Thin Film Technology Corp.

TCR IN ULTRA-HIGH PRECISION CURRENT SENSE RESISTORS

Purpose:
The purpose of this paper is to show the significance of Temperature Coefficient of a Resistance (TCR) in ultra-high precision current sense resistors and how it can fundamentally change an electrical circuit functionality.

What is TCR

TCR is essentially the computation of a relative change in resistance value per degree of temperature change as the formula below shows, where R is the resistance at temperature T, and Ro is the resistance at room temperature To, usually 25 °C. Due to its relatively small value, TCR is normally specified in parts per million per degrees Celsius, (ppm/ °C).

$$\boldsymbol{TCR}\left(\frac{\boldsymbol{ppm}}{\mathbf{°C}}\right) = \frac{\mathbf{\Delta R}}{\mathbf{Ro.\Delta T}} = \frac{\mathbf{R - Ro}}{\mathbf{Ro.(\,T - To)}}$$

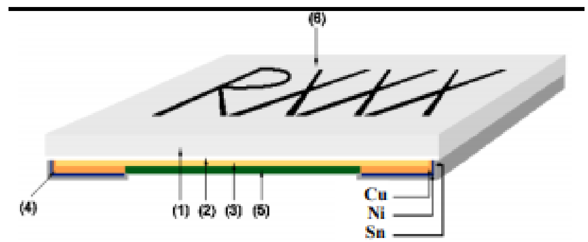
Temperature change in a resistor is caused by either the thermal energy generated due to the electrical current flow (Joule's effect) or from a change in the ambient temperature. Both factors have an effect on TCR and will lead to a resistance drift. One must keep in mind that both temperature changes add together. For example, if applying the full rated power relates to a self-heating of 80°C and the surrounding ambient temperature is also increased by 10°C, the resistor will see an increase of 90°C

TFT Metal Foil Technology

When manufacturing a precision current sense resistor, both internal and external stresses are considered in order to ensure the best optimal performance and stability. Some of these stressors are associated with power consumption and dissipation, manufacturing process, the structure of the material and more. TFT's cutting edge foil technology is designed to compensate for these effects using our well-established design and manufacturing techniques to provide thermal efficiencies resulting in lower maximum resistances and noise reduction.

TFT uses innovative construction techniques and a superior low resistance metal alloy resistive element, thus removing sources of parasitic noise and providing a more direct current flow while increasing long term stability.

Features of TFT's Structure



1. Ceramic Substate
2. Adhesive (Epoxy Resin)
3. Resistive Element (Copper Alloy Foil)
4. Copper Plated Terminals (100% Matte Tin over Nickel)
5. Protection Coating (Epoxy Resin, Meets UL-94-V0 Requirements)

Figure 1: TFT's Current Sense Resistor Structure

The metal resistive foil is laminated to an Alumina substrate using a thermally conductive adhesive resin.

The Alumina substrate is a carrier for the foil resistor element as shown in Figure 1. It also functions as a heat dissipation path and is capable of dissipating hot spots that are likely to appear on the center of the resistor element.

High heat-resistant epoxy resin is coated on the resistor element which is located on the bottom side of the resistor body. This resin protects the resistor element and helps prevent the heat generated by the resistor from directly influencing the PCB. The formation of the electrodes by direct plating of the electrodes on the same foil used for the resistive element minimizes unwanted parasitic resistance and allows for smaller resistance variations and tighter tolerances.

TCR Measurement Method

The resistor manufacturer will typically indicate the TCR specification and the associated temperatures used to define the TCR. Because all applications will have different thermal signature, the user should determine the required TCR for the temperatures which the resistor is expected to endure in their application.

Pre-test Preparation:
Before the testing is started, the component to be tested should be mounted to an FR4 circuit board material. The land pattern on the circuit board should be as recommended by the manufacturer and the reflow mounting profile should also follow the manufacturer's recommendation.

