MLCC substitution with Al-capacitor technology

In cooperation with TTI and Nichicon

NICHICON (AUSTRIA) GmbH
5/September/2018

Possible reasons for MLCC shortages:

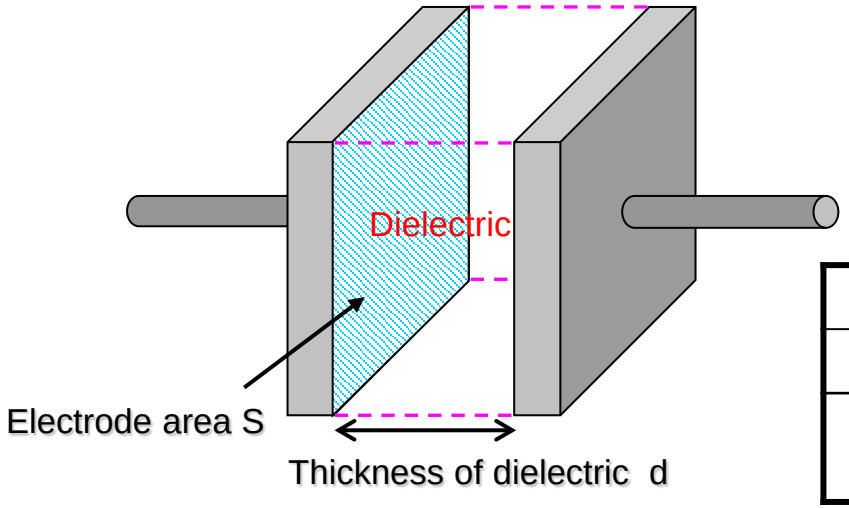
- Increase in very complex electrification and the need of MLCC's especially for smartphones & IoT, automotive ECU and industrial applications, block chain technology etc.
- Various changes within the whole MLCC supply structure.
- 1.5 billion smartphone users, each phone with several ten MLCC's equipped

  ⇒ **There is demand for billions of MLCC's even only for the smartphone industry (multiple 1000kk pcs demand)**

Our task is to prevent shortages and offer sustainable solutions with AI-technology!!

