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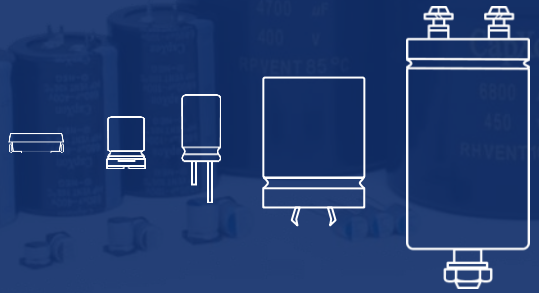
Solid Conductive Polymer and Hybrid Conductive Polymer Technologies



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Agenda

Technology Comparison

- Aluminum Electrolytic Capacitors
- Solid Conductive Polymer Capacitors
- Hybrid Conductive Polymer Capacitors

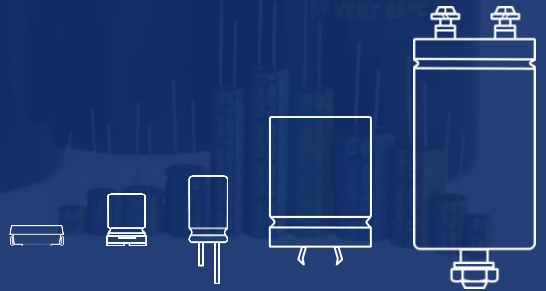
Hybrid Conductive Polymer Capacitors

- Features & Characteristics
- Life Performance

Solid Conductive Polymer Capacitors

- Features & Characteristics
- Replacing MLCCs with Solid Conductive Polymer Caps

Typical Applications & Summary



PSMA

Short Introduction

Todays Presenter is:

M.Eng.

Stephan Menzel

Senior Key Account Manager

Oversea Sales Division

Background:

- More than 12 years of work experience in passive components & electronics industry
- Expertise in global sales & product marketing, industrial engineering and quality management
- In charge for strategic sales accounts, direct business and product marketing

+49 151 52851347

s.menzel@capxon-europe.com

www.capxongroup.com

That‘s who we are

10 facts about CapXon

CAPXON

Manufacturer of Electrolytic Capacitors

Founded 1980
by Victor Lin

Established in Taipei
Taiwan

Family owned and
independent

40 years experience in
electrolytic capacitors

2500 professional
employees

Fully owned factories
1 e-cap and 3 foil factories

ISO9001, ISO14001
and IATF 16949 certified

Patented production
process

Belongs to the TOP 10
manufacturers in e-caps

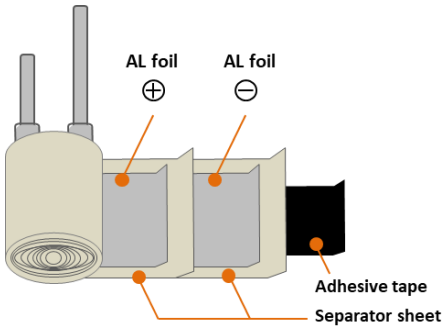
Production of more than
1 bio pcs per month

PATENTED

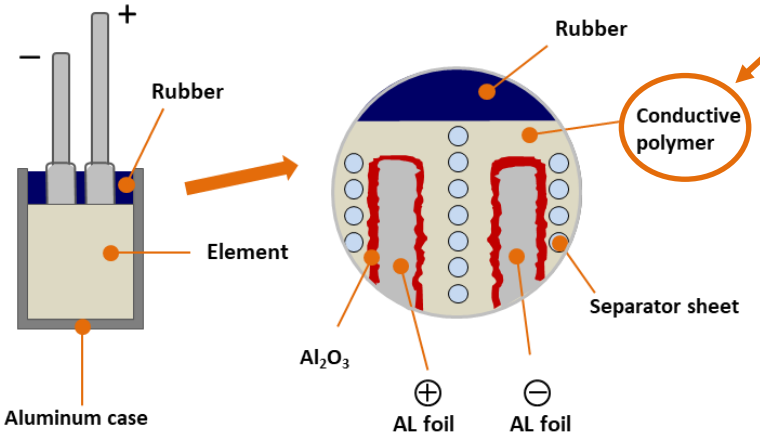
10

E-Cap Construction

What is different with Polymer ?



