SIEMENS

SIMATIC TI505

8IN/4OUT Analog Modules

User Manual

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SIMATIC TI505 8IN/4OUT Analog Modules User Manual
Order Manual Number: PPX:505–8110–2

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4-1 — 4-3	Second Edition		
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Preface

This manual describes installing and calibrating the SIMATIC® TI505™ 8IN/4OUT Analog Module (PPX:505–7012) and the SIMATIC TI505 8IN/4OUT Bipolar Analog Module (PPX:505–7016).

Other Manuals

Refer to the manuals listed below for instructions on installing, programming, and troubleshooting your controller and I/O.

- *Series 500™/505™ Programming Reference Manual* (PPX:505–8104–x)
- *SIMATIC®TI525™/TI535™ Hardware/Installation Manual* (PPX:505–8103–x)
- *SIMATIC® TI545™ System Manual* (PPX:545–8101–x)
- *SIMATIC® TI555™ System Manual* (PPX:555–8101–x)
- *SIMATIC®TI560T™/TI565T™ System Manual* (PPX:560/565–8109–x)
- The *user manual* for your release of TISOFT™

Agency Approvals

The 8IN/4OUT Analog and Bipolar Analog Modules meet the standards of the following agencies:

- Underwriters Laboratories: UL®Listed (Industrial Control Equipment)
- Canadian Standards Association: CSA Certified (Process Control Equipment)
- Factory Mutual Approved; Class I, Div. 2 Hazardous Locations
- Verband Deutscher Elektrotechniker (VDE) 0160 Clearance/Creepage for Electrical Equipment (Self-Compliance)

Series 505 products have been developed with consideration of the draft standard of the International Electrotechnical Commission Committee proposed standard (IEC-65A/WG6) for programmable controllers.

Telephoning for Assistance

For technical assistance, contact your Siemens Industrial Automation, Inc. distributor or sales office. If you need assistance in contacting your U.S. distributor or sales office, call 1–800–964–4114.

Chapter 1
Product Overview

1.1 Features

Description

The 8IN/4OUT Analog Modules provide eight differential, bipolar analog input points and four analog output points in a single-wide, Series 505 format. These modules are useful in applications such as loop/temperature control and machine control. See Figure 1-1. The features of these modules are detailed in Table 1-1 and Table 1-2; see Appendix B for more detailed specifications.

The combination of inputs and outputs in the same module, combined with the ability to scale points individually, allows you to reduce the number of modules you need. Potential applications include the following:

- Loop control
- Weighing systems
- Machine control
- Temperature control

Module features:

- Reduced I/O module count; I/O are mixed within a single module
- Independent input and output ranges
- High-density configuration of eight inputs and four outputs (available with certain controllers; see Table 1-3.)

  a) 12 WX and 4 WY
  (4 WX points used to echo 4 WY values and report errors)

  b) 20 WX and 4 WY
  (8 WX points used for error reporting on the 8 input points, and 4 WX points used to echo 4 WY valves and report errors)

- Low-density 8-point configurations
- Selectable output fault state

  a) Output voltage/current driven to analog zero

  b) Last value written before fault held

- Isolation

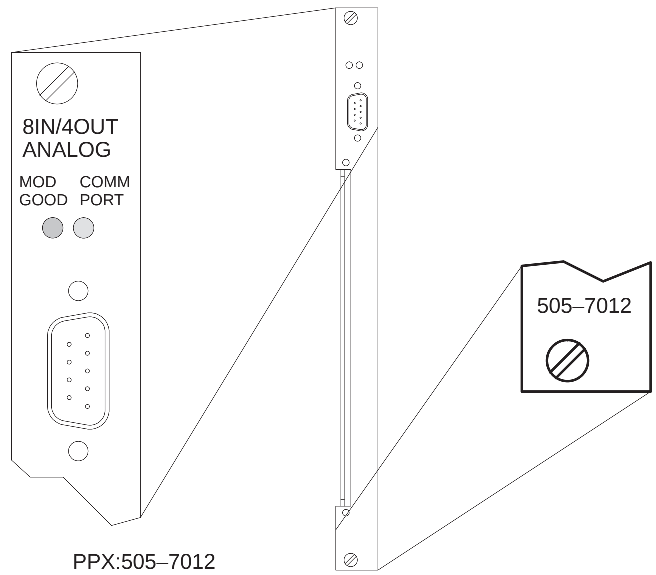
  >1 MΩ input point-to-point impedance

  1500 V rms field-side-to-controller

Immediate I/O

The 8IN/4OUT Analog Module (PPX:505–7016) is compatible with the TI545 Release 2.1 or greater immediate I/O operation. Refer to the *SIMATIC® TI505™ System Manual* for a description of immediate I/O.

8IN/4OUT Analog:
Standard speed
High accuracy
Bipolar inputs voltage *or* current
Unipolar outputs voltage *and* current



8IN/4OUT Bipolar:
High speed
Standard accuracy
Bipolar inputs voltage *or* current
Bipolar outputs voltage
Unipolar outputs current
Compatible with immediate I/O

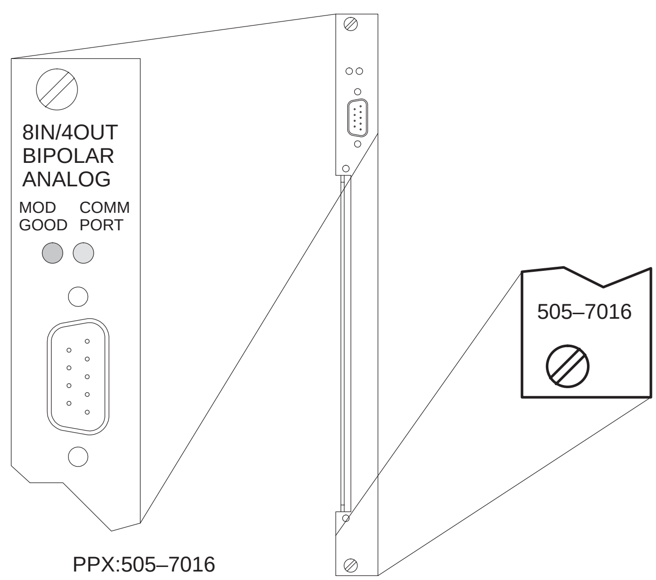


Figure 1-1 8IN/4OUT Analog Module (PPX:505–7012 and PPX:505–7016)

1.2 General Specifications

Input Features Refer to Appendix B for more detailed specifications.

Table 1-1 Input Features of Modules

Item	PPX:505–7012	PPX:505–7016
Input points	8 differential bipolar	8 differential bipolar
Input current	±20 mA, 250 Ω 0.5 W internal resistor 32 mA maximum continuous	±20 mA ,250 Ω 0.5 W internal resistor 32 mA maximum continuous
Input voltage range	50 mV, 100 mV, 500 mV, 1 V, 2 V, 5 V,10 V set during calibration	±5 V or ±10 V, switch selectable per input
Isolation	1500 V rms inputs-to-controller, inputs-to-outputs 1 MΩ inputs-to-inputs	1500 V rms inputs-to-controller 1 MΩ inputs-to-inputs
Accuracy, overall	≤0.1% of full-scale typical <0.3% of full-scale over full operating temperature range	≤0.1% of full-scale typical <0.3% of full-scale over full operating temperature range
Resolution	15 bits over selected span, plus sign bit	13 bits over selected span, plus sign bit
Repeatability	0.02% (200 ppm) at calibrated temperature	0.04% (400 ppm) at calibrated temperature
Update time	20 ms per input at 60 and 300 Hz 24 ms per input at 10 and 50 Hz	3.124 msec/4 inputs
Common-mode rejection	100 V rms with <0.1% additional inaccuracy	100 V rms with <0.1% additional inaccuracy
Common-mode rejection ratio	>80 dB	>80 dB
Normal-mode rejection ratio	>40 dB at 60 Hz	>32 dB at 60 Hz
Software filtering, selectable	10, 50, 60, or 300 Hz	on/off
Hardware filtering	1 Hz low-pass	7 kHz
Overvoltage withstand	200 V peak, differential or common-mode	200 V peak, differential or common-mode
Out-of-range inputs	Reported as error words	Reported as error words (selectable error point configuration)
Calibration	ASCII terminal Analog 0 compensation Autoranging span selection during calibration: 50 mV, 100 mV, 500 mV, 1 V, 2 V, 5 V, 10 V	ASCII terminal analog 0 compensation Autoranging span selection during calibration, two ranges, user selectable
Scaling	Data can be scaled to engineering units	Data can be scaled to engineering units

Output Features

Refer to Appendix B for more detailed specifications.

Table 1-2 Output Features of Modules

Item	PPX:505–7012	PPX:505–7016
Output points	4	4
Output current*	0–20 mA, <600 Ω load <0.1 μF	0–20 mA, <600 Ω load <0.1 μF
Output voltage	0 – 10 V, >5 kΩ load	± 10 V or ±5 V, jumper selectable per output, >5 kΩ load
Accuracy	≤0.1% of full-scale typical <0.25% of full-scale over full operating temperature range	≤0.1% of full-scale typical <0.25% of full-scale over full operating temperature range
Isolation	Fully isolated when each has separate isolated power supply 1500 V rms output-to-output, output-to-controller, output-to-inputs	Impedance isolation when each has separate isolated power supply 1500 V rms output-to-controller
Resolution	12-bit	12-bit, plus sign
Output withstand	Driving open and shorted conditions, on either or both output types per point	Driving open and shorted conditions, on either or both output types per point
Output value on failure	Selectable to 0 V/mA or last value	Selectable to 0 V/mA or last value
Scale	Data can be scaled to engineering units	Data can be scaled to engineering units
Update time	<24 ms/4 output	3.124 msec/4 outputs
Output or error word	Read back in high-density configuration	Read back in high-density configuration
User power	User power is required for this module	None required for voltage output; loop power is not provided by this module
Compliance voltage	User supply – $(9\ V)_{msx}$	User supply – $(9\ V)_{msx}$

*Current up to 600 Ω with a 24 V nominal power supply. For increased load drive: increase power supply voltage (up to 40 V), such that $V_{power\ supply} = (R_{load}) \times (20\ mA) + (9\ V)$.

Table 1-3 I/O Mixes and Compatible Controllers

I/O	Density	Controllers
8/4 (20 WX/4 WY)	High	SIMATIC®TI530T™, TI535, TI545, SIMATIC®TI560™/TI565™, TI560T, and later
8/4 (12 WX/4 WY)	High	TI530T, TI535, TI545, TI560/TI565, TI560T, and later
8/0 (8 WX)	Low	All Series 500 & 505, including TI525, SIMATIC®TI530C™
6/2 (6 WX/2 WY)	Low	All Series 500 & 505, except TI525 and TI530C
4/4 (4 WX/4 WY)	Low	All Series 500 & 505, except TI525 and TI530C

NOTE: The Models TI525 and TI530C support only the 8/0 configuration.

User Power Requirements

User-supplied power is required only for the module outputs. Low density configurations 6 WX/2 WY and 4 WX/4 WY on the 8IN/4OUT Analog Module (PPX:505–7012) require user–supplied power for the module to function properly. Power to all four outputs are required. MOD GOOD LED will not be on without power, and will indicate a module failure to the PLC. If your application does not use the current output feature on the 8IN/4OUT Bipolar Analog Module (PPX:505–7016), there is no need to provide any power other than that available from the base. See Section 2.2 for switch settings.

Type of Power Supply Required for Outputs

Use a Class 2 power supply that provides power in the range of 24 VAC rms or 24 VDC. You can use up to four power supplies. Details of power supply requirements are provided in Appendix B. Multiple outputs may be connected to a power supply, based on the power supply drive capacity total load and the isolation requirements of the system. Using four isolated power supplies with the 8IN/4OUT Analog Module (PPX:505–7012) provides four isolated voltage and current output drive. Using four power supplies in the 8IN/4OUT Bipolar analog Module (PPX:505–7016), although not providing isolation, provides the user with the ability to use four separate loop power sources.

1.3 Calibration

Overview

8IN/4OUT modules are calibrated for zero and span, and adjusted for scale. You can calibrate all inputs or outputs, or you can calibrate each of the eight inputs and each of the four outputs. To calibrate the module, you need a current or voltage source that can provide the minimum and maximum signal needed for your application, and a programming device with cable.

Calibration Types

You can calibrate I/O for three types of values:

- Zero—minimum process value
- Span—maximum process value minus the calibrated zero value
- Scale—high and low values in the controller

Factory Calibration for PPX:505–7012

The inputs and outputs are factory-calibrated for a 0–20 mA range, 0–32000 PLC word representation. The 250 ohm internal resistor is connected across the input terminals. Separate output terminals allow you to simultaneously use the 0–10 V output. (Additional calibration error is <0.2%.)

During calibration, you may see the following menu:

Load Defaults
CALIBRATION DATA
WILL BE LOST
Continue (Y/N)?

If you press [Y], the memory is over-written with data that represents predetermined calibration and analog compensation values.

NOTE: This does not restore Factory Calibration values to the module. This feature is only a starting point: you must recalibrate the module after this completes.

Factory Calibration for PPX:505–7016

The inputs and outputs are calibrated for ±10 V (input range switch up) and ±5 V (input range switch down, and with the 250 ohm internal resistor to select current input). Outputs are calibrated for ±10 V. You can set the ±5 V output range by changing the voltage jumper for each output. Separate output terminals allow you to simultaneously use the 0–20 mA output. (Additional calibration error is <0.2%.)

When you are prompted by the **Load Defaults** menu during calibration, additional menus prompt for:

- **(C)lear DATA**: clears calibration and compensation values
- **(F)actory CAL**: restores factory calibration values
- **(L)ast User CAL**: restores the last user-saved calibration values
- **(Q)uit**: allows you to quit a screen function

If you press Y in answer to the following prompt:

Load Defaults
CALIBRATION DATA
WILL BE LOST
Continue (Y/N)?

the memory is overwritten.

Chapter 2
Installing the Module

2.1 Overview of Installation

Flow of Tasks

Figure 2-1 shows the organization of the tasks described in this chapter.

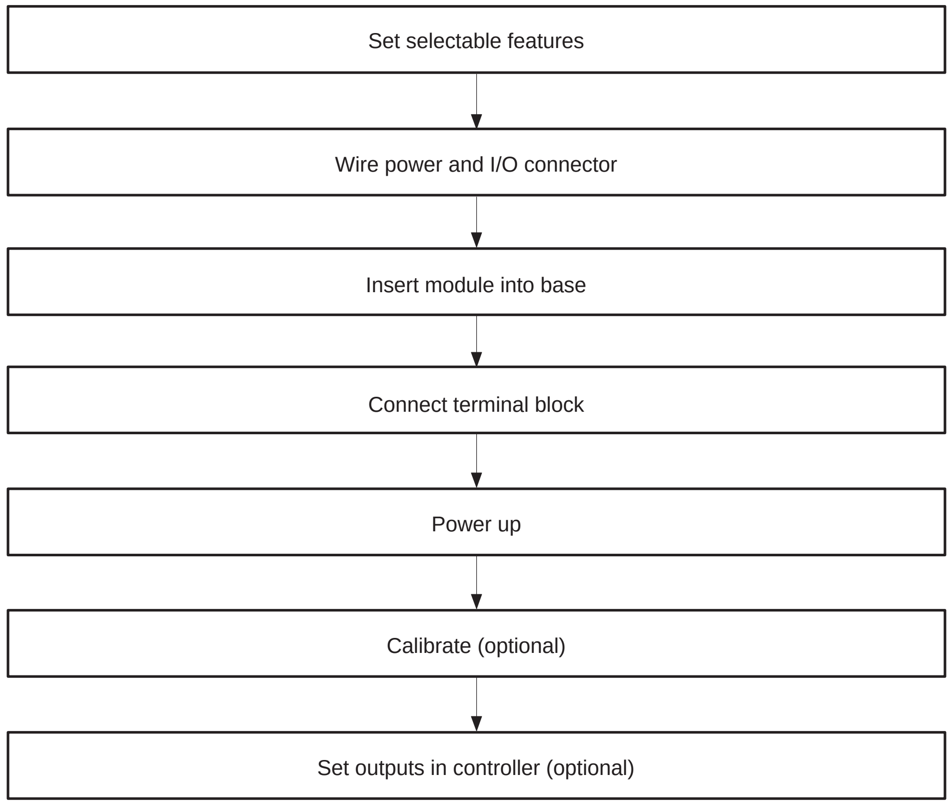


Figure 2-1 Flowchart of Installation

Handling the Module

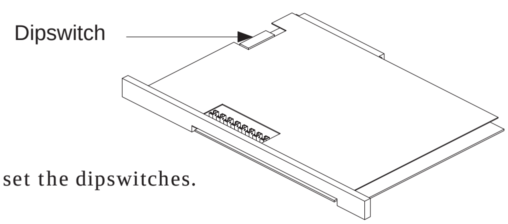
Many integrated circuit (IC) devices are susceptible to damage by the discharge of static electricity. Follow the suggestions listed below to reduce the probability of damage to these devices when you are handling a controller, a base controller, or any of the I/O modules.

Both the module and the person handling the module should be at the same ground potential. To accomplish this, fulfill the following conditions.

- Transport the module in an anti-static container or antistatic material.
- Ensure that the work area has a conductive pad with a lead connecting it to a common ground.
- Ground yourself by making contact with the conductive pad and/or by wearing a grounded wrist strap.

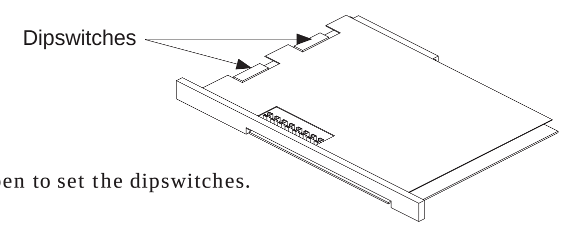
Visual Inspection

If there is any visible damage to the module, contact your vendor for replacement.



