

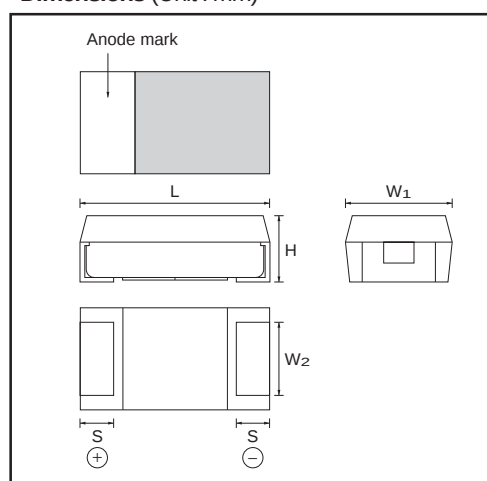
Chip tantalum capacitors (Fail-safe open structure type)

TCFG Series B Case

●Features

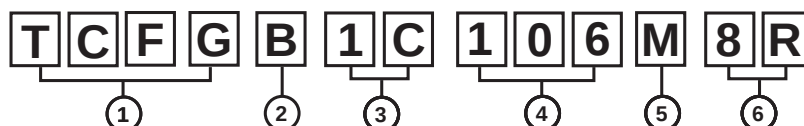
- 1) Safety design by open function built - in.
- 2) Wide capacitance range
- 3) Screening by thermal shock.

●Dimensions (Unit : mm)



Case code	L	W ₁	W ₂	H	S
B 3528-21(1411)	3.5±0.2	2.8±0.2	1.9±0.2	1.9±0.2	0.8±0.3

●Product No. Explanation



① Series name

TCFG

② Case code

TCFG B

③ Rated voltage

Rated voltage (V)	2.5	4	6.3	10	16	20	25
CODE	0E	0G	0J	1A	1C	1D	1E

④ Capacitance

Nominal capacitance in pF in 3 digits : 2significant figure representing the number of 0's.

⑤ Capacitance tolerance

M : ±20% K : ±10%

⑥ Taping

8 : Tape width (8mm)

R : Positive electrode on the side opposite to sprocket hole

Tantalum capacitors

●Capacitance range

TCFG series B Case

(μF)	Rated voltage (V)						
	2.5 0E	4 0G	6.3 0J	10 1A	16 1C	20 1D	25 1E
3.3 (335)					B	B	B
4.7 (475)				B	B	B *	New B
6.8 (685)				B	B	B *	
10 (106)			B	B	B	B *	
15 (156)		B	B	B	B		
22 (226)		B	B	B	B		
33 (336)		B	B	B			
47 (476)		B	B	B			
68 (686)		B	B	New B			
100 (107)		B	B	New B			
150 (157)		B	New B	B *			
220 (227)	B	B	New B				

Remark) Case size codes (B) in the above show each size products line-up.

* : Under development

New : New product

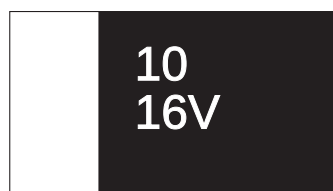
●Marking

The indications listed below should be given on the surface of a capacitor.

- ① Polarity : The polarity should be shown by □ bar. (on the anode side)
- ② Rated DC voltage : Due to the small size of A case, a voltage code is used as shown below.
- ③ Nominal capacitance

[B Case] note 1) Visual typical example (1) voltage code (2) capacitance code

10	16V
(1)	(2)



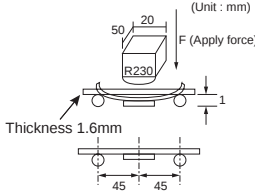
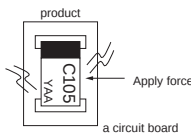
note 2) voltage code and capacitance code are variable with parts number

