

Solid Tantalum Chip Capacitors

298D MICROTAN[®], 298W Extended Range MICROTAN[®], Leadframeless Molded


FEATURES

- Small sizes include 0603 and 0402 footprint
- Lead (Pb)-free L-shaped face-down terminations
- 8 mm tape and reel packaging available per EIA-481 and reeling per IEC 60286-3 7" [178 mm] standard
- Mounting: surface mount
- Material categorization: for definitions of compliance please see www.vishay.com/doc?99912



RoHS
COMPLIANT
HALOGEN
FREE
GREEN
(5-2008)

PERFORMANCE CHARACTERISTICS
www.vishay.com/doc?40169
Operating Temperature:

298D: -55 °C to +125 °C

(above 85 °C, voltage derating is required)

298W: -55 °C to +125 °C

(above 40 °C, voltage derating is required)

Capacitance Range:

298D: 0.33 µF to 330 µF

298W: 2.2 µF to 220 µF

Capacitance Tolerance: ± 20 % standard, ± 10 % available

Voltage Range: 2.5 V_{DC} to 50 V_{DC}

| ORDERING INFORMATION | | | | | | |
|----------------------|--|-----------------------------------|--|----------------------------------|---|--|
| 298D | 335 | X0 | 010 | M | 2 | T |
| TYPE | CAPACITANCE | CAPACITANCE TOLERANCE | DC VOLTAGE RATING | CASE CODE | TERMINATION | REEL SIZE AND PACKAGING |
| 298D 298W | This is expressed in picofarads. The first two digits are the significant figures. The third is the number of zeros to follow. | X0 = ± 20 % X9 = ± 10 % | This is expressed in volts. To complete the three-digit block, zeros precede the voltage rating. A decimal point is indicated by an "R" (6R3 = 6.3 V). | See Ratings and Case Codes table | 2 = 100 % tin 4 = gold plated | T = tape and reel 7" [178 mm] reel |

Note

- Preferred tolerance and reel sizes are in bold. We reserve the right to supply higher voltage ratings and tighter capacitance tolerance capacitors in the same case size. Voltage substitutions will be marked with the higher voltage rating.

| DIMENSIONS in inches [millimeters] | | | | | | |
|------------------------------------|--------------------------------|--------------------------------|-----------------|--------------------------------|-----------------|--------------------------------|
| | | | | | | |
| CASE CODE | L | W | H (MAX.) | P1 | P2 (REF.) | C |
| K | 0.039 ± 0.008 [1.0 ± 0.2] | 0.020 ± 0.008 [0.5 ± 0.2] | 0.024 [0.6] | 0.01 ± 0.004 [0.25 ± 0.1] | 0.02 [0.5] | 0.015 ± 0.004 [0.38 ± 0.1] |
| M | 0.063 ± 0.008 [1.60 ± 0.2] | 0.033 ± 0.008 [0.85 ± 0.2] | 0.035 [0.9] | 0.020 ± 0.004 [0.50 ± 0.1] | 0.024 [0.60] | 0.024 ± 0.004 [0.60 ± 0.1] |
| S | 0.079 ± 0.008 [2.00 ± 0.20] | 0.050 ± 0.008 [1.25 ± 0.20] | 0.035 [0.9] | 0.020 ± 0.004 [0.50 ± 0.10] | 0.040 [1.00] | 0.035 ± 0.004 [0.90 ± 0.10] |
| R | 0.081 ± 0.006 [2.06 ± 0.15] | 0.053 ± 0.006 [1.35 ± 0.15] | 0.062 [1.57] | 0.020 ± 0.004 [0.51 ± 0.1] | 0.043 [1.1] | 0.035 ± 0.004 [0.90 ± 0.1] |
| P | 0.094 ± 0.004 [2.4 ± 0.1] | 0.057 ± 0.004 [1.45 ± 0.1] | 0.047 [1.2] | 0.020 ± 0.004 [0.50 ± 0.1] | 0.057 [1.40] | 0.035 ± 0.004 [0.90 ± 0.1] |
| Q | 0.126 ± 0.008 [3.2 ± 0.2] | 0.063 ± 0.008 [1.6 ± 0.2] | 0.039 [1.0] | 0.031 ± 0.004 [0.80 ± 0.1] | 0.063 [1.60] | 0.047 ± 0.004 [1.20 ± 0.1] |
| A | 0.126 ± 0.008 [3.2 ± 0.2] | 0.063 ± 0.008 [1.6 ± 0.2] | 0.071 [1.8] | 0.031 ± 0.004 [0.80 ± 0.1] | 0.063 [1.60] | 0.047 ± 0.004 [1.20 ± 0.1] |
| B | 0.138 ± 0.008 [3.5 ± 0.2] | 0.112 ± 0.008 [2.8 ± 0.2] | 0.08 [2.0] | 0.031 ± 0.008 [0.80 ± 0.2] | 0.077 [1.95] | 0.094 ± 0.004 [2.4 ± 0.1] |

| RATINGS AND CASE CODES (298D, 298W Extended Range) | | | | | | | | | | | | | | |
|---|-------|------|------------------|------|-------|------|------|------------------|------|------|------|-------|------|------|
| μF | 2.5 V | | 4 V | | 6.3 V | | 10 V | | 16 V | | 20 V | 25 V | 35 V | 50 V |
| | 298D | 298W | 298D | 298W | 298D | 298W | 298D | 298W | 298D | 298W | 298D | 298D | 298D | 298D |
| 0.33 | | | | | | | | | | | K | | | |
| 0.68 | | | | | | | | | | | M | M | | |
| 1.0 | | | | | K | | K/M | | K/M | | S | M/R/S | | P |
| 1.5 | | | | | | | M | | | | | | | |
| 2.2 | | | | | K/M | | K/M | | M | K | | | P | |
| 3.3 | | | | | M | | M | | | | | | | |
| 4.7 | | K | | | M | | M/P | K | M/P | | P | P | | |
| 10 | | K/M | | | M/S | K | M | | R | | | A | | |
| 15 | | K | | | M | | M | | | | | | | |
| 22 | K | K/M | | | M | | M | | | | | | | |
| 33 | | M | | | M | | P | M ⁽¹⁾ | | | | | | |
| 47 | M | M | | | R/P/A | M | P | | | | | | | |
| 100 | | P | M ⁽¹⁾ | | P/A | | | Q | | | | | | |
| 220 | P | P/Q | Q | | | | | | | | | | | |
| 330 | | | | | B | | | | | | | | | |

