

Chip tantalum capacitors with built-in open-function

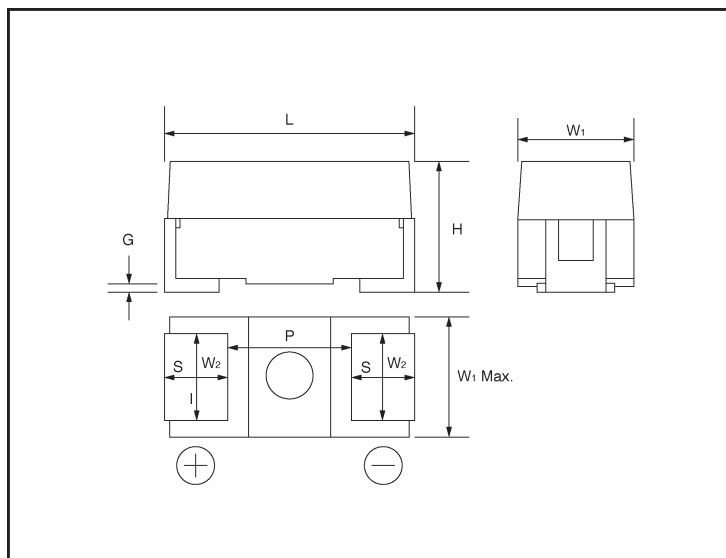
TCFG series

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.

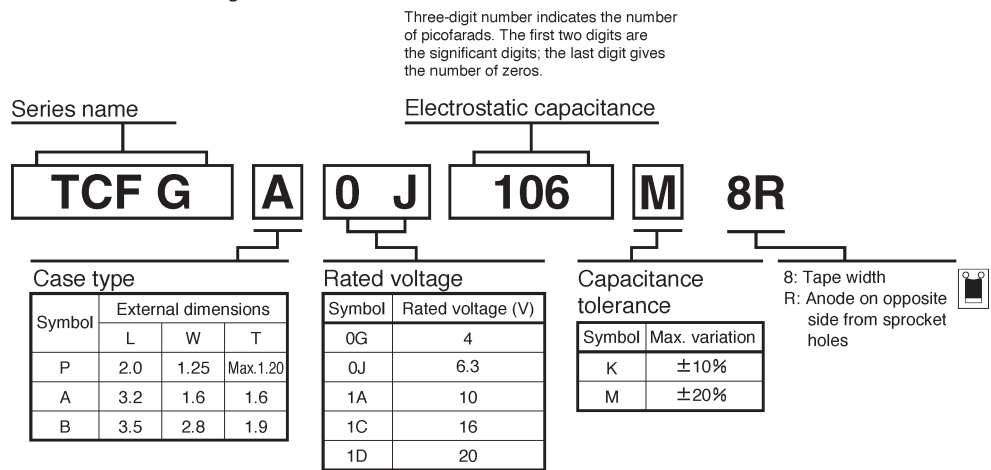
●External dimensions (mm)



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.



●Capacitance range

TCFG series

μF	Rated voltage (V. DC)				
	4 0G	6.3 0J	10 1A	16 1C	20 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					

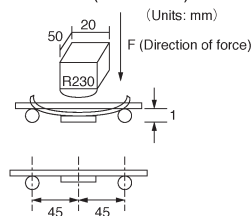
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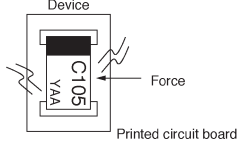
●Characteristics

