

Lifetime Estimation of Conductive Polymer Aluminum Solid Capacitors

Subject series : PXN, PXT, PXJ, PXG, PKX, PXS, PXF, PXE, PXA, PXD, PXH, PSW, PSJ, PSG, PSK, PSF, PSE, PSC

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 $\tan \delta$ 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 $\tan \delta$ 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 reducing by half at every 10°C rise 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.

$$L_x = L_o \times 2^{\frac{T_o - T_x}{10}} \times 2^{\frac{-\Delta T}{10}} \dots\dots\dots(1)$$

- 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)
Use 40°C if the actual ambient temperature is below it.
- ΔT : Rise of internal temperature due to the rated ripple current (°C)

Longer lifetime is expected by lowering the ripple current and the ambient temperature.

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

$$\Delta T = \Delta T_o \times \left(\frac{I_x}{I_o} \right)^2 \dots\dots\dots(2)$$

ΔTo : Rise in internal temperature due to the rated ripple current

Maximum category temperature	ΔT _o	
	T _x ≤ 105°C	105°C < T _x ≤ 125°C
105°C	20°C	-
125°C	20°C	3°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

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. The ESR value differs depending on the frequency, thus the degree of self-heat rise differs depending on the ripple current frequency. Therefore, if the actual ripple current frequency differs from the specifications stated in the standard ratings, use the value obtained by multiplying the rated ripple current multiplier to convert the rated current.

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 small ripple current in low-frequency range.

Please ensure that excessive ripple current is not applied to the capacitors in all frequency range.

3. Restriction of estimated lifetime calculation

The result calculated by the estimated lifetime formula, it is not guaranteed lifetime by Nippon Chemi-Con Corporation.

When designer calculate the lifetime of apparatus, please include an ample margin in consideration to the estimated lifetime of a capacitor.

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.

If 15 years or more may be required as an expected lifetime, please consult us.