TECHNICAL INFORMATION

NEW TANTALUM CAPACITOR DESIGN FOR 0603 SIZE

by Ian Salisbury
AVX - Paignton, UK

Abstract:

This paper reports on how AVX has responded to the market needs for high capacitance in small body size, by developing a surface mount type of Tantalum capacitor that has high capacitance volumetric efficiency and a body size reduced to 0603.

NEW TANTALUM CAPACITOR DESIGN FOR 0603 SIZE

by Ian Salisbury
AVX - Paignton, UK

Introduction

The demand for high component packing density on printed circuit boards in electronic equipment is driven by four factors:

Small equipment size demonstrated by the Mobile Phone industry, Personal Computers, Cameras, Hearing Aids and Mobile office equipment,

Increased functionality which requires an increase in electronic circuit packing density,

Smaller PCB and smaller equipment case size which reduce manufacturing costs,

Higher circuit speeds which require short path lengths between components in order to reduce inductance and resistance.

The capacitor industry is driven by customer demand. The change to surface mount in the 1980's required component manufacturers to replace wires with lead frames.

The tantalum capacitor industry responded by changing the packing and terminations configuration, but the design within the component remained the same. However, in the late 1980's circuit technology demanded lower working voltage and higher capacitance. This required development of new tantalum powders with high surface area to increase the capacitance and development of high purity powders and new dielectric formation methods to reduce electrical leakage currents.

The mechanical design of the tantalum capacitor element had remained unchanged for 25 years but in the early 90's it became apparent that only a major change in the build construction of the tantalum capacitor would give a significant improvement in capacitance volumetric efficiency.

AVX embarked on a total redesign concept to allow small tantalum capacitors to be manufactured in high volume down to sizes of 0603 with high capacitance and high frequency performance.

Design Discussion

Present design/construction of the anode element is to press tantalum powder into a pellet, insert a wire into one end of the pellet and sinter at high temperature. The sinter operation welds the wire to the tantalum powder within the anode element.

The reason why this wire has remained a design feature for the last 25 years is that it is an integral part of the manufacturing process. Many anode elements may be attached to a support bar by the wire, thus allowing the anode element to be submerged into the electrolyte for dielectric formation, with the electrical energy applied through the support bar.

This process is repeated, dipping into manganese solution for the formation of the cathode, then subsequently dipping into the carbon and silver conductive resins, which form the cathode connections. To design this wire out would mean a total change in the manufacturing equipment.

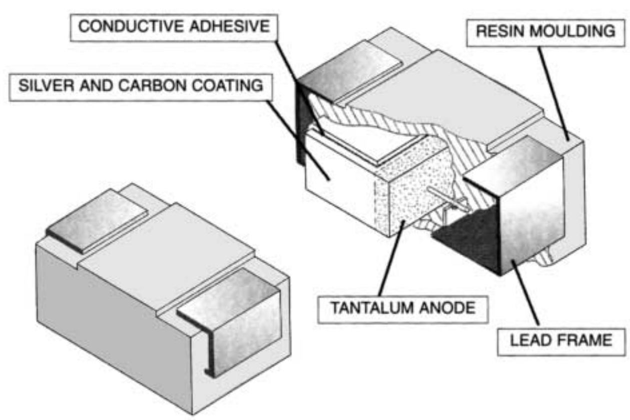
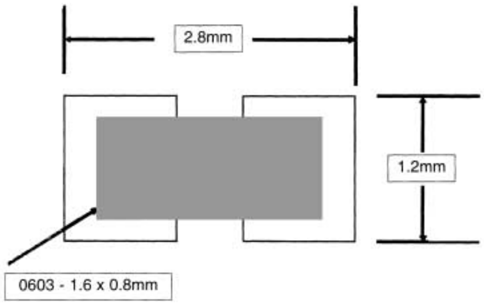


Figure 1. Mechanical Construction of a Tantalum Capacitor

It can be seen from Figure 1 that a large volume of the capacitor package is devoted to the wire connection and lead frame assembly. In the case of a 0805 size capacitor, 50% of the volume is taken up by the wire connection concept. Also, the lead frame is an inductive loop which increases inductance.

