

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

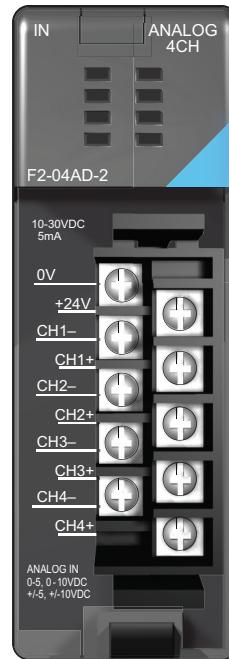
Module Specifications

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F2-04AD-2L is Obsolete



F2-04AD-2



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.

Chapter 3: F2-04AD-2, F2-04AD-2L, 4-Channel Analog Voltage Input

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, ± 5 V, ± 10 V
Resolution	12 bit (1 in 4096) unipolar (0–4096) 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 20M Ω
Absolute Maximum Ratings	± 75 VDC
Converter Type	Successive approximation
Linearity Error (End to End)	± 1 count (0.025% of span) maximum unipolar ± 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	$\pm 0.1\%$ @ 25°C (77°F) $\pm 0.3\%$ 0–60°C (32–140°F)
Accuracy vs. Temperature	± 50 ppm / °C full scale calibration change (including maximum offset change of 2 counts)

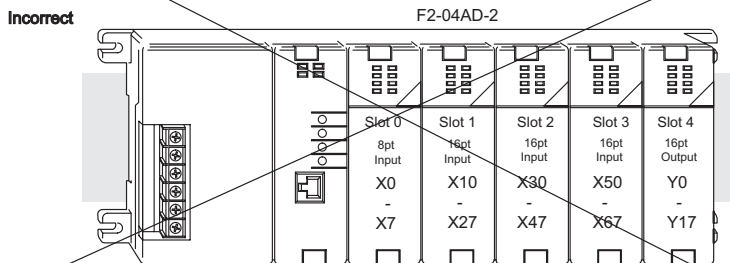
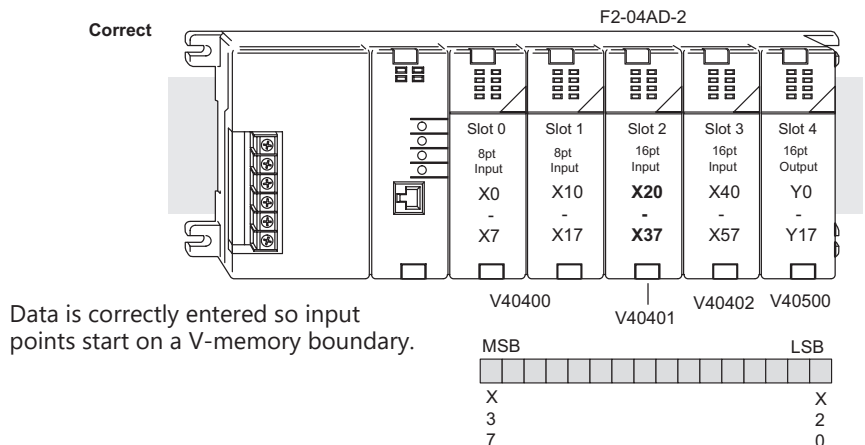
General Specifications	
PLC Update Rate	1 channel per scan maximum (D2-230 CPU) 4 channels per scan maximum (D2-240/D2-250-1/D2-260/D2-262 CPU)
Digital Inputs Input points required	12 binary data bits, 2 channel ID bits, 1 sign/diagnostic bit, 1 diagnostic bit 16 point (X) input module
Power Budget Requirement	110mA (*60mA maximum, 5VDC (supplied by base)
External Power Supply	F2-04AD-2: 5mA, 10–30 VDC (*90mA max, 18–26.4 VDC) 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.



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.

