

Ultra-Low ESR Tantalum Chip Capacitor

by: John Moore, Director, Technical Marketing Services

Introduction:

As the electronics industry moves into the new millennium, the old statement of "smaller, faster, better, and cheaper" has never been more true. Customers have come to expect this, and throughout the last forty years, the industry has not disappointed them.

Although all four items mentioned are important, the item that has been receiving the most attention from researchers and engineers is "faster." Nowhere is the need for speed more obvious than in the PC industry. It was just five years ago when the big debate was whether it was necessary to upgrade the 286 to the 386. Today, the PC industry is producing processor speeds of 166MHz and 200MHz, with seemingly no limit to how fast they will operate. These higher operating frequencies have really presented a challenge for tantalum capacitor manufacturers. In the typical applications of decoupling and voltage regulation of the microprocessor, the higher frequencies mean that the current has to be transferred faster from the capacitors to the processor. This means that maintaining a low circuit impedance is critical. As part of this low overall circuit impedance, the tantalum capacitor has to have lower and lower ESR. Other applications that have likewise required low ESR performance in a tantalum capacitor are the switch mode power supply (SMPS) input and output filtering, as well as just about any portable-type device that is battery driven. Lower ESR in the SMPS application leads to better efficiency in the device and allows higher power output. All portable devices using low ESR tantalum components can extend their battery life because of better power efficiency.

For the most part, the tantalum capacitor manufacturers have been able to meet the challenge. Last year, KEMET introduced the T494, a low ESR series which compliments the T495 Low ESR/Surge Robust series KEMET introduced in 1992. These decreases in ESR have been attained through materials and process changes in the present manufacturing systems, and have been imitated by other tantalum capacitor manufacturers. In addition to the existing materials system, some tantalum suppliers have gone to a conductive polymer counter-electrode system to obtain lower ESR¹. However, even with these low ESR tantalum components, the users have still had to use multiple capacitors in parallel to get the total functional ESR as low as possible. This use of multiple capacitors in parallel, although necessary, is undesirable because it uses valuable circuit board real estate and involves excessive placement cost because of the high number of

components involved. The user community has been looking at alternatives to this, and KEMET has taken this as a technology driver that was instrumental in developing the new T510 Ultra-Low ESR product.

Description:

The T510 Ultra-Low ESR Tantalum Chip Capacitor is a unique device that combines the latest technology for low ESR tantalum capacitor devices with the idea of using more than one device in parallel. The result is a multi-anode tantalum capacitor with an ESR that is 50% to 66% lower than a comparable single anode unit.

Essentially, KEMET is assembling a parallel array of tantalum pellets, commonly referred to throughout the industry as anodes, inside a standard EIA 7343H (X) molded case. This is not a new concept. The original idea was patented by Dr. John Piper of KEMET Electronics in 1972 when KEMET was still part of the Union Carbide Corporation². The principle works the same as inserting the capacitors in parallel in the circuit. The resistance of all three is equal to their average individual resistance divided by three. If you were to place three 150 μ F/6 V capacitors in parallel in a circuit, and each had an ESR @ 100kHz of 45 mOhms, the total circuit resistance would be $45/3 = 15$ mOhms. In the T510 device, the same parallel mechanism is employed inside the molded case. First, three thin tantalum pellets are processed so that they are functioning capacitors. This means the dielectric layer, MnO₂, carbon, and silver processes have all been completed and the tantalum pellet is completely functional. These thin pellets are the same as those used to make KEMET's "V" case (EIA 7343L) package. This "V" size pellet is very thin by design, and is the same width as the height of the "X" size tantalum capacitor (See Figure 1). A special assembly

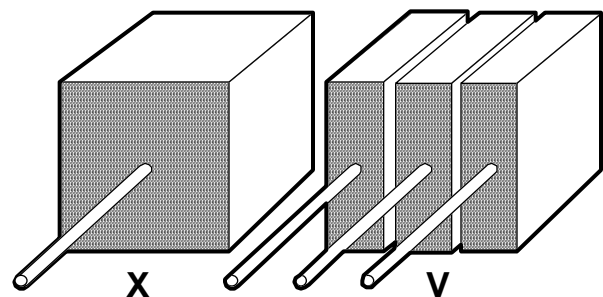


Figure 1

machine, developed by KEMET engineers, takes three of these pellets, turns them on their thin edge, places them on "X" size leadframe, welds the positive tantalum lead, and glues

the negative lead with conductive adhesive. The remainder of the process is the same as any "X" size part. The only difference is that the ESR is considerably lower (See Figure 2).

