# Chip tantalum capacitors with built–in open–function

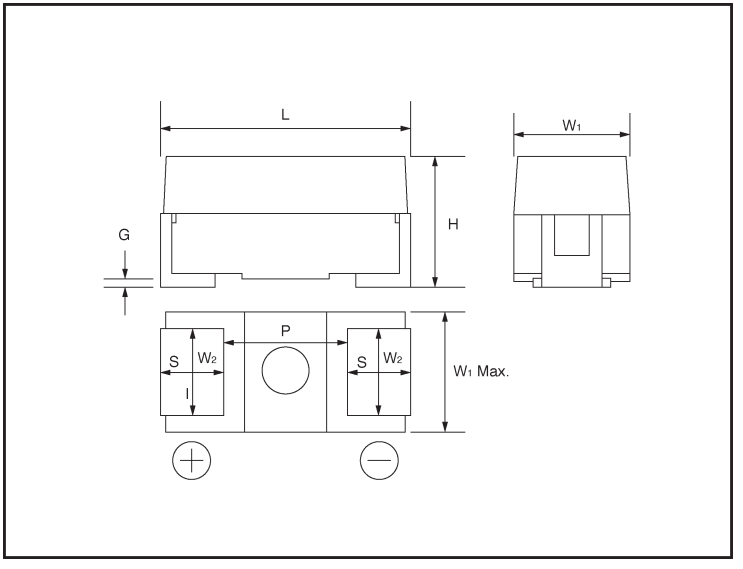
## TCFG series

Semiconductor manufacturing technology has been used to include a temperature fuse in TCFG series capacitors. These capacitors feature low impedance and are ideal for digital circuits and low–voltage circuits in portable electronic equipment.

●Features

1) Open–function built into every package.
2) High capacitance in a small package.
3) Low impedance.
4) Use of semiconductor manufacturing technology provides high reliability.
5) Superb solderability.

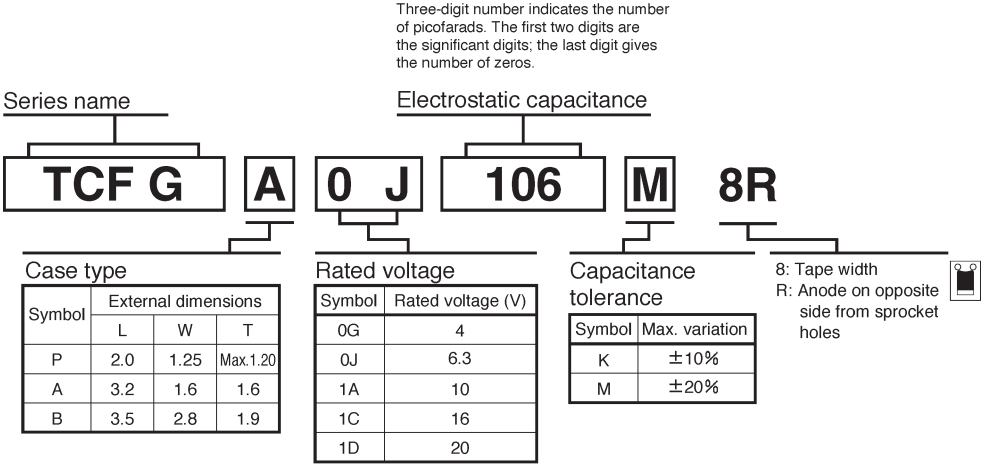
●External dimensions (mm)




| Case code | L | $W_1$ | $W_2$ | H | S | G | P |
|---|---|---|---|---|---|---|---|
| P (2012) | 2.0±0.2 | 1.25±0.2 | 0.9±0.2 | Max.1.20 | 0.45±0.3 | Max. 0.15 | 1.3±0.3 |
| A (3216) | 3.2±0.2 | 1.6±0.2 | 1.2±0.2 | 1.6±0.2 | 0.8±0.3 | Max. 0.15 | 1.6±0.3 |
| B (3528) | 3.5±0.2 | 2.8±0.2 | 1.9±0.2 | 1.9±0.2 | 0.8±0.3 | Max. 0.15 | 1.9±0.3 |

## ●Product designation

· When ordering, please specify the part No.
· Please check to be sure of what combination of features you wish to order.
· Fill in the blanks from left to right.




