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

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 module has a removable terminal block so the module can be easily removed or changed without disconnecting the wiring.

- With a DL240, DL250–1 or DL260 CPU, you can update both channels in one scan.

- F2-02DA-1: Low-power CMOS design requires less than 60mA from an external 18–30 VDC power supply.

- F2-02DA-1L: Low-power CMOS design requires less than 70mA from an external 10–15 VDC power supply.
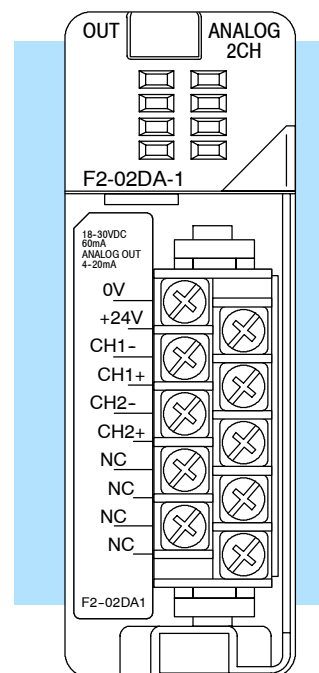
F2-02DA–1

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 your module does not work, check the terminal label to see if you have a 12 volts (L) or a 24 volts model and that it is being supplied with the proper input voltage.

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 Ranges	4 to 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 to 60°C (32 to 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) 2 channels per scan maximum (D2–240/250–1/260 CPU)
Digital outputs Output points required	12 binary data bits, 2 channel ID bits 16 point (Y) output module
Power Budget Requirement	40 mA @ 5 VDC (supplied by base)
External Power Supply	F2–02DA–1: 18-30 VDC, 60 mA F2–02DA–1L: 12-15 VDC, 70 mA (add 20 mA for each current loop used)
Operating Temperature	0 to 60° C (32 to 140° F)
Storage Temperature	–20 to 70° C (–4 to 158° F)
Relative Humidity	5 to 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

One count in the specification table is equal to one least significant bit of the analog data value (1 in 4096).
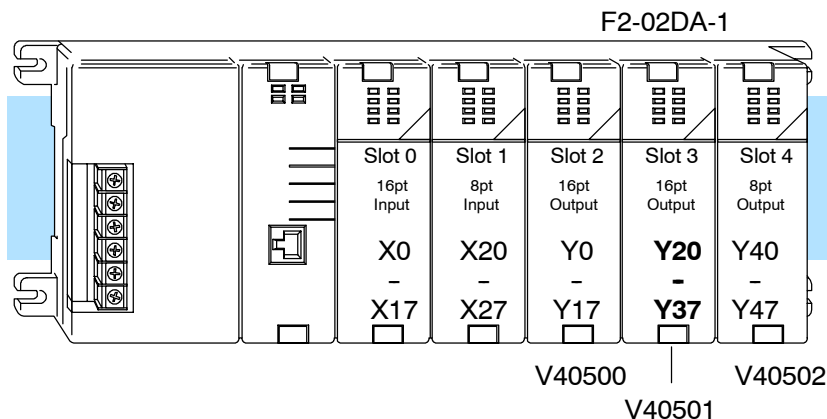
Analog Output Configuration Requirements

The F2-02DA-1 (L) Analog output appears as a 16-point discrete output module. The module can be installed in any slot if you are using a DL240 CPU (firmware V1.5 or later) or DL250 CPU. The available power budget and discrete I/O points are the limiting factors. Check the user manual for your particular model of CPU and I/O base for more information regarding power budget and number of local, local expanison or remote I/O points.
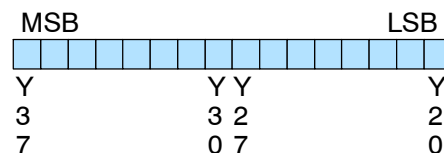
F2-02DA-1, (L) 2-Ch. Current Output

