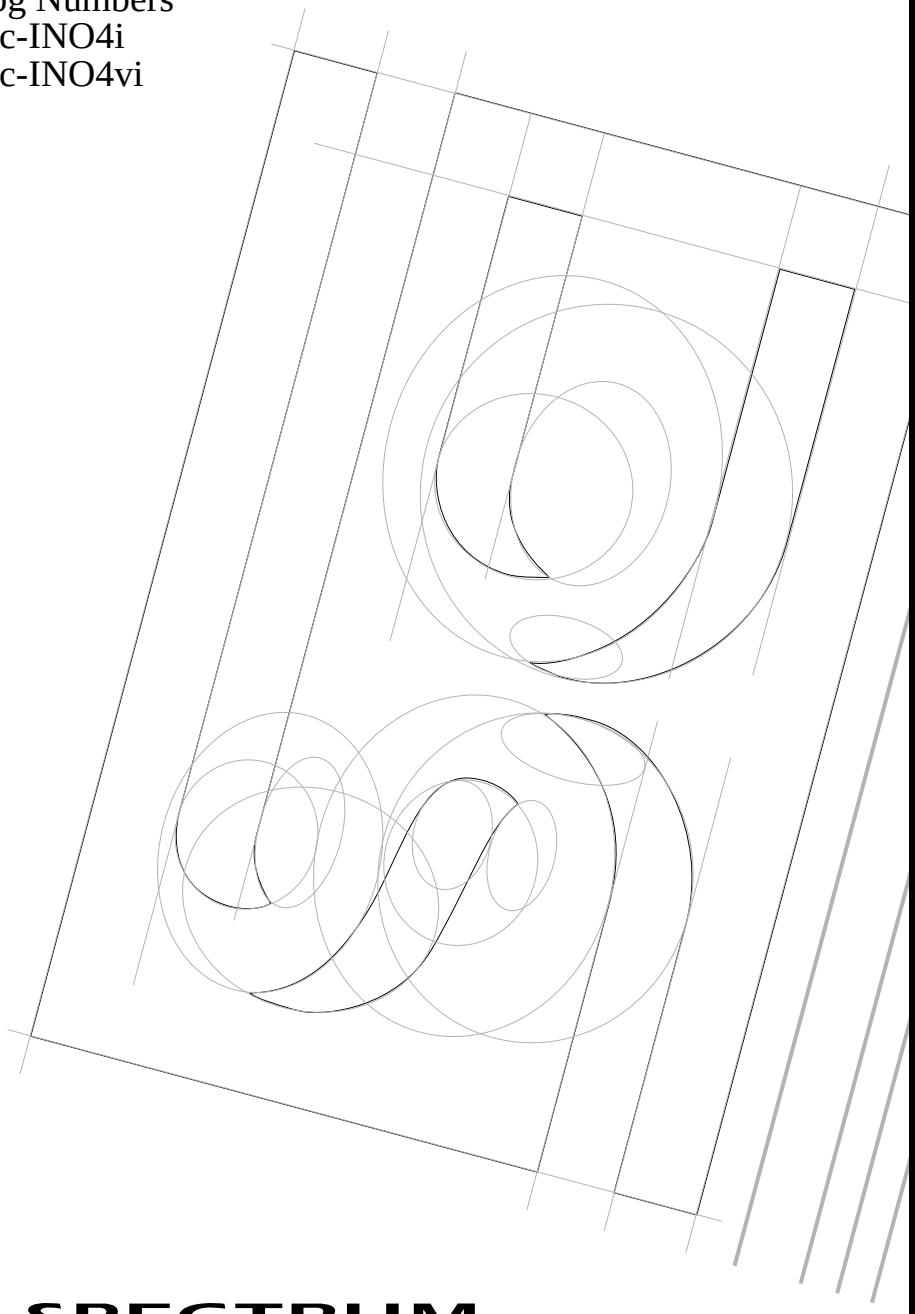
Owner's Guide 0300128-03 Rev. D

SLC 500™ Isolated Analog Output Modules

Catalog Numbers
1746sc-INO4i
1746sc-INO4vi



SPECTRUM CONTROLS

Important Notes

1. Please read all the information in this owner’s guide before installing the product.
2. The information in this owner's guide applies to hardware and firmware version 1.0 or later.
3. This guide assumes that the reader has a full working knowledge of the relevant processor.

Notice

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Preface

Read this preface to familiarize yourself with the rest of the owner's guide. This preface covers:

- who should use this guide
- what this guide covers
- related Allen-Bradley documents
- terms & abbreviations you should know

Who Should Use This Guide

Use this guide if you design, install, program, or maintain a control system that uses Allen-Bradley Small Logic Controllers.

You should have a basic understanding of SLC 500 products. You should also understand electronic process control and the ladder program instructions required to generate the electronic signals that control your application. If you do not, contact your local Allen-Bradley representative for the proper training before using these products.

What This Guide Covers

This guide covers the 1746sc-INO4i and 1746sc-INO4vi isolated analog output modules. It contains the information you need to install, wire, use, and maintain these modules. It also provides diagnostic and troubleshooting help should the need arise.

Related Allen-Bradley Documents

Table 1 lists several Allen-Bradley documents that may help you as you use these products.

Table 1. Related Allen-Bradley documents

Allen-Bradley Doc. No.	Title
1747-2.30	SLC 500 System Overview
SGI-1.1	Application Considerations for Solid State Controls
1770-4.1	Allen-Bradley Programmable Controller Grounding and Wiring Guidelines
1747-6.2	Installation & Operation Manual for Modular Hardware Style Programmable Controllers
1747-NI001	Installation & Operation Manual for Fixed Hardware Style Programmable Controllers
1747-6.4	Allen-Bradley Advanced Programming Software (APS) User Manual
1747-6.11	Allen-Bradley Advanced Programming Software (APS) Reference Manual
1747-6.3	Getting Started Guide for Advanced Programming Software (APS)
ABT-1747-TSG001	SLC 500 Software Programmers's Quick Reference Guide
1747-NP002	Allen-Bradley HHT (Hand-Held Terminal) User Manual
1747-NM009	Getting Started Guide for HHT (Hand-Held Terminal)
SD499	Allen-Bradley Publication Index
AG-7.1	Allen-Bradley Industrial Automation Glossary

To obtain a copy of any of the Allen-Bradley documents listed, contact your local Allen-Bradley office or distributor.

Terms & Abbreviations You Should Know

You should understand the following terms and abbreviations before using this guide. For the definitions of terms not listed here, refer to *Allen-Bradley's Industrial Automation Glossary*, Publication AG-7.1

Attenuation – The reduction in magnitude of a signal as it passes through a system. The opposite of gain.

Channel – Refers to one of the sets of signal interfaces available on a module's terminal block.

Channel update time – For analog outputs, the time required for the channel to convert the data received from the processor to analog output signals at the terminals.

Chassis – See rack.

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 – 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.

D/A – Refers to digital-to-analog conversion. The conversion produces an analog output signal whose magnitude is proportional to the digital value.

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

Data scaling - The data format that you select to define the logical increments of the channel data word.

Data word – A 16-bit integer that represents the value of the analog output channel. The channel data word is valid only when the channel is enabled and there are no channel errors.

Differential operation – The difference in voltage between a channel's positive and negative terminals.

Effective resolution – The number of bits in the channel data word that do not vary due to noise.

Full-scale error (gain error) – The difference in slope between the actual and ideal analog transfer functions.

Full-scale range (FSR) – The difference between the maximum and minimum specified analog values.

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

LSB (least significant bit) – The bit that represents the smallest value within a string of bits. The "weight" of this value is defined as the full-scale range divided by the resolution.

Maximum differential voltage – The largest voltage difference allowed between the negative terminal and positive terminal during normal differential operation.

Module ID code – A unique number associated with 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.

Module update time – See channel update time.

Overall accuracy – The worst-case deviation of the signal over the full range, expressed in percent of full scale.

Rack – A hardware assembly that houses devices such as I/O modules, adapter modules, processor modules, and power supplies.

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 (e.g. 0.15 °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. See also effective resolution.