NOTE: Use a ballpoint pen to set the dipswitches.

Figure 2-2 Dipswitch Locations for 8IN/4OUT Analog Module



NOTE: Use a ballpoint pen to set the dipswitches.

Figure 2-3 Dipswitch Locations for 8IN/4OUT Bipolar Analog Module

2.2 Setting Options

Setting the Module Configuration Dipswitch

Set the module configuration dipswitch as shown in Figure 2-4 and Figure 2-5.

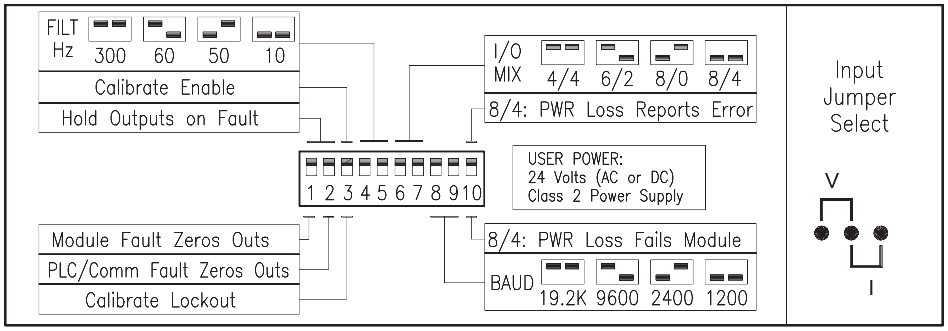


Figure 2-4 Dipswitch Label 8IN/4OUT Analog Module

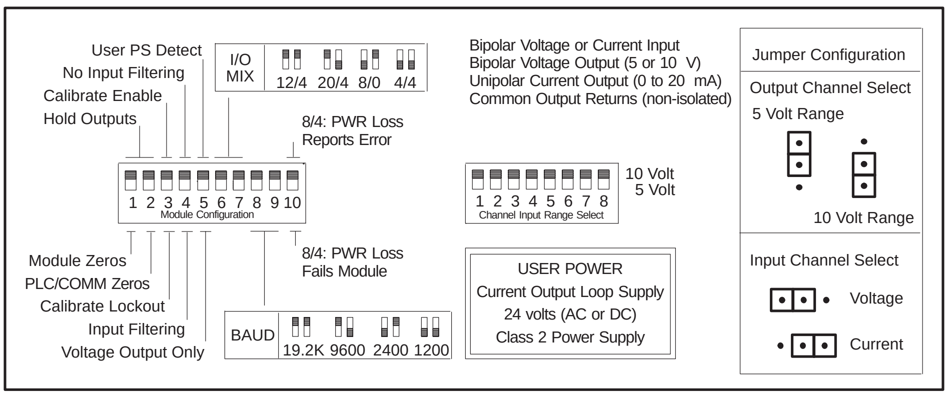


Figure 2-5 Dipswitch Label 8IN/4OUT Bipolar Analog Module

Calibration Lockout (Switch 3)

The calibration lockout feature is provided to help deter tampering with the module calibration. First, calibrate or adjust the module as required. Then power down, pull the module out of the base, set the calibration lockout switch (switch 3), and install the module.

Baud Rate (Switches 8 and 9)

Set the communication rate with switches 8 and 9, as shown in Figure 2-4 and Figure 2-5.

PPX:505–7012 Input Filtering and Step Response Time (Switches 4 and 5)

The effect of input filtering (switches 4 and 5) on response time is shown in Table 2-1. Values are for inputs registering a change from ±10 V. The digital word output requires the combined hardware and software response times shown to register a change to within 0.1% of the analog input value.

Table 2-1 Effects of Input Filtering on 8IN/4OUT Analog Module

Filter	Per Point Response		Per Point Module Response			
	Hardware	Software	SW Samples	4 Inputs	6 Inputs	8 Inputs
10 Hz	800 ms	24 ms	25	2400 ms	3600 ms	4800 ms
50 Hz	800 ms	24 ms	5	480 ms	720 ms	960 ms
60 Hz	800 ms	20 ms	5	400 ms	600 ms	800 ms
300 Hz	800 ms	20 ms	1	80 ms	120 ms	160 ms

PPX:505–7016 Input Filtering and Step Response Time (Switch 4)

The effect of input filtering (switch 4) on response time is shown in Table 2-2.

Table 2-2 Effects of Input Filtering on 8IN/4OUT Bipolar Analog Module

Per Point Response			Per Point Module Response	
Filter	Hardware	Software	4-inputs	8-inputs
OFF	138 μsec	781 μsec	3.124 mSec	6.248 mSec
ON	138 μsec	781 μsec	100 mSec	100 mSec

I/O Mix and Density (Switches 6 and 7)

Table 2-3 shows the available I/O combinations (switches 6 and 7). Use TISOFT to configure I/O. Refer to Chapter 4.

Table 2-3 I/O Mixes and Compatible Controllers

I/O	Density	Controllers
8/4 (20 WX/4 WY)	High	TI530T, TI535, TI545, TI560/TI565, TI560T, and later
8/4 (12 WX/4 WY)	High	TI530T, TI535, TI545, TI560/TI565, TI560T, and later
8/0 (8 WX)	Low	All Series 500 & 505, including TI525, TI530C
6/2 (6 WX/2 WY)	Low	All Series 500 & 505, except TI525 and TI530C
4/4 (4 WX/4 WY)	Low	All Series 500 & 505, except TI525 and TI530C

NOTE: The Models TI525 and TI530C support only the 8/0 configuration.

Output State when the Module Fails (Switch 1)

Use switch 1 to designate the output state when the module fails self-diagnostics or when a power supply fails. With switch 1 down, the output values all go to 0. With switch 1 up, the output values are held at their last value. Refer to Table 2-4 and Table 2-5.

Output State when a Controller or Communication Failure Occurs (Switch 2)

Use switch 2 to designate the output state when the controller has a fatal error or has a communication failure. With switch 2 down, the output values all go to 0. With switch 2 up, the output values are held at their last value. Refer to Table 2-4 and Table 2-5, for which the following guidelines apply.

- Normally, outputs update when written by the controller. Any changes listed here occur within one output update.
- The output states shown are for multiple power supplies.
- When the outputs are held, they do not update.
- When outputs are set to go to zero, all eight outputs return to 0 current and voltage.
- In high density configuration, outputs with user power fault report the error in the output echo word WX locations.

Module Failure in High-Density Mode (Switch 10 or Switches 5 and 10)

For the 8IN/4OUT Analog Module in high-density mode, with Switch 10 down, the module fails if power loss occurs. With switch 10 up, the module reports an error. For the 8IN/4OUT Bipolar Analog Module, switch 5 is used to select voltage only outputs. If user power is present, current is still generated, but the power supplies are not checked. The voltage output power is generated by the module from the PLC backplane. User power fault does not clear outputs. Use RLL to integrate error reporting into your application. Refer to Chapters 4 and 5 for the information required to implement this feature.

Table 2-4 Output Point Fault States: High-density with Sw 10 Up

Condition			Switches			
Power	Module	Comm/PLC	1 hold / hold 2	1 hold / zero 2	1 zero / hold 2	1 zero / zero 2
√	√	Fault	Hold	0	Hold	0
√	Fault	√	Hold	Hold	0	0
√	Fault	Fault	Hold	0	0	0
Fault	√	√	Normal Operation of Powered Points			

Table 2-5 Output Point Fault States: Low/High-density with Sw10 Down

Condition		Switches			
Module/ Power	Comm/PLC	1 hold / hold 2	1 hold / zero 2	1 zero / hold 2	1 zero / zero 2
√	Fault	Hold	0	Hold	0
Fault	√	Hold	Hold	0	0
Fault	Fault	Hold	0	0	0

2.3 Selecting Current or Voltage for Inputs

The 8IN/4OUT modules (PPX:505–7012 and PPX:505–7016) allow you to connect input devices that produce either current or voltage. Each input is individually jumper-selectable to accept either. There is one three-pin jumper per input. Jumper locations are shown in Figure 2-6. (Section 3.3 explains the factory-set default calibration.)

NOTE: Select voltage or current for outputs by wiring to the correct terminals. Refer to Section 2.6.

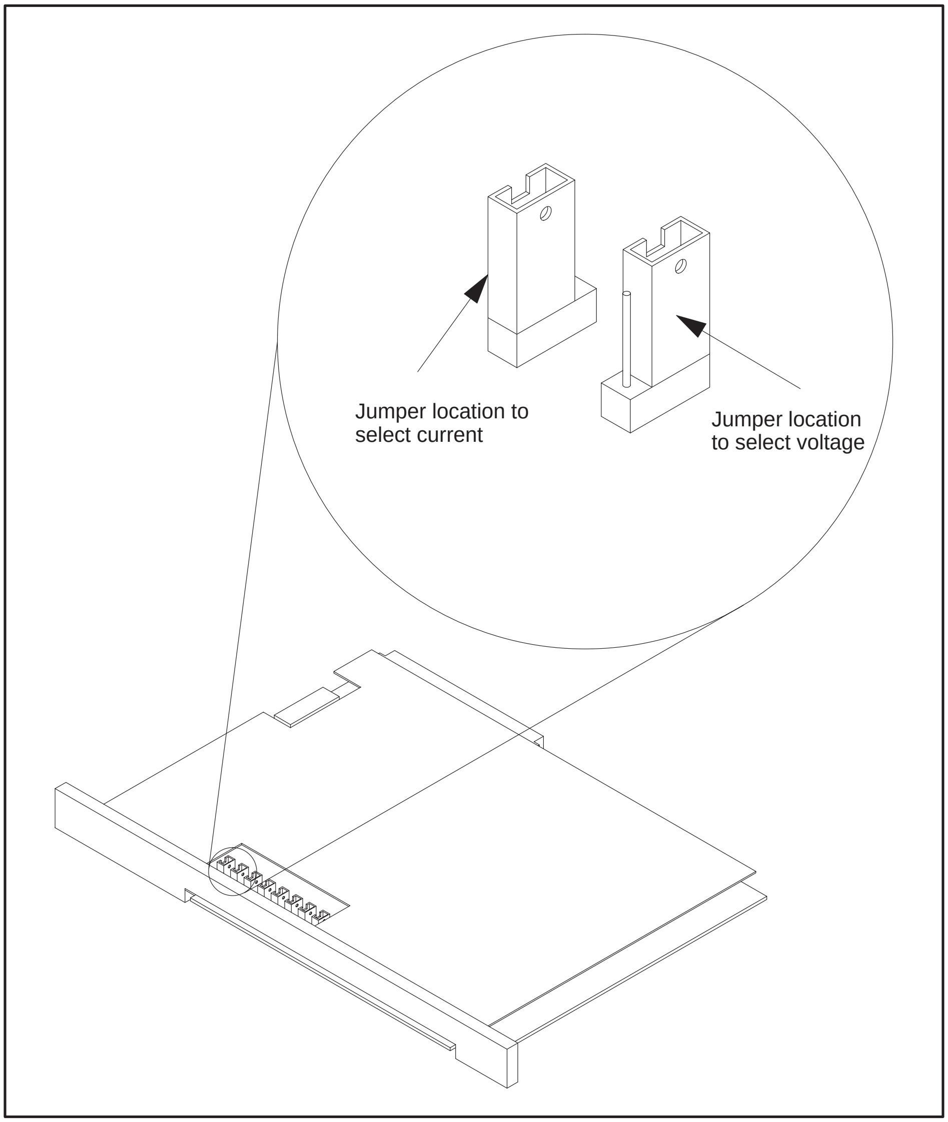


Figure 2-6 Jumper Locations for Selecting Current or Voltage for Inputs

2.4 Selecting Input and Output Voltage Ranges

PPX:505–7016 Range Selection

The 8IN/4OUT Bipolar Analog Module is equipped with ±10 and ±5 volt ranges on the analog inputs and outputs. An eight position dipswitch is used to select an individual range for each analog input. There is one three-pin jumper per output used to select the desired analog range. Dipswitch and jumper locations are shown in Figure 2-7.

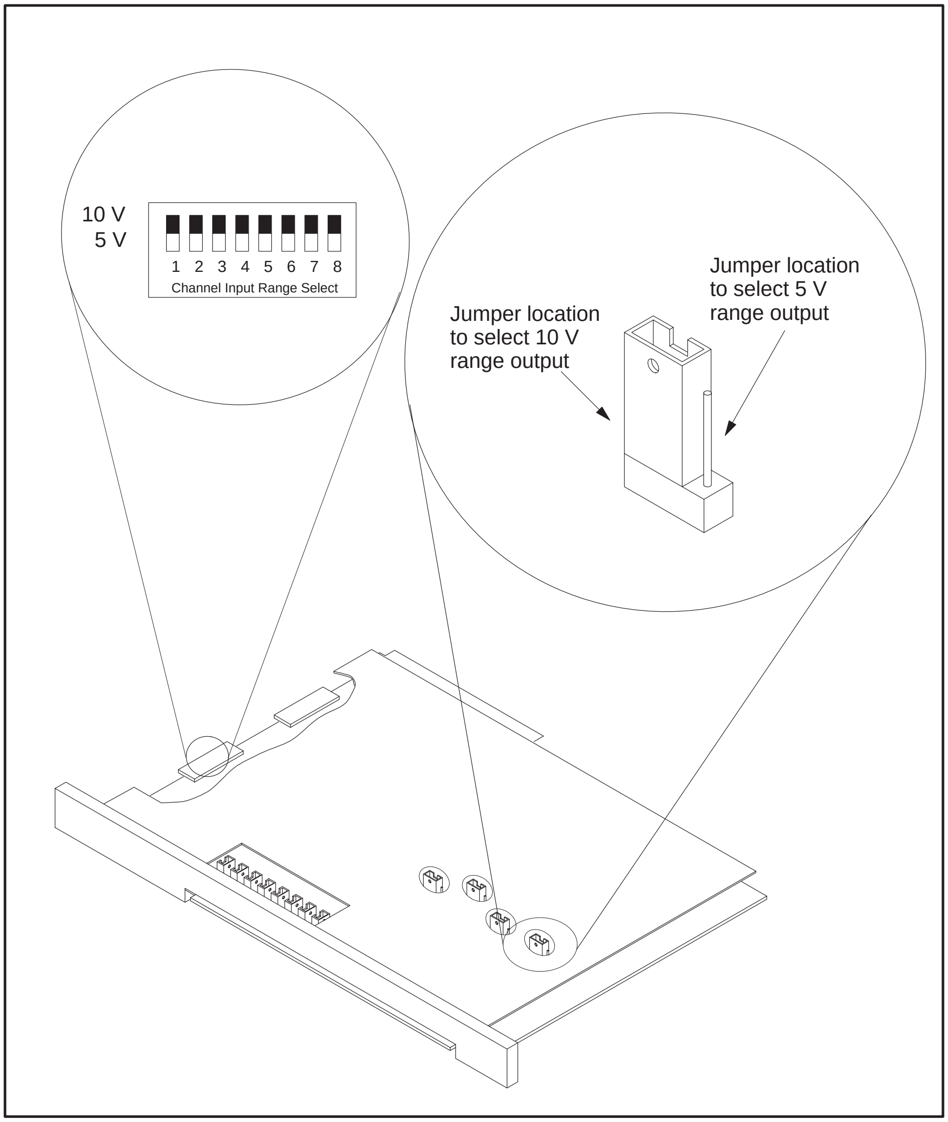


Figure 2-7 Jumper Locations for Selecting Input and Output Ranges

2.5 Inserting the Module into the Base

⚠ WARNING **To minimize risk of potential shock hazard, turn off power to the I/O base and to any modules installed in the base before inserting or removing a module or installing a terminal block. Failure to do so may result in potential injury to personnel or damage to equipment.**

Inserting the Module

The 8IN/4OUT analog modules are single-wide modules. Insert the module into any available I/O slot on any Series 505 base (see the next paragraph if your CPU is a model TI535 or TI530T). Insert as shown in Figure 2-8. Note the minimum torque required to help prevent noise.

Guidelines for CPU Models TI535 & TI530T

Do not install this module in slot 1 of any Series 505 base controlled by a TI535 or TI530T CPU. If you do install a high-density, mixed I/O module in slot 1, discrete modules in base 0 do not register in controller memory.

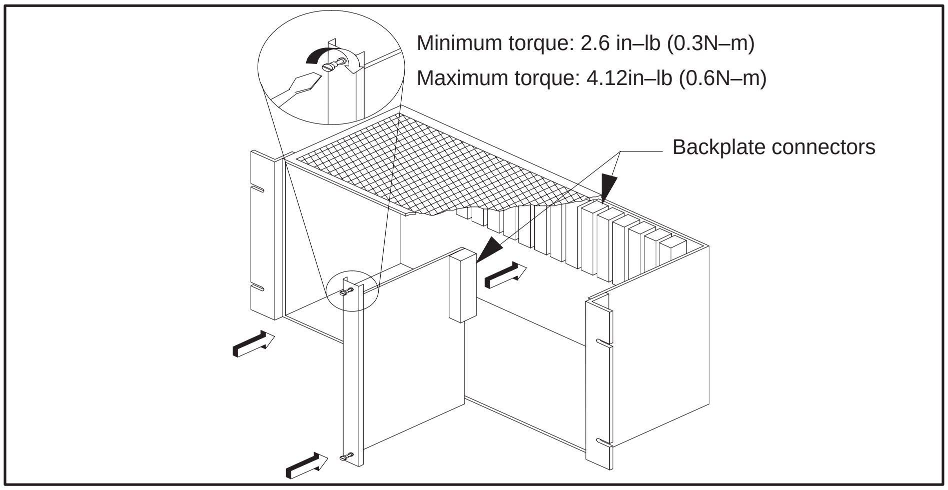


Figure 2-8 Inserting the Module into the Base

Connecting the Terminal Block

To connect the terminal block to the module, perform these steps.

