F2-08DA-2, 8-Channel Analog Voltage Output

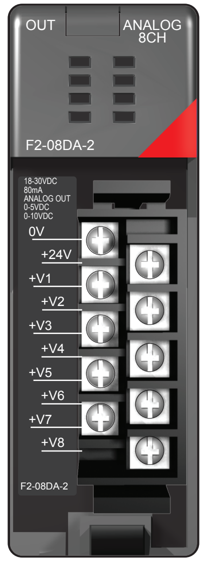
Chapter 11

In This Chapter...

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) 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) ± 0.45% 0–60°C (32–140°F)
Accuracy vs. Temperature	± 57ppm/°C full scale calibration change (Including maximum offset change of 2 counts)

General Specifications	
PLC Update Rate	1 channel per scan maximum (multiplexing) 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; 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

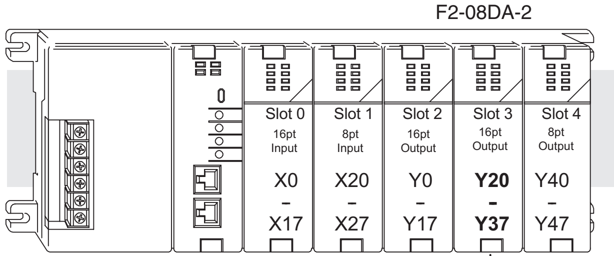
Analog Output Configuration Requirements

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.

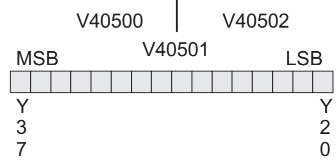
Special Placement Requirements (D2-230 and Remote I/O Bases)

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.

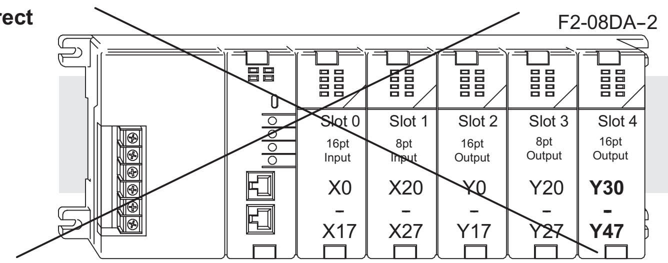
Correct!



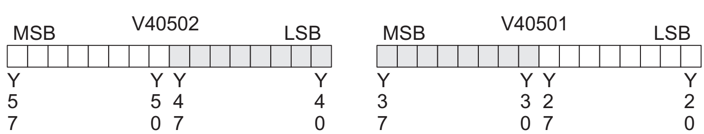
Data can be written correctly because the output points start on a V-memory boundary address as seen this table.



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).



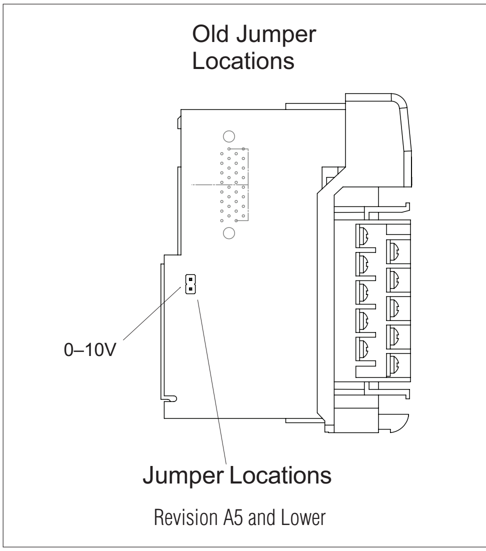
To use the V-memory references required for a D2-230 CPU, the first output address assigned to the module must be one of the following Y locations. The table also shows the V-memory addresses that correspond to these Y locations.

