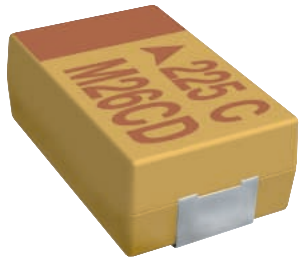
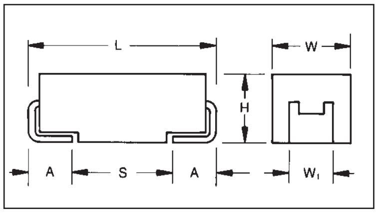
TAJ Series

Low Profile



Five additional case sizes are available in the TAJ range offering low profile solid tantalum chip capacitors. Designed for applications where maximum height of components above or below board are of prime consideration, this height of 1.2, 1.5 and 2.0mm equates to that of a standard integrated circuit package after mounting. The S&T footprints are identical to the A&B case size parts and the W&Y footprints to C&D case size parts.

CASE DIMENSIONS: millimeters (inches)



For part marking see page 50

Code	EIA Code	Dimension Low Profile	L±0.2 (0.008)	W+0.2 (0.008) -0.1 (0.004)	H Max.	W_1±0.2 (0.008)	A+0.3 (0.012) -0.2 (0.008)	S Min.
R*	2012	R Case (1.2)	2.05 (0.081)	1.3 (0.051)	1.2 (0.047)	1.2 (0.047)	0.5 (0.020)	0.85 (0.033)
S**	3216L	A Case (1.2)	3.2 (0.126)	1.6 (0.063)	1.2 (0.047)	1.2 (0.047)	0.8 (0.031)	1.1 (0.043)
T**	3528L	B Case (1.5)	3.5 (0.138)	2.8 (0.110)	1.2 (0.047)	2.2 (0.087)	0.8 (0.031)	1.4 (0.055)
W**	6032L	C Case (2.0)	6.0 (0.236)	3.2 (0.126)	1.5 (0.059)	2.2 (0.087)	1.3 (0.051)	2.9 (0.114)
Y**	7343L	D Case (2.4)	7.3 (0.287)	4.3 (0.169)	2.0 (0.079)	2.4 (0.094)	1.3 (0.051)	4.4 (0.173)
†X**	7343L	D Case (1.5)	7.3 (0.287)	4.3 (0.169)	1.5 (0.059)	2.4 (0.094)	1.3 (0.051)	4.4 (0.173)

*** 0805 Footprint Compatible**
**** Low Profile Versions of A & B & C & D Case**
† Developmental Only

W_1 dimension applies to the termination width for A dimensional area only.
Pad Stand-off is 0.1±0.1.

HOW TO ORDER

TAJ	Y	107	M	010	R	**
Type	**Case Code** See table above	**Capacitance Code** pF code: 1st two digits represent significant figures 3rd digit represents multiplier (number of zeros to follow)	**Tolerance** K=±10% M=±20%	**Rated DC Voltage** 002=2Vdc 004=4Vdc 006=6.3Vdc 010=10Vdc 016=16Vdc 020=20Vdc 025=25Vdc 035=35Vdc 050=50Vdc	**Packaging** **Packaging** See Tape and Reel Packaging R=7" T/R S=13" T/R (see page 49)	**Additional characters may be added for special requirements**

TECHNICAL SPECIFICATIONS

Technical Data:		All technical data relate to an ambient temperature of +25°C								
Capacitance Range:		0.1μF to 470μF								
Capacitance Tolerance:		±10%; ±20%								
Rated Voltage (V_R)	≦ +85°C:	2	4	6.3	10	16	20	25	35	50
Category Voltage (V_C)	≦ +125°C:	1.3	2.7	4	7	10	13	17	23	33
Surge Voltage (V_S)	≦ +85°C:	2.7	5.2	8	13	20	26	32	46	65
Surge Voltage (V_S)	≦ +125°C:	1.7	3.2	5	8	12	16	20	28	40
Temperature Range:		-55°C to +125°C								
Reliability:		1% per 1000 hours at 85°C with 0.1Ω/V series impedance, 60% confidence level								

CAPACITANCE AND VOLTAGE RANGE (LETTER DENOTES CASE SIZE)

Capacitance		Rated voltage (V_R) at 85°C (Voltage Code)							
µF	Code	2V (F)	4V (G)	6.3V (J)	10V (A)	16V (C)	20V (D)	25V (E)	35V (V)
0.10	104						R/S		
0.15	154						R/S		
0.22	224						R/S		
0.33	334						R/S		
0.47	474						R/S		
0.68	684					R/S	R/S/T		Ⓢ
1.0	105				R/S	R/S/T	R/S/T	Ⓢ	Ⓢ
1.5	155			R/S	R/S	S	T/Ⓡ		Ⓣ
2.2	225		R/S	R/S	R/S	T/Ⓡ	T	Ⓣ	Ⓣ
3.3	335		R/S	R/S	R/S/T	T	T	Ⓣ	
4.7	475	R	R/S	R/S/T	R/T	S			W
6.8	685	R	S/T	R/T	T	T		Ⓦ	
10	106	S	R/S/T	R/S	S/T	T/W	W	w	Ⓧ/Y
15	156		S	S/T	T		W	Ⓧ/Y	Ⓨ
22	226			T	T	W	Ⓦ/Y	Ⓨ	
33	336			T/W	W	W/Y	Ⓧ		
47	476			W	W	Ⓧ/Y	Ⓨ		
68	686			W	Ⓦ/Y	Y	Ⓨ		
100	107		Ⓦ	W/Y	X/Y	Y			
150	157	W		Ⓧ	Ⓧ/Y				
220	227		Ⓧ	Ⓨ	Y				
330	337	Ⓧ	Ⓨ	Ⓨ					
470	477	Ⓨ							

● = In Development

RATINGS & PART NUMBER REFERENCE

AVX Part No.	Case Size	Capacitance µF	DCL (µA) Max.	DF % Max.	ESR max. (Ω) @ 100 kHz
Voltage/Code	**2 volt @ 85°C (1.2 volt @ 125°C) / F**				
TAJR475*002	R	4.7	0.5	6	20.0
TAJR685*002	R	6.8	0.5	6	20.0
TAJS106*002	S	10.0	0.5	6	8.0
Voltage/Code	**4 volt @ 85°C (2.5 volt @ 125°C) / G**				
TAJR225*004	R	2.2	0.5	6	25.0
TAJS225*004	S	2.2	0.5	6	25.0
TAJR335*004	R	3.3	0.5	6	20.0
TAJS335*004	S	3.3	0.5	6	18.0
TAJR475*004	R	4.7	0.5	6	12.0
TAJS475*004	S	4.7	0.5	6	10.0
TAJS685*004	S	6.8	0.5	6	8.0
TAJT685*004	T	6.8	0.5	6	6.0
TAJR106*004	R	10.0	0.5	6	7.0
TAJT106*004	T	10.0	0.5	6	5.0
Voltage/Code	**6.3 volt @ 85°C (4 volt @ 125°C) / J**				
TAJR155*006	R	1.5	0.5	6	25.0
TAJS155*006	S	1.5	0.5	6	25.0
TAJR225*006	R	2.2	0.5	6	20.0
TAJS225*006	S	2.2	0.5	6	18.0
TAJR335*006	R	3.3	0.5	6	12.0
TAJS335*006	S	3.3	0.5	6	9.0
TAJS475*006	S	4.7	0.5	6	7.5
TAJT475*006	T	4.7	0.5	6	6.0
TAJT685*006	T	6.8	0.5	6	5.0
TAJR106*006	R	10.0	0.6	8	6.0
TAJT156*006	T	15.0	1.0	6	3.5
TAJW336*006	W	33.0	2.1	6	1.8
TAJW686*006	W	68.0	4.3	6	1.5
Voltage/Code	**10 volt @ 85°C (6.3 volt @ 125°C) / A**				
TAJR105*010	R	1.0	0.5	4	25.0
TAJS105*010	S	1.0	0.5	4	25.0
TAJR155*010	R	1.5	0.5	6	20.0
TAJS155*010	S	1.5	0.5	6	20.0
TAJR225*010	R	2.2	0.5	6	15.0
TAJS225*010	S	2.2	0.5	6	12.0
TAJS335*010	S	3.3	0.5	6	8.0
TAJT335*010	T	3.3	0.5	6	6.0
TAJR475*010	R	4.7	0.5	6	9.0
TAJT475*010	T	4.7	0.5	6	5.0
TAJT685*010	T	6.8	0.7	6	4.0
TAJT106*010	T	10.0	1.0	6	3.0
TAJW336*010	W	33	3.3	6	1.6
TAJY686*010	Y	68	6.8	6	0.9
TAJY107*010	Y	100	10	6	0.9
TAJY157*010	Y	150	15	6	1.2

All technical data relates to an ambient temperature of +25°C. Capacitance and DF are measured at 120Hz, 0.5V RMS with a maximum DC bias of 2.2 volts. DCL is measured at rated voltage after 5 minutes.

*Insert K for ±10% and M for ±20%.

NOTE: AVX reserves the right to supply a higher voltage rating or tighter tolerance part in the same case size, to the same reliability standards.

AVX Part No.	Case Size	Capacitance µF	DCL (µA) Max.	DF % Max.	ESR max. (Ω) @ 100 kHz
Voltage/Code	**16 volt @ 85°C (10 volt @ 125°C) / C**				
TAJR684M016	R	0.68	0.5	4	25.0
TAJS684M016	S	0.68	0.5	4	25.0
TAJR105*016	R	1.0	0.5	4	20.0
TAJS105*016	S	1.0	0.5	4	15.0
TAJT105*016	T	1.0	0.5	4	5.0
TAJS155*016	S	1.5	0.5	6	12.0
TAJT225*016	T	2.2	0.5	6	6.5
TAJT335*016	T	3.3	0.5	6	5.0
TAJW106*016	W	10.0	1.6	6	2.0
TAJW226*016	W	22.0	3.5	6	1.6
TAJW336*016	W	33.0	5.3	6	1.5
TAJY336*016	Y	33.0	5.3	6	0.9
TAJY476*016	Y	47.0	7.5	6	0.9
TAJY686*016	Y	68.0	10.9	6	0.9
TAJY107*016	Y	100.0	16.0	6	0.9
Voltage/Code	**20 volt @ 85°C (13 volt @ 125°C) / D**				
TAJR104M020	R	0.1	0.5	4	25.0
TAJS104M020	S	0.1	0.5	4	25.0
TAJR154M020	R	0.15	0.5	4	25.0
TAJS154M020	S	0.15	0.5	4	25.0
TAJR224M020	R	0.22	0.5	4	25.0
TAJS224M020	S	0.22	0.5	4	25.0
TAJR334M020	R	0.33	0.5	4	25.0
TAJS334M020	S	0.33	0.5	4	25.0
TAJR474M020	R	0.47	0.5	4	25.0
TAJS474M020	S	0.47	0.5	4	25.0
TAJR684M020	R	0.68	0.5	4	20.0
TAJS684M020	S	0.68	0.5	4	15.0
TAJT684M020	T	0.68	0.5	4	15.0
TAJR105*020	R	1.0	0.5	4	20.0
TAJS105*020	S	1.0	0.5	4	12.0
TAJT105*020	T	1.0	0.5	4	9.0
TAJT155*020	T	1.5	0.5	6	6.5
TAJT225*020	T	2.2	0.5	6	6.0
TAJW156*020	W	15.0	3.0	6	1.7
TAJW226*020	W	22.0	4.4	6	1.6
Voltage/Code	**25 volt @ 85°C (16 volt @ 125°C) / E**				
TAJY156*025	Y	15.0	3.8	6	1.0
Voltage/Code	**35 volt @ 85°C (23 volt @ 125°C) / V**				
TAJY106*035	Y	10.0	3.5	6	1.0

For parametric information on development codes, please contact your local AVX sales office.

Introduction

AVX Tantalum

APPLICATIONS

2-16 Volt	**50 Volt @ 85°C**	**2-35 Volt**
Low ESR	**33 Volt @ 125°C**	**Low ESR**
Low Profile Case	**Automotive Range**	**Low Profile Case**
0603 available	**High Reliability**	**0603 available**
Low Failure Rate	**Temperature Stability**	**Low Failure Rate**
High Volumetric Efficiency	**QS9000 Approved**	**High Volumetric Efficiency**
Temperature Stability	**Up to 150°C**	**Temperature Stability**
Stable over Time		**Stable over Time**

QUALITY STATEMENTS

AVX's focus is CUSTOMER satisfaction - customer satisfaction in the broadest sense: product quality, technical support, product availability and all at a competitive price.

In pursuance of the established goals of our corporate wide QV2000 program, it is the stated objective of AVX Tantalum to supply our customers with a world class service in the manufacturing and supplying of electronic components which will result in an adequate return on investment.

This world class service shall be defined as consistently supplying product and services of the highest quality and reliability.

This should encompass, but not be restricted to all aspects of the customer supply chain.

In addition any new or changed products, processes or services will be qualified to established standards of quality and reliability.

The objectives and guidelines listed above shall be achieved by the following codes of practice:

1. *Continual objective evaluation of customer needs and expectations for the future and the leverage of all AVX resources to meet this challenge.*

2. *By continually fostering and promoting culture of continuous improvement through ongoing training and empowered participation of employees at all levels of the company.*

3. *By Continuous Process Improvement using sound engineering principles to enhance existing equipment, material and processes. This includes the application of the science of S.P.C. focused on improving the Process Capability Index, Cpk.*

All AVX Tantalum manufacturing locations are approved to ISO9001/ISO9002 and QS9000 - Automotive Quality System Requirements.

