

I .Lifetime Estimation

Subject series : FR/FH/FG/FF/FS/FL/FT/FP/VB/VP/VS

Conductive polymer aluminum solid capacitors are finite life electronic components like aluminum electrolytic capacitors. The lifetime is affected by ambient temperature, humidity, ripple current and surge voltage.

The lifetime of aluminum electrolytic capacitors is affected mainly by the loss of electrolyte as the result of the liquid electrolyte evaporating through the rubber seal materials, resulting in capacitance drop and tanδ rise. On the other hand, the lifetime of conductive polymer aluminum solid capacitors is affected mainly by oxidation degradation of the conductive polymer caused by osmose of oxygen or the thermal degradation of the conductive polymer by ambient temperature or self-heating, resulting in ESR rise and tanδ rise. The infiltration rate of the oxygen is depend on the temperature as the liquid electrolyte evaporation and the relationship follows the Arrhenius's Law, too. Similarly, thermal degradation of the conductive polymer by self-heating follows the Arrhenius's Law, too. Therefore, the lifetime estimation has been using the theory of lifetime increasing by 10 times at every 20°C reducing of the ambient temperature.

1. Lifetime Estimation

Equation (1) can be used for estimating the lifetime of the conductive polymer aluminum solid capacitors based on the ambient temperature and the rise of internal temperature due to ripple current.

$$L_x = L_0 \times 10^{(T_0 - T_x) / 20} \text{-----(1)}$$

- Lx : Estimation of actual lifetime (hour)
- Lo : Specified lifetime with the rated voltage at the upper limit of the category temperature (hour)
- To : Maximum category temperature (°C)
- Tx : Actual ambient temperature of the capacitor (°C)

Longer lifetime is expected by lowering the ripple current and the ambient temperature.
Please consult us about lifetime equations for the series of the category temperature 125°C.
Subject series : FT

An approximate value of ripple current-caused ΔT can be calculated using Equation (2)

$$\Delta T = \Delta T_0 \times (I_x / I_0)^2 \text{-----(2)}$$

- ΔTo : Rise in internal temperature due to the rated ripple current (20°C) The product that the maximum category temperature is less than 105°C
 - Ix : Operating ripple current (Arms) actually flowing in the capacitor
 - Io : Rated ripple current (Arms), frequency compensated, at the upper limit of the category temperature range
- Please contact us about the product that the maximum category temperature is more than 125°C.
To determine more accurate values of ΔT, they can be actually measured using a thermocouple.

2. Rated Ripple Current Frequency Multipliers

Self-heat rise is generated by the ripple current even though the conductive polymer aluminum solid capacitors have low ESR compared to liquid based electrolyte aluminum electrolytic capacitor. Longer lifetime is expected by lowering the ripple current and the ambient temperature. Table 1 shows Frequency Multipliers of Rated ripple current.

Frequency Multipliers

Frequency [Hz]	120	1k	10k	50k	100k~500k
SMD type	0.05	0.3	0.55	0.7	1
Radial lead type	0.1	0.35	0.6	0.8	1

Conductive polymer aluminum solid capacitors have super low ESR characteristic in high-frequency range. On the whole, ESR in low-frequency range relatively rises. Therefore, they can use only 1 ripple current in low-frequency range.

3. Restriction of calculated lifetime

- (1) The result calculated by the estimated lifetime formula, it is not guaranteed lifetime by Nippon Chemi-Con Corporation.
- (2) When designer calculate the lifetime of apparatus, please include an ample margin in consideration to the estimated lifetime of a capacitor.
- (3) When calculated lifetime result are over 15 years by using the estimated lifetime formula, please consider 15 years to be a maximum in considering that the sealing rubber characteristics vary during the lifetime.
- (4) If 15 years or more may be required as an expected lifetime, please consult us.

II . About failure and shelf-life

Failure rate (failure rate level) subject to 0.5 %/1000 h of JIS C 5003 (Credibility level 60 %)
The main failure mode of polymer solid aluminum electrolytic capacitor of is shown below.

1. Random failure

The main cause of failure mold is short-circuit due to heat stress, electrical stressing and mechanical stress in using environment or welding.

- (1) applied voltage more than rated voltage
- (2) applied reverse voltage
- (3) Excessive mechanical stress
- (4) Applying fast charging and discharging that more than specifications and cause surge current

a. If the short circuit current flows through the solid capacitor will cause the following phenomenon.

- (1) When the electric current is less after short-circuit (φ10 : about below 1 A , φ8 : about below 0.5 A , φ6.3 : about below 0.2 A) PC-CON body will have little heat but appearance is normal even continuous electricity.

1 . Overview of Aluminum Electrolytic Capacitors

1-1 Basic Model of Aluminum Electrolytic Capacitors

1) Capacitors are passive components. Among the various kinds of capacitors, aluminum electrolytic capacitors offer larger CV product per case size and lower cost than the others. In principles of capacitor, its fundamental model is shown in Fig.1 and its capacitance © is expressed by Equation (1) below:

$$C = 8.854 \times 10^{-12} \epsilon S (F) \dots\dots\dots (1)$$

- ε : Dielectric constant
- S : Surface area of dielectric (m²)
- d : Thickness of dielectric (m)

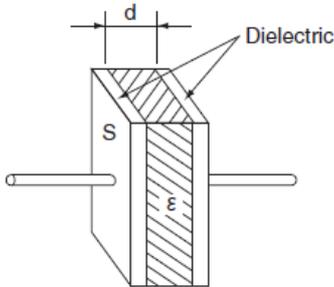


Fig-1 Basic model of capacitor

2) Equation (1) shows that the capacitance (C) increases as the dielectric constant (ε) and/or its surface area (S) increases and/or the dielectric thickness (d) decreases.

