User Manual

Allen-Bradley

Compact I/O RTD/Resistance Input Module

Catalog Number 1769-IR6

Allen-Bradley • Rockwell Software

Rockwell Automation

Important User Information

Solid-state equipment has operational characteristics differing from those of electromechanical equipment. Safety Guidelines for the Application, Installation and Maintenance of Solid State Controls (publication SGI-1.1 available from your local Rockwell Automation® sales office or online at http://www.rockwellautomation.com/literature/) describes some important differences between solid-state equipment and hard-wired electromechanical devices. Because of this difference, and also because of the wide variety of uses for solid-state equipment, all persons responsible for applying this equipment must satisfy themselves that each intended application of this equipment is acceptable.

In no event will Rockwell Automation, Inc. be responsible or liable for indirect or consequential damages resulting from the use or application of this equipment.

The examples and diagrams in this manual are included solely for illustrative purposes. Because of the many variables and requirements associated with any particular installation, Rockwell Automation, Inc. cannot assume responsibility or liability for actual use based on the examples and diagrams.

No patent liability is assumed by Rockwell Automation, Inc. with respect to use of information, circuits, equipment, or software described in this manual.

Throughout this manual, when necessary, we use notes to make you aware of safety considerations.

WARNING: Identifies information about practices or circumstances that can cause an explosion in a hazardous environment, which may lead to personal injury or death, property damage, or economic loss.

ATTENTION: Identifies information about practices or circumstances that can lead to personal injury or death, property damage, or economic loss. Attentions help you identify a hazard, avoid a hazard, and recognize the consequence.

SHOCK HAZARD: Labels may be on or inside the equipment, for example, a drive or motor, to alert people that dangerous voltage may be present.

BURN HAZARD: Labels may be on or inside the equipment, for example, a drive or motor, to alert people that surfaces may reach dangerous temperatures.

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

This manual contains new and updated information. Changes throughout this revision are marked by change bars, as shown to the right of this paragraph.

New and Updated Information

This table contains the changes made to this revision.

Topic	Page
Updated RTD accuracy and temperature drift values	14
Updated module accuracy values	79

Notes:

Chapter 4

Module Data, Status, and Channel Configuration

Chapter 5

Diagnostics and Troubleshooting

Appendix A

Module Addressing and Programming with MicroLogix 1500 and RSLogix 500

Appendix B

Configuring the 1769-IR6 RTD Module with the Generic Profile

Appendix C

Configuring the 1769-IR6 Module in a Remote DeviceNet System with a 1769-ADN DeviceNet Adapter

Appendix D

Two’s Complement Binary Numbers

Notes:

Read this preface to familiarize yourself with the rest of the manual.

Who Should Use This Manual

Use this manual if you are responsible for designing, installing, programming, or troubleshooting control systems that use Allen-Bradley Compact™ I/O and/or compatible controllers, such as MicroLogix 1500 or CompactLogix.

How to Use This Manual

As much as possible, we organized this manual to explain, in a task-by-task manner, how to install, configure, program, operate and troubleshoot a control system using the 1769-IR6.

Conventions Used in This Manual

The following conventions are used throughout this manual:

- Bulleted lists (like this one) provide information not procedural steps.
- Numbered lists provide sequential steps or hierarchical information.
- *Italic* type is used for emphasis.
- Text in this font indicates words or phrases you should type.

Additional Resources

These documents contain additional information concerning related products from Rockwell Automation.

Resource	Description
1769 Compact I/O Modules Specifications Technical Data, publication 1769-TD006	Specifications of all 1769 Compact I/O modules
Industrial Automation Wiring and Grounding Guidelines, publication 1770-4.1	Provides general guidelines for installing a Rockwell Automation industrial system.
Product Certifications website, http://www.ab.com	Provides declarations of conformity, certificates, and other certification details.

You can view or download publications at http:/www.rockwellautomation.com/literature/. To order paper copies of technical documentation, contact your local Allen-Bradley distributor or Rockwell Automation sales representative.

Notes:

Overview

This chapter describes the six-channel 1769-IR6 RTD/resistance Input module and explains how the controller reads resistance temperature detector (RTD) or direct resistance-initiated analog input data from the module. Included is:

- a general description of hardware features
- an overview of module and system operation
- compatibility

General Description

The 1769-IR6 module supports RTD and direct resistance signal measurement applications that require up to six channels. The module digitally converts analog data and then stores the converted data in its image table.

The module supports connections from any combination of up to six input devices. Each channel is individually configurable via software for 2- or 3-wire RTD or direct resistance input devices. Channels are compatible with 4-wire sensors, but the fourth sense wire is not used. Two programmable excitation current values (0.5mA and 1.0mA) are provided, to limit RTD self-heating. When configured for RTD inputs, the module can convert the RTD readings into linearized digital temperature readings in °C or °F. When configured for resistance analog inputs, the module can convert voltages into linearized resistance values in ohms. The module assumes that the direct resistance input signal is linear prior to input to the module.

Each channel provides open-circuit (all wires), short-circuit (excitation and return wires only), and over- and under-range detection and indication.

IMPORTANT	The module accepts input from RTDs with up to 3 wires. If your application requires a 4-wire RTD, one of the two lead compensation wires is not used, and the RTD is treated like a 3-wire sensor. The third wire provides lead wire compensation. See Chapter 3, *Installation and Wiring*, for more information.

The following data formats are supported by the module.:

- raw/proportional
- engineering units x 1
- engineering units x 10
- scaled-for-PID
- percent full scale

Available filter frequencies are:

- 10 Hz
- 50 Hz
- 60 Hz
- 250 Hz
- 500 Hz
- 1 kHz

The module uses eight input words for data and status bits and seven configuration words. Module configuration is stored in the controller memory. Normally configuration is done via the controller's programming software. In addition, some controllers support configuration via the user program. Refer to your controller manual for additional information. See Chapter 4, *Module Data, Status, and Channel Configuration*, for details on module configuration.

RTD Compatibility

An RTD consists of a temperature-sensing element connected by two, three, or four wires that provide input to the module. The following table lists the RTD types that you can use with the module, including their temperature range, effective resolution, and repeatability for both excitation currents, 0.5 and 1.0 mA.

Table 1 - RTD Specifications

RTD Type[1]		Temperature Range Using 0.5 mA Excitation	Temperature Range Using 1.0 mA Excitation	Maximum Scaled Resolution	Maximum Scaled Repeatability
Copper 426	10 Ω	Not allowed	-100…260 °C (-148…500 °F)	0.1 °C (0.1 °F)	±0.2 °C (±0.4 °F)
Nickel 618[2]	120 Ω	-100…260 °C (-148…500 °F)	-100…260 °C (-148…500 °F)	0.1 °C (0.1 °F)	±0.1 °C (±0.2 °F)
Nickel 672	120 Ω	-80…260 °C (-112…500 °F)	-80…260 °C (-112…500 °F)	0.1 °C (0.1 °F)	±0.1 °C (±0.2 °F)
Nickel-Iron 518	604 Ω	-200…180 °C (-328…338 °F)	-100…200 °C (-148…392 °F)	0.1 °C (0.1 °F)	±0.1 °C (±0.2 °F)
Platinum 385	100 Ω	-200…850 °C (-328…1562 °F)	-200…850 °C (-328…1562 °F)	0.1 °C (0.1 °F)	±0.2 °C (±0.4 °F)
	200 Ω	-200…850 °C (-328…1562 °F)	-200…850 °C (-328…1562 °F)	0.1 °C (0.1 °F)	±0.2 °C (±0.4 °F)
	500 Ω	-200…850 °C (-328…1562 °F)	-200…850 °C (-328…1562 °F)	0.1 °C (0.1 °F)	±0.2 °C (±0.4 °F)
	1000 Ω	-200…850 °C (-328…1562 °F)	Not Allowed	0.1 °C (0.1 °F)	±0.2 °C (±0.4 °F)
Platinum 3916	100 Ω	-200C…630 °C (-328…1166 °F)	-200…630 °C (-328…1166 °F)	0.1 °C (0.1 °F)	±0.2 °C (±0.4 °F)
	200 Ω	-200…630 °C (-328…1166 °F)	-200…630 °C (-328…1166 °F)	0.1 °C (0.1 °F)	±0.2 °C (±0.4 °F)
	500 Ω	-200…630 °C (-328…1166 °F)	-200…630 °C (-328…1166 °F)	0.1 °C (0.1 °F)	±0.2 °C (±0.4 °F)
	1000 Ω	-200…630 °C (-328…1166 °F)	Not Allowed	0.1 °C (0.1 °F)	±0.2 °C (±0.4 °F)

(1) Digits following the RTD type represent the temperature coefficient of resistance (α), which is defined as the resistance change per ohm per °C. For instance, platinum 385 refers to a platinum RTD with α = 0.00385 ohm/ohm - °C, or simply 0.00385/°C.

(2) Actual value at 0 °C is 100 Ω per DIN standard.

The table below provide specifications for RTD accuracy and temperature drift. The ratings apply when a 50/60 Hz filter is used.

Table 2 - RTD Accuracy and Temperature Drift

RTD Type		Maximum Scaled Accuracy (25 °C with Calibration)	Maximum Scaled Accuracy (0…60 °C with Calibration)	Maximum Temperature Drift (from 25 °C without Calibration)
Copper 426	10 Ω	±0.8 °C (1.44 °F)	±1.1 °C (1.98 °F)	±0.032 °C/°C (0.032 °F/°F)
Nickel 618	120 Ω	±0.3 °C (±0.54 °F)	±0.5 °C (±0.9 °F)	±0.012 °C/°C (±0.012 °F/°F)
Nickel 672	120 Ω	±0.3 °C (±0.54 °F)	±0.5 °C (±0.9 °F)	±0.012 °C/°C (±0.012 °F/°F)
Nickel-Iron 518	604 Ω	±0.3 °C (±0.54 °F)	±0.5 °C (±0.9 °F)	±0.015 °C/°C (±0.015 °F/°F)
Platinum 385	100 Ω	±0.5 °C (±0.9 °F)	±0.9 °C (±1.62 °F)	±0.026 °C/°C (±0.026 °F/°F)
	200 Ω	±0.5 °C (±0.9 °F)	±0.9 °C (±1.62 °F)	±0.026 °C/°C (±0.026 °F/°F)
	500 Ω	±0.5 °C (±0.9 °F)	±0.9 °C (±1.62 °F)	±0.026 °C/°C (±0.026 °F/°F)
	1000 Ω	±0.5 °C (±0.9 °F)	±0.9 °C (±1.62 °F)	±0.026 °C/°C (±0.026 °F/°F)
Platinum 3916	100 Ω	±0.4 °C (±0.72 °F)	±0.8 °C (±1.44 °F)	±0.023 °C/°C (±0.023 °F/°F)
	200 Ω	±0.4 °C (±0.72 °F)	±0.8 °C (±1.44 °F)	±0.023 °C/°C (±0.023 °F/°F)
	500 Ω	±0.4 °C (±0.72 °F)	±0.8 °C (±1.44 °F)	±0.023 °C/°C (±0.023 °F/°F)
	1000 Ω	±0.4 °C (±0.72 °F)	±0.8 °C (±1.44 °F)	±0.023 °C/°C (±0.023 °F/°F)

IMPORTANT

When you are using any platinum (385) RTDs with 0.5 mA excitation current, the module’s accuracy is:

- ±0.5 °C (0.9 °F) after you apply power to the module or perform an autocalibration at 25 °C (77 °F) ambient, with module operating temperature at 25 °C (77 °F).
- ±[0.5 °C (0.9 °F) + DT ± 0.026 deg./°C (±0.026 deg./°F)] after you apply power to the module or perform an autocalibration at 25 °C (77 °F) ambient, with module operating temperature between 0…60 °C (140 °F). DT is the temperature difference between the actual module operating temperature and 25°C (77 °F). The value 0.026 deg./°C (±0.026 deg./°F) is the temperature drift shown in the table above.
- ±0.9 °C after you apply power to the module or perform an autocalibration at 60 °C (140 °F) ambient, with module operating temperature at 60 °C (140 °F).

Resistance Device Compatibility

The following table lists the specifications for the resistance devices that you can use with the module.

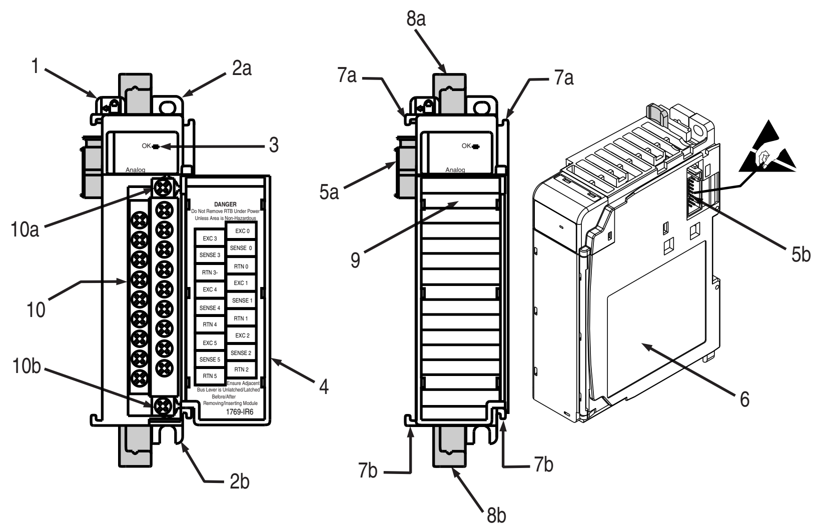
Table 3 - Resistance Device Specifications

Resistance Device Type	Resistance Range (0.5 mA Excitation)	Resistance Range (1.0 mA Excitation)	Accuracy(1)	Temperature Drift	Resolution	Repeatability
150 Ω	0…150 Ω	0…150 Ω	±0.15 Ω	±0.007 Ω/°C (±0.013 Ω/°F)	0.01 Ω	±0.04 Ω
500 Ω	0…500 Ω	0…500 Ω	±0.5 Ω	±0.023 Ω/°C (±0.041 Ω/°F)	0.1 Ω	±0.2 Ω
1000 Ω	0…1000 Ω	0…1000 Ω	±1.0 Ω	±0.043 Ω/°C (±0.077 Ω/°F)	0.1 Ω	±0.2 Ω
3000 Ω	0…3000 Ω	Not allowed	±1.5 Ω	±0.072 Ω/°C (±0.130 Ω/°F)	0.1 Ω	±0.2 Ω

(1) Accuracy values are based on the assumption that the module has been calibrated to the temperature range of 0…60 °C (32…140 °F).

Hardware Features

The RTD/resistance module contains a removable terminal block (spare part number 1769-RTBN18) providing connections for six 3-wire inputs for any combination of RTD and resistance input devices. Channels are wired as differential inputs. The illustration below shows the hardware features of the module.



Item	Description
1	bus lever (with locking function)
2a	upper panel mounting tab
2b	lower panel mounting tab
3	module status indicator
4	module door with terminal identification label
5a	movable bus connector with female pins
5b	stationary bus connector with male pins
6	nameplate label
7a	upper tongue-and-groove slots
7b	lower tongue-and-groove slots
8a	upper DIN rail latch
8b	lower DIN rail latch
9	write-on label (user ID tag)
10	removable terminal block with finger-safe cover
10a	terminal block upper retaining screw
10b	terminal block lower retaining screw

General Diagnostic Features

A single diagnostic indicator helps you identify the source of problems that may occur during powerup or during normal channel operation. The indicator shows both status and power. See Chapter 5, *Diagnostics and Troubleshooting*, for details on power-up and channel diagnostics.

System Overview

The modules communicate to the local controller or communication adapter through the 1769 bus interface. The modules also receive 5 and 24V DC power through the bus interface.

System Operation

At powerup, the module performs a check of its internal circuits, memory, and basic functions. During this time, the module status indicator remains off. If no faults are found during power-up diagnostics, the module status indicator is turned on.

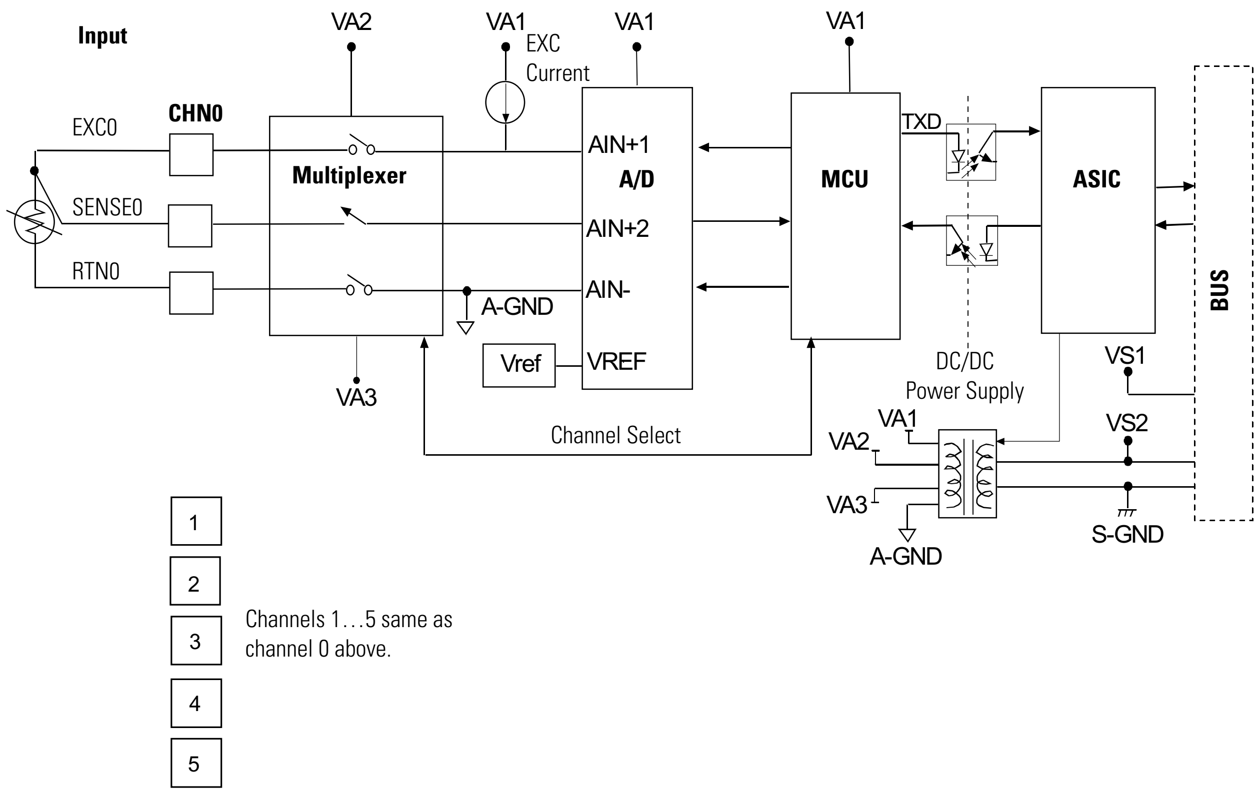
After power-up checks are complete, the module waits for valid channel configuration data. If an invalid configuration is detected, the module generates a configuration error. Once a channel is properly configured and enabled, the module continuously converts the RTD or resistance input to a value within the range selected for that channel.

Each time the module reads an input channel, it tests the data for a fault (over- or under-range, short-circuit, or open-circuit condition). If it detects a fault, the module sets a unique bit in the channel status word. See Input Data File on page 47.

Using the module image table, the controller reads the two's compliment binary converted input data from the module. This typically occurs at the end of the program scan or when commanded by the control program. If the controller and the module determine that the data transfer has been made without error, the data is used in the control program.

Module Operation

As shown in the block diagram below, each input channel of the module consists of an RTD/resistance connection that accepts excitation current; a sense connection that detects lead wire resistance; and a return connection. The signals are multiplexed to an A/D converter that reads the RTD or resistance value and the lead wire resistance.



From the readings taken by the converter, the module returns an accurate temperature or resistance to the controller user program through the microprocessor. The module uses two bidirectional serial ports for communication, each using an optocoupler for isolation. A third optocoupler is used to reset the microprocessor if the module detects a loss of communication.

Module Field Calibration

The input module performs autocalibration when a channel is initially enabled. Autocalibration compensates for offset and gain drift of the A/D converter caused by temperature change within the module. An internal, high-precision, low drift voltage and system ground reference is used for this purpose. In addition, you can program the module to perform a calibration cycle once every 5 minutes. See Selecting Enable/Disable Cyclic Autocalibration (Word 6, Bit 0) on page 65 for information on configuring the module to perform periodic calibration.

Notes:

Quick Start for Experienced Users

Before You Begin

This chapter can help you to get started using the 1769-IR6 module. We base the procedures here on the assumption that you have an understanding of Allen-Bradley controllers. You should understand electronic process control and be able to interpret the ladder logic instructions required to generate the electronic signals that control your application.

Because it is a start-up guide for experienced users, this chapter *does not* contain detailed explanations about the procedures listed. It does, however, reference other chapters in this book where you can get more information about applying the procedures described in each step.

If you have any questions or are unfamiliar with the terms used or concepts presented in the procedural steps, *always read the referenced chapters* and other recommended documentation before trying to apply the information.

Required Tools and Equipment

Have the following tools and equipment ready:

- medium blade or cross-head screwdriver
- RTD or direct resistance input device
- shielded, twisted-pair cable for wiring (Belden 9501 or equivalent)
- controller (for example, a MicroLogix 1500 or CompactLogix controller)
- programming device and software (for example, RSLogix 500™ or RSLogix 5000™)

What You Need To Do

This chapter covers:

1. Ensuring that your power supply is adequate
2. Attaching and locking the module
3. Wiring the module
4. Configuring the module
5. Going through the startup procedure

6. Monitoring module operation

Step 1:	**Ensure that your 1769 system power supply[(1)] has sufficient current output to support your system configuration.**	**Reference** Chapter 3 (Installation and Wiring)

The modules maximum current draw is shown below.

5V DC	24V DC
100 mA	45 mA

TIP The module cannot be located more than 8 modules away from the 1769 system power supply.

(1) The system power supply could be a 1769-PA2, -PB2, -PA4, -PB4, or the internal power supply of a MicroLogix 1500 packaged controller.

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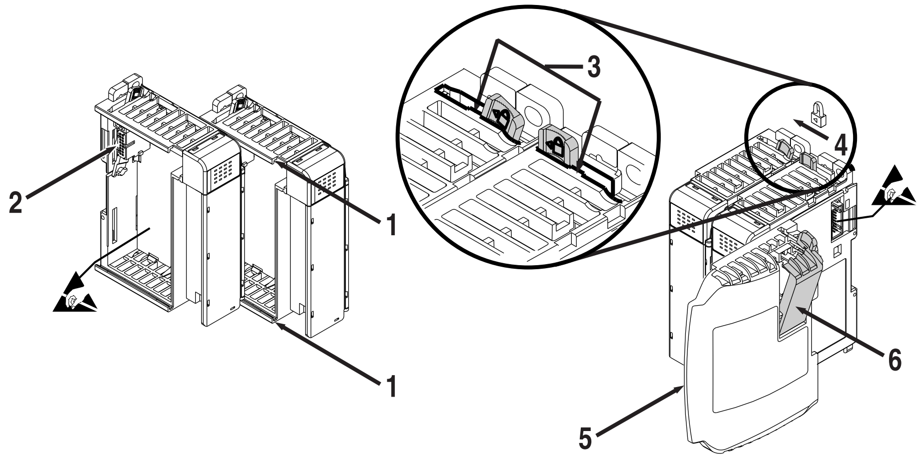
Step 2:	**Attach and lock the module.**	**Reference** Chapter 3 (Installation and Wiring)

TIP The modules can be panel or DIN rail mounted. Modules can be assembled before or after mounting.

ATTENTION: Remove power before removing or inserting this module. When you remove or insert a module with power applied, an electrical arc may occur.



1. Check that the bus lever of the module to be installed is in the unlocked (fully right) position.

2. Use the upper and lower tongue-and-groove slots (1) to secure the modules together (or to a controller).

3. Move the module back along the tongue-and-groove slots until the bus connectors (2) line up with each other.

4. Push the bus lever back slightly to clear the positioning tab (3). Use your fingers or a small screwdriver.

5. To allow communication between the controller and module, move the bus lever fully to the left (4) until it clicks. Ensure it is locked firmly in place.

⚠	**ATTENTION:** When attaching I/O modules, it is very important that the bus connectors are securely locked together to ensure proper electrical connection.

6. Attach an end cap terminator (5) to the last module in the system by using the tongue-and-groove slots as before.

7. Lock the end cap bus terminator (6).

IMPORTANT	A 1769-ECR or 1769-ECL right or left end cap respectively must be used to terminate the end of the bus.

Step 3:	**Wire the module.**	**Reference**
		Chapter 3 (Installation and Wiring)

Follow the guidelines below when wiring the module.

General

- This product is intended to be mounted to a well-grounded mounting surface such as a metal panel. Additional grounding connections from the module's mounting tabs or DIN rail (if used) are not required unless the mounting surface cannot be grounded.
- Power and input wiring must be in accordance with Class I, Division 2 wiring methods (Article 501-4(b) of the National Electric Code NFPA70), and in accordance with the authority having jurisdiction.
- Channels are isolated from one another by ±10V DC maximum.
- Route field wiring away from any other wiring and as far as possible from sources of electrical noise, such as motors, transformers, contactors, and AC devices. In general, allow at least 15.2 cm (6 in.) of separation for every 120V of power.
- Routing field wiring in a grounded conduit can reduce electrical noise.
- If field wiring must cross AC or power cables, ensure that they cross at right angles.
- To ensure optimum accuracy, limit overall cable impedance by keeping your cable as short as possible. Locate the I/O system as close to your sensors or actuators as your application will permit.
- Use Belden shielded, twisted-pair wire to ensure proper operation and high immunity to electrical noise. See the table below for recommended types.

Configuration	**Recommended Cable**
2-wire	Belden 9501 or equivalent
3-wire less than 30.48 m (100 ft)	Belden 9533 or equivalent
3-wire greater than 30.48 m (100 ft) or high humidity conditions	Belden 83503 or equivalent

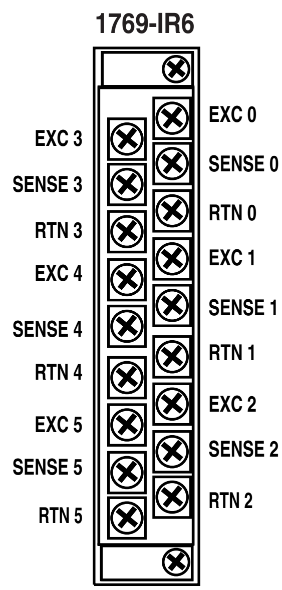
- Keep cable shield connection to ground as short as possible.
- Under normal conditions, the drain wire and shield junction should be connected to earth ground, via a panel or DIN rail mounting screw at the 1769-IR6 module end.
- If noise persists for a device, try grounding the opposite end of the cable. (You can only ground one end at a time.)

