



Application Note 113

Scaling Analog Inputs with the 2200 PCX Explorer

Introduction

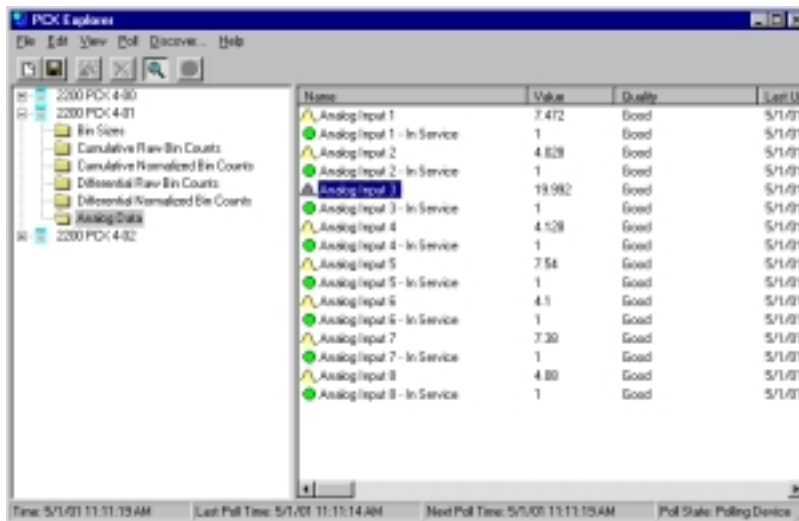
The 2200 PCX Particle Counter with the Analog Input option can accept eight analog signal inputs. In many applications the analog value "0" is not 0 milliamp or 0 volts, but may be 4 milliamp or 1 volt. This requires that not only a slope or gain be set but that an offset must be set so that the analog signal is scaled to display the proper engineering units, i.e. 4 -20 milliamp scaled to 0 - 25 PSI.

Fortunately the 2200 PCX Explorer Analog Input Scaling Wizard makes scaling easy to do.

Default Settings and Manual Calculations

The eight analog inputs of the 2200 PCX can range from 0 to 20 milliamp for IN0 and IN1 current inputs, and 0-5 VDC or 0-10 VDC for the AN2 -AN5 inputs. The voltage inputs can be configured as current inputs by connecting a 1/2 watt, 1% 249 Ohm resistor from the voltage input to ANGND (analog ground) and passing the loop current through the resistor. Please refer to the 2200PCX Particle Counter Instrument Manual #57050-18 for detailed information on the inputs.

The default settings of the analog inputs of the 2200 PCX Explorer are set to display 0 to 20 for an input of 0 to 20 milliamp or 0 to 5 volts.



Name	Value	Quality	Last Up
Analog Input 1	7.472	Good	5/1/01
Analog Input 1 - In Service	1	Good	5/1/01
Analog Input 2	4.828	Good	5/1/01
Analog Input 2 - In Service	1	Good	5/1/01
Analog Input 3	19.982	Good	5/1/01
Analog Input 3 - In Service	1	Good	5/1/01
Analog Input 4	4.128	Good	5/1/01
Analog Input 4 - In Service	1	Good	5/1/01
Analog Input 5	7.54	Good	5/1/01
Analog Input 5 - In Service	1	Good	5/1/01
Analog Input 6	4.1	Good	5/1/01
Analog Input 6 - In Service	1	Good	5/1/01
Analog Input 7	7.38	Good	5/1/01
Analog Input 7 - In Service	1	Good	5/1/01
Analog Input 8	4.80	Good	5/1/01
Analog Input 8 - In Service	1	Good	5/1/01

Figure 1 2200 PCX Explorer

To view the default settings, select an Analog Input in the Explorer, i.e. Analog Input 3, and click the menu item **Edit|Properties** to display the Tag Configuration window.

