Notes on the Correct Use of Tantalum Capacitors
[MEMO]
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While NEC Corporation has been making continuous effort to enhance the reliability of its electronic components, the possibility of defects cannot be eliminated entirely. To minimize risks of damage or injury to persons or property arising from a defect in an NEC electronic components, customers must incorporate sufficient safety measures in its design, such as redundancy, fire-containment, and anti-failure features.

NEC devices are classified into the following three quality grades: "Standard", "Special", and "Specific". The Specific quality grade applies only to devices developed based on a customer designated "quality assurance program" for a specific application. The recommended applications of a device depend on its quality grade, as indicated below. Customers must check the quality grade of each device before using it in a particular application.

Standard: Computers, office equipment, communications equipment, test and measurement equipment, audio and visual equipment, home electronic appliances, machine tools, personal electronic equipment and industrial robots

Special: Transportation equipment (automobiles, trains, ships, etc.), traffic control systems, anti-disaster systems, anti-crime systems, safety equipment and medical equipment (not specifically designed for life support)

Specific: Aircrafts, aerospace equipment, submersible repeaters, nuclear reactor control systems, life support systems or medical equipment for life support, etc.

The quality grade of NEC devices is "Standard" unless otherwise specified in NEC's Data Sheets or Data Books. If customers intend to use NEC devices for applications other than those specified for Standard quality grade, they should contact an NEC sales representative in advance.

Anti-radioactive design is not implemented in this product.
To ensure correct use of the tantalum capacitor, be sure to read these notes beforehand.

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[MEMO]
Preface

Since 1959 – starting to sale of the tantalum capacitors, NEC has made every efforts in trying extension and quality improvement of the products, while NEC has been received to many customers in patronage. However, as the tantalum capacitors have the very thin dielectric, they rarely cause failures such as short and give troubles on the customers.

With the miniaturization of the electronic equipment, further miniaturization has also been required the capacitors. In such situation, this manual was arranged in order to improve the reliability of your systems and in order to handle the tantalum capacitors safely.

Therefore, be sure to read this document before using NEC’s tantalum capacitors.
[MEMO]
1. Notes on the Precautions on Circuit Design

1.1 Circuit Design

Expecting 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 to these conditions, 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.)

\( T_0 \), \( V_0 \)

### Failure Rate

<table>
<thead>
<tr>
<th>Series</th>
<th>Failure Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>PSL</td>
<td>1%/1000 h</td>
</tr>
<tr>
<td>PSN</td>
<td>1%/1000 h</td>
</tr>
<tr>
<td>PSM</td>
<td>1%/1000 h</td>
</tr>
<tr>
<td>R (standard)</td>
<td>1%/1000 h</td>
</tr>
<tr>
<td>R (extended)</td>
<td>1%/1000 h</td>
</tr>
<tr>
<td>SVS</td>
<td>1%/1000 h</td>
</tr>
<tr>
<td>SVH</td>
<td>0.5%/1000 h</td>
</tr>
<tr>
<td>SVF</td>
<td>1%/1000 h</td>
</tr>
<tr>
<td>SVZ</td>
<td>1%/1000 h</td>
</tr>
</tbody>
</table>

**<Test Conditions>**

Temperature: 85°C
Voltage: Rated Voltage
Rs: 3 \( \Omega \)

This figure graphically indicates \((V/V_0)^3 \times 2^{(T-T_0)/10}\) in the expression \( \lambda = \lambda_0 (V/V_0)^3 \times 2^{(T-T_0)/10} \). By using this figure, the estimated failure rate can be easily calculated.

Connect the desired temperature and voltage ratio with a straight line (form the leftmost vertical axis in the figure to the rightmost axis) in the figure. The multiple of the failure rate can be obtained at the intersection of the line drawn and the middle vertical axis in the figure.

Therefore

\[ \lambda = \lambda_0 \times F. \]

where,

\( F \): multiple of failure rate at given temperature and ratio of working voltage to rated voltage.
1.2 Ripple Voltage

(1) Keep the sum of the DC voltage and peak value of the ripple voltage to within the rated voltage.