Item		Performance	Test methods / conditions (based on JIS C 5102, 5143)
Operating temperature		−55°C ~ +125°C	
Max. operating temperature at rated voltage		+85°C	
Rated voltage (V. DC)		4 6.3 10 16 20	
Derated voltage (V. DC)		2.5 4 6.3 10 13	at 125°C
Surge voltage (V. DC)		5.2 8 13 20 26	
Leakage current		Less than or equal to the larger of 0.5 μ A 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 μ F	Measured frequency: 120 $\pm$ 12Hz Measured voltage: 0.5Vrms+1.5V. DC Measured circuit: equivalent series circuit
tan δ	P case	0.08 max.	Measured frequency: 120 $\pm$ 12Hz Measured voltage: 0.5Vrms+1.5V. DC Measured circuit: equivalent series circuit
	A case	1 μ F max.: 0.04 max.	
	B case	1.5 μ F to 22 μ F max.: 0.06 max. 3.3 μ F to 47 μ F max.: 0.06 max.	
Impedance	P case	27.5 Ω max.	Measured frequency: 100 $\pm$ 10Hz Measured voltage: 0.5Vrms max. Measured circuit: equivalent series circuit
	A case	20.0 Ω max.	
	B case	15.0 Ω max.	
Resistance to solder heat	Appearance	No noticeable irregularities, and the markings must be easy to read.	Direct immersion into solder bath Solder bath temperature: 260 $\pm$ 5°C Immersion time: 5s Immersion cycles: 1 time
	L.C	Must satisfy the initial specified value.	
	$\Delta C / C$	Within $\pm 5\%$ P case= $\pm 10\%$	
	tan δ	P case 1.5 times or less or initial specified tolerance. A·B case must satisfy the initial specified value.	
Fuse operation		320°C for 20s or less	Direct immersion into solder bath (320 $\pm$ 5°C)
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. P case=Within 150% of initial limit.	
	$\Delta C / C$	P case within $\pm 10\%$ A·B case within $\pm 5\%$	
	tan δ	P case 1.5 times or less or initial specified tolerance. 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 $\pm$ 12hrs. at 60 $\pm$ 2°C and 90 to 95% RH, then 1 to 2 hrs. at normal room temperature and humidity.
	L.C	Must satisfy the initial specified value.	
	$\Delta C / C$	P case within $\pm 20\%$ A·B case within $\pm 10\%$	
	tan δ	P case 1.5 times or less or initial specified tolerance. A·B case must satisfy the initial specified value.	

	Temperature	Time
1	−55 $\pm$ 3°C	30 $\pm$ 3mins.
2	Room temperature	3mins. max.
3	125 $\pm$ 2°C	30 $\pm$ 3mins.
4	Room temperature	3mins. max.

Item		Performance	Test methods / conditions (based on JIS C 5102,5143)
Temperature characteristics	Temperature	-55°C	
	$\Delta C / C$	P case within +0% and -15% of the value before testing. A·B case within +10% and -0% of the value before testing.	
	$\tan \delta$	P case within 1.5 times of the value before testing. A·B case must satisfy the initial specified value.	
	L.C	—	
	Temperature	+85°C	
	$\Delta C / C$	P case within +0% and -15% of the value before testing. A·B case within +10% and -0% of the value before testing.	
	$\tan \delta$	Must satisfy the initial specified value.	
	L.C	Less than or equal to the larger of $5 \mu A$ or 0.1CV.	
	Temperature	+125°C	
	$\Delta C / C$	P case within +20% and -0% of the value before testing. A·B case within +15% and -0% of the value before testing.	
	$\tan \delta$	P case within 1.5 times of the value before testing. A·B case must satisfy the initial specified value.	
	L.C	Less than or equal to the larger of $6.3 \mu A$ 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 $30 \pm 5s$ at intervals of $5 \pm 0.5mins$. 1000 times, with the temperature at $85 \pm 2^\circ C$.
	L.C	Must satisfy the initial specified value.	
	$\Delta C / C$	P case within $\pm 10\%$ A·B case within $\pm 5\%$	
	$\tan \delta$	P case within 1.5 times of the value before testing. 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 resistor 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.	
	$\Delta C / C$	Within $\pm 10\%$	
	$\tan \delta$	P case within 1.5 times of the value before testing. 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).
	Appearance	No noticeable irregularities.	