Safe state – The state of the analog outputs entered when the processor is not in RUN mode. The user must ensure that this state is a safe state for the application.

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 – The time required for the output signal to reach 95% of its expected, final value, given a full-scale step change in the output data word.

Useful resolution – See effective resolution.

Overview And Specifications

The 1746sc-INO4i provides four isolated channels of current outputs, while the 1746sc-INO4vi provides four isolated channels of current *or* voltage outputs (in any combination). In both modules, the voltage and/or current ranges are independently configurable for each channel. These modules also provide new, advanced features to make your control systems more dependable and flexible.

Read this chapter to familiarize yourself further with your isolated analog module (shown above). This chapter covers:

- general features and benefits
- detailed specifications

General Features And Benefits

Increased System Accuracy and Reliability

Both modules provide 750 Vdc channel-to-channel isolation, which means no electrical noise crosstalk between channels (resulting in a high *usable* resolution). They also provide 750 Vdc field-wiring-to-backplane isolation to protect the processor and rack. These modules even feature onboard temperature compensation to maintain their accuracy with fluctuating ambient temperatures, which is important for crowded control cabinets.

Reduced System Costs

Because isolation is built into these modules, you can improve system accuracy while saving hundreds of dollars on system installation costs. Expensive, external isolation blocks are simply not required. They also

provide a single-slot solution for applications requiring up to four, mixed analog outputs, so you don't have to buy more I/O than you need.

State-of-the-Art Performance

These modules incorporate proprietary Allen-Bradley technology, so they operate and perform like the latest Allen-Bradley products. They also provide 16-bits of resolution, user-programmable range settings, continuous temperature compensation (no field calibration), software configuration, programmable output limits, and programmable safe states in case of a fault.

Detailed Specifications

Table 2. Electrical specifications—module

Backplane Current Consumption (maximum)	
1746sc-INO4i	120 mA @ 5 Vdc 250 mA @ 24 Vdc
1746sc-INO4vi	120 mA @ 5 Vdc 250 mA @ 24 Vdc
Backplane Power Consumption (typical)	0.6 W
Number Of Channels	4 (differential, individually isolated)
I/O Chassis Location	Any 1746 I/O module slot except slot 0
A/D Conversion Method	Sigma-Delta
Calibration	Factory calibrated Temperature compensation once a minute
Opto-Electrical Isolation	750 Vdc channel-to-channel 750 Vdc field wiring-to-backplane
Module ID Code	
1746sc-INO4i	3521
1746sc-INO4vi	3519
Thermal Dissipation	4.5 W maximum

Table 3. Electrical specifications—outputs

Output Current Ranges (selectable for each channel)	4 to 20 mA 0 to 20 mA 0 to 21 mA
Output Voltage Ranges—INO4vi only (selectable for each channel)	-10 to +10 Vdc 0 to 10 Vdc 0 to 5 Vdc 1 to 5 Vdc
SLC Communication Formats (selectable for each channel)	Scaled engineering units Scaled for PID Proportional counts 1746-NO4 format User-defined scale
Output Impedance Current Outputs Voltage Outputs—INO4vi only	 Greater than 1 MΩ Less than 1.0 Ω
Load Range Current Outputs Voltage Outputs—INO4vi only	 0 to 500 Ω 1 kΩ and greater
Max. Current, Voltage Mode—INI4vi only	10 mA
Output Step Response Time	1 ms (0–95% of full scale)
Channel Update Time (maximum)	33.7 ms for all 4 channels in parallel
Output Resolution Current Outputs Voltage Outputs—INO4vi only	16-bit 366 nA/count 320 µV/count
Overall Accuracy Current Outputs Voltage Outputs—INO4vi only	 0.08% of full scale @ 25 °C 0.15% of full scale @ 60 °C 0.08% of full scale @ 25 °C 0.35% of full scale @ 60 °C

Table 4. Physical specifications

LED Indicators	Four green channel status indicators, one for each channel One green module status indicator
Recommended Cable	Belden 8761 (shielded, twisted-pair) or equivalent
Wire Size (maximum)	One 12–24 AWG wire per terminal
Terminal Block	Removable (supplied)

Table 5. Environmental specifications

Operating Temperature	0 to 60 °C (32 to 140 °F)
Storage Temperature	-40 to 85 °C (-40 to 185 °F)
Relative Humidity	5 to 95% non-condensing
Certifications	UL/CUL and CE
Hazardous Environment Classifications	Class I Division 2 Groups ABCD

Installing And Wiring Your Module

Read this chapter to install and wire your module. This chapter covers:

- avoiding electrostatic damage
- determining power requirements
- setting the DIP switch
- selecting a rack slot
- inserting your module into the rack
- wiring your module

Note that although your module has a jumper on its printed circuit board, this jumper is for the manufacturer's use only. Also, your module was calibrated by the manufacturer, so you don't need to perform this task.

Important - For UL and CUL compliance, power and input/output (I/O) wiring must be in accordance with Class I, Division 2, wiring methods [Article 501-4 (b) of the National Electrical Code , NFPA 70] and in accordance with the authority having jurisdiction. Also, you must observe the warnings shown below. Failure to observe these warnings can cause personal injury.

WARNING

EXPLOSION HAZARD

Substitution of components may impair suitability for Class I, Division 2;

When in hazardous locations, turn off power before replacing or wiring modules;

Do not disconnect equipment unless power has been switched off or the area is known to be non-hazardous.

The following documents contain information that may help you as you install and wire your module:

- *National Electrical Code*, published by the National Fire Protection Association of Boston, MA
- IEEE Standard 518-1977, *Guide for the Installation of Electrical Equipment to Minimize Electrical Noise Inputs to Controllers from External Sources*
- IEEE Standard 142-1982, *Recommended Practices for Grounding of Industrial and Commercial Power Systems*
- *Noise Reduction Techniques in Electronic Systems*, by Henry W. Ott; published by Wiley-Interscience of New York in 1976

Avoiding Electrostatic Damage

Guard against electrostatic damage by observing the following precautions:

CAUTION

ELECTROSTATICALLY SENSITIVE COMPONENTS

- **Before handling the module, touch a grounded object to rid yourself of electrostatic charge.**
- **When handling the module, wear an approved wrist strap grounding device.**
- **Handle the module from the front, away from the backplane connector. Do not touch backplane connector pins.**
- **Keep the module in its static-shield container when not in use or during shipment.**

Failure to observe these precautions can degrade the module's performance or cause permanent damage.

Determining Power Requirements

The backplane of the SLC 500 system can provide both 5 Vdc and 24 Vdc power. The following table shows the maximum current consumed by your module when using these power sources:

Table 6. Backplane current consumed

		24 Vdc *	
Catalog Number	**5 Vdc**	**w/o ext. supply**	**w/ ext. supply**
1746-sc-INO4i	120 mA	250 mA	0 mA
1746sc-INO4vi	120 mA	250 mA	0 mA

* The 1746sc-INO4i and 1746sc-INO4vi output modules can use an external 24 Vdc power supply to reduce backplane loading. To use an external 24 Vdc power supply, you must set your module's DIP switch as indicated in the following subsection.

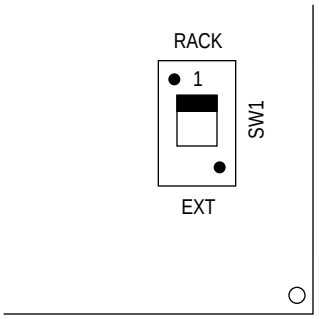
Use Table 6 to calculate the total load on the system power supply. For more information, see the Allen-Bradley system *Installation and Operation Manual*.

Setting The DIP Switch

The 1746sc-INO4i and 1746sc-INO4vi output modules have an external 24 Vdc power switch, SW1, giving you the option of using an external power supply:

- With the switch in the **RACK** position, the module draws all its power from the backplane of the SLC system.
- With the switch in the **EXT** position, the module draws its 24 Vdc power from an external power source; however, the module still draws its 5 Vdc power from the backplane.

The switch, SW1, is located in the bottom corner of the module's large circuit board.



