Rockwell Automation
Allen-Bradley

Analog I/O Modules for SLC™ Processors

(Catalog Numbers 1746-FIO4I, -FIO4V, -NI4, -NI8, -NIO4I, -NIO4V, -NO4I, and -NO4V)

Product Data

The 1746- analog I/O modules offer you a wide range of solutions to your analog control applications.

The 1746-NI4, NIO4I, NIO4V, NO4I, and NO4V are 4-channel analog input, output, and combination modules. These modules provide high resolution (16-bit inputs, 14-bit outputs) and superior input filtering resulting in a high degree of noise immunity. Combination I/O modules help lower system cost and reduce chassis size by incorporating 2 analog inputs and 2 analog outputs on the same module.

The 1746-FIO4I and FIO4V are 2-input/2-output combination modules ideal for high speed applications with more rapidly changing analog signals. These fast response modules are best suited for control of pressure and position in equipment such as hydraulic presses and molding machines.

The 1746-NI8 module is a high density, 8-channel input module best suited for demanding process control applications with a large number of analog input signals. This module provides faster, more accurate measurement and is channel-to-channel configurable for added application flexibility.

Publication 1746-2.34

What's Inside... **Page**

Overview of Analog Modules

The catalog numbers are coded as follows:

F = faster-response combination analog module
N = higher-resolution 4- and 8-channel analog modules
I (prefix) = input
O (prefix) = output
n = total number of input and/or output channels
I (last) = current output
V (last) = voltage output

For example, the 1746-FIO4I is a faster input/output module with 2 inputs (voltage and/or current selectable) and 2 current outputs.

Module Selection Tables are provided below:

Input Characteristics

	FIO4I	FIO4V	NI4	NI8	NIO4I	NIO4V
Number of inputs	2	2	4	8	2	2
Voltage input ranges (Select a current or voltage signal for each channel.)	0 to 10V dc –1 LSB includes 0 to 5V dc 1 to 5V dc		± 10V dc –1 LSB includes 0 to 10V dc 0 to 5V dc 1 to 5V dc			
Current Input ranges (Select a current or voltage signal for each channel.)	0 to 21 mA includes 0 to 20 mA 4 to 20 mA		± 20 mA includes 0 to 20 mA 4 to 20 mA 0 to 1 mA (NI8 only)			
Step response	100 µs	100 µs	60 ms	selectable see page 28	60 ms	60 ms
Input filter at 3 dB	7k Hz	7k Hz	10 Hz	selectable see page 26	10 Hz	10 Hz
Input A/D converter	12-bit	12-bit	16-bit	16-bit	16-bit	16-bit
Input resolution (I)	9.76 µA/bit	9.76 µA/bit	1.22 µA/LSB	1 µA/bit	1.22 µA/LSB	1.22 µA/LSB
Input resolution (V)	2.44 mV/LSB	2.44 mV/LSB	305.2 µV/LSB	1 mV/bit	305.2 µV/LSB	305.2 µV/LSB
Input coding (I)	0 to 2047	0 to 2047	± 16,384	depends on data format, see page 21	± 16,384	± 16,384
Input coding (V)	0 to 4095	0 to 4095	± 32,768		± 32,768	± 32,768
Input non-linearity	± 0.073% FS	± 0.073% FS	± 0.01% FS	± 0.01% FS	± 0.01% FS	± 0.01% FS
CMR at 60 Hz	50 dB	50 dB	105 dB	100 dB	105 dB	105 dB

Output Characteristics

	FIO4I	NIO4I	NO4I	FIO4V	NIO4V	NO4V
Number of Outputs	2	2	4	2	2	4
Output range	0 to 21 mA –1 LSB includes 0 to 20 mA 4 to 20 mA			± 10V dc –1 LSB includes 0 to 10V dc 0 to 5V dc 1 to 5V dc		
Output D/A converter	14-bit	14-bit	14-bit	14-bit	14-bit	14-bit
Output coding 0 to 21 mA	0 to 32,764	0 to 32,764	0 to 32,764	n/a	n/a	n/a
Output coding ± 10V dc	n/a	n/a	n/a	± 32,764	± 32,764	± 32,764

4-Channel Modules Features and Benefits

Single-Slot Module. Compact I/O structure for your control system.

User Selectable Inputs. Lets you configure each input channel for a voltage or current signal from the sensor.

High Resolution (14-bit) Outputs. Provides for precision control of analog outputs.

Input Filtering. Provides higher immunity to electrical noise (Nxxx) or a faster input response (Fxxx modules).

Automatic End-of-Scan I/O Updates. No need to program special commands to access analog data, reducing programming time.

Backplane Isolation. Isolates input signals from the backplane.

Removable Terminal Blocks. Lets you replace a module quickly without removing the wiring.

Choice of Backplane Power or External Power Supply. Provides flexibility to minimize the cost of power supplies.

UL 508 listed, CSA 22.2 142 Approved, and CE Compliant. Lets you install modules in those environments.

Unique Characteristics of FIO4I and FIO4V Modules

FIO4I and FIO4V modules respond faster because the input filter has been modified to allow for higher frequency signals. As a result, the filter may pass more electrical noise. You must take precautions to thoroughly ground and shield the input transducer, its power supply, and cables. Input characteristics of the 1746 analog modules are shown below:

Characteristic	FIO4I and FIO4V	NI4, NIO4I, NIO4V	NI8
Input filter at 3 dB	7k Hz	10 Hz	selectable
Common-mode rejection at 60 Hz	50 dB	105 dB	≥100 dB

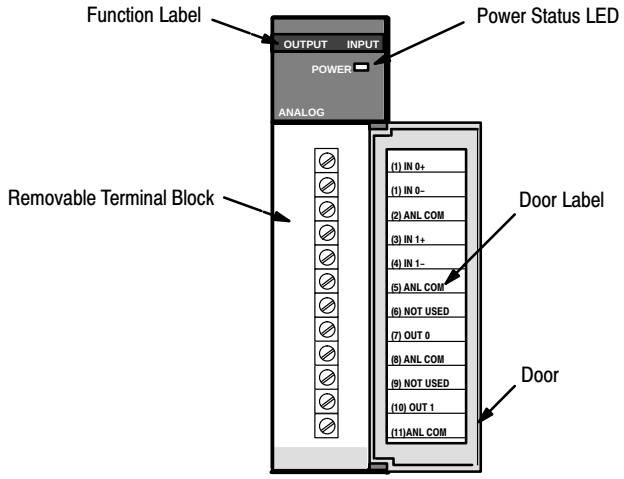
Also, the input resolution of FIO4I and FIO4V modules is considerably less (fewer counts per full scale input) compared to NI4, NI8, NIO4I, and NIO4V modules. For example:

Input Resolution	FIO4I and FIO4V	NI4, NIO4I, NIO4V	NI8
0 to 20 mA inputs	0 to 2047 counts	0 to 16,384 counts	±32,768 counts
0 to 10V dc inputs	0 to 4095 counts	0 to 32,767 counts	±32,768 counts

A resolution of 0 to 2047 counts is sufficient for many applications.

4-Channel Modules Hardware Features

The module contains a removable terminal block providing connection for the analog input and/or output channels, which is specifically designed to interface with analog current and voltage input signals. The channels can be wired as either single-ended or differential inputs. There are DIP switches on the circuit board for selecting voltage or current input.



Front View (Generic)

Hardware Feature	Function
Function Label	Indicates input, output, or both.
Power Status LED	Indicates when backplane power is applied to the module.
Removable Terminal Block	Provides physical connection to input devices.
Door Label	Permits easy terminal identification.
Door	Protects terminal connections and label.

4-Channel Modules Operation

4-Channel Modules Characteristics of the Input A/D Converter

The NI4, NIO4I, and NIO4V modules have different A/D converter characteristics than the FIO4I and FIO4V modules. Differences include:

- input signal ranges
- decimal representation of the analog signal (in the input image table)
- number of significant bits to store the decimal representation
- resolution of the input signal

NI4, NIO4I, and NIO4V Analog Modules

The module converts analog input signals to 16-bit binary values for storage in the SLC processor's input image table. The decimal range, number of significant bits, and converter resolution depend on the input range that you use for the channel.

NI4, NIO4I, & NIO4V Input Range	Decimal Range (input image table)	Number of Significant Bits	Nominal Resolution
± 10V dc –1 LSB	–32,768 to +32,767	16	305.176 μV/LSB
0 to 10V dc –1 LSB	0 to 32,767	15	
0 to 5V dc	0 to 16,384	14	
1 to 5V dc	3,277 to 16,384	13.67	
± 20 mA	± 16,384	15	1.22070 μA/LSB
0 to 20 mA	0 to 16,384	14	
4 to 20 mA	3,277 to 16,384	13.67	

FIO4I and FIO4V Analog Modules

The module converts analog input signals to 12-bit binary values for storage in the SLC processor's input image table. The decimal range, number of significant bits, and converter resolution depend on the input range that you use for the channel.

FIO4I & FIO4V Input Range	Decimal Range (input image table)	Number of Significant Bits	Nominal Resolution
0 to 10V dc –1LSB	0 to 4095	12	2.4414 mV/LSB
0 to 5V dc	0 to 2047	11	
1 to 5V dc	409 to 2047	10.67	
0 to 20 mA	0 to 2047	11	9.7656 μA/LSB
4 to 20 mA	409 to 2047	10.67	

4-Channel Modules Characteristics of the Output D/A Converter

The analog modules have the same output characteristics.

