Lifetime Estimation of Electrolytic Aluminum Capacitors from Jianghai

To estimate the Lifetime of a non-solid Electrolytic Aluminum Capacitor from **Jianghai**, the following formulas can be utilized. The Lifetime depends mainly on the ambient temperature, the ripple current and the rated voltage applied. Other parameters may also affect the Lifetime. Moreover, L_0 can be interpreted in many different ways, which has a fundamental influence on the numerical result. **Jianghai** offers a high transparency by publishing the different typical definitions of Lifetimes in each datasheet. Lifetime estimations are approximations by nature.

Please let **JIANGHAI EUROPE** confirm any result before using it. The formulas given here do not constitute part of a contract nor of a specification. The formulas do not cover additional aging effects of certain electrolytic systems or other chemical effects. Please contact us should you need Lifetime estimates for Solid Electrolyte Polymer Capacitors. Also the dimensions of the components may have an effect. Forced cooling or other additional cooling-methods have a strong impact on the Lifetime and are not covered by the formulas.

For the estimation and interpretation of Lifetime, a close collaboration with **JIANGHAI EUROPE** is strongly advised.

Structural formula:

$$L_X = L_0 \cdot K_T \cdot K_R \cdot K_V$$

Where:

- L_X Total Lifetime
- L_0 Lifetime under Rated Ripple Current at Upper Category Temperature (see catalogue)
- K_T Temperature Factor
- K_R Ripple Current Factor
- K_V Voltage Factor

1. **K_T Temperature Factor:**
   Aluminum Electrolytic Capacitors follow roughly the 10 K rule of Arrhenius. It is possible to estimate the Lifetime by rule of thumb: When the operational temperature is reduced by 10 K, the Lifetime will double.
   The formula for K_T in detail is:

$$K_T = 2^{\frac{T_0 - T_X}{10K}}$$

Where:

- T_0 Rated Temperature
- T_X Actual Operational Temperature

2. **K_R Ripple Current Factor:** The influence of ripple current on Lifetime can be estimated according to the following formula:

$$K_R = K_i^{\,A\frac{\Delta T_0}{10K}}$$

With:

$$A = 1 - \left(\frac{I}{I_0}\right)^2$$

Where:

- I Actual Rated Ripple Current
- I_0 Ripple Current at Upper Category Temperature (databook value)
- ΔT_0 Core Temperature Rise of the capacitor (typically 5K for T_0 = 105°C and 10K for T_0 = 85°C)
- K_i Safety Coefficient, defined as

T_0 = 105°C	$I > I_0$:	$K_i = 4$
	$I \leq I_0$:	$K_i = 2$
T_0 = 85°C		$K_i = 2$

3. **K_V Voltage Factor:** For Radial Electrolytic Capacitors, this part of the formula has no impact ($K_V = 1$). But for some bigger capacitors like Snap-In and Screw-Terminal types, the operational voltage will affect their Lifetime. It is expressed as follows:

$$K_V = \left(\frac{U_R}{U_x}\right)^n$$

Where:

U_R Rated Voltage
U_x Actual Operation Voltage
n Coefficient, defined as:

$$1 \le \frac{U_R}{U_x} \le 1,25 \rightarrow n = 5$$

$$1,25 < \frac{U_R}{U_x} \le 2 \rightarrow n = 3$$

$$2 < \frac{U_R}{U_x} \rightarrow n = 1$$

4. **Frequency Correction Factors:** If the actual Ripple Currents I are not given at the same frequency like I_0, weighing factors need to be applied.

$$I = \sqrt{\left(\frac{I_{f1}}{F_{f1}}\right)^2 + \left(\frac{I_{f2}}{F_{f2}}\right)^2 + \cdots \left(\frac{I_{fn}}{F_{fn}}\right)^2}$$

I Actual Rated Ripple Current at different frequencies
$I_{f1} \ldots I_{fn}$ Ripple Current at different frequencies
$F_{f1} \ldots F_{fn}$ Frequency Correction Factors for different frequencies

5. **JIANGHAI Electrolytic Capacitor Lifetime Estimation Formula**

$$L_x = L_0 \cdot K_T \cdot K_R \cdot K_V$$

$$= L_0 \cdot 2^{\frac{T_0 - T_x}{10K}} \cdot K_i^{\left[1-\left(\frac{I}{I_0}\right)^2\right] \cdot \frac{\Delta T_0}{10K}} \cdot \left(\frac{U_R}{U_x}\right)^n$$

$T_0 = 105°C$ $\quad I > I_0 \rightarrow K_i = 4$
$\quad I \le I_0 \rightarrow K_i = 2$
$T_0 = 85°C$ $\quad \rightarrow K_i = 2$

$$1 \le \frac{U_R}{U_x} \le 1,25 \rightarrow n = 5$$

$$1,25 < \frac{U_R}{U_x} \le 2 \rightarrow n = 3$$

$$2 < \frac{U_R}{U_x} \rightarrow n = 1$$