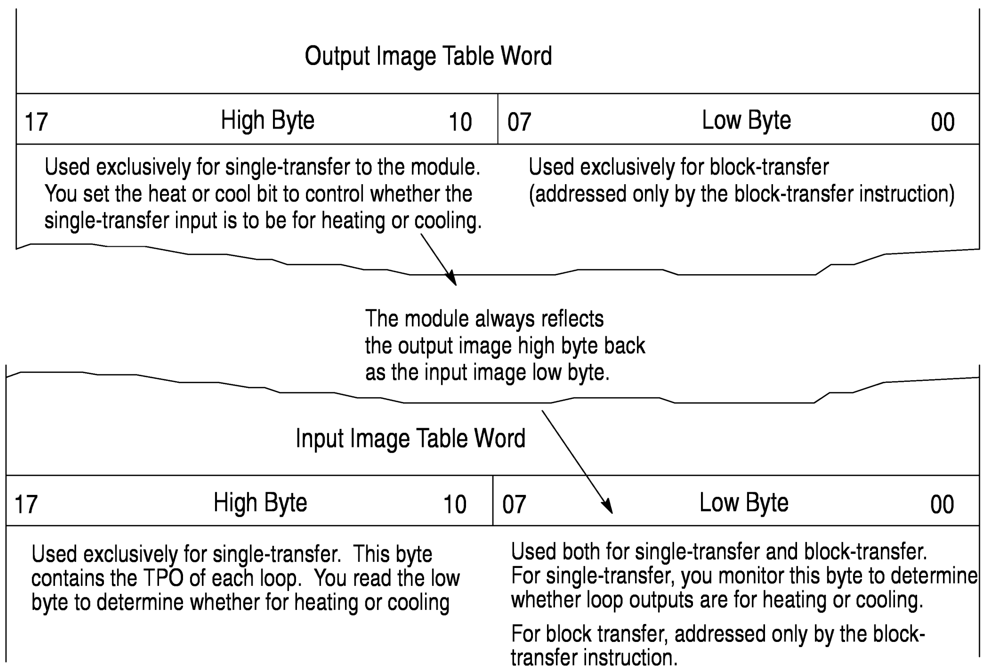
About The Ladder Program

Appendix C describes the communication program we provide on diskette for you to use as a basis for your application program. If you use it, this section can help you understand how it works. If you develop your own application program and use the single-transferred TPO bits, it is crucial that you understand the concepts explained here. The same TPO bits are made available with block-transfer. However, the period for updating the TPO outputs can be much shorter by using the single-transferred bits.

Important: The communication program and configuration software are available to you from the Internet. Access them from our website:
www.ab.com/plclogic/prodinfo/io/I_O/tcmsw/index.html
(INTERCHANGE™ and programming softwares required to use them)

I/O Image

I/O data is both block-transferred and single transferred between the module and the PLC processor. Therefore, the module uses a word of input image table and a word of output image table as follows:



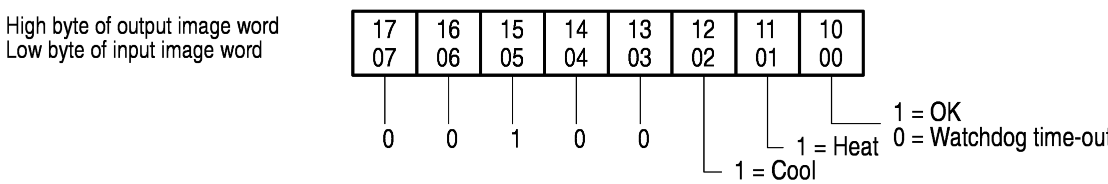
Single-Transfer Programming

ATTENTION: If the module is located in an I/O chassis (with a 1771-ASB I/O adapter) on a universal remote I/O link, you can not make use of its single-transferred I/O data to control *both* heating *and* cooling elements because the single-transfer TPO signal may be unreliable. However, if the module is located in a local I/O chassis (processor-resident or extended local) or in an I/O chassis (with a 1771-ACN I/O adapter) on a ControlNet link or is used for heat-only control, you **can** make use of single-transferred I/O data.

Single-transfer of I/O data occurs automatically in each I/O scan. That is, a single unit of I/O data can be exchanged between each I/O module and its corresponding address in the I/O image table. The size of the unit of I/O data available for transfer to/from each I/O module is determined by the I/O addressing mode you selected for the I/O chassis. The module uses 16 bits of input image and 16 bits of output image. Therefore, the I/O chassis must be set for either 1-slot or ½-slot addressing.

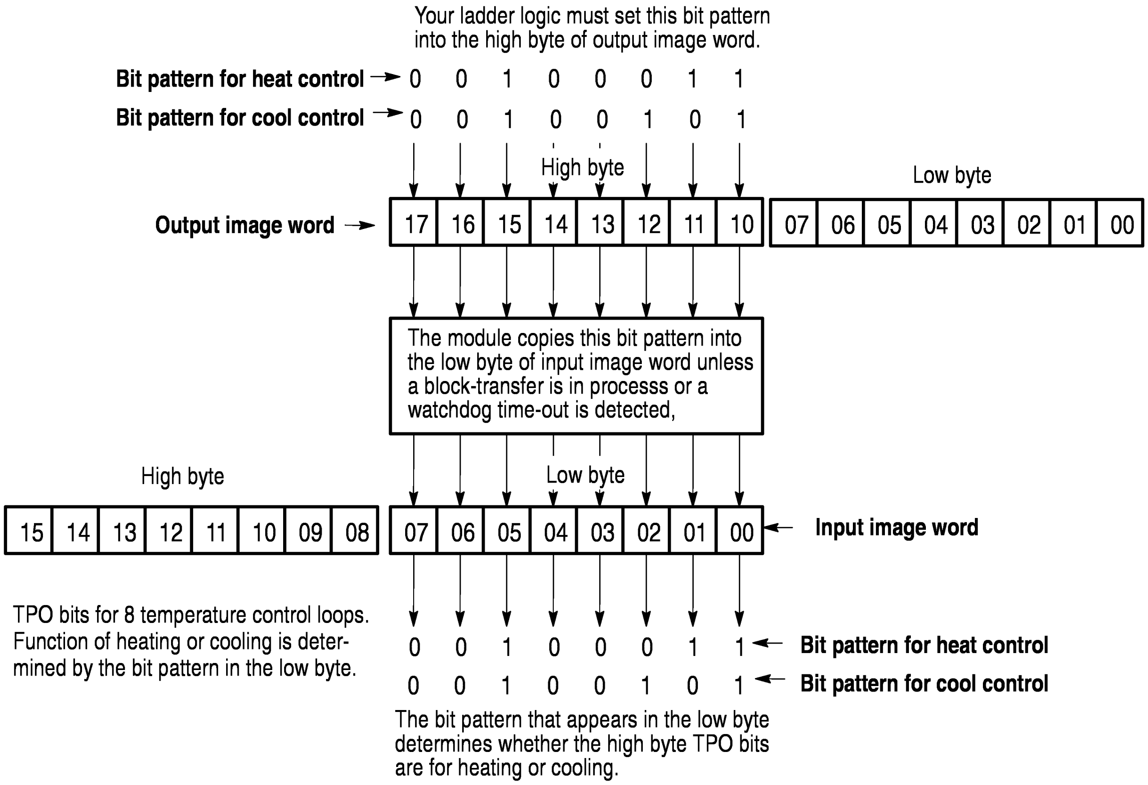
Control Bits

The meaning of the control bits in the high byte of the output image word and the low byte of the input image word are as follows.



The ladder logic must:

1. Set bits of the high byte of the output image word to tell the module whether to send TPO bits (outputs) for heating or cooling for the 8 loops.
2. Monitor the low byte of the input image word to determine whether the module has sent outputs for heating or cooling.
3. Based on step 2, move TPO bits from the high byte of the input image word to the output image byte of other output modules controlling heating or cooling.



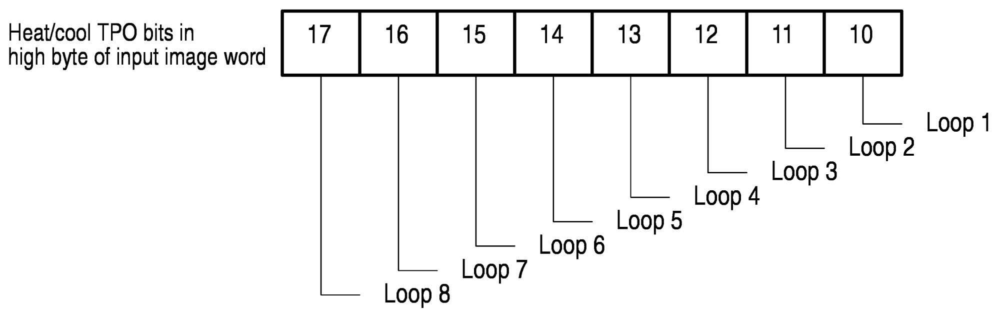
Important: In reading the low byte of the input image word, if the ladder logic detects bits 7, 6, and 0 to be off (watchdog time-out) it must turn off all heat and cool outputs. At that point you must:

- cycle power (off then on) to the module
- reconfigure the module

If the watchdog timer bit stays off, replace the module.

TPO Bits

The loop designations of the heat/cool TPO bits in the high byte of the input image word are as follows.



Controlling Heating Elements Only

In single-transfer heating applications, the ladder logic must write to and read from the module's I/O image table words as follows:

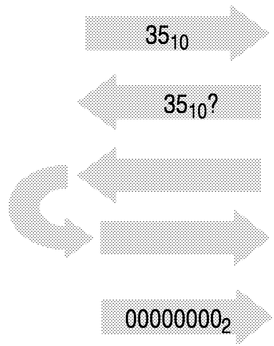
Write the decimal value 35 (binary 00100011) to the high byte of the output image word.

Read the low byte of the input image word.

If the low byte has the value 35_{10}, move the value from the high byte of the input image word to the output image byte of the output module driving the heating elements.

If bit 0 (watchdog timer) of the low byte of the input image word is **off**, zero the output image byte of the output module driving the heating elements.

If bit 0 (watchdog timer) of the low byte of the input image word **is on** and the low byte of the input image word does not have the value 35_{10}, do not write to the output image byte of the outputs driving the heating elements.



High byte of module's output word

Low byte of module's input word

High byte of module's input word

Heating-element outputs (separate output module)

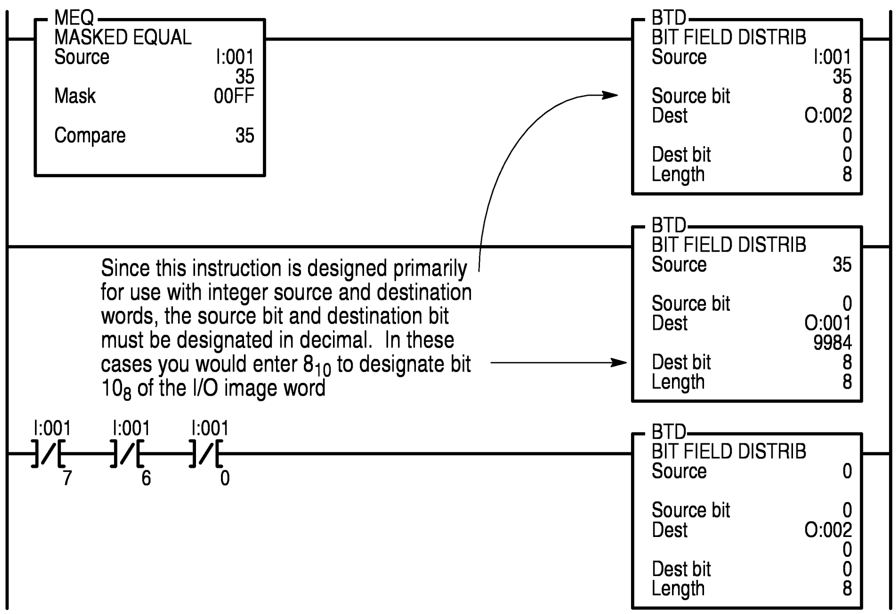
Heating-element outputs (separate output module)

The following shows ladder logic to handle data single-transferred to/from the module in an application where the TPO of each loop is used only for heating.

This rung examines the low byte of the module's input image word to see if it is equal to 35_{10}. If true, it copies the high byte of the module's input image word to the output image byte of an output module driving the heating elements.

This rung unconditionally writes the value 35_{10} to the high byte of the module's input image word.

If the module's watchdog timer bit is off, this rung zeros the output image byte of the outputs driving the heating elements.



In this example:

- the module and another output module driving the heating elements are in the same I/O chassis with the PLC-5 processor
- the chassis is set for 1-slot addressing
- the module is in slot 1 (I/O group 1)
- the module driving the heating elements is in slot 2 (I/O group 2)

Controlling Heating and Cooling Elements

In single-transfer applications for heating and cooling, ladder logic must write to and read from the module's I/O image table words as follows:

Step 1 Write the decimal value 35 (binary 00100011) to the high byte of the output image word.

Step 2 Read the low byte of the input image word.

Step 3 If the low byte of the input image word has the value 35_{10}, move the value from the high byte of the input image word to the output image byte of the outputs driving the heating elements.

Step 4 Write the decimal value 37 (binary 00100101) to the high byte of the output image word.

Step 5 Read the low byte of the input image word.

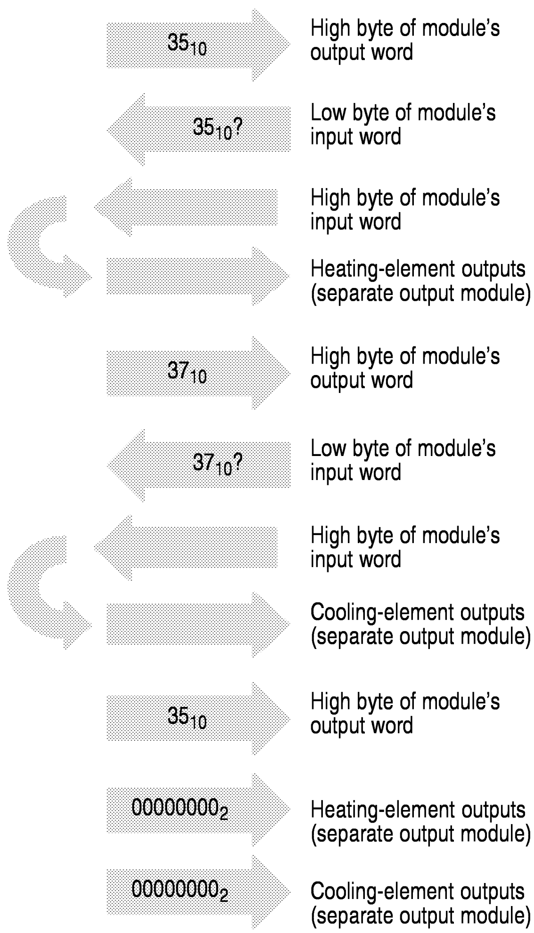
Step 6 If the low byte of the input image word has the value 37_{10}, move the value from the high byte of the input image word to the output image byte of the outputs driving the cooling elements.

Step 7 Write the decimal value 35 (binary 00100011) to the high byte of the output image word.

Step 8 If bit 0 (watchdog timer) of the low byte of the input image word is **off**, zero both of the output image bytes of outputs driving heating and cooling elements.

Step 9 If bit 0 (watchdog timer) of the low byte of the input image word is **on** and the low byte of the input image word does not have the value 35_{10} or 37_{10}, do not write to the output image byte of the outputs driving the heating elements.

Step 10 Loop back to step 2.



The key to this logic is the switching between reading heat bits and reading cool bits from the same input image byte. The following figure shows an example of PLC-5 ladder logic to handle data single-transferred to/from the module in an application where the TPO of each loop is used for both heating and cooling.

The module, the output modules driving the heating and cooling elements, and the input module providing the input for the manual-start pushbutton switch are in the same I/O chassis with the PLC-5 processor.

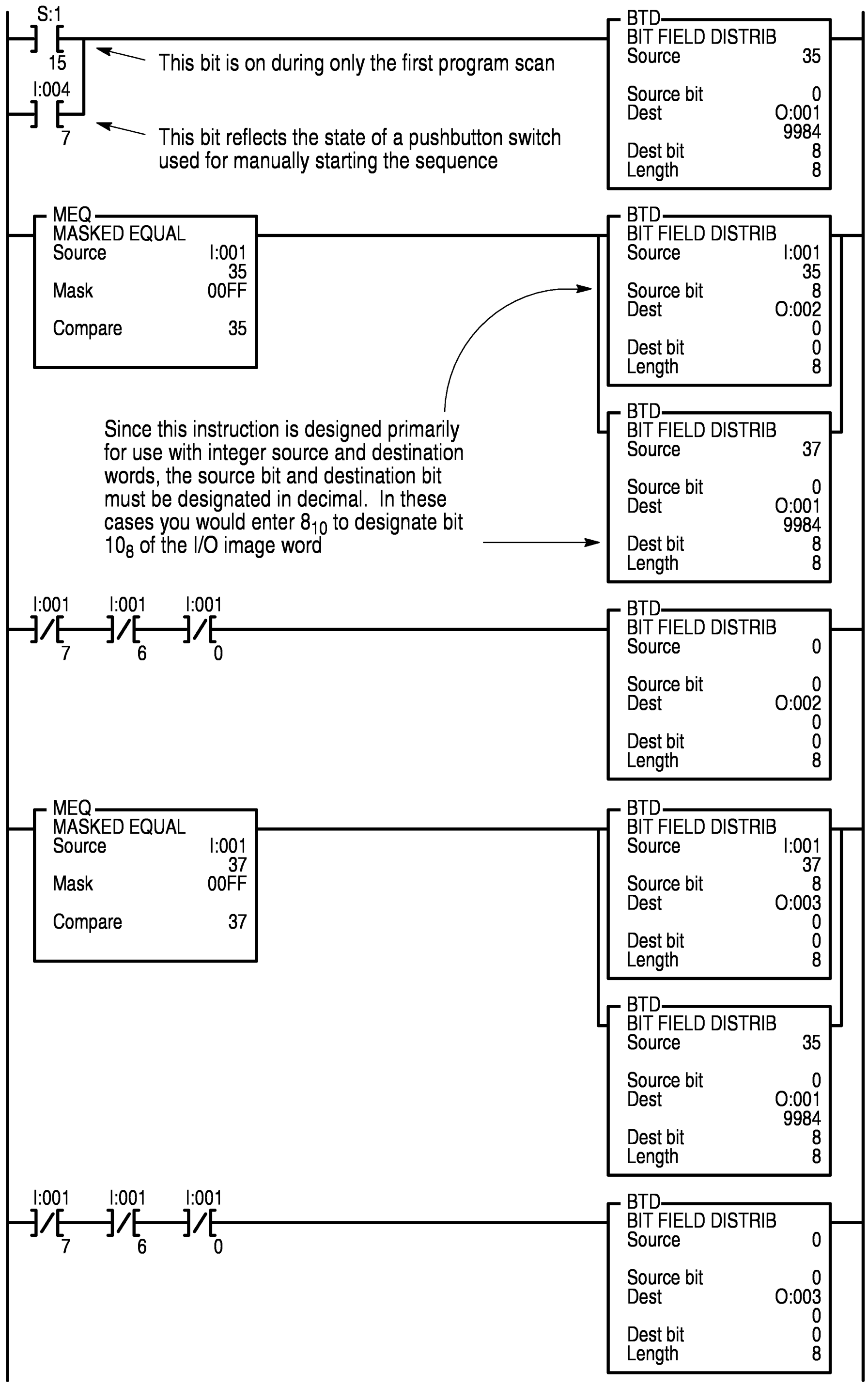
This rung examines status bit S:1/15, which is on only during the first program scan, and input image I:004/7, which reflects the state of a pushbutton switch connected to that input. If either is on, it writes the value 35_{10} to the high byte of the module's input image word.

This rung examines the low byte of the module's input image word to see if it is equal to 35_{10}. If true, it copies the high byte of the module's input image word to the output image byte of the module driving the heating elements, and writes the value 37_{10} to the high byte of the module's input image word.

If the module's watchdog timer bit is off, this rung zeros the output image byte for the outputs driving the heating elements.

This rung examines the low byte of the module's input image word to see if it is equal to 37_{10}. If true, it copies the high byte of the module's input image word to the output image byte of an output module driving the heating elements, and writes the value 35_{10} to the high byte of the module's input image word.

If the module's watchdog timer bit is off, this rung zeros the output image byte for the outputs driving the cooling elements.

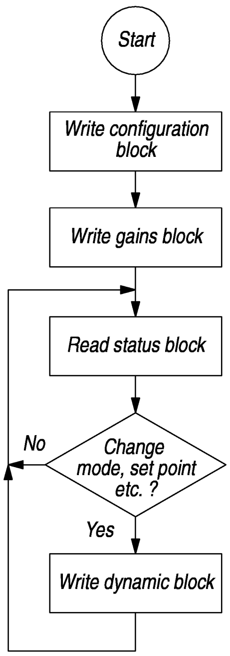


In this example:

- the chassis is set for 1-slot addressing
- the module is in slot 1 (I/O group 1)
- the module driving the heating elements is in slot 2 (I/O group 2)
- the module driving the cooling elements is in slot 3 (I/O group 3)
- the module providing the input for the manual-start pushbutton switch is in slot 4 (I/O group 4)

Communication Sequence

The module can be configured for different types of applications and set for different modes of operation. Ladder logic for your application must provide the proper sequence of block-transfer and single-transfer communication with the module to provide desired control. Here we explain the operation of the communication program (appendix C) that accompanied the module. We suggest that you use it as the foundation of your application program.

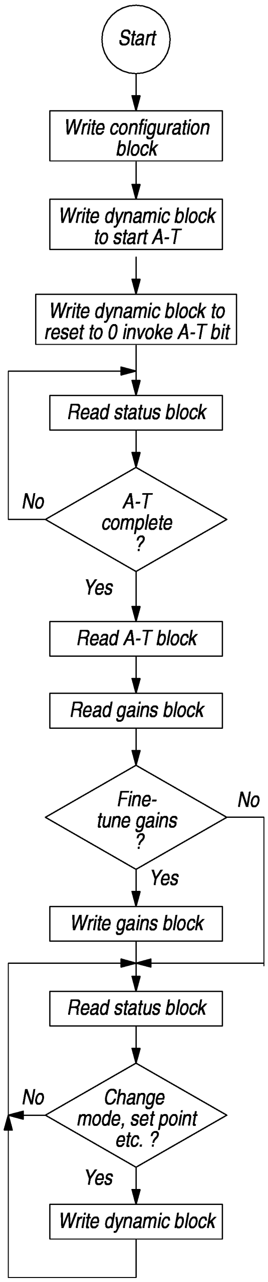


Communication from start-up (without auto-tuning):

1. Download the configuration block.
   With each loop configuration block configured for your application, set download request bits (N7:0/00-07). Set them all at once (for all active loops) with your programming terminal or with ladder logic that you write. (Prior to sending it the configuration block, the module will function in monitor mode, but with the default configuration listed in appendix B).
2. Download the gains block.
   With loop gains configured for your application, set the download request bit (N7:0/10) to establish PID gains.
3. Read status blocks.
   The communication program (appendix C) reads loop temperature data from the module at regular timed intervals.
4. If desired, change module operation.
   If you want to change module operation, modify the dynamic block to command the changes. It is downloaded at regular timed intervals (just as the status block is returned at regular intervals.)
5. If using single-transfer, your ladder logic must write (map) the single-transferred TPO bits in word N7:9 to the output image table addresses of modules controlling your heat/cool outputs. This may occur whenever the low byte of the input image indicates heat/cool TPO bits are available in the high byte (when the module is not processing block transfers).

Communication from start-up (with auto-tuning):

Important: So as NOT to clear the gains block on first scan, you may want to modify the initialization logic (rung 2) of the communication program (appendix C) that accompanied the module. Look for the move (MOV) instruction having a source of 511 and a destination of N7:0. Change the source of 511 to 255 to omit the gains block from the initialization download (refer to page C-10).



1. Download the configuration block.
With each loop configuration block configured for your application including the selected loop auto-tuning response (word 2 bits 8, 9), set configuration block download request bits (N7:0/00-07) to send loop configurations to the module.

2. Start auto-tuning.
Set the dynamic block for running the module with loop auto-tuning bits On and with the module's auto-tuning bit On (word 33, bit 1 = 1). The communication program (appendix C) downloads the dynamic block periodically..

3. Reset the auto-tuning bit.
Reset the module's auto-tuning bit (word 33, bit 1 = 0) in the dynamic block. It is downloaded automatically.

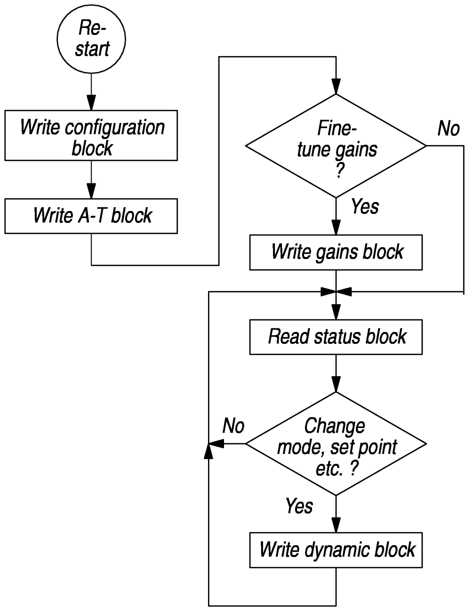
4. Read status blocks.
The communication program (appendix C) reads module status to determine when auto-tuning is complete for each loop.
When a loop's auto-tuning is complete:

- set N7:0/09 to read the loop's auto-tune block and store the values measured during auto-tuning.
- set N7:0/11 to read the loop's gain block and store the new PID gains derived from auto-tuning

5. If you want to fine-tune PID gains, adjust them in the gains block. Then set the gains download request bit (N7:0/10) to send the PID gains block to the module.

6. If you want to change module operation, set desired command bits in the dynamic block. It is downloaded automatically.

7. If using single-transfer, your ladder logic must write (map) the single-transferred TPO bits in word N7:9 to the output image table addresses of modules controlling your heat/cool outputs. This may occur whenever the low byte of the input image indicates heat/cool TPO bits are available in the high byte (when the module is not processing block transfers).



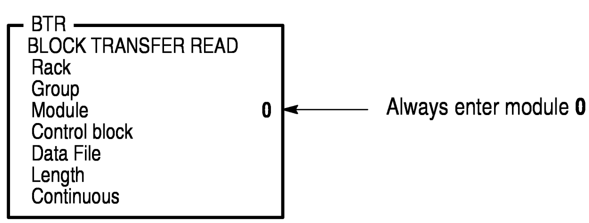
Re-start after power loss after auto-tuning:
(because the module's memory is volatile, after a power loss, the module configuration and tuning values must be restored)

1. Write (block-transfer) the configuration block for each loop to the module to ensure the correct loop configuration.
2. Write (block-transfer) the auto-tuning block to the module. This will trigger the module to use these values to calculate the PID parameters and provide the start-up algorithm.
3. If you don't want to use the gains derived from the auto-tuning parameters, change the gains in the gains block and write (block-transfer) the gains block to the module.
4. Read (block-transfer) the system status block from the module to monitor the loops.
5. Write (block-transfer) the dynamic block to the module to control the loops.

Block-Transfer Programming

If the module is located in an I/O chassis (with a 1771-ACN I/O adapter) on a ControlNet link, use unscheduled transfers to transfer the blocks of data (refer to publication 1785-6.5.14). Unless the module is located in an I/O chassis (with a 1771-ACN I/O adapter) on a ControlNet link, you must use block- transfer instructions to transfer the blocks of data. To generate a block- transfer to the module, your ladder logic must execute a block- transfer write instruction. To generate a block-transfer from the module, your ladder logic must execute a block-transfer read instruction.

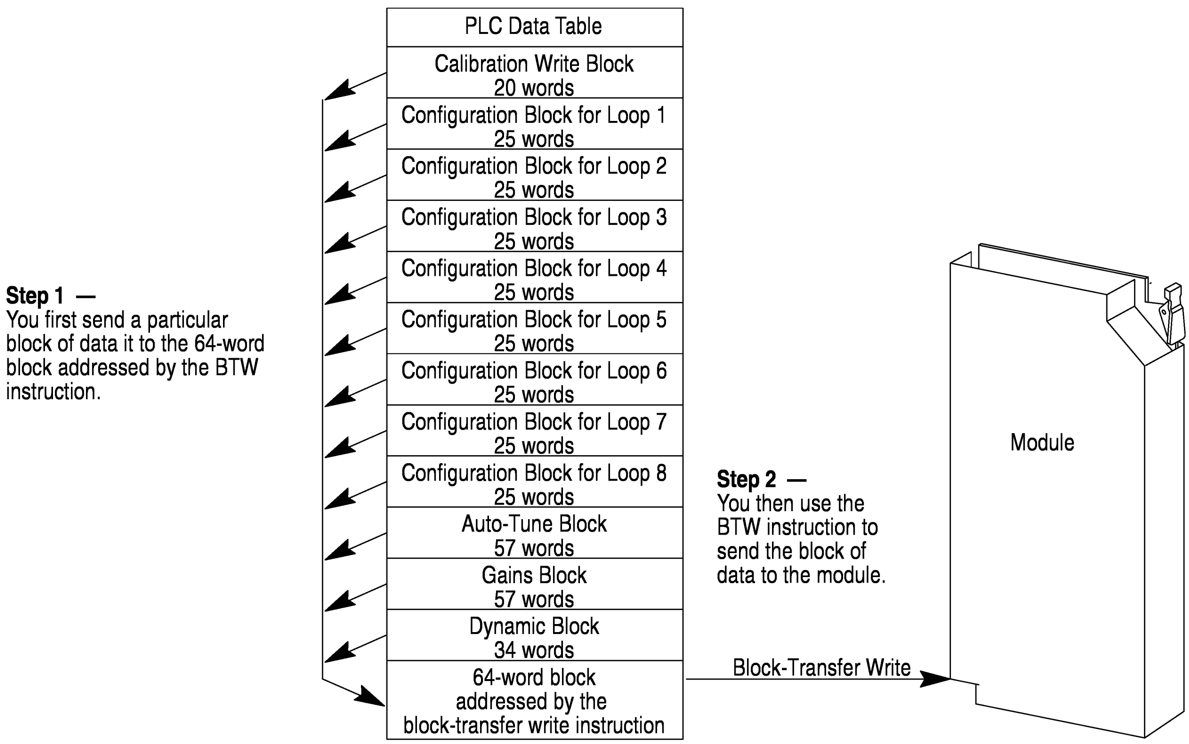
Enter the rack number and group number based on the module's physical location as with any other block-transfer module. The module entry specifies the byte (0 or 1) of the I/O image word. Although the module uses a full word of I/O image space, the low byte of the module's I/O image word is used for block-transfer. Therefore, in the block-transfer instruction, you must address the module as module **0**.