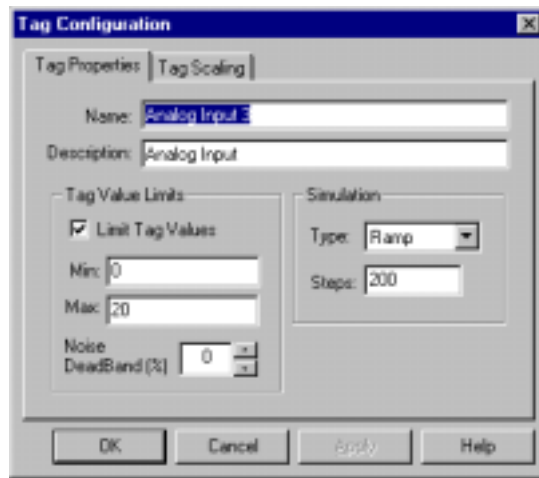


Figure 2 Tag Properties

The default Tag Value Limits (the Maximum and Minimum values the Explorer will display for the particular analog tag) are 0 and 20. Select the Tag Scaling tab in the Tag Configuration window.

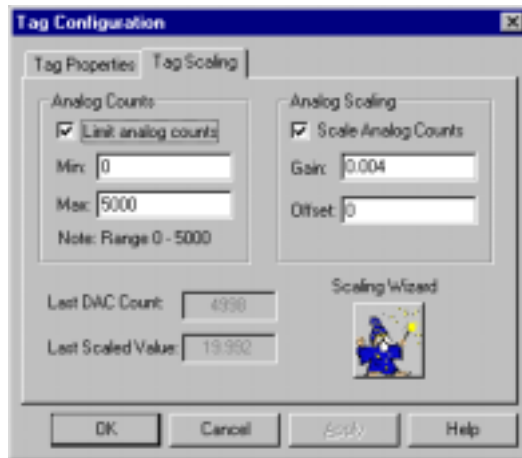


Figure 3 Tag Scaling

The range of the Analog to Digital converter on the 2200PCX analog input card option is 0 to 5000 counts. Zero volts or zero milliamps at the input will produce zero counts and 20 milliamp or 5 volts at the input will produce 5000 counts. The default Gain is 0.004 and the default offset is 0.

The **Basic Scaling Relationship (BSR)** of the calculated or displayed value in the 2200 PCX Explorer is:

$$(Gain \times Counts) + Offset = DisplayedValue$$

For example, at an analog input of 0mA or 0 volts, the counts are equal to 0, therefore using the default values for gain (0.004) and offset (0.0), we can compute the displayed value as:

$$(0.004 \times 0) + 0 = 0$$

At an analog input of 20mA or 5 volts the counts are equal to 5000. The displayed value computes as:

$$(0.004 \times 5000) + 0 = 20$$

Suppose we have a system where the analog signal is 4 to 20mA and it represents a Turbidity value of 0 to 1 NTU. To properly scale the system we need to calculate both the **Gain** and **offset** such that the following holds true:

$$(Gain \times Counts \text{ at } 4mA) + offset = 0$$

And

$$(Gain \times Counts \text{ at } 20mA) + offset = 1.0$$

To solve these two equations we need to first determine the counts we will have at both 4mA and 20mA. With this information we can compute the Gain value. Then we solve the equation for the final unknown, the offset.

We know that 20mA will yield 5000 counts from the Analog to Digital Converter. We can use this information to compute the analog counts at 4mA:

$$20mA = 5000 \text{ counts}$$

so

$$\frac{5000 \text{ counts}}{20mA} = \frac{250 \text{ counts}}{1mA}$$

therefore

$$\frac{250 \text{ counts}}{1mA} \times 4mA = 1000 \text{ counts}$$

We know now that 4mA should be about 1000 counts, now we have to solve for gain.