1. Align the terminal block with the edge card connector on the bezel.
2. Press firmly at both ends of the terminal block until it is seated.
3. Tighten the screws at the top and bottom. Do not over-tighten.

After you power up the base, it takes approximately four seconds for the MOD GOOD LED to come on.

2.6 Field Wiring

Providing External Power

No user-supplied power is needed if your application includes inputs only (8 WX configuration). The module consumes 3.5 W of +5 V and 30 mW of –5 V power from the base.

NOTE: The number of external power supplies used with the 8IN/4OUT Analog Module (PPX:505–7012) depends on the isolation requirements for your application. If you do not need isolation between outputs, use one power supply. If you need outputs to be isolated from each other, use a separate power supply for each one. Use a Class 2 power supply that supplies 24 VAC rms or 24 VDC nominal, ±10%.

On the 8IN/4OUT Bipolar Analog Module (PPX:505–7016), no user power is required for voltage output only. One to four supplies may be used for current output.

Wiring Unused Terminations

To reduce output signal noise, wire each output that is not wired to a power supply as follows:

4. Wire the positive and negative power supply terminals together.
5. Wire the combined terminals to the chassis ground. See Figure 2-9 for an example.

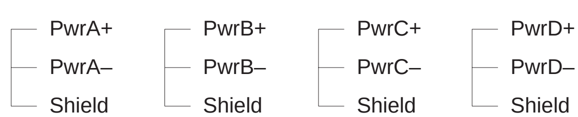


Figure 2-9 Wiring for Unused Outputs, Models 505–7012 and 505–7016

You can use either of the terminal blocks shown in Figure 2-10. Both terminal blocks are removable.

To prevent noise on the signal wiring, keep signal and power wiring separate. For input or output signals and class 2 power supply wires, use shielded, twisted-pair cable (12–26 AWG or 0.16–3.2 mm^2, either stranded or solid-type).

⚠ WARNING

Use supply wires suitable for at least 75° C. Signal wiring connected to this module must be rated at least 300 V.

ATTENTION

Employer des fils d'alimentation pour au moins 75° C. Le cablage de signalisation raccorde dans cette boite doit convenir pour une tension nominale d'au moins 300 V.

Avoiding Noise

To minimize unwanted noise, follow these guidelines when installing the module.

- Use the shortest possible wires.
- Separate discrete and analog wires.
- Avoid placing signal wires parallel to high-energy wires. If the two must meet, cross them at right angles.
- Avoid bending the wire into sharp angles.
- Use wireways for wire routing.
- When using shielded wires, ground them only at the source end for better noise immunity.
- Place wires so that they do not interfere with existing wiring.
- Label the wires.

NOTE: Terminate shielding for the output cable at the same earth ground as the user power supply. Terminate shielding for the input signal wire at the same earth ground as the transmitter.

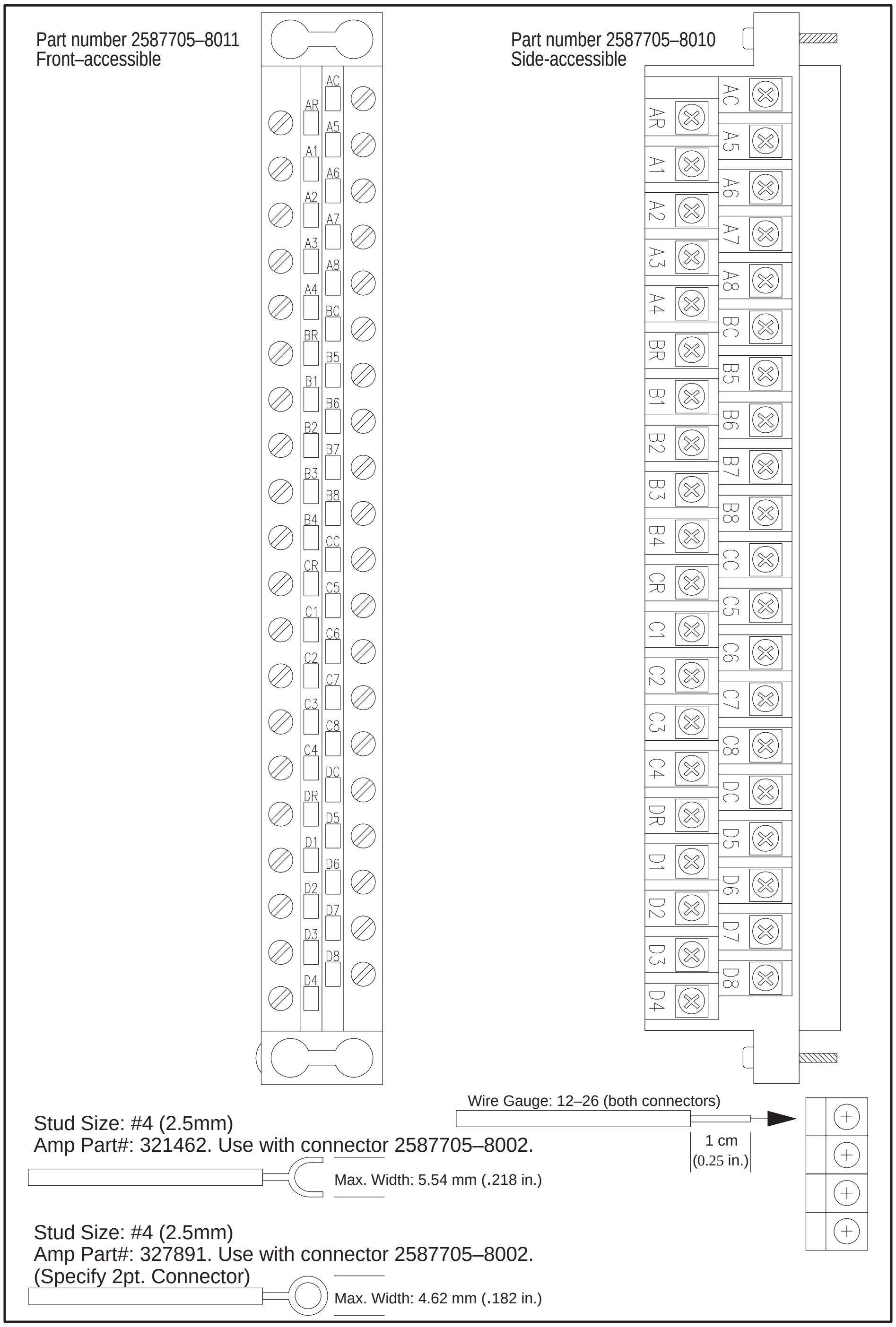


Figure 2-10 Termination Blocks

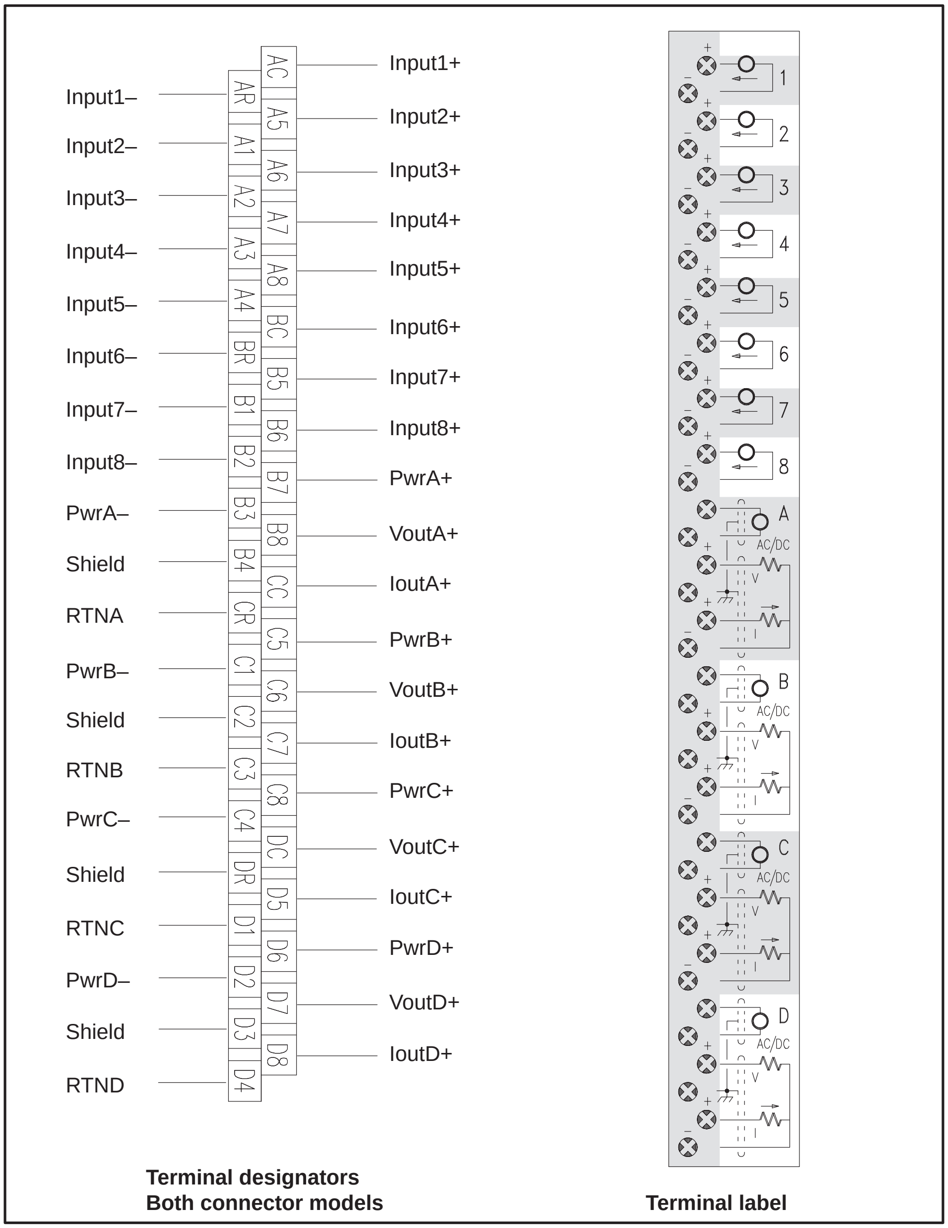


Figure 2-11 I/O Terminations

2.7 Connecting Transmitter to Current Input

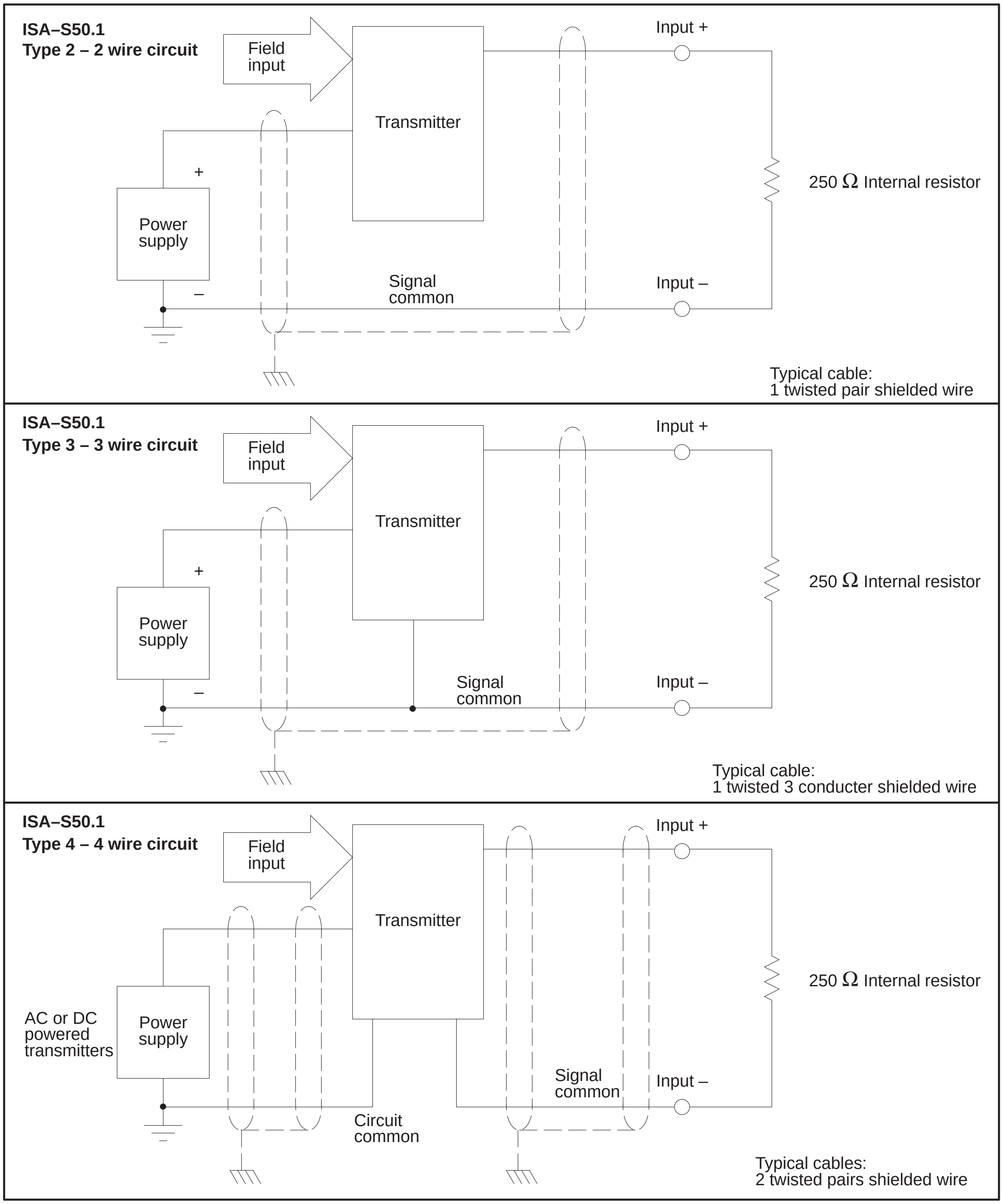


Figure 2-12 Wiring a Transmitter

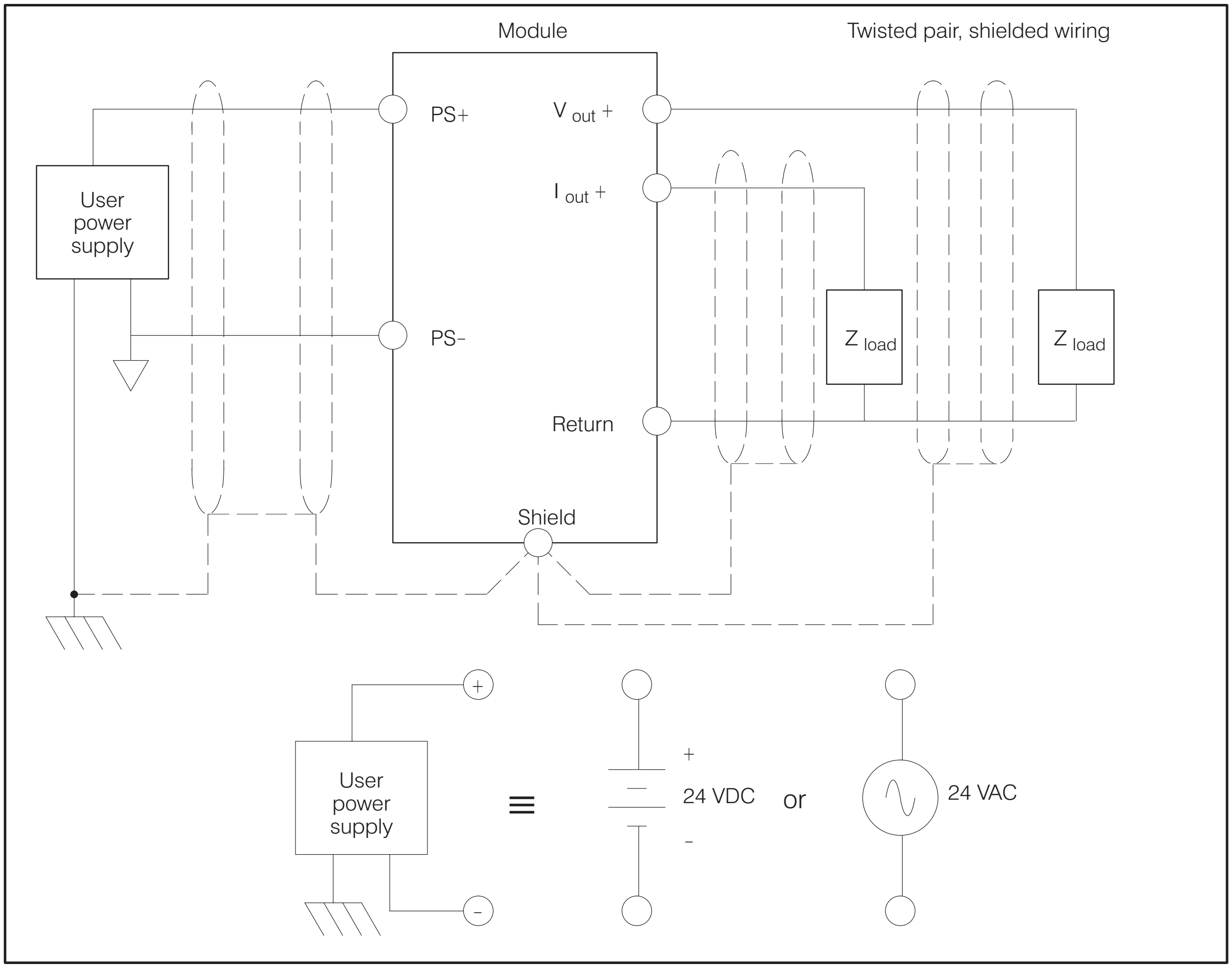


Figure 2-13 Output Wiring Diagram

Selecting Current or Voltage for Outputs

If your application requires both current and voltage terminations, simply wire the outputs using terminals for both.

