

Surface Mount Chip Resistors Terminology Glossary

Selecting the optimum chip technology necessary to best match the performance requirements

Surface mount resistors are main key of electronic components composed electronic circuit. Chips are developed with demands of diverse electronic circuits and used. To summarize the application technique about surface mount resistors use for electric machine and tools, especially, which need high density mount in these chips. To make the best fit selection of chip resistors, in general, confirm with the characteristic of that circuit, as following steps:

1. Single chip resistor or Composite chip resistor;
2. For single chip resistor, there is an option of thick-film chip or thin-film chip;
3. For composite chips, there is another option of chip resistor array (common terminal circuit) or chip resistor network (isolated circuit);
4. For applications required pulse withstanding, working voltage ratings (power wattage) is one of key factors.
5. For applications required stability and precision, look for Token's Electrical Specifications for TCR and Resistance Tolerance parameters.

Whether you're designing circuit for telecommunications, computers, consumer electronics or office equipment, Token has the right chips for your application.

The Difference between Thin Film and Thick Film

The principal difference between thick film and thin film resistors is not the actual thickness of the film, but rather how the film is applied to the chip substrate surface (SMD resistors) or the cylinder (axial resistors).

Thin film resistors are made by sputtering (a method of vacuum deposition) the resistive material onto an insulating substrate. The film is then etched in a similar manner to the old (subtractive) process for making printed circuit boards; that is, the surface is coated with a photo-sensitive material, then covered by a pattern film, irradiated with ultraviolet light, and then the exposed photo-sensitive coating is developed, and underlying thin film is etched away.

Thick Film Resistor is manufactured by screen-printed a much thicker conductive paste of Ceramic and Metal, called Cermet, onto an alumina ceramic substrate. This composite of glass and conductive ceramic (cermet) material is then baked in an oven at about 850 °C to form the film.

Thin film resistor has better TCR and tighter tolerance than thick film due to sputtering technology precision timing control while thick film resistor has better pulse withstanding ability than thin film because of the thickness of film.

ESD Sensitivity of Chip Resistors

The sensitivity level of resistors used in electronic equipment to an electrostatic discharge (ESD) varies from a few hundred volts to a few tens of kilovolts. Ways to make resistors more robust to ESD are suggested.

The most popular electronic assembly method today is the surface mount technology, SMT. Manufacturers of components responded to this trend by developing standard sizes of surface mounted chips. Miniaturization leads to the use of smaller sized SMT chips and this causes an increase in the sensitivity of electronic equipment to ESD. ESD voltage levels which do not affect larger resistor chips may be dangerous for smaller sizes because of their smaller heat capacity.

Therefore, resistance value by ESD characteristic tends to become large following on becoming small. Moreover, it is influenced by conductive mechanism of resistive material, resistance value trends to be influenced with the range from 100 Ω to 100k Ω, and the ESD characteristic is hard to be influenced by ESD in the domain where resistance value is lower than that range or a high domain.

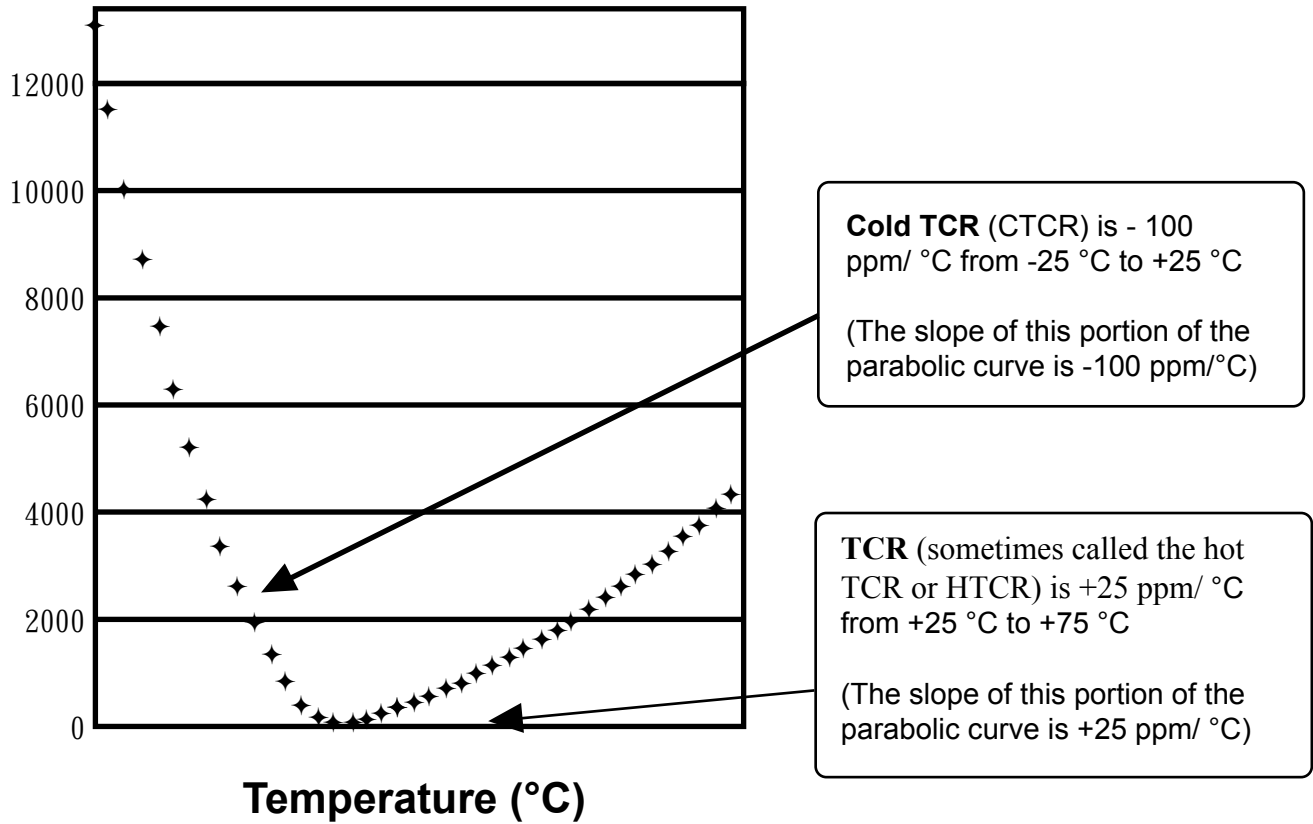
Temperature Coefficient of Resistance (TCR)

