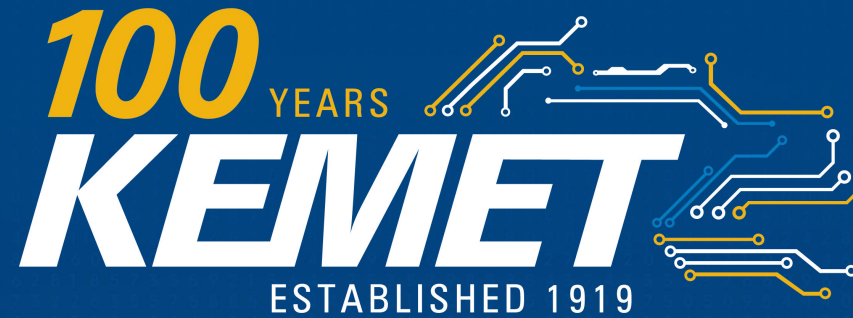




Film Capacitors Industrial & Automotive Market

Andy Chen

PM, Film Capacitors Asia

Global Market Share & Leadtimes

Technology & Market Share	Low	Medium	High	Plant Region
EMI/RFI Suppressors				China
Pulse PP				China & Europe
Power Box				China
Power Cans				Europe

KEMET Advantages

- Low Cost-Region Production With Vertical Integration
- Different Locations and Regions Capable to Provide Same Solutions

Anting Today

General Information

- Founded 2002 by Italia Arcotronics
- 2007 Aquired by KEMET
- 350 Colleagues

Capabilities

- Film Capacitor P10 – P52.5
- Production: 12 lines
- Output (30+m pcs/month)

Key Points

- IATF 16949 / ISO 14001 / OHSAS18001
- Competitive Cost with Sound Quality
- LEAN and High Performance

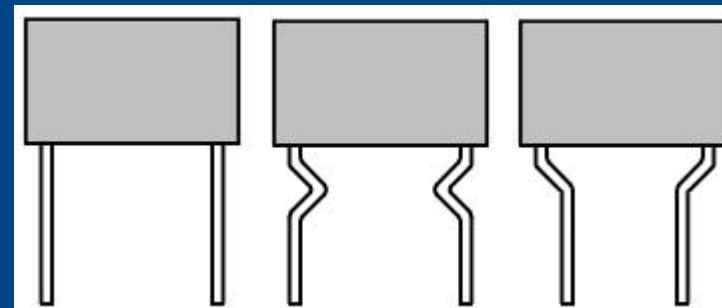


Anting DC Film Capacitor

KEMET Anting Film Capacitor										
Category	EMI				Pulse				GP / EMI / Pulse	
KEMET Type	R46	R47	R49	R41	R71	R74	R75	R76	PHE	F Series
Application	X2	X1	X1	Y2	PFC	Resonant	Snubber	Big Pulse	Multi-	Multi-
Pitch 10	Available	Available	Available	Available	Available	Available	Available	Available		
Pitch 15	Available	Available	Available	Available	Available	Available	Available	Available		
Pitch 22.5	Available	Available	Available	Available	Available	Available	Available	Available		
Pitch 27.5	Available	Available	Available	Available	Available	Available	Available	Available		
Pitch 37.5	Available	Available	Available	Available			Available	Available	Available	
Approval	ENEC60384-14, UL60384-14, CQC								ENEC/UL/CQC	

Feature:

- Self-healing and high reliability
- Flame retardant material envelopment
- RoHS & REACH complacence
- Halogen free products available on request
- Taping and loose packaging are available
- Low profile, high profile, and customized capacitors are available



Anting DC Film Capacitor - Auto Grade

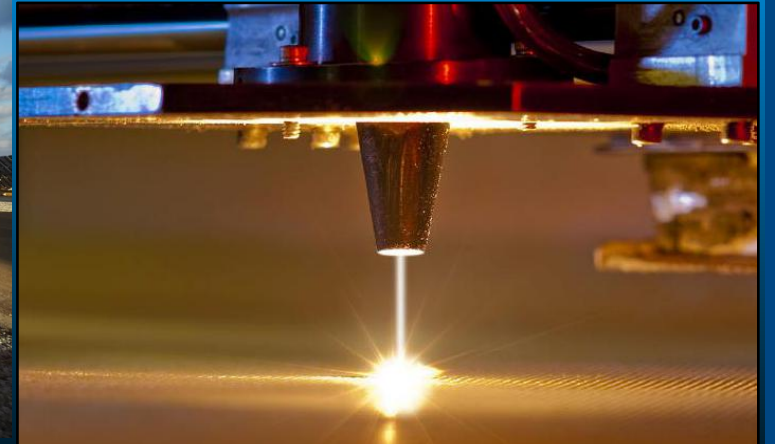


AEC-Q200 Automotive Grade Film Capacitor:

Anting AEC-Q200 Automotive Grade Film Capacitor								
Category	EMI			Pulse			DC-Link	AC Filter
KEMET Series	F862 AUTO	F863 AUTO	R41 AUTO	R74 AUTO	R75 AUTO	R76 AUTO	C4AQ	C4AF
Application	X2 (85/85/1000h)	X2 (85/85/500h)	Y2 (40/93/1000h)	Resonance	PFC / Snubber	Resonance / Pulse	DC Filtering	AC Filtering
Pitch 10		Planning	Available	Available	Available	Available		
Pitch 15	Planning	In progress	Available	Available	Available	Available		
Pitch 22.5	Planning	In progress	Available	Available	Available	Available		
Pitch 27.5	Planning	In progress					Available	Available
Pitch 37.5							Available	Available
Pitch 52.5							Available	Available
Approval	ENEC60384-14, UL60384-14, CQC							

- IATF16949 certificate available
- AEC-Q200 standard compliant
- There is the suffix of 'AUTO' for Automotive Grade DC Film Capacitor
- Potential market is EV & PHEV AC/DC Converters & Battery charger

Power Converter Capacitors



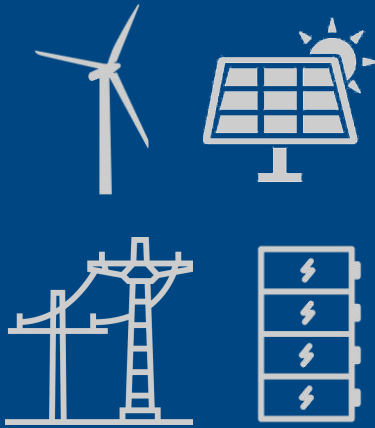
AUTOMOTIVE	GREEN ENERGY	INDUSTRIAL
On Board Battery Chargers	Solar Inverters	Power Conversion
Charging stations	Solar Microinverters	Motor Driver
DC- DC Converter	LED Lighting	Welding Machinery
Electrical Power Steering	Energy Storage	Rectifiers
DC Motor Filtering	Grid Optimizer	SMPS
Power Train Inverters	Hybrid Inverters	HVAC

Key Customer's Profile

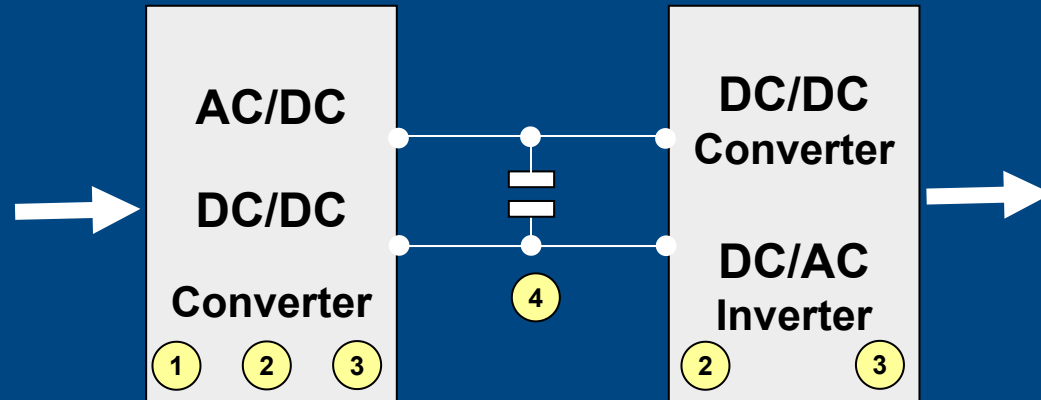
- Using IGBT's, SiC Mosfet's, Thyrestors, or Power Transistors as Switching Devices
 - High Power (>1KWatt), High Voltage (> 450VDC/120 VAC) Designs