Introduction

AVX Tantalum

AVX Paignton is the Divisional Headquarters for the Tantalum division which has manufacturing locations in Paignton in the UK, Biddeford in Maine, USA, Juarez in Mexico, Lanskroun in the Czech Republic and El Salvador.

The Division takes its name from the raw material used to make its main products, Tantalum Capacitors. Tantalum is an element extracted from ores found alongside tin and niobium deposits; the major sources of supply are Canada, Brazil and Australasia.

So for high volume tantalum capacitors with leading edge technology call us first - ***AVX your global partner***.

TECHNOLOGY TRENDS

The amount of capacitance possible in a tantalum capacitor is directly related to the type of tantalum powder used to manufacture the anode.

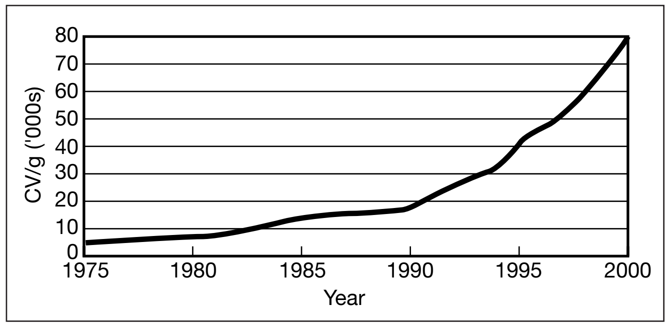
The graph following shows how the (capacitance) x (voltage) per gram (CV/g) has steadily increased over time, thus allowing the production of larger and larger capacitances with the same physical volume. CV/g is the measure used to define the volumetric efficiency of a powder, a high CV/g means a higher capacitance from the same volume.

These improvements in the powder have been achieved through close development with the material suppliers.

AVX Tantalum is committed to driving the available technology forwards as is clearly identified by the new TACmicrochip technology and the standard codes under development.

If you have any specific requirements, please contact your local AVX sales office for details on how AVX Tantalum can assist you in addressing your future requirements.

Tantalum Powder CV/gm



WORKING WITH THE CUSTOMER - ONE STOP SHOPPING

In line with our desire to become the number one supplier in the world for passive and interconnection components, AVX is constantly looking forward and innovating.

It is not good enough to market the best products; the customer must have access to a service system which suits their needs and benefits their business.

The AVX 'one stop shopping' concept is already beneficial in meeting the needs of major OEMs while worldwide partnerships with only the premier division of distributors aids the smaller user.

Helping to market the breadth and depth of our electronic component line card and support our customers are a dedicated team of commercial sales people, applications engineers and product marketing managers. Their qualifications are hopefully always appropriate to your commercial need, but as higher levels of technical expertise are required, access directly to the appropriate department is seamless and transparent.

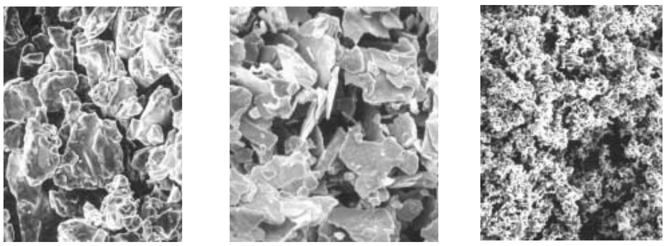
Total quality starts and finishes with our customer service, and where cost and quality are perceived as given quantities the AVX service invariably has us selected as the preferred supplier.

Facilities are equipped with instant worldwide computer and telecommunication links connected to every sales and production site worldwide. That ensures that our customers delivery requirements are consistently met wherever in the world they may be.

INTRODUCTION

Tantalum capacitors are manufactured from a powder of pure tantalum metal. The typical particle size is between 2 and 10 µm.

Figure below shows typical powders. Note the very great difference in particle size between the powder CVs.



4000µFV 20000µFV 50000µFV

Figure 1.

The powder is compressed under high pressure around a Tantalum wire (known as the Riser Wire) to form a "pellet". The riser wire is the anode connection to the capacitor.

This is subsequently vacuum sintered at high temperature (typically 1400 - 1800°C). This helps to drive off any impurities within the powder by migration to the surface.

During sintering the powder becomes a sponge like structure with all the particles interconnected in a huge lattice.

This structure is of high mechanical strength and density, but is also highly porous giving a large internal surface area (see Figure 2).

The larger the surface area the larger the capacitance. Thus high CV (capacitance/voltage product) powders, which have a low average particle size, are used for low voltage, high capacitance parts.

By choosing which powder is used to produce each capacitance/voltage rating the surface area can be controlled.

The following example uses a 220µF 10V capacitor to illustrate the point.

$$C = \frac{\varepsilon_0 \varepsilon_r A}{d}$$

where ε_0 is the dielectric constant of free space (8.855 x 10^{-12} Farads/m)

ε_r is the relative dielectric constant for Tantalum Pentoxide (27)

d is the dielectric thickness in meters

C is the capacitance in Farads

and A is the surface area in meters

Rearranging this equation gives:

$$A = \frac{Cd}{\varepsilon_0 \varepsilon_r}$$

thus for a 220µF 10V capacitor the surface area is 550 square centimeters, or nearly twice the size of this page.

The dielectric is then formed over all the tantalum surfaces by the electrochemical process of anodization. To achieve this, the "pellet" is dipped into a very weak solution of phosphoric acid.

The dielectric thickness is controlled by the voltage applied during the forming process. Initially the power supply is kept in a constant current mode until the correct thickness of dielectric has been reached (that is the voltage reaches the 'forming voltage'), it then switches to constant voltage mode and the current decays to close to zero.

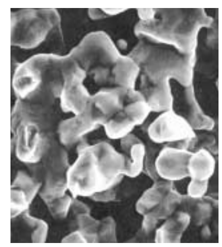


Figure 2. Sintered Tantalum

The chemical equations describing the process are as follows:

Anode: $2\,Ta \rightarrow 2\,Ta^{5+} + 10\,e$

$2\,Ta^{5+} + 10\,OH^{-} \rightarrow Ta_2O_5 + 5\,H_2O$

Cathode: $10\,H_2O - 10\,e \rightarrow 5H_2 \uparrow + 10\,OH^{-}$

The oxide forms on the surface of the Tantalum but it also grows into the metal. For each unit of oxide two thirds grows out and one third grows in. It is for this reason that there is a limit on the maximum voltage rating of Tantalum capacitors with present technology powders (see Figure 3).

The dielectric operates under high electrical stress. Consider a 220µF 10V part:

Formation voltage = Formation Ratio x Working Voltage
= 3.5 x 10
= 35 Volts

The pentoxide (Ta_2O_5) dielectric grows at a rate of 1.7 x 10^{-9} m/V

Dielectric thickness (d)	=	35 x 1.7 x 10^{-9}
	=	0.06 µm
Electric Field strength	=	Working Voltage / d
	=	167 KV/mm

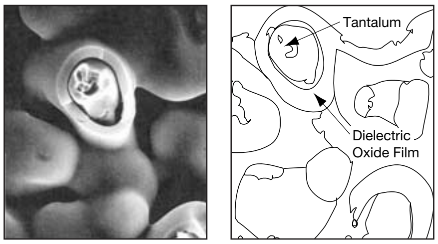


Figure 3. Dielectric Layer

The next stage is the production of the cathode plate. This is achieved by pyrolysis of Manganese Nitrate into Manganese Dioxide.

The "pellet" is dipped into an aqueous solution of nitrate and then baked in an oven at approximately 250°C to produce the dioxide coat. The chemical equation is:

$$Mn\,(NO_3)_2 \rightarrow Mn\,O_2 + 2NO_2\uparrow$$

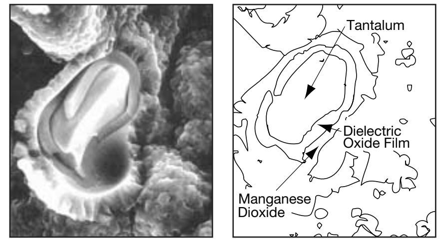


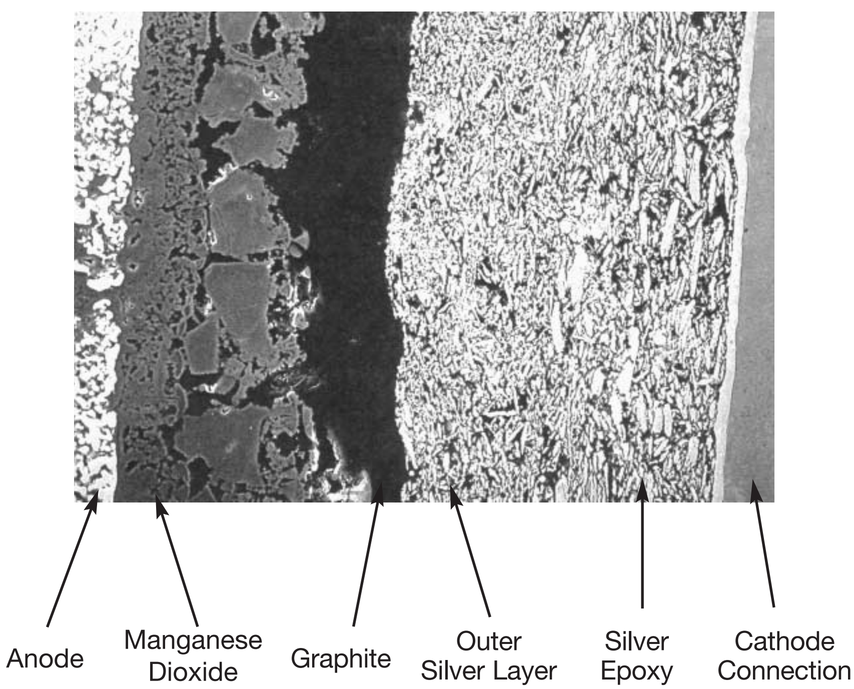
Figure 4. Manganese Dioxide Layer

This process is repeated several times through varying specific densities of nitrate to build up a thick coat over all internal and external surfaces of the "pellet", as shown in Figure 4.

The "pellet" is then dipped into graphite and silver to provide a good connection to the Manganese Dioxide cathode plate. Electrical contact is established by deposition of carbon onto the surface of the cathode. The carbon is then coated with a conductive material to facilitate connection to the cathode termination (see Figure 5). Packaging is carried out to meet individual specifications and customer requirements. This manufacturing technique is adhered to for the whole range of AVX tantalum capacitors, which can be sub-divided into four basic groups: Chip / Resin dipped / Rectangular boxed / Axial.

Further information on the production of Tantalum Capacitors can be obtained from the technical paper "Basic Tantalum Technology", by John Gill, available from your local AVX representative.

Figure 5.



Technical Summary and Application Guidelines

SECTION 1
ELECTRICAL CHARACTERISTICS AND EXPLANATION OF TERMS

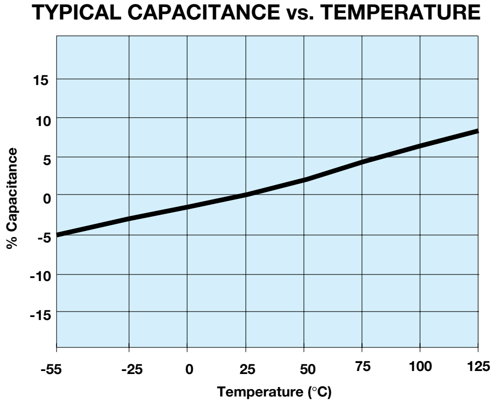
1.1 CAPACITANCE

1.1.1 Rated capacitance (C_R).
This is the nominal rated capacitance. For tantalum capacitors it is measured as the capacitance of the equivalent series circuit at 20°C using a measuring bridge supplied by a 0.5Vpk-pk 120Hz sinusoidal signal, free of harmonics with a maximum bias of 2.2Vd.c.

1.1.2 Capacitance tolerance.
This is the permissible variation of the actual value of the capacitance from the rated value. For additional reading, please consult the AVX technical publication “Capacitance Tolerances for Solid Tantalum Capacitors”.

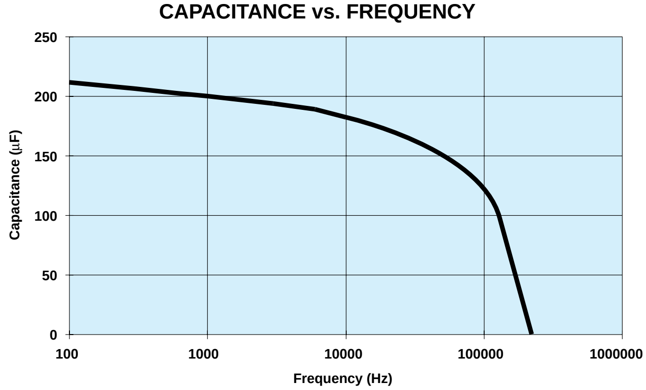
1.1.3 Temperature dependence of capacitance.
The capacitance of a tantalum capacitor varies with temperature. This variation itself is dependent to a small extent on the rated voltage and capacitor size.