Note

(1) Preliminary values, contact factory for availability.

| MARKING | | | | | |
|--|---------------------|-------------|-------------------------|-------------|--|
| <p>M-Case</p> <p>K-Case</p> <p>B-Case</p> | VOLTAGE CODE | | CAPACITANCE CODE | | <p>P, R, S-Case</p> <p>A, Q-Case</p> |
| | V | CODE | CAP, μF | CODE | |
| | 2.5 | e | 0.68 | w̄ | |
| | 4.0 | G | 1.0 | A | |
| | 6.3 | J | 2.2 | J | |
| | 10 | A | 3.3 | N | |
| | 16 | C | 4.7 | S | |
| | 20 | D | 6.8 | W | |
| | 25 | E | 10 | α | |
| | 35 | V | 15 | e | |
| 50 | T | 22 | j | | |
| | | 33 | n | | |
| | | 47 | s | | |
| | | 68 | w | | |
| | | 100 | Ā | | |
| | | 150 | Ē | | |
| | | 220 | J | | |



| STANDARD RATINGS (298D, 298W Extended Range) | | | | | | |
|--|------------------|--------------------|-------------------------------------|-----------------------------|--|--|
| CAPACITANCE (μ F) | CASE CODE | PART NUMBER | MAX. DCL AT +25 °C (μ A) | MAX. DF AT +25 °C (%) | MAX. ESR AT +25 °C 100 kHz (Ω) | MAX. RIPPLE 100 kHz I_{RMS} (A) |
| 2.5 V_{DC} AT +85 °C; 1.6 V_{DC} AT +125 °C | | | | | | |
| 22 | K | 298D226X02R5K(2)T | 10 | 40 | 20.00 | 0.027 |
| 47 | M | 298D476X02R5M(2)T | 2.4 | 20 | 4.00 | 0.080 |
| 220 | P | 298D227X02R5P(2)T | 11 | 30 | 3.00 | 0.122 |
| 298D: 4 V_{DC} AT +85 °C; 2.7 V_{DC} AT +125 °C 298W: 4 V_{DC} AT +40 °C; 2.5 V_{DC} AT +85 °C; 1.6 V_{DC} AT +125 °C | | | | | | |
| 4.7 | K | 298D475X0004K(2)T | 0.5 | 15 | 20.00 | 0.027 |
| 10 | K | 298D106X0004K(2)T | 4.0 | 50 | 20.00 | 0.027 |
| 10 | M | 298D106(1)004M(2)T | 0.5 | 8 | 5.00 | 0.071 |
| 15 | K | 298D156X0004K(2)T | 10 | 50 | 20.00 | 0.027 |
| 22 | K | 298D226X0004K(2)T | 25 | 40 | 20.00 | 0.027 |
| 22 | M | 298D226X0004M(2)T | 0.9 | 15 | 4.00 | 0.080 |
| 33 | M | 298D336X0004M(2)T | 2.6 | 30 | 4.00 | 0.080 |
| 47 | M | 298D476X0004M(2)T | 3.8 | 40 | 7.50 | 0.080 |
| 100 | P | 298D107X0004P(2)T | 4.0 | 30 | 2.00 | 0.100 |
| 100 | M ⁽¹⁾ | 298W107X0004M(2)T | 110 | 60 | 15.00 | 0.041 |
| 220 | P | 298D227(1)004P(2)T | 17.6 | 30 | 3.00 | 0.122 |
| 220 | Q | 298D227X0004Q(2)T | 88 | 80 | 15.00 | 0.061 |
| 220 | Q | 298W227X0004Q(2)T | 88 | 80 | 15.00 | 0.061 |
| 298D: 6.3 V_{DC} AT +85 °C; 4 V_{DC} AT +125 °C 298W: 6.3 V_{DC} AT +40 °C; 4.0 V_{DC} AT +85 °C; 2.5 V_{DC} AT +125 °C | | | | | | |
| 1.0 | K | 298D105X06R3K(2)T | 0.5 | 6 | 20.00 | 0.027 |
| 2.2 | K | 298D225X06R3K(2)T | 0.5 | 8 | 20.00 | 0.027 |
| 2.2 | M | 298D225(1)6R3M(2)T | 0.5 | 10 | 5.00 | 0.070 |
| 3.3 | M | 298D335(1)6R3M(2)T | 0.5 | 8 | 6.00 | 0.090 |
| 4.7 | M | 298D475(1)6R3M(2)T | 0.5 | 8 | 3.00 | 0.090 |
| 10 | M | 298D106X06R3M(2)T | 0.6 | 8 | 5.00 | 0.071 |
| 10 | S | 298D106X06R3S(2)T | 0.6 | 8 | 5.00 | 0.084 |
| 10 | K | 298W106X06R3K(2)T | 10 | 30 | 15.00 | 0.032 |
| 15 | M | 298D156X06R3M(2)T | 1.0 | 20 | 7.00 | 0.060 |
| 22 | M | 298D226X06R3M(2)T | 2.8 | 20 | 5.50 | 0.067 |
| 33 | M | 298D336X06R3M(2)T | 4.2 | 30 | 7.50 | 0.058 |
| 47 | M | 298W476X06R3M(2)T | 29.6 | 45 | 10.00 | 0.050 |
| 47 | R | 298D476X06R3R(2)T | 3.0 | 25 | 3.00 | 0.122 |
| 47 | P | 298D476X06R3P(2)T | 3.0 | 22 | 3.00 | 0.122 |
| 47 | A | 298D476X06R3A(2)T | 3.0 | 10 | 2.00 | 0.150 |
| 100 | P | 298D107X06R3P(2)T | 6.3 | 30 | 2.00 | 0.150 |
| 100 | A | 298D107X06R3A(2)T | 6.3 | 20 | 1.00 | 0.270 |
| 330 | B | 298D337X06R3B(2)T | 64 | 50 | 3.00 | 0.412 |