Module	Output Range	Decimal Range (output image table)	Significant Bits	Resolution
FIO4I NIO4I NO4I	0 to 21 mA –1 LSB	0 to 32,764	13 bits	2.56348 μA/LSB
	0 to 20 mA	0 to 31,208	12.92 bits	
	4 to 20 mA	6,242 to 31,208	12.6 bits	
FIO4V NIO4V NO4V	± 10V dc –1 LSB	–32,768 to +32,764	14 bits	1.22070 mV/LSB
	0 to 10V dc –1 LSB	0 to 32,764	13 bits	
	0 to 5V dc	0 to 16,384	12 bits	
	1 to 5V dc	3,277 to 16,384	11.67 bits	

4-Channel Modules Configuration

This section describes how to set up an analog module.

Entering Module ID Codes

When configuring an analog module for an SLC 500™ system using your programming software, a list of the I/O modules is most likely provided for you. If a list is not provided, you need to enter the module identification code when configuring the slot. Refer to the following table for the appropriate analog module ID code.

Catalog No.	Module ID Code
1746-FIO4I	3224
1746-FIO4V	3218
1746-NI4	4401
1746-NIO4I	3201
1746-NIO4V	3202
1746-NO4I	5401
1746-NO4V	5402

Using the Hand-Held Terminal (HHT) firmware v1.1, enter the proper MODULE ID CODE under the “other” selection. Version 2.0 or later of the HHT firmware provides a list of I/O modules. Refer to the following publications for complete information:

- your programming software’s user manual
- the Hand-Held Terminal User Manual

Addressing Analog Modules

NI4 – Each input channel of the NI4 is addressed as a single word in the input image table. The NI4 uses a total of 4 words in the input image table. The converted values from channels 0 through 3 are addressed as input words 0 through 3 respectively for the slot where the module resides.

Example – If you want to address input channel 2 of the NI4 in slot 4, you would address it as input word 2 in slot 4 (I:4.2).

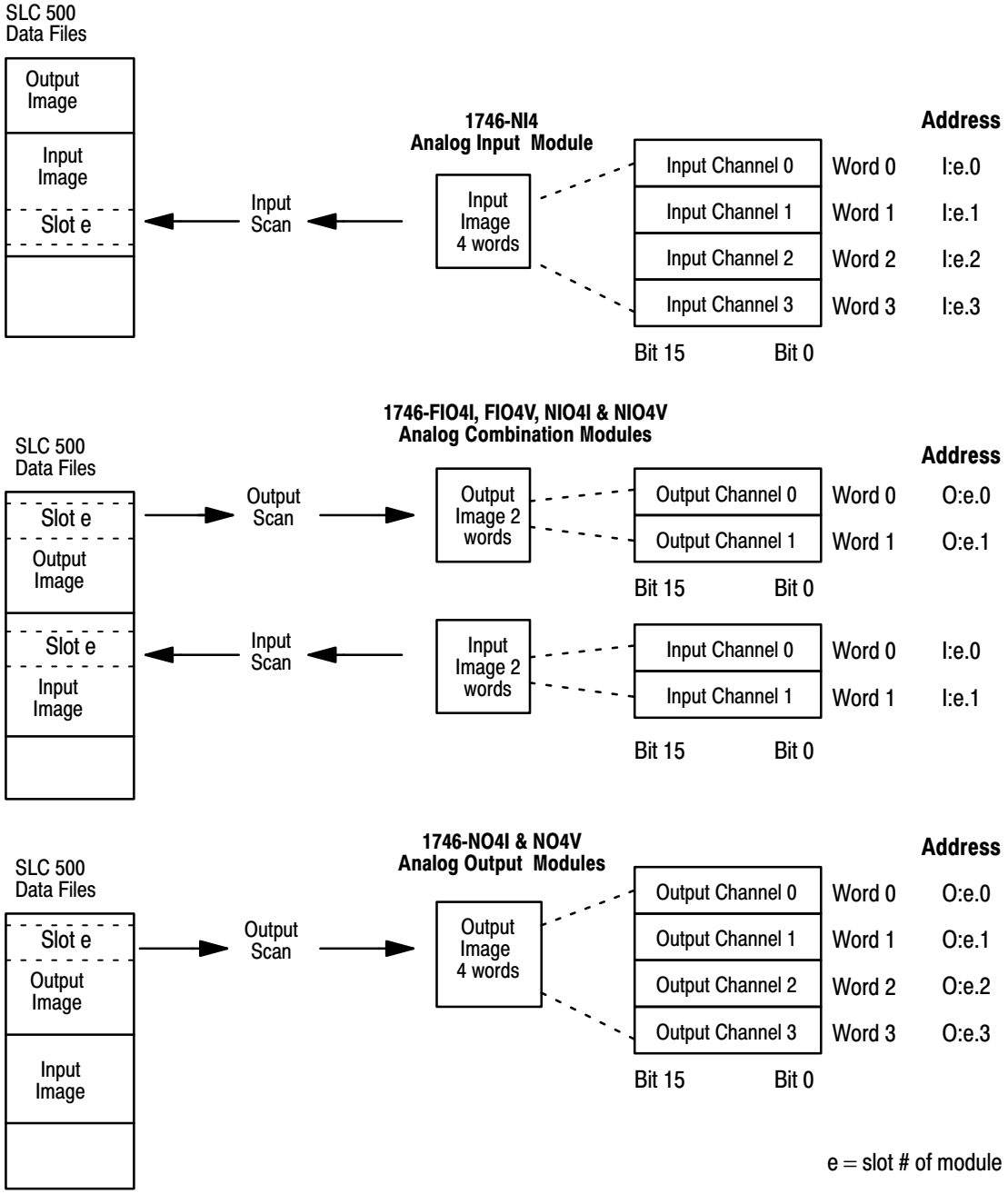
FIO4I, FIO4V, NIO4I, and NIO4V – Each input channel is addressed as a single word in the input image table and each output channel is addressed as a single word in the output image table. These modules use a total of 2 input words and 2 output words.

The converted input values from input channels 0 and 1 are addressed as words 0 and 1 of the slot where the module resides. The output values for the output channels 0 and 1 are addressed as output words 0 and 1 of the slot where the module resides.

Example – If you want to address output channel 0 of the NIO4I in slot 3, you would address it as output word 0 in slot 3 (O:3.0).

NO4I and NO4V – Each output channel of the NO4I and NO4V is addressed as a single word in the output image table. Both modules use a total of 4 output words. The converted output values from output channels 0 through 3 are addressed as words 0 through 3 respectively for the slot where the module resides.

Example – If you want to address output channel 3 of the NO4I in slot 3, you would address it as output word 3 in slot 3 (O:3.3).



4-Channel Modules Wiring

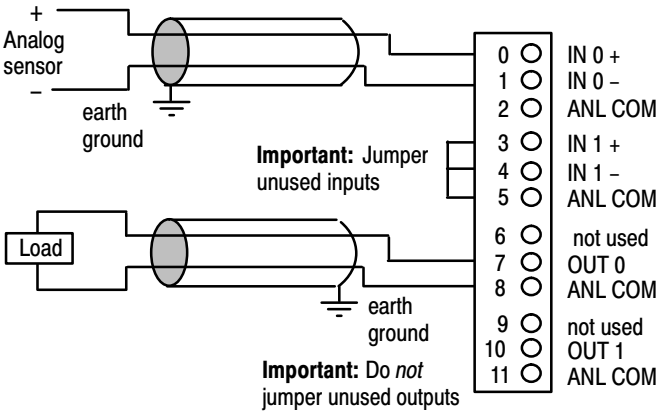
Your module is designed for differential inputs and outputs. Wire them as follows:

ATTENTION: Disconnect power to the SLC before attempting to install, remove, or wire the removable terminal wiring block.

To avoid cracking the removable terminal block, alternate the removal of the slotted terminal block release screws.

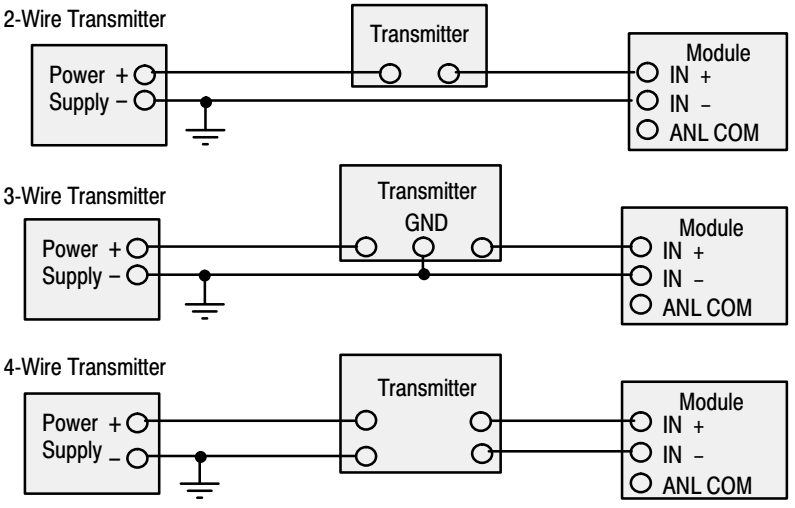
Wiring Differential Analog Inputs and Outputs

Important: Channels are not isolated from each other. All analog commons (ANL COM) are connected together internally.



Wiring Single-Ended Current-Loop Analog Inputs

As an alternative, you may wire input transmitters having 2-wire, 3-wire, or 4-wire inputs in a single-ended current-loop configuration.



