Capacitor Committee –

Capacitor Fundamentals 401:

Choosing a Capacitor From Start To Finish

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PSMA

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Background:

- 37 years of work experience in the Automotive and Electronics industry
- Background in Manufacturing, Design, Program Management, and Sales Engineering
- FTWLLC, LLC formed in 2001 a Sales Representative firm focused on Power Electronics and Services in the Great Lakes States.

Webinar Presented by

PSMA

The principal activities of PSMA include:

- Co-Sponsors of the Applied Power Electronics Conference (APEC)
- Provides and maintains a Web Site with relevant industry and member information
- Conducts regular member surveys to identify areas of importance or concern
- Develops standard industry terminology
- Generates and publishes technology and market reports
- Provides regulatory agency interface
- Organizes technical workshops and seminars
- Coordinates with other power related organizations
- Facilitates benchmarking studies with member companies
- Promotes liaison with users, academia and government

PSMA Benefits:

- **Networking:** Opportunity to meet and interact with your counterparts in other companies on an on-going basis
- **Valuable Information:** Members enjoy access to information in the Members Only area of the Web site
- **Involvement:** Opportunity to be involved with the planning and managing of APEC -- Applied Power Electronics Conference -- sessions that focus on the specific interest of members
- **Participation:** Participate in committees, workgroups and studies to derive a better understanding of market trends, industry trends and better operational procedures to improve performance
- **Discounts:** Receive discounts on registration fees for attending APEC and other PSMA sponsored events
- **PSMA/APEC Passport Program:** All PSMA members exhibiting at APEC can be included in the Passport to increase booth traffic.
- **Finding Trends:** Increase awareness and knowledge of trends and factors that can impact your company
- **Company Profile:** Listing of your company's profile on the PSMA Web Site with a hyperlink directly to your company Web Site
- **Resources:** Opportunity to post job openings and view resumes
- **PSMA Publications:** Regular members receive a copy of all new PSMA publications and reports with discounts for additional copies. Affiliate members may purchase the publications and reports at a discount
- **Power Technology Roadmap Report:** Regular a members receive a copy with discounts for additional copies. Affiliate members may purchase the report at a discount
- **Benchmarking:** Improve the operation of your company by participating in benchmarking studies with other companies in your industry
- **PSMA Newsletter:** Receive "Update" the quarterly newsletter of the PSMA, with information on activities in the industry and upcoming events. You may contribute articles for publication in the "Update"
- **Member Company Spotlight Banner:** Feature your company's products on the PSMA Home Page

Capacitor Committee

- Meets once per month for 1 hour
- Creating a new sub-committee for "Energy Storage & Their Applications"
- Members are both from Industry & Universities
- Organizes Workshops, Webinars, and Industry Sessions
- **Workshops** – Chaired by Pierre Lohrber / Wurth
  Full day event typically held the Saturday before APEC in the same venue
- **Industry Session** – Chaired by Wilmer Companioni / KEMET
  6 or 7 subject event held during APEC
- **Webinars** – Chaired by Fred Weber / FTW
  Several different formats – Capacitor Fundamentals Series
  Roadmap Submissions
  Automotive Capacitor Fundamentals

Capacitor Committee Workshops Mission Statement

The PSMA Capacitor Committee Annual Workshop aligned with APEC has a mission to <u>educate the attendees on capacitor trends</u>, <u>technologies, and innovations</u>. Wherever and whenever applications need energy, Capacitors are at the spotlight, and as energy moves the world it is incumbent for everyone to keep their finger on the pulse of capacitor issues. PSMA's Capacitor Committee is committed to present the best material available to meet the industry's needs.

IEEE POWER ELECTRONICS SOCIETY
Powering a Sustainable Future

Capacitor Committee Webinars

Automotive Capacitor Fundamentals

3 Webinar Series

Abstract

PSMA Capacitor Committee will be offering a series of 3 educational webinars presented by design leaders in the industry explaining a best practices approach to choosing the capacitor that will be best for your application. The Webinars will be separated by their voltage levels:

1) 12 Volt System – John Rice, Maxim

2) 48 Volt System - TBD

3) High Voltage System (400V to 800V) – Eric Schneider, Independent

IEEE POWER ELECTRONICS SOCIETY
Powering a Sustainable Future

Introduction of the Presenter

Eric Schneider

Independent Electrical Engineer

Message me on LinkedIn:
www.linkedin.com
Eric Schneider
Technical Specialist - Development and Application of Power Electronics, Energy Storage, and Rotating Machines

Background:

- More than 35 years of engineering and management experience in industry
- Background in Power Electronics, Energy Conversion, and Energy Storage Development
- Application capability includes consumer products, automotive components and systems, and aerospace systems

Agenda

- In this webinar:
  - We explore the use and placement of capacitors in a widely used power supply type – a charger/supply for a laptop computer.
  - We will look at a schematic and discuss the roles of the capacitors within the circuit.
  - We will then focus our attention on the input and output bulk filter capacitors, and what types of capacitors could be used in those spots in the circuit.
  - We will look at data sheets for capacitors with specific traits based on values from a design example, and compare advantages and disadvantages from a technical point of view.