Gain is defined as the change in displayed value divided by the change in counts.

$$Gain = \frac{\Delta Value}{\Delta Counts}$$

Our change in displayed value is:

$$\begin{aligned} ValueMax - ValueMin &= \Delta Value \\ 1.0NTU - 0.0NTU &= 1.0NTU \end{aligned}$$

Our change in counts is:

$$\begin{aligned} CountMax - CountMin &= \Delta Counts \\ 5000 - 1000 &= 4000 \text{ Counts} \end{aligned}$$

therefore

$$Gain = \frac{\Delta Value}{\Delta Counts} = \frac{1.0NTU}{4000Counts} = 0.00025NTU / Count$$

We now have calculated the Gain and Counts for the two original equations. Finally we finish by computing the **offset**:

$$\left(\frac{0.00025 NTU}{Count} \times 1000 Counts \right) + offset = 0 NTU$$

$$0.25 NTU + offset = 0.0 NTU$$

$$offset = -0.25 NTU$$

We can check our calculations at 0 and 1 NTU using the **BSR**:

$$(Gain \times Counts) + Offset = DisplayedValue$$

$$\left(\frac{0.00025 NTU}{Count} \times 1000 Counts \right) + (-0.25 NTU) = 0 NTU$$

and

$$\left(\frac{0.00025 NTU}{Count} \times 5000 Counts \right) + (-0.25 NTU) = 1.0 NTU$$

The Offset value and Gain values can be entered into the appropriate boxes on the Tag Configuration Scaling window and the apply button clicked to set the scaling. If this approach is used to set the scaling, we recommend that you leave the Analog Counts Minimum and Maximum settings at 0 and 5000, or the full range of the Analog to Digital Converter.



Figure 4 Tag Scaling

Also, the Tag Value Limits on the Tag Properties tab need to be set at your minimum and maximum engineering values (0 and 1 NTU) in this example. The Tag Value Limits can be set outside this range, i.e. (-0.5 NTU and 1.5 NTU) and the OPC Server will display the proper readings, but if the limits are set inside the desired range, the OPC Server will truncate the readings to the limits you set.

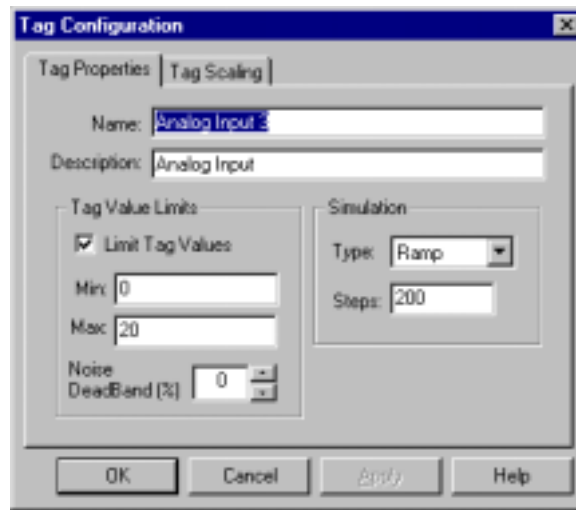


Figure 5 Tag Properties

Using the Scaling Wizard

Thanks to the Scaling Wizard, there is a much easier way to set the scaling of the analog tag. As before, let's assume a system where the analog input signal is 4 to 20 milliamp and it represents 0 to 1 NTU of turbidity.

Note: This method does require the ability to force the analog input signal to its low and high extremes, i.e. 4 and 20 milliamp limits.

This time we will use the Scaling Wizard on the Tag Scaling tab of the Tag Configuration dialog.



Figure 6 Scaling Wizard

Click on the Scaling Wizard button.



Figure 7 Scaling Wizard Step 1

Force the sensor signal to its 4 milliamp point, or 0 NTU in this example and then click Next.



Figure 8 Scaling Wizard Step 2

We recommend keeping the #Samples to Collect at 5 if there is noise or variation in the signal. Click Next to begin collecting samples at the minimum analog input level.



Figure 9 Scaling Wizard Step 3

After the samples have been collected the Next button will become activated. Click Next.



Figure 10 Scaling Wizard Step 4

Enter the Scaled Value, 0 in this example for 0 NTU and click Next to continue.



Figure 11 Scaling Wizard Step 5

Force the sensor signal to its 20-milliamp point, or 1 NTU in this example and then click Next to begin collecting samples at the maximum analog input level.



Figure 12 Scaling Wizard Step 6

After the 5 samples have been collected, click Next to continue.



Figure 13 Scaling Wizard Step 7

Enter the Scaled Value, 1 in this example for 1 NTU and click Next to continue.



