TAJ Series

Standard Tantalum

FEATURES

- General purpose SMT chip tantalum series
- 7 case sizes available
- Low profile options available
- CV range: 0.10-2200μF / 2.5-50V

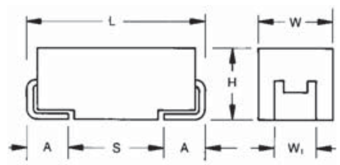
APPLICATIONS

- General low power DC/DC and LDO

LEAD-FREE
LEAD-FREE COMPATIBLE COMPONENT

RoHS COMPLIANT

SnPb termination option is not RoHS compliant.



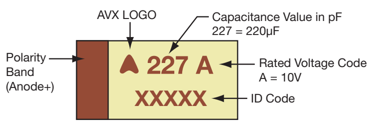
CASE DIMENSIONS: millimeters (inches)

Code	EIA Code	EIA Metric	L±0.20 (0.008)	W+0.20 (0.008) -0.10 (0.004)	H+0.20 (0.008) -0.10 (0.004)	W_1±0.20 (0.008)	A+0.30 (0.012) -0.20 (0.008)	S Min.
A	1206	3216-18	3.20 (0.126)	1.60 (0.063)	1.60 (0.063)	1.20 (0.047)	0.80 (0.031)	1.10 (0.043)
B	1210	3528-21	3.50 (0.138)	2.80 (0.110)	1.90 (0.075)	2.20 (0.087)	0.80 (0.031)	1.40 (0.055)
C	2312	6032-28	6.00 (0.236)	3.20 (0.126)	2.60 (0.102)	2.20 (0.087)	1.30 (0.051)	2.90 (0.114)
D	2917	7343-31	7.30 (0.287)	4.30 (0.169)	2.90 (0.114)	2.40 (0.094)	1.30 (0.051)	4.40 (0.173)
E	2917	7343-43	7.30 (0.287)	4.30 (0.169)	4.10 (0.162)	2.40 (0.094)	1.30 (0.051)	4.40 (0.173)
U	2924	7361-43	7.30 (0.287)	6.10 (0.240)	4.10 (0.162)	3.10 (0.120)	1.30 (0.051)	4.40 (0.173)
V	2924	7361-38	7.30 (0.287)	6.10 (0.240)	3.55 (0.140)	3.10 (0.120)	1.30 (0.051)	4.40 (0.173)

W_1 dimension applies to the termination width for A dimensional area only.

MARKING

A, B, C, D, E, U, V CASE



HOW TO ORDER

TAJ	C	106	M	035	R	NJ	–
Type	**Case Size** 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 = 2.5Vdc 004 = 4Vdc 006 = 6.3Vdc 010 = 10Vdc 016 = 16Vdc 020 = 20Vdc 025 = 25Vdc 035 = 35Vdc 050 = 50Vdc	**Packaging** R = Pure Tin 7" Reel S = Pure Tin 13" Reel A = Gold Plating 7" Reel B = Gold Plating 13" Reel H = Tin Lead 7" Reel (Contact Manufacturer) K = Tin Lead 13" Reel (Contact Manufacturer) H, K = Non RoHS	**Specification Suffix** NJ = Standard Suffix	**Additional characters may be added for special requirements** V = Dry pack Option (selected codes only)

TECHNICAL SPECIFICATIONS

Technical Data:		All technical data relate to an ambient temperature of +25°C								
Capacitance Range:		0.10 μF to 2200 μF								
Capacitance Tolerance:		±10%; ±20%								
Rated Voltage (V_R)	≤ +85°C:	2.5	4	6.3	10	16	20	25	35	50
Category Voltage (V_C)	≤ +125°C:	1.7	2.7	4	7	10	13	17	23	33
Surge Voltage (V_S)	≤ +85°C:	3.3	5.2	8	13	20	26	32	46	65
Surge Voltage (V_S)	≤ +125°C:	2.2	3.4	5	8	13	16	20	28	40
Temperature Range:		-55°C to +125°C								
Reliability:		1% per 1000 hours at 85°C, V_R with 0.1Ω/V series impedance, 60% confidence level								
Qualification:		CECC 30801 - 005 issue 2 EIA 535BAAC								
Termination Finished:		Sn Plating (standard), Gold and SnPb Plating upon request								
		For AEC-Q200 availability, please contact AVX								

CAPACITANCE AND RATED VOLTAGE RANGE (LETTER DENOTES CASE SIZE)

Capacitance		Rated voltage DC (V_R) to 85°C								
μF	Code	2.5V (e)	4V (G)	6.3V (J)	10V (A)	16V (C)	20V (D)	25V (E)	35V (V)	50V (T)
0.10	104								A	A
0.15	154								A	A/B
0.22	224								A	A/B
0.33	334								A	A/B
0.47	474							A	A/B	A/B/C
0.68	684						A	A	A/B	A/B/C
1.0	105					A	A	A	A/B	A/B/C
1.5	155				A	A	A	A/B	A/B/C	B/C/D
2.2	225			A	A	A/B	A/B	A/B	A/B/C	B/C/D
3.3	335			A	A	A/B	A/B	A/B/C	B/C	C/D
4.7	475		A	A	A/B	A/B	A/B/C	A/B/C	B/C/D	C/D
6.8	685		A	A/B	A/B	A/B/C	A/B/C	B/C	C/D	C/D
10	106		A	A/B	A/B/C	A/B/C	A(M)*/B/C	B/C/D	C/D/E	D/E/V
15	156		A/B	A/B	A/B/C	A(M)/B/C	B/C/D	C/D	C/D	D/E/V
22	226		A	A/B/C	A/B/C	B/C/D	B/C/D	C/D	D/E	V
33	336	A	A/B	A/B/C	A/B/C/D	B/C/D	C/D	C/D/E	D/E/V	
47	476	A	A/B	A/B/C/D	B/C/D	C/D	C/D/E	D/E	E/V	
68	686	A	A/B/C	B/C/D	B/C/D	C/D	C(M)/D/E	D/E/V	V	
100	107	A/B	A/B/C	B/C/D	B(M)/C/D/E	C/D/E	D/E/V	E(M)/V		
150	157	B	B/C	B(M)/C/D	C/D/E	D/E/V	E/V	V(M)		
220	227	B/D	B(M)/C/D	C/D/E	C/D/E	E/V				
330	337	D	C/D/E	C/D/E	D/E/V	E(M)				
470	477	C/D	C/D/E	D/E/V	E/U/V					
680	687	C/D/E	D/E	E/V						
1000	108	D(M)/E	D/E/V	E(M)/V(M)						
1500	158	D/E/V(M)	E/V(M)							
2200	228	V(M)								

Not recommended for new designs, higher voltage or smaller case size substitution are offered.

Released codes (M tolerance only)

Engineering samples - please contact manufacturer

*Codes under development - subject to change

Note: Voltage ratings are minimum values. AVX reserves the right to supply higher ratings in the same case size, to the same reliability standards.

RATINGS & PART NUMBER REFERENCE

AVX Part No.	Case Size	Capacitance (µF)	Rated Voltage (V)	Rated Temperature (°C)	Category Voltage (V)	Category Temperature (°C)	DCL (µA) Max.	DF % Max.	ESR Max. (Ω) @ 100kHz	MSL	100kHz RMS Current (mA)		
											25°C	85°C	125°C
2.5 Volt @ 85°C													
TAJA336*002#NJ	A	33	2.5	85	1.7	125	0.8	8	1.7	1	210	189	84
TAJA476*002#NJ	A	47	2.5	85	1.7	125	0.9	6	3	1	158	142	63
TAJA686*002#NJ	A	68	2.5	85	1.7	125	1.4	8	1.5	1	224	201	89
TAJA107*002#NJ	A	100	2.5	85	1.7	125	2.5	30	1.4	1	231	208	93
TAJB107*002#NJ	B	100	2.5	85	1.7	125	2.5	8	1.4	1	246	222	99
TAJB157*002#NJ	B	150	2.5	85	1.7	125	3	10	1.6	1	230	207	92
TAJB227*002#NJ	B	220	2.5	85	1.7	125	4.4	16	1.6	1	230	207	92
TAJD227*002#NJ	D	220	2.5	85	1.7	125	5.5	8	0.3	1	707	636	283
TAJD337*002#NJ	D	330	2.5	85	1.7	125	8.2	8	0.3	1	707	636	283
TAJC477*002#NJ	C	470	2.5	85	1.7	125	9.4	12	0.2	1	742	667	297
TAJD477*002#NJ	D	470	2.5	85	1.7	125	11.6	8	0.2	1	866	779	346
TAJC687*002#NJ	C	680	2.5	85	1.7	125	17	18	0.2	1	742	667	297
TAJD687*002#NJ	D	680	2.5	85	1.7	125	17	16	0.2	1	866	779	346
TAJE687*002#NJ	E	680	2.5	85	1.7	125	17	10	0.2	1[1)]	908	817	363
TAJD108M002#NJ	D	1000	2.5	85	1.7	125	25	20	0.2	1	866	779	346
TAJE108*002#NJ	E	1000	2.5	85	1.7	125	20	14	0.4	1[1)]	642	578	257
TAJD158*002#NJ	D	1500	2.5	85	1.7	125	37.5	60	0.2	1	866	779	346
TAJE158*002#NJ	E	1500	2.5	85	1.7	125	37	20	0.2	1[1)]	908	817	363
TAJV158M002#NJ	V	1500	2.5	85	1.7	125	30	20	0.2	1[1)]	1118	1006	447
TAJV228M002#NJ	V	2200	2.5	85	1.7	125	55	50	0.2	1[1)]	1118	1006	447
4 Volt @ 85°C													
TAJA336*004#NJ	A	33	4	85	2.7	125	1.3	6	3	1	158	142	63
TAJA476*004#NJ	A	47	4	85	2.7	125	1.9	8	2.6	1	170	153	68
TAJA686*004#NJ	A	68	4	85	2.7	125	2.7	10	1.5	1	224	201	89
TAJB686*004#NJ	B	68	4	85	2.7	125	2.7	6	1.8	1	217	196	87
TAJA107*004#NJ	A	100	4	85	2.7	125	4	30	1.4	1	231	208	93
TAJB107*004#NJ	B	100	4	85	2.7	125	4	8	0.9	1	307	277	123
TAJB157*004#NJ	B	150	4	85	2.7	125	6	10	1.5	1	238	214	95
TAJC157*004#NJ	C	150	4	85	2.7	125	6	6	0.3	1	606	545	242
TAJB227M004#NJ	B	220	4	85	2.7	125	8.8	12	1.1	1	278	250	111
TAJC227*004#NJ	C	220	4	85	2.7	125	8.8	8	1.2	1	303	272	121
TAJD227*004#NJ	D	220	4	85	2.7	125	8.8	8	0.9	1	408	367	163
TAJC337*004#NJ	C	330	4	85	2.7	125	13.2	8	0.3	1	606	545	242
TAJD337*004#NJ	D	330	4	85	2.7	125	13.2	8	0.9	1	408	367	163
TAJC477*004#NJ	C	470	4	85	2.7	125	18.8	14	0.3	1	606	545	242
TAJD477*004#NJ	D	470	4	85	2.7	125	18.8	12	0.9	1	408	367	163
TAJE477*004#NJ	E	470	4	85	2.7	125	18.8	10	0.5	1[1)]	574	517	230
TAJD687*004#NJ	D	680	4	85	2.7	125	27.2	14	0.5	1	548	493	219
TAJE687*004#NJ	E	680	4	85	2.7	125	27.2	14	0.9	1[1)]	428	385	171
TAJD108*004#NJ	D	1000	4	85	2.7	125	40	60	0.2	1	866	779	346
TAJE108*004#NJ	E	1000	4	85	2.7	125	40	14	0.4	1[1)]	642	578	257
TAJV108*004#NJ	V	1000	4	85	2.7	125	40	16	0.2	1[1)]	1118	1006	447
TAJE158*004#NJ	E	1500	4	85	2.7	125	60	30	0.2	1[1)]	908	817	363
TAJV158M004#NJ	V	1500	4	85	2.7	125	60	30	0.2	1[1)]	1118	1006	447
6.3 Volt @ 85°C													
TAJA106*006#NJ	A	10	6.3	85	4	125	0.6	6	4	1	137	123	55
TAJA156*006#NJ	A	15	6.3	85	4	125	0.9	6	3.5	1	146	132	59
TAJA226*006#NJ	A	22	6.3	85	4	125	1.4	6	3	1	158	142	63
TAJA336*006#NJ	A	33	6.3	85	4	125	2.1	8	2.2	1	185	166	74
TAJA476*006#NJ	A	47	6.3	85	4	125	2.8	10	1.6	1	217	195	87
TAJB476*006#NJ	B	47	6.3	85	4	125	3	6	2	1	206	186	82
TAJC476*006#NJ	C	47	6.3	85	4	125	3	6	1.6	1	262	236	105
TAJB686*006#NJ	B	68	6.3	85	4	125	4	8	0.9	1	307	277	123
TAJC686*006#NJ	C	68	6.3	85	4	125	4.3	6	1.5	1	271	244	108
TAJB107*006#NJ	B	100	6.3	85	4	125	6.3	10	1.7	1	224	201	89
TAJC107*006#NJ	C	100	6.3	85	4	125	6.3	6	0.9	1	350	315	140
TAJB157M006#NJ	B	150	6.3	85	4	125	9.5	10	1.2	1	266	240	106
TAJC157*006#NJ	C	150	6.3	85	4	125	9.5	6	1.3	1	291	262	116
TAJD157*006#NJ	D	150	6.3	85	4	125	9.5	6	0.9	1	408	367	163
TAJC227*006#NJ	C	220	6.3	85	4	125	13.9	8	1.2	1	303	272	121
TAJD227*006#NJ	D	220	6.3	85	4	125	13.9	8	0.4	1	612	551	245
TAJE227*006#NJ	E	220	6.3	85	4	125	13.9	8	0.4	1[1)]	642	578	257
TAJC337*006#NJ	C	330	6.3	85	4	125	19.8	12	0.5	1	469	422	188
TAJD337*006#NJ	D	330	6.3	85	4	125	20.8	8	0.4	1	612	551	245
TAJE337*006#NJ	E	330	6.3	85	4	125	20.8	8	0.4	1[1)]	642	578	257
TAJD477*006#NJ	D	470	6.3	85	4	125	28	12	0.4	1	612	551	245
TAJE477*006#NJ	E	470	6.3	85	4	125	28	10	0.4	1[1)]	642	578	257
TAJV477*006#NJ	V	470	6.3	85	4	125	28	10	0.4	1[1)]	791	712	316
TAJE687*006#NJ	E	680	6.3	85	4	125	42.8	10	0.5	1[1)]	574	517	230
TAJV687*006#NJ	V	680	6.3	85	4	125	42.8	10	0.5	1[1)]	707	636	283

RATINGS & PART NUMBER REFERENCE

AVX Part No.	Case Size	Capacitance (µF)	Rated Voltage (V)	Rated Temperature (ºC)	Category Voltage (V)	Category Temperature (ºC)	DCL (µA) Max.	DF % Max.	ESR Max. (Ω) @ 100kHz	MSL	100kHz RMS Current (mA)		
											25ºC	85ºC	125ºC
TAJE108M006#NJ	E	1000	6.3	85	4	125	60	20	0.2	1[1)]	908	817	363
TAJV108M006#NJ	V	1000	6.3	85	4	125	60	16	0.2	1[1)]	1118	1006	447
10 Volt @ 85°C													
TAJA475*010#NJ	A	4.7	10	85	7	125	0.5	6	5	1	122	110	49
TAJA685*010#NJ	A	6.8	10	85	7	125	0.7	6	4	1	137	123	55
TAJA106*010#NJ	A	10	10	85	7	125	1	6	3	1	158	142	63
TAJA156*010#NJ	A	15	10	85	7	125	1.5	6	3.2	1	153	138	61
TAJB156*010#NJ	B	15	10	85	7	125	1.5	6	2.8	1	174	157	70
TAJA226*010#NJ	A	22	10	85	7	125	2.2	8	3	1	158	142	63
TAJB226*010#NJ	B	22	10	85	7	125	2.2	6	2.4	1	188	169	75
TAJA336*010#NJ	A	33	10	85	7	125	3.3	8	1.7	1	210	189	84
TAJB336*010#NJ	B	33	10	85	7	125	3.3	6	1.8	1	217	196	87
TAJC336*010#NJ	C	33	10	85	7	125	3.3	6	1.6	1	262	236	105
TAJB476*010#NJ	B	47	10	85	7	125	4.7	8	1	1	292	262	117
TAJC476*010#NJ	C	47	10	85	7	125	4.7	6	1.2	1	303	272	121
TAJB686*010#NJ	B	68	10	85	7	125	6.8	6	1.4	1	246	222	99
TAJC686*010#NJ	C	68	10	85	7	125	6.8	6	1.3	1	291	262	116
TAJB107M010#NJ	B	100	10	85	7	125	10	8	1.4	1	246	222	99
TAJC107*010#NJ	C	100	10	85	7	125	10	8	1.2	1	303	272	121
TAJD107*010#NJ	D	100	10	85	7	125	10	6	0.9	1	408	367	163
TAJC157*010#NJ	C	150	10	85	7	125	15	8	0.9	1	350	315	140
TAJD157*010#NJ	D	150	10	85	7	125	15	8	0.9	1	408	367	163
TAJE157*010#NJ	E	150	10	85	7	125	15	8	0.9	1[1)]	428	385	171
TAJC227*010#NJ	C	220	10	85	7	125	22	16	0.5	1	469	422	188
TAJD227*010#NJ	D	220	10	85	7	125	22	8	0.5	1	548	493	219
TAJE227*010#NJ	E	220	10	85	7	125	22	8	0.5	1[1)]	574	517	230
TAJD337*010#NJ	D	330	10	85	7	125	33	8	0.9	1	408	367	163
TAJE337*010#NJ	E	330	10	85	7	125	33	8	0.9	1[1)]	428	385	171
TAJV337*010#NJ	V	330	10	85	7	125	33	10	0.9	1[1)]	572	474	211
TAJE477*010#NJ	E	470	10	85	7	125	47	10	0.5	1[1)]	574	517	230
TAJU477*010RNJ	U	470	10	85	7	125	47	12	0.5	1[1)]	574	517	230
TAJV477*010#NJ	V	470	10	85	7	125	47	10	0.5	1[1)]	707	636	283
16 Volt @ 85°C													
TAJA225*016#NJ	A	2.2	16	85	10	125	0.5	6	6.5	1	107	97	43
TAJA335*016#NJ	A	3.3	16	85	10	125	0.5	6	5	1	122	110	49
TAJB335*016#NJ	B	3.3	16	85	10	125	0.5	6	4.5	1	137	124	55
TAJA475*016#NJ	A	4.7	16	85	10	125	0.8	6	4	1	137	123	55
TAJB475*016#NJ	B	4.7	16	85	10	125	0.8	6	3.5	1	156	140	62
TAJA685*016#NJ	A	6.8	16	85	10	125	1.1	6	3.5	1	146	132	59
TAJB685*016#NJ	B	6.8	16	85	10	125	1.1	6	2.5	1	184	166	74
TAJA106*016#NJ	A	10	16	85	10	125	1.6	6	3	1	158	142	63
TAJB106*016#NJ	B	10	16	85	10	125	1.6	6	2.8	1	174	157	70
TAJC106*016#NJ	C	10	16	85	10	125	1.6	6	2	1	235	211	94
TAJA156M016#NJ	A	15	16	85	10	125	2.4	6	2	1	194	174	77
TAJB156*016#NJ	B	15	16	85	10	125	2.4	6	2.5	1	184	166	74
TAJC156*016#NJ	C	15	16	85	10	125	2.4	6	1.8	1	247	222	99
TAJB226*016#NJ	B	22	16	85	10	125	3.5	6	2.3	1	192	173	77
TAJC226*016#NJ	C	22	16	85	10	125	3.5	6	1	1	332	298	133
TAJD226*016#NJ	D	22	16	85	10	125	3.5	6	1.1	1	369	332	148
TAJB336*016#NJ	B	33	16	85	10	125	5.3	8	2.1	1	201	181	80
TAJC336*016#NJ	C	33	16	85	10	125	5.3	6	1.5	1	271	244	108
TAJD336*016#NJ	D	33	16	85	10	125	5.3	6	0.9	1	408	367	163
TAJC476*016#NJ	C	47	16	85	10	125	7.5	6	0.5	1	469	422	188
TAJD476*016#NJ	D	47	16	85	10	125	7.5	6	0.9	1	408	367	163
TAJC686*016#NJ	C	68	16	85	10	125	10.9	6	1.3	1	291	262	116
TAJD686*016#NJ	D	68	16	85	10	125	10.9	6	0.9	1	408	367	163
TAJC107*016#NJ	C	100	16	85	10	125	16	8	1	1	332	298	133
TAJD107*016#NJ	D	100	16	85	10	125	16	6	0.6	1	500	450	200
TAJE107*016#NJ	E	100	16	85	10	125	16	6	0.9	1[1)]	428	385	171
TAJD157*016#NJ	D	150	16	85	10	125	24	6	0.9	1	408	367	163
TAJE157*016#NJ	E	150	16	85	10	125	23	8	0.3	1[1)]	742	667	297
TAJV157*016#NJ	V	150	16	85	10	125	24	8	0.5	1[1)]	707	636	283
TAJE227*016#NJ	E	220	16	85	10	125	35.2	10	0.5	1[1)]	574	517	230
TAJV227*016#NJ	V	220	16	85	10	125	35.2	8	0.9	1[1)]	527	474	211
TAJE337M016#NJ	E	330	16	85	10	125	52.8	30	0.4	1[1)]	642	578	257
20 Volt @ 85°C													
TAJA105*020#NJ	A	1	20	85	13	125	0.5	4	9	1	91	82	37
TAJA155*020#NJ	A	1.5	20	85	13	125	0.5	6	6.5	1	107	97	43
TAJA225*020#NJ	A	2.2	20	85	13	125	0.5	6	5.3	1	119	107	48
TAJB225*020#NJ	B	2.2	20	85	13	125	0.5	6	3.5	1	156	140	62
TAJA335*020#NJ	A	3.3	20	85	13	125	0.7	6	4.5	1	129	116	52

