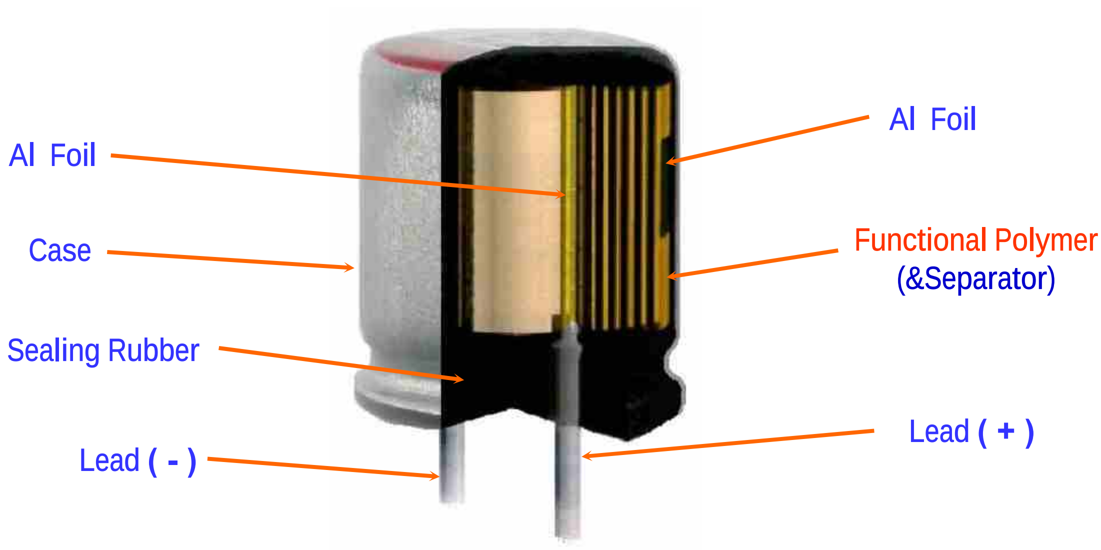
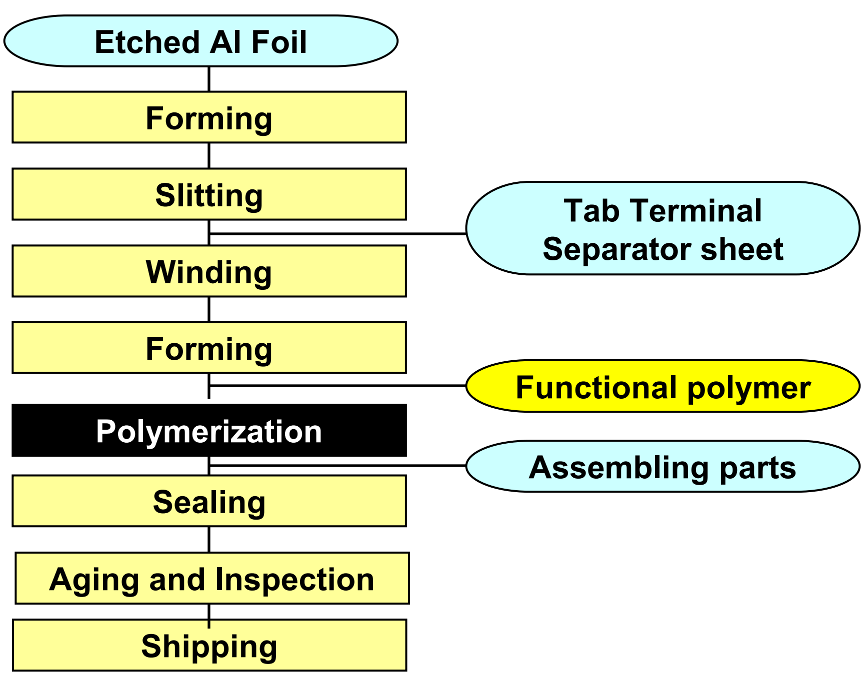
Construction and Characteristics of FPCAP

Construction of FPCAP

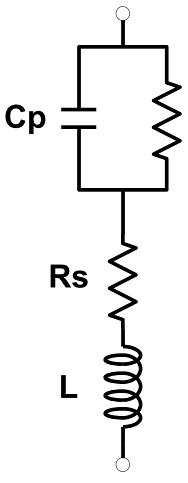


FPCAP is roughly the same construction as an aluminum electrolytic capacitor, and uses rolled aluminum foils in its capacitor element.