Principle of capacitors

Capacitance of parallel plate capacitor ＝ C



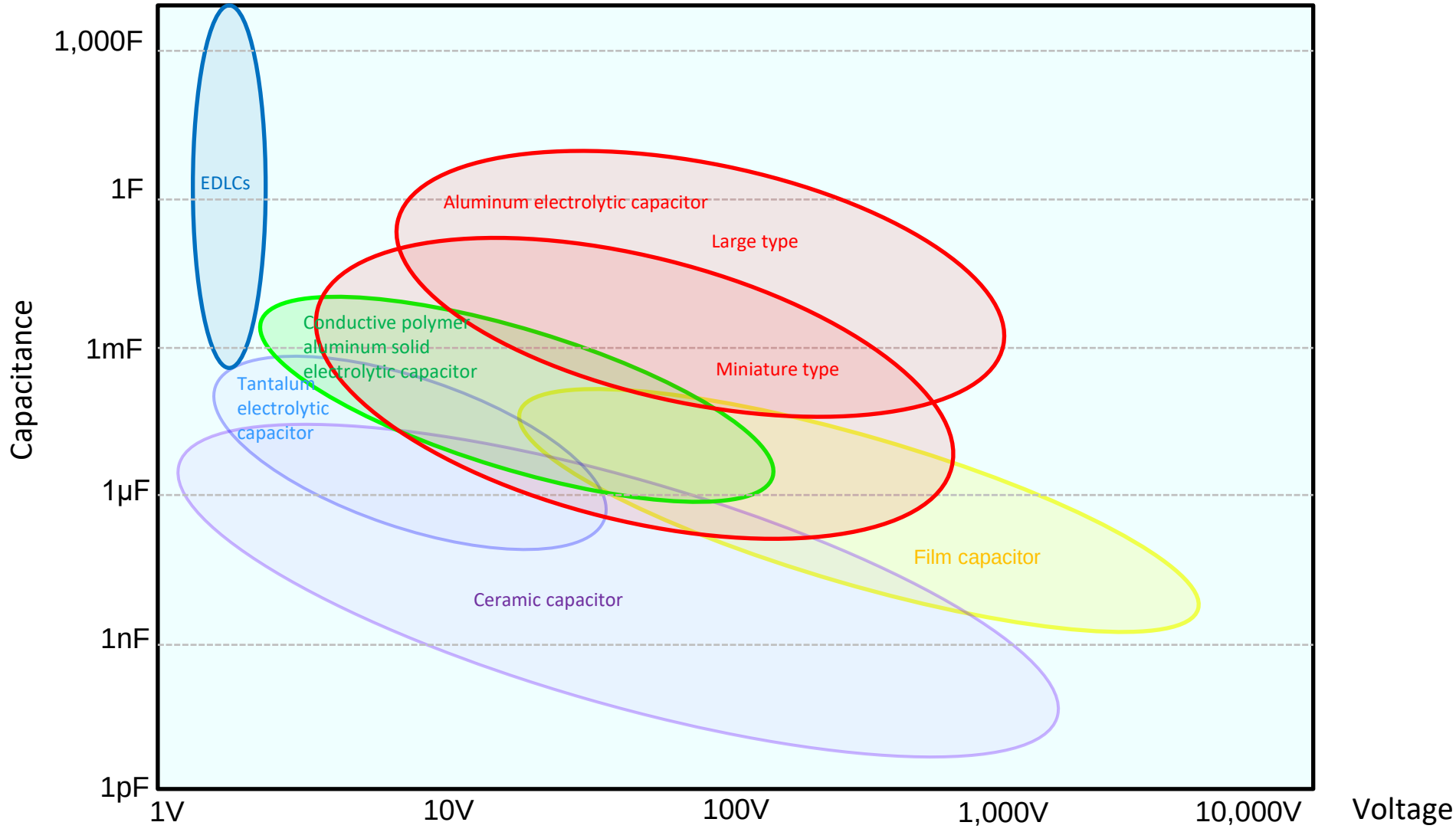
$$C = \varepsilon_0 \varepsilon_S \frac{S}{d} = 8.854 \times 10^{-12} \frac{\varepsilon_S S}{d} (F)$$

ε_0 : Dielectric constant of vacuum
εs : Dielectric constant

Capacitance C	**Small**	⟷	**Large**
Electrode area S	**Small**	⟷	**Large**
Thickness of dielectric d	**Far**	⟷	**Be close**

Type of capacitor	Dielectric	Dielectric constant ε_S	Thickness of dielectric d (m)
Aluminum electrolytic capacitor	Aluminum oxide	7～10	$1.3 \sim 1.5 \times 10^{-9}$
Tantalum electrolytic capacitor	Tantalum oxide	24	$1.0 \sim 1.5 \times 10^{-9}$
Film capacitor (Metalized)	Polyester film	3.2	$0.5 \sim 2.0 \times 10^{-6}$
Ceramic capacitor (High dielectric constant type)	Barium titanate	500～20,000	$2 \sim 3 \times 10^{-6}$
Ceramic capacitor (Temp. compensation type)	Titanium oxide	15～250	$2 \sim 3 \times 10^{-6}$

Relationship between capacitance and voltage



Aluminum electrolytic capacitors are smaller and have higher capacitance than other capacitor technologies. In addition, the price around capacitance is cheap.

※ Nichicon does not manufacture tantalum capacitors and ceramic capacitors.