TYPICAL CAPACITANCE vs. TEMPERATURE



1.1.4 Frequency dependence of the capacitance.
The effective capacitance decreases as frequency increases. Beyond 100KHz the capacitance continues to drop until resonance is reached (typically between 0.5 - 5MHz depending on the rating). Beyond the resonant frequency the device becomes inductive.

TAJE227K010
CAPACITANCE vs. FREQUENCY

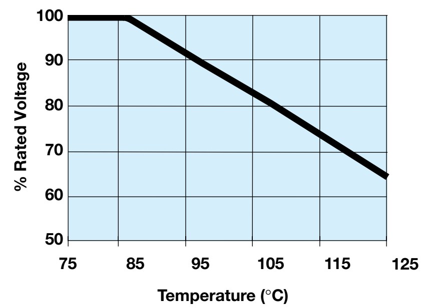


1.2 VOLTAGE

1.2.1 Rated d.c. voltage (V_R)
This is the rated d.c. voltage for continuous operation at 85°C.

1.2.2 Category voltage (V_C)
This is the maximum voltage that may be applied continuously to a capacitor. It is equal to the rated voltage up to +85°C, beyond which it is subject to a linear derating, to 2/3 V_R at 125°C.

MAXIMUM CATEGORY VOLTAGE vs. TEMPERATURE



1.2.3 Surge voltage (V_S)
This is the highest voltage that may be applied to a capacitor for short periods of time in circuits with minimum series resistance of 1Kohm. The surge voltage may be applied up to 10 times in an hour for periods of up to 30 seconds at a time. The surge voltage must not be used as a parameter in the design of circuits in which, in the normal course of operation, the capacitor is periodically charged and discharged.

85°C		125°C	
Rated Voltage (Vdc.)	Surge Voltage (Vdc.)	Category Voltage (Vdc.)	Surge Voltage (Vdc.)
4	5.2	2.7	3.2
6.3	8	4	5
10	13	7.0	8
16	20	10	12
20	26	13	16
25	32	17	20
35	46	23	28
50	65	33	40

1.2.4 Effect of surges
The solid Tantalum capacitor has a limited ability to withstand voltage and current surges. This is in common with all other electrolytic capacitors and is due to the fact that they operate under very high electrical stress across the dielectric. For example a 25 volt capacitor has an Electrical Field of 147 KV/mm when operated at rated voltage.

It is important to ensure that the voltage across the terminals of the capacitor never exceeds the specified surge voltage rating.

Solid tantalum capacitors have a self healing ability provided by the Manganese Dioxide semiconducting layer used as the negative plate. However, this is limited in low impedance applications.

In the case of low impedance circuits, the capacitor is likely to be stressed by current surges. Derating the capacitor by 50% or more increases the reliability of the component. (See Figure 2 page 45). The "AVX Recommended Derating Table" (page 46) summarizes voltage rating for use on common voltage rails, in low impedance applications.

In circuits which undergo rapid charge or discharge a protective resistor of 1Ω/V is recommended. If this is impossible, a derating factor of up to 70% should be used.

In such situations a higher voltage may be needed than is available as a single capacitor. A series combination should be used to increase the working voltage of the equivalent capacitor: For example two 22μF 25V parts in series is equivalent to one 11μF 50V part. For further details refer to J.A. Gill's paper "Investigation into the effects of connecting Tantalum capacitors in series", available from AVX offices worldwide.

NOTE:
While testing a circuit (e.g. at ICT or functional) it is likely that the capacitors will be subjected to large voltage and current transients, which will not be seen in normal use. These conditions should be borne in mind when considering the capacitor's rated voltage for use. These can be controlled by ensuring a correct test resistance is used.

1.2.5 Reverse voltage and Non-Polar operation.

The values quoted are the maximum levels of reverse voltage which should appear on the capacitors at any time. These limits are based on the assumption that the capacitors are polarized in the correct direction for the majority of their working life. They are intended to cover short term reversals of polarity such as those occurring during switching transients of during a minor portion of an impressed waveform. Continuous application of reverse voltage without normal polarization will result in a degradation of leakage current. In conditions under which continuous application of a reverse voltage could occur two similar capacitors should be used in a back-to-back configuration with the negative terminations connected together. Under most conditions this combination will have a capacitance one half of the nominal capacitance of either capacitor. Under conditions of isolated pulses or during the first few cycles, the capacitance may approach the full nominal value.

The reverse voltage ratings are designed to cover exceptional conditions of small level excursions into incorrect polarity. The values quoted are not intended to cover continuous reverse operation.

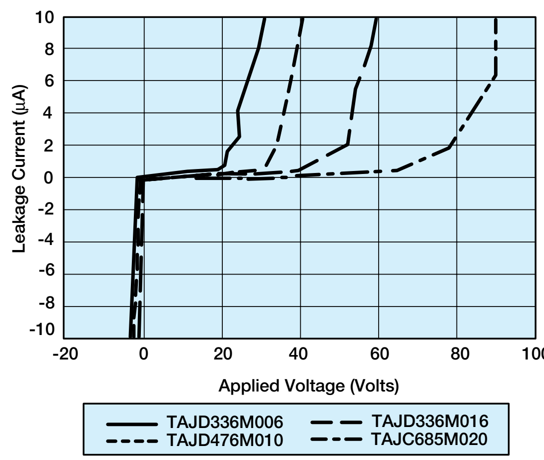
The peak reverse voltage applied to the capacitor must not exceed:

10% of the rated d.c. working voltage to a maximum of 1.0v at 25°C

3% of the rated d.c. working voltage to a maximum of 0.5v at 85°C

1% of the category d.c. working voltage to a maximum of 0.1v at 125°C

LEAKAGE CURRENT vs. BIAS VOLTAGE



1.2.6 Superimposed A.C. Voltage (Vr.m.s.) - Ripple Voltage.

This is the maximum r.m.s. alternating voltage; superimposed on a d.c. voltage, that may be applied to a capacitor. The sum of the d.c. voltage and peak value of the super-imposed a.c. voltage must not exceed the category voltage, Vc.

Full details are given in Section 2.

1.2.7 Forming voltage.

This is the voltage at which the anode oxide is formed. The thickness of this oxide layer is proportional to the formation voltage for a tantalum capacitor and is a factor in setting the rated voltage.

1.3 DISSIPATION FACTOR AND TANGENT OF LOSS ANGLE (TAN δ)

1.3.1 Dissipation factor (D.F.).

Dissipation factor is the measurement of the tangent of the loss angle (tan δ) expressed as a percentage. The measurement of DF is carried out using a measuring bridge which supplies a 0.5Vpk-pk 120Hz sinusoidal signal, free of harmonics with a maximum bias of 2.2Vdc. The value of DF is temperature and frequency dependent.

Note: For surface mounted products the maximum allowed DF values are indicated in the ratings table and it is important to note that these are the limits met by the component AFTER soldering onto the substrate.

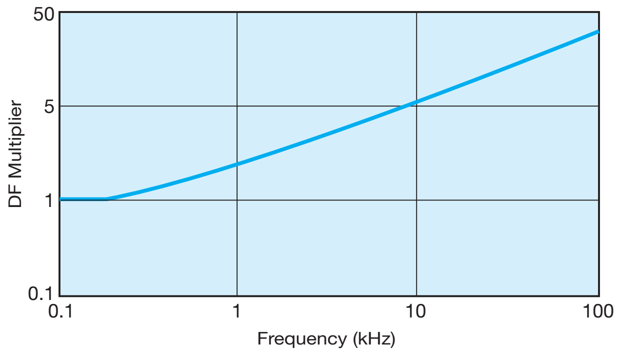
1.3.2 Tangent of Loss Angle (tan δ).

This is a measurement of the energy loss in the capacitor. It is expressed as tan δ and is the power loss of the capacitor divided by its reactive power at a sinusoidal voltage of specified frequency. Terms also used are power factor, loss factor and dielectric loss. Cos (90 - δ) is the true power factor. The measurement of tan δ is carried out using a measuring bridge which supplies a 0.5Vpk-pk 120Hz sinusoidal signal, free of harmonics with a maximum bias of 2.2Vdc.

1.3.3 Frequency dependence of Dissipation Factor.

Dissipation Factor increases with frequency as shown in the typical curves:

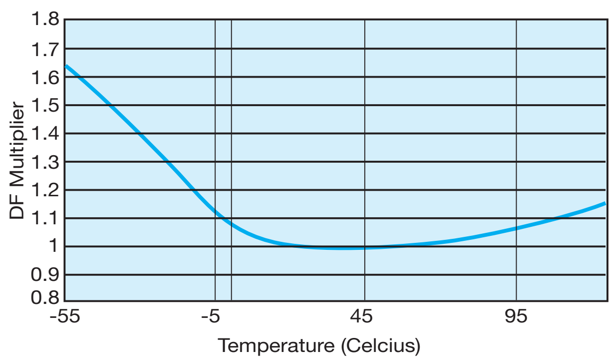
Typical DF vs Frequency



1.3.4 Temperature dependence of Dissipation Factor.

Dissipation factor varies with temperature as the typical curves show. For maximum limits please refer to ratings tables.

Typical DF vs Temperature



1.4 IMPEDANCE, (Z) AND EQUIVALENT SERIES RESISTANCE (ESR)

1.4.1 Impedance, Z.

This is the ratio of voltage to current at a specified frequency. Three factors contribute to the impedance of a tantalum capacitor; the resistance of the semiconductor layer; the capacitance value and the inductance of the electrodes and leads.

At high frequencies the inductance of the leads becomes a limiting factor. The temperature and frequency behavior of these three factors of impedance determine the behavior of the impedance Z. The impedance is measured at 20°C and 100kHz.

1.4.2 Equivalent Series Resistance, ESR.

Resistance losses occur in all practical forms of capacitors. These are made up from several different mechanisms, including resistance in components and contacts, viscous forces within the dielectric and defects producing bypass current paths. To express the effect of these losses they are considered as the ESR of the capacitor. The ESR is frequency dependent and can be found by using the relationship;

$$ESR = \frac{\tan \delta}{2\pi fC}$$

Where f is the frequency in Hz, and C is the capacitance in farads.

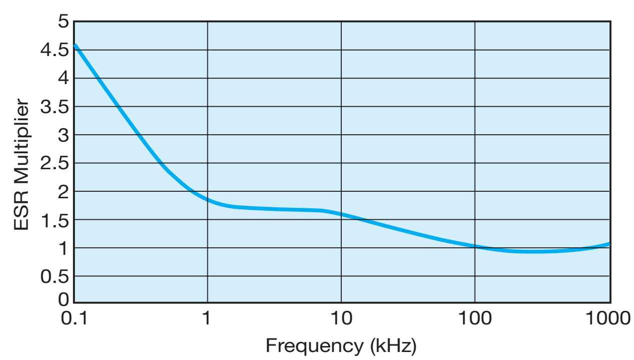
The ESR is measured at 20°C and 100kHz.

ESR is one of the contributing factors to impedance, and at high frequencies (100kHz and above) it becomes the dominant factor. Thus ESR and impedance become almost identical, impedance being only marginally higher.

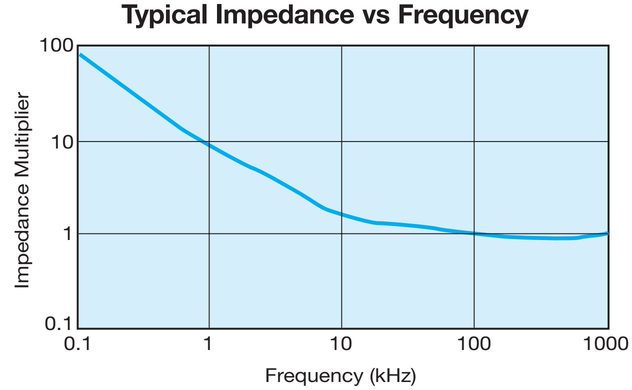
1.4.3 Frequency dependence of Impedance and ESR.

ESR and Impedance both increase with decreasing frequency. At lower frequencies the values diverge as the extra contributions to impedance (due to the reactance of the capacitor) become more significant. Beyond 1MHz (and beyond the resonant point of the capacitor) impedance again increases due to the inductance of the capacitor.

Typical ESR vs Frequency



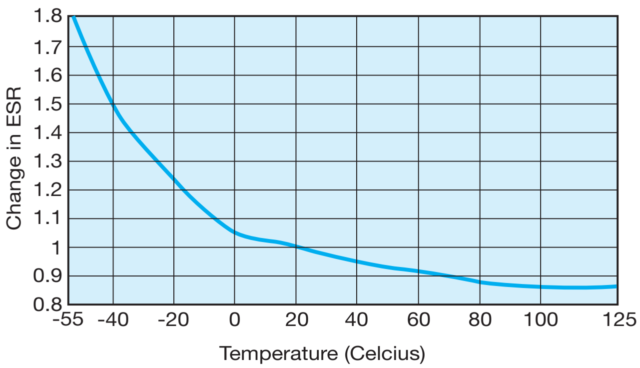
Typical Impedance vs Frequency



1.4.4 Temperature dependence of the Impedance and ESR.

At 100kHz, impedance and ESR behave identically and decrease with increasing temperature as the typical curves show.