NOTE: Module calibration applies to either voltage or current; there is <0.2% variation in the value for which you do not calibrate.

Chapter 3

Calibrating the Module

3.1 Overview

You can calibrate each group of inputs and outputs separately or together, for the following values.

- Zero—minimum process value
- Span—maximum process value minus the calibrated zero value
- Scale—high and low process values in the controller

Altering Values

If your application requires calibrating for any of these reasons, you can alter the setup for various offsets, maximum signal levels, and compensation for other system errors.

Although the module does not normally require periodic calibration, check the module for accuracy approximately once a year. On the 8IN/4OUT Analog (PPX:505–7012) module only, to achieve published accuracy, recalibrate the module when you change the filter selection.

Echo Feature

In high-density mode the last four WX words represent the output echo feature and report the status of the output values back to the controller. Use this feature for recognizing output errors. Configuration 20 WX/4 WY represents the input and output echo feature. The second eight WX point words are used to report errors on the inputs. Refer to Chapters 4 and 5 for details on using error reporting. Table 5-3 shows all error words used.

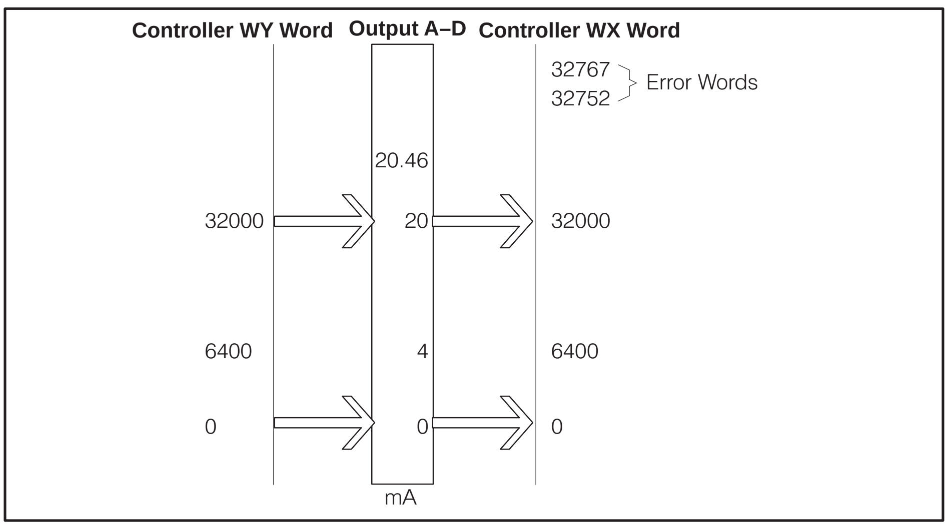


Figure 3-1 Feedback Words in High-density Mode

3.2 Using the Module Simulator

A module simulator is included on disk with your module. The simulator allows you to experiment with various calibration and scaling configurations before actually calibrating the module. You can enter specific values for zero, span, and scale and the simulator reads back the full-scale voltage range and controller values based on the values you entered.

Bringing Up the Simulator Program

Load the disk into your computer drive A. Type **A:sim_8i4o** and press [Return]. You are prompted as shown in Figure 3-2.

```
FULL SCALE VOLTAGE RANGE = +/– 10.000 V

(Z)   PROCESS ZERO VOLTAGE = 0.000
      PROCESS SPAN VOLTAGE = 10.000
(L)   PLC LOW SCALE VALUE = 0
(H)   PLC HIGH SCALE VALUE = 32000

      INPUT PROCESS VALUE = 0.000
      PLC VALUE = 0
```

Figure 3-2 Simulator Screen

Changing Values

Type the letter for the value to be changed:

- Press [Z] for process zero voltage; process span voltage follows automatically
- Press [L] for PLC low scale value
- Press [H] for PLC high scale value

Changes to zero and span affect the full-scale voltage range by toggling it between ±10 and ±5 V. Changes to the process value are reflected in the PLC value.

NOTE: If the input process value exceeds that of the module capability, the message **INPUT VOLTAGE OVER RANGE** is displayed.

- Press [Esc] to exit.

3.3 Factory Calibration

Inputs

When you receive the 8IN/4OUT Analog Module from the factory, all eight inputs are calibrated for current inputs as shown in Figure 3-3. The 8IN/4OUT Bipolar Analog Module is calibrated for voltage as shown in Figure 3-4, selected by having the channel input range select switch up; and calibrated for current as shown in Figure 3-5 with channel input select switch down and the 250 ohm jumper installed for current sensing. See Figure 2-6.

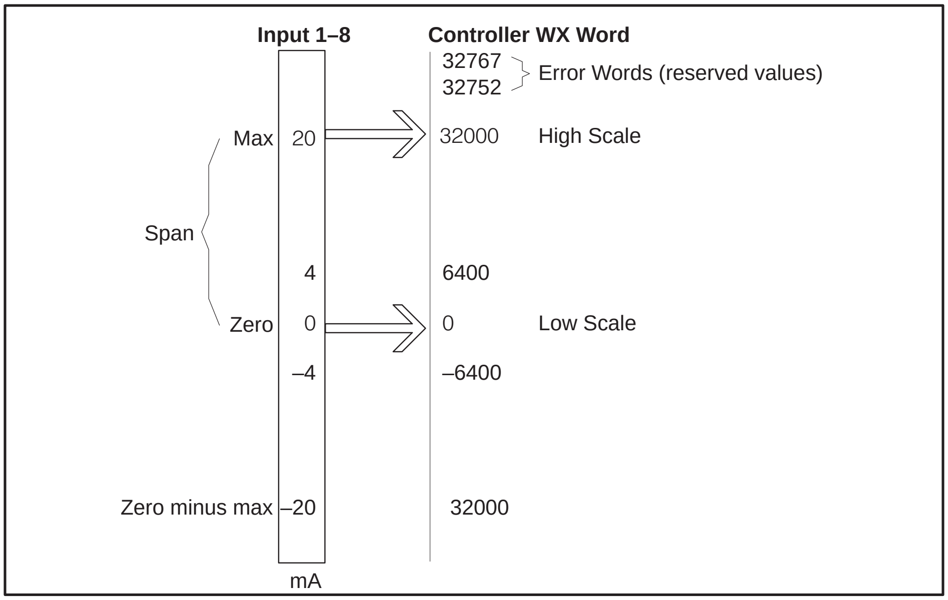


Figure 3-3 Factory Calibration for Current Inputs

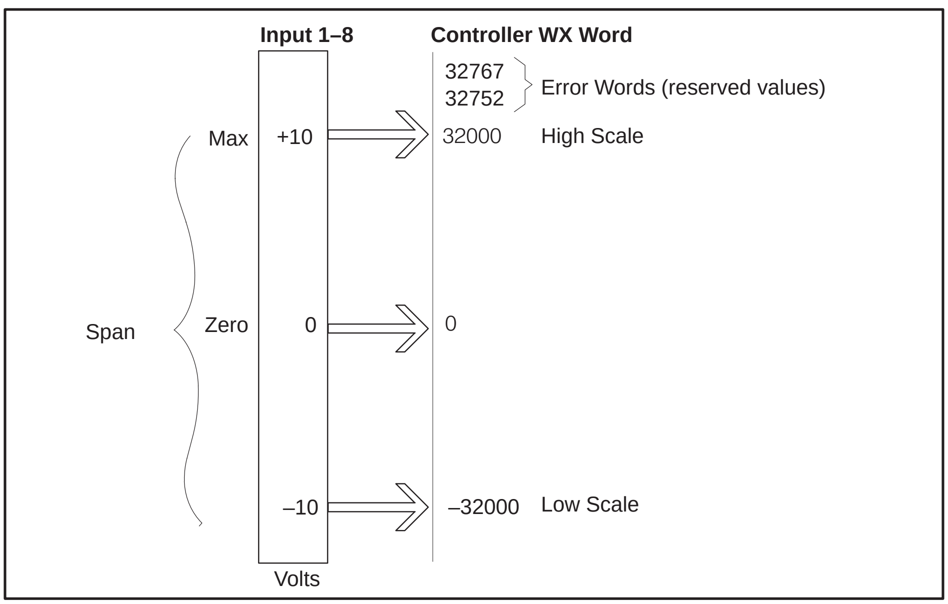


Figure 3-4 Factory Calibration for Voltage Inputs

Outputs

When you receive the 8IN/4OUT Analog Module from the factory, all four outputs are calibrated for current outputs as shown in Figure 3-5. The Bipolar Analog Module is calibrated for voltage as shown in Figure 3-6.

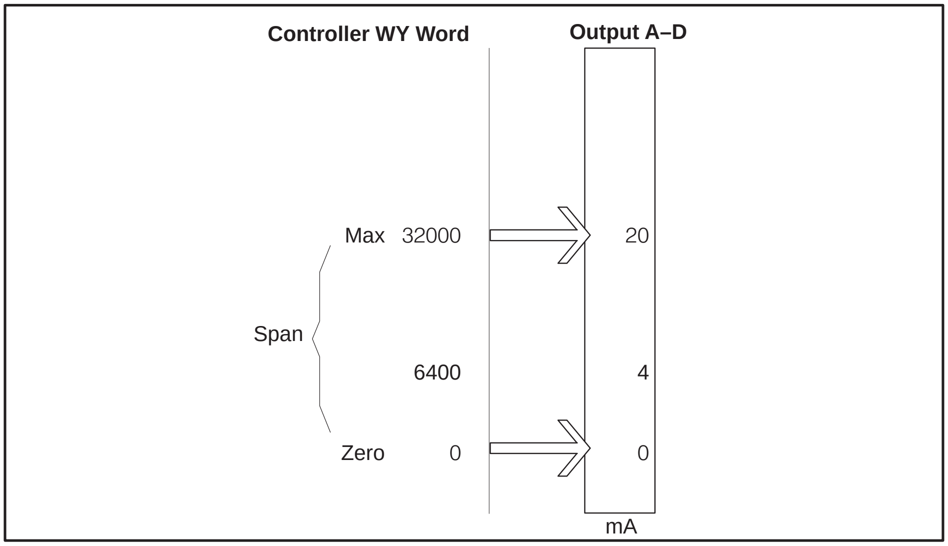


Figure 3-5 Factory Calibration for Current Outputs

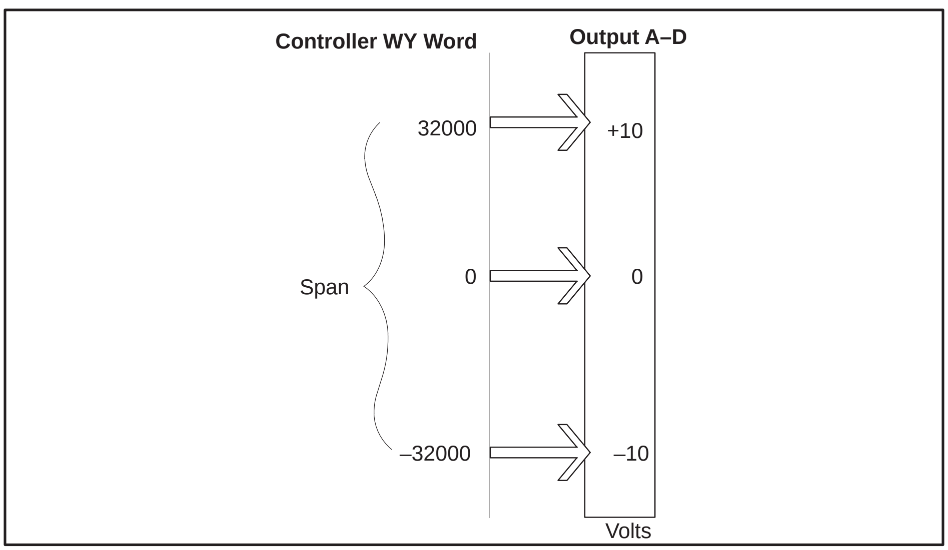


Figure 3-6 Factory Calibration for Voltage Outputs

3.4 How the Module Works

The 8IN/4OUT Analog Modules feature flexible module calibration and data scaling facilities. You can set zero and span values to those of the process under control. You can also scale the information to engineering units.

Field Input Processing

Figure 3-7 shows how the module processes field inputs.

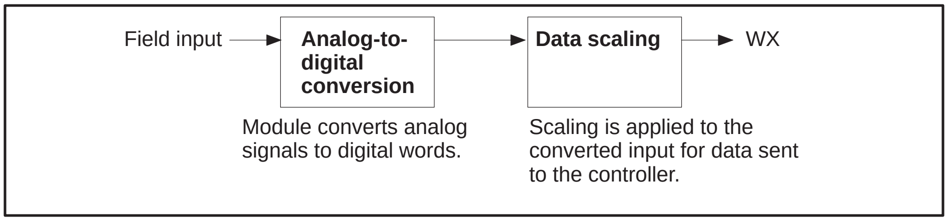


Figure 3-7 Module Operation on Inputs

Analog-to-Digital Conversion

Analog input data is converted to a digital word by first conditioning the signal, then amplified, and then doing an analog conversion on the signal. On the 8IN/4OUT Analog Module only, the amplifier has seven possible gain stages for full-scale values as shown in Table 3-1. The 8IN/4OUT Bipolar Analog Module auto ranges a gain value.

Table 3-1 Amplifier Gain Stages

Input Volts	±10 V	±5 V	±2 V	±1 V	±500 mV	±100 mV	±50 mV
Milliamps	±40 mA	±20 mA	±8 mA	±4 mA	±2.0 mA	±0.4 mA	±0.2 mA

Autoranging

The gain stage is selected automatically by the module during calibration to give the best possible signal resolution. Other input voltages can be calibrated, but are not rated or specified.

Offsets

The last parameter affecting the signal conversion is that of the input offset. The input offset is computed by the module during calibration. It applies internal offsets to bring the selected signal to the zero point. Analog inputs can be over-ranged up to 20% above the maximum value specified by the selectable gain stage, and you can set the module scale to take advantage of this expanded range.

Data Scaling

Data scaling gives a high degree of flexibility in the way that the analog data can be presented in the controller. When calibrating the module, you also can modify the controller word range limits. The low and high values map directly to the zero and max analog process values. Linear scaling converts the data to a WX word. The WX words range from –32,768 to +32,751. The uppermost 16 words are reserved for error reporting. For example, you can set the WX low and high limits to 4000 and 20,000 if the process zero and max are 4 mA and 20 mA. This represents the analog input in 1 μA increments.

Figure 3-8 shows how the default values are mapped to scaled controller values.

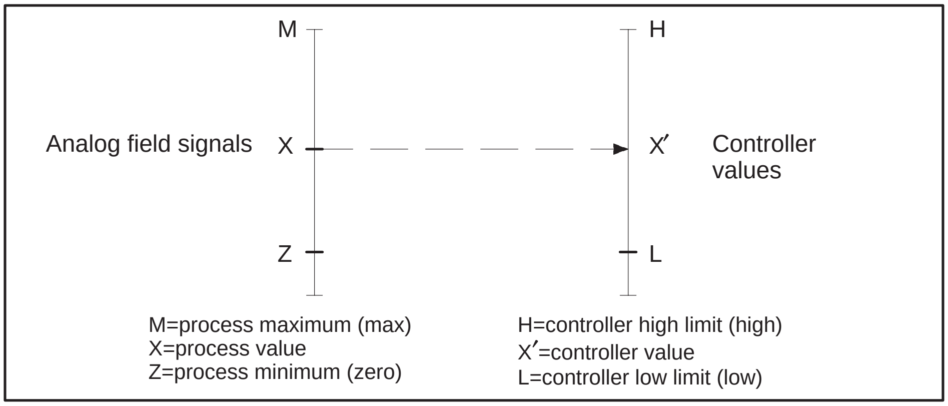


Figure 3-8 Mapping to Scaled Controller Values

To find out to which point X′ on the controller scale is mapped by a particular point X on the field signal scale, use the following equation:

$$X' = \left[\frac{(X - Z)}{(M - Z)} \times (H - L)\right] + L$$

Likewise, to find what field signal value X yields a WX value X′, use the following equation:

$$X = \left[\frac{(X' - L)}{(H - L)} \times (M - Z)\right] + Z$$

3.5 Equipment

Calibrating Equipment

To calibrate 8IN/OUT Analog Modules, you need a current or voltage source to provide the minimum and maximum signal required for your application (for instance, ±10 V or 20 mA), and a volt meter or current meter for monitoring outputs during calibration.

For some applications it may be appropriate to connect field transmitters and actuators to inputs and outputs during calibraton.

Terminal Devices

You can use any of the following devices to calibrate 8IN/4OUT Analog Modules.

- Standard, non-intelligent ASCII terminal
- Handheld Intelligent Terminal (PPX:505–7510) set up as a terminal
- Any IBM or IBM-compatible computer with terminal emulator

NOTE: If you use the IBM or another intelligent device for calibration, you must use a terminal emulator as well. For your convenience, one is enclosed on a disk with your module. Simply insert it in drive A: and type **A:TERM**.