(2) If a ripple voltage is applied to the capacitor, the peak value of the ripple voltage must be kept to within the values shown in the following figures:

<Resin Molded Chip Type R, SVS, SVH, SVF, SVZ Series, except NeoCapacitors>

Calculate the permissible ripple voltage at a temperature higher than that specified in these figure by using the following expression;

\[ V_{\text{r.m.s.}} \text{ (at } 50^\circ\text{C)} = 0.7 \times V_{\text{r.m.s.}} \text{ (at } 25^\circ\text{C)} \]
\[ V_{\text{r.m.s.}} \text{ (at } 85^\circ\text{C)} = 0.5 \times V_{\text{r.m.s.}} \text{ (at } 25^\circ\text{C)} \]
\[ V_{\text{r.m.s.}} \text{ (at } 125^\circ\text{C)} = 0.3 \times V_{\text{r.m.s.}} \text{ (at } 25^\circ\text{C)} \]

(3) Keep the negative peak value of the ripple voltage to within the permissible reverse voltage value.
1.3 Reverse Voltage

(1) Do not apply a reverse voltage to the solid tantalum capacitor because the capacitor is of polar type. If reverse voltage cannot be avoided, it must be applied for a short time and must not exceed the following value:
- 25°C ...... 10% max. of rated voltage or 3 Vdc, which is smaller
- 85°C ...... 5% max. of rated voltage
- 125°C .... 1% max. of rated voltage

(2) The figure on the right shows the relations between current and reverse voltage.

1.4 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 to within 30% (50% max.) of the rated voltage to avoid adverse influence of inrush current.

(3) Derated voltage at 85°C or more.
When using the 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 125°C.

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

\[
U_T = U_R - \frac{U_R - U_C}{40} (T-85)
\]

Where,
- \( U_R \) : rated voltage (V)
- \( U_C \) : derated voltage at 125°C
- \( T \) : ambient temperature (°C)

1.5 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.
1.6 Voltage Division

When two or more capacitors are connected in series and a voltage more than the rated voltage of anyone is applied to the both ends of the capacitors, a voltage proportional to the insulation resistance of a capacitor will be applied and, as a result, a voltage more than the rated voltage may be applied to each capacitor. Therefore, do not connect capacitors in series.
2. Notes on Mounting

2.1 Mounting

(1) Direct Soldering

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

(a) Temporarily fixing resin

Because the chip tantalum capacitors are larger in size and subject to more force than the 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 adhered to the patterns on a printed circuit board may adversely affect the solderability.

(b) Pad Pattern Design

![Diagram of pad pattern design]

Unit: mm

<table>
<thead>
<tr>
<th>Case Size</th>
<th>a</th>
<th>b</th>
<th>c</th>
</tr>
</thead>
<tbody>
<tr>
<td>P</td>
<td>2.2</td>
<td>1.4</td>
<td>0.7</td>
</tr>
<tr>
<td>A2, A</td>
<td>2.9</td>
<td>1.7</td>
<td>1.2</td>
</tr>
<tr>
<td>B3, B2</td>
<td>3.0</td>
<td>2.8</td>
<td>1.6</td>
</tr>
<tr>
<td>B</td>
<td>3.3</td>
<td>1.9</td>
<td>2.4</td>
</tr>
<tr>
<td>C</td>
<td>4.1</td>
<td>2.3</td>
<td>2.4</td>
</tr>
<tr>
<td>D2</td>
<td>5.4</td>
<td>2.9</td>
<td>2.4</td>
</tr>
<tr>
<td>V, D</td>
<td>5.2</td>
<td>2.9</td>
<td>3.7</td>
</tr>
</tbody>
</table>

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 to within the following values:

- Solder temperature ... 260°C max.
- Time ...................... 5 seconds max. (10 seconds max. for SVH)

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

(d) Component Layout

If many types of chip components are mounted on a printed circuit board which 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 in mind the following points when soldering the capacitor in a soldering oven or with a hot plate:

(a) **Pad Pattern Design**

![Diagram of pad pattern design](image)