RATINGS & PART NUMBER REFERENCE

AVX Part No.	Case Size	Capacitance (µF)	Rated Voltage (V)	Rated Temperature (°C)	Category Voltage (V)	Category Temperature (°C)	DCL (µA) Max.	DF % Max.	ESR Max. (Ω) @ 100kHz	MSL	100kHz RMS Current (mA)		
											25°C	85°C	125°C
TAJB335*020#NJ	B	3.3	20	85	13	125	0.7	6	3	1	168	151	67
TAJA475*020#NJ	A	4.7	20	85	13	125	0.9	6	4	1	137	123	55
TAJB475*020#NJ	B	4.7	20	85	13	125	0.9	6	3	1	168	151	67
TAJA685*020#NJ	A	6.8	20	85	13	125	1.4	6	2.4	1	177	159	71
TAJB685*020#NJ	B	6.8	20	85	13	125	1.4	6	2.5	1	184	166	74
TAJC685*020#NJ	C	6.8	20	85	13	125	1.4	6	2	1	235	211	94
TAJB106*020#NJ	B	10	20	85	13	125	2	6	2.1	1	201	181	80
TAJC106*020#NJ	C	10	20	85	13	125	2	6	1.2	1	303	272	121
TAJB156*020#NJ	B	15	20	85	13	125	3	6	2	1	206	186	82
TAJC156*020#NJ	C	15	20	85	13	125	3	6	1.7	1	254	229	102
TAJB226*020#NJ	B	22	20	85	13	125	4.4	6	1.8	1	217	196	87
TAJC226*020#NJ	C	22	20	85	13	125	4.4	6	1.6	1	262	236	105
TAJD226*020#NJ	D	22	20	85	13	125	4.4	6	0.9	1	408	367	163
TAJC336*020#NJ	C	33	20	85	13	125	6.6	6	1.5	1	271	244	108
TAJD336*020#NJ	D	33	20	85	13	125	6.6	6	0.9	1	408	367	163
TAJC476*020#NJ	C	47	20	85	13	125	9.4	6	0.5	1	469	422	188
TAJD476*020#NJ	D	47	20	85	13	125	9.4	6	0.9	1	408	367	163
TAJE476*020#NJ	E	47	20	85	13	125	9.4	6	0.9	1[1)]	428	385	171
TAJC686M020#NJ	C	68	20	85	13	125	13.6	8	0.5	1	469	422	188
TAJD686*020#NJ	D	68	20	85	13	125	13.6	6	0.4	1	612	551	245
TAJE686*020#NJ	E	68	20	85	13	125	13.6	6	0.9	1[1)]	428	385	171
TAJD107*020#NJ	D	100	20	85	13	125	20	6	0.5	1	548	493	219
TAJE107*020#NJ	E	100	20	85	13	125	20	6	0.4	1[1)]	642	578	257
TAJV107*020#NJ	V	100	20	85	13	125	20	8	0.9	1[1)]	527	474	211
TAJE157*020#NJ	E	150	20	85	13	125	30	8	0.3	1[1)]	742	667	297
TAJV157*020#NJ	V	150	20	85	13	125	30	8	0.3	1[1)]	913	822	365
25 Volt @ 85°C													
TAJA474*025#NJ	A	0.47	25	85	17	125	0.5	4	14	1	73	66	29
TAJA684*025#NJ	A	0.68	25	85	17	125	0.5	4	10	1	87	78	35
TAJA105*025#NJ	A	1	25	85	17	125	0.5	4	8	1	97	87	39
TAJA155*025#NJ	A	1.5	25	85	17	125	0.5	6	7.5	1	100	90	40
TAJB155*025#NJ	B	1.5	25	85	17	125	0.5	6	5	1	130	117	52
TAJA225*025#NJ	A	2.2	25	85	17	125	0.6	6	7	1	104	93	41
TAJB225*025#NJ	B	2.2	25	85	17	125	0.6	6	4.5	1	137	124	55
TAJA335*025#NJ	A	3.3	25	85	17	125	0.8	6	3.7	1	142	128	57
TAJB335*025#NJ	B	3.3	25	85	17	125	0.8	6	3.5	1	156	140	62
TAJA475*025#NJ	A	4.7	25	85	17	125	1.2	6	3.1	1	156	140	62
TAJB475*025#NJ	B	4.7	25	85	17	125	1.2	6	1.5	1	238	214	95
TAJB685*025#NJ	B	6.8	25	85	17	125	1.7	6	2.8	1	174	157	70
TAJC685*025#NJ	C	6.8	25	85	17	125	1.7	6	2	1	235	211	94
TAJB106*025#NJ	B	10	25	85	17	125	2.5	6	2.5	1	184	166	74
TAJC106*025#NJ	C	10	25	85	17	125	2.5	6	1.8	1	247	222	99
TAJD106*025#NJ	D	10	25	85	17	125	2.5	6	1.2	1	354	318	141
TAJC156*025#NJ	C	15	25	85	17	125	3.8	6	1.6	1	262	236	105
TAJD156*025#NJ	D	15	25	85	17	125	3.8	6	1	1	387	349	155
TAJC226*025#NJ	C	22	25	85	17	125	5.5	6	1.4	1	280	252	112
TAJD226*025#NJ	D	22	25	85	17	125	5.5	6	0.9	1	408	367	163
TAJC336*025#NJ	C	33	25	85	17	125	8.3	6	0.9	1	350	315	140
TAJD336*025#NJ	D	33	25	85	17	125	8.3	6	0.9	1	408	367	163
TAJE336*025#NJ	E	33	25	85	17	125	8.3	6	0.9	1[1)]	428	385	171
TAJD476*025#NJ	D	47	25	85	17	125	11.8	6	0.9	1	408	367	163
TAJE476*025#NJ	E	47	25	85	17	125	11.8	6	0.9	1[1)]	428	385	171
TAJD686*025#NJ	D	68	25	85	17	125	17	6	0.9	1	408	367	163
TAJE686*025#NJ	E	68	25	85	17	125	17	6	0.9	1[1)]	428	385	171
TAJV686*025#NJ	V	68	25	85	17	125	17	6	0.9	1[1)]	527	474	211
TAJE107M025#NJ	E	100	25	85	17	125	25	10	0.3	1[1)]	742	667	297
TAJV107*025#NJ	V	100	25	85	17	125	25	8	0.4	1[1)]	791	712	316
TAJV157M025#NJ	V	150	25	85	17	125	37.5	10	0.4	1[1)]	791	712	316
35 Volt @ 85°C													
TAJA104*035#NJ	A	0.1	35	85	23	125	0.5	4	24	1	56	50	22
TAJA154*035#NJ	A	0.15	35	85	23	125	0.5	4	21	1	60	54	24
TAJA224*035#NJ	A	0.22	35	85	23	125	0.5	4	18	1	65	58	26
TAJA334*035#NJ	A	0.33	35	85	23	125	0.5	4	15	1	71	64	28
TAJA474*035#NJ	A	0.47	35	85	23	125	0.5	4	12	1	79	71	32
TAJB474*035#NJ	B	0.47	35	85	23	125	0.5	4	10	1	92	83	37
TAJA684*035#NJ	A	0.68	35	85	23	125	0.5	4	8	1	97	87	39
TAJB684*035#NJ	B	0.68	35	85	23	125	0.5	4	8	1	103	93	41
TAJA105*035#NJ	A	1	35	85	23	125	0.5	4	7.5	1	100	90	40
TAJB105*035#NJ	B	1	35	85	23	125	0.5	4	6.5	1	114	103	46
TAJA155*035#NJ	A	1.5	35	85	23	125	0.5	6	7.5	1	100	90	40
TAJB155*035#NJ	B	1.5	35	85	23	125	0.5	6	5.2	1	128	115	51
TAJC155*035#NJ	C	1.5	35	85	23	125	0.5	6	4.5	1	156	141	63

RATINGS & PART NUMBER REFERENCE

AVX Part No.	Case Size	Capacitance (µF)	Rated Voltage (V)	Rated Temperature (ºC)	Category Voltage (V)	Category Temperature (ºC)	DCL (µA) Max.	DF % Max.	ESR Max. (Ω) @ 100kHz	MSL	100kHz RMS Current (mA)		
											25ºC	85ºC	125ºC
TAJA225*035#NJ	A	2.2	35	85	23	125	0.8	6	4.5	1	129	116	52
TAJB225*035#NJ	B	2.2	35	85	23	125	0.8	6	4.2	1	142	128	57
TAJC225*035#NJ	C	2.2	35	85	23	125	0.8	6	3.5	1	177	160	71
TAJB335*035#NJ	B	3.3	35	85	23	125	1.2	6	3.5	1	156	140	62
TAJC335*035#NJ	C	3.3	35	85	23	125	1.2	6	2.5	1	210	189	84
TAJB475*035#NJ	B	4.7	35	85	23	125	1.6	6	3.1	1	166	149	66
TAJC475*035#NJ	C	4.7	35	85	23	125	1.6	6	2.2	1	224	201	89
TAJD475*035#NJ	D	4.7	35	85	23	125	1.6	6	1.5	1	316	285	126
TAJC685*035#NJ	C	6.8	35	85	23	125	2.4	6	1.8	1	247	222	99
TAJD685*035#NJ	D	6.8	35	85	23	125	2.4	6	1.3	1	340	306	136
TAJC106*035#NJ	C	10	35	85	23	125	3.5	6	1.6	1	262	236	105
TAJD106*035#NJ	D	10	35	85	23	125	3.5	6	1	1	387	349	155
TAJE106*035#NJ	E	10	35	85	23	125	3.5	6	0.9	1[1)]	428	385	171
TAJC156*035#NJ	C	15	35	85	23	125	5.3	6	1.4	1	280	252	112
TAJD156*035#NJ	D	15	35	85	23	125	5.3	6	0.9	1	408	367	163
TAJD226*035#NJ	D	22	35	85	23	125	7.7	6	0.9	1	408	367	163
TAJE226*035#NJ	E	22	35	85	23	125	7.7	6	0.5	1[1)]	574	517	230
TAJD336*035#NJ	D	33	35	85	23	125	11.6	6	0.9	1	408	367	163
TAJE336*035#NJ	E	33	35	85	23	125	11.6	6	0.9	1[1)]	428	385	171
TAJV336*035#NJ	V	33	35	85	23	125	11.6	6	0.5	1[1)]	707	636	283
TAJE476*035#NJ	E	47	35	85	23	125	16.5	6	0.9	1[1)]	428	385	171
TAJV476*035#NJ	V	47	35	85	23	125	16.5	6	0.4	1[1)]	791	712	316
TAJV686*035#NJ	V	68	35	85	23	125	23.8	6	0.5	1[1)]	707	363	283
50 Volt @ 85°C													
TAJA104*050#NJ	A	0.1	50	85	33	125	0.5	4	22	1	58	53	23
TAJA154*050#NJ	A	0.15	50	85	33	125	0.5	4	15	1	71	64	28
TAJB154*050#NJ	B	0.15	50	85	33	125	0.5	4	17	1	71	64	28
TAJA224*050#NJ	A	0.22	50	85	33	125	0.5	4	18	1	65	58	26
TAJB224*050#NJ	B	0.22	50	85	33	125	0.5	4	14	1	78	70	31
TAJA334*050#NJ	A	0.33	50	85	33	125	0.5	4	17	1	66	60	27
TAJB334*050#NJ	B	0.33	50	85	33	125	0.5	4	12	1	84	76	34
TAJA474*050#NJ	A	0.47	50	85	33	125	0.5	4	9.5	1	89	80	36
TAJB474*050#NJ	B	0.47	50	85	33	125	0.7	4	9.5	1	95	85	38
TAJC474*050#NJ	C	0.47	50	85	33	125	0.5	4	8	1	117	106	47
TAJA684*050#NJ	A	0.68	50	85	33	125	0.5	4	7.9	1	97	88	39
TAJB684*050#NJ	B	0.68	50	85	33	125	0.5	4	8	1	103	93	41
TAJC684*050#NJ	C	0.68	50	85	33	125	0.5	4	7	1	125	113	50
TAJA105*050#NJ	A	1	50	85	33	125	0.5	4	6.6	1	107	96	43
TAJB105*050#NJ	B	1	50	85	33	125	0.5	6	7	1	110	99	44
TAJC105*050#NJ	C	1	50	85	33	125	0.5	4	5.5	1	141	127	57
TAJB155*050#NJ	B	1.5	50	85	33	125	0.8	8	5.4	1	125	113	50
TAJC155*050#NJ	C	1.5	50	85	33	125	0.8	6	4.5	1	156	141	63
TAJD155*050#NJ	D	1.5	50	85	33	125	0.8	6	4	1	194	174	77
TAJB225*050#NJ	B	2.2	50	85	33	125	1.1	8	4.5	1	137	124	55
TAJC225*050#NJ	C	2.2	50	85	33	125	1.1	8	2.5	1	210	189	84
TAJD225*050#NJ	D	2.2	50	85	33	125	1.1	6	2.5	1	245	220	98
TAJC335*050#NJ	C	3.3	50	85	33	125	1.6	6	2.5	1	210	189	84
TAJD335*050#NJ	D	3.3	50	85	33	125	1.7	6	2	1	274	246	110
TAJC475*050#NJ	C	4.7	50	85	33	125	0.5	4	1.4	1	280	252	112
TAJD475*050#NJ	D	4.7	50	85	33	125	2.4	6	1.4	1	327	295	131
TAJC685*050#NJ	C	6.8	50	85	33	125	3.4	6	1	1	332	298	133
TAJD685*050#NJ	D	6.8	50	85	33	125	3.4	6	1	1	387	349	155
TAJD106*050#NJ	D	10	50	85	33	125	5	6	0.8	1	433	390	173
TAJE106*050#NJ	E	10	50	85	33	125	5	6	1	1[1)]	406	366	162
TAJV106*050#NJ	V	10	50	85	33	125	5	6	0.65	1[1)]	620	558	248
TAJD156*050#NJ	D	15	50	85	33	125	7.5	6	0.6	1	500	450	200
TAJE156*050#NJ	E	15	50	85	33	125	7.5	6	0.6	1[1)]	524	472	210
TAJV156*050#NJ	V	15	50	85	33	125	7.5	6	0.6	1[1)]	645	581	258
TAJV226*050#NJ	V	22	50	85	33	125	11	8	0.6	1[1)]	645	581	258

1[1)] – Dry pack option (see How to order) recommended for reduction of stress during soldering. Dry pack parts should be treated as MSL 3.

Moisture Sensitivity Level (MSL) is defined according to J-STD-020.

For AEC-Q200 availability, please contact AVX.

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.

For typical weight and composition see page 214.

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.

QUALIFICATION TABLE

TEST	TAJ series (Temperature range -55ºC to +125ºC) Condition	Characteristics	
Endurance	Determine after application of rated voltage for 2000 +48/-0 hours at 85±2ºC and then leaving 1-2 hours at room temperature. Also determine of 125ºC temperature, category voltage for 2000 +48/-0 hours and then leaving 1-2 hours at room temperature. Power supply impedance to be ≤0.1Ω/V.	Visual examination	no visible damage
		DCL	1.25 x initial limit
		ΔC/C	within ±10% of initial value
		DF	initial limit
Humidity	Determine after storage without applied voltage at 65±2ºC and 95±2% relative humidity for 500 hours and then recovery 1-2 hours at room temperature.	Visual examination	no visible damage
		DCL	initial limit
		ΔC/C	within ±10% of initial value
		DF	1.2 x initial limit

Temperature Stability

Step	Temperature°C	Duration(min)
1	+20±2	15
2	-55+0/-3	15
3	+20±2	15
4	+85+3/-0	15
5	+125+3/-0	15
6	+20±2	15

	+20ºC	-55ºC	+20ºC	+85ºC	+125ºC	+20ºC
DCL	IL*	n/a	IL*	10 x IL*	12.5 x IL*	IL*
ΔC/C	n/a	+0/-10%	±5%	+10/-0%	+12/-0%	±5%
DF	IL*	1.5 x IL*	IL*	1.5 x IL*	2 x IL*	IL*

TEST	Condition	Characteristics	
Surge Voltage	Test temperature: 125ºC+3/0ºC Test voltage: Category voltage at 125ºC Surge voltage: 1.3 x category voltage at 125ºC Series protection resistance 1000±100Ω Discharge resistance: 1000Ω Number of cycles: 1000x Cycle duration: 6 min; 30 sec charge, 5 min 30 sec discharge	Visual examination	no visible damage
		DCL	initial limit
		ΔC/C	within ±5% of initial value
		DF	initial limit

*Initial Limit

TAJ Automotive Range

Standard Tantalum - Automotive Product Range

TAJ AUTOMOTIVE RANGE
CAPACITANCE AND RATED VOLTAGE RANGE
(LETTER DENOTES CASE SIZE)

Capacitance		Rated voltage DC (V_R) to 85°C						
μF	Code	6.3V (J)	10V (A)	16V (C)	20V (D)	25V (E)	35V (V)	50V (T)
0.10	104							
0.15	154							
0.22	224							A
0.33	334						A	A
0.47	474					A	A	A/B
0.68	684					A	A	B
1.0	105			A	A	A	A/B	B/C
1.5	155				A	A/B	A/B	C
2.2	225		A	A	A/B	A/B	B/C	C/D
3.3	335	A		A/B	A/B	B	B/C	C/D
4.7	475		A/B	A/B	A/B	B/C	B/C/D	C/D
6.8	685		A/B	A/B	B/C	B/C	C/D	D
10	106	A/B	A/B	A/B/C	B/C	C/D	C/D	D/E
15	156	A	A/B/C	B/C	B/C	C/D	D	E
22	226	A/B/C	A/B/C	B/C/D	C/D	C/D	D/E	
33	336	A/B	B/C	C/D	C/D	D	E	
47	476	B/C	B/C/D	C/D	D	D/E		
68	686	B/C	C/D	C/D	D/E			
100	107	C/D	C/D	D/E	E			
150	157	C/D	D/E	E				
220	227	D	D/E					
330	337	D/E	E					
470	477	D/E						
680	687	E						

Not recommended for new designs, higher voltage or smaller case size substitution are offered.

Released codes

Engineering samples - please contact manufacturer

Note: Voltage ratings are minimum values. AVX reserves the right to supply higher ratings in the same case size, to the same reliability standards.

HOW TO ORDER

TAJ	C	106	M	035	T	NJ	V
Type	**Case Size** 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** 006 = 6.3Vdc 010 = 10Vdc 016 = 16Vdc 020 = 20Vdc 025 = 25Vdc 035 = 35Vdc 050 = 50Vdc	**Packaging** T = Automotive Lead Free 7" Reel U = Automotive Lead Free 13" Reel	**Specification Suffix** NJ = Std Suffix	**Dry Pack Option** (D,E case sizes mandatory)

LEAD-FREE

LEAD-FREE COMPATIBLE COMPONENT

RoHS COMPLIANT

TECHNICAL SPECIFICATIONS

Technical Data:	All technical data relate to an ambient temperature of +25°C							
Capacitance Range:	0.22 μF to 680 μF							
Capacitance Tolerance:	±10%; ±20%							
Rated Voltage (V_R) ≤ +85°C:	6.3	10	16	20	25	35	50	
Category Voltage (V_C) ≤ +125°C:	4	7	10	13	17	23	33	
Surge Voltage (V_S) ≤ +85°C:	8	13	20	26	32	46	65	
Surge Voltage (V_S) ≤ +125°C:	5	8	13	16	20	28	40	
Temperature Range:	-55°C to +125°C							
Environmental Classification:	55/125/56 (IEC 68-2)							
Reliability:	1% per 1000 hours at 85°C, V_R with 0.1Ω/V series impedance, 60% confidence level							
Termination Finished:	Sn Plating (standard), Gold and SnPb Plating upon request							
	Meets requirements of AEC-Q200							

TAJ Automotive Range

Standard Tantalum - Automotive Product Range

RATINGS & PART NUMBER REFERENCE

AVX Part No.	Case Size	Capacitance (µF)	Rated Voltage (V)	Rated Temperature (ºC)	Category Voltage (V)	Category Temperature (ºC)	DCL (µA) Max.	DF % Max.	ESR Max. (Ω) @ 100kHz	MSL	100kHz RMS Current (mA) 25ºC	85ºC	125ºC
6.3 Volt @ 85°C													
TAJA335*006TNJ	A	3.3	6.3	85	4	125	0.5	6	7	1	104	93	41
TAJA106*006TNJ	A	10	6.3	85	4	125	0.6	6	4	1	137	123	55
TAJB106*006TNJ	B	10	6.3	85	4	125	0.6	6	3	1	168	151	67
TAJA156*006TNJ	A	15	6.3	85	4	125	0.9	6	3.5	1	146	132	59
TAJA226*006TNJ	A	22	6.3	85	4	125	1.4	6	3	1	158	142	63
TAJB226*006TNJ	B	22	6.3	85	4	125	1.4	6	2.5	1	184	166	74
TAJC226*006TNJ	C	22	6.3	85	4	125	1.4	6	2	1	235	211	94
TAJA336*006TNJ	A	33	6.3	85	4	125	2.1	8	2.2	1	185	166	74
TAJB336*006TNJ	B	33	6.3	85	4	125	2.1	6	2.2	1	197	177	79
TAJB476*006TNJ	B	47	6.3	85	4	125	3	6	2	1	206	186	82
TAJC476*006TNJ	C	47	6.3	85	4	125	3	6	1.6	1	262	236	105
TAJB686*006TNJ	B	68	6.3	85	4	125	4	8	0.9	1	307	277	123
TAJC686*006TNJ	C	68	6.3	85	4	125	4.3	6	1.5	1	271	244	108
TAJC107*006TNJ	C	100	6.3	85	4	125	6.3	6	0.9	1	350	315	140
TAJD107*006TNJV	D	100	6.3	85	4	125	6.3	6	0.9	3	408	367	163
TAJC157*006TNJ	C	150	6.3	85	4	125	9.5	6	1.3	1	291	262	116
TAJD157*006TNJV	D	150	6.3	85	4	125	9.5	6	0.9	3	408	367	163
TAJD227*006TNJV	D	220	6.3	85	4	125	13.9	8	0.4	3	612	551	245
TAJD337*006TNJV	D	330	6.3	85	4	125	20.8	8	0.4	3	612	551	245
TAJE337*006TNJV	E	330	6.3	85	4	125	20.8	8	0.4	3	642	578	257
TAJD477*006TNJV	D	470	6.3	85	4	125	28	12	0.4	3	612	551	245
TAJE477*006TNJV	E	470	6.3	85	4	125	28	10	0.4	3	642	578	257
TAJE687*006TNJV	E	680	6.3	85	4	125	42.8	10	0.5	3	574	517	230
10 Volt @ 85°C													
TAJA225*010TNJ	A	2.2	10	85	7	125	0.5	6	7	1	104	93	41
TAJA475*010TNJ	A	4.7	10	85	7	125	0.5	6	5	1	122	110	49
TAJB475*010TNJ	B	4.7	10	85	7	125	0.5	6	4	1	146	131	58
TAJA685*010TNJ	A	6.8	10	85	7	125	0.7	6	4	1	137	123	55
TAJB685*010TNJ	B	6.8	10	85	7	125	0.7	6	3	1	168	151	67
TAJA106*010TNJ	A	10	10	85	7	125	1	6	3	1	158	142	63
TAJB106*010TNJ	B	10	10	85	7	125	1	6	2.1	1	201	181	80
TAJA156*010TNJ	A	15	10	85	7	125	1.5	6	3.2	1	153	138	61
TAJB156*010TNJ	B	15	10	85	7	125	1.5	6	2.8	1	174	157	70
TAJC156*010TNJ	C	15	10	85	7	125	1.5	6	2	1	235	211	94
TAJA226*010TNJ	A	22	10	85	7	125	2.2	8	3	1	158	142	63
TAJB226*010TNJ	B	22	10	85	7	125	2.2	6	2.4	1	188	169	75
TAJC226*010TNJ	C	22	10	85	7	125	2.2	6	1.8	1	247	222	99
TAJB336*010TNJ	B	33	10	85	7	125	3.3	6	1.8	1	217	196	87
TAJC336*010TNJ	C	33	10	85	7	125	3.3	6	1.6	1	262	236	105
TAJB476*010TNJ	B	47	10	85	7	125	4.7	8	1	1	292	262	117
TAJC476*010TNJ	C	47	10	85	7	125	4.7	6	1.2	1	303	272	121
TAJD476*010TNJV	D	47	10	85	7	125	4.7	6	0.4	3	612	551	245
TAJC686*010TNJ	C	68	10	85	7	125	6.8	6	1.3	1	291	262	116
TAJD686*010TNJV	D	68	10	85	7	125	6.8	6	0.9	3	408	367	163
TAJC107*010TNJ	C	100	10	85	7	125	10	8	1.2	1	303	272	121
TAJD107*010TNJV	D	100	10	85	7	125	10	6	0.9	3	408	367	163
TAJD157*010TNJV	D	150	10	85	7	125	15	8	0.9	3	408	367	163
TAJE157*010TNJV	E	150	10	85	7	125	15	8	0.9	3	428	385	171
TAJD227*010TNJV	D	220	10	85	7	125	22	8	0.5	3	548	493	219
TAJE227*010TNJV	E	220	10	85	7	125	22	8	0.5	3	574	517	230
TAJE337*010TNJV	E	330	10	85	7	125	33	8	0.9	3	428	385	171
16 Volt @ 85°C													
TAJA105*016TNJ	A	1	16	85	10	125	0.5	4	11	1	83	74	33
TAJA225*016TNJ	A	2.2	16	85	10	125	0.5	6	6.5	1	107	97	43
TAJA335*016TNJ	A	3.3	16	85	10	125	0.5	6	5	1	122	110	49
TAJB335*016TNJ	B	3.3	16	85	10	125	0.5	6	4.5	1	137	124	55
TAJA475*016TNJ	A	4.7	16	85	10	125	0.8	6	4	1	137	123	55
TAJB475*016TNJ	B	4.7	16	85	10	125	0.8	6	3.5	1	156	140	62
TAJA685*016TNJ	A	6.8	16	85	10	125	1.1	6	3.5	1	146	132	59
TAJB685*016TNJ	B	6.8	16	85	10	125	1.1	6	2.5	1	184	166	74
TAJA106*016TNJ	A	10	16	85	10	125	1.6	6	3	1	158	142	63
TAJB106*016TNJ	B	10	16	85	10	125	1.6	6	2.8	1	174	157	70
TAJC106*016TNJ	C	10	16	85	10	125	1.6	6	2	1	235	211	94
TAJB156*016TNJ	B	15	16	85	10	125	2.4	6	2.5	1	184	166	74
TAJC156*016TNJ	C	15	16	85	10	125	2.4	6	1.8	1	247	222	99
TAJB226*016TNJ	B	22	16	85	10	125	3.5	6	2.3	1	192	173	77
TAJC226*016TNJ	C	22	16	85	10	125	3.5	6	1	1	332	298	133
TAJD226*016TNJV	D	22	16	85	10	125	3.5	6	1.1	3	369	332	148
TAJC336*016TNJ	C	33	16	85	10	125	5.3	6	1.5	1	271	244	108
TAJD336*016TNJV	D	33	16	85	10	125	5.3	6	0.9	3	408	367	163

