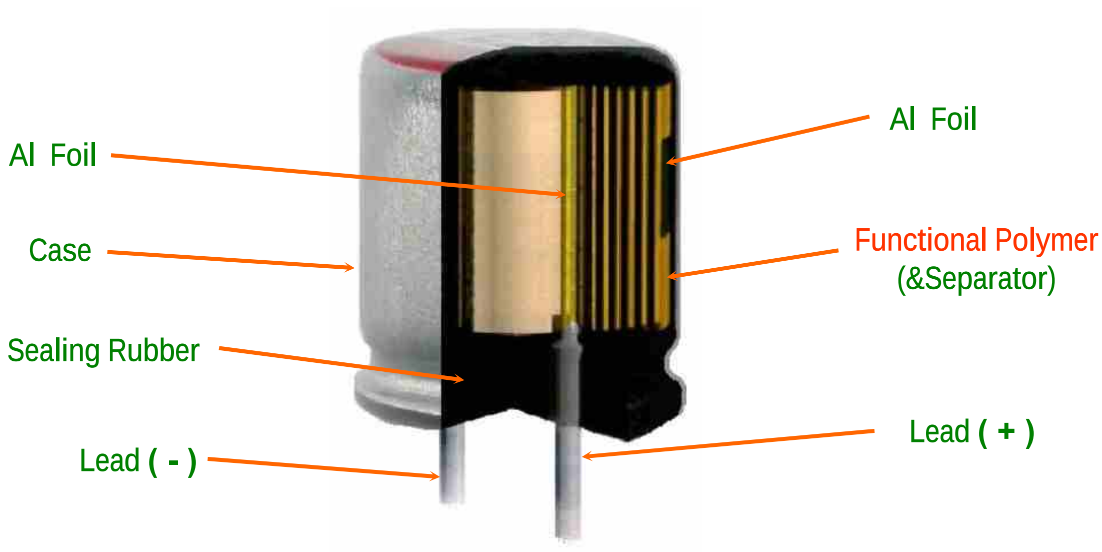
FPCAP *Functional Polymer Aluminum Solid Electrolytic Capacitors*

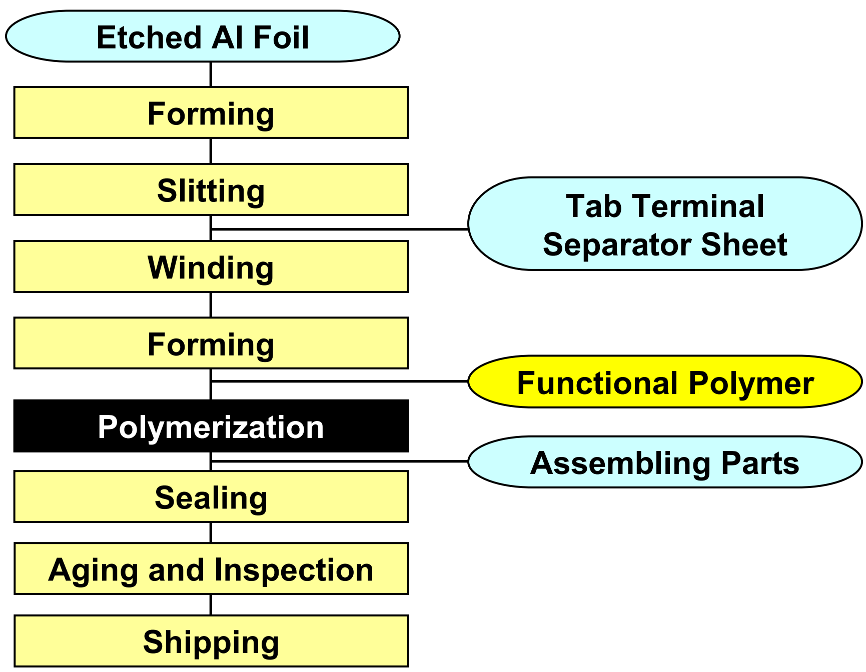
Construction and Characteristics of FPCAP

Construction of FPCAP

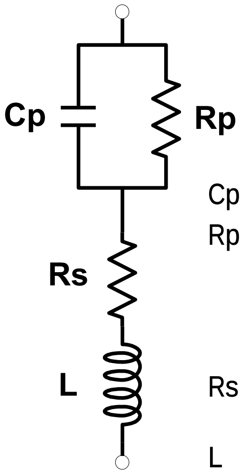


FPCAP is roughly the same construction as an aluminum electrolytic capacitor, and uses rolled aluminum foils in its capacitor element.