| Symbol | External dimensions | | |
|---|---|---|---|
| | L | W | T |
| P | 2.0 | 1.25 | Max.1.20 |
| A | 3.2 | 1.6 | 1.6 |
| B | 3.5 | 2.8 | 1.9 |

| Symbol | Rated voltage (V) |
|---|---|
| 0G | 4 |
| 0J | 6.3 |
| 1A | 10 |
| 1C | 16 |
| 1D | 20 |

| Symbol | Max. variation |
|---|---|
| K | ±10% |
| M | ±20% |

## ●Capacitance range

TCFG series

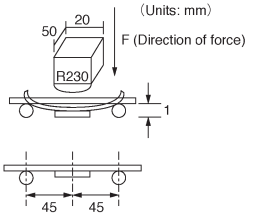
| μF | Rated voltage (V. DC) | | | | |
|---|---|---|---|---|---|
| | 4<br>0G | 6.3<br>0J | 10<br>1A | 16<br>1C | 20<br>1D |
| 0.68 | | | | | |
| 1.0 | | | P | P A | A |
| 1.5 | | P | A | A | |
| 2.2 | P | P | A | A | |
| 3.3 | P | P A | P A | A B | |
| 4.7 | P A | P A | P A B | A B | |
| 6.8 | P A | P A | A B | A B | |
| 10 | P A | P A B | A B | B | |
| 15 | P A B | A B | A B | | |
| 22 | A B | A B | B | | |
| 33 | A B | B | B | | |
| 47 | B | B | | | |
| 68 | B | | | | |
| 100 | | | | | |

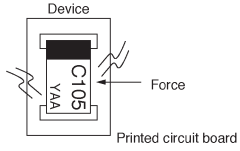
red characters : under the development

## ●Characteristics

| Item | | Performance | Test methods / conditions (based on JIS C 5102, 5143) |
|---|---|---|---|
| Operating temperature | | −55℃～+125℃ | |
| Max. operating temperature at rated voltage | | +85℃ | |
| Rated voltage (V. DC) | | 4 \| 6.3 \| 10 \| 16 \| 20 | |
| Derated voltage (V. DC) | | 2.5 \| 4 \| 6.3 \| 10 \| 13 | at 125℃ |
| Surge voltage (V. DC) | | 5.2 \| 8 \| 13 \| 20 \| 26 | |
| Leakage current | | Less than or equal to the larger of 0.5 μA or 0.01CV. Details are given in Table 1, "Standard Product List". | Measured value 60s after application of rated voltage. |
| Capacitance range | | 1.0～47 μF | Measured frequency: 120±12Hz<br>Measured voltage: 0.5Vrms+1.5V. DC<br>Measured circuit: equivalent series circuit |
| tan δ | P case<br>A case<br><br>B case | 0.08 max.<br>1 μF max.: 0.04 max.<br>1.5 μF to 22 μF max.: 0.06 max.<br>3.3 μF to 47 μF max.: 0.06 max. | Measured frequency: 120±12Hz<br>Measured voltage: 0.5Vrms+1.5V. DC<br>Measured circuit: equivalent series circuit |
| Impedance | P case | 27.5Ω max. | Measured frequency: 100±10Hz<br>Measured voltage: 0.5Vrms max.<br>Measured circuit: equivalent series circuit |
| | A case | 20.0Ω max. | |
| | B case | 15.0Ω max. | |
| Resistance to solder heat | Appearance | No noticeable irregularities, and the markings must be easy to read. | Direct immersion into solder bath<br>Solder bath temperature: 260±5℃<br>Immersion time: 5s<br>Immersion cycles: 1 time |
| | L.C | Must satisfy the initial specified value. | |
| | △C / C | Within ±5%<br>P case=±10% | |
| | tan δ | P case 1.5 times or less or initial specified tolerance.<br>A·B case must satisfy the initial specified value. | |
| Fuse operation | | 320℃ for 20s or less | Direct immersion into solder bath (320±5℃) |
| Temperature cycle | Appearance | No noticeable irregularities, and the markings must be easy to read. | The four cycles in the table below are repeated five times in succession. |
| | L.C | Must satisfy the initial specified value.<br>P case=Within 150% of initial limit. | |
| | △C / C | P case within ±10%<br>A・B case within ±5% | |
| | tan δ | P case 1.5 times or less or initial specified tolerance.<br>A·B case must satisfy the initial specified value. | |
| Resistance to humidity (steady state) | Appearance | No noticeable irregularities, and the markings must be easy to read. | Measured after being left for 500 ±12hrs. at 60±2℃ and 90 to 95% RH, then 1 to 2 hrs. at normal room temperature and humidity. |
| | L.C | Must satisfy the initial specified value. | |
| | △C / C | P case within ±20%<br>A・B case within ±10% | |
| | tan δ | P case 1.5 times or less or initial specified tolerance.<br>A·B case must satisfy the initial specified value. | |

