B

Appendix B Analog I/O Scaling Examples

— Analog Input Module
— Analog Output Module

Analog Input Module

Scaling the Input Data

Most applications usually require measurements in engineering units, which provide more meaningful data. 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.

$$\text{Units} = A\,\frac{H - L}{8191}$$

H = high limit of the Engineering unit range

L = low limit of the Engineering unit range

A = Analog value (0 – 8191)

For example, if you wanted to measure pressure (PSI) from 0.0 to 99.9 then you would have to multiply the analog value by 10 in order to imply a decimal place when you view the value with the programming software or a handheld programmer. Notice how the calculations differ when you use the multiplier.

Analog Value of 4047, slightly less than half scale of 8191, should yield 49.4 PSI

Example without multiplier

$$\text{Units} = A\,\frac{H - L}{8191}$$

$$\text{Units} = 4047\,\frac{100 - 0}{8191}$$

$$\text{Units} = 49$$

Example with multiplier

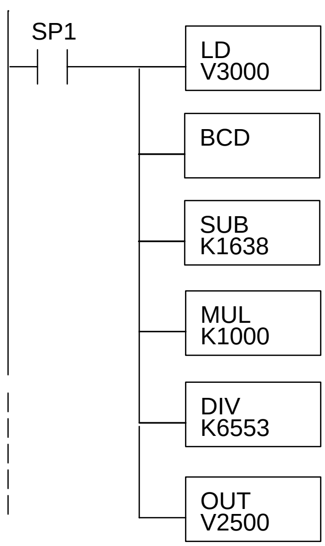
$$\text{Units} = 10\,A\,\frac{H - L}{8191}$$

$$\text{Units} = 40470\,\frac{100 - 0}{8191}$$

$$\text{Units} = 494$$

Example 1: Scaling 4–20mA Input Signal

Here’s how you would write the program to perform the engineering unit conversion for a 4 – 20mA input signal. This example uses SP1 which is always on. You could also use an X, C, etc. permissive contact.



When C0 is on, channel 1 data is loaded into the accumulator.

Converts the binary analog data to BCD to perform math operations. Omit this instruction if binary data is to be used for binary math operations.

Subtracts 1638 from the incoming signal to adjust the 4mA offset.

Multiplies the accumulator data by 1000 (to start the conversion).

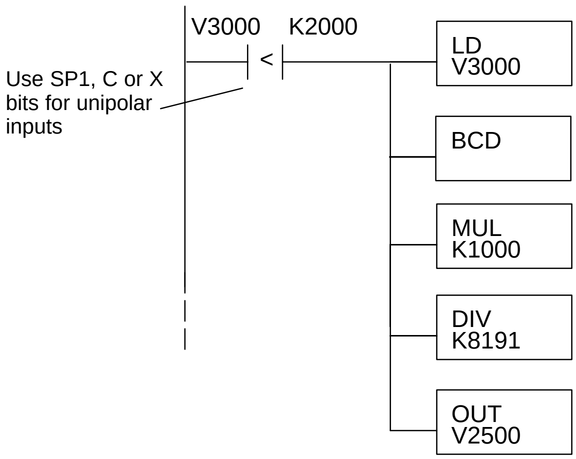
Divides the accumulator data by 6553. (8191 – 1638)

Stores the result in location V2500.

Example 2: Scaling Unipolar and Bipolar Input Signals

Here's how you would write the program to perform the engineering unit conversion for a 0–5V, 0–10V, ±5, ±10, 0–20mA or ±20mA input signal. The example assumes the analog data is in V3000.

This rung executes if the channel data is positive



Channel 1 data is loaded into the accumulator.

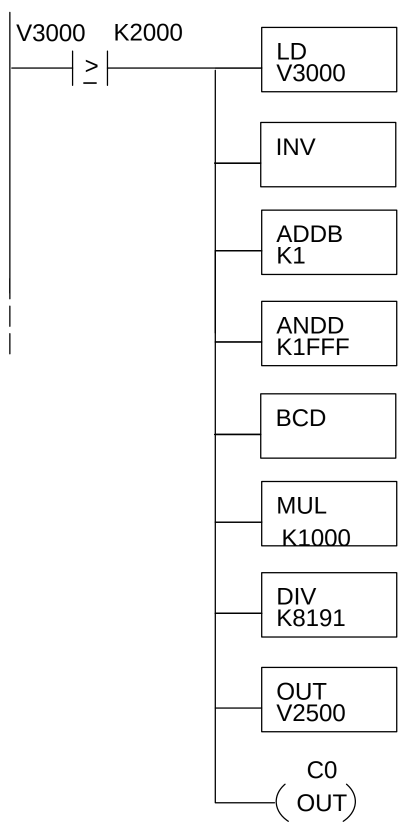
Converts the binary analog data to BCD to perform math operations. Omit this instruction if binary data is to be used for binary math operations.

Multiplies the accumulator data by 1000 (to start the conversion).

Divides the accumulator data by 8191. **Divide by 4095 for 0–5V or ±5V input signal ranges.**

Stores the result in location V2500.

This rung executes if the channel data is negative. It can be omitted for unipolar inputs.



Channel 1 data is loaded into the accumulator.

The INV and ADDB instructions convert the incoming 2's complement analog data into binary

Masks the channel sign bit

Converts the binary analog data to BCD to perform math operations. Omit this instruction if binary data is to be used for binary math operations.

Multiplies the accumulator data by 1000 (to start the conversion).

Divides the accumulator data by 8191. **Divide by 4095 for 0–5V or ±5V input signal ranges.**

Stores the result in location V2500.

C0 is ON when the input signal is negative

Analog Output Module

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 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

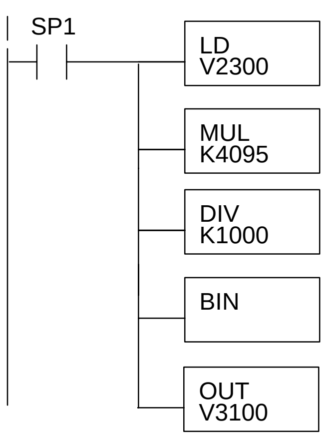
L = Low limit of the engineering unit range

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 must adjust the formula to compensate for it.

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

Engineering Unit Conversion

The following example program shows how you would write the program to perform the engineering unit conversion to output data formats 0–4095. This example assumes you have calculated or loaded the engineering unit values in BCD format and stored it in V2300. 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.



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).

Convert the data to binary format before sending it to the module

Send the binary data to channel 1 of the module