Notes

- Part number definitions:
 - Tolerance: for 10 % tolerance, specify "X9"; for 20 % tolerance, change to "X0"
 - Termination: for 100 % tin specify "2", for gold plated specify "4"
- Rating in development, contact factory for availability



| STANDARD RATINGS (298D, 298W Extended Range) | | | | | | |
|--|------------------|--------------------|--|-----------------------------|--|---|
| CAPACITANCE (μF) | CASE CODE | PART NUMBER | MAX. DCL AT +25 °C (μA) | MAX. DF AT +25 °C (%) | MAX. ESR AT +25 °C 100 kHz (Ω) | MAX. RIPPLE 100 kHz I_{RMS} (A) |
| 298D: 10 V_{DC} AT +85 °C; 7 V_{DC} AT +125 °C 298W: 10 V_{DC} AT +40 °C; 6.3 V_{DC} AT +85 °C; 4.0 V_{DC} AT +125 °C | | | | | | |
| 1.0 | K | 298D105X0010K(2)T | 0.5 | 6 | 20.00 | 0.027 |
| 1.0 | M | 298D105(1)010M(2)T | 0.5 | 6 | 12.00 | 0.045 |
| 1.5 | M | 298D155(1)010M(2)T | 0.5 | 6 | 14.00 | 0.040 |
| 2.2 | K | 298D225X0010K(2)T | 2.2 | 8 | 15.00 | 0.027 |
| 2.2 | M | 298D225X0010M(2)T | 0.5 | 10 | 10.00 | 0.050 |
| 3.3 | M | 298D335(1)010M(2)T | 0.5 | 8 | 6.00 | 0.090 |
| 4.7 | K | 298W475X0010K(2)T | 10 | 50 | 50.00 | 0.017 |
| 4.7 | M | 298D475(1)010M(2)T | 0.5 | 6 | 5.00 | 0.071 |
| 4.7 | P | 298D475(1)010P(2)T | 0.5 | 6 | 4.00 | 0.106 |
| 10 | M | 298D106X0010M(2)T | 1.0 | 20 | 7.50 | 0.058 |
| 15 | M | 298D156X0010M(2)T | 1.5 | 30 | 7.50 | 0.058 |
| 22 | M | 298D226X0010M(2)T | 22 | 40 | 10.00 | 0.050 |
| 33 | M ⁽¹⁾ | 298W336(1)010M(2)T | 66 | 75 | 21.00 | 0.035 |
| 33 | P | 298D336X0010P(2)T | 3.3 | 20 | 4.00 | 0.150 |
| 47 | P | 298D476X0010P(2)T | 4.7 | 22 | 3.00 | 0.122 |
| 100 | Q | 298W107X0010Q(2)T | 100 | 50 | 15.00 | 0.060 |
| 298D: 16 V_{DC} AT +85 °C; 10 V_{DC} AT +125 °C 298W: 16 V_{DC} AT +40 °C; 10 V_{DC} AT +85 °C; 6.3 V_{DC} AT +125 °C | | | | | | |
| 1.0 | K | 298D105X0016K(2)T | 1.6 | 10 | 20.00 | 0.027 |
| 1.0 | M | 298D105(1)016M(2)T | 0.5 | 6 | 12.00 | 0.045 |
| 2.2 | K | 298W225(1)016K(2)T | 10 | 50 | 50.00 | 0.017 |
| 2.2 | M | 298D225(1)016M(2)T | 0.5 | 10 | 12.00 | 0.045 |
| 4.7 | M | 298D475X0016M(2)T | 0.8 | 12 | 12.00 | 0.046 |
| 4.7 | P | 298D475(1)016P(2)T | 0.8 | 6 | 4.00 | 0.106 |
| 10 | R | 298D106(1)016R(2)T | 1.6 | 8 | 8.00 | 0.075 |
| 20 V_{DC} AT +85 °C; 13 V_{DC} AT +125 °C | | | | | | |
| 0.33 | K | 298D334(1)020K(2)T | 0.5 | 6 | n/a | n/a |
| 0.68 | M | 298D684(1)020M(2)T | 0.5 | 6 | 20.00 | 0.042 |
| 1.0 | S | 298D105X0020S(2)T | 0.5 | 6 | 10.00 | 0.059 |
| 4.7 | P | 298D475(1)020P(2)T | 1.0 | 6 | 4.00 | 0.106 |
| 25 V_{DC} AT +85 °C; 17 V_{DC} AT +125 °C | | | | | | |
| 0.68 | M | 298D684(1)025M(2)T | 0.5 | 6 | 20.00 | 0.042 |
| 1.0 | M | 298D105(1)025M(2)T | 0.5 | 6 | 10.00 | 0.050 |
| 1.0 | S | 298D105X0025S(2)T | 0.5 | 6 | 10.00 | 0.059 |
| 1.0 | R | 298D105(1)025R(2)T | 0.5 | 6 | 10.00 | 0.067 |
| 4.7 | P | 298D475(1)025P(2)T | 1.2 | 6 | 4.00 | 0.106 |
| 10 | A | 298D106X0025A(2)T | 2.5 | 10 | 3.50 | 0.146 |
| 35 V_{DC} AT +85 °C; 23 V_{DC} AT +125 °C | | | | | | |
| 2.2 | P | 298D225X0035P(2)T | 0.8 | 8 | 8.00 | 0.075 |
| 50 V_{DC} AT +85 °C; 33 V_{DC} AT +125 °C | | | | | | |
| 1.0 | P | 298D105X0050P(2)T | 0.5 | 8 | 8.00 | 0.075 |

