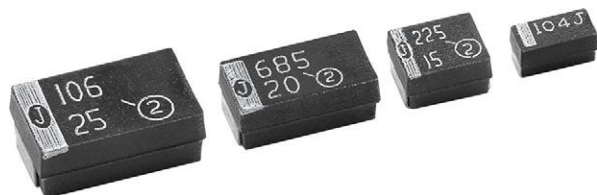


Solid Tantalum Surface Mount Chip Capacitors

TANTAMOUNT™ Molded Case, Military MIL-PRF-55365/8 Qualified



PERFORMANCE / ELECTRICAL CHARACTERISTICS

www.vishay.com/doc?40211

Operating Temperature: -55 °C to +125 °C
(above 85 °C, voltage derating is required)

Capacitance Range: 0.10 µF to 100 µF

Capacitance Tolerance: ± 5 %, ± 10 %, ± 20 %

Voltage Rating: 4 V_{DC} to 50 V_{DC}

FEATURES

- Weibull failure rate codes B, C, D, and T
- Surge current options A, B, and C
- Termination: H = solder plated, K = solder fused
- Molded case available in four case codes
- Compatible with “high volume” automatic pick and place equipment
- Moisture sensitivity level 1
- The molding compound has been selected to meet the requirements of UL 94 V-0 and outgassing requirements of ASTM E-595

APPLICATIONS

- Military / aerospace
- General purpose
- High reliability

ORDERING INFORMATION

CWR11	D	H	155	K	B	A	/HR
TYPE	VOLTAGE	TERMINATION FINISH	CAPACITANCE	CAPACITANCE TOLERANCE	FAILURE RATE %/1000 h	SURGE CURRENT (OPTIONAL)	PACKAGING OPTION
	C = 4 V D = 6 V F = 10 V H = 15 V J = 20 V K = 25 V M = 35 V N = 50 V	H = solder plated K = solder fused	This is expressed in picofarads. The first two digits are the significant figures. The third is the number of zeros to follow.	J = ± 5 % K = ± 10 % M = ± 20 %	M = 1.0 P = 0.1 R = 0.01 S = 0.001 B = 0.1 C = 0.01 D = 0.001 T = 0.01 ⁽¹⁾	Blank = no surge A = 10 cycles at +25 °C B = 10 cycles at -55 °C / +85 °C C = 10 cycles at -55 °C / +85 °C (before Weibull grading)	Blank = full reel /PR = 100 pcs reel /HR = half reel /PT = bulk, plastic tray /FA = waffle pack

Note

- ⁽¹⁾ T level requires surge current option “C”. Capacitors are recommended for “space applications”.
Shipped in tape and reel or waffle packaging only

DIMENSIONS in inches [millimeters]

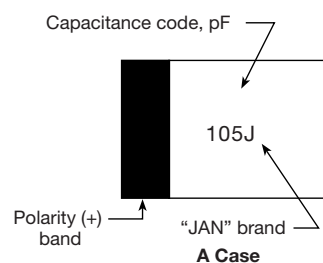
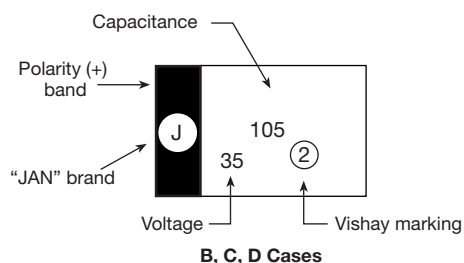
CASE CODE	EIA SIZE	L	W	H	P	T _W	T _H MIN.
A	3216-18	0.126 ± 0.008 [3.2 ± 0.20]	0.063 ± 0.008 [1.6 ± 0.20]	0.063 ± 0.008 [1.6 ± 0.20]	0.031 ± 0.012 [0.80 ± 0.30]	0.047 ± 0.004 [1.2 ± 0.10]	0.028 [0.70]
B	3528-21	0.138 ± 0.008 [3.5 ± 0.20]	0.110 ± 0.008 [2.8 ± 0.20]	0.075 ± 0.008 [1.9 ± 0.20]	0.031 ± 0.012 [0.80 ± 0.30]	0.087 ± 0.004 [2.2 ± 0.10]	0.028 [0.70]
C	6032-28	0.236 ± 0.012 [6.0 ± 0.30]	0.126 ± 0.012 [3.2 ± 0.30]	0.098 ± 0.012 [2.5 ± 0.30]	0.051 ± 0.012 [1.3 ± 0.30]	0.087 ± 0.004 [2.2 ± 0.10]	0.039 [1.0]
D	7343-31	0.287 ± 0.012 [7.3 ± 0.30]	0.170 ± 0.012 [4.3 ± 0.30]	0.110 ± 0.012 [2.8 ± 0.30]	0.051 ± 0.012 [1.3 ± 0.30]	0.095 ± 0.004 [2.4 ± 0.10]	0.039 [1.0]

Note

- Glue pad (non-conductive, part of molded case) is dedicated for glue attachment (as user option)

RATINGS AND CASE CODES

μF	4 V	6 V	10 V	15 V	20 V	25 V	35 V	50 V
0.10							A	A
0.15							A	B
0.22							A	B
0.33						A	A	B
0.47					A	A	B	C
0.68				A	A	B	B	C
1.0			A	A	A	B	B	C
1.5		A	A	A	B	B	C	D
2.2	A	A	A	B	B	C	C	D
3.3		A	B	B	B	C	C	D
4.7	A	B	B	B	C	C	D	D
6.8	B	B	B		C	D	D	
10	B	B		C		D		
15	B	C	C		D	D		
22		C		D	D			
33	C		D	D				
47		D	D					
68	D	D						
100	D							

MARKING

STANDARD RATINGS

CAPACITANCE (μ F)	CASE CODE	PART NUMBER	MAX. DC LEAKAGE (μ A) AT			MAX. DF 120 Hz (%) AT			MAX. ESR AT +25 °C 100 kHz (Ω)
			+25 °C	+85 °C	+125 °C	+25 °C	+85 °C +125 °C	-55 °C	
			4 V _{DC} AT +85 °C; 2.7 V _{DC} AT +125 °C						
2.2	A	CWR11C(1)225(2)(3)(4)(5)	0.5	5.0	6.0	6	9	9	8.0
4.7	A	CWR11C(1)475(2)(3)(4)(5)	0.5	5.0	6.0	6	9	9	8.0
6.8	B	CWR11C(1)685(2)(3)(4)(5)	0.5	5.0	6.0	6	9	9	5.5
10	B	CWR11C(1)106(2)(3)(4)(5)	0.5	5.0	6.0	6	9	9	4.0
15	B	CWR11C(1)156(2)(3)(4)(5)	0.6	6.0	7.2	6	9	9	3.5
33	C	CWR11C(1)336(2)(3)(4)(5)	1.3	13.0	15.6	6	9	9	2.2
68	D	CWR11C(1)686(2)(3)(4)(5)	2.7	27.0	32.4	6	9	9	1.1
100	D	CWR11C(1)107(2)(3)(4)(5)	4.0	40.0	48.0	8	12	12	0.9

Note

- Part number definitions:
 - Termination: H, K
 - Capacitance tolerance: J, K, M
 - Failure rate: B, C, D, M, P, R, S, T
Exponential failure rate levels M, P, R, and S are inactive for new design per MIL-PRF-55365
Capacitors qualified to Weibull failure rate levels are substitutable for exponential failure rate levels
 - Surge current (optional): A, B, C
 - Packaging: blank, /HR, /PR, /PT, /FA



