

## Application Guide

TANTALUM CHIP/DIP CAPACITOR

### ⚠ CAUTION OF DESIGN

The main failure modes of Tantalum Capacitors are open and short of circuit by leakage current, and these failure modes are over 90% of all of failures at Tantalum Capacitors. As the main parameters that multiply leakage current are voltage and ambient temperature, consider the following recommendations for the safe design of circuit.

### 1. REVERSE VOLTAGE

As Tantalum Capacitors have polarity and have rectifying properties, if reverse voltage is applied, large current is surged at the low voltage and Ta<sub>2</sub>O<sub>5</sub> dielectric layer is broken out and become shorted.

Basically, reverse voltage should not be applied.

But, in the place where reverse voltage is inevitable, design the circuit with recommendation belows

- 1) **Permittable reverse voltage:** lower value whichever 5% of Working Voltage or 1.0V,
- 2) **At the high temperature(125°C):** control the applied voltage to the capacitor under the 1% of the Working Voltage.

### 2. RIPPLE VOLTAGE AND CURRENT

When excessive ripple voltage and current is applied to the Tantalum Capacitor, the reliability and characteristics of that is degraded because temperature of the Tantalum Capacitor increases by Joule's exothermic reaction.

Pls, design the circuit as recommendation belows.

- 1) The peak value of direct voltage and ripple voltage should not exceed the Working Voltage.
- 2) The reverse voltage by voltage fluctuation should not be occurred.
- 3) As permissible ripple voltage and current could be changed by ambient temperature and frequency and capacitor's working voltage, the maximum permissible ripple voltage may be calculated as belows.

$$I_{max} = \sqrt{\frac{P_{max}}{ESR}}$$

$I_{max}$  : Permissible ripple current

$P_{max}$  : Permissible power loss (W)

Variant with temperature and size  
(at 25°C, P,A,B2,C=0.10, D=0.12)  
(at 85°C, P,A,B2,C=0.05, D=0.06)

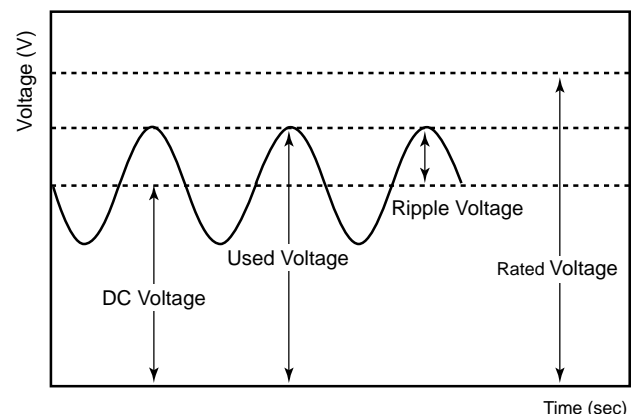
$ESR$  : Equivalent Series Resistance ( $\Omega$ , at 100KHz)

Ripple Voltage with the ambient temperature can be calculated as belows.

$$V_{rms}(at\ 55^{\circ}C) = 0.7 \times V_{rms}(at\ 25^{\circ}C)$$

$$V_{rms}(at\ 85^{\circ}C) = 0.6 \times V_{rms}(at\ 25^{\circ}C)$$

$$V_{rms}(at\ 125^{\circ}C) = 0.4 \times V_{rms}(at\ 25^{\circ}C)$$



[Fig.1] Ripple voltage

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## 3. WORKING VOLTAGE

### 1) Establishment of Working Voltage

When the excessive voltage over the working voltage is applied, leakage current increases rapidly, dielectric layer could be broken down and heat occurs. Because leakage current increases exponentially to the applied voltage.

- To improve the reliability of circuit, please limit the applied voltage under 50% of working voltage
- When used at the power circuit, low impedance circuit, coupling circuit or witching circuit which has leakage current problems, please design the circuit with voltage under 1/3 of the working voltage.
- When used at the circuit which is connected to the power source, because this circuit has low impedance, voltage should be under 1/3 of working voltage to decrease failure rate.

Used voltage (V)	Rated voltage (V)
3~5 V	10 V
5 V	16 V
12~16 V	35 V
24 V	50 V

[Table 1] Example of the used voltage and rated voltage

## 4. PROTECTIVE RESISTANCE

As dielectric breakdown could be occurred when rapid charge/discharge and in-rush current is happen, to protect the circuit, circuit designer should consider the introduction of protective resistance.