Selecting A Rack Slot

Two factors determine where you should install your module in the rack: ambient temperature and electrical noise. When selecting a slot for your module, try to position your module:

- in a rack close to the bottom of the enclosure (where the air is cooler)
- away from modules that generate significant heat, such as 32-point input/output modules
- in a slot away from ac or high-voltage dc modules, hard contact switches, relays, and ac motor drives
- away from the rack power supply (if using a modular system)

Remember that in a modular system, the processor always occupies the first slot of the rack.

Inserting Your Module Into The Rack

CAUTION

POSSIBLE EQUIPMENT OPERATION

Before installing or removing your module, always disconnect power from the SLC 500 system and from any other source to the module (in other words, don't "hot swap" your module), and disconnect any devices wired to the module.

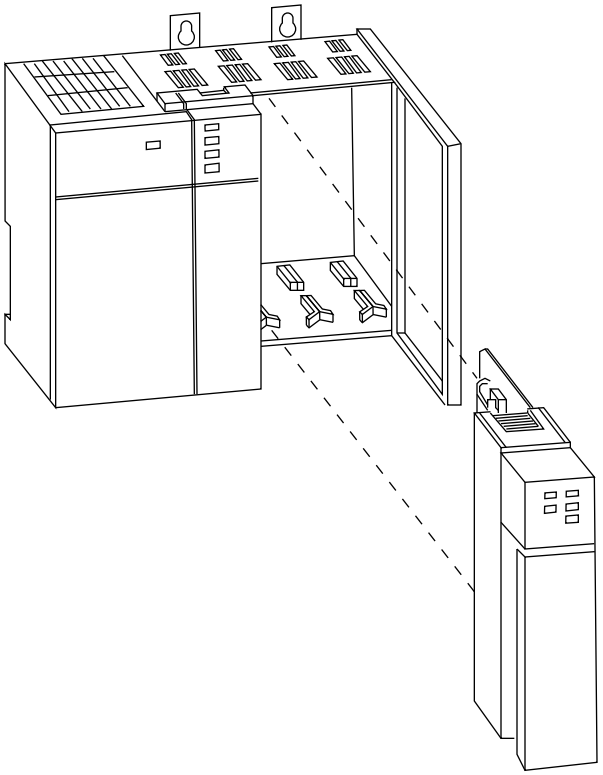
Failure to observe this precaution can cause unintended equipment operation and damage.

When inserting your module into the rack, you do not need to remove the supplied 16-position terminal block from the module. If, however, you do remove the terminal block, apply the supplied write-on label to the terminal block, and use the write-on label to identify your module's location.

To remove the terminal block, unscrew the two retaining screws at the top and bottom of the terminal block, and using a screwdriver or needle-nose pliers, carefully pry the terminal block loose.

To insert your module into the rack, follow these steps:

1. Align the circuit board of your module with the card guides at the top and bottom of the chassis.



2. Slide your module into the chassis until both top and bottom retaining clips are secure. Apply firm even pressure on your module to attach it to its backplane connector. Never force your module into the slot.

Cover all unused slots with the Card Slot Filler, Allen-Bradley part number 1746-N2.

To remove your module, press the retaining clips at the top and bottom of your module and slide it out.

Wiring Your Module

To wire the terminal block, you need:

- a small, flat-blade screwdriver
- Belden 8761 (shielded, twisted pair) cable or equivalent

CAUTION

POSSIBLE EQUIPMENT OPERATION

Before wiring your module, always disconnect power from the SLC 500 system and from any other source to the module.

Failure to observe this precaution can cause unintended equipment operation and damage.

Before wiring the terminal block, take some time to plan your system:

- Ensure that the SLC 500 system is installed in a NEMA-rated enclosure and that the SLC 500 system is properly grounded.
- Ensure that the load resistance for a current output channel is less than 500 Ω.
- Ensure that the load resistance for a voltage output channel is greater than 1 kΩ.
- Route the 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 lease 6 in. (about 15.2 cm) of separation for every 120 V of power.
- Routing the field wiring in grounded a conduit can reduce electrical noise further.
- If the field wiring must cross ac or power cables, ensure that they cross at right angles.

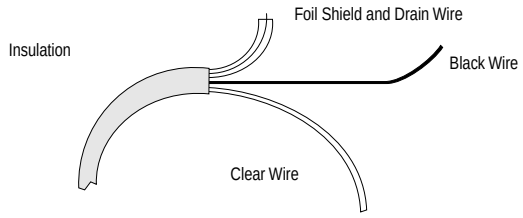
To wire your module, follow these steps:

1 Determine the length of cable you need to connect a channel to its field device. Remember to include additional cable to route the drain wire and foil shield to their ground points.

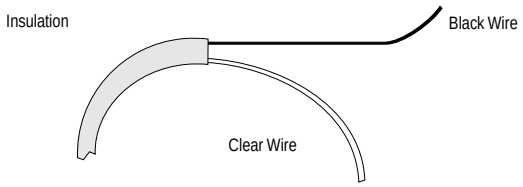
2. At each end of the cable, strip some casing to expose the individual wires.

3. Trim the exposed signal wires to 2 in. lengths. Strip about 3/16 in. (about 5 mm) of insulation away to expose the end of each wire.

4. At one end of the cable, twist the drain wire and foil shield together, bend them away from the cable, and apply shrink wrap.



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

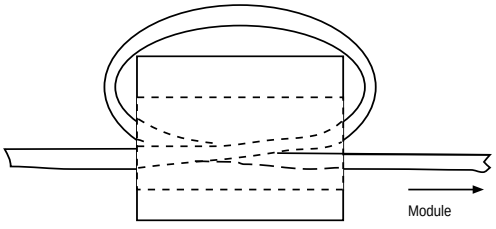


6. Connect the wires to the terminal block and field device as shown in the following figures and table. The recommended maximum torque is 5 in-lb (0.565 Nm) for all terminal screws.

   To guard against electrostatic damage and improve chassis grounding, connect one of the shield pins on the terminal block of your module to the chassis itself.

   Important: For CE compliance, Ferrite EMI Suppressors are needed on each channel's terminal block connection. Apply the suppressor close to the module terminal block, as shown below. A Steward Part 28B2024-0A0 or equivalent is recommended. The Steward 28B2024-0A0 has an impedance of 157 Ω at 25 MHz, 256 Ω at 100 MHz, and can accommodate one turn of wire.