Basic Schematic and Capacitor Roles

- Ref.:AN-6094 from ON Semicondutor
- Flyback type converter – typical output switching frequency around 100kHz.
- Different roles of capacitors in the circuit:
  - Capacitors for the control circuit, like C_{FB}
  - Capacitors for voltage spike cancellation, like C_{SNB}
  - Capacitors for DC bus smoothing, like C_{DL1} and C_{O1} – also referred to as "bulk" filtering capacitors

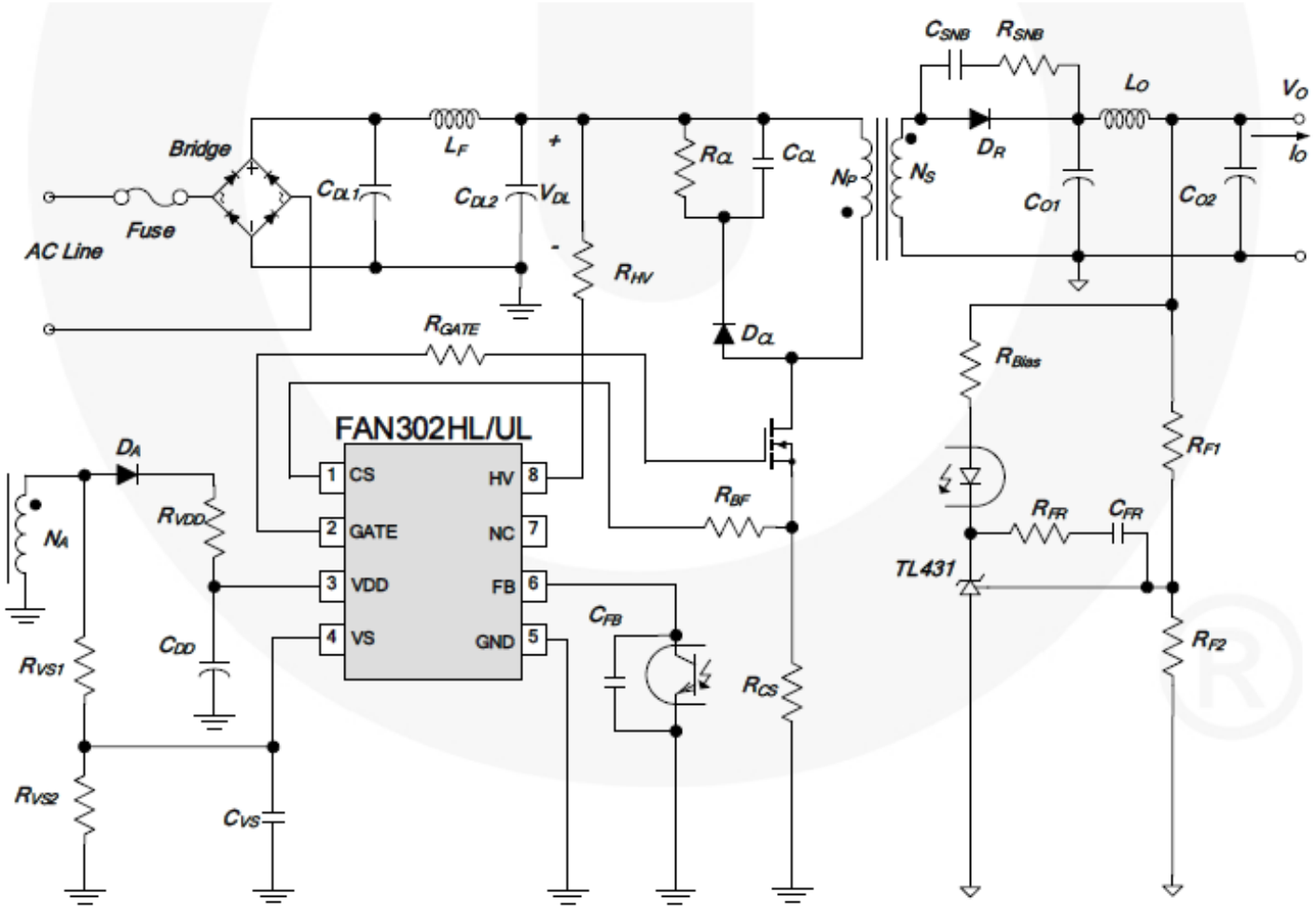


Figure 1. Typical Application Circuit

DC Bus Capacitors

For this presentation, we will concentrate on choosing the DC bus smoothing (bulk)capacitors