Film Capacitors for Energy Conversion Systems

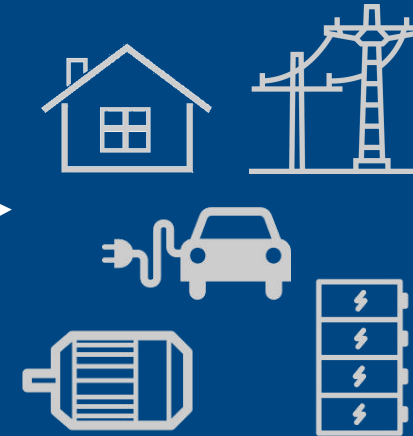
Energy Source



Conversion System



Energy Output



F862
F863
R41
R47



EMI Suppression

1

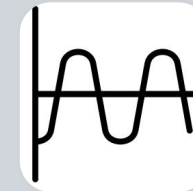
R73
R74
R75
R76
C4AS/C4BS



Pulse
Snubber

2

C4AF
C44P-R
C20A



AC Filtering

3

C4AQ
C44U
C4E



DC-Link

4

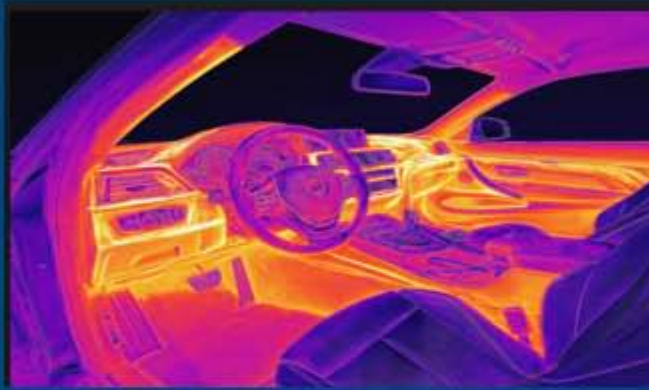
Focus - Film Solution by Market & Applications Not Automotive

Applications



	Solar Low & Medium Power	Solar High Power	Wind	Motor Drives Medium & High Power	UPS High Power
AC Harmonic Filtering	C4AF	C20A C44P-R*	C20A C44P-R	C4AF C20A, C44P-R*	C20A C44P-R
Snubber IGBT protection	C4AS R76	C4BS	C4BS	C4BS	C4BS
DC Link	C4AQ	C44U	C44U	Electrolytic	Electrolytic
RFI	F862/F863 R46 310Vac R41	F862/F863 R46 310Vac R41	F862/F863 R46 310Vac R41	F862/F863 R46 310Vac R41	F862/F863 R46 310Vac R41