Tantalum capacitors

●Characteristics

Item		Performance							Test conditions (based on JIS C5101-1 and JIS C5101-3)															
Operating Temperature		-55 °C to +125 °C							Voltage reduction when temperature exceeds +85°C															
Maximum operating temperature with no voltage derating		+85 °C																						
Rated Voltage (V.DC)		2.5	4	6.3	10	16	20	25	at 85°C															
Category Voltage (V.DC)		1.6	2.5	4	6.3	10	13	16	at 125°C															
Surge Voltage		3.2	5.0	8	13	20	26	32	at 85°C															
DC leakage current		0.5μA or 0.01CV whichever is greater (Shown in "Standard list")							As per 4.9 JIS C 5101-1 As per 4.5.1 JIS C 5101-3 Voltage : Rated voltage for 1 min															
Capacitance tolerance		Shall be satisfied allowance range. ±10%, ±20%							As per 4.7 JIS C 5101-1 As per 4.5.2 JIS C 5101-3 Measuring frequency : 120±12Hz Measuring voltage : 0.5Vrms, +1.5V.DC Measuring circuit : DC Equivalent series circuit															
Tangent of loss angle (Df, tanδ)		Shall be satisfied the voltage on "Standard list"							As per 4.8 JIS C 5101-1 As per 4.5.3 JIS C 5101-3 Measuring frequency : 120±12Hz Measuring voltage : 0.5Vrms, +1.5V.DC Measuring circuit : DC Equivalent series circuit															
Impedance		Shall be satisfied the voltage on "Standard list"							As per 4.10 JIS C 5101-1 As per 4.5.4 JIS C 5101-3 Measuring frequency : 100±10kHz Measuring voltage : 0.5Vrms or less Measuring circuit : DC Equivalent series circuit															
Resistance to soldering heat	Appearance	There should be no significant abnormality. The indications should be clear.							As per 4.14 JIS C 5101-1 As per 4.6 JIS C 5101-3															
	L.C	TCFGB1E475 : Less than 150% of initial limit TCFGB0G227 : Less than 150% of initial limit Others : Less than initial limit							Dip in the solder bath Solder temp : 260±5°C Duration : 5±0.5s Repetition : 1															
	ΔC / C	TCFGB1E475 : ±10% TCFGB0G227 : ±15% Others : ±5%							After the specimens, leave it at room temperature for over 24h and then measure the sample.															
	tanδ	3.3 to 33μF : Less than initial limit 47 to 220μF : Less than 150% of initial limit TCFGB0E227 : Less than 200% of initial limit																						
Fail-Safe open unit actuation		Within 320°C – 20s							Dip in the solder bath Solder temp : 320±5°C															
Temperature cycle	Appearance	There should be no significant abnormality.							As per 4.16 JIS C 5101-1 As per 4.10 JIS C 5101-3															
	L.C	TCFGB1E475 : Less than 150% of initial limit TCFGB0G227 : Less than 150% of initial limit Others : Less than initial limit							Repetition : 5 cycles (1 cycle : steps 1 to 4) without discontinuation.															
	ΔC / C	TCFGB0G227 : Within ±15% TCFGB0E227 : Within ±15% Others : Within ±10%							<table><tr><th>Step</th><th>Temp.</th><th>Time</th></tr><tr><td>1</td><td>-55±3°C</td><td>30±3min</td></tr><tr><td>2</td><td>Room temp.</td><td>3min. or less</td></tr><tr><td>3</td><td>125±2°C</td><td>30±3min</td></tr><tr><td>4</td><td>Room temp.</td><td>3min. or less</td></tr></table>	Step	Temp.	Time	1	-55±3°C	30±3min	2	Room temp.	3min. or less	3	125±2°C	30±3min	4	Room temp.	3min. or less
	Step	Temp.	Time																					
1	-55±3°C	30±3min																						
2	Room temp.	3min. or less																						
3	125±2°C	30±3min																						
4	Room temp.	3min. or less																						
tanδ	3.3 to 33μF : Less than initial limit 47 to 220μF : Less than 150% of initial limit TCFGB1C336 : Less than 150% of initial limit							After the specimens, leave it at room temperature for over 24h and then measure the sample.																
Moisture resistance	Appearance	There should be no significant abnormality. The indications should be clear.							As per 4.22 JIS C 5101-1 As per 4.12 JIS C 5101-3															
	L.C	TCFGB1E475 : Less than 150% of initial limit TCFGB0G227 : Less than 150% of initial limit Others : Less than initial limit							After leaving the sample under such atmospheric condition that the temperature and humidity are 60±2°C and 90 to 95%RH, respectively, for 500±12h level it at room temperature for over 24h and then measure the sample.															
	ΔC / C	TCFGB0G227 : Within ±15% Others : Within ±10%																						
	tanδ	3.3 to 33μF : Less than initial limit 47 to 100μF : Less than 150% of initial limit TCFGB1C336 : Less than 150% of initial limit																						

