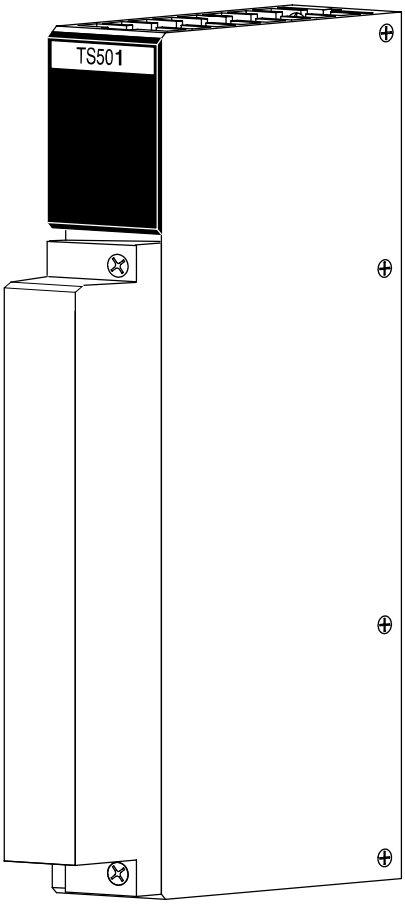
SYSMAC
C1000H/C2000H
CV1000/CV2000/CVM1

C500-TS501
Thermocouple Input Module
Operation Manual

January 1996



Notice:

OMRON products are manufactured for use by a qualified operator according to proper procedures and only for the purposes described in this manual.

The following conventions are used to indicate and classify warnings in this manual. Always heed the information provided with them.

DANGER! Indicates information that, if not heeded, could result in loss of life or serious injury.

Caution Indicates information that, if not heeded, could result in minor injury or damage to the product.

OMRON Product References

All OMRON product names are capitalized in this manual.

The abbreviation Ch, which appears in some displays and on some OMRON products, means word and is sometimes abbreviated Wd in documentation.

Visual Aids

The following headings appear in the left column of the manual to help you locate different types of information.

Note Indicates information of particular interest for efficient and convenient operation of the product.

1, 2, 3... 1. Indicates lists of one sort or another, such as procedures, precautions, etc.

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1–1 Terminology

The following terms are used throughout this manual. Review these terms as necessary.

Note:	Alerts the user about special features or procedures.
Caution:	Indicates information that, if not heeded, could result in minor injury or damage to the product.
DANGER!:	Indicates information that, if not heeded, could result in loss of life or serious injury.
2 Word Mode	Refers to the 2 word communication mode between the I/O module and the PLC's CPU. This mode communicates with the CPU using two I/O words and the Special I/O Read and Write commands.
4 Word Mode	Refers to the 4 word communication mode between the I/O module and the PLC's CPU. This mode communicates with the CPU using four I/O Words and Standard Data Movement Instructions.
Data Memory	Refers to the 16 bit register memory in the PLC's CPU used to store and manipulate data.
Bit	Set by the user to enable a particular function. 0=OFF/DISABLE, 1=ON/ENABLE
LSB	Least significant bit.
Jumper Pins (8 sets of 16 pins)	Jumper pins consist of 16 pins per terminal. There are eight terminals. Jumpers are installed on a pair of pins to set a specific thermocouple type.
Jumpers (16)	Jumpers are plastic devices. They are located under the terminal block cover. Jumpers are used to connect pairs of jumper pins for specific thermocouple type.
Rotary switches (8)	Rotary switches are located at the back of the module and are used to set the type of thermocouple input.
Captive screws (2)	Spring-loaded screws which are retained in the terminal block cover and used to secure this cover to the module.
Terminal block cover	A plastic cover located at the front of the module which is used to cover and protect the internal components of the module.
Terminal Connectors (24)	A device used to clamp-down electrical wiring to the module.
Word	Indicates a memory location in the PLC data memory or in the module memory map. A word can contain a single piece of data or it can contain bits or flags for each of 16 input points.

1–2 Quick Start Procedure

The following steps are used as a quick reference guide when installing and setting up the module. For specific details, refer to the appropriate section.

1. Unpacking the module . . . . . Section 2
2. Set rotary switches and jumpers . . . . . Section 3
3. Install the module on the backplane . . . . . Section 3
4. Wire the I/O terminal block . . . . . Section 3
5. Record settings in the configuration worksheet . . . . . Appendix D
6. Power-up the module
7. Verify default ladder programs . . . . . Section 1
8. Check module indicators . . . . . Section 2

1–3 Default Settings

Default settings from the factory apply to the rotary switches and jumpers, data format, and memory map.

1–3–1 Rotary Switches and Jumpers

Rotary switches and jumpers are factory set for all input points to J-Type thermocouple(s). The interface mode is factory set to 2 word mode.

1–3–2 Data Format

The default data format is BCD which gives a resolution of 1°C or °F. Binary data format gives a resolution of 0.1°C or °F. The default range is J-Type, with data reported as 0000 for 0°C, and 0760 for 760°C.

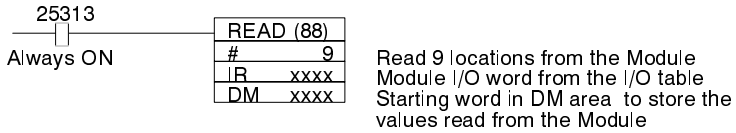
1–3–3 Memory Map

The module has a memory map that is used to store data and select the different functions that the module can perform.

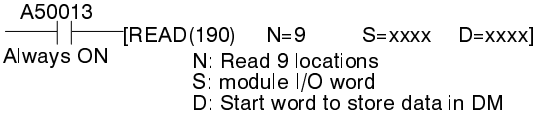
1–4 Default Ladder Programs

The ladder diagram below is used in conjunction with the default settings. It can be entered to read the thermocouple data and alarm flags for each input point into the PLC data memory (DM) area. This program assumes that the module is in its factory default settings.

C-series



CV-series



Alarm flags and analog conversion data is stored in PLC memory beginning at the DM address specified in the ladder diagram instruction.

Data in PLC Memory

DM N	Module alarm flags
DM N + 1 to N + 8	Input conversion data in BCD format, for inputs 1 to 8

1–5 Reference Manuals

CV Installation Manual	W195
CV Operation Manual: Ladder Diagram	W202
C1000H, 2000H Installation Manual	W139
C1000H, 2000H Operation Manual	W140

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2–1 Unpacking the Module

To unpack the module, open the shipping carton and slide out the corrugated insert containing the module. Remove the module from the insert, making sure to retain the installation slip which accompanies the module. Keep the shipping carton and corrugated insert in the event it becomes necessary to return the module for service.

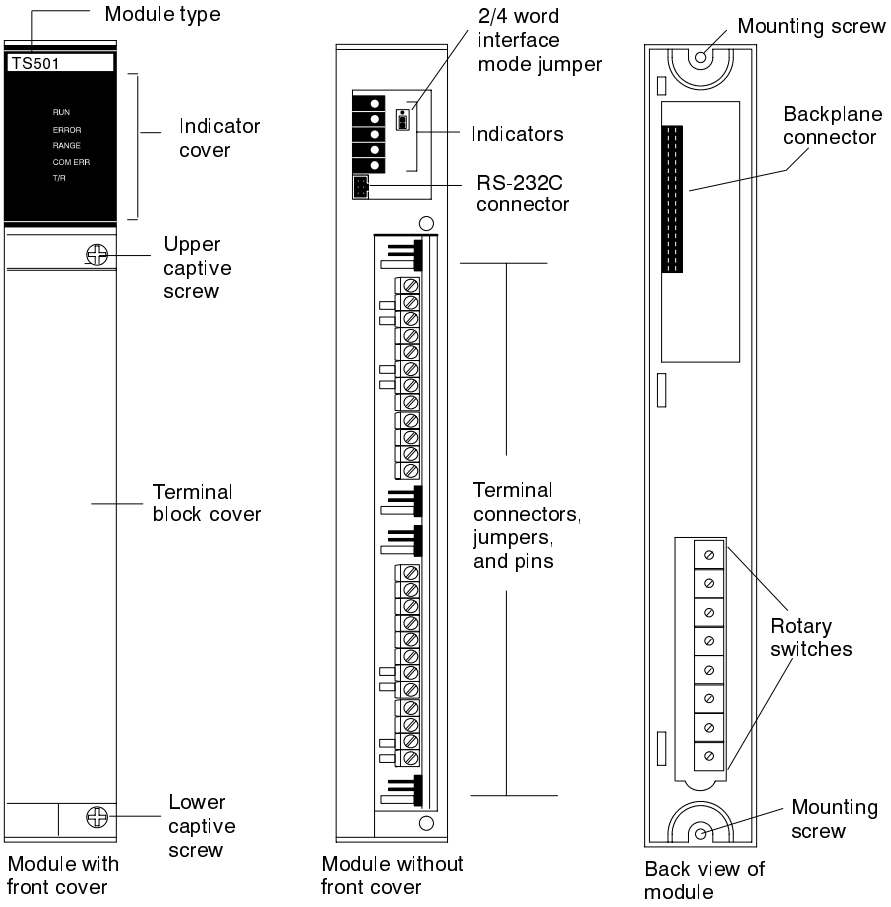
Caution: The module components can be damaged by static electricity if not properly handled. Therefore, appropriate static control precautions must be observed during installation and setup.

2–2 Model Numbers

C500-TS501	8-Point Isolated Thermocouple Module
H02TAZ2	Operation Manual for C500-TS501

2–3 Module Identification

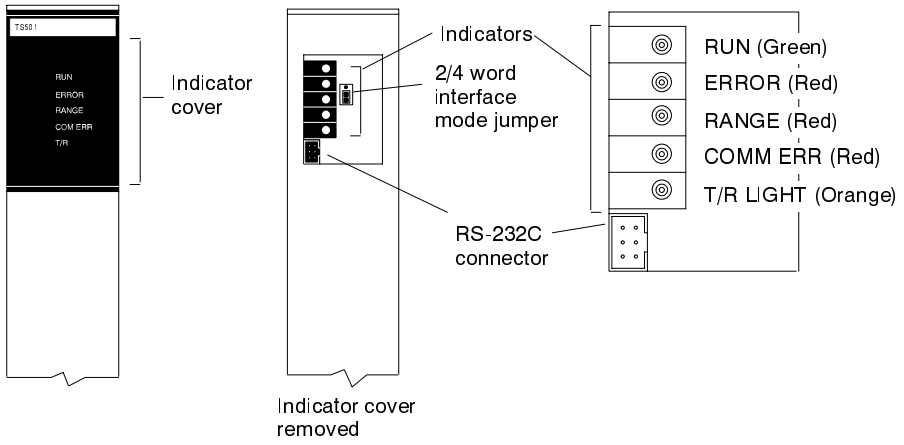
The areas of the module are identified below:



2–4 Indicators

The indicator lights are located behind the indicator cover. To access this area of the module, remove the indicator cover by rotating it clockwise or counterclockwise until the cover is free, then lift the cover off. The indicators allow the operator to monitor the status and operation of the module. Refer to the chart which describes each indicator function. Refer to the illustration to identify and locate the indicators and the connector.

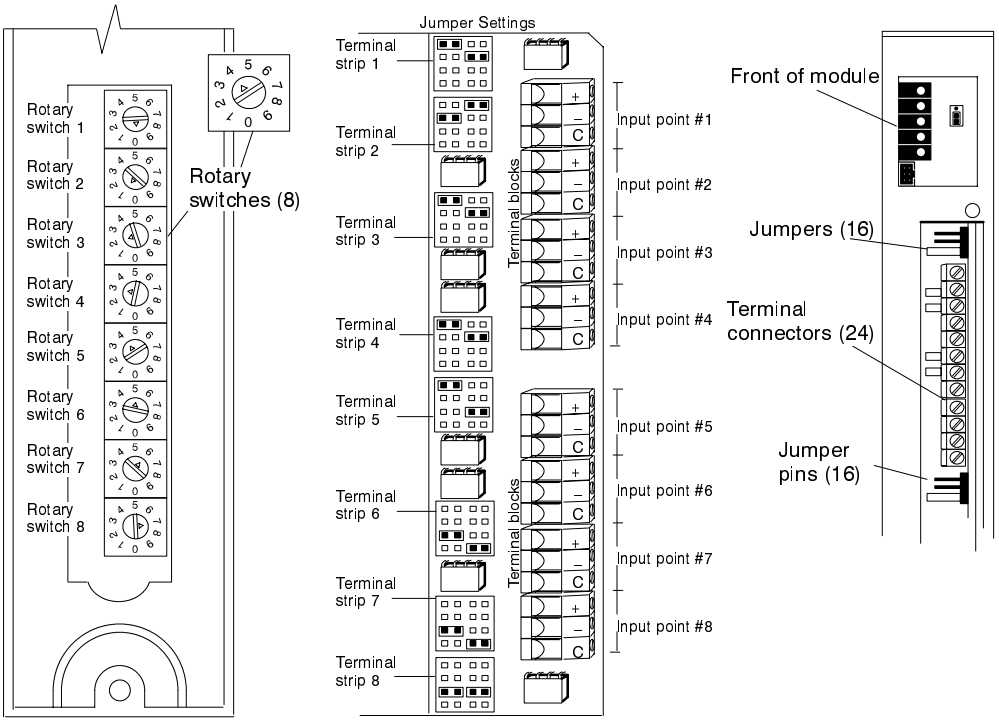
Indicators	Function
RUN (Green)	When the indicator is illuminated, the microprocessor is operating correctly.
ERROR (Red)	When the indicator is illuminated, an internal module diagnostic failure, an out-of-range error, or a communication error has occurred.
RANGE (Red)	When the indicator is illuminated, an input signal is outside the selected range. This condition occurs when an enabled input point is not connected to an thermocouple, or the temperature has gone above or below the specific range.
COM ERR (Red)	When the indicator is illuminated, a communication error has occurred when communicating over the serial port.
T/R (Orange)	When the indicator is illuminated, communication is occurring over the serial port.



2–5 Setting the Rotary Switches and Jumpers

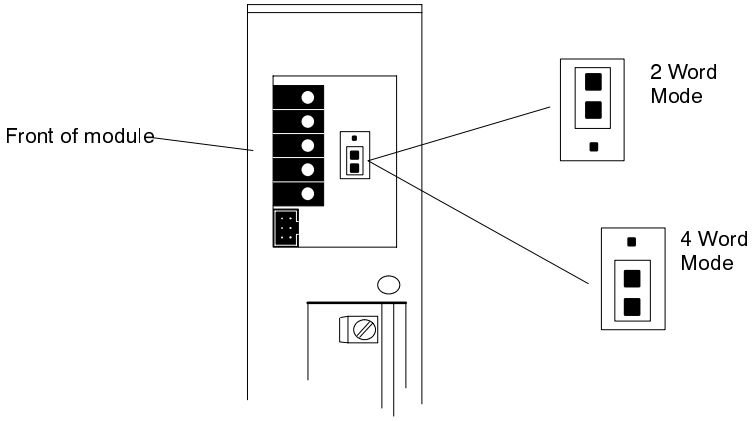
2–5–1 Thermocouple Type

There are eight rotary switches located in the back of the module. Each switch has a slotted dial which will accommodate a small, straight-blade screwdriver. To set the input range for a specific thermocouple type, rotate the rotary switch(es) until the arrow points to the specified numerical setting. Refer to Section 3 of this manual for rotary setting instructions. In addition to the rotary switches, there are sixteen plastic jumpers. Each jumper is mounted on a pair jumper pins to set cold junction compensation. Refer to Section 3 of this manual for jumper setting instructions.



2–5–2 2/4 Word Mode Jumper

The communication mode of the module with the PLC is set by one jumper located behind the indicator cover. The jumper is mounted on the upper two pins for 2 word mode, and on the lower two pins for 4 word mode. Refer to Section 5 for details on 2 word and 4 word mode communication.



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3–1 Installation and Wiring

3–1–1 Signal Requirements

Before setting input ranges, make sure to review the application requirements, temperature ranges or millivolt range, and input cable configuration. Thermocouple signal cable generally have two signal wires which are labeled plus (+) and minus (–). Verify the thermocouple's plus and minus wire using wire manufacture's color code. The wire may also have an optional shield wire. Use the configuration worksheet in Appendix D to record module settings. Refer to this section for specific wiring examples.

3–1–2 Power Consumption

The module uses 5 volt power from the PLC power supply. The maximum current consumption is 1.4 Amps. Refer to the CV Installation Manual W195 or C1000H Installation Manual W139 to determine total system power requirements.

3–1–3 Module Locations

The module uses the Special I/O READ/WRITE ladder instruction to communicate with the PLC's CPU. Each module has two or four I/O words in the PLC I/O table. The modules may be located in the following racks:

- CPU Rack
- CV CPU Expansion Rack
- I/O Expansion Rack
- Local Expansion Rack
- SYSMAC BUS/2 I/O Rack

Any number of modules may be inserted into any single backplane. The only limitations are total system I/O capacity and the maximum power from the backplane. A maximum of eight 2 word modules can be mounted in a CPU or CPU Expansion Rack. Refer to Installation Manual W195 for the current limitation of the power supply modules. Refer to the following chart as a guide to the number of modules that can be placed in the rack.

	CV	CVM1
CPU rack	6	3
CPU expansion	7	5
I/O expansion	7	5

C-Series			
Power supply type	PS221	PS223	PS222
CPU Rack	2	6	
I/O expansion			4

3–1–4 Wiring Practices

The following practices are recommended when routing and connecting wires to the module:

- Always use the shortest possible cables.
- Avoid placing low voltage wire (i.e. analog input cables) parallel to high-energy wire.
- Use wireways for routing. Run signal wires and power wires in separate wireways or conduit if possible.
- Avoid bending cables into sharp angles.
- Use shielded cables for input signals.
- Do not place wires on vibrating surfaces.

- Connect the shield wire only at the module end of the cable.