Notes

- Part number definitions:
 - Tolerance: for 10 % tolerance, specify "X9"; for 20 % tolerance, change to "X0"
 - Termination: for 100 % tin specify "2", for gold plated specify "4"
- ⁽¹⁾ Rating in development, contact factory for availability



| RECOMMENDED VOLTAGE DERATING (298D) | |
|-------------------------------------|---------------------|
| +85 °C RATING | +125 °C RATING |
| WORKING VOLTAGE (V) | WORKING VOLTAGE (V) |
| 2 | 1.3 |
| 4 | 2.7 |
| 6.3 | 4 |
| 10 | 7 |
| 15 | 10 |
| 16 | 10 |
| 20 | 13 |
| 25 | 17 |
| 35 | 23 |
| 50 | 33 |

| RECOMMENDED VOLTAGE DERATING (298W) | | |
|-------------------------------------|----------------------|-----------------------|
| -55 °C/+40 °C RATING | +40 °C/+85 °C RATING | +85 °C/+125 °C RATING |
| RATED VOLTAGE (V) | CATEGORY VOLTAGE (V) | CATEGORY VOLTAGE (V) |
| 4 | 2.5 | 1.6 |
| 6.3 | 4 | 2.5 |
| 10 | 6.3 | 4 |
| 16 | 10 | 6.3 |
| 20 | 13 | 8 |
| 25 | 17 | 10 |
| 35 | 23 | 14 |





| STANDARD PACKAGING QUANTITY | |
|-----------------------------|---------------------|
| CASE CODE | QUANTITY (pcs/reel) |
| | 7" REEL |
| K | 5000 |
| M | 4000 |
| S | 3000 |
| R | 2500 |
| P | 3000 |
| Q | 2500 |
| A | 2000 |
| B | 2000 |

| POWER DISSIPATION | |
|-------------------|---|
| CASE CODE | MAXIMUM PERMISSIBLE POWER DISSIPATION AT +25 °C (W) IN FREE AIR |
| K | 0.015 |
| M | 0.025 |
| S | 0.035 |
| R | 0.045 |
| P | 0.045 |
| Q | 0.055 |
| A | 0.075 |
| B | 0.085 |

| PRODUCT INFORMATION | |
|-------------------------------------|--|
| Micro Guide | www.vishay.com/doc?40115 |
| Pad Dimensions | |
| Packaging Dimensions | |
| Moisture Sensitivity | www.vishay.com/doc?40135 |
| Typical Performance Characteristics | www.vishay.com/doc?40169 |
| 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 Leadframeless 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 "tantallite" when its contents are more than one-half tantalum. Important sources of tantallite include Australia, Brazil, Canada, China, and several African countries. Synthetic tantallite 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. 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.