Typical 100kHz ESR vs Temperature



1.5 D.C. LEAKAGE CURRENT

1.5.1 Leakage current.

The leakage current is dependent on the voltage applied, the elapsed time since the voltage was applied and the component temperature. It is measured at +20°C with the rated voltage applied. A protective resistance of 1000Ω is connected in series with the capacitor in the measuring circuit. Three to five minutes after application of the rated voltage the leakage current must not exceed the maximum values indicated in the ratings table. These are based on the formulae 0.01CV or 0.5µA (whichever is the greater).

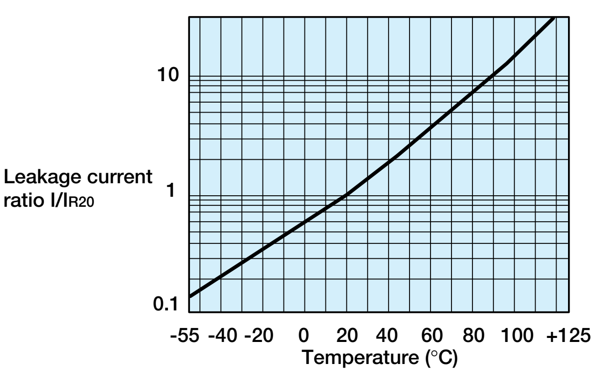
Reforming of tantalum capacitors is unnecessary even after prolonged storage periods without the application of voltage.

1.5.2 Temperature dependence of the leakage current.

The leakage current increases with higher temperatures, typical values are shown in the graph. For operation between 85°C and 125°C, the maximum working voltage must be derated and can be found from the following formula.

$$V_{max} = \left(1 - \frac{(T - 85)}{125}\right) \times V_R$$ volts, where T is the required operating temperature.

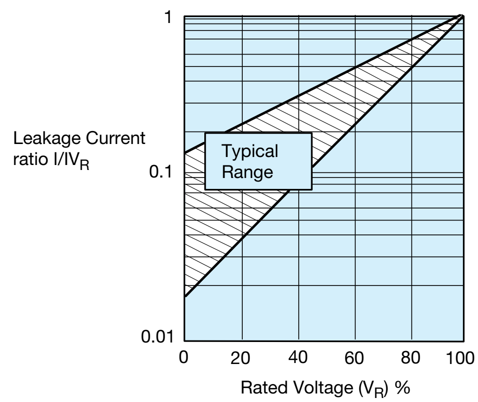
LEAKAGE CURRENT vs. TEMPERATURE



1.5.3 Voltage dependence of the leakage current.

The leakage current drops rapidly below the value corresponding to the rated voltage V_R when reduced voltages are applied. The effect of voltage derating on the leakage current is shown in the graph. This will also give a significant increase in the reliability for any application. See Section 3.1 for details.

LEAKAGE CURRENT vs. RATED VOLTAGE



For additional information on Leakage Current, please consult the AVX technical publication “Analysis of Solid Tantalum Capacitor Leakage Current” by R. W. Franklin.

1.5.4 Ripple current.

The maximum ripple current allowed is derived from the power dissipation limits for a given temperature rise above ambient temperature (please refer to Section 2).

SECTION 2
A.C. OPERATION, RIPPLE VOLTAGE AND RIPPLE CURRENT

2.1 RIPPLE RATINGS (A.C.)

In an a.c. application heat is generated within the capacitor by both the a.c. component of the signal (which will depend upon the signal form, amplitude and frequency), and by the d.c. leakage. For practical purposes the second factor is insignificant. The actual power dissipated in the capacitor is calculated using the formula:

$$P = I^2 R$$

and rearranged to $I = \sqrt{(P/R)}$ .....(Eq. 1)

and substituting $P = \frac{E^2 R}{Z^2}$

where
I = rms ripple current, amperes
R = equivalent series resistance, ohms
E = rms ripple voltage, volts
P = power dissipated, watts
Z = impedance, ohms, at frequency under consideration

Maximum a.c. ripple voltage (E_{max}).

From the previous equation:

$$E_{max} = Z \sqrt{(P/R)}$$ .....(Eq. 2)

Where P is the maximum permissible power dissipated as listed for the product under consideration (see tables). However care must be taken to ensure that:

1. The d.c. working voltage of the capacitor must not be exceeded by the sum of the positive peak of the applied a.c. voltage and the d.c. bias voltage.

2. The sum of the applied d.c. bias voltage and the negative peak of the a.c. voltage must not allow a voltage reversal in excess of the "Reverse Voltage".

Historical ripple calculations.
Previous ripple current and voltage values were calculated using an empirically derived power dissipation required to give a 10°C rise of the capacitors body temperature from room temperature, usually in free air. These values are shown in Table I. Equation 1 then allows the maximum ripple current to be established, and Equation 2, the maximum ripple voltage. But as has been shown in the AVX article on thermal management by I. Salisbury, the thermal conductivity of a Tantalum chip capacitor varies considerably depending upon how it is mounted.

Table I: Power Dissipation Ratings (In Free Air)

TAJ/TPS/CWR11/THJ Series Molded Chip

Case size	Max. power dissipation (W)
A	0.075
B	0.085
C	0.110
D	0.150
E	0.165
R	0.055
S	0.065
T	0.080
V	0.250
W	0.090
Y	0.125

TAZ/CWR09 Series Molded Chip

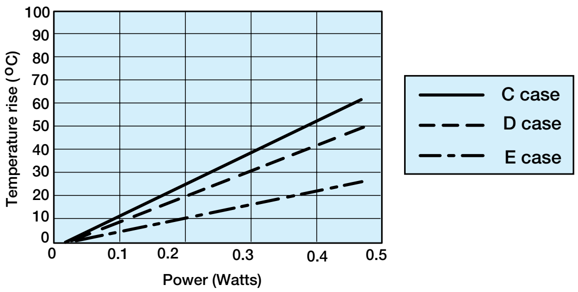
Case size	Max. power dissipation (W)
A	0.050
B	0.070
C	0.075
D	0.080
E	0.090
F	0.100
G	0.125
H	0.150

TAJ/TPS/CWR11/THJ TAZ/CWR09 Series Molded Chip

Temperature correction factor for ripple current	
Temp. °C	Factor
+25	1.0
+55	0.95
+85	0.90
+125	0.40

A piece of equipment was designed which would pass sine and square wave currents of varying amplitudes through a biased capacitor. The temperature rise seen on the body for the capacitor was then measured using an infra-red probe. This ensured that there was no heat loss through any thermocouple attached to the capacitor's surface.

Results for the C, D and E case sizes



Several capacitors were tested and the combined results are shown above. All these capacitors were measured on FR4 board, with no other heatsinking. The ripple was supplied at various frequencies from 1KHz to 1MHz.

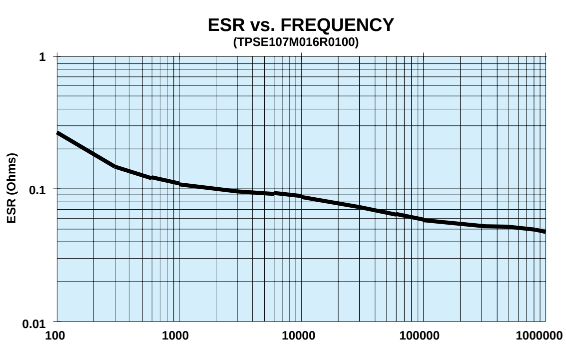
As can be seen in the figure above, the average P_{max} value for the C case capacitors was 0.11 Watts. This is the same as that quoted in Table I.

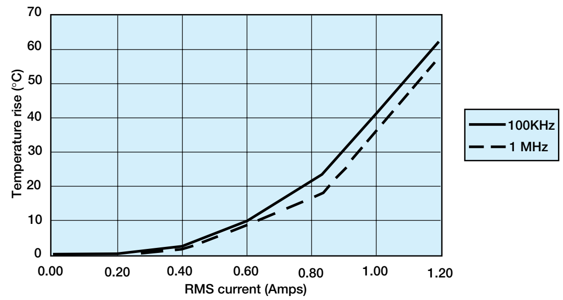
The D case capacitors gave an average P_{max} value 0.125 Watts. This is lower than the value quoted in the Table I by 0.025 Watts.

The E case capacitors gave an average P_{max} of 0.200 Watts which was much higher than the 0.165 Watts from Table I.

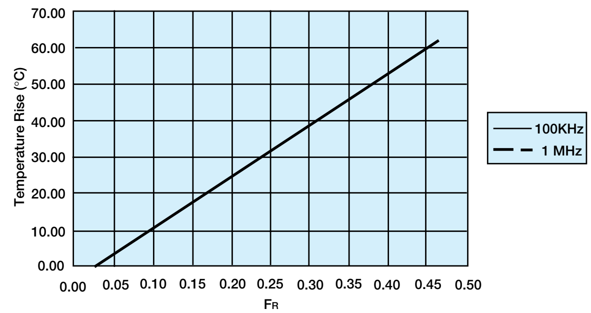
If a typical capacitor's ESR with frequency is considered, e.g. figure below, it can be seen that there is variation. Thus for a set ripple current, the amount of power to be dissipated by the capacitor will vary with frequency. This is clearly shown in figure in top of next column, which shows that the surface temperature of the unit rises less for a given value of ripple current at 1MHz than at 100KHz.

The graph below shows a typical ESR variation with frequency. Typical ripple current versus temperature rise for 100KHz and 1MHz sine wave inputs.





If I^2R is then plotted it can be seen that the two lines are in fact coincident, as shown in figure below.



Example

A Tantalum capacitor is being used in a filtering application, where it will be required to handle a 2 Amp peak-to-peak, 200KHz square wave current.

A square wave is the sum of an infinite series of sine waves at all the odd harmonics of the square waves fundamental frequency. The equation which relates is:

$$I_{Square} = I_{pk}\sin(2\pi f) + I_{pk}\sin(6\pi f) + I_{pk}\sin(10\pi f) + I_{pk}\sin(14\pi f) + \ldots$$

Thus the special components are:

Frequency	Peak-to-peak current (Amps)	RMS current (Amps)
200 KHz	2.000	0.707
600 KHz	0.667	0.236
1 MHz	0.400	0.141
1.4 MHz	0.286	0.101

Let us assume the capacitor is a TAJD686M006
Typical ESR measurements would yield.

Frequency	Typical ESR (Ohms)	Power (Watts) I_{rms}^2 x ESR
200 KHz	0.120	0.060
600 KHz	0.115	0.006
1 MHz	0.090	0.002
1.4 MHz	0.100	0.001

Thus the total power dissipation would be 0.069 Watts.

From the D case results shown in figure top of previous column, it can be seen that this power would cause the capacitors surface temperature to rise by about 5°C. For additional information, please refer to the AVX technical publication "Ripple Rating of Tantalum Chip Capacitors" by R.W. Franklin.

2.2 Thermal Management

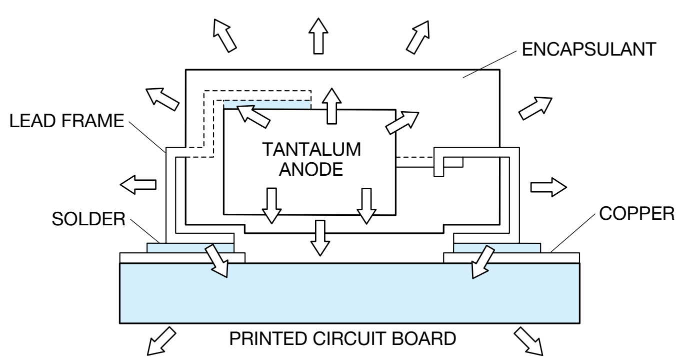
The heat generated inside a tantalum capacitor in a.c. operation comes from the power dissipation due to ripple current. It is equal to I^2R, where I is the rms value of the current at a given frequency, and R is the ESR at the same frequency with an additional contribution due to the leakage current. The heat will be transferred from the outer surface by conduction. How efficiently it is transferred from this point is dependent on the thermal management of the board.

The power dissipation ratings given in Section 2.1 are based on free-air calculations. These ratings can be approached if efficient heat sinking and/or forced cooling is used.

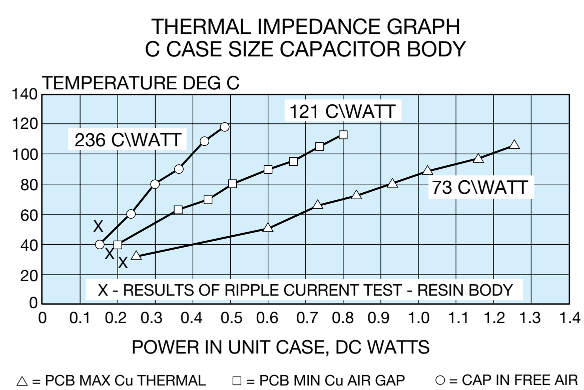
In practice, in a high density assembly with no specific thermal management, the power dissipation required to give a 10°C rise above ambient may be up to a factor of 10 less. In these cases, the actual capacitor temperature should be established (either by thermocouple probe or infra-red scanner) and if it is seen to be above this limit it may be necessary to specify a lower ESR part or a higher voltage rating.

Please contact application engineering for details or contact the AVX technical publication entitled "Thermal Management of Surface Mounted Tantalum Capacitors" by Ian Salisbury.