| | Temperature | Time |
|---|---|---|
| 1 | −55±3℃ | 30±3mins. |
| 2 | Room temperature | 3mins. max. |
| 3 | 125±2℃ | 30±3mins. |
| 4 | Room temperature | 3mins. max. |

| Item | | Performance | Test methods / conditions (based on JIS C 5102,5143) |
|---|---|---|---|
| Temperature characteristics | Temperature | -55℃ | |
| | △C / C | P case within +0% and -15% of the value before testing.<br>A・B case within +10% and -0% of the value before testing. | |
| | tan δ | P case within 1.5 times of the value before testing.<br>A・B case must satisfy the initial specified value. | |
| | L.C | — | |
| | Temperature | +85℃ | |
| | △C / C | P case within +0% and -15% of the value before testing.<br>A・B case within +10% and -0% of the value before testing. | |
| | tan δ | Must satisfy the initial specified value. | |
| | L.C | Less than or equal to the larger of 5 μA or 0.1CV. | |
| | Temperature | +125℃ | |
| | △C / C | P case within +20% and -0% of the value before testing.<br>A・B case within +15% and -0% of the value before testing. | |
| | tan δ | P case within 1.5 times of the value before testing.<br>A・B case must satisfy the initial specified value. | |
| | L.C | Less than or equal to the larger of 6.3 μA or 0.125CV. | |
| Surge resistance | Appearance | A・B case no noticeable irregularities, and the markings must be easy to read. | Apply the rated surge voltage for 30 ±5s at intervals of 5±.05mins. 1000 times, with the temperature at 85±2℃. |
| | L.C | Must satisfy the initial specified value. | |
| | △C / C | P case within ±10%<br>A・B case within ±5% | |
| | tan δ | P case within 1.5 times of the value before testing.<br>A・B case must satisfy the initial specified value. | |
| High-temperature load | Appearance | No noticeable irregularities, and the markings must be easy to read. | Apply the rated voltage continuously for 2000 to 2072hrs. via a series resister of 3Ω max., then make the measurement after leaving the device at room temperature and humidity for 1 to 2hrs. |
| | L. C | Must satisfy the initial specified value. | |
| | △C / C | Within ±10% | |
| | tan δ | P case within 1.5 times of the value before testing.<br>A・B case must satisfy the initial specified value. | |
| Terminal strength | Capacitance | Value must be stable during measurement. | Apply pressure to the device using the specified tool for 5s so that the center deflection is 1mm (see below).<br>  |
| | Appearance | No noticeable irregularities. | |

| Item | | Performance | Test conditions |
|---|---|---|---|
| Adhesion | | Terminals must not detach. | With the device mounted on the printed circuit board, apply a force of 0.5kg・f from each side for a period of 10±1s.   |
| External dimensions | | Refer to Fig. 1, "External dimensions" | Measure using slide calipers that meet the requirements of JIS B7507 Class 2. |
| Markings | Resistance to solvents | Marking must be easy to read. | Immerse in isopropyl alcohol for 30±5s. |
| Solderability<br>Inspect the solder cover of the terminals using a solder immersion test | | At least 3 / 4 of the surface of the immersed terminals must be covered with new solder. | Immersion speed: 25±2.5mm / s<br>Pre-processing (accelerated aging): leave for 1hr over boiling distilled water<br>Solder temperature: 235±5℃<br>Immersion time: 2±0.5s<br>Solder type: H63A<br>Flux: rosin 25%, IPA 75% |
| Resistance to vibration | Capacitance | Value must be stable during measurement. | Vibrate in the X / Y axis at frequencies of 10Hz, 55Hz and 10Hz for two hours each, with a total vibration amplitude of 1.5mm. |
| | Appearance | No noticeable irregularities. | |
| Reverse polarity withstanding voltage | Appearance | No noticeable irregularities, and the markings must be easy to read. | Apply either 0.1 times the rated voltage, or 3V, whichever is smaller, via a series resister of 3Ω max. and 0.1Ω min. at a temperature of 85±2℃. |
| | L.C | Must be less than or equal to twice the initial specified value. | |
| | △C / C | Within ±10% of the value before the test. | |
| | tan $\delta$ | Must be less than or equal to 1.5 times the initial specified value. | |

