



TOOLS FOR SMART MINDS

**iDaq**

# **How to configure pressure sensors**

January 2015

Rev 02

**Worldwide technical support and product information:**

[www.toolsforsmartminds.com](http://www.toolsforsmartminds.com)

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## INTRODUCTION

A pressure sensor measures pressure, typically of gases or liquids. Pressure is an expression of the force required to stop a fluid from expanding, and is usually stated in terms of force per unit area. A pressure sensor generates a electrical signal as a function of the pressure imposed. Pressure sensors are used for the control and monitoring of thousands of everyday applications and can alternatively be called:

- pressure transducers
- pressure transmitters
- pressure senders
- pressure indicators
- piezometers and manometers

Pressure sensors can vary in technology, design, performance, application suitability and cost.

Analog pressure sensors uses different technologies to generate electrical signal proportional to measured pressure. The most common technology is **Force collector type**. These type of electronic pressure sensor generally uses a force collector to measure strain or deflection due to applied force (pressure) over its area. common sensors with this technology are:

- Piezoresistive strain gauge
- Capacitive
- Electromagnetic
- Piezoelectric
- Optical
- Potentiometric

## USING CURRENT OR VOLTAGE TO TRANSMIT TRANSDUCER DATA

Industrial-grade transducers commonly use current or voltage signals to transmit data. While voltage-based transducers are sufficient in many environments, current-based transducers are at times preferred. For instance, the inherent disadvantage of using voltage to transmit signals in an industrial environment is voltage drops over long cable lengths due to wire resistance. You can use high input impedance devices to avoid signal loss. However, these devices are sensitive to the noise induced by nearby motors, conveyor belts, and radio transmissions.

## DYNAMIC LINEARITY

The dynamic linearity of the sensor is a measure of its ability to follow rapid changes in the input parameter. Amplitude distortion characteristics, phase distortion characteristics, and response time are important in determining dynamic linearity. Given a system of low hysteresis (always desirable), the amplitude response is represented by:

$$F(X) = aX + bX^2 + cX^3 + dX^4 + \dots + K \quad (6-2)$$

In Equation above, the term  $F(X)$  is the output signal, while the  $X$  terms represent the input parameter and its harmonics, and  $K$  is an offset constant (if any). The harmonics become especially important when the error harmonics generated by the sensor action falls into the same frequency bands as the natural harmonics produced by the dynamic action of the input parameter. Harmonics present will be that can be affected by the action of the sensor.

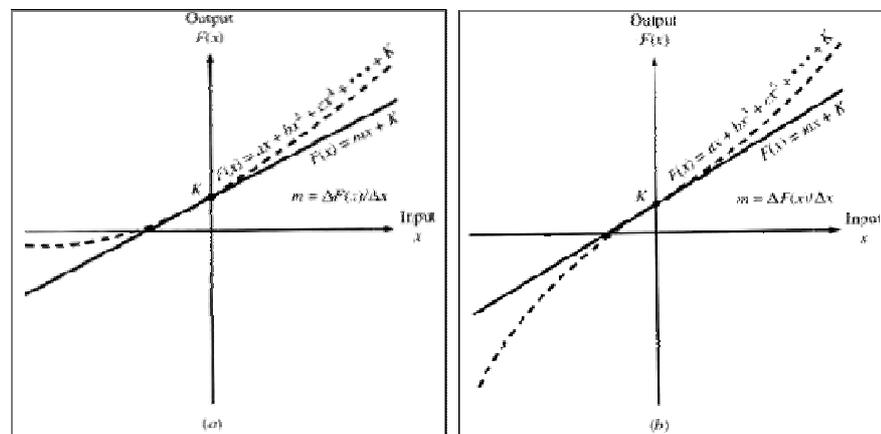


FIGURE 1 OUTPUT VERSUS INPUT SIGNAL CURVES SHOWING (A) QUADRATIC ERROR; (B) CUBIC ERROR.

SOURCE: J.J. CARR, SENSORS AND CIRCUITS PRENTICE HALL.

The nature of the nonlinearity of the calibration curve (Figure above) provides information about which harmonics are present. The calibration curve (shown as a dotted line) is asymmetrical, so only odd harmonic terms exist. Assuming a form for the ideal curve of  $F(x) = mx + K$ , Equation becomes for the symmetrical case:

$$F(X) = aX + bX^2 + cX^4 + \dots + K \quad (6-3)$$

In the other type of calibration curve, the indicated values are symmetrical about the ideal  $mx + K$  curve. In this case,  $F(X) = -F(-X)$ , and the form of equation is:

$$F(X) = aX + bX^3 + cX^5 + \dots + K \quad (6-4)$$

## HOW TO CONFIGURE PRESSURE SENSORS WITH IDAQ

iDaq allows to manipulate raw signals acquired from a wide range of sensors and electronic devices and to get values in engineering units with specific scales.

