DID YOU KNOW?

LOW ESR TANTALUM CAPACITORS

Vishay TR3 Low ESR Tantalum Capacitors and Where to Use Them

Capacitor technologies offer different benefits in an application depending upon the circuit function and operational environment. Choosing the right device enables design engineers to maximize system performance and reliability. For example, solid tantalum (MnO_2) offers higher and more stable capacitance values (C) based on volumetric efficiency compared to other common types, such as MLCCs.

A key parameter of any capacitor is its equivalent series resistance (ESR). In general, lower ESR improves capacitor performance. For solid tantalum devices, manufacturers offer a range of low ESR options that result from optimized mechanical and material design changes. Two primary functions for these capacitors are bulk energy storage and waveform filtering.

Bulk Capacitance

An important characteristic of any capacitor is the ability to store an electrical charge. Some applications require the capacitor to store large amounts of charge. Solid tantalum devices are well suited for bulk energy storage and are widely used to hold up voltage rails during times of peak current demand in the circuit. Here, two factors must be considered. The first is the total capacitance required to supply the required energy for the time needed. In many cases this can involve using multiple capacitors in parallel, and then enabling the energy to be “dumped” into the circuit. This prevents voltage rails from falling below specified limits over the given timeframe, therefore maintaining proper circuit performance.

An example of this would be for the bulk capacitance required on a 3.3 V rail that supplies a microprocessor. During turn-on, the processor may see a large current transient that must be satisfied. This is also known as slew rate and is defined as “idle current” to “peak current” with a specified slope “A / µs.” During this time it is necessary to keep the voltage within the typical specification range (for example, a drop of less than 10 % = 0.33 V). Capacitors with lower ESR can provide higher discharge currents to meet these demands more quickly.

Designers may actually place several high capacitance / voltage (CV) MLCCs close to the processor for short term current supply, and add the bulk capacitors (tantalum, polymer, or aluminum electrolytic devices) slightly further away from the IC. In this circumstance the MLCCs can supply limited high current energy very quickly to meet short term demands, but the low capacitance of the MLCCs means they are able to perform this for only a short period of time. After that, the bulk capacitors can take over for the required longer periods. When lower ESR tantalum capacitors are used for this purpose, there is less reliance on MLCCs and fewer of them are required. This saves PCB board space as well as component acquisition costs.

Another advantage of low ESR tantalum devices as bulk energy capacitors is lower heat generation when charged / discharged, which further improves circuit efficiency. This can result in lower operational temperature for the circuit, which may allow for the use of smaller power supplies for further cost savings.

Filter Functions

When low ESR capacitors are used for smoothing a signal, they reduce the amount of ripple current that appears on the DC bus. This is accomplished by allowing for higher charge / discharge currents to better follow the voltage cycles and supply energy during any peaks and valleys in the waveform. As the ripple current (peak to peak) is reduced, less heat is dissipated on each charge / discharge cycle. Lower ESR (and lower inductance) capacitors also allow the ripple filtering capacitors to be used in circuits containing components with higher frequency noise.

Overall, the benefits of low ESR capacitors are that they allow higher charge and discharge currents and reduce the effects of heating caused during the charge and discharge cycles of the capacitor.

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