11

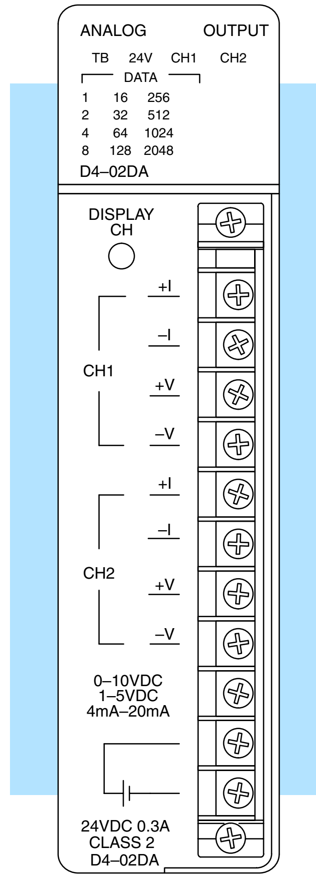
D4-02DA 2-Channel Analog Output

In This Chapter. . . .

Module Specifications

The D4–02DA 2-Channel Analog Output module provides several features and benefits.

- It provides two channels of voltage or current outputs.
- Analog outputs are optically isolated from PLC logic components.
- The module has a removable terminal block, so the module can be easily removed or changed without disconnecting the wiring.
- Both analog outputs may be set in one CPU scan.



Analog Output Configuration Requirements

The D4–02DA Analog Output requires 32 discrete output points from the CPU. The module can be installed in any slot of a DL405 system, including remote bases. The limitations on the number of analog modules are:

- For local and expansion systems, the available power budget and discrete I/O points.
- For remote I/O systems, the available power budget and number of remote I/O points.

Check the user manual for your particular model of CPU for more information regarding power budget and number of local or remote I/O points.

The following table provides the specifications for the D4–02DA Analog Output Module. Review these specifications to ensure the module meets your application requirements.

Output Specifications

Number of Channels	2 (independent)
Output Ranges	0–10V, 1–5V, 4–20 mA
Resolution	12 bit (1 in 4096)
Output Type	Single ended
Output Impedance	0.5Ω maximum, voltage output
Output Current	5 mA maximum, voltage output
Load Impedance	550Ω max., 5.0Ω min.,current output, 2KΩ minimum, voltage output
Linearity	±0.1% maximum
Accuracy vs. Temperature	±70 ppm / °C maximum
Maximum Inaccuracy	±0.2% maximum at 25° C
Conversion Method	Integration
Conversion Time	Start of scan, 30μS + one scan

General Module Specifications

PLC Update Rate	1 or 2 channels per scan
Digital Output Points Required	32 (Y) output points 12 binary data bits per channel (24 bits total with 8 unused bits)
Power Budget Requirement	250 mA (from base)
External Power Supply	24VDC, ±10%, 300 mA, class 2
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
Insulation Resistance	10 MΩ, 500 VDC
Noise Immunity	NEMA ICS3–304

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.
- 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 D4–02DA requires a separate power supply. The DL430/440/450 CPUs, D4–RS Remote I/O Controller, and D4–EX Expansion Units have built-in 24 VDC power supplies that provide up to 400mA of current. If you only have one analog module, you can use this power source instead of a separate supply. If you have more than one analog module, or you would rather use a separate supply, choose one that meets the following requirements: 24 VDC $\pm$10%, Class 2, 300mA (per module).

Load Requirements

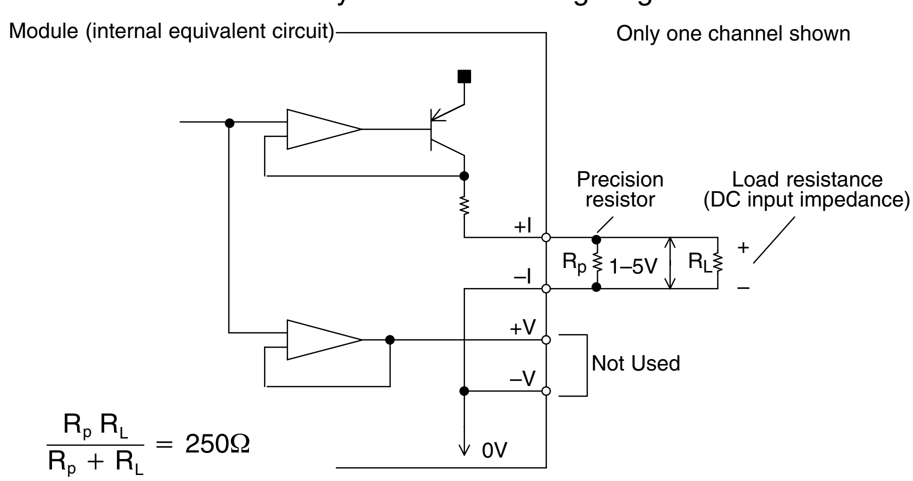
Each channel can be wired independently for voltage or current.

