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# DL205 Analog I/O Manual

**Manual Number: D2-ANLG-M**

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# DL205 Analog I/O Modules

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Please include the Manual Number and Issue, both shown below, when communicating with Technical Support regarding this publication.

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| Publication History | | |
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| **Issue** | **Date** | **Description of Changes** |
| 1st Edition | 1/94 | Original Edition |
| 2nd Edition | 4/95 | New Edition |
| 3rd Edition | 9/97 | Added new modules |
| 4th Edition | 4/99 | Added new modules |
| 5th Edition | 5/00 | Added new modules |
| 6th Edition | 4/02 | Added new modules |
| Rev. A | 6/02 | Added D2-250-1 and D2-260 CPUs and removed references to D2-250 CPU. (Note: D2-250 has same functionality as a D2-250-1 except for local expansion capability). |
| Rev. B | 8/02 | Minor corrections |
| 7th Edition | 8/05 | Added new F2-8AD4DA chapters 15 and 16 and miscellaneous minor changes. |
| Rev A | 11/06 | Added information about changes to F2-04THM jumper link locations in chapter 7. |
| Rev. B | 4/10 | Added information about jumper link locations and some input specification changes on F2-04AD-1, F2-04AD-2, F2-08AD-1, F2-08AD-2, and F2-02DAS-2 modules. Also added R Wide input range to F2-04THM specification table. |
| Rev. C | 9/17 | Minor changes - changed to download version only |
| Rev. D | 12/17 | Made correction to wiring diagram in Chapter 11 |
| Rev. E | 12/18 | Added D2-262 CPU and revised complete manual. |
| Rev. F | 5/19 | Chapter 16 - revised ladder examples 1, 2, and 3; updated V-memory location tables. |
| Rev. G | 6/20 | Chapter 8 & 9 - revised external power supply value requirements in data tables. |
| Rev. H | 11/24 | Removed Type 1 fonts, added hyperlinks to footers. |

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# GETTING STARTED

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# Introduction

## The Purpose of this Manual

This manual shows how to select and install analog input and analog output modules. It also shows several ways to use the analog data in a PLC program. If you understand the DL205 instruction set and system setup requirements, this manual will provide the information needed to install and use the analog modules. This manual is not intended to be a tutorial on analog signal theory, but rather a user reference manual for the DL205 Analog I/O modules.

## Supplemental Manuals

A copy of the DL205 User Manual (D2-USER-M) will be helpful when working with the analog modules. The DL205 User Manual is not absolutely necessary, but it does provide detailed descriptions of the instructions used to acquire the analog data. The User Manual also provides a more thorough description of how the I/O points are assigned to the module. This is all the material necessary to quickly understand the DL205 Analog I/O modules.

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# Conventions Used

When the "notepad" icon is in the left–hand margin, the paragraph to its immediate right will be a special note.

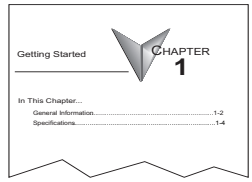
The word **NOTE** in boldface will mark the beginning of the text.

When the "exclamation mark" icon is in the left–hand margin, the paragraph to its immediate right will be a warning. This information could prevent injury, loss of property, or even death (in extreme cases).

The word WARNING in boldface will mark the beginning of the text which will also be in boldface..

## Key Topics for Each Chapter

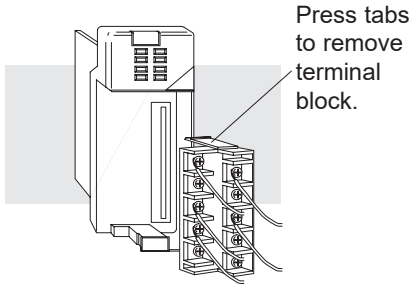
The beginning of each chapter will list the key topics that can be found in that chapter.




# Physical Characteristics

The DL205 Analog Modules provide many features that make the modules easy to use. With the exception of the thermocouple module, the terminal blocks are removable, which makes wiring a simple task. All of the DL205 analog modules have normal screw terminal connectors. Access the module terminals by removing the front cover (not shown). To remove the front cover, press the tab on the lower front corner of the cover. For ease of removal, the terminal blocks have squeeze tabs on the top and bottom. To remove a terminal block, press the tabs and pull the terminal block away from the module.

**WARNING: For some modules, field device power may still be present on the terminal block even though the PLC system is turned off. To minimize the risk of electrical shock, check all field device power before you remove the connector.**



# Analog Input Module Terminology

Several different terms are used throughout the rest of this manual. The terms may be helpful to make it easier to select the appropriate analog modules. Take a few minutes to review these definitions.

**Channels per Module -** The total number of analog signals the module receives from field devices.

**Input Ranges -** The minimum to maximum spans in voltage or current the module will successfully convert to digital values.

**Resolution -** The number of binary weighted bits available on the digital side of the module for use in converting the analog value to a digital value.

**Input Type -** Specifies if the module accepts single ended, or differential input signals.

**Input Impedance -** The resistive load of the module as seen by a voltage or current input signal.

**Conversion Method -** The method the module uses to convert the analog signal to a digital value.

**PLC Update Rate -** Speed at which the analog signals are digitized and acknowledged in the PLC.

**Linearity Error -** The relative accuracy of the digital representation over the entire input range.

**Maximum Inaccuracy -** Maximum absolute error of the digital representation of the signal over the entire input range. Factors which contribute to maximum inaccuracy are also specified separately. These factors are full-scale calibration error, offset calibration error, and accuracy vs. temperature.

**Accuracy vs. Temperature -** The variations in the module's conversion accuracy with temperature over the module's operating temperature range.

**I/O Points Required -** The number of I/O points the CPU must dedicate to the module.

**External Power Source -** Some modules require a separate 12VDC or 24VDC power source. The 24VDC output supply at the local base can be used as long as you do not exceed the current ratings of 300mA.

**Base Power Required -** The amount of base current required by the module. Use this value in your power budget calculations.

**Operating Temperature -** The minimum and maximum temperatures the module will operate within.

**Relative Temperature -** The minimum and maximum humidity the module will operate within.

**Step Response -** The time required for an analog input to reach 95% of its final value at the converter following a step change in the input signal level.

# Analog Output Module Terminology

**Channels per Module -** The total number of analog signals the module sends to field devices.

**Output Ranges -** The minimum to maximum spans in voltage or current the module outputs, converted from digital values.

**Resolution -** The number of binary weighted bits available on the digital side of the module for use in converting the digital value to an analog signal.

**Output Current -** The maximum current the module will drive using a voltage output signal.

**Output Impedance -** The output impedance of the module using a voltage output signal.

**Load Impedance -** The minimum and maximum resistance the module can drive, specified for current and voltage output signals.

**PLC Update Rate -** The speed at which digital values in the PLC are converted to analog output signals.

**Linearity Error -** The relative accuracy of the digital representation over the entire output range.

**Maximum Inaccuracy -** Maximum absolute error of the digital representation of the signal over the entire output range. Factors which contribute to maximum inaccuracy are also specified separately. These factors are full-scale calibration error, offset calibration error, and accuracy vs temperature.

**Accuracy vs. Temperature -** The variations in the module's conversion accuracy with temperature over the module's operating temperature range.

**External Power -** All output modules contain circuitry which is optically isolated from PLC-side logic. That circuitry requires field-side power from a separate 24VDC power source. The 24VDC output supply at the local base can be used as long as you do not exceed the current ratings.

**Base Power Required -** The amount of base current required by the module. Use this value in your power budget calculations.

**Operating Temperature -** The minimum and maximum temperatures the module will operate within.

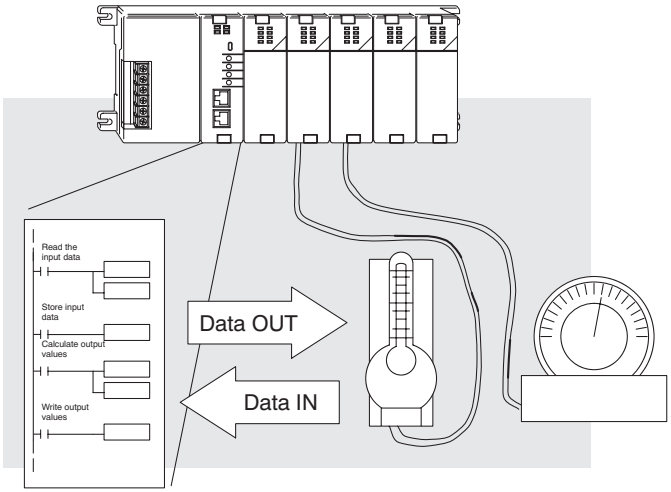
**Relative Humidity -**The range of air humidity over which the module will operate properly.

**I/O Points Required -** The number of I/O points the CPU must dedicate to the module.

# Selecting the Appropriate Module

## Wide Variety of Modules

There are a wide variety of analog I/O modules available for use with the DL205 family of automation products. These modules are well suited for monitoring and controlling various types of analog signals such as pressure, temperature, etc. No complex programming or module setup software is required. Simply install the module, add a few lines to the RLL program. That's all.




Analog input, temperature input and analog output modules are available. These modules are designed and manufactured by FACTS Engineering. FACTS has been producing feature-packed products for the DirectLOGIC families (and compatible products) for years! These modules are readily identifiable by their F2- prefix in the part number.

## Diagnostic Features

The DL205 Analog Modules use an on-board microcontroller that automatically monitors module diagnostics. Missing field-side supply 24VDC voltage or a loose terminal block can be easily detected.

The following tables provide a condensed version of the information needed to select the appropriate module. The most important thing is to simply determine the number of channels required and the signal ranges that must be supported. Once the parameters have been determined, look in the specific chapter for the selected module to determine the installation and operation requirements.

| Analog Input Modules | | | | |
|---|---|---|---|---|
| Specification | F2-04AD-1, (L) | F2-04AD-2, (L) | F2-08AD-1 | F2-08AD-2 |
| *Channels* | 4 | 4 | 8 | 8 |
| *Input Ranges* | 4–20 mA | 0–5 V, 0–10 V, ±5V, ±10V | 4–20 mA | 0–5 V, 0–10 V, ±5V, ±10V |
| *Resolution* | 12 bit (1 in 4096) | 12 bit (1 in 4096), and 13 bit (1 in 8192) | 12 bit (1 in 4096) | 12 bit (1 in 4096), and 13 bit (1 in 8192) |
| *Input Type* | Single ended | Single ended | Single ended | Single ended |
| *Maximum Inaccuracy* | ±0.5% at 25°C (77°F), ±0.65% at 0°–60°C (32°–140°F) | ±0.1% at 25°C (77°F), ±0.3% at 0°–60°C (32°–140°F) | ±0.1% at 25°C (77°F), ±0.25% at 0°–60°C (32°–140°F) | ± 0.1% at 25°C (77°F), ± 0.3% at 0°–60°C (32°–140°F) |
| *See Chapter...* | 2 | 3 | 4 | 5 |

| Special Input | | |
|---|---|---|
| Specification | F2-04RTD | F2-04THM |
| *Input Channels* | 4 | 4 |
| *Resolution* | 16 bit internal | 16 bit voltage ranges<br>24 bit internal |
| *Input Ranges* | Pt100Ω, -200.0–850.0 °C (-328–1562 °F)<br>Pt1000Ω, -200.0–595.0 °C (-328–1103 °F)<br>Pt100Ω, -38.0–450.0 °C (-36–842 °F)<br>Cu. 25Ω, Cu. 10Ω -200.0–260.0 °C (-328–500 °F) | Type J -190–760.0 °C<br>E -210–1000.0 °C<br>K -150–1372.0 °C<br>R 65–1768.0 °C<br>R Wide -0–1768.0 °C<br>S 65–1768.0 °C<br>T -230–400.0 °C<br>B 529–1820.0 °C<br>N -70–1300.0 °C<br>C 65–2320.0 °C |
| *Input Type* | Differential | Differential |
| *Maximum Input Inaccuracy* | ±1.0 °C | ±3.0 °C Temperature<br>±0.02% Voltage |
| *See Chapter...* | 6 | 7 |

| Analog Output | | |
|---|---|---|
| Specification | F2-02DA-1, (L) | F2-02DA-2, (L) |
| *Channels* | 2 | 2 |
| *Output Ranges* | 4–20 mA | 0–5 V, 0–10 V,<br>±5V,<br>±10V |
| *Resolution* | 12 bit (1 in 4096) | 12 bit (1 in 4096) |
| *Output Type* | Single ended | Single ended |
| *See Chapter...* | 8 | 9 |

| Analog Output | | |
|---|---|---|
| Specification | F2-08DA-1 | F2-08DA-2 |
| *Channels* | 8 | 8 |
| *Output Ranges* | 4–20 mA | 0–5 V, 0–10 V |
| *Resolution* | 12 bit (1 in 4096) | 16 bit (1 in 4096) |
| *Output Type* | Single ended | Single ended, 1 common |
| *See Chapter...* | 10 | 11 |

| Analog Output | | |
|---|---|---|
| Specification | F2-02DAS-1 | F2-02DAS-2 |
| *Channels* | 2 | 2 |
| *Output Ranges* | 4–20 mA | 0–5 V, 0–10 V |
| *Resolution* | 16 bit (1 in 65536) | 16 bit (1 in 65536) |
| *Output Type* | Current sourcing | Isolated |
| *See Chapter...* | 12 | 13 |

| Combination Analog | | | |
|---|---|---|---|
| Specification | F2-4AD2DA | F2-8AD4DA-1 | F2-8AD4DA-2 |
| *Input Channels* | 4 | 8 | 8 |
| *Output Channels* | 2 | 4 | 4 |
| *Input Ranges* | 4–20 mA | 0–20 mA | 0–5 V, 0–10 V |
| *Output Ranges* | 4–20 mA | 4–20 mA | 0–5 V, 0–10 V |
| *Resolution* | 12 bit (1 in 4096) | 12-bit, 14 bit or 16 bit; selectable | 12-bit, 14 bit or 16 bit; selectable |
| *Channel Isolation* | Non-isolated (one common) | Isolated (one common) | Isolated (one common) |
| *Input and Output Types* | Single ended | Single ended | Single ended |
| *Maximum Input Inaccuracy* | ±0.3% at 25°C (77°F),<br>±0.45% at 0°–60°C (32°–140°F) | ±0.1% of range maximum | ±0.1% of range maximum |
| *Maximum Output Inaccuracy* | ±0.1% at 25°C (77°F),<br>±0.3% at 0°–60°C (32°–140°F) | ±0.1% of range maximum | ±0.1% of range maximum |
| *See Chapter* | 14 | 15 | 16 |

# Analog Made Easy – Four Steps

Once the appropriate module has been selected, use the chapter that describes that module and complete the following steps.

## Step 1.

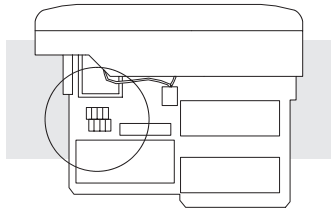
Take a moment to review the detailed specifications to be sure the module chosen will meet the application requirements.

| Specification | | |
|---|---|---|
| Channels | 2 | 2 |
| Output Ranges | 4 – 20 mA | 0 – 5V<br>0 – 10V<br>–5 – +5V<br>–10 – +10V |
| Resolution | 12 bit (1 in 4096) | 12 bit (1 in 4096) |
| Channel Isolation | Non-isolated | Non-isolated |
| Output Type | Single ended | Single ended |
| Maximum Inaccuracy:<br>at 25 °C (77 °F)<br><br>at 0° - 55° C (32° - 140° F) | ± 0.1%<br><br>± 0.3% | ± 0.2% unipolar<br>± 0.4% bipolar |
| See Chapter . . . . | 4 | 5 |

## Step 2.

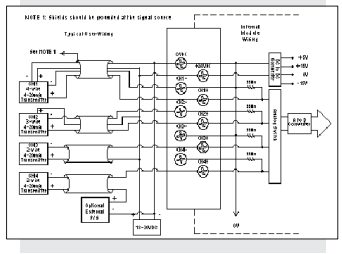
If applicable, set the module switches and/or jumpers to select:

- Number of channels
- The operating ranges.



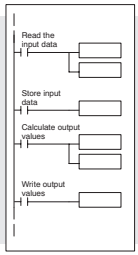
## Step 3.

Connect the field wiring to the module connector.



## Step 4.

Review the module operating characteristics and write the control program.



# F2-04AD-1, F2-04AD-1L, 4-Channel Analog Current Input

In This Chapter...

Module Specifications ..... 2-2
Setting the Module Jumpers ..... 2-6
Connecting the Field Wiring ..... 2-7
Module Operation ..... 2-10
Writing the Control Program ..... 2-14

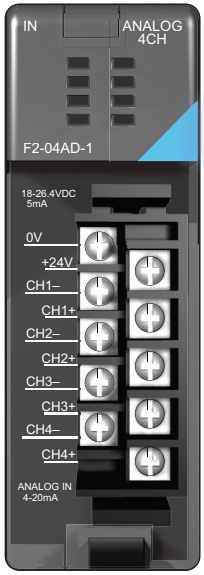
# Module Specifications

## F2-04AD-1

The F2-04AD-1 analog Input module provides several hardware features.

- On-board 250 ohm, 1/2 Watt precision resistors provide substantial over-current-protection for 4–20mA current loops.
- Analog inputs are optically isolated from the PLC logic.
- The module has a removable terminal block so the module can be easily removed or changed without disconnecting the wiring.
- With a D2-240, D2-250-1, D2-260 or D2-262 CPU, all four channels can be read in one scan.

On-board active analog filtering and RISC-like microcontroller provide digital signal processing to maintain precision analog measurements in noisy environments.




## F2-04AD-1L is Obsolete

***NOTE:*** *In 2009 the F2-04AD-1L was discontinued. A re-designed F2-04AD-1 was released at the same time which can be powered by either 12VDC or 24VDC input power supplies. This new module is a direct replacement for legacy F2-04AD-1 and all F2-04AD-1L modules. The new module is a single circuit board design so the jumper link locations are different. See "Setting the Module Jumpers" on page 2-6. Also, some specifications were changed on page 2-3. Otherwise, the re-designed module functions the same as the prior designs.*

All specifications are the same for both modules except for the input voltage requirements. Review these specifications to make sure the module meets your application requirements.

| Input Specifications | |
|---|---|
| ***Number of Channels*** | 4, single ended (one common) |
| ***Input Range*** | 4–20 mA current |
| ***Resolution*** | 12 bit (1 in 4096) |
| ***Step Response*** | 4.9 ms (*4.0 ms) to 95% of full step change |
| ***Crosstalk*** | -80 dB, 1/2 count maximum |
| ***Active Low-pass Filtering*** | -3 dB at 120Hz (*80Hz), 2 poles (-12dB per octave) |
| ***Input Impedance*** | 250Ω ±0.1% 1/2 W current input |
| ***Absolute Maximum Ratings*** | ±40mA, current input |
| ***Converter type*** | Successive approximation |
| ***Linearity Error (End to End)*** | ±1 count (0.025% of full scale) maximum |
| ***Input Stability*** | ±1 count |
| ***Full Scale Calibration Error (Offset error not included)*** | ±12 counts maximum @ 20mA current input |
| ***Offset Calibration Error*** | ±7 counts maximum @ 4mA current input |
| ***Maximum Inaccuracy*** | ± 0.5% @ 25°C (77°F)<br>±0.65% 0–60°C (32–140°F) |
| ***Accuracy vs. Temperature*** | ±50ppm/°C maximum full scale calibration (including maximum offset change) |
| ***Recommended Fuse (external)*** | 0.032 A, Series 217 fast-acting, current inputs |

| General Specifications | |
|---|---|
| ***PLC Update Rate*** | 1 channel per scan maximum (D2-230 CPU)<br>4 channels per scan maximum (D2-240, D2-250-1, D2-260 or D2-262 CPU) |
| ***Digital Inputs Input points required*** | 12 binary data bits, 2 channel ID bits, 2 diagnostic bits<br>16 point (X) input module |
| ***Power Budget Requirement*** | 100mA (*50mA maximum, 5VDC (supplied by base) |
| ***External Power Supply*** | F2-04AD-1: 5mA, 10–30 VDC (*80mA max, 18–30 VDC),<br>F2-04AD-1L: *90mA max, 10–15 VDC |
| ***Operating Temperature*** | 0°C to 60°C (32°F to 140°F) |
| ***Storage Temperature*** | -20°C to 70°C (-4°F to 158°F) |
| ***Relative Humidity*** | 5–95% (non-condensing) |
| ***Environmental Air*** | No corrosive gases permitted |
| ***Vibration*** | MIL STD 810C 514.2 |
| ***Shock*** | MIL STD 810C 516.2 |
| ***Noise Immunity*** | NEMA ICS3-304 |

***NOTE:*** *Values in parenthesis with an* ***asterisk*** *are for older modules with two circuit board design and date codes 0609F3 or previous. Values not in parenthesis are for single circuit board models with date code 0709G or above.*

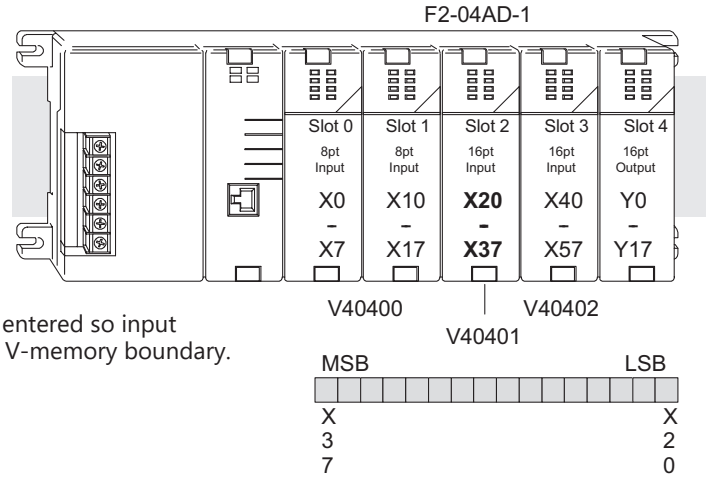
## Analog Input Configuration Requirements

The analog input module will appear as a 16-point discrete input module and can be installed in any slot of a DL205 system. The available power budget and discrete I/O points are the limiting factors. For more information check the user manual for the CPU model and I/O base being used regarding power budget and number of local, local expansion or remote I/O points.

## Special Placement Requirements (D2-230 and Remote I/O Bases)

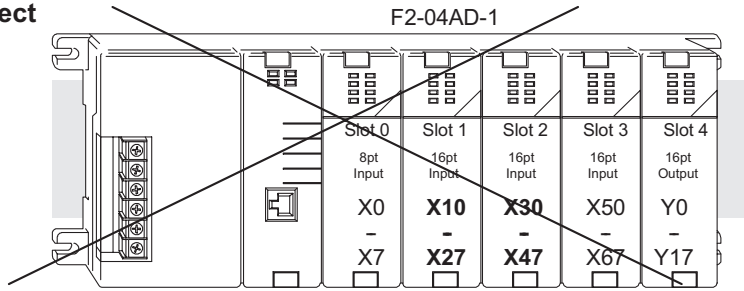
Even though the module can be placed in any slot, it is important to examine the configuration if a D2-230 CPU is used, as can be seen in the section about Writing the Program located in this chapter. V-memory locations are used to extract the analog data. If the module is placed so the input points do not start on a V-memory boundary, the instructions cannot access the data. This also applies when placing this module in a remote base using a D2-RSSS in the CPU slot.

**Correct!**




Data is correctly entered so input points start on a V-memory boundary.

**Incorrect**




Data is split over two locations, so instructions cannot access data from a D2-230.

To use the V-memory references required for a D2-230 CPU, the first input address assigned to the module must be one of the following X locations. The table also shows the V-memory addresses that correspond to these X locations.

| ***X*** | X0 | X20 | X40 | X60 | X100 | X120 | X140 | X160 |
|---|---|---|---|---|---|---|---|---|
| ***V*** | V40400 | V40401 | V40402 | V40403 | V40404 | V40405 | V40406 | V40407 |

# Setting the Module Jumpers

## Selecting the Number of Channels

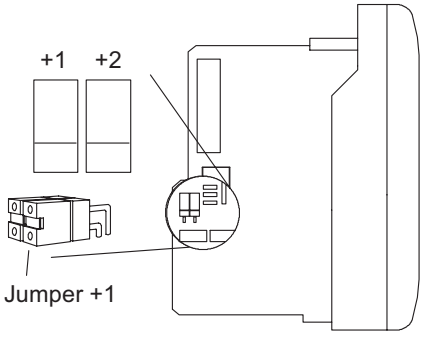
There are two jumpers, labeled +1 and +2, that are used to select the number of channels that will be used. Use the figures below to locate the jumpers on the module. The module is set from the factory for four channel operation.

The unused channels are not processed, so if only channels 1 thru 3 are selected, then channel 4 will not be active. The following table shows how to use the jumpers to select the number of channels.

| *No. of Channels* | *+1* | *+2* |
|---|---|---|
| 1 | No | No |
| 1, 2 | Yes | No |
| 1, 2, 3 | No | Yes |
| 1, 2, 3, 4 | Yes | Yes |

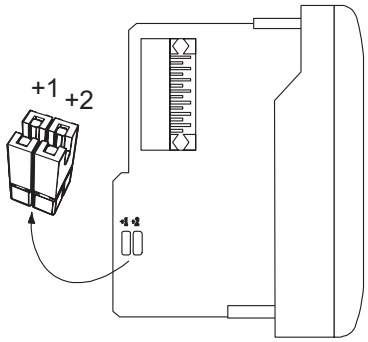
For example, to select all 4 channels (1–4), leave both jumpers installed. To select channel 1, remove both jumpers

**Jumper location on modules having date code 0609F3 and previous (two circuit board design)**




These jumpers are located on the motherboard, the one with the black D-shell style backplane connector.

**Jumper location on modules having date code 0709G and above (single circuit board design)**



# Connecting the Field Wiring

## Wiring Guidelines

Your company may have guidelines for wiring and cable installation. If so, check them before starting the installation. Here are some general things to consider:

- Use the shortest wiring route whenever possible.
- Use shielded wiring and ground the shield at the transmitter source. Do not ground the shield at both the module and the source.
- Do not run the signal wiring next to large motors, high current switches, or transformers. This may cause noise problems.
- Route the wiring through an approved cable housing to minimize the risk of accidental damage. Check local and national codes to choose the correct method for your application.

## User Power Supply Requirements

The F2-04AD-1 module requires at least one field-side power supply. The same or separate power sources can be used for the module supply and the current transmitter supply. The module requires 10–30 VDC, at 5mA, from the external power supply. The DL205 AC bases have a built-in 24VDC power supply that provide up to 300mA of current. This can be used instead of a separate supply. Check the power budget to be safe.

It is desirable in some situations to power the transmitters separately in a location remote from the PLC. This will work as long as the transmitter supply meets the voltage and current requirements, and the transmitter's minus (-) side and the module supply's minus (-) side are connected together.

**WARNING: If using the 24VDC base power supply, make sure to calculate the power budget. Exceeding the power budget can cause unpredictable system operation that can lead to a risk of personal injury or damage to equipment.**

The DL205 base has a switching type power supply. As a result of switching noise, ±3–5 counts of instability may be noticed in the analog input data if the base power supply is used. If this is unacceptable, try one of the following:

1. Use a separate linear power supply.
2. Connect the 24VDC common to the frame ground, which is the screw terminal marked on the screw terminal marked "G" on the base.

By using these methods, the input stability is rated at ± 1 count.

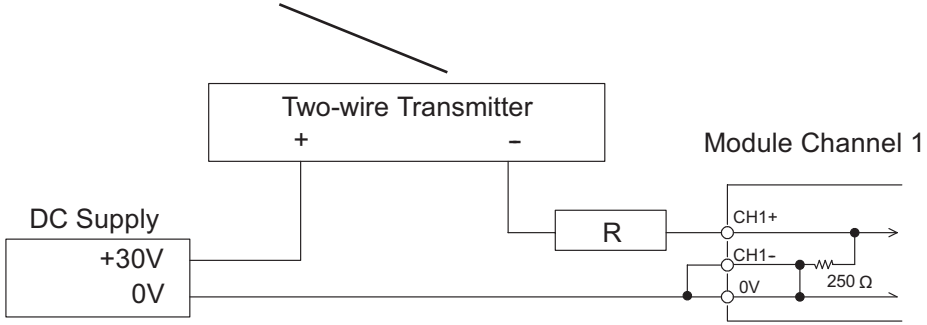
## Current Loop Transmitter Impedance

Standard 4–20 mA transmitters and transducers can operate from a wide variety of power supplies. Not all transmitters are alike and the manufacturers often specify a minimum loop or load resistance that must be used with the transmitter.

The F2-04AD-1, provides 250Ω resistance for each channel. If the transmitter being used requires a load resistance below 250Ω, it is not necessary to make any adjustments. However, if the transmitter requires a load resistance higher than 250Ω, a resistor will need to be added in series with the input.

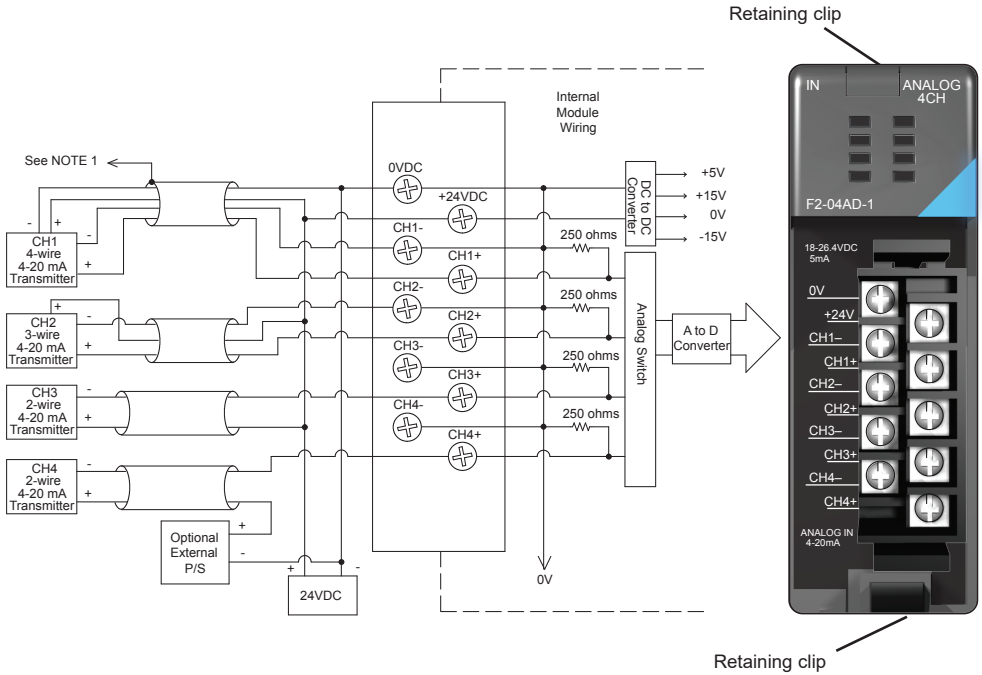
Consider the following example for a transmitter being operated from a 30VDC supply with a recommended load resistance of 750Ω. Since the module has a 250Ω resistor, an additional resistor needs to be added.

| | |
|---|---|
| R = Tr - Mr | R - Resistor to add |
| R = 750–250 | Tr - Transmitter Requirement |
| R ≥ 500 | Mr - Module resistance (internal 250Ω) |



## Wiring Diagram

The F2-04AD-1, module has a removable connector to simplify wiring the module. Just squeeze the top and bottom retaining clips and gently pull the connector from the module. Use the following diagram to connect the field wiring




***NOTE 1:*** *Shields should be grounded at the signal source.*

***NOTE 2:*** *More than one external power supply can be used, provided all the power supply commons are connected.*

***NOTE 3:*** *A Series 217, 0.032 A fast-acting fuse is recommended for 4–20 mA current loops.*

***NOTE 4:*** *If the power supply common of an external power supply is not connected to 0 VDC on the module, then the output of the external transmitter must be isolated. To avoid "ground loop" errors, recommended 4–20 mA transmitter types are:*

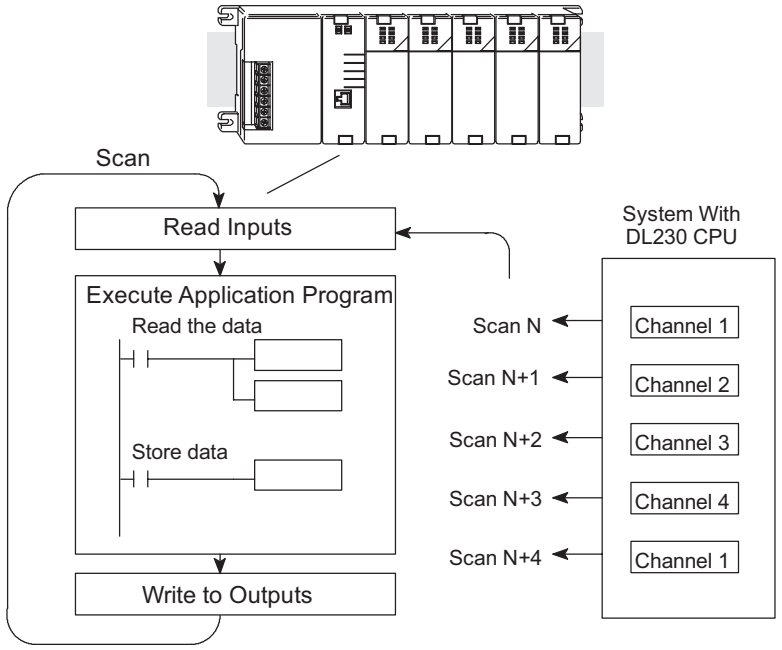
*2 or 3 wire: Isolation between input signal and power supply.*
*4 wire: Isolation between input signal, power supply, and 4–20 mA output.*

# Module Operation

## Channel Scanning Sequence (Multiplexing) for a D2-230 CPU

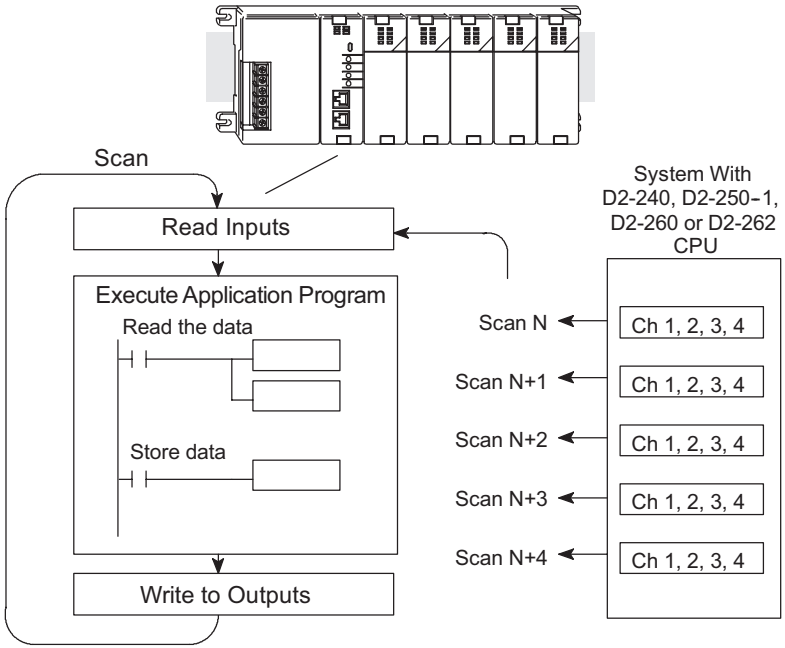
Before beginning to write the control program, it is important to take a few minutes to understand how the module processes and represents the analog signals.

The module can supply different amounts of data per scan, depending on the type of CPU being used. The D2-230 can obtain one channel of data per CPU scan. Since there are four channels, it can take up to four scans to get data for all channels. Once all channels have been scanned the process starts over with channel 1. Unused channels are not processed, so if only two channels are selected, then each channel will be updated every other scan. The multiplexing method can also be used for the D2-240, D2-250-1, D2-260 and D2-262 CPUs.



## Channel Scanning Sequence (Pointer method) for D2-240, D2-250-1, D2-260 or D2-262 CPU

If a D2-240, a D2-250-1, a D2-260 or a D2-262 CPU is used, all four channels of input data can be collected in one scan. This is because the D2-240, D2-250-1, D2-260 and D2-262 CPU supports special V-memory locations that are used to manage the data transfer. This is discussed in more detail in the section on Writing the Control Program later in this chapter.




## Analog Module Updates

Even though the channel updates to the CPU are synchronous with the CPU scan, the module asynchronously monitors the analog transmitter signal and converts the signal to a 12-bit binary representation. This enables the module to continuously provide accurate measurements without slowing down the discrete control logic in the RLL program.

For the vast majority of applications, the values are updated much faster than the signal changes. However, in some applications, the update time can be important. The module takes approximately 4.9 milliseconds to sense 95% of the change in the analog signal.

***NOTE:*** *This is not the amount of time required to convert the signal to a digital representation. The conversion to the digital representation takes only a few microseconds. Many manufacturers list the conversion time, but it is the settling time of the filter that really determines the update time.*

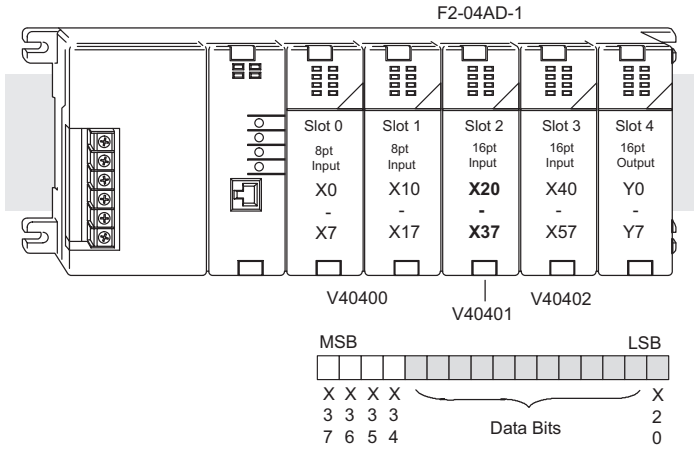
## Understanding the Input Assignments

It was mentioned earlier in this chapter that the F2-04AD-1 module appears as a 16-point discrete input module to the CPU. These points can be used to obtain:

- An indication of which channel is active
- The digital representation of the analog signal
- Module diagnostic information

Since all input points are automatically mapped into V-memory, it is very easy to determine the location of the data word that will be assigned to the module.

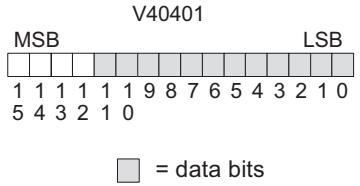
Within these word locations, the individual bits represent specific information about the analog signal.




## Analog Data Bits

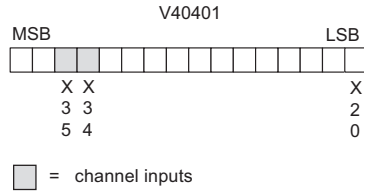
The first twelve bits represent the analog data in binary format.

| Bit | Value | Bit | Value |
|---|---|---|---|
| 0 | 1 | 6 | 64 |
| 1 | 2 | 7 | 128 |
| 2 | 4 | 8 | 256 |
| 3 | 8 | 9 | 512 |
| 4 | 16 | 10 | 1024 |
| 5 | 32 | 11 | 2048 |



## Active Channel Indicator Inputs

Two of the inputs are binary-encoded to indicate the active channel (remember, the V-memory bits are mapped directly to discrete inputs). The inputs are automatically turned on and off to indicate the active channel for each scan.

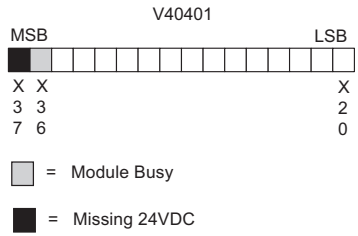



| Scan | X35 | X34 | Channel |
|---|---|---|---|
| N | Off | Off | 1 |
| N+1 | Off | On | 2 |
| N+2 | On | Off | 3 |
| N+3 | On | Off | 4 |
| N+4 | Off | Off | 1 |

## Module Diagnostic Inputs

The last two inputs are used for module diagnostics.

Module Busy - The first diagnostic input (X36 in this example) indicates a "busy" condition. This input will always be active on the first PLC scan, to tell the CPU the analog data is not valid. After the first scan, the input usually only comes on when extreme environmental (electrical) noise problems are present.




The programming examples in the next section shows how this input can be used. The wiring guidelines shown earlier in this chapter provide steps that can help reduce noise problems.

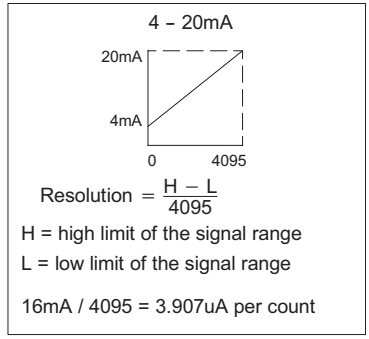
Missing 24VDC - The last diagnostic input (X37 in this example) indicates that 24VDC has not been applied to the card. For example, when using the multiplexing method, if the 24VDC input power is missing or if the terminal block is loose, the module will turn on this input point and it also returns a data value of zero to further indicate there is a problem. If using the pointer method, the value placed into the V-memory location will be 8000 instead of bit 15 (i.e. X37 in this example) being set.

The next section, Writing the Control Program, explains how these inputs can be used in a program.

## Module Resolution

Since the module has 12-bit resolution, the analog signal is converted into 4096 counts ranging from 0 - 4095 (212). For example, a 4mA signal would be 0 and a 20mA signal would be 4095. This is equivalent to a a binary value of 0000 0000 0000 to 1111 1111 1111, or 000 to FFF hexadecimal. The diagram shows how this relates to the signal range.

Each count can also be expressed in terms of the signal level by using the equation shown.



# Writing the Control Program

## Reading Values: Pointer Method and Multiplexing

There are two methods which can be used to read values:

- The pointer method
- Multiplexing

The multiplexing method must be used when using a D2-230 CPU. The multiplexing method must also be used with remote I/O modules (the pointer method will not work). Either method can be used with the D2-240, D2-250-1, D2-260 and D2-262 CPUs, but for ease of programming it is strongly recommended to use the pointer method.

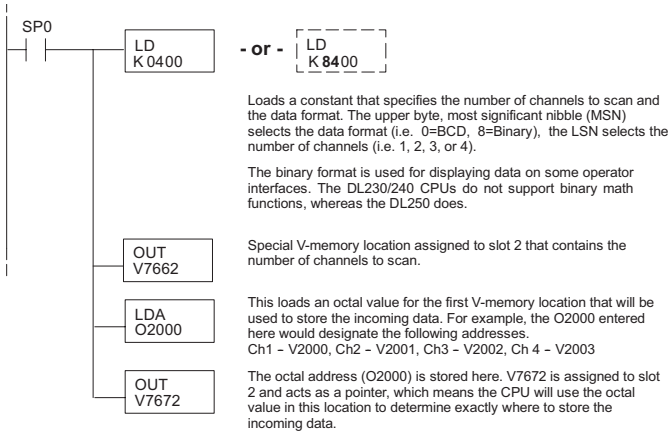
## Pointer Method for D2-240, D2-250-1, D2-260 and D2-262

The DL205 series has special V-memory locations assigned to each base slot that will greatly simplify the programming requirements. These V-memory locations allow you to:

- Specify the data format
- Specify the number of channels to scan
- Specify the storage locations.

***NOTE:*** *D2-250 CPUs with firmware release version 1.06 or later support this method. If the D2-230 example needs to be used, module placement in the base is very important. Review the section earlier in this chapter for guidelines.*

The example program shows how to setup these locations. Place this rung anywhere in the ladder program, or in the initial stage if stage programming instructions are being used. This is all that is required to read the data into V-memory locations. Once the data is in V-memory, math can be used on the data to compare the data against preset values, and so forth. V2000 is used in the example but you can use any user V-memory location. In this example the module is installed in slot 2. Be sure to use the V-memory locations for the module placement. The pointer method automatically converts values to BCD (depending on the LD statement in the ladder logic).



The tables below show the special V-memory locations used by the D2-240, D2-250-1, D2-260 and D2-262 for the CPU base and local expansion base I/O slots. Slot 0 (zero) is the module next to the CPU or the D2-CM module. Slot 1 is the module two places from the CPU or the D2-CM, and so on. Remember, the CPU only examines the pointer values at these locations after a mode transition. Also, if the D2-230 (multiplexing) method is used, verify that these addresses in the CPU are zero.

The table below applies to the D2-240, D2-250-1, D2-260 and D2-262 CPU base.

| CPU Base: Analog Input Module Slot-Dependent V-memory Locations | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| ***Slot*** | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| ***No. of Channels*** | V7660 | V7661 | V7662 | V7663 | V7664 | V7665 | V7666 | V7667 |
| ***Storage Pointer*** | V7670 | V7671 | V7672 | V7673 | V7674 | V7675 | V7676 | V7677 |

The table below applies to the D2-250-1, D2-260 or D2-262 expansion base 1.

| Expansion Base D2-CM #1: Analog Input Module Slot-Dependent V-memory Locations | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| ***Slot*** | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| ***No. of Channels*** | V36000 | V36001 | V36002 | V36003 | V36004 | V36005 | V36006 | V36007 |
| ***Storage Pointer*** | V36010 | V36011 | V36012 | V36013 | V36014 | V36015 | V36016 | V36017 |

The table below applies to the D2-250-1, D2-260 or D2-262 expansion base 2.

| Expansion Base D2-CM #2: Analog Input Module Slot-Dependent V-memory Locations | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| ***Slot*** | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| ***No. of Channels*** | V36100 | V36101 | V36102 | V36103 | V36104 | V36105 | V36106 | V36107 |
| ***Storage Pointer*** | V36110 | V36111 | V36112 | V36113 | V36114 | V36115 | V36116 | V36117 |

The table below applies to the D2-260 and D2-262 CPU expansion base 3.

| Expansion Base D2-CM #3: Analog Input Module Slot-Dependent V-memory Locations | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| ***Slot*** | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| ***No. of Channels*** | V36200 | V36201 | V36202 | V36203 | V36204 | V36205 | V36206 | V36207 |
| ***Storage Pointer*** | V36210 | V36211 | V36212 | V36213 | V36214 | V36215 | V36216 | V36217 |

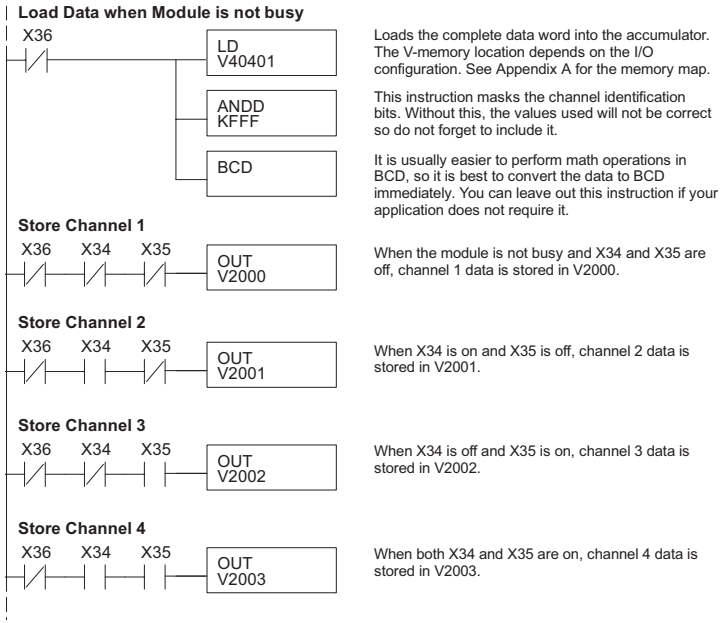
The table below applies to the D2-260 and D2-262 CPU expansion base 4.

| Expansion Base D2-CM #4: Analog Input Module Slot-Dependent V-memory Locations | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| ***Slot*** | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| ***No. of Channels*** | V36300 | V36301 | V36302 | V36303 | V36304 | V36305 | V36306 | V36307 |
| ***Storage Pointer*** | V36310 | V36311 | V36312 | V36313 | V36314 | V36315 | V36316 | V36317 |

## Reading Values (Multiplexing) for D2-230, D2-240, D2-250-1, D2-260 and D2-262 CPUs

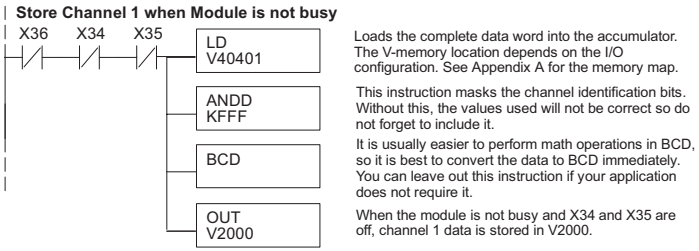
The D2-230 CPU does not have the special V-memory locations which will allow data transfer to be automatically enabled. Since all channels are multiplexed into a single data word, the control program must be setup to determine which channel is being read. Since the module appears as X input points to the CPU, it is very easy to use the active channel status bits to determine which channel is being monitored.

***NOTE:*** *This example is for a module installed as shown in the previous examples. The addresses used would be different if the module was installed in a different I/O arrangement. The rungs can be placed anywhere in the program, or if stage programming is being used, place them in a stage that is always active.*




## Single Channel Selected

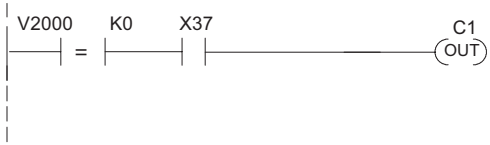
Since it isn't necessary to know which channel is selected, the single channel program is even more simple as shown in the example below.



## Analog Power Failure Detection

The Analog module has an on-board processor that can diagnose analog input circuit problems. A ladder rung can be edited to detect these problems. This rung shows an input point that would be assigned if the module was installed as shown in the previous examples. A different point would be used if the module was installed in a different I/O arrangement.

Multiplexing method




V-memory location V2000 holds channel 1 data. When a data value of zero is returned and input X37 is on, then the analog circuitry is not operating properly.

Pointer method

V-memory location V2000 holds channel 1 data. When a data value of 8000 is returned, then the analog circuitry is not operating properly.

## Scaling the Input Data

Most applications require measurements in engineering units which provides more meaningful data. This is accomplished by using the conversion formula shown.

$$\text{Units} = A \frac{H - L}{4095}$$

**U = Engineering Units**

**A = Analog Value (0 – 4095)**

**H = High limit of the engineering unit range**

**L = Low limit of the engineering unit range**

Adjustments may be needed to the formula depending on the scale being used for the engineering units.

For example, if pressure (psi) is to be measured from 0.0 – 99.9 then multiply the value by 10 in order to imply a decimal place when viewing the value with the programming software or with a handheld programmer. Notice how the calculations differ when the multiplier is used.

An analog value of 2024, slightly less than half scale, should yield 49.4 psi.

**Example without multiplier**

$$\text{Units} = A \frac{H - L}{4095}$$

$$\text{Units} = 2024 \frac{100 - 0}{4095}$$

$$\text{Units} = 49$$

**Example with multiplier**

$$\text{Units} = 10A \frac{H - L}{4095}$$

$$\text{Units} = 20240 \frac{100 - 0}{4095}$$

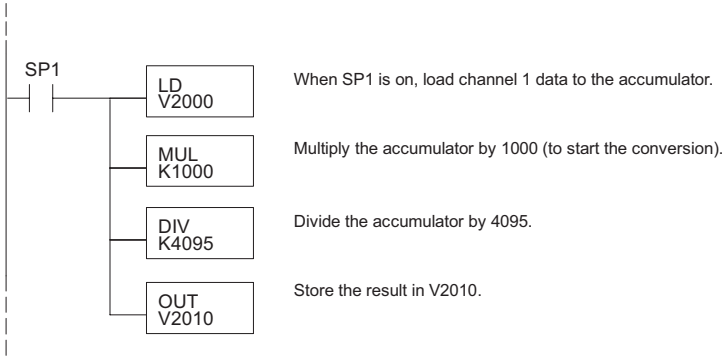
$$\text{Units} = 494$$

## The Conversion Program

The following example shows how to write the program to perform the engineering unit conversion. This example assumes that the data is in BCD and loaded into the appropriate V-memory locations using instructions that apply the CPU being used in the PLC.

***NOTE:*** *This example uses SP1, which is always on, but any permissive contact such as, X, C, etc., can be used.*

## Analog and Digital Value Conversions




Sometimes it is useful to be able to quickly convert between the signal levels and the digital values. This is especially helpful during machine startup or troubleshooting. The following table provides formulas to make this conversion more simple.

| Range | If the digital value is known | If the analog signal level is known. |
|---|---|---|
| ***4–20 mA*** | $A = \frac{16D + 4}{4095}$ | $D = \frac{4095\ (A - 4)}{16}$ |

As an example, if the measured signal is 10mA, the formula can be used to easily determine the digital value that will be stored in the V-memory location that contains the data.

$$D = \frac{4095\ (A - 4)}{16}$$

$$D = \frac{4095\ (10mA - 4)}{16}$$

$$D = (255.93)\ (6)$$

$$D = 1536$$

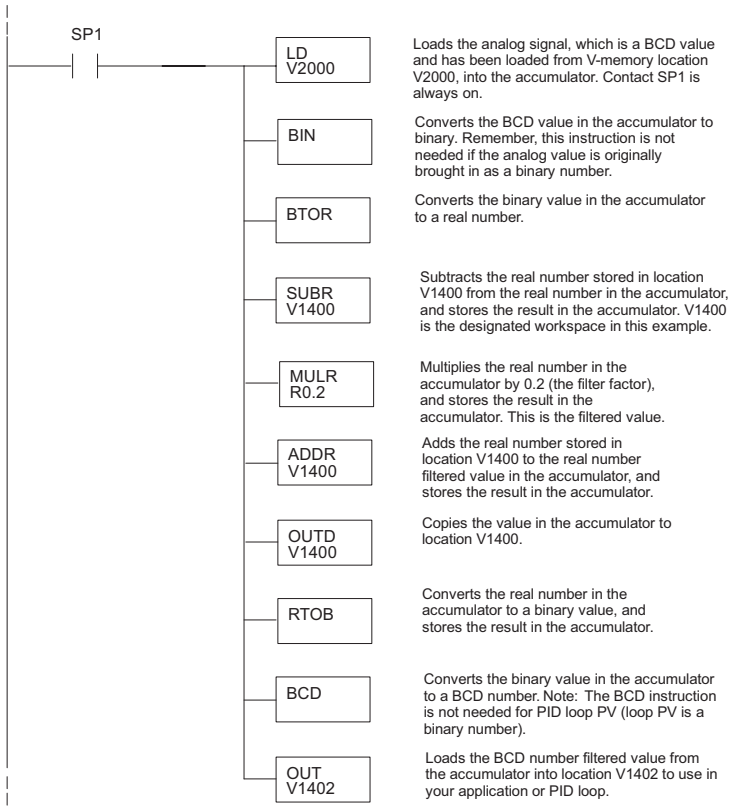
## Filtering Input Noise for D2-250-1, D2-260 and D2-262 CPUs Only

Add the following logic to filter and smooth analog input noise in D2-250-1, D2-260 and D2-262 CPUs. This is especially useful when using PID loops. Noise can be generated by the field device and/or induced by field wiring.

In the following example, the analog value in BCD is first converted to a binary number. Memory location V1400 is the designated work space in this example. The MULR instruction is the filter factor, which can be from 0.1 to 0.9. The example uses 0.2. A smaller filter factor increases filtering. A higher precision value can be used, but it is not generally needed. The filtered value is then converted back to binary and then to BCD. The filtered value is stored in location V1402 for use in your application or PID loop.

***NOTE:*** *Please review intelligent instructions (IBox) in Chapter 5 of D2-USER-M, which simplify this and other functions. The IBox instructions are supported by the D2-250-1, D2-260 and D2-262 CPUs.*

***NOTE:*** *Be careful not to do a multiple number conversion on a value. For example, if you are using the pointer method to get the analog value, it is in BCD and must be converted to binary. However, if you are using the conventional method of reading analog and are masking the first twelve bits, then it is already in binary and no conversion using the BIN instruction is needed.*



# F2-04AD-2, F2-04AD-2L 4-Channel Analog Voltage Input

## In This Chapter...

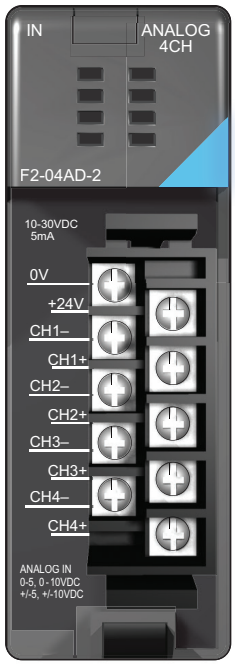
Module Specifications ..... 3-2
Setting the Module Jumpers ..... 3-5
Connecting the Field Wiring ..... 3-7
Module Operation ..... 3-10
Understanding Input Assignments ..... 3-12
Writing the Control Program ..... 3-15

# Module Specifications

## F2-04AD-2

The F2-04AD-2 analog Input module provides several hardware features.

- Analog inputs are optically isolated from the PLC logic.
- The module has a removable terminal block so the module can be easily removed or changed without disconnecting the wiring.
- With a D2-240, D2-250-1, D2-260 and D2-262 CPU, all four channels can be read in one scan.
- On-board active analog filtering and microcontroller provide digital signal processing to maintain precision analog measurements in noisy environments..




**F2-04AD-2**

## F2-04AD-2L is Obsolete

***NOTE:*** *In 2009 the F2-04AD-2L was discontinued. A re-designed F2-04AD-2 was released at the same time which can be powered by either 12VDC or 24VDC input power supplies. This new module is a direct replacement for prior F2-04AD-2 and all F2-04AD-2L modules. The new module is a single circuit board design and the jumper link locations are different. See Setting the Module Jumpers on page 3-5. Also, some specifications were changed on page 3-3. Otherwise, the re-designed module functions the same as the prior designs.*

## Analog Input Configuration Requirements

The F2-04AD-2 analog input module requires 16 discrete input points and can be installed in any slot of a DL205 system. The available power budget and discrete I/O points are the limiting factors. For more information regarding power budget and number of local, local expansion or remote I/O points, check the user manual for the particular CPU model and I/O base being used.

All specifications are the same for both modules except for the input voltage requirements. Review these specifications to make sure the module meets your application requirements.

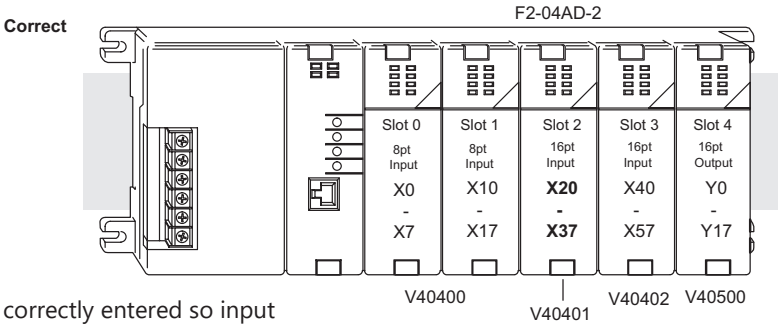
| Input Specifications | |
|---|---|
| ***Number of Channels*** | 4, single ended (one common) |
| ***Input Range*** | 0–5 VDC, 0–10 VDC, ±5V, ±10V |
| ***Resolution*** | 12 bit (1 in 4096) unipolar (0–4096)<br>13 bit (1 in 8192) bipolar (-4095 to +4095) |
| ***Common Mode Rejection*** | - 50db at 800Hz |
| ***Step Response*** | 8.2 ms (*10ms) to 95% of full step change |
| ***Crosstalk*** | -70db, 1 count maximum |
| ***Active Low-pass Filtering*** | -3 db at 80Hz, 2 poles (-12db per octave) |
| ***Input Impedance*** | Greater than 20MΩ |
| ***Absolute Maximum Ratings*** | ±75VDC |
| ***Converter Type*** | Successive approximation |
| ***Linearity Error (End to End)*** | ± 1 count (0.025% of span) maximum unipolar<br>± 2 counts maximum bipolar |
| ***Input Stability*** | ± 1 count |
| ***Full Scale Calibration Error (Offset error included)*** | ± 3 counts maximum |
| ***Offset Calibration Error*** | ± 1 count maximum (0V input) |
| ***Maximum Inaccuracy*** | ± 0.1% @ 25°C (77°F)<br>± 0.3% 0–60°C (32–140°F) |
| ***Accuracy vs. Temperature*** | ± 50ppm / °C full scale calibration change (including maximum offset change of 2 counts) |

| General Specifications | |
|---|---|
| ***PLC Update Rate*** | 1 channel per scan maximum (D2-230 CPU)<br>4 channels per scan maximum (D2-240/D2-250-1/D2-260/D2-262 CPU) |
| ***Digital Inputs Input points required*** | 12 binary data bits, 2 channel ID bits, 1 sign/diagnostic bit, 1 diagnostic bit<br>16 point (X) input module |
| ***Power Budget Requirement*** | 110mA (*60mA maximum, 5VDC (supplied by base) |
| ***External Power Supply*** | F2-04AD-2: 5mA, 10–30 VDC (*90mA max, 18–26.4 VDC)<br>F2-04AD-2L: *90mA max, 10–15 VDC |
| ***Operating Temperature*** | 0°C to 60°C (32°F to 140°F) |
| ***Storage Temperature*** | -20°C to 70°C (-4°F to 158°F) |
| ***Relative Humidity*** | 5–95% (non-condensing) |
| ***Environmental Air*** | No corrosive gases permitted |
| ***Vibration*** | MIL STD 810C 514.2 |
| ***Shock*** | MIL STD 810C 516.2 |
| ***Noise Immunity*** | NEMA ICS3-304 |

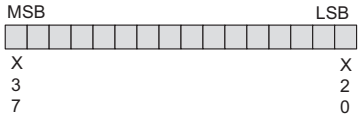
***NOTE:*** *Values in parenthesis with an asterisk are for older modules with two circuit board design and date codes 0609F4 and previous. Values not in parenthesis are for single circuit board models with date code 0709G and above.*

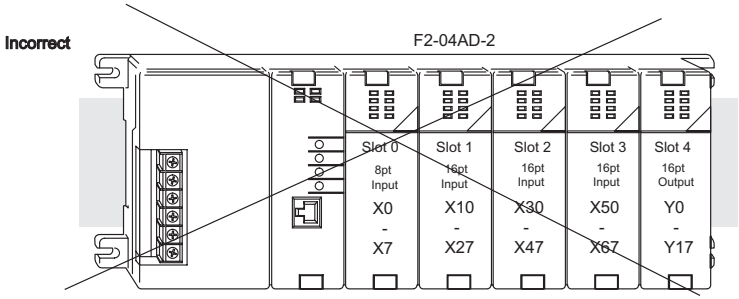
## Special Placement Requirements (D2-230 and Remote I/O Bases)

Even though the module can be placed in any slot, it is important to examine the configuration if a D2-230 CPU is used, as can be seen in the section about Writing the Program, located in this chapter. V-memory locations are used to extract the analog data. If the module is placed so the input points do not start on a V-memory boundary, the instructions cannot access the data. This also applies when placing this module in a remote base using a D2-RSSS in the CPU slot.

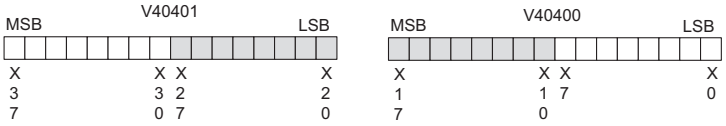



Data is correctly entered so input points start on a V-memory boundary.




Data is split over two locations, so instructions cannot access data from a D2-230.




To use the V-memory references required for a D2-230 CPU, the first input address assigned to the module must be one of the following X locations. The table also shows the V-memory addresses that correspond to these X locations.

| ***X*** | X0 | X20 | X40 | X60 | X100 | X120 | X140 | X160 |
|---|---|---|---|---|---|---|---|---|
| ***V*** | V40400 | V40401 | V40402 | V40403 | V40404 | V40405 | V40406 | V40407 |

# Setting the Module Jumpers

## Selecting the Number of Channels

There are two jumpers, labeled +1 and +2, that are used to select the number of channels that will be used. Use the figures below to locate the jumpers on the module. The module is set from the factory for four channel operation.

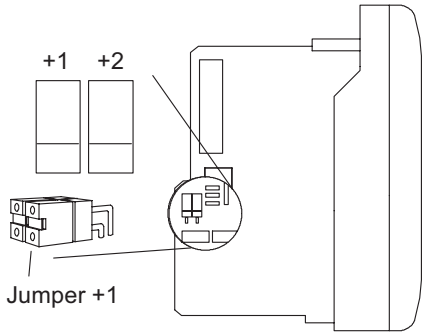
The unused channels are not processed, so if only channels 1 through 3 are selected, then channel 4 will not be active. The following table shows how to place the jumpers to select the number of channels.

| *No. of Channels* | *+1* | *+2* |
|---|---|---|
| 1 | No | No |
| 1, 2 | Yes | No |
| 1, 2, 3 | No | Yes |
| 1, 2, 3, 4 | Yes | Yes |

Yes = jumper installed
No = jumper removed

For example, to select all 4 channels (1 - 4), leave both jumpers installed. To select channel 1, remove both jumpers

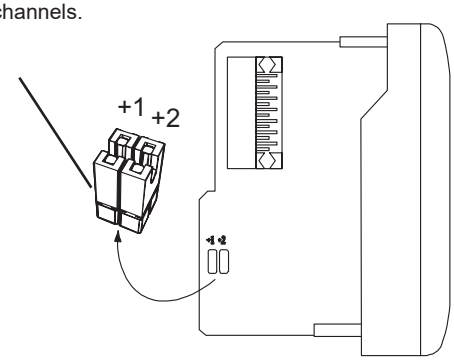
**Jumper location on modules having Date Code 0609F4 and previous (two circuit board design)**




These jumpers are located on the motherboard, the one with the black D-shell style backplane connector.

**Jumper location on modules having Date Code 0709G and above (single circuit board design)**

Use jumpers +1 and +2 to select number of channels.

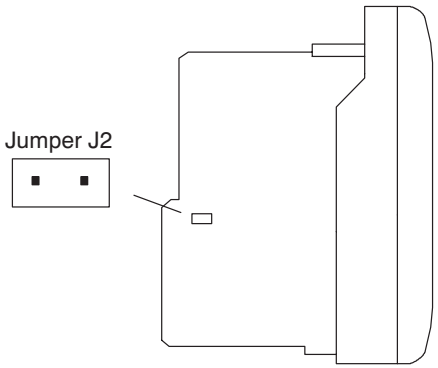


## Selecting the Input Signal Range

There is another jumper, labeled either J2 or J3 that is used to select between the 5V ranges and the 10V ranges (depending whether it is a single or double circuit board module). See the figures below to locate the jumper on the module being used. The module comes from the factory set for 10V operation (jumper not installed).

***Note:*** *Install jumper J2 or J3 for 0–5 V or ±5V operation.*
*Remove J2 or J3, or store on a single pin, for 0–10 V or ±10V operation.*

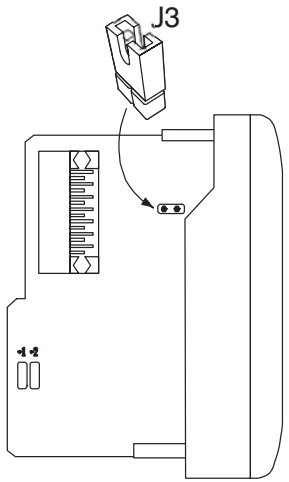
**Jumper J2 location on modules having Date Code 0609F4 and previous (two circuit board design)**




Jumper J2 is located on the smaller circuit board, which is on top of the motherboard.

Install J2 for 0–5 V or ±5V operation. Remove J2, or store on a single pin, for 0–10 V or ±10V operation.

**Jumper J3 location on modules having Date Code 0709G and above (single circuit board design)**




Install J3 for 0–5 V or ±5V operation. Remove J3, or store on a single pin, for 0–10 V or ±10V operation.

# Connecting the Field Wiring

## Wiring Guidelines

Your company may have guidelines for wiring and cable installation. If so, check them before starting the installation. Here are some general things to consider:

- Use the shortest wiring route whenever possible.
- Use shielded wiring and ground the shield at the transmitter source. Do not ground the shield at both the module and the source.
- Do not run the signal wiring next to large motors, high current switches, or transformers. This may cause noise problems.
- Route the wiring through an approved cable housing to minimize the risk of accidental damage. Check local and national codes to choose the correct method for your application.

## User Power Supply Requirements

The F2-04AD-2 module requires at least one field-side power supply. The same or separate power sources can be used for the module supply and the voltage transmitter supply. The module requires 10–30 VDC, at 5mA, from the external power supply.

The DL205 AC bases have a built-in 24VDC power supply that provide up to 300mA of current. This can be used instead of a separate supply. Check the power budget to be safe.

It is desirable in some situations to power the transmitters separately in a location remote from the PLC. This will work as long as the transmitter supply meets the voltage and current requirements, and the transmitter's minus (-) side and the module supply's minus (-) side are connected together.

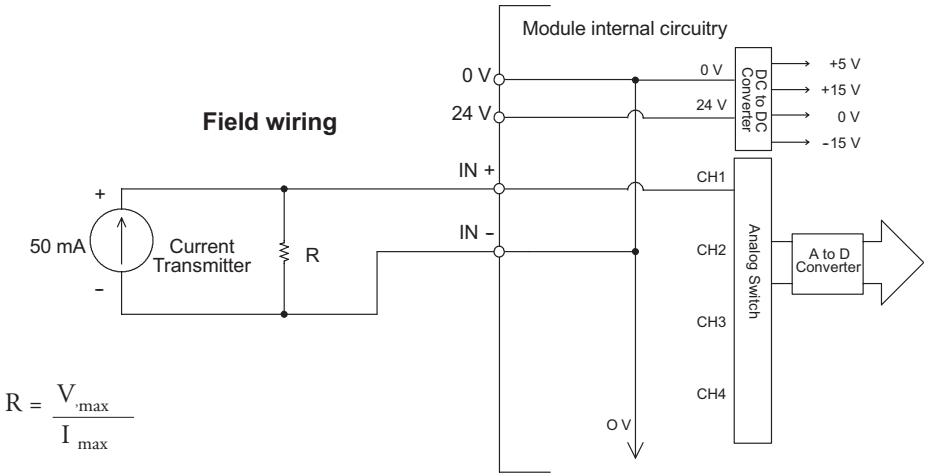
**WARNING: If the 24VDC base power supply is used, Be sure to calculate the power budget. Exceeding the power budget can cause unpredictable system operation that can lead to a risk of personal injury or damage to equipment.**

The DL205 base has a switching type power supply. As a result of switching noise, ±3–5 counts of instability may be noticed in the analog input data if this power supply is used. If this is unacceptable, try using one of the following.

1. Use a separate linear power supply.
2. Connect the 24VDC common to the frame ground, which is the screw terminal marked on the screw terminal marked "G" on the base.
3. By using these methods, the input stability is rated at ±1 count.

## Custom Input Ranges

At times, there may be a need to connect a (current) transmitter with an unusual signal range. By changing the wiring slightly and adding an external resistor to convert the current to voltage, the module can be easily adapted to meet the specifications for a transmitter that does not adhere to one of the standard input ranges. The following diagram shows how this can be done. The example below only shows channel 1, but the other channels can be used as well.




$$R = \frac{V_{,max}}{I_{max}}$$

R = value of external resistor
$V_{max}$ = high limit of selected voltage range (5V or 10V)
$I_{max}$ = maximum current supplied by the transmitter

Example: current transmitter capable of 50mA, 0–10 V range selected.

$$R = \frac{10V}{50mA} \qquad R = 200\Omega$$

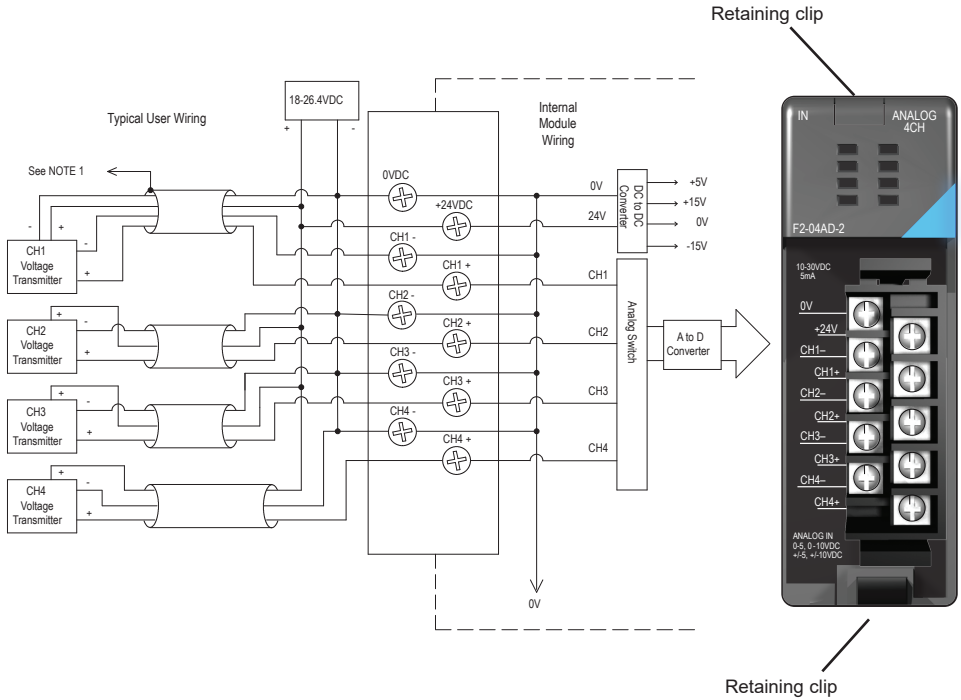
***NOTE:*** *The choice of resistor can affect the accuracy of the module. A resistor that has ± 0.1% tolerance and a ± 50 ppm/°C temperature coefficient is recommended.*

If a 4–20 mA signal is used and converted to voltage using this method, a broken transmitter condition can easily be detected. For example, if using the 0–5V range and the lowest signal for the 4–20 mA transmitter is 4mA, the lowest digital value for the signal is not 0, but instead is 819.

If the transmitter is working properly, the smallest value would be 819 in the DL205. If the value is less than about 750 (allowing for tolerance), then the transmitter is broken.

## Wiring Diagram

The module has a removable connector to simplify wiring the module. Just squeeze the top and bottom retaining clips and gently pull the connector from the module. Use the following diagram to connect the field wiring



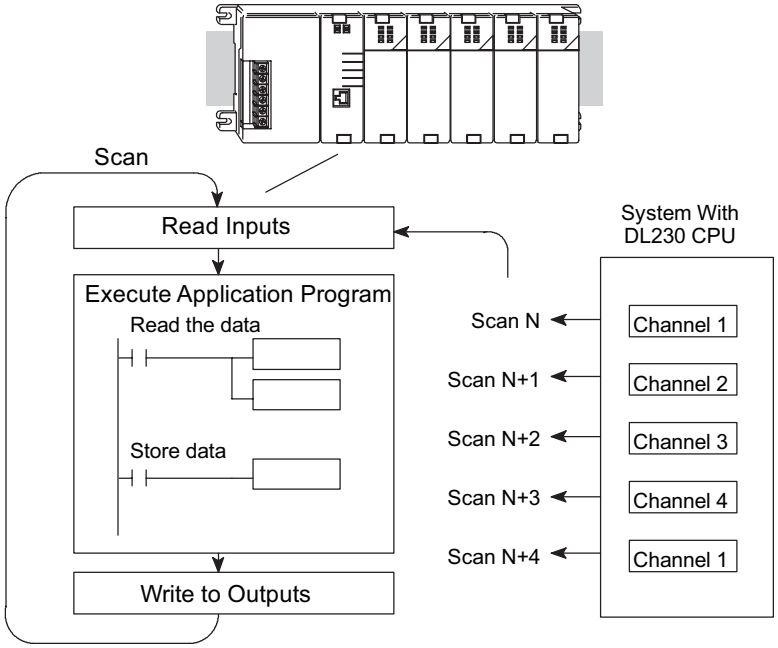

***NOTE:*** *Shields should be grounded at the signal source.*

# Module Operation

## Channel Scanning Sequence (Multiplexing) for a D2-230 CPU

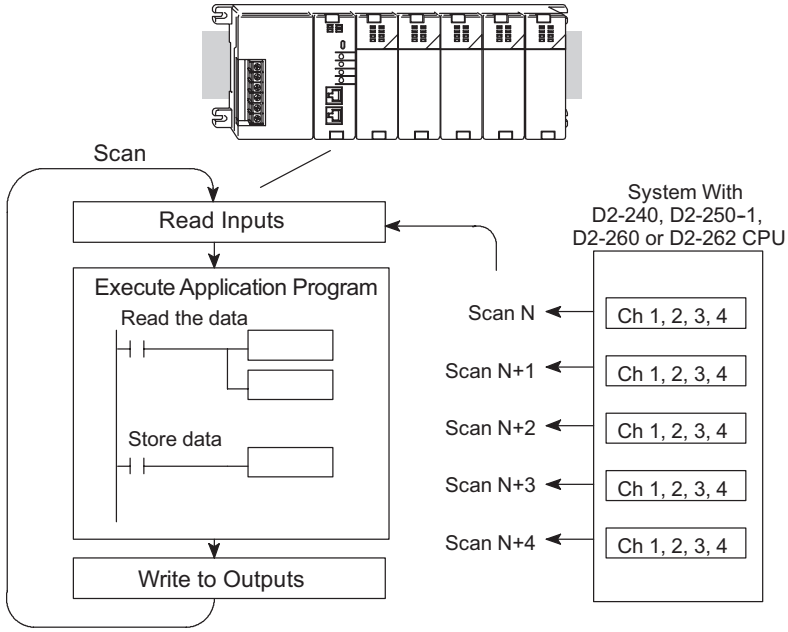
Before beginning to write the control program, it is important to take a few minutes to understand how the module processes and represents the analog signals.

Depending on the type of CPU being used, the module can supply different amounts of data per scan. The D2-230 can obtain one channel of data per CPU scan. Since there are four channels, it can take up to four scans to get data for all channels. Once all channels have been scanned the process starts over with channel 1. Unused channels are not processed, so if only two channels are selected, then each channel will be updated every other scan. The multiplexing method can also be used for the D2-240, 250-1, D2-260 and D2-262 CPUs.



## Channel Scanning Sequence (Pointer method) for D2-240, D2-250-1, D2-260 or D2-262 CPUs

If either a D2-240, a D2-250-1, a D2-260 or a D2-262 CPU are used, all four channels of input data can be collected in one scan. This is because the D2-240, D2-250-1, D2-260 and D2-262 CPUs support special V-memory locations that are used to manage the data transfer. This is discussed in more detail in the section on Writing the Control Program later in this chapter.




## Analog Module Updates

Even though the channel updates to the CPU are synchronous with the CPU scan, the module asynchronously monitors the analog transmitter signal and converts the signal to a 12-bit binary representation. This enables the module to continuously provide accurate measurements without slowing down the discrete control logic in the RLL program.

For the vast majority of applications, the values are updated much faster than the signal changes. However, in some applications, the update time can be important. The module takes approximately 8.2 milliseconds to sense 95% of the change in the analog signal.

***NOTE:*** *This is not the amount of time required to convert the signal to a digital representation. The conversion to the digital representation takes only a few microseconds. Many manufacturers list the conversion time, but it is the settling time of the filter that really determines the update time.*

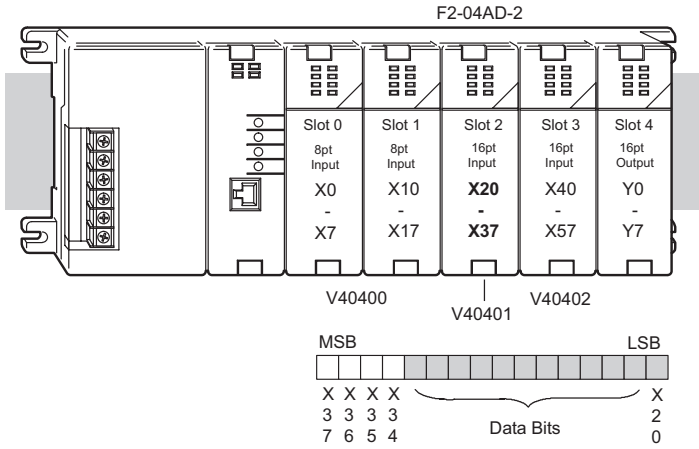
# Understanding Input Assignments

It was mentioned earlier in this chapter that the F2-04AD-2 module appears as a 16-point discrete input module to the CPU. These points can be used to obtain:

- An indication of which channel is active
- The digital representation of the analog signal
- Module diagnostic information

Since all input points are automatically mapped into V-memory, it is very easy to determine the location of the data word that will be assigned to the module.

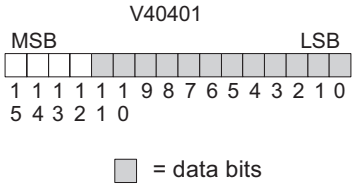
Within these word locations, the individual bits represent specific information about the analog signal.




## Analog Data Bits

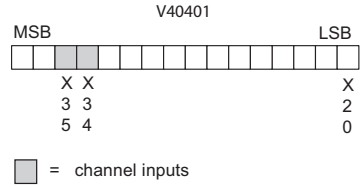
The first twelve bits represent the analog data in binary format.

| Bit | Value | Bit | Value |
|---|---|---|---|
| 0 | 1 | 6 | 64 |
| 1 | 2 | 7 | 128 |
| 2 | 4 | 8 | 256 |
| 3 | 8 | 9 | 512 |
| 4 | 16 | 10 | 1024 |
| 5 | 32 | 11 | 2048 |



## Active Channel Indicator Inputs

Two of the inputs are binary-encoded to indicate the active channel (remember, the V-memory bits are mapped directly to discrete inputs). The inputs automatically turn on and off to indicate the current channel for each scan.

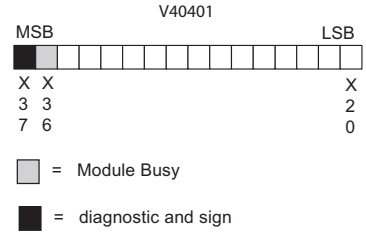



| Scan | X35 | X34 | Channel |
|---|---|---|---|
| N | Off | Off | 1 |
| N+1 | Off | On | 2 |
| N+2 | On | Off | 3 |
| N+3 | On | On | 4 |
| N+4 | Off | Off | 1 |

## Module Diagnostic and Sign Inputs

The last two inputs are used for module diagnostics.

Module Busy - The first diagnostic input (X36 in this example) indicates a "busy" condition. This input will always be active on the first PLC scan, to tell the CPU the analog data is not valid. After the first scan, the input usually only comes on when extreme environmental (electrical) noise problems are present.




The last input (X37 in this example) is used for two purposes.

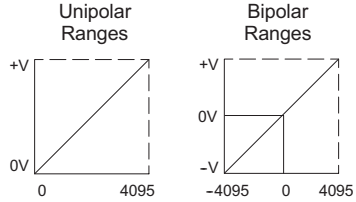
Signal Sign - When using bipolar ranges the value returned needs to be known if it is either positive or negative. When this input is off, the value stored represents a positive analog signal (0V or greater). If the input is on, then the value stored represents a negative input signal (less than 0V).

Channel Failure - The last diagnostic input can also indicate an analog channel failure. For example, if the 24VDC input power is missing or if the terminal block is loose, the module will turn on this input point and also returns a data value of zero (remember, if this input is on and the data value is not equal to zero, then it is just showing the sign).

The next section, Writing the Control Program, shows how these inputs can be used in a program.

## Module Resolution

Since the module has 12-bit unipolar resolution, the analog signal is converted into 4096 counts ranging from 0 - 4095 (212). For example, with a 0–10 V scale, a 0V signal would be 0 and a 10V signal would be 4095. This is equivalent to a binary value of 0000 0000 0000 to 1111 1111 1111, or 000 to FFF hexadecimal. The diagram shows how this relates to the signal range.




Each count can also be expressed in terms of the signal level by using the equation shown.

$$\text{Unipolar Resolution} = \frac{H - L}{4095}$$

$$\text{Bipolar Resolution} = \frac{H - L}{8191}$$

H or L = high or low limit of the range

Each count can also be expressed in terms of the signal level by using the equation shown.

The following table shows the smallest detectable signal change that will result in one LSB change in the data value for each input signal range.

| *Voltage Range* | *Signal Span (H–L)* | *Divide By* | *Smallest Detectable Change* |
|---|---|---|---|
| **0 to +10V** | 10V | 4095 | 2.44 mV |
| **-10V to +10V** | 20V | 8191 | 2.44 mV |
| **0 to +5V** | 5V | 4095 | 1.22 mV |
| **-5V to +5V** | 10V | 8191 | 1.22 mV |

# Writing the Control Program

## Reading Values: Pointer Method and Multiplexing

There are two methods of reading values:

- The pointer method
- Multiplexing

The multiplexing method must be used when using a D2-230 CPU. The multiplexing method must also be used with remote I/O modules (the pointer method will not work). Either method can be used with the D2-240, D2-250-1, D2-260 and D2-262 CPUs, but for ease of programming it is strongly recommended to use the pointer method.

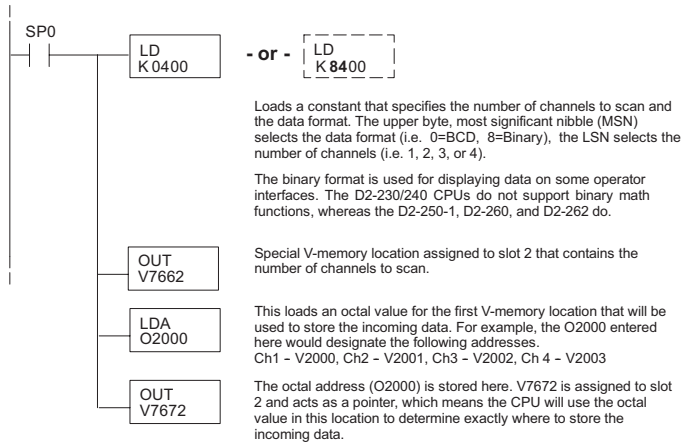
## Pointer Method for the D2-240, D2-250-1, D2-260 and D2-262 CPUs

The DL205 series has special V-memory locations assigned to each base slot that will greatly simplify the programming requirements. These V-memory locations allow you to:

- Specify the data format
- Specify the number of channels to scan
- Specify the storage locations.

***NOTE:*** *D2-250 CPUs with firmware release version 1.06 or later support this method. If the D2-230 example needs to be used, module placement in the base is very important. Review the section earlier in this chapter for guidelines.*

The example program shows how to setup these locations. Place this rung anywhere in the ladder program, or in the initial stage if stage programming instructions are being used. This is all that is required to read the data into V-memory locations. Once the data is in V-memory, math can be used on the data, compare the data against preset values, and so forth. V2000 is used in the example but you can use any user V-memory location. In this example the module is installed in slot 2. Be sure to use the V-memory locations for the module placement. The pointer method automatically converts values to BCD (depending on the LD statement in the ladder logic).



The tables below show the special V-memory locations used by the D2-240, D2-250-1, D2-260 and D2-262 for the CPU base and local expansion base I/O slots. Slot 0 (zero) is the module next to the CPU or D2-CM module. Slot 1 is the module two places from the CPU or D2-CM, and so on. Remember, the CPU only examines the pointer values at these locations after a mode transition. Also, if you use the D2-230 (multiplexing) method, verify that these addresses in the CPU are zero.

The Table below applies to the D2-240, D2-250-1, D2-260 and D2-262 CPU base.

| CPU Base: Analog Input Module Slot-Dependent V-memory Locations | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Slot** | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| **No. of Channels** | V7660 | V7661 | V7662 | V7663 | V7664 | V7665 | V7666 | V7667 |
| **Storage Pointer** | V7670 | V7671 | V7672 | V7673 | V7674 | V7675 | V7676 | V7677 |

The Table below applies to the D2-250-1, D2-260 or D2-262 CPU base 1.

| Expansion Base D2-CM #1: Analog Input Module Slot-Dependent V-memory Locations | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Slot** | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| **No. of Channels** | V36000 | V36001 | V36002 | V36003 | V36004 | V36005 | V36006 | V36007 |
| **Storage Pointer** | V36010 | V36011 | V36012 | V36013 | V36014 | V36015 | V36016 | V36017 |

The Table below applies to the D2-250-1, D2-260 or D2-262 CPU base 2.

| Expansion Base D2-CM #2: Analog Input Module Slot-Dependent V-memory Locations | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Slot** | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| **No. of Channels** | V36100 | V36101 | V36102 | V36103 | V36104 | V36105 | V36106 | V36107 |
| **Storage Pointer** | V36110 | V36111 | V36112 | V36113 | V36114 | V36115 | V36116 | V36117 |

The Table below applies to the D2-260 or D2-262 CPU base 3.

| Expansion Base D2-CM #3: Analog Input Module Slot-Dependent V-memory Locations | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Slot** | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| **No. of Channels** | V36200 | V36201 | V36202 | V36203 | V36204 | V36205 | V36206 | V36207 |
| **Storage Pointer** | V36210 | V36211 | V36212 | V36213 | V36214 | V36215 | V36216 | V36217 |

The Table below applies to the D2-260 or D2-262 CPU base 4.

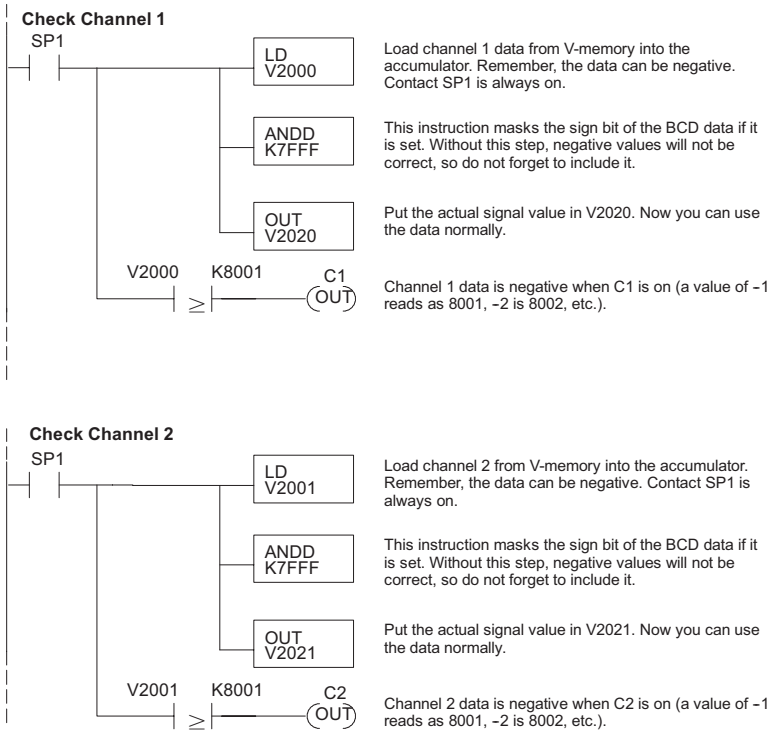
| Expansion Base D2-CM #4: Analog Input Module Slot-Dependent V-memory Locations | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Slot** | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| **No. of Channels** | V36300 | V36301 | V36302 | V36303 | V36304 | V36305 | V36306 | V36307 |
| **Storage Pointer** | V36310 | V36311 | V36312 | V36313 | V36314 | V36315 | V36316 | V36317 |

## Using Bipolar Ranges (Pointer Method) for D2-240, D2-250-1, D2-260 and D2-262 CPUs

Some additional logic is needed with bipolar ranges to determine whether the value being returned represents a positive voltage or a negative voltage. For example, the user may need to know the direction of a motor. With the D2-240, D2-250-1, D2-260, and D2-262 CPUs, the last input cannot be used to show the sign for each channel (X37 in the previous examples). This is because the pointer method reads all four channels in one scan. Therefore, if X37 were used, it would not be possible to determine if the first three channels returned negative voltage. Only the last channel can be checked to determine if it returned a negative voltage. A simple solution is to check if the returned value is greater than or equal to 8001. If it is greater than or equal to 8001 the returned value is negative.

The sign bit is the most significant bit, which combines 8000 with the data value. If the value is greater than or equal to 8001, only the most significant bit and the active channel bits will need to be masked to determine the actual data value.

The following program shows how to accomplish this. Since a negative value is always meant to be known, these rungs should be placed before any other operations that use the data, such as math instructions, scaling operations, and so forth. Also, if stage programming instructions are being used, place these rungs in a stage that is always active. Please note, this logic is only needed for each channel that is using bipolar input signals. The following example only shows two channels.

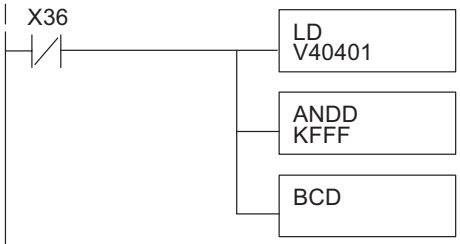


## Reading Values (Multiplexing) for D2-230, D2-240, D2-250-1, D2-260 and D2-262 CPUs

The D2-230 CPU does not have the special V-memory locations which will allow data transfer to be automatically enabled. Since all channels are multiplexed into a single data word, the control program must be setup to determine which channel is being read. Since the module appears as 16 X input points to the CPU, it is very easy to use the active channel status bits to determine which channel is being monitored.