EV / HEV Focus applications



Heating
Air conditioning



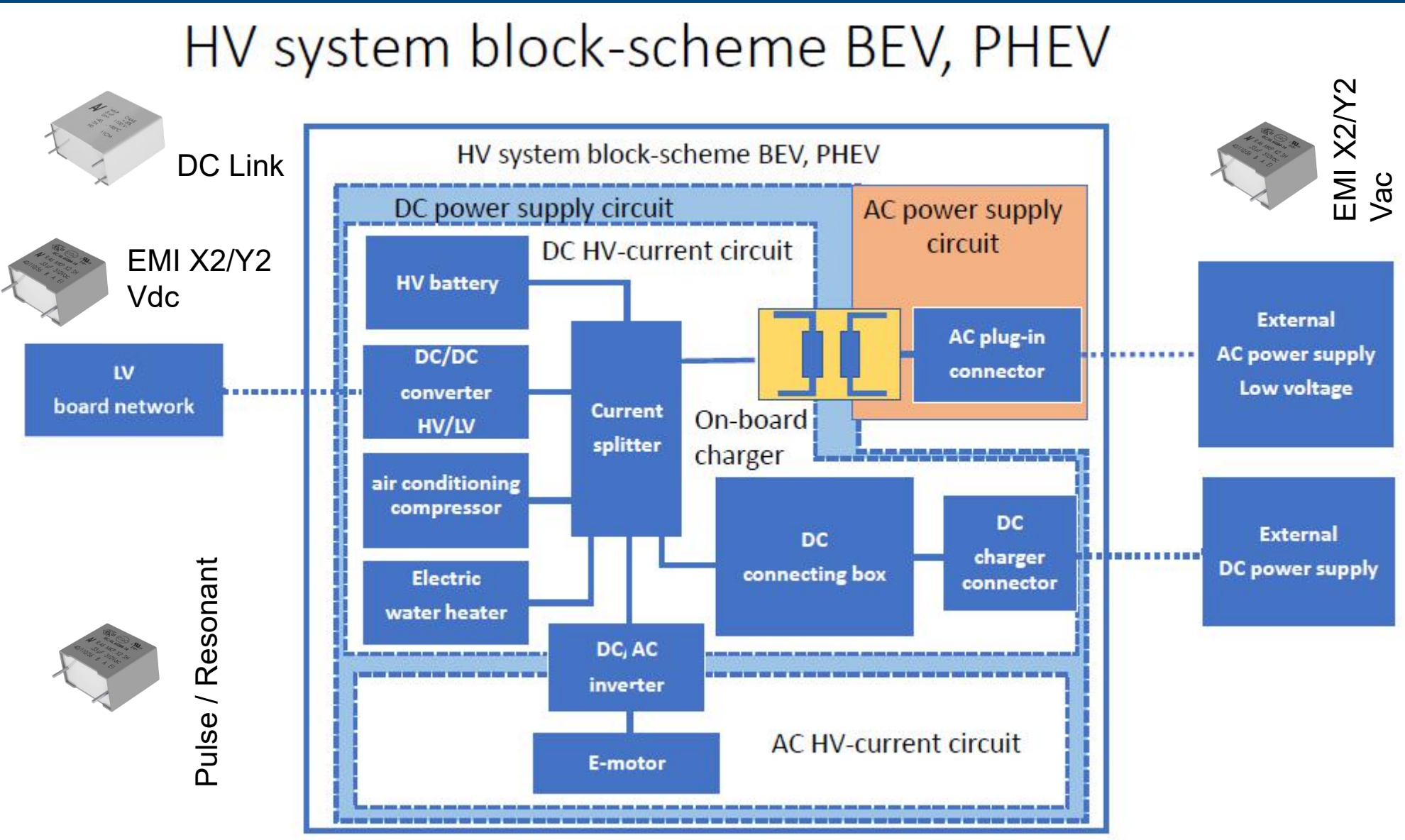
On Board Chargers



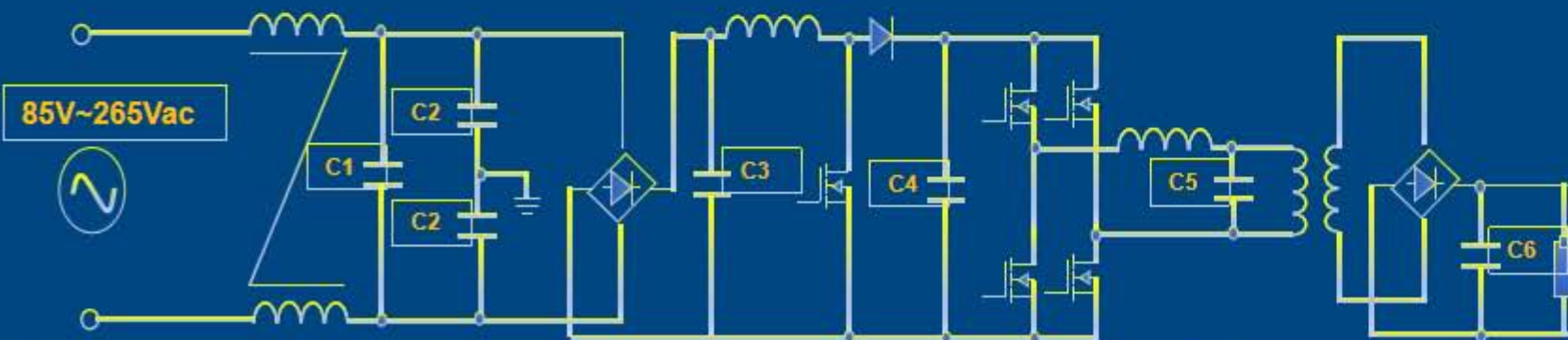
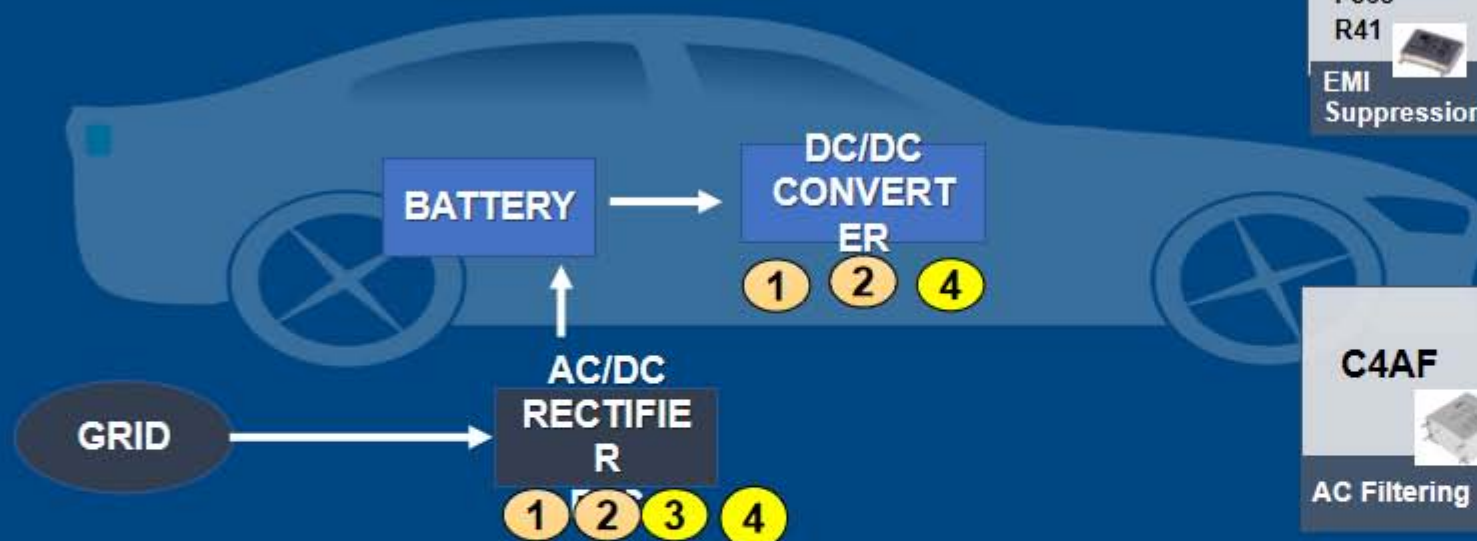
DC/DC Converters
HEV/EV traction inverters



Focus - Film Solution for Automotive



(Bi) On Board Battery Charger ;DC/DC Automotive Applications



**C1;C2 - EMI
X / Y cap Solution**

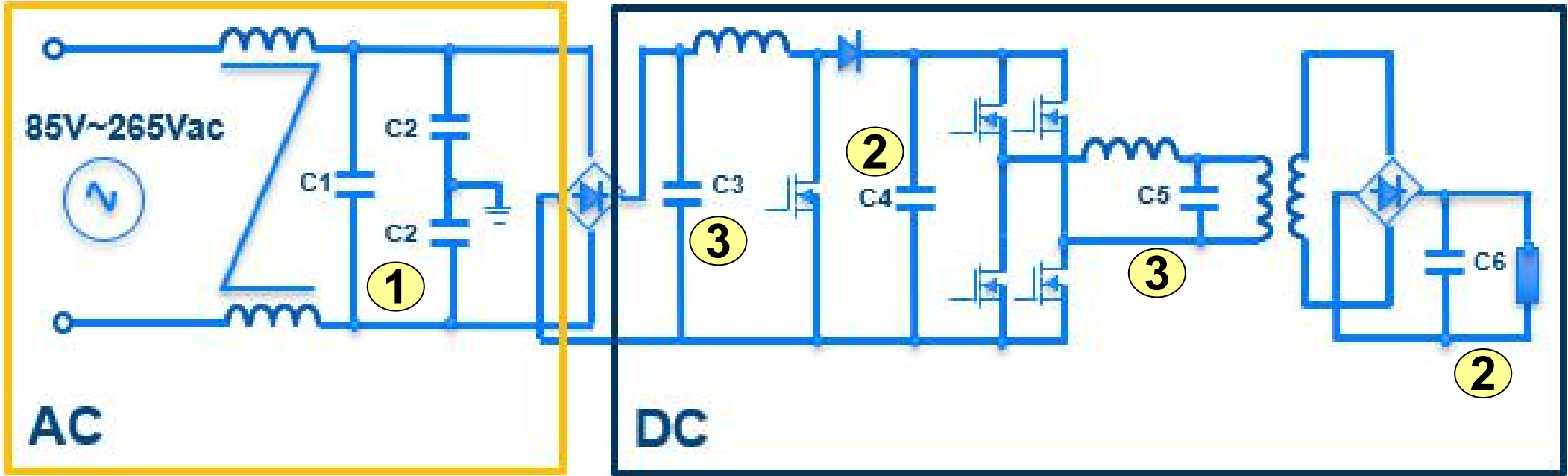
**C3 ; C5 - Resonant Cap
- R75/R76 Solution**

**C4 - DC Link
- Power Box Solution**

**C6 – Output Filter
- Power Box Solution**

Item	Series	Typical values
C1	F862/F863	0,47uF-2,2uF
C2	R41/ F882	1nF – 2,2nF
C3	R75/R76	0,47 – 2,2uF
C4	C4AQ /C4AU	100UF~1300UF
C5	R75,R76	10nF
C6	C4AQ /C4AU	4-5uF; 700VDC

On Board Battery Charger



1

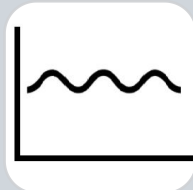
F862
F863
R41 AUTO



C1 – C2 :
EMI Suppression

2

C4AQ



C4: DC Link
C6: Output Filter

3

R75
R76



C3: PFC
C5: Resonant

1 EMI Suppression

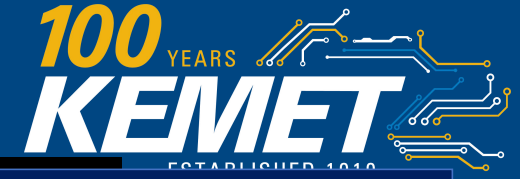


F863	F862	R41 AUTO
X2 ENEC, UL, cUL, CQC	X2 ENEC, UL, cUL, CQC	Y2 ENEC, UL, cUL, CQC
310Vac	310Vac	300Vac
630Vdc	630Vdc	1000Vdc
Climatic category: 40/110/56	Climatic category: 40/110/56	Climatic category: 40/110/56
Capacitance range: 0.1 – 10.0 μ F	Capacitance range: 0.1 – 4.7 μ F	Capacitance range: 0.001 – 1 μ F
Lead spacing: 15.0 – 37.5 mm	Lead spacing: 15.0 – 27.5 mm	Lead spacing: 10 – 37.5 mm
AEC Q200	AEC Q200	AEC Q200
THB 85°C / 85% R.H: 240Vac – 500hrs	THB 85°C / 85% R.H: 240Vac – 1000hrs	

- ✓ Used for EMI Suppression typically in AC applications
- ✓ Design focused to maximize Selfhealing properties and Peak Voltage withstanding
- ✓ Not designed for high ripple current capability

1

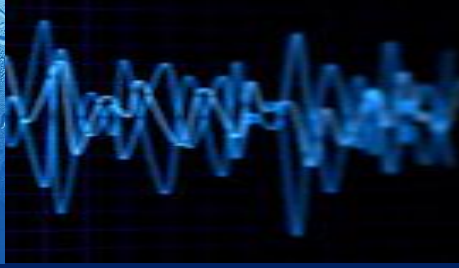
KEMET Film Meet the Latest Electronic Industry Spec's for Harsh Environment



