HEARST
Electronic PRODUCTS

○ All ○ Feature Article ○ Product ○ Reference Design ○ Video [   ] **SEARCH**

Home | Articles | Products | News | What's Inside | Engineering Distribution | Video | Forums | Calculators and Tools | Blogs | New Product Introductions +

SAMPLE CENTER *NEW!* | Technology Centers ▼ | End Markets ▼ | Download Center ▼ | Buyers Guide ▼ | Education Center ▼ | DIY ▼ | Our Network ▼

This article was posted on 11/26/2012.

Taking a look at electrical properties of thin film chip resistor arrays

Increasing Accuracy in Feedback Circuits and Voltage Dividers

BY SEBASTIAN WEIHAUSEN Vishay Draloric
www.vishay.com

When we think about electrical resistors and their properties, the primary characteristics that come to mind are case size and resistance value as well as temperature coefficient (TCR), tolerance, and rated power. For many applications, these characteristics are sufficient to define the resistor that is needed to perform the required tasks. When it comes to analog precision circuits, however, we need to look deeper, and in particular at the behavior of the resistors throughout their intended lifetime. For feedback circuits and voltage dividers, the parameters mentioned above as well as a stable divider ratio have a decisive impact on the accuracy of the circuit. The stability of a voltage divider or a feedback circuit can only be achieved and maintained if the resistance values remain unchanged relative to one another over the lifetime of the circuit.

This application note is intended to show designers how to optimize the behavior and stability of electronic circuits by using thin film chip resistor arrays. The relative properties of the particular resistor elements of a thin film array — tolerance matching 1, TCR tracking2, and relative resistance drift — are the key parameters for precision and long-term stability, and are explained in greater detail below.

Influence of the resistance properties

Before we take a closer look at the electrical properties of thin film resistor arrays, it is important to understand the impact of resistance properties on a comparably simple circuit. For this purpose, let's take the example of the feedback loop of a non-inverting amplifier. We'll compare a configuration using discrete resistors with one, using a resistor array in the feedback loop. A worst-case consideration of both scenarios demonstrates that the absolute gain error is drastically reduced by using an array.

The application's intended lifetime in this example is assumed to be about 10 years and the resistance layer temperature3 to be 70° C. These conditions are not unusual for today's industrial, automotive but also high-end multimedia applications.

Feedback loop consisting of two discrete precision resistors

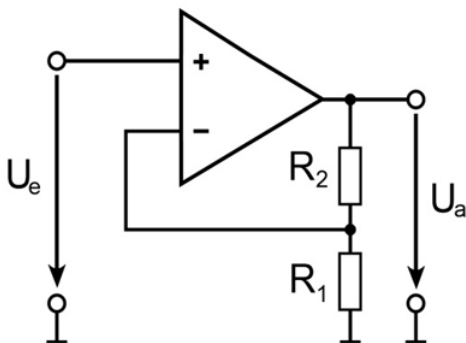Technical specification of the resistors:

Fig. 1 Feedback with discrete resistors

Temperature coefficient (TCR): ±25 ppm/K

Tolerance: ±0.1 %

The gain factor is calculated as:

$V = 1 + (R2/R1)$

In this example $R1 = 100\ \Omega$ and $R2 = 900\ \Omega$

Consequential: $V = 10$

The overall gain error is the sum of all gain errors, caused by nominal tolerance, temperature coefficient and drift of the resistors4.
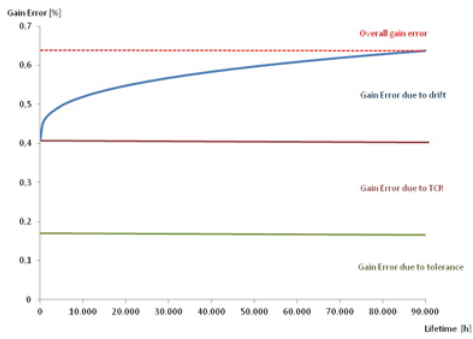
Fig. 2 Gain error with discrete resistors Feedback loop consisting of a resistor array