***NOTE:*** *This example is for a module installed as shown in the previous examples. The addresses used would be different if the module is installed in a different I/O arrangement. The rungs can be placed anywhere in the program, or if stage programming is being used, place them in a stage that is always active.*

**Load Data when Module is not busy**

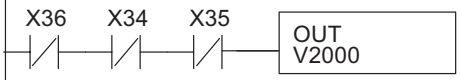



Loads the complete data word into the accumulator. The V-memory location depends on the I/O configuration. See Appendix A for the memory map.

This instruction masks the channel identification bits. Without this, the values used will not be correct so do not forget to include it.

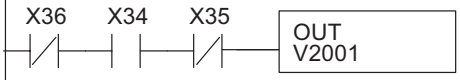
It is usually easier to perform math operations in BCD, so it is best to convert the data to BCD immediately. You can leave out this instruction if your application does not require it.

**Store Channel 1**



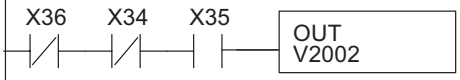

When the module is not busy and X34 and X35 are off, channel 1 data is stored in V2000.

**Store Channel 2**



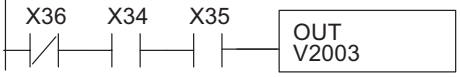

When X34 is on and X35 is off, channel 2 data is stored in V2001.

**Store Channel 3**




When X34 is off and X35 is on, channel 3 data is stored in V2002.

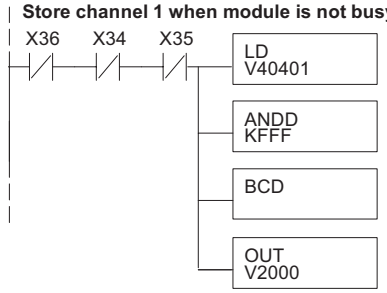
**Store Channel 4**




When both X34 and X35 are on, channel 4 data is stored in V2003.

## Single Channel Selected

The single channel program makes it easy to determine which channel has been selected.




Loads the complete data word into the accumulator. The V-memory location depends on the I/O configuration. See Appendix A for the memory map.

This instruction masks the channel identification bits. Without this, the values used will not be correct, so do not forget to include it.

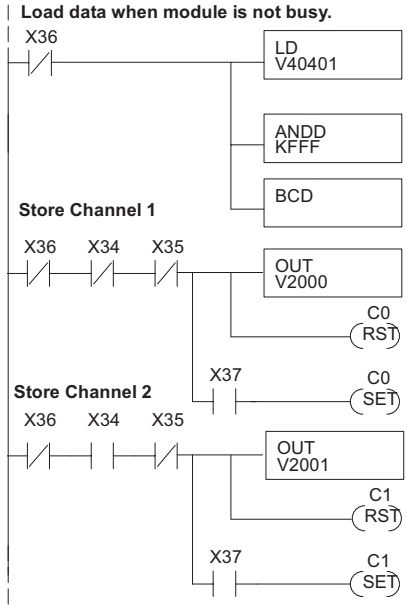
It is usually easier to perform math operations in BCD, so it is best to convert the data to BCD immediately. You can leave out this instruction if your application does not require it.

When the module is not busy and X34 and X35 are off, channel 1 data is stored in V2000.

## Using Bipolar Ranges (Multiplexing)

Some additional logic is needed with bipolar ranges to determine whether the value being returned represents a positive voltage or a negative voltage. For example, the direction of a motor may be needed to be known. Since the D2-230 only reads one channel per scan, the last input can be used to show the sign (X37 in the examples).

The following program shows how to accomplish this. Since a negative value is always needed to be known, these rungs should be placed before any other operations that use the data, such as math instructions, scaling operations, and so forth. Also, if stage programming instructions are being used, place these rungs in a stage that is always active. Please note, this logic is only needed for each channel that is using bipolar input signals. The following example only shows two channels but the rungs can be repeated for all four channels if needed.




Loads the complete data word into the accumulator. The V-memory location depends on the I/O configuration. See Appendix A for the memory map.

This instruction masks the channel identification bits. Without this, the values used will not be correct, so do not forget to include it.

It is usually easier to perform math operations in BCD, so it is best to convert the data to BCD immediately. You can leave out this instruction if your application does not require it.

When the module is not busy and X34 and X35 are off, channel 1 data is stored in V2000. C0 is reset to indicate channel one's value is positive.

If X37 is on, then the data value represents a negative voltage. C0 is set to indicate channel 1's value is negative.

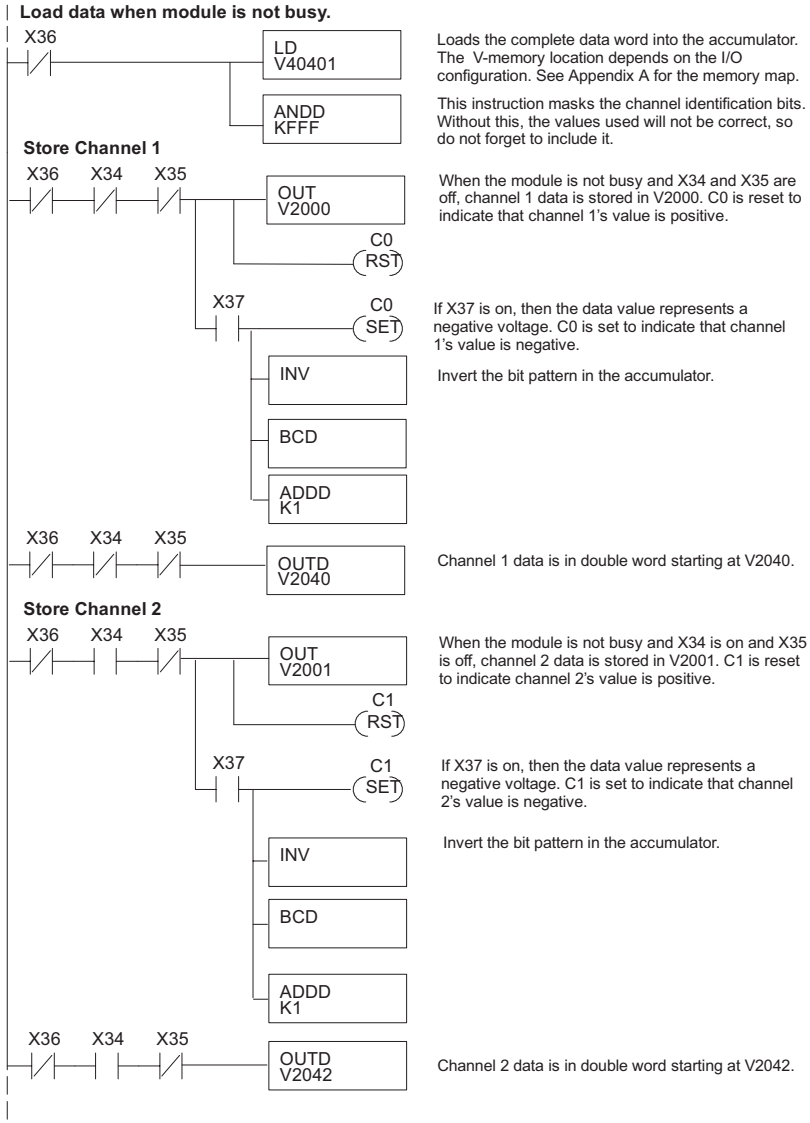
When the module is not busy, and X34 is on and X35 is off, channel 2 data is stored in V2001. C1 is reset to indicate that channel 2's value is positive.

If X37 is on, then the data value represents a negative voltage. C1 is set to indicate that channel 2's value is negative.

## Using 2's Complement (Multiplexing) for D2-230, D2-240, D2-250-1, D2-260 and D2-262 CPUs

The 2's complement data format may be required to display negative values on some operator interface devices. It could also be used to simplify data averaging on bipolar signals.

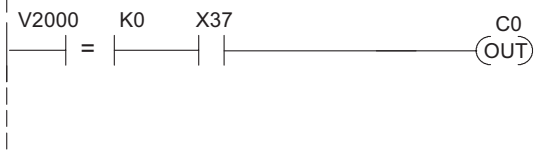
The example shows two channels, but these steps can be repeated for all four channels if necessary.



## Analog Power Failure Detection

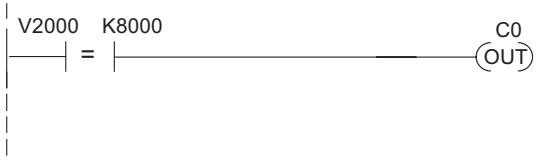
The analog module has a microcontroller which can diagnose analog input circuit problems. A ladder rung can be added to program to detect these problems. This rung shows an input point that would be assigned if the module was used as shown in the previous examples. A different point would be used if the module was installed in a different I/O configuration.

Multiplexing method




V-memory location V2000 holds channel 1 data. When a data value of zero is returned and input X37 is on, then the analog circuitry is not operating properly.

Pointers method




V-memory location V2000 holds channel 1 data. When a data value of 8000 is returned, then the analog circuitry is not operating properly.

## Scaling the Input Data

Most applications usually require measurements in engineering units which provides more meaningful data. This is accomplished by using the conversion formula shown.

$$\text{Units} = A \frac{H - L}{4095}$$

U = Engineering Units

A = Analog Value (0 – 4095)

H = High limit of the engineering unit range

L = Low limit of the engineering unit range

Adjustments may be needed to the formula depending on the scale being used for the engineering units.

For example, if pressure (psi) is to be measured from 0.0–99.9 then multiply the value by 10 in order to imply a decimal place when viewing the value with the programming software or with a handheld programmer. Notice how the calculations differ when the multiplier is used.

An analog value of 2024, slightly less than half scale, should yield 49.4 psi.

**Example without multiplier**

$$\text{Units} = A \frac{H - L}{4095}$$

$$\text{Units} = 2024 \frac{100 - 0}{4095}$$

$$\text{Units} = 49$$

**Example with multiplier**

$$\text{Units} = 10A \frac{H - L}{4095}$$

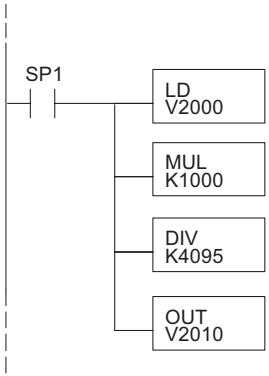
$$\text{Units} = 20240 \frac{100 - 0}{4095}$$

$$\text{Units} = 494$$

## The Conversion Program

The following example shows how to write the program to perform the engineering unit conversion from input data formats 0–4095. This example assumes the raw input data read at V2000 is in BCD format.

***NOTE:*** *This example uses SP1, which is always on, but any permissive contact such as, X, C, etc., can be used.*




When SP1 is on, load channel 1 data to the accumulator.

Multiply the accumulator by 1000 (to start the conversion).

Divide the accumulator by 4095.

Store the result in V2010.

## Analog and Digital Value Conversions

Sometimes it is useful to be able to quickly convert between the signal levels and the digital values. This is especially helpful during machine startup or troubleshooting. Remember, that this module does not operate like other versions of analog input modules. The bipolar ranges use 0–4095 for both positive and negative voltages. The sign bit allows this, which actually provides better resolution than those modules that do not offer a sign bit. The following table provides formulas to make this conversion easier.

| *Range* | *If the digital value is known* | *If the analog signal level is known.* |
|---|---|---|
| **0–5V**<br>**–5V to +5V** | $A = \frac{5D}{4095}$ | $D = \frac{4095\ (A)}{5}$ |
| **0–0V**<br>**–10V to +10V** | $A = \frac{5D}{4095}$ | $D = \frac{4095\ ABS(A)}{10}$ |

As an example, if the range being used is ±10V and the measured signal is 6V, use the formula to the right to determine the digital value that is stored in the V-memory location that contains the data.

$$D = \frac{4095\ (A)}{10}$$

$$D = \frac{4095\ (6V)}{10}$$

$$D = (409.5)\ (6)$$

$$D = 2457$$

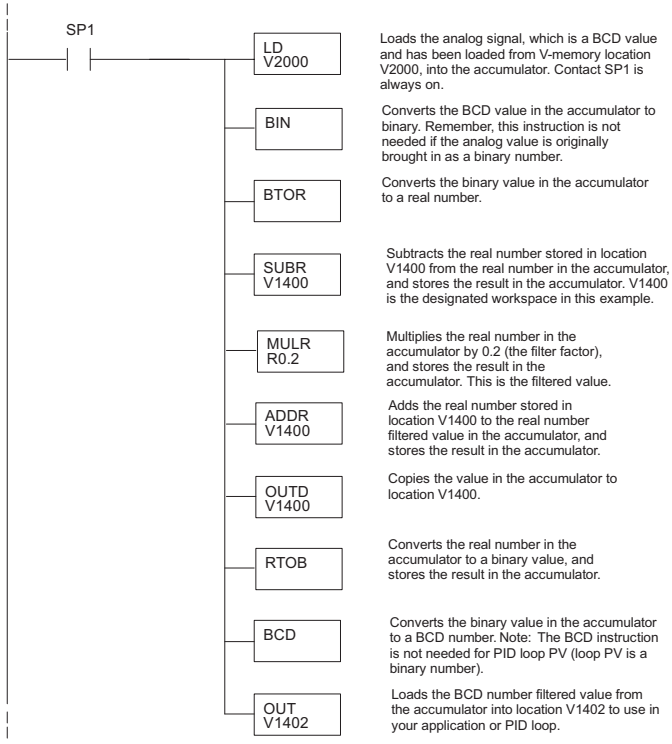
## Filtering Input Noise for D2-250-1, D2-260 and D2-262 CPUs

Add the following logic to filter and smooth analog input noise in D2-250-1, D2-260 and D2-262 CPUs. This is especially useful when using PID loops. Noise can be generated by the field device and or induced by field wiring.

In the following example, the analog value in BCD is first converted to a binary number. Memory location V1400 is the designated work space in this example. The MULR instruction is the filter factor, which can be from 0.1–0.9. The example uses 0.2. Using a smaller filter factor increases filtering. A higher precision value can be used, but it is not generally needed. The filtered value is then converted back to binary and then to BCD. The filtered value is stored in location V1402 for use in your application or PID loop.

***NOTE:*** *Please review intelligent instructions (IBox) in Chapter 5 of D2-USER-M, which simplify this and other functions. The IBox instructions are supported by the D2-250-1, D2-260 and D2-262.*

***NOTE:*** *Be careful not to do a multiple number conversion on a value. For example, if you are using the pointer method to get the analog value, it is in BCD and must be converted to binary. However, if you are using the conventional method of reading analog and are masking the first twelve bits, then it is already in binary and no conversion using the BIN instruction is needed.*



# F2-08AD-1, 8-Channel Analog Current Input

## In This Chapter...

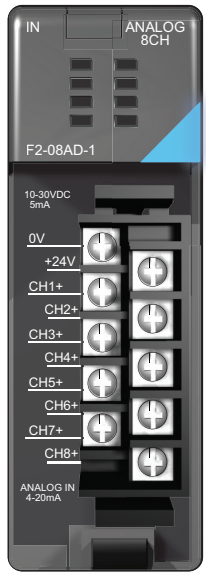
Module Specifications ..... 4-2
Setting the Module Jumpers ..... 4-5
Connecting the Field Wiring ..... 4-6
Module Operation ..... 4-9
Writing the Control Program ..... 4-13

# Module Specifications

*NOTE: A re-designed F2-08AD-1 with a single circuit board design was released in 2009. The jumper link location is different. See Setting the Module Jumpers on page 4-6. Also, some specifications were changed on page 4-3. Otherwise, the re-designed module functions the same as the prior design.*

The F2-08AD-1 Analog Input module provides several hardware features:

- Analog inputs are optically isolated from the PLC logic.
- On-board 250 ohm, 1/2 Watt precision resistors provide substantial over-current-protection for 4-20mA current loops.
- The module has a removable terminal block so the module can be easily removed or changed without disconnecting the wiring.
- With a D2-240, D2-250-1, D2-260 or D2-262 CPU, you can read all channels in one scan.



F2-08AD-1

## Firmware Requirements:

To use this module with a D2-230 CPU the CPU must have firmware version 1.6 or later. To use the pointer method of writing values, D2-240 CPUs require firmware version 2.2 or later. All versions of the D2-250-1, D2-260 and D2-262 CPU's firmware support this module and the pointer method.

## Analog Input Configuration Requirements

The F2-08AD-1 appears as a 16-point discrete input module and can be installed in any slot of a DL205 system. The available power budget and discrete I/O points are the limiting factors. For more information regarding power budget and number of local, local expansion or remote I/O points, check the user manual for the particular CPU model and I/O base being used

The following tables provide the specifications for the F2-08AD-1 Analog Input Module. Review these specifications to make sure the module meets your application requirements.

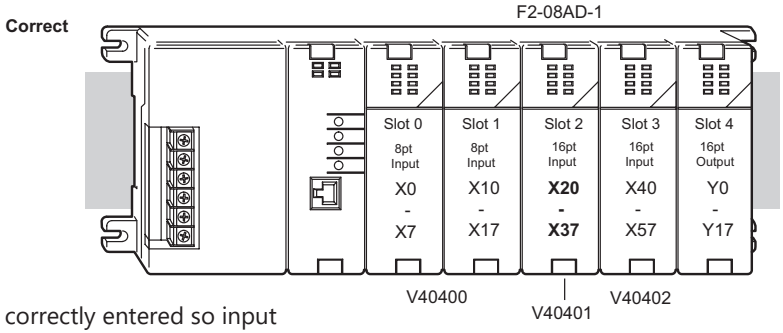
| Input Specifications | |
|---|---|
| ***Number of Channels*** | 8, single ended (one common) |
| ***Input Range*** | 4–20 mA, current |
| ***Resolution*** | 12 bit (1 in 4096) |
| ***Step Response*** | 1ms (*7ms) to 95% of full step change |
| ***Crosstalk*** | -70db, 1 count maximum |
| ***Active Low-pass Filtering*** | -3db at 200Hz, (-6db per octave) |
| ***Input Impedance*** | 250MΩ ±0.1%, 1/2 W current input |
| ***Absolute Maximum Ratings*** | -45mA to + 45mA, current input |
| ***Linearity Error (End to End)*** | ± 1 count (0.025% of full scale) maximum |
| ***Input Stability*** | ± 1 count |
| ***Full Scale Calibration Error (Offset error included)*** | ± 5 counts maximum @ 20.000 mA |
| ***Offset Calibration Error*** | ± 2 count maximum @ 4.000 mA |
| ***Maximum Inaccuracy*** | ± 0.1% @ 25°C (77°F)<br>± 0.25% 0–60°C (32–140°F) |
| ***Accuracy vs. Temperature*** | ± 50ppm / °C full scale calibration change (including maximum offset change) |
| ***Recommended Fuse (external)*** | 0.032 A, Series 217 fast-acting, current inputs |

| General Specifications | |
|---|---|
| ***PLC Update Rate*** | 1 channel per scan maximum (D2-230 CPU)<br>8 channels per scan maximum (D2-240, D2-250-1, D2-260 and D2-262 CPU) |
| ***Data Acquisition Time*** | 3ms / channel (asynchronous) |
| ***Digital Inputs***<br>***Input points required*** | 12 binary data bits, 3 channel ID bits, 1 broken transmitter detection bit<br>16 point (X) input module |
| ***Power Budget Requirement*** | 100mA (*50mA maximum, 5VDC (supplied by base) |
| ***External Power Supply*** | 5mA maximum, 10–30 VDC (*80mA max, 18–26.4 VDC) |
| ***Operating Temperature*** | 0°C to 60°C (32°F to 140° F) |
| ***Storage Temperature*** | -20°C to 70°C (-4°F to 158°F) |
| ***Relative Humidity*** | 5–95% (non-condensing) |
| ***Environmental Air*** | No corrosive gases permitted |
| ***Vibration*** | MIL STD 810C 514.2 |
| ***Shock*** | MIL STD 810C 516.2 |
| ***Noise Immunity*** | NEMA ICS3-304 |

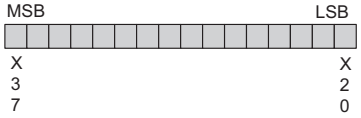
*NOTE: Values in parenthesis with an **asterisk** are for older modules with two circuit board design and date codes 0609B5 or previous. Values not in parenthesis are for single circuit board models with date code 0709C1 or above.*

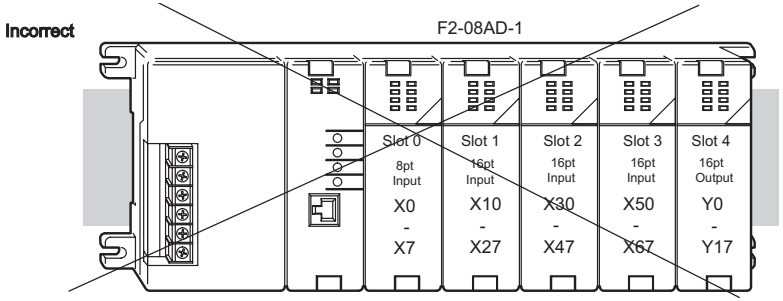
## Special Placement Requirements (D2-230 and Remote I/O Bases)

Even though the module can be placed in any slot, it is important to examine the configuration if a D2-230 CPU is used, as can be seen in the section about Writing the Program located in this chapter. V-memory locations are used to extract the analog data. If the module is placed so the input points do not start on a V-memory boundary, the instructions cannot access the data. This also applies when placing this module in a remote base using a D2-RSSS in the CPU slot.

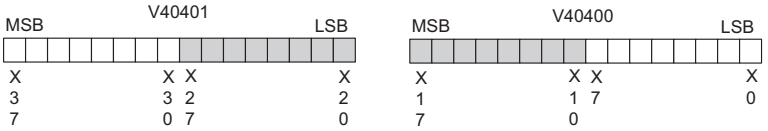



Data is correctly entered so input points start on a V-memory boundary.




Data is split over two locations, so instructions cannot access data from a D2-230.




To use the V-memory references required for a D2-230 CPU, the first input address assigned to the module must be one of the following X locations. The table also shows the V-memory addresses that correspond to these X locations.

| ***X*** | X0 | X20 | X40 | X60 | X100 | X120 | X140 | X160 |
|---|---|---|---|---|---|---|---|---|
| ***V*** | V40400 | V40401 | V40402 | V40403 | V40404 | V40405 | V40406 | V40407 |

# Setting the Module Jumpers

## Selecting the Number of Channels

There are two jumpers, labeled +1, +2, and +4 which are used to select the number of channels that will be used. Use the figures below to locate the jumpers on the module. The module is set from the factory for eight channel operation (all three jumpers installed).

The unused channels are not processed, so if only channels 1 thru 3 are selected, channels 4 through 8 will not be active. The following table shows how to use the jumpers to select the number of channels.

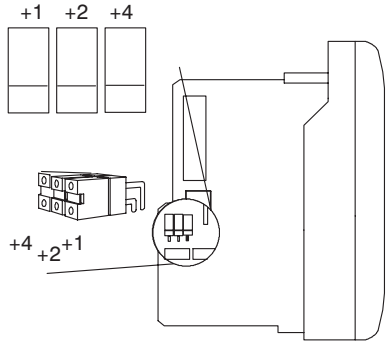
| *No. of Channels* | *+1* | *+2* | *+4* |
|---|---|---|---|
| 1 | No | No | No |
| 1, 2 | Yes | No | No |
| 1, 2, 3 | No | Yes | No |
| 1, 2, 3, 4 | Yes | Yes | No |
| 1, 2, 3, 4, 5 | No | No | Yes |
| 1, 2, 3, 4, 5, 6 | Yes | No | Yes |
| 1, 2, 3, 4, 5, 6, 7 | No | Yes | Yes |
| 1, 2, 3, 4, 5, 6, 7, 8 | Yes | Yes | Yes |

For example, to select all 8-channel operation, leave three jumpers installed. To select channel 1, remove (or store on a single post to prevent losing them) all three jumpers

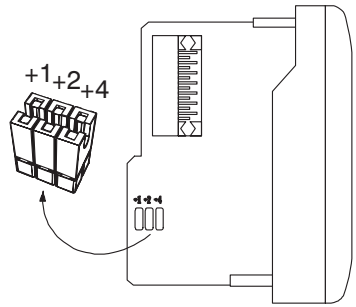
Yes = jumper installed

No = jumper removed

**Jumper location on modules having date code 0609B9 and previous (two circuit board design)**




**Jumper location on modules having date code 0709C1 and above (single circuit board design)**




These jumpers are located on the motherboard, the one with the black D-shell style backplane connector.

# Connecting the Field Wiring

## Wiring Guidelines

Your company may have guidelines for wiring and cable installation. If so, check them before starting the installation. Here are some general things to consider:

- Use the shortest wiring route whenever possible.
- Use shielded wiring and ground the shield at the transmitter source. Do not ground the shield at both the module and the source.
- Do not run the signal wiring next to large motors, high current switches, or transformers. This may cause noise problems.
- Route the wiring through an approved cable housing to minimize the risk of accidental damage. Check local and national codes to choose the correct method for your application.

## User Power Supply Requirements

The F2-08AD-1 module requires at least one field-side power supply. The same or separate power sources can be used for the module supply and the current transmitter supply. The module requires 10–30 VDC, at 5mA, from the external power supply.

The DL205 AC bases have a built-in 24VDC power supply that provide up to 300mA of current. This can be used instead of a separate supply. Check the power budget to be safe.

It is desirable in some situations to power the transmitters separately in a location remote from the PLC. This will work as long as the transmitter supply meets the voltage and current requirements, and the transmitter and module supply minus (-) side are connected together.

**WARNING: If using the 24VDC base power supply, make sure to calculate the power budget. Exceeding the power budget can cause unpredictable system operation that can lead to a risk of personal injury or damage to equipment.**

**The DL205 base has a switching type power supply. As a result of switching noise, ±3–5 counts of instability may be noticed in the analog input data if the base power supply is used. If this is unacceptable, try one of the following:**

1. Use a separate linear power supply.
2. Connect the 24VDC common to the frame ground, which is the screw terminal marked on the screw terminal marked "G" on the base.

By using these methods, the input stability is rated at ±1 count.

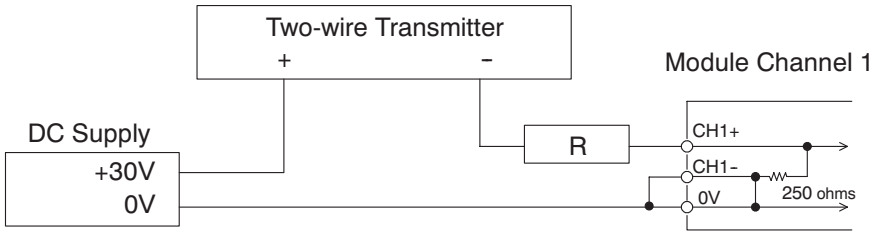
## Current Loop Transmitter Impedance

Standard 4–20 mA transmitters and transducers can operate from a wide variety of power supplies. Not all transmitters are alike and the manufacturers often specify a minimum loop or load resistance that must be used with the transmitter.

The F2-08AD-1 provides 250Ω resistance for each channel. If the transmitter being used requires a load resistance below 250Ω, it will not be necessary to make any adjustments. However, if the transmitter requires a load resistance higher than 250Ω, a resistor will need to be added in series with the input.

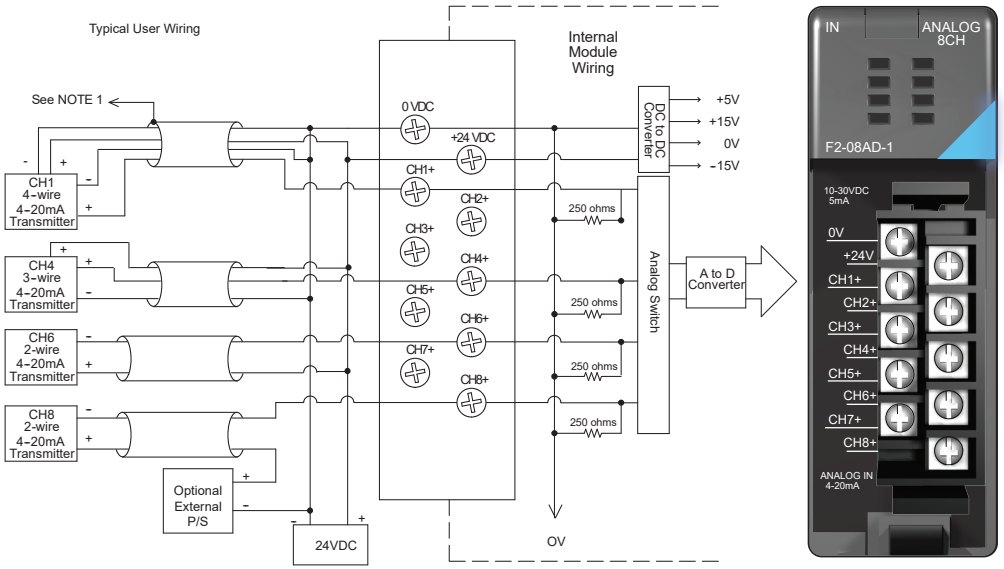
Consider the following example for a transmitter being operated from a 30VDC supply with a recommended load resistance of 750Ω. Since the module has a 250Ω resistor, an additional resistor needs to be added.

| | |
|---|---|
| R = Tr - Mr | R - Resistor to add |
| R = 750–250 | Tr - Transmitter Requirement |
| R ≥ 500 | Mr - Module resistance (internal 250Ω) |



## Wiring Diagram

The F2-08AD-1 module has a removable connector to simplify wiring the module. Just squeeze the top and bottom retaining clips and gently pull the connector from the module. Use the following diagram to connect the field wiring.




***NOTE 1:*** *Shields should be grounded at the signal source.*
***NOTE 2:*** *More than one external power supply can be used, provided all the power supply commons are connected.*
***NOTE 3:*** *A Series 217, 0.032A fast-acting fuse is recommended for 4-20 mA current loops.*
***NOTE 4:*** *If the power supply common of an external power supply is not connected to 0 VDC on the module, then the output of the external transmitter must be isolated. To avoid "ground loop" errors, recommended 4-20 mA transmitter types are:*

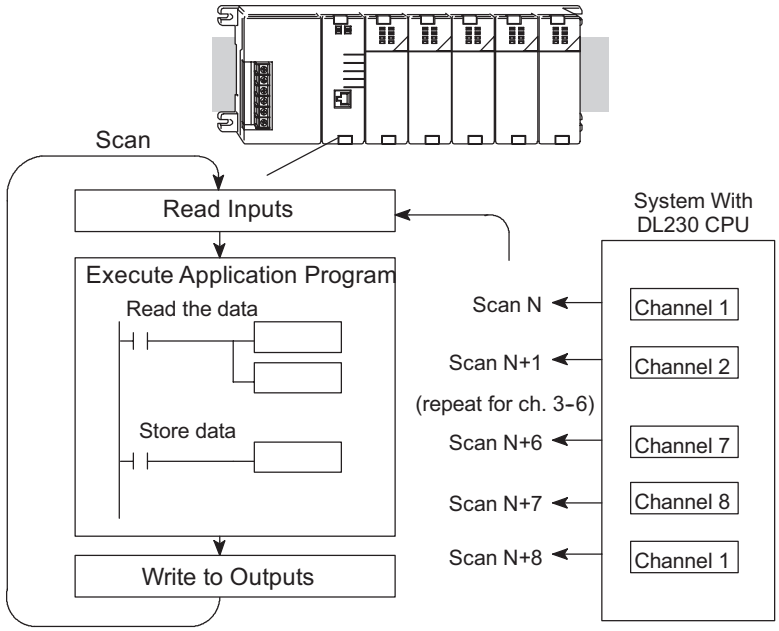
*2 or 3 wire: Isolation between input signal and power supply.*
*4 wire: Isolation between input signal, power supply, and 4-20 mA output.*

# Module Operation

## Channel Scanning Sequence (Multiplexing) for a D2-230 CPU

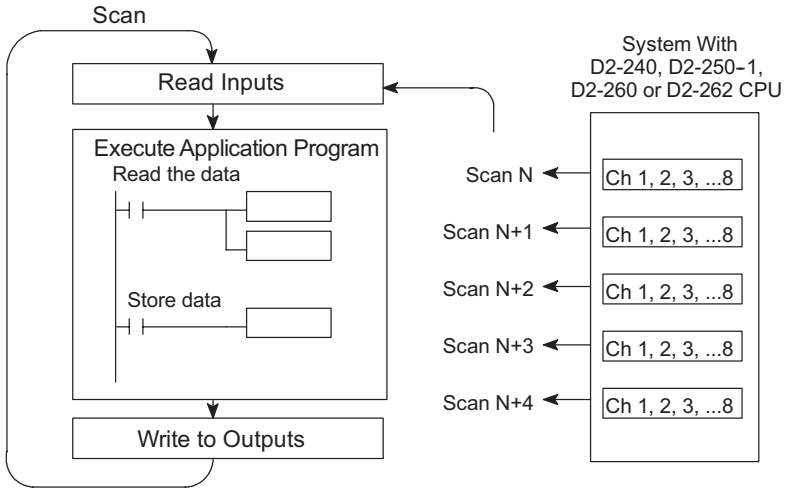
Before beginning to write the control program, it is important to take a few minutes to understand how the module processes and represents the analog signals.

The F2-08AD-1 can supply different amounts of data per scan, depending on the type of CPU being used. The D2-230 can obtain one channel of data per CPU scan. Since there are eight channels, it can take up to eight scans to get data for all channels. Once all channels have been scanned the process starts over with channel 1. Unused channels are not processed, so if only two channels are selected, then each channel will be updated every other scan. The multiplexing method can also be used for the D2-240, D2-250-1, D2-260 and D2-262 CPUs.



## Channel Scanning Sequence (Pointer method) for D2-240, D2-250-1, D2-260 or D2-262 CPUs

If a D2-240, D2-250-1, D2-260 or a D2-262 CPU is used, all four channels of input data can be collected in one scan. This is because the D2-240, D2-250-1, D2-260 and D2-262 CPUs supports special V-memory locations that are used to manage the data transfer. This is discussed in more detail in the section on Writing the Control Program later in this chapter.




## Analog Module Updates

Even though the channel updates to the CPU are synchronous with the CPU scan, the module asynchronously monitors the analog transmitter signal and converts the signal to a 12-bit binary representation. This enables the module to continuously provide accurate measurements without slowing down the discrete control logic in the RLL program.

For the vast majority of applications, the values are updated much faster than the signal changes. However, in some applications, the update time can be important. The module takes approximately one millisecond to sense 95% of the change in the analog signal.

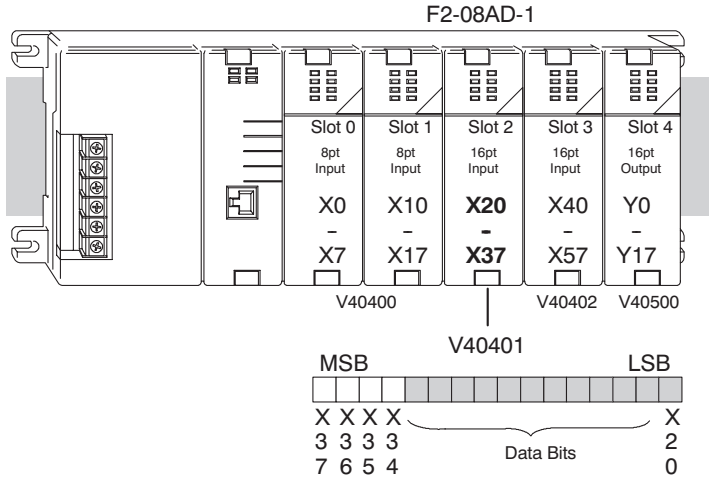
*NOTE: This is not the amount of time required to convert the signal to a digital representation. The conversion to the digital representation takes only a few microseconds. Many manufacturers list the conversion time, but it is the settling time of the filter that really determines the update time.*

## Understanding the Input Assignments

It was mentioned earlier in this chapter that the F2-08AD-1 module appears as a 16-point discrete input module to the CPU. These points can be used to obtain:

- An indication of which channel is active
- The digital representation of the analog signal
- Module diagnostic information

Since all input points are automatically mapped into V-memory, it is very easy to determine the location of the data word that will be assigned to the module.

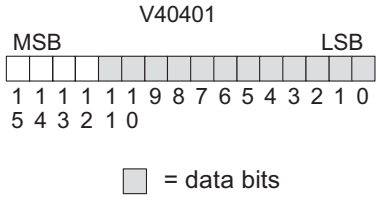



Within these word locations, the individual bits represent specific information about the analog signal.

## Analog Data Bits

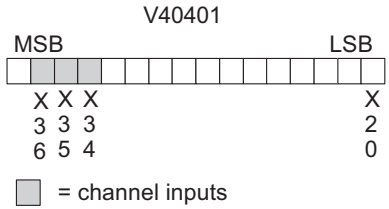
The first twelve bits represent the analog data in binary format.

| Bit | Value | Bit | Value |
|---|---|---|---|
| 0 | 1 | 6 | 64 |
| 1 | 2 | 7 | 128 |
| 2 | 4 | 8 | 256 |
| 3 | 8 | 9 | 512 |
| 4 | 16 | 10 | 1024 |
| 5 | 32 | 11 | 2048 |



## Active Channel Indicator Inputs

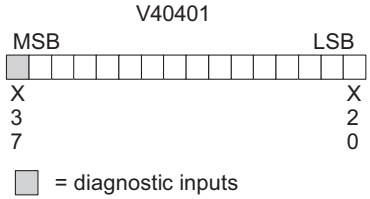
Three of the inputs are binary-encoded to indicate the active channel (remember, the V-memory bits are mapped directly to discrete inputs). The inputs are automatically turned on and off to indicate the active channel for each scan.




| Scan | X34 | X35 | X36 | Channel |
|---|---|---|---|---|
| N | Off | Off | Off | 1 |
| N+1 | On | Off | Off | 2 |
| N+2 | Off | On | Off | 3 |
| N+3 | On | On | Off | 4 |
| N+4 | Off | Off | On | 5 |
| N+5 | On | Off | On | 6 |
| N+6 | Off | On | On | 7 |
| N+7 | On | On | On | 8 |

## Module Diagnostic Inputs

The last input (X37 in this example) is the broken transmitter and missing 24 volts input power indicator.

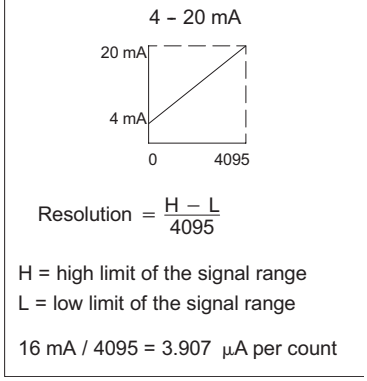



When X37 is on, the input transmitter may be broken for the corresponding input. If there is no external 24 volts input power, or if there is a loose or missing terminal block, then X37 goes on and a value of zero is returned for all enabled channels.

## Module Resolution

Since the module has 12-bit resolution, the analog signal is converted into 4096 counts ranging from 0 - 4095 (212). For example, a 4 mA signal would be 0 and a 20 mA signal would be 4095. This is equivalent to a binary value of 0000 0000 0000 to 1111 1111 1111, or 000 to FFF hexadecimal. The diagram shows how this relates to the signal range.

Each count can also be expressed in terms of the signal level by using the equation shown.



# Writing the Control Program

## Reading Values: Pointer Method and Multiplexing

There are two methods which can be used to read values:

- Pointer method
- Multiplexing

The multiplexing method must be used when using a D2-230 CPU. The multiplexing method must also be used with remote I/O modules (the pointer method will not work). Either method can be used with the D2-240, D2-250-1, D2-260 and D2-262 CPUs, but for ease of programming it is strongly recommended to use the pointer method.

## Pointer Method for D2-240, D2-250-1, D2-260 and D2-262 CPUs

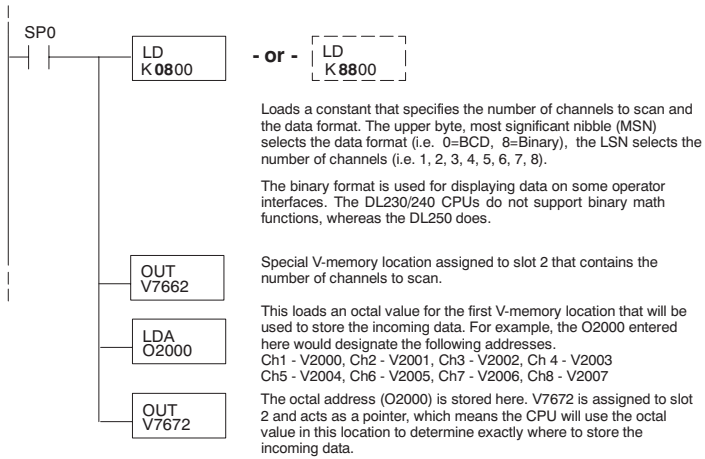
The DL205 series has special V-memory locations (shown in tables on the following page) assigned to each base slot that will greatly simplify the programming requirements. These V-memory locations allow you to:

- Specify the data format
- Specify the number of channels to scan
- Specify the storage locations

*NOTE: D2-240 CPUs with firmware release version 2.2 or later support this method. Also, D2-250 CPUs with firmware release version 1.06 or later support this method. If the D2-230 example needs to be used, module placement in the base is very important. Review the section earlier in this chapter for guidelines.*

The example program shows how to setup these locations. Place this rung anywhere in the ladder program, or, if RLLPLUS instructions are being used, in the Initial Stage.

This is all that is required to read the analog data into V-memory locations. Once the data is in V-memory, it can be used to perform math, compare the data against preset values, etc. V2000 is used in the example but any user V-memory location can be used. The pointer method automatically converts values to BCD.



The tables below show the special V-memory locations used by the D2-240, D2-250-1, D2-260 and D2-262 for the CPU base and local expansion base I/O slots. Slot 0 (zero) is the module next to the CPU or the D2-CM module. Slot 1 is the module two places from the CPU or the D2-CM, and so on. Remember, the CPU only examines the pointer values at these locations after a mode transition. Also, if the D2-230 (multiplexing) method is used, verify that these addresses in the CPU are zero.

The table below applies to the D2-240, D2-250-1, D2-260 and D2-262 CPU base.

| CPU Base: Analog Input Module Slot-Dependent V-memory Locations | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| *Slot* | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| *No. of Channels* | V7660 | V7661 | V7662 | V7663 | V7664 | V7665 | V7666 | V7667 |
| *Storage Pointer* | V7670 | V7671 | V7672 | V7673 | V7674 | V7675 | V7676 | V7677 |

The table below applies to the D2-250-1, D2-260 or the D2-262 expansion base 1.

| Expansion Base D2-CM #1: Analog Input Module Slot-Dependent V-memory Locations | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| *Slot* | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| *No. of Channels* | V36000 | V36001 | V36002 | V36003 | V36004 | V36005 | V36006 | V36007 |
| *Storage Pointer* | V36010 | V36011 | V36012 | V36013 | V36014 | V36015 | V36016 | V36017 |

The table below applies to the D2-250-1, D2-260 or the D2-262 expansion base 2.

| Expansion Base D2-CM #2: Analog Input Module Slot-Dependent V-memory Locations | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| *Slot* | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| *No. of Channels* | V36100 | V36101 | V36102 | V36103 | V36104 | V36105 | V36106 | V36107 |
| *Storage Pointer* | V36110 | V36111 | V36112 | V36113 | V36114 | V36115 | V36116 | V36117 |

The table below applies to the D2-260 and D2-262 CPU expansion base 3.

| Expansion Base D2-CM #3: Analog Input Module Slot-Dependent V-memory Locations | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| *Slot* | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| *No. of Channels* | V36200 | V36201 | V36202 | V36203 | V36204 | V36205 | V36206 | V36207 |
| *Storage Pointer* | V36210 | V36211 | V36212 | V36213 | V36214 | V36215 | V36216 | V36217 |

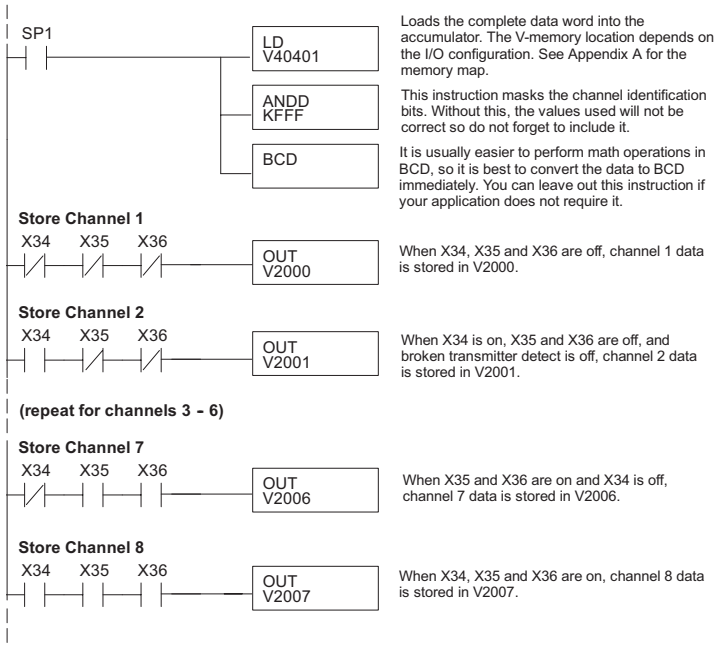
The table below applies to the D2-260 and D2-262 CPU expansion base 4.

| Expansion Base D2-CM #4: Analog Input Module Slot-Dependent V-memory Locations | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| *Slot* | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| *No. of Channels* | V36300 | V36301 | V36302 | V36303 | V36304 | V36305 | V36306 | V36307 |
| *Storage Pointer* | V36310 | V36311 | V36312 | V36313 | V36314 | V36315 | V36316 | V36317 |

## Reading Values (Multiplexing) for D2-230, D2-240, D2-250-1, D2-260 and D2-262 CPUs

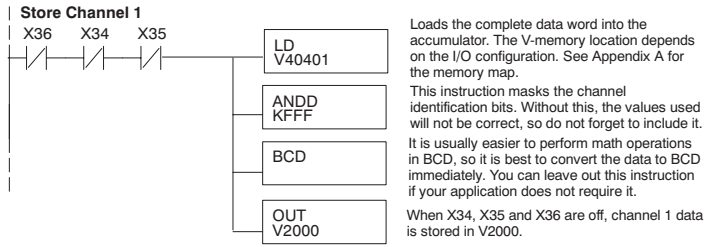
The D2-230 CPU does not have the special V-memory locations which will allow data transfer to be automatically enabled. Since all channels are multiplexed into a single data word, the control program must be setup to determine which channel is being read. Since the module appears as X input points to the CPU, it is very easy to use the active channel status bits to determine which channel is being monitored.

*NOTE: This example is for a module installed as shown in the previous examples. The addresses used would be different if the module was installed in a different I/O arrangement. The rungs can be placed anywhere in the program, or if stage programming is being used, place them in a stage that is always active.*




## Single Channel Selected

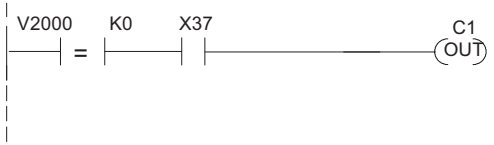
Since it isn't necessary to know which channel is selected, the single channel program is even more simple as shown in the example below.



## Analog Power Failure Detection

The Analog module has an on-board processor that can diagnose analog input circuit problems. A ladder rung can be edited to detect these problems. This rung shows an input point that would be assigned if the module was installed as shown in the previous examples. A different point would be used if the module was installed in a different I/O arrangement.

Multiplexing method




V-memory location V2000 holds channel 1 data. When a data value of zero is returned and input X37 is on, then the analog circuitry is not operating properly.

Pointers method

V-memory location V2000 holds channel 1 data. When a data value of 8000 is returned, then the analog circuitry is not operating properly.

## Scaling the Input Data

Most applications usually require measurements in engineering units which provides more meaningful data. This is accomplished by using the conversion formula shown.

$$\text{Units} = A \frac{H - L}{4095}$$

U = Engineering Units

A = Analog Value (0 – 4095)

H = High limit of the engineering unit range

L = Low limit of the engineering unit range

Adjustments to the formula may be needed depending on the scale being used for the engineering units.

For example, if pressure (psi) is to be measured from 0.0 to 99.9 then multiply the value by 10 in order to imply a decimal place when viewing the value with the programming software or with a handheld programmer. Notice how the calculations differ when the multiplier is used.

Analog Value of 2024, slightly less than half scale, should yield 49.4 psi.

**Example without multiplier**

$$\text{Units} = A \frac{H - L}{4095}$$

$$\text{Units} = 2024 \frac{100 - 0}{4095}$$

Units = 49

**Example with multiplier**

$$\text{Units} = 10A \frac{H - L}{4095}$$

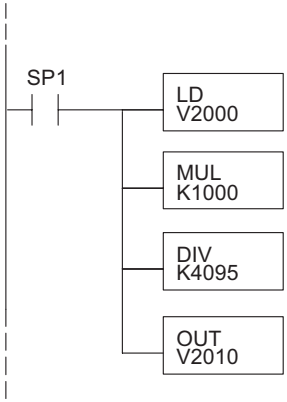
$$\text{Units} = 20240 \frac{100 - 0}{4095}$$

Units = 494

## The Conversion Program

The following example shows how to write the program to perform the engineering unit conversion. This example assumes that the data is in BCD and loaded into the appropriate V-memory locations using instructions that apply to the CPU being used in the PLC.

*NOTE: This example uses SP1, which is always on, but any permissive contact such as, X, C, etc., can be used.*




When SP1 is on, load channel 1 data to the accumulator.

Multiply the accumulator by 1000 (to start the conversion).

Divide the accumulator by 4095.

Store the result in V2010.

## Analog and Digital Value Conversions

Sometimes it is useful to be able to quickly convert between the signal levels and the digital values. This is especially helpful during machine startup or troubleshooting. The following table provides formulas to make this conversion more simple.

| Range | If the digital value is known | If the analog signal level is known. |
|---|---|---|
| 4 to 20 mA | $A = \frac{16D + 4}{4095}$ | $D = \frac{4095\ (A - 4)}{16}$ |

As an example, if the measured signal is 10mA, the formula can be used to easily determine the digital value that will be stored in the V-memory location that contains the data.

$$D = \frac{4095}{10}(A)$$

$$D = \frac{4095}{10}(6V)$$

$$D = (409.5)(6)$$

$$D = 2457$$

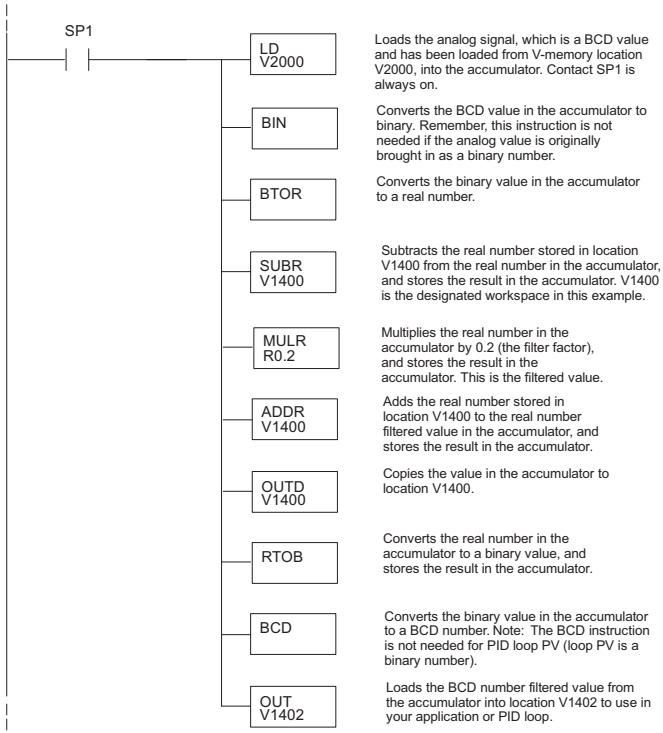
## Filtering Input Noise for D2-250-1, D2-260 and D2-262 CPUs

Add the following logic to filter and smooth analog input noise in D2-250-1, D2-260 and D2-262 CPUs. This is especially useful when using PID loops. Noise can be generated by the field device and/or induced by field wiring.

In the following example, the analog value in BCD is first converted to a binary number. Memory location V1400 is the designated work space in this example. The MULR instruction is the filter factor, which can be from 0.1 to 0.9. The example uses 0.2. A smaller filter factor increases filtering. A higher precision value can be used, but it is not generally needed. The filtered value is then converted back to binary and then to BCD. The filtered value is stored in location V1402 for use in your application or PID loop.

*NOTE: Please review intelligent instructions (IBox) in Chapter 5 of D2-USER-M, which simplify this and other functions. The IBox instructions are supported by the D2-250-1, D2-260 and D2-262.*

***NOTE:*** *Be careful not to do a multiple number conversion on a value. For example, if the pointer method is used to get the analog value, it is in BCD and must be converted to binary. However, if the conventional method of reading analog is used and the first twelve bits are masked, then it is already in binary and no conversion using the BIN instruction is needed.*



# F2-08AD-2 8-Channel Analog Voltage Input

In This Chapter...

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# Module Specifications

***NOTE**: A re-designed F2-08AD-2 with a single circuit board design was released in 2009. The jumper link location is different. See Setting the Module Jumpers on pages 5-5 and 5-6. Also, some specifications were changed on page 5-3. Otherwise, the re-designed module functions the same as the prior design.*

The F2-08AD-2 Analog Voltage Input module provides several hardware features:

- Analog inputs are optically isolated from the PLC logic.
- The module has a removable terminal block so the module can be easily removed or changed without disconnecting the wiring.
- With a D2-240, D2-250-1, D2-260 or D2-262 CPU, all channels can be updated in one scan.

**F2-08AD-2**

## Firmware Requirements:

To use this module, D2-230 CPUs must have firmware version 1.6 or later. To use the pointer method of writing values, D2-240 CPUs require firmware version 2.2 or later. All versions of the D2-250-1 and D2-260 CPU's firmware support this module and the pointer method.

## Analog Input Configuration Requirements

The F2-08AD-2 Analog Input requires 16 discrete input points. The module can be installed in any slot of a DL205 system. The available power budget and discrete I/O points are the limiting factors. Check the user manual for the CPU model and I/O base being used for more information regarding power budget and number of local, local expansion or remote I/O points.

The following tables provide the specifications for the F2–08AD–2 Analog Input Module. Review these specifications to make sure the module meets your application requirements.

| Input Specifications | |
|---|---|
| ***Number of Channels*** | 8, single ended (one common) |
| ***Input Ranges*** | 0–5 V, 0–10 V, ±5V, ±10V |
| ***Resolution*** | 12 bit (1 in 4096) unipolar (0 – 4095)<br>13 bit (1 in 8192) bipolar (– 4095 – +4095) |
| ***Step Response*** | 1.0 ms (* 4 ms) – 95% of full step change |
| ***Crosstalk*** | –70dB, 1 count maximum |
| ***Active Low-pass Filtering*** | –3 dB @ 200Hz (– 6dB per octave) |
| ***Input Impedance*** | Greater than 20MΩ |
| ***Maximum Continuous Overload*** | ±75VDC |
| ***Linearity Error (End to End)*** | ±0.025% of span (±1 count maximum unipolar)<br>(±2 count maximum bipolar) |
| ***Input Stability*** | ±1 count |
| ***Full Scale Calibration Error (Offset error not included)*** | ±3 counts maximum |
| ***Offset Calibration Error*** | ±1 count maximum, @ 0VDC |
| ***Maximum Inaccuracy*** | ±0.1% @ 25°C<br>±0.3% 0–60°C (32–140°F) |
| ***Accuracy vs. Temperature*** | ±50ppm/°C maximum full scale calibration<br>(Including maximum offset change of 2 counts) |

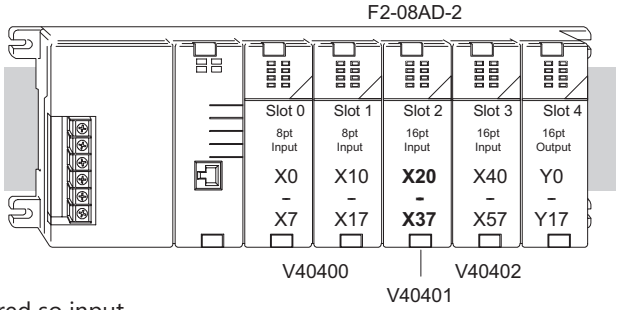
| General Specifications | |
|---|---|
| ***PLC Update Rate*** | 1 channel per scan maximum (D2-230 CPU)<br>8 channels per scan maximum<br>(D2-240, D2-250 – 1, D2-260 or D2-262 CPU) |
| ***Data Acquisition Time*** | 3ms / channel (asynchronous) |
| ***Digital Inputs Input points required*** | 12 binary data bits, 1 sign bit 3 channel ID bits,<br>1 diagnostic bit<br>16 point (X) input module |
| ***Power Budget Requirement*** | 100mA (* 60mA) maximum, 5VDC (supplied by base) |
| ***External Power Supply*** | 5mA, 10–30 VDC (*80mA, 18-26.4 VDC) |
| ***Operating Temperature*** | 0°C–60°C (32°F to 140°F) |
| ***Storage Temperature*** | -20°C to 70°C (-4°F to 158°F) |
| ***Relative Humidity*** | 5–95% (non-condensing) |
| ***Environmental air*** | No corrosive gases permitted |
| ***Vibration*** | MIL STD 810C 514.2 |
| ***Shock*** | MIL STD 810C 516.2 |
| ***Noise Immunity*** | NEMA ICS3-304 |

***NOTE:*** *Values in parenthesis with an asterisk are for older modules with two circuit board design and date codes 0609D4 and prior. Values not in parenthesis are for single circuit board models with date code 0709E1 and above.*

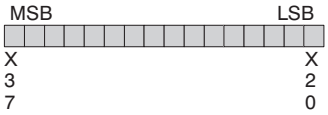
## Special Placement Requirements (D2-230 and Remote I/O Bases)

Even though the module can be placed in any slot, it is important to examine the configuration if a D2-230 CPU is used, as can be seen in the section about Writing the Program, located in this chapter. V-memory locations are used to extract the analog data. If the module is placed so the input points do not start on a V-memory boundary, the instructions cannot access the data. This also applies when placing this module in a remote base using a D2-RSSS in the CPU slot.

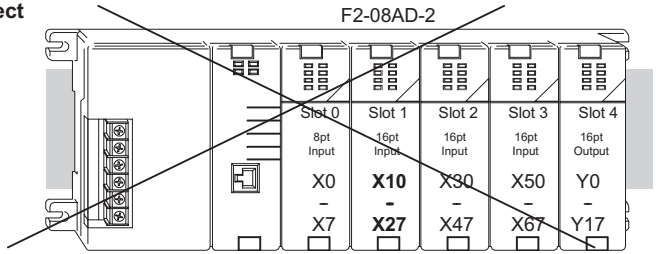
**Correct!**




Data is correctly entered so input points start on a V-memory boundary.




**Incorrect**




Data is split over two locations, so instructions cannot access data from a D2-230.

To use the V-memory references required for a D2-230 CPU, the first input address assigned to the module must be one of the following X locations. The table also shows the V-memory addresses that correspond to these X locations.

| ***X*** | X0 | X20 | X40 | X60 | X100 | X120 | X140 | X160 |
|---|---|---|---|---|---|---|---|---|
| ***V*** | V40400 | V40401 | V40402 | V40403 | V40404 | V40405 | V40406 | V40407 |

# Setting the Module Jumpers

## Selecting the Number of Channels

There are two jumpers, labeled +1, +2, and +4 that are used to select the number of channels that will be used. Use the figures below to locate the jumpers on the module. The module is set from the factory for eight channel operation (all jumpers installed).

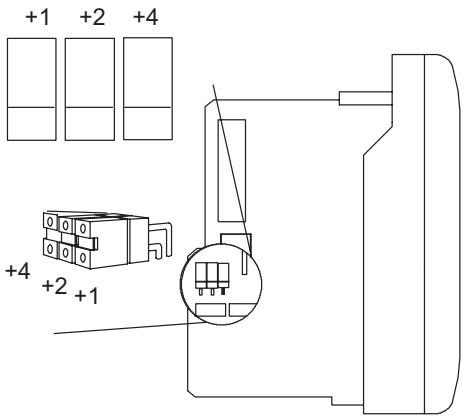
Unused channels are not processed. For example, if only channels 1 through 3 are selected, then channels 4 through 8 will not be active. The following table shows how to place the jumpers to select the number of channels.

| *No. of Channels* | *+1* | *+2* | *+4* |
|---|---|---|---|
| 1 | No | No | No |
| 1, 2 | Yes | No | No |
| 1, 2, 3 | No | Yes | No |
| 1, 2, 3, 4 | Yes | Yes | No |
| 1, 2, 3, 4, 5 | No | No | Yes |
| 1, 2, 3, 4, 5, 6 | Yes | No | Yes |
| 1, 2, 3, 4, 5, 6, 7 | No | Yes | Yes |
| 1, 2, 3, 4, 5, 6, 7, 8 | Yes | Yes | Yes |

For example, to select all 8 channel operation, leave all jumpers installed. To select 1 channel, remove all three jumpers.
Note that removed jumpers can be stored on a single post to prevent from losing them.

Yes = jumper installed
No = jumper removed

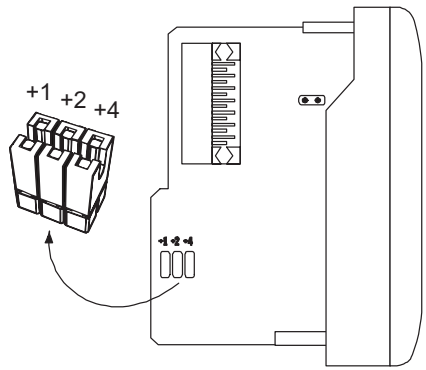
**Jumper location on modules having Date Code 0609D4 and previous (two circuit board design)**




These jumpers are located on the motherboard, the one with the black D-shell style backplane connector.

**Jumper location on modules having Date Code 0709E1 and above (single circuit board design)**

Use jumpers +1, +2 and +4 to select number of channels.

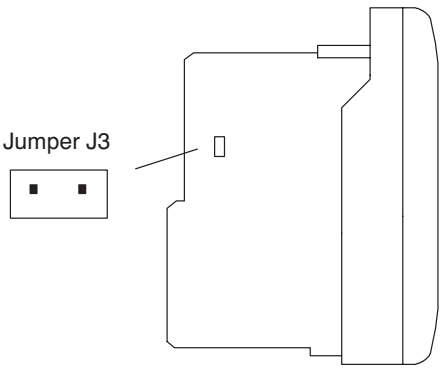


## Selecting the Input Voltage

There is another jumper, labeled J3 that is used to select between the 5V ranges and the 10V ranges  See the figures below to locate the jumper on the  module being used. The module comes from the factory set for 10V operation (jumper is removed and is stored on one of the pins).

***NOTE:*** *Install jumper J3 for 0–5 V or ±5V operation.*
*Remove J3, or store on a single pin, for 0 to 10V or ±10V operation.*

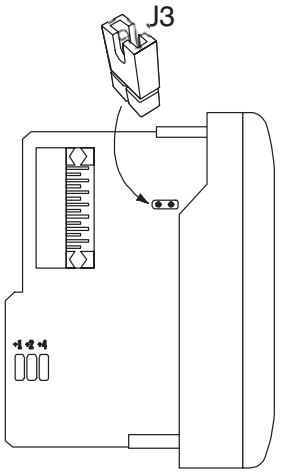
**Jumper J3 location on modules having Date Code 0609D4 and previous (two circuit board design)**




Jumper J3 is located on the smaller circuit board, which is on top of the motherboard.

Install J3 for 0–5 V or ±5V operation.
Remove J3, or store on a single pin, for 0–10V or ±10V operation.

**Jumper J3 location on modules having Date Code 0709E1 and above (single circuit board design)**




Install J3 for 0–5 V or ±5V operation.
Remove J3, or store on a single pin, for 0–10V or ±10V operation.

# Connecting the Field Wiring

## Wiring Guidelines

Your company may have guidelines for wiring and cable installation. If so, check them before starting the installation. Here are some general things to consider:

- Use the shortest wiring route whenever possible.
- Use shielded wiring and ground the shield at the transmitter source. Do not ground the shield at both the module and the source.
- Do not run the signal wiring next to large motors, high current switches, or transformers. This may cause noise problems.
- Route the wiring through an approved cable housing to minimize the risk of accidental damage. Check local and national codes to choose the correct method for your application.

## User Power Supply Requirements

The F2-08AD-2 module requires at least one field-side power supply. The same or separate power sources can be used for the module supply and the voltage transmitter supply. The module requires 10–30 VDC, at 5mA, from the external power supply.

The DL205 AC bases have a built-in 24VDC power supply that provide up to 300mA of current. This can be used instead of a separate supply. Check the power budget to be safe.

It is desirable in some situations to power the transmitters separately in a location remote from the PLC. This will work as long as the transmitter supply meets the voltage and current requirements, and that the transmitter and the module supply minus (-) side are connected together.

**WARNING: If the 24VDC base power supply is used, Be sure to calculate the power budget. Exceeding the power budget can cause unpredictable system operation that can lead to a risk of personal injury or damage to equipment.**

The DL205 base has a switching type power supply. As a result of switching noise, ±3–5 counts of instability may be noticed in the analog input data if this power supply is used. If this is unacceptable, try using one of the following.

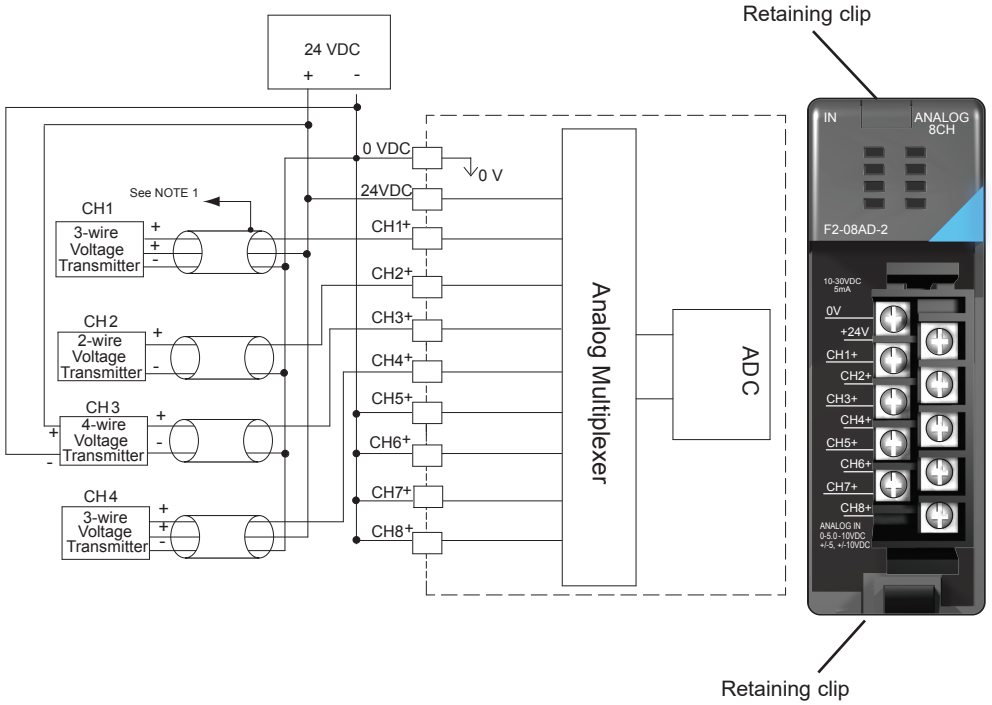
1. Use a separate linear power supply.
2. Connect the 24VDC common to the frame ground, which is the screw terminal marked on the screw terminal marked "G" on the base.

By using these methods, the input stability is rated at ±1 count.

Unused inputs should be shorted together and connected to common.

## Wiring Diagram

The F2-08AD-2 module has a removable connector to simplify wiring the module. Just squeeze the top and bottom retaining clips and gently pull the connector from the module. Use the following diagram to connect the field wiring



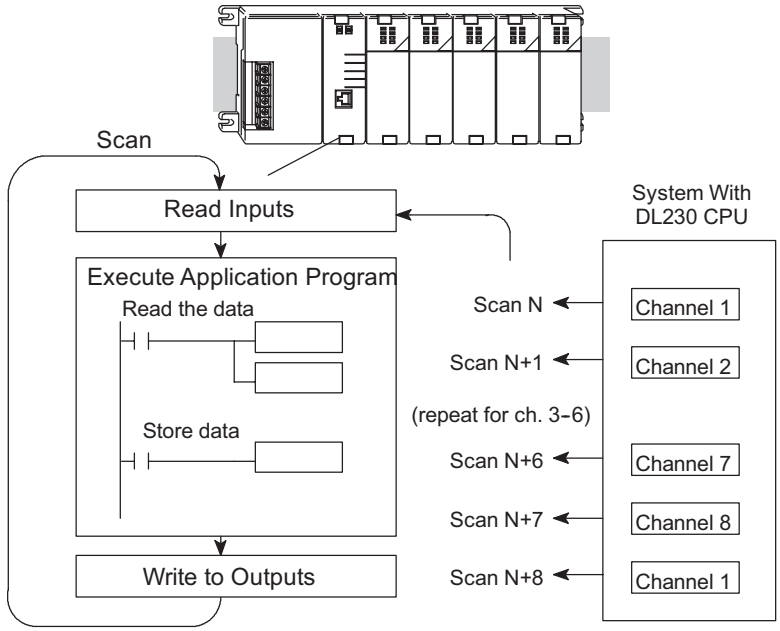

***NOTE:*** *Connect unused channels (CH5+, CH6+, CH7+, CH8+ in this diagram) to common (0VDC).*

# Module Operation

## Channel Scanning Sequence (Multiplexing) for a D2-230 CPU

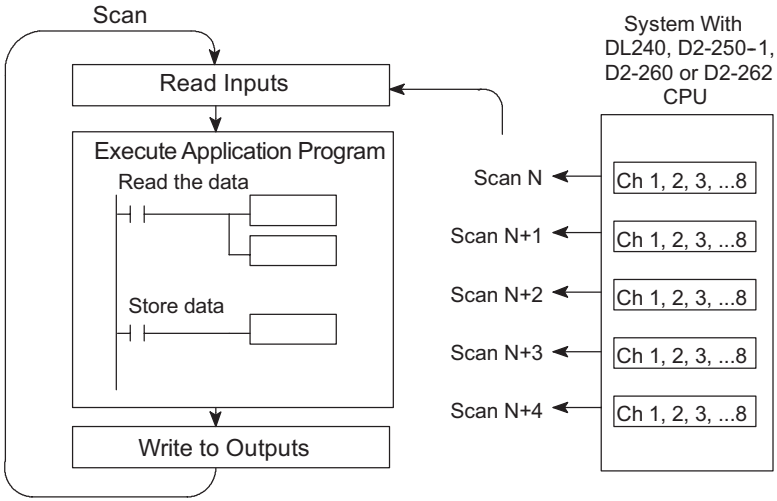
Before beginning to write the control program, it is important to take a few minutes to understand how the module processes and represents the analog signals.

Depending on the type of CPU being used, the F2-08AD-2 module can supply different amounts of data per scan. The D2-230 can obtain one channel of data per CPU scan. Since there are eight channels, it can take up to eight scans to get data for all channels. Once all channels have been scanned the process starts over with channel 1. Unused channels are not processed, so if only two channels are selected, each channel will be updated every other scan. The multiplexing method can also be used for the D2-240, D2-250-1, D2-260 and D2-262 CPUs.



## Channel Scanning Sequence (Pointer method) for D2-240, D2-250-1, D2-260 or D2-262 CPUs

If either a D2-240, a D2-250-1, a D2-260 or a D2-262 CPU are used, all eight channels of input data can be collected in one scan. This is because the D2-240, D2-250-, D2-260 and D2-262 CPUs support special V-memory locations that are used to manage the data transfer which is discussed in more detail in the section on Writing the Control Program later in this chapter.




## Analog Module Updates

Even though the channel updates to the CPU are synchronous with the CPU scan, the module asynchronously monitors the analog transmitter signal and converts the signal to a 12-bit binary representation. This enables the module to continuously provide accurate measurements without slowing down the discrete control logic in the RLL program.

For the vast majority of applications, the values are updated much faster than the signal changes. However, in some applications, the update time can be important. The module takes approximately one millisecond to sense 95% of the change in the analog signal.

***NOTE:*** *This is not the amount of time required to convert the signal to a digital representation. The conversion to the digital representation takes only a few microseconds. Many manufacturers list the conversion time, but it is the settling time of the filter that really determines the update time.*

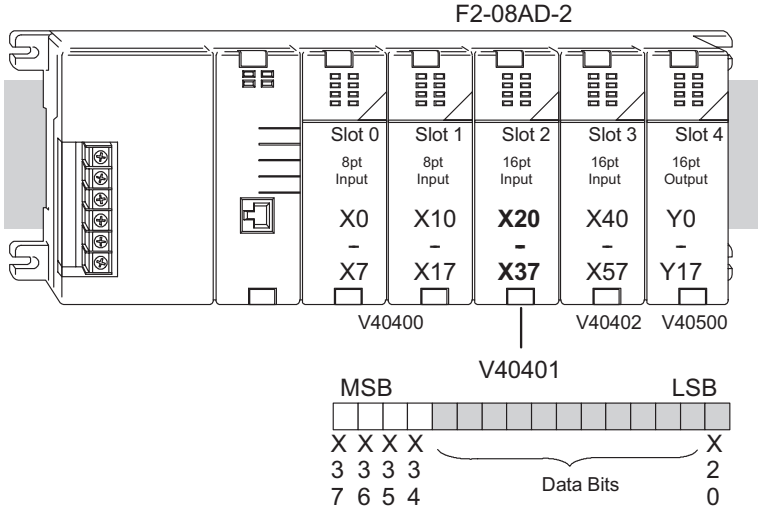
## Understanding the Input Assignments

It was mentioned earlier in this chapter that the F2-08AD-2 module appears as a 16-point discrete input module to the CPU. These points can be used to obtain:

- An indication of which channel is active
- The digital representation of the analog signal
- Module diagnostic information

Since all input points are automatically mapped into V-memory, it is very easy to determine the location of the data word that will be assigned to the module.

Within these word locations, the individual bits represent specific information about the

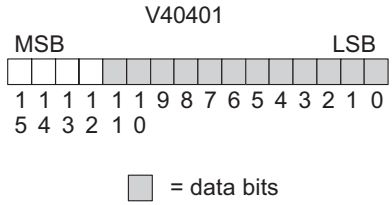



analog signal.

## Analog Data Bits

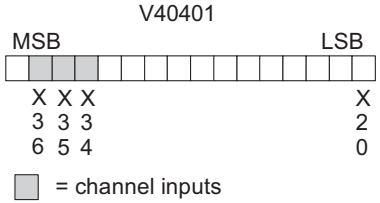
The first twelve bits represent the analog data in binary format.

| Bit | Value | Bit | Value |
|---|---|---|---|
| 0 | 1 | 6 | 64 |
| 1 | 2 | 7 | 128 |
| 2 | 4 | 8 | 256 |
| 3 | 8 | 9 | 512 |
| 4 | 16 | 10 | 1024 |
| 5 | 32 | 11 | 2048 |



## Active Channel Indicator Inputs

Three of the inputs are binary-encoded to indicate the active channel (remember, the V-memory bits are mapped directly to discrete inputs). The inputs automatically turn on and off to indicate the current channel for each scan.

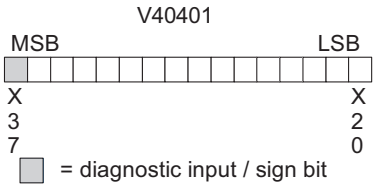



| Scan | X34 | X35 | X36 | Channel |
|---|---|---|---|---|
| N | Off | Off | Off | 1 |
| N+1 | On | Off | Off | 2 |
| N+2 | Off | On | Off | 3 |
| N+3 | On | On | Off | 4 |
| N+4 | Off | Off | On | 5 |
| N+5 | On | Off | On | 6 |
| N+6 | Off | On | On | 7 |
| N+7 | On | On | On | 8 |

### Module Diagnostic and Sign

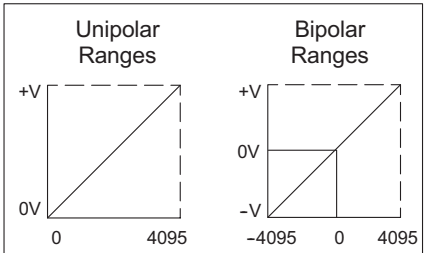
The MSB input bit is the broken transmitter/ no 24V indicator and the sign indicator.

If the bit is on and the data is zero, there is no 24V input power or the terminal block is loose or missing. If the data is not 0 (zero), the input represents the sign bit.



## Module Resolution

Since the module has 12-bit unipolar resolution, the analog signal is converted into 4096 counts ranging from 0–4095 (212). For example, with a 0–10V scale, a 0V signal would be 0, and a 10V signal would be 4095. This is equivalent to a binary value of 0000 0000 0000 to 1111 1111 1111, or 000 to FFF hexadecimal. The diagram shows how this relates to each signal range. The bipolar ranges utilize a sign bit to provide 13-bit resolution. A value of 4095 can represent the upper limit of either side of the range. Use the sign bit to determine negative values.




$$\text{Unipolar Resolution} = \frac{H - L}{4095}$$

$$\text{Bipolar Resolution} = \frac{H - L}{8191}$$

H or L = high or low limit of the range

Each count can also be expressed in terms of the signal level by using the equation shown on the facing page. The following table shows the smallest detectable signal change that will result in one LSB change in the data value for each input signal range.

| Voltage Range | Signal Span (H – L) | Divide By | Smallest Detectable Change |
|---|---|---|---|
| ***0V to +10V*** | 10V | 4095 | 2.44 mV |
| ***-10V to +10V*** | 20V | 8191 | 2.44 mV |
| ***0V to + 5V*** | 5V | 4095 | 1.22 mV |
| ***-5V to + 5V*** | 10V | 8191 | 1.22 mV |

# Writing the Control Program

## Reading Values: Pointer Method and Multiplexing

There are two methods of reading values:

1. The pointer method
2. Multiplexing

The multiplexing method must be used when using a D2-230 CPU. The multiplexing method must also be used with remote I/O modules (the pointer method will not work). Either method can be used with the D2-240, D2-250-1, D2-260 and D2-262 CPUs, but for ease of programming it is strongly recommended to use the pointer method.

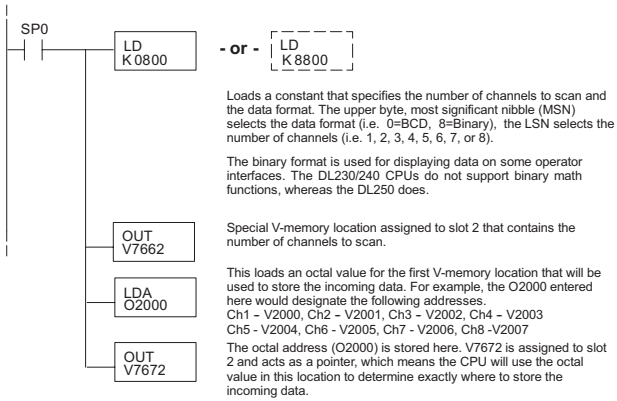
## Pointer Method for D2-240, D2-250-1, D2-260 and D2-262 CPUs

The DL205 series has special V-memory locations assigned to each base slot that will greatly simplify the programming requirements. These V-memory locations allow you to:

- Specify the data format
- Specify the number of channels to scan
- Specify the storage locations

***NOTE:*** *D2-240 CPUs with firmware release version 2.2 or later support this method. D2-250 CPUs with firmware release version 1.06 or later support this method. If the D2-230 example needs to be used, module placement in the base is very important. Review the section earlier in this chapter for guidelines.*

The example program shows how to setup these locations. Place this rung anywhere in the ladder program, or in the initial stage if stage programming instructions are being used. This is all that is required to read the data into V-memory locations. Once the data is in V-memory, math can be used on the data, compare the data against preset values, and so forth. V2000 is used in the example but any user V-memory location can be used. In this example the module is installed in slot 2. Be sure to use the V-memory locations for the module placement. The pointer method automatically converts values to BCD (depending on the LD statement in the ladder logic).



The tables below show the special V-memory locations used by the D2-240, D2-250-1, D2-260 and D2-262 CPUs for the base and local expansion base I/O slots. Slot 0 (zero) is the module next to the CPU or D2-CM module. Slot 1 is the module two places from the CPU or D2-CM, and so on. Remember, the CPU only examines the pointer values at these locations after a mode transition. Also, if you use the D2-230 (multiplexing) method, verify that these addresses in the CPU are 0 (zero).

The Table below applies to the D2-240, D2-250-1, D2-260 and D2-262 CPU base.

| CPU Base: Analog Input Module Slot-Dependent V-memory Locations | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| ***Slot*** | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| ***No. of Channels*** | V7660 | V7661 | V7662 | V7663 | V7664 | V7665 | V7666 | V7667 |
| ***Storage Pointer*** | V7670 | V7671 | V7672 | V7673 | V7674 | V7675 | V7676 | V7677 |

The Table below applies to the D2-250-1, D2-260 or the D2-262 CPU base 1.

| Expansion Base D2-CM #1: Analog Input Module Slot-Dependent V-memory Locations | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| ***Slot*** | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| ***No. of Channels*** | V36000 | V36001 | V36002 | V36003 | V36004 | V36005 | V36006 | V36007 |
| ***Storage Pointer*** | V36010 | V36011 | V36012 | V36013 | V36014 | V36015 | V36016 | V36017 |

The Table below applies to the D2-250-1, D2-260 or the D2-262 CPU base 2.

| Expansion Base D2-CM #2: Analog Input Module Slot-Dependent V-memory Locations | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| ***Slot*** | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| ***No. of Channels*** | V36100 | V36101 | V36102 | V36103 | | V36105 | V36106 | V36107 |
| ***Storage Pointer*** | V36110 | V36111 | V36112 | V36113 | V36114 | V36115 | V36116 | V36117 |

The Table below applies to the D2-260 and D2-262 CPU base 3.

| Expansion Base D2-CM #3: Analog Input Module Slot-Dependent V-memory Locations | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| ***Slot*** | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| ***No. of Channels*** | V36200 | V36201 | V36202 | V36203 | V36204 | V36205 | V36206 | V36207 |
| ***Storage Pointer*** | V36210 | V36211 | V36212 | V36213 | V36214 | V36215 | V36216 | V36217 |

The Table below applies to the D2-260 and D2-262 CPU base 4.

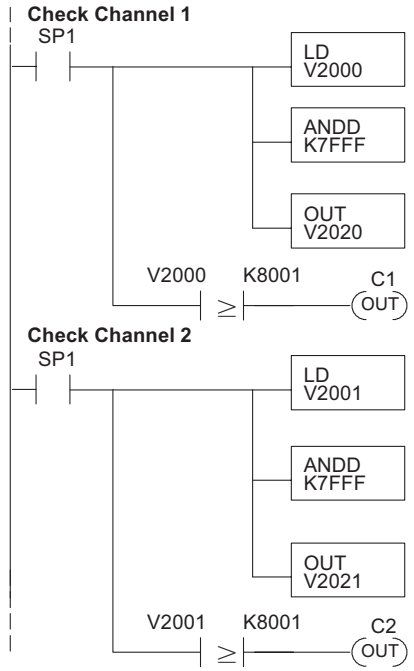
| Expansion Base D2-CM #4: Analog Input Module Slot-Dependent V-memory Locations | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| ***Slot*** | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| ***No. of Channels*** | V36300 | V36301 | V36302 | V36303 | V36304 | V36305 | V36306 | V36307 |
| ***Storage Pointer*** | V36310 | V36311 | V36312 | V36313 | V36314 | V36315 | V36316 | V36317 |

## Using Bipolar Ranges (Pointer Method) for D2-240, D2-250-1, D2-260 and D2-262 CPUs

Some additional logic is needed with bipolar ranges to determine whether the value being returned represents a positive voltage or a negative voltage. For example, the direction of a motor may be needed to be known. With the D2-240 or D2-250 CPU, the last input cannot be used to show the sign for each channel (X37 in the previous examples). This is because the D2-240, D2-250-1, D2-260 and D2-262 reads all eight channels in one scan. Therefore, if X37 were used, the last channel read would just be monitored and the sign would not be able to be determined for the previous channels. A simple solution is if the value read is greater than or equal to 8001, the value is negative.

The sign bit is the most significant bit, which combines 8000 with the data value. If the value is greater than or equal to 8001, only the most significant bit and the active channel bits will need to be masked to determine the actual data value.

The following program shows how to accomplish this. Since a negative value is always meant to be known, these rungs should be placed before any other operations that use the data, such as math instructions, scaling operations, and so forth. Also, if stage programming instructions are being used, place these rungs in a stage that is always active. Please note, this logic is only needed for each channel that is using bipolar input signals. The following example only shows two channels.




Load channel 1 data from V-memory into the accumulator. Remember, the data can be negative. Contact SP1 is always on.

This instruction masks the sign bit of the BCD data if it is set. Without this step, negative values will not be correct, so do not forget to include it.

Put the actual signal value in V2020. Now you can use the data normally.

Channel 1 data is negative when C1 is on (a value of -1 reads as 8001, -2 is 8002, etc.).

Load channel 2 from V-memory into the accumulator. Remember, the data can be negative. Contact SP1 is always on.

This instruction masks the sign bit of the BCD data, if it is set. Without this step, negative values will not be correct, so do not forget to include it.

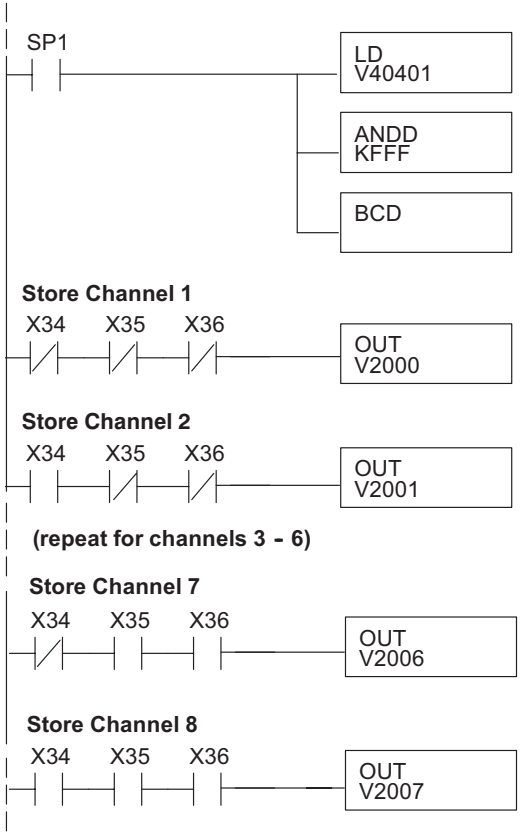
Put the actual signal value in V2021. Now you can use the data normally.

Channel 2 data is negative when C2 is on (a value of -1 reads as 8001, -2 is 8002, etc.).

## Reading Values (Multiplexing) for D2-230, D2-240, D2-250-1, D2-260 and D2-262 CPUs

The D2-230 CPU does not have the special V-memory locations which will allow data transfer to be automatically enabled. Since all channels are multiplexed into a single data word, the control program must be setup to determine which channel is being read. Since the module appears as X input points to the CPU, it is very easy to use the active channel status bits to determine which channel is being monitored.

***NOTE:*** *This example is for a module installed as shown in the previous examples. The addresses used would be different if the module is installed in a different I/O arrangement. The rungs can be placed anywhere in the program, or if stage programming is being used, place them in a stage that is always active.*




Loads the complete data word into the accumulator. The V-memory location depends on the I/O configuration. See Appendix A for the memory map.

This instruction masks the channel identification bits. Without this, the values used will not be correct so do not forget to include it.

It is usually easier to perform math operations in BCD, so it is best to convert the data to BCD immediately. You can leave out this instruction if your application does not require it.

When X34, X35 and X36 are off, channel 1 data is stored in V2000.

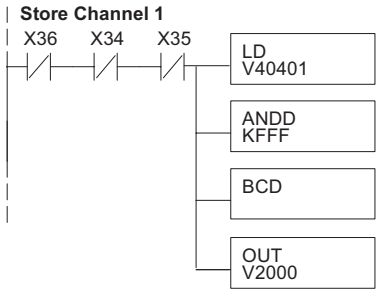
When X34 is on, X35 and X36 are off, and broken transmitter detect is off, channel 2 data is stored in V2001.

When X35 and X36 are on and X34 is off, channel 7 data is stored in V2006.

When X34, X35 and X36 are on, channel 8 data is stored in V2007.

## Single Channel Selected

The single channel program makes it easy to determine which channel has been selected.




Loads the complete data word into the accumulator. The V-memory location depends on the I/O configuration. See Appendix A for the memory map.

This instruction masks the channel identification bits. Without this, the values used will not be correct, so do not forget to include it.

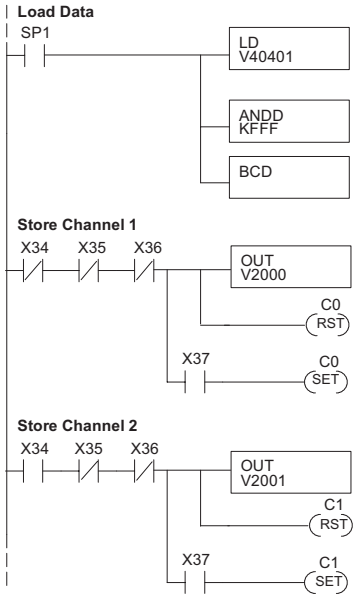
It is usually easier to perform math operations in BCD. So it is best to convert the data to BCD immediately. You can leave out this instruction if your application does not require it.

When the module is not busy, and X34 and X35 are off, channel 1 data is stored in V2000.

## Using Bipolar Ranges (Multiplexing)

Some additional logic is needed with bipolar ranges to determine whether the value being returned represents a positive voltage or a negative voltage. For example, the direction of a motor may be needed to be known. Since the D2-230 only reads one channel per scan, the last input can be used to show the sign (X37 in the examples).

The following program shows how to accomplish this. Since a negative value is always needed to be known, these rungs should be placed before any other operations that use the data, such as math instructions, scaling operations, and so forth. Also, if stage programming instructions are being used, place these rungs in a stage that is always active. Please note, this logic is only needed for each channel that is using bipolar input signals. The following example only shows two channels but the rungs can be repeated for all eight channels if needed.




Loads the complete data word into the accumulator. The V-memory location depends on the I/O configuration. See Appendix A for the memory map.

This instruction masks the channel identification bits. Without this, the values used will not be correct, so do not forget to include it.

It is usually easier to perform math operations in BCD, so it is best to convert the data to BCD immediately. You can leave out this instruction if your application does not require it.

When the module is not busy, and X34, X35 and X36 are off, channel 1 data is stored in V2000. C0 is reset to indicate channel 1's value is positive.

If X37 is on, then the data value represents a negative voltage. C0 is set to indicate channel 1's value is negative.

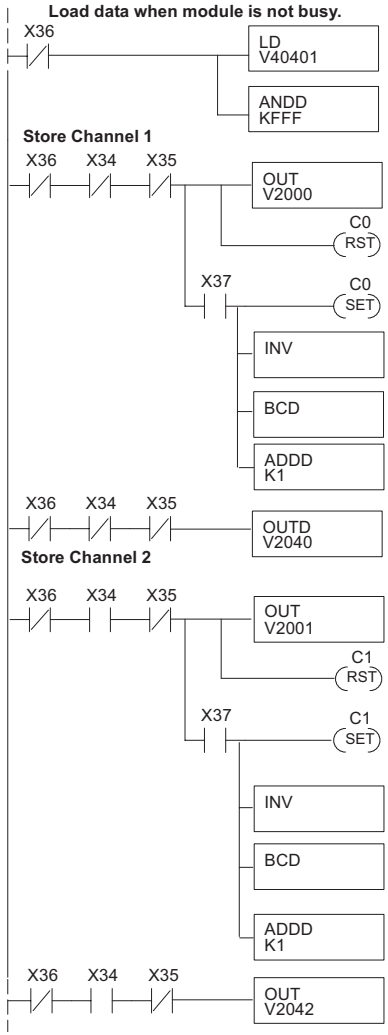
When the module is not busy, and X34 is on and X35 and X36 are off, channel 2 data is stored in V2001. C1 is reset to indicate channel 2's value is positive.

If X37 is on, then the data value represents a negative voltage. C1 is set to indicate channel 2's value is negative.

## Using 2's Complement (Multiplexing) for D2-230, D2-240, D2-250-1, D2-260 and D2-262 CPUs

The 2's complement data format may be required to display negative values on some operator interface devices. It could also be used to simplify data averaging on bipolar signals.

The example shows two channels, but these steps can be repeated for all eight channels if necessary.




Loads the complete data word into the accumulator. The V-memory location depends on the I/O configuration. See Appendix A for the memory map.

This instruction masks the channel identification bits Without this, the values used will not be correct, so do not forget to include it.

When the module is not busy, and X34, X35 and X36 are off, channel 1 data is stored in V2000. C0 is reset to indicate that channel 1's value is positive.

If X37 is on, then the data value represents a negative voltage. C0 is set to indicate that channel 1's value is negative.

Invert the bit pattern in the accumulator.

Channel 1 data is in double word starting at V2040.

When the module is not busy, and X34 is on and X35 and X36 are off, channel 2 data is stored in V2001. C1 is reset to indicate that channel 2's value is positive.

If X37 is on, then the data value represents a negative voltage. C1 is set to indicate that channel 2's value is negative.

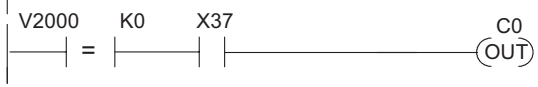
Invert the bit pattern in the accumulator.

Channel 2 data is in double word starting at V2042.

