Smart transmitters give better measurement accuracy

Machine builders have been using standard measuring chains for a long time. An example would be a chain with three-wire Pt100 sensor, a transmitter and A/D conversion in PLC connected to a superior control system. However, there are now ways to dramatically improve the accuracy for the same price or less .

The measuring chains we are referring to are found in industries like food, packaging and pharmaceuticals, in sterilisation equipment (autoclaves), and in other processes that require accurate temperature measurement and temperature control.

In itself, Pt100 resistance is extremely stable. However, measuring this resistance easily introduces significant sources of error in situations with two- and three-wire connections (see Figure 1). To the lead resistance you have to add the transition resistances in terminals and connectors all the way up to the measuring equipment. In facilities with high humidity or inappropriate gases in the environment there is a clear risk of the terminals oxidising, which considerably increases the transition resistances. Nor can we presume that the top-quality work environment which we have in northern Europe, for instance, exists everywhere in the world.

A typical measuring chain starts with a Pt100 sensor with a three-wire connection (see Figure 2). This connection is linked to a PLC via a transmitter. There then follows an A/D transducer which converts the 4-20 mA analog signal into digital form. All these devices add measurement uncertainty to the signal. [Ref 1]

Three-wire connection unreliable

A three-wire connection requires absolutely identical resistance between the wires, especially R1 and R3 in Figure 1. This requirement applies regardless of the attached electronic devices. The contact resistance varies over time, according to the environment, and individually between the wires, and it can therefore not be calibrated away. The total measurement uncertainty is therefore at least ±0.8 °C at 150 °C but can easily become considerably greater. In addition, temperature drift can also occur in transmitters and other electronic devices. It is not uncommon to have up to 2 °C drift per 10 °C change in the surrounding environment.

By using a four-wire connected Pt100 sensor and a transmitter, which in Situation 1) in Figure 3 is DIN rail mounted, we completely eliminate the problems of the three-wire connection. The measurement error of the four-wire connection is negligible in this context (see the table in Figure 1). An improved transmitter gives greater stability and less temperature drift. The total measurement uncertainty in Situation 1) is reduced to ±0.6 °C at 150 °C. At lower temperatures down to zero, the tolerance of the Pt100 resistance is gradually reduced down to ±0.15 °C in accordance with IEC class A and the total uncertainty becomes ±0.3 °C.

Situation 2) includes system calibration of a Pt100 sensor and a transmitter combined into a single device. Calibration at 150 °C means that the sensor tolerance at this temperature can reasonably be reduced to ±0.15 °C, which is one-third of the corresponding tolerance in Situation 1). The total uncertainty is then reduced down towards ±0.3 °C across the entire interval.

Developing a digital measuring chain

Pentronic is developing a fully digital sensor/transmitter device for Pt100s and thermocouples. The most important drivers of the project are even better accuracy, minimal temperature drift, reduced wiring and simpler installation as well as a lower power requirement and thereby greater ambient temperature resistance. [Ref 2]

The digital transmitter houses all the functions from the sensor to the digital output signal. In this way the user has both analog and digital control over the entire measurement chain. The calibration applies to the entire chain, which makes it possible to reduce the measurement uncertainty for each individual sensor down to ±0.05 °C. However, the sensor must be sufficiently well suited to its measurement task that the readings are not affected by measurement errors such as stem losses due to too short insertion depth of the sensor probe. [Ref 3]

References see www.pentronic.se >> Pentronic News >> Pentronic News archive
[Ref 1] See Pentronic News 2009-3 page 4
[Ref 2] See Pentronic News 2010-3 page 2
[Ref 3] See Pentronic News 2009-5 page 4

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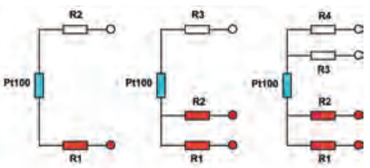

Connection	What is measured
2 wires	Pt100 + (R1 + R2)
3 wires	Pt100 + (R3 – R1)
4 wires	Pt100

Figure 1. Wiring layouts for a Pt100 sensor. The table shows how the total lead resistances influence the reading depending on the selected wiring layout.

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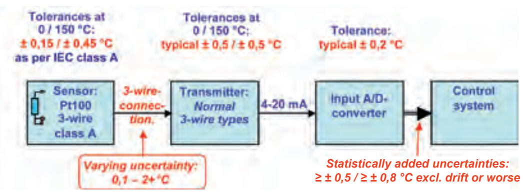

Figure 2. A typical measuring chain in use today. The measurement uncertainty at 0 °C is ≥ ±0.5 °C and at 150 °C is ≥ ±0.8 °C. If the three-wire error is ±1 °C then the measurement uncertainty is ±1.4 °C and is dominated by this error, which usually varies over time. Time-dependent errors can unfortunately not be calibrated away, and nor can drift versus the ambient temperature, which can be up to 2 °C per 10 degree change.

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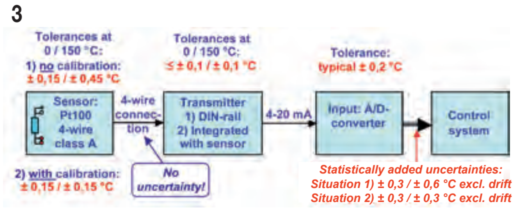

Figure 3. Situation 1: Improved measurement uncertainty can be achieved by using a four-wire connection and more stable transmitter. Situation 2: A combined sensor/transmitter device permits convenient system calibration, which reduces uncertainty across the entire measuring range. Pentronic is developing transmitters for both situations.

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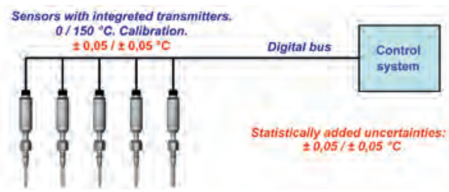

Figure 4. You can achieve the lowest measurement uncertainty by using a combined sensor/digital transmitter device and calibrating this system. This assumes that the sensor component is built to give minimal losses in its measuring position. The transmitter component must be built using high-temperature components. The Pentronic PLB digital bus can be connected to standard buses via a gateway.

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