●Table 1 Standard parts list, TCFG series

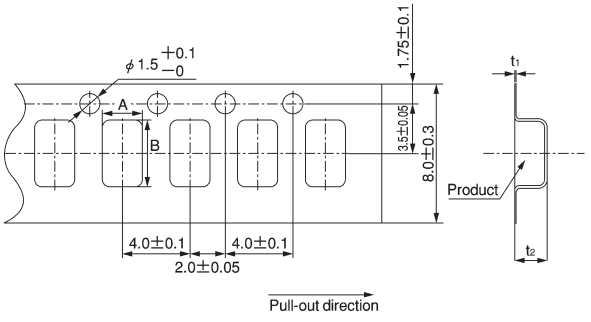
| Part No. | Rated voltage at 85℃ (V) | Derated voltage at 125℃ (V) | Surge voltage at 85℃ (V) | Capacitance (μF) | Tolerance (%) | Leakage current at 25℃ 1WV.60s (μA) | DF 120Hz 25℃ (%) |
|---|---|---|---|---|---|---|---|
| TCF GP 0G 225_ | 4 | 2.5 | 5.2 | 2.2 | ±20,10 | 0.5 | 8 |
| TCF GP 0G 335_ | 4 | 2.5 | 5.2 | 3.3 | ±20,10 | 0.5 | 8 |
| TCF GP 0G 475_ | 4 | 2.5 | 5.2 | 4.7 | ±20,10 | 0.5 | 6 |
| TCF GA 0G 685_ | 4 | 2.5 | 5.2 | 6.8 | ±20,10 | 0.5 | 6 |
| TCF GA 0G 106_ | 4 | 2.5 | 5.2 | 10 | ±20,10 | 0.5 | 6 |
| TCF GA 0G 156_ | 4 | 2.5 | 5.2 | 15 | ±20,10 | 0.6 | 6 |
| TCF GB 0G 156_ | 4 | 2.5 | 5.2 | 15 | ±20,10 | 0.6 | 6 |
| TCF GA 0G 226_ | 4 | 2.5 | 5.2 | 22 | ±20,10 | 0.9 | 6 |
| TCF GB 0G 226_ | 4 | 2.5 | 5.2 | 22 | ±20,10 | 0.9 | 6 |
| TCF GB 0G 336_ | 4 | 2.5 | 5.2 | 33 | ±20,10 | 1.3 | 6 |
| TCF GB 0G 476_ | 4 | 2.5 | 5.2 | 47 | ±20,10 | 1.9 | 6 |
| TCF GP 0J 155_ | 6.3 | 4 | 8 | 1.5 | ±20,10 | 0.5 | 6 |
| TCF GP 0J 225_ | 6.3 | 4 | 8 | 2.2 | ±20,10 | 0.5 | 6 |
| TCF GA 0J 335_ | 6.3 | 4 | 8 | 3.3 | ±20,10 | 0.5 | 6 |
| TCF GA 0J 475_ | 6.3 | 4 | 8 | 4.7 | ±20,10 | 0.5 | 6 |
| TCF GA 0J 685_ | 6.3 | 4 | 8 | 6.8 | ±20,10 | 0.5 | 6 |
| TCF GA 0J 106_ | 6.3 | 4 | 8 | 10 | ±20,10 | 0.6 | 6 |
| TCF GA 0J 156_ | 6.3 | 4 | 8 | 15 | ±20,10 | 0.9 | 6 |
| TCF GB 0J 106_ | 6.3 | 4 | 8 | 10 | ±20,10 | 0.6 | 6 |
| TCF GB 0J 156_ | 6.3 | 4 | 8 | 15 | ±20,10 | 0.8 | 6 |
| TCF GB 0J 226_ | 6.3 | 4 | 8 | 22 | ±20,10 | 1.4 | 6 |
| TCF GB 0J 336_ | 6.3 | 4 | 8 | 33 | ±20,10 | 2.1 | 6 |
| TCF GP 1A 105_ | 10 | 6.3 | 13 | 1.0 | ±20,10 | 0.5 | 8 |
| TCF GA 1A 225_ | 10 | 6.3 | 13 | 2.2 | ±20,10 | 0.5 | 6 |
| TCF GA 1A 335_ | 10 | 6.3 | 13 | 3.3 | ±20,10 | 0.5 | 6 |
| TCF GA 1A 475_ | 10 | 6.3 | 13 | 4.7 | ±20,10 | 0.5 | 6 |
| TCF GB 1A 475_ | 10 | 6.3 | 13 | 4.7 | ±20,10 | 0.5 | 6 |
| TCF GA 1A 685_ | 10 | 6.3 | 13 | 6.8 | ±20,10 | 0.7 | 6 |
| TCF GB 1A 685_ | 10 | 6.3 | 13 | 6.8 | ±20,10 | 0.7 | 6 |
| TCF GA 1A 106_ | 10 | 6.3 | 13 | 10 | ±20,10 | 1.0 | 6 |
| TCF GB 1A 106_ | 10 | 6.3 | 13 | 10 | ±20,10 | 1.0 | 6 |
| TCF GB 1A 156_ | 10 | 6.3 | 13 | 15 | ±20,10 | 1.5 | 6 |
| TCF GA 1C 105_ | 16 | 10 | 20 | 1.0 | ±20,10 | 0.5 | 4 |
| TCF GA 1C 155_ | 16 | 10 | 20 | 1.5 | ±20,10 | 0.5 | 6 |
| TCF GA 1C 225_ | 16 | 10 | 20 | 2.2 | ±20,10 | 0.5 | 6 |