## Analog Power Failure Detection

The analog module has a microcontroller which can diagnose analog input circuit problems. A ladder rung can be added to program to detect these problems. This rung shows an input point that would be assigned if the module was used as shown in the previous examples. A different point would be used if the module was installed in a different I/O configuration.

Multiplexing method




V-memory location V2000 holds channel 1 data. When a data value of zero is returned and input X37 is on, then the analog circuitry is not operating properly.

Pointers method

V-memory location V2000 holds channel 1 data. When a data value of 8000 is returned, then the analog circuitry is not operating properly.

## Scaling the Input Data

Most applications usually require measurements in engineering units which provides more meaningful data. This is accomplished by using the conversion formula shown.

$$\text{Units} = A\,\frac{H-L}{4095}$$

**U = Engineering Units**

**A = Analog Value (0 – 4095)**

**H = High limit of the engineering unit range**

**L = Low limit of the engineering unit range**

Adjustments may be needed to the formula depending on the scale being used for the engineering units.

For example, if pressure (psi) is to be measured from 0.0–99.9 then multiply the value by 10 in order to imply a decimal place when viewing the value with the programming software or with a handheld programmer. Notice how the calculations differ when the multiplier is used.

Analog Value of 2024, slightly less than half scale, should yield 49.4 psi.

Example without multiplier

$$\text{Units} = A\,\frac{H-L}{4095}$$

$$\text{Units} = 2024\,\frac{100-0}{4095}$$

$$\text{Units} = 49$$

Example with multiplier

$$\text{Units} = 10A\,\frac{H-L}{4095}$$

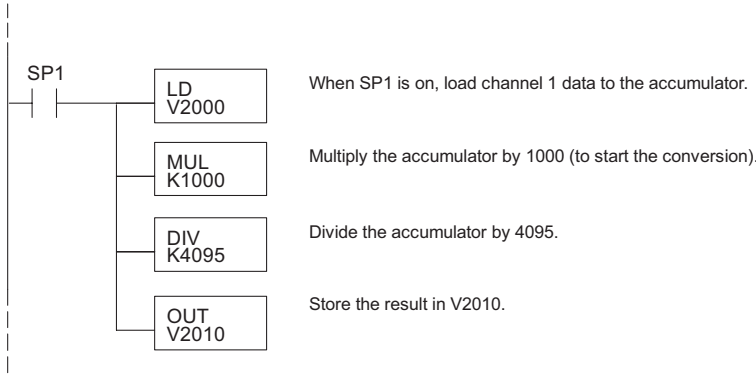
$$\text{Units} = 20240\,\frac{100-0}{4095}$$

$$\text{Units} = 494$$

## The Conversion Program

The following example shows how to write the program to perform the engineering unit conversion. This example assumes the raw input data read at V2000 is in BCD format.

***NOTE:*** *This example uses SP1, which is always on, but any permissive contact such as, X, C, etc., can be used.*




## Analog and Digital Value Conversions

Sometimes it is useful to be able to quickly convert between the signal levels and the digital values. This is especially helpful during machine startup or troubleshooting. Remember, that this module does not operate like other versions of analog input modules. The bipolar ranges use 0-4095 for both positive and negative voltages. The sign bit allows this, which actually provides better resolution than those modules that do not offer a sign bit. The following table provides formulas to make this conversion easier.

| Range | If the digital value is known | If the analog signal level is known. |
|---|---|---|
| 0–5 V<br>±5V | A = 5D<br>4095 | D = 4095 (A)<br>5 |
| 0–10 V<br>±10V | A = 5D<br>4095 | D = 4095 ABS(A)<br>10 |

As an example, if the range being used is ±10V and the measured signal is 6V, use the formula to the right to determine the digital value that is stored in the V-memory location that contains the data.

$$D = \frac{4095\ (A)}{10}$$

$$D = \frac{4095\ (6V)}{10}$$

$$D = (409.5)\ (6)$$

$$D = 2457$$

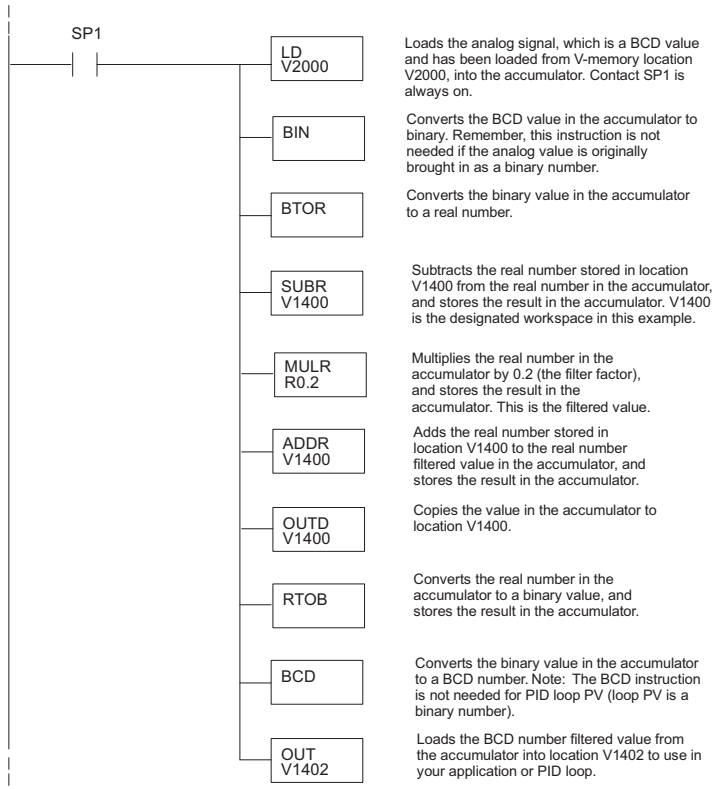
## Filtering Input Noise for D2-250-1, D2-260 and D2-262 CPUs

Add the following logic to filter and smooth analog input noise in D2-250-1, D2-260 and D2-262 CPUs. This is especially useful when using PID loops. Noise can be generated by the field device and or induced by field wiring.

In the following example, the analog value in BCD is first converted to a binary number. Memory location V1400 is the designated work space in this example. The MULR instruction is the filter factor, which can be from 0.1–0.9. The example uses 0.2. A smaller filter factor increases filtering. A higher precision value can be used, but it is not generally needed. The filtered value is then converted back to binary and then to BCD. The filtered value is stored in location V1402 for use in your application or PID loop.

***NOTE:*** *Please review intelligent instructions (IBox) in Chapter 5 of D2-USER-M, which simplify this and other functions. The IBox instructions are supported by the D2-250-1, D2-260 and D2-262.*

***NOTE:*** *Be careful not to do a multiple number conversion on a value. For example, if you are using the pointer method to get the analog value, it is in BCD and must be converted to binary. However, if you are using the conventional method of reading analog and are masking the first twelve bits, then it is already in binary and no conversion using the BIN instruction is needed.*



# F2-04RTD 4-Channel RTD Input

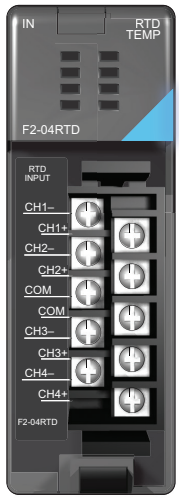
In This Chapter...

Module Specifications ..... 6-2
Setting the Module Jumpers ..... 6-5
Connecting the Field Wiring ..... 6-7
Module Operation ..... 6-9
Writing the Control Program ..... 6-11

# Module Specifications

The F2-04RTD 4-Channel Resistive Temperature Detector Input Module provides the following features and benefits:

- Provides four RTD input channels with 0.1 °F temperature resolution.
- Automatically converts type Pt100Ω, jPt100Ω, Pt1000Ω, Cu25Ω, Cu10Ω signals into direct temperature readings. No extra scaling or complex conversion is required.
- Temperature data can be expressed in °F or °C, and as magnitude plus sign or 2's complement.
- Precision lead wire resistance compensation by dual matched current sources and ratiometric measurements.
- The temperature calculation and linearization are based on data provided by the National Institute of Standards and Technology (NIST).
- Diagnostic features include detection of short circuits and input power disconnection.




## Module Calibration

The module automatically re-calibrates every five seconds to remove any offset and gain errors. The F2-04RTD module requires no user calibration. However, if your process requires calibration, it is possible to correct the RTD tolerance using ladder logic. A constant can be added or subtracted to the actual reading for that particular RTD.

## RTD Input Configuration Requirements

The F2-04RTD temperature input module requires 32 discrete input points. The module can be installed in any slot of a DL205 system, including remote bases. The limiting factors on the number of analog modules used are:

- For local and local expansion systems, the available power budget and number of discrete I/O points.
- For remote I/O systems, the available power budget and number of remote I/O points.

Check the user manual for the particular CPU model being used for more information regarding the available power budget and number of local, local expansion or remote I/O points.

***NOTE**: D2-230 CPUs with firmware release version 1.6 or later, D2-240 CPUs with firmware release 2.5 or later, D2-250 CPUs with firmware release version 1.06 or later are required for proper operation.*

## Input Specifications

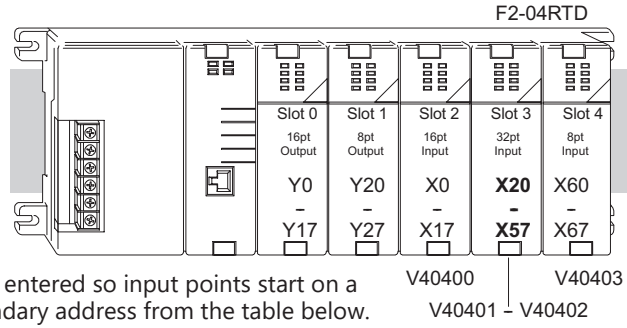
The following table provides the specifications for the F2-04RTD Input Module. Review these specifications to make sure the module meets your application requirements.

| Input Specifications | |
|---|---|
| ***Number of Channels*** | 4, differential inputs |
| ***Input Ranges*** | Pt100 -200.0°C – 850.0°C (-328°F – 1562°F)<br>PT1000 -200.0°C – 595.0°C (-328°F – 1103°F)<br>jPt100 -38.0°C – 450.0°C (-36°F – 842°F)<br>Cu10Ω -200.0°C – 260.0°C (-328°F – 500°F)<br>Cu25Ω -200.0°C – 260.0°C (-328°F – 500°F) |
| ***Resolution*** | ±0.1°C, ±0.1°F (±3276.7) |
| ***Absolute Maximum Ratings*** | Fault Protected Inputs to ±50VDC |
| ***Converter Type*** | Charge Balancing, 24 bit |
| ***Sampling Rate*** | 160ms per channel |
| ***Linearity Error (End to End)*** | ±0.05°C maximum, ±0.01°C typical |
| ***PLC Update Rate*** | 4 channels per scan max. (D2-240, D2-250–1, D2-260 or D2-262 CPU)<br>1 channel per scan max. (230 CPU) |
| ***Temperature Drift*** | 5ppm per °C (maximum) |
| ***Maximum Inaccuracy*** | maximum inaccuracy = ±1°C |
| ***RTD Excitation Current*** | 200µA |
| ***Common Mode Range*** | 0–5 VDC |
| ***Notch Filter*** | >100dB notches @ 50/60Hz<br>f-3dB = 13.1 Hz |
| ***Digital Input Points Required*** | 32 (X) input points<br>15 binary data bits, 1 sign bit, 2 channel ID bits<br>4 fault bits |
| ***Power Budget Requirements*** | 90mA @ 5VDC (supplied by base) |
| ***Operating Temperature*** | 0–60°C (32–140°F) |
| ***Storage Temperature*** | -20 to 70°C (-4 to 158°F) |
| ***Relative Humidity*** | 5–95% (non-condensing) |
| ***Environmental Air*** | No corrosive gases permitted |
| ***Vibration*** | MIL STD 810C 514.2 |
| ***Shock*** | MIL STD 810C 516.2 |
| ***Noise Immunity*** | NEMA ICS3-304 |

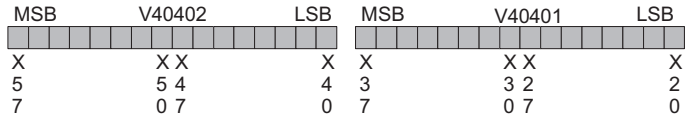
## Special Placement Requirements (D2-230 and Remote I/O Bases)

It is important to examine the configuration if a D2-230 CPU is being used. As can be seen in the section on Writing the Control Program, V-memory locations are used to manage the analog data. If the module is placed so that the input points do not start on a V-memory boundary, the instructions will not be able to access the data. This also applies when placing this module in a remote base using a D2-RSSS in the CPU slot. Refer to the diagrams below.

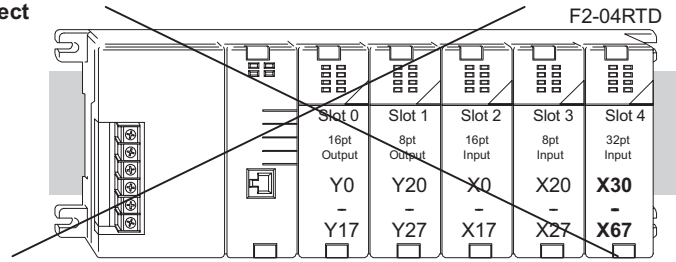
**Correct!**




Data is correctly entered so input points start on a V-memory boundary address from the table below.




**Incorrect**




Data is split over three locations, so instructions cannot access data from a D2-230.

To use the V-memory references required for a D2-230 CPU, the first input address assigned to the module must be one of the following X locations. The table also shows the V-memory addresses that correspond to these X locations.

| ***X*** | X0 | X20 | X40 | X60 | X100 | X120 | X140 | X160 |
|---|---|---|---|---|---|---|---|---|
| ***V*** | V40400 | V40401 | V40402 | V40403 | V40404 | V40405 | V40406 | V40407 |

# Setting the Module Jumpers

## Jumper Locations

Locate the bank of seven jumpers (J8) on the PC board. Notice that the description of each jumper is on the PC board. The following options can be selected by installing or removing the jumpers:

- Number of channels: 1–4.
- The input type: 10Ω or 25Ω copper, jPt100Ω, Pt100Ω or Pt1000Ω RTDs
- Temperature conversion: 2's complement or magnitude plus sign format in Fahrenheit or Celsius.

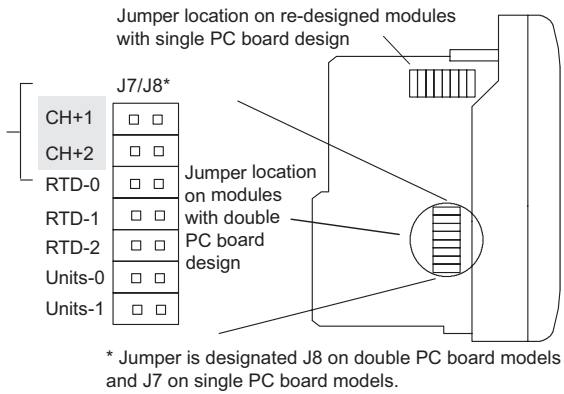
To prevent losing a jumper when it is removed, store it near its original location by sliding one of its sockets over a single pin.

## Selecting the Number of Channels

The two jumpers labeled CH+1 and CH+2 are used to select the number of channels that will be used. The factory default setting is four-channel operation (both jumpers installed). Any unused channels are not processed. For example, if you select channels 1 – 3, channel 4 will be inactive. The table shows how to arrange the jumpers to select the number of channels.

**X = jumper installed, empty space = jumper removed**

| Number of Channels | Jumper | |
|---|---|---|
| | *CH+1* | *CH+2* |
| *1* | | |
| *2* | X | |
| *3* | | X |
| *4* | X | X |




* Jumper is designated J8 on double PC board models and J7 on single PC board models.

## Setting Input Type

The jumpers labeled RTD-0, RTD-1, and RTD-2 are used to select the type of RTD. The module can be used with many types of RTDs however, all channels of the module must be the same RTD type.

The default setting from the factory is Pt100Ω (RTD-2 comes with the jumper removed). This selects the DIN 43760 European type RTD. European curve type RTDs are calibrated to DIN 43760, BS1905, or IEC751 specification which is 0.00385 Ω/Ω/°C (100°C = 138.5Ω).

The jPt100Ω type is used for the American curve (0.00392 Ω/Ω/°C), platinum 100Ω RTDs. The 10Ω and 25Ω RTD settings are used with copper RTDs.

The table shows how to arrange the jumpers to set the input type.

**X = jumper installed, empty space = jumper removed.**

| RTD Inputs | Jumper Pins | | |
|---|---|---|---|
| | *RTD-0* | *RTD-1* | *RTD-2* |
| *Cu 10Ω* | | | |
| *Cu 25Ω* | X | | |
| *jPt100Ω* | | X | |
| *Pt100Ω* | X | X | |
| *Pt1000Ω* | | | X |

## Selecting the Conversion Units

Use the last two jumpers, Units-0 and Unit-1, to set the conversion unit. The options are magnitude + sign or 2's complement in Fahrenheit or Celsius. The module comes from the factory with both jumpers installed for magnitude + sign conversion in Fahrenheit.

All RTD types are converted into a direct temperature reading in either Fahrenheit or Celsius. The data contains one implied decimal place. For example, a value in V-memory of 1002 would be 100.2°C or °F.

Negative temperatures can be represented in either 2's complement or magnitude plus sign form. If the temperature is negative, the most significant bit in the V-memory location is set (X17, if the starting address for the module is X0).

The 2's complement data format may be required to correctly display bipolar data on some operator interfaces. This data format could also be used to simplify averaging a bipolar signal. To view this data format in DirectSoft, select Signed Decimal.

The table shows how to arrange the jumpers.

**X = jumper installed, empty space = jumper removed.**

| Number of Channels | Temperature Conversion Units | | | |
|---|---|---|---|---|
| | *Magnitude + Sign* | | *2's Compliment* | |
| | *°F* | *°C* | *°F* | *°C* |
| *Units-0* | X | | X | |
| *Units-1* | X | X | | |

# Connecting the Field Wiring

## Wiring Guidelines

Your company may have guidelines for wiring and cable installation. If so, check the guidelines before beginning the installation. Here are some general things to consider:

- Use the shortest wiring route whenever possible.
- Use shielded wiring and ground the shield at the transmitter source. Do not ground the shield at both the module and the source.
- Do not run the signal wiring next to large motors, high current switches, or transformers. This may cause noise problems.
- Route the wiring through an approved cable housing to minimize the risk of accidental damage. Check local and national codes to choose the correct method for your application.

## RTD - Resistance Temperature Detector

Use shielded RTDs whenever possible to minimize noise on the input signal. Ground the shield wire at one end only, preferably at the RTD source.

Lead Configuration for RTD Sensors

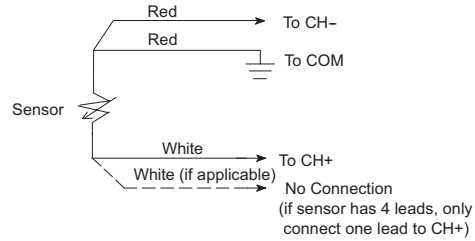
The suggested three-lead configuration shown below provides one lead to the CH+ terminal, one lead to the CH– terminal, and one lead to the common terminal. Compensation circuitry nulls out the lead length for accurate temperature measurements.

Some sensors have four leads. When making connections, do not connect the second lead to the CH+ input; leave that lead unconnected.

Do not use configurations that lack the use of the same color lead to both the CH– and COM terminals. There is no compensation so temperature readings will be inaccurate.

This module has low RTD excitation current, the worse case dissipation with 100Ω RTDs connected is only
0.016 mW.

Wiring Connections For Typical RTD Sensor



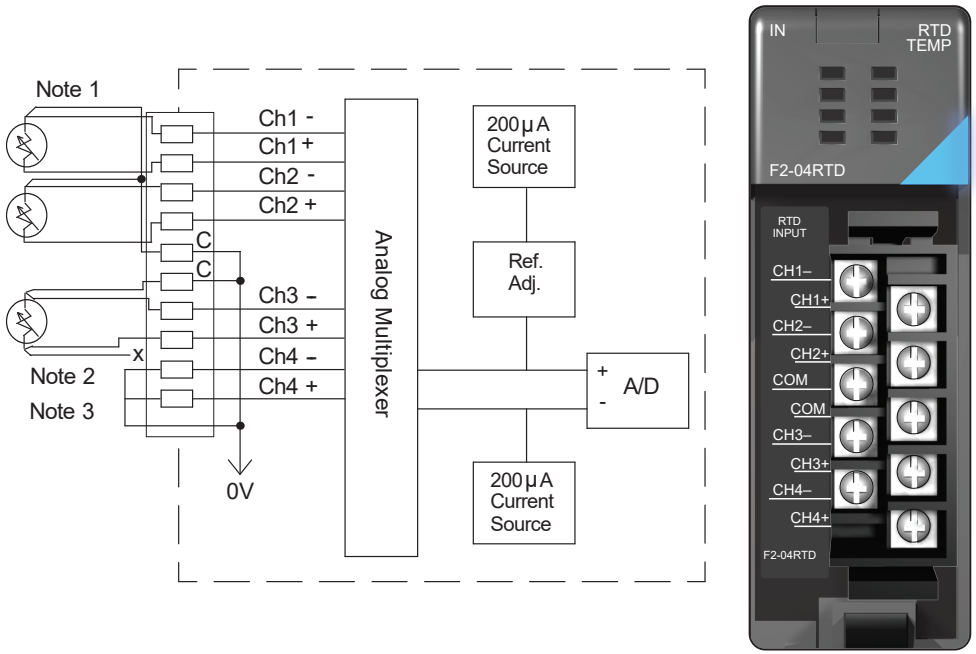
## Ambient Variations in Temperature

The F2-04RTD module has been designed to operate within the ambient temperature range of 0 to 60°C.

Precision analog measurement with no long term temperature drift is assured by a chopper stabilized programmable gain amplifier, ratiometric referencing, and automatic offset and gain calibration.

## Wiring Diagram

The F2-04RTD module has a removable connector to make wiring easier. Simply squeeze the top and bottom retaining clips and gently pull the connector from the module.



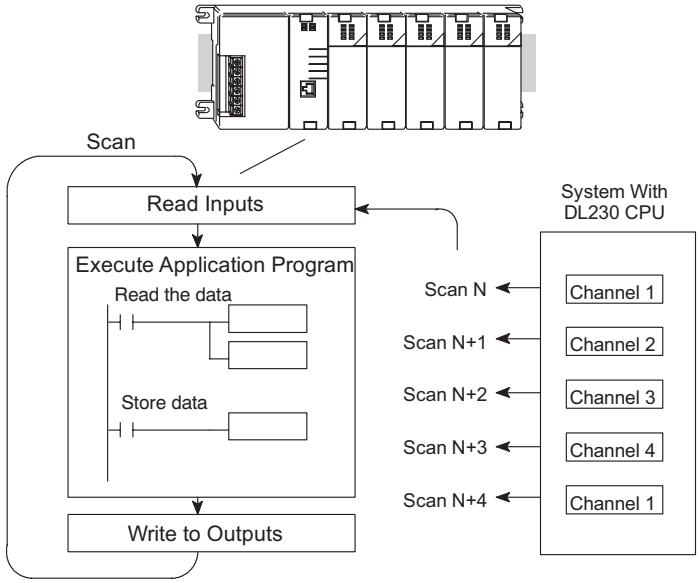

***NOTE** 1: The three wires connecting an RTD to the module must be the same type and length. Do not use the shield or drain wire for the third connection.*
***NOTE 2:** If an RTD sensor has four wires, the plus (+) sense wire should be left unconnected as shown.*
***NOTE 3:** Short unused channels to COM terminal (C)*

# Module Operation

Before beginning to write the control program, it is important to take a few minutes to understand how the module processes the analog signals.

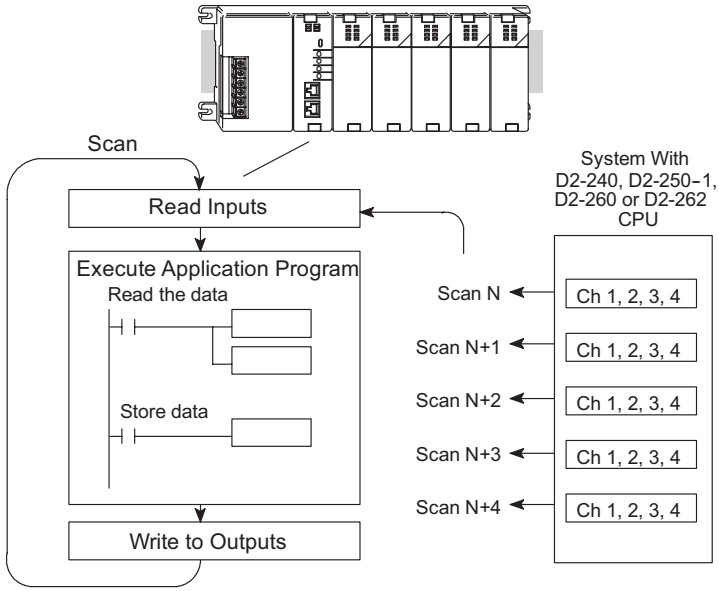
## Channel Scanning Sequence (Multiplexing) for a D2-230 CPU

The F2-04RTD module can supply different amounts of data per scan, depending on the type of CPU being used. The D2-230 can obtain one channel of data per CPU scan. Since there are four channels, it can take up to four scans to get data for all channels. Once all channels have been scanned the process starts over with channel 1. Unused channels are not processed, so if only two channels are selected, each channel will be updated every other scan. The multiplexing method can also be used for the D2-240, D2-250-1, D2-260 or D2-262 CPUs.



## Channel Scanning Sequence (Pointer Method) for D2-240, D2-250-1, D2-260 or D2-262 CPUs

If a D2-240, a D2-250-1, a D2-260 or a D2-262 CPU is being used, all four channels of input data can be captured in one scan. This is because the D2-240, D2-250-1, D2-260 and D2-262 CPUs support special V-memory locations that are used to manage the data transfer. This is discussed in more detail in the next section on Writing the Control Program.




## Analog Module Updates

Even though the channel updates to the CPU are synchronous with the CPU scan, the module asynchronously monitors the analog transmitter signal and converts the signal to a 16-bit binary representation. This enables the module to continuously provide accurate measurements without slowing down the discrete control logic in the RLL program.

The time required to sense the temperature and copy the value to V-memory is 160ms minimum to 640ms plus 1 scan time maximum (number of channels x 160ms + 1 scan time).

# Writing the Control Program

## Reading Values: Pointer Method and Multiplexing

There are two methods of reading values:

- Pointer method
- Multiplexing

The multiplexing method must be used with a D2-230 CPU. The multiplexing method must also be used with remote I/O modules (the pointer method will not work). Either method can be used with the D2-240, D2-250-1, D2-260 or D2-262 CPUs, but for ease of programming it is highly recommended to use the pointer method.

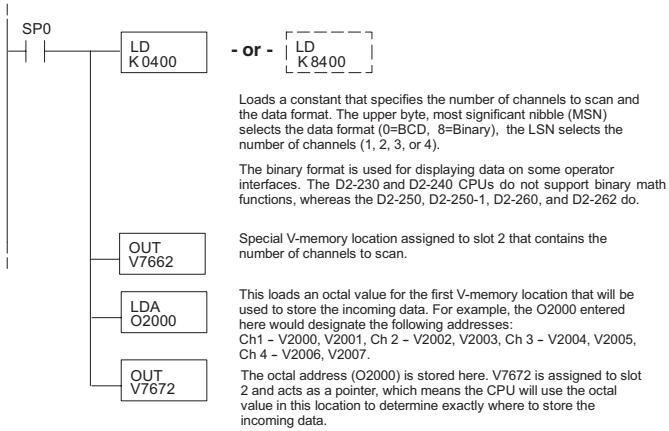
## Pointer Method for the D2-240, D2-250-1, D2-260 or D2-262 CPUs

The CPU has special V-memory locations (shown in tables on the following page) assigned to each base slot that greatly simplifies the programming requirements. These V-memory locations allow you to:

- Specify the data format
- Specify the number of channels to scan.
- Specify the storage locations.

The example program shows how to setup these locations. Place this rung anywhere in the ladder program, or in the initial stage if stage programming instructions are used. This is all that is required to read the data into V-memory locations. Once the data is in V-memory, math instructions can be used on the data, compare the data against preset values, etc. V2000 is used in the example, but any user V-memory location can be used. The module is installed in slot 2 for the examples. Use the V-memory locations shown in the application. The pointer method automatically converts values to BCD.

***NOTE:*** *D2-240 CPUs with firmware release version 2.5 or later and D2-250 CPUs with firmware release version 1.06 or later support this method. Use the D2-230 multiplexing example if the firmware revision is earlier .*



The following tables show the special V-memory locations used by the D2-240, D2-250-1, D2-260 or D2-262 for the CPU base and local expansion base I/O slots. Slot 0 (zero) is the module next to the CPU or D2-CM module. Slot 1 is the module two places from the CPU or D2-CM, and so on. Remember, the CPU only examines the pointer values at these locations after a mode transition. Also, if the D2-230 (multiplexing) method is used, verify that these addresses in the CPU are 0 (zero).

The Table below applies to the D2-240, D2-250-1, D2-260 or D2-262 CPU base.

| CPU Base: Analog Input Module Slot-Dependent V-memory Locations | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Slot | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| No. of Channels | V7660 | V7661 | V7662 | V7663 | V7664 | V7665 | V7666 | V7667 |
| Storage Pointer | V7670 | V7671 | V7672 | V7673 | V7674 | V7675 | V7676 | V7677 |

The Table below applies to the D2-250-1, D2-260 or D2-262 CPU base 1.

| Expansion Base D2-CM #1: Analog Input Module Slot-Dependent V-memory Locations | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Slot | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| No. of Channels | V36000 | V36001 | V36002 | V36003 | V36004 | V36005 | V36006 | V36007 |
| Storage Pointer | V36010 | V36011 | V36012 | V36013 | V36014 | V36015 | V36016 | V36017 |

The Table below applies to the D2-250-1, D2-260 or D2-262 CPU base 2.

| Expansion Base D2-CM #2: Analog Input Module Slot-Dependent V-memory Locations | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Slot | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| No. of Channels | V36100 | V36101 | V36102 | V36103 | V36104 | V36105 | V36106 | V36107 |
| Storage Pointer | V36110 | V36111 | V36112 | V36113 | V36114 | V36115 | V36116 | V36117 |

The Table below applies to the D2-260 and D2-262 CPU base 3.

| Expansion Base D2-CM #3: Analog Input Module Slot-Dependent V-memory Locations | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Slot | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| No. of Channels | V36200 | V36201 | V36202 | V36203 | V36204 | V36205 | V36206 | V36207 |
| Storage Pointer | V36210 | V36211 | V36212 | V36213 | V36214 | V36215 | V36216 | V36217 |

The Table below applies to the D2-260 and D2-262 CPU base 4.

| Expansion Base D2-CM #4: Analog Input Module Slot-Dependent V-memory Locations | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| *Slot* | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| *No. of Channels* | V36300 | V36301 | V36302 | V36303 | V36304 | V36305 | V36306 | V36307 |
| *Storage Pointer* | V36310 | V36311 | V36312 | V36313 | V36314 | V36315 | V36316 | V36317 |

## Negative Temperature Readings with Magnitude Plus Sign (Pointer Method) for the D2-240, D2-250-1, D2-260 or D2-262 CPUs

With bipolar ranges, some additional logic will be needed to determine whether the value being returned represents a positive voltage or a negative voltage. For example, the direction for a motor might need to be known. There is a solution for this:

- If bipolar ranges are used and a value greater than or equal to 8000hex is obtained, the value is negative.
- If a value less than or equal to 7FFFhex is obtained, then the value is positive.

The sign bit is the most significant bit, which combines 8000hex to the data value. If the value is greater than or equal to 8000hex, only the most significant bit and the active channel bits need to be masked to determine the actual data value.

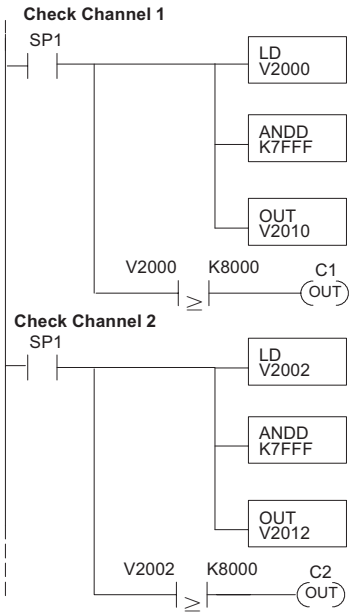
***NOTE:*** *D2-240 CPUs with firmware release version 2.5 or later and D2-250 CPUs with firmware release version 1.06 or later support this method. Use the D2-230 multiplexing example if your firmware is an earlier version.*

The two programs on the next page show how this can be accomplished. The first example uses magnitude plus sign (binary) and the second example uses magnitude plus sign (BCD). The examples only show two channels.

It is good to know when a value is negative, so these rungs should be placed before any other operations that use the data, such as math instructions, scaling operations, etc. Also, if stage programming instructions are being used, these rungs should be in a stage that is always active.

***NOTE:*** *This logic is only needed for each channel that is using bipolar input signals.*

## Magnitude Plus Sign (Binary)




Load channel 1 data from V-memory into the accumulator. Contact SP1 is always on.

This instruction masks the sign bit of the binary data, if it is set. Without this step, negative values will not be correct so do not forget to include it.

Put the actual signal value in V2010. Now you can use the data normally.

Channel 1 data is negative when C1 is on (a value of -1.0 reads as 8010, -2.0 is 8020, etc.).

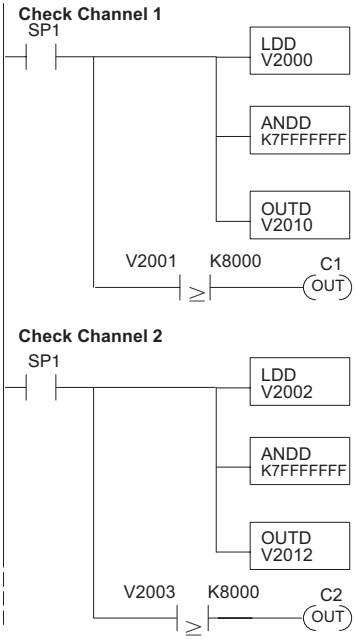
Load channel 2 from V-memory into the accumulator. Contact SP1 is always on.

This instruction masks the sign bit of the binary data, if it is set. Without this step, negative values will not be correct so do not forget to include it.

Put the actual signal value in V2012. Now you can use the data normally.

Channel 2 data is negative when C2 is on (a value of -1.0 reads as 8010, -2.0 is 8020, etc.).

## Magnitude Plus Sign (BCD)




Load channel 1 data from V-memory into the accumulator. Remember, the data can be negative. Contact SP1 is always on.

This instruction masks the sign bit of the BCD data, if it is set. Without this step, negative values will not be correct so do not forget to include it.

Put the actual signal value in V2010. Now you can use the data normally.

Channel 1 data is negative when C1 is on (a value of -1.0 reads as 8000 0010, -2.0 is 8000 0020, etc.).

Load channel 2 from V-memory into the accumulator. Remember, the data can be negative. Contact SP1 is always on.

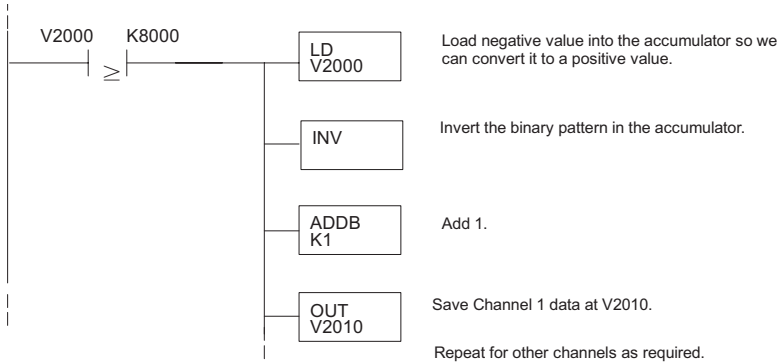
This instruction masks the sign bit of the BCD data, if it is set. Without this step, negative values will not be correct so do not forget to include it.

Put the actual signal value in V2012. Now you can use the data normally.

Channel 2 data is negative when C2 is on (a value of -1.0 reads as 8000 0010, -2.0 is 8000 0020, etc.).

## Negative Temperatures 2's Complement (Binary/Pointer Method) for the D2-240, D2-250-1, D2-260 or D2-262 CPUs

The 2's complement mode is used for negative temperature display purposes, while at the same time using the magnitude plus sign of the temperature in a control program. The DirectSoft element Signed Decimal is used to display negative numbers in 2's complement form. To find the absolute value of a negative number in 2's complement, invert the number and add 1 as shown in the following example.

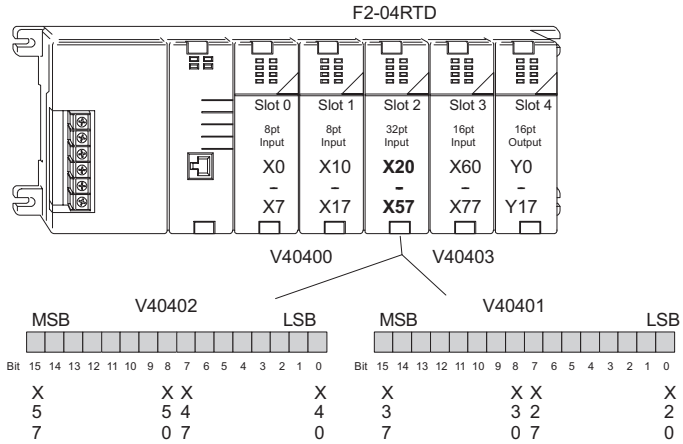



## Understanding the Input Assignments (Multiplexing Ladder Only)

Remember that this module appears to the CPU as a 32-point discrete input module. Use these points to obtain:

- An indication of which channel is active
- The digital representation of the analog signal
- Module diagnostic information

Since all input points are automatically mapped into V-memory, it is easy to determine the location of the data word that will be assigned to the module.



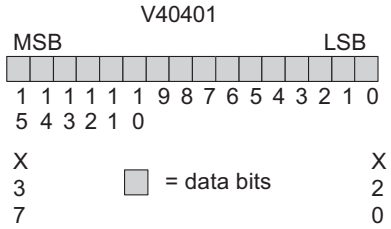
When a D2-230 CPU is used, the input points must start on a V-memory boundary. To use the V-memory references required for a D2-230 CPU, refer to the table below. The first input address assigned to a module must be one of the X inputs shown. The table also shows the V-memory addresses that correspond to these X inputs.

| ***X*** | X0 | X20 | X40 | X60 | X100 | X120 | X140 | X160 |
|---|---|---|---|---|---|---|---|---|
| ***V*** | V40400 | V40401 | V40402 | V40403 | V40404 | V40405 | V40406 | V40407 |

## Analog Data Bits

The first 16 bits represent the analog data in binary format.

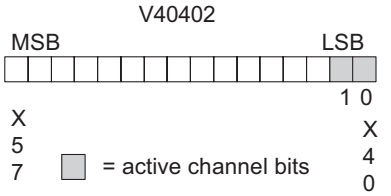
| Bit | Value | Bit | Value |
|---|---|---|---|
| 0 | 1 | 8 | 256 |
| 1 | 2 | 9 | 512 |
| 2 | 4 | 10 | 1024 |
| 3 | 8 | 11 | 2048 |
| 4 | 16 | 12 | 4096 |
| 5 | 32 | 13 | 8192 |
| 6 | 64 | 14 | 16384 |
| 7 | 128 | 15 | 32768 |




## Active Channel Bits

The active channel bits represent the multiplexed channel selections in binary format.

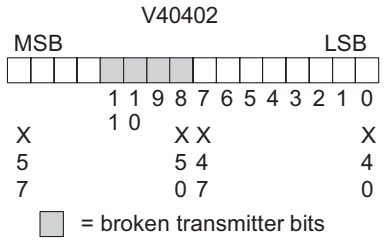
| Bit 1 | Bit 0 | Channel |
|---|---|---|
| 0 | 0 | 1 |
| 0 | 1 | 2 |
| 1 | 0 | 3 |
| 1 | 1 | 4 |




## Broken Transmitter Bits (Multiplexing Ladder Methods)

The broken transmitter bits are on when the corresponding RTD is open.

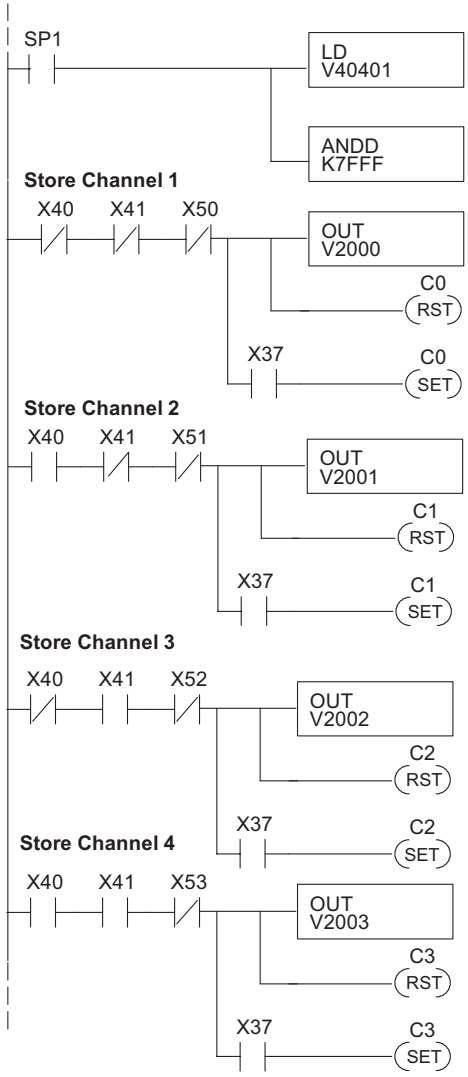
***NOTE:*** *The broken transmitter bits only function using the Multiplexing method.*



## Reading Magnitude Plus Sign Values (Multiplexing)

The D2-230 CPU does not have the special V-memory locations that allows for automatic management of the data transfer. Since all channels are multiplexed into a single data word, the control program must be set up to determine which channel is being read. Since the module appears as X input points to the CPU, it is very easy to use the active channel status bits to determine which channel is being monitored.

***NOTE:*** *D2-230 CPUs with firmware release version 1.6 or later required for multiplexing ladder.*




Loads the complete data word into the accumulator. The V-memory location depends on the I/O configuration. See Appendix A for the memory map.

This instruction masks the sign bit. Without this, the values used will not be correct so do not forget to include it.

When X40, X41, and X50 are off, channel 1 data is stored in V2000. C0 is reset to indicate that channel 1's value is positive.

If X37 is on, the data value represents a negative temperature. C0 is set to indicate that channel 1's value is negative.

When X40 is on and X41 and X51 are off, channel 2 data is stored in V2001. C1 is reset to indicate that channel 2's value is positive.

If X37 is on, the data value represents a negative temperature. C1 is set to indicate that channel 2's value is negative.

When X40 and X52 are off and X41 is on, channel 3 data is stored in V2002. C2 is reset to indicate that channel 3's value is positive.

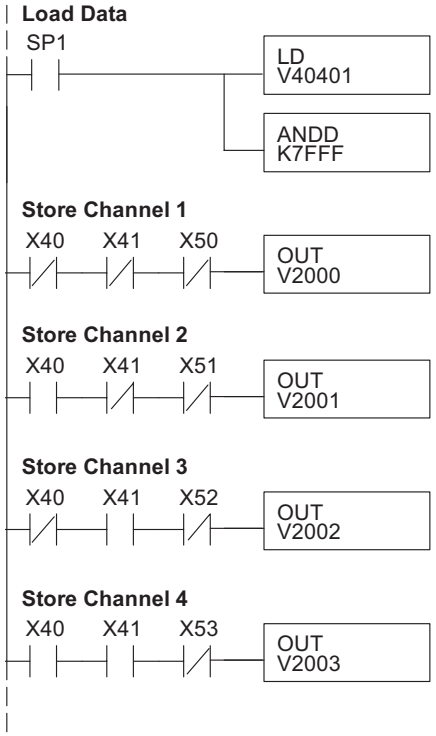
If X37 is on, then the data value represents a negative temperature. C2 is set to indicate that channel 3's value is negative.

When both X40 and X41 are on and X53 is off, channel 4 data is stored in V2003. C3 is reset to indicate that channel 4's value is positive.

If X37 is on, the data value represents a negative temperature. C3 is set to indicate that channel 4's value is negative.

## Reading 2's Compliment Values (Multiplexing)

The D2-230 CPU does not have the special V-memory locations that allows for automatic management of the data transfer. Since all channels are multiplexed into a single data word, the control program must be set up to determine which channel is being read. Since the module appears as X input points to the CPU, it is very easy to use the active channel status bits to determine which channel is being monitored. The 2's complement data format may be required to correctly display bipolar data on some operator interfaces. This data format could also be used to simplify averaging a bipolar signal. To view this data format in DirectSOFT, select Signed Decimal.




Loads the complete data word into the accumulator. The V-memory location depends on the I/O configuration.

This instruction masks the channel sign bit.

When X40, X41 and X50 are off, channel 1 data is stored in V2000.

When X40 is on and X41 and X51 are off, channel 2 data is stored in V2001.

When X40 and X52 are off and X41 is on, channel 3 data is stored in V2002.

When both X40 and X41 are on and X53 is off, channel 4 data is stored in V2003.

## Scaling the Input Data

No scaling of the input temperature is required. The readings directly reflect the actual temperatures. For example: a reading of 8482 is 848.2°C, a reading of 16386 is -0.2°C (magnitude plus sign) and a reading of 32770 is -0.2° (2's complement).

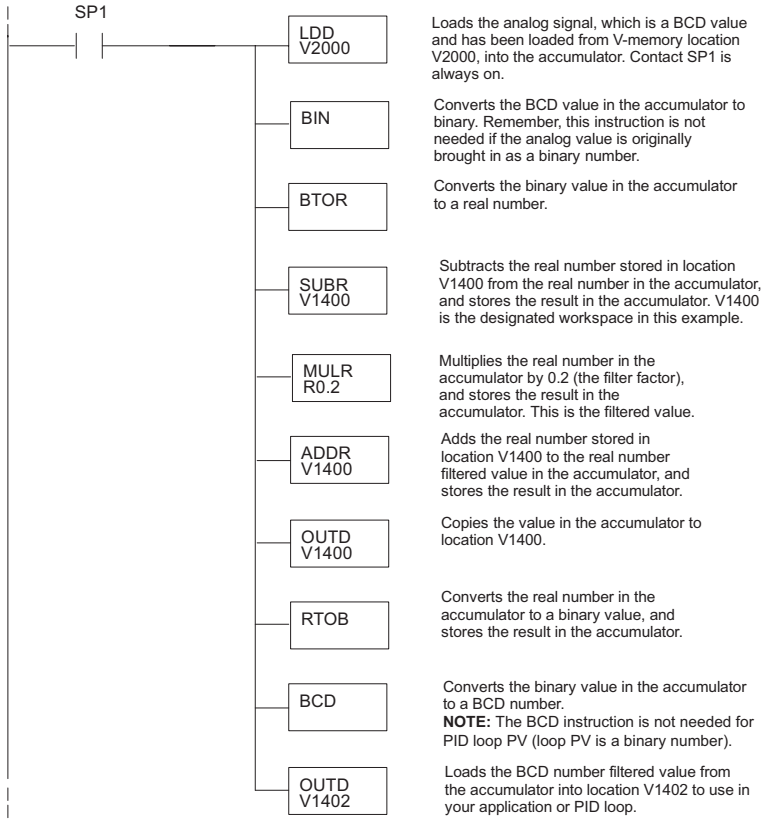
## Filtering Input Noise (D2-250-1, D2-260 and D2-262 CPUs Only)

Add the following logic to filter and smooth analog input noise in D2-250-1, D2-260 and D2-262 CPUs. This is especially useful when using PID loops. Noise can be generated by the field device and/or induced by field wiring.

In the following example, the analog value in BCD is first converted to a binary number. Memory location V1400 is the designated workspace in this example. The MULR instruction is the filter factor, which can be from 0.1–0.9. The example uses 0.2. Using a smaller filter factor increases filtering. A higher precision value can be used, but it is not generally needed. The filtered value is then converted back to binary and then to BCD. The filtered value is stored in location V1402 for use in the application program or a PID loop.

***NOTE** 1: Please review intelligent instructions (IBox) in Chapter 5 of D2-USER-M, which simplify this and other functions. The IBox instructions are supported by the D2-250-1, D2-260 and D2-262.*

***NOTE 2:** Be careful not to do a multiple number conversion on a value. For example, if the pointer method is used to get the analog value, it is in BCD and must be converted to binary. However, if the conventional method of reading analog is used and the first 15 bits are masked, the value is already in binary and no conversion is needed. Also, if the conventional method is used, change the LDD V2000 instruction to LD V2000.*



# F2-04THM 4-Channel Thermocouple Input

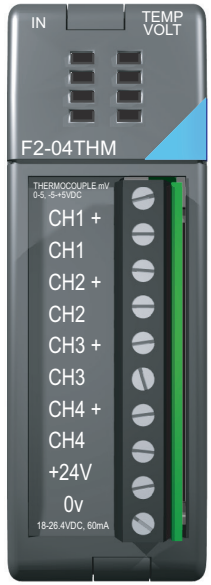
## In This Chapter...

Module Specifications ..... 7-2
Setting the Module Jumpers ..... 7-6
Connecting the Field Wiring ..... 7-9
Module Operation ..... 7-13
Writing the Control Program ..... 7-15

# Module Specifications

The F2-04THM, 4-Channel Thermocouple Input Module provides the following features and benefits:

- Four thermocouple input channels with 16-bit voltage resolution or 0.1°F/°C temperature resolution.
- Automatically converts type E, J, K, R, S, T, B, N, or C thermocouple signals into direct temperature readings. No extra scaling or complex conversion is required.
- Temperature data can be expressed in °F or °C.
- Module can be configured as ±5V, ±156mV, 0–5V, 0–156mV input and will convert volts and millivolt signal levels into 16-bit digital (0–65535) values.
- Signal processing features include automatic cold junction compensation, thermocouple linearization, and digital filtering.
- The temperature calculation and linearization are based on data provided by the National Institute of Standards and Technology (NIST).
- Diagnostic features include detection of thermocouple burnout or disconnection.



The following tables provide the specifications for the F2-04THM Analog Input Module. Review these specifications to make sure the module meets your application requirements.

| General Specifications | |
|---|---|
| ***Number of Channels*** | 4, differential |
| ***Common Mode Range*** | ±5VDC |
| ***Common Mode Rejection*** | 90dB min. @ DC, 150dB min. @ 50/60Hz. |
| ***Input Impedance*** | 1MΩ min. |
| ***Absolute Maximum Ratings*** | Fault-protected inputs to ±50VDC |
| ***Accuracy vs. Temperature*** | ±5ppm/ºC maximum; full scale calibration (including maximum offset change) |
| ***Sampling Rate*** | All 4 channels: 1.4 seconds (*5.4 seconds) |
| ***PLC Update Rate*** | 4 channels per scan max. (D2-240, D2-250–1, D2-260 and D2-262 CPU)<br>1 channel per scan ,max. D2-230 CPU |
| ***Digital Inputs Input Points Required*** | 16 binary data bits, 2 channel ID bits, 4 diagnostic bits<br>32 point (X) input module |
| ***Power Budget Requirement*** | 80mA (*100mA ) maximum, 5VDC (supplied by base) |
| ***External Power Supply*** | 40 mA, 10-30 VDC (*60 mA, 18-26.4 VDC) |
| ***Operating Temperature*** | 0–60ºC (32–140ºF) |
| ***Storage Temperature*** | -2ºC to70ºC (-4ºF to158ºF) |
| ***Relative Humidity*** | 5–95% (non-condensing) |
| ***Environmental air*** | No corrosive gases permitted |
| ***Vibration*** | MIL STD 810C 514.2 |
| ***Shock*** | MIL STD 810C 516.2 |
| ***Noise Immunity*** | NEMA ICS3-304 |

| Thermocouple Specifications | | | |
|---|---|---|---|
| ***Input Ranges*** | Type J | -190–760ºC | (-310–1400ºF) |
| | Type K | -150–1372ºC | (-238–2502ºF) |
| | Type E | -210–1000ºC | (-346–1832ºF) |
| | Type R | 65–1768ºC | (149–3214ºF) |
| | *Type R Wide | 65–1768ºC | (149–3214ºF) |
| | Type S | 65–1768ºC | (149–3214ºF) |
| | Type T | -230–400ºC | (-382–752ºF) |
| | Type B | 529–1820ºC | (984–3308ºF) |
| | Type N | -70–1300ºC | (-94–2372ºF) |
| | Type C | 65–2320ºC | (149–4208ºF) |
| ***Display Resolution*** | ±0.1ºC or ±0.1ºF | | |
| ***Cold Junction Compensation*** | Automatic | | |
| ***Warm-Up Time*** | 30 minutes typically ±1ºC repeatability | | |
| ***Linearity Error (End to End)*** | ±1ºC maximum, ±0.5ºC typical | | |
| ***Maximum Inaccuracy*** | ±3ºC (excluding thermocouple error) | | |

***NOTE:*** **R Wide range is available only on modules with date code 0410E2 and later.*

***NOTE:*** *Values in parenthesis with an asterisk are for older modules with two circuit board design and date codes 0806E1 or previous. Values not in parenthesis are for single circuit board models with date code 0806E1 and above.*

| Voltage Input Specifications | |
|---|---|
| ***Voltage Ranges*** | Voltage: 0-5V, ±5V, 0-156.25 mV, ±156.25 mVDC, |
| ***Resolution*** | 16 bit (1 in 65535) |
| ***Full Scale Calibration Error (Offset Error Included)*** | ±13 count typical, ±33 maximum |
| ***Offset Calibration Error*** | ±1 count maximum @ 0V input |
| ***Linearity Error (End to End)*** | ±1 count maximum |
| ***Maximum Inaccuracy*** | ±0.02% @ 25ºC (77ºF) |

## Module Calibration

The F2-04THM module requires no calibration. The module automatically calibrates every five seconds, which removes offset and gain errors. For each thermocouple type, the temperature calculation and linearization performed by the microprocessor is accurate to within 0.01°C.

## Thermocouple Input Configuration Requirements

The F2-04THM temperature input module requires 32 discrete input points. The module can be installed in any slot of a DL205 system. The limitations on the number of analog modules are:

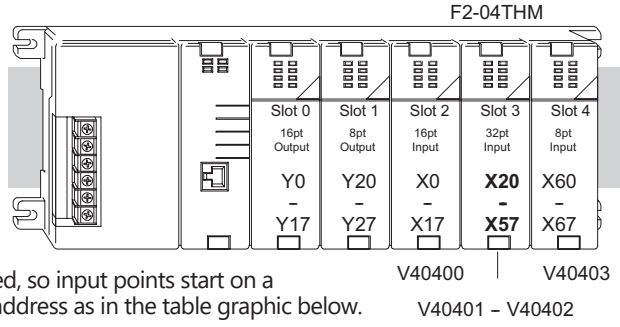
- For local and local expansion systems, the available power budget and number of discrete I/O points.
- For remote I/O systems, the available power budget and number of remote I/O points.

Check the user manual for the particular model of CPU and I/O base being used for more information regarding power budget and number of local, local expansion or remote I/O points.

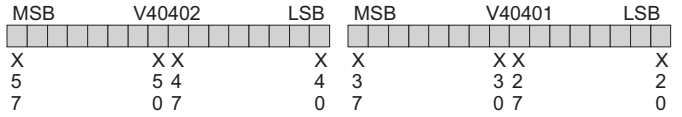
## Special Placement Requirements (D2-230 and Remote I/O Bases)

It is important to examine the configuration if a D2-230 CPU is being used. As can be seen in the section on Writing the Control Program, V-memory locations are used to manage the analog data. If the module is placed in a slot so that the input points do not start on a V-memory boundary, the program instructions aren't able to access the data. This also applies when placing this module in a remote base using a D2-RSSS in the CPU slot.

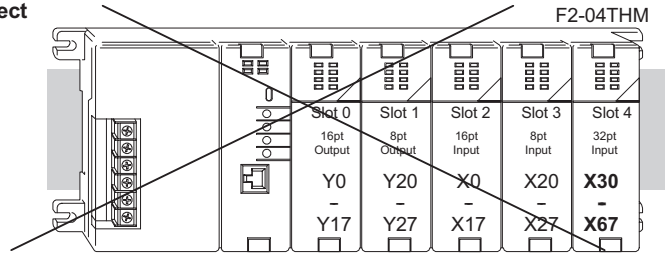
**Correct!**




Data is correctly entered, so input points start on a V-memory boundary address as in the table graphic below.




**Incorrect**




Data is split over three locations, (see graphic below) so instructions cannot access data from a D2-230 CPU.

V-memory references required for a D2-230 CPU, the first input address assigned to the module must be one of the following X locations. The corresponding V-memory addresses for the X locations are shown below.

| ***X*** | X0 | X20 | X40 | X60 | X100 | X120 | X140 | X160 |
|---|---|---|---|---|---|---|---|---|
| ***V*** | V40400 | V40401 | V40402 | V40403 | V40404 | V40405 | V40406 | V40407 |

# Setting the Module Jumpers

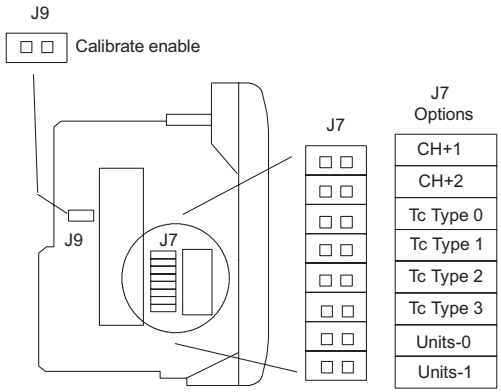
## Jumper Locations

Use the figures below to locate the single jumper (J9) and the bank of eight jumpers (J7) on the PC board. Notice that the PC board was re-designed starting with date code 0806E1 and the jumper locations changed; the functionality of the jumpers did not change. To prevent losing a jumper when it is removed, store it in its original location by sliding one of its sockets over a single pin. The following options can be selected by installing or removing the appropriate jumpers:

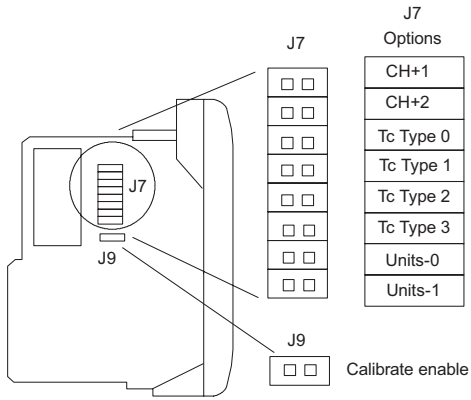
- Number of channels
- Input type
- Conversion unit
- Calibrate enable

## Calibrate Enable

**Jumper locations for modules having date code prior to 0806E1.**




**Jumper locations for modules having date code 0806E1 and later.**




Locate the "Calibrate enable" jumper J9.
The jumper comes from the factory with the jumper removed (the jumper is installed on one of the two pins only). Installing this jumper disables the thermocouple active burn-out detection circuitry, which enables a thermocouple calibrator to be attached to the module.

To be certain that the output of the thermocouple calibrator is within the 5V common mode voltage range of the module, connect the negative side of the differential voltage input channel to the 0V terminal, then connect the thermocouple calibrator to the differential inputs (for example, Ch 3+ and Ch 3).

For the voltage input ranges, this jumper is inactive and can be installed or removed with no effect on voltage input.

## Selecting the Number of Channels

The top two J7 jumpers labeled CH+1 and CH+2 determine the number of channels that will be used. The table shows how to set the jumpers for channels 1 to 4. The module comes with both jumpers installed for four channel operation. For example, to select channels 1 to 3, leave the CH+2 jumper installed and remove the CH+1 jumper. Any unused channels are not processed. For example, if channels 1 to 3 are selected, channel 4 will not be active.

X = jumper installed
Blank space = jumper removed

| Number of Channels | Jumper | |
|---|---|---|
| | CH+1 | CH+2 |
| 1 | – | – |
| 2 | X | – |
| 3 | – | X |
| 4 | X | X |

## Setting Input Type

The next four jumpers, Tc Type 0, Tc Type 1, Tc Type 2, and Tc Type 3, must be set to match either the type of thermocouple being used or the input voltage level. Since the module can be used with many types of thermocouples, use the table below to determine the proper settings for the thermocouple being used.

The module comes from the factory with all four jumpers installed for use with a J type thermocouple. To use a K type thermocouple, remove the jumper labeled Tc Type 0.

***NOTE:*** *All channels of the module must be the same thermocouple type or voltage range.*

X = Jumper installed, and blank space = Jumper removed.

| Thermocouple/ Voltage Inputs | Jumper | | | |
|---|---|---|---|---|
| | Tc Type 0 | Tc Type 1 | Tc Type 2 | Tc Type 3 |
| J | X | X | X | X |
| K | – | X | X | X |
| E | X | – | X | X |
| R | – | – | X | X |
| R Wide* | – | X | – | – |
| S | X | X | – | X |
| T | – | X | – | X |
| B | X | – | – | X |
| N | – | – | – | X |
| C | X | X | X | – |
| 0–5V | – | X | X | – |
| ±5V | X | – | X | – |
| 0–156 mV | – | – | X | – |
| ±156 mV | X | X | – | – |

***NOTE:** R Wide is only available on modules with date code 0410E2 and later.*

## Selecting the Conversion Units

Use the last two jumpers, Units-0 and Units-1, to set the conversion unit used for either thermocouple or voltage inputs. The options are magnitude plus sign or 2's complement, plus Fahrenheit or Celsius for thermocouples. See the next two sections for jumper settings when using either thermocouple or voltage inputs.

## Thermocouple Conversion Units

All thermocouple types are converted into a direct temperature reading in either Fahrenheit or Celsius. The data contains one implied decimal place. For example, a value in V-memory of 1002 would be 100.2°F or °C.

For thermocouple ranges which include negative temperatures (J,E,K,T,N), the display resolution is from -3276.7 to +3276.7. For positive-only thermocouple ranges (R,S,B,C), the display resolution is 0 – 6553.5.

Negative temperatures can be represented in either 2's complement or magnitude plus sign form. If the temperature is negative, the most significant bit in the V-memory location is set (X17, if the starting address for the module is X0).

The 2's complement data format may be required to correctly display bipolar data on some operator interfaces. This data format could also be used to simplify averaging a bipolar signal. To view this data format in DirectSoft, select Signed Decimal.

For unipolar thermocouple ranges (R,S,B,C), it does not matter if magnitude plus sign or 2's complement is selected.

Use the table to select settings. The module comes with both jumpers installed for magnitude plus sign conversion in Fahrenheit. For example, remove the Units-0 jumper and leave the Units-1 jumper installed for magnitude plus sign conversion in Celsius.

**X** = Jumper installed, and

**blank space** = Jumper removed.

| Number of Channels | Temperature Conversion Units | | | |
|---|---|---|---|---|
| | *Magnitude + Sign* | | *2's Compliment* | |
| | *°F* | *°C* | *°F* | *°C* |
| *Units-0* | X | – | X | – |
| *Units-1* | X | X | – | – |

## Voltage Conversion Units

The bipolar voltage input ranges, 5V or 156mV (see previous page for 5V and 156mV settings), may be converted to a 15-bit magnitude plus sign or a 16-bit 2's complement value.

Use the table to select settings. The module comes with both jumpers installed for magnitude plus sign conversion. Remove the Units-1 jumper and leave the Units-0 jumper installed for 2's complement conversion.

**X** = Jumper installed, and
**blank space** = Jumper removed.

| Jumper Pins | Voltage Conversion Units | |
|---|---|---|
| | *Magnitude Plus Sign* | *2's Compliment* |
| *Units-0* | X | X |
| *Units-1* | X | – |

***NOTE:*** *When selecting a Unipolar Voltage mode (0-5V, 0-156mV), BCD data type will not give a correct reading. Decimal data type should always be used for Unipolar Voltage modes.*

# Connecting the Field Wiring

## Wiring Guidelines

Your company may have guidelines for wiring and cable installation. If so, check the guidelines before beginning the installation. Here are some general things to consider:

- Use the shortest wiring route whenever possible.
- Use shielded wiring and ground the shield at the transmitter source. Do not ground the shield at both the module and the source.
- Do not run the signal wiring next to large motors, high current switches, or transformers. This may cause noise problems.
- Route the wiring through an approved cable housing to minimize the risk of accidental damage. Check local and national codes to choose the correct method for your application.

## User Power Supply Requirements

The F2-04THM module requires at least one field-side power supply. The same or separate power sources can be used for the 0–5 V or 0–156 mV transmitter voltage supply. The module requires 10–30 VDC, at 40mA, from the external power supply.

The DL205 AC bases have a built-in 24VDC power supply that provide up to 300mA of current. This can be used instead of a separate supply. Check the power budget to be safe.

It is desirable in some situations to power the transmitters separately in a location remote from the PLC. This will work as long as the transmitter supply meets the voltage and current requirements, and the transmitter's minus (-) side and the module supply's minus (-) side are connected together.

**WARNING: If the internal 24VDC power budget is exceeded, it may cause unpredictable system operation that can lead to a risk of personal injury or equipment damage.**

The DL205 base has a switching type power supply. As a result of switching, noise may cause some instability into the analog input data if the base power supply is used. If this is unacceptable, try one of the following:

1. Use a separate linear power supply.
2. Connect the 24VDC common to the frame ground, which is the screw terminal marked "G" on the base.

Unused temperature inputs should be shorted together and connected to common.

## Thermocouples

Use shielded thermocouples whenever possible to minimize the presence of noise on the thermocouple wire. Ground the shield wire at one end only. For grounded thermocouples, connect the shield at the sensor end. For ungrounded thermocouples, connect the shield to the 0V (common) terminal.

Grounded Thermocouple Assembly

A grounded thermocouple provides better response time than an ungrounded thermocouple because the tip of the thermocouple junction is in direct contact with the protective case.

Ungrounded Thermocouple Assembly

An ungrounded thermocouple is electrically isolated from the protective case. If the case is electrically grounded it provides a low-impedance path for electrical noise to travel. The ungrounded thermocouple provides a more stable and accurate measurement in a noisy environment.

Exposed Grounded Thermocouple

The thermocouple does not have a protective case and is directly connected to a device with a higher potential. Grounding the thermocouple assures that the thermocouple remains within the common mode specifications. Because a thermocouple is essentially a wire, it provides a low-impedance path for electrical noise. The noise filter has a response of >100dB @ 50/60 Hz.

**WARNING: A thermocouple can become shorted to a high voltage potential. Because common terminals are internally connected together, whatever voltage potential exists on one thermocouple will exist on the other channels.**

## Ambient Variations in Temperature

The F2-04THM module has been designed to operate within the ambient temperature range of 0 to 60°C.

The cold junction compensation is calibrated to operate in a still-air environment. If the module is used in an application that has forced convection cooling, an error of 2 to 3°C may be introduced. To compensate for this, ladder logic can be used to correct the values.

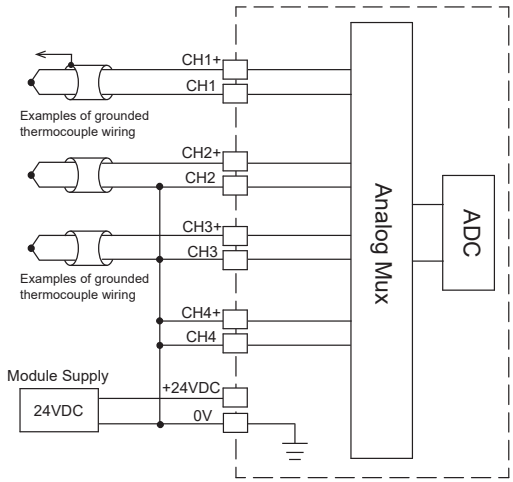
When configuring the system design it is best to locate any heat-producing devices above and away from the PLC chassis because the heat will affect the temperature readings. For example, heat introduced at one end of the terminal block can cause a channel-to-channel variation.

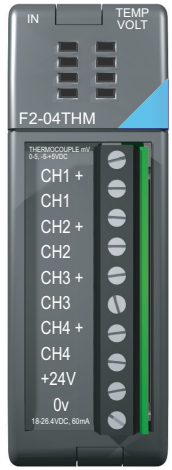
When exposing the F2-04THM module to abrupt ambient temperature changes it will take several minutes for the cold junction compensation and terminal block to stabilize. Errors introduced by abrupt ambient temperature changes will be less than 4°C.

## Wiring Diagrams

Use the following diagrams to connect the field wiring.

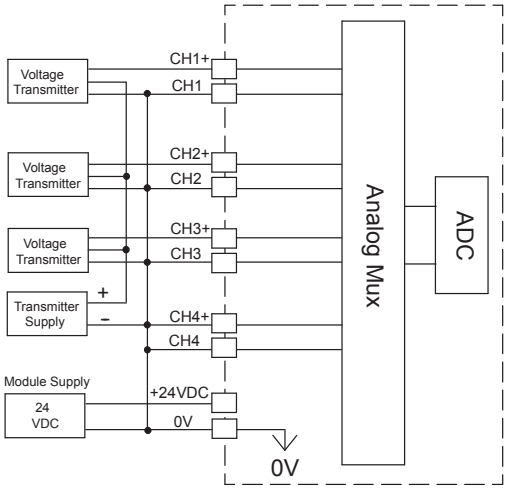
### Thermocouple Input Wiring Diagram

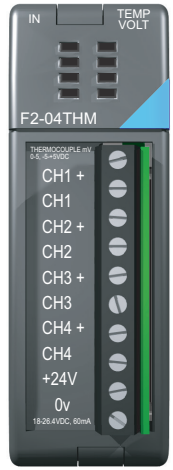



***NOTE:*** *Terminate shields at the respective signal source. Also, connect unused channels to a common terminal (0V, CH4+, CH4).*

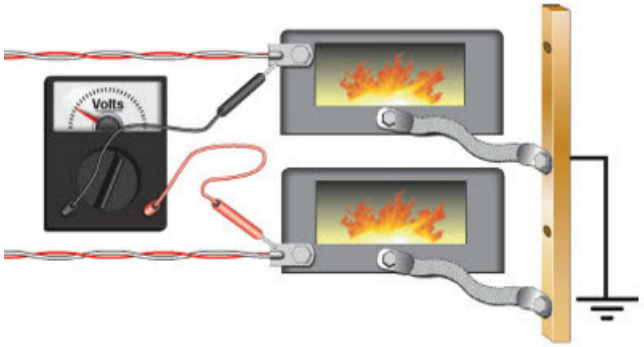
### Voltage Input Wiring Diagram




***NOTE:*** *Connect unused channels to a common terminal (0V, CH4+, CH4). Also, when using 0-156 mV and 5V ranges, connect (-) or 0V terminals (CH1, CH2, CH3, CH4) to 0V module supply terminal to ensure common mode acceptance.*

With grounded thermocouples, take precautions to prevent having a voltage potential between thermocouple tips. A voltage of 1.25V or greater between tips will skew measurements.

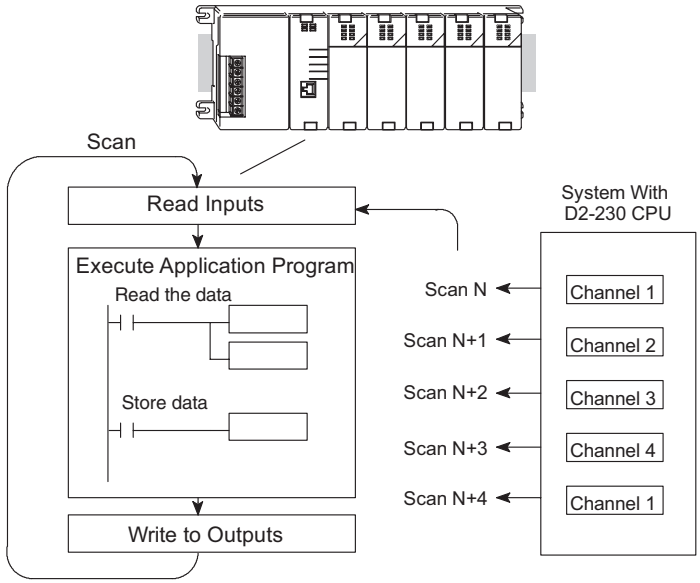


# Module Operation

Before beginning to write the control program, it is important to take a few minutes to understand how the module processes the analog signals.

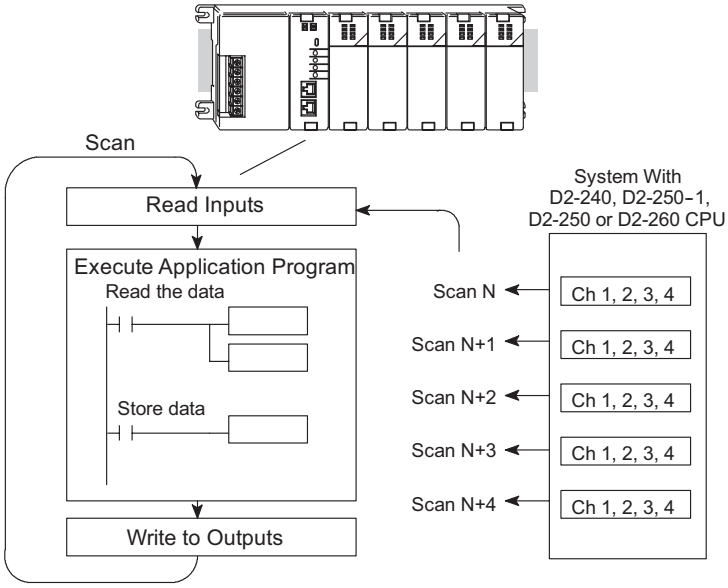
## Channel Scanning Sequence (Multiplexing) for a D2-230 CPU

The F2-04THM module can supply different amounts of data per scan, depending on the type of CPU being used. The D2-230 can obtain one channel of data per CPU scan. Since there are four channels, it can take up to four scans to get data for all channels. Once all channels have been scanned the process starts over with channel 1. Unused channels are not processed, so if only two channels are selected, each channel will be updated every other scan. The multiplexing method can also be used for the D2-240, D2-250-1, D2-260 or D2-262 CPUs.



## Channel Scanning Sequence (Pointer Method) for D2-240, D2-250-1, D2-260 and D2-262 CPUs

If a D2-240, a D2-250-1, a D2-260 or a D2-262 CPU is being used, all four channels of input data can be captured in one scan. This is because the D2-240, D2-250-1, D2-260 and D2-262 CPUs support special V-memory locations that are used to manage the data transfer. This is discussed in more detail in the next section on Writing the Control Program.




## Analog Module Updates

Even though the channel updates to the CPU are synchronous with the CPU scan, the module asynchronously monitors the analog transmitter signal and converts the signal to a 16-bit binary representation. This enables the module to continuously provide accurate measurements without slowing down the discrete control logic in the RLL program.

The time required to sense the temperature and copy the value to V-memory is 1.4 seconds for a single board design module (5.4 seconds for a two board design module) plus 1 scan time maximum.

# Writing the Control Program

## Reading Values Pointer Method and Multiplexing

There are two methods of reading values:

- Pointer method
- Multiplexing

The multiplexing method must be used with a D2-230 CPU. The multiplexing method must also be used with remote I/O modules (the pointer method will not work). Either method can be used with the D2-240, D2-250-1, D2-260 and D2-262 CPUs, but for ease of programming it is highly recommended to use the pointer method.

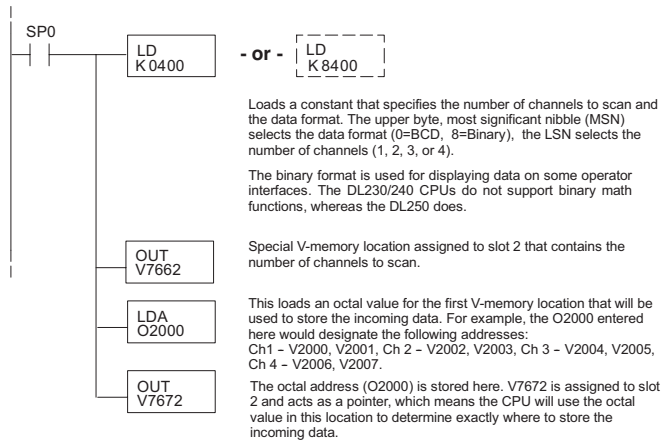
## Pointer Method for the D2-240, D2-250-1, D2-260 and D2-262 CPUs

The CPU has special V-memory locations (shown in tables on the following page) assigned to each base slot that greatly simplifies the programming requirements. These V-memory locations allow you to:

- Specify the data format
- Specify the number of channels to scan
- Specify the storage locations

The example program shows how to setup these locations. Place this rung anywhere in the ladder program, or in the initial stage if stage programming instructions are used. This is all that is required to read the data into V-memory locations. Once the data is in V-memory, math instructions can be used on the data, compare the data against preset values, etc. V2000 is used in the example, but any user V-memory location can be used. The module is installed in slot 2 for the examples. Use the V-memory locations shown in the application. The pointer method automatically converts values to BCD.

***NOTE:*** *D2-240 CPUs with firmware release version 2.5 or later and D2-250 CPUs with firmware release version 1.06 or later support this method. Use the D2-230 multiplexing example if the firmware revision is earlier.*



The following tables show the special V-memory locations used by the D2-240, D2-250-1, D2-260 and D2-262 for the CPU base and local expansion base I/O slots. Slot 0 (zero) is the module next to the CPU or D2-CM module. Slot 1 is the module two places from the CPU or D2-CM, and so on. Remember, the CPU only examines the pointer values at these locations after a mode transition. Also, if the D2-230 (multiplexing) method is used, verify that these addresses in the CPU are 0 (zero).

The Table below applies to the D2-240, D2-250-1, D2-260 and D2-262 CPU base.

| CPU Base: Analog Input Module Slot-Dependent V-memory Locations | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| ***Slot*** | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| ***No. of Channels*** | V7660 | V7661 | V7662 | V7663 | V7664 | V7665 | V7666 | V7667 |
| ***Storage Pointer*** | V7670 | V7671 | V7672 | V7673 | V7674 | V7675 | V7676 | V7677 |

The Table below applies to the D2-250-1, D2-260 and D2-262 CPU base 1.

| Expansion Base D2-CM #1: Analog Input Module Slot-Dependent V-memory Locations | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| ***Slot*** | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| ***No. of Channels*** | V36000 | V36001 | V36002 | V36003 | V36004 | V36005 | V36006 | V36007 |
| ***Storage Pointer*** | V36010 | V36011 | V36012 | V36013 | V36014 | V36015 | V36016 | V36017 |

The Table below applies to the D2-250-1, D2-260 and D2-262 CPU base 2.

| Expansion Base D2-CM #2: Analog Input Module Slot-Dependent V-memory Locations | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| ***Slot*** | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| ***No. of Channels*** | V36100 | V36101 | V36102 | V36103 | V36104 | V36105 | V36106 | V36107 |
| ***Storage Pointer*** | V36110 | V36111 | V36112 | V36113 | V36114 | V36115 | V36116 | V36117 |

The Table below applies to the D2-260 and D2-262 CPU base 3.

| Expansion Base D2-CM #3: Analog Input Module Slot-Dependent V-memory Locations | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| ***Slot*** | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| ***No. of Channels*** | V36200 | V36201 | V36202 | V36203 | V36204 | V36205 | V36206 | V36207 |
| ***Storage Pointer*** | V36210 | V36211 | V36212 | V36213 | V36214 | V36215 | V36216 | V36217 |

The Table below applies to the D2-260 and D2-262 CPU base 4.

| Expansion Base D2-CM #4: Analog Input Module Slot-Dependent V-memory Locations | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| ***Slot*** | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| ***No. of Channels*** | V36300 | V36301 | V36302 | V36303 | V36304 | V36305 | V36306 | V36307 |
| ***Storage Pointer*** | V36310 | V36311 | V36312 | V36313 | V36314 | V36315 | V36316 | V36317 |

## Negative Temperature Readings with Magnitude Plus Sign (Pointer Method) for D2-240, D2-250-1, D2-260 and D2-262 CPUs

With bipolar ranges, some additional logic will be needed to determine whether the value being returned represents a positive voltage or a negative voltage. For example, the direction for a motor might need to be known. There is a solution for this:

- If bipolar ranges are used and a value greater than or equal to 8000hex is obtained, the value is negative.
- If a value less than or equal to 7FFFhex is obtained, then the value is positive.

The sign bit is the most significant bit, which combines 8000hex to the data value. If the value is greater than or equal to 8000hex, only the most significant bit and the active channel bits need to be masked to determine the actual data value.

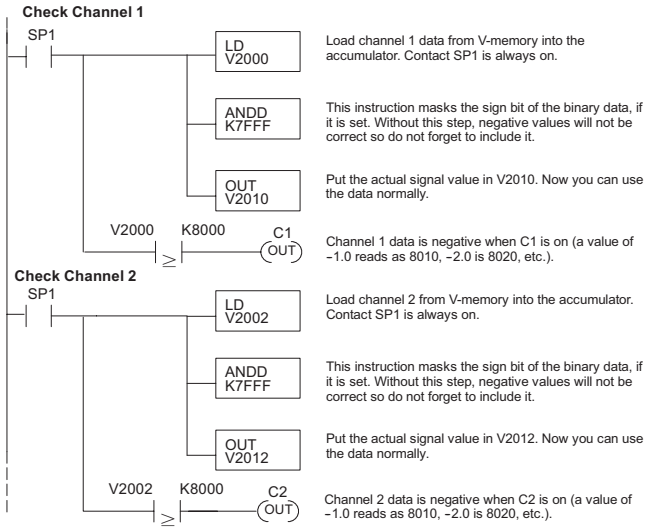
***NOTE:*** *D2-240 CPUs with firmware release version 2.5 or later and D2-250 CPUs with firmware release version 1.06 or later support this method. Use the D2-230 multiplexing example if your firmware is an earlier version.*

The following two programs on this page and the next page show how this can be accomplished. The first example uses magnitude plus sign (binary) and the second example uses magnitude plus sign (BCD). The examples only show two channels.

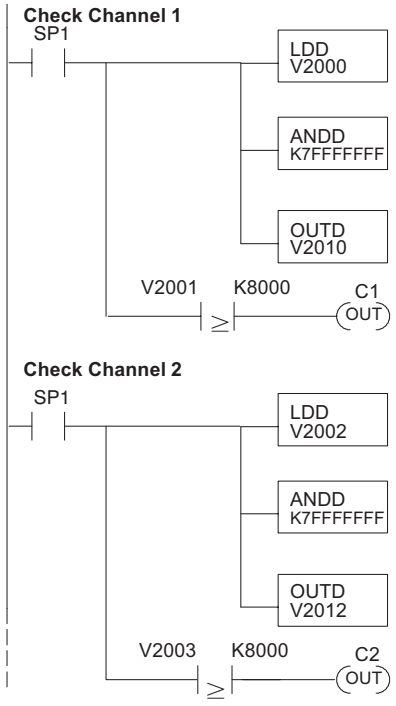
It is good to know when a value is negative, so these rungs should be placed before any other operations that use the data, such as math instructions, scaling operations, etc. Also, if stage programming instructions are being used, these rungs should be in a stage that is always active.

***NOTE:*** *This logic is only needed for each channel that is using bipolar input signals.*

## Magnitude Plus Sign (Binary)



## Magnitude Plus Sign (BCD)




Load channel 1 data from V-memory into the accumulator. Remember, the data can be negative. Contact SP1 is always on.

This instruction masks the sign bit of the BCD data, if it is set. Without this step, negative values will not be correct so do not forget to include it.

Put the actual signal value in V2010. Now you can use the data normally.

Channel 1 data is negative when C1 is on (a value of -1.0 reads as 8000 0010, -2.0 is 8000 0020, etc.).

Load channel 2 from V-memory into the accumulator. Remember, the data can be negative. Contact SP1 is always on.

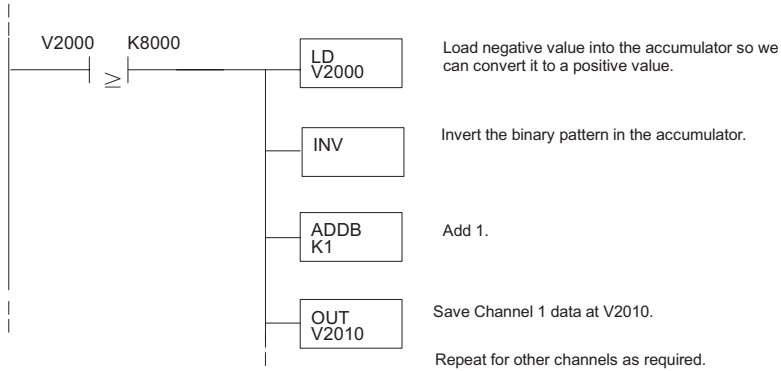
This instruction masks the sign bit of the BCD data, if it is set. Without this step, negative values will not be correct so do not forget to include it.

Put the actual signal value in V2012. Now you can use the data normally.

Channel 2 data is negative when C2 is on (a value of -1.0 reads as 8000 0010, -2.0 is 8000 0020, etc.).

## Negative Temperatures 2's Complement (Binary/Pointer Method) for D2-240, D2-250-1, D2-260 and D2-262 CPUs

The 2's complement mode is used for negative temperature display purposes, while at the same time using the magnitude plus sign of the temperature in a control program. The DirectSoft element Signed Decimal is used to display negative numbers in 2's complement form. To find the absolute value of a negative number in 2's complement, invert the number and add 1 as shown in the following example:

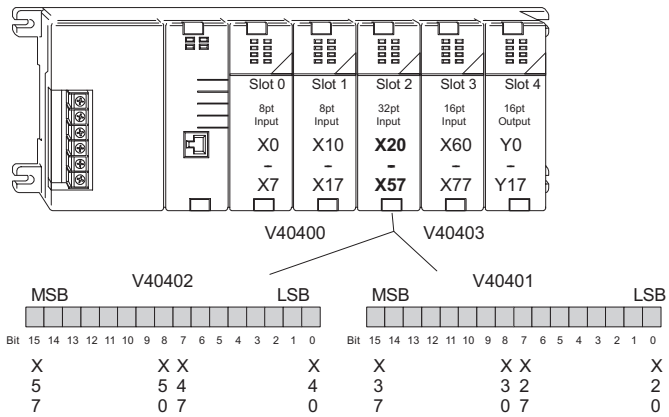



## Understanding the Input Assignments (Multiplexing Ladder Only)

Remember that the F2-04THM module appears as a 32-point discrete input module to the CPU. Use these points to obtain:

- An indication of which channel is active
- The digital representation of the analog signal
- Module diagnostic information

Since all input points are automatically mapped into V-memory, it is easy to determine the location of the data word that will be assigned to the module.



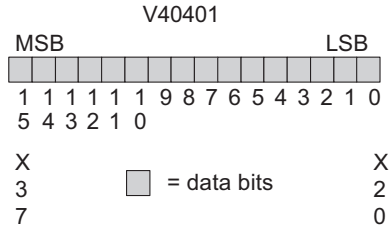
When a D2-230 CPU is used, the input points must start on a V-memory boundary. To use the V-memory references required for a D2-230 CPU, refer to the table below. The first input address assigned to a module must be one of the X inputs shown. The table also shows the V-memory addresses that correspond to these X inputs.

| X | X0 | X20 | X40 | X60 | X100 | X120 | X140 | X160 |
|---|---|---|---|---|---|---|---|---|
| V | V40400 | V40401 | V40402 | V40403 | V40404 | V40405 | V40406 | V40407 |

## Analog Data Bits

The first 16 bits represent the analog data in binary format.

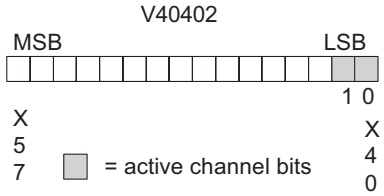
| Bit | Value | Bit | Value |
|---|---|---|---|
| 0 | 1 | 8 | 256 |
| 1 | 2 | 9 | 512 |
| 2 | 4 | 10 | 1024 |
| 3 | 8 | 11 | 2048 |
| 4 | 16 | 12 | 4096 |
| 5 | 32 | 13 | 8192 |
| 6 | 64 | 14 | 16384 |
| 7 | 128 | 15 | 32768 |




## Active Channel Bits

The active channel bits represent the multiplexed channel selections in binary format.

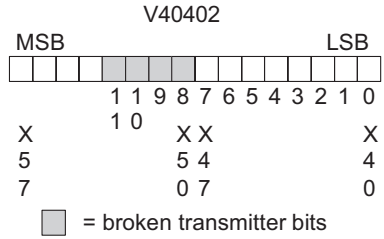
| Bit 1 | Bit 0 | Channel |
|---|---|---|
| 0 | 0 | 1 |
| 0 | 1 | 2 |
| 1 | 0 | 3 |
| 1 | 1 | 4 |




## Broken Transmitter Bits (Pointer and Multiplexing Ladder Methods)

The broken transmitter bits are on when the corresponding RTD is open.

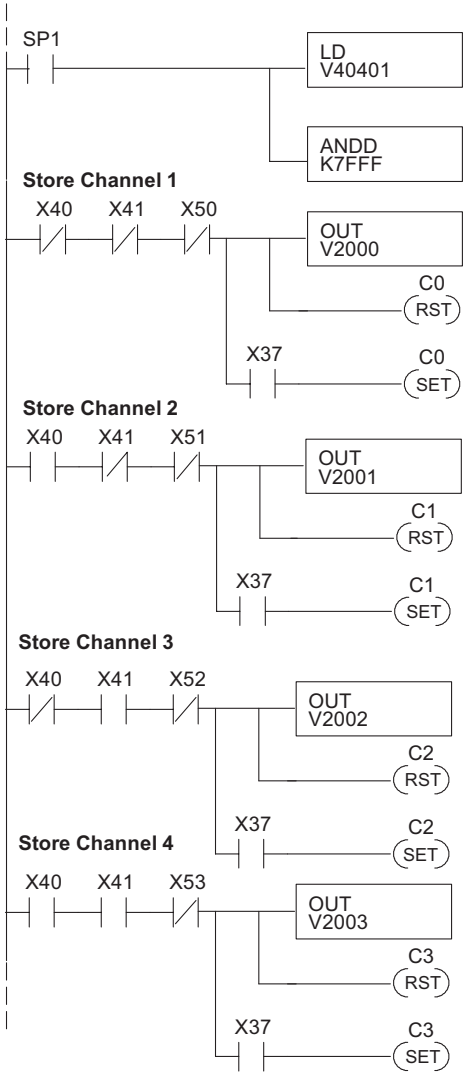
| Bit | Channel |
|---|---|
| 8 | 1 |
| 9 | 2 |
| 10 | 3 |
| 11 | 4 |



## Reading Magnitude Plus Sign Values (Multiplexing)

The D2-230 CPU does not have the special V-memory locations that allows for automatic management of the data transfer. Since all channels are multiplexed into a single data word, the control program must be set up to determine which channel is being read. Since the module appears as X input points to the CPU, it is very easy to use the active channel status bits to determine which channel is being monitored.

***NOTE:*** *D2-230 CPUs with firmware release version 1.6 or later required for multiplexing ladder.*




Loads the complete data word into the accumulator. The V-memory location depends on the I/O configuration. See Appendix A for the memory map.

This instruction masks the sign bit. Without this, the values used will not be correct so do not forget to include it.

When X40, X41, and X50 are off, channel 1 data is stored in V2000. C0 is reset to indicate that channel 1's value is positive.

If X37 is on, the data value represents a negative temperature. C0 is set to indicate that channel 1's value is negative.

When X40 is on and X41 and X51 are off, channel 2 data is stored in V2001. C1 is reset to indicate that channel 2's value is positive.

If X37 is on, the data value represents a negative temperature. C1 is set to indicate that channel 2's value is negative.

When X40 and X52 are off and X41 is on, channel 3 data is stored in V2002. C2 is reset to indicate that channel 3's value is positive.

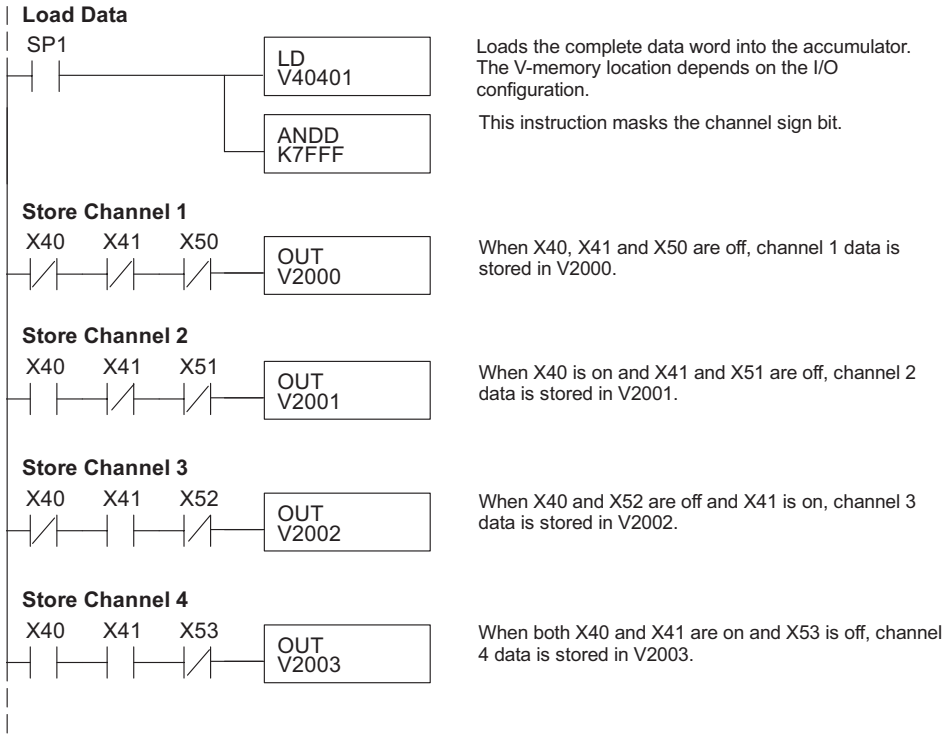
If X37 is on, then the data value represents a negative temperature. C2 is set to indicate that channel 3's value is negative.