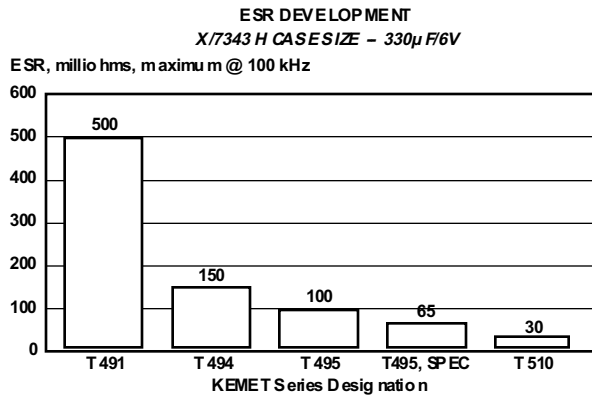


Figure 2

This unique construction offers several other advantages. The individual thinner tantalum pellets occupy approximately the same volume as a large "X" size tantalum pellet, but the distance from the center of the pellet to the external surface is about two-thirds less. Because of this, more total tantalum element is available at high frequencies (see Figures 3 and 4). This results in substantially higher capacitance levels at

Anode Penetration vs Thickness

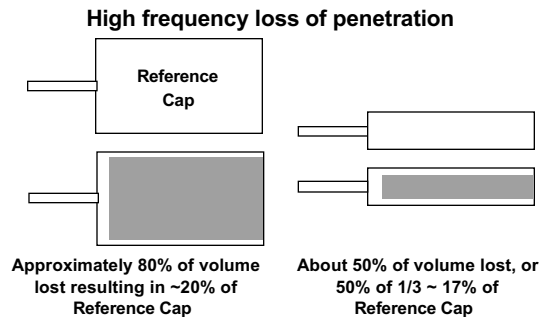


Figure 3

Multiple Anode Penetration

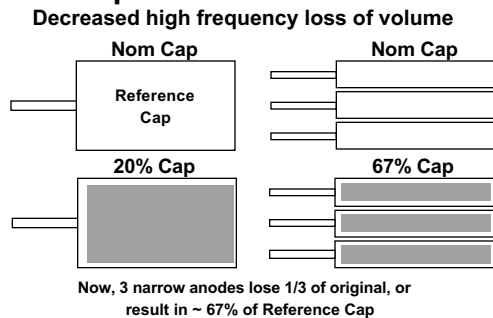


Figure 4

high frequencies (see Figure 5). And, because the cross-sectional area of the "V" sized tantalum pellet is so much smaller than an "X" size tantalum pellet, the part is much easier to penetrate with formation electrolyte, wash solutions

T510X477M006

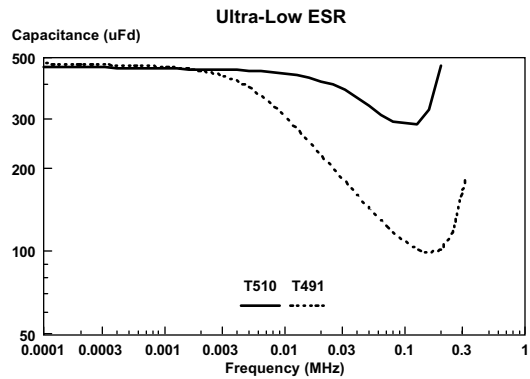


Figure 5

and manganese nitrate for counter-electrode deposition. This means that processing the new higher CV/gram tantalum powders will be easier and more reliable. With the use of the T510 technology, higher CV in an "X" sized part can be more readily achieved, along with further reductions in ESR.

Conclusion:

As we head into the 21st century, the T510 Ultra-Low ESR Tantalum Chip capacitor is only the beginning to solutions for low ESR tantalum capacitors. The T510 Ultra-Low ESR Tantalum Chip Capacitor offers some exciting new possibilities as extensions of the T494 and T495 low ESR product in various applications, and also as a surface mount alternative to aluminum capacitors being used in similar applications. The three part types and their specifications that are being offered can be seen in Figure 6. This is truly an exciting time for the KEMET development team, our customers, and the electronics world as a whole.

KEMET Part Number	EIA Case Code	Cap 120 Hz Nom. µF	Rated Voltage	DF 120 Hz Max. %	DCL 25°C Max. µA	100 kHz Max. Limits			
						ESR Ohms		Ripple Current Arms	
						25°C	25°C	85°C	125°C
T510X687(1)004AS*	X/7343H	680.0	4V	6.0	27.2	0.030	3.0	2.2	1.0
T510X477(1)006AS	X/7343H	470.0	6V	6.0	28.2	0.030	3.0	2.2	1.0
T510X337(1)010AS*	X/7343H	330.0	10V	6.0	33.0	0.035	2.8	2.0	0.9

Figure 6

* Under Development

References:

- "History of the Development of Tantalum Capacitor and Future Trend", Nakata, Takehiko, Morimoto, K., Saiki, Y., Nishiyama, T., International Symposium on Tantalum and Niobium, Sept 24 - 28, 1995, Goslar, Germany, pp. 177-194
- US Patent#3,686,535 Aug 22, 1972, "Electrolytic Capacitor with Separate Interconnected Anode Bodies, John Piper, Union Carbide Corporation, Filed: July 2, 1971