In many practical cases, pressure signals are assumed to be linear or are approximated with polynomial curves. iDaq allows to configure pressure signals in both cases.

### CONVERSION TYPE

According to the calibration curve of the sensor, two different configurations can be applied:

- Probe conversion
- Polynomial conversion

### PROBE CONVERSION

This is the simpler case. Probe conversion can be applied when the sensor in use has a linear characteristic curve, that is the Pressure and Electrical quantity have a linear relationship and offset value is zero. For this type of sensor, Pressure-Electrical quantity relationship is represented by a single value (sensitivity). The following image shows an example of a linear characteristic curve.

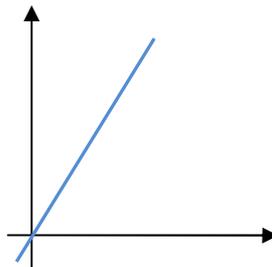


FIGURE 2 LINEAR CHARACTERISTIC CURVE WITH NULL OFFSET.

For this type of sensors, acquired signals can be processed using the WPU Probe conversion. This WPU returns the acquired signal scaled with the formula  $S_{out} = K * S_{in}$ . By setting the multiplier factor (K) to the value of the sensor in use, acquired signals will automatically rescaled.

To apply this type of conversion to a specific channels, open channel editor, and press "Processing" button highlighted in following figure.

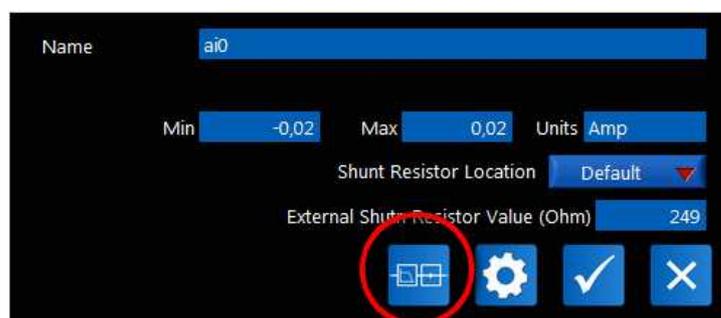


FIGURE 3 HOW TO APPLY A PROBE CONVERSION ON A CHANNEL.

In Processing Windows there are different processing methods. As shown in the following figure, select "Probe".

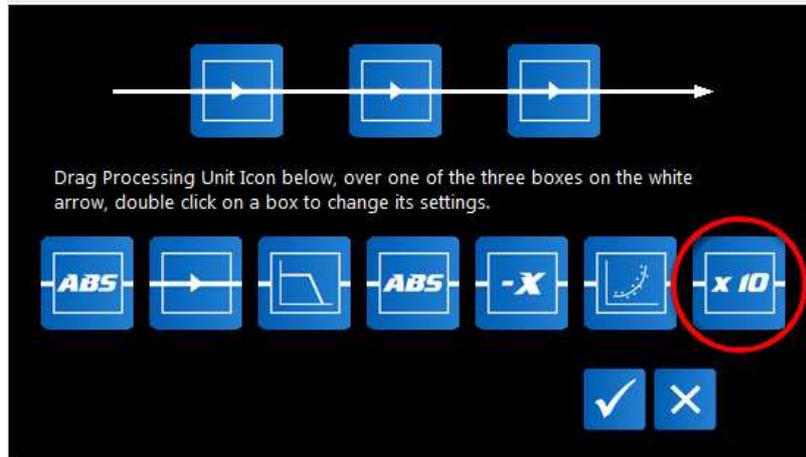


FIGURE 4 WAVEFORM PROCESSING UNIT WINDOW.

Drag Probe icon over one of the three icons in the upper part of the window. During the dragging action, icon color changes to red, as illustrated below.