When both X40 and X41 are on and X53 is off, channel 4 data is stored in V2003. C3 is reset to indicate that channel 4's value is positive.

If X37 is on, the data value represents a negative temperature. C3 is set to indicate that channel 4's value is negative.

## Reading 2's Compliment Values (Multiplexing)

The D2-230 CPU does not have the special V-memory locations that allows for automatic management of the data transfer. Since all channels are multiplexed into a single data word, the control program must be set up to determine which channel is being read. Since the module appears as X input points to the CPU, it is very easy to use the active channel status bits to determine which channel is being monitored. The 2's complement data format may be required to correctly display bipolar data on some operator interfaces. This data format could also be used to simplify averaging a bipolar signal. To view this data format in DirectSOFT, select Signed Decimal.




## Scaling the Input Data

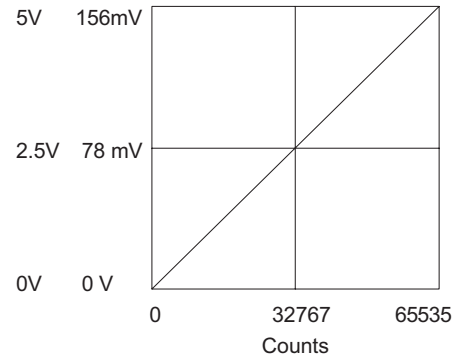
No scaling of the input temperature is required. The readings directly reflect the actual temperatures. For example: a reading of 8482 is 848.2°C, a reading of 16386 is -0.2°C (magnitude plus sign) and a reading of 32770 is -0.2°C (2's complement).

## Module Resolution 16-Bit (Unipolar Voltage Input)

Unipolar analog signals are converted into 65536 counts ranging from 0–65535 (216). For example, with a 0–156mV signal range, 78mV would be 32767. A value of 65535 represents the upper limit of the range.

**H or L = high or low limit of the range**

$$\text{Unipolar Resolution} = \frac{H - L}{65535}$$

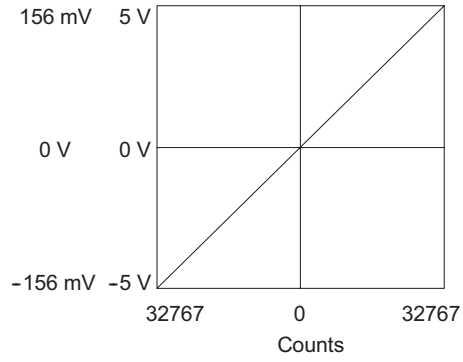



## Module Resolution 15-Bit Plus Sign(Bipolar Voltage Input)

The module has 16-bit unipolar or 15-bit + sign bipolar resolution. Bipolar analog signals are converted into 32768 counts ranging from 0–32767 (215). For example, with a -156mV–156mV signal range, 156mV would be 32767. The bipolar ranges utilize a sign bit to provide 16-bit resolution. A value of 32767 can represent the upper limit of either side of the range. Use the sign bit to determine negative values.

**H or L = high or low limit of the range**

$$\text{Bipolar Resolution} = \frac{H - L}{32767}$$



## Analog and Digital Value Conversions

Sometimes it is useful to be able to quickly convert between the signal levels and the digital values. This is especially helpful during startup or troubleshooting. This module does not operate like other versions of analog input modules. The bipolar ranges use 0–32767 for both positive and negative voltages. The sign bit allows this and it actually provides better resolution than those modules that do not offer a sign bit. The following table provides formulas to make this conversion easier.

| Range | If the digital value is known | If the analog signal level is known. |
|---|---|---|
| ***0–5 V*** | $A = \frac{5D}{65535}$ | $D = \frac{65535}{5}(A)$ |
| ***0–156.25 mV*** | $A = \frac{0.15625D}{65535}$ | $D = \frac{65535}{0.15625}(A)$ |
| ***±5V*** | $A = \frac{10D}{65535}$ | $D = \frac{65535}{10}(A)$ |
| ***±156.25 mV*** | $A = \frac{0.3125D}{65535}$ | $D = \frac{65535}{0.3125}(A)$ |

For example, if the ±5V range is used and the signal is measured at 2.5V, use the following formula to determine the digital value that is stored in the V-memory location that contains the data.

$$D = \frac{65535}{10}(A)$$

$$D = \frac{65535}{10}(2.5V)$$

$$D = 6553.5\ (2.5)$$

$$D = 16383.75$$

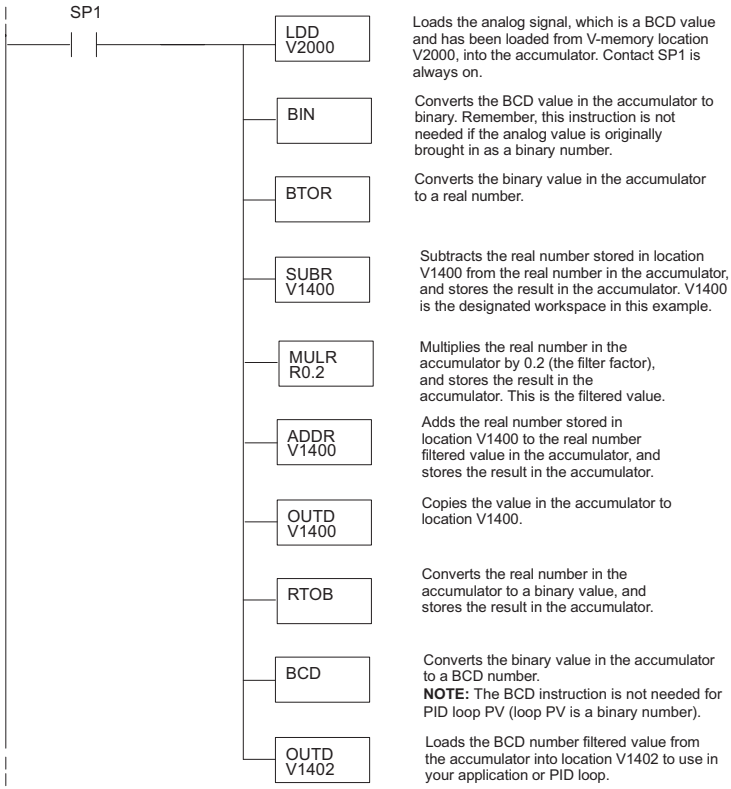
## Filtering Input Noise (D2-250-1, D2-260 and D2-262 CPUs Only)

Add the following logic to filter and smooth analog input noise in D2-250-1, D2-260 and D2-262 CPUs. This is especially useful when using PID loops. Noise can be generated by the field device and/or induced by field wiring.

In the following example, the analog value in BCD is first converted to a binary number. Memory location V1400 is the designated workspace in this example. The MULR instruction is the filter factor, which can be from 0.1–0.9. The example uses 0.2. Using a smaller filter factor increases filtering. A higher precision value can be used, but it is not generally needed. The filtered value is then converted back to binary and then to BCD. The filtered value is stored in location V1402 for use in the application program or a PID loop.

***NOTE:*** *Please review intelligent instructions (IBox) in Chapter 5, which simplify this and other functions. The IBox instructions are supported by the D2-250-1, D2-260 and D2-262.*

***NOTE:*** *Be careful not to do a multiple number conversion on a value. For example, if the pointer method is used to get the analog value, it is in BCD and must be converted to binary. However, if the conventional method of reading analog is used and the first 15 bits are masked, the value is already in binary and no conversion is needed. Also, if the conventional method is used, change the LDD V2000 instruction to LD V2000.*



# F2-02DA-1, F2-02DA-1L 2-Channel Analog Current Output

In This Chapter...

Module Specifications ..... 8-2
Connecting and Disconnecting the Field Wiring ..... 8-5
Module Operation ..... 8-7
Writing the Control Program ..... 8-11

# Module Specifications

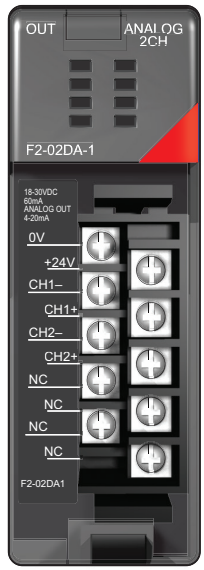
The F2-02DA-1 and F2-02DA-1L Analog Output modules provide several hardware features:

- Analog outputs are optically isolated from the PLC logic.
- The modules have a removable terminal block so the module can be easily removed or changed without disconnecting the wiring.
- Both channels can be updated in one scan when a D2-240, D2-250-1, D2-260 or D2-262 CPU is used in the DL205 PLC.
- F2-02DA-1: Low-power CMOS design requires less than 60mA from an external 24VDC power supply.
- F2-02DA-1L: Low-power CMOS design requires less than 70mA from an external 12VDC power supply.

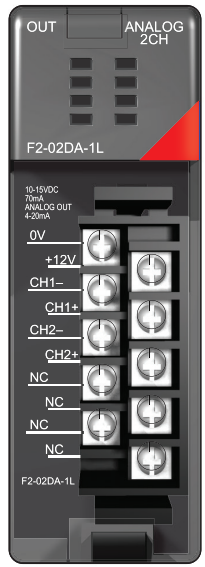
***NOTE:*** *The F2-02DA-1 and F2-02DA-1L modules look very similar and it is very easy to mistake one module for the other. If the module being used does not work, check the terminal label to see if it is a 12V (L) or a 24V model and that it is being supplied with the proper input voltage.*

## Analog Output Configuration Requirements

The F2-02DA-1(L) Analog output module requires 16 discrete output points. The module can be installed in any slot when using a D2-240 (firmware V1.5 or later), D2-250-1, D2-260 or D2-262 CPUs. The available power budget and discrete I/O points are the limiting factors. Check the user manual for the particular model of CPU and I/O base being used for more information regarding power budget and number of local, local expansion or remote I/O points.




F2-02DA-1




F2-02DA-1L

The following tables provide the specifications for the F2-02DA-1 and F2-02DA-1L Analog Output Modules. Review these specifications to make sure the module meets your application requirements.

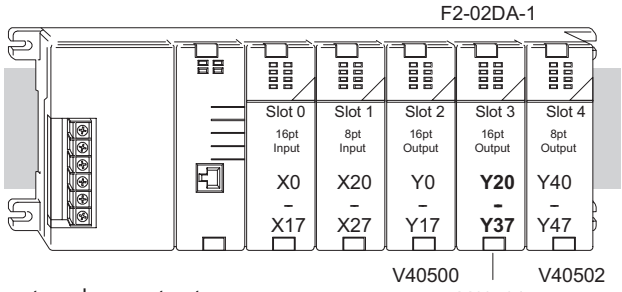
| Output Specifications | |
|---|---|
| ***Number of Channels*** | 2 |
| ***Output Range*** | 4–20 mA |
| ***Resolution*** | 12 bit (1 in 4096) |
| ***Output Type*** | Single ended, 1 common |
| ***Maximum Loop Supply*** | 30VDC |
| ***Peak Output Voltage*** | 40VDC (clamped by transient voltage suppressor) |
| ***Load Impedance*** | 0Ω minimum |
| ***Maximum Load / Power Supply*** | 620Ω / 18V, 910Ω / 24V, 1200Ω / 30V |
| ***Linearity Error (end to end)*** | ±1 count (±0.025% of full scale) maximum |
| ***Conversion Settling Time*** | 100µs maximum (full scale change) |
| ***Full-scale Calibration Error (offset error included)*** | ±5 counts maximum, 20mA @ 25°C (77°F) |
| ***Offset Calibration Error*** | ±3 counts maximum, 4mA @ 25°C (77°F) |
| ***Maximum Inaccuracy*** | 0.1% @ 25°C (77°F)<br>0.3% @ 0–60°C (32–140°F) |
| ***Accuracy vs. Temperature*** | ±50ppm /°C full scale calibration change;<br>(including maximum offset change of 2 counts) |

| General Specifications | |
|---|---|
| ***PLC Update Rate*** | 1 channel per scan maximum (D2-230 CPU)<br>2 channels per scan maximum<br>(D2-240, D2-250-1, D2-260 and D2-262 CPUs) |
| ***Digital Outputs Output Points Required*** | 12 binary data bits, 2 channel ID bits<br>16 (Y) output points required |
| ***Power Budget Requirement*** | 40mA @ 5VDC (supplied by the base) |
| ***External Power Supply*** | F2-02DA-1: 12–30 VDC (±10%), 60mA<br>F2-02DA-1L: 12VDC (±10%), 70mA<br>(add 20mA for each current loop used) |
| ***Operating Temperature*** | 0–60°C (32–140°F) |
| ***Storage Temperature*** | -20°C to 70°C (-4°F to 158°F) |
| ***Relative Humidity*** | 5–95% (non-condensing) |
| ***Environmental air*** | No corrosive gases permitted |
| ***Vibration*** | MIL STD 810C 514.2 |
| ***Shock*** | MIL STD 810C 516.2 |
| ***Noise Immunity*** | NEMA ICS3-304 |

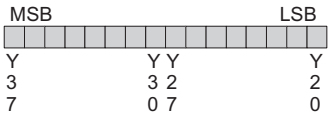
## Special Placement Requirements (D2-230 and Remote I/O Bases)

It is important to examine the configuration if a D2-230 CPU is being used. As can be seen in the section on Writing the Control Program in this chapter, V-memory locations are used to hold the analog data that will be written to the output. If the module is placed in a slot so that the output points do not start on a V-memory boundary, the program instructions aren't able to access the data. This also applies when placing this module in a remote base using a D2-RSSS in the CPU slot.

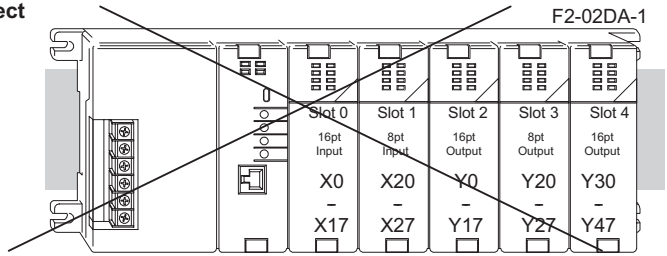
**Correct!**



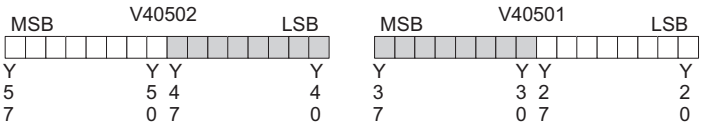

Data is correctly entered, so output points start on a V-memory boundary address from the table below.




**Incorrect**




Data is split over three locations, so instructions cannot access data from a D2-230.




To use the V-memory references required for a D2-230 CPU, the first output address assigned to the module must be one of the following Y locations. The table also shows the V-memory addresses that correspond to these Y locations.

| ***X*** | Y0 | Y20 | Y40 | Y60 | Y100 | Y120 | Y140 | Y160 |
|---|---|---|---|---|---|---|---|---|
| ***V*** | V40500 | V40501 | V40502 | V40503 | V40504 | V40505 | V40506 | V40507 |

# Connecting and Disconnecting the Field Wiring

## Wiring Guidelines

Your company may have guidelines for wiring and cable installation. If so, check the guidelines before beginning the installation. Here are some general things to consider:

- Use the shortest wiring route whenever possible.
- Use shielded wiring and ground the shield at the transmitter source. Do not ground the shield at both the module and the source.
- Do not run the signal wiring next to large motors, high current switches, or transformers. This may cause noise problems.
- Route the wiring through an approved cable housing to minimize the risk of accidental damage. Check local and national codes to choose the correct method for your application.

## User Power Supply Requirements

The F2-02DA-1 (L) module requires at least one field-side power supply. The same or separate power sources can be used for the module supply and the current transmitter supply. The F2-02DA-1 module requires 18–30 VDC, at 60mA and the F2-02DA-1L module requires 12–15 VDC, at 70mA, from the external power supply.

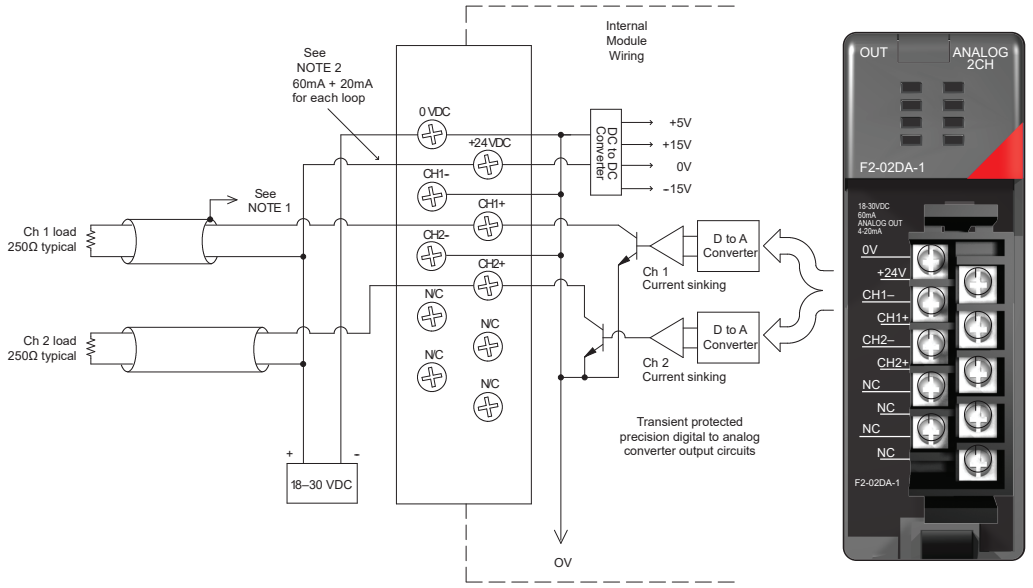
The DL205 AC bases have a built-in 24VDC power supply that provide up to 300mA of current. This can be used instead of a separate supply. Check the power budget to be safe.

It is desirable in some situations to power the transmitters separately in a location remote from the PLC. This will work as long as the transmitter supply meets the voltage and current requirements, and the transmitter negative (-) side and the module power supply negative (-) side are connected together.

**WARNING: If the internal 24VDC power budget is exceeded, it may cause unpredictable system operation that can lead to a risk of personal injury or equipment damage.**

## Wiring Diagram

The F2-02DA-1(L) module has a removable connector which helps to simplify wiring. Just squeeze the top and bottom retaining clips and gently pull the connector from the module. Use the following diagram to connect field wiring to a F2-02DA-1. Wiring for a F2-02DA-1L is similar except it uses a 12-15 VDC power source.




***NOTE** 1: Shields should be connected to the 0V terminal of the module or 0V of the power supply.*
***NOTE 2:** This is 70mA + 20mAonly for the F2-02DA-1L.*

## Load Range

The maximum load resistance depends on the particular loop power supply being used.

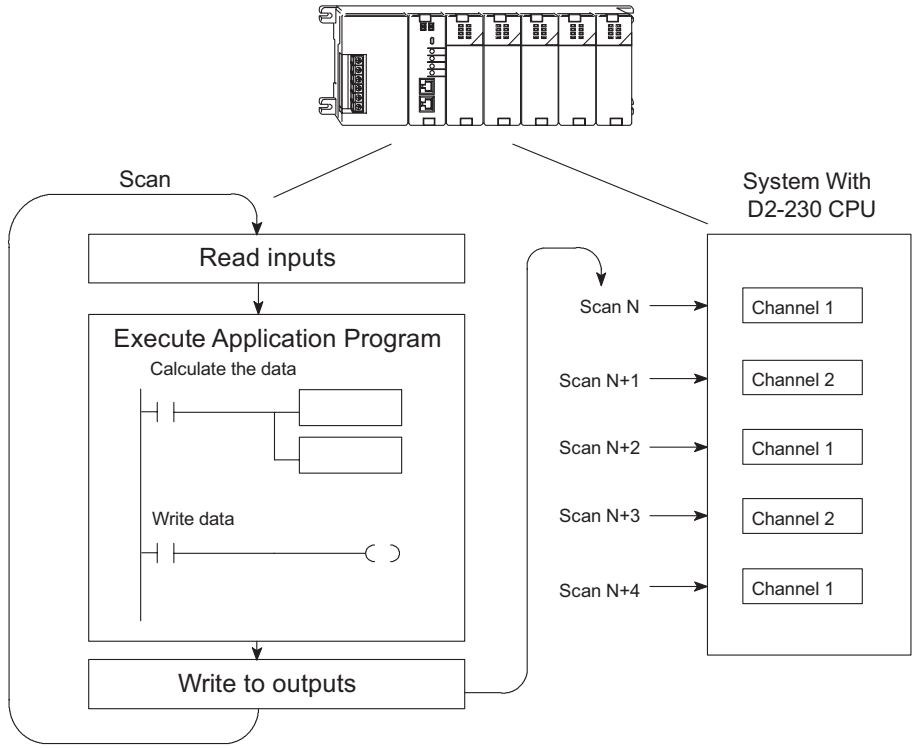
| Loop Power Supply Voltage | Acceptable Load Range |
|---|---|
| 30VDC | 0–1200 Ω |
| 24VDC | 0–910 Ω |
| 18VDC | 0–620 Ω |

# Module Operation

Before beginning to write the control program, it is important to take a few minutes to understand how the module processes the analog signals.

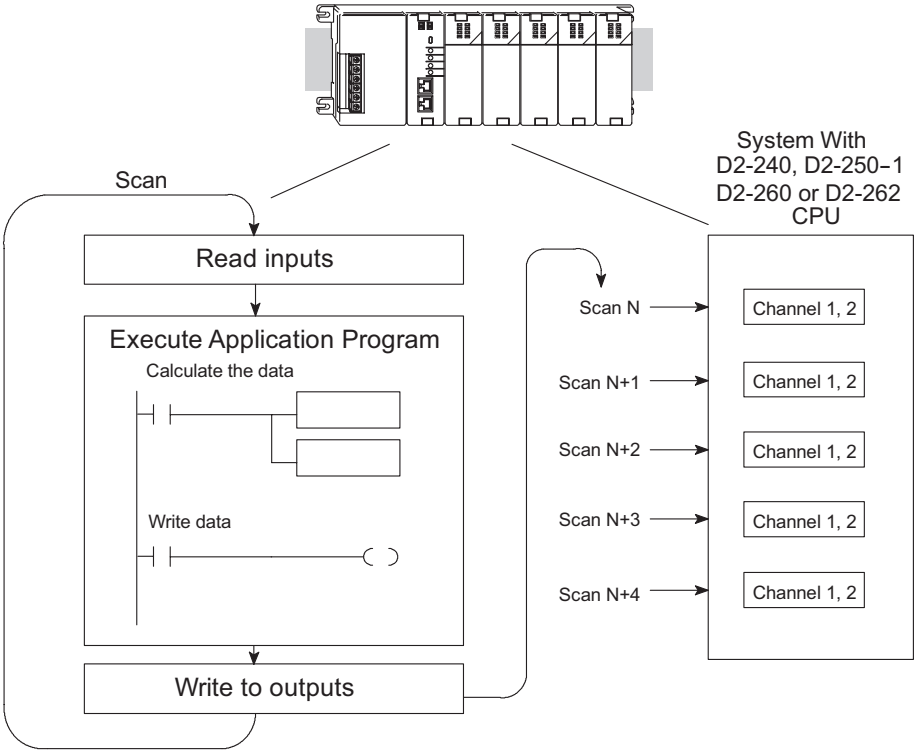
## Channel Scanning Sequence (Multiplexing) for a D2-230 CPU

The D2-230 can send one channel of data per CPU scan. The module refreshes two field devices on each scan, but new data can only be obtained from the CPU at the rate of one channel per scan. Since there are two channels, it can take two scans to update both channels. However, if only one channel is being used, then that channel will be updated on every scan. The multiplexing method can also be used for the D2-240, D2-250-1, D2-260 and D2-262 CPUs.



## Channel Scanning Sequence (Pointer Method) for D2-240, D2-250-1, D2-260 and D2-262 CPUs

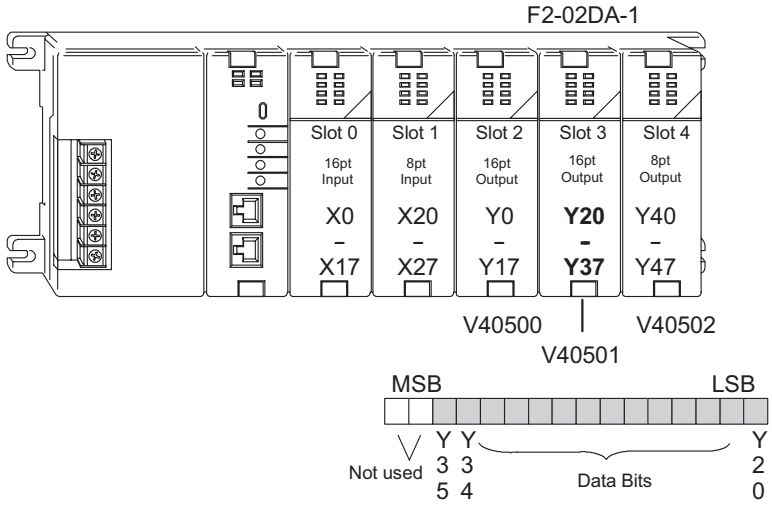
If either a D2-240, D2-250-1, D2-260 or D2-262 CPU is used, both channels can be updated on every scan. This is because the all three CPUs support special V-memory locations that are used to manage the data transfer. This is discussed in more detail in the next section in this chapter on Writing the Control Program.



## Understanding the Output Assignments

Remember that the F2-02DA-1 (L) module appears to the CPU as a 16-point discrete output module. These points provide the data value and an indication of which channel to update. Note, if either a D2-240, D2-250-1, D2-260 or a D2-262 CPU is being used, these bits may never have to be used, but it may be an aid to help understand the data format.

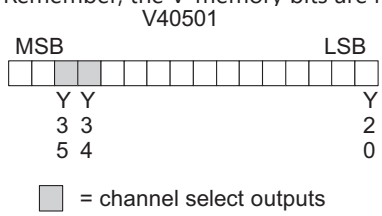
Since all output points are automatically mapped into V-memory, the location of the data word that will be assigned to the module can be simply determined.




The individual bits in this data word location, represents specific information about the analog signal.

## Channel Select Outputs

Two of the outputs select the active channel. Remember, the V-memory bits are mapped directly to discrete outputs. Turning a bit OFF selects its channel. By controlling these outputs, the channel(s) to be updated can be selected.

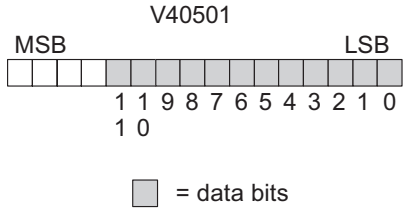



| Y35 | Y34 | Channel |
|---|---|---|
| On | Off | 1 |
| Off | On | 2 |
| Off | Off | 1 & 2 (same data to both channels) |
| On | On | None (both channels hold current values) |

## Analog Data Bits

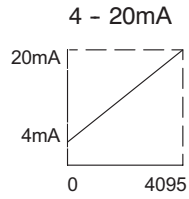
The first twelve bits represent the analog data in binary format.

| Bit | Value | Bit | Value |
|---|---|---|---|
| 0 | 1 | 6 | 64 |
| 1 | 2 | 7 | 128 |
| 2 | 4 | 8 | 256 |
| 3 | 8 | 9 | 512 |
| 4 | 16 | 10 | 1024 |
| 5 | 32 | 11 | 2048 |




## Module Resolution

Since the module has 12-bit resolution, the analog signal is converted into 4096 counts ranging from 0–4095 (212). For example, send a 0 to get a 4mA signal and 4095 to get a 20mA signal. This is equivalent to a binary value of 0000 0000 0000 to 1111 1111 1111, or 000 to FFF hexadecimal. The diagram shows how this relates to the signal range. Each count can also be expressed in terms of the signal level by using the equation shown.




$$\text{Resolution} = \frac{H - L}{4095}$$

H = high limit of the signal range

L = low limit of the signal range

16mA / 4095 = 3.907µA per count

# Writing the Control Program

## Writing Values: Pointer Method and Multiplexing

There are two methods which can be used to write values from the CPU to the module:

- The pointer method
- Multiplexing

The multiplexing method must be used when using a D2-230 CPU. The multiplexing method must also be used with remote I/O modules (the pointer method will not work). Either method can be used with the D2-240, D2-250-1, D2-260 and D2-262 CPUs, however, the pointer method will simplify programming the PLC.

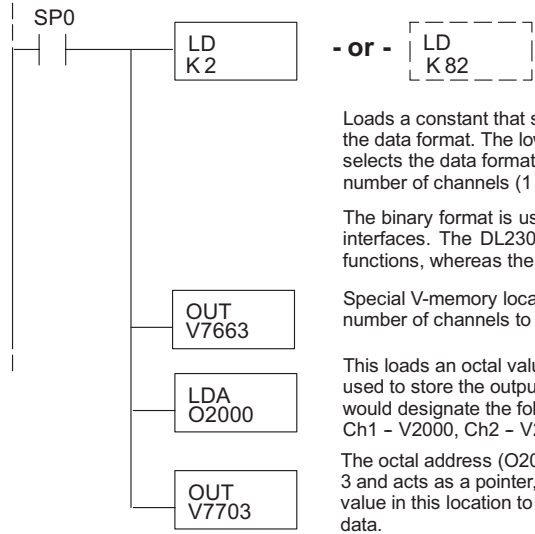
## Pointer Method for the D2-240, D2-250-1, D2-260 and D2-262 CPUs

The D2-240, D2-250-1, D2-260 and D2-262 CPUs have special V-memory locations assigned to each base slot that will greatly simplify the programming requirements. These V-memory locations allow you to:

- Specify the data format
- Specify the number of channels to scan
- Specify the location of the data that will be written to the module

***NOTE:*** *D2-240 CPUs with firmware release version 1.5 or later and. D2-250 CPUs with firmware release version 1.06 or later support this method.*

The following example program shows how to setup these locations. Place this rung anywhere in the ladder program, or in the initial stage if stage programming instructions are being used. V2000 is used in the example but any user V-memory location can be used. In this example the module is installed in slot 3. Be sure to use the V-memory locations for the module placement. The pointer method automatically converts values to BCD




Loads a constant that specifies the number of channels to scan and the data format. The lower byte, most significant nibble (MSN) selects the data format (i.e. 0=BCD, 8=Binary), the LSN selects the number of channels (1 or 2).

The binary format is used for displaying data on some operator interfaces. The DL230/240 CPUs do not support binary math functions, whereas the DL250 does.

Special V-memory location assigned to slot 3 that contains the number of channels to scan.

This loads an octal value for the first V-memory location that will be used to store the output data. For example, the O2000 entered here would designate the following addresses.
Ch1 – V2000, Ch2 – V2001

The octal address (O2000) is stored here. V7703 is assigned to slot 3 and acts as a pointer, which means the CPU will use the octal value in this location to determine exactly where to store the output data.

The following tables show the special V-memory locations used by the D2-240, D2-250-1, D2-260 and D2-262 for the CPU base and local expansion base I/O slots. Slot 0 (zero) is the module next to the CPU or D2-CM module. Slot 1 is the module two places from the CPU or D2-CM, and so on. Remember, the CPU only examines the pointer values at these locations after a mode transition. Also, if the D2-230 (multiplexing) method is used, verify that these addresses in the CPU are 0 (zero).

The table below applies to the D2-240, D2-250-1, D2-260 and D2-262 CPU base.

| CPU Base: Analog Input Module Slot-Dependent V-memory Locations | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| ***Slot*** | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| ***No. of Channels*** | V7660 | V7661 | V7662 | V7663 | V7664 | V7665 | V7666 | V7667 |
| ***Storage Pointer*** | V7700 | V7701 | V7702 | V7703 | V7704 | V7705 | V7706 | V7707 |

The table below applies to the D2-250-1, D2-260 or D2-262 CPU base 1.

| Expansion Base D2-CM #1: Analog Input Module Slot-Dependent V-memory Locations | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| ***Slot*** | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| ***No. of Channels*** | V36000 | V36001 | V36002 | V36003 | V36004 | V36005 | V36006 | V36007 |
| ***Storage Pointer*** | V36020 | V36021 | V36022 | V36023 | V36024 | V36025 | V36026 | V36027 |

The table below applies to the D2-250-1, D2-260 or D2-262 CPU base 2.

| Expansion Base D2-CM #2: Analog Input Module Slot-Dependent V-memory Locations | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| ***Slot*** | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| ***No. of Channels*** | V36100 | V36101 | V36102 | V36103 | V36104 | V36105 | V36106 | V36107 |
| ***Storage Pointer*** | V36120 | V36121 | V36122 | V36123 | V36124 | V36125 | V36126 | V36127 |

The table below applies to the D2-260 and D2-262 CPU base 3.

| Expansion Base D2-CM #3: Analog Input Module Slot-Dependent V-memory Locations | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| ***Slot*** | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| ***No. of Channels*** | V36200 | V36201 | V36202 | V36203 | V36204 | V36205 | V36206 | V36207 |
| ***Storage Pointer*** | V36220 | V36221 | V36222 | V36223 | V36224 | V36225 | V36226 | V36227 |

The table below applies to the D2-260 and D2-262 CPU base 4.

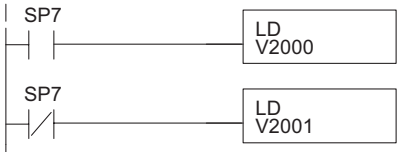
| Expansion Base D2-CM #4: Analog Input Module Slot-Dependent V-memory Locations | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| ***Slot*** | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| ***No. of Channels*** | V36300 | V36301 | V36302 | V36303 | V36304 | V36305 | V36306 | V36307 |
| ***Storage Pointer*** | V36320 | V36321 | V36322 | V36323 | V36324 | V36325 | V36326 | V36327 |

## Writing Data (Multiplexing)

The D2-230 CPU does not have the special V-memory locations that allows for automatic management of data transfer. Since all channels are multiplexed into a single data word, the control program must be written in such a way to determine which channel to write the data to. Since the module appears as Y output points to the CPU, it is very easy to use the channel selection outputs to determine which channel to update.

The following example is for a module installed as shown in the previous examples. The addresses used would be different if the module were located in a different slot. These rungs can be placed anywhere in the user program or, if using stage programming, placed in an active stage. This example is a two-channel multiplexer that updates each channel on alternate scans. Relay SP7 is a special relay that is on for one scan, then off for one scan.

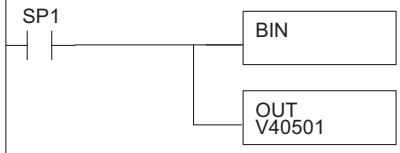
**Load data into the accumulator.**




Loads the data for channel 1 into the accumulator.

Loads the data for channel 2 into the accumulator.

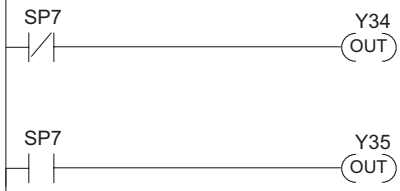
**Send data to V-memory assigned to the module.**




Convert the data to binary (omit this this step if data is already in binary).
SP1 is always on.

The OUT instruction writes the data to the module. Our example starts with V40501, but the actual value depends on the location of the module in your application.

**Select the channel to update.**



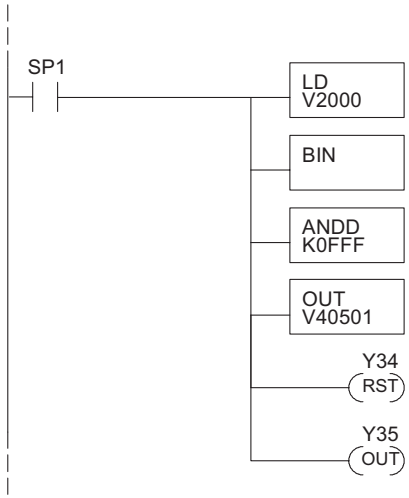

Selects channel 1 for update when Y34 is OFF (Y35–ON deselects channel 2). Note, Y34 and Y35 are used as in the previous examples. If the module was installed in a different slot the addresses would be different.

Selects channel 2 for update when Y35 is OFF (Y34–ON deselects channel 1). Note, Y34 and Y35 are used as in the previous examples. If the module was installed in a different slot the addresses would be different.

***NOTE:*** *Use binary data to write to the module outputs. Do not use a BIN instruction if the data is already in binary format.*

## Write Data to One Channel

The following example can be used if only one channel is to be written to, or if the outputs are to be controlled individually. In this example data is written to output channel 1.




The LD instruction loads the data into the accumulator. Since SP1 is used, this rung automatically executes on every scan. Permissive contacts X, C, etc. could also be used.

The BIN instruction converts the accumulator data to binary (omit this step a if is already in binary format).

This AND Double instruction logically ANDs the accumulator with the constant FFF. It keeps the data from affecting channel select bits.

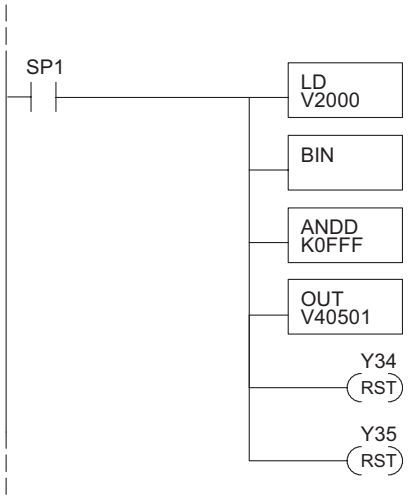
The OUT instruction writes the data to the module output. This example starts with V40501, but the actual value depends on the location of the module in your application.

Y34–OFF selects channel 1 for updating.

Y35–ON deselects channel 2 (do not update).

## Write Data to Both Channels

In the example below, if both selected channels are off, they will be updated with the same data.




The LD instruction loads the data into the accumulator. Since SP1 is used, this rung automatically executes on every scan. Permissive contacts X, C, etc. could also be used.

The BIN instruction converts the accumulator data to binary (omit this step a if is already in binary format).

This AND Double instruction logically ANDs the accumulator with the constant FFF. It keeps the data from affecting channel select bits.

The OUT instruction writes the data to the module output. This example starts with V40501, but the actual value depends on the location of the module in your application.

Y34–OFF selects channel 1 for updating.

Y35–OFF selects channel 2 for updating.

## Calculating the Digital Value

The control program must calculate the digital value that is sent to the analog output. Several methods can be used to do this, but the best method is to convert the values to engineering units. This is accomplished by using the formula shown.

Adjustments may have to be made to the formula depending on the scale of the engineering units.

Consider the following example which controls pressure from 0.0 – 99.9 PSI. To calculate the digital value, use the formula. The result will be sent to the analog output. The example shows the conversion required to yield 49.4 PSI. The multiplier of 10 is used because the decimal portion of 49.4 cannot be loaded in the program, so it is shifted right one decimal place to make a usable value of 494.

$$A = U\frac{4095}{H-L}$$

A = Analog Value (0 – 4095)

U = Engineering Units

H = High limit of the engineering unit range

L = Low limit of the engineering unit range

$$A = 10U\frac{4095}{10(H-L)}$$

$$A = 494\frac{4095}{1000-0}$$

$$A = 2023$$

## Analog and Digital Value Conversions

It is sometimes useful to do quick conversions between the signal levels and the digital values. This can be helpful during startup or troubleshooting. The following table shows some formulas to help with the conversions.

| Range | If the digital value is known | If the analog signal level is known. |
|---|---|---|
| ***4–20 mA*** | $A = \frac{16D}{4095} + 4$ | $D = \frac{4095}{16}(A\ 4)$ |

For example, to convert a 10mA signal level to a digital value, in the above equation substitute 10 for A and complete the math as shown in the example to the right.

$$D = \frac{4095}{16}(A-4)$$

$$D = \frac{4095}{16}(10mA-4)$$

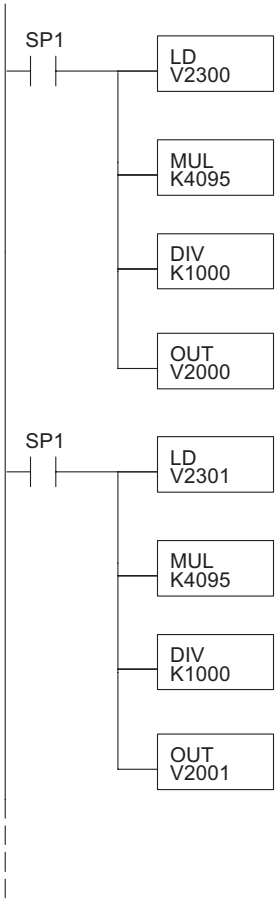
$$D = (255.93)(6)$$

$$D = 1536$$

## The Conversion Program

The example program shows how to write the program to perform the engineering unit conversion. This example assumes that a BCD value has been stored in V2300 and V2301 for channels 1 and 2 respectively.

***NOTE**: The DL205 has many instructions available so that math operations can be performed simply using BCD format. Do the math in BCD, then convert to binary before writing to the module output.*




The LD instruction loads the engineering units used for channel 1 to the accumulator. This example assumes the numbers are BCD. Since SP1 is used, this rung automatically executes on every scan. A permissive contact, such as, an X, C, etc. can also be used.

Multiply the accumulator by 4095 (to start the conversion).

Divide the accumulator by 1000 (because a multiplier of 10 was used, 1000 is used instead of 100).

Store the BCD result in V2000 (the actual steps to write the data were shown earlier).

The LD instruction loads the engineering units used for channel 2 to the accumulator. This example assumes the numbers are BCD. Since SP1 is used, this rung automatically executes on every scan. A permissive contact, such as, an X, C, etc. can also be used.

Multiply the accumulator by 4095 (to start the conversion).

Divide the accumulator by 1000 (because a multiplier of 10 was used, 1000 is used instead of 100).

Store the BCD result in V2001 (the actual steps to write the data were shown earlier).

# F2-02DA-2, F2-02DA-2L* 2-Channel Analog Voltage Output

## In This Chapter...

Module Specifications ..... 9-2
Setting the Module Jumpers ..... 9-5
Connecting and Disconnecting the Field Wiring ..... 9-8
Module Operation ..... 9-10
Writing the Control Program ..... 9-15

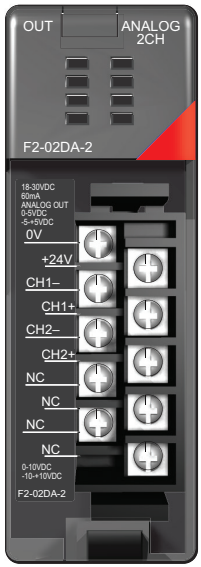
***NOTE:** The F2-02DA-2L module has been discontinued. Please consider F2-02DA-2 as a replacement.*

# Module Specifications

The F2-02DA-2 and *F2-02DA-2L Analog Output modules provide several hardware features:

- Analog outputs are optically isolated from the PLC logic.
- The modules have a removable terminal block so the module can be easily removed or changed without disconnecting the wiring.
- Both channels can be updated in one scan if either a D2-240, a D2-250-1, a D2-260 or a D2-262 CPU is used in the PLC.
- F2-02DA-2: Low-power CMOS design requires less than 60mA from an external 24VDC power supply.
- *F2-02DA-2L: Low-power CMOS design requires less than 70mA from an external 12VDC power supply.
- Outputs can be independently configured for any of the following ranges:

  1. 0–5 VDC
  2. 0–10 VDC
  3. ±5VDC
  4. ±10VDC

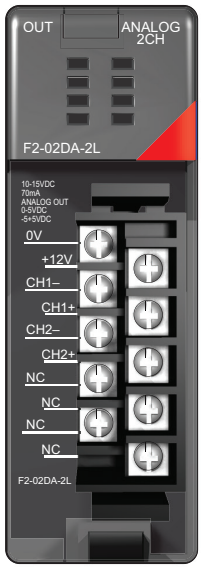



F2-02DA-2

***NOTE:*** *The F2-02DA-2 and F2-02DA-2L modules look very similar and it is very easy to mistake one module for the other. If the module being used does not work, check the terminal label to see if it is a 12V (L) or a 24V model and that it is being supplied with the proper input voltage.*

## Analog Output Configuration Requirements

The F2-02DA-2(L) analog output module requires 16 discrete output points. The module can be installed in any slot of a DL205 PLC, but the available power budget and discrete I/O points are the limiting factors. Check the DL205 PLC User Manual for the particular model of CPU and I/O base being used for information regarding power budget and number of local, local expansion or remote I/O points.




*F2-02DA-2L

***NOTE**: The F2-02DA-2L module has been discontinued. Please consider F2-02DA-2 as a replacement.*

The following tables provide the specifications for the F2–02DA –2 and *F2-02DA-2L Analog Output Modules.

| Output Specifications | |
|---|---|
| ***Number of Channels*** | 2 |
| ***Output Range*** | 0–5V, 0–10V, ±5V, ±10V |
| ***Resolution*** | 12 bit (1 in 4096) |
| ***Output Type*** | Single ended, 1 common |
| ***Peak Output Voltage*** | 15VDC (clamped by transient voltage suppressor) |
| ***Load Impedance*** | 2000Ω minimum |
| ***Load Capacitance*** | 0.01 µF maximum |
| ***Linearity Error (end to end)*** | ±1 count (±0.025% of full scale) maximum |
| ***Conversion Settling Time*** | 5µs maximum (full scale change) |
| ***Full-scale Calibration Error (offset error included)*** | ±12 counts maximum, @ 25°C (77°F) unipolar<br>±16 counts maximum, @ 25°C (77°F) bipolar |
| ***Offset Calibration Error*** | ±3 counts maximum, @ 25°C (77°F) unipolar<br>±8 counts maximum, @ 25°C (77°F) bipolar |
| ***Maximum Inaccuracy*** | Unipolar ranges ± 0.3% @ 25°C (77°F)<br>± 0.45% 0–60°C (32–140°F)<br>Bipolar ranges ± 0.4% @ 25°C (77°F)<br>± 0.55% 0–60°C (32–140°F) |
| ***Accuracy vs. Temperature*** | ±50ppm/°C full scale calibration change;<br>(including maximum offset change of 2 counts) |

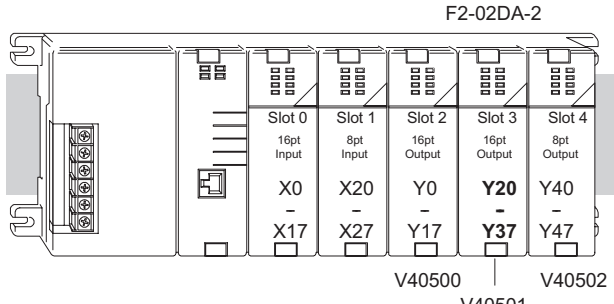
| General Specifications | |
|---|---|
| ***PLC Update Rate*** | 1 channel per scan maximum (D2-230 CPU)<br>2 channels per scan maximum<br>(D2-240, D2-250-1, D2-260 and D2-262 CPUs) |
| ***Digital Outputs Output Points Required*** | 12 binary data bits, 2 channel ID bits, 1 sign bit<br>16 point (Y) output module |
| ***Power Budget Requirement*** | 40mA @ 5VDC (supplied by the base) |
| ***External Power Supply*** | F2-02DA-2: 24–30 VDC (±10%), 60mA (outputs fully loaded)<br>F2-02DA-2L: 12VDC (±10%), 70mA (outputs fully loaded) |
| ***Operating Temperature*** | 0–60°C (32–140°F) |
| ***Storage Temperature*** | –20°C to 70°C (-4°F to 158°F) |
| ***Relative Humidity*** | 5–95% (non-condensing) |
| ***Environmental Air*** | No corrosive gases permitted |
| ***Vibration*** | MIL STD 810C 514.2 |
| ***Shock*** | MIL STD 810C 516.2 |
| ***Noise Immunity*** | NEMA ICS3-304 |

***NOTE:** The F2-02DA-2L module has been discontinued. Please consider F2-02DA-2 as a replacement.*

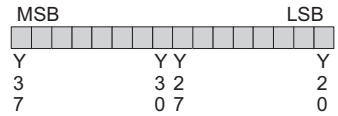
## Special Placement Requirements (D2-230 and Remote I/O Bases)

It is important to examine the configuration if a D2-230 CPU is being used. As can be seen in the section on Writing the Control Program, V-memory locations are used to hold the analog data that will be written to the output. If the module is placed in a slot such that the output points do not start on a V-memory boundary, the program instructions aren't able to access the data. This also applies when placing this module in a remote base using a D2-RSSS in the CPU slot.

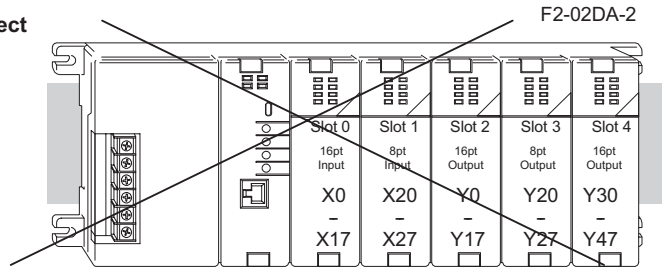
**Correct!**




Data is correctly entered, so output points start on a V-memory boundary.




**Incorrect**




Data is split over three locations, so instructions cannot access data from a D2-230.

To use the V-memory references required for a D2-230 CPU, the first output address assigned to the module must be one of the following Y locations. The table also shows the V-memory addresses corresponding to these Y locations.

| ***X*** | Y0 | Y20 | Y40 | Y60 | Y100 | Y120 | Y140 | Y160 |
|---|---|---|---|---|---|---|---|---|
| ***V*** | V40500 | V40501 | V40502 | V40503 | V40504 | V40505 | V40506 | V40507 |

# Setting the Module Jumpers

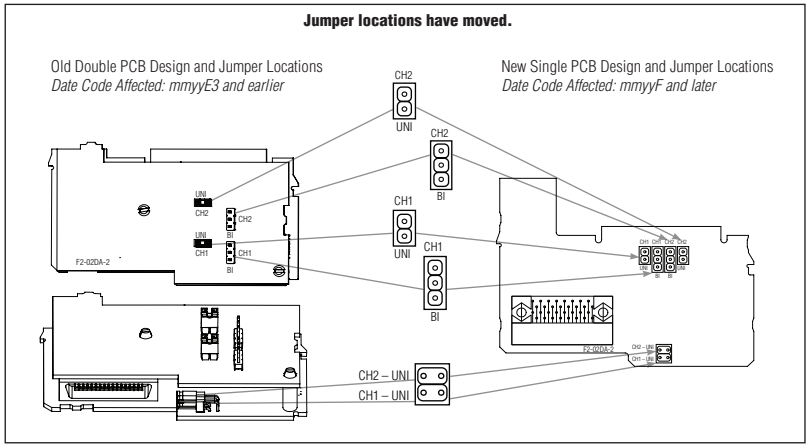
The F2-02DA-2 (L) Analog Output module uses jumpers for selecting the voltage ranges for each channel. The range of each channel can be independently set. Available operating ranges are 0–5 V, 0–10 V, ±5V, and ±10V.

There are three jumpers for each channel. Two sets are on the top board, and the third set is along the edge of the bottom board with the black D-shell backplane connector. Install or remove these jumpers to select the desired range. Unused jumpers can be stored on a single pin so they do not get lost.

- Two of the top board jumpers are labeled "UNI / ±5" and there is one for each channel.
- The two bottom board jumpers are labeled "UNI" and there is one for each channel. These jumpers determine the format of the channel output data, and the effect of their settings is independent from that of the other jumpers on the module. With a UNI jumper removed, the corresponding channel requires data values in the range of ±2047. With a UNI jumper installed, the channel requires data values in the range of 0–4095.
- The other two top board jumpers are labeled "BI-P0-5" and there is one for each channel. These jumpers each have three possible settings (including jumper removed) since there are three pins.

***NOTE:*** *It is important to set the module jumpers correctly. The module will not operate correctly if the jumpers are not properly set for the desired voltage range.*

This figure shows the jumper locations. See the table on the following page to determine the proper settings for your application.



## Voltage Range and Output Combinations

The table lists the eight possible combinations of voltage ranges and data formats, along with the corresponding jumper settings. For most applications, use one of the four standard selections (indicated by an asterisk) in the table below. Standard unipolar voltage ranges accept a data format of 0–4095. Standard bipolar ranges accept a data format of -2047 to +2047.

**Voltage Range and Output Combinations**

| *Voltage Range* | *Output Data Format* | *UNI / ± 5V Jumper Settings (top board)* | *UNI Output Format Jumper Settings (bottom board)* | *BI-P 0–5 V Jumper Settings (top board)* | |
|---|---|---|---|---|---|
| | | | | *BI-P (Bipolar) Position* | *0–5 V Position* |
| 0–5 V * | 0–4095 * | Install | Install | | Install here |
| 0–10 V * | 0–4095 * | Install | Install | Completely remove | |
| 0–5 V | ± 2047 | Install | Remove | | Install here |
| 0–10 V | ± 2047 | Install | Remove | Completely remove | |
| ± 5V * | ± 2047 * | Install | Remove | Install here | |
| ± 10V * | ± 2047 * | Remove | Remove | Install here | |
| ± 5V | 0–4095 | Install | Install | Install here | |
| ± 10V | 0–4095 | Remove | Install | Install here | |

**Standard selections are shown with an *.**

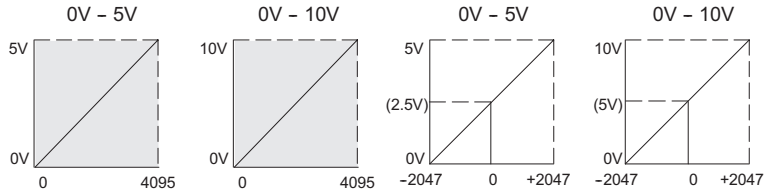
For example, to select settings of "±5V" voltage range with a "±2047" output data format for channel 1, refer to the table above and the figure on the previous page and arrange the jumpers as follows:

- Install the "CH1 UNI / ±5V" jumper.
- Remove the "CH1-UNI" jumper. Store the jumper so it does not get lost by placing it on one pin.
- Install the "CH1" "BI-P0-5" jumper in the BI-P (bipolar) position on the left pin and center pin.

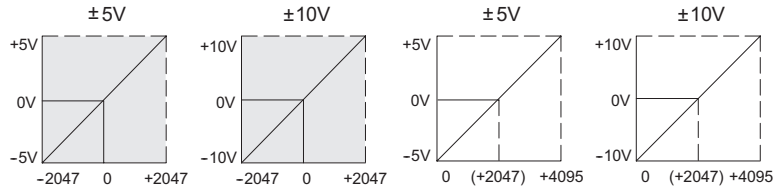
The non-standard selections in the table provide the opposite data format for both unipolar and bipolar voltage ranges. If you are using unipolar output (0-5 V or 0-10 V) on one channel and bipolar output (±5V, ±10V) on the other channel, then one of the outputs will use a non-standard data format.

The following graphs show the voltage range to output data format relationship for each of the eight selections.

**Unipolar Ranges**




**Bipolar Ranges**



# Connecting and Disconnecting the Field Wiring

## Wiring Guidelines

Your company may have guidelines for wiring and cable installation. If so, check the guidelines before beginning the installation. Here are some general things to consider:

- Use the shortest wiring route whenever possible.
- Use shielded wiring and ground the shield at the transmitter source. Do not ground the shield at both the module and the source.
- Do not run the signal wiring next to large motors, high current switches, or transformers. This may cause noise problems.
- Route the wiring through an approved cable housing to minimize the risk of accidental damage. Check local and national codes to choose the correct method for your application.

## User Power Supply Requirements

The F2-02DA-2 (L) module requires at least one field-side power supply. The same or separate power sources can be used for the module supply and the voltage transmitter supply. The F2-02DA-2 module requires 18–30 VDC, at 60mA and the *F2-02DA-2L module requires 10–15 VDC, at 70mA, from the external power supply.

The DL205 AC bases have a built-in 24VDC power supply that provide up to 300mA of current. This can be used instead of a separate supply. Check the power budget to be safe.

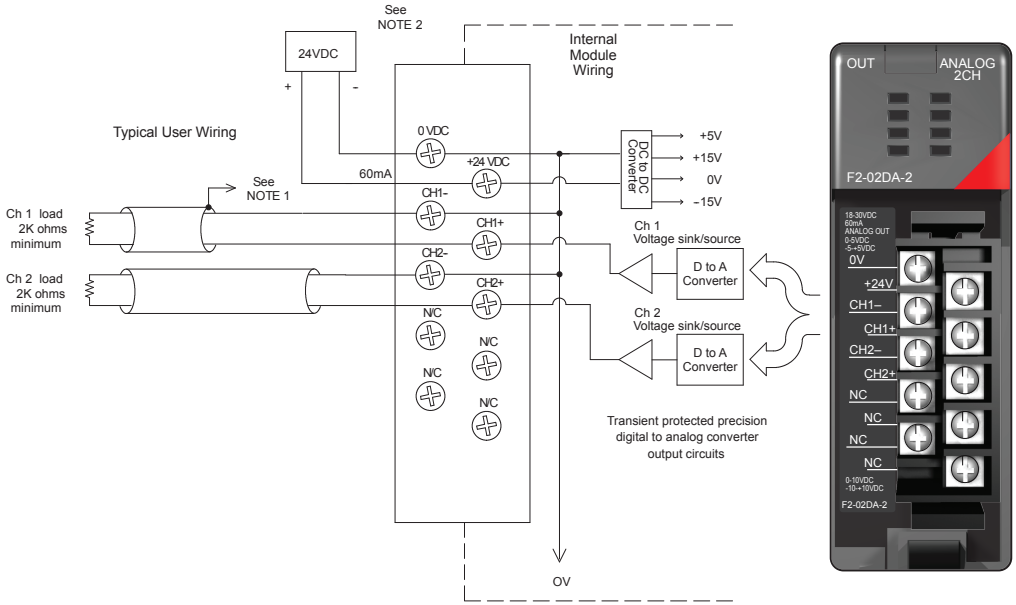
It is desirable in some situations to power the transmitters separately in a location remote from the PLC. This will work as long as the transmitter supply meets the voltage and current requirements, and the transmitter negative (-) side and the module supply negative (-) side are connected together..

**WARNING: If the internal 24VDC base power is used, be sure to calculate the power budget. Exceeding the power budget can cause unpredictable system operation that can lead to a risk of personal injury or equipment damage.**

***NOTE:** The F2-02DA-2L module has been discontinued. Please consider F2-02DA-2 as a replacement.*

## Wiring Diagram

The F2-02DA-2(L) module has a removable connector which helps to simplify wiring. Just squeeze the top and bottom retaining clips and gently pull the connector from the module. Use the following diagram to connect the field wiring.



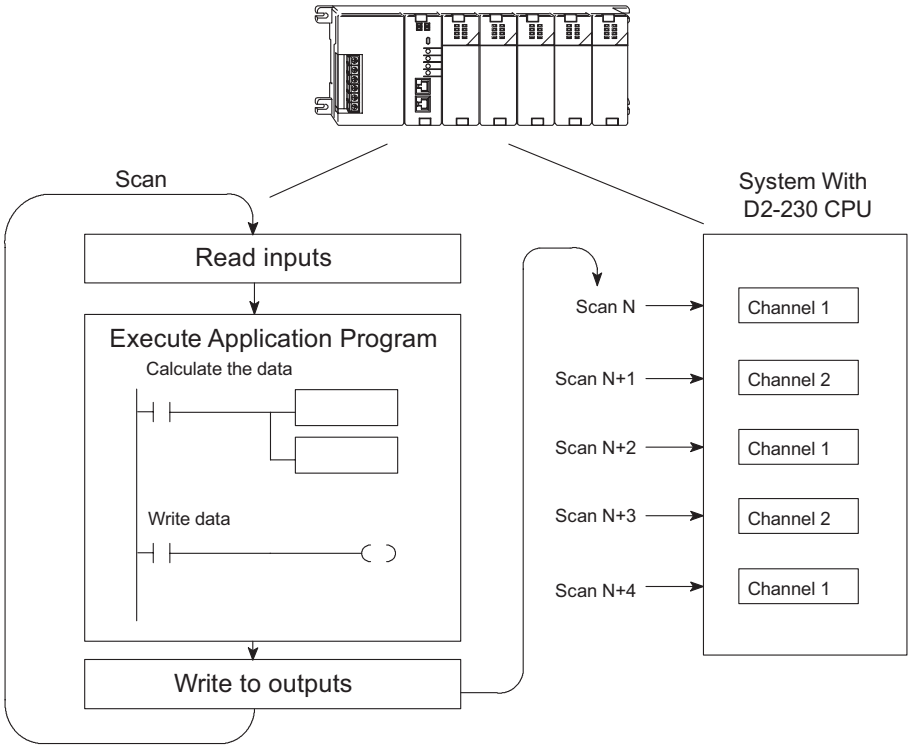

***NOTE** 1: Shields should be connected to the 0V terminal of the module or 0V of the power supply.*
***NOTE 2:** The F2-02DA-2L module must use a 12VDC, at 70mA, external power supply.*
***NOTE 3:** Unused voltage outputs should remain open (no connections) for minimum power consumption.*

# Module Operation

Before beginning to write the control program, it is important to take a few minutes to understand how the module processes the analog signals.

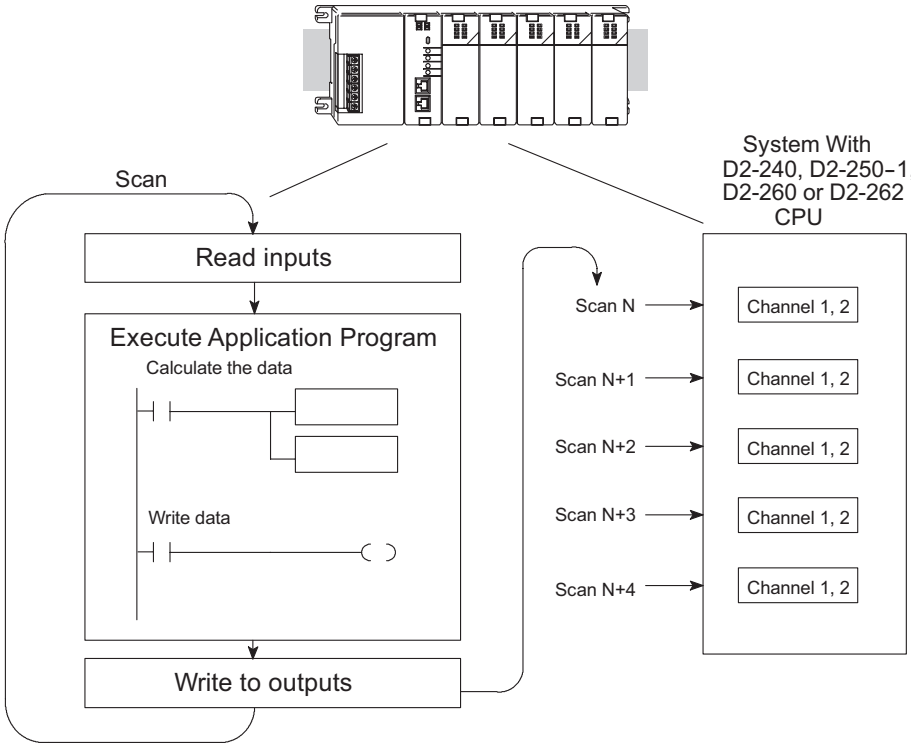
## Channel Scanning Sequence (Multiplexing) for a D2-230 CPU

The D2-230 can send one channel of data per CPU scan. The module refreshes two field devices on each scan, but new data can only be obtained from the CPU at the rate of one channel per scan. Since there are two channels, it can take two scans to update both channels. However, if only one channel is being used, then that channel will be updated on every scan. The multiplexing method can also be used for the D2-240, D2-250-1, D2-260 and D2-262 CPUs.



## Channel Scanning Sequence (Pointer Method) for D2-240, D2-250-1, D2-260 and D2-262 CPUs

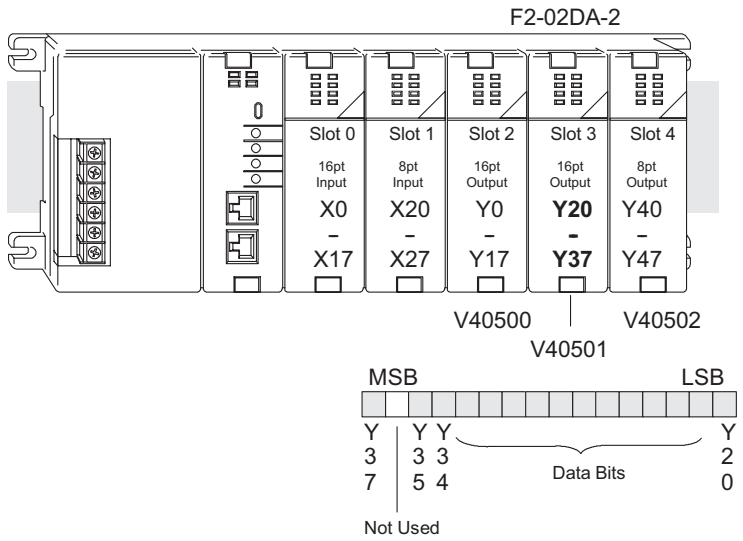
If either a D2-240, D2-250-1, D2-260 or D2-262 CPU is used, both channels can be updated on every scan. These CPUs support special V-memory locations that are used to manage the data transfer. This is discussed in more detail in the section Writing the Control Program later in this chapter.



## Understanding the Output Assignments

Remember that the F2-02DA-2 (L) module appears to the CPU as a 16-point discrete output module. These points provide the data value and an indication of which channel to update. Note, if either a D2-240, DL250-1, D2-260 or D2-262 CPU is being used, these bits may never have to be used, but it may be an aid to help understand the data format.

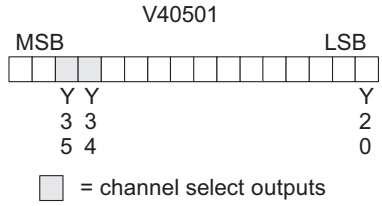
Since all output points are automatically mapped into V-memory, the location of the data word that will be assigned to the module can be simply determined.




The individual bits in this data word location, represents specific information about the analog signal.

## Channel Select Outputs

Two of the outputs select the active channel. Remember, the V-memory bits are mapped directly to discrete outputs. Turning a bit OFF selects its channel. By controlling these outputs, the channel(s) to be updated can be selected.

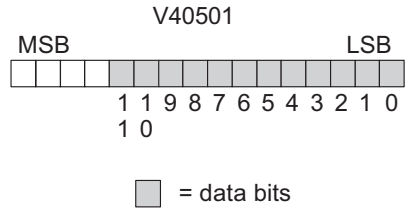



| Y35 | Y34 | Channel |
|---|---|---|
| On | Off | 1 |
| Off | On | 2 |
| Off | Off | 1 & 2 (same data to both channels) |
| On | On | None (both channels hold current values) |

## Analog Data Bits

The first twelve bits represent the analog data in binary format.

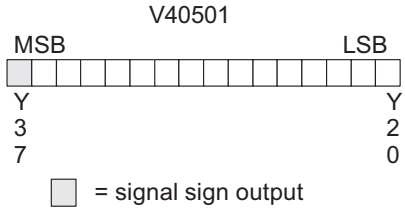
| Bit | Value | Bit | Value |
|---|---|---|---|
| 0 | 1 | 6 | 64 |
| 1 | 2 | 7 | 128 |
| 2 | 4 | 8 | 256 |
| 3 | 8 | 9 | 512 |
| 4 | 16 | 10 | 1024 |
| 5 | 32 | 11 | 2048 |




## Signal Sign Output

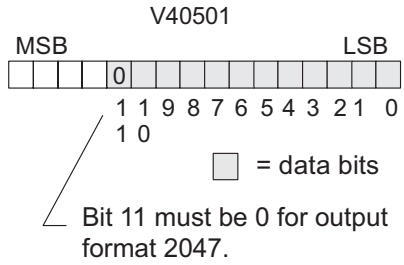
The last output can be used to select the signal sign (+ or -) for bipolar ranges. By controlling this output, positive and negative data values can be easily selected.

Programming examples in the next section, Writing the Control Program, will show how to make sign selection part of the program.




## Bipolar Output Data

If an output channel is configured for an output format of 0–2047, the maximum valid value for the lower 12 bits is 2047. This means that bit 11 (bit position 12) must always be 0 (zero).

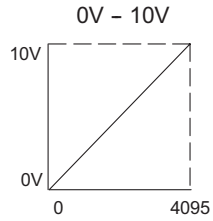



**WARNING: If the data value exceeds 2047, bit 11 becomes a "1", and the other eleven bits start over at "00000000000". At this point the module's channel output voltage also goes back to the bottom of its range and begins to increase again. The RLL program will be expecting a maximum output, but it will be minimum instead. This can have serious consequences in some applications, and may result in personal injury or damage to equipment. Therefore, in standard bipolar ranges (or whenever the output format is ±2047 in general), be sure that the RLL program does not create numbers with absolute values greater than 2047.**

## Module Resolution

Since the module has 12-bit resolution, the analog signal is converted into 4096 counts ranging from 0–4095 (212). For example, with a 0–10 V range, send a 0 to get a 0V signal, and send 4095 to get a 10V signal. This is equivalent to a binary value of 0000 0000 0000 to 1111 1111 1111, or 000 to FFF hexadecimal.

Each count can also be expressed in terms of the signal level by using the following equation.




$$\text{Resolution} = \frac{H - L}{4095}$$

H = High limit of the signal range

L = Low limit of the signal range

| Voltage Range | Signal Span | Divide By | Smallest Output Change |
|---|---|---|---|
| ***0–5 V*** | 5V | 4095 | 1.22 mV |
| ***0–10 V*** | 10V | 4095 | 2.44 mV |
| ***± 5V*** | 10V | 4095 | 2.44 mV |
| ***± 10V*** | 20V | 4095 | 4.88 mV |

The following table shows the smallest change in signal level due to a digital value change of 1 LSB count.

# Writing the Control Program

## Calculating the Digital Value

The control program must calculate the digital value that is sent to the analog output. Several methods can be used to do this, but the best method is to convert the values to engineering units. This is accomplished by using the formula shown.

Adjustments may have to be made to the formula depending on the scale of the engineering units.

$$A = U\frac{4095}{H - L}$$ for 0–4095 output format

$$A = U\frac{2047}{H - L}$$ for 0–2047 output format

A = Analog Value (0 – 4095)

U = Engineering Units

H = High limit of the engineering unit range

L = Low limit of the engineering unit range

Consider the following example which controls pressure from 0.0–99.9 psi. Using the formula will calculate the digital value to be sent to the analog output. The example shows the conversion required to yield 49.4 psi. The multiplier of 10 is because the decimal portion of 49.4 cannot be loaded in the program, so it is shifted right one decimal place to make a usable value of 494.

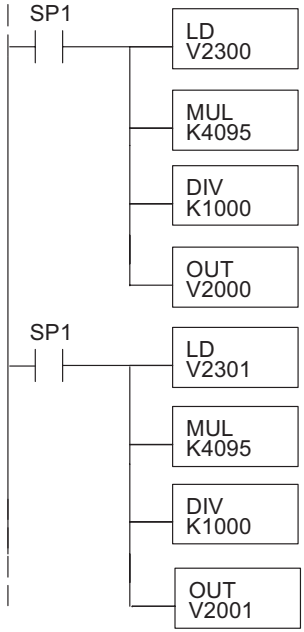
Refer to the example on the next page to write the conversion program.

$$A = 10U\frac{4095}{10\,(H - L)} \qquad A = 494\frac{4095}{1000 - 0} \qquad A = 2023$$

## The Conversion Program

This example program shows how to write the program to perform the engineering unit conversion to output data formats 0–4095. This example assumes that a BCD value has been stored in V2300 and V2301 for channels 1 and 2 respectively.

***NOTE:*** *The DL205 has many instructions available so that math operations can simply be performed using BCD format. Do the math in BCD, then convert to binary before writing to the module output.*




The LD instruction loads the engineering units used with channel 1 into the accumulator. This example assumes the numbers are BCD. Since SP1 is used, this rung automatically executes on every scan. You could also use an X, C, etc. permissive contact.

Multiply the accumulator by 4095 (to start the conversion).

Divide the accumulator by 1000 (because we used a multiplier of 10, we have to use 1000 instead of 100).

Store the BCD result in V2000 (the actual steps required to send the data are shown later).

The LD instruction loads the engineering units used with channel 2 into the accumulator. This example assumes the numbers are BCD. Since SP1 is used, this rung automatically executes on every scan. You could also use an X, C, etc. permissive contact.

Multiply the accumulator by 4095 (to start the conversion).

Divide the accumulator by 1000 (because we used a multiplier of 10, we have to use 1000 instead of 100).

Store the BCD result in V2001 (the actual steps required to send the data are shown later).

## Negative Values with Bipolar Range

If the bipolar ranges (±5V, ±10V) are used or an output data format of ±2047, the data value needs to be specified whether it is positive or negative. There are two ways to show that the value is negative:

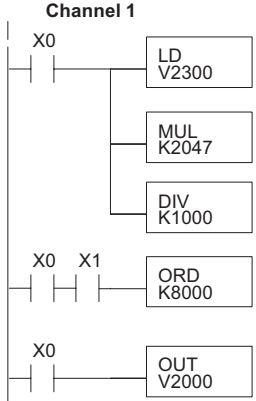
- Turn on the sign output (Y37 in the examples, D2-230 only).
- Embed the sign output in the data value (required for the D2-240, D2-250-1, D2-260 and D2-262 using the pointer method, an optional method for the D2-230).

To embed the sign output in the data values, OR 8000 to the value. This has the same effect as turning on Y37. Remember, the V-memory location is mapped directly to the outputs.

If bipolar ranges are used, logic needs to be added to indicate either positive or negative values. The logic would be similar for both values, but some type of permissive contact needs to be used to select the appropriate section of logic. Following is an example that re-scales a variable from a 0–1000 range to a 0–2047 range. It includes a step that combines 8000 with the value to make it negative.

***NOTE:*** *Do not exceed a value of 2047 for ±2047 output formats.*

**Channel 1**




The LD instruction loads the engineering units used with Channel 1 into the accumulator. This example assumes the numbers are BCD. Since X0 is used, this rung only executes when X0 is on (X1 would be the input that would indicate a negative value should be used).

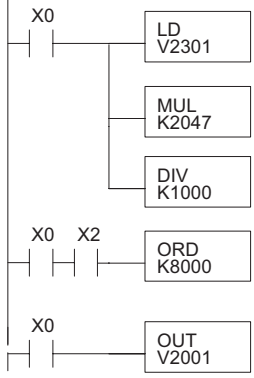
Multiply the accumulator by 2047 (to start the conversion).

Divide the accumulator by 1000 (because we used a multiplier of 10, we have to use 1000 instead of 100).

This ORD instruction imbeds the sign output in the data value when X0 and X1 are on. It combines the BCD value (8000) with the accumulator value to make it negative. Omit this rung if you choose to control the sign bit of the module (Y37) directly.

Store the result in V2000. This is the digital value, in BCD form, that should be sent to the module (the actual steps required to send the data are shown later).

**Channel 2**




The LD instruction loads the engineering units used with Channel 2 into the accumulator. This example assumes the numbers are BCD. Since X0 is used, this rung only executes when X0 is on (X2 would be the input that would indicate a negative value should be used).

Multiply the accumulator by 2047 (to start the conversion).

Divide the accumulator by 1000 (because we used a multiplier of 10, we have to use 1000 instead of 100).

This ORD instruction imbeds the sign output in the data value when X0 and X1 are on. It combines the BCD value (8000) with the accumulator value to make it negative. Omit this rung if you choose to control the sign bit of the module (Y37) directly.

Store the result in V2001. This is the digital value, in BCD form, that should be sent to the module (the actual steps required to send the data are shown later).

## Writing Values: Pointer Method and Multiplexing

There are two methods which can be used to write values from the CPU to the module:

- The pointer method
- Multiplexing

The multiplexing method must be used when using a D2-230 CPU. The multiplexing method must also be used with remote I/O modules (the pointer method will not work). Either method can be used with the D2-240, D2-250-1, D2-260 and D2-262 CPUs, however, the pointer method will simplify programming the PLC.

## Writing Values (Pointer Method) for D2-240, D2-250-1, D2-260 and D2-262 CPUs

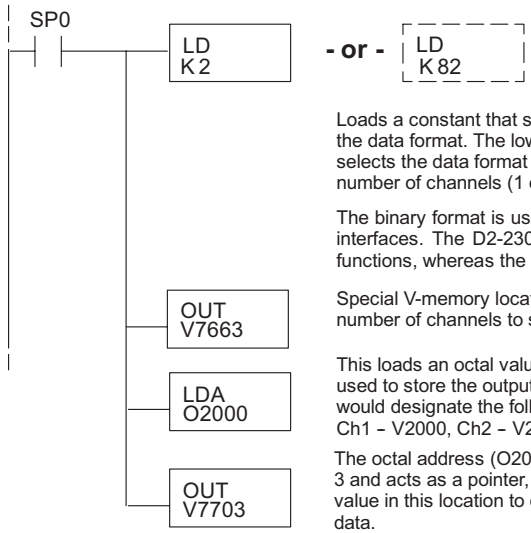
The D2-240, D2-250-1, D2-260 and D2-262 CPUs have special V-memory locations assigned to each base slot that will greatly simplify the programming requirements.

These V-memory locations allow you to:

- Specify the data format
- Specify the number of channels to scan
- Specify the location of the data that will be written to the module

***NOTE:*** *D2-240 CPUs with firmware release version 1.5 or later and. D2-250-1 CPUs with firmware release version 1.06 or later support this method.*

The following example program shows how to setup these locations. Place this rung anywhere in the ladder program, or in the initial stage if stage programming instructions are being used. V2000 is used in the example but any user V-memory location can be used. In this example the module is installed in slot 3. Be sure to use the V-memory locations for the module placement. The pointer method automatically converts values to BCD.




Loads a constant that specifies the number of channels to scan and the data format. The lower byte, most significant nibble (MSN) selects the data format (i.e. 0=BCD, 8=Binary), the LSN selects the number of channels (1 or 2).

The binary format is used for displaying data on some operator interfaces. The D2-230 and D2-240 CPUs do not support binary math functions, whereas the D2-250-1, D2-260, and D2-252 do.

Special V-memory location assigned to slot 3 that contains the number of channels to scan.

This loads an octal value for the first V-memory location that will be used to store the output data. For example, the O2000 entered here would designate the following addresses.
Ch1 – V2000, Ch2 – V2001

The octal address (O2000) is stored here. V7703 is assigned to slot 3 and acts as a pointer, which means the CPU will use the octal value in this location to determine exactly where to store the output data.

The following tables show the special V-memory locations used by the D2-240, D2-250-1, D2-260 and D2-262 for the CPU base and local expansion base I/O slots. Slot 0 (zero) is the module next to the CPU or D2-CM module. Slot 1 is the module two places from the CPU or D2-CM, and so on. Remember, the CPU only examines the pointer values at these locations after a mode transition. Also, if the D2-230 (multiplexing) method is used, verify that these addresses in the CPU are 0 (zero).

The table below applies to the D2-240, D2-250-1, D2-260 and D2-262 CPU base.

| CPU Base: Analog Output Module Slot-Dependent V-memory Locations | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| ***Slot*** | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| ***No. of Channels*** | V7660 | V7661 | V7662 | V7663 | V7664 | V7665 | V7666 | V7667 |
| ***Storage Pointer*** | V7700 | V7701 | V7702 | V7703 | V7704 | V7705 | V7706 | V7707 |

The table below applies to the D2-250-1, D2-260 and D2-262 CPU base 1.

| Expansion Base D2-CM #1: Analog Output Module Slot-Dependent V-memory Locations | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| ***Slot*** | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| ***No. of Channels*** | V36000 | V36001 | V36002 | V36003 | V36004 | V36005 | V36006 | V36007 |
| ***Storage Pointer*** | V36020 | V36021 | V36022 | V36023 | V36024 | V36025 | V36026 | V36027 |

The table below applies to the D2-250-1, D2-260 and D2-262 CPU base 2.

| Expansion Base D2-CM #2: Analog Output Module Slot-Dependent V-memory Locations | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| ***Slot*** | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| ***No. of Channels*** | V36100 | V36101 | V36102 | V36103 | V36104 | V36105 | V36106 | V36107 |
| ***Storage Pointer*** | V36120 | V36121 | V36122 | V36123 | V36124 | V36125 | V36126 | V36127 |

The table below applies to the D2-260 and D2-262 CPU base 3.

| Expansion Base D2-CM #3: Analog Output Module Slot-Dependent V-memory Locations | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| ***Slot*** | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| ***No. of Channels*** | V36200 | V36201 | V36202 | V36203 | V36204 | V36205 | V36206 | V36207 |
| ***Storage Pointer*** | V36220 | V36221 | V36222 | V36223 | V36224 | V36225 | V36226 | V36227 |

The table below applies to the D2-260 and D2-262 CPU base 4.

| Expansion Base D2-CM #4: Analog Output Module Slot-Dependent V-memory Locations | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| ***Slot*** | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| ***No. of Channels*** | V36300 | V36301 | V36302 | V36303 | V36304 | V36305 | V36306 | V36307 |
| ***Storage Pointer*** | V36320 | V36321 | V36322 | V36323 | V36324 | V36325 | V36326 | V36327 |

## Writing Data (Multiplexing)

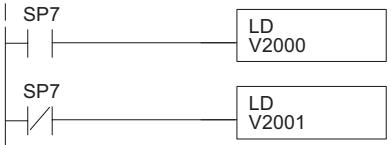
The D2-230 CPU does not have the special V-memory locations that allows for automatic management of data transfer. Since all channels are multiplexed into a single data word, the control program must be written in such a way to determine which channel to write the data to. Since the module appears as Y output points to the CPU, it is very easy to use the channel selection outputs to determine which channel to update.

The following example is for a module installed as shown in previous examples. The addresses used would be different if the module were located in a different slot. These rungs can be placed anywhere in the user program or, if using stage programming, placed in an active stage.

This example is a two-channel multiplexer that updates each channel on alternate scans. Relay SP7 is a special relay that is on for one scan, then off for one scan. A permissive contact on the last rung handles an embedded sign bit.

***NOTE:*** *Use binary data to write to the module outputs. Do not use a BIN instruction if the data is already in binary format.*

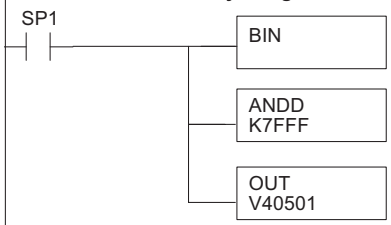
**Load data into the accumulator.**




Loads the data for channel 1 into the accumulator.

Loads the data for channel 2 into the accumulator.

**Send data to V-memory assigned to the module.**

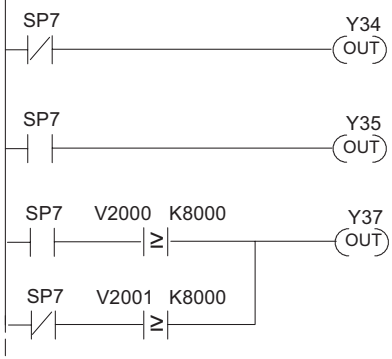



Convert the data to binary (you must omit this step if you have converted the data elsewhere).

Remove sign bit for BCD to binary conversion. SP1 is always on.

The OUT instruction sends the data to the module. Our example starts with V40501 but the actual value depends on the location of the module in your application.

**Select the channel to update.**




Selects channel 1 for update when Y34 is OFF (Y35–ON deselects channel 2). Note, Y34 and Y35 are used due to the previous examples. If the module was installed in a different I/O arrangement, the addresses would be different.

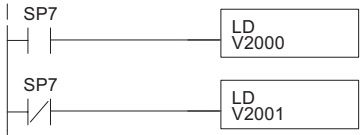
Selects channel 2 for update when Y35 is OFF (Y34–ON deselects channel 1). Note, Y34 and Y35 are used due to the previous examples. If the module was installed in a different I/O arrangement, the addresses would be different.

If the output format is –2047 to +2047, include this rung to embed the sign bit. For the output format 0 to 4095, omit this rung.

If the output range format of ±2047 is used (also most commonly used with bipolar voltage ranges), the data values must be specified as either positive or negative. The previous example could be used with an addition to activate the sign output bit, or use the following example which uses individual contacts to determine the sign bit status for each channel.

**WARNING: DO NOT USE THIS METHOD if the sign information is embedded into the data value by adding 8000 to it. Use the previous example.**

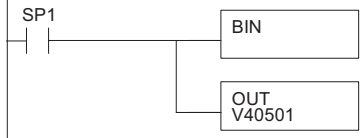
**Load data into the accumulator.**




Loads the data for channel 1 into the accumulator.

Loads the data for channel 2 into the accumulator.

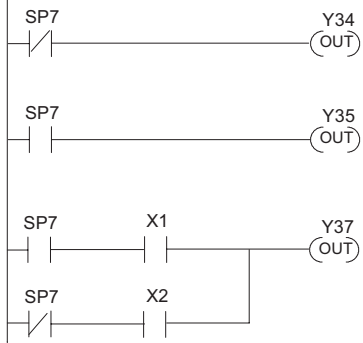
**Send data to V-memory assigned to the module.**




Convert the data to binary (you must omit this step if you have converted the data to binary). SP1 is always on.

The OUT instruction sends the data to the module. Our example starts with V40501, but the actual value depends on the location of the module in your application.

**Select the channel to update.**




Selects channel 1 for update when Y34 is OFF (Y35–ON deselects channel 2). Note, Y34 and Y35 are used due to the previous examples. If the module was installed in a different I/O arrangement, the addresses would be different.

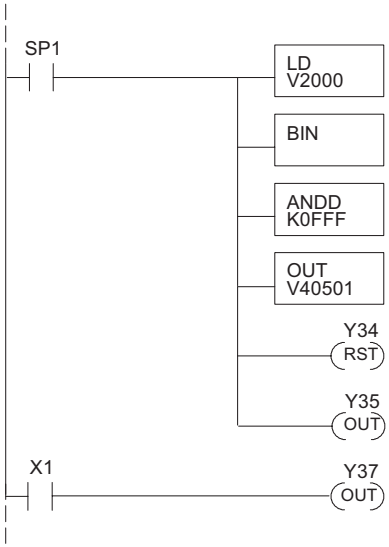
Selects channel 2 for update when Y35 is OFF (Y34–ON deselects channel 1). Note, Y34 and Y35 are used due to the previous examples. If the module was installed in a different I/O arrangement, the addresses would be different.

The permissive X1 activates Y37 (sign bit) during a channel 1 update scan. The permissive X2 activates Y37 during a channel 2 update scan. The sign bit (Y37 ON) indicates that the value is negative. You could use another permissive, such as a CR, etc.

***NOTE:*** *Do not exceed a value of 2047 for* ±2047 output data formats.

## Write Data to One Channel

The following example can be used if only one channel is to be written to, or if the outputs are to be controlled individually. Don't forget to either embed the sign information or use the sign output bit for bipolar ranges. In this example below, data is written to output channel 1.




The LD instruction loads the data into the accumulator. Since SP1 is used, this rung automatically executes on every scan. You could also use an X, C, etc. permissive contact.

The BIN instruction converts the accumulator data to binary (you must omit this step if you have already converted the data elsewhere).

The ANDD instruction masks off the channel select bits to prevent an accidental channel selection.

The OUT instruction sends the data to the module. Our example starts with V40501, but the actual value depends on the location of the module in your application.

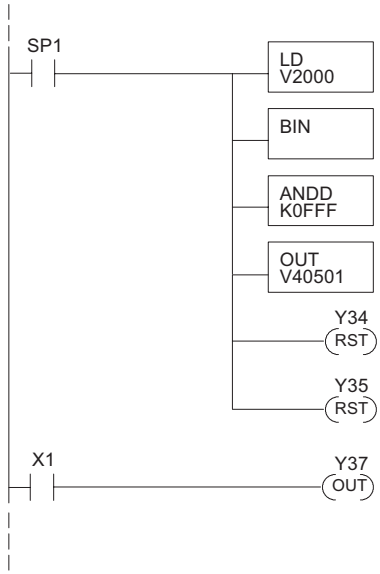
Y34–OFF selects channel 1 for updating.

Y35–ON deselects channel 2 (do not update).

The permissive X1 activates Y37, which is the sign bit. The sign bit indicates that the value is negative. You could use another permissive, such as a CR, etc. Omit this rung if you are using the 0 to +4095 output format.

## Write Data to Both Channels

In the example below, if both selection channels are off, they will be updated with the same data. Remember to either embed the sign information or use the sign output bit.




The LD instruction loads the data into the accumulator. Since SP1 is used, this rung automatically executes on every scan. You could also use an X, C, etc. permissive contact.

The BIN instruction converts the accumulator data to binary (you must omit this step if you have already converted the data elsewhere.

The ANDD instruction masks off the channel select bits to prevent an accidental channel selection.

The OUT instruction sends the data to the module. Our example starts with V40501, but the actual value depends on the location of the module in your application.

Y34–OFF selects channel 1 for updating.

Y35–OFF selects channel 2 for updating.

The permissive X1 activates Y37, which is the sign bit. The sign bit indicates that the value is negative. You could use another permissive, such as a CR, etc. Omit this rung if you are using the 0 to +4095 output format.

## Analog and Digital Value Conversions

It is sometimes useful to do quick conversions between the signal levels and the digital values. This can be helpful during startup or troubleshooting. The following table shows some formulas to help with the conversions.

| Range | The digital value is known | The analog signal level is known |
|---|---|---|
| ***0–10V*** | $A = \frac{10D}{4095}$ | $D = \frac{4095\ (A)}{10}$ |
| ***±10V (output format ±2047)*** | $A = \frac{10D}{2047}$ | $D = \frac{2047\ (A)}{10}$ |
| ***0–5V*** | $A = \frac{5D}{4095}$ | $D = \frac{4095\ (A)}{5}$ |
| ***± 5V (output format ±2047)*** | $A = \frac{5D}{2047}$ | $D = \frac{2047\ (A)}{5}$ |

For example, if a ±10V range with an output format of ±2047 is used, and a 6V signal level is needed, use the formula to the right to determine the digital value "D" to be stored in the V-memory location which contains the data.

$$D = \frac{2047}{10}(A)$$

$$D = \frac{2047}{10}(6V)$$

$$D = (204.7)(6)$$

$$D = 1228$$

# F2-08DA-1, 8-Channel Analog Current Output

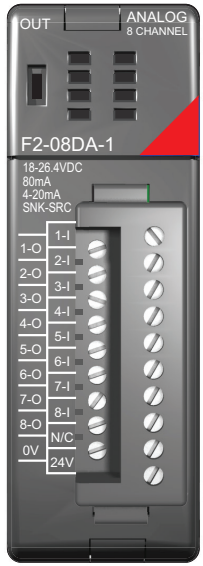
In This Chapter...

Module Specifications ..... 10-2
Connecting and Disconnecting the Field Wiring ..... 10-5
Module Operation ..... 10-7
Writing the Control Program ..... 10-11

# Module Specifications

The F2-08DA-1 Analog Output module provides several hardware features:

- Supported by D2-230, D2-240, D2-250-1, D2-260 and D2-262 CPUs (see firmware requirements).
- Analog outputs are optically isolated from the PLC logic.
- The module has a removable terminal block so the module can be easily removed or changed without disconnecting the wiring.
- All channels can be updated in one scan (D2-240, D2-250-1, D2-260 and D2-262 only).
- Outputs are both current sinking and sourcing.




F2-08DA-1

## Firmware Requirements:

- To use this module, D2-230 CPUs must have firmware version 2.7 or later.
- To use the pointer method for writing values, D2-240 CPUs require firmware version 3.0 or later.
- D2-250-1 CPU requires firmware version 1.33 or later.

## Analog Output Configuration Requirements

The F2-08DA-1 analog output module requires 16 discrete output points. The module can be installed in any slot of a DL205 PLC system, but the available power budget and discrete I/O points can be the limiting factors. Check the user manual for the particular model of CPU and I/O base being used for information regarding power budget and number of local, local expansion or remote I/O points.

The following tables provide the specifications for the F2–08DA–1 Analog Output Module. Review these specifications to make sure the module meets your application requirements.