Tantalum capacitors

Item	Performance	Test conditions (based on JIS C5101-1 and JIS C5101-3)
Temperature Stability	Temp.	-55°C
	$\Delta C / C$	Within 0/-12% of initial value TCFGB0G227 : Within 0/-15% of initial value
	$\tan \delta$	Shall be satisfied the voltage on "Standard list"
	L.C	-
	Temp.	+85°C
	$\Delta C / C$	Within +10/0% of initial value TCFGB0G227 : Within +12/0% of initial value
	$\tan \delta$	Shall be satisfied the voltage on "Standard list"
	L.C	5 μ A or 0.1CV whichever is greater TCFGB0G227 : 5 μ A or 0.2CV whichever is greater
	Temp.	+125°C
	$\Delta C / C$	Within +15/0% of initial value
	$\tan \delta$	Shall be satisfied the voltage on "Standard list"
	L.C	6.3 μ A or 0.125CV whichever is greater TCFGB1E475 : 0.2CV TCFGB0G227 : 0.25CV
Surge Voltage	Appearance	There should be no significant abnormality.
	L.C	TCFGB1E475 : Less than 150% of initial limit TCFGB0G227 : Less than 150% of initial limit Others : Less than initial limit
	$\Delta C / C$	TCFGB0G227 : Less than $\pm 15\%$ TCFGB0E227 : Less than $\pm 12\%$ Others : Less than initial value
	$\tan \delta$	3.3 to 33 μ F : Less than initial limit 47 to 220 μ F : Less than 150% of initial limit TCFGB0G227 : Less than 200% of initial limit
Loading at High temperature	Appearance	There should be no significant abnormality. The indications should be clear.
	L.C	TCFGB0G227 : Less than 150% of initial limit TCFGB1E475 : Less than 150% of initial limit TCFGB0E227 : Less than 125% of initial limit Others : Less than initial limit
	$\Delta C / C$	TCFGB0G227 : Within $\pm 15\%$ Others : Within $\pm 10\%$
	$\tan \delta$	3.3 to 33 μ F : Less than initial limit 47 to 220 μ F : Less than 150% of initial limit TCFGB0G227 : Less than 200% of initial limit TCFGB1C336 : Less than 150% of initial limit
Terminal Strength	Capacitance	The measured value should be stable.
	Appearance	There should be no significant abnormality.
		As per 4.35 JIS C 5101-1 As per 4.9 JIS C 5101-3 A force is applied to the terminal until it bends to 1mm and by a prescribed tool maintain the condition for 5s. (See the figure below.) (Unit : mm)  Thickness 1.6mm
Adhesiveness		As per 4.34 JIS C 5101-1 As per 4.8 JIS C 5101-3 Apply force of 5N in the two directions shown in the figure below for 10$\pm$1s after mounting the terminal on a circuit board. 

TCFG Series B Case

Tantalum capacitors

Item		Performance	Test conditions (based on JIS C5101-1 and JIS C5101-3)
Dimensions		Be based on "External dimensions"	Measure using a caliper of JIS B 7505 Class 2 or higher grade.
Resistance to solvents		The indication should be clear.	As per 4.32 JIS C 5101-1 As per 4.18 JIS C 5101-3 Dip in the isopropyl alcohol for 30±5s, at room temperature.
Solderability		3/4 or more surface area of the solder coated terminal dipped in the soldering bath should be covered with the new solder.	As per 4.15.2 JIS C 5101-1 As per 4.7 JIS C 5101-3 Dip speed = 25±2.5mm/s Pre-treatment (accelerated aging) : Leave the sample on the boiling distilled water for 1h. Solder temp. : 245±5°C Duration : 3±0.5s Solder : M705 Flux : Rosin 25%, IPA 75%
Vibration	Capacitance	Measure value should not fluctuate during the measurement.	As per 4.17 JIS C 5101-1 Frequency : 10 to 55 to 10Hz/min. Amplitude : 1.5mm Time : 2h each in X and Y directions Mounting : The terminal is soldered on a print circuit board.
	Appearance	There should be no significant abnormality.	