- Current loads must have an impedance between 5 and 500 ohms.
- Voltage loads must have an impedance greater than 2K ohms.

Using the 1–5 VDC Range

Since the module provides a 0–10V signal on the voltage outputs, you have to use the current outputs and a precision resistor to generate the 1–5V signal.

With a 250 ohm precision resistor across the current outputs, the module converts the current signals to voltage for you (4mA x 250 ohms = 1V, 20mA x 250 ohms = 5V). The transducer should be connected in parallel with the precision resistor and the parallel equivalent resistance should be approximately 250 ohms ($\pm$0.1%). Field devices that have impedances of greater than 250K ohms can be used with less than 0.1% additional inaccuracy. See the following diagram.



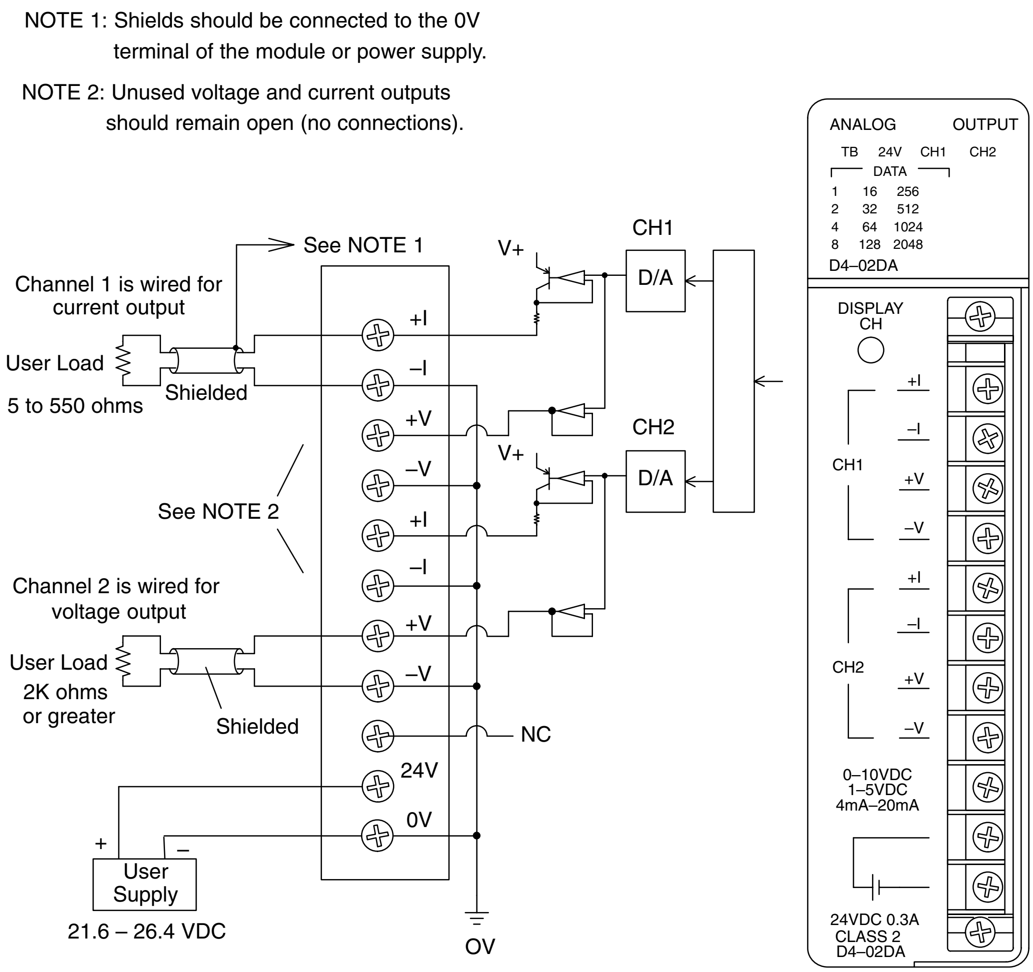
$$\frac{R_p\, R_L}{R_p + R_L} = 250\Omega$$