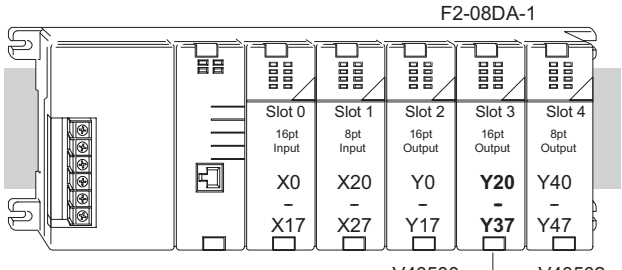
| Output Specifications | |
|---|---|
| ***Number of Channels*** | 8, single-ended |
| ***Output Range*** | 4–20 mA |
| ***Resolution*** | 12 bit (1 in 4096) |
| ***Output Type*** | Current sinking and current sourcing |
| ***Maximum Loop Supply*** | 30VDC |
| ***Source Load*** | 0–400 Ω (for loop power 18–30 V) |
| ***Sink Load*** | 0–600 Ω / 18V, 900Ω / 24V, 1200Ω / 30V |
| ***Total Load (sink plus source)*** | 600Ω / 18V, 900Ω / 24V, 1200Ω / 30V |
| ***Linearity Error (end to end)*** | ±2 counts (±0.050% of full scale) maximum |
| ***Conversion Settling Time*** | 400µs maximum (full scale change) |
| ***Full-scale Calibration Error*** | ±12 counts maximum, sinking (any load)<br>±12 counts maximum, sourcing (125Ω load)<br>±18 counts maximum, sourcing (250Ω load)<br>±26 counts maximum, sourcing (400Ω load) |
| ***Offset Calibration Error*** | ±9 counts maximum, sinking (any load)<br>±9 counts maximum, sourcing (125Ω load)<br>±11 counts maximum, sourcing (250Ω load)<br>±13 counts maximum, sourcing (400Ω load) |
| ***Maximum Full Scale Inaccuracy @ 0–60°C*** | 0.5% sinking (any load) & sourcing (125Ω load )<br>0.64% sourcing (250Ω load )<br>0.83% sourcing (400Ω load) |
| ***Maximum Full Scale Inaccuracy @ 0–25°C (includes all errors & temperature drift)*** | 0.3% sinking (any load) & sourcing (125Ω load )<br>0.44% sourcing (250Ω load )<br>0.63% sourcing (400Ω load) |

| General Specifications | |
|---|---|
| ***PLC Update Rate*** | 8 channel per scan maximum |
| ***Digital Outputs / Output Points Required*** | 12 binary data bits, 3 channel ID bits, 1 output enable bit<br>16 (Y) output points required |
| ***Power Budget Requirement*** | 30mA @ 5VDC (supplied by the base) |
| ***External Power Supply*** | 18–30 VDC, 50mA plus 20mA / output loop, class 2 |
| ***Operating Temperature*** | 0–60°C (32–140°F) |
| ***Storage Temperature*** | -20°C to 70°C (-4°F to 158°F) |
| ***Relative Humidity*** | 5–95% (non-condensing) |
| ***Environmental air*** | No corrosive gases permitted |
| ***Vibration*** | MIL STD 810C 514.2 |
| ***Shock*** | MIL STD 810C 516.2 |
| ***Noise Immunity*** | NEMA ICS3-304 |

## Special Placement Requirements (D2-230 and Remote I/O Bases)

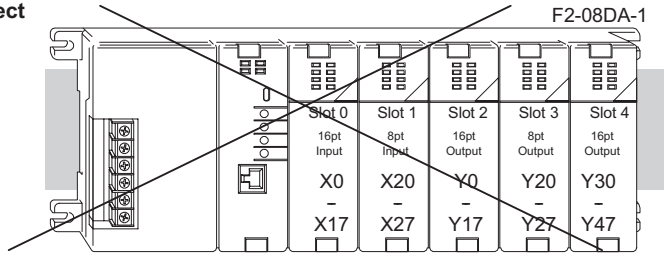
It is important to examine the configuration if a D2-230 CPU is being used. As can be seen in the section on Writing the Control Program, V-memory locations are used to hold the analog data that will be written to the output. If the module is placed in a slot so that the output points do not start on a
V-memory boundary, the program instructions aren't able to access the data. This also applies when placing this module in a remote base using a D2-RSSS in the CPU slot.

**Correct!**




Data can be written correctly because the output points start on a V-memory boundary address as seen in the table below.

**Incorrect**




Data is split over two locations, so instructions cannot access data from a D2-230 (or when the module is placed in a remote base).

To use the V-memory references required for the multiplexing method, the first output address assigned to the module must be one of the following Y locations. The table also shows the V-memory addresses that correspond to these Y locations.

| ***X*** | Y0 | Y20 | Y40 | Y60 | Y100 | Y120 | Y140 | Y160 |
|---|---|---|---|---|---|---|---|---|
| ***V*** | V40500 | V40501 | V40502 | V40503 | V40504 | V40505 | V40506 | V40507 |

# Connecting and Disconnecting the Field Wiring

## Wiring Guidelines

Your company may have guidelines for wiring and cable installation. If so, check the guidelines before beginning the installation. Here are some general things to consider:

- Use the shortest wiring route whenever possible.
- Use shielded wiring and ground the shield at the transmitter source. Do not ground the shield at both the module and the source.
- Do not run the signal wiring next to large motors, high current switches, or transformers. This may cause noise problems.
- Route the wiring through an approved cable housing to minimize the risk of accidental damage. Check local and national codes to choose the correct method for your application.

## User Power Supply Requirements

The F2-08DA-1 module requires at least one field-side power supply. The same or separate power sources can be used for the module supply and the current transmitter supply. The F2-08DA-1 module requires 18–30 VDC (at 50mA) and each current loop requires 18–30 VDC (at 20mA), from the external power supply.

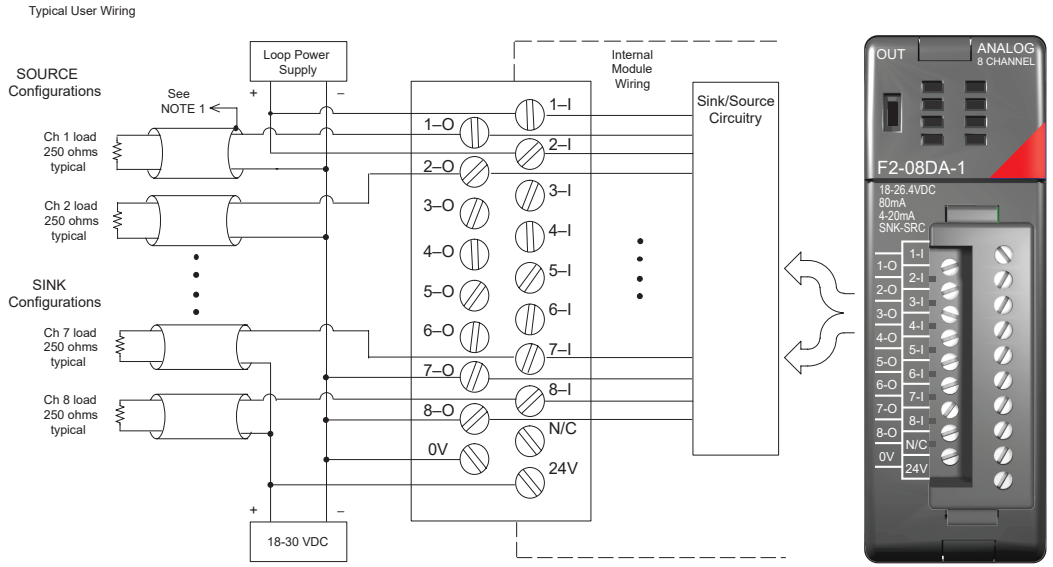
The DL205 AC bases have a built-in 24VDC power supply that provides up to 300mA of current. This can be used instead of a separate supply. Check the power budget to be safe.

It is desirable in some situations to power the transmitters separately in a location remote from the PLC. This will work as long as the transmitter supply meets the required operating current and the transmitter negative (-) side and the module power supply negative (-) side are connected together.

**WARNING: If the internal 24VDC power budget is exceeded, it may cause unpredictable system operation that can lead to a risk of personal injury or equipment damage.**

## Wiring Diagram

The F2-08DA-1 module has a removable connector which helps to simplify wiring. Just squeeze the top and bottom retaining clips and gently pull the connector from the module. Use the following diagram to connect the field wiring. Channels 1 and 2 are shown wired for sourcing, and channels 7 and 8 are shown wired for sinking. The diagram also shows how to wire an optional loop power supply.




***NOTE 1:*** *Shields should be connected to the 0V terminal of the module.*

## Load Range

The maximum load resistance depends on the particular loop power supply being used.

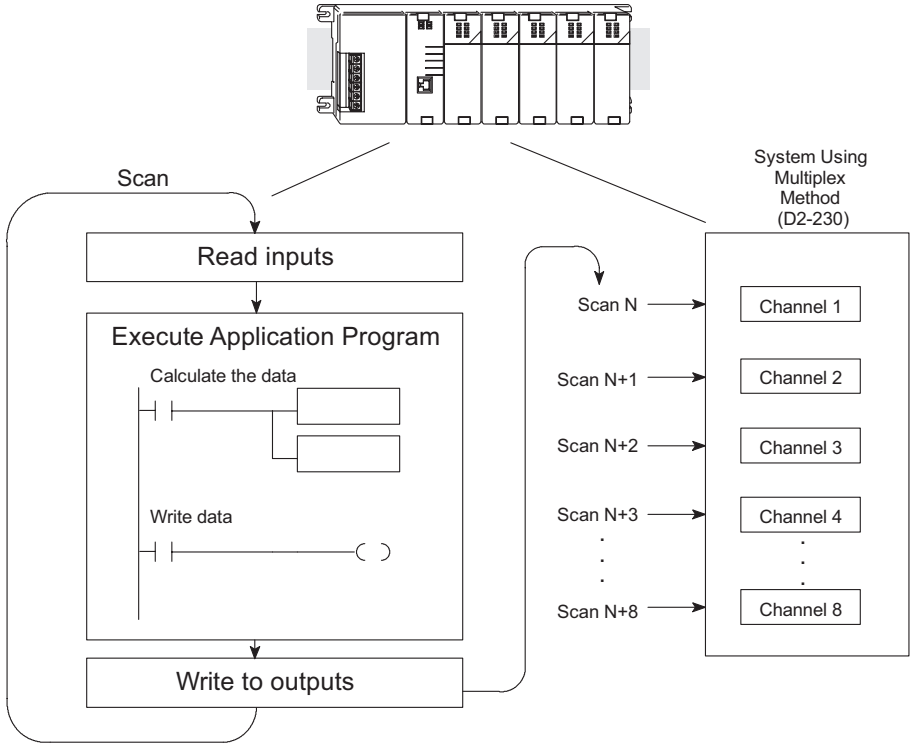
| *Loop Power Supply Voltage* | *Source Load Range* | *Sink Load Range* |
|---|---|---|
| 30VDC | 0–400 Ω | 0–1200 Ω |
| 24VDC | | 0–900 Ω |
| 18VDC | | 0–600 Ω |

# Module Operation

Before beginning to write the control program, it is important to take a few minutes to understand how the module processes the analog signals.

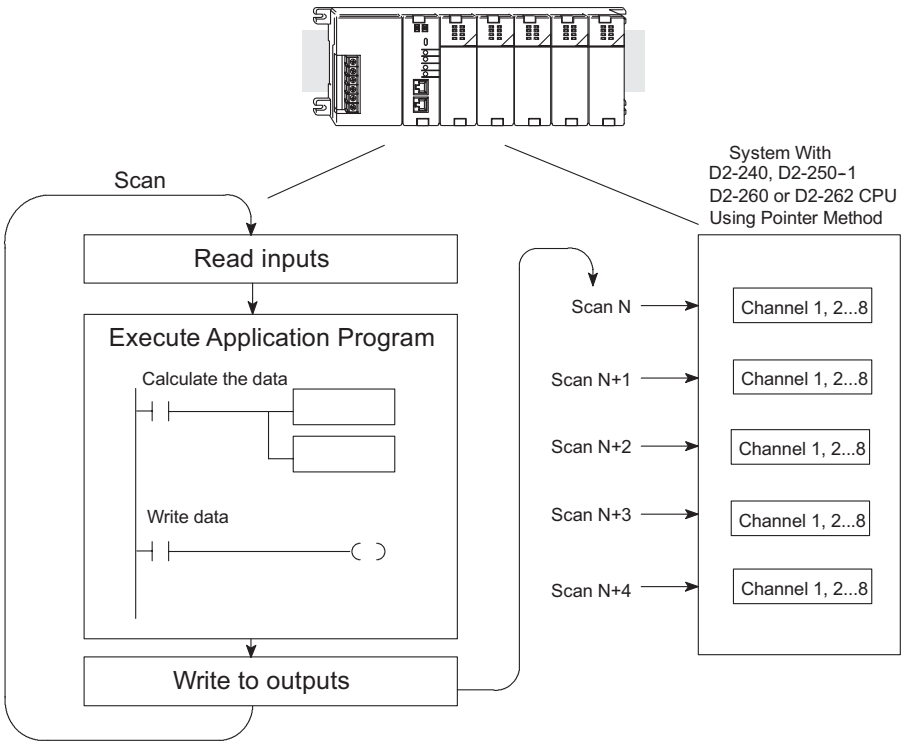
## Channel Scanning Sequence (Multiplexing) for a D2-230 CPU

The D2-230 can send one channel of data to the output per CPU scan if the multiplexing method is used. The module refreshes all field devices on each scan, but new data can only be obtained from the CPU at the rate of one channel per scan. Since there are eight channels, it can take eight scans to update all channels. However, if only one channel is being used, then that channel will be updated on every scan. The multiplexing method can also be used for the D2-240, D2-250-1, D2-260 and D2-262 CPUs.



## Channel Scanning Sequence (Pointer Method) for D2-240, D2-250-1, D2-260 and D2-262 CPUs

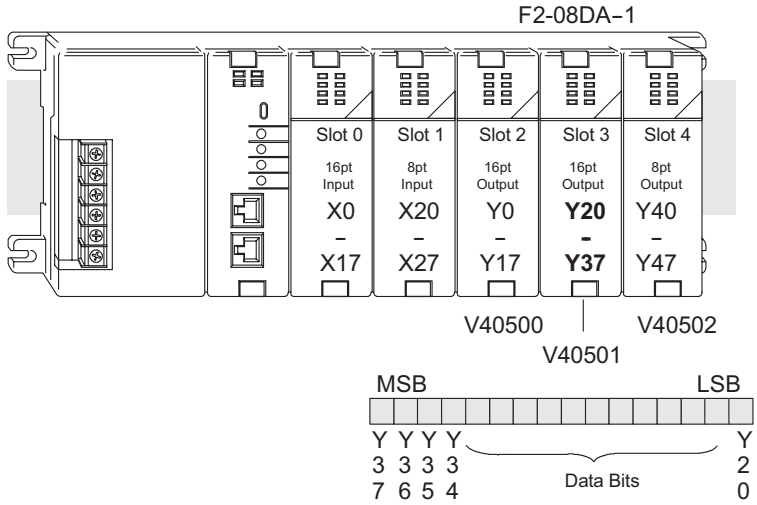
If either a D2-240, D2-250-1, D2-260 or D2-262 CPU is used, all channels can be updated on every scan. This is because the all three CPUs support special V-memory locations that are used to manage the data transfer. This is discussed in more detail in the section on Writing the Control Program later in this chapter.




## Understanding the Output Assignments

Remember that the F2-08DA-1 module appears to the CPU as a 16-point discrete output module. These points provide the data value and an indication of which channel to update. Note, if either a D2-240, D2-250-1, D2-260 or a D2-262 CPU is being used, these bits may never have to be used, but it may be an aid to help understand the data format.

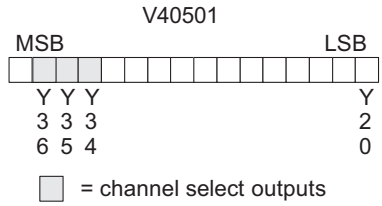
Since all output points are automatically mapped into V-memory, the location of the data word that will be assigned to the module can be simply determined.




The individual bits in this data word location, represents specific information about the analog signal.

## Channel Select Outputs

Three of the outputs select the active channel. Remember, the V-memory bits are mapped directly to discrete outputs. The binary weight of the three bits will determine the selected bit. By controlling these outputs, the channel to be updated can be selected.

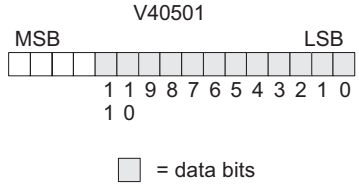



| Select Channel Outputs | | | |
|---|---|---|---|
| ***Y36*** | ***Y35*** | ***Y34*** | ***Channel Number Selected*** |
| – | – | – | 1 |
| – | – | X | 2 |
| – | X | – | 3 |
| – | X | X | 4 |
| X | – | – | 5 |
| X | – | X | 6 |
| X | X | – | 7 |
| X | X | X | 8 |

## Analog Data Bits

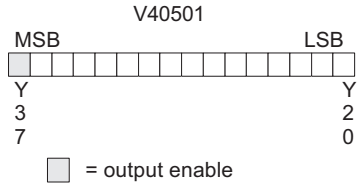
The first twelve bits represent the analog data in binary format.

| Bit | Value | Bit | Value |
|---|---|---|---|
| 0 | 1 | 6 | 64 |
| 1 | 2 | 7 | 128 |
| 2 | 4 | 8 | 256 |
| 3 | 8 | 9 | 512 |
| 4 | 16 | 10 | 1024 |
| 5 | 32 | 11 | 2048 |



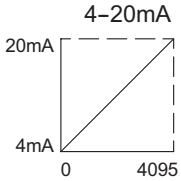

## Output Enable

The last output can be used to update outputs. If t
output is OFF, the outputs will be cleared.




## Module Resolution

Since the module has 12-bit resolution, the analog signal is converted into 4096 counts ranging from 0–4095 (212). For example, send a 0 to get a 4mA signal, and 4095 to get a 20mA signal. This is equivalent to a binary value of 0000 0000 0000 to 1111 1111 1111, or 000 to FFF hexadecimal. The diagram shows how this relates to the signal range. Each count can also be expressed in terms of the signal level by using the equation shown.




$$\text{Resolution} = \frac{H - L}{4095}$$

H = high limit of the signal range

L = low limit of the signal range

16mA/4095 = 3.9 µA per count

# Writing the Control Program

## Calculating the Digital Value

The control program must calculate the digital value that is sent to the analog output. Several methods can be used to do this, but the best method is to convert the values to engineering units. This is accomplished by using the formula shown.

Adjustments may have to be made to the formula depending on the scale of the engineering units.

**For 0–4095 output format**

$$A = U\frac{4095}{H-L}$$

**A = Analog Value (0–4095)**

**U = Engineering Units**

**H = High limit of the engineering unit range**

**L = Low limit of the engineering unit range**

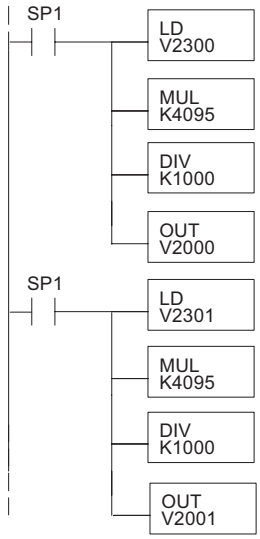
Consider the following example which controls pressure from 0.0–99.9 psi. Using the formula will calculate the digital value to be sent to the analog output. The example shows the conversion required to yield 49.4 psi. The multiplier of 10 is used because the decimal portion of 49.4 cannot be loaded in the program, so it is shifted right one decimal place to make a usable value of 494.

$$A = 10U\ \frac{4095}{10\ (H-L)} \qquad A = 494\ \frac{4095}{(1000-0)} \qquad A = 2023$$

## The Conversion Program

The example program shows how to write the program to perform the engineering unit conversion. This example assumes that a BCD value has been stored in V2300 and V2301 for channels 1 and 2 respectively.

***NOTE:*** *The DL205 has many instructions available so that math operations can simply be performed using BCD format. Do the math in BCD, then convert to binary before writing to the module output.*




The LD instruction loads the engineering units used with channel 1 into the accumulator. This example assumes the numbers are BCD. Since SP1 is used, this rung automatically executes on every scan. You could also use an X, C, etc. permissive contact.

Multiply the accumulator by 4095 (to start the conversion).

Divide the accumulator by 1000 (because we used a multiplier of 10, we have to use 1000 instead of 100).

Store the BCD result in V2000 (the actual steps required to send the data are shown later).

The LD instruction loads the engineering units used with channel 2 into the accumulator. This example assumes the numbers are BCD. Since SP1 is used, this rung automatically executes on every scan. You could also use an X, C, etc. permissive contact.

Multiply the accumulator by 4095 (to start the conversion).

Divide the accumulator by 1000 (because we used a multiplier of 10, we have to use 1000 instead of 100).

Store the BCD result in V2001 (the actual steps required to send the data are shown later).

## Writing Values: Pointer Method and Multiplexing

### Pointer Method for the D2-240, D2-250-1, D2-260 and D2-262 CPUs

There are two methods of reading values:

- Pointer method
- Multiplexing

The multiplexing method must be used with a D2-230 CPU. The multiplexing method must also be used with remote I/O modules (the pointer method will not work). Either method can be used with the D2-240, D2-250-1, D2-260 and D2-262 CPUs, but for ease of programming it is highly recommended to use the pointer method.

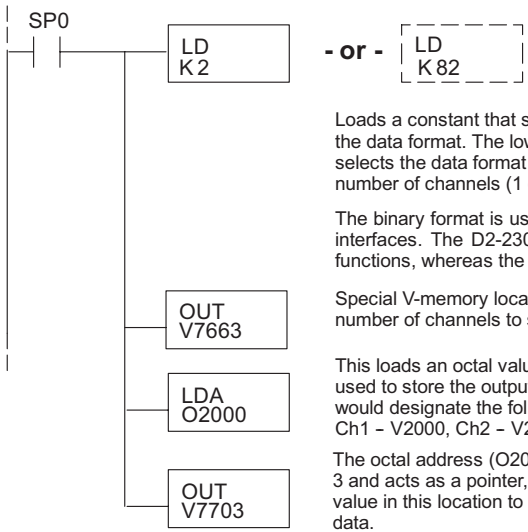
The D2-240, D2-250-1, D2-260 and D2-262 CPUs have special V-memory locations assigned to each base slot that will greatly simplify the programming requirements.

These V-memory locations allow you to:

- Specify the data format
- Specify the number of channels to scan
- Specify the location of the data that will be written to the module

***NOTE:*** *D2-240 CPUs with firmware release version 1.5 or later and. D2-250-1 CPUs with firmware release version 1.06 or later support this method.*

The following example program shows how to setup these locations. Place this rung anywhere in the ladder program, or in the initial stage if stage programming instructions are being used. V2000 is used in the example but any user V-memory location can be used. In this example the module is installed in slot 3. Be sure to use the V-memory locations for the module placement. The pointer method automatically converts values to BCD.




Loads a constant that specifies the number of channels to scan and the data format. The lower byte, most significant nibble (MSN) selects the data format (i.e. 0=BCD, 8=Binary), the LSN selects the number of channels (1 or 2).

The binary format is used for displaying data on some operator interfaces. The D2-230 and D2-240 CPUs do not support binary math functions, whereas the D2-250-1, D2-260, and D2-262 do.

Special V-memory location assigned to slot 3 that contains the number of channels to scan.

This loads an octal value for the first V-memory location that will be used to store the output data. For example, the O2000 entered here would designate the following addresses.
Ch1 – V2000, Ch2 – V2001

The octal address (O2000) is stored here. V7703 is assigned to slot 3 and acts as a pointer, which means the CPU will use the octal value in this location to determine exactly where to store the output data.

The following tables show the special V-memory locations used by the D2-240, D2-250-1, D2-260 and D2-262 for the CPU base and local expansion base I/O slots. Slot 0 (zero) is the module next to the CPU or D2-CM module. Slot 1 is the module two places from the CPU or D2-CM, and so on. Remember, the CPU only examines the pointer values at these locations after a mode transition. Also, if the D2-230 (multiplexing) method is used, verify that these addresses in the CPU are 0 (zero).

The table below applies to the D2-240, D2-250-1, D2-260 and D2-262 CPU base.

| CPU Base: Analog Output Module Slot-Dependent V-memory Locations | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| ***Slot*** | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| ***No. of Channels*** | V7660 | V7661 | V7662 | V7663 | V7664 | V7665 | V7666 | V7667 |
| ***Storage Pointer*** | V7700 | V7701 | V7702 | V7703 | V7704 | V7705 | V7706 | V7707 |

The table below applies to the D2-250-1, D2-260 or the D2-262 CPU base 1.

| Expansion Base D2-CM #1: Analog Output Module Slot-Dependent V-memory Locations | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| ***Slot*** | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| ***No. of Channels*** | V36000 | V36001 | V36002 | V36003 | V36004 | V36005 | V36006 | V36007 |
| ***Storage Pointer*** | V36020 | V36021 | V36022 | V36023 | V36024 | V36025 | V36026 | V36027 |

The table below applies to the D2-250-1, D2-260 or the D2-262 CPU base 2.

| Expansion Base D2-CM #2: Analog Output Module Slot-Dependent V-memory Locations | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| ***Slot*** | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| ***No. of Channels*** | V36100 | V36101 | V36102 | V36103 | V36104 | V36105 | V36106 | V36107 |
| ***Storage Pointer*** | V36120 | V36121 | V36122 | V36123 | V36124 | V36125 | V36126 | V36127 |

The table below applies to the D2-260 and D2-262 CPU base 3.

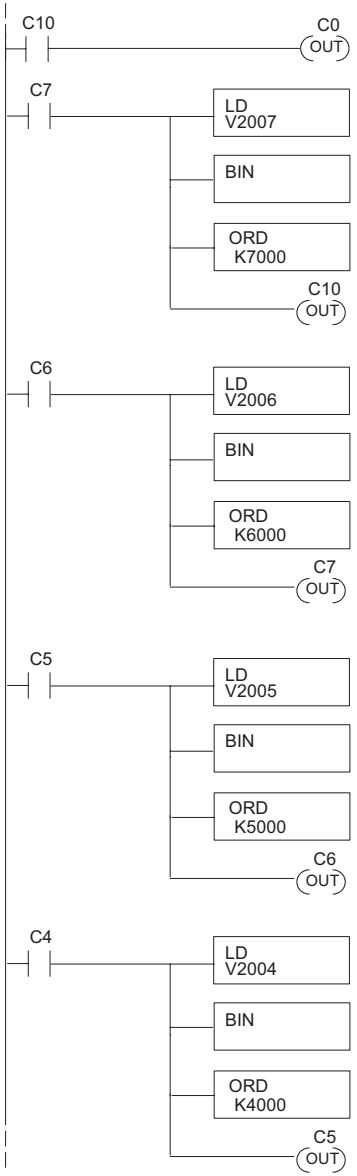
| Expansion Base D2-CM #3: Analog Output Module Slot-Dependent V-memory Locations | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| ***Slot*** | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| ***No. of Channels*** | V36200 | V36201 | V36202 | V36203 | V36204 | V36205 | V36206 | V36207 |
| ***Storage Pointer*** | V36220 | V36221 | V36222 | V36223 | V36224 | V36225 | V36226 | V36227 |

The table below applies to the D2-260 and D2-262 CPU base 4.

| Expansion Base D2-CM #4: Analog Output Module Slot-Dependent V-memory Locations | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| ***Slot*** | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| ***No. of Channels*** | V36300 | V36301 | V36302 | V36303 | V36304 | V36305 | V36306 | V36307 |
| ***Storage Pointer*** | V36320 | V36321 | V36322 | V36323 | V36324 | V36325 | V36326 | V36327 |

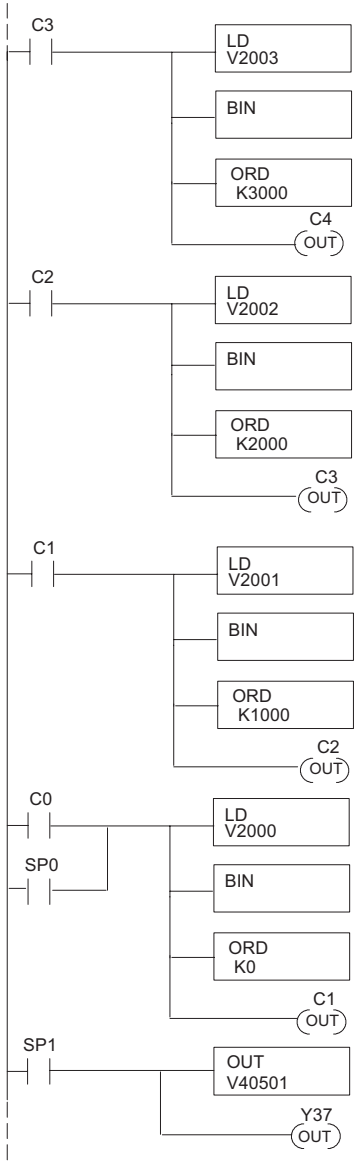
## Writing Data (Multiplexing Example)

The following example program shows how to write data using the multiplexing method. This may be used with all the DL205 CPUs.




**Continued**

## Write Data (Multiplexing Example) Continued




Updates channel 4.

Updates channel 3.

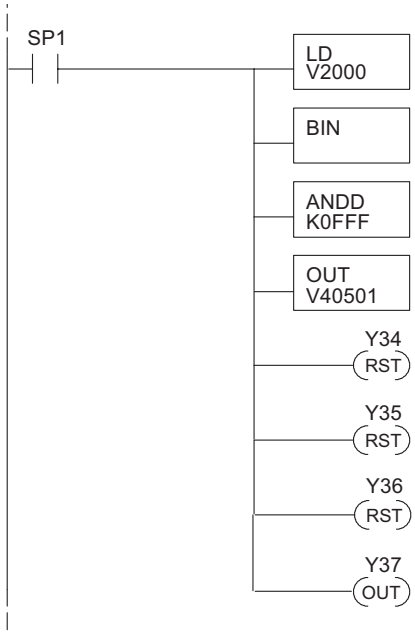
Updates channel 2.

Updates channel 1.

Sends the data to the module. Our example starts with V40501, but the actual value depends on the location of the module in your application.

## Write Data to One Channel

If more than one channel is used, or if updates are to be controlled separately, the following program can be used.




The LD instruction loads the data into the accumulator. Since SP1 is used, this rung automatically executes on every scan. You could also use an X, C, etc. permissive contact.

The BIN instruction converts the accumulator data to binary (you must omit this step if you have already converted the data elsewhere).

The ANDD instruction masks off the channel select bits to prevent an accidental channel selection.

The OUT instruction sends the data to the module. Our example starts with V40501, but the actual value depends on the location of the module in your application.

Y34, Y35, Y36–OFF selects channel 1 for updating.

Y37 is the output enable bit.

## Analog and Digital Value Conversions

It is sometimes useful to do quick conversions between the signal levels and the digital values. This can be helpful during startup or troubleshooting. The following table shows some formulas help with the conversions.

| Range | If the digital value is known | If the analog signal level is known. |
|---|---|---|
| ***4–20 mA*** | $A = \frac{16D}{4095} + 4$ | $D = \frac{4095\ (A\ 4)}{16}$ |

For example, to covert a 10mA signal level to a digital value, substitute 10 for A and complete the math as shown in the example to the right.

$$D = \frac{4095}{16}(A - 4)$$

$$D = \frac{4095}{16}(10mA - 4)$$

$$D = (255.93)(6)$$

$$D = 1536$$

# F2-08DA-2, 8-Channel Analog Voltage Output

## In This Chapter...

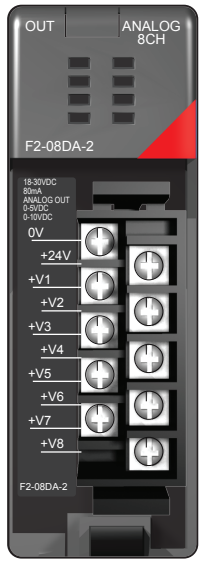
Module Specifications ..... 11-2
Setting the Module Jumpers ..... 11-5
Connecting the Field Wiring ..... 11-6
Module Operation ..... 11-8
Writing the Control Program ..... 11-12

# Module Specifications

The F2-08DA-2 Analog Output module provides several hardware features:

- Analog outputs are optically isolated from the PLC logic.
- The module has a removable terminal block so the module can be easily removed or changed without disconnecting the wiring.
- All channels can be updated in one scan if either a D2-240, a D2-250-1, a D2-260 or a D2-262 CPU is used in the PLC.
- Outputs are voltage sourcing.
- Outputs can be configured for either of the following ranges:

  1. 0–5 VDC
  2. 0–10 VDC



F2-08DA-2

## Firmware Requirements:

- To use this module, D2-230 CPUs must have firmware version 2.7 or later.
- To use the pointer method for writing values, D2-240 CPUs require firmware version 3.0 or later.
- D2-250-1, D2-260, and D2-262 CPUs require firmware version 1.33 or later.

The following tables provide the specifications for the F2–08DA –2 Analog Output Module. Review these specifications to make sure the module meets your application requirements.

| Output Specifications | |
|---|---|
| *Number of Channels* | 8, single-ended |
| *Output Range* | 0–5 V, 0–10 V |
| *Resolution* | 12 bit (1 in 4096) |
| *Output Type* | Voltage sourcing |
| *Peak Output Voltage* | 15VDC (clamped by transient voltage suppressor) |
| *Load Impedance* | 1kΩ (0–5 V range); 10kΩ (0–10 V range) |
| *Load Capacitance* | 0.01 µF maximum |
| *Linearity Error (end to end)* | ± 1 count (± 0.025% of full scale) maximum |
| *Conversion Settling Time* | 400µs maximum (full scale change)<br>4.5 – 9.0 ms for digital out to analog out |
| *Full-scale Calibration Error (offset error included)* | ± 12 counts maximum, @ 25°C (77°F) |
| *Offset Calibration Error* | ± 3 counts maximum, @ 25°C (77°F) |
| *Maximum Inaccuracy* | ± 0.3% @ 25°C (77°F)<br>± 0.45% 0–60°C (32–140°F) |
| *Accuracy vs. Temperature* | ± 57ppm/°C full scale calibration change<br>(Including maximum offset change of 2 counts) |

| General Specifications | |
|---|---|
| *PLC Update Rate* | 1 channel per scan maximum (multiplexing)<br>8 channels per scan maximum (pointer – D2-240/D2-250-1/D2-260 and D2-262 only) |
| *Digital Outputs / Output Points Required* | 12 binary data bits, 3 channel ID bits, 1 output enable bit;<br>16 (Y) output points required |
| *Power Budget Requirement* | 60mA @ 5VDC (supplied by the base) |
| *External Power Supply* | 24VDC(± 10%), 140mA (outputs fully loaded) |
| *Operating Temperature* | 0–60°C (32–140°F) |
| *Storage Temperature* | -20°C to 70°C (-4°F to 158°F) |
| *Relative Humidity* | 5–95% (non-condensing) |
| *Environmental Air* | No corrosive gases permitted |
| *Vibration* | MIL STD 810C 514.2 |
| *Shock* | MIL STD 810C 516.2 |
| *Noise Immunity* | NEMA ICS3-304 |

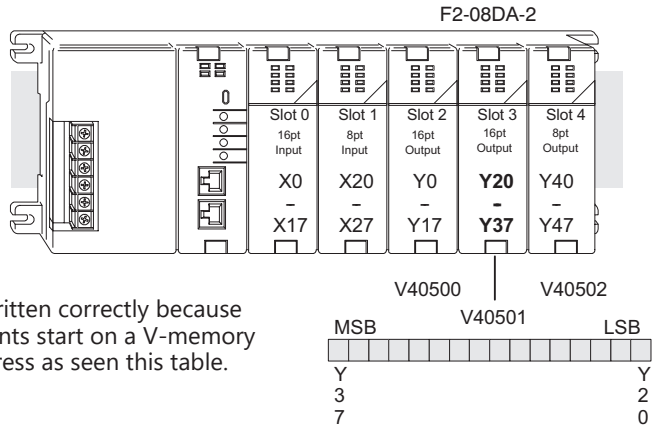
## Analog Output Configuration Requirements

The F2-08DA-2 analog output module requires 16 discrete output points. The module can be installed in any slot of a DL205 PLC, but the available power budget and discrete I/O points are the limiting factors. Check the DL205 PLC User Manual for the particular model of CPU and I/O base being used for information regarding power budget and number of local base, local expansion base or remote I/O points.

## Special Placement Requirements (D2-230 and Remote I/O Bases)

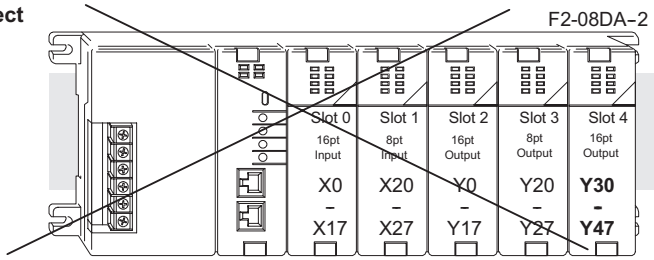
It is important to examine the configuration if a D2-230 CPU is being used. As can be seen in the section on Writing the Control Program, V-memory locations are used to hold the analog data that will be written to the output. If the module is placed in a slot so that the output points do not start on a V-memory boundary, the program instructions aren't able to access the data. This also applies when placing this module in a remote base using a D2-RSSS in the CPU slot.

**Correct!**




Data can be written correctly because the output points start on a V-memory boundary address as seen this table.

**Incorrect**




Data is split over three locations, so instructions cannot access data from a D2-230 (or when the module is placed in a remote base).

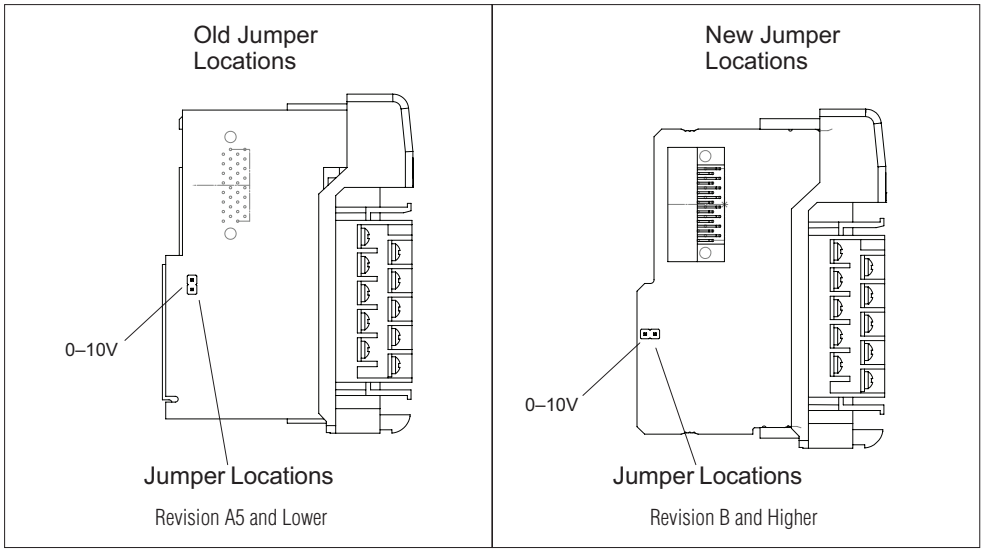
To use the V-memory references required for a D2-230 CPU, the first output address assigned to the module must be one of the following Y locations. The table also shows the V-memory addresses that correspond to these Y locations.

| Y | Y0 | Y20 | Y40 | Y60 | Y100 | Y120 | Y140 | |
|---|---|---|---|---|---|---|---|---|
| V | V40500 | V40501 | V40502 | V40503 | V40504 | V40505 | V40506 | V40507 |

# Setting the Module Jumpers

The F2-08DA-2 Analog Output module uses a jumper for selecting the voltage ranges of 0–5 V or 0–10 V.

This figure shows the jumper locations. See the table on the following page to determine the proper settings for your application.



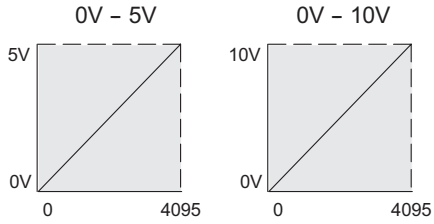

## Voltage Range and Output Combinations

The table lists both possible combinations of voltage ranges and data formats, along with the corresponding jumper settings.

| Voltage Range | Output Data Format | Jumper Setting (top board) |
|---|---|---|
| 0–5V | 0–4095 | Install |
| 0–10V | 0–4095 | Remove |

The following graphs show the voltage range to output data format relationship for each of the two selections.

### Ranges



# Connecting the Field Wiring

## Wiring Guidelines

Your company may have guidelines for wiring and cable installation. If so, check the guidelines before beginning the installation. Here are some general things to consider:

- Use the shortest wiring route whenever possible.
- Use shielded wiring and ground the shield at the transmitter source. Do not ground the shield at both the module and the source.
- Do not run the signal wiring next to large motors, high current switches, or transformers. This may cause noise problems.
- Route the wiring through an approved cable housing to minimize the risk of accidental damage. Check local and national codes to choose the correct method for your application.

## User Power Supply Requirements

The F2-08DA-2 module requires at least one field-side power supply. The same or separate power sources can be used for the module supply and the voltage transmitter supply. The F2-08DA-2 module requires 21.6-26.4 VDC (at 140 mA), from the external power supply.

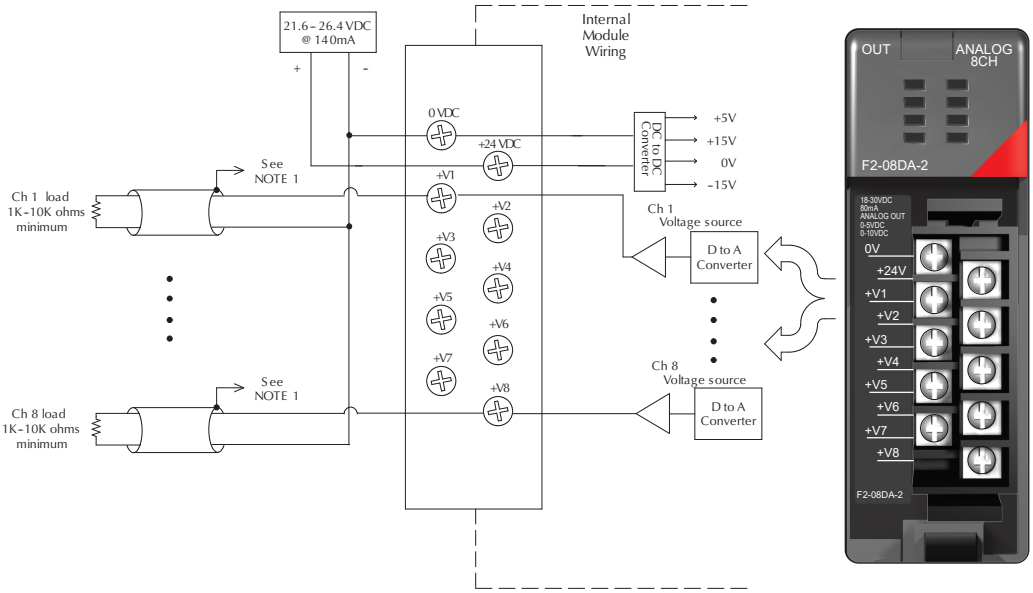
The DL205 AC bases have a built-in 24VDC power supply that provide up to 300 mA of current. This can be used instead of a separate supply. Check the power budget to be safe.

It is desirable in some situations to power the transmitters separately in a location remote from the PLC. This will work as long as the transmitter supply meets the current requirements, and the transmitter's minus (-) side and the module supply's minus (-) side are connected together.

**WARNING: If the internal 24VDC base power is used, be sure to calculate the power budget. Exceeding the power budget can cause unpredictable system operation that can lead to a risk of personal injury or equipment damage.**

## Wiring Diagram

The F2-08DA-2 module has a removable connector which helps to simplify wiring. Squeeze the top and bottom retaining clips and gently pull the connector from the module. Use the following diagram to connect the field wiring.



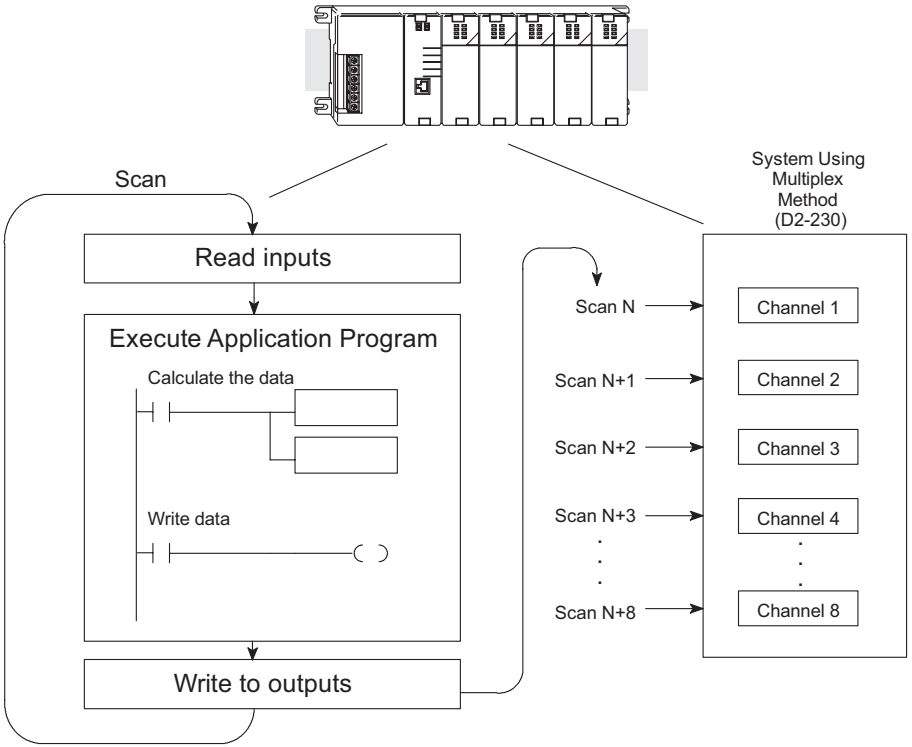

***NOTE 1:*** *Shields should be connected to the 0V terminal of the module or 0V of the power supply.*

# Module Operation

Before beginning to write the control program, it is important to take a few minutes to understand how the module processes the analog signals.

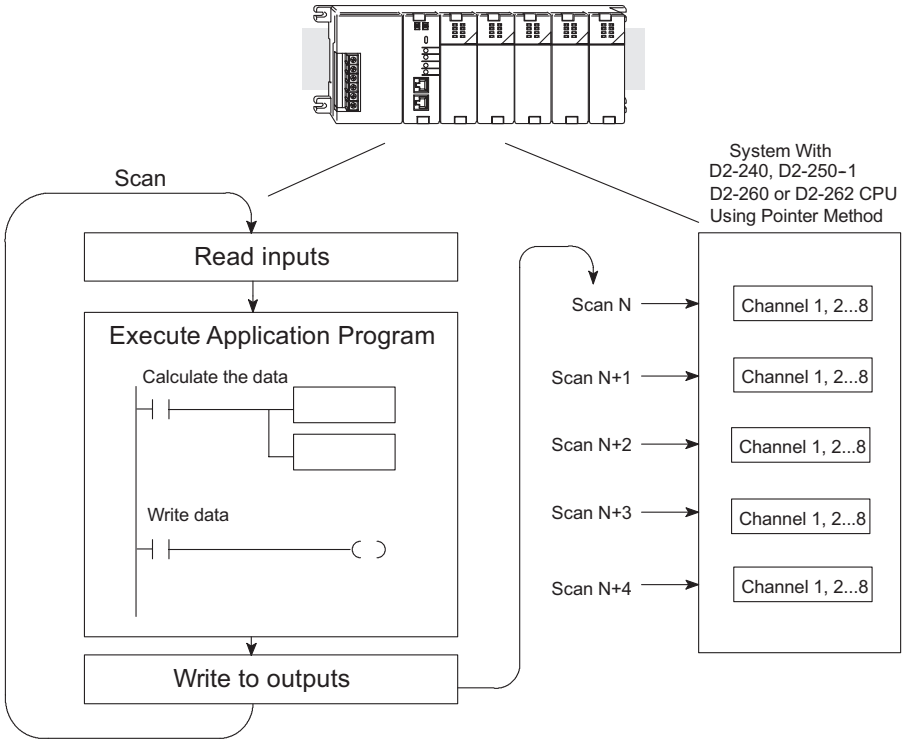
## Channel Update Sequence (Multiplexing) for a D2-230 CPU

If a multiplexing program is being used, only one channel of data can be sent to the output module on each scan. The module refreshes both field devices on each scan, but new data can only be obtained from the CPU at the rate of one channel per scan. Since there are eight channels, it can take eight scans to update all channels. However, if only one channel is being used, that channel will be updated on every scan. The multiplexing method can also be used for the D2-240, D2-250-1, D2-260 and D2-262 CPUs.



## Channel Update Sequence (Pointer Method) for D2-240, D2-250-1, D2-260 and D2-262 CPUs

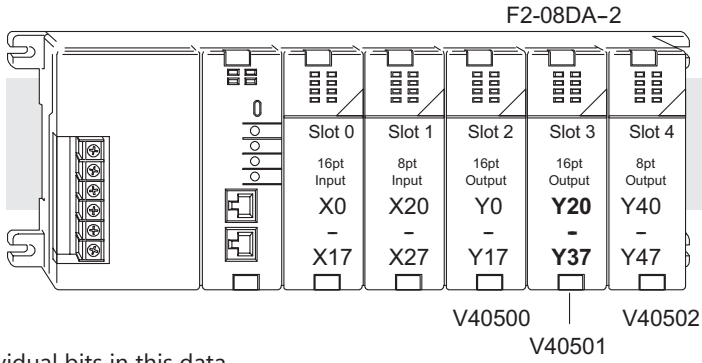
If either a D2-240, D2-250-1, D2-260 or a D2-262 CPU is used with the pointer method, all channels can be updated on every scan. This is because the three CPUs support special V-memory locations that are used to manage the data transfer. This is discussed in more detail in the section on Writing the Control Program later in this chapter.



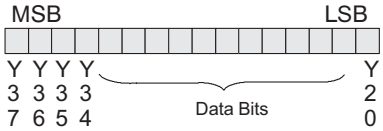
## Understanding the Output Assignments

Remember that the F2-08DA-2 module appears to the CPU as a 16-point discrete output module. These points provide the data value and an indication of which channel to update. Note, if either a D2-240, D2-250-1, D2-260 or a D2-262 CPU is being used, these bits may never have to be used, but it may be an aid to help understand the data format.

Since all output points are automatically mapped into V-memory, the location of the data word that will be assigned to the module can be simply determined.

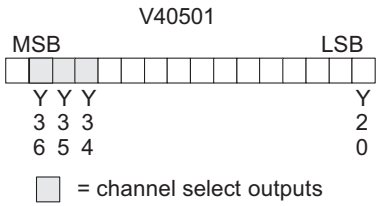



The individual bits in this data word location, represents specific information about the analog signal.




## Channel Select Outputs

Three of the outputs select the active channel. Remember, the V-memory bits are mapped directly to discrete outputs. The binary weight of these three bits determines which channel is selected. The channel to be updated is controlled by these three outputs.

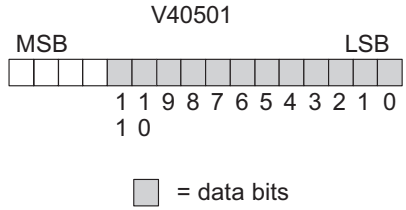



| Select Channel Outputs | | | |
|---|---|---|---|
| Y36 | Y35 | Y34 | Channel Number Selected |
| – | – | – | 1 |
| – | – | X | 2 |
| – | X | – | 3 |
| – | X | X | 4 |
| X | – | – | 5 |
| X | – | X | 6 |
| X | X | – | 7 |
| X | X | X | 8 |

## Analog Data Bits

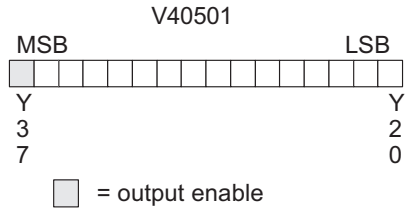
The first twelve bits represent the analog data in binary format.

| Bit | Value | Bit | Value |
|---|---|---|---|
| 0 | 1 | 6 | 64 |
| 1 | 2 | 7 | 128 |
| 2 | 4 | 8 | 256 |
| 3 | 8 | 9 | 512 |
| 4 | 16 | 10 | 1024 |
| 5 | 32 | 11 | 2048 |




## Output Enable

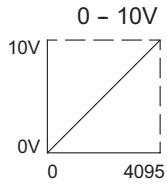
The last output can be used to update outputs. If this output is OFF, the outputs are cleared.




## Module Resolution

Since the module has 12-bit resolution, the analog signal is converted into 4096 counts ranging from 0–4095 (212). For example, for a 0–10 V range, send a 0 to get a 0V signal, and 4095 to get a 10V signal. This is equivalent to a binary value of 0000 0000 0000 to 1111 1111 1111, or 000 to FFF hexadecimal.

Each count can also be expressed in terms of the signal level by using the equation shown.




$$\text{Resolution} = \frac{H - L}{4095}$$

H = High limit of the signal range

L = Low limit of the signal range

The table below shows the smallest change in signal level due to a digital value change of 1 LSB count.

| Voltage Range | Signal Span | Divide By | Smallest Output Change |
|---|---|---|---|
| 0–5 V | 5 volts | 4095 | 1.22 mV |
| 0–10 V | 10 volts | 4095 | 2.44 mV |

# Writing the Control Program

## Calculating the Digital Value

The control program must calculate the digital value that is sent to the analog output. Several methods can be used to do this, but the best method is to convert the values to engineering units. This is accomplished by using the formula shown.

Adjustments may need to be made to the formula depending on the scale of the engineering units.

$$A = U\frac{4095}{H-L}$$ for 0–4095 output format

A = Analog Value (0 – 4095)

U = Engineering Units

H = High limit of the engineering unit range

L = Low limit of the engineering unit range

Consider the following example which controls pressure from 0.0 – 99.9 psi. Using the formula will calculate the digital value to be sent to the analog output. The example shows the conversion required to yield 49.4 psi. The multiplier of 10 is because the decimal portion of 49.4 cannot be loaded in the program, so it is shifted right one decimal place to make a usable value of 494.

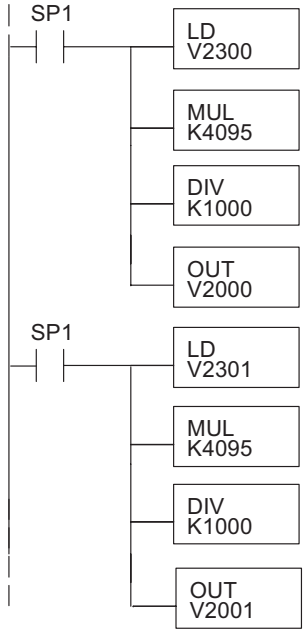
$$A = 10U\frac{4095}{10\,(H-L)} \qquad A = 494\frac{4095}{(1000-0)} \qquad A = 2023$$

Refer to the example on the next page to write the conversion program.

## The Conversion Program

This example program shows how to write the program to perform the engineering unit conversion to output data formats 0–4095. This example assumes that a BCD value has been stored in V2300 and V2301 for channels 1 and 2 respectively.

*NOTE: The DL205 has many instructions available so that math operations can simply be performed using BCD format. Do the math in BCD, then convert to binary before writing to the module output.*




The LD instruction loads the engineering units used with channel 1 into the accumulator. This example assumes the numbers are BCD. Since SP1 is used, this rung automatically executes on every scan. You could also use an X, C, etc. permissive contact.

Multiply the accumulator by 4095 (to start the conversion).

Divide the accumulator by 1000 (because we used a multiplier of 10, we have to use 1000 instead of 100).

Store the BCD result in V2000 (the actual steps required to send the data are shown later).

The LD instruction loads the engineering units used with channel 2 into the accumulator. This example assumes the numbers are BCD. Since SP1 is used, this rung automatically executes on every scan. You could also use an X, C, etc. permissive contact.

Multiply the accumulator by 4095 (to start the conversion).

Divide the accumulator by 1000 (because we used a multiplier of 10, we have to use 1000 instead of 100).

Store the BCD result in V2001 (the actual steps required to send the data are shown later).

## Writing Values: Pointer Method and Multiplexing

There are two methods of reading values:

- Pointer method
- Multiplexing

The multiplexing method must be used with a D2-230 CPU. The multiplexing method must also be used with remote I/O modules (the pointer method will not work). Either method can be used with the D2-240, D2-250-1, D2-260 and D2-262 CPUs, but for ease of programming it is highly recommended to use the pointer method.

## Pointer Method for the D2-240, D2-250-1, D2-260 and D2-262 CPUs

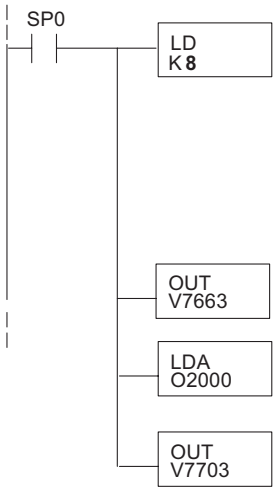
The D2-240, D2-250-1, D2-260 and D2-262 CPUs have special V-memory locations assigned to each base slot that will greatly simplify the programming requirements.

These V-memory locations allow you to:

- Specify the data format
- Specify the number of channels to scan
- Specify the location of the data that will be written to the module

***NOTE:*** *D2-240 CPUs with firmware release version 3.0 or later and. D2-250-1 CPUs with firmware release version 1.33 or later support this method.*

The following example program shows how to setup these locations. Place this rung anywhere in the ladder program, or in the initial stage if stage programming instructions are being used. V2000 is used in the example but any user V-memory location can be used. In this example the module is installed in slot 3. Be sure to use the V-memory locations for the module placement. The pointer method automatically converts values to BCD.




**- or -**

LD
K 88

Loads a constant that specifies the number of channels to scan and the data format. The lower byte, most significant nibble (MSN) selects the data format (0=BCD, 8=Binary), the LSN selects the number of channels (1–8).

The binary format is used for displaying data on some operator interfaces. The D2-230 and D2-240 CPUs do not support binary math functions, whereas the D2-250-1, D2-260, and D2-262 do.

Special V-memory location assigned to slot 3 that contains the number of channels to scan.

This loads an octal value for the first V-memory location that will be used to store the output data. For example, the O2000 entered here would designate the following addresses:
Ch1 – V2000, Ch 2 – V2001.....Ch8 – V2007

The octal address (O2000) is stored here. V7703 is assigned to slot 3 and acts as a pointer, which means the CPU will use the octal value in this location to determine exactly where to store the output data.

The following tables show the special V-memory locations used by the D2-240, D2-250-1, D2-260 and D2-262 for the CPU base and local expansion base I/O slots. Slot 0 (zero) is the module next to the CPU or D2-CM module. Slot 1 is the module two places from the CPU or D2-CM, and so on. Remember, the CPU only examines the pointer values at these locations after a mode transition. Also, if the D2-230 (multiplexing) method is used, verify that these addresses in the CPU are 0 (zero).

The table below applies to the D2-240, D2-250-1, D2-260 or the D2-262 CPU base.

| CPU Base: Analog Output Module Slot-Dependent V-memory Locations | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| ***Slot*** | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| ***No. of Channels*** | V7660 | V7661 | V7662 | V7663 | V7664 | V7665 | V7666 | V7667 |
| ***Storage Pointer*** | V7700 | V7701 | V7702 | V7703 | V7704 | V7705 | V7706 | V7707 |

The table below applies to the D2-250-1, D2-260 or the D2-262 CPU base 1.

| Expansion Base D2-CM #1: Analog Output Module Slot-Dependent V-memory Locations | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| ***Slot*** | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| ***No. of Channels*** | V36000 | V36001 | V36002 | V36003 | V36004 | V36005 | V36006 | V36007 |
| ***Storage Pointer*** | V36020 | V36021 | V36022 | V36023 | V36024 | V36025 | V36026 | V36027 |

The table below applies to the D2-250-1, D2-260 or the D2-262 CPU base 2.

| Expansion Base D2-CM #2: Analog Output Module Slot-Dependent V-memory Locations | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| ***Slot*** | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| ***No. of Channels*** | V36100 | V36101 | V36102 | V36103 | V36104 | V36105 | V36106 | V36107 |
| ***Storage Pointer*** | V36120 | V36121 | V36122 | V36123 | V36124 | V36125 | V36126 | V36127 |

The table below applies to the D2-260 and D2-262 CPU base 3.

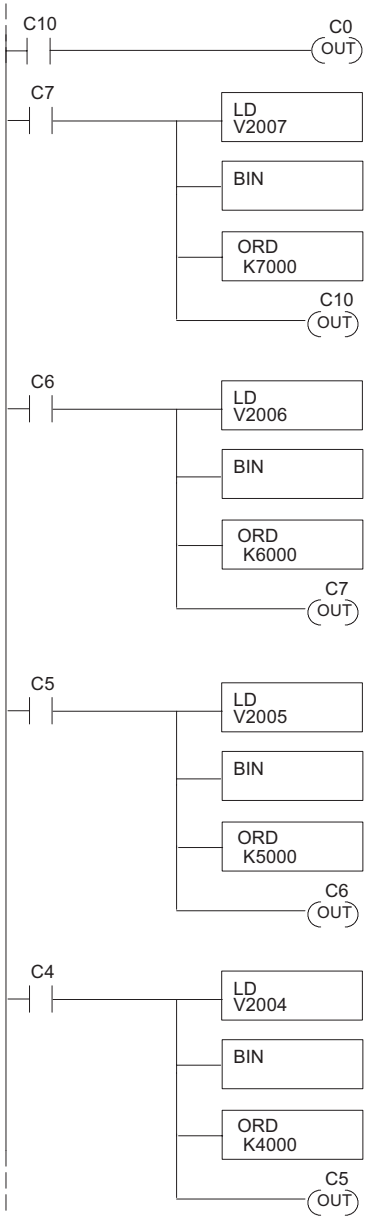
| Expansion Base D2-CM #3: Analog Output Module Slot-Dependent V-memory Locations | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| ***Slot*** | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| ***No. of Channels*** | V36200 | V36201 | V36202 | V36203 | V36204 | V36205 | V36206 | V36207 |
| ***Storage Pointer*** | V36220 | V36221 | V36222 | V36223 | V36224 | V36225 | V36226 | V36227 |

The table below applies to the D2-260 and D2-262 CPU base 4.

| Expansion Base D2-CM #4: Analog Output Module Slot-Dependent V-memory Locations | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| ***Slot*** | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| ***No. of Channels*** | V36300 | V36301 | V36302 | V36303 | V36304 | V36305 | V36306 | V36307 |
| ***Storage Pointer*** | V36320 | V36321 | V36322 | V36323 | V36324 | V36325 | V36326 | V36327 |

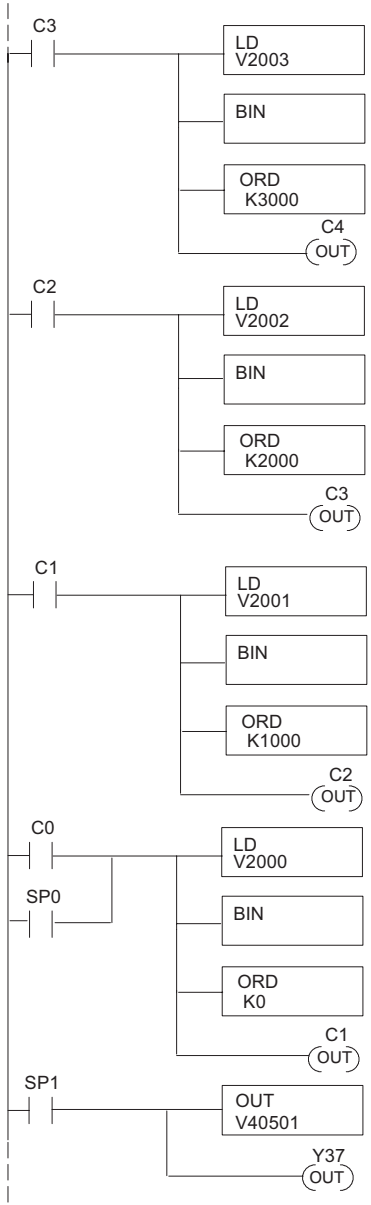
## Writing Data Example (Multiplexing)

The following example shows how to write the data to be sent to the output using the multiplexing method. This can be used with all DL205 CPUs.



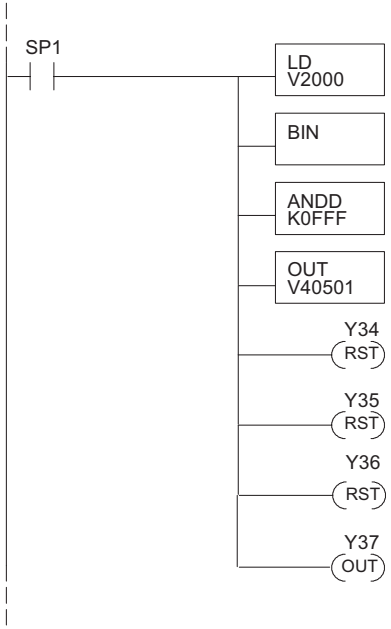

**Continued**

## Writing Data Example (Multiplexing) continued



## Write Data to One Channel

The following example can be used if only one channel is to be written to, or if the outputs are to be controlled individually. Don't forget to either embed the sign information or use the sign output bit for bipolar ranges.




The LD instruction loads the data into the accumulator. Since SP1 is used, this rung automatically executes on every scan. You could also use an X, C, etc. permissive contact.

The BIN instruction converts the accumulator data to binary (you must omit this step if you have already converted the data elsewhere).

The ANDD instruction masks off the channel select bits to prevent an accidental channel selection.

The OUT instruction sends the data to the module. Our example starts with V40501, but the actual value depends on the location of the module in your application.

Y34, Y35, Y36–OFF selects channel 1 for updating.

Y37 is the output enable bit.

## Analog and Digital Value Conversions

It is sometimes useful to do quick conversions between the signal levels and the digital values. This can be helpful during startup or troubleshooting. The following table shows some formulas to help with the conversions.

| Range | If the digital value is known | If the analog signal level is known. |
|---|---|---|
| **0–10 V** | $A = \frac{10D}{4095}$ | $D = \frac{4095}{10}(A)$ |
| **0–5 V** | $A = \frac{5D}{4095}$ | $D = \frac{4095}{5}(A)$ |

For example, if a 0–10 V range is used, and a 6V signal level is needed, use the formula to the right to determine the digital value "D" to be stored in the V-memory location which contains the data.

$$D = \frac{4095}{10}(A)$$

$$D = \frac{4095}{10}(6V)$$

$$D = (409.5)(6)$$

$$D = 2457$$

# F2-02DAS-1, Isolated 2-Channel Analog Current Output

In This Chapter...

Module Specifications ..... 12-2
Connecting the Field Wiring ..... 12-5
Module Operation ..... 12-7
Writing the Control Program ..... 12-11

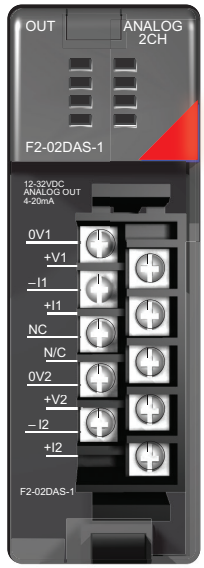
# Module Specifications

The F2-02DAS-1 Analog Output module provides several hardware features:

- Analog outputs are isolated from channel to channel and channel to PLC logic.
- The module has a removable terminal block so the module can be easily removed or changed without disconnecting the wiring.
- All channels can be updated in one scan if either a D2-240, a D2-250-1, D2-260 or a D2-262 CPU is used in the PLC.
- Outputs are sourced through external loop supply.
- Loop power supply requirements: 18–32 VDC

## Firmware Requirements:

- To use this module, D2-230 CPUs must have firmware version 1.7 or later.
- To use the pointer method for writing values, D2-240 CPUs require firmware version 2.9 or later.
- D2-250 CPUs require firmware version 1.30 or later.




**F2-02DAS-1**

The following tables provide the specifications for the F2–02DAS –1, Isolated Analog Output Module.

| Output Specifications | |
|---|---|
| ***Number of Channels*** | 2, isolated (2 commons) |
| ***Output Range*** | 4–20 mA |
| ***Resolution*** | 16 bit (1 in 65536) |
| ***Output Type*** | Current sourcing |
| ***Isolation Voltage*** | ±750V continuous, channel to channel, channel to logic |
| ***Loop Supply*** | 18–32 VDC |
| ***Max Load Impedance*** | 525Ω |
| ***Linearity Error (end to end)*** | ±10 counts (±0.015% of full scale) maximum |
| ***Conversion Settling Time*** | 3ms to 0.1% of full scale |
| ***Gain Calibration Error*** | ±32 counts (±0.05%) |
| ***Offset Calibration Error*** | ±13 counts (±0.02%) |
| ***Output Drift*** | 50ppm / °C |
| ***Maximum Inaccuracy*** | ±0.07% @ 25°C (77°F)<br>±0.18% 0–60 °C (32–140 °F) |

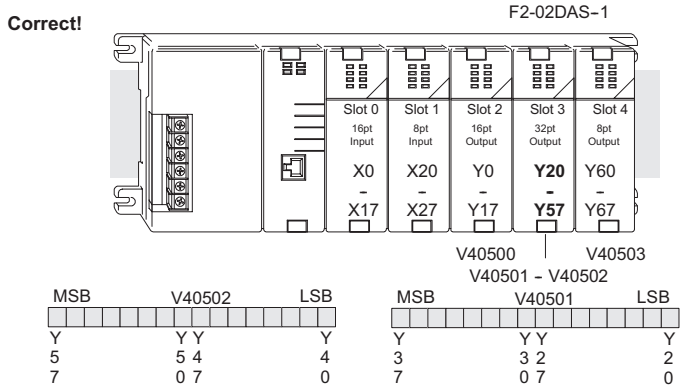
| General Specifications | |
|---|---|
| ***PLC Update Rate*** | 1 channel per scan maximum (multiplexing)<br>2 channels per scan maximum (pointer –<br>D2-240/D2-250-1/D2-260 and D2-262 only) |
| ***Digital Outputs / Output Points Required*** | 16 binary data bits, 2 channel ID bits;<br>32 point (Y) output module |
| ***Power Budget Requirement*** | 100mA @ 5VDC (supplied by the base) |
| ***External Power Supply*** | 18–32 VDC, 50mA per channel, Class 2 |
| ***Operating Temperature*** | 0–60 °C (32–140 °F) |
| ***Storage Temperature*** | -20°C to 70°C (-4°F to 158°F) |
| ***Relative Humidity*** | 5–95% (non-condensing) |
| ***Environmental Air*** | No corrosive gases permitted |
| ***Vibration*** | MIL STD 810C 514.2 |
| ***Shock*** | MIL STD 810C 516.2 |
| ***Noise Immunity*** | NEMA ICS3-304 |

## Analog Output Configuration Requirements

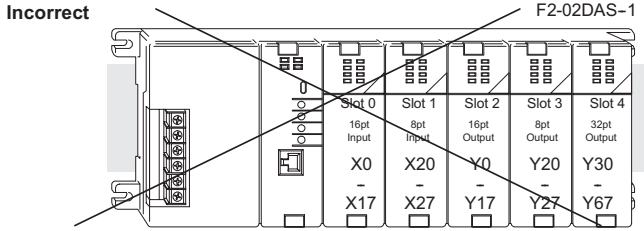
The F2-02DAS-1 analog output module requires 32 discrete output points. The module can be installed in any slot of a DL205 system, but the available power budget and discrete I/O points are the limiting factors. Check the DL205 PLC User Manual for the particular model of CPU and I/O base being used for information regarding power budget and number of local, local expansion or remote I/O points.

## Special Placement Requirements (D2-230 and Remote I/O Bases)

It is important to examine the configuration if a D2-230 CPU is being used in a multiplexing program. As can be seen in the section on Writing the Control Program, V-memory locations are used to hold the analog data that will written to the output. If the module is placed in a slot so that the output points do not start on a V-memory boundary, the program instructions aren't able to access the data. This also applies when placing this module in a remote base using a D2-RSSS in the CPU slot.




Data can be written correctly because the output points start on a V-memory boundary address as seen in the table above.




Data is split over three locations, so instructions cannot access data from a D2-230 (or when module is placed in a remote I/O base).

To use the V-memory references required for a D2-230 CPU, the first output address assigned to the module must be one of the following Y locations. The table also shows the V-memory addresses that correspond to these Y locations.

| **Y** | Y0 | Y20 | Y40 | Y60 | Y100 | Y120 | Y140 | Y160 |
|---|---|---|---|---|---|---|---|---|
| **V** | V40500 | V40501 | V40502 | V40503 | V40504 | V40505 | V40506 | V40507 |

# Connecting the Field Wiring

## Wiring Guidelines

Your company may have guidelines for wiring and cable installation. If so, check the guidelines before beginning the installation. Here are some general things to consider:

- Use the shortest wiring route whenever possible.
- Use shielded wiring and ground the shield at the transmitter source. Do not ground the shield at both the module and the source.
- Do not run the signal wiring next to large motors, high current switches, or transformers. This may cause noise problems.
- Route the wiring through an approved cable housing to minimize the risk of accidental damage. Check local and national codes to choose the correct method for your application.

## Loop Power Supply Requirements

The F2-02DAS-1 module requires at least one field-side power supply. Separate power sources should be used to maintain the channel to channel isolation. The F2-02DAS-1 module requires 18–32 VDC (at 50mA per channel) from the external power supply.

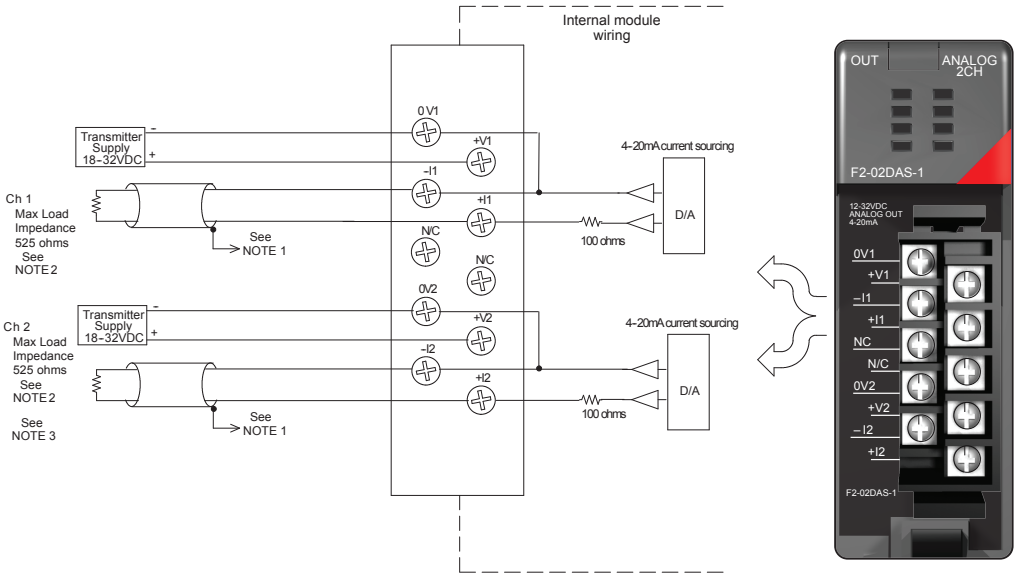
The DL205 AC bases have a built-in 24VDC power supply that provide up to 300mA of current. This can be used instead of a separate supply. Check the power budget to be safe.

It is desirable in some situations to power the transmitters separately in a location remote from the PLC. This will work as long as the transmitter supply meets the current requirements, and the transmitter's negative (-) side and the module supply's negative (-) side are connected together.

**WARNING: If the internal 24VDC base power is used, be sure to calculate the power budget. Exceeding the power budget can cause unpredictable system operation that can lead to a risk of personal injury or equipment damage.**

## Wiring Diagram

The F2-02DAS-1 module has a removable connector which helps to simplify wiring. Squeeze the top and bottom retaining clips and gently pull the connector from the module. Use the following diagram to connect the field wiring.



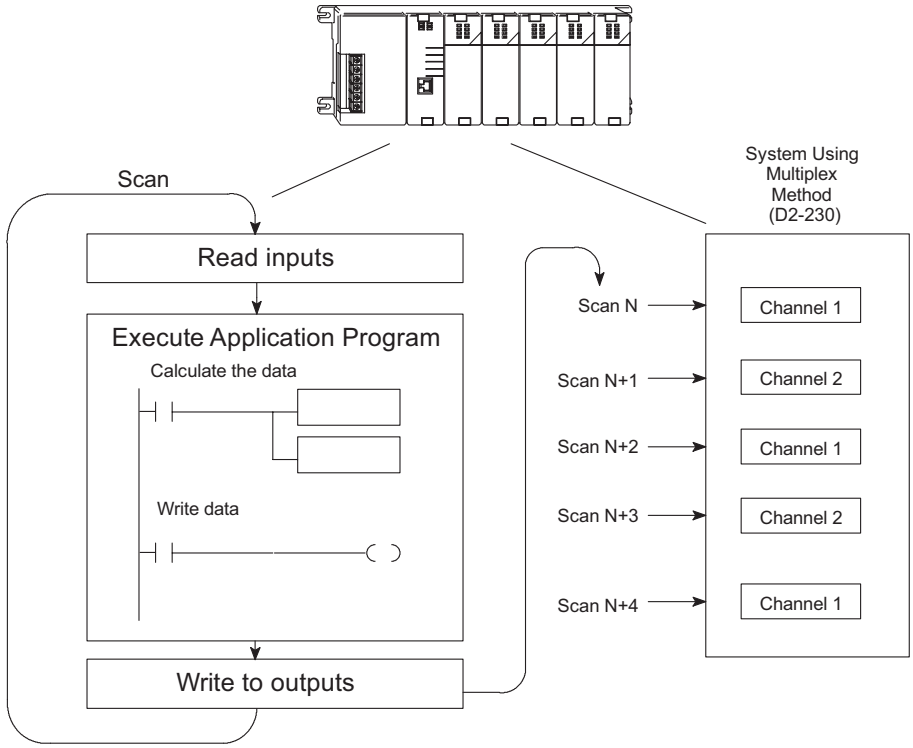

***NOTE 1**: Shields should be connected to the 0V terminal of the module or 0V of the power supply.*
***NOTE 2**: Loads must be within the compliance voltage.*
***NOTE 3**: For non-isolated outputs, connect (0V1.& 0V2) together and connect (+V1.&.+V2) together*

# Module Operation

Before beginning to write the control program, it is important to take a few minutes to understand how the module processes the analog signals.

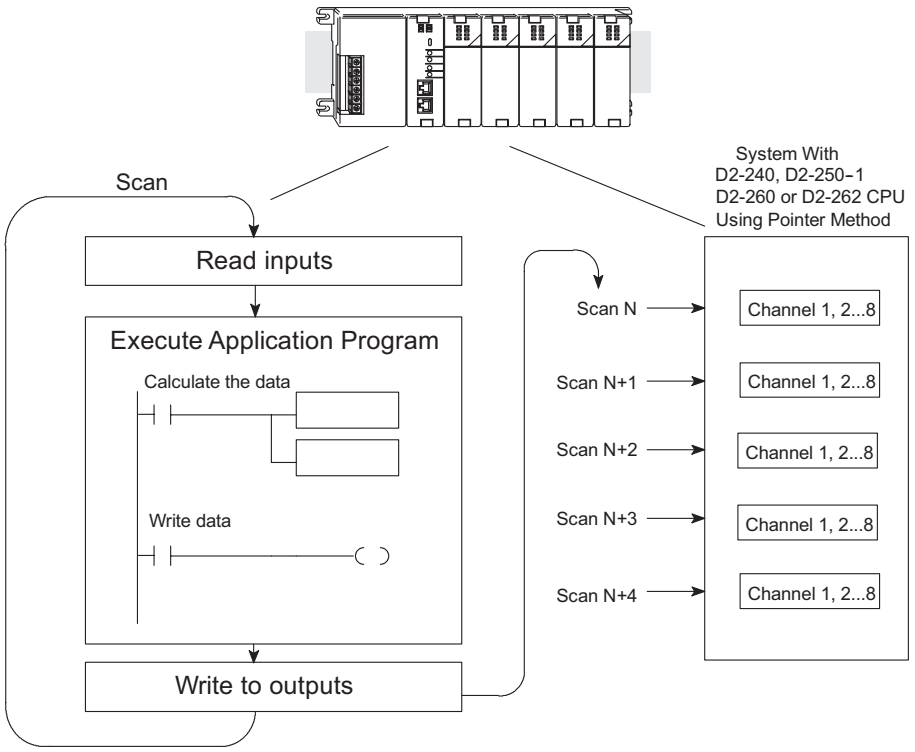
## Channel Update Sequence (Multiplexing) for a D2-230 CPU

If a multiplexing program is being used, only one channel of data can be sent to the output module on each scan. The module refreshes both field devices on each scan, but new data can only be obtained from the CPU at the rate of one channel per scan. Since there are two channels, it can take two scans to update both channels. However, if only one channel is being used, that channel will be updated on every scan. The multiplexing method can also be used for the D2-240, D2-250-1, D2-260 and D2-262 CPUs.



## Channel Update Sequence (Pointer Method) for D2-240, D2-250-1, D2-260 and D2-262 CPUs

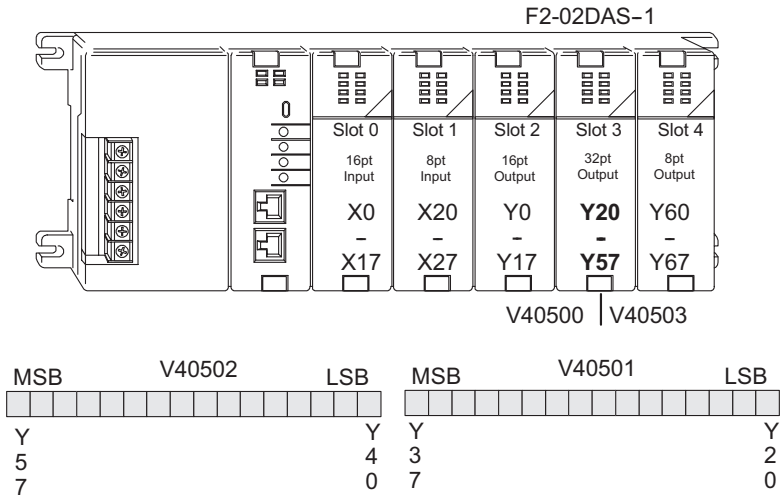
If either a D2-240, D2-250-1, D2-260 or D2-262 CPU is used with the pointer method, all channels can be updated on every scan. This is because the three CPUs support special V-memory locations that are used to manage the data transfer. This is discussed in more detail in the section on Writing the Control Program later in this chapter.



## Understanding the Output Assignments

Remember that the F2-02DAS-1 module appears to the CPU as a 32-point discrete output module. These points provide the data value and an indication of which channel to update. Note, if either a D2-240, D2-250-1, D2-260 or D2-262 CPU is being used, these bits may never have to be used, but it may be an aid to help understand the data format.

Since all output points are automatically mapped into V-memory, the location of the data word that will be assigned to the module can simply be determined.

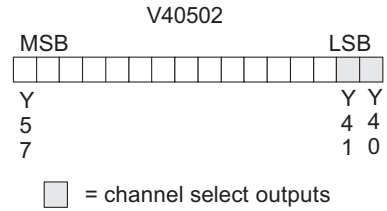



The individual bits in this data word location, represents specific information about the analog signal.

## Channel Select Outputs

Two of the outputs select the active channel. Remember, the V-memory bits are mapped directly to discrete outputs. Turning a bit OFF selects a channel. By controlling these outputs, the channel to be updated is selected.

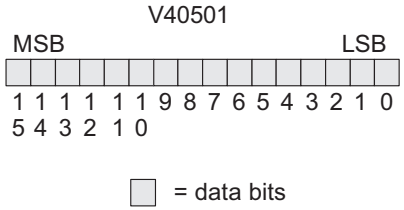
| Y41 | Y40 | Channel |
|---|---|---|
| On | Off | 1 |
| Off | On | 2 |
| Off | Off | 1 & 2 (same data to both channels) |
| On | On | None (both channels hold current values) |



## Analog Data Bits

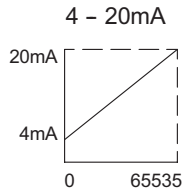
The first sixteen bits represent the analog data in binary format.

| Bit | Value | Bit | Value |
|---|---|---|---|
| 0 | 1 | 8 | 256 |
| 1 | 2 | 9 | 512 |
| 2 | 4 | 10 | 1024 |
| 3 | 8 | 11 | 2048 |
| 4 | 16 | 12 | 4096 |
| 5 | 32 | 13 | 8192 |
| 6 | 64 | 14 | 16384 |
| 7 | 128 | 15 | 32768 |




## Module Resolution

Since the module has 16-bit resolution, the analog signal is converted into 65536 counts ranging from 0-65535 (216). For example, send a 0 to get a 4mA signal, and 65535 to get a 20mA signal. This is equivalent to a binary value of 0000 0000 0000 0000 to 1111 1111 1111 1111, or 0000 to FFFF hexadecimal. The diagram below shows how this relates to the signal range.




$$\text{Resolution} = \frac{H - L}{65535}$$

H = High limit of the signal range
L = Low limit of the signal range

16mA / 65535 = 0.2241 µA per count

Each count can also be expressed in terms of the signal level by using the equation shown.

# Writing the Control Program

## Calculating the Digital Value

The control program must calculate the digital value that is sent to the analog output. Several methods can be used to do this, but the best method is to convert the values to engineering units. This is accomplished by using the formula shown.

Adjustments may need to be made to the formula depending on the scale of the engineering units.

$$A = U \frac{65535}{H - L}$$

A = Analog Value (0 – 65535)

U = Engineering Units

H = High limit of the engineering unit range

L = Low limit of the engineering unit range

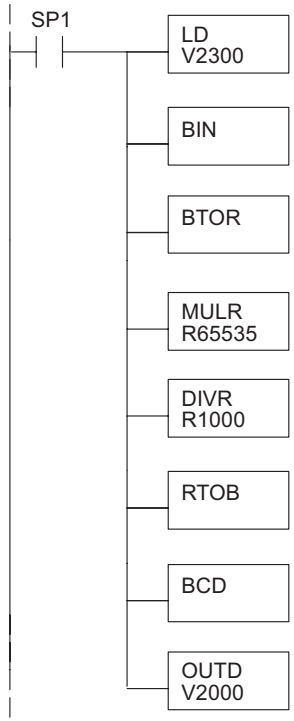
Consider the following example which controls pressure from 0.0–99.9 PSI. Using the formula will calculate the digital value to be sent to the analog output. The example shows the conversion required to yield 49.4 PSI. The multiplier of 10 is because the decimal portion of 49.4 cannot be loaded in the program, so it is shifted right one decimal place to make a usable value of 494.

$$A = 10U \frac{65535}{10\,(H - L)} \qquad A = 494 \frac{65535}{1000 - 0} \qquad A = 32374$$

Refer to the example on the next page to write the conversion program.

## Engineering Units Conversion

This example program shows how to write the program to perform the engineering unit conversion to output data formats 0–65535 when using a D2-250-1 CPU. This example assumes that a BCD value has been stored in V2300 for channel 1.




The LD instruction loads the engineering units used with channel 1 into the accumulator. This example assumes the numbers are BCD. Since SP1 is used, this rung automatically executes on every scan. An X, C, etc. could also be used as a permissive contact.

Convert BCD number to binary number.

Convert binary number to real number.

Multiply the accumumlator by 65535 to start the conversion.

Divide the accumulator by 1000 (1000 = 100.0%).

Convert the result to binary.

Convert the result to BCD.

Store the BCD double word result in V2000 / V2001.

## Writing Values: Pointer Method and Multiplexing

Two methods are used to read data values:

- Pointer method
- Multiplexing

The multiplexing method must be used with a D2-230 CPU. The multiplexing method must also be used with remote I/O modules (the pointer method will not work). Either method can be used with the D2-240, D2-250-1, D2-260 and D2-262 CPUs, but for ease of programming it is highly recommended to use the pointer method.

## Pointer Method for D2-240, D2-250-1, D2-260 and D2-262 CPUs

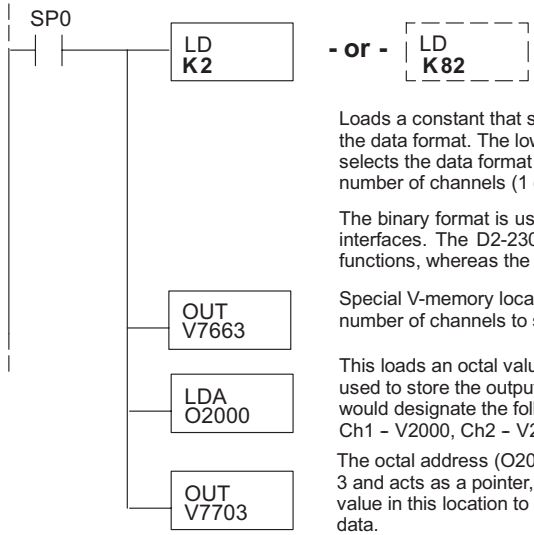
The D2-240, D2-250-1, D2-260 and D2-262 CPUs have special V-memory locations assigned to each base slot that will greatly simplify the programming requirements.

These V-memory locations allow you to:

- Specify the data format
- Specify the number of channels to scan
- Specify the location of the data that will be written to the module

***NOTE:*** *D2-240 CPUs with firmware release version 3.0 or later and. D2-250 CPUs with firmware release version 1.33 or later support this method.*

The following example program shows how to setup these locations. Place this rung anywhere in the ladder program, or in the initial stage if stage programming instructions are being used. In this example V2000 and V2002 are used to store the calculated values, the analog module is installed in slot 3. Be sure to use the V-memory locations for the module placement. The pointer method automatically converts values to binary.




Loads a constant that specifies the number of channels to scan and the data format. The lower byte, most significant nibble (MSN) selects the data format (i.e. 0=BCD, 8=Binary), the LSN selects the number of channels (1 or 2).

The binary format is used for displaying data on some operator interfaces. The D2-230/ D2-240 CPUs do not support binary math functions, whereas the D2-250-1, D2-260, and D2-262 do.

Special V-memory location assigned to slot 3 that contains the number of channels to scan.

This loads an octal value for the first V-memory location that will be used to store the output data. For example, the O2000 entered here would designate the following addresses.
Ch1 – V2000, Ch2 – V2002

The octal address (O2000) is stored here. V7703 is assigned to slot 3 and acts as a pointer, which means the CPU will use the octal value in this location to determine exactly where to store the output data.

The following tables show the special V-memory locations used by the D2-240, D2-250-1, D2-260 and D2-262 for the CPU base and local expansion base I/O slots. Slot 0 (zero) is the module next to the CPU or D2-CM module. Slot 1 is the module two places from the CPU or D2-CM, and so on. Remember, the CPU only examines the pointer values at these locations after a mode transition. Also, if the D2-230 (multiplexing) method is used, verify that these addresses in the CPU are 0 (zero).

The table below applies to the D2-240, D2-250-1, D2-260 and D2-262 CPU base.

| CPU Base: Analog Output Module Slot-Dependent V-memory Locations | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| ***Slot*** | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| ***No. of Channels*** | V7660 | V7661 | V7662 | V7663 | V7664 | V7665 | V7666 | V7667 |
| ***Storage Pointer*** | V7700 | V7701 | V7702 | V7703 | V7704 | V7705 | V7706 | V7707 |

The table below applies to the D2-250-1, D2-260 or a D2-262 CPU base 1.

| Expansion Base D2-CM #1: Analog Output Module Slot-Dependent V-memory Locations | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| ***Slot*** | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| ***No. of Channels*** | V36000 | V36001 | V36002 | V36003 | V36004 | V36005 | V36006 | V36007 |
| ***Storage Pointer*** | V36020 | V36021 | V36022 | V36023 | V36024 | V36025 | V36026 | V36027 |

The table below applies to the D2-250-1, D2-260 or a D2-262 CPU base 2.

| Expansion Base D2-CM #2: Analog Output Module Slot-Dependent V-memory Locations | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| ***Slot*** | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| ***No. of Channels*** | V36100 | V36101 | V36102 | V36103 | V36104 | V36105 | V36106 | V36107 |
| ***Storage Pointer*** | V36120 | V36121 | V36122 | V36123 | V36124 | V36125 | V36126 | V36127 |

The table below applies to the D2-260 and D2-262 CPU base 3.

| Expansion Base D2-CM #3: Analog Output Module Slot-Dependent V-memory Locations | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Slot** | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| **No. of Channels** | V36200 | V36201 | V36202 | V36203 | V36204 | V36205 | V36206 | V36207 |
| **Storage Pointer** | V36220 | V36221 | V36222 | V36223 | V36224 | V36225 | V36226 | V36227 |

The table below applies to the D2-260 and D2-262 CPU base 4.

| Expansion Base D2-CM #4: Analog Output Module Slot-Dependent V-memory Locations | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| ***Slot*** | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| ***No. of Channels*** | V36300 | V36301 | V36302 | V36303 | V36304 | V36305 | V36306 | V36307 |
| ***Storage Pointer*** | V36320 | V36321 | V36322 | V36323 | V36324 | V36325 | V36326 | V36327 |

## Write Data Example (Multiplexing)

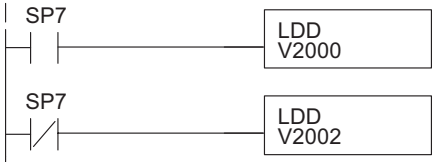
Since all channels are multiplexed into a single data word, the control program can be setup to determine which channel to write the data to. Since the module appears as Y output points to the CPU, it is simple to use the channel selection outputs to determine which channel to update.

Note, this example is for a module installed in slot 3, as shown in the previous examples. The addresses used would be different if the module was used in a different slot. These rungs can be placed anywhere in the program or if stage programming is being used, place them in a stage that is always active.

This example is a two-channel multiplexer that updates each channel on alternate scans. Relay SP7 is a special relay that is on for one scan, then off for one scan. This multiplexing example can be used with all of the DL205 CPUs.

***NOTE:*** *Binary data must be sent to the output module. If the data is already in binary format,do not use the BIN instruction shown in this example.*

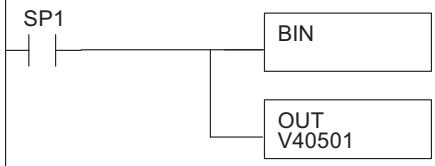
**Load data into the accumulator.**




Loads the data for channel 1 into the accumulator.
Note: Use LD if using binary, and use LDD if using BCD.