Figure 1. Ferrite EMI suppressor for CE compliance

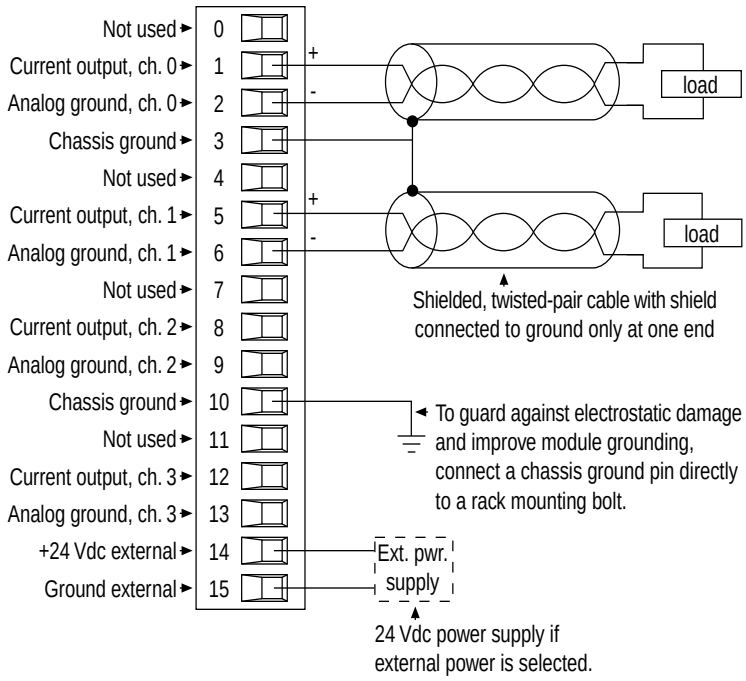


7. Repeat steps 1 through 6 for each channel on your module.

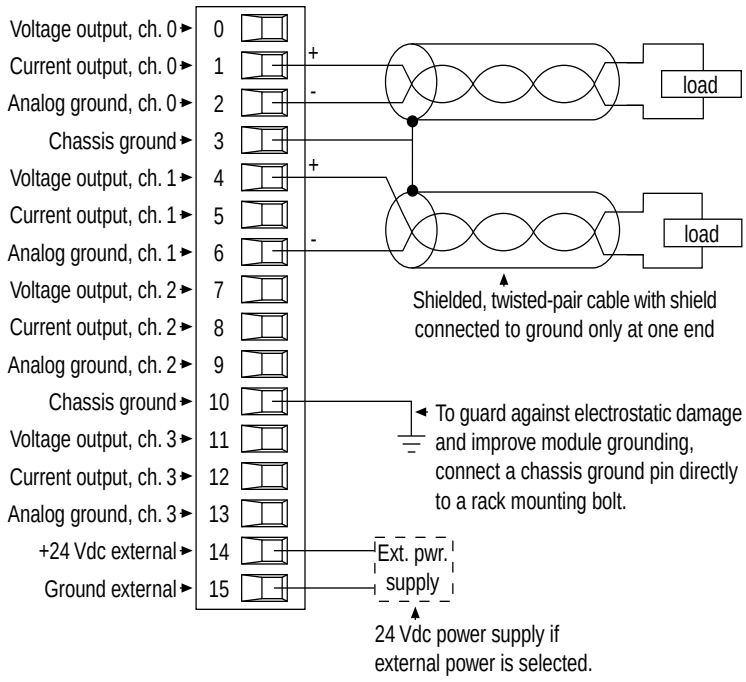
A system may malfunction due to a change in its operating environment. After installing and wiring your module, check system operation. See the Allen-Bradley system *Installation and Operation Manual* for more information.

Figure 2. Wiring diagrams (showing differential outputs).

-INO4i



-INO4vi



Things To Consider Before Using Your Module

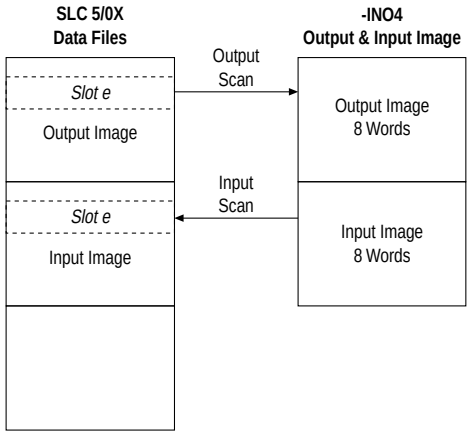
Read this chapter to familiarize yourself with:

- how the processor communicates with your module
- channel update time
- channel enable and disable times
- temperature calibration time
- output mode change time (-INO4vi only)
- your module's response to slot disabling

How The Processor Communicates With Your Module

Your processor transfers data to (and receives data from) the processor through an image table residing in the data files of your processor. The processor updates this image table once during each scan of your ladder program. Figure 4 shows the image table for your output module.

Figure 3. Output and input scans



Channel Update Time

For an output module, channel update time is the time required for the module to convert the channel data received from the processor to an analog output signal at the terminals.

In general, you can reduce the channel update time by disabling unused channels, as shown in the following table:

Table 7. Channel update time (channels already enabled ①)

	# of ch. enabled	Time
Current output	1	24.3 ms (typical)
	2	27.3
	3	30.7
	4	33.7
Voltage output (-INO4vi only)	1	24.3
	2	26.9
	3	30.1
	4	32.7

① When the module must enable a disabled channel, add 1.2 ms to the time shown.

For the fastest possible channel update time, enable only one channel.

Temperature Calibration Time

About once a minute, if no update is occurring, your module performs a temperature calibration. During this time, your module cannot convert the channel data received from the processor to an analog output signal at the terminals. The temperature calibration takes about 56.2 ms.

Output Mode Change Time (-INO4vi only)

Whenever the output mode is changed (usually on module start-up), the power supplied to the isolated channels has to go through a power cycle, affecting all 4 channels. During this time, your module cannot convert channel data from the processor to analog output signals at the terminals. The power cycle takes about 5.2 seconds.

Your Module's Response To Slot Disabling

By writing to the status file in the modular SLC processor, you can disable any chassis slot. Refer to your SLC programming manual for the slot disable/enable procedure.

CAUTION — POSSIBLE EQUIPMENT OPERATION

Always understand the implications of disabling a module before using the slot disable feature.

Failure to observe this precaution can cause unintended equipment operation.

When you disable an output module's slot, the module holds its outputs in their last state. When you re-enable the output module's slot, the data that is in the processor image table is converted to an analog output signal during the next scan. Slot disabling only affects enabled channels.

Using Your Output Module

Read this chapter to:

- enter your output module's ID code
- configure each output channel
- set the output data limits or user-defined scale (optional)
- control each output channel's signal
- monitor each output channel
- check each output channel's configuration and status

To use your module, you need:

- programming equipment
- Allen-Bradley Advanced Programming Software (APS)

For help with APS, see the *Getting Started Guide for APS.*

Entering Your Module's ID Code

Before using your module, you must configure the slot your module is in by entering your module's ID code in APS.

When using APS version 6 or later, simply select your module from the list of modules on the system I/O configuration display to automatically enter the ID code.

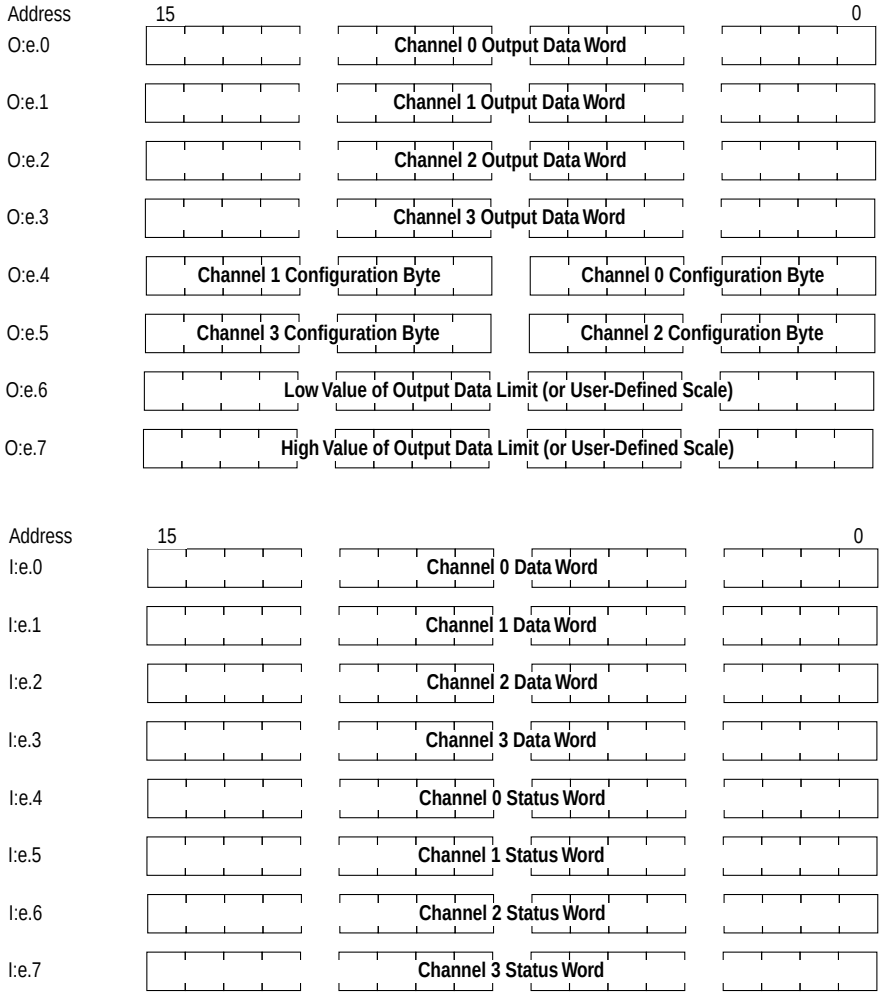
With earlier versions of APS (4 through 5), you must manually enter the ID code. To enter your module's ID code, select "other" from the list of modules on the APS system I/O configuration display, and enter your module's ID code at the prompt. The module ID code for your module is:

Table 8. Output module ID code

Catalog Number	Module ID Code
1746sc-INO4i	3521
1746sc-INO4vi	3519

No special I/O configuration (SPIO CONFIG) information is required. The module ID code automatically assigns the correct number of input and output words for the processor to access.