TAJ Automotive Range

Standard Tantalum - Automotive Product Range

RATINGS & PART NUMBER REFERENCE

AVX Part No.	Case Size	Capacitance (µF)	Rated Voltage (V)	Rated Temperature (ºC)	Category Voltage (V)	Category Temperature (ºC)	DCL (µA) Max.	DF % Max.	ESR Max. (Ω) @ 100kHz	MSL	100kHz RMS Current (mA)		
											25ºC	85ºC	125ºC
TAJC476*016TNJ	C	47	16	85	10	125	7.5	6	0.5	1	469	422	188
TAJD476*016TNJV	D	47	16	85	10	125	7.5	6	0.9	3	408	367	163
TAJC686*016TNJ	C	68	16	85	10	125	10.9	6	1.3	1	291	262	116
TAJD686*016TNJV	D	68	16	85	10	125	10.9	6	0.9	3	408	367	163
TAJD107*016TNJV	D	100	16	85	10	125	16	6	0.6	3	500	450	200
TAJE107*016TNJV	E	100	16	85	10	125	16	6	0.9	3	428	385	171
TAJE157*016TNJV	E	150	16	85	10	125	23	8	0.3	3	742	667	297
20 Volt @ 85°C													
TAJA105*020TNJ	A	1	20	85	13	125	0.5	4	9	1	91	82	37
TAJA155*020TNJ	A	1.5	20	85	13	125	0.5	6	6.5	1	107	97	43
TAJA225*020TNJ	A	2.2	20	85	13	125	0.5	6	5.3	1	119	107	48
TAJB225*020TNJ	B	2.2	20	85	13	125	0.5	6	3.5	1	156	140	62
TAJA335*020TNJ	A	3.3	20	85	13	125	0.7	6	4.5	1	129	116	52
TAJB335*020TNJ	B	3.3	20	85	13	125	0.7	6	3	1	168	151	67
TAJA475*020TNJ	A	4.7	20	85	13	125	0.9	6	4	1	137	123	55
TAJB475*020TNJ	B	4.7	20	85	13	125	0.9	6	3	1	168	151	67
TAJB685*020TNJ	B	6.8	20	85	13	125	1.4	6	2.5	1	184	166	74
TAJC685*020TNJ	C	6.8	20	85	13	125	1.4	6	2	1	235	211	94
TAJB106*020TNJ	B	10	20	85	13	125	2	6	2.1	1	201	181	80
TAJC106*020TNJ	C	10	20	85	13	125	2	6	1.2	1	303	272	121
TAJB156*020TNJ	B	15	20	85	13	125	3	6	2	1	206	186	82
TAJC156*020TNJ	C	15	20	85	13	125	3	6	1.7	1	254	229	102
TAJC226*020TNJ	C	22	20	85	13	125	4.4	6	1.6	1	262	236	105
TAJD226*020TNJV	D	22	20	85	13	125	4.4	6	0.9	3	408	367	163
TAJC336*020TNJ	C	33	20	85	13	125	6.6	6	1.5	1	271	244	108
TAJD336*020TNJV	D	33	20	85	13	125	6.6	6	0.9	3	408	367	163
TAJD476*020TNJV	D	47	20	85	13	125	9.4	6	0.9	3	408	367	163
TAJD686*020TNJV	D	68	20	85	13	125	13.6	6	0.4	3	612	551	245
TAJE686*020TNJV	E	68	20	85	13	125	13.6	6	0.9	3	428	385	171
TAJE107*020TNJV	E	100	20	85	13	125	20	6	0.4	3	642	578	257
25 Volt @ 85°C													
TAJA474*025TNJ	A	0.47	25	85	17	125	0.5	4	14	1	73	66	29
TAJA684*025TNJ	A	0.68	25	85	17	125	0.5	4	10	1	87	78	35
TAJA105*025TNJ	A	1	25	85	17	125	0.5	4	8	1	97	87	39
TAJA155*025TNJ	A	1.5	25	85	17	125	0.5	6	7.5	1	100	90	40
TAJA225*025TNJ	A	2.2	25	85	17	125	0.6	6	7	1	104	93	41
TAJB155*025TNJ	B	1.5	25	85	17	125	0.5	6	5	1	130	117	52
TAJB225*025TNJ	B	2.2	25	85	17	125	0.6	6	4.5	1	137	124	55
TAJB335*025TNJ	B	3.3	25	85	17	125	0.8	6	3.5	1	156	140	62
TAJB475*025TNJ	B	4.7	25	85	17	125	1.2	6	1.5	1	238	214	95
TAJC475*025TNJ	C	4.7	25	85	17	125	1.2	6	2.4	1	214	193	86
TAJB685*025TNJ	B	6.8	25	85	17	125	1.7	6	2.8	1	174	157	70
TAJC685*025TNJ	C	6.8	25	85	17	125	1.7	6	2	1	235	211	94
TAJC106*025TNJ	C	10	25	85	17	125	2.5	6	1.8	1	247	222	99
TAJD106*025TNJV	D	10	25	85	17	125	2.5	6	1.2	3	354	318	141
TAJC156*025TNJ	C	15	25	85	17	125	3.8	6	1.6	1	262	236	105
TAJD156*025TNJV	D	15	25	85	17	125	3.8	6	1	3	387	349	155
TAJC226*025TNJ	C	22	25	85	17	125	5.5	6	1.4	1	280	252	112
TAJD226*025TNJV	D	22	25	85	17	125	5.5	6	0.9	3	408	367	163
TAJD336*025TNJV	D	33	25	85	17	125	8.3	6	0.9	3	408	367	163
TAJD476*025TNJV	D	47	25	85	17	125	11.8	6	0.9	3	408	367	163
TAJE476*025TNJV	E	47	25	85	17	125	11.8	6	0.9	3	428	385	171
35 Volt @ 85°C													
TAJA334*035TNJ	A	0.33	35	85	23	125	0.5	4	15	1	71	64	28
TAJA474*035TNJ	A	0.47	35	85	23	125	0.5	4	12	1	79	71	32
TAJA684*035TNJ	A	0.68	35	85	23	125	0.5	4	8	1	97	87	39
TAJA105*035TNJ	A	1	35	85	23	125	0.5	4	7.5	1	100	90	40
TAJB105*035TNJ	B	1	35	85	23	125	0.5	4	6.5	1	114	103	46
TAJA155*035TNJ	A	1.5	35	85	23	125	0.5	6	7.5	1	100	90	40
TAJB155*035TNJ	B	1.5	35	85	23	125	0.5	6	5.2	1	128	115	51
TAJB225*035TNJ	B	2.2	35	85	23	125	0.8	6	4.2	1	142	128	57
TAJC225*035TNJ	C	2.2	35	85	23	125	0.8	6	3.5	1	177	160	71
TAJB335*035TNJ	B	3.3	35	85	23	125	1.2	6	3.5	1	156	140	62
TAJC335*035TNJ	C	3.3	35	85	23	125	1.2	6	2.5	1	210	189	84
TAJB475*035TNJ	B	4.7	35	85	23	125	1.6	6	3.1	1	166	149	66
TAJC475*035TNJ	C	4.7	35	85	23	125	1.6	6	2.2	1	224	201	89
TAJD475*035TNJV	D	4.7	35	85	23	125	1.6	6	1.5	3	316	285	126
TAJC685*035TNJ	C	6.8	35	85	23	125	2.4	6	1.8	1	247	222	99
TAJD685*035TNJV	D	6.8	35	85	23	125	2.4	6	1.3	3	340	306	136
TAJC106*035TNJ	C	10	35	85	23	125	3.5	6	1.6	1	262	236	105
TAJD106*035TNJV	D	10	35	85	23	125	3.5	6	1	3	387	349	155

TAJ Automotive Range

Standard Tantalum - Automotive Product Range

RATINGS & PART NUMBER REFERENCE

AVX Part No.	Case Size	Capacitance (µF)	Rated Voltage (V)	Rated Temperature (ºC)	Category Voltage (V)	Category Temperature (ºC)	DCL (µA) Max.	DF % Max.	ESR Max. (Ω) @ 100kHz	MSL	100kHz RMS Current (mA) 25ºC	85ºC	125ºC
TAJD156*035TNJV	D	15	35	85	23	125	5.3	6	0.9	3	408	367	163
TAJD226*035TNJV	D	22	35	85	23	125	7.7	6	0.9	3	408	367	163
TAJE226*035TNJV	E	22	35	85	23	125	7.7	6	0.5	3	574	517	230
TAJE336*035TNJV	E	33	35	85	23	125	11.6	6	0.9	3	428	385	171
50 Volt @ 85°C													
TAJA224*050TNJ	A	0.22	50	85	33	125	0.5	4	18	1	65	58	26
TAJA334*050TNJ	A	0.33	50	85	33	125	0.5	4	17	1	66	60	27
TAJA474*050TNJ	A	0.47	50	85	33	125	0.5	4	9.5	1	89	80	36
TAJB474*050TNJ	B	0.47	50	85	33	125	0.7	4	9.5	1	95	85	38
TAJB684*050TNJ	B	0.68	50	85	33	125	0.5	4	8	1	103	93	41
TAJB105*050TNJ	B	1	50	85	33	125	0.5	6	7	1	110	99	44
TAJC105*050TNJ	C	1	50	85	33	125	0.5	4	5.5	1	141	127	57
TAJC155*050TNJ	C	1.5	50	85	33	125	0.8	6	4.5	1	156	141	63
TAJC225*050TNJ	C	2.2	50	85	33	125	1.1	8	2.5	1	210	189	84
TAJD225*050TNJV	D	2.2	50	85	33	125	1.1	6	2.5	3	245	220	98
TAJC335*050TNJ	C	3.3	50	85	33	125	1.6	6	2.5	1	210	189	84
TAJD335*050TNJV	D	3.3	50	85	33	125	1.7	6	2	3	274	246	110
TAJC475*050TNJ	C	4.7	50	85	33	125	0.5	4	1.4	1	280	252	112
TAJD475*050TNJV	D	4.7	50	85	33	125	2.4	6	1.4	3	327	295	131
TAJD685*050TNJV	D	6.8	50	85	33	125	3.4	6	1	3	387	349	155
TAJD106*050TNJV	D	10	50	85	33	125	5	6	0.8	3	433	390	173
TAJE106*050TNJV	E	10	50	85	33	125	5	6	1	3	406	366	162
TAJE156*050TNJV	E	15	50	85	33	125	7.5	6	0.6	3	524	472	210

Moisture Sensitivity Level (MSL) is defined according to J-STD-020

*Please use "U" instead of "T" in the suffix letter for 13'' reel packaging

Please use specific PN for automotive version – see "HOW TO ORDER".

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.

For typical weight and composition see page 214.

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.

QUALIFICATION TABLE

TEST	TAJ automotive series (Temperature range -55ºC to +125ºC) Condition	Characteristics	
Endurance	Determine after application of rated voltage for 2000 +48/-0 hours at 85±2ºC and then leaving 1-2 hours at room temperature. Also determine of 125ºC temperature, category voltage for 2000 +48/-0 hours and then leaving 1-2 hours at room temperature. Power supply impedance to be ≤0.1Ω/V.	Visual examination	no visible damage
		DCL	1.25 x initial limit
		ΔC/C	within ±10% of initial value
		DF	initial limit
		ESR	initial limit
Storage Life	125ºC, 0V, 2000h	Visual examination	no visible damage
		DCL	1.25 x initial limit
		ΔC/C	within ±10% of initial value
		DF	initial limit
		ESR	initial limit
Humidity	Determine after storage without applied voltage at 65±2ºC and 95±2% relative humidity for 500 hours and then recovery 1-2 hours at room temperature.	Visual examination	no visible damage
		DCL	1.5 x initial limit
		ΔC/C	within ±10% of initial value
		DF	1.2 x initial limit
		ESR	initial limit
Biased Humidity	Determine after leaving for 1000 hours at 85±2ºC, 85% relative humidity and rated voltage and then recovery 1-2 hours at room temperature.	Visual examination	no visible damage
		DCL	2 x initial limit
		ΔC/C	within ±10% of initial value
		DF	1.2 x initial limit
		ESR	initial limit

Temperature Stability — Condition:

Step	Temperature°C	Duration(min)
1	+20±2	15
2	-55+0/-3	15
3	+20±2	15
4	+85+3/-0	15
5	+125+3/-0	15
6	+20±2	15

Temperature Stability — Characteristics:

	+20ºC	-55ºC	+20ºC	+85ºC	+125ºC	+20ºC
DCL	IL*	n/a	IL*	10 x IL*	12.5 x IL*	IL*
ΔC/C	n/a	+0/-10%	±5%	+10/-0%	+12/-0%	±5%
DF	IL*	1.5 x IL*	IL*	1.5 x IL*	2 x IL*	IL*
ESR	IL*	2 x IL*	IL*	IL*	IL*	IL*

TEST	Condition	Characteristics	
Surge Voltage	Test temperature: 125ºC+3/0ºC Test voltage: Category voltage at 125ºC Surge voltage: 1.3 x category voltage at 125ºC Series protection resistance 1000±100Ω Discharge resistance: 1000Ω Number of cycles: 1000x Cycle duration: 6 min; 30 sec charge, 5 min 30 sec discharge	Visual examination	no visible damage
		DCL	initial limit
		ΔC/C	within ±5% of initial value
		DF	initial limit
		ESR	initial limit

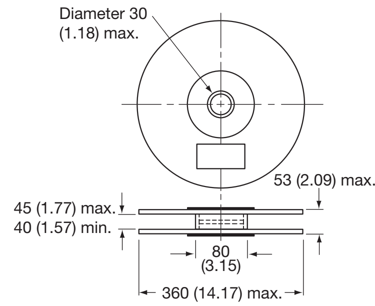
*Initial Limit

SOLID TANTALUM RESIN DIPPED TAP/TEP

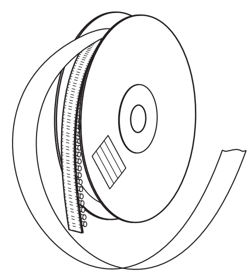
CASE DIMENSIONS: millimeters (inches)

Description	Code	Dimension
Feed hole pitch	P	12.7 ± 0.30 (0.500 ± 0.010)
Hole center to lead	P_1	3.85 ± 0.70 (0.150 ± 0.030) to be measured at bottom of clench
		5.05 ± 1.00 (0.200 ± 0.040) for S wire
Hole center to component center	P_2	6.35 ± 0.40 (0.250 ± 0.020)
Change in pitch	Δp	± 1.00 (± 0.040)
Lead diameter	d	0.50 ± 0.05 (0.020 ± 0.003)
Lead spacing	S	See wire form table
Component alignment	Δh	0 ± 2.00 (0 ± 0.080)
Feed hole diameter	D	4.00 ± 0.20 (0.150 ± 0.008)
Tape width	W	18.0 + 1.00 - 0.50 (0.700 + 0.040 - 0.020)
Hold down tape width	W_1	6.00 (0.240) min.
Hold down tape position	W_2	1.00 (0.040) max.
Lead wire clench height	H	16.0 ± 0.50 (0.630 ± 0.020) 19.0 ± 1.00 (0.750 ± 0.040) on request
Hole position	H_1	9.00 ± 0.50 (0.350 ± 0.020)
Base of component height	H_2	18.0 (0.700) min. (S wire only)
Component height	H_3	32.25 (1.300) max.
Length of snipped lead	L	11.0 (0.430) max.
Total tape thickness	T	0.70 ± 0.20 (0.030 ± 0.001)
		Carrying card 0.50 ± 0.10 (0.020 ± 0.005)

REEL CONFIGURATION AND DIMENSIONS: millimeters (inches)



Manufactured from cardboard with plastic hub.



Holding tape outside. Positive terminal leading.

PACKAGING QUANTITIES

For Reels

Style	Case size	No. of pieces
TAP TEP	A	1500
	B, C, D	1250
	E, F	1000
	G, H, J	750
	K, L, M, N, P, R	500

For 'Ammo' pack

Style	Case size	No. of pieces
TAP TEP	A, B, C, D	3000
	E, F, G	2500
	H, J	2000
	K, L, M, N, P, R	1000

For bulk products

Style	Case size	No. of pieces
TAP TEP	A to H	1000
	J to L	500
	M to R	100

AMMO PACK DIMENSIONS

millimeters (inches) max.

Height 360 (14.17), width 360 (14.17), thickness 60 (2.36)

GENERAL NOTES

Resin dipped tantalum capacitors are only available taped in the range of case sizes and in the modular quantities by case size as indicated.

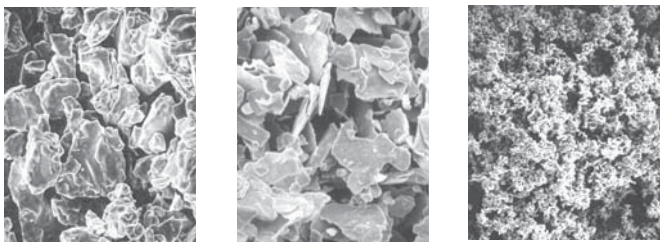
Packaging quantities on tape may vary by ±1%.

Section 4: Technical Summary and Application Guidelines

INTRODUCTION

Tantalum capacitors are manufactured from a powder of pure tantalum metal. OxiCap® - niobium oxide capacitor is made from niobium oxide NbO powder. 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/g.



4000µFV **20000µFV** **50000µFV**

Figure 1a. Tantalum powder

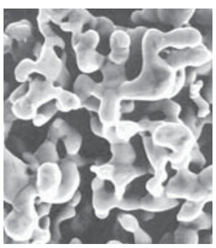


Figure 1b. Niobium Oxide powder

The powder is compressed under high pressure around a Tantalum or Niobium 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 1200 - 1800°C) which produces a mechanically strong pellet and drives off any impurities within the powder.

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/g (capacitance voltage product per gram) powders, which have a low average particle size, are used for low voltage, high capacitance parts.

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

The following example uses a 220µF 6V capacitor to illustrate the point.

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

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

ε_r is the relative dielectric constant

= 27 for Tantalum Pentoxide

= 41 for Niobium Pentoxide

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:

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

thus for a 220µF/6V capacitor the surface area is 346 square centimeters, or nearly a half times the size of this page.

The dielectric is then formed over all the Tantalum or niobium oxide surfaces by the electrochemical process of anodization. To activate 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.

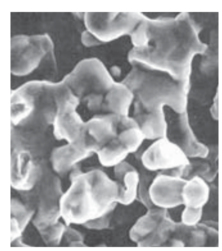


Figure 2. Sintered Anode

The chemical equations describing the process are as follows:

Tantalum Anode: $2\ Ta \rightarrow 2\ Ta^{5+} + 10\ e^-$
$2\ Ta^{5+} + 10\ OH^- \rightarrow Ta_2O_5 + 5\ H_2O$

Niobium Oxide Anode:
$2\ NbO \rightarrow 2\ NbO^{3+} + 6\ e^-$
$2\ NbO^{3+} + 6\ OH^- \rightarrow Nb_2O_5 + 3\ H_2O$

Cathode:

Tantalum: $10\ H_2O - 10\ e \rightarrow 5H_2 + 10\ OH^-$

Niobium Oxide: $6\ H_2O - 6\ e^- \rightarrow 3H_2 + 6\ OH^-$

The oxide forms on the surface of the Tantalum or Niobium Oxide but it also grows into the material. 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 & Niobium Oxide capacitors with present technology powders (see Figure 3).