General inner structure of all Al E-caps



Solid Conductive Polymer as cathode material

- High conductivity (10^2 ~ 10^3 S/cm)
- Solid material (no freezing or dry-out possible)
- High de-composition temperature ~300°C

Benefits

- Low ESR@high frequency 100kHz ~ 300kHz
- Wide operating temperature range -55°C ~ +150°C
- High max. permissible ripple current
- Long life – stable performance over product life cycle
- High thermal stability over the whole temp. range

Quality Factors

- Material: mainly foil, seperator, leads, polymer
- Polymer: impregnation or dispersion solution
- Production: Parameters polymerization process
- Capabilities: Techn. potential and quality of machinery

Influence of Cathode Material

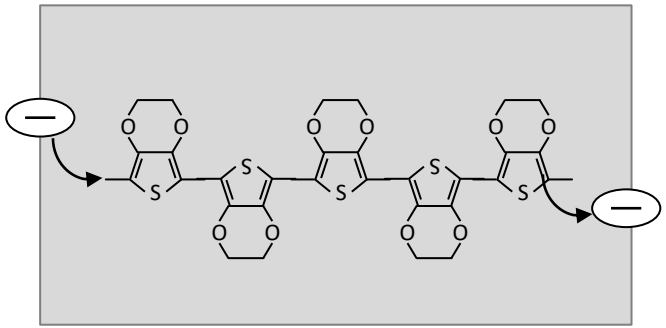
Solid Conductive Polymer vs. Liquid electrolyte

What is the difference between Solid Conductive Polymer and Liquid Electrolyte?

Solid Conductive Polymer

Electrons can move on molecules *FAST*

(low resistance)



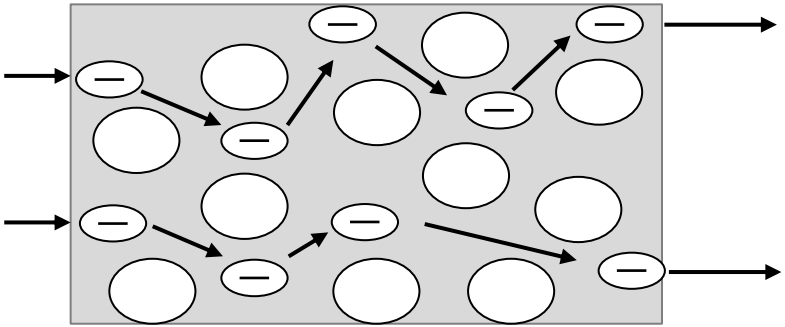
Conductivity index: 1 000 to 10 000 !!!

Liquid Electrolyte

Electrons can move in solution

S L O W

(high resistance)



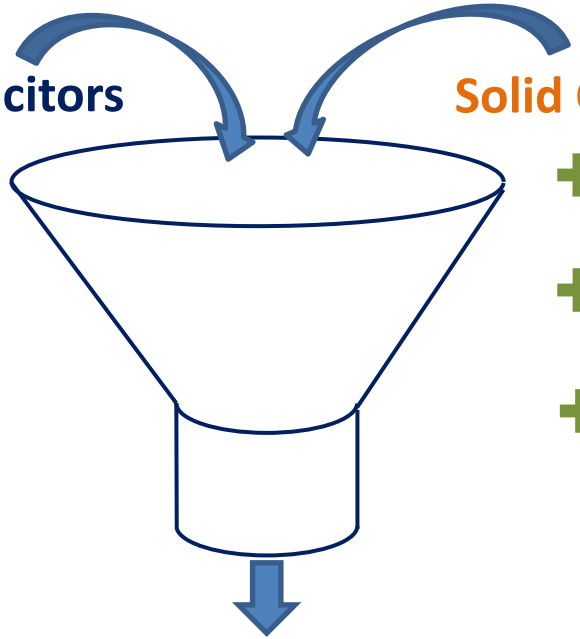
Conductivity index: 1

Best of Both Worlds

Let's mix it!

Aluminum Electrolytic Capacitors

- Low Leakage current
- High temperature capabilities
- High voltage capabilities



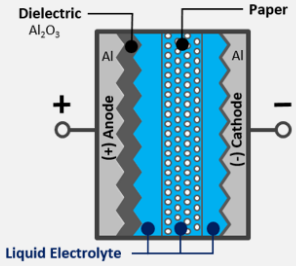
Solid Conductive Polymer Capacitors

- High Lifetime Performance
- High Ripple Current
- Low ESR

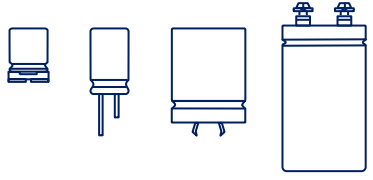
Hybrid Conductive Polymer Capacitors

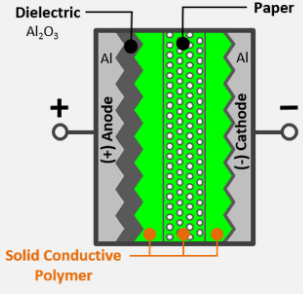
>> combining best features of both techologies <<