The customer requirement is for the area of the PCB occupied by the component to be as small as possible. This requires a small footprint size as well as a small component.

For example, the present design of a ceramic 0603 would have 5 metallized faces at each end. The international PCB footprint mounting pad would occupy a board area of the next size up of component.



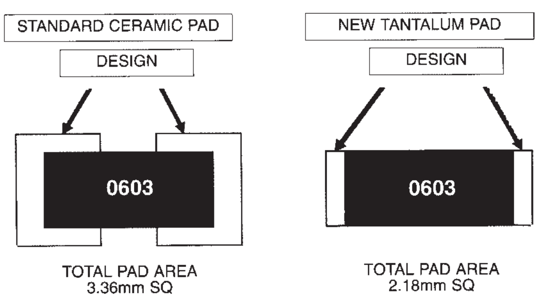
PLAN AREA OF 0603 - 1.28mm
AREA OF COPPER MOUNTING PADS - 3.38mm
THE PAD AREA IS 2.625 TIMES THE AREA
OF 0603 DEVICE

Figure 2. Copper Land Area Footprint for 0603 Chip Ceramic Based on IPC-SM-782 Publication

If the dimensional body size tolerance is large, the footprint has to allow the increase in tolerance. The increased footprint size occupies a larger area of PCB. The aim of the redesign was therefore to design a small body capacitor down to 0603 size with very tight tolerance on dimensions, which required a small area of PCB, and was suitable for mounting by solder reflow.

Capacitor Design

The first task was to look at the footprint size. The conventional ceramic capacitor has 5 faces on each end for solder attachment which means that the footprint has to extend to either side of the capacitor on length and width.



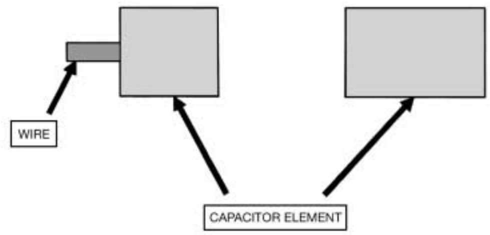
A SAVING OF 35% PCB BOARD AREA

Figure 3. Printed Circuit Board Pad Area Comparison for a 0603 Capacitor

By designing the capacitor with only end face metallization for soldering the footprint could be significantly reduced in width to the size of the capacitor body. With no solder on the side faces, the body size can be increased without exceeding the accepted category size.

Maintaining a very tight tolerance on the width allows maximum tantalum anode size to be fitted into the body size giving an increase in capacitance volumetric efficiency.

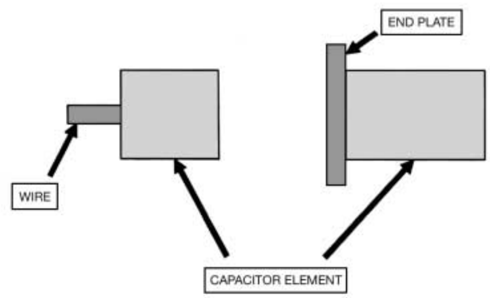
The next step was to redesign the tantalum anode assembly by removing both the wire connection from the anode and the lead frame.



REPLACING THE WIRE WITH A END PLATE
INCREASES THE VOLUME OF THE ANODE

Figure 4. Capacitor Element Design Change

Figure 4 shows the concept of increasing anode size by removing the wire and lead frame. The wire was replaced with a tantalum plate bonded to the total end face of the enlarged capacitor element.



REPLACING THE WIRE WITH A END PLATE
INCREASES THE VOLUME OF THE ANODE

Figure 5. Capacitor Element Design Change

The next step was to add the cathode termination plate, which is bonded to the end face of the silver coated anode assembly. The bonding material had to be electrically conductive as well as mechanically stress absorbent. This was necessary to compensate for the difference in temperature coefficient of expansion between the tantalum anode assembly and the PCB during the solder mounting of the capacitor to the PCB and for operational life.