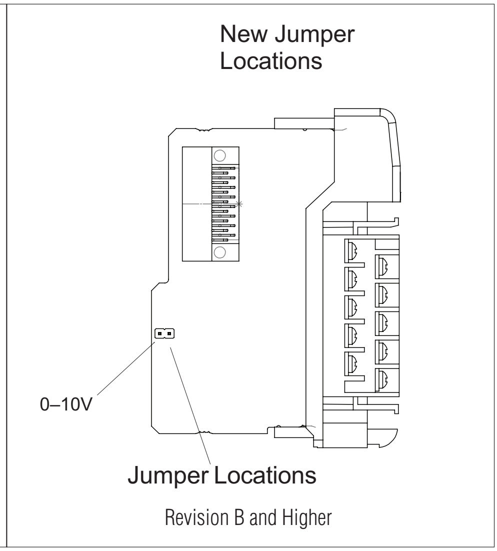
Y	Y0	Y20	Y40	Y60	Y100	Y120	Y140	
V	V40500	V40501	V40502	V40503	V40504	V40505	V40506	V40507

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.





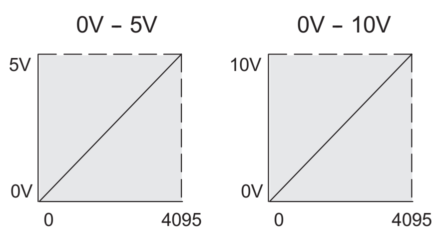
Voltage Range and Output Combinations

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.

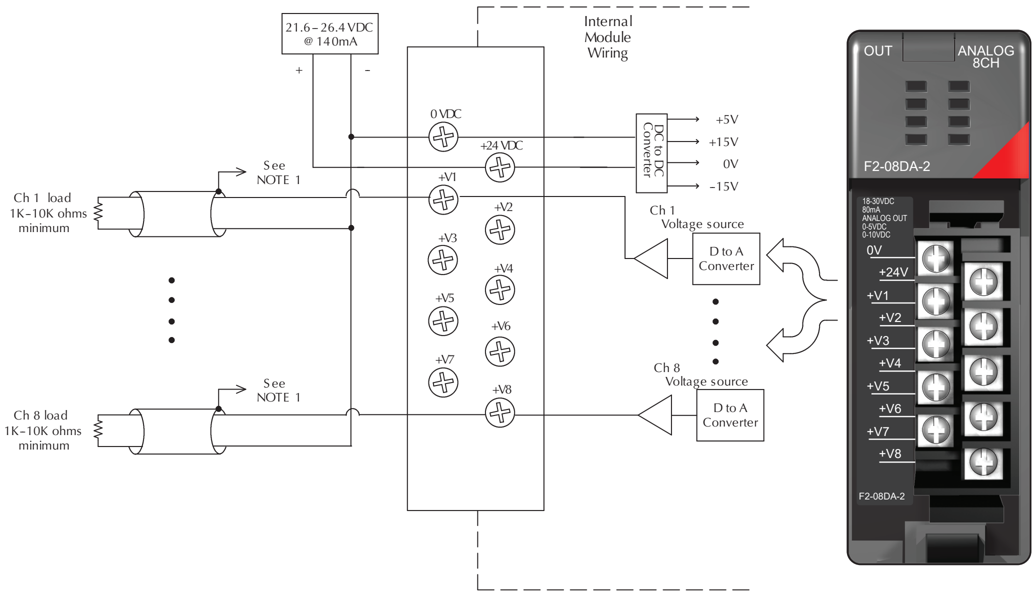
The DL205 AC bases have a built-in 24VDC power supply that provide up to 300 mA of current. This can be used instead of a separate supply. Check the power budget to be safe.

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.