- Refer to Industrial Automation Wiring and Grounding Guidelines, publication 1770-4.1, for additional information.

RTD Wiring Considerations

- The module requires three wires to compensate for lead resistance error.
- If using a 3-wire configuration for module connections, select cable to ensure that lead wire resistances match as closely as possible. Consider the following:
  - To ensure temperature or resistance value accuracy, the resistance difference of the cable lead wires must be less than or equal to 0.01 Ω..
  - Keep lead wire resistance as small as possible and less than 25 Ω .
  - Use quality cable that has a small tolerance impedance rating and consistent impedance throughout its length.
  - Use a heavy gauge lead wire with less resistance per foot.

Terminal Connections



For examples of RTD and resistance device wiring see Wiring RTDs on page 41 and Wiring Resistance Devices (Potentiometers) on page 42.

Step 4:	**Configure the module.**	**Reference** Chapter 4 (Module Data, Status, and Channel Configuration)

The configuration file is typically modified using the programming software configuration screen as shown below. It can also be modified through the control program, if supported by the controller. See the configuration file chart on Configuration Data File on page 50.

TIP The configuration default is to enable an analog channel. For improved system performance, disable any unused channels.

Step 5:	Go through the startup procedure.	Reference
		Chapter 5 (Module Diagnostics and Troubleshooting)

1. Apply power to the system.

2. Download your program, which contains the module configuration settings, to the controller.

3. Put the controller into Run mode. During a normal start-up, the module status indicator turns on.

TIP If the module status indicator does not turn on, cycle power. If the condition persists, contact your local distributor or Rockwell Automation for assistance.

Step 6:	Monitor the module status to check if the module is operating correctly	Reference
		Chapter 5 (Module Diagnostics and Troubleshooting)

Module and channel configuration errors are reported to the controller. These errors are typically reported in the controller's I/O status file. Channel status data is also reported in the module's input data table, so these bits can be used in your control program to flag a channel error.

Installation and Wiring

This chapter tells you how to:

- determine the power requirements for the modules
- avoid electrostatic damage
- install the module
- wire the module's terminal block

Compliance to European Union Directives

This product is approved for installation within the European Union and EEA regions. It has been designed and tested to meet the following directives.

EMC Directive

The 1769-IR6 module is tested to meet Council Directive 89/336/EEC Electromagnetic Compatibility (EMC) and the following standards, in whole or in part, documented in a technical construction file:

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

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

This product is intended for use in an industrial environment.

Low Voltage Directive

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

Power Requirements

The module receives +5V DC and 24V DC power from the system power supply through the CompactBus interface.

The maximum current drawn by the module is shown in the table below.

5V DC	24V DC
100 mA	45 mA

TIP When you configure your system, ensure that the total current draw of all the modules does not exceed the maximum current output of the system power supply.

General Considerations

Compact I/O is suitable for use in an industrial environment when installed in accordance with these instructions. Specifically, this equipment is intended for use in clean, dry environments (Pollution degree 2(1)) and to circuits not exceeding Over Voltage Category II(2) (IEC 60664-1).(3)

(1) Pollution Degree 2 is an environment where, normally, only non-conductive pollution occurs except that occasionally a temporary conductivity caused by condensation shall be expected.
(2) Over Voltage Category II is the load level section of the electrical distribution system. At this level transient voltages are controlled and do not exceed the impulse voltage capability of the product's insulation.
(3) Pollution Degree 2 and Over Voltage Category II are International Electrotechnical Commission (IEC) designations.

Hazardous Location Considerations

This equipment is suitable for use in Class I, Division 2, Groups A, B, C, D or non-hazardous locations only. The following WARNING statement applies to use in hazardous locations.

WARNING: EXPLOSION HAZARD

- Substitution of components may impair suitability for Class I, Division 2.
- Do not replace components or disconnect equipment unless power has been switched off or the area is known to be non-hazardous.
- Do not connect or disconnect components unless power has been switched off or the area is known to be non-hazardous.
- This product must be installed in an enclosure.
- All wiring must comply with N.E.C. article 501-4(b).

Prevent Electrostatic Discharge

ATTENTION: Electrostatic discharge can damage integrated circuits or semiconductors if you touch analog I/O module bus connector pins or the terminal block on the input module. Follow these guidelines when you handle the module:

- Touch a grounded object to discharge static potential.
- Wear an approved wrist-strap grounding device.
- Do not touch the bus connector or connector pins.
- Do not touch circuit components inside the module.
- If available, use a static-safe work station.
- When it is not in use, keep the module in its static-shield box.

Remove Power

WARNING: Remove power before removing or inserting this module. When you remove or insert a module with power applied, an electrical arc may occur. An electrical arc can cause personal injury or property damage by:

- sending an erroneous signal to your system's field devices, causing unintended machine motion
- causing an explosion in a hazardous environment
- Electrical arcing causes excessive wear to contacts on both the module and its mating connector and may lead to premature failure.

Selecting a Location

Reducing Noise

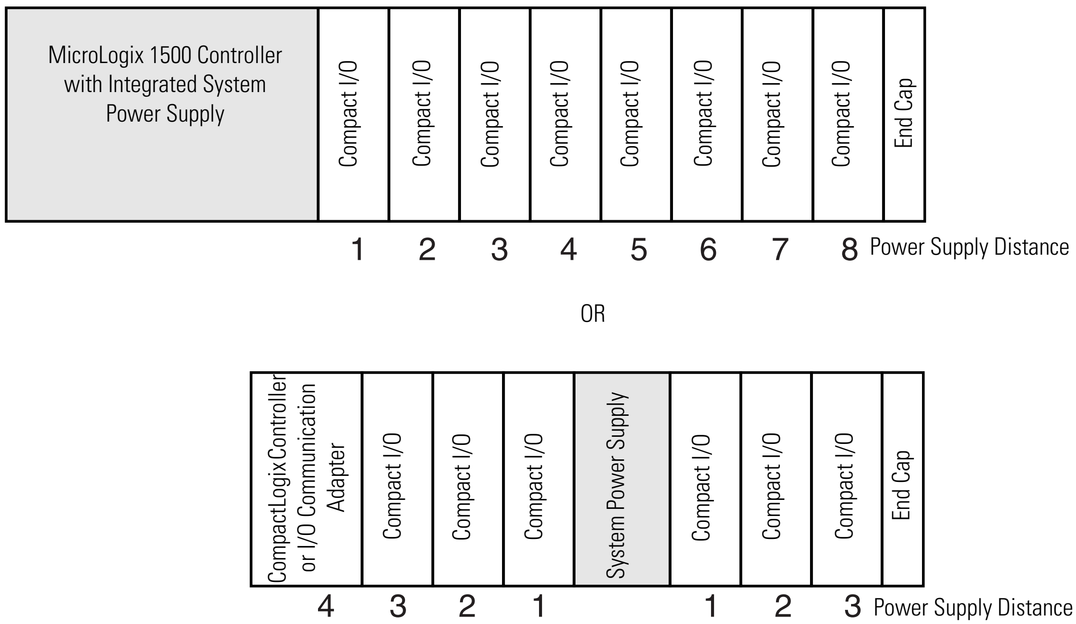
Most applications require installation in an industrial enclosure to reduce the effects of electrical interference. RTD inputs are highly susceptible to electrical noise. Electrical noise coupled to the RTD inputs will reduce the performance (accuracy) of the module.

Group your modules to minimize adverse effects from radiated electrical noise and heat. Consider the following conditions when selecting a location for the module. Position the module:

- away from sources of electrical noise such as hard-contact switches, relays, and AC motor drives
- away from modules which generate significant radiated heat, such as the 1769-IA16. Refer to the module's heat dissipation specification.

In addition, route shielded, twisted-pair wiring away from any high voltage I/O wiring.

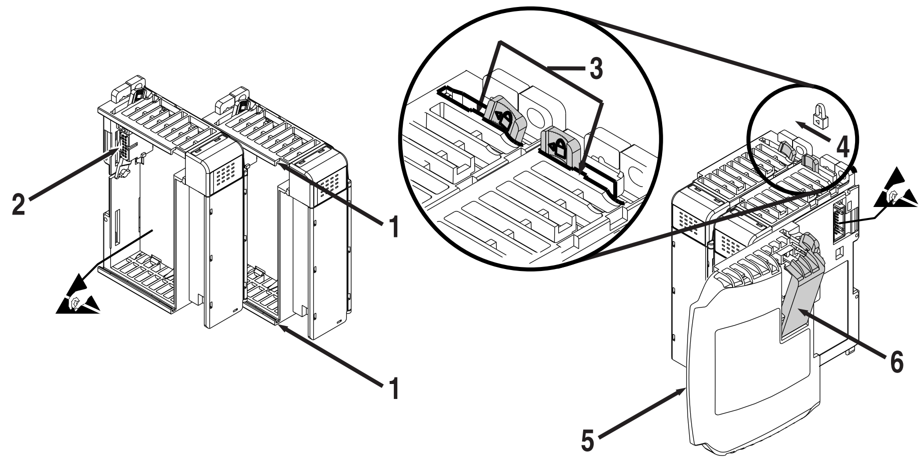
You can install as many modules as your power supply can support. However, all 1769 I/O modules have power supply distance rating. The maximum power supply distance rating is 8, which means that a module may not be located more than 8 modules away from the system power supply. The illustration below shows how power supply distance is determined.



System Assembly

The module can be attached to the controller or an adjacent I/O module *before* or *after* mounting. For mounting instructions, see Panel Mounting Using the Dimensional Template on page 34, or DIN Rail Mounting on page 35. To work with a system that is already mounted, see Replacing a Single Module within a System on page 35.

The following procedure shows you how to assemble the Compact I/O system.



1. Disconnect power.

2. Check that the bus lever of the module to be installed is in the unlocked (fully right) position.

3. Use the upper and lower tongue-and-groove slots (1) to secure the modules together (or to a controller).

4. Move the module back along the tongue-and-groove slots until the bus connectors (2) line up with each other.

5. Push the bus lever back slightly to clear the positioning tab (3). Use your fingers or a small screwdriver.

6. To allow communication between the controller and module, move the bus lever fully to the left (4) until it clicks. Ensure it is locked firmly in place.

> **ATTENTION:** When attaching I/O modules, it is very important that the bus connectors are securely locked together to ensure proper electrical connection.

7. Attach an end cap terminator (5) to the last module in the system by using the tongue-and-groove slots as before.

8. Lock the end cap bus terminator (6).

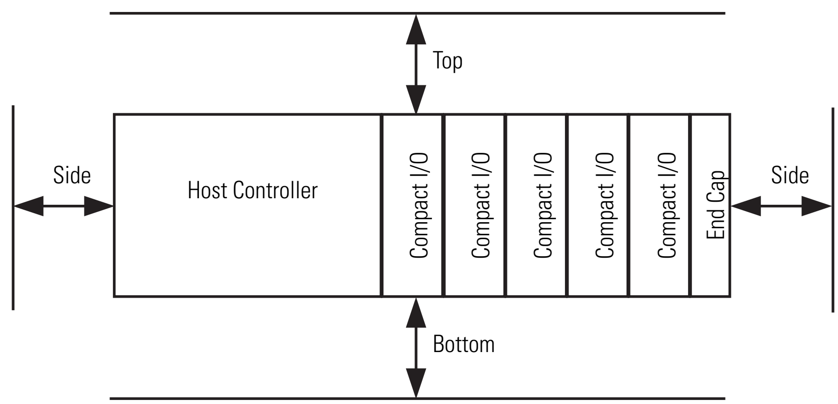
IMPORTANT	A 1769-ECR or 1769-ECL right or left end cap respectively must be used to terminate the end of the bus.

Mounting

ATTENTION: During panel or DIN rail mounting of all devices, be sure that all debris (metal chips, wire strands) is kept from falling into the module. Debris that falls into the module could cause damage at power up.

Minimum Spacing

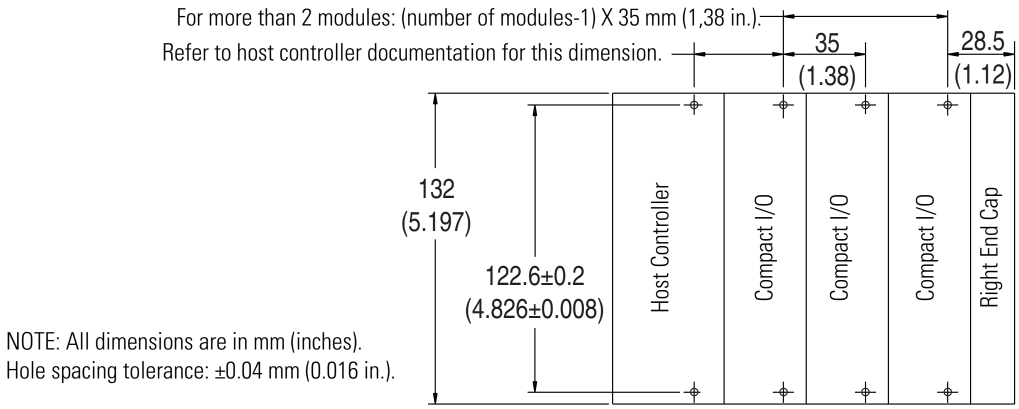
Maintain spacing from enclosure walls, wireways, and adjacent equipment. Allow 50 mm (2 in.) of space on all sides for adequate ventilation, as shown below:



Panel Mounting

Mount the module to a panel using two screws per module. Use M4 or #8 panhead screws. Mounting screws are required on every module.

Panel Mounting Using the Dimensional Template



Panel Mounting Procedure Using Modules as a Template

The following procedure lets you use the assembled modules as a template for drilling holes in the panel. If you have sophisticated panel mounting equipment, you can use the dimensional template provided on page 34. Due to module mounting hole tolerance, it is important to follow these procedures:

1. On a clean work surface, assemble no more than three modules.
2. Using the assembled modules as a template, carefully mark the center of all module-mounting holes on the panel.
3. Return the assembled modules to the clean work surface, including any previously mounted modules.
4. Drill and tap the mounting holes for the recommended M4 or #8 screw.
5. Place the modules back on the panel, and check for proper hole alignment.
6. Attach the modules to the panel using the mounting screws.

   TIP If mounting more modules, mount only the last one of this group and put the others aside. This reduces remounting time during drilling and tapping of the next group.

7. Repeat steps 1…6 for any remaining modules.

DIN Rail Mounting

The module can be mounted using the following DIN rails:

- 35 x 7.5 mm (EN 50 022 - 35 x 7.5), or
- 35 x 15 mm (EN 50 022 - 35 x 15).

Before mounting the module on a DIN rail, close the DIN rail latches. Press the DIN rail mounting area of the module against the DIN rail. The latches will momentarily open and lock into place.

Replacing a Single Module within a System

The module can be replaced while the system is mounted to a panel (or DIN rail). Follow these steps in order:

1. Remove power. See important note on page 30.
2. On the module to be removed, remove the upper and lower mounting screws from the module (or open the DIN latches using a flat-blade or phillips-style screwdriver).
3. Move the bus lever to the right to disconnect (unlock) the bus.
4. On the right-side adjacent module, move its bus lever to the right (unlock) to disconnect it from the module to be removed.
5. Gently slide the disconnected module forward. If you feel excessive resistance, check that the module has been disconnected from the bus, and that both mounting screws have been removed (or DIN latches opened).

   TIP It may be necessary to rock the module slightly from front to back to remove it, or, in a panel-mounted system, to loosen the screws of adjacent modules.

6. Before installing the replacement module, be sure that the bus lever on the module to be installed and on the right-side adjacent module are in the unlocked (fully right) position.
7. Slide the replacement module into the open slot.
8. Connect the modules together by locking (fully left) the bus levers on the replacement module and the right-side adjacent module.
9. Replace the mounting screws (or snap the module onto the DIN rail).

Field Wiring Connections

System Wiring Guidelines

Consider the following when wiring your system:

General

- This product is intended to be mounted to a well-grounded mounting surface such as a metal panel. Additional grounding connections from the module's mounting tabs or DIN rail (if used) are not required unless the mounting surface cannot be grounded.
- Channels are isolated from one another by ±10V DC maximum.
- Route field wiring away from any other wiring and as far as possible from sources of electrical noise, such as motors, transformers, contactors, and AC devices. As a general rule, allow at least 15.2 cm (6 in.) of separation for every 120V of power.
- Routing field wiring in a grounded conduit can reduce electrical noise.
- If field wiring must cross AC or power cables, ensure that they cross at right angles.
- To ensure optimum accuracy, limit overall cable impedance by keeping your cable as short as possible. Locate the I/O system as close to your sensors or actuators as your application will permit.
- Tighten terminal screws with care. Excessive tightening can strip a screw.

Shield Grounding

- Use Belden shielded, twisted-pair wire to ensure proper operation and high immunity to electrical noise. Refer to the following table and the RTD Wiring Considerations below.

Configuration	Recommended Cable
2-wire	Belden 9501 or equivalent
3-wire less than 30.48 m (100 ft)	Belden 9533 or equivalent
3-wire greater than 30.48 m (100 ft) or high humidity conditions	Belden 83503 or equivalent

- Under normal conditions, the drain wire and shield junction should be connected to earth ground, via a panel or DIN rail mounting screw at the 1769-IR6 module end.
- Keep shield connection to ground as short as possible.
- If noise persists for a device, try grounding the opposite end of the cable. (You can only ground one end at a time.)
- Refer to Industrial Automation Wiring and Grounding Guidelines, publication 1770-4.1, for additional information.

RTD Wiring Considerations

Since the operating principle of the RTD module is based on the measurement of resistance, take special care when selecting your input cable. For 2-wire or 3-wire configurations, select a cable that has a consistent impedance throughout its entire length.

IMPORTANT	The RTD module requires three wires to compensate for lead resistance error. We recommend that you do not use 2-wire RTDs if long cable runs are required, as it reduces the accuracy of the system. However, if a two-wire configuration is required, reduce the effect of the lead wire resistance by using a lower gauge wire for the cable (for example, use AWG #16 instead of AWG #24). The module's terminal block accepts two AWG #14 gauge wires.

When using a 3-wire configuration, the module compensates for resistance error due to lead wire length. For example, in a 3-wire configuration, the module reads the resistance due to the length of one of the wires and assumes that the resistance of the other wire is equal. If the resistances of the individual lead wires are much different, an error may exist. The closer the resistance values are to each other, the greater the amount of error that is eliminated.

IMPORTANT	To ensure temperature or resistance value accuracy, the resistance difference of the cable lead wires must be equal to or less than 0.01 Ω .

To insure that the lead values match as closely as possible:

- Keep lead resistance as small as possible and less than 25 Ω .
- Use quality cable that has a small tolerance impedance rating.
- Use a heavy-gauge lead wire which has less resistance per foot.

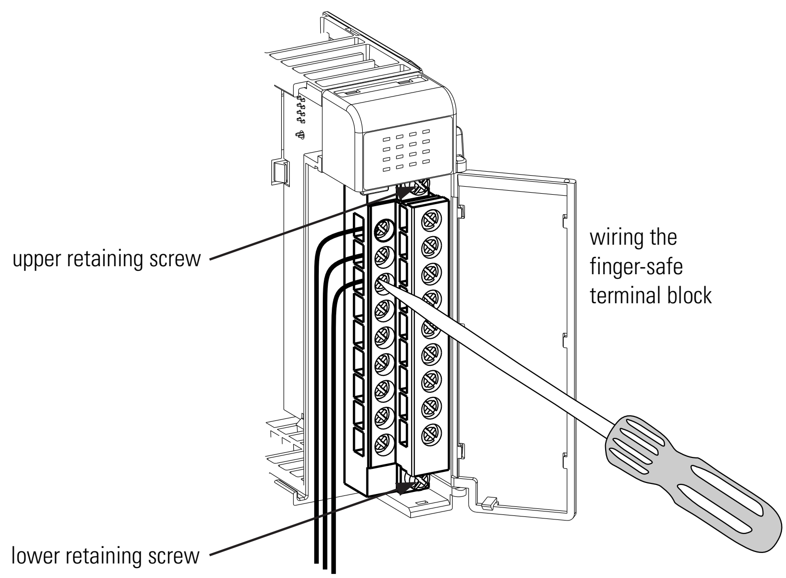
Terminal Door Label

A removable, write-on label is provided with the module. Remove the label from the door, mark your unique identification of each terminal with permanent ink, and slide the label back into the door. Your markings (ID tag) will be visible when the module door is closed.

Removing and Replacing the Terminal Block

When wiring the module, you do not have to remove the terminal block. If you remove the terminal block, use the write-on label located on the side of the terminal block to identify the module location and type.

To remove the terminal block, loosen the upper and lower retaining screws. The terminal block will back away from the module as you remove the screws. When replacing the terminal block, torque the retaining screws to 0.46 Nm (4.1 in-lbs).



Wiring the Finger-Safe Terminal Block

When wiring the terminal block, keep the finger-safe cover in place.

TIP If you need to remove the finger-safe cover, insert a screwdriver into one of the square, wiring holes and gently pry the cover off. If you wire the terminal block with the finger-safe cover removed, you will not be able to put it back on the terminal block because the wires will be in the way.

1. Loosen the terminal screws to be wired.
2. Route the wire under the terminal pressure plate. You can use the bare wire or a spade lug. The terminals accept a 6.35 mm (0.25 in.) spade lug.

   TIP The terminal screws are non-captive. Therefore, it is possible to use a ring lug [maximum 1/4 inch o.d. with a 0.139 inch minimum i.d. (M3.5)] with the module.

3. Tighten the terminal screw making sure the pressure plate secures the wire. Recommended torque when tightening terminal screws is 0.68 Nm (6 in-lbs).

Wire Size and Terminal Screw Torque

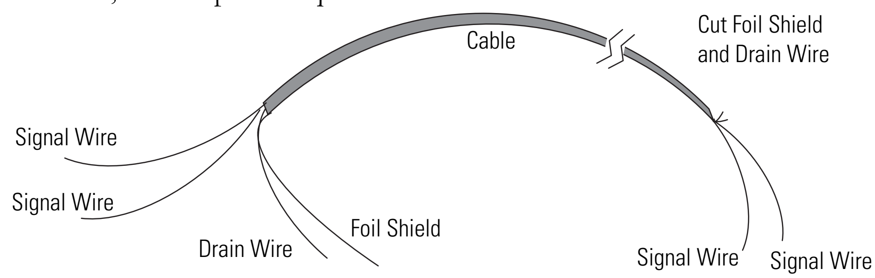
Each terminal accepts up to two wires with the following restrictions:

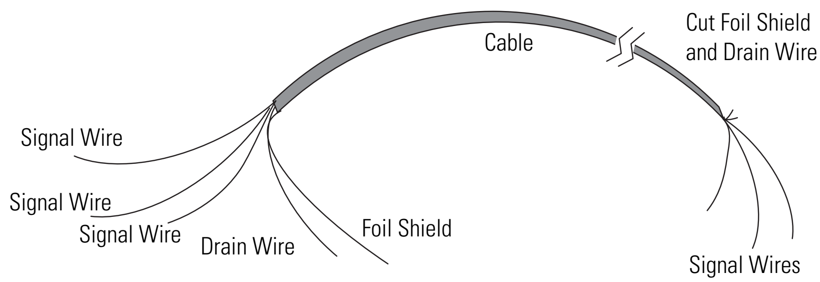
Wire Type		Wire Size	Terminal Screw Torque	Retaining Screw Torque
Solid	Cu-90 °C (194 °F)	14…22 AWG	0.68 Nm (6 in-lbs)	0.46 Nm (4.1 in-lbs)
Stranded	Cu-90 °C (194 °F)	16…22 AWG	0.68 Nm (6 in-lbs)	0.46 Nm (4.1 in-lbs)

Wiring the Modules

ATTENTION: To prevent shock hazard, care should be taken when wiring the module to analog signal sources. Before wiring any module, disconnect power from the system power supply and from any other source to the module.

After the module is properly installed, follow the wiring procedure below and the RTD and potentiometer wiring diagrams on pages 3-41…3-43. To ensure proper operation and high immunity to electrical noise, always use Belden shielded, twisted-pair or equivalent wire.





To wire your module follow these steps:

1. At each end of the cable, strip some casing to expose the individual wires.

2. Trim the signal wires to 2-inch (5 cm) lengths. Strip about 3/16 inch (5 mm) of insulation away to expose the end of the wire.

ATTENTION: Be careful when stripping wires. Wire fragments that fall into a module could cause damage at powerup.

3. At the module end of the cable, twist the drain wire and foil shield together, bend them away from the cable, and apply shrink wrap. Then earth ground via a panel or DIN rail mounting screw at the end of the module. Keep the length of the drain wire as short at possible.

4. At the other end of the cable, cut the drain wire and foil shield back to the cable and apply shrink wrap.

5. Connect the signal wires to the terminal block as described for each type of input. See Wiring RTDs on page 41 or Wiring Resistance Devices (Potentiometers) on page 42.

6. Connect the other end of the cable to the analog input device.

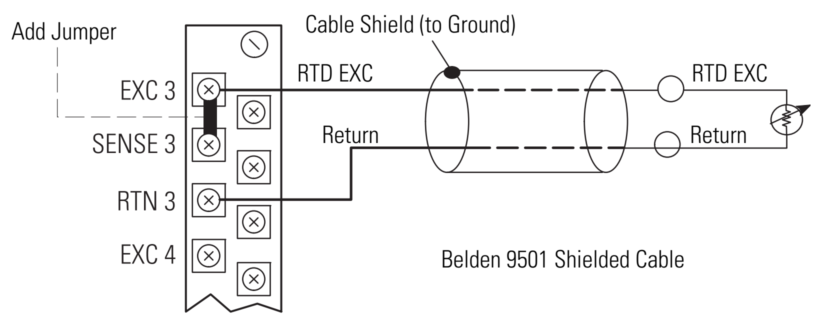
7. Repeat steps 1…6 for each channel on the module.

Wiring RTDs

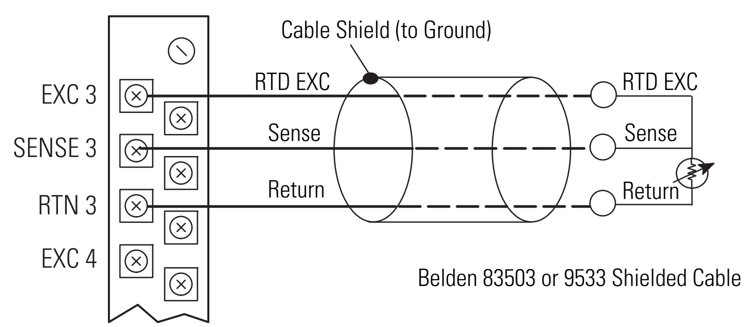
Three types of RTDs can be connected to the 1769-IR6 module:

- 2-wire RTD, which is composed of an RTD EXC (excitation) lead wire and a RTN (return) lead wire
- 3-wire RTD, which is composed of a Sense and 2 RTD lead wires (RTD EXC and RTN)
- 4-wire RTD, which is composed of a Sense and 2 RTD lead wires (RTD EXC and RTN). The second sense wire from the 4-wire RTD is left open.