The communication program (appendix C) or your ladder logic (if not using appendix C) will need to execute the block-transfer write instruction whenever necessary to transfer the specific write blocks to the module. The logic will need to execute the block-transfer read instruction on a regular basis at timed intervals. The module's period for updating temperature values it makes available by block-transfer is approximately one second. Therefore, if using single-transferred TPO bits, executing the block-transfer read more often then once per second does not provide any benefit and may unnecessarily lengthen your I/O scan time. However, if relying on block-transfer for the TPO bits, you may want to execute the block-transfer read as often as possible because the TPO bits are updated by the module about every 100ms.

Block-Transfer Write

The communication program (aappendix C) generates all block-transfer writes to the module by a single block-transfer write instruction in a multiplexing operation. (see *"Communication Sequence",* page 3–7.)

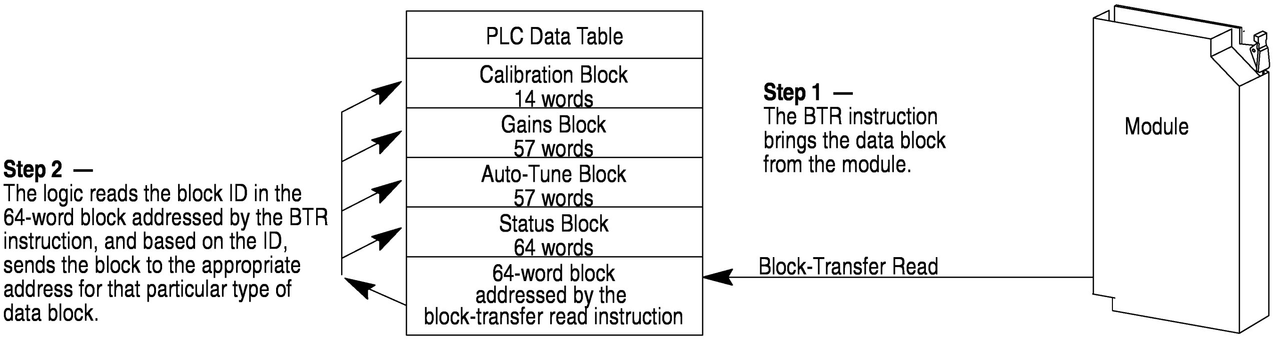


Use a block length of **64** words. When sending a particular data block to the module, the ladder logic first sends it to the 64-word block addressed by the BTW instruction and then uses the BTW instruction to send it to the module. (See Communication Sequence, page 3-7.)

The block ID code at the beginning of each block tells the module which block it is. The module automatically uses only the number of words appropriate for that particular type of block.

Block-Transfer Read

All block-transfer reads from the module are generated by a single block-transfer read instruction. Use a block length of **64** words. When a data block is received in the 64-word block addressed by the block-transfer read instruction, the ladder logic first reads the block ID code, and then based on the ID, sends the data block to the appropriate address for that particular type of block

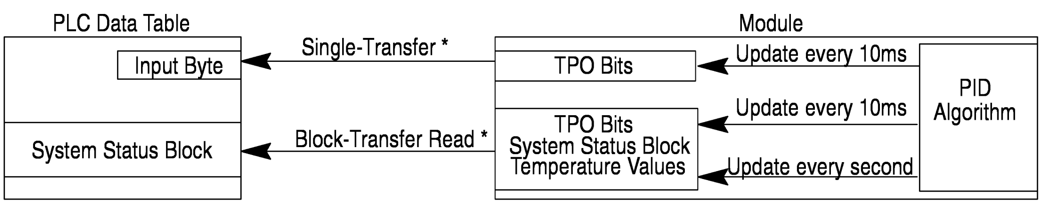


In the dynamic block (word 33, bits 0 & 6), you specify whether the module should send back a gains block, auto-tune block, or status block in subsequent block-transfer reads.

Module Update Period

The module updates TPO data for single-transfer on a shorter time period than it updates data for block-transfer.

- The module's period for updating the heat only and cool only TPO bits it makes available thru single-transfer is approximately **10ms**. If you alternately examine heating and cooling TPO bits, the effective period for updating heat and cool TPO bits is approximately **20ms**.
- The module's period for updating the heat and cool TPO bits it makes available thru block-transfer is approximately **100ms**.
- The module's period for updating the temperature values it makes available thru block-transfer is **1 second**.
- The module's period for updating the outputs it makes available thru block-transfer for heating is set by the heat TPO period you enter in the configuration block (word 11).
- The module's period for updating the outputs it makes available thru block-transfer for cooling is set by the cool TPO period you enter in the configuration block (word 13).



* The time required for single-transfer and block-transfer depend on the specific PLC system configuration.

Notes:

Configuring the Module

This chapter shows you how to independently configure each of the eight temperature control loops. This includes:

- block identification
- open-circuit detection
- barrel/non-barrel control
- inner/outer zone
- thermal integrity loss detection
- alarms
- alarm dead band
- loop operational mode
- inferred decimal point
- the configuration block

Block Identification

The first word of each block contains a block identification code that you use to tell the module that it is a configuration block and that you use to tell the module which loop the block is to configure.

Open-Circuit Detection

If a loop input circuit becomes open (a wire breaks or vibrates loose) the loop can not measure the temperature. In automatic mode, the lack of temperature feedback would make it impossible to control the temperature. To guard against such a lack of temperature control, the module provides open-circuit detection.

With bits 1 and 2 of word 1 of the configuration block, you select a mode to which the loop is to switch when an open input circuit is detected in automatic mode. The selections are:

- disable the PID loop by forcing M to zero
- set the output (M) to the open-circuit forced value (set in word 8)
- set the loop to the manual mode (force M to manual output value)

Note: For consistency and to comply with ISA/IEE terminology, we have changed terminology in this manual as follows:

Previous terminology:	Changed to:	Meaning:
CV (control variable)	M (manipulated variable)	loop output
PV (process variable)	C (controlled variable)	loop input

Barrel/Non-Barrel Control

With bit 12 of word 2, you select between barrel and non-barrel control. Barrel control can be used for either heat-only or heat/cool applications. Non-barrel control can be use for either heat-only, cool only, or heat/cool applications.

Barrel control is for multiple-zone applications in which there is thermal conduction between the zones. Injection molding and extruding are good examples of this because there are multiple heater bands (zones) mounted on one thermal conductor (the metal barrel). The barrel conducts heat between the different zones. If you select barrel control, with bit 11 of word 2, must also select between inner and outer zone. If you select barrel control, word 24 does not apply. A barrel loop is auto-tuned as the temperature rises from ambient to a fixed set-point during startup.

Non-barrel control is for independent loops with no thermal conduction between the zones. If you select non-barrel control, the inner/outer zone selection of bit 11 of word 2 does not apply. If you select non-barrel control, the loop is auto-tuned as it reacts to the set-point disturbance you enter in word 24.

Switch to Barrel Control?

For some applications, even though the loops are independent with no thermal conductivity between zones, barrel control may provide better performance than non-barrel control. If a loop has any of these characteristics, you may want to try switching it to barrel control.

- time constant is greater than 100.0 seconds
  (You can read the time constant for each loop in the auto-tune block.)
- loop has a problem overshooting the set point
- loop output is saturating (M at 100%) for a significant duration

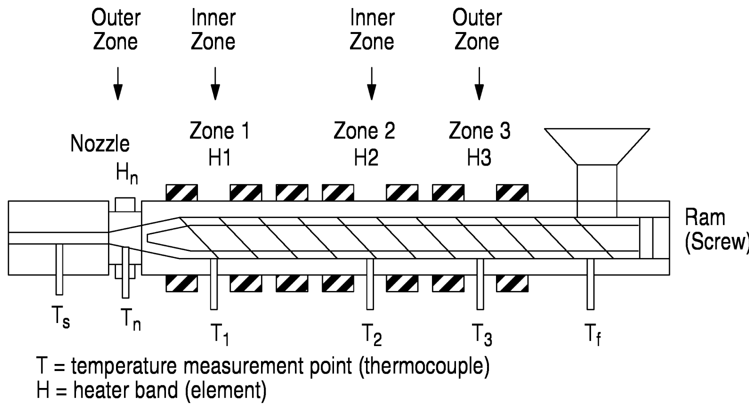
If you switch a loop to barrel control for one of these reasons, select it to be an outer zone.

ATTENTION: If you switch a loop between non-barrel control and barrel control, you must auto-tune the loop again before operating it. If you fail to auto-tune the loop after making such a switch, the auto-tuning values will be wrong for the application and the gains will be greatly distorted.

Inner/Outer Zone

If you make the selection for barrel temperature control, you also have a selection for whether it is an inner zone or an outer zone. An outer zone is a zone at either end of the barrel. An inner zone is any zone other than at the very end of the barrel (between two other zones). The PID gain calculation algorithm for an inner zone is slightly different from that for an outer zone to account for an inner zone being more affected by adjacent zones. The inner zones are treated as more of an integrating process than are outer zones.

Typical plastic injection barrel with multiple temperature zones



Thermal Integrity Loss Detection (formerly called thermal runaway)

The loss of thermal integrity is detected when the loop output (M) is at 100% while the temperature rate of change measured by the module is below the minimum expected rate. Detecting the loss of thermal integrity requires an assumption of a minimum rate of change in the temperature input value (C) when the output (M) is at 100%. An example of a loss of thermal integrity could be because the contactor for a heating band fails open; or the sensor is not in proper position to measure the true temperature.

The values you enter into words 21 and 22 establish a minimum rate of change (°/min) in the temperature input (C) that you will allow when the output (M) is at 100%. The temperature change value you enter in word 21 divided by the period value you enter in word 22 is the thermal integrity rate. With bits 4 and 5 of word 1 of the configuration block, you select a mode for switching the output (M) to a forced value when the rate of change of the temperature input (C) does not reach the minimum for thermal integrity. The selections are:

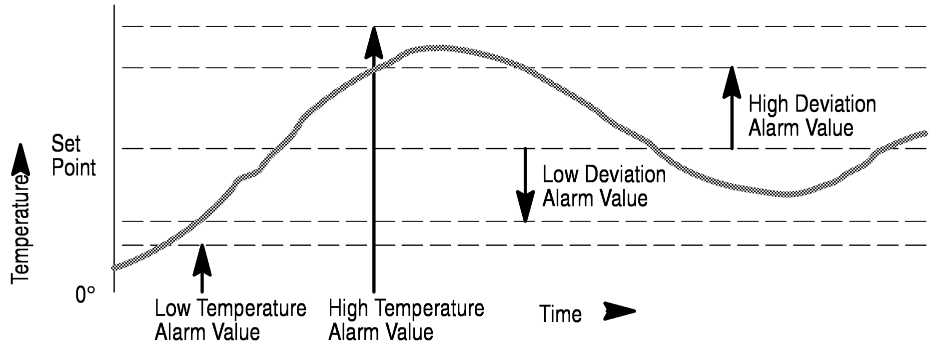
- disable the PID loop by forcing M to zero
- set output (M) to the thermal runaway forced value (set in word 9)
- set the output (M) to the manual-mode value by setting the loop into manual mode

Once a thermal integrity is detected, to clear this condition, you must disable the affected loop and then re-enable it (bits 7 and 8 of word 1).

Alarms

In the configuration block you select values for the following temperature-level alarms:

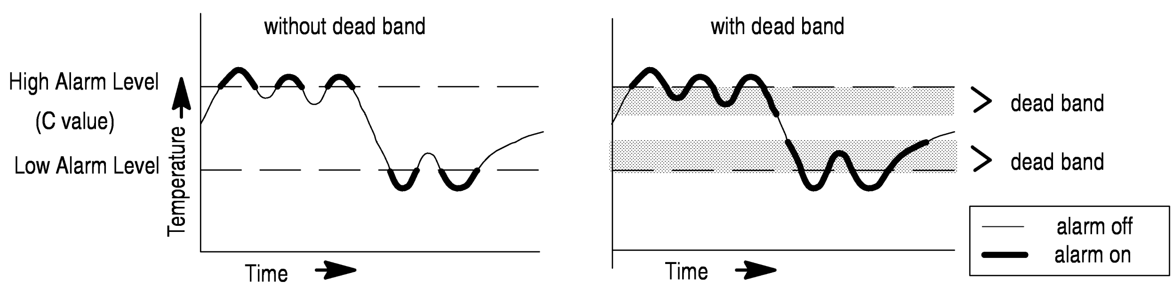
- low temperature alarm (word 16)
- high temperature alarm (word 17)
- low deviation alarm (deviation from the set point)(word 18)
- high deviation alarm (deviation from the set point)(word 19)



Alarm Dead Band

Once the temperature alarm bits are on, they are kept on until the temperature drops below the high alarm by the alarm dead-band value or rise above the low alarm by this value. You specify the temperature alarm dead band in word 20. *It applies to the C value at the high and low temperature alarms and deviation alarm values.* The dead band provides a hysteresis effect.

- **Low Alarm With Dead Band** — When the temperature falls below the user-defined low alarm value, the low alarm bit is turned on. When the temperature rises above the level of the low alarm value but still below the level of the dead-band value, the low alarm bit remains on. Only when the temperature rises above the dead-band level will the alarm bit be turned off.
- **High Alarm With Dead Band** — When the temperature rises above the user-defined high alarm value, the high alarm bit is turned on. When the temperature falls below the level of the high alarm value but still above the level of the dead-band value, the high alarm bit remains on. Only when the temperature falls below the dead-band level will the alarm bit be turned off.

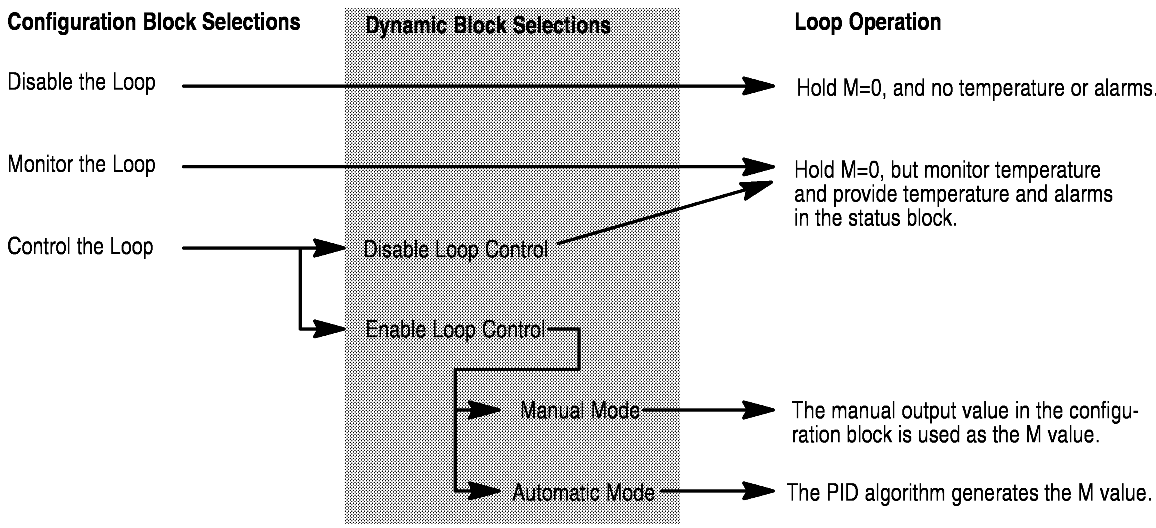


Important: The temperature passes thru the dead band before the alarm is turned on or off to provide stability to alarm indicators. Dead bands apply to C and deviation alarms.

Loop Operational Mode

In the configuration block (bits 7 and 8 of word 1) you select between disabling the loop, only monitoring the loop, or a control mode for the loop. If in the configuration block you select control mode, in the dynamic block you can select between:

- disabling loop control (monitor only)
- enabling manual control mode
- enabling automatic PID control mode



Inferred Decimal Point

For words 3 thru 19, you enter a 16-bit signed integer value. However, as you enter the value you must be aware of an inferred decimal point.

- For these values in words 3 and 6 thru 13, the inferred decimal point is **2** places from the right (causing the resolution to be **0.01**). For example, if in word 6 you enter the value 4999, the module infers the value to be **49.99**.
- For the temperature values in words 15 thru 20, the inferred decimal point is **1** place from the right (causing the resolution to be **0.1**). For example, if in word 16 you enter a value of 4999, the module infers the value to be **499.9**. Also, for each of these values, the range is dependant upon the type of thermocouple used. The range for each type of thermocouple is specified in appendix A.

Configuration Block

The following table describes the 25-word configuration block. The ID code in word 0 identifies the loop. Default values are shown in *italics.*

Word	Bits	Description
0	0–15	**Block Identification Code** **bit 15 . . . . bit 0** • loop 1 = 1000 1000 0000 0001 (8801$_{16}$)(–30719$_{10}$) • loop 2 = 1000 1000 0000 0010 (8802$_{16}$)(–30718$_{10}$) • loop 3 = 1000 1000 0000 0011 (8803$_{16}$)(–30717$_{10}$) • loop 4 = 1000 1000 0000 0100 (8804$_{16}$)(–30716$_{10}$) • loop 5 = 1000 1000 0000 0101 (8805$_{16}$)(–30715$_{10}$) • loop 6 = 1000 1000 0000 0110 (8806$_{16}$)(–30714$_{10}$) • loop 7 =1000 1000 0000 0111 (8807$_{16}$)(–30713$_{10}$) • loop 8 = 1000 1000 0000 1000 (8808$_{16}$)(–30712$_{10}$)
1	0	Always = 0.
	1–2	**Open-Circuit Detection Configuration (for 2-wire sensors*)** — When an open input circuit is detected (if auto mode had been selected in the dynamic block), the operating mode is switched to: **bit 2 bit 1 selection** • *0 0 = Disable PID loop (M = 0)* • 0 1 = Set output to open-circuit forced M value (set in word 8). • 1 0 = Set output to manual-mode M value. • 1 1 Do not use this selection. It will freeze the output at the current M value. However, the M value will have already moved to beyond a satisfactory value before the open circuit is detected. * For a 3-wire RTD, the software is designed to detect an open-sensor condition.)
	3	Always = 0.
	4–5	**Thermal Integrity Loss Configuration** — When a loss of thermal integrity is detected, the operating mode is set as: **bit 5 bit 4 selection** • *0 0 = Disable PID loop (M = 0)* • 0 1 = Set output to thermal-integrity-loss forced M value (set in word 9). • 1 0 = Set output to manual-mode M value. • 1 1 is not used (illegal value).
	6	Always = 0.
	7–8	**Loop Operational Mode** **bit 8 bit 7 selection** • *0 0 = Monitor input to indicate temperature and alarms, but no control of M value (M value held at **0**).* • 0 1 = Control mode (disable, manual, or automatic PID control of loop as directed in the dynamic block). • 1 0 = Disable loop (M=0, and no temperature value or alarms). • 1 1 is not used (illegal value).
	9–11	Always = 000.
	12–15	**Thermocouple Type for TCM Module** (ignored by TCMR module) **bit 15 . . 12 selection** • 0 0 0 0 = mV • 0 0 0 1 = B • 0 0 1 0 = E **bit 15 . . 12 selection** • *0 0 1 1 = J* • 0 1 0 0 = K • 0 1 0 1 = R **bit 15 . . 12 selection** • 0 1 1 0 = S • 0 1 1 1 = T

Word	Bits	Description
2	0	Always = 0.
	1	**Control Action** • *0 = Control action is — E = SP–C (Reverse acting)* • 1 = Control action is — E = C–SP (Direct acting)
	2–3	Always = 00.
	4	**Set Point Ramping Enable** — Selects whether to use a fixed set-point ramp rate (set in word 3) for the current set point to reach the selected set point. • *0 = Disable set-point ramping.* • 1 = Enable set-point ramping.
	5–6	Always = 00.
	7	**Alarm Enable** • *0 = Suppress all alarms.* • 1 = Report all alarm conditions.
	8–9	**Desired System Response** — At the completion of auto-tuning, the module calculates the PID gains based on the system parameters it has just measured and this selection for the desired system response. **bit 9 bit 8 selection** • 0 0 = Slow (reach the set point slowly). • *0 1 = Medium (reach the set point faster without overshooting).* • 1 0 = Fast (overshoot the set point). • 1 1 = Very fast.
	10	Always = 0.
	11	**Zone Select** — Applies only if barrel control is selected. • *0 = Inner zone.* • 1 = Outer zone.
	12	**Barrel/Non-barrel Control** • *0 = Barrel control.* • 1 = Non-barrel control.
	13	**Input Filter Enable** — Used with word 25. • *0 = Disable the input filter.* • 1 = Enable the input filter.
	14–15	Always = 000.
3	0–15	**Set-Point Ramp Rate** — If enabled by bit 4 of word 2, the rate (degrees/minute) at which the current set point is increased or decreased to reach the selected set-point. (*0.00* thru 99.99°/min)
4	0–15	Always = 0.
5	0–15	Always = 0.
6	0–15	**High M Limit** — The maximum M percentage allowable. (–100.00 thru *+100.00*) (If >0, heating is inferred.)
7	0–15	**Low M Limit** — The minimum M percentage allowable. (–100.00 thru +100.00) (If <0, cooling is inferred.) *(default = 0.00)*
8	0–15	**Forced M Value on Open Circuit** — The percentage value forced into the M when an open input circuit is detected. (–100.00 thru +100.00) *(default = 0.00)*
9	0–15	**Forced M Value on Thermal Integrity Loss** — The percentage value forced into the M when thermal integrity loss is detected. (–100.00 thru +100.00) *(default = 0.00)*
10	0–15	**Heat Minimum On Time** — Minimum time in seconds that the heat bit is on during the TPO period. If the calculated time is less than this minimum, the heat bit will remain off. This value must be less than 5% of the heat TPO period. (*0.00* thru 100.00)

Word	Bits	Description
11	0–15	**Heat TPO Period** — The period in seconds at which the heat TPO bit is cycled and the M is updated. This value must be less than the system lag time. (0.00 thru 100.00s accepted but truncated to 0 thru 100s) *(default = 5s)*
12	0–15	**Cool Minimum On Time** — Minimum time in seconds that the cool bit is on during the TPO period. If the calculated time is less than this minimum, the cool bit will remain off. This value must be less than 5% of the cool TPO period. (*0.00* thru 100.00)
13	0–15	**Cool TPO Period** — The period in seconds at which the cool TPO bit is cycled and the M is updated. This value must be less than the system lag time. (0.00 thru 100.00s accepted but truncated to 0 thru 100s) *(default = 5s)*
14	0–15	**Auto-Tune Startup Aggressiveness** — The lower the value, the longer the time to reach initial setpoint with less overshoot. The higher the value, the faster you reach initial setpoint but with greater overshoot. Optimum is an aggressiveness value that reaches initial setpoint fast with tolerable overshoot. Has no affect after reaching initial setpoint (0-100 unit-less) *default = 0*. **Important:** For Heat/Cool operation only, the default value is 25.
15	0–15	**C Alarm Rate** — If the rate of temperature increase is greater than this value, the C rate alarm bit is turned on. A value of 0.0 disables the C rate alarm. (*–3276.8* thru 3276.7°/s)
16	0–15	**Low Temperature Alarm Value** — A C value at the low end of the sensor limit, but still above the minimum C value (*–3276.8* thru 3276.7°)
17	0–15	**High Temperature Alarm Value** — A C value at the high end of the sensor limit, but still below the max C value (–3276.8 thru *3276.7*°)
18	0–15	**Low Deviation Alarm Value** — A value that specifies the greatest deviation below the set point that the process can tolerate. (–3276.8 thru *3276.7*°)
19	0–15	**High Deviation Alarm Value** — A value that specifies the greatest deviation above the set point that the process can tolerate. (–3276.8 thru *3276.7*°)
20	0–15	**Temperature Alarm Dead Band** — Once the temperature alarm bits are on, they are kept on until the temperature drops below the high alarm by this value or rise above the low alarm by this value. The dead-band value applies to the high and low temperature and deviation alarm values. (*0.0* thru 10.0°)
21	0–15	**Thermal Integrity Temperature Change Value** — This temperature-change value divided by the period is the thermal integrity rate. (0 thru 100°) *(default = 5°)*
22	0–15	**Thermal Integrity Period in Minutes** — The temperature-change value divided by this period is the thermal integrity rate. (0 thru 100 min) *(default = 20 min)*
23		**RTD Type for TCMR Module** — (ignored by TCM module)
	0-7	Offset for Cu RTD (–0.99 to +0.99 in units of 0.01 ohm) – Offset = resistance of RTD – 10.00. For example, if the Cu RTD is 9.74 ohms (at 25° C), the offset would be 9.74 – 10.00 = –0.26.
	8–10	RTD Selection **bit 10-9-8** **selection** • *0 0 0* *= ohms* • 0 0 1 = 100 ohm Pt (Euro) • 0 1 0 = 100 ohm Pt (USA) • 0 1 1 = 10 ohm Cu • 1 0 0 = 120 Ni
	11–15	Reserved
24	0–15	**Non-Barrel Auto-Tune Disturbance Size** — The size of disturbance used to auto-tune if non-barrel is selected. For auto-tuning cool-only zones. Ignored for barrel zones. Entering 0.00 selects 100%. (*0.00* thru 100.00%)
25	0-15	**Time Constant for the Input Filter** — The time constant in seconds that controls filtering of the temperature input. The larger the value, the more it will affect the response. Adjust the value just high enough to minimize spurious alarms. A value of zero disables the filter. (*0.0* thru 9.9)

The following table lists word addresses in file N7 for each loop configuration block in the communication program (appendix C).

Parameter	Word No.	Word in File N7 of the Communication Program (Appendix C)							
		Loop 1	Loop 2	Loop 3	Loop 4	Loop 5	Loop 6	Loop 7	Loop 8
Block Identification Code	0	10	40	70	100	130	160	190	220
Miscellaneous Control Bits	1	11	41	71	101	131	161	191	221
Miscellaneous Control Bits	2	12	42	72	102	132	162	192	222
Set-Point Ramp Rate	3	13	43	73	103	133	163	193	223
Always = 0.	4	14	44	74	104	134	164	194	224
Always = 0.	5	15	45	75	105	135	165	195	225
High Output (M) Limit	6	16	46	76	106	136	166	196	226
Low Output (M) Limit	7	17	47	77	107	137	167	197	227
Forced Output (M) Value on Open Circuit	8	18	48	78	108	138	168	198	228
Forced Output (M) Value, Thermal Integrity Loss	9	19	49	79	109	139	169	199	229
Heat Minimum On Time	10	20	50	80	110	140	170	200	230
Heat TPO Period	11	21	51	81	111	141	171	201	231
Cool Minimum On Time	12	22	52	82	112	142	172	202	232
Cool TPO Period	13	23	53	83	113	143	173	203	233
Auto-tune Startup Aggressiveness	14	24	54	84	114	144	174	204	234
C Alarm Rate	15	25	55	85	115	145	175	205	235
Low Temperature Alarm Value	16	26	56	86	116	146	176	206	236
HIgh Temperature Alarm Value	17	27	57	87	117	147	177	207	237
Low Deviation Alarm Value	18	28	58	88	118	148	178	208	238
High Deviation Alarm Value	19	29	59	89	119	149	179	209	239
Temperature Alarm Dead Band	20	30	60	90	120	150	180	210	240
Thermal Runaway Temperature Change Value	21	31	61	91	121	151	181	211	241
Thermal Runaway Period in Minutes	22	32	62	92	122	152	182	212	242
Reserved	23	33	63	93	123	153	183	213	243
Non-Barrel Auto-Tune Disturbance Size	24	34	64	94	124	154	184	214	244
Time Constant for the Input Filter	25	35	65	95	125	155	185	215	245

Notes:

Saving/Restoring Auto-Tuning Parameters

This chapter shows you how auto-tuning parameters are saved by reading the auto-tune block from the module; and restored by writing the auto-tune block to the module.

This includes:

- sequence of block-transfers
- block identification
- inferred decimal point
- the auto-tune block

Important: Auto-tuning parameters are not PID gains, but are measured process dynamics that the module uses to calculate PID gains (chapter 6).

Sequence of Block-Transfers

Once auto-tuning is complete, ladder logic must read (block-transfer) the auto-tune block from the module to store it in PLC processor memory. The module's memory is volatile. Whenever power to the module is interrupted, unless you execute auto-tuning again, you must again send the auto-tuning block to the module. Writing the auto-tune block to the module establishes the start-up algorithm and the values the module uses to calculate PID gains. However, you can override the gains calculated from auto-tuning by sending the gains block anytime after the auto-tune block.

In the dynamic block (bits 0 and 6 of word 33) you select which block (auto-tune, gains, or status) the module should send in response to a block-transfer read instruction.

Block Identification

The first word of each auto-tuning block contains a block ID code (1000 1000 0000 1011, $880B_{16}$, or -30709_{10}) that you use to tell the module that it is an auto-tuning block.

Inferred Decimal Point

Values are expressed as 16-bit integers with *inferred* decimal point.

- For each **gain**, the inferred decimal point is **2** places from the right (causing the resolution to be **0.01**). For example, if in word 1 you enter the value 4999, the module infers the value to be **49.99**.
- For each **time constant**, the inferred decimal point is **1** place from the right (causing the resolution to be **0.1**). For example, if in word 2 you enter the value 4999, the module infers the value to be **499.9**.
- For each **dead time**, the inferred decimal point is **1** place from the right (causing the resolution to be **0.1**). For example, if in word 3 you enter the value 4999, the module infers the value to be **499.9**.

Auto-Tune Block

The auto-tune block contains 57 words. We include corresponding word addresses in file N7 of the communication program (appendix C). These values are measured process dynamics that the module uses to calculate PID gains. Descriptions are for barrel and non-barrel loops.

