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Resistor Glossary

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Common Resistor Terminology

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Critical Resistance Value

The maximum nominal resistance value at which the rated power can be loaded without exceeding the maximum working voltage.
The rated voltage is equal to the maximum working voltage in the critical resistance value.

Derating Curve

The curve that expresses the relation between the ambient temperature and the maximum value of continuously loadable power at its temperature, which is generally expressed as a percentage.

Dielectric Withstanding Voltage

The rated voltage that can be applied to a designated point between the resistive element and the outer coating, or the resistive element and the mounting surface, without causing dielectric breakdown.

Maximum Overload Voltage

The maximum value of voltage capable of being applied to resistors for a short period of time in the overload test.
Typically the applied voltage in the short time overload test is 2.5 times larger than the rated voltage. However, it should not exceed the maximum overload voltage.

Maximum Working Voltage (or Maximum Limiting Element Voltage)

The maximum value of DC voltage or AC voltage (rms) capable of being applied continuously to resistors or element.
However, the maximum value of the applicable voltage is the rated voltage at the critical resistance value or lower.

Noise

Noise is an unwanted AC signal from within the resistor. Resistive noise can have a devastating effect on low-level signals, charge amplifiers, high gain amplifiers, and other applications sensitive to noise. The best approach is to use resistor types with low or minimal noise in applications that are sensitive to noise.

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 less than their maximum rated temperature and power.

Rated Ambient Temperature

The maximum ambient temperature at which resistors are capable of being used continuously with the prescribed rated power.
The rated ambient temperature refers to the temperature around the resistors inside the equipment, not to the air temperature outside the equipment.

Rated Power

The maximum amount of power that can be continuously loaded to a resistor at a rated ambient temperature. Network and array products have both rated power per package as well as per element.

Rated Voltage

The maximum value of DC voltage or AC voltage (rms) capable of being applied continuously to resistors at the rated ambient temperature.

Reliability

Reliability is the probability that a resistor (or any other device) will perform its desired function.
There are two ways of defining reliability. One is Mean Time between Failures (MTBF) and the other is Failure Rate per 1,000 hours of operation.
Both of these means of evaluating reliability must be determined with a specific group of tests and a definition of what is the end of life for a device, such as a maximum change in resistance or a catastrophic failure (short or open).
Various statistical studies are used to arrive at these failure rates and large samples are tested at the maximum rated temperature with rated load for up to 10,000 hours (24 hours per day for approximately 13 months).
Reliability is generally higher at lower power levels.

Resistor Tolerance

Resistor tolerance is expressed as the deviation from nominal value in percent and is measured at 25 ˚C only with no appreciable power applied.
A resistor’s value will also change with applied voltage (VCR) and temperature (TCR).
For networks, absolute resistor tolerance refers to the overall tolerance of the network.
Ratio tolerance refers to the relationship of each resistor to the others in the package.

Stability

Stability is the change in resistance with time at a specific load, humidity level, stress, or ambient temperature. When these stresses are minimized, the better the stability.

Temperature Rating

Temperature rating is the maximum allowable temperature at which the resistor may be used. It is generally defined with two temperatures.
For example, a resistor may be rated at full load up to +70℃ derated to no load at +125℃.
This means that with certain allowable changes in resistance over the life of the resistor, it may be operated at +70℃ at rated power.
It also may be operated with temperatures in excess of +70℃ if the load is reduced, but in no case should the temperature exceed the design temperature of +125℃ with a combination of ambient temperature and self-heating due to the applied load.

Voltage Coefficient of Resistance (VCR)

The voltage coefficient is the change in resistance with applied voltage. This is entirely different and in addition to the effects of self-heating when power is applied.
A resistor with a VCR of 100PPM/V will change 0.1% over a 10 V change and 1% over a 100 V change.
In the context of a resistor network, this VCR value is called the absolute VCR in that it defines the VCR of a specific resistor element.
The term VCR tracking refers to the difference in VCR between each specific resistor in a network.

Snubber circuits

Familiar wire wound and low-inductance carbon-composition and film resistors most often don't hold up well under a combination of high-voltage, current, or energy conditions.
Using snubber-circuit applications as an example, a comparison of these resistors shows that they do not match the performance and reliability of the bulk ceramic resistor.

As power is dissipated in a short spike, the instantaneous peak power may measure many megawatts. Because of the small mass of the resistive element, film and wire wound resistors suffer degradation and failure through thermal shock, jeopardizing the devices they are intended to protect.

Even so-called non-inductive wire wound resistors display some inductance, which may not be appreciable at tens or even hundreds of hertz used in older designs.
However, the high operating speeds used in applications such as modern power-conversion systems can render these resistors useless because low-nanohenry inductance is needed.

Carbon-composition resistors are non-inductive and provide an adequate solution at low average power, but they can be unstable because of moisture or high voltage.
Carbon-composition resistors rated at 2 W and higher are almost impossible to source.

Temperature Coefficient of Resistance (TCR also known as RTC)

The rate of change in resistance value per 1℃ in the prescribed temperature within the range of resistors operating temperature shall be expressed in the following formula:

T.C.R. (PPM/℃) = $(R-R_o)/R_o \times 1/(T-T_o) \times 10^6$

R: Measured resistance (Ω) at T ℃

R_o: Measured resistance (Ω) at T_o ℃

T: Measured test temperature (℃)

T_o: Measured base temperature (℃)

TCR is expressed as the change in resistance in PPM (0.0001%) with each degree Celsius of change in temperature.
TCR is typically referenced at +25℃ and changes as the temperature increases (or decreases).
A resistor with a TCR of 100PPM/℃ will change 0.1% over a 10℃ change and 1% over a 100℃ change.
In the context of a resistor network, the TCR value is called the absolute TCR in that it defines the TCR of a specific resistor element.
The term TCR tracking refers to the difference in TCR between each specific resistor in a network.

Understanding Temperature Coefficient of Resistance

A resistor's Temperature Coefficient of Resistance (TCR) tells how much its value changes as its temperature changes.
It is usually expressed in PPM/℃ (parts per million per degree Centigrade) units. What does that really mean?
Let's use an example: Token's 50 ohm RJ series precision resistor has a (standard) TCR of 20PPM/℃.
That means its resistance will not change more than 0.000020 ohms (20¸1,000,000) per ohm per degree Centigrade temperature change (within the rated temperature range of -55 to +145℃, measured from 25℃ room temperature.)

Assume our resistor is in a product that heats up from room temperature to 50℃.
To find our 50ohm resistor's (maximum) change caused by that 25℃ rise, multiply 0.000020 times 50 (the resistor value) times 25 (the temperature change.)
The resistor's value would change no more than 0.025 ohms. (0.000020 × 50 × 25 = 0.025 Ohm.)

The actual change may be much smaller, depending on the specific characteristics of that resistor.
If you must guarantee a smaller resistance change in your application, Token Electronics can provide a custom TCR as low as 2 PPM/℃.