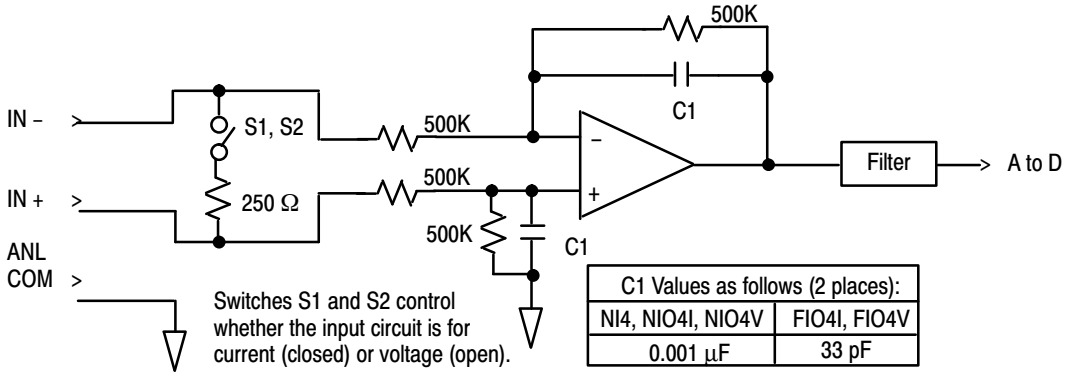
Important: If using single-ended inputs, take extra precautions for proper grounding and shielding because of the greater noise susceptibility of single-ended inputs.

Important: The module does not provide loop power for analog inputs. Use a power supply that matches the transmitter specifications.

4-Channel Modules Internal Input and Output Circuits

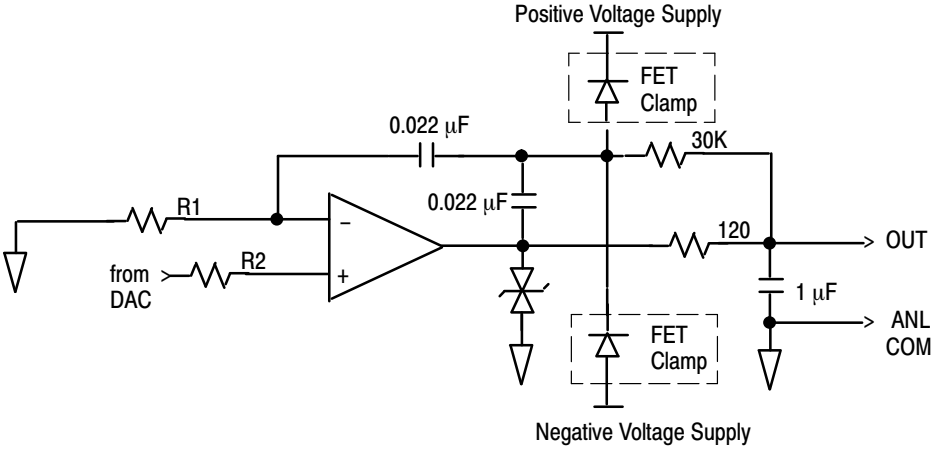
The following input and output circuits are provided to help you match the analog module to your input and output devices:

Input Circuit

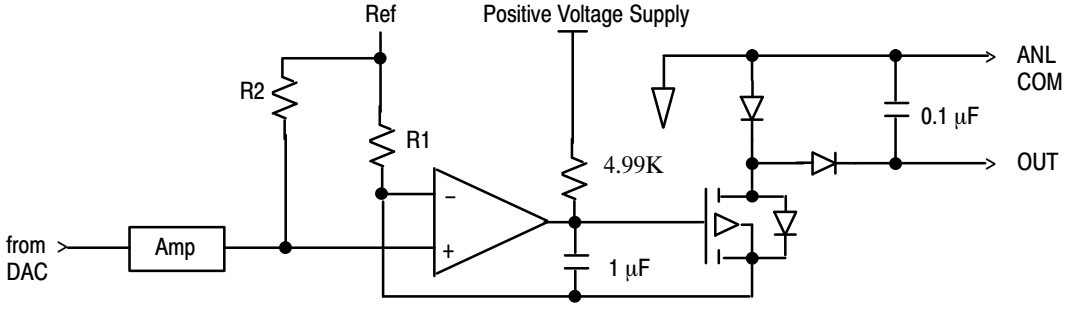


C1 Values as follows (2 places):	
NI4, NIO4I, NIO4V	FIO4I, FIO4V
0.001 µF	33 pF

Voltage Output Circuit



Current Output Circuit



4-Channel Modules Specifications

General Specifications

Catalog 1746-	ID Code	Input Channels per Module①	Output Channels per Module①	Backplane Current	
				5V	24V
NI4	4401	4 differential, select V or I per channel	NA	25 mA	85 mA
NIO4I	3201	2 differential, select V or I per channel	2 current outputs	55 mA	145 mA
NIO4V	3202	2 differential, select V or I per channel	2 voltage outputs	55 mA	115 mA
NO4I	5401	NA	4 current outputs	55 mA	195 mA②
NO4V	5402	NA	4 voltage outputs	55 mA	145 mA②
FIO4I	3224	2 differential, select V or I per channel	2 current output	55 mA	150 mA
FIO4V	3218	2 differential, select V or I per channel	2 voltage outputs	55 mA	120 mA

① Input and output channels are isolated from the backplane but not from each other.

② If an external 24V power supply is required, the tolerance must be 24V ± 10% (21.6 to 26.4V dc.) The modular system power supply, 1746-P1 or -P2, does NOT meet this specification.

Description	Specification
SLC Communication Format	16-bit two's compliment binary
Location of LSB in I/O Image Word	0000 0000 0000 0001
Impedance to ANL COM	500K ohms
Impedance, Channel-to-Channel	1M ohms
Field Wiring to Backplane Isolation	500V dc (continuous)
Cable	shielded, Belden #8761 (recommended)
Wire Size	#14 AWG (max)
Grounding Wire (optional)	1/4" wide (min) braid
Terminal Block, 1746-RT28	removable
Installation	single slot in the 1746 I/O Rack
Calibration	factory calibrated
Noise Immunity	NEMA standard ICS 2–230
Environmental Conditions Operating Temperature Storage Temperature Relative Humidity	 0°C to +60°C (+32°F to +140°F) –40°C to +85°C (–40°F to +185°F) 5 to 95% (non-condensing)
Certification	UL 508 listed, CSA 22.2 142 approved, CE compliant for all applicable directives when product or packaging is marked

General Input Specifications

Description	General Input Specifications NI4, NIO4I, and NIO4V	General Input Specifications FIO4I and FIO4V
Step Response (5 to 95%)	60 ms	100 μsec
Converter Resolution	16-bit	12-bit
Conversion Method	sigma-delta modulation	successive approximation
Non-linearity	0.01% of full scale (max)	±0.073% of full scale (max)
Common Mode Voltage Range	± 20V dc	0 to 20V dc (max)
Common Mode Rejection Ratio at 10 Hz	50 db	n/a
Common Mode Rejection Ratio at 60 Hz	105 db	50 db (min), 1K ohm imbalance
Normal Mode Rejection at 60 Hz (min.)	55 db	n/a
Channel Bandwidth	10 Hz	7.0K Hz (min) @ 3 dB point
Image Format (HEX)	0FFF	0FFF
Track/hold Time to Get Signal before Conversion	n/a for sigma-delta modulation	1.5 μs (nominal)
Signal Convert From Hold	n/a for sigma-delta modulation	6.0 μsec (nominal)
Conversion Time	n/a for sigma-delta modulation	7.5 μsec every 512 μsec (nominal)
Module Throughput Delay	512 μsec (nominal)	1.10 ms (max①) 512 μsec (typical)

① Worst case throughput occurs when the module just misses seeing an event occur.

Current-Loop Input Specifications

Description	Current Input Specifications NI4, NIO4I, and NIO4V	Current Input Specifications FIO4I and FIO4V
Full Scale	20 mA	20 mA
Input Range	± 20 mA (nominal) ± 30 mA (max)	0 to 20 mA (nominal) 0 to 30 mA (max)
Current Input Coding	± 16,384 for ± ≃ 0 mA	0 to 2047 counts for 0 to 20 mA
Absolute Maximum Input Voltage	±7.5V dc or 7.5V ac RMS	±7.5V dc or 7.5V ac RMS
Input Impedance	250 ohms	250 ohms (nominal)
Resolution	1.22070 μA per LSB	9.7656 μA per bit
Overall Accuracy at +25°C (+77°F)	±0.365% of full scale	±0.510% of full scale
Overall Accuracy, 0°C to +60°C (+32°F to +140°F)	±0.642% of full scale (max)	±0.850% of full scale
Overall Accuracy Drift	±79 ppm/°C of full scale	±98 ppm/°C of full scale (max)
Gain Error at +25°C (+77°F)	±0.323% (max)	±0.400% of full scale
Gain Error, 0°C to +60°C (+32°F to +140°F)	±0.556% (max)	±0.707% of full scale
Gain Error Drift	±67 ppm/°C	±89 ppm/°C (max)
Offset Error at +25°C (+77°F)	±7 LSB (max)	±2 LSB (typical)
Offset Error, 0°C to +60°C (+32°F to +140°F)	±14 LSB (max)	±4 LSB
Offset Error Drift	±0.20 LSB/°C	±0.14 LSB/°C (max②)
Overvoltage Capability	7.5V ac RMS (max)	7.5V ac RMS (max)

② Computed by box method: 2 [max offset error] / +60°C

Voltage Input Specifications

Description	Voltage Input Specifications NI4, NIO4I, and NIO4V	Voltage Input Specifications FIO4I and FIO4V
Full Scale	10V dc	10V dc
Input Range	± 10V dc –1 LSB	0 to 10V dc –1 LSB
Input Impedance	1M ohms	1M ohms (nominal)
Overvoltage Protection (IN+ to IN–)	220V dc or ac RMS continuously	220V dc or ac RMS, continuously
Resolution	305.176 μV per LSB	2.4414 mV per LSB (nominal)
Voltage Input Coding	–32,768 to +32,767 for ± 10V dc	0 to 4095 counts for 0 to 10V dc
Overall Accuracy at +25°C (+77°F)	±0.284% of full scale (max)	±0.440% of full scale
Overall Accuracy, 0°C to +60°C (+32°F to +140°F)	±0.504% of full scale (max)	±0.750% of full scale
Overall Accuracy Drift	±63 ppm/°C of full scale (max)	±88 ppm/°C (max)
Gain Error at +25°C (+77°F)	±0.263% (max)	±0.323% of full scale
Gain Error, 0 to +60°C (+32°F to +140°F)	±0.461% (max)	±0.530% of full scale
Gain Error Drift	±57 ppm/°C (max)	±79 ppm/°C (max)
Offset Error, +25°C (+77°F)	±7 LSB (max)	±4 LSB (max)
Offset Error at 0°C to +60°C (+32°F to +140°F)	±14 LSB (max)	±2 LSB (typical)
Offset Error Drift	±0.20 LSB/°C (max)	±0.14 LSB/°C (max[①])

