How Ground Loops Harm your Control System

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When you encounter malfunctions and gross measurement errors, particularly on newly installed or modified systems, **ground loops and misconnections** are often implicated.
As you study your wiring drawings keep in mind the specifications of your sensors, control components and final control devices. It is always hard to relate the drawings to the jungle of wires, identification labels and components on the plant and inside the control enclosure. You may have to go round the process and re-identify zones, terminations and components then mark up the drawings to correspond to reality.
As you focus on the suspect area you will already have checked that the correct power is there and no power or signal polarities are reversed.

The nature of ground loops

Fig 1 shows part of a typical control system with the controller handling various incoming and outgoing signals. Asume that each of the four control components has its own dc power supply for the internal electronics. For now assume that no part of the circuit is grounded.

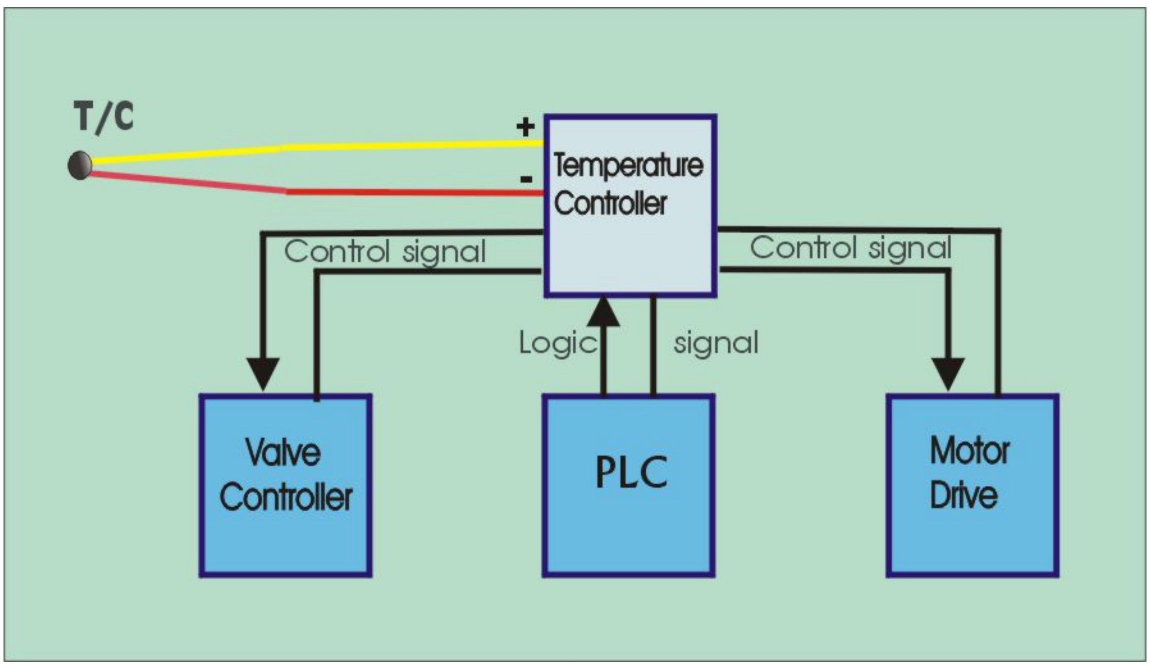


Fig 1. Control Loop

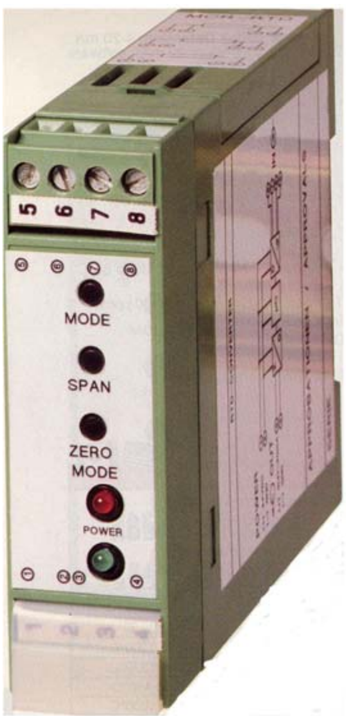
If any one point is grounded, such as the tip of the thermocouple (a common practice), it will not disturb the controller's indication or its other functions. Now let's ground a second point of the circuit. It could be any one of the terminals on any of the four control components. If there is an internal conductive path from this point to the controller input you have a "ground loop" which will cause a wrong indication on the controller and upset all control functions.
I say **ground** but the guilty connections are just as likely to be to any common reference line, such as the negative line of an internal dc supply or the common logic output line of the PLC.

You will not see this problem if all components have inputs and outputs that are electrically isolated from each other, from ground and from common lines. These are sometimes called **floating** inputs or outputs. Control equipment specifications must define which terminals are isolated and the maximum voltage they will tolerate relative to ground and other terminals. You need to know these details.

There are controllers whose thermocouple inputs are not isolated from the outgoing control and logic signals. Installers may ground these outputs and if you have a grounded thermocouple you have trouble. Avoid such controllers but if you have to use one, make sure that the outgoing signals only go to isolated device terminals.

Another example. If the PLC in Fig 1 has logic outputs that have one side grounded or commoned with other outputs or inputs, make sure that the controller's logic inputs are isolated from the T/C input and from everything else.

You can measure and control temperature difference using back-to-back connected thermocouples fed into a single controller. You can even ground one hot junction. Ground both hot junctions and a major error appears even if the instrument input is isolated. It is good practice to isolate both thermocouples from ground and from common metal parts. While this method of deriving temperature difference is cheap and simple I'm not fond of this arrangement because thermocouple wire-to-sheath clearance and thermal expansion make it vulnerable to leakage and short circuits. This arrangement was covered in another article on Master/Slave control.



Signal Converters. If you are stuck with components that have non-isolated inputs or outputs that would cause conflict, you can use one of the many varieties of stand-alone isolators or converters. E.g. mA/mA , Thermocouple/mA, RTD/mA. The technique in these components and in controllers is to pass a representation of the signal through a transformer or optical isolator. Insulation good for 2 to 3 kV is typical.

Another advantage of converters is that you can amplify low millivolt signals up to a level where they can be transmitted in copper cable over long distances with minimal interference. In the case of thermocouples you save the higher cost of extension cable. You are also more likely to have spare copper cores in the plant wiring if ever you need them.

It is rarely necessary to ground working signals but it is advisable to ground signal cable shielding to prevent capacitive pickup of ac interference. Select only one point as a ground. Multiple grounds on machines or pipes can assume different voltages that vary with time and plant power consumption.

Fig 2. Signal Converter