Loads the data for channel 2 into the accumulator.
Note: Use LD if using binary, and use LDD if using BCD.

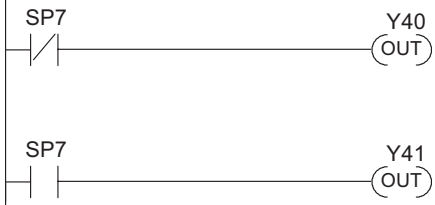
**Send data to V-memory assigned to the module.**




Convert the data to binary (you must omit this step if you have converted the data elsewhere). SP1 is always on.

The OUT instruction sends the data to the module. Our example starts with V40501, but the actual value depends on the location of the module in your application.

**Select the channel to update.**

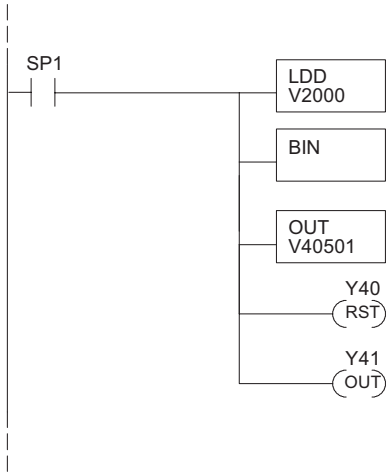



Selects channel 2 for update when Y41 is OFF (Y40–ON deselects channel 1). Note, Y40 and Y41 are used as in the previous examples. If the module was installed in a different I/O arrangement the addresses would be different.

Selects channel 1 for update when Y41 is OFF (Y41–ON deselects channel 2). Note, Y40 and Y41 are used as in the previous examples. If the module was installed in a different I/O arrangement the addresses would be different.

## Write Data to One Channel

If only one channel is being used, or if the updates are to be controlled separately, the following program can be used.




The LD instruction loads the data into the accumulator. Since SP1 is used, this rung automatically executes on every scan. X, C, etc. can also be used as permissive contacts.

Note: Use LD if using binary, and use LDD if using BCD.

The BIN instruction converts the accumulator data to binary (you must omit this step if you have already converted the data elsewhere).

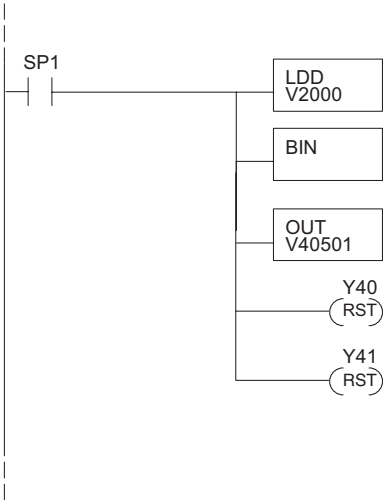
The OUT instruction sends the data to the module. Our example starts with V40501, but the actual value depends on the location of the module in your application.

Y40–OFF selects channel 1 for updating.

Y41–ON deselects channel 2 (do not update).

## Write the same Data to Both Channels

If both channel select outputs are off, then both channels will be updated with the same data.




The LD instruction loads the data into the accumulator. Since SP1 is used, this rung automatically executes on every scan. The X, C, etc. can also be used as permissive contacts.

Note: Use LD if using binary, and use LDD if using BCD.

The BIN instruction converts the accumulator data to binary (you must omit this step if you have already converted the data elsewhere).

The OUT instruction sends the data to the module. Our example starts with V40501, but the actual value depends on the location of the module in your application.

Y40–OFF selects channel 1 for updating.

Y41–OFF selects channel 2 for updating.

## Analog and Digital Value Conversions

It is sometimes useful to do quick conversions between the signal levels and the digital values. This can be helpful during startup and/or troubleshooting. The following table shows some formulas to help with the conversions.

| Range | If the digital value is known | If the analog signal level is known. |
|---|---|---|
| ***4–20 mA*** | $A = \frac{16D}{65535} + 4$ | $D = \frac{65535}{16}(A - 4)$ |

For example, if a 10mA signal level is needed, use the formula to the right to determine the digital value "D" to be stored in the V-memory location which is designated to store the data.

**D = 65535 (A–4)**
**16**

**D = 65535 (10mA–4)**
**16**

**D = (4095.94) (6)**

**D = 24575 (5FFFh)**

# F2-02DAS-2, 0-5 V, 0-10 V, 2-Channel Isolated Analog Output

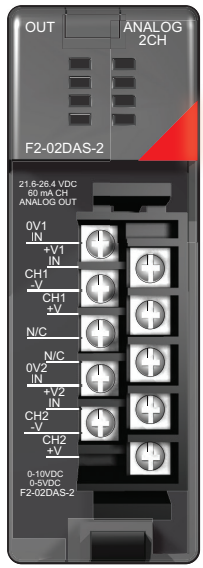
In This Chapter...

Module Specifications ..... 13-2
Setting the Module Jumpers ..... 13-5
Connecting the Field Wiring ..... 13-6
Module Operation ..... 13-8
Writing the Control Program ..... 13-12

# Module Specifications

The F2-02DAS-2 Analog Output module provides several hardware features:

- Analog outputs are isolated from channel to channel and channel to PLC logic.
- The module has a removable terminal block so the module can be easily removed or changed without disconnecting the wiring.
- All channels can be updated in one scan if either a D2-240, a D2-250-1, a D2-260 or a D2-262 CPU is used in the PLC.
- Outputs are sourced through external loop supply.




**F2-02DAS-2**

## Firmware Requirements:

- To use this module, D2-230 CPUs must have firmware version 2.7 or later.
- To use the pointer method for writing values, D2-240 CPUs require firmware version 3.0 or later.
- D2-250 CPUs require firmware version 1.33 or later.

The following tables provide the specifications for the F2–02DAS –2, Isolated Analog Output Module.

| Output Specifications | |
|---|---|
| ***Number of Channels*** | 2, isolated |
| ***Output Range*** | 0–5 VDC, 0–10 VDC |
| ***Resolution*** | 16 bit (1 in 65536) |
| ***Isolation Voltage*** | ±750V continuous, channel to channel, channel to logic |
| ***Load Impedance*** | 2kΩ minimum |
| ***Linearity Error (end to end)*** | ±10 counts (±0.015% of full scale) maximum |
| ***Conversion Settling Time*** | 3ms to 0.1% of full scale |
| ***Full Scale Calibration Error*** | ±32 counts (±0.05%) |
| ***Offset Calibration Error*** | ±13 counts (±0.02%) |
| ***Maximum Inaccuracy*** | ±0.07% @ 25°C (77°F)<br>±018% 0–60°C (32–140°F) |

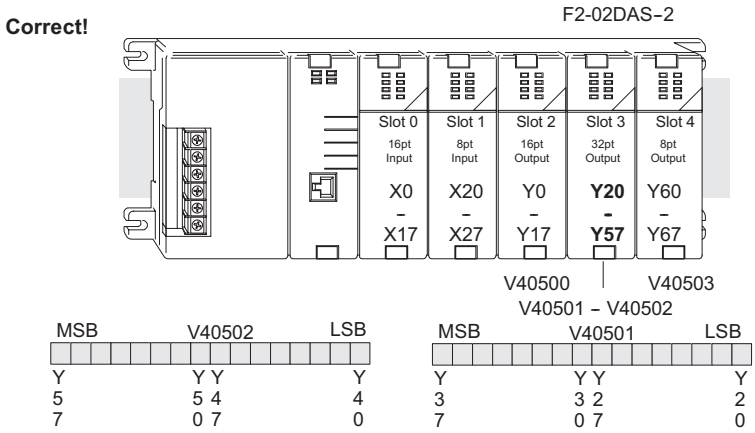
| General Specifications | |
|---|---|
| ***PLC Update Rate*** | 1 channel per scan maximum (multiplexing)<br>2 channels per scan maximum (pointer –<br>D2-240/D2-250-1/D2-260/ D2-262 CPUs) |
| ***Digital Outputs /<br>Output Points Required*** | 16 binary data bits, 2 channel ID bits;<br>32 point (Y) output module |
| ***Power Budget Requirement*** | 60mA @ 5VDC (supplied by the base) |
| ***External Power Supply*** | 21.6–26.4 VDC @ 60mA |
| ***Operating Temperature*** | 0–60°C (32–140°F) |
| ***Storage Temperature*** | –20°C to 70°C (-4°F to 158°F) |
| ***Relative Humidity*** | 5–95% (non-condensing) |
| ***Environmental Air*** | No corrosive gases permitted |
| ***Vibration*** | MIL STD 810C 514.2 |
| ***Shock*** | MIL STD 810C 516.2 |
| ***Noise Immunity*** | NEMA ICS3-304 |

## Analog Output Configuration Requirements

The F2-02DAS-2 analog output module requires 32 discrete output points. The module can be installed in any slot of a DL205 system, but the available power budget and discrete I/O points are the limiting factors. Check the DL205 PLC User Manual for the particular model of CPU and I/O base being used for information regarding power budget and number of local, local expansion or remote I/O points.

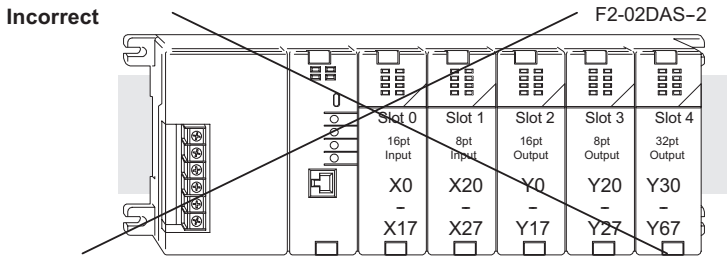
## Special Placement Requirements (D2-230 and Remote I/O Bases)

It is important to examine the configuration if a D2-230 CPU is being used in a multiplexing program. As can be seen in the section on Writing the Control Program, V-memory locations are used to hold the analog data that will be written to the output. If the module is placed in a slot so that the output points do not start on a V-memory boundary, the program instructions will not be able to access the data. This also applies when placing this module in a remote base using a D2-RSSS in the CPU slot.

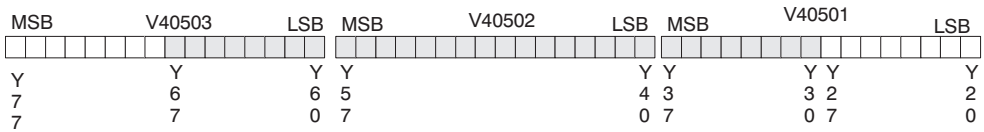



Data can be written correctly because the output points start on a V-memory boundary address as seen in the table above.

To use the V-memory references required for a D2-230 CPU, the first output address assigned to the module must be one of the following Y locations. The table also shows the V-memory addresses that correspond to these Y locations.




Data is split over three locations, so instructions cannot access data from a D2-230 (or when module is placed in a remote base).




| Y | Y0 | Y20 | Y40 | Y60 | Y100 | Y120 | Y140 | Y160 |
|---|---|---|---|---|---|---|---|---|
| V | V40500 | V40501 | V40502 | V40503 | V40504 | V40505 | V40506 | V40507 |

# Setting the Module Jumpers

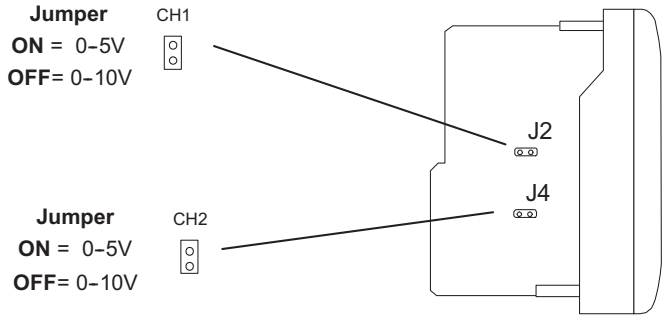
The F2-02DAS-2 Analog Output module uses jumpers for selecting the voltage range for each channel. The range of each channel can be independently set. The available operating ranges are 0–5V and 0–10V.

There is one jumper for each channel. Install or remove these jumpers to select the desired range. Unused jumpers can be stored on a single pin so they will not get lost. The module comes from the factory set for the 0–5V range.

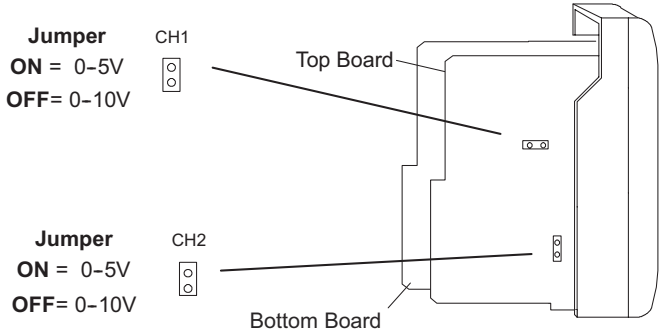
***NOTE:*** *Be sure to set the range jumpers properly for the module will not function properly if the range jumpers are not set for the desired voltage range.*

The following diagrams show the jumper locations. The newer models have a single circuit board design. Refer to the top diagram if one of these modules is used in your system. The older modules have a two circuit board design. The range jumpers for this module is located on the top circuit board. Refer to the lower diagram.

### Single Circuit Board Design




### Two Circuit Board Design



# Connecting the Field Wiring

## Wiring Guidelines

Your company may have guidelines for wiring and cable installation. If so, check the guidelines before beginning the installation. Here are some general things to consider:

- Use the shortest wiring route whenever possible.
- Use shielded wiring and ground the shield at the transmitter source. Do not ground the shield at both the module and the source.
- Do not run the signal wiring next to large motors, high current switches, or transformers. This may cause noise problems.
- Route the wiring through an approved cable housing to minimize the risk of accidental damage. Check local and national codes to choose the correct method for your application.

## Transmitter Power Supply Requirements

The F2-02DAS-2 module requires at least one field-side power supply. Separate power sources should be used to maintain the channel to channel isolation. The F2-02DAS-2 module requires 21.6–26.4 VDC (at 60mA per channel) from the external power supply.

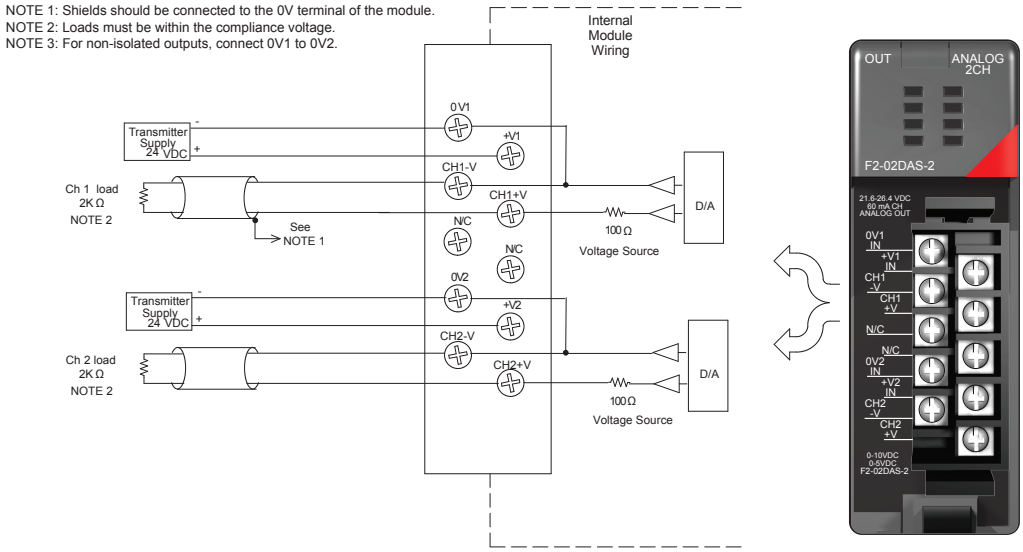
The DL205 AC bases have a built-in 24VDC power supply that provide up to 300mA of current. This can be used instead of a separate supply. Check the power budget to be safe.

It is desirable in some situations to power the transmitters separately in a location remote from the PLC. This will work as long as the transmitter supply meets the current requirements, and the transmitter's negative (-) side and the module supply's negative (-) side are connected together.

**WARNING: If the internal 24VDC base power is used, be sure to calculate the power budget. Exceeding the power budget can cause unpredictable system operation that can lead to a risk of personal injury or equipment damage.**

## Wiring Diagram

The F2-02DAS-2 module has a removable connector which helps to simplify wiring. Squeeze the top and bottom retaining clips and gently pull the connector from the module. Use the following diagram to connect the field wiring.

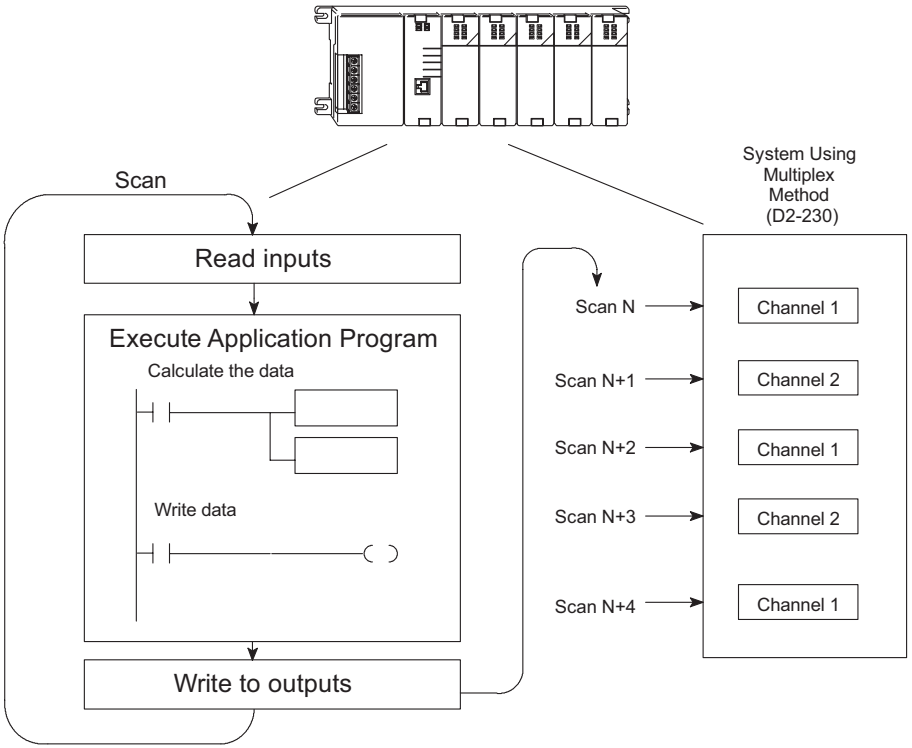


# Module Operation

Before beginning to write the control program, it is important to take a few minutes to understand how the module processes the analog signals.

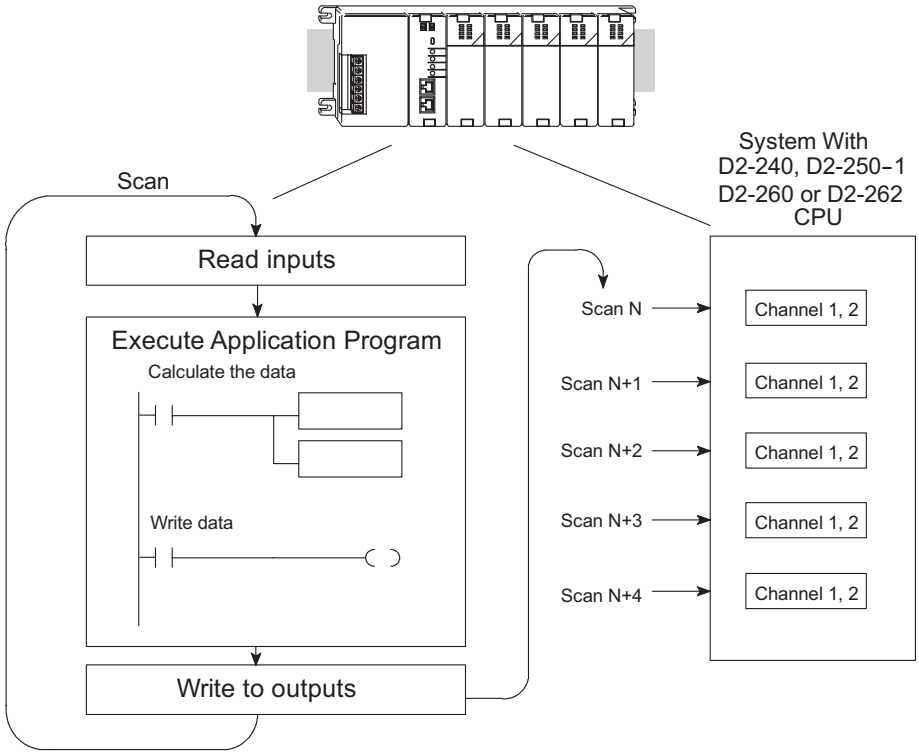
## Channel Update Sequence (Multiplexing) for a D2-230 CPU

If a multiplexing program is being used, only one channel of data can be sent to the output module on each scan. The module refreshes both field devices on each scan, but new data can only be obtained from the CPU at the rate of one channel per scan. Since there are two channels, it can take two scans to update both channels. However, if only one channel is being used, that channel will be updated on every scan. The multiplexing method can also be used for the D2-240, D2-250-1, D2-260 and D2-262 CPUs.



## Channel Update Sequence (Pointer Method) for D2-240, D2-250-1, D2-260 and D2-262 CPUs

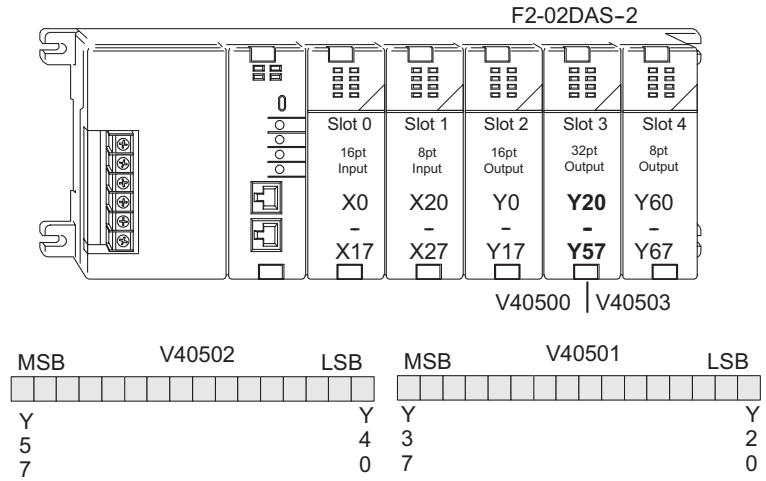
If either a D2-240, D2-250-1, D2-260 or a D2-262 CPU is used with the pointer method, all channels can be updated on every scan. This is because the three CPUs support special V-memory locations that are used to manage the data transfer. This is discussed in more detail in the section on Writing the Control Program later in this chapter.




## Understanding the Output Assignments

Remember that the F2-02DAS-2 module appears to the CPU as a 32-point discrete output module. These points provide the data value and an indication of which channel to update. Note, if either a D2-240, D2-250, D2-260 or D2-262 CPU is being used, these bits may never have to be used, but it may be an aid to help understand the data format.

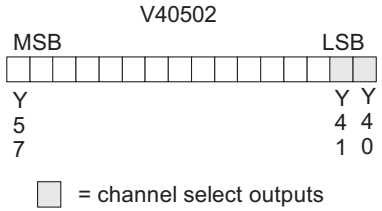
Since all output points are automatically mapped into V-memory, the location of the data word that will be assigned to the module can simply be determined.




The individual bits in this data word location, represents specific information about the analog signal.

## Channel Select Outputs

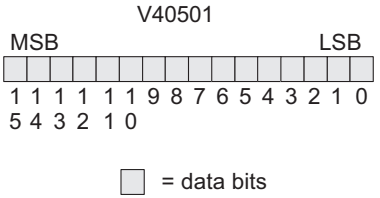
Two of the outputs select the active channel. Remember, the V-memory bits are mapped directly to discrete outputs. Turning a bit OFF selects a channel. By controlling these outputs, the channel to be updated can be selected.




| Y41 | Y40 | Channel |
|---|---|---|
| On | Off | 1 |
| Off | On | 2 |
| Off | Off | 1 & 2 (same data to both channels) |
| On | On | None (both channels hold current values) |

## Analog Data Bits

The first sixteen bits represent the analog data in binary format.

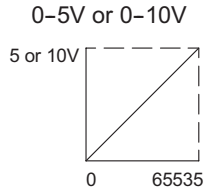



| Bit | Value | Bit | Value |
|---|---|---|---|
| 0 | 1 | 8 | 256 |
| 1 | 2 | 9 | 512 |
| 2 | 4 | 10 | 1024 |
| 3 | 8 | 11 | 2048 |
| 4 | 16 | 12 | 4096 |
| 5 | 32 | 13 | 8192 |
| 6 | 64 | 14 | 16384 |
| 7 | 128 | 15 | 32768 |

## Module Resolution

Since the module has 16-bit resolution, the analog signal is converted into 65536 counts ranging from 0–65535 (216). For example, send a 0 to get a 0V signal, and 65535 to get a 10V signal. This is equivalent to a binary value of 0000 0000 0000 0000 to 1111 1111 1111 1111, or 0000 to FFFF hexadecimal. The diagram shows how this relates to the signal range.

Each count can also be expressed in terms of the signal level by using the equation shown.




$$\text{Resolution} = \frac{H - L}{65535}$$

H = High limit of the signal range
L = Low limit of the signal range

# Writing the Control Program

## Calculating the Digital Value

The control program must calculate the digital value that is sent to the analog output. Several methods can be used to do this, but the best method is to convert the values to engineering units. This is accomplished by using the formula shown.

Adjustments may need to be made to the formula depending on the scale of the engineering units.

$$A = U \frac{65535}{H-L}$$

A = Analog Value (0–65535)

U = Engineering Units

H = High limit of the engineering unit range

L = Low limit of the engineering unit range

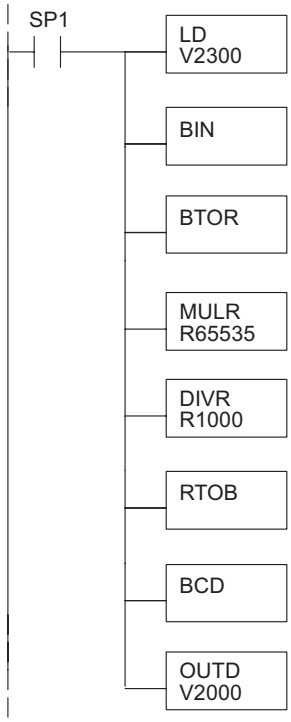
Consider the following example which controls pressure from 0.0–99.9 PSI. Using the formula will calculate the digital value to be sent to the analog output. The example shows the conversion required to yield 49.4 PSI. The multiplier of 10 is because the decimal portion of 49.4 cannot be loaded in the program, so it is shifted right one decimal place to make a usable value of 494.

$$A = 10U \frac{65535}{10\ (H-L)} \qquad A = 494 \frac{65535}{1000-0} \qquad A = 32374$$

Refer to the example on the next page to write the conversion program.

## Engineering Units Conversion

This example program shows how to write the program to perform the engineering unit conversion to output data formats 0–65535 when using a D2-250 CPU. This example assumes that a BCD value has been stored in V2300 for channel 1.




The LD instruction loads the engineering units used with channel 1 into the accumulator. This example assumes the numbers are BCD. Since SP1 is used, this rung automatically executes on every scan. An X, C, etc. could also be used as a permissive contact.

Convert BCD number to binary number.

Convert binary number to real number.

Multiply the accumumlator by 65535 to start the conversion.

Divide the accumulator by 1000 (1000 = 100.0%).

Convert the result to binary.

Convert the result to BCD.

Store the BCD double word result in V2000 / V2001.

## Writing Values: Pointer Method and Multiplexing

There are two methods of reading values:

- Pointer method
- Multiplexing

The multiplexing method must be used with a D2-230 CPU. The multiplexing method must also be used with remote I/O modules (the pointer method will not work). Either method can be used with the D2-240, D2-250-1, D2-260 and D2-262 CPUs, but for ease of programming it is highly recommended to use the pointer method.

## Pointer Method for the D2-240, D2-250-1, D2-260 and D2-262 CPUs

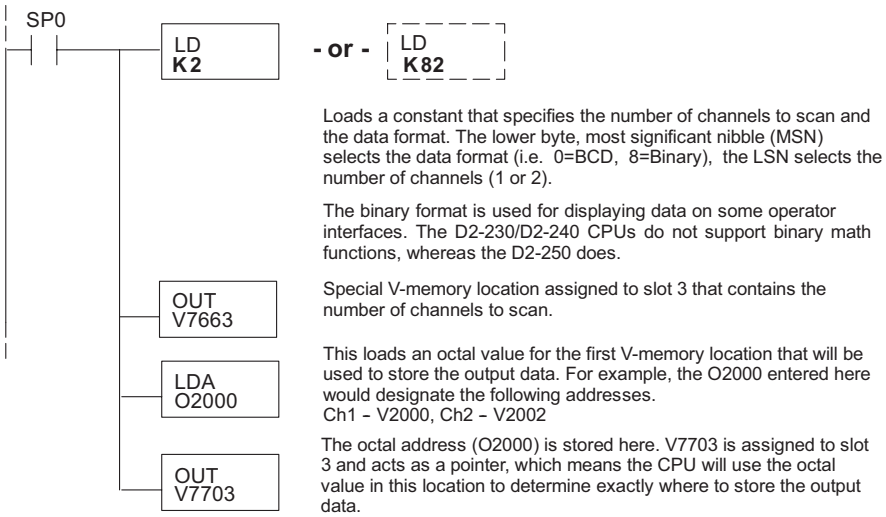
The D2-240, D2-250-1, D2-260 and D2-262 CPUs have special V-memory locations assigned to each base slot that will greatly simplify the programming requirements.

These V-memory locations allow you to:

- Specify the data format
- Specify the number of channels to scan
- Specify the location of the data that will be written to the modules.

***NOTE:*** *D2-240 CPUs with firmware release version 3.0 or later and. D2-250 CPUs with firmware release version 1.33 or later support this method.*

The following example program shows how to setup these locations. Place this rung anywhere in the ladder program, or in the initial stage if stage programming instructions are being used. In this example V2000 and V2002 are used to store the calculated values, the analog module is installed in slot 3. Be sure to use the V-memory locations for the module placement. The pointer method automatically converts values to binary.



The following tables show the special V-memory locations used by the D2-240, D2-250-1 and D2-260 and D2-262 for the CPU base and local expansion base I/O slots. Slot 0 (zero) is the module next to the CPU or D2-CM module. Slot 1 is the module two places from the CPU or D2-CM, and so on. Remember, the CPU only examines the pointer values at these locations after a mode transition. Also, if the D2-230 (multiplexing) method is used, verify that these addresses in the CPU are 0 (zero).

The table below applies to the D2-240, D2-250-1, D2-260 and D2-262 CPU base.

| CPU Base: Analog Output Module Slot-Dependent V-memory Locations | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Slot | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| No. of Channels | V7660 | V7661 | V7662 | V7663 | V7664 | V7665 | V7666 | V7667 |
| Storage Pointer | V7700 | V7701 | V7702 | V7703 | V7704 | V7705 | V7706 | V7707 |

The table below applies to the D2-250-1, D2-260 or D2-262 CPU base 1.

| Expansion Base D2-CM #1: Analog Output Module Slot-Dependent V-memory Locations | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| *Slot* | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| *No. of Channels* | V36000 | V36001 | V36002 | V36003 | V36004 | V36005 | V36006 | V36007 |
| *Storage Pointer* | V36020 | V36021 | V36022 | V36023 | V36024 | V36025 | V36026 | V36027 |

The table below applies to the D2-250-1, D2-260 or D2-262 CPU base 2.

| Expansion Base D2-CM #2: Analog Output Module Slot-Dependent V-memory Locations | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| *Slot* | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| *No. of Channels* | V36100 | V36101 | V36102 | V36103 | V36104 | V36105 | V36106 | V36107 |
| *Storage Pointer* | V36120 | V36121 | V36122 | V36123 | V36124 | V36125 | V36126 | V36127 |

The table below applies to the D2-260 and D2-262 CPU base 3.

| Expansion Base D2-CM #3: Analog Output Module Slot-Dependent V-memory Locations | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| *Slot* | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| *No. of Channels* | V36200 | V36201 | V36202 | V36203 | V36204 | V36205 | V36206 | V36207 |
| *Storage Pointer* | V36220 | V36221 | V36222 | V36223 | V36224 | V36225 | V36226 | V36227 |

The table below applies to the D2-260 and D2-262 CPU base 4.

| Expansion Base D2-CM #4: Analog Output Module Slot-Dependent V-memory Locations | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| *Slot* | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| *No. of Channels* | V36300 | V36301 | V36302 | V36303 | V36304 | V36305 | V36306 | V36307 |
| *Storage Pointer* | V36320 | V36321 | V36322 | V36323 | V36324 | V36325 | V36326 | V36327 |

## Write Data Example (Multiplexing)

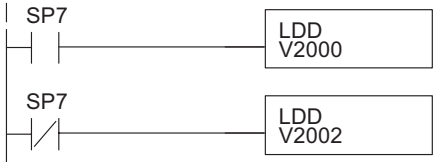
Since all channels are multiplexed into a single data word, the control program can be setup to determine which channel to write the data to. Since the module appears as Y output points to the CPU, it is simple to use the channel selection outputs to determine which channel to update.

Note, this example is for a module installed in slot 3, as shown in the previous examples. The addresses used would be different if the module was used in a different slot. These rungs can be placed anywhere in the program or if stage programming is being used, place them in a stage that is always active.

This example is a two-channel multiplexer that updates each channel on alternate scans. Relay SP7 is a special relay that is on for one scan, then off for one scan. This multiplexing example can be used with all of the DL205 CPUs.

***NOTE:*** *Binary data must be sent to the output module. If the data is already in binary format,do not use the BIN instruction shown in this example.*

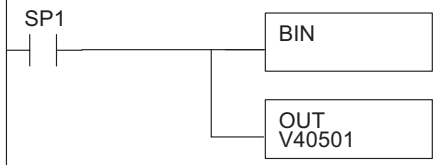
**Load data into the accumulator.**




Loads the data for channel 1 into the accumulator.
Note: Use LD if using binary, and use LDD if using BCD.

Loads the data for channel 2 into the accumulator.
Note: Use LD if using binary, and use LDD if using BCD.

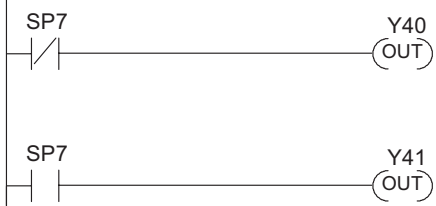
**Send data to V-memory assigned to the module.**




Convert the data to binary (you must omit this step if you have converted the data elsewhere). SP1 is always on.

The OUT instruction sends the data to the module. Our example starts with V40501, but the actual value depends on the location of the module in your application.

**Select the channel to update.**

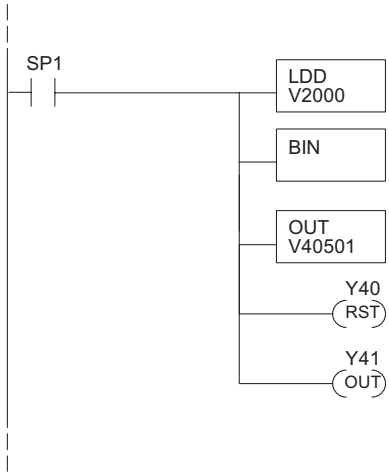



Selects channel 2 for update when Y41 is OFF (Y40–ON deselects channel 1). Note, Y40 and Y41 are used as in the previous examples. If the module was installed in a different I/O arrangement the addresses would be different.

Selects channel 1 for update when Y41 is OFF (Y41–ON deselects channel 2). Note, Y40 and Y41 are used as in the previous examples. If the module was installed in a different I/O arrangement the addresses would be different.

## Write Data to One Channel

If only one channel is being used, or if the updates are to be controlled separately, the following program can be used.




The LD instruction loads the data into the accumulator. Since SP1 is used, this rung automatically executes on every scan. X, C, etc. can also be used as permissive contacts.

Note: Use LD if using binary, and use LDD if using BCD.

The BIN instruction converts the accumulator data to binary (you must omit this step if you have already converted the data elsewhere).

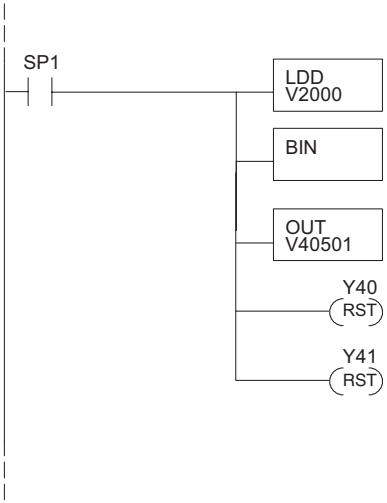
The OUT instruction sends the data to the module. Our example starts with V40501, but the actual value depends on the location of the module in your application.

Y40–OFF selects channel 1 for updating.

Y41–ON deselects channel 2 (do not update).

## Write the same Data to Both Channels

If both channel select outputs are off, then both channels will be updated with the same data.




The LD instruction loads the data into the accumulator. Since SP1 is used, this rung automatically executes on every scan. The X, C, etc. can also be used as permissive contacts.

Note: Use LD if using binary, and use LDD if using BCD.

The BIN instruction converts the accumulator data to binary (you must omit this step if you have already converted the data elsewhere).

The OUT instruction sends the data to the module. Our example starts with V40501, but the actual value depends on the location of the module in your application.

Y40–OFF selects channel 1 for updating.

Y41–OFF selects channel 2 for updating.

## Analog and Digital Value Conversions

It is sometimes useful to do quick conversions between the signal levels and the digital values. This can be helpful during startup and/or troubleshooting. The following table shows some formulas to help with the conversions.

| Range | If the digital value is known | If the analog signal level is known. |
|---|---|---|
| ***0–5 VDC*** | $A = \frac{5D}{65535}$ | $D = \frac{65535}{5} A$ |
| ***0–10 VDC*** | $A = \frac{10D}{65535}$ | $D = \frac{65535}{10} A$ |

For example, if a 4V signal is needed, use the formula to the right to determine the digital value to be stored in the V-memory location which is designated to store the data.

$$D = \frac{65535}{5} A$$

$$D = \frac{65535}{5} (4)$$

$$D = (13107) (4)$$

$$D = 52428 (CCCC_h)$$

# F2-4AD2DA 4-Ch. In / 2-Ch. Out Analog Combination

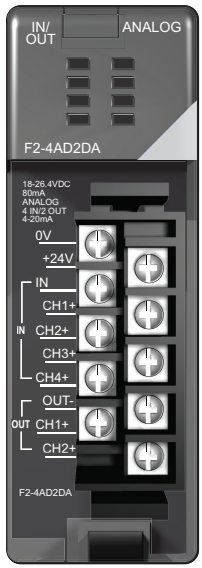
In This Chapter...

Module Specifications ..... 14-2
Connecting the Field Wiring ..... 14-5
Module Operation ..... 14-8
Writing the Control Program ..... 14-13

# Module Specifications

The F2-4AD2DA analog current input/output module provides several hardware features:

- On-board 250 ohm, 1/2 watt precision resistors provide substantial over-current-protection for 4–20 mA current loops.
- Analog inputs and outputs are optically isolated from the PLC logic.
- The module has a removable terminal block so the module can be easily removed or changed without disconnecting the wiring.
- All input and output channels can be updated in one scan if either a D2-240, a D2-250-1, a D2-260 or a D2-262 CPU is used in the PLC.
- On-board active analog filtering and RISC-like microcontroller provide digital signal processing to maintain precision analog measurements in noisy environments.
- Low-power CMOS design requires less than 80mA from an external 24VDC power supply.




**F2-4AD2DA**

The following tables provide the specifications for the F2-4AD2DA analog current input/output module. Review these specifications to make sure the module meets your application requirements.

| Input Specifications | |
|---|---|
| ***Number of Input Channels*** | 4, single ended (one common) |
| ***Range*** | 4–20 mA |
| ***Resolution*** | 12 bit (1 in 4096) |
| ***Input Impedance*** | 250Ω, ±0.1%, 1/2 W, 25ppm / °C current input resistance |
| ***Maximum Continuous Overload*** | ±40mA, each current input |
| ***Input Stability*** | ±1 count |
| ***Crosstalk*** | -70dB, 1 count maximum |
| ***Common Mode Rejection*** | -50dB @ 800Hz |
| ***Active Low-Pass Filter*** | -3dB @ 50Hz, 2 poles (-12dB per octave) |
| ***Step Response*** | 10ms to 95% |
| ***Full Scale Calibration Error*** | ±12 counts maximum, @ 20mA current input |
| ***Offset Calibration Error*** | ±8 counts maximum, @ 4mA current input |
| ***Maximum Inaccuracy*** | ±0.3% @ 25°C (77°F)<br>±0.45% @ 0–60°C (32–140°F) |
| ***Recommended External Fuse*** | 0.032 A, series 217 fast-acting, current inputs |

| Output Specifications | |
|---|---|
| ***Number of Output Channels*** | 2, single ended (one common) |
| ***Range*** | 4–20 mA |
| ***Resolution*** | 12 bit (1 in 4096) |
| ***Peak Withstanding Voltage*** | 75VDC, current outputs |
| ***External Load Resistance*** | 0Ω minimum, current outputs |
| ***Loop Supply Voltage Range*** | 18–30 VDC, current outputs |
| ***Maximum Load / Power Supply*** | 910Ω / 24V, 620Ω / 18V, 1200Ω / 30V, current outputs |
| ***Linearity Error (best fit)*** | ±1 count (± 0.025% of full scale) maximum |
| ***Settling Time*** | 100µs maximum (full scale change) |
| ***Maximum Inaccuracy*** | ±0.1% @ 25°C (77°F)<br>±0.3% 0–60°C (32–140°F) |
| ***Full Scale Calibration Error*** | ±5 counts @ 20mA current output |
| ***Output Calibration Error*** | ±3 counts @ 4mA current output |

| General Module Specifications | |
|---|---|
| ***Digital Input and Output Points Required*** | 16 point (X) Inputs<br>16 point (Y) Outputs |
| ***PLC Update Rate*** | 4 input channels per scan maximum<br>(D2-240, D2-250-1, D2-260 and D2-262 CPU)<br>2 output channels per scan maximum<br>(D2-240, D2-250-1, D2-260 and D2-262 CPU)<br>1 input and 1 output channels per scan maximum (D2-230 CPU) |
| ***Power Budget Requirement*** | 60mA @ 5VDC (supplied by the base) |
| ***External Power Supply Requirement*** | 24VDC (±10%), 80mA max. plus 20mA per loop output |
| ***Accuracy vs. Temperature*** | ±45 ppm / °C full scale calibration range<br>(including maximum offset change). |
| ***Operating Temperature*** | 0–60°C (32–140°F) |
| ***Storage Temperature*** | –20°C to 70°C (-4°F to 158°F) |
| ***Relative Humidity*** | 5–95% (non-condensing) |
| ***Environmental Air*** | No corrosive gases permitted |
| ***Vibration*** | MIL STD 810C 514.2 |
| ***Shock*** | MIL STD 810C 516.2 |
| ***Noise Immunity*** | NEMA ICS3-304 |

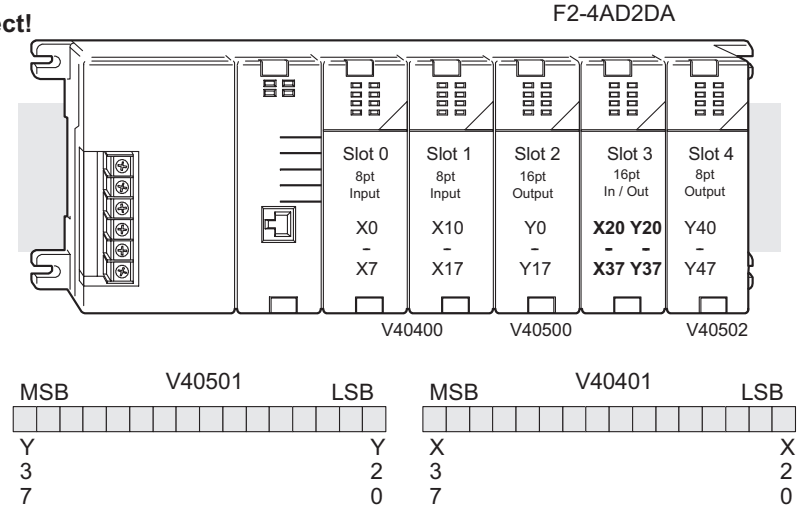
## Combination Analog Configuration Requirements

The F2-4AD2DA analog current input/output module requires 16 discrete input points and 16 discrete output points. The module can be installed in any slot of a DL205 system, except when the D2-230 CPU is used. The available power budget may also be a limiting factors. Check the DL205 PLC User Manual for the particular model of CPU and I/O base being used for more information regarding power budget and number of local, local expansion or remote I/O points.

## Special Placement Requirements (D2-230 and Remote I/O Bases)

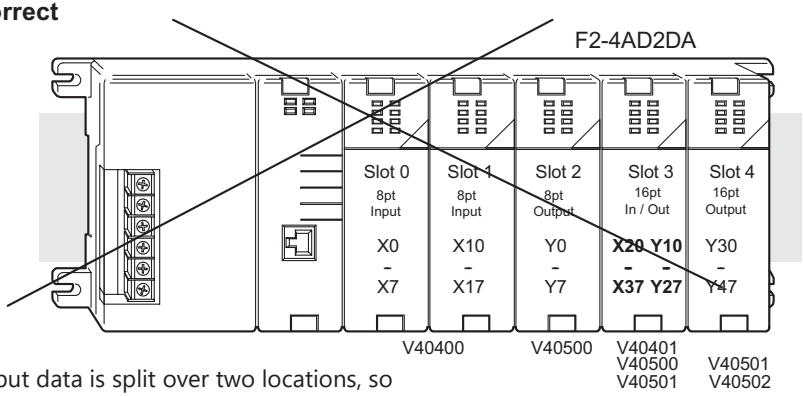
It is important to examine the configuration if a D2-230 CPU is being used with a multiplexing program. As can be seen in the section on Writing the Control Program, V-memory locations are used to manage the analog data. If the module is placed in a slot so that either the input or the output points do not start on a V-memory boundary, the program instructions aren't able to access the data. This also applies when placing this module in a remote base using a D2-RSSS in the CPU slot.

**Correct!**




Data can be read and written correctly because the input and output points start on a V-memory boundary address as seen in the table on the following page.

**Incorrect**




Output data is split over two locations, so instructions cannot write data from a D2-230.

To use the V-memory references required for a D2-230 CPU, the first input and output addresses assigned to the module must be one of the following X and Y locations. The table also shows the V-memory addresses that correspond to these locations.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| ***X*** | X0 | X20 | X40 | X60 | X100 | X120 | X140 | X160 |
| ***V*** | V40400 | V40401 | V40402 | V40403 | V40404 | V40405 | V40406 | V40407 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| ***Y*** | Y0 | Y20 | Y40 | Y60 | Y100 | Y120 | Y140 | Y160 |
| ***V*** | V40500 | V40501 | V40502 | V40503 | V40504 | V40505 | V40506 | V40507 |

# Connecting the Field Wiring

## Wiring Guidelines

Your company may have guidelines for wiring and cable installation. If so, check the guidelines before beginning the installation. Here are some general things to consider:

- Use the shortest wiring route whenever possible.
- Use shielded wiring and ground the shield at the transmitter source. Do not ground the shield at both the module and the source.
- Do not run the signal wiring next to large motors, high current switches, or transformers. This may cause noise problems.
- Route the wiring through an approved cable housing to minimize the risk of accidental damage. Check local and national codes to choose the correct method for your application.

## Loop Power Supply Requirements

The F2-4AD2DA module requires at least one field-side power supply. The same or separate power sources can be used for the module supply and the current transmitter supply. The F2-4AD2DA module requires 24VDC (at 80mA) and each current loop requires 20mA (a total of 120mA for six current loops), from the external power supply.

The DL205 AC bases have a built-in 24VDC power supply that provide up to 300mA of current. This can be used instead of a separate supply. Check the power budget to be safe.

It is desirable in some situations to power the transmitters separately in a location remote from the PLC. This will work as long as the transmitter supply meets the current requirements, and the transmitter's minus (-) side and the module supply's minus (-) side are connected together.

**WARNING: If the internal 24VDC base power is used, be sure to calculate the power budget. Exceeding the power budget can cause unpredictable system operation that can lead to a risk of personal injury or equipment damage.**

The DL205 base has a switching type power supply. As a result of switching noise, ±3–5 counts of instability may be noticed in the analog input data if the base power supply is used. If this is unacceptable, try one of the following:

- Use a separate linear power supply.
- Connect the 24VDC common to the frame ground, which is the screw terminal marked "G" on the base.

When using these methods, the input stability is rated at ±1 count.

## Current Loop Transmitter Impedance

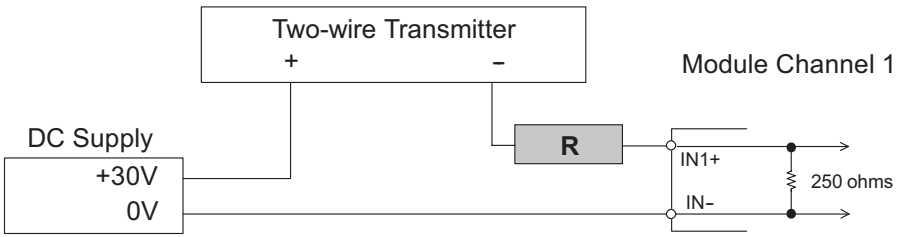
Standard 4–20 mA transmitters and transducers can operate from a wide variety of power supplies. Not all transmitters are alike and the manufacturers often specify a minimum loop or load resistance that must be used with the transmitter.

The F2-4AD2DA provides 250 ohm resistance for each input channel. If the transmitter being used requires a load resistance below 250 ohms, adjustments do not have to be made. However, if the transmitter requires a load resistance higher than 250 ohms, add a resistor in series with the module.

Consider the following example for a transmitter being operated from a 30VDC supply with a recommended load resistance of 750 ohms. Since the module has a 250 ohm resistor, add an additional resistor.

Example:

| | |
|---|---|
| R = Tr − Mr | R – resistor to add |
| R = 750 − 250 | Tr – Transmitter total resistance requirement |
| R ≥ 500 | Mr – Module resistance (internal 250 ohms) |




In the example, add a 500 ohm resistor (R) in series with the module.

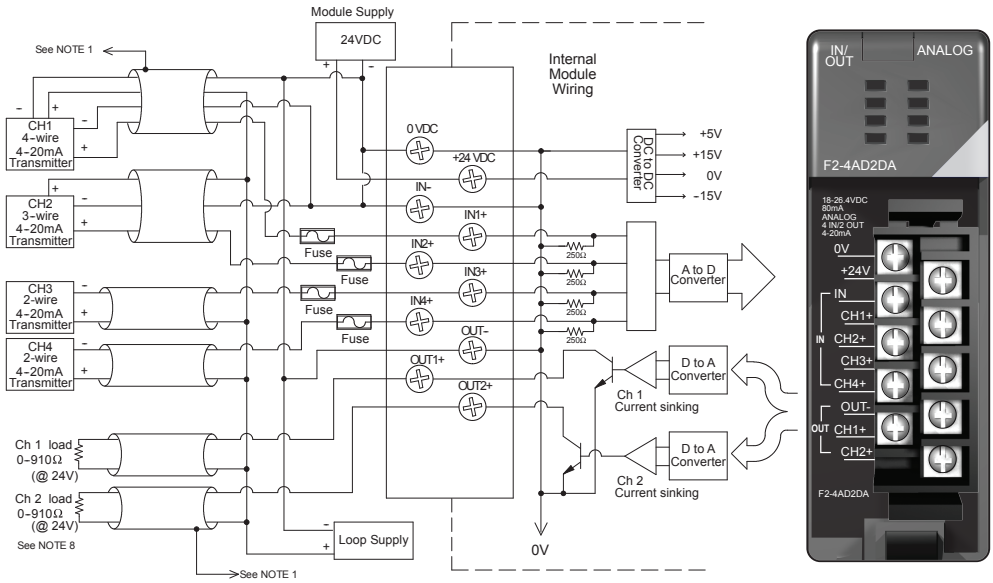
## Wiring Diagram

The F2-4AD2DA module has a removable connector to simplify wiring. Simply squeeze the top and bottom retaining clips and gently pull the connector from the module. Use the following diagram to connect the field wiring. The diagram shows separate module and loop power supplies. If it is desired to use only one external supply, just combine the supply's positive (+) terminals into one node, and remove the loop supply.

***NOTE 1:*** *Shields should be connected at their respective signal source.*
***NOTE 2:*** *Unused channels should remain open (no connections) for minimum power consumption.*
***NOTE 3:*** *More than one external power supply can be used provided all the power supply commons are connected together.*
***NOTE 4:*** *A series 217, 0.032 A, fast-acting fuse is recommended for 4–20 mA current input loops.*
***NOTE 5:*** *If the power supply common of an external power supply is not connected to 0V on the module, then the output of the external transmitter must be isolated. To avoid "ground loop" errors, recommended 4–20 mA transmitter types are:*

*a. For 2 or 3 wire: Isolation between input signal and power supply.*
*b. For 4 wire: Isolation between input signal, power supply, and 4–20 mA output.*

***NOTE 6:*** *If an analog channel is connected backwards, then incorrect data values will be returned for that channel. Input signals in the ±4mA range return a zero value. Signals in the -4 to -40 mA range return a non-zero value.*
***NOTE 7:*** *To avoid small errors due to terminal block losses, connect 0V, IN– and OUT– on the terminal block as shown. The module's internal connection of these nodes is not sufficient to permit module performance up to the accuracy specifications.*
***NOTE 8:*** *Choose an output transducer resistance according to the maximum load / power supply listed in the Output Specifications table.*

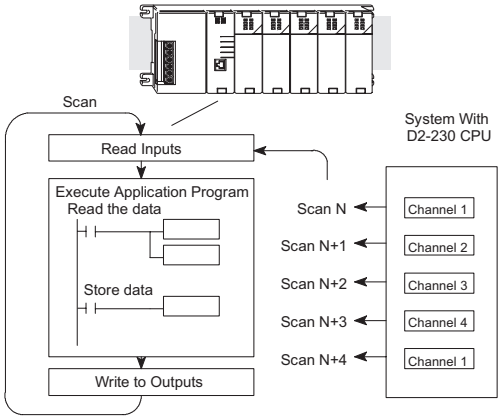


# Module Operation

Before beginning to write the control program, it is important to take a few minutes to understand how the module processes the analog signals.

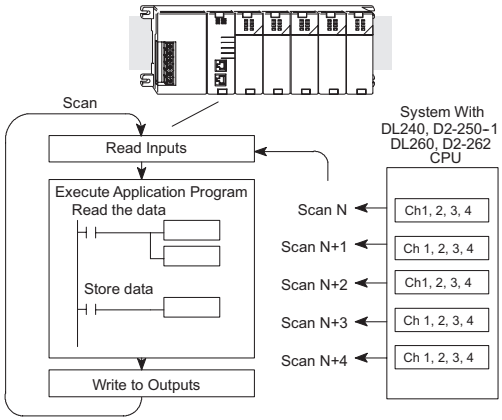
## Input Channel Scanning Sequence (Multiplexing) for a D2-230 CPU

The F2-4AD2DA module can supply different amounts of data per scan, depending on the type of CPU being used. The D2-230 can obtain one channel of input data per CPU scan. Since there are four channels, it can take up to four scans to get the data for all channels. Once all channels have been scanned the process starts over with channel 1. Unused channels are not processed, so if only two channels are selected, each channel will be updated every other scan.



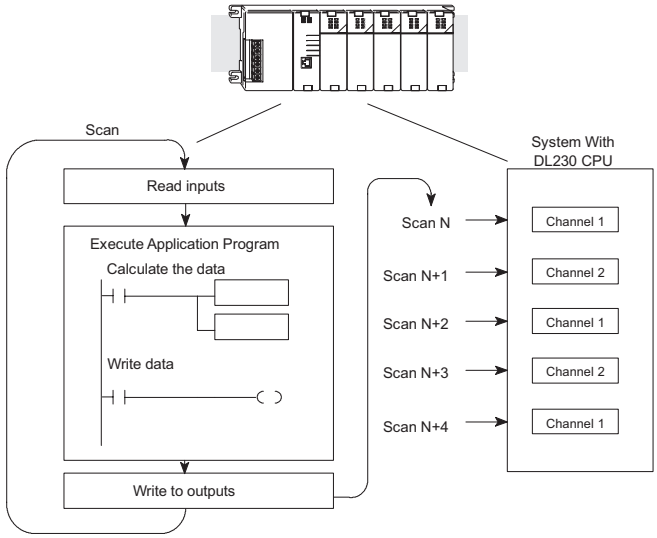

## Input Channel Scanning Sequence (Pointer Method) for D2-240, D2-250-1, D2-260 and D2-262 CPUs

If a D2-240, a D2-250-1, a D2-260or a D2-262 CPU is being used, the input data for all four channels can be obtained in one scan. This is because the D2-240, D2-250-1, D2-260 and D2-262 CPUs supports special V-memory locations that are used to manage the data transfer. This is discussed in more detail in the section on Writing the Control Program later in this chapter.



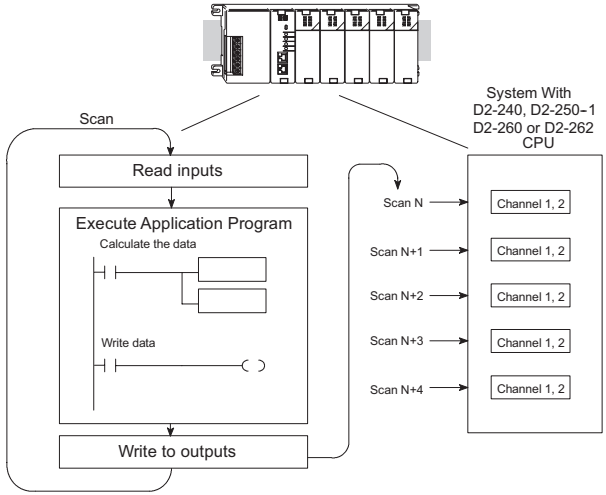
## Output Channel Update Sequence (Multiplexing) for a D2-230 CPU

If a D2-230 CPU is used, only one channel of data can be sent to the output module on each scan. Since there are two channels, it can take two scans to update both channels. However, if only one channel is being used, then that channel can be updated on every scan.




## Output Channel Update Sequence (Pointer Method) for D2-240, D2-250-1, D2-260 and D2-262 CPUs

If either a D2-240, D2-250-1, D2-260 or D2-262 CPU is used with the pointer method, both channels can be updated on every scan. This is because these CPUs support special V-memory locations that are used to manage the data transfer. This is discussed in more detail in the section on Writing the Control Program later in this chapter.



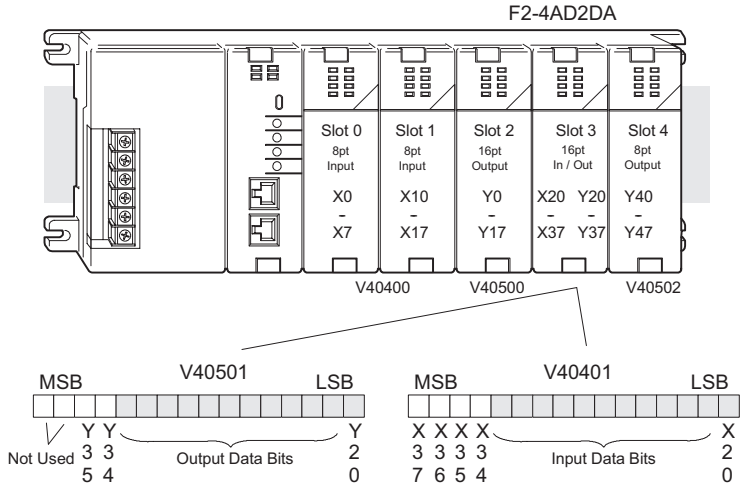
## Understanding the I/O Assignments

Remember that the F2-4AD2DA requires 16 discrete input points and 16 discrete output points. These points can be used to obtain:

- An indication of which channel is active,
- The digital representation of the analog signal and,
- Module diagnostic information.

If a D2-240, D2-250-1, D2-260 or D2-262 CPU is being used, these bits may never have to be used, but it may be an aid to help understand the data format.

Since all I/O points are automatically mapped into V-memory, the location of the data words that will be assigned to the module can simply be determined.

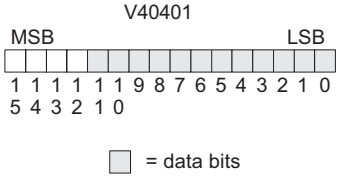



The individual bits in this data word location represent specific information about the analog signal.

## Input Data Bits

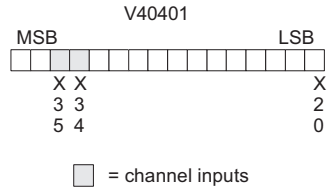
The first twelve bits of the input word represent the analog data in binary format.

| Bit | Value | Bit | Value |
|---|---|---|---|
| 0 | 1 | 6 | 64 |
| 1 | 2 | 7 | 128 |
| 2 | 4 | 8 | 256 |
| 3 | 8 | 9 | 512 |
| 4 | 16 | 10 | 1024 |
| 5 | 32 | 11 | 2048 |



## Active Channel Indicator Bits

Two of the inputs are binary encoded to indicate the active input channel. Remember, the V-memory bits are mapped directly to discrete inputs. The module automatically turns these inputs On and Off to indicate the active input channel for each scan.

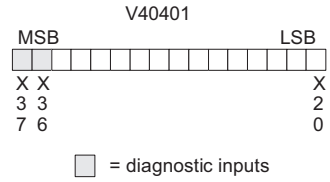



| Scan | X36 | X37 | Channel |
|---|---|---|---|
| N | Off | Off | 1 |
| N+1 | Off | On | 2 |
| N+2 | On | Off | 3 |
| N+3 | On | On | 4 |
| N+4 | Off | Off | 1 |

## Diagnostic Indicator Inputs

The last two inputs are used for module diagnostics.

Module Busy – The first diagnostic input (X36 in this example) indicates a "busy" condition. This input will always be active on the first PLC scan to tell the CPU the analog data is not valid. After the first scan, the input will normally turn on when environmental (electrical) noise problems are present. The programming examples in the next section will show how this input can be used. The wiring guidelines presented earlier in this chapter provide steps that can help reduce noise problems.



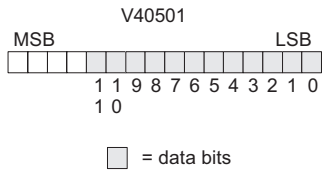
***NOTE:*** *When using the pointer method, the value placed into the V-memory location will be 8000 instead of the bit being set.*

Module Failure – The last diagnostic input (X37 in this example) indicates that the analog module is not operating. For example, if the 24VDC input power is missing, or if the terminal block is loose, then the module will turn on this input point. The module will also return a data value of zero to further indicate there is a problem. This input point cannot detect which individual channel is at fault. If the cause of the failure goes away, the module turns this bit off.

## Output Data Bits

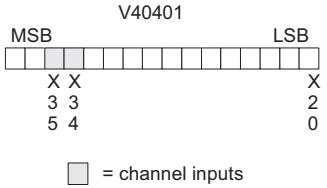
The first twelve bits of the output word represent the analog data in binary format.

| Bit | Value | Bit | Value |
|---|---|---|---|
| 0 | 1 | 6 | 64 |
| 1 | 2 | 7 | 128 |
| 2 | 4 | 8 | 256 |
| 3 | 8 | 9 | 512 |
| 4 | 16 | 10 | 1024 |
| 5 | 32 | 11 | 2048 |



## Output Channel Selection Bits

Two of the outputs select the active channel. Remember, the V-memory bits are mapped directly to discrete outputs. Turning a bit Off selects its channel. By controlling these outputs, the channel(s) to be updated can be selected.

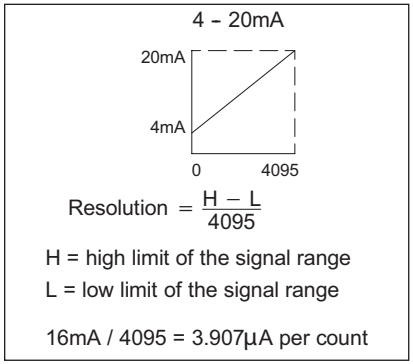



| Y35 | Y34 | Channel |
|---|---|---|
| On | Off | 1 |
| Off | On | 2 |
| Off | Off | 1 & 2 (same data to both channels) |
| On | On | None (both channels hold current values) |

## Module Resolution

Since the module has 12-bit resolution, the analog signal is converted into 4096 counts ranging from 0–4095 (212). For example, a 4mA signal would be 0, and a 20mA signal would be 4095. This is equivalent to a binary value of 0000 0000 0000 to 1111 1111 1111, or 000 to FFF hexadecimal. The diagram shows how this relates to the signal range.

Each count can also be expressed in terms of the signal level by using the equation shown.



# Writing the Control Program

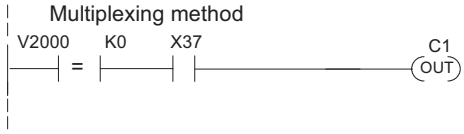
Before starting to write the program, some supplemental examples can be very helpful to the programmer, such as:

- Input power failure detection
- Output data calculation
- Input data scaling

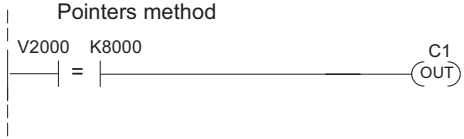
## Analog Input Failure Detection

The analog module has a microcontroller that can diagnose analog input circuit problems. Ladder logic can be written to detect these problems. The following rung shows an input point that would be assigned if the module was used as shown in the previous and following examples.

## Calculating the Digital Value




V-memory location V2000 holds channel 1 data. When a data value of zero is returned and input X37 is on, then the analog channel is not operating properly.




V-memory location V2000 holds channel 1 data. When a data value of 8000 is returned, then the analog channel is not operating properly.

The control program must calculate the digital value that is sent to the analog output. Several methods can be used to do this, but the best method is to convert the values to engineering units. This is accomplished by using the formula shown.

Adjustments may need to be made to the formula depending on the scale of the engineering units.

Consider the following example which controls pressure from 0.0–99.9 PSI. Using the formula will calculate the digital value to be sent to the analog output. The example shows the conversion required to yield 49.4 PSI. The multiplier of 10 is used because the decimal portion of 49.4 cannot be loaded in the program, so it is shifted right one decimal place to make a usable value of 494.

$$A = U\,\frac{4095}{H-L}$$

A = Analog Value (0–4095)

U = Engineering Units

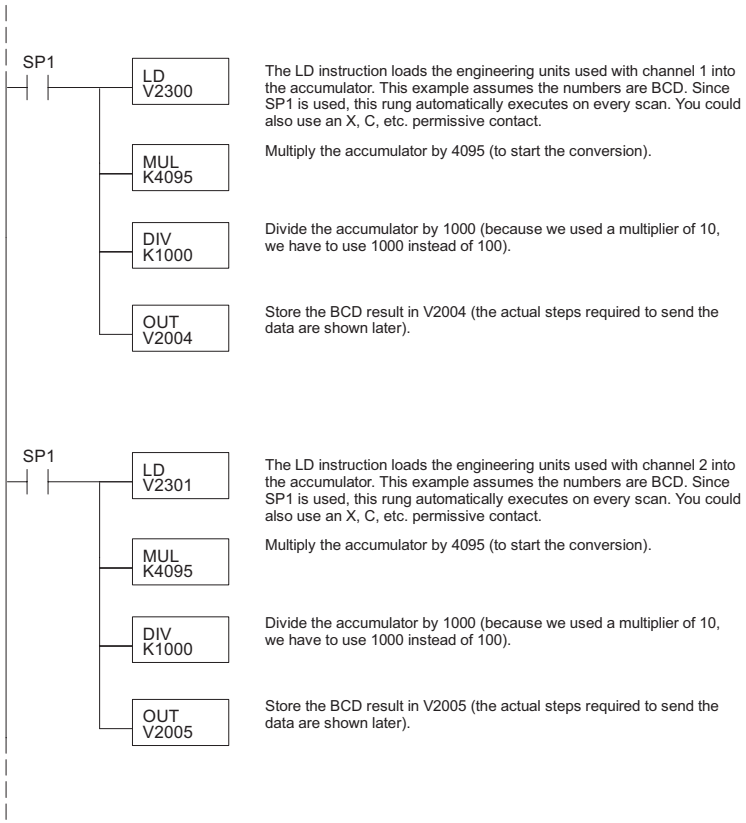
H = High limit of the engineering unit range

L = Low limit of the engineering unit range

$$A = 10U\,\frac{4095}{10\ (H-L)} \qquad A = 494\,\frac{4095}{(1000-0)} \qquad A = 2023$$

The example program below shows how to write the program to perform engineering unit conversions. This example will work with all CPUs and assumes that the engineering unit values have been calculated or loaded and stored in V2300 and V2301 for channels 1 and 2 respectively. Also, the final values are moved to V2004 and V2005, which are memory locations that are used in the following examples. Any user V-memory locations can be used, but they must match the locations that are specified as the source for the output data (see the next section for an example).

***NOTE:*** *Since the D2-250 can do math operations in BCD format, it is better to perform the math calculations in BCD.*




The LD instruction loads the engineering units used with channel 1 into the accumulator. This example assumes the numbers are BCD. Since SP1 is used, this rung automatically executes on every scan. You could also use an X, C, etc. permissive contact.

Multiply the accumulator by 4095 (to start the conversion).

Divide the accumulator by 1000 (because we used a multiplier of 10, we have to use 1000 instead of 100).

Store the BCD result in V2004 (the actual steps required to send the data are shown later).

The LD instruction loads the engineering units used with channel 2 into the accumulator. This example assumes the numbers are BCD. Since SP1 is used, this rung automatically executes on every scan. You could also use an X, C, etc. permissive contact.

Multiply the accumulator by 4095 (to start the conversion).

Divide the accumulator by 1000 (because we used a multiplier of 10, we have to use 1000 instead of 100).

Store the BCD result in V2005 (the actual steps required to send the data are shown later).

## Scaling the Input Data

Most applications usually require measurements in engineering units, which provide more meaningful data. This is accomplished by using the conversion formula shown.

Adjustments to the formula may be needed depending on the scale chosen for the engineering units.

For example, if pressure (PSI) is to be measured with a scale of 0.0–99.9, a multiplication factor of 10 would be needed in order to imply a decimal place when the value is used in the user program.

$$\text{Units} = A \frac{H-L}{4095}$$

U = Engineering Units

A = Analog Value (0–4095)

H = High limit of the engineering unit range

L = Low limit of the engineering unit range

**Example without multiplier**

$$\text{Units} = A \frac{H-L}{4095}$$

$$\text{Units} = 2024 \frac{100-0}{4095}$$

$$\text{Units} = 49$$

**Example with multiplier**

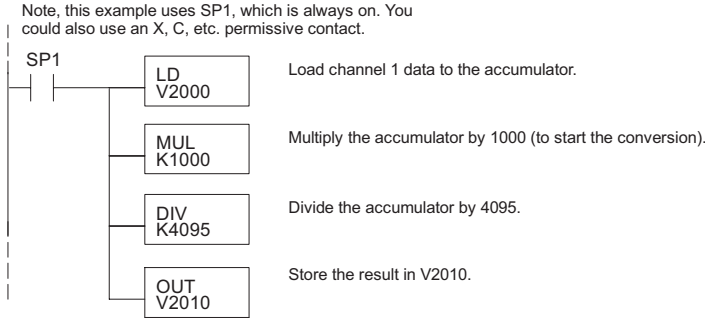
$$\text{Units} = 10A \frac{H-L}{4095}$$

$$\text{Units} = 20240 \frac{100-0}{4095}$$

$$\text{Units} = 494$$

Analog Value of 2024, slightly less than half scale, should yield 49.4 PSI.

The following rung of logic is an example showing how the program can be written to perform the engineering unit conversion. This example assumes the data is in BCD format before being loaded into the appropriate V-memory locations using instructions that apply to the CPU module being used.



## Read / Write Program (Pointer Method) for D2-240, D2-250-1, D2-260 and D2-262 CPUs

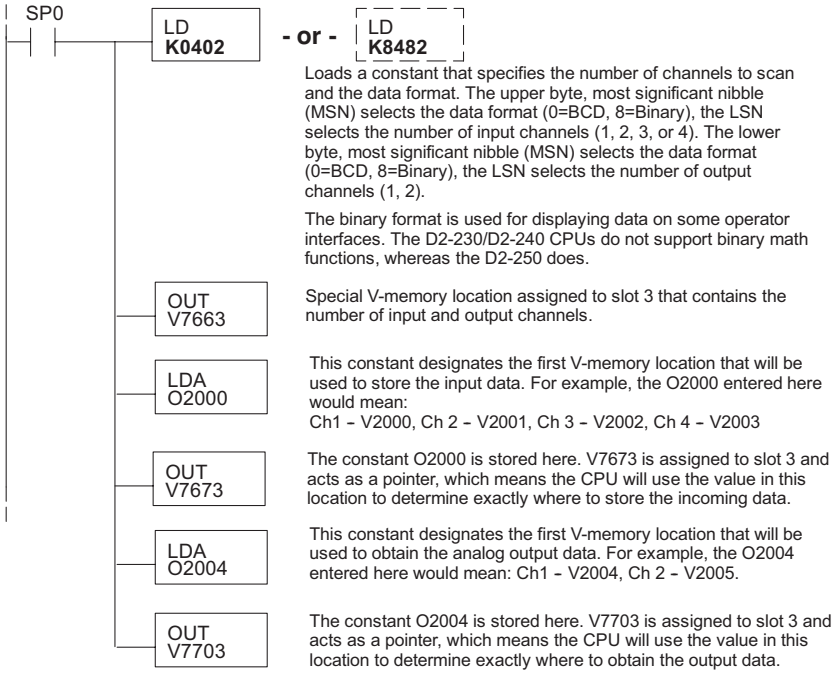
The D2-240, D2-250-1, D2-260 and D2-262 CPUs have special V-memory locations assigned to each base slot that simplifies the programming requirements. The V-memory locations:

- Specify the number of input and output channels to scan.
- Specify the storage location for the input data.
- Specify the source location for the output data.

***NOTE:*** *In order to use the pointer method, D2-250 CPUs must have firmware revision 1.09 or later, and F2-4AD2DA modules must be revision C1 or later*

The following example rung of logic shows how to setup these locations. Place this rung anywhere in the ladder program, or in the initial stage if stage programming instructions are being used.

In this example V2000 and V2004 are used to store the calculated values, but any V-memory location can be used. For this example, the analog module is installed in slot 3. Be sure to use the V-memory locations for which ever slot the module is placed in your system. The pointer method automatically converts values to binary.



The following tables show the special V-memory locations used by the D2-240, D2-250-1, D2-260 and D2-262 for the CPU base and local expansion base I/O slots. Slot 0 (zero) is the module next to the CPU or D2-CM module. Slot 1 is the module two places from the CPU or D2-CM, and so on. Remember, the CPU only examines the pointer values at these locations after a mode transition. Also, if the D2-230 (multiplexing) method is used, verify that these addresses in the CPU are 0 (zero).

The table below applies to the D2-240, D2-250-1, D2-260 and D2-262 CPU base.

| CPU Base: Analog In/Out Module Slot-Dependent V-memory Locations | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| ***Slot*** | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| ***No. of Channels*** | V7660 | V7661 | V7662 | V7663 | V7664 | V7665 | V7666 | V7667 |
| ***Input Pointer*** | V7670 | V7671 | V7672 | V7673 | V7674 | V7675 | V7676 | V7677 |
| ***Output Pointer*** | V7700 | V7701 | V7702 | V7703 | V7704 | V7705 | V7706 | V7707 |

The table below applies to the D2-250-1, D2-260 or D2-262 CPU base 1.

| Expansion Base D2-CM #1: Analog In/Out Module Slot-Dependent V-memory Locations | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| ***Slot.*** | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| ***No. of Channels*** | V36000 | V36001 | V36002 | V36003 | V36004 | V36005 | V36006 | V36007 |
| ***Input Pointer*** | V36010 | V36011 | V36012 | V36013 | V36014 | V36015 | V36016 | V36017 |
| ***Output Pointer*** | V36020 | V36021 | V36022 | V36023 | V36024 | V36025 | V36026 | V36027 |

The table below applies to the D2-250-1, D2-260 or D2-262 CPU base 2.

| Expansion Base D2-CM #2: Analog In/Out Module Slot-Dependent V-memory Locations | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| ***Slot*** | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| ***No. of Channels*** | V36100 | V36101 | V36102 | V36103 | V36104 | V36105 | V36106 | V36107 |
| ***Input Pointer*** | V36110 | V36111 | V36112 | V36113 | V36114 | V36115 | V36116 | V36117 |
| ***Output Pointer*** | V36120 | V36121 | V36122 | V36123 | V36124 | V36125 | V36126 | V36127 |

The table below applies to the D2-260 and D2-262 CPU base 3.

| Expansion Base D2-CM #3: Analog In/Out Module Slot-Dependent V-memory Locations | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| ***Slot*** | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| ***No. of Channels*** | V36200 | V36201 | V36202 | V36203 | V36204 | V36205 | V36206 | V36207 |
| ***Input Pointer*** | V36210 | V36211 | V36212 | V36213 | V36214 | V36215 | V36216 | V36217 |
| ***Output Pointer*** | V36220 | V36221 | V36222 | V36223 | V36224 | V36225 | V36226 | V36227 |

The table below applies to the D2-260 and D2-262 CPU base 4.

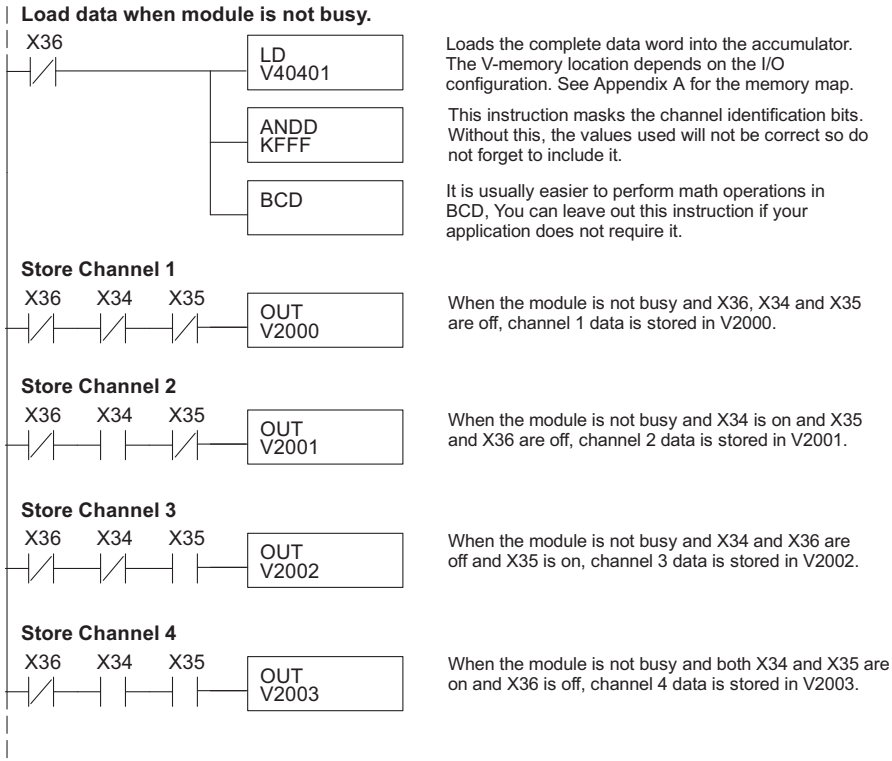
| Expansion Base D2-CM #4: Analog In/Out Module Slot-Dependent V-memory Locations | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| ***Slot*** | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| ***No. of Channels*** | V36300 | V36301 | V36302 | V36303 | V36304 | V36305 | V36306 | V36307 |
| ***Input Pointer*** | V36310 | V36311 | V36312 | V36313 | V36314 | V36315 | V36316 | V36317 |
| ***Output Pointer*** | V36320 | V36321 | V36322 | V36323 | V36324 | V36325 | V36326 | V36327 |

## Read Input Values (Multiplexing)

The D2-230 CPU does not use special V-memory locations for transferring data. Since all channels are multiplexed into a single data word, the control program must be setup to determine which channel is being read. Since the module appears as X input points to the CPU, simply use the active channel status bits to determine which channel is being read.

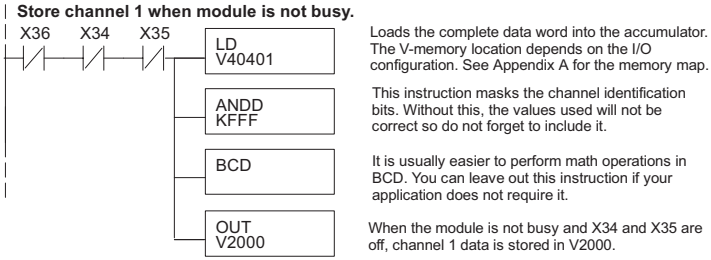
Note, this example is for a module installed in slot 3, as shown in the previous examples. The addresses used would be different if the module was used in a different slot. These rungs can be placed anywhere in the program or if stage programming is being used, place them in a stage that is always active.

The following multiplexing example can be used with all of the DL205 CPUs.



## Single Input Channel Selected (Multiplexing)

Since it isn't necessary to determine which channel is selected, the single channel example shown below can be implemented in the user program.



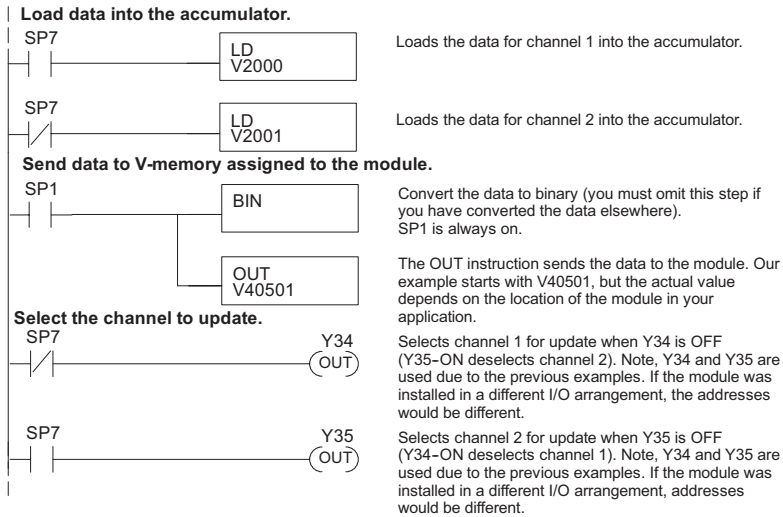

## Write Output Values (Multiplexing)

Since all channels are multiplexed into a single data word, the control program can be setup to determine which channel to write the data to. Since the module appears as Y output points to the CPU, it is simple to use the channel selection outputs to determine which channel to update.

Note, this example is for a module installed in slot 3, as shown in the previous examples. The addresses used would be different if the module was used in a different slot. These rungs can be placed anywhere in the program or if stage programming is being used, place them in a stage that is always active.

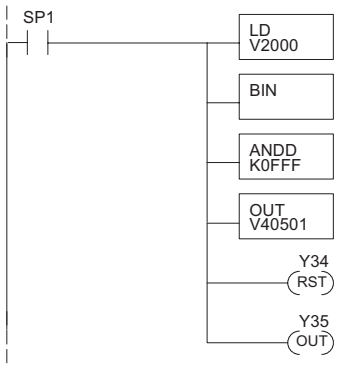
This example is a two-channel multiplexer that updates each channel on alternate scans. Relay SP7 is a special relay that is On for one scan, then Off for one scan. This multiplexing example can be used with all of the DL205 CPUs.

***NOTE:*** *Binary data must be sent to the output module. If the data is already in binary format, do not use the BIN instruction shown in this example.*



## Write Data to One Channel

If only one channel is being used, or if the updates are to be controlled separately, the following logic can be used.




The LD instruction loads the data into the accumulator. Since SP1 is used, this rung automatically executes on every scan. You could also use an X, C, etc. permissive contact.

The BIN instruction converts the accumulator data to binary (you must omit this step if you have already converted the data elsewhere).

The ANDD instruction masks off the channel select bits to prevent an accidental channel selection.

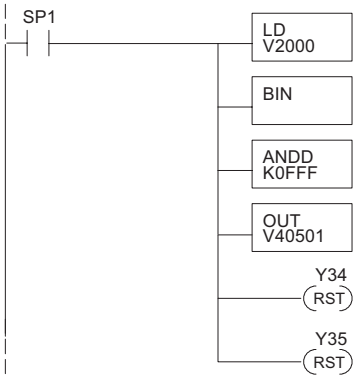
The OUT instruction sends the data to the module. Our example starts with V40501, but the actual value depends on the location of the module in your application.

Y34–OFF selects channel 1 for updating.

Y35–ON deselects channel 2 (do not update).

## Write the same Data to Both Channels

If both channel select outputs are Off, then both channels will be updated with the same data.




The LD instruction loads the data into the accumulator. Since SP1 is used, this rung automatically executes on every scan. You could also use an X, C, etc. permissive contact.

The BIN instruction converts the accumulator data to binary (you must omit this step if you have already converted the data elsewhere).

The ANDD instruction masks off the channel select bits to prevent an accidental channel selection.

The OUT instruction sends the data to the module. Our example starts with V40501, but the actual value depends on the location of the module in your application.

Y34–OFF selects channel 1 for updating.

Y35–OFF selects channel 2 for updating.

## Analog and Digital Value Conversions

It is sometimes useful to do quick conversions between the signal levels and the digital values. This can be helpful during startup and/or troubleshooting. The following table shows some formulas to help with the conversions.

| Range | If the digital value is known | If the analog signal level is known. |
|---|---|---|
| ***4–20 mA*** | $A = \frac{16D}{4095} + 4$ | $D = \frac{4095}{16}(A - 4)$ |

For example, if a 10mA signal level is needed, use the formula to the right to determine the digital value "D" to be stored in the V-memory location which is designated to store the data.

$$D = \frac{4095}{16}(A - 4)$$

$$D = \frac{4095}{16}(10mA - 4)$$

$$D = (255.93)(6) \qquad D = 1536$$

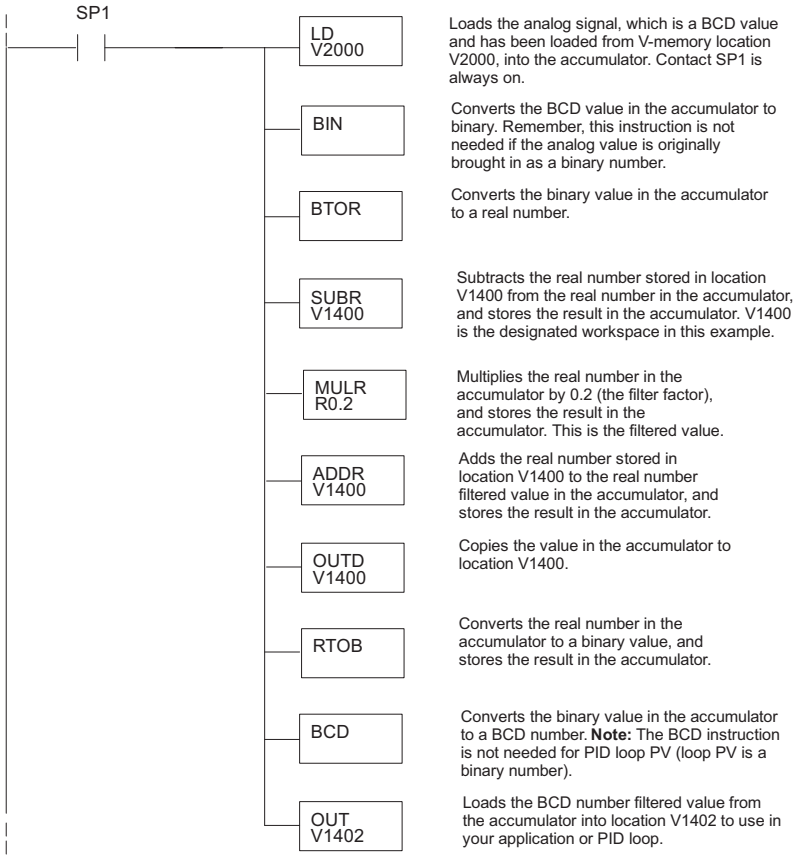
## Filtering Input Noise (D2-250-1, D2-260 and D2-262 CPUs Only)

Add the following logic to filter and smooth analog input noise in D2-250-1, D2-260 or D2-262 CPUs. This is especially useful when using PID loops. Noise can be generated by the field device and/or induced by field wiring.

In the following example, the analog value in BCD is first converted to a binary number. Memory location V1400 is the designated workspace in this example. The MULR instruction is the filter factor, which can be from 0.1–0.9. The example uses 0.2. A smaller filter factor increases filtering. A higher precision value can be used, but it is not generally needed. The filtered value is then converted back to binary and then to BCD. The filtered value is stored in location V1402 for use in your application or PID loop.

***NOTE:*** *Be careful not to do a multiple number conversion on a value. For example, if the pointer method is used to get the analog value, it is in BCD and must be converted to binary. However, if the conventional method is used to read a value and the first twelve bits are masked, then it is already in binary and no conversion using the BIN instruction is needed.*

***NOTE****: Please review intelligent instructions (IBox) in Chapter 5, which simplify this and other functions. The IBox instructions are supported by the D2-250-1, D2-260 and D2-262.*



# F2-8AD4DA-1 8-Ch. In/4-Ch. Out Current Analog Combination

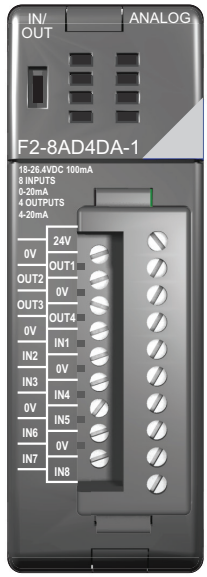
In This Chapter...

Module Specifications ..... 15-2
Connecting the Field Wiring ..... 15-6
Module Operation ..... 15-9
Special V-Memory Locations ..... 15-13
Writing the Control Program ..... 15-16

# Module Specifications

The F2-8AD4DA-1 Analog Current Input/Output module provides several hardware features:

- Analog inputs and outputs are optically isolated from the PLC logic.
- The module has a removable terminal block so the module can be easily removed or changed without disconnecting the wiring.
- All input and output channels are updated in one scan.
- On-board active analog filtering, two CISC microcontrollers and CPLD provide digital signal processing to maintain precision analog measurements in noisy environments.
- Low-power CMOS design requires only 100mA from an external 18–26.4 VDC power supply.
- Input resolution is independently adjustable for each channel. Users may select 12-bit, 14-bit or 16-bit.
- Output resolution is 16-bit.
- Broken transmitter detection bit (input <2mA) for use with 4–20 mA input device.
- Each input can be independently configured to return the present value, or to track and hold the maximum or minimum value.
- No jumper settings.