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

It is important to examine the configuration if you are using a DL230 CPU. As you can see in the section on writing the program, you use V-memory locations to send the analog data. If you place the module so that the output points do not start on a V-memory boundary, the instructions cannot access the data. This also applies when placing this module in a remote base using a D2–RSSS in the CPU slot.
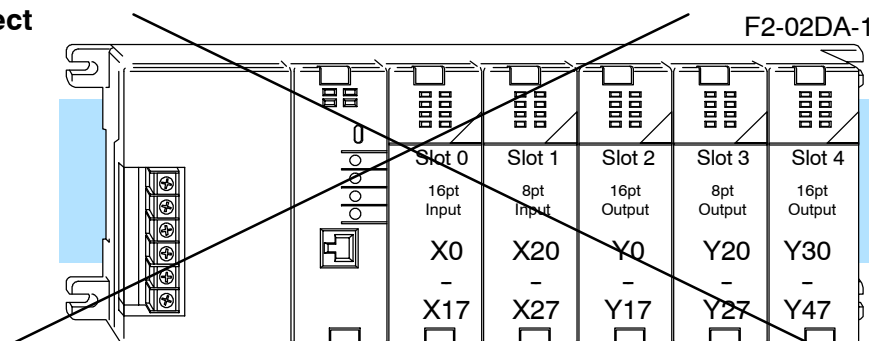
Correct!

F2-02DA-1

	Slot 0	Slot 1	Slot 2	Slot 3	Slot 4
	16pt Input	8pt Input	16pt Output	16pt Output	8pt Output
	X0 – X17	X20 – X27	Y0 – Y17	**Y20 - Y37**	Y40 – Y47

V40500   V40502

V40501

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

MSB   LSB

Y3 7   Y3 0   Y2 7   Y2 0

Incorrect

F2-02DA-1

	Slot 0	Slot 1	Slot 2	Slot 3	Slot 4
	16pt Input	8pt Input	16pt Output	8pt Output	16pt Output
	X0 – X17	X20 – X27	Y0 – Y17	Y20 – Y27	Y30 – Y47

Data is split over two locations, so instructions cannot access data from a DL230.

MSB   V40502   LSB   MSB   V40501   LSB

Y5 7   Y5 0   Y4 7   Y4 0   Y3 7   Y3 0   Y2 7   Y2 0
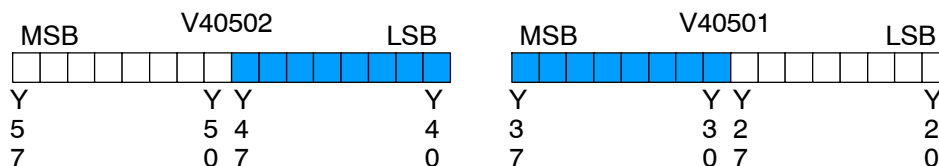
To use the required V-memory references, the *first* output address assigned to the module must be one of the following Y locations. The table also shows the V-memory addresses that correspond to these Y locations.

Y	Y0	Y20	Y40	Y60	Y100	Y120	Y140	Y160
V	V40500	V40501	V40502	V40503	V40504	V40505	V40506	V40507

Connecting the Field Wiring

**Wiring
Guidelines**

Your company may have guidelines for wiring and cable installation. If so, you should check those before you begin 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 signal source. *Do not* ground the shield at both the module and the load.
- 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) requires at least one field-side power supply. You may use the same or separate power sources for the module supply and loop supply. The module requires 18–30VDC, at 60 mA. The two current loops also require 18–30VDC, but at 20 mA each.

The DL205 bases have built-in 24 VDC power supplies that provide up to 300mA of current. You may use this instead of a separate supply if you are using only a couple of analog modules. The current required is 60 mA (module) plus 40 mA (two current loops) for a total of 100 mA.

It is desirable in some situations to power the loops separately in a location remote from the PLC. This will work as long as the loop supply meets the voltage and current requirements, and the transmitter's minus (–) side and the module supply's minus (–) side are connected together.
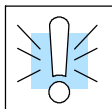
WARNING: If you are using the 24 VDC base power supply, make sure you calculate the power budget. Exceeding the power budget can cause unpredictable system operation that can lead to a risk of personal injury or damage to equipment.

F2-02DA-1, (L)
2-Ch. Current Output

Wiring Diagram   The F2-02DA-1 (L) module has a removable connector to make wiring easier. Simply squeeze the top and bottom retaining clips and gently pull the connector from the module. Use the following diagram to connect the field wiring. The diagram shows separate module and loop power supplies. If you desire to use only one field-side supply, just combine the supplies' positive (+) terminals into one node and remove the loop supply.

