Application Guidelines For Aluminum Electrolytic Capacitors

1. Circuit Design
1.1 Please make sure the environmental and mounting conditions to which the capacitor will be exposed to are within the conditions specified in this catalog (or alternate Acon's specifications, such as series drawings).

1.2 Operating temperature and applied ripple current must be within ACON'S specification.
   - The capacitor must not be used in an ambient temperature which exceeds the operating temperature specified in this catalog.
   - Do not apply excessive current which exceeds the allowable ripple current.

1.3 Appropriate capacitors which comply with the life requirement of the products should be selected when designing the circuit.

1.4 Aluminum electrolytic capacitors are polarized. Do not apply reverse voltage or AC voltage. Please use non-polarized capacitors for a circuit that can possibly see reversed polarity. Note: Even non-polarized capacitors can not be used for AC voltage application.

1.5 Do not use aluminum electrolytic capacitors in a circuit that requires rapid and very frequent charge/discharge. In this type of circuit, it is necessary to use a special design capacitor with extended life characteristics.

1.6 Do not apply excess voltage.
   - Please pay attention so that the peak voltage, which is DC voltage overlapped by ripple current, will not exceed the rated voltage.
   - In the case where more than 2 aluminum electrolytic capacitors are used in series, please make sure that applied voltage will be lower than rated voltage and the voltage will be applied to each capacitor equally using a balancing resistor in parallel with the capacitor.

1.7 Outer sleeve of the capacitor is not guaranteed as an electrical insulator. Do not use a standard sleeve on a capacitor in applications that require the electrical insulation. When the application requires special insulation, please contact our sales office for details.
   - Do not connect the blank terminal (reinforcing terminal) of a multi-terminal (three- or four-terminal) product of the snap-in type to another circuit, it may cause a short circuit.

1.8 Capacitors must not be used under the following conditions:
   - (a) Capacitors must not be exposed to water (including condensation), brine or oil
   - (b) Ambient conditions that include toxic gases such as hydrogen sulfide, sulfurous acid, nitrous acid, chlorine, ammonium, etc....
   - (c) Ambient conditions that expose the capacitor. to ozone, ultraviolet ray and radiation.
   - Severe vibration and physical shock conditions that exceed ACON's specifications.

1.9 When designing a circuit board, please pay attention to following:
   - Make the hole spacing on the PC. Board match the lead space of the capacitor.
   - There should not be any circuit pattern or circuit wire above the capacitor safety vent.
   - Unless otherwise specified, following clearance should be made above the pressure relief vent.

<table>
<thead>
<tr>
<th>Case Diameter</th>
<th>Gap Required</th>
</tr>
</thead>
<tbody>
<tr>
<td>Φ6.3～16</td>
<td>2mm or more</td>
</tr>
<tr>
<td>Φ18～35</td>
<td>3mm or more</td>
</tr>
<tr>
<td>Φ40 or more</td>
<td>5mm or more</td>
</tr>
</tbody>
</table>

   - In case the vent side is placed toward PC. board (such as end seal vented parts), make a corresponding hole on the PC. board to release the gas when vent Is operated. The hole should be made to match the capacitor vent position.
   - Do not install screw terminal capacitor with end seal she down. When you Install a screw terminal capacitor in a horizontal mount, the positive terminal must be in the upper position.
1.10 The main chemical solution of the electrolyte and the separator paper used in the capacitors are combustible. The electrolyte is conductive. When it comes in contact with the PC. board, there is a possibility of pattern corrosion of Short circuit between the circuit pattern which could result in smoking or catching fire. Do not locate any circuit pattern beneath the capacitor end seal.

1.11 Do not design a circuit board so that heat generating components such as resistor and transistors are placed near an aluminum or side of PC. board (under the capacitor).

1.12 Electrical characteristics may vary depending on changes in temperature and frequency. Please consider this variation when you design circuits.

1.13 When you are designing capacitors for use on double-sided PC. Boards avoid circuit patterns or through holes (such to connect both sides), that are placed under the capacitor.

1.14 The torque for terminal screw or brackets screws must be within the specified value on ACON’S drawings.

1.15 When you install more than 2 capacitors in parallel, consider the balance of current flowing into the capacitors.

2. Mounting

2.1 Once a capacitor has been assembled in the set and power applied, do not attempt to reuse the capacitor in other circuits or application.

2.2 Electric potential between positive and negative terminal may exist as a result or returned electromotive force, so please discharge the capacitor using a 1kΩ resistor.

2.3 Leakage current of the parts that have been stored for more than 6 months may increase. When leakage current has increased, please perform a voltage treatment using 1kΩ resistor.

