

F3-04DA-1

4-Channel

Analog Output

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Module Specifications

The following table provides the specifications for the F3-04DA-1 Analog Output Module. Review these specifications to make sure the module meets your application requirements.

Number of Channels	4
Output Ranges	0 – 5V, 0 – 10V, 4 – 12 mA, 4 – 20 mA (source)
Resolution	12 bit (1 in 4096)
Output Type	Single ended (one common)
Output Impedance	0.5 Ω typical, voltage output
Output Current	5 mA source, 2.5 mA sink (voltage)
Short-circuit Current	40 mA typical, voltage output
Load Impedance	1K Ω maximum, current output 2K Ω minimum, voltage output
Linearity Error	± 1 count ($\pm 0.03\%$ maximum)
Maximum Inaccuracy at 77 °F (25 °C)	$\pm 0.6\%$ of span, current output $\pm 0.2\%$ of span, voltage output
Accuracy vs. Temperature	± 50 ppm / °C maximum
Conversion Time	30 μ S maximum
Power Budget Requirement	144 mA @9V, 108 mA @ 24V
External Power Supply	None required
Operating Temperature	32° to 140° F (0° to 60° C)
Storage Temperature	-4° to 158° F (-20° to 70° C)
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

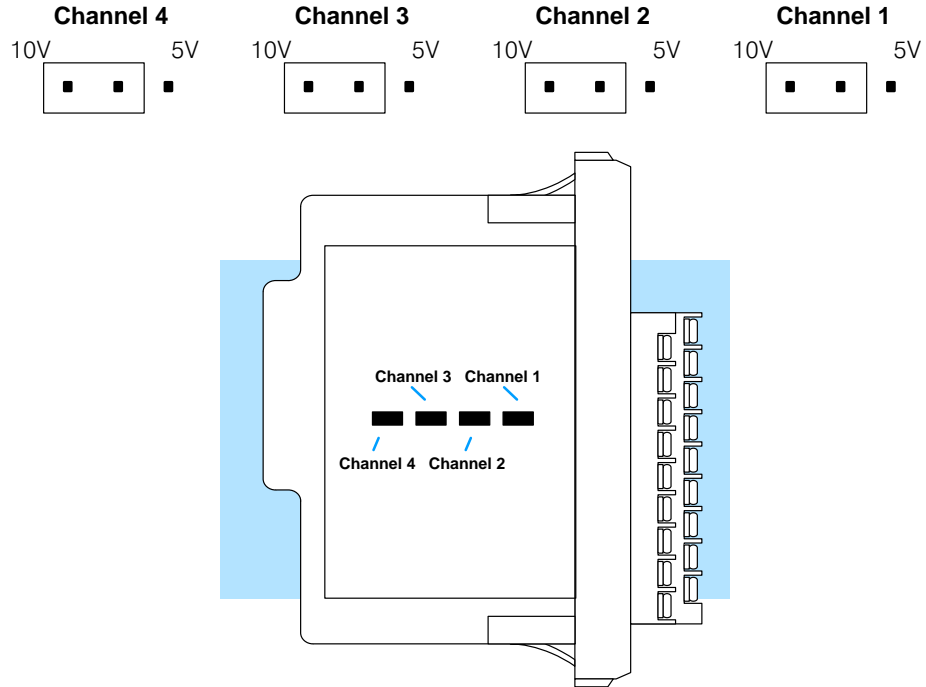
Analog Output Configuration Requirements

The F3-04DA-1 Analog Output appears as a 16-point module. The module can be installed in any slot configured for 16 points. See the DL305 User Manual for details on using 16 point modules in DL305 systems. The limitation on the number of analog modules are:

- For local and expansion systems, the available power budget and 16-point module usage are the limiting factors.

Setting the Module Jumpers

Jumper Locations The module is set at the factory for a 0–10V signal on all four channels. (This range also allows 4–20 mA operation since there are separate I and V wiring terminals.) If this is acceptable you do not have to change any of the jumpers. The following diagram shows the jumper locations.



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Selecting Output Signal Ranges The jumper is set from the factory to allow either 0–10V or 4–20mA operation on all channels. In addition, you can select 0 – 5V or 4 – 12 mA operation by moving the jumper. (Only channel 1 is used in the example, but all channels must be set.)

Signal Range	Jumper Settings
0 to +5 VDC 4 to 12 mA	Range 0-10V 0-5V
0 VDC to +10 VDC 4 to 20 mA	Range 0-10V 0-5V

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 module or the power supply return (0V). *Do not* ground the shield at both the module and the transducer.
- Don't 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 F3-04DA-1 receives all power from the base. A separate power supply is not required.

Load Requirements Each channel can be wired independently for a voltage or current transducer.

- Current transducers must have an impedance less than 1K ohm.
- Voltage transducers must have an impedance greater than 2K ohms.