R_p = value of external precision resistor

R_L= load impedance

Wiring Diagram

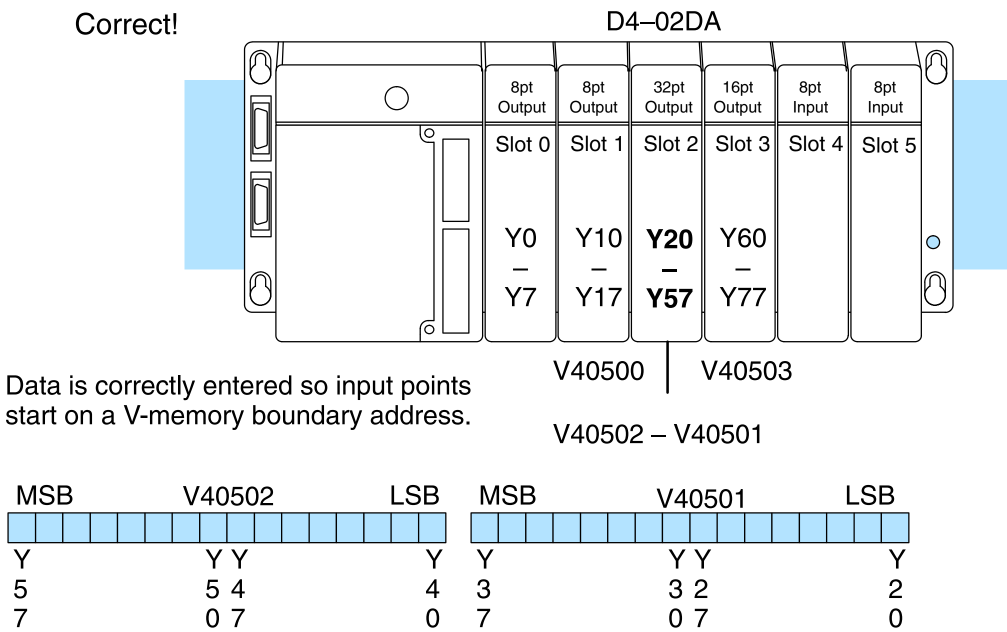
The D4–02DA module has a removable connector to make wiring easier. Simply remove the retaining screws and gently pull the connector from the module.