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

NOTE 2: Unused current outputs should remain open (no connections) for minimum power consumption.
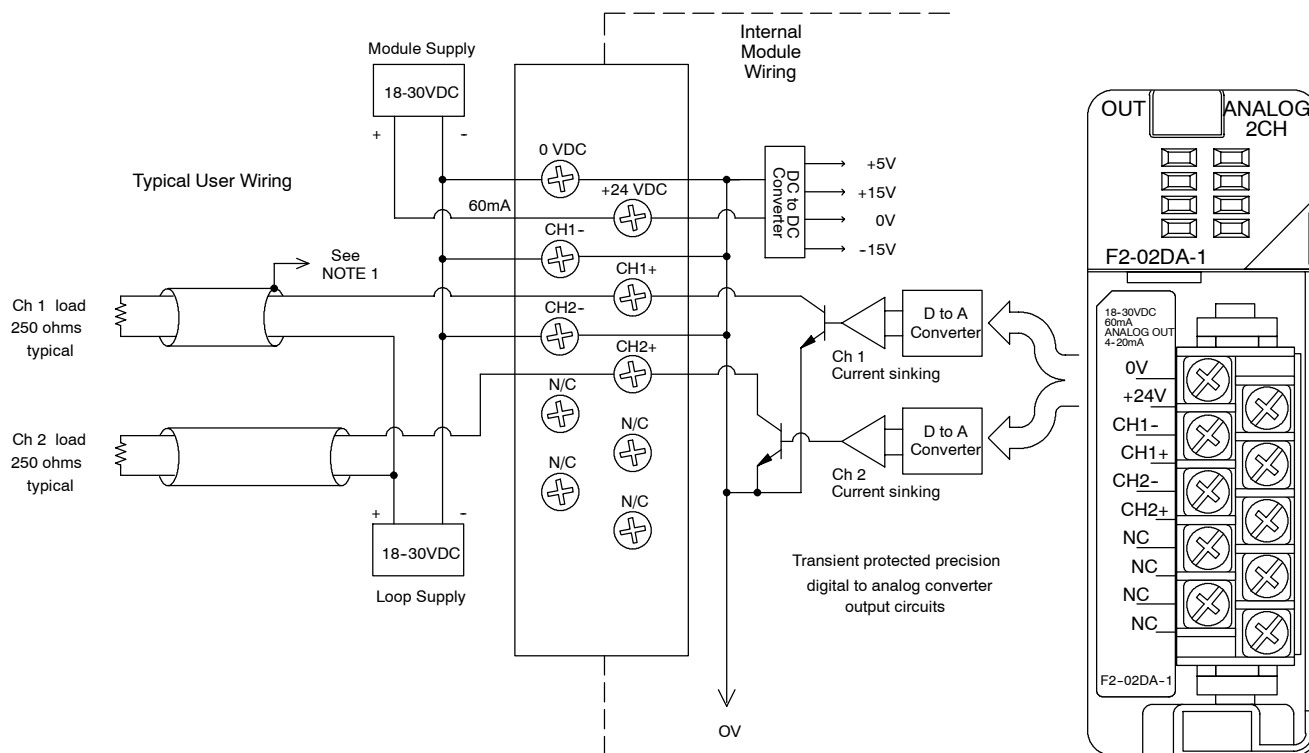
**Load Range**   The maximum load resistance depends on the particular loop power supply in use.

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

Module Operation

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

Channel Update Sequence for a DL230 CPU (Multiplexing)