TCFG Series B Case

Tantalum capacitors

●Standard list, TCFG series B Cases

(B : 3528)

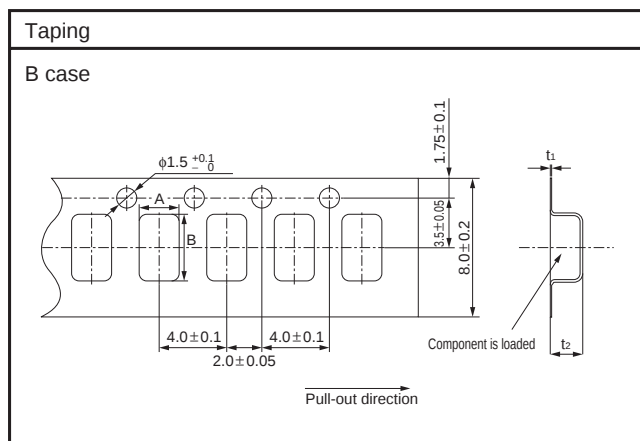
Part No.	Rated Voltage @85°C (V)	Derated Voltage @125°C (V)	Surge Voltage @85°C (V)	Capacitance 120Hz (μF)	Tolerance (%)	Leakage current 25°C 1WV.60s (μA)	DF 120Hz (%)			Impedance 100kHz (Ω)	Case code
							-55°C	25°C 85°C	125°C		
TCFG B 0E 227□	2.5	1.6	3.2	220	±20,10	5.5	34	18	22	1.5	B
TCFG B 0G 156□	4	2.5	5	15	±20,10	0.6	12	8	10	3.0	B
TCFG B 0G 226□	4	2.5	5	22	±20,10	0.9	12	8	10	3.0	B
TCFG B 0G 336□	4	2.5	5	33	±20,10	1.3	12	8	10	2.5	B
TCFG B 0G 476□	4	2.5	5	47	±20,10	1.9	14	10	12	2.0	B
TCFG B 0G 686□	4	2.5	5	68	±20,10	2.7	14	10	12	1.9	B
TCFG B 0G 107□	4	2.5	5	100	±20,10	4.0	30	12	16	1.6	B
TCFG B 0G 157□	4	2.5	5	150	±20,10	6.3	34	18	22	1.3	B
TCFG B 0G 227□	4	2.5	5	220	±20,10	8.8	40	20	30	1.3	B
TCFG B 0J 106 □	6.3	4	8	10	±20,10	0.6	12	8	10	3.0	B
TCFG B 0J 156 □	6.3	4	8	15	±20,10	0.9	12	8	10	3.0	B
TCFG B 0J 226 □	6.3	4	8	22	±20,10	1.4	12	8	10	2.5	B
TCFG B 0J 336 □	6.3	4	8	33	±20,10	2.1	12	8	10	2.0	B
TCFG B 0J 476 □	6.3	4	8	47	±20,10	3.0	14	10	12	1.9	B
TCFG B 0J 686 □	6.3	4	8	68	±20,10	4.3	30	12	16	1.6	B
TCFG B 0J 107 □	6.3	4	8	100	±20,10	6.3	30	12	16	1.5	B
TCFG B 0J 157 □	6.3	4	8	150	±20,10	9.5	34	18	22	1.5	B
TCFG B 0J 227 □	6.3	4	8	220	±20,10	70	60	30	45	1.3	B
TCFG B 1A 475 □	10	6.3	13	4.7	±20,10	0.5	10	6	8	3.0	B
TCFG B 1A 685 □	10	6.3	13	6.8	±20,10	0.7	12	8	10	3.0	B
TCFG B 1A 106 □	10	6.3	13	10	±20,10	1.0	12	8	10	3.0	B
TCFG B 1A 156 □	10	6.3	13	15	±20,10	1.5	12	8	10	2.5	B
TCFG B 1A 226 □	10	6.3	13	22	±20,10	2.2	12	8	10	2.0	B
TCFG B 1A 336 □	10	6.3	13	33	±20,10	3.3	14	10	12	1.9	B
TCFG B 1A 476 □	10	6.3	13	47	±20,10	4.7	14	10	12	1.6	B
TCFG B 1C 335 □	16	10	20	3.3	±20,10	0.5	10	6	8	4.2	B
TCFG B 1C 475 □	16	10	20	4.7	±20,10	0.8	10	6	8	3.0	B
TCFG B 1C 685 □	16	10	20	6.8	±20,10	1.1	10	6	8	3.0	B
TCFG B 1C 106 □	16	10	20	10	±20,10	1.6	10	6	8	2.5	B
TCFG B 1C 156 □	16	10	20	15	±20,10	2.4	10	6	8	2.0	B
TCFG B 1C 226 □	16	10	20	22	±20,10	3.5	10	6	8	1.9	B
TCFG B 1D 335 □	20	13	26	3.3	±20,10	0.66	10	6	8	4.2	B
TCFG B 1E 335 □	25	16	32	3.3	±20,10	0.83	10	6	8	4.2	B
TCFG B 1E 475 □	25	16	32	4.7	±20,10	1.2	10	6	8	3.0	B