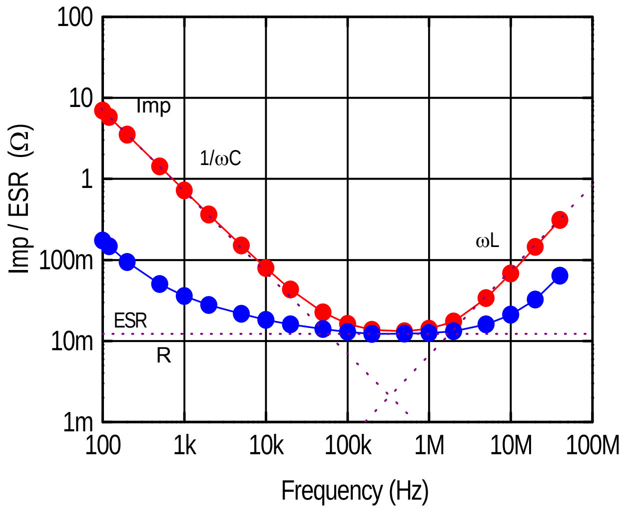
Manufacturing Process of FPCAP



Equivalent Circuit of Capacitor

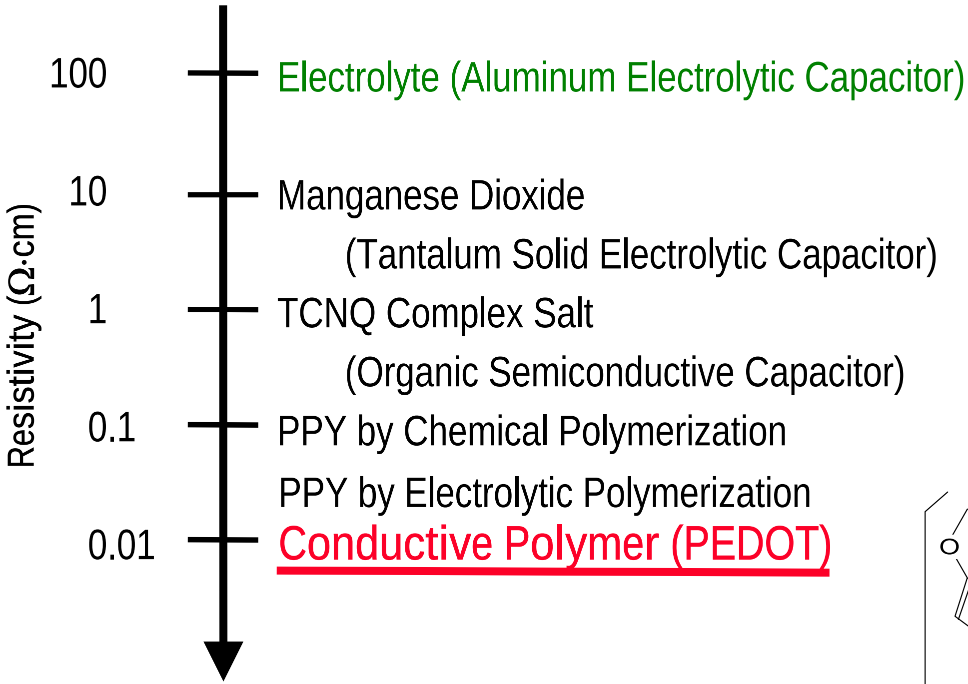


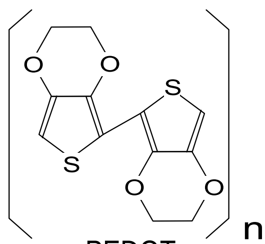
Cp : Capacitance
Rp : Equivalent parallel resistance (Insulation resistance) (≅Rated Voltage/LC)
Rs : Equivalent series resistance
L : Inductance