Figure 4. Output and input words



Example – If you want to reconfigure channel 2 on your module, and it is in slot 4 of the SLC chassis, you would modify the configuration word at address O:4.5. Alternatively, if you want to obtain the status of channel 2, you would check the status word at address I:4.6.

Output Image

The 8-word, output image (defined as the output from the SLC processor to your module) defines how each channel on your module works:

- The **output data words** control output signal levels for each channel.
- The **configuration bytes** replace configuration DIP switches on your module. In your output module, each word configures two channels (one independent byte per channel).
- The **output limit values** define minimum and maximum output data values, if output data limits are properly enabled.
- The **user-defined scale values** define how your module scales output data values to analog output signals, if the User-Defined Scale data format is selected.

For more information on the user-defined scale and output data limits, see *Optional: Setting The Output Data Limits (or User-Defined Scale)*, later in this chapter.

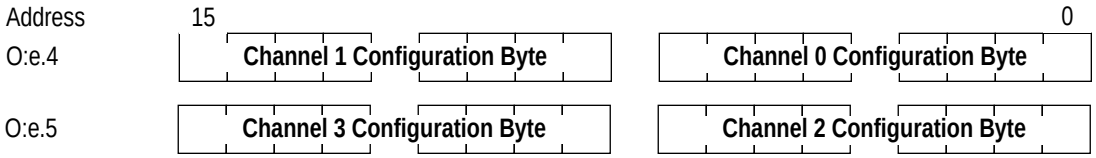
Input Image

The 8-word, input image (defined as the input from your module to the SLC processor) holds the data received by your module and provides the status (configuration and operational state) of each channel.

Important – A data word is valid only when the channel is enabled and there are no channel errors. A status word is valid only when the channel is enabled and the module has processed all configuration changes.

Configuring Each Output Channel

After installing your module, you must configure each channel by setting bit values in each configuration word. Output words 4 and 5 of the output image file (addresses O:e.4 and O:e.5) configure channels 0–1 and 2–3, respectively.



A detailed explanation appears in the following table:

Table 9. Channel configuration word details, Output Words 4 and 5 (O:e.4 and O:e.5)

To select...	Use these bit settings...															
	For Channel 1 (and 3)								For Channel 0 (and 2)							
Bit:	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Output channel disable								0								0
Output channel enable								1								1
±10 Vdc output range (-INO4vi only)					0	0	0						0	0	0	
1–5 Vdc output range (-INO4vi only)					0	0	1						0	0	1	
0–5 Vdc output range (-INO4vi only)					0	1	0						0	1	0	
0–10 Vdc output range (-INO4vi only)					0	1	1						0	1	1	
0–20 mA output range					1	0	0						1	0	0	
4–20 mA output range					1	0	1						1	0	1	
0–21 mA output range					1	1	0						1	1	0	
Invalid					1	1	1						1	1	1	
Engineering units		0	0	0						0	0	0				
Scaled for PID		0	0	1						0	0	1				
Proportional counts		0	1	0						0	1	0				
1746-NO4 compatible format		0	1	1						0	1	1				
User-defined scale		1	1	0						1	1	0				
Invalid		1	0	0						1	0	0				
Invalid		1	0	1						1	0	1				
Invalid		1	1	1						1	1	1				
Reset output on fault	0								0							
Hold last value on fault	1								1							

Output Channel Enable (configuration bits 0 and 8)

Use this bit to enable or disable a channel. To minimize update times, disable any unused channels.

When you set the channel enable bit to one, the module reads the configuration word. Before accepting any new data as valid, verify that the status word (described in the last subsection of this chapter) reflects the changes you made.

While the channel enable bit is set to zero, the channel data word and status word are also set to zero. When you reset the channel enable bit to one, the channel data word remains set to zero until your module updates the channel status word.

Output Range (configuration bits 1–3 and 9–11)

Use this bit field to configure the channel for the type of output device you have connected to the module.

Data Format (configuration bits 4–6 and 12–14)

Use this bit field to select one of the following formats:

- engineering units (mV or nA)
- scaled for PID (works with the SLC PID instruction)
- proportional counts (two’s complement binary)
- 1746-NO4 compatible format (the format used by the 1746-NO4)
- user-defined scale

These data formats are defined in the following table:

Table 10. Data format definitions

Data Format	Selected Output Range	Data Value (counts) Min.	Data Value (counts) Max.	Corresponding Signal Min.	Corresponding Signal Max.
Engineering Units	±10 V	-10250	+10250	-10.25 V	+10.25 V
	0–10 V	-500	+10250	-0.50 V	+10.25 V
	0–5 V	-500	+5500	-0.50 V	+5.50 V
	1–5 V	+500	+5500	+0.50 V	+5.50 V
	0–20 mA	0	+20500	0.0 mA	+20.5 mA
	0–21 mA	0	+21500	0.0 mA	+21.5 mA
	4–20 mA	+3500	+20500	+3.5 mA	+20.5 mA
Scaled for PID	±10 V	0	+16383	-10 V	+10 V
	0–10 V	0	+16383	0 V	+10 V
	0–5 V	0	+16383	0 V	+5 V
	1–5 V	0	+16383	+1 V	+5 V
	0–20 mA	0	+16383	0 mA	+20 mA
	0–21 mA	0	+16383	0 mA	+21 mA
	4–20 mA	0	+16383	+4 mA	+20 mA
Proportional Counts	±10 V	-32768	+32767	-10.25 V	+10.25 V
	0–10 V	-32768	+32767	-0.50 V	+10.25 V
	0–5 V	-32768	+32767	-0.50 V	+5.50 V
	1–5 V	-32768	+32767	+0.50 V	+5.50 V
	0–20 mA	-32768	+32767	0.0 mA	+20.5 mA
	0–21 mA	-32768	+32767	0.0 mA	+21.5 mA
	4–20 mA	-32768	+32767	+3.5 mA	+20.5 mA
1746-NO4-	±10 V	-32768	+32767	-10 V	+10 V
Compatible ①	0–10 V	0	+32767	0 V	+10 V
	0–5 V	0	+16384	0 V	+5 V
	1–5 V	+3277	+16384	+1 V	+5 V
	0–20 mA	0	+31208	0 mA	+20 mA
	0–21 mA	0	+32767	0 mA	+21 mA
	4–20 mA	+6242	+31208	+4 mA	+20 mA
User-Defined	±10 V			-10.25 V	+10.25 V
Scale	0–10 V			-0.50 V	+10.25 V
	0–5 V			-0.50 V	+5.50 V
	1–5 V	See note ②		+0.50 V	+5.50 V
	0–20 mA			0.0 mA	+20.5 mA
	0–21 mA			0.0 mA	+21.5 mA
	4–20 mA			+3.5 mA	+20.5 mA

① Provides direct compatibility with the 1746-NO4 module.

② For the user-defined scale, the data in output words 6 and 7 determine the count limits. See the next subsection, *Optional: Setting The Output Data Limits (or User-Defined Scale)*, for information on the User-Defined Scale data format.

Reset Output Or Hold Last Value On Fault (configuration bits 7 and 15)

Use this bit to select how your module responds to a fault:

- If you set this bit to 1, your module holds the output signal at its last value when it detects a fault.
- If you set this bit to 0, your module resets the output signal to the power-up setting (0 V or 0 mA) when it detects a fault.