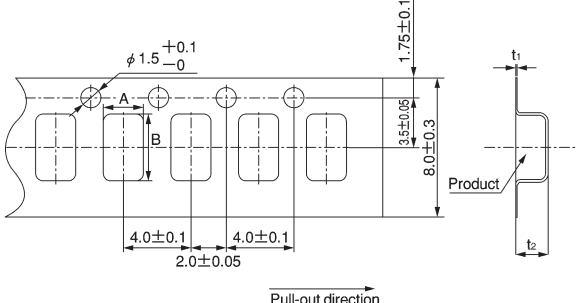
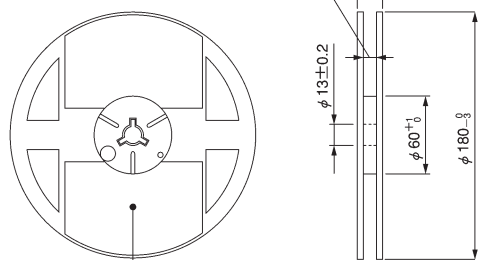
Item		Performance	Test conditions
Adhesion		Terminals must not detach.	With the device mounted on the printed circuit board, apply a force of $0.5\text{kg} \cdot f$ from each side for a period of $10 \pm 1\text{s}$. 
External dimensions		Refer to Fig. 1, "External dimensions"	Measure using slide calipers that meet the requirements of JIS B7507 Class 2.
Markings	Resistance to solvents	Marking must be easy to read.	Immerse in isopropyl alcohol for $30 \pm 5\text{s}$.
Solderability 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: $25 \pm 2.5\text{mm} / \text{s}$ Pre-processing (accelerated aging): leave for 1hr over boiling distilled water Solder temperature: $235 \pm 5^\circ\text{C}$ Immersion time: $2 \pm 0.5\text{s}$ Solder type: H63A 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 resistor of 3Ω max. and 0.1Ω min. at a temperature of $85 \pm 2^\circ\text{C}$.
	L.C	Must be less than or equal to twice the initial specified value.	
	$\Delta C / C$	Within $\pm 10\%$ 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°C	Derated voltage at 125°C	Surge voltage at 85°C	Capacitance	Tolerance	Leakage current at 25°C 1WV.60s	DF 120Hz 25°C
	(V)	(V)	(V)	(μ F)	(%)	(μ A)	(%)
TCF GP 0G 225_	4	2.5	5.2	2.2	$\pm 20,10$	0.5	8
TCF GP 0G 335_	4	2.5	5.2	3.3	$\pm 20,10$	0.5	8
TCF GP 0G 475_	4	2.5	5.2	4.7	$\pm 20,10$	0.5	6
TCF GA 0G 685_	4	2.5	5.2	6.8	$\pm 20,10$	0.5	6
TCF GA 0G 106_	4	2.5	5.2	10	$\pm 20,10$	0.5	6
TCF GA 0G 156_	4	2.5	5.2	15	$\pm 20,10$	0.6	6
TCF GB 0G 156_	4	2.5	5.2	15	$\pm 20,10$	0.6	6
TCF GA 0G 226_	4	2.5	5.2	22	$\pm 20,10$	0.9	6
TCF GB 0G 226_	4	2.5	5.2	22	$\pm 20,10$	0.9	6
TCF GB 0G 336_	4	2.5	5.2	33	$\pm 20,10$	1.3	6
TCF GB 0G 476_	4	2.5	5.2	47	$\pm 20,10$	1.9	6
TCF GP 0J 155_	6.3	4	8	1.5	$\pm 20,10$	0.5	6
TCF GP 0J 225_	6.3	4	8	2.2	$\pm 20,10$	0.5	6
TCF GA 0J 335_	6.3	4	8	3.3	$\pm 20,10$	0.5	6
TCF GA 0J 475_	6.3	4	8	4.7	$\pm 20,10$	0.5	6
TCF GA 0J 685_	6.3	4	8	6.8	$\pm 20,10$	0.5	6
TCF GA 0J 106_	6.3	4	8	10	$\pm 20,10$	0.6	6
TCF GA 0J 156_	6.3	4	8	15	$\pm 20,10$	0.9	6
TCF GB 0J 106_	6.3	4	8	10	$\pm 20,10$	0.6	6
TCF GB 0J 156_	6.3	4	8	15	$\pm 20,10$	0.8	6
TCF GB 0J 226_	6.3	4	8	22	$\pm 20,10$	1.4	6
TCF GB 0J 336_	6.3	4	8	33	$\pm 20,10$	2.1	6
TCF GP 1A 105_	10	6.3	13	1.0	$\pm 20,10$	0.5	8
TCF GA 1A 225_	10	6.3	13	2.2	$\pm 20,10$	0.5	6
TCF GA 1A 335_	10	6.3	13	3.3	$\pm 20,10$	0.5	6
TCF GA 1A 475_	10	6.3	13	4.7	$\pm 20,10$	0.5	6
TCF GB 1A 475_	10	6.3	13	4.7	$\pm 20,10$	0.5	6
TCF GA 1A 685_	10	6.3	13	6.8	$\pm 20,10$	0.7	6
TCF GB 1A 685_	10	6.3	13	6.8	$\pm 20,10$	0.7	6
TCF GA 1A 106_	10	6.3	13	10	$\pm 20,10$	1.0	6
TCF GB 1A 106_	10	6.3	13	10	$\pm 20,10$	1.0	6
TCF GB 1A 156_	10	6.3	13	15	$\pm 20,10$	1.5	6
TCF GA 1C 105_	16	10	20	1.0	$\pm 20,10$	0.5	4
TCF GA 1C 155_	16	10	20	1.5	$\pm 20,10$	0.5	6
TCF GA 1C 225_	16	10	20	2.2	$\pm 20,10$	0.5	6