The dielectric operates under high electrical stress. Consider a 220µF 6V part:

Formation voltage = Formation Ratio x Working Voltage
= 3.5 x 6
= 21 Volts

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

Dielectric thickness (d) = $21 \times 1.7 \times 10^{-9}$
= 0.036 µm

Electric Field strength = Working Voltage / d
= 167 KV/mm

Niobium Oxide:
The niobium oxide (Nb_2O_5) dielectric grows at a rate of 2.4×10^{-9} m/V

Dielectric thickness (d) = $21 \times 2.4 \times 10^{-9}$
= 0.050 µm

Electric Field strength = Working Voltage / d
= 120 KV/mm

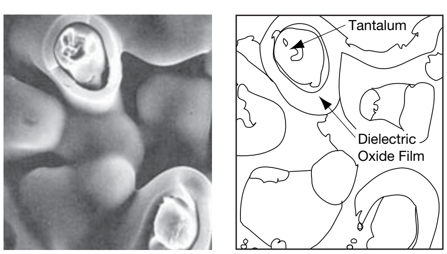


Figure 3. Dielectric layer

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:

$$Mn\ (NO_3)_2 \rightarrow MnO_2 + 2NO_2\ -$$

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.

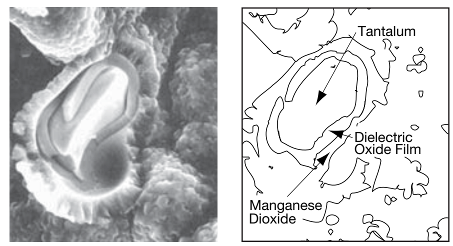


Figure 4. Manganese Dioxide Layer

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 subdivided into four basic groups: Chip / Resin dipped / Rectangular boxed / Axial.

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

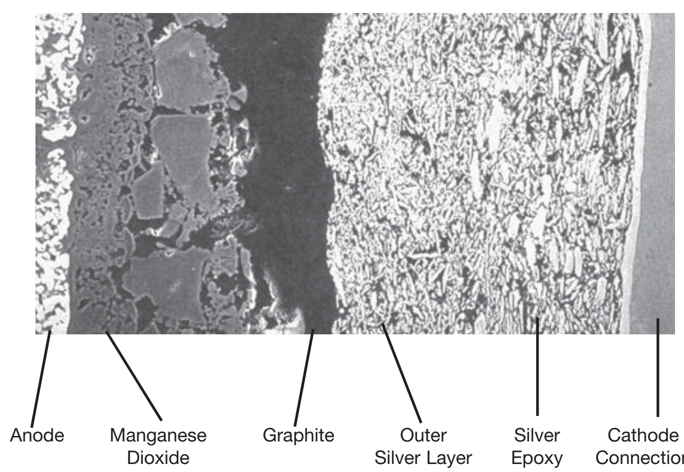


Figure 5. Cathode Termination

SECTION 1
ELECTRICAL CHARACTERISTICS AND EXPLANATION OF TERMS

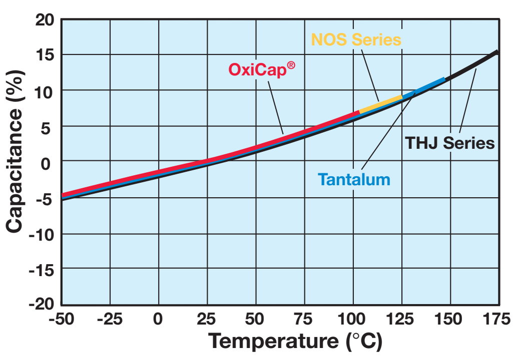
1.1 CAPACITANCE

1.1.1 Rated capacitance (C_R).
This is the nominal rated capacitance. For tantalum and OxiCap® capacitors it is measured as the capacitance of the equivalent series circuit at 25°C using a measuring bridge supplied by a 0.5V rms 120Hz sinusoidal signal, free of harmonics with a 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.

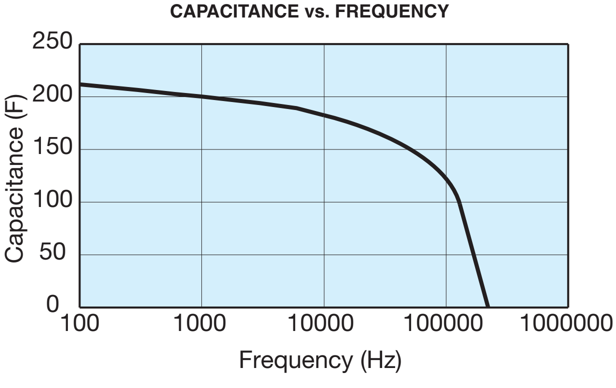
TYPICAL CAPACITANCE vs. TEMPERATURE



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



For individual part number please refer to SpiTan Software for frequency and temperature behavior found on AVX Corporation website.

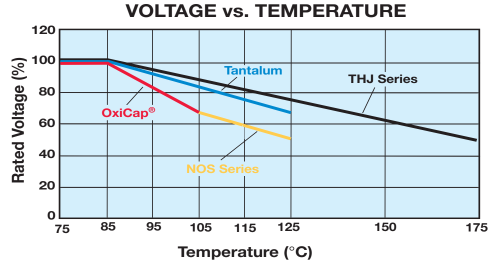
1.2 VOLTAGE

1.2.1 Rated d.c. voltage (V_R).
This is the rated d.c. voltage for continuous operation up to 85°C (up to 40°C for TLJ, TLN, NLJ series).

Operating voltage consists of the sum of DC bias voltage and ripple peak voltage. The peak voltage should not exceed the category voltage. For recommended voltage (application) derating refer to figure 2c of the SECTION 3.

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 (up to 40°C for TLJ, TLN, NLJ series), beyond which it is subject to a linear derating, to 2/3 V_R at 125°C for tantalum and 2/3 V_R at 105°C for OxiCap®.

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 33Ohms (CECC states 1kΩ). 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 Tantalum		125°C Tantalum*	
Rated Voltage V_R	Surge Voltage V_S	Category Voltage V_C	Surge Voltage V_S
2	2.7	1.3	1.7
2.5	3.3	1.7	2.2
3	3.9	2	2.6
4	5.2	2.7	3.4
5	6.5	3.3	4
6.3	8	4	5
10	13	7	8
16	20	10	13
20	26	13	16
25	32	17	20
35	46	23	28
50	65	33	40

85°C OxiCap®		105°C OxiCap®	
Rated Voltage V_R	Surge Voltage V_S	Category Voltage V_C	Surge Voltage V_S
1.8	2.3	1.2	1.6
2.5	3.3	1.7	2.2
4	5.2	2.7	3.4
6.3	8	4	5
10	13	7	8

*For THJ 175°C Category & Surge voltage see THJ section on pages 152-155.

1.2.4 Effect of surges

The solid Tantalum and OxiCap® capacitors have 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 6 volt tantalum capacitor has an Electrical Field of 167 kV/mm when operated at rated voltage. OxiCap® capacitors operate at electrical field significantly less than 167 kV/mm.

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

Solid tantalum capacitors and OxiCap® 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 increases the reliability of the component. (See Figure 2b page 205). The "AVX Recommended Derating Table" (page 207) summarizes voltage rating for use on common voltage rails, in low impedance applications for both Tantalum and OxiCap® capacitors.

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 on tantalum capacitors. OxiCap® capacitors can be used with derating of 20% minimum.

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:

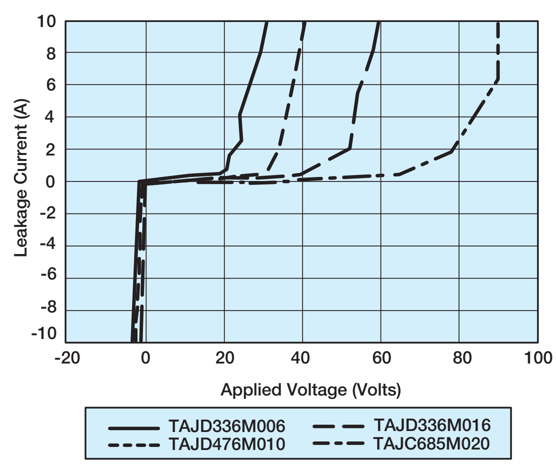
10% of the rated d.c. working voltage to a maximum of 1.0v at 25°C

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

1% of the rated d.c. working voltage to a maximum of 0.1v at 125°C (0.1v at 150°C THJ Series)

Note: Capacitance and DF values of OxiCap® may exceed specification limits under these conditions.

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 superimposed a.c. voltage must not exceed the category voltage, v.c.

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 capacitor and is a factor in setting the rated voltage.

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

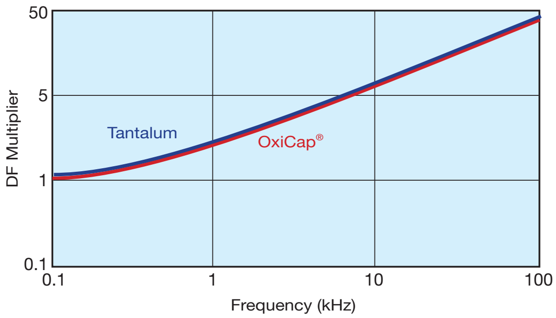
1.3.1 Dissipation factor (D.F.).
Dissipation factor is the measurement of the tangent of the loss angle (tan δ) expressed as a percentage. The measurement of DF is carried out using a measuring bridge that supplies a 0.5V rms 120Hz sinusoidal signal, free of harmonics with a bias of 2.2Vdc. The value 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 that supplies a 0.5V rms 120Hz sinusoidal signal, free of harmonics with a bias of 2.2Vdc.

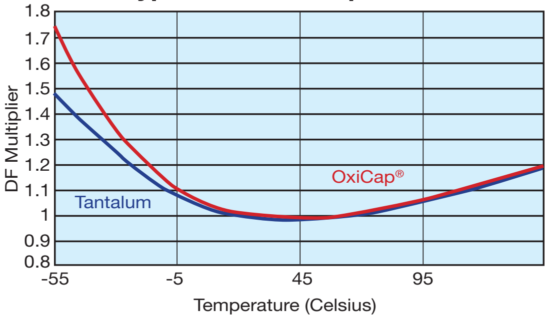
1.3.3 Frequency dependence of Dissipation Factor.
Dissipation Factor increases with frequency as shown in the typical curves that are for tantalum and OxiCap® capacitors identical:

Typical DF vs Frequency



1.3.4 Temperature dependence of Dissipation Factor.
Dissipation factor varies with temperature as the typical curves show. These plots are identical for both Tantalum and OxiCap® capacitors. 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 25°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;

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

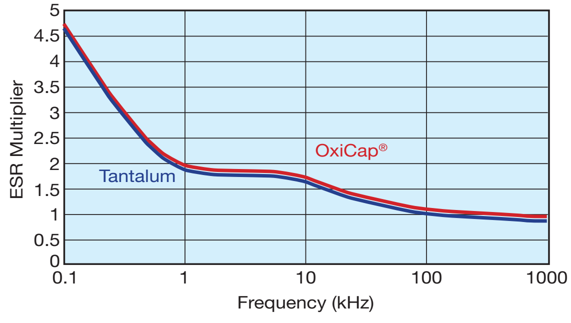
Where f is the frequency in Hz, and C is the capacitance in farads.

The ESR is measured at 25°C and 100kHz.

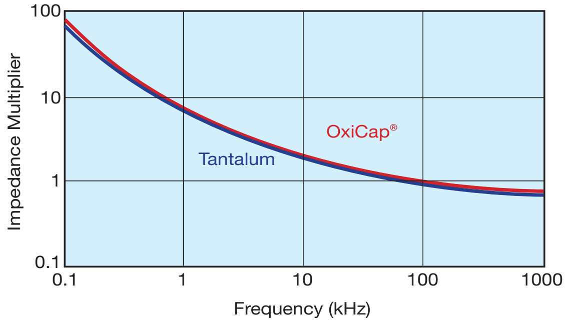
ESR is one of the contributing factors to impedance, and at high frequencies (100kHz and above) it becomes the dominant factor. Thus ESR and impedance become almost identical, impedance being only marginally higher.

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 and Impedance values are similar for both tantalum and niobium oxide materials and thus the same charts are valid for both for Tantalum and OxiCap® capacitors.

Typical ESR vs Frequency



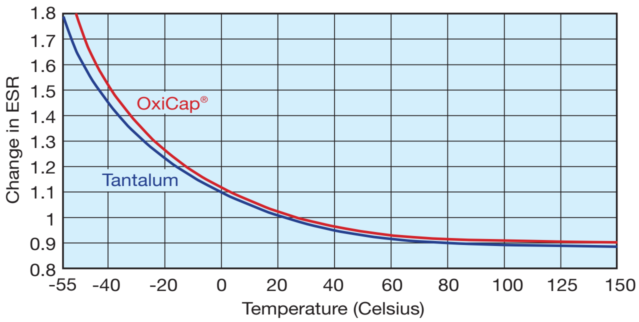
Typical Impedance vs Frequency



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. Leakage current is referenced as DCL (for Direct Current Leakage). The default maximum limit for DCL Current is given by DCL = 0.01CV, where DCL is in microamperes, and C is the capacitance rating in microfarads, and V is the voltage rating in volts. DCL of tantalum capacitors vary within arrange of 0.01 - 0.1CV or 0.5μA (whichever is the greater). And 0.02 - 0.1CV or 1.0μA (whichever is the greater) for OxiCap® capacitors.

Reforming of Tantalum or OxiCap® capacitors is unnecessary even after prolonged storage periods without the application of voltage.

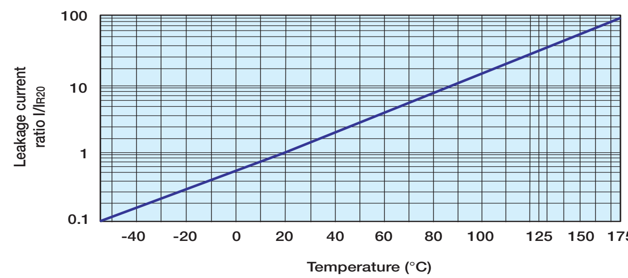
1.5.2 Temperature dependence of the leakage current.

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.

$$V_{max} = \left(1 - \frac{(T - 85)}{125}\right) \times V_R$$

where T is the required operating temperature.

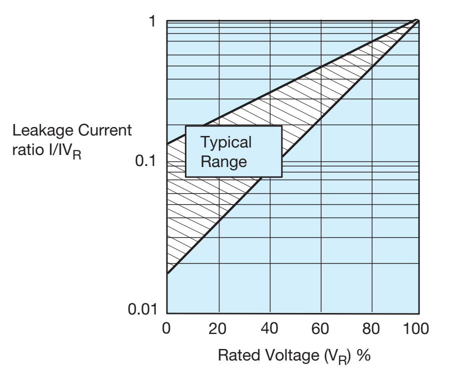
LEAKAGE CURRENT vs. TEMPERATURE



1.5.3 Voltage dependence of the leakage current.

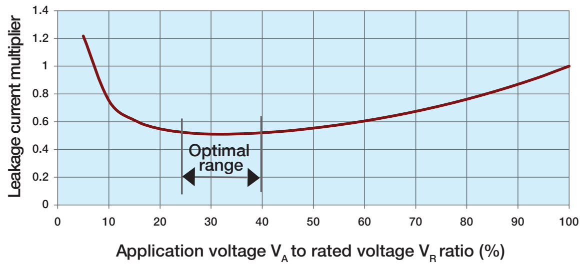
The leakage current drops rapidly below the value corresponding to the rated voltage V_R when reduced voltages are applied. The effect of voltage derating on the leakage current is shown in the graph. This will also give a significant increase in the reliability for any application. See Section 3.1 (page 205) for details.

LEAKAGE CURRENT vs. RATED VOLTAGE



For input condition of fixed application voltage and including median curve of the Leakage current vs. Rated voltage graph displayed above we can evaluate following curve.

LEAKAGE CURRENT MULTIPLIER **vs.** VOLTAGE DERATING **for** FIXED APPLICATION VOLTAGE V_A



We can identify the range of V_A/V_R (derating) values with minimum actual DCL as the "optimal" range. Therefore the minimum DCL is obtained when capacitor is used at 25 to 40 % of rated voltage - when the rated voltage of the capacitor is 2.5 to 4 times higher than actual application 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, pages 202-203).

1.6 SELF INDUCTANCE (ESL)

The self-inductance value (ESL) can be important for resonance frequency evaluation. See figure below typical ESL values per case size.

TAJ/TMJ/TPS/TRJ/THJ/TLJ/TCJ/TCR/NLJ/NOJ/NOS

Case Size	Typical Self Inductance value (nH)	Case Size	Typical Self Inductance value (nH)	Case Size	Typical Self Inductance value (nH)
A	1.8	H	1.8	U	2.4
B	1.8	K	1.8	V	2.4
C	2.2	N	1.4	W	2.2
D	2.4	P	1.4	X	2.4
E	2.5	R	1.4	Y	2.4
F	2.2	S	1.8		
G	1.8	T	1.8		

TAC/TLC/TPC

Case Size	Typical Self-Inductance value (nH)
A	1.5
B	1.6
D	1.4
E	1.0
H	1.4
J	1.2
K	1.1
L	1.2
M	1.3
R	1.4
T	1.6
U	1.3
V	1.5
Z	1.1

TCM/TPM TRM/NOM

Case Size	Typical Self-Inductance value (nH)
D	1.0
E	2.5
V	2.4
Y	1.0

TLN/TCN

Case Size	Typical Self-Inductance value (nH)
K	1.0
L	1.0
M	1.3
N	1.3
S	1.0
T	1.0
4	2.2
6	2.5

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)

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

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

From the Ohms' law equation:

$U_{max} = IR$ .....(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/TMJ/TPS/TPM/TRJ/TRM/THJ/TLJ/TLN/TCJ/TCM TCN/NLJ/NOJ/NOS/NOM Series Molded Chip

Case Size	Max. power dissipation (W)						
	Tantalum					OxiCap®	
	TAJ/TMJ/TPS TRJ/THJ TLJ	TLN	TPM TRM	TCJ TCN TCR	TCM	NLJ NOJ NOS	NOM
A	0.075	—	—	0.100	–	0.090	—
B	0.085	—	—	0.125	–	0.102	—
C	0.110	—	—	0.175	–	0.132	—
D	0.150	—	0.255	0.225	0.355	0.180	—
E	0.165	—	0.270	0.250	0.410	0.198	0.324
F	0.100	—	—	0.150	–	0.120	—
G	0.070	0.060	—	0.100	–	0.084	—
H	0.080	0.070	—	0.100	–	0.096	—
K	0.065	0.055	—	0.090	–	0.078	—
L	0.070	0.060	—	0.095	–	0.084	—
M	—	0.040	—	0.080	–	—	—
N	0.050	0.040	—	0.080	–	—	—
P	0.060	—	—	0.090	–	0.072	—
R	0.055	–	—	0.085	–	0.066	—
S	0.065	0.055	—	0.095	–	0.078	—
T	0.080	0.070	—	0.100	–	0.096	—
U	0.165	—	—	0.380	–	—	—
V	0.250	—	0.285	0.360	0.420	0.300	—
W	0.090	—	—	0.130	–	0.108	—
X	0.100	—	—	0.175	–	0.120	—
Y	0.125	0.115	0.210	0.185	0.310	0.150	—
4	—	0.165	—	0.190	–	—	—
6	—	0.230	—	–	–	—	—

TACmicrochip® Series

Case Size	Max. power dissipation (W)
A	0.040
B	0.040
D	0.035
E	0.010
H	0.040
J	0.020
K	0.015
L	0.025
M	0.030
Q	0.040
R	0.045
T	0.040
U	0.035
V	0.035
X	0.040
Z	0.020

NLJ/NOJ/NOS/NOM

Temperature correction factor for ripple current	
Temp. °C	Factor
+25	1.00
+55	0.95
+85	0.90
+105	0.40
+125 (NOS,NOM)	0.40

TAJ/TPS/TPM/TRJ/TRM/THJ/TLJ/TLN

Temp °C	Correction Factor for ripple current	Correction Factor for Power Dissipation	Max. Temperature rise °C
+25	1.00	1.00	10
+55	0.95	0.90	9
+85	0.90	0.81	8.1
+105	0.65	0.42	4.2
+115	0.49	0.24	2.4
+125	0.40	0.16	1.6
+175 (THJ)	0.20	0.04	0.4
+200 (THJ)	0.10	0.01	0.1

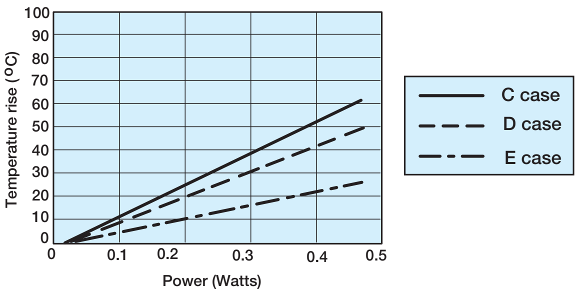
TCJ/TCM/TCN/TCR

Temp °C	Correction Factor for ripple current	Correction Factor for Power Dissipation	Max. Temperature rise °C
+25	1.00	1.00	30
+85	0.70	0.49	15
+105	0.45	0.20	6
+125	0.25	0.06	1.8

Technical Summary and Application Guidelines

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 thermo-couple attached to the capacitor's surface.

Results for the C, D and E case sizes



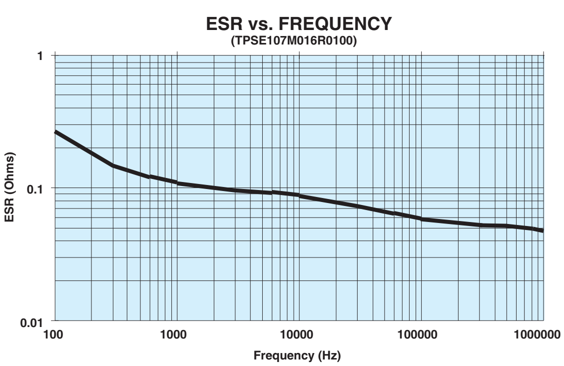
Several capacitors were tested and the combined results are shown above. All these capacitors were measured on FR4 board, with no other heat sinking. The ripple was supplied at various frequencies from 1kHz to 1MHz.

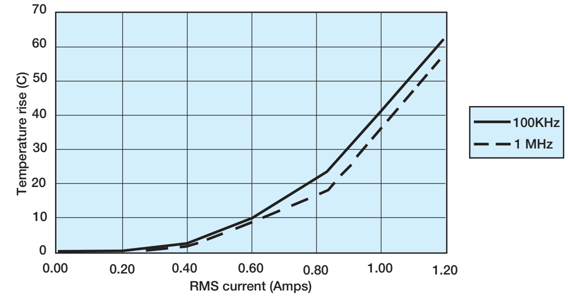
As can be seen in the figure above, the average P_{max} value for the C case capacitors was 0.11 Watts. This is the same as that quoted in Table I.

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 that was much higher than the 0.165 Watts from Table I.