High
Temperature
Conditions



High
Humidity
Environments



High Switching
Frequency
& Harmonics



High
Voltage
& Surge



Long Life
High
Reliability

1

F862

- X2 310 VAC
- EMI Suppressor
- 85°C/85 R.H.
- 1000 Hrs
- AEC-Q200

1

F863

- X2 310 VAC
- EMI Suppressor
- 85°C/85 R.H.
- 500 Hrs
- AEC-Q200

1

R41
V026

- Y2 300 VAC
- EMI Suppressor
- 85°C / 85 R.H.
- 1,000hrs
- AEC-Q200

3

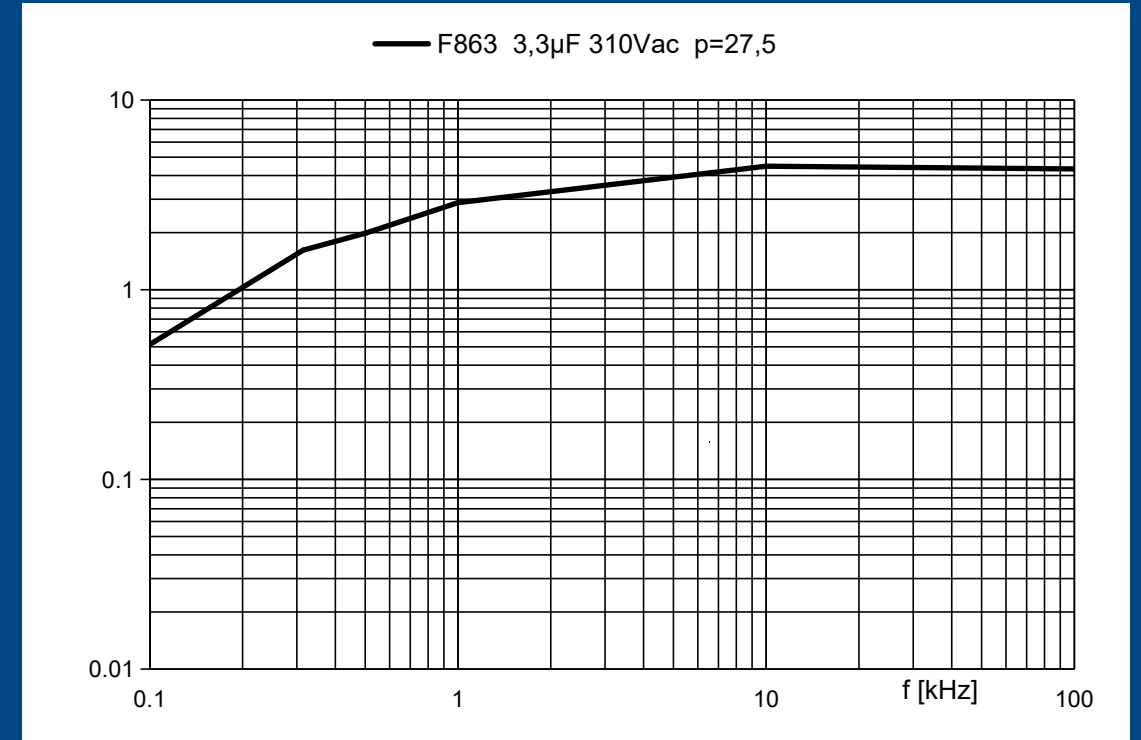
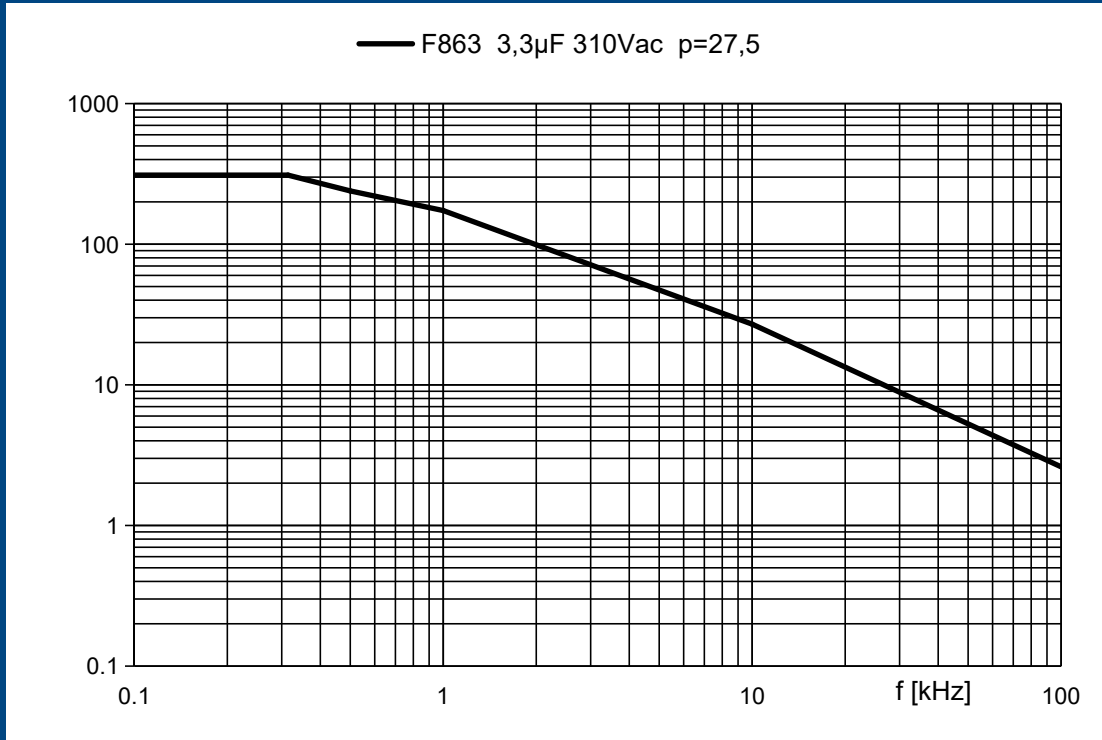
C4AF

- AC Filter
- Up to 400VAC
- 85°C/85 R.H.
- 500 Hrs
- AEC-Q200

1 EMI Suppression



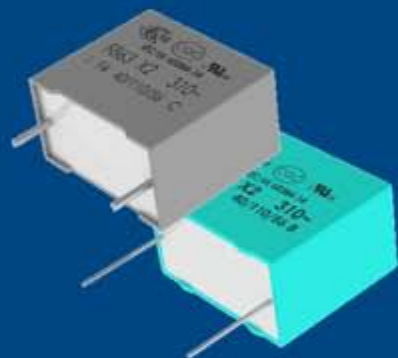
Example of ripple current graph: F863 1uF



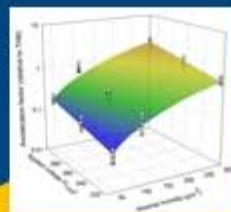
60°C ambient temperature

max. DT [°C]: 20,00

1 EMI Suppression



- **2020**
- Voltage / Humidity and Temperature Life Model



- **2019**
- Y2 300Vac
- Vr 85°C/85%R.H. 1000hrs
- Short life at 125°C
- High Pot test declaration

- **2020**
- X2 THB Grade IIIB
- Vr 85°C/85%R.H. 1000hrs

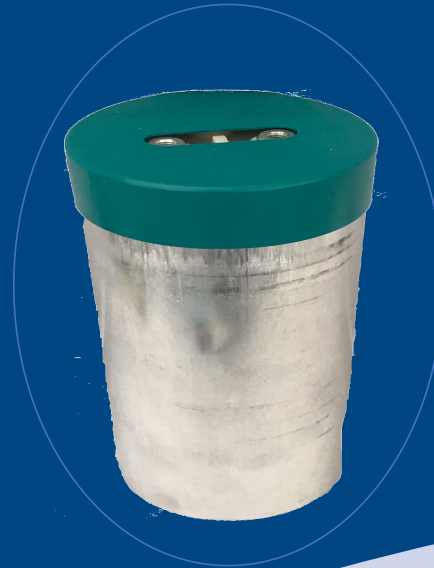
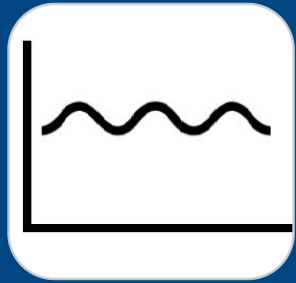
Automotive

Now

- X2 THB series F862, F863
- 85°C/85%R.H. 240Vac 1000hrs (500hrs)

Irms curves

DC-Link Capacitors



C4E

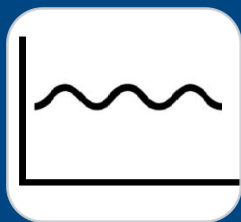


C4AQ

Power & Complexity

2

DC-Link Capacitor – C4AQ



Two and Four Leads Available



SOLAR



UPS
DRIVES



AUTO

- Self Healing
- High ripple current
- Life expectancy > 100'000 hours
- Up to 105°C working temperature
- AECQ200
- ESR design optimization

FOCUS APPLICATIONS

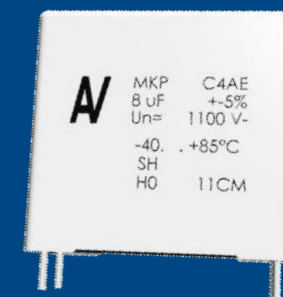
- DC Link in Solar Converters
- DC Link in UPS and Motor Drives
- DC Link in automotive inverters, On Board Chargers