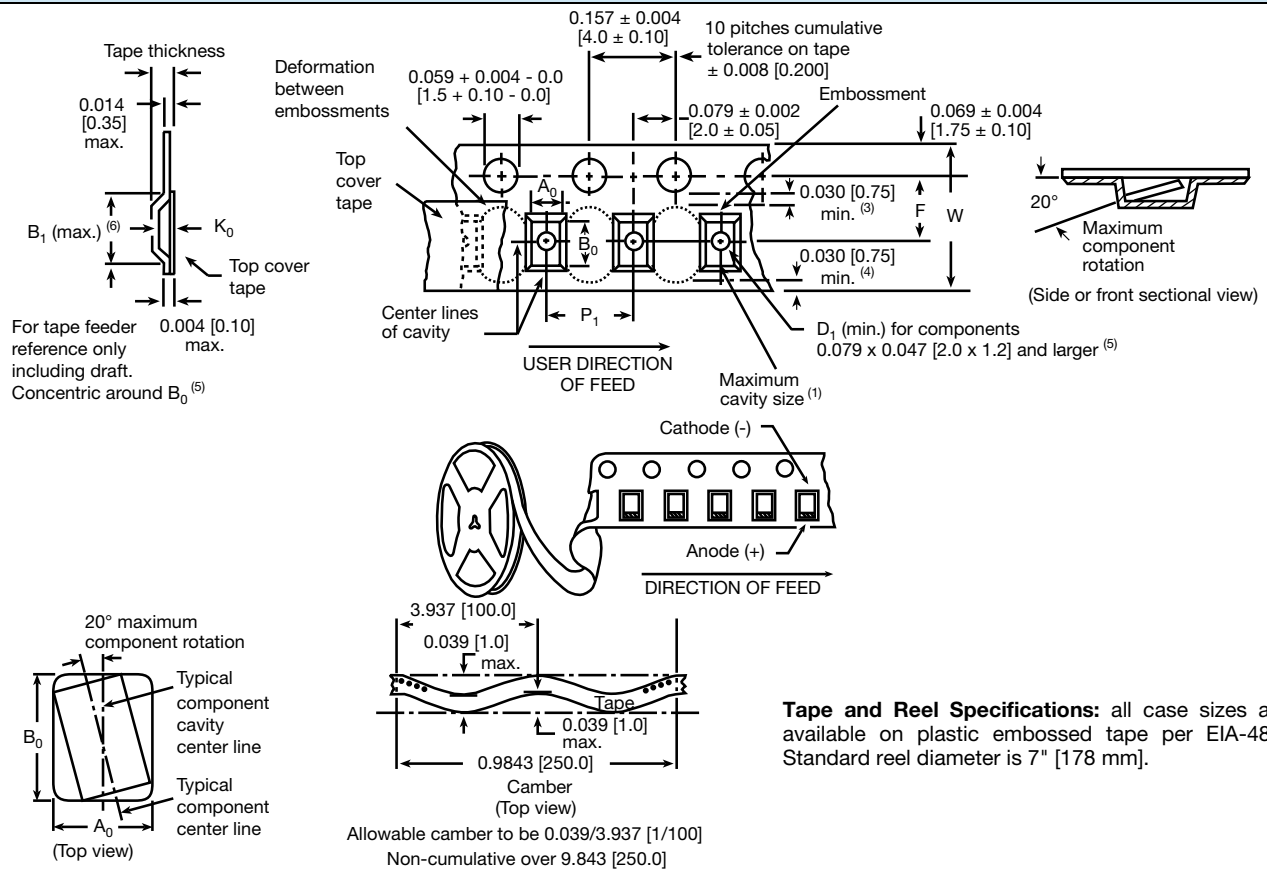


Fig. 1 - Leadframeless Molded Capacitors, All Types

| SOLID TANTALUM CAPACITORS - LEADFRAMELESS MOLDED | | | | |
|---|--|--|--|--|
| SERIES | TL8 | 298D | 298W | TR8 |
| PRODUCT IMAGE | | | | |
| TYPE | Solid tantalum leadframeless molded chip capacitors | | | |
| FEATURES | Small size including 0603 and 0402 foot print | | | |
| | Ultra low profile | Industrial grade | Industrial grade, extended range | Low ESR |
| TEMPERATURE RANGE | Operating Temperature: -55 °C to +125 °C (above 40 °C, voltage derating is required) | Operating Temperature: -55 °C to +125 °C (above 85 °C, voltage derating is required) | Operating Temperature: -55 °C to +125 °C (above 40 °C, voltage derating is required) | Operating Temperature: -55 °C to +125 °C (above 85 °C, voltage derating is required) |
| CAPACITANCE RANGE | 0.68 µF to 220 µF | 0.68 µF to 330 µF | 2.2 µF to 220 µF | 1 µF to 330 µF |
| VOLTAGE RANGE | 4 V to 35 V | 2.5 V to 50 V | 4 V to 16 V | 2.5 V to 25 V |
| CAPACITANCE TOLERANCE | ± 20 %, ± 10 % | | | |
| DISSIPATION FACTOR | 6 % to 80 % | 6 % to 80 % | 30 % to 80 % | 6 % to 80 % |
| CASE CODES | W0, W9, A0, B0 | K, M, R, P, Q, A, S, B | K, M, Q | M, R, P, Q, A, B |
| TERMINATION | 100 % tin | 100 % tin or gold plated | | |

| SOLID TANTALUM CAPACITORS - LEADFRAMELESS MOLDED | | | | |
|---|--|---------------------------------------|---|---------------------------------------|
| SERIES | TP8 | TM8 | DLA 11020 | T42 |
| PRODUCT IMAGE | | | | |
| TYPE | Solid tantalum leadframeless molded chip capacitors | | | |
| FEATURES | Small size including 0603 and 0402 foot print | | | Built in fuse, double-stacked |
| | High performance, automotive grade | High reliability | High reliability, DLA approved | High reliability, ultra-low ESR |
| TEMPERATURE RANGE | Operating Temperature: -55 °C to +125 °C (above 85 °C, voltage derating is required) | | | |
| CAPACITANCE RANGE | 1 µF to 100 µF | 0.68 µF to 47 µF | 1 µF to 47 µF | 10 µF to 470 µF |
| VOLTAGE RANGE | 6.3 V to 40 V | 2 V to 40 V | 6.3 V to 40 V | 16 V to 75 V |
| CAPACITANCE TOLERANCE | ± 20 %, ± 10 % | | | |
| DISSIPATION FACTOR | 6 % to 30 % | 6 % to 20 % | 6 % to 8 % | 6 % to 15 % |
| CASE CODES | M, W, R, P, A, N, T, B | K, M, W, R, P, A, N, T | M, W, R, P, A, N, T | M2 |
| TERMINATION | 100 % tin | Tin / lead solder plated or 100 % tin | Tin / lead solder plated or gold plated | Tin / lead solder plated or 100 % tin |

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 embossement. Dimensions of embossement location shall be applied independent of each other.
- B_1 dimension is a reference dimension tape feeder clearance only.