Recommended Communication Cables

For high-noise environments, it is recommended that you use a standard communications cable with your programming device. Refer to Table 3-2. Either configuration is compatible with your controller programming arrangement.

Table 3-2 Standard Communication Cables

Port	Cable	Cable P/N	Adapter at Module
9-pin	Standard 9-pin null modem	2601094–8001	None required
25-pin serial	Standard 25-pin	VPU200–3605	9F–to–25M pin port adapter

Building a Cable

If you prefer to build your own nine-pin cable, refer to Figure 3-9 for the pinouts. Ensure that the following requirements are met.

- Cable conductors—26 AWG, tinned and stranded copper wire, with one uninsulated 26 AWG tinned copper drain wire
- Cable shield—AL foil or aluminum-polyester foil and a 65% minimum tinned copper braid shield
- Outer jacket—polyvinyl chloride (PVC) or equivalent material, with a UL rating of 30V, 60°C minimum
- Connectors—D-subminiature 9-pin female, with contact pins of copper alloy with gold flashing over nickel plate.

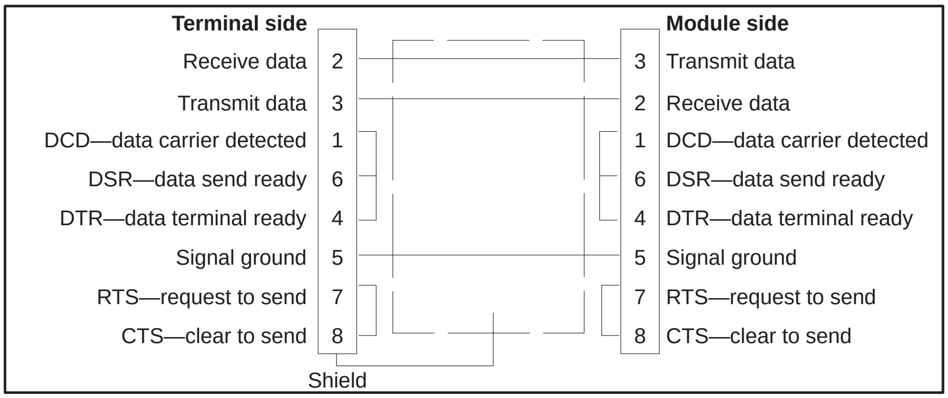


Figure 3-9 9-pin to 9-pin Connector Cable Pinouts

⚠ WARNING

To help minimize the risk of potential damage to equipment, disconnect all loads and field devices from the output connector. If you fail to do so, equipment connected to the module may be actuated. This can cause potential personal injury or property damage if safety considerations (2588015–0002) are not followed.

3.6 Changing Calibration

Initiating Calibration

Before you plug your cable into the communication port, set up the terminal as follows:

- Eight data bits
- One stop bit
- No parity
- Echo off
- DSR active
- Baud rate matches

NOTE: You *must* set the HIT up as a terminal *before* you plug in the cable.

Plug the cable into the module communication port and press any key. The following prompt appears:

PPX:505–7012 (OR PPX:505–7016)
Release x.x
7777777–4444
(C)ontinue

When you press C, the following menu appears:

(C)alibrate
(R)un
(S)et Outputs
(D)isplay Config

Using Menu Prompts

The menus on the screen prompt your key response. The characters inside a parenthesis indicate which key to press. In this example, **(C)ontinue** prompts you to press C. If any other key is pressed, the terminal bell sounds, and that key is ignored by the module.

You should follow all menu prompts:

- (**Q)uit** allows you to quit a screen function.
- **(R)un** allows you to exit when the calibration is complete.
- A fast-blinking green COMM LED tells you that the cable was removed after the start of calibration. Connecting the cable restarts the menus.

3.7 Changing Calibration

NOTE: To calibrate all inputs, apply signals to all inputs simultaneously.

Changing Input Zero and Span

To change input zero and span, follow these steps:

1. Follow the menu prompts to calibrate input zero/span.
2. Apply the zero process signal.
3. Press [S] to set. This sets the zero.
4. Apply the maximum process signal.
5. Press [S] to set. This sets the span.

You are prompted: **Span other side of zero?** Use this option to calibrate bipolar readings. At the **Span other side of zero?** prompt, perform these steps:

1. Press [Y].
2. Apply the inverse of the maximum process value (zero minus span). For instance, if max = 8 V and zero =1 V, the inverse is –6 V.
3. Press [S]. If you exceed the 5% range for an inverted maximum value, you are prompted:

   ERROR ON Pt x
   Inverted Max
   out of 5% range
   Reapply. (C)ont

   Recalculate the maximum values and try this procedure again.

Scaling Inputs

To scale inputs, follow these steps.

1. Follow the menu prompts and press [S] to set input scaling.
2. Press [L] to enter the low value or [H] to enter the high value. The present value is shown and you are prompted for a new value. If you press [Enter] without entering a new value, the procedure is aborted and no new value is entered. The value is not stored in nonvolatile memory until you exit from input calibration by pressing [Q].
3. Type the new value and press [Enter]; the new value is accepted. Read the the new configuration of inputs before exiting to confirm the expected scaling of zero/span relationship.

Changing Calibration (continued)

4. Apply the process value and use the [R] key to confirm the scaled readings. If you have set all the inputs at once, the screen shows all points at once. If you have set a point by itself, the screen displays the high, low, and WX values for that point.

5. To **SAVE CHANGES,** answer **yes**. To return to the previous setup, choose **no.**

Changing Output Zero and Span

To change output zero and span, follow these steps:

1. Follow the menu prompts to calibrate output zero/span.

2. Select mA or V.

3. Use the **Up**, **Down**, and **Fast** options to adjust the zero value and monitor the process output to give the process zero. The fast key speeds up the process in the direction you already have selected.

4. Press [S] to set. This sets the zero.

5. Use the same procedure to adjust the span.

6. Press [S] to set.

Scaling Outputs

To scale outputs, follow these steps.

1. Follow the menu prompts to set output scaling.

2. Press [L] to enter the low value or [H] to enter the high value. The present value is shown and you are prompted for a new value. If you press [Enter] without entering a new value, the procedure is aborted and no new value is entered. The value is not stored in nonvolatile memory until you exit from output calibration.

3. Type the new value and press [Enter]; the new value is accepted. Read the the new configuration before exiting to confirm the expected scaling of zero/span relationship

4. If the new number is correct, exit the menu and answer **yes** to **SAVE CHANGES.** To return to the previous setup, choose **no.**

3.8 Exiting Calibration, Setting Output Values and Placing the Module in RUN

Overview

The 8IN/4OUT Analog Module output values can be set to a required value before placing the module in run mode. The value is held until the controller writes new WY values to the module.

Bringing Up Set Output Menu

Use the calibration menu to set the output values. Bring up the calibration menu:

(C)alibrate
(R)un
(S)et Outputs
(D)isplay Config

press S. Follow the prompts.

Placing the Module in Run Mode

Use the calibration menu to place the module in run mode.

Bring up the calibration menu:

(C)alibrate
(R)un
(S)et Outputs
(D)isplay Config

then press R.

NOTE: The module makes the transition to run mode when you remove the communication cable from the module connector.

3.9 Scaling I/O to Engineering Units

You can set up this module to express I/O values in engineering units. This saves ladder logic and scan time. There is no change in update time. See Figure 3-10 and Figure 3-11 for an examples of scaling to engineering units. If the module is replaced, the new module must be configured before use. Therefore, this configuration should be saved for future reference.

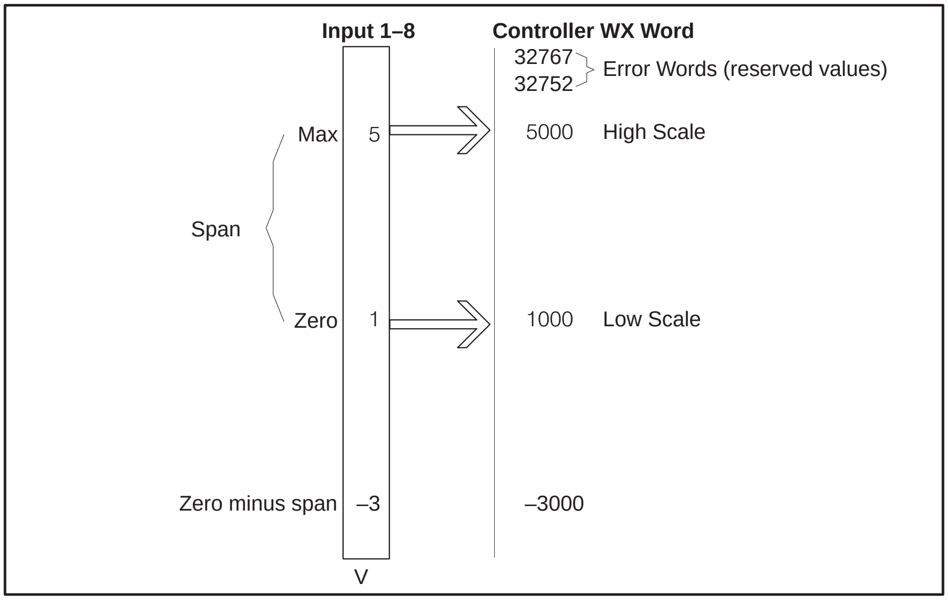


Figure 3-10 Scaling 5 V Inputs to 1 mV/Count

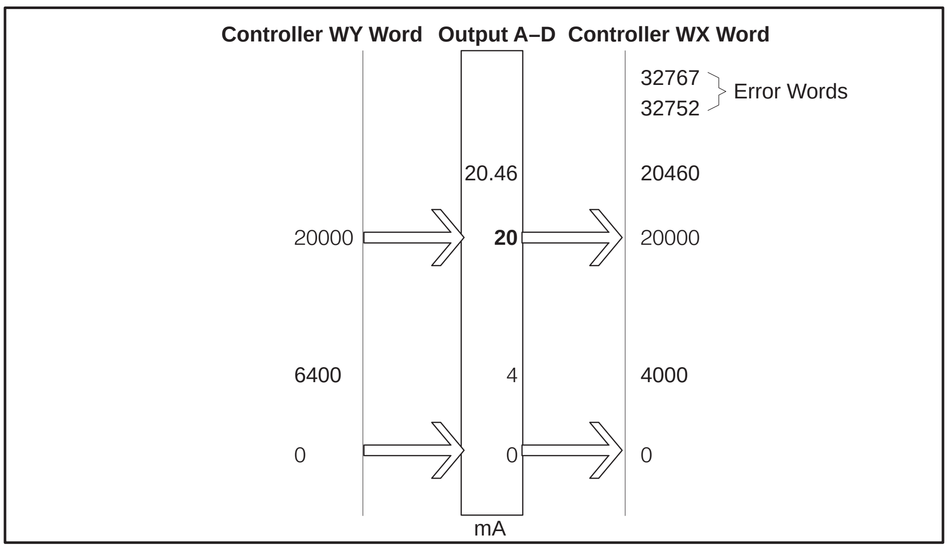


Figure 3-11 Scaling 20 mA Output to Engineering Units of 0 to 20,000

3.10 Compensating for Process Offsets

You can change the offset of the inputs and outputs to compensate for offsets in the process. For example, if a transducer sends 2 V when it is reading 0 pressure, and 6 V at full scale, use the **calibrate inputs** option to recalibrate the input to read zero when 2 V is input and to span to 32,000 when 6 V is applied. These adjustments do not affect ladder logic, scan time, or module response time.

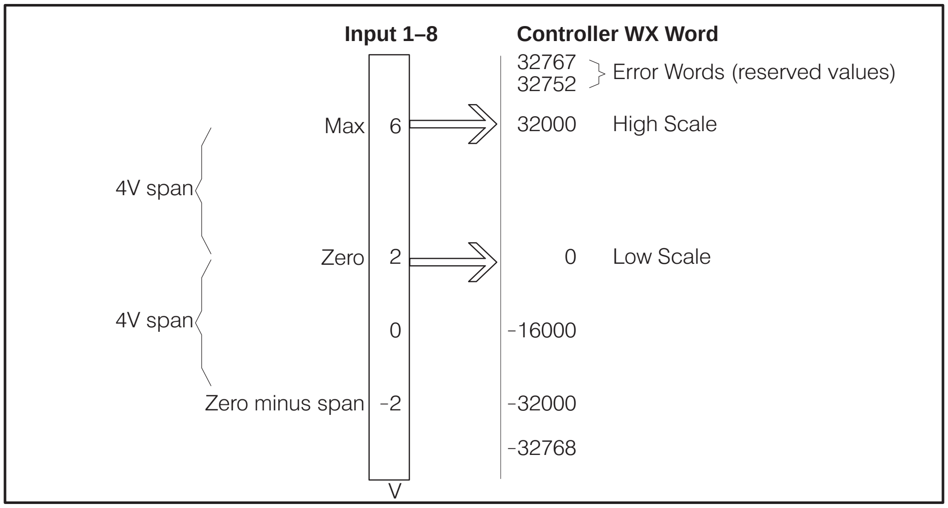


Figure 3-12 Changing Input Offsets

Similarly, if a valve actually is fully open at 19.5 mA and fully closed at 1.1 mA, use the **calibrate outputs** option to recalibrate the output to be 1.1 mA for a WY of zero and span to 19.5 mA for a WY of 32,000. These adjustments do not affect ladder logic, scan time, or module response time.

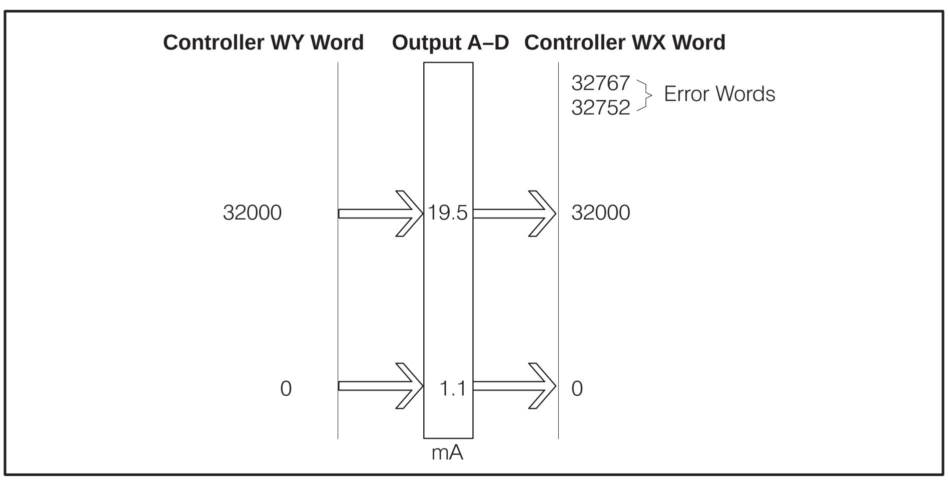


Figure 3-13 Changing Output Offsets

3.11 Adjusting Input Gain

Gain Range for PPX:505–7012

The 8IN/4OUT Analog Module autoranges to one of seven input ranges during calibration to give maximum resolution for your input signals.

Gain Range for PPX:505–7016

The 8IN/4OUT Bipolar Analog Module autoranges during calibration to give maximum resolution for your input signals.

For example, assume a sensor that provides 0 V at its zero position and 100 mV at the max position. Use the **calibrate inputs** option to read zero when 0 V is applied, and use **span** to read 32,000 when 100 mV is applied. The module does not simply expand the scaling mathematically in this case, but automatically adjusts the input gain to give a full 15 bits of resolution over the 100 mV input range. This also does not affect ladder logic, scan time, or module response time.

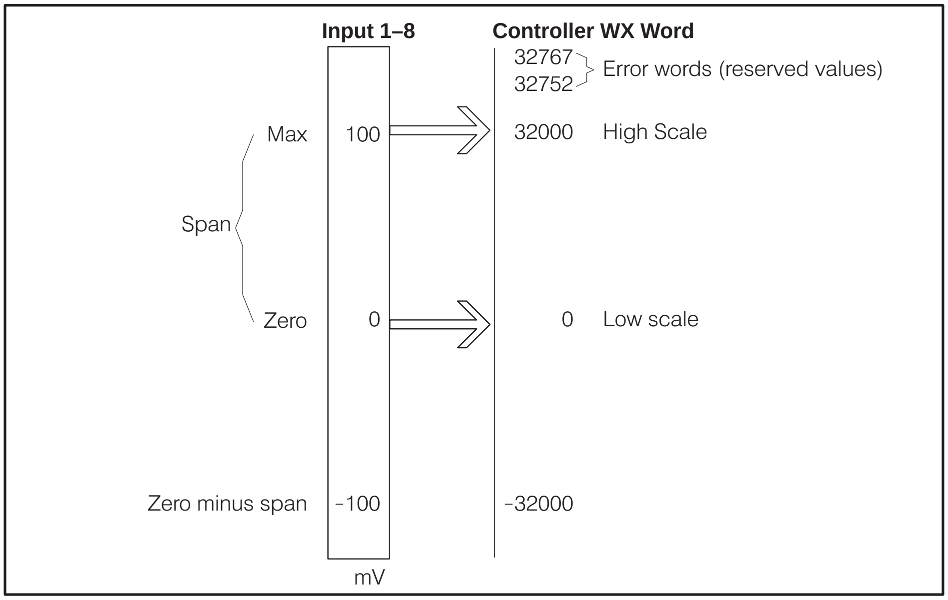


Figure 3-14 Setting Zero and Span to Adjust Input Gain

3.12 Calibration Worksheet to Photocopy and Fill Out

Point	Zero	Span	Scale Low	Scale High
1				
2				
3				
4				
5				
6				
7				
8				
A				
B				
C				
D				

Chapter 4

Programming and Assigning I/O Points

4.1 Programming the Controller

Refer to the *SIMATIC TI500/TI505 Programming Reference Manual* for specific details on designing a program.