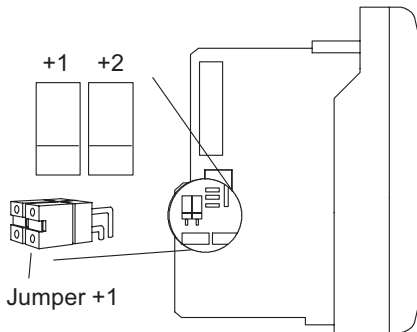
No. of Channels	+1	+2
1	No	No
1, 2	Yes	No
1, 2, 3	No	Yes
1, 2, 3, 4	Yes	Yes

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

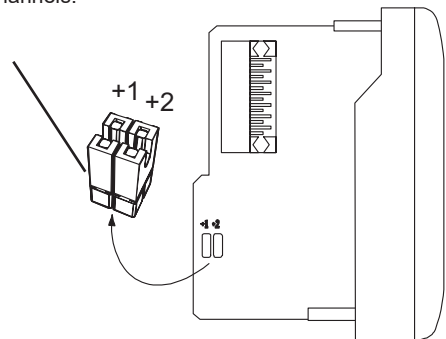
Jumper location on modules having Date Code 0609F4 and previous (two circuit board design)



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.



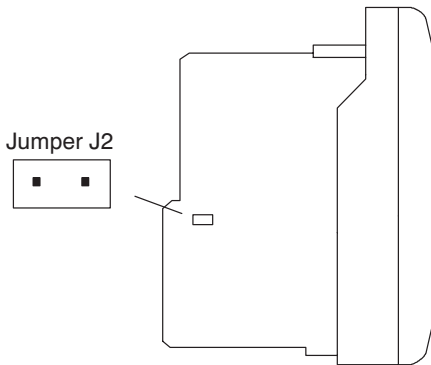
Selecting the Input Signal Range

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 $\pm 5V$ operation.
Remove J2 or J3, or store on a single pin, for 0–10 V or $\pm 10V$ operation.

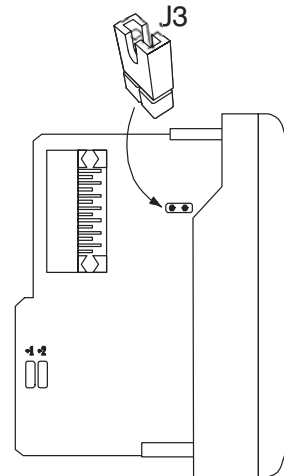
Jumper J2 location on modules having
Date Code 0609F4 and previous
(two circuit board design)



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

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

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



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



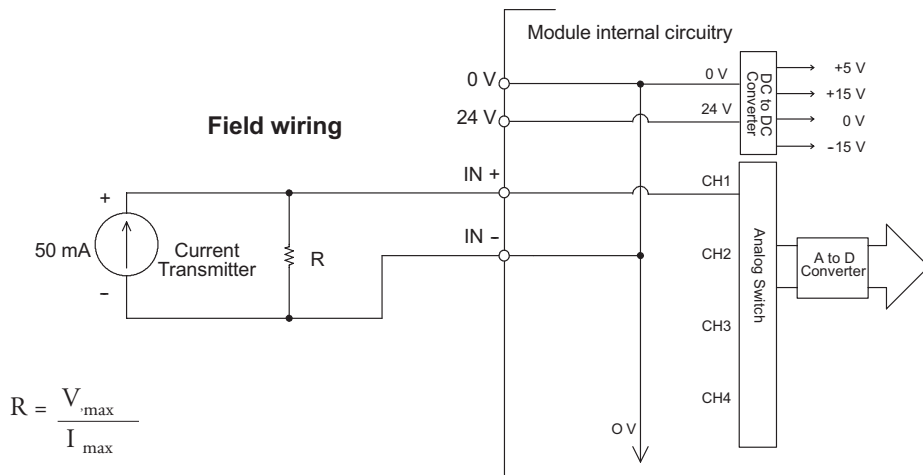
WARNING: If the 24VDC base power supply is used, Be sure to calculate the power budget. Exceeding the power budget can cause unpredictable system operation that can lead to a risk of personal injury or damage to equipment.