| CARRIER TAPE DIMENSIONS in inches [millimeters] FOR 298D, 298W, TR8, TP8, TL8 | | | | | | | |
|--|-----------|-----------------------------|--------------|-------------|--------------|-------------|--------------|
| CASE CODE | TAPE SIZE | B_1 (MAX.) ⁽¹⁾ | D_1 (MIN.) | F | K_0 (MAX.) | P_1 | W |
| M ⁽²⁾ | 8 mm | 0.075 [1.91] | 0.02 [0.5] | 0.138 [3.5] | 0.043 [1.10] | 0.157 [4.0] | 0.315 [8.0] |
| W | 8 mm | 0.112 [2.85] | 0.039 [1.0] | 0.138 [3.5] | 0.053 [1.35] | 0.157 [4.0] | 0.315 [8.0] |
| R | 8 mm | 0.098 [2.46] | 0.039 [1.0] | 0.138 [3.5] | 0.066 [1.71] | 0.157 [4.0] | 0.315 [8.0] |
| P | 8 mm | 0.108 [2.75] | 0.02 [0.5] | 0.138 [3.5] | 0.054 [1.37] | 0.157 [4.0] | 0.315 [8.0] |
| A | 8 mm | 0.153 [3.90] | 0.039 [1.0] | 0.138 [3.5] | 0.078 [2.00] | 0.157 [4.0] | 0.315 [8.0] |
| A0, Q | 8 mm | - | 0.02 [0.5] | 0.138 [3.5] | 0.049 [1.25] | 0.157 [4.0] | 0.315 [8.0] |
| B | 8 mm | 0.157 [4.0] | 0.039 [1.0] | 0.138 [3.5] | 0.087 [2.22] | 0.157 [4.0] | 0.315 [8.0] |
| W0 | 8 mm | 0.094 [2.40] | 0.029 [0.75] | 0.138 [3.5] | 0.045 [1.15] | 0.157 [4.0] | 0.315 [8.0] |
| W9, S | 8 mm | 0.126 [3.20] | 0.029 [0.75] | 0.138 [3.5] | 0.045 [1.15] | 0.157 [4.0] | 0.315 [8.0] |
| B0 | 12 mm | 0.181 [4.61] | 0.059 [1.5] | 0.217 [5.5] | 0.049 [1.25] | 0.157 [4.0] | 0.472 [12.0] |

Notes

- (1) For reference only
- (2) Packaging of M case in plastic tape is available per request

| CARRIER TAPE DIMENSIONS in inches [millimeters] FOR TM8 | | | | | | | |
|---|-----------|--------------------------------------|-----------------------|-------------|-----------------------|----------------|--------------|
| CASE CODE | TAPE SIZE | B ₁ (MAX.) ⁽¹⁾ | D ₁ (MIN.) | F | K ₀ (MAX.) | P ₁ | W |
| M | 8 mm | 0.075 [1.91] | 0.02 [0.5] | 0.138 [3.5] | 0.043 [1.10] | 0.157 [4.0] | 0.315 [8.0] |
| W | 8 mm | 0.112 [2.85] | 0.039 [1.0] | 0.138 [3.5] | 0.053 [1.35] | 0.157 [4.0] | 0.315 [8.0] |
| R | 8 mm | 0.098 [2.46] | 0.039 [1.0] | 0.138 [3.5] | 0.066 [1.71] | 0.157 [4.0] | 0.315 [8.0] |
| P | 8 mm | 0.108 [2.75] | 0.02 [0.5] | 0.138 [3.5] | 0.054 [1.37] | 0.157 [4.0] | 0.315 [8.0] |
| A | 8 mm | 0.153 [3.90] | 0.039 [1.0] | 0.138 [3.5] | 0.078 [2.00] | 0.157 [4.0] | 0.315 [8.0] |
| N | 12 mm | 0.154 [3.90] | 0.059 [1.5] | 0.216 [5.5] | 0.051 [1.30] | 0.157 [4.0] | 0.472 [12.0] |
| T | 12 mm | 0.154 [3.90] | 0.059 [1.5] | 0.216 [5.5] | 0.067 [1.70] | 0.157 [4.0] | 0.472 [12.0] |

Notes
⁽¹⁾ For reference only

| CARRIER TAPE DIMENSIONS in inches [millimeters] FOR T42 | | | | | | | |
|---|-----------|--------------------------------------|-----------------------|-------------|-----------------------|----------------|--------------|
| CASE CODE | TAPE SIZE | B ₁ (MAX.) ⁽¹⁾ | D ₁ (MIN.) | F | K ₀ (MAX.) | P ₁ | W |
| M2 | 16 mm | 0.404 [10.3] | 0.059 [1.5] | 0.295 [7.5] | 0.176 [4.5] | 0.472 [12.0] | 0.630 [16.0] |

Note
⁽¹⁾ For reference only

| PAPER TAPE AND REEL PACKAGING in inches [millimeters] FOR 298D, 298W, TR8, TP8, TL8 | | | | | | | | | | | |
|---|-----------|--------------------------------|--------------------------------|-----------------------------|------------------------------|------------------------------|-------------------------------|-------------------------------|--------------------------------|------------------------------|--------------------------------|
| | | | | | | | | | | | |
| CASE SIZE | TAPE SIZE | A ₀ | B ₀ | D ₀ | P ₀ | P ₁ | P ₂ | E | F | W | T |
| K | 8 mm | 0.033 ± 0.002 [0.85 ± 0.05] | 0.053 ± 0.002 [1.35 ± 0.05] | 0.06 ± 0.004 [1.5 ± 0.1] | 0.157 ± 0.004 [4.0 ± 0.1] | 0.078 ± 0.004 [2.0 ± 0.1] | 0.079 ± 0.002 [2.0 ± 0.05] | 0.069 ± 0.004 [1.75 ± 0.1] | 0.0138 ± 0.002 [3.5 ± 0.05] | 0.315 ± 0.008 [8.0 ± 0.2] | 0.03 ± 0.002 [0.75 ± 0.05] |
| M | 8 mm | 0.041 ± 0.002 [1.05 ± 0.05] | 0.071 ± 0.002 [1.8 ± 0.05] | 0.06 ± 0.004 [1.5 ± 0.1] | 0.157 ± 0.004 [4.0 ± 0.1] | 0.157 ± 0.004 [4.0 ± 0.1] | 0.079 ± 0.002 [2.0 ± 0.05] | 0.069 ± 0.004 [1.75 ± 0.1] | 0.0138 ± 0.002 [3.5 ± 0.05] | 0.315 ± 0.008 [8.0 ± 0.2] | 0.037 ± 0.002 [0.95 ± 0.05] |

Note
⁽¹⁾ A₀, B₀ 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) 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°.