3–2 Setting the Thermocouple Input Range

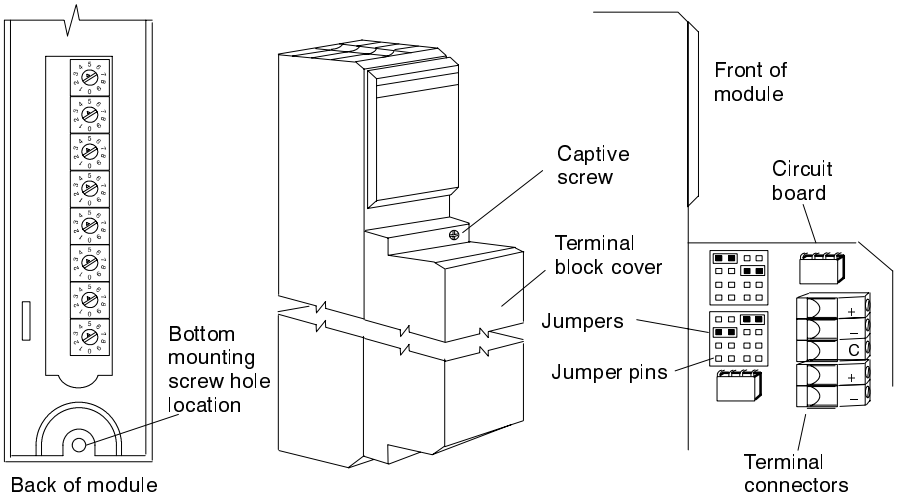
The C500-TS501 Thermocouple Module is initially set at the factory for a J-Type thermocouple for all input points. This module can be set to a total of 7 different thermocouple types and to low level voltages up to 50 millivolts. Setting input ranges is accomplished with jumpers and rotary switches. The following chart indicates the thermocouple input ranges.

Thermocouple Input Ranges		
Type	°C	°F
J	0-760	32-1400
K	0-1372	32-2501
R	0-1765	32-3209
S	0-1766	32-3211
T	0-400	32-752
E	0-1000	32-1832
J-DIN	0-900	32-1652

Millivolt Input Ranges	
Millivolt	0-50

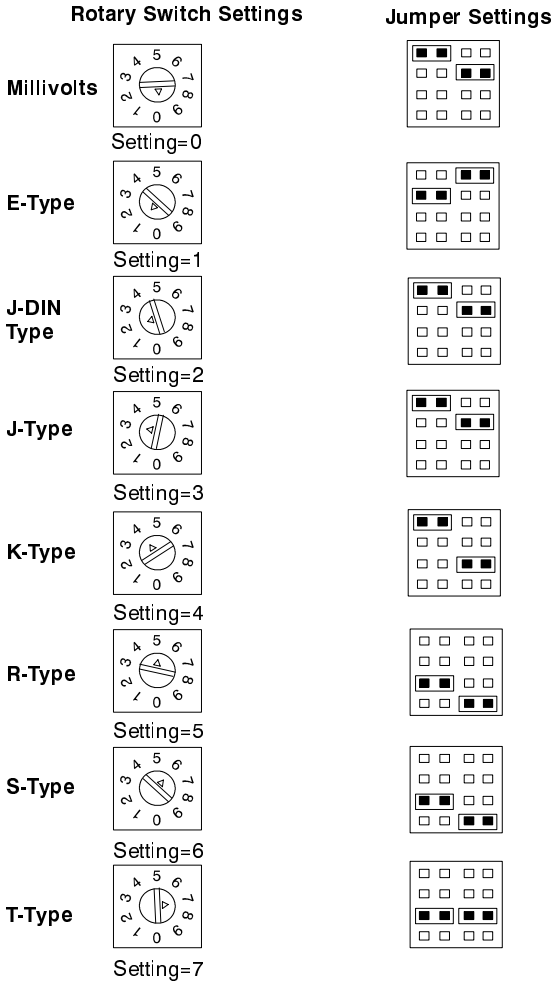
To set the various input ranges for each input point, proceed as follows.

1. For existing installations, remove the module from the backplane to gain access to the rotary switches, otherwise proceed to step 2.
2. Remove the terminal block cover at the front of the module.

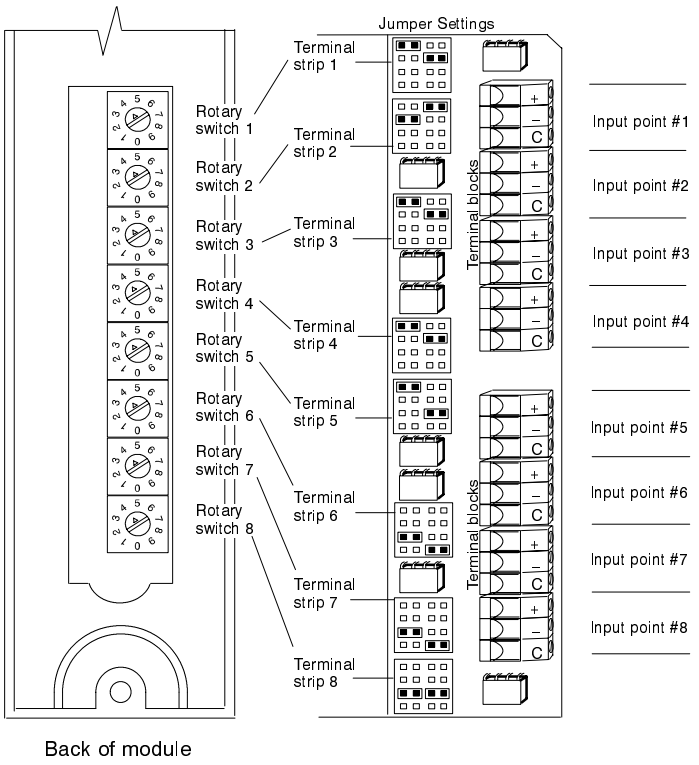


3. Set each jumper and rotary switch for the selected input point.

Note: Make settings to the rotary switch and to its corresponding jumper block for the designated input point. In the back of the module, the rotary switch located nearest to the top of the module is designated rotary switch number 1 and corresponds to Input Point 1. The bottom rotary switch corresponds to Input Point 8. Rotary switch position 0 and positions 4 through 9 are non-functional.



4. After making settings, record the module settings in the Configuration Sheet in Appendix D.
5. Reinstall the module to the backplane. Make sure that it seats in the backplane slot.
6. Install the terminal block cover.



Note: Rotary switch 1, terminal strip 1, and input point 1 all correspond to each other, etc. All switches and jumpers are factory set to the J-Type setting.

3–3 Wiring the Module

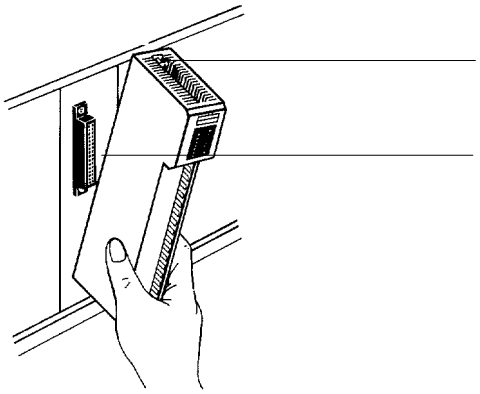
Wiring is accomplished at the terminal connectors or also referred to as terminal blocks. To access the terminal connectors proceed as follows.

1. Remove the front cover.
2. Insert each wire in the appropriate connector.
3. Secure each wire with the terminal screw.
4. Replace the front cover.

Note: By jumping any + and – input terminals, that input will return module ambient temperature.

3–4 Mounting the Module to the Backplane

When mounting the module on the backplane, make sure that it seats in the backplane slot, then tighten the top and bottom captive screws. For mounting location see below.



Mounting screws are provided at the top and bottom of the Unit.

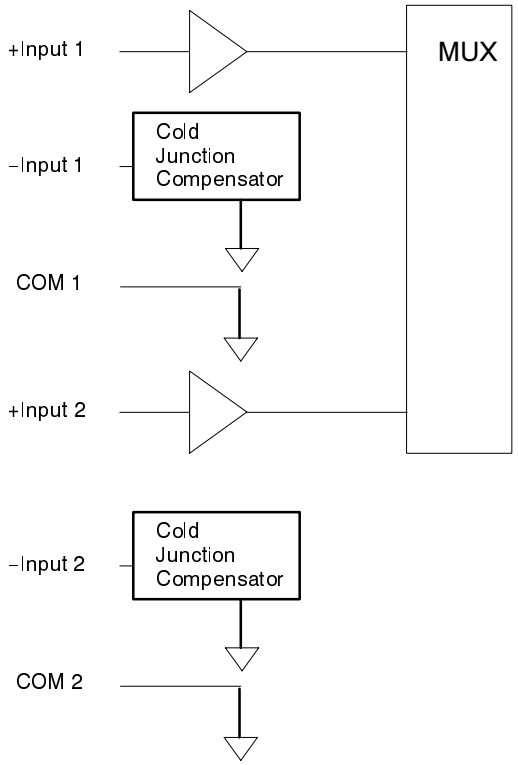
Connector
Make sure the connectors are properly mated.

3–5 Wiring Diagrams

The module can accept a variety of input signals. The following diagrams show the various input signal wiring configurations.

3–5–1 Module Front End

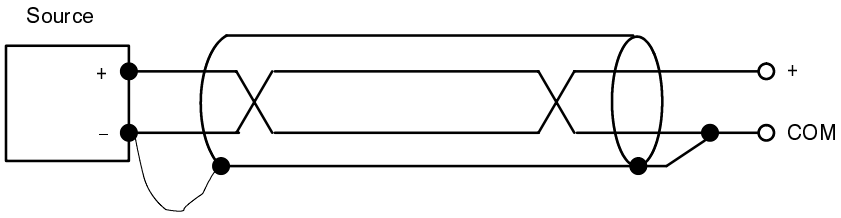
The diagram below is a simplified schematic of the front end of the module.



Input points 3-8 are similar.

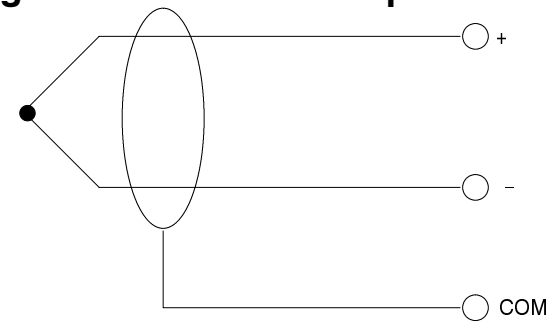
Note: COM terminals are not referenced to the chassis ground of the PLC. They are connected to the isolated internal analog ground plane for each input point.

3–5–2 Single-ended and Differential Millivolt Input with Shield (+, common, shield)



3–5–3 Grounded and Ungrounded Thermocouple without Shield

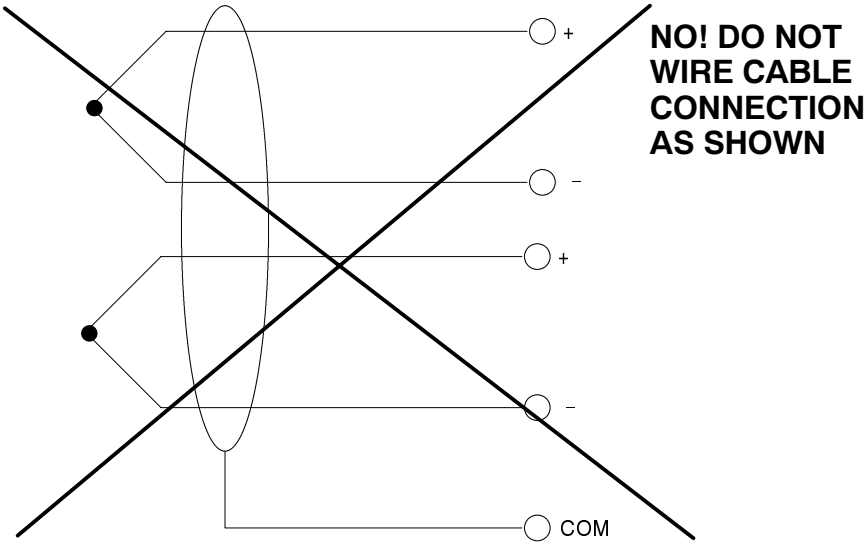
3–5–4 Grounded and Ungrounded Thermocouple with Shield



Note: For best results, OMRON recommends using only shielded, twisted-pair thermocouple wire. Shields should be connected to channel common.

Note: Shield terminals are not directly connected to chassis ground of the PLC. They are used as a floating reference for the isolated analog ground plane for each channel in the module.

3–5–5 Cable Connection



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4–1 Overview

The C500-TS501 Thermocouple Input module offers maximum application flexibility and high performance processing by combining the latest in analog and software technology to provide:

- Flexible configuration options
- High point density
- High accuracy and conversion speed
- Advanced intelligent functions

This section describes the module operation and performance of the intelligent functions that are built into the module.

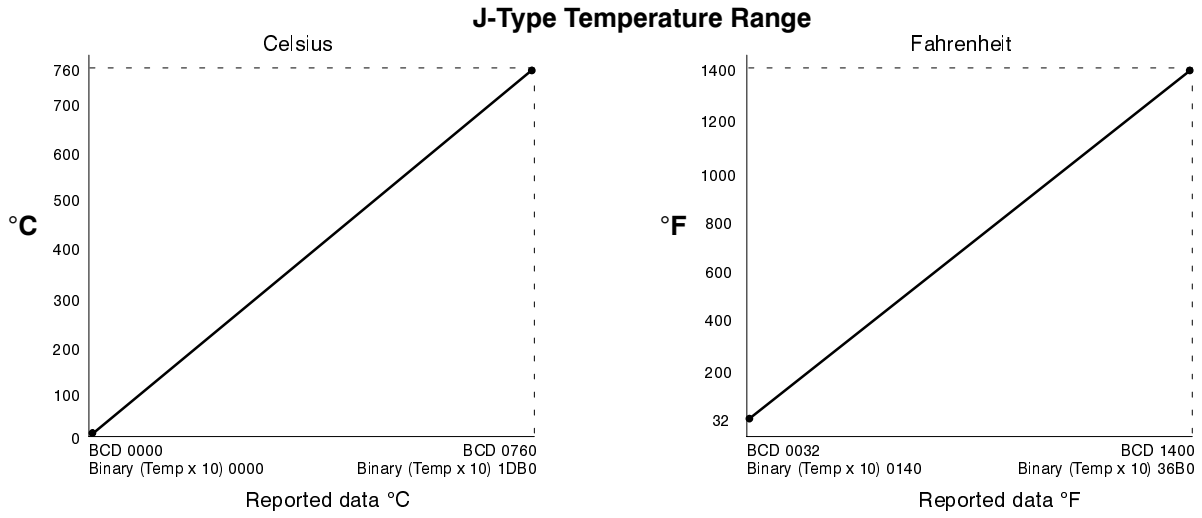
4–1–1 Theory of Operation

The module converts field signals (thermocouple and millivolt) to digital values that are available to the programmable controller ladder logic program for processing. A microprocessor allows the module to perform advanced intelligent functions on the converted data prior to being accessible to the controller. The module's microprocessor reduces the amount of ladder logic required to perform intelligent functions such as scaling, averaging, filtering, peak hold, and alarming. These functions are executed in the module which reduce the burden on the programmable controller. For specific programming examples refer to *Section 5.*

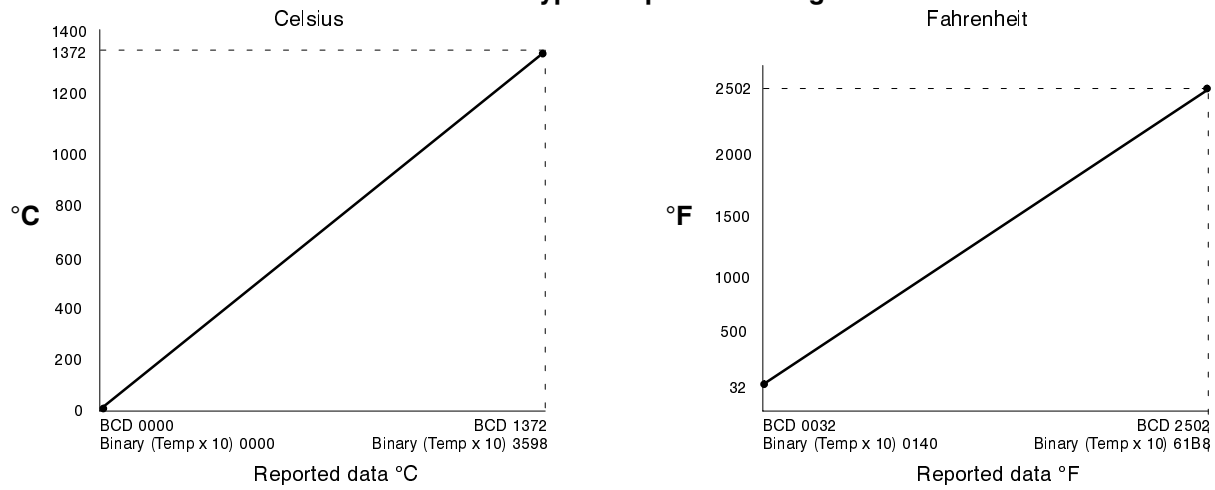
4–1–2 A/D Conversion

The following graphs show the conversion of various input signal types and the resulting digital numbers. The conversions are linear. Linearization is performed by a cold junction compensating device for each channel, and tables based on NIST IPTS-88, and DIN 73410 1985. These numbers can be transferred to the programmable controller or processed further in the module using intelligent functions.