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 = 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.

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



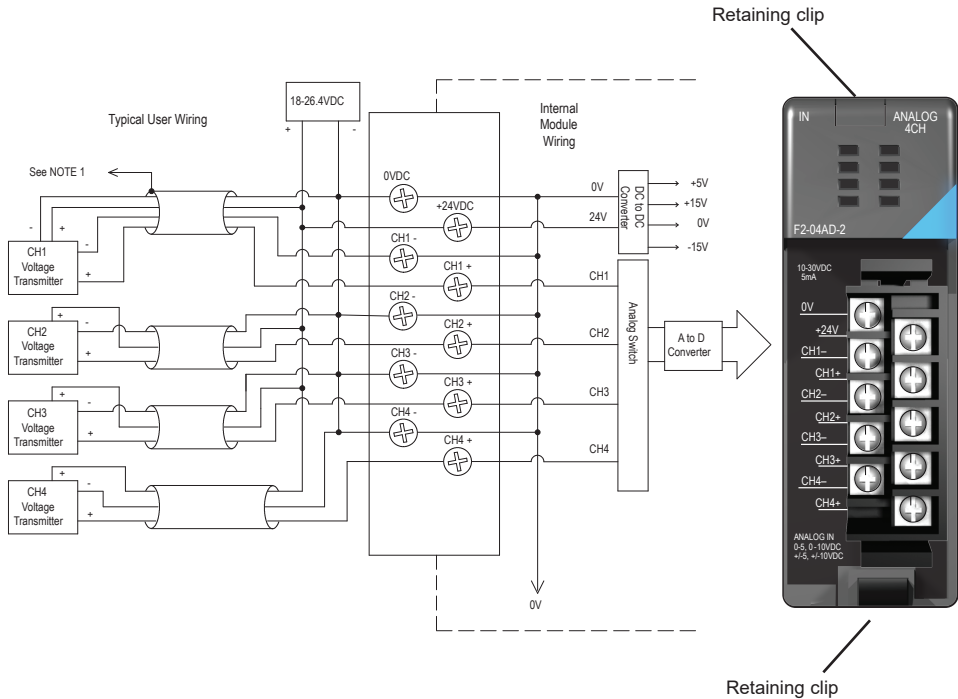
NOTE: The choice of resistor can affect the accuracy of the module. A resistor that has $\pm 0.1\%$ tolerance and a ± 50 ppm/ $^{\circ}\text{C}$ temperature coefficient is recommended.

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



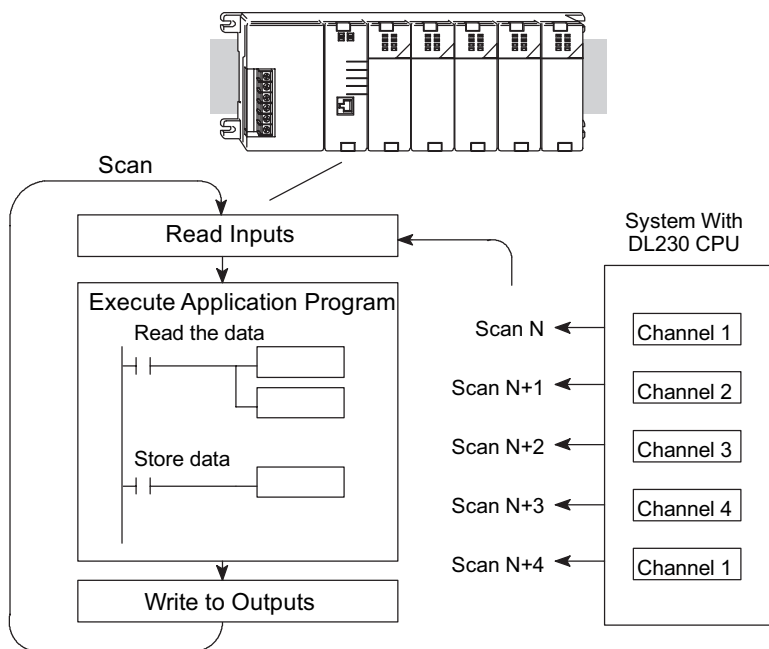
NOTE: Shields should be grounded at the signal source.

