F2-08DA-1, 8-Channel Analog Current Output

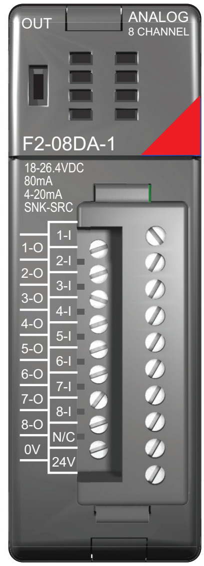
Chapter 10

In This Chapter...

Module Specifications

The F2-08DA-1 Analog Output module provides several hardware features:

- Supported by DL230, DL240, DL250-1 and DL260 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 (DL240, DL250-1 and DL260 only).
- Outputs are both current sinking and sourcing.



F2-08DA-1

Firmware Requirements:

- To use this module, DL230 CPUs must have firmware version 2.7 or later.
- To use the pointer method for writing values, DL240 CPUs require firmware version 3.0 or later.
- DL250 CPUs require firmware version 1.33 or later.

Analog Output Configuration Requirements

The F2-08DA-1 Analog output 16-point 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 – 400Ω (for loop power 18 – 30V)
Sink Load	0 – 600Ω / 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) ±12 counts maximum, sourcing (125Ω load) ±18 counts maximum, sourcing (250Ω load) ±26 counts maximum, sourcing (400Ω load)
Offset Calibration Error	±9 counts maximum, sinking (any load) ±9 counts maximum, sourcing (125Ω load) ±11 counts maximum, sourcing (250Ω load) ±13 counts maximum, sourcing (400Ω load)
Maximum Full Scale Inaccuracy @ 0–60°C	0.5% sinking (any load) & sourcing (125Ω load) 0.64% sourcing (250Ω load) 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) 0.44% sourcing (250Ω load) 0.63% sourcing (400Ω load)

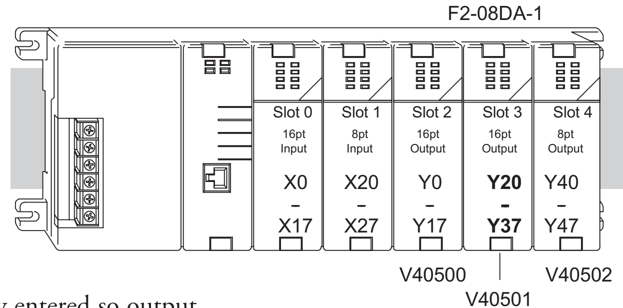
NOTE: *One count in the specifications table is equal to one least significant bit of the analog data value (1 in 4096)*

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 / 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	-20–70°C (-4–158°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

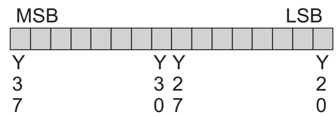
Special Placement Requirements (DL230 and Remote I/O Bases)

It is important to examine the configuration if a DL230 CPU is being used. As can be seen in the section on **Writing the Control Program**, V-memory locations are used to capture the analog data. 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.

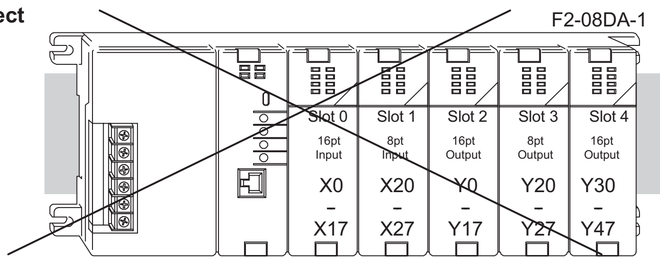
Correct!



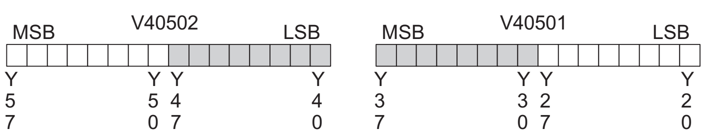
Data is correctly entered so output points start on a V-memory boundary address from the table below.