If you are using a DL230 CPU, you can send one channel of data to the output module on each scan. The module refreshes both field devices on each scan, but you can only get new data 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 you are only using one channel, then you can update that channel on every scan. The multiplexing method can also be used for the DL240/250–1/260 CPUs.
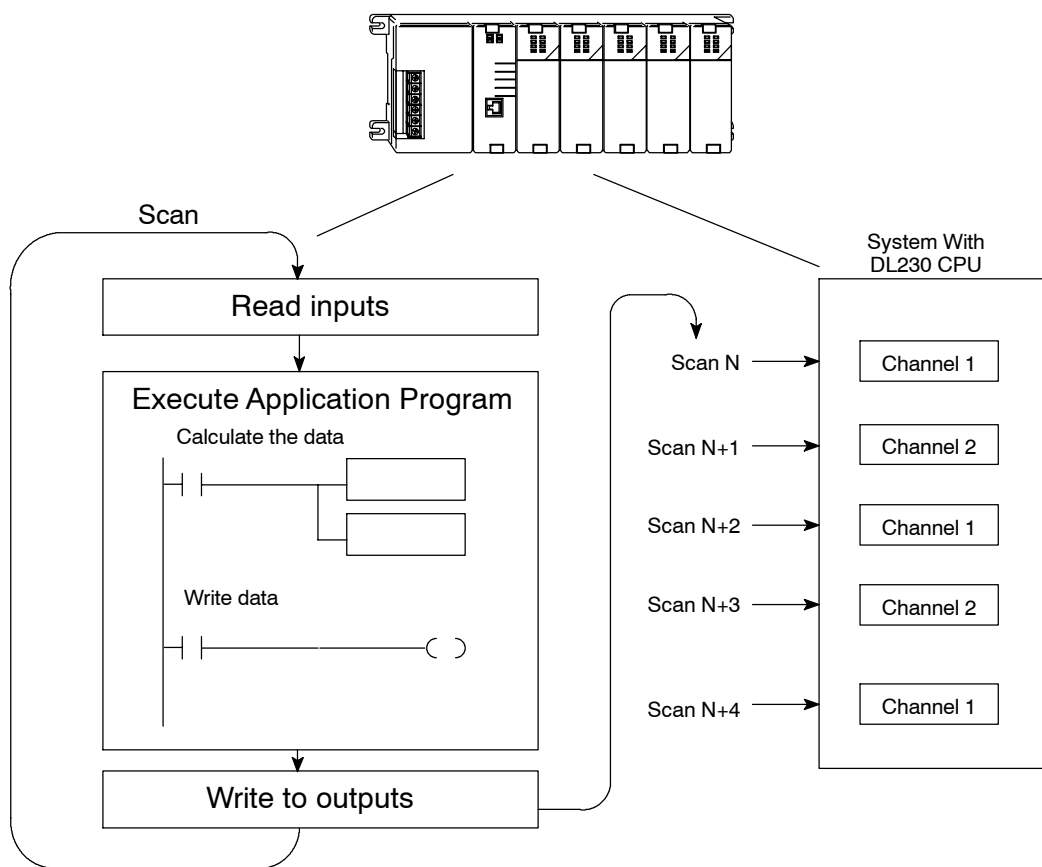
Channel Update Sequence for a DL240, DL250-1 or DL260 CPU (Pointer Method)

If you are using a DL240, DL250-1 or DL260 CPU, you can update both channels on every scan. This is because those 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.
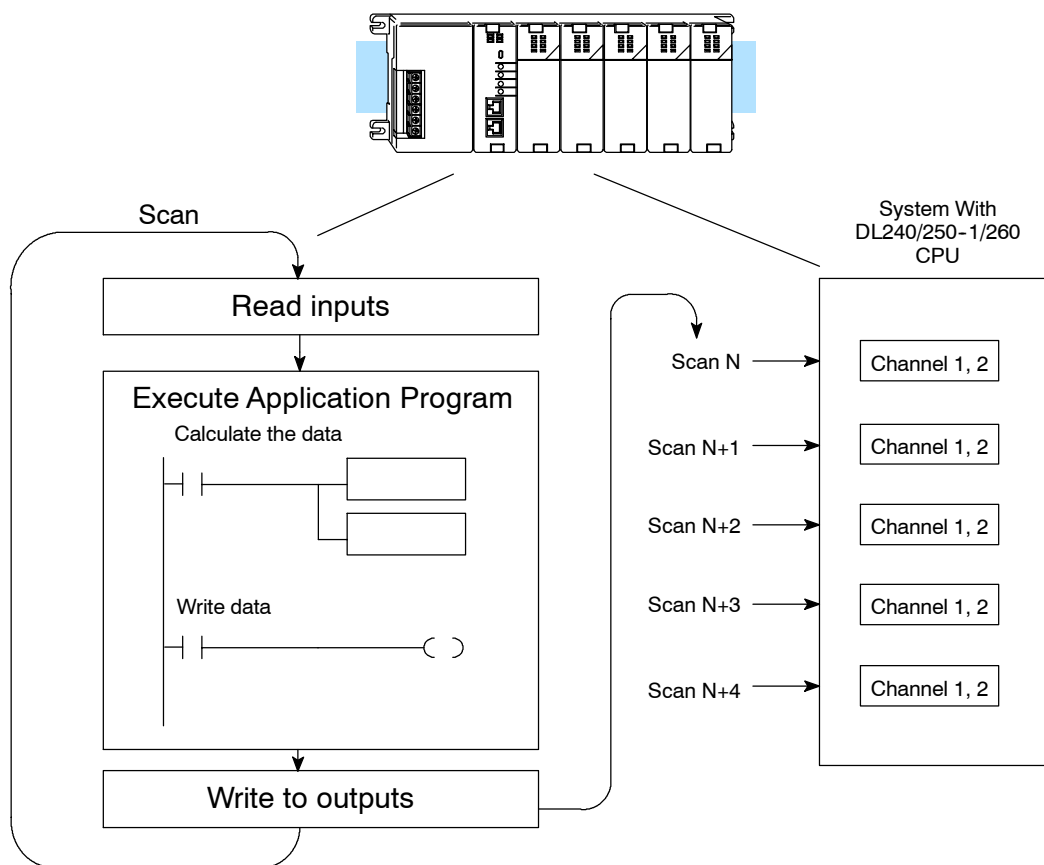
Understanding the Output Assignments