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

Feature of Functional Polymer



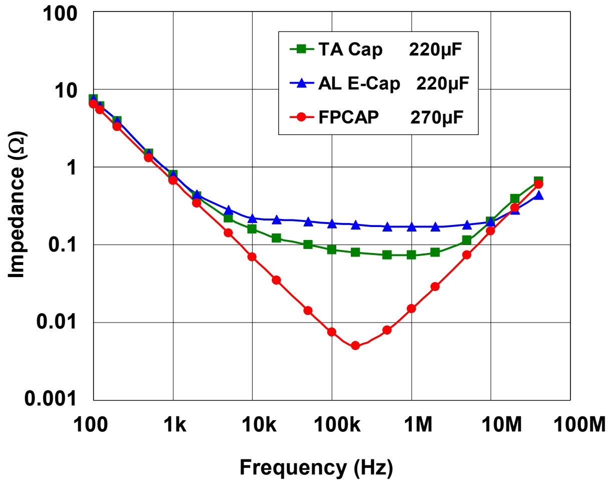


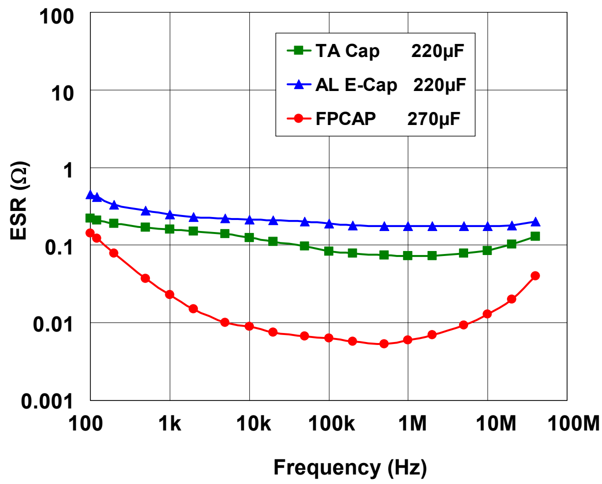
PEDOT

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

Typical Electrical Characteristics of Capacitors

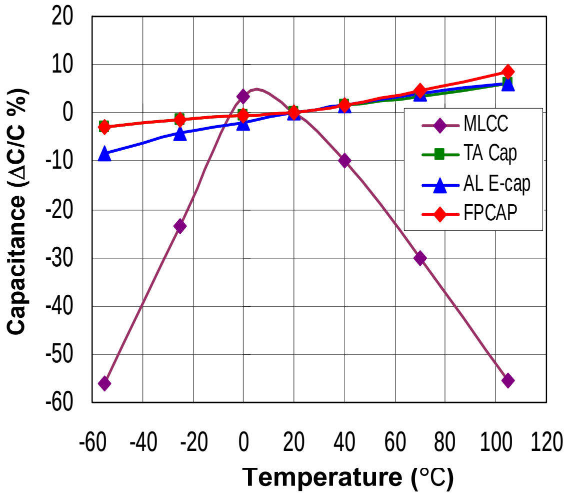
Frequency Dependence

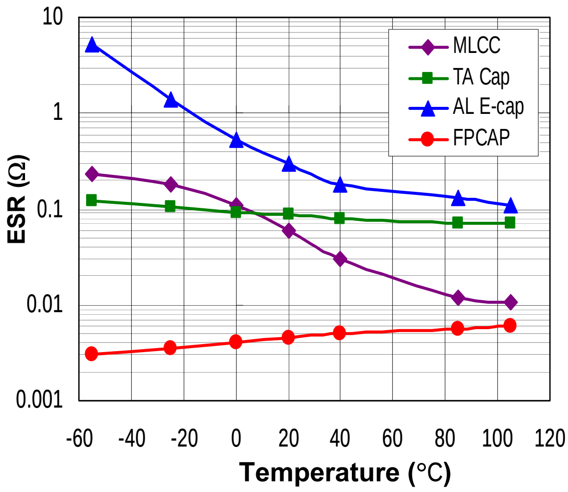




FPCAP has excellent frequency characteristic nearly equal to the film capacitor.
Using the high conductivity of the Functional polymer with an electrolyte, and adopting the winding element for layer thinness of electrolyte, the ESR is improved greatly and has the frequency characteristic that is nearly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

Typical Temperature Dependence of Capacitors

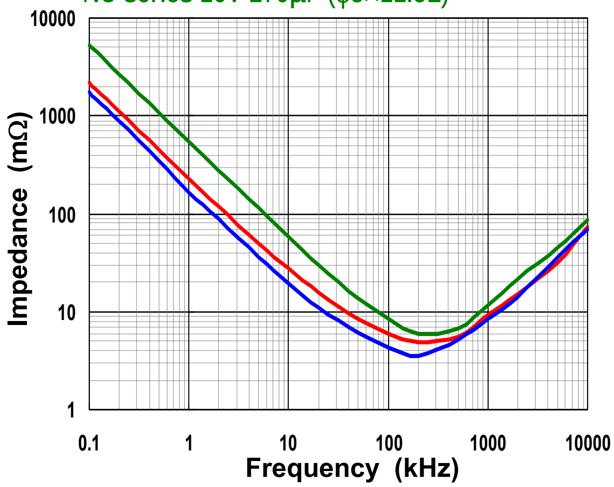


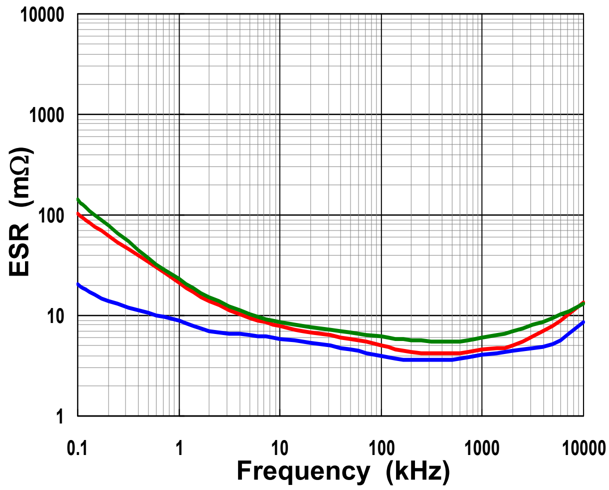


The temperature dependence of the FPCAP is that it features little change in temperature for the ESR.
Since ESR is dominant at high range of impedance (near resonance point), the ESR value greatly affects Noise clearing capacity.
What ESR changes little against temperature means that Noise clearing ability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