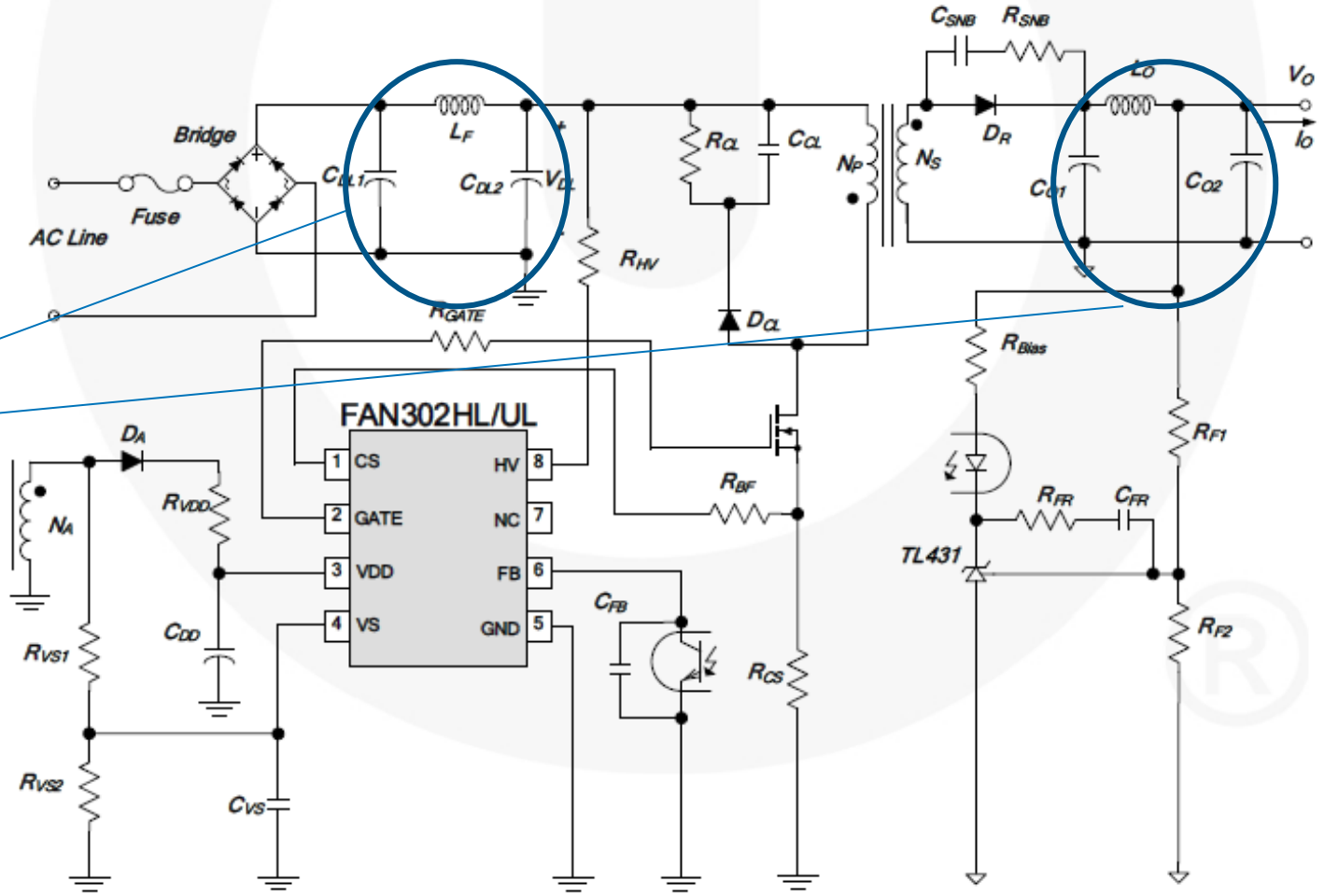
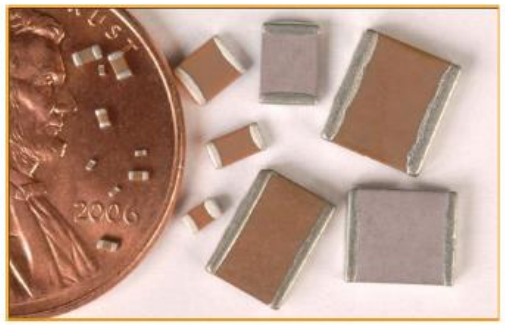


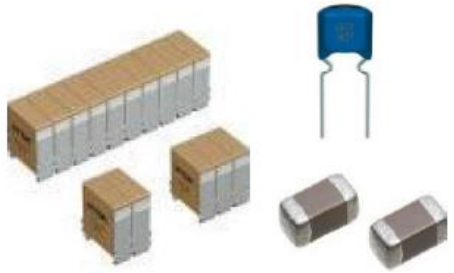
Figure 1. Typical Application Circuit

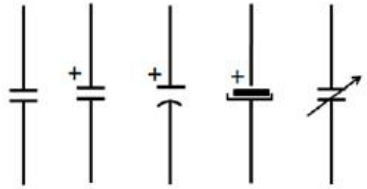
Capacitor Technology Slide from Webinar 301