You may recall 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 you are using a DL240/250260 CPU, you may never have to use these bits, but it may help you understand the data format.

Since all output 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.

F2-02DA-1
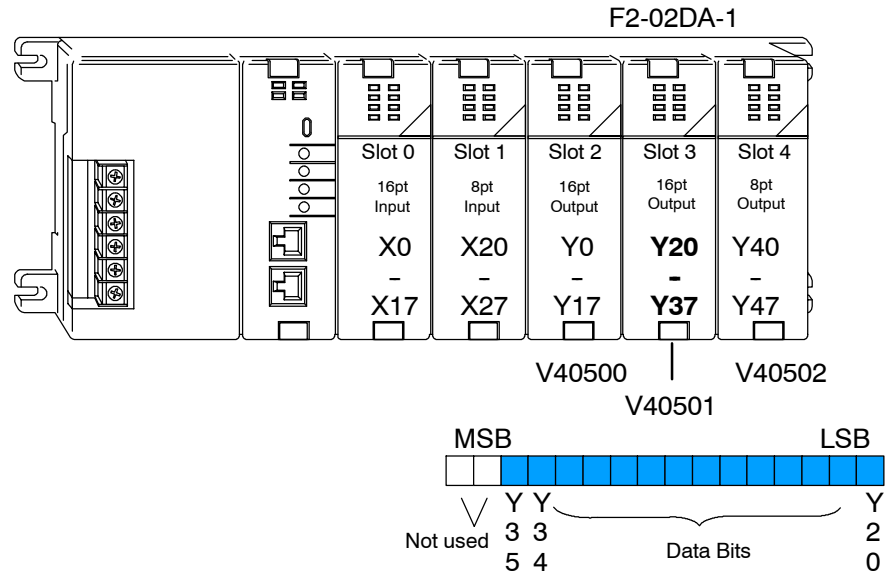
Within this word location, the individual bits represent specific information about the analog signal.

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, you can select which channel(s) gets updated.

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)

V40501
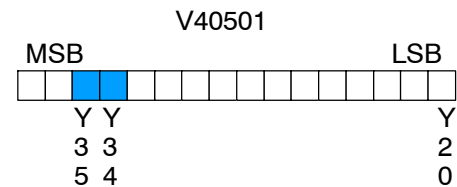
□ = channel select outputs

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

V40501

MSB   LSB

1 1 9 8 7 6 5 4 3 2 1 0
1 0

■ = data bits
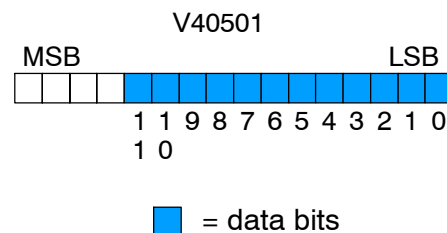
Module Resolution

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.

4 – 20mA

20mA

4mA

0   4095
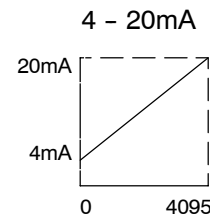
$$\text{Resolution} = \frac{H - L}{4095}$$

H = high limit of the signal range

L = low limit of the signal range

16mA / 4095 = 3.907µA per count

Writing the Control Program

Reading Values: Pointer Method and Multiplexing

There are two methods of reading values:
- The pointer method
- Multiplexing

You *must* use the multiplexing method when using a DL230 CPU. You must also use the multiplexing method with remote I/O modules (the pointer method will not work). You can use either method when using DL240, DL250–1 and DL260 CPUs, but for ease of programming it is strongly recommended that you use the pointer method.