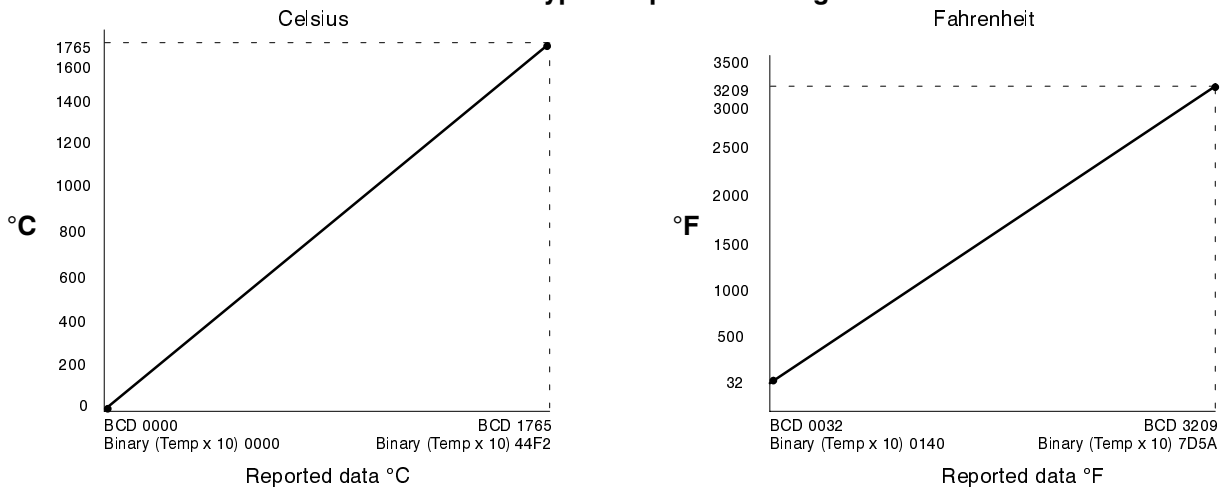
Input Signal Ranges vs A/D Conversion Data Diagram



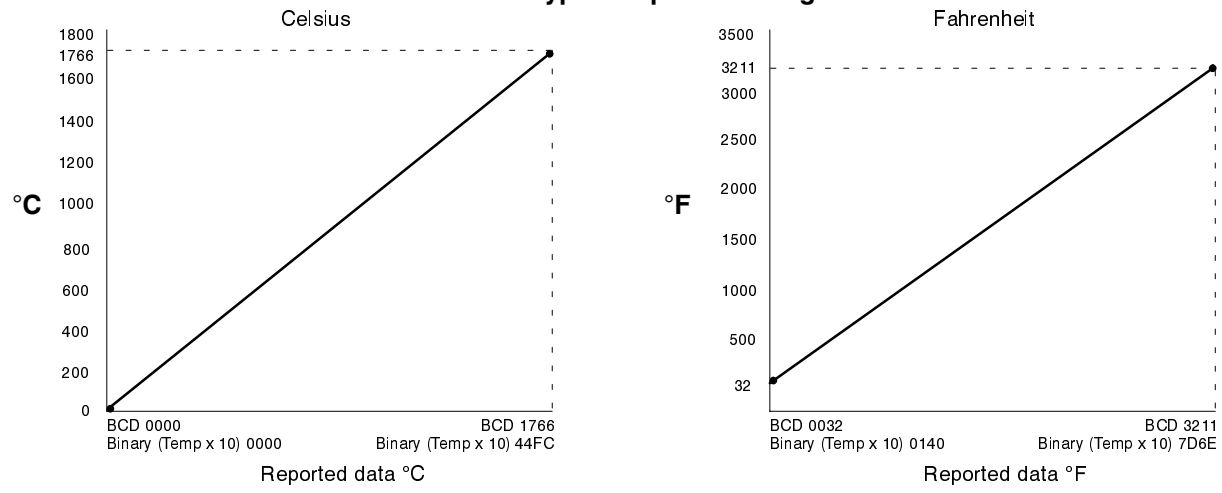
K-Type Temperature Range



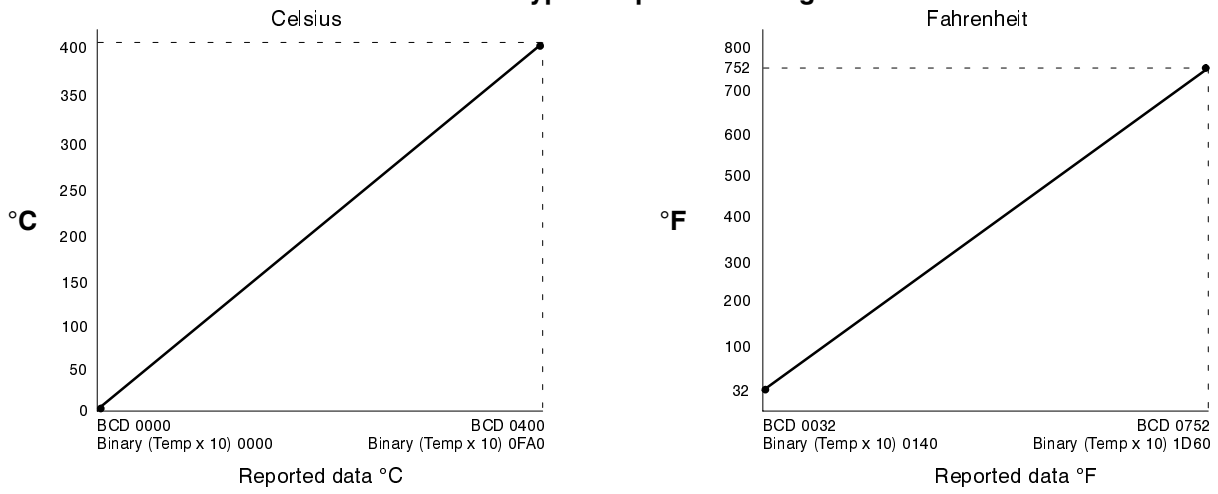
R-Type Temperature Range



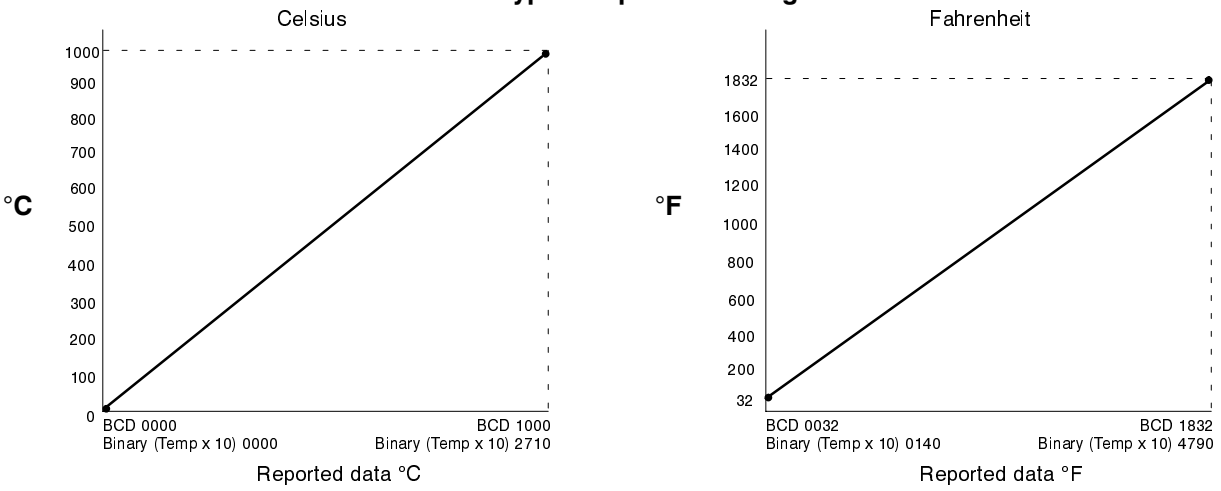
S-Type Temperture Range



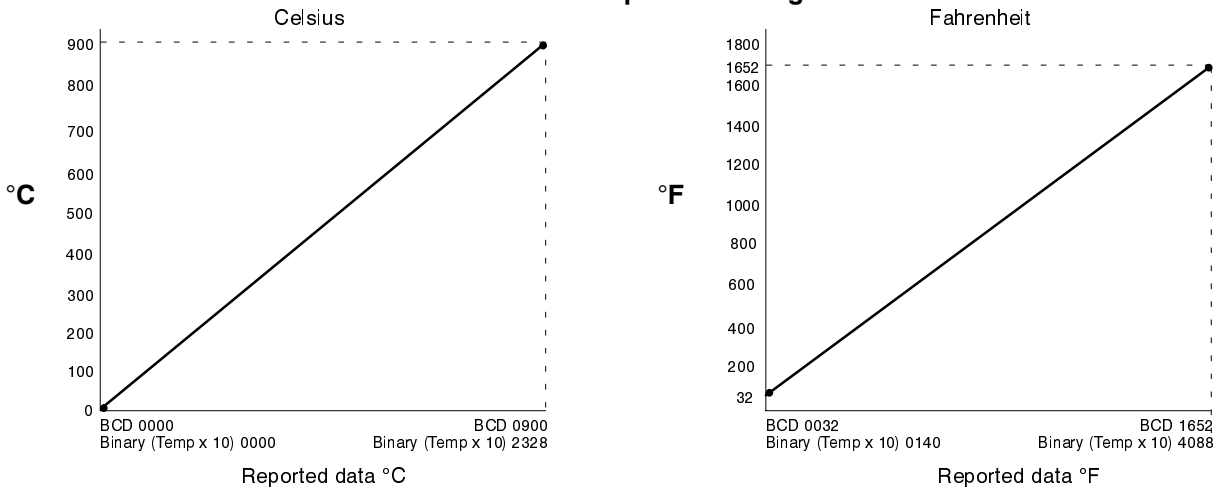
T-Type Temperature Range

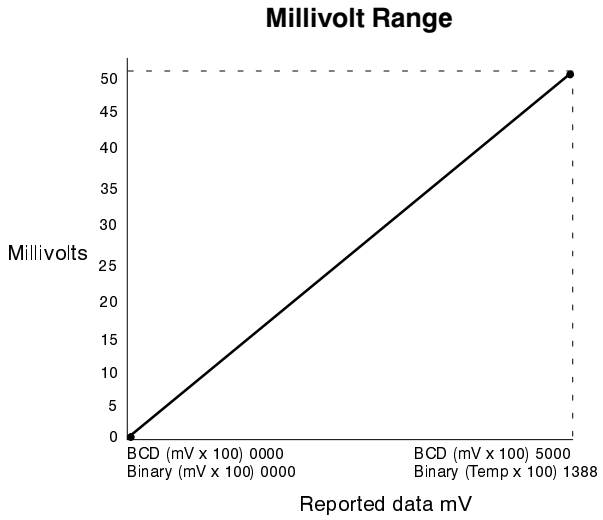


E-Type Temperature Range



J-DIN Temperature Range





4–1–3 Reading the Data Format

When an input point is configured to report data in binary, the data is reported in 0.1 degree increments. To convert it to a BCD number, perform the function Double Binary to Double BCD - BCDL in the ladder program. For example:

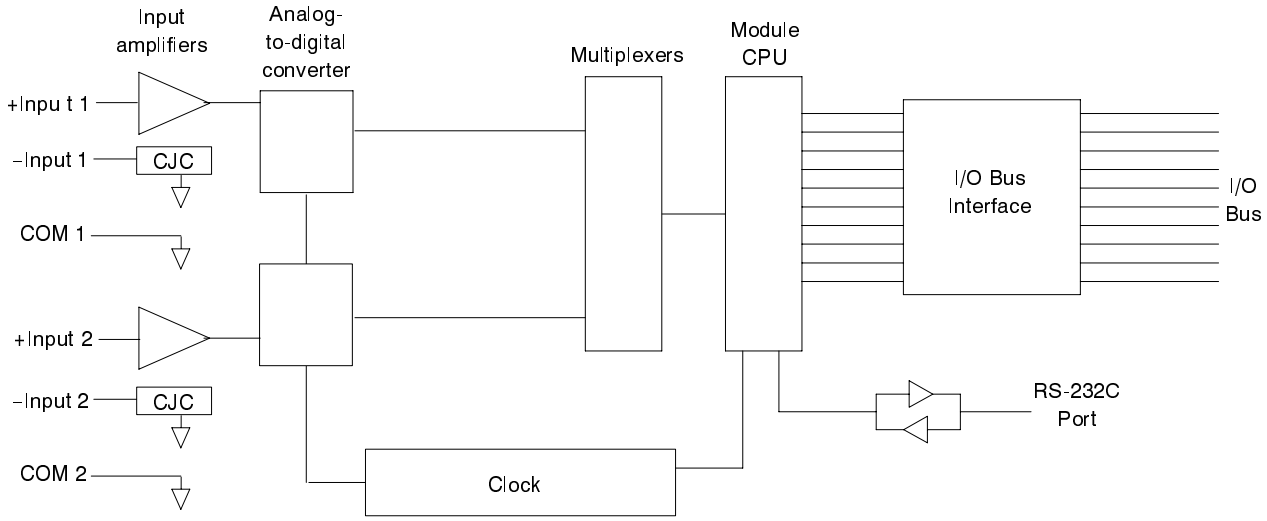
Binary Data Format			
Reported Data (Binary)	**Equivalent Decimal Value**	**Divided by 10**	**Equivalent Temperature***
1A8C	6796	679.6	679.6°
3093	12435	1243.5	1243.5°

BCD Data Format		
Reported Data (BCD)	**Equivalent Decimal Value**	**Equivalent Temperature***
0725	725	725°
2300	2300	2300°

***** The temperature scale, °C or °F, is set by the user in module memory map location 29 bits 00-07.

4–1–4 Block Diagram

The following diagram shows a simplified schematic of the module. The inputs are different for each point. See *Section 3* for field wiring examples.



Note: COM terminals are not referenced to the chassis ground of the PLC. They are connected to the internal analog ground plane for each input point.

4–1–5 Communications with the PLC

The module communicates with the programmable controller in 2 word mode using the intelligent Special I/O read/write instructions, and in the 4 word mode using Data Movement Instructions. Specific ladder logic examples are in *Section 5- Programming Examples*. Details about the ladder instructions and their execution can be found in *W202 - CV Operation Manual: Ladder Diagrams*.

The module has an extended internal memory map that provides storage for the module data and configuration parameters. This map contains both read and write areas, and is accessed by the programmable controller through the Special I/O ladder instructions, and using Data Movement Instructions. *Section 5* describes details of specific read/write operations between the module and the controller. This includes enabling the intelligent functions.

4–2 Module Data Formats

The module memory map consists of 16 bit words that contain either data or are bit oriented as flags or bits. The module can be configured to report data in two different formats. They are signed BCD and 2's Complement Binary. These formats can be selected per input point with the default set to BCD. The following conventions are used when describing the module memory map locations and their functions.

Word	Indicates a memory location in the PLC data memory or in the module memory map. A word can contain a single piece of data or it can contain bits or flags for each of 8 input points (see table below).
Bit	Set by the user to enable a particular function. 0=OFF/DISABLE, 1=ON/ENABLE
Flag	Set by the module to indicate status of a module function. 0=OFF/DISABLE, 1=ON/ENABLE

Both bits and flags are arranged in the following format and correspond to the input points indicated below.

Bit (MSB)	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	(LSB)
Input point	8	7	6	5	4	3	2	1	8	7	6	5	4	3	2	1	

Default values and valid data ranges for all module memory map words are in *Appendix E*.

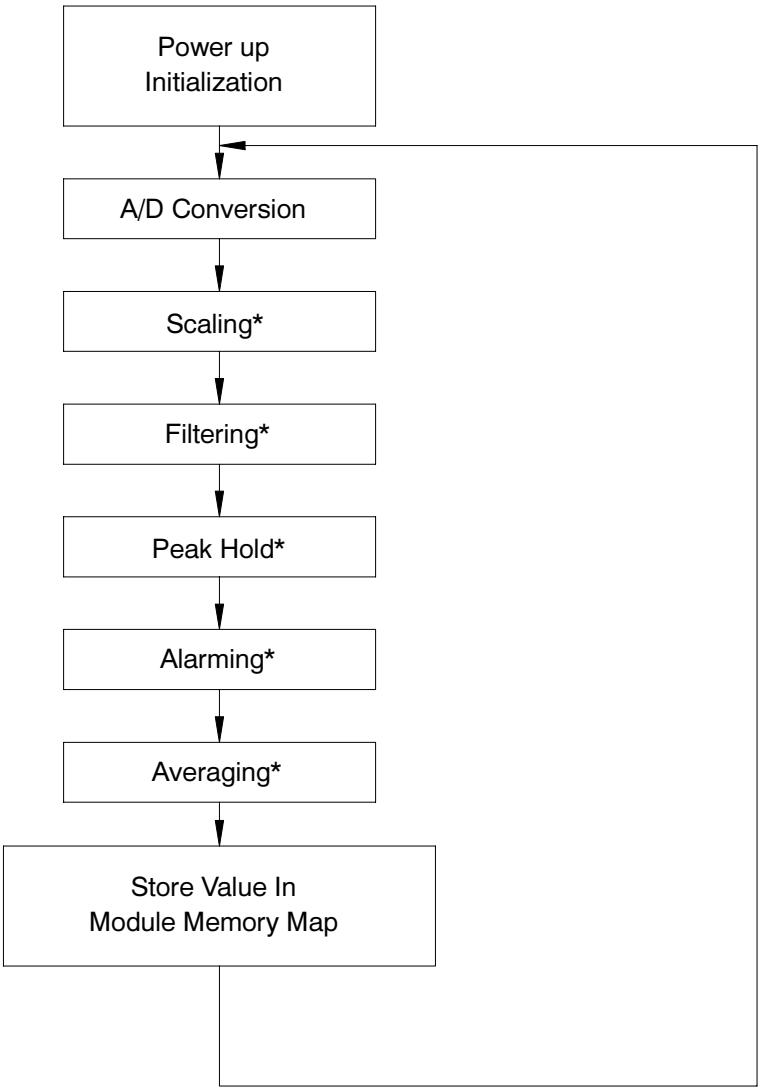
Data in the module memory map can be formatted in either signed BCD or 2's Complement Binary. All values for a specific input point must be in the same format. Some values are entered in unsigned BCD. Reference *Appendix E* for valid data ranges for all module memory map locations.