PSMA MOST COMMON CAPACITOR TECHNOLOGIES

Ceramic (MLCC)







Film (Metalized Film)

Aluminum (Electrolytic)

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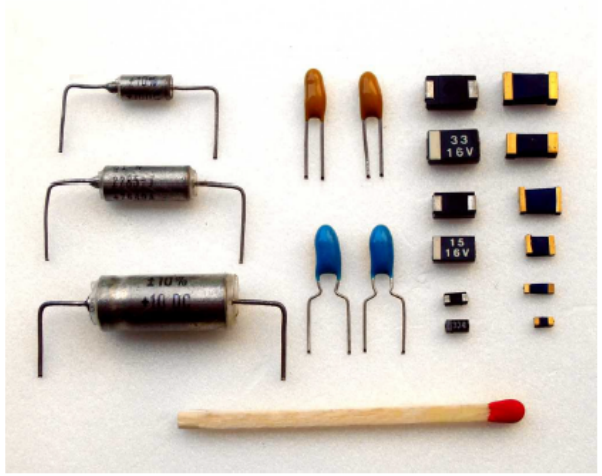
PSMA OTHER CAPACITOR TECHNOLOGIES

Tantalum

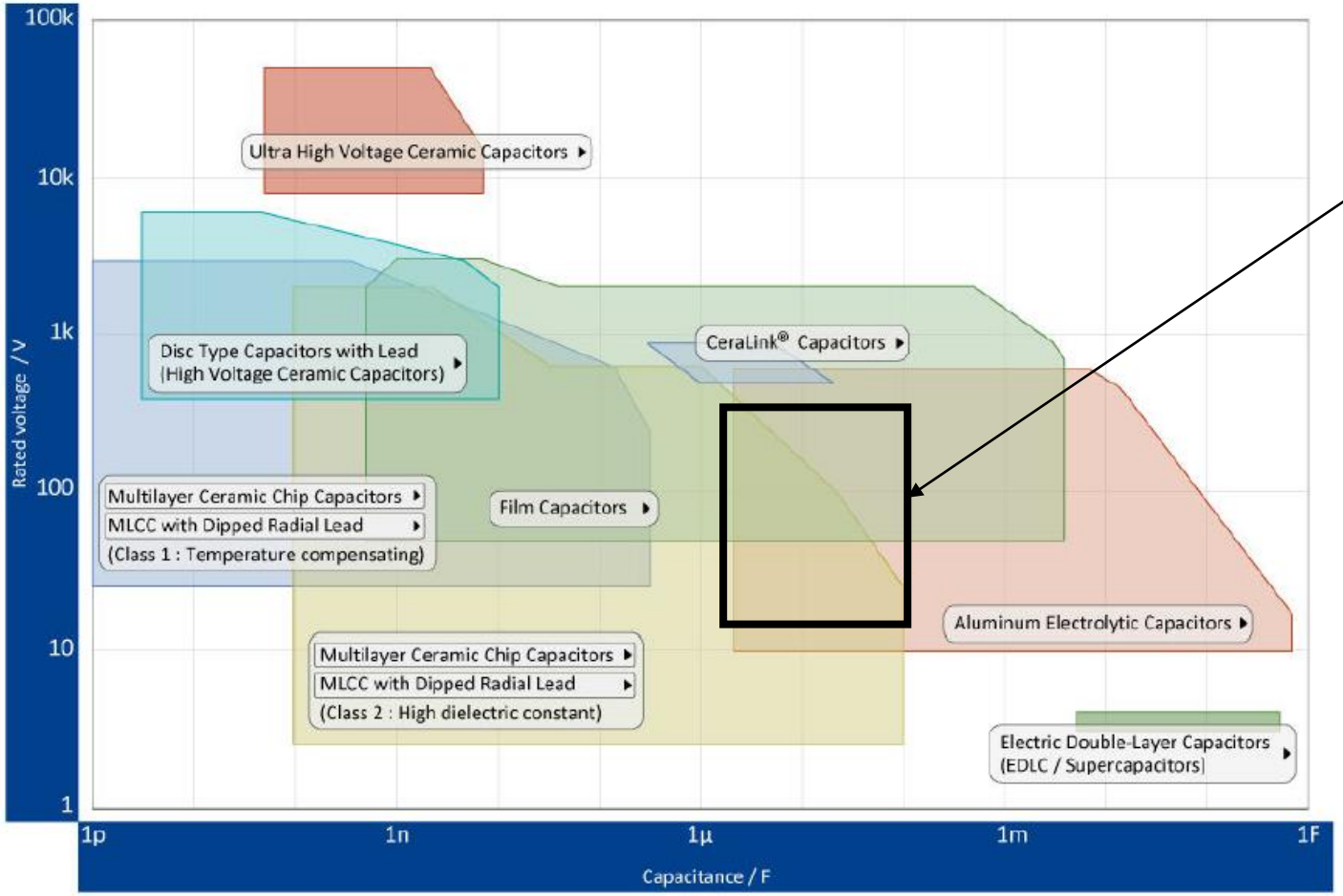


Supercapacitors

TDK

Operating Areas of Capacitor Technologies

PSMA TECHNOLOGIES OVERVIEW

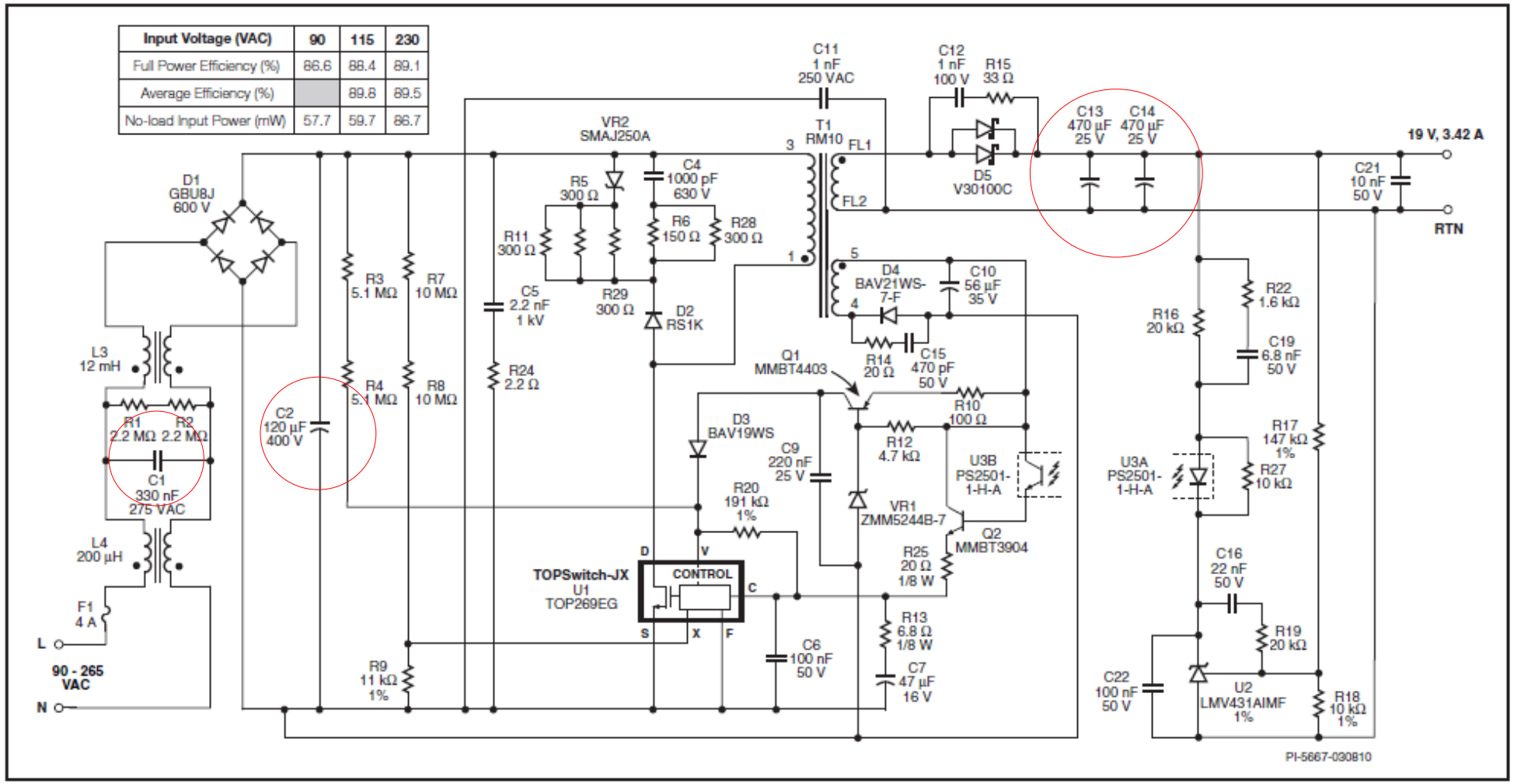


Area of interest – Capacitor Tech. Overlap

TDK PSMA

A Complete Circuit Schematic

- In this specific example,the input bulk capacitor, C2, is shown as 120uF, 400V.
- The output bulk capacitance is shown as 2 capacitors, C13 and C14, and listed as 470uF, 25 V.
- Capacitor C1, which wasn't shown in the first circuit example, is for electromagnetic interference (EMI) filtering.
    - This role could be the subject of another presentation



Design Considerations and Calculations

- Considerations:
  - The power supply spends the vast majority of operational time at an ambient between 20 and 30 deg. C;
  - The temperature rise is somewhat moderate by design;
  - The device can be handled without discomfort;
  - Therefore, the highest ambient temperature inside for the capacitor under continuous full load condition is 60 deg. C;
  - The device life expectancy is less than 5 years, with about 1/3 of the time at full load conditions;
  - The full load ripple current for the input capacitor is about 1.2a rms; (see next page)
  - The full load ripple current for each output capacitor is about 3.4a rms; (see next page)

