

## NOTES ON USING THE SOLID TANTALUM CAPACITORS

About 90% of the failure mode of the solid tantalum capacitor is short-circuit. Please take surplus for the operating condition.

### 1. Circuit Design

#### (1) Reliability

The reliability of the solid tantalum capacitor is heavily influenced by environmental conditions such as temperature, humidity, shock, vibration, mechanical stresses, and electric stresses, including applied voltage, current, ripple current, transient current and voltage, and frequency. When using solid tantalum capacitors, therefore, provide enough margin so that the reliability of the capacitors is maintained.

Voltage and temperature are important parameters when estimating the reliability (field failure rate).

The field failure rate of a solid tantalum capacitor can be calculated by the following expression if emphasis is placed only on the voltage and temperature:

$$\lambda = \lambda_0 (V/V_0)^3 \times 2^{(T-T_0)/10}$$

Where

$\lambda$ : estimated failure rate in actual working condition

temperature: T; voltage: V

$\lambda_0$ : failure rate under rated load (See table below.)

temperature: T<sub>0</sub>; voltage: V<sub>0</sub>

#### Failure rate level $\lambda_0$ of each series

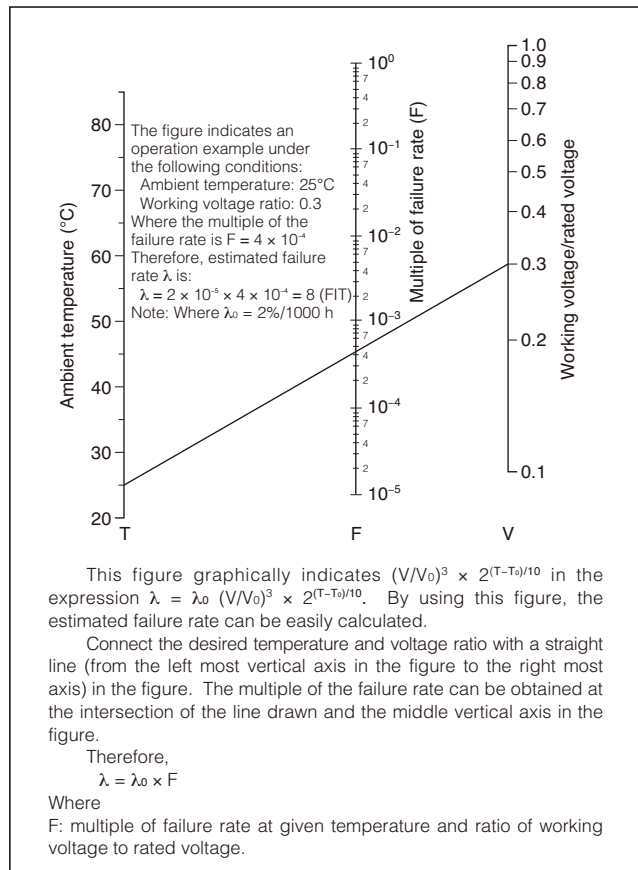
Series	Failure rate level
PS/L	1%/1000 h
E/SV	1%/1000 h
F/SV	1%/1000 h
PS/G	1%/1000 h
SV/Z	1%/1000 h
F/PS	1%/1000 h

#### <Test conditions>

**Temperature: 85°C**

**Voltage: rated voltage**

**R<sub>s</sub>: 3Ω**



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## 2. Ripple Current and Ripple Voltage

If ripple current is applied, heat is generated within capacitor by Joule's heat (power dissipation) and it may affect to the reliability of the capacitor.