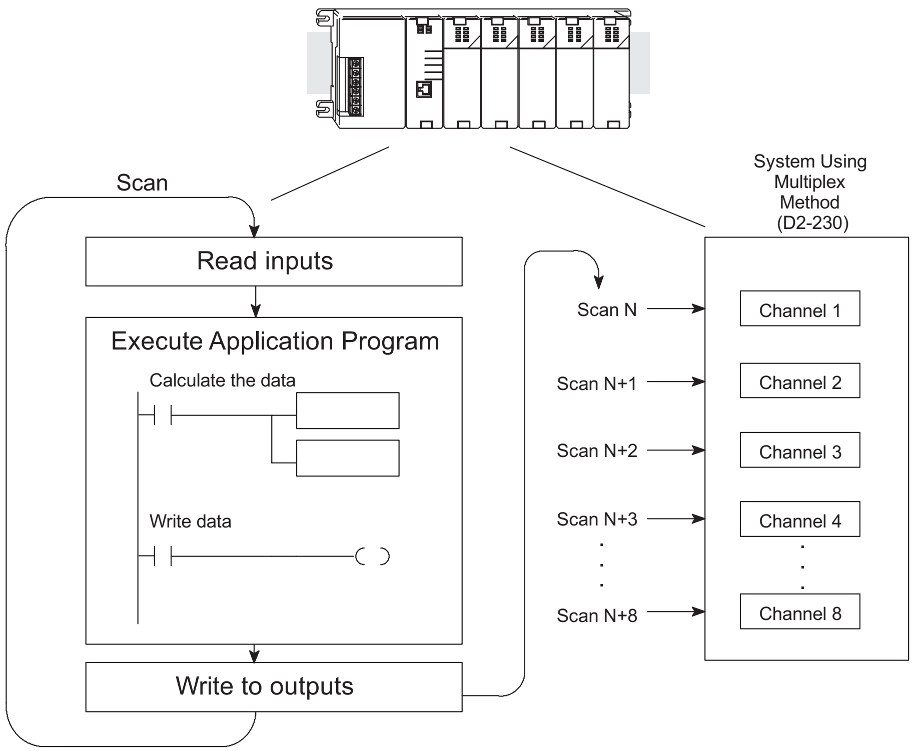
NOTE 1: *Shields should be connected to the 0V terminal of the module or 0V of the power supply.*

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.

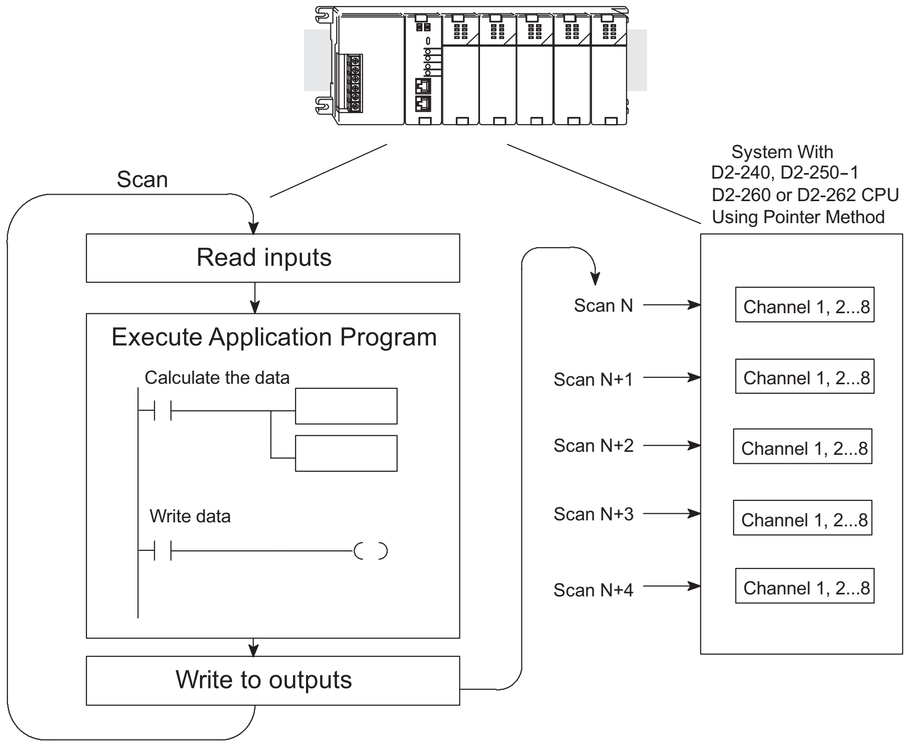
Channel Update Sequence (Multiplexing) for a D2-230 CPU

