Thin Film Application Note

Custom Thin Film Networks

Industry:

Automotive, Industrial, Instrumentation

Application:

Precision Measurement by Sensor/Half-Bridge Combination

Statement of the Problem:

The measurement of temperature, strain and pressure is frequently accomplished using resistive sensors, such as thermistors and strain gauges, in voltage dividers formed with resistors. Often, these sensors, and their accompanying bias resistors, must operate over a broad temperature range. It is not uncommon to require a maximum operating temperature of +125 °C, or even +150 °C.

A Wheatstone bridge is the source of the output voltage in this type of application. In Figure 1, R1 and R4 are biasing resistors, which act as the reference half of the voltage dividers formed with the two sensing resistors, R2 and R3, respectively. The matching of R1 to R4 directly affects the accuracy of the output voltage.

If the accuracy of the bridge needs to be ±1.0 % excluding the error of the sensors, the combination of errors introduced by ratio tolerance (ratio match) and temperature coefficient of resistance (TCR) tracking must be less than ±1.0 %. The absolute properties of R1 and R4 individually are not important in this application, since it is the matching of these two resistors that influences the output of the resistor side of the bridge.

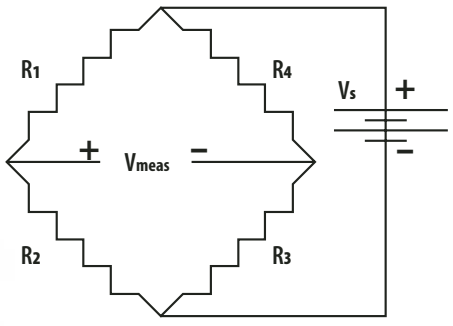

Figure 1: Wheatstone bridge configuration

The output voltage from the Wheatstone bridge is given by the following equation:
Vmeas = Vs {R2/(R1 + R2) – R3/(R3 + R4)}

Since R2 and R3 are sensors, their resistive value changes in response to physical input. Therefore, the higher the initial precision (ratio match) and TCR tracking of R1 and R4, the more accurately the output voltage will depict the sensor readings.

Solution:

If standard ±1 % chip resistors with TCR of ±100 PPM/°C were used as R1 and R4, a ratio match error of as much as 2 % could occur. If the two resistors had the same value, their TCR tracking would be approximately 100 PPM/°C. The tracking error at +125 °C would be: (125 °C – 25 °C) x 100 PPM/°C = 10,000 PPM = 1.0 %. Therefore, the total error introduced by R1 and R4 could be as high as 3 % (2 % ratio match + 1 % TCR tracking).

Thin-film resistor networks can provide more precise ratio properties than discrete resistors. If a design required a maximum ratio error between R1 and R4 of 0.2%, a thin-film resistor network, such as Bourns 4304S series, could be specified with a ratio tolerance of 0.1% and TCR tracking of 5 PPM/°C. The total error at +125 °C for a resistor network with these ratio properties would be 0.1 % + {(125 ° -25 °C) x 5 PPM/°C} = 0.1 % + 0.05 % = 0.15 %. No pair of chip resistors could match that performance.

The TCR tracking for all of Bourns® standard thin-film resistor networks is 5 PPM/°C. The ratio tolerance may be chosen from values of 0.5 %, 0.1 %, and 0.05 %. The cost of the resistor networks decrease as the value of ratio tolerance increases.

Bourns supplies a range of standard and custom resistor networks in through-hole and surface-mount packages. Customized solutions in standard packaging can be supplied to customer requirements. Resistor values from 10 Ω through 150 KΩ in thin film, and 10 Ω through 10 MΩ in thick film, can be configured in unique schematics for specialized applications.

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