Technology Comparison

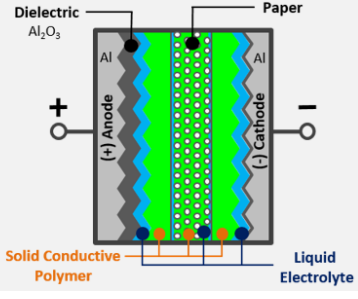
Aluminum Electrolytic	Description	Features
	Rated Voltage • V_R	4 VDC to 650 VDC
	Cathode Material	Liquid Electrolyte
	Self-healing of Dielectric	Yes
	Package	Widest range in all sizes
	Stability	Reduced performance at low temperature
	Lifetime	Limited life at high temperature
	Reliability	Automotive AEC-Q200 products available

SMD, Radial, Snap-In, Screw

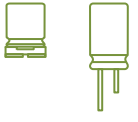


Solid Conductive Polymer	Description	Features
	Rated Voltage • V_R	2.5 VDC to 100 VDC
	Cathode Material	Solid Conductive Polymer
	Self-Healing of Dielectric	No
	ESR	Ultra-low ESR at high frequency
	Stability	Stable for low and high temperature
	Lifetime	Very stable and long life - no dry out
	Reliability	Only internal standard qualification

MLPC, SMD, Radial

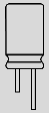
Hybrid Conductive Polymer	Description	Features
	Rated Voltage • V_R	16 VDC to 400 VDC
	Cathode Material	Solid Conductive Polymer & Liquid Electrolyte
	Self-Healing of Dielectric	Yes
	ESR	Very low ESR at high frequency
	Stability	Even more stable than liquid type
	Leakage Current • I_{LEAK}	Lower leakage current than Solid Conductive Polymer Type
	Reliability	Automotive AEC-Q200 products available

SMD, Radial



Technology Comparison

Electrical Performance & Life Estimation

Case	V_R (V)	C_R (µF)	Size ø DxL (mm)	Technology	Part Number	ESR (mΩ, 100kHz)	Leakage current (µA) after 2 min	Maximum permissible ripple current (mA, RMS)	Temperature Range	Endurance (h)
	16	270	8 x 11.5	Liquid	GF271M016F115ETD	120	43	600	-55°C to +105°C	3000
			8 x 9	Hybrid	AS271M016F090PTD	26	43.2	2000	-55°C to +105°C	7000
			8 x 11.5	Polymer	PL271M016F115PTD	9	864	5600	-55°C to +105°C	2000

Aluminum Electrolytic

$$L_A = L_0 \cdot 2^{\frac{T_{0\_Max} - T_A}{10°C}}$$

10°C reduced
2 x lifetime

Endurance Calculation

3000h@105°C

95°C	6000 h
85°C	12000 h
75°C	24000 h
65°C	**48000 h**

Hybrid Polymer

$$L_A = L_0 \cdot 2^{\frac{T_{0\_Max} - T_A}{10°C}}$$

10°C reduced
2 x lifetime

Endurance Calculation

7000h@105°C

95°C	14000 h
85°C	28000 h
75°C	56000 h
65°C	**112000 h**

Solid Conductive Polymer

$$L_A = L_0 \cdot 10^{\frac{T_{0\_Max} - T_A}{20°C}}$$

20°C reduced
10 x lifetime

Endurance Calculation

2000h@105°C

95°C	6325 h
85°C	20000 h
75°C	63246 h
65°C	**200000 h**

L_0... Endurance value per datasheet
L_A... Expectedlife within application
T_0... Max. temp. according datasheet
T_A... Application temperature