| Part No. | Rated voltage at 85℃ (V) | Derated voltage at 125℃ (V) | Surge voltage at 85℃ (V) | Capacitance (μF) | Tolerance (%) | Leakage current at 25℃ 1WV.60s (μA) | DF 120Hz 25℃ (%) |
|---|---|---|---|---|---|---|---|
| TCF GA 1C 335_ | 16 | 10 | 20 | 3.3 | ±20,10 | 0.5 | 6 |
| TCF GB 1C 335_ | 16 | 10 | 20 | 3.3 | ±20,10 | 0.5 | 6 |
| TCF GB 1C 475_ | 16 | 10 | 20 | 4.7 | ±20,10 | 0.8 | 6 |
| TCF GB 1C 685_ | 16 | 10 | 20 | 6.8 | ±20,10 | 1.1 | 6 |
| TCF GB 1C 106_ | 16 | 10 | 20 | 10 | ±20,10 | 1.6 | 6 |
| TCF GA 1D 105_ | 20 | 16 | 26 | 1.0 | ±20,10 | 0.5 | 4 |

## ●Packaging specifications

### Taping

TCFG / TCFP

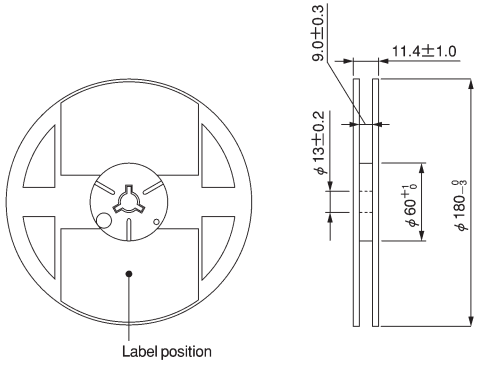



| Case code | A±0.1 | B±0.1 | $t_1$±0.05 | $t_2$±0.2 |
|---|---|---|---|---|
| P (2012) | 1.55 | 2.3 | 0.25 | 1.5 |
| A (3216) | 1.9 | 3.5 | 0.25 | 1.9 |
| B (3528) | 3.3 | 3.8 | 0.25 | 2.2 |

Some emboss tapes have the center hole on its bottom.

### Reel

Plastic reel




EIAJ ETX - 7001compliant

## ●Packaging style

| Part no. | Package type | Packaging style | | Symbol | Basic ordering unit (pcs) |
|---|---|---|---|---|---|
| TCFG | Taping | Plastic taping | φ180 mm reel | R | 2,000 |
| TCFP | Taping | Plastic taping | φ180 mm reel | R | 2,000 |

●Electrical characteristics and operation notes

(1) Soldering conditions (soldering temperature and soldering time)

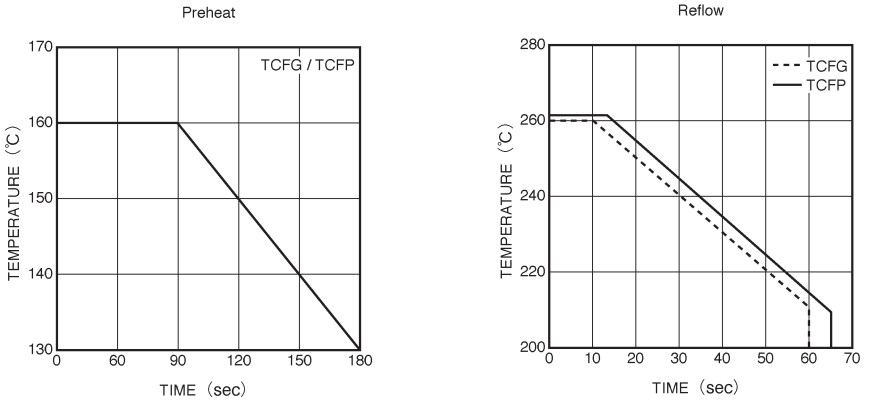



Fig.1 Reflow (Infrared Ray, Hot Plate, Hot Air)