□ = Tolerance (M : ±20%, K : ±10%)

Tantalum capacitors

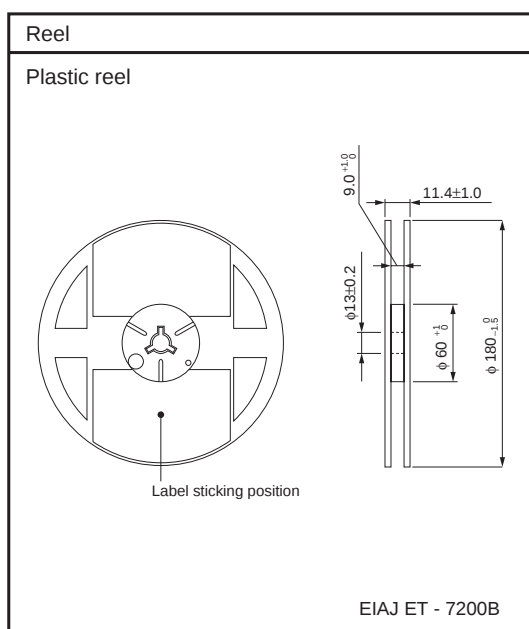
●Packaging specifications

Case code	A $\pm$ 0.1	B $\pm$ 0.1	t ₁ $\pm$ 0.05	t ₂ $\pm$ 0.1
B (3528)	3.3	3.8	0.25	2.2



●Packaging style

Case code	Packaging	Packaging style		Symbol	Basic ordering unit
B Case	Taping	Plastic taping	$\phi 180$ mm reel	R	2,000



Tantalum capacitors

● Recommended condition of reflow soldering

(1) Leakage current-to-voltage ratio

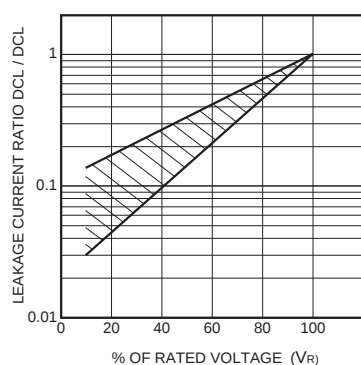


Fig.1

(2) Derating voltage as function of temperature

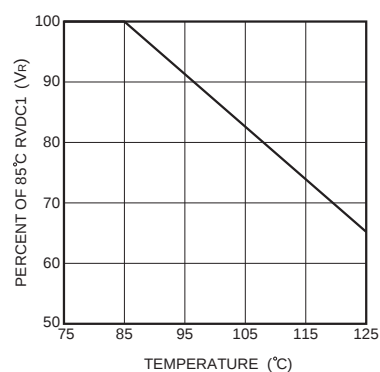


Fig.2

85°C		125°C	
Rated Voltage (V.DC)	Surge Voltage (V.DC)	Category Voltage (V.DC)	Surge Voltage (V.DC)
2.5	3.2	1.6	2.0
4	5.0	2.5	3.2
6.3	8	4	5
10	13	6.3	8
16	20	10	13
20	26	13	16
25	32	16	20

(3) 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.