Format type	Decimal range	Memory map format
Signed BCD	-7999	F999 (Bit 15 is the sign bit)
	+7999	7999
2's Complement Binary	-32767	8001
	-1	FFFF
	0	0000
	+32767	7FFF

4–3 Intelligent Functions

4–3–1 Intelligent Function Processing Overview

The C500-TS501 is microprocessor based and can perform a number of intelligent functions on the converted data before putting it in the module memory map where it can be read by the controller. The following pages describe the operation of these functions and how to enable the functions. The specific module memory map locations, valid values, and functions are described in *Section 5*.



Note: *Performed when the intelligent function is enabled. If not enabled, skip to the next step. When the functions are disabled, the module conversion time is decreased.

4–3–2 Scaling Description

The scaling function can be used to perform conversion of data to engineering units prior to transfer to the PLC. With this feature enabled, the module maps the selected range of the analog input to a new user-specified range. The range can have upper and lower limits anywhere in the range -32767 to +32767 (binary) or -7999 to 7999 (BCD). Scaling can even be used to accomplish a sign inversion by setting the lower scale value positive and the upper scale value negative. Examples 1 and 2 illustrates scaling:

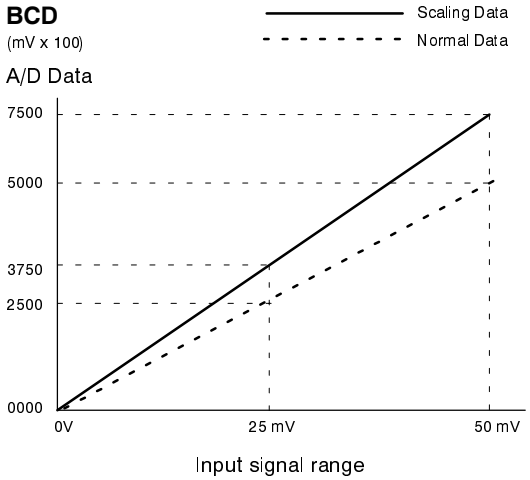
Example 1 - Scaling 0-50 Millivolts to Engineering Units (0-7500 GPM)

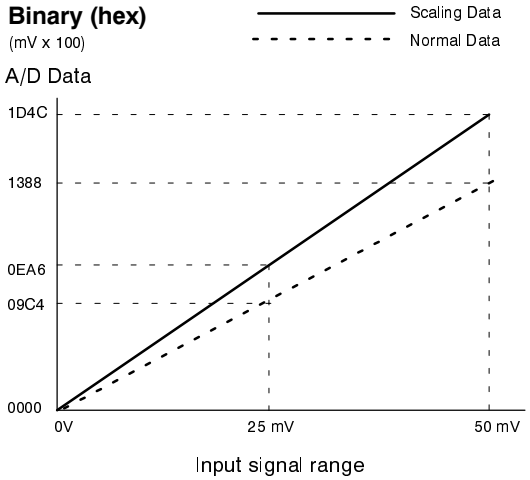
Input point 6 of the module is connected to a 50 mV signal from a flow sensor in a pipe. It has been determined that a 0 V reading on the sensor indicates no flow in the pipe and a 50 mV reading on the sensor indicates 7500 gallons/minute.

To configure the module to report the data in GPM:

1. Set the scaling low and high limits to 0000 and 7500.
2. Set the scaling enable bit to 1 for input point 6.

Input Range: 0-50 mV
Scaling High: 7500 gallons/minute
Scaling Low: 0000 gallons/minute





Module memory map location	Description	Valid data
20, bits 8-15	Scaling active flags	0 or 1
26, bits 8-15	Scaling enable bits	0 or 1
62 to 77	Scaling low and high limits	BCD or 2's Complement Binary

To use the scaling function for each input point do the following:

1. Set the input point scaling low and input point scaling high values for each input point.
2. Set the scaling enable/disable bit for the input point.

4–3–3 Averaging

The averaging function can be used to perform averaging of many samples of data prior to reporting the value to the PLC. This function is useful for reducing or eliminating noise commonly found in analog input signals. When averaging is enabled for a particular input point, the module takes the requested number of input samples for that input point and computes an average before reporting data to the PLC. The average is the algebraic sum of all of the conversions for the user-specified count divided by the sample count value. These values are then discarded and new samples are taken for the next average computation.

$$\text{1st Reported Value} = \frac{Conv_1 + Conv_2 + ... + Conv_n}{n}$$

$$\text{2nd Reported Value} = \frac{Conv_{n+1} + Conv_{n+2} + ... + Conv_{n+n}}{n}$$

n = number of sample counts, in BCD, specified by the user (minimum of 1, maximum of 9999)

Module memory map location	Description	Valid data
21, bits 0-7	Averaging active flags	0 or 1
27, bits 0-7	Averaging enable bits	0 or 1
54 to 61	Averaging sample counts	BCD 0001 to 9999 binary 0001 to 7FFF

To use this function for each input point do the following:

1. Set the input point averaging sample counts value for each input point.
2. Set the averaging enable bit for each input point.

4–3–4 Filtering

The filtering function is used to filter samples of data prior to reporting the value to the PLC. The filtering option is similar in function to the averaging function. While the averaging function is based on a quantity of counts to reach the data, the filtering function is based on a time. The units for the filtering time constants is milliseconds. The filtering function is useful for eliminating aberrations in the data due to noise or stray induced signals.

Module memory map location	Description	Valid data
21 bits 8-15	Filtering active flags	0 or 1
27 bits 8-15	Filtering enable bits	0 or 1
46 to 53	Filtering time constants	BCD 0001 to 9999 binary 0001 to 7FFF

To use this function for each input point do the following:

1. Set the input point filtering time constant value for each input point.
2. Set the filtering enable bit for each input point.

4–3–5 Peak Hold

The peak hold function can be used to detect peak conversion values of rapidly changing analog input signals. These values are stored in separate memory locations in the module memory map. This data is reset each time the peak hold function is enabled for the input point. There is also a Peak Hold Reset Bit and Acknowledge flag in the I/O Words described in Section 5.

Module memory map location	Description	Valid data
11 to 18	Peak hold data	BCD -7999 to +7999 Binary -32767 to +32767
19, bits 8-15	Peak hold active flags	0 or 1
25, bits 8-15	Peak hold enable bits	0 or 1

To use this function for each input point proceed as follows:

1. Set the input point peak hold enable bit for each input point.

Note: The peak hold function retains invalid values when changing from binary to BCD. Therefore, the peak hold enable bit should be reenabled after changing data formats.

4–3–6 Alarms

The alarm function can be used to perform a comparison of the input point conversion data to specific low and high limits that are stored in the module memory map. The module sets the alarm bits in the module memory map when the input point conversion data is outside the specified limits. The module can perform low alarming, high alarming, or both.

Module memory map location	Description	Valid data
00 bits 0-7	Alarm flags	0 or 1
9 bits 0-7	Low alarm flags	0 or 1
9 bits 8-15	High alarm flags	0 or 1
22 bits 0-7	Low alarm active flags	0 or 1
22 bits 8-15	High alarm active flags	0 or 1
28 bits 0-7	Low alarm enable bits	0 or 1
28 bits 8-15	High alarm enable bits	0 or 1
30 to 45	Low and high alarm limits	BCD -7999 to +7999 2's Complement Binary -32767 to +32767

To use this function for each input point proceed as follows:

1. Set the input point low alarm limit value and input point high alarm limit value for each input point.
2. Set the input point low alarm enable bit and input point high alarm enable enable bit for each input point.

4–3–7 EEPROM Functions

The module has an internal EEPROM memory which stores the module memory map. When power is applied, the module uploads the EEPROM to RAM and begins execution using the RAM values in the module memory map. There is an EEPROM write function which allows the user to store new default module memory map values that will be uploaded on the next power up of the module.

Module memory map location	Description	Valid data
80	EEPROM total write cycle count	0000 to 9999
81 bit 00-05	EEPROM error flags 0 = Ladder command write complete 1 = 5000 writes to EEPROM 2 = 10000 writes to EEPROM 3 = Write disabled to serial port 4 = Calibration data error 5 = Parameter data error 6 through 15 reserved	0 or 1
82	EEPROM compare word	0000 to 9999

To store the current module memory map into EEPROM, do the following:

1. Read module memory map location 80.
2. Set module memory map location 82 equal to location 80.
3. Set bit 03 of the module I/O word n to 1. On the rising edge, the module will write the module memory map to the EEPROM. The module will then increment location 80 by 1. Location 82 must be updated with the new value to enable another another write cycle to take place.

Note: The module will refuse additional EEPROM write cycles after 5000 until the release code, 4F43, is written to the module with a 1-word I/O write command.

Note: The EEPROM has a life of 10000 write cycles. When writing to the EEPROM, use caution to avoid continuous write operations by executing the ladder logic only one time or updating the location manually using data memory. The module will require a replacement EEPROM at 10000 write cycles.

Note: During the EEPROM write cycle, the module temporarily suspends the cycling of the module good flag in I/O word N+1 bit 07 (I/O word N+3 bit 10: 4 word). The cycling resumes after the EEPROM has been written.

4–4 Module Internal Processing

The module has an internal processor that controls the A/D conversion and performs the intelligent functions. Steps 1 and 2 describe the internal processing of the module.

1. When power is applied; the module initializes RAM, performs all internal diagnostics, and uploads the default module memory map from EEPROM.
2. The module scans all 8 input points and performs a conversion internally every 15 ms. Module update time can be up to 40 ms with special functions enabled.
3. The execution of the I/O read and write ladder instructions do not interrupt the module scan. The module and programmable controller transfer information to and from the module memory map (RAM) in the module.

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Programming the Module

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5–1 Module Memory Map

The C500-TS501 has internal RAM for storage of operating parameters during execution. Internal EEPROM memory provides non-volatile storage for these parameters without the need for batteries. Both memory areas have a module memory map which defines the operating parameters for the module. This module memory map is uploaded from EEPROM on power up and used by the module during operation. The EEPROM default parameters may be customized and changed by the user to meet the application requirements.

The table below is an outline of the complete module memory map. The module memory map has read/write and read only areas. These are marked in the module memory map. A detailed functional description of each location and default values are also provided.

Word	Indicates a memory location in the PLC data memory or in the module memory map. A word can contain a single piece of data or it can contain bits or flags for each of 8 input points (see format below).
Bit	Set by the user to enable a particular function. 0=OFF/DISABLE, 1=ON/ENABLE
Flag	Set by the module to indicate status of a module function. 0=OFF/DISABLE, 1=ON/ENABLE

Both bits and flags are arranged in the following format and correspond to the input points indicated below.

Bit (MSB)	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	(LSB)
Input point	8	7	6	5	4	3	2	1	8	7	6	5	4	3	2	1	

Default values and valid data ranges for all module memory map words are in *Appendix E*.

Data in the module memory map can be formatted in either signed BCD or 2's Complement Binary. All values for a specific input point must be in the same format. Some values are entered in unsigned BCD. Reference *Appendix E* for valid data ranges for all module memory map locations.

Format type	Decimal range	Memory map format
Signed BCD	-7999	F999 (Bit 15 is the sign bit)
	+7999	7999
2's Complement Binary	-32767	8001
	-1	FFFF
	0	0000
	+32767	7FFF

References in parenthesis ( ) indicate addresses in 4-word interface mode. The Module Memory Map is common to both 2 and 4 word interface modes. The exception is the pointer word, 24, which has no meaning in the 4 word mode.

Read/ write	Memory map word	Bits	Input point	Function	Description
R	00	0 to 7	1 thru 8	Alarm flags	These flags are set by the module when a low or high alarm condition occurs (word 9). Reset occurs when individual alarms are reset in word 9.
R	00	8 to 15	1 thru 8	Unconfirmed data error flags	These flags are set by the module when invalid configuration data is written to the module memory map for an input point. The bits are cleared when valid data is written to the module memory map. The module also sets bit 3 of I/O word n+1 (bit 12 n+3) when this error occurs. See *Appendix E* for information about default and valid data values for all module memory maps words.

Read/ write	Memory map word	Bits	Input point	Function	Description
R	01 02 03 04 05 06 07 08		1 2 3 4 5 6 7 8	Conversion data	These words contain the last A/D conversion values for each input point. The data format is selected by word 26, bits 0 to 7 for each input point. Default format is BCD. If intelligent functions such as scaling, filtering, and averaging are enabled, they are performed on the data before it is entered into these locations.
R	09	0 to 7	1 thru 8	Low alarm flags	These flags are set by the module when a low alarm condition occurs for each input point. The module also sets bit 5 of I/O word n+1 (bit 04 n+3; bit 08 n+3). These bits are reset by bit 5 of I/O word n for the module (bit 11 n+3).
R	09	8 to 15	1 thru 8	High alarm flags	These flags are set by the module when a high alarm condition occurs for each input point. The module also sets bit 5 of I/O word n+1 (bit o4 n+3; bit 08 n+3). These bits are reset by bit 5 of I/O word n for the module (bit 11 n+3).
R	10	0 to 7	1 thru 8	Under range flags	These flags are set by the module when an under range condition occurs for each input point. This occurs when module detects a temperature lower than the range setting for each input. These alarms are always active. The module also sets bit 6 of I/O word n+1 (bit 05 n+3; bit 09 n+3) when this error occurs. These bits are reset by bit 6 of I/O word n (bit 12 n+1) for the module.
R	10	8 to 15	1 thru 8	Over range flags	These flags are set by the module when an over range condition occurs for each input point. This occurs when module detects a temperature higher than the range setting for each input. These alarms are always active. The module also sets bit 6 of I/O word n+1 (bit 05 n+3; bit 09 n+3) when this error occurs. These bits are reset by bit 6 of I/O word n (bit 12 n+1) for the module.
R	11 12 13 14 15 16 17 18		1 2 3 4 5 6 7 8	Peak hold data	These words contain the latest peak hold values for each input point. The data format Is determined by word 26, bits and 0 to 7. The module performs scaling and filtering functions if selected before placing peak hold values in these words. The peak hold function is enabled/ disabled for each input point by setting bits in word 25, bits 8 to 15. These words are reset by I/O word n, bits 8 thru 15 (bit 13 n+1). The module acknowledges the reset in I/O word n+1 bits 8 to15. See *Section 4–3–5* for operation details of the peak hold function.
R	19	0 to 7	1 thru 8	Input point active flags	These flags are set by the module indicating the enable/disable status of each input point that is set in word 25, bits 0 to 7.

Read/ write	Memory map word	Bits	Input point	Function	Description
R	19	8 to 15	1 thru 8	Peak hold active flags	These flags are set by the module indicating the enable/disable status of the peak hold function for each input point set in word 25, bits 8 to 15.
R	20	0 to 7	1 thru 8	BCD/binary select flags	These flags are set by the module indicating the data format selected for each input point in word 26, bits 0 to 7.
R	20	8 to 15	1 thru 8	Scaling active flags	These flags are set by the module indicating the enable/disable status of the scaling function for each input point set in word 26, bits 8 to 15.
R	21	0 to 7	1 thru 8	Averaging active flags	These flags are set by the module indicating the enable/disable status of the averaging function for each input point set in word 27, bits 0 to 7.
R	21	8 to 15	1 thru 8	Filtering active flags	These flags are set by the module indicating the enable/disable status of the filtering function for each input point set in word 27, bits 8 to 15.
R	22	0 to 7	1 thru 8	Low alarm active flags	These flags are set by the module indicating the enable/disable status of the low alarm function for each input point set in word 28, bits 0 to 7.
R	22	8 to 15	1 thru 8	High alarm active flags	These flags are set by the module indicating the enable/disable status of the high alarm function for each input point set in word 28, bits 8 to 15.
R	23	0 to 7	1 thru 8	°C/°F select flags	These flags are set by the module indicating the scale format selected for each input point in word 29, bits 0 to 7.
R/W	24			Pointer word	The pointer word is used to set the starting location in the module memory map for the Special I/O read and I/O write instructions that are executed in ladder logic in the PLC. This allows the user to selectively read and write parts of the module memory map.
R/W	25	0 to 7	1 thru 8	Input point enable bits	These bits are set by the user to enable/disable each input point. The module scans only input points that are enabled. The default value is all input points enabled.
R/W	25	8 to 15	1 thru 8	Peak hold enable bits	These bits are set by the user to enable/disable the peak hold function for each input point. The default value is disabled (0) for all input points.
R/W	26	0 to 7	1 thru 8	BCD/binary select bits	These bits are set by the user to select the data format used by each input point. BCD = 1 and binary = 0. This selection specifies the format of the conversion data in words 01 to 08 and peak hold data in words 11 to 18. BCD and binary can be used at the same time for different input points. **NOTE:** When specifying a data format for an input point, all module memory map words for that specific input point must have the same format. Mixing formats for an input point will cause erroneous results to be reported. The default value is BCD (1) for all input points.

Read/ write	Memory map word	Bits	Input point	Function	Description
R/W	26	8 to 15	1 thru 8	Scaling enable bits	These bits are set by the user to enable/disable the scaling function for each input point. The default value is disabled (0) for all input points.
R/W	27	0 to 7	1 thru 8	Averaging enable bits	These bits are set by the user to enable/disable the Averaging function for each input point. The default value is disabled (0) for all input points.
R/W	27	8 to 15	1 thru 8	Filtering enable bits	These bits are set by the user to enable/disable the filtering function for each input point. The default value is disabled (0) for all input points.
R/W	28	0 to 7	1 thru 8	Low alarm enable bits	These bits are set by the user to enable/disable the low alarm function for each input point. The default value is disabled (0) for all input points.
R/W	28	8 to 15	1 thru 8	High alarm enable bits	These bits are set by the user to enable/disable the high alarm function for each input point. The default value is disabled (0) for all input points.
R/W	29	0 to 7	1 thru 8	°C/°F select bits	These bits are set by the user to select the scale format used by each input point. Celsius = 0 and Fahrenheit = 1. This selection specifies the format of the conversion data in words 01 to 08 and peak hold data in words 11 to 18. °C and °F can be used at the same time for different input points. The default value is °C (0) for all input points.
R/W	30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45		1 1 2 2 3 3 4 4 5 5 6 6 7 7 8 8	Low alarm limit High alarm limit Low alarm limit High alarm limit Low alarm limit High alarm limit Low alarm limit High alarm limit Low alarm limit High alarm limit Low alarm limit High alarm limit Low alarm limit High alarm limit Low alarm limit High alarm limit	These words contain the low and high alarm limits for each input point. The format of these values should match the data format selected for each input point in word 26. Valid values are -32767 to +32767 (8001 to 7FFF) binary and -7999 to +7999 BCD. Alarm limits must be specified in scaled units if the scaling function is enabled for the input point. The default values are 0100 for the low limit and 3900 for the high limit.
R/W	46 47 48 49 50 51 52 53		1 2 3 4 5 6 7 8	Filtering time constants	These words contain the filtering time constants for each input point. The values are in milliseconds. Valid values are BCD 0001 to 9999 and binary 0001 to 7FFF. The default value is 0100 BCD. The filtering function is performed prior to the data being placed in the conversion data words (01 thru 08).
R/W	54 55 56 57 58 59 60 61		1 2 3 4 5 6 7 8	Averaging sample counts	These words contain the number of module samples to average before reporting conversion data to words 01 to 08. The values are in number of samples. Valid values are BCD 0001 to 9999 and binary 0001 to 7FFF. The default value is 0020 BCD. The averaging function is performed prior to the data being placed in the conversion data words (01 thru 08).