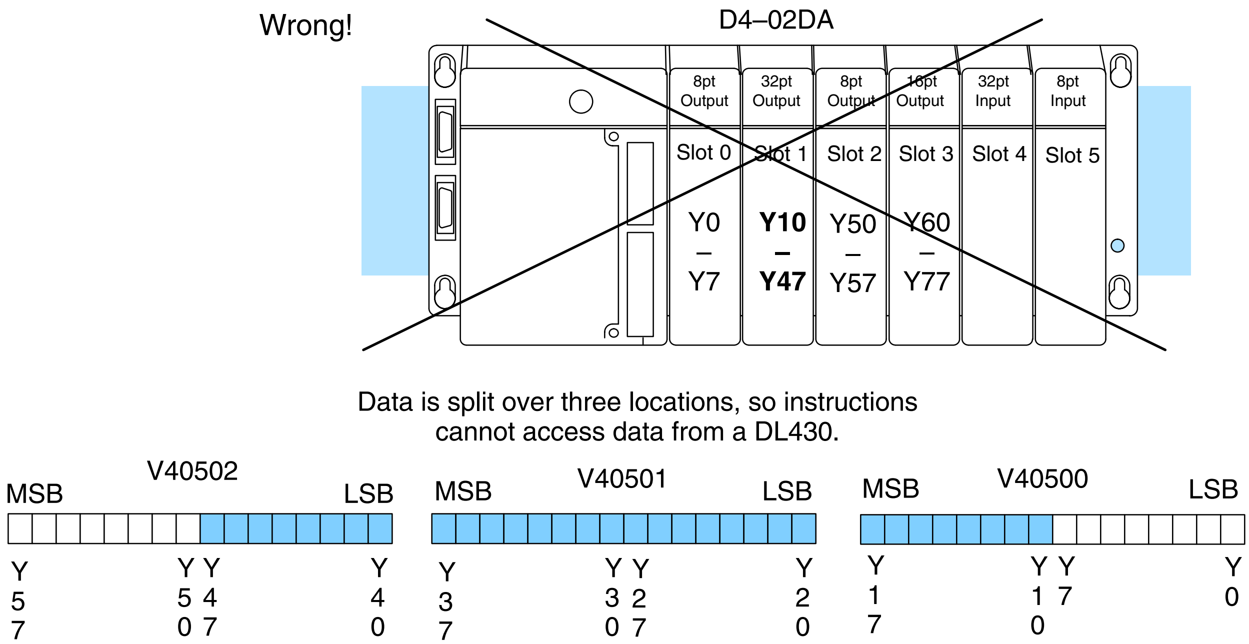


Module Operation

DL430 Special Requirements

Even though the module can be placed in any slot, it is important to examine the configuration if you're using a DL430 CPU. As you'll see in the section on writing the program, you use V-memory locations to extract the analog data. As shown in the following diagram, if you place the module so that the input points do not start on a V-memory boundary, the instructions can't access the data.

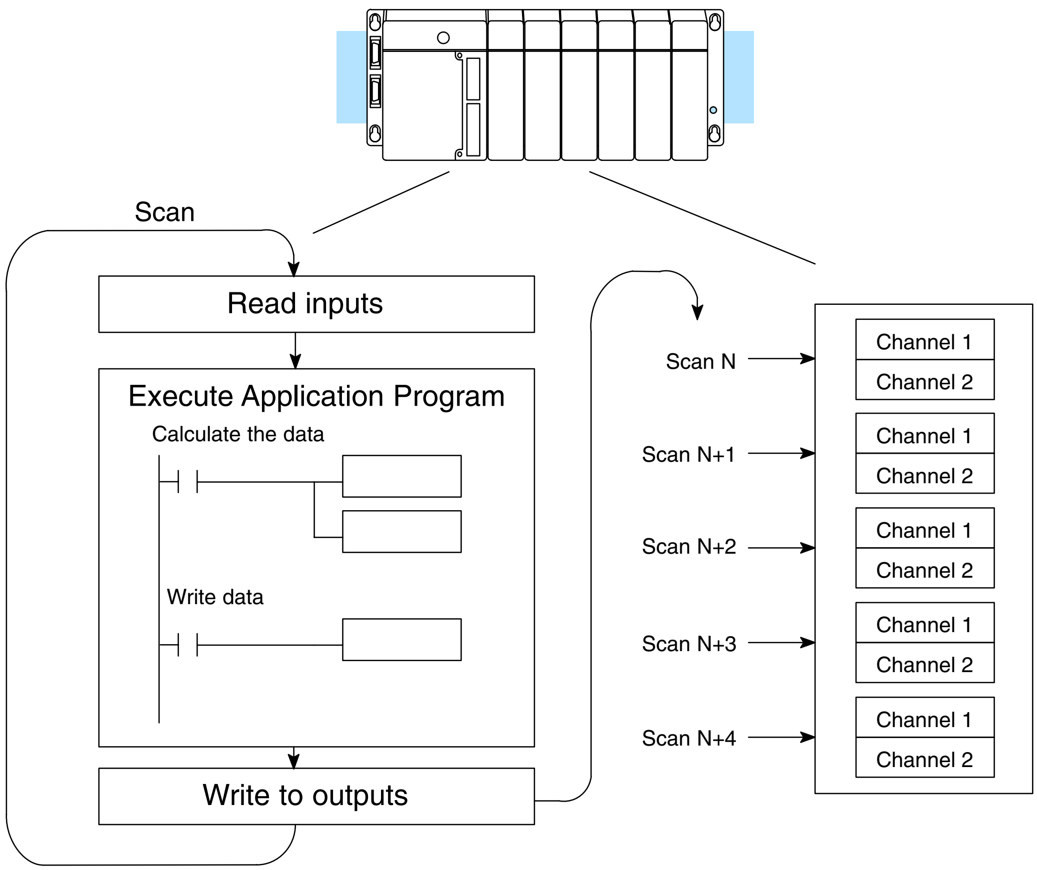




Before you begin writing the control program, it is important to take a few minutes to understand how the module processes and represents the analog signals.