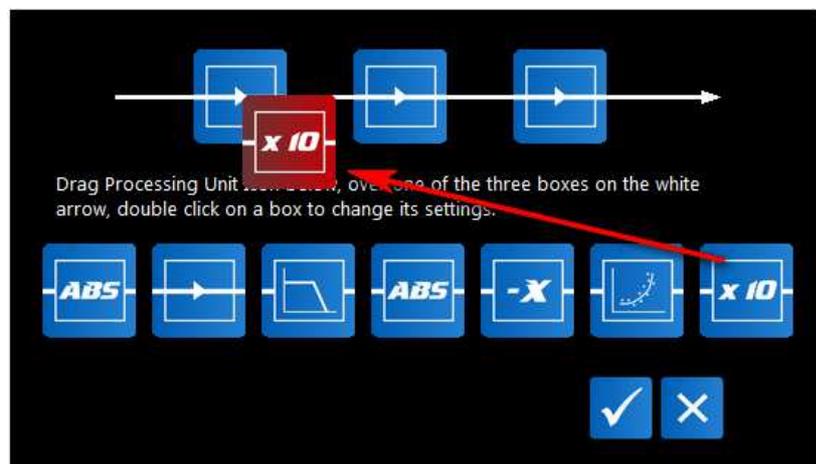


FIGURE 5 DRAGGING SELECTED WAVEFORM PROCESSING UNIT.

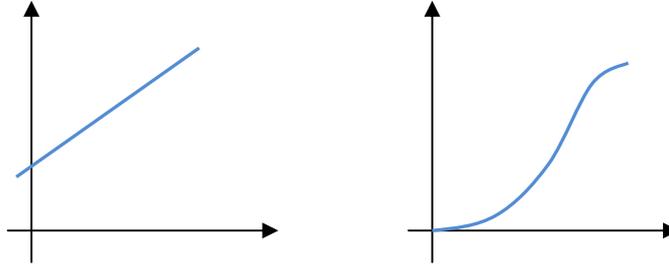
Release the Probe icon over one of the three nodes in upper diagram, iDaq will display Probe dialog window, shown in next figure.



FIGURE 6 PROBE EDITOR.

## POLYNOMIAL CONVERSION

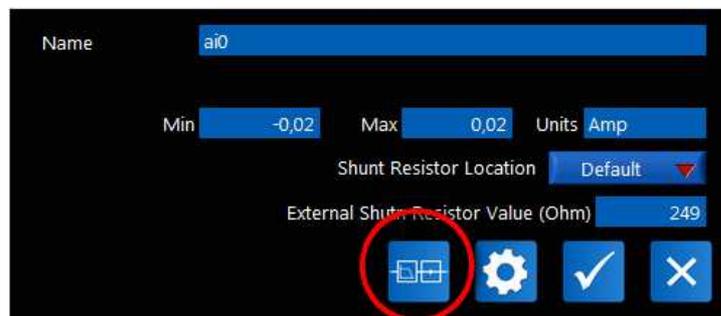
Polynomial conversion is used when the sensor has a non-passing-through-the-origin curve or a non-linear curve. The following image shows an example of linear characteristic with offset and non-linear characteristic curves.



**FIGURE 7 LINEAR CHARACTERISTIC WITH OFFSET AND NON LINEAR CHARACTERISTIC.**

For this type of sensors, acquired signals can be processed using the WPU Polynomial. This WPU allows the definition of a curve fitting to convert acquired data into physical quantities. Curve fitting is a mathematical function that has the best adherence to a series of data points. Curve fitting can involve either interpolation, when the function fits the data exactly, or smoothing, when the function fits the data approximately. Polynomial WPU allows to define a polynomial function up to the fourth order.

To apply this type of conversion to a specific channels, open channel editor, and press "Processing" button highlighted in following figure.



**FIGURE 8 HOW TO APPLY A POLYNOMIAL CONVERSION ON A CHANNEL.**

In Processing Windows there are different processing methods, select "Polynomial", (highlighted in following figure).