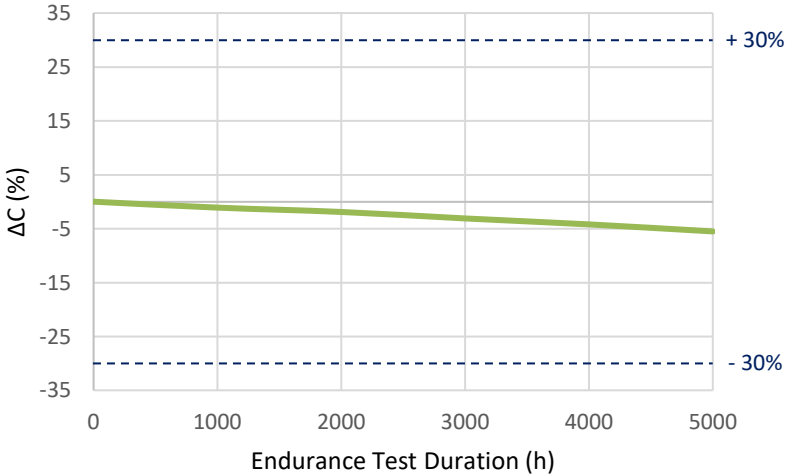
Life Performance - Hybrid Caps

Endurance Test Examples – Capacitance Change

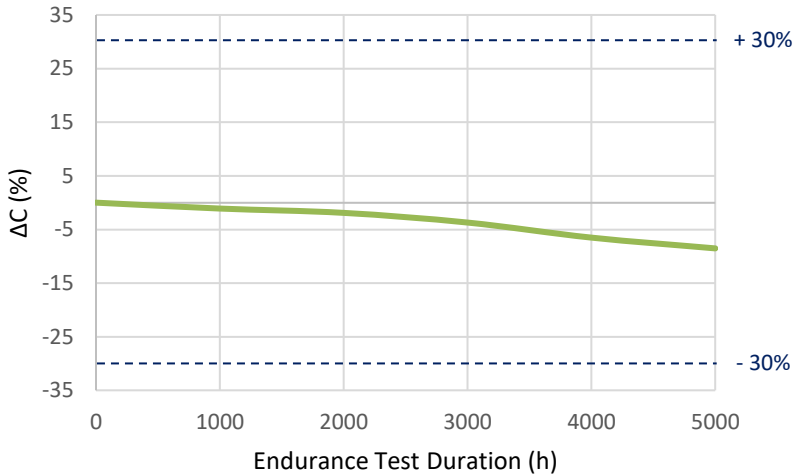
Endurance Test Criteria:
± 30%

Hybrid Conductive Polymer Capacitors

Capacitance Change
@ Max. Temp, V_R (I=0A)



Capacitance Change
@ Max. Temp, V_R, I_R



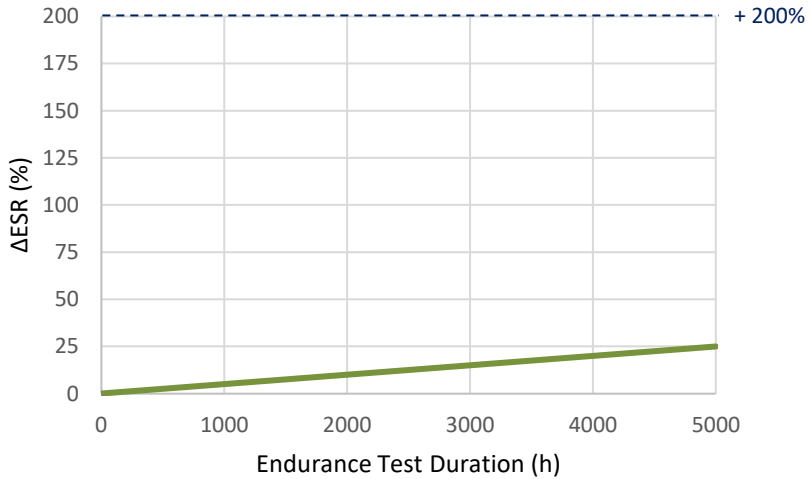
Life Performance - Hybrid Caps

Endurance Test Examples – ESR Change

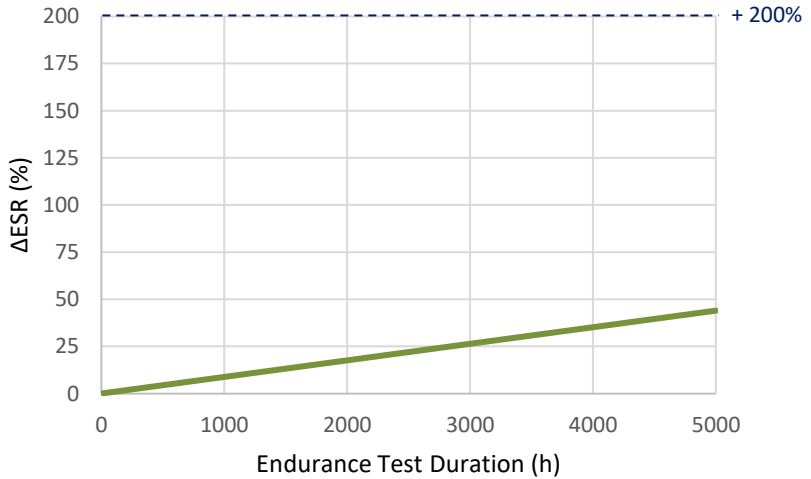
Hybrid Conductive Polymer Capacitors

Endurance Test Criteria:
max. 200%

ESR Change
@ Max. Temp, V_R (I=0A)