WXs and WYs

Refer to Table 4-1 for the WX and WY mix.

Table 4-1 WXs and WYs

Configuration Density	Analog		I/O Words	Values
	Inputs	Outputs		
High (12 WX/4 WY)	8	4	WX 1–8 WX 9–12 WY 13–16	Input points 1–8 Echo of output values/error words Output points A–D
High (20 WX/4 WY) (505–7016 only)	8	4	WX 1–8 WX 9–16 WX 17–20 WY 21–24	Input Error words for each input Echo of output values/error words Outputs points A–D
Low (8 WX)	8	0	WX 1–8	Input points 1–8
Low (6 WX/12 WY) (505–7012 only)	6	2	WX 1–6 WY 7 & 8	Input points 1–6 Output points A & B
Low (4 WX/4 WY)	4	4	WX 1–4 WY 5–8	Input points 1–4 Output points A–D

NOTE: The Models TI525 and TI530C support only the 8/0 configuration.

Word Format

Words are signed, 16-bit numbers. Refer to Figure 4-1 for the word format.

	MSB														LSB
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
sign bit	Process value														

Figure 4-1 Word Format

4.2 Logging the Module into the Controller

Selecting the I/O Definition Chart

Figure 4-2 shows a sample TISOFT I/O definition chart with four modules installed; each is configured differently. Refer to your TISOFT manual for detailed instructions.

I/O MODULE DEFINITION FOR: CHANNEL . . . 1 BASE . . . 00						
	I/O	NUMBER OF BIT AND WORD I/O				SPECIAL
SLOT	ADDRESS	X	Y	WX	WY	FUNCTION
1	0001	00	00	12	04	NO
2	0017	00	00	08	00	NO
3	0025	00	00	06	02	NO
4	0033	00	00	04	04	NO
5	0041	00	00	20	04	NO
6	0000	00	00	00	00	NO
7	0000	00	00	00	00	NO
8	0000	00	00	00	00	NO

Figure 4-2 Sample I/O Definition Chart

Viewing the I/O Configuration Chart

Use SHOW or a similar TISOFT menu selection to display the I/O Configuration Chart. The configurations in Figure 4-2 appear as shown in Figure 4-3.

I/O CONFIGURATION CHART FOR CHANNEL . . . 1 BASE . . . . . 00 I/O POINTS								
	1	2	3	4	5	6	7	8
SLOT 1	WX0001	WX0002	WX0003	WX0004	WX0005	WX0006	WX0007	WX0008
	9	10	11	12	13	14	15	16
SLOT 1	WX0009	WX0010	WX0011	WX0012	WY0013	WY0014	WY0015	WY0016
	17	18	19	20	21	22	23	24
SLOT 2	WX0017	WX0018	WX0019	WX0020	WX0021	WX0022	WX0023	WX0024
	25	26	27	28	29	30	31	32
SLOT 3	WX0025	WX0026	WX0027	WX0028	WX0029	WX0030	WY0031	WY0032
	33	34	35	36	37	38	39	40
SLOT 4	WX0033	WX0034	WX0035	WX0036	WY0037	WY0038	WY0039	WY0040
	41	42	43	44	45	46	47	48
SLOT 5	WX0041	WX0042	WX0043	WX0044	WX0045	WX0046	WX0047	WX0048
	49	50	51	52	53	54	55	56
SLOT 5	WX0049	WX0050	WX0051	WX0052	WX0053	WX0054	WX0055	WX0056
	57	58	59	60	61	62	63	64
SLOT 5	WX0057	WX0058	WX0059	WX0060	WY0061	WY0062	WY0063	WT0064

Figure 4-3 I/O Configuration Chart

Chapter 5
Troubleshooting

5.1 Symptoms and Corrective Action

Table 5–1 describes some common symptoms, possible causes, and corrective action to take.

Table 5-1 Symptoms and Corrective Actions

Symptom	Possible Cause	Corrective Action
Incorrect readings	Connections incorrect	Trace wiring connections
	Scaling incorrect	Check scaling
	Signal wire noise	Use shielded wire and separate from power wiring
	Module not configured	Check I/O configuration
	Module incorrectly calibrated	Recalibrate the module
CPU nonfatal error on TISOFT screen	Module configured incorrectly	Reconfigure the module
	Module not seated in base	Install correctly and reconfigure
	Module failed	Return the module for repair

Table 5–2 gives LED combinations and describes the conditions they indicate.

Table 5-2 LED Combinations

MOD GOOD	COMM PORT	Condition
Off	Off	No base power or fatal error exists; fatal error condition must be corrected before recalibrating the module; user power fault detected
On	Off	Normal run condition
On	On	Module in calibration mode
Off	On	Fatal error has occurred, but the module can be recalibrated; module is in calibration mode.
On	Blinking	Module good but cable removed without transition to run mode; also might be a hardware problem with the cable
Off	Blinking	Fatal error has occurred, but module can be recalibrated; or cable has been removed during calibration in a module with a fatal error
Off	Slow double blink	User power supply fault detected
Off	Slow single blink	Module fault

5.2 Error Codes

Table 5–3 lists Error Codes in controller memory, and gives definitions.

Table 5-3 Error Codes in Controller Memory

Signed Integer	Hex Code	Definition
32767	7FFF	Module failed
32766	7FFE	Module in calibration mode
32765	7FFD	Error in calibration data stored in EEPROM
32764	7FFC	Communication port failure while in calibration mode
32763	7FFB	Module software failed
32762	7FFA	Boundary data error
32761	7FF9	Reserved for future use
32760	7FF8	Input filter error
32759	7FF7	Input overrange
32758	7FF6	Input underrange
32757	7FF5	Input failure
32756	7FF4	Input conversion overflow
32755	7FF3	Output overrange
32754	7FF2	Output underrange
32753	7FF1	Output power failed
32752	7FF0	Output data error
0	0000	Input error word (PPX:505-7016) 20 WX/4 WY mix Module input readings are functioning properly

5.3 Error Messages

Table 5–4 contains calibration error messages, explanations for each, and corrective action to take.

Table 5-4 Calibration Error Messages

Message	Explanation	Action
Input value too high. Reapply value.	Input signal value too large to convert.	Reduce the magnitude of the input signal.
Input value too low. Reapply value.	Input signal value of inverse magnitude too large to convert.	Reduce the magnitude of the inverse input signal.
Calibration data lost. Calibrate module.	Calibration data previously stored is no longer valid.	Recalibrate the module.
Low value must be less than hi value.	Attempted to set a low scaling value above the high value.	Set the low scaling value below the high scaling value.
Value out of range – Reenter.	Attempted to set a scaling parameter to a value outside the module operating range	Reenter parameter using value within operating range of the module. (–32000 ≤ value ≤ 32000)
Output failed. Consult user manual.	The output under consideration is reporting a failure.	Check the user power supply. Check for a module failure with switch 1 active.
Parameters not equal. Set A . . D only.	Tried to set all outputs to the same value and they were scaled differently.	Set the outputs individually.
Zero must not equal Span. Reapply.	The process zero value is the same as the span value.	Recalibrate zero and span values.
Expected Inverse Maximum Value. Reapply.	The inverse span value equals the span value.	Recalibrate inverse span value.
Inverted Max out of 5% range. Reapply.	Inverse span magnitude differs from span by more than 5%.	Recalibrate inverse span value.
Point not Available.	Point addressed is outside the user-configured range.	Address lower point or reconfigure module.

NOTE: For technical assistance, contact your Siemens Industrial Automation, Inc. distributor or sales office. If you need assistance in contacting your distributor or sales office in the United States, call 1–800–964–4114.

Appendix A
Applications

A.1 Loop/Temperature Control

Description

A simple loop control is needed for a cooker as shown in Figure A-1. The cooker has a temperature transducer that provides a 4 to 20 mA signal proportional to 0 to 500°. The temperature is controlled by a steam pressure valve operated by a 4 to 20 mA signal.

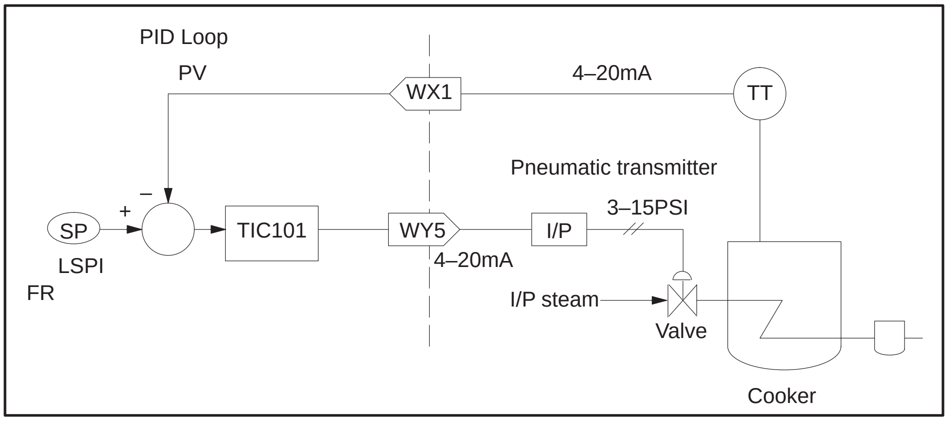


Figure A-1 Cooker Application

Solution

Use a simple, process variable (PV)-type PID loop in the TI545 to control the temperature. An 8IN/4OUT analog module can provide the analog interface with no changes to the factory settings.

Leave the temperature input with the factory calibration of ±20mA and connect the output to the current output terminals with the factory calibration of ±20 mA. Offsets are handled by the TI545 PID loop box with no recalibration required at the module.

Wire the module as shown in Figure A-2. Set the I/O configuration to 4 WX/4 WY. The PV for the loop is WX1 and the loop output is WY5.

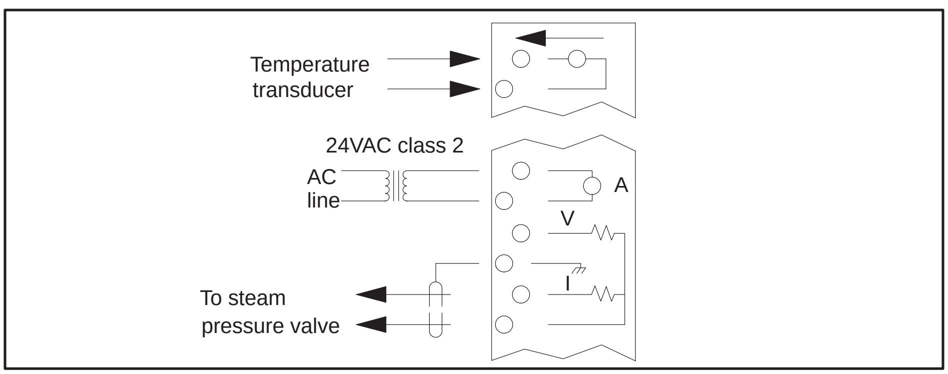


Figure A-2 Wiring Diagram

The PID loop settings shown in Figure A-3 are typical starting values for a process loop of this type. In particular, note the selection of 20% offset on PV and 20% offset on output. These settings cause the PID algorithm to treat 4 mA as the 0 process value. Also note the PV range settings of *low* = + 0.00000 and *high* = + 500.000. These settings scale the 4 to 20 mA output temperature to engineering units of temperature for the loop to work with.

PID LOOP 1 TITLE:	TIC101	REMOTE SETPOINT:	NONE
		CLAMP SP LIMITS: LOW =	+0.00000
POS/VEL PID ALGORITHM:	POS	HIGH=	+210.000
LOOP VFLAG ADDRESS:	C100		
SAMPLE RATE (SECS):	+1.00000	LOOP GAIN:	+1.00000
		RESET (INTEGRAL TIME):	+2.50000
PROCESS VARIABLE ADDRESS:	WX1	RATE (DERIVATIVE TIME):	+0.00000
PV RANGE: LOW =	+0.00000	FREEZE BIAS:	NO
HIGH =	+500.000		
		DERIVATIVE GAIN LIMITING:	NO
PV IS BIPOLAR:	NO	LIMITING COEFFICIENT:	+10.0000
SQUARE ROOT OF PV:	NO		
20% OFFSET ON PV:	YES	SPECIAL CALCULATION ON:	NONE
		SPECIAL FUNCTION:	NONE
LOOP OUTPUT ADDRESS:	WY5		
OUTPUT IS BIPOLAR:	NO	LOCK SETPOINT:	NO
20% OFFSET ON OUTPUT:	YES	LOCK AUTO/MANUAL:	NO
		LOCK CASCADE:	NO
RAMP/SOAK PROGRAMMED:	NO		
RAMP/SOAK FOR SP:	NO	ERROR OPERATION:	NONE
		REVERSE ACTING:	NO
ALARM DEADBAND:	+0.00000	MONITOR DEVIATION:	YES
		DEVIATION ALARM: YELLOW =	+5.00000
MONITOR LOW–LOW/HI–HI:	YES	ORANGE :	+12.0000
MONITOR LOW/HIGH:	YES		
PV ALARMS: LOW–LOW =	+55.0000	MONITOR RATE OF CHANGE:	YES
LOW =	155.000	RATE OF CHANGE ALARM:	+25.0000
HIGH =	+210.000		
HIGH–HIGH =	+212.000	MONITOR BROKEN XMITTER:	YES

Figure A-3 PID Loop Settings

A.2 Lead-Compensated Load Cell Application

Description

In this example, a load cell measures weight up to 10,000 pounds. The application requires long wires that normally cause a loss in the drive to the cell. This example provides a method for excitation voltage compensation. In addition, the example shows how to convert engineering units into pounds for a simpler operator interface. Following are the load cell specifications:

- 10 V excitation voltage
- 0 to 10,000 pounds load range
- 3 mV/V sensitivity

Solution

The module can supply excitation voltage for the load cell. By connecting one input with sense lines to the cell, you can use ladder logic to compensate for the excitation voltage variations. Use shielded wire to wire the load cell. Refer to Figure A-4. Note the shield connections; keep the ±30mV signal lines separate from excitation lines. As the excitation changes, the output value changes. Compensate for these changes in the readings with the following equation:

$$3mV/V \times \left(10V \times \left(\frac{expected\ excitation}{actual\ excitation}\right)\right) \Rightarrow weight$$

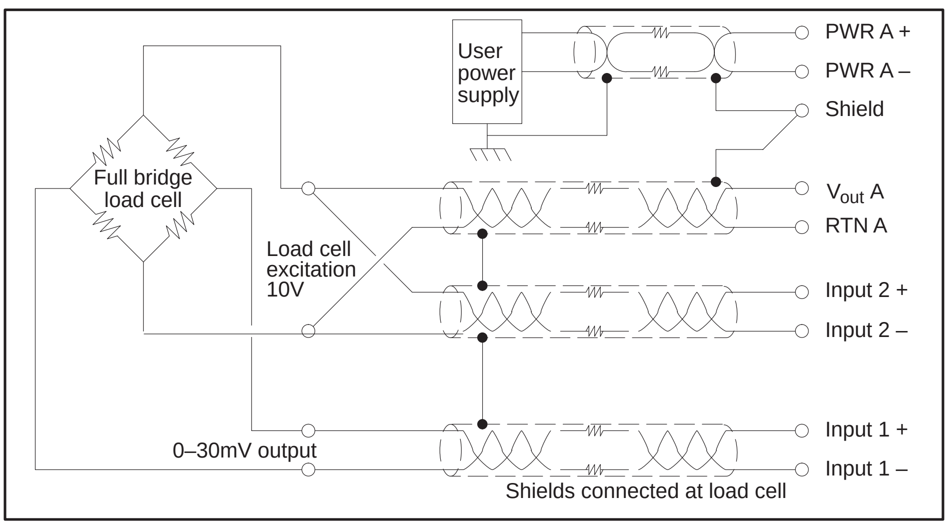


Figure A-4 Wiring the Load Cell

Input 2 of the module measures variations in the excitation voltage at the load cell.

Output A supplies the excitation voltage of 10 volts. Calibrate the output for +10 V at the load cell excitation terminals. When output calibration completes, the voltage output remains at its calibrated level, used to calibrate input 2.

Calibrate individual input 2 with the leads connected to the load cell excitation source terminals. Calibrate 0 by shorting out the terminals. Calibrate the span by removing the temporary short. Set the word high value to 10,000.

Calibrate individual input 1. Use load cell and range 0 and full-scale deflection or an external voltage source. Set controller word high to 10,000. The ladder logic shown in Figure A-5 maintains run-time compensation.