Maximum Capacitance	270 μ F
Maximum Voltage	1,500 VDC
Maximum Temperature	+105 °C
Qualification	AEC-Q200

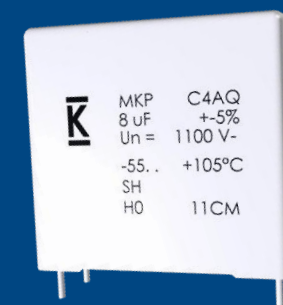
C4AQ and C4AE in DC-Link Applications

1. Both Produced in Anting, China (Competitive Pricing)
2. AEC-Q200 Certified. Higher Reliability vs. Not Automotive
3. Rated voltages per temperatures match derating from competitors for easier crossings
4. Larger boxes available (high C density)
5. Wider temperature range reaching -55 °C up to 105 °C, with Longer Life
6. Coming Soon **THB 85°C/85 R.H. Solution** & High Temperature, 125 °C, capability (Short Life) – Q2FY2020

Before



Now



C4	A	Q	U	B	W	5270	A	3	N	J
Series	Type	Application	Rated Voltage (VDC)	Case	Terminals Code	Capacitance Code (pF)	C-Spec	Lead Diameter (mm)	Size Code: B x H x L (mm)	Tolerance

2 DC Link BOX Low profile

Cap Value (μF)	VDC@85°C	Dimensions (mm)					PART NUMBER
B	H	L	P	P1			
5	500	21	12,5	31,5	27,5	/	C4AQLLU4500A1-K
7	500	24	15	32	27,5	/	C4AQLLU4700A3-J
13,5	500	31	19	31,5	27,5	/	C4AQLLU5135A1-J
10,5	500	24	15	41,5	37,5	10,2	C4AQLLW5105A34J
14	500	24	19	41,5	37,5	10,2	C4AQLLW5140A33J
30	500	35	24	42	37,5	20,3	C4AQLLW5300A36J
40	500	43	25	42	37,5	20,3	C4AQLLW5400A38J
3,5	650	21	12,5	31,5	27,5	/	C4AQCLU4350A1-K
5	650	24	15	32	27,5	/	C4AQCLU4500A3-J
10	650	31	19	31,5	27,5	/	C4AQCLU5100A1-J
7,5	650	24	15	41,5	37,5	10,2	C4AQCLW4750A34J
10,5	650	24	19	41,5	37,5	10,2	C4AQCLW5105A33J
22	650	35	24	42	37,5	20,3	C4AQCLW5220A36J
30	650	43	25	42	37,5	20,3	C4AQCLW5300A38K
2,7	800	21	12,5	31,5	27,5	/	C4AQILU4270A1-K
3,9	800	24	15	32	27,5	/	C4AQILU4390A3-J
7,5	800	31	19	31,5	27,5	/	C4AQILU4750A1-J
5,8	800	24	15	41,5	37,5	10,2	C4AQILW4580A34J
8	800	24	19	41,5	37,5	10,2	C4AQILW4800A33J
17	800	35	24	42	37,5	20,3	C4AQILW5170A36J
22	800	43	25	42	37,5	20,3	C4AQILW5220A38J

Cap Value (μF)	VDC@85°C	Dimensions (mm)					PART NUMBER
B	H	L	P	P1			
1,7	1100	21	12,5	31,5	27,5	/	C4AQQLU4170A1-K
2,5	1100	24	15	32	27,5	/	C4AQQLU4250A3-J
4,8	1100	31	19	31,5	27,5	/	C4AQQLU4480A1-J
3,8	1100	24	15	41,5	37,5	10,2	C4AQQLW4380A34J
5	1100	24	19	41,5	37,5	10,2	C4AQQLW4500A33J
10,5	1100	35	24	42	37,5	20,3	C4AQQLW5105A36J
14	1100	43	25	42	37,5	20,3	C4AQQLW5140A38J
1,2	1300	21	12,5	31,5	27,5	/	C4AQULU4120A1-K
1,8	1300	24	15	32	27,5	/	C4AQULU4180A3-J
3,3	1300	31	19	31,5	27,5	/	C4AQULU4330A1-J
2,6	1300	24	15	41,5	37,5	10,2	C4AQULW4260A34J
3,5	1300	24	19	41,5	37,5	10,2	C4AQULW4350A33J
7,5	1300	35	24	42	37,5	20,3	C4AQULW4750A36J
10	1300	43	25	42	37,5	20,3	C4AQULW5100A38J

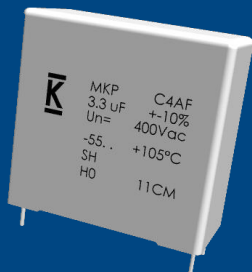


2

AC Filtering Capacitor – C4AF



Two and Four Leads Available



- Self healing
- High ripple current
- THB 85/85 qualified
- AECQ 200 qualified
- Max operative temperature 105°C
- Available in pitch 27.5 - 37.5 - 52.5



SOLAR



UPS

FOCUS APPLICATIONS

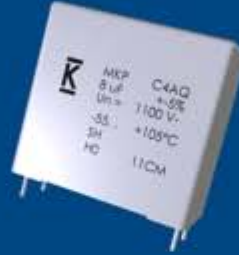
- AC Filter in Solar Converters
- AC Filter in UPS both Input and Output

Maximum Capacitance	210 uF
Maximum Voltage	400 VAC
Maximum Temperature	+105 °C
THB @ 85°C / 85 R.H.	500 Hours
Qualification	AEC-Q200

They Look Alike Outside “but” Different Constructions and Applications

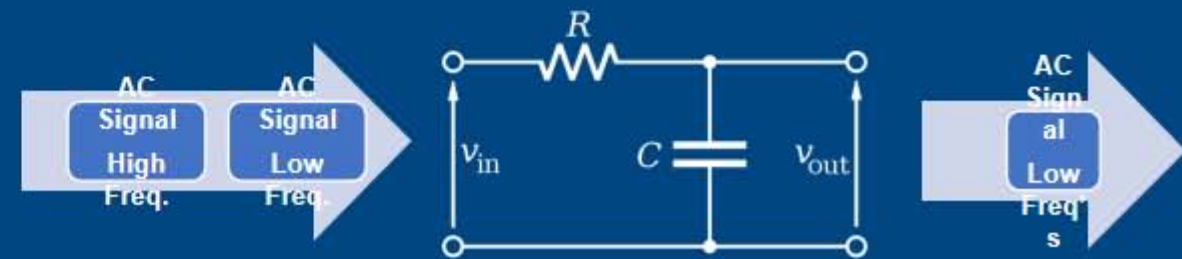
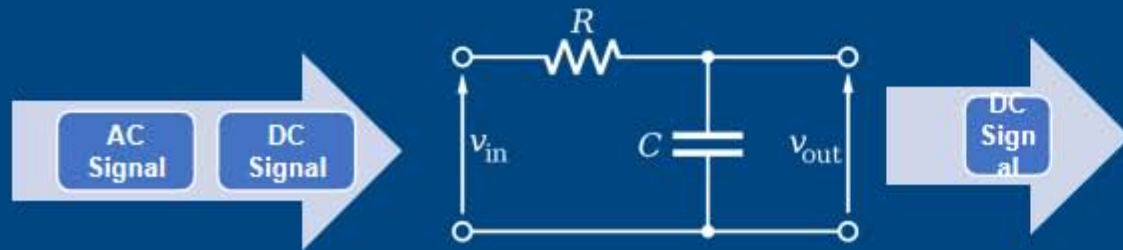
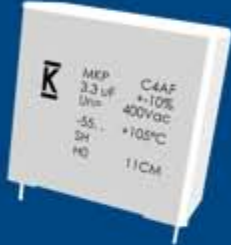
C4AQ

- Capacitance Density is priority
- Rated as DC Voltage
- Never to be used in pure AC lines
- Internal construction used aluminum metallization, better for DC applications, and epoxy to pass AEC-Q200 qualification



C4AF

- Voltage and RMS current is priority
- Rated as AC Voltage
- Designed to be used in AC lines*
- Special, Internal construction to protect against oxidation of the metallization material (zinc better for AC applications) and Corona. Also AEC-Q200



* Consult with your FAE and PM if needed in DC applications. Example: PFC

2 C4AQ series for DC-Link Applications Life Expectancy



Life calculation example:

Hotspot = 85°C

Working voltage 810Vdc,

Rated Voltage 1100Vdc (select the graph)