Thermal Dissipation from the Mounted Chip



Thermal Impedance Graph with Ripple Current

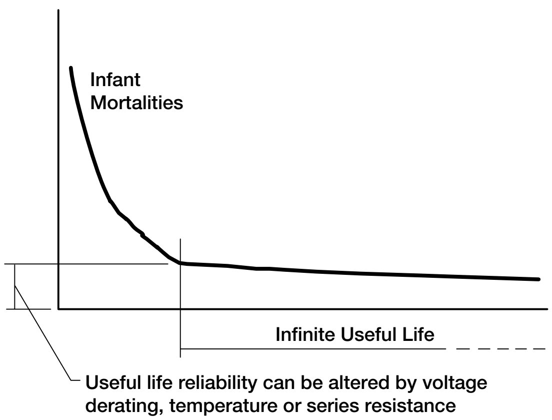


SECTION 3
RELIABILITY AND CALCULATION OF FAILURE RATE

3.1 STEADY-STATE

Tantalum Dielectric has essentially no wear out mechanism and in certain circumstances is capable of limited self healing. However, random failures can occur in operation. The failure rate of Tantalum capacitors will decrease with time and not increase as with other electrolytic capacitors and other electronic components.

Figure 1. Tantalum Reliability Curve



The useful life reliability of the Tantalum capacitor is affected by three factors. The equation from which the failure rate can be calculated is:

F = FU x FT x FR x FB

where FU is a correction factor due to operating voltage/voltage derating
FT is a correction factor due to operating temperature
FR is a correction factor due to circuit series resistance
FB is the basic failure rate level. For standard Tantalum product this is 1%/1000 hours

Base failure rate.
Standard tantalum product conforms to Level M reliability (i.e., 1%/1000 hrs.) at rated voltage, rated temperature, and 0.1Ω/volt circuit impedance. This is known as the base failure rate, FB, which is used for calculating operating reliability. The effect of varying the operating conditions on failure rate is shown on this page.

Operating voltage/voltage derating.
If a capacitor with a higher voltage rating than the maximum line voltage is used, then the operating reliability will be improved. This is known as voltage derating.

The graph, Figure 2a, shows the relationship between voltage derating (the ratio between applied and rated voltage) and the failure rate. The graph gives the correction factor FU for any operating voltage.

Figure 2a. Correction factor to failure rate F for voltage derating of a typical component (60% con. level).

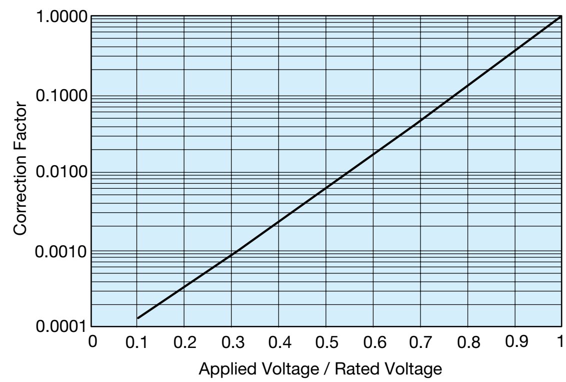


Figure 2b. Gives our recommendation for voltage derating to be used in typical applications.

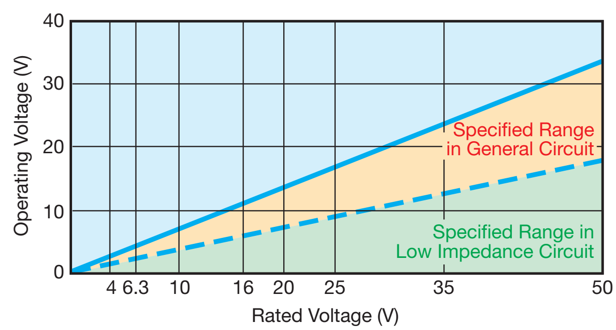
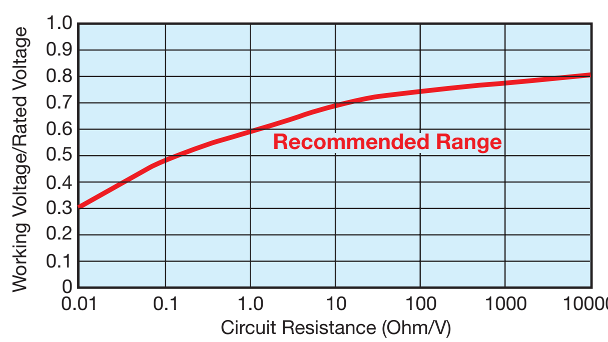


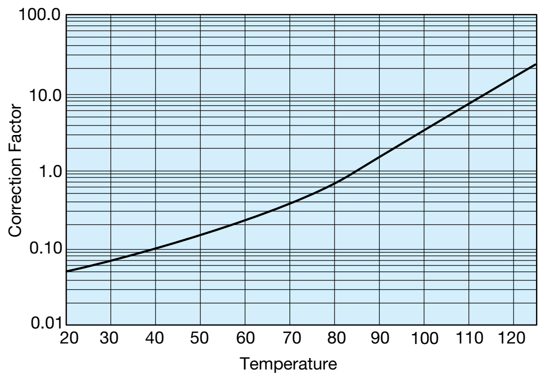
Figure 2c. Gives voltage derating recommendations as a function of circuit impedance.



Operating Temperature.

If the operating temperature is below the rated temperature for the capacitor then the operating reliability will be improved as shown in Figure 3. This graph gives a correction factor FT for any temperature of operation.

Figure 3: Correction factor to failure rate F for ambient temperature T for typical component (60% con. level).



Circuit Impedance.

All solid tantalum capacitors require current limiting resistance to protect the dielectric from surges. A series resistor is recommended for this purpose. A lower circuit impedance may cause an increase in failure rate, especially at temperatures higher than 20°C. An inductive low impedance circuit may apply voltage surges to the capacitor and similarly a non-inductive circuit may apply current surges to the capacitor, causing localized over-heating and failure. The recommended impedance is 1 Ω per volt. Where this is not feasible, equivalent voltage derating should be used (See MIL HANDBOOK 217E). The graph, Figure 4, shows the correction factor, FR, for increasing series resistance.

Figure 4. Correction factor to failure rate F for series resistance R on basic failure rate FB for a typical component (60% con. level).

Circuit resistance ohms/volt	FR
3.0	0.07
2.0	0.1
1.0	0.2
0.8	0.3
0.6	0.4
0.4	0.6
0.2	0.8
0.1	1.0

For circuit impedances below 0.1 ohms per volt, or for any mission critical application, circuit protection should be considered. An ideal solution would be to employ an AVX SMT thin-film fuse in series.

Example calculation

Consider a 12 volt power line. The designer needs about 10μF of capacitance to act as a decoupling capacitor near a video bandwidth amplifier. Thus the circuit impedance will be limited only by the output impedance of the board's power unit and the track resistance. Let us assume it to be about 2 Ohms minimum, i.e. 0.167 Ohms/Volt. The operating temperature range is -25°C to +85°C. If a 10μF 16 Volt capacitor was designed in the operating failure rate would be as follows.

a) FT = 1.0 @ 85°C
b) FR = 0.85 @ 0.167 Ohms/Volt
c) FU = 0.08 @ applied voltage/rated voltage = 75%
d) FB = 1%/1000 hours, basic failure rate level

Thus F = 1.0 x 0.85 x 0.08 x 1 = 0.068%/1000 Hours

If the capacitor was changed for a 20 volt capacitor, the operating failure rate will change as shown.

FU = 0.018 @ applied voltage/rated voltage = 60%
F = 1.0 x 0.85 x 0.018 x 1 = 0.0153%/1000 Hours

3.2 Dynamic.

As stated in Section 1.2.4, the solid Tantalum capacitor has a limited ability to withstand voltage and current surges. Such current surges can cause a capacitor to fail. The expected failure rate cannot be calculated by a simple formula as in the case of steady-state reliability. The two parameters under the control of the circuit design engineer known to reduce the incidence of failures are derating and series resistance.

The table below summarizes the results of trials carried out at AVX with a piece of equipment which has very low series resistance with no voltage derating applied. That is the capacitor was tested at its rated voltage.

Results of production scale derating experiment

Capacitance and Voltage	Number of units tested	50% derating applied	No derating applied
47μF 16V	1,547,587	0.03%	1.1%
100μF 10V	632,876	0.01%	0.5%
22μF 25V	2,256,258	0.05%	0.3%

As can clearly be seen from the results of this experiment, the more derating applied by the user, the less likely the probability of a surge failure occurring.

It must be remembered that these results were derived from a highly accelerated surge test machine, and failure rates in the low ppm are more likely with the end customer.

A commonly held misconception is that the leakage current of a Tantalum capacitor can predict the number of failures which will be seen on a surge screen. This can be disproved by the results of an experiment carried out at AVX on 47μF 10V surface mount capacitors with different leakage currents. The results are summarized in the table on the following page.

Leakage current vs number of surge failures

	Number tested	Number failed surge
Standard leakage range 0.1 µA to 1µA	10,000	25
Over Catalog limit 5µA to 50µA	10,000	26
Classified Short Circuit 50µA to 500µA	10,000	25

Again, it must be remembered that these results were derived from a highly accelerated surge test machine, and failure rates in the low ppm are more likely with the end customer.

AVX recommended derating table

Voltage Rail	Working Cap Voltage
3.3	6.3
5	10
10	20
12	25
15	35
≥24	Series Combinations (11)

For further details on surge in Tantalum capacitors refer to J.A. Gill's paper "Surge in solid Tantalum capacitors", available from AVX offices worldwide.

An added bonus of increasing the derating applied in a circuit, to improve the ability of the capacitor to withstand surge conditions, is that the steady-state reliability is improved by up to an order. Consider the example of a 6.3 volt capacitor being used on a 5 volt rail.

The steady-state reliability of a Tantalum capacitor is affected by three parameters; temperature, series resistance and voltage derating. Assume 40°C operation and 0.1 Ohms/Volt series resistance.

The capacitors reliability will therefore be:

Failure rate = F_U x F_T x F_R x 1%/1000 hours
= 0.15 x 0.1 x 1 x 1%/1000 hours
= 0.015%/1000 hours

If a 10 volt capacitor was used instead, the new scaling factor would be 0.006, thus the steady-state reliability would be:

Failure rate = F_U x F_T x F_R x 1%/1000 hours
= 0.006 x 0.1 x 1 x 1%/1000 hours
= 6 x 10^{-4} %/1000 hours

SECTION 4
APPLICATION GUIDELINES FOR TANTALUM CAPACITORS

So there is an order improvement in the capacitors steady-state reliability.

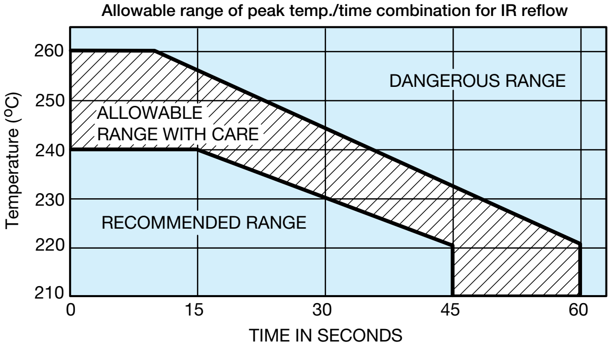
Soldering Conditions and Board Attachment.
The soldering temperature and time should be the minimum for a good connection.

A suitable combination for wavesoldering is 230 - 250°C for 3 - 5 seconds.

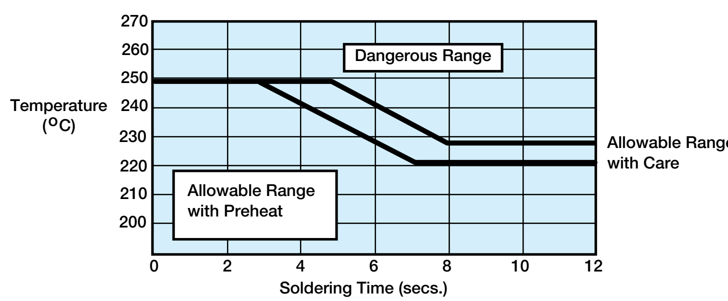
For vapor phase or infra-red reflow soldering the profile below shows allowable and dangerous time/temperature combinations. The profile refers to the peak reflow temperature and is designed to ensure that the temperature of the internal construction of the capacitor does not exceed 220°C. Preheat conditions vary according to the reflow system used, maximum time and temperature would be 10 minutes at 150°C. Small parametric shifts may be noted immediately after reflow, components should be allowed to stabilize at room temperature prior to electrical testing.

Both TAJ and TAZ series are designed for reflow and wave soldering operations. In addition TAZ is available with gold terminations compatible with conductive epoxy or gold wire bonding for hybrid assemblies.

Allowable range of peak temp./time combination for IR reflow



Allowable range of peak temp./time combination for wave soldering



Under the CECC 00 802 International Specification, AVX Tantalum capacitors are a Class A component.