Technical specification of the resistor array:

facn_vishay03_dec2012

Fig. 3 Feedback with a resistor array

Absolute temperature coefficient: ±25 ppm/K

Absolute tolerance: ±0.25 %

Relative TCR (TCR Tracking):10 ppm/K

Relative tolerance (Tolerance Matching): 0.1 %

The gain factor is calculated as $V = 1 + (R2/ R1)$

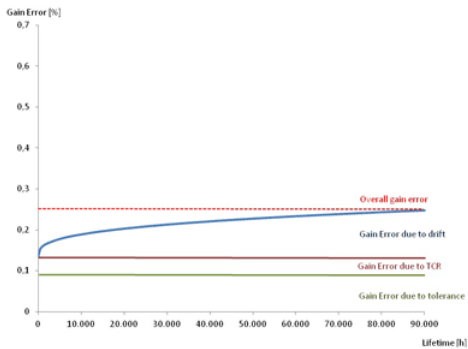In this example $R1 = 100\ \Omega$ and $R2 = 900\ \Omega$

Consequential: $V = 10$

Fig 4 Gain error with a resistor array

As we see, simply by using a resistor array with specified relative properties such as tolerance matching and TCR tracking (and relative drift), the possible absolute gain error can be reduced significantly.

Advantages of resistor arrays

The behavior of thin film resistor arrays is determined by the manufacturing process as well as the material properties of the resistive layer. The thermal coupling of the individual resistors and the homogeneous heat distribution arising from this also have a significant impact on the relative resistance drift.

Relative tolerance (Tolerance Matching)

The nominal value of a chip resistor is achieved by using laser trimming. During the trimming process, the resistance value is continuously monitored, in order to ensure that the resistance value lies within the specified tolerance.

Precision laser systems allow different resistance values to be created on the same array. Low energy input during laser processing allows a high degree of structuring and therefore high resistance ratios without influencing other resistor parameters. Sophisticated technical measurement allows precise trimming of the resistors and almost perfect ratio with very tight tolerances.

The variance with respect to the nominal resistance value is defined as absolute tolerance. The difference between the individual resistance values is described as tolerance matching, sometimes also called "relative tolerance" or "ratio tolerance".

Figure 5 shows an example of a resistor array's tolerances with 4 integrated resistors. The relative limits for voltage dividers are the decisive parameters, here specified with ± 0.05 %.
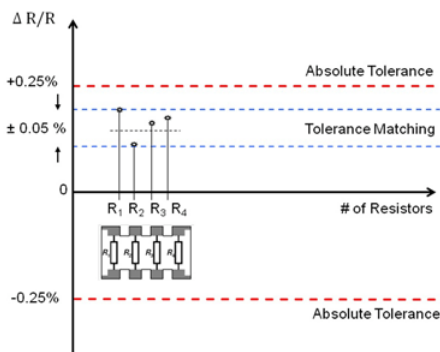
Fig.5 Tight relative tolerance:"Tolerance Matching

Relative temperature coefficient (TCR Tracking)

Ideally electrical circuits should operate independent from temperature changes. One approach in reducing the temperature dependence is to apply resistors with a low temperature coefficient. The temperature coefficient of thin film resistors (TCR) is influenced by various parameters such as alloy composition of the applied resistive material, sputtering process conditions, and temperature treatments during the manufacturing process. Each of these parameters needs to be controlled very accurate to enable small temperature coefficients.

For voltage divider and feedback circuits, the relative TCR of the individual resistors is even more important than their absolute values. For resistor arrays, this feature is specified by the TCR tracking. The specification of a TCR tracking is possible for resistor arrays, because the individual resistor elements are all influenced by temperature to the same extent. In other words, the temperature coefficient curves of all the resistors in the array follow one another, caused by virtually identical processes conditions during manufacturing and homogeneous heat distribution within the array during operation. The local proximity of the individual resistors on an array ensures a homogeneous layer thickness during the sputtering process. During the subsequent heat treatments, the individual resistors are constantly subjected to identical temperatures. Thus, to the benefit of any electronic design where relative stability of resistors is needed, thin film resistor arrays make the circuit almost independent from temperature changes.

Figure 6 shows schematically the example of an array with a TCR specification of ±25 ppm/K (red curves) and a TCR tracking specification of ±5 ppm/K (blue curves).
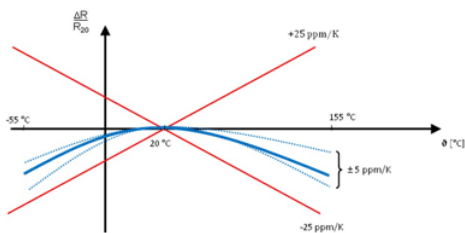

Fig.6 Absolute TCR limits (red) and TCR curves with TCR tracking (blue)

Relative resistance drift

All resistors have something in common: their resistance values change under the influence of temperature over time. The extent of the change is highly dependent on the underlying resistor technology, e.g. resistive material composition, process conditions, etc.