ESR Change
@ Max. Temp, V_R ,I_R



Polymer Caps vs. Others

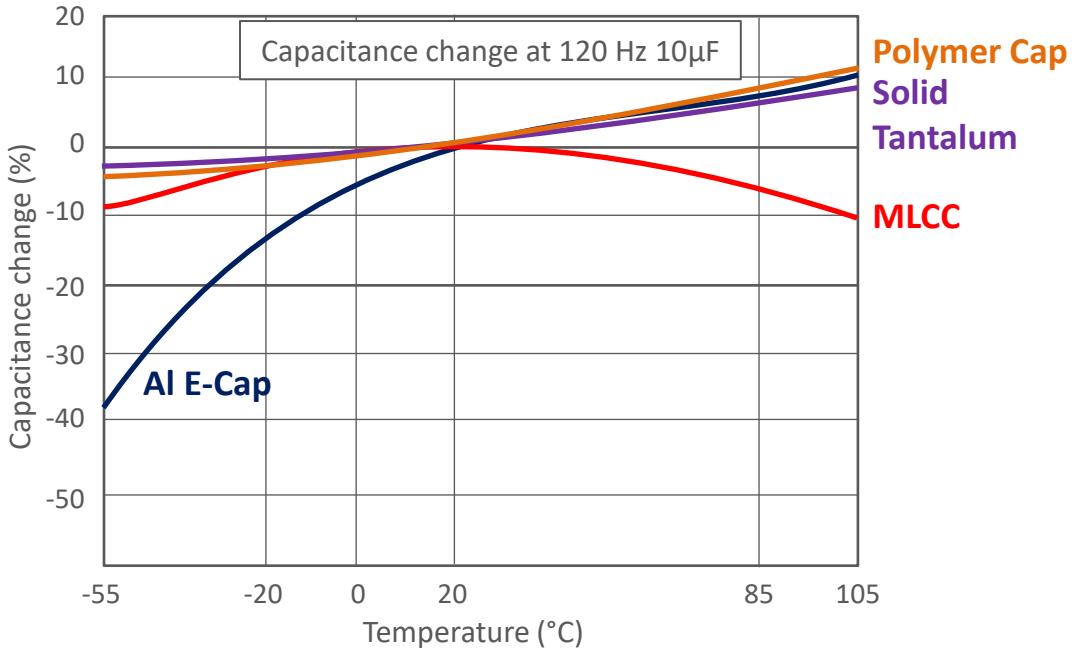
Capacitance change vs. temperature

Comparison: capacitance – temperature characteristics

The **Solid Conductive Polymer** offers:

- Low temperature – stable capacitance
- Stable capacitance in a wide temperature range

Much better „C“ on low temperature



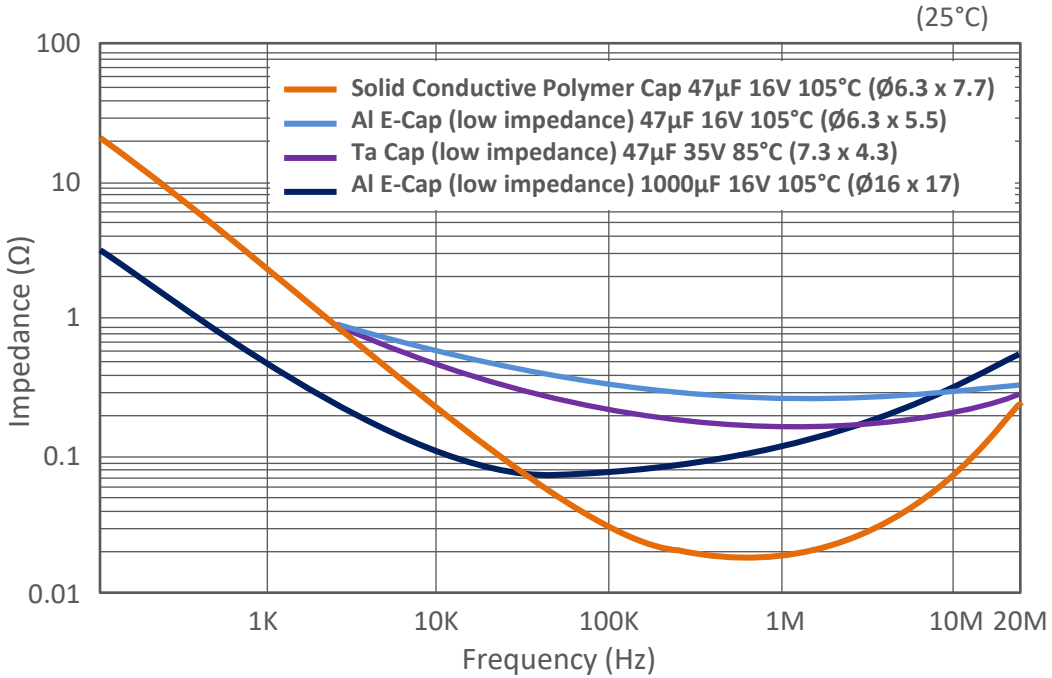
Conductive Polymer

Impedance vs. frequency

Comparison: impedance – frequency characteristics

The Solid Polymer Al cap offers

- High frequency and low impedance
- It‘s like the ideal capacitor impedance frequency curve
- Allows to carry large ripple current
- Quick discharge
- It is particularly suitable as coupling capacitor to smooth the ripple in the circuit, pulse, electrostatic and other various kinds of noise