Tantalum capacitors

Malfunction rate as function of operating temperature and rated voltage

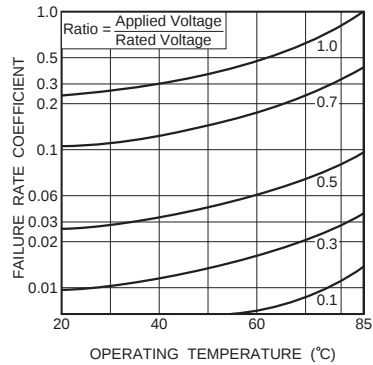


Fig.3

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

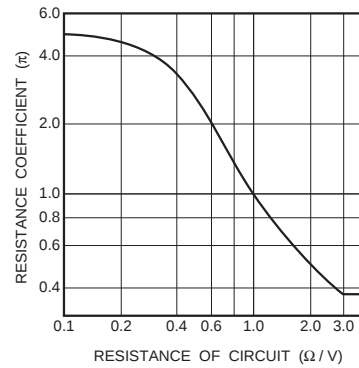


Fig.4

(4) External temperature vs. fuse blowout

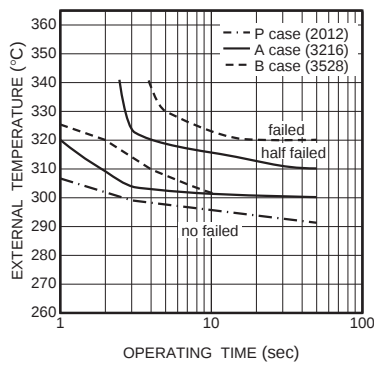


Fig.5

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

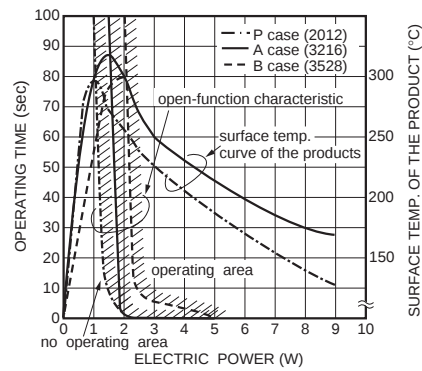


Fig.6

Note: Solder the chip at 300°C or less. If it is soldered using a temperature higher than 300°C, open function built-in may operate.

Tantalum capacitors

(6) 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

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°C	+55°C	+85°C	+125°C
B case (3528)	0.080	0.072	0.064	0.032
Max. Temp Rise[°C]	5	5	5	2