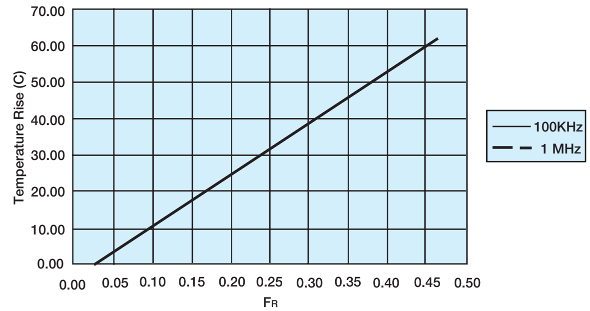
If a typical capacitor's ESR with frequency is considered, e.g. figure below, it can be seen that there is variation. Thus for a set ripple current, the amount of power to be dissipated by the capacitor will vary with frequency. This is clearly shown in figure in top of next column, which shows that the surface temperature of the unit raises 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) $Irms^2$ 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 OxiCap® RIPPLE RATING

OxiCap® capacitors showing 20% higher power dissipation allowed compared to tantalum capacitors as a result of twice higher specific heat of niobium oxide compared to Tantalum powders. (Specific heat is related to energy necessary to heat a defined volume of material to a specified temperature.)

2.3 THERMAL MANAGEMENT

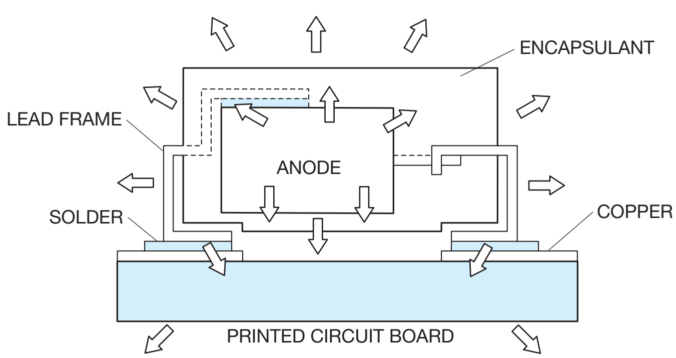
The heat generated inside a tantalum capacitor in a.c. operation comes from the power dissipation due to ripple current. It is equal to I^2R, where I is the rms value of the current at a given frequency, and R is the ESR at the same frequency with an additional contribution due to the leakage current. 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 (page 202) are based on free-air calculations. These ratings can be approached if efficient heat sinking and/or forced cooling is used.

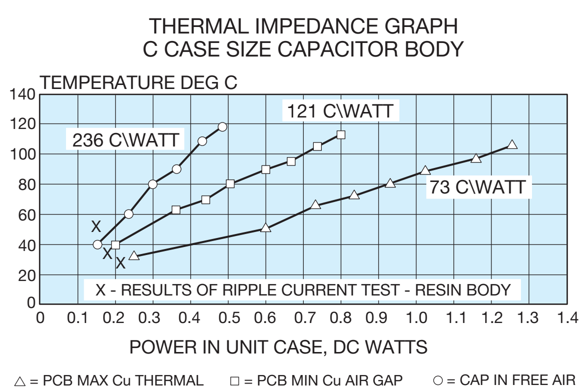
In practice, in a high density assembly with no specific thermal management, the power dissipation required to give a 10°C rise above ambient may be up to a factor of 10 less. In these cases, the actual capacitor temperature should be established (either by thermocouple probe or infra-red scanner) and 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

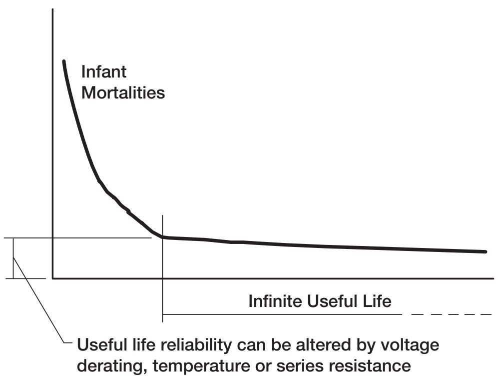


SECTION 3
RELIABILITY AND CALCULATION OF FAILURE RATE

3.1 STEADY-STATE

Both Tantalum and Niobium Oxide dielectric have 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 and OxiCap® Reliability Curve



The useful life reliability of the Tantalum and OxiCap® capacitors in steady-state is affected by three factors. The equation from which the failure rate can be calculated is:

$$F = F_V \times F_T \times F_R \times F_B$$

where F_V is a correction factor due to operating voltage/voltage derating

F_T is a correction factor due to operating temperature

F_R is a correction factor due to circuit series resistance

F_B is the basic failure rate level

Base failure rate.

Standard Tantalum conforms to Level M reliability (i.e. 1%/1000 hrs) or better at rated voltage, 85°C and 0.1Ω/volt circuit impedance.

F_B = 1.0% / 1000 hours for TAJ, TPS, TPM, TCJ, TCM, TCN, TAC

0.5% / 1000 hours for TCR, TMJ, TRJ, TRM, THJ and NOJ

0.2% / 1000 hours for NOS and NOM

TLJ, TLN, TLC and NLJ series of tantalum capacitors are defined at 0.5 x rated voltage at 85°C due to the temperature derating.

F_B = 0.2%/1000 hours at 85°C and 0.5xV_R with 0.1Ω/V series impedance with 60% confidence level.

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_V for voltage derating of a typical component (60% con. level).

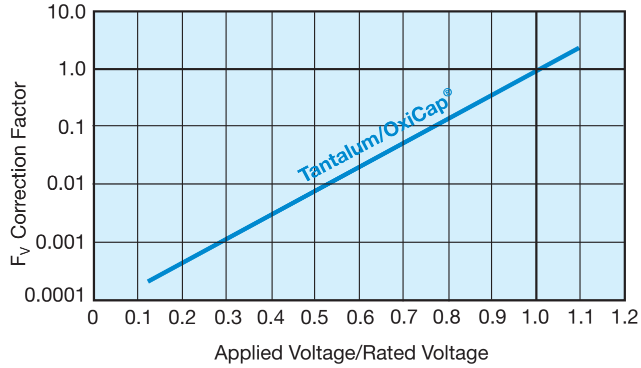


Figure 2b. Gives our recommendation for voltage derating for tantalum capacitors to be used in typical applications.

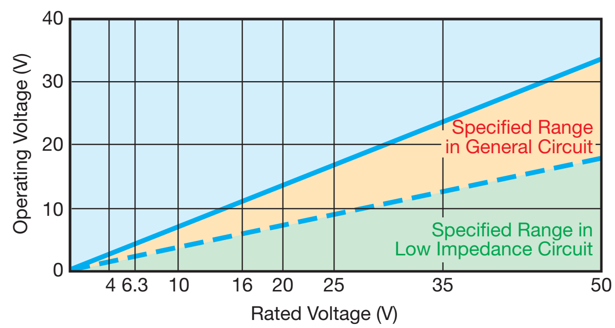
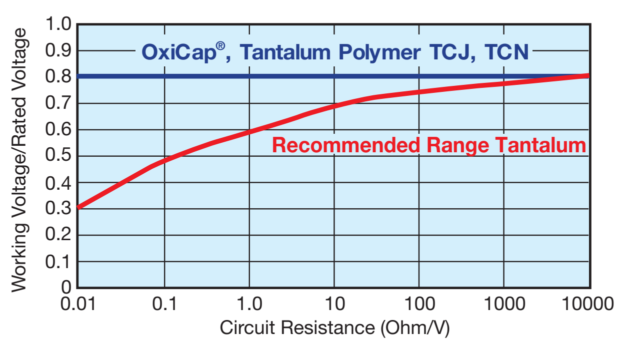


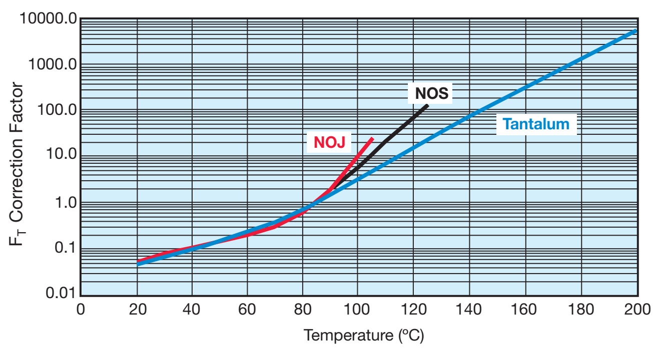
Figure 2c. Gives voltage derating recommendations for tantalum capacitors as a function of circuit impedance.



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 F_T for any temperature of operation.

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



Circuit Impedance.

All solid Tantalum and/or niobium oxide 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, F_R, for increasing series resistance.

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

Circuit resistance ohms/volt	F_R
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) F_T = 1.0 @ 85°C
b) F_R = 0.85 @ 0.167 Ohms/Volt
c) F_V = 0.08 @ applied voltage/rated voltage = 75%
d) F_B = 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.

F_V = 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 (page 198), the solid 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 if the capacitor was tested at its rated voltage. It has been tested on tantalum capacitors, however the conclusions are valid for both tantalum and OxiCap® capacitors.

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 below.

Leakage current vs number of surge failures.

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.

	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

OxiCap® capacitor is less sensitive to an overloading stress compared to Tantalum and so a 20% minimum derating is recommended. It may be necessary in extreme low impedance circuits of high transient or 'switch-on' currents to derate the voltage further. Hence in general a lower voltage OxiCap® part number can be placed on a higher rail voltage compared to the tantalum capacitor – see table below.

AVX recommended derating table.

Voltage Rail (V)	Rated Voltage of Cap (V)	
	Tantalum	OxiCap®
3.3	6.3	4
5	10	6.3
8	16	10
10	20	–
12	25	–
15	35	–
>24	Series Combination	–

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:

$$\begin{aligned}\text{Failure rate} &= F_U \times F_T \times F_R \times 1\%/1000 \text{ hours}\\ &= 0.15 \times 0.1 \times 1 \times 1\%/1000 \text{ hours}\\ &= 0.015\%/1000 \text{ hours}\end{aligned}$$

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

$$\begin{aligned}\text{Failure rate} &= F_U \times F_T \times F_R \times 1\%/1000 \text{ hours}\\ &= 0.006 \times 0.1 \times 1 \times 1\%/1000 \text{ hours}\\ &= 6 \times 10^{-4}\ \%/1000 \text{ hours}\end{aligned}$$

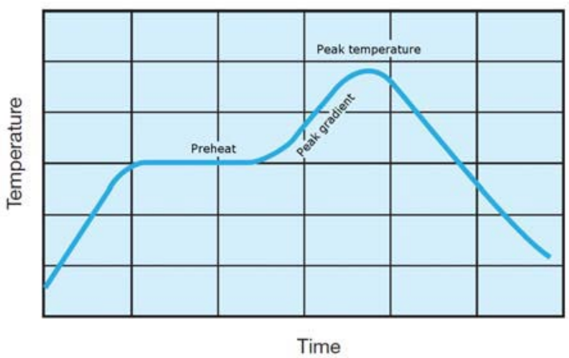
So there is an order improvement in the capacitors steady-state reliability.

SECTION 4
RECOMMENDED SOLDERING CONDITIONS

Both Tantalum and OxiCap® are lead-free system compatible components, meeting requirements of J-STD-020 standard. The maximum conditions with care: Max. Peak Temperature: 260ºC for maximum 10s, 3 reflow cycles. 2 cycles are allowed for F-series capacitors.

Small parametric shifts may be noted immediately after reflow, components should be allowed to stabilize at room temperature prior to electrical testing.

RECOMMENDED REFLOW PROFILE



Lead-free soldering:

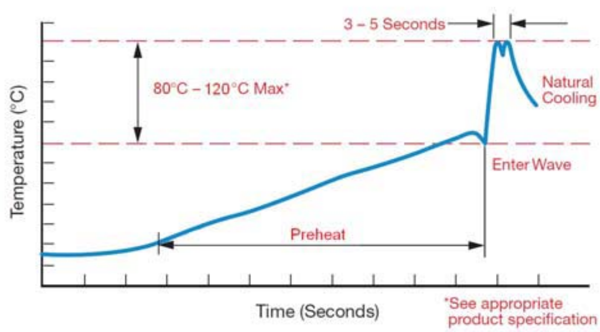
Pre-heating: 150±15ºC/60–120sec.
Max. Peak Temperature: 245±5ºC
Max. Peak Temperature Gradient: 2.5ºC/sec.
Max. Time above 230ºC: 40sec. max.

SnPb soldering:

Pre-heating: 150±15ºC/60–90sec.
Max. Peak Temperature: 220±5ºC
Max. Peak Temperature Gradient: 2ºC/sec.
Max. Time above solder melting point: 60sec.

RECOMMENDED WAVE SOLDERING

Lead-free soldering:



Pre-heating: 50-165ºC/90-120sec.
Max. Peak Temperature: 250-260ºC
Time of wave: 3-5sec.(max. 10sec.)

SnPb soldering:

Pre-heating: 50-165ºC/90–120sec.
Max. Peak Temperature: 240-250ºC
Time of wave: 3-5sec.(max.10sec.)

The upper side temperature of the board should not exceed +150ºC.

GENERAL LEAD-FREE NOTES

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.

Note: TCJ, TCM, TCN, TCR, F38, TLN and F98 series are not dedicated to wave soldering.

RECOMMENDED HAND SOLDERING

Recommended hand soldering condition:

Tip Diameter	Selected to fit Application
Max. Tip Temperature	+370°C
Max. Exposure Time	3s
Anti-static Protection	Non required

Note: TCJ, TCM, TCN, TCR, F38, TLN and F98 series are not dedicated to hand soldering.

SECTION 5
TERMINATIONS

5.1 Basic Materials

Two basic materials are used for termination leads: Nilo 42 (Fe58Ni42) and copper. Copper lead frame is mainly used for products requiring low ESR performance, while Nilo 42 is used for other products. The actual status of basic material per individual part type can be checked with AVX.

5.2 Termination Finishes – Coatings

Three terminations plating are available. Standard plating material is pure matte tin (Sn). Gold or tin-lead (SnPb) are available upon request with different part number suffix designations.*

5.2.1. Pure matte tin is used as the standard coating material meeting lead-free and RoHS requirements. AVX carefully monitors the latest findings on prevention of whisker formation. Currently used techniques include use of matte tin electrodeposition, nickel barrier underplating and recrystallization of surface by reflow. Terminations are tested for whiskers according to NEMI recommendations and JEDEC standard requirements. Data is available upon request.

5.2.2. Gold Plating is available as a special option* mainly for hybrid assembly using conductive glue.

5.2.3. Tin-lead (90%Sn 10%Pb) electroplated termination finish is available as a special option* upon request.

* Some plating options can be limited to specific part types. Please check availability of special options with AVX.

SECTION 6
MECHANICAL AND THERMAL PROPERTIES OF CAPACITORS

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

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

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

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

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

6.6 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.

6.7 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.

6.8 Installation Position
No restriction.

6.9 Soldering Instructions
Fluxes containing acids must not be used.

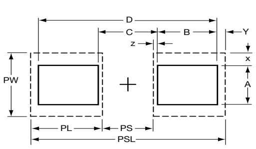
6.9.1 Guidelines for Surface Mount Footprints
Component footprint and reflow pad design for AVX capacitors.

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 (c for F-series) (Pad Separation) and PW (a for F-series) (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 (b for positive terminal of F-series; b' for negative terminal of F-series) (Pad Length), PW (a) (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. In the case of mounting conformal coated capacitors, excentering (Δc) is needed to except anode tab [⎍].



NOTE:

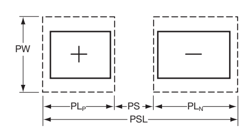
These recommendations (also in compliance with EIA) are guidelines only. With care and control, smaller footprints may be considered for reflow soldering.

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

PAD DIMENSIONS: millimeters (inches)

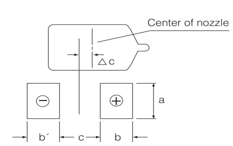
Case Size		PSL	PL	PS	PW	PWw
Series	A	4.00 (0.157)	1.40 (0.054)	1.20 (0.047)	1.80 (0.071)	0.90 (0.035)
	B	4.00 (0.157)	1.40 (0.054)	1.20 (0.047)	2.80 (0.110)	1.60 (0.063)
	C	6.50 (0.256)	2.00 (0.079)	2.50 (0.098)	2.80 (0.110)	1.60 (0.063)
	D	8.00 (0.315)	2.00 (0.079)	4.00 (0.157)	3.00 (0.119)	1.70 (0.068)
	E	8.00 (0.315)	2.00 (0.079)	4.00 (0.157)	3.00 (0.119)	1.70 (0.068)
	F	6.50 (0.256)	2.00 (0.079)	2.50 (0.098)	2.80 (0.110)	1.60 (0.063)
	G	4.00 (0.157)	1.40 (0.054)	1.20 (0.047)	1.80 (0.071)	0.90 (0.035)
	H	4.00 (0.157)	1.40 (0.054)	1.20 (0.047)	2.80 (0.110)	1.60 (0.063)
SMD 'J' Lead & OxiCap® (excluding F-series)	K	4.00 (0.157)	1.40 (0.054)	1.20 (0.047)	1.80 (0.071)	0.90 (0.035)
	L	4.00 (0.157)	1.40 (0.054)	1.20 (0.047)	2.80 (0.110)	1.60 (0.063)
	N	2.70 (0.100)	0.95 (0.037)	0.80 (0.030)	1.60 (0.060)	0.80 (0.030)
	P	2.70 (0.100)	0.95 (0.037)	0.80 (0.030)	1.60 (0.060)	0.80 (0.030)
	R	2.70 (0.100)	0.95 (0.037)	0.80 (0.030)	1.60 (0.060)	0.80 (0.030)
	S	4.00 (0.157)	1.40 (0.054)	1.20 (0.047)	1.80 (0.071)	0.90 (0.035)
	T	4.00 (0.157)	1.40 (0.054)	1.20 (0.047)	2.80 (0.110)	1.60 (0.063)
	U	8.00 (0.315)	2.00 (0.079)	4.00 (0.157)	3.70 (0.145)	1.80 (0.071)
	V	8.00 (0.315)	2.00 (0.079)	4.00 (0.157)	3.70 (0.145)	1.80 (0.071)
	W	6.50 (0.256)	2.00 (0.079)	2.50 (0.098)	2.80 (0.110)	1.60 (0.063)
	X	8.00 (0.315)	2.00 (0.079)	4.00 (0.157)	3.00 (0.119)	1.70 (0.068)
	Y	8.00 (0.315)	2.00 (0.079)	4.00 (0.157)	3.00 (0.119)	1.70 (0.068)
	Z	8.00 (0.315)	2.00 (0.079)	4.00 (0.157)	3.70 (0.145)	1.80 (0.071)
TLN & TCN Undertab	H	4.00 (0.157)	1.40 (0.054)	1.20 (0.047)	2.80 (0.110)	N/A
	K	4.00 (0.157)	1.40 (0.054)	1.20 (0.047)	1.80 (0.071)	N/A
	L	3.50 (0.138)	1.15 (0.045)	1.20 (0.047)	2.40 (0.047)	N/A
	M	2.30 (0.091)	0.90 (0.035)	0.50 (0.020)	1.10 (0.043)	N/A
	N	2.00 (0.079)	0.70 (0.028)	0.60 (0.024)	1.10 (0.043)	N/A
	S	3.50 (0.138)	1.15 (0.045)	1.20 (0.047)	1.20 (0.047)	N/A
	T	3.50 (0.138)	1.15 (0.045)	1.20 (0.047)	2.40 (0.047)	N/A
	Y	7.20 (0.283)	1.50 (0.059)	4.20 (0.165)	2.50 (0.098)	N/A
	6	15.20 (0.598)	3.00 (0.120)	9.20 (0.360)	5.50 (0.217)	N/A
TACmicrochip® Series	A	4.40 (0.173)	1.60 (0.063)	1.20 (0.047)	1.80 (0.071)	0.90 (0.035)
	B	4.70 (0.185)	1.70 (0.070)	1.30 (0.051)	3.00 (0.118)	1.50 (0.059)
	C	4.40 (0.173)	1.60 (0.063)	1.20 (0.047)	1.80 (0.071)	0.90 (0.035)
	D	4.40 (0.173)	1.60 (0.063)	1.20 (0.047)	1.80 (0.071)	0.90 (0.035)
	E	0.90 (0.035)	0.30 (0.012)	0.30 (0.012)	0.30 (0.012)	N/A
	H	3.20 (0.126)	1.30 (0.051)	0.60 (0.024)	1.50 (0.059)	0.075 (0.375)
	J	2.80 (0.110)	1.10 (0.043)	0.60 (0.024)	1.00 (0.039)	0.50 (0.020)
	K	2.20 (0.087)	0.90 (0.035)	0.40 (0.016)	0.70 (0.028)	0.35 (0.014)
	L	2.80 (0.110)	1.10 (0.043)	0.60 (0.024)	1.00 (0.039)	0.50 (0.020)
	M	3.20 (0.126)	1.30 (0.051)	0.60 (0.024)	1.00 (0.039)	0.50 (0.020)
	Q	3.20 (0.126)	1.30 (0.051)	0.60 (0.024)	1.50 (0.059)	0.075 (0.375)
	R	3.20 (0.126)	1.30 (0.051)	0.60 (0.024)	1.50 (0.059)	0.075 (0.375)
	S	4.40 (0.173)	1.60 (0.063)	1.20 (0.047)	1.80 (0.071)	0.90 (0.035)
	T	4.70 (0.185)	1.70 (0.070)	1.30 (0.051)	3.00 (0.118)	1.50 (0.059)
	U	3.20 (0.126)	1.30 (0.051)	0.60 (0.024)	1.50 (0.059)	0.075 (0.375)
	V	4.40 (0.173)	1.60 (0.063)	1.20 (0.047)	1.80 (0.071)	0.90 (0.035)
	Z	2.80 (0.110)	1.10 (0.043)	0.60 (0.024)	0.70 (0.028)	0.35 (0.014)

Note: SMD 'J' Lead = TAJ, TMJ, TPS, TPM, TRJ, TRM, THJ, TLJ, TCJ, TCM, TCR



Case Size		PSL	PL$_P$	PL$_N$	PS	PW
Series TLN & TCN Undertab	4	7.60 (0.299)	2.20 (0.087)	3.40 (0.134)	2.00 (0.079)	4.80 (0.190)

PAD DIMENSIONS F-SERIES: millimeters (inches)

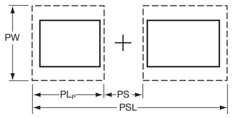


Case Size		a	b	b'	c	Δc*
Series	U	0.35 (0.014)	0.40 (0.016)	0.40 (0.016)	0.40 (0.016)	0.00
	M	0.65 (0.026)	0.70 (0.028)	0.70 (0.028)	0.60 (0.024)	0.00
	S	0.90 (0.035)	0.70 (0.028)	0.70 (0.028)	0.80 (0.032)	0.00
F38, F91, F92, F93, F97, F98	P	1.00 (0.039)	1.10 (0.043)	1.10 (0.043)	0.40 (0.016)	0.00
	A	1.30 (0.051)	1.40 (0.060)	1.40 (0.055)	1.00 (0.039)	0.00
	B	2.30 (0.091)	1.40 (0.060)	1.40 (0.055)	1.30 (0.051)	0.00
	C	2.30 (0.091)	2.00 (0.079)	2.00 (0.079)	2.70 (0.106)	0.00
	N	2.50 (0.091)	2.00 (0.079)	2.00 (0.079)	4.00 (0.158)	0.00
F95, AUDIO F95 Conformal	R·P	1.40 (0.055)	0.60 (0.024)	0.50 (0.020)	0.70 (0.028)	0.20 (0.008)
	Q·S	1.70 (0.067)	0.70 (0.028)	0.60 (0.024)	1.10 (0.043)	0.20 (0.008)
	A	1.80 (0.071)	0.70 (0.028)	0.60 (0.024)	1.10 (0.043)	0.20 (0.008)
	T	2.60 (0.102)	0.70 (0.028)	0.60 (0.024)	1.20 (0.047)	0.20 (0.008)
	B	2.60 (0.102)	0.80 (0.032)	0.70 (0.028)	1.10 (0.043)	0.20 (0.008)
F72 Conformal	R·M	5.80 (0.228)	1.20 (0.047)	1.20 (0.047)	3.90 (0.154)	0.50 (0.020)
F75 Conformal	U·C	3.00 (0.118)	1.20 (0.047)	1.20 (0.047)	3.30 (0.130)	0.50 (0.020)
	D	4.10 (0.161)	1.20 (0.047)	1.20 (0.047)	3.90 (0.154)	0.50 (0.020)
	R	5.80 (0.228)	1.20 (0.047)	1.20 (0.047)	3.90 (0.154)	0.50 (0.020)

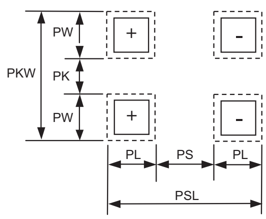
*In the case of mounting conformal coated capacitors, excentering (Δc) is needed to except anode tab [⎍].