**F2-8AD4DA-1**

## F2-8AD4DA-1 Requirements

The F2-8AD4DA-1 Analog Current Input/Output Module requires one of the following components as a CPU or controller.

| Hardware and Firmware Requirements | | |
|---|---|---|
| ***Base Type*** | ***CPU/Controller*** | ***Firmware Version*** |
| ***Local*** | D2-250-1 | 4.40 or later |
| | D2-260 | 2.20 or later |
| | D2-262 | 1.0 TBD |
| ***Expansion*** | D2-CM | 1.30 or later |
| ***Remote I/O*** | H2-EBC(-F) | 2.1.441 or later |
| | H2-EBC100 | 4.0.457 or later |

The following tables provide the specifications for the F2-8AD4DA-1 Analog Current Input/ Output Module. Review these specifications to be certain that it will meet the requirements of your application.

| Input Specifications | |
|---|---|
| ***Number of Input Channels*** | 8, single ended (one common) |
| ***Input Range*** | 0–20 mA |
| ***Input Resolution / Value of LSB*** | 12, 14, or 16-bit; selectable<br>12-bit, 0–20 mA = 4.88 µA<br>14-bit, 0–20 mA = 1.22 µA<br>16-bit, 0–20 mA = 0.305 µA |
| ***Input Impedance*** | 100Ω, ±0.1%, 1/4W |
| ***Maximum Continuous Overload*** | ±45mA |
| ***Loop Supply Voltage Range*** | 18–26.4 VDC |
| ***Filter Characteristics*** | Active low pass; -3 dB @ 80Hz |
| ***PLC Input Update Rate*** | 8 channels per scan (max. with pointers; local base) |
| ***Sample Duration Time (note)*** | 2ms @ 12-bit; 5.52 ms @ 14-bit; 23ms @ 16-bit |
| ***Conversion Time (note)*** | 12-bit =1.5 ms per channel<br>14-bit = 6ms per channel<br>16-bit = 25ms per channel |
| ***Conversion Method*** | Over sampling successive approximation |
| ***Accuracy vs. temperature*** | 25ppm / °C maximum |
| ***Input Stability and Repeatability*** | ± 0.025% of range (after 30 minute warm-up) |
| ***Input Inaccuracy*** | 0.1% of range maximum |
| ***Linearity Error (end to end)*** | 12-bit = ±2 counts max. (± 0.06% of range)<br>14-bit = ±10 counts max. (± 0.06% of range)<br>16-bit = ±40 counts max. (± 0.06% of range)<br>Monotonic with no missing codes |
| ***Full Scale Calibration Error (not including offset error)*** | ±0.07% of range maximum |
| ***Offset Calibration Error*** | ±0.03% of range maximum |
| ***Common Mode Rejection*** | -90dB min. @ DC; -150dB min. @ 50/60Hz |
| ***Crosstalk*** | ±0.025% of range max. @ DC, 50/60Hz |
| ***Recommended External Fuse*** | 0.032 A, series 217 fast-acting, current inputs |

***NOTE:*** *The values listed for Sample Duration Time and Conversion Time are for a single channel, and do not include PLC scan times.*

| Output Specifications | |
|---|---|
| ***Number of Output Channels*** | 4 |
| ***Output Range*** | 4–20 mA |
| ***Output Resolution*** | 16-bit; 0.244 µA / bit |
| ***Output Type*** | Current sourcing at 20mA max. |
| ***Output Signal at Power-up & Power-down*** | ≤4mA |
| ***External Load Resistance*** | 0–750 Ω |
| ***Maximum Inductive Load*** | 1mH |
| ***Allowed Load Type*** | Grounded |
| ***Output Voltage Drop*** | 6V max.; 1V min. |
| ***Max. Continuous Output Overload*** | Open circuit protected |
| ***Type of Output Protection*** | Electronically current limited to 20mA or less |
| ***PLC Output All Channel Update Time*** | 4ms (local base) |
| ***Output Settling Time*** | 0.5 ms max.; 5µs min. (full scale change) |
| ***Output Ripple*** | 0.005% of full scale |
| ***Accuracy vs. Temperature*** | ±25 ppm/°C max. full scale calibration change (±0.0025% of range/°C) |
| ***Output Stability and Repeatability*** | ±1 LSB after 10 minute warm-up typical |
| ***Output Inaccuracy*** | 0.1% of range maximum |
| ***Linearity Error (end to end)*** | ±33 counts max. ( ±0.05% of full scale)<br>Monotonic with no missing codes |
| ***Full Scale Calibration Error (not including offset error)*** | ±0.07% of range maximum |
| ***Offset Calibration Error*** | ±0.03% of range maximum |
| ***Crosstalk at DC, 50/60Hz*** | -70dB or 0.025% of full scale |

***NOTE:*** *One count in the specifications table is equal to one least significant bit of analog data value (1 in 65536)*

| General Module Specifications | |
|---|---|
| ***Digital Input and Output Points Required*** | 32 point (X) Inputs<br>32 point (Y) Outputs |
| ***Power Budget Requirement*** | 35mA @ 5VDC (supplied by the base) |
| ***External Power Supply Requirement*** | 18–26.4 VDC, 100mA maximum plus 20mA per loop output |
| ***Field Side to Logic Side Isolation*** | 1800VAC applied for 1 second (100% tested) |
| ***Insulation Resistance*** | >10MΩ @ 500VDC |
| ***Operating Temperature*** | 0–60°C (32–140°F); IEC60068-2-14 |
| ***Storage Temperature*** | –20°C to 70°C (- 4°F to 158°F); IEC60068-2-1, -2-2, -2-14 |
| ***Relative Humidity*** | 5–95% (non-condensing); IEC60068-2-30 |
| ***Environmental Air*** | No corrosive gases permitted; EN61131-2 pollution degree 1 |
| ***Vibration*** | MIL STD 810C 514.2; IEC60068-2-6 |
| ***Shock*** | MIL STD 810C 516.2; IEC60068-2-27 |
| ***Noise Immunity*** | NEMA ICS3-304; IEC61000-4-2, -4-3, -4-4 |
| ***Emissions*** | EN61000-6-4 (conducted and radiated RF emissions) |
| ***Module Location*** | Any non-CPU slot in local, expansion, or Ethernet remote base of DL205 system with D2-250-1, D2-260 or D2-262 CPU |
| ***Field Wiring*** | 19 point removable terminal block included.<br>Optional remote wiring using ZL-CM20 remote feed-through terminal block module and ZL-2CBL2# cable. |
| ***Agency Approvals*** | UL508; UL6079-15 Zone 2; CE (EN61131-1) |

## Module Placement and Configuration Requirements

The F2-8AD4DA-1 analog current input/output module requires 32 discrete input and 32 discrete output points.

The module can be installed in any non-CPU slot of D2-250-1, D2-260 or D2-262 local bases,
D2-CM expansion bases, H2-EBC(100)(-F) Ethernet remote bases, H2-PBC Profibus slave bases, or H2-WPLCx-xx WinPLC bases.

***NOTE:*** *The module is NOT supported by D2-230, D2-240, or D2-250 CPUs. It is also not supported by D2-RMSM and D2-RSSS remote I/O master/slave modules.*

The available power budget may also be a limiting factor. Check the user manual for the particular module of CPU and I/O base for more information regarding power budget and number of local, local expansion, or Ethernet remote I/O points.

# Connecting the Field Wiring

## Wiring Guidelines

Your company may have guidelines for wiring and cable installation. If so, check the guidelines before beginning the installation. Here are some general things to consider:

- Use the shortest wiring route whenever possible.
- Use shielded wiring and ground the shield at the transmitter source. Do not ground the shield at both the module and the load or source.
- Do not run the signal wiring next to large motors, high current switches, or transformers. This may cause noise problems.
- Route the wiring through an approved cable housing to minimize the risk of accidental damage. Check local and national codes to choose the correct method for your application.

## User Power Supply Requirements

The F2-8AD4DA-1 module requires at least one field-side power supply. The same or separate power sources can be used for the module supply and the current loop supply. The module requires 18-26.4 VDC (at 100mA) plus 20mA for each current loop (a total of 240mA for twelve current loops), from the external power supply.

The DL205 AC bases have a built-in 24VDC power supply that provide up to 300mA of current. This can be used instead of a separate supply if you are using only one F2-8AD4DA-1 module with less than 10 loops. Check the power budget to be safe.

It is desirable in some situations to power the transmitters separately in a location remote from the PLC. This will work as long as the transmitter supply meets the voltage and current requirements, and that the transmitter and the module power supply negative (-) side are connected together.

**WARNING: If the internal 24VDC base power is used, be sure to calculate the power budget. Exceeding the power budget can cause unpredictable system operation that can lead to a risk of personal injury or equipment damage.**

The DL205 base has a switching type power supply. As a result of switching noise, ±3–5 counts of instability may be noticed in the analog input data if the base power supply is used. If this is unacceptable, try one of the following:

1. Use a separate linear power supply.
2. Connect the 24VDC common to the frame ground, which is the screw terminal marked "G" on the base.

When using these methods, the input stability is rated at ±0.025% of range.

## Current Loop Transmitter Impedance

Standard 0–20 mA and 4–20 mA transmitters and transducers can operate from a wide variety of power supplies. Not all transmitters are alike and the manufacturers often specify a minimum loop or load resistance that must be used with the transmitter.

The F2-8AD4DA-1 provides 100 ohms resistance for each input channel. If the transmitter being used requires a load resistance below 100 ohms, adjustments do not have to be made. However, if the transmitter requires a load resistance higher than 100 ohms, add a resistor in series with the module.

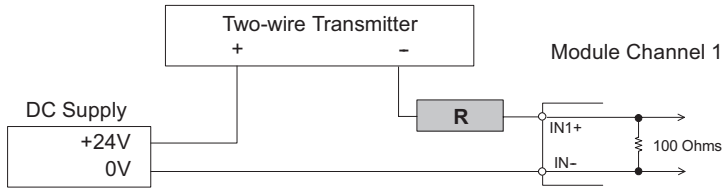
Consider the following example for a transmitter being operated from a 24VDC supply with a recommended load resistance of 750 ohms. Since the module has a 100 ohms resistance, add an additional resistor.

In the example, add a 650 ohm resistor (R) in series with the module.

Example:

$R = Tr - Mr$
$R = 750 - 100$
$R \geq 650$

R – resistor to add
Tr – Transmitter total resistance requirement
Mr – Module resistance (internal 100 Ohms)

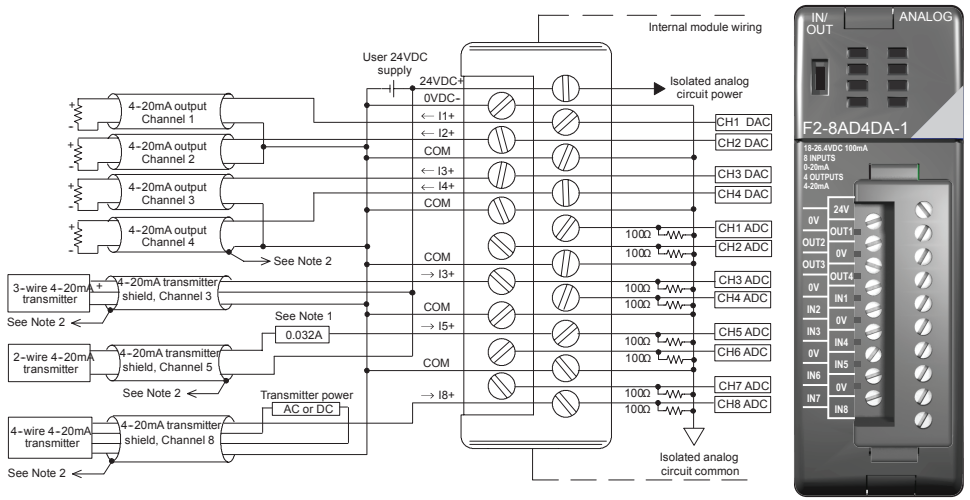


## Wiring Diagram

The F2-8AD4DA-1 module has a removable connector to simplify wiring. Simply squeeze the top and bottom retaining clips and gently pull the connector from the module. Use the following diagram to connect the field wiring.

The diagram shows one power supply for both the module and the I/O signal loops. If a separate module and loop supplies are to be used, connect the power supply 0V commons together.

The four wire transmitter connected to input channel 8 is powered by an independent power source. In this case, the transmitter is treated as a 2-wire transmitter.

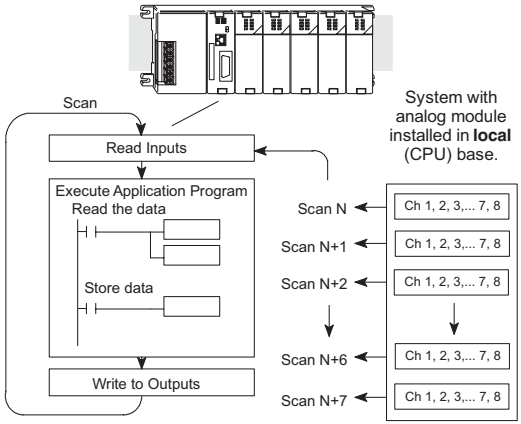


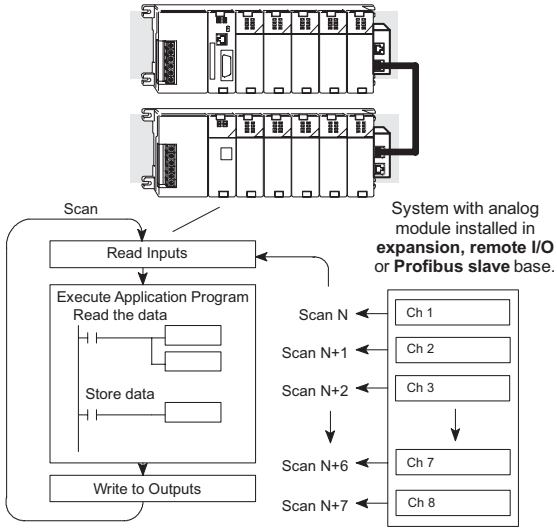

***NOTE 1:*** *Shields should be connected at their respective signal source.*
***NOTE 2:*** *A series 217, 0.032 A, fast-acting fuse is recommended for 4–20 mA current input loops.*

# Module Operation

## Input Channel Scanning Sequence (Pointer Method)

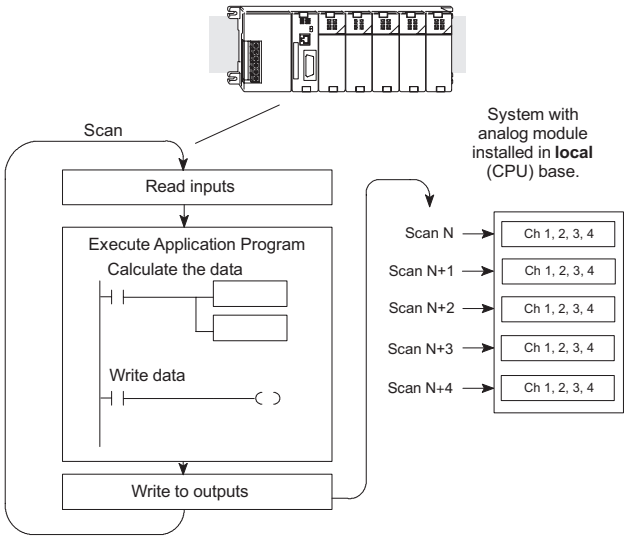
If the F2-8AD4DA-1 module is installed in a local (CPU) base, the input data for all eight channels can be obtained in one scan. However, only one channel of input data can be obtained per scan if the module is installed in an expansion, remote I/O, or Profibus slave base.

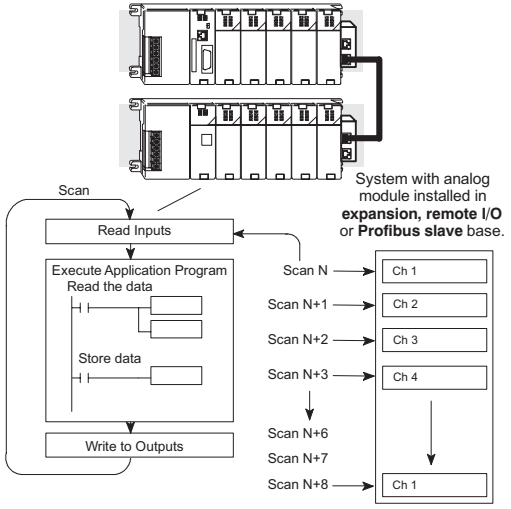


## Output Channel Update Sequence (Pointer Method)

If the F2-8AD4DA-1 is installed in a local (CPU) base, all four output channels can be updated on every scan. However, only one channel can be updated per scan if the module is installed in an expansion, remote I/O, or Profibus slave base. The timing is synchronized with the timing of reading the input channels, so each output channel can be updated every eight scans.



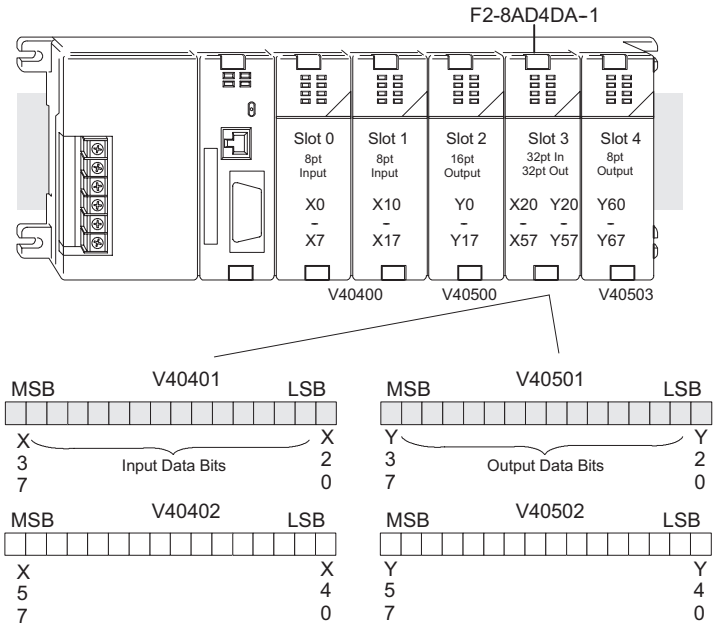



## Understanding the I/O Assignments

Remember that the F2-8AD4DA-1 module appears to the CPU as a 32-point discrete input module and a 32-point discrete output module. These points can be used to obtain:

- An indication of which channel is active
- The digital representation of the analog signal
- Module diagnostic information
- Settings for resolution, range, and track and hold

These bits may never have to be used, but it may be an aid to help understand the data format.Since all I/O points are automatically mapped into V-memory, the location of the datawords that will be assigned to the module can simply be determined.



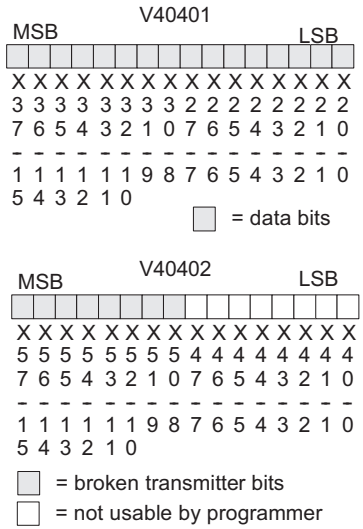

The individual bits in these data word locations represent specific information about the analog signal. (The specific memory locations may vary, depending upon the slot where the F2-8AD4DA-1 module is located.)

## Input Data Bits

Depending upon the resolution selected, up to 16-bits of the input word represent the analog data in binary format.

| Bit | Value | Bit | Value |
|---|---|---|---|
| 0 | 1 | 8 | 256 |
| 1 | 2 | 9 | 512 |
| 2 | 4 | 10 | 1024 |
| 3 | 8 | 11 | 2048 |
| 4 | 16 | 12 | 4096 |
| 5 | 32 | 13 | 8192 |
| 6 | 64 | 14 | 16384 |
| 7 | 128 | 15 | 32768 |

The upper byte of the second input word represents the broken transmitter detection bits for use only with 4–20 mA input devices. The lower byte is not usable by the programmer.




**Broken Transmitter Detection Bits (seocond input word)**

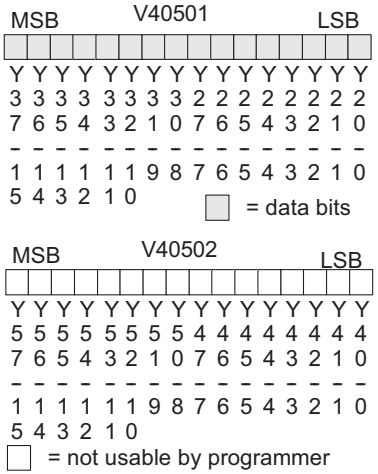
| *V40402 Input Address #* | X 57 | X 56 | X 55 | X 54 | X 53 | X 52 | X 51 | X 50 | X 47 | .... | X 40 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| *Input Bit #* | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | .... | 0 |
| *BT for Channel #* | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | n/a | .... | n/a |

## Output Data Bits

All 16-bits of the first output word represent the analog data in binary format.

| Bit | Value | Bit | Value |
|---|---|---|---|
| 0 | 1 | 8 | 256 |
| 1 | 2 | 9 | 512 |
| 2 | 4 | 10 | 1024 |
| 3 | 8 | 11 | 2048 |
| 4 | 16 | 12 | 4096 |
| 5 | 32 | 13 | 8192 |
| 6 | 64 | 14 | 16384 |
| 7 | 128 | 15 | 32768 |

The second output word is not usable by the programmer.



# Special V-Memory Locations

The D2-250-1, D2-260 and D2-262 CPUs have special V-memory locations assigned to each base slot that greatly simplifies the programming requirements. These V-memory locations specify:

- The number of input and output channels to scan
- The storage locations for the input and output data
- The resolution for the inputs
- The range selections for the inputs and outputs
- The track and hold selections for the inputs

## Module Configuration Registers

The following tables show the special V-memory used by the CPUs for the CPU base and local expansion base I/O slots. Slot 0 is the module slot next to the CPU or D2-CM module. Slot 1 is the module slot two places from the CPU or D2-CM, and so on. The CPU needs to examine the pointer values at these locations only after a mode transition.

| CPU Base: Analog In/Out Module Slot-Dependent V-memory Locations | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| ***Slot*** | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| ***No. of I/O Channels Enabled & Format*** | V7660 | V7661 | V7662 | V7663 | V7664 | V7665 | V7666 | V7667 |
| ***Input Pointer*** | V7670 | V7671 | V7672 | V7673 | V7674 | V7675 | V7676 | V7677 |
| ***Output Pointer*** | V7700 | V7701 | V7702 | V7703 | V7704 | V7705 | V7706 | V7707 |
| ***Input Resolutions*** | V36400 | V36401 | V36402 | V36403 | V36404 | V36405 | V36406 | V36407 |
| ***(Reserved)*** | V36410 | V36411 | V36412 | V36413 | V36414 | V36415 | V36416 | V36417 |
| ***Input Track & Hold*** | V36420 | V36421 | V36422 | V36423 | V36424 | V36425 | V36426 | V36427 |

| Expansion Base D2-CM #1: Analog In/Out Module Slot-Dependent V-memory Locations | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| ***Slot*** | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| ***No. of I/O Channels Enabled & Format*** | V36000 | V36001 | V36002 | V36003 | V36004 | V36005 | V36006 | V36007 |
| ***Input Pointer*** | V36010 | V36011 | V36012 | V36013 | V36014 | V36015 | V36016 | V36017 |
| ***Output Pointer*** | V36020 | V36021 | V36022 | V36023 | V36024 | V36025 | V36026 | V36027 |
| ***Input Resolutions*** | V36030 | V36031 | V36032 | V36033 | V36034 | V36035 | V36036 | V36037 |
| ***(Reserved)*** | V36040 | V36041 | V36042 | V36043 | V36044 | V36045 | V36046 | V36047 |
| ***Input Track & Hold*** | V36050 | V36051 | V36052 | V36053 | V36054 | V36055 | V36056 | V36057 |

| Expansion Base D2-CM #2: Analog In/Out Module Slot-Dependent V-memory Locations | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| ***Slot*** | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| ***No. of I/O Channels Enabled & Format*** | V36100 | V36101 | V36102 | V36103 | V36104 | V36105 | V36106 | V36107 |
| ***Input Pointer*** | V36110 | V36111 | V36112 | V36113 | V36114 | V36115 | V36116 | V36117 |
| ***Output Pointer*** | V36120 | V36121 | V36122 | V36123 | V36124 | V36125 | V36126 | V36127 |
| ***Input Resolutions*** | V36130 | V36131 | V36132 | V36133 | V36134 | V36135 | V36136 | V36137 |
| ***(Reserved)*** | V36140 | V36141 | V36142 | V36143 | V36144 | V36145 | V36146 | V36147 |
| ***Input Track & Hold*** | V36150 | V36151 | V36152 | V36153 | V36154 | V36155 | V36156 | V36157 |

| Expansion Base D2-CM #3: Analog In/Out Module Slot-Dependent V-memory Locations | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| ***Slot*** | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| ***No. of I/O Channels Enabled & Format*** | V36200 | V36201 | V36202 | V36203 | V36204 | V36205 | V36206 | V36207 |
| ***Input Pointer*** | V36210 | V36211 | V36212 | V36213 | V36214 | V36215 | V36216 | V36217 |
| ***Output Pointer*** | V36220 | V36221 | V36222 | V36223 | V36224 | V36225 | V36226 | V36227 |
| ***Input Resolutions*** | V36230 | V36231 | V36232 | V36233 | V36234 | V36235 | V36236 | V36237 |
| ***(Reserved)*** | V36240 | V36241 | V36242 | V36243 | V36244 | V36245 | V36246 | V36247 |
| ***Input Track & Hold*** | V36250 | V36251 | V36252 | V36253 | V36254 | V36255 | V36256 | V36257 |

| Expansion Base D2-CM #4: Analog In/Out Module Slot-Dependent V-memory Locations | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| ***Slot*** | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| ***No. of I/O Channels Enabled & Format*** | V36300 | V36301 | V36302 | V36303 | V36304 | V36305 | V36306 | V36307 |
| ***Input Pointer*** | V36310 | V36311 | V36312 | V36313 | V36314 | V36315 | V36316 | V36317 |
| ***Output Pointer*** | V36320 | V36321 | V36322 | V36323 | V36324 | V36325 | V36326 | V36327 |
| ***Input Resolutions*** | V36330 | V36331 | V36332 | V36333 | V36334 | V36335 | V36336 | V36337 |
| ***(Reserved)*** | V36340 | V36341 | V36342 | V36343 | V36344 | V36345 | V36346 | V36347 |
| ***Input Track & Hold*** | V36350 | V36351 | V36352 | V36353 | V36354 | V36355 | V36356 | V36357 |

## Number of I/O Channels Enabled & Data Format

Load this V-memory location with a constant that specifies the number of enabled I/O channels and their data formats. The upper byte applies to the inputs, and the lower byte applies to the outputs. The most significant nibbles specify the data formats, and the least significant nibbles specify the number of channels enabled.

| V-memory Locations for No. of I/O Channels Enabled & Format | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| ***No. of Channels Enabled*** | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| ***BCD Input*** | K01xx | K02xx | K03xx | K04xx | K05xx | K06xx | K07xx | K08xx |
| ***Binary Input*** | K81xx | K82xx | K83xx | K84xx | K85xx | K86xx | K87xx | K88xx |
| ***BCD Output*** | Kxx01 | Kxx02 | Kxx03 | Kxx04 | n/a | n/a | n/a | n/a |
| ***Binary Output*** | Kxx81 | Kxx82 | Kxx83 | Kxx84 | n/a | n/a | n/a | n/a |

## Input Selection Resolution Bits

Each of the eight input channels can be individually disabled or configured for 12, 14, or 16-bit resolution.

V36403: (specific memory location will vary depending upon the base and slot location).

| 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R-8H | R-8L | R-7H | R-7L | R-6H | R-6L | R-5H | R-5L | R-4H | R-4L | R-3H | R-3L | R-2H | R-2L | R-1H | R-1L |

RnH = Resolution channel n High bit

RnL = Resolution channel n Low bit

| Input Resolution Select | RnH | RnL |
|---|---|---|
| 12-bit | 0 | 0 |
| 14-bit | 0 | 1 |
| 16-bit | 1 | 0 |
| Disabled | 1 | 1 |

Example: Input channels 1–4 are 12-bit, channel 5 is 14-bit, and channel 6 is 16-bit, and channels 7 and 8 are disabled; V36403 - F900(hex).

| 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R-8H | R-8L | R-7H | R-7L | R-6H | R-6L | R-5H | R-5L | R-4H | R-4L | R-3H | R-3L | R-2H | R-2L | R-1H | R-1L |
| 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| F | | | | 9 | | | | 0 | | | | 0 | | | |

## Input Track and Hold Selection Bits

The track and hold feature for each of the eight inputs can be individually configured for minimum, maximum, no hold, or reset held value. This configuration can be changed "on the fly" while the program is running.

V36423: (specific memory location will vary depending upon the base and slot location).

| 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| T-8H | T-8L | T-7H | T-7L | T-6H | T-6L | T-5H | T-5L | T-4H | T-4L | T-3H | T-3L | T-2H | T-2L | T-1H | T-1L |

TnH = Track and hold channel n High bit

TnL = Track and hold channel n Low bit

| Track and Hold Select | TnH | TnL | Result |
|---|---|---|---|
| No Track and Hold | 0 | 0 | Returns real time input value |
| Track and Hold Minimum Value | 0 | 1 | Maintains lowest measured value |
| Track and Hold Maximum Value | 1 | 0 | Maintains highest measured value |
| Reset Track and Hold Value | 1 | 1 | Resets previously held input value |

Example: Input channel track and hold settings:
1-3 = none, ch 4-5 = minimum, ch 6-7 = maximum, ch 8 = reset; V36423=E940(hex).

| 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| T-8H | T-8L | T-7H | T-7L | T-6H | T-6L | T-5H | T-5L | T-4H | T-4L | T-3H | T-3L | T-2H | T-2L | T-1H | T-1L |
| 1 | 1 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| E | | | | 9 | | | | 4 | | | | 0 | | | |

# Writing the Control Program

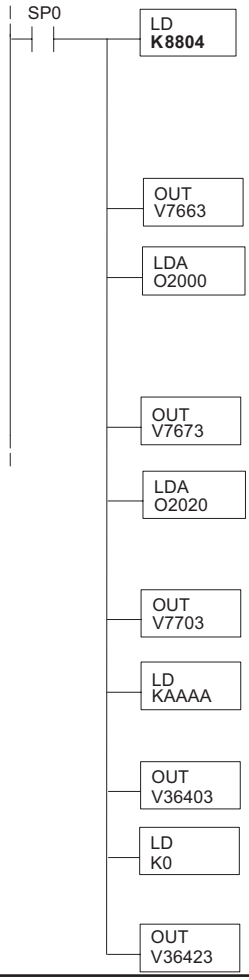
## Configuring the Module to Read/Write I/O (Pointer Method) for D2-250-1, D2-260 and D2-262

The example programs that follow show how to configure the special V-memory locations to read/write data from/to the I/O module. The module configuration rung needs to be read by the CPU only after a mode transition, and does not need to be read every scan. Place the configuration rung anywhere in the ladder program, or in the initial stage if stage programming instructions is being used. This is all that is required to read the input data and write the output data to/from the V-memory locations. Once the input data is in V-memory, math can be used for data calculations, compare the data against preset values, and so forth.

V2000 and V2020 are used as the beginning of the data areas in the example, but any user V-memory locations can be used. Also, these examples assume that the module is installed in slot 3 of the CPU base. The pointer V-memory locations determined by the layout of the application should be used.

## Module Configuration Example 1:

Number of Channels = 8 in, 4 out,
Data Format = binary in, BCD out,
Input Resolution = 16-bit,
Input Track and Hold = none, real time value.




Loads a constant that specifies the number of channels to scan and the data format. (See note below regarding data format.)

The upper byte applies to the inputs. The most significant ribble (MSN) selects the data format (0=BCD, 8=Binary), and the LSN selects the number of channels (1, 2, 3, 4, 5, 6, 7, or 8) to scan.

The lower byte applies to the outputs. The most significant nibble (MSN) selects the data format (0=BCD, 8=Binary), and the LSN selects the number of channels (1, 2, 3, or 4) to scan.

Special V-memory location assigned to slot 3 that contains the number of input and output channels.

This constant designates the first V-memory location that will be used to store the input data. For example, the O2000 entered here would mean: Ch1 – V2000, V2001; Ch2 – V2002, V2003; Ch3 – V2004, V2005; Ch4 – V2006, V2007; Ch5 – V2010, V2011; Ch6 – V2012, V2013; Ch7 – V2014, V2015; Ch8 – V2016, V2017. For each channel, the 1st word holds the data, and the 2nd word is needed only when displaying 14 or 16 bit data in BCD format. The 2nd word contains the most significant digit in those cases.

The constant O2000 is stored here. V7673 is assigned to slot 3 and acts as a pointer, which means the CPU will use the value in this location to determine exactly where to store the incoming data.

This constant designates the first V-memory location that will be used for the analog output data. For example, the O2020 entered here would mean: Ch1 – V2020, V2021; Ch2 – V2022, V2023; Ch3 – V2024, V2025; Ch4 – V2026, V2027. For each channel, the 1st word holds the data, and the 2nd word is needed only when displaying 14 or 16 bit data in BCD format. The 2nd word contains the most significant digit in those cases.

The constant O2020 is stored here. V7703 is assigned to slot 3 and acts as a pointer, which means the CPU will use the value in this location to determine exactly where to obtain the output data.

Loads a constant that specifies the resolutions for each of the input channels. This constant is determined by the values of two bits per channel, as shown previously in "Input Resolutions Selection Bits". The constant AAAA(hex) configures each of the eight input channels for 16 bits.

Special V-memory location assigned to slot 3 that contains the resolution settings for each of the input channels.

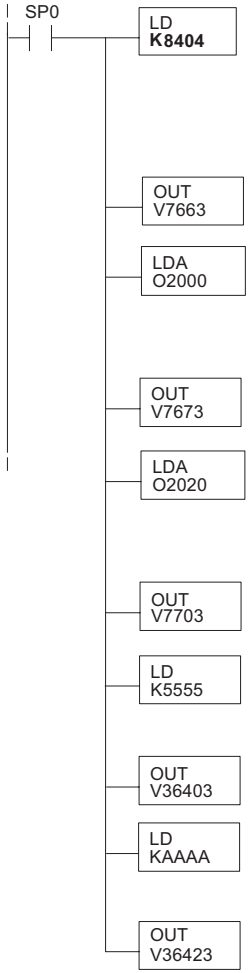
Loads a constant that specifies the track and hold settings for each of the input channels. This constant is determined by the values of two bits per channel, as previously shown in "Track and Hold Selection Bits". The constant 0 configures each of the eight input channels for no track and hold.

Special V-memory location assigned to slot 3 that contains the track and hold settings for each of the input channels..

***NOTE: Binary data format** is recommended for **14 or 16-bit resolution input data,** especially if the input data is to be used in any math instructions (DL205 User Manual, ch.5). There is only one V-memory word (16-bits) available for the actual data. Although the 12-bit resolution maximum value of 4095 can be stored in one word using either binary or BCD formats, the 14 and 16-bit resolution maximum values of 16383 and 65535 both exceed the BCD format's maximum single word capacity of 9999. Double word math would be required for 14 or 16-bit data in BCD format**. Binary data format is also useful for displaying data on some operator interfaces.***

## Module Configuration Example 2:

Number of Channels = 4 in, 4 out,
Data Format = binary in, BCD out,
Input Resolution = 14-bit,
Input Track and Hold = all inputs maximum value.




Loads a constant that specifies the number of channels to scan and the data format. (See note below regarding data format.)

The upper byte applies to the inputs. The most significant nibble (MSN) selects the data format (0=BCD, 8=Binary), and the LSN selects the number of channels (1, 2, 3, 4, 5, 6, 7, or 8) to scan.

The lower byte applies to the outputs. The most significant nibble (MSN) selects the data format (0=BCD, 8=Binary), and the LSN selects the number of channels (1, 2, 3, or 4) to scan.

Special V-memory location assigned to slot 3 that contains the number of input and output channels.

This constant designates the first V-memory location that will be used to store the input data. For example, the O2000 entered here would mean: Ch1 – V2000, V2001; Ch2 – V2002, V2003; Ch3 – V2004, V2005; Ch4 – V2006, V2007. For each channel, the 1st word holds the data, and the 2nd word is needed only when displaying 14 or 16 bit data in BCD format. The 2nd word contains the most significant digit in those cases.

The constant O2000 is stored here. V7673 is assigned to slot 3 and acts as a pointer, which means the CPU will use the value in this location to determine exactly where to store the incoming data.

This constant designates the first V-memory location that will be used for the analog output data. For example, the O2020 entered here would mean: Ch1 – V2020, V2021; Ch2 – V2022, V2023; Ch3 – V2024, V2025; Ch4 – V2026, V2027. For each channel, the 1st word holds the data, and the 2nd word is needed only when displaying 14 or 16 bit data in BCD format. The 2nd word contains the most significant digit in those cases.

The constant O2020 is stored here. V7703 is assigned to slot 3 and acts as a pointer, which means the CPU will use the value in this location to determine exactly where to obtain the output data.

Loads a constant that specifies the resolutions for each of the input channels. This constant is determined by the values of two bits per channel, as shown previously in "Input Resolutions Selection Bits". The constant 5555(hex) configures each of the eight input channels for 14 bits.

Special V–memory location assigned to slot 3 that contains the resolution settings for each of the input channels.

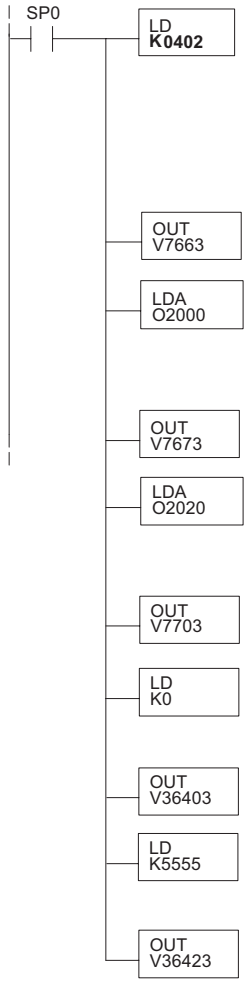
Loads a constant that specifies the track and hold settings for each of the input channels. This constant is determined by the values of two bits per channel, as previously shown in "Track and Hold Selection Bits". The constant AAAA(hex) configures each of the eight input channels to track and hold the maximum value.

Special V–memory location assigned to slot 3 that contains the track and hold settings for each of the input channels.

***NOTE: Binary data format** is recommended for **14 or 16-bit resolution input data,** especially if the input data is to be used in any math instructions (DL205 User Manual, ch.5). There is only one V-memory word (16-bits) available for the actual data. Although the 12-bit resolution maximum value of 4095 can be stored in one word using either binary or BCD formats, the 14 and 16-bit resolution maximum values of 16383 and 65535 both exceed the BCD format's maximum single word capacity of 9999. Double word math would be required for 14 or 16-bit data in BCD format.* ***Binary data format is also useful for displaying data on some operator interfaces.***

## Module Configuration Example 3:

Number of Channels = 4 in, 2 out,
Data Format = BCD in, BCD out,
Input Resolution = 12-bit,
Input Track and Hold = all inputs minimum value.




Loads a constant that specifies the number of channels to scan and the data format. (See note below regarding data format.) (The leading zero in this LD instruction is shown for clarity. It can be entered by the programmer, but it will be dropped by the programming software.)

The upper byte applies to the inputs. The most significant nibble (MSN) selects the data format (0=BCD, 8=Binary), and the LSN selects the number of channels (1, 2, 3, 4, 5, 6, 7, or 8) to scan.

The lower byte applies to the outputs. The most significant nibble (MSN) selects the data format (0=BCD, 8=Binary), and the LSN selects the number of channels (1, 2, 3, or 4) to scan.

Special V-memory location assigned to slot 3 that contains the number of input and output channels.

This constant designates the first V-memory location that will be used to store the input data. For example, the O2000 entered here would mean: Ch1 – V2000, V2001; Ch2 – V2002, V2003; Ch3 – V2004, V2005; Ch4 – V2006, V2007. For each channel, the 1st word holds the data, and the 2nd word is needed only when displaying 14 or 16 bit data in BCD format. The 2nd word contains the most significant digit in those cases.

The constant O2000 is stored here. V7673 is assigned to slot 3 and acts as a pointer, which means the CPU will use the value in this location to determine exactly where to store the incomingdata.

This constant designates the first V-memory location that will be used for the analog output data. For example, the O2020 entered here would mean: Ch1 – V2020, V2021; Ch2 – V2022, V2023. For each channel, the 1st word holds the data, and the 2nd word is needed only when displaying 14 or 16 bit data in BCD format. The 2nd word contains the most significant digit in those cases.

The constant O2020 is stored here. V7703 is assigned to slot 3 and acts as a pointer, which means the CPU will use the value in this location to determine exactly where to obtain the outputdata.

Loads a constant that specifies the resolutions for each of the input channels. This constant is determined by the values of two bits per channel, as shown previously in "Input Resolutions Selection Bits". The constant 0 configures each of the eight input channels for 12 bits.

Special V–memory location assigned to slot 3 that contains the resolution settings for each of the inputchannels.

Loads a constant that specifies the track and hold settings for each of the input channels. This constant is determined by the values of two bits per channel, as previously shown in "Track and Hold Selection Bits". The constant 5555(hex) configures each of the eight input channels to track and hold the minimum value.

Special V–memory location assigned to slot 3 that contains the track and hold settings for each of the inputchannels..

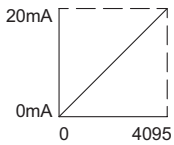
***NOTE: Binary data format** is recommended for **14 or 16-bit resolution input data,** especially if the input data is to be used in any math instructions (DL205 User Manual, ch.5). There is only one V-memory word (16-bits) available for the actual data. Although the 12-bit resolution maximum value of 4095 can be stored in one word using either binary or BCD formats, the 14 and 16-bit resolution maximum values of 16383 and 65535 both exceed the BCD format's maximum single word capacity of 9999. Double word math would be required for 14 or 16-bit data in BCD format.* ***Binary data format is also useful for displaying data on some operator interfaces.***

## Module 12-bit Input Resolution

When the 0–20 mA module inputs are configured for 12-bit resolution, the analog signal is converted into 4096 (212) counts ranging from 0–4095. For example, a 0mA signal would be 0, and a 20mA signal would be 4095. This is equivalent to a binary value of 0000 0000 0000 to 1111 1111 1111, or 000 to FFF hexadecimal. The diagram shows how this relates to the signal range.

Each count can also be expressed in terms of the signal level by using the equation shown.

0–20 mA 12 Bit Resolution




$$12\ \text{Bit Resolution} = \frac{H - L}{4095}$$

H = high limit of the signal range
L = low limit of the signal range

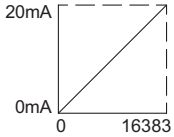
20mA / 4095 = 4.88µA per count

## Module 14-bit Input Resolution

When the 0–20 mA module inputs are configured for 14-bit resolution, the analog signal is converted into 16384 (214) counts ranging from 0–16383. For example, a 0mA signal would be 0, and a 20mA signal would be 16383. This is equivalent to a binary value of 00 0000 0000 0000 to 11 1111 1111 1111, or 0000 to 3FFF hexadecimal. The diagram shows how this relates to the signal range.

Each count can also be expressed in terms of the signal level by using the equation shown.

0 – 20 mA 14 Bit Resolution




$$14\ \text{Bit Resolution} = \frac{H - L}{16383}$$

H = high limit of the signal range
L = low limit of the signal range

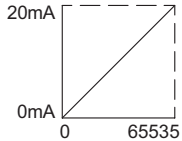
20mA / 16383 = 1.22µA per count

## Module 16-bit Input Resolution

When the 0–20 mA module inputs are configured for 16-bit resolution, the analog signal is converted into 65536 (216) counts ranging from 0–65535. For example, a 0mA signal would be 0, and a 20mA signal would be 65535. This is equivalent to a binary value of 0000 0000 0000 0000 to 1111 1111 1111 1111, or 0000 to FFFF hexadecimal. The diagram shows how this relates to the signal range.

Each count can also be expressed in terms of the signal level by using the equation shown.

0 – 20 mA 16 Bit Resolution




$$16\ \text{Bit Resolution} = \frac{H - L}{65535}$$

H = high limit of the signal range
L = low limit of the signal range

20mA / 65535 = 0.305µA per count

## Analog and Digital Input Data Value Conversion

Sometimes it is useful to be able to quickly convert between the signal levels and the digital values. This is especially helpful during machine startup or troubleshooting. The table below provides formulas to simplify the conversion.

$A = (D)(A_{max}) / (D_{max})$

$D = (A)(D_{max}) / (A_{max})$

A = Analog value from current transmitter
$A_{max}$ = Maximum analog value
D = Digital value of input provided to PLC CPU
$D_{max}$ = Maximum digital value

| Analog and Digital Input Data Conversion | | | |
|---|---|---|---|
| ***Resolution*** | ***X-mitter Range*** | ***If the digital value is known*** | ***If the analog signal is known*** |
| 12-bit<br>0–4095 | 0–20 mA<br>4–20 mA | A = (D)(20) / 4095 | D = (A)(4095) / 20 |
| 14-bit<br>0–16383 | 0–20 mA<br>4–20 mA | A = (D)(20) / 16383 | D = (A)(16383) / 20 |
| 16-bit<br>0–65535 | 0–20 mA<br>4–20 mA | A = (D)(20) / 65535 | D = (A)(65535) / 20 |

For example, if 16-bit resolution is being used, and the signal measured is 12mA, the formula can be easily used to determine the digital value (D) that should be stored in the V-memory location that contains the data.

$D = (A)\frac{65535}{20}$

D = (12) (3276.75)

D = 39321

Notice that the mathematical relationship between the analog and digital values remains the same regardless of whether 4–20 mA or 0–20 mA transmitters are used. Only the engineering unit input scaling will vary, as will be shown later.

## Input Value Comparisons: Analog, Digital, Engineering Units

The following table shows how the input analog, digital, and engineering unit values are related to each other. The above example is a measurement of pressure from 0.0–140.0 PSI, using a multiplier of 10 for one implied decimal place.

| Analog, Digital, and Engineering Units Input Comparisons | | | | | |
|---|---|---|---|---|---|
| ***Analog (mA)*** | ***Digital 12-bit*** | ***Digital 14-bit*** | ***Digital 16-bit*** | ***E.U. 0–20 mA Transmitter*** | ***E.U. 4–20 mA Transmitter*** |
| 20 | 4095 | 16383 | 65535 | 1400 | 1400 |
| 12 | 2457 | 9830 | 39321 | 840 | 700 |
| 10 | 2048 | 8192 | 32768 | 700 | 525 |
| 4 | 819 | 3277 | 13107 | 280 | 0 |
| 0 | 0 | 0 | 0 | 0 | N/A |

## Scaling the Input Data

Most applications require measurements in engineering units, which provide more meaningful data. This can be accomplished by using the conversion formulas shown below.

EU = (A - Aoffset)(EUH - EUL) / (Amax - Aoffset)

EU = (D - Doffset)(EUH - EUL) / (Dmax - Doffset)

- A = analog value from current transmitter
- Aoffset = 4mA offset when using 4-20 mA current transmitter
- D = digital value of input provided to PLC CPU
- Doffset = digital value of 4mA offset with 4-20 mA current transmitter
- EU = engineering units
- EUH = engineering units high value
- EUL = engineering units low value

The following examples show a 16-bit measurement of pressure (PSI) from 0.0–140.0. The analog value needs to be multiplied by 10 in order to imply a decimal place when the value is viewed with the programming software. Notice how the calculations differ when the multiplier is used.

## Scaling Example

Analog Value = 12.6 mA; Transmitter = 4–20 mA; Resolution = 16-bit

Result should yield 75.2 PSI

Example without multiplier

$$EU = (D - D_{offset}) \frac{EU_H - EU_L}{D_{max} - D_{offset}}$$

$$EU = (41287 - 13107) \frac{140 - 0}{65535 - 13107}$$

$$EU = 75$$

Example with multiplier

$$EU = (10)(D - D_{offset}) \frac{EU_H - EU_L}{D_{max} - D_{offset}}$$

$$EU = (10)(41287 - 13107) \frac{140 - 0}{65535 - 13107}$$

$$EU = 752$$

***NOTE: Binary data format*** *is recommended for* ***14 or 16-bit resolution input data,*** *especially if the input data is to be used in any math instructions (DL205 User Manual, ch.5). There is only one V-memory word (16-bits) available for the actual data. Although the 12-bit resolution maximum value of 4095 can be stored in one word using either binary or BCD formats, the 14 and 16-bit resolution maximum values of 16383 and 65535 both exceed the BCD format's maximum single word capacity of 9999. Double word math would be required for 14 or 16-bit data in BCD format.* ***Binary data format is also useful for displaying data on some operator interfaces.***

## Input Engineering Unit Conversion Example 1:

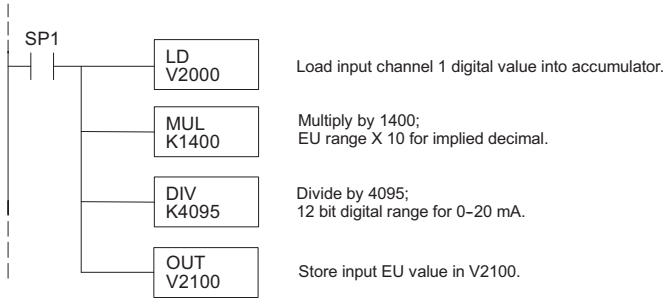
Data format = BCD,

Channel 1 data memory location = V2000,

Channel 1 resolution = 12-bits,

Channel 1 engineering units = 0.0–140.0 PSI,

Channel 1 input device = 0–20 mA transmitter




## Input Engineering Unit Conversion Example 2:

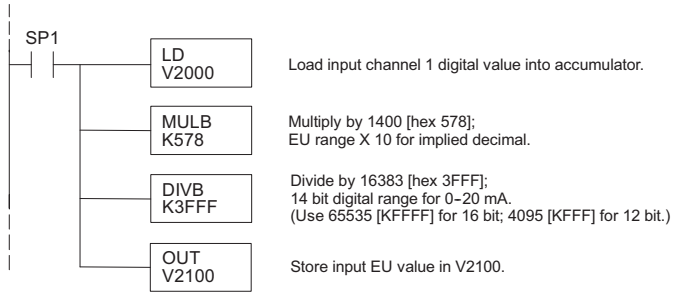
Data format = binary,

Channel 1 data memory location = V2000,

Channel 1 resolution = 14-bits,

Channel 1 engineering units = 0.0–140.0 PSI,

Channel 1 input device = 0–20 mA transmitter



***NOTE:*** *The above examples use SP1 (which is always on) as a permissive contact for the engineering unit conversions. X, C, etc., could also be used as a permissive contact.*

## Input Engineering Unit Conversion Example 3:

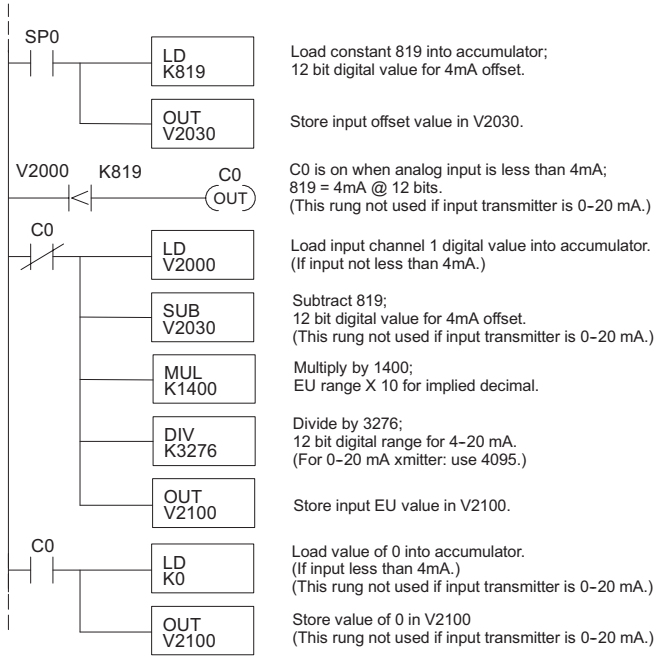
Data format = BCD,

Channel 1 data memory location = V2000,

Channel 1 resolution = 12-bits,

Channel 1 engineering units = 0.0–140.0 PSI,

Channel 1 input device = 4–20 mA transmitter.



## Input Engineering Unit Conversion Example 4:

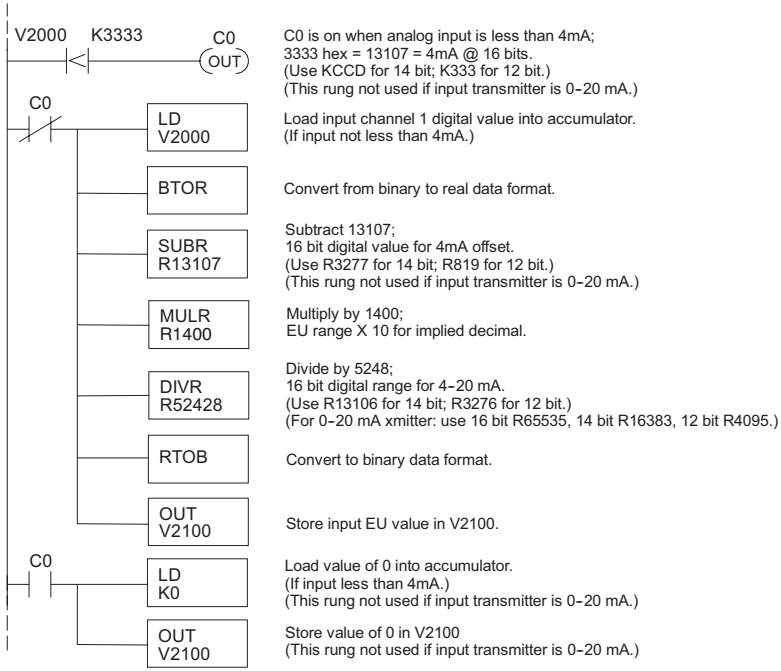
Data format = binary,

Channel 1 data memory location = V2000,

Channel 1 resolution = 16-bits,

Channel 1 engineering units = 0.0–140.0 PSI,

Channel 1 input device = 4–20 mA transmitter.




## Using the Input Track and Hold Feature

The input Track and Hold feature allows the individual inputs to be separately configured to maintain their maximum or minimum data values. If No Track and Hold is selected, the present real time value of the input will be stored in the input data V-memory location. If Track and Hold minimum value is selected, the first input value less than or equal to full scale will be read and maintained until a lower value is measured, or until Track and Hold is reset. If maximum value is selected, the first input value greater than or equal to zero will be read and maintained until a higher value is measured, or until Track and Hold is reset.

To reset Track and Hold, write a value of one to the Track and Hold selection high and low bits. When Track and Hold is reset, the module will display the real-time input value. When the selection is changed from reset to minimum value or maximum value, the input will start over as described previously.

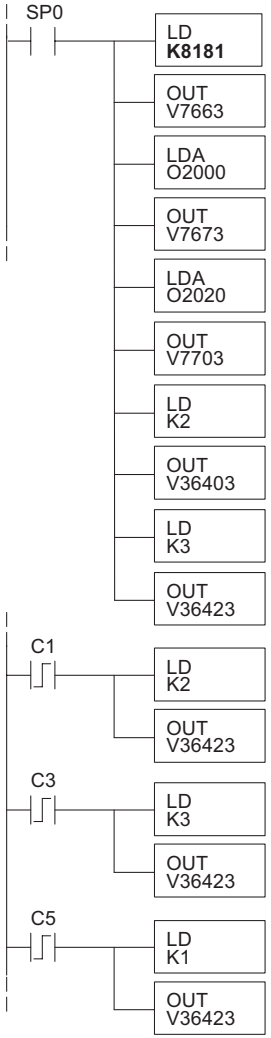
## Track and Hold Example:

Number of Channels = 1 in, 1 out,

Data Format = binary in, binary out,

Input resolution = 16-bits,

Input Track and Hold = channel 1 reset.




Rung 1, Module Configuration:

Input: binary data format, 1 channel.
Output: binary data format, 1 channel.
Module location: local base, slot 3.
Input data 1st memory location: V2000
Output data 1st memory location: V2020
Input resolution: 16 bit channel 1.
Input Track and Hold: reset channel 1.

C1 loads value of 2 (binary 10) into the Track and Hold Selection register. This sets input channel 1 for Track and Hold Maximum Value. As the analog value varies, only a measured value higher than the previously stored value will be written to V2000.

C3 loads a value of 3 (binary 11) into the Track and Hold Selection register. This sets input channel 1 for Track and Hold Reset Value. Real-time measured values will be written to V2000 until another Track and Hold Selection is made.

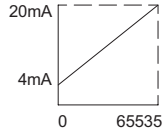
C5 loads value of 1 (binary 01) into the Track and Hold Selection register. This sets input channel 1 for Track and Hold Minimum Value. As the analog value varies, only a measured value lower than the previously stored stored will be written to V2000.

## Module 16-bit Output Resolution

Since the 4–20 mA output module has 16-bit resolution, the analog signal is converted into 65536 (216) counts ranging from 0–65535. For example, a 4mA signal would be 0, and a 20mA signal would be 65535. This is equivalent to a binary value of 0000 0000 0000 0000 – 1111 1111 1111 1111, or 0000 – FFFF hexadecimal. The diagram shows how this relates to the signal range.

Each count can also be expressed in terms of the signal level by using the equation shown.

4 – 20 mA 16 Bit Output Resolution




$$\text{Resolution} = \frac{H - L}{65535}$$

H = high limit of the signal range

L = low limit of the signal range

16mA / 65535 = 0.244μA per count

## Digital and Analog Output Data Value Conversion

Sometimes it is useful to be able to quickly convert between the signal levels and the digital values. This is especially helpful during machine startup or troubleshooting. The table below provides formulas to make this conversion easier.

A = Amin + [(D)(Amax - Amin) / (Dmax)]

D = (A - Amin)(Dmax) / (Amax - Amin)

- A = analog current output value
- Amax = maximum analog value
- Amin = minimum analog value
- D = digital value from PLC CPU
- Dmax = maximum digital value

| Resolution | Output Range | If the digital value is known | If the analog signal level is known |
|---|---|---|---|
| 16-bit 0–65535 | 4–20 mA | $A = 4 + \frac{16D}{65535}$ | $D = (A - 4)\frac{65535}{16}$ |

For example, if a 10mA analog output signal is needed, the formula could be used to determine the digital value (D) to be stored in the V-memory location that contains the output data.

$$D = (10-4)\frac{65535}{16}$$

$$D = (6)(4095.94)$$

$$D = 24576$$

## Output Value Comparisons: Analog, Digital, Engineering Units

The table at right shows how the output analog, digital, and engineering unit values are related to each other. The example is a measurement of pressure from 0.0–140.0 PSI, using a multiplier of 10 for one implied decimal place.

| Analog, Digital, and Engineering Units Output Comparisons | | |
|---|---|---|
| *Analog (mA)* | *Digital 16-bit* | *E.U.* |
| 20 | 65535 | 1400 |
| 12 | 39321 | 700 |
| 10 | 32768 | 525 |
| 4 | 13107 | 0 |

## Calculating the Digital Output Value

The value sent to the 16-bit analog output module must be in digital form. A very good method to do this is to convert the value into engineering units. Use the formula shown on the right to accomplish this.

$$D = 10EU \frac{D_{max}}{(EU_H - EU_L)}$$

D = digital value

EU = engineering units

$EU_H$ = engineering unit range high limit

$EU_L$ = engineering unit range low limit

Adjustments to the formula may be needed depending on the scale chosen for the engineering units.

Consider the following example which controls pressure from 0.0–140.0 PSI. By using the formula, the digital value can be determined that can be sent to the module. The example shows the conversion required to yield 52.5 PSI. Notice the formula divides by 10, because the BCD representation of 52.5 includes a multiplier of 10 to allow for the implied decimal. The division corrects for the multiplier.

$$D = 10EU \frac{Dmax}{10(EUH - EUL)} \qquad D = 525 \frac{100 - 0}{10(140)} \qquad D = 24576$$

## Calculating Output Data: Engineering Units Conversion

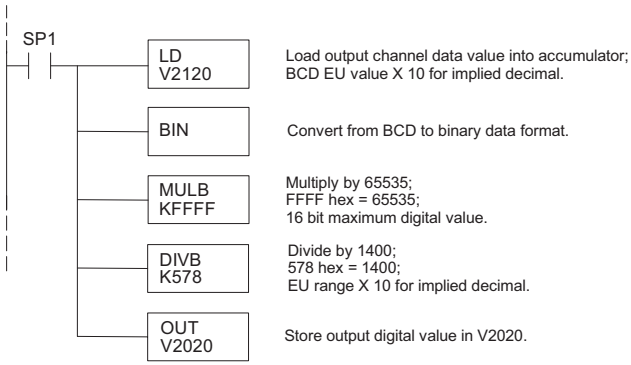
The below example program shows how to write the program to perform the engineering unit conversion to output the 16-bit data format of 0–65535. This example assumes that the engineering units have been calculated or loaded, including a multiplier of 10, in BCD format and stored it in V2120 for output channel 1.

## Output Engineering Unit Conversion / Output Data Calculation Example:

Data format = binary

Channel 1 data memory location = V2020

Channel 1 engineering units = 0.0–140.0 PSI



# F2-8AD4DA-2 8-Ch. In/4-Ch. Out Current Voltage Combination

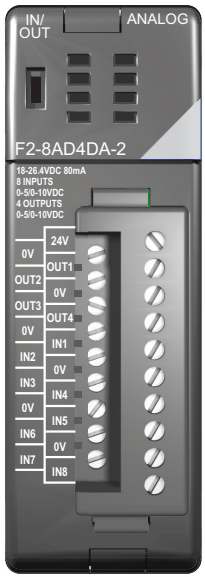
In This Chapter...

Module Specifications ..... 16-2
Connecting the Field Wiring ..... 16-6
Module Operation ..... 16-8
Special V-Memory Locations ..... 16-12
Writing the Control Program ..... 16-16

# Module Specifications

The F2-8AD4DA-2 Analog Voltage Input/Output module provides several hardware features:

- Analog inputs and outputs are optically isolated from the PLC logic.
- The module has a removable terminal block so the module can be easily removed or changed without disconnecting the wiring.
- All input and output channels are updated in one scan.
- On-board active analog filtering, two CISC microcontrollers and CPLD provide digital signal processing to maintain precision analog measurements in noisy environments.
- Low-power CMOS design requires only 80mA from an external 18–26.4 VDC power supply.
- Input resolution is independently adjustable for each channel. Users may select 12-bit, 14-bit or 16-bit.
- Output resolution is 16-bit.
- Each input can be independently configured to return the present value, or to track and hold the maximum or minimum value.
- No jumper settings.




**F2-8AD4DA-2**

## F2-8AD4DA-2 Hardware and Firmware Requirements

The F2-8AD4DA-2 Analog Voltage Input/Output Module requires one of the following components as a CPU or controller.

| Hardware and Firmware Requirements | | |
|---|---|---|
| **Base Type** | **CPU/Controller** | **Firmware Version** |
| ***Local*** | D2-250-1 | 4.40 or later |
| | D2-260 | 2.20 or later |
| | D2-262 | 1.0 TBD |
| ***Expansion*** | D2-CM | 1.30 or later |
| ***Remote I/O*** | H2-EBC(-F) | 2.1.441 or later |
| | H2-EBC100 | 4.0.457 or later |

The following tables provide the specifications for the F2-8AD4DA-2 Analog Voltage Input/ Output Module. Review these specifications to be certain that it will meet the requirements of your application.

| Input Specifications | |
|---|---|
| **Number of Input Channels** | 8, single ended (one common) |
| **Input Range** | 0–5 V, 0–10 V |
| **Input Resolution / Value of LSB** | 12, 14, or 16-bit; selectable<br>12-bit, 0–5 V = 1.22 mV<br>12-bit, 0–10 V = 2.44 mV<br>14-bit, 0–5 V = 305µV<br>14-bit, 0–10 V = 610µV<br>16-bit, 0–5 V = 76µV<br>16-bit, 0–10 V = 152µV |
| **Input Impedance** | 1MΩ, ±5% |
| **Maximum Continuous Overload** | ±100V |
| **Filter Characteristics** | Active low pass; -3 dB @ 80Hz |
| **PLC Input Update Rate** | 8 channels per scan (max. with pointers; local base) |
| **Sample Duration Time (note)** | 2ms @ 12-bit; 5.52ms @ 14-bit; 23ms @ 16-bit |
| **Conversion Time (note)** | 12-bit = 1.5 ms per channel<br>14-bit = 6ms per channel<br>16-bit = 25ms per channel |
| **Conversion Method** | Over sampling successive approximation |
| **Accuracy vs. temperature** | 25ppm / °C maximum |
| **Input Stability and Repeatability** | ±0.03% of range (after 30 minute warm-up) |
| **Input Inaccuracy** | 0.1% of range maximum |
| **Linearity Error (end to end)** | 12-bit = ±2 counts max. (±0.06% of range)<br>14-bit = ±10 counts max. (±0.06% of range)<br>16-bit = ±40 counts max. (±0.06% of range)<br>Monotonic with no missing codes |
| **Full Scale Calibration Error (not including offset error)** | ±0.07% of range maximum |
| **Offset Calibration Error** | ±0.025% of range maximum |
| **Common Mode Rejection** | -90dB min. @ DC; -150dB min. @ 50/60Hz |
| **Crosstalk** | ±0.025% of range max. @ DC, 50/60Hz |

***NOTE:*** *The values listed for Sample Duration Time and Conversion Time are for a single channel, and do not include PLC scan times.*

| Output Specifications | |
|---|---|
| **Number of Output Channels** | 4 |
| **Output Range** | 0–5 V, 0–10 V |
| **Output Resolution** | 16-bit |
| **Output Type** | Voltage sourcing / sinking at 10mA max. |
| **Output Signal at Power-up & Power-down** | 0V |
| **Output Impedance** | 0.2 Ω typical |
| **External Load Resistance** | >1000Ω |
| **Maximum Capacitive Load** | 0.1 µF |
| **Allowed Load Type** | Grounded |
| **Max. Continuous Output Overload** | Limited to 15mA typical |
| **Type of Output Protection** | 15VDC Peak Output Voltage<br>(clamped by transient voltage suppressor) |
| **PLC Output All Channel Update Time** | 4ms (local base) |
| **Output Settling Time** | 0.5 ms max.; 5µs min. (full scale change) |
| **Output Ripple** | 0.005% of full scale |
| **Accuracy vs. Temperature** | ±25 ppm/ °C max. full scale calibration change (±0.0025% of range / °C) |
| **Output Stability and Repeatability** | ±1 LSB after 10 minute warm-up typical |
| **Output Inaccuracy** | 0.1% of range maximum |
| **Linearity Error (end to end)** | ±33 counts max. ( ±0.05% of full scale)<br>Monotonic with no missing codes |
| **Full Scale Calibration Error (not including offset error)** | ±0.07% of range maximum |
| **Offset Calibration Error** | ±0.03% of range maximum |
| **Crosstalk at DC, 50/60Hz** | -70dB or 0.025% of full scale |

***NOTE:*** *One count in the specifications table is equal to one least significant bit of analog data value (1 in 65536)*

| General Module Specifications | |
|---|---|
| **Digital Input and Output Points Required** | 32 point (X) Inputs<br>32 point (Y) Outputs |
| **Power Budget Requirement** | 35mA @ 5VDC (supplied by the base) |
| **External Power Supply Requirement** | 18–26.4 VDC, 80mA maximum |
| **Field Side to Logic Side Isolation** | 1800VAC applied for 1 second (100% tested) |
| **Insulation Resistance** | >10MΩ @ 500VDC |
| **Operating Temperature** | 0–60°C (32–140°F); IEC60068-2-14 |
| **Storage Temperature** | –20–70°C (- 4–158°F); IEC60068-2-1, -2-2, -2-14 |
| **Relative Humidity** | 5–95% (non-condensing); IEC60068-2-30 |
| **Environmental Air** | No corrosive gases permitted; EN61131-2 pollution degree 1 |
| **Vibration** | MIL STD 810C 514.2; IEC60068-2-6 |
| **Shock** | MIL STD 810C 516.2; IEC60068-2-27 |
| **Noise Immunity** | NEMA ICS3-304; IEC61000-4-2, -4-3, -4-4 |
| **Emissions** | EN61000-6-4 (conducted and radiated RF emissions) |
| **Module Location** | Any non-CPU slot in local, expansion, or Ethernet remote base of DL205 system with D2-250-1, D2-260 or D2-262 CPU |
| **Field Wiring** | 19 point removable terminal block included.<br>Optional remote wiring using ZL-CM20 remote feed-through terminal block module and ZL-2CBL2# cable. |
| **Agency Approvals** | UL508; UL6079-15 Zone 2; CE (EN61131-1) |

## Module Placement and Configuration Requirements

The F2-8AD4DA-2 analog voltage input/output module requires 32 discrete input and 32 discrete output points.

The module can be installed in any non-CPU slot of D2-250-1, D2-260 or D2-262 local bases, D2-CM expansion bases, H2-EBC(100)(-F) Ethernet remote bases, H2-PBC Profibus slave bases, or H2-WPLCx-xx WinPLC bases.

***NOTE:*** *The module is NOT supported by D2-230, D2-240, or D2-250 CPUs. It is also not supported by D2-RMSM and D2-RSSS remote I/O master/slave modules.*

The available power budget may also be a limiting factor. Check the user manual for the particular module of CPU and I/O base for more information regarding power budget and number of local, local expansion, or Ethernet remote I/O points.

# Connecting the Field Wiring

## Wiring Guidelines

Your company may have guidelines for wiring and cable installation. If so, check the guidelines before beginning the installation. Here are some general things to consider:

- Use the shortest wiring route whenever possible.
- Use shielded wiring and ground the shield at the transmitter source. Do not ground the shield at both the module and the load or source.
- Do not run the signal wiring next to large motors, high current switches, or transformers. This may cause noise problems.
- Route the wiring through an approved cable housing to minimize the risk of accidental damage. Check local and national codes to choose the correct method for your application.
- Unused inputs should be shorted together and connected to common.

## User Power Supply Requirements

The F2-8AD4DA-2 module requires at least one field-side power supply. The same or separate power sources can be used for the module supply and the transmitter supply. The module requires 18-26.4 VDC (at 80mA), from the external power supply.

The DL205 AC bases have a built-in 24VDC power supply that provide up to 300mA of current. This can be used instead of a separate supply. Check the power budget to be safe.

It is desirable in some situations to power the transmitters separately in a location remote from the PLC. This will work as long as the transmitter supply meets the voltage and current requirements, and that the transmitter and the module power supply negative (-) side are connected together.

**WARNING: If the 24VDC base power is used, be sure to calculate the power budget. Exceeding the power budget can cause unpredictable system operation that can lead to a risk of personal injury or equipment damage.**

The DL205 base has a switching type power supply. As a result of switching noise, ±3–5 counts of instability may be noticed in the analog input data if the base power supply is used. If this is unacceptable, try one of the following:

- Use a separate linear power supply.
- Connect the 24VDC common to the frame ground, which is the screw terminal marked "G"
  on the base.

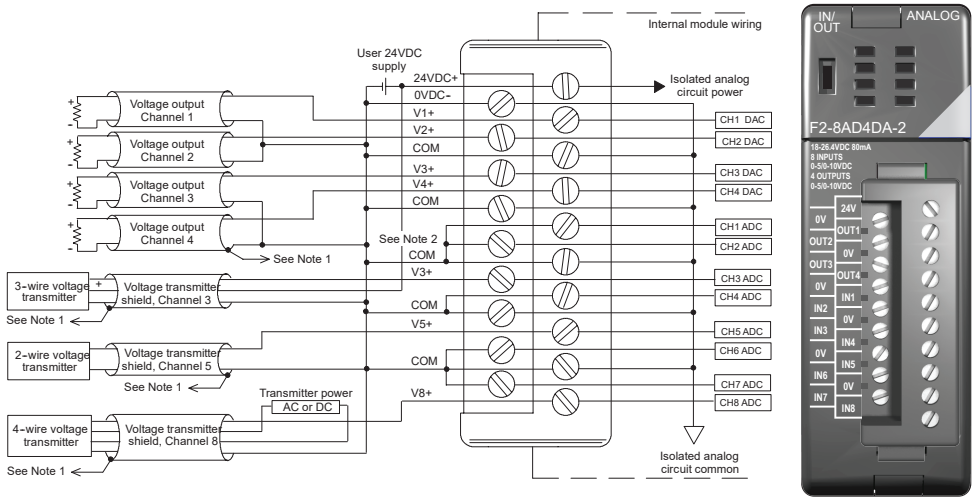
When using these methods, the input stability is rated at ±0.03% of range.

## Wiring Diagram

The F2-8AD4DA-2 module has a removable connector to simplify wiring. Simply squeeze the top and bottom retaining clips and gently pull the connector from the module. Use the following diagram to connect the field wiring.

The diagram shows one power supply for both the module and the I/O signal loops. If a separate module and transmitter supplies are to be used, connect the power supply 0V commons together.

The four wire transmitter connected to input channel 8 is powered by an independent power source. In this case, the transmitter is treated as a 2-wire transmitter.

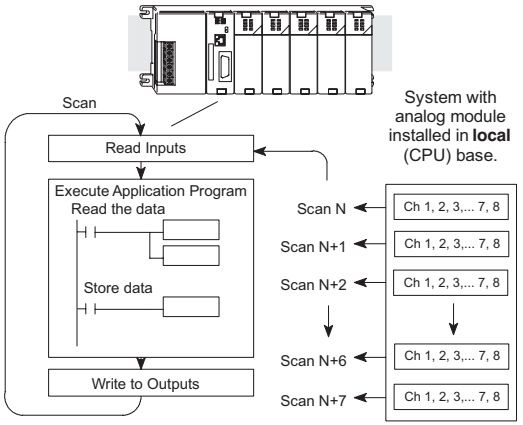


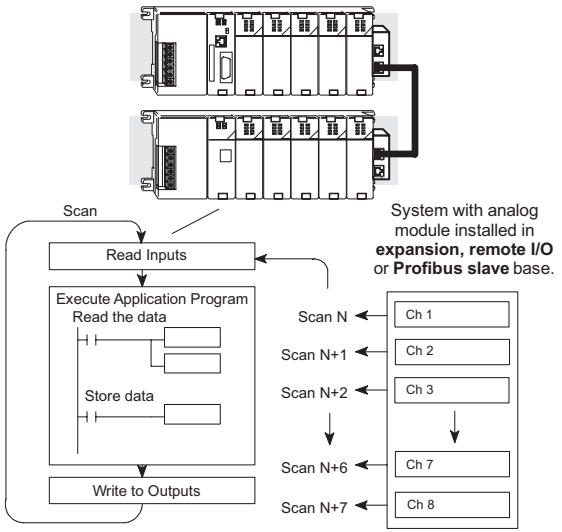

***NOTE** 1: Connect shields to the 0V of the module; do not connect both ends of the shield.*
***NOTE 2**: Short unused inputs together and connect them to common.*

# Module Operation

## Input Channel Scanning Sequence (Pointer Method)

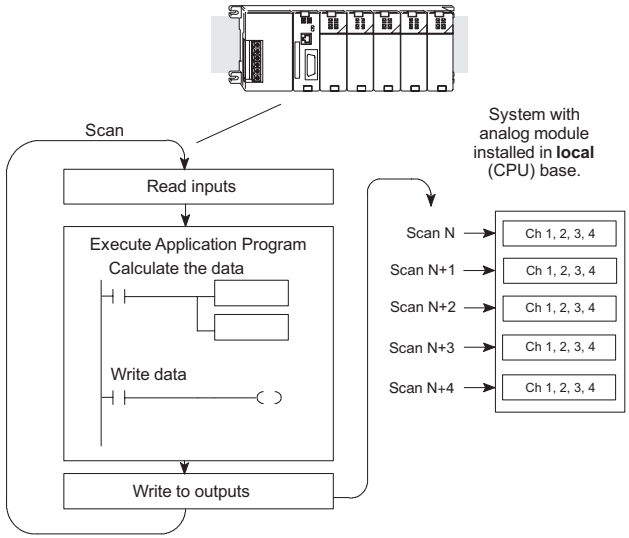
If the F2-8AD4DA-2 module is installed in a local (CPU) base, the input data for all eight channels can be obtained in one scan. However, only one channel of input data can be obtained if the module is installed in an expansion, remote I/O, or Profibus slave base.

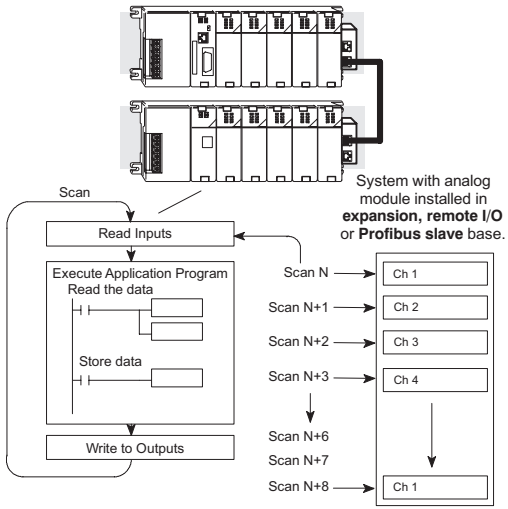


## Output Channel Update Sequence (Pointer Method)

If the F2-8AD4DA-2 is installed in a local (CPU) base, all four output channels can be updated on every scan. However, only one channel can be updated per scan if the module is installed in an expansion, remote I/O, or Profibus slave base. The timing is synchronized with the timing of reading the input channels, so each output channel can be updated every eight scans.



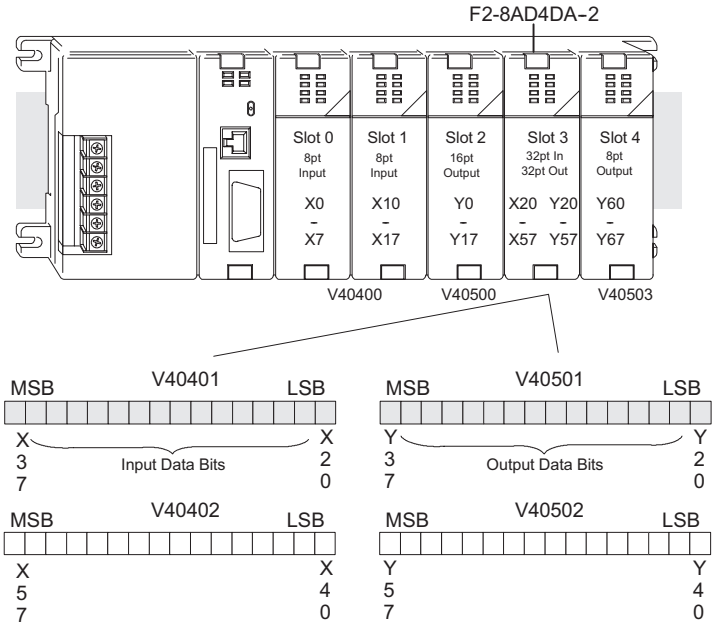
## Understanding the I/O Assignments

Remember that the F2-8AD4DA-2 module appears to the CPU as a 32-point discrete input module and a 32-point discrete output module. These points can be used to obtain:

- An indication of which channel is active,
- The digital representation of the analog signal,
- Module diagnostic information,
- Settings for resolution, range, and track and hold.

These bits may never have to be used, but it may be an aid to help understand the data format.

Since all I/O points are automatically mapped into V-memory, the location of the data words that will be assigned to the module can simply be determined.



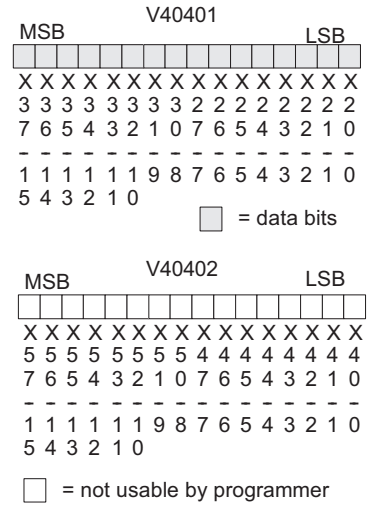

The individual bits in these data word locations represent specific information about the analog signal. (The specific memory locations may vary, depending upon the slot where the F2-8AD4DA-2 module is located.)

## Input Data Bits

Depending upon the resolution selected, up to 16-bits of the first input word represent the analog data in binary format.

| Bit | Value | Bit | Value |
|---|---|---|---|
| 0 | 1 | 8 | 256 |
| 1 | 2 | 9 | 512 |
| 2 | 4 | 10 | 1024 |
| 3 | 8 | 11 | 2048 |
| 4 | 16 | 12 | 4096 |
| 5 | 32 | 13 | 8192 |
| 6 | 64 | 14 | 16384 |
| 7 | 128 | 15 | 32768 |

The input word is not usable by the programmer.

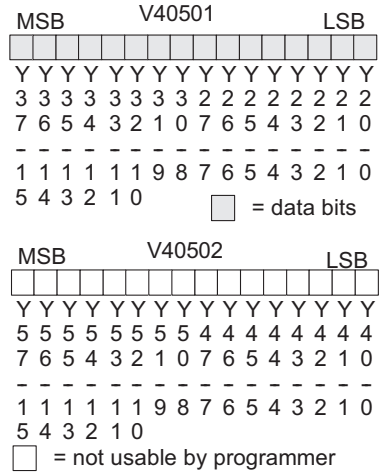



## Output Data Bits

All 16-bits of the first output word represent the analog data in binary format.

| Bit | Value | Bit | Value |
|---|---|---|---|
| 0 | 1 | 8 | 256 |
| 1 | 2 | 9 | 512 |
| 2 | 4 | 10 | 1024 |
| 3 | 8 | 11 | 2048 |
| 4 | 16 | 12 | 4096 |
| 5 | 32 | 13 | 8192 |
| 6 | 64 | 14 | 16384 |
| 7 | 128 | 15 | 32768 |

The second output word is not usable by the programmer.



# Special V-Memory Locations

The D2-250-1, D2-260 and D2-262 CPUs have special V-memory locations assigned to each base slot that greatly simplifies the programming requirements. These V-memory locations specify:

- The number of input and output channels to scan
- The storage locations for the input and output data
- The resolution for the inputs
- The range selections for the inputs and outputs
- The track and hold selections for the inputs

## Module Configuration Registers

The following tables show the special V-memory used by the CPUs for the CPU base and local expansion base I/O slots. Slot 0 is the module slot next to the CPU or D2-CM module. Slot 1 is the module slot two places from the CPU or D2-CM, and so on. The CPU needs to examine the pointer values at these locations only after a mode transition.

| CPU Base: Analog In/Out Module Slot-Dependent V-memory Locations | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Slot** | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| **No. of I/O Channels Enabled & Format** | V7660 | V7661 | V7662 | V7663 | V7664 | V7665 | V7666 | V7667 |
| **Input Pointer** | V7670 | V7671 | V7672 | V7673 | V7674 | V7675 | V7676 | V7677 |
| **Output Pointer** | V7700 | V7701 | V7702 | V7703 | V7704 | V7705 | V7706 | V7707 |
| **Input Resolutions** | V36400 | V36401 | V36402 | V36403 | V36404 | V36405 | V36406 | V36407 |
| **I/O Range Selection** | V36410 | V36411 | V36412 | V36413 | V36414 | V36415 | V36416 | V36417 |
| **Input Track & Hold** | V36420 | V36421 | V36422 | V36423 | V36424 | V36425 | V36426 | V36427 |

| Expansion Base D2-CM #1: Analog In/Out Module Slot-Dependent V-memory Locations | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Slot** | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| **No. of I/O Channels Enabled & Format** | V36000 | V36001 | V36002 | V36003 | V36004 | V36005 | V36006 | V36007 |
| **Input Pointer** | V36010 | V36011 | V36012 | V36013 | V36014 | V36015 | V36016 | V36017 |
| **Output Pointer** | V36020 | V36021 | V36022 | V36023 | V36024 | V36025 | V36026 | V36027 |
| **Input Resolutions** | V36030 | V36031 | V36032 | V36033 | V36034 | V36035 | V36036 | V36037 |
| **I/O Range Selection** | V36040 | V36041 | V36042 | V36043 | V36044 | V36045 | V36046 | V36047 |
| **Input Track & Hold** | V36050 | V36051 | V36052 | V36053 | V36054 | V36055 | V36056 | V36057 |

| Expansion Base D2-CM #2: Analog In/Out Module Slot-Dependent V-memory Locations | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Slot** | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| **No. of I/O Channels Enabled & Format** | V36100 | V36101 | V36102 | V36103 | V36104 | V36105 | V36106 | V36107 |
| **Input Pointer** | V36110 | V36111 | V36112 | V36113 | V36114 | V36115 | V36116 | V36117 |
| **Output Pointer** | V36120 | V36121 | V36122 | V36123 | V36124 | V36125 | V36126 | V36127 |
| **Input Resolutions** | V36130 | V36131 | V36132 | V36133 | V36134 | V36135 | V36136 | V36137 |
| **I/O Range Selection** | V36140 | V36141 | V36142 | V36143 | V36144 | V36145 | V36146 | V36147 |
| **Input Track & Hold** | V36150 | V36151 | V36152 | V36153 | V36154 | V36155 | V36156 | V36157 |

| Expansion Base D2-CM #3: Analog In/Out Module Slot-Dependent V-memory Locations | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Slot** | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| **No. of I/O Channels Enabled & Format** | V36200 | V36201 | V36202 | V36203 | V36204 | V36205 | V36206 | V36207 |
| **Input Pointer** | V36210 | V36211 | V36212 | V36213 | V36214 | V36215 | V36216 | V36217 |
| **Output Pointer** | V36220 | V36221 | V36222 | V36223 | V36224 | V36225 | V36226 | V36227 |
| **Input Resolutions** | V36230 | V36231 | V36232 | V36233 | V36234 | V36235 | V36236 | V36237 |
| **I/O Range Selection** | V36240 | V36241 | V36242 | V36243 | V36244 | V36245 | V36246 | V36247 |
| **Input Track & Hold** | V36250 | V36251 | V36252 | V36253 | V36254 | V36255 | V36256 | V36257 |

| Expansion Base D2-CM #4: Analog In/Out Module Slot-Dependent V-memory Locations | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Slot** | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| **No. of I/O Channels Enabled & Format** | V36300 | V36301 | V36302 | V36303 | V36304 | V36305 | V36306 | V36307 |
| **Input Pointer** | V36310 | V36311 | V36312 | V36313 | V36314 | V36315 | V36316 | V36317 |
| **Output Pointer** | V36320 | V36321 | V36322 | V36323 | V36324 | V36325 | V36326 | V36327 |
| **Input Resolutions** | V36330 | V36331 | V36332 | V36333 | V36334 | V36335 | V36336 | V36337 |
| **I/O Range Selection** | V36340 | V36341 | V36342 | V36343 | V36344 | V36345 | V36346 | V36347 |
| **Input Track & Hold** | V36350 | V36351 | V36352 | V36353 | V36354 | V36355 | V36356 | V36357 |

## Number of I/O Channels Enabled & Data Format

Load this V-memory location with a constant that specifies the number of enabled I/O channels and their data formats. The upper byte applies to the inputs, and the lower byte applies to the outputs. The most significant nibbles specify the data formats, and the least significant nibbles specify the number of channels enabled.

| V-memory Locations for No. of I/O Channels Enabled & Format | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **No. of Channels Enabled** | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| **BCD Input** | K01xx | K02xx | K03xx | K04xx | K05xx | K06xx | K07xx | K08xx |
| **Binary Input** | K81xx | K82xx | K83xx | K84xx | K85xx | K86xx | K87xx | K88xx |
| **BCD Output** | Kxx01 | Kxx02 | Kxx03 | Kxx04 | n/a | n/a | n/a | n/a |
| **Binary Output** | Kxx81 | Kxx82 | Kxx83 | Kxx84 | n/a | n/a | n/a | n/a |

## Input Selection Resolution Bits

Each of the eight input channels can be individually disabled or configured for 12, 14, or 16-bit resolution.

V36403: (specific memory location will vary depending upon the base and slot location).

| 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R-8H | R-8L | R-7H | R-7L | R-6H | R-6L | R-5H | R-5L | R-4H | R-4L | R-3H | R-3L | R-2H | R-2L | R-1H | R-1L |

RnH = Resolution channel n High bit

RnL = Resolution channel n Low bit

| Input Resolution Select | RnH | RnL |
|---|---|---|
| 12-bit | 0 | 0 |
| 14-bit | 0 | 1 |
| 16-bit | 1 | 0 |
| Disabled | 1 | 1 |

Example: Input channels 1–4 are 12-bit, channel 5 is 14-bit, and channel 6 is 16-bit, and channels 7 and 8 are disabled; V36403-F900(hex).

| 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R-8H | R-8L | R-7H | R-7L | R-6H | R-6L | R-5H | R-5L | R-4H | R-4L | R-3H | R-3L | R-2H | R-2L | R-1H | R-1L |
| 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| F | | | | 9 | | | | 0 | | | | 0 | | | |

## Input and Output Range Selection Bits

The range of the eight input channels can be collectively set for 0–5 V or for 0–10 V. The range of the four output channels can also be collectively set for either of the same two voltage ranges.

V36413: (specific memory location will vary depending upon the base and slot location).

| 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| – | – | – | – | – | – | – | OR | – | – | – | – | – | – | – | IR |

IR = Input Range

OR = Output Range

| Input/Output Range | IR | OR |
|---|---|---|
| 0–5 V | 0 | 0 |
| 0–10 V | 1 | 1 |

Example: Input channel range is 0–5 V, and output channel range is 0–10 V; V36413=100(hex).

| 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| – | – | – | – | – | – | – | OR | – | – | – | – | – | – | – | IR |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | | | | 1 | | | | 0 | | | | 0 | | | |

## Input Track and Hold Selection Bits

The track and hold feature for each of the eight inputs can be individually configured for minimum, maximum, no hold, or reset held value. This configuration can be changed "on the fly" while the program is running.

V36423: (specific memory location will vary depending upon the base and slot location).

| 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| T-8H | T-8L | T-7H | T-7L | T-6H | T-6L | T-5H | T-5L | T-4H | T-4L | T-3H | T-3L | T-2H | T-2L | T-1H | T-1L |

TnH = Track and hold channel n High bit

TnL = Track and hold channel n Low bit

| Track and Hold Select | TnH | TnL | Result |
|---|---|---|---|
| No Track and Hold | 0 | 0 | returns real time input value |
| Track and Hold Minimum Value | 0 | 1 | maintains lowest measured value |
| Track and Hold Maximum Value | 1 | 0 | maintains highest measured value |
| Reset Track and Hold Value | 1 | 1 | resets previously held input value |

Example: Input channel track and hold settings:
1-3 = none, ch 4-5 = minimum,
ch 6-7 = maximum, ch 8 = reset; V36423=E940(hex).

| 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| T-8H | T-8L | T-7H | T-7L | T-6H | T-6L | T-5H | T-5L | T-4H | T-4L | T-3H | T-3L | T-2H | T-2L | T-1H | T-1L |
| 1 | 1 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| E | | | | 9 | | | | 4 | | | | 0 | | | |

# Writing the Control Program

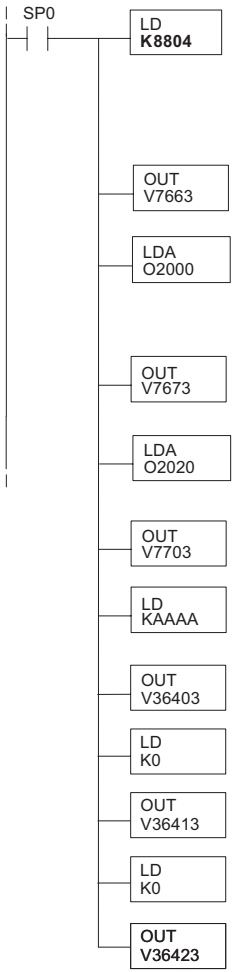
## Configuring the Module to Read/Write I/O (Pointer Method) for D2-250-1, D2-260 and D2-262

The example programs that follow show how to configure the special V-memory locations to read/write data from/to the I/O module. The module configuration rung needs to be read by the CPU only after a mode transition, and does not need to be read every scan. Place the configuration rung anywhere in the ladder program, or in the initial stage if stage programming instructions is being used. This is all that is required to read the input data and write the output data to/from the V-memory locations. Once the input data is in V-memory, math can be used for data calculations, compare the data against preset values, and so forth.

V2000 and V2020 are used as the beginning of the data areas in the example, but any user V-memory locations can be used. Also, these examples assume that the module is installed in slot 3 of the CPU base. The pointer V-memory locations determined by the layout of the application should be used.

## Module Configuration Example 1:

Number of Channels = 8 in, 4 out,
Data Format = binary in, BCD out,
Input Resolution = 16-bit,
Input/Output Range = 0–5 V in, 0–5 V out
Input Track and Hold = none, real time value.




Loads a constant that specifies the number of channels to scan and the data format. (See note below regarding data format.)

The upper byte applies to the inputs. The most significant nibble (MSN) selects the data format (0=BCD, 8=Binary), and the LSN selects the number of channels selects the number of channels (1, 2, 3, 4, 5, 6, 7, or 8) to scan.

The lower byte applies to the outputs. The most significant nibble (MSN) selects the data format (0=BCD, 8=Binary), and the LSN selects the number of channels (1, 2, 3, or 4) to scan.

Special V-memory location assigned to slot 3 that contains the number of input and output channels.

This constant designates the first V-memory location that will be used to store the input data For example, the O2000 entered here would mean: Ch1 – V2000, V2001; Ch2 – V2002, V2003; Ch3 – V2004, V2005; Ch4 – V2006, V2007; Ch5 – V2010, V2011; Ch6 – V2012, V2013; Ch7 – V2014, V2015; Ch8 – V2016, V2017. For each channel, the 1st word holds the data, and the 2nd word is needed only when displaying 14 or 16 bit data in BCD format. The 2nd word contains the most significant digit in those cases.

The constant O2000 is stored here. V7673 is assigned to slot 3 and acts as a pointer, which means the CPU will use the value in this location to determine exactly where to store the incoming data.

This constant designates the first V-memory location that will be used for the analog output data. For example, the O2020 entered here would mean: Ch1 – V2020, V2021; Ch2 – V2022, V2023; Ch3 – V2024, V2025; Ch4 – V2026, V2027. For each channel, the 1st word holds the data, and the 2nd word is needed only when displaying 14 or 16 bit data in BCD format. The 2nd word contains the most significant digit in those cases.

The constant O2020 is stored here. V7703 is assigned to slot 3 and acts as a pointer, which means the CPU will use the value in this location to determine exactly where to obtain the output data.

Loads a constant that specifies the resolutions for each of the input channels. This constant is determined by the values of two bits per channel, as shown previously in "Input Resolutions Selection Bits". The constant AAAA(hex) configures each of the eight input channels for 16-bits.

Special V-memory location assigned to slot 3 that contains the resolution settings for each of the input channels.

Loads a constant that specifies the collective range of the input channels. The range can be 0–5 V or 0–10 V. For example, the constant fo K0 loaded here sets the input channels and the ouput channels to a range of 0–5 V

Special V-memory location assigned to slot 3 that contains the track and hold settings for each of the input channels.

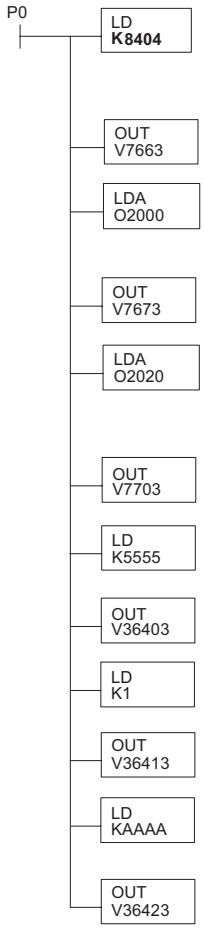
Loads a constant that specifies the track and hold settings for each of the input channels. This constant is determined by the values of two bits per channel, as previously shown in "Track and Hold Selection Bits". The constant 0 configures each of the eight input channels for no track and hold.