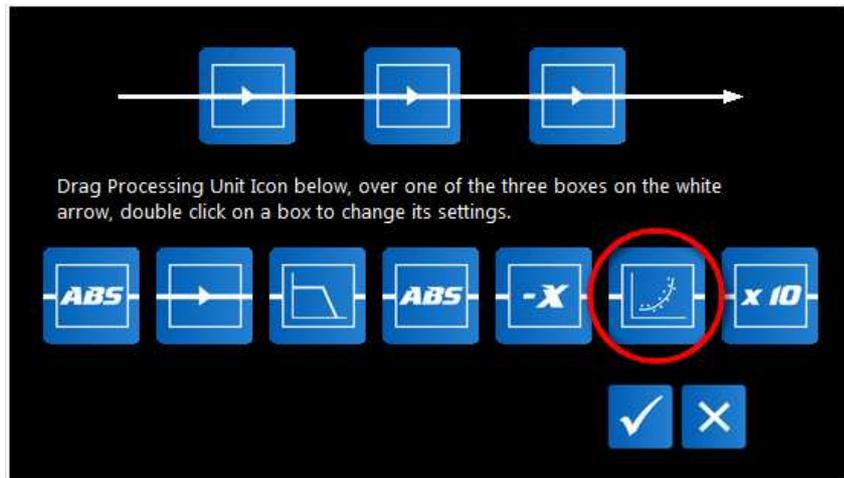


FIGURE 9 WAVEFORM PROCESSING UNIT WINDOW.

Drag Polynomial icon over one of the three icons in the upper part of the window. As shown below, during the dragging action, icon color changes to red.

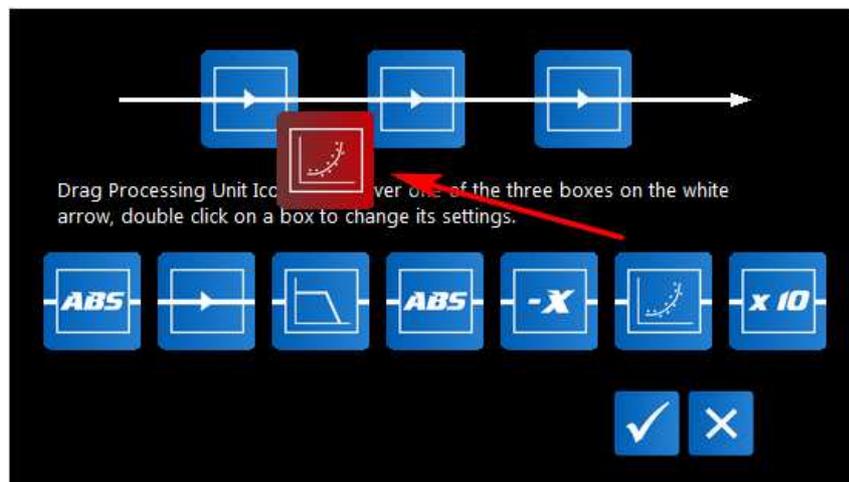


FIGURE 10 DRAGGING SELECTED WAVEFORM PROCESSING UNIT.

Release the Polynomial icon over one of the three nodes in upper diagram, iDaq will display Polynomial dialog window, shown in next figure.

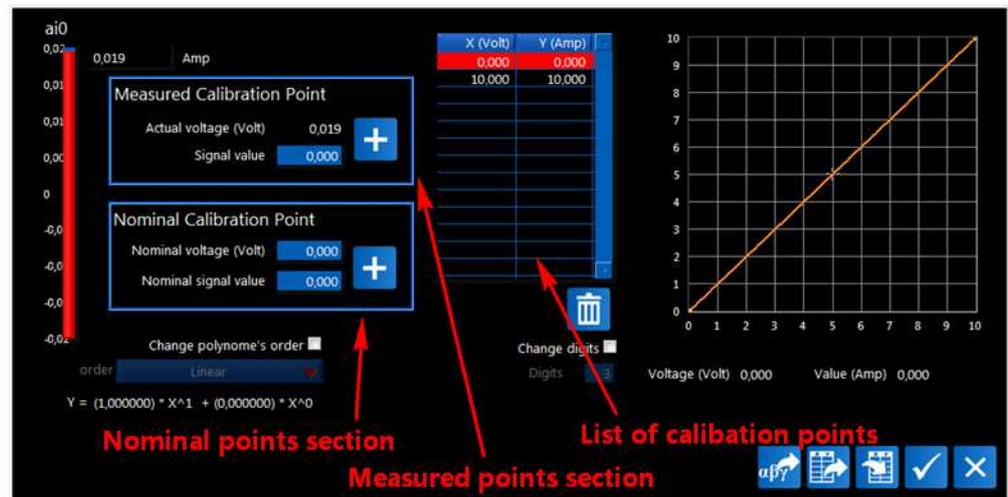


FIGURE 11 POLYNOMIAL SETTINGS DIALOG.

At this point, you can define the conversion curve in two different ways

- *Using nominal points.*

You can insert calibration points that iDaq uses to calculate the best fit. Through the indication of those calibration points, iDaq calculates the appropriate function for converting your signals.