Pointer Method

✕	✓	✓	✓
230	**240**	**250-1**	**260**

Once you have calculated the data values (shown previously) you have to enter the program that actually updates the module. The DL240/250–1/260 has special V-memory locations assigned to each base slot that greatly simplify the programming requirements. By using these V-memory locations you can:
- specify the number of channels to update.
- specify where to obtain the output data.

NOTE: DL240 CPUs with firmware version 1.5 or later and DL250 CPUs with firmware version 1.06 or later support this method. If using the DL230 example, module placement in the base is very important. Refer to the earlier module placement section.

The following program example shows how to set up these locations. Place this rung anywhere in the ladder program, or in the initial stage when using stage programming. The pointer method automatically converts values to BCD.

SP0

| LD K **2** | - **or** - | LD K **82** |
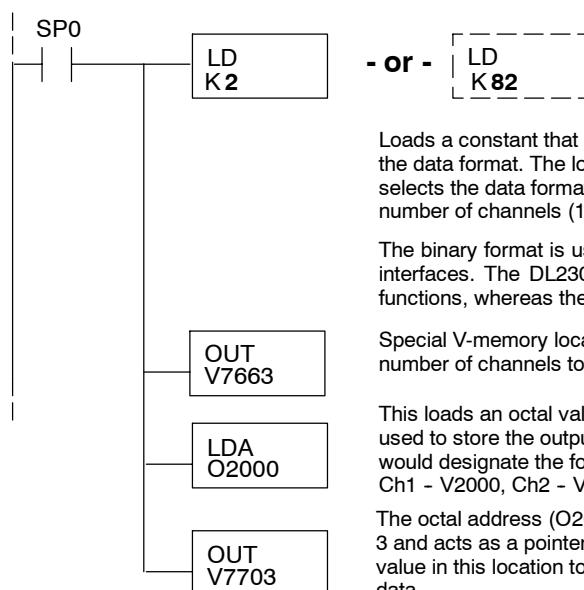
Loads a constant that specifies the number of channels to scan and the data format. The lower byte, most significant nibble (MSN) selects the data format (i.e. 0=BCD, 8=Binary), the LSN selects the number of channels (1 or 2).

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.

| OUT V7663 |

Special V-memory location assigned to slot 3 that contains the number of channels to scan.

| LDA O2000 |

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

| OUT V7703 |

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 tables below 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 you use the DL230 (multiplexing) method, verify that these addresses in the CPU are 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 DL260 expansion 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 DL260 expansion 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 expansion 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 expansion 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)