Incorrect



Data is split over two locations, so instructions cannot access data from a DL230 (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 requires an external power supply. The same or separate power sources may be used for the module supply and loop supply. The module requires 18–30 VDC, at 50mA. The two current loops also require 18–30 VDC, but at 20mA each.

The DL205 bases have internal 24VDC power supplies that provide up to 300mA of current. This power source can be used instead of a separate power supply if only a few analog modules are being used. The current required will be 50mA (module) plus 160mA (eight loops) for a total of 210mA.

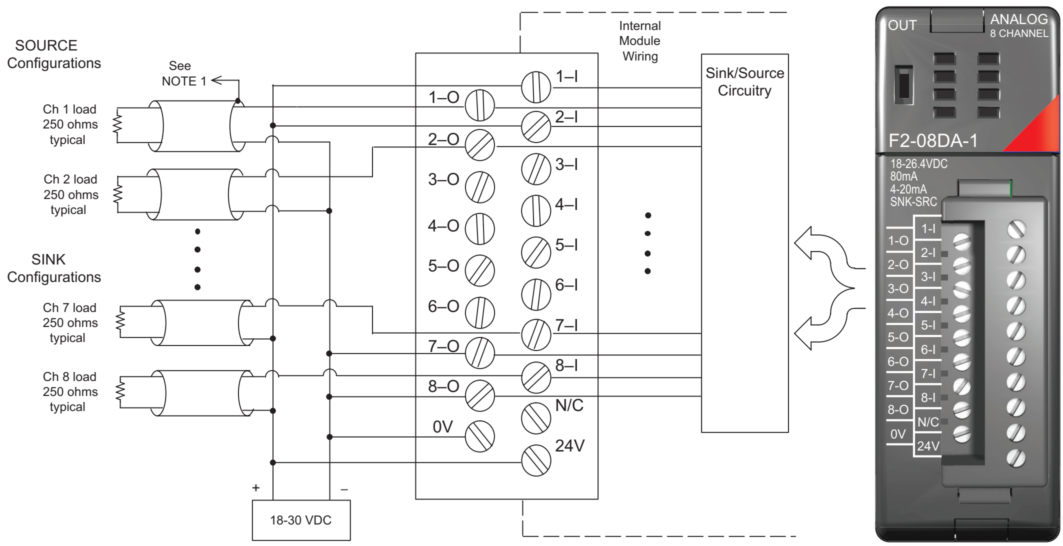
It is desirable in some situations to power the transmitters separately in a location remote from the PLC. This will work as long as the transmitter supply meets the voltage and current requirements and the transmitter's minus (-) side and the module supply's minus (-) side are connected together.

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.

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.

Typical User Wiring



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.

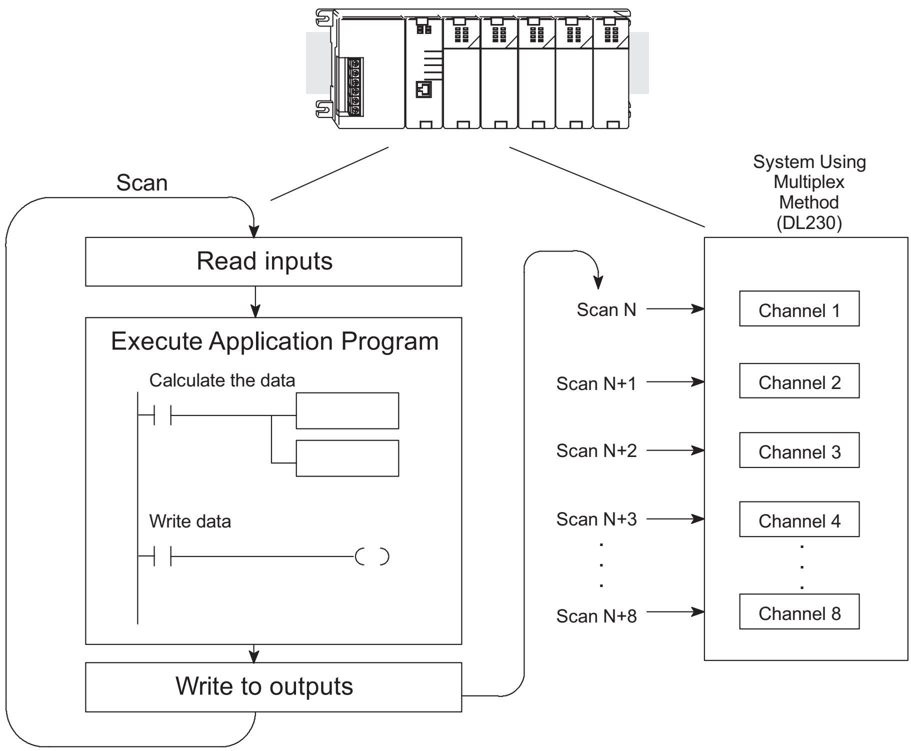
Loop Power Supply Voltage	Source Load Range	Sink Load Range
30VDC	0 – 400Ω	0 – 1200Ω
24VDC		0 – 900Ω
18VDC		0 – 600Ω