Figure 14 Scaling Wizard Summary

Click Finish to complete the Wizard process.



Figure 15 Tag Configuration

Notice that the Gain and Offset derived from using the Scaling Wizard are almost identical to the values we manually calculated in the previous example.

Click the OK button to complete the Scaling process.

The Scaling Wizard method of setting the scale for the analog tag is the preferred method and should yield the most accurate results.

Notes Regarding the Scaling Wizard

Sometimes it is not possible to control the sensor signal so that it can be forced to its limit points (4 and 20 milliamp or 0 and 1 NTU in our example). It may be possible to set the sensor signal to a smaller range, for example 6 milliamp (0.125 NTU) and 18 milliamp (0.875 NTU). The Scaling Wizard can still be used, but we will need to edit the limits after the Wizard completes its process. After the Wizard finishes, on the Tag Scaling tab of the Tag Configuration window, set the Analog Counts limits Min. equal to 0 and Max. equal to 5000. On the Tag Properties tab, set the Tag Value Limits Min. equal to 0 and Max. equal to 1.

What to Do When You Can't Adjust the Sensor Output to a Min. and Max. Value

In some applications it may not be possible to adjust the sensor output to a minimum or maximum value. The following is a trick that can be used to simulate the spanning of the sensor.

Consider the following wiring diagram:

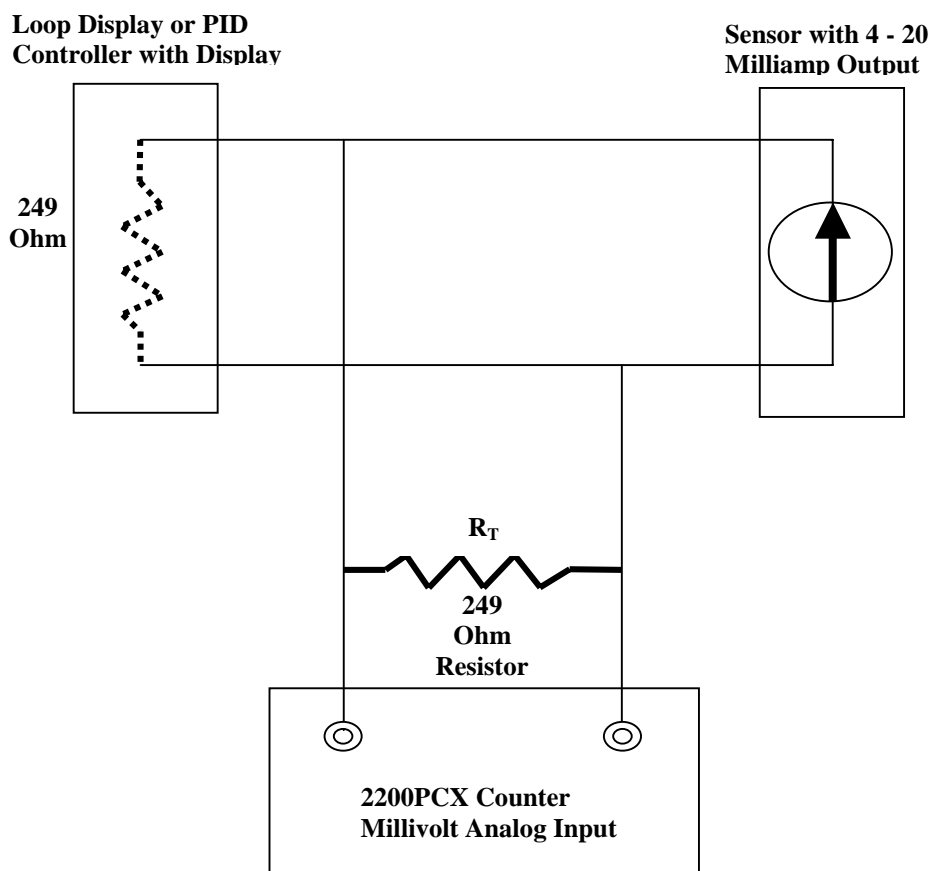


Figure 16 2200 PCX Counter, Millivolt Input

In a typical sensor application, the sensor's current loop signal may be wired to a loop display device or PID with display. Typically the displays have a 249 ohm input impedance. The 2200 PCX analog inputs can be wired to accept a millivolt signal in the range of 0 to 5000 millivolt (refer to the 2200 PCX Instruction manual for details). By connecting the Counters Analog Input across the input of the display or PID device, an input signal range of 1000 to 5000 millivolt for a loop current range of 4 to 20 milliamp can be derived.