<table>
<thead>
<tr>
<th>Case Size</th>
<th>G max.</th>
<th>Z min.</th>
<th>X min.</th>
</tr>
</thead>
<tbody>
<tr>
<td>P</td>
<td>0.5</td>
<td>2.6</td>
<td>1.2</td>
</tr>
<tr>
<td>A2, A</td>
<td>1.1</td>
<td>3.8</td>
<td>1.5</td>
</tr>
<tr>
<td>B3, B2</td>
<td>1.4</td>
<td>4.1</td>
<td>2.7</td>
</tr>
<tr>
<td>B</td>
<td>2.6</td>
<td>5.9</td>
<td>2.9</td>
</tr>
<tr>
<td>C</td>
<td>2.9</td>
<td>6.9</td>
<td>2.7</td>
</tr>
<tr>
<td>D2</td>
<td>2.7</td>
<td>6.7</td>
<td>2.9</td>
</tr>
<tr>
<td>V, D</td>
<td>4.1</td>
<td>8.2</td>
<td>2.9</td>
</tr>
</tbody>
</table>
(b) Temperature and Time

Keep the peak temperature and time to within the following values:

Solder temperature ... 260°C max.

Time: 10 seconds max.

Whenever possible, perform preheating (at 150°C max.) for smooth temperature profile. To maintain the reliability, mount the capacitor at a low temperature and in a short time whenever possible. 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 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 ..... 300°C max.

Time ....................... 3 seconds max.

Iron Power .................. 30 W max.
3. Cleaning and Others

3.1 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, and one of these 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 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 capacitors 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.

*Ultrasonic cleaning

This cleaning method is extremely effective for eliminating dust that has been generated as result of mechanical processes, but may pose a problem depending on the condition. As a result of an experiment conducted by NEC, it was 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 considered metal fatigue of the capacitor terminals that occurred 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 a possible solution. However, it is difficult to specify the 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 abnormality occur as a result to the cleaning. For further information, consult NEC.

3.2 Others

(1) Do not touch the capacitor with the probe of a tester inadvertently. If a probe makes contact with the capacitor, an overvoltage or reverse voltage may be applied to the capacitor.
(2) Do not apply excessive vibration and shock to the capacitor.
(3) If the capacitor is used in an environment with high humidity, perform damp-proofing on the PC board on which the capacitor is mounted.
(4) Do not use the capacitor in mist containing acid or alkali.
(5) The solderability of the capacitor may be degraded by humidity. Store the capacitor at (–5 to +40°C) room temperature and (40 to 60% RH) humidity.
(6) Exercise care that no external force is applied to the tape packaged products (if the packaging material is deformed, the capacitor may not be automatically mounted by a chip mounter).
4. Functional Polymer-type (Neocapacitor) Notes on Correct Use

4.1 Ripple Current

Permissible ripple current shall be derated as follows

a. Temperature
   -55 to +85°C Rating value (PSN series)
   -55 to +105°C Rating value (PSL, PSM series)

b. Frequency
   1 MHz Rating value
   500 kHz 0.9 times rating value
   100 kHz 0.75 times rating value

4.2 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. For the conditions for flow soldering, contact NEC.)

(1) Reflow soldering

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

(a) Pattern design (in accordance with IEC1188)

<table>
<thead>
<tr>
<th>Case</th>
<th>G max.</th>
<th>Z min.</th>
<th>X min.</th>
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<td>2.9</td>
<td>6.9</td>
<td>2.7</td>
</tr>
<tr>
<td>V, D</td>
<td>4.1</td>
<td>8.2</td>
<td>2.9</td>
</tr>
</tbody>
</table>

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 to within the following conditions.

![Temperature and Time Graph]

- Pre-heating time: 150°C to 150°C, 120 sec. MAX.
- Peak Temperature: 230°C
- Soldering time: 200°C to 200°C, 30 sec. MAX.

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

(2) Using 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: 300 °C max.
- Time: 3 seconds max.
- Iron power: 30 W max.
[MEMO]
[MEMO]