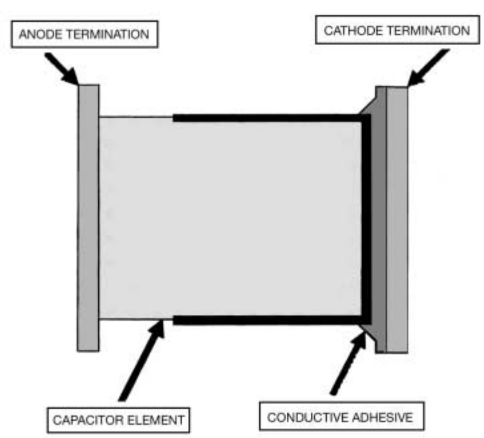


Figure 6. Capacitor Element Cathode Termination

The capacitor element had to have protection against solder and flux so a thin resin encapsulation coat which incorporated a polarity band was added.

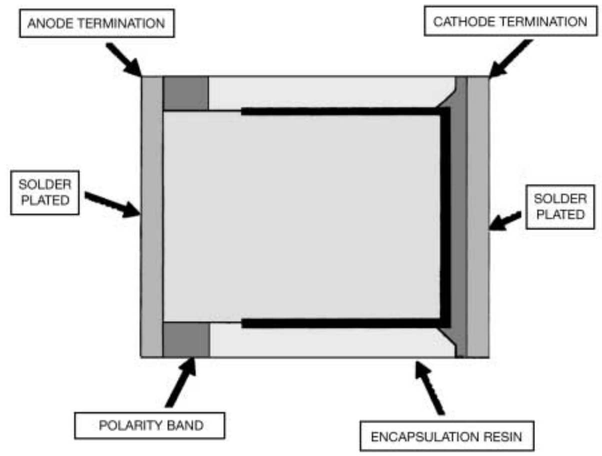


Figure 7. Encapsulated Chip Tantalum Capacitor

Comparison of the old and new construction methods shows that the anode volume increased considerably. This construction also allows capacitors to be manufactured down to 0603 size.

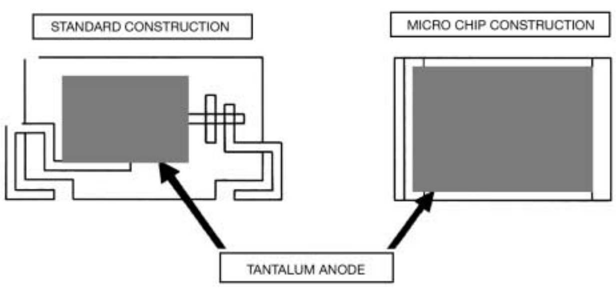


Figure 8. Capacitor Element Cathode Termination

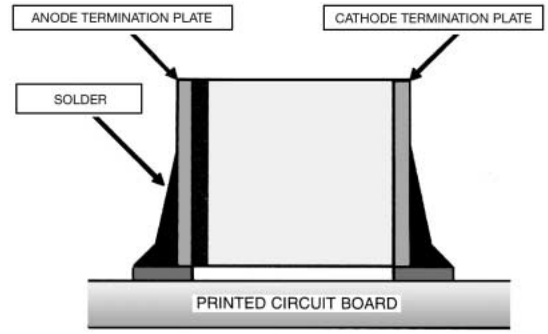


Figure 9. Capacitor Element Cathode Termination

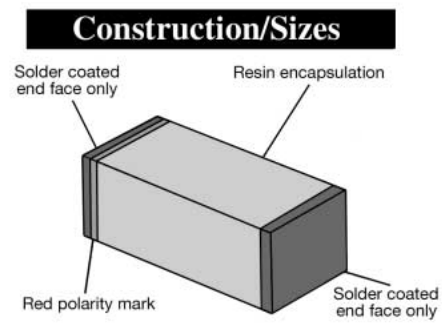


Table 2. Size Outline for the Tantalum Micro Chip Capacitor

Case Size	Length (mm) + 0.15 - 0.10	Width (mm) ± 0.10	Height (mm) ±0.10
0603	1.60	0.85	0.85