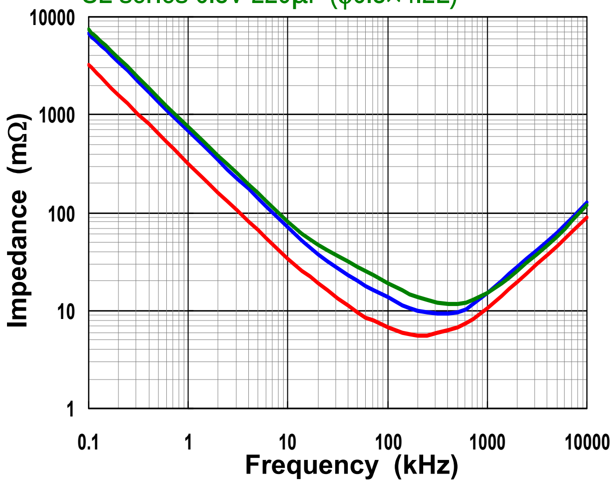
Frequency Dependence

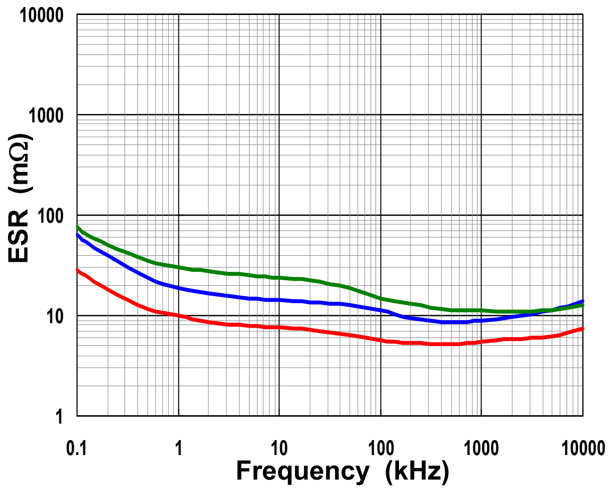
L8 series 2.5V 560μF (ϕ8×8L)
NU series 6.3V 1000μF (ϕ8×11.5L)
NU series 16V 270μF (ϕ8×11.5L)



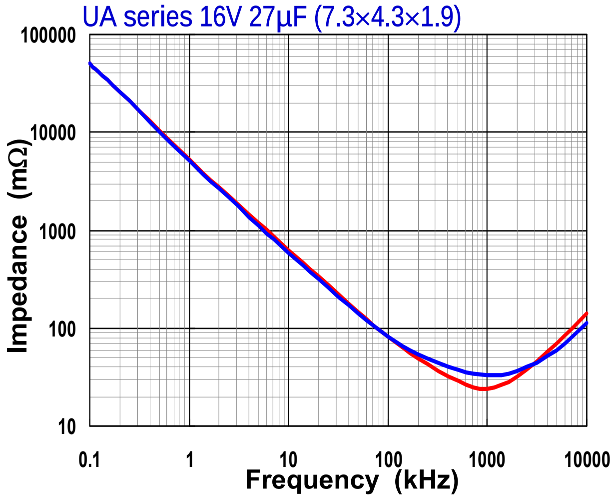


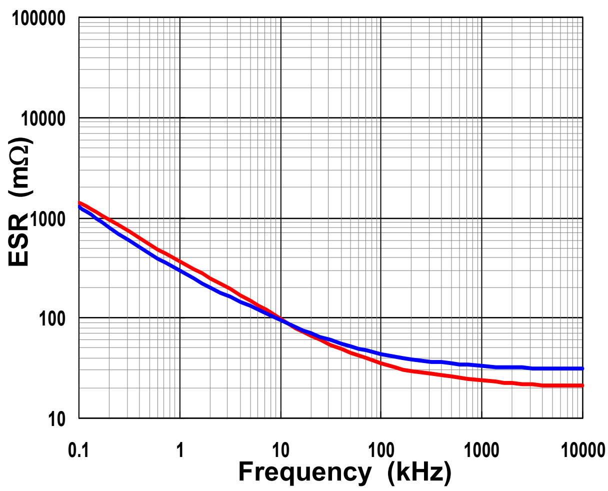
HS series 6.3V 390μF (ϕ8×6.7L)
SA series 6.3V 220μF (ϕ6.3×5.7L)
SL series 6.3V 220μF (ϕ6.3×4.2L)





VA series 16V 33μF (7.3×4.3×2.8)
UA series 16V 27μF (7.3×4.3×1.9)