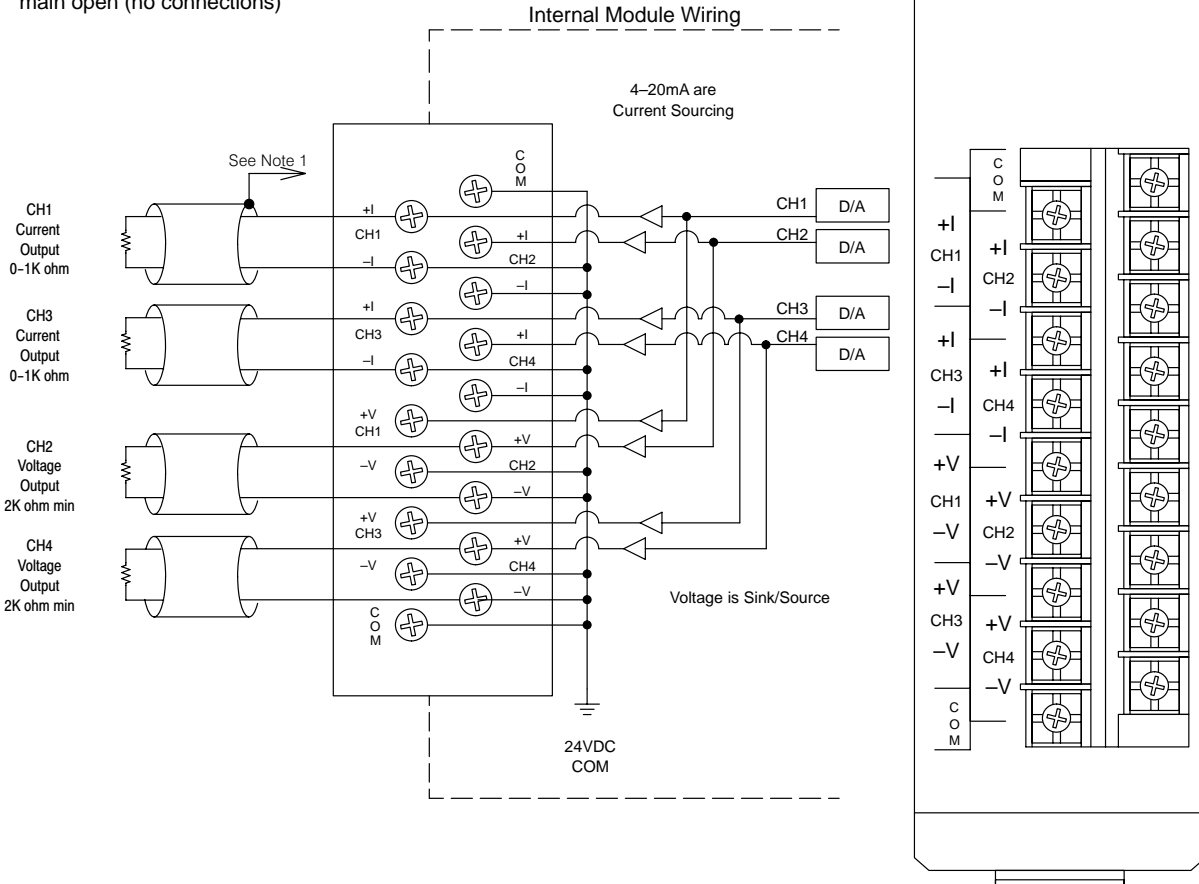
Removable Connector

The F3-04DA-1 module has a removable connector to make wiring easier. Simply squeeze the top and bottom tabs and gently pull the connector from the module.

Wiring Diagram

Note 1: Shields should be connected to the 0V (COM) of the module

Note 2: Unused voltage & current outputs should remain open (no connections)



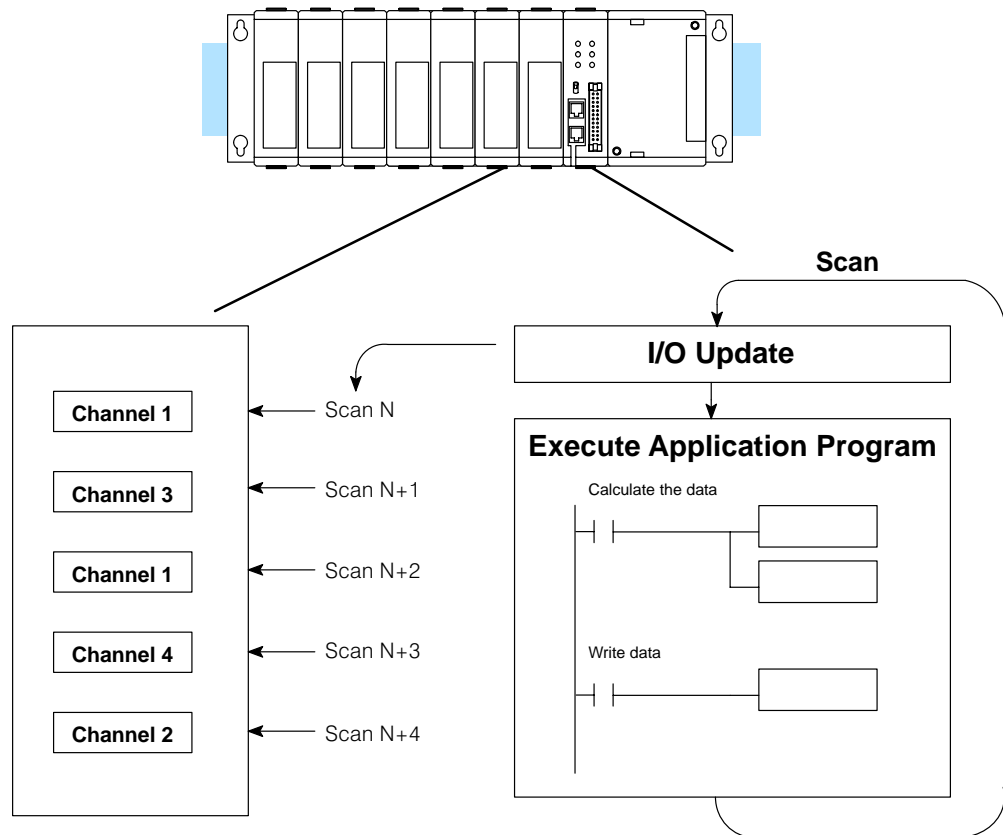
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4-Channel Analog Output

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 Scanning Sequence

The F3-04DA-1 module can update one channel per CPU scan. Your RLL program selects which channel to update, so you have complete flexibility to solve your application requirements.

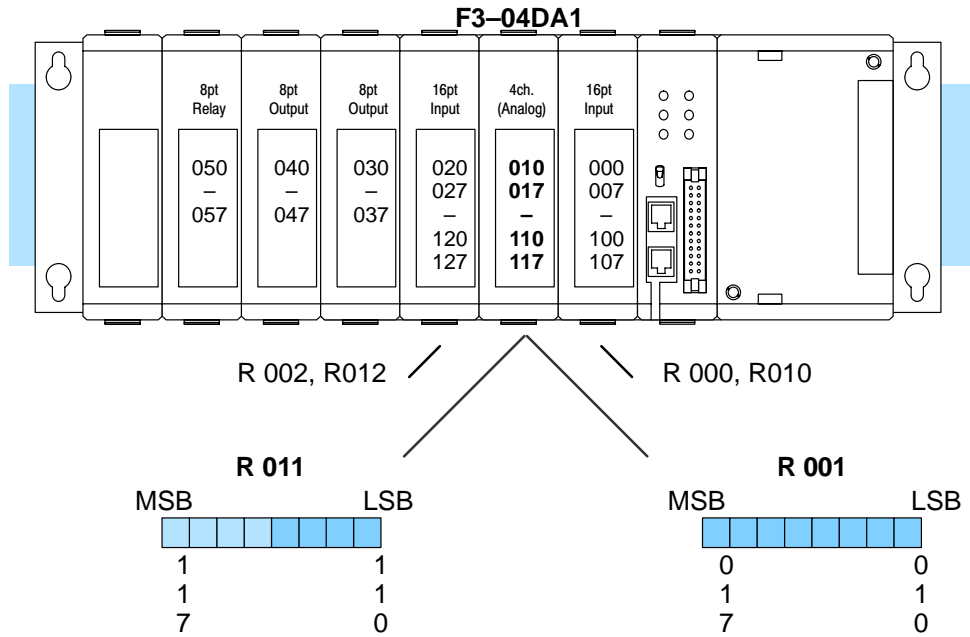


Understanding the I/O Assignments

You may recall the F3-04DA-1 module appears to the CPU as a 16-point module. These 16 points provide:

- the digital representation of the analog signal.
- identification of the channel to receive the data.

Since all I/O points are automatically mapped into Register (R) memory, it is very easy to determine the location of the data word that will be assigned to the module.