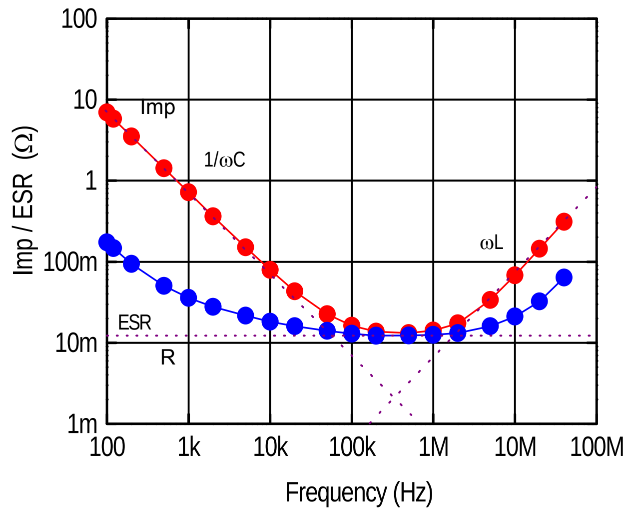
Manufacturing Process of FPCAP



Equivalent Circuit of Capacitor



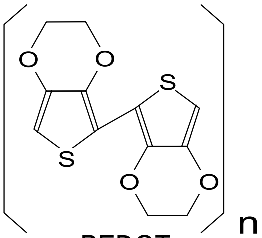
Cp : Capacitance
Rp : Equivalent parallel resistance (Insulation resistance) (≅Rated Voltage/LC)
Rs : Equivalent series resistance
L : Inductance



$$|Z| = \sqrt{\left\{Rs + \frac{Rp}{(1+\omega^2Cp^2Rp^2)}\right\}^2 + \left\{\omega L - \frac{\omega CpRp^2}{(1+\omega^2Cp^2Rp^2)}\right\}^2}$$

Feature of Functional Polymer

(Ω·cm)	
100	Electrolyte (Aluminum Electrolytic Capacitor)
10	Manganese dioxide (Tantalum Solid Electrolytic Capacitor)
1	TCNQ Complex salt (Organic Semiconductive Capacitor)
0.1	PPY by Chemical Polymerization
	PPY by Electrolytic Polymerization
0.01	Conductive Polymer (PEDOT)

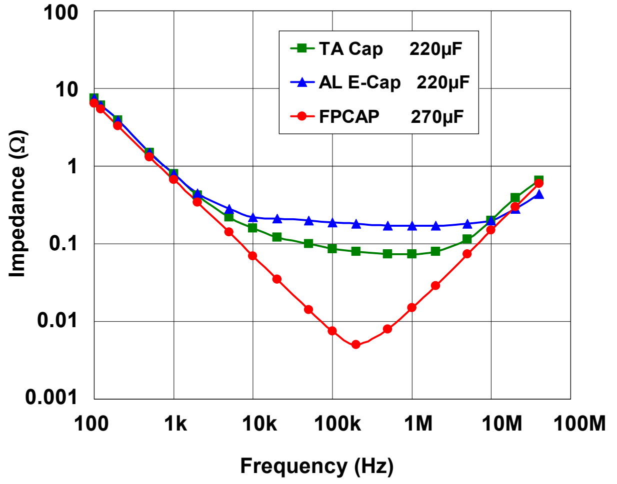


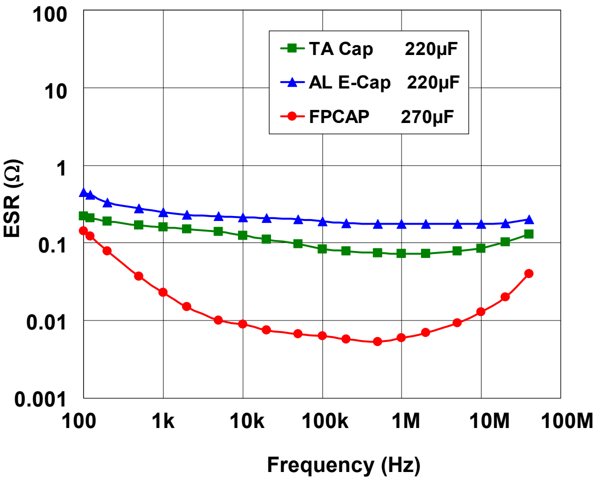
PEDOT

FPCAP differs from the aluminum electrolytic capacitor in that in place of the electrolyte, functional polymer is impregnated.