Characteristics and applications of capacitors

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Capacitor type	Advantage	Disadvantage	Main applications
Aluminum electrolytic capacitor	• High capacitance • High voltage • High cost performance • Self healing	• Limited lifetime • Large size	• Rectifying power supply circuit / high frequency circuit / coupling circuit • Consumer electronics / industrial • EMC filtering • PWM filtering • Buffer / energy reserve
Conductive polymer aluminum electrolytic capacitor	• High frequency characteristics • Longer life • Increased ripple current capability	• Higher price	
Conductive polymer hybrid aluminum electrolytic capacitor			
Film capacitor	• High frequency characteristics • Temperature characteristics • Self healing	• Large size	• Bypass circuit / oscillation circuit / coupling circuit / phase advancing circuit • Consumer electronics /industrial
EDLCs	• Ultra high capacitance • High energy density	• Low voltage • Limited temperature range	• Memory backup / for Power / for energy storage • AV equipment/Mobile equipment / automotive applications
Tantalum solid electrolytic capacitor	• High capacitance • Long life • High frequency characteristics	• High price • Short failure mode	• Supply noise removal / high frequency circuit • AV equipment / communications equipment / mobile equipment
Conductive polymer tantalum solid electrolytic capacitor	• High frequency characteristics • Long life	・High price ・Low voltage	
Ceramic capacitor (High dielectric constant)	• Small and high capacitance • High frequency characteristics	• Large temperature change • Large bias change	• Smoothing circuit / coupling circuit / decoupling circuit
Ceramic capacitor (Temperature compensation)	• High frequency characteristics • Temperature characteristics	• Small capacitance	• For temperature compensation / high frequency circuit

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Comparison of characteristics between Aluminum electrolytic capacitors and MLCC

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Classification by type of dielectric

Dielectric type		Dielectric constant	Dielectric material	Features
Low dielectric constant (Class I)		εs ＜400	Titanium oxide (TiO_2), Alkaline- earth titanate compound	The capacity is small but the characteristics are stable.
High dielectric constant (Class II)	B Characteristic	εs ＝3,000	Add metal oxide to barium titanate ($TiBa0_3$)	The higher the Dielectric constant, the smaller the size is. But the characteristics change drastically
	D Characteristic	εs =6,500		
	F Characteristic	εs ＝18,000		

The concept of "the ceramic capacitor has stable characteristics" is a recognition for a ceramic capacitor using a low dielectric constant dielectric, and characteristics of a small-sized large capacitance ceramic capacitor using a high dielectric constant dielectric are shown as followings:

(1) Capacitance largely changes with temperature and shows an irregular change with temperature..

(Capacitance of aluminum electrolytic capacitor increases linearly as temperature rises.)

(2) Capacitance changes with the voltage applied, and Capacitance decreases when voltage increases.

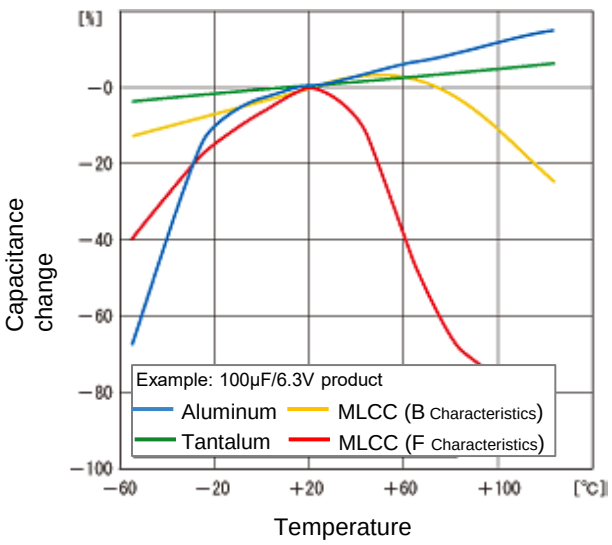
(Capacitance of aluminum electrolytic capacitor does not change with voltage applied.)

(3) Capacitance continuously decreases with logarithm of time. (Having aging characteristics)

(Changes in capacitance of aluminum electrolytic capacitors when left at room temperature are extremely small)

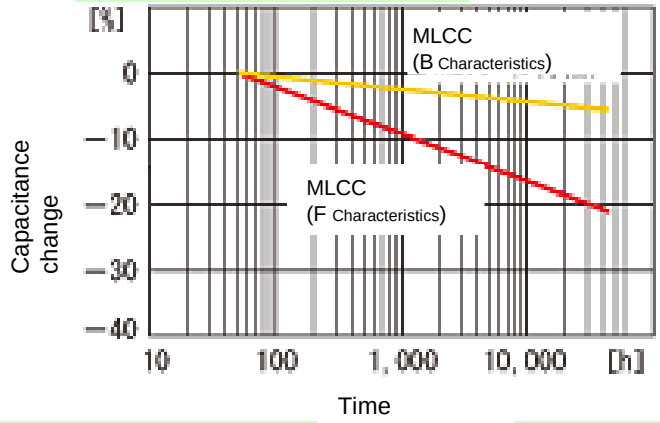
Differences between characteristics of Aluminum electrolytic capacitors and MLCC