- (1) Power Dissipation  
The actual power dissipated in the capacitor is calculated using the formula1.

$$P = I^2 \times ESR \dots \text{Formura1}$$

$$\left( \begin{array}{l} P : \text{Power Dissipation (Watts)} \\ I : \text{Ripple Current (Arms)} \\ ESR : \text{Equivalent Series Resistance } (\Omega) \end{array} \right)$$

- (2) Ripple Current  
Using P Max from TABLE1, maximum ripple current I (Arms) may be determined as follow :

$$I = \sqrt{P_{Max} / ESR} \times K \times F \dots \text{Formura2}$$

$$\left( \begin{array}{l} K : \text{Temperature Derating Factor TABLE2} \\ \quad \text{E/SV, F/SV, SV/Z} \dots \text{TABLE2-1,} \\ \quad \text{P/SL, PS/G, F/PS} \dots \text{TABLE2-2} \\ F : \text{Frequency Derating Factor} \dots \text{TABLE3} \\ ESR : \text{refer to Ratings} \end{array} \right)$$

Ripple voltage E is calculated using the formura3.

$$E = Z \times I \dots \text{Formura3}$$

$$\left( \begin{array}{l} E : \text{Ripple voltage} \\ Z : \text{Impedance at specified frequency} \end{array} \right)$$

- (3) Ripple Voltage  
The ripple voltage which may be applied is limited by three criteria :
- The power dissipated in the ESR of the capacitor must not exceed the appropriate value specified in TABLE1.
  - The sum of the DC voltage and peak value of the ripple voltage must not exceed the rated voltage.
  - The negative peak value of the ripple voltage must not exceed the permissible reverse voltage value specified in the following section, Reverse Voltage.

## 3. Reverse Voltage

- Because the solid tantalum capacitor is of polar type, do not apply a reverse voltage to it.
- The figure on the right shows the relationship between current and reverse voltage.

**Dissipation Ratings**  
**TABLE 1 -1E/SV,SV/Z,PS/L, PS/G series**

Case Code	Maximum Power Dissipation Watts, 100kHz, at 25°C
J	0.010
P	0.025
A2	0.060
A	0.075
B3	0.075
B2	0.085
C2	0.090
C	0.110
V	0.125
D	0.150

**TABLE 1 -2F/SV,F/PS series**

Case Code	Maximum Power Dissipation Watts, 100kHz, at 25°C
J	0.010
P2	0.025
A3	0.060

**TABLE 2-1 E/SV, F/SV, SV/Z Series**

Temp.	Temperature Derating Factor K
25°C	1
45°C	1
85°C	0.9
125°C	0.4

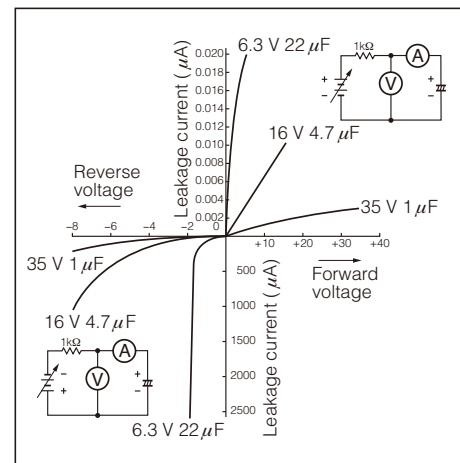
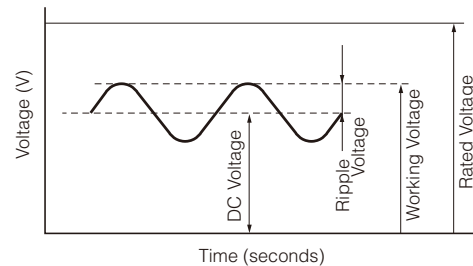
**TABLE 2-2 P/SL, PS/G, F/PS Series**

Temp.	Temperature Derating Factor K
25°C	1
45°C	1
85°C	0.9
105°C	0.4

**TABLE 3 Frequency Derating Factor F**

Series	10kHz	100kHz	300kHz	500kHz	1MHz
I	0.80	1.00	1.00	1.15	1.20
II	0.75	1.00	1.00	1.10	1.30

I : E/SV, F/SV, SV/Z  
II : PS/L, PS/G, F/PS



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#### 4. Applied Voltage

- (1) For general applications, apply 70% or less of the rated voltage to the capacitor.
- (2) When the capacitor is used in a power line or a low-impedance circuit, keep the applied voltage within 30% (50% max.) of the rated voltage to avoid the adverse influence of inrush current.
- (3) For conductive polymer type, NeoCapacitor, apply 80% or less of the rated voltage to the capacitor.