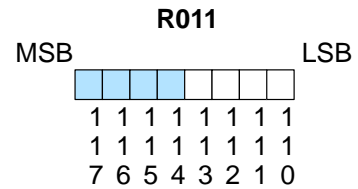
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Within these two word locations, the individual bits represent specific information about the analog signal.

Channel Selection Inputs

The last four points of the upper register are used as outputs to tell the module which channel to update. In our example, when output 114 is on, channel 1 will be updated. Here's how the outputs are assigned.

Output	Channels
114	1
115	2
116	3
117	4

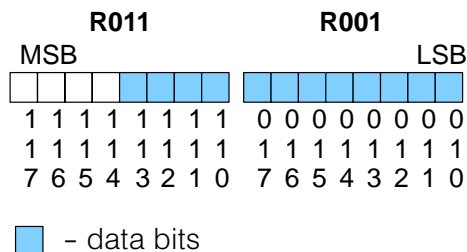


■ - channel selection outputs

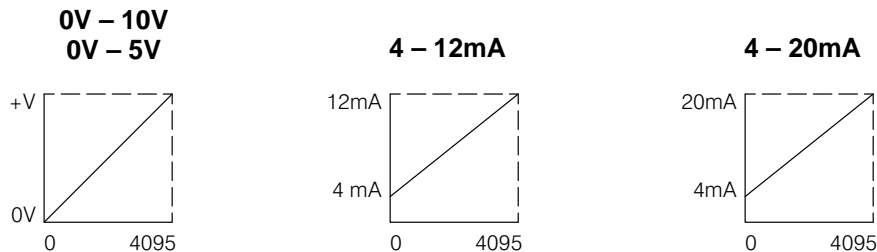
Analog Data Bits

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

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



Since the module has 12-bit resolution, the analog signal is converted into 4096 “pieces” ranging from 0 – 4095 (2¹²). For example, with a 0 to 10V scale, a 0V signal would be 0, and a 10V signal would be 4095. This is equivalent to a binary value of 0000 0000 0000 to 1111 1111 1111, or 000 to FFF hexadecimal. The following diagram shows how this relates to each signal range.



Each “piece” can also be expressed in terms of the signal level by using the equation shown. The following table shows the smallest signal levels that will possibly result in a change in the data value for each signal range.

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

H = high limit of the signal range
L = low limit of the signal range

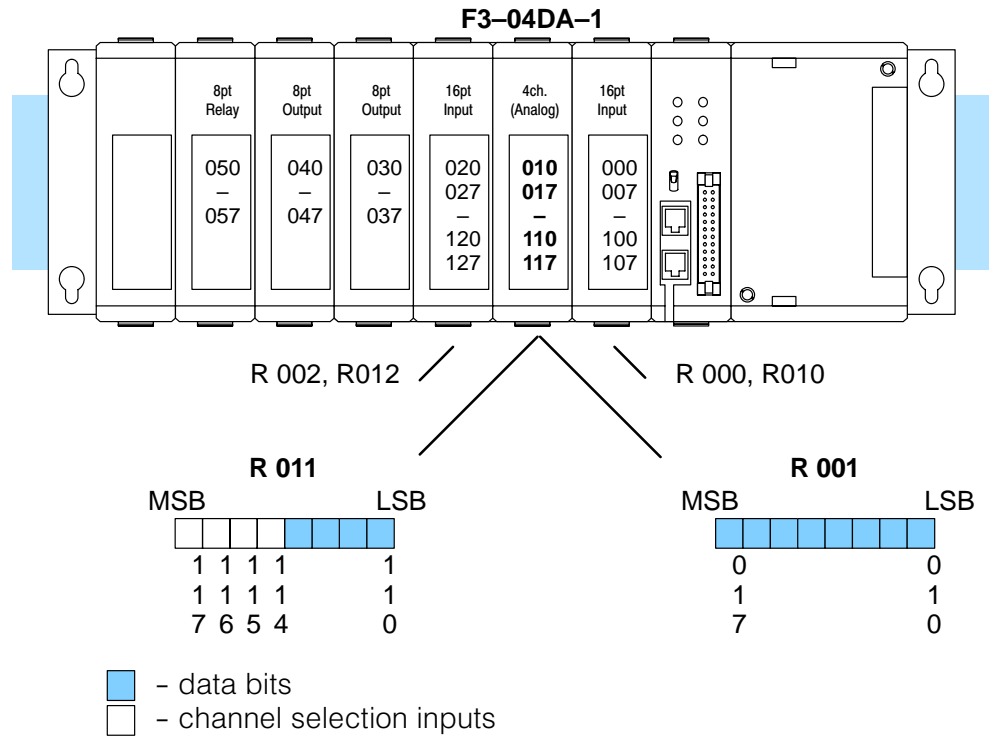
Range	Highest Signal	Lowest Signal	Smallest Change
0 to 5V	5V	0V	1.22 mV
0 to 10V	10V	0V	2.44 mV
4 to 12mA	12mA	4mA	1.95 μA
4 to 20mA	20mA	4mA	3.91 μA

Now that you understand how the module and CPU work together to gather and store the information, you’re ready to write the control program.

Writing the Control Program (DL330 / DL340)

Identifying the Data Locations

As mentioned earlier, you can use the channel selection bits to determine which channels will be updated. The following diagram shows the location for both the channel selection bits and data bits.



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Calculating the Digital Value

Your program has to calculate the digital value to send to the analog module. There are many ways to do this, but most all 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.

$$A = 4096 \frac{U}{H - L}$$

- A = Analog value (0 - 4095)
- U = Engineering Units
- H = high limit of the Engineering unit range
- L = low limit of the Engineering unit range