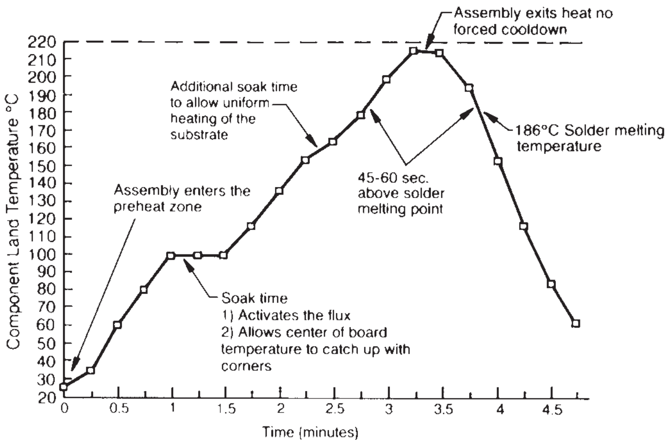
The capacitors can therefore be subjected to one IR reflow, one wave solder and one soldering iron cycle.

If more aggressive mounting techniques are to be used please consult AVX Tantalum for guidance.

SECTION 4
APPLICATION GUIDELINES FOR TANTALUM CAPACITORS

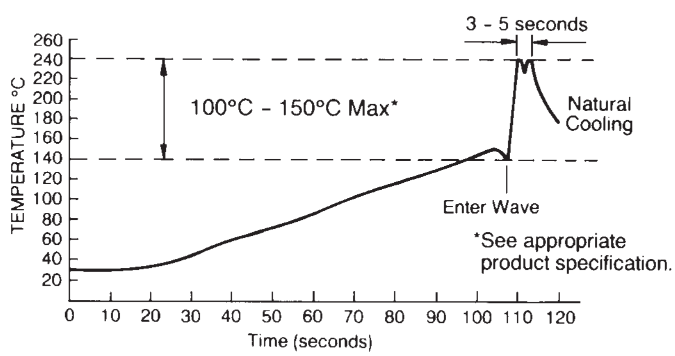
Recommended soldering profiles for surface mounting of tantalum capacitors is provided in figure below.

IR REFLOW



Recommended Ramp Rate Less than 2°C/sec.

WAVE SOLDERING



LEAD FREE PROGRAM

AVX will implement a change to the termination finish on its TAJ, THJ and TPS series surface mount tantalum capacitors effective January 1, 2001.

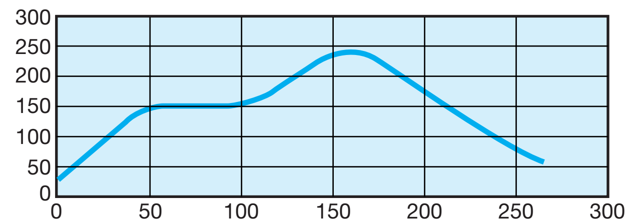
After that date all products manufactured will utilize lead free terminations.

The termination is compatible with the following lead free solder pastes; SnCu, SnCuAg and SnCuAgBi.

It is also compatible with existing SnPb solder pastes / systems in use today.

The recommended IR reflow profile is shown below.

LEAD FREE REFLOW PROFILE



- Pre-heating: 150 ±15C / 60-90s
- Max. Peak Gradient 2.5C/s
- Peak Temperature: 240 ±5C
- Time at >230C: 40s Max.

The following should be noted by customers changing from lead based systems to the new lead free pastes.

a) The visual standards used for evaluation of solder joints will need to be modified as lead free joints are not as bright as with tin-lead pastes and the fillet may not be as large.

b) Resin color may darken slightly due to the increase in temperature required for the new pastes.

c) Lead free solder pastes do not allow the same self alignment as lead containing systems. Standard mounting pads are acceptable, but machine set up may need to be modified.

SECTION 5
MECHANICAL AND THERMAL PROPERTIES OF CAPACITORS

5.1 Acceleration
98.1m/s^2 (10g)

5.2 Vibration Severity
10 to 2000Hz, 0.75mm of 98.1m/s^2 (10g)

5.3 Shock
Trapezoidal Pulse, 98.1m/s^2 for 6ms.

5.4 Adhesion to Substrate
IEC 384-3. minimum of 5N.

5.5 Resistance to Substrate Bending
The component has compliant leads which reduces the risk of stress on the capacitor due to substrate bending.

5.6 Soldering Conditions
Dip soldering is permissible provided the solder bath temperature is ≤ 270°C, the solder time < 3 seconds and the circuit board thickness ≥ 1.0mm.

5.7 Installation Instructions
The upper temperature limit (maximum capacitor surface temperature) must not be exceeded even under the most unfavorable conditions when the capacitor is installed. This must be considered particularly when it is positioned near components which radiate heat strongly (e.g. valves and power transistors). Furthermore, care must be taken, when bending the wires, that the bending forces do not strain the capacitor housing.

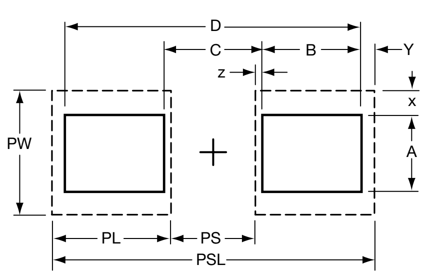
5.8 Installation Position
No restriction.

5.9 Soldering Instructions
Fluxes containing acids must not be used.

5.9.1 Guidelines for Surface Mount Footprints
Component footprint and reflow pad design for AVX capacitors.

The component footprint is defined as the maximum board area taken up by the terminators. The footprint dimensions are given by A, B, C and D in the diagram, which corresponds to W, max., A max., S min. and L max. for the component. The footprint is symmetric about the center lines.

The dimensions x, y and z should be kept to a minimum to reduce rotational tendencies while allowing for visual inspection of the component and its solder fillet.



Dimensions PS (Pad Separation) and PW (Pad Width) are calculated using dimensions x and z. Dimension y may vary, depending on whether reflow or wave soldering is to be performed.

For reflow soldering, dimensions PL (Pad Length), PW (Pad Width), and PSL (Pad Set Length) have been calculated. For wave soldering the pad width (PWw) is reduced to less than the termination width to minimize the amount of solder pick up while ensuring that a good joint can be produced.

NOTE: These recommendations (also in compliance with EIA) are guidelines only. With care and control, smaller footprints may be considered for reflow soldering.

Nominal footprint and pad dimensions for each case size are given in the following tables:

PAD DIMENSIONS: millimeters (inches)

CASE		PSL	PL	PS	PW	PWw
TAJ	A	4.0 (0.157)	1.4 (0.054)	1.2 (0.047)	1.8 (0.071)	0.9 (0.035)
	B	4.0 (0.157)	1.4 (0.054)	1.2 (0.047)	2.8 (0.110)	1.6 (0.063)
	C	6.5 (0.256)	2.0 (0.079)	2.5 (0.098)	2.8 (0.110)	1.6 (0.063)
	D	8.0 (0.315)	2.0 (0.079)	4.0 (0.157)	3.0 (0.119)	1.7 (0.068)
	V	8.3 (0.325)	2.3 (0.090)	3.7 (0.145)	3.7 (0.145)	1.7 (0.068)
	E	8.0 (0.315)	2.0 (0.079)	4.0 (0.157)	3.0 (0.119)	1.7 (0.068)
	R	2.7 (0.100)	1.0 (0.040)	1.0 (0.040)	1.6 (0.060)	0.8 (0.030)
	S	4.0 (0.160)	1.4 (0.050)	1.0 (0.040)	1.8 (0.070)	0.8 (0.030)
	T	4.0 (0.160)	1.4 (0.050)	1.0 (0.040)	2.8 (0.110)	0.8 (0.030)
	W	6.5 (0.256)	2.0 (0.079)	2.5 (0.098)	2.8 (0.110)	1.6 (0.063)
	Y	8.0 (0.315)	2.0 (0.079)	4.0 (0.157)	3.0 (0.119)	1.7 (0.068)
TAC	L	2.4 (0.095)	0.7 (0.027)	0.9 (0.035)	1.0 (0.039)	-
	R	3.0 (0.120)	0.7 (0.027)	1.6 (0.063)	1.5 (0.059)	-
TAZ	A	3.3 (0.126)	1.4 (0.054)	0.5 (0.020)	2.5 (0.098)	1.0 (0.039)
	B	4.5 (0.178)	1.4 (0.054)	1.8 (0.070)	2.5 (0.098)	1.0 (0.039)
	D	4.5 (0.178)	1.4 (0.054)	1.8 (0.070)	3.6 (0.143)	2.0 (0.079)
	E	5.8 (0.228)	1.4 (0.054)	3.0 (0.120)	3.6 (0.143)	2.2 (0.085)
	F	6.3 (0.248)	1.4 (0.054)	3.6 (0.140)	4.5 (0.178)	3.0 (0.119)
	G	7.4 (0.293)	1.9 (0.074)	3.7 (0.145)	4.0 (0.157)	2.4 (0.095)
	H	8.0 (0.313)	1.9 (0.074)	4.2 (0.165)	5.0 (0.197)	3.4 (0.135)

5.10 PCB Cleaning
Ta chip capacitors are compatible with most PCB board cleaning systems.

If aqueous cleaning is performed, parts must be allowed to dry prior to test. In the event ultrasonics are used power levels should be less than 10 watts per/litre, and care must be taken to avoid vibrational nodes in the cleaning bath.

SECTION 6
EPOXY FLAMMABILITY

EPOXY	UL RATING	OXYGEN INDEX
TAJ	UL94 V-0	35%
TPS	UL94 V-0	35%
TAZ	UL94 V-0	35%
THJ	UL94 V-0	35%

SECTION 7
QUALIFICATION APPROVAL STATUS

DESCRIPTION	STYLE	SPECIFICATION
Surface mount capacitors	TAJ	CECC 30801 - 005 Issue 2 CECC 30801 - 011 Issue 1 MIL-C-55365/8 (CWR11)
	TAZ	MIL-C-55365/4 (CWR09)

Tape and Reel Packaging

Tape and reel packaging for automatic component placement.

Please enter required Suffix on order. Bulk packaging is not available.

TAJ, TPS AND TAC TAPING SUFFIX TABLE

Case Size reference	Tape width mm	P mm	100mm (4") reel		180mm (7") reel		330mm (13") reel	
			Suffix	Qty.	Suffix	Qty.	Suffix	Qty.
A	8	4			R	2000	S	8000
B	8	4			R	2000	S	8000
C	12	8			R	500	S	3000
D	12	8			R	500	S	2500
E	12	8			R	400	S	1500
V	12	8			R	400	S	1500
R	8	4			R	2500	S	10000
S	8	4			R	2500	S	10000
T	8	4			R	2500	S	10000
W	12	8			R	1000	S	5000
Y	12	8			R	1000	S	4000
X	12	8			R	1000	S	5000
TACR	8	4	X	500	R	2500		
TACL	8	4	X	500	R	3500		

TAPE SPECIFICATION

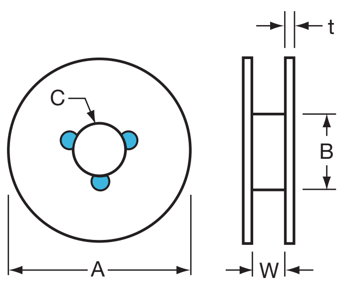
Tape dimensions comply to EIA 481-1

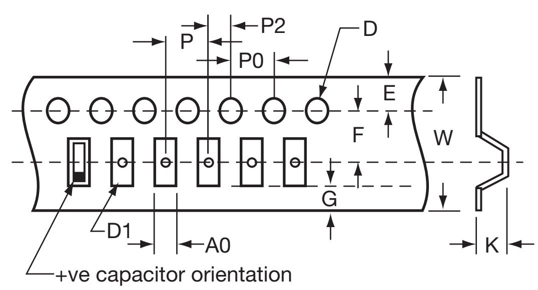
Dimensions A_0 and B_0 of the pocket and the tape thickness, K, are dependent on the component size.

Tape materials do not affect component solderability during storage. Carrier Tape Thickness <0.4mm.

