Temperature Dependence and TC of the Resistor

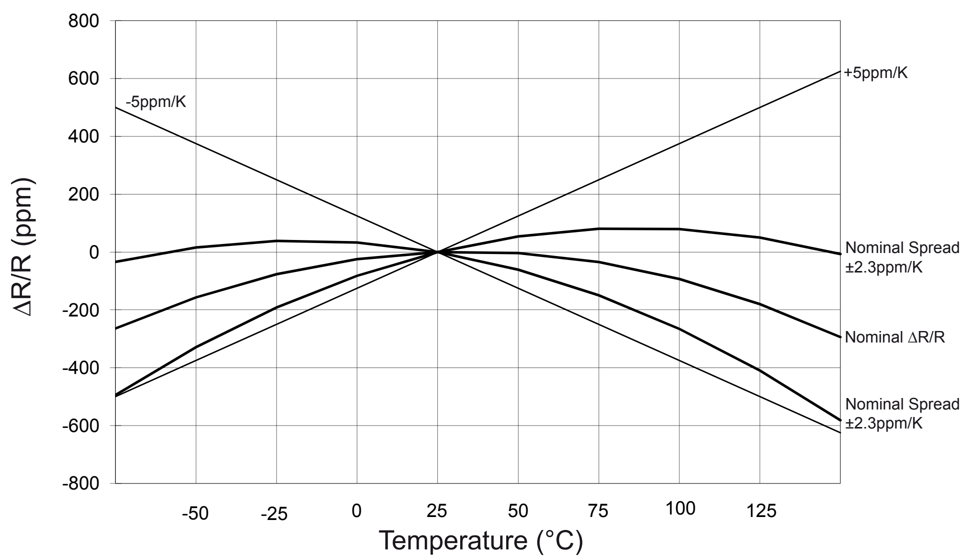
The absolute ohmic value of a resistor is dependent on temperature.

In today's fields of measurement and electronics – particularly in such industries as heating and ventilation (HVAC), medical technology, and military applications – precision, stability, and dependability are important criterions. Here the highest demands are made on every component; and for this reason, precision and ultra-precision resistors have been developed. In these devices, the base of the resistance element is a special resistive film.

With the use of special technological processes, we are able to synchronize the substrate and the resistor material. This means that we can produce resistors with a very low temperature coefficient.

1. Ultra-Precision Resistors (USR/USN, UNR, UHR, and UPW Series)

Picture 1 - dR/R (T) for the USR/USN, UNR, and UHR series



The TC adjustment is per charge at the reference temperature of +25°C (T0).

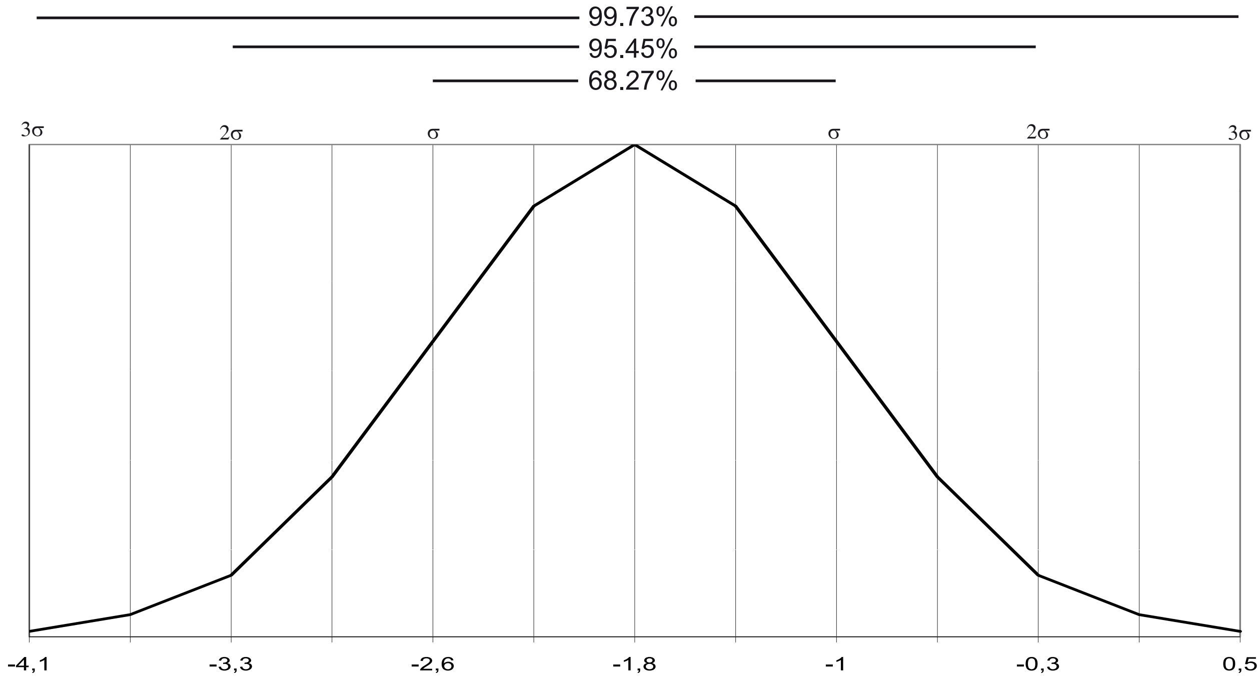
For the USR/USN series, as well as the UNR and UHR, when adjusting the dR/R (T) curve, we are able to reach a TC1 of -1.8 ppm/K with an inherent temperature of +125°C (T1) and a TC2 of +2.2 ppm/K with an inherent temperature of -55°C (T2). These curves are given as the nominal dR/R curves, or the nominal TCs (Picture 1).

