F2-02DA-1, F2-02DA-1L 2-Channel Analog Current Output

Chapter 8

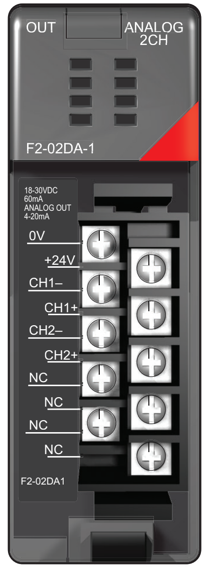
In This Chapter...

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.

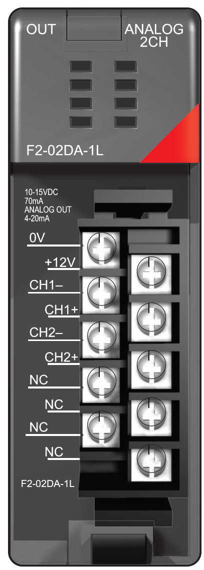
NOTE: *The F2-02DA-1 and F2-02DA-1L modules look very similar and it is very easy to mistake one module for the other. If the module being used does not work, check the terminal label to see if it is a 12V (L) or a 24V model and that it is being supplied with the proper input voltage.*



F2-02DA-1

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-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.

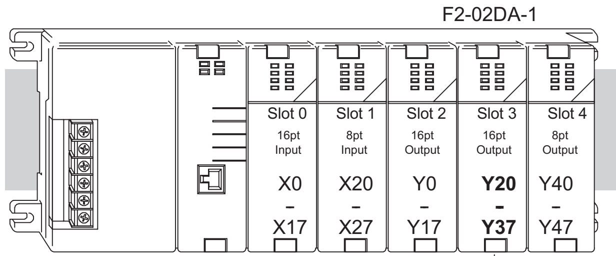
Output Specifications	
Number of Channels	2
Output Range	4–20 mA
Resolution	12 bit (1 in 4096)
Output Type	Single ended, 1 common
Maximum Loop Supply	30VDC
Peak Output Voltage	40VDC (clamped by transient voltage suppressor)
Load Impedance	0Ω minimum
Maximum Load / Power Supply	620Ω / 18V, 910Ω / 24V, 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) 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) 2 channels per scan maximum (D2-240, D2-250-1, D2-260 and D2-262 CPUs)
Digital Outputs Output Points Required	12 binary data bits, 2 channel ID bits 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 F2-02DA-1L: 12VDC (±10%), 70mA (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

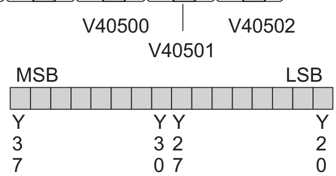
Special Placement Requirements (D2-230 and Remote I/O Bases)

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.

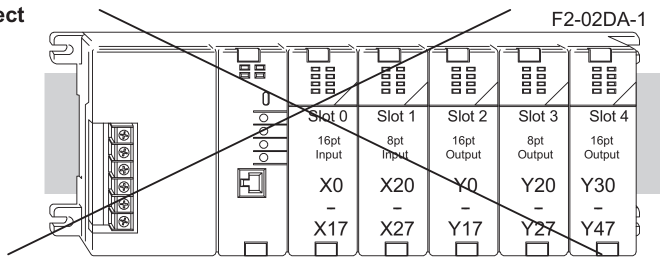
Correct!



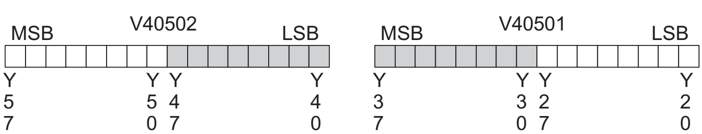
Data is correctly entered, so output points start on a V-memory boundary address from the table below.



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.