STANDARD RATINGS									
CAPACITANCE (μF)	CASE CODE	PART NUMBER	MAX. DC LEAKAGE (μA) AT			MAX. DF 120 Hz (%) AT			MAX. ESR AT +25 °C 100 kHz (Ω)
			+25 °C	+85 °C	+125 °C	+25 °C	+85 °C +125 °C	-55 °C	
6 V _{DC} AT +85 °C; 4 V _{DC} AT +125 °C									
1.5	A	CWR11D(1)155(2)(3)(4)(5)	0.5	5.0	6.0	6	9	9	8.0
2.2	A	CWR11D(1)225(2)(3)(4)(5)	0.5	5.0	6.0	6	6	9	8.0
3.3	A	CWR11D(1)335(2)(3)(4)(5)	0.5	5.0	6.0	6	9	9	8.0
4.7	B	CWR11D(1)475(2)(3)(4)(5)	0.5	5.0	6.0	6	9	9	5.5
6.8	B	CWR11D(1)685(2)(3)(4)(5)	0.5	5.0	6.0	6	6	9	4.5
10	B	CWR11D(1)106(2)(3)(4)(5)	0.6	6.0	7.2	6	9	9	3.5
15	C	CWR11D(1)156(2)(3)(4)(5)	0.9	9.0	10.8	6	6	9	3.0
22	C	CWR11D(1)226(2)(3)(4)(5)	1.4	14.0	16.8	6	9	9	2.2
47	D	CWR11D(1)476(2)(3)(4)(5)	2.8	28.0	33.6	6	6	9	1.1
68	D	CWR11D(1)686(2)(3)(4)(5)	4.3	43.0	51.6	6	9	9	0.9
10 V _{DC} AT +85 °C; 7 V _{DC} AT +125 °C									
1.0	A	CWR11F(1)105(2)(3)(4)(5)	0.5	5.0	6.0	4	6	6	10.0
1.5	A	CWR11F(1)155(2)(3)(4)(5)	0.5	5.0	6.0	6	6	9	8.0
2.2	A	CWR11F(1)225(2)(3)(4)(5)	0.5	5.0	6.0	6	9	9	8.0
3.3	B	CWR11F(1)335(2)(3)(4)(5)	0.5	5.0	6.0	6	9	9	5.5
4.7	B	CWR11F(1)475(2)(3)(4)(5)	0.5	5.0	6.0	6	9	9	4.5
6.8	B	CWR11F(1)685(2)(3)(4)(5)	0.7	7.0	8.4	6	9	9	3.5
15	C	CWR11F(1)156(2)(3)(4)(5)	1.5	15.0	18.0	6	6	9	2.5
33	D	CWR11F(1)336(2)(3)(4)(5)	3.3	33.0	39.6	6	9	9	1.1
47	D	CWR11F(1)476(2)(3)(4)(5)	4.7	47.0	56.4	6	9	9	0.9
15 V _{DC} AT +85 °C; 10 V _{DC} AT +125 °C									
0.68	A	CWR11H(1)684(2)(3)(4)(5)	0.5	5.0	6.0	4	6	6	12.0
1.0	A	CWR11H(1)105(2)(3)(4)(5)	0.5	5.0	6.0	4	6	6	10.0
1.5	A	CWR11H(1)155(2)(3)(4)(5)	0.5	5.0	6.0	6	9	9	8.0
2.2	B	CWR11H(1)225(2)(3)(4)(5)	0.5	5.0	6.0	6	9	9	5.5
3.3	B	CWR11H(1)335(2)(3)(4)(5)	0.5	5.0	6.0	6	8	9	5.0
4.7	B	CWR11H(1)475(2)(3)(4)(5)	0.7	7.0	8.4	6	9	9	4.0
10	C	CWR11H(1)106(2)(3)(4)(5)	1.6	16.0	19.2	6	8	9	2.5
22	D	CWR11H(1)226(2)(3)(4)(5)	3.3	33.0	39.6	6	8	9	1.1
33	D	CWR11H(1)336(2)(3)(4)(5)	5.3	53.0	63.6	6	9	9	0.9
20 V _{DC} AT +85 °C; 13 V _{DC} AT +125 °C									
0.47	A	CWR11J(1)474(2)(3)(4)(5)	0.5	5.0	6.0	4	6	6	14.0
0.68	A	CWR11J(1)684(2)(3)(4)(5)	0.5	5.0	6.0	4	6	6	12.0
1.0	A	CWR11J(1)105(2)(3)(4)(5)	0.5	5.0	6.0	4	6	6	10.0
1.5	B	CWR11J(1)155(2)(3)(4)(5)	0.5	5.0	6.0	6	9	9	6.0
2.2	B	CWR11J(1)225(2)(3)(4)(5)	0.5	5.0	6.0	6	8	9	5.0
3.3	B	CWR11J(1)335(2)(3)(4)(5)	0.7	7.0	8.4	6	9	9	4.0
4.7	C	CWR11J(1)475(2)(3)(4)(5)	1.0	10.0	12.0	6	8	9	3.0
6.8	C	CWR11J(1)685(2)(3)(4)(5)	1.4	14.0	16.8	6	9	9	2.4
15	D	CWR11J(1)156(2)(3)(4)(5)	3.0	30.0	36.0	6	8	9	1.1
22	D	CWR11J(1)226(2)(3)(4)(5)	4.4	44.0	52.8	6	9	9	0.9

Note

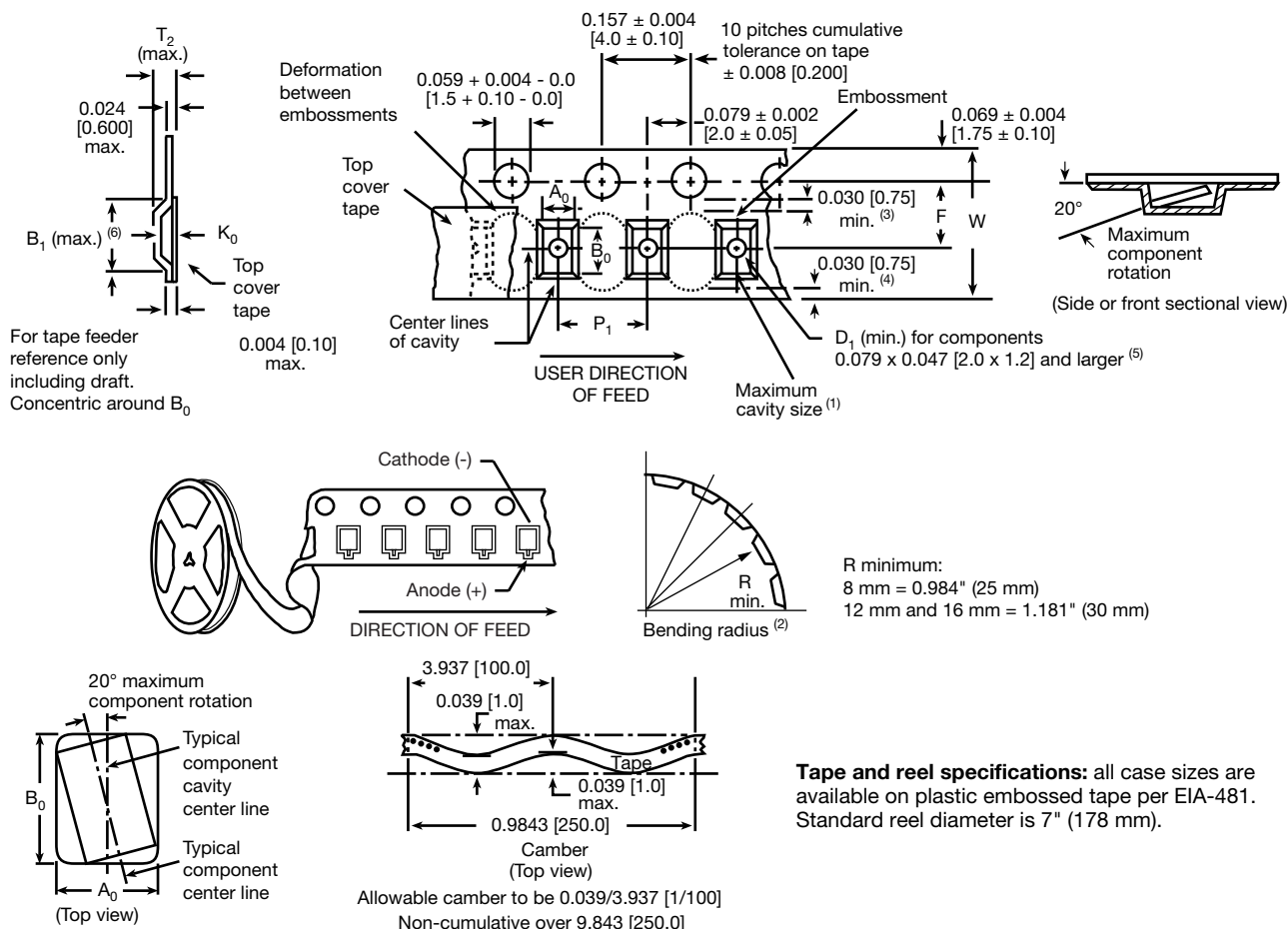
- Part number definitions:
 - Termination: H, K
 - Capacitance tolerance: J, K, M
 - Failure rate: B, C, D, M, P, R, S, T
Exponential failure rate levels M, P, R, and S are inactive for new design per MIL-PRF-55365
Capacitors qualified to Weibull failure rate levels are substitutable for exponential failure rate levels
 - Surge current (optional): A, B, C
 - Packaging: blank, /HR, /PR, /PT, /FA