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

●Packaging specifications

Taping	Reel																				
TCFG / TCFP	Plastic reel																				
 <table><tr><th>Case code</th><th>A±0.1</th><th>B±0.1</th><th>t₁±0.05</th><th>t₂±0.2</th></tr><tr><td>P (2012)</td><td>1.55</td><td>2.3</td><td>0.25</td><td>1.5</td></tr><tr><td>A (3216)</td><td>1.9</td><td>3.5</td><td>0.25</td><td>1.9</td></tr><tr><td>B (3528)</td><td>3.3</td><td>3.8</td><td>0.25</td><td>2.2</td></tr></table> Some emboss tapes have the center hole on its bottom.	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	 Label position EIAJ ETX - 7001compliant
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																	

●Packaging style

Part no.	Package type	Packaging style		Symbol	Basic ordering unit (pcs)
TCFG	Taping	Plastic taping	ϕ 180 mm reel	R	2,000
TCFP	Taping	Plastic taping	ϕ 180 mm reel	R	2,000

●Electrical characteristics and operation notes

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

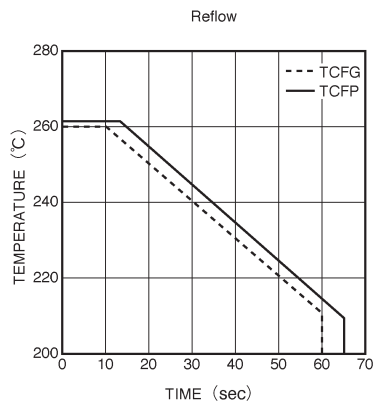
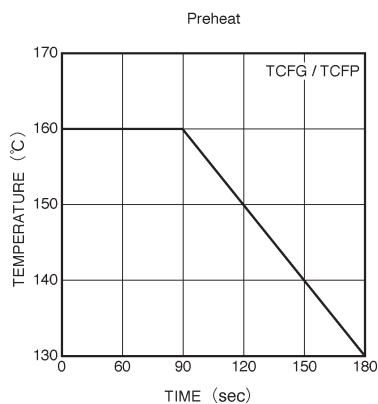


Fig.1 Reflow (Infrared Ray, Hot Plate, Hot Air)

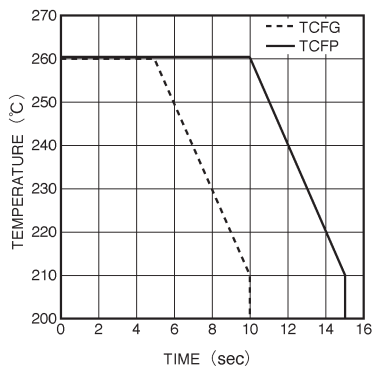


Fig.2 Flow
(Dipping wave soldering)

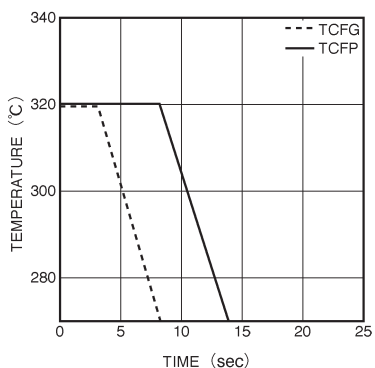


Fig.3 Hand soldering
(soldering gun output:
30W or less)

(2) Leakage current-to-voltage ratio

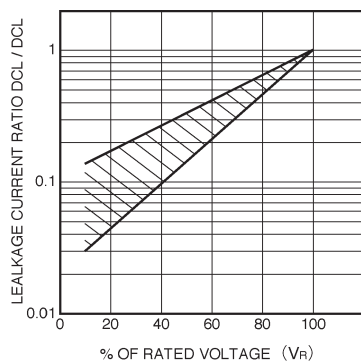


Fig.4

(3) Derating voltage as function of temperature

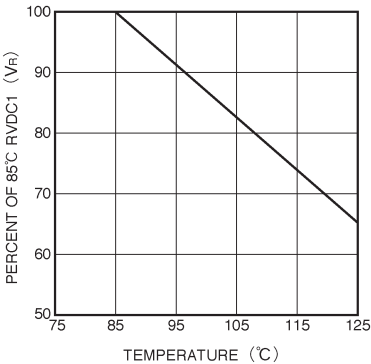


Fig.5

85°C		125°C	
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

(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

$\lambda_p = \lambda_b \times (\pi_E \times \pi_{SR} \times \pi_Q \times \pi_{CV})$