RECOMMENDED REFLOW PROFILES



| PROFILE FEATURE | SnPb EUTECTIC ASSEMBLY | LEAD (Pb)-FREE ASSEMBLY |
|---|------------------------|-------------------------|
| PREHEAT AND SOAK | | |
| Temperature min. ($T_{Smin.}$) | 100 °C | 150 °C |
| Temperature max. ($T_{Smax.}$) | 150 °C | 200 °C |
| Time (t_s) from ($T_{Smin.}$ to $T_{Smax.}$) | 60 s to 90 s | 60 s to 150 s |
| RAMP UP | | |
| Ramp-up rate (T_L to T_p) | 3 °C/s maximum | |
| Liquidous temperature (T_L) | 183 °C | 217 °C |
| Time (t_L) maintained above T_L | 60 s to 150 s | |
| Peak package body temperature (T_p) max. | 235 °C | 260 °C |
| Time (t_p) within 5 °C of the peak max. temperature | 20 s | 30 s |
| RAMP DOWN | | |
| Ramp-down rate (T_p to T_L) | 6 °C/s maximum | |
| Time from 25 °C to peak temperature | 6 min maximum | 8 min maximum |

Note

- Capacitors should withstand reflow profile as per J-STD-020 standard

PAD DIMENSIONS in inches [millimeters]



| CASE CODE | A (MIN.) | B (NOM.) | C (NOM.) | D (NOM.) |
|-----------------|--------------|--------------|--------------|--------------|
| K | 0.028 [0.70] | 0.018 [0.45] | 0.024 [0.60] | 0.059 [1.50] |
| M | 0.039 [1.00] | 0.028 [0.70] | 0.024 [0.60] | 0.080 [2.00] |
| R, W, W0, W9, S | 0.059 [1.50] | 0.031 [0.80] | 0.039 [1.00] | 0.102 [2.60] |
| P | 0.063 [1.60] | 0.031 [0.80] | 0.047 [1.20] | 0.110 [2.80] |
| A, Q, A0 | 0.071 [1.80] | 0.067 [1.70] | 0.053 [1.35] | 0.187 [4.75] |
| B, B0, N, T | 0.118 [3.00] | 0.071 [1.80] | 0.065 [1.65] | 0.207 [5.25] |
| M2 | 0.315 [8.00] | 0.098 [2.50] | 0.197 [5.00] | 0.394 [10.0] |

TYPICAL LEAKAGE CURRENT FACTOR RANGE



Notes

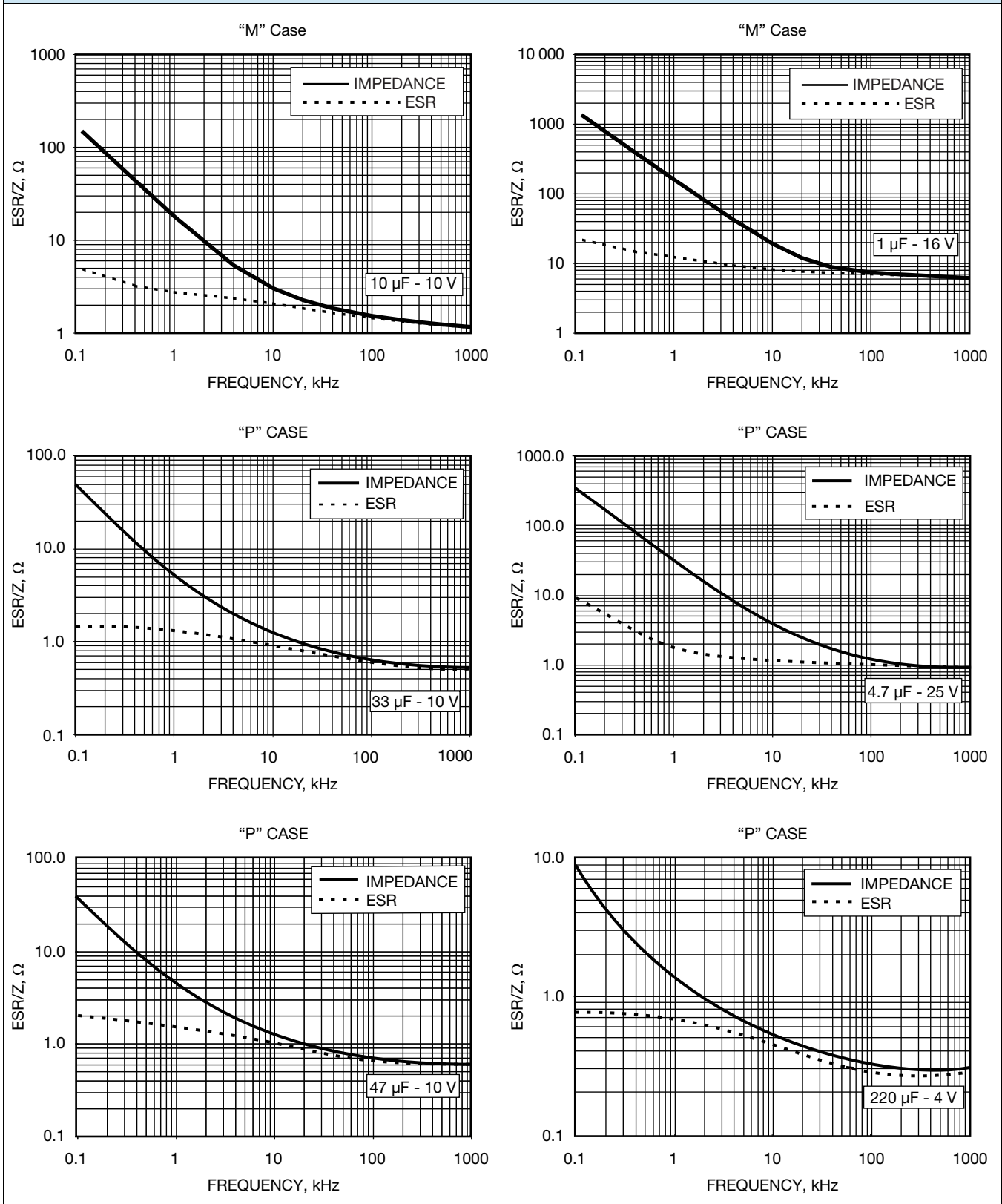
- At +25 °C, the leakage current shall not exceed the value listed in the Standard Ratings table
- At +85 °C, the leakage current shall not exceed 10 times the value listed in the Standard Ratings table
- At +125 °C, the leakage current shall not exceed 12 times the value listed in the Standard Ratings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