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

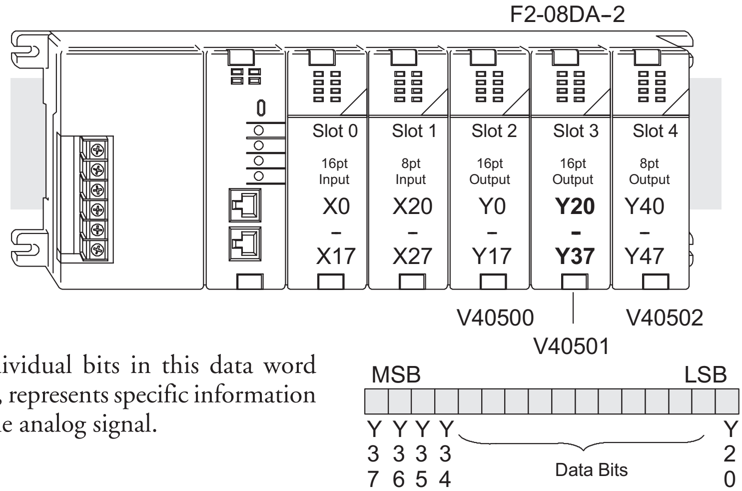
If either a D2-240, D2-250-1, D2-260 or a D2-262 CPU is used with the pointer method, all channels can be updated on every scan. This is because the three CPUs support special V-memory locations that are used to manage the data transfer. This is discussed in more detail in the section on **Writing the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

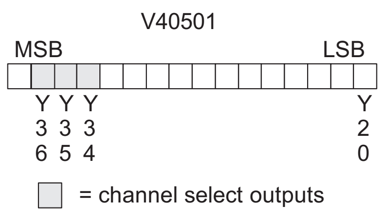
Since all output points are automatically mapped into V-memory, the location of the data word that will be assigned to the module can be simply determined.



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.

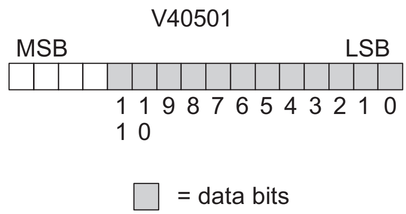


Select Channel Outputs			
Y36	Y35	Y34	Channel Number Selected
–	–	–	1
–	–	X	2
–	X	–	3
–	X	X	4
X	–	–	5
X	–	X	6
X	X	–	7
X	X	X	8

Analog Data Bits

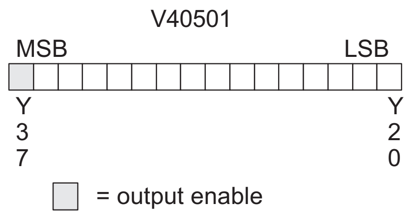
The first twelve bits represent the analog data in binary format.

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

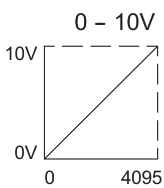
The last output can be used to update outputs. If this output is OFF, the outputs are cleared.



Module Resolution

Since the module has 12-bit resolution, the analog signal is converted into 4096 counts ranging from 0–4095 (2^{12}). 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.

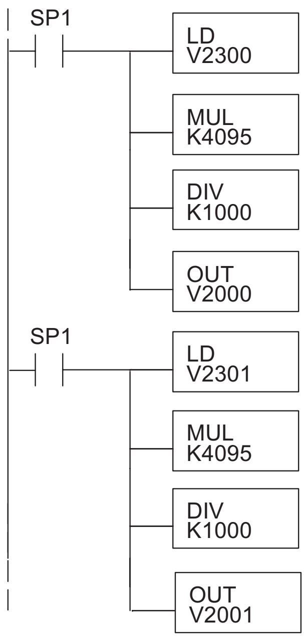
$$A = 10U \frac{4095}{10\,(H-L)} \qquad A = 494 \frac{4095}{(1000-0)} \qquad A = 2023$$