PAD DIMENSIONS SMD HERMETIC:

millimeters (inches)



Case Size SERIES		PSL	PL	PS	PW	PW_W
TCH & THH J-lead only	9	13.20 (0.520)	2.40 (0.094)	8.40 (0.331)	11.80 (0.465)	N/A
THH J-lead only	I	13.00 (0.512)	3.80 (0.150)	5.40 (0.213)	5.30 (0.210)	N/A
THH Undertab only	I	10.60 (0.417)	3.00 (0.118)	4.60 (0.181)	4.00 (0.157)	N/A



Case Size SERIES		PSL	PL	PS	PKW	PW	PK
TCH & THH Undertab only	9	11.00(0.433)	1.70(0.067)	7.60(0.300)	10.60(0.417)	3.00(0.118)	4.60(0.181)

6.10 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 7: EPOXY FLAMMABILITY

EPOXY	UL RATING	OXYGEN INDEX
TAJ/TMJ/TPS/TPM/TRJ/TRM THJ/TLJ/TLN/TCJ/TCM TCN/TCR/NLJ/NOJ/NOS/NOM	UL94 V-0	35%

SECTION 8: QUALIFICATION APPROVAL STATUS

DESCRIPTION	STYLE	SPECIFICATION
Surface mount capacitors	TAJ	CECC 30801 - 005 Issue 2 CECC 30801 - 011 Issue 1

Product Safety Information Datasheet

Material Data and Handling

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

1. Material Content

Solid Tantalum and OxiCap® capacitors do not contain liquid hazardous materials.

The operating section contains:

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

The encapsulation contains:

TAC - epoxy molding compound, solder/tin coated terminal pads

TAJ, TMJ, TPS, TPM, TRJ, TRM, TLJ, TLN, TCJ, TCM, TCN, TCR, NLJ, NOJ, NOS and NOM - epoxy molding compound, tin/solder coated terminal pads

THJ - may contain Antimony trioxide and Bromide compounds as fire retardants.

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

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

Both Tantalum and OxiCap® 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 datasheets. 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
- surge voltage exceeded
- reverse voltage exceeded
- temperature too high
- ripple rating 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 1Ω/V should be derated by minimum 50% for tantalum and 20% for OxiCap®. Precautions should be 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

Both Tantalum and OxiCap® 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 datasheets.

5. Storage

AVX Tantalum dielectric chip capacitors are unaffected by the following storage condition for 2 years:

Temperature: -10°C – +50°C
Humidity: 75% RH maximum
Atmospheric pressure: 860 mbar ~ 1060mbar

Tantalum and OxiCap® 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 2 years. If F-series capacitors should be stored more than 1 year please contact AVX for advice.

6. Moisture Sensitivity Level

MSL is defined in J-STD-020. It is applicable to non-hermetic surface mount devices, and is focussed on parts in plastic packages.

The basic concept is that a plastic package may contain moisture, which can become a high pressure vapour during solder reflow. If this occurs, the vapor pressure may cause internal cracking or damage to the device. It can also result in external steam jets from the package, and these may displace other nearby components on the circuit board during the solder process. A common industry reference for this is “popcorning”.

AVX solid tantalum and OxiCap® chips which are considered MSL 1 are molded in plastic packages, and are packaged in standard packaging, not including a moisture barrier unless dry pack MSL 3 special option is used (special character V in part number).

AVX solid tantalum and OxiCap® chips which are considered MSL 3 are molded in plastic packages, and are distributed in packaging including a moisture barrier.

AVX solid tantalum TCN PulseCap™ chips are considered MSL4 and are moulded in plastic packages and are distributed in packaging including a moisture barrier.

AVX solid tantalum TACmicrochips® (TAC, TPC) are considered MSL 1 and supplied in packaging with a moisture barrier. TLC series is considered MSL 3 and is distributed in packaging including a moisture barrier.

7. 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.

8. 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 datasheets represents unsafe use.

9. 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 Datasheet

Environmental Information

AVX has always sought to minimize the environmental impact of its manufacturing operations and of its 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/Niobium and Tantalum/Niobium oxide
- Manganese dioxide
- Carbon/graphite
- Silver
- Tin/Tin-lead alloy plating
- Nickel-iron alloy or Copper alloy depending on design (consult factory for details)
- 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 and fire retardants.

2. Packaging Material

The component packing tape is recyclable Polycarbonate 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 overpacked in recyclable fiber board boxes. None of the packing contains heavy metals.

3. Lead (Pb)

Parts supplied today are electroplated over the terminal contact area with 100% fused matte Tin (Sn). Parts with SnPb termination finish are available upon request only. Contact AVX for availability of parts with SnPb termination finish.

4. Fire Retardants

A combustible encapsulant free of antimony trioxide and organic bromide compound are supplied today. 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 and OxiCap® 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 or niobium oxide 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 and OxiCap® 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. Landfill may be considered for disposal, bearing in mind the small lead content.

Under certain extreme physical conditions it is possible to generate ignition of Tantalum, Niobium and Niobium oxide capacitors. These physical conditions relate to high-speed impact and although not considered to be a normal operating occurrence may occur as a method of material(s) recovery. Therefore appropriate safeguards procedures and methodologies need to be adopted to eliminate any risks of material ignition.

For further information, please contact your local AVX sales office or representative.

8. Typical Weight by Case Sizes

The approximate content of some materials is given in the table below.
The specific weight of other materials contained in the various case sizes is available on written request.

Case Size	TAJ, TMJ TPS, TRJ TLJ, THJ	TPM TRM	TLN	TCJ	TCM	TCN	TCR	NOJ NOS NLJ	NOM	TAC TLC TPC	F38	F72	F75	F91 F93 F97	F92	F95	F98	TCH	THH
	Typical Weight (mg)																		
A	29			28				25		57.3				28	19	37			
B	68			72				57		83.6				65	36	68			
C	166			137				154					240	160					
D	290	298		346			278	265		14			400	300					
E	512	527		472	474			392	402	0.5									
F	148							109											
G	28			25				23											
H	52			51						15.2									
I																			543
J										5.9									
K	17		22	15		20				2.8									
L			41			38				9									
M			10							11.3	5.7	330					6		
N	9		10	9		10								350					
P	15			15				12							9	18			
Q																20			
R	10			10						23.4		180	670			7			
S	19		27	18		25		17			12.4					25	13		
T	35		47	39		43		32		65.8						41			
U	738									8.5			160				1.6		
V	641	649		655				510		16.4									
W	99			100				82											
X	152			151		190		126											
Y	223	237		215				178											
Z										3.9									
4			426			355													
6			1056																
9																		2185	2210

9. RoHS Compliance

9.1 Tantalum & Niobium Oxide Capacitors (excluding F-series)

AVX can declare that we do not add any materials from the list below to series TAJ, TMJ, TPS, TPM, TRJ, TRM, THJ, TLJ, TLN, TCJ, TCM, TCN, TCR, TAC, TLC, TPC, NLJ, NOJ, NOS and NOM during production, so they are not contained in any significant level.

9.2 F-Series Eco-Products "GeoCap"

AVX promotes environmentally conscious practices.

AVX offers "GeoCap", witch has completely lead free terminals and contains no polyvinyl chloride in the sleeve.

Substances		Taping Code	RoHS Compliance
Heavy Metals	Cadmium and cadmium compounds	All	YES
	Lead and lead compounds	A,B,Y,P	YES
		R,S,T,U	YES, since production date 1/1/04
		K,H	NO
	Mercury and mercury compounds	All	YES
	Hexavalent chromium compounds	All	YES
Chlorinated organic compounds	Polychlorinated biphenyls (PCB)	All	YES
	Polychlorinated naphthalenes (PCN)	All	YES
	Chlorinated paraffins (CP)	All	YES
	Mirex (Perchlordecone)	All	YES
Brominated organic compounds	Polybrominated biphenyls (PBB)	All	YES
	Polybrominated diphenylethers (PBDE)	All	YES

F-SERIES TANTALUM CAPACITORS

Type · Classification		Series	Lead-Free Compliance	Anti Polyvinyl Chloride Compliance
Surface Mount type	Reisin-Molded type	F38, F91, F92, F93, F97, F98	Complied	Complied
	Conformal Coated type	AUDIO F95, F95, F72, F75		

F-SERIES TANTALUM CAPACITORS CORRESPONDING TO RoHS DIRECTIVE

	Resin-Molded Chip F91/F92/F93/F97 Series	Frameless Conformal Coated Chip Audio F95/F95/F72/F75 Series	Frameless Resin-Molded Chip F98 Series	Conductive Polymer Frameless Resin-Molded Chip F38 Series
Compliance with RoHS Directive	Compliant	Compliant	Compliant	Compliant
Construction of Electrode Terminal	42 Alloy/ Ni/ Sn plating	Ni/ Sn-Cu solder	U Case Cu/ Ni/ Au/ Sn-3.5Ag plating M, S Case Cu/ Ni/ Au plating	Cu/ Ni/ Au plating
	Sn thickness 5μm Plating type matte No heat treatment after plating	Sn-Cu thickness 30μm (Solder dipping) No heat treatment after Solder dipping	U Case Sn-Ag thickness 5μm M, S Case Au thickness 0.05μm Plating type matte No heat treatment after plating	Au thickness 0.05μm Plating type matte No heat treatment after plating
Lead (Pb) Chromium (VI) Mercury Cadmium PBB PBDE	Does not contain	Does not contain	Does not contain	Does not contain
MSL (IPC/ JEDEC J-STD 020)	LEVEL 1 No need for dry package	*LEVEL 1 to LEVEL 3 If you need detailed Information about MSL LEVEL, please contact us.	*LEVEL 1 to LEVEL 3 If you need detailed Information about MSL LEVEL, please contact us.	LEVEL 3

Tantalum & Niobium Oxide Capacitors (excluding F-series)

Tape & Reel Packaging

Tape and reel packaging for automatic component placement.

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

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.

TAPING SUFFIX TABLE TAJ, TMJ, TPS, TPM, TRJ, TRM, THJ, TLJ, TLN TCJ, TCM, TCN, TCR, NLJ, NOJ, NOS, NOM

Case Size	Tape width mm	P mm	180mm (7") reel Tin Termination			330mm (13") reel Tin Termination			180mm (7") reel & Gold Termination	
			Suffix	Automotive Suffix	Qty.	Suffix	Automotive Suffix	Qty.	Suffix	Qty.
A	8	4	R	T	2,000	S	U	8,000	A	2,000
B	8	4	R	T	2,000	S	U	8,000	A	2,000
C	12	8	R	T	500	S	U	3,000	A	500
D	12	8	R	T	500	S	U	2,500	A	500
E	12	8	R	T	400	S	U	1,500	A	400
F	12	8	R	–	1,000	S	–	4,000	A	1,000
G	8	4	R	–	2,500	S	–	10,000	A	2,500
H	8	4	R	–	2,500	S	–	10,000	A	2,500
K	8	4	R	–	3,000	S	–	13,000	A	3,000
L	8	4	R	–	2,500	S	–	10,000	A	2,500
M	8	4	R	–	3,000	S	–	13,000	A	3,000
N	8	4	R	–	3,000	S	–	13,000	A	3,000
P	8	4	R	–	2,500	S	–	10,000	A	2,500
R	8	4	R	–	2,500	S	–	10,000	A	2,500
S	8	4	R	–	2,500	S	–	10,000	A	2,500
T	8	4	R	–	2,500	S	–	10,000	A	2,500
U	16	8	R	–	400	–	–	–	–	–
V	12	8	R	–	400	S	–	1,500	A	400
W	12	8	R	–	1,000	S	–	5,000	A	1,000
X	12	8	R	–	1,000	S	–	5,000	A	1,000
Y	12	8	R	–	1,000	S	–	4,000	A	1,000
Z	16	8	R	–	400	S	–	1,500	–	–
4	16	8	R	–	800	S	–	TBD	–	–
6	24	12	R	–	500	S	–	TBD	–	–

Under Development

TAPING SUFFIX TABLE TAC AND TLC

Case Size	Tape width mm	P mm	100mm (4") reel Tin Termination		180mm (7") reel Tin Termination		100mm (4") reel & Gold Termination		180mm (7") reel & 100% Gold Termination	
			Suffix	Qty.	Suffix	Qty.	Suffix	Qty.	Suffix	Qty.
A	8	4	XTA	500	RTA	2,000	FTA	500	ATA	2,000
B	8	4	XTA	500	RTA	2,500	FTA	500	ATA	2,500
C	8	4	XTA	500	RTA	3,500	-	-	-	-
D	8	4	XTA	500	RTA	2,500	-	-	-	-
H	8	4	XTA	500	RTA	3,500	FTA	500	ATA	3,500
J	8	4	XTA	500	RTA	3,500	FTA	500	ATA	3,500
K	8	2	QTA	1,000	PTA	10,000	NTA	1,000	MTA	10,000
L	8	4	XTA	500	RTA	3,500	FTA	500	ATA	3,500
M	8	4	XTA	500	RTA	2,500	FTA	500	ATA	2,500
N	8	2	QTA	1,000	PTA	10,000	-	-	-	-
Q	8	4	XTA	500	RTA	2,500	-	-	-	-
R	8	4	XTA	500	RTA	2,500	FTA	500	ATA	2,500
S	8	4	XTA	500	RTA	2,500	-	-	-	-
T	8	4	XTA	500	RTA	2,500	FTA	500	ATA	2,500
U	8	4	XTA	500	RTA	3,500	FTA	500	ATA	3,500
V	8	4	XTA	500	RTA	2,500	FTA	500	ATA	2,500
Z	8	2	QTA	1,000	PTA	10,000	-	-	-	-

Under Development

CHIP TRAY (WAFFLE) TABLE TLC

Case Size	Chip Tray Qty.	Tin Termination Suffix	Gold Termination Suffix
E	Each	HTA	–

Tantalum & Niobium Oxide Capacitors (excluding F-series)

Tape & Reel Packaging

TAPING SUFFIX TABLE TPC

Case Size	Tape width mm	P mm	100mm (4") reel Tin Termination		180mm (7") reel Tin Termination		100mm (4") reel & Gold Termination		180mm (7") reel & 100% Gold Termination	
			Suffix	Qty.	Suffix	Qty.	Suffix	Qty.	Suffix	Qty.
H	8	4	Xxxxx	500	Rxxxx	3,500	Fxxxx	500	Axxxx	3,500
K	8	2	Qxxxx	1,000	Pxxxx	10,000	Nxxxx	1,000	Mxxxx	10,000
L	8	4	Xxxxx	500	Rxxxx	3,500	Fxxxx	500	Axxxx	3,500
R	8	4	Xxxxx	500	Rxxxx	2,500	Fxxxx	500	Axxxx	2,500

Note: xxxx = ESR value in Milliohms

TAPING SUFFIX TABLE TLC

Case Size	Tape width mm	P mm	100mm (4") reel Tin Termination		180mm (7") reel Tin Termination		100mm (4") reel & Gold Termination		180mm (7") reel & 100% Gold Termination	
			Suffix	Qty.	Suffix	Qty.	Suffix	Qty.	Suffix	Qty.
L	8	4	Xxxxx	500	Rxxxx	3,500	Fxxxx	500	Axxxx	3,500

Note: xxxx = ESR value in Milliohms

Tantalum & Niobium Oxide Capacitors (excluding F-series)

Tape & Reel Packaging

PLASTIC TAPE DIMENSIONS TAJ, TMJ, TPS, TPM, TRJ, TRM, THJ, TLJ, TLN, TCJ, TCM, TCN, TCR, NLJ, NOJ, NOS AND NOM

Case	A0±0.10	B0±0.10	K±0.10	W±0.30	E±0.10	F±0.05	G min.	P±0.10	P2±0.05	P0±0.10	D $^{+0.20}_{-0.00}$	D1 $^{+0.25}_{-0.00}$
A	1.83	3.57	1.87	8.00	1.75	3.50	0.75	4.00	2.00	4.00	1.50	1.00
B	3.15	3.77	2.22	8.00	1.75	3.50	0.75	4.00	2.00	4.00	1.50	1.00
C	3.45	6.40	2.92	12.00	1.75	5.50	0.75	8.00	2.00	4.00	1.50	1.50
D	4.48	7.62	3.22	12.00	1.75	5.50	0.75	8.00	2.00	4.00	1.50	1.50
E	4.50	7.50	4.50	12.00	1.75	5.50	0.75	8.00	2.00	4.00	1.50	1.50
F	3.35	6.40	2.20	12.00	1.75	5.50	0.75	8.00	2.00	4.00	1.50	1.50
G	1.83	3.57	1.65	8.00	1.75	3.50	0.75	4.00	2.00	4.00	1.50	1.00
H	3.15	3.77	1.66	8.00	1.75	3.50	0.75	4.00	2.00	4.00	1.50	1.00
K	1.95	3.55	1.15	8.00	1.75	3.50	0.75	4.00	2.00	4.00	1.50	1.00
L	3.10	3.80	1.30	8.00	1.75	3.50	0.75	4.00	2.00	4.00	1.50	1.00
M	1.60	2.35	1.10	8.00	1.75	3.50	0.75	4.00	2.00	4.00	1.50	1.00
N	1.60	2.30	1.10	8.00	1.75	3.50	0.75	4.00	2.00	4.00	1.50	1.00
P	1.65	2.45	1.60	8.00	1.75	3.50	0.75	4.00	2.00	4.00	1.50	1.00
R	1.65	2.45	1.30	8.00	1.75	3.50	0.75	4.00	2.00	4.00	1.50	1.00
S	1.95	3.55	1.30	8.00	1.75	3.50	0.75	4.00	2.00	4.00	1.50	1.00
T	3.20	3.80	1.30	8.00	1.75	3.50	0.75	4.00	2.00	4.00	1.50	1.00
U	6.19	7.66	4.72	16.00	1.75	7.50	0.75	8.00	2.00	4.00	1.50	1.50
V	6.43	7.44	3.84	12.00	1.75	5.50	0.75	8.00	2.00	4.00	1.50	1.50
W	3.57	6.40	1.65	12.00	1.75	5.50	0.75	8.00	2.00	4.00	1.50	1.50
X	4.67	7.62	1.65	12.00	1.75	5.50	0.75	8.00	2.00	4.00	1.50	1.50
Y	4.67	7.62	2.15	12.00	1.75	5.50	0.75	8.00	2.00	4.00	1.50	1.50
4	6.25	7.88	2.25	16.00	1.75	7.50±0.1	0.75	8.00	2.00±0.1	4.00	1.50	1.50
6	8.55	15.60	2.25	24.00	1.75	11.50	0.75	12.00	2.00	4.00	1.50	1.50

PLASTIC TAPE DIMENSIONS TAC, TLC AND TPC

Case	A0±0.10	B0±0.10	K±0.10	W±0.30	E±0.10	F±0.05	G min.	P±0.10	P2±0.05	P0±0.10	D $^{+0.20}_{-0.00}$	D1 $^{+0.20}_{-0.00}$
A	1.83±0.10	3.57±0.10	1.87±0.10	8.00	1.75	3.50	0.75	4.00	2.00	4.00	1.50	1.00
B	3.15±0.10	3.77±0.10	1.66±0.10	8.00	1.75	3.50	0.75	4.00	2.00	4.00	1.50	1.00
C	1.95±0.10	3.55±0.10	1.15±0.10	8.00	1.75	3.50	0.75	4.00	2.00	4.00	1.50	1.00
D	1.95±0.10	3.60±0.10	0.90±0.10	8.00	1.75	3.50	0.75	4.00	2.00	4.00	1.50	1.00
H	1.65±0.10	2.45±0.10	1.10±0.05	8.00	1.75	3.50	0.75	4.00	2.00	4.00	1.50	1.00
J	$1.05^{+0.10}_{-0.00}$	$1.90^{+0.10}_{-0.00}$	$0.80^{+0.10}_{-0.00}$	8.00	1.75	3.50	0.75	4.00	2.00	4.00	1.50	0.80
K	$0.75^{+0.05}_{-0.00}$	$1.26^{+0.10}_{-0.00}$	$0.67^{+0.10}_{-0.00}$	8.00	1.75	3.50	0.75	2.00	2.00	2.00	1.50	0.50
L	$1.05^{+0.10}_{-0.00}$	$1.90^{+0.10}_{-0.00}$	$1.05^{+0.10}_{-0.00}$	8.00	1.75	3.50	0.75	4.00	2.00	4.00	1.50	0.80
M	$1.05^{+0.10}_{-0.00}$	2.45±0.10	$1.05^{+0.10}_{-0.00}$	8.00	1.75	3.50	0.75	4.00	2.00	4.00	1.50	0.80
Q	1.65±0.10	2.45±0.10	1.30±0.10	8.00	1.75	3.50	0.75	4.00	2.00	4.00	1.50	1.00
R	1.65±0.10	2.45±0.10	1.60±0.10	8.00	1.75	3.50	0.75	4.00	2.00	4.00	1.50	1.00
S	1.95±0.10	3.55±0.10	1.30±0.10	8.00	1.75	3.50	0.75	4.00	2.00	4.00	1.50	1.00
T	3.20±0.10	3.80±0.10	1.30±0.10	8.00	1.75	3.50	0.75	4.00	2.00	4.00	1.50	1.00
U	1.65±0.10	2.45±0.10	0.80±0.05	8.00	1.75	3.50	0.75	4.00	2.00	4.00	1.50	1.00
V	1.95±0.10	3.60±0.10	0.90±0.10	8.00	1.75	3.50	0.75	4.00	2.00	4.00	1.50	1.00
X	1.83±0.10	3.57±0.10	1.87±0.10	8.00	1.75	3.50	0.75	4.00	2.00	4.00	1.50	1.00
Z	$0.75^{+0.05}_{-0.00}$	$1.90^{+0.10}_{-0.00}$	$0.67^{+0.10}_{-0.00}$	8.00	1.75	3.50	0.75	2.00	2.00	2.00	1.50	0.50