TYPICAL CURVES AT +25 °C, IMPEDANCE AND ESR VS. FREQUENCY





TYPICAL CURVES AT +25 °C, IMPEDANCE AND ESR VS. FREQUENCY





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 watts at +25 °C (see paragraph number 5 and the table Power Dissipation as given in the tables in the product datasheets)

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:

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

or, from the formula:

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

where,

P = power dissipation in watts at +25 °C (see paragraph number 5 and the table Power Dissipation as given in the tables in the product datasheets)

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:** these capacitors are capable of withstanding peak voltages in the reverse direction equal to 10 % of the DC rating at +25 °C, 5 % of the DC rating at +25 °C, 5 % of the DC rating at +85 °C, and 1 % of the DC rating at +125 °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 | DERATING FACTOR |
|-------------|-----------------|
| +25 °C | 1.0 |
| +85 °C | 0.9 |
| +125 °C | 0.4 |

- 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 2 °C per s. 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.

- 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, Chlorethane, 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.



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.

Except as expressly indicated in writing, Vishay products are not designed for use in medical, life-saving, or life-sustaining applications or for any other application in which the failure of the Vishay product could result in personal injury or death. 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.

Material Category Policy

Vishay Intertechnology, Inc. hereby certifies that all its products that are identified as RoHS-Compliant fulfill the definitions and restrictions defined under Directive 2011/65/EU of The European Parliament and of the Council of June 8, 2011 on the restriction of the use of certain hazardous substances in electrical and electronic equipment (EEE) - recast, unless otherwise specified as non-compliant.

Please note that some Vishay documentation may still make reference to RoHS Directive 2002/95/EC. We confirm that all the products identified as being compliant to Directive 2002/95/EC conform to Directive 2011/65/EU.

Vishay Intertechnology, Inc. hereby certifies that all its products that are identified as Halogen-Free follow Halogen-Free requirements as per JEDEC JS709A standards. Please note that some Vishay documentation may still make reference to the IEC 61249-2-21 definition. We confirm that all the products identified as being compliant to IEC 61249-2-21 conform to JEDEC JS709A standards.

Компания «Океан Электроники» предлагает заключение долгосрочных отношений при поставках импортных электронных компонентов на взаимовыгодных условиях!

Наши преимущества:

- Поставка оригинальных импортных электронных компонентов напрямую с производств Америки, Европы и Азии, а так же с крупнейших складов мира;
- Широкая линейка поставок активных и пассивных импортных электронных компонентов (более 30 млн. наименований);
- Поставка сложных, дефицитных, либо снятых с производства позиций;
- Оперативные сроки поставки под заказ (от 5 рабочих дней);
- Экспресс доставка в любую точку России;
- Помощь Конструкторского Отдела и консультации квалифицированных инженеров;
- Техническая поддержка проекта, помощь в подборе аналогов, поставка прототипов;
- Поставка электронных компонентов под контролем ВП;
- Система менеджмента качества сертифицирована по Международному стандарту ISO 9001;
- При необходимости вся продукция военного и аэрокосмического назначения проходит испытания и сертификацию в лаборатории (по согласованию с заказчиком);
- Поставка специализированных компонентов военного и аэрокосмического уровня качества (Xilinx, Altera, Analog Devices, Intersil, Interpoint, Microsemi, Actel, Aeroflex, Peregrine, VPT, Syfer, Eurofarad, Texas Instruments, MS Kennedy, Miteq, Cobham, E2V, MA-COM, Hittite, Mini-Circuits, General Dynamics и др.);

Компания «Океан Электроники» является официальным дистрибьютором и эксклюзивным представителем в России одного из крупнейших производителей разъемов военного и аэрокосмического назначения «JONHON», а так же официальным дистрибьютором и эксклюзивным представителем в России производителя высокотехнологичных и надежных решений для передачи СВЧ сигналов «FORSTAR».



JONHON

«JONHON» (основан в 1970 г.)

Разъемы специального, военного и аэрокосмического назначения:

(Применяются в военной, авиационной, аэрокосмической, морской, железнодорожной, горно- и нефтедобывающей отраслях промышленности)

«FORSTAR» (основан в 1998 г.)

ВЧ соединители, коаксиальные кабели,
кабельные сборки и микроволновые компоненты:

(Применяются в телекоммуникациях гражданского и специального назначения, в средствах связи, РЛС, а так же военной, авиационной и аэрокосмической отраслях промышленности).



Телефон: 8 (812) 309-75-97 (многоканальный)

Факс: 8 (812) 320-03-32

Электронная почта: ocean@oceanchips.ru

Web: <http://oceanchips.ru/>

Адрес: 198099, г. Санкт-Петербург, ул. Калинина, д. 2, корп. 4, лит. А