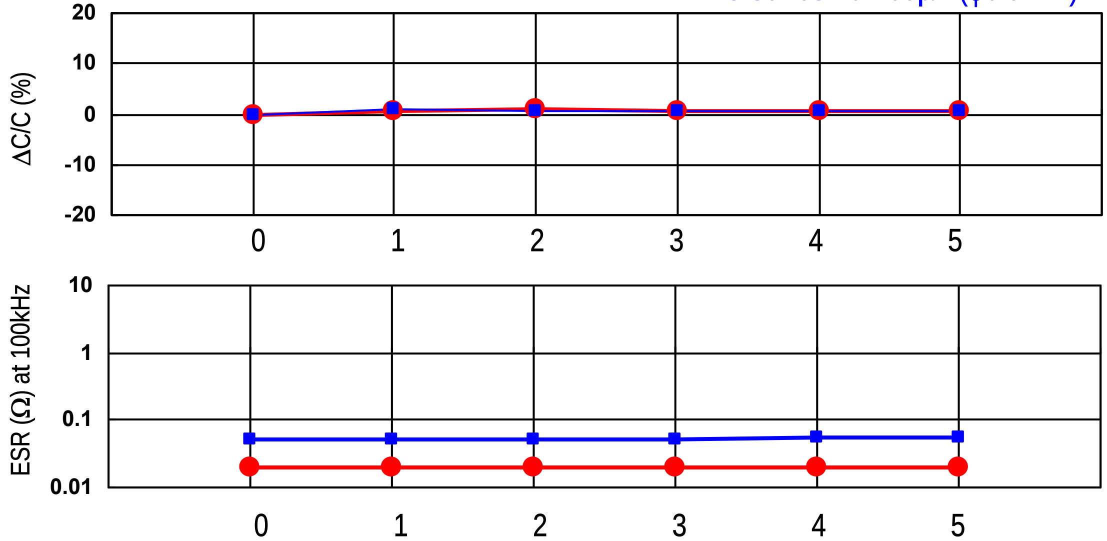




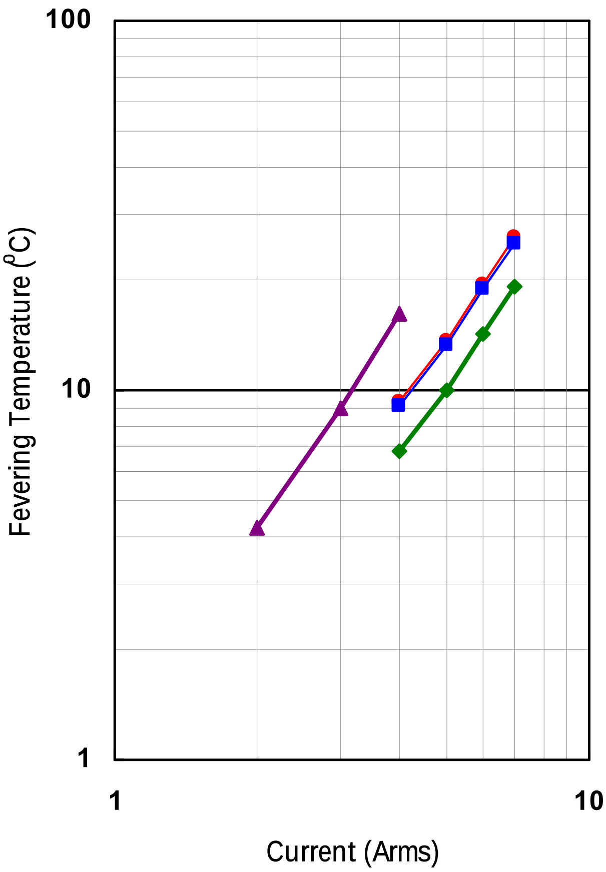
Resistance to Soldering Heat

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)
VB series 2.0V 330µF (7.3×4.3×2.8)

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

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

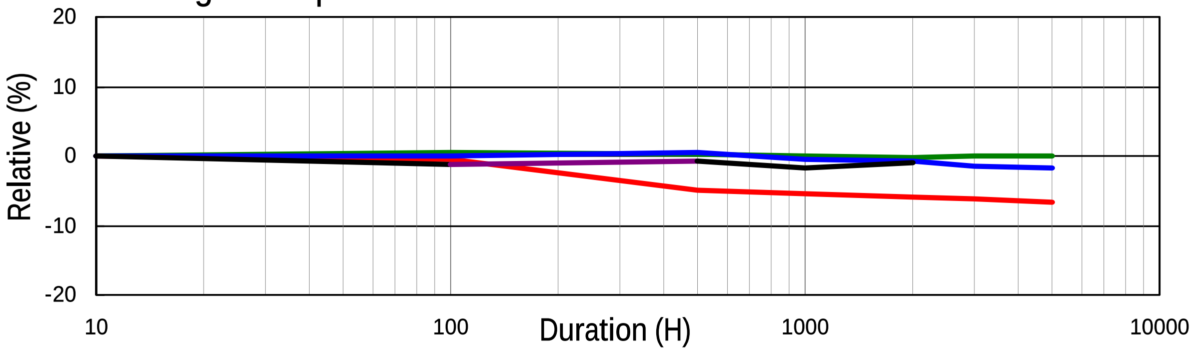
$\log \Delta Tc = \log (I^2 R) / (\alpha\beta S)$
$= \log I^2 + \log R - \log \alpha\beta S$
$= 2 \times \log I + (\log R - \log \alpha\beta S)$