An aluminum electrolytic capacitor comprises a dielectric layer of aluminum oxide (Al₂O₃), the dielectric constant (ε) of which is 8 to 10. This value is not significantly larger than those of other types of capacitors

However, by extending the surface area (S) of the aluminum foil electrode by means of etching, and by electrochemically forming a thinner but highly voltage-withstandable layer of oxide layer dielectric, the aluminum electrolytic capacitor can offer a larger CV product per case than other types of capacitors.

3) A basic model of aluminum electrolytic capacitor is shown in Fig. 2.

An aluminum electrolytic capacitor comprises

- Anode ...Aluminum foil
- Dielectric...Electrochemically formed oxide layer (Al₂O₃) on the anode
- Cathode ...A true cathode is electrolytic solution (electrolyte).

Other component materials include a paper separator that holds electrolyte in place and another aluminum foil that functions as a draw-out electrode coming into contact with the true cathode (electrolyte). In general, an aluminum electrolytic capacitor is asymmetrical in structure and polarized. The other capacitor type known as a bi-polar (non-polar) comprises the anodic aluminum foils for both electrodes.

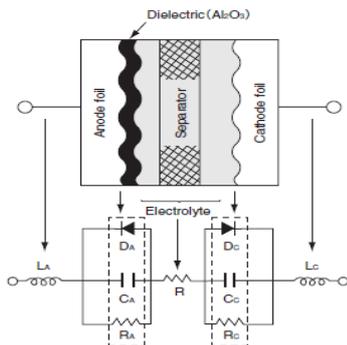


Fig-2 Basic model and equivalent circuit aluminum electrolytic capacitor

- CA, CC : Capacitance due to anode and cathodes foils
- DA, DC : Diode effects due to oxide layer on anode and cathode foils
- LA, LC : Inductance due to anode and cathode terminals
- R : Resistance of electrolyte and separator
- RA, RC : Internal resistance of oxide layer on anode and cathode foils.

1-2 Structure of Aluminum Electrolytic Capacitor

1) The aluminum electrolytic capacitor has, as shown in Fig. 3, a roll of anode foil, paper separator, cathode foil and electrode terminals (internal and external terminals) with the electrolyte impregnated, which is sealed in an aluminum can case with a sealing material. The terminal draw-out structure, sealing material and structure

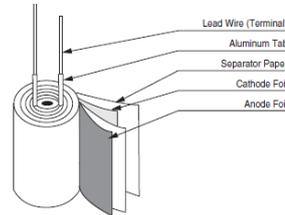


Fig-3 Basic model of element

2) The terminal draw-out structure, sealing material and structure differ depending on the type of the capacitor. Figure 4 shows typical examples.

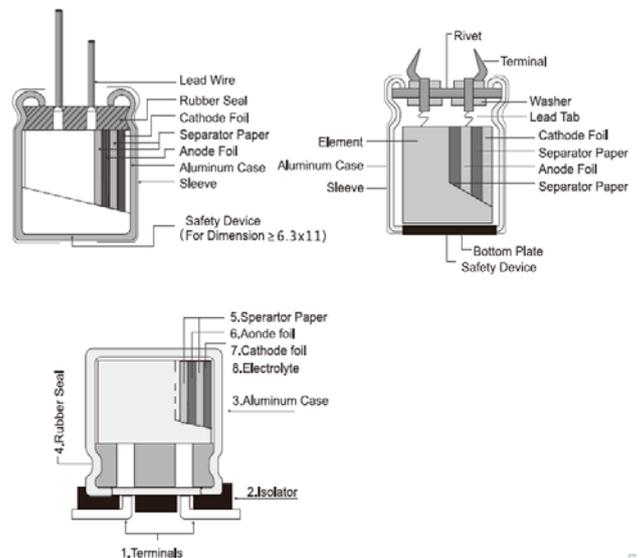


Fig-4 Construction of Aluminum Electrolytic Capacitors

1-3 Features of Capacitor Materials

Aluminum, which is main material in an aluminum electrolytic capacitor, forms an oxide layer (Al₂O₃) on its surface when the aluminum is set as anode and charged with electricity in electrolyte. The aluminum foil with an oxide layer formed thereon, as shown in Fig. 5, is capable of rectifying electric current in electrolyte. Such a metal is called a valve metal.