Temperature characteristics



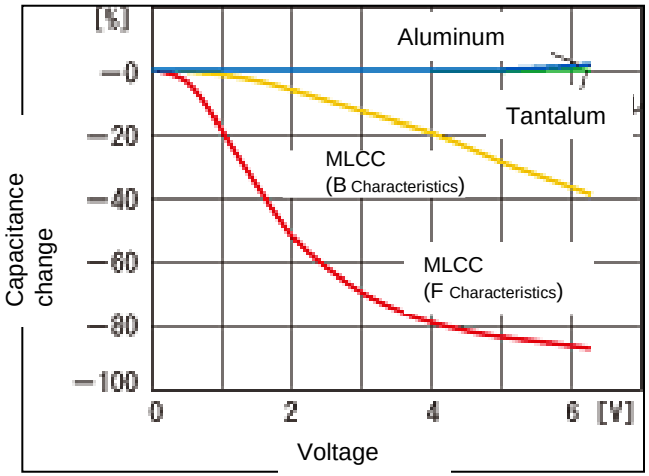
Aluminum electrolytic capacitors and Tantalum electrolytic capacitors change linearly with temperature. MLCC behaves nonlinearly and changes greatly.

Changes over time



When left at normal temperature with no load, Aluminum electrolytic capacitors and Tantalum electrolytic capacitors do not change in characteristics, but MLCC's capacitance decreases almost linearly with logarithm of time. Decrease by about 20% in roughly one year.

DC voltage characteristics



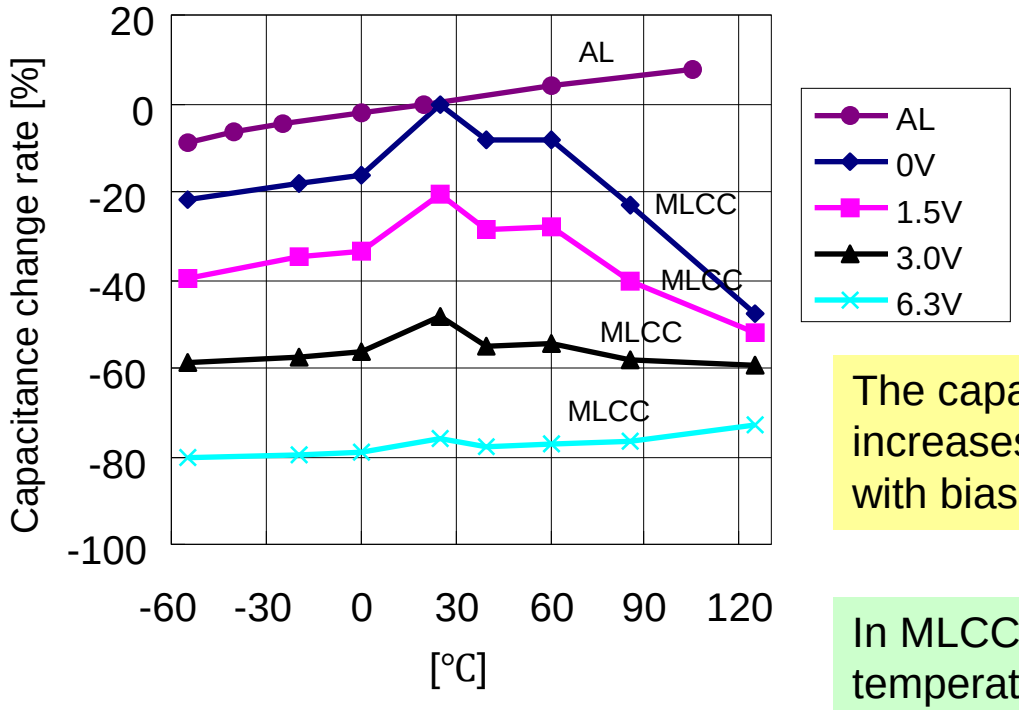
Capacitance of Aluminum electrolytic capacitors and Tantalum electrolytic do not change with the voltage, but capacitance of MLCC changes. When rated voltage of 6.3V is applied, capacitance of F characteristic product decreases by 80% or more.