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

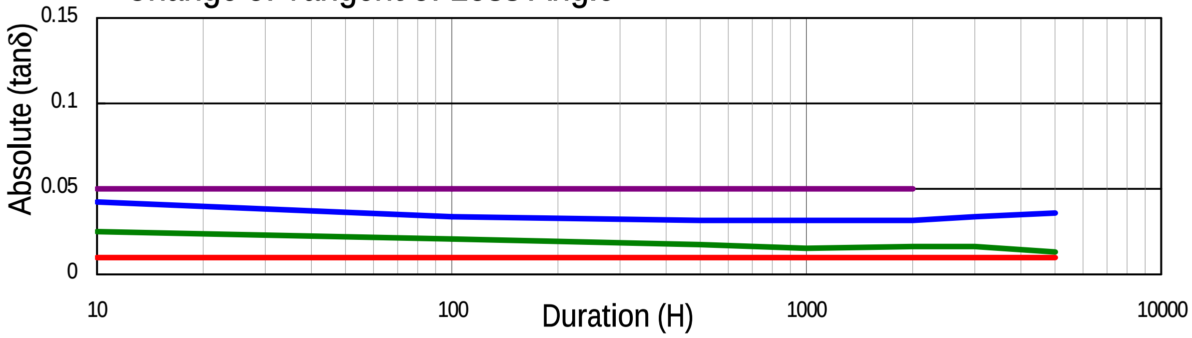
Reliability at 105°C

NS series 6.3V 47µF (ϕ6.3×7L)
L8 series 2.5V 560µF (ϕ 8×8L)
NS series 4.0V 1200µF (ϕ10×12.5L)
VA series 16V 33µF (7.3×4.3×2.8)

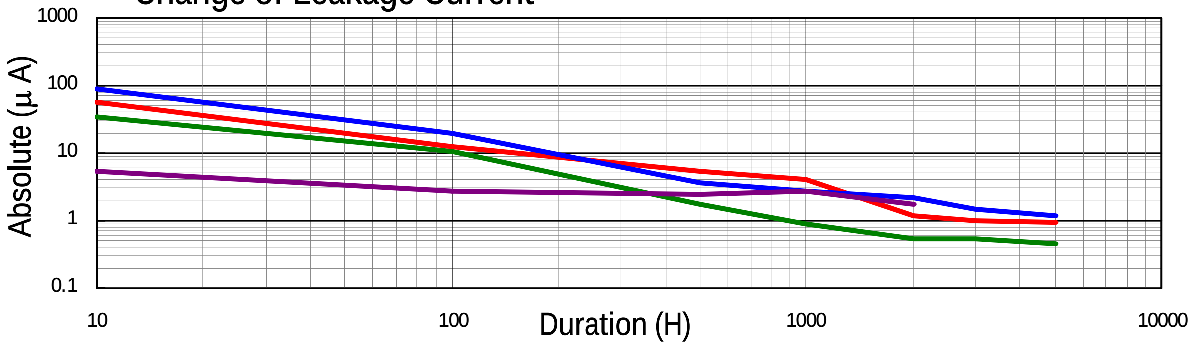
Change of Capacitance



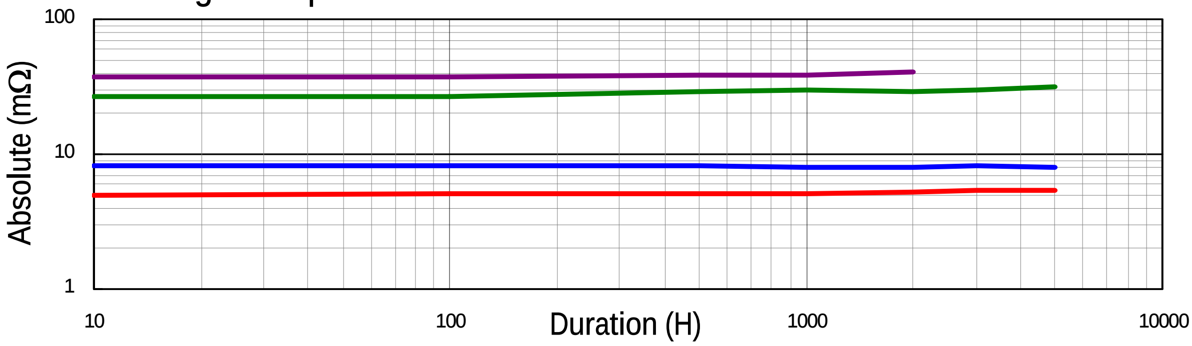
Change of Tangent of Loss Angle



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

There are two methods to calculate the heat rise (ΔT) of a capacitor by ripple current.

a) Measure the temperature of a capacitor in operation by means of fixing a thermocouple on the case of a capacitor or other suitable methods.
The temperature difference between the temperature measured of the capacitor and the ambient temperature is considered as the heat rise by ripple current.

b) The heat rise by ripple current is calculated by the following formula.