Program Addr:	Word:	Bits:	Description for Barrel Loops:	Description for Non-Barrel Loops:
420	0	0–15	**Block Identification Code** — 1000 1000 0000 1011 ($880B_{16}$) (-30709_{10})	**Block Identification Code** — 1000 1000 0000 1011 ($880B_{16}$) (-30709_{10})
421	1	0–15	**Loop-1 Heat Slope** (0.00 thru 327.67°/%/s)	**Loop-1 Heat Process Gain** (0.00 thru 327.67°/%)
422	2	0–15	**Loop-1 Heat Time Constant** (0.0 thru 3276.7s)	**Loop-1 Heat Time Constant** (0.0 thru 3276.7s)
423	3	0–15	**Loop-1 Heat Dead Time** (0.0 thru 3276.7s)	**Loop-1 Heat Dead Time** (0.0 thru 3276.7s)
424	4	0–15	**Loop-1 Cool Slope** (0.00 thru 327.67°/%/s)	**Loop-1 Cool Process Gain** (0.00 thru 327.67°/%)
425	5	0–15	**Loop-1 Cool Time Constant** (0.0 thru 3276.7s)	**Loop-1 Cool Time Constant** (0.0 thru 3276.7s)
526	6	0–15	**Loop-1 Cool Dead Time** (0.0 thru 3276.7s)	**Loop-1 Cool Dead Time** (0.0 thru 3276.7s)
427	7	0–15	Reserved	Reserved
428	8	0–15	**Loop-2 Heat Slope** (0.00 thru 327.67°/&/s)	**Loop-2 Heat Process Gain** (0.00 thru 327.67°/%)
429	9	0–15	**Loop-2 Heat Time Constant** (0.0 thru 3276.7s)	**Loop-2 Heat Time Constant** (0.0 thru 3276.7s)
430	10	0–15	**Loop-2 Heat Dead Time** (0.0 thru 3276.7s)	**Loop-2 Heat Dead Time** (0.0 thru 3276.7s)
431	11	0–15	**Loop-2 Cool Slope** (0.00 thru 327.67°/%/s)	**Loop-2 Cool Process Gain** (0.00 thru 327.67°/%)
432	12	0–15	**Loop-2 Cool Time Constant** (0.0 thru 3276.7s)	**Loop-2 Cool Time Constant** (0.0 thru 3276.7s)
433	13	0–15	**Loop-2 Cool Dead Time** (0.0 thru 3276.7s)	**Loop-2 Cool Dead Time** (0.0 thru 3276.7s)
434	14	0–15	Reserved	Reserved
435	15	0–15	**Loop-3 Heat Slope** (0.00 thru 327.67°/%/s)	**Loop-3 Heat Process Gain** (0.00 thru 327.67°/%)
436	16	0–15	**Loop-3 Heat Time Constant** (0.0 thru 3276.7s)	**Loop-3 Heat Time Constant** (0.0 thru 3276.7s)
437	17	0–15	**Loop-3 Heat Dead Time** (0.0 thru 3276.7s)	**Loop-3 Heat Dead Time** (0.0 thru 3276.7s)
438	18	0–15	**Loop-3 Cool Slope** (0.00 thru 327.67°/%/s)	**Loop-3 Cool Process Gain** (0.00 thru 327.67°/%)
438	19	0–15	**Loop-3 Cool Time Constant** (0.0 thru 3276.7s)	**Loop-3 Cool Time Constant** (0.0 thru 3276.7s)
440	20	0–15	**Loop-3 Cool Dead Time** (0.0 thru 3276.7s)	**Loop-3 Cool Dead Time** (0.0 thru 3276.7s)
441	21	0–15	Reserved	Reserved
442	22	0–15	**Loop-4 Heat Slope** (0.00 thru 327.67°/%/s)	**Loop-4 Heat Process Gain** (0.00 thru 327.67°/%)
443	23	0–15	**Loop-4 Heat Time Constant** (0.0 thru 3276.7s)	**Loop-4 Heat Time Constant** (0.0 thru 3276.7s)
444	24	0–15	**Loop-4 Heat Dead Time** (0.0 thru 3276.7s)	**Loop-4 Heat Dead Time** (0.0 thru 3276.7s)
445	25	0–15	**Loop-4 Cool Slope** (0.00 thru 327.67°/%/s)	**Loop-4 Cool Process Gain** (0.00 thru 327.67°/%)
446	26	0–15	**Loop-4 Cool Time Constant** (0.0 thru 3276.7s)	**Loop-4 Cool Time Constant** (0.0 thru 3276.7s)
447	27	0–15	**Loop-4 Cool Dead Time** (0.0 thru 3276.7s)	**Loop-4 Cool Dead Time** (0.0 thru 3276.7s)
448	28	0–15	Reserved	Reserved
449	29	0–15	**Loop-5 Heat Slope** (0.00 thru 327.67°/%/s)	**Loop-5 Heat Process Gain** (0.00 thru 327.67°/%)
450	30	0–15	**Loop-5 Heat Time Constant** (0.0 thru 3276.7s)	**Loop-5 Heat Time Constant** (0.0 thru 3276.7s)
451	31	0–15	**Loop-5 Heat Dead Time** (0.0 thru 3276.7s)	**Loop-5 Heat Dead Time** (0.0 thru 3276.7s)
452	32	0–15	**Loop-5 Cool Slope** (0.00 thru 327.67°/%/s)	**Loop-5 Cool Process Gain** (0.00 thru 327.67°/%)
453	33	0–15	**Loop-5 Cool Time Constant** (0.0 thru 3276.7s)	**Loop-5 Cool Time Constant** (0.0 thru 3276.7s)
454	34	0–15	**Loop-5 Cool Dead Time** (0.0 thru 3276.7s)	**Loop-5 Cool Dead Time** (0.0 thru 3276.7s)
455	35	0–15	Reserved	Reserved
456	36	0–15	**Loop-6 Heat Slope** (0.00 thru 327.67°/%/s)	**Loop-6 Heat Process Gain** (0.00 thru 327.67°/%)
457	37	0–15	**Loop-6 Heat Time Constant** (0.0 thru 3276.7s)	**Loop-6 Heat Time Constant** (0.0 thru 3276.7s)
458	38	0–15	**Loop-6 Heat Dead Time** (0.0 thru 3276.7s)	**Loop-6 Heat Dead Time** (0.0 thru 3276.7s)
459	39	0–15	**Loop-6 Cool Slope** (0.00 thru 327.67°/%/s)	**Loop-6 Cool Process Gain** (0.00 thru 327.67°/%)
460	40	0–15	**Loop-6 Cool Time Constant** (0.0 thru 3276.7s)	**Loop-6 Cool Time Constant** (0.0 thru 3276.7s)
461	41	0–15	**Loop-6 Cool Dead Time** (0.0 thru 3276.7s)	**Loop-6 Cool Dead Time** (0.0 thru 3276.7s)
462	42	0–15	Reserved	Reserved

Program Addr:	Word:	Bits:	Description for Barrel Loops:	Description for Non-Barrel Loops:
463	43	0–15	**Loop-7 Heat Slope** (0.00 thru 327.67°/%/s)	**Loop-7 Heat Process Gain** (0.00 thru 327.67°/%)
464	44	0–15	**Loop-7 Heat Time Constant** (0.0 thru 3276.7s)	**Loop-7 Heat Time Constant** (0.0 thru 3276.7s)
465	45	0–15	**Loop-7 Heat Dead Time** (0.0 thru 3276.7s)	**Loop-7 Heat Dead Time** (0.0 thru 3276.7s)
466	46	0–15	**Loop-7 Cool Slope** (0.00 thru 327.67°/%/s)	**Loop-7 Cool Process Gain** (0.00 thru 327.67°/%)
467	47	0–15	**Loop-7 Cool Time Constant** (0.0 thru 3276.7s)	**Loop-7 Cool Time Constant** (0.0 thru 3276.7s)
468	48	0–15	**Loop-7 Cool Dead Time** (0.0 thru 3276.7s)	**Loop-7 Cool Dead Time** (0.0 thru 3276.7s)
469	49	0–15	Reserved	Reserved
470	50	0–15	**Loop-8 Heat Slope** (0.00 thru 327.67°/%/s)	**Loop-8 Heat Process Gain** (0.00 thru 327.67°/%)
471	51	0–15	**Loop-8 Heat Time Constant** (0.0 thru 3276.7s)	**Loop-8 Heat Time Constant** (0.0 thru 3276.7s)
472	52	0–15	**Loop-8 Heat Dead Time** (0.0 thru 3276.7s)	**Loop-8 Heat Dead Time** (0.0 thru 3276.7s)
473	53	0–15	**Loop-8 Cool Slope** (0.00 thru 327.67°/%/s)	**Loop-8 Cool Process Gain** (0.00 thru 327.67°/%)
474	54	0–15	**Loop-8 Cool Time Constant** (0.0 thru 3276.7s)	**Loop-8 Cool Time Constant** (0.0 thru 3276.7s)
475	55	0–15	**Loop-8 Cool Dead Time** (0.0 thru 3276.7s)	**Loop-8 Cool Dead Time** (0.0 thru 3276.7s)
476	56	0–15	Reserved	Reserved

Notes:

Chapter 6

Setting Proportional-Integral-Derivative Gains

This chapter shows you how to independently set the gains for each of the eight PID loops. This includes:

- sequence of block-transfers
- auto-tuning the loops
- fine tuning the loops
- block identification
- inferred decimal point
- the gains block

Sequence of Block-Transfers

Auto-tuning causes the module to measure the process dynamics and calculate PID gains.

Reading the gains block from the module copies the gains generated by auto-tuning into the PLC data table.

Writing the gains block to the module overwrites any PID gains that had been in the module.

Auto-tuning or writing the auto-tune block to the module causes the module to calculate PID gains and overwrite any PID gains that had been in the module.

Any time you cause successful auto-tuning of a loop, write an auto-tune block to the module, or write a gains block to the module, the module computes and stores a new set of PID gains.

At start-up, ladder logic must either write (block-transfer) the PID gains block to the module or perform auto-tuning. If you select auto-tuning, the module computes PID gains for each auto-tuned loop. Gains that you sent to the module previous to auto-tuning will be superseded by PID gains derived from auto-tuning. Subsequent PID gains blocks, read from the module, will contain the gains derived from auto-tuning.

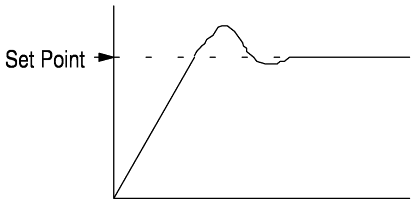
If the auto-tuning of a loop is not successful (as indicated in the status block) the loop gains you had sent before auto-tuning will be retained and used by the module.

Once auto-tuning is complete, ladder logic must read (block-transfer) the gains block from the module to store it in PLC processor memory. When you want the module to switch from sending the block it has been sending, you must send a dynamic block to establish the module's return of either an auto-tune, gains, or status block in response to block-transfer reads (selected by dynamic block word 33, bits 0 & 6).

The module's memory is volatile. Whenever power to the module is interrupted, you must re-establish PID gains: sending the auto-tune block establishes the start-up algorithm and the values the module uses to re-calculate PID gains which it does. However, you can override the auto-tune PID gains by sending the gains block after sending the auto-tune block.

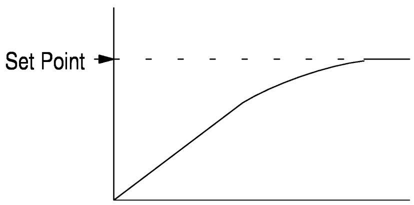
Fine-Tuning the Loops

During auto-tuning, the module computes and stores PID gains. You may want to fine-tune the loops by manually adjusting PID gains. First adjust controller gain. It has the greatest impact. Then adjust integral gain. The derivative gain should be the last adjustment for fine-tuning a loop.



If the loop **over-shoots** the setpoint either at start-up or at a change of setpoint, dampen the loop response as follows (in order of effectiveness):

1. decrease controller gain
2. decrease integral gain
3. increase derivative gain



If the loop is **slow** in reaching setpoint either at start-up or at a change of setpoint, improve the loop response as follows:

1. increase controller gain
2. increase integral gain
3. decrease derivative gain

The PID Equation

The module provides dependant PID control action which can be represented by the equation:

$$M' = K_c \left[E + K_i \int_0^t E \cdot dt + K_d \frac{dE}{dt} \right]$$

Where:
M = Manipulated variable
K_c = Controller gain (no units)
E = Error (SP–C or C–SP)
K_i = Integral gain (repeats/second)
K_d = Derivative gain (seconds)
t = Time

The module performs PID control by computing the solution to an approximation of the PID equation as follows:

$$M' = K_c \left(E + K_i \sum_0^t E \cdot \Delta t + K_d \frac{\Delta E}{\Delta t} \right)$$

Where:

$$\sum_0^t E \cdot \Delta t = E_1 \cdot \Delta t + E_2 \cdot \Delta t + E_3 \cdot \Delta t + \cdots$$

Note: For consistency and to comply with ISA/IEE terminology, we have changed terminology in this manual as follows:

Previous terminology:	Changed to:	Meaning:
CV (control variable)	M (manipulated variable)	loop output
K_p (proportional gain)	K_c (controller gain)	module's algorithm gain

Block Identification

The first word of each gains block contains a block ID code (1000 1000 0000 1001, 8809_{16}, or -30711_{10}) that tells the module that it is a gains block.

Inferred Decimal Point

For each gain value, you enter a 16-bit integer value. However, as you enter each gain value, be aware of an inferred decimal point.

- For each **proportional** gain, the inferred decimal point is **3** places from the right (causing the resolution to be **0.001**). For example, if you enter the value 14999, the module infers the value to be **14.999**.
- For each **integral** gain, the inferred decimal point is **4** places from the right (causing the resolution to be **0.0001**). For example, if you enter the value 14999, the module infers the value to be **1.4999**.
- For each **derivative** gain, the inferred decimal point is **1** place from the right (causing the resolution to be **0.1**). For example, if you enter the value 14999, the module infers the value to be **1499.9**.

Gains Block

The gains block contains 57 words. We included corresponding word addresses in file N7 of the communication program (appendix C). Default values are shown in *italics*.

Program Addr:	Word:	Bits:	Description:
250	0	0–15	**Block Identification Code** — 1000 1000 0000 1001 (8809_{16}) (-30711_{10})
251	1	0–15	**Loop-1 Heat Proportional Gain** — (*0.000* thru 32.767)
252	2	0–15	**Loop-1 Heat Integral Gain** — (*0.0000* thru 3.2767 repeats/s)
253	3	0–15	**Loop-1 Heat Derivative Gain** — (*0.0* thru 3276.7s)
254	4	0–15	**Loop-1 Cool Proportional Gain** — (*0.000* thru 32.767)
255	5	0–15	**Loop-1 Cool Integral Gain** — (*0.0000* thru 3.2767 repeats/s)
256	6	0–15	**Loop-1 Cool Derivative Gain** — (*0.0* thru 3276.7s)
257	7	0–15	Reserved
258	8	0–15	**Loop-2 Heat Proportional Gain** — (*0.000* thru 32.767)
259	9	0–15	**Loop-2 Heat Integral Gain** — (*0.0000* thru 3.2767 repeats/s)
260	10	0–15	**Loop-2 Heat Derivative Gain** — (*0.0* thru 3276.7s)
261	11	0–15	**Loop-2 Cool Proportional Gain** — (*0.000* thru 32.767)
262	12	0–15	**Loop-2 Cool Integral Gain** — (*0.0000* thru 3.2767 repeats/s)
263	13	0–15	**Loop-2 Cool Derivative Gain** — (*0.0* thru 3276.7s)
264	14	0–15	Reserved
265	15	0–15	**Loop-3 Heat Proportional Gain** — (*0.000* thru 32.767)
266	16	0–15	**Loop-3 Heat Integral Gain** — (*0.0000* thru 3.2767 repeats/s)
267	27	0–15	**Loop-3 Heat Derivative Gain** — (*0.0* thru 3276.7s)
268	18	0–15	**Loop-3 Cool Proportional Gain** — (*0.000* thru 32.767)
269	19	0–15	**Loop-3 Cool Integral Gain** — (*0.0000* thru 3.2767 repeats/s)
270	20	0–15	**Loop-3 Cool Derivative Gain** — (*0.0* thru 3276.7s)
271	21	0–15	Reserved

Program Addr:	Word:	Bits:	Description:
272	22	0–15	**Loop-4 Heat Proportional Gain** — (*0.000* thru 32.767)
273	23	0–15	**Loop-4 Heat Integral Gain** — (*0.0000* thru 3.2767 repeats/s)
274	24	0–15	**Loop-4 Heat Derivative Gain** — (*0.0* thru 3276.7s)
275	25	0–15	**Loop-4 Cool Proportional Gain** — (*0.000* thru 32.767)
276	26	0–15	**Loop-4 Cool Integral Gain** — (*0.0000* thru 3.2767 repeats/s)
277	27	0–15	**Loop-4 Cool Derivative Gain** — (*0.0* thru 3276.7s)
278	28	0–15	Reserved
279	29	0–15	**Loop-5 Heat Proportional Gain** — (*0.000* thru 32.767)
280	30	0–15	**Loop-5 Heat Integral Gain** — (*0.0000* thru 3.2767 repeats/s)
281	31	0–15	**Loop-5 Heat Derivative Gain** — (*0.0* thru 3276.7s)
282	32	0–15	**Loop-5 Cool Proportional Gain** — (*0.000* thru 32.767)
283	33	0–15	**Loop-5 Cool Integral Gain** — (*0.0000* thru 3.2767 repeats/s)
384	34	0–15	**Loop-5 Cool Derivative Gain** — (*0.0* thru 3276.7s)
285	35	0–15	Reserved
286	36	0–15	**Loop-6 Heat Proportional Gain** — (*0.000* thru 32.767)
287	37	0–15	**Loop-6 Heat Integral Gain** — (*0.0000* thru 3.2767 repeats/s)
288	38	0–15	**Loop-6 Heat Derivative Gain** — (*0.0* thru 3276.7s)
289	39	0–15	**Loop-6 Cool Proportional Gain** — (*0.000* thru 32.767)
290	40	0–15	**Loop-6 Cool Integral Gain** — (*0.0000* thru 3.2767 repeats/s)
291	41	0–15	**Loop-6 Cool Derivative Gain** — (*0.0* thru 3276.7s)
292	42	0–15	Reserved
293	43	0–15	**Loop-7 Heat Proportional Gain** — (*0.000* thru 32.767)
294	44	0–15	**Loop-7 Heat Integral Gain** — (*0.0000* thru 3.2767 repeats/s)
295	45	0–15	**Loop-7 Heat Derivative Gain** — (*0.0* thru 3276.7s)
296	46	0–15	**Loop-7 Cool Proportional Gain** — (*0.000* thru 32.767)
297	47	0–15	**Loop-7 Cool Integral Gain** — (*0.000* thru 3.2767 repeats/s)
298	48	0–15	**Loop-7 Cool Derivative Gain** — (*0.0* thru 3276.7s)
299	49	0–15	Reserved
300	50	0–15	**Loop-8 Heat Proportional Gain** — (*0.000* thru 32.767)
301	51	0–15	**Loop-8 Heat Integral Gain** — (*0.0000* thru 3.2767 repeats/s)
302	52	0–15	**Loop-8 Heat Derivative Gain** — (*0.0* thru 3276.7s)
303	53	0–15	**Loop-8 Cool Proportional Gain** — (*0.000* thru 32.767)
304	54	0–15	**Loop-8 Cool Integral Gain** — (*0.0000* thru 3.2767 repeats/s)
305	55	0–15	**Loop-8 Cool Derivative Gain** — (*0.0* thru 3276.7s)
306	56	0–15	Reserved

Operating the Module (Dynamic Block)

This chapter shows how to modify the dynamic block to control loop operation. This includes.

- sequence of block-transfers
- block identification
- control mode selection
- inferred decimal point
- the dynamic block

Sequence of Block-Transfers

At start-up, ladder logic must write (block-transfer) the dynamic block to the module to establish its control mode. After that, ladder logic must send a dynamic block any time you want to change its control mode.

The dynamic block also lets you control the module's response to the execution of a block-transfer read instruction. The module can send a gains block, an auto-tune block, or a status block in response to a block-transfer read. Whenever you want the module to switch from sending the block it has been sending, ladder logic must send a revised dynamic block to change the module's response to block-transfer reads (selected by dynamic block word 33, bits 0 and 6).

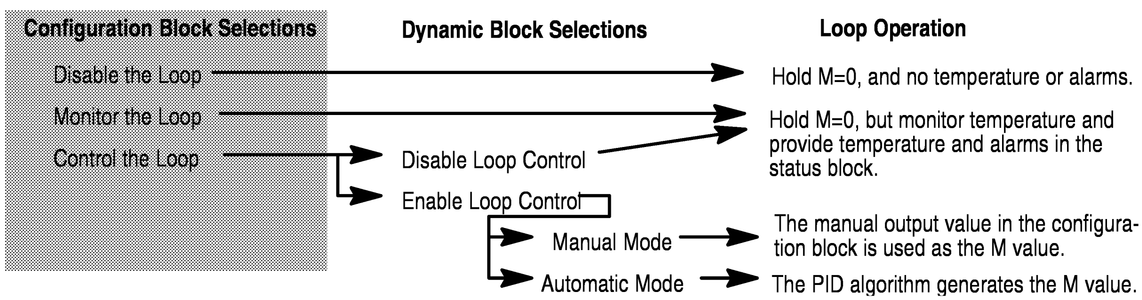
Block Identification

The first word of each dynamic block contains a block identification code (1000 1000 0000 1010, $880A_{16}$, or -30710_{10}) that tells the module that it is a dynamic block.

Control Mode Selection

In loop configuration blocks, you select between disable, monitor only, or control mode. If you select control mode, then you can select between the following with the *dynamic* block:

- disable loop control (monitor only)
- enable manual control mode
- enable automatic PID control mode



Inferred Decimal Point

For the manual output (M), the run temperature set-point, and the standby temperature set-point, you enter a 16-bit signed integer value. As you enter the value, be aware of an inferred decimal point.

- For manual output value (M) , the inferred decimal point is **2** places from the right (causing the resolution to be **0.01**). For example, if in word 4 you enter the value 4999, the module infers a value of **49.99**.
- For the run temperature set-point, and the standby temperature set-point, the inferred decimal point is **1** place from the right (causing the resolution to be **0.1**). For example, if in word 3 you enter the value 4999, the module infers a value of **499.9**.

Dynamic Block

The dynamic block contains 34 words. We provide corresponding word addresses in file N7 of the communication program (appendix C). Default values are shown in *italics*.

Program Addr.	Word	Bits	Description
310	0	0–15	**Block Identification Code** — 1000 1000 0000 1010 ($880A_{16}$) (-30710_{10})
311	1	0	**Loop-1 Control Enable** • *0 = Disable loop-1 control (M=0, but allow monitor if monitor or control mode is selected in config block).* • 1 = Enable loop-1 control if control mode is selected (bits 7–8, word 1, config block).
		1	**Loop-1 Auto/Manual Control Mode Select (if enabled by bit 0)** • *0 = Set loop-1 to manual mode — the manual output value (from word 4) is used as the M value.* • 1 = Set loop-1 to automatic mode — the PID algorithm generates the M value.
		2	**Loop-1 Set-Point Select** • 0 = Select the standby-temperature set-point value from word 2. • 1 = Select the run-temperature set-point value from word 3.
		3	**Loop-1 Auto-Tuning Enable** • *0 = Disable auto-tuning for loop 1.* • 1 = Enable auto-tuning for loop 1 to be invoked by an off-to-on transition of bit 1 of word 33.
		4	Always = 0.
		5	**Loop-1 PID Integral Term Reset Enable** • 0 = Accumulate PID integral term. • 1 = Reset PID integral term on the 0-to-1 transition, and then immediately resume accumulation after reset.
		6	**Setpoint Ramp-Hold Enable** • *0 = Disable the hold. (ramping is enabled by Configuration block word 2, bit 4)* • 1 = Hold the setpoint at the current value.
		7-15	Not used.
312	2	0–15	**Loop-1 Standby Temperature Set-point Value** — Used when bit 2 of word 1 is off (0 thru 3276.7°).
313	3	0–15	**Loop-1 Run Temperature Set-point Value** — Used when bit 2 of word 1 is on (0 thru 3276.7°).
314	4	0–15	**Loop-1 Manual Output Value (M)** — Used when bit 1 of word 1 is off (–100.00 thru +100.00).

Program Addr.	Word	Bits	Description
315	5	0	**Loop-2 Control Enable** • *0 = Disable loop-2 control (M=0, but allow monitor if monitor or control mode is selected in config block).* • 1 = Enable loop-2 control if control mode is selected (bits 7–8, word 1, config block).
		1	**Loop-2 Auto/Manual Control Mode Select (if enabled by bit 0)** • *0 = Set loop 2 to manual mode — the manual output value (from word 8) is used as the M value.* • 1 = Set loop 2 to automatic mode — the PID algorithm generates the M value.
		2	**Loop-2 Set-Point Select** • 0 = Select the standby-temperature set-point value from word 6. • 1 = Select the run-temperature set-point value from word 7.
		3	**Loop-2 Auto-Tuning Enable** • *0 = Disable auto-tuning for loop 2.* • 1 = Enable auto-tuning for loop 2 to be invoked by an off-to-on transition of bit 1 of word 33.
		4	Always = 0.
		5	**Loop-2 PID Integral Term Reset Enable** • 0 = Accumulate PID integral term. • 1 = Reset PID integral term on the 0-to-1 transition, and then immediately resume accumulation after reset.
		6	**Setpoint Ramp-Hold Enable** • *0 = Disable the hold. (ramping is enabled by Configuration block word 2, bit 4)* • 1 = Hold the setpoint at the current value.
		7–15	Always = 0.
316	6	0–15	**Loop-2 Standby Temperature Set-point Value** — Used when bit 2 of word 5 is off (0 thru 3276.7°).
317	7	0–15	**Loop-2 Run Temperature Set-point Value** — Used when bit 2 of word 5 is on (0 thru 3276.7°).
318	8	0–15	**Loop-2 Manual Output Value (M)** — Used when bit 1 of word 5 is off (–100.00 thru +100.00).
319	9	0	**Loop-3 Control Enable** • *0 = Disable loop-3 control (M=0, but allow monitor if monitor or control mode is selected in config block).* • 1 = Enable loop-3 control if control mode is selected (bits 7–8, word 1, config block).
		1	**Loop-3 Auto/Manual Control Mode Select (if enabled by bit 0)** • *0 = Set loop 3 to manual mode — the manual output value (from word 12) is used as the M value.* • 1 = Set loop 3 to automatic mode — the PID algorithm generates the M value.
		2	**Loop-3 Set-Point Select** • 0 = Select the standby-temperature set-point value from word 10. • 1 = Select the run-temperature set-point value from word 11.
		3	**Loop-3 Auto-Tuning Enable** • *0 = Disable auto-tuning for loop 3.* • 1 = Enable auto-tuning for loop 3 to be invoked by an off-to-on transition of bit 1 of word 33.
		4	Always = 0.
		5	**Loop-3 PID Integral Term Reset Enable** • 0 = Accumulate PID integral term. • 1 = Reset PID integral term on the 0-to-1 transition, and then immediately resume accumulation after reset.
		6	**Setpoint Ramp-Hold Enable** • *0 = Disable the hold. (ramping is enabled by Configuration block word 2, bit 4)* • 1 = Hold the setpoint at the current value.
		7–15	Always = 0.
320	10	0–15	**Loop-3 Standby Temperature Set-point Value** — Used when bit 2 of word 9 is off (0 thru 3276.7°).
321	11	0–15	**Loop-3 Run Temperature Set-point Value** — Used when bit 2 of word 9 is on (0 thru 3276.7°).
322	12	0–15	**Loop-3 Manual Output Value (M)** — Used when bit 1 of word 9 is off (–100.00 thru +100.00).

Program Addr.	Word	Bits	Description
323	13	0	**Loop-4 Control Enable** • *0 = Disable loop-4 control (M=0, but allow monitor if monitor or control mode is selected in config block).* • 1 = Enable loop-4 control if control mode is selected (bits 7–8, word 1, config block).
		1	**Loop-4 Auto/Manual Control Mode Select (if enabled by bit 0)** • *0 = Set loop 4 to manual mode — the manual output value (from word 16) is used as the M value.* • 1 = Set loop 4 to automatic mode — the PID algorithm generates the M value.
		2	**Loop-4 Set-Point Select** • 0 = Select the standby-temperature set-point value from word 14. • 1 = Select the run-temperature set-point value from word 15.
		3	**Loop-4 Auto-Tuning Enable** • *0 = Disable auto-tuning for loop 4.* • 1 = Enable auto-tuning for loop 4 to be invoked by an off-to-on transition of bit 1 of word 33.
		4	Always = 0.
		5	**Loop-4 PID Integral Term Reset Enable** • 0 = Accumulate PID integral term. • 1 = Reset the PID integral term on the 0-to-1 transition, and then immediately resume accumulation after reset.
		6	**Setpoint Ramp-Hold Enable** • *0 = Disable the hold. (ramping is enabled by Configuration block word 2, bit 4)* • 1 = Hold the setpoint at the current value.
		7–15	Always = 0.
324	14	0–15	**Loop-4 Standby Temperature Set-point Value** — Used when bit 2 of word 13 is off (0 thru 3276.7°).
425	15	0–15	**Loop-4 Run Temperature Set-point Value** — Used when bit 2 of word 13 is on (0 thru 3276.7°).
326	16	0–15	**Loop-4 Manual Output Value (M)** — Used when bit 1 of word 13 is off (–100.00 thru +100.00).
327	17	0	**Loop-5 Control Enable** • *0 = Disable loop-5 control (M=0, but allow monitor if monitor or control mode is selected in config block).* • 1 = Enable loop-5 control if control mode is selected (bits 7–8, word 1, config block).
		1	**Loop-5 Auto/Manual Control Mode Select (if enabled by bit 0)** • *0 = Set loop 5 to manual mode — the manual output value (from word 20) is used as the M value.* • 1 = Set loop 5 to automatic mode — the PID algorithm generates the M value.
		2	**Loop-5 Set-Point Select** • 0 = Select the standby-temperature set-point value from word 18. • 1 = Select the run-temperature set-point value from word 19.
		3	**Loop-5 Auto-Tuning Enable** • *0 = Disable auto-tuning for loop 5.* • 1 = Enable auto-tuning for loop 5 to be invoked by an off-to-on transition of bit 1 of word 33.
		4	Always = 0.
		5	**Loop -5 PID Integral Term Reset Enable** • 0 = Accumulate PID integral term. • 1 = Reset PID integral term on the 0-to-1 transition, and then immediately resume accumulation after reset.
		6	**Setpoint Ramp-Hold Enable** • *0 = Disable the hold. (ramping is enabled by Configuration block word 2, bit 4)* • 1 = Hold the setpoint at the current value.
		7–15	Always = 0.
328	18	0–15	**Loop-5 Standby Temperature Set-point Value** — Used when bit 2 of word 17 is off (0 thru 3276.7°).
329	19	0–15	**Loop-5 Run Temperature Set-point Value** — Used when bit 2 of word 17 is on (0 thru 3276.7°).
330	20	0–15	**Loop-5 Manual Output Value (M)** — Used when bit 1 of word 17 is off (–100.00 thru +100.00).