MLCC also has the character of piezoelectric element (Electromotive force will generate when pressure is applied), and when mechanical shock is applied, pulsed noise is generated. Squealing phenomenon is also well known.

Temperature dependence: Aluminum electrolytic capacitor vs MLCC

Temperature-Capacitance characteristics

Aluminum electrolytic capacitor Vs MLCC



Samples：

Al-cap: 6.3V / 100μF, φ6.3x5.8Lmm

MLCC: 6.3V / 100μF, (3216 size)

The capacitance of the Al-Electrolytic capacitor linearly increases with temperature. Also it does not change with bias voltage.

In MLCC, the capacitance changes nonlinearly with temperature, the capacitance decreases greatly with the bias voltage, and decreases to about 1/5 at the rated voltage.

Supply shortage of MLCC

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News about MLCC supply shortage

2018年06月07日

空前のコンデンサー不足、太陽誘電が新工場検討

太陽誘電の登坂正一社長インタビュー

積極投資に出る登坂社長

https://newswitch.jp/p/13214

潮流を掴め

深刻化するコンデンサー不足 「村田製作所」に強気判断

ツイート　シェア 0

>> バックナンバー　2018年6月19日

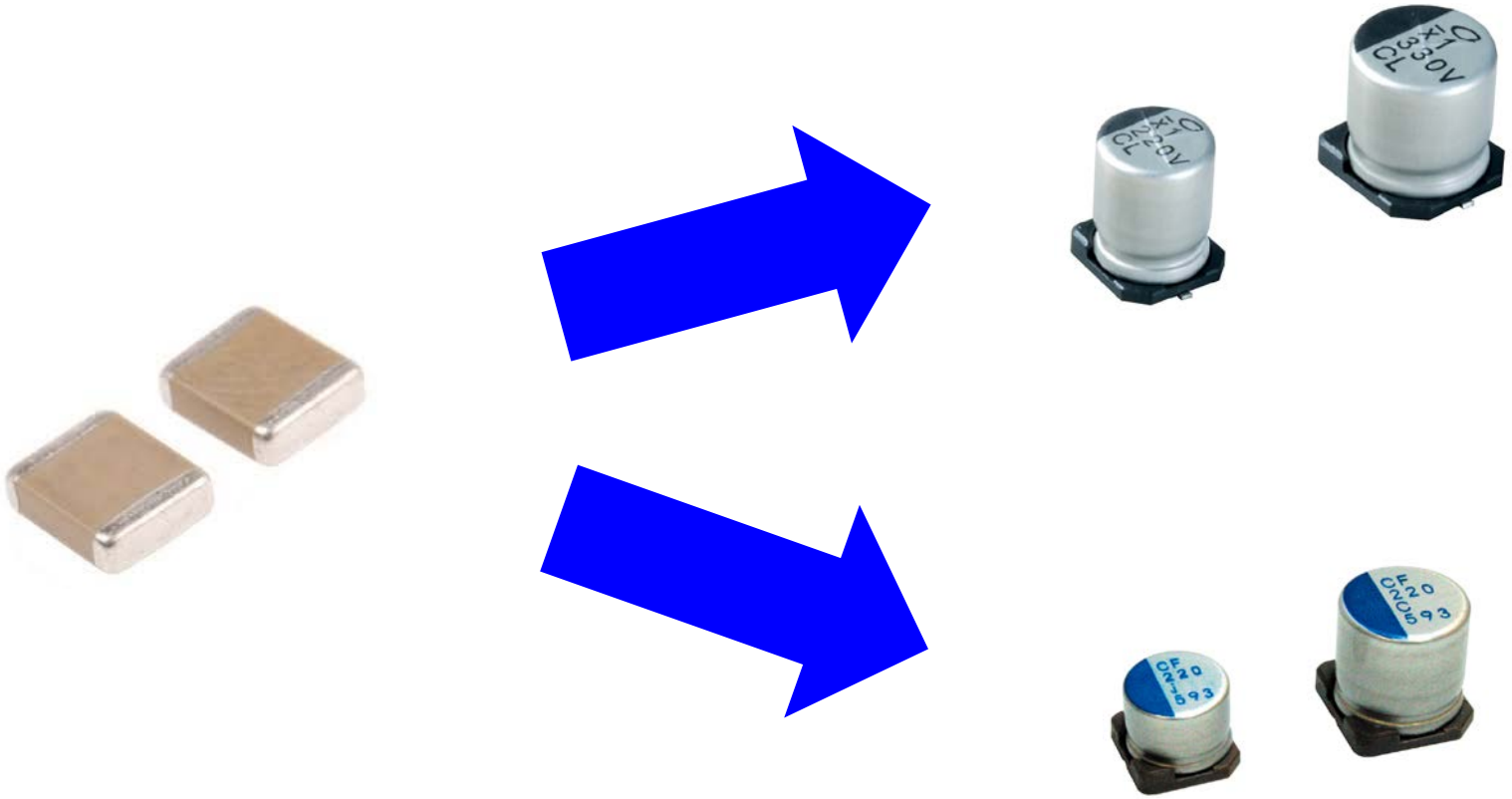
代表的な電子部品のひとつであるコンデンサーの品不足が深刻化している。これは「コンデンサー・ショック」といわれ、今後数年は解消されないとの見方がもっぱらだ。