Module Operation

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

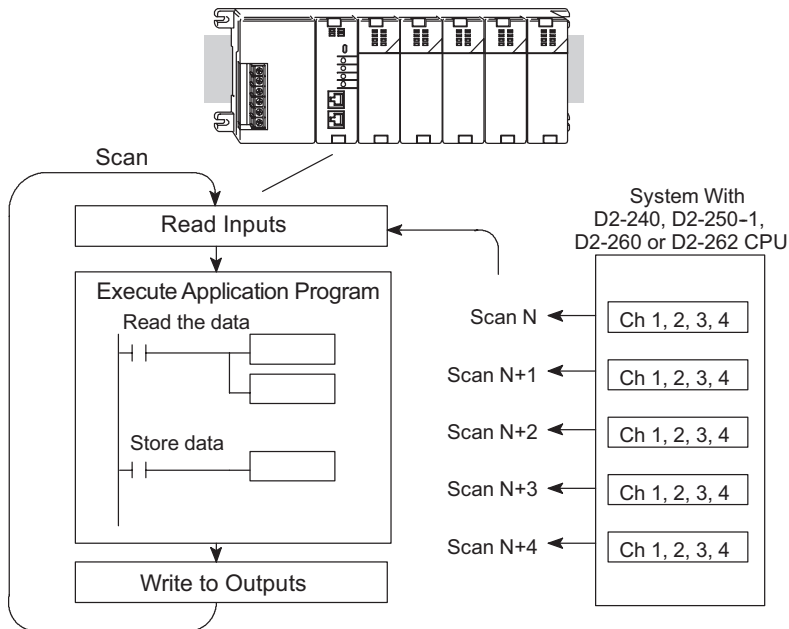
Before beginning to write the control program, it is important to take a few minutes to understand how the module processes and represents the analog signals.

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.

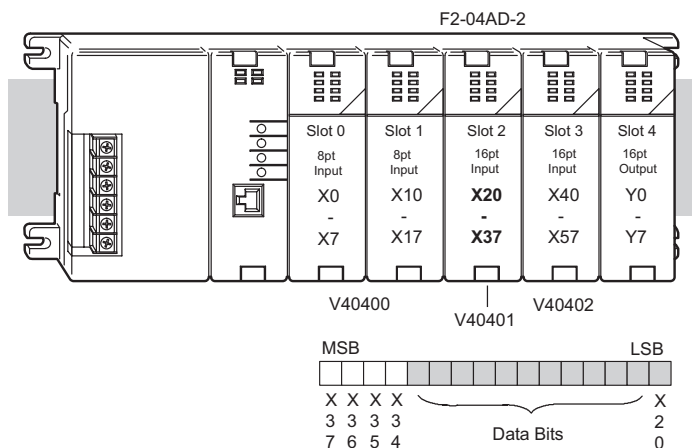
Understanding Input Assignments

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.

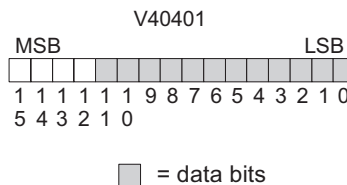
Within these word locations, the individual bits represent specific information about the analog signal.



Analog Data Bits

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

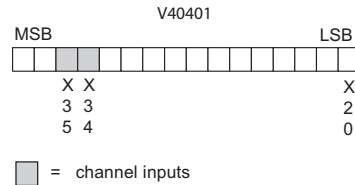
Bit	Value	Bit	Value
0	1	6	64
1	2	7	128
2	4	8	256
3	8	9	512
4	16	10	1024
5	32	11	2048



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.