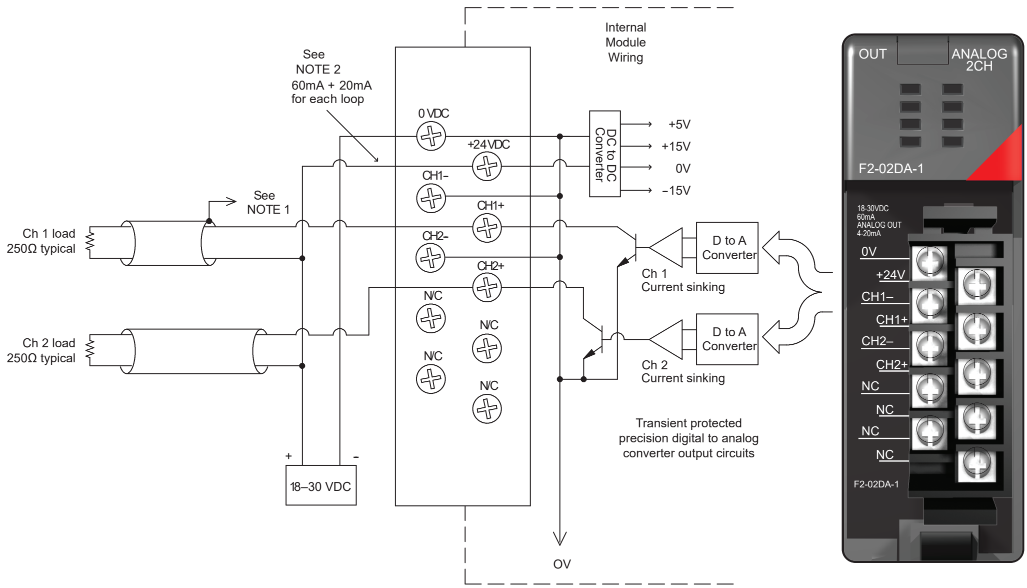
The DL205 AC bases have a built-in 24VDC power supply that provide up to 300mA of current. This can be used instead of a separate supply. Check the power budget to be safe.

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.

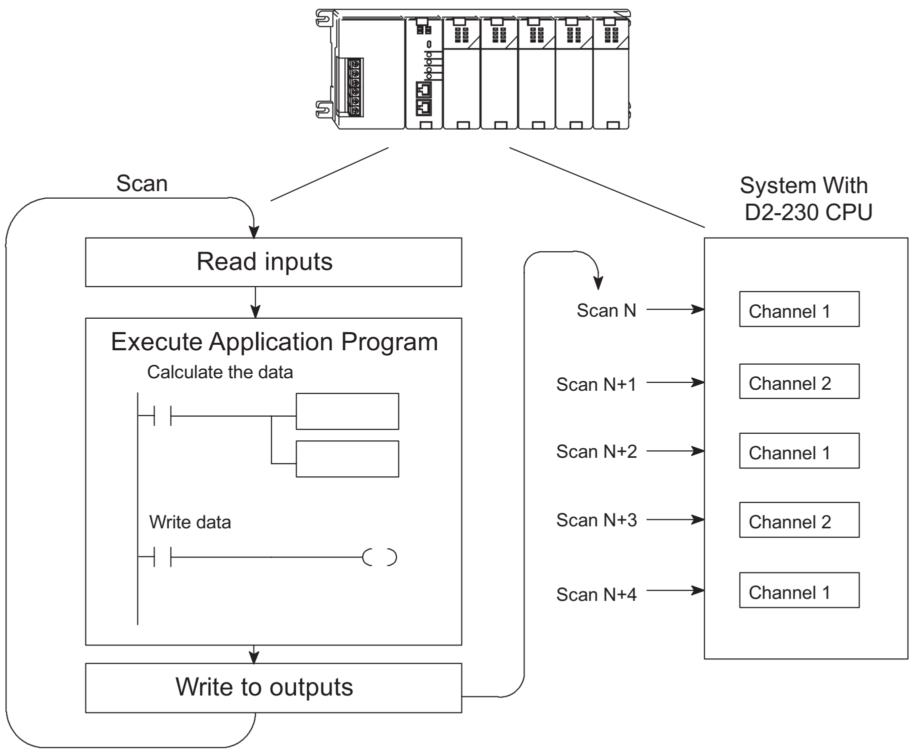
Loop Power Supply Voltage	Acceptable Load Range
30VDC	0–1200 Ω
24VDC	0–910 Ω
18VDC	0–620 Ω

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.