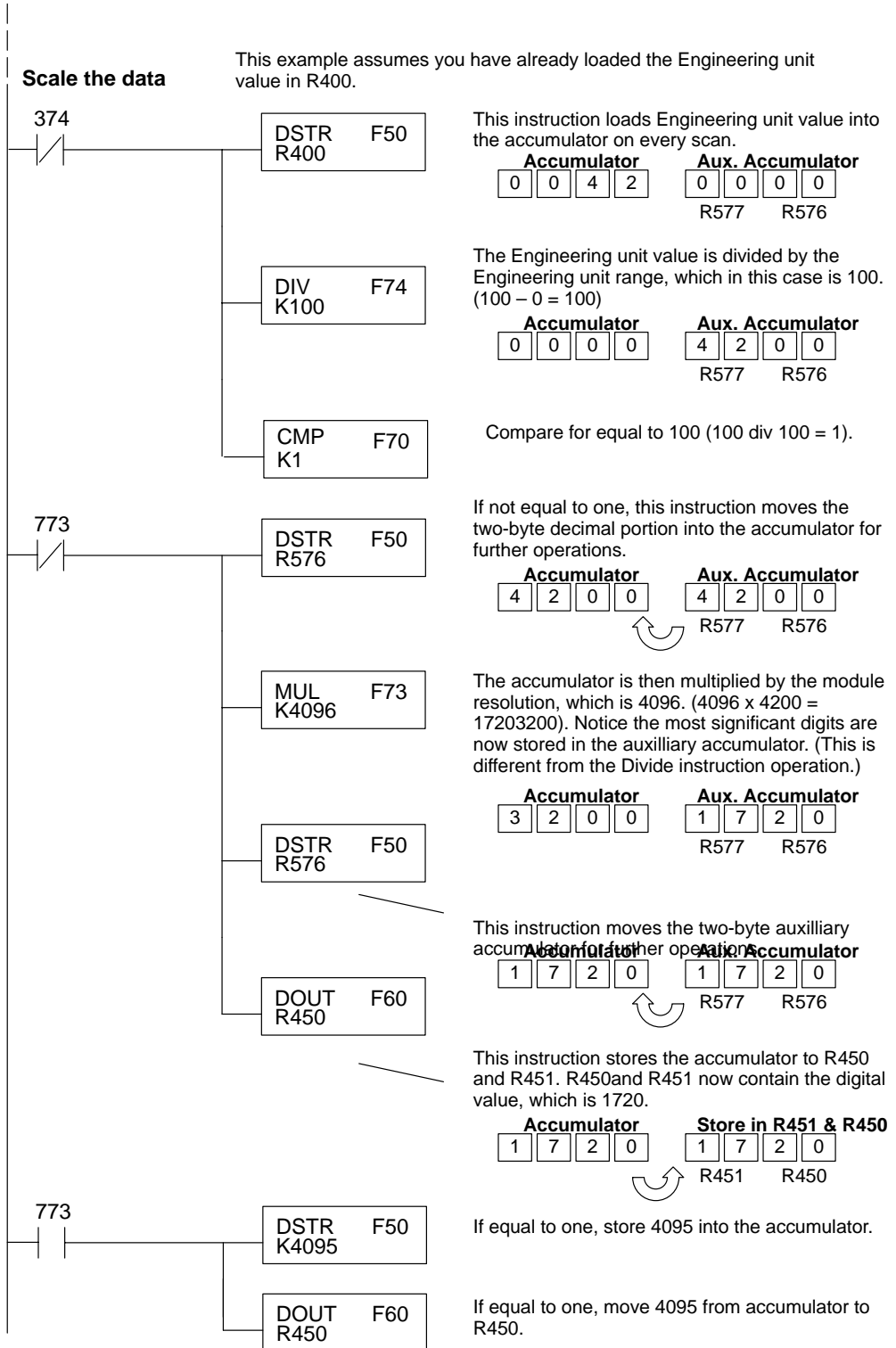
The following example shows how you would use Engineering units to obtain the digital value to represent pressure (PSI) from 0 to 100. This example assumes you want to obtain a pressure of 42 PSI, which is slightly less than half scale.

$$A = 4096 \frac{U}{H - L}$$

$$A = 4096 \frac{42}{100 - 0}$$

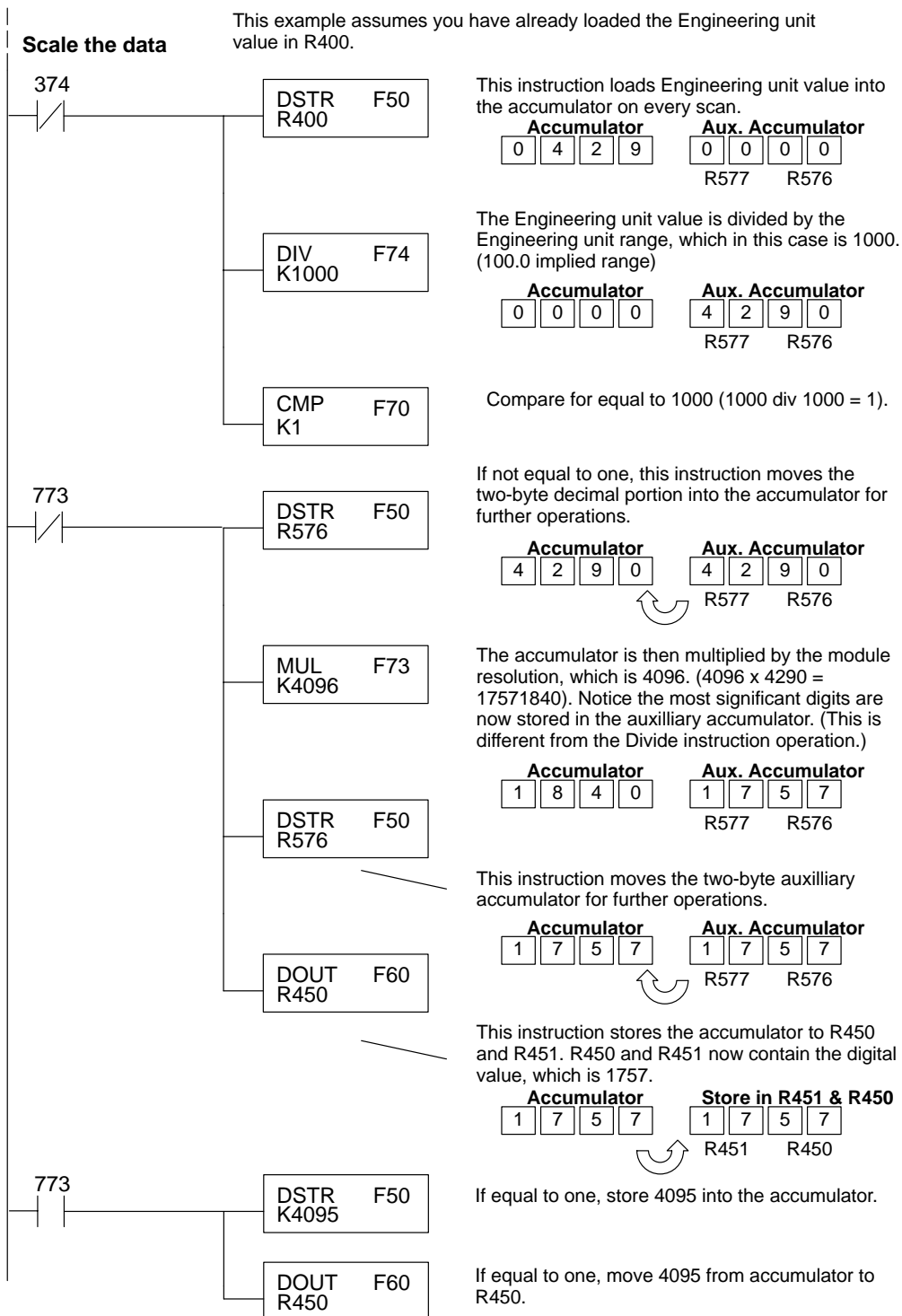
$$A = 1720$$

Here's how you would write the program to perform the Engineering unit conversion. This example assumes you have calculated or loaded the engineering unit value and stored it in R400. Also, you have to perform this for all channels if you're using different data for each channel.