CAPACITANCE µF	Code	RATED VOLTAGE d,c 2V	3V	4V	6.3V	10V
0.47	474					L
0.68	684					L
1.0	105				L	L (ext)
1.5	155			L	L (ext)	L
2.2	225		L	L (ext)	L	
3.3	335	L	L (ext)	L		
4.7	475	L (ext)	L			R
6.8	685	L			R	R (ext)
10	106			R	R (ext)	
15	156		R	R (ext)		
22	226		R (ext)			

Table 1. Micro Chip Tantalum Capacitor Capacitance Range / Rated Voltage

Capacitor Performance Information

Typical range of the new style microchip tantalum capacitor.

The physical size has tight tolerance which is inherent in the capacitor manufacturing process. After encapsulation and solder terminating, capacitors are accurately profiled to size using precise cutting techniques.

This insures very close tolerances on the finished capacitor and perfect coplanar alignment of the end terminations. The symmetrical outline is eminently suitable for pick and place equipment, and along with the improved mounting pad design, allows close packing densities.

The +ve and -ve terminations are thin metal plates because this capacitor design only uses the end faces for soldering.

The use of a solder plated metal plate insures very high adhesion strengths between the PCB and the capacitor termination.

Had conductive resin or conductive glass frit materials been used dimensional tolerance would have been much larger and adhesion strengths been more difficult on an end face connection. Comparison of ceramic capacitor technology (Y5V) and present tantalum capacitor technology shows that the new design of microchip tantalum capacitor has a superior capacitance/volumetric efficiency while retaining stability with temperature and applied voltage.

Conclusions

1. The new design uses the same Tantalum technology as the conventional Tantalum capacitor, therefore it exhibits the same excellent reliability and temperature stability as the standard products.

2. Ceramic capacitors using Y5V dielectric can reduce in capacitance by 80%, when 100% of rated voltage is applied. Tantalum is not sensitive to working voltage, and therefore has excellent stability in circuit applications where voltage changes occur.

3. Ceramic capacitors using Y5V dielectric can reduce in capacitance by 50% when heated to 85ºC. Tantalum increases in capacitance by only 5% when heated to 85ºC and has excellent stability against temperature change.

4. Small capacitor size down to 0603 in Tantalum technology can now be realized, with high capacitance/volumetric efficiency.

5. High frequency performance is assured by virtue of low inductance design.

6. By using only end termination soldering, the capacitor uses a much smaller PCB area.

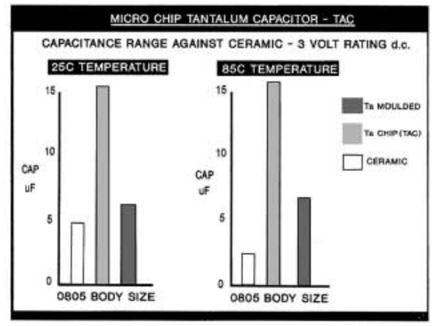


Figure 10. 0805 Comparison Capacitance Range

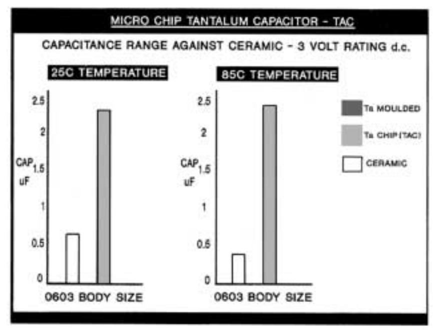


Figure 11. 0603 Comparison Capacitance Range

Comparison of capacitance stability against temperature and applied voltage.