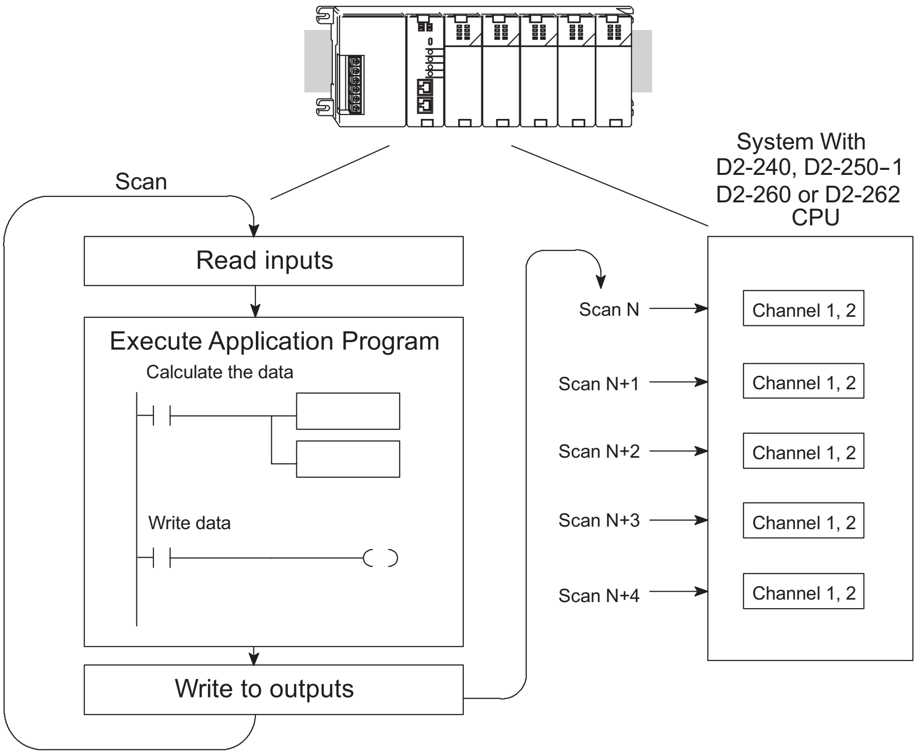
Channel Scanning Sequence (Multiplexing) for a D2-230 CPU

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

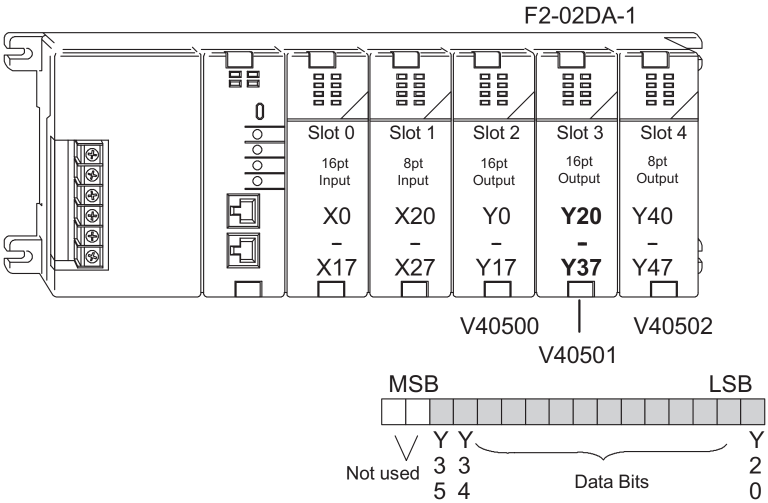
If either a D2-240, D2-250-1, D2-260 or D2-262 CPU is used, both channels can be updated on every scan. This is because the all three CPUs support special V-memory locations that are used to manage the data transfer. This is discussed in more detail in the next section in this chapter on Writing the 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.

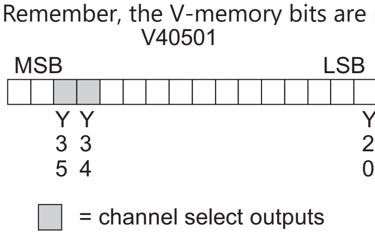
Since all output points are automatically mapped into V-memory, the location of the data word that will be assigned to the module can be simply determined.



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.

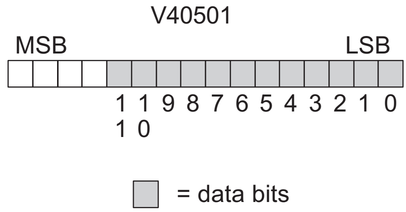


Y35	**Y34**	**Channel**
On	Off	1
Off	On	2
Off	Off	1 & 2 (same data to both channels)
On	On	None (both channels hold current values)

Analog Data Bits

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

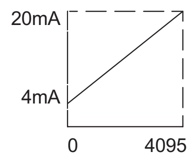
Bit	Value	Bit	Value
0	1	6	64
1	2	7	128
2	4	8	256
3	8	9	512
4	16	10	1024
5	32	11	2048



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.

4 – 20mA



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

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.