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

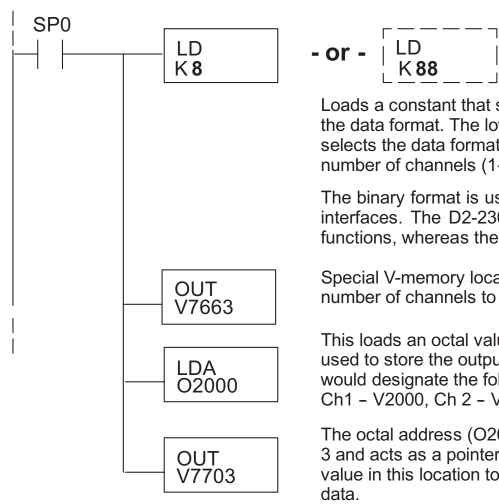
The D2-240, D2-250-1, D2-260 and D2-262 CPUs have special V-memory locations assigned to each base slot that will greatly simplify the programming requirements.

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.



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.

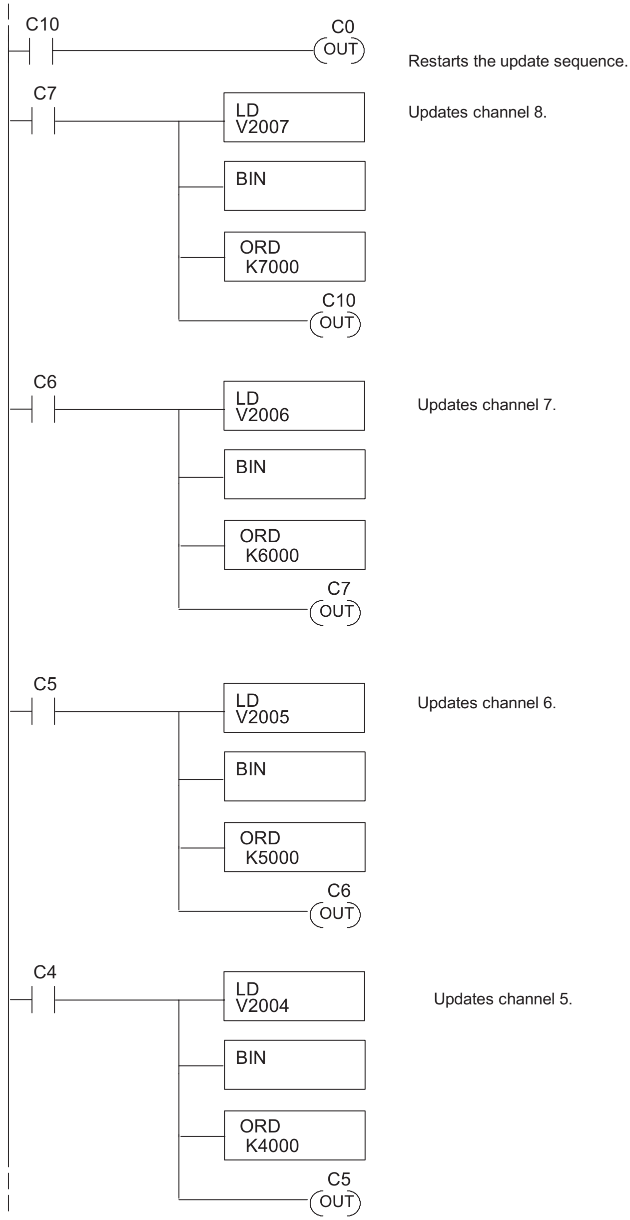
Expansion Base D2-CM #3: Analog Output Module Slot-Dependent V-memory Locations								
Slot	0	1	2	3	4	5	6	7
No. of Channels	V36200	V36201	V36202	V36203	V36204	V36205	V36206	V36207
Storage Pointer	V36220	V36221	V36222	V36223	V36224	V36225	V36226	V36227

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.



