

System Calibration & Engineering Units Conversion Using $mx + b$

In many data acquisition software programs, the $mx + b$ application is a powerful tool, which can be used to adjust displayed readings and/or values obtained from stored data. Using this software computational feature, it is possible to convert voltage readings to any more useful or appropriate engineering units, and simultaneously accomplish channel calibration to reduce or eliminate offset and gain errors. The following examples demonstrate how either or both objectives are accomplished for:

- [Engineering Units Conversion \(1 example\)](#)
- [System Channel Calibration \(2 examples\)](#)
- [Combined System Channel Calibration and Engineering Units Conversion \(1 example\)](#)

Engineering Units Conversion

A pressure transducer with a 0-600 psi range has a 4-20mA output and is connected in a closed loop to drop 1-5 volts across a 250-ohm resistor. The theoretical nameplate relationship establishes that 1 V = 0 psi and 5 volts = 600 psi.

A units conversion equation can be written in the following form:

$$\text{Desired Reading} = m(\text{Available Reading}) + b$$

Write a pair of equations, representing the two *known* points.

$$\begin{aligned} 0 &= m(1) + b && (1) \\ 600 &= m(5) + b && (2) \end{aligned}$$

Solve for m by multiplying equation (1) by -1 and adding to equation (2).

$$\begin{aligned} 0 &= m(1) - b \\ 600 &= m(5) + b \\ \hline 600 &= m(5 - 1) && (3) \\ m &= 600/(5 - 1) && (4) \\ m &= 150 \end{aligned}$$

Substitute the value for m into equation (1) to determine the value for b .

$$\begin{aligned} 0 &= 150(1) + b && (5) \\ b &= -150 \end{aligned}$$

Write the correction equation using the previously determined values for m and b .

$$\text{Desired Reading in psi} = 150(\text{Available Reading in volts}) - 150$$

Check the result with the two original voltage readings.

$$\begin{aligned} \text{Correct Reading for } 600 &= 150(5) - 150 \\ &= 600.00 \\ \text{Correct Reading for } 0 &= 150(1) - 150 \\ &= 0.00 \end{aligned}$$

Any readings in the region between these two points provide the proportional psi reading as provided by the transducer.

System Channel Calibration

(Example 1 of 2)

A DBK9 and a DaqBook are connected to a precision 100.0 ohm resistor and read 0.2 °C; However, in this instance we know that 0.0 °C is the correct value. When connected to a 350.1 ohm resistor, the channel reads 719 °C. In this second instance we know that 716 °C is the correct value. From these two “points,” a correction [or calibration] equation can be derived. The equation has the $mx + b$ form of:

Correct Reading = $m(\text{Erroneous Reading}) + b$

Write a pair of equations, representing the two *known* points.

$$0 = m(0.2) + b \quad (1)$$

$$716 = m(719) + b \quad (2)$$

Solve for m by multiplying equation (1) by -1 and adding to equation (2).

$$0 = m(-0.2) - b$$

$$716 = m(719) + b$$

$$716 = m(719 - 0.2) \quad (3)$$

$$m = 716 / (719 - 0.2) \quad (4)$$

$$m = 0.9961$$

Substitute the value for m into equation (1) to determine the value for b .

$$0 = 0.9961(0.2) + b \quad (5)$$

$$b = -0.1992$$

Write the correction equation using the previously determined values for m and b .

$$\text{Correct Reading} = 0.9961(\text{Erroneous Reading}) - 0.1992$$

Check the result with the two original erroneous values.

$$\begin{aligned} \text{Correct Reading for } 716 &= 0.9961(719) - 0.1992 \\ &= 715.99 \end{aligned}$$

$$\begin{aligned} \text{Correct Reading for } 0 &= 0.9961(0.2) - 0.1992 \\ &= 0.00002 \end{aligned}$$

Any readings in the region of these two points should be much more accurate after being adjusted by the *correction equation*.

System Channel Calibration

(Example 2 of 2)

A DBK8 and a DaqBook are configured for a 50 volt range. Shorting the inputs together delivers a reading of 0.022 volts and applying a DC calibrator set at 47.5 volts produces a reading of 48.3 volts. From these two “points” a correction or calibration equation can be derived which has the form:

Correct Reading = m(Erroneous Reading) + b

Write a pair of equations, representing the two *known* points.

$$\begin{aligned}0 &= m(0.022) + b & (1) \\47.5 &= m(48.3) + b & (2)\end{aligned}$$

Solve for m by multiplying equation (1) by -1 and adding to equation (2).

$$\begin{aligned}0 &= m(-0.022) - b \\47.5 &= m(48.3) + b \\47.5 &= m(48.3 - 0.022) & (3) \\m &= 47.5/(48.3 - 0.022) & (4) \\m &= 0.9839\end{aligned}$$

Substitute the value for m into equation (1) to determine the value for b.

$$\begin{aligned}0 &= 0.9839(0.022) + b & (5) \\b &= -0.0216\end{aligned}$$

Write the correction equation using the previously determined values for m and b.

$$\text{Correct Reading} = 0.9839(\text{Erroneous Reading}) - 0.0216$$

Check the result with the two original erroneous values.

$$\begin{aligned}\text{Correct Reading for } 47.5 &= 0.9839(48.3) - 0.0216 \\&= 47.501 \\ \text{Correct Reading for } 0 &= 0.9839(0.022) - 0.0216 \\&= 0.00004\end{aligned}$$

Any readings in the region of these two points should be much more accurate after being adjusted by the *correction equation*.

Combined System Channel Calibration and Engineering Units Conversion

A DBK15 and a DaqBook are connected to a string pot to measure the open position of a vertical bay door. When the door is closed, the voltage reading given by the DaqBook is 0.175 volts. When the door is raised to a height of 12 feet, the voltage reading provided by the DaqBook is 4.572 volts. From these two “points” a correction [or calibration] equation can be derived which has the form:

$$\text{Correct Reading} = m(\text{Erroneous Reading}) + b$$

Write a pair of equations, representing the two *known* points.

$$0 = m(0.175) + b \quad (1)$$

$$12 = m(4.572) + b \quad (2)$$

Solve for *m* by multiplying equation (1) by -1 and adding to equation (2).

$$0 = m(-0.175) - b$$

$$12 = m(4.572) + b$$

$$12 = m(4.572 - 0.175) \quad (3)$$

$$m = 12 / (4.572 - 0.175) \quad (4)$$

$$m = 2.729$$

Substitute the value for *m* into equation (1) to determine the value for *b*.

$$0 = 2.729(0.175) + b \quad (5)$$

$$b = -0.478$$

Write the correction equation using the previously determined values for *m* and *b*.

$$\text{Correct Reading} = 2.729(\text{Erroneous Reading}) - 0.478$$

Check the result with the two original erroneous values.

$$\begin{aligned} \text{Correct Reading for 12} &= 2.729(4.572) - 0.478 \\ &= 12.00 \end{aligned}$$

$$\begin{aligned} \text{Correct Reading for 0} &= 2.729(0.175) - 0.478 \\ &= 0.00 \end{aligned}$$

Any readings in the region of these two points should be much more accurate after being adjusted by the *correction equation*.