Design Considerations and Calculations

- Input Capacitor Ripple Current Estimate
  - Capacitor DC voltage approx.:
    - V_c (DC) ~ VAC * Sqrt.2 = 90 * 1.414 ~ 125VDC
  - Input power ~ Output power/ efficiency = 65/.9 ~ 72W
  - Input side DC current = Input Power/Capacitor DC voltage = 72/125 ~ 0.6 A
  - Ripple current is approx. 2 x Input side DC current (rule of thumb) = 1.2a rms

- Output Capacitor ESR requirements and Ripple Current Estimate
  - Assume peak-peak ripple voltage (Vop-p) of 200mV
  - Total peak capacitor current (Icpk) is 4 x the rated output = 4 * 3.42= 13.7a
  - Total ESR = Vop-p/Icpk = 0.014 ohm
  - Total Ripple current is approx. 2 * output side DC current (rule of thumb) = 6.8a rms
  - Since we are split between 2 capacitors, each cap has an ESR of 0.028 ohm, and a ripple current of 3.4a rms

Input Capacitor – Electrolytic Type

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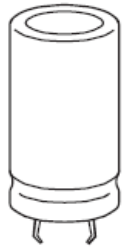
Our application

Important for portable equipment

Snap-in capacitors	B43647
Ultra compact – 105 °C	

Long-life grade capacitors



Applications
- Power supplies
- Frequency converters
- Uninterruptible power supplies
- Medical appliances
- Solar inverters
- Not for automotive applications unless otherwise specified

Features
- Extremely high CV product, ultra compact
- High reliability
- High ripple current capability
- Capacitors pass the needle flame test according to IEC 60695-11-5 for all flame exposure times up to 120 s
- RoHS-compatible

Construction
- Charge/discharge-proof, polar
- Aluminum case, insulated with PET sleeve without insulation sheet at the can bottom
- Snap-in solder pins to hold component in place on PC-board
- Minus pole marking on case surface
- Minus pole not insulated from case
- Overload protection by safety vent on the base

Terminals
- Standard version with 2 terminals, 2 lengths available: 6.3 and 4.5 mm
- 3 terminals to ensure correct insertion: length 4.5 mm

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Input Capacitor – Electrolytic Type

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Understanding useful life and how it is calculated is the key to choosing an electrolytic capacitor.

B43647

Ultra compact – 105 °C

Specifications and characteristics in brief

Rated voltage V_R Surge voltage V_S	450 V DC 1.10 · V_R	
Rated capacitance C_R Capacitance tolerance	120 ... 1000 µF ±20% ≙ M	
Dissipation factor tan δ (20 °C, 120 Hz)	tan δ ≤ 0.20	
Leakage current I_{leak} (5 min, 20 °C)	$I_{leak} \le 0.3\ \mu A \cdot \left(\frac{C_R}{\mu F} \cdot \frac{V_R}{V}\right)^{0.7} + 4\ \mu A$	
Self-inductance ESL	Approx. 20 nH	
Useful life[1)] 105 °C; V_R; $I_{AC,R}$	> 2000 h	Requirements: $\lvert\Delta C/C\rvert$ ≤ 20% of initial value tan δ ≤ 2 times initial specified limit I_{leak} ≤ initial specified limit
Voltage endurance test 105 °C; V_R	2000 h	Post test requirements: $\lvert\Delta C/C\rvert$ ≤ 10% of initial value tan δ ≤ 1.3 times initial specified limit I_{leak} ≤ initial specified limit
Vibration resistance test	To IEC 60068-2-6, test Fc: Frequency range 10 Hz ... 55 Hz, displacement amplitude 0.35 mm, acceleration max. 5 *g*, duration 3 × 2 h. Capacitor mounted by its body which is rigidly clamped to the work surface.	
Characteristics at low temperature	Max. impedance ratio at 100 Hz	V_R: 450 V $Z_{-25\,°C} / Z_{20\,°C}$: 5 $Z_{-40\,°C} / Z_{20\,°C}$: 14
IEC climatic category	To IEC 60068-1: 25/105/56 (−25 °C/+105 °C/56 days damp heat test) The capacitors can be operated in the temperature range of −40 °C to +105 °C but the impedance at −40 °C must be taken into consideration.	
Sectional specification	IEC 60384-4	

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Input Capacitor – Electrolytic Type