① Computed by box method: 2 [max offset error] / +60°C

Output Specifications

Description	Current Output Specifications FIO4I, NIO4I, and NO4I	Voltage Output Specifications FIO4V, NIO4V, and NO4V
Full Scale	21 mA	10V dc
Output Range	0 to 20 mA –1 LSB (normal)	± 10V dc –1 LSB (normal)
Output Coding	0 to 32,764 for 0 to 21 mA	–32,768 to +32,764 for ± 10V dc
Output Resolution	2.56348 μA per LSB	1.22070 mV per LSB
Converter Resolution	14-bit	14-bit
Location of LSB in I/O Image Word	0000 0000 0000 01XX	0000 0000 0000 01XX
Non-linearity	0.05% of full scale (max)	0.05% of full scale
Conversion Method	R–2R ladder	R–2R ladder
Step Response	2.5 ms (5 to 95%)	2.5 ms (normal)
Load Range	0 to 500 ohms	1K to ∞ ohms
Load Current	n/a	10 mA (max)
Load Reactance	100 μH (max)	1 μF (max)
Over-range Capability	5% (0 to 21 mA –1 LSB)	n/a
Overall Accuracy at +25°C (+77°F)	±0.298% of full scale	±0.208% of full scale
Overall Accuracy, 0°C to +60°C (+32°F to +140°F)	±0.541% of full scale	±0.384% of full scale
Overall Accuracy Drift	±70 ppm/°C of full scale (max)	±54 ppm/°C of full scale (max)
Gain Error at +25°C (+77°F)	±0.298% of full scale	±0.208% of full scale
Gain Error, 0°C to +60°C (+32°F to +140° F)	±0.516% of full scale	±0.374% of full scale
Gain Error Drift	±62 ppm/°C (max)	±47 ppm/°C (max)
Offset Error at +25°C (+77°F)	±10 LSB (typical)	±9 LSB (typical)
Offset Error, 0°C to +60°C (+32°F to +140° F)	±12 LSB	±11 LSB
Offset Error Drift	±0.06 LSB/°C (max)	±0.05 LSB/°C (max)

8-Channel Module Features and Benefits

Broader Control Capability. Small programmable controllers continue to be placed in process control applications demanding higher densities, faster, more accurate measurement and the flexibility to interface to a variety of temperature, pressure, and flow transducers. The 1746-NI8 analog input module broadens the control capabilities of the SLC 500 to serve these demanding process applications.

High Density. This new eight channel analog module provides more efficient use of rack space and lower cost per point compared to competitive four and eight channel analog modules. A color coded removable terminal block facilitates wiring and module replacement.

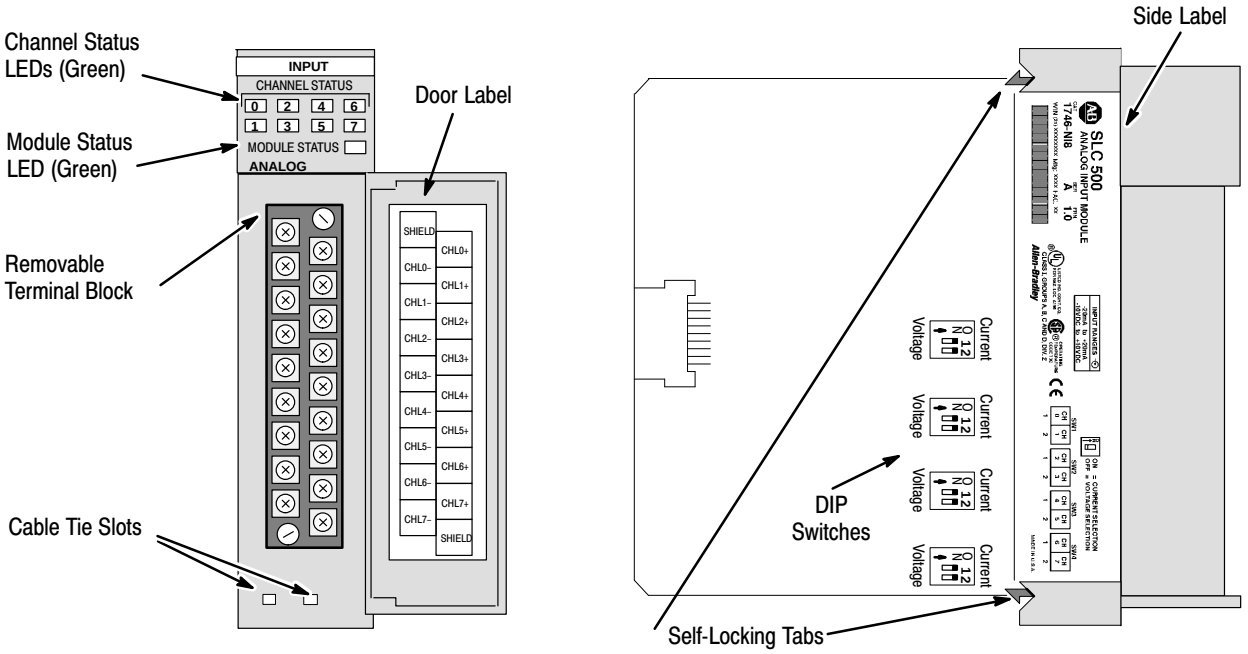
Excellent Performance. The module is extremely accurate at up to 0.05% of full scale and offers an analog data update rate of up to 0.75 msec per enabled channel. The module provides 14 to 16 bit resolution and can interface to current or voltage signals from various process sensors.

Diagnostic Feedback. Machine uptime is increased and troubleshooting time reduced with the help of diagnostic status bits for open-circuit and out-of-range detection. Eight channel status indicators and a module status indicator are also provided.

Software Configurable. Each channel can be individually configured with the ladder program and can be reconfigured without interrupting CPU operation. An easy-to-use bit configuration table allows the user to choose the input type, data format, filter frequency, and status data best suited to the application. On-board scaling is provided, eliminating the need to program this function with complex ladder programming.

8-Channel Module Hardware Features

The module contains a removable terminal block providing connection for eight analog input channels, which is specifically designed to interface with analog current and voltage input signals. The channels can be wired as either single-ended or differential inputs. There are no output channels on the module. Module configuration is done via the user program. There are DIP switches on the circuit board for selecting voltage or current input.



Hardware Feature	Function
Channel Status LED Indicators	Displays channel operating and fault status.
Module Status LED	Displays module operating and fault status.
Side Label (Nameplate)	Provides module information.
Removable Terminal Block	Provides physical connection to input devices.
Door Label	Permits easy terminal identification.
Cable Tie Slots	Secures and route wiring from module.
Self-Locking Tabs	Secures module in chassis slot.
Voltage/current Selection DIP Switches	Selects voltage or current input type to match the analog sensor.

8-Channel Module Operation

The module fits into any single slot, except the processor slot, in either an SLC 500 modular system or an SLC 500 fixed system expansion chassis. It can be used in either Class 1 or Class 3 installations. Class 1 is the default configuration. The module can be configured through the user program for Class 3 which enables user defined data scaling and monitoring of channel status words.

Configuration	Class 1①	Class 3
Compatible SLC Processors	SLC 500 fixed, SLC 5/01™, SLC 5/02™, SLC 5/03™, and SLC 5/04™	SLC 5/02, SLC 5/03, and SLC 5/04
Compatible Chassis	local chassis or remote chassis with a 1747-ASB module	local chassis
Input and Output Images	**8 input words:** 8 channel data words **8 output words:** 8 channel configuration words	**16 input words:** 8 channel data words and 8 channel status words **12 output words:** 8 channel configuration words and 4 limit ranges for user-defined scaling data format
Default	Class 1 is the default on power-up	Class 3 is programmable by user

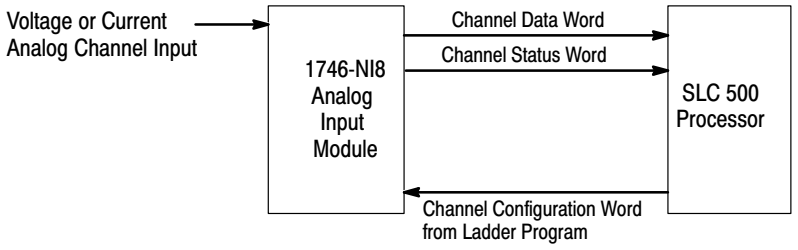
① Requires use of Block Transfer in a remote configuration.

Data Transfer

The 1746-NI8 module sequentially samples the channels in a continuous loop. Each time a channel is read by the module, that data value is tested by the module for a fault condition (i.e., open-circuit, over-range, and under-range). If such a condition is detected, a unique bit is set in the channel status word and the channel status LED blinks.

The SLC processor reads the converted analog data from the module at the end of the program scan, or when commanded by the ladder program. The processor and module determine that the backplane data transfer was made without error, and the data is used in your ladder program. A graphic representation of this is shown below.