Circuit	Manganese dioxide type E/SV, F/SV, SV/Z series	Conductive polymer type (NeoCapacitor) PS/L, PS/G, F/PS series	
		Rated Voltage	
		2.5V, 4V, 6.3V	10V, 16V
high-impedance	70% or less	90% or less	80% or less
low-impedance	within 30% (50% max)	90% or less	80% or less

- (4) Derated voltage at 85°C or more.  
When using a Chip-type capacitor at a temperature of 85°C or higher, calculate reduced voltage  $U_T$  from the following expression. Note, however, that the ambient temperature must not exceed the maximum operating temperature.

The rated voltage ratio is as shown in the figure on the right.

$$U_T = U_R - \frac{U_R - U_C}{T_{max} - 85} (T - 85)$$

Where

$U_R$ : rated voltage (V)

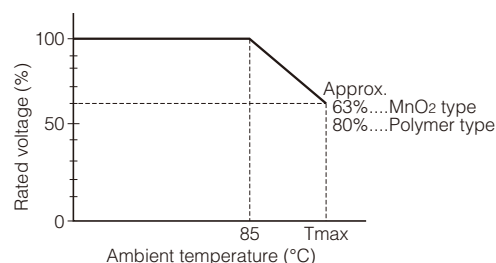
$U_C$ : derated voltage at  $T_{max}$

T: ambient temperature (°C)

$T_{max}$ : Maximum Operating temperature

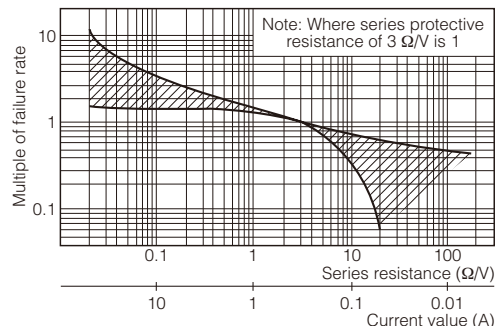
MnO<sub>2</sub> type E/SV, F/SV, SV/Z ..... 125°C

Conductive Polymer type PS/L, PS/G, F/PS ..... 105°C



#### 5. Current (Series Resistance)

As shown in the figure on the right, reliability is increased by inserting a series resistance of at least  $3\Omega/V$  into circuits where current flow is momentary (switching circuits, charge/discharge circuits, etc). If the capacitor is in a low-impedance circuit, the voltage applied to the capacitor should be less than 1/2 to 1/3 of the DC rated voltage.



#### 6. In the Case of Short-Circuit

- (1) Manganese oxide tantalum capacitor (conventional tantalum capacitor) is heated and may generate fire and be burned depending upon its excess current, time and other factors.
- (2) Conductive polymer tantalum capacitor (NeoCapacitor) is heated and may generate smoke emission depending upon its excess current, time and other factors.

(Conductive polymer used for electrolyte is superior in insulating the damaged portion to manganese oxide (used in conventional tantalum capacitor).)

When designing the circuit, provide as much margin as possible to maintain capacitor reliability.



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## NOTES ON USING THE CHIP TANTALUM CAPACITORS, EXCLUDING NeoCapacitors

### 1. Mounting

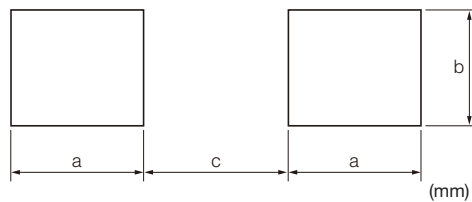
#### (1) Direct Soldering

Keep the following points in mind when soldering the capacitor by means of jet soldering or dip soldering:

##### (a) Temporarily fixing resin

Because chip tantalum capacitors are larger and subject to more force than chip multilayer ceramic capacitors or chip resistors, more resin is required to temporarily secure the solid tantalum capacitors. However, if too much resin is used, the resin adhering to the patterns on a printed circuit board may adversely affect the solderability.