Typical Electrical Characteristics of Capacitors

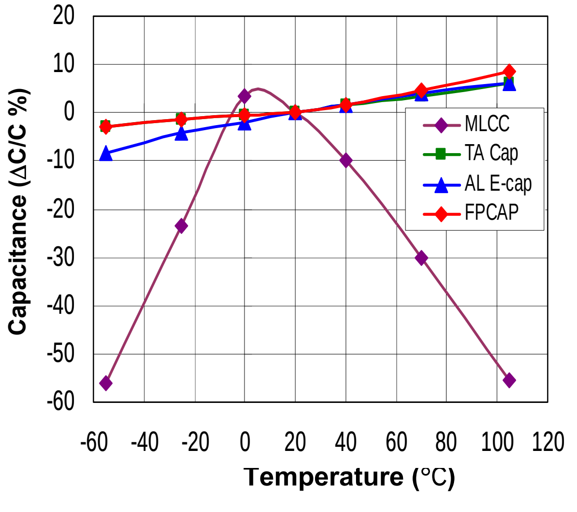
Frequency Dependence

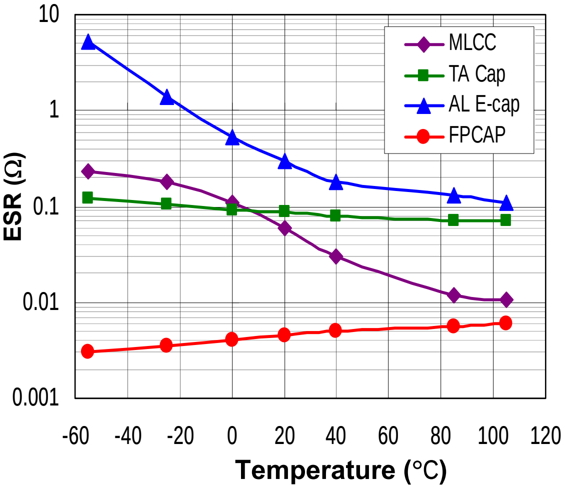




FPCAP has excellent frequency characteristic nearly equal to the film capacitor.
Using the high conductivity of the Functional polymer with an electrolyte, and adopting the winding element for layer thinness of electrolyte, the ESR is improved greatly and has the frequency characteristic that is nearly equal to the film capacitor.

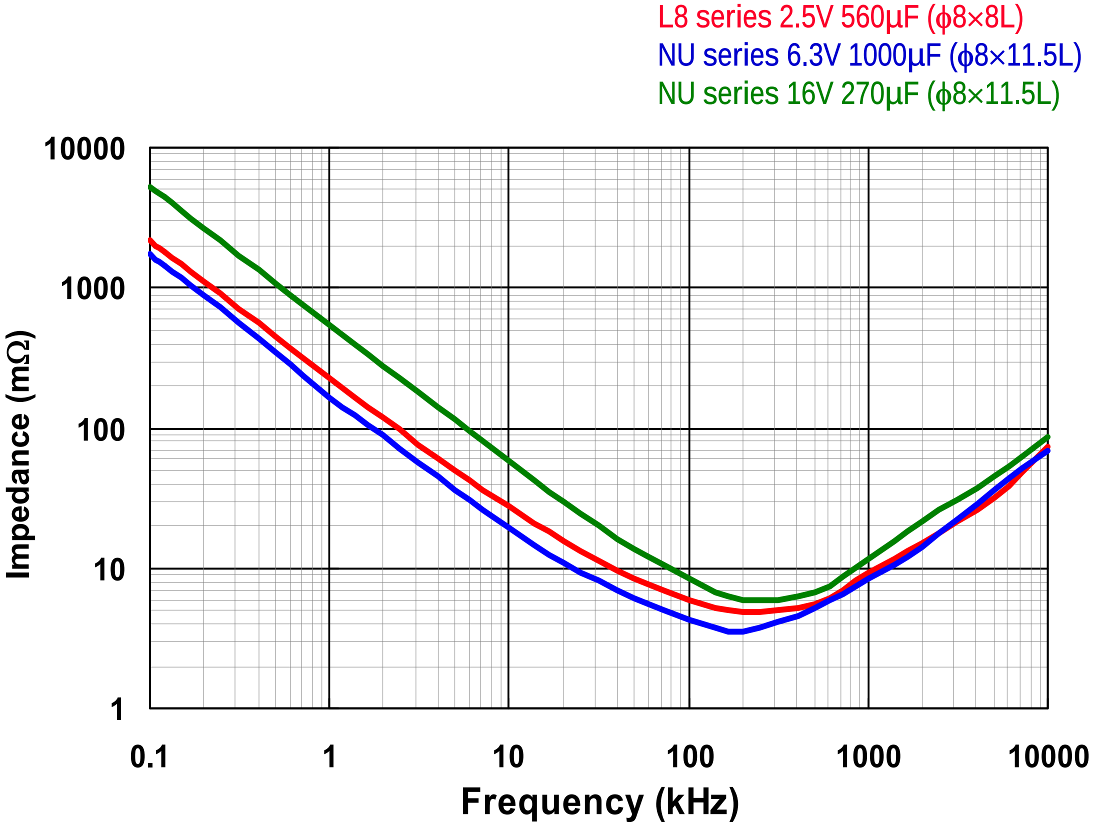
Typical Temperature Dependence of Capacitors