Data Transfer Between the Module and Processor (shown for one channel)



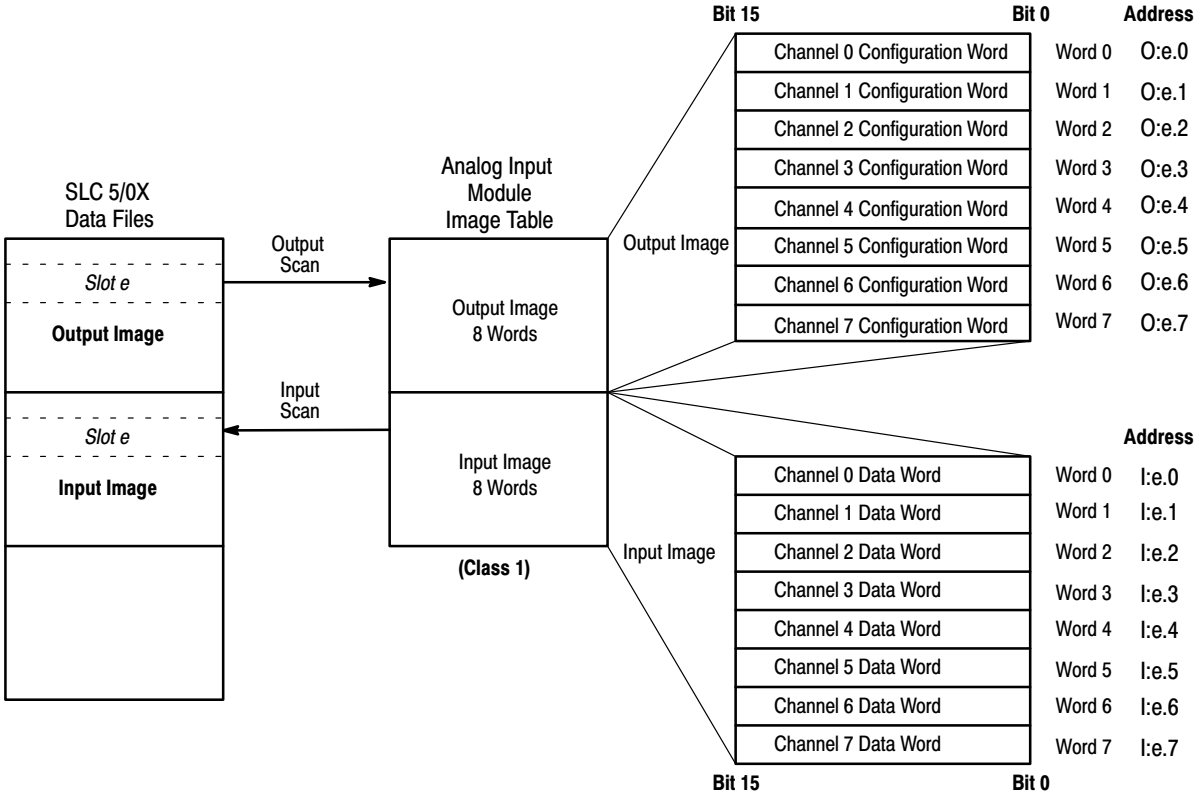
Calibration

The module performs continuous autocalibration for all the channels that are enabled. There is no need to invoke a calibration cycle to compensate for changes in temperature.

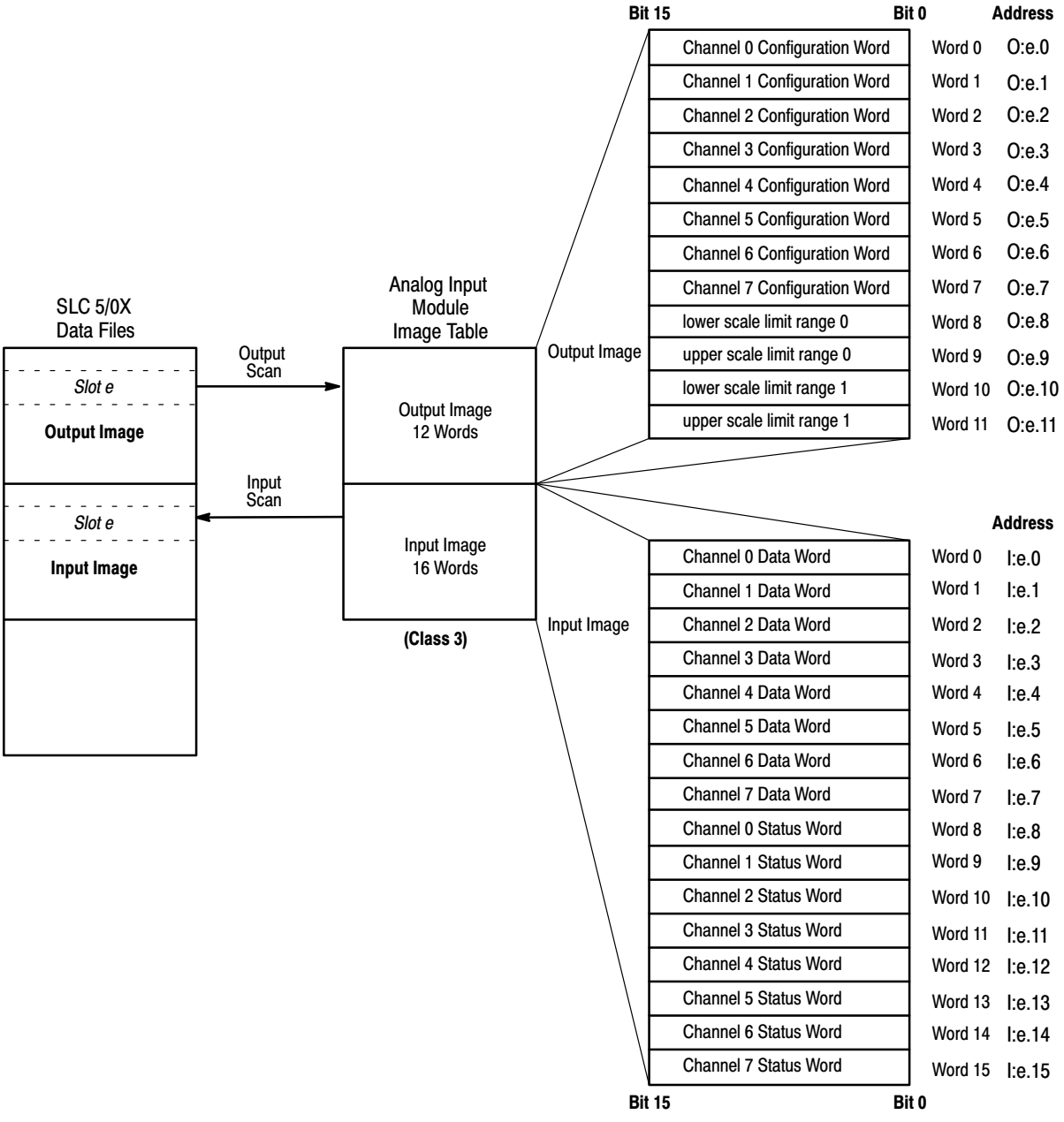
8-Channel Module Addressing

The following memory maps show you how the input and output image tables are defined for Class 1 and Class 3.

Class 1 Memory Map



Class 3 Memory Map



8-Channel Module Configuration, Data, and Status

Module ID Code

The module identification code is a unique number encoded for each 1746 I/O module. The code defines for the processor the type of I/O or specialty module residing in a specific slot in the 1746 chassis.

Catalog Number	ID Code
1746-NI8	3526 – Class 1 interface 12726 – Class 3 interface

Important: All programming software does not support configuration for Class 3 operation.

- Advanced Programming Software (APS) supports Class 3 configuration. After entering the ID code (12726), enter 16 input words and 12 output words.
- SLC 500 A.I. Series™ Programming Software supports Class 3 configuration. After entering the ID code (12726), enter 16 input words and 12 output words.
- RSLogix 500™, version 1.30 or later, supports Class 3 configuration. After entering the ID code (12726), select Class 3 operation.
- Earlier versions of RSLogix 500 will only support configuration for Class 1 operation. Contact Rockwell Software for information on upgrading your software.

Channel Configuration

Once the module has been installed, each channel on the module can be configured to establish the way the channel will operate. You configure the channel by entering bit values into the configuration word using your programming software. The bit values are defined in the following table. In the table:

Engineering units are 1 mV/step for voltage input types, and 1.0 μA/step for current input types.

The **scaled-for-PID** value is a 14-bit unsigned integer, with 0 representing the low scale value and 16,383 representing the full scale value minus 1 lsb. The input signal range is proportional to your selected input type and scaled into a 0 to 16,383 range, which is standard to the SLC PID algorithm.

The **proportional count** value is a 16-bit signed integer. The input signal range is proportional to your selected input and scaled into a –32,768 to +32,767 range.

User defined scaling count (Class 3 operation only) allows the output image data words 8 and 9 (or words 10 and 11) to be selected to represent low scale and high scale limits. The module uses these limits and scales proportionately between them.

The **1746-NI4 data format** converts the current and voltage signals into 16-bit 2's complement binary values. If you are replacing 1746-NI4 modules with the new 1746-NI8, refer to the *SLC 500™ Analog Input Module (Cat. No. 1746-NI8) User Manual*, publication 1746-6.8 for information on how to do so.