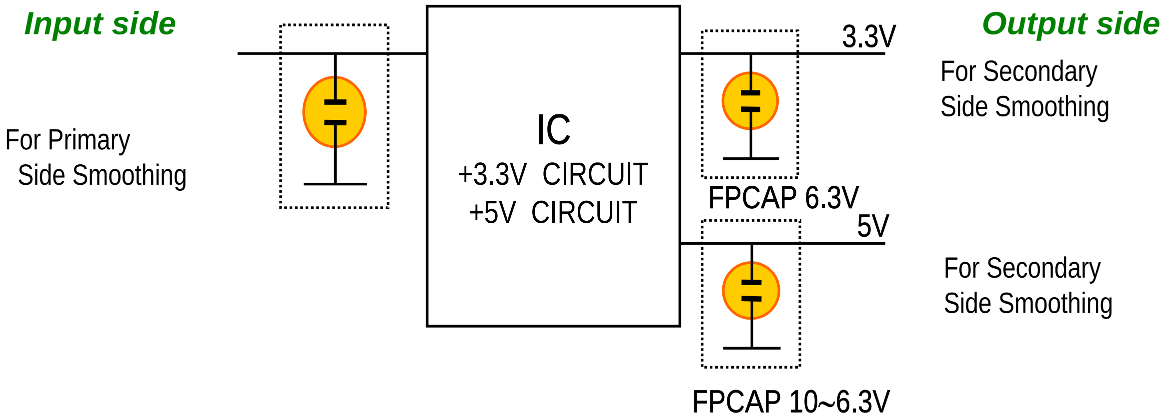
$$\Delta T = (I / I_0)^2 \times \Delta T_0$$

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
[Aluminum Can Type: About 20°C, Molded Chip Type: About 10°C]

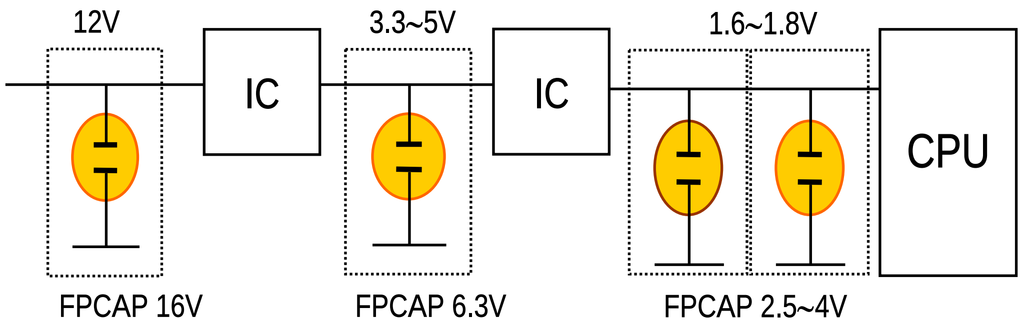
Remark:<It is recommended to use the method of formula calculation during the design phase, and use the method of actual measurement when checking as a set.>

FPCAP *Functional Polymer Aluminum Solid Electrolytic Capacitors*

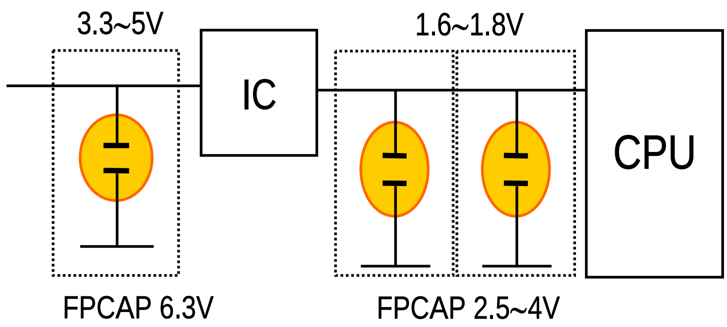
DC/DC Converter Primary, Secondary Side Smoothing