STANDARD RATINGS									
CAPACITANCE (μF)	CASE CODE	PART NUMBER	MAX. DC LEAKAGE (μA) AT			MAX. DF 120 Hz (%) AT			MAX. ESR AT +25 °C 100 kHz (Ω)
			+25 °C	+85 °C	+125 °C	+25 °C	+85 °C +125 °C	-55 °C	
25 V _{DC} AT +85 °C; 17 V _{DC} AT +125 °C									
0.33	A	CWR11K(1)334(2)(3)(4)(5)	0.5	5.0	6.0	4	6	6	15.0
0.47	A	CWR11K(1)474(2)(3)(4)(5)	0.5	5.0	6.0	4	6	6	14.0
0.68	B	CWR11K(1)684(2)(3)(4)(5)	0.5	5.0	6.0	4	6	6	7.5
1.0	B	CWR11K(1)105(2)(3)(4)(5)	0.5	5.0	6.0	4	6	6	6.5
1.5	B	CWR11K(1)155(2)(3)(4)(5)	0.5	5.0	6.0	6	8	9	6.5
2.2	C	CWR11K(1)225(2)(3)(4)(5)	0.6	6.0	7.2	6	9	9	3.5
3.3	C	CWR11K(1)335(2)(3)(4)(5)	0.9	9.0	10.8	6	8	9	3.5
4.7	C	CWR11K(1)475(2)(3)(4)(5)	1.2	12.0	14.4	6	9	9	2.5
6.8	D	CWR11K(1)685(2)(3)(4)(5)	1.7	17.0	20.4	6	9	9	1.4
10	D	CWR11K(1)106(2)(3)(4)(5)	2.5	25.0	30.0	6	8	9	1.2
15	D	CWR11K(1)156(2)(3)(4)(5)	3.8	38.0	45.6	6	9	9	1.0
35 V _{DC} AT +85 °C; 23 V _{DC} AT +125 °C									
0.10	A	CWR11M(1)104(2)(3)(4)(5)	0.5	5.0	6.0	4	6	6	24.0
0.15	A	CWR11M(1)154(2)(3)(4)(5)	0.5	5.0	6.0	4	6	6	21.0
0.22	A	CWR11M(1)224(2)(3)(4)(5)	0.5	5.0	6.0	4	6	6	18.0
0.33	A	CWR11M(1)334(2)(3)(4)(5)	0.5	5.0	6.0	4	6	6	15.0
0.47	B	CWR11M(1)474(2)(3)(4)(5)	0.5	5.0	6.0	4	6	6	10.0
0.68	B	CWR11M(1)684(2)(3)(4)(5)	0.5	5.0	6.0	4	6	6	8.0
1.0	B	CWR11M(1)105(2)(3)(4)(5)	0.5	5.0	6.0	4	6	6	6.5
1.5	C	CWR11M(1)155(2)(3)(4)(5)	0.5	5.0	6.0	6	8	9	4.5
2.2	C	CWR11M(1)225(2)(3)(4)(5)	0.8	8.0	9.6	6	8	9	3.5
3.3	C	CWR11M(1)335(2)(3)(4)(5)	1.2	12.0	14.4	6	8	9	2.5
4.7	D	CWR11M(1)475(2)(3)(4)(5)	1.7	17.0	20.4	6	8	9	1.5
6.8	D	CWR11M(1)685(2)(3)(4)(5)	2.4	24.0	28.8	6	9	9	1.3
50 V _{DC} AT +85 °C; 33 V _{DC} AT +125 °C									
0.10	A	CWR11N(1)104(2)(3)(4)(5)	0.5	5.0	12.0	6	8	8	22.0
0.15	B	CWR11N(1)154(2)(3)(4)(5)	0.5	5.0	6.0	4	6	6	17.0
0.22	B	CWR11N(1)224(2)(3)(4)(5)	0.5	5.0	6.0	4	6	6	14.0
0.33	B	CWR11N(1)334(2)(3)(4)(5)	0.5	5.0	6.0	4	6	6	12.0
0.47	C	CWR11N(1)474(2)(3)(4)(5)	0.5	5.0	6.0	4	6	6	8.0
0.68	C	CWR11N(1)684(2)(3)(4)(5)	0.5	5.0	6.0	4	6	6	7.0
1.0	C	CWR11N(1)105(2)(3)(4)(5)	0.5	5.0	6.0	4	6	6	6.0
1.5	D	CWR11N(1)155(2)(3)(4)(5)	0.8	8.0	9.6	6	8	9	4.0
2.2	D	CWR11N(1)225(2)(3)(4)(5)	1.1	11.0	13.2	6	8	9	2.5
3.3	D	CWR11N(1)335(2)(3)(4)(5)	1.7	17.0	20.4	6	9	9	2.0
4.7	D	CWR11N(1)475(2)(3)(4)(5)	2.4	24.0	28.8	6	9	9	1.5

Note

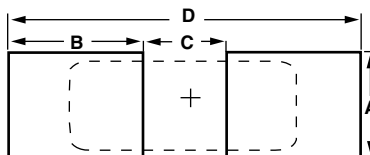
- Part number definitions:
 - Termination: H, K
 - Capacitance tolerance: J, K, M
 - Failure rate: B, C, D, M, P, R, S, T
Exponential failure rate levels M, P, R, and S are inactive for new design per MIL-PRF-55365
Capacitors qualified to Weibull failure rate levels are substitutable for exponential failure rate levels
 - Surge current (optional): A, B, C
 - Packaging: blank, /HR, /PR, /PT, /FA

TAPE AND REEL PACKAGING in inches [millimeters]

Notes

- Metric dimensions will govern. Dimensions in inches are rounded and for reference only
- (1) A₀, B₀, K₀, are determined by the maximum dimensions to the ends of the terminals extending from the component body and / or the body dimensions of the component. The clearance between the ends of the terminals or body of the component to the sides and depth of the cavity (A₀, B₀, K₀) must be within 0.002" (0.05 mm) minimum and 0.020" (0.50 mm) maximum. The clearance allowed must also prevent rotation of the component within the cavity of not more than 20°
- (2) Tape with components shall pass around radius "R" without damage. The minimum trailer length may require additional length to provide "R" minimum for 12 mm embossed tape for reels with hub diameters approaching N minimum
- (3) This dimension is the flat area from the edge of the sprocket hole to either outward deformation of the carrier tape between the embossed cavities or to the edge of the cavity whichever is less
- (4) This dimension is the flat area from the edge of the carrier tape opposite the sprocket holes to either the outward deformation of the carrier tape between the embossed cavity or to the edge of the cavity whichever is less
- (5) The embossed hole location shall be measured from the sprocket hole controlling the location of the embossment. Dimensions of embossment location shall be applied independent of each other
- (6) B₁ dimension is a reference dimension tape feeder clearance only