とりわけ足りないのが、主にスマホなどの精密電子機器に多用される積層セラミックコンデンサー（…

https://www.nikkan-gendai.com/articles/view/news/231508

MLCC has exceeded expectations.
The supply and demand structure of MLCC is completely collapsed.
It is a major issue for the MLCC industry as a whole.
The situation is expected to last for the time being.

Replacement of aluminum electrolytic capacitor to MLCC



Replacement of MLCC to aluminum electrolytic capacitors is accelerating.

Replacement of Aluminum Electrolytic capacitor to MLCC

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>For example 1 （line voltage 5V or less）

6.3V, 22μF
（3216 size）

6.3V 22μF

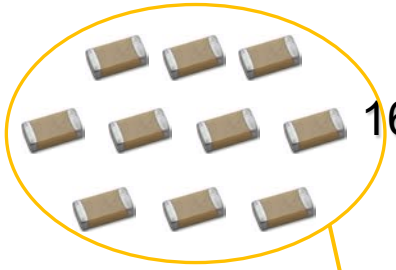
UCL0J220MCL1GS
(φ4 x 5.8L)

Rated ripple current
160mArms (at 105℃ 100kHz)

UWF0J220MCL1GB
(φ4 x 5.4L)

Rated ripple current
50mArms (at 105℃ 100kHz)

>For example 2 （line voltage 15V or less）



16V, 2.2μF x10
（2012 size）

16V 22μF

PCF1C220MCL1GS
(φ5 x 6L)

Rated ripple current
1210mArms (at 105℃ 100kHz)

UCL1C220MCL1GS
(φ5 x 5.8L)

Rated ripple current
240mArms (at 105℃ 100kHz)

>For example 3 （line voltage 20V or less）

25V, 1μF x5
（1608 size）

25V 4.7μF

UWF1E4R7MCL1GB
(φ4 x 5.4L)

Rated ripple current
50mArms (at 105℃ 100kHz)

For current filter, please also consider ripple current requirement!

Recommended series

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D (mm)	Voltage (V)	UWT L (mm)	UWT Cap. (μF)	UWT Rated ripple current★	UWF L (mm)	UWF Cap. (μF)	UWF Rated ripple current★	UCL L (mm)	UCL Cap. (μF)	UCL Rated ripple current★	UCJ L (mm)	UCJ Cap. (μF)	UCJ Rated ripple current★
Φ4	6.3V	5.4	22	33	5.4	22	50	5.8	47	160			
	25V	5.4	4.7	19.5	5.4	6.8	50	5.8	10	160			
Φ5	6.3V	5.4	47	54	5.4	47	80	5.8	100	240			
	25V	5.4	10	34.5	5.4	10	80	5.8	33	240			
Φ6.3	6.3V	5.4	100	90	5.4	100	115	5.8	220	300	8.7	100(10V)	95
	25V	5.4	33	72	5.4	33	115	5.8	68	300	8.7	47	95