Read/ write	Memory map word	Bits	Input point	Function	Description
R/W	62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77		1 1 2 2 3 3 4 4 5 5 6 6 7 7 8 8	Scaling low limit Scaling high limit Scaling low limit Scaling high limit Scaling low limit Scaling high limit Scaling low limit Scaling high limit Scaling low limit Scaling high limit Scaling low limit Scaling high limit Scaling low limit Scaling high limit Scaling low limit Scaling high limit	These words contain the scaling low and high limits for each input point. The values are in engineering units. The default values are 0000 for the low limit and 100 for the high limit. The scaling function is performed prior to the data being placed in the conversion data words (0 to 08).
R	78	0 to 3 4 to 7 8 to11 12 to 15	1 2 3 4	0 = mV 1 = E 2 = J-DIN 3 = J 4 = K 5 = R 6 = S 7 = T 8 and 9 = non functional	These words reflect the status of the thermocouple type selected from the rotary switches.
R	79	0 to 3 4 to 7 8 to11 12 to 15	5 6 7 8		
R	80			EEPROM total write cycle count	This word contains the current number of write operations that have been executed for the EEPROM.
R	81	00 to 05		EEPROM error flags 0 = Ladder command write complete 1 = 5000 writes to EEPROM 2 = 10000 writes to EEPROM 3 = Write disabled to serial port 4 = Calibration data error 5 = Parameter data error 6 - 15 reserved	This word contains error flags that occur during the EEPROM write operation.
R/W	82			EEPROM compare word	This word is set by the user to confirm that an EEPROM write Operation should occur. This is a safety to prevent erroneous writes from occurring and damaging the EEPROM chip.
R	83	0 to 7 8 to 15	1-8 reserved	Open thermocouple flags	These flags are set by the module for each input point when it detects an open or disconnected thermocouple for an enabled input point. These bits are reset by bit 5 of I/O word n (bit 12 n+1) for the module.

5–1–1 Using the Module Memory Map Configuration Sheet

To assist in the custom configuration of the module, a Configuration Worksheet has been provided in *Appendix D*. Values for all intelligent functions can be entered in the worksheet. These values can then be easily transferred to data memory for use by the module.

5–2 Troubleshooting Memory Map Error Flags

There are a number of memory map error flags in the module which can be used to verify status and operation. These flags include:

Flag type	Function
High and low alarm flags	Indicate the input signal is outside the alarm limits specified in the module memory map.
Over and under range errors	Indicate the input signal is outside the specified range selected by the jumpers and rotary switches.
Unconfirmed data error flags	Indicate a data conversion error in the module.
EEPROM error flags	Indicate errors with the EEPROM write function and write cycle counts.
Module good flag	This flag oscillates at a one hertz rate when the module is operating correctly, one-half second on, one-half second off. During the EEPROM write cycle, the module temporarily suspends the cycling of the module good flag in I/O word N+1 bit 07. The cycling resumes after the EEPROM has been written.

5–3 Interface to the PLC - 2 Word Mode

The C500-TS501 Thermocouple Input Module communicates with the programmable controller using the 2 Word Mode when the 2/4 word mode jumper is set in the 2 word position. The intelligent I/O read/write instructions are used to transfer data between the PLC and the module memory map. Details of these instructions can be found in the Operation Manuals for the controllers. For jumper settings, refer to Section 2 in this manual.

This section describes the bit assignments and the functions for the two I/O words that the module occupies in the programmable controller I/O table.

5–3–1 Operation

The module communicates with the PLC using two word mode addressing. The I/O read and I/O write ladder instructions are used to read/write data between the module and the PLC. The module requires two words in the I/O table, one output word from the PLC to the module, and one input word from the module to the PLC. The functions of these words are described in the table below.

Output Word

I/O word	Bit	Description	Function
N Output to module	0	Reserved	–
	1	Reserved	–
	2	Reserved	–
	3	EEPROM write	Setting this bit to '1' triggers the module to write the current RAM configuration to EEPROM memory in the module. On power up, the new parameters will be the default start up parameters.
	4	Enable serial port write	Setting this bit to '1' enables the serial port on the module to write to the module memory map. A '0' disables writing from the port.
	5	Reset low/high alarm flag	Setting this bit to '1' resets bit 5 of word n+1, the low/high alarm flag.
	6	Reset over/under range error flag Reset open T/C flag	Setting this bit to '1' resets bit 6 of word n+1, module memory map 10; the under/over range flag; word n+1 bit 6 the open T/C flag; resets module memory map 83, the open T/C flags.
	7	Unused	
	8	Reset peak hold register 1	Setting this bit to '1' resets the peak hold register in the module memory map for the input points specified.
	9	Reset peak hold register 2	
	10	Reset peak hold register 3	
	11	Reset peak hold register 4	
	12	Reset peak hold register 5	
	13	Reset peak hold register 6	
	14	Reset peak hold register 7	
	15	Reset peak hold register 8	

Input Word

I/O word	Bit	Description	Function
N+1 Input from module	0	Reserved	–
	1	Reserved	–
	2	Reserved	–
	3	Unconfirmed data error	This flag is set to '1' when invalid data is received from the serial port or an intelligent I/O write command. The flag is set to '0' when valid data is sent to the module.
	4	Conversion error	This flag is set to '1' if the module detects an internal conversion or calculation error.
	5	Low/high alarm error	This flag is set to '1' when a low/high alarm occurs for any input point.
	6	Over/under range error Open T/C	This flag is set to '1' when an under/over range error occurs for any input point, or the module detects and open thermocouple.
	7	Module good flag	This flag toggles ON and OFF at a 1 Hz rate with a 45 - 55% duty cycle when the module is operating normally.
	8	Acknowledge peak hold reset 1	These flags acknowledge that the peak hold registers have been reset by the module.
	9	Acknowledge peak hold reset 2	
	10	Acknowledge peak hold reset 3	
	11	Acknowledge peak hold reset 4	
	12	Acknowledge peak hold reset 5	
	13	Acknowledge peak hold reset 6	
	14	Acknowledge peak hold reset 7	
	15	Acknowledge peak hold reset 8	

5–4 Programming Examples of 2-Word Mode

5–4–1 Using the Module Configuration Worksheet – *Appendix D*

Appendix D is a worksheet to use when configuring the special functions available in the module. It is particularly useful in setting up a table in the PLC data memory area that corresponds to the module memory map. The data can then be easily transferred to the module using the I/O write ladder instruction. See the programming examples in the following sections for more details.

5–4–2 Using the Pointer Word in the Module Memory Map

The module has an internal memory map for storage of data and configuration parameters. The table is 83 words in length, with both read only and read/write registers. The pointer word is used to set the beginning memory map location for either the I/O read or I/O write ladder instructions. This allows the user to access any area of the table directly without reading or writing data that is not required. The result is faster module processing, and faster data transfer between the module and the PLC. The pointer word is memory map location 24. The format is unsigned BCD. Valid values are 0 to 83. The default value is 0000.The following sections explain the operation of the pointer word with both the I/O read and I/O write ladder instructions.

5–4–3 Writing Data to the Module - I/O

This section describes the use of the pointer word with the I/O write ladder instruction. For additional information regarding the I/O write instruction, see the *CV Operation Manual W202 and C1000H, C2000H Operation Manual W140. .*

There are two rules when using the pointer word with the I/O write instruction.

1. If the number of words transferred (specified in the instruction) to the module is one:

- The module writes the value of this word to the pointer word location in the module memory map (24).
- This value now becomes the first memory location to be read in subsequent I/O read instructions.
- The pointer word retains this value unless another 1 word I/O write is executed, or the system power is cycled. If the value has been saved to the EEPROM in the module, then it is automatically uploaded on power up.

EXAMPLE:

Execute a 1 word I/O write to the module. The value of the word transferred is 0022. The module sees the number of words is 1, and places the value 0022 into memory map location 24.

Execute an I/O read instruction specifying the number of words to be read as 0016.

The module returns 16 words to the PLC, beginning with module memory map location 22 thru 37.

Note The I/O read instruction can transfer a maximum of 127 words. If the read request is from a pointer location for a number of words that goes past the end of the table, those locations beyond word 83 will return the value 0000.

2. If the number of words transferred to the module is greater than one:

- The module interprets the first word as a temporary pointer value which does not replace word 24 in the module memory map.

- If the value of first word is 0000, then the module updates the memory map beginning at location 25 with the remaining words transferred. This is the first word of the write area in the module memory map.
- If the first word is greater than 0 and less than 25, the module sets the unconfirmed data error flag because an attempt has been made to write to a read only area of the module memory map. The data sent is ignored.
- If the temporary pointer value is greater than 24, the module writes the data following the temporary pointer value into the module memory map beginning at the location specified by the temporary pointer value. The temporary pointer value is then discarded.

EXAMPLE:

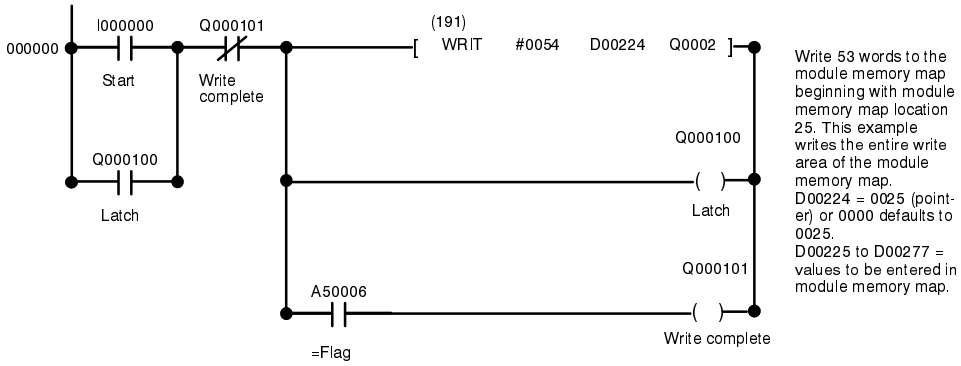
Execute a 10 word I/O write to the module. The value of the first word transferred is 0025.

The module sees the number of words is greater than one, and reads the first word as the temporary pointer value. The module then updates its memory map with the remaining nine words beginning at location 25.

Example 1

WRITE Data Memory to the Module Memory Map

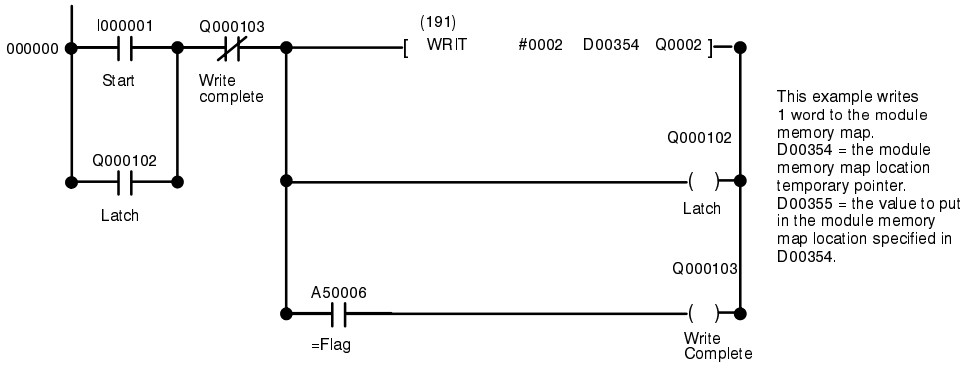
This example show how to write the entire Module Memory Map Write area (Locations 25-77). These are the user configurable locations in the Module Memory Map that enable the various module functions. The Data Memory in the programmable controller can be set up using the module configuration worksheet in Appendix D of this manual. The first word is the temporary write pointer.



Example 2

WRITE to Selected Locations in the Module Memory Map

This example shows how to write a specific value to a single Module Memory Map Location.



5–4–4 Reading Data from the Module – I/O Read

I/O Read Instruction (Read 190)) and the Pointer Word Operation

This section describes the use of the pointer word with the I/O read ladder instruction. For additional information regarding the I/O read instruction, see the *CV Operation Manual # W202*.

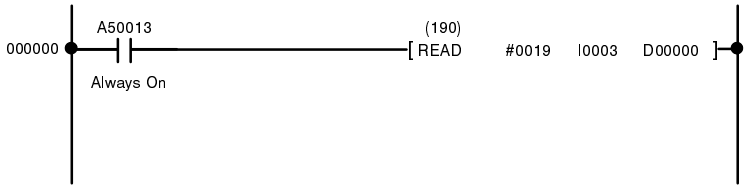
There are three rules when using the pointer word with the I/O read instruction.

1. The default value of the Pointer word is 0000, except when the value has been modified and this modified value saved to the EEPROM in the module. On power up, the module uploads this value from the EEPROM into RAM prior to execution.
2. When an I/O read instruction is executed, the module reads the value of the pointer word and returns the number of words requested beginning with the location specified by the pointer word in the module memory map. The pointer word value can be 0000 to 0083.
3. If the number of words requested extends beyond the end of the table given a value in the pointer word, then the remaining words transferred up to 127 will be filled with zeros (0000).

Example 1

READ Alarm and Conversion Data from the Module

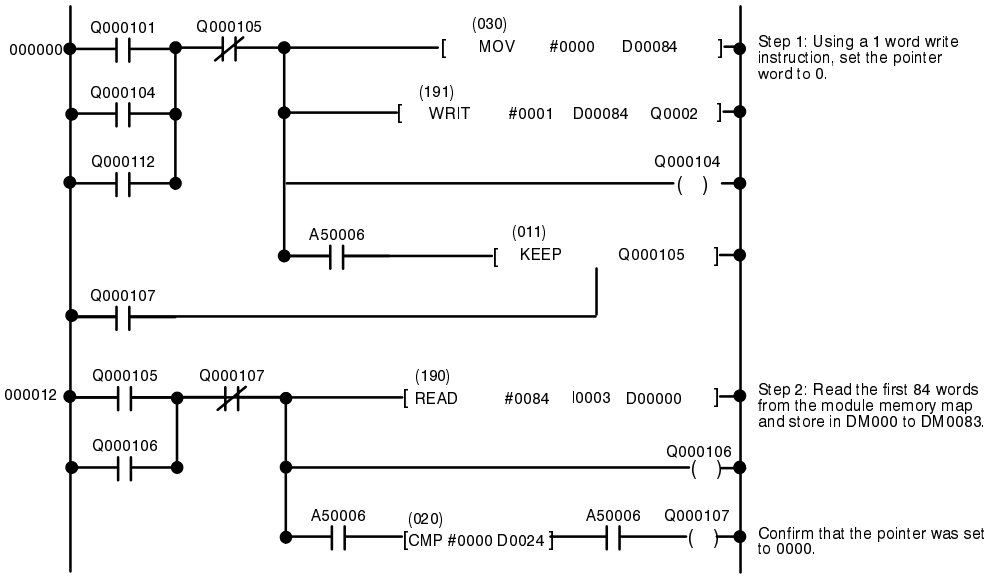
This example shows how to read the first 19 words from the Module Memory Map, assuming the pointer word is 0000. This data includes the Conversion Data, Alarm Data, and Peak Hold Data.



Example 2

READ the Entire Module Memory Map into Data Memory

This example shows how to read the entire Module Memory Map into the Data Memory of the Programmable Controller.