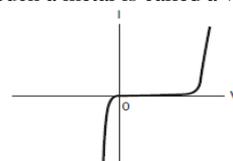


Fig-5 V-I characteristics of aluminum oxide

<Anode aluminum foil>

First, the foil material is electromechanically etched in a chloride solution to extend the surface area of the foil. Secondly, for the foil to form an aluminum oxide layer (Al_2O_3) as a dielectric, more than the rated voltage is applied to the foil in a solution such as ammonium borate. This dielectric layer is as dense and thin as 1.1 - 1.5 nm/volt and showing a high insulation resistance (108 - 109 Ω/m). The thickness of the oxide layer determines withstand voltage according to their direct proportional relationship. For the etching pits to be shaped to the intended thickness of the oxide, the pit patterns have been designed to have efficient surface area extension depending on the intended withstand voltage (see Fig. 6)

<Cathode aluminum foil>

An etching process is performed to the cathode aluminum foil as well as the anode foil. However, the formation process for oxide layer is generally not performed. Therefore, the surface of the cathode foil only has an oxide layer (Al_2O_3) that has spontaneously formed, which gives a withstand voltage of about 0.5 volt

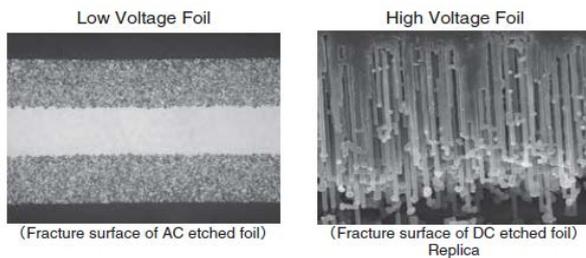


Fig-6 Cross section of aluminum etched foil (SEM)

<Electrolyte>

The electrolyte, an ion-conductive liquid functions as a true coming into contact with the dielectric layer on the surface of the foil. The cathode foil serves as a collector electrode to connect the cathode with the external circuit. Electrolyte is an essential controls the performance of the capacitor (temperature frequency characteristics, service life, etc.).

<Paper separator >

The separator maintains uniform distribution of the electrolyte and keeps the anode-to-cathode foil distance unchanged.

<Can case and sealing materials>

An aluminum can case and seal materials mainly consisting of rubber are used for the purpose of keeping airtightness.

1-4 Manufacturing Process

① Etching (for extending the surface area)

This etching process serves to extend the surface area of the foil. This is an AC or DC current-employed electrochemical process for etching the foil surface in a chloride solution (see Fig. 7)

② Formation (for forming a dielectric)

This is a process for forming a dielectric layer (Al_2O_3), which is normally performed on the anode aluminum foil. (see Fig. 8)

③ Slitting

This is a process for slitting aluminum foils (both the anode and cathode) and separator paper to the specified product size. (see Fig. 9)

④ Winding

This is a process for rolling a set of anode and cathode foils into a cylindrical form with a paper separator inserted between them. During this process, an inner terminal (called a tab) is attached to each of the aluminum foils. The roll made at this process is called a capacitor element.

⑤ Impregnation

This is a process for impregnating the element with electrolyte as a true cathode. The electrolyte also functions to repair the dielectric layer. (see Fig. 11)

⑥ Sealing

This process seals the element using the aluminum can case and sealing materials (rubber, rubber-lined cover, etc.) for keeping the case airtight. (see Fig. 12)

⑦ Aging (reforming)

The process of applying voltage to a post-sealed capacitor at high temperature is called "aging". This serves to repair defective dielectrics that have been made on the foil during the slitting or winding process.

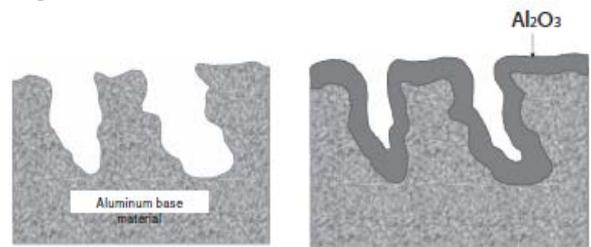
⑧ 100% inspection and packaging

After the aging, all products shall undergo testing for checking their electrical characteristics with chip termination, lead reforming, taping etc. finished, and then be packaged.

⑨ Outgoing inspections

Outgoing inspections are performed as per standard inspection procedures.

⑩ Shipment

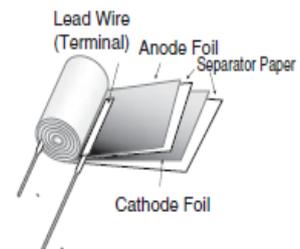


see Fig. 7 Etching Model

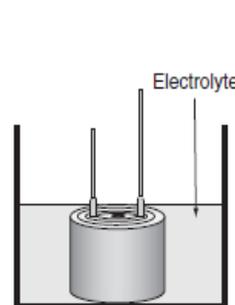
see Fig. 8 Forming Model



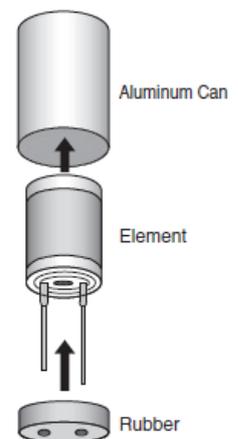
see Fig. 9 Slitting Model



see Fig. 10 Cathode Foil



see Fig. 11 Impregnation



see Fig. 12

2 . Basic Performance

2-1 Basic Electrical Characteristics

2-1-1 Capacitance

The larger the surface area of an electrode is, the higher the capacitance (capacity for storing electricity) is. For aluminum electrolytic capacitors, capacitance is measured under the standard of 20°C and a 120Hz AC signal of about 0.5V. Generally, as the temperature rises, the capacitance increases; as the temperature decreases, the capacitance decreases (Fig. 13). With a higher frequency, the capacitance is smaller; with a lower frequency, the capacitance is larger (Fig.14).