Under development

CHIP TRAY DIMENSIONS

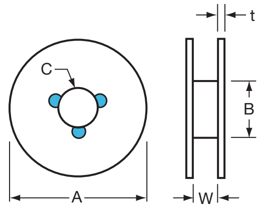
Case	X Pocket Size	Y Pocket Size	Z Pocket Depth	A Pocket Draft Angle	Array
E	0.76mm ±0.05mm	0.43mm ±0.05mm	0.41mm ±0.05mm	5° ±1/2°	20 x 20 (400)

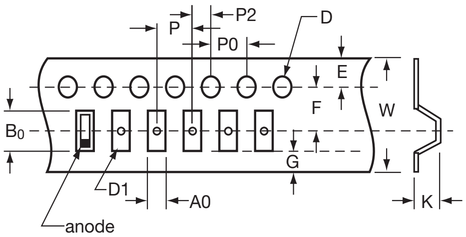
Tantalum & Niobium Oxide Capacitors (excluding F-series)

Tape & Reel Packaging

REEL DIMENSIONS

Reel Size	Tape	A	B	C	W	t
180mm (7")	12mm	178±2.00	50 min	13.0±0.50	12.4+1.5/-0	1.50±0.50
180mm (7")	8mm	178±2.00	50 min	13.0±0.50	8.4+1.5/-0	1.50±0.50
330mm (13")	12mm	328±2.00	50 min	13.0±0.50	12.4+1.5/-0	1.50±0.50
330mm (13")	8mm	328±2.00	50 min	13.0±0.50	8.4+1.5/-0	1.50±0.50
108mm (4.25")	8mm	108±2.00		13.0±0.50	8.4+1.5/-0	1.50±0.50



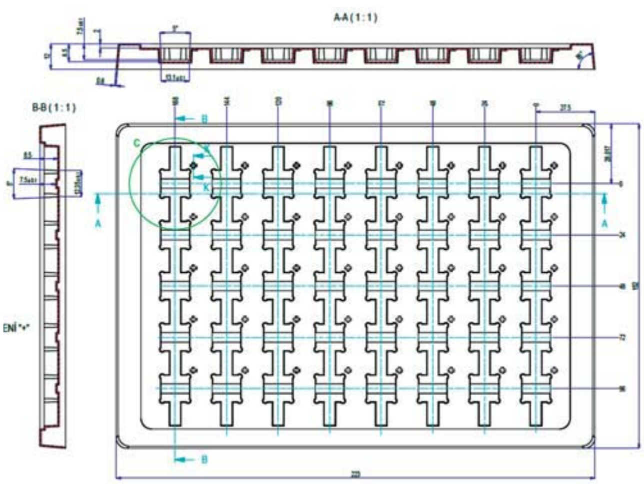


COVER TAPE NOMINAL DIMENSIONS

Thickness: 75μm
Width of tape: 5.5mm (8mm tape)
9.5mm (12mm tape)

TCH AND THH PACKAGING SPECIFICATION

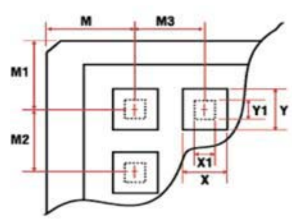
The dimensions of the tray see in the figure below. Tolerance of dimensions are ±0.1 mm. Both case size "9" and "I" have 40 pcs per tray.



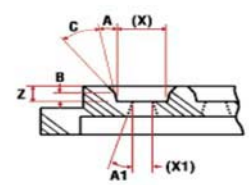
OVERALL CHIP TRAY SIZE

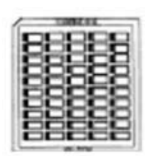
Size	Height	Flatness
50.80mm±0.10mm	3.96mm +0.05mm/-0.08mm	0.10mm

PLASTIC CHIP TRAY



anode





E Case

F-Series Tantalum Capacitors

Tape & Reel Packaging

TAPING QUANTITY TABLE – F-SERIES CAPACITORS

Series	Case Size	180mm (7") Reel Tin Termination Qty.	330mm (13") Reel Tin Termination Qty.
F38, F98	U	10,000	–
	M, S	4,000	–
F92	P	3,000	8,000
	A, B	2,500	8,000
F91 F93 F97	A	2,000	8,000
	B	2,000	6,000
	C, N	500	2,500
F95 AUDIO F95	R, P	3,000	10,000
	Q, S, A, T	2,500	10,000
	B	2,000	8,500
F72	R	1,000	–
	M	500	–
F75	U, C, D, R	500	–

( )*: Export packaging. There are some differences between actual minimum quantity and above list. Please confirm before you order.

TYPE NUMBERING SYSTEM

1 2 3 4 5 6 7 8 9 10 11 12 13 14

F 9 3 1 A 1 0 6 M A A

F 9 5 0 G 3 3 7 M A A A Q 2

Series · Rated voltage · Rated capacitance · Capacitance tolerance · Case code

F95 series have single-side electrode structures as illustrated below, code "AQ2" is added at the end of each type number to distinguish from other case sizes.

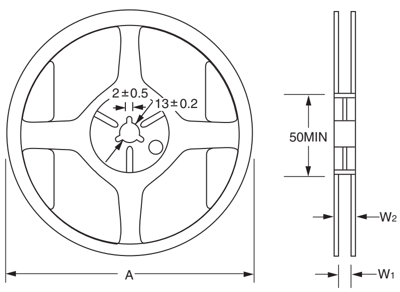
Their electrode area at the cover tape side becomes lessened, accordingly

Tape Width (mm)	Polarity	Tape Reel Dia φ180 mm	Tape Reel Dia φ330 mm	Applicable Case Size F91, F92 F93, F97 F98	Applicable Case Size F95 AUDIO F95	Applicable Case Size F72 F75
8	R (Anode is at opposite side of feeding holes)	A	E	U, M, S P, A, B	R, P, Q S, A, T B	–
12	R (Anode is at opposite side of feeding holes)	C	G	C, N	–	U, C D, R M

REEL DIMENSIONS (mm)

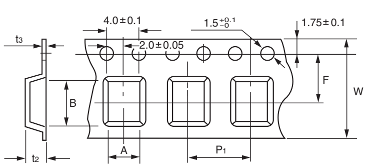
Item	Reel Diameter 180φ	Reel Diameter 330φ
A	$\phi 180^{+0}_{-3}$	φ330±2

Item	Tape Width 8	Tape Width 12
W_1	9.0±0.3	13±0.3
W_2	11.4±1.0	15.4±1.0

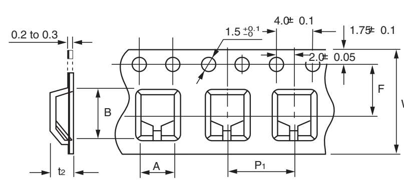


Note: The above shows the dimensions of φ180 reel. In case of φ330 reel, the appearance shape is slightly different.

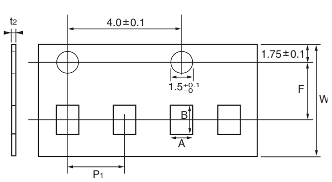
CARRIER TAPE DIMENSIONS (mm)



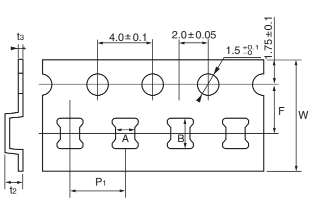
F91, F92, F93, F97, F98 M, F38 M



F95, AUDIO F95, F72, F75



F98U



F98 S, F38 S

Case Code	W	A	B	F	P_1	t_2	t_3
U	8.0±0.3	0.73±0.08	1.20±0.05	3.5±0.05	2.0±0.1	0.7 Max.	–
M		0.97±0.05	1.85±0.05		4.0±0.1	1.3 Max.	0.20±0.05
S		1.35±0.1	2.15±0.1	3.5±0.1		1.4 Max.	0.2 to 0.3
P		1.55±0.1	2.3±0.1	3.5±0.05		(1.7 Max.)	
A		1.9±0.1	3.5±0.1			2.1 Max. (1.7)	
B		3.3±0.1	3.8±0.1			2.4 Max. (1.7)	
C	12.0±0.3	3.6±0.1	6.3±0.1	5.5±0.05	8.0±0.1	2.9 Max.	
N		4.8±0.1	7.7±0.1			3.5 Max.	

Type	Case Code	W	A	B	F	P_1	t_2
F95 AUDIO F95	R	8.0±0.3	1.5±0.2	2.6±0.2	3.5±0.05	4.0±0.1	1.05 Max.
	P						1.5 Max.
	Q, S		2.0±0.2	3.6±0.2			1.5 Max.
	A		2.1±0.2	3.7±0.2			2.0 Max.
	T		3.0±0.2	3.75±0.2			1.5 Max.
	B		3.25±0.2	3.7±0.2			2.4 Max.
F72	R	12.0±0.3	6.5±0.2	7.6±0.2	5.5±0.1	8.0±0.1	2.2 Max.
	M		6.6±0.2	7.8±0.2			2.5 Max.
F75	U		3.7±0.2	7.6±0.2			2.7 Max.
	C						3.6 Max.
	D		4.8±0.2	7.9±0.2			3.9 Max.
	R		6.7±0.2	7.6±0.2			4.6 Max.

TAP/TEP 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 in a measuring bridge supplied by a 120 Hz source free of harmonics with 2.2V DC bias max.

1.1.2 Temperature dependence on the 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. See graph below for typical capacitance changes with temperature.

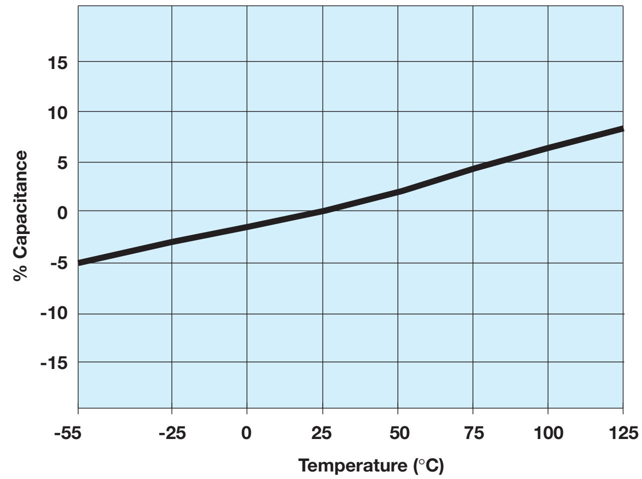
1.1.3 Capacitance tolerance

This is the permissible variation of the actual value of the capacitance from the rated value.

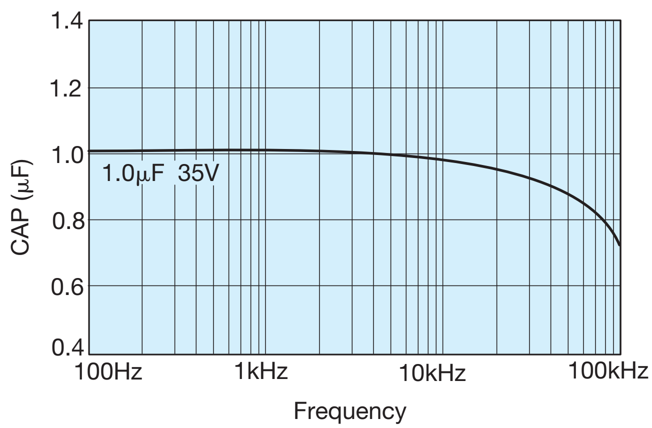
1.1.4 Frequency dependence of the capacitance

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

Typical Capacitance vs. Temperature



Typical Curve Capacitance vs. Frequency



1.2 VOLTAGE

1.2.1 Rated DC voltage (V_R)

This is the rated DC voltage for continuous operation up to +85°C.

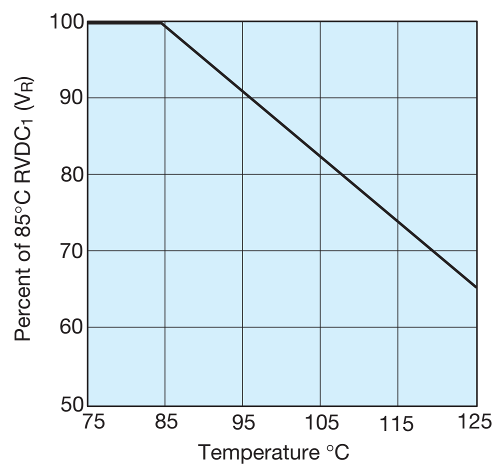
1.2.2 Category voltage (V_C)

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.

1.2.3 Surge voltage (V_S)

This is the highest voltage that may be applied to a capacitor for short periods of time. 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.

Category Voltage vs. Temperature



85°C		125°C	
Rated Voltage (V DC)	Surge Voltage (V DC)	Category Voltage (V DC)	Surge Voltage (V DC)
2	2.6	1.3	1.7
3	4	2	2.6
4	5.2	2.6	3.4
6.3	8	4	5
10	13	6.3	9
16	20	10	12
20	26	13	16
25	33	16	21
35	46	23	28
50	65	33	40

1.2.4 Effect of surges

The solid Tantalum capacitor has a limited ability to withstand surges (15% to 30% of rated voltage). This is in common with all other electrolytic capacitors and is due to the fact that they operate under very high electrical stress within the oxide layer. In the case of 'solid' electrolytic capacitors this is further complicated by the limited self healing ability of the manganese dioxide semiconductor.

It is important to ensure that the voltage across the terminals of the capacitor does not exceed the surge voltage rating at any time. This is particularly so in low impedance circuits where the capacitor is likely to be subjected to the full impact of surges, especially in low inductance applications. Even an extremely short duration spike is likely to cause damage. In such situations it will be necessary to use a higher voltage rating.

1.2.5 Reverse voltage and non-polar operation

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 1V at 25°C

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

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

1.2.6 Non-polar operation

If the higher reverse voltages are essential, then two capacitors, each of twice the required capacitance and of equal tolerance and rated voltage, should be connected in a back-to-back configuration, i.e., both anodes or both cathodes joined together. This is necessary in order to avoid a reduction in life expectancy.

1.2.7 Superimposed AC voltage (V_{rms}) - Ripple Voltage

This is the maximum RMS alternating voltage, superimposed on a DC voltage, that may be applied to a capacitor. The sum of the DC voltage and the surge value of the superimposed AC voltage must not exceed the category voltage, V_c. Full details are given in Section 2.

1.2.8 Voltage derating

Refer to section 3.2 (pages 225-228) for the effect of voltage derating on reliability.

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

1.3.1 Dissipation factor (DF)

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 at +25°C and 120 Hz with 2.2V DC bias max. with an AC voltage free of harmonics. The value of DF is temperature and frequency dependent.

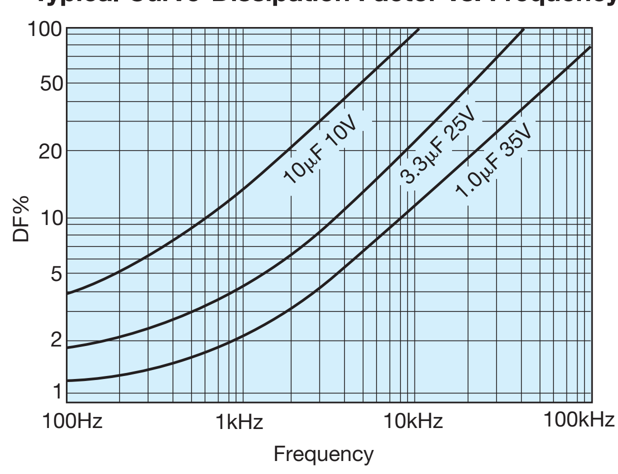
1.3.2 Tangent of loss angle (Tan δ)

This is a measure 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 at +20°C and 120 Hz with 2.2V DC bias max. with an AC voltage free of harmonics.

1.3.3 Frequency dependence of dissipation factor

Dissipation Factor increases with frequency as shown in the typical curves below.

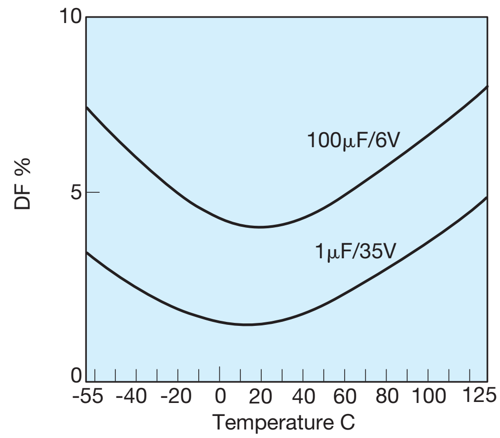
Typical Curve-Dissipation Factor vs. Frequency



1.3.4 Temperature dependence of dissipation factor

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

Typical Curves-Dissipation Factor 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 semiconducting layer, the capacitance, 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 25°C and 100 kHz.

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. The ESR can be found by using the relationship:

$$ESR = \frac{\tan \delta}{2\pi f C}$$

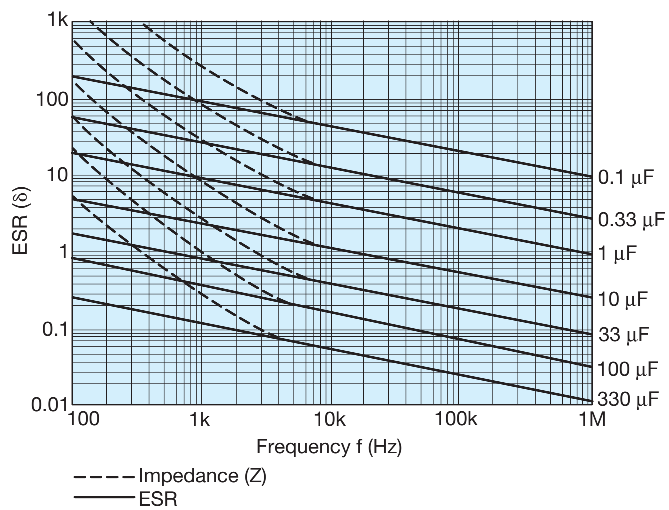
where f is the frequency in Hz, and C is the capacitance in farads. The ESR is measured at 25°C and 100 kHz.

ESR is one of the contributing factors to impedance, and at high frequencies (100 kHz and above) is the dominant factor, so that ESR and impedance become almost identical, impedance being 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 (resistance of the semiconducting layer, etc.) become more significant. Beyond 1 MHz (and beyond the resonant point of the capacitor) impedance again increases due to induction.

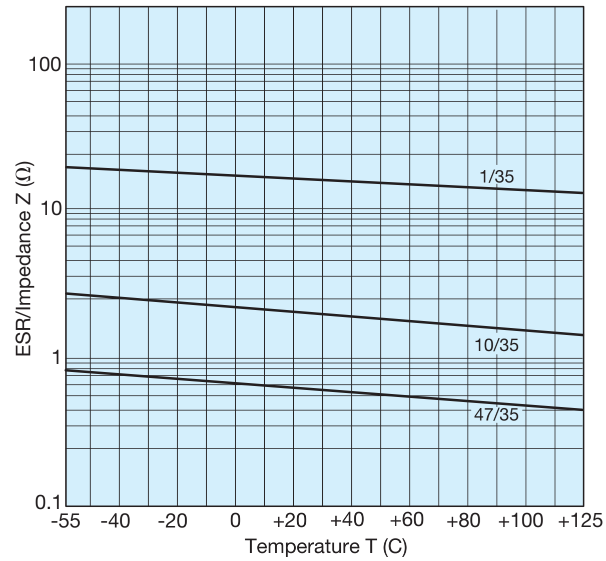
Frequency Dependence of Impedance and ESR



1.4.4 Temperature dependence of the impedance and ESR

At 100 kHz, impedance and ESR behave identically and decrease with increasing temperature as the typical curves show. For maximum limits at high and low temperatures, please refer to graph opposite.

Temperature Dependence of the Impedance and ESR



1.5 DC LEAKAGE CURRENT (DCL)

1.5.1 Leakage current (DCL)

The leakage current is dependent on the voltage applied, the time, and the capacitor temperature. It is measured at +25°C with the rated voltage applied. A protective resistance of 1000Ω is connected in series with the capacitor in the measuring circuit.

Three minutes after application of the rated voltage the leakage current must not exceed the maximum values indicated in the ratings table. Reforming is unnecessary even after prolonged periods without the application of voltage.

1.5.2 Temperature dependence of the leakage current

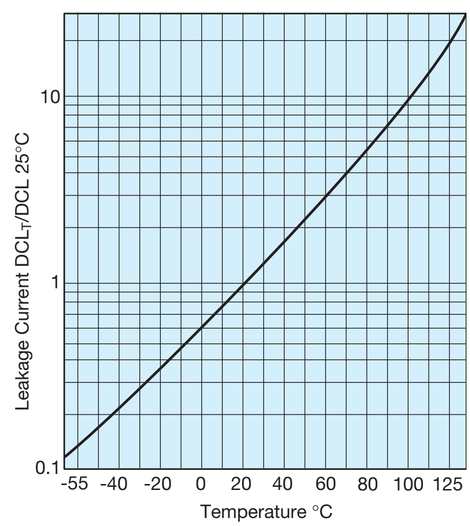
The leakage current increases with higher temperatures, typical values are shown in the graph.

For operation between 85°C and 125°C, the maximum working voltage must be derated and can be found from the following formula.

$$V\,max = \left(1 - \frac{(T-85)}{120}\right) \times V_R \text{ volts}$$

where T is the required operating temperature. Maximum limits are given in rating tables.

Temperature Dependence of the Leakage Current for a Typical Component

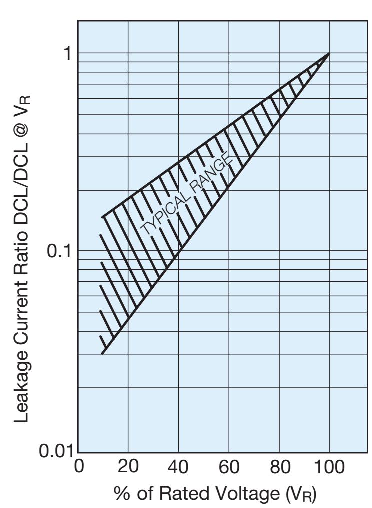


1.5.3 Voltage dependence of the leakage current

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 reliability for any application. See Section 3 (pages 225-227) for details.