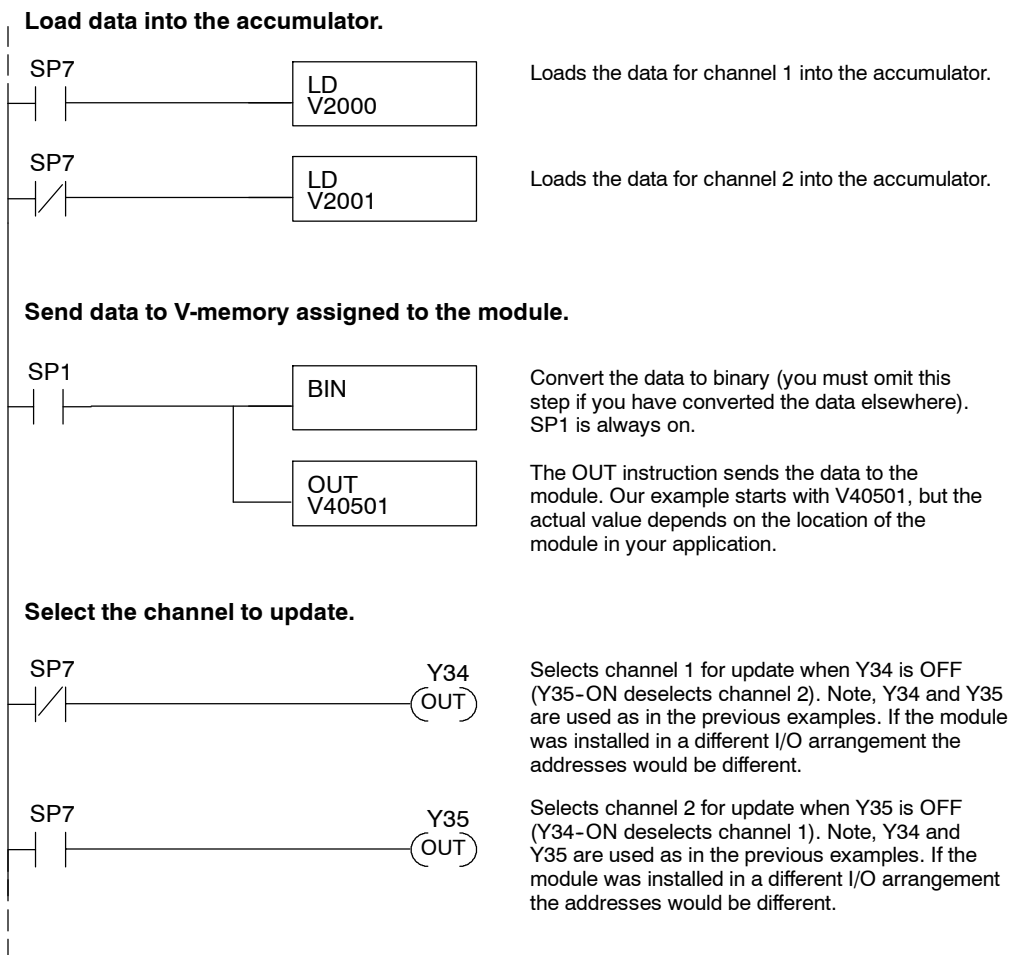| ✓	✓	✓	✓
230	240	250-1	260

The DL230 CPU *does not* have the special V-memory locations that allow you to automatically enable the data transfer. Since all channels are multiplexed into a single data word, the control program must be setup to determine which channel to write. 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.

Note, this example is for a module installed as shown in the previous examples. The addresses used would be different if the module was used in a different slot. You can place these rungs anywhere in the program or if you are using stage programming, place them in a stage that is always active.

This example is a two-channel multiplexer that updates each channel on alternate scans. Relay SP7 is a special relay that is on for one scan, then off for one scan.
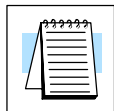
NOTE: You must send binary data to the module. If the data is already in binary format, you should not use the BIN instruction shown in this example.

Load data into the accumulator.

SP7
```
LD
V2000
```
Loads the data for channel 1 into the accumulator.

SP7
```
LD
V2001
```
Loads the data for channel 2 into the accumulator.

Send data to V-memory assigned to the module.

SP1
```
BIN
```
Convert the data to binary (you must omit this step if you have converted the data elsewhere). SP1 is always on.

```
OUT
V40501
```
The OUT instruction sends the data to the module. Our example starts with V40501, but the actual value depends on the location of the module in your application.

Select the channel to update.

SP7 — Y34 (OUT)
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 I/O arrangement the addresses would be different.

SP7 — Y35 (OUT)
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 I/O arrangement the addresses would be different.

Sending Data to One Channel

If you are not using both channels, or if you want to control the updates separately, use the following program.
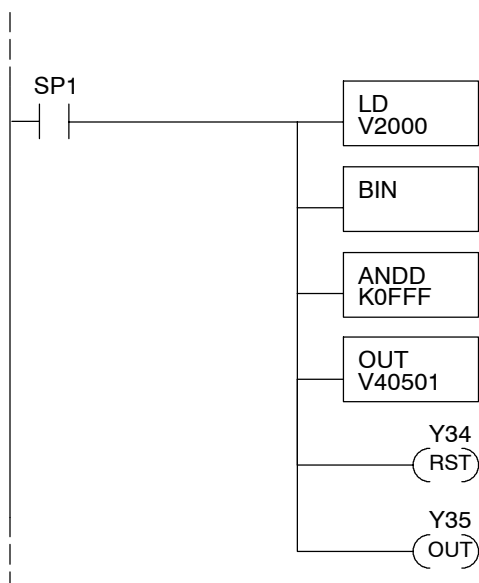
SP1
┤ ├

LD V2000	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.
BIN	The BIN instruction converts the accumulator data to binary (you must omit this step if you have already converted the data elsewhere).
ANDD K0FFF	This AND Double instruction logically ANDs the accumulator with the constant FFF. It keeps the data from affecting channel select bits.
OUT V40501	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 (RST)	Y34–OFF selects channel 1 for updating.
Y35 (OUT)	Y35–ON deselects channel 2 (do not update).

Sending the Same Data to Both Channels

If both channel selection outputs are off, both channels will be updated with the same data.