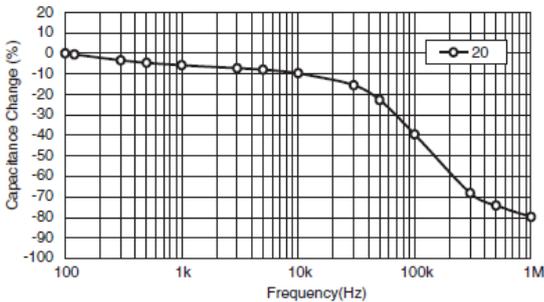
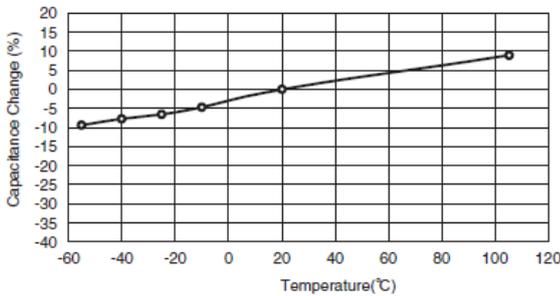


Fig-14 Frequency Characteristics of Capacitance

2-1-2 Tanδ (also called tangent of loss angle or dissipation factor)

(Fig. 15) is a simplified model of the equivalent circuit shown in (Fig. 15). For an ideal capacitor with an equivalent series resistance of R = 0, the tanδ shown in (Fig. 10) is zero. For an aluminum electrolytic capacitor, the equivalent series resistance (R) is not zero due to the presence of resistance of the electrolyte and paper separator and other contact resistances. 1/ωC and R are correlated as shown in (Fig. 16) and Equation (2).

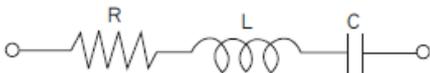


Fig-15 Simplified equivalent circuit

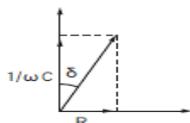


Fig-16 Dissipation Factor (tanδ)

$$\tan \delta = \frac{R}{1/\omega C} = \omega CR \dots\dots\dots (2)$$

ω : 2 π f
 π = Circular constant, f : Frequency (f = 120Hz)

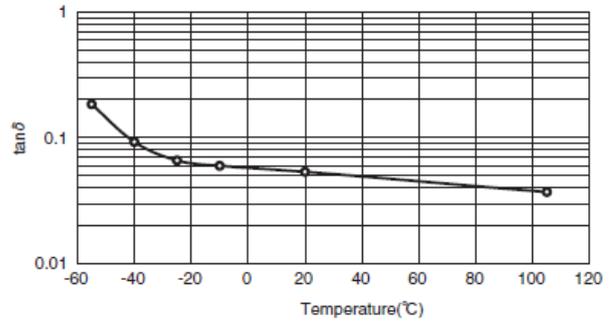


Fig-17 Temperature Characteristics of tanδ

2-1-3 Leakage Current (LC)

- ① As a feature of an aluminum electrolytic capacitor, when DC voltage is applied to it, the oxide layer that acts as a dielectric in the electrolyte allows a small amount of electric current to flow in it. The small amount of current is called a leakage current (LC). An ideal capacitor does not allow the leakage current to flow (this is not the case for charging current).
- ② The leakage current (LC) changes with time as shown in (Fig. 18). Therefore, the specifications of LC are defined as a value of the rated voltage at 20°C. As the temperature rises, the LC increases; as the temperature decreases, the LC decreases (Fig.19). As the applied voltage decreases, the LC decreases.

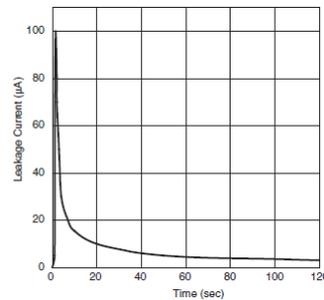


Fig-18 Leakage Current vs. Time

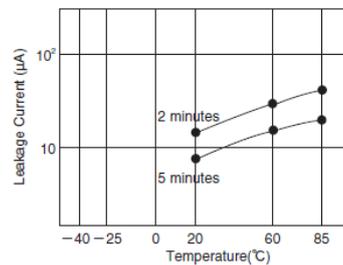


Fig-19 Temperature Characteristics of Leakage Current

2-2 Frequency Characteristics of Impedance (Z)

- ① When a capacitor is applied with a voltage with the frequency changed, the impedance (Z), a factor of preventing the AC current changes as shown in (Fig. 14). This is the impedance-frequency characteristics of the capacitor.
- ② (Fig. 15) is a simplified model of an equivalent circuit of an aluminum electrolyte capacitor. (Fig. 20) shows dotted lines representing a breakdown of the impedance-frequency characteristic curve into components (C, R and L). As can be seen in this figure, the impedance-frequency characteristics are a composition of C, R and L frequency characteristics.