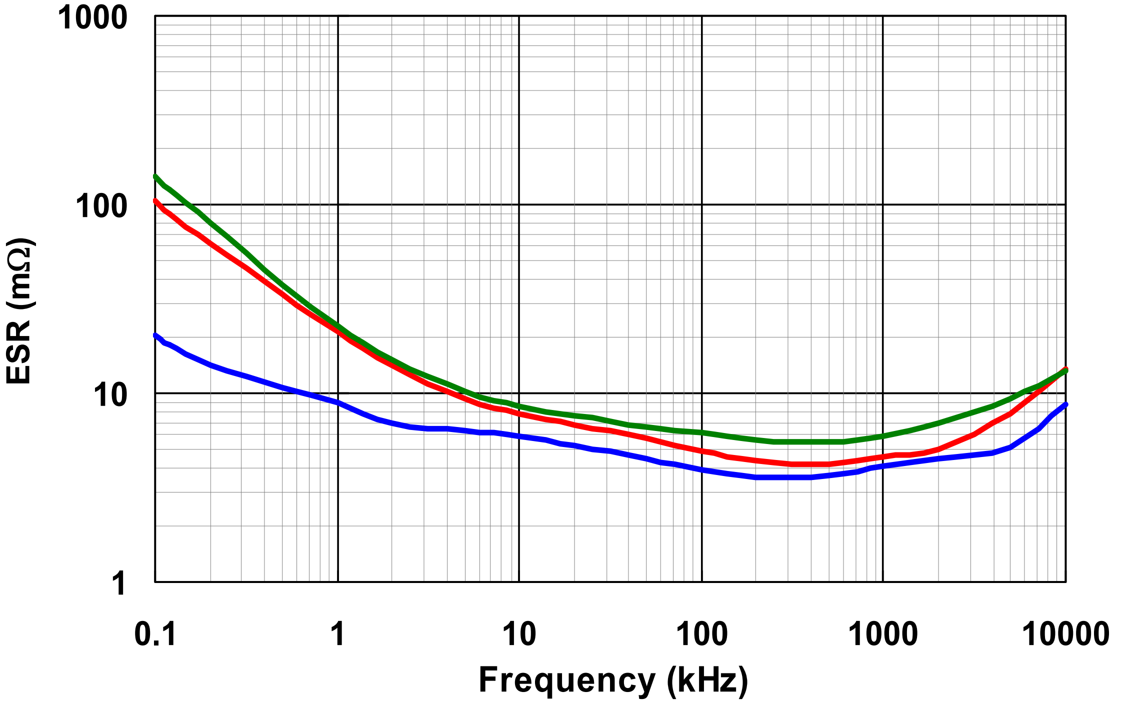




The temperature dependence of the FPCAP is that it features little change in temperature for the ESR.
Since ESR is dominant at high range of impedance (near resonance point), the ESR value greatly affects Noise clearing capacity.
What ESR changes little against temperature means that Noise clearing ability changes little against temperature as well.