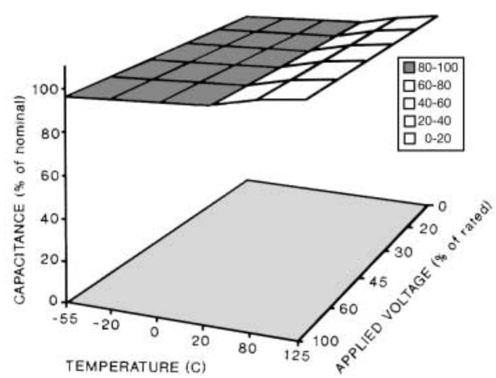


Figure 12. Tantalum Stability

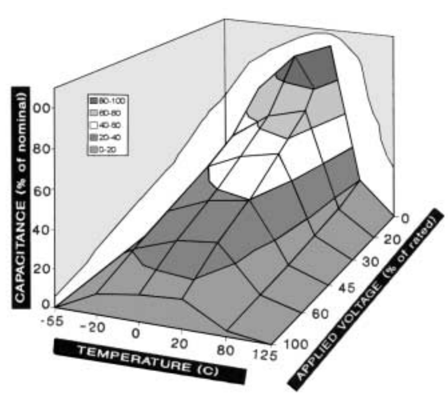


Figure 13. Ceramic Stability

USA

AVX Myrtle Beach, SC
Corporate Offices
Tel: 843-448-9411
FAX: 843-626-5292

AVX Northwest, WA
Tel: 360-699-8746
FAX: 360-699-8751

AVX North Central, IN
Tel: 317-848-7153
FAX: 317-844-9314

AVX Mid/Pacific, MN
Tel: 952-974-9155
FAX: 952-974-9179

AVX Southwest, AZ
Tel: 480-539-1496
FAX: 480-539-1501

AVX South Central, TX
Tel: 972-669-1223
FAX: 972-669-2090

AVX Southeast, NC
Tel: 919-878-6223
FAX: 919-878-6462

AVX Canada
Tel: 905-564-8959
FAX: 905-564-9728

EUROPE

AVX Limited, England
European Headquarters
Tel: ++44 (0) 1252 770000
FAX: ++44 (0) 1252 770001

AVX S.A., France
Tel: ++33 (1) 69.18.46.00
FAX: ++33 (1) 69.28.73.87

AVX GmbH, Germany - AVX
Tel: ++49 (0) 8131 9004-0
FAX: ++49 (0) 8131 9004-44

AVX GmbH, Germany - Elco
Tel: ++49 (0) 2741 2990
FAX: ++49 (0) 2741 299133

AVX srl, Italy
Tel: ++390 (0)2 614571
FAX: ++390 (0)2 614 2576

AVX Czech Republic, s.r.o.
Tel: ++420 (0)467 558340
FAX: ++420 (0)467 558345

ASIA-PACIFIC

AVX/Kyocera, Singapore
Asia-Pacific Headquarters
Tel: (65) 258-2833
FAX: (65) 350-4880

AVX/Kyocera, Hong Kong
Tel: (852) 2-363-3303
FAX: (852) 2-765-8185

AVX/Kyocera, Korea
Tel: (82) 2-785-6504
FAX: (82) 2-784-5411

AVX/Kyocera, Taiwan
Tel: (886) 2-2696-4636
FAX: (886) 2-2696-4237

AVX/Kyocera, China
Tel: (86) 21-6249-0314-16
FAX: (86) 21-6249-0313

AVX/Kyocera, Malaysia
Tel: (60) 4-228-1190
FAX: (60) 4-228-1196

Elco, Japan
Tel: 045-943-2906/7
FAX: 045-943-2910

Kyocera, Japan - AVX
Tel: (81) 75-604-3426
FAX: (81) 75-604-3425

Kyocera, Japan - KDP
Tel: (81) 75-604-3424
FAX: (81) 75-604-3425

Contact:

AVX
A KYOCERA GROUP COMPANY

http://www.avxcorp.com

S-NTCD00M301-N