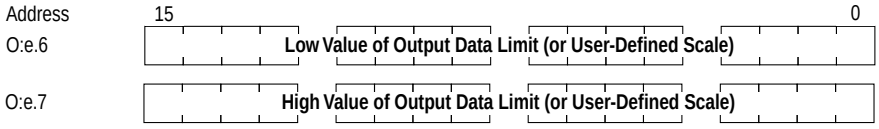
Optional: Setting The Output Data Limits (or User-Defined Scale)

Words 6 and 7 of the output image file (addresses O:e.6 and O:e.7) let you define either:

- the low and high values of the output data limits

  or

- the low and high values of the user-defined scale, if the User-Defined Scale data format is selected



If you do not want to use user-defined scaling or output data limiting, set output words 6 and 7 to zero. Setting output words 6 and 7 to zero disables output data limiting and invalidates user-defined scaling.

Because they share the same output words, you cannot use output data limiting with the User-Defined Scale data format.

Important – The values in output words 6 and 7 apply to all four channels. If you want to use user-defined scaling or output data limiting, you must set all four channels to the same data format.

Output Data Limits

For added safety, the 1746sc-INO4i and 1746sc-INO4vi output modules let you define limits for the values in the output data words of all four channels. These data limits, in turn, limit the output signals that your module provides. When an output data word exceeds the data limit, the output value is truncated to the limit.

You can use output data limiting to prevent PID loops from exceeding safety limits, to prevent operators from inadvertently setting incorrect values, etc.

To properly enable output data limiting, the low and high output limits (output words 6 and 7, respectively) musts be non-zero and non-equal,

and the low limit (output word 6) must be lower than the high limit (output word 7).

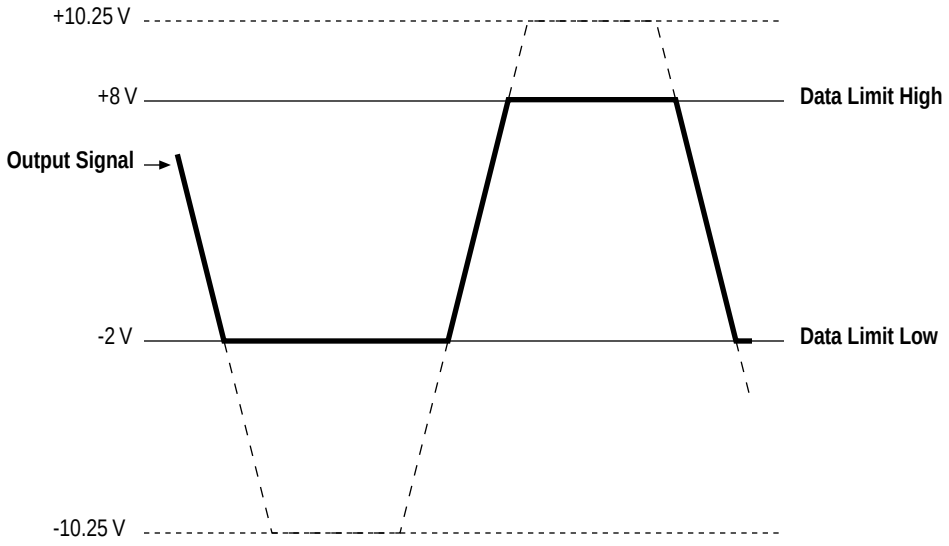
Example – Suppose you have four valves with a ±10 V operating range, and you want to use the Engineering Units data format. For this application, you would use the following bit settings for the channel configuration bytes (output words 4 and 5):

Address	15															0
O:e.4	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
O:e.5	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1

Suppose, also, that you would like to set the output limits to -2 V and +8 V. After entering the above bit settings for output words 4 and 5, you would enter the following for output words 6 and 7:

Address	15															0
O:e.6	1	1	1	1	1	0	0	0	0	0	1	1	0	0	0	0
O:e.7	0	0	0	1	1	1	1	1	0	1	0	0	0	0	0	0

Your module will now limit the output signal as shown below.



Note that whenever the requested output data values meet or attempt to exceed the output data limits, your module sets bits 10 or 11 in the channel status word to indicate a limit error. Note also that words 0 through 3 of the input image file (addresses I:e.0 through I:e.3) reflect the requested output data values and are not truncated.

User-Defined Scale

For special applications, the 1746sc-INO4i and 1746sc-INO4vi output modules let you define a custom data format. This “user-defined scale” is very similar to the “proportional counts” data format—except that instead of converting the output data to an output signal using a previously defined scale (-32,768 to 32,767), your module converts the output data using a scale defined by the values in output words 6 (low limit of scale) and 7 (high limit of scale).

The high limit value must be greater than the low limit value for proper operation. Also, the difference between the low and high values should be greater than 1024 counts. If the difference between the low and high values is less than 1024 counts, unexpected results can occur (especially at the extreme ends of the range).

You select the data format for each channel using that channel’s configuration bits, described in the previous subsection, *Configuring Each Output Channel*.

The following equations show you how to convert user-defined scale units (or any type of units) to engineering units, and vice versa:

$$S = \{(U - U_{low}) \times (\Delta S) \div (\Delta U)\} + S_{low}$$

$$D = \{(S - S_{low}) \times (\Delta U) \div (\Delta S)\} + U_{low}$$

where S = signal value (in engineering units, such as psi)

S_{low} = low limit of signal value

S_{high} = high limit of signal value

$\Delta S = S_{high} - S_{low}$

D = data value (user-defined scale)

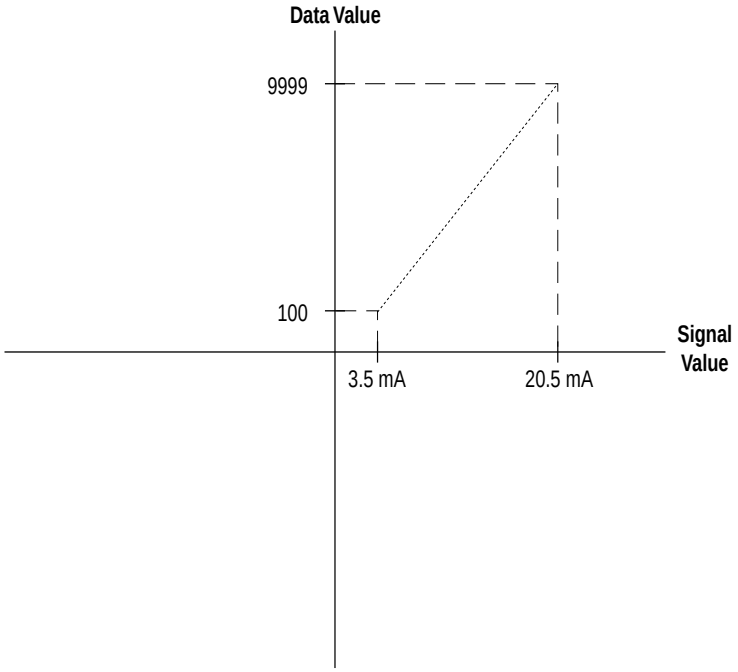
U_{low} = low value of user-defined scale

U_{high} = high value of user-defined scale

$\Delta U = U_{high} - U_{low}$

Example – Suppose you have a valve with a 4–20 mA range, and you want your scale to go from 100 to 9999 counts. For a 4–20 mA output with user-defined scaling, your module sets the signal limits to 3.5 mA and 20.5 mA (see Table 14). After entering 100 and 9999 into output words 6 and 7, respectively, the relationship between data value (counts) and output signal would be as follows:

Figure 5. Example relationship between output signal and channel data



In the preceding example...