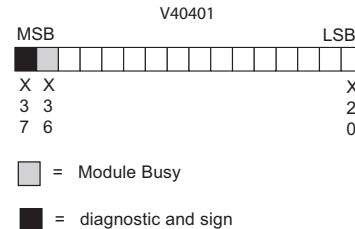
Module Busy - The first diagnostic input (X36 in this example) indicates a "busy" condition. This input will always be active on the first PLC scan, to tell the CPU the analog data is not valid. After the first scan, the input usually only comes on when extreme environmental (electrical) noise problems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



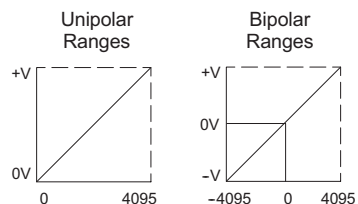
Module Resolution

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.

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.



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

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

H or L = high or low limit of the 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

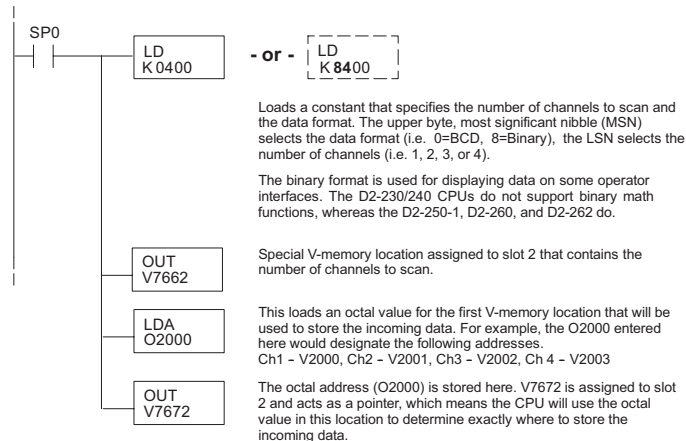
The DL205 series has special V-memory locations assigned to each base slot that will greatly simplify the programming requirements. These V-memory locations allow you to:

- 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).



Chapter 3: F2-04AD-2 , F2-04AD-2L, 4-Channel Analog Voltage Input

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.

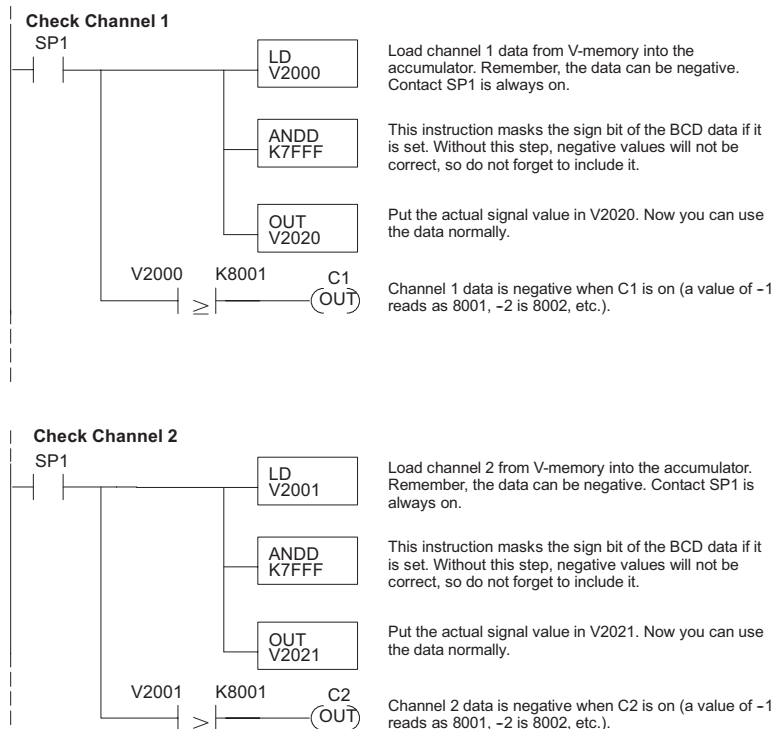
Expansion Base D2-CM #4: Analog Input Module Slot-Dependent V-memory Locations								
Slot	0	1	2	3	4	5	6	7
No. of Channels	V36300	V36301	V36302	V36303	V36304	V36305	V36306	V36307
Storage Pointer	V36310	V36311	V36312	V36313	V36314	V36315	V36316	V36317

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.



