Resistor Alternatives

Brian McCabe
Director of Sales
bmccabe@seielect.com

As the global economy struggles to recover, Covid-19 continues to impact the supply chain for many products and raw materials, including resistors. Companies are not able to find the components they qualified and are forced to settle for alternatives. Resistors are basic electronic components, however, there are significant differences between resistor technologies.

It is important for engineers and buyers to understand these differences to ensure they are selecting substitutes that will work sufficiently in their products. This article explores alternatives to the most common resistors and key criteria to consider before purchasing a substitute.

Same Resistive Element Alternative

The most straight-forward alternatives are parts made using the same materials. This type of substitution is commonly done with axial resistors. A supplier will suggest a higher wattage miniature version of the same technology for a standard size version. For example, if a customer is using a carbon film, 0.25W, 1KΩ, 5% resistor in standard size, the 0.5W miniature version can be used as a drop-in replacement. Dimensionally the parts are the same. The only difference is the mini version uses enhanced materials to aid in the dissipation of heat. These substitutions are typically done with carbon film, metal film and metal oxide resistors. The industry is introducing higher power SMD parts that are allowing customers to do the same with thick film and thin film resistors. For example, a customer that is using a standard general-purpose, 0805 case size rated at 0.125W (like Stackpole's RMCF0805) can also use a higher power, 0805 case size rated at 0.33W (Stackpole's RMCP0805). The RMCP is dimensionally identical and electrically superior. Since these alternatives are using the same materials with equal to greater than electrical performance, engineers can quickly and confidently approve these suggested replacements.

Same Size / Different Resistive Element Alternatives

There are many situations when the available alternatives meet many of the common parameters of a resistor - value, wattage, tolerance and size – but may not be viable options. A common example is customers using metal film resistors frequently cannot use carbon film resistors as alternatives. One of the obvious reasons would be metal films typically are used in 1% or tighter tolerance and carbon films are mostly used in 5% tolerance. However, the tolerance is only part of the consideration. Let us assume the customer is using a 5% metal film. In this scenario, a metal film, 0.25W, 47KΩ, 5% is out of stock and the customer needs an alternative. The carbon film resistor is a logical choice – 0.25W, 47KΩ, 5% and the size would be the same. One of the conflicts is the metal film has a temperature coefficient of ±100 PPM whereas, its carbon film equivalent would have TCR in the 0 ~ -500 PPM range. In this scenario, the customer needs to work with its engineer(s) to understand the application. If the application is sensitive to ambient temperatures, the carbon film may not be a viable option.

Another common example is when customers try to substitute thin film resistors or thick film resistors. Assuming the customer is willing to pay a premium for an upgraded part, there are other considerations. For instance, if a customer is using a general-purpose thick film with the following specifications: 0402 case size, 75KΩ, 1% tolerance, (s)he may or may not be able to substitute a nichrome thin film resistor with the same specifications. In this case, the TCR will be equal to or superior to the thick film part. However, thick film is inherently resistant to moisture whereas the nichrome thin film will erode and create an open circuit when exposed to moisture.

Current sensing resistors are conceivably the most complicated to cross. Current sense resistors are produced with ruthenium thick film, foil on ceramic substrates, metal alloy, bulk metal foil and even thin film. When crossing one current sense part for another, the customer needs to look beyond the basic resistor criterion (value, size, wattage, tolerance). An example would be a 2512 case size, 0.015Ω value, 1% tolerance. There are several parts that meet these specifications – thick film, foil on ceramic and metal shunt – but the user needs to understand other factors to determine if each option is compatible for the application. The metal shunt resistor is going to handle far more current than a foil on ceramic. A foil on ceramic will have better temperature coefficient of resistance than a thick film. Without understanding the specific electrical events the part will be exposed to, a customer is taking a big risk of using a part that may not be adequate for the application.

Other Potential Alternatives

As lead-times continue to extend and availability remains scarce, it is advantageous to quickly identify potential resistor alternatives. Above, we highlighted some of the potential problems with crossing various technologies, but resistors essentially perform the same function and there are plenty of potential alternatives. Here are some of the most common alternatives:

- Same type / Different functions. Thick film SMD resistors are very common and are designed for various applications and purposes. The general-purpose resistor is typically designed for basic applications at the lowest possible cost. Pulse chip resistors use the same materials but are designed to handle surge events. Although the cost difference is significant, a customer can use a higher end, more specialized thick film as an alternative for a general-purpose thick film. Likewise, a trimmable resistor could be used to replace a pulse handling resistor. And a high voltage chip resistor could be a suitable alternative for a high value resistor.

- Different type / Same functions. As materials and manufacturing processes improve, tolerances and TCR's also continue to improve. Historically, if a customer required a 0.5% tolerance part, they were limited to thin film (NiCr or TaN). Today, many suppliers offer 0.5% or tighter in thick film resistors. Although these parts are not typically stocked, they do provide customers with an alternative to thin film resistors and vice versa. When considering thin film as an alternative for thick film it is imperative to consider the moisture levels to which the part will be exposed. When contemplating thick film as a substitute for thin film, it is important to understand thick film is less stable and typically carries more noise than its thin film equivalent. However, the tolerance, TCR and other key factors are identical and therefore, provide a viable option for customers. For axial resistors there are various films that have different characteristics, but essentially perform like each other. For example, a mini, metal oxide, 1W, 5% resistor can typically be used as an alternative to a carbon film, 0.5W, 5% resistor. It is important to review proposed alternatives because there may be subtle differences, like the coating, that have significant impact to the application.

When considering an alternative that uses a different resistive material, it is imperative to involve engineers to make sure the proposed alternative is compatible with the application and product. This article explored some of the most common alternative and also some of the considerations that must be considered when selecting an alternative to the part that was originally designed in to the application. Thank you for reading.