Program Addr.	Word	Bits	Description
331	21	0	**Loop-6 Control Enable** • *0 = Disable loop-6 control (M=0, but allow monitor if monitor or control mode is selected in config block).* • 1 = Enable loop-6 control if control mode is selected (bits 7–8, word 1, config block).
		1	**Loop-6 Auto/Manual Control Mode Select (if enabled by bit 0)** • *0 = Set loop 6 to manual mode — the manual output value (from word 24) is used as the M value.* • 1 = Set loop 6 to automatic mode — the PID algorithm generates the M value.
		2	**Loop-6 Set-Point Select** • 0 = Select the standby-temperature set-point value from word 22. • 1 = Select the run-temperature set-point value from word 23.
		3	**Loop-6 Auto-Tuning Enable** • *0 = Disable auto-tuning for loop 6.* • 1 = Enable auto-tuning for loop 6 to be invoked by an off-to-on transition of bit 1 of word 33.
		4	Always = 0.
		5	**Loop 6 PID Integral Term Reset Enable** • 0 = Accumulate PID integral term. • 1 = Reset PID integral term on the 0-to-1 transition, and then immediately resume accumulation after reset.
		6	**Setpoint Ramp-Hold Enable** • *0 = Disable the hold. (ramping is enabled by Configuration block word 2, bit 4)* • 1 = Hold the setpoint at the current value.
		7–15	Always = 0.
332	22	0–15	**Loop-6 Standby Temperature Set-point Value** — Used when bit 2 of word 21 is off (0 thru 3276.7°).
333	23	0–15	**Loop-6 Run Temperature Set-point Value** — Used when bit 2 of word 21 is on (0 thru 3276.7°).
334	24	0–15	**Loop-6 Manual Output Value (M)** — Used when bit 1 of word 21 is off (–100.00 thru +100.00).
335	25	0	**Loop-7 Control Enable** • *0 = Disable loop-7 control (M=0, but allow monitor if monitor or control mode is selected in config block).* • 1 = Enable loop-7 control if control mode is selected (bits 7–8, word 1, config block).
		1	**Loop-7 Auto/Manual Control Mode Select (if enabled by bit 0)** • *0 = Set loop 7 to manual mode — the manual output value (from word 28) is used as the M value.* • 1 = Set loop 7 is to automatic mode — the PID algorithm generates the M value.
		2	**Loop-7 Set-Point Select** • 0 = Select the standby-temperature set-point value from word 26. • 1 = Select the run-temperature set-point value from word 27.
		3	**Loop-7 Auto-Tuning Enable** • *0 = Disable auto-tuning for loop 7.* • 1 = Enable auto-tuning for loop 7 to be invoked by an off-to-on transition of bit 1 of word 33.
		4	Always = 0.
		5	**Loop-7 PID Integral Term Reset Enable** • 0 = Accumulate PID integral term. • 1 = Reset PID integral term on the 0-to-1 transition, and then immediately resume accumulation after reset.
		6	**Setpoint Ramp-Hold Enable** • *0 = Disable the hold. (ramping is enabled by Configuration block word 2, bit 4)* • 1 = Hold the setpoint at the current value.
		7–15	Always = 0.
336	26	0–15	**Loop-7 Standby Temperature Set-point Value** — Used when bit 2 of word 25 is off (0 thru 3276.7°).
337	27	0–15	**Loop-7 Run Temperature Set-point Value** — Used when bit 2 of word 25 is on (0 thru 3276.7°).
338	28	0–15	**Loop-7 Manual Output Value (M)** — Used when bit 1 of word 25 is off (–100.00 thru +100.00).

Program Addr:	Word	Bits	Description
339	29	0	**Loop-8 Control Enable** • *0 = Disable loop-8 control (M=0, but allow monitor if monitor or control mode is selected in config block).* • 1 = Enable loop-8 control if control mode is selected (bits 7–8, word 1, config block).
		1	**Loop-8 Auto/Manual Control Mode Select (if enabled by bit 0)** • 0 = *Set loop 8 to manual mode — the manual output value (from word 32) is used as the M value.* • 1 = Set loop 8 is to automatic mode — the PID algorithm generates the M value.
		2	**Loop-8 Set-Point Select** • 0 = Select the standby-temperature set-point value from word 30. • 1 = Select the run-temperature set-point value from word 31.
		3	**Loop-8 Auto-Tuning Enable** • *0 = Disable auto-tuning for loop 8.* • 1 = Enable auto-tuning for loop 8 to be invoked by an off-to-on transition of bit 1 of word 33.
		4	Always = 0.
		5	**Loop-8 PID Integral Term Reset Enable** • 0 = Accumulate PID integral term. • 1 = Reset tPID integral term on the 0-to-1 transition, and then immediately resume accumulation after reset.
		6	**Setpoint Ramp-Hold Enable** • *0 = Disable the hold. (ramping is enabled by Configuration block word 2, bit 4)* • 1 = Hold the setpoint at the current value.
		7–15	Always = 0.
340	30	0–15	**Loop-8 Standby Temperature Set-point Value** — Used when bit 2 of word 29 is off (0 thru 3276.7°).
341	31	0–15	**Loop-8 Run Temperature Set-point Value** — Used when bit 2 of word 29 is on (0 thru 3276.7°).
342	32	0–15	**Loop-8 Manual Output Value (M)** — Used when bit 1 of word 29 is off (–100.00 thru +100.00).
343	33	0, 6	**Read-Block Select** **bit 6 bit 0 selection** • *0 0 = Block-transfer read will return the status block.* • 0 1 = Block-transfer read will return the gains block. • 1 0 = Block-transfer read will return the auto-tuning block. • 1 1 Do not use (illegal value).
		1	**Invoke Auto-Tuning** • 0-to-1 transition invokes auto-tuning of all loops with auto-tuning enable bit turned on.
		2	Always = 0.
		3	**Cold-Junction Alarm Enable** • *0 = Disable alarm for cold-junction temperature over and under limits.* • 1 = Enable alarm for cold-junction temperature over the upper limit (70°C) or under the lower limit (0°C).
		4	**Celsius/Fahrenheit Select** — For all temperature values. • 0 = Celsius • *1 = Fahrenheit*
		5	**Abort Auto-Tuning** • 0 = Do not abort auto-tuning. • 1 = Abort auto-tuning.
		6	See bit 0 above for the combination of bits 0 and 6
		7	Always = 0
		8	**Integer Display Mode Enable** — Temperature display mode that displays temperature in 1.0º increments, and creates a ± 1º deadband at the setpoint. • *0 = Mode disabled.* • 1 = Mode enabled.
343	33	9–15	Always = 0

Monitoring Status Data

This chapter shows how to monitor module status. This includes:

- sequence of block-transfers
- block identification
- inferred decimal point
- the module status block

Sequence of Block-Transfers

At start-up, ladder logic must write (block-transfer) the dynamic block to the module to establish its control mode. After that, ladder logic must send a dynamic block to change its control mode.

With the dynamic block, ladder logic also controls the module's response to a block-transfer read instruction: the module can return a gains block, an auto-tune block, or a module status block. Whenever you want the module to switch from sending the block it has been sending, you modify the dynamic block (word 33, bits 0 and 6) to request the change.

Block Identification

The first word of each system status block contains a block ID code (1000 1000 1111 1111, $88FF_{16}$, or -30465_{10}) that ladder logic uses to identify the block as module status.

Implied Decimal Point

For M, PID error, and temperature, you read a 16-bit signed integer value. As you read the value, be aware of an implied decimal point.

- For M, the implied decimal point is **2** places from the right (causing the resolution to be **0.01%**). For example, if in word 34 you read the value 4999, the module implies a value of **49.99**.
- For PID errors and temperature values (words 26-33 and 42-58), the implied decimal point is **1** place from the right (causing the resolution to be **0.1**). For example, if in word 26 you read the value 4999, the module implies a value of **4.999**.

Module Status Block

The module status block contains 64 words. We include corresponding word addresses in file N7 of the communication program (appendix C).

Alarms Returned in the Module Status Block

The module status block returns error and alarm bits.

If using TemperatureControl™ configuration software that came with the module, alarms (when detected) can be displayed on the alarm screen of an operator interface terminal. You may also write ladder logic that examines alarm and error bits and activates appropriate responses. These bits (starting at N7:350) are returned in three different ways:

- in 1st word of 3-word loop status groupings
  (in word 1, 4, 7, 10, 13, 16, 19, and 22 for loop 1-8, respectively)
- in 2nd and 3rd words of 3-word loop status groupings, pointing to lookup code or to a word number containing an error
- in words 59-61 (N7:409-411)

in 1st word of 3-word loop status groupings

This alarm:	Indicated by:*	Indicates for the loop:	And can be detected:	And is reset when:
TC break	N7:35x/02	break in TC input	anytime except when loop is disabled	loop is restored
calibration fault	N7:35x/04	running uncalibrated	anytime	by calibration
C Rate	N7:35x/09	change in C > C rate alarm	when loop & C rate alarm are enabled	loop or alarm is disabled
thermal integrity	N7:35x/10	max M but C increasing too slow	when loop PID is enabled	loop disabled or in manual
high M limit	N7:35x/11	M @ M max	anytime except when loop is disabled	M < M max
low M limit	N7:35x/12	M @ M min	anytime except when loop is disabled	M > M min
TC overrange	N7:35x/14	C > TC upper range limit	anytime	C < TC upper range limit
TC underrange	N7:35x/15	C < TC lower range limit	anytime	C > TC lower range limit

* where x is word 1, 4, 7, 10, 13, 16, 19, 22 for loop 1-8, respectively in the status block starting at N7:350

in 2nd and 3rd words of 3-word loop status groupings, point to errors
– you made when entering data
– the module detected during auto-tuning

This error/alarm:	Indicated by:	Points to:	And is reset when:
gains block error	N7:35x/8-15*	word location of a bad parameter in gains block	module accepts block with valid parameter
config block error	N7:35x/0-7*	word location of a bad parameter in config block	module accepts block with valid parameter
auto-tune alarm	N7:35y/8-15**	lookup code 65-72 (chapter 10)	auto-tunning successfully completed
dynamic block error	N7:35y/0–7**	word location of a bad parameter in dynamic block	module accepts block with valid parameter

* where x = word 2, 5, 8, 11, 14, 17, 20, 23 for loop 1-8, respectively ** where y = word 3, 6, 9, 12, 15, 18, 21, 24 for loop 1-8, respectively

in block words 59-61 (N7:409-411)

This alarm:	Set by:	Indicates:	And can be detected when:	And is reset when:
high cold junction	N7:409/1***	cold junction temp > 70°C	alarm is enabled	cold junction temp ⩽ 70°C
low cold junction	N7:409/0***	cold junction temp < 0°C	alarm is enabled	cold junction temp ⩾ 0°C
high temperature	N7:410/8-15*	C ⩾ high temp limit	alarm and loop PID enabled	C⩽high temp limit – deadband
low temperature	N7:410/0-7**	C ⩽ low temp limit	alarm and loop PID enabled	C⩾low temp limit + deadband
high deviation	N7:411/8-15*	SP–C⩽ –high deviation value	alarm and loop PID enabled	SP–C⩾ –high deviation + deadband
low deviation	N7:411/0–7**	SP–C⩾ +low deviation value	alarm and loop PID enabled	SP–C⩽ +low deviation – deadband

*** for the module **bit 0-7 for loop 1-8, respectively * bit 8–15 for loop 1-8, respectively

Program Addr:	Word:	Bits:	Description:
350	0	0–15	**Block Identification Code** — 1000 1000 1111 1111 ($88FF_{16}$) (-30465_{10})
351	1	0	**Loop-1 Control Enabled** 0 = Loop 1 control is disabled. 1 = Loop 1 control is enabled.
		1	**Loop-1 Auto/Manual Mode Selected** — (controlled by bit 1 of word 1 of the dynamic block) 0 = Loop 1 is in the manual mode — manual output value (word 4, dynamic block) is used as M value. 1 = Loop 1 is in the automatic mode — PID algorithm generates the M value.
		2	**Loop-1 Open Circuit** 0 = Loop-1 thermocouple circuit is closed (connection OK). 1 = Loop-1 thermocouple circuit is open (connection broken).
		3	**Loop-1 Configuration Block Parameters Valid** 0 = Power has been interrupted since valid config block parameters for loop 1 were block-transferred. 1 = Valid configuration block parameters for loop 1 **have** been block-transferred after last loss of power.
		4	**Loop-1 Calibration Fault** 0 = Loop-1 calibration is OK. 1 = Loop-1 has bad calibration data and is running uncalibrated.
		5	**Loop-1 Set-Point Selection** — (controlled by bit 2 of word 1 of the dynamic block) 0 = The standby-temperature set-point value from word 2 of the dynamic block is selected. 1 = The run-temperature set-point value from word 3 of the dynamic block is selected.
		6	**Loop-1 Parameter Value Error** 0 = Loop-1 parameter values OK. 1 = Loop-1 parameter value error.
		7	**Loop-1 Auto-Tuning Complete** 0 = Loop-1 auto-tuning **is not** complete. 1 = Loop-1 auto-tuning **is** complete.
		8	**Loop-1 Setpoint Ramp Direction** (used with bit 13) 0 = Loop-1 ramp direction is down. 1 = Loop-1 ramp direction is up.
		9	**Loop-1 C Rate Alarm** 0 = Loop-1 rate of temperature increase is below or equal to the alarm value. 1 = Loop-1 rate of temperature increase is above alarm value from word 15 of configuration block.
		10	**Loop-1 Thermal Integrity** — (set in words 21 and 22 of the configuration block) 0 = Loop-1 response meets the thermal integrity rate. 1 = Loop-1 has lost thermal integrity and the M value has been forced.
		11	**Loop-1 High M Limit** — (set in word 6 of the configuration block) 0 = Loop-1 M value is below the high M limit. 1 = Loop-1 M value is at the high M limit.
		12	**Loop-1 Low M Limit** — (set in word 7 of the configuration block) 0 = Loop-1 M value is above the low M limit. 1 = Loop-1 M value is at the low M limit.
		13	**Loop-1 Set-Point Ramping** — (selected in bit 4 of word 2 of the configuration block) 0 = Loop-1 set point is not ramping. 1 = Loop-1 set-point is ramping at the rate entered in word 3 of the configuration block.
		14	**Loop-1 Input High TC Range Alarm** — (based on TC type set in bits 12–15 of word 1 of configuration block) 0 = Loop-1 C input is below the high TC-range alarm value. 1 = Loop-1 C input is at or above the high TC-range alarm value.
		15	**Loop-1 Input Low TC-Range Alarm** — (based on TC type set in bits 12–15 of word 1 of configuration block) 0 = Loop-1 C input is above the low TC-range alarm value. 1 = Loop-1 C input is at or below the low TC-range alarm value.
352	2	0–15	**Loop-1 Configuration and Gains Block Error Pointers** — Indicates words containing data-entry errors (out-of-range value or incompatible bit selection). (See chapter 10 for locating errors.) 0 = No error detected in configuration or gains block for the loop. 2-23 = configuration-block error pointer to by lower pair of digits (yy): error in word yy–1 2-57 = gains-block error pointed to by upper pair of digits (**xx**): error in word **xx**–1
353	3	0–15	**Loop-1 Dynamic Block and Auto-Tuning Pointers** — Indicates Dynamic block words containing data-entry errors (out-of-range value or incompatible bit selection) or auto-tuning alarms detected by module (chapter 10). 0 = No error detected in dynamic block or in auto-tuning for the loop. 2-34 = dynamic-block error pointed to by lower pair of digits (yy): error in word yy–1 65-72 = auto-tuning alarm code in upper pair of digits: see lookup table, chapter 10.

Program Addr:	Word:	Bits:	Description:
354	4	0	**Loop-2 Control Enabled** 0 = Loop 2 control is disabled. 1 = Loop 2 control is enabled.
		1	**Loop-2 Auto/Manual Mode Selected** — (controlled by bit 1 of word 5 of the dynamic block) 0 = Loop 2 is in the manual mode — manual output value (word 8, dynamic block) is used as M value. 1 = Loop 2 is in the automatic mode — PID algorithm generates the M value.
		2	**Loop-1 Open Circuit** 0 = Loop-2 thermocouple circuit is closed (connection OK). 1 = Loop-2 thermocouple circuit is open (connection broken).
		3	**Loop-1 Configuration Block Parameters Valid** 0 = Power has been interrupted since valid config block parameters for loop 2 were block-transferred. 1 = Valid configuration block parameters for loop 2 **have** been block-transferred after last loss of power.
		4	**Loop-2 Calibration Fault** 0 = Loop-2 calibration is OK. 1 = Loop-2 has bad calibration data and is running uncalibrated.
		5	**Loop-2 Set-Point Selection** — (controlled by bit 2 of word 5 of the dynamic block) 0 = The standby-temperature set-point value from word 6 of the dynamic block is selected. 1 = The run-temperature set-point value from word 7 of the dynamic block is selected.
		6	**Loop-2 Parameter Value Error** 0 = Loop-2 parameter values OK. 1 = Loop-2 parameter value error.
		7	**Loop-2 Auto-Tuning Complete** 0 = Loop-2 auto-tuning **is not** complete. 1 = Loop-2 auto-tuning **is** complete.
		8	**Loop-2 Setpoint Ramp Direction** (used with bit 13) 0 = Loop-2 ramp direction is down. 1 = Loop-2 ramp direction is up.
		9	**Loop-2 C Rate Alarm** 0 = Loop-2 rate of temperature increase is below or equal to the alarm value. 1 = Loop-2 rate of temperature increase is above alarm value from word 15 of configuration block.
		10	**Loop-2 Thermal Integrity** — (set in words 21 and 22 of the configuration block) 0 = Loop-2 response meets the thermal integrity rate. 1 = Loop-2 has lost thermal integrity and the M value has been forced.
		11	**Loop-2 High M Limit** — (set in word 6 of the configuration block) 0 = Loop-2 M value is below the high M limit. 1 = Loop-2 M value is at the high M limit.
		12	**Loop-2 Low M Limit** — (set in word 7 of the configuration block) 0 = Loop-2 M value is above the low M limit. 1 = Loop-2 M value is at the low M limit.
		13	**Loop-2 Set-Point Ramping** — (selected in bit 4 of word 2 of the configuration block) 0 = Loop-2 set point is not ramping. 1 = Loop-2 set-point is ramping at the rate entered in word 3 of the configuration block.
		14	**Loop-2 Input High TC Range Alarm** — (based on TC type set in bits 12–15 of word 1 of configuration block) 0 = Loop-2 C input is below the high TC-range alarm value. 1 = Loop-2 C input is at or above the high TC-range alarm value.
		15	**Loop-2 Input Low TC-Range Alarm** — (based on TC type set in bits 12–15 of word 1 of configuration block) 0 = Loop-2 C input is above the low TC-range alarm value. 1 = Loop-2 C input is at or below the low TC-range alarm value.
355	5	0–15	**Loop-2 Configuration and Gains Block Error Pointers** — Indicates words containing data-entry errors (out-of-range value or incompatible bit selection). (See chapter 10 for locating errors.) 0 = No error detected in configuration or gains block for the loop. 2-23 = configuration-block error pointer to by lower pair of digits (yy): error in word yy–1 2-57 = gains-block error pointed to by upper pair of digits (xx): error in word xx–1
356	6	0–15	**Loop-2 Dynamic Block and Auto-Tuning Pointers** — Indicates Dynamic block words containing data-entry errors (out-of-range value or incompatible bit selection) or auto-tuning alarms detected by module (chapter 10). 0 = No error detected in dynamic block or in auto-tuning for the loop. 2-34 = dynamic-block error pointed to by lower pair of digits (yy): error in word yy–1 65-72 = auto-tuning alarm code in upper pair of digits: see lookup table, chapter 10.

Program Addr:	Word:	Bits:	Description:
357	7	0	**Loop-3 Control Enabled** 0 = Loop 3 control is disabled. 1 = Loop 3 control is enabled.
		1	**Loop-3 Auto/Manual Mode Select** — (controlled by bit 1 of word 9 of the dynamic block) 0 = Loop 3 is in the manual mode — manual output value (word 12, dynamic block) is used as the M value. 1 = Loop 3 is in the automatic mode — the PID algorithm generates the M value.
		2	**Loop-3 Open Circuit** 0 = Loop-3 thermocouple circuit is closed (connection OK). 1 = Loop-3 thermocouple circuit is open (connection broken).
		3	**Loop-3 Configuration Block Parameters Valid** 0 = Power has been interrupted since valid config block parameters for loop 3 have been block-transferred. 1 = Valid configuration block parameters for loop 3 **have** been block-transferred since last loss of power .
		4	**Loop-3 Calibration Fault** 0 = Loop-3 calibration is OK. 1 = Loop-3 has bad calibration data and is running uncalibrated.
		5	**Loop-3 Set-Point Selection** — (controlled by bit 2 of word 9 of the dynamic block) 0 = The standby-temperature set-point value from word 10 of the dynamic block is selected. 1 = The run-temperature set-point value from word 11 of the dynamic block is selected.
		6	**Loop-3 Parameter Value Error** 0 = Loop-3 parameter values OK. 1 = Loop-3 parameter value error.
		7	**Loop-3 Auto-Tuning Complete** 0 = Loop-3 auto-tuning **is not** complete. 1 = Loop-3 auto-tuning **is** complete.
		8	**Loop-3 Setpoint Ramp Direction** (used with bit 13) 0 = Loop-3 ramp direction is down. 1 = Loop-3 ramp direction is up.
		9	**Loop-3 M Rate Alarm** 0 = Loop-3 rate of temperature increase is below or equal to the alarm value. 1 = Loop-3 rate of temperature increase is above the alarm value from word 15 of the configuration block.
		10	**Loop-3 Thermal Integrity** — (set in words 21 and 22 of the configuration block) 0 = Loop-3 response meets the thermal integrity rate. 1 = Loop-3 has lost thermal integrity and the M value has been forced.
		11	**Loop-3 High M Limit** — (set in word 6 of the configuration block) 0 = Loop-3 M value is below the high M limit. 1 = Loop-3 M value is at the high M limit.
		12	**Loop-3 Low M Limit** — (set in word 7 of the configuration block) 0 = Loop-3 M value is above the low M limit. 1 = Loop-3 M value is at the low M limit.
		13	**Loop-3 Set-Point Ramping** — (selected in bit 4 of word 2 of the configuration block) 0 = Loop-3 set point is not ramping. 1 = Loop-3 set point is ramping at the rate entered in word 3 of the configuration block.
		14	**Loop-3 Input High TC Range Alarm** — (based on TC type set in bits 12–15 of word 1 of configuration block) 0 = Loop-3 C input is below the high TC-range alarm value. 1 = Loop-3 C input is at or above the high TC-range alarm value.
		15	**Loop-3 Input Low TC-Range Alarm** — (based on thermocouple type set in bits 12–15 of word 1 of the configuration block) 0 = Loop-3 C input is above the low TC-range alarm value. 1 = Loop-3 C input is at or below the low TC-range alarm value.
358	8	0–15	**Loop-3 Configuration and Gains Block Error Pointers** — Indicates words containing data-entry errors (out-of-range value or incompatible bit selection). (See chapter 10 for locating errors.) 0 = No error detected in configuration or gains block for the loop. 2-23 = configuration-block error pointer to by lower pair of digits (yy): error in word yy–1 2-57 = gains-block error pointed to by upper pair of digits (**xx**): error in word **xx**–1
359	9	0–15	**Loop-3 Dynamic Block and Auto-Tuning Pointers** — Indicates Dynamic block words containing data-entry errors (out-of-range value or incompatible bit selection) or auto-tuning alarms detected by module (chapter 10). 0 = No error detected in dynamic block or in auto-tuning for the loop. 2-34 = dynamic-block error pointed to by lower pair of digits (yy): error in word yy–1 65-72 = auto-tuning alarm code in upper pair of digits: see lookup table, chapter 10.

Program Addr:	Word:	Bits:	Description:
360	10	0	**Loop-4 Control Enabled** 0 = Loop 4 control is disabled. 1 = Loop 4 control is enabled.
		1	**Loop-4 Auto/Manual Mode Selected** — (controlled by bit 1 of word 13 of the dynamic block) 0 = Loop 4 is in the manual mode — manual output value (word 16, dynamic block) is used as M value. 1 = Loop 4 is in the automatic mode — PID algorithm generates the M value.
		2	**Loop-44 Open Circuit** 0 = Loop-4 thermocouple circuit is closed (connection OK). 1 = Loop-4 thermocouple circuit is open (connection broken).
		3	**Loop-4 Configuration Block Parameters Valid** 0 = Power has been interrupted since valid config block parameters for loop 4 were block-transferred. 1 = Valid configuration block parameters for loop 4 **have** been block-transferred after last loss of power.
		4	**Loop-4 Calibration Fault** 0 = Loop-4 calibration is OK. 1 = Loop-4 has bad calibration data and is running uncalibrated.
		5	**Loop-4 Set-Point Selection** — (controlled by bit 2 of word 13 of the dynamic block) 0 = The standby-temperature set-point value from word14 of the dynamic block is selected. 1 = The run-temperature set-point value from word 15 of the dynamic block is selected.
		6	**Loop-44 Parameter Value Error** 0 = Loop-4 parameter values OK. 1 = Loop-4 parameter value error.
		7	**Loop-4 Auto-Tuning Complete** 0 = Loop-4 auto-tuning **is not** complete. 1 = Loop-4 auto-tuning **is** complete.
		8	**Loop-4 Setpoint Ramp Direction** (used with bit 13) 0 = Loop-4 ramp direction is down. 1 = Loop-4 ramp direction is up.
		9	**Loop-4 C Rate Alarm** 0 = Loop-4 rate of temperature increase is below or equal to the alarm value. 1 = Loop-4 rate of temperature increase is above alarm value from word 15 of configuration block.
		10	**Loop-4 Thermal Integrity** — (set in words 21 and 22 of the configuration block) 0 = Loop-4 response meets the thermal integrity rate. 1 = Loop-4 has lost thermal integrity and the M value has been forced.
		11	**Loop-4 High M Limit** — (set in word 6 of the configuration block) 0 = Loop-4 M value is below the high M limit. 1 = Loop-4 M value is at the high M limit.
		12	**Loop-4 Low M Limit** — (set in word 7 of the configuration block) 0 = Loop-4 M value is above the low M limit. 1 = Loop-4 M value is at the low M limit.
		13	**Loop-4 Set-Point Ramping** — (selected in bit 4 of word 2 of the configuration block) 0 = Loop-4 set point is not ramping. 1 = Loop-4 set-point is ramping at the rate entered in word 3 of the configuration block.
		14	**Loop-4 Input High TC Range Alarm** — (based on TC type set in bits 12–15 of word 1 of configuration block) 0 = Loop-4 C input is below the high TC-range alarm value. 1 = Loop-4 C input is at or above the high TC-range alarm value.
		15	**Loop-4 Input Low TC-Range Alarm** — (based on TC type set in bits 12–15 of word 1 of configuration block) 0 = Loop-4 C input is above the low TC-range alarm value. 1 = Loop-4 C input is at or below the low TC-range alarm value.
361	11	0–15	**Loop-4 Configuration and Gains Block Error Pointers** — Indicates words containing data-entry errors (out-of-range value or incompatible bit selection). (See chapter 10 for locating errors.) 0 = No error detected in configuration or gains block for the loop. 2-23 = configuration-block error pointer to by lower pair of digits (yy): error in word yy–1 2-57 = gains-block error pointed to by upper pair of digits (xx): error in word xx–1
362	12	0–15	**Loop-4 Dynamic Block and Auto-Tuning Pointers** — Indicates Dynamic block words containing data-entry errors (out-of-range value or incompatible bit selection) or auto-tuning alarms detected by module (chapter 10). 0 = No error detected in dynamic block or in auto-tuning for the loop. 2-34 = dynamic-block error pointed to by lower pair of digits (yy): error in word yy–1 65-72 = auto-tuning alarm code in upper pair of digits: see lookup table, chapter 10.

Program Addr:	Word:	Bits:	Description:
363	13	0	**Loop-5 Control Enabled** 0 = Loop 5 control is disabled. 1 = Loop 5 control is enabled.
		1	**Loop-5 Auto/Manual Mode Selected** — (controlled by bit 1 of word 17 of the dynamic block) 0 = Loop 5 is in the manual mode — manual output value (word 20, dynamic block) is used as M value. 1 = Loop 5 is in the automatic mode — PID algorithm generates the M value.
		2	**Loop-5 Open Circuit** 0 = Loop-5 thermocouple circuit is closed (connection OK). 1 = Loop-5 thermocouple circuit is open (connection broken).
		3	**Loop-5 Configuration Block Parameters Valid** 0 = Power has been interrupted since valid config block parameters for loop 5 were block-transferred. 1 = Valid configuration block parameters for loop 5 **have** been block-transferred after last loss of power.
		4	**Loop-5 Calibration Fault** 0 = Loop-5 calibration is OK. 1 = Loop-5 has bad calibration data and is running uncalibrated.
		5	**Loop-5 Set-Point Selection** — (controlled by bit 2 of word 1 of the dynamic block) 0 = The standby-temperature set-point value from word 2 of the dynamic block is selected. 1 = The run-temperature set-point value from word 3 of the dynamic block is selected.
		6	**Loop-5 Parameter Value Error** 0 = Loop-5 parameter values OK. 1 = Loop-5 parameter value error.
		7	**Loop-5 Auto-Tuning Complete** 0 = Loop-5 auto-tuning **is not** complete. 1 = Loop-5 auto-tuning **is** complete.
		8	**Loop-5 Setpoint Ramp Direction** (used with bit 13) 0 = Loop-5 ramp direction is down. 1 = Loop-5 ramp direction is up.
		9	**Loop-5 C Rate Alarm** 0 = Loop-5 rate of temperature increase is below or equal to the alarm value. 1 = Loop-55 rate of temperature increase is above alarm value from word 15 of configuration block.
		10	**Loop-5 Thermal Integrity** — (set in words 21 and 22 of the configuration block) 0 = Loop-5 response meets the thermal integrity rate. 1 = Loop-5 has lost thermal integrity and the M value has been forced.
		11	**Loop-5 High M Limit** — (set in word 6 of the configuration block) 0 = Loop-5 M value is below the high M limit. 1 = Loop-5 M value is at the high M limit.
		12	**Loop-5 Low M Limit** — (set in word 7 of the configuration block) 0 = Loop-5 M value is above the low M limit. 1 = Loop-5 M value is at the low M limit.
		13	**Loop-5 Set-Point Ramping** — (selected in bit 4 of word 2 of the configuration block) 0 = Loop-5 set point is not ramping. 1 = Loop-5 set-point is ramping at the rate entered in word 3 of the configuration block.
		14	**Loop-5 Input High TC Range Alarm** — (based on TC type set in bits 12–15 of word 1 of configuration block) 0 = Loop-5 C input is below the high TC-range alarm value. 1 = Loop-5 C input is at or above the high TC-range alarm value.
		15	**Loop-5 Input Low TC-Range Alarm** — (based on TC type set in bits 12–15 of word 1 of configuration block) 0 = Loop-5 C input is above the low TC-range alarm value. 1 = Loop-5 C input is at or below the low TC-range alarm value.
364	14	0–15	**Loop-5 Configuration and Gains Block Error Pointers** — Indicates words containing data-entry errors (out-of-range value or incompatible bit selection). (See chapter 10 for locating errors.) 0 = No error detected in configuration or gains block for the loop. 2-23 = configuration-block error pointer to by lower pair of digits (yy): error in word yy–1 2-57 = gains-block error pointed to by upper pair of digits (**xx**): error in word **xx**–1
365	15	0–15	**Loop-5 Dynamic Block and Auto-Tuning Pointers** — Indicates Dynamic block words containing data-entry errors (out-of-range value or incompatible bit selection) or auto-tuning alarms detected by module (chapter 10). 0 = No error detected in dynamic block or in auto-tuning for the loop. 2-34 = dynamic-block error pointed to by lower pair of digits (yy): error in word yy–1 65-72 = auto-tuning alarm code in upper pair of digits: see lookup table, chapter 10.