CARRIER TAPE DIMENSIONS in inches [millimeters]

CASE CODE	TAPE SIZE	B ₁ (max.)	D ₁ (min.)	F	P ₁	T ₂ (max.)	W
A, B	8 mm	0.165 [4.2]	0.039 [1.0]	0.138 ± 0.002 [3.5 ± 0.05]	0.157 ± 0.004 [4.0 ± 0.1]	0.094 [2.4]	0.315 ± 0.012 [8.0 ± 0.30]
C, D	12 mm	0.323 [8.2]	0.059 [1.5]	0.217 ± 0.002 [5.5 ± 0.05]	0.315 ± 0.004 [8.0 ± 1.0]	0.177 [4.5]	0.472 ± 0.012 [12.0 ± 0.30]

PAD DIMENSIONS in inches [millimeters]


CASE CODE	A (min.)	B (nom.)	C (nom.)	D (nom.)
A	0.071 [1.80]	0.067 [1.70]	0.053 [1.35]	0.187 [4.75]
B	0.118 [3.00]	0.071 [1.80]	0.065 [1.65]	0.207 [5.25]
C	0.118 [3.00]	0.094 [2.40]	0.118 [3.00]	0.307 [7.80]
D	0.157 [4.00]	0.098 [2.50]	0.150 [3.80]	0.346 [8.80]

POWER DISSIPATION

CASE CODE	MAXIMUM PERMISSIBLE POWER DISSIPATION AT +25 °C (W) IN FREE AIR
A	0.075
B	0.085
C	0.110
D	0.150

STANDARD PACKAGING QUANTITY

CASE CODE	UNITS PER REEL			BULK, PLASTIC TRAY QUANTITIES
	7" REEL	HALF 7" REEL (/HR)	PARTIAL 7" REEL (/PR)	
A	2000	1000	100	50
B	2000	1000	100	50
C	500	250	100	50
D	500	250	100	50

Notes

- Bulk capacitors are shipped in plastic trays
- T level capacitors are only shipped in tape and reel / or waffle packaging
Contact factory for waffle pack quantities

PRODUCT INFORMATION

Guide for Molded Tantalum Capacitors	www.vishay.com/doc?40074
Pad Dimensions	
Packaging Dimensions	
Moisture Sensitivity (MSL)	www.vishay.com/doc?40135
SELECTOR GUIDES	
Solid Tantalum Selector Guide	www.vishay.com/doc?49053
Solid Tantalum Chip Capacitors	www.vishay.com/doc?40091
FAQ	
Frequently Asked Questions	www.vishay.com/doc?40110



Guide for Molded Tantalum Capacitors

INTRODUCTION

Tantalum electrolytic capacitors are the preferred choice in applications where volumetric efficiency, stable electrical parameters, high reliability, and long service life are primary considerations. The stability and resistance to elevated temperatures of the tantalum / tantalum oxide / manganese dioxide system make solid tantalum capacitors an appropriate choice for today's surface-mount assembly technology.

Vishay Sprague has been a pioneer and leader in this field, producing a large variety of tantalum capacitor types for consumer, industrial, automotive, military, and aerospace electronic applications.

Tantalum is not found in its pure state. Rather, it is commonly found in a number of oxide minerals, often in combination with Columbium ore. This combination is known as "tantalite" when its contents are more than one-half tantalum. Important sources of tantalite include Australia, Brazil, Canada, China, and several African countries. Synthetic tantalite concentrates produced from tin slags in Thailand, Malaysia, and Brazil are also a significant raw material for tantalum production.

Electronic applications, and particularly capacitors, consume the largest share of world tantalum production. Other important applications for tantalum include cutting tools (tantalum carbide), high temperature super alloys, chemical processing equipment, medical implants, and military ordnance.

Vishay Sprague is a major user of tantalum materials in the form of powder and wire for capacitor elements and rod and sheet for high temperature vacuum processing.

THE BASICS OF TANTALUM CAPACITORS

Most metals form crystalline oxides which are non-protecting, such as rust on iron or black oxide on copper. A few metals form dense, stable, tightly adhering, electrically insulating oxides. These are the so-called "valve" metals and include titanium, zirconium, niobium, tantalum, hafnium, and aluminum. Only a few of these permit the accurate control of oxide thickness by electrochemical means. Of these, the most valuable for the electronics industry are aluminum and tantalum.

Capacitors are basic to all kinds of electrical equipment, from radios and television sets to missile controls and automobile ignitions. Their function is to store an electrical charge for later use.

Capacitors consist of two conducting surfaces, usually metal plates, whose function is to conduct electricity. They are separated by an insulating material or dielectric. The dielectric used in all tantalum electrolytic capacitors is tantalum pentoxide.

Tantalum pentoxide compound possesses high-dielectric strength and a high-dielectric constant. As capacitors are being manufactured, a film of tantalum pentoxide is applied to their electrodes by means of an electrolytic process. The film is applied in various thicknesses and at various voltages and although transparent to begin with, it takes on different colors as light refracts through it. This coloring occurs on the tantalum electrodes of all types of tantalum capacitors.

Rating for rating, tantalum capacitors tend to have as much as three times better capacitance / volume efficiency than aluminum electrolytic capacitors. An approximation of the capacitance / volume efficiency of other types of capacitors may be inferred from the following table, which shows the dielectric constant ranges of the various materials used in each type. Note that tantalum pentoxide has a dielectric constant of 26, some three times greater than that of aluminum oxide. This, in addition to the fact that extremely thin films can be deposited during the electrolytic process mentioned earlier, makes the tantalum capacitor extremely efficient with respect to the number of microfarads available per unit volume. The capacitance of any capacitor is determined by the surface area of the two conducting plates, the distance between the plates, and the dielectric constant of the insulating material between the plates.

COMPARISON OF CAPACITOR DIELECTRIC CONSTANTS

DIELECTRIC	ϵ DIELECTRIC CONSTANT
Air or vacuum	1.0
Paper	2.0 to 6.0
Plastic	2.1 to 6.0
Mineral oil	2.2 to 2.3
Silicone oil	2.7 to 2.8
Quartz	3.8 to 4.4
Glass	4.8 to 8.0
Porcelain	5.1 to 5.9
Mica	5.4 to 8.7
Aluminum oxide	8.4
Tantalum pentoxide	26
Ceramic	12 to 400K

In the tantalum electrolytic capacitor, the distance between the plates is very small since it is only the thickness of the tantalum pentoxide film. As the dielectric constant of the tantalum pentoxide is high, the capacitance of a tantalum capacitor is high if the area of the plates is large:

$$C = \frac{\epsilon A}{t}$$

where

C = capacitance

ϵ = dielectric constant

A = surface area of the dielectric

t = thickness of the dielectric

Tantalum capacitors contain either liquid or solid electrolytes. In solid electrolyte capacitors, a dry material (manganese dioxide) forms the cathode plate. A tantalum lead is embedded in or welded to the pellet, which is in turn connected to a termination or lead wire. The drawings show the construction details of the surface-mount types of tantalum capacitors shown in this catalog.

SOLID ELECTROLYTE TANTALUM CAPACITORS

Solid electrolyte capacitors contain manganese dioxide, which is formed on the tantalum pentoxide dielectric layer by impregnating the pellet with a solution of manganous nitrate. The pellet is then heated in an oven, and the manganous nitrate is converted to manganese dioxide.

The pellet is next coated with graphite, followed by a layer of metallic silver, which provides a conductive surface between the pellet and the leadframe.