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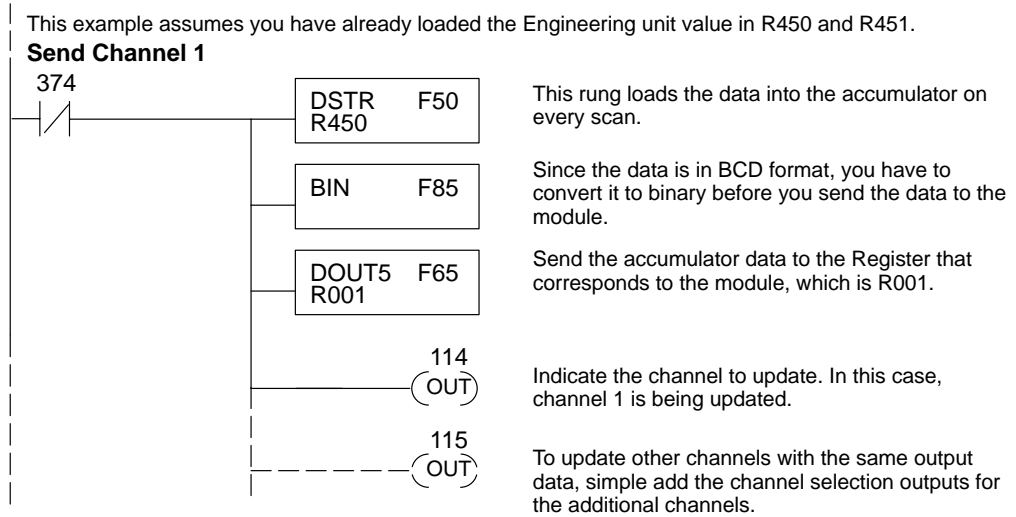
There will probably be times when you need more precise control. For example, maybe your application requires 42.9 PSI, not just 42 PSI. By changing the scaling value slightly, we can “imply” an extra decimal of precision. Notice in the following example we’ve entered 429 as the Engineering unit value and we’ve added another digit to the scale. Instead of a scale of 100, we’re using 1000, which implies 100.0 for the PSI range.



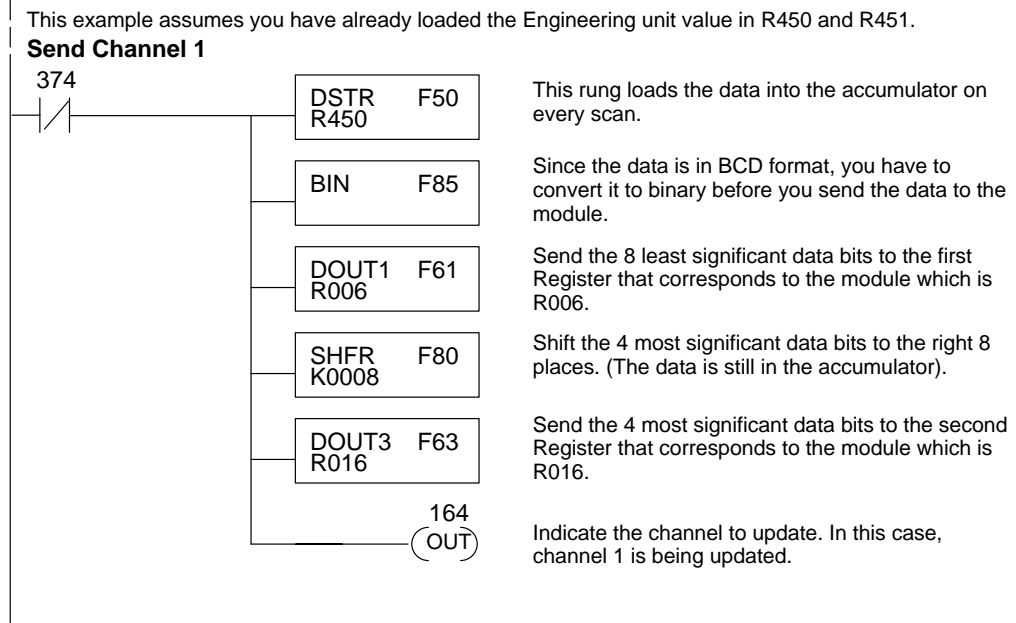
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Sending Data to a Single Channel

The following program example shows how to send the digital value to a single channel.



If you install the F3-04DA-1 in the slot corresponding to registers 6 and 16, you have to make a slight program adjustment. This is because the DOUT5 instruction is not supported for this slot.