The Temperature Coefficient of Resistance (TCR) is expressed as the change in resistance in ppm (0.0001%) with each degree of change in temperature Celsius (°C). For example, a resistor with a TCR of +100 ppm/°C will change +0.1% total over a 10-degree change and +1% total over a 100-degree change.

The TCR value quoted on specification sheets is typically quoted as being referenced at +25°C and is the +25°C to +75°C slope of the TCR curve. TCR is typically not linear, but parabolic with temperature, as illustrated by the accompanying fig-1. Often the circuit designer treats the TCR as being linear unless very accurate measurements are needed. MIL STD 202 Method 304 is often referenced as a standard for measuring TCR. The following formula expresses the rate of change in resistance value per 1 °C in a prescribed temperature range:

- $TCR (ppm/°C) = (R - R_0) / R_0 \times 1 / (T - T_0) \times 10^6$
- **R:** Measured resistance (Ω) at T °C; **R₀:** Measured resistance (Ω) at T₀ °C
- **T:** Measured test temperature (°C); **T₀:** Measured test temperature (°C)

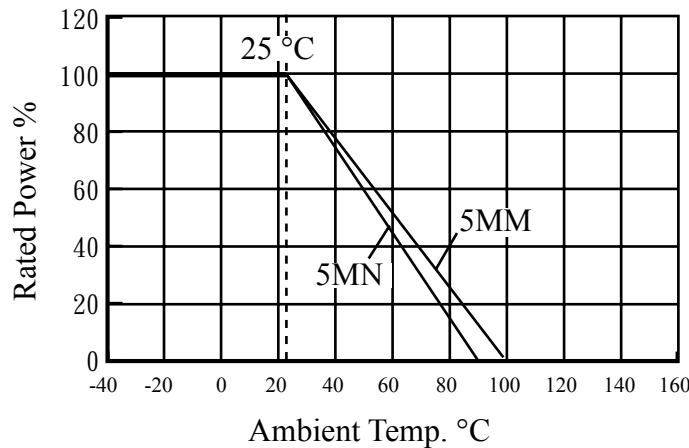
In the context of a resistor network, this TCR value is called the absolute TCR in that it defines the TRC of a specific resistor element.



Maximum Working Voltage

The maximum voltage applied continuously to a resistor or a resistor element. The maximum value of the applicable voltage is the rated voltage at the critical resistance value or lower. If the circuit designs permits, the choice of a high ohmic value resistor or divider network will improve the resistor's performance because it will operate at lower power.

Power Derating Curve



Power Rating

Power ratings are based on physical size, allowable change in resistance over life, thermal conductivity of materials, insulating and resistive materials, and ambient operating conditions. For best results, employ the largest physical size resistors at the less than their maximum rated temperature and power. Never use them continuously at their maximum rating unless you are prepared to accept the maximum allowed life cycle changes. If the circuit designs permits, the choice of a high ohmic value resistor or divider network will minimize the power level and improve the resistor’s performance as it is operating at a lower power level.

Rated Power

Rated power is the maximum value of power (watts), which can be continuously applied to a resistor at a rated ambient temperature. The basic mathematical relationship is **Equation: Power (Watts) = (Current (Amps))² × Resistance (Ohm)**.

If the circuit designs permits, the choice of a high ohmic value resistor or divider network will minimize the power level and improve the resistor’s performance because it is operating at a lower power and temperature level.

Rated Voltage

The maximum voltage applied continuously to a resistor at the rated ambient temperature. Rated voltage is calculated from the following formula, but it must not exceed the maximum working voltage. **Equation: Rated Voltage (V) = (Rated Power (W) × Nominal Resistance Value (Ω))^{1/2}**

High voltage resistors often are potted or operated in oil as the arc over voltage, in air, is approximately 10,000 volts per inch. Token’s resistors feature higher voltage ratings due to their high square count and associated design characteristics.