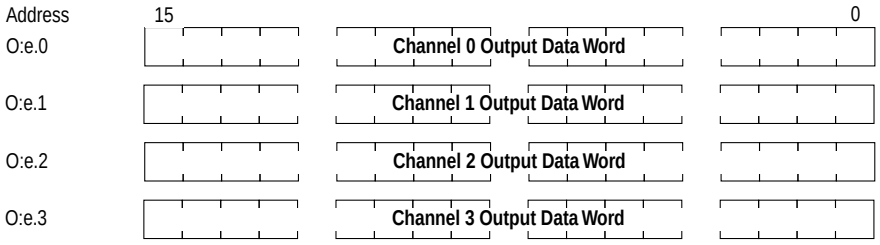
$S_{low} = 3.5$ $U_{low} = 100$

$S_{high} = 20.5$ $U_{high} = 9999$

$\Delta S = 17$ $\Delta U = 9899$

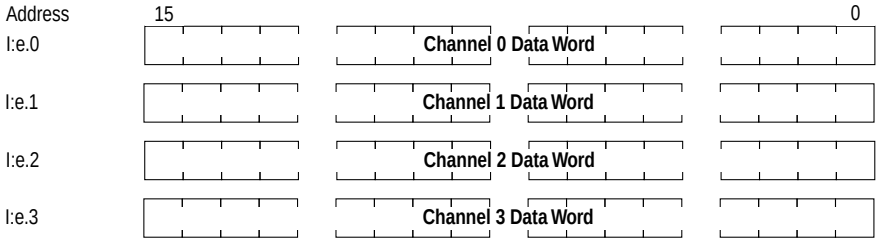
Controlling Each Output Channel's Signal

Output words 0 through 3 determine the output signal levels for channels 0 through 3, respectively. The output signal level depends on the output range and data format selected.



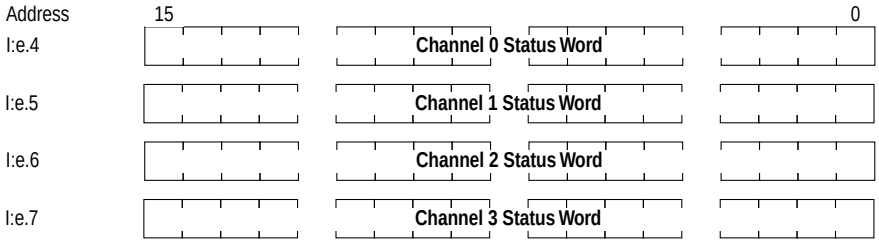
Monitoring Each Output Channel

The requested output data values are reflected in words 0 through 3 of the input image file (addresses I:e.0 through I:e.3). Whenever a channel is disabled, its data word is reset to zero.



Checking Each Output Channel's Configuration And Status

Words 4 through 7 of the input image file (addresses I:e.4 through I:e.7) reflect the configuration and status of each channel. Use the data provided in these status words to determine if the configuration data for any channel is valid.



Whenever a channel is disabled, its status word is set to zero.

A detailed explanation appears in Table 12.

Table 11. Channel status word details, Input Words 4 through 7 (I:e.4 through I:e.7)

These bit settings in the status word				Indicate this
Bit: 15 14 13 12	11 10 9 8	7 6 5 4	3 2 1 0	
			0	Output channel disabled
			1	Output channel enabled
			0 0 1	1–5 Vdc output range
			0 1 0	0–5 Vdc output range
			0 1 1	0–10 Vdc output range
			1 0 0	0–20 mA output range
			1 0 1	4–20 mA output range
			1 1 0	0–21 mA output range
		0 0 0		Engineering units
		0 0 1		Scaled for PID
		0 1 0		Proportional counts
		0 1 1		1746-NO4 format
		1 1 0		User-defined scale
		0		Reset output on fault
		1		Hold last value on fault
	0			No output data limiting
	1			Output data limiting
	0			No error
	1			Operating temperature error
	0			No error
	1			Over-limit error
	0			No error
	1			Under-limit error
0				No error
1				Over-range error
0				No error
1				Under-range error
0				No error
1				Non-fatal channel error
0				No error
1				Fatal channel error

The first 8 status bits reflect the settings in the channel configuration word. The remaining status bits flag the various errors that the module can detect.

Output Data Limiting Enabled (status bit 8)

This bit is set to one whenever output data limiting is properly enabled. To properly enable output data limiting, the low and high output limits (output words 6 and 7, respectively) musts be non-zero and non-equal, and the low limit (output word 6) must be lower than the high limit (output word 7). See *Optional: Setting The Output Data Limits (or User-Defined Scale)*, earlier in this chapter, for more information.

Operating Temperature Error (status bit 9)

This bit is set to one whenever the operating temperature exceeds the specified range (0 to 60 ˚C). This bit is reset to zero when the operating temperature returns to the specified range.

Over-Limit Error (status bit 10)

This bit is set to one whenever the output data meets or attempts to exceed the output data limit in output word 7, if output data limiting is properly enabled. This bit is reset to zero when the output data falls below the output data limit in output word 7.

Under-Limit Error (status bit 11)

This bit is set to one whenever the output data meets or attempts to exceed the output data limit in output word 6, if output data limiting is properly enabled. This bit is reset to zero when the output data rises above the output data limit in output word 6.

Over-Range Error (status bit 12)

This bit is set to one whenever the output data meets or attempts to exceed the maximum count limit defined by the data format and output range selected (see Table 11). This bit is reset to zero when the output data falls below the maximum count limit.

Under-Range Error (status bit 13)

This bit is set to one whenever the output data meets or attempts to exceed the minimum count limit defined by the data format and output range selected (see Table 11). This bit is reset to zero when the output data rises above the minimum count limit.

Non-Fatal Channel Error (status bit 14)

This bit is set to one whenever your module detects a recoverable channel error, such as an invalid configuration word or an operating temperature error (see above), or while the SLC 500 processor is resetting. This bit is reset to zero when the error no longer exists.

Fatal Channel Error (status bit 15)

This bit is set to one whenever your module detects a “non-recoverable” channel error, such as a software power-up failure due to corrupt hardware or malfunctioning software. You may be able to recover from this type of error by resetting the SLC 500 processor or cycling power to your module.

Testing Your Module

Read this chapter to prevent potential problems. This chapter covers:

- inspecting your module
- disconnecting prime movers
- powering up
- interpreting the LED indicators
- interpreting I/O error codes
- troubleshooting

Before testing your module, test your SLC 500 system using the procedures described in your Allen-Bradley system *Installation & Operation Manual*.

Important — If your module appears to be functioning, but the terminals aren't providing an output signal, the 24 Vdc power source (backplane or external) may not be providing enough current (250 mA).

Inspecting Your Module

You can prevent many potential problems by simply inspecting your analog module:

1. Ensure that the external 24 Vdc power switch (SW1, located in the bottom corner of the module's large circuit board) is set properly:
   - With the switch in the **RACK** position, the module draws all its power from the backplane of the SLC system.
   - With the switch in the **EXT** position, the module draws its 24 Vdc power from an external power source; however, the module still draws its 5 Vdc power from the backplane.
2. Ensure that all wire connections are correct and secure and that no wires are missing or broken. Refer to Chapter 2, *Installing And Wiring Your Module*, for more information.
3. Ensure that the shield for the cable used to wire your module is properly grounded.
4. Ensure that the removable terminal block on your module is secure.

Disconnecting Prime Movers

Before testing your module, ensure that machine motion will not occur:

- Disconnect motor wires at the motor starter or the motor itself. This lets you test the operation of the starter coil, verifying that the output circuit is wired correctly and functioning.
- Disconnect solenoids by disengaging the solenoid valves, leaving the coils connected.

If you cannot disconnect a device in the preferred way, open the output circuit as close as possible to the motion-causing device.

Example – If you have a relay coil that in turn energizes a motor starter and you cannot disconnect the motor wires, open the circuit at a point between the motor starter and the relay contact.

WARNING

POSSIBLE UNEXPECTED MACHINE MOTION

During all testing, always disconnect all devices that, when energized, might cause machine motion.

Failure to observe this precaution can cause equipment damage or personal injury.

Powering Up

When you apply power to the system, your module's status LED should illuminate, indicating that your module is receiving power and has completed its onboard self-test. If the LED does not illuminate after several seconds, your module is not functional. Discontinue testing until you can get the LED to illuminate.

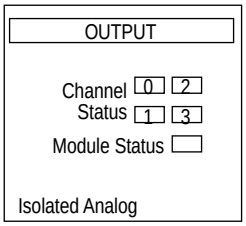
The most probable reasons for the LED not illuminating are:

- The SLC 500 system is not receiving power from its power supply.
- The rest of the SLC 500 system is not receiving power.
- The rack slot where your module is located is defective.
- Your module is defective.