##### (b) Pattern design



Case	a	b	c
P	2.2	1.4	0.7
A2 (U), A	2.9	1.7	1.2
B3 (W), B2 (S)	3.0	2.8	1.6
C2, C	4.1	2.7	2.4
V, D	5.2	2.9	3.7

The above dimensions are for reference only. If the capacitor is to be mounted by this method, and if the pattern is too small, the solderability may be degraded.

##### (c) Temperature and time

Keep the peak temperature and time within the following values:

Solder temperature .....260°C max.

Time .....5 seconds max.

Whenever possible, perform preheating (at 150°C max.) for a smooth temperature profile. To maintain reliability, mount the capacitor at low temperature and in a short time.

##### (d) Component layout

If many types of chip components are mounted on a printed circuit board that is to be soldered by means of jet soldering, solderability may not be uniform over the entire board, depending on the layout and density of the components on the board (also take into consideration generation of flux gas).

##### (e) Flux

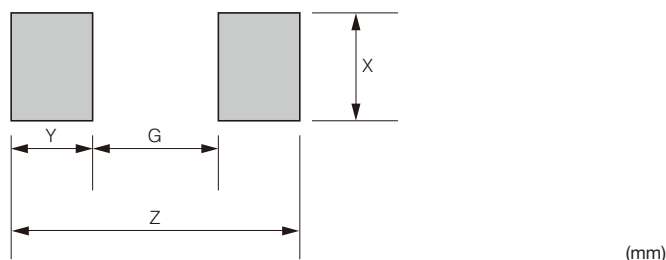
Use resin-based flux. Do not use flux with strong acidity.



## (2) Reflow Soldering

Keep the following points in mind when soldering the capacitor in a soldering oven or with a hot plate:

### (a) Pattern design (in accordance with IEC61188)



Case	G Max.	Z Min.	X Min.	Y (reference)
J *	0.65	1.65	0.65	0.5
P2 *	1.05	2.05	0.80	0.5
A3 *	1.65	3.25	1.1	0.8
J	0.7	2.5	1.0	0.9
P	0.5	2.6	1.2	1.05
A2 (U), A	1.1	3.8	1.5	1.05
B3 (W), B2 (S)	1.4	4.1	2.7	1.35
C2, C	2.9	6.9	2.7	2.0
V, D	4.1	8.2	2.9	2.05

\* F/SV Series only (Conform to IEC 61188-5-2)

The above dimensions are recommended. Note that if the pattern is too big, the component may not be mounted in place.

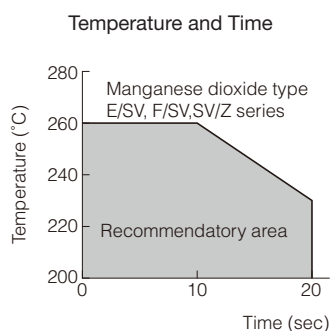
### (b) Temperature and time

Keep the peak temperature and time within the following values:

Solder temperature.....260°C max.

Time .....10 seconds max.

Whenever possible, perform preheating (at 150°C max.) for a smooth temperature profile. To maintain reliability, mount the capacitor at low temperature and in a short time. The peak temperature and time shown above are applicable when the capacitor is to be soldered in a soldering oven or with a hot plate. When the capacitor is soldered by means of infrared reflow soldering, the internal temperature of the capacitor may rise beyond the surface temperature.



### (3) Using a Soldering Iron

When soldering the capacitor with a soldering iron, controlling the temperature at the tip of the soldering iron is very difficult. However, it is recommended that the following temperature and time be observed to maintain the reliability of the capacitor:

Iron temperature ..... 350°C max.

Time ..... 3 seconds max.

Iron power ..... 30 W max.



