Blanes PRESSURE SOLUTIONS

C107: Current Loop

Transmitting voltage signals over a significant distance has problems. The technical problem is voltage drop, which can introduce significant errors. The commercial one is cost, with 3 conductors required.

Most analogue process transmitters work on a 4 – 20 mA signal.

The well-known 4 – 20 mA current loop eliminates these problems. By converting the signal into a regulated current, there are two significant advantages. First, the voltage drop in the lines does not affect the measurement of the current. Secondly, the signal only needs 2 wires, not 3, thus making significant savings on cabling. Everything in the loop, which at a minimum will be a transmitter and a receiver, is connected in series.

The 4mA zero signal allows a bit over 3mA to be used for powering the transmitter. Some advanced systems use signals less than 4mA or greater than 20 mA to indicate abnormal conditions or faults.

Concept:
This is a modification of the industry standard 3 – 15 lb/in^2 pneumatic signal.

The 4 – 20 mA current loop signal is a standard transmitter signal that modulates the output from 4 to 20 mA, where 4 mA represents the bottom of the range, and 20 mA represents the top of the transmitter range. Whether the transmitter is measuring pH or pressure or anything else, the output is a standard electrical signal.

The concept provides the following advantages, in addition to the advantages of standardisation:-

- Only 2 wires required for signal and power supply.
- No voltage drops to affect the signal on long lines.
- Differentiation between instrument not working, and instrument working but measuring zero.
- Ability to indicate malfunction or out-of-range conditions.

Practice:
The signal span is 16 mA (20 – 4).
When interpreting the signal, we have to look at the calibrated range of the transmitter, and correlate between signal output and assigned values. Usually the signal will be linear, any linearisation being done in the transmitter, but this is not always the case.

For example, using a DP transmitter to measure flow using an orifice plate means that the flow is proportional to the square root of the pressure. Most transmitters will linearise this, so that the output is proportional to flow rather than pressure. Another example is using pressure to measure volume in a tank. A round horizontal tank will have a sine-wave calibration. In such cases a calibration chart can get quite complex, but if we explain the interpretation of a linear signal, this will demonstrate the theory, which can then be adjusted for non-linear signals

Usually the output signal follows the measured input. This is called direct signal. It may be reversed, (reverse signal) where 20 mA corresponds to minimum input, and 4 mA corresponds to maximum input. This is sometimes used for level applications.

Scaling the Signal:
This requires some arithmetic.

It can be said that 4mA represents 0% of the desired signal, and 20 mA represents 100% of the desired signal.

We can for example allocate a range of say 400 kPa to a transmitter.
This means that 4mA = 0 kPa and 20 mA = 400 kPa.

Therefore 16 mA = 400 kPa and 1 mA = 25 kPa.

If we want to know what a signal of 12 mA represents, we must take away the 4mA zero signal, leaving 8 mA of actual signal. We can calculate this in two ways, either 8 mA at 25 kPa = 200 kPa, or more basically, 8/16 x 400 kPa.

Algebraically, we can look at things like this:-
L = Lower range limit, often but not always zero
U = Upper range limit
P = Process Value
I = Transmitter signal.

To calculate current expected for a given process value:
I = (P-L)/(U-L)*16 + 4

To calculate process value for a given current:
P = (I-4)*(U-L)/16 + L.

Example:
If we have a pressure transmitter with a calibrated range of -100 to 300 kPa, usually -100 kPa input would give a 4 mA output, and 300 kPa input would give a 20 mA output.

In the formula above, L = -100 kPa and U = 300 kPa.

So If P = -100, mA = 4 + (-100 – (-100))* 16/(300 – (-100)) which Ps 4 + 0*16/400 = 4 mA (0%)
If P = 0, mA = 4 + (0 – (-100))* 16/(300 – (-100)) which Ps 4 + 100*16/400 = 8 mA (25%)
If P = 100, mA = 4 + (100 – (-100))* 16/(300 – (-100)) which Ps 4 + 200*16/400 = 12 mA (50%)
If P = 200, mA = 4 + (200 – (-100))* 16/(300 – (-100)) which Ps 4 + 300*16/400 = 16 mA (75%)
If P = 300, mA = 4 + (300 – (-100))* 16/(300 – (-100)) which Ps 4 + 400*16/400 = 20 mA (100%)

If P = 132, mA = 4 + (132 – (-100))* 16/(300 – (-100)) which is 4 + 232*16/400 = 13,28 mA

Worksheet:
We have a 1-2-3- spreadsheet titled “maloop”, which will do all the calculations automatically for you.