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 for a DL230 CPU (Multiplexing)

The DL230 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 DL240, DL250-1, and DL260 CPUs.



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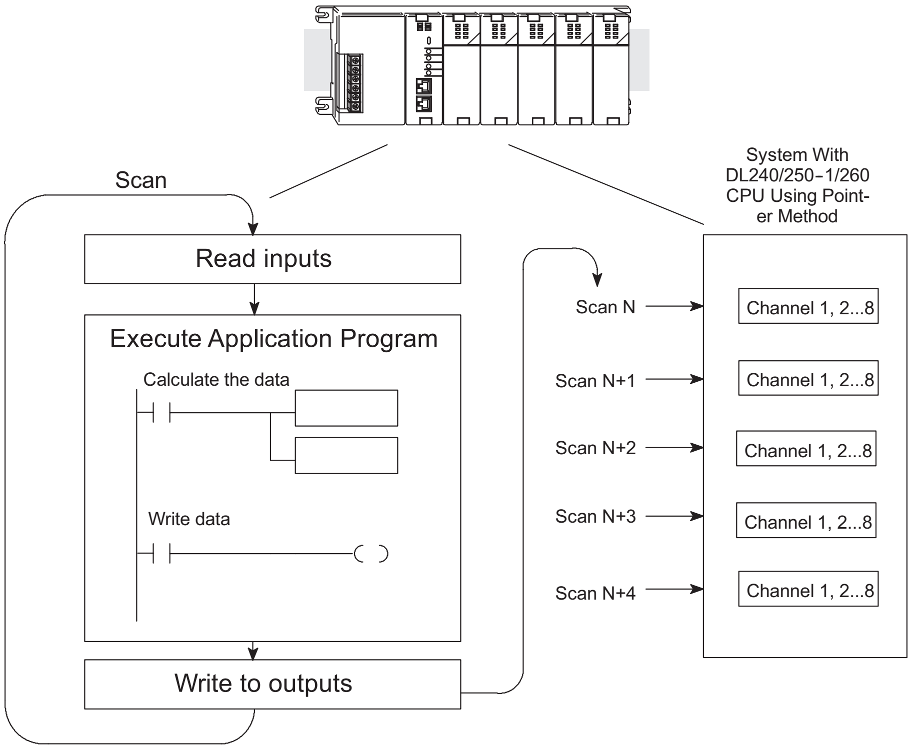
Channel Scanning Sequence for DL240, DL250-1, and DL260 CPUs (Pointer Method)