SP1
┤ ├

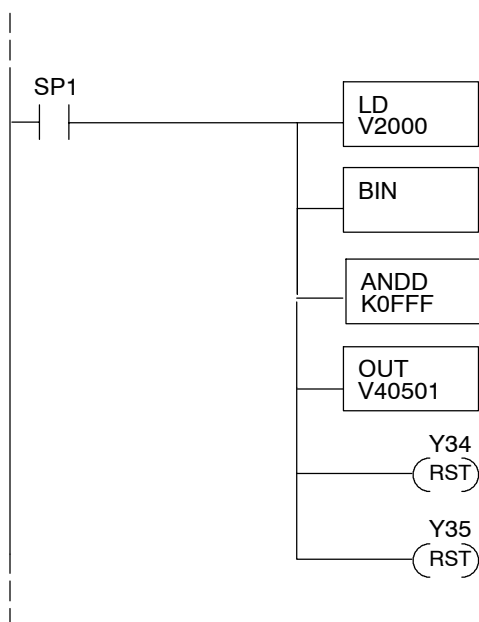| LD V2000 | The LD instruction loads the data into the accumulator. Since SP1 is used, this rung automatically executes on every scan. You could also use an X, C, etc. permissive contact. |
BIN	The BIN instruction converts the accumulator data to binary (you must omit this step if you have already converted the data elsewhere).
ANDD K0FFF	The AND Double instruction logically ANDs the accumulator value with the constant FFF. It keeps the data from affecting channel select bits.
OUT V40501	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 (RST)	Y34–OFF selects channel 1 for updating.
Y35 (RST)	Y35–OFF selects channel 2 for updating.

Calculating the Digital Value

Your program must calculate the digital value to send to the analog module. There are many ways to do this, but most applications are understood more easily if you use measurements in engineering units. This is accomplished by using the conversion formula shown.

You may have to make adjustments to the formula depending on the scale you choose for the engineering units.

$$A = U \frac{4095}{H - L}$$

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 to 99.9 PSI. By using the formula, you can easily determine the digital value that should be sent to the module. The example shows the conversion required to yield 49.4 PSI. Notice the formula uses a multiplier of 10. This is because the decimal portion of 49.4 cannot be loaded, so you adjust the formula to compensate for it.

$$A = 10U \frac{4095}{10(H - L)}$$

$$A = 494 \frac{4095}{1000 - 0}$$

$$A = 2023$$

Analog and Digital Value Conversions

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

Range	If you know the digital value ...	If you know the signal level ...
4 to 20mA	$A = \dfrac{16D}{4095} + 4$	$D = \dfrac{4095}{16} (A - 4)$

For example, if you know you need a 10mA signal to achieve the desired result, you can easily determine the digital value that should be used.

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

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

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

$$D = 1536$$

F2-02DA-1, (L)
2-Ch. Current Output

The example program shows how you would write the program to perform the engineering unit conversion. This example assumes you have calculated or loaded the engineering unit values in BCD and stored them in V2300 and V2301 for channels 1 and 2 respectively.

NOTE: The DL205 offers various instructions that allow you to perform math operations using BCD format. It is easier to perform math calculations in BCD and then convert the value to binary before sending the data to the module.

<table>
<tr><td>SP1
─┤├─</td><td>LD
V2300</td><td>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.</td></tr>
<tr><td></td><td>MUL
K4095</td><td>Multiply the accumulator by 4095 (to start the conversion).</td></tr>
<tr><td></td><td>DIV
K1000</td><td>Divide the accumulator by 1000 (because we used a multiplier of 10, we have to use 1000 instead of 100).</td></tr>
<tr><td></td><td>OUT
V2000</td><td>Store the BCD result in V2000 (the actual steps to write the data were shown earlier).</td></tr>
<tr><td>SP1
─┤├─</td><td>LD
V2301</td><td>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.</td></tr>
<tr><td></td><td>MUL
K4095</td><td>Multiply the accumulator by 4095 (to start the conversion).</td></tr>
<tr><td></td><td>DIV
K1000</td><td>Divide the accumulator by 1000 (because we used a multiplier of 10, we have to use 1000 instead of 100).</td></tr>
<tr><td></td><td>OUT
V2001</td><td>Store the BCD result in V2001 (the actual steps to write the data were shown earlier).</td></tr>
</table>

F2-02DA-1 (L)
2-Ch. Current Output