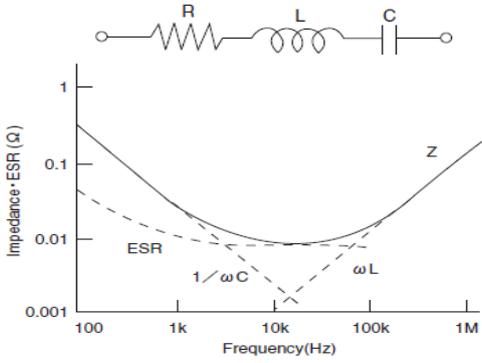


Fig-20 Factor of Impedance Frequency

③ The value $1/\omega C$ shows the pure capacitive reactance graphically presented by a straight line going downward at an angle of 45° , and ωL shows the pure inductive reactance graphically presented by a straight line going upward at 45° . R shows the equivalent series resistance (ESR). At a range of lower frequencies, the R curve goes downward due to the dielectric loss frequency-dependence. At a range of higher frequencies, the R curve tends to be almost flat since resistance of electrolyte and paper separator is dominant and independent on frequency. Equation (3) shows this tendency.

$$Z = \sqrt{R^2 + \left(\omega L - \frac{1}{\omega C}\right)^2} \dots\dots\dots (3)$$

④ Because the impedance characteristics of an aluminum electrolyte capacitor depend on resistance of the electrolyte and paper separator, the Z value at the self-resonant frequency tends to be shown by the solid line in (Fig.21). The resistance of the electrolyte varies depending on temperature: as the temperature rises, the impedance decreases; and as the temperature decreases, the impedance increases, as shown in (Fig. 22).

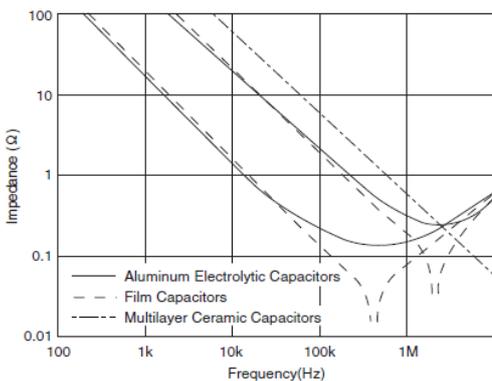


Fig-21 Frequency Characteristics of each Capacitors Impedance

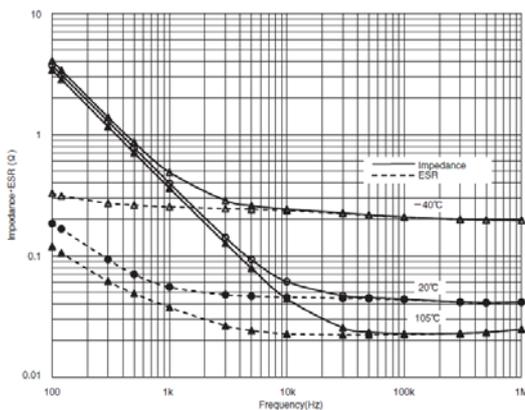


Fig-22 Temperature and Frequency Characteristics of Impedance · ESR

3 . Reliability

For designing the device with aluminum electrolytic capacitors, a failure rate and useful life are necessary to be considered for their reliability. The failure rate of aluminum electrolytic capacitors is approximated by the bathtub curve shown in (Fig.23).

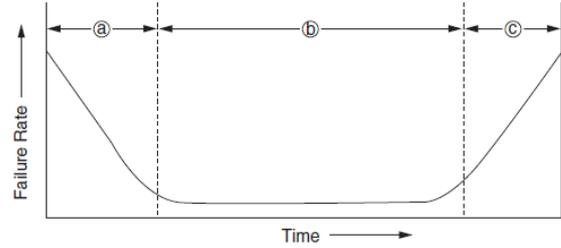


Fig-23 Bathtub curve

- a Early failure period
At the comparatively early periods of use, devices/components fail by deficiencies in design or manufacturing process or incompatibility with operation conditions. For aluminum electrolytic capacitors, these defectives are removed by debugging at one of manufacturing processes before shipments.
- b Random failure period
Failure is stable low in occurrence and appears unrelated to their served term. Aluminum electrolytic capacitors are low in failures in this period compared with semi-conductors and solid tantalum capacitors.
- c Wear-out failure period
In this period, the failure rate increases with the served time. For aluminum electrolytic capacitors, since they were completed in manufacturing, the electrolyte impregnated has gradually evaporated and diffused out of the capacitors through the rubber seal materials with time, which leads to decrease in the capacitance and/or increase in $\tan\delta$. When any of these values changes beyond the allowable range of specifications, the capacitors are defined as “fell into the wear-out failure”. The served term until the capacitors fall into the wear-out failure period is called a useful life.

4 . Failure Modes

Aluminum electrolytic capacitors have two categories of failures: catastrophic failure and wear-out failure.

<Catastrophic failure>

This is a failure mode that completely destroys the function of the capacitor such as short circuit and open circuit failure

<Wear-out failure>

This is a failure mode where the electrical parameters of the capacitor gradually deteriorate and fail. The criteria for determining if this failure has occurred depend on the purpose of a device.