- At the rapid charge/discharge circuit, the electrical load charged to the dielectric layer must be reduced by adoption of equivalent series resistance over  $1\Omega$  per voltage.
- At switching circuit and the circuit which has large pulse voltage, designer must fit the sufficient derating voltage(1/3) and adopt equivalent series resistance( $3\Omega/V$ ) to limit the in-rushed current under 300mA.

If capacitor is shorted, the applied voltage to the capacitor could not be controlled and then the heat generation by short circuit could be occurred and a fire also could happen.

In the case that protective resistance could not be introduced inevitably, the used voltage could not be over 1/3 of the working voltage.

## 5. RELIABILITY

The steady state reliability of Ta capacitor is determined by the various factors.

(ex. Operating temperature, Voltage, Series resistance of the external circuit.)

Therefore, if set the additional margins at circuit design, long time steady-state good performance of the capacitor could be derived. The capacitors are designed as to the failure rate per 1000 hrs in applying rated voltage at 85°C.

The failure rate of capacitor can be calculated from the formula below,

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## 5.1 Formula of failure rate

$$\lambda_{use} = \lambda_{85} \times K_V \times K_R$$

$$K = \frac{\text{Operating voltage}}{\text{Rated voltage}}$$

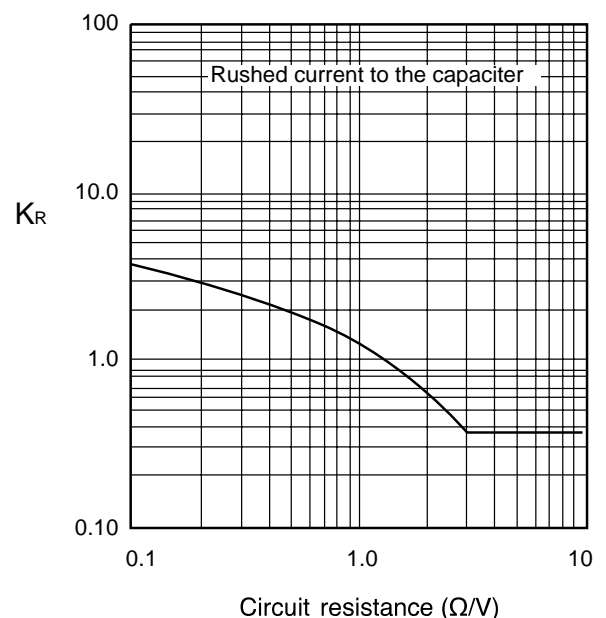
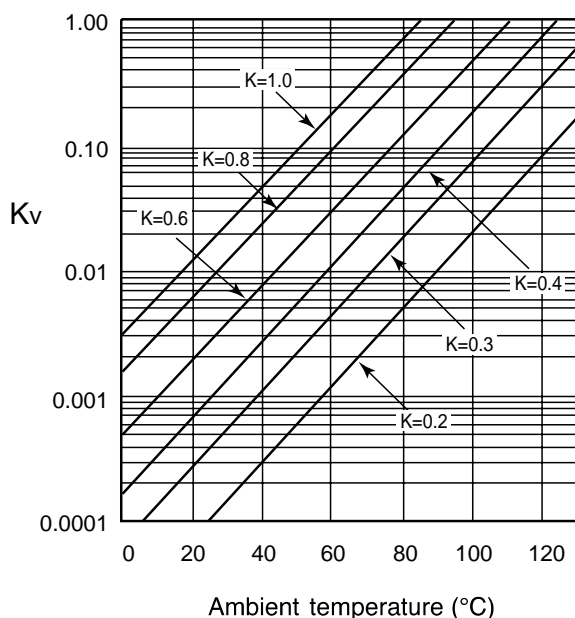
$\lambda_{use}$  : Estimated capacitor's failure rate under operating condition 1%/1,000hrs

$\lambda_{85}$  : Basic failure rate (1%/1,000hrs)

$K_V$  : Failure rate correction coefficient by the ambient temp. and derating factor

$K_R$  : Failure rate correction coefficient by the circuit resistance\*

\* Circuit resistance = Serial resistance / Applied voltage



[Fig.2] Failure rate correction coefficients

## 5.2 Example of capacitor failure rate calculation

### 1) Operating conditions

- ① Item type : 10V/100μF ( TEM )
- ② Operating temp. : 40°C
- ③ Derating factor : 0.3 [  $K = \text{Operating voltage} / \text{Rated voltage} = 3V/10V = 0.3$  ]
- ④ Circuit resistance : 3Ω/V
- ⑤  $\lambda_{85}$  : 1%/1000h
- ⑥  $K_V$  : 0.0012
- ⑦  $K_R$  : 0.38