Channel Scanning Sequence

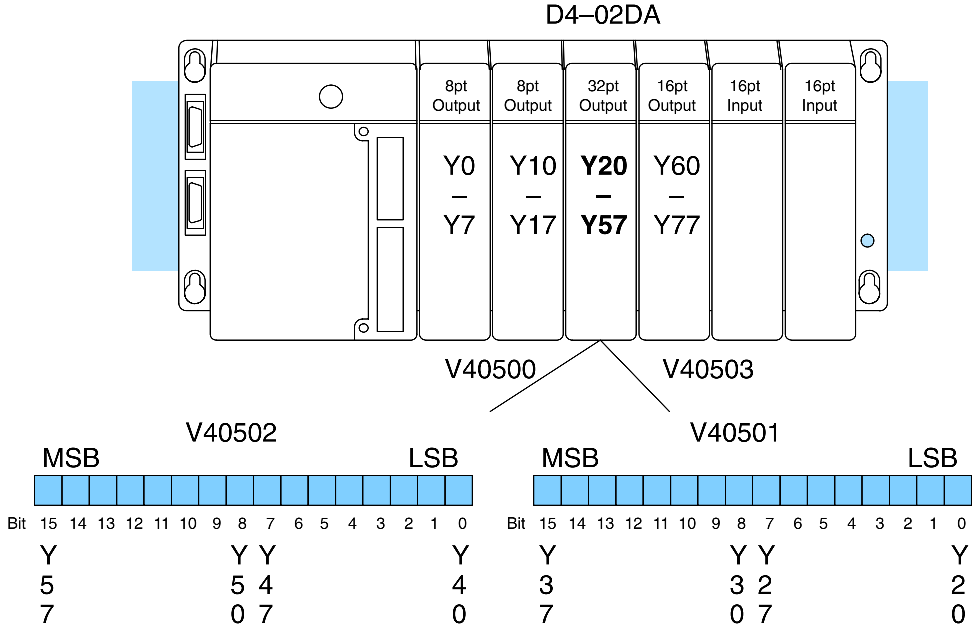
The D4–02DA module updates both channels in the same scan. The control program updates the two channels of this module independent of each other and each channel does not have to be refreshed on every scan.



Output Bit Assignments

You may recall the D4–02DA module requires 32 discrete output points. These 32 points provide the digital representation of the analog signals.

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.

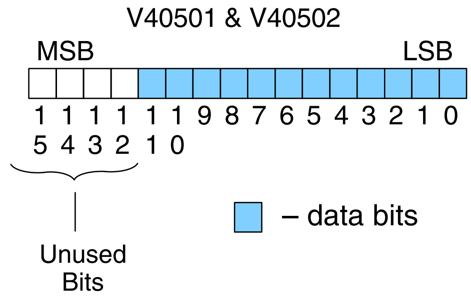


Within these two word locations, the individual bits represent specific information about the analog signal.

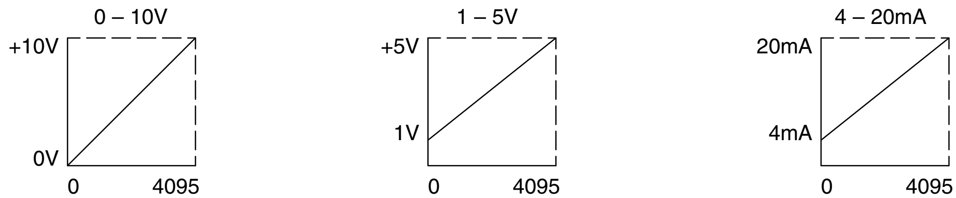
Analog Data Bits

The first twelve bits of each V-memory location represent the analog data in binary format. The remaining four bits are not used and are ignored by the module.

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



Since the module has 12-bit resolution, the analog signal is made of 4096 counts ranging from 0 – 4095 (2^{12}). For example, with a 0 to 10V scale, you would 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. The following diagram shows how this relates to each signal range.



Each count can also be expressed in terms of the signal level by using the equation shown. The following table shows the smallest signal change that occurs when the digital value is increased.