Program Addr:	Word:	Bits:	Description:
366	16	0	**Loop-6 Control Enabled** 0 = Loop 6 control is disabled. 1 = Loop 6 control is enabled.
		1	**Loop-6 Auto/Manual Mode Selected** — (controlled by bit 1 of word 21 of the dynamic block) 0 = Loop 6 is in the manual mode — manual output value (word 24, dynamic block) is used as M value. 1 = Loop 6 is in the automatic mode — PID algorithm generates the M value.
		2	**Loop-6 Open Circuit** 0 = Loop-6 thermocouple circuit is closed (connection OK). 1 = Loop-6 thermocouple circuit is open (connection broken).
		3	**Loop-6 Configuration Block Parameters Valid** 0 = Power has been interrupted since valid config block parameters for loop 16 were block-transferred. 1 = Valid configuration block parameters for loop 6 **have** been block-transferred after last loss of power.
		4	**Loop-6 Calibration Fault** 0 = Loop-6 calibration is OK. 1 = Loop-6 has bad calibration data and is running uncalibrated.
		5	**Loop-6 Set-Point Selection** — (controlled by bit 2 of word 21 of the dynamic block) 0 = The standby-temperature set-point value from word 22 of the dynamic block is selected. 1 = The run-temperature set-point value from word 23 of the dynamic block is selected.
		6	**Loop-6 Parameter Value Error** 0 = Loop-6 parameter values OK. 1 = Loop-6 parameter value error.
		7	**Loop-6 Auto-Tuning Complete** 0 = Loop-6 auto-tuning **is not** complete. 1 = Loop-6 auto-tuning **is** complete.
		8	**Loop-6 Setpoint Ramp Direction** (used with bit 13) 0 = Loop-6 ramp direction is down. 1 = Loop-6 ramp direction is up.
		9	**Loop-6 C Rate Alarm** 0 = Loop-6 rate of temperature increase is below or equal to the alarm value. 1 = Loop-6 rate of temperature increase is above alarm value from word 15 of configuration block.
		10	**Loop-6 Thermal Integrity** — (set in words 21 and 22 of the configuration block) 0 = Loop-6 response meets the thermal integrity rate. 1 = Loop-6 has lost thermal integrity and the M value has been forced.
		11	**Loop-6 High M Limit** — (set in word 6 of the configuration block) 0 = Loop-6 M value is below the high M limit. 1 = Loop-6 M value is at the high M limit.
		12	**Loop-6 Low M Limit** — (set in word 7 of the configuration block) 0 = Loop-6 M value is above the low M limit. 1 = Loop-6 M value is at the low M limit.
		13	**Loop-6 Set-Point Ramping** — (selected in bit 4 of word 2 of the configuration block) 0 = Loop-6 set point is not ramping. 1 = Loop-6 set-point is ramping at the rate entered in word 3 of the configuration block.
		14	**Loop-6 Input High TC Range Alarm** — (based on TC type set in bits 12–15 of word 1 of configuration block) 0 = Loop-6 C input is below the high TC-range alarm value. 1 = Loop-6 C input is at or above the high TC-range alarm value.
		15	**Loop-6 Input Low TC-Range Alarm** — (based on TC type set in bits 12–15 of word 1 of configuration block) 0 = Loop-6 C input is above the low TC-range alarm value. 1 = Loop-6 C input is at or below the low TC-range alarm value.
367	17	0–15	**Loop-6 Configuration and Gains Block Error Pointers** — Indicates words containing data-entry errors (out-of-range value or incompatible bit selection). (See chapter 10 for locating errors.) 0 = No error detected in configuration or gains block for the loop. 2-23 = configuration-block error pointer to by lower pair of digits (yy): error in word yy–1 2-57 = gains-block error pointed to by upper pair of digits (xx): error in word xx–1
368	18	0–15	**Loop-6 Dynamic Block and Auto-Tuning Pointers** — Indicates Dynamic block words containing data-entry errors (out-of-range value or incompatible bit selection) or auto-tuning alarms detected by module (chapter 10). 0 = No error detected in dynamic block or in auto-tuning for the loop. 2-34 = dynamic-block error pointed to by lower pair of digits (yy): error in word yy–1 65-72 = auto-tuning alarm code in upper pair of digits: see lookup table, chapter 10.

Program Addr:	Word:	Bits:	Description:
369	19	0	**Loop-7 Control Enabled** 0 = Loop 7 control is disabled. 1 = Loop 7 control is enabled.
		1	**Loop-7 Auto/Manual Mode Selected** — (controlled by bit 1 of word 25 of the dynamic block) 0 = Loop 7 is in the manual mode — manual output value (word 28, dynamic block) is used as M value. 1 = Loop 7 is in the automatic mode — PID algorithm generates the M value.
		2	**Loop-7 Open Circuit** 0 = Loop-7 thermocouple circuit is closed (connection OK). 1 = Loop-7 thermocouple circuit is open (connection broken).
		3	**Loop-7 Configuration Block Parameters Valid** 0 = Power has been interrupted since valid config block parameters for loop 7 were block-transferred. 1 = Valid configuration block parameters for loop 7 **have** been block-transferred after last loss of power.
		4	**Loop-7 Calibration Fault** 0 = Loop-7 calibration is OK. 1 = Loop-7 has bad calibration data and is running uncalibrated.
		5	**Loop-7 Set-Point Selection** — (controlled by bit 2 of word 25 of the dynamic block) 0 = The standby-temperature set-point value from word 26 of the dynamic block is selected. 1 = The run-temperature set-point value from word 27 of the dynamic block is selected.
		6	**Loop-7 Parameter Value Error** 0 = Loop-7 parameter values OK. 1 = Loop-7 parameter value error.
		7	**Loop-7 Auto-Tuning Complete** 0 = Loop-7 auto-tuning **is not** complete. 1 = Loop-7 auto-tuning **is** complete.
		8	**Loop-7 Setpoint Ramp Direction** (used with bit 13) 0 = Loop-7 ramp direction is down. 1 = Loop-7 ramp direction is up.
		9	**Loop-7 C Rate Alarm** 0 = Loop-7 rate of temperature increase is below or equal to the alarm value. 1 = Loop-7 rate of temperature increase is above alarm value from word 15 of configuration block.
		10	**Loop-7 Thermal Integrity** — (set in words 21 and 22 of the configuration block) 0 = Loop-7 response meets the thermal integrity rate. 1 = Loop-7 has lost thermal integrity and the M value has been forced.
		11	**Loop-7 High M Limit** — (set in word 6 of the configuration block) 0 = Loop-7 M value is below the high M limit. 1 = Loop-7 M value is at the high M limit.
		12	**Loop-7 Low M Limit** — (set in word 7 of the configuration block) 0 = Loop-7 M value is above the low M limit. 1 = Loop-7 M value is at the low M limit.
		13	**Loop-7 Set-Point Ramping** — (selected in bit 4 of word 2 of the configuration block) 0 = Loop-7 set point is not ramping. 1 = Loop-7 set-point is ramping at the rate entered in word 3 of the configuration block.
		14	**Loop-7 Input High TC Range Alarm** — (based on TC type set in bits 12–15 of word 1 of configuration block) 0 = Loop-7 C input is below the high TC-range alarm value. 1 = Loop-7 C input is at or above the high TC-range alarm value.
		15	**Loop-7 Input Low TC-Range Alarm** — (based on TC type set in bits 12–15 of word 1 of configuration block) 0 = Loop-7 C input is above the low TC-range alarm value. 1 = Loop-7 C input is at or below the low TC-range alarm value.
370	20	0–15	**Loop-7 Configuration and Gains Block Error Pointers** — Indicates words containing data-entry errors (out-of-range value or incompatible bit selection). (See chapter 10 for locating errors.) 0 = No error detected in configuration or gains block for the loop. 2-23 = configuration-block error pointer to by lower pair of digits (yy): error in word yy–1 2-57 = gains-block error pointed to by upper pair of digits (**xx**): error in word **xx**–1
371	21	0–15	**Loop-7 Dynamic Block and Auto-Tuning Pointers** — Indicates Dynamic block words containing data-entry errors (out-of-range value or incompatible bit selection) or auto-tuning alarms detected by module (chapter 10). 0 = No error detected in dynamic block or in auto-tuning for the loop. 2-34 = dynamic-block error pointed to by lower pair of digits (yy): error in word yy–1 65-72 = auto-tuning alarm code in upper pair of digits: see lookup table, chapter 10.

Program Addr:	Word:	Bits:	Description:
372	22	0	**Loop-8 Control Enabled** 0 = Loop 8 control is disabled. 1 = Loop 8 control is enabled.
		1	**Loop-8 Auto/Manual Mode Selected** — (controlled by bit 1 of word 29 of the dynamic block) 0 = Loop 8 is in the manual mode — manual output value (word 32, dynamic block) is used as M value. 1 = Loop 8 is in the automatic mode — PID algorithm generates the M value.
		2	**Loop-8 Open Circuit** 0 = Loop-8 thermocouple circuit is closed (connection OK). 1 = Loop-88 thermocouple circuit is open (connection broken).
		3	**Loop-8 Configuration Block Parameters Valid** 0 = Power has been interrupted since valid config block parameters for loop 8 were block-transferred. 1 = Valid configuration block parameters for loop 8 **have** been block-transferred after last loss of power.
		4	**Loop-8 Calibration Fault** 0 = Loop-8 calibration is OK. 1 = Loop-8 has bad calibration data and is running uncalibrated.
		5	**Loop-8 Set-Point Selection** — (controlled by bit 2 of word 29 of the dynamic block) 0 = The standby-temperature set-point value from word 30 of the dynamic block is selected. 1 = The run-temperature set-point value from word 31 of the dynamic block is selected.
		6	**Loop-8 Parameter Value Error** 0 = Loop-8 parameter values OK. 1 = Loop-8 parameter value error.
		7	**Loop-8 Auto-Tuning Complete** 0 = Loop-8 auto-tuning **is not** complete. 1 = Loop-8 auto-tuning **is** complete.
		8	**Loop-8 Setpoint Ramp Direction** (used with bit 13) 0 = Loop-8 ramp direction is down. 1 = Loop-8 ramp direction is up.
		9	**Loop-8 C Rate Alarm** 0 = Loop-8 rate of temperature increase is below or equal to the alarm value. 1 = Loop-8 rate of temperature increase is above alarm value from word 15 of configuration block.
		10	**Loop-8 Thermal Integrity** — (set in words 21 and 22 of the configuration block) 0 = Loop-8 response meets the thermal integrity rate. 1 = Loop-8 has lost thermal integrity and the M value has been forced.
		11	**Loop-8 High M Limit** — (set in word 6 of the configuration block) 0 = Loop-8 M value is below the high M limit. 1 = Loop-8 M value is at the high M limit.
		12	**Loop-8 Low M Limit** — (set in word 7 of the configuration block) 0 = Loop-8 M value is above the low M limit. 1 = Loop-8 M value is at the low M limit.
		13	**Loop-8 Set-Point Ramping** — (selected in bit 4 of word 2 of the configuration block) 0 = Loop-8 set point is not ramping. 1 = Loop-8 set-point is ramping at the rate entered in word 3 of the configuration block.
		14	**Loop-8 Input High TC Range Alarm** — (based on TC type set in bits 12–15 of word 1 of configuration block) 0 = Loop-8 C input is below the high TC-range alarm value. 1 = Loop-8 C input is at or above the high TC-range alarm value.
		15	**Loop-8 Input Low TC-Range Alarm** — (based on TC type set in bits 12–15 of word 1 of configuration block) 0 = Loop-8 C input is above the low TC-range alarm value. 1 = Loop-8 C input is at or below the low TC-range alarm value.
373	23	0–15	**Loop-8 Configuration and Gains Block Error Pointers** — Indicates words containing data-entry errors (out-of-range value or incompatible bit selection). (See chapter 10 for locating errors.) 0 = No error detected in configuration or gains block for the loop. 2-23 = configuration-block error pointer to by lower pair of digits (yy): error in word yy–1 2-57 = gains-block error pointed to by upper pair of digits (xx): error in word xx–1
374	24	0–15	**Loop-8 Dynamic Block and Auto-Tuning Pointers** — Indicates Dynamic block words containing data-entry errors (out-of-range value or incompatible bit selection) or auto-tuning alarms detected by module (chapter 10). 0 = No error detected in dynamic block or in auto-tuning for the loop. 2-34 = dynamic-block error pointed to by lower pair of digits (yy): error in word yy–1 65-72 = auto-tuning alarm code in upper pair of digits: see lookup table, chapter 10.

Program Addr:	Word:	Bits:	Description:
375	25	0	**Loop-1 Heat TPO Bit**
		1	**Loop-2 Heat TPO Bit**
		2	**Loop-3 Heat TPO Bit**
		3	**Loop-4 Heat TPO Bit**
		4	**Loop-5 Heat TPO Bit**
		5	**Loop-6 Heat TPO Bit**
		6	**Loop-7 Heat TPO Bit**
		7	**Loop-8 Heat TPO Bit**
		8	**Loop-1 Cool TPO Bit**
		9	**Loop-2 Cool TPO Bit**
		10	**Loop-3 Cool TPO Bit**
		11	**Loop-4 Cool TPO Bit**
		12	**Loop-5 Cool TPO Bit**
		13	**Loop-6 Cool TPO Bit**
		14	**Loop-7 Cool TPO Bit**
		15	**Loop-8 Cool TPO Bit**
376	26	0–15	**Loop-1 Temperature** — (–3276.7 thru +3276.7, but restricted by thermocouple type and C/F selection)
377	27	0–15	**Loop-2 Temperature** — (–3276.7 thru +3276.7, but restricted by thermocouple type and C/F selection)
378	28	0–15	**Loop-3 Temperature** — (–3276.7 thru +3276.7, but restricted by thermocouple type and C/F selection)
379	29	0–15	**Loop-4 Temperature** — (–3276.7 thru +3276.7, but restricted by thermocouple type and C/F selection)
380	30	0–15	**Loop-5 Temperature** — (–3276.7 thru +3276.7, but restricted by thermocouple type and C/F selection)
381	31	0–15	**Loop-6 Temperature** — (–3276.7 thru +3276.7, but restricted by thermocouple type and C/F selection)
382	32	0–15	**Loop-7 Temperature** — (–3276.7 thru +3276.7, but restricted by thermocouple type and C/F selection)
383	33	0–15	**Loop-8 Temperature** — (–3276.7 thru +3276.7, but restricted by thermocouple type and C/F selection)
384	34	0–15	**Loop-1 M Value** — (–100.00% thru +100.00%)
385	35	0–15	**Loop-2 M Value** — (–100.00% thru +100.00%)
386	36	0–15	**Loop-3 M Value** — (–100.00% thru +100.00%)
387	37	0–15	**Loop-4 M Value** — (–100.00% thru +100.00%)
388	38	0–15	**Loop-5 M Value** — (–100.00% thru +100.00%)
389	39	0–15	**Loop-6 M Value** — (–100.00% thru +100.00%)
390	40	0–15	**Loop-7 M Value** — (–100.00% thru +100.00%)
391	41	0–15	**Loop-8 M Value** — (–100.00% thru +100.00%)
392	42	0–15	**Loop-1 Current Set-Point Value** — (this value reflects ramping if ramping is selected) — (0 thru 3276.7°)
393	43	0–15	**Loop-2 Current Set-Point Value** — (this value reflects ramping if ramping is selected) — (0 thru 3276.7°)
394	44	0–15	**Loop-3 Current Set-Point Value** — (this value reflects ramping if ramping is selected) — (0 thru 3276.7°)
395	45	0–15	**Loop-4 Current Set-Point Value** — (this value reflects ramping if ramping is selected) — (0 thru 3276.7°)
396	46	0–15	**Loop-5 Current Set-Point Value** — (this value reflects ramping if ramping is selected) — (0 thru 3276.7°)
397	47	0–15	**Loop-6 Current Set-Point Value** — (this value reflects ramping if ramping is selected) — (0 thru 3276.7°)
398	48	0–15	**Loop-7 Current Set-Point Value** — (this value reflects ramping if ramping is selected) — (0 thru 3276.7°)
399	49	0–15	**Loop-8 Current Set-Point Value** — (this value reflects ramping if ramping is selected) — (0 thru 3276.7°)
400	50	0–15	**Loop-1 PID Error Value** — (–3276.7° thru +3276.7°)
401	51	0–15	**Loop-2 PID Error Value** — (–3276.7° thru +3276.7°)
402	52	0–15	**Loop-3 PID Error Value** — (–3276.7° thru +3276.7°)
403	53	0–15	**Loop-4 PID Error Value** — (–3276.7° thru +3276.7°)
404	54	0–15	**Loop-5 PID Error Value** — (–3276.7° thru +3276.7°)
405	55	0–15	**Loop-6 PID Error Value** — (–3276.7° thru +3276.7°)
406	56	0–15	**Loop-7 PID Error Value** — (–3276.7° thru +3276.7°)
407	57	0–15	**Loop-8 PID Error Value** — (–3276.7° thru +3276.7°)

Program Addr:	Word:	Bits:	Description:
408	58	0–15	**Cold-Junction-Compensation Temperature** — (0°C thru +70.0°C)(–32.0 thru +158.0°F)
409	59	0	**Cold-Junction-Compensation Temperature Low Alarm** 0 = Cold-junction-compensation temperature is 0°C (32.0°F) or above. 1 = Cold-junction-compensation temperature is below 0°C (32.0°F).
		1	**Cold-Junction-Compensation Temperature High Alarm** 0 = Cold-junction-compensation temperature is 70°C (158.0°F) or below. 1 = Cold-junction-compensation temperature is above 70°C (158.0°F).
		2	**Auto-Tuning in Progress** — (controlled by bit 1 of word 33 of the dynamic block) 0 = Auto-tuning not in progress 1 = Auto-tuning in progress
		3–15	Reserved.
410	60	0	**Loop-1 Input Low Temperature Alarm** — (set in word 16 of the configuration block) 0 = Loop-1 C input is above the low temperature alarm value. 1 = Loop-1 C input is at or below the low temperature alarm value.
		1	**Loop-2 Input Low Temperature Alarm** — (set in word 16 of the configuration block) 0 = Loop-2 C input is above the low temperature alarm value. 1 = Loop-2 C input is at or below the low temperature alarm value.
		2	**Loop-3 Input Low Temperature Alarm** — (set in word 16 of the configuration block) 0 = Loop-3 C input is above the low temperature alarm value. 1 = Loop-3 C input is at or below the low temperature alarm value.
		3	**Loop-4 Input Low Temperature Alarm** — (set in word 16 of the configuration block) 0 = Loop-4 C input is above the low temperature alarm value. 1 = Loop-4 C input is at or below the low temperature alarm value.
		4	**Loop-5 Input Low Temperature Alarm** — (set in word 16 of the configuration block) 0 = Loop-5 C input is above the low temperature alarm value. 1 = Loop-5 C input is at or below the low temperature alarm value.
		5	**Loop-6 Input Low Temperature Alarm** — (set in word 16 of the configuration block) 0 = Loop-6 C input is above the low temperature alarm value. 1 = Loop-6 C input is at or below the low temperature alarm value.
		6	**Loop-7 Input Low Temperature Alarm** — (set in word 16 of the configuration block) 0 = Loop-7 C input is above the low temperature alarm value. 1 = Loop-7 C input is at or below the low temperature alarm value.
		7	**Loop-8 Input Low Temperature Alarm** — (set in word 16 of the configuration block) 0 = Loop-8 C input is above the low temperature alarm value. 1 = Loop-8 C input is at or below the low temperature alarm value.
410	60	8	**Loop-1 Input High Temperature Alarm** — (set in word 17 of the configuration block) 0 = Loop-1 C input is below the high temperature alarm value. 1 = Loop-1 C input is at or above the high temperature alarm value.
		9	**Loop-2 Input High Temperature Alarm** — (set in word 17 of the configuration block) 0 = Loop-2 C input is below the high temperature alarm value. 1 = Loop-2 C input is at or above the high temperature alarm value.
		10	**Loop-3 Input High Temperature Alarm** — (set in word 17 of the configuration block) 0 = Loop-3 C input is below the high temperature alarm value. 1 = Loop-3 C input is at or above the high temperature alarm value.
		11	**Loop-4 Input High Temperature Alarm** — (set in word 17 of the configuration block) 0 = Loop-4 C input is below the high temperature alarm value. 1 = Loop-4 C input is at or above the high temperature alarm value.
		12	**Loop-5 Input High Temperature Alarm** — (set in word 17 of the configuration block) 0 = Loop-4 C input is below the high temperature alarm value. 1 = Loop-4 C input is at or above the high temperature alarm value.
		13	**Loop-6 Input High Temperature Alarm** — (set in word 17 of the configuration block) 0 = Loop-5 C input is below the high temperature alarm value. 1 = Loop-5 C input is at or above the high temperature alarm value.
		14	**Loop-7 Input High Temperature Alarm** — (set in word 17 of the configuration block) 0 = Loop-6 C input is below the high temperature alarm value. 1 = Loop-6 C input is at or above the high temperature alarm value.
		15	**Loop-8 Input High Temperature Alarm** — (set in word 17 of the configuration block) 0 = Loop-7 C input is below the high temperature alarm value. 1 = Loop-7 C input is at or above the high temperature alarm value.

Program Addr:	Word:	Bits:	Description:
411	61	0	**Loop-1 Low Deviation Alarm** — (set in word 18 of the configuration block) 0 = Loop-1 C input is above the low deviation alarm value. 1 = Loop-1 C input is at or below the low deviation alarm value.
		1	**Loop-2 Low Deviation Alarm** — (set in word 18 of the configuration block) 0 = Loop-2 C input is above the low deviation alarm value. 1 = Loop-2 C input is at or below the low deviation alarm value.
		2	**Loop-3 Low Deviation Alarm** — (set in word 18 of the configuration block) 0 = Loop-3 C input is above the low deviation alarm value. 1 = Loop-3 C input is at or below the low deviation alarm value.
		3	**Loop-4 Low Deviation Alarm** — (set in word 18 of the configuration block) 0 = Loop-4 C input is above the low deviation alarm value. 1 = Loop-4 C input is at or below the low deviation alarm value.
		4	**Loop-5 Low Deviation Alarm** — (set in word 18 of the configuration block) 0 = Loop-5 C input is above the low deviation alarm value. 1 = Loop-5 C input is at or below the low deviation alarm value.
		5	**Loop-6 Low Deviation Alarm** — (set in word 18 of the configuration block) 0 = Loop-6 C input is above the low deviation alarm value. 1 = Loop-6 C input is at or below the low deviation alarm value.
		6	**Loop-7 Low Deviation Alarm** — (set in word 18 of the configuration block) 0 = Loop-7 C input is above the low deviation alarm value. 1 = Loop-7 C input is at or below the low deviation alarm value.
		7	**Loop-8 Low Deviation Alarm** — (set in word 18 of the configuration block) 0 = Loop-8 C input is above the low deviation alarm value. 1 = Loop-8 C input is at or below the low deviation alarm value.
		8	**Loop-1 High Deviation Alarm** — (set in word 19 of the configuration block) 0 = Loop-1 C input is below the high deviation alarm value. 1 = Loop-1 C input is at or above the high deviation alarm value.
		9	**Loop-2 High Deviation Alarm** — (set in word 19 of the configuration block) 0 = Loop-2 C input is below the high deviation alarm value. 1 = Loop-2 C input is at or above the high deviation alarm value.
		10	**Loop-3 High Deviation Alarm** — (set in word 19 of the configuration block) 0 = Loop-3 C input is below the high deviation alarm value. 1 = Loop-3 C input is at or above the high deviation alarm value.
		11	**Loop-4 High Deviation Alarm** — (set in word 19 of the configuration block) 0 = Loop-4 C input is below the high deviation alarm value. 1 = Loop-4 C input is at or above the high deviation alarm value.
		12	**Loop-5 High Deviation Alarm** — (set in word 19 of the configuration block) 0 = Loop-5 C input is below the high deviation alarm value. 1 = Loop-5 C input is at or above the high deviation alarm value.
		13	**Loop-6 High Deviation Alarm** — (set in word 19 of the configuration block) 0 = Loop-6 C input is below the high deviation alarm value. 1 = Loop-6 C input is at or above the high deviation alarm value.
		14	**Loop-7 High Deviation Alarm** — (set in word 19 of the configuration block) 0 = Loop-7 C input is below the high deviation alarm value. 1 = Loop-7 C input is at or above the high deviation alarm value.
		15	**Loop-8 High Deviation Alarm** — (set in word 19 of the configuration block) 0 = Loop-8 C input is below the high deviation alarm value. 1 = Loop-8 C input is at or above the high deviation alarm value.

Program Addr:	Word:	Bits:	Description:
412	62	0	**Loop-1 Auto-Tuning successful** 0 = Auto-tuning was not successful for loop-1 1 = Auto-tuning was successful in determining PID gains for loop-1.
		1	**Loop-2 Auto-Tuning successful** 0 = Auto-tuning was not successful for loop-2 1 = Auto-tuning was successful in determining PID gains for loop-2.
		2	**Loop-3 Auto-Tuning successful** 0 = Auto-tuning was not successful for loop-3 1 = Auto-tuning was successful in determining PID gains for loop-3.
		3	**Loop-4 Auto-Tuning successful** 0 = Auto-tuning was not successful for loop-4 1 = Auto-tuning was successful in determining PID gains for loop-4.
		4	**Loop-5 Auto-Tuning successful** 0 = Auto-tuning was not successful for loop-5 1 = Auto-tuning was successful in determining PID gains for loop-5.
		5	**Loop-6 Auto-Tuning successful** 0 = Auto-tuning was not successful for loop-6 1 = Auto-tuning was successful in determining PID gains for loop-6.
		6	**Loop-7 Auto-Tuning successful** 0 = Auto-tuning was not successful for loop-7 1 = Auto-tuning was successful in determining PID gains for loop-7.
		7	**Loop-8 Auto-Tuning successful** 0 = Auto-tuning was not successful for loop-8 1 = Auto-tuning was successful in determining PID gains for loop-8.
		8–15	Reserved.
413	63	0–7	**Firmware Revision** — In ASCII. (1 thru 9)
		8–15	**Firmware Series** — In ASCII. (3)

Calibrating the Module

In this chapter, for calibrating your module, we describe:

- tools and equipment
- when to calibrate
- calibration methods
- indicator operation during calibration
- preparing to calibrate
- write calibration block
- read calibration block
- calibration procedure

Tools and Equipment

In order to calibrate your temperature control module you will need the following tools and equipment:

Tool or Equipment	Description
Precision Voltage Source	0–10V, 1μV resolution
Precision Multimeter	10V, 1μV resolution
Industrial Terminal and Interconnect Cable	Programming terminal for PLC processors

When to Calibrate

The module is shipped factory calibrated. We recommend you recalibrate it after 6 months, then yearly.

Indicator Operation During Calibration

During calibration, the RUN/FLT indicator will turn to green; the CAL/COM indicator will turn to flashing red. The indicators will remain with these indications throughout the calibration procedure.

Preparing to Calibrate

During calibration, the module must communicate with the PLC processor and an industrial terminal (or compatible personal computer). Before calibrating the module, enter ladder logic into processor memory so that it can transfer calibration data to and from the module.

Calibration Write Block

The calibration write block contains 20 words as shown.

Word	Bits	Description
0	0–15	**Block Identification Code** — 1100 1100 0000 0000 ($CC00_{16}$) ($–30720_{10}$)
1	0	**Calibration High/Low** • 0 = Low • 1 = High
	1	**Calibration Clock** — 0-to-1 transition triggers calibration functions
	2–15	Always = 0
2	0–7	**Input Calibration Mask** — Bits 0-7 respectively correspond to loops 1-8 respectively.
	8–15	Always = 0
3-19	0–15	Always = 0

Calibration Read Block

The calibration read block contains 14 words.

Word	Bits	Description
0	0–15	**Block Identification Code** — 1100 0000 0000 0000 ($C000_{16}$) ($–16384_{10}$)
1	0	**Bad Calibration Procedure** • 0 = OK • 1 = Wrong calibration procedure was attempted with the calibration write block.
	1	**Calibration Hardware Failure** • 0 = OK • 1 = Calibration cannot take place due to hardware failure.
	2	**Calibration Reference Out of Range** • 0 = OK • 1 = Incorrect reference signal was used during calibration.
	3–15	Reserved
2	0	**Loop-1 Input Calibration Done**
	1	**Loop-2 Input Calibration Done**
	2	**Loop-3 Input Calibration Done**
	3	**Loop-4 Input Calibration Done**
	4	**Loop-5 Input Calibration Done**
	5	**Loop-6 Input Calibration Done**
	6	**Loop-7 Input Calibration Done**
	7	**Loop-8 Input Calibration Done**
	8–15	Reserved
3	0–15	Reserved
4	0	**Loop-1 Input Calibration Bad**
	1	**Loop-2 Input Calibration Bad**
	2	**Loop-3 Input Calibration Bad**
	3	**Loop-4 Input Calibration Bad**
	4	**Loop-5 Input Calibration Bad**
	5	**Loop-6 Input Calibration Bad**
	6	**Loop-7 Input Calibration Bad**
	7	**Loop-8 Input Calibration Bad**
	8–15	Reserved
5-12	0–15	Reserved

Calibration Procedure

You can calibrate any number of loop input channels, in any order. First, set up a calibration write block as we presented above.

Important: Warm up the module for 30 minutes before calibrating.

1. In the input calibration mask (word 2) of the calibration write block, turn on one bit (0-7) corresponding to the loop you want to calibrate.

2. Apply the low reference signal (for TCM) or resistance (for TCMR) to the input (on the RTP panel) of each loop being calibrated.

