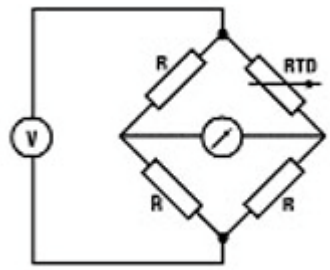
3 AND 4 WIRE Pt100 MEASUREMENT

Introduction

Two, Three and Four wire measurement techniques have been developed for measuring accurately the resistance of resistive temperature detectors (RTD). This application note looks at the new techniques being adopted in ‘Smart’ instruments where, using the intelligence of a microprocessor, the traditional drawbacks of 3 wire systems no longer apply.

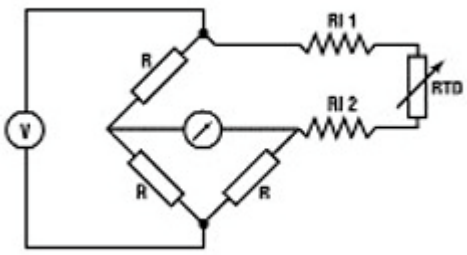
Three wire measurement

The traditional method of accurately measuring a resistance, is to incorporate the resistance into a Wheatstone bridge circuit (see figure below).

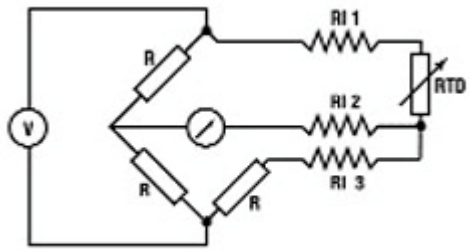


A voltage excites the bridge and the voltage across the bridge is proportional to the resistance of the RTD.

A problem occurs when we introduce lead resistances (See figure below). It is apparent that any resistance in the lead looks as though there is additional resistance in the element to be measured.



To minimise these errors the three wire compensated bridge was introduced (see figure below).



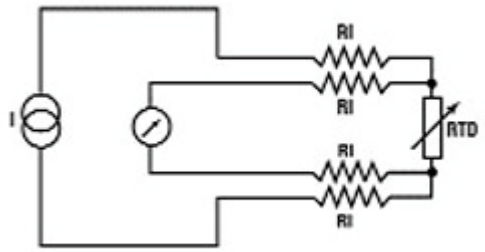
This has the effect of removing the error introduced by the lead resistance as long as lead resistances RL1 and RL3 are matched.

However the effect of the lead resistance can be to cause less current to flow in the detector leg and hence introduce a small but possibly significant span error. This can be eliminated by exciting the bridge from a constant current source rather than a constant voltage and so whatever the lead resistance, the same current always flows through the detector. With this method there are no lead resistance errors introduced as long as the lead resistances are equally matched. In practice they are very closely matched as long as the wire used is part of the same multi-core cable.

The exception to this is when the sensor is used in a Hazardous area and connected to the bridge circuit via a Zener Barrier. Here any mis-match in the resistance of the two legs of the Zener barrier can appear as a sensor error. Although still small, this error can be as much as 0.15 ohm or approx. 0.3°C.(MTL 155 Barrier).

For analogue transmitters Status Instruments Ltd. have traditionally used a variation of this technique using an in house active bridge circuit. The exception being the new ‘Smart’ series of instruments which use a different technique which will be explained later.

Another way of measuring Pt100 elements is to use a 4 wire current and voltage method (see figure below).

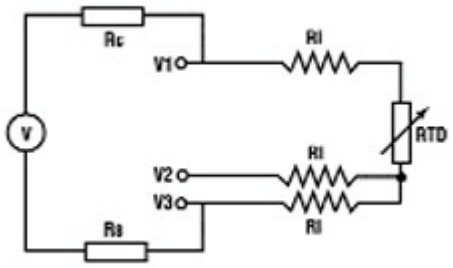


Here the detector is excited by a constant current and the voltage across the detector measured by an amplifier with a high impedance input. If the current source is perfect and the input impedance of the voltage measuring circuit is infinite, then there is no error whatsoever introduced by the lead resistances even if they are mismatched.

The ‘smart’ way forward

This paragraph describes the method used to measure Pt100 on the new DM3000 series instruments.

The current trend for so called SMART instruments is to have a universal input capable of supporting a wide range of inputs. It is inconvenient (and unnecessary) to dedicate input pins and electronics to support a constant current supply and a bridge arrangement. The input circuit measures voltages to a high degree of accuracy and the microprocessor performs the calculation in the figure below.



Rc is used solely to limit the current flowing and Rs is a stable reference resistor.

Having computed the resistance, the microprocessor applies the corrections required and translates the resistance to an accurate temperature reading.

In addition, the microprocessor can determine which if any, of the RTD inputs has become disconnected and detect other errors such as RTD short circuit. This is an improvement over both conventional three and four wire circuits because you can now have a predictable failure mode which does not depend upon which of the three wires has become disconnected.

This technique removes lead resistance effects as long as they are equal. Again, we have the problem when using Zener barriers, in that if the legs of the barrier are not accurately matched, then a small error could be introduced.