Molded Chip tantalum capacitor encases the element in plastic resins, such as epoxy materials. The molding compound has been selected to meet the requirements of UL 94 V-0 and outgassing requirements of ASTM E-595. After assembly, the capacitors are tested and inspected to assure long life and reliability. It offers excellent reliability and high stability for consumer and commercial electronics with the added feature of low cost

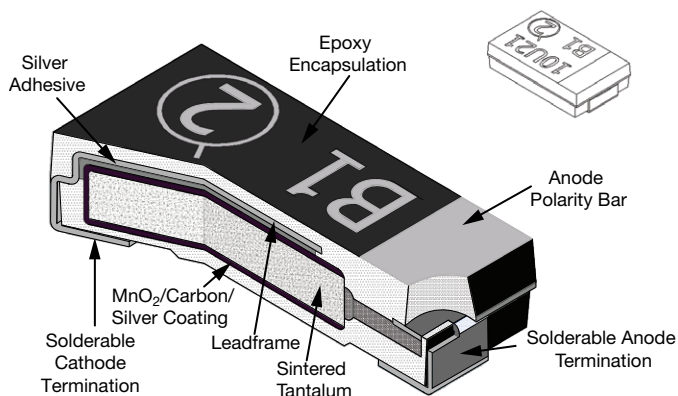
Surface-mount designs of “solid tantalum” capacitors use lead frames or lead frameless designs as shown in the accompanying drawings.

TANTALUM CAPACITORS FOR ALL DESIGN CONSIDERATIONS







Solid electrolyte designs are the least expensive for a given rating and are used in many applications where their very small size for a given unit of capacitance is of importance. They will typically withstand up to about 10 % of the rated DC working voltage in a reverse direction. Also important are their good low temperature performance characteristics and freedom from corrosive electrolytes.





Vishay Sprague patented the original solid electrolyte capacitors and was the first to market them in 1956. Vishay Sprague has the broadest line of tantalum capacitors and has continued its position of leadership in this field. Data sheets covering the various types and styles of Vishay Sprague capacitors for consumer and entertainment electronics, industry, and military applications are available where detailed performance characteristics must be specified.

MOLDED CHIP CAPACITOR







COMMERCIAL PRODUCTS

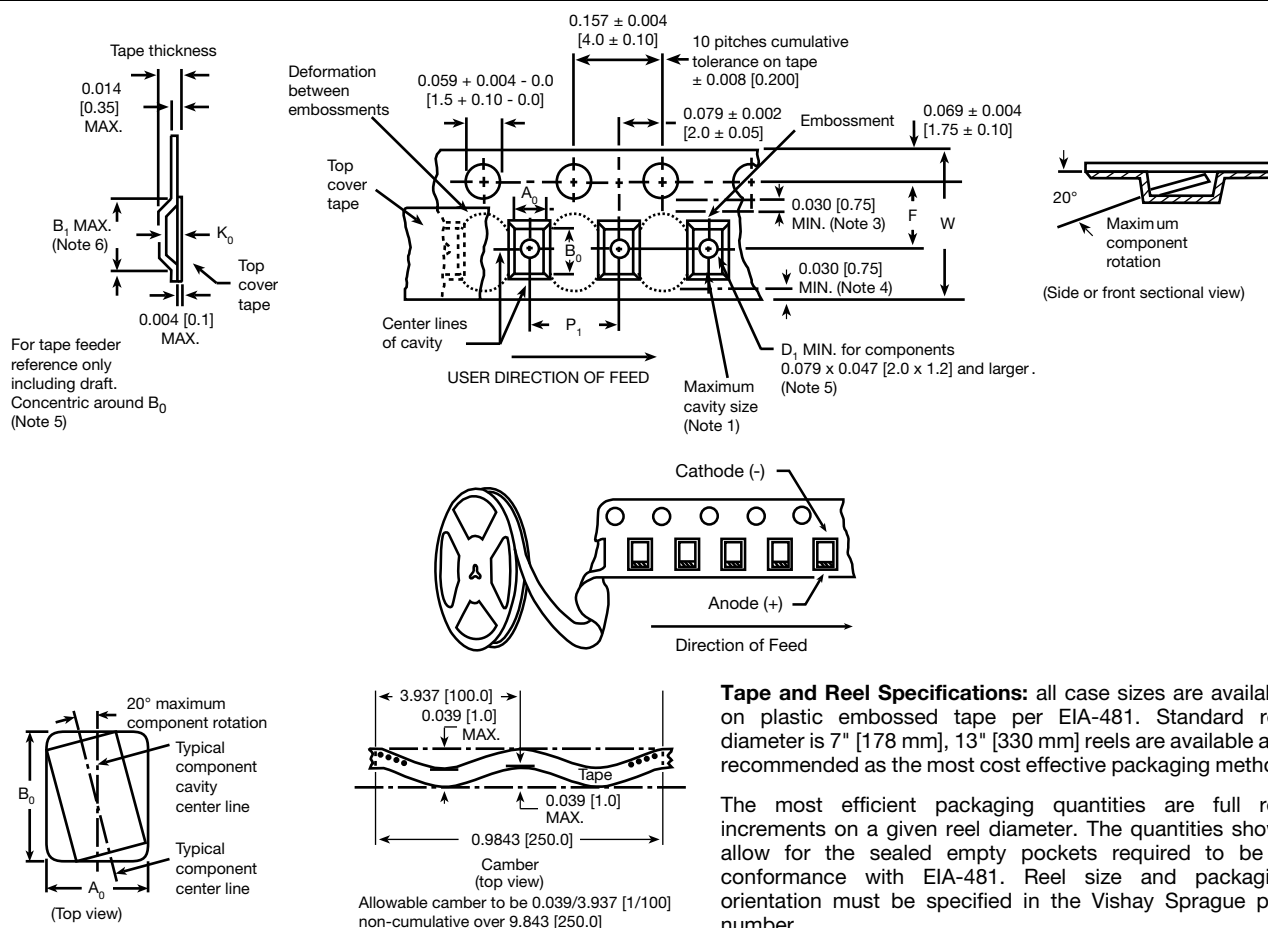
SOLID TANTALUM CAPACITORS - MOLDED CASE						
SERIES	293D	793DX-CTC3-CTC4	593D	TR3	TP3	TL3
PRODUCT IMAGE						
TYPE	Surface-mount TANTAMOUNT™, molded case					
FEATURES	Standard industrial grade	CECC approved	Low ESR	Low ESR	High performance, automotive grade	Very low DCL
TEMPERATURE RANGE	-55 °C to +125 °C					
CAPACITANCE RANGE	0.1 µF to 1000 µF	0.1 µF to 100 µF	1 µF to 470 µF	0.47 µF to 1000 µF	0.1 µF to 470 µF	0.1 µF to 470 µF
VOLTAGE RANGE	4 V to 75 V	4 V to 50 V	4 V to 50 V	4 V to 75 V	4 V to 50 V	4 V to 50 V
CAPACITANCE TOLERANCE	± 10 %, ± 20 %					
LEAKAGE CURRENT	0.01 CV or 0.5 µA, whichever is greater					0.005 CV or 0.25 µA, whichever is greater
DISSIPATION FACTOR	4 % to 30 %	4 % to 6 %	4 % to 15 %	4 % to 30 %	4 % to 15 %	4 % to 15 %
CASE CODES	A, B, C, D, E	A, B, C, D	A, B, C, D, E	A, B, C, D, E, W	A, B, C, D, E	A, B, C, D, E
TERMINATION	100 % matte tin standard, tin / lead available					