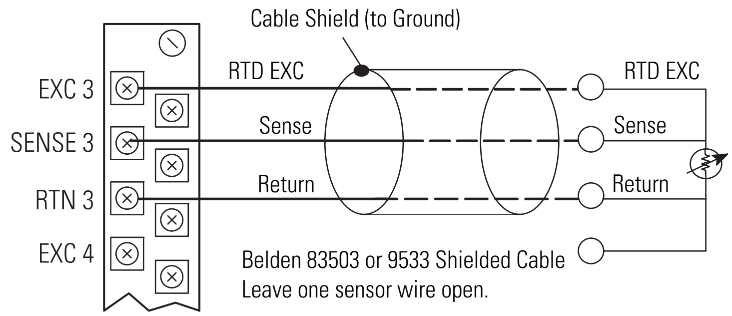
2-Wire RTD Configuration



3-Wire RTD Configuration



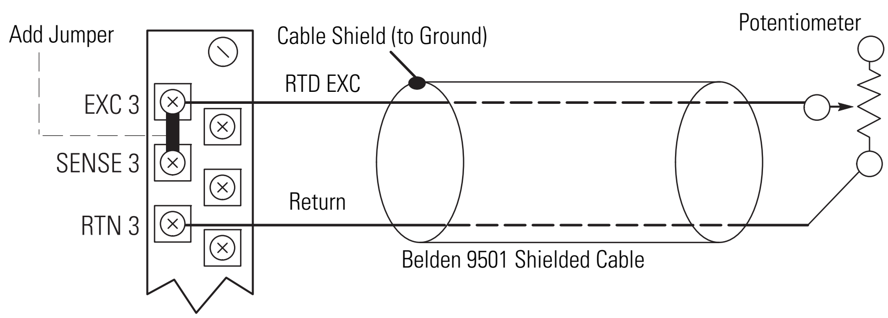
4-Wire RTD Configuration

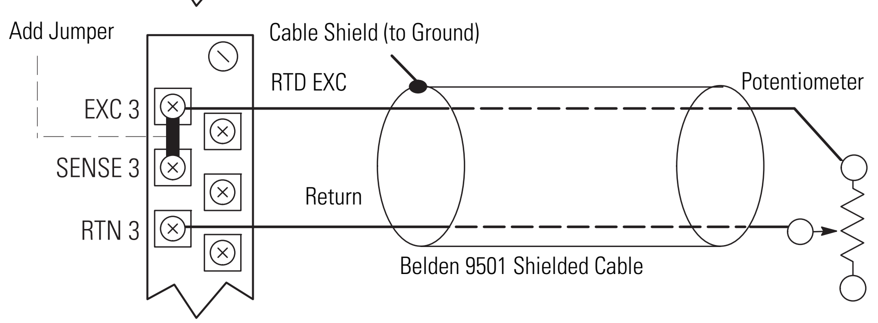


Wiring Resistance Devices (Potentiometers)

Potentiometer wiring requires the same type of cable as that for the RTDs described on page 3-37. Potentiometers can be connected to the module as a 2-wire or 3-wire connection as shown on page 3-42.

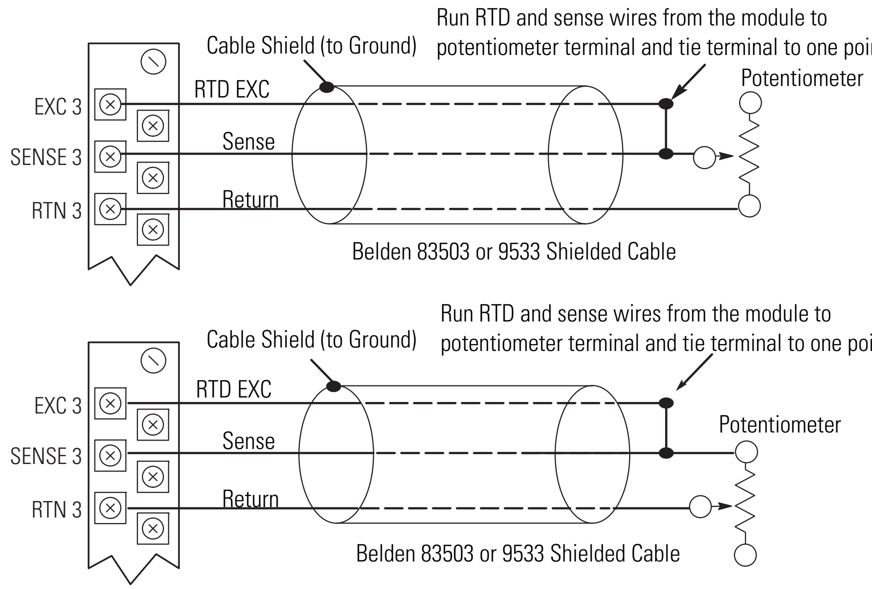
2-Wire Potentiometer Interconnection





TIP The potentiometer wiper arm can be connected to either the EXC or return terminal depending on whether you want increasing or decreasing resistance.

3-Wire Potentiometer Interconnection



TIP The potentiometer wiper arm can be connected to either the EXC or return terminal depending on whether you want increasing or decreasing resistance.

Notes:

Module Data, Status, and Channel Configuration

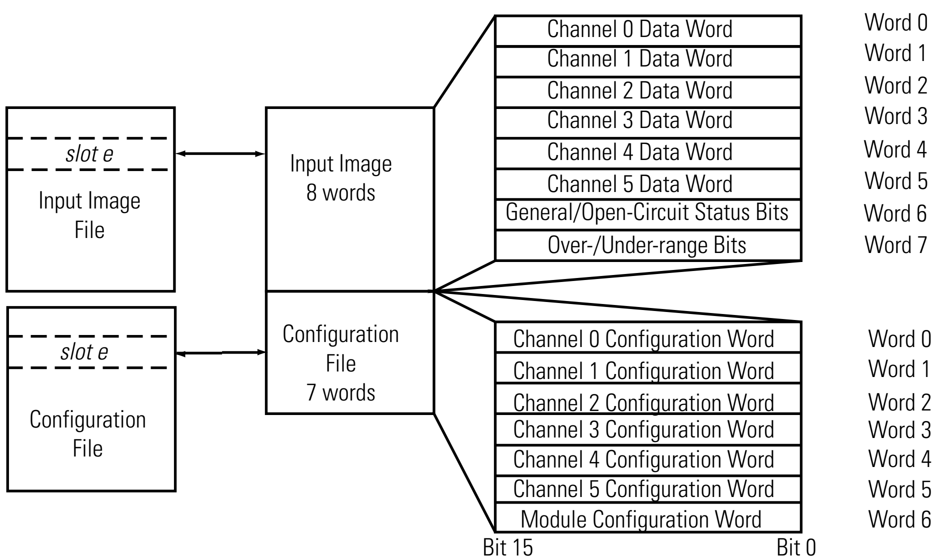
After installation of the 1769-IR6 RTD/resistance input module, you must configure it for operation, usually using the programming software compatible with the controller (for example, RSLogix 500™ or RSLogix 5000™). Once configuration is complete and reflected in ladder logic, you will need to get the module up and running and then verify its operation. This chapter includes information on the following:

- module memory map
- accessing input image file data
- configuring channels
- configuring periodic calibration
- preparing ladder logic to reflect the configuration
- running the module
- verifying the configuration

Module Memory Map

The module uses eight input words for data and status bits (input image), and seven configuration words.

Memory Map



Input Image

The input image file represents data words and status words. Input words 0…5 hold the input data that represents the value of the analog inputs for channels 0…5. These data words are valid only when the channel is enabled and there are no errors. Input words 6 and 7 hold the status bits. To receive valid status information, the channel must be enabled.

Configuration File

The configuration file contains information that you use to define the way a specific channel functions. The configuration file is explained in more detail in Configuration Data File on page 50.

TIP Not all controllers support program access to the configuration file. Refer to your controller's user manual.

Accessing Input Image File Data

Eight words of the processor input image table are reserved for the module's image data. You can access the information in the input image file using the programming software configuration screen. For more information on configuration using MicroLogix 1500 and RSLogix 500, see Appendix A. For CompactLogix and RSLogix 5000, see Appendix B. For 1769-ADN DeviceNet Adapter and RSNetworx, see Appendix C.

Input Data File

The input data table lets you access RTD input module read data for use in the control program, via word and bit access. The data table structure is shown in table below.

Table 4 - Input Data Table

Word/Bit(1)	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Analog Input Data Channel 0															
1	Analog Input Data Channel 1															
2	Analog Input Data Channel 2															
3	Analog Input Data Channel 3															
4	Analog Input Data Channel 4															
5	Analog Input Data Channel 5															
6	Not Used		OC5	OC4	OC3	OC2	OC1	OC0	Not Used		S5	S4	S3	S2	S1	S0
7	U0	O0	U1	O1	U2	O2	U3	O3	U4	O4	U5	O5	Not Used			

(1) Modifying bit values is not supported by all controllers. Refer to your controller manual for details.

Input Data Values

Data words 0…5 correspond to channels 0…5 and contain the converted analog input data from the input device.

TIP Status bits for a particular channel reflect the configuration settings for that channel. To receive valid status, the channel must be enabled and the module must have stored a valid configuration word for that channel.

General Status Flag Bits (S0…S5)

Bits S0…S5 of word 6 contain the general status information for channels 0…5, respectively. This bit is set (1) when an error (over- or under-range, short-circuit, open-circuit, or input data not valid) exists for that channel. The error conditions of the General Status bits are logically ORed. Therefore, the user control program determines which condition is setting the general status bit by viewing the following bits: open-circuit, over-range, or under-range. The data not valid condition is described below.

Input Data Not Valid Condition

The general status bits S0…S5 also indicate whether or not the input data for a particular channel, 0…5, is being properly converted (valid) by the module. This "invalid data" condition can occur (bit set) when the download of a new configuration to a channel is accepted by the module (proper configuration) but before the A/D converter can provide valid (properly configured) data to the 1769 bus master/controller. The following information highlights the bit operation of the Data Not Valid condition.

1. The default and module power-up bit condition is reset (0).

2. The bit condition is set (1) when a new configuration is received and determined valid by the module. The set (1) bit condition remains until the module begins converting analog data for the previously accepted configuration. When conversion is complete, the bit condition is reset (0) by the module. The amount of time it takes for the module to begin the conversion process depends on the number of channels being configured and the amount of configuration data downloaded by the controller.

TIP	If the new configuration is invalid, the bit function remains reset (0) and the module posts a configuration error. See Configuration Errors on page 86.

3. If A/D hardware errors prevent the conversion process from taking place, the bit condition is set (1).

Open-Circuit Flag Bits (OC0…OC5)

Bits OC0…OC5 of word 6 contain open-circuit error information for channels 0…5, respectively. For an RTD input, the bits indicate either an open-circuit or short-circuit condition when set (1). For a resistance input, the bits indicate an open-circuit when set (1).

TIP Short-circuit detection for direct resistance inputs is not indicated because 0 is a valid number.

Over-Range Flag Bits (O0…O5)

Over-range bits for channels 0…5 are contained in word 7, even-numbered bits. They apply to all input types. When set (1), the over-range flag bit indicates an RTD temperature that is greater than the maximum allowed temperature or a resistance input that is greater than the maximum allowed resistance for the module. The module automatically resets (0) the bit when the data value is again within the normal operating range.

Under-Range Flag Bits (U0…U5)

Under-range bits for channels 0…5 are contained in word 7, odd-numbered bits. They apply only to RTD input types. When set (1), the under-range flag bit indicates an RTD temperature that is less than the minimum allowed temperature. The module automatically resets (0) the bit when the data value is again within the normal operating range.

TIP There is no under-range error for a direct resistance input, because 0 is a valid number.

Configuring Channels

After module installation, you must configure operation details, such as RTD type and temperature units, for each channel. Channel configuration data for the module is stored in the controller configuration file, which is both readable and writable.

Configuration Data File

The configuration data file is shown below. Bit definitions are provided in Channel Configuration on page 51. Detailed definitions of each of the configuration parameters follows the table.

TIP Normal channel configuration is done using programming software. In that case, it is not necessary to know the meaning of the bit location. However, some systems allow configuration to be changed by the control program. Refer to your controller's documentation for details.

The default configuration of the table is all zeros, which yields the following.

Table 5 - Default Configuration

Parameter	Default Setting
Channel Enable/Disable	Disable
Data Format	Raw/Proportional
Input/Sensor Type	100 Ω Platinum 385
Temperature Units/Mode	°C (not applicable with Raw/Proportional)
Open/Broken Circuit Response	Upscale
Cyclic Lead Compensation	Enable
Excitation Current	1.0 mA
Input FIlter Frequency	60 Hz

The following table shows the basic arrangement of the configuration data file.

Table 6 - Configuration Data File

Word/Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Enable/Disable Channel 0	Data Format Channel 0			Input/Sensor Type Channel 0				Temperature Units/Mode Channel 0	Open/Broken Circuit Response Channel 0		Cyclic Lead Compensation Channel 0	Excitation Current Channel 0	Filter Frequency Channel 0		
1	Enable/Disable Channel 1	Data Format Channel 1			Input/Sensor Type Channel 1				Temperature Units/Mode Channel 1	Open/Broken Circuit Response Channel 1		Cyclic Lead Compensation Channel 1	Excitation Current Channel 1	Filter Frequency Channel 1		
2	Enable/Disable Channel 2	Data Format Channel 2			Input/Sensor Type Channel 2				Temperature Units/Mode Channel 2	Open/Broken Circuit Response Channel 2		Cyclic Lead Compensation Channel 2	Excitation Current Channel 2	Filter Frequency Channel 2		
3	Enable/Disable Channel 3	Data Format Channel 3			Input/Sensor Type Channel 3				Temperature Units/Mode Channel 3	Open/Broken Circuit Response Channel 3		Cyclic Lead Compensation Channel 3	Excitation Current Channel 3	Filter Frequency Channel 3		
4	Enable/Disable Channel 4	Data Format Channel 4			Input/Sensor Type Channel 4				Temperature Units/Mode Channel 4	Open/Broken Circuit Response Channel 4		Cyclic Lead Compensation Channel 4	Excitation Current Channel 4	Filter Frequency Channel 4		
5	Enable/Disable Channel 5	Data Format Channel 5			Input/Sensor Type Channel 5				Temperature Units/Mode Channel 5	Open/Broken Circuit Response Channel 5		Cyclic Lead Compensation Channel 5	Excitation Current Channel 5	Filter Frequency Channel 5		
6	Not Used															Enable/Disable Cyclic Calibration(1)

(1) When enabled, an autocalibration cycle is performed on all enabled channels every 5 minutes.

Channel Configuration

Words 0…5 of the configuration file let you change the parameters of each channel independently. For example, word 0 corresponds to channel 0 and word 1 to channel 1. The functional arrangement of the bits for one word is shown in the table on page 4-52.

Table 7 - Channel Configuration Bit Definitions

To Select		Make these bit settings															
		15	**14**	**13**	**12**	**11**	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
Filter Frequency	10 Hz														1	1	0
	60 Hz														0	0	0
	50 Hz														0	0	1
	250Hz														0	1	1
	500 Hz														1	0	0
	1 kHz														1	0	1
Excitation Current	1.0 mA													0			
	0.5 mA													1			
Cyclic Lead Compensation	Enable												0				
	Disable												1				
Open/Broken Circuit Response	Upscale										0	0					
	Downscale										0	1					
	Last State										1	0					
	Zero										1	1					
Temperature Units/Mode(1)	°C									0							
	°F									1							
Input/Sensor Type	100 Ω Platinum 385					0	0	0	0								
	200 Ω Platinum 385					0	0	0	1								
	500 Ω Platinum 385					0	0	1	0								
	1000 Ω Platinum 385(2)					0	0	1	1								
	100 Ω Platinum 3916					0	1	0	0								
	200 Ω Platinum 3916					0	1	0	1								
	500 Ω Platinum 3916					0	1	1	0								
	1000 Ω Platinum 3916(2)					0	1	1	1								
	10 Copper 426(3)					1	0	0	0								
	120 Nickel 618					1	0	0	1								
	120 Nickel 672					1	0	1	0								
	604 Nickel-Iron 518					1	0	1	1								
	150 Ω					1	1	0	0								
	500 Ω					1	1	0	1								
	1000 Ω					1	1	1	0								
	3000 Ω(2)					1	1	1	1								

Table 7 - Channel Configuration Bit Definitions

To Select		Make these bit settings															
		15	**14**	**13**	**12**	**11**	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
Data Format	Raw/Proportional		0	0	0												
	Engineering Units		0	0	1												
	Engr. Units X 10		1	0	0												
	Scaled-for-PID		0	1	0												
	Percent Range		0	1	1												
Enable/Disable Channel	Enable	1															
	Disable	0															

(1) Ignored for a resistance device input.
(2) Valid only with the 0.5 mA excitation current.
(3) Valid only with the 1.0 mA excitation current.

Enabling or Disabling a Channel (Bit 15)

Bit 15 enables or disables each of the six channels individually. The module only scans those channels that are enabled. Enabling a channel forces it to be recalibrated before it measures input data. Turning a channel off results in the channel data being set to zero.

TIP When a channel is not enabled, the A/D converter provides no input to the controller. This speeds up the system response of the active channels.

The configuration default is to disable each input channel to maximize module performance.

Selecting Data Format (Bits 12…14)

Bits 12…14 of the channel configuration word are used to indicate the input data format. You may choose any of the following formats:

- raw/proportional
- engineering units x 1
- engineering units x 10
- scaled for PID
- percent of full scale

TIP The engineering units data formats represent real temperature or resistance engineering units provided by the module. The raw/proportional counts, scaled-for-PID, and percent of full scale data formats The raw/proportional counts, scaled-for-PID and percent of full-scale data formats may yield the highest effective resolutions, but may also require that you convert channel data to real engineering units in your control program.

Table 8 - Data Formats for RTD Temperature Ranges for 0.5 and 1.0 mA Excitation Current

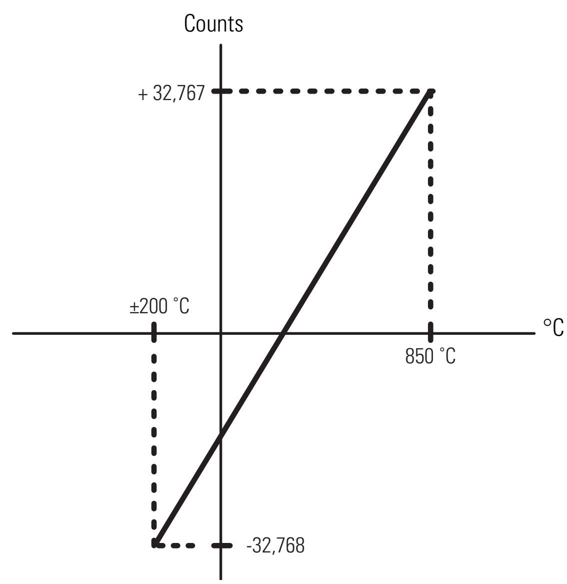
RTD Input Type	Data Format					
	Engineering Units x1		Engineering Units x10		Scaled-for-PID	Proportional Counts
	0.1 °C	0.1 °F	1.0 °C	1.0 °F		
100 Ω Platinum 385	-2000…8500	-3280…15620	-200…850	-328…1562	0…16383	-32768…32767
200 Ω Platinum 385	-2000…8500	-3280…15620	-200…850	-328…1562	0…16383	-32768…32767
500 Ω Platinum 385	-2000…8500	-3280…15620	-200…850	-328…1562	0…16383	-32768…32767
1000 Ω Platinum 385	-2000…8500	-3280…15620	-200…850	-328…1562	0…16383	-32768…32767
100 Ω Platinum 3916	-2000…6300	-3280…11660	-200…630	-328…1166	0…16383	-32768…32767
200 Ω Platinum 3916	-2000…6300	-3280…11660	-200…630	-328…1166	0…16383	-32768…32767
500 Ω Platinum 3916	-2000…6300	-3280…11660	-200…630	-328…1166	0…16383	-32768…32767
1000 Ω Platinum 3916	-2000…6300	-3280…11660	-200…630	-328…1166	0…16383	-32768…32767
10 Ω Copper 426	-1000…2600	-1480…5000	100…260	-148…500	0…16383	-32768…32767
120 Ω Nickel 618	-1000…2600	-1480…5000	-100…260	-148…500	0…16383	-32768…32767
120 Ω Nickel 672	-800…2600	-1120…5000	-80…260	-112…500	0…16383	-32768…32767
60 Ω Nickel Iron 518	-1000…2000	-3280…1560	-100…200	-328…156	0…16383	-32768…32767

Raw/Proportional Data Format

The raw/proportional data format provides the greatest resolution of all the data formats. For this format, the value presented to the controller is proportional to the selected input. It is also scaled to the maximum data range allowed by the bit resolution of the A/D converter and selected filter frequency.

If you select the raw/proportional data format for a channel, the data word will be a linearized number between -32768…32767. The value -32768 corresponds to the lowest temperature value for an RTD or the lowest resistance value for a resistance device.

Linear Relationship Between Temperature and Proportional Counts



The value +32767 corresponds to the highest value for the device. For example, if a 100 Ω platinum 385 RTD is selected, the lowest temperature of -200 °C corresponds to -32768 counts. The highest temperature of 850 °C corresponds to +32767 counts. See Determining Effective Resolution and Range on page 65.

Scaling Examples

EXAMPLE Scaled-for-PID to Engineering Units x1

- input type = 200 Ω Platinum RTD
- α = 0.00385 °C
- range = -200…850 °C S_{LOW} = -200 °C S_{HIGH} = 850 °C
- channel data = 3421(scaled-for-PID)

Engineering Units Equivalent = S_{LOW} + [S_{HIGH} - S_{LOW}) x (channel data/16383)]

Engineering Units Equivalent = -200 °C + [(850 °C -(-200 °C)) x (3421/16383)] = 19.25 °C

EXAMPLE Engineering Units x1 to Scaled-for-PID

- input type = 200 Ω Platinum RTD
- α = 0.00385 °C
- range = -200…850 °C S_{LOW} = -200 °C S_{HIGH} = 850 °C
- desired channel temperature = 344 °C (engineering units)

Scaled-for-PID Equivalent = 16383 x [(desired ch. temp. - S_{LOW})/(S_{HIGH} - S_{LOW})]

Scaled-for-PID Equivalent = 16383 x [(344 °C - (-200 °C))/(850 °C - (-200 °C))] = 8488

EXAMPLE Proportional Counts to Engineering Units x1

- input type = 1000 Ω potentiometer
- range = 0…1000 Ω S_{LOW} = 0 Ω S_{HIGH} = 1000 Ω
- channel data = 21567 (proportional counts)

Engineering Units Equivalent = S_{LOW} + {(S_{HIGH} - S_{LOW}) x [(ch. data + 32768)/65536]}

Engineering Units Equivalent = 0 + {(1000 - 0) x [(21567 + 32768)/65536]} = 829Ω

EXAMPLE Engineering Units x1 to Proportional Counts

- input type = 3000 Ω potentiometer
- range = 0…3000 Ω S_{LOW} = 0 Ω S_{HIGH} = 3000 Ω
- desired channel resistance = 1809 Ω (engineering units x 1)

Prop. Counts Equivalent = {65536 x [(ch. resistance - S_{LOW})/(S_{HIGH} - S_{LOW})]} - 32768

Proportional Counts Equivalent = {65536 x [(1809 Ω - 0)/(3000 – 0)]} – 32768 = 6750

Engineering Units x 1 Data Format

If you select engineering units x 1 as the data format for an RTD input, the module scales input data to the actual temperature values for the selected RTD type per RTD standard. It expresses temperatures in 0.1 °C units. For resistance inputs, the module expresses resistance in 0.1 Ω units, for all ranges except the 150 Ω range. For the latter, resistance is expressed in 0.01 Ω units.

TIP Use the engineering units x 10 setting to produce temperature readings in whole degrees Celsius or Fahrenheit. See Engineering Units x 10 Data Format below.

The resolution of the engineering units x 1 format is dependent on the range selected and the filter selected. See Determining Effective Resolution and Range on page 65.

Engineering Units x 10 Data Format

For the engineering units x 10 data format for an RTD input, the module scales input data to the actual temperature values for the selected RTD type per RTD standard. With this format, the module expresses temperatures in 1 °C units. For resistance inputs, the module expresses resistance in 1 Ω units, for all ranges except the 150 Ω range. For the latter, resistance is expressed in 0.1 Ω units.

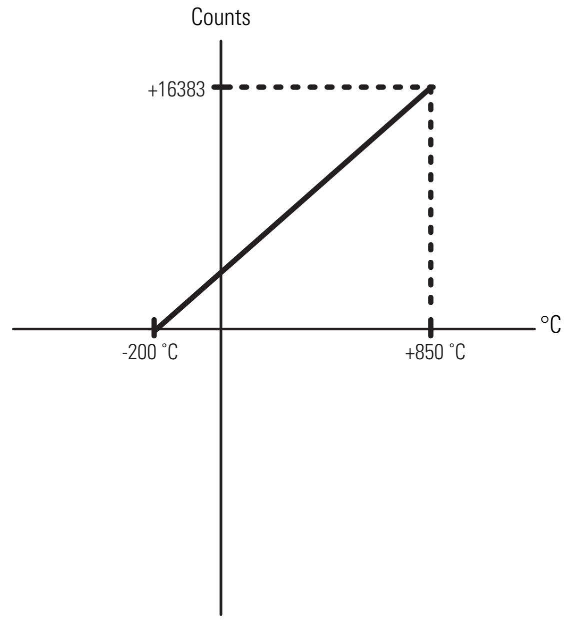
The resolution of the engineering units x 10 format is dependent on the range selected and the filter selected. See Determining Effective Resolution and Range on page 65.

Scaled-for-PID Data Format

If you select the scaled-for-PID data format, the module presents to the controller a signed integer representing the input signal range proportional to the selected input type. The integer value is the same for RTD and resistance input types.

To obtain the value, the module scales the input signal range to a linearized 0…16383 range, which is standard to the PID algorithm for the MicroLogix, SLC, and PLC controllers. The 0 value corresponds to the lowest temperature or resistance value, while 16383 corresponds to the highest value. For example, if a 100 Ω platinum 385 RTD is selected, the lowest temperature for the RTD, -200 °C, corresponds to 0. The highest temperature, 850 °C, corresponds to 16383.