PLASTIC TAPE DIMENSIONS

Code	Ao	Bo	K	W	E	F	G	P	P2	Po	D	D1
A	1.83±0.1	3.57±0.1	1.87±0.1	8±0.3	1.75±0.1	3.5±0.05	0.75 min	4±0.1	2±0.05	4±0.1	1.5+0.2-0.0	1+0.2-0.0
B	3.15±0.1	3.77±0.1	2.22±0.1	8±0.3	1.75±0.1	3.5±0.05	0.75 min	4±0.1	2±0.05	4±0.1	1.5+0.2-0.0	1+0.2-0.0
C	3.45±0.1	6.4±0.1	2.92±0.1	12±0.3	1.75±0.1	5.5±0.05	0.75 min	8±0.1	2±0.05	4±0.1	1.5+0.2-0.0	1.5+0.2-0.0
D	4.48±0.1	7.62±0.1	3.22±0.1	12±0.3	1.75±0.1	5.5±0.05	0.75 min	8±0.1	2±0.05	4±0.1	1.5+0.2-0.0	1.5+0.2-0.0
E	4.50±0.1	7.5±0.1	4.5±0.1	12±0.3	1.75±0.1	5.5±0.05	0.75 min	8±0.1	2±0.05	4±0.1	1.5+0.2-0.0	1.5+0.2-0.0
V	6.43±0.1	7.44±0.1	3.84±0.1	12±0.3	1.75±0.1	5.5±0.05	0.75 min	8±0.1	2±0.05	4±0.1	1.5+0.2-0.0	1.5+0.2-0.0
W	3.57±0.1	6.4±0.1	1.65±0.1	12±0.3	1.75±0.1	5.5±0.05	0.75 min	8±0.1	2±0.05	4±0.1	1.5+0.2-0.0	1.5+0.2-0.0
X	4.67±0.1	7.62±0.1	1.65±0.1	12±0.3	1.75±0.1	5.5±0.05	0.75 min	8±0.1	2±0.05	4±0.1	1.5+0.2-0.0	1.5+0.2-0.0
Y	4.67±0.1	7.62±0.1	2.15±0.1	12±0.3	1.75±0.1	5.5±0.05	0.75 min	8±0.1	2±0.05	4±0.1	1.5+0.2-0.0	1.5+0.2-0.0
R	1.65±0.1	2.45±0.1	1.3±0.1	8±0.3	1.75±0.1	3.5±0.05	0.75 min	4±0.1	2±0.05	4±0.1	1.5+0.2-0.0	1+0.2-0.0
S	1.95±0.1	3.55±0.1	1.3±0.1	8±0.3	1.75±0.1	3.5±0.05	0.75 min	4±0.1	2±0.05	4±0.1	1.5+0.2-0.0	1+0.2-0.0
T	3.20±0.1	3.8±0.1	1.35±0.1	8±0.3	1.75±0.1	3.5±0.05	0.75 min	4±0.1	2±0.05	4±0.1	1.5+0.2-0.0	1+0.2-0.0
TACR	1.65±0.1	2.45±0.1	1.3±0.1	8±0.3	1.75±0.1	3.5±0.05	0.75 min	4±0.1	2±0.05	4±0.1	1.5+0.2-0.0	1+0.2-0.0
TACL	1.10±0.1	2±0.1	1.1±0.1	8±0.3	1.75±0.1	3.5±0.05	0.75 min	4±0.1	2±0.05	4±0.1	1.5+0.2-0.0	1+0.2-0.0





REEL DIMENSIONS

Code	Tape	A	B	C	W	t
R	12mm	180±2.0	50 min	13±0.5	12.4±1.5,-0	1.5±0.5
R	8mm	180±2.0	50 min	13±0.5	8.4±1.5,-0	1.5±0.5
S	12mm	330±2.0	50 min	13±0.5	12.4±1.5,-0	1.5±0.5
S	8mm	330±2.0	50 min	13±0.5	8.4±1.5,-0	1.5±0.5
X	8mm	100±2.0		13±0.5	8.4±1.5,-0	1.5±0.5

Cover Tape Dimensions

Thickness: 75±25μm

Width of tape:

5.5mm + 0.2mm (8mm tape)

9.5mm + 0.2mm (12mm tape)

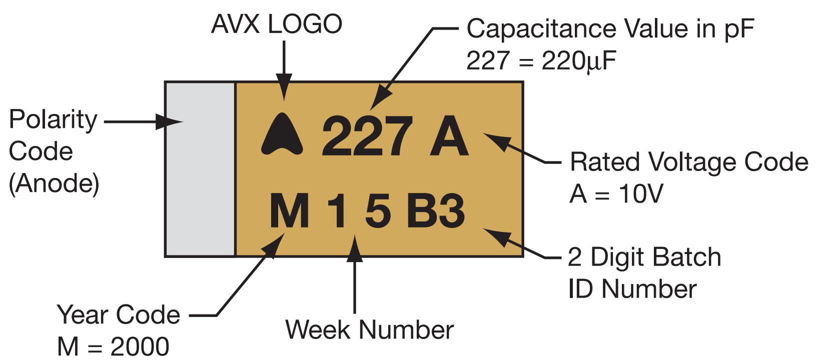
TAJ, THJ & TPS Marking

For TAJ & TPS & THJ, the positive end of body has videcon readable polarity marking as shown in the diagram. Bodies are marked by indelible laser marking on top surface with capacitance value, voltage and date of manufacture and batch ID number. R case is an exception due to the small size in which only the voltage and capacitance values are printed.

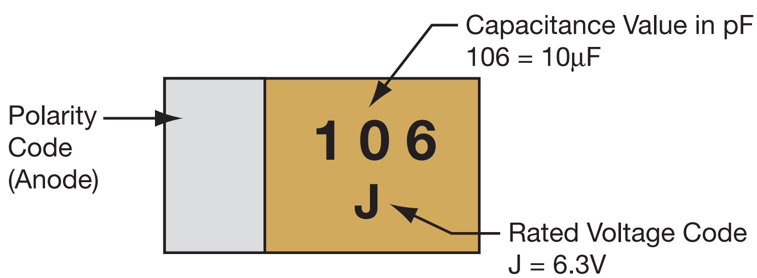
Year	Year Code
1999	L
2000	M
2001	N
2002	P

Voltage Code	Rated Voltage at 85°C
F	2
G	4
J	6.3
A	10
C	16
D	20
E	25
V	35
T	50

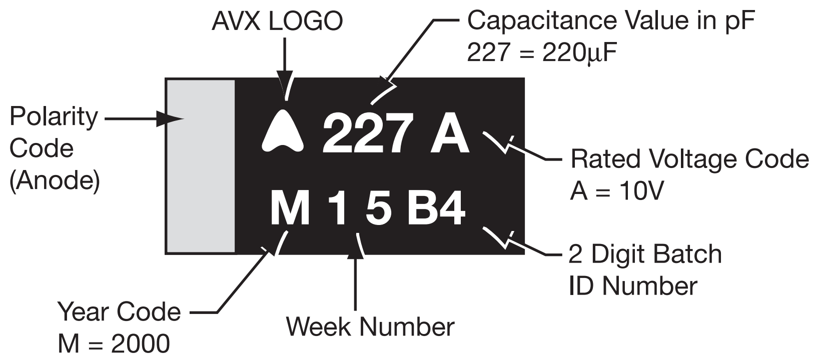
TAJ & TPS - A, B, C, D, E, S, T, V, W, Y AND X CASE:



TAJ - R CASE:



THJ - A, B, C, D AND E CASE:



TAZ, CWR09, CWR11 Series

Tape and Reel Packaging

Solid Tantalum Chip TAZ   Tape and reel packaging for automatic component placement.
Please enter required Suffix on order.   Bulk packaging is standard.

TAZ TAPING SUFFIX TABLE

Case Size reference	Tape width mm	P mm	7" (180mm) reel Suffix	7" (180mm) reel Qty.	13" reel (330mm) reel Suffix	13" reel (330mm) reel Qty.
A	8	4	R	2500	S	9000
B	12	4	R	2500	S	9000
D	12	4	R	2500	S	8000
E	12	4	R	2500	S	8000
F	12	8	R	1000	S	3000
G	12	8	R	500	S	2500
H	12	8	R	500	S	2500

Total Tape Thickness — K max	
TAZ	
Case size reference	Millimeters (Inches) DIM
A	2.0 (0.079)
B	4.0 (0.157)
D	4.0 (0.157)
E	4.0 (0.157)
F	4.0 (0.157)
G	4.0 (0.157)
H	4.0 (0.157)

Code	8mm Tape		12mm Tape	
P*	4±0.1 or 8±0.1	(0.157±0.004) (0.315±0.004)	4±0.1 or 8±0.1	(0.157±0.004) (0.315±0.004)
G	0.75 min	(0.03 min)	0.75 min	(0.03 min)
F	3.5±0.05	(0.138±0.002)	5.5±0.05	(0.22±0.002)
E	1.75±0.1	(0.069±0.004)	1.75±0.1	(0.069±0.004)
W	8±0.3	(0.315±0.012)	12±0.3	(0.472±0.012)
P_2	2±0.05	(0.079±0.002)	2±0.05	(0.079±0.002)
P_0	4±0.1	(0.157±0.004)	4±0.1	(0.157±0.004)
D	1.5±0.1 -0	(0.059±0.004) (-0)	1.5±0.1 -0	(0.059±0.004) (-0)
D_1	1.0 min	(0.039 min)	1.5 min	(0.059 min)

*See taping suffix tables for actual P dimension (component pitch).

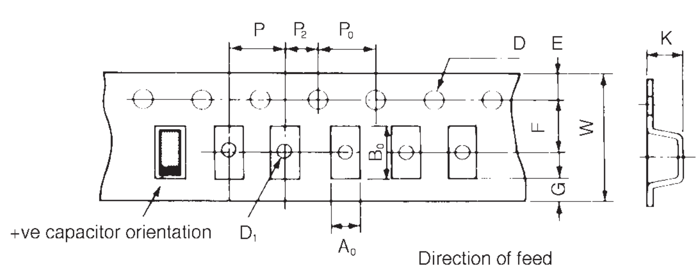
TAPE SPECIFICATION

Tape dimensions comply to EIA RS 481 A

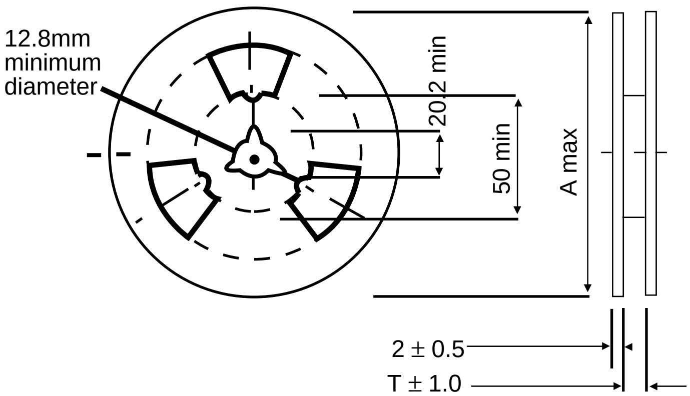
Dimensions A_0 and B_0 of the pocket and the tape thickness, K, are dependent on the component size.

Tape materials do not affect component solderability during storage.

Carrier Tape Thickness <0.4mm



PLASTIC TAPE REEL DIMENSIONS



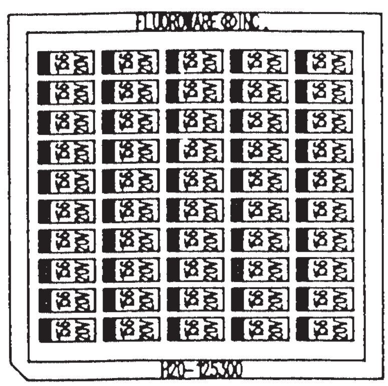
Standard Dimensions mm
T: 9.5mm (8mm tape)
13.0mm (12mm tape)

A: See page 49

Cover Tape Dimensions
Thickness: 75±25μ
Width of tape:
5.5mm + 0.2mm (8mm tape)
9.5mm + 0.2mm (12mm tape)

Waffle Packaging - 2" x 2" hard plastic waffle trays. To order Waffle packaging use a "W" in part numbers packaging position.

Case Size	Maximum Quantity Per Waffle
TAZ A	160
TAZ B	112
TAZ D	88
TAZ E	60
TAZ F	48
TAZ G	50
TAZ H	28
CWR11 A	96
CWR11 B	72
CWR11 C	54
CWR11 D	28



NOTE: Orientation of parts in waffle packs varies by case size.

Product Safety Information Sheet

Material Data and Handling

This should be read in conjunction with the Product Data Sheet. Failure to observe the ratings and the information on this sheet may result in a safety hazard.

1. Material Content

Solid tantalum capacitors do not contain liquid hazardous materials.

The operating section contains:

Tantalum	Graphite/carbon
Tantalum oxide	Conducting paint/resins
Manganese dioxide	Fluoropolymers (not TAC)

The encapsulation contains:

TAA - solder, metal case, solder coated terminal wires, glass seal and plastic sleeve

TAC - epoxy molding compound, tin coated terminal pads

TAJ - epoxy molding compound, solder coated terminal pads

TAP - solder, solder coated terminal wires, epoxy dipped resin

THJ - epoxy molding compound, solder coated terminal pads

TPS - epoxy molding compound, solder coated terminal pads

The epoxy resins may contain Antimony trioxide and Bromine compounds as fire retardants. The capacitors do not contain PBB or PBBO/PBBE. The solder alloys may contain lead.

2. Physical Form

These capacitors are physically small and are either rectangular with solderable terminal pads, or cylindrical or bead shaped with solderable terminal wires.

3. Intrinsic Properties

Operating

Solid tantalum capacitors are polarized devices and operate satisfactorily in the correct d.c. mode. They will withstand a limited application of reverse voltage as stated in the data sheets. However, a reverse application of the rated voltage will result in early short circuit failure and may result in fire or explosion. Consequential failure of other associated components in the circuit e.g. diodes, transformers, etc. may also occur. When operated in the correct polarity, a long period of satisfactory operation will be obtained but failure may occur for any of the following reasons:

- normal failure rate
- temperature too high
- surge voltage exceeded
- ripple rating exceeded
- reverse voltage exceeded

If this failure mode is a short circuit, the previous conditions apply. If the adjacent circuit impedance is low, voltage or current surges may exceed the power handling capability of the capacitor. For this reason capacitors in circuits of below 3Ω/V should be derated by 50% and precautions taken to prevent reverse voltage spikes. Where capacitors may be subjected to fast switched, low impedance source voltages, the manufacturers advice should be sought to determine the most suitable capacitors for such applications.

Non-operating

Solid tantalum capacitors contain no liquids or noxious gases to leak out. However, cracking or damage to the encapsulation may lead to premature failure due to ingress of material such as cleaning fluids or to stresses transmitted to the tantalum anode.

4. Fire Characteristics

Primary

Any component subject to abnormal power dissipation may

- self ignite
- become red hot
- break open or explode emitting flaming or red hot material, solid, molten or gaseous.