2.4 Please confirm ratings before installing capacitors on the PC.board.

2.5 Please confirm polarity before installing capacitors on the PC. Board.

2.6 Do not drop capacitors on the floor, nor use a capacitor that was dropped.

2.7 Be careful not to deform the capacitor during installation.

2.8 Please confirm that the lead spacing of the capacitor matches the hole spacing of the PC. board prior to installation.

2.9 Snap-In can type capacitor such as JIS configuration 692, 693, 694 and 695 type should be installed tightly to the PC. board (No gap between the PC. board and bottom of the capacitor).

2.10 Please pay attention that the clinch force is not too strong when capacitors are placed and fixed by an automatic insertion machine(≤2.5kg).

2.11 Please pay attention to that the mechanical shock to the capacitor by suction nozzle of the automatic insertion machine or automatic mounter, or by product checker, or by centering mechanism.

2.12 Soldering condition must be confirmed to be within ACON’S specification.

2.13 Do not tilt lay down or twist the capacitor body after the capacitor are soldered to the PCB board.

2.14 Do not carry the PCB board by grasping the soldered capacitor.

2.15 Please do not allow anything to touch the capacitor after soldering. If PCB board are stored in stack, please make sure PCB board or the other components do not touch the capacitor.

The capacitors shall not be affected by any radiated heat from the soldered PCB board or other components after soldering.

2.16 Do not clean capacitors with halogenated cleaning agent.

2.17 Fixing materials and coating materials

- Do not use any ingredients which contain halogen.
- Please pay attention to remove flux and any contamination which remains in the gap between the end seal and PC. board and dry that portion well before coating.
- Please do not apply any material all around the capacitor body but apply it partially
- Please contact our sales office to make sure whether the curing condition of coating material would cause any problems.

3. Storage

The characteristics of aluminum electrolytic capacitors degrade when stored in a static condition for long periods of
time. The rate of deterioration depends upon temperature and humidity. Capacitors should be stored at the temperature of 5°C to 35°C, the humidity of less than 75% RH and out of direct sunlight. Capacitors that have been stored for long periods normally over one year should be subjected to a “voltage aging” treatment before use. This will reform and repair the oxide dielectric. Suggested aging procedure is gradually apply the rated voltage to the capacitors while monitoring the leakage current. Do not exceed the specified leakage current value. when rated voltage has been reached, maintain for 30 to 60 minutes.

4. Printed Circuit Board Cleaning

4.1 Foreword

It had been generally accepted that halogen type organic solvents were hazardous to aluminum electrolytic capacitors. This is because an organic solvent can permeate the capacitor through the end seal. Then, the solvent dissolves and free chlorine ions(Cl⁻), which can corrode the aluminum electrodes.

The following measures were previously the only way to avoid the phenomenon.

1. Use of cleaning agents, not hazardous to capacitors such as water or alcohol.
2. Mount capacitors on PCB boards cleaned with a halogen type solvent before hand.
3. Use of epoxy end seals.

These measures have disadvantages with respect to working efficiency, cleaning capability, cost etc. Therefore, aluminum electrolytic capacitors which can withstand halogen type cleaning agents are desirable.

4.2 Types of Cleaning Agents

Generally there are three types of cleaning agents.

1. Water type
2. Alcohol type
3. Halogen type

of these, water and alcohol will have little effect even if they permeate the capacitor. However, halogens can cause corrosion of aluminum foil and tab. Common types of halogen cleaning agents are listed in table below:

<table>
<thead>
<tr>
<th>Trichlorotrifluoroethane</th>
<th>C₂Cl₃F₃</th>
<th>Freon TF, Daiflon S-3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fluorotrichloromethane</td>
<td>CCl₃F</td>
<td>Freon-11, Daiflon S-1</td>
</tr>
<tr>
<td>Trichloroethylene</td>
<td>CHCl₃</td>
<td>Chloroethylene</td>
</tr>
<tr>
<td>Trichloroethylene</td>
<td>C₂HCl₃</td>
<td>Trichlene</td>
</tr>
<tr>
<td>Methyl Chloride</td>
<td>CH₂Cl</td>
<td>MC</td>
</tr>
</tbody>
</table>

The last four solvents listed above are particularly corrosive to aluminum and are not recommended to use as cleaning solvents.

4.3 Penetration Channel of Solvent and Corrosion Mechanism

The three channels by which solvents can penetrate into the capacitor are illustrated:

1. Penetration through a clearance between the rubber and the aluminum case (curled section)
2. Penetration through a clearance between the rubber and the lead wires.
3. Permeation through the rubber end seal.