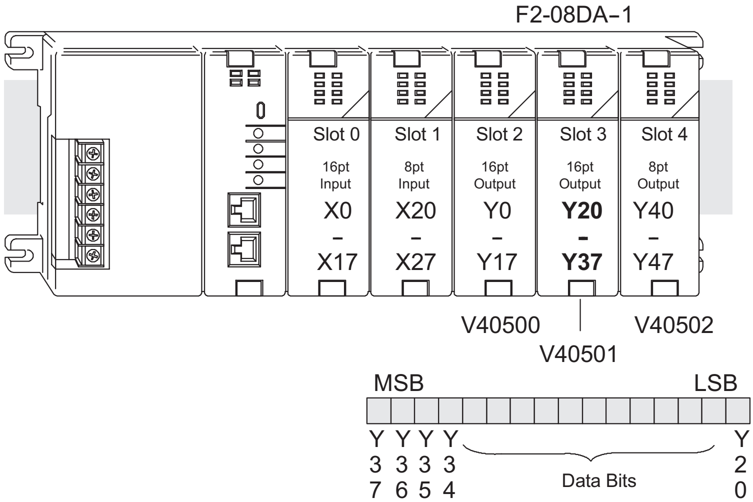
If either a DL240, DL250-1 or a DL260 CPU is used, all channels can be updated on every scan. This is because the all three CPUs support special V-memory locations that are used to manage the data transfer. This is discussed in more detail in the next section on **Writing the Control Program**.



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 DL240, DL250 or a DL260 CPU is being used, these bits may never have to be used, but it may be an aid to help understand the data format.

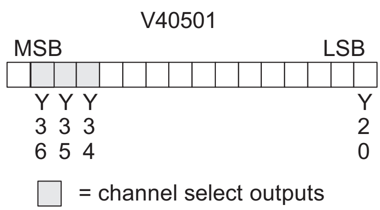
Since all output points are automatically mapped into V-memory, the location of the data word that will be assigned to the module can be simply determined.



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.

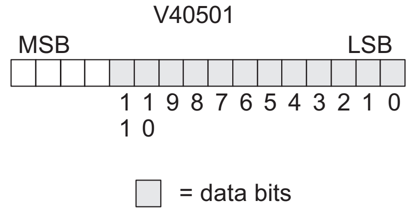


Select Channel Outputs			
Y36	**Y35**	**Y34**	**Channel Number Selected**
			1
		X	2
	X		3
	X	X	4
X			5
X		X	6
X	X		7
X	X	X	8

Analog Data Bits

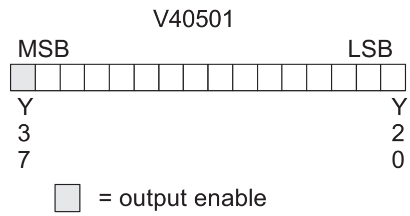
The first twelve bits represent the analog data in binary format.

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



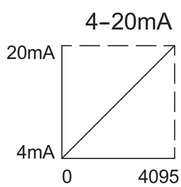
Output Enable

The last output can be used to update outputs. If this 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 (2^{12}). 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

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

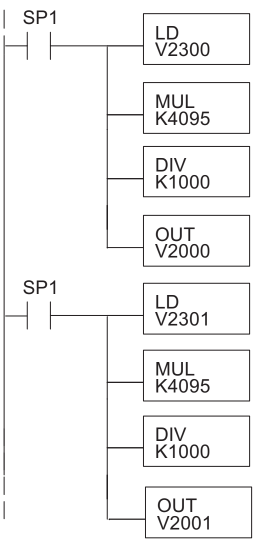
Consider the following example which controls pressure from 0.0–99.9 PSI. Using the formula will calculate the digital value to be sent to the analog output. The example shows the conversion required to yield 49.4 PSI. The multiplier of 10 is used because the decimal portion of 49.4 cannot be loaded 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).