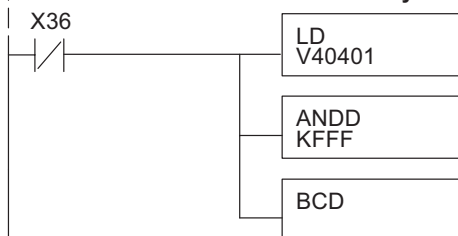
Reading Values (Multiplexing) for D2-230, D2-240, D2-250-1, D2-260 and D2-262 CPUs

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

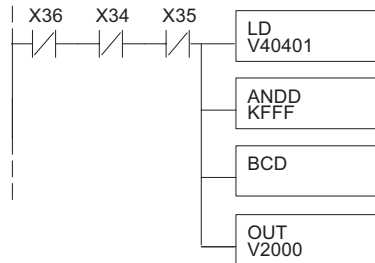


When both X34 and X35 are on, channel 4 data is stored in V2003.

Single Channel Selected

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

Store channel 1 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.

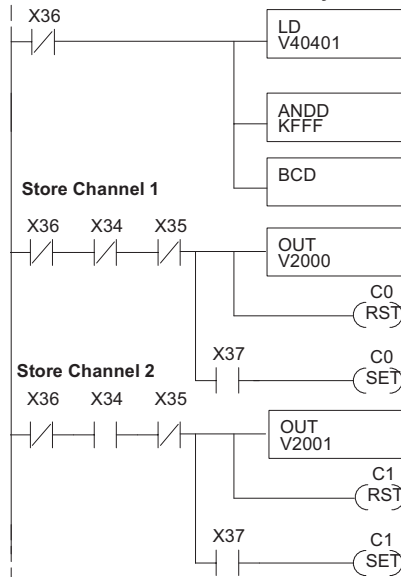
When the module is not busy and X34 and X35 are off, channel 1 data is stored in V2000.

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.

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.

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.

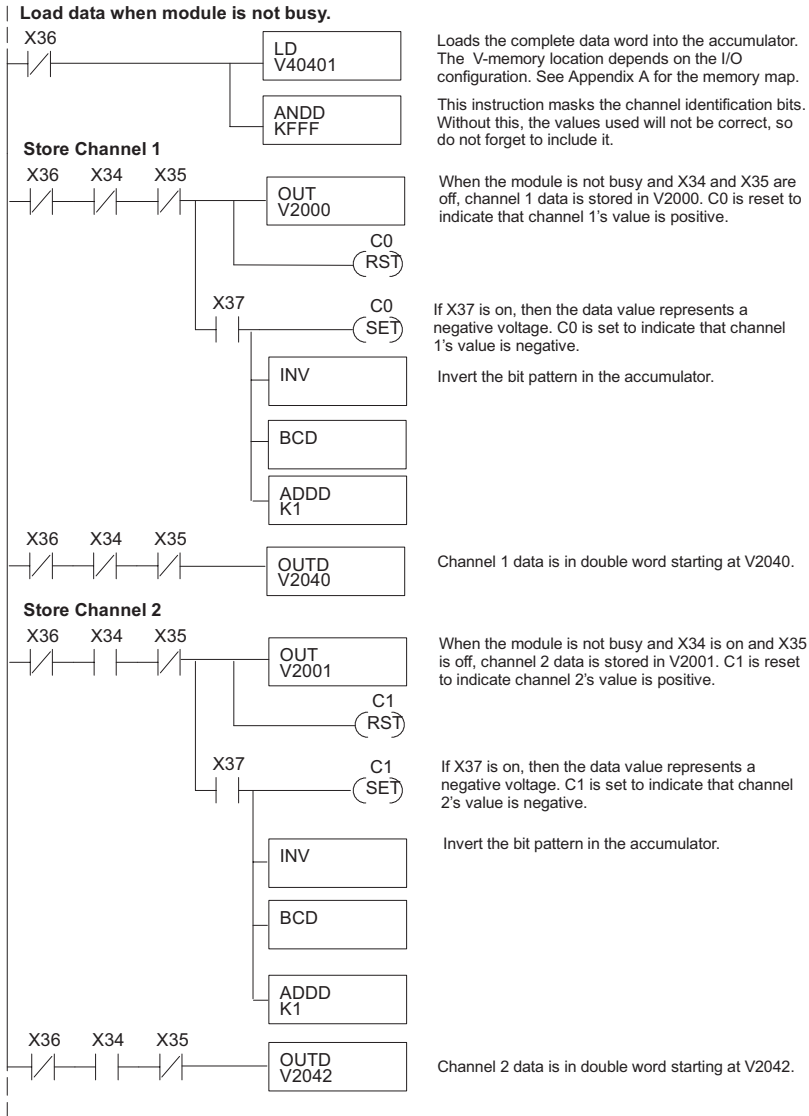
When the module is not busy, and X34 is on and X35 is off, channel 2 data is stored in V2001. C1 is reset to indicate that channel 2's value is positive.