Fumes from burning components will vary in composition depending on the temperature, and should be considered to be hazardous, although fumes from a single component in a well ventilated area are unlikely to cause problems.

Secondary

Induced ignition may occur from an adjacent burning or red hot component. Epoxy resins used in the manufacture of capacitors give off noxious fumes when burning as stated above. Wherever possible, capacitors comply with the following: BS EN 60065
UL 492.60A/280
LOI (ASTM D2863-70) as stated in the data sheets.

5. Storage

Solid tantalum capacitors exhibit a very low random failure rate after long periods of storage and apart from this there are no known modes of failure under normal storage conditions. All capacitors will withstand any environmental conditions within their ratings for the periods given in the detail specifications. Storage for longer periods under high humidity conditions may affect the leakage current of resin protected capacitors. Solderability of solder coated surfaces may be affected by storage of excess of one year under high temperatures (>40°C) or humidity (>80%RH).

6. Disposal

Incineration of epoxy coated capacitors will cause emission of noxious fumes and metal cased capacitors may explode due to build up of internal gas pressure. Disposal by any other means normally involves no special hazards. Large quantities may have salvage value.

7. Unsafe Use

Most failures are of a passive nature and do not represent a safety hazard. A hazard may, however, arise if this failure causes a dangerous malfunction of the equipment in which the capacitor is employed. Circuits should be designed to fail safe under the normal modes of failure. The usual failure mode is an increase in leakage current or short circuit. Other possible modes are decrease of capacitance, increase in dissipation factor (and impedance) or an open-circuit. Operations outside the ratings quoted in the data sheets represents unsafe use.

8. Handling

Careless handling of the cut terminal leads could result in scratches and/or skin punctures. Hands should be washed after handling solder coated terminals before eating or smoking, to avoid ingestion of lead. Capacitors must be kept out of the reach of small children. Care must be taken to discharge capacitors before handling as capacitors may retain a residual charge even after equipment in which they are being used has been switched off. Sparks from the discharge could ignite a flammable vapor.

Product Safety Information Sheet

Environmental Information

AVX has always sought to minimize the environmental impact of its manufacturing operations and of its tantalum capacitors supplied to customers throughout the world.

We have a policy of preventing and minimizing waste streams during manufacture, and recycling materials wherever possible. We actively avoid or minimize environmentally hazardous materials in our production processes.

1. Material Content

For customers wishing to assess the environmental impact of AVX's capacitors contained in waste electrical and electronic equipment, the following information is provided:

Surface mount tantalum capacitors contain:

- Tantalum and Tantalum oxide
- Manganese dioxide
- Carbon/graphite
- Silver
- Nickel-iron alloy or Copper alloy depending on design (consult factory for details)
- Tin-lead alloy plating
- Polymers including fluorinated polymers
- Epoxide resin encapsulant

The encapsulant is made fire retardant to UL 94 V-0 by the inclusion of inert mineral filler, antimony trioxide and an organic bromine compound.

2. AVX capacitors do not contain any Poly Brominated Biphenyl (PBB) or PBBE/PBBO.

The approximate content of some materials is given in the table below:

Case Size	Typical Weight mg	Lead %	Antimony Trioxide %	Organic Bromine Compound %
A	25	0.13	1.7	2.5
B	65	0.11	1.4	2.1
C	137	0.04	2.3	3.4
D	330	0.023	1.5	2.2
E	460	0.017	1.2	1.8

The specific weight of other materials contained in the various case sizes is available on written request.

The component packing tape is either recyclable Polycarbonate or PVC (depending on case size), and the sealing tape is a laminate of halogen-free polymers. The reels are recyclable polystyrene, and marked with the recycling symbol. The reels are over-packed in recyclable fiber board boxes. None of the packing contains heavy metals.

3. Future Proposals

Lead

TAJ, TPS and THJ series supplied today are electroplated over the terminal contact area with 90:10 tin:lead alloy. Although the lead comprises much less than 0.2% of the component weight, TAC series currently have lead free (100% tin) terminations. Parts will be converted to 100% tin in 2001.

4. Fire Retardants

Currently the only known way of supplying a fire retardant encapsulant which meets all our performance requirements, is to incorporate antimony trioxide and an organic bromine compound. These materials are commonly used in many plastic items in the home and industry. We expect to be able to offer an alternative fire retardant encapsulant, free of these materials, by 2004. A combustible encapsulant free of these materials could be supplied today, but AVX believes that the health and safety benefits of using these materials to provide fire retardancy during the life of the product, far outweigh the possible risks to the environment and human health.

5. Nickel alloy

It is intended that all case sizes will be made with a high copper alloy termination. Some case sizes are supplied now with this termination, and other sizes may be available. Please contact AVX if you prefer this.

6. Recycling

Surface mount tantalum capacitors have a very long service life with no known wear-out mechanism, and a low failure rate. However, parts contained in equipment which is of no further use will have some residual value mainly because of the tantalum metal contained. This can be recovered and recycled by specialist companies. The silver and nickel or copper alloy will also have some value. Please contact AVX if you require assistance with the disposal of parts. Packaging can by recycled as described above.

7. Disposal

Surface mount tantalum capacitors do not contain any liquids and no part of the devices is normally soluble in water at neutral pH values. Incineration will cause the emission of noxious fumes and is not recommended except by specialists. Land fill may be considered for disposal, bearing in mind the small lead content.

Some commonly asked questions regarding Tantalum Capacitors:

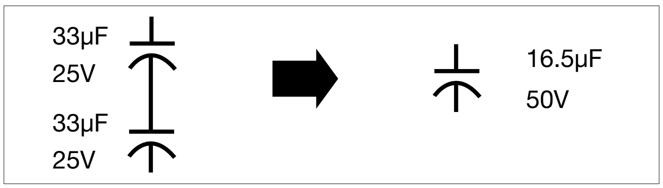
Question: If I use several tantalum capacitors in serial/parallel combinations, how can I ensure equal current and voltage sharing?

Answer: Connecting two or more capacitors in series and parallel combinations allows almost any value and rating to be constructed for use in an application. For example, a capacitance of more than 60μF is required in a circuit for stable operation. The working voltage rail is 24 volts dc with a superimposed ripple of 1.5 volts at 120 Hz.

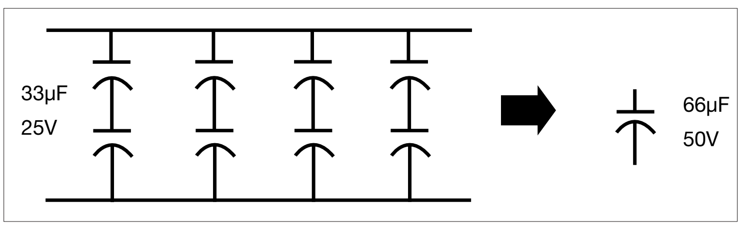
The maximum voltage seen by the capacitor is $V_{dc} + V_{ac}$=25.5V

Applying the 50% derating rule tells us that a 50V capacitor is required.

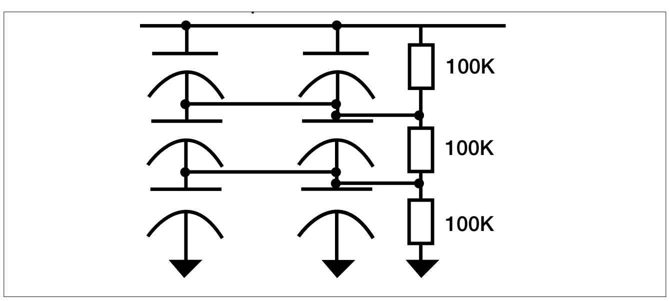
Connecting two 25V rated capacitors in series will give the required capacitance voltage rating, but the



effective capacitance will be halved, so for greater than 60μF, four such series combinations are required, as shown.



In order to ensure reliable operation, the capacitors should be connected as shown below to allow current sharing of the ac noise and ripple signals. This prevents any one capacitor heating more than its neighbors and thus being the weak link in the chain.



The two resistors are used to ensure that the leakage currents of the capacitors does not affect the circuit reliability, by ensuring that all the capacitors have half the working voltage across them.

Question: What are the advantages of tantalum over other capacitor technologies?

Answer:

1. Tantalum capacitors have high volumetric efficiency.
2. Electrical performance over temperature is very stable.
3. They have a wide operating temperature range -55 degrees C to +125 degrees C.
4. They have better frequency characteristics than aluminum electrolytics.
5. No wear out mechanism. Because of their construction, solid tantalum capacitors do not degrade in performance or reliability over time.

Question: How does TPS differ from your standard product?

Answer: TPS has been designed from the initial anode production stages for power supply applications. Special manufacturing processes provide the most robust capacitor dielectric by maximizing the volumetric efficiency of the package. After manufacturing, parts are conditioned by being subjected to elevated temperature overvoltage burn in applied for a minimum of two hours. Parts are monitored on a 100% basis for their direct current leakage performance at elevated temperatures. Parts are then subjected to a low impedance current surge. This current surge is performed on a 100% basis with each capacitor individually monitored. At this stage, the capacitor undergoes 100% test for capacitance, Dissipation Factor, leakage current, and 100 KHz ESR to TPS requirements.

Question: If the part is rated as a 25 volt part and you have current surged it, why can't I use it at 25 volts in a low impedance circuit?

Answer: The high volumetric efficiency obtained using tantalum technology is accomplished by using an extremely thin film of tantalum pentoxide as the dielectric. Even an application of the relatively low voltage of 25 volts will produce a large field strength as seen by the dielectric. As a result of this, derating has a significant impact on reliability as described under the reliability section. The following example uses a 22 microfarad capacitor rated at 25 volts to illustrate the point. The equation for determining the amount of surface area for a capacitor is as follows:

$C = ((E) (E_o) (A)) / d$

$A = ((C) (d)) /((E_o)(E))$

$A = ((22 \times 10^{-6}) (170 \times 10^{-9})) / ((8.85 \times 10^{-12}) (27))$

A = 0.015 square meters (150 square centimeters)

Where

C = Capacitance in farads

A = Dielectric (Electrode) Surface Area (m^2)

d = Dielectric thickness (Space between dielectric) (m)

E = Dielectric constant (27 for tantalum)

E_o = Dielectric Constant relative to a vacuum (8.855×10^{-12} Farads x m^{-1})

To compute the field voltage potential felt by the dielectric we use the following logic.

Dielectric formation potential = Formation Ratio x Working Voltage

= 4 x 25

Formation Potential = 100 volts

Dielectric (Ta_2O_5) Thickness (d) is 1.7×10^{-9} Meters Per Volt

d = 0.17 μ meters

Electric Field Strength = Working Voltage / d

= (25 / 0.17 μ meters)

= 147 Kilovolts per millimeter

= 147 Megavolts per meter

No matter how pure the raw tantalum powder or the precision of processing, there will always be impurity sites in the dielectric. We attempt to stress these sites in the factory with overvoltage surges, and elevated temperature burn in so that components will fail in the factory and not in your product. Unfortunately, within this large area of tantalum pentoxide, impurity sites will exist in all capacitors. To minimize the possibility of providing enough activation energy for these impurity sites to turn from an amorphous state to a crystalline state that will conduct energy, series resistance and derating is recommended. By reducing the electric field within the anode at these sites, the tantalum capacitor has increased reliability. Tantalums differ from other electrolytics in that charge transients are carried by electronic conduction rather than absorption of ions.

Question: What negative transients can Solid Tantalum Capacitors operate under?

Answer: The reverse voltage ratings are designed to cover exceptional conditions of small level excursions into incorrect polarity. The values quoted are not intended to cover continuous reverse operation. The peak reverse voltage applied to the capacitor must not exceed:

10% of rated DC working voltage to a maximum of 1 volt at 25°C.

3% of rated DC working voltage to a maximum of 0.5 volt at 85°C.

1% of category DC working voltage to a maximum of 0.1 volt at 125°C.

Question: I have read that manufacturers recommend a series resistance of 0.1 ohm per working volt. You suggest we use 1 ohm per volt in a low impedance circuit. Why?

Answer: We are talking about two very different sets of circuit conditions for those recommendations. The 0.1 ohm per volt recommendation is for steady-state conditions. This level of resistance is used as a basis for the series resistance variable in a 1% / 1000 hours 60% confidence level reference. This is what steady-state life tests are based on. The 1 ohm per volt is recommended for dynamic conditions which include current in-rush applications such as inputs to power supply circuits. In many power supply topologies where the di/dt through the capacitor(s) is limited, (such as most implementations of buck (current mode), forward converter, and flyback), the requirement for series resistance is decreased.

Question: How long is the shelf life for a tantalum capacitor?

Answer: Solid tantalum capacitors have no limitation on shelf life. The dielectric is stable and no reformation is required. The only factors that affect future performance of the capacitors would be high humidity conditions and extreme storage temperatures. Solderability of solder coated surfaces may be affected by storage in excess of one year under temperatures greater than 40°C or humidities greater than 80% relative humidity. Terminations should be checked for solderability in the event an oxidation develops on the solder plating.

Question: Do you recommend the use of tantalum capacitors on the input side of DC-DC converters?

Answer: No. Typically the input side of a converter is fed from the voltage sources which are not regulated and are of nominally low impedance. Examples would be Nickel-Metal-Hydride batteries, Nickel-Cadmium batteries, etc., whose internal resistance is typically in the low milliohm range.