TCM Input (mV)	Low Ref.	High Ref.		TCMR Input (Ω)	Low Ref.	High Ref.
between I(+) & R(–)	0.000mV	100.000mV		between O & RI	1.000Ω	649.0Ω

3. In the calibration write block

   A. turn off the calibration high/low bit (word 1, bit 0)

   B. turn on the calibration clock bit (word 1, bit 1)

4. Send (block-transfer write) the calibration write block to the module.

5. In the calibration write block

   A. turn off the calibration high/low bit (word 1, bit 0)

   B. turn off the calibration clock bit (word 1, bit 1)

6. Send (block-transfer write) the calibration write block to the module.

7. Apply the high reference (see table at step 2) to the input of each loop being calibrated.

8. In the calibration write block

   A. turn on the calibration high/low bit (word 1, bit 0)

   B. turn on the calibration clock bit (word 1, bit 1)

9. Send (block-transfer write) the calibration write block to the module.

10. In the calibration write block

   A. turn on the calibration high/low bit (word 1, bit 0)

   B. turn off the calibration clock bit (word 1, bit 1)

11. Send (block-transfer write) the calibration write block to the module.

12. Request (block-transfer read) the calibration read block from the module. It tells you that either the calibration procedure was successful or where the module may have detected an error.

If this bit:	Is:	And:	Is:	Then:
input-calibration-bad (one of loop bits 00-07 in word 4)	Off	corresponding input-calibration-done bit (same bit in word 2)	On	Calibration of that loop is complete. Go to text.
bad-calibration-procedure (bit 00 in word 1)	On	anytime during the procedure	–	An error occurred. Repeat the procedure.
calibration-hardware-fault (bit 01 in word 1)	On	anytime during the procedure	–	Module is faulty. It cannot be calibrated.
calibration reference out-of-range (bit 02 in word 1)	On	input did not calibrate because a reference signal was out of range		Repeat the procedure. Check equipment.

Notes:

Troubleshooting

We describe how to troubleshoot by observing diagnostic indicators and interpreting error codes reported in the system status block.

Diagnostics Reported through the Indicators

At power-up, the module turns the RUN/FLT (run/fault) indicator to red, then checks for:

- correct RAM operation
- EPROM operation
- EEPROM operation

After passing initial diagnostics, the module flashes the run/fault indicator green. The indicator will continue to flash green until it receives a valid loop configuration. Then, it remains green (not flashing) during normal operation. It will turn red if it detects a fault condition. If the run/fault indicator is red, block-transfers will stop.

The lower CAL/COM (calibrate/communication) indicator flashes green when the module is communicating with the processor. The speed of the flashing is dependent upon system speed.

Indicator	When Green	When Red
Run/Fault	**flashes** during initial power-up **continuous** — first valid loop configuration successfully completed	a fault is detected
Calibrate/ Communication	**flashes** during communication between the PLC processor and the module	**flashes** during calibration

Troubleshooting with Indicators

We show indications, probable causes, and recommended actions to correct common faults which may occur.

Indication	Probable Cause	Recommended Action
Both indicators are OFF	No power to module	Check/recycle power to I/O chassis.
	Possible short on the module or LED driver failure.	Replace module.
RUN/FLT red indicator ON	Microprocessor, oscillator or EPROM failure	Replace module.
	If at power–up, indicates RAM or EPROM failure.	Replace module.
	If during operation, indicates possible microprocessor or backplane interface failure.	Replace module.
RUN/FLT indicator is flashing green	Power–up diagnostics successfully completed.	Normal operation.
RUN/FLT indicator is continuous green	Initial loop configuration successfully completed	Normal operation.
CAL/COM indicator is green	Normal operation	None required
CAL/COM indicator is green and RUN/FLT indicator is green but module data is wrong (for example, with cable off, input channel data values are at minimum scale values)	Internal fuse may be bad	Replace module

Locating Errors with the Status Block

The module reports status and specific faults (if they occur) in every block-transfer of status data to the processor. You can design your ladder program to monitor module- and loop-status bits, and to take appropriate action, depending on your application requirements. You may also want to monitor these bits while troubleshooting with your industrial terminal.

If you enter a value out of range or bit selections that conflict with each other, two words per loop in the system status block point to words in data blocks containing the errors.

Pointer for Errors in the Configuration Block and Gains Blocks

The second word of the 3-word grouping for each loop in the system status block points to data entry errors in the configuration and/or gains block. For example, we show the 3-word grouping for loop 1.

Example	Word	Bits	Description
351	1	0	**Reflects bits 00-15 of the Dynamic Block for Loop 1**
352	2	0–15	**Loop-1 Configuration and Gains Block Error Pointers** — Indicates words containing data-entry errors (out-of-range value or incompatible bit selection). (See chapter 10 for locating errors.) • 0 = No error detected in configuration or gains block for the loop. • 2-23 = configuration-block error pointer to by lower pair of digits (yy): error in word yy–1 • 2-57 = gains-block error pointed to by upper pair of digits (xx): error in word xx–1
353	3	0–15	**Loop-1 Dynamic Block and Auto-Tuning Pointers** — Indicates Dynamic block words containing data-entry errors (out-of-range value or incompatible bit selection) or auto-tuning alarms detected by module (chapter 10). • 0 = No error detected in dynamic block or in auto-tuning for the loop. • 2-34 = dynamic-block error pointed to by lower pair of digits (yy): error in word yy–1 • 65-72 = auto-tuning alarm code in upper pair of digits: see lookup table, chapter 10.

Look at word 2. (Also applies to corresponding words for loops 2-8.)

Display of integer value in word 2, 5, 8, 11, 14, 17, 20, or 23 of the status block — **xxyy**

xx: indicates an error in the **gains block**
yy: indicates an error in the **configuration block**

Example:
If 0513 is displayed, the 05 in the upper pair of digits indicates an error in the **gains block.** The 13 in the lower pair of digits indicates an error in the **configuration block**. The table tells you to look for the error in gains block word 04 and configuration block word 12.

If Status Block Word:	Contains a Value:	The Error is:
2 (loop 1) 5 (loop 2) 8 (loop 3) 11 (loop 4) 14 (loop 5) 17 (loop 6) 20 (loop 7) 23 (loop 8)	xx00	not in the configuration block
	xx02 thru xx25	in the **configuration block:** an out-of-range value or incompatible bit selection. Locate the word containing the error by subtracting **1** from the value in **lower two digits**. Example: If value in word 2 is xx13, word 12 contains an error.
	00yy	not in the gains block
	02yy thru 57yy	in the **gains block:** an out-of-range value. Locate the word containing the error by subtracting **1** from the value in the **upper two digits**. Example: If the value in word 2 is 05xx, word 04 (loop-1 cool proportional gain) of the gains block has an out-of-range value.

Pointer for Dynamic-Block Errors and Auto-Tuning Alarms

Look at word 3. (Also applies to corresponding words for loops 2-8.)

The third word of the 3-word grouping for each loop in the system status block points to your data entry errors in the dynamic-block and/or auto-tuning alarms detected by the module.

Display of integer value in word 3, 6, 9, 12, 15, 18, 21, or 24 of the status block —— **xxyy**

- xx: indicates an alarm in the **auto-tuning** process
- yy: indicates an error in the **dynamic block**

Example:
If 6724 is displayed, the 67 in the upper pair of digits indicates an alarm in auto-tuning, and the 24 in the lower pair of digits indicates a data entry error in the **dynamic block.** The table tells you the meaning of auto-tuning alarm code 67, and to look for a data entry error in dynamic block word 23.

If Status Block Word:	Contains a Value:	The Error is:
3 (loop 1) 6 (loop 2) 9 (loop 3) 12 (loop 4) 15 (loop 5) 18 (loop 6) 21 (loop 7) 24 (loop 8)	xx00	not in the dynamic block
	xx02 thru xx34	in the **dynamic block:** an out-of-range value or incompatible bit selection. Locate the word containing the error by subtracting **1** from the value in the **lower two digits**. Example: If value in word 3 is xx24, word 23 contains an error.
	00yy	not in **auto-tuning** the loop.
		Use the following table for module-detected auto-tuning alarms:
	65yy	Auto-tuning terminated because of thermal runaway.
	66yy	Auto-tuning terminated because of thermocouple break.
	67yy	Heat auto-tuning is inhibited because of the starting conditions.
	68yy	Cool auto-tuning is inhibited because of the starting conditions.
	69yy	Set point will be reached before auto-tuning is complete.
	70yy	Too much noise causing time constant to be 0.
	71yy	Very small gain.
	72yy	Set point exceeded before auto-tuning completed.

Notes:

Specifications

General Specifications

Number of PID Loops	8 individually isolated
I/O Chassis Location	any single I/O module slot
A/D Resolution	16 bits or 15 bits plus sign bit
Input Filtering	6-pole low-pass hardware filter
Calibration Interval	6 months, then yearly
Isolation Voltage	Designed to withstand 1000V dc continuous between input channels and between input and backplane connections. Modules are 100% tested at 1200V dc for 1 second between input channels and backplane connections.
Backplane Current Load • **steady-state maximum** • **surge at power turn-on**	**1771-TCM** **1771-TCMR** • 1.1A (1.0A for series B, C, D) 1.3A for series A • 1.5A (1.0A for series B, C, D) 1.5A for series B
Environmental Conditions • **Operating Temperature** • **Rate of Change** • **Storage Temperature** • **Relative Humidity**	 • 0 to 60ºC (32 to 140ºF) • Ambient changes greater than 0.5ºC/minute may degrade performance during periods of change. • –40 to 85ºC (–40 to 185ºF) • 5 to 95% (without condensation)
Connecting Cable(s)	1771-NC6 = 1.8m (6 ft) 1771-NC15 = 4.6m (15 ft)
Keying	Between 26 and 28 Between 32 and 34
Weight	0.8 kg (1.8 lb)
Agency Certification (when product is marked)	• CSA Class I, Division 2 Hazardous • UL listed • CE marked for all applicable directives (series C only)
Default Display Resolution	0.1°C (0.1°F)
Temperature Scale	°C (°F)
Input Impedance	> 10 MΩ
Open Input Detection	upscale
Time to Detect Open Input	5s (maximum)
Input Overvoltage Protection	140V ac rms continuous
Normal Mode Rejection (50/60Hz)	50dB / 60dB (minimum)
Common Mode Rejection (60Hz)	150dB (typical)
Input Bandwidth	9Hz
Update Time (8 loops)	1s
TPO Update Time (block-transfer)	100ms (typical) — 500ms (maximum)
TPO Update Time for heat/cool (single-transfer)	20ms (maximum)
TPO Update Time for heat only (single-transfer)	10ms (maximum)
Settling Time to within 0.1% Full Scale	125ms (maximum)
Non-linearity	0.02% of full range (maximum)

Temperature Specifications (1771-TCM)

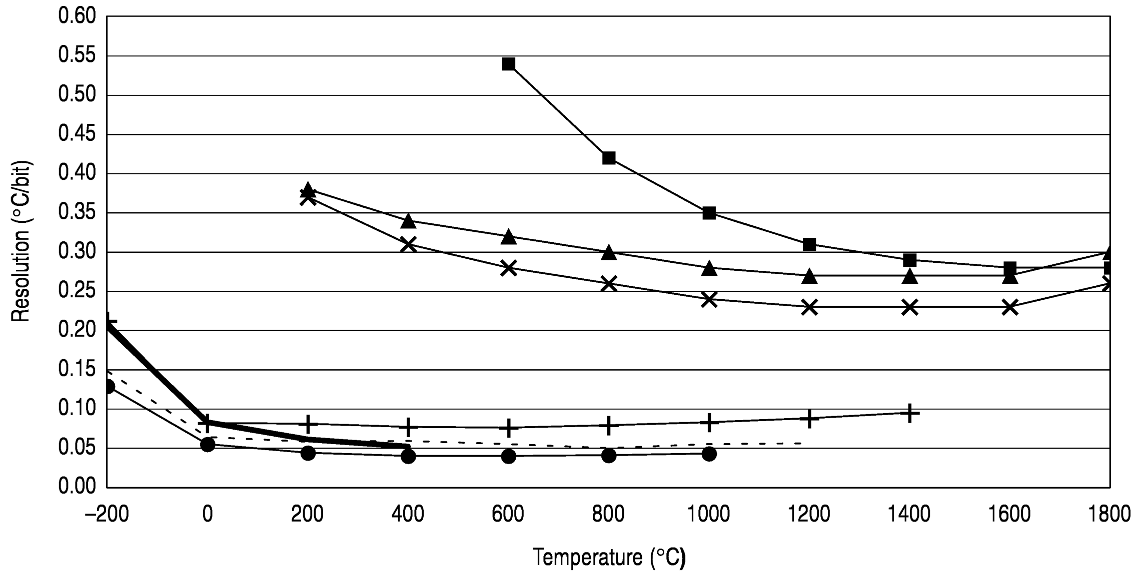
Input Range (selectable)	**Millivolt**: ±105mV
	Thermocouple (TC) Type B: 300 to 1800°C (572 to 3272°F) Type E: –270 to 1000°C (–454 to 1832°F) Type J: –210 to 1200°C (–346 to 2192°F) Type K: –270 to 1372°C (–454 to 2502°F) Type R: –50 to 1768°C (–58 to 3214°F) Type S: –50 to 1768°C (–58 to 3214°F) Type T: –270 to 400°C (–454 to 752°F)
Maximum Input Resolution [1]	3.3µV/bit @ 15 bits with sign bit Type E, J, K, T 0.1°C (0.2°F) [2] Type B, R, S: 0.3°C (0.6°F) [2]
Thermocouple Linearization	IPTS-68 standard, NBS MN-125
Cold Junction Compensation	0 to 70°C ±0.25°C
Open TC Leakage Current	< 10 nA (maximum)
Offset Drift (maximum)	±0.50µV/°C
Gain Drift (maximum)	±35ppm/°C
Accuracy with Calibration (includes non-linearity, gain, offset)	0.01% of full range @ 25°C (typical) 0.05% of full range @ 25°C (maximum)
Calibration Values	0.000 / 100.000mV
Underrange Threshold	–103.0mV
Overrange Threshold	+103.0mV
Rate Alarm Value **Minimum (0.04% FSR)** **Maximum (50% FSR)**	 0.08mV / 0.9°C (1.6°F) per second 100mV / 1050°C (1890°F) per second
Scaling Points → **Default Scaling Values**	–100/+100mV → –100.00/+100.00 –300/+1800°C → –300.0/1800.0 –508/+3272°F → –508.0/3272.0

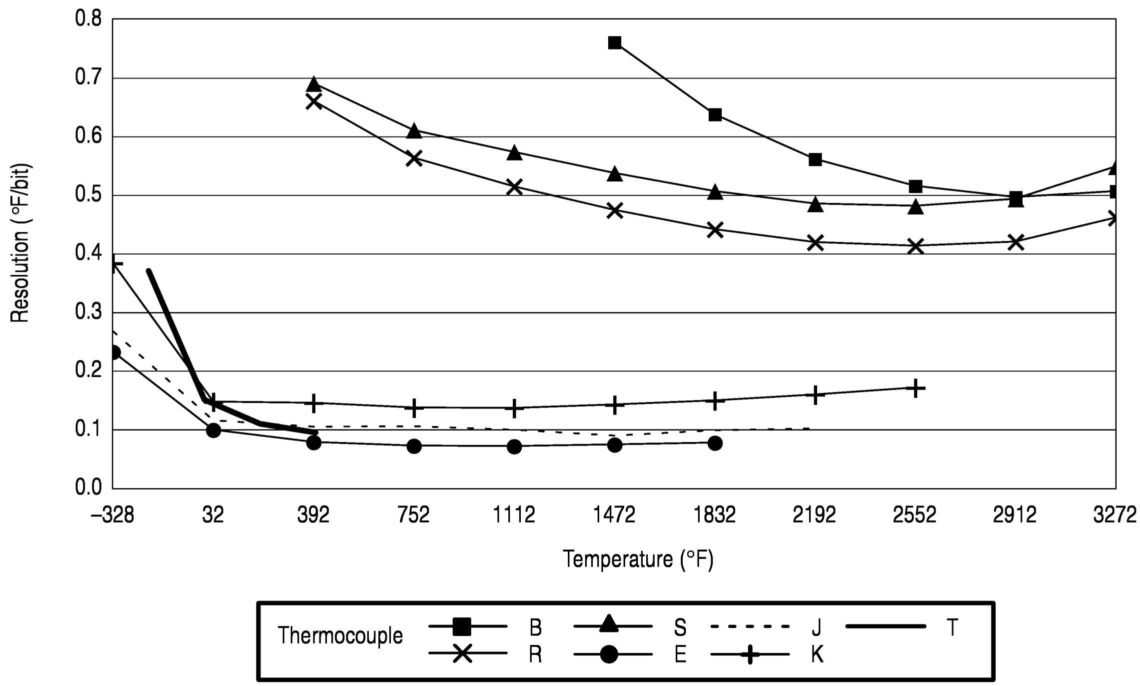
[1] Maximum resolution is obtained by rescaling input data to counts.
[2] These resolutions apply to the commonly used ranges for these thermocouples. See graphs.

Temperature Specifications (1771-TCMR)

Input Range (selectable)	**Resistance Type (RTD)** 100 ohm platinum (Euro) –200 to +870°C (–328 to +1598°F 100 ohm platinum (USA) –200 to +630°C (–328 to +1166°F 120 ohm Nickel –80 to +320°C (–112 to + 608°F 10 ohm copper –200 to + 260°C (–328 to +500°F
Maximum Input Resolution [1]	10mΩ/bit@16 bits unipolar 100ΩPt & 120ΩNi 0.03°C(0.06°F) 10Ω Cu 0.3°C (0.5°F)
RTD excitation current	1mA (typical)
Offset Drift (maximum)	±25mΩ/°C
Gain Drift (maximum)	±50ppm/°C
Accuracy with Calibration (includes non-linearity, gain, offset)	0.025% of full range @ 25°C (typical) 0.05% of full range @ 25°C (maximum)
Calibration Values	1.00 / 649.0Ω
Underrange Threshold	0.9Ω
Overrange Threshold	650Ω
Rate Alarm Value **Minimum (0.04% FSR)** **Maximum (50% FSR)**	 0.26Ω / 0.44°C (0.8°F) per second 325Ω / 550°C (990°F) per second
Scaling Points → **Default Scaling Values**	+1/650Ω → 10/6500 –200/900°C → –2000/9000 –328/1652°F → –3280/16520

Thermocouple Characteristics





Notes:

Default Parameter Values

This appendix lists the module's power-up default parameters stored in the module before any communication occurrs (prior to downloading configuration, gains, or dynamic blocks.) You may want to test the module in the default configuration before you configure it for your application. In default configuration, you can only monitor loops by reading the status block.

For the Configuration Block

Parameter:	Default Value: (bit = 0)
TC Break Detection Configuration	Disable PID loop (M = 0)
Thermal Runaway Configuration	Disable PID loop (M = 0)
Loop Operational Mode	Monitor mode
Thermocouple Type	J
Control Action	E = SP–C
Output Ramping	Disable ramping
Alarm Enable	Suppress all alarms
Auto-Tuning System Response	Medium
Zone Select	Inner zone
Barrel/Non-barrel Control	Barrel control
Input Filter Enable	Disable Filter
Setpoint Ramp Rate	0.00º/min
High Output Limit	100.00%
Low Output Limit	0.00%
Forced Output Value on TC Break	0.00%
Forced Output Value on Thermal Runaway	0.00%
Heat Minimum On Time	0.00s
Heat TPO Period	5s
Cool Minimum On Time	0.00s
Cool TPO Period	5s
Auto-tune Startup Aggressiveness	0
Input Temperature Alarm Rate	Disabled
Low temperature Alarm Value	0.0°
High Temperature Alarm Value	3276.7°
Low Deviation Alarm Value	3276.7°
High Deviation Alarm Value	3276.7°
Temperature Alarm Dead Band	0.0°
Thermal Runaway Temperature Change Value	5°
Thermal Runaway Period	20 minutes
RTD Type	000 ohms
Non-barrel Auto-tune Disturbance Size	0.00
Time Constant for Input Filter	0.0

For the Gains Block

Parameter:	Default Value:
Proportional Gain	0.00
Integral Gain	0.0000
Derivative Gain	0.0

For the Dynamic Block

Parameter:	Default Value: (bit = 0)
Loop Enable/Disable	Disabled
Loop Auto/Manual Mode Select	Manual
Loop Auto-tune Enable/disable	Disable
Loop Setpoint Ramp-hold Enable/Disable	Disable
Read-block Select	Returns System Status
Cold-junction Alarm Enable	Disable
Celsius/Fahrenheit Select	Fahrenheit (Bit = 1)
Integer Display Mode Enable	Disable

Appendix C

Communication Program

The Ladder Program

This program is on disk with TemperatureControl™ configuration software that came with the module. Use it to test the module or as a model to develop your own application program. It has two versions:

For processor-module communcation:	Use this file:
in a local system or on a remote I/O link with 1771-ASB I/O adapter	TCMRIO.AF5
on ControlNet link with 1771-ACN I/O adapter	TCMNET.AF5

Important: If using Pro-Set 700 software, do not use this program. Pro-Set 700 software includes its own for interfacing with the module.

This program is also available from the Allen-Bradley SupportPlus bulletin board by calling (216) 646-6728. Look for TCMRIO.ZIP or TCMNET.ZIP located in the PLC-5 section of the control-processor file area under 6200 Arch Files. You can download this archive file by copying it and, if necessary, renaming it.

Program File

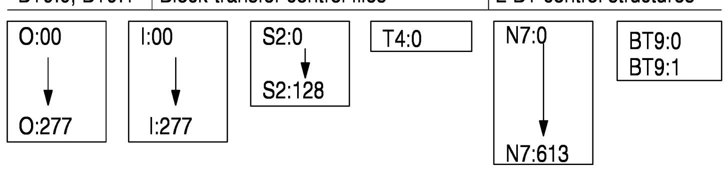
This program is assigned to program file 2. This file was selected because it is the default main control program (MCP), which will assure that it is executed every program scan. If you place this program in another program file, you must ensure its execution is within the time base required.

If you have an existing application program, you can add this to it. Take special care to assign data table addresses correctly to ensure there is no conflict between your program and what you add. If you install multiple temperature control modules in your PLC system, you will need to assign a separate integer file for each of them. Only one module can use file N7. You will have to make the corresponding address changes for each additional module.

Data-Table Files

This program uses the following data table files.

File:	Used For:	Minimum File Size
O:00	Output file	Fixed by PLC type
I:00	Input file	Fixed by PLC type
S2:0	Status file	Fixed at 129 words
T4:0	Timer file	1 timer structure
N7:0	Integer file	613 integer words
BT9:0, BT9:1	Block-transfer control files	2 BT control structures

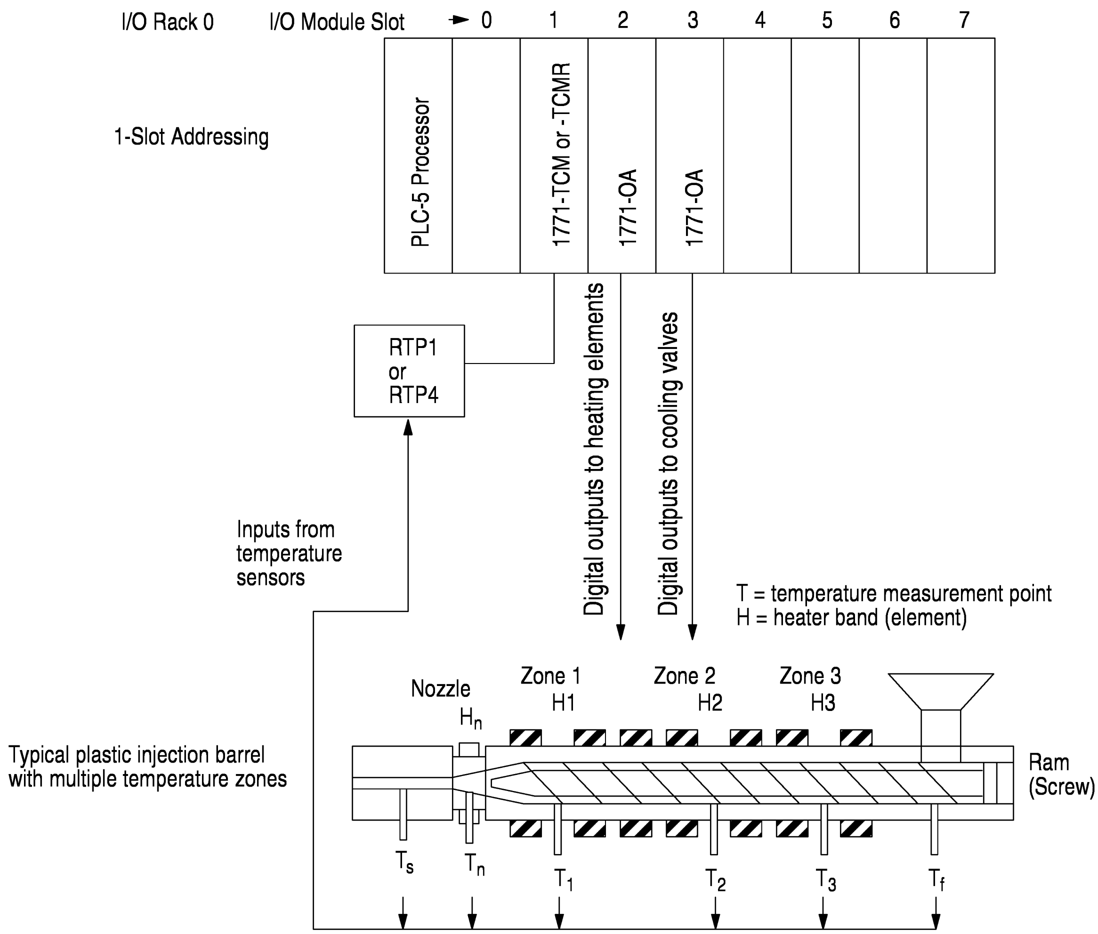


Data-Table Files O and I

The module has the capability of both single-transferring and block-transferring control data to/from the PLC data table. This example shows the use of both block-transferred and single-transferred TPO signals. Typically there is no need to use the single-transferred TPO signals (in the I/O image files) unless your application requires very precise turn-on/turn-off times (typically ± 10ms). Most applications can easily be controlled by the block-transferred TPO signals (typically ± 100ms). In this example, the module is in I/O group 1 of I/O rack 0 and digital output modules for TPO signals are in I/O groups 2 and 3.

File	Word	Description
O	0	
	1	TCM or TCMR module
	2	Digital output module to control heating elements
	3	Digital output module to control cooling elements
I	0	
	1	TCM or TCMR module

The addressing in this example is based on 1-slot addressing with the following hardware configuration.



Data-Table File 7 (N) Integer

To simplify the interface, we established a 615 word integer file (N7) exclusively for the module. All information concerning that module is contained in this file. The specific data layout is as follows:

File	Word	Description
N7	0	Communication control word (initiates block-transfer of configuration, auto-tune, or gains values when you set a specific bit) (See page C–4)
	1	BT ID bits
	2	BT check mask
	3	Cycle sequence number
	4	Loop offset value
	5	Data-table file offset
	6	reserved
	7	reserved
	8	reserved
	9	TPO bits — single-transferred
	10 – 39	Loop-1 configuration data
	40 – 69	Loop-2 configuration data
	70 – 99	Loop-3 configuration data
	100 – 129	Loop-4 configuration data
	130 – 159	Loop-5 configuration data
	160 – 189	Loop-6 configuration data
	190 – 219	Loop-7 configuration data
	220 – 249	Loop-8 configuration data
	250 – 309	Gains block
	310 – 349	Dynamic block
	350 – 419	Status block
	420 – 479	Auto-tune block
	480 – 549	Scratch-pad area addressed by the block-transfer write instruction
	550 – 613	Scratch-pad area addressed by the block-transfer read instruction

Data-Table File 9 (BT) Block Transfer

This file contains the block-transfer control structures for communication with the module. The block-transfer write control structure is BT9:0. The block-transfer read control structure is BT:9:1.

Data-Table Interface Layout

This program uses a data-table layout which has been organized to provide a convenient interface for these bits and words:

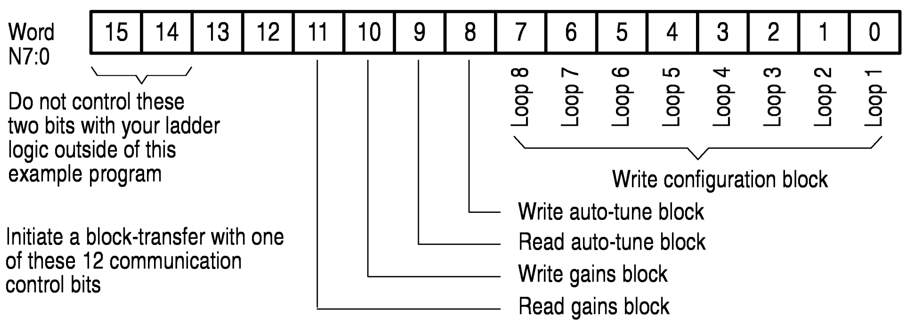
- communication control bits
- single-transferred TPO bits
- block-transferred TPO bits
- temperature monitor words
- loop output words
- current setpoint words

Communication Control Bits

By one-shot latching any one of bits 0-11 of N7:0, you initiate a corresponding block-transfer. Bits 14 and 15, which are used internal to the program, can be monitored.

ATTENTION: Communication control bits 8-11 for requesting a gains block read or write, and an auto-tune block read or write have been changed since the original version of this program. Check your version.

File	Word	Bit	Description
N7	0	0	Loop-1 configuration block write to module
		1	Loop-2 configuration block write to module
		2	Loop-3 configuration block write to module
		3	Loop-4 configuration block write to module
		4	Loop-5 configuration block write to module
		5	Loop-6 configuration block write to module
		6	Loop-7 configuration block write to module
		7	Loop-8 configuration block write to module
		8	Auto-tune block write to module
		9	Auto-tune block read from module
		10	Gains block write to module
		11	Gains block read from module
		12	reserved
		13	reserved
		14	Manual download requested. No BT in progress **(monitor only)**
		15	Block-transfer to/from module in progress **(monitor only)**



Single-Transferred TPO Bits

Output control (TPO) bit values are single-transferred from the module to the input image table in TPO form. You can use these bits to control digital outputs driving heating and cooling elements. For heat-only or cool-only operation, the effective period for the module updating the heat or cool TPO bits is approximately 10ms. However, if you use both heating and cooling, the effective period for updating the TPO bits is about 20ms. If you use the TPO signals block-transferred from the module, you do not need to read these bits.