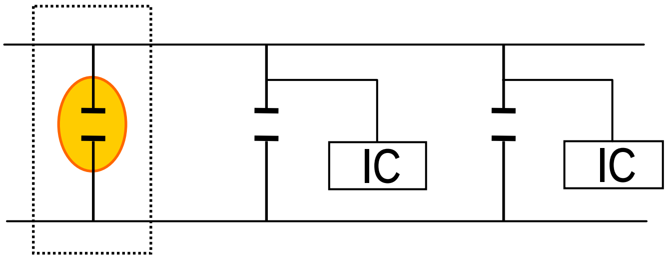
Back-up Capacitor for Variable Load (1)



Back-up Capacitor for Variable Load (2)

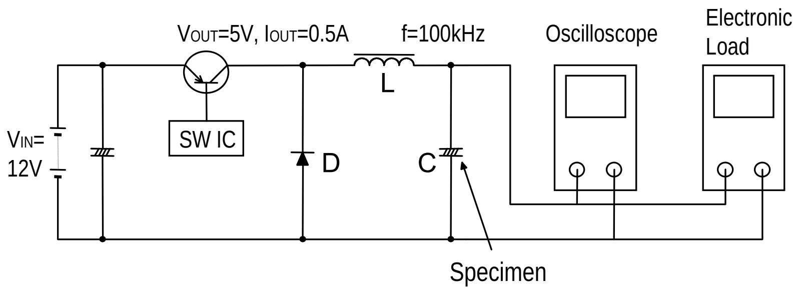


Noise Filters

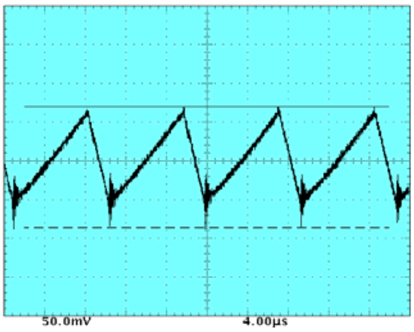


Ripple Removal Capability

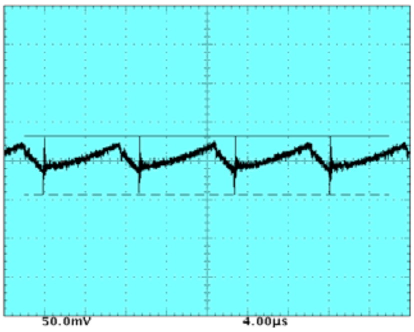
We measured ripple voltage by oscilloscope for output capacitor change on the typical chopper type DC-DC converter. (described below)



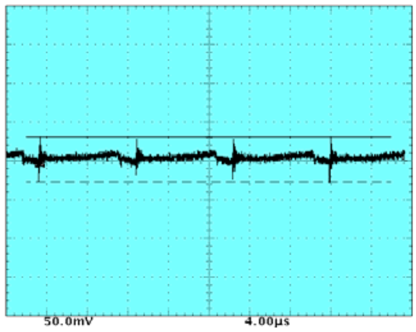
Comparison Between FPCAP and Other Capacitors with Same Capacitance



Low Impedance Aluminum Capacitor
16V100uF (ϕ6.3×11L)
ΔV=156mV



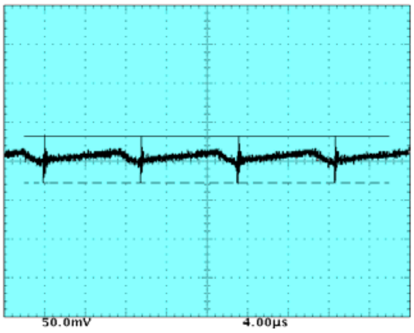
Low ESR Tantalum Capacitor
16V100uF (7.3×4.3×2.9)
ΔV=76mV



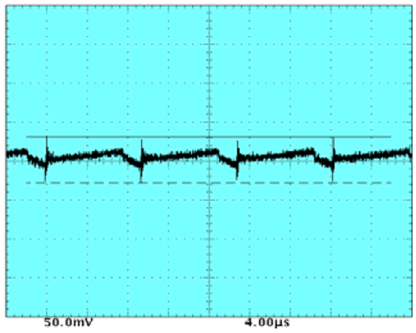
FPCAP
16V100uF (ϕ8×11.5L)
ΔV=58mV

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 (ϕ16×25L)
ΔV=60mV



Low ESR Tantalum Capacitor
16V100uF (7.3×4.3×2.9) × 4 pcs.
ΔV=59mV

Spice Model for Simulation Circuits with Computer

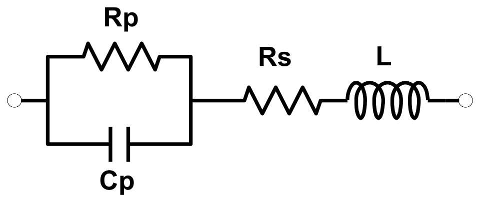
Spice Model of Radial Lead Type (L8 and S8 series)

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
	7.3×4.3×1.9	1.3 to 1.5
	7.3×4.3×2.8	1.6 to 1.8

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.