### 2) Calculating example

$$\begin{aligned} \lambda_{use} &= \lambda_{85} \times K_V \times K_R \\ &= 1\%/1000h \times 0.0012 \times 0.38 \\ &= 4.56 \times 10^{-9} \\ &= 0.000456\% / 1000h \\ &= 4.56 \text{ Fit} \end{aligned}$$

Series	Classification	Basic failure rate
TS	Standard	1%/1000h
TE	Low ESR	
TJ	Ultra miniaturized	
TP	Small size	
TK	Conductive Polymer	
TL	Downsizing	

[Table 2] Basic failure rate

## PRECAUTIONS IN INSTALLATION

### 1. Maximum pressure in capacitor installation with mouter

The pressure must not exceed 500g with a tools whose end diameter is 1.5 mm when applied to the capacitors. An excessive low absorber setting position would result in not only the application of undue force to the capacitors but also other component scattering, circuit board breakage, and / or cracking, particularly when the capacitors are mounted together with other chips having a height of 1mm or less.

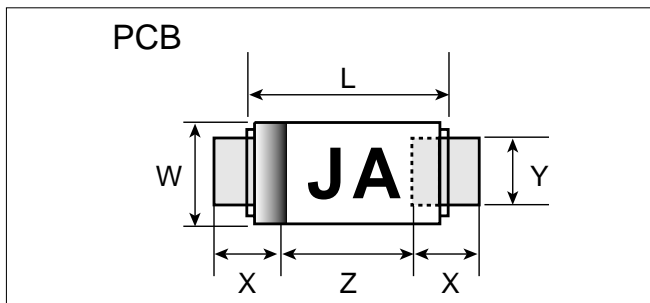
### 2. Flux Selection

- Select the flux with minimum chlorine and amine.
- After using flux with chlorine and amine, remove these compounds clearly.

### 3. Recommendation of Soldering Pattern Dimension

The recommended chip soldering pattern dimensions are shown in Table and Figure belows.

However, note that these are affected by various factors such as reflow conditions, solder type, and PCB type. If the pattern area is significantly larger than the capacitor terminal area, the capacitor in place would be displaced when the solder melts.



Dime. Size	Case Size		Patterm dimension		
	L	W	X	y	z
J	1.6	0.8	0.9	0.8	0.4
P	2.0	1.25	1.2	1.1	0.8
A	3.2	1.6	1.6	1.2	1.2
B2	3.5	2.8	1.6	2.2	1.4
C	6.0	3.2	2.3	2.4	2.4
D	7.3	4.3	2.3	2.6	3.8

[Fig. 3] Recommended soldering pattern dimensions

### 4. Cleaning after Mounting

The following solvents are used as cleaning agents after mounting. Do not use solvents with high reaction energy degree such as cleaning solvents.

- Halogen Organic Solvent (HCFC225, methylene chloride)
- IPA, ethanol
- Petroleum solvent, alkali agent, water etc.

Circuit board cleaning must be conducted at the temperature lower than 50°C, and the immersing time must not be longer than 30 minutes. If a ultrasonic vibrator is used as cleaning instrument, cleaning must be conducted at a frequency of MAX. 48KHz(vibrato power : max 0.02W/cm<sup>3</sup>) and for a time of 5 min or shorter.