Frequency Dependence

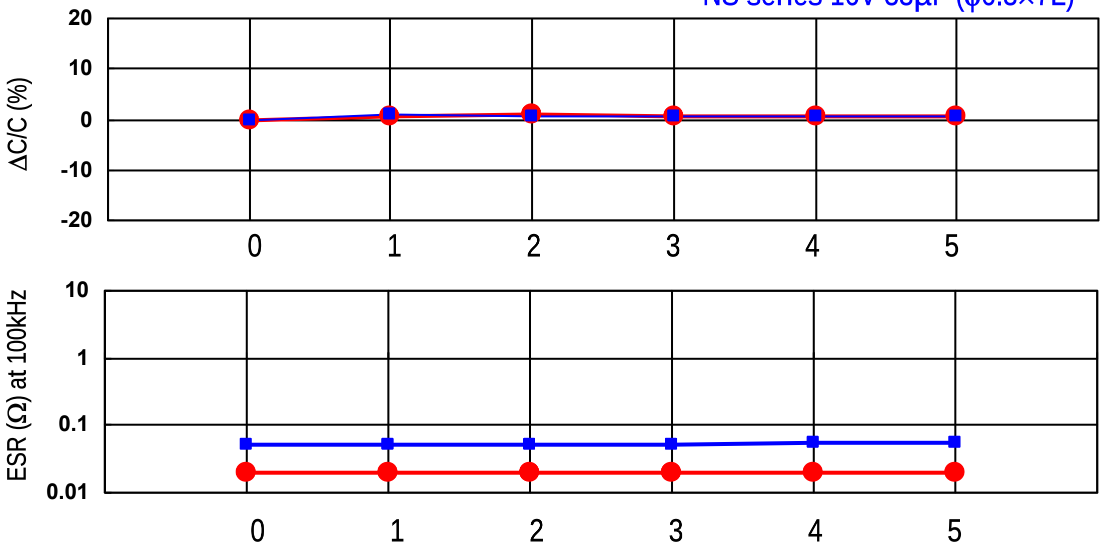




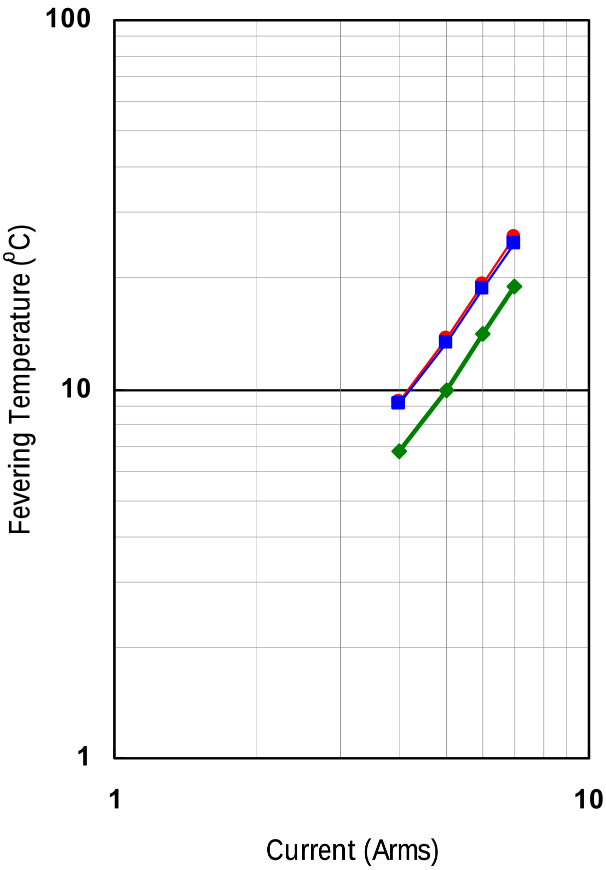
Resistance to Soldering Heat

Test condition : 260°C, 30sec

NS series 10V 220µF (ϕ10×12.5L)
NS series 16V 33µF (ϕ6.3×7L)



Fevering Temperature by Ripple Current



L8 series 2.5V 560µF (ϕ8×8L)
R7 series 2.5V 820µF (ϕ8×11.5L)
R7 series 4.0V 820µF (ϕ10×12.5L)

$I^2 R = \Delta T \times \beta \times S = \Delta Tc \times \alpha \times \beta \times S$
$\Delta Tc = (I^2 R) / (\alpha \times \beta \times S)$

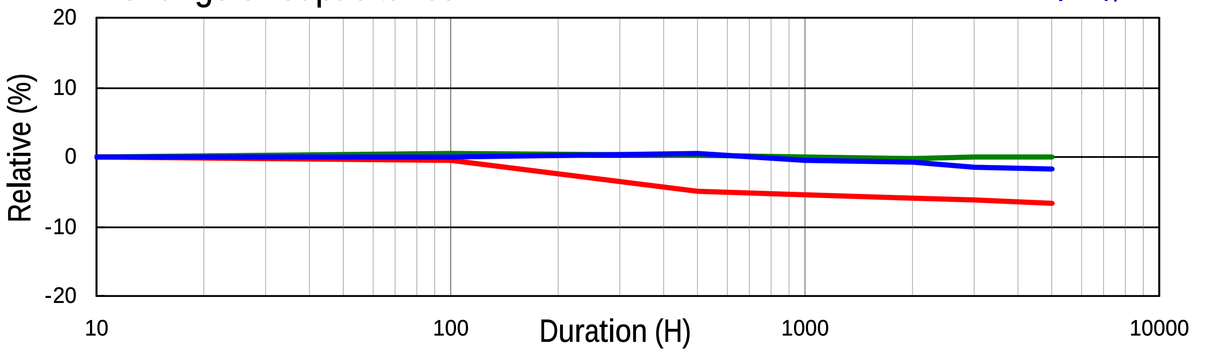
$\log \Delta Tc = \log (I^2 R) / (\alpha\beta S)$
$= \log I^2 + \log R - \log \alpha\beta S$
$= 2 \times \log I + (\log R - \log \alpha\beta S)$
$= 2 \times \log I + A$

Where,
I : Ripple Current (Arms)
R : ESR (Ω)
ΔT : Fevering Temp. at Outside Wall of Capacitor (°C)
ΔTc : Fevering Temp. at Inside of Capacitor (°C)
β : Heat Radiation coefficient (W/ °C×cm^2)
S : Surface Area of Aluminum Case(cm^2)
α : Ratio of ΔTc/ ΔT