Let's assume that our display is already calibrated to the sensor and reading 0.511 NTU. If we shunt the input to the 2200 PCX Counter with a 249-ohm resistor, R_T , as shown in figure 13, the current to the display will be reduced in half and the display should read 0.124 if the system is linear.

We can now use the Scaling Wizard to perform our scaling. The minimum value we will use is 0.124 NTU with our resistor shunt attached and our maximum value will be 0.511 NTU with our shunt removed. After the Scaling Wizard is ran, our summary should look like the following:



Figure 17 Scaling Wizard Summary

Click on Finish to complete the Wizard process.

The Tag Configuration now shows the Gain and Offset values. Notice that they are very close to the previous examples.

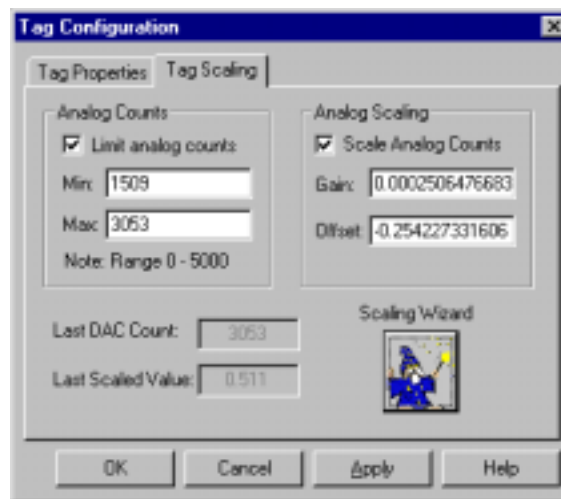


Figure 18 Tag Configuration

To make this work, we need to adjust the Analog Counts. Set them to 0 and 5000 for the Min. and Max.

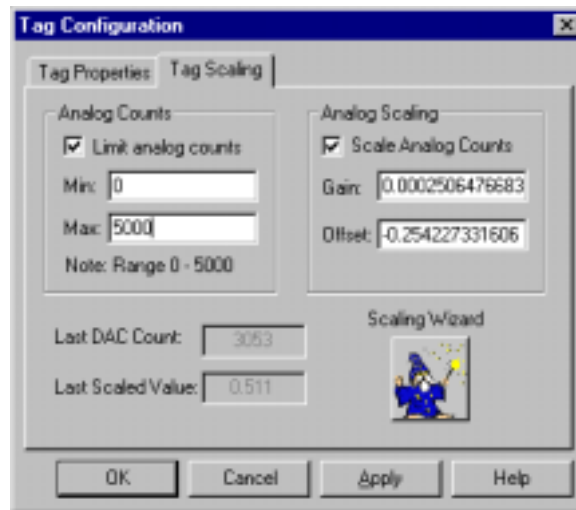


Figure 19 Adjusting Analog Counts

We will also need to adjust the Tag Value Limits on the Tag Properties tab so that they will cover our desired range of 0 to 1 NTU. Set them to 0 and 1.1 NTU, which covers our range.