Channel Configuration Word (O:e.0 through O:e.11) – Bit Definitions

Bit(s)	Define	To Select①		Make these bit settings in the Channel Configuration Word															
				15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0 to 2	Input Type	*SET DIP SWITCH TO "OFF" FOR VOLTAGE INPUT*	±10V dc														0	0	0
			1 to 5V dc														0	0	1
			0 to 5V dc														0	1	0
			0 to 10V dc														0	1	1
		SET DIP SWITCH TO "ON" FOR CURRENT INPUT	0 to 20 mA														1	0	0
			4 to 20 mA														1	0	1
			±20 mA														1	1	0
			0 to 1 mA														1	1	1
3 to 5	Data Format	Engineering Units												0	0	0			
		Scaled-for-PID												0	0	1			
		Proportional Counts												0	1	0			
		1746-NI4 Data Format												0	1	1			
		User Defined (Class 3)												1	0	0			
		User Defined (Class 3)												1	0	1			
		Illegal (configuration error)																	
		Illegal (configuration error)																	
6 and 7	Open Circuit	Zero										0	0						
		Upscale										0	1						
		Downscale										1	0						
		Illegal																	
8 to 10	Filter Frequency	No Filter							0	0	0								
		75 Hz							0	0	1								
		50 Hz							0	1	0								
		20 Hz							0	1	1								
		10 Hz							1	0	0								
		5 Hz							1	0	1								
		2 Hz							1	1	0								
		1 Hz							1	1	1								
11	Channel Enable	Channel Disabled						0											
		Channel Enabled						1											
12 to 15	Unused	Unused②		0	0	0	0												

① In addition to programming the configuration word, you must also use the DIP switches to select voltage or current.

② Ensure unused bits 12 to 15 are always set to zeros.

Channel Data

The channel data word contains a 16-bit integer that represents the value of the analog input channel. The module input image uses 8 data word values whether the module is in Class 1 or Class 3 mode. The converted voltage or current input data values reside in I:e.0 through I:e.7 of the module's input image file. When an input channel is disabled, its data word is reset to zero.

The channel data word contains a 16-bit integer that represents the value of the analog input channel. The tables below show the channel data word values for various input types and data formats. The second table shows the default full-scale values for the proportional counts data format. The table does not imply the entire data value range is usable resolution.

Channel Data Word Values for Engineering Units

Input Type	Signal Range	Engineering Units	Engineering Units Scale
±10V dc	–10.25 to +10.25V dc	–10250 to +10250	1 mV/step
0 to 5V dc	–0.5 to +5.5V dc	–500 to +5500	1 mV/step
1 to 5V dc	0.5 to 5.5V dc	500 to 5500	1 mV/step
0 to 10V dc	–0.5 to +10.25V dc	–500 to +10250	1 mV/step
0 to 20 mA	–0.5 to +20.5 mA	–500 to +20500	1.0 uA/step
4 to 20 mA	3.5 to 20.5 mA	3500 to 20500	1.0 uA/step
±20 mA	–20.5 to +20.5 mA	–20500 to +20500	1.0 uA/step
0 to 1 mA	–0.05 to +1.05 mA	–50 to +1050	1.0 uA/step

Channel Data Word Values for Scaled Data

Input Type	Signal Range	Scaled-for-PID	Proportional Counts (default)	NI4 Data Format
±10V dc	–10.00 to +10.00V dc	0 to 16383	–32768 to +32767	–32768 to +32767
0 to 5V dc	0.0 to 5.00V dc	0 to 16383	–32768 to +32767	0 to 16384
1 to 5V dc	1.00 to 5.00V dc	0 to 16383	–32768 to +32767	3277 to 16384
0 to 10V dc	0.0 to 10.00V dc	0 to 16383	–32768 to +32767	0 to 32767
0 to 20 mA	0.0 to 20.0 mA	0 to 16383	–32768 to +32767	0 to 16384
4 to 20 mA	4.0 to 20.0 mA	0 to 16383	–32768 to +32767	3277 to 16384
±20 mA	–20.0 to +20.0 mA	0 to 16383	–32768 to +32767	–16384 to +16384
0 to 1 mA	0.0 to 1.00 mA	0 to 16383	–32768 to +32767	0 to 1000 ①

① This data format is not supported by the 1746-NI4 module, but is available for the 1746-NI8 module.

Channel Status

The channel status word can be analyzed bit by bit. In addition to providing information about an enabled or disabled channel, each bit's status (0 or 1) tells you how the input data from the voltage or current analog sensor connected to a specific channel will be translated for your application. The bit status also informs you of any error condition and can tell you what type of error occurred.

A bit-by-bit examination of the status word is provided below:

Channel 0 to 7 Status Word (I:e.8 through I:e.15) – Bit Definitions

Bit(s)	Define	These bit settings																Indicate this
		15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
0 to 2	Input Type														0	0	0	±10 V dc
															0	0	1	1 to 5V dc
															0	1	0	0 to 5V dc
															0	1	1	0 to 10V dc
															1	0	0	0 to 20 mA
															1	0	1	4 to 20 mA
															1	1	0	±20 mA
															1	1	1	0 to 1 mA
3 to 5	Data Format											0	0	0				Engineering Units
												0	0	1				Scaled-for-PID
												0	1	0				Proportional Counts
												0	1	1				1746-NI4 Data Format
												1	0	0				User Defined (Class 3)
												1	0	1				User Defined (Class 3)
																		Illegal (configuration error)
																		Illegal (configuration error)
6 and 7	Open Circuit									0	0							Zero
										0	1							Upscale
										1	0							Downscale
																		Illegal (configuration error)
8 to 10	Filter Frequency						0	0	0									No Filter
							0	0	1									75 Hz
							0	1	0									50 Hz
							0	1	1									20 Hz
							1	0	0									10 Hz
							1	0	1									5 Hz
							1	1	0									2 Hz
							1	1	1									1 Hz
11	Channel Status					0												Channel Disabled
						1												Channel Enabled
12	Open-Circuit Error				0													No Error
					1													Open-Circuit Detected
13	Over-Range Error			0														No error
				1														Over-Range Condition
14	Under-Range Error		0															No Error
			1															Under-Range Condition
15	Configuration Error	0																No Error
		1																Configuration Error

Important: The status word for any disabled channel is always 0000 0000 0000 0000 regardless of any previous setting that may have been made to the configuration word.

8-Channel Module Wiring

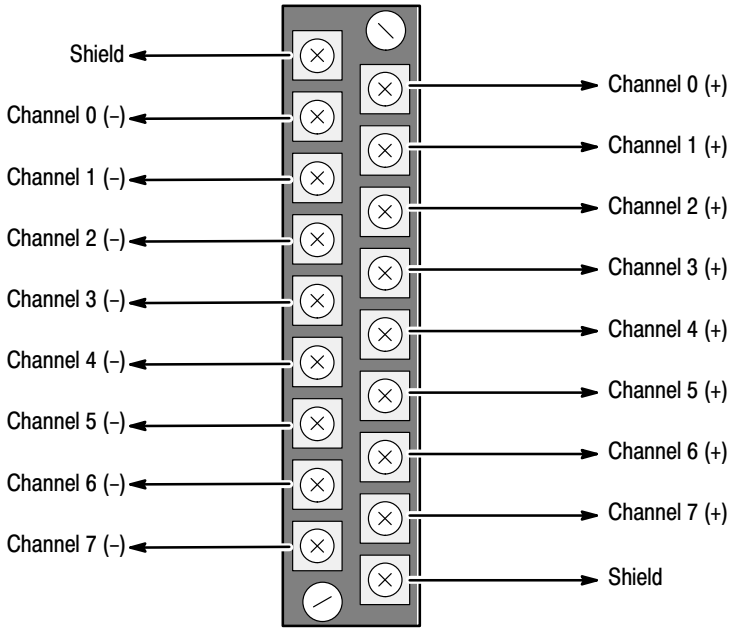
The 1746-NI8 module contains an 18-position, removable terminal block. The terminal pin-out is shown below.

ATTENTION: Disconnect power to the SLC before attempting to install, remove, or wire the removable terminal wiring block.

To avoid cracking the removable terminal block, alternate the removal of the slotted terminal block release screws.

Terminal Block

(Terminal Block Spare Part Catalog Number 1746-RT25G)