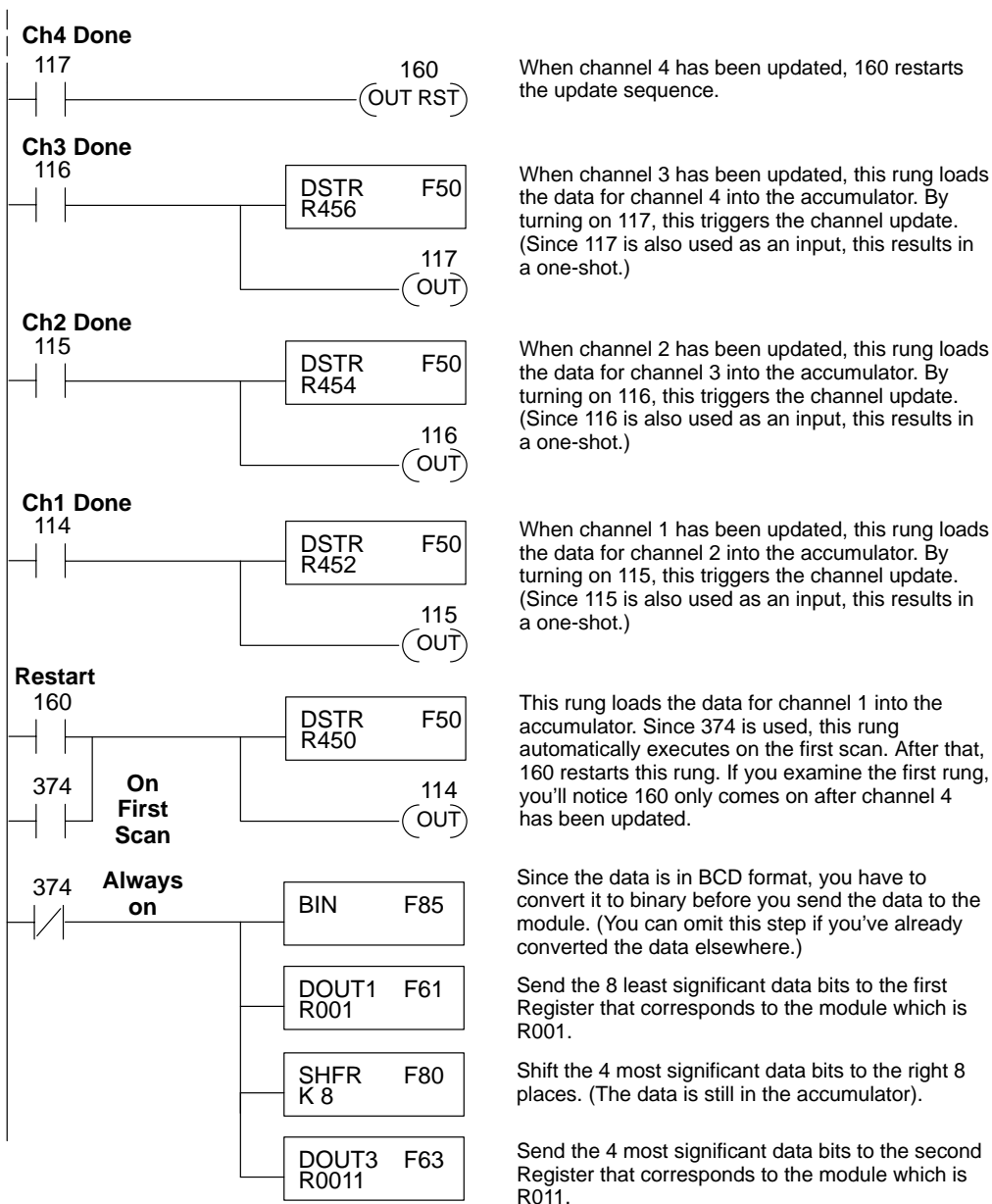


Sequencing the Channel Updates

This example shows how to send digital values to the module when you have more than one channel. This example will automatically update all four channels over four scans. The example is fairly simple and will work in most all situations, but there are instances where problems can occur. The logic must be active on the first CPU scan and all subsequent scans. If the logic gets stopped or disabled for some reason, there is no way to restart it. If you're using an RLL^{PLUS} (Stage) program, put this logic in an initial stage that is always active. Also, you should avoid using the this example if you require the analog output logic to be used inside a Master Control Relay field of control. Even if you do not have a need for the MCR, you can still accidentally disable the analog output logic by inadvertently writing to the multiplexing control relays with an operator interface or intelligent module, such as an ASCII BASIC module, etc.

Sequencing Example

The following program example shows how to send the digital values to multiple channels. With this program, all channels will be updated within four scans. You must use the rungs in the order shown, but you can include them anywhere in the program.



Writing the Control Program (DL350)

Reading Values: Pointer Method and Multiplexing

There are two methods of reading values:

- The pointer method (**all system bases must be D3-xx-1 to support the pointer method**)
- Multiplexing

You must use the multiplexing method with remote I/O modules (the pointer method will not work). You can use either method when using DL350 CPU, but for ease of programming it is strongly recommended that you use the pointer method.

Pointer Method

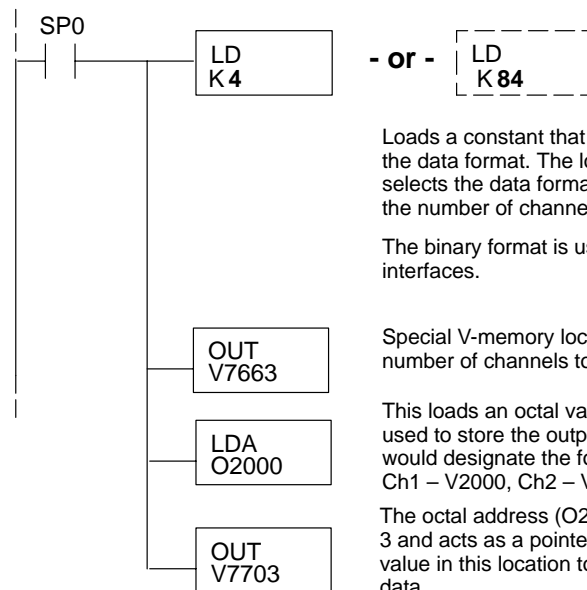
The DL350 has special V-memory locations assigned to each base slot that greatly simplifies the programming requirements. By using these V-memory locations you can:

- specify the number of channels to update.
- specify where to obtain the output data.



NOTE: Do not use the pointer method and the PID Control Output auto transfer to I/O module function together for the same module. If using PID loops, use the pointer method and ladder logic code to map the analog output data from the PID loop to the output module memory location(s).

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.