The film temperature of the resistor is determined by the applied power, it's thermal resistance and the ambient temperature. The substrate material (Al_2O_3) has a very good heat conductivity, thereby resulting in a good thermal coupling of the individual elements of a resistor array.

This thermal coupling ensures homogeneous heat distribution across the entire array, almost regardless of whether power is applied to one or several resistors and irrespective of where the array is located on the printed circuit board.

This homogeneous heat distribution in turn ensures that all the resistors within the array will age at virtually the same rate. The relative resistance change over time is therefore negligible and the long-term stability of the resistance ratio consequently very high.

Thin film chip resistor arrays consist of several resistors of equal or different values combined in one package. During the manufacturing processes and the device's lifecycle, all the particular resistors virtually experience identical conditions, which allow the specification of their relative tolerances, relative temperature coefficients, and even a relative resistance drift. These relative parameters provide precise and stable resistance ratios and far better long-term stability of feedback circuits and voltage dividers compared to discrete resistors.

Vishay's thin film resistor array series, the ACAS AT, has proven its accuracy and long-term stability in the field since many years. In addition to technical support, samples are also available for testing and development purposes.

For more technical information please refer to the product data sheet: http://www.vishay.com/docs/28770/acasat.pdf

Your contact for technical support and samples: thinfilmarray@vishay.com

Reference:

Vishay, Technical Note: "Drift Calculation for Thin Film Resistors"

Revision: 24-Jul-12; Document Number: 28809

http://www.vishay.com/docs/28809/driftcalculation.pdf

1 Relative tolerances

2 Synchronization of the temperature coefficients

3 The resistance layer temperature is the sum of the environmental temperature of the component and the electrical energy converted to heat in the resistance layer.

4 Dependent on the application type and operating conditions, further factors must be taken into account in addition to tolerance, temperature coefficient and resistance drift.

Learn more about Vishay Intertechnology

Purchase the resistor

RESISTOR	**BUY NOW**
RESISTOR*006OHMS	**BUY NOW**
RESISTOR*015OHMS	**BUY NOW**
RESISTOR*01OHMS	**BUY NOW**
RESISTOR*025OHMS	**BUY NOW**
RESISTOR*035OHMS	**BUY NOW**
RESISTOR*05OHMS	**BUY NOW**
RESISTOR*10OHMS	**BUY NOW**
RESISTOR12KOHM14W	**BUY NOW**
RESISTOR 1/2W 150 OHM 5%	**BUY NOW**
RESISTOR 1/4W 100K OHM CF	**BUY NOW**
RESISTOR 1/4W 10K OHM CF	**BUY NOW**
RESISTOR 1/4W 150 OHM 5%	**BUY NOW**
RESISTOR*18OHMS	**BUY NOW**
RESISTOR*1OHMS	**BUY NOW**
RESISTOR*25OHMS	**BUY NOW**
RESISTOR25W150K5	**BUY NOW**
RESISTOR33-OHMS	**BUY NOW**
RESISTOR*35OHMS	**BUY NOW**
RESISTOR*51OHMS	**BUY NOW**
RESISTOR620OHM2W5	**BUY NOW**
RESISTOR; 78.7 OHM; DATA BUS	**BUY NOW**
RESISTOR900OHMS1	**BUY NOW**
RESISTORCAT 06-08	**BUY NOW**
RESISTOR CF 1/4W 560 OHM	**BUY NOW**
RESISTORS27KOHMS5350V	**BUY NOW**

BOOKMARK   E-Mail Article   Printer Friendly

Related Articles

- Vishay Intertechnology: Resistor networks handle high temperatures
- Precision resistor pair is AEC-Q200 qualified
- Varistors protect autos from surges
- Precision resistors have TCR of 0.2 PPM/°C
- Battery shunt resistor is 100 µΩ ±5%

Learn more about:

- Resistors
- Potentiometers, Trimmers & Controls

Related Videos

Vishay VCNL4000
Fully Integrated Proximity and Ambient Light Sensor

Vishay Intertechnology introduces the VCNL4000 Integrated Proximity and Ambient Light Sensor, the industry's first optical sensor combining an IR emitter, PIN photodiode, and ambient light detector.

Related: **WEEE Compliance** | **Recycling Services** | **Electronic Waste Recycling** | **Recycling Information** |