SOLID TANTALUM CAPACITORS - MOLDED CASE				
SERIES	TX3	TH3	TH4	TH5
PRODUCT IMAGE				
TYPE	Surface-mount TANTAMOUNT™, molded case			
FEATURES	E-detonators	High temperature +150 °C, automotive grade	High temperature +175 °C, automotive grade	Very high temperature +200 °C
TEMPERATURE RANGE	-55 °C to +125 °C	-55 °C to +150 °C	-55 °C to +175 °C	-55 °C to +200 °C
CAPACITANCE RANGE	10 µF to 100 µF	0.33 µF to 220 µF	10 µF to 100 µF	4.7 µF to 100 µF
VOLTAGE RANGE	16 V to 25 V	6.3 V to 50 V	6.3 V to 35 V	5 V to 24 V
CAPACITANCE TOLERANCE	± 10 %, ± 20 %			
LEAKAGE CURRENT	0.005 CV	0.01 CV or 0.5 µA, whichever is greater		
DISSIPATION FACTOR	6 % to 20 %	4 % to 8 %	4.5 % to 8 %	6 % to 10 %
CASE CODES	B, C	A, B, C, D, E	B, C, D, E	D, E
TERMINATION	100 % matte tin	100 % matte tin standard, tin / lead and gold plated available	100 % matte tin	Gold plated

HIGH RELIABILITY PRODUCTS

SOLID TANTALUM CAPACITORS - MOLDED CASE				
SERIES	TM3	T83	CWR11	95158
PRODUCT IMAGE				
TYPE	TANTAMOUNT™, molded case, hi-rel.	TANTAMOUNT™, molded case, hi-rel. COTS	TANTAMOUNT™, molded case, DLA approved	
FEATURES	High reliability, for medical Instruments	High reliability, standard and low ESR	MIL-PRF-55365/8 qualified	Low ESR
TEMPERATURE RANGE	-55 °C to +125 °C			
CAPACITANCE RANGE	1 µF to 220 µF	0.1 µF to 470 µF	0.1 µF to 100 µF	4.7 µF to 220 µF
VOLTAGE RANGE	4 V to 20 V	4 V to 63 V	4 V to 50 V	
CAPACITANCE TOLERANCE	± 10 %, ± 20 %		± 5 %, ± 10 %, ± 20 %	± 10 %, ± 20 %
LEAKAGE CURRENT	0.005 CV or 0.25 µA, whichever is greater	0.01 CV or 0.5 µA, whichever is greater		
DISSIPATION FACTOR	4 % to 8 %	4 % to 15 %	4 % to 6 %	4 % to 12 %
CASE CODES	A, B, C, D, E	A, B, C, D, E	A, B, C, D	C, D, E
TERMINATION	100 % matte tin; tin / lead	100 % matte tin; tin / lead; tin / lead solder fused	Tin / lead; tin / lead solder fused	Tin / lead solder plated; gold plated

PLASTIC TAPE AND REEL PACKAGING in inches [millimeters]



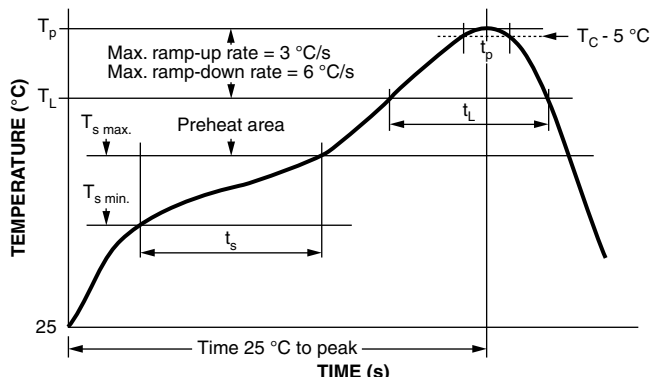
Notes

- Metric dimensions will govern. Dimensions in inches are rounded and for reference only
- A_0 , B_0 , K_0 , are determined by the maximum dimensions to the ends of the terminals extending from the component body and / or the body dimensions of the component. The clearance between the ends of the terminals or body of the component to the sides and depth of the cavity (A_0 , B_0 , K_0) must be within 0.002" (0.05 mm) minimum and 0.020" (0.50 mm) maximum. The clearance allowed must also prevent rotation of the component within the cavity of not more than 20°
- Tape with components shall pass around radius "R" without damage. The minimum trailer length may require additional length to provide "R" minimum for 12 mm embossed tape for reels with hub diameters approaching N minimum
- This dimension is the flat area from the edge of the sprocket hole to either outward deformation of the carrier tape between the embossed cavities or to the edge of the cavity whichever is less
- This dimension is the flat area from the edge of the carrier tape opposite the sprocket holes to either the outward deformation of the carrier tape between the embossed cavity or to the edge of the cavity whichever is less
- The embossed hole location shall be measured from the sprocket hole controlling the location of the embossment. Dimensions of embossment location shall be applied independent of each other
- B_1 dimension is a reference dimension tape feeder clearance only

CASE CODE	TAPE SIZE	B_1 (MAX.)	D_1 (MIN.)	F	K_0 (MAX.)	P_1	W
MOLDED CHIP CAPACITORS; ALL TYPES							
A	8 mm	0.165	0.039	0.138 ± 0.002	0.094	0.157 ± 0.004	0.315 ± 0.012
B		[4.2]	[1.0]	[3.5 ± 0.05]	[2.4]	[4.0 ± 1.0]	[8.0 ± 0.30]
C							
D	12 mm	0.32	0.059	0.217 ± 0.00	0.177	0.315 ± 0.004	0.472 ± 0.012
E		[8.2]	[1.5]	[5.5 ± 0.05]	[4.5]	[8.0 ± 1.0]	[12.0 ± 0.30]
W							

RECOMMENDED REFLOW PROFILES

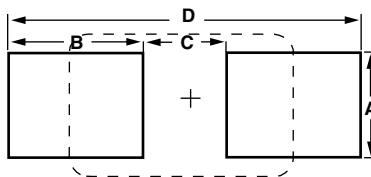
Capacitors should withstand reflow profile as per J-STD-020 standard, three cycles.



PROFILE FEATURE	SnPb EUTECTIC ASSEMBLY	LEAD (Pb)-FREE ASSEMBLY
Preheat / soak		
Temperature min. ($T_{s \text{ min.}}$)	100 °C	150 °C
Temperature max. ($T_{s \text{ max.}}$)	150 °C	200 °C
Time (t_s) from ($T_{s \text{ min.}}$ to $T_{s \text{ max.}}$)	60 s to 120 s	60 s to 120 s
Ramp-up		
Ramp-up rate (T_L to T_p)	3 °C/s max.	3 °C/s max.
Liquidus temperature (T_L)	183 °C	217 °C
Time (t_L) maintained above T_L	60 s to 150 s	60 s to 150 s
Peak package body temperature (T_p)	Depends on case size - see table below	
Time (t_p) within 5 °C of the specified classification temperature (T_C)	20 s	30 s
Time 25 °C to peak temperature	6 min max.	8 min max.
Ramp-down		
Ramp-down rate (T_p to T_L)	6 °C/s max.	6 °C/s max.

PEAK PACKAGE BODY TEMPERATURE (T_p)

CASE CODE	PEAK PACKAGE BODY TEMPERATURE (T_p)	
	SnPb EUTECTIC PROCESS	LEAD (Pb)-FREE PROCESS
A, B, C	235 °C	260 °C
D, E, W	220 °C	250 °C

PAD DIMENSIONS in inches [millimeters]


CASE CODE	A (MIN.)	B (NOM.)	C (NOM.)	D (NOM.)
MOLDED CHIP CAPACITORS, ALL TYPES				
A	0.071 [1.80]	0.067 [1.70]	0.053 [1.35]	0.187 [4.75]
B	0.118 [3.00]	0.071 [1.80]	0.065 [1.65]	0.207 [5.25]
C	0.118 [3.00]	0.094 [2.40]	0.118 [3.00]	0.307 [7.80]
D	0.157 [4.00]	0.098 [2.50]	0.150 [3.80]	0.346 [8.80]
E	0.157 [4.00]	0.098 [2.50]	0.150 [3.80]	0.346 [8.80]
W	0.185 [4.70]	0.098 [2.50]	0.150 [3.80]	0.346 [8.80]



GUIDE TO APPLICATION

1. **AC Ripple Current:** the maximum allowable ripple current shall be determined from the formula:

$$I_{RMS} = \sqrt{\frac{P}{R_{ESR}}}$$

where,

P = power dissipation in W at +25 °C as given in the tables in the product datasheets (Power Dissipation).