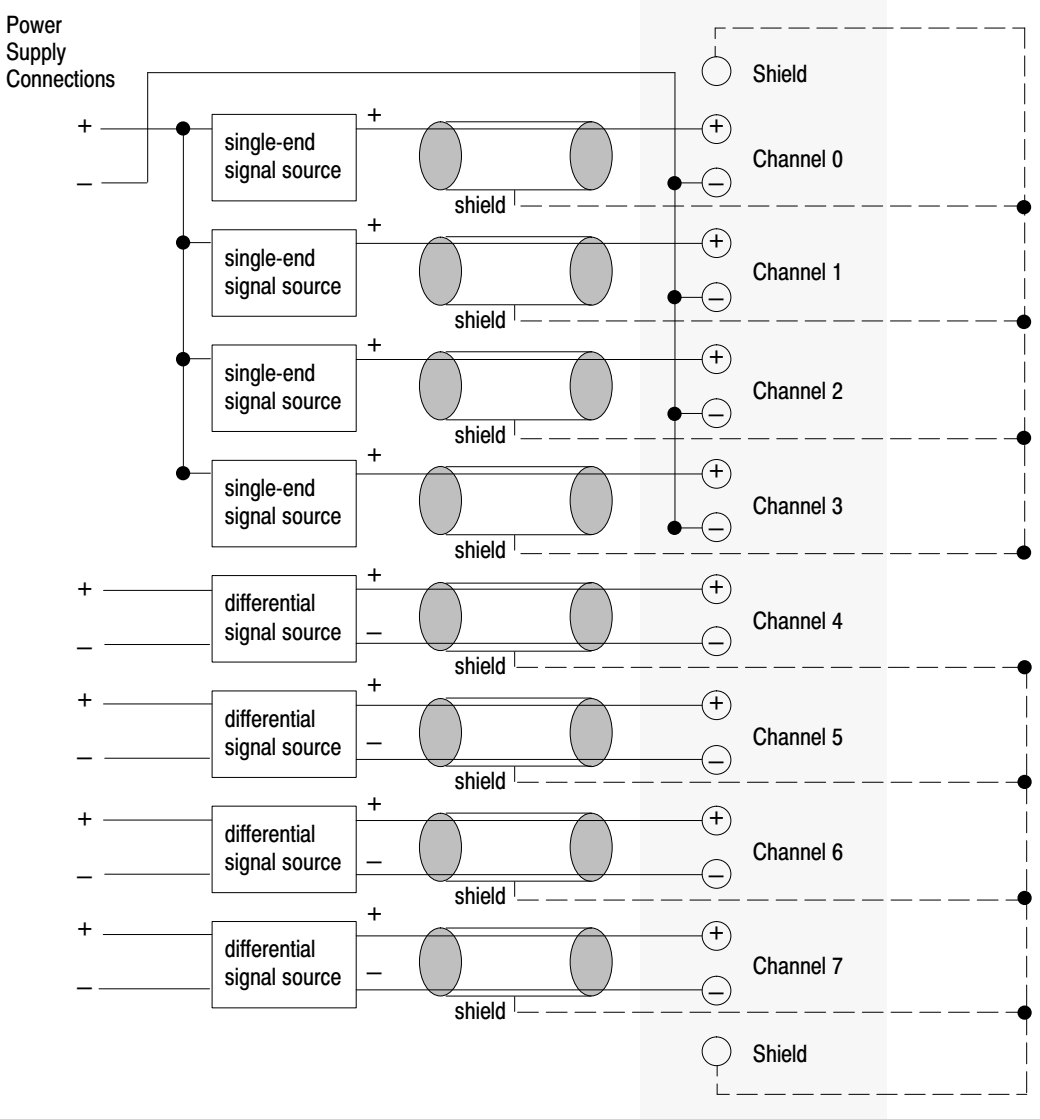


Wiring Single-Ended and Differential Inputs

The diagram below shows typical wiring for the module.

Important: Follow these guidelines when wiring the module.

- Use shielded communication cable (Belden 8761) and keep length as short as possible.
- Connect only one end of the cable shield to earth ground.
- Connect the shield drain wires for channels 0–3 to the top shield terminal.
- Connect the shield drain wires for channels 4–7 to the bottom shield terminal.
- Shield terminals are internally connected to chassis ground which is connected to earth ground via the SLC backplane.
- Single-ended source commons may be jumpered together at the terminal block.
- Channels are not isolated from each other.
- If a differential signal source has an analog common, it can not and must not be connected to the module.
- Common mode voltage range is ±10.5 volts. The voltage between any two terminals must be less than 21 volts.
- The module does not provide power for the analog inputs.
- Use a power supply that matches the transmitter (sensor) specifications.

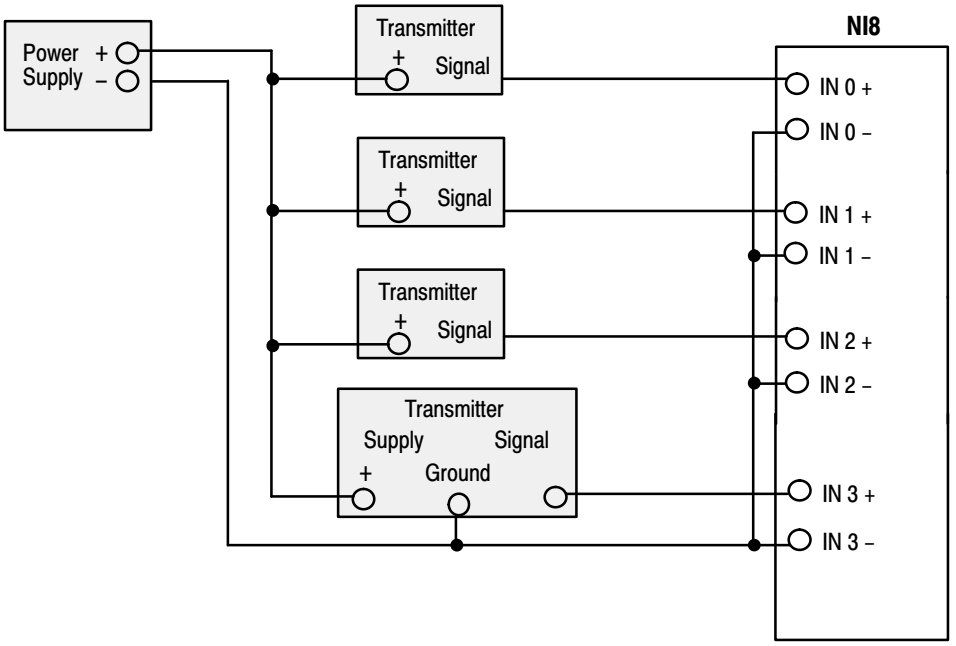


When wiring single-ended analog input devices to the analog input module, the number of total wires necessary can be limited by jumpering all "IN–" terminals together. Note that differential inputs are more immune to noise than single-ended inputs.

Important: The module does *not* provide loop power for analog inputs. Use a power supply that matches the transmitter specifications.

Important: Follow the guidelines on page 24 when wiring the module.

Wiring Schematic for Single-ended Analog Input Connections

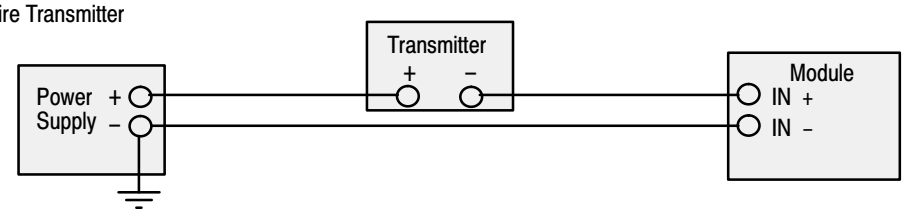


Important: The module does *not* provide loop power for analog inputs. Use a power supply that matches the transmitter specifications.

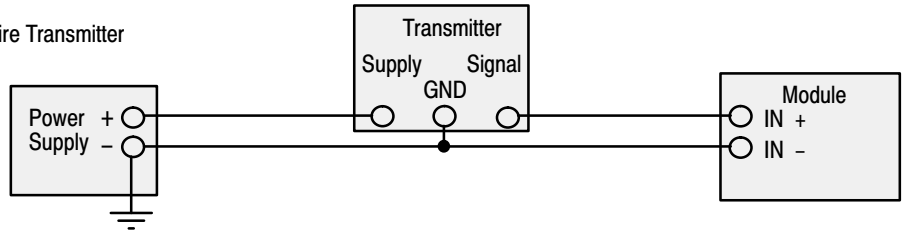
Important: Follow the guidelines on page 24 when wiring the module.

Wiring Schematics for 2, 3, and 4-Wire Analog Input Devices

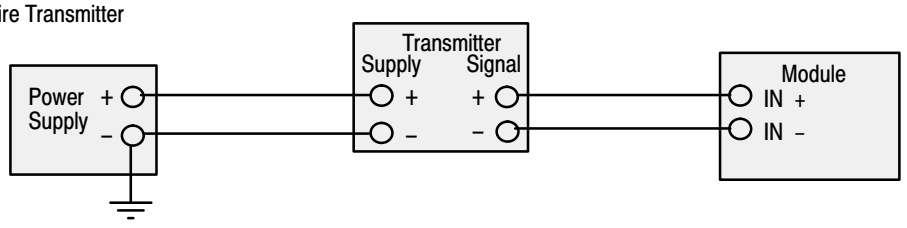
2-Wire Transmitter



3-Wire Transmitter

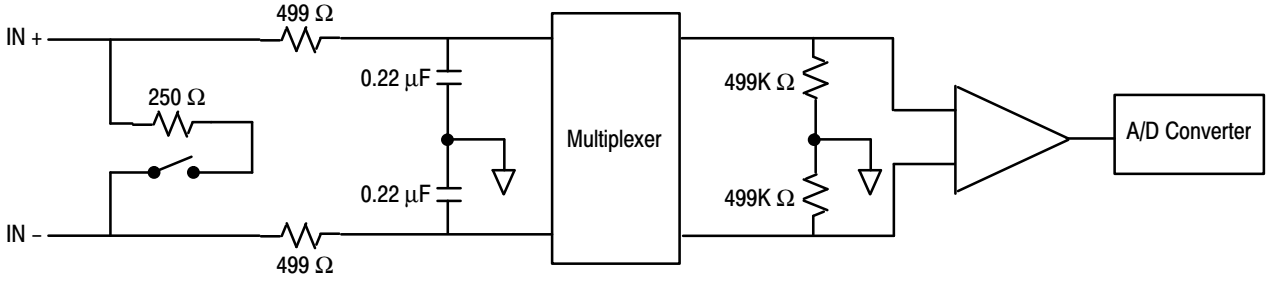


4-Wire Transmitter



8-Channel Module Internal Input Circuit

The following input circuit is provided to help you match the analog module to your input device:



8-Channel Module Specifications

Electrical Specifications

Description	Specification
Backplane Current Consumption	200 mA at 5V dc 100 mA at 24V dc
Backplane Power Consumption	3.4W maximum (1.0W @ 5V dc, 2.4W @ 24V dc)
Number of Channels	8 (backplane isolated)
I/O Chassis Location	Any I/O module slot except slot 0
A/D Conversion Method	Successive approximation, switched capacitor
Input Filtering	Low pass digital filter with programmable filter frequencies
Normal Mode Rejection (between [+] input and [–] input)	Provided by low-pass filter
Common Mode Rejection (between inputs and chassis ground)	Greater than or equal to 75 dB at DC Greater than or equal to 100 dB at 50/60 Hz
Input Filter Frequencies	1 Hz 2 Hz 5 Hz 10 Hz 20 Hz 50 Hz 75 Hz
Calibration	The module performs continuous autocalibration.
Isolation	50V dc continuous between the analog inputs and the backplane 530V ac or 750V dc pulse withstand for 1 second
Common-Mode Voltage Range	±10.5V (21V maximum between any two terminals)

