

Lifetime Estimation of Aluminum Electrolytic Capacitors from Jianghai

To estimate the Lifetime of a non-solid Aluminum Electrolytic Capacitor from **Jianghai**, the following formulas can be utilized. The Lifetime depends mainly on the ambient temperature, the ripple current and, within certain limits, the operating 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:

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

Where:

L	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:

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

Where:

T_0	Rated Temperature, Upper Category Temperature
T_A	Ambient Temperature

2. K_R Ripple Current Factor:

To estimate the influence of ripple current on lifetime, Jianghai uses a safety factor K_i . Under certain conditions this value can be set to $K_i=2$, which is prolonging the lifetime. Please contact Jianghai Europe for details and approval.

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

With:

$$A = 1 - \left(\frac{I_A}{I_R} \right)^2$$

Where:

I_A	Actual Rated Ripple Current
I_R	Ripple Current at Upper Category Temperature (databook value)
ΔT_0	Core Temperature Rise of the capacitor (typically 3,5~5K for $T_0 = 105^\circ\text{C}$ and 3,5~10K for $T_0 = 85^\circ\text{C}$, see databook value)
K_i	Basis, typically defined as
$T_0 = 105^\circ\text{C}$	$I_A > I_R: K_i = 4$
	$I_A \leq I_R: K_i = 2$
$T_0 = 85^\circ\text{C}$	$K_i = 2$

Remark: Safety Factor K_i may be set as $K_i=2$ under certain defined condition. Please contact Jianghai Europe for approval.

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 with rated voltages above 160V, the operating voltage will affect their Lifetime. It is expressed as follows:

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

Where:

U_R Rated Voltage
 U_A Actual Operating Voltage
 n Exponent, defined as:

$$0,6 \leq \frac{U_A}{U_R} \leq 1 \rightarrow n = 2,5$$

$$0 < \frac{U_A}{U_R} < 0,6 \rightarrow K_V = 3,59$$

4. Frequency Correction Factors:

If the actual Ripple Currents are not given at the same frequency like I_0 , weighted factors need to be applied.

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

I_A Actual Rated Ripple Current (normalized)
 $I_{f1} \dots I_{fn}$ Ripple Currents at different frequencies
 $F_{f1} \dots F_{fn}$ Frequency Correction Factors for different frequencies

5. JIANGHAI Electrolytic Capacitor Lifetime Estimation Formula (incl. Safety Factors).

$$L = L_0 \cdot 2^{\frac{T_0 - T_A}{10K}} \cdot K_i \left[1 - \left(\frac{I_A}{I_R} \right)^2 \right]^{\frac{\Delta T_0}{10K}} \cdot \left(\frac{U_A}{U_R} \right)^{-n}$$

with typical values:

$T_0 = 105^\circ\text{C}$	$I_A > I_R \rightarrow K_i = 4$
	$I_A \leq I_R \rightarrow K_i = 2$
$T_0 = 85^\circ\text{C}$	$\rightarrow K_i = 2$

$$0,6 \leq \frac{U_A}{U_R} \leq 1 \rightarrow n = 2,5$$

$$0 < \frac{U_A}{U_R} < 0,6 \rightarrow K_V = \left(\frac{U_A}{U_R} \right)^{-n} = 3,59$$

ΔT_0 depending on the series: 3,5~10K, see databook value
 $K_V = 1$ for radial electrolytic capacitors or rated voltages <160V.