APPLICATION NOTE:

KULITE 5TH WIRE COMBINATION PRESSURE AND TEMPERATURE TRANSDUCERS

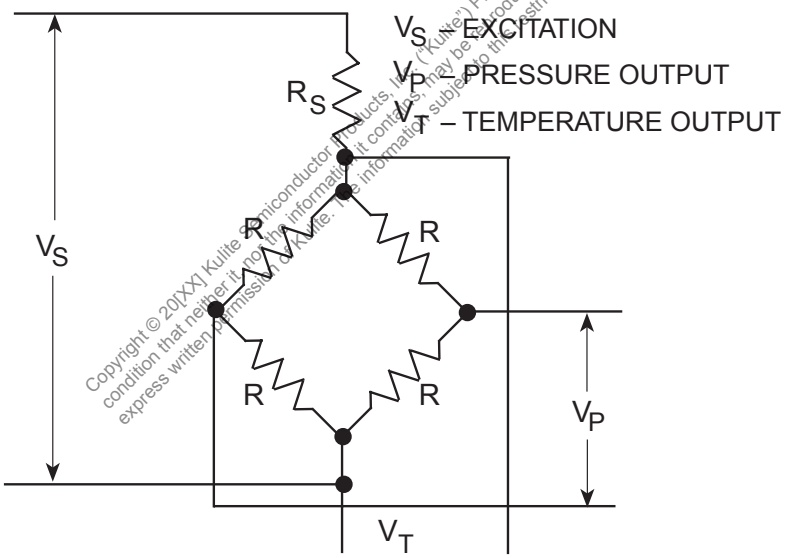
The Kulite 5th wire transducer was developed to allow customers to obtain data about the sensing chip temperature of the pressure transducer in order to digitally compensate the sensor for thermal errors. If this temperature signal is used correctly it can result in a very accurate pressure measurement even over a wide temperature range.

DESCRIPTION:

It is well known that with passive compensation the compensation components do not have to be in the same thermal environment as the sensing element.

In addition, the nature of passive span compensation allows Kulite to easily extract a voltage signal from the pressure transducer that is proportional to temperature.

This is done by attaching a fifth lead to the transducer at a point between the span compensation resistor and the SOI wheatstone bridge, as shown below:



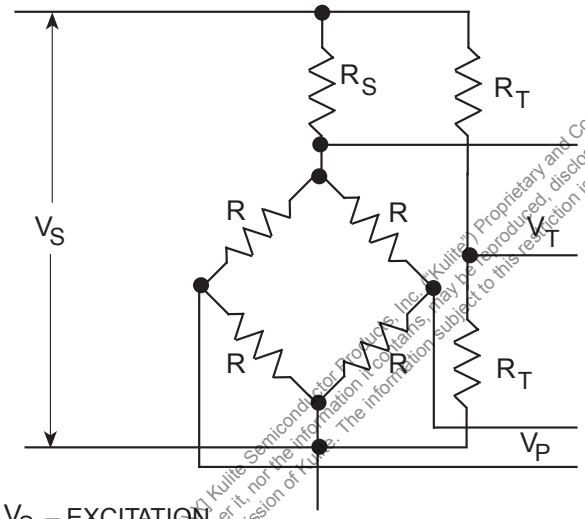
The temperature signal out is then given by:

$$V_T = \frac{R}{R + R_S} V_S \qquad \text{EQ 1}$$

In a silicon piezoresistive bridge the bridge resistance R changes linearly with temperature and the fixed resistor R_S does not vary with temperature; therefore the voltage V_T is an excellent measure of the temperature of the bridge.

Typically this results in a temperature signal that is approximately 5 volts at room temperature and increases by 2 mv/^{o}F nominal.

If the 5 volt signal causes a problem with signal conditioning additional resistors can be incorporated into the transducer (or supplied for external use if there is a size constraint), to reduce the output at room temperature (or any other temperature within the operating range) to approximately zero millivolts, which still maintaining the 2 mv/^{o}F nominal change with temperature. This circuit is as illustrated below:



V_S – EXCITATION
V_P – PRESSURE OUTPUT
V_T – TEMPERATURE OUTPUT

The additional resistors have no effect on the properties of the transducer.

Referring back to EQ 1, it can be seen that the temperature output signal is slightly non-linear because R – the bridge resistance which changes linearly with temperature – is in both the numerator and the denominator of the equation. This produces a temperature output that is slightly non-linear.

The bridge resistance also changes slightly with pressure typically 0.2% at full scale pressure. This effect would cause an error of approximately 2^{o}F.

Tests have shown that the typical error band, including all error sources, for the temperature output is less than $\pm$ 1% F.S. over a 200^{o}F temperature span.

CAUTIONS:

Customers can experience a problem when this temperature measurement is used for purposes other than compensation of the pressure transducer.

The Kulite pressure transducer was not designed to be an effective temperature probe and therefore it does not have a good response to temperature changes. Due to the relatively large mass of the silicon sensor and its metal housing, it may take on the order of minutes for the sensor to reach a stable temperature. During this stabilization time a measurement using the 5th wire will give the exact temperature of the silicon bridge but will give a very bad measurement of the surrounding media's temperature. Typically when calibrating transducers, Kulite allows them to soak for at least half an hour at temperature in order to stabilize all temperature readings.

Even after the temperature has completely stabilized in the system the Kulite sensor may still be at a slightly different temperature then the surrounding media. This is due to the fact that the sensor housing is made of steel, which has a relatively low specific heat, and can conduct some amount of heat to or from the outside. While this small amount of heat is not enough to affect the temperature of the surrounding media it may change the temperature of the sensor enough to make readings of the media temperature inaccurate.

CONCLUSION:

The 5th wire measurement works very well in compensating the pressure measurements of a Kulite sensor because the thermal errors in measurement arise from the temperature of the sensor, which the 5th wire measures exactly. It does not, however, work well to measure the temperature of the media due to time lag effects as well as a small amount of heat sinking/sourcing.