For each series of capacitors, the following electrical parameters have been defined as criteria in the specifications of Endurance in the catalogs or product specifications:

- Change in capacitance
- $\tan\delta$
- Leakage current

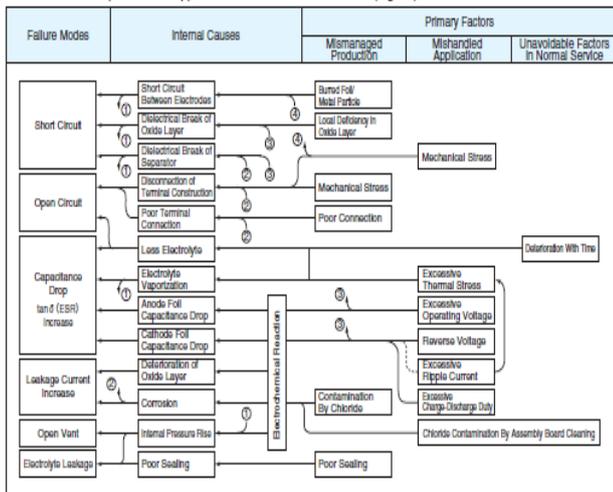
① Failure rates are often measured in units of % per 1000 hours (10^{-5} /hour). For higher reliability devices designed with a smaller failure rate, units of Failure In Time (FIT) (10^{-9} /hour) is used.

② Aluminum electrolytic capacitors are considered as components of wear-out failure mode, the electrical characteristics of which gradually deteriorate and their failure rate increases with time. In general, the failure rate in FIT is determined by total component-

hours (product of the number of tested components and test hours).

③ Due to the definition of FIT, the same FIT rate can be calculated in both cases of testing on the large number of tested components and also testing for long test periods of time. However, these cases mean differently for aluminum electrolytic capacitors. Using the failure rate is not suited to express the reliability of aluminum electrolytic capacitors, but the electrical characteristics based lifetime in hour should be considered to express the reliability.

④ Also, there are MTBF (Mean Time Between Failures) and MTTF (Mean Time To Failure) to express reliability. The latter is applicable for aluminum electrolytic capacitors because they are categorized into a group of non-repairable systems, equipment and devices for which MTTF is applicable. Failure modes depend on the application conditions that lead to fail. (Fig. 24).



- L_x = Expected life period (hrs) at actual operating temperature
- T_0 = Maximum operating temperature (°C) allowed
- T_x = Actual operating ambient temperature (°C)
- I_x = Actual applied ripple current (mA rms) at operating frequency f_0 (Hz)
- I_0 = Rated maximum permissible ripple current IR (mA rms) x frequency multiplier (Cf) at f_0 (Hz)
- V_0 = Rated voltage (V)
- V_x = Actual applied voltage (V)
- ※ Ripple Current calculation: no need Temperature Multiplying Factor.
- ※ For Ripple life, I_x and V_x Should be 80% equal or more of I_0 and V_0 , if less than 80%, calculate with 80%.
- $\Delta T_0 \leq 5^\circ\text{C}$ = Maximum temperature rise (°C) for applying I_0 (mA rms)
- ΔT_c = Temperature rise (°C) of capacitor case for applying I_x (mA rms)
- ΔT_x = Temperature rise (°C) of capacitor element for applying I_x (mA rms)

$\Delta T_c = T_c - T_x$
 $\Delta T_x = K_c \Delta T_c = K_c (T_c - T_x)$
 where T_c is the surface temperature (°C) of capacitor case
 T_x is ditto.

K_c is transfer coefficient between element and case of capacitor from table below :

Φ	≤ 8	10	12.5/13	16	18	22	25	30	35
K_c	1.10	1.15	1.20	1.25	1.30	1.35	1.40	1.50	1.65

※ The estimated life is limited to 15 years, if it exceeds 15 years, take 15 years as standard.

★ The formula of Equivalent Series Resistance (ESR)
 The operating frequency of ESR, DF, f & C must be the same, usually they test at 120 Hz.

$$ESR = DF / 2\pi f C \dots \dots \dots (2)$$

Where DF: Dissipation Factor (tanδ) f: Operating frequency (Hz)
 C: Capacitance (F)

★ Estimation of life considering the ripple current

The ripple current affects the life of a capacitor because the internal loss (ESR) generates heat. The generated heat will be:

$$P = I^2 R \dots \dots \dots (3)$$

Where I: Ripple current (Arms.) R: ESR (Ω)

At this time the increase in the capacitor temperature will be:

$$\Delta T = I^2 R / AH \dots \dots \dots (4)$$

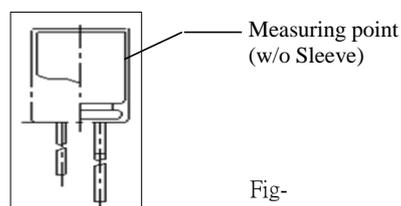
Where ΔT: Temperature increase in the capacitor core (degree)

I: Ripple current (Arms) R: ESR (Ω)

A: Surface area of the capacitor (cm²)

H: Radiation coefficient (Approx. 1.5~2.0 · 10⁻³ W / cm² · °C)

The above equation (4) shows that the temperature of a capacitor increases in proportion to the square of the applied ripple current and ESR, and in inverse proportion to the surface area. Therefore, the amount of the ripple current determines the heat generation, which affects the life. The values of ΔT varies depending on the capacitor types and operating conditions. The usage is generally desirable if ΔT remains less than 5°C. The measuring point for temperature increase due to ripple current is shown below. (Fig. 25).



5. Circuit Design Fig-24 Failure Modes

1) Operating Temperature, Equivalent Series Resistance (ESR), Ripple Current and Load Life

★ MTTF (Mean-Time-To-Failure) means the useful life at room temperature 25°C.