D (mm)	Voltage (V)	PCF L (mm)	PCF Cap. (μF)	PCF Rated ripple current★	PCJ L (mm)	PCJ Cap. (μF)	PCJ Rated ripple current★	PCX L (mm)	PCX Cap. (μF)	PCX Rated ripple current★	RFS L (mm)	RFS Cap. (μF)	RFS Rated ripple current★
Φ4	6.3V										5.2	10(10V)	700
	25V												
Φ5	6.3V	6	47	1600	6	100	2500				5.7	120	2500
	25V										5.7	27	2450
Φ6.3	6.3V	5.5	100	2800	6	220	3200				for consumer & white goods replacement!!		
	25V	6	6.8	1200				6	22	900			

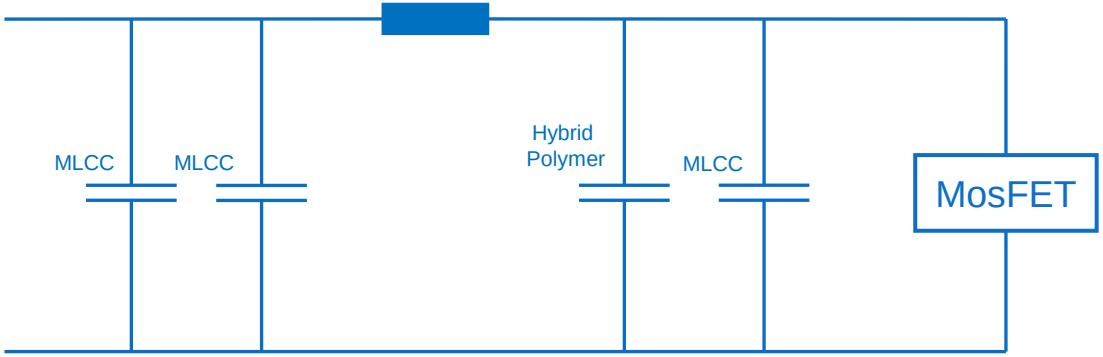
★Rated ripple current （mArms）at 105℃, 100kHz

Notes

- Please offer alternatives with our Aluminum electrolytic as well as Polymer capacitors to overcome the MLCC shortage.
- Please kindly go through a sufficient verification before proposal as well as usage.
- Please contact our sales for any concerns or in case you need samples.

Success stories for MLCC replacement

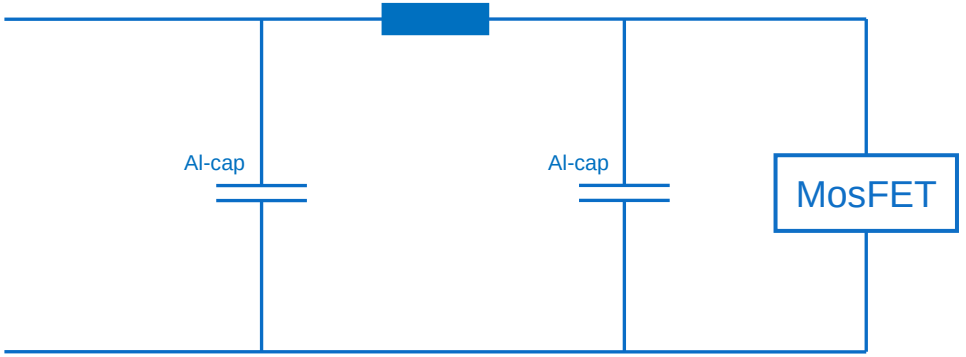
Example – CLC filter:



2x MLCC, 50V/4.7uF
(input buffer, 1210, 2220)

35V Polymer capacitor (8x10L, 10x10L) &
1x MLCC, 50V/4.7uF (1210, 2220)

insufficient EMC performance as well as concern on MLCC availability



1x UCH1V101MCL
(custom PN, for input buffer)

35V rated Al-cap
for PWM filtering(10x10L)

- Improved EMC behaviour, due to Al-cap for input filter instead of MLCC.
- Improved ripple current distribution, less PWM filter load, hybrid with Al-cap replacement.

EXAMPLE FOR REFERENCE PURPOSE!!