Special V-memory location assigned to slot 3 that contains the track and hold settings for each of the input channels.

***NOTE: Binary data format** is recommended for **14 or 16-bit resolution input data**, especially if the input data is to be used in any math instructions (DL205 User Manual, ch.5). There is only one V-memory word (16-bits) available for the actual data. Although the 12-bit resolution maximum value of 4095 can be stored in one word using either binary or BCD formats, the 14 and 16-bit resolution maximum values of 16383 and 65535 both exceed the BCD format's maximum single word capacity of 9999. Double word math would be required for 14 or 16-bit data in BCD format. **Binary data format** is also useful for displaying data on some **operator interfaces.***

## Module Configuration Example 2:

Number of Channels = 4 in, 4 out,
Data Format = binary in, BCD out,
Input Resolution = 14-bit,
Input/Output Range = 0–10 V in, 0–5 V out,
Input Track and Hold = all inputs maximum value.




Loads a constant that specifies the number of channels to scan and the data format. (See note below regarding data format.)

The upper byte applies to the inputs. The most significant nibble (MSN) selects the data format (0=BCD, 8=Binary), and the LSN selects the number of channels (1, 2, 3, 4, 5, 6, 7, or 8) to scan.

The lower byte applies to the outputs. The most significant nibble (MSN) selects the data format (0=BCD, 8=Binary), and the LSN selects the number of channels (1, 2, 3, or 4) to scan.

Special V-memory location assigned to slot 3 that contains the number of input and output channels.

This constant designates the first V-memory location that will be used to store the input data. For example, the O2000 entered here would mean: Ch1 – V2000, V2001; Ch2 – V2002, V2003; Ch3 – V2004, V2005; Ch4 – V2006, V2007. For each channel, the 1st word holds the data, and the 2nd word is needed only when displaying 14 or 16 bit data in BCD format. The 2nd word contains the most significant digit in those cases.

The constant O2000 is stored here. V7673 is assigned to slot 3 and acts as a pointer, which means the CPU will use the value in this location to determine exactly where to store the incoming data.

This constant designates the first V-memory location that will be used for the analog output data For example, the O2020 entered here would mean: Ch1 – V2020, V2021; Ch2 – V2022, V2023;

Ch3 – V2024, V2025; Ch4 – V2026, V2027. For each channel, the 1st word holds the data, and the 2nd word is needed only when displaying 14 or 16 bit data in BCD format. The 2nd word contains the most significant digit in those cases.

The constant O2020 is stored here. V7703 is assigned to slot 3 and acts as a pointer, which means the CPU will use the value in this location to determine exactly where to obtain the output data.

Loads a constant that specifies the resolutions for each of the input channels. This constant is determined by the values of two bits per channel, as shown previously in "Input Resolutions Selection Bits". The constant 5555(hex) configures each of the eight input channels for 14 bits.

Special V–memory location assigned to slot 3 that contains the resolution settings for each of the input channels.

Loads a constant that specifies the collective range of the input channels and the collective range of the output channels. The range can be 0–5 V or 0–10 V. For example, the constant of K1 loaded here sets the input channels to a range of 0–10 V and the output channels to a range 0–5 V.

Special V–memory location assigned to slot 3 that contains the track and hold settings for each of the input channels.

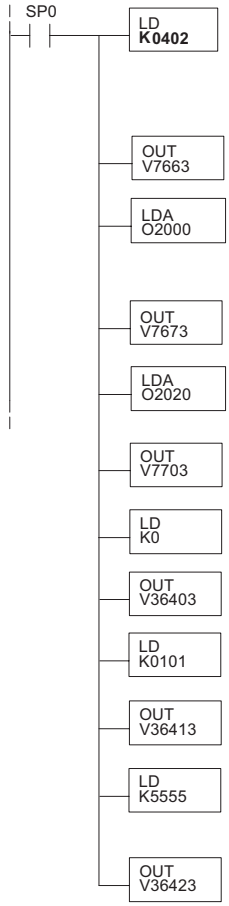
Loads a constant that specifies the track and hold settings for each of the input channels. This constant is determined by the values of two bits per channel, as previously shown in "Track and Hold Selection Bits". The constant AAAA(hex) configures each of the eight input channels to track and hold the maximum value.

Special V–memory location assigned to slot 3 that contains the track and hold settings for each of the input channels.

***NOTE: Binary data format** is recommended for **14 or 16-bit resolution input data**, especially if the input data is to be used in any math instructions (DL205 User Manual, ch.5). There is only one V-memory word (16-bits) available for the actual data. Although the 12-bit resolution maximum value of 4095 can be stored in one word using either binary or BCD formats, the 14 and 16-bit resolution maximum values of 16383 and 65535 both exceed the BCD format's maximum single word capacity of 9999. Double word math would be required for 14 or 16-bit data in BCD format. **Binary data format** is also useful for displaying data on some **operator interfaces**.*

## Module Configuration Example 3:

Number of Channels = 4 in, 2 out,
Data Format = BCD in, BCD out,
Input Resolution = 12-bit,
Input/Output Range = 0–10 V in, 0–10 V out,
Input Track and Hold = all inputs minimum value.




Loads a constant that specifies the number of channels to scan and the data format. (See note below regarding data format.) (The leading ero in this LD instruction is shown for clarity. It can be entered by the programmer, but it will be dropped by the programming software.)

The upper byte applies to the inputs. The most significant nibble (MSN) selects the data format (0=BCD, 8=Binary), and the LSN selects the number of channels (1, 2, 3, 4, 5, 6, 7, or 8) to scan.

The lower byte applies to the outputs. The most significant nibble (MSN) selects the data format (0=BCD, 8=Binary), and the LSN selects the number of channels (1, 2, 3, or 4) to scan.

Special V-memory location assigned to slot 3 that contains the number of input and output channels.

This constant designates the first V-memory location that will be used to store the input data. For example, the O2000 entered here would mean: Ch1 – V2000, V2001; Ch2 – V2002, V2003; Ch3 – V2004, V2005; Ch4 – V2006, V2007. For each channel, the 1st word holds the data, and the 2nd word is needed only when displaying 14 or 16 bit data in BCD format. The 2nd word contains the most significant digit in those cases.

The constant O2000 is stored here. V7673 is assigned to slot 3 and acts as a pointer, which means the CPU will use the value in this location to determine exactly where to store the incoming data.

This constant designates the first V-memory location that will be used for the analog output data. For example, the O2020 entered here would mean: Ch1 – V2020, V2021; Ch2 – V2022, V2023. For each channel, the 1st word holds the data, and the 2nd word is needed only when displaying 14 or 16 bit data in BCD format. The 2nd word contains the most significant digit in those cases.

The constant O2020 is stored here. V7703 is assigned to slot 3 and acts as a pointer, which means the CPU will use the value in this location to determine exactly where to obtain the output data.

Loads a constant that specifies the resolutions for each of the input channels. This constant is determined by the values of two bits per channel, as shown previously in "Input Resolutions Selection Bits". The constant 0 configures each of the eight input channels for 12 bits.

Special V-memory location assigned to slot 3 that contains the resolution settings for each of the input channels.

Loads a constant that specifies the collective range of the input channels and the collective range of the output channels. The range can be 0–5 V or 0–10 V. For example, the constant of K0101 loaded here sets the input channels and the output channels to a range 0–10 V. (The leading zero in this LD instruction is shown for clarity. It can be entered by the programmer, but it will be dropped by the programming software.)

Special V-memory location assigned to slot 3 that contains the track and hold settings for each of the input channels.

Loads a constant that specifies the track and hold settings for each of the input channels. This constant is determined by the values of two bits per channel, as previously shown in "Track and Hold Selection Bits". The constant 5555(hex) configures each of the eight input channels to track and hold the minimum value.

Special V-memory location assigned to slot 3 that contains the track and hold settings for each of the input channels.

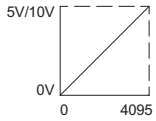
***NOTE: Binary data format** is recommended for **14 or 16-bit resolution input data**, especially if the input data is to be used in any math instructions (DL205 User Manual, ch.5). There is only one V-memory word (16-bits) available for the actual data. Although the 12-bit resolution maximum value of 4095 can be stored in one word using either binary or BCD formats, the 14 and 16-bit resolution maximum values of 16383 and 65535 both exceed the BCD format's maximum single word capacity of 9999. Double word math would be required for 14 or 16-bit data in BCD format. **Binary data format** is also useful for displaying data on some **operator interfaces.***

## Module 12-bit Input Resolution

When the module voltage inputs are configured for 12-bit resolution, the analog signal is converted into 4096 (212) counts ranging from 0–4095. For example, a 0V signal would be 0, and a full scale 5V or 10V signal would be 4095. This is equivalent to a binary value of 0000 0000 0000 to 1111 1111 1111, or 000 to FFF hexadecimal. The diagram shows how this relates to the signal range.

Each count can also be expressed in terms of the signal level by using the equation shown.

0 – 5V/10V 12 Bit Resolution




$$\text{12 Bit Resolution} = \frac{H - L}{4095}$$

H = high limit of the signal range
L = low limit of the signal range

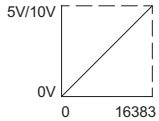
5V / 4095 = 1.22mV per count
10V / 4095 = 2.44mV per count

## Module 14-bit Input Resolution

When the module voltage inputs are configured for 14-bit resolution, the analog signal is converted into 16384 (214) counts ranging from 0–16383. For example, a 0V signal would be 0, and a full scale 5V or 10V signal would be 16383. This is equivalent to a binary value of 00 0000 0000 0000 to 11 1111 1111 1111, or 0000 to 3FFF hexadecimal. The diagram shows how this relates to the signal range.

Each count can also be expressed in terms of the signal level by using the equation shown.

0 – 5V/10V 14 Bit Resolution




$$\text{14 Bit Resolution} = \frac{H - L}{16383}$$

H = high limit of the signal range
L = low limit of the signal range

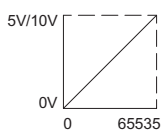
5V / 16383 = 305 µA per count
10V / 16383 = 610 µA per count

## Module 16-bit Input Resolution

When the module voltage inputs are configured for 16-bit resolution, the analog signal is converted into 65536 (216) counts ranging from 0–65535. For example, a 0V signal would be 0, and a full scale 5V or 10V signal would be 65535. This is equivalent to a binary value of 0000 0000 0000 0000 to 1111 1111 1111 1111, or 0000 to FFFF hexadecimal. The diagram shows how this relates to the signal range.

Each count can also be expressed in terms of the signal level by using the equation shown.

0 – 5V/10V 16 Bit Resolution




$$\text{16 Bit Resolution} = \frac{H - L}{65535}$$

H = high limit of the signal range
L = low limit of the signal range

5V / 65535 = 76 µA per count
10V / 65535 = 152 µA per count

## Analog and Digital Input Data Value Conversion

Sometimes it is useful to be able to quickly convert between the signal levels and the digital values. This is especially helpful during machine startup or troubleshooting. The table provides formulas to simplify the conversion.

A = (D)(Amax) / (Dmax)

D = (A)(Dmax) / (Amax)

A = Analog value from current transmitter
Amax = Maximum analog value
D = Digital value of input provided to PLC CPU
Dmax = Maximum digital value

**Analog and Digital Input Data Conversion**

| Resolution | Input Range | If the digital value is known | If the analog signal is known |
|---|---|---|---|
| 12-bit 0–4095 | 0–5 V | A = (D)(5) / 4095 | D = (A)(4095) / 5 |
| | 0–10 V | A = (D)(10) / 4095 | D = (A)(4095) / 10 |
| 14-bit 0–16383 | 0–5 V | A = (D)(5) / 16383 | D = (A)(16383) / 5 |
| | 0–10 V | A = (D)(10) / 16383 | D = (A)(16383) / 10 |
| 16-bit 0–65535 | 0–5 V | A = (D)(5) / 65535 | D = (A)(65535) / 5 |
| | 0–10 V | A = (D)(10) / 65535 | D = (A)(65535) / 10 |

For example, if a 0–10 V range with 16-bit resolution is being used, and the signal measured is 6V, the formula can be easily used to determine the digital value (D) that should be stored in the V-memory location that contains the data.

**D = (A) 65535**
**10**

**D = (6) (6553.5)**

**D = 39321**

## Scaling the Input Data

Most applications require measurements in engineering units, which provide more meaningful data. For input ranges with a minimum value of zero, this can be accomplished by using the conversion formulas shown below.

EU = (A)(EUH - EUL) / (Amax)

EU = (D)(EUH - EUL) / (Dmax)

- A = analog value from current transmitter
- D = digital value of input provided to PLC CPU
- EU = engineering units
- EUH = engineering units high value
- EUL = engineering units low value

The following examples show a 16-bit measurement of pressure (PSI) from 0.0–140.0. The analog value needs to be multiplied by 10 in order to imply a decimal place when the value is viewed with the programming software. Notice how the calculations differ when the multiplier is used.

## Scaling Example

Analog Value of 6.3 V, 0–10 V transmitter, 16-bit resolution, should yield 88.2 psi.

| Example without multiplier | Example with multiplier |
|---|---|
| $EU = (D)\frac{EU_H - EU_L}{D_{max}}$ | $EU = (10)(D)\frac{EU_H - EU_L}{D_{max}}$ |
| $EU = (41287)\frac{140 - 0}{65535}$ | $EU = (10)(41287)\frac{140 - 0}{65535}$ |
| EU = 88 | EU = 882 |

***NOTE: Binary data format** is recommended for **14 or 16-bit resolution input data**, especially if the input data is to be used in any math instructions (DL205 User Manual, ch.5). There is only one V-memory word (16-bits) available for the actual data. Although the 12-bit resolution maximum value of 4095 can be stored in one word using either binary or BCD formats, the 14 and 16-bit resolution maximum values of 16383 and 65535 both exceed the BCD format's maximum single word capacity of 9999. Double word math would be required for 14 or 16-bit data in BCD format. **Binary data format** is also useful for displaying data on some **operator interfaces.***

## Input Engineering Unit Conversion Example 1:

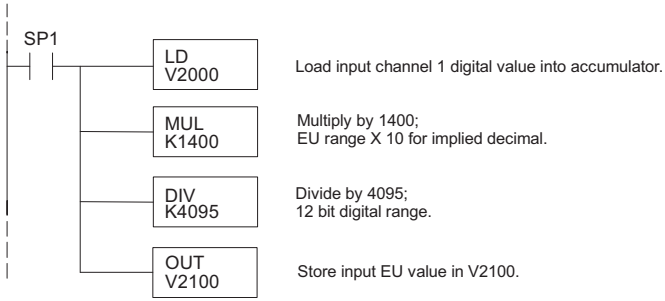
Data format = BCD,

Channel 1 data memory location = V2000,

Channel 1 resolution = 12-bits,

Channel 1 engineering units = 0.0–140.0 PSI,

Channel 1 input device = 0–5 V or 0–10 V transmitter.




## Input Engineering Unit Conversion Example 2:

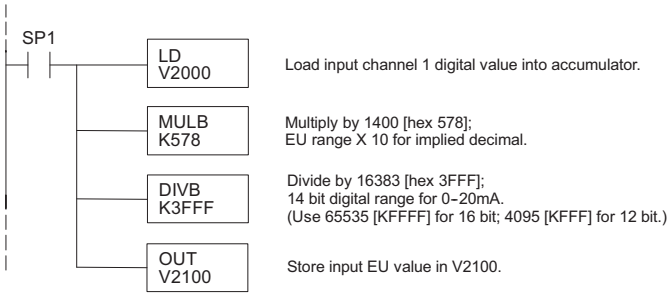
Data format = binary,

Channel 1 data memory location = V2000,

Channel 1 resolution = 14-bits,

Channel 1 engineering units = 0.0–140.0 PSI,

Channel 1 input device = 0–5 V or 0–10 V transmitter.



***NOTE:*** *The above examples use SP1 (which is always on) as a permissive contact for the engineering unit conversions. X, C, etc., could also be used as a permissive contact.*

## Input Engineering Unit Conversion Example 3:

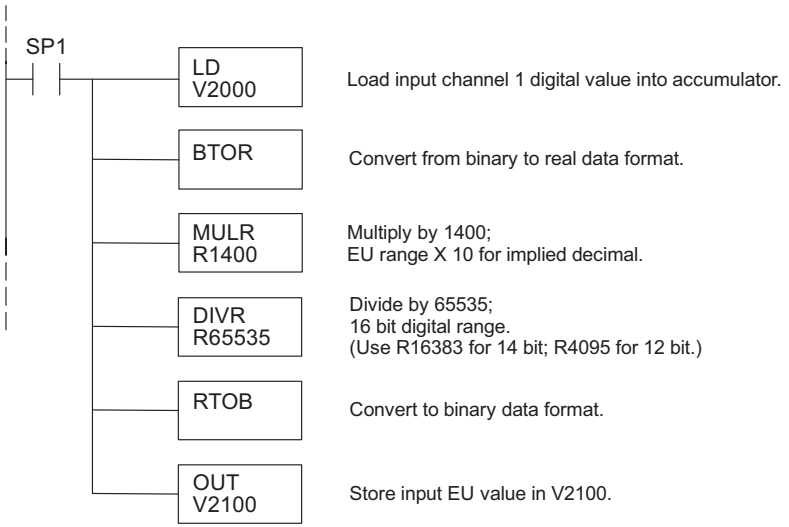
Data format = binary,

Channel 1 data memory location = V2000,

Channel 1 resolution = 16-bits,

Channel 1 engineering units = 0.0–140.0 PSI,

Channel 1 input device = 0–5 V or 0–10 V transmitter.




## Using the Input Track and Hold Feature

The input Track and Hold feature allows the individual inputs to be separately configured to maintain their maximum or minimum data values. If No Track and Hold is selected, the present real time value of the input will be stored in the input data V-memory location. If Track and Hold minimum value is selected, the first input value less than or equal to full scale will be read and maintained until a lower value is measured, or until Track and Hold is reset. If maximum value is selected, the first input value greater than or equal to zero will be read and maintained until a higher value is measured, or until Track and Hold is reset.

To reset Track and Hold, write a value of one to the Track and Hold selection high and low bits. When Track and Hold is reset, the module will display the real-time input value. When the selection is changed from reset to minimum value or maximum value, the input will start over as described previously.

## Track and Hold Example:

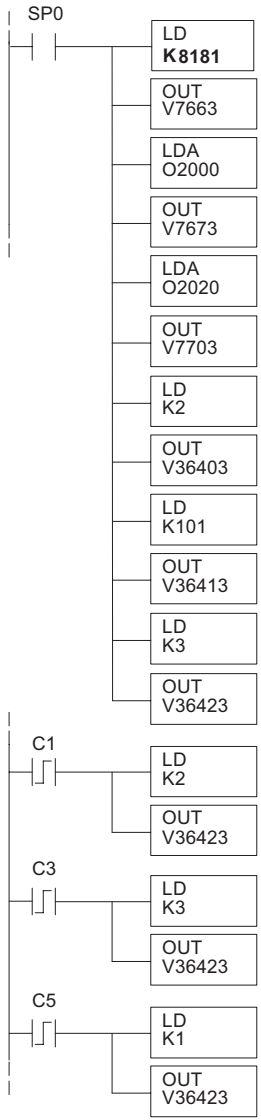
Number of Channels = 1 in, 1 out,

Data Format = binary in, binary out,

Input resolution = 16-bits,

Input/Output Range = 0–10 V in, 0–10 V out,

Input Track and Hold = channel 1 reset.




Rung 1, Module Configuration:

Input: binary data format, 1 channel.
Output: binary data format, 1 channel.
Module location: local base, slot 3.
Input data 1st memory location: V2000.
Output data 1st memory location: V2020.
Input resolution: 16 bit channel 1.
Input/Output range: 0–10V in, 0–10V out.
Input Track and Hold: reset channel 1.

C1 loads value of 2 (binary 10) into the Track and Hold Selection register. This sets input channel 1 for Track and Hold Maximum Value. As the analog value varies, only a measured value higher than the previously stored value will be written to V2000.

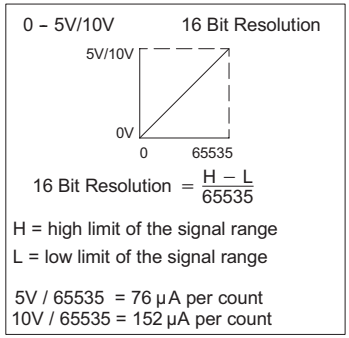
C3 loads a value of 3 (binary 11) into the Track and Hold Selection register. This sets input channel 1 for Track and Hold Reset Value. Real–time measured values will be written to V2000 until another Track and Hold Selection is made.

C5 loads value of 1 (binary 01) into the Track and Hold Selection register. This sets input channel 1 for Track and Hold Minimum Value. As the analog value varies, only a measured value lower than the previously stored stored will be written to V2000.

## Module 16-bit Output Resolution

Since the voltage output module has 16-bit resolution, the analog signal is converted into 65536 (216) counts ranging from 0-65535. For example, a 0V signal would be 0, and a full scale 5V or 10V signal would be 65535. This is equivalent to a binary value of 0000 0000 0000 0000 to 1111 1111 1111 1111, or 0000 to FFFF hexadecimal. The diagram shows how this relates to the signal range.

Each count can also be expressed in terms of the signal level by using the equation shown.




## Digital and Analog Output Data Value Conversion

Sometimes it is useful to be able to quickly convert between the signal levels and the digital values. This is especially helpful during machine startup or troubleshooting. For output ranges with a minimum value of zero, the table below provides formulas to make this conversion easier.

A = (D)(Amax) / (Dmax)

D = (A)(Dmax) / (Amax)

- A = analog current output value
- Amax = maximum analog value
- D = digital value from PLC CPU
- Dmax = maximum digital value

| Resolution | Output Range | If the digital value is known | If the analog signal level is known. |
|---|---|---|---|
| 16-bit 0–65535 | 0–5 V | A = (D)(5) / 65535 | D = (A)(65535) / 5 |
| | 0–10 V | A = (D)(10) / 65535 | D = (A)(65535) / 10 |

For example, if a 6V analog output signal with a 0–10 V output range, the formula could be used to determine the digital value (D) to be stored in the V-memory location that contains the output data.

$$D = (6)\frac{65535}{10}$$

$$D = (6)(6553.5)$$

$$D = 39321$$

## Output Value Comparisons: Analog, Digital, Engineering Units

The table to the right shows how the output analog, digital, and engineering unit values are related to each other. The example is a measurement of pressure from 0.0–140.0 psi, using a multiplier of 10 for one implied decimal place.

| Output Value Comparisons | | | |
|---|---|---|---|
| Analog Range | | Digital 16-bit | E.U. |
| 0–5 V | 0–10 V | | |
| 5 | 10 | 65535 | 1400 |
| 2.5 | 5 | 32768 | 700 |
| 0 | 0 | 0 | 0 |

## Calculating the Digital Output Value

The value sent to the 16-bit analog output module must be in digital form. A very good method to do this is to convert the value into engineering units. Use the formula shown on the right to accomplish this.

$$D = EU \frac{D_{max}}{(EU_H - EU_L)}$$

D = digital value

EU = engineering units

$EU_H$ = engineering unit range high limit

$EU_L$ = engineering unit range low limit

Adjustments to the formula may be needed depending on the scale chosen for the engineering units.

Consider the following example which controls pressure from 0.0–140.0 psi. By using the formula, the digital value can be determined that can be sent to the module. The example shows the conversion required to yield 52.5 psi. Notice the formula divides by 10, because the BCD representation of 52.5 includes a multiplier of 10 to allow for the implied decimal. The division corrects for the multiplier.

## Calculating Output Data: Engineering Units Conversion

$$D = 10EU \frac{Dmax}{10(EUH - EUL)} \qquad D = 525\ 65535 \quad D = 24576\ 10(140)$$

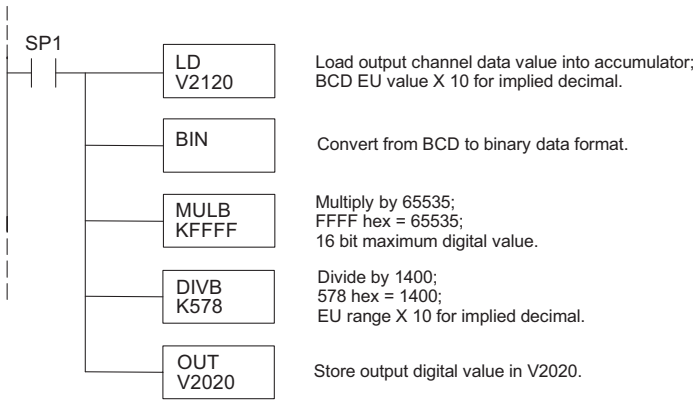
The below example program shows how to write the program to perform the engineering unit conversion to output the 16-bit data format of 0–65535. This example assumes that the engineering units have been calculated or loaded, including a multiplier of 10, in BCD format and stored it in V2120 for output channel 1.

Output Engineering Unit Conversion / Output Data Calculation Example:

Data format = binary,

Channel 1 data memory location = V2020,

Channel 1 engineering units = 0.0–140.0 psi,



# DL205 Discrete I/O Memory Map

## In This Chapter...

Input (X) / Output (Y) Bit Map ..... A-2
Control Relay Bit Map ..... A-4
Remote I/O Bit Map (D2-260 and D2-262 only) ..... A-8

# Input (X) / Output (Y) Bit Map

This table provides a listing of the individual Input points associated with each V-memory address bit for the various CPUs. The D2-250–1 ranges apply to the D2-250.

| MSB | Input (X) and Output (Y) Points for D2-230, D2-240, D2-250-1, D2-260 and D2-262 CPUs | | | | | | | | | | | | | | LSB | X Input Address | Y Output Address |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 | | |
| 017 | 016 | 015 | 014 | 013 | 012 | 011 | 010 | 007 | 006 | 005 | 004 | 003 | 002 | 001 | 000 | V40400 | V40500 |
| 037 | 036 | 035 | 034 | 033 | 032 | 031 | 030 | 027 | 026 | 025 | 024 | 023 | 022 | 021 | 020 | V40401 | V40501 |
| 057 | 056 | 055 | 054 | 053 | 052 | 051 | 050 | 047 | 046 | 045 | 044 | 043 | 042 | 041 | 040 | V40402 | V40502 |
| 077 | 076 | 075 | 074 | 073 | 072 | 071 | 070 | 067 | 066 | 065 | 064 | 063 | 062 | 061 | 060 | V40403 | V40503 |
| 117 | 116 | 115 | 114 | 113 | 112 | 111 | 110 | 107 | 106 | 105 | 104 | 103 | 102 | 101 | 100 | V40404 | V40504 |
| 137 | 136 | 135 | 134 | 133 | 132 | 131 | 130 | 127 | 126 | 125 | 124 | 123 | 122 | 121 | 120 | V40405 | V40505 |
| 157 | 156 | 155 | 154 | 153 | 152 | 151 | 150 | 147 | 146 | 145 | 144 | 143 | 142 | 141 | 140 | V40406 | V40506 |
| 177 | 176 | 175 | 174 | 173 | 172 | 171 | 170 | 167 | 166 | 165 | 164 | 163 | 162 | 161 | 160 | V40407 | V40507 |

| MSB | Input (X) and Output (Y) Points for D2-240, D2-250-1, D2-260 and D2-262 CPUs | | | | | | | | | | | | | | LSB | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 217 | 216 | 215 | 214 | 213 | 212 | 211 | 210 | 207 | 206 | 205 | 204 | 203 | 202 | 201 | 200 | V40410 | V40510 |
| 237 | 236 | 235 | 234 | 233 | 232 | 231 | 230 | 227 | 226 | 225 | 224 | 223 | 222 | 221 | 220 | V40411 | V40511 |
| 257 | 256 | 255 | 254 | 253 | 252 | 251 | 250 | 247 | 246 | 245 | 244 | 243 | 242 | 241 | 240 | V40412 | V40512 |
| 277 | 276 | 275 | 274 | 273 | 272 | 271 | 270 | 267 | 266 | 265 | 264 | 263 | 262 | 261 | 260 | V40413 | V40513 |
| 317 | 316 | 315 | 314 | 313 | 312 | 311 | 310 | 307 | 306 | 305 | 304 | 303 | 302 | 301 | 300 | V40414 | V40514 |
| 337 | 336 | 335 | 334 | 333 | 332 | 331 | 330 | 327 | 326 | 325 | 324 | 323 | 322 | 321 | 320 | V40415 | V40515 |
| 357 | 356 | 355 | 354 | 353 | 352 | 351 | 350 | 347 | 346 | 345 | 344 | 343 | 342 | 341 | 340 | V40416 | V40516 |
| 377 | 376 | 375 | 374 | 373 | 372 | 371 | 370 | 367 | 366 | 365 | 364 | 363 | 362 | 361 | 360 | V40417 | V40517 |
| 417 | 416 | 415 | 414 | 413 | 412 | 411 | 410 | 407 | 406 | 405 | 404 | 403 | 402 | 401 | 400 | V40420 | V40520 |
| 437 | 436 | 435 | 434 | 433 | 432 | 431 | 430 | 427 | 426 | 425 | 424 | 423 | 422 | 421 | 420 | V40421 | V40521 |
| 457 | 456 | 455 | 454 | 453 | 452 | 451 | 450 | 447 | 446 | 445 | 444 | 443 | 442 | 441 | 440 | V40422 | V40522 |
| 477 | 476 | 475 | 474 | 473 | 472 | 471 | 470 | 467 | 466 | 465 | 464 | 463 | 462 | 461 | 460 | V40423 | V40523 |

| MSB | Additional Input (X) and Output (Y) Points for D2-250-1, D2-260, D2-262 CPUs | | | | | | | | | | | | | | LSB | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 517 | 516 | 515 | 514 | 513 | 512 | 511 | 510 | 507 | 506 | 505 | 504 | 503 | 502 | 501 | 500 | V40424 | V40524 |
| 537 | 536 | 535 | 534 | 533 | 532 | 531 | 530 | 527 | 526 | 525 | 524 | 523 | 522 | 521 | 520 | V40425 | V40525 |
| 557 | 556 | 555 | 554 | 553 | 552 | 551 | 550 | 547 | 546 | 545 | 544 | 543 | 542 | 541 | 540 | V40426 | V40526 |
| 577 | 576 | 575 | 574 | 573 | 572 | 571 | 570 | 567 | 566 | 565 | 564 | 563 | 562 | 561 | 560 | V40427 | V40527 |
| 617 | 616 | 615 | 614 | 613 | 612 | 611 | 610 | 607 | 606 | 605 | 604 | 603 | 602 | 601 | 600 | V40430 | V40530 |
| 637 | 636 | 635 | 634 | 633 | 632 | 631 | 630 | 627 | 626 | 625 | 624 | 623 | 622 | 621 | 620 | V40431 | V40531 |
| 657 | 656 | 655 | 654 | 653 | 652 | 651 | 650 | 647 | 646 | 645 | 644 | 643 | 642 | 641 | 640 | V40432 | V40532 |
| 677 | 676 | 675 | 674 | 673 | 672 | 671 | 670 | 667 | 666 | 665 | 664 | 663 | 662 | 661 | 660 | V40433 | V40533 |
| 717 | 716 | 715 | 714 | 713 | 712 | 711 | 710 | 707 | 706 | 705 | 704 | 703 | 702 | 701 | 700 | V40434 | V40534 |
| 737 | 736 | 735 | 734 | 733 | 732 | 731 | 730 | 727 | 726 | 725 | 724 | 723 | 722 | 721 | 720 | V40435 | V40535 |
| 757 | 756 | 755 | 754 | 753 | 752 | 751 | 750 | 747 | 746 | 745 | 744 | 743 | 742 | 741 | 740 | V40436 | V40536 |
| 777 | 776 | 775 | 774 | 773 | 772 | 771 | 770 | 767 | 766 | 765 | 764 | 763 | 762 | 761 | 760 | V40437 | V40537 |

# Input (X) / Output (Y) Bit Map, Continued

| MSB | Additional Input (X) and Output (Y) Points for D2-260 and D2-262 CPUs | | | | | | | | | | | | | | | LSB | X Input Address | Y Output Address |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 | | | |
| 1017 | 1016 | 1015 | 1014 | 1013 | 1012 | 1011 | 1010 | 1007 | 1006 | 1005 | 1004 | 1003 | 1002 | 1001 | 1000 | V40440 | V40540 |
| 1037 | 1036 | 1035 | 1034 | 1033 | 1032 | 1031 | 1030 | 1027 | 1026 | 1025 | 1024 | 1023 | 1022 | 1021 | 1020 | V40441 | V40541 |
| 1057 | 1056 | 1055 | 1054 | 1053 | 1052 | 1051 | 1050 | 1047 | 1046 | 1045 | 1044 | 1043 | 1042 | 1041 | 1040 | V40442 | V40542 |
| 1077 | 1076 | 1075 | 1074 | 1073 | 1072 | 1071 | 1070 | 1067 | 1066 | 1065 | 1064 | 1063 | 1062 | 1061 | 1060 | V40443 | V40543 |
| 1117 | 1116 | 1115 | 1114 | 1113 | 1112 | 1111 | 1110 | 1107 | 1106 | 1105 | 1104 | 1103 | 1102 | 1101 | 1100 | V40444 | V40544 |
| 1137 | 1136 | 1135 | 1134 | 1133 | 1132 | 1131 | 1130 | 1127 | 1126 | 1125 | 1124 | 1123 | 1122 | 1121 | 1120 | V40445 | V40545 |
| 1157 | 1156 | 1155 | 1154 | 1153 | 1152 | 1151 | 1150 | 1147 | 1146 | 1145 | 1144 | 1143 | 1142 | 1141 | 1140 | V40446 | V40546 |
| 1177 | 1176 | 1175 | 1174 | 1173 | 1172 | 1171 | 1170 | 1167 | 1166 | 1165 | 1164 | 1163 | 1162 | 1161 | 1160 | V40447 | V40547 |
| 1217 | 1216 | 1215 | 1214 | 1213 | 1212 | 1211 | 1210 | 1207 | 1206 | 1205 | 1204 | 1203 | 1202 | 1201 | 1200 | V40450 | V40550 |
| 1237 | 1236 | 1235 | 1234 | 1233 | 1232 | 1231 | 1230 | 1227 | 1226 | 1225 | 1224 | 1223 | 1222 | 1221 | 1220 | V40451 | V40551 |
| 1257 | 1256 | 1255 | 1254 | 1253 | 1252 | 1251 | 1250 | 1247 | 1246 | 1245 | 1244 | 1243 | 1242 | 1241 | 1240 | V40452 | V40552 |
| 1277 | 1276 | 1275 | 1274 | 1273 | 1272 | 1271 | 1270 | 1267 | 1266 | 1265 | 1264 | 1263 | 1262 | 1261 | 1260 | V40453 | V40553 |
| 1317 | 1316 | 1315 | 1314 | 1313 | 1312 | 1311 | 1310 | 1307 | 1306 | 1305 | 1304 | 1303 | 1302 | 1301 | 1300 | V40454 | V40554 |
| 1337 | 1336 | 1335 | 1334 | 1333 | 1332 | 1331 | 1330 | 1327 | 1326 | 1325 | 1324 | 1323 | 1322 | 1321 | 1320 | V40455 | V40555 |
| 1357 | 1356 | 1355 | 1354 | 1353 | 1352 | 1351 | 1350 | 1347 | 1346 | 1345 | 1344 | 1343 | 1342 | 1341 | 1340 | V40456 | V40556 |
| 1377 | 1376 | 1375 | 1374 | 1373 | 1372 | 1371 | 1370 | 1367 | 1366 | 1365 | 1364 | 1363 | 1362 | 1361 | 1360 | V40457 | V40557 |
| 1417 | 1416 | 1415 | 1414 | 1413 | 1412 | 1411 | 1410 | 1407 | 1406 | 1405 | 1404 | 1403 | 1402 | 1401 | 1400 | V40460 | V40560 |
| 1437 | 1436 | 1435 | 1434 | 1433 | 1432 | 1431 | 1430 | 1427 | 1426 | 1425 | 1424 | 1423 | 1422 | 1421 | 1420 | V40461 | V40561 |
| 1457 | 1456 | 1455 | 1454 | 1453 | 1452 | 1451 | 1450 | 1447 | 1446 | 1445 | 1444 | 1443 | 1442 | 1441 | 1440 | V40462 | V40562 |
| 1477 | 1476 | 1475 | 1474 | 1473 | 1472 | 1471 | 1470 | 1467 | 1466 | 1465 | 1464 | 1463 | 1462 | 1461 | 1460 | V40463 | V40563 |
| 1517 | 1516 | 1515 | 1514 | 1513 | 1512 | 1511 | 1510 | 1507 | 1506 | 1505 | 1504 | 1503 | 1502 | 1501 | 1500 | V40464 | V40564 |
| 1537 | 1536 | 1535 | 1534 | 1533 | 1532 | 1531 | 1530 | 1527 | 1526 | 1525 | 1524 | 1523 | 1522 | 1521 | 1520 | V40465 | V40565 |
| 1557 | 1556 | 1555 | 1554 | 1553 | 1552 | 1551 | 1550 | 1547 | 1546 | 1545 | 1544 | 1543 | 1542 | 1541 | 1540 | V40466 | V40566 |
| 1577 | 1576 | 1575 | 1574 | 1573 | 1572 | 1571 | 1570 | 1567 | 1566 | 1565 | 1564 | 1563 | 1562 | 1561 | 1560 | V40467 | V40567 |
| 1617 | 1616 | 1615 | 1614 | 1613 | 1612 | 1611 | 1610 | 1607 | 1606 | 1605 | 1604 | 1603 | 1602 | 1601 | 1600 | V40470 | V40570 |
| 1637 | 1636 | 1635 | 1634 | 1633 | 1632 | 1631 | 1630 | 1627 | 1626 | 1625 | 1624 | 1623 | 1622 | 1621 | 1620 | V40471 | V40571 |
| 1657 | 1656 | 1655 | 1654 | 1653 | 1652 | 1651 | 1650 | 1647 | 1646 | 1645 | 1644 | 1643 | 1642 | 1641 | 1640 | V40472 | V40572 |
| 1677 | 1676 | 1675 | 1674 | 1673 | 1672 | 1671 | 1670 | 1667 | 1666 | 1665 | 1664 | 1663 | 1662 | 1661 | 1660 | V40473 | V40573 |
| 1717 | 1716 | 1715 | 1714 | 1713 | 1712 | 1711 | 1710 | 1707 | 1706 | 1705 | 1704 | 1703 | 1702 | 1701 | 1700 | V40474 | V40574 |
| 1737 | 1736 | 1735 | 1734 | 1733 | 1732 | 1731 | 1730 | 1727 | 1726 | 1725 | 1724 | 1723 | 1722 | 1721 | 1720 | V40475 | V40575 |
| 1757 | 1756 | 1755 | 1754 | 1753 | 1752 | 1751 | 1750 | 1747 | 1746 | 1745 | 1744 | 1743 | 1742 | 1741 | 1740 | V40476 | V40576 |
| 1777 | 1776 | 1775 | 1774 | 1773 | 1772 | 1771 | 1770 | 1767 | 1766 | 1765 | 1764 | 1763 | 1762 | 1761 | 1760 | V40477 | V40577 |

# Control Relay Bit Map

This table provides a listing of the individual control relays associated with each V-memory address bit.

| MSB | Control Relays (C) for D2-230, D2-240, D2-250-1, D2-260 and D2-262 | | | | | | | | | | | | | | | LSB | Address |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 | | |
| 017 | 016 | 015 | 014 | 013 | 012 | 011 | 010 | 007 | 006 | 005 | 004 | 003 | 002 | 001 | 000 | | V40600 |
| 037 | 036 | 035 | 034 | 033 | 032 | 031 | 030 | 027 | 026 | 025 | 024 | 023 | 022 | 021 | 020 | | V40601 |
| 057 | 056 | 055 | 054 | 053 | 052 | 051 | 050 | 047 | 046 | 045 | 044 | 043 | 042 | 041 | 040 | | V40602 |
| 077 | 076 | 075 | 074 | 073 | 072 | 071 | 070 | 067 | 066 | 065 | 064 | 063 | 062 | 061 | 060 | | V40603 |
| 117 | 116 | 115 | 114 | 113 | 112 | 111 | 110 | 107 | 106 | 105 | 104 | 103 | 102 | 101 | 100 | | V40604 |
| 137 | 136 | 135 | 134 | 133 | 132 | 131 | 130 | 127 | 126 | 125 | 124 | 123 | 122 | 121 | 120 | | V40605 |
| 157 | 156 | 155 | 154 | 153 | 152 | 151 | 150 | 147 | 146 | 145 | 144 | 143 | 142 | 141 | 140 | | V40606 |
| 177 | 176 | 175 | 174 | 173 | 172 | 171 | 170 | 167 | 166 | 165 | 164 | 163 | 162 | 161 | 160 | | V40607 |
| 217 | 216 | 215 | 214 | 213 | 212 | 211 | 210 | 207 | 206 | 205 | 204 | 203 | 202 | 201 | 200 | | V40610 |
| 237 | 236 | 235 | 234 | 233 | 232 | 231 | 230 | 227 | 226 | 225 | 224 | 223 | 222 | 221 | 220 | | V40611 |
| 257 | 256 | 255 | 254 | 253 | 252 | 251 | 250 | 247 | 246 | 245 | 244 | 243 | 242 | 241 | 240 | | V40612 |
| 277 | 276 | 275 | 274 | 273 | 272 | 271 | 270 | 267 | 266 | 265 | 264 | 263 | 262 | 261 | 260 | | V40613 |
| 317 | 316 | 315 | 314 | 313 | 312 | 311 | 310 | 307 | 306 | 305 | 304 | 303 | 302 | 301 | 300 | | V40614 |
| 337 | 336 | 335 | 334 | 333 | 332 | 331 | 330 | 327 | 326 | 325 | 324 | 323 | 322 | 321 | 320 | | V40615 |
| 357 | 356 | 355 | 354 | 353 | 352 | 351 | 350 | 347 | 346 | 345 | 344 | 343 | 342 | 341 | 340 | | V40616 |
| 377 | 376 | 375 | 374 | 373 | 372 | 371 | 370 | 367 | 366 | 365 | 364 | 363 | 362 | 361 | 360 | | V40617 |

| MSB | Additional Control Relays (C) for D2-250-1, D2-260 and D2-262 | | | | | | | | | | | | | | | LSB | Address |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 417 | 416 | 415 | 414 | 413 | 412 | 411 | 410 | 407 | 406 | 405 | 404 | 403 | 402 | 401 | 400 | | V40620 |
| 437 | 436 | 435 | 434 | 433 | 432 | 431 | 430 | 427 | 426 | 425 | 424 | 423 | 422 | 421 | 420 | | V40621 |
| 457 | 456 | 455 | 454 | 453 | 452 | 451 | 450 | 447 | 446 | 445 | 444 | 443 | 442 | 441 | 440 | | V40622 |
| 477 | 476 | 475 | 474 | 473 | 472 | 471 | 470 | 467 | 466 | 465 | 464 | 463 | 462 | 461 | 460 | | V40623 |
| 517 | 516 | 515 | 514 | 513 | 512 | 511 | 510 | 507 | 506 | 505 | 504 | 503 | 502 | 501 | 500 | | V40624 |
| 537 | 536 | 535 | 534 | 533 | 532 | 531 | 530 | 527 | 526 | 525 | 524 | 523 | 522 | 521 | 520 | | V40625 |
| 557 | 556 | 555 | 554 | 553 | 552 | 551 | 550 | 547 | 546 | 545 | 544 | 543 | 542 | 541 | 540 | | V40626 |
| 577 | 576 | 575 | 574 | 573 | 572 | 571 | 570 | 567 | 566 | 565 | 564 | 563 | 562 | 561 | 560 | | V40627 |
| 617 | 616 | 615 | 614 | 613 | 612 | 611 | 610 | 607 | 606 | 605 | 604 | 603 | 602 | 601 | 600 | | V40630 |
| 637 | 636 | 635 | 634 | 633 | 632 | 631 | 630 | 627 | 626 | 625 | 624 | 623 | 622 | 621 | 620 | | V40631 |
| 657 | 656 | 655 | 654 | 653 | 652 | 651 | 650 | 647 | 646 | 645 | 644 | 643 | 642 | 641 | 640 | | V40632 |
| 677 | 676 | 675 | 674 | 673 | 672 | 671 | 670 | 667 | 666 | 665 | 664 | 663 | 662 | 661 | 660 | | V40633 |
| 717 | 716 | 715 | 714 | 713 | 712 | 711 | 710 | 707 | 706 | 705 | 704 | 703 | 702 | 701 | 700 | | V40634 |
| 737 | 736 | 735 | 734 | 733 | 732 | 731 | 730 | 727 | 726 | 725 | 724 | 723 | 722 | 721 | 720 | | V40635 |
| 757 | 756 | 755 | 754 | 753 | 752 | 751 | 750 | 747 | 746 | 745 | 744 | 743 | 742 | 741 | 740 | | V40636 |
| 777 | 776 | 775 | 774 | 773 | 772 | 771 | 770 | 767 | 766 | 765 | 764 | 763 | 762 | 761 | 760 | | V40637 |

# Control Relay Bit Map, Continued

| MSB | Additional Control Relays (C) for D2-250-1, D2-260 and D2-262 | | | | | | | | | | | | | | | LSB | Address |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 | |
| 1017 | 1016 | 1015 | 1014 | 1013 | 1012 | 1011 | 1010 | 1007 | 1006 | 1005 | 1004 | 1003 | 1002 | 1001 | 1000 | V40640 |
| 1037 | 1036 | 1035 | 1034 | 1033 | 1032 | 1031 | 1030 | 1027 | 1026 | 1025 | 1024 | 1023 | 1022 | 1021 | 1020 | V40641 |
| 1057 | 1056 | 1055 | 1054 | 1053 | 1052 | 1051 | 1050 | 1047 | 1046 | 1045 | 1044 | 1043 | 1042 | 1041 | 1040 | V40642 |
| 1077 | 1076 | 1075 | 1074 | 1073 | 1072 | 1071 | 1070 | 1067 | 1066 | 1065 | 1064 | 1063 | 1062 | 1061 | 1060 | V40643 |
| 1117 | 1116 | 1115 | 1114 | 1113 | 1112 | 1111 | 1110 | 1107 | 1106 | 1105 | 1104 | 1103 | 1102 | 1101 | 1100 | V40644 |
| 1137 | 1136 | 1135 | 1134 | 1133 | 1132 | 1131 | 1130 | 1127 | 1126 | 1125 | 1124 | 1123 | 1122 | 1121 | 1120 | V40645 |
| 1157 | 1156 | 1155 | 1154 | 1153 | 1152 | 1151 | 1150 | 1147 | 1146 | 1145 | 1144 | 1143 | 1142 | 1141 | 1140 | V40646 |
| 1177 | 1176 | 1175 | 1174 | 1173 | 1172 | 1171 | 1170 | 1167 | 1166 | 1165 | 1164 | 1163 | 1162 | 1161 | 1160 | V40647 |
| 1217 | 1216 | 1215 | 1214 | 1213 | 1212 | 1211 | 1210 | 1207 | 1206 | 1205 | 1204 | 1203 | 1202 | 1201 | 1200 | V40650 |
| 1237 | 1236 | 1235 | 1234 | 1233 | 1232 | 1231 | 1230 | 1227 | 1226 | 1225 | 1224 | 1223 | 1222 | 1221 | 1220 | V40651 |
| 1257 | 1256 | 1255 | 1254 | 1253 | 1252 | 1251 | 1250 | 1247 | 1246 | 1245 | 1244 | 1243 | 1242 | 1241 | 1240 | V40652 |
| 1277 | 1276 | 1275 | 1274 | 1273 | 1272 | 1271 | 1270 | 1267 | 1266 | 1265 | 1264 | 1263 | 1262 | 1261 | 1260 | V40653 |
| 1317 | 1316 | 1315 | 1314 | 1313 | 1312 | 1311 | 1310 | 1307 | 1306 | 1305 | 1304 | 1303 | 1302 | 1301 | 1300 | V40654 |
| 1337 | 1336 | 1335 | 1334 | 1333 | 1332 | 1331 | 1330 | 1327 | 1326 | 1325 | 1324 | 1323 | 1322 | 1321 | 1320 | V40655 |
| 1357 | 1356 | 1355 | 1354 | 1353 | 1352 | 1351 | 1350 | 1347 | 1346 | 1345 | 1344 | 1343 | 1342 | 1341 | 1340 | V40656 |
| 1377 | 1376 | 1375 | 1374 | 1373 | 1372 | 1371 | 1370 | 1367 | 1366 | 1365 | 1364 | 1363 | 1362 | 1361 | 1360 | V40657 |
| 1417 | 1416 | 1415 | 1414 | 1413 | 1412 | 1411 | 1410 | 1407 | 1406 | 1405 | 1404 | 1403 | 1402 | 1401 | 1400 | V40660 |
| 1437 | 1436 | 1435 | 1434 | 1433 | 1432 | 1431 | 1430 | 1427 | 1426 | 1425 | 1424 | 1423 | 1422 | 1421 | 1420 | V40661 |
| 1457 | 1456 | 1455 | 1454 | 1453 | 1452 | 1451 | 1450 | 1447 | 1446 | 1445 | 1444 | 1443 | 1442 | 1441 | 1440 | V40662 |
| 1477 | 1476 | 1475 | 1474 | 1473 | 1472 | 1471 | 1470 | 1467 | 1466 | 1465 | 1464 | 1463 | 1462 | 1461 | 1460 | V40663 |
| 1517 | 1516 | 1515 | 1514 | 1513 | 1512 | 1511 | 1510 | 1507 | 1506 | 1505 | 1504 | 1503 | 1502 | 1501 | 1500 | V40664 |
| 1537 | 1536 | 1535 | 1534 | 1533 | 1532 | 1531 | 1530 | 1527 | 1526 | 1525 | 1524 | 1523 | 1522 | 1521 | 1520 | V40665 |
| 1557 | 1556 | 1555 | 1554 | 1553 | 1552 | 1551 | 1550 | 1547 | 1546 | 1545 | 1544 | 1543 | 1542 | 1541 | 1540 | V40666 |
| 1577 | 1576 | 1575 | 1574 | 1573 | 1572 | 1571 | 1570 | 1567 | 1566 | 1565 | 1564 | 1563 | 1562 | 1561 | 1560 | V40667 |
| 1617 | 1616 | 1615 | 1614 | 1613 | 1612 | 1611 | 1610 | 1607 | 1606 | 1605 | 1604 | 1603 | 1602 | 1601 | 1600 | V40670 |
| 1637 | 1636 | 1635 | 1634 | 1633 | 1632 | 1631 | 1630 | 1627 | 1626 | 1625 | 1624 | 1623 | 1622 | 1621 | 1620 | V40671 |
| 1657 | 1656 | 1655 | 1654 | 1653 | 1652 | 1651 | 1650 | 1647 | 1646 | 1645 | 1644 | 1643 | 1642 | 1641 | 1640 | V40672 |
| 1677 | 1676 | 1675 | 1674 | 1673 | 1672 | 1671 | 1670 | 1667 | 1666 | 1665 | 1664 | 1663 | 1662 | 1661 | 1660 | V40673 |
| 1717 | 1716 | 1715 | 1714 | 1713 | 1712 | 1711 | 1710 | 1707 | 1706 | 1705 | 1704 | 1703 | 1702 | 1701 | 1700 | V40674 |
| 1737 | 1736 | 1735 | 1734 | 1733 | 1732 | 1731 | 1730 | 1727 | 1726 | 1725 | 1724 | 1723 | 1722 | 1721 | 1720 | V40675 |
| 1757 | 1756 | 1755 | 1754 | 1753 | 1752 | 1751 | 1750 | 1747 | 1746 | 1745 | 1744 | 1743 | 1742 | 1741 | 1740 | V40676 |
| 1777 | 1776 | 1775 | 1774 | 1773 | 1772 | 1771 | 1770 | 1767 | 1766 | 1765 | 1764 | 1763 | 1762 | 1761 | 1760 | V40677 |

# Control Relay Bit Map, Continued

This portion of the table shows additional Control Relays points available with the D2-260 and D2-262.

| MSB | Additional Control Relays (C) for D2-260 and D2-262 CPUs | | | | | | | | | | | | | | LSB | Address |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 | |
| 2017 | 2016 | 2015 | 2014 | 2013 | 2012 | 2011 | 2010 | 2007 | 2006 | 2005 | 2004 | 2003 | 2002 | 2001 | 2000 | V40700 |
| 2037 | 2036 | 2035 | 2034 | 2033 | 2032 | 2031 | 2030 | 2027 | 2026 | 2025 | 2024 | 2023 | 2022 | 2021 | 2020 | V40701 |
| 2057 | 2056 | 2055 | 2054 | 2053 | 2052 | 2051 | 2050 | 2047 | 2046 | 2045 | 2044 | 2043 | 2042 | 2041 | 2040 | V40702 |
| 2077 | 2076 | 2075 | 2074 | 2073 | 2072 | 2071 | 2070 | 2067 | 2066 | 2065 | 2064 | 2063 | 2062 | 2061 | 2060 | V40703 |
| 2117 | 2116 | 2115 | 2114 | 2113 | 2112 | 2111 | 2110 | 2107 | 2106 | 2105 | 2104 | 2103 | 2102 | 2101 | 2100 | V40704 |
| 2137 | 2136 | 2135 | 2134 | 2133 | 2132 | 2131 | 2130 | 2127 | 2126 | 2125 | 2124 | 2123 | 2122 | 2121 | 2120 | V40705 |
| 2157 | 2156 | 2155 | 2154 | 2153 | 2152 | 2151 | 2150 | 2147 | 2146 | 2145 | 2144 | 2143 | 2142 | 2141 | 2140 | V40706 |
| 2177 | 2176 | 2175 | 2174 | 2173 | 2172 | 2171 | 2170 | 2167 | 2166 | 2165 | 2164 | 2163 | 2162 | 2161 | 2160 | V40707 |
| 2217 | 2216 | 2215 | 2214 | 2213 | 2212 | 2211 | 2210 | 2207 | 2206 | 2205 | 2204 | 2203 | 2202 | 2201 | 2200 | V40710 |
| 2237 | 2236 | 2235 | 2234 | 2233 | 2232 | 2231 | 2230 | 2227 | 2226 | 2225 | 2224 | 2223 | 2222 | 2221 | 2220 | V40711 |
| 2257 | 2256 | 2255 | 2254 | 2253 | 2252 | 2251 | 2250 | 2247 | 2246 | 2245 | 2244 | 2243 | 2242 | 2241 | 2240 | V40712 |
| 2277 | 2276 | 2275 | 2274 | 2273 | 2272 | 2271 | 2270 | 2267 | 2266 | 2265 | 2264 | 2263 | 2262 | 2261 | 2260 | V40713 |
| 2317 | 2316 | 2315 | 2314 | 2313 | 2312 | 2311 | 2310 | 2307 | 2306 | 2305 | 2304 | 2303 | 2302 | 2301 | 2300 | V40714 |
| 2337 | 2336 | 2335 | 2334 | 2333 | 2332 | 2331 | 2330 | 2327 | 2326 | 2325 | 2324 | 2323 | 2322 | 2321 | 2320 | V40715 |
| 2357 | 2356 | 2355 | 2354 | 2353 | 2352 | 2351 | 2350 | 2347 | 2346 | 2345 | 2344 | 2343 | 2342 | 2341 | 2340 | V40716 |
| 2377 | 2376 | 2375 | 2374 | 2373 | 2372 | 2371 | 2370 | 2367 | 2366 | 2365 | 2364 | 2363 | 2362 | 2361 | 2360 | V40717 |
| 2417 | 2416 | 2415 | 2414 | 2413 | 2412 | 2411 | 2410 | 2407 | 2406 | 2405 | 2404 | 2403 | 2402 | 2401 | 2400 | V40720 |
| 2437 | 2436 | 2435 | 2434 | 2433 | 2432 | 2431 | 2430 | 2427 | 2426 | 2425 | 2424 | 2423 | 2422 | 2421 | 2420 | V40721 |
| 2457 | 2456 | 2455 | 2454 | 2453 | 2452 | 2451 | 2450 | 2447 | 2446 | 2445 | 2444 | 2443 | 2442 | 2441 | 2440 | V40722 |
| 2477 | 2476 | 2475 | 2474 | 2473 | 2472 | 2471 | 2470 | 2467 | 2466 | 2465 | 2464 | 2463 | 2462 | 2461 | 2460 | V40723 |
| 2517 | 2516 | 2515 | 2514 | 2513 | 2512 | 2511 | 2510 | 2507 | 2506 | 2505 | 2504 | 2503 | 2502 | 2501 | 2500 | V40724 |
| 2537 | 2536 | 2535 | 2534 | 2533 | 2532 | 2531 | 2530 | 2527 | 2526 | 2525 | 2524 | 2523 | 2522 | 2521 | 2520 | V40725 |
| 2557 | 2556 | 2555 | 2554 | 2553 | 2552 | 2551 | 2550 | 2547 | 2546 | 2545 | 2544 | 2543 | 2542 | 2541 | 2540 | V40726 |
| 2577 | 2576 | 2575 | 2574 | 2573 | 2572 | 2571 | 2570 | 2567 | 2566 | 2565 | 2564 | 2563 | 2562 | 2561 | 2560 | V40727 |
| 2617 | 2616 | 2615 | 2614 | 2613 | 2612 | 2611 | 2610 | 2607 | 2606 | 2605 | 2604 | 2603 | 2602 | 2601 | 2600 | V40730 |
| 2637 | 2636 | 2635 | 2634 | 2633 | 2632 | 2631 | 2630 | 2627 | 2626 | 2625 | 2624 | 2623 | 2622 | 2621 | 2620 | V40731 |
| 2657 | 2656 | 2655 | 2654 | 2653 | 2652 | 2651 | 2650 | 2647 | 2646 | 2645 | 2644 | 2643 | 2642 | 2641 | 2640 | V40732 |
| 2677 | 2676 | 2675 | 2674 | 2673 | 2672 | 2671 | 2670 | 2667 | 2666 | 2665 | 2664 | 2663 | 2662 | 2661 | 2660 | V40733 |
| 2717 | 2716 | 2715 | 2714 | 2713 | 2712 | 2711 | 2710 | 2707 | 2706 | 2705 | 2704 | 2703 | 2702 | 2701 | 2700 | V40734 |
| 2737 | 2736 | 2735 | 2734 | 2733 | 2732 | 2731 | 2730 | 2727 | 2726 | 2725 | 2724 | 2723 | 2722 | 2721 | 2720 | V40735 |
| 2757 | 2756 | 2755 | 2754 | 2753 | 2752 | 2751 | 2750 | 2747 | 2746 | 2745 | 2744 | 2743 | 2742 | 2741 | 2740 | V40736 |
| 2777 | 2776 | 2775 | 2774 | 2773 | 2772 | 2771 | 2770 | 2767 | 2766 | 2765 | 2764 | 2763 | 2762 | 2761 | 2760 | V40737 |

# Control Relay Bit Map, Continued

| MSB | Additional Control Relays (C) for D2-260 and D2-262 CPUs | | | | | | | | | | | | | | LSB | Address |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 | |
| 3017 | 3016 | 3015 | 3014 | 3013 | 3012 | 3011 | 3010 | 3007 | 3006 | 3005 | 3004 | 3003 | 3002 | 3001 | 3000 | V40740 |
| 3037 | 3036 | 3035 | 3034 | 3033 | 3032 | 3031 | 3030 | 3027 | 3026 | 3025 | 3024 | 3023 | 3022 | 3021 | 3020 | V40741 |
| 3057 | 3056 | 3055 | 3054 | 3053 | 3052 | 3051 | 3050 | 3047 | 3046 | 3045 | 3044 | 3043 | 3042 | 3041 | 3040 | V40742 |
| 3077 | 3076 | 3075 | 3074 | 3073 | 3072 | 3071 | 3070 | 3067 | 3066 | 3065 | 3064 | 3063 | 3062 | 3061 | 3060 | V40743 |
| 3117 | 3116 | 3115 | 3114 | 3113 | 3112 | 3111 | 3110 | 3107 | 3106 | 3105 | 3104 | 3103 | 3102 | 3101 | 3100 | V40744 |
| 3137 | 3136 | 3135 | 3134 | 3133 | 3132 | 3131 | 3130 | 3127 | 3126 | 3125 | 3124 | 3123 | 3122 | 3121 | 3120 | V40745 |
| 3157 | 3156 | 3155 | 3154 | 3153 | 3152 | 3151 | 3150 | 3147 | 3146 | 3145 | 3144 | 3143 | 3142 | 3141 | 3140 | V40746 |
| 3177 | 3176 | 3175 | 3174 | 3173 | 3172 | 3171 | 3170 | 3167 | 3166 | 3165 | 3164 | 3163 | 3162 | 3161 | 3160 | V40747 |
| 3217 | 3216 | 3215 | 3214 | 3213 | 3212 | 3211 | 3210 | 3207 | 3206 | 3205 | 3204 | 3203 | 3202 | 3201 | 3200 | V40750 |
| 3237 | 3236 | 3235 | 3234 | 3233 | 3232 | 3231 | 3230 | 3227 | 3226 | 3225 | 3224 | 3223 | 3222 | 3221 | 3220 | V40751 |
| 3257 | 3256 | 3255 | 3254 | 3253 | 3252 | 3251 | 3250 | 3247 | 3246 | 3245 | 3244 | 3243 | 3242 | 3241 | 3240 | V40752 |
| 3277 | 3276 | 3275 | 3274 | 3273 | 3272 | 3271 | 3270 | 3267 | 3266 | 3265 | 3264 | 3263 | 3262 | 3261 | 3260 | V40753 |
| 3317 | 3316 | 3315 | 3314 | 3313 | 3312 | 3311 | 3310 | 3307 | 3306 | 3305 | 3304 | 3303 | 3302 | 3301 | 3300 | V40754 |
| 3337 | 3336 | 3335 | 3334 | 3333 | 3332 | 3331 | 3330 | 3327 | 3326 | 3325 | 3324 | 3323 | 3322 | 3321 | 3320 | V40755 |
| 3357 | 3356 | 3355 | 3354 | 3353 | 3352 | 3351 | 3350 | 3347 | 3346 | 3345 | 3344 | 3343 | 3342 | 3341 | 3340 | V40756 |
| 3377 | 3376 | 3375 | 3374 | 3373 | 3372 | 3371 | 3370 | 3367 | 3366 | 3365 | 3364 | 3363 | 3362 | 3361 | 3360 | V40757 |
| 3417 | 3416 | 3415 | 3414 | 3413 | 3412 | 3411 | 3410 | 3407 | 3406 | 3405 | 3404 | 3403 | 3402 | 3401 | 3400 | V40760 |
| 3437 | 3436 | 3435 | 3434 | 3433 | 3432 | 3431 | 3430 | 3427 | 3426 | 3425 | 3424 | 3423 | 3422 | 3421 | 3420 | V40761 |
| 3457 | 3456 | 3455 | 3454 | 3453 | 3452 | 3451 | 3450 | 3447 | 3446 | 3445 | 3444 | 3443 | 3442 | 3441 | 3440 | V40762 |
| 3477 | 3476 | 3475 | 3474 | 3473 | 3472 | 3471 | 3470 | 3467 | 3466 | 3465 | 3464 | 3463 | 3462 | 3461 | 3460 | V40763 |
| 3517 | 3516 | 3515 | 3514 | 3513 | 3512 | 3511 | 3510 | 3507 | 3506 | 3505 | 3504 | 3503 | 3502 | 3501 | 3500 | V40764 |
| 3537 | 3536 | 3535 | 3534 | 3533 | 3532 | 3531 | 3530 | 3527 | 3526 | 3525 | 3524 | 3523 | 3522 | 3521 | 3520 | V40765 |
| 3557 | 3556 | 3555 | 3554 | 3553 | 3552 | 3551 | 3550 | 3547 | 3546 | 3545 | 3544 | 3543 | 3542 | 3541 | 3540 | V40766 |
| 3577 | 3576 | 3575 | 3574 | 3573 | 3572 | 3571 | 3570 | 3567 | 3566 | 3565 | 3564 | 3563 | 3562 | 3561 | 3560 | V40767 |
| 3617 | 3616 | 3615 | 3614 | 3613 | 3612 | 3611 | 3610 | 3607 | 3606 | 3605 | 3604 | 3603 | 3602 | 3601 | 3600 | V40770 |
| 3637 | 3636 | 3635 | 3634 | 3633 | 3632 | 3631 | 3630 | 3627 | 3626 | 3625 | 3624 | 3623 | 3622 | 3621 | 3620 | V40771 |
| 3657 | 3656 | 3655 | 3654 | 3653 | 3652 | 3651 | 3650 | 3647 | 3646 | 3645 | 3644 | 3643 | 3642 | 3641 | 3640 | V40772 |
| 3677 | 3676 | 3675 | 3674 | 3673 | 3672 | 3671 | 3670 | 3667 | 3666 | 3665 | 3664 | 3663 | 3662 | 3661 | 3660 | V40773 |
| 3717 | 3716 | 3715 | 3714 | 3713 | 3712 | 3711 | 3710 | 3707 | 3706 | 3705 | 3704 | 3703 | 3702 | 3701 | 3700 | V40774 |
| 3737 | 3736 | 3735 | 3734 | 3733 | 3732 | 3731 | 3730 | 3727 | 3726 | 3725 | 3724 | 3723 | 3722 | 3721 | 3720 | V40775 |
| 3757 | 3756 | 3755 | 3754 | 3753 | 3752 | 3751 | 3750 | 3747 | 3746 | 3745 | 3744 | 3743 | 3742 | 3741 | 3740 | V40776 |
| 3777 | 3776 | 3775 | 3774 | 3773 | 3772 | 3771 | 3770 | 3767 | 3766 | 3765 | 3764 | 3763 | 3762 | 3761 | 3760 | V40777 |

# Remote I/O Bit Map (D2-260 and D2-262 only)

This table provides a listing of the individual remote I/O points associated with each V-memory address bit.

| MSB | Remote I/O (GX) and (GY) Points for D2-260 and D2-262 CPUs | | | | | | | | | | | | | | | LSB | GX Address | GY Address |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 | | | |
| 017 | 016 | 015 | 014 | 013 | 012 | 011 | 010 | 007 | 006 | 005 | 004 | 003 | 002 | 001 | 000 | | V40000 | V40200 |
| 037 | 036 | 035 | 034 | 033 | 032 | 031 | 030 | 027 | 026 | 025 | 024 | 023 | 022 | 021 | 020 | | V40001 | V40201 |
| 057 | 056 | 055 | 054 | 053 | 052 | 051 | 050 | 047 | 046 | 045 | 044 | 043 | 042 | 041 | 040 | | V40002 | V40202 |
| 077 | 076 | 075 | 074 | 073 | 072 | 071 | 070 | 067 | 066 | 065 | 064 | 063 | 062 | 061 | 060 | | V40003 | V40203 |
| 117 | 116 | 115 | 114 | 113 | 112 | 111 | 110 | 107 | 106 | 105 | 104 | 103 | 102 | 101 | 100 | | V40004 | V40204 |
| 137 | 136 | 135 | 134 | 133 | 132 | 131 | 130 | 127 | 126 | 125 | 124 | 123 | 122 | 121 | 120 | | V40005 | V40205 |
| 157 | 156 | 155 | 154 | 153 | 152 | 151 | 150 | 147 | 146 | 145 | 144 | 143 | 142 | 141 | 140 | | V40006 | V40206 |
| 177 | 176 | 175 | 174 | 173 | 172 | 171 | 170 | 167 | 166 | 165 | 164 | 163 | 162 | 161 | 160 | | V40007 | V40207 |
| 217 | 216 | 215 | 214 | 213 | 212 | 211 | 210 | 207 | 206 | 205 | 204 | 203 | 202 | 201 | 200 | | V40010 | V40210 |
| 237 | 236 | 235 | 234 | 233 | 232 | 231 | 230 | 227 | 226 | 225 | 224 | 223 | 222 | 221 | 220 | | V40011 | V40211 |
| 257 | 256 | 255 | 254 | 253 | 252 | 251 | 250 | 247 | 246 | 245 | 244 | 243 | 242 | 241 | 240 | | V40012 | V40212 |
| 277 | 276 | 275 | 274 | 273 | 272 | 271 | 270 | 267 | 266 | 265 | 264 | 263 | 262 | 261 | 260 | | V40013 | V40213 |
| 317 | 316 | 315 | 314 | 313 | 312 | 311 | 310 | 307 | 306 | 305 | 304 | 303 | 302 | 301 | 300 | | V40014 | V40214 |
| 337 | 336 | 335 | 334 | 333 | 332 | 331 | 330 | 327 | 326 | 325 | 324 | 323 | 322 | 321 | 320 | | V40015 | V40215 |
| 357 | 356 | 355 | 354 | 353 | 352 | 351 | 350 | 347 | 346 | 345 | 344 | 343 | 342 | 341 | 340 | | V40016 | V40216 |
| 377 | 376 | 375 | 374 | 373 | 372 | 371 | 370 | 367 | 366 | 365 | 364 | 363 | 362 | 361 | 360 | | V40017 | V40217 |
| 417 | 416 | 415 | 414 | 413 | 412 | 411 | 410 | 407 | 406 | 405 | 404 | 403 | 402 | 401 | 400 | | V40020 | V40220 |
| 437 | 436 | 435 | 434 | 433 | 432 | 431 | 430 | 427 | 426 | 425 | 424 | 423 | 422 | 421 | 420 | | V40021 | V40221 |
| 457 | 456 | 455 | 454 | 453 | 452 | 451 | 450 | 447 | 446 | 445 | 444 | 443 | 442 | 441 | 440 | | V40022 | V40222 |
| 477 | 476 | 475 | 474 | 473 | 472 | 471 | 470 | 467 | 466 | 465 | 464 | 463 | 462 | 461 | 460 | | V40023 | V40223 |
| 517 | 516 | 515 | 514 | 513 | 512 | 511 | 510 | 507 | 506 | 505 | 504 | 503 | 502 | 501 | 500 | | V40024 | V40224 |
| 537 | 536 | 535 | 534 | 533 | 532 | 531 | 530 | 527 | 526 | 525 | 524 | 523 | 522 | 521 | 520 | | V40025 | V40225 |
| 557 | 556 | 555 | 554 | 553 | 552 | 551 | 550 | 547 | 546 | 545 | 544 | 543 | 542 | 541 | 540 | | V40026 | V40226 |
| 577 | 576 | 575 | 574 | 573 | 572 | 571 | 570 | 567 | 566 | 565 | 564 | 563 | 562 | 561 | 560 | | V40027 | V40227 |
| 617 | 616 | 615 | 614 | 613 | 612 | 611 | 610 | 607 | 606 | 605 | 604 | 603 | 602 | 601 | 600 | | V40030 | V40230 |
| 637 | 636 | 635 | 634 | 633 | 632 | 631 | 630 | 627 | 626 | 625 | 624 | 623 | 622 | 621 | 620 | | V40031 | V40231 |
| 657 | 656 | 655 | 654 | 653 | 652 | 651 | 650 | 647 | 646 | 645 | 644 | 643 | 642 | 641 | 640 | | V40032 | V40232 |
| 677 | 676 | 675 | 674 | 673 | 672 | 671 | 670 | 667 | 666 | 665 | 664 | 663 | 662 | 661 | 660 | | V40033 | V40233 |
| 717 | 716 | 715 | 714 | 713 | 712 | 711 | 710 | 707 | 706 | 705 | 704 | 703 | 702 | 701 | 700 | | V40034 | V40234 |
| 737 | 736 | 735 | 734 | 733 | 732 | 731 | 730 | 727 | 726 | 725 | 724 | 723 | 722 | 721 | 720 | | V40035 | V40235 |
| 757 | 756 | 755 | 754 | 753 | 752 | 751 | 750 | 747 | 746 | 745 | 744 | 743 | 742 | 741 | 740 | | V40036 | V40236 |
| 777 | 776 | 775 | 774 | 773 | 772 | 771 | 770 | 767 | 766 | 765 | 764 | 763 | 762 | 761 | 760 | | V40037 | V40237 |

# Remote I/O Bit Map (D2-260 and D2-262 only), Continued

| MSB | Additional Remote I/O (GX) and (GY) Points for D2-260 and D2-262 CPUs | | | | | | | | | | | | | | | LSB | GX Address | GY Address |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 | | | |
| 1017 | 1016 | 1015 | 1014 | 1013 | 1012 | 1011 | 1010 | 1007 | 1006 | 1005 | 1004 | 1003 | 1002 | 1001 | 1000 | V40040 | V40240 |
| 1037 | 1036 | 1035 | 1034 | 1033 | 1032 | 1031 | 1030 | 1027 | 1026 | 1025 | 1024 | 1023 | 1022 | 1021 | 1020 | V40041 | V40241 |
| 1057 | 1056 | 1055 | 1054 | 1053 | 1052 | 1051 | 1050 | 1047 | 1046 | 1045 | 1044 | 1043 | 1042 | 1041 | 1040 | V40042 | V40242 |
| 1077 | 1076 | 1075 | 1074 | 1073 | 1072 | 1071 | 1070 | 1067 | 1066 | 1065 | 1064 | 1063 | 1062 | 1061 | 1060 | V40043 | V40243 |
| 1117 | 1116 | 1115 | 1114 | 1113 | 1112 | 1111 | 1110 | 1107 | 1106 | 1105 | 1104 | 1103 | 1102 | 1101 | 1100 | V40044 | V40244 |
| 1137 | 1136 | 1135 | 1134 | 1133 | 1132 | 1131 | 1130 | 1127 | 1126 | 1125 | 1124 | 1123 | 1122 | 1121 | 1120 | V40045 | V40245 |
| 1157 | 1156 | 1155 | 1154 | 1153 | 1152 | 1151 | 1150 | 1147 | 1146 | 1145 | 1144 | 1143 | 1142 | 1141 | 1140 | V40046 | V40246 |
| 1177 | 1176 | 1175 | 1174 | 1173 | 1172 | 1171 | 1170 | 1167 | 1166 | 1165 | 1164 | 1163 | 1162 | 1161 | 1160 | V40047 | V40247 |
| 1217 | 1216 | 1215 | 1214 | 1213 | 1212 | 1211 | 1210 | 1207 | 1206 | 1205 | 1204 | 1203 | 1202 | 1201 | 1200 | V40050 | V40250 |
| 1237 | 1236 | 1235 | 1234 | 1233 | 1232 | 1231 | 1230 | 1227 | 1226 | 1225 | 1224 | 1223 | 1222 | 1221 | 1220 | V40051 | V40251 |
| 1257 | 1256 | 1255 | 1254 | 1253 | 1252 | 1251 | 1250 | 1247 | 1246 | 1245 | 1244 | 1243 | 1242 | 1241 | 1240 | V40052 | V40252 |
| 1277 | 1276 | 1275 | 1274 | 1273 | 1272 | 1271 | 1270 | 1267 | 1266 | 1265 | 1264 | 1263 | 1262 | 1261 | 1260 | V40053 | V40253 |
| 1317 | 1316 | 1315 | 1314 | 1313 | 1312 | 1311 | 1310 | 1307 | 1306 | 1305 | 1304 | 1303 | 1302 | 1301 | 1300 | V40054 | V40254 |
| 1337 | 1336 | 1335 | 1334 | 1333 | 1332 | 1331 | 1330 | 1327 | 1326 | 1325 | 1324 | 1323 | 1322 | 1321 | 1320 | V40055 | V40255 |
| 1357 | 1356 | 1355 | 1354 | 1353 | 1352 | 1351 | 1350 | 1347 | 1346 | 1345 | 1344 | 1343 | 1342 | 1341 | 1340 | V40056 | V40256 |
| 1377 | 1376 | 1375 | 1374 | 1373 | 1372 | 1371 | 1370 | 1367 | 1366 | 1365 | 1364 | 1363 | 1362 | 1361 | 1360 | V40057 | V40257 |
| 1417 | 1416 | 1415 | 1414 | 1413 | 1412 | 1411 | 1410 | 1407 | 1406 | 1405 | 1404 | 1403 | 1402 | 1401 | 1400 | V40060 | V40260 |
| 1437 | 1436 | 1435 | 1434 | 1433 | 1432 | 1431 | 1430 | 1427 | 1426 | 1425 | 1424 | 1423 | 1422 | 1421 | 1420 | V40061 | V40261 |
| 1457 | 1456 | 1455 | 1454 | 1453 | 1452 | 1451 | 1450 | 1447 | 1446 | 1445 | 1444 | 1443 | 1442 | 1441 | 1440 | V40062 | V40262 |
| 1477 | 1476 | 1475 | 1474 | 1473 | 1472 | 1471 | 1470 | 1467 | 1466 | 1465 | 1464 | 1463 | 1462 | 1461 | 1460 | V40063 | V40263 |
| 1517 | 1516 | 1515 | 1514 | 1513 | 1512 | 1511 | 1510 | 1507 | 1506 | 1505 | 1504 | 1503 | 1502 | 1501 | 1500 | V40064 | V40264 |
| 1537 | 1536 | 1535 | 1534 | 1533 | 1532 | 1531 | 1530 | 1527 | 1526 | 1525 | 1524 | 1523 | 1522 | 1521 | 1520 | V40065 | V40265 |
| 1557 | 1556 | 1555 | 1554 | 1553 | 1552 | 1551 | 1550 | 1547 | 1546 | 1545 | 1544 | 1543 | 1542 | 1541 | 1540 | V40066 | V40266 |
| 1577 | 1576 | 1575 | 1574 | 1573 | 1572 | 1571 | 1570 | 1567 | 1566 | 1565 | 1564 | 1563 | 1562 | 1561 | 1560 | V40067 | V40267 |
| 1617 | 1616 | 1615 | 1614 | 1613 | 1612 | 1611 | 1610 | 1607 | 1606 | 1605 | 1604 | 1603 | 1602 | 1601 | 1600 | V40070 | V40270 |
| 1637 | 1636 | 1635 | 1634 | 1633 | 1632 | 1631 | 1630 | 1627 | 1626 | 1625 | 1624 | 1623 | 1622 | 1621 | 1620 | V40071 | V40271 |
| 1657 | 1656 | 1655 | 1654 | 1653 | 1652 | 1651 | 1650 | 1647 | 1646 | 1645 | 1644 | 1643 | 1642 | 1641 | 1640 | V40072 | V40272 |
| 1677 | 1676 | 1675 | 1674 | 1673 | 1672 | 1671 | 1670 | 1667 | 1666 | 1665 | 1664 | 1663 | 1662 | 1661 | 1660 | V40073 | V40273 |
| 1717 | 1716 | 1715 | 1714 | 1713 | 1712 | 1711 | 1710 | 1707 | 1706 | 1705 | 1704 | 1703 | 1702 | 1701 | 1700 | V40074 | V40274 |
| 1737 | 1736 | 1735 | 1734 | 1733 | 1732 | 1731 | 1730 | 1727 | 1726 | 1725 | 1724 | 1723 | 1722 | 1721 | 1720 | V40075 | V40275 |
| 1757 | 1756 | 1755 | 1754 | 1753 | 1752 | 1751 | 1750 | 1747 | 1746 | 1745 | 1744 | 1743 | 1742 | 1741 | 1740 | V40076 | V40276 |
| 1777 | 1776 | 1775 | 1774 | 1773 | 1772 | 1771 | 1770 | 1767 | 1766 | 1765 | 1764 | 1763 | 1762 | 1761 | 1760 | V40077 | V40277 |

# Remote I/O Bit Map (D2-260 and D2-262 only), Continued

| MSB | Additional Remote I/O (GX) and (GY) Points for D2-260 and D2-262 CPUs | | | | | | | | | | | | | | | LSB | GX Address | GY Address |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 | | | |
| 2017 | 2016 | 2015 | 2014 | 2013 | 2012 | 2011 | 2010 | 2007 | 2006 | 2005 | 2004 | 2003 | 2002 | 2001 | 2000 | | V40100 | V40300 |
| 2037 | 2036 | 2035 | 2034 | 2033 | 2032 | 2031 | 2030 | 2027 | 2026 | 2025 | 2024 | 2023 | 2022 | 2021 | 2020 | | V40101 | V40301 |
| 2057 | 2056 | 2055 | 2054 | 2053 | 2052 | 2051 | 2050 | 2047 | 2046 | 2045 | 2044 | 2043 | 2042 | 2041 | 2040 | | V40102 | V40302 |
| 2077 | 2076 | 2075 | 2074 | 2073 | 2072 | 2071 | 2070 | 2067 | 2066 | 2065 | 2064 | 2063 | 2062 | 2061 | 2060 | | V40103 | V40303 |
| 2117 | 2116 | 2115 | 2114 | 2113 | 2112 | 2111 | 2110 | 2107 | 2106 | 2105 | 2104 | 2103 | 2102 | 2101 | 2100 | | V40104 | V40304 |
| 2137 | 2136 | 2135 | 2134 | 2133 | 2132 | 2131 | 2130 | 2127 | 2126 | 2125 | 2124 | 2123 | 2122 | 2121 | 2120 | | V40105 | V40305 |
| 2157 | 2156 | 2155 | 2154 | 2153 | 2152 | 2151 | 2150 | 2147 | 2146 | 2145 | 2144 | 2143 | 2142 | 2141 | 2140 | | V40106 | V40306 |
| 2177 | 2176 | 2175 | 2174 | 2173 | 2172 | 2171 | 2170 | 2167 | 2166 | 2165 | 2164 | 2163 | 2162 | 2161 | 2160 | | V40107 | V40307 |
| 2217 | 2216 | 2215 | 2214 | 2213 | 2212 | 2211 | 2210 | 2207 | 2206 | 2205 | 2204 | 2203 | 2202 | 2201 | 2200 | | V40110 | V40310 |
| 2237 | 2236 | 2235 | 2234 | 2233 | 2232 | 2231 | 2230 | 2227 | 2226 | 2225 | 2224 | 2223 | 2222 | 2221 | 2220 | | V40111 | V40311 |
| 2257 | 2256 | 2255 | 2254 | 2253 | 2252 | 2251 | 2250 | 2247 | 2246 | 2245 | 2244 | 2243 | 2242 | 2241 | 2240 | | V40112 | V40312 |
| 2277 | 2276 | 2275 | 2274 | 2273 | 2272 | 2271 | 2270 | 2267 | 2266 | 2265 | 2264 | 2263 | 2262 | 2261 | 2260 | | V40113 | V40313 |
| 2317 | 2316 | 2315 | 2314 | 2313 | 2312 | 2311 | 2310 | 2307 | 2306 | 2305 | 2304 | 2303 | 2302 | 2301 | 2300 | | V40114 | V40314 |
| 2337 | 2336 | 2335 | 2334 | 2333 | 2332 | 2331 | 2330 | 2327 | 2326 | 2325 | 2324 | 2323 | 2322 | 2321 | 2320 | | V40115 | V40315 |
| 2357 | 2356 | 2355 | 2354 | 2353 | 2352 | 2351 | 2350 | 2347 | 2346 | 2345 | 2344 | 2343 | 2342 | 2341 | 2340 | | V40116 | V40316 |
| 2377 | 2376 | 2375 | 2374 | 2373 | 2372 | 2371 | 2370 | 2367 | 2366 | 2365 | 2364 | 2363 | 2362 | 2361 | 2360 | | V40117 | V40317 |
| 2417 | 2416 | 2415 | 2414 | 2413 | 2412 | 2411 | 2410 | 2407 | 2406 | 2405 | 2404 | 2403 | 2402 | 2401 | 2400 | | V40120 | V40320 |
| 2437 | 2436 | 2435 | 2434 | 2433 | 2432 | 2431 | 2430 | 2427 | 2426 | 2425 | 2424 | 2423 | 2422 | 2421 | 2420 | | V40121 | V40321 |
| 2457 | 2456 | 2455 | 2454 | 2453 | 2452 | 2451 | 2450 | 2447 | 2446 | 2445 | 2444 | 2443 | 2442 | 2441 | 2440 | | V40122 | V40322 |
| 2477 | 2476 | 2475 | 2474 | 2473 | 2472 | 2471 | 2470 | 2467 | 2466 | 2465 | 2464 | 2463 | 2462 | 2461 | 2460 | | V40123 | V40323 |
| 2517 | 2516 | 2515 | 2514 | 2513 | 2512 | 2511 | 2510 | 2507 | 2506 | 2505 | 2504 | 2503 | 2502 | 2501 | 2500 | | V40124 | V40324 |
| 2537 | 2536 | 2535 | 2534 | 2533 | 2532 | 2531 | 2530 | 2527 | 2526 | 2525 | 2524 | 2523 | 2522 | 2521 | 2520 | | V40125 | V40325 |
| 2557 | 2556 | 2555 | 2554 | 2553 | 2552 | 2551 | 2550 | 2547 | 2546 | 2545 | 2544 | 2543 | 2542 | 2541 | 2540 | | V40126 | V40326 |
| 2577 | 2576 | 2575 | 2574 | 2573 | 2572 | 2571 | 2570 | 2567 | 2566 | 2565 | 2564 | 2563 | 2562 | 2561 | 2560 | | V40127 | V40327 |
| 2617 | 2616 | 2615 | 2614 | 2613 | 2612 | 2611 | 2610 | 2607 | 2606 | 2605 | 2604 | 2603 | 2602 | 2601 | 2600 | | V40130 | V40330 |
| 2637 | 2636 | 2635 | 2634 | 2633 | 2632 | 2631 | 2630 | 2627 | 2626 | 2625 | 2624 | 2623 | 2622 | 2621 | 2620 | | V40131 | V40331 |
| 2657 | 2656 | 2655 | 2654 | 2653 | 2652 | 2651 | 2650 | 2647 | 2646 | 2645 | 2644 | 2643 | 2642 | 2641 | 2640 | | V40132 | V40332 |
| 2677 | 2676 | 2675 | 2674 | 2673 | 2672 | 2671 | 2670 | 2667 | 2666 | 2665 | 2664 | 2663 | 2662 | 2661 | 2660 | | V40133 | V40333 |
| 2717 | 2716 | 2715 | 2714 | 2713 | 2712 | 2711 | 2710 | 2707 | 2706 | 2705 | 2704 | 2703 | 2702 | 2701 | 2700 | | V40134 | V40334 |
| 2737 | 2736 | 2735 | 2734 | 2733 | 2732 | 2731 | 2730 | 2727 | 2726 | 2725 | 2724 | 2723 | 2722 | 2721 | 2720 | | V40135 | V40335 |
| 2757 | 2756 | 2755 | 2754 | 2753 | 2752 | 2751 | 2750 | 2747 | 2746 | 2745 | 2744 | 2743 | 2742 | 2741 | 2740 | | V40136 | V40336 |
| 2777 | 2776 | 2775 | 2774 | 2773 | 2772 | 2771 | 2770 | 2767 | 2766 | 2765 | 2764 | 2763 | 2762 | 2761 | 2760 | | V40137 | V40337 |

# Remote I/O Bit Map (D2-260 and D2-262 only), Continued

| MSB | Additional Remote I/O (GX) and (GY) Points for D2-260 and D2-262 CPUs | | | | | | | | | | | | | | | LSB | GX Address | GY Address |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 | | | |
| 3017 | 3016 | 3015 | 3014 | 3013 | 3012 | 3011 | 3010 | 3007 | 3006 | 3005 | 3004 | 3003 | 3002 | 3001 | 3000 | V40140 | V40340 |
| 3037 | 3036 | 3035 | 3034 | 3033 | 3032 | 3031 | 3030 | 3027 | 3026 | 3025 | 3024 | 3023 | 3022 | 3021 | 3020 | V40141 | V40341 |
| 3057 | 3056 | 3055 | 3054 | 3053 | 3052 | 3051 | 3050 | 3047 | 3046 | 3045 | 3044 | 3043 | 3042 | 3041 | 3040 | V40142 | V40342 |
| 3077 | 3076 | 3075 | 3074 | 3073 | 3072 | 3071 | 3070 | 3067 | 3066 | 3065 | 3064 | 3063 | 3062 | 3061 | 3060 | V40143 | V40343 |
| 3117 | 3116 | 3115 | 3114 | 3113 | 3112 | 3111 | 3110 | 3107 | 3106 | 3105 | 3104 | 3103 | 3102 | 3101 | 3100 | V40144 | V40344 |
| 3137 | 3136 | 3135 | 3134 | 3133 | 3132 | 3131 | 3130 | 3127 | 3126 | 3125 | 3124 | 3123 | 3122 | 3121 | 3120 | V40145 | V40345 |
| 3157 | 3156 | 3155 | 3154 | 3153 | 3152 | 3151 | 3150 | 3147 | 3146 | 3145 | 3144 | 3143 | 3142 | 3141 | 3140 | V40146 | V40346 |
| 3177 | 3176 | 3175 | 3174 | 3173 | 3172 | 3171 | 3170 | 3167 | 3166 | 3165 | 3164 | 3163 | 3162 | 3161 | 3160 | V40147 | V40347 |
| 3217 | 3216 | 3215 | 3214 | 3213 | 3212 | 3211 | 3210 | 3207 | 3206 | 3205 | 3204 | 3203 | 3202 | 3201 | 3200 | V40150 | V40350 |
| 3237 | 3236 | 3235 | 3234 | 3233 | 3232 | 3231 | 3230 | 3227 | 3226 | 3225 | 3224 | 3223 | 3222 | 3221 | 3220 | V40151 | V40351 |
| 3257 | 3256 | 3255 | 3254 | 3253 | 3252 | 3251 | 3250 | 3247 | 3246 | 3245 | 3244 | 3243 | 3242 | 3241 | 3240 | V40152 | V40352 |
| 3277 | 3276 | 3275 | 3274 | 3273 | 3272 | 3271 | 3270 | 3267 | 3266 | 3265 | 3264 | 3263 | 3262 | 3261 | 3260 | V40153 | V40353 |
| 3317 | 3316 | 3315 | 3314 | 3313 | 3312 | 3311 | 3310 | 3307 | 3306 | 3305 | 3304 | 3303 | 3302 | 3301 | 3300 | V40154 | V40354 |
| 3337 | 3336 | 3335 | 3334 | 3333 | 3332 | 3331 | 3330 | 3327 | 3326 | 3325 | 3324 | 3323 | 3322 | 3321 | 3320 | V40155 | V40355 |
| 3357 | 3356 | 3355 | 3354 | 3353 | 3352 | 3351 | 3350 | 3347 | 3346 | 3345 | 3344 | 3343 | 3342 | 3341 | 3340 | V40156 | V40356 |
| 3377 | 3376 | 3375 | 3374 | 3373 | 3372 | 3371 | 3370 | 3367 | 3366 | 3365 | 3364 | 3363 | 3362 | 3361 | 3360 | V40157 | V40357 |
| 3417 | 3416 | 3415 | 3414 | 3413 | 3412 | 3411 | 3410 | 3407 | 3406 | 3405 | 3404 | 3403 | 3402 | 3401 | 3400 | V40160 | V40360 |
| 3437 | 3436 | 3435 | 3434 | 3433 | 3432 | 3431 | 3430 | 3427 | 3426 | 3425 | 3424 | 3423 | 3422 | 3421 | 3420 | V40161 | V40361 |
| 3457 | 3456 | 3455 | 3454 | 3453 | 3452 | 3451 | 3450 | 3447 | 3446 | 3445 | 3444 | 3443 | 3442 | 3441 | 3440 | V40162 | V40362 |
| 3477 | 3476 | 3475 | 3474 | 3473 | 3472 | 3471 | 3470 | 3467 | 3466 | 3465 | 3464 | 3463 | 3462 | 3461 | 3460 | V40163 | V40363 |
| 3517 | 3516 | 3515 | 3514 | 3513 | 3512 | 3511 | 3510 | 3507 | 3506 | 3505 | 3504 | 3503 | 3502 | 3501 | 3500 | V40164 | V40364 |
| 3537 | 3536 | 3535 | 3534 | 3533 | 3532 | 3531 | 3530 | 3527 | 3526 | 3525 | 3524 | 3523 | 3522 | 3521 | 3520 | V40165 | V40365 |
| 3557 | 3556 | 3555 | 3554 | 3553 | 3552 | 3551 | 3550 | 3547 | 3546 | 3545 | 3544 | 3543 | 3542 | 3541 | 3540 | V40166 | V40366 |
| 3577 | 3576 | 3575 | 3574 | 3573 | 3572 | 3571 | 3570 | 3567 | 3566 | 3565 | 3564 | 3563 | 3562 | 3561 | 3560 | V40167 | V40367 |
| 3617 | 3616 | 3615 | 3614 | 3613 | 3612 | 3611 | 3610 | 3607 | 3606 | 3605 | 3604 | 3603 | 3602 | 3601 | 3600 | V40170 | V40370 |
| 3637 | 3636 | 3635 | 3634 | 3633 | 3632 | 3631 | 3630 | 3627 | 3626 | 3625 | 3624 | 3623 | 3622 | 3621 | 3620 | V40171 | V40371 |
| 3657 | 3656 | 3655 | 3654 | 3653 | 3652 | 3651 | 3650 | 3647 | 3646 | 3645 | 3644 | 3643 | 3642 | 3641 | 3640 | V40172 | V40372 |
| 3677 | 3676 | 3675 | 3674 | 3673 | 3672 | 3671 | 3670 | 3667 | 3666 | 3665 | 3664 | 3663 | 3662 | 3661 | 3660 | V40173 | V40373 |
| 3717 | 3716 | 3715 | 3714 | 3713 | 3712 | 3711 | 3710 | 3707 | 3706 | 3705 | 3704 | 3703 | 3702 | 3701 | 3700 | V40174 | V40374 |
| 3737 | 3736 | 3735 | 3734 | 3733 | 3732 | 3731 | 3730 | 3727 | 3726 | 3725 | 3724 | 3723 | 3722 | 3721 | 3720 | V40175 | V40375 |
| 3757 | 3756 | 3755 | 3754 | 3753 | 3752 | 3751 | 3750 | 3747 | 3746 | 3745 | 3744 | 3743 | 3742 | 3741 | 3740 | V40176 | V40376 |
| 3777 | 3776 | 3775 | 3774 | 3773 | 3772 | 3771 | 3770 | 3767 | 3766 | 3765 | 3764 | 3763 | 3762 | 3761 | 3760 | V40177 | V40377 |