5–4–5 Typical Programming Examples

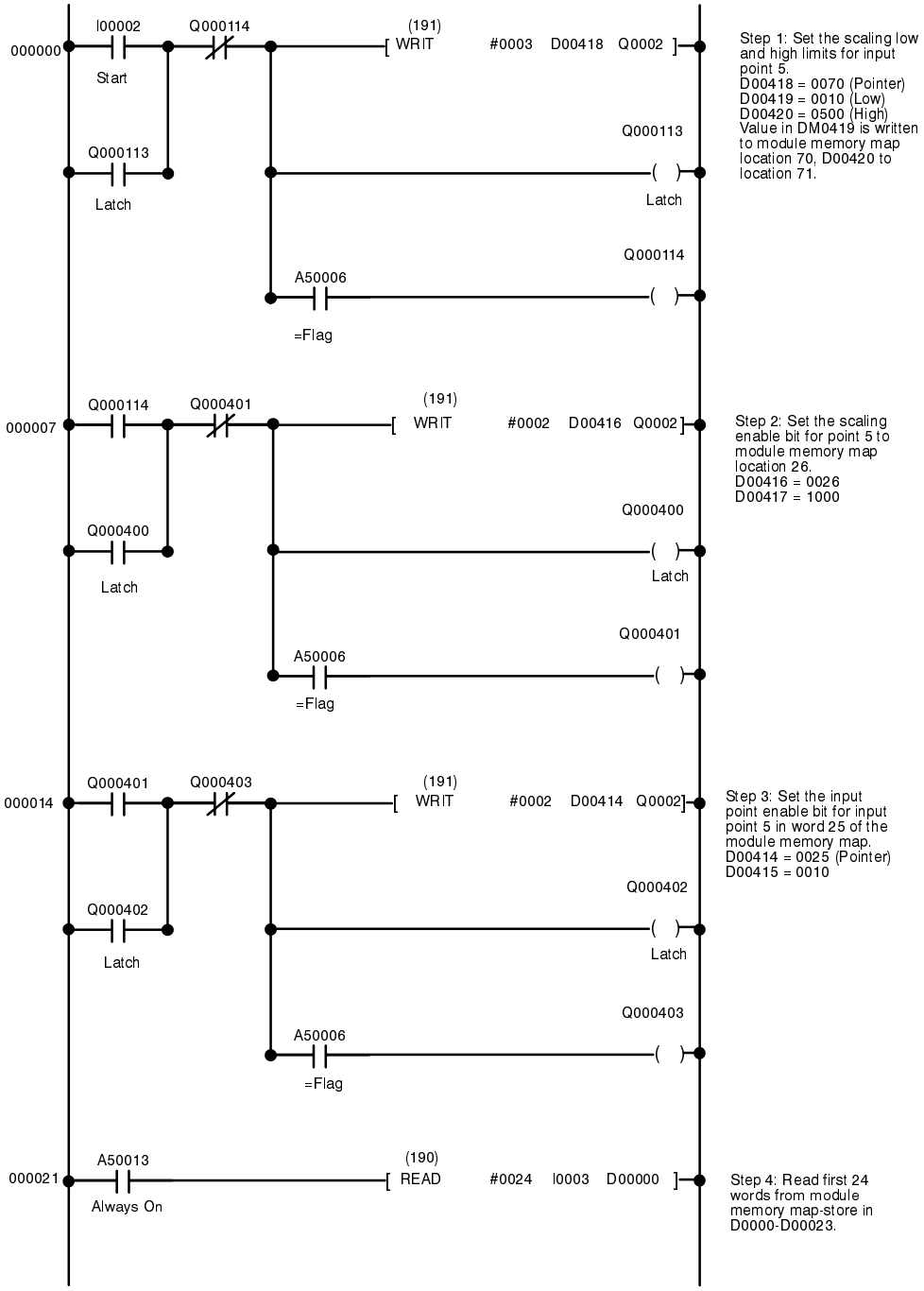
Examples 1 through 4 are typical ladder diagrams that show the flexible access to the module set up and intelligent functions.

Example 1

Configuring the Scaling Function

This example shows how to configure the scaling function for specific input points. See Section 4 for general information on using the scaling function.

CV-Series

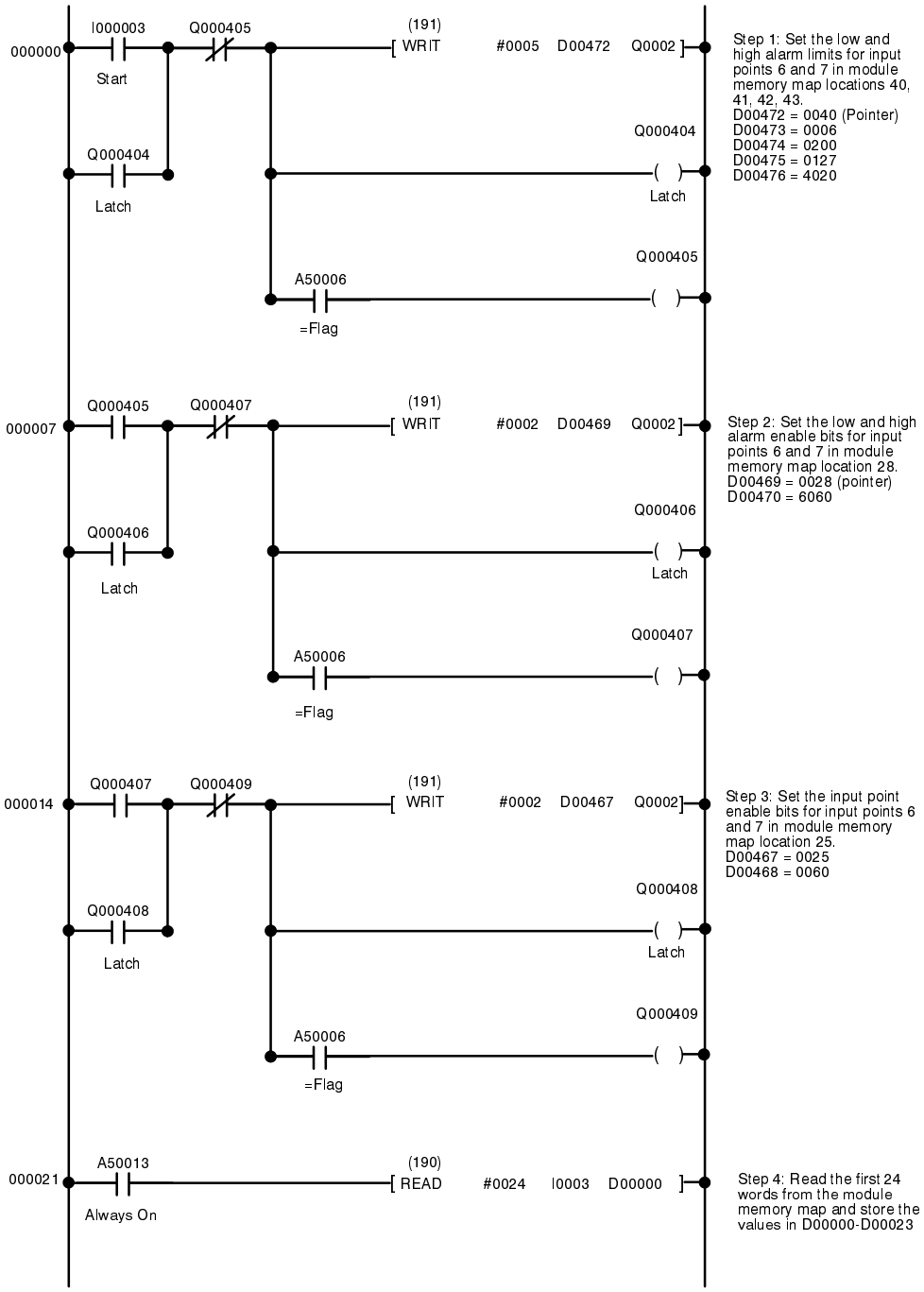


Example 2

Configuring the Alarm Function

This example shows how to configure the alarm function for specific input points. See Section 4 for general information on using the alarming function.

CV-Series

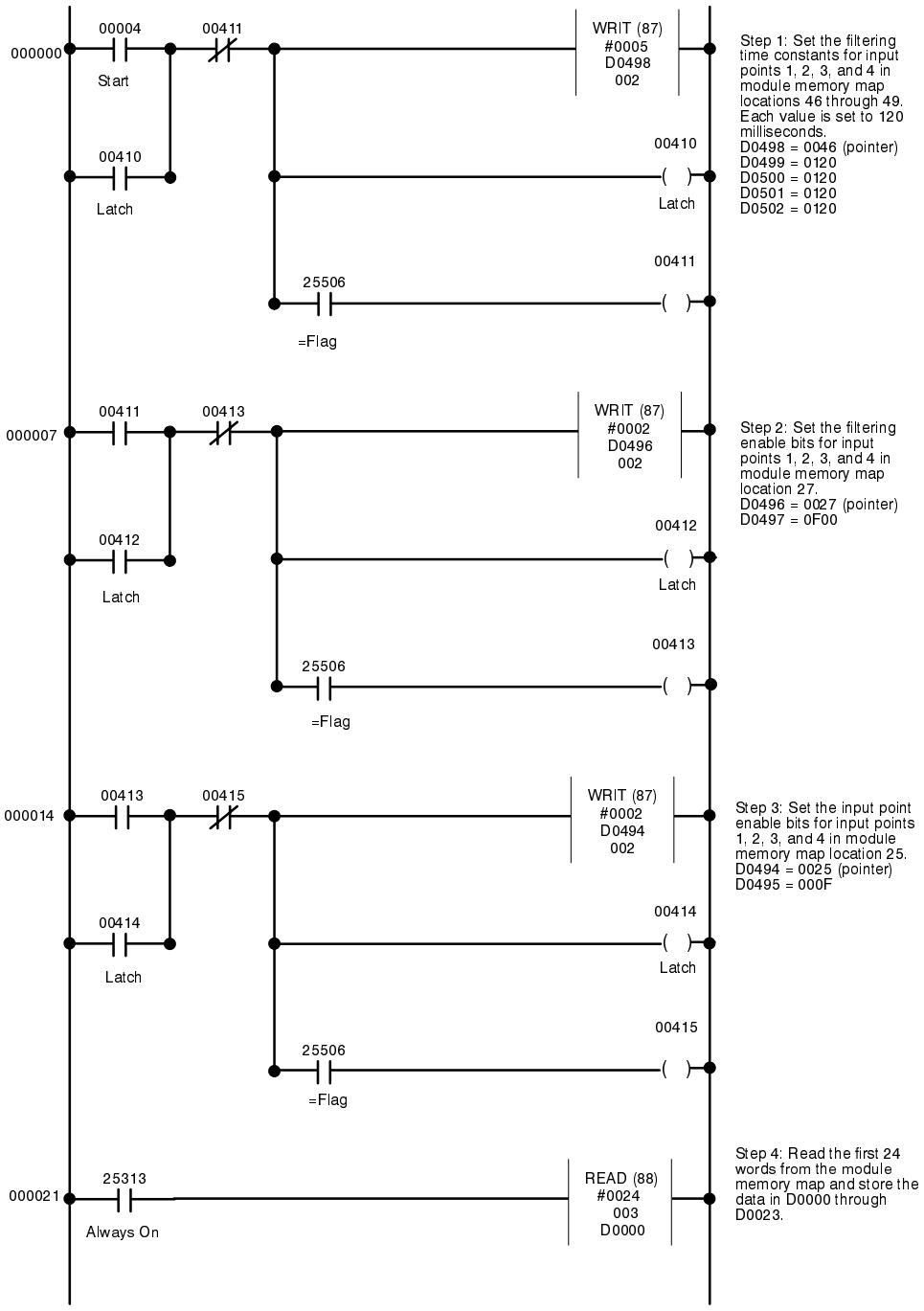


Example 3

Configuring the Filtering Function

This example shows how to configure the filtering function for specific input points. See Section 4 for general information on using the filtering function.

C-Series

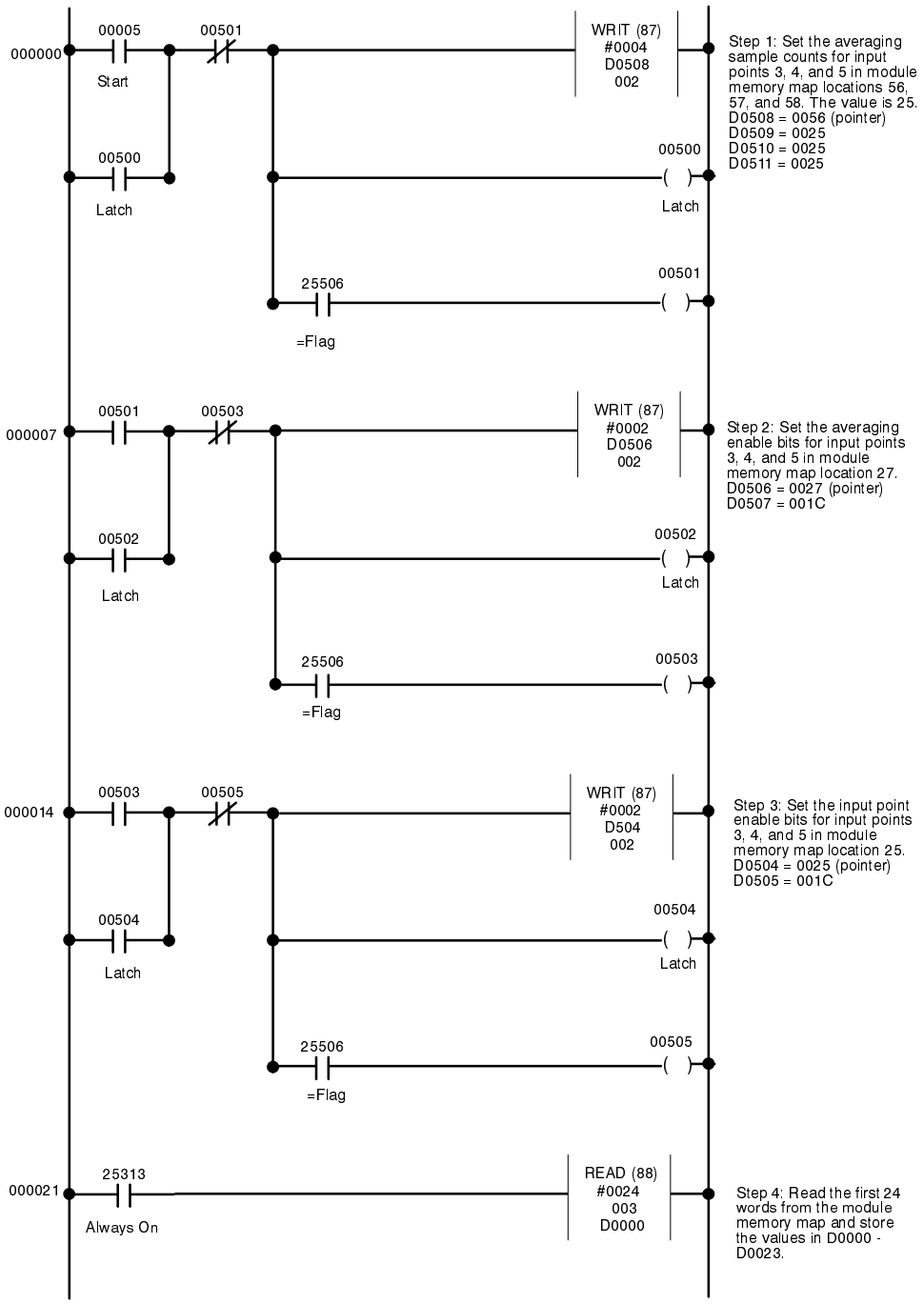


Example 4

Configuring the Averaging Function

This example shows how to configure the averaging function for specific input points. See Section 4 for general information on using the averaging function.

C-Series



5–5 Interface to the PLC using 4-Word Mode

The C500-TS501 Thermocouple Input Module communications with the programmable controller using the 4-Word Mode when the 2/4-Word Mode Jumper is set in the 4-word position. Standard Data Movement Instructions are used to transfer data between the PLC and the module memory map. Details of these instructions can be found in the Operation Manuals for the controllers. For jumper settings, see Section 2.

5–5–1 Operation

In the 4 word interface mode, the module communicates with the PLC using four I/O words. Standard data movement instructions are used to read and write data between the module and the PLC. The module requires four words in the I/O table, two output words from the PLC to the module, and two input words from the module to the PLC. The functions of these words are described in the table below.

Output Words

I/O Word	Bit(s)	Description	Function
N	00-15	Write Data Word	This word contains the data which will be transferred to the module memory map when a write cycle is executed.
N+1	00-07	Memory Map Location, Peak Hold Reset Enable	These bits specify the module memory map location when data is read from or written to the module. Valid values are 00 to 83 in BCD only. Also, when Peak Hold Reset is set to ‘1’, these bits 00 to 07 indicate for which Input Point(s) 1 to 8 respectively the Peak Hold Function is to be reset.
	08	Read/Write Request	This bit specifies whether the access to the module is a read (0) or write (1) request. For a read request, the module returns in word N+2 the data at the memory location specified in bits 00-07. For a write request, the module writes the data from word N into the memory location specified in bits 00-07.
	09	EEPROM Write Enable	Setting this bit to ‘1’ triggers the module to write the current RAM configuration to EEPROM in module memory. On power up, the new parameters will be the default start-up parameters.
	10	Serial Port Write Enable	Setting this bit to ‘1’ enables the serial port on the module to write to the module memory map. A ‘0’ disables writing from the port.
	11	Low/High Alarm Reset	Setting this bit to ‘1’ resets the Alarm Flags DM00 Bits 00-07, the Low/High Alarm Flags DM09 Bits 00-15, the Input Point Specific Low/High Alarm Flag Word N+3 Bit 04, and the Low/High Alarm Flag Word N+3 Bit 08.
	12	Out of Range Reset Open T/C Reset	Setting this bit to ‘1’ resets the Out of Range Flags DM10, the Input Point Specific Out of Range Error Flag Word N+3 Bit 05, and the Out of Range Error Flag Word N+3 Bit 09. This bit also resets the Open T/C Detect Flags module memory map 83, the Input Point Specific Open T/C Detect Flag Word N+3 Bit 07, and the Open T/C Detect Flag Word N+3 Bit 13.
	13	Peak Hold Reset	Setting this bit to ‘1’ resets the Peak Hold function for the Input Points whose respective bit is set in Word N+1 Bits 00 thru 07.
	14	PC Write Finished	This bit is set by the PLC to indicate to the module that there is new data in words N and N+1. This bit should be latched high until TS Read Finished, Word N+3 Bit 14, is set by the module. Note: PC Write Finished does not need to be set when setting or resetting Word N+1 bits 09 thru13.
	15	PC Read Finished	This bit is set by the PLC to indicate to the module that the data has been read from words N+2 and N+3. This bit resets TS Write Finished, Word N+3 Bit 15, which was set by the module.