## 2. Cleaning

Generally, several organic solvents are used for flux cleaning of an electronic component after soldering. Many cleaning methods, such as immersion cleaning, rinse cleaning, brush cleaning, shower cleaning, vapor cleaning, and ultrasonic cleaning, are available; cleaning methods may be used alone or two or more may be used in combination. The temperature of the organic solvent may vary from room temperature to several 10°C, depending on the desired effect. If cleaning is carried out with emphasis placed only on the cleaning effect, however, the marking on the electronic component cleaned may be erased, the appearance of the component may be damaged, and, in the worst case, the component may be functionally damaged. It is therefore recommended that the R series solid tantalum capacitor be cleaned under the following conditions:

### Recommended conditions of flux cleaning

- (1) Cleaning solvent ..... Chlorosen, isopropyl alcohol
- (2) Cleaning method..... Shower cleaning, rinse cleaning, vapor cleaning
- (3) Cleaning time ..... 5 minutes max.

### **Note.** Ultrasonic cleaning

This cleaning method is extremely effective for eliminating dust generated by mechanical processes, but may pose problems depending on the condition. An experiment conducted by NEC TOKIN confirmed that the external terminals of the capacitor were cut when it was cleaned with some ultrasonic cleaning machines. The cause of this phenomenon is metal fatigue of the capacitor terminals due to ultrasonic cleaning. To prevent the terminal from being cut, decreasing the output power of the ultrasonic cleaning machine or shortening the cleaning time may be effective. However, it is difficult to specify the cleaning conditions because there are many factors involved, such as the conversion efficiency of the ultrasonic oscillator, transfer efficiency of the cleaning bath, difference in cleaning effect depending on the location in the cleaning bath, the size and quantity of the printed circuit boards to be cleaned, and the securing states of the components on the boards. It is therefore recommended that ultrasonic cleaning be avoided as much as possible.

If ultrasonic cleaning is essential, make sure through experiments that no abnormalities occur as a result of the cleaning. For further information, consult NEC TOKIN.

## 3. Other

- (1) Do not subject the capacitor to excessive vibration and shock.
- (2) The solderability of the capacitor may be degraded by humidity. Store the capacitor at room temperature (-5 to +40°C) and humidity (40 to 60% RH).
- (3) Take care that no external force is applied to tape-packaged products (if the packaging material is deformed, the capacitor may not be automatically mounted by a chip mounter).



## NOTES ON USING NeoCapacitor

### 1. Permissible Ripple Current

Permissible ripple current shall be derated as follows:

#### (1) Temperature Change

25°C: Rating value  
 85°C: 0.9 times rating value  
 105°C: 0.4 times rating value

#### (2) Switching Frequency

10 kHz: 0.75 times rating value  
 100 kHz : rating value  
 500 kHz : 1.1 times rating value  
 1 MHz: 1.3 times rating value

### 2. Mounting

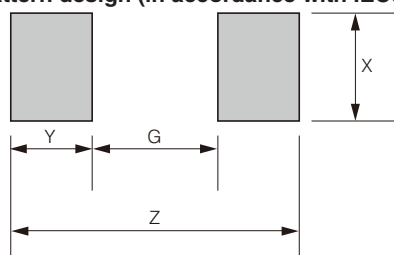
This capacitor is designed to be surface mounted by means of reflow soldering.

(The conditions under which the capacitor should be soldered with a soldering iron are explained in (2) Using a Soldering Iron. Because the capacitor is not designed to be soldered by means of laser beam soldering, VPS, or flow soldering, the conditions for these soldering methods are not explained in this document.

#### (1) Reflow Soldering

Keep the following points in mind when soldering the capacitor in a soldering oven with a hot plate:

##### (a) Pattern design (in accordance with IEC61188)



(mm)

Case	G Max.	Z Min.	X Min.	Y (reference)
J	0.7	2.5	1.0	0.9
P	0.5	2.6	1.2	1.05
A3*	1.65	3.25	1.1	0.8
A2 (U), A	1.1	3.8	1.5	1.35
B3(W), B2(S)	1.4	4.1	2.7	1.35
C2, C	2.9	6.9	2.7	2.0
V, D	4.1	8.2	2.9	2.05

\* F/PS Series only (Conform to IEC 61188-5-2)

The above dimensions are recommended. Note that if the pattern is too big, the component may not be mounted in place.