- λ_p : Malfunction rate stemming from operation
- λ_b : Basic malfunction rate
- π_E : Environmental factors
- π_{SR} : Series resistance
- π_Q : Level of malfunction rate
- π_{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

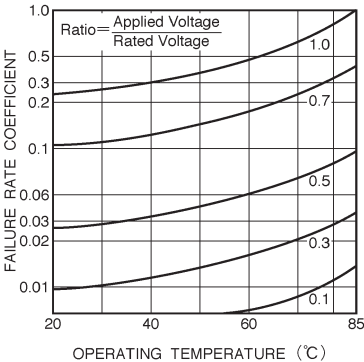


Fig.6

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

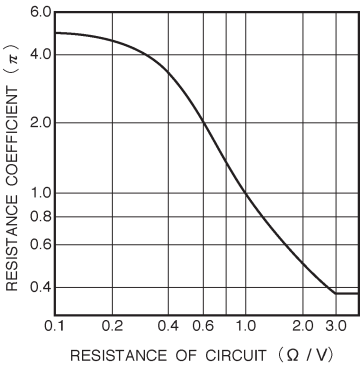


Fig.7

(5) External temperature vs. fuse blowout

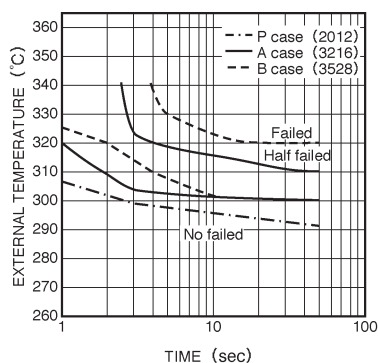


Fig.8

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.

$$\text{Power dissipation (P)} = I^2 \cdot R$$

Ripple current

P: As shown in table at right

R: Equivalent series resistance

(8) Impedance frequency characteristics

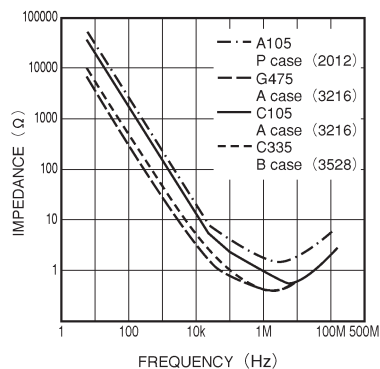


Fig.10

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

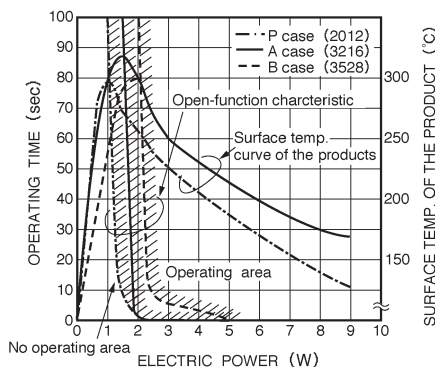


Fig.9

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

Ambient temp.	+25°C	+55°C	+85°C	+125°C
Case				
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

