XP Power

Electrolytic Capacitor Lifetime

May 2013

Effects On Capacitor Lifetime

- Design life at rated temperature
- Ambient temperature & local heating effects
- Ripple current applied
- Frequency of operation
- Core & case surface temperature

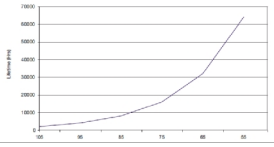
XP Design Rules

- Minimum lifetime of 3 years (24/7/365) under the following operational conditions……
- Nominal input voltage (normally 115VAC)
- 75% of full load
- Ambient temperature 40ºC
- Design rules based on competitive size, power density & cost and compare favourably with competitors
- Lifetime is application specific & by measurement – Load, cooling/positioning, average temperature or mission profile

Mission Profile	
SMPS solution ambient air temperature (°C)	Hours
0-5 deg	0
6-10 deg	21
11-15 deg	5083
16-20 deg	8467
21-25 deg	14896
26-30 deg	42946
31-35 deg	100458
36-40 deg	38792
41-45 deg	3704
46-50 deg	1146
Sum Hours	215513

Arrhenius Equation

- All capacitor lifetime calculations are based on the Arrhenius Equation
- Rate of a reaction doubles with every 10ºC rise in temperature
- In an electrolytic capacitor lifetime doubles for every 10ºC drop in ambient temperature



$$L = L_0 \times 2^{\frac{T_{max} - T_a}{10}}$$

L : Estimated life(Hr)
L_0 : Life at rated temperature (Hr)
T_{max} : Rated Temperature (℃)
T_a : Ambient Temperature (℃)

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Lifetime & Ripple Current

- Heat generated when ripple current applied
  - Ripple current
  - ESR (Ω)
  - Surface area
  - Heat radiation factor (ß)
- Value of (ß) reduces as surface area increases
- Temperature slope between core & surface

$$\Delta T_c = \frac{I^2 \times R}{\beta \times S} \quad \text{----- 4.2}$$

ΔT_c : Surface heat rise (℃)
I : Ripple current (Arms)
R : ESR of capacitor (Ω)
S : Surface area of capacitor (cm^2)
β : Heat radiation factor ($W/℃•cm^2$)

$$\beta = 2.3 \times 10^{-3} \times S^{-0.2}$$

$$\Delta T_j = \alpha \bullet \Delta T_c$$
$$= \Delta T_s \bullet \left(\frac{I}{I_0}\right)^2$$

ΔT_j : Heat rise at core (℃)
α : Factor of temperature difference between core and surface
ΔT_c : Heat rise at surface (℃)
ΔT_s : Heat rise at core when rated ripple current is applied (℃)
I : Actual ripple current converted to specified frequency (Arms)
I_0 : Rated ripple current (Arms)

Table 4-1 Temperature Difference Factor (Radial Lead Capacitors)

Case Dia (mm)	3 to 8	10, 12.5	16, 18
α	1	1.1	1.2

Table 4-2 Temperature Difference Factor (Snap-In Capacitors)

Case Dia (mm)	20	22	25	30	35
α	1.3	1.3	1.4	1.5	1.64

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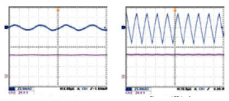
Ripple Current Specifications

- Rated ripple current at rated temperature
- Frequency multiplier
- Temperature multiplier



◆ **MULTIPLIER FOR RIPPLE CURRENT**
Frequency coefficient

Frequency (Hz)		60(50)	120	500	1k	10k≦
Coefficient	200WV	0.80	1.00	1.20	1.30	1.50
	400～450WV	0.80	1.00	1.20	1.25	1.40

105°C type:

Ambient Temp.(°C)	105	85	≤ 65
Coefficient	1.0	1.7	2.1

$$I = \sqrt{\left(\frac{I_1}{k_1}\right)^2 + \left(\frac{I_2}{k_2}\right)^2 + \left(\frac{I_3}{k_3}\right)^2} \quad \text{----- 4.6}$$

I : Converted ripple current value to specified frequency (Arms)
I_n : Actual ripple current (Arms)
k_n : Frequency coefficient listed in catalog

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Lifetime Formula

$$L = \frac{Lo * 2^{\frac{105 - Tcase - \frac{(Ir - Ir105)(Ir + Ir105)}{(Ir85 - Ir105)(Ir85 + Ir105)} X\,20}{10}}}{365 * 24}$$

Results

C14 15-0304-107
100uF 25V 6.3x11.2mm
Cap Temp= 72 C

Symbol	Specifications	Lo (hrs)	Rated Ripple Ir105 (mA)	Measured Ripple (mA)	Estimated Life (yrs)	Min Years
C14	Nichicon UPW1E101MED	2000	290	2	4.5	3
C14	Rubycon 25YXF100MS3X11	5000	250	2	11.3	3
C14	Taicon THW1E101MK06110LL	5000	340	2	11.3	3
C14	Chemicon ELXZ250ELL101MFB5D	2000	290	2	4.5	3

C48 10005970
1200uF 16V 10x25mm
Cap Temp= 78 C

Symbol	Specifications	Lo (hrs)	Rated Ripple Ir105 (mA)	Measured Ripple (mA)	Estimated Life (yrs)	Min Years
C48	Panasonic EEUFR1C122L	5000	2470	1800	5.1	3

Lifetime Estimation

- Measured case temperature is a good indication of lifetime
- Lifetime at rated temperature provides a base for calculation
- Apply multiplication factor of 2 for every 10ºC below rated temperature

105ºC	2000hrs (0.23 years)	105ºC	5000hrs (0.57 years)
95ºC	4000hrs (0.46 years)	95ºC	10000hrs (1.14 years)
85ºC	8000hrs (0.91 years)	85ºC	20000hrs (2.28 years)
75ºC	16000hrs (1.82 years)	75ºC	40000hrs (4.56 years)
65ºC	32000hrs (3.65 years)	65ºC	80000hrs (9.31 years)
55ºC	64000hrs (7.30 years)	55ºC	160000hrs (18.2 years)*

* Lifetime calculations above 15 years should be considered as 15 years maximum

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