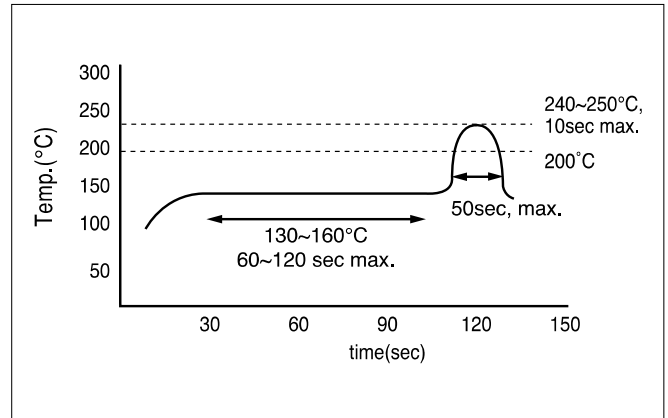
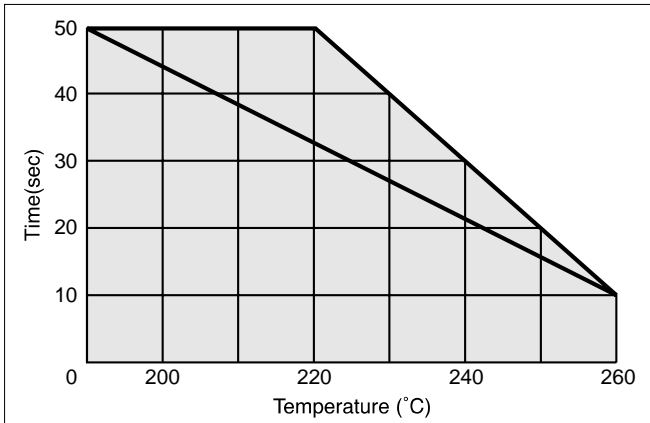
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## 5. Soldering time and temperature

(1) Reflow soldering condition (infrared ray, hot air, hot plate)

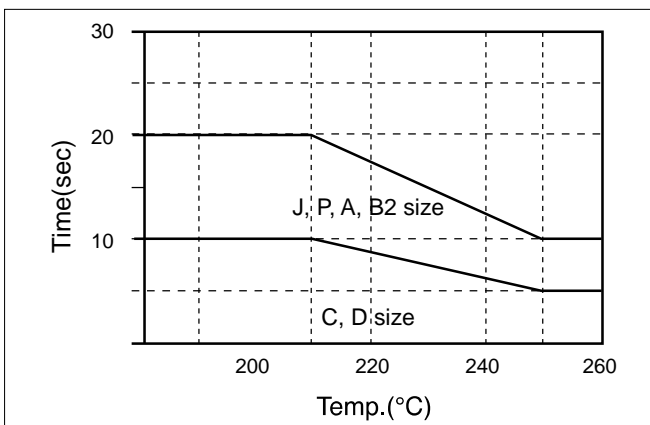
- ① Capacitor body temperature : less than 260°C ( TK Series ; less than 240°C)
- ② Time : Max. 10 sec.
- ③ Permitted temperature / time range : see the Fig. 4 below.



[Fig. 4] Reflow soldering condition

(2) Flow Soldering

- ① Solder bath temperature : less than 260°C  
- As to TK Series capacitor, we recommend not to use flow soldering , but to use reflow soldering.
- ② Time : P, J, A, B2 Size - within the 10 sec. / C, D Size - within the 5 sec.
- ③ Permitted temperature / time range : see the fig. 5 below.



[Fig. 5] Flow soldering condition

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## 6. Others

### (1) Soldering Repetition

The soldering conditions for soldering operations from 5. 1), 5. 2) above are established on the presumption that only one type of soldering.

When the repetition of a reflow soldering and a combined flow-and-reflow soldering operations are conducted, comply with the following conditions.

- ① Once the capacitor is mounted, it must be removed for reuse.
- ② Any type of soldering operation may be performed to the capacitors only twice.
- ③ The second performance of a type of soldering operation must be initiated until a 2-hour or longer heat dissipation period has elapsed after completion of the first performance.
- ④ Cleaning must be conducted on completion of the second performance.

### (2) Soldering with a soldering iron

The use of iron soldering should be avoided if possible, but if it is indispensable follow the instructions below.

<b>Iron Temp.</b>	less than 350°C
<b>Time</b>	within 3 sec.
<b>Wattage</b>	less than 300W

[Table 3] Condition for soldering iron

- (3) If you have more questions about Tantalum capacitors, contact to us.  
(Web site / Telephone / Fax. : see the cover of this book)

## NOTE ON STORAGE AND DISPOSAL

### 1. Storage

- 1) It is desirable to store Tantalum Capacitors under standard state\*.

As the properties and solderability of capacitors could be affected over the standard state\*, keep the temperature and humidity under the above conditions and if stored over the above conditions, it is preferable to store for only 1 year.

- 2) Please keep away from the direct ray of light.
- 3) Please do not apply excessive force to the capacitor's body and especially to the lead terminals.
- 4) Please do not apply shock and vibration by dropping or squeezing the capacitors.

\*Condition of standard state : 5~35°C, 45~85%RH

### 2. Disposal

Tantalum Capacitors include various types of metals and resins. Ask a specialist for the Disposal of industrial wastes.