(7) Impedance frequency characteristics

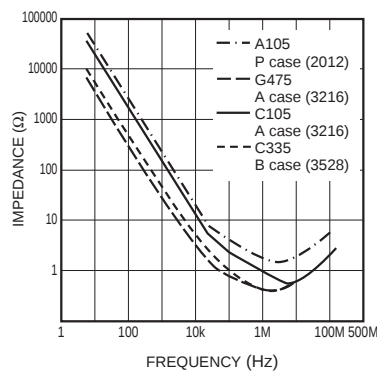


Fig.7

(8) ESR frequency characteristics

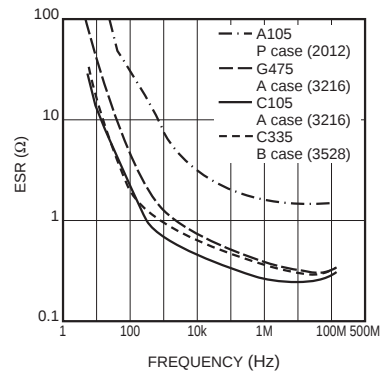


Fig.8

(9) Temperature characteristics

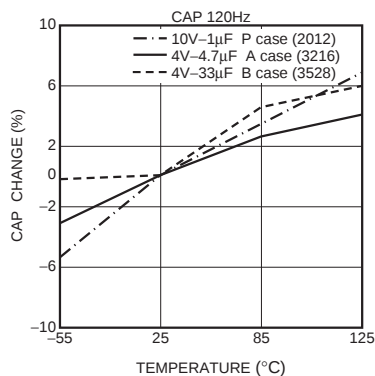


Fig.9

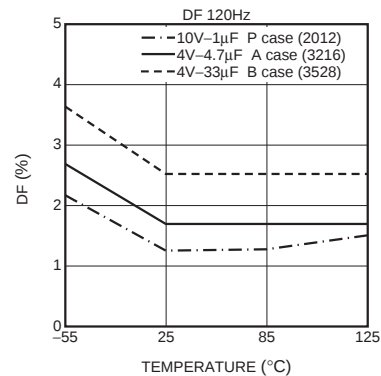


Fig.10

Tantalum capacitors

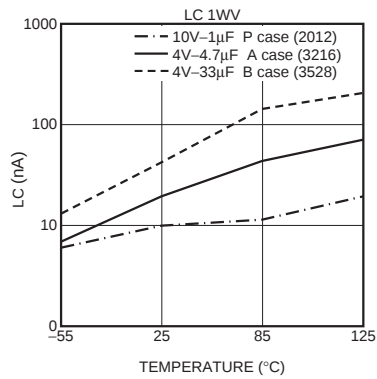


Fig.11

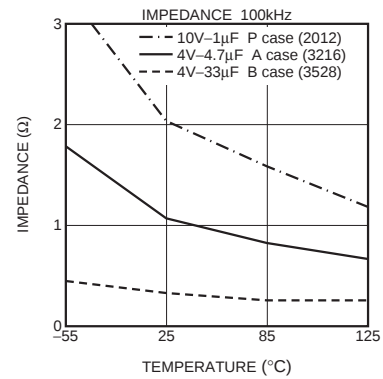


Fig.12

Inrush current

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

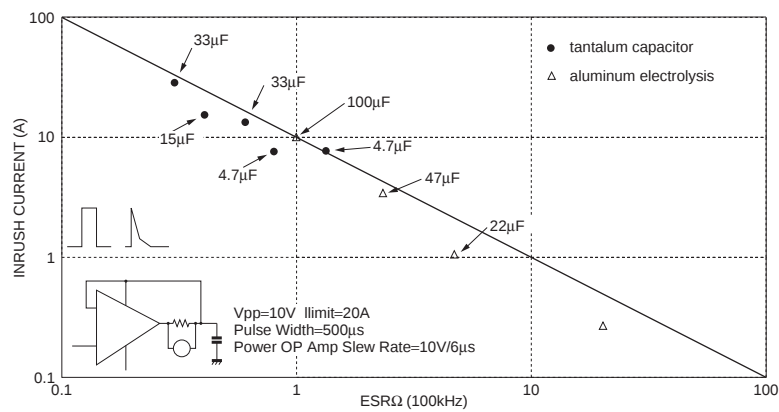


Fig. 13 Maximum inrush current and ESR

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

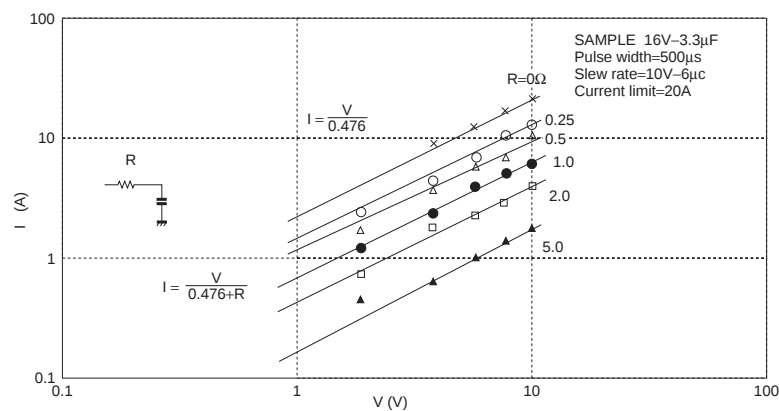


Fig. 14 I_{max} change due to protective resistor R

Tantalum capacitors

(10) Ultrasonic cleaning

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

Example : water

Propagation speed 1500m / s

Solvent density 1g / cm³

Frequency and wavelength

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

● 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

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

Notes

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