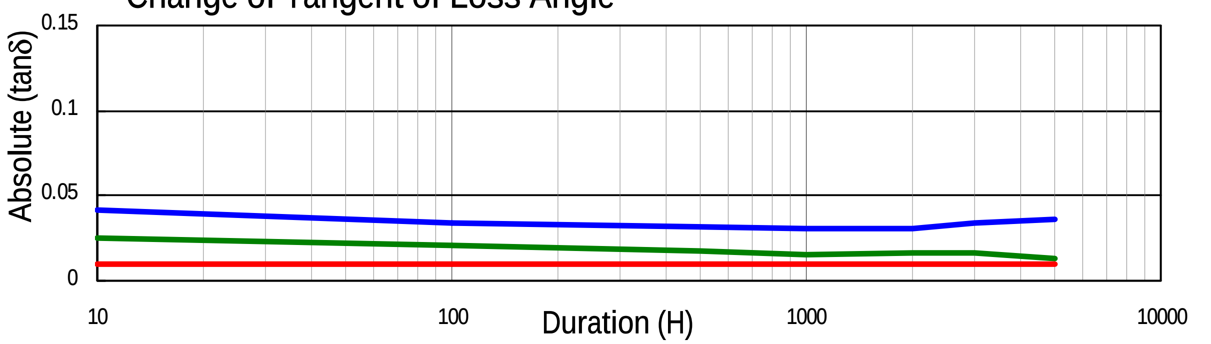
Reliability at 105°C

NS series 6.3V 47μF (ϕ6.3×7L)
L8 series 2.5V 560μF (ϕ 8×8L)
NS series 4.0V 1200μF (ϕ10×12.5L)

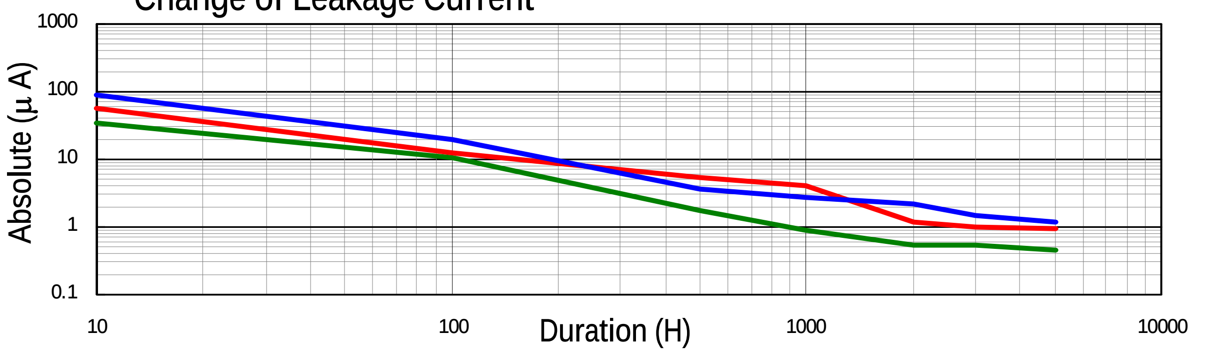
Change of Capacitance



Change of Tangent of Loss Angle



Change of Leakage Current



Change of Equivalent Series Resistance

FPCAP *Functional Polymer Aluminum Solid Electrolytic Capacitors*

Calculation Formula of Lifetime

For FPCAP

In general, calculation formula of lifetime of capacitors is appeared as follows.
The calculation formula of lifetime on FPCAP is same as usual Aluminum capacitor.

$$L_X = L_0 \times 10^{(T_0 - T_X)/20}$$

Where,

L_X (Hrs) =Life expectance in actual use
L_0 (Hrs) =Life time
T_0 (105°C) =Maximum operating temperature (105°C)
T_X (°C) =Temperature of capacitor in actual use

On the other hand, temperature Tx adds the circumference temperature T as the capacitor temperature and the generating temperature ΔT by ripple current.

$$T_X = T + \Delta T$$

T (°C) = Ambient temperature
ΔT (°C) = generating temperature

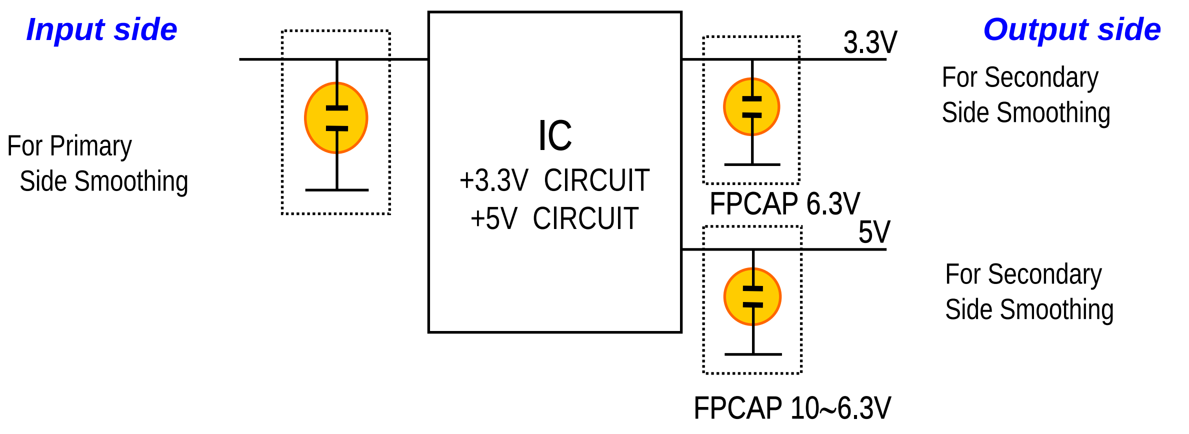
Furthermore, the generating temperature ΔT by the ripple current is proportional to ripple current, and is shown by the following formula.