Input Words

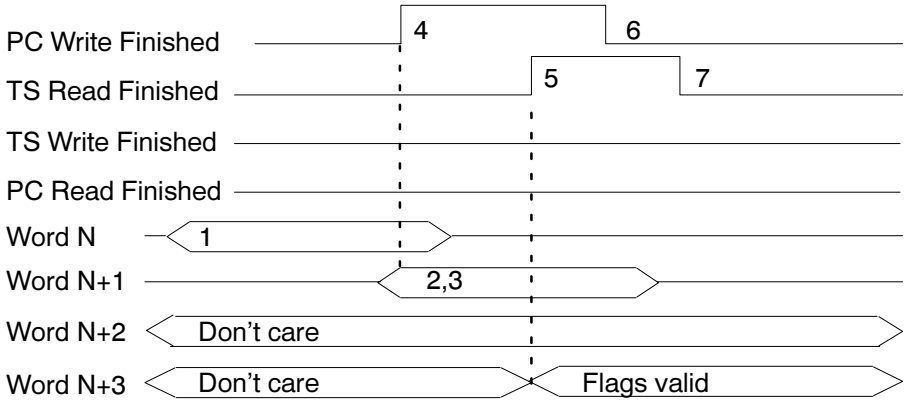
I/O Word	Bit(s)	Description	Function
N+2	00-15	Read Data Word	This word contains the data which was requested from the memory map after a read cycle is executed.
N+3	00-02		Reserved
	03	Data Transfer Sequence Error Flag	This bit signals that an error in the data transfer protocol has occurred. This includes attempting to write to read-only memory locations. To recover from a Data Transfer Sequence Error, the PLC must set the PC Read Finished bit.
	04	Input Point Specific Low/High Alarm Flag	This bit indicates if an alarm condition has occurred for a specific Input Point and corresponds with the respective bit in DM09. The flag reports only when data is requested from the corresponding memory locations DM01-08 or DM11-18 and otherwise reports '0'.
	05	Input Point Specific Out of Range Flag	This bit indicates if an out of range condition has occurred for a specific Input Point and corresponds with the respective bit in DM10. The flag reports only when data is requested from the corresponding memory locations DM01-08 or DM11-18 and otherwise reports '0'.
	06	Input Point Specific Degrees C/F Flag	This bit indicates the configuration for a specific Input Point and corresponds with the respective bit in DM23. The flag reports only when data is requested from the corresponding memory locations DM01-08 or DM11-18 and otherwise reports '0'.
	07	Input Point Specific Open T/C Detect Flag	This bit indicates if an open T/C has been detected for a specific Input Point and corresponds with the respective bit in DM83. The flag reports only when data is requested from the corresponding memory locations DM01-08 or DM11-18 and otherwise reports '0'.
	08	Low/High Alarm Flag	This bit indicates if an alarm condition has occurred for a enabled Input Point, corresponding with any bit set in DM09, and reports continuously.
	09	Out of Range Error Flag	This bit indicates if out of range condition has occurred for any enabled Input Point, corresponding with any bit set in DM09, and reports continuously.
	10	Module Good Flag	This bit toggles ON and OFF at a 1 Hz rate with a 45-55% duty cycle to indicate that the module is operational.
	11	Conversion Error Flag	This bit is set when a calculation resulting in an out of range value is performed. This can occur with parameter values when the mode is changed from Binary to BCD. This flag reports continuously.
	12	Unconfirmed Data Error Flag	This bit is set when an attempt is made to write an invalid value or a value of improper format into parameter locations DM30 thru DM77, and is cleared on the next valid write cycle. This flag corresponds with any bit set in Data Error Status DM00 Bits 08-15 and reports continuously.
	13	Open T/C Detect Flag	This bit indicates if an open T/C condition has occurred for any enabled Input Point, corresponding with any bit set in DM83, and reports continuously.
	14	TS Read Finished	This bit is set by the module to indicate to the PLC that it has read the data in words N and N+1. It is reset by the module when the PC Write Finished, Word N+1 Bit 14 is reset by the PLC.
	15	TS Write Finished	This bit is set by the module to indicate to the PLC that it has written the requested data into words N+2 and N+3. It is reset by the module when PC Read Finished, Word N+1 Bit 15 is set by the PLC.

5–5–2 Protocol

The 4 Word Mode Interface provides four status bits for handshaking during communications between the module and the PLC. These bits are read and written through PLC ladder logic and must be manipulated in the proper sequence for successful communication with the module. Two bits, PC Write Finished and PC Read Finished, word N+1 bits 14 and 15, are set by the PLC. The other two bits, TS Read Finished and TS Write Finished, word N+3 bits 14 and 15, are set by the module. See the table in the previous section for a description of these bits.

Write Sequence Timing Diagram

The proper sequence of writing data to the module memory map is shown in the following timing diagram. The sequence of the two events with PC Write Finished and TS Read Finished must occur for data to be successfully transferred from the PLC to the module. Any deviation from this sequence will result in the module setting the Data Transfer Sequence Error Flag. To recover from a Data Transfer Sequence Error the PLC must assert PC Read Finished.



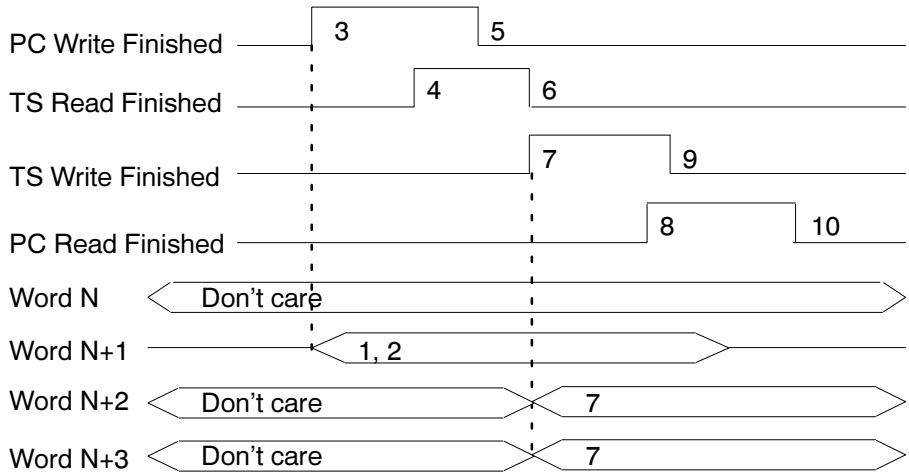
1. PLC sets data to be written in Word N.
2. PLC sets the module memory location address to be written in Word N+1 Bits 00-07.
3. PLC sets Word N+1 Bit 08 to indicate a write cycle to the module.
4. PLC sets PC Write Finished, Word N+1 Bit 14 indicating to the module that new data is available.

Note Steps 2, 3 and 4 may be performed simultaneously by writing the entire word N+1.

5. When the module has read the data, it sets TS Read Finished, Word N+3 Bit 14.
6. Seeing TS Read Finished go high, the PLC resets PC Write Finished.
7. Seeing PC Write Finished go low, the module then resets TS Read Finished ending the write cycle.

Read Sequence Timing Diagram

The proper sequence of reading to the module memory map is shown in the following timing diagram. The sequence of the four events with PC Write Finished, TS Read Finished, TS Write Finished, and PC Read Finished must occur for data to be successfully transferred from the module to the PLC. Any deviation from this sequence will result in the module setting the Data Transfer Sequence Error Flag. To recover from a Data Transfer Sequence Error the PLC must assert PC Read Finished.



1. PLC sets the memory location addresses to be read in Word N+1 Bits 00-07.
2. PLC resets Word N+1 Bit 08 to indicate a read cycle from the module.
3. PLC sets PC Write Finished, Word N+1 Bit 14 indicating to the module that the address has been written.

Note Steps 1, 2 and 3 may be performed simultaneously by writing the entire word N+1.

4. When the module has read the address, it sets TS Read Finished, Word N+3 Bit 14.
5. Seeing TS Read Finished go high, the PLC resets PC Write Finished.
6. Seeing PC Write Finished go low, the module resets TS Read Finished.
7. When the module has retrieved the requested data and placed it in Word N+2, it sets TS Write Finished, Word N+3 Bit 15.
8. Seeing TS Write Finished go high, the PLC reads the data from Word N+2 and sets PC Read Finished, Word N+1 Bit 15.
9. Seeing PC Read Finished go high, the module resets TS Write Finished.
10. Seeing TS Write Finished go low, the PLC then resets PC Read Finished ending the read cycle.

5–6 Programming Examples of 4-Word Mode

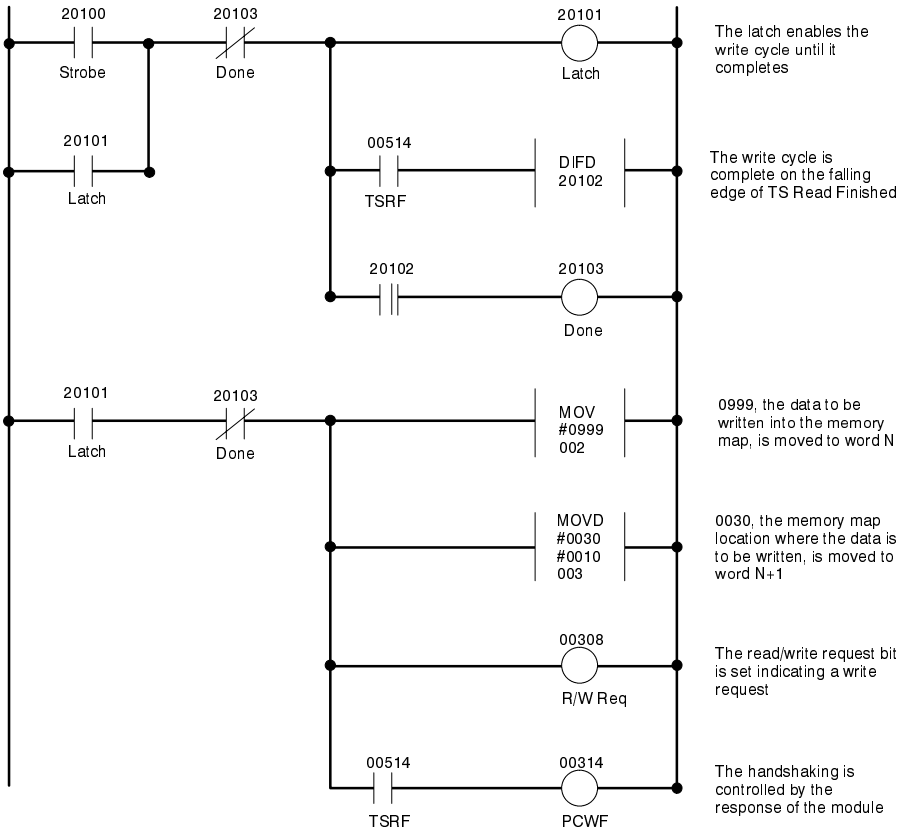
5–6–1 Writing Data to the Module

Example 1

Write a Single Memory Map Location

The T/C Module occupies locations 002, 003, 004, and 005. In this example, the data value 0999 is written into location DM30.

C-Series

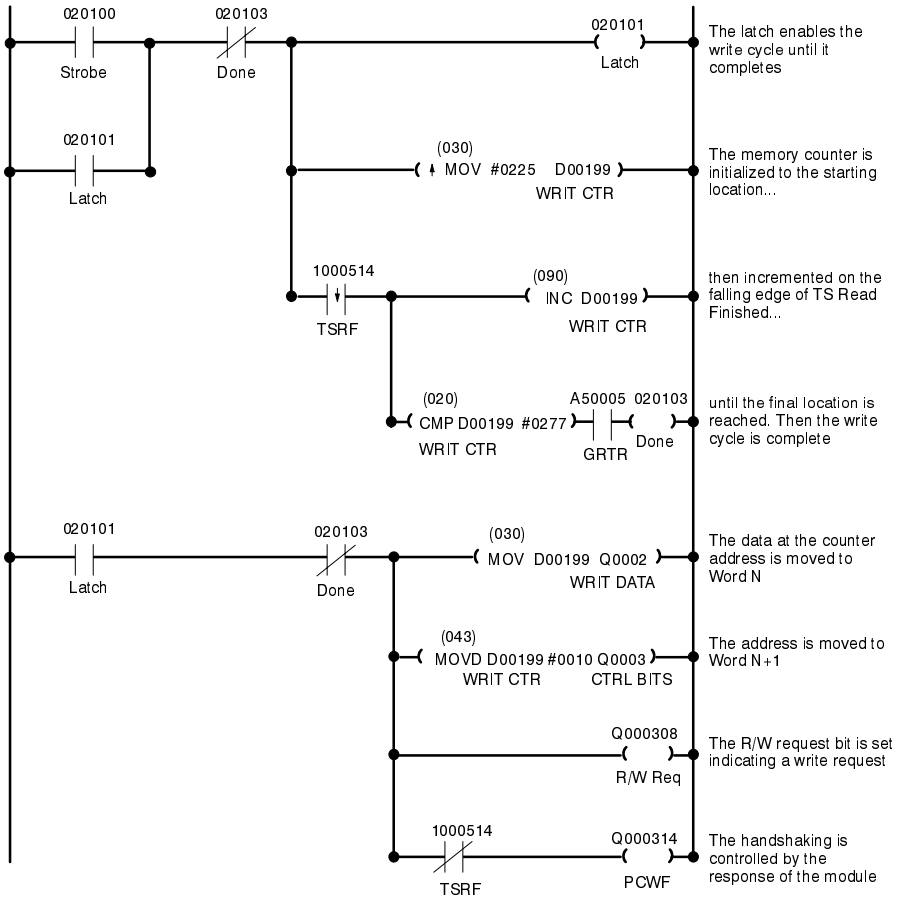


Example 2

Writing a Block of Memory Map Locations

The T/C Module occupies locations 002, 003, 004, and 005. This example writes a block of data from PLC memory locations D00225 thru D00277 to module locations DM25 thru DM77. Note that the lower two digits of the two memory areas correspond. This was done intentionally to simplify programming.

CV-Series



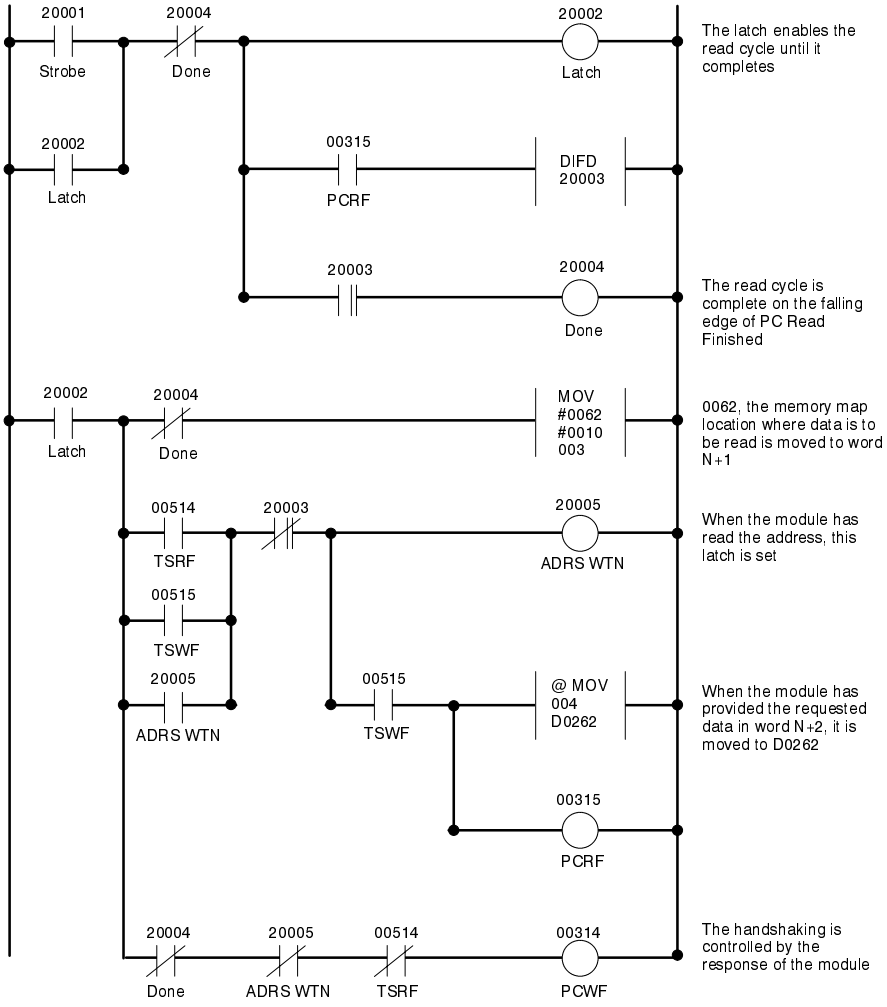
5–6–2 Reading Data from the Module

Example 1

Reading a Single Memory Map Location

The T/C Module occupies locations 002, 003, 004, and 005. In this example, the data value from DM62 is stored in PLC memory D0262.

C-Series

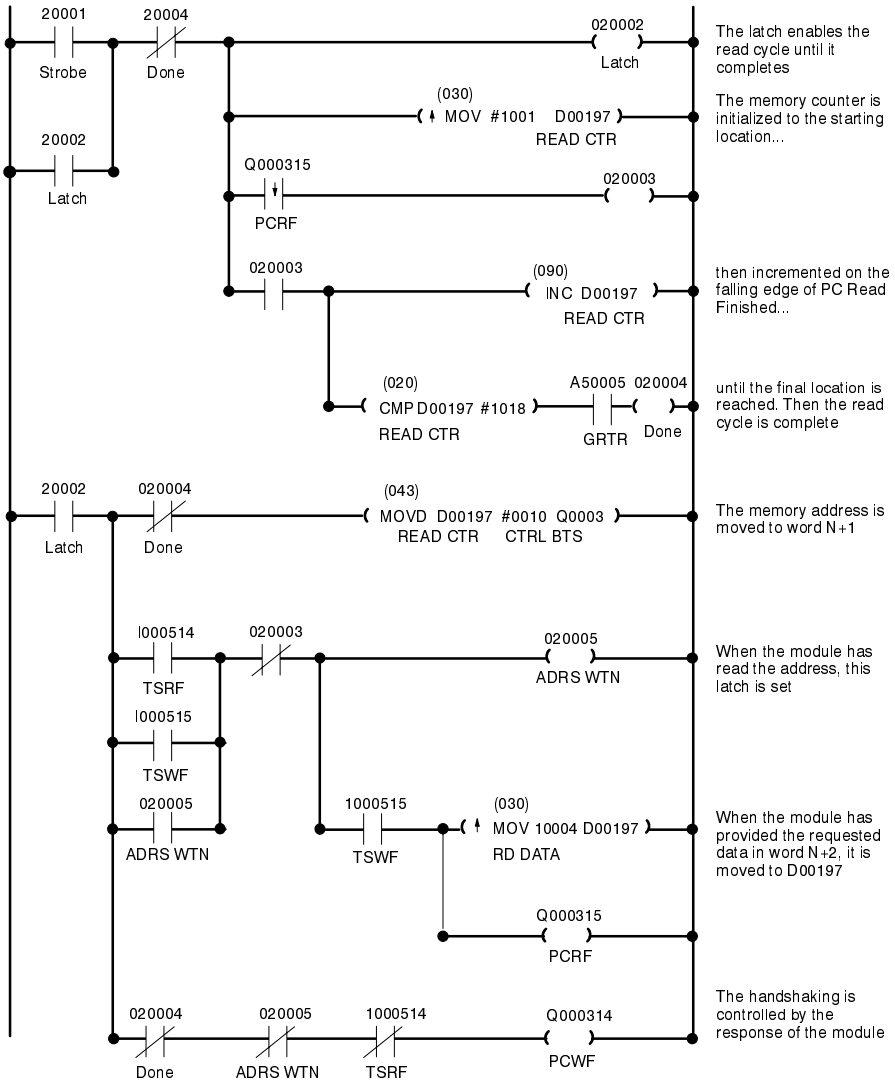


Example 2

Reading a Block of Memory Map Locations

The T/C Module occupies locations 002, 003, 004, and 005. This example reads a block of data from module memory locations 01 through 18 and stores it in PLC memory locations D01001 thru D01018. Note that the lower two digits of the two memory areas correspond. This was done intentionally to simplify programming.