The specific TC can be determined by the rise of the secant between dR/R (T1;T2) and dR/R (T0).

Normally there is a spread of values when the TC adjustment is made, due to the technical processes and the normal difference in the materials. Therefore it is possible that the real dR/R (T) curves, the TK1 and TK2, of all the resistors varies from the nominal mentioned parameters.

In the normal production process and during big charges, the TCs of all resistors are within the Gaussian distribution.
For the USR/USN series, as well as the UNR and UHR, the nominal spread is ±2.3 ppm/K (for TK1 as well as TK2). This is the 3σ area.
The TCs of 99.73% of all resistors in one charge belong to this area (Picture 2).

Picture 2 - Nominal distribution of the TCs (USR/USN and UNR series)



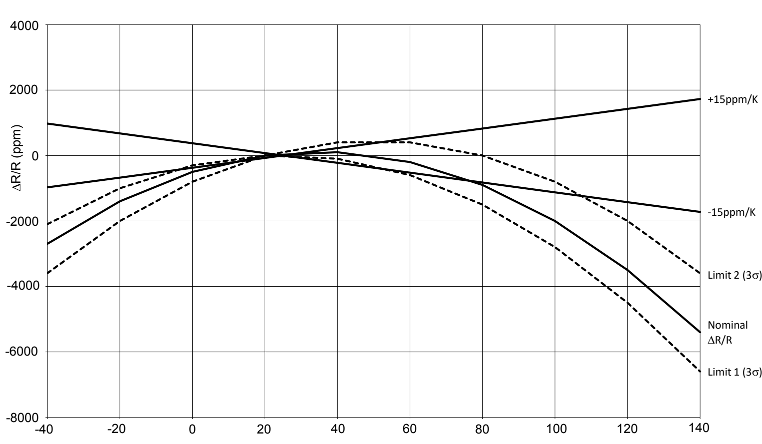
For a reduced temperature range from 0°C to +60°C, the nominal TCs are -0.6 ppm/K / +0.6 ppm/K, and the nominal spread (3σ area) of one charge is at ±2.5 ppm/K.

Upon customer request, we can measure each resistor to secure that the TC in the temperature range of +25°C to +60°C of all delivered resistors is ±1.0 ppm/K.

For the UPW series, the TK1 is -3.6 ppm/K and the TK2 is +4.4 ppm/K. The nominal spread of the TCs of all resistors during one charge at +25°C is ±2.8 ppm/K.

2. Precision Resistors (FPR/FPN, FHR/FHN, and FNR/FNN Series)

Picture 3 - dR/R (T) for the FPR/FPN, FHR/FHN, and FNR/FNN series



The dR/R (T) curve of the FPR, FHR, and FNR precision resistors series, as well as the FPN, FHN, and FNN precision network series, is more curved when compared with the USR/USN, UNR, and UHR ultra-precision resistor series.

Even then we can reach nominal TCs smaller than ±15 ppm/K in a temperature range of +20°C to +60°C, and smaller than ±10 ppm/K in a temperature range of +20°C to +40°C. This is possible through the use of a 4-pol technology, where the current intake and the voltage tapping are separated (Kelvin connection).

In Picture 3, the middle nominal dR/R (T) curve, as well as the border curves of the nominal spread (3σ area), are shown. These curves are only for low-ohm values used with a 4-pol connection.

For 2-pol resistors, the influence of the contact elements on the TCs of the complete resistance value is very big. In Picture 4, the change of the TC for 2-pol resistors is shown (dependent on the nominal resistor value).

Picture 4 – TC shift (low-ohm, 2-pol resistors)