Reading Values Pointer Method and Multiplexing

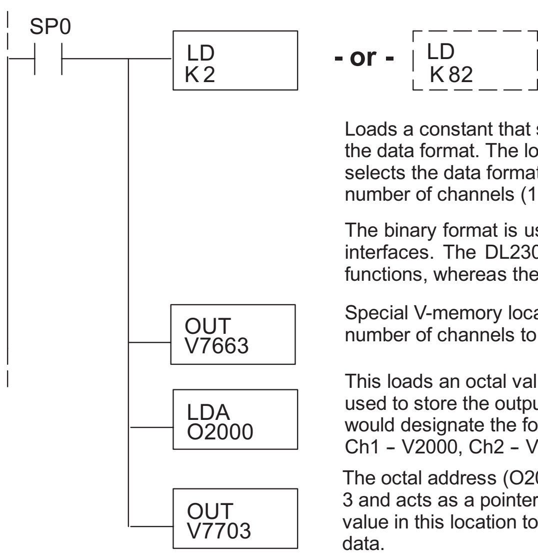
Two methods are used to read data values in the DL205, pointer and multiplexing methods. When to use either method and how to use it will be discussed here. Since the pointer method will not work if the PLC has a DL230 installed, only the multiplexing method can be used. Either method for reading the data values can be used with the DL240, DL250-1 and DL260 CPUs, however, the pointer method will simplify programming the PLC.

Pointer Method for the DL240, DL250-1 and DL260 CPUs

Once the data values have been calculated they must be entered into the program in order to output the values. The DL205 series has special V-memory locations assigned to each base slot that will greatly simplify the programming requirements. With these V-memory locations, the number of channels to update are specified, also, where to read the data that is written to the output is specified.

NOTE: *DL240 CPUs with firmware release version 1.5 or later and. DL250 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. This is all that is required to write the data to V-memory locations. Once the data has been written to V-memory math 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. 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.



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 DL240, DL250-1 and DL260 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 DL230 (multiplexing) method is used, verify that these addresses in the CPU are 0 (zero).

The table below applies to the DL240, DL250-1 and DL260 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 DL250-1 or the DL260 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 DL250-1 or the DL260 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 DL260 CPU base 3.

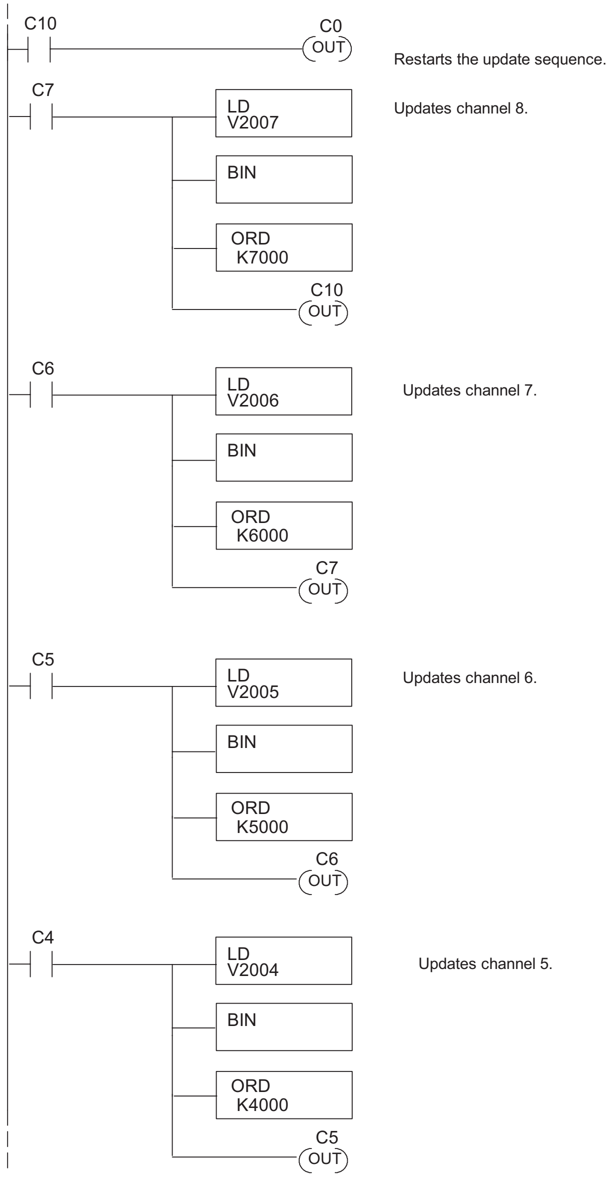
Expansion Base D2-CM #3: Analog Output Module Slot-Dependent V-memory Locations								
Slot	0	1	2	3	4	5	6	7
No. of Channels	V36200	V36201	V36202	V36203	V36204	V36205	V36206	V36207
Storage Pointer	V36220	V36221	V36222	V36223	V36224	V36225	V36226	V36227

The table below applies to the DL260 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 is used for all the DL205 CPUs.