File	Word	Bit	Description
N7	9	0	Loop-1 Heat TPO Bit — Single-Transferred
		1	Loop-2 Heat TPO Bit — Single-Transferred
		2	Loop-3 Heat TPO Bit — Single-Transferred
		3	Loop-4 Heat TPO Bit — Single-Transferred
		4	Loop-5 Heat TPO Bit — Single-Transferred
		5	Loop-6 Heat TPO Bit — Single-Transferred
		6	Loop-7 Heat TPO Bit — Single-Transferred
		7	Loop-8 Heat TPO Bit — Single-Transferred
		8	Loop-1 Cool TPO Bit — Single-Transferred
		9	Loop-2 Cool TPO Bit — Single-Transferred
		10	Loop-3 Cool TPO Bit — Single-Transferred
		11	Loop-4 Cool TPO Bit — Single-Transferred
		12	Loop-5 Cool TPO Bit — Single-Transferred
		13	Loop-6 Cool TPO Bit — Single-Transferred
		14	Loop-7 Cool TPO Bit — Single-Transferred
		15	Loop-8 Cool TPO Bit — Single-Transferred

Block-Transferred TPO Bits

Output control (TPO) bit values are block-transferred from the module in TPO form. You can use these bits to control digital outputs driving heating and cooling elements. The module's period for updating the heat and cool TPO bits it makes available by block-transfer is about 100ms. If you use TPO signals single-transferred to the input image table, you do not need to read these bits.

File	Word	Bit	Description
N7	375	0	Loop-1 Heat TPO Bit — Block-Transferred
		1	Loop-2 Heat TPO Bit — Block-Transferred
		2	Loop-3 Heat TPO Bit — Block-Transferred
		3	Loop-4 Heat TPO Bit — Block-Transferred
		4	Loop-5 Heat TPO Bit — Block-Transferred
		5	Loop-6 Heat TPO Bit — Block-Transferred
		6	Loop-7 Heat TPO Bit — Block-Transferred
		7	Loop-8 Heat TPO Bit — Block-Transferred
		8	Loop-1 Cool TPO Bit — Block-Transferred
		9	Loop-2 Cool TPO Bit — Block-Transferred
		10	Loop-3 Cool TPO Bit — Block-Transferred
		11	Loop-4 Cool TPO Bit — Block-Transferred
		12	Loop-5 Cool TPO Bit — Block-Transferred
		13	Loop-6 Cool TPO Bit — Block-Transferred
		14	Loop-7 Cool TPO Bit — Block-Transferred
		15	Loop-8 Cool TPO Bit — Block-Transferred

Temperature Monitor Words

These words contain the input temperature value for each loop. These values are in °C or °F as you select in the module configuration.

File	Word	Bit	Description
N7	376	0–15	Loop-1 input temperature in degrees
	377	0–15	Loop-2 input temperature in degrees
	378	0–15	Loop-3 input temperature in degrees
	379	0–15	Loop-4 input temperature in degrees
	380	0–15	Loop-5 input temperature in degrees
	381	0–15	Loop-6 input temperature in degrees
	382	0–15	Loop-7 input temperature in degrees
	383	0–15	Loop-8 input temperature in degrees

Loop Output Words

These output control words contain the loop output (as % of output) block-transferred from the module in numeric-value form. You can use these words to control analog outputs driving heating and cooling elements or you can monitor them from your man-machine interface.

File	Word	Bit	Description
N7	384	0–15	Loop-1 output in % (heat/cool –100.00% thru +100.00%)
	385	0–15	Loop-2 output in % (heat/cool –100.00% thru +100.00%)
	386	0–15	Loop-3 output in % (heat/cool –100.00% thru +100.00%)
	387	0–15	Loop-4 output in % (heat/cool –100.00% thru +100.00%)
	388	0–15	Loop-5 output in % (heat/cool –100.00% thru +100.00%)
	389	0–15	Loop-6 output in % (heat/cool –100.00% thru +100.00%)
	390	0–15	Loop-7 output in % (heat/cool –100.00% thru +100.00%)
	391	0–15	Loop-8 output in % (heat/cool –100.00% thru +100.00%)

Current Setpoint Words

These words contain the current setpoint values block-transferred from the module. This value reflects ramping if ramping is selected and validates the actual setpoint to which the loop is being controlled.

File	Word	Bit	Description
N7	392	0–15	Loop-1 current setpoint value — (0 thru +999.9°)
	393	0–15	Loop-2 current setpoint value — (0 thru +999.9°)
	394	0–15	Loop-3 current setpoint value — (0 thru +999.9°)
	395	0–15	Loop-4 current setpoint value — (0 thru +999.9°)
	396	0–15	Loop-5 current setpoint value — (0 thru +999.9°)
	397	0–15	Loop-6 current setpoint value — (0 thru +999.9°)
	398	0–15	Loop-7 current setpoint value — (0 thru +999.9°)
	399	0–15	Loop-8 current setpoint value — (0 thru +999.9°)

Establish the Module Interface for Your Application

This ladder logic is written for a PLC configuration of:

- 1-slot addressing
- the module in I/O slot 1
- 1771-OA module for controlling heating elements in I/O slot 2
- 1771-OA module for controlling cooling elements in I/O slot 3
- pushbutton switch for manually re-starting the single-transfer sequence is connected to input I:004/7.

If your configuration is different, change the addresses as follows:

- In the block-transfer write instructions on rungs 5 and 6, enter the rack, group, and module slot to identify the module's location address.
- In the block-transfer read instruction on rung 7, enter the rack, group, and module slot to identify the module's location address.
- On rungs 9-13, replace each O:001 address to reflect the location of the module.
- On rung 9, change the I:004/07 address to reflect the location of the connection to the pushbutton switch for manually starting the single-transfer sequence.

ATTENTION: This program does not provide an interlock for TPO outputs. If your application requires these outputs to be held off for some reason separate from the module, or in the case of the module losing communication, add your own logic to provide the appropriate output signal for your application.

Configure the Control Loops

To configure the module for your application, manipulate the data table values as follows:

1. Set the bits in data-table words N7:10 thru N7:249 to configure each loop as required for your application (see page C-3 and chapter 4 for details).
2. You can also enter PID gains/constants in words N7:250 thru N7:309 (see chapter 6). However, if you are going to use auto-tuning, you don't need to enter anything there.
3. Set the bits (0-7) in the communication control word N7:0 to initiate a block-transfer write to the module. This loads the configuration values for each loop. If the module looses power, you will have to reload configuration values into the module.

You can monitor and set values in these data table files with any online programming or MMI (such as PanelView™ or a PC with ControlView™ software) that can access PLC data tables.

Start Up and Auto-Tune Loops Set for Barrel Control

Once the loops that are to be used are configured, you can start up and auto-tune the loops with the following procedure. The specific example addresses given are for loop 1 for this example program.

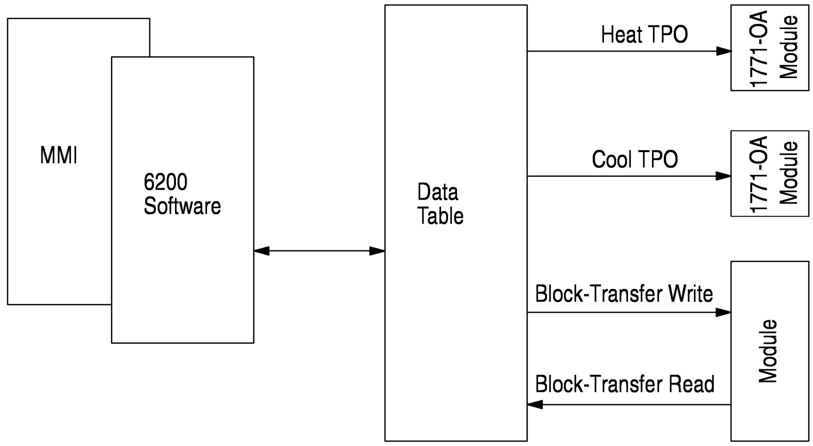
1. Set the loop operational mode to control mode for the loop(s): configuration block, word 1, bits 7–8 (N7:11/7, N7:11/8)
2. Set manual output value for the loop(s) to current steady-state output: dynamic block, word 4 (N7:314)
3. Set the loop(s) to manual control mode: dynamic block, word 1, bit 1 (N7:311/1)
4. Enable loop control for the loop(s): dynamic block, word 1, bit 0 (N7:311/0)
5. Enter the run-temperature set-point value: dynamic block, word 1 (N7:313)
6. Select the run-temperature set point: dynamic block, word 1, bit 2 (N7:311/2)
7. Select to enable auto-tuning: dynamic block, word 1, bit 3 (N7:311/3). This begins the auto-tuning and start-up cycle.
8. Turn on the invoke-auto-tuning bit: dynamic block, word 43, bit 1 (N7:343/1). This starts the auto-tuning and start-up cycle.
9. Once auto-tuning has begun, set the loop to automatic control mode: dynamic block, word 1, bit 1 (N7:311/1). This will then return the loop to auto control once the auto-tune and start-up are complete.

Important: Auto-tuning has been optimized for tuning multiple loops for plastic injection molding and extruder barrels. The concept is to start-up a process from ambient and tune the loops as the system is starting up.

Basic Operation of the Communication Program

The communication program was developed to assist you in applying the module. This program provides the basic logic to:

- communicate with the module
- load loop configuration data when requested
- provide an interactive interface for the dynamic information
- provide continuous monitoring of the module status data
- load or read PID parameter data when requested



To accomplish this, communication with the module is established by:

- continuously requesting block-transfers at 250ms intervals in the following sequence:

  1. write dynamic block which provides a control interface with the module (selecting to read the status block)

  2. read status block which provides data such as loop and module status, and M and C values

  This will update all run-time information to and from the module in one module (loop) update period of 500ms. However, if you have a requirement to continually monitor the gains block, then you could have the dynamic block alternate between requesting a status block and requesting a gains block. In this case, you could only read the status block once every second.

- writing a loop configuration block and reading or writing the gains block or auto-tune block to/from the module on demand as a priority request in place of the dynamic block.

To request this block transfer:	Set this bit:
write loop configuration	appropriate bit in communication control word (N7:0). Bits 0-7 correspond to loops 1-8 configuration blocks.
read gains block	N7:0/11
write gains block	N7:0/10
read auto-tune	N7:0/9
write auto-tune	N7:0/8

Multiple simultaneous requests are allowed. To configure all loops, write $00FF_{16}$ to N7:0 (set bits 0-7). The requests are serviced sequentially with priority over dynamic-block writes.

When a block-transfer write is completed as requested, the corresponding request is cleared by the program. When a request for a block-transfer write results in an error or no response, the request is re-queued. This re-queuing will continue until that request is successfully serviced. Re-queuing does not impede other requests.

Rung 2:0
Initialization

This rung ensures that the program is reset and ready to run. When the PLC processor is powered up, bit S:1/15 is turned on for only the first program scan. This bit being on is used to reset initialization values.

- Word N7:2, the loop check mask, is set to 1.
- Word N7:3, the cycle sequence number, is set to 1.
- Word N7:4, the loop offset value is set to 0.
- The proper block ID is put into the first word of each block (words N7:10, N7:40, N7:70, N7:130, N7:160, N7:190, N7:220, N7:250, and N7:310).

```
Rung 2:0
/                                                                 /
/                                                                 /
/                                                                 /
|  S:1                                              +MOV---------------+  |
+--] [--------------------------------------------++MOVE              ++-+
|   15                                             ||Source           1||  |
|                                                  ||                   ||  |
|                                                  ||Destination   N7:2||  |
|                                                  ||                 1||  |
|                                                  |+-------------------+  |
|                                                  |                N7:3|  |
|                                                  +-----------------(L)-+
|                                                  |                   0|  |
|                                                  |+CLR---------------+|  |
|                                                  ++CLEAR             ++  |
|                                                  ||Destination   N7:4||  |
|                                                  ||                 0||  |
|                                                  |+-------------------+|  |
|                                                  |+MOV---------------+|  |
|                                                  ++MOVE              ++  |
|                                                  ||Source      -30719||  |
|                                                  ||                   ||  |
/                                                                 /
/                                                                 /
/                                                                 /

/                                                                 /
/                                                                 /
/                                                                 /
|                                                  ||Source      -30714||  |
|                                                  ||                   ||  |
|                                                  ||Destination N7:160||  |
|                                                  ||            -30714||  |
|                                                  |+-------------------+|  |
|                                                  |+MOV---------------+|  |
|                                                  ++MOVE              ++  |
|                                                  ||Source      -30713||  |
|                                                  ||                   ||  |
|                                                  ||Destination N7:190||  |
|                                                  ||            -30713||  |
|                                                  |+-------------------+|  |
|                                                  |+MOV---------------+|  |
|                                                  ++MOVE              ++  |
|                                                  ||Source      -30712||  |
|                                                  ||                   ||  |
|                                                  ||Destination N7:220||  |
|                                                  ||            -30712||  |
|                                                  |+-------------------+|  |
|                                                  |+MOV---------------+|  |
|                                                  ++MOVE              ++  |
|                                                  ||Source      -30711||  |
|                                                  ||                   ||  |
|                                                  ||Destination N7:250||  |
|                                                  ||            -30711||  |
|                                                  |+-------------------+|  |
|                                                  |+MOV---------------+|  |
|                                                  ++MOVE              ++  |
|                                                  ||Source      -30710||  |
|                                                  ||                   ||  |
|                                                  ||Destination N7:310||  |
|                                                  ||            -30710||  |
|                                                  |+-------------------+|  |
/                                                                 /
/                                                                 /
```

```
                                                                 |               N7:0  |  |
                                                                 +---------------(U)--+  |
                                                                 |                 15  |  |
                                                                 |             N7:343|  |
                                                                 +---------------(U)--+  |
                                                                 |                  0  |  |
                                                                 |             N7:343|  |
                                                                 +---------------(U)--+  |
                                                                 |                  6  |  |
                                                                 |+MOV---------------+|  |
                                                                 ++MOVE              ++  |
                                                                 ||Source           0||  |
                                                                 ||                  ||  |
                                                                 ||Destination   N7:9||  |
                                                                 ||                  ||  |
                                                                 |+------------------+|  |
                                                                 |+MOV---------------+|  |
                                                                 ++MOVE              ++  |
                                                                 ||Source           0||  |
                                                                 ||                  ||  |
                                                                 ||Destination N7:375||  |
                                                                 ||                  ||  |
                                                                 |+------------------+|  |
   Important:  If not using TemperatureControl                   |+MOV---------------+|  |
   Connfig Software included with the module,                    ++MOVE              ++  |
   you may want to delete this instruction or   >>               ||Source         511||  |
   change Source from 511 to 255 so as NOT to,                   ||                  ||  |
   clear the gains block on first scan.                          ||Destination   N7:0||  |
                                                                 ||                  ||  |
                                                                 |+------------------+|  |
```

Rung 2:1 and 2:2
250ms Time Base for Automatic Block-Transfer

If there are no manual downloads (loop configuration or tuning data) required, the program automatically sequences thru a pair of preset transfers of data blocks.

1. Write the dynamic block to the module.
2. Read the status block (loop I/O signals, alarms) from the module.

The sequence number, which dictates which block-transfer to execute, is toggled every 250ms thru the exclusive or instruction.

```
Rung 2:1
|  T4:0                                                                +TON---------------+      |
+--]/[-----------------------------------------------------------------+TIMER ON DELAY    +-(EN)-+
|     DN                                                               |Timer         T4:0|      |
|                                                                      |Time base     0.01+-(DN) |
|                                                                      |Preset          25|      |
|                                                                      |Accum            3|      |
|                                                                      +------------------+      |
Rung 2:2
|  T4:0                                                           +XOR-------------------------+ |
+--] [------------------------------------------------------------+BITWISE EXCLUSIVE OR       +-+
|     DN                                                          |Source A                N7:3| |
|                                                                 |                           0| |
|                                                                 |Source B    0000000000000001| |
|                                                                 |                            | |
|                                                                 |Destination             N7:3| |
|                                                                 |                           0| |
|                                                                 +----------------------------+ |
```

Rung 2:3
Manual Block-Transfer Request, Identification, and Control

Before responding to the automatic block-transfers, a check is made to determine whether a block-transfer has been manually requested (N7:0, bits 1 thru 11) by an NEQ instruction (N7:0 $\neq$ 0). If a bit has been turned on, then this rung will filter the request to ensure that only bits 1-11 have been turned on, then begin the process of establishing which bit has been turned on so that only the corresponding block of data is transferred to/from the module.

This rung (together with rung 2:4) detects a loop (1-8) configuration request, and then calculates the data-table file offset.

A bit-wise AND is used to determine which loop has its manual request bit set. A bit in word N7:1 gets turned on only if the corresponding bit in N7:0 and the corresponding bit in N7:2 are turned on.

If N7:0 > 0, the bits in N7:2 are turned on one at a time, starting at bit 0 and proceeding to bit 11, until a match is found; then all are zeroed. (By counting the number of tests, the loop number is determined for transferring a configuration block.) By using a bit-wise AND (N7:0/*x* AND N7:2/y) the corresponding bit is set in word N7:1. When N7:1 > 0, testing is stopped.

If the value at N7:1 is less than 256, (meaning a configuration block request — bits 0-7) the following offset calculation is performed to establish the starting word for the loop's configuration file.

1. Calculate the data set number (30 words/loop): N7:4 X 30 = N7:5
2. Add 10 to the data set number: N7:5 + 10 = N7:5
3. This result points to the word in file N7 that is the start of configuration data for the loop. N7:5 is used as an indirect address in the copy instruction.

Downloading the PID gains block or auto-tune block occurs when bit 10 is On (for PID gains block at N7:250) or bit 8 is On (for auto-tune block at N7:420). The block is copied into the block-transfer write scratchpad area starting at N7:480 for download to the module.

```
Rung 2:3
| +NEQ-----------+ +EQU-----------+ BT9:0 +AND--------------------------+                                  |
+-+NOT EQUAL     +-+EQUAL         +--]/[-++BITWISE AND                  +------------------------------+-+
| |Source A  N7:0| |Source A  N7:1|    EN||Source A                 N7:0|                              | |
| |             0| |             0|      ||                            0|                              | |
| |Source B     0| |Source B     0|      ||Source B    1100111111111111|                              | |
| |              | |              |      ||                             |                              | |
| +--------------+ +--------------+      ||Destination              N7:0|                              | |
|                                        ||                            0|                              | |
|                                        |+-----------------------------+                              | |
|                                        |+NEQ---------------+  N7:0                                  | |
|                                        ++NOT EQUAL         +--(U)-----------------------------------+ |
|                                        ||Source A    N7:420|      8                                 | |
|                                        ||              -30709|                                      | |
|                                        ||Source B    -30709|                                        | |
|                                        ||                  |                                        | |
|                                        |+------------------+                                        | |
|                                        |+AND---------------+                                        | |
|                                        ++BITWISE AND       +----------------------------------------+ |
|                                        ||Source A      N7:0|                                        | |
|                                        ||                 0|                                        | |
|                                        ||Source B      N7:2|                                        | |
|                                        ||                 2|                                        | |
|                                        ||Destination   N7:1|                                        | |
|                                        ||                 0|                                        | |
|                                        |+------------------+                                        | |
|                                        |+NEQ-----------+ +LES-----------+ +MUL----------------+     | |
|                                        ++NOT EQUAL     +++LESS THAN     +++MULTIPLY           +---+++ |
|                                        ||Source A  N7:1|||Source A  N7:1|||Source A      N7:4|   ||| |
|                                        ||             0|||             0|||                 1|   ||| |
|                                        ||Source B     0|||Source B   256|||Source B        30|   ||| |
|                                        ||              |||              |||                  |   ||| |
|                                        |+--------------+|+--------------+||Destination   N7:5|   ||| |
|                                        |                |                ||                11|   ||| |
|                                        |                |                |+------------------+   ||| |
|                                        |                |                |+ADD----------------+   || |
|                                        |                |                ++ADD                +---+| |
|                                        |                |                ||Source A      N7:5|    | |
|                                        |                |                ||                11|    | |
|                                        |                |                ||Source B        10|    | |
|                                        |                |                ||                  |    | |
|                                        |                |                ||Destination   N7:5|    | |
|                                        |                |                ||                11|    | |
|                                        |                |                |+------------------+    | |
|                                        |                |                |+COP-------------------+| |
|                                        |                |                ++COPY FILE             ++ |
|                                        |                |                 |Source      #N7[N7:5]|  | |
|                                        |                |                 |Destination   #N7:480|  | |
|                                        |                |                 |Length             26|  | |
|                                        |                |                 +----------------------+  | |
|                                        |                | N7:1            +COP-------------------+  | |
|                                        |                +-] [-------------+COPY FILE             +-+ |
|                                        |                |   10            |Source        #N7:250|  | |
|                                        |                |                 |Destination   #N7:480|  | |
|                                        |                |                 |Length             57|  | |
|                                        |                |                 +----------------------+  | |
|                                        |                | N7:1                  N7:1                | |
|                                        |                +-] [---+--------------(U)---+--------------+ |
|                                        |                |   11  |                11  |                | |
|                                        |                |       |   N7:343     N7:0  |                | |
|                                        |                |       +---]/[---+---(U)---+                | |
|                                        |                |              6  |    11   |                | |
|                                        |                |                 |   N7:343|                | |
|                                        |                |                 +---(L)---+                | |
|                                        |                |                       0                    | |
|                                        |                | N7:1            +COP-------------------+  | |
|                                        |                +-] [-------------+COPY FILE             +-+ |
|                                        |                |    8            |Source        #N7:420|  | |
|                                        |                |                 |Destination   #N7:480|  | |
|                                        |                |                 |Length             56|  | |
|                                        |                |                 +----------------------+  | |
|                                        |                | N7:1                  N7:1                | |
|                                        |                +-] [---+--------------(U)---+--------------+ |
|                                        |                    9   |                 9  |                | |
|                                        |                        |   N7:343     N7:0  |                | |
|                                        |                        +---]/[---+---(U)---+                | |
|                                        |                               0  |     9   |                | |
|                                        |                                  |   N7:343|                | |
|                                        |                                  +---(L)---+                | |
|                                        | N7:0                                   6                    | |
|                                        +-( )----------------------------------------------------------+ |
|                                            14                                                          |
```

Rung 2:4
Loop Configuration/Gain Data Download Control Support

This rung is used in connection with rung 2:3 to increment the loop check mask. When rung 2:3 is actively testing for a loop, it turns on bit N7:0/14. This enables the logic on rung 4 that:

- by multiplying the value in the loop check mask (N7:2) by 2, shifts the single bit that is on in the loop check mask to the next higher bit position, starting at the 2^0 bit (bit 0) and shifting each scan time until reaching the 2^9 bit (bit 9)
- by incrementing the value in N7:4 by 1 each time this logic is executed, accumulates the total number of iterations, to establish the loop offset value
- when the BT check mask has been shifted up to bit 9, meaning all possible loops have been scanned, resets the loop offset value (N7:4) to 0 and resets the loop check mask (N7:2) to 1 (bit 0 turned on)

```
Rung 2:4
| N7:0                                                                              +MUL---------------+  |
+-] [-----------------------------------------------------------+----------------------+MULTIPLY          ++-+
    14                                                          |                      |Source A      N7:2||  |
                                                                |                      |                 2||  |
                                                                |                      |Source B         2||  |
                                                                |                      |                  ||  |
                                                                |                      |Destination   N7:2||  |
                                                                |                      |                 2||  |
                                                                |                      +------------------+|  |
                                                                |                      +ADD---------------+|  |
                                                                +----------------------+ADD               ++  |
                                                                |                      |Source A      N7:4||  |
                                                                |                      |                 1||  |
                                                                |                      |Source B         1||  |
                                                                |                      |                  ||  |
                                                                |                      |Destination   N7:4||  |
                                                                |                      |                 1||  |
                                                                |                      +------------------+|  |
                                                                | N7:2               +MOV---------------+  |  |
                                                                +-] [----------------++MOVE             +++  |
                                                                    12               ||Source          1|||  |
                                                                                     ||                 |||  |
                                                                                     ||Destination  N7:2|||  |
                                                                                     ||                2|||  |
                                                                                     |+-----------------+||  |
                                                                                     |+MOV--------------+|   |
                                                                                     ++MOVE             ++   |
                                                                                      |Source          0|    |
                                                                                      |                 |    |
                                                                                      |Destination  N7:4|    |
                                                                                      |                1|    |
                                                                                      +-----------------+    |
                                                                |                                  N7:0|   |
                                                                +---------------------------------------(U)-+
                                                                                                   14      |
```

Rung 2:5
Automatic Dynamic-Block-Transfer Writes

If no block-transfer writes are in progress (BT9:0/EN), the communication sequence timer has timed out, and no manual configuration download request has been made, then the dynamic block is written to the module. The copy instruction causes the current data for the dynamic block to be loaded into the scratch-pad area for block-transfer writes. The block-transfer write instruction causes the current data in the scratch-pad area to be written to the module.

```
Rung 2:5
| BT9:0  T4:0  N7:3 +MEQ---------------+                                    +COP--------------------+  |
+--]/[---] [---]/[--+MASKED EQUAL      +------------------------------+-----+COPY FILE              ++-+
|    EN    DN     0 |Source        N7:0|                              |     |Source          #N7:310|| |
|                   |                 0|                              |     |Destination     #N7:480|| |
|                   |Mask          F5FF|                              |     |Length               34|| |
|                   |                  |                              |     +-----------------------+| |
|                   |Compare          0|                              |+BTW--------------------+     | |
|                   |                  |                              ++BLOCK TRANSFER WRITE   +-(EN)+ |
|                   +------------------+                               |Rack                 00|       |
|                                                                      |Group                 1+-(DN)  |
|                                                                      |Module                0|       |
|                                                                      |Control block     BT9:0+-(ER)  |
|                                                                      |Data file        N7:480|       |
|                                                                      |Length                0|       |
|                                                                      |Continuous            N|       |
|                                                                      +-----------------------+       |
|                                                                                                      |
```

Rung 2:6
Manual-Request Block-Transfer Write Control

If a manual request has been made, and the loop number has been established (and data loaded into the block-transfer write scratch-pad area in rung 2:3) the block-transfer write instruction is executed. This instruction is used to generate all blocks transfers to the module (configuration, dynamic, and gains). Once the block-transfer write has been completed, the manual loop request bit is cleared (XOR) and the loop identity bits (N7:1) are cleared. Upon detection of a block-transfer error or no response, this rung also clears the loop identity bits; however, since the manual request bit is not cleared, the logic is enabled to retry that request again until the bit is cleared.

```
Rung 2:6
| +NEQ---------------+                                    BT9:0  N7:0 +BTW--------------------+        |
+-+NOT EQUAL         +-----------------------------------+-]/[---]/[-++BLOCK TRANSFER WRITE   +-(EN)++-+
| |Source A      N7:1|                                   |   EN    15||Rack                 00|     || |
| |                 0|                                   |           ||Group                 1+-(DN)|| |
| |Source B         0|                                   |           ||Module                0|     || |
| |                  |                                   |           ||Control block     BT9:0+-(ER)|| |
| +------------------+                                   |           ||Data file        N7:480|     || |
|                                                        |           ||Length                0|     || |
|                                                        |           ||Continuous            N|     || |
|                                                        |           |+-----------------------+     || |
|                                                        |           |                          N7:0|| |
|                                                        |           +--------------------------(L)-+| |
|                                                        |                                       15 | |
|                                                        | BT9:0                        N7:0        | |
|                                                        ++-] [-++---------------------------(U)-+----+ |
|                                                         |    ER||                            15|      |
|                                                         |BT9:0||BT9:0 +XOR--------------------+|      |
|                                                         +-] [-++-] [--+BITWISE EXCLUSIVE OR   ++      |
|                                                         |    NR||   DN |Source A          N7:0||      |
|                                                         |BT9:0||       |                     0||      |
|                                                         +-] [-+|       |Source B          N7:1||      |
|                                                             DN |       |                     0||      |
|                                                                |       |Destination       N7:0||      |
|                                                                |       |                     0||      |
|                                                                |       +-----------------------+|      |
|                                                                |           +CLR---------------+|      |
|                                                                +-----------+CLEAR             ++      |
|                                                                            |Destination   N7:1|       |
|                                                                            |                 0|       |
|                                                                            +------------------+       |
```

Rung 2:7
Block-Transfer Read Control

If no block-transfer reads are in process (BT9:1/EN) and the sequence timer has timed out, the current sequence number (N7:3) is checked to see whether it is equal to 1. If true, a block-transfer read is executed that loads the data into the block-transfer read scratch-pad area (N7:550 thru N7:613). This instruction is for all blocks transferred from the module (status, gains, and auto-tuning).

```
Rung 2:7
|  T4:0 BT9:1  N7:3                                                  +BTR--------------------+     |
+--] [---]/[---] [---------------------------------------------------+BLOCK TRANSFER READ    +-(EN)-+
|     DN    EN     0                                                  |Rack                  00|     |
|                                                                     |Group                  1+-(DN) |
|                                                                     |Module                 0|     |
|                                                                     |Control block     BT9:1+-(ER) |
|                                                                     |Data file        N7:550|     |
|                                                                     |Length                 0|     |
|                                                                     |Continuous             N|     |
|                                                                     +-----------------------+     |
```

Rung 2:8
Block-Transfer Read Data Distribution

When the block-transfer read done bit (BT9:1) is on, the first word of the block-transfer read scratch-pad area is compared to the block ID codes. The data is then copied to the appropriate block area based on the block ID code detected.