Physical Specifications

Description	Specification
LED Indicators	9 green status indicators one for each of 8 channels and one for module status
Module ID Code	Class 1 Interface: 3526 Class 3 Interface: 12726
Recommended Cable	Belden #8761 or equivalent
Maximum Wire Size	Two 14 AWG wires per terminal
Maximum Cable Impedance	Voltage Source (with less than 10Ω impedance): 40Ω maximum loop impedance, for <1LSB error Current Source (transmitter properly wired to its power supply): 250Ω maximum loop impedance, to meet common-mode voltage requirements
Terminal Block	Removable, Allen-Bradley spare part Catalog Number 1746-RT25G

Environmental Specifications

Description	Specification
Operating Temperature	0°C to +55°C (+32°F to +131°F) in any slot except slot 0 0°C to +60°C (+32°F to +140°F) in right most slot of chassis
Storage Temperature	–40°C to +85°C (–40°F to +185°F)
Relative Humidity	5% to 95% (without condensation)
Certification	UL listed, CSA approved CE compliant for all applicable directives
Hazardous Environment Classification	Class I Division 2 Hazardous Environment

General Input Specifications

Description	Specification
Type of Input (Selectable)	±10V dc, 0 to 5V dc, 0 to 20 mA, ±20 mA 1 to 5V dc, 0 to 10V dc, 4 to 20 mA, 0 to 1 mA
Type of Data (Selectable)	Engineering Units Scaled-for-PID Proportional Counts (–32,768 to +32,767 range) Proportional Counts (User Defined Range, Class 3 only) 1746-NI4 Data Format
Time to Detect Open Circuit	1 module scan
Input Step Response	See Step Response Time table on page 28.
Non-linearity	0.01% of full scale maximum
Module Update Time	0.75 msec per enabled channel
Channel Turn-On Time	101 to 107 msec maximum
Channel Turn-Off Time	1 to 7 msec maximum
Channel Reconfiguration Time	101 to 107 msec maximum

Filter Frequency	Step Response Time		
	1% Accuracy①	0.1% Accuracy①	0.05% Accuracy①
1 Hz	730 msec + module update time	1100 msec + module update time	1200 msec + module update time
2 Hz	365 msec + module update time	550 msec + module update time	600 msec + module update time
5 Hz	146 msec + module update time	220 msec + module update time	240 msec + module update time
10 Hz	73 msec + module update time	110 msec + module update time	120 msec + module update time
20 Hz	36.5 msec + module update time	55 msec + module update time	60 msec + module update time
50 Hz	14.5 msec + module update time	22 msec + module update time	24 msec + module update time
75 Hz	10 msec + module update time	15 msec + module update time	18 msec + module update time
no filter	0.5 msec + module update time	0.75 msec + module update time	0.75 msec + module update time

① The module accuracy for current inputs is 0.05%, and for voltage inputs is 0.1%.

Current-Loop Input Specifications

Description	Specification
Current Input (maximum)	±30 mA
Input Impedance	250 ohms
Input Resolution	1 μA
Display Resolution	1 μA
Overall Module Accuracy 0°C to +60°C (+32°F to +140°F)	0 to 20 mA, 4 to 20 mA, ±20 mA: ±0.05% 0 to 1 mA: ±0.5%
Overall Module Accuracy Drift	±12 ppm/°C
Gain Error at +25°C (+77°F)	±0.025% (max)
Gain Error, 0°C to +60°C (+32°F to +140°F)	±0.05% (max)
Gain Error Drift	±12 ppm/°C
Offset Error at +25°C (+77°F)	±2 LSB (max)
Offset Error, 0°C to +60°C (+32°F to +140°F)	±3 LSB (max)
Offset Error Drift	±0.03 LSB/°C
Overvoltage Capability	7.5V ac RMS (max)

Voltage Input Specifications

Description	Specification
Voltage Input (maximum)	±30V between any two signal terminals
Input Impedance	1 MΩ
Input Resolution	1 mV
Display Resolution	1 mV
Overall Module Accuracy 0°C to +60°C (+32°F to +140°F)	±0.1%
Overall Module Accuracy Drift	±17 ppm/°C
Gain Error at +25°C (+77°F)	±0.05% (max)
Gain Error, 0°C to +60°C (+32°F to +140°F)	±0.1% (max)
Gain Error Drift	±17 ppm/°C (max)
Offset Error, +25°C (+77°F)	±2 LSB (max)
Offset Error at 0°C to +60°C (+32°F to +140°F)	±3 LSB (max)
Offset Error Drift	±0.03 LSB/°C (max)

Terms and Abbreviations

Listed below and on the following page are definitions of some of the terms and abbreviations used in the specification tables. For definitions of terms not listed here refer to *Allen-Bradley's Industrial Automation Glossary*, Publication AG-7.1.

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 ratio – 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 – A voltage that appears in common at both input terminals of a differential analog input with respect to ground.

common mode voltage range – The largest voltage allowed at either input terminal of a differential analog input with respect to ground.

configuration word – Contains the channel configuration information needed by the module to configure and operate each channel. Information is written to the configuration word through the logic supplied in your ladder program.

data word – A 16-bit integer that represents the value of the analog 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).

differential operation – The use of floating analog inputs or outputs where neither terminal of the input pair or output pair is grounded.

gain error – The "gain" of an analog input or output is the scale factor which provides the nominal conversion relationship. Typically, this is the slope of the line when analog voltage or current is plotted versus the corresponding digital codes. Gain error is the deviation of the scale factor or slope of the line from the ideal or nominal value. Gain error is expressed in percent of the input or output value.

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

gain error drift – The effect of temperature on gain error is expressed by gain error drift. As temperature varies from +25°C, the possible gain error increases. The gain error drift is specified in percent of input or output value /°C.

input image – The input from the analog module to the SLC processor. The input image contains the module data words and status words.

linearity error – An analog input or output is composed of a series of voltage or current values corresponding to digital codes. For an ideal analog input or output, the values lie in a straight line spaced by a voltage or current corresponding to 1 LSB. Any deviation of the converted input or actual output from this line is the linearity error of the input or output. The linearity is expressed in percent of full scale.

maximum differential voltage – The largest voltage difference allowed between negative and positive terminals during normal differential operation.

module access time – The time between updates of the analog input value available to the backplane.

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 SLC processor. For analog outputs, the time between the digital code received at the module and the analog output signal appearing at the channel's output terminals.

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.

offset error – For analog inputs, the offset error is the non-zero digital code when zero voltage or zero current is applied to the input terminals. For analog outputs, the offset error is the non-zero digital code required to produce zero voltage or current at the output terminals.

offset error drift – The effect of temperature on offset error is expressed by offset error drift. As temperature varies from +25°C, the possible offset error increases. The offset error drift is specified in LSB /°C of full scale.

output image – The output from the SLC processor to the analog module. The output image contains the module configuration information. Each output word configures a single channel.

overall accuracy – The worst case deviation of the output voltage or current from the ideal over the full output range is the overall accuracy. For inputs, the worst case deviation of the digital representation of the input signal from the ideal over the full input range is the overall accuracy. This is expressed in percent of full scale. Gain error, offset error, and linearity error all contribute to input and output channel accuracy.

status word – Contains status information about the channel's current configuration and operational state. You can use this information in your ladder program to determine whether the channel data word is valid.

step response time – This is the time required for the channel data word signal to reach a specified percentage of its expected final value, given a large step change in the input signal.

Determining Power Requirements

Analog modules require both 5V dc and 24V dc power from the backplane of the SLC 500 system. However, the 1746-NO4I and 1746-NO4V analog modules can use an external 24V dc power supply. This eliminates the 24V dc backplane power requirement, providing configuration flexibility if SLC power supply loading is critical. These two modules have terminals for external 24V dc power supply connections.①

When you are using a modular system configuration, add the values shown in the table below to the requirements of all other modules in the SLC chassis to prevent overloading the chassis power supply. The maximum current drawn by the module is shown in the table below.

Important: The analog modules do not supply loop power for the input device. You must supply the appropriate loop power for loop-powered input devices.

Backplane Current Draw		
Catalog Number	**5 Volt Current**	**24 Volt Current**
1746-FIO4I	55 mA	150 mA
1746-FIO4V	55 mA	120 mA
1746-NI4	35 mA	85 mA
1746-NI8	200 mA	100 mA
1746-NIO4I	55 mA	145 mA
1746-NIO4V	55 mA	115 mA
1746-NO4I	55 mA	195 mA②
1746-NO4V	55 mA	145 mA②

① The 24V dc external power connection on a fixed SLC 500 can power an NO4I or NO4V analog module. However, the regulation of the 24V dc external connection on a modular SLC 500 power supplies (catalog numbers 1746-P1, -P2, and -P4) is outside of the requirements of the NO4I and NO4V analog modules and cannot be used.

② Omit these values from your SLC power supply loading calculations if you decide to use an external power supply.

Place your analog module in any slot of an SLC 500 modular, or modular expansion chassis, except for the extreme left slot (slot 0) in the first chassis. This slot is reserved for the processor or adapter modules.

Important: For applications using the upper limit of the operating temperature range, the 1746-NI8 module (or multiple 1746-NI8 modules) should be placed in the right most slot(s) of the chassis. The specification for operating temperature is:

Operating Temperature Range
0°C to +55°C (+32°F to +131°F) in any slot except slot 0
0°C to +60°C (+32°F to +140°F) in right most slot of chassis

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