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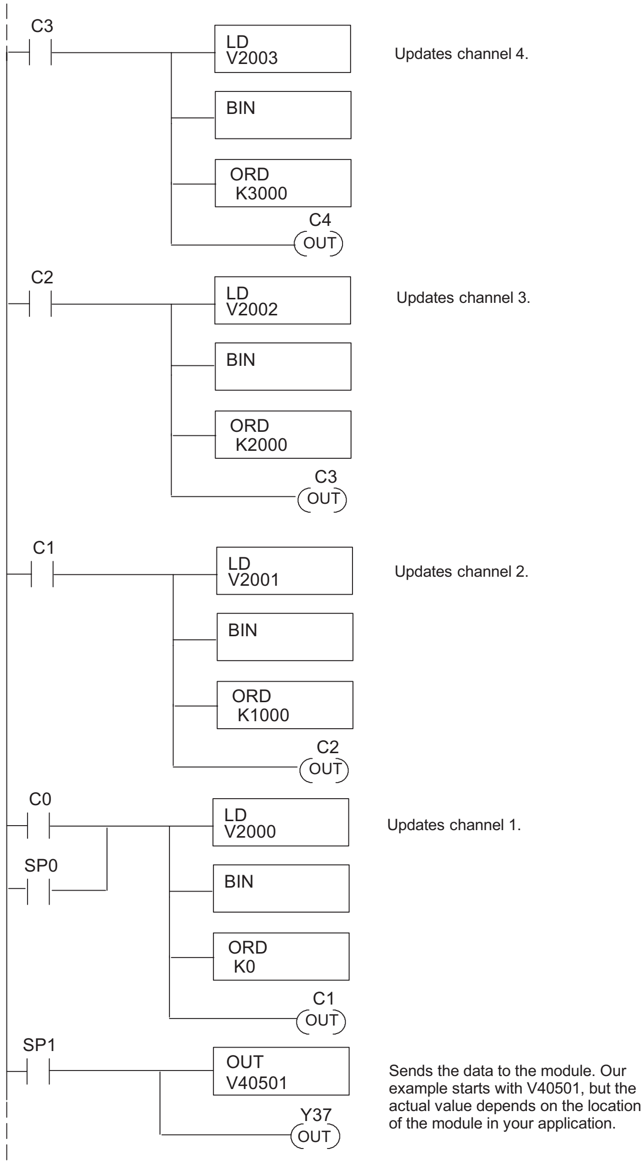
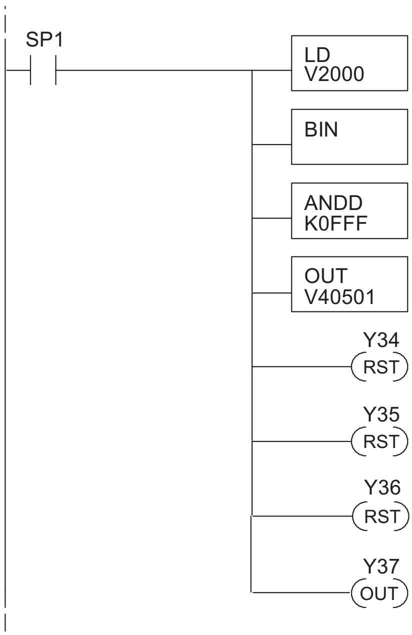
Write Data (Multiplexing Example) Continued



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

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.

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

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

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

$$D = 1536$$