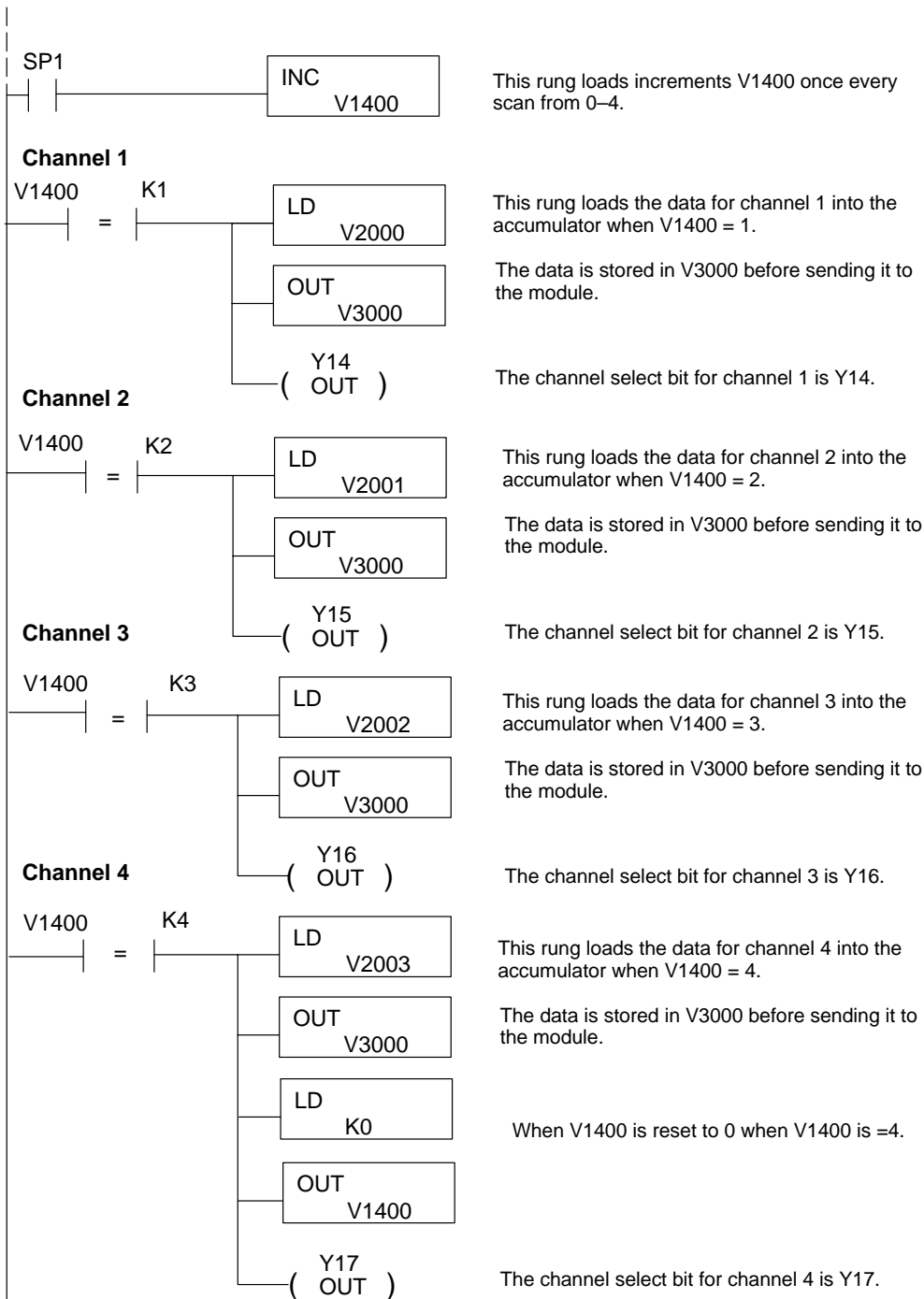


The table shows the special V-memory locations used with the DL350. Slot 0 (zero) is the module next to the CPU. Remember, the CPU only examines the pointer values at these locations after a mode transition. The pointer method is supported on expansion bases (all bases must be D3-xx-1) up to a total of 8 slots away from the DL350. The pointer method is not supported in slot 8 of a 10 slot 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

**Multiplexing:
DL350 with a
D3-xx-01 Base**

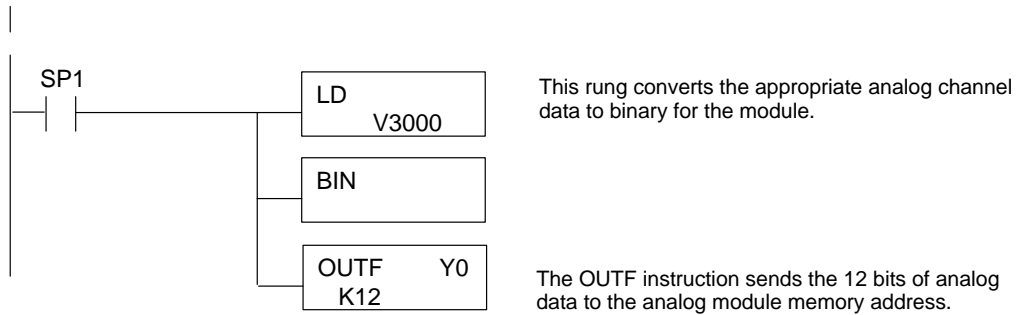
This example assumes the module is in Y0 address slot of D3-xx-1 base. In this example V2000 contains the data for channel and V2001 for channel 2, etc. If any expansion bases are used in the system, they must all be D3-xx-1 to be able to use this example. Otherwise, the conventional base addressing must be used.



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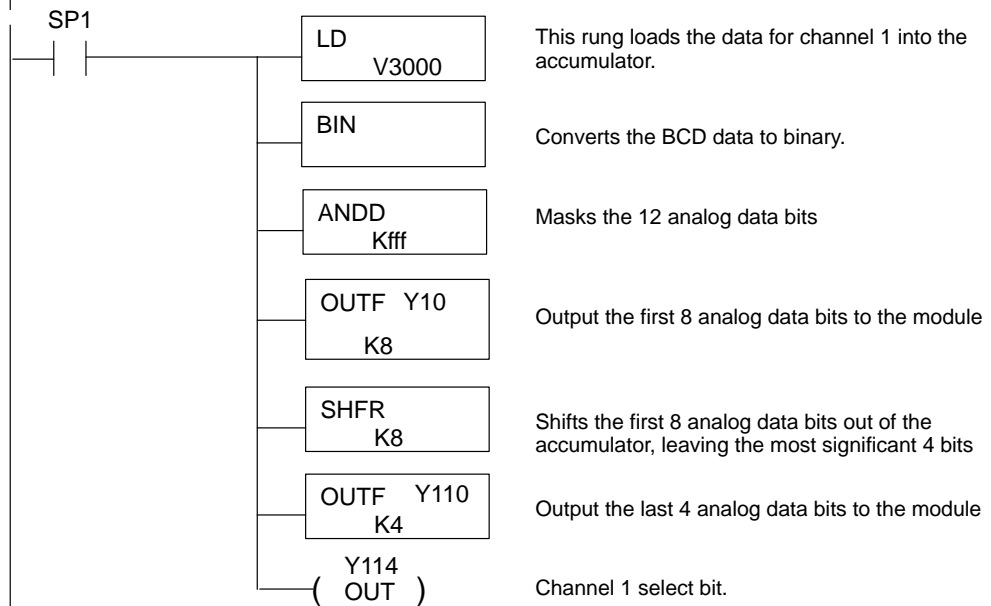
example program continued from previous page