R_{ESR} = the capacitor equivalent series resistance at the specified frequency

2. **AC Ripple Voltage:** the maximum allowable ripple voltage shall be determined from the formula:

$$V_{RMS} = I_{RMS} \times Z$$

or, from the formula:

$$V_{RMS} = Z \sqrt{\frac{P}{R_{ESR}}}$$

where,

P = power dissipation in W at +25 °C as given in the tables in the product datasheets (Power Dissipation).

R_{ESR} = the capacitor equivalent series resistance at the specified frequency

Z = the capacitor impedance at the specified frequency

- 2.1 The sum of the peak AC voltage plus the applied DC voltage shall not exceed the DC voltage rating of the capacitor.
- 2.2 The sum of the negative peak AC voltage plus the applied DC voltage shall not allow a voltage reversal exceeding 10 % of the DC working voltage at +25 °C.
3. **Reverse Voltage:** solid tantalum capacitors are not intended for use with reverse voltage applied. However, they have been shown to be capable of withstanding momentary reverse voltage peaks of up to 10 % of the DC rating at 25 °C and 5 % of the DC rating at +85 °C.
4. **Temperature Derating:** if these capacitors are to be operated at temperatures above +25 °C, the permissible RMS ripple current shall be calculated using the derating factors as shown:

TEMPERATURE (°C)	DERATING FACTOR
+25	1.0
+85	0.9
+125	0.4
+150 ⁽¹⁾	0.3
+175 ⁽¹⁾	0.2
+200 ⁽¹⁾	0.1

Note

⁽¹⁾ Applicable for dedicated high temperature product series

5. **Power Dissipation:** power dissipation will be affected by the heat sinking capability of the mounting surface. Non-sinusoidal ripple current may produce heating effects which differ from those shown. It is important that the equivalent I_{RMS} value

be established when calculating permissible operating levels. (Power dissipation calculated using +25 °C temperature rise).

6. **Printed Circuit Board Materials:** molded capacitors are compatible with commonly used printed circuit board materials (alumina substrates, FR4, FR5, G10, PTFE-fluorocarbon and porcelainized steel).

7. **Attachment:**

- 7.1 **Solder Paste:** the recommended thickness of the solder paste after application is 0.007" ± 0.001" [0.178 mm ± 0.025 mm]. Care should be exercised in selecting the solder paste. The metal purity should be as high as practical. The flux (in the paste) must be active enough to remove the oxides formed on the metallization prior to the exposure to soldering heat. In practice this can be aided by extending the solder preheat time at temperatures below the liquidous state of the solder.

- 7.2 **Soldering:** capacitors can be attached by conventional soldering techniques; vapor phase, convection reflow, infrared reflow, wave soldering, and hot plate methods. The soldering profile charts show recommended time / temperature conditions for soldering. Preheating is recommended. The recommended maximum ramp rate is 3 °C per second. Attachment with a soldering iron is not recommended due to the difficulty of controlling temperature and time at temperature. The soldering iron must never come in contact with the capacitor. For details see www.vishay.com/doc?40214.

- 7.2.1 **Backward and Forward Compatibility:** capacitors with SnPb or 100 % tin termination finishes can be soldered using SnPb or lead (Pb)-free soldering processes.

8. **Cleaning (Flux Removal) After Soldering:** molded capacitors are compatible with all commonly used solvents such as TES, TMS, Prelete, Chloroethane, Terpene and aqueous cleaning media. However, CFC / ODS products are not used in the production of these devices and are not recommended. Solvents containing methylene chloride or other epoxy solvents should be avoided since these will attack the epoxy encapsulation material.

- 8.1 When using ultrasonic cleaning, the board may resonate if the output power is too high. This vibration can cause cracking or a decrease in the adherence of the termination. DO NOT EXCEED 9W/l at 40 kHz for 2 min.

9. **Recommended Mounting Pad Geometries:** proper mounting pad geometries are essential for successful solder connections. These dimensions are highly process sensitive and should be designed to minimize component rework due to unacceptable solder joints. The dimensional configurations shown are the recommended pad geometries for both wave and reflow soldering techniques. These dimensions are intended to be a starting point for circuit board designers and may be fine tuned if necessary based upon the peculiarities of the soldering process and / or circuit board design.



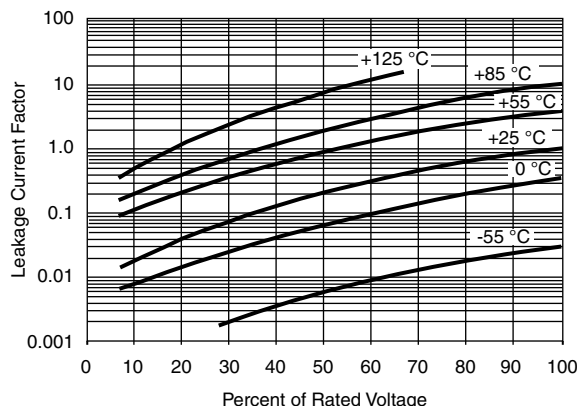
Solid Tantalum Chip Capacitors

MIL-PRF-55365 Qualified and DLA Approved

ELECTRICAL PERFORMANCE CHARACTERISTICS			
ITEM	PERFORMANCE CHARACTERISTICS		
Category temperature range	-55 °C to +85 °C (to +125 °C with voltage derating)		
Capacitance tolerance	± 20 %, ± 10 %, tested via bridge method, at 25 °C, 120 Hz		
Dissipation factor	Limit per Standard Ratings table. Tested via bridge method, at 25 °C, 120 Hz		
ESR	Limit per Standard Ratings table. Tested via bridge method, at 25 °C, 100 kHz		
Leakage current	<p>After application of rated voltage applied to capacitors for 5 min using a steady source of power with 1 kΩ resistor in series with the capacitor under test, leakage current at 25 °C is not more than described in Standard Ratings table of appropriate datasheet.</p> <p><i>Note that the leakage current varies with temperature and applied voltage. See graph below for the appropriate adjustment factor.</i></p>		
Reverse voltage	<p>Capacitors are capable of withstanding peak voltages in the reverse direction equal to:</p> <p>10 % of the DC rating at +25 °C 5 % of the DC rating at +85 °C 1 % of the DC rating at +125 °C</p> <p>Vishay does not recommend intentional or repetitive application of reverse voltage.</p>		
Ripple current	<p>For maximum ripple current values calculation (at 25 °C) refer to "Guide to Application" part of product guide which is linked with relevant datasheet. If capacitors are to be used at temperatures above +25 °C, the permissible ripple current (or voltage) shall be calculated using the derating factors:</p> <p>1.0 at +25 °C 0.9 at +85 °C 0.4 at +125 °C</p>		
Maximum operating and surge voltages vs. temperature	+85 °C		+125 °C
	RATED VOLTAGE (V)	SURGE VOLTAGE (V)	CATEGORY VOLTAGE (V)
	4.0	5.3	2.7
	6.3	8.0	4.0
	10	13.3	6.7
	15 / 16	20	10
	20	26.7	13.3
	25	33.3	16.7
	35	46.7	23.3
	50	66.7	33.3
Recommended voltage derating guidelines (below 85 °C)	VOLTAGE RAIL (V)		CAPACITOR VOLTAGE RATING (V)
	≤ 3.3		6.3
	5		10
	10		20
	12		25
	15		35
	24		50 or series configuration