Lifetime expectancy requested → > 100.000 h

Step 1) Select 85°C Hotspot curve

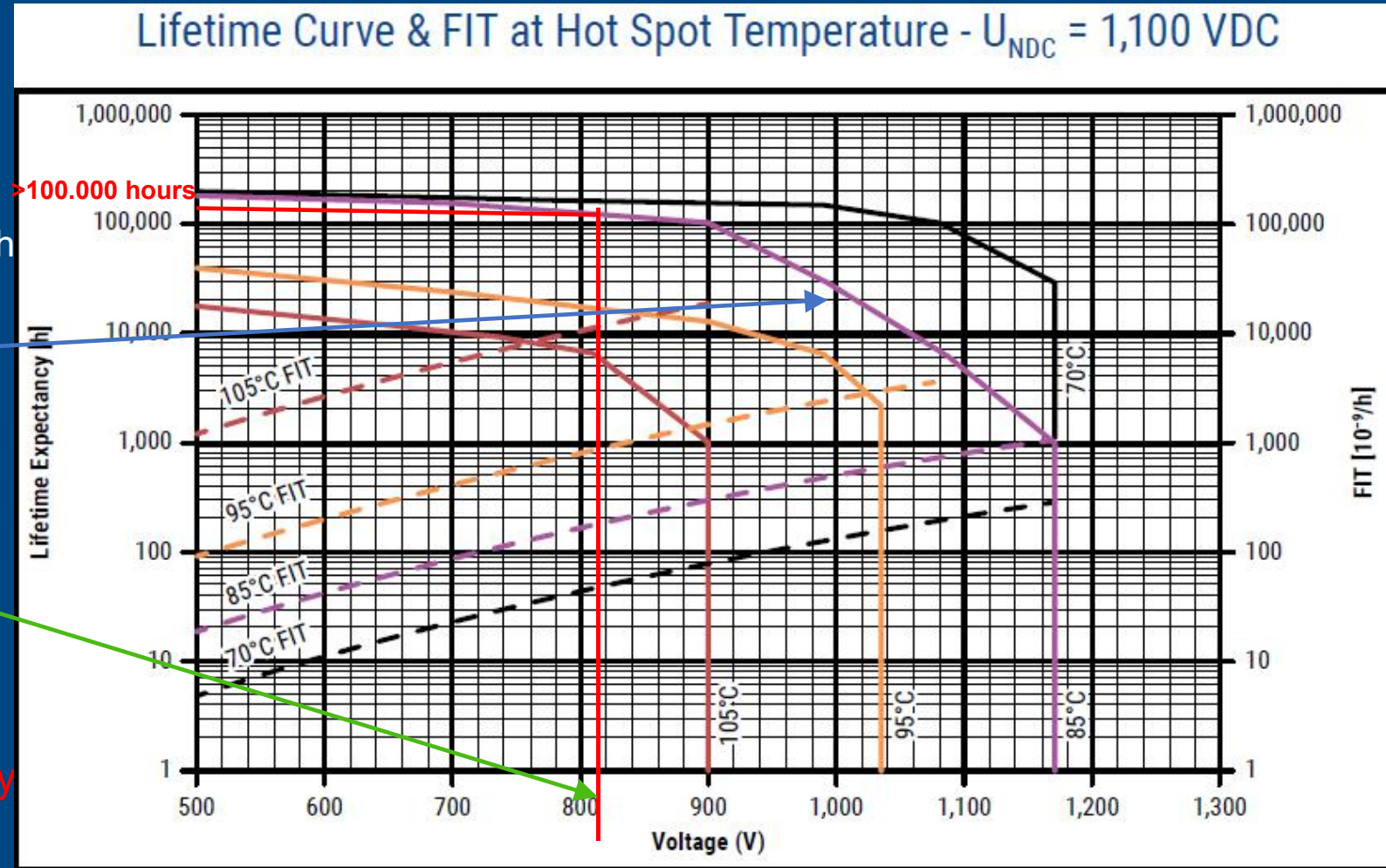


Step 2) Select the Voltage



Step 3) Output lifetime expectancy

The value of Lifetime Expectancy
is higher than 100k hours



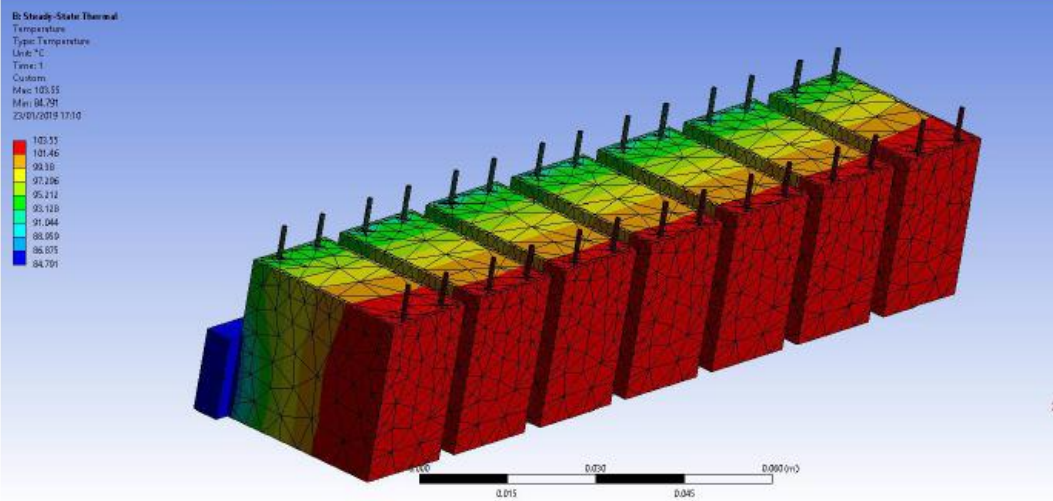
2

C4AQ series for DC-Link Applications Life Expectancy

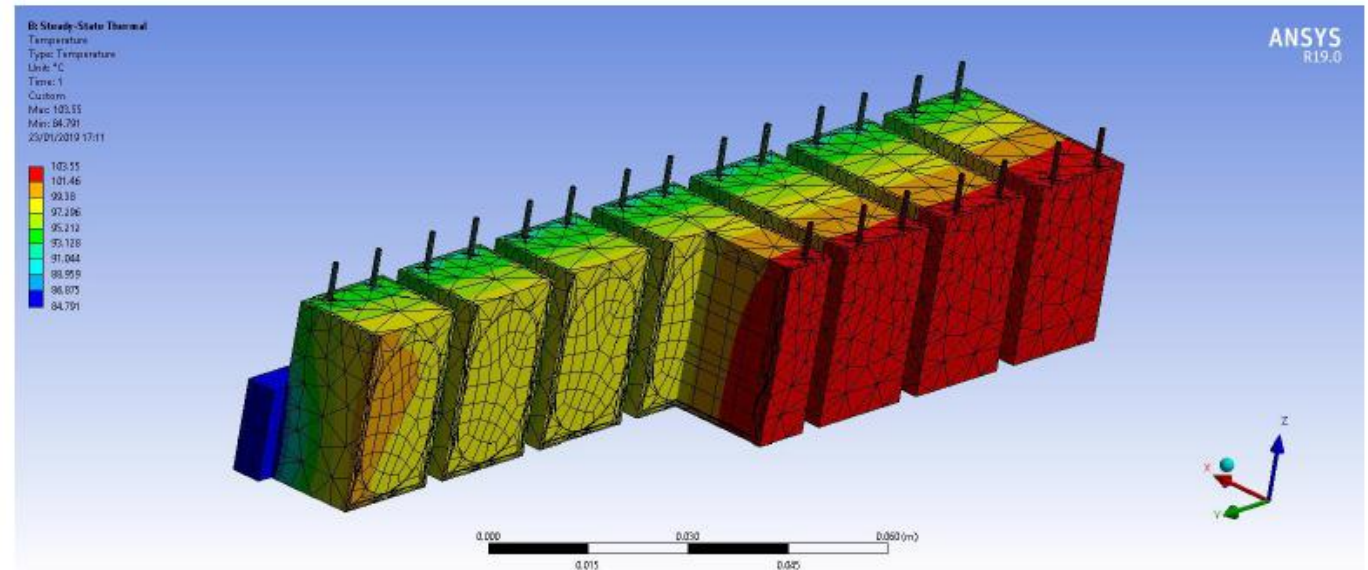


Simulation 1 - conditions:

- Cooler temperature: 85°C;
- Radiation to ambient: 105°C;
- Emissivity coefficient of box: 0,8
- Current: 28 A;
- No convection;



- Tmax = 103,6°C;
- With ambient temperature at 105°C the max Irms current is 28 A (considering all 7 caps). Increasing the current the hot spot temperature will go up than 104°C and the life expected would be lower.