$$\Delta T = (I / I_0)^2 \times \Delta T_0$$

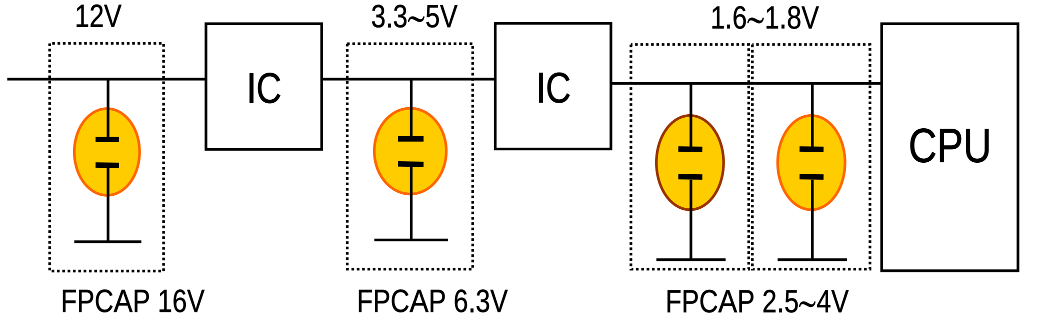
I (A rms) = Ripple current in actual use
I_0 (A rms) = Maximum permissible ripple current
ΔT_0 (°C) = Generated temperature value by maximum permissible ripple current
[About 20 (°C)]

FPCAP Functional Polymer Aluminum Solid Electrolytic Capacitors

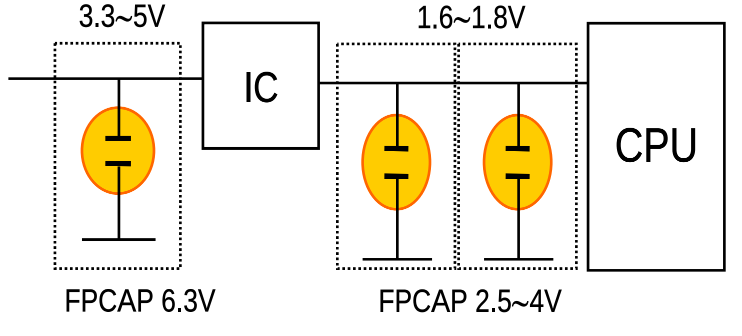
DC/DC Converter Primary, Secondary Side Smoothing



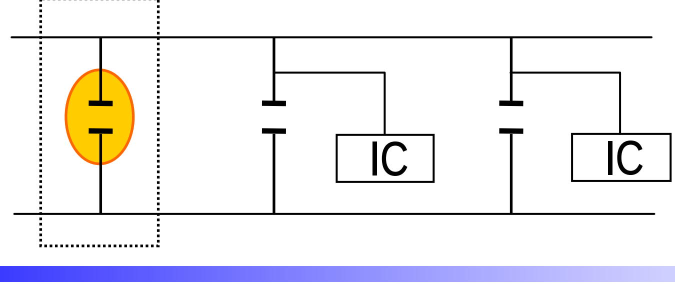
Back-up Capacitor for Variable Load (1)



Back-up Capacitor for Variable Load (2)

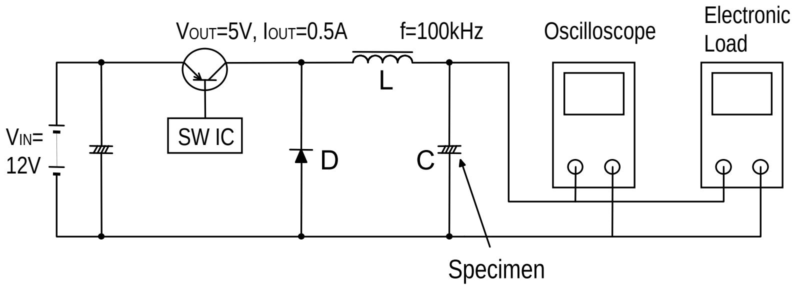


Noise Filters

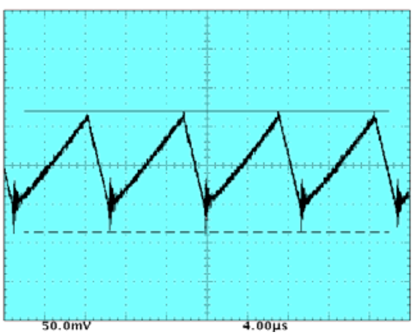


Ripple Removal Capability

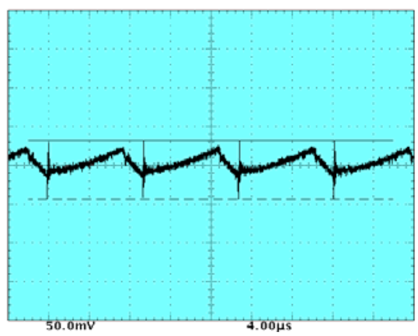
We measured ripple voltage by oscilloscope for output capacitor change on the typical chopper type DC-DC converter. (described below)