- If the value is –30465, data returned is status, including TPO signals.
- If the value is –30711, data is the PID gains.
- If the value is –30709, data is the system ID data from auto-tuning.

```
Rung 2:8
| BT9:1                                          +EQU---------------+  +COP--------------------+  |
+--] [-------------------------------------------++EQUAL             +--+COPY FILE              ++-+
|     DN                                         ||Source A    N7:550|  |Source          #N7:550||  |
|                                                ||            -30465|  |Destination     #N7:350||  |
|                                                ||Source B    -30465|  |Length               64||  |
|                                                ||                  |  +-----------------------+|  |
|                                                |+------------------+                           |  |
|                                                |+EQU---------------+ +COP--------------------+ |  |
|                                                ++EQUAL             +++COPY FILE               +++ |
|                                                 |Source A    N7:550|||Source          #N7:550|| |
|                                                 |            -30465|||Destination     #N7:250|| |
|                                                 |Source B    -30711|||Length               57|| |
|                                                 |                  ||+-----------------------+| |
|                                                 +------------------+|                N7:343| |
|                                                                     +---------------------(U)--+ |
|                                                 |                                          0     |
|                                                 |+EQU---------------+ +COP--------------------+ |
|                                                 ++EQUAL             +++COPY FILE               +++
|                                                  |Source A    N7:550|||Source          #N7:550||
|                                                  |            -30465|||Destination     #N7:420||
|                                                  |Source B    -30709|||Length               56||
|                                                  |                  ||+-----------------------+|
|                                                  +------------------+|                N7:343|
|                                                                      +---------------------(U)--+
|                                                                                          6      |
```

Rungs 2:9 thru 2:13
Single-Transfer TPO Interface

These rungs provide the logic for using TPO signals single-transferred from the module. Do not use these single-transferred TPO signals if the module is in a remote I/O chassis. The logic of these rungs is explained in detail in chapter 3. However, there is a difference in addressing between the rungs shown in chapter 3 and the rungs shown here. In chapter 3, heat TPO bits are written to an output module at O:002, and cool TPO bits are written to an output module at O:003. Here, heat TPO bits are written to the low byte of N7:9, and cool TPO bits are written to the high byte of N7:9. With this arrangement, in your application logic you can use either block-transferred or single-transferred TPO bits to control outputs at any address you want to use. In your output control logic, you should also provide an interlock logic to hold these outputs in a safe state whenever appropriate for your application

```
Rung 2:9
|    S:1                                                                        +BTD---------------+ |
+-+-] [-+-----------------------------------------------------------------------+BIT FIELD DISTRIB +-+
| |    15|                                                                      |Source          35| |
| |I:004 |                                                                      |                  | |
| +-] [-+                                                                       |Source bit       0| |
|      07                                                                       |Destination  O:001| |
|                                                                               |              8960| |
|                                                                               |Destination bit  8| |
|                                                                               |Length           8| |
|                                                                               +------------------+ |
Rung 2:10
| +MEQ---------------+                                                        +BTD---------------+  |
+-+MASKED EQUAL      +-----------------------------------------------------------++BIT FIELD DISTRIB ++-+
| |Source       I:001|                                                        ||Source       I:001|| |
| |                 0|                                                        ||                 0|| |
| |Mask          00FF|                                                        ||Source bit       8|| |
| |                  |                                                        ||Destination   N7:9|| |
| |Compare         35|                                                        ||                 0|| |
| |                  |                                                        ||Destination bit  0|| |
| +------------------+                                                        ||Length           8|| |
|                                                                             |+------------------+| |
|                                                                             |+BTD---------------+| |
|                                                                             ++BIT FIELD DISTRIB ++ |
|                                                                              |Source          37|  |
|                                                                              |                  |  |
|                                                                              |Source bit       0|  |
|                                                                              |Destination  O:001|  |
|                                                                              |              8960|  |
|                                                                              |Destination bit  8|  |
|                                                                              |Length           8|  |
|                                                                              +------------------+  |
Rung 2:11
| I:001 I:001 I:001                                                             +BTD---------------+ |
+--]/[---]/[---]/[--------------------------------------------------------------+BIT FIELD DISTRIB +-+
|     07    06    00                                                            |Source           0| |
|                                                                               |                  | |
|                                                                               |Source bit       0| |
|                                                                               |Destination   N7:9| |
|                                                                               |                 0| |
|                                                                               |Destination bit  0| |
|                                                                               |Length           8| |
|                                                                               +------------------+ |
Rung 2:12
| +MEQ---------------+                                                        +BTD---------------+  |
+-+MASKED EQUAL      +-----------------------------------------------------------++BIT FIELD DISTRIB ++-+
| |Source       I:001|                                                        ||Source       I:001|| |
| |                 0|                                                        ||                 0|| |
| |Mask          00FF|                                                        ||Source bit       8|| |
| |                  |                                                        ||Destination   N7:9|| |
| |Compare         37|                                                        ||                 0|| |
| |                  |                                                        ||Destination bit  8|| |
| +------------------+                                                        ||Length           8|| |
|                                                                             |+------------------+| |
|                                                                             |+BTD---------------+| |
|                                                                             ++BIT FIELD DISTRIB ++ |
|                                                                              |Source          35|  |
|                                                                              |                  |  |
|                                                                              |Source bit       0|  |
|                                                                              |Destination  O:001|  |
|                                                                              |              8960|  |
|                                                                              |Destination bit  8|  |
|                                                                              |Length           8|  |
|                                                                              +------------------+  |
Rung 2:13
| I:001 I:001 I:001                                                             +BTD---------------+ |
+--]/[---]/[---]/[--------------------------------------------------------------+BIT FIELD DISTRIB +-+
|     07    06    00                                                            |Source           0| |
|                                                                               |                  | |
|                                                                               |Source bit       0| |
|                                                                               |Destination   N7:9| |
|                                                                               |                 0| |
|                                                                               |Destination bit  8| |
|                                                                               |Length           8| |
|                                                                               +------------------+ |
Rung 2:14
|                                                                                                    |
+-------------------------------------------------------[END OF FILE]--------------------------------+
|                                                                                                    |
```

Notes:

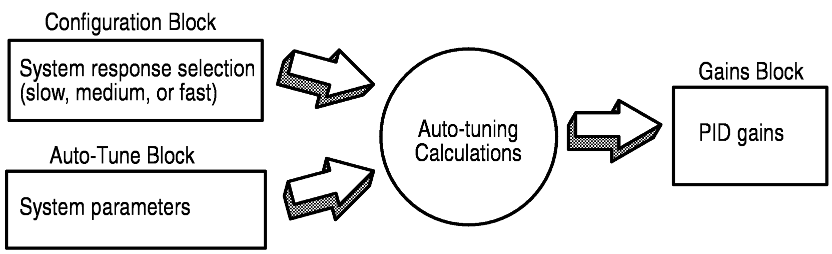
Auto-tuning

Auto-Tuning the Loops

You select auto-tuning from the dynamic block. For each loop, you must turn on the *"auto-tuning enable"* bit to enable auto-tuning for that corresponding loop. To trigger the start of auto-tuning, you must also cause a 0-to-1 transition of the *"invoke auto-tuning"* bit (bit 1 of word 33) that applies to all loops.

During auto-tuning, the module measures the system parameters which it then makes available in the auto-tune block (chapter 5). At the end of auto-tuning, the module calculates PID gains based on the measured system parameters and the system response (slow, medium, or fast) you had selected with bits 8 and 9 in word 2 of the configuration block (chapter 4). When auto-tuning is complete, the PID gains calculated from auto-tuning are available in the gains block returned by the module.

Whenever you write the auto-tune block back to the module, it re-calculates the PID gains based on the measured system parameters in the auto-tune block and the system response (slow, medium, or fast) you had selected in the latest configuration block. If you had changed the system response selection in the configuration block since then, the PID gains calculated would be different from those calculated originally.



Important: Auto-tune the heat-only loops separately from heat/cool loops.

Important: Do not start auto-tuning for a barrel-zone loop unless its temperature input (C) is stable. If not stable, auto-tuning may not provide suitable gains for the application.

Important: If the temperature input (C) is within 50°F of the run set point for a barrel-zone loop, auto-tuning will not start.

Important: The auto-tuning algorithm will not work well if the system lag time is less than the TPO period. In that case, the auto-tuning will calculate large gain values, which will probably cause C to overshoot the set point.

Note: We have changed terminology in this manual as follows:

Previous terminology:	Changed to:	Meaning:
CV (control variable)	M (manipulated variable)	loop output
PV (process variable)	C (controlled variable)	loop input

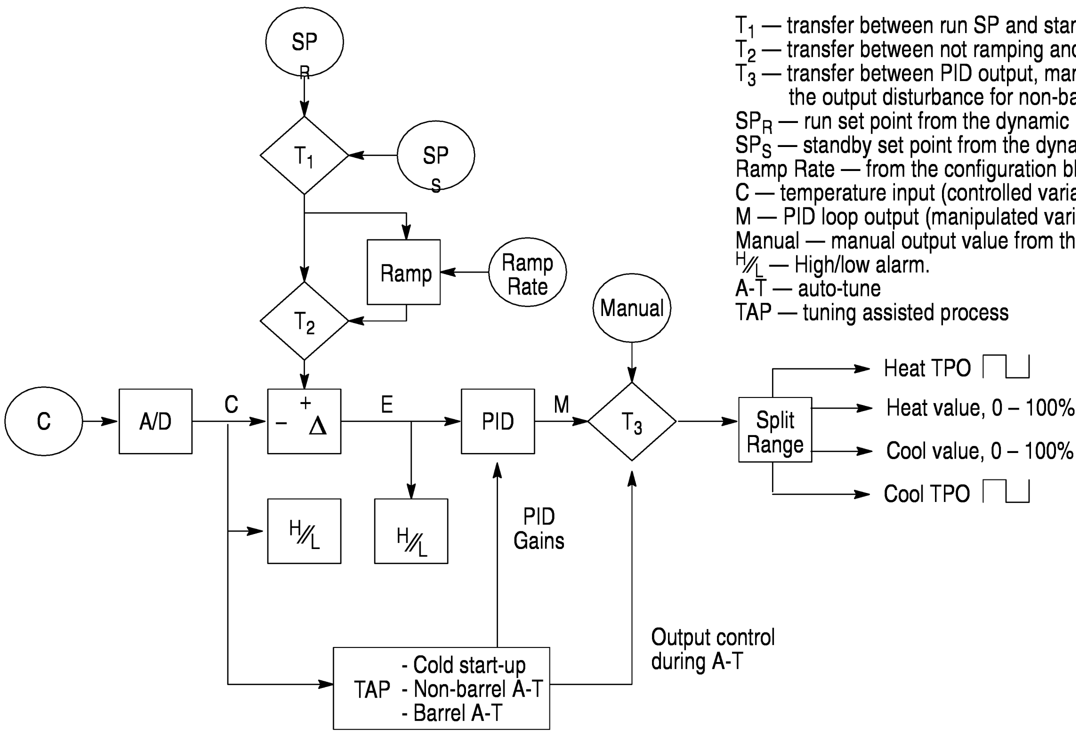
For **barrel control**, the best results are achieved when you select *auto-tuning enable* for all loops associated with the barrel; then generate a 0-to-1 transition for the *"invoke auto-tuning"* bit. The module coordinates and manages all selected loops thru start-up, auto-tuning, and into run. The module leaves the loop in the selected mode.

For **non-barrel**, the module does not coordinate multiple loops during auto-tuning, each loop is started up and auto-tuned independently. After reaching the desired temperature (C) by manual or automatic control mode, select *auto-tuning enable* for the loop; then generate a 0-to-1 transition for the *"invoke auto-tuning"* bit. The module leaves the loop in the selected mode.

For the listing of the auto-tune block, refer to chapter 5.

Module Function

We show a simplified view of module functions:



T_1 — transfer between run SP and standby SP.
T_2 — transfer between not ramping and ramping the SP.
T_3 — transfer between PID output, manual output, and the output disturbance for non-barrel A-T from TAP.
SP_R — run set point from the dynamic block.
SP_S — standby set point from the dynamic block.
Ramp Rate — from the configuration block.
C — temperature input (controlled variable) from TC or RTD
M — PID loop output (manipulated variable)
Manual — manual output value from the dynamic block.
H/L — High/low alarm.
A-T — auto-tune
TAP — tuning assisted process

During auto-tuning, the TAP function controls the output. In manual mode, the manual value you set in the dynamic block controls the output. In automatic mode, the PID function controls the output.

Using Pro-Set 700 Software

The 1771-TCM is compatible with Pro-Set 700 software release 2.0 or higher. The 1771-TCMR is not supported by Pro-Set 700 software.

Use the 1771-TCM to control barrel and other injection molding temperatures in a Pro-Set 700 system or individually without Pro-Set. For more information, refer to user manual (publication 6500-6.5.18). Here we give you information on using Pro-Set 700 software for:

- loop configuration and setup
- loop startup and tuning
- special considerations needed for Pro-Set 700 release 2.0

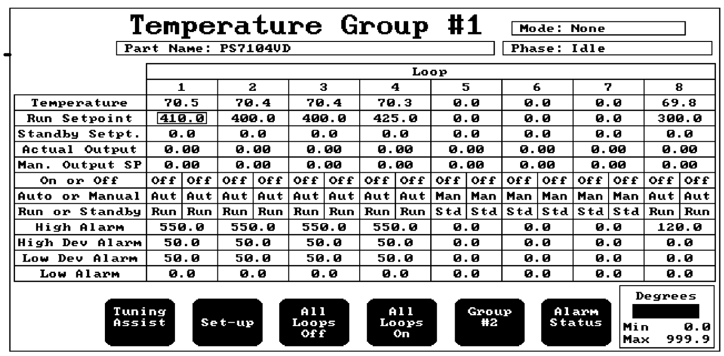
Configuring and Setting Up Loops

You can configure the module and set up the temperature loops with the Pro-Set 700 temperature control screens as follows.

1. At the main screen, from the icon bar, select the process (temperature-group-#1) screen by pressing:

 (Loops 1–8) or  (Loops 9–16).

Barrel Temperature 



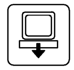
Temperature Group #1 Mode: None

Part Name: PS7104VD Phase: Idle

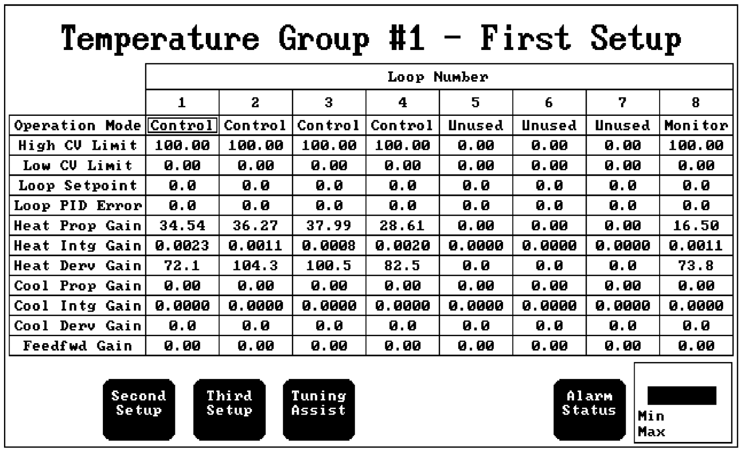
	Loop 1	Loop 2	Loop 3	Loop 4	Loop 5	Loop 6	Loop 7	Loop 8
Temperature	70.5	70.4	70.4	70.3	0.0	0.0	0.0	69.8
Run Setpoint	410.0	400.0	400.0	425.0	0.0	0.0	0.0	300.0
Standby Setpt.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Actual Output	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Man. Output SP	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
On or Off	Off Off	Off Off	Off Off	Off Off	Off Off	Off Off	Off Off	Off Off
Auto or Manual	Aut Aut	Aut Aut	Aut Aut	Aut Aut	Man Man	Man Man	Man Man	Aut Aut
Run or Standby	Run Run	Run Run	Run Run	Run Run	Std Std	Std Std	Std Std	Run Run
High Alarm	550.0	550.0	550.0	550.0	0.0	0.0	0.0	120.0
High Dev Alarm	50.0	50.0	50.0	50.0	0.0	0.0	0.0	0.0
Low Dev Alarm	50.0	50.0	50.0	50.0	0.0	0.0	0.0	0.0
Low Alarm	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

2. At this screen, enter temperature configuration values for each loop.

In this field:	Select or enter:
Run Setpoint	The run set-point value
Standby Setpt	The standby set-point value
Man. Output SP	The fixed output value for manual mode
	⚠ **ATTENTION**: This output can overheat and damage zone
On or Off	Set to **On** each loop you intend to use.
	To turn all your loops on /off, press [All Loops On] or [All Loops Off]
Auto or Manual	Manual mode
Run or Standby	Run (use the run set point) or standby (use the standby set point)
High Alarm	The high temperature alarm value
High Dev Alarm	The high deviation alarm value
Low Dev Alarm	The low deviation alarm value
Low Alarm	The low temperature alarm value

3. To download your edits, press: 

4. Go to the first setup screen by pressing: [Set-up]



Temperature Group #1 – First Setup

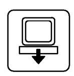
	Loop Number							
	1	2	3	4	5	6	7	8
Operation Mode	Control	Control	Control	Control	Unused	Unused	Unused	Monitor
High CV Limit	100.00	100.00	100.00	100.00	0.00	0.00	0.00	100.00
Low CV Limit	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Loop Setpoint	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Loop PID Error	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Heat Prop Gain	34.54	36.27	37.99	28.61	0.00	0.00	0.00	16.50
Heat Intg Gain	0.0023	0.0011	0.0008	0.0020	0.0000	0.0000	0.0000	0.0011
Heat Derv Gain	72.1	104.3	100.5	82.5	0.0	0.0	0.0	73.8
Cool Prop Gain	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cool Intg Gain	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Cool Derv Gain	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Feedfwd Gain	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Second Setup · Third Setup · Tuning Assist · Alarm Status · Min Max

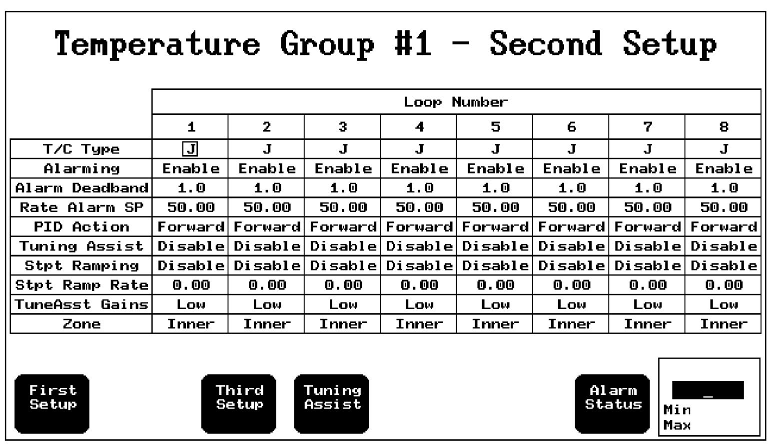
5. At this screen, enter these temperature setup values for each loop.

In this field:	Select or enter:
Operation Mode	Control
Loop Setpoint	Monitor data in this read-only field.
High CV Limit	The maximum output percentage allowable.
Low CV Limit	The minimum output percentage allowable.
Loop PID Error	Monitor data in this read-only field.
Heat Prop Gain	Heat proportional gain.
Heat Intg Gain	Heat integral gain.
Heat Derv Gain	Heat derivative gain.
Cool Prop Gain	Cool proportional gain.
Cool Intg Gain	Cool integral gain.
Cool Derv Gain	Cool derivative gain.

If you do NOT enter gains, follow auto-tuning procedure in the next section, Loop Start-up and Tuning, step 8. (Also refer to appendix D.)

6. To download your edits, press: 

7. Go to the second setup screen by pressing: [Second Setup]



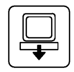
Temperature Group #1 – Second Setup

	Loop Number							
	1	2	3	4	5	6	7	8
T/C Type	J	J	J	J	J	J	J	J
Alarming	Enable	Enable	Enable	Enable	Enable	Enable	Enable	Enable
Alarm Deadband	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Rate Alarm SP	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00
PID Action	Forward	Forward	Forward	Forward	Forward	Forward	Forward	Forward
Tuning Assist	Disable	Disable	Disable	Disable	Disable	Disable	Disable	Disable
Stpt Ramping	Disable	Disable	Disable	Disable	Disable	Disable	Disable	Disable
Stpt Ramp Rate	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TuneAsst Gains	Low	Low	Low	Low	Low	Low	Low	Low
Zone	Inner	Inner	Inner	Inner	Inner	Inner	Inner	Inner

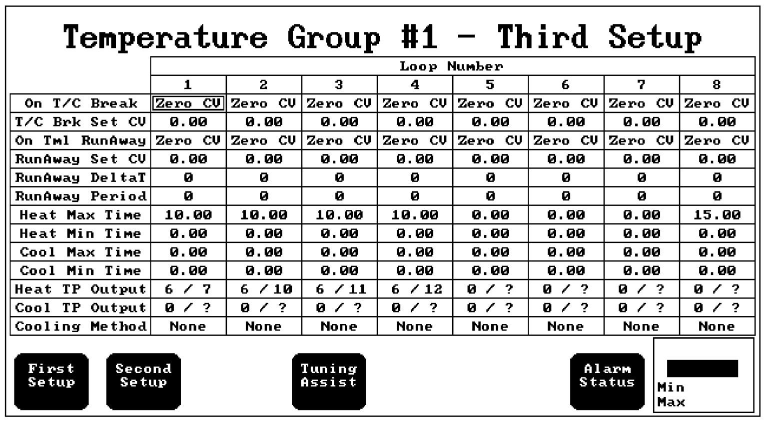
First Setup · Third Setup · Tuning Assist · Alarm Status · Min Max

8. At this screen, enter these temperature setup values for each loop.

In this field:	Select or enter:
T/C type	The type of thermocouple used in your machine (typically type J)
Alarming	Enable or Disable alarms (default is to disable alarms).
Alarm Deadband	The dead-band value for C alarms (typically 1–2 degrees).
Rate Alarm SP	The input (PV) rate alarm value (default is 0.0 for disabled).
PID Action	Forward (E = SP – PV) or Reverse (E = PV – SP).
Tuning Assist	Enable for each loop that you want to tune later.
Stpt Ramping	Enable — if your equipment is sensitive to rapid temperature changes; otherwise, disable.
Spt Ramp Rate	A set-point ramp rate — if you enable set-point ramping.
Tuning-Assist Gains	The level of PID gains (low, medium, or high) that you want to be calculated as a result of the auto-tuning.
Zone	Inner zone or outer zone.

9. To download your edits, press: 

10. Go to the third setup screen by pressing: [Third Setup]

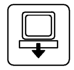


Temperature Group #1 - Third Setup

	Loop Number							
	1	2	3	4	5	6	7	8
On T/C Break	Zero CV	Zero CV	Zero CV	Zero CV	Zero CV	Zero CV	Zero CV	Zero CV
T/C Brk Set CV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
On Tml RunAway	Zero CV	Zero CV	Zero CV	Zero CV	Zero CV	Zero CV	Zero CV	Zero CV
RunAway Set CV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RunAway DeltaT	0	0	0	0	0	0	0	0
RunAway Period	0	0	0	0	0	0	0	0
Heat Max Time	10.00	10.00	10.00	10.00	0.00	0.00	0.00	15.00
Heat Min Time	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cool Max Time	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cool Min Time	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Heat TP Output	6 / 7	6 / 10	6 / 11	6 / 12	0 / ?	0 / ?	0 / ?	0 / ?
Cool TP Output	0 / ?	0 / ?	0 / ?	0 / ?	0 / ?	0 / ?	0 / ?	0 / ?
Cooling Method	None	None	None	None	None	None	None	None

11. At this screen, enter these temperature setup values for each loop.

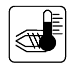
In this field:	Select or enter:
On T/C Break	Select the output action to be taken when the module detects a break in a connection to the corresponding thermocouple: • Zero output (set to 0) • Set output (set to the TC-break forced output value) • Manual output (set to the manual-mode output value)
T/C Break Set CV	The forced output value to be used upon detecting a TC break
On Tml Runaway	Select the output action to be taken upon detection of thermal runaway in the corresponding loop: • Zero output (set to 0) • Set output (set to the thermal-runaway forced output value) • Manual output (set to the manual-mode output value)
RunAway Set CV	The forced output value upon detecting thermal runaway
RunAway DeltaT	The thermal runaway temperature change value
RunAway Period	The thermal runaway period
Heat Max Time	The heat TPO period
Heat Min Time	The heat minimum on time during the TPO period
Cool Max Time	The cool TPO period
Cool Min Time	The cool minimum on time during the TPO period
Heat TP Output	The address of the heat TPO (word/bit)
Cool TP Output	The address of the cool TPO (word/bit)

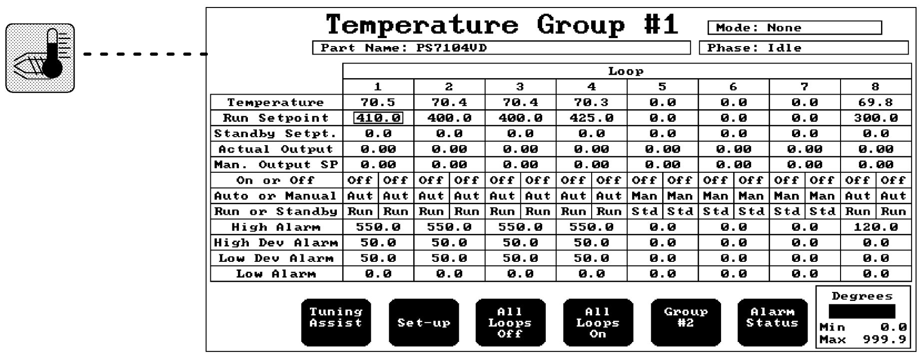
12. To download your edits, press: 

Important: Several of the advanced control features such as identification of the zone type (inner/outer) or selection of a non-barrel loop can not be set with these screens. to set these selections, you would have to set the proper bits in the data-table blocks as described in chapter 4 of the user manual.

Loop Start-Up and Tuning

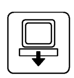
Although you can select individual loops for auto-tuning, when tuning barrel temperature zones, you will get better results if all zones (loops) are tuned together; this lets the module compensate for cross-zone heat flow. After the loops have been configured, you can start up and tune the module with Pro-Set 700 temperature control screens as follows.

1. At the main Pro-Set screen, from the icon bar, select the process (temperature-group-#1) screen by pressing  (Loops 1–8) or  (Loops 9–16).

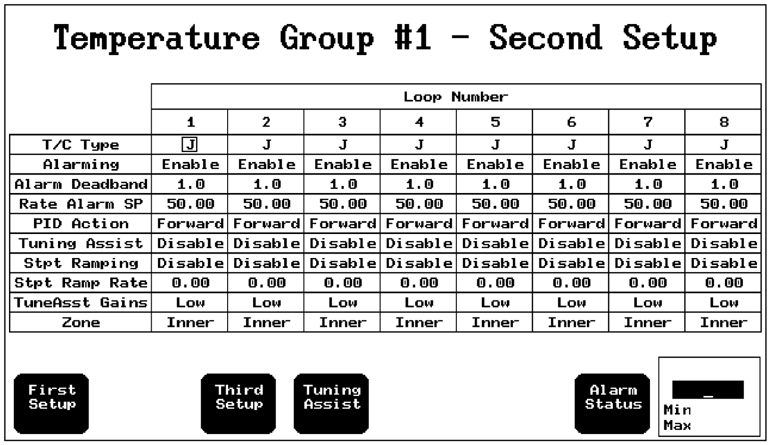


2. At this screen, enter temperature configuration values for each loop.

In this field:	Select or enter:
Run Setpoint	The run set-point value
Man. Output SP	Set to 0
On or Off	Set to **On** each loop you intend to start up
Auto or Manual	Manual mode
Run or Standby	Run

3. To download your edits, press: 

4. Go to the second setup screen by pressing: Second Set-up



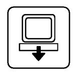
Temperature Group #1 - Second Setup

	Loop Number							
	1	2	3	4	5	6	7	8
T/C Type	J	J	J	J	J	J	J	J
Alarming	Enable	Enable	Enable	Enable	Enable	Enable	Enable	Enable
Alarm Deadband	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Rate Alarm SP	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00
PID Action	Forward	Forward	Forward	Forward	Forward	Forward	Forward	Forward
Tuning Assist	Disable	Disable	Disable	Disable	Disable	Disable	Disable	Disable
Stpt Ramping	Disable	Disable	Disable	Disable	Disable	Disable	Disable	Disable
Stpt Ramp Rate	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TuneAsst Gains	Low	Low	Low	Low	Low	Low	Low	Low
Zone	Inner	Inner	Inner	Inner	Inner	Inner	Inner	Inner

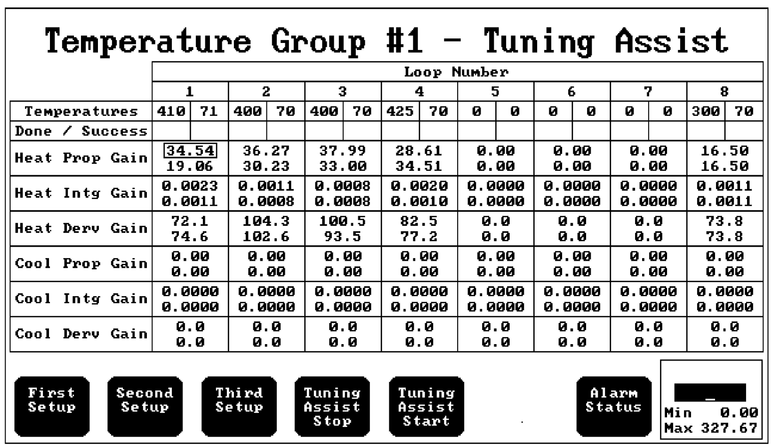
5. At this screen, enter these temperature setup values for each loop.

In this field:	Select or enter:
Tuning Assist	Enable for each loop that you want to tune.

You do not have to auto-tune the loops at every start up. The system parameter values derived from previous auto-tuning are stored in the PLC data table for use after subsequent start-ups.

6. To download your edits, press: 

7. Go to the tuning assist screen by pressing: [Tuning Assist]



Temperature Group #1 - Tuning Assist

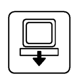
	Loop Number															
	1		2		3		4		5		6		7		8	
Temperatures	410	71	400	70	400	70	425	70	0	0	0	0	0	0	300	70
Done / Success																

	1	2	3	4	5	6	7	8
Heat Prop Gain	34.54 19.06	36.27 30.23	37.99 33.00	28.61 34.51	0.00 0.00	0.00 0.00	0.00 0.00	16.50 16.50
Heat Intg Gain	0.0023 0.0011	0.0011 0.0008	0.0008 0.0008	0.0020 0.0010	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0011 0.0011
Heat Derv Gain	72.1 74.6	104.3 102.6	100.5 93.5	82.5 77.2	0.0 0.0	0.0 0.0	0.0 0.0	73.8 73.8
Cool Prop Gain	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00
Cool Intg Gain	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000
Cool Derv Gain	0.0 0.0	0.0 0.0	0.0 0.0	0.0 0.0	0.0 0.0	0.0 0.0	0.0 0.0	0.0 0.0

8. To provide auto-tuning, at the tuning-assist screen:

A. When ready, press [Tuning Assist Start]

B. If necessary, you can stop the action by pressing [Tuning Assist Stop]

C. To download your edits, press: 

D. Once auto-tuning is started:
– Return to the Temperature Group #1 screen.
– Set each loop for **Auto** mode (step 2).

When auto-tuning is complete and new PID values are calculated, on the tuning assist screen, **done** and **success** are indicated by check marks (✔) in their respective fields. If a problem prevents the module from completing the task, only **done** is indicated. When **done** is indicated, the module puts the loops under PID control.

Considerations for Pro-Set 700 Release 2.0 Software

If you are using Pro-Set 700 release 2.0 software, in addition to the preceding procedures, include the following steps:

1. At the first setup screen, leave the feedforward gain at 0.00 (Temperature Group #1 – First Setup, paga E-2)
2. At the third setup screen, select the cooling method as none. (Temperature Group #1 – Third Setup, page E-3)
3. Once auto-tuning is complete and successful, copy the calculated PID parameters into the active column before downloading. If you fail to do this, you will cause the PID parameters in the module to be overwritten.

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