Interpreting The LED Indicators

Your output module has 5 LEDs: 4 channel status LEDs (numbered 0–3 for channels 0–3, respectively) and 1 module status LED.

Figure 6. LED block



Use the following table to interpret the LEDs:

Table 12. LED definition

If the module status LED is...	And the channel status LED is...	Then...
On	On	The channel is enabled.
	Blinking	One of the following channel errors occurred: • circuit open (4–20 mA outputs only) • signal is near or beyond end of range • channel configured incorrectly Refer to the following section, *Troubleshooting.*
	Off	Either your module is powering up **or** the channel is disabled.
Off	Off	Either the power is off, the module is powering up, **or** a module fault occurred. Cycle power. If the condition persists, call your local distributor or Spectrum Controls for assistance.

Interpreting I/O Error Codes

I/O error codes appear in word S:6 of the SLC processor status file. The first two digits of the error code identify the slot (in hexadecimal) with the error. The last two digits identify the I/O error code (in hexadecimal).

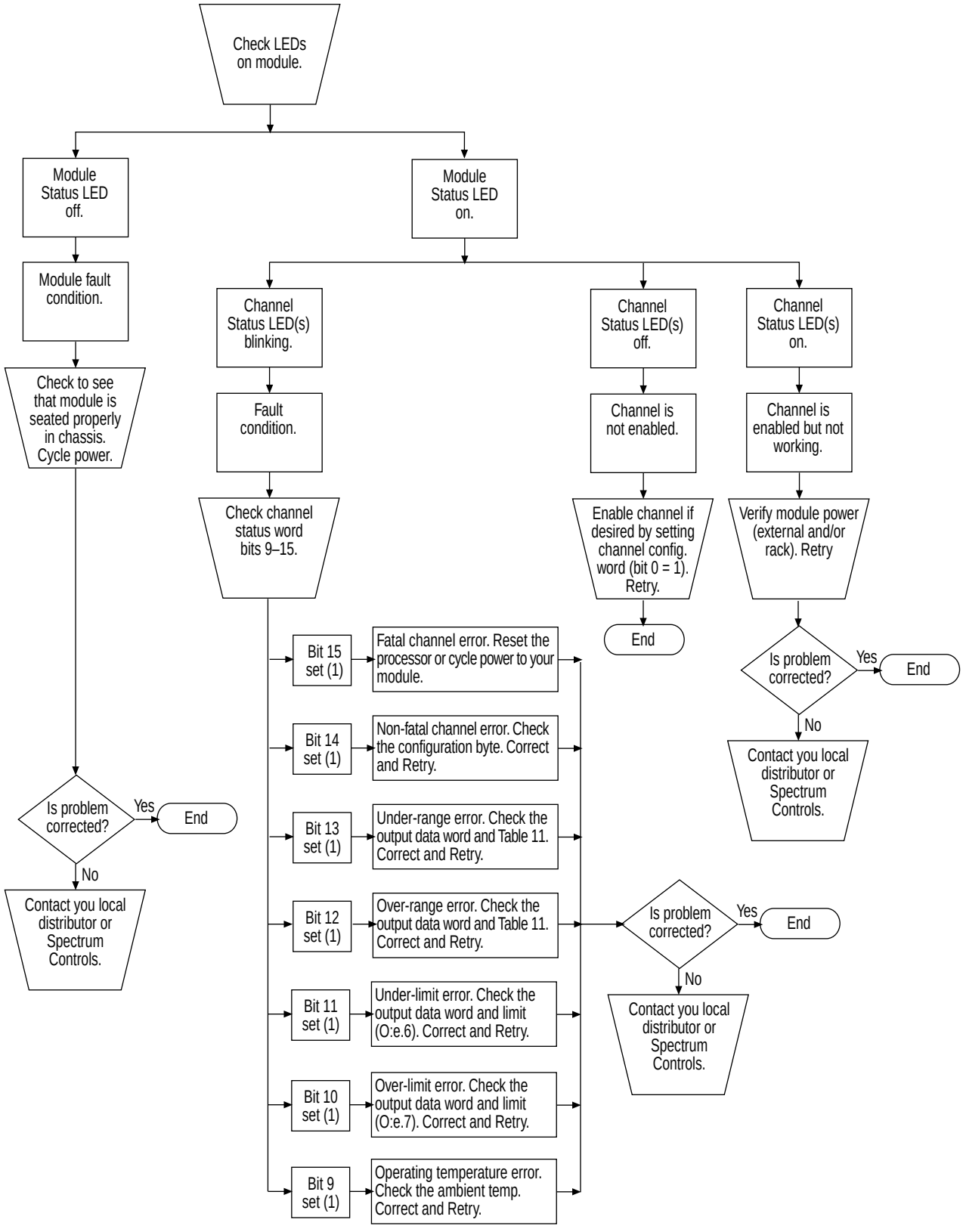
The error codes that apply to your module include (in hexadecimal):

- 50–5E
- 71 (watchdog error)
- 90–94

For a description of the error codes, refer to the *Allen-Bradley Advanced Programming Software (APS) Reference Manual*, Allen-Bradley publication 1746-6.11.

Troubleshooting

Figure 7. Problem resolution flowchart



Maintaining Your Module And Ensuring Safety

Read this chapter to familiarize yourself with:

- preventive maintenance
- safety considerations

The National Fire Protection Association (NFPA) recommends maintenance procedures for electrical equipment. Refer to article 70B of the NFPA for general safety-related work practices.

Preventive Maintenance

The printed circuit boards of your module must be protected from dirt, oil, moisture, and other airborne contaminants. To protect these boards, install the SLC 500 system in an enclosure suitable for its operating environment. Keep the interior of the enclosure clean, and whenever possible, keep the enclosure door closed.

Also, regularly inspect the terminal connections for tightness. Loose connections may cause a malfunctioning of the SLC system or damage to the components.

WARNING

POSSIBLE LOOSE CONNECTIONS

Before inspecting connections, always ensure that incoming power is OFF.

Failure to observe this precaution can cause personal injury and equipment damage.

Safety Considerations

Safety is always the most important consideration. Actively think about the safety of yourself and others, as well as the condition of your equipment. The following are some things to consider:

Indicator Lights – When the module status LED on your module is illuminated, your module is receiving power.

Activating Devices When Troubleshooting – Never reach into a machine to activate a device; the machine may move unexpectedly. Use a wooden stick.

Standing Clear Of Machinery – When troubleshooting a problem with any SLC 500 system, have all personnel remain clear of machinery. The problem may be intermittent, and the machine may move unexpectedly. Have someone ready to operate an emergency stop switch.

CAUTION

POSSIBLE EQUIPMENT OPERATION

Never reach into a machine to actuate a switch. Also, remove all electrical power at the main power disconnect switches before checking electrical connections or inputs/ outputs causing machine motion.

Failure to observe these precautions can cause personal injury or equipment damage.

Safety Circuits – Circuits installed on machinery for safety reasons (like over-travel limit switches, stop push-buttons, and interlocks) should always be hard-wired to the master control relay. These circuits should also be wired in series so that when any one circuit opens, the master control relay is de-energized, thereby removing power. Never modify these circuits to defeat their function. Serious injury or equipment damage may result.

Refer to your system's *Installation & Operation Manual* for more information.

Getting Technical Assistance

If you need technical assistance, please review the information in Chapter 5, “Testing Your Module,” before calling your local distributor of Spectrum Controls.

Note that your module contains electronic components which are susceptible to damage from electrostatic discharge (ESD). An electrostatic charge can accumulate on the surface of ordinary plastic wrapping or cushioning material. **In the unlikely event that the module should need to be returned to Spectrum Controls, please ensure that the unit is enclosed in approved ESD packaging (such as static-shielding / metallized bag or black conductive container)**. Spectrum Controls reserves the right to void the warranty on any unit that is improperly packaged for shipment.

For further information or assistance, please contact your local distributor or call Spectrum Controls Customer Satisfaction department at (425) 746-9481 from 8:00 A.M. to 5:00 P.M. Pacific Time.

Declaration of Conformity

Available upon request.

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