1-1 Load life:

If the capacitor's max. operating temperature is at 105°C (85°C), then after applying capacitor's rated voltage (WV) for L_0 hours at 105°C (85°C), the capacitor shall meet the requirements in detail specification. where L_0 is called "load life" or "useful life (lifetime) at 105°C (85°C)".

$$V_0 \leq 100\text{WV} : L_x = L_0 \times 2^{(T_0 - T_x) / 10} \times 2^{-\Delta T_x / 5}$$

$$V_0 \geq 160\text{WV} : L_x = L_0 \times 2^{(T_0 - T_x) / 10} \times 2^{-\Delta T_x / 5} \times (V_0 / V_x)^{4.4}$$

where $\Delta T_x = \Delta T_0 \times (I_x / I_0)^2$

1-2 Ripple life:

If the capacitor's max. operating temperature is at 105°C (85°C), then after applying capacitor's rated voltage (WV) with the ripple current for L_r hours at 105°C (85°C), the capacitor shall meet the requirements in detail specification. where L_r is called "ripple life" or "useful ripple life (ripple lifetime) at 105°C (85°C)".

$$V_0 \leq 100\text{WV} : L_x = L_r \times 2^{(T_0 - T_x) / 10} \times 2^{(\Delta T_0 - \Delta T_x) / 5}$$

$$V_0 \geq 160\text{WV} : L_x = L_r \times 2^{(T_0 - T_x) / 10} \times 2^{(\Delta T_0 - \Delta T_x) / 5} \times (V_0 / V_x)^{4.4}$$

where $\Delta T_x = \Delta T_0 \times (I_x / I_0)^2$

The (ripple) life expectancy at a lower temperature than the specified maximum temperature may be estimated by the following equation, but this expectancy formula does not apply for ambient below +40°C.

L_0 = Expected life period (hrs) at maximum operating temperature allowed.
 L_r = Expected ripple life period (hrs) at maximum operating temperature allowed

(2) When the short circuit current value exceeds the above numerical, internal temperature will increased, encapsulation adhesive pad summoned and the odorous gases to overflow.

b. In order to ensure the safety in case of occurs short circuit, please take the following countermeasures

- (1) Cut off the main power supply and stop using immediately if overflow the odorous gases.
- (2) Due to the different conditions , the odorous gases occurrence generally takes a few seconds to several minutes, When using protection circuits we recommend to start protect function in this period.
- (3) Cleaned immediately if the gas enters into eye , gargle immediately if inhalation into mouth.
- (4) Don't lick the electrolyte if electrolyte contact with the skin please washing with soap immediately.
- (5) PC - CON including combustibile material, current value greatly after the short circuit and short circuit parts will have a possibility of spark. In order to protect safety, please pay attention to the design structure and use protection circuit.

2. The wear failure (Shelf life)

Electrical characteristics can make a big change when more than the guarantee time of durability and high temperature and high humidity test, electrolyte will insulation (degradation) formation of open mode eventually.

Even used within the prescribed scope of electrical and mechanical properties, it may also reducing capacitance and increase ESR, so please take care when design.

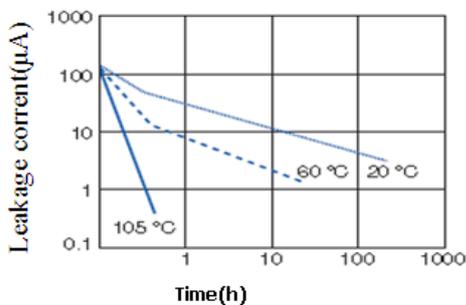
III .Leak Current

The leak current of conductive polymer solid aluminum electrolytic capacitor will increase due to the mechanical stress .

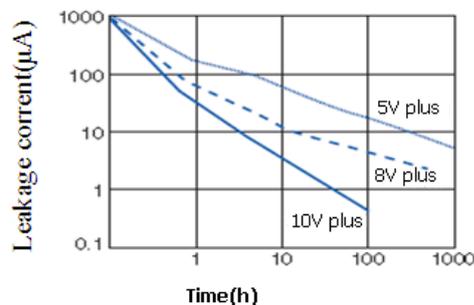
In this case, if the solid capacitor apply voltage below the high using temperature, the repairing effect of leak current will reducing gradually.

If the solid capacitor applies rated voltage within the high using temperature, the repairing speed of leak current will faster.

Conductive polymer solid aluminum electrolytic capacitor
Repiring character of leak current
10 μ F/16 V.DC (apply 16 V.DC)



Conductive polymer solid aluminum electrolytic capacitor
Repiring character of leak current
33 μ F/10 V.DC (ambient temperature65°C)
(Test voltage10V.DC)



※In order to show more clearly said repair of leakage current , we use the sample of apply stress to PC-CON that increased leak current on purp

IV.The limited of faster charging and discharging

Faster charging and discharging will lead to large surge current and then result in short-circuit or increase leak current.

When the surge current value as below, we recommend to use protection circuit in order to maintain high reliability.

- (1) more than 10 A
- (2) exceed rated ripple current 10times

V. Correct mounting

1. About the soldering iron soldering

- (a)Avoiding applying stress on PC - CON body when it need to process lead due to unconformity between lead gap and circuit board gap of plug-in mounting.
- (b)Avoiding applying excessive stress on PC - CON body when soldering.
- (c) When need to take out PC-CON after soldering, please melt molten solder sufficient, implement under the condition of not put stress on the PC - CON body.
- (d) Don't let the tip of the soldering iron to touch the PC - CON body.