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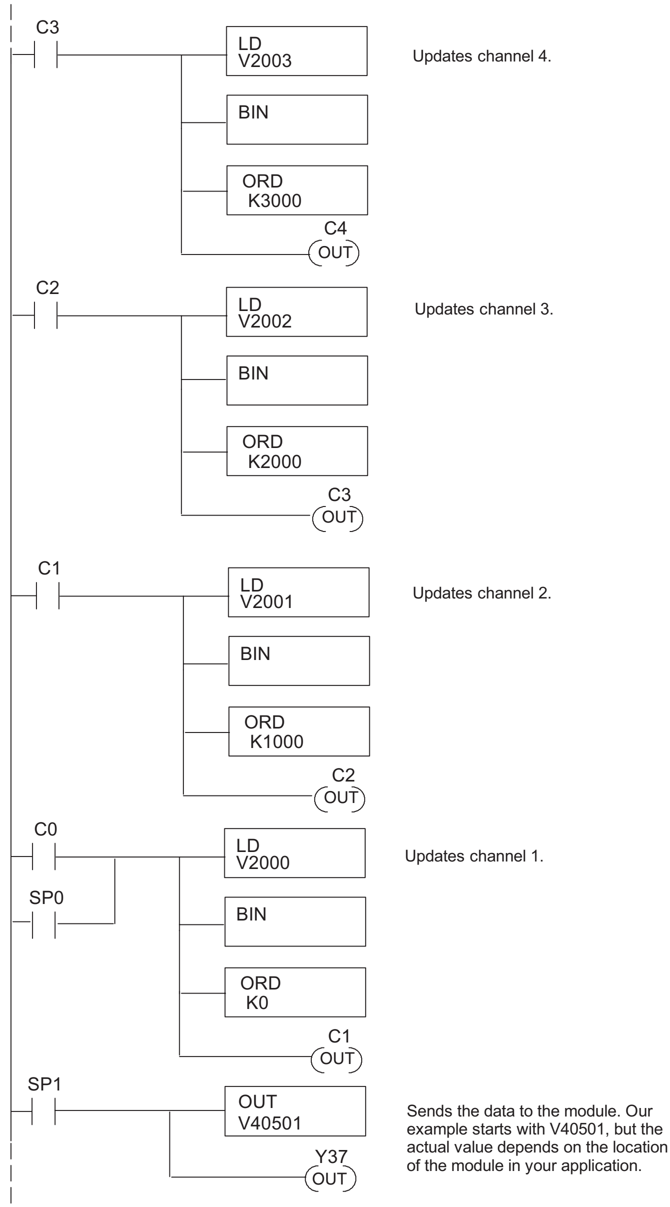
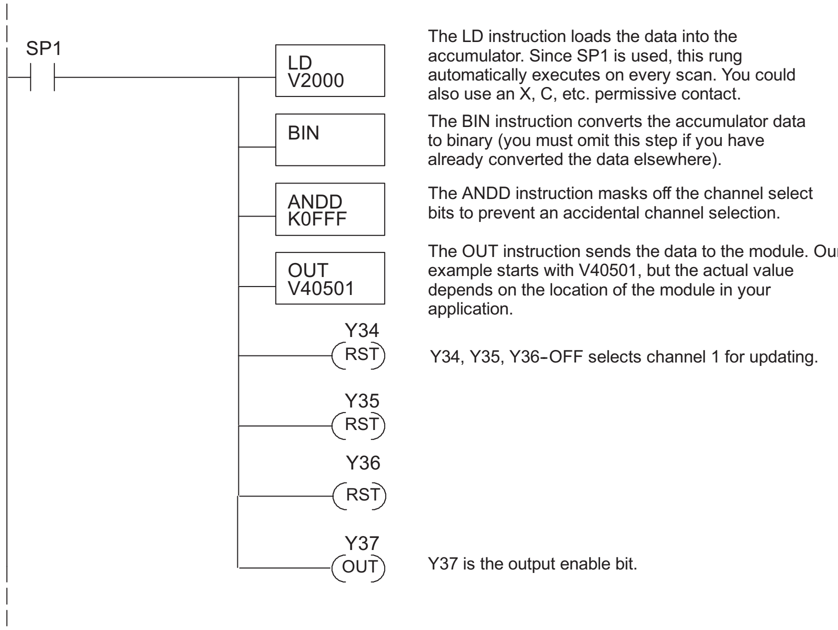
Writing Data Example (Multiplexing) continued



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.



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.

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

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

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

$$D = 2457$$