To reduce the possibility of solvents entering a capacitor, tight sealing is required to eliminate clearances between the rubber and the aluminum case/lead wires. A solvent resistant rubber material is also a necessity.

when a solvent, for example, trichlorotrifluoroethane gets inside a non antisolvent capacitor, the chlorine ion is free as shown by the following reaction formula.

\[
\begin{array}{c}
F & F & F & F & F \\
\mid & \mid & \mid & \mid & \mid \\
F - C - C - C - Cl \rightarrow F - C = C - Cl + 2Cl^- \\
\mid & \mid & \mid & \mid & \mid \\
Cl & Cl & & & \\
\end{array}
\]

This chlorine ion reacts with aluminum as follows: \( Al + 3Cl^- \rightarrow AlCl_3 + 3e^- \)

Then AlCl₃ resolves in water, and it becomes:
PRECAUTIONS AND GUIDELINES

AlCl₃ + 3H₂O → Al₃(OH)₃ + 3H⁺ + 3Cl⁻

thus, the Cl⁻ ion is free again and repeats the corrosion of aluminum. The degree of this reaction depends on the volume of solvent, the ambient temperature of the capacitor in service, the applied voltage and time etc.

5. Basic Electrical Characteristics

5.1 Capacitance:

The capacitance of capacitor is determined as AC capacitance by measuring its impedance. As the AC capacitance depends on frequency, voltage and other measuring methods, JIS C 5102 prescribes that the series capacitive component of an equivalent series circuit shall be considered as the capacitance by measuring it at a frequency of 120Hz and a maximum AC voltage of 0.5Vrms with a DC bias voltage of 1.5 to 2.0V applied for aluminum electrolytic capacitors.

The capacitance of an aluminum electrolytic capacitor shows smaller values as a measuring frequency increases. See the typical behavior shown below:

Capacitance vs. Frequency

Measuring temperature as well as frequency effects the capacitance. As the measuring temperature decreases, the capacitance shows smaller values. See the typical behavior shown below:

Capacitance vs. Temperature

On one hand, DC capacitance, which can be determined by measuring the change when a DC voltage is applied, shows a slightly larger value than the AC capacitance at a normal temperature and has the flatter characteristic over the temperature range.

The tanδ is the ratio of the resistive component (ESR) to the capacitive reactance (1/ωC) in the equivalent series circuit, and its measuring conditions are the same as the capacitance.
Tan\(\delta\) = \frac{\text{ESR}}{(1/\omega C)} = \omega C \cdot \text{ESR}

Where:
- \(\text{ESR}\) = Equivalent series resistor at 120Hz
- \(\omega = 2\pi f\)
- \(f = 120\text{Hz}\)

The \(\tan\delta\) show higher values as a measuring frequency increases and a measuring temperature decreases, as follows:

Temperature Characteristics of \(\tan\delta\)

**Equivalent series resistance (ESR):**

The ESR is comprised of the resistance due to aluminum oxide layer and electrolyte/separator combination and other resistance effects with foil length, foil surface area, etc. The ESR value depends on the temperature. Decreasing the temperature makes the resistivity of the electrolyte increase with the result of the ESR increasing. As the measuring frequency increases, the ESR decreases and reaches an almost constant value that is mainly the frequency-independent resistance due to electrolyte/separator combination.

**Impedance (Z):**

The impedance is the resistance which opposes the flow of alternating current at a specific frequency. It is related to capacitance(C) and inductance(L) in terms of capacitive and inductive reactance, and also related to the ESR. It is expressed as follows:

\[
Z = \sqrt{\text{ESR}^2 + (X_L - X_C)^2}
\]

Where:
- \(X_L = \frac{1}{\omega L} = \frac{1}{2\pi fL}\)
- \(X_C = \frac{1}{\omega C} = \frac{1}{2\pi fC}\)

As shown below, the capacitive reactance \((X_C)\) predominates at the range of low frequencies, and the impedance decreases with increasing frequency until it reaches the ESR in the middle frequency range. At the range of the higher frequencies the inductive reactance \((X_L)\) comes to predominate, so that the impedance increases with increasing the measuring frequency.
As shown below, the impedance value varies with temperature, because the resistance of the electrolyte strongly changes with temperature.

**Leakage current:**

The dielectric of a capacitor has a very high resistance which prevents the flow of DC current. However, due to the characteristics of the aluminum oxide layer that functions as a dielectric in contact with electrolyte, a small amount of current, called leakage current, will flow to reform and repair the oxide layer while a voltage is being applied. As shown below, a blah leakage current flows in me first minutes as a voltage is applied to the capacitor, and then the leakage current will decrease and reach an almost steady—state value with time.

Measuring temperature and voltage effect the leakage current. The leakage current shows higher values as the temperature and voltage increase.
Typical Temperature Characteristics

In general, the leakage current is measured at 20°C by applying the rated voltage, which is applied through a resistor of 1,000 connected in series with the capacitor, and several minutes after the capacitor reached the rated voltage. The catalog prescribes the measuring temperature and time.