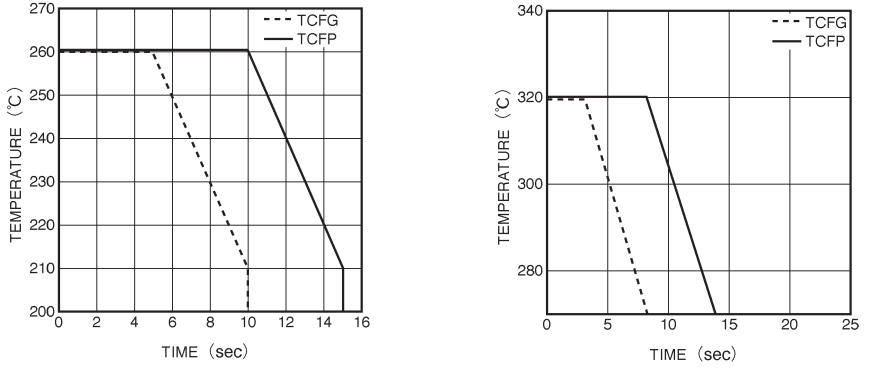



Fig.2 Flow
(Dipping wave soldering)

Fig.3 Hand soldering
(soldering gun output:
30W or less)

(2) Leakage current–to–voltage ratio

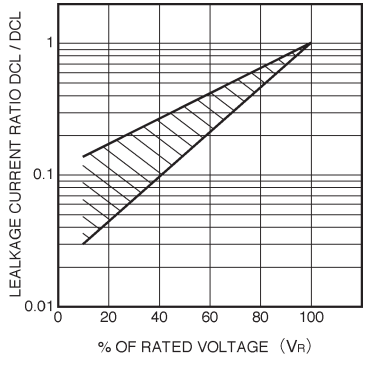
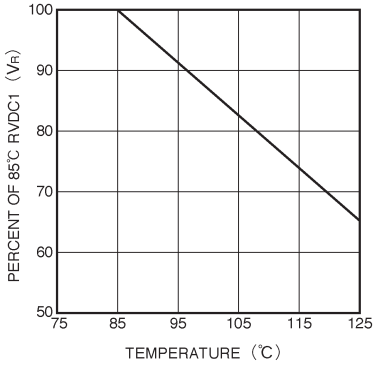



Fig.4

(3) Derating voltage as function of temperature




| 85℃ | | 125℃ | |
|---|---|---|---|
| Rated Voltage (V.DC) | Surge Voltage (V.DC) | Category Voltage (V.DC) | Surge Voltage (V.DC) |
| 4 | 5.2 | 2.5 | 3.4 |
| 6.3 | 8 | 4 | 5 |
| 10 | 13 | 6.3 | 9 |
| 16 | 20 | 10 | 12 |
| 20 | 26 | 13 | 16 |

Fig.5

(4) Reliability

The malfunction rate of tantalum solid state electrolytic capacitors varies considerably depending on the conditions of usage (ambient temperature, applied voltage, circuit resistance).

Formula for calculating malfunction rate

$\lambda p = \lambda b \times (\pi_E \times \pi_{SR} \times \pi_Q \times \pi_{CV})$

- $\lambda p$ : Malfunction rate stemming from operation
- $\lambda b$ : Basic malfunction rate
- $\pi_E$ : Environmental factors
- $\pi_{SR}$ : Series resistance
- $\pi_Q$ : Level of malfunction rate
- $\pi_{CV}$ : Capacitance

For details on how to calculate the malfunction rate stemming from operation, see the tantalum solid state electrolytic capacitors column in MIL–HDBK–217.

Malfunction rate as function of operating temperature and rated voltage

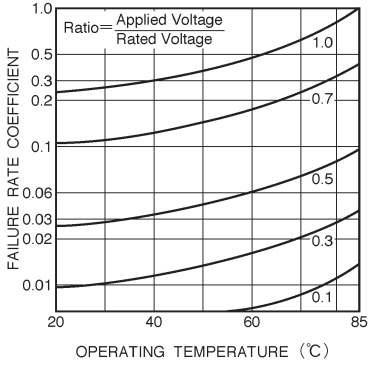



Fig.6

Malfunction rate as function of circuit resistance (Ω/V)