Linear Relationship Between Temperature and PID Counts



The amount over and under user range (full-scale range -410…16793) is also included in the signed integer provided to the controller. Allen-Bradley controllers, such as the MicroLogix 1500, use this range in their PID equations. See Determining Effective Resolution and Range on page 65.

Percent of Full Scale Data Format

With the percent of full scale data format, the module presents input data to the user as a percent of the user-specified range. For example, for a 100 Ω platinum 385 RTD, the range -200 °C…850 °C is represented as 0 percent to 100 percent. See Determining Effective Resolution and Range on page 65.

Selecting Input/Sensor Type (Bits 8…11)

You can set bits 8…11 in the channel configuration word to indicate the type of input sensor, for example, 100 Ω platinum 385 RTD. Each channel can be configured for any input type. The valid input types and bit settings are listed in the channel configuration table on page 4-51.

Selecting Temperature Units/Mode (Bit 7)

The module supports two different linearized, scaled temperature ranges for RTDs, degrees Celsius (°C) and degrees Fahrenheit (°F). You can select the type that is appropriate for your application by setting bit 7 in the channel configuration word. Bit 7 is ignored for resistance input types or when raw/proportional, scaled-for-PID, or percent data formats are used.

Selecting Open-Circuit Response (Bits 5 and 6)

Broken inputs for the module include open-circuit and short-circuit conditions. An open-circuit occurs when the module's maximum input voltage is reached. This can happen if the wire is cut or disconnected from the terminal block. The module can encounter an open-circuit for any RTD or resistance input.

A short-circuit occurs when the calculated lead wire compensated resistance is less than 3 Ω The module can only report a short-circuit for an RTD.

Use bits 5 and 6 of channel configuration word 6 to define the state of the channel data word when a broken input condition is detected for the corresponding channel. When it detects an open circuit or a short circuit, the module overrides the actual input data with the value that you specify.

Table 9 - Open/Broken Circuit Response Definitions

Open/Broken Circuit Value	Response Definition
Upscale	Sets input to full upper scale value of channel data word. The full-scale value is determined by the selected input type, data format, and scaling.
Downscale	Sets input to full lower scale value of channel data word. The low scale value is determined by the selected input type, data format, and scaling.
Last State	Sets input to last input value.
Zero	Sets input to 0 to force the channel data word to 0.

Selecting Cyclic Lead Compensation (Bit 4)

For each channel, the module measures lead resistance in one of two ways. Set bit 4 to 0 to *enable* measurement and compensation of lead resistance every five minutes. One channel is measured per module update to limit the impact to channel throughput. You can also implement a lead wire calibration cycle any time, at your command, by enabling and then disabling this bit in your control program.(1) Regardless of the state of bit 4, lead wire compensation occurs automatically on a system mode change from Program-to-Run or if any online configuration change is made to a channel.

Selecting Excitation Current (Bit 3)

The module is capable of exciting each individual RTD/resistance device with either 0.5 mA or 1.0 mA of current. Setting bit 3 to 0 provides 1.0 mA, while a setting of 1 provides 0.5 mA.

The 0.5 mA excitation current is recommended for use with 1000 Ω RTDs and 3000 Ω direct resistance inputs. An excitation current of 1.0 mA is recommended for all other RTDs except the 1000 Ω devices, and all other direct resistance devices except the 3000 Ω devices. Refer to the input device literature for the manufacturer's recommendations.

TIP A lower excitation current reduces error due to RTD self-heating, but provides a lower signal-to-noise ratio. See the manufacturer's recommendations for your particular RTD.

(1) Not all controllers allow online configuration changes. Refer to your controller's user manual for details. During an online configuration change, input data for that channel is not updated by the module.

Setting Filter Frequency (Bits 0…2)

The module supports filter selections corresponding to filter frequencies of 10 Hz, 50 Hz, 60 Hz, 250 Hz, 500 Hz, and 1 kHz. Your filter frequency selection is determined by the desired range for the input type, and the required effective resolution, which indicates the number of bits in the channel configuration word that do not vary due to noise. Also consider the required module update time when choosing a filter frequency. For example, the 10 Hz filter provides the greatest attenuation of 50 and 60 Hz noise and the greatest resolution, but also provides the slowest response speed.

The choice that you make for filter frequency will affect:

- noise rejection characteristics for module input
- channel step response
- channel cutoff frequency
- module autocalibration
- effective resolution
- module update time

Effects of Filter Frequency on Noise Rejection

The filter frequency that you choose for a channel determines the amount of noise rejection for the inputs. A smaller filter frequency (such as 10Hz) provides the best noise rejection and increases effective resolution, but also increases channel update time. A larger filter frequency (such as 1 kHz) provides lower noise rejection, but also decreases the channel update time and effective resolution.

When selecting a filter frequency, be sure to consider channel cutoff frequency and channel step response to obtain acceptable noise rejection. Choose a filter frequency so that your fastest-changing signal is below that of the filter's cutoff frequency.

Common mode noise rejection for the module is better than 110 dB at 50 Hz (50 Hz filter) and 60 Hz (60 Hz filter). The module performs well in the presence of common mode noise as long as the signals applied to the input terminals do not exceed the common mode voltage rating (±2.5V) of the module. Improper earth ground can be a source of common mode noise.

TIP Transducer power supply noise, transducer circuit noise, and process variable irregularities can also be sources of common mode noise.

Channel Step Response

Another module characteristic determined by filter frequency is channel step response, as shown in the following table. The step response is the time required for the analog input signal to reach 100 percent of its expected final value, given a full-scale step change in the input signal. Thus, if an input signal changes faster than the channel step response, a portion of that signal will be attenuated by the channel filter. The channel step response is calculated by a settling time of 3 x (1 / filter frequency).

Table 10 - Filter Frequency versus Channel Step Response

Filter Frequency	Step Response
10 Hz	300 ms
50 Hz	60 ms
60 Hz	50 ms
250 Hz	12 ms
500 Hz	6 ms
1 kHz	3 ms

Channel Cutoff Frequency

The channel cutoff frequency (-3 dB) is the point on the input channel frequency response curve where frequency components of the input signal are passed with 3 dB of attenuation. The following table shows cutoff frequencies for the supported filters.

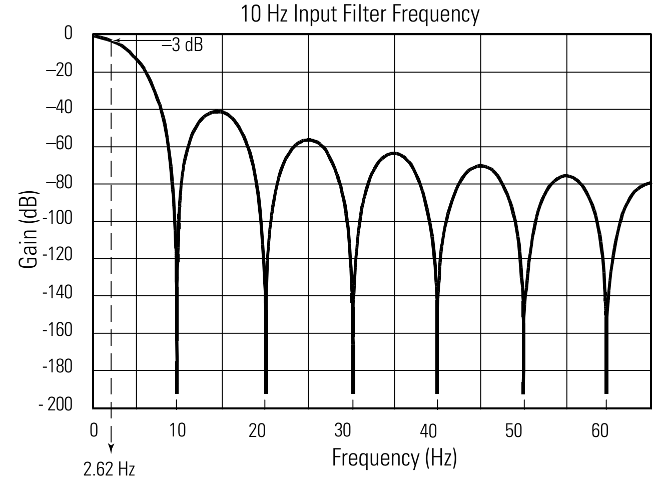
Table 11 - Filter Frequency versus Channel Cutoff Frequency

Filter Frequency	Channel Cutoff Frequency
10 Hz	2.62 Hz
50 Hz	13.1 Hz
60 Hz	15.7 Hz
250 Hz	65.5 Hz
500 Hz	131 Hz
1 kHz	262 Hz

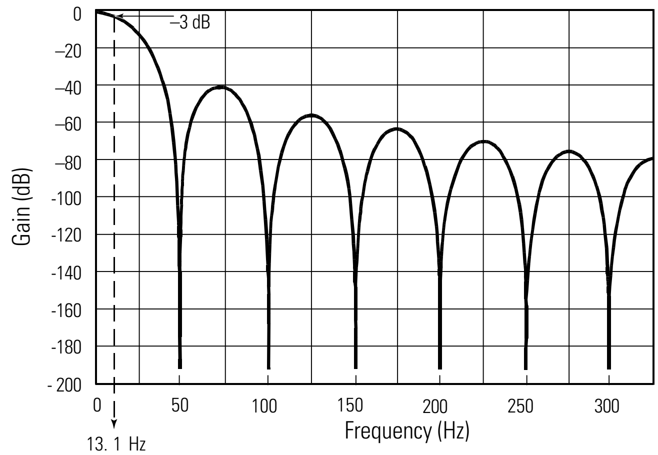
All frequency components at or below the cutoff frequency are passed by the digital filter with less than 3 dB of attenuation. All frequency components above the cutoff frequency are increasingly attenuated, as shown in the graphs below for several of the input filter frequencies.

TIP Channel cutoff frequency should not be confused with channel update time. The cutoff frequency simply determines how the digital filter attenuates frequency components of the input signal. See Determining Module Update Time on page 72.

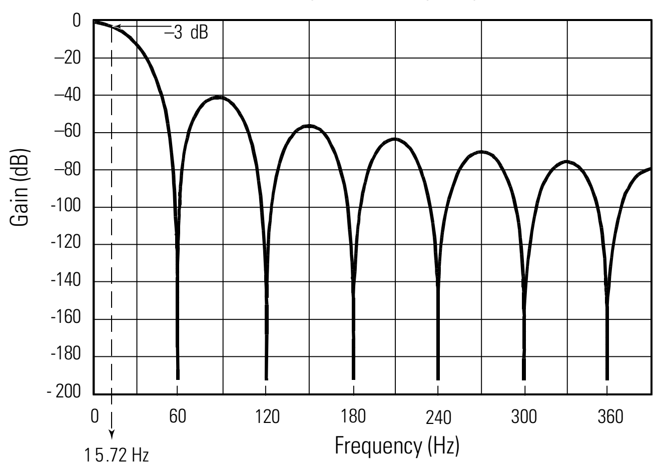
Frequency Response Graphs



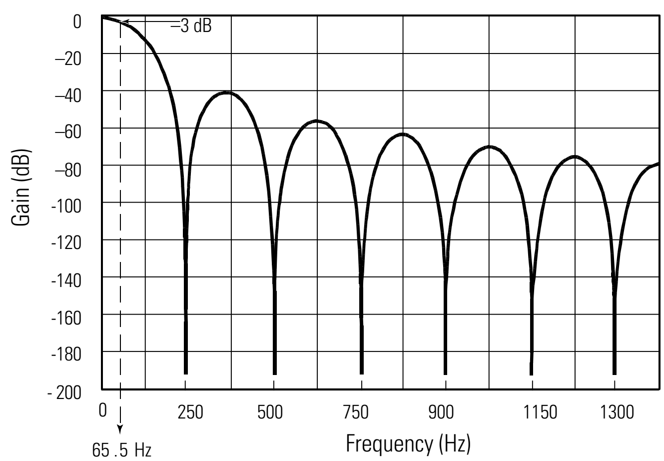
10 Hz Input Filter Frequency



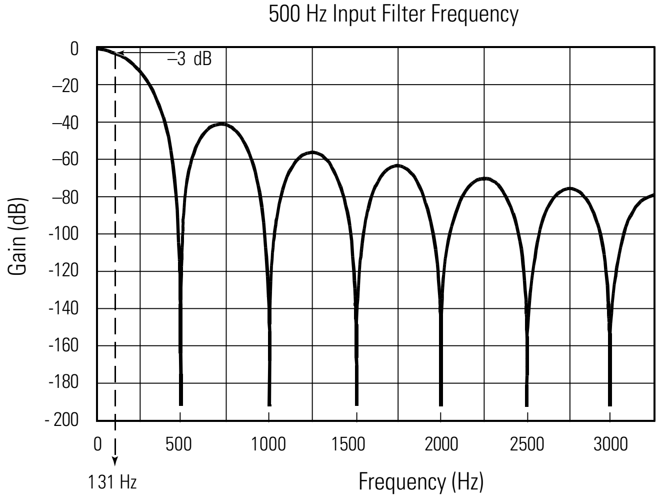
50 Hz Input Filter Frequency



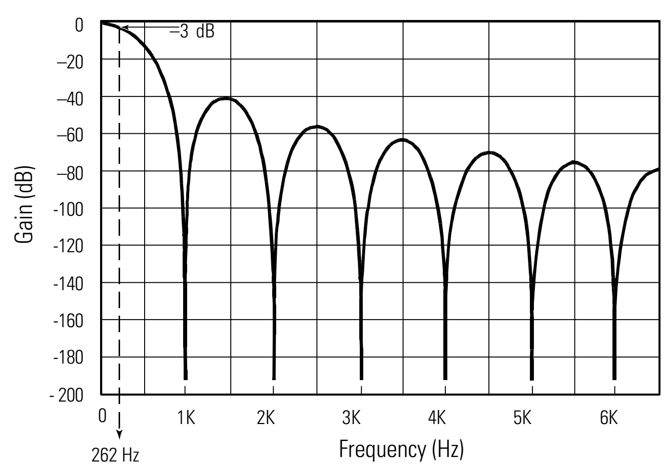
60 Hz Input Filter Frequency



250 Hz Input Filter Frequency



500 Hz Input Filter Frequency



1 kHz Input Filter Frequency

Selecting Enable/Disable Cyclic Autocalibration (Word 6, Bit 0)

Configuration word 6, bit 0 lets you configure the module to perform an autocalibration cycle of all enabled channels once every 5 minutes. Cyclic calibration functions to reduce offset and gain drift errors due to temperature changes within the module. Setting this bit to 1 disables cyclic calibration, the default (0) enables the autocalibration function. See Effects of Autocalibration on Accuracy on page 79.

TIP	For systems that allow modifying the state of this bit, you can program the autocalibration cycle to occur whenever you desire via the ladder program, by cycling the bit from 0 to 1.

Determining Effective Resolution and Range

This section provides tables showing effective resolution and range for all possible input data types at each filter frequency. Look up your required resolution, range, and input type in the tables. Choose the frequency that most closely matches your requirements.

Table 12 - Effective Resolution and Range for 10 Hz Filter Frequency

Input Type	Raw/Proportional Data Over Full Input Range			Engineering Units x 1 Over Full Range			Engineering Units x 10 Over Full Range			Scaled for PID Over Full Range			Percent of Full Scale 0…100%		
	Decimal Range	Resolution °C	Resolution °F	Decimal Range	Resolution °C	Resolution °F	Decimal Range	Resolution °C	Resolution °F	Decimal Range	Resolution °C	Resolution °F	Decimal Range	Resolution °C	Resolution °F
100 Ω Pt 385	±32767	0.054 °C / 4 counts	0.097 °F/ 4 counts	-2000 … 8500	0.1 °C / 1 count	0.1 °F/ 1 count	-200 … 850	1.0 °C / 1 count	1.0 °F/ 1 count	0 … 16383	0.064 °C / 1 count	0.115 °F/ 1 count	0 … 10000	0.105 °C / 1 count	0.189 °F/ 1 count
200 Ω Pt 385		0.054 °C / 4 counts	0.097 °F/ 4 counts	-2000 … 8500	0.1 °C / 1 count	0.1 °F/ 1 count	-200 … 850	1.0 °C / 1 count	1.0 °F/ 1 count		0.064 °C / 1 count	0.115 °F/ 1 count		0.105 °C / 1 count	0.189 °F/ 1 count
500 Ω Pt 385		0.043 °C / 4 counts	0.077 °F/ 4 counts	-2000 … 8500	0.1 °C / 1 count	0.1 °F/ 1 count	-200 … 850	1.0 °C / 1 count	1.0 °F/ 1 count		0.064 °C / 1 count	0.115 °F/ 1 count		0.105 °C / 1 count	0.189 °F/ 1 count
1000 Ω Pt 385		0.043 °C / 4 counts	0.077 °F/ 4 counts	-2000 … 8500	0.1 °C / 1 count	0.1 °F/ 1 count	-200 … 850	1.0 °C / 1 count	1.0 °F/ 1 count		0.064 °C / 1 count	0.115 °F/ 1 count		0.105 °C / 1 count	0.189 °F/ 1 count
100 Ω Pt 3916		0.051 °C / 4 counts	0.091 °F/ 4 counts	-2000 … 6300	0.1 °C / 1 count	0.1 °F/ 1 count	-200 … 630	1.0 °C / 1 count	1.0 °F/ 1 count		0.051 °C / 1 count	0.091 °F/ 1 count		0.083 °C / 1 count	0.149 °F/ 1 count
200 Ω Pt 3916		0.051 °C / 4 counts	0.091 °F/ 4 counts	-2000 … 6300	0.1 °C / 1 count	0.1 °F/ 1 count	-200 … 630	1.0 °C / 1 count	1.0 °F/ 1 count		0.051 °C / 1 count	0.091 °F/ 1 count		0.083 °C / 1 count	0.149 °F/ 1 count
500 Ω Pt 3916		0.041 °C / 4 counts	0.073 °F/ 4 counts	-2000 … 6300	0.1 °C / 1 count	0.1 °F/ 1 count	-200 … 630	1.0 °C / 1 count	1.0 °F/ 1 count		0.051 °C / 1 count	0.091 °F/ 1 count		0.083 °C / 1 count	0.149 °F/ 1 count
1000 Ω Pt 3916		0.041 °C / 4 counts	0.073 °F/ 4 counts	-2000 … 6300	0.1 °C / 1 count	0.1 °F/ 1 count	-200 … 630	1.0 °C / 1 count	1.0 °F/ 1 count		0.051 °C / 1 count	0.091 °F/ 1 count		0.083 °C / 4 counts	0.149 °F/ 1 count
10 Ω Cu 426		0.123 °C / 16 counts	0.221 °F/ 16 counts	-1000 … 2600	0.1 °C / 4 counts	0.2 °F/ 4 count	-100 … 260	1.0 °C / 4 counts	1.0 °F/ 4 count		0.123 °C / 6 counts	0.221 °F/ 6 counts		0.123 °C / 6 counts	0.221 °F/ 6 counts
120 Ω Ni 618		0.028 °C / 4 counts	0.050 °F/ 4 counts	-1000 … 2600	0.1 °C / 1 count	0.1 °F/ 1 count	-100 … 260	1.0 °C / 1 count	1.0 °F/ 1 count		0.028 °C / 1 count	0.040 °F/ 1 count		0.036 °C / 1 count	0.064 °F/ 1 count
120 Ω Ni 672		0.021 °C / 2 counts	0.038 °F/ 2 counts	-800 … 2600	0.1 °C / 1 count	0.1 °F/ 1 count	-80 … 260	1.0 °C / 1 count	1.0 °F/ 1 count		0.021 °C / 1 count	0.038 °F/ 1 count		0.034 °C / 1 count	0.061 °F/ 1 count
604 Ω NiFe 518		0.025 °C / 4 counts	0.045 °F/ 4 counts	-1000 … 2000	0.1 °C / 1 count	0.1 °F/ 1 count	-100 … 200	1.0 °C / 1 count	1.0 °F/ 1 count		0.025 °C / 1 count	0.045 °F/ 1 count		0.030 °C / 1 count	0.048 °F/ 1 count
150 Ω		0.009 Ω /4 counts		0 … 15000	0.1Ω / 1 count		0 … 1500	1.0 Ω / 1 count			0.009 Ω / 1 count			0.015 Ω / 1 count	
500 Ω		0.019 Ω /4 counts		0 … 5000	0.1Ω / 1 count		0 … 500	1.0 Ω / 1 count			0.019 Ω / 1 count			0.050 Ω / 1 count	
1000 Ω		0.038 Ω /4 counts		0 … 10000	0.1Ω / 1 count		0 … 1000	1.0 Ω / 1 count			0.038 Ω / 1 count			0.100 Ω / 1 count	
3000 Ω		0.152 Ω /4 counts		0 … 30000	0.2Ω / 2 counts		0 … 3000	1.0 Ω / 2 counts			0.152 Ω / 1 count			0.300 Ω / 1 count	

Table 13 - Effective Resolution and Range for 50-60 Hz Filter Frequency

Input Type	Raw/Proportional Data Over Full Input Range			Engineering Units x 1 Over Full Range			Engineering Units x 10 Over Full Range			Scaled for PID Over Full Range			Percent of Full Scale 0 … 100%		
	Decimal Range	Resolution		Decimal Range	Resolution		Decimal Range	Resolution		Decimal Range	Resolution		Decimal Range	Resolution	
		°C	°F		°C	°F		°C	°F		°C	°F		°C	°F
100 Ω Pt 385		0.215 °C / 14 counts	0.387 °F/ 14 counts	-2000 … 8500	0.215 °C / 2 counts	0.387 °F/ 2 counts	-200 … 850	1.0 °C /1 count	1.0 °F/ 1 count		0.215 °C / 4 counts	0.387 °F/ 4 counts		0.215 °C / 2 counts	0.387 °F/ 2 counts
200 Ω Pt 385		0.215 °C / 14 counts	0.387 °F/ 14 counts	-2000 … 8500	0.215 °C / 2 counts	0.387 °F/ 2 counts	-200 … 850	1.0 °C /1 count	1.0 °F/ 1 count		0.215 °C / 4 counts	0.387 °F/ 4 counts		0.215 °C / 2 counts	0.387 °F/ 2 counts
500 Ω Pt 385		0.172 °C / 11 counts	0.310 °F/ 11 counts	-2000 … 8500	0.172 °C / 2 counts	0.310 °F/ 2 counts	-200 … 850	1.0 °C /1 count	1.0 °F/ 1 count		0.172 °C / 2 counts	0.310 °F/ 2 counts		0.172 °C / 2 counts	0.310 °F/ 2 counts
1000 Ω Pt 385		0.172 °C / 11 counts	0.310 °F/ 11 counts	-2000 … 8500	0.172 °C / 2 counts	0.310 °F/ 2 counts	-200 … 850	1.0 °C /1 count	1.0 °F/ 1 count		0.172 °C / 2 counts	0.310 °F/ 2 counts		0.172 °C / 2 counts	0.310 °F/ 2 counts
100 Ω Pt 3916		0.203 °C / 16 counts	0.365 °F/ 16 counts	-2000 … 6300	0.203 °C / 1 count	0.365 °F/ 1 count	-200 … 630	1.0 °C / 1 count	1.0 °F/ 1 count		0.203 °C / 4 counts	0.365 °F/ 4 counts		0.203 °C / 2 counts	0.365 °F/ 2 counts
200 Ω Pt 3916		0.203 °C / 16 counts	0.365 °F/ 16 counts	-2000 … 6300	0.203 °C / 1 count	0.365 °F/ 1 count	-200 … 630	1.0 °C / 1 count	1.0 °F/ 1 count		0.203 °C / 4 counts	0.365 °F/ 4 counts		0.203 °C / 2 counts	0.365 °F/ 2 counts
500 Ω Pt 3916		0.163 °C / 13 counts	0.293 °F/ 13 counts	-2000 … 6300	0.163 °C / 2 counts	0.293 °F/ 2 counts	-200 … 630	1.0 °C / 1 count	1.0 °F/ 1 count		0.163 °C / 4 counts	0.293 °F/ 4 counts		0.163 °C / 2 counts	0.293 °F/ 2 counts
1000 Ω Pt 3916	±32767	0.163 °C / 13 counts	0.293 °F/ 13 counts	-2000 … 6300	0.163 °C / 2 counts	0.293 °F/ 2 counts	-200 … 630	1.0 °C / 1 count	1.0 °F/ 1 count	0 … 16383	0.163 °C / 4 counts	0.293 °F/ 4 counts	0 … 10000	0.163 °C / 2 counts	0.293 °F/ 2 counts
10 Ω Cu 426		0.492 °C / 64 counts	0.886 °F/ 64 counts	-1000 … 2600	0.492 °C / 8 counts	0.886 °F/ 8 counts	-100 … 260	1.0 °C / 4 counts	1.0 °F/ 4 counts		0.492 °C / 24 counts	0.886 °F/ 24 counts		0.492 °C / 16 counts	0.886 °F/ 16 counts
120 Ω Ni 618		0.110 °C / 20 counts	0.198 °F/ 20 counts	-1000 … 2600	0.110 °C / 1 count	0.198 °F/ 1 count	-100 … 260	1.0 °C / 1 count	1.0 °F/ 1 count		0.110 °C / 5 counts	0.198 °F/ 5 counts		0.110 °C / 3 counts	0.198 °F/ 3 counts
120 Ω Ni 672		0.082 °C / 16 counts	0.148 °F/ 16 counts	-800 … 2600	0.1 °C / 1 count	0.148 °F/ 1 count	-80 … 260	1.0 °C / 1 count	1.0 °F/ 1 count		0.082 °C / 4 counts	0.148 °F/ 4 counts		0.082 °C / 2 counts	0.148 °F/ 2 counts
604 Ω NiFe 518		0.098 °C / 21 counts	0.176 °F/ 21 counts	-1000 … 2000	0.1 °C / 1 counts	0.176 °F/ 1 count	-100 … 200	1.0 °C / 1 counts	1.0 °F/ 1 count		0.098 °C / 5 counts	0.176 °F/ 5 counts		0.098 °C / 3 counts	0.176 °F/ 3 counts
150 Ω		0.038 Ω /16 counts		0 … 15000	0.1Ω / 4 counts		0 … 1500	1.0 Ω /1 count			0.038 Ω / 4 counts			0.038 Ω / 2 counts	
500 Ω		0.076 Ω /10 counts		0 … 5000	0.1Ω / 1 count		0 … 500	1.0 Ω / 1 count			0.076 Ω / 2 counts			0.076 Ω / 2 counts	
1000 Ω		0.152 Ω /10 counts		0 … 10000	0.152 Ω / 2 counts		0 … 1000	1.0 Ω / 1 count			0.152 Ω / 2 counts			0.152 Ω / 2 counts	
3000 Ω		0.608 Ω /13 counts		0 … 30000	0.608 Ω / 6 counts		0 … 3000	1.0Ω /1 count			0.608 Ω /3 counts			0.608 Ω /2 counts	

