Isolated measuring junctions are safest

Many models of PLCs and loggers do not have any galvanic isolation in their input circuits. Thermocouples with an isolated measuring junction provide the necessary isolation at low cost.

Pentronic sometimes receives questions about sensors it is "impossible to measure with". On closer examination it often turns out that the sensors have what is known as a grounded measuring junction combined with a PLC or logger that does not have any isolation between the inputs. Grounded measuring junction (see Figure 1B) means that the wires in the thermocouples are in electrical (galvanic) contact with the protection tube or sheath, which in turn is in direct contact with an electrically conductive measured object.

Figure 2 shows the basic construction of an input circuit which is not galvanically isolated and to which grounded thermocouples are connected. The multiplexer is single-pole and only acts on one of the legs of the thermocouples. One thermocouple is on while one pole is off on the others. Because the measuring junctions of the thermocouples are in galvanic contact with the same measured object, a parallel circuit arises between one leg of the active thermocouple and the on legs of the other thermocouples.

INSIDIOUS MEASUREMENT ERRORS

The parallel connection causes measurement errors as the measuring junctions have a different temperature or potential. In both cases the closed loops give rise to circulating currents, with the result that the mutual resistances of the wires also affect the size of the error. If the temperatures (T) of the measured object are all of similar size, the errors will be small and difficult to detect.

Less well considered locations of ground connections in complex measured objects may lead to ground currents that may in turn give the measuring junctions different potential (V, voltage). In view of the fact that thermocouples have a sensitivity (Seebeck coefficient) of around 40 µV/ °C, it can be appreciated that even small currents can easily cause measurement errors. The resistance with the same type of thermocouple varies with the length and cross-sectional area of the wire. The wires normally have the same diameter (cross-sectional area), and lengths are therefore of crucial significance to the effect of the errors. Choosing thermocouples with an isolated measuring junction, as shown in Figure 3, eliminates the parallel connection via the disconnected sensors.

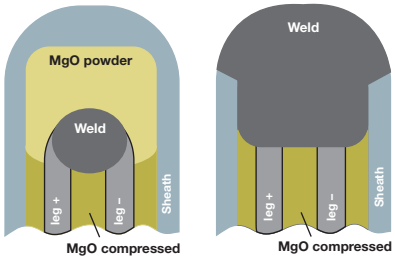

Figure 1. 1A: An isolated measuring junction in a thermocouple is galvanically separated from the steel sheath and is a simple way of reducing the risks with single-pole switching in PLCs and loggers. 1B: A grounded measuring junction is galvanically combined with the sheath.

ISOLATION ERRORS

There are occasions when galvanically isolated inputs have to be used. In some cases isolating capacity may already decrease substantially from around 600 degrees in magnesia (MgO), which is a very common isolating material in sheathed thermocouples. This means that even an isolated measuring junction is gradually grounded through the increasing conductivity of magnesia between wires and sheath. Measuring errors grow accordingly. The dimensions of the thermocouple, conduction length at high temperature, the temperature level and, where applicable, potential differences decide when conductivity is sufficient to cause noticeable measuring errors. By disconnecting a thermocouple with an isolated measuring junction and connecting an isolation tester between the wire and sheath it is possible to detect the level of the isolation resistance in the working temperature. At room temperature a sheathed single circuit thermocouple of 3 mm diameter in any case manages more than 1000 Mohms isolation resistance at 500 Vdc. Two-pole switching as shown in Figure 4 effectively breaks tendencies towards parallel connections due to high temperature.

INCREASING RELIABILITY

To avoid the risks associated with non-isolated input circuits, Pentronic primarily recommends thermocouples with an isolated measuring junction. Only if the response time is critical and the measuring equipment is definitely isolated galvanically should grounded measuring junctions be considered. At high temperature and when there are large potential differences between the measuring junctions and non-isolated PLC an alternative method of isolation is to install transmitters with galvanic isolation between input and output. The PLC must then be programmed for 4-20 mA input. There are transmitters that isolate up to 3.75 kV.

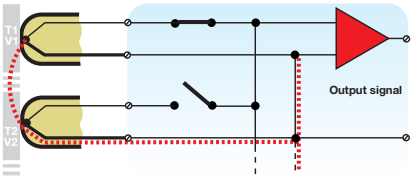

Figure 2. Without galvanic isolation in the measuring junction or instrument input the negative leg of the connected thermocouple in the figure is parallel-connected to the negative legs of the others via the conductive measured object. The measured value for T1 becomes incorrect.

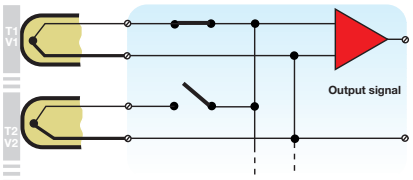

Figure 3. With isolated measuring junctions the short circuit through the measured object is broken.

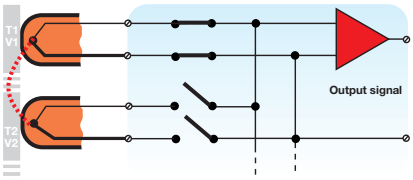

Figure 4: In some cases from as low as 600 °C the isolation of the thermocouples may fall so much that a creeping parallel connection effect occurs, resulting in increasingly incorrect readings. Here isolation on the inputs of the instrument is essential. Alternatively the thermocouples can be connected via isolating transmitters.

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