Conductive Polymer

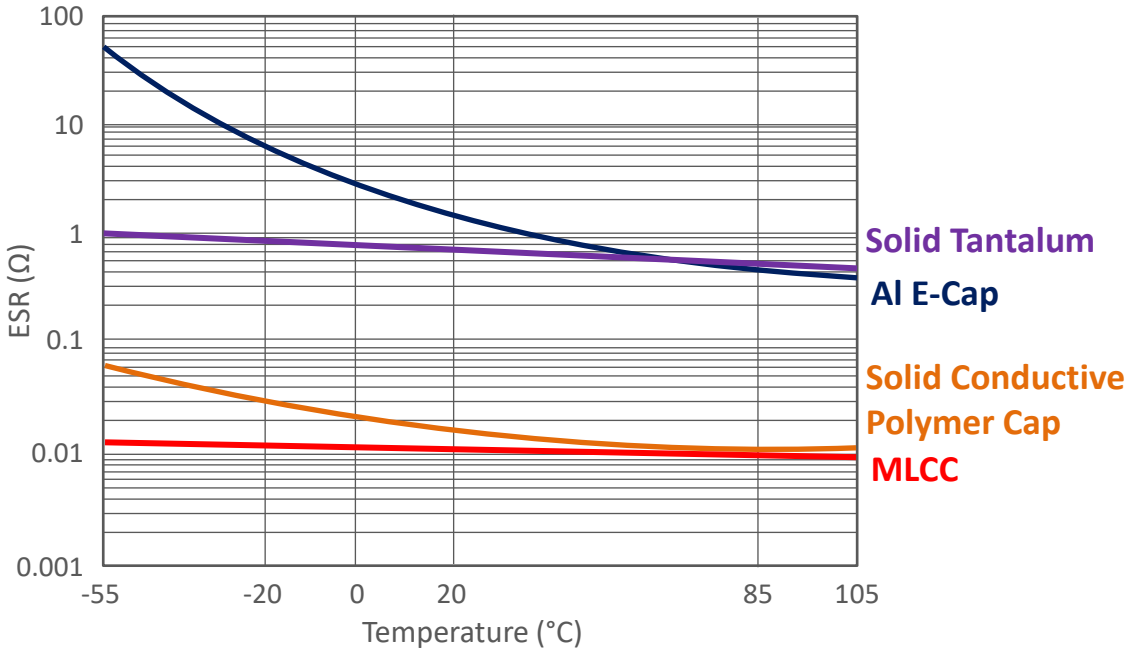
ESR vs. temperature

Comparison: ESR – temperature characteristics

The Solid Polymer Al offers

- ESR hardly changes with temperature

Stable ESR over temperature



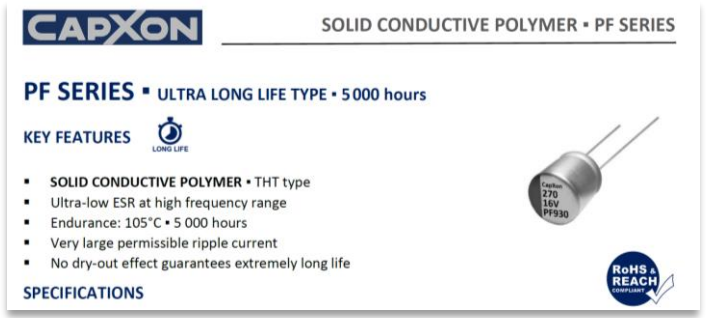
Conductive Polymer

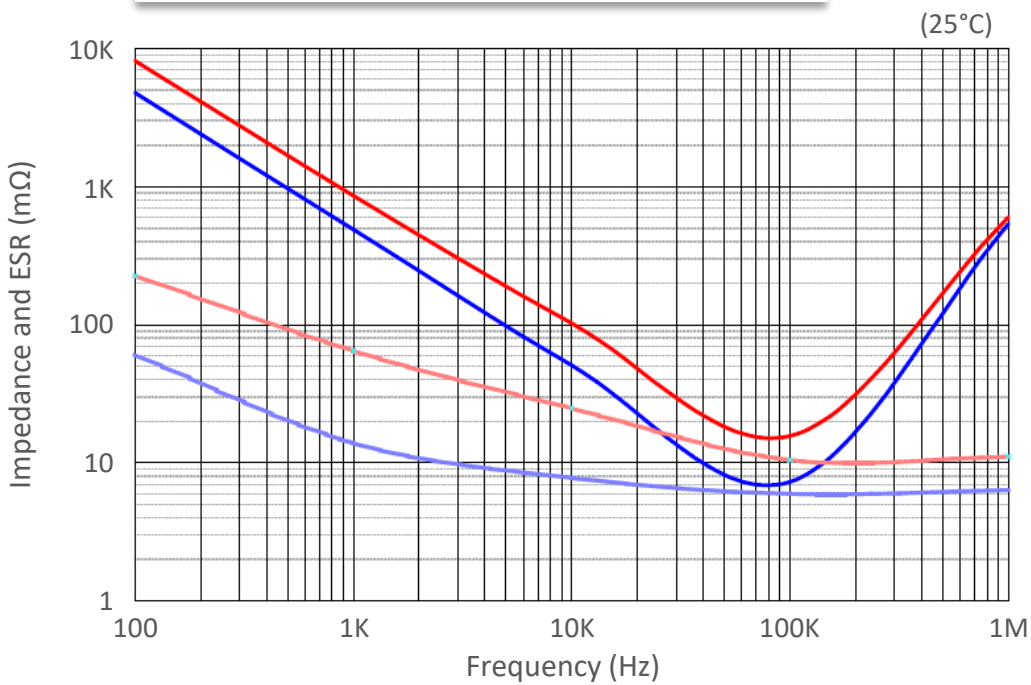
Impedance / ESR vs. frequency

Impedance and ESR for radial PF series

PF151M035G125PTA
150µF 35V 105°C (Ø10 x 12.5) 18mΩ
Impedance
ESR

PF471M016F115PTD