Table 14 - Effective Resolution and Range for 250 Hz Filter Frequency

Input Type	Raw/Proportional Data Over Full Input Range			Engineering Units x 1 Over Full Range			Engineering Units x 10 Over Full Range			Scaled for PID Over Full Range			Percent of Full Scale 0 … 100%		
	Decimal Range	Resolution		Decimal Range	Resolution		Decimal Range	Resolution		Decimal Range	Resolution		Decimal Range	Resolution	
		°C	°F		°C	°F		°C	°F		°C	°F		°C	°F
100 Ω Pt 385	±32767	0.858 °C / 32 counts	1.54 °F/ 32 counts	-2000 … 8500	0.858 °C / 8 counts	1.54 °F/ 8 counts	-200 … 850	1.0 °C / 1 count	1.54 °F/1 count	0 … 16383	0.858 °C / 32 counts	1.54 °F/ 32 counts	0 … 10000	0.429 °C / 8 counts	1.54 °F/ 32 counts
200 Ω Pt 385		0.858 °C / 32 counts	1.54 °F/ 32 counts	-2000 … 8500	0.858 °C / 8 counts	1.54 °F/ 8 counts	-200 … 850	1.0 °C / 1 count	1.54 °F/ 1 count		0.858 °C / 14 counts	1.54 °F/ 14 counts		0.429 °C / 8 counts	1.54 °F/ 8 counts
500 Ω Pt 385		0.687 °C / 32 counts	1.34 °F/ 32 counts	-2000 … 8500	0.687 °C / 8 counts	1.34 °F/ 8 counts	-200 … 850	1.0 °C / 1 count	1.34 °F/1 count		0.687 °C / 10 counts	1.34 °F/ 10 counts		0.343 °C / 6 counts	1.34 °F/6 counts
1000 Ω Pt 385		0.485 °C / 32 counts	0.873 °F/ 32 counts	-2000 … 8500	0.485 °C / 8 counts	0.873 °F/ 8 counts	-200 … 850	1.0 °C / 1 count	1.0 °F/ 1 count		0.485 °C / 12 counts	0.873 °F/ 12 counts		0.243 °C / 4 counts	0.873 °F/ 4 counts
100 Ω Pt 3916		0.814 °C / 32 counts	1.46 °F/ 32 counts	-2000 … 6300	0.814 °C / 8 counts	1.46 °F/ 8 counts	-200 … 630	1.0 °C / 1 count	1.46 °F/ 1 count		0.814 °C / 16 counts	1.46 °F/ 16 counts		0.407 °C / 10 counts	1.46 °F/ 10 counts
200 Ω Pt 3916		0.814 °C / 32 counts	1.46 °F/ 32 counts	-2000 … 6300	0.814 °C / 8 counts	1.46 °F/ 8 counts	-200 … 630	1.0 °C / 1 count	1.46 °F/ 1 count		0.814 °C / 16 counts	1.46 °F/ 16 counts		0.407 °C / 10 counts	1.46 °F/ 10 counts
500 Ω Pt 3916		0.651 °C / 32 counts	1.17 °F/ 32 counts	-2000 … 6300	0.651 °C / 8 counts	1.17 °F/ 8 counts	-200 … 630	1.0 °C / 1 count	1.17 °F/ 1 count		0.651 °C / 12 counts	1.17 °F/ 12 counts		0.326 °C / 8 counts	1.17 °F/8 counts
1000 Ω Pt 3916		0.460 °C / 16 counts	0.828 °F/ 16 counts	-2000 … 6300	0.460 °C / 8 counts	0.828 °F/ 8 counts	-200 … 630	1.0 °C / 1 count	1.0 °F/ 1 count		0.460 °C / 10 counts	0.828 °F/ 10 counts		0.230 °C / 6 counts	0.828 °F/ 6 counts
10 Ω Cu 426		0.984 °C / 128 counts	1.77 °F/ 128 counts	-1000 … 2600	0.984 °C / 32 counts	1.77 °F/ 32 counts	-100 … 260	1.0 °C / 4 counts	1.77 °F/ 4 counts		0.984 °C / 88 counts	1.77 °F/ 88 counts		0.984 °C / 56 counts	1.77 °F/ 56 counts
120 Ω Ni 618		0.442 °C / 32 counts	0.796 °F/ 32 counts	-1000 … 2600	0.442 °C / 8 counts	0.796 °F/ 8 counts	-100 … 260	1.0 °C / 1 count	1.0 °F/1 count		0.442 °C / 20 counts	0.796 °F/ 20 counts		0.221 °C / 12 counts	0.796 °F/ 12 counts
120 Ω Ni 672		0.329 °C / 32 counts	0.592 °F/ 32 counts	-800 … 2600	0.329 °C / 8 counts	0.592 °F/ 8 counts	-80 … 260	1.0 °C / 1 count	1.0 °F/ 1 count		0.329 °C / 32 counts	0.592 °F/ 32 counts		0.165 °C / 10 counts	0.592 °F/ 10 counts
604 Ω NiFe 518		0.555 °C / 32 counts	1.00 °F/ 32 counts	-1000 … 2000	0.555 °C / 8 counts	1.00 °F/ 8 counts	-100 … 200	1.0 °C / 1 count	1.0 °F/ 1 count		0.555 °C / 14 counts	1.00 °F/ 14 counts		0.278 °C / 18 counts	1.00 °F/ 18 counts
150 Ω		0.152 Ω /32 counts		0 … 15000	0.152 Ω /8 counts		0 … 1500	1.0 Ω /1 count			0.152 Ω /16 counts			0.076 Ω /10 counts	
500 Ω		0.304 Ω /32 counts		0 … 5000	0.304 Ω /8 counts		0 … 500	1.0 Ω /1 count			0.304 Ω /10 counts			0.152 Ω /6 counts	
1000 Ω		0.608 Ω /32 counts		0 … 10000	0.608 Ω /8 counts		0 … 1000	1.0 Ω /1 count			0.608 Ω /10 counts			0.304 Ω /6 counts	
3000 Ω		1.720 Ω /32 counts		0 … 30000	1.720 Ω /16 counts		0 … 3000	1.720 Ω /2 counts			1.720 Ω /10 counts			0.860 Ω /3 counts	

Table 15 - Effective Resolution and Range for 500 Hz Filter Frequency

Input Type	Raw/Proportional Data Over Full Input Range			Engineering Units x 1 Over Full Range			Engineering Units x 10 Over Full Range			Scaled for PID Over Full Range			Percent of Full Scale 0 … 100%		
	Decimal Range	Resolution		Decimal Range	Resolution		Decimal Range	Resolution		Decimal Range	Resolution		Decimal Range	Resolution	
		°C	°F		°C	°F		°C	°F		°C	°F		°C	°F
100 Ω Pt 385	±32767	2.42 °C / 151 counts	4.35 °F/ 151 counts	-2000 … 8500	2.42 °C / 24 counts	4.35 °F/ 24 counts	-200 … 850	2.42 °C / 2.4 counts	4.35 °F/ 2.4 counts	0 … 16383	2.42 °C / 37 counts	4.35 °F/ 37 counts	0 … 10000	2.42 °C / 23 counts	4.35 °F/ 23 counts
200 Ω Pt 385		1.72 °C / 107 counts	3.10 °F/ 107 counts	-2000 … 8500	1.72 °C / 14 counts	3.10 °F/ 14 counts	-200 … 850	1.72 °C / 1.7 counts	3.10 °F/ 1.7 counts		1.72 °C / 26.7 counts	3.10 °F/ 26.7 counts		1.72 °C / 16 counts	3.10 °F/ 16 counts
500 Ω Pt 385		1.37 °C / 85 counts	2.47 °F/ 85 counts	-2000 … 8500	1.37 °C / 14 counts	2.47 °F/ 14 counts	-200 … 850	1.37 °C / 1.37 counts	2.47 °F/ 1.37 counts		1.37 °C / 21 counts	2.47 °F/ 21 counts		1.37 °C / 13 counts	2.47 °F/ 13 counts
1000 Ω Pt 385		1.37 °C / 85 counts	2.47 °F/ 85 counts	-2000 … 8500	1.37 °C / 14 counts	2.47 °F/ 14 counts	-200 … 850	1.37 °C / 1.37 counts	2.47 °F/ 1.37 counts		1.37 °C / 21 counts	2.47 °F/ 21 counts		1.37 °C / 13 counts	2.47 °F/ 13 counts
100 Ω Pt 3916		2.30 °C / 181 counts	4.14 °F/ 181 counts	-2000 … 6300	2.30 °C / 23 counts	4.14 °F/ 23 counts	-200 … 630	2.30 °C / 181 counts	4.14 °F/ 181 counts		2.30 °C / 45 counts	4.14 °F/ 45 counts		2.30 °C / 28 counts	4.14 °F/ 28 counts
200 Ω Pt 3916		1.63 °C / 128 counts	2.93 °F/ 128 counts	-2000 … 6300	1.63 °C / 16 counts	2.93 °F/ 16 counts	-200 … 630	1.63 °C / 1.63 counts	2.93 °F/ 1.63 counts		1.63 °C / 32 counts	2.93 °F/ 32 counts		1.63 °C / 20 counts	2.93 °F/ 20 counts
500 Ω Pt 3916		1.30 °C / 102 counts	2.34 °F/ 102 counts	-2000 … 6300	1.30 °C / 13 counts	2.34 °F/ 13 counts	-200 … 630	1.30 °C / 1.3 counts	2.34 °F/ 1.3 counts		1.30 °C / 26 counts	2.34 °F/ 26 counts		1.30 °C / 16 counts	2.34 °F/ 16 counts
1000 Ω Pt 3916		1.30 °C / 102 counts	2.34 °F/ 102 counts	-2000 … 6300	1.30 °C / 13 counts	2.34 °F/ 13 counts	-200 … 630	1.30 °C / 1.3 counts	2.34 °F/ 1.3 counts		1.30 °C / 26 counts	2.34 °F/ 26 counts		1.30 °C / 16 counts	2.34 °F/ 16 counts
10 Ω Cu 426		2.78 °C / 506 counts	5.00 °F/ 506 counts	-1000 … 2600	2.78 °C / 28 counts	5.00 °F/ 28 counts	-100 … 260	2.78 °C / 2.78 counts	5.00 °F/ 2.78 counts		2.78 °C / 127 counts	5.00 °F/ 127 counts		2.78 °C / 77 counts	5.00 °F/ 77 counts
120 Ω Ni 618		1.25 °C / 227 counts	2.25 °F/ 227 counts	-1000 … 2600	1.25 °C / 9 counts	2.25 °F/ 9 counts	-100 … 260	1.25 °C / 1.25 counts	2.25 °F/ 1.25 counts		1.25 °C / 45 counts	2.25 °F/ 45 counts		1.25 °C / 35 counts	2.25 °F/ 35 counts
120 Ω Ni 672		0.93 °C / 180 counts	1.67 °F/ 180 counts	-800 … 2600	0.93 °C / 9 counts	1.67 °F/ 9 counts	-80 … 260	1.0 °C / 0.93 counts	1.67 °F/ 0.93 counts		0.93 °C / 32 counts	1.67 °F/ 32 counts		0.93 °C / 27 counts	1.67 °F/ 27 counts
604 Ω NiFe 518		0.78 °C / 172 counts	1.40 °F/ 172 counts	-1000 … 2000	0.78 °C / 8 counts	1.40 °F/ 8 counts	-100 … 200	1.0 °C / 0.785 counts	1.40 °F/ 0.785 counts		0.78 °C / 47 counts	1.40 °F/ 47 counts		0.78 °C / 26 counts	1.40 °F/ 26 counts
150 Ω		0.43 Ω /188 counts		0 … 15000	0.43 Ω /43 counts		0 … 1500	1.0 Ω /4.3 counts			0.43 Ω /47 counts			0.43 Ω /29 counts	
500 Ω		0.86 Ω /113 counts		0 … 5000	0.86 Ω /8.6 counts		0 … 500	1.0 Ω /.86 counts			0.86 Ω /20 counts			0.86 Ω /17 counts	
1000 Ω		1.22 Ω /80 counts		0 … 10000	1.22 Ω /12 counts		0 … 1000	1.22 Ω /1.2 counts			1.22 Ω /20 counts			1.22 Ω /12 counts	
3000 Ω		4.86 Ω /106 counts		0 … 30000	4.86 Ω /48 counts		0 … 3000	4.86 Ω /4.86 counts			4.86 Ω /27 counts			4.86 Ω /16 counts	

Table 16 - Effective Resolution and Range for 1 kHz Filter Frequency

Input Type	Raw/Proportional Data Over Full Input Range			Engineering Units x 1 Over Full Range			Engineering Units x 10 Over Full Range			Scaled for PID Over Full Range			Percent of Full Scale 0 … 100%		
	Decimal Range	Resolution		Decimal Range	Resolution		Decimal Range	Resolution		Decimal Range	Resolution		Decimal Range	Resolution	
		°C	°F		°C	°F		°C	°F		°C	°F		°C	°F
100 Ω Pt 385	±32767	13.7 °C / 857 counts	24.6 °F/ 857 counts	-2000 … 8500	13.7 °C / 137 counts	24.6 °F/ 137 counts	-200 … 850	13.7 °C / 14 counts	24.6 °F/ 14 counts	0 … 16383	13.7 °C / 214 counts	24.6 °F/ 214 counts	0 … 10000	13.7 °C / 130 counts	24.6 °F/ 130 counts
200 Ω Pt 385		13.7 °C / 857 counts	24.6 °F/ 857 counts	-2000 … 8500	13.7 °C / 137 counts	24.6 °F/ 137 counts	-200 … 850	13.7 °C / 14 counts	24.6 °F/ 14 counts		13.7 °C / 214 counts	24.6 °F/ 214 counts		13.7 °C / 130 counts	24.6 °F/ 130 counts
500 Ω Pt 385		10.9 °C / 686 counts	19.6 °F/ 686 counts	-2000 … 8500	10.9 °C / 110 counts	19.6 °F/ 110 counts	-200 … 850	10.9 °C / 11 counts	19.6 °F/ 11 counts		10.9 °C / 171 counts	19.6 °F/ 171 counts		10.9 °C / 105 counts	19.6 °F/ 105 counts
1000 Ω Pt 385		7.77 °C / 485 counts	13.9 °F/ 485 counts	-2000 … 8500	7.77 °C / 78 counts	13.9 °F/ 78 counts	-200 … 850	7.77 °C / 7.7 counts	13.9 °F/ 7.7 counts		7.77 °C / 121 counts	13.9 °F/ 121 counts		7.77 °C / 74 counts	13.9 °F/ 74 counts
100 Ω Pt 3916		13.0 °C / 1028 counts	23.4 °F/ 1028 counts	-2000 … 6300	13.0 °C / 130 counts	23.4 °F/ 130 counts	-200 … 630	13.0 °C / 13 counts	23.4 °F/ 13 counts		13.0 °C / 257 counts	23.4 °F/ 257 counts		13.0 °C / 157 counts	23.4 °F/ 157 counts
200 Ω Pt 3916		13.0 °C / 1028 counts	23.4 °F/ 1028 counts	-2000 … 6300	13.0 °C / 130 counts	23.4 °F/ 130 counts	-200 … 630	13.0 °C / 13 counts	23.4 °F/ 13 counts		13.0 °C / 257 counts	23.4 °F/ 257 counts		13.0 °C / 157 counts	23.4 °F/ 157 counts
500 Ω Pt 3916		10.4 °C / 822 counts	18.7 °F/ 822 counts	-2000 … 6300	10.4 °C / 104 counts	18.7 °F/ 104 counts	-200 … 630	10.4 °C / 10 counts	18.7 °F/ 10 counts		10.4 °C / 205 counts	18.7 °F/ 205 counts		10.4 °C / 125 counts	18.7 °F/ 125 counts
1000 Pt 3916		7.36 °C / 582 counts	13.2 °F/ 582 counts	-2000 … 6300	7.36 °C / 74 counts	13.2 °F/ 74 counts	-200 … 630	7.36 °C / 7.3 counts	13.2 °F/ 7.3 counts		7.36 °C / 145 counts	13.2 °F/ 145 counts		7.36 °C / 89 counts	13.2 °F/ 89 counts
10 Ω Cu 426		15.7 °C / 2864 count	28.2 °F/ 2864 counts	-1000 … 2600	15.7 °C / 157 count	28.2 °F/ 157 counts	-100 … 260	15.7 °C / 15.7 count	28.2 °F/ 15.7 counts		15.7 °C / 716 count	28.2 °F/ 716 counts		15.7 °C / 437 count	28.2 °F/ 437 counts
120 Ω Ni 618		7.0 °C / 1286 counts	12.6 °F/ 1286 counts	-1000 … 2600	7.0 °C / 71 counts	12.6 °F/ 71 counts	-100 … 260	7.0 °C / 7.0 counts	12.6 °F/ 7.0 counts		7.0 °C / 321 counts	12.6 °F/ 321 counts		7.0 °C / 196 counts	12.6 °F/ 196 counts
120 Ω Ni 672		5.2 °C / 1016 counts	9.36 °F/ 1016 counts	-800 … 2600	5.2 °C / 52 counts	9.36 °F/ 52 counts	-80 … 260	5.2 °C / 5.2 counts	9.36 °F/ 5.2 counts		5.2 °C / 254 counts	9.36 °F/ 254 counts		5.2 °C / 155 counts	9.36 °F/ 155 counts
604 Ω NiFe 518		6.2 °C / 1372 counts	11.2 °F/ 1372 counts	-1000 … 2000	6.2 °C / 63 counts	11.2 °F/ 63 counts	-100 … 200	6.2 °C / 6.2 counts	11.2 °F/ 6.2 counts		6.2 °C / 343 counts	11.2 °F/ 343 counts		6.2 °C / 209 counts	11.2 °F/ 209 counts
150 Ω		2.4 Ω /1062 counts		0 … 15000	2.4 Ω /243 counts		0 … 1500	2.4Ω /24 counts			2.4 Ω /265 counts			2.4 Ω /162 counts	
500 Ω		4.8 Ω /637 counts		0 … 5000	4.8 Ω /48 counts		0 … 500	4.8Ω /4.8 counts			4.8 Ω /159 counts			4.8 Ω /97 counts	
1000 Ω		9.7 Ω /637 counts		0 … 10000	9.7 Ω /97 counts		0 … 1000	9.7Ω /9.7 counts			9.7 Ω /159 counts			9.7 Ω /97 counts	
3000 Ω		27.5 Ω /600 counts		0 … 30000	27.5 Ω /275 counts		0 … 3000	27.5Ω /27 counts			27.5 Ω /150 counts			27.5 Ω /91 counts	

The table below identifies the number of significant bits used to represent the input data for each available filter frequency. The number of significant bits is defined as the number of bits that will have little or no jitter due to noise, and is used in defining the effective resolution. Note that the resolutions provided by the filters apply to the raw/proportional data format only.

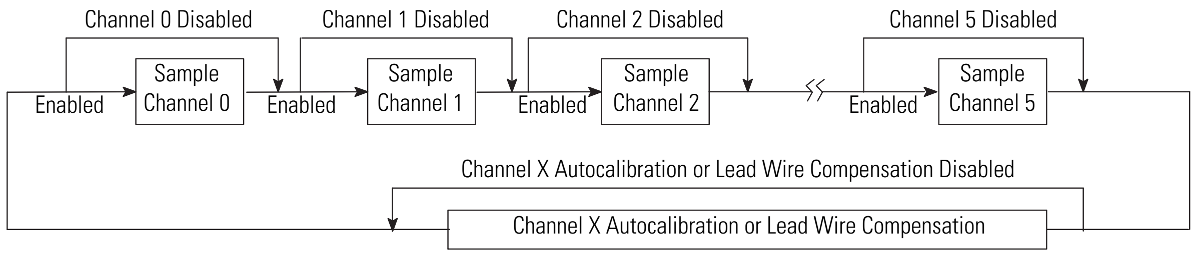
Table 17 - Input Effective Resolution Versus Input Filter Selection (Across Full Raw/Proportional Range)

Input Type	Number of Significant Bits				
	10 Hz	50/60 Hz	250 Hz	500 Hz	1000 Hz
100 Ω Platinum 385	Sign + 13 bits	Sign + 11 bits	Sign + 9 bits	Sign + 8 bits	Sign + 6 bits
200 Ω Platinum 385	Sign + 13 bits	Sign + 11 bits	Sign + 9 bits	Sign + 8 bits	Sign + 6 bits
500 Ω Platinum 385 with 0.5 mA excitation current	Sign + 13 bits	Sign + 11 bits	Sign + 9 bits	Sign + 8 bits	Sign + 6 bits
500 Ω Platinum 385 with 1.0 mA excitation current	Sign + 13 bits	Sign + 11 bits	Sign + 9 bits	Sign + 8 bits	Sign + 7 bits
1000 Ω Platinum 385 with 0.5 mA excitation current	Sign + 13 bits	Sign + 11 bits	Sign + 9 bits	Sign + 8 bits	Sign + 6 bits
1000 Ω Platinum 385 with 1.0 mA excitation current	not valid				
100 Ω Platinum 3916	Sign + 13 bits	Sign + 11 bits	Sign + 9 bits	Sign + 8 bits	Sign + 6 bits
200 Ω Platinum 3916	Sign + 13 bits	Sign + 11 bits	Sign + 9 bits	Sign + 8 bits	Sign + 6 bits
500 Ω Platinum 3916 with 0.5 mA excitation current	Sign + 13 bits	Sign + 11 bits	Sign + 9 bits	Sign + 8 bits	Sign + 6 bits
500 Ω Platinum 3916 with 1.0 mA excitation current	Sign + 13 bits	Sign + 11 bits	Sign + 9 bits	Sign + 8 bits	Sign + 7 bits
1000 Ω Platinum 3916 with 0.5 mA excitation current	Sign + 13 bits	Sign + 11 bits	Sign + 9 bits	Sign + 8 bits	Sign + 6 bits
1000 Ω Platinum 3916 with 1.0 mA excitation current	not valid				
10 Ω Copper 426 with 0.5 mA excitation current	not valid				
10 Ω Copper 426 with 1.0 mA excitation current	Sign + 11 bits	Sign + 10 bits	Sign + 9 bits	Sign + 8 bits	Sign + 6 bits
120 Ω Nickel 618	Sign + 13 bits	Sign + 11 bits	Sign + 9 bits	Sign + 8 bits	Sign + 6 bits
120 Ω Nickel 672	Sign + 13 bits	Sign + 11 bits	Sign + 9 bits	Sign + 8 bits	Sign + 6 bits
604 Ω Nickel-Iron 518 with 0.5 mA excitation current	Sign + 13 bits	Sign + 11 bits	Sign + 9 bits	Sign + 8 bits	Sign + 6 bits
604 Ω Nickel-Iron 518 with 1.0 mA excitation current	Sign + 13 bits	Sign + 11 bits	Sign + 9 bits	Sign + 8 bits	Sign + 7 bits
150 Ω with 0.5 mA excitation current	Sign + 13 bits	Sign + 11 bits	Sign + 9 bits	Sign + 8 bits	Sign + 6 bits
150 Ω with 1.0 mA excitation current	Sign + 13 bits	Sign + 11 bits	Sign + 9 bits	Sign + 8 bits	Sign + 6 bits
500 Ω	Sign + 13 bits	Sign + 11 bits	Sign + 9 bits	Sign + 8 bits	Sign + 6 bits
1000 Ω with 0.5 mA excitation current	Sign + 13 bits	Sign + 11 bits	Sign + 9 bits	Sign + 8 bits	Sign + 6 bits
1000 Ω with 1.0 mA excitation current	not valid				
3000 Ω with 0.5 mA excitation current	Sign + 13 bits	Sign + 11 bits	Sign + 9 bits	Sign + 8 bits	Sign + 6 bits
3000 Ω with 1.0 mA excitation current	not valid				

Determining Module Update Time

The module update time is defined as the time required for the module to sample and convert the input signals of all enabled input channels and provide the resulting data values to the processor. The module sequentially samples the channels in a continuous loop as shown below.

Module Update Sequence



Module update time is dependent on the number of input channels enabled, input filter selection, and whether or not a calibration or lead wire compensation sequence is in progress.

The fastest module update time occurs when only one channel is enabled with a 1 kHz filter, with autocalibration and cyclic lead compensation disabled. If more than one channel is enabled, the update time is faster if all channels use the fastest filter, as shown in example 1 below. The slowest module update time occurs when all six channels are enabled with the 10Hz filter.

The following table shows the channel update times for all filter frequencies assuming that no calibration or lead wire compensation is in progress.

Table 18 - Channel Update Time versus Filter Frequency

Filter Frequency	Maximum Channel Update Time(1)	
	with 1 channel enabled	with 6 channels enabled
10 Hz	303 ms	1818 ms
50 Hz	63 ms	378 ms
60 Hz	53 ms	318 ms
250 Hz	15 ms	90 ms
500 Hz	9 ms	54 ms
1 kHz	6 ms	36 ms

(1) Update times do not include cyclic calibration or lead wire compensation.

Module update time can be calculated by obtaining the sum of all enabled channel update times. Channel update times include channel scan time, channel switching time, and reconfiguration time.

EXAMPLE

1. Module Update Time with all channels enabled and configured with 10Hz filter = 6 x 303 ms = 1818 ms
2. Module Update Time with all channels enabled and using the 1 kHz filter = 6 x 6 ms = 36 ms

Effects of Autocalibration on Module Update Time

The module's autocalibration feature lets it correct for accuracy errors caused by component temperature drift over the module operating temperature range (0…60 °C). Autocalibration occurs automatically on a system mode change from Program-to-Run for all configured channels. It also occurs if any online(1) configuration change is made to a channel. In addition, the module lets you configure it to perform an autocalibration cycle every 5 minutes during normal operation or to disable this feature using the Enable/Disable Cyclic Calibration function (default: Enable). With this feature, you can implement a calibration cycle anytime, using your control program to enable and then disable this bit.(1)

If you enable the autocalibration function, the module update time increases when the autocalibration cycle occurs. To limit its impact on module update time, the autocalibration function is divided over several module scans.

Each enabled channel requires a separate 6-step cycle, unless *any* enabled channel to be scanned (see Module Update Sequence on page 72) uses an Input Type of the same Input Class (see Table 20 -) as *any previously calibrated* channel. In that case, the calibration values from the previous channel are used, and no additional calibration cycle time is required. The module current source (0.5 mA and 1.0 mA) is also calibrated(2) during an autocalibration cycle to ensure its accuracy. This uses a single module scan cycle for all enabled channels. The following table defines these calibration steps, and the time added to the normal module update time per step for each channel. The calibration times are independent of the channel filter frequency selected.

(1) Not all controllers allow online configuration changes. Refer to your controller's user manual for details. During an online configuration change, input data for that channel is not updated by the module.
(2) "Current source zero" and "current source gain" calibration times from Table 19 - are not needed if Class 3 input type is selected.

Table 19 - Calibration Steps and Their Affect on Module Update Time

Calibration Step	Calibration Time (ms)
Step 1 RTD ADC zero	73 ms
Step 2 RTD ADC span	106 ms
Step 3 RTD system zero	73 ms
Step 4 RTD ADC wire zero	73 ms
Step 5 RTD ADC wire span	106 ms
Step 6 system wire zero	73 ms
Current Source Calibration	**Calibration Time (ms)**
Current source zero	73 ms
Current source gain	106 ms
Current source resistor calibration	303 ms

Table 20 - Input Type and Class

Input Type	Input Class	
	Using 0.5 mA Source	Using 1.0 mA Source
100 Ω Pt 385	1	2
200 Ω Pt 385	2	3
500 Ω Pt 385	3	4
1000 Ω Pt 385	4	Cannot use this source
100 Ω Pt 3916	1	2
200 Ω Pt 3916	2	3
500 Ω Pt 3916	3	4
1000 Ω Pt 3916	4	Cannot use this source
10 Ω Cu 426	Cannot use this source	6
120 Ω Ni 618	1	2
120 Ω Ni 672	1	2
604 Ω NiFe 518	3	4
150 Ω	5	1
500 Ω	1	2
1000 Ω	2	3
3000 Ω	4	Cannot use this source

Calculating Module Update Time with Autocalibration Enabled

The following example illustrates how to determine module update time with autocalibration enabled.