This approach can be used when the sensor has a list of calibration points in its datasheet.

Referring to Figure 11, to add a new nominal point, insert the value of Nominal voltage (Y) and Nominal Signal Value (X) in the Nominal Calibration Point section and press Add button: the nominal point will be added to the list of points. This procedure can be repeated for all the available nominal points.

- *Using measured points.*

This approach can be used when measurements of known quantities can be performed. Referring to the pressure sensor, this approach can be applied if measurement on different values of pressure can be performed, for example 1, 2, 5, and 10 Bar. For each pressure value, the correspondent value of the sensor can be directly measured and used to define a new calibration point.

Referring to Figure 11, to add a new measured point, insert the value of Signal Value (the pressure value) and and press Add button: the measured point will be added to the list of points.

The list of calibration points can be populated using both nominal and measured points. When a new point is added, iDaq automatically calculates the sensor characteristic using the “Ordinary Least Squares” method (OLS).

By default, iDaq calculates a straight line (polynomial order = 1) and this can be useful when the sensor in use has a non-passing-through-the-origin curve. To change the polynomial order, click on Order and select the most suitable polynomial order for the sensor in use.

The following window shows an example of non-linear conversion curve calculated by iDaq.

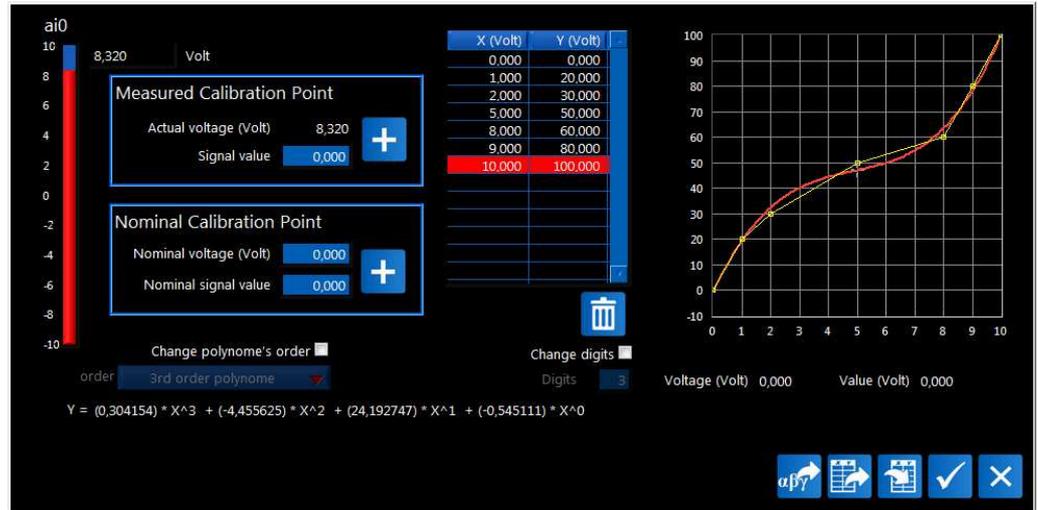


FIGURE 12 EXAMPLE OF NON-LINEAR CONVERSION CURVE.

The curve is a 3<sup>rd</sup>-order polynomial calculated from seven calibration points.

## ABOUT IDAQ

iDaq is a professional solution for data logging capable to acquire signals from a large variety of devices with different connection BUS. iDaq is simplest solution for technicians and engineers who want to get the best from their sensors and measurement hardware, without learning all details about hardware configuration and capabilities. iDaq is a data logger that can be customized with new functionalities by every LabVIEW developer. Many companies world-wide have chosen iDaq to boost their performance and save time.

## ABOUT TOOLS FOR SMART MINDS

TOOLS for SMART MINDS (T4SM) is software company committed to development of professional tools for engineers and LabVIEW developers. In last 20 years, T4SM has gain great experience in development of many inspection and data logging solutions for fields such: Automotive, Avionics, food processing and end-line measurements systems.

## PUBLICATION INFORMATION

"Introduction to Biomedical Equipment Technology" Third Edition by Joseph J. Carr John M. Brown, 1998, ISBN: 0-13-849431-2

## USEFUL LINKS

iDaq product page: <http://www.idaq-datalogger.com/idaq.php>

iDaq ADD-ON Store <http://www.idaq-datalogger.com/addons.php>

Support: <http://www.idaq-datalogger.com/support.php>

Current loop fundamentals: <http://www.ni.com/white-paper/6940/en/>