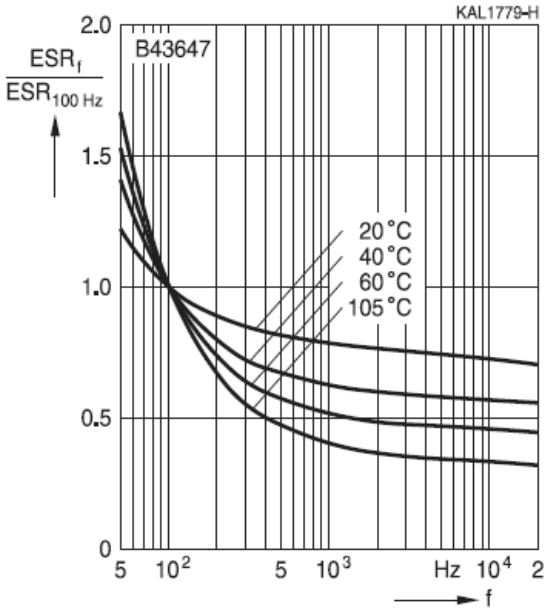
- $I_{AC,R}$ is the ripple current rating.
- We said before that it needs to be 1.2 A.
- Is this a good candidate?

Technical data and ordering codes

C_R 100 Hz 20 °C µF	Case dimensions d × l mm	ESR_{typ} 100 Hz 20 °C mΩ	ESR_{typ} 300 Hz 60 °C mΩ	Z_{max} 10 kHz 20 °C mΩ	$I_{AC,max}$ 100 Hz 60 °C A	$I_{AC,max}$ 100 Hz 85 °C A	$I_{AC,R}$ 100 Hz 105 °C A	Ordering code (composition see below)
V_R = 450 V DC								
120	22 × 25	880	230	1320	1.70	1.28	0.76	B43647A5127M05#
150	22 × 30	700	180	1060	2.03	1.53	0.90	B43647A5157M05#
150	25 × 25	710	190	1070	1.94	1.46	0.86	B43647B5157M05#

- ESR, which generates heat, changes with temperature and frequency.
- So will the ripple current capability.
- The useful life tool predicts 32000 hours if the supply was always at max.

Frequency characteristics of ESR
Typical behavior



Useful life[1)]

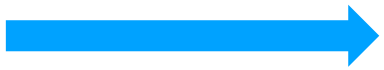
For useful life calculations, please use our web-based "AlCap Useful Life Calculation Tool", which can be found on the Internet under the following link:
www.tdk-electronics.tdk.com/alcap
The AlCap Useful Life Calculation Tool provides calculations of useful life as well as additional data for selected capacitor types under operating conditions defined by the user.

In addition, it is possible to calculate useful life expectancies based on temperatures measured by the user in the application.

Input Capacitor – Electrolytic Type

TDK

- Here is the capacitor and the load condition table.
- The temperature input and voltage levels and frequency were set higher than expected.



Aluminum Electrolytic Capacitors — B43647A5127M05#

Useful life calculation — B43647

Selected capacitor

Ordering code: B43647A5127M05#

Rated capacitance	C_R	100 Hz, 20 °C	120 µF ±20 %	
Rated voltage	V_R		450 V	
Diameter x Length	d x l		22 mm x 25 mm	
Rated temperature	T_R		105 °C	
Rated ripple current	$I_{AC,R}$	100 Hz, 105 °C	0.76 A	
Rated useful life	L_R	105 °C, V_R, $I_{AC,R}$	2000 h	

Please refer to the data sheet for further product specifications.

Load condition

Calculation method: Ripple current spectrum

Operating voltage	V_{op}	150 V
Ambient temperature	T_A	70 °C
Air speed	v_a	0.0 m/s

		1	2	3	4	5	6	7	8	9	10
Frequency	f (Hz)	120									
Ripple current	$I_{AC,f}$ (A)	1.2									

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Input Capacitor – Electrolytic Type

Calculation results

Values at chosen load condition

Operating useful life	L_{op}		18000 h	
Max. current in percent			74 %	
Power loss	P		0.44 W	
Thermal resistance	R_{th}	Core to ambient	33.8 K/W	
Inner thermal resistance	$R_{th,i}$	Core to case	10.1 K/W	
Hot spot temperature	T_H	Core	84.8 °C	
Base temperature	T_B	Case	80.4 °C	

The calculation results obtained are typical values and are intended for guidance purposes only.
The useful life does not constitute a warranty of any kind or a prolongation of the agreed warranty period.

The calculation shows 18000 hours of operation. The temperature rise had the largest effect.

Input Capacitor Alternative - Film Type

- Film capacitors have a very long life compared to electrolytics.
- Want to show what is available if long life is required.
- Package sizes and current ratings comparable to our application do not seem available.

Printed Circuit Board Mount Power Film Capacitors

C4AE, Radial, 2 or 4 Leads, 450 – 1,100 VDC for DC Link

Electronic Components KEMET CHARGED.

Overview

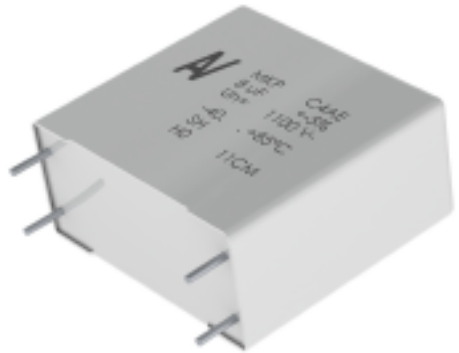
The C4AE capcitor is a polypropylene metallized film capacitor with a rectangular, plastic box-type design (white or grey in color) filled with resin, and uses 2 or 4 tinned copper wires.