EXAMPLE **Two Channels Enabled Using the Same Input Class with Cyclic Calibration Enabled**

Channel 0 Input: 100 Ω Platinum 385, 1.0 mA source (Class 2) with 60 Hz filter
Channel 1 Input: 1000 Ω resistance, 0.5 mA source (Class 2) with 60 Hz filter

From Table 18, Channel Update Time versus Filter Frequency, on page 4-72:

1. Calculate Module Update Time *without* an Autocalibration Cycle

= Ch 0 Update Time + Ch 1 Update Time = 53 ms + 53 ms = 106 ms

2. Calculate Module Update Time *during* an Autocalibration Cycle

Channel 0 Step 1 (Module Scan 1)
= Ch 0 Update Time + Ch 1 Update Time + *Ch 0 Offset Time* = 53 ms + 53 ms + *73* ms = 179 ms

Channel 0 Step 2 (Module Scan 2)
= Ch 0 Update Time + Ch 1 Update Time + *Ch 0 Gain Time* = 53 ms + 53 ms + *106* ms = 212 ms

Channel 0, Step 3 (Module Scan 3)
= Ch 0 Update Time + Ch 1 Update Time + *Ch 0 Gain Time* = 53 ms + 53 ms + *73* ms = 179 ms

Channel 0, Step 4 (Module Scan 4)
= Ch 0 Update Time + Ch 1 Update Time + *Ch 0 Gain Time* = 53 ms + 53 ms + *73* ms = 179 ms

Channel 0 Step 5 (Module Scan 5)
= Ch 0 Update Time + Ch 1 Update Time + *Ch 0 Gain Time* = 53 ms + 53 ms + *106* ms = 212 ms

Channel 0 Step 6 (Module Scan 6)
= Ch 0 Update Time + Ch 1 Update Time + *Ch 0 Gain Time* = 53 ms + 53 ms + *73* ms = 179 ms

The above 6-step cycle could potentially take place for channel 1 as well. However, since channel 1 is the same input class as channel 0, it uses the same calibration factors as channel 0, and no additional time is required. At this point, the current source calibration cycle is run.

Current Source (Module Scan 7)
= Ch 0 Update Time + Ch 1 Update Time + *Current Source Offset Time*
= 53 ms + 53 ms + *73* ms = 179 ms

Current Source (Module Scan 8)
= Ch 0 Update Time + Ch 1 Update Time + *Current Source Offset Time*
= 53 ms + 53 ms + *106* ms = 212 ms

Current Source (Module Scan 9)
= Ch 0 Update Time + Ch 1 Update Time + *Current Source Resistor Time*
= 53 ms + 53 ms + *303* ms = 409 ms

3. Calculate Total Time to Complete Autocalibration Cycle

= (Channel Step Times) + (Current Source Times)
= (179 ms + 212 ms + 179 ms + 179 ms + 212 ms + 179 ms) + (179 ms + 212 ms + 409 ms)
= 1140 ms + 800 ms = 1940 ms = 1.940 seconds

After the above cycles are complete, the module returns to scans without autocalibration for approximately 5 minutes. At that time, the autocalibration cycle repeats.

If both cyclic autocalibration and lead wire compensation (see page 4-76) are enabled, the two functions run concurrent to one another.

Effects of Cyclic Lead Wire Compensation on Module Update Time

The 1769-IR6 module provides the option to enable lead wire compensation for each channel. This feature improves measurement accuracy for 3- and 4-wire RTDs by compensating for the resistance of the RTD lead wire. Lead wire compensation occurs automatically on a mode change from Program-to-Run for all configured channels or if any online(1) configuration change is made to a channel regardless of the type of RTD being used. In addition, you can either configure the module to perform a lead wire compensation cycle every 5 minutes during normal operation or disable this feature using the Enable/ Disable Cyclic Lead Wire function (default: Enable). You can also implement a lead wire compensation cycle anytime, using your control program to enable and then disable this function.(1)

If you enable the cyclic lead wire compensation function, the module update time will increase when the lead wire compensation cycle occurs. To limit its impact on module update time, the lead wire compensation function is divided over 3 module scans. The amount of time added for lead wire compensation per module scan depends on the filter frequency (channel update time) selected for that channel.

(1) Not all controllers allow online configuration changes. Refer to your controller’s user manual for details. During an online configuration change, input data for that channel is not updated by the module.

Calculating Module Update Time with Cyclic Lead Wire Compensation Enabled

The following example illustrates how to determine module update time with cyclic lead wire compensation enabled.

EXAMPLE **Two Channels Configured with Cyclic Lead Wire Compensation Enabled**

Channel 0 Input: 100 Ω Platinum 385 with 60 Hz filter (use 60 Hz filter for lead wire)
Channel 1 Input: 100 Ω Platinum 385 with 250 Hz filter (use 250 Hz filter for lead wire)

From Table 18, Channel Update Time versus Filter Frequency, on page 4-72:

1. Calculate Module Update Time *without* a Lead Wire Compensation Cycle

= Ch 0 Update Time + Ch 1 Update Time = 53 ms + 15 ms = 68 ms

2. Calculate Module Update Time *during* a Lead Wire Compensation Cycle

Channel 0 Scan 1 (Module Scan 1)
Ch 0 Update Time + *Ch 0 Lead Wire Compensation Time* + Ch 1 Update Time
= 53 ms + *53* ms + 15 ms = 121 ms

The above module update time impact lasts for two more module scans, before the lead-wire compensation cycle is complete for Channel 0:

Channel 0 Lead Wire Compensation Cycle Time
= (3 x 121 ms) = 363 ms.

After that, a 3-scan lead wire cycle begins for Channel 1:

Channel 1 Scan 1 (Module Scan 4)
= Ch 0 Update Time + Ch 1 Update Time + *Ch 1 Lead Wire Compensation Time*
= 53 ms + 15 ms + *15* ms = 83 ms

The above module update time impact lasts for two more module scans, before the lead-wire compensation cycle is complete for Channel 1:

Channel 1 Lead Wire Compensation Cycle Time
= (3 x 83 ms) = 249 ms.

3. Calculate Total Time to Complete Lead Wire Compensation Cycle

= (Ch 0 Lead Wire Compensation Cycle Time) + (Ch 1 Lead Wire Compensation Cycle Time)
= (363 ms) + (249 ms)
= 612 ms = 0.612 seconds

After the above cycles are complete, the module returns to scans without lead wire compensation for approximately 5 minutes. At that time, the lead wire compensation cycle repeats.

If both cyclic autocalibration (see page 4-73) and lead wire compensation are enabled, the two functions run concurrent to one another.

Impact of Autocalibration and Lead Wire Compensation on Module Startup

Regardless of the selection of the Enable/Disable Cyclic Calibration and Enable/Disable Cyclic Lead Calibration functions, an cycle of both of these functions occurs automatically on a mode change from Program-to-Run and on subsequent module startups/initialization for all configured channels. During module startup, input data is not updated by the module until the calibration and compensation cycles are complete. During this time the General Status bits (S0…S5) are set to 1, indicating a Data Not Valid condition. The time it takes the module to startup is dependent on channel filter frequency selections and other items defined in the previous sections. The following examples show how to calculate the module startup time.

EXAMPLE

1. **Six Channels Enabled with Same Configurations**

   All 6 Channels: 100 Ω Platinum 385 RTD, 1.0 mA current source, 60 Hz filter

   Module Startup Time
   = (6-step Calibration Time + Current Source Calibration Time)
   + (Lead Wire Compensation Time x 6 channels)
   + (Channel 0…5 Data Acquisition Time)
   = (504 ms + 482 ms) + (53 ms x 6) + (53 ms x 6)
   = 986 ms + 318 ms + 318 ms = 1622 ms = 1.622 seconds

2. **Six Channels Enabled with Different Configurations (worst-case startup time)**

   All 6 Channels: 100 Ω Platinum 385 RTD, 1.0 mA current source, 60 Hz filter

   Module Startup Time
   = [(6-step Calibration Time x 6 channels) + Current Source Calibration Time] + (Lead Wire Compensation Time for Ch 0 to 5 x 3) + (Channel 0 to 5 Data Acquisition Time)
   = [(504 ms x 6) + 482 ms] + (449 ms x 3)
   + (303 ms + 63 ms + 53 ms + 15 ms + 9 ms + 6 ms)
   = 3506 ms + 1347 ms + 449 ms = 5302 ms = 5.302 seconds

Effects of Autocalibration on Accuracy

The module performs autocalibration to correct for drift errors over temperature. Autocalibration occurs immediately following configuration of a previously unselected channel, during power cycle of enable channels and every 5 minutes if so configured. The table below shows module accuracy with and without calibration.

Table 21 - Module Accuracy

Input Type(1) (2)	With Autocalibration		Without Autocalibration
	Maximum Error at 25 °C (77 °F)	Maximum Error at 60 °C (140 °F)	Temperature Drift (0…60 °C) (32…140 °F)
100 Ω Platinum 385	±0.5 °C (±0.9 °F)	±0.9 °C (±1.62 °F)	±0.026 °C/°C (±0.026 °F/°F)
200 Ω Platinum 385	±0.5 °C (±0.9 °F)	±0.9 °C (±1.62 °F)	±0.026 °C/°C (±0.026 °F/°F)
500 Ω Platinum 385	±0.5 °C (±0.9 °F)	±0.9 °C (±1.62 °F)	±0.026 °C/°C (±0.026 °F/°F)
1000 Ω Platinum 385	±0.5 °C (±0.9 °F)	±0.9 °C (±1.62 °F)	±0.026 °C/°C (±0.026 °F/°F)
100 Ω Platinum 3916	±0.4 °C (±0.72 °F)	±0.8 °C (±1.44 °F)	±0.023 °C/°C (±0.023 °F/°F)
200 Ω Platinum 3916	±0.4 °C (±0.72 °F)	±0.8 °C (±1.44 °F)	±0.023 °C/°C (±0.023 °F/°F)
500 Ω Platinum 3916	±0.4 °C (±0.72 °F)	±0.8 °C (±1.44 °F)	±0.023 °C/°C (±0.023 °F/°F)
1000 Ω Platinum 3916	±0.4 °C (±0.72 °F)	±0.8 °C (±1.44 °F)	±0.023 °C/°C (±0.023 °F/°F)
10 Ω Copper 426	±0.8 °C (±1.44 °F)	±1.1 °C (±1.98 °F)	±0.032 °C/°C (±0.032 °F/°F)
120 Ω Nickel 618	±0.3 °C (±0.54 °F)	±0.5 °C (±0.9 °F)	±0.012 °C/°C (±0.012 °F/°F)
120 Ω Nickel 672	±0.3 °C (±0.54 °F)	±0.5 °C (±0.9 °F)	±0.012 °C/°C (±0.012 °F/°F)
604Ω Nickel-Iron 518	±0.3 °C (±0.54 °F)	±0.5 °C (±0.9 °F)	±0.015 °C/°C (±0.015 °F/°F)
150 Ω	±0.15 Ω	±0.25 Ω	±0.007 Ω/°C (±0.012 Ω/°F)
500 Ω	±0.5 Ω	±0.8 Ω	±0.023 Ω/°C (±0.041 Ω/°F)
1000 Ω	±1.0 Ω	±1.5 Ω	±0.043 Ω/°C (±0.077 Ω/°F)
3000 Ω	±1.5 Ω	±2.5 Ω	±0.07 Ω/°C (±0.130 Ω/°F)

(1) The accuracy values apply to both current sources.
(2) Above ratings apply when a 50/60 Hz filter is used.

Notes:

Diagnostics and Troubleshooting

This chapter describes module troubleshooting, containing information on:

- safety considerations when troubleshooting
- module versus channel operation
- the module's diagnostic features
- critical versus non-critical errors
- module condition data
- contacting Rockwell Automation for assistance

Safety Considerations

Safety considerations are an important element of proper troubleshooting procedures. Actively thinking about the safety of yourself and others, as well as the condition of your equipment, is of primary importance.

The following sections describe several safety concerns you should be aware of when troubleshooting your control system.

ATTENTION: Never reach into a machine to actuate a switch because unexpected motion can occur and cause injury.

Remove all electrical power at the main power disconnect switches before checking electrical connections or inputs/outputs causing machine motion.

Indicator Lights

When the green indicator on the thermocouple module is illuminated, it indicates that power is applied to the module and that it has passed its internal tests.

Activating Devices When Troubleshooting

When troubleshooting, never reach into the machine to actuate a device. Unexpected machine motion could occur.

Stand Clear of the Equipment

When troubleshooting any system problem, have all personnel remain clear of the equipment. The problem could be intermittent, and sudden unexpected machine motion could occur. Have someone ready to operate an emergency stop switch in case it becomes necessary to shut off power.

Program Alteration

There are several possible causes of alteration to the user program, including extreme environmental conditions, Electromagnetic Interference (EMI), improper grounding, improper wiring connections, and unauthorized tampering. If you suspect a program has been altered, check it against a previously saved master program.

Safety Circuits

Circuits installed on the machine for safety reasons, like over-travel limit switches, stop push buttons, and interlocks, should always be hard-wired to the master control relay. These devices must be wired in series so that when any one device opens, the master control relay is de-energized, thereby removing power to the machine. Never alter these circuits to defeat their function. Serious injury or machine damage could result.

Module Operation versus Channel Operation

The module performs diagnostic operations at both the module level and the channel level. Module-level operations include functions such as power-up, configuration, and communication with a 1769 bus master, such as a MicroLogix 1500 controller, 1769-ADN DeviceNet Adapter or CompactLogix controller.

Channel-level operations describe channel related functions, such as data conversion and over- or under-range detection.

Internal diagnostics are performed at both levels of operation. When detected, module error conditions are immediately indicated by the module status indicator. Both module hardware and channel configuration error conditions are reported to the controller. Channel over-range or under-range conditions are reported in the module's input data table. Module hardware errors are typically reported in the controller's I/O status file. Refer to your controller manual for details.

Power-up Diagnostics

At module power-up, a series of internal diagnostic tests are performed. These diagnostic tests must be successfully completed or the module status indicator remains off and a module error results and is reported to the controller.

Module Status Indicator	Condition	Corrective Action
On	Proper Operation	No action required.
Off	Module Fault	Cycle power. If condition persists, replace the module. Call your local distributor or Rockwell Automation for assistance.

Channel Diagnostics

When an input channel is enabled, the module performs a diagnostic check to see that the channel has been properly configured. In addition, the channel is tested on every scan for configuration errors, over-range and under-range, and broken input conditions.

Invalid Channel Configuration Detection

Whenever a channel configuration word is improperly defined, the module reports an error. See pages 84…88 for a description of module errors.

Out-of-Range Detection

When the input signal data received at the channel word is out of the defined operating range, an over-range or under-range error is indicated in input data word 7.

IMPORTANT	There is no under-range error for direct resistance inputs because 0 is a valid number.

Possible causes for an out-of-range condition include:

- The temperature is too hot or too cold for the RTD being used.
- The wrong RTD is being used for the input type selected, or for the configuration that you have programmed.
- The input device is faulty.
- The signal input from the input device is beyond the scaling range.

Open-Wire or Short-Circuit Detection

The module performs an open-circuit or short-circuit input test on all enabled channels on each scan. Whenever an open-circuit or short-circuit condition occurs, the broken input bit for that channel is set in input data word 6.

Possible causes of a broken input condition include:

- the input device is broken
- a wire is loose or cut
- the input device is not installed on the configured channel
- an RTD is internally shorted
- an RTD is not installed correctly

TIP See Open-Circuit Flag Bits (OC0…OC5) on page 49.

Non-critical versus Critical Module Errors

Non-critical module errors are typically recoverable. Channel errors (over-range or under-range errors) are non-critical. Non-critical error conditions are indicated in the module input data table. Non-critical configuration errors are indicated by the extended error code. See Table 24 Extended Error Codes on page 87.

Critical module errors are conditions that may prevent normal or recoverable operation of the system. When these types of errors occur, the system typically leaves the run mode of operation until the error can be dealt with. Critical module errors are indicated in Table 24 Extended Error Codes on page 87.

Module Error Definition Table

Module errors are expressed in two fields as four-digit Hex format with the most significant digit as irrelevant ("don't care"). The two fields are "Module Error" and "Extended Error Information". The structure of the module error data is shown below.

Table 22 - Module Error Table

"Don't Care" Bits				Module Error			Extended Error Information								
15	**14**	**13**	**12**	**11**	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hex Digit 4				**Hex Digit 3**				**Hex Digit 2**				**Hex Digit 1**			

Module Error Field

The purpose of the module error field is to classify module errors into three distinct groups, as described in the table below. The type of error determines what kind of information exists in the extended error information field. These types of module errors are typically reported in the controller's I/O status file. Refer to your controller manual for details.

Table 23 - Module Error Types

Error Type	Module Error Field Value Bits 11…09 (Bin)	Description
No Errors	000	No error is present. The extended error field holds no additional information.
Hardware Errors	001	General and specific hardware error codes are specified in the extended error information field.
Configuration Errors	010	Module-specific error codes are indicated in the extended error field. These error codes correspond to options that you can change directly. For example, the input range or input filter selection.

Extended Error Information Field

Check the extended error information field when a non-zero value is present in the module error field. Depending upon the value in the module error field, the extended error information field can contain error codes that are module-specific or common to all 1769 analog modules.

TIP If no errors are present in the module error field, the extended error information field will be set to zero.

Hardware Errors

General or module-specific hardware errors are indicated by module error code 2. See Table 24 Extended Error Codes on page 87.

Configuration Errors

If you set the fields in the configuration file to invalid or unsupported values, the module ignores the invalid configuration, generates a non-critical error, and keeps operating with the previous configuration.

Table 24 Extended Error Codes on page 87 lists the possible module-specific configuration error codes defined for the module.

Error Codes

The table below explains the extended error code.

Table 24 - Extended Error Codes

Error Type	Hex Equivalent[1]	Module Error Code	Extended Error Information Code	Error Description
		Binary	Binary	
No Error	X000	000	0 0000 0000	No Error
General Common Hardware Error	X200	001	0 0000 0000	General hardware error; no additional information
	X201	001	0 0000 0001	Power-up reset state
Hardware-Specific Error	X300	001	1 0000 0000	General hardware error, loss of external 24V DC power
	X301	001	1 0000 0001	Hardware ROM error
	X302	001	1 0000 0010	Hardware EEPROM error
	X303	001	1 0000 0011	Channel 0 calibration error
	X304	001	1 0000 0100	Channel 1 calibration error
	X305	001	1 0000 0101	Channel 2 calibration error
	X306	001	1 0000 0110	Channel 3 calibration error
	X307	001	1 0000 0111	Channel 4 calibration error
	X308	001	1 0000 1000	Channel 5 calibration error
	X309	001	1 0000 1001	Channel 0 Analog/Digital Converter error
	X30A	001	1 0000 1010	Channel 1 Analog/Digital Converter error
	X30B	001	1 0000 1011	Channel 2 Analog/Digital Converter error
	X30C	001	1 0000 1100	Channel 3 Analog/Digital Converter error
	X30D	001	1 0000 1101	Channel 4 Analog/Digital Converter error
	X30E	001	1 0000 1110	Channel 5 Analog/Digital Converter error

Table 24 - Extended Error Codes

Error Type	Hex Equivalent(1)	Module Error Code	Extended Error Information Code	Error Description
		Binary	Binary	
Module Specific Configuration Error	X400	010	0 0000 0000	General configuration error; no additional information
	X401	010	0 0000 0001	Invalid input filter selected (channel 0)
	X402	010	0 0000 0010	Invalid input filter selected (channel 1)
	X403	010	0 0000 0011	Invalid input filter selected (channel 2)
	X404	010	0 0000 0100	Invalid input filter selected (channel 3)
	X405	010	0 0000 0101	Invalid input filter selected (channel 4)
	X406	010	0 0000 0110	Invalid input filter selected (channel 5)
	X407	010	0 0000 0111	Invalid input format selected (channel 0)
	X408	010	0 0000 1000	Invalid input format selected (channel 1)
	X409	010	0 0000 1001	Invalid input format selected (channel 2)
	X40A	010	0 0000 1010	Invalid input format selected (channel 3)
	X40B	010	0 0000 1011	Invalid input format selected (channel 4)
	X40C	010	0 0000 1100	Invalid input format selected (channel 5)
	X40D	010	0 0000 1101	Invalid excitation current for input range selected (channel 0)
	X40E	010	0 0000 1110	Invalid excitation current for input range selected (channel 1)
	X40F	010	0 0000 1111	Invalid excitation current for input range selected (channel 2)
	X410	010	0 0001 0000	Invalid excitation current for input range selected (channel 3)
	X411	010	0 0001 0001	Invalid excitation current for input range selected (channel 4)
	X412	010	0 0001 0010	Invalid excitation current for input range selected (channel 5)
	X413	010	0 0001 0011	Invalid calibration enable word

(1) X represents the “Don’t Care” digit.

Module Inhibit Function

Some controllers support the module inhibit function. See your controller manual for details.

Whenever the 1769-IR6 module is inhibited, the module continues to provide information about changes at its inputs to the 1769 CompactBus master (for example, a CompactLogix controller).

Contacting Rockwell Automation

If you need to contact Rockwell Automation for assistance, please have the following information available when you call:

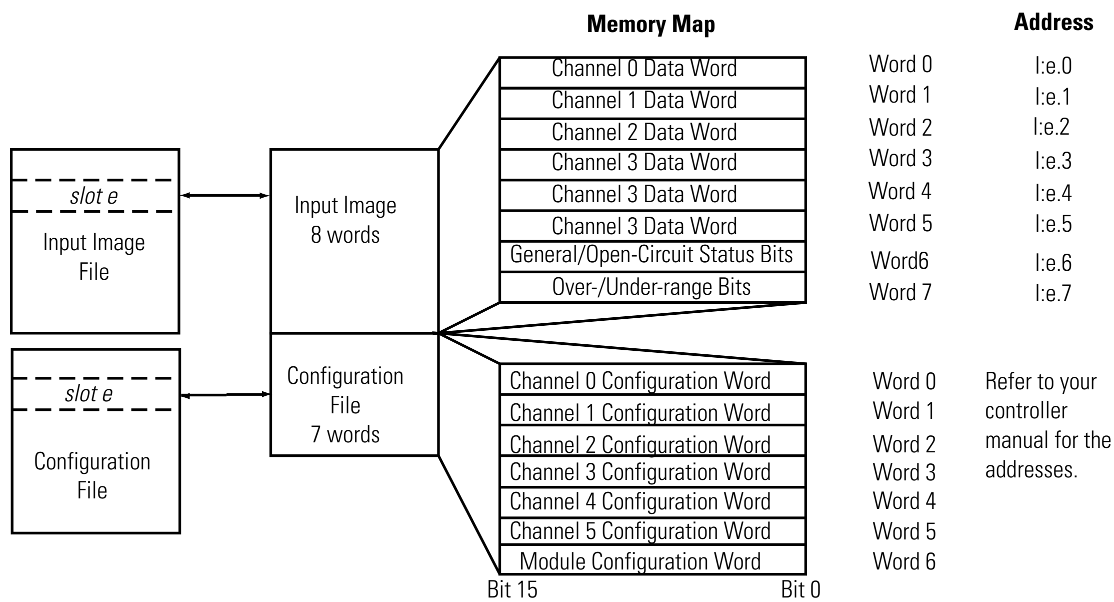
- a clear statement of the problem, including a description of what the system is actually doing. Note the indicator state; also note input and output image words for the module.
- a list of remedies you have already tried
- processor type and firmware number (See the label on the processor.)
- hardware types in the system, including all I/O modules
- fault code if the processor is faulted

Notes:

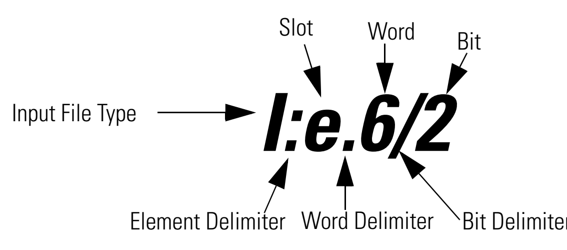
Module Addressing and Programming with MicroLogix 1500 and RSLogix 500

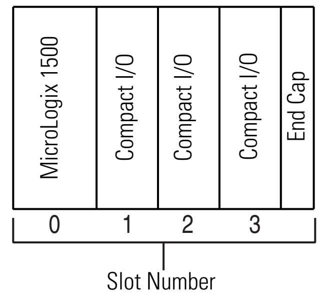
Module Addressing

The module uses eight input words for data and status bits (input image), and seven configuration words.



For example, to obtain the general status of channel 2 of the module located in slot e, use address I:e.6/2.





TIP The end cap does not use a slot address.

1769-IR6 Configuration File

The configuration file contains information you use to define the way a specific channel functions. The configuration file is explained in more detail in Configuring Channels on page 50.

The default configuration of the table is all zeros, which yields the following.

