Wet Tantalum Capacitors in High Reliability Applications

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ABSTRACT

For decades, it has been said that wet tantalum capacitors would be replaced by other technologies for a variety of reasons. However, for the high reliability environments of the aviation, military, and space (AMS) market, as well as for oil and gas exploration, wet tantalum capacitors continue to be the best choice in most cases. This is largely due to the fact that no other capacitor technology other than wet tantalum provides the combination of energy density, high reliability, and long life demanded by the AMS, oil, and gas markets.

TANTALUM VS. OTHER CAPACITOR TECHNOLOGIES

Tantalum capacitors in general have developed a bad reputation in the last two decades. During the dot-com bubble, when tantalum supplies were short, designers began to use other technologies such as MLCCs for their needs. Furthermore, tantalum was one of several minerals connected to poor labor conditions, primarily in the People's Republic of the Congo, which are said to have claimed millions of lives. Most respectable tantalum capacitor vendors now have conflict mineral statements that vow to avoid sourcing from certain areas. However, while MLCC technology has now started to encroach on the capacitance / voltage space once owned by tantalums, tantalum capacitors still have several advantages over MLCCs. For example, as Fig. 1 shows, tantalums are very stable over voltage, unlike MLCCs. Fig. 2 shows that tantalum is also much more stable over temperature.

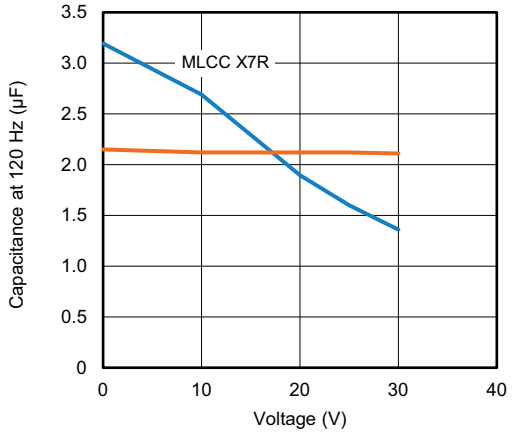

Fig. 1

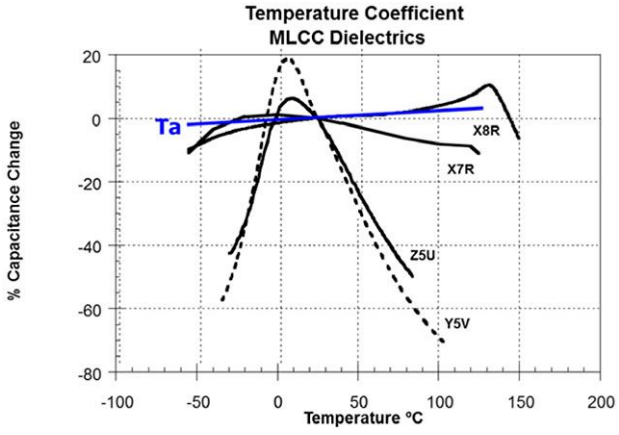

Fig. 2 - Temperature Coefficient MLCC Dielectrics

Aluminum electrolytic capacitors are generally non-hermetic, their electrolyte will dry out, and they will eventually lose significant capacitance over time. And though they are much less expensive than tantalums, they do not have the energy density that tantalum technology has. Therefore, they are larger in size. With today's ever-rising pressure for designers to pack more and more technology into a smaller space, this is often a constraint. Aluminums also have a limited shelf life before the need for reforming is necessary, whereas wets have essentially unlimited shelf life.

WHITE PAPER

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WHAT IS A WET SLUG TANTALUM?

We will start with explaining why these devices are called “wet” tantalums. Essentially, there are two types of tantalum technologies: solid and wet. A solid tantalum capacitor consists of a sintered anode with an oxide formed throughout its body, creating tantalum pentoxide as the dielectric. Then, a magnesium dioxide (MnO_2) or polymer system is applied to form the cathode. The formation of the anode slug for a wet tantalum capacitor is done in much the same way as the solid tantalum capacitor. Tantalum powder is pressed into a shape and sintered, then an electrochemical reaction forms the tantalum pentoxide as the dielectric. The anode slug is then inserted into a metal or tantalum cylinder that contains a liquid electrolyte as part of the cathode system in conjunction with the tantalum sleeve. The body is then hermetically sealed so that the electrolyte will not leak out.

ADVANTAGES OF WET TANTALUM CAPACITORS

All tantalum capacitors have a self-healing effect. This is the capacitor’s ability to inherently re-grow any thinning or defective areas of the dielectric that could potentially cause resistive or hard shorts between the anode and cathode. This is why the time before failure rates for tantalum capacitors are typically calculated in the tens or hundreds of millions of hours. This self-healing effect is especially pronounced for the wet tantalum capacitor because the dielectric is in constant contact with a chemical similar to the one used to form the dielectric to begin with. As current flows through the device and heat is generated, the chemical reaction will improve the dielectric thickness and make the part more reliable over time. Another advantage of this process is that DC leakage is also improved.

Another advantage of wet tantalum technology is the lack of voltage derating required, as compared to solid MnO_2 cathode tantalums. Since the 1950s, it has been established that in order to get the longest reliability and MTBF from a solid MnO_2 tantalum capacitor, the recommendation from all manufacturers is to derate the voltage by 50 % or even 60 %, depending on the application conditions. As Fig. 3 shows, wet tantalum capacitors need no derating up to 85 °C and only about 30 % derating at 125 °C.

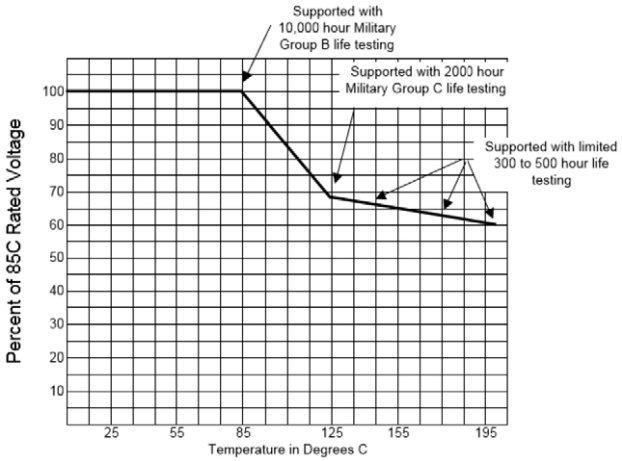

Fig. 3 - Wet Tantalum Voltage Derating Guidelines

Wet tantalum capacitors continue to be widely used primarily in the AMS and oil and gas exploration markets. While the technology comes at a higher cost due to the manual process involved and more expensive materials, no other technology, tantalum or otherwise, can match its capacitance to voltage ratio. Additionally, wet tantalum capacitors, using the proper derating, can withstand temperatures as high as 230 °C, which is required by the oil and gas industry. Vishay continues its leadership position in wet tantalum capacitors with the acquisition of companies such as Arcotronics, Mallory, and Sprague. Please contact your local Vishay sales representative for your tantalum capacitor needs. For technical questions, send an email to tantalum@vishay.com.