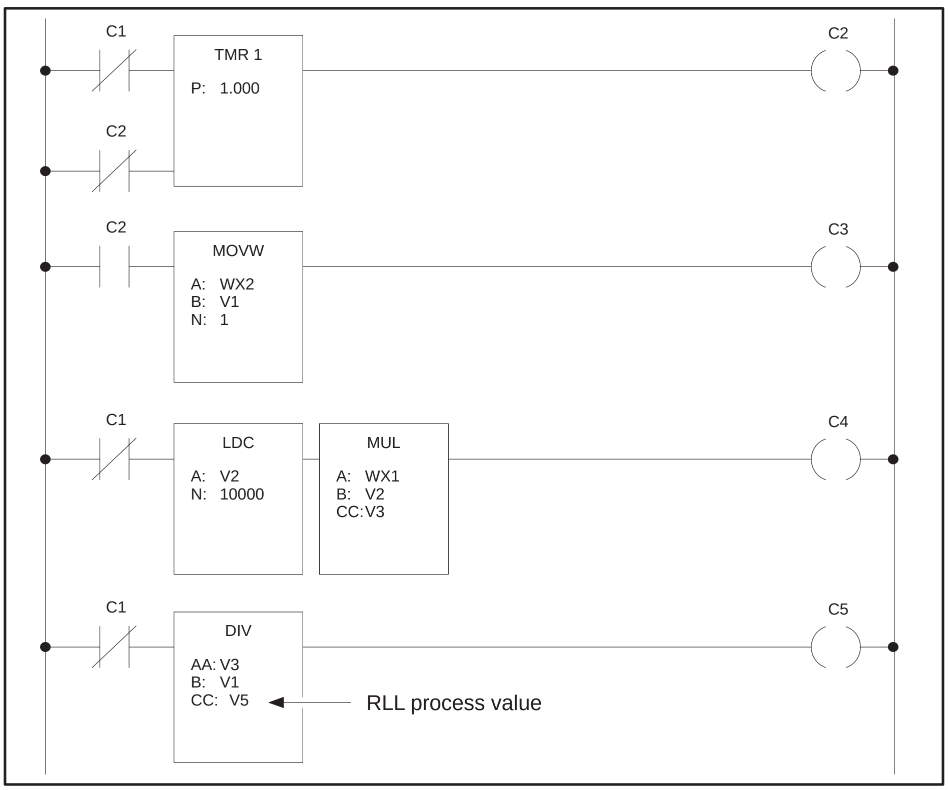


Figure A-5 Ladder Logic for Load Cell Example

A.3 Measuring Temperature with RTD Sensors

Resistance temperature detectors (RTDs) have an approximately linear relationship between their resistance and their temperature. For purposes of this application example, assume that across the range of temperatures being measured the relationship is linear. This means you can use an interpolation routine or a scaling routine to determine the temperature. The accuracy obtainable is dependent on:

- The range of temperature being measured; the narrower the range, the more accurate the measurement.
- The length of the RTD leads; the lead resistance is not a major consideration unless lead length is several hundred feet. A method is demonstrated below to cancel out this effect if required.

Set up the module as shown in Table A-1.

Table A-1 Module Setup

Inputs	Two channels jumper-selected for voltage and calibrated for zero = 0 V and span = 500 mV.
Outputs	Wired for current output; use factory calibration of ±20 mA.
Ladder logic	Set output for 1 mA: 32000 counts = 20 mA and 1600 counts = 1 mA
I/O mix	Mixed, according to your application; assume the first point is WX1 so the output channel is WY13.
Filtering	10 Hz

Two-wire RTD or Three-wire RTD Without Lead Resistance Compensation

The main advantage of this method is that you can read the temperature directly from the module as a scaled value. Whatever lead wire resistance exists is included in the value of the RTD resistance, and the reading is inaccurate to that extent.

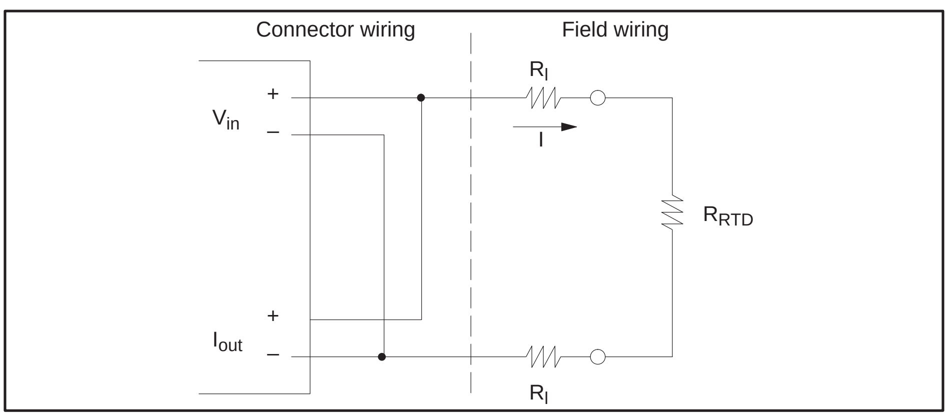


Figure A-6 Two-wire RTD

With the RTD measuring the minimum process value, use the terminal to set process zero. Change the temperature to the maximum process value and set process span.

NOTE: You must allow enough time for the process and the RTD to settle at each temperature. This method is dependent on solid, accurate minimum and maximum measurements.

Next, scale the high and low values to correspond to the measured minimum and maximum temperatures. If the minimum process value is 100°C, set the low span to 100. Assuming the corresponding maximum process value is 250°C, set the high span value to 250. The module now reports the interpolated temperature to the controller, assuming it is between the minimum and maximum values.

Four-wire RTD

A four-wire RTD is not affected by lead resistance and thus yields a more accurate result.

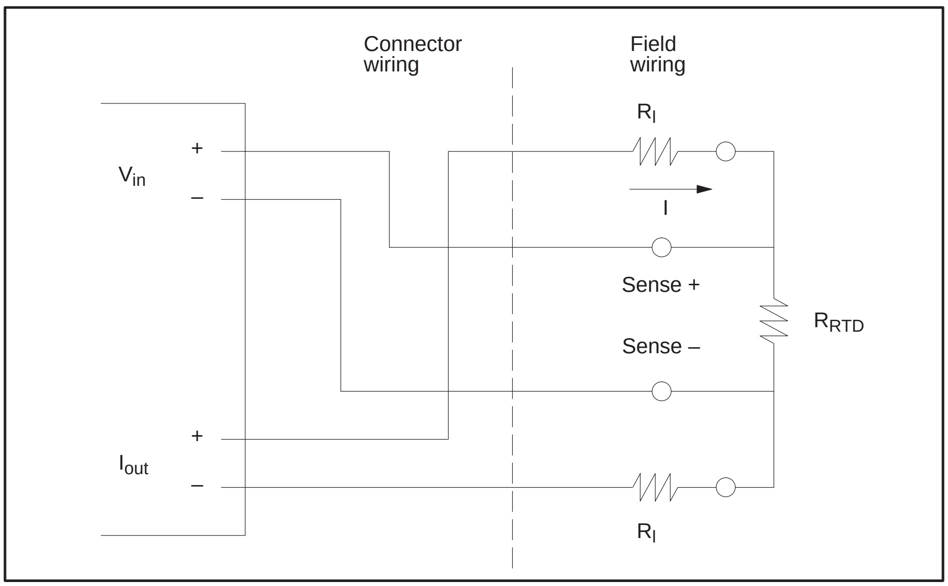


Figure A-7 Four-wire RTD

The configuration procedure is the same as for a two-wire RTD; only the wiring connections are changed. Since negligible current flows in the sense leads, the lead wire resistance is not a factor.

Three-wire RTD with Lead Resistance Compensation

Note the following assumptions for this example:

- All leads are the same length and same wire gauge so all lead resistances (R_l) are the same value.
- V_{in1} and V_{in2-} connections to I_{out} are made at the module, so error voltage is zero.
- $V_{in2}+$ connection is made to the sense lead of the RTD. Very little current flows through the sense lead, so the lead resistance on $V_{in2}+$ is negligible.

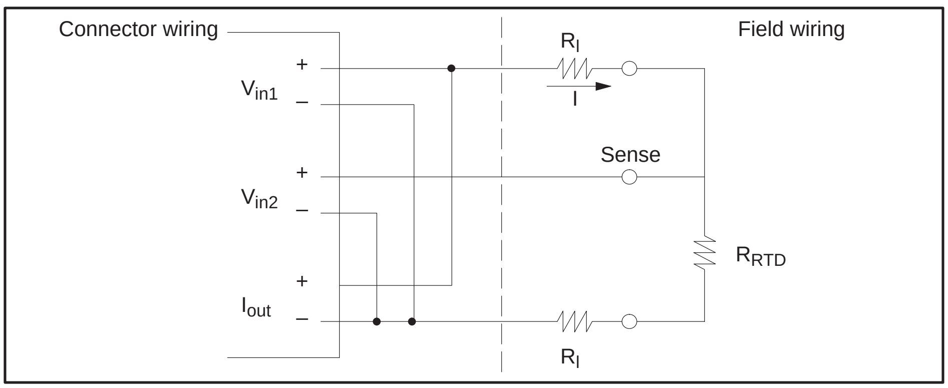


Figure A-8 Three-wire RTD

The following equations yield the RTD resistance:

$$V_{in1} = IR_l + IR_{RTD} + IR_l \qquad \text{(Equation A.1)}$$

$$V_{in2} = I_{RTD} + IR_l \qquad \text{(Equation A.2)}$$

Take $2 \times Equation\ A.2 - Equation\ A.1$

$2V_{in2} - V_{in1} = 2IR_{RTD} + 2IR_l - IR_l - IR_{RTD} - IR_l = IR_{RTD}$
so that $R_{RTD} = (2V_{in2} - V_{in1})/I$

Comparing this to known temperature/resistance measurement points yields the unknown temperature shown in Figure A-9.

$$\begin{array}{ccc} RTD_{ref1} & \leftrightarrow & T_{ref1} \\ \updownarrow & & \updownarrow \\ RTD_{meas} & \leftrightarrow & Temp \\ \updownarrow & & \updownarrow \\ RTD_{ref2} & \leftrightarrow & T_{ref2} \end{array}$$

Figure A-9 Unknown Temperature

The reference points must be the pre-measured minimum and maximum points of the process being measured or specified by the RTD manufacturer to a known accuracy. Interpolate to find Temp:

$$\frac{R_{RTD_{meas}} - R_{RTD_{ref2}}}{R_{RTD_{ref1}} - R_{RTD_{ref2}}} = \frac{Temp - T_{ref2}}{T_{ref1} - T_{ref2}}$$

The reference terms can be computed and stored as constants so that the equation becomes:

$$Temp = \frac{(R_{RTD_{meas}} - R_{RTD_{ref2}}) \times K_T}{K_{RTD}} + T_{ref2}$$

Where $KT = T_{ref1} - T_{ref2}$ and $K_{RTD} = RTD_1 - RTD_2$.

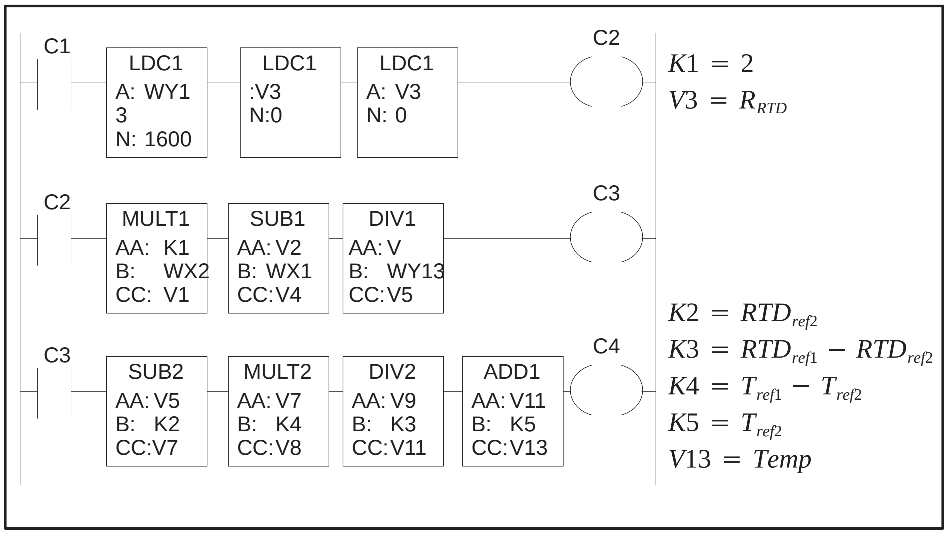


Figure A-10 Ladder Logic for Three-wire RTD

```
00001  IMATHWY13 := 1600
00002  IMATHV3 := 0
00003  IMATHV9 := 0
00004  IMATHV2 :=K ♦ WX2
00005  IMATHV4 :=V2 – WX1
00006  IMATHV5 := V3 / WY13
00007  IMATHV7 := V5 = K2
00008  IMATHV8 := V7 ♦ K4
00009  IMATHV11 := V9 / K3
0010   IMATHV13 := V11 + K5
```

Figure A-11 Special Function Program for Three-wire RTD

Eight RTDs on One Module

You can connect eight RTDs to the module, but only in the two-wire or four-wire configuration. Use one current output to stimulate multiple RTDs.

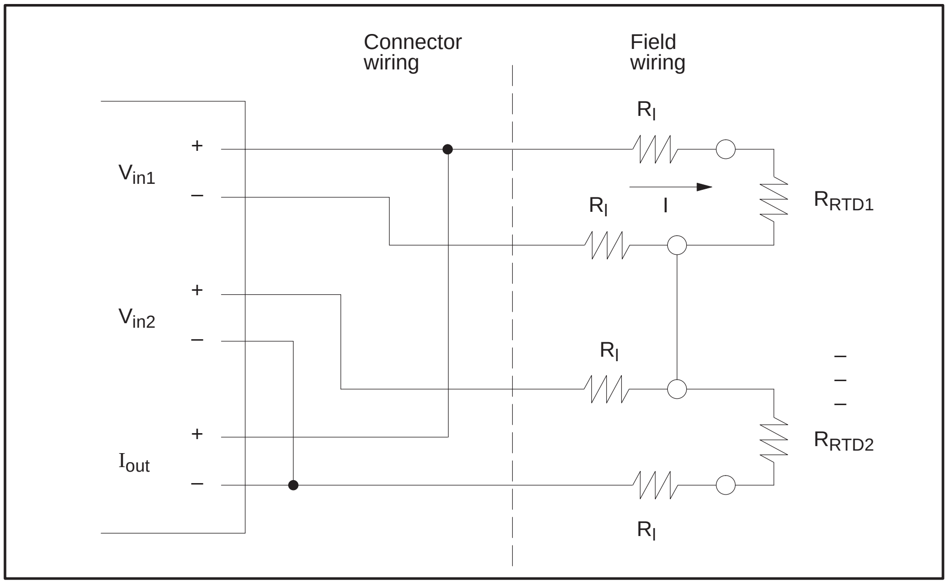


Figure A-12 Eight RTDs on One Module

Appendix B

Specifications

B.1 PPX:505–7012 Typical Input Values, After User Calibration: 60 Hz Filter, 25° C

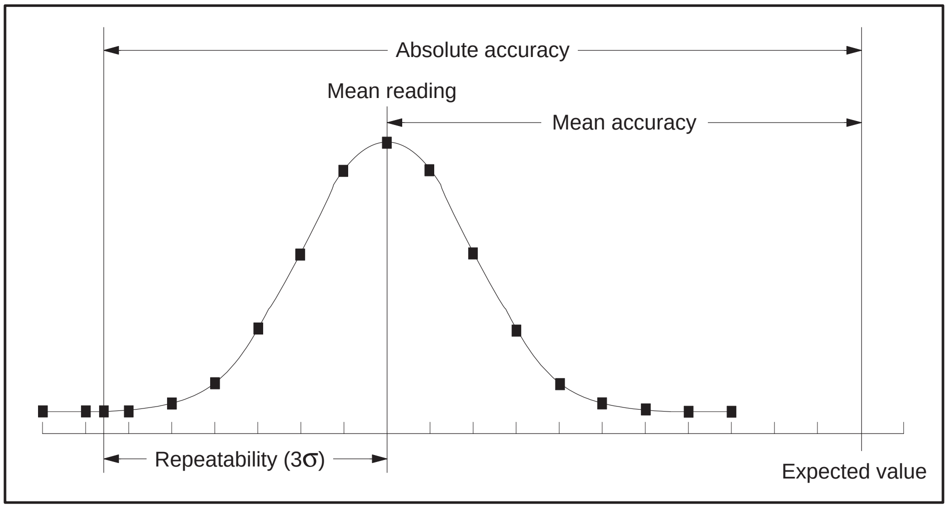


Figure B-1 Distribution of Readings

Mean Accuracy Average deviation from the expected value on a given point. The normal distribution is constructed of discrete step sizes. The mean accuracy and the three σ points are the result of statistical calculations.

Repeatability Three standard deviations from the mean reading (3σ) on a given channel. This is a measurement of the noise in the module.

Absolute Accuracy Sum of mean accuracy and repeatability; e.g., a mean accuracy of 15 counts plus a repeatability of 5 counts yields an absolute accuracy of 20 counts.

Resolution The amount of change in the input needed to cause a one-count change in the output.