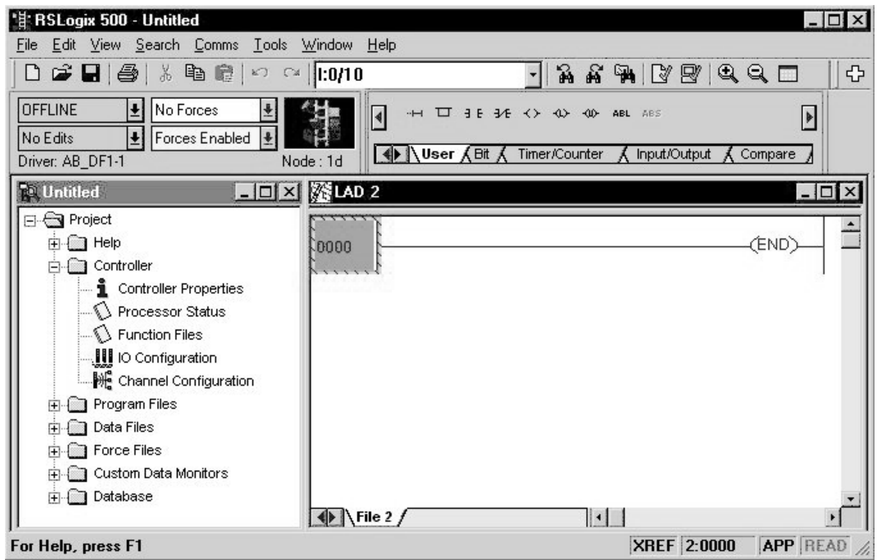
Table 25 - Default Configuration

Parameter	Default Setting
Channel Enable/Disable	Disable
Input Type	100Ω Platinum 385
Data Format	Raw/Proportional
Temperature Units	°C (not applicable with Raw/Proportional)
Broken Input	Upscale
Disable Cyclic Lead Compensation	Enable
Excitation Current	1.0 mA
Input FIlter Frequency	60 Hz

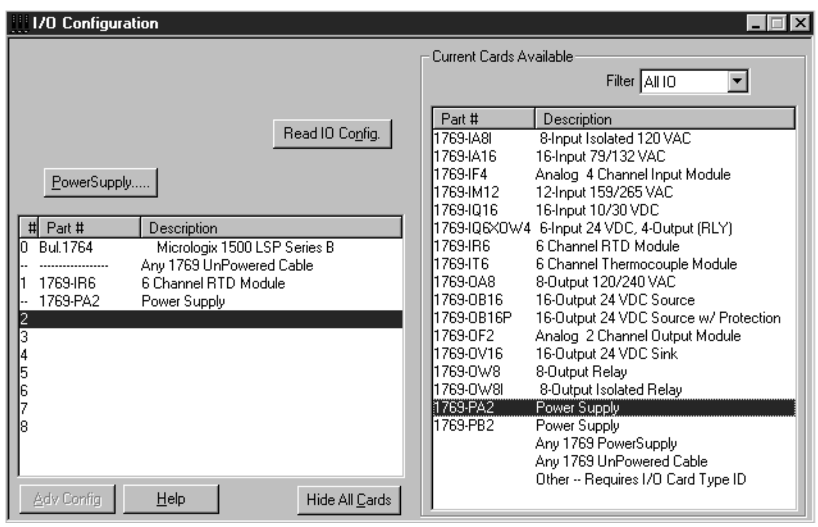
Configuring the 1769-IR6 in a MicroLogix 1500 System

This example takes you through configuring your 1769-IR6 RTD/resistance input module with RSLogix 500 programming software, assumes your module is installed as expansion I/O in a MicroLogix 1500 system, and that RSLinx™ is properly configured and a communications link has been established between the MicroLogix processor and RSLogix 500.

Start RSLogix and create a MicroLogix 1500 application. The following screen appears:

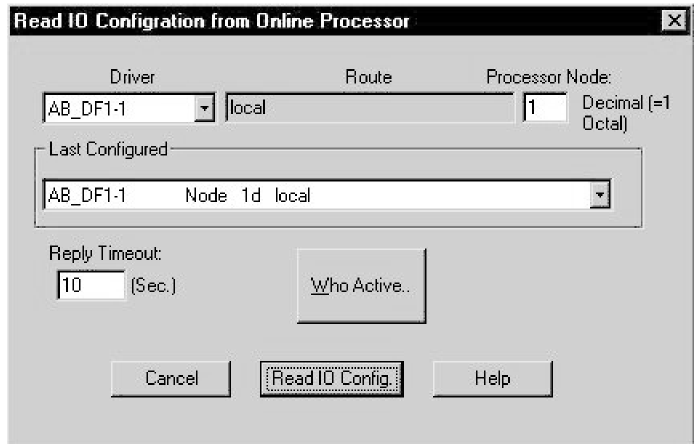


While offline, double-click on the IO Configuration icon under the controller folder and the following IO Configuration screen appears.



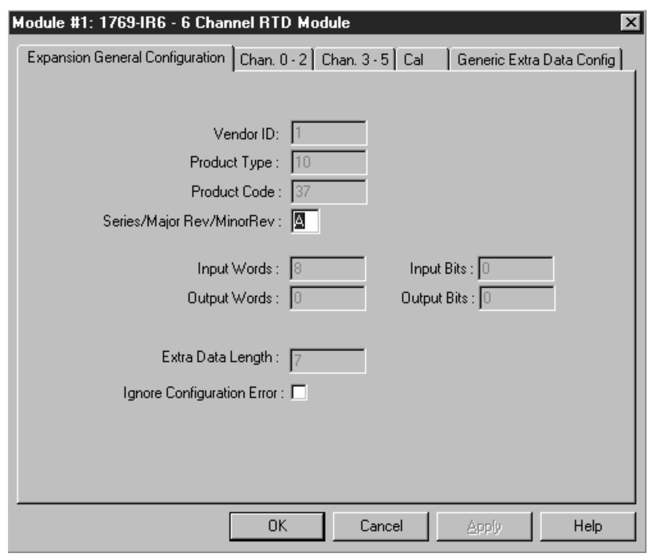
This screen lets you manually enter expansion modules into expansion slots, or to automatically read the configuration of the controller. To read the existing controller configuration, click on the Read IO Config button.

A communications dialog appears, identifying the current communications configuration so that you can verify the target controller. If the communication settings are correct, click on Read IO Config.

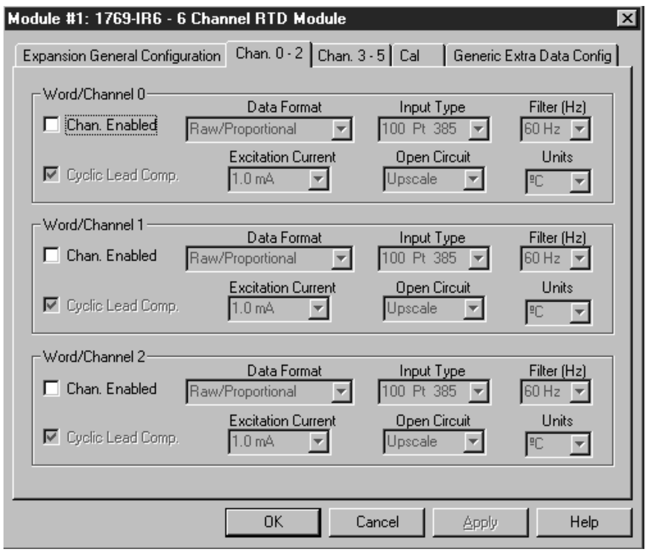


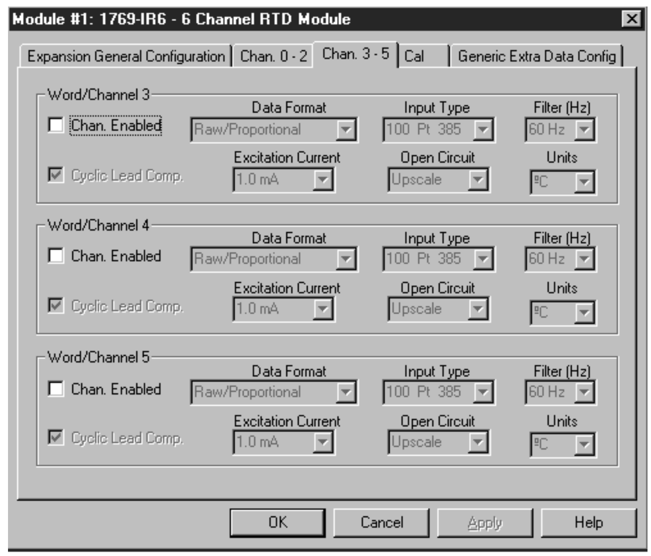
The actual I/O configuration will be displayed.

The 1769-IR6 module is installed in slot 1. To configure the module, double-click on the module/slot. The general configuration screen appears.

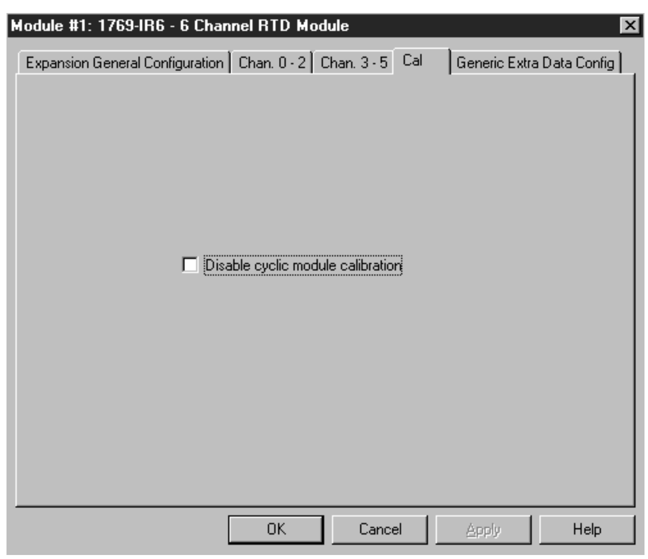


Configuration options for channels 0…2 are located on a separate tab from channels 3…5, as shown below. To enable a channel, click its Enable box so that a check mark appears in it. For optimum module performance, disable any channel that is not hardwired to a real input. Then, choose your Data Format, Input Type, Filter Frequency, Open Circuit response, and Units for each channel. You can also choose to disable cyclic lead compensation for each channel. For more information on cyclic lead compensation, see Selecting Cyclic Lead Compensation (Bit 4) on page 60.

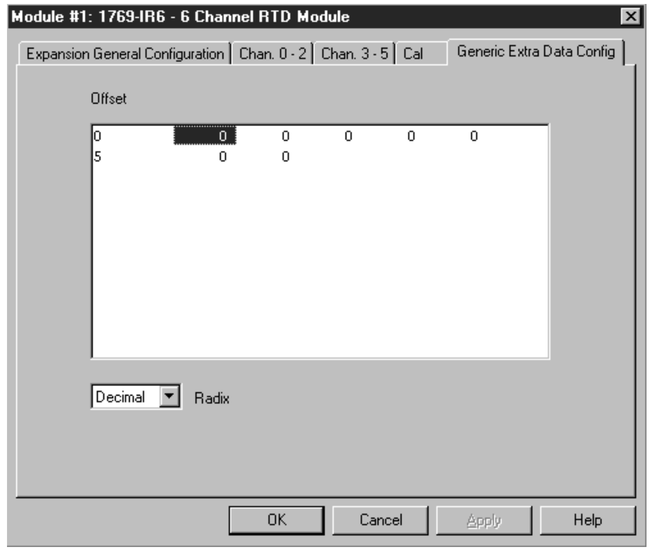




Use the Calibration tab (Cal) to disable cyclic calibration. For more information on the autocalibration feature, see Selecting Enable/Disable Cyclic Autocalibration (Word 6, Bit 0) on page 65.



Generic Extra Data Configuration

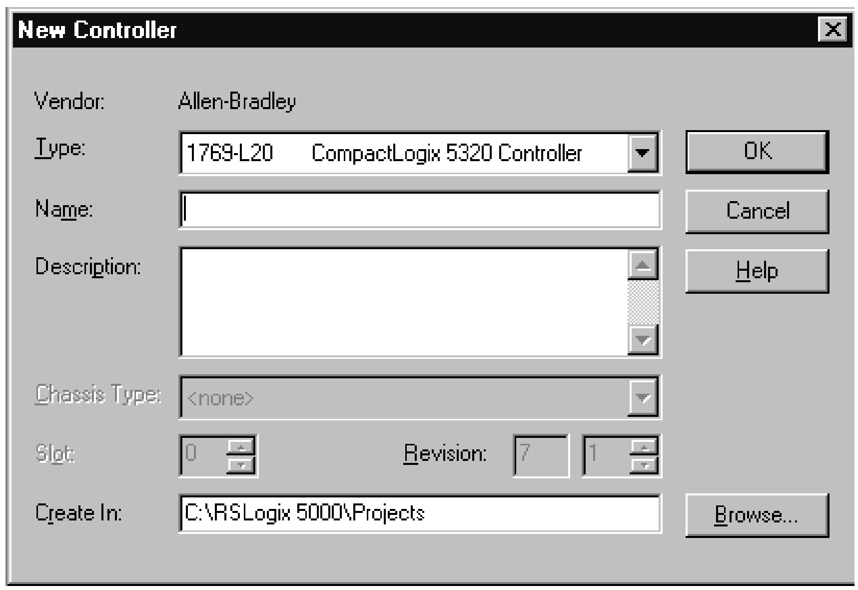


This tab redisplays the configuration information entered on the Analog Input Configuration screen in a raw data format. You have the option of entering the configuration using this tab instead of the module Configuration tab. You do not have to enter data in both places.

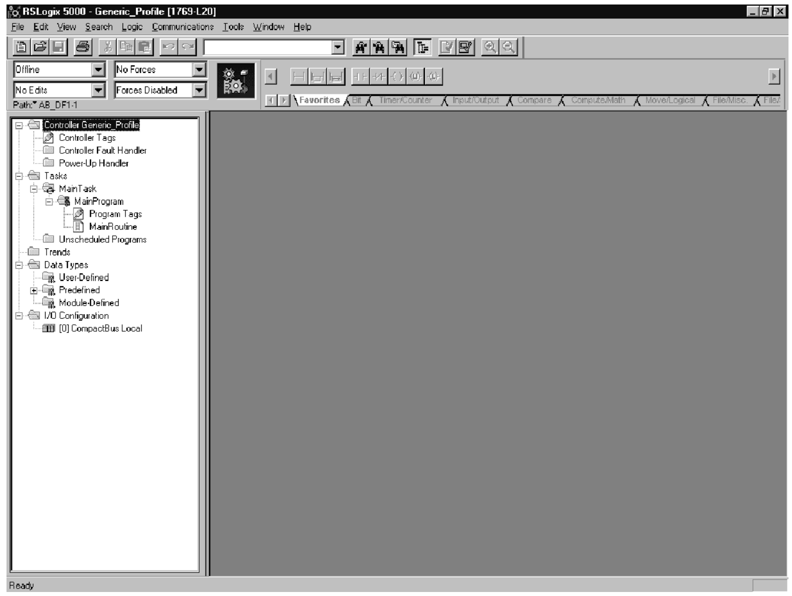
Configuring the 1769-IR6 RTD Module with the Generic Profile

The following is used only when your 1769-IR6 RTD Input module profile is not available in RSLogix 5000 programming software.

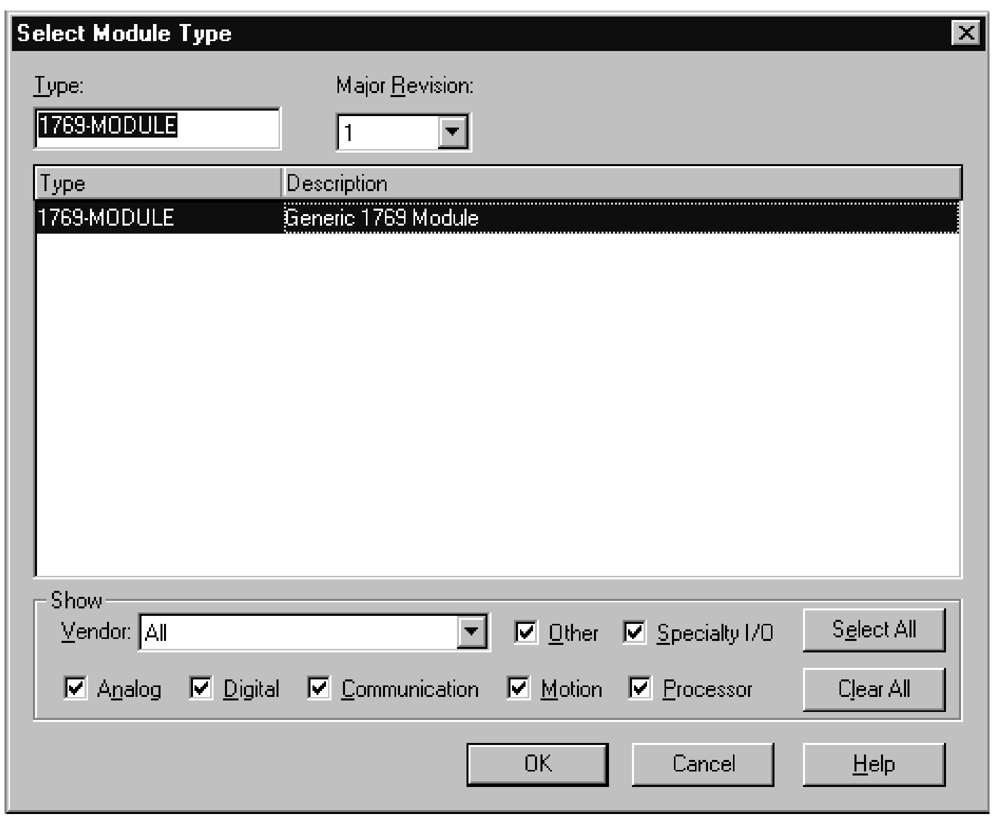
To configure a 1769-IR6 module for a CompactLogix Controller using RSLogix 5000 software with the Generic Profile, first begin a new project in RSLogix 5000 software. Click on the new project icon or on the FILE pull-down menu and select NEW. The following screen appears:



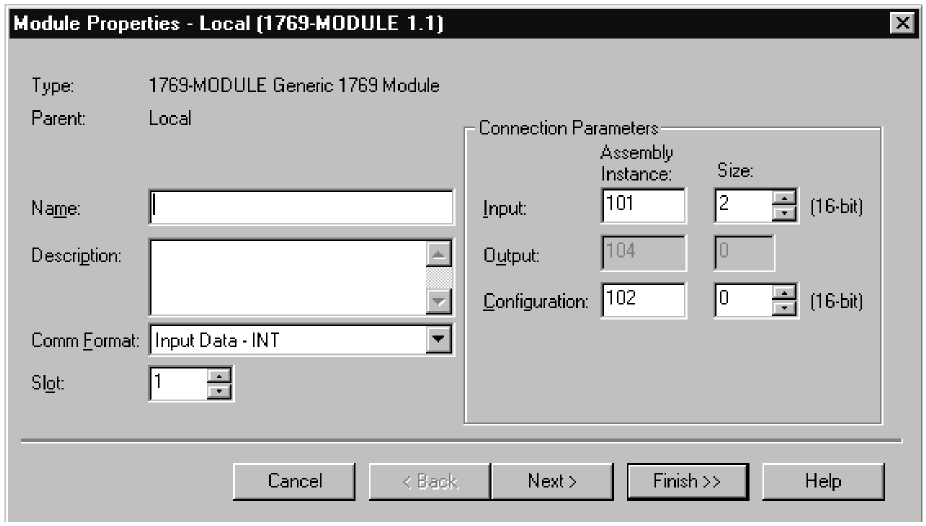
Choose your controller type and enter a name for your project, then click OK. The following main RSLogix 5000 screen appears:



The last entry in the Controller Organizer on the left of the screen shown above is a line labeled "[0] CompactBus Local". Right click on this line, select "New Module" and the following screen appears:



This screen narrows your search for I/O modules to configure into your system. With the initial release of the CompactLogix5320 controller, this screen only includes the “Generic 1769 Module”. Click the OK button and the following default Generic Profile screen appears:



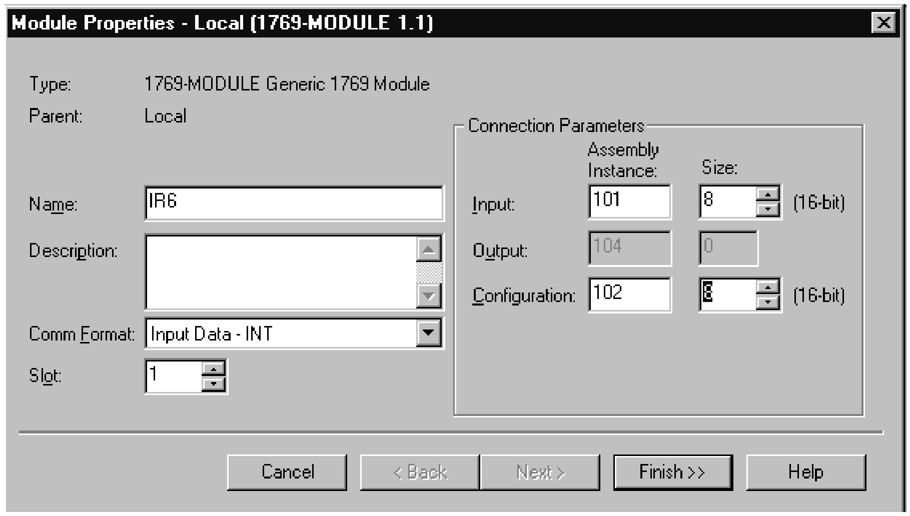
This is the default Generic Profile screen. First, select the Comm Format (“Input Data – INT” for the 1769-IR6), then fill in the name field. In this example, “IR6” is used to help identify the module type in the Controller Organizer. The Description field is optional and may be used to provide more details concerning this I/O module in your application.

The slot number must be selected next, although it begins with the first available slot number, 1, and increments automatically for each subsequent Generic Profile you configure. In this example, the 1769-IR6 RTD Input module is located in slot 1.

The Comm Format, Assembly Instance and Size values can be found in the following table for the 1769-IR6 RTD Input module:

Comm Format	Parameter	Assembly Instance	Size (16-bit)
Input Data – INT	Input Output Config	101 104 102	8 0 8

Note the Assembly Instance numbers and their associated sizes for the 1769-IR6 module and enter them into the Generic Profile. The Generic Profile for a 1769-IR6 should look like the following:



Click "Finish" to complete the configuration of your I/O module.

Configure each RTD Input module in this manner. The CompactLogix5320 controller supports a maximum of eight I/O modules. The valid slot numbers to select when configuring I/O modules are 1…8.

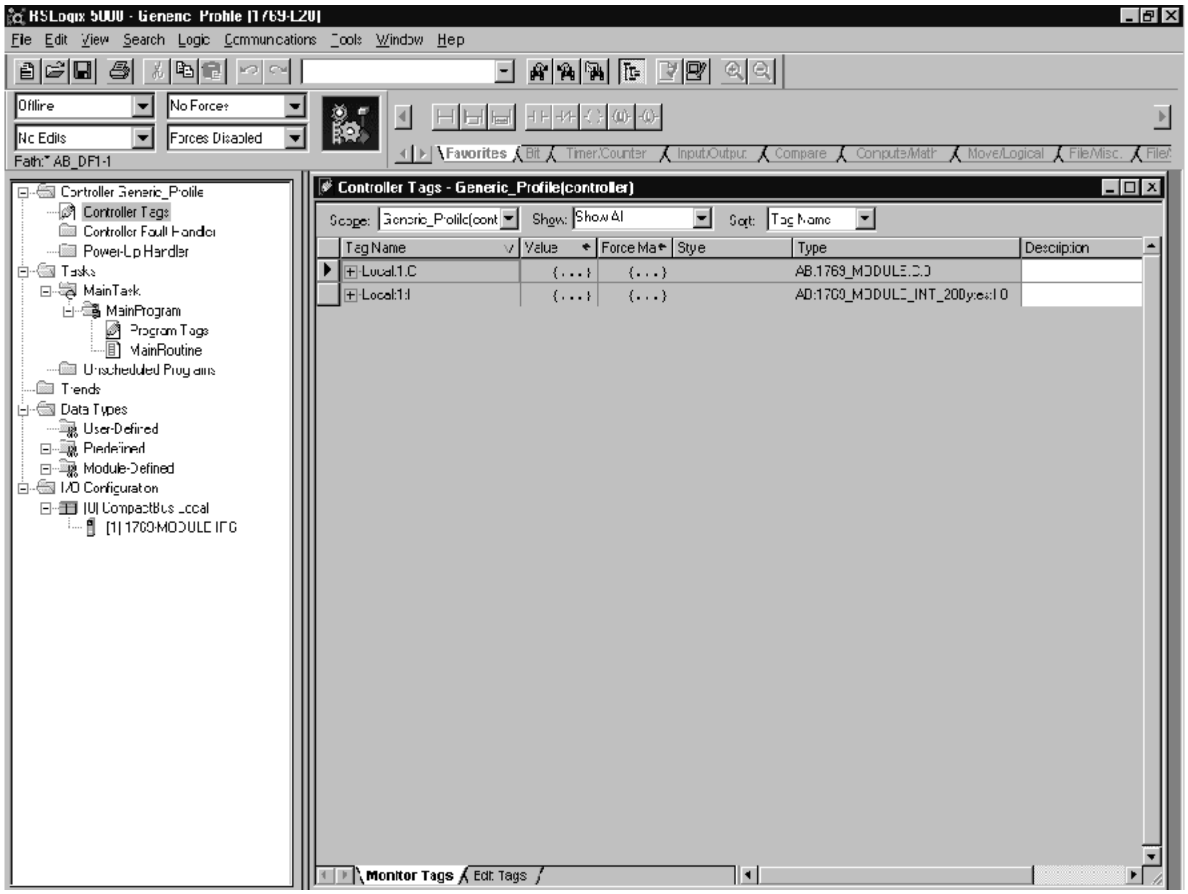
Configuring I/O Modules

Once you have created a Generic Profile for the 1769-IR6 RTD Input module, you must then enter configuration information into the Tag database that has been automatically created from the Generic Profile information you entered. This configuration information is then downloaded to each module at program download, at power up and when an inhibited module is uninhibited.

This section shows how and where to enter configuration data for your IR6 module, once Generic Profiles have been created for them.

We must first enter the Controller Tag database, by double-clicking on "Controller Tags" in the upper portion of the Controller Organizer.

For demonstration purposes, a Generic Profile has been created for 1769- IR6 module. The Controller Tags screen looks like the following:



Tag addresses are automatically created for configured I/O modules. All local I/O addresses are preceded by the word Local. These addresses have the following format:

- Input Data: Local:s:I
- Configuration Data: Local:s:C

  Where s is the slot number assigned the I/O modules in the Generic Profiles.

In order to configure an I/O module, you must open up the configuration tag for that module by clicking on the plus sign to the left of its configuration tag in the Controller Tag data base.

Configuring a 1769-IR6 RTD Input Module

To configure the 1769-IR6 module in slot 1, click on the plus sign left of Local:1:C. Configuration data is entered under the Local:1:C.Data tag. Click the plus sign to the left of Local:1:C.Data to reveal the 8 integer data words where configuration data may be entered for the 1769-IR6 module. The tag addresses for these 8 words are Local:1:C.Data[0]…Local:1:C.Data[7]. Only the first 6 words of the configuration file apply. The last 2 words must exist but should each contain a value of 0 decimal.

The 6 configuration words, 0…5 apply to IR6 channels 0…5 respectively. All 6 words configure the same parameters for the 6 different channels. The following shows the various parameters to configure in each configuration word. For a complete description of each of these parameters and their possible settings, see Channel Configuration on page 51.