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

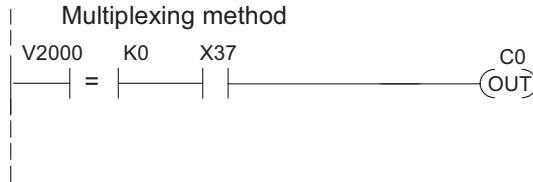
The 2's complement data format may be required to display negative values on some operator interface devices. It could also be used to simplify data averaging on bipolar signals.

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

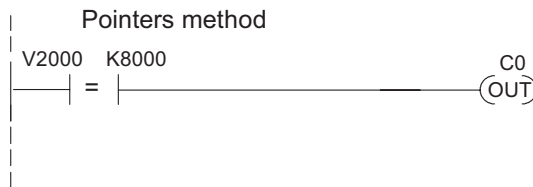


Analog Power Failure Detection

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.



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.



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.

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.

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

U = Engineering Units

A = Analog Value (0 – 4095)

H = High limit of the engineering unit range

L = Low limit of the engineering unit range

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

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

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

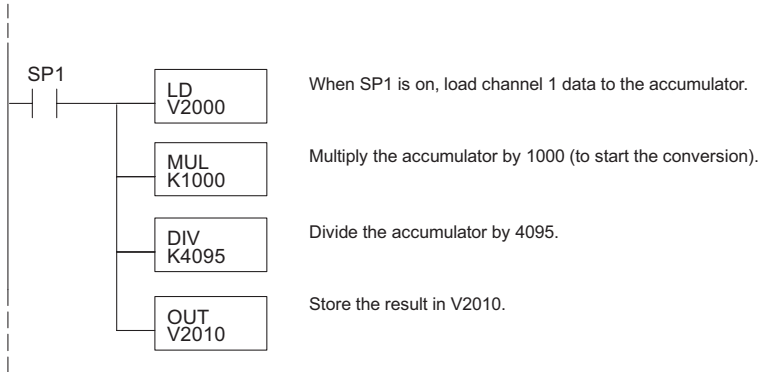
$$\text{Units} = 494$$

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.



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 -5V to +5V	$A = \frac{5D}{4095}$	$D = \frac{4095(A)}{5}$
0-0V -10V to +10V	$A = \frac{5D}{4095}$	$D = \frac{4095 \text{ ABS}(A)}{10}$

As an example, if the range being used is $\pm 10V$ 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.

$$\begin{aligned} D &= \frac{4095(A)}{10} \\ D &= \frac{4095(6V)}{10} \\ D &= (409.5)(6) \\ D &= 2457 \end{aligned}$$

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.