(9) ESR frequency characteristics

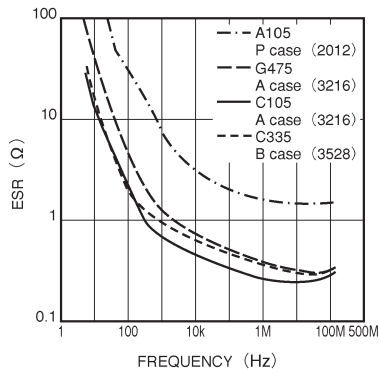


Fig.11

(10) Temperature characteristics

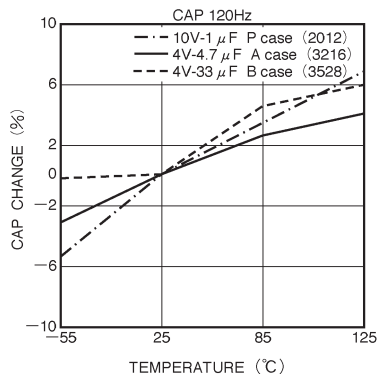


Fig.12

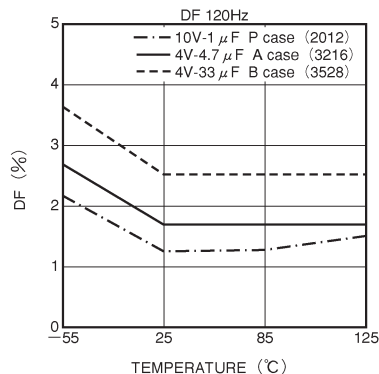


Fig.13

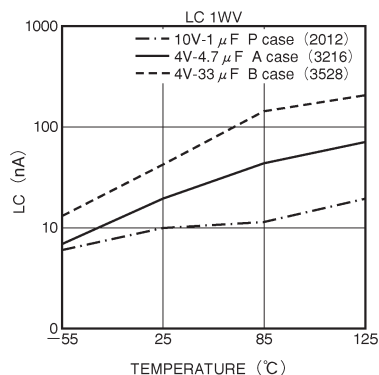


Fig.14 Inrush current

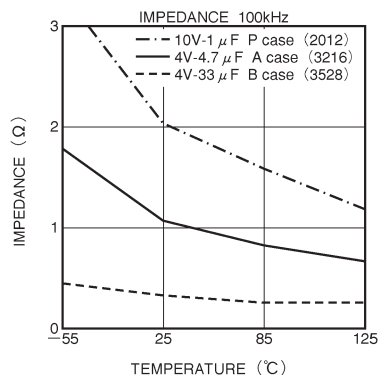


Fig.15

Beware of inrush current.

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

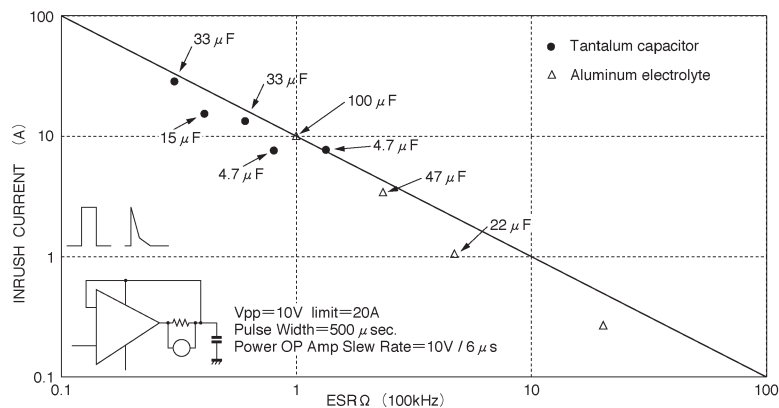


Fig.16 Maximum inrush current and ESR

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

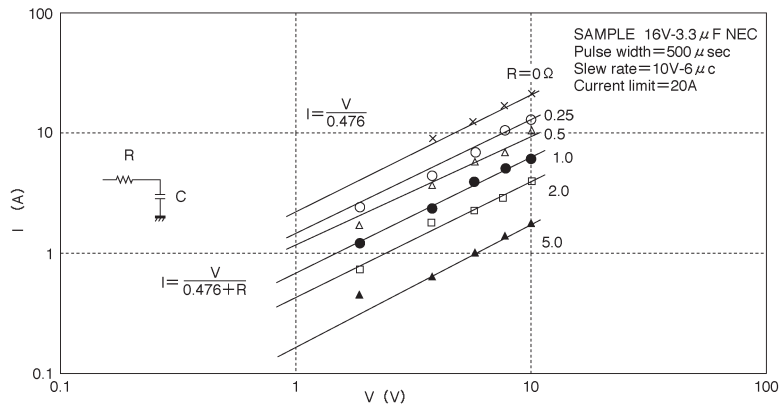


Fig.17 I_{max} change due to protective resistor R

(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.

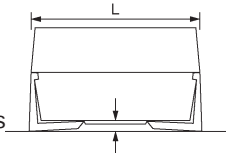
Example: water
Propagation speed 1500 m/s
Solvent density 1g/cm³

Frequency and wavelength

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

Design

G dimension : 150μm or less



G dimension : 150 μm or less

Precautions

- 1) Do not allow solvent to come to a boil (kinetic energy increases).
 - Ultrasonic output 0.5W/cm² 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

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