470µF 16V 105°C (Ø8 x 11.5) 10mΩ
Impedance
ESR





MLCC vs. Polymer Caps

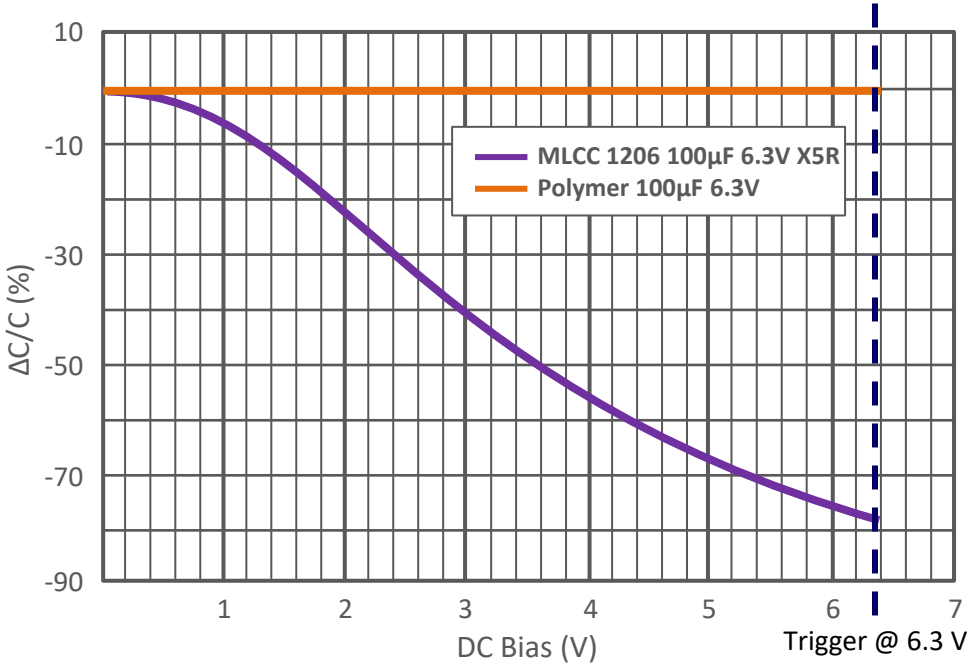
DC bias Polymer vs. MLCC

Comparison capacitance – voltage characteristics

The **Solid Conductive Polymer** offers:

- Stable capacitance over the whole voltage range
- Smaller dimensions and less pcb area

much better „available“ capacitance on higher voltage level



Saving Costs by Design

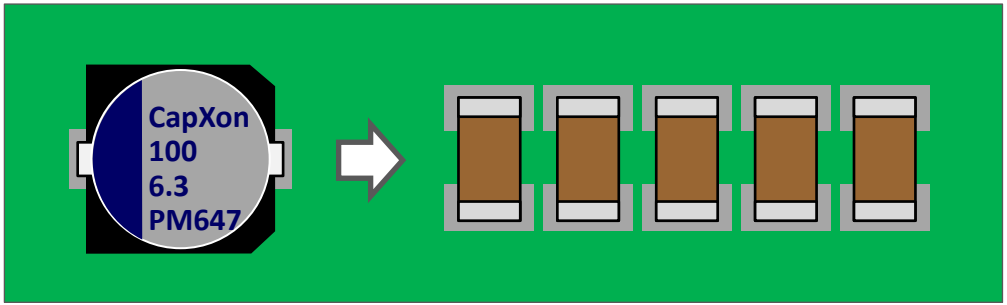
Substitution of MLCCs by Solid Conductive Polymer Caps

vs.