ANSYS software can be used to provide more specific thermal simulations

2 DC Link BOX Roadmap



- **2021**
- $T > 125^{\circ}\text{C}$
- Life increase

- **2020**
- Long Life @ 125°C
- Low ESL

- **2019**
- $85^{\circ}\text{C}/85\%\text{R.H.}$ Vr 1000hrs (C4AU)
- Limited Life @ 125°C (C4AQ)
- Low profile extension

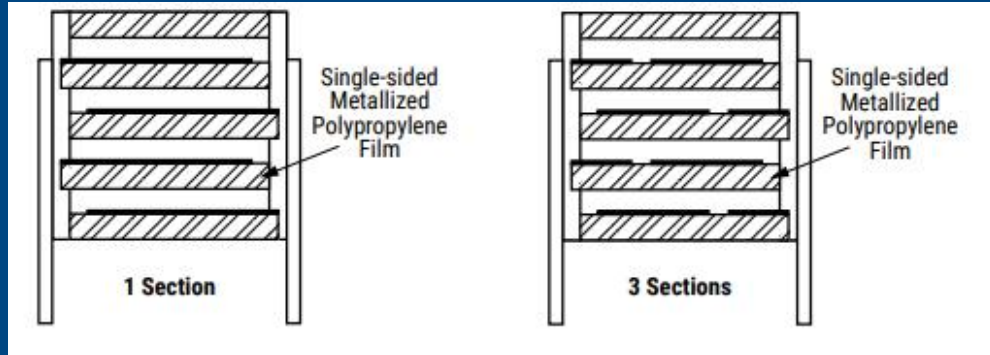
Now

- AECQ200 qualified
- $T < 105^{\circ}\text{C}$

3 Pulse & Resonant overview

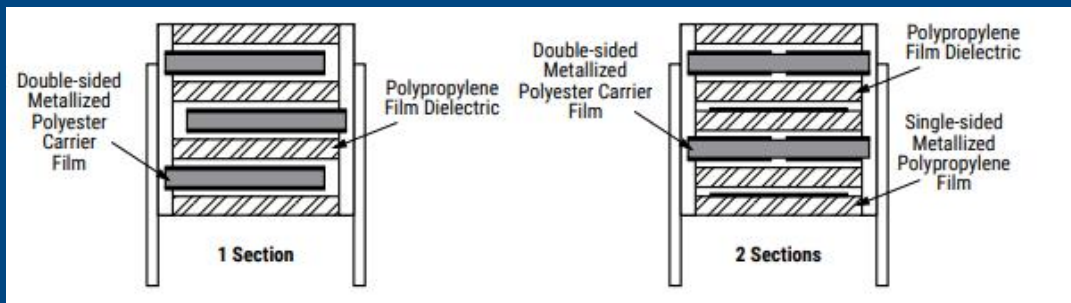


- ✓ Pulse capacitors are designed for high dv/dt and high current capability



R75

- Voltage range: 160 – 2,000 VDC
- Capacitance range: 1 nF – 33 μ F
- Lead Spacing: 7.5 – 37.5 mm
- Max dV/dt : 9500V/us
- Temperature range: -55°C +105°C



R76

- Voltage range: 250 – 2500 VDC
- Capacitance range: 100 pF – 12 μ F
- Lead Spacing: 7.5 – 37.5 mm
- Max dV/dt : 11000V/us
- Temperature range: -55°C +110°C

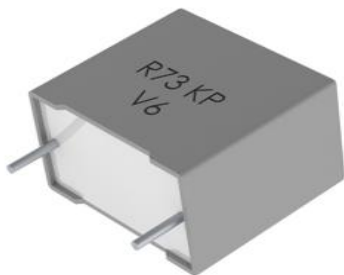
R76 125°C

- Voltage range: 250 – 2500 VDC
- Capacitance range: 3.3nF – 12 μ F
- Lead Spacing: 7.5 – 37.5 mm
- Max dV/dt : 9500V/us
- Temperature range: -55°C +125°C

NEW!

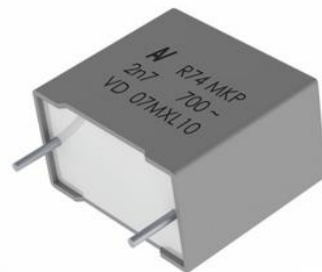
Pulse, Snubber Capacitors Radial Polypropylene Technology

AEC-Q200



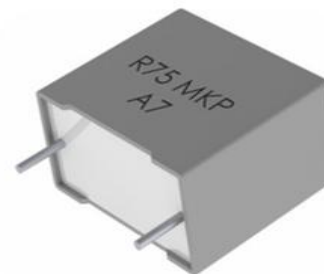
R73

- Film- Foil
- $-55^{\circ}\text{C} \sim +105^{\circ}\text{C}$
- 100 ~ 2,000 VDC
- 100 pF ~ 2.2 μF
- Resonance,
- Snubber, and
- Switching circuits



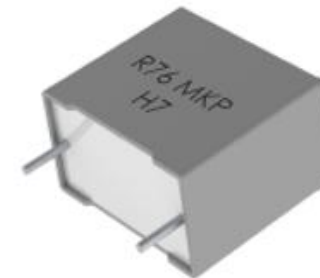
R74

- Single Metallized
- Up to 125°C Available
 - 250-900 VDC
 - 470 pF – 3.3 μF
- High current & voltage applications
- Electronic Lighting
- Pulse with high AC content



R75

- Single Metallized
- -55°C to $+105^{\circ}\text{C}$
- 160 – 2,000 VDC
- 220 pF – 33 μF
- Multi purposes
- Resonant Circuits
- PFC, Coupling
- Timing, Oscillators

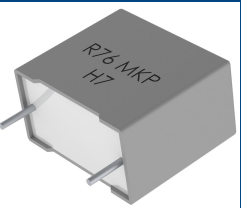


R76

- Double Metallized
- -55°C to $+105^{\circ}\text{C}$
- 250 – 2,000 VDC
- 100 pF – 15 μF
- Switching
- spikes suppression
 - High voltage
 - & high current
- Commutation circuits

3

Pulse – Snubber – R76 / R75



Two and Four Leads Available



SOLAR



UPS



AUTO

- Self healing
- MMKP brings high ripple current
- Cover full capacitance and voltage range
- AECQ 200 qualified
- *Max operative temperature 125°C
- **THB 85/85 under qualifiation
- Available in pitch from 7.5 to 37.5

FOCUS APPLICATIONS

- Snubber in Solar Converters
- Snubber in UPS and Motor Drives
- Resonant in automotive inverters, On Board Chargers

Maximum Capacitance	15 uF
Maximum Voltage	2000 VDC
Maximum Temperature	*+125 °C
THB @ 85°C / 85 R.H.	**Per Request
Qualification	AEC-Q200