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

H = high limit of the signal range

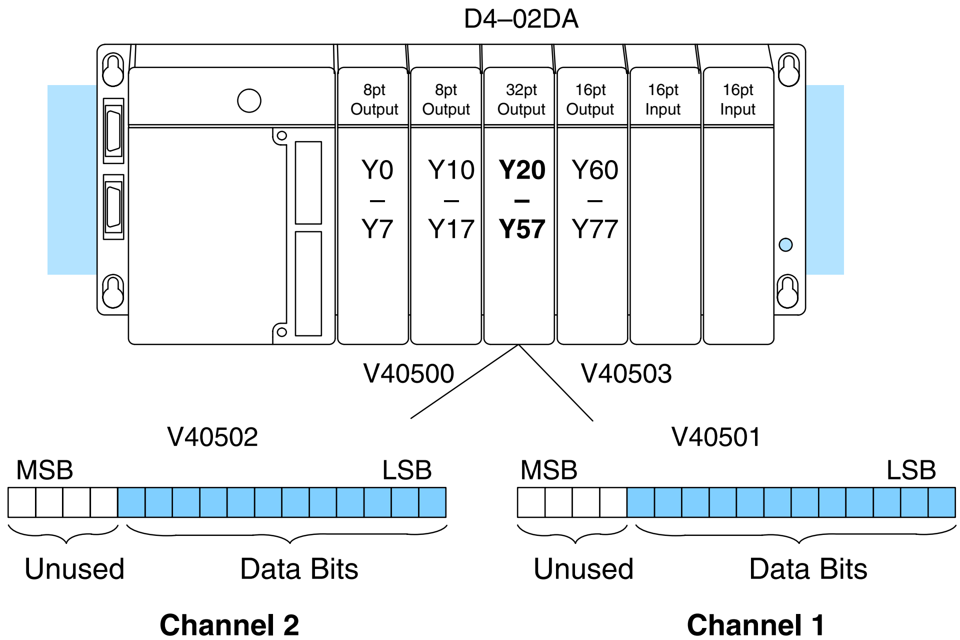
L = low limit of the signal range

Signal Range	Span (H – L)	Divide By	Smallest Change
0 to 10V	10V	4095	2.44 mV
1 to 5V	4V	4095	0.98 mV
4 to 20mA	16mA	4095	3.91 µA

Writing the Control Program

Update Either Channel

As mentioned earlier, you can update either channel or both channels during the same scan. Since the module does not have any channel select bits, you just simply determine the location of the data word and send the data word to the output module whenever you need to update the data.



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.

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

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.

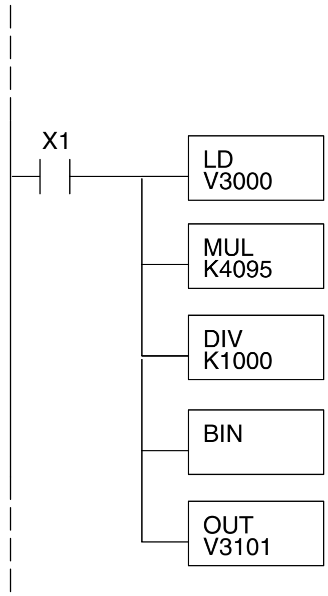
$$A = 10U \frac{4095}{10(H - L)}$$

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

$$A = 2023$$

Here is 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 V3000. Also, you have to perform this for both channels if you're using different data for each channel.

NOTE: The DL405 offers various instructions that allow you to perform math operations using binary, BCD, etc. It is usually easier to perform any math calculations in BCD and then convert the value to binary before you send the data to the module. If you are using binary math, you do not have to include the BIN conversion.



When X1 is on, the engineering units (stored in V3000) are loaded into the accumulator. This example assumes the numbers are BCD.

Multiply the accumulator by 4095 (to start the conversion).

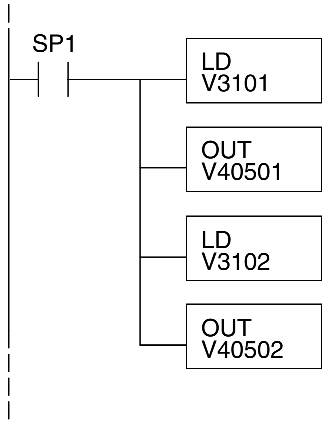
Divide the accumulator by 1000 (because we used a multiplier of 10, we have to use 1000 instead of 100).

Convert the BCD number to binary.

Store the result in V3101. This is the digital value, in binary form, that should be sent to the module.

Sending the Data to the Module

The following program example shows how to send the digital values to the module.



Loads the complete data word into the accumulator. This is the digital value that will be sent to the module for channel 1.

Channel 1 is mapped to V40501, so this OUT instruction sends the channel 1 data to that address.

Loads the complete data word into the accumulator. This is the digital value that will be sent to the module for channel 2.

Channel 2 is mapped to V40502, so this OUT instruction sends the channel 2 data to that address.

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 useful 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 10V	$A = \frac{10D}{4095}$	$D = \frac{4095}{10}(A)$
1 to 5V	$A = \frac{4D}{4095} + 1$	$D = \frac{4095}{4}(A - 1)$
4 to 20mA	$A = \frac{16D}{4095} + 4$	$D = \frac{4095}{16}(A - 4)$

For example, if you are using the 0 to 10V range and you know you need a 6V signal level, you would use the following formula to determine the digital value that should be stored in the V-memory location that contains the data.

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

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

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

$$D = 2457$$