Category	Series	Capacitance	Voltage	Max. Temperature	Impedance at 100kHz	Comment	Type	Price per pcs
MLCC	Low impedance	100 µF	6.3V	85 °C	50 mΩ	X5R ceramic	CL31A107MQHNNNE	USD 0.121
Polymer Cap	Low impedance	100 µF	6.3V	105 °C	30 mΩ		PM101M6R3C055PTR	USD 0.104

	Worst Case Scenario	Solid Conductive Polymer 100 µF 6.3V ±20%	MLCC 100 µF 6.3V ±20% X5R
Nominal value		100 µF	100 µF
Nominal tolerance	Polymer: -20% MLCC: -20%	80 µF	80 µF
ΔC/C (DC Bias) at 6.3V	Polymer: 0 MLCC: -75%	80 µF	20 µF
ΔC/C (Temp.) at 85°C	Polymer: +5% MLCC: -15%	84 µF	17 µF
Result		**84 µF**	**17 µF * 5 = 85 µF**
Price (USD /pcs)		0.1039	0.1203
Total amount		**0.104 · 1 = 0.104**	**0.121 · 5 = 0.605**

One Solid Conductive Polymer Cap replaces five MLCCs



>> possible cost reduction of 83%

>> cost savings of about 50k USD per 100k boards

Typical Applications

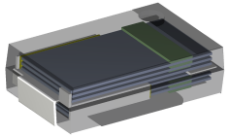
Which job they can do best?

Hybrid Conductive Polymer Capacitors

Applications:

- Automotive Electronics
- DC Link in brushless DC motor drives
- Smoothing for gate drive circuits
- ECU input filtering
- DC/DC power supply input filtering
- Output smoothing in LED power supplies
- Power and battery decoupling
- Server, base stations and industrial PCs

Solid Conductive Polymer Capacitors



Applications:

- High frequency applications
- Voltage stabilizing in LCD and LED panels
- Input and Output filtering of DC/DC power supplies
- Medical Equipment or any application with high expected life

Applications:

- Digital and high frequency devices
- Voltage stabilizing in LCD and LED panels
- Buffering of CPUs, FPGAs, graphical cards and sensor ICs
- Input and output smoothing in USB power supplies and power banks

Summary

++ ... best performance

\+ ... well performance

● ... basic performance

Characteristics	Aluminum Electrolytic Capacitor	Solid Conductive Polymer Capacitor	Hybrid Conductive Polymer Capacitor
ESR at High Frequency	● (120 ~ 1 000 mΩ)	++ (7 ~ 15 mΩ)	\+ (20 ~ 30 mΩ)
Leakage Current ▪ I_{LEAK}	++ ($0.01*C_R*V_R$)	● ($0.2*C_R*VR$)	++ ($0.01*C_R*V_R$)
Ripple Current ▪ I_R	● (~ 600 mA)	++ (2 000 ~ 7 000 mA)	\+ (2 000 ~ 3 000 mA)
Rated Voltage ▪ V_R	++ (~ 700 V)	● (~ 100 V)	\+ (~ 400 V)
Operating Temperature Characteristics	\+ (-40 ~ + 125 °C)	\+ (-55 ~ + 125 °C)	++ (-55 ~ + 150 °C)
Low Temperature Characteristics	● (-40 ~ + 125 °C)	++ (-55 ~ + 125 °C)	\+ (-55 ~ + 150 °C)
Lifetime	● (105 °C / 3 000h)	++ (105 °C / 5 000h)	++ (105 °C / 10 000h)
Failure Mode	\+ Open	● Short	\+ Open

Professional is ...

CAPXON

Headquarters
CapXon
Technology Ltd. Taiwan Branch
5F, 157, Sec 2, Datong Road
Xizhi District
New Taipei City 22183 ▪ Taiwan
T + 886 2 869 26 611
F + 886 2 869 26 447
www.capxongroup.com

Production
CapXon
Electronic (Shenzhen) Co., Ltd.
No. 4132, Songbai Road
Guanming New District
Shenzhen City ▪ China
T + 86 755 271 77 888
F + 86 755 271 77 802