Notes

- All information presented in this document reflects typical performance characteristics
- For more information about recommended voltage derating see: www.vishay.com/doc?40246

**TYPICAL LEAKAGE CURRENT - TEMPERATURE FACTOR****Notes**

- At +25 °C, the leakage current shall not exceed the value listed in the Standard Ratings table
- At +85 °C, the leakage current shall not exceed 10 times the value listed in the Standard Ratings table
- At +125 °C, the leakage current shall not exceed 12 times the value listed in the Standard Ratings table

ENVIRONMENTAL PERFORMANCE CHARACTERISTICS

ITEM	CONDITION	POST TEST PERFORMANCE															
Moisture resistance	MIL-STD-202, method 106, 20 cycles	Capacitance change Dissipation factor Leakage current	Within ± 15 % of initial value Shall not exceed 150 % of initial limit Shall not exceed 200 % of initial limit														
		Visual examination: there shall be no evidence of harmful corrosion, mechanical damage, or obliteration of marking (if applicable)															
Stability at low and high temperatures	MIL-PRF-55365 <table><tr><th>Step</th><th>Test Temperature (°C)</th></tr><tr><td>1</td><td>+25 ± 3</td></tr><tr><td>2</td><td>-55 + 0 / - 6</td></tr><tr><td>3</td><td>+25 ± 3</td></tr><tr><td>4</td><td>+85 + 4 / - 0</td></tr><tr><td>5</td><td>+125 + 4 / - 0</td></tr><tr><td>6</td><td>+25 ± 3</td></tr></table>	Step	Test Temperature (°C)	1	+25 ± 3	2	-55 + 0 / - 6	3	+25 ± 3	4	+85 + 4 / - 0	5	+125 + 4 / - 0	6	+25 ± 3	Delta cap limit at -55 °C is ± 10 % (20 % for CWR15) of initial value Delta cap limit at 85 °C is ± 10 % (15 % for CWR15) of initial value Delta cap limit at 125 °C is ± 15 % (20 % for CWR15) of initial value Delta cap at step 3 and final step 25 °C is ± 5 % (10 % for CWR15) of initial value DCL at 85 °C: 10 x initial specified value DCL at 125 °C: 12 x initial specified value DCL at 25 °C: initial specified value at rated voltage DF change: refer to performance specification sheet for applicable capacitor style	
		Step	Test Temperature (°C)														
		1	+25 ± 3														
		2	-55 + 0 / - 6														
		3	+25 ± 3														
		4	+85 + 4 / - 0														
		5	+125 + 4 / - 0														
		6	+25 ± 3														
Surge voltage	MIL-PRF-55365 1000 successive test cycles at 85 °C of applicable surge voltage (as specified in the table above), in series with a 33 Ω resistor at the rate of 30 s ON, 30 s OFF	Capacitance change Dissipation factor Leakage current	Within ± 5 % of initial value Initial specified limit Initial specified limit														
Life test at +85 °C	MIL-STD-202, method 108 2000 h application of rated voltage at 85 °C	Capacitance change Dissipation factor Leakage current	Within ± 5 % (10 % for CWR15) of initial value Initial specified limit Shall not exceed 200 % of initial limit														
		There shall be no evidence of harmful corrosion or obliteration of marking (if applicable), mechanical damage, intermittent shorts, or permanent shorts or opens															
Life test at +125 °C	MIL-STD-202, method 108 2000 h application 2/3 of rated voltage at 125 °C	Capacitance change Dissipation factor Leakage current	Within ± 5 % (10 % for CWR15) of initial value Initial specified limit Shall not exceed 200 % of initial limit														
		There shall be no evidence of harmful corrosion or obliteration of marking (if applicable), mechanical damage, intermittent shorts, or permanent shorts or opens															



MECHANICAL PERFORMANCE CHARACTERISTICS		
ITEM	CONDITION	POST TEST PERFORMANCE
Vibration	MIL-STD-202, method 204, condition D, 10 Hz to 2000 Hz, 20 g peak, in 2 directions, 4 hours in each, at rated voltage	Measurements during vibration: During the last cycle of each plane, electrical measurements shall be made to determine the intermittent open or short circuits. Intermittent contact and arcing shall also be determined. Measurements after vibration: not applicable Visual examination after test: there shall be no evidence of mechanical damage
Thermal shock (mounted)	MIL-STD-202, method 107 -65 °C / +125 °C, for 10 cycles, 30 min at each temperature	Capacitance change Within ± 5 % of initial value Dissipation factor Initial specified limit Leakage current Initial specified limit Visual examination: there shall be no evidence of harmful corrosion, mechanical damage, or obliteration of marking (if applicable)
Resistance to soldering heat	MIL-STD-202, method 210, condition J (convection reflow, 235 °C \pm 5 °C), one heat cycle	Capacitance change Within ± 5 % of initial value Dissipation factor Initial specified limit Leakage current Initial specified limit Visual examination: there shall be no evidence of mechanical damage
Solderability	MIL-STD-202, method 208, ANSI/J-STD-002, test B (dip- and look, 245 °C \pm 5 °C). Preconditioning per category C (steam aging, 8 hours). Does not apply to gold terminations.	Solder coating of all capacitors shall meet specified requirements. There shall be no mechanical or visual damage to capacitors post-conditioning.
Resistance to solvents	MIL-STD-202, method 215	There shall be no mechanical or visual damage to capacitors post-conditioning. Body marking shall remain legible and shall not smear.
Flammability	Encapsulation materials meet UL 94 V-0 with an oxygen index of 32 %	



Disclaimer

ALL PRODUCT, PRODUCT SPECIFICATIONS AND DATA ARE SUBJECT TO CHANGE WITHOUT NOTICE TO IMPROVE RELIABILITY, FUNCTION OR DESIGN OR OTHERWISE.

Vishay Intertechnology, Inc., its affiliates, agents, and employees, and all persons acting on its or their behalf (collectively, "Vishay"), disclaim any and all liability for any errors, inaccuracies or incompleteness contained in any datasheet or in any other disclosure relating to any product.

Vishay makes no warranty, representation or guarantee regarding the suitability of the products for any particular purpose or the continuing production of any product. To the maximum extent permitted by applicable law, Vishay disclaims (i) any and all liability arising out of the application or use of any product, (ii) any and all liability, including without limitation special, consequential or incidental damages, and (iii) any and all implied warranties, including warranties of fitness for particular purpose, non-infringement and merchantability.

Statements regarding the suitability of products for certain types of applications are based on Vishay's knowledge of typical requirements that are often placed on Vishay products in generic applications. Such statements are not binding statements about the suitability of products for a particular application. It is the customer's responsibility to validate that a particular product with the properties described in the product specification is suitable for use in a particular application. Parameters provided in datasheets and / or specifications may vary in different applications and performance may vary over time. All operating parameters, including typical parameters, must be validated for each customer application by the customer's technical experts. Product specifications do not expand or otherwise modify Vishay's terms and conditions of purchase, including but not limited to the warranty expressed therein.

Hyperlinks included in this datasheet may direct users to third-party websites. These links are provided as a convenience and for informational purposes only. Inclusion of these hyperlinks does not constitute an endorsement or an approval by Vishay of any of the products, services or opinions of the corporation, organization or individual associated with the third-party website. Vishay disclaims any and all liability and bears no responsibility for the accuracy, legality or content of the third-party website or for that of subsequent links.

Vishay products are not designed for use in life-saving or life-sustaining applications or any application in which the failure of the Vishay product could result in personal injury or death unless specifically qualified in writing by Vishay. Customers using or selling Vishay products not expressly indicated for use in such applications do so at their own risk. Please contact authorized Vishay personnel to obtain written terms and conditions regarding products designed for such applications.

No license, express or implied, by estoppel or otherwise, to any intellectual property rights is granted by this document or by any conduct of Vishay. Product names and markings noted herein may be trademarks of their respective owners.