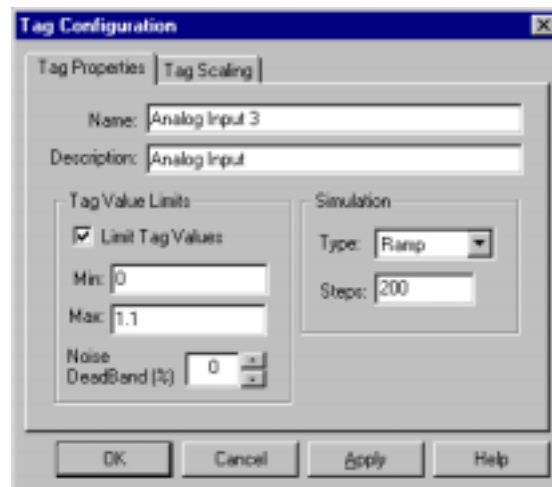


Figure 20 Adjusting Tag Value Limits

A similar process can be followed to scale the analog tag if the system is wired with current or milliamp analog input to the 2200 PCX Counter as shown in the following figure:

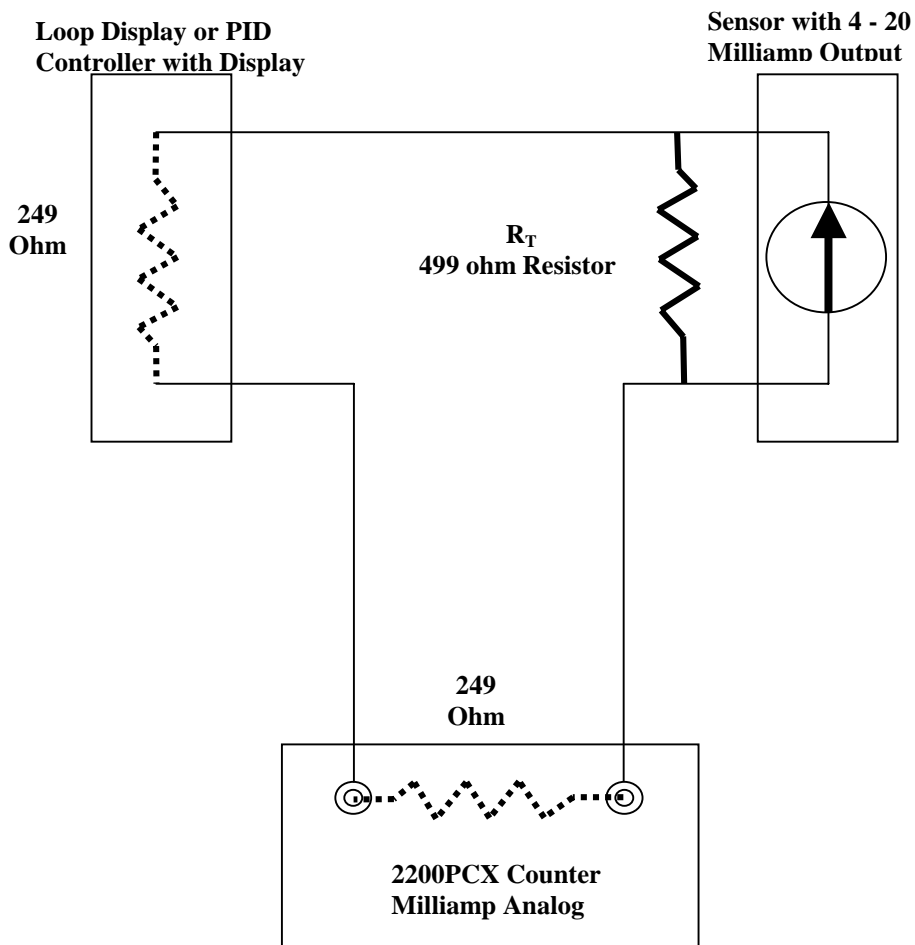


Figure 21 2200 PCX Counter, Milliamp Input

The current analog input to the 2200 PCX counter has a 249-ohm impedance and the millivolt inputs can be made to act like current inputs if a 249-ohm resistor is wired across the input as outline in the 2200 PCX instruction manual. The same process as followed previously to scale the analog tag can be used, but in this case, we would use a 499-ohm resistor to shunt the system to simulate our lower limit scaling value.

Note: The two methods using a shunt resistor to simulate a lower limit are not as accurate as the other two methods, but scaling can be set within 2 to 3 percent using the shunt method.

For more information, visit our AquaTrend Technical Information site at:

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