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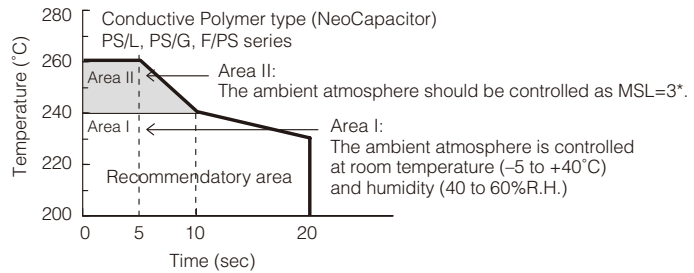
### (b) Temperature and time

Keep the peak temperature and time within the following recommended conditions.

Solder temperature ... 240°C max.  
Time ..... 10 seconds max.

In the case of moisture control condition equivalent to MSL=3.  
(Refer to JEDEC J-STD-020D.01 Table 5-1 Moisture Sensitivity Levels)

Solder temperature ... 260°C max.  
Time ..... 5 seconds max.



(\*):Moisture Control Condition equivalent to MSL=3.

After opening the bag, store the capacitor at 30°C-60%R.H.max, and mount within 168 Hr.

Whenever possible, perform preheating (at 150°C max.) for a smooth temperature profile. To maintain reliability, mount the capacitor at low temperature and in a short time. The peak temperature and time shown above are applicable when the capacitor is to be soldered in a soldering oven or with a hot plate. When the capacitor is soldered by means of infra-red reflow soldering, the internal temperature of the capacitor may rise beyond the surface temperature.

### (2) Using a Soldering Iron

When soldering the capacitor with a soldering iron, controlling the temperature at the tip of the soldering iron is very difficult. However, it is recommended that the following temperature and time be observed to maintain the reliability of the capacitor:

Iron temperature ... 350°C max.  
Time ..... 3 seconds max.  
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Generally, several organic solvents are used for flux cleaning of an electronic component after soldering. Many cleaning methods, such as immersion cleaning, rinse cleaning, brush cleaning, shower cleaning, vapor cleaning, and ultrasonic cleaning, are available, which may be used alone or in combination. The temperature of the organic solvent may vary from room temperature to several 10°C, depending on the desired effect. If cleaning is carried out with emphasis placed only on the cleaning effect, however, the marking on the electronic component cleaned may be erased, the appearance of the component may be damaged, and, in the worst case, the component may be functionally damaged. It is therefore recommended that the NeoCapacitor be cleaned under the following conditions:

#### [Recommended conditions of flux cleaning]

- (1) Cleaning solvent ..... Isopropyl alcohol
- (2) Cleaning method ..... Shower cleaning, rinse cleaning, vapor cleaning
- (3) Cleaning time ..... 5 minutes max.

#### Note: Ultrasonic cleaning

This cleaning method is extremely effective for eliminating dust generated by mechanical processes, but may pose problems, depending on the condition. An experiment conducted by NEC TOKIN confirmed that the external terminals of the capacitor were cut when it was cleaned with some ultrasonic cleaning machines. The cause of this phenomenon is metal fatigue of the capacitor terminals due to ultrasonic cleaning. To prevent the terminal from being cut, decreasing the output power of the ultrasonic cleaning machine or decreasing the cleaning time may be effective. However, it is difficult to specify safe cleaning conditions because there are many factors involved, such as the conversion efficiency of the ultrasonic oscillator, transfer efficiency of the cleaning bath, difference in cleaning effect depending on the location in the cleaning bath, the size and quantity of the printed circuit boards to be cleaned, and the securing states of the components on the boards. It is therefore recommended that ultrasonic cleaning be avoided as much as possible. If ultrasonic cleaning is essential, make sure through experiments that no abnormalities occur as a result of the cleaning. For further information, contact NEC TOKIN.



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