CV-Series



5–6–3 Setting and Resetting, Enables and Resets

Example 1

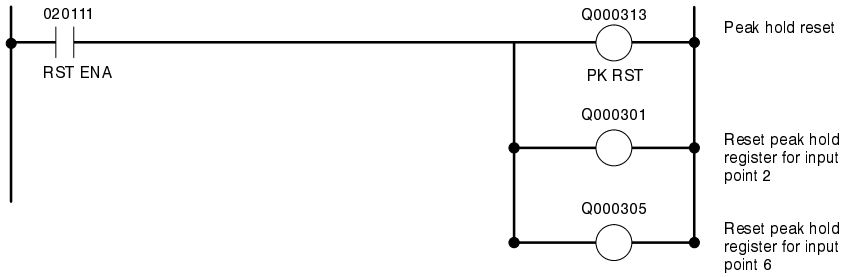
Reset Low/High Alarm

C-Series

Example 2

Reset Selected Peak Hold Registers

CV-Series



5–6–4 Programming Note

Most programs will contain programming for both reading from and writing to the module as shown in the previous sections. However, since the same handshaking bits are used in both operations, the two cannot be performed simultaneously. In fact, care in programming must be exercised to insure that they are not. The easiest way to do this is to have one section prevent the other from being initiated while it itself is enabled, and vice versa. The LATCH bits in the programming examples, which indicate which section is enabled at the time, can be used for this.

Furthermore, the handshaking bit PC Write Finished appears in both writing and reading sections. While one section may turn the bit ON, the section that follows, though disabled, will turn it OFF since that section's logic is still scanned if programmed exactly as shown. One way to solve this problem is to use jumps in the program to jump over the disabled section so that the logic is not scanned. A second way is to store the logic leading up to PC Write Finished in a temporary location in each section, then logically OR the two temporary locations together and store the result in PC Write Finished.

The Enables and Resets in Word N+1 Bits 09 thru 13 should be set to '1' for at least about 30 milliseconds to ensure that they are read by the module. In programs whose scan time is 30 ms or more, this is not a problem. In very short programs, these bits may need to be set for two or more program scans.

5–7 Using the Heartbeat

The Module Good Flag, in both 2-word and 4-word modes, pulses at 1 Hz rate (0.5 second ON, 0.5 second OFF) with a 45-55% duty cycle. This is the heartbeat. It indicates that the microprocessor in the module is operating properly and is providing updated input point conversion data to the PLC. In critical applications, the PLC program can verify that the T/C module is operational by examining and timing the heartbeat.

Simple programs to monitor the heartbeat are shown below. A pulse is generated on the rising edge of the heartbeat signal to reset the timer. The timer is set for 1.5 seconds to allow for the variation in the heartbeat. More complicated programs using both rising and falling edges of the heartbeat, and a timer setting of 0.8 seconds can also be used.

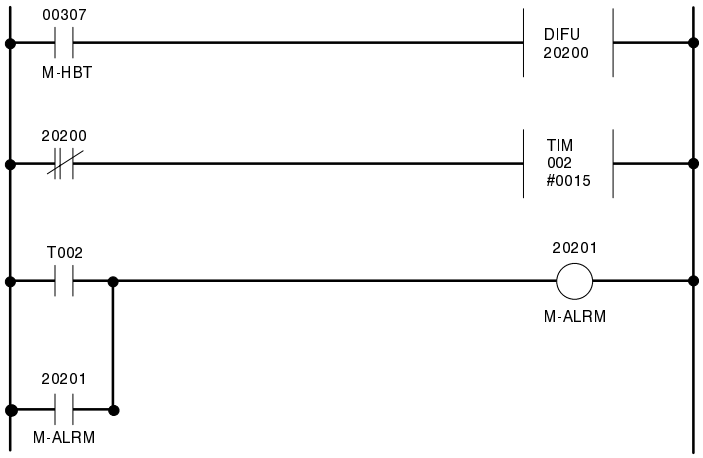
Example 1 - Heartbeat in 2-word mode, module base addresses at I/O 002, in C-Series.

Example 2 - Heartbeat in 4-word mode, module base addresses at I/O 002, in CV-Series.

Example 1

C-Series, 2-Word Mode

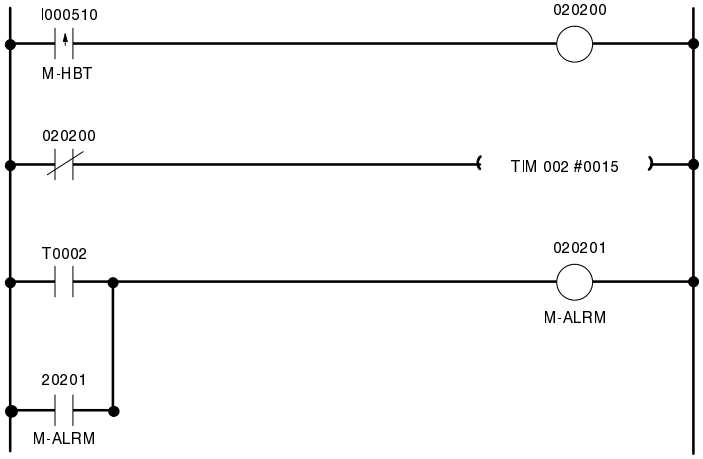
C-Series



Example 2

CV-Series, 4-Word Mode

CV-Series



APPENDIX A
Standard Models and Manuals

Name	Description	Part number
C500-TS501	8 Point Thermocouple Input Module	
	Manual for C500 TS501	H02TAZ2
CV Installation Manual	–	W195
CV Operation Manual: Ladder Diagram	–	W202
C Installation Manual	–	W139
C Operation Manual	–	W140
CVSS	CV Support Software	CV500-ZS3AT1-E
LSS	Ladder Support Software	C500-Y9LS11-EV3

APPENDIX B
Specifications

Number of thermocouple inputs		8 channels, isolated		
Input signal ranges		**°C**	**°F**	
J-Type		0–760	32–1400	
K-Type		0–1372	32–2501	
R-Type		0–1765	32–3209	
S-Type		0–1766	32–3211	
T-Type		0–400	32–752	
E-Type		0–1000	32–1832	
J-DIN Type		0–900	32–1652	
Millivolts		0 – 50 mV		
Intelligent functions		Scaling, alarming, averaging, filtering, peak hold. Selectable and configurable per input point		
Resolution		1° in BCD, 0.1° in binary		
Accuracy		J, K, R, S, E, J-DIN	T	Millivolts
25°C		±0.15%	±0.55%	±0.1%
0-55°C at 0-95% relative humidity		±0.56%	±1.8%	±0.1%
Under extreme noise conditions*		±1.25%	±1.25%	±1.25%
Repeatability		0.08%		
Conversion time		15 ms minimum, all 8 inputs		
Reporting data format		Signed BCD 2's Complement binary Configurable from PLC or serial port		
Allocated words		2 words/4 words - selectable		
PLC communications		Intelligent I/O read/write instructions for OMRON C, CV, CVM1 series		
Internal memory		RAM EEPROM for memory map storage		
Front window indicators		Run, error, range, comm error, transmit/receive		
Input connector		24 point terminal block		
Vibration resistance	Durability	10 to 54.8 Hz at 0.25 mm amplitude in X, Y and Z directions for 12 sweeps in 10 min. 54.8 to 300 Hz at 3G in X, Y and Z directions for 12 sweeps in 10 min.		
	Malfunction	10 to 61.2 Hz at 0.1 mm amplitude in X, Y and Z directions for 4 sweeps in 8 min. 61.2 to 150 Hz acceleration at 1.5 G in X, Y and Z directions for 4 sweeps in 8 min.		
Impact resistance	Durability	30 G in X, Y and Z directions three times each direction		
Isolation		Optical isolation between input terminals and PLC: 1500 VAC Optical isolation for RS-232C: 1500 VAC		
Power consumption		1.4 A from backplane; 7.4 W max.		
Dimensions		34.5(W) x 250(H) x 127(D)		
Weight		700 g maximum		

Note: Immune to operational malfunction when subjected to electrical noise:

100ns and 1μs, 1500V pulses induced on power supply

100ns and 1μs, 1200V pulses induced on frame ground

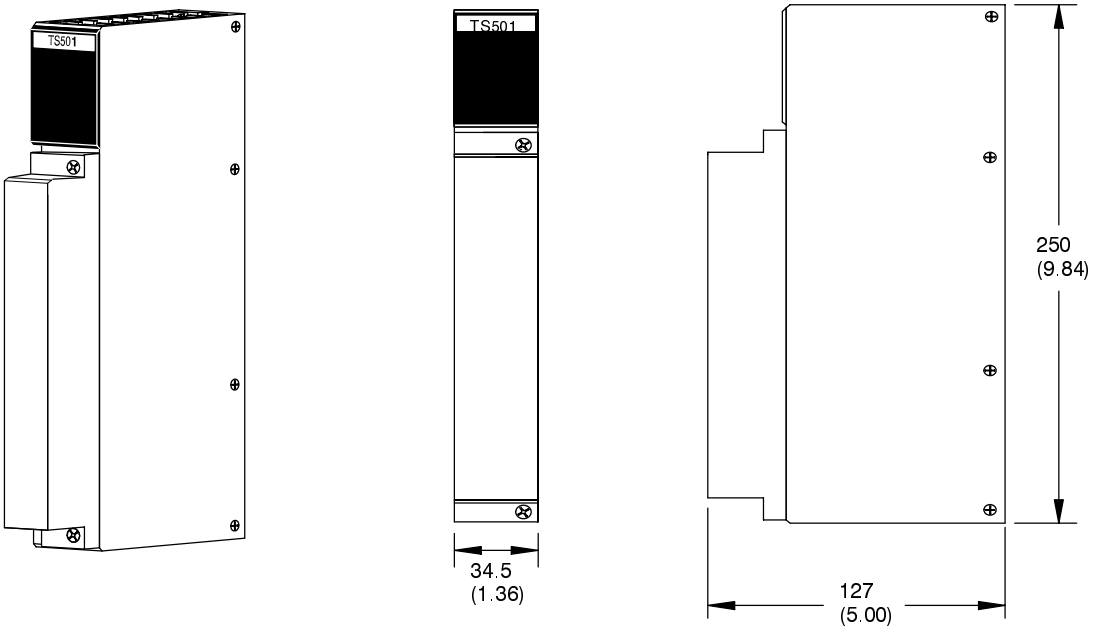
100ns and 1μs, 1200V pulses induced on 10 turn winding on input cables

100ns and 1μs, 600 V pulses induced on 3 turn winding on case

APPENDIX C
Dimensions

C500-TS501 Thermocouple Module

Unit: mm (inch)



APPENDIX D
Configuration Worksheet

C500-TS501 8-Point Thermocouple Input Module Configuration Worksheet

Bit			15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	Hex/BCD value			
Data memory	**Module memory map**	**Input point**	8	7	6	5	4	3	2	1	8	7	6	5	4	3	2	1				
		Function																				
	25	Input point enable bits																				
		Input point peak hold enable bits																				
	26	Input point binary/BCD select enable bits																				
		Input point scaling enable bits																				
	27	Input point averaging enable bits																				
		Input point filtering enable bits																				
	28	Input point low alarm enable bits																				
		Input point high alarm enable bits																				
	29	Input point degrees C/F select bits	0																0	0		

Data memory	Module memory map	Function	Decimal value	Hex/BCD value			
	30	Low alarm limit – input point 1					
	31	High alarm limit – input point 1					
	32	Low alarm limit – input point 2					
	33	High alarm limit – input point 2					
	34	Low alarm limit – input point 3					
	35	High alarm limit – input point 3					
	36	Low alarm limit – input point 4					
	37	High alarm limit – input point 4					
	38	Low alarm limit – input point 5					
	39	High alarm limit – input point 5					
	40	Low alarm limit – input point 6					
	41	High alarm limit – input point 6					
	42	Low alarm limit – input point 7					
	43	High alarm limit – input point 7					
	44	Low alarm limit – input point 8					
	45	High alarm limit – input point 8					

Data memory	Module memory map	Function	Decimal value	Hex/BCD value			
	46	Filtering time constant – input point 1					
	47	Filtering time constant – input point 2					
	48	Filtering time constant – input point 3					
	49	Filtering time constant – input point 4					
	50	Filtering time constant – input point 5					
	51	Filtering time constant – input point 6					
	52	Filtering time constant – input point 7					
	53	Filtering time constant – input point 8					
	54	Averaging sample counts – input point 1					
	55	Averaging sample counts – input point 2					
	56	Averaging sample counts – input point 3					
	57	Averaging sample counts – input point 4					
	58	Averaging sample counts – input point 5					
	59	Averaging sample counts – input point 6					
	60	Averaging sample counts – input point 7					
	61	Averaging sample counts – input point 8					
	62	Scaling low limit – input point 1					
	63	Scaling high limit – input point 1					
	64	Scaling low limit – input point 2					
	65	Scaling high limit – input point 2					
	66	Scaling low limit – input point 3					
	67	Scaling high limit – input point 3					
	68	Scaling low limit – input point 4					
	69	Scaling high limit – input point 4					
	70	Scaling low limit – input point 5					
	71	Scaling high limit – input point 5					
	72	Scaling low limit – input point 6					
	73	Scaling high limit – input point 6					
	74	Scaling low limit – input point 7					
	75	Scaling high limit – input point 7					
	76	Scaling low limit – input point 8					
	77	Scaling high limit – input point 8					

APPENDIX E
Module Memory Map Values and Functions

Data/flag	Module memory	Read/ write	Data format	Valid data range	Out of box power up default	Save/ load EEPROM	Reset input point enable	Reset on function enable	Conditions
Input point alarm and invalid data error flags	00	R	Binary	0 or 1	0	No	No	No	User-reset from I/O word
Input point conversion data	01 to 08	R	Binary BCD	–32767 to 32767 –7999 to 7999	0 0	No	Yes	Yes	Set by module
Input point alarm flags	09 to 10	R	Binary	0 or 1	0	No	No	No	Set by module
Input point peak hold data	11 to 18	R	Binary BCD	–32767 to 32767 –7999 to 7999	0 0	No	Yes	Yes	Set by module
Input point active flags	19, bits 0-7	R	Binary	0 or 1	All 1	No	Yes	No	Set by module
Input point function active flags	19 to 23	R	Binary	0 or 1	0	No	No	Yes	Set by module
Pointer word	24	R/W	BCD	00 to 83	0	No	No	No	Set by user
Input point enable flags	25, bits 0-7	R/W	Binary	0 or 1	All 1	Yes	No	No	Set by user
Input point binary/BCD section	26, bits 0-7	R/W	Binary	0 or 1	All 1 (BCD)	Yes	No	No	Set by user
Input point function enable flags	25 to 29	R/W	Binary	0 or 1	0	Yes	No	No	Set by user
Input point alarm limits	30 to 45	R/W	Binary BCD	–32767 to 32767 –7999 to 7999	100 low 3900 high	Yes	No	No	Set by user
Input point filtering constants	46 to 53	R/W	Binary BCD	1 to 32767 1 to 9999	100	Yes	No	No	Set by user
Input point averaging counts	54 to 61	R/W	Binary BCD	1 to 32767 1 to 9999	20	Yes	No	No	Set by user
Input point scaling limits	62 to 77	R/W	Binary BCD	–32767 to 32767 –7999 to 7999	0 low 100 high	Yes	No	No	Set by user
Input point type select	78 to 79	R	BCD	0 to 7	3	No	No	No	Set by module
EEPROM total writes	80	R	Binary	0000 to 9999	0	Yes	No	No	Set by module
EEPROM error flags	81	R	Binary	0 or 1	0	No	No	No	Set by module
EEPROM compare register	82	R/W	Binary	0000 to 9999	0	No	No	No	Set by user
Input point open thermocouple flags	83	R	Binary	0 or 1	0	No	No	No	Set by module

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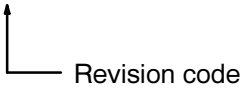
Revision History

A manual revision code appears as a suffix to the catalog number on the front cover of the manual.

SYSMAC C1000H/C2000H
CV1000/CV2000/CVM1
C500-TS501 Thermocouple Input Module
Operation Manual

Cat. No. H02TAZ2



The following table outlines the changes made to the manual during each revision. Page numbers refer to the previous version.

Revision code	Date	Revised content
H02TAZ1	October 1994	Original production C500-TS501EU
H02TAZ2	January 1996	C500-TS501EU revised to C500-TS501