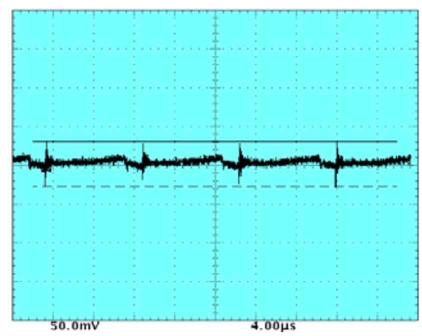
Comparison Between FPCAP and Other Capacitors with Same Capacitance



Low Impedance Aluminum Capacitor
16V100uF (φ6.3x11L)
ΔV=156mV



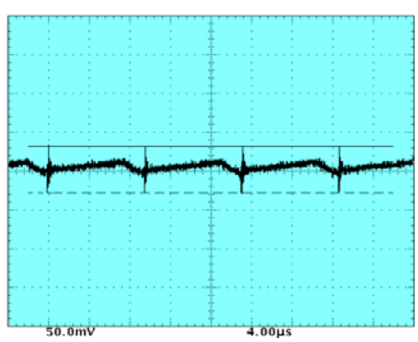
Low ESR Tantalum Capacitor
16V100uF (7.3x4.3x2.9)
ΔV=76mV



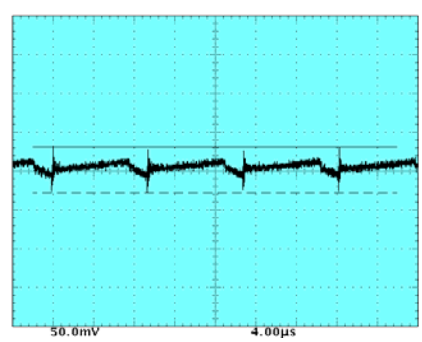
FPCAP
16V100uF (φ8x11.5L)
ΔV=58mV

Examination of Same Level Residual Ripple Voltage

To obtain same level of ripple voltage to FPCAP, Low Impedance Aluminum capacitor needs 16V3300uF, even Low ESR tantalum capacitor needs 4 pcs. of same capacitance.



Low Impedance Aluminum Capacitor
16V3300uF (φ16x25L)
ΔV=60mV



Low ESR Tantalum Capacitor
16V100uF (7.3x4.3x2.9) X4 pcs.
ΔV=59mV

Spice Model for Simulation Circuits with Computer

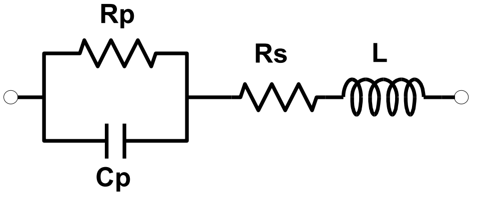
Spice Model of Radial lead type (L8 and S8 Series)

Part Number	Cp (μF)	Rs (mΩ)	L (nH)	LC (μA)	Rp (kΩ)
RL80E821MDN1	820	4.2	2.9	100	25
RL80G561MDN1	560	4.2	2.9	100	40
RL80J561MDN1	560	5.0	2.9	100	63
RS80E331MDN1	330	5.3	2.0	30	83
RS80E471MDN1	470	5.3	2.0	50	50
RS80E561MDN1	560	5.3	2.0	100	25

Typical ESL by Case Size

Classification	Case Size (mm)	ESL (nH,40MHz)
Radial lead type	ϕ6.3×8L (S8)	1.8 to 2.2
	ϕ6.3×10L	2.8 to 3.0
	ϕ8×8L (L8)	2.7 to 3.1
	ϕ8×11.5L	3.9 to 4.1
	ϕ8×11.5L (R7)	4.6 to 4.9
	ϕ10×12.5L	5.4 to 5.6
SMD type	ϕ4×5.2L	1.0 to 1.2
	ϕ6.3×5.7L	2.5 to 2.7
	ϕ8×11.7L	3.1 to 3.3
	ϕ10×12.4L	4.5 to 4.7

Equivalent Circuit of Capacitor



Cp : Capacitance
Rp : Equivalent Parallel Resistance
(Insulation resistance) (≅Rated Voltage/LC)
Rs : Equivalent Series Resistance
L : Inductance

$$|Z| = \sqrt{\left\{Rs + \frac{Rp}{(1+\omega^2 Cp^2 Rp^2)}\right\}^2 + \left\{\omega L - \frac{\omega Cp Rp^2}{(1+\omega^2 Cp^2 Rp^2)}\right\}^2}$$

* It is available to present the spice model of other parts for customers.