Testing:
After mounting of the components to the circuit board they should be allowed to cool to an ambient room temperature of 25°C. The board should then be placed into the test fixture, similar to those shown in Figure 2. For 4-terminal components, the test fixture must use 4-terminal connections all the way from the meter to the component. For 2-terminal components, the board should be designed to bring 4 wire measurements all the way from the meter to as close as possible to the component bonding location.

After the component is in the test fixture and has stabilized to 25°C, the resistance measurement of each component should be measured and then calculate the TCR per the earlier provided formula. The temperature of the oven should then be raised to 125°C and the component should be allowed to stabilize at that temperature for at least 15 minutes after the oven has reached that temperature. The resistance of each component should then be measured again at the 125°C temperature.

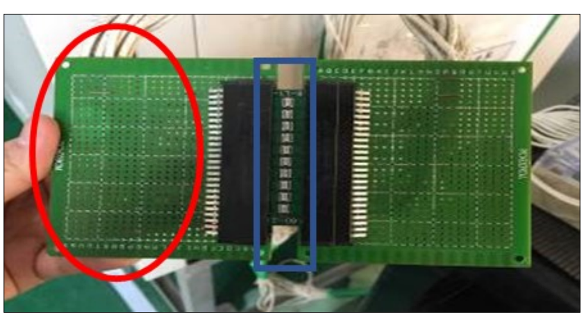


Figure 2: Test Fixture (red) with PCB (blue)

TFT's CPA0612QR005FF TCR Measurements

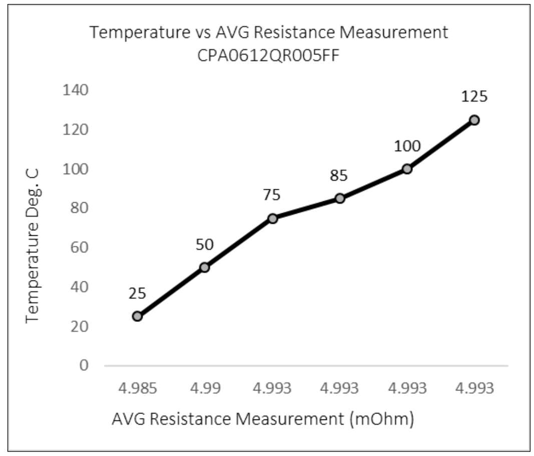


Figure 3: Temperature vs AVG Resistance Measurement

Figure 3 plot illustrates the average resistance measurement (10 samples) of TFT's CPA0612QR005FF high precision current sense resistor as temperature increases. It also shows an average percentage of 0.002% in resistance change. Similarly, Figure 4 illustrates the low TCR data for CPA0612QR005FF as temperature increases. These characteristics make current measurement very accurate. It also shows a very low measurement temperature dependency for excellent long-term stability.

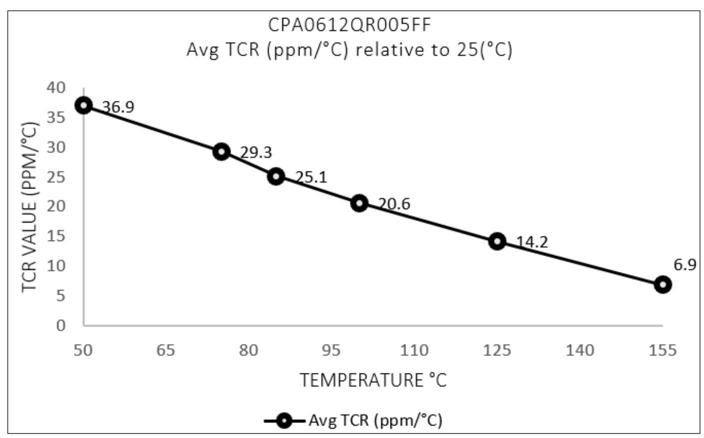


Figure 4: TCR Data on CPA0612QR005FF

Visit our virtual booth on the electronica website or learn more about our products and offerings at thin-film.com.