2. Wave-soldering

- (a) Do not have wave soldering to SMD product.
- (b) Do not dip the PC-CON body into dissolved soldering flux.
- (c) Welding parts only limited between the circuit board and the opposite side of the PC - CON.
- (d) Don't splash other place expectation rosin.
- (e)Avoiding other parts lie down and touching PC-CON when soldering.

3. Reflow soldering

- (a) Do not have reflow soldeering to plug-in mounting product .
- (b) Please consult us when use VPS for solderinig.

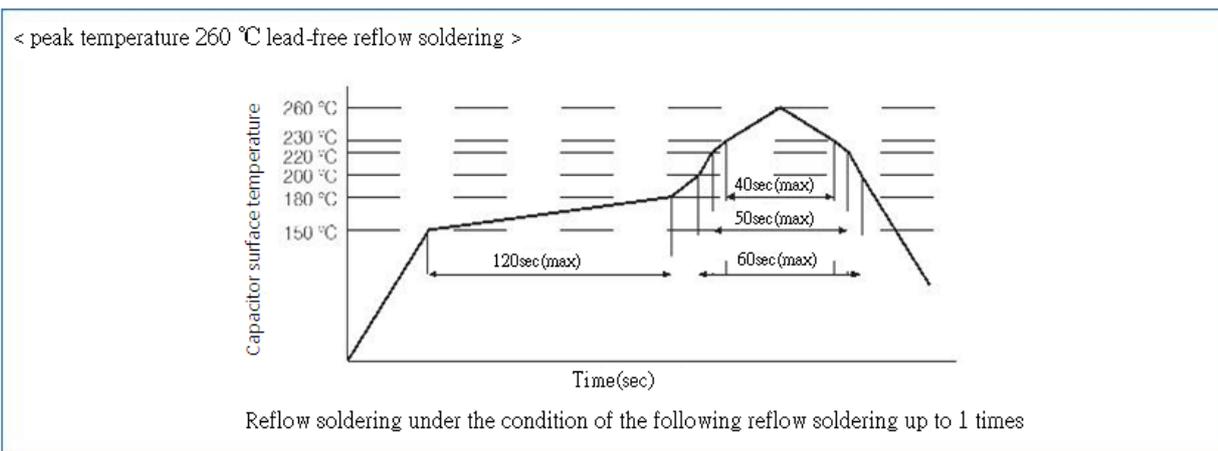
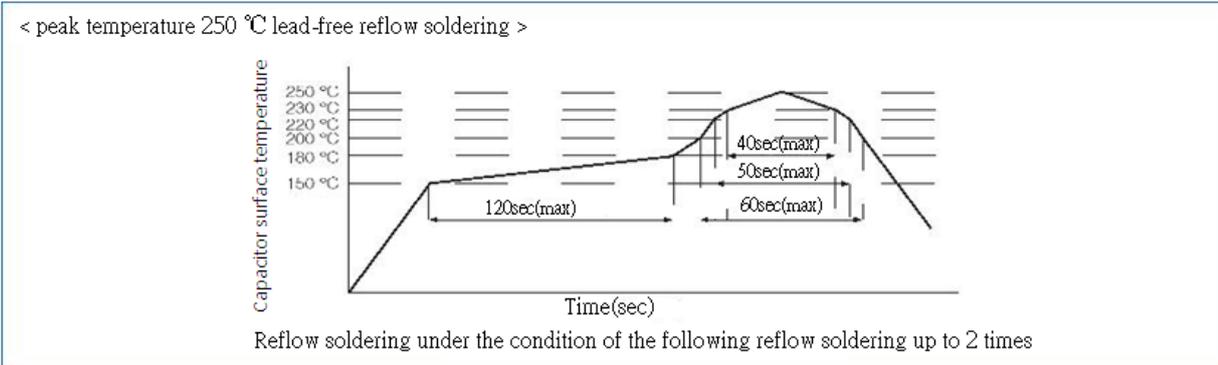
The Proper Usage Method of Conductive Polymer Solid Aluminum Electrolytic Capacitor

4. Precaution after soldering

Take care for not to apply the following excessive stress for polymer solid aluminum electrolytic capacitor.

- (a) Do not tilt down or distorted capacitor.
- (b) Mobile circuit board can not handle PC - CON.
- (c) Do not crash PC-CON.
- (d) Do not make the PC - CON touch PCB circuit boards and other components when stacked.

5. Recommended conditions for solder



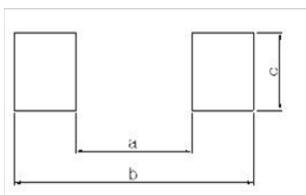
6. Solder iron temperature : less than 400°C±10°C ; working hours : within 5s

Wave-soldering

	Temperature	Time	Number of Time
Preheat	120°C below (ambient temperature)	less than 120s	once
Welding Condition	260°C+ 5°C below	less than 10+ 1s	less than twice*1

*1 : For 2 times, solder dipping time total of 10 + 1 seconds.

7. Recommend the bonding pad size



Unit : mm

Size Code	a	b	c
φ5.0	1.4	7.4	1.6
φ6.3	2.1	9.1	1.6
φ8.0	2.8	11.1	1.9
φ10.0	4.3	13.1	1.9