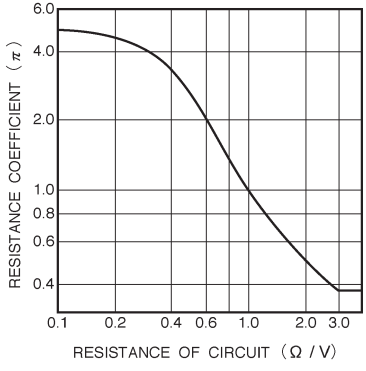



Fig.7

(5) External temperature vs. fuse blowout

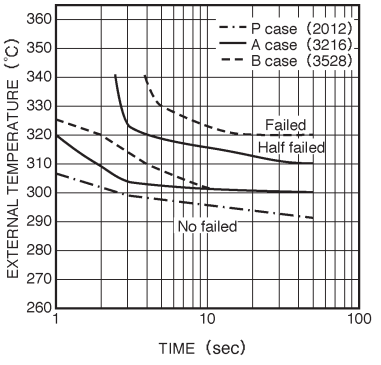



Fig.8

(6) Power vs. fuse blowout characteristics / Product surface temperature

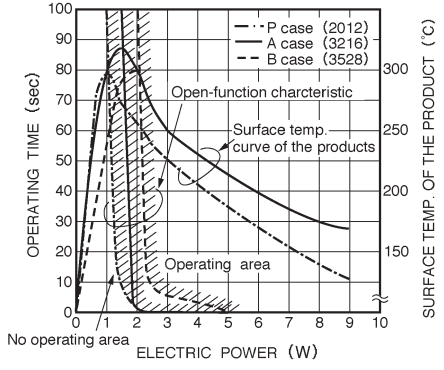



Fig.9

Note: Solder the chip at 300°C or less. If it is soldered using a temperature higher than 300°C, the built–in temperature fuse may blow out.

(7) Maximum power dissipation

Warming of the capacitor due to ripple voltage balances with warming caused by Joule heating and by radiated heat. Maximum allowable warming of the capacitor is to 5°C above ambient temperature. When warming exceeds 5°C, it can damage the dielectric and cause a short circuit.

Power dissipation (P) = $I^2$ ▪ R

Ripple current

P: As shown in table at right

R: Equivalent series resistance

Notes:

1. Please be aware that when case size is changed, maximum allowable power dissipation is reduced.
2. Maximum power dissipation varies depending on the package. Be sure to use a case which will keep warming within the limits shown in the table below.

Allowable power dissipation (W) and maximum temperature rising

| Case \ Ambient temp. | +25℃ | +55℃ | +85℃ | +125℃ |
|---|---|---|---|---|
| P case (2012) | 0.025 | 0.022 | 0.020 | 0.010 |
| A case (3216) | 0.070 | 0.063 | 0.056 | 0.028 |
| B case (3528) | 0.080 | 0.072 | 0.064 | 0.032 |
| Max. temp rise | 5 | 5 | 5 | 2 |