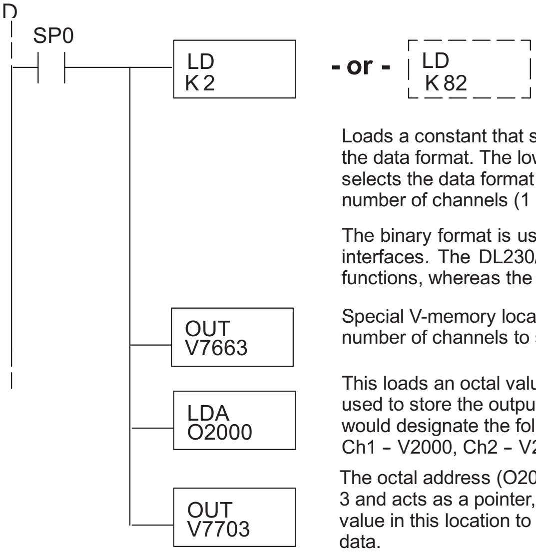
Pointer Method for the D2-240, D2-250-1, D2-260 and D2-262 CPUs

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

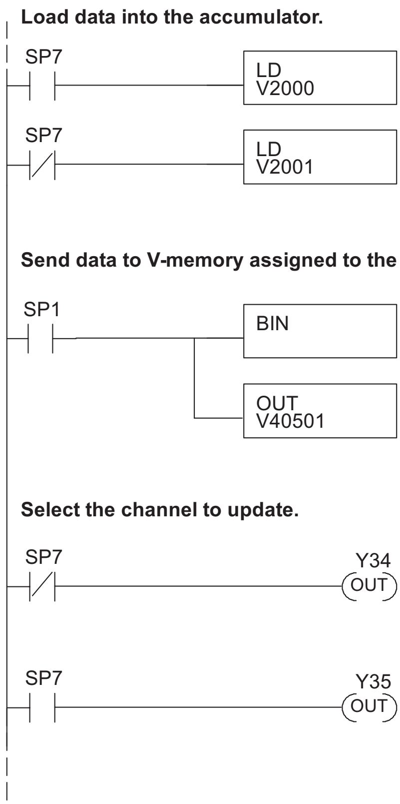
The table below applies to the D2-260 and D2-262 CPU base 4.

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.



Loads the data for channel 1 into the accumulator.

Loads the data for channel 2 into the accumulator.

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.

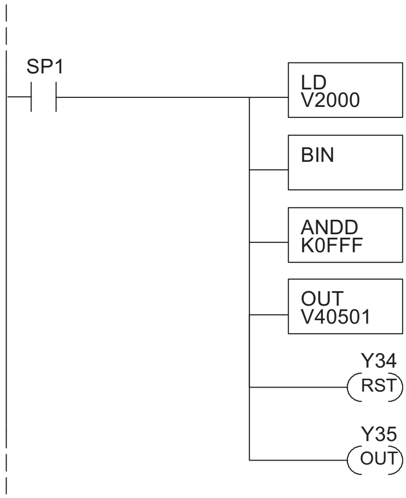
Selects channel 1 for update when Y34 is OFF (Y35-ON deselects channel 2). Note, Y34 and Y35 are used as in the previous examples. If the module was installed in a different slot the addresses would be different.

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.

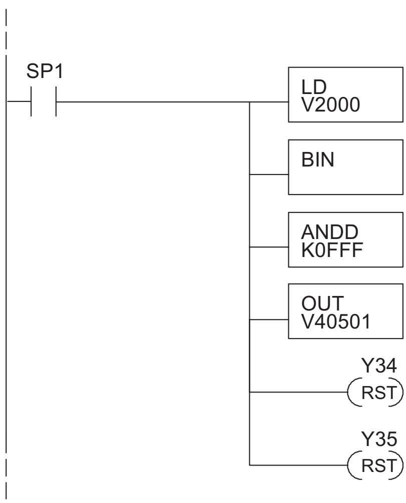
The OUT instruction writes the data to the module output. This example starts with V40501, but the actual value depends on the location of the module in your application.

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.

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

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

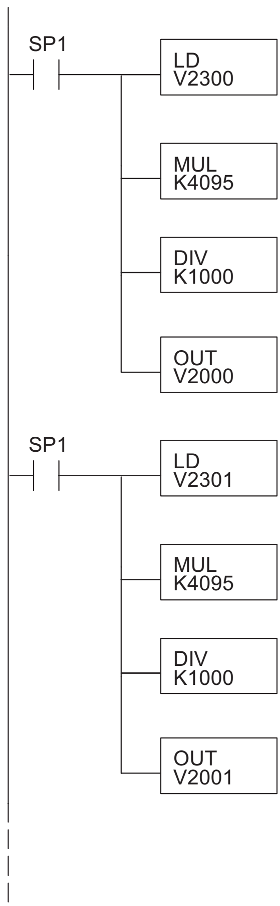
$$D = (255.93)(6)$$

$$D = 1536$$

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).