Range	Absolute Accuracy	Repeatability	Drift	Full-scale Drift	Calculated Worst-case Percent of Full-scale
±10 V	0.03%	0.02%	25ppm/°C	0.15%	0.3%
±5 V/20 mA*	0.03%	0.02%	25ppm/°C	0.15%	0.3%
±2 V	0.03%	0.02%	25ppm/°C	0.15%	0.3%
±1 V	0.03%	0.02%	25ppm/°C	0.15%	0.3%
±500 mV	0.03%	0.02%	25ppm/°C	0.15%	0.3%
±100 mV	0.08%	0.04%	100ppm/°C	0.60%	1.0%
±50 mV	0.10%	0.08%	200ppm/°C	1.20%	3.0%

* Factory calibration ±0.2%

B.2 Physical and Environmental Specifications

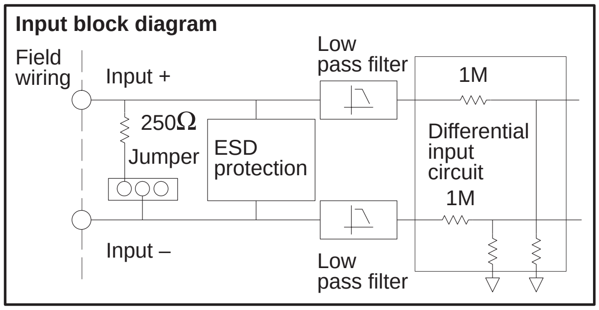
Table B-1 Physical and Environmental Specifications for Both Models

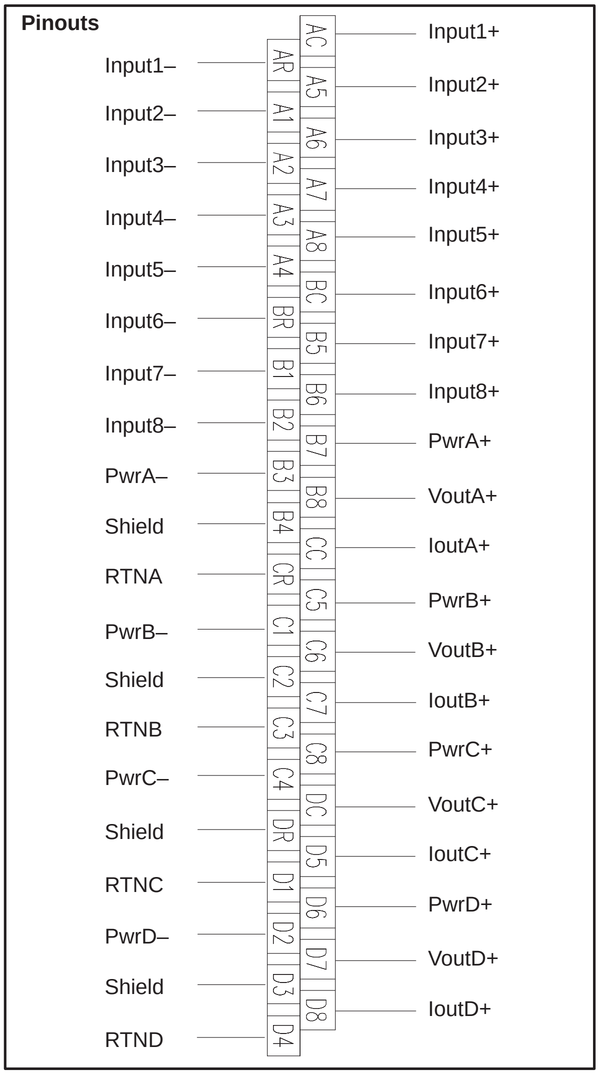
Minimum torque for bezel screws	2.6 in-lb (0.3 N-m)
Maximum torque for bezel screws	4.12 in-lb (0.6 N-m)
Weight and dimensions of packed module	2 pounds 15 ounces; 12.75″ × 13.5″ × 3.75″
Weight and dimensions of unpacked module	1 pound 8 ounces; 10.5″ × 8″ × 0.8
Input signal wiring	Shielded, twisted-pair cable (12–26 AWG or 0.16–3.2 mm^2, either stranded or solid-type)
Spade lug for use with connector 2587705–8002	Amp part number 321462
Ring lug for use with connector 2587705–8002	Amp part number 327891
Module power required from base	3.0 W of +5 V and 30 mW of –5 V
Operating temperature	0 to 60° C (32 to 140° F)
Storage temperature	–40 to +70° C (–40 to 158° F)
Relative humidity	5% to 95% noncondensing
Pollution degree	2, IEC 664, 664A
Vibration	Sinusoidal IEC 68-2-6, Test Fc 0.15mm peak-to-peak, 10–57Hz; 1.0g, 57–150Hz Random IEC 68-2-34, Test Fdc, equivalent to NAVMAT P–9492 0.04 g^2/ Hz, 80–350 Hz
Electrostatic discharge	IEC 801, Part 2, Level 4, (15 kV)*
Shock	IEC 68-2-27; Test Ea
Noise immunity, conducted	IEC 801, Part 4, Level 3
Noise immunity on user power lines	MIL STD 461B CS01, CS02, and CS06 per part 4, IEC 255-4, Appendix E*; IEEE 472, 2.5 kV; EEC 4517
Noise immunity, radiated	IEC 801, Part 3, Level 3, MIL STD 461B RS01, &RS02
Isolation, 505–7012	1500 V rms, input-to-controller, input-to-output, and output-to-output; >1 MΩ input-to-input
Isolation, 505–7016	1500 V rms, input-to-controller
Corrosion protection	All parts of corrosion-resistant material or plated or painted as corrosion protection

NOTE: On the Analog Module, all immunity tests were performed with the filter set to 300 Hz. All inputs exhibit less than 5% of full-scale in the presence of the specified noise except those marked with an asterisk (*). There may be variations of up to 50% of full-scale in the presence of noise of the type marked.

On the Bipolar Analog Module, no filter selected.

B.3 PPX:505–7012 Input Specifications



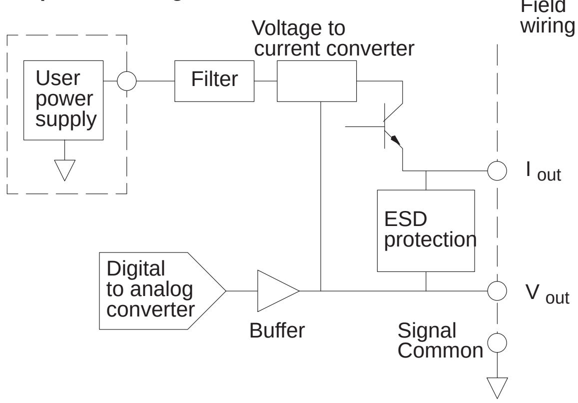


Item	Description
Input points	8 differential bipolar analog points
Input signal	Current or voltage 250 Ω 0.5 W internal resistor for current input
User power*	None required; but loop power is not supplied by the module
Isolation	1500 V rms inputs-to-controller, inputs-to-outputs >1 MΩ inputs-to-inputs
Input impedance	>1 MΩ
Accuracy, overall	≤0.1% of full-scale typical <0.3% of full-scale over full operating temperature range
Resolution	15 bits over selected span, plus sign
Repeatability	200 ppm (0.02%) at calibrated temperature
Overcurrent protection	0.5 W resistor allows continuous 32 mA on a single point
Update time	20 ms per input at 60 and 300 Hz 24 ms per input at 10 and 50 Hz
Common-mode rejection voltage	100 V rms with <0.1% additional inaccuracy
Common-mode rejection ratio	>80 dB
Normal-mode rejection ratio	>40 dB at 60 Hz
Selectable filtering	10, 50, 60, or 300 Hz
Hardware filtering	1 Hz low-pass
Overvoltage withstand	200 V peak, differential or common-mode
Out-of-range inputs	Reported as error words
Calibration	ASCII terminal Analog 0 compensation Autoranging span selection during calibration: 50 mV, 100 mV, 500 mV, 1 V, 2 V, 5 V, 10 V
Scaling	Data can be scaled to engineering units

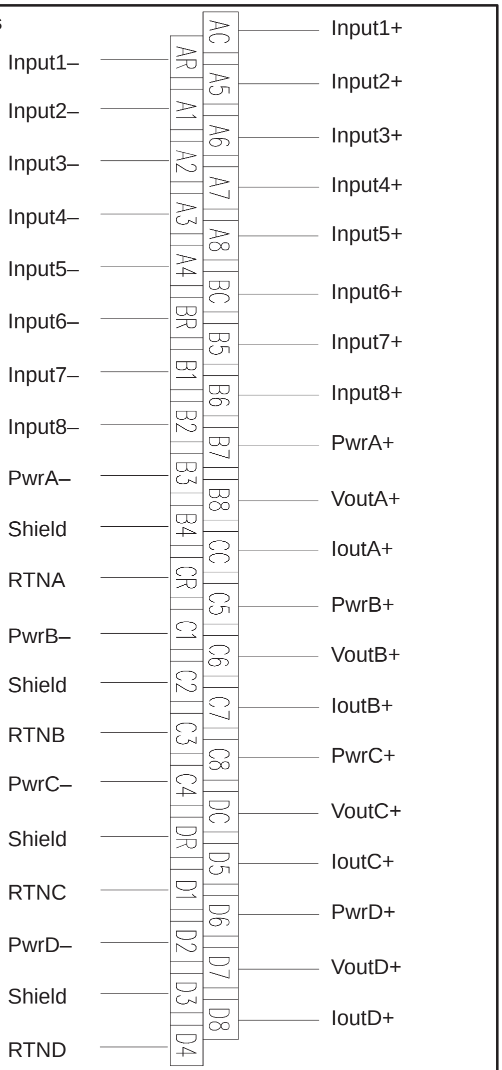
*Power to operate the input circuitry is provided by the module from the base power supply. Power to operate transmitters or other sensor input devices must be provided by the user.

B.4 PPX:505–7012 Output Specifications

Output block diagram



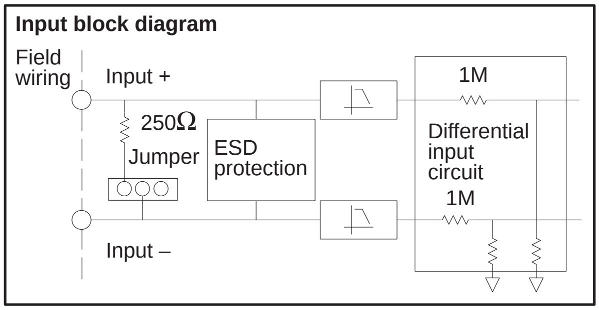
Pinouts

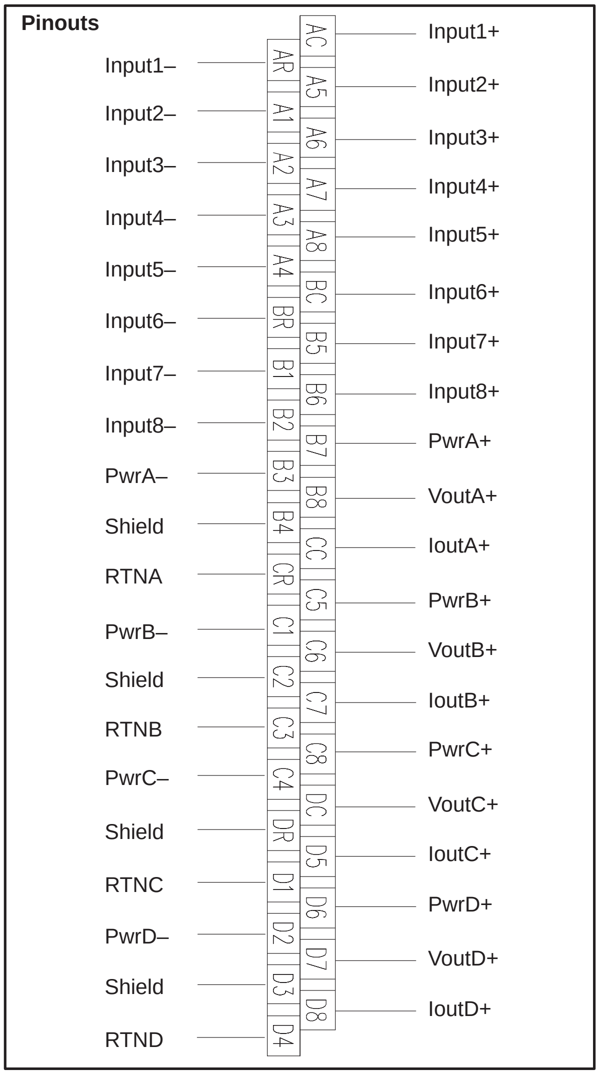


Output points	Four differential, unipolar analog outputs
Output signal	Current (0–20 mA) and voltage (0–10 V), both available on separate terminals with a common return
Output loads	Volt > 5 kΩ Current <600 Ω* Capacitance <0.1 μF
Compliance voltage	User supply – $(9\ V)_{msx}$
Accuracy	≤0.1% of full-scale typical <0.25% of full-scale over full operating temperature range
Isolation	Fully isolated when each has separate isolated power supply 1500 V rms output-to-output, output-to-controller, output-to-inputs
Resolution	12-bit
Overvoltage withstand	Driving open and shorted conditions, on either or both output types per point
Output value on failure	Selectable to 0 V/mA or last value
Scale	Data can be scaled to engineering units
Update time	All outputs updated <24 ms
Output or error word	Read back in high-density configuration
User power requirement, per point	Class 2, 24 VAC rms or 24 VDC, nominal; ±10% 125 mA plus output load current

*Current up to 600 Ω with a 24 V nominal power supply. For increased load drive: increase the power supply voltage (up to 40 V), such that $V_{power\ supply}$, = $(R_{load}) \times (20\ mA) + (9\ V)$.

B.5 PPX:505–7016 Input Specifications



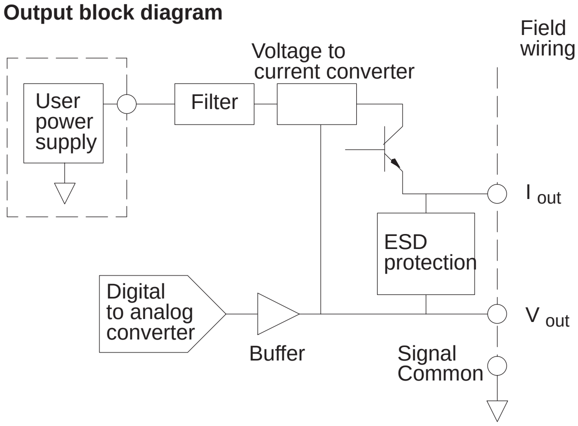


Item	Description
Input points	8 differential bipolar analog points
Input signal	Current or voltage 250 Ω 0.5 W internal resistor for current input
User power*	None required but loop power is not supplied by the module
Isolation	1500 V rms inputs-to-controller, >1 MΩ inputs-to-inputs
Input impedance	>1 MΩ
Accuracy, overall	≤0.1% of full-scale typical <0.3% of full-scale over full operating temperature range
Resolution	13 bits over selected span, plus sign
Repeatability	400ppm (0.04%) at calibrated temperature
Overcurrent protection	0.5 W resistor allows continuous 32mA on a single point
Update time	3.124 msec/4 inputs
Common-mode rejection voltage	100 V
Common-mode rejection ratio	>80 dB
Normal-mode rejection ratio	>32 dB
Selectable filtering	Software digital filter, on/off
Hardware filtering	7.2 kHz
Overvoltage withstand	200 V peak, differential or common-mode
Out-of-range inputs	Reported as error words
Calibration	ASCII terminal Analog 0 compensation Autoranging span selection during calibration
Scaling	Data can be scaled to engineering units

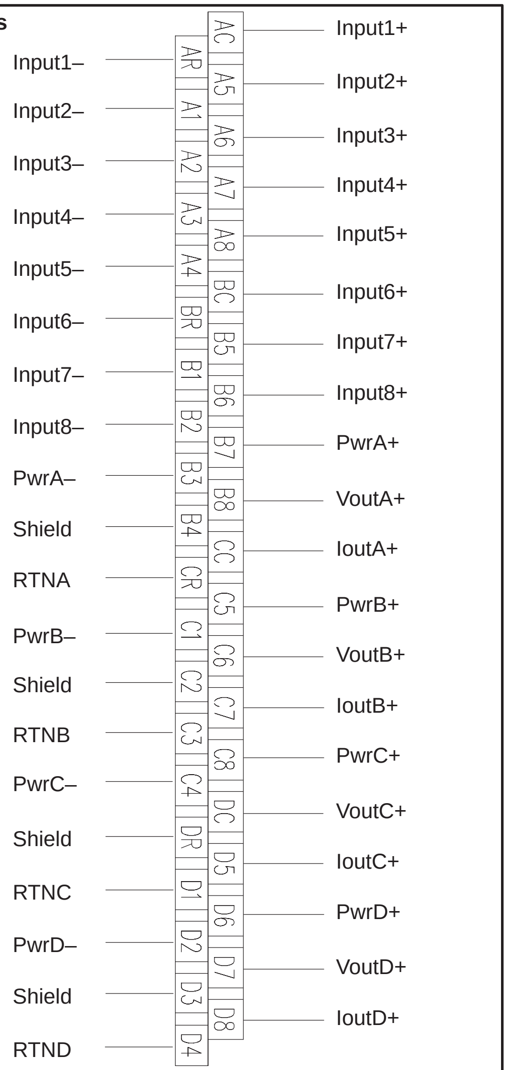
*Power to operate the input circuitry is provided by the module from the base power supply. Power to operate transmitters or other sensor input devices must be provided by the user.

B.6 PPX:505–7016 Output Specifications

Output block diagram



Pinouts



Output points	Four analog outputs, bipolar voltage, unipolar current
Output signal	Current (20 mA) and voltage 〈±10/±5) both available on separate terminals with a common return
Output loads	Volt > 5 kΩ Current <600 Ω* Capacitance <0.1 μF
Compliance voltage	User supply – (9 V)$_{msx}$
Accuracy	≤0.1% of full-scale typical <0.25% of full-scale over full operating temperature range
Isolation	1500 V rms output-to-controller,
Resolution	12-bit + sign
Output withstand	Driving open and shorted conditions, on either or both output types per point
Output value on failure	Selectable to 0 V/mA or last value
Scale	Data can be scaled to engineering units
Update time	3.124 mSec/.4 outputs
Output or error word	Read back in high-density configuration
User power requirement, per point	Class 2, 24 VAC rms or 24 VDC, nominal; ±10% 125 mA plus output load current (User power not required for voltage applications)
*Current up to 600 Ω with a 24 V nominal power supply. For increased load drive: increase the power supply voltage (up to 40 V), such that $V_{power\ supply}$, = (R_{load}) × (20 mA) + (9 V).	

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