(8) Impedance frequency characteristics

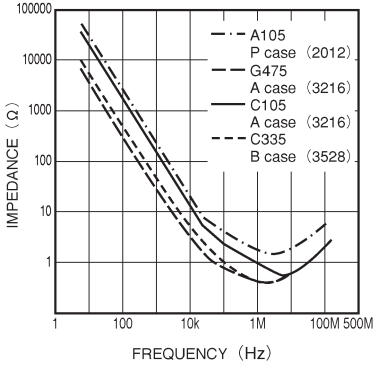



Fig.10

(9) ESR frequency characteristics

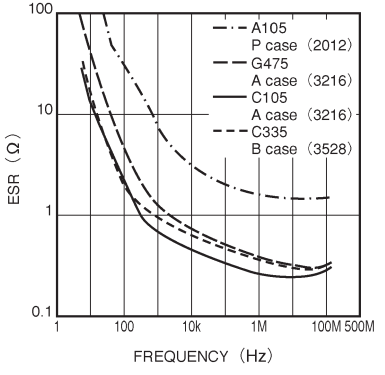



Fig.11

(10) Temperature characteristics

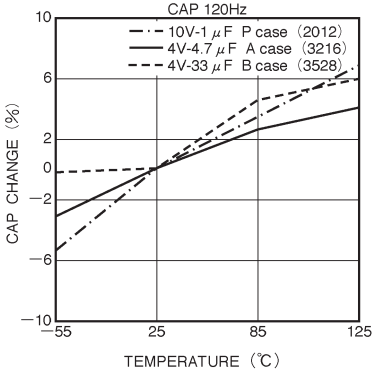



Fig.12

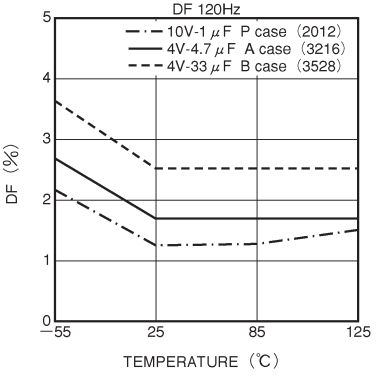



Fig.13

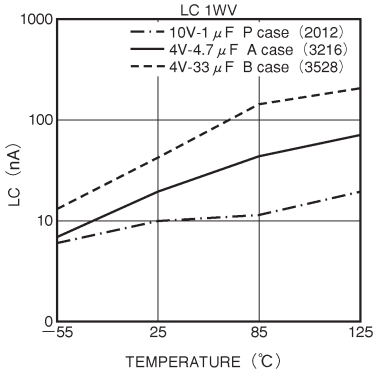



Fig.14 Inrush current

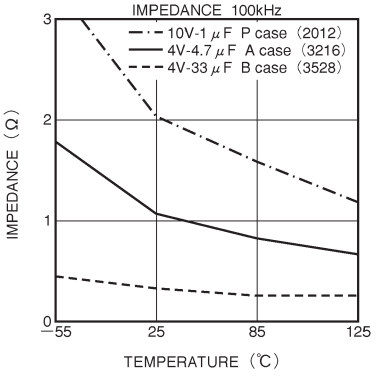



Fig.15

Beware of inrush current.
Inrush currents are inversely proportional to ESR. Large inrush currents can cause component failure.

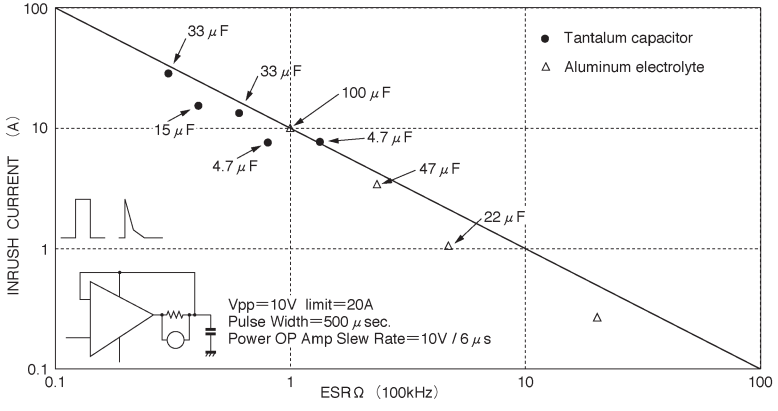



Fig.16 Maximum inrush current and ESR

Inrush current can be limited by means of a protective resistor.

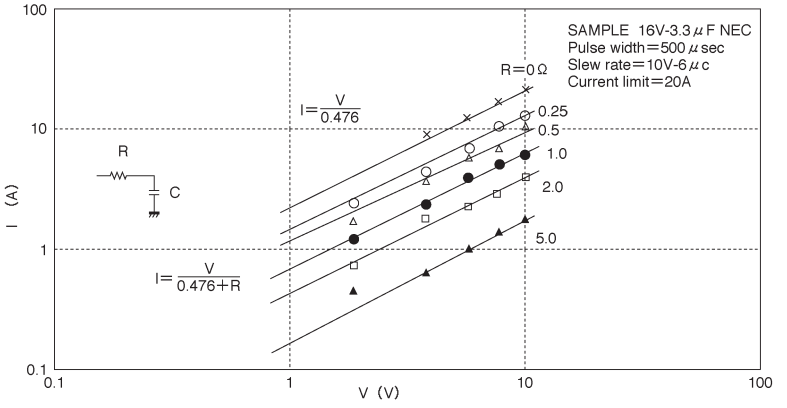



Fig.17 Imax change due to protective resistor R

(11) Ultrasonic cleaning

Carry out cleaning under the mildest conditions possible. The internal element of a tantalum capacitor are larger than those of a transistor or diode, so it is not as resistant to ultrasonic waves.

Example: water

Propagation speed 1500 m/s

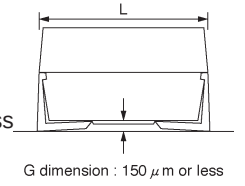
Solvent density 1g/cm$^3$

Frequency and wavelength

| Frequency | Wavelength |
|---|---|
| 20kHz | 7.5cm |
| 28kHz | 5.3cm |
| 50kHz | 3.0cm |

Design

G dimension : 150μm or less




Precautions

1) Do not allow solvent to come to a boil (kinetic energy increases).
   - Ultrasonic output 0.5W/cm$^2$ or less
   - Use a solvent with a high boiling point.
   - Lower solvent temperature.
2) Ultrasonic cleaning frequency
   28 kHz or less
3) Keep cleaning time as short as possible.
4) Move item being cleaned.
   Standing waves caused by the ultrasonic waves can cause stress to build up in part of the item being cleaned.

Reference

$$\text{Kinetic energy} = 2 \times \pi \times \text{frequency} \times \sqrt{\frac{2 \times \text{ultrasonic output}}{\text{propagation speed} \times \text{solvent density}}}$$