3 Pulse & Resonant



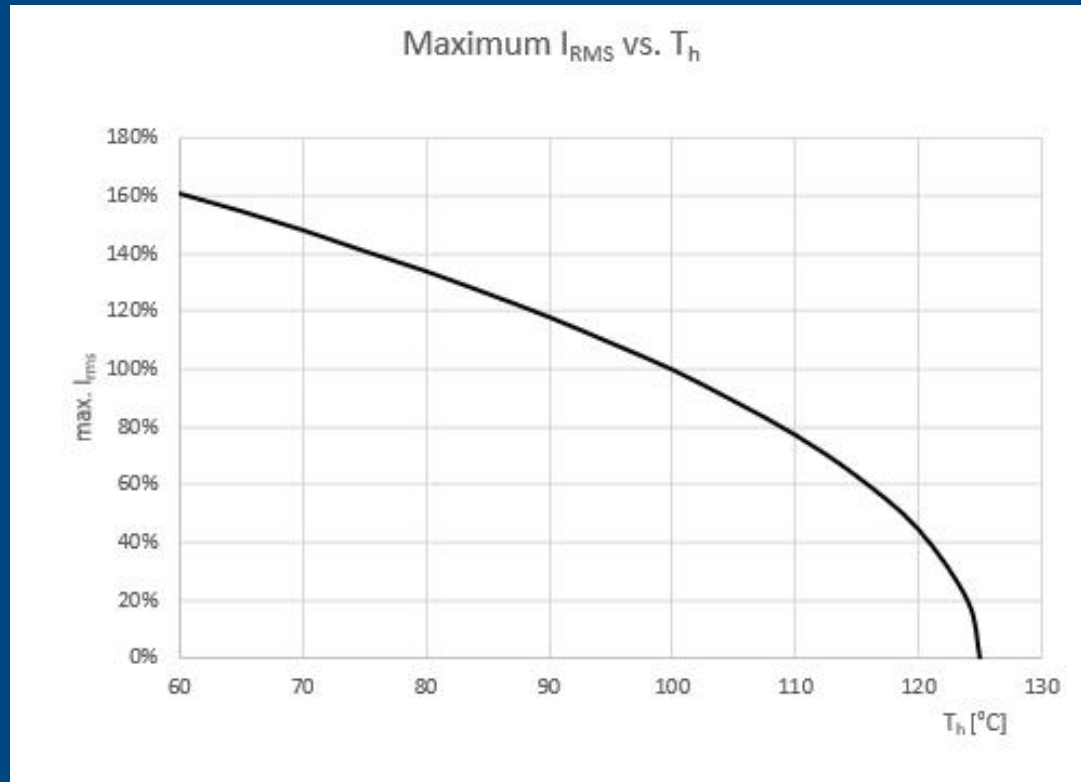
R76 125°C

Example for finding correct I_{rms} max value in the graph

In the datasheet the curves in the graphs for I_{rms} and V_{rms} show values at 100°C ambient temperature.

For the calculation the I_{rms} and V_{rms} values for different ambient temperatures we should use the following graph.

The graph show dependence of max I_{rms} vs. T_h



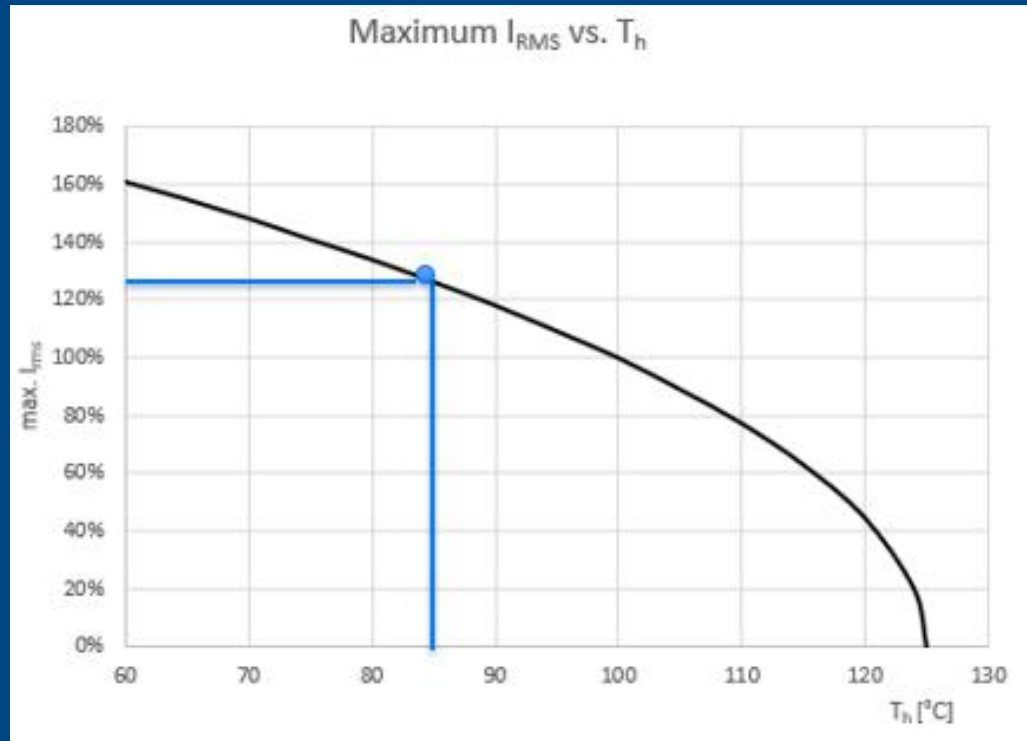
T_h is the maximum ambient temperature surrounding the capacitor or hottest contact point (e.g. tracks), whichever is higher, in the worst operation conditions in °C

③ Pulse & Resonant



R76 125°C

If we want to calculate I_{rms} at 85°C, firstly we should find the value in the graph



The value is 125% or 1,25

3 Pulse & Resonant



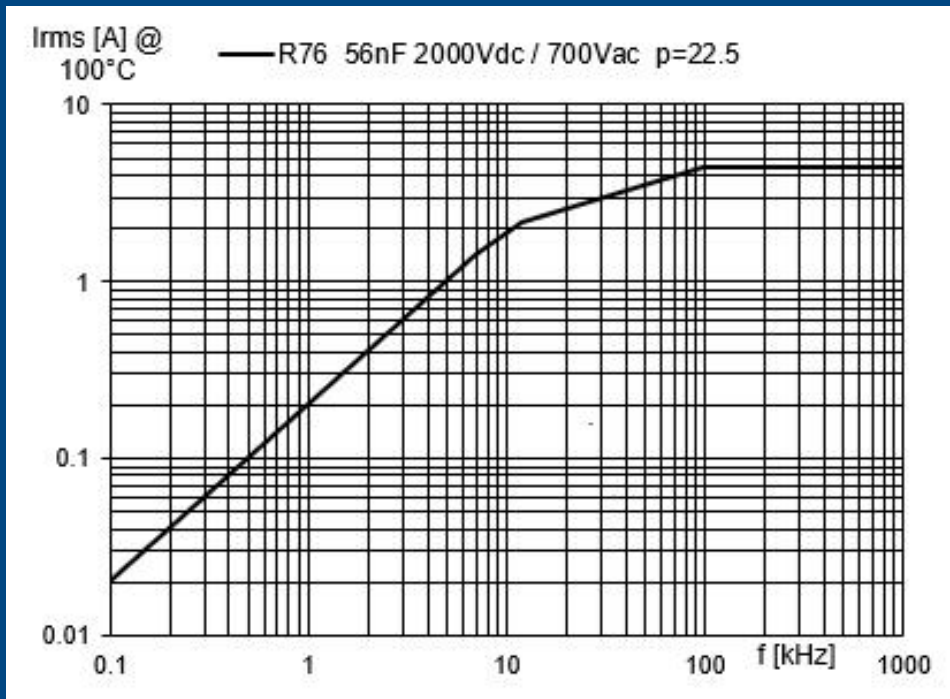
R76 125°C

In the table for all PNs in the datasheet show values at 100 °C @100KHz
For the required capacitance value 0.056 uF the Irms max is 4,46A at 100°C

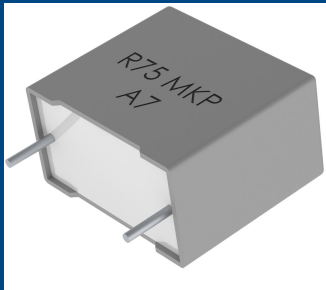
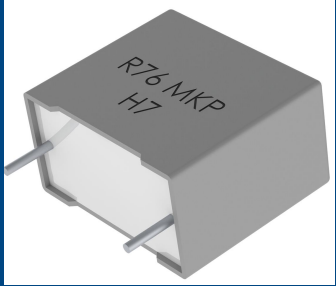
Table 1 – Ratings & Part Number Reference

VDC	VAC	Capacitance Value (μF)	Dimensions in mm			Lead Spacing (p)	dV/dt (V/μs)	Max K ₀ (V ² /μs)	I _{pk}	ESL	ESR	I _{rms} max (*)	R _{th}	KEMET Part Number
										lead length 2x 4mm	@100 kHz	@100 kHz 100°C		
			W	H	L					A _{pk}	nH	mΩ	Arms	
2000	700	0.0560	11.0	20.0	26.5	22.5	4,500	18,000,000	252	16	23	4.46	34	76UN2560(1)H4(2)

For ambient temperature 85°C the calculation of Irms max will be $4,46 \times 1,25 = 5,575$ A
For different range of frequency we should use the following graphs given in the datasheet



③ Pulse & Resonant Roadmap



Now

- R76 - R75 AECQ200 pitch 22.5m
- $T < 110^{\circ}\text{C}$

2019

- R75T , R76T
- $85^{\circ}\text{C}/85\%\text{R.H. Vr } 1000\text{hrs}$
- AECQ200

- R75H , R76H
- AECQ200
- $T = 125^{\circ}\text{C}$

- 2021
- R76Y
- Low ESL
- $T > 125^{\circ}\text{C}$

Thank you!

If you have any question, please don't hesitate to get in touch with us