**Multiplexing:
DL350 with a
Conventional
DL305 Base**

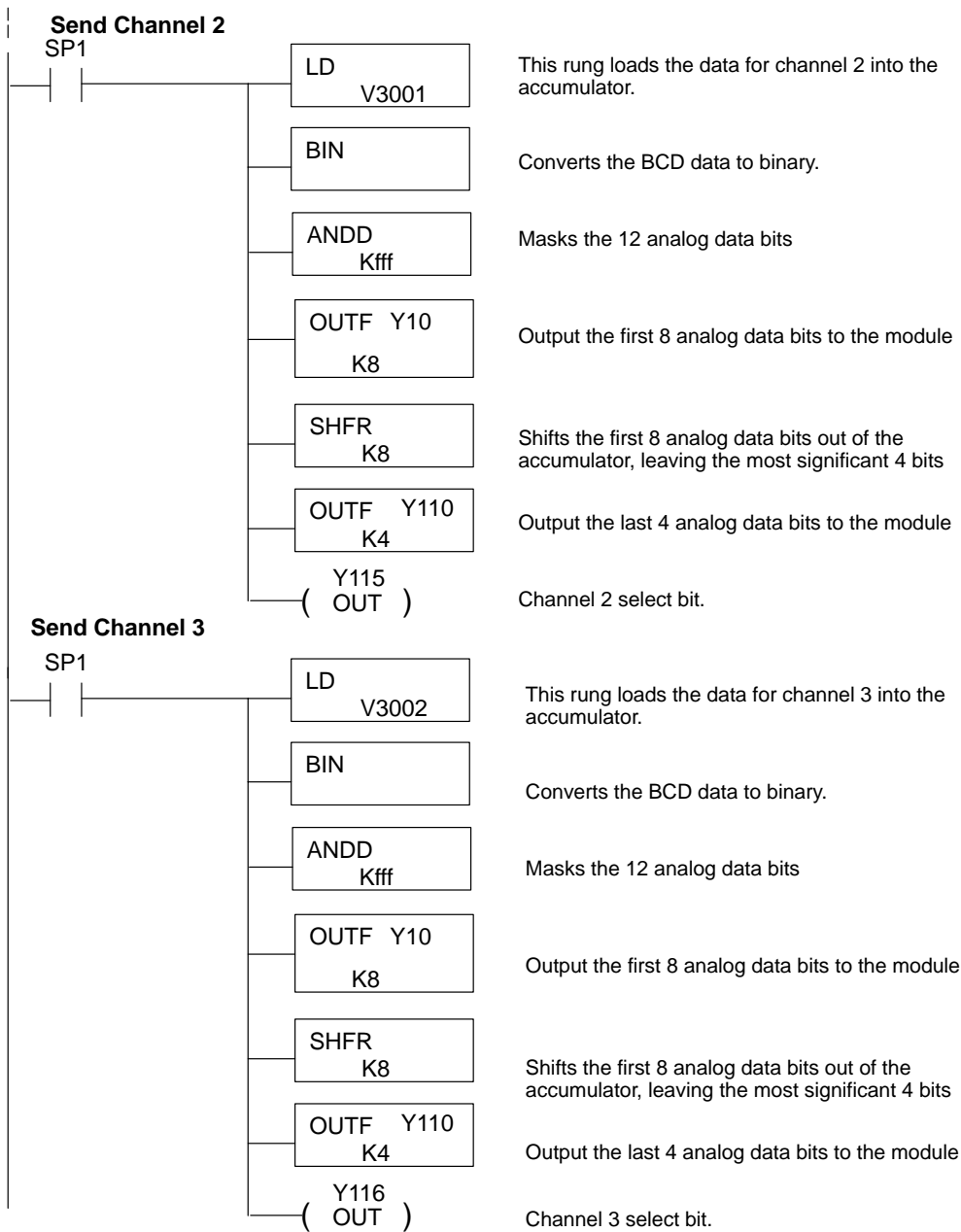
This example assumes the module is in the 10-17 / 110-117 slot of a 305 conventional base. In this example V3000 contains the BCD data for channel 1 and V3001 contains the data for channel 2, etc. One more rung would be necessary for channel 4.

Send Channel 1



example program continued on next page

example program continued from previous page.



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.

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

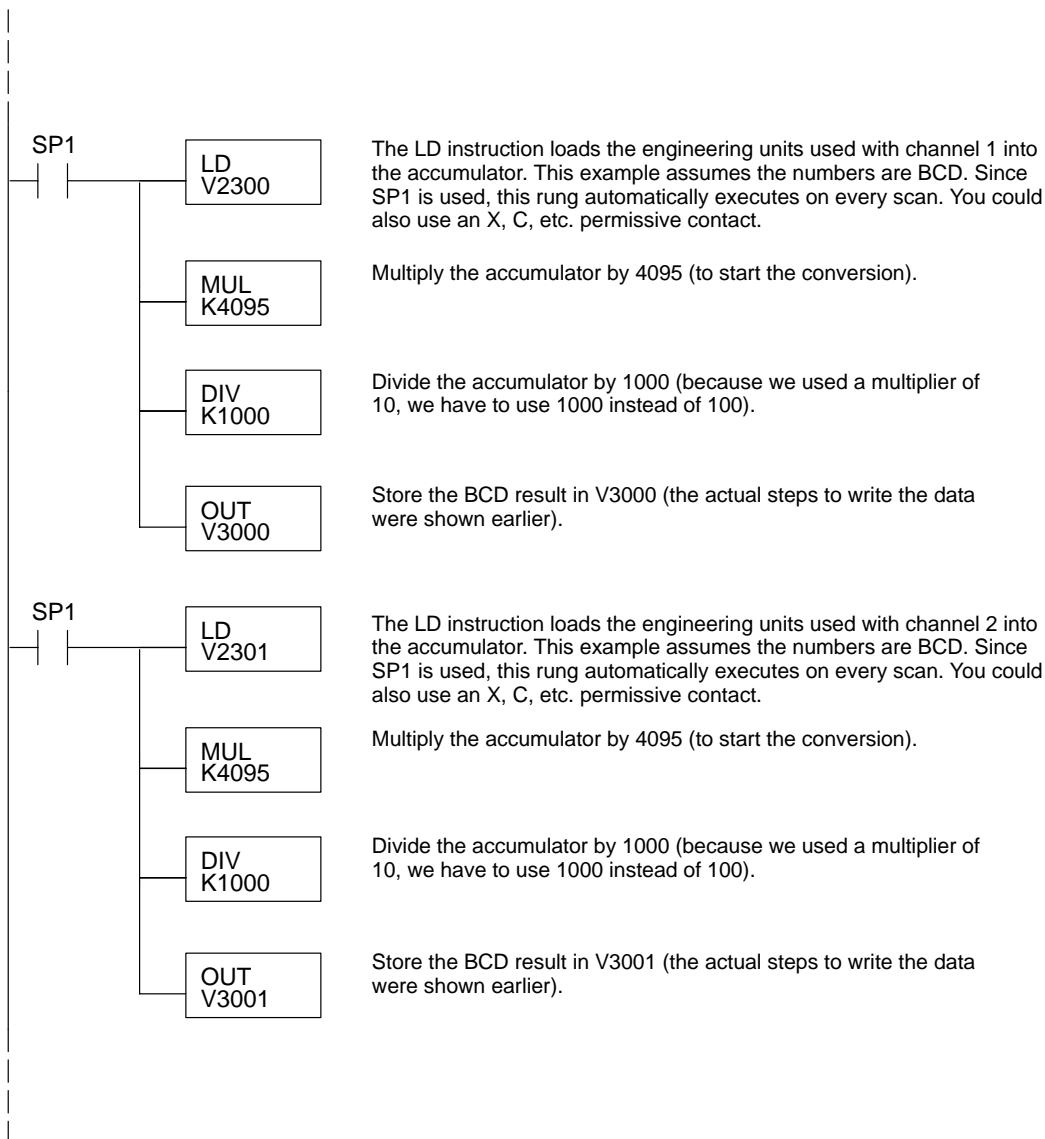
$$A = 494 \frac{4095}{1000 - 0}$$

$$A = 2023$$

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 DL350 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.



Analog and Digital Value Conversions

Sometimes it is helpful to be able to quickly convert between the voltage or current 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 analog signal level ...
0 to 5V	$A = \frac{5D}{4095}$	$D = \frac{4095}{5} A$
0 to 10V	$A = \frac{10D}{4095}$	$D = \frac{4095}{10} A$
4 to 12mA	$A = \frac{12D}{4095} + 4$	$D = \frac{4095}{12} (A - 4)$
4 to 20mA	$A = \frac{16D}{4095} + 4$	$D = \frac{4095}{16} (A - 4)$

For example, if you are using the 4–20mA range and you know you need a 10mA signal level, you would use the following formula to determine the digital value that should be sent to the module.

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

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

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

$$D = 1536$$