Bit	Parameter
0…2	Filter Frequency
3	Excitation Current Bit
4	Lead Resistance Enable Bit
5 and 6	Broken Input Condition
7	Temperature Units Bit
8…11	Input Type
12…14	Data Format
15	Enable Channel Bit

Once you have entered your configuration selections for each channel, enter your program, save your project, and download it to your CompactLogix Controller. Your module configuration data is downloaded to your I/O modules at this time. You 1769-IR6 module input data is located in the following tag addresses when the controller is in Run mode.

1769-IR6 Channel	Tag Address
0	Local:1:I.Data[0]
1	Local:1:I.Data[1]
2	Local:1:I.Data[2]
3	Local:1:I.Data[3]
4	Local:1:I.Data[4]
5	Local:1:I.Data[5]
where 1 represents the slot number of the 1769-IR6 module	

Configuring the 1769-IR6 Module in a Remote DeviceNet System with a 1769-ADN DeviceNet Adapter

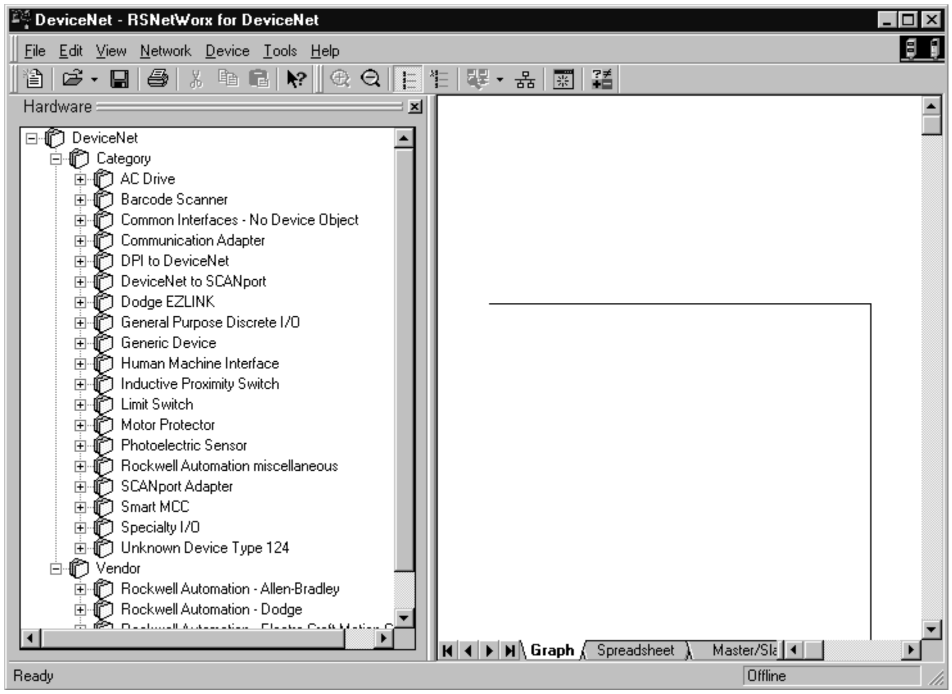
This application example assumes your 1769-IR6 RTD/resistance input module is in a remote DeviceNet system controlled by a 1769-ADN DeviceNet adapter. RSNetworx for DeviceNet is not only used to configure your DeviceNet network, but is also used to configure individual I/O modules in remote DeviceNet adapter systems.

For additional information on configuring your DeviceNet scanners and adapters, please refer to the documentation for these products. This includes the Compact I/O 1769-ADN DeviceNet Adapter user manual, publication 1769-UM001. The adapter manual also contains examples on how to modify I/O module configuration with Explicit Messages, while the system is running.

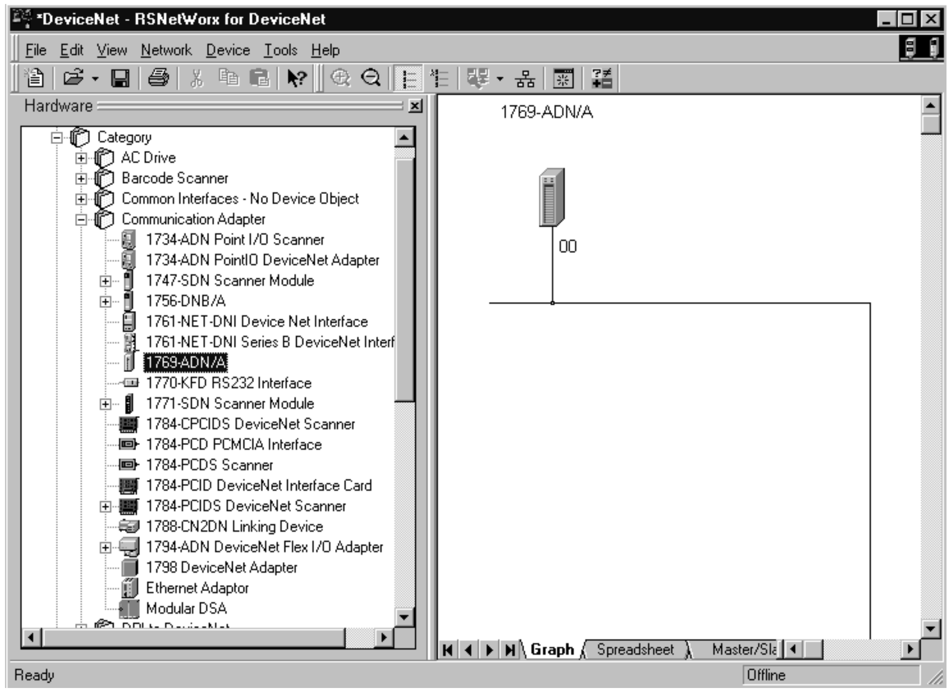
Whether you configure an I/O module offline, then download to the adapter or you accomplish the configuration online, the 1769 RTD/resistance Input module must be configured prior to configuring the DeviceNet adapter in the DeviceNet scanner's scanlist. The only ways to configure or re-configure I/O modules after the adapter is placed in the scanners scanlist are via Explicit Messages or by removing the adapter from the scanner's scanlist, modifying the configuration of the I/O module, then adding the adapter back into the scanner's scanlist.

This example takes you through configuring your 1769 RTD Input module with RSNetWorx for DeviceNet, version 3.00 or later, prior to adding your adapter to the scanlist of your DeviceNet scanner.

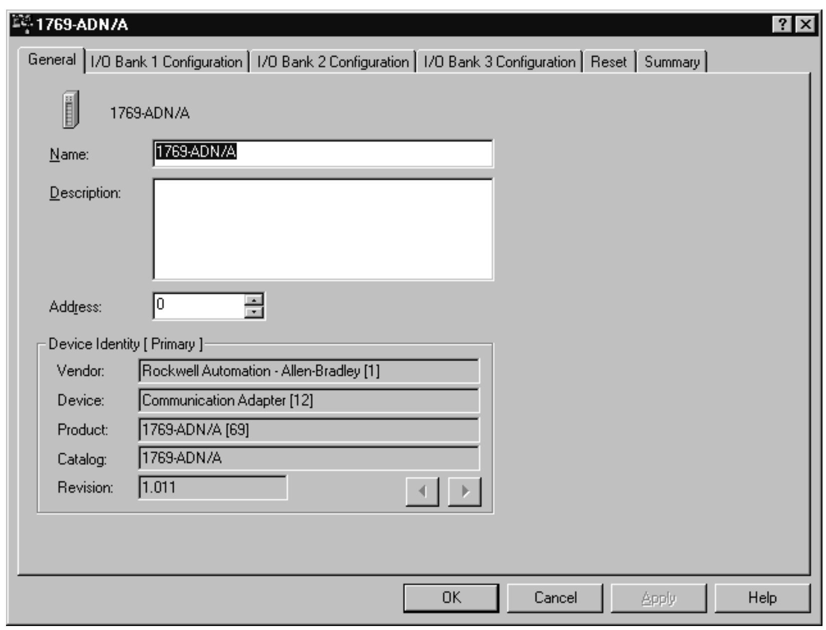
Start RSNetworx for DeviceNet. The following screen appears:



In the left column under Category, click on the "+" sign next to Communication Adapters. In the list of products under Communication Adapters is the 1769-ADN/A. Should this adapter not appear under Communication Adapters, your RSNetworx for DeviceNet software is not version 3.00 or later. To continue, you will need to obtain an upgrade for your software. If the 1769-ADN/A does appear, double-click it and it will be placed on the network to the right as shown below.

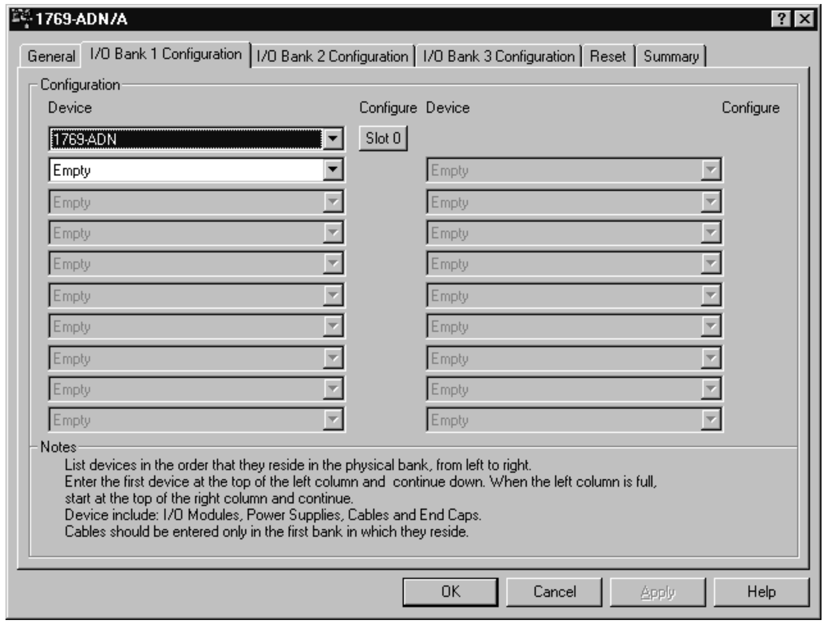


To configure I/O for the adapter, double-click on the adapter that you just placed on the network and the following screen appears:



At this point you may modify the adapters DeviceNet node address, if desired.

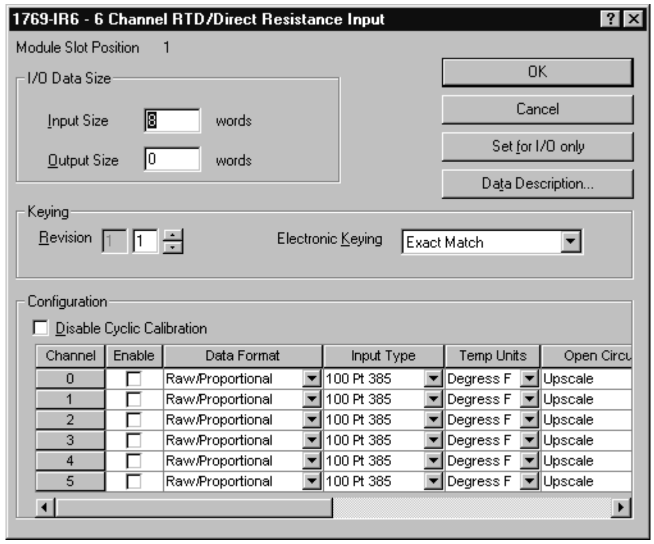
Next, click on the I/O Bank 1 Configuration tab. The following screen appears:



Configuring the 1769-IR6

The 1769-ADN appears in slot 0. Your I/O modules, power supplies, end cap and interconnect cables must be entered in the proper order, following the 1769 I/O rules contained in the 1769-ADN user manual. In this example, we place the 1769-IR6 in slot 1 to show how it is configured. As a minimum, a power supply and end cap must also be placed after the 1769-IR6 module, even though they do not have a slot number associated with them.

To place the 1769-IR6 into Bank 1, click the arrow next to the first empty slot after the 1769-ADN. A list of all possible 1769 I/O products appear. Select the 1769-IR6. Slot 1 appears to the right of the 1769-IR6. Click this Slot 1 box and the following 1769-IR6 configuration screen appears:



By default, the 1769-IR6 module contains eight input words and no output words. Click on the “Data Description…” button. This shows what the eight input words represent, that is the first six words are the actual RTD input data, while the following two words contain status, open-circuit bits and over- and under-range bits for the six channels. Click OK or CANCEL to exit this screen and return to the Configuration screen.

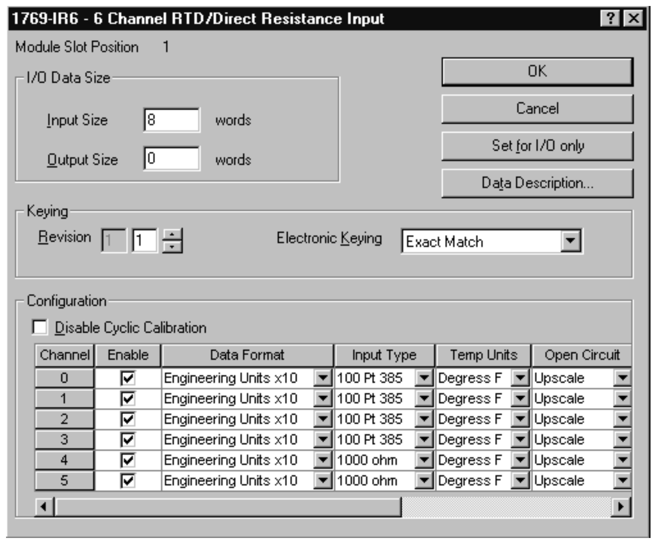
If your application only requires the six data words and not the status information, click the “Set for I/O only” button and the Input Size will change to six words. You may leave the Electronic Keying to “Exact Match”. It is not recommended to Disable Keying, but if you are not sure of the exact revision of your module, selecting Compatible Module will let your system operate and the system will still require a 1769-IR6 in slot 1.

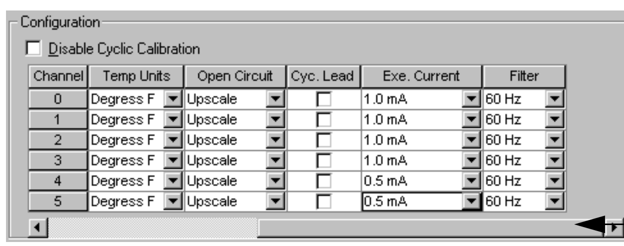
Each of the six RTD input channels are disabled by default. To enable a channel, click its Enable box so a check mark appears in it. Then, choose your Data Format, Input Type, Open Circuit selection, Cyclic Lead Resistance, Excitation Current, and Filter Frequency for each channel you are using. See Channel Configuration on page 51 for a complete description of each of these configuration parameters.

In this example, all six channels are used. Channels 0…3 have 100 ohm Platinum 385 RTD sensors connected and channels 4 and 5 have 1000 ohm potentiometers connected. A 60Hz Filter Frequency (the default) is used for all 6 channels.

The RTD input data is in Engineering Units x 10. We also chose degrees F for the Temperature Units for channels 0…3. This coupled with Engineering Units x 10 as the data format for these four channels, lets you receive the data into the controllers tag database as actual temperature data in degrees F. For the thermocouple used, the default Excitation Current of 1.0 mA is used.

Temperature Units is ignored for the resistance device inputs for channels 4 and 5. However, Engineering Units x 10 is used for these channels to receive actual resistance in ohms in the tag database. The Excitation Current for channels 4 and 5 must be 0.5mA. The Open-Circuit Selection is Upscale. This means that if an open-circuit or short-circuit condition should occur at any of the 6 input channels, the input value for that channel is the full-scale value selected by the input type and data format. We can therefore monitor each channel for full scale (open-circuit) as well as monitor the Open-Circuit bits in Input word 6, for each channel. When complete, the configuration screen looks like the following:





Scroll to see all the configuration parameters.

Click OK and your configuration for the 1769-IR6 RTD Input module is complete.

Two's Complement Binary Numbers

The processor memory stores 16-bit binary numbers. Two's complement binary is used when performing mathematical calculations internal to the processor. Analog input values from the analog modules are returned to the processor in 16-bit two's complement binary format. For positive numbers, the binary notation and two's complement binary notation are identical.

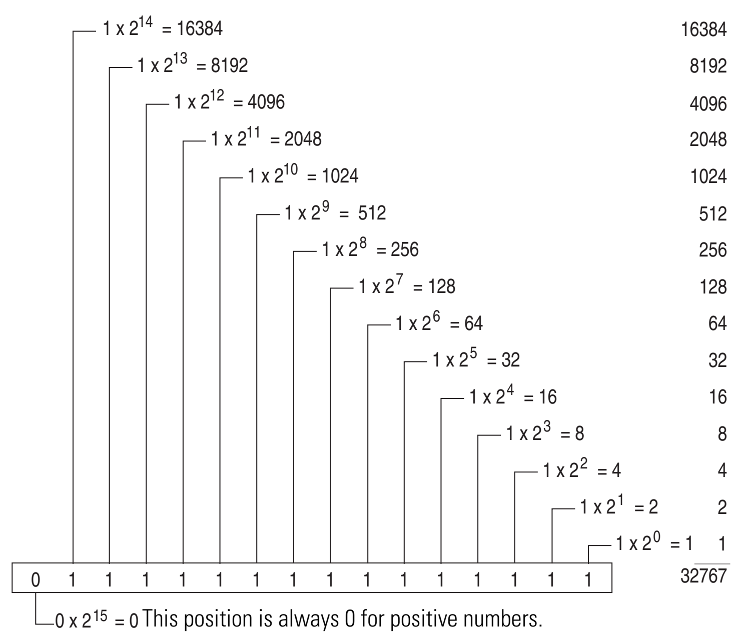
As indicated in the figure on the next page, each position in the number has a decimal value, beginning at the right with 2^0 and ending at the left with 2^{15}. Each position can be 0 or 1 in the processor memory. A 0 indicates a value of 0; a 1 indicates the decimal value of the position. The equivalent decimal value of the binary number is the sum of the position values.

Positive Decimal Values

The far left position is always 0 for positive values. As indicated in the figure below, this limits the maximum positive decimal value to 32767 (all positions are 1 except the far left position). For example:

0000 1001 0000 1110 = $2^{11}+2^8+2^3+2^2+2^1$ = 2048+256+8+4+2 = 2318

0010 0011 0010 1000 = $2^{13}+2^9+2^8+2^5+2^3$ = 8192+512+256+32+8 = 9000

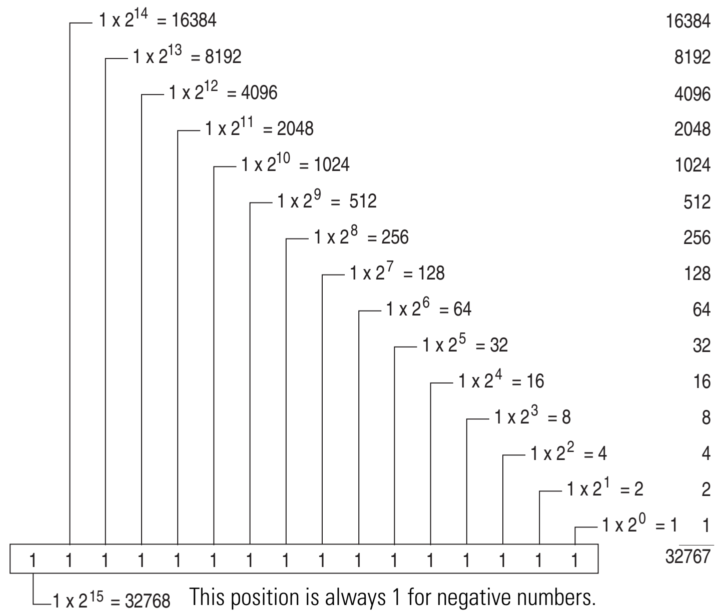


Negative Decimal Values

In two's complement notation, the far left position is always 1 for negative values. The equivalent decimal value of the binary number is obtained by subtracting the value of the far left position, 32768, from the sum of the values of the other positions. In the figure below (all positions are 1), the value is 32767 - 32768 = -1. For example:

$$1111\ 1000\ 0010\ 0011 = (2^{14}+2^{13}+2^{12}+2^{11}+2^{5}+2^{1}+2^{0}) - 2^{15} =$$

$$(16384+8192+4096+2048+32+2+1) - 32768 = 30755 - 32768 = -2013$$



Glossary

The following terms and abbreviations are used throughout this manual. For definitions of terms not listed here refer to the Industrial Automation Glossary, publication AG-7.1.

A/D Converter– Refers to the analog to digital converter inherent to the module. The converter produces a digital value whose magnitude is proportional to the magnitude of an analog input signal.

attenuation – The reduction in the magnitude of a signal as it passes through a system.

bus connector – A 16-pin male and female connector that provides electrical interconnection between the modules.

channel – Refers to input interfaces available on the module's terminal block. Each channel is configured for connection to a thermocouple or millivolt input device, and has its own data and diagnostic status words.

channel update time – The time required for the module to sample and convert the input signals of one enabled input channel and update the channel data word.

common mode rejection – For analog inputs, the maximum level to which a common mode input voltage appears in the numerical value read by the processor, expressed in dB.

common mode rejection ratio (CMMR) – The ratio of a device's differential voltage gain to common mode voltage gain. Expressed in dB, CMRR is a comparative measure of a device's ability to reject interference caused by a voltage common to its input terminals relative to ground. $CMRR=20\ Log_{10\ (V1/V2)}$

common mode voltage – The voltage difference between the negative terminal and analog common during normal differential operation.

common mode voltage range – The largest voltage difference allowed between either the positive or negative terminal and analog common during normal differential operation.

configuration word – Word containing the channel configuration information needed by the module to configure and operate each channel.

cut-off frequency – The frequency at which the input signal is attenuated 3 dB by a digital filter. Frequency components of the input signal that are below the cut-off frequency are passed with under 3 dB of attenuation for low-pass filters.

data word – A 16-bit integer that represents the value of the input channel. The channel data word is valid only when the channel is enabled and there are no channel errors. When the channel is disabled the channel data word is cleared (0).

dB – (decibel) A logarithmic measure of the ratio of two signal levels.

digital filter – A low-pass filter incorporated into the A/D converter. The digital filter provides very steep roll-off above it's cut-off frequency, which provides high frequency noise rejection.

effective resolution – The number of bits in a channel configuration word that do not vary due to noise.

excitation current – A user-selectable current that the module sends through the input device to produce an analog signal that the module can process and convert to temperature (RTD) or resistance in ohms (resistance device).

filter – A device that passes a signal or range of signals and eliminates all others.

filter frequency – The user-selectable frequency for a digital filter.

full-scale – The magnitude of input over which normal operation is permitted.

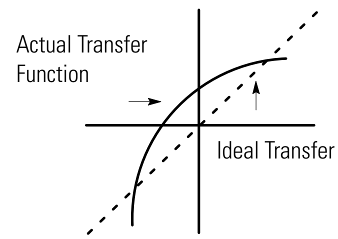
full-scale range – The difference between the maximum and minimum specified analog input values for a device.

gain drift – Change in full-scale transition voltage measured over the operating temperature range of the module.

input data scaling – Data scaling that depends on the data format selected for a channel configuration word. Scaling is selected to fit the temperature or voltage resolution for your application.

input image – The input from the module to the controller. The input image contains the module data words and status bits.

linearity error – Any deviation of the converted input or actual output from a straight line of values representing the ideal analog input. An analog input is composed of a series of input values corresponding to digital codes. For an ideal analog input, the values lie in a straight line spaced by inputs corresponding to 1 LSB. Linearity is expressed in percent full-scale input. See the variation from the straight line due to linearity error (exaggerated) in the example below.



LSB – Least significant bit. The LSB represents the smallest value within a string of bits. For analog modules, 16-bit, two's complement binary codes are used in the I/O image. For analog inputs, the LSB is defined as the rightmost bit of the 16-bit field (bit 0). The weight of the LSB value is defined as the full-scale range divided by the resolution.

module scan time – same as *module update time*

module update time – The time required for the module to sample and convert the input signals of all enabled input channels and make the resulting data values available to the processor.

multiplexer – A switching system that lets several signals share a common A/D converter.

normal mode rejection – (differential mode rejection) A logarithmic measure, in dB, of a device's ability to reject noise signals between or among circuit signal conductors. The measurement does not apply to noise signals between the equipment grounding conductor or signal reference structure and the signal conductors.

number of significant bits – The power of two that represents the total number of completely different digital codes to which an analog signal can be converted or from which it can be generated.

overall accuracy – The worst-case deviation of the digital representation of the input signal from the ideal over the full input range is the overall accuracy. Overall accuracy is expressed in percent of full scale.

repeatability – The closeness of agreement among repeated measurements of the same variable under the same conditions.

resolution – The smallest detectable change in a measurement, typically expressed in engineering units (such as 1 °C) or as a number of bits. For example a 12-bit system has 4096 possible output states. It can therefore measure 1 part in 4096.

RTD – Resistance temperature detector. A temperature-sensing device that consists of a temperature-sensing element connected by two, three, or four lead wires that provide input to the module. The RTD uses the basic concept that the electrical resistances of metals increase with temperature. When a small current is applied to the RTD, it creates voltage that varies with temperature. The module processes and converts this voltage into a temperature value.

sampling time – The time required by the A/D converter to sample an input channel.

step response time – The time required for the channel data word signal to reach a specified percentage of its expected final value, given a full-scale step change in the input signal.

update time – see "module update time"

Notes:

Rockwell Automation Support

Rockwell Automation provides technical information on the Web to assist you in using its products. At http://www.rockwellautomation.com/support, you can find technical manuals, technical and application notes, sample code and links to software service packs, and a MySupport feature that you can customize to make the best use of these tools. You can also visit our Knowledgebase at http://www.rockwellautomation.com/knowledgebase for FAQs, technical information, support chat and forums, software updates, and to sign up for product notification updates.

For an additional level of technical phone support for installation, configuration, and troubleshooting, we offer TechConnect[SM] support programs. For more information, contact your local distributor or Rockwell Automation representative, or visit http://www.rockwellautomation.com/support/.

Installation Assistance

If you experience a problem within the first 24 hours of installation, review the information that is contained in this manual. You can contact Customer Support for initial help in getting your product up and running.

United States or Canada	1.440.646.3434
Outside United States or Canada	Use the Worldwide Locator at http://www.rockwellautomation.com/support/americas/phone_en.html, or contact your local Rockwell Automation representative.

New Product Satisfaction Return

Rockwell Automation tests all of its products to ensure that they are fully operational when shipped from the manufacturing facility. However, if your product is not functioning and needs to be returned, follow these procedures.

United States	Contact your distributor. You must provide a Customer Support case number (call the phone number above to obtain one) to your distributor to complete the return process.
Outside United States	Please contact your local Rockwell Automation representative for the return procedure.

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