Effect of Voltage Derating on Leakage Current



1.5.4 Ripple current

The maximum ripple current allowance can be calculated from the power dissipation limits for a given temperature rise above ambient. Please refer to Section 2 (page 224) for details.

SECTION 2: AC OPERATION — RIPPLE VOLTAGE AND RIPPLE CURRENT

2.1 RIPPLE RATINGS (AC)

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

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

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

Using this formula it is possible to calculate the maximum AC ripple current and voltage permissible for a particular application.

2.2 MAXIMUM AC RIPPLE VOLTAGE (E_{MAX})

From the previous equation:

$$E_{(max)} = Z \sqrt{\frac{P_{max}}{R}}$$

where P_{max} is the maximum permissible ripple voltage as listed for the product under consideration (see table).

However, care must be taken to ensure that:

1. The DC working voltage of the capacitor must not be exceeded by the sum of the positive peak of the applied AC voltage and the DC bias voltage.
2. The sum of the applied DC bias voltage and the negative peak of the AC voltage must not allow a voltage reversal in excess of that defined in the sector, 'Reverse Voltage'.

2.3 MAXIMUM PERMISSIBLE POWER DISSIPATION (WATTS) @ 25°C

The maximum power dissipation at 25°C has been calculated for the various series and are shown in Section 2.4, together with temperature derating factors up to 125°C.

For leaded components the values are calculated for parts supported in air by their leads (free space dissipation).

The ripple ratings are set by defining the maximum temperature rise to be allowed under worst case conditions, i.e., with resistive losses at their maximum limit. This differential is normally 10°C at room temperature dropping to 2°C at 125°C. In application circuit layout, thermal management, available ventilation, and signal waveform may significantly affect the values quoted below. It is recommended that temperature measurements are made on devices during operating conditions to ensure that the temperature differential between the device and the ambient temperature is less than 10°C up to 85°C and less than 2°C between 85°C and 125°C. Derating factors for temperatures above 25°C are also shown below. The maximum permissible proven dissipation should be multiplied by the appropriate derating factor.

For certain applications, e.g., power supply filtering, it may be desirable to obtain a screened level of ESR to enable higher ripple currents to be handled. Please contact our applications desk for information.

2.4 POWER DISSIPATION RATINGS (IN FREE AIR)

TAR – Molded Axial

Case size	Max. power dissipation (W)
Q	0.065
R	0.075
S	0.09
W	0.105

Temperature derating factors	
Temp. °C	Factor
+25	1.0
+85	0.6
+125	0.4

TAA – Hermetically Sealed Axial

Case size	Max. power dissipation (W)
A	0.09
B	0.10
C	0.125
D	0.18

Temperature derating factors	
Temp. °C	Factor
+20	1.0
+85	0.9
+125	0.4

TAP/TEP – Resin Dipped Radial

Case size	Max. power dissipation (W)
A	0.045
B	0.05
C	0.055
D	0.06
E	0.065
F	0.075
G	0.08
H	0.085
J	0.09
K	0.1
L	0.11
M/N	0.12
P	0.13
R	0.14

Temperature derating factors	
Temp. °C	Factor
+25	1.0
+85	0.4
+125	0.09

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, 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.

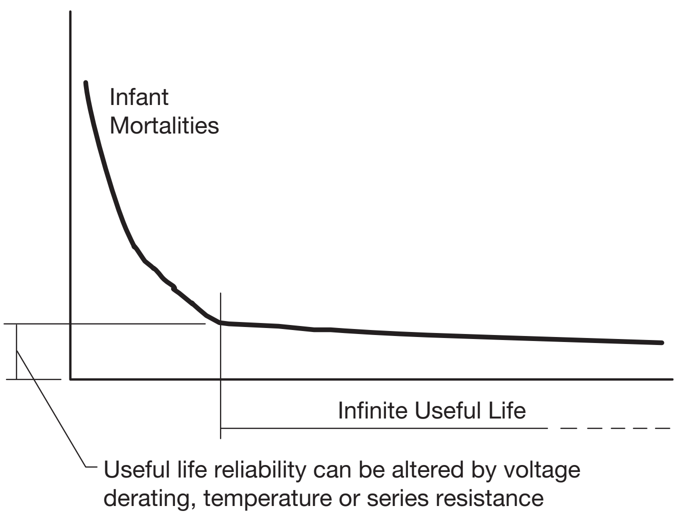


Figure 1. Tantalum reliability curve.

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

$$F = F_U \times F_T \times F_R \times F_B$$

where F_U is a correction factor due to operating voltage/voltage derating

F_T is a correction factor due to operating temperature

F_R is a correction factor due to circuit series resistance

F_B is the basic failure rate level. For standard leaded Tantalum product this is 1%/1000hours

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

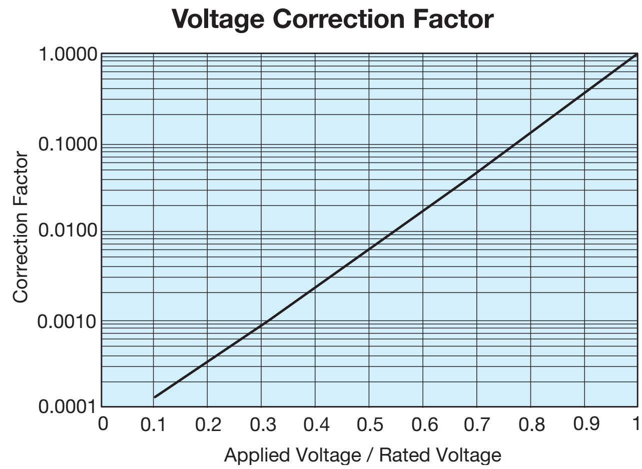


Figure 2. Correction factor to failure rate F for voltage derating of a typical component (60% con. level).

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 F_T for any temperature of operation.

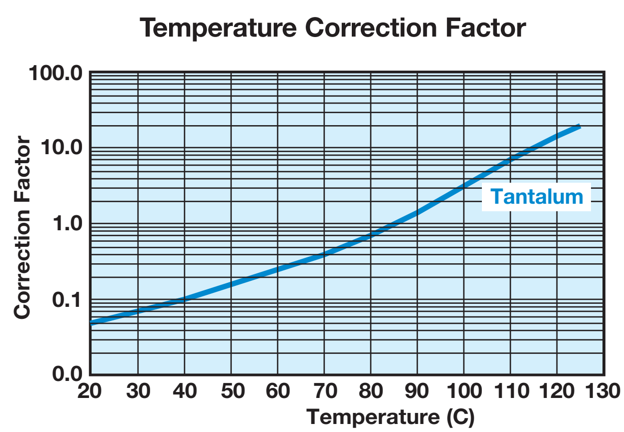


Figure 3. Correction factor to failure rate F for ambient temperature T for typical component (60% con. level).

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 1Ω per volt. Where this is not feasible, equivalent voltage derating should be used (See MIL HANDBOOK 217E). Table I shows the correction factor, F_R, for increasing series resistance.

Table I: Circuit Impedance

Correction factor to failure rate F for series resistance R on basic failure rate F_B 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

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 boards 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) F_T = 0.8 @ 85°C

b) F_R = 0.7 @ 0.167 Ohms/Volt

c) F_U = 0.17 @ applied voltage/rated voltage = 75%

Thus F_B = 0.8 x 0.7 x 0.17 x 1 = 0.0952%/1000 Hours

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

F_U = 0.05 @ applied voltage/rated voltage = 60%

F_B = 0.8 x 0.7 x 0.05 x 1 = 0.028%/1000 Hours

3.2 DYNAMIC

As stated in Section 1.2.4 (page 222), 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 and applied no derating. So that 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 below.

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. Assuming 40°C operation and 0.1Ω/volt of series resistance, the scaling factors for temperature and series resistance will both be 0.05 [see Section 3.1 (page 226)]. The derating factor will be 0.15. The capacitors reliability will therefore be

$$\begin{aligned} \text{Failure rate} &= F_U \times F_T \times F_R \times 1\%/1000 \text{ hours} \\ &= 0.15 \times 0.05 \times 1 \times 1\%/1000 \text{ hours} \\ &= 7.5\% \times 10^{-3}/\text{hours} \end{aligned}$$

If a 10 volt capacitor was used instead, the new scaling factor would be 0.017, thus the steady-state reliability would be

$$\begin{aligned} \text{Failure rate} &= F_U \times F_T \times F_R \times 1\%/1000 \text{ hours} \\ &= 0.017 \times 0.05 \times 1 \times 1\%/1000 \text{ hours} \\ &= 8.5\% \times 10^{-4}/ 1000 \text{ hours} \end{aligned}$$

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

3.3 RELIABILITY TESTING

AVX performs extensive life testing on tantalum capacitors.

- 2,000 hour tests as part of our regular Quality Assurance Program.

Test conditions:

- 85°C/rated voltage/circuit impedance of 3Ω max.
- 125°C/0.67 x rated voltage/circuit impedance of 3Ω max.

3.4 Mode of Failure

This is normally an increase in leakage current which ultimately becomes a short circuit.

SECTION 4: APPLICATION GUIDELINES FOR TANTALUM CAPACITORS

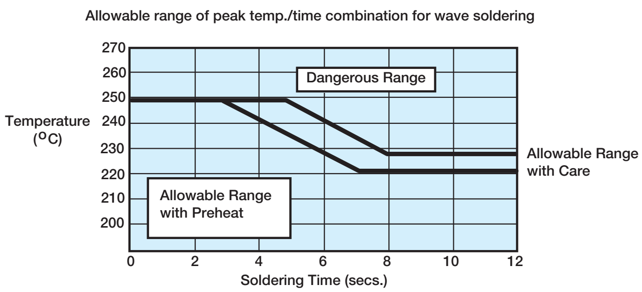
4.1 SOLDERING CONDITIONS AND BOARD ATTACHMENT

The soldering temperature and time should be the minimum for a good connection.

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

Small parametric shifts may be noted immediately after wave solder, components should be allowed to stabilize at room temperature prior to electrical testing.

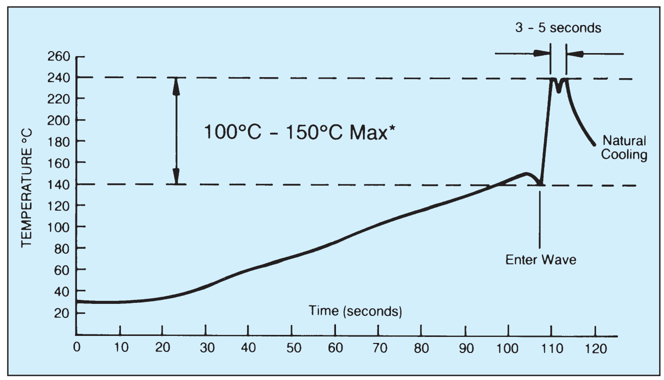
AVX leaded tantalum capacitors are designed for wave soldering operations.



4.2 RECOMMENDED SOLDERING PROFILES

Recommended wave soldering profile for mounting of tantalum capacitors is shown below.

After soldering the assembly should preferably be allowed to cool naturally. In the event that assisted cooling is used, the rate of change in temperature should not exceed that used in reflow.



*See appropriate product specification

SECTION 5: MECHANICAL AND THERMAL PROPERTIES, LEADED CAPACITORS

5.1 ACCELERATION

10 g (981 m/s)

5.2 VIBRATION SEVERITY

10 to 2000 Hz, 0.75 mm or 98 m/s^2

5.3 SHOCK

Trapezoidal Pulse 10 g (981 m/s) for 6 ms

5.4 TENSILE STRENGTH OF CONNECTION

10 N for type TAR, 5 N for type TAP/TEP.

5.5 BENDING STRENGTH OF CONNECTIONS

2 bends at 90°C with 50% of the tensile strength test loading.

5.6 SOLDERING CONDITIONS

Dip soldering permissible provided solder bath temperature ≦270°C; solder time <3 sec.; circuit board thickness ≧1.0 mm.

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.

QUESTIONS AND ANSWERS

Some commonly asked questions regarding Tantalum Capacitors:

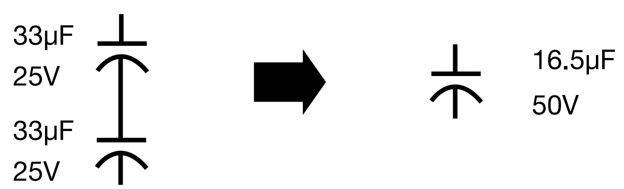
Question: If I use several tantalum capacitors in serial/parallel combinations, how can I ensure equal current and voltage sharing?

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.

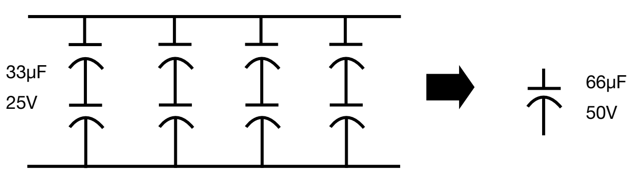
The maximum voltage seen by the capacitor is V_{dc} + V_{ac}=25.5V

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

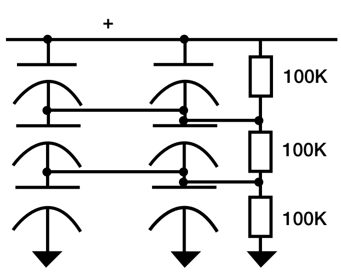
Connecting two 25V rated capacitors in series will give the required capacitance voltage rating, but the effective capacitance will be halved, so for greater than



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. Tantalums 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: 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°= 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

QUESTIONS AND ANSWERS

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 2 years. Recommended storage conditions are: Temperature between -10ºC – +50ºC with humidity 75% RH maximum and atmospheric pressure 860 mbar-1060 mbar. Terminations should be checked for solderability in the event an oxidation develops on the solder plating.

Question: Are any recommendations/limitation for capacitor selection in parallel combination of capacitors?

Answer: Higher performance series TPS, TPM, NOS, NOM, TCJ, TCN are designed to provide lower ESR values and make the product more robust against current surges. The design differences make the better performance distribution of parameters, namely ESR is lower and tighter compared to the general purpose TAJ series. The surge current load in a parallel combination of capacitors is therefore shared more evenly amongst the capacitors and thus it is better suited for this application.

In a parallel combination is is strongly recommended to use the low ESR series of Tantalum Capacitors such as TPS, TPM, NOS, NOM, TCJ and TCN. Do not combine different series of manufacturers within one parallel combination.

Question: What level of voltage derating is needed for Tantalum Capacitors?

Answer: For many years whenever people have asked a tantalum capacitor manufacturer about what were the safe guidelines for using their product, they spoke with one voice "a minimum of 50% voltage derating should be applied". This message has since become ingrained and automatic. This article challenges this statement and explains why it is not necessarily the case.

The 50% rule came about when tantalum capacitors started to be used on low impedance sources. In such applications, the available current is high and therefore a risk of failure is inherent. Well established by empirical methods and covered in MIL-STD 317, was the fact that the amount of voltage derating has a major influence on the failure rate of a tantalum capacitor (Figure 1). Indeed, from rated voltage to 50% of rated voltage is an improvement in failure rate of more than 100.

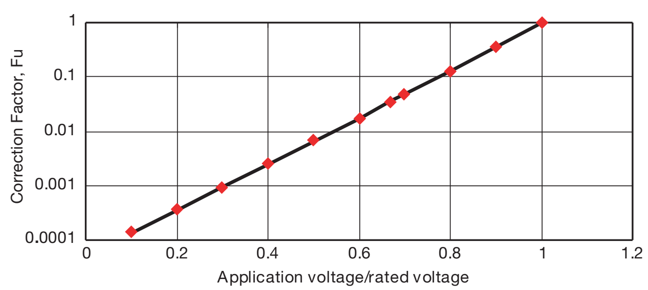
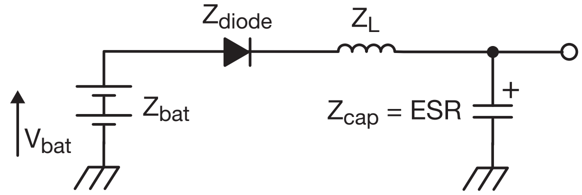


Figure 1

It was also proved that the same was true of dynamic, high current pulse conditions[1], hence the recommendation.

Now let us look more closely at the type of circuits in use. Below is a simple circuit which will be discussed further in this text.



Let us assume this is a 2 cell battery system, therefore

$V_{bat} = 3.2$ Volts

Also, let us assume

$Z_{bat} = 60\ m\Omega$, $Z_{diode} = 70\ m\Omega$, $Z_{cap} = 120\ m\Omega$, $Z_L = 70\ m\Omega$

If the "50% rule" was followed, the designer should chose a 6.3V rated capacitor.

The total circuit impedance of the system is 320 mΩ. So by Ohm's law the peak current would be 10 Amps.

This exceeds the test conditions used by AVX to screen its product for high current pulses[1], so a risk of failure exists. Clearly a minimum of a 10 volt rate capacitor is required in this application.

As a general rule of thumb, the maximum current a tantalum capacitor can withstand (provided it has not been damaged by thermomechanical damage[2 3] or some other external influence) is given by the equation:

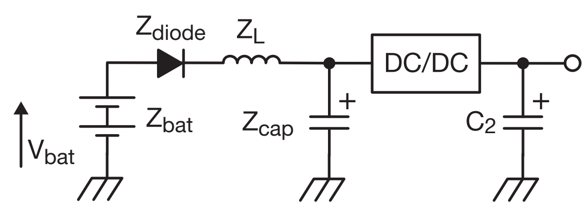
$$Imax = V_{rated} / (1 + \text{Catalog ESR})$$

So for example for a 100µF 10V D case capacitor (Catalog ESR = 0.9 Ohms), this would be:

$$Imax = 10 / (1 + 0.9) = 5.2 \text{ Amps}$$

In some circuits, because of size restrictions, a tantalum capacitor may be the only option available. If this is the case, AVX recommends a PFET integrator be used to slow the voltage ramp at turn on, which in effect reduces the peak current, and therefore reduces the risk of failure[4].

Now, let's consider a continuation of the circuit with the addition of an LDO or DC/DC convertor.



The risk of a high surge current being seen by the capacitor in location C_2 is very small. Therefore if we assume the voltage rail is 2.8 volts and the maximum current seen by C_2 is <1.5 Amps, a 4 volt capacitor could be able to be used in this application.

This all seems like good news, but as always, there are some downsides to using a part nearer to its rated voltage. The first is the steady-state life, or MTBF. The MTBF of a tantalum capacitor is easily calculated from MIL-STD 317 or the supplier's catalog data. An example is given below:

Assume operating temperature is 85°C and circuit impedance 0.1 Ohms/volt ($F_T = 1$).

For a 10 volt rated capacitor on a 5 volt rated line, the failure rate is:

$$F_R = 1\%/1000 \text{ hours} \times F_T \times F_U \times F_R$$
$$= 1\%/1000 \text{ hours} \times 1 \times 0.007 \text{ (from Figure 1)} \times 1$$
$$= 0.007\%/1000 \text{ hours}$$

$$MTBF = 10^5 / F_R$$
$$= 14{,}285{,}238 \text{ hours}$$
$$= 1{,}631 \text{ years}$$

For a 6.3 volt rated capacitor on a 5 volt rated line, the failure rate is:

$$F_R = 1\%/1000 \text{ hours} \times F_T \text{ X } F_U \text{ X } F_R$$
$$= 1\%/1000 \text{ hours} \times 1 \times 0.12 \text{ (from Figure 1)} \times 1$$
$$= 0.12\ \%/1000 \text{ hours}$$

$$MTBF = 10^5 / F_R$$
$$= 833{,}333 \text{ hours}$$
$$= 95 \text{ years}$$

The second factor to be considered is that the more derating applied to a tantalum capacitor, the lower the leakage current level (Figure 2). Therefore a part used at 50% of its rated voltage will have more than 3 times better leakage levels than one used at 80%.

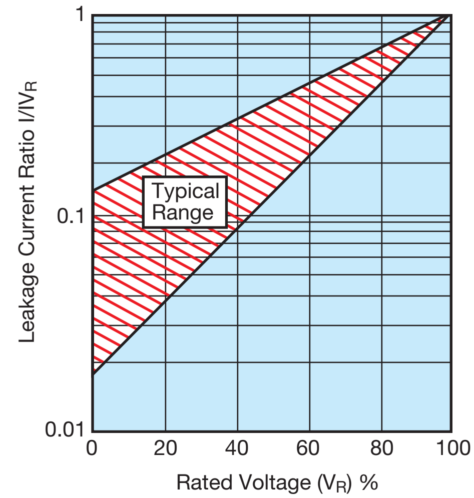


Figure 2

One final point worthy of mention with the introduction of higher reflow temperatures with the introduction of lead-free solders is that voltage derating can help to reduce the risk of failures due to thermomechanical damage during reflow.

To summarize, a tantalum capacitor is capable of being used at its rated voltage or close to it, provided that the user obeys the rules outlined in this document and is prepared for the reduced steady-state life performance and higher leakage current levels this would produce.

1 Surge in Solid Tantalum Capacitors, John Gill, AVX Tantalum

2 IR Reflow Guidelines for Tantalum Capacitors, Steve Warden & John Gill, AVX Tantalum

3 Mounting Guidelines in AVX Tantalum Catalog

4 Improving Reliability of Tantalum Capacitors in Low Impedance Circuits, Dave Mattingly, AVX

Question: What does failure rate mean?

Answer: Failure rate is expressed as the number of parts (as a percentage) that can be expected to fail in a given time period under specific conditions of temperature, applied voltage (ratio to rated voltage - usually 1.0) and circuit impedance.

Question: What does ppm mean?

Answer: PPM is defined as 'PARTS PER MILLION' and can be used to express how many parts within a million pieces may fail to the specification.

Question: What is the difference between %/1000hrs and FITs?

Answer: The failure rate as the mathematic quantity can be expressed in several units of measurement - mostly in %/1000hrs or in FITs. FITs are usually used for the high-reliability components where expression in %/1000hrs would be more difficult to read. The conversion is as follows: e.g. 0.01%/1000hrs = 100 FIT for specified conditions ([%/1000hrs] = x 10000 [FIT]).

Question: What are the standards for reliability calculations?

Answer: The standards used in the AVX specification are based on the European norm EN 61709 with the added feature of series resistance in order to better reflect real application conditions. The basic failure rate in the AVX test is given for conditions - 85°C, Vrated, 0.1 Ohm/V. To calculate the actual failure rate for specific conditions you have to consider the influence of different factors which have an impact on reliability - correction factors for temperature (FT), voltage derating (FV),(circuit) impedance (FR) and the base failure rate (Fbase) for the series being used.

Question: Are tantalum capacitors ESD (i.e. Electrostatic Discharge) sensitive devices?

Answer: All tantalum and niobium Oxide capacitors are not ESD sensitive devices.