Applications

Typical applications include DC filtering and energy storage.

Benefits

- Self-healing
- Low loss
- High ripple current
- High capacitance density
- High contact reliability
- Suitable for high frequency applications



Input Capacitor Alternative - Film Type

Life Expectancy

Long life

Life expectancy	100,000 hours at V_{NDC} at Hot spot temperature T_{HS} = +85°C
Capacitance drop at end of life	-5% (typical)
Failure rate IEC 61709	≤ 300 FIT at V_{NDC} at Hot spot temperature T_{HS} = +85°C

Table 1 – Ratings & Part Number Reference

Cap Value (µF)	VDC	Dimensions (mm)					dV/dt (V/µs)	Ipkr	ESL	ESR	Irms*	Rth	PART NUMBER
		B	H	L	P	P1		Apk	nH	70°C at 10 kHz mΩ	70°C at 10 kHz Arms	(HS/Amb) (°C/W)	
5.6	450	11	20	31.5	27.5	\	10	54	25	13.1	4.5	44	C4AEGBU4560A1WK
10	450	13	25	31.5	27.5	\	10	96	25	8.1	6.5	36	C4AEGBU5100A1XK
12.5	450	14	28	31.5	27.5	\	10	122	26	6.8	7.5	33	C4AEGBU5125A1YK
15	450	19	29	31.5	27.5	\	10	147	26	6	8.5	29	C4AEGBU5150A11K
25	450	22	37	31.5	27.5	\	10	245	28	4.5	11.5	23	C4AEGBU5250A12K
40	450	20	40	42	37.5	10.2	7	262	30	3.5	13.5	20	C4AEGBW5400A3FK
50	450	28	37	42	37.5	10.2	7	332	30	2.8	16	18	C4AEGBW5500A3JK
55	450	24	44	42	37.5	10.2	9	481	30	2.6	17	17	C4AEGBW5550A3HK
70	450	30	45	42	37.5	20.3	7	464	30	2.1	20.5	15	C4AEGBW5700A3LK
100	450	30	45	57.5	52.5	20.3	4	442	35	3	19	12	C4AEGBW6100A3MK
130	450	35	50	57.5	52.5	20.3	4	581	35	2.4	23	10	C4AEGBW6130A3NK
2.2	600	11	20	31.5	27.5	\	12	41	25	17	4	44	C4AEHBU4220A1WJ

High Current

Input Capacitor Alternative - Film Type

The dissipation factor is a fraction of the electrolytic example

WIMA DC-LINK MKP 4

Metallized Polypropylene (PP) - Capacitors for DC-Link Applications.
Capacitances from 1.0 µF to 400 µF.
Rated Voltages from 400 VDC to 1300 VDC.

Special Features

- **Capacitances up to 400 µF**
- **High volume/capacitance ratio**
- **Excellent self-healing properties**
- **Very low dissipation factor**
- **High reliability**
- **2-pin and 4-pin contact configuration (plate versions on request)**
- **AEC-Q200 qualified** AEC-Q200
- **According to RoHS 2011/65/EU**

Typical Applications

As intermediate circuit capacitor e.g. in high power converter technology, power supplies, solar inverters etc.

Electrical Data

Capacitance range: 1 µF to 400 µF (intermediate values on request)
Rated voltages: 400 VDC, 500 VDC, 600 VDC, 800 VDC, 900 VDC, 1100 VDC, 1300 VDC
Capacitance tolerances: ±20%, ±10%, ±5%
Operating temperature range: –55° C to +105° C (hot spot including self-heating)
Climatic test category: 55/085/56 in accordance with IEC
Dissipation factors at +20° C:

PCM	1 kHz	10 kHz
27.5	⩽ 15 x 10^{-4}	⩽ 160 x 10^{-4}

Insulation resistance at +20° C:
⩾ 30 000 sec (MΩ x µF)
Measuring voltage: 100 V/1 min.
Test voltage:
1.2 U_r, 2sec
Dielectric absorption: 0.05 %
Specific dissipation:

Box size W x H x L in mm	Specific dissipation in Watts per K above the ambient temperature
9 x 19 x 31.5	0.021
11 x 21 x 31.5	0.025
13 x 24 x 31.5	0.030
15 x 26 x 31.5	0.034
17 x 29 x 31.5	0.039
27 x 15 x 41.5	0.043

Input Capacitor Alternative - Film Type

WIMA DC-LINK MKP 4

General Data

Capacitance	400 VDC (70° C) / 300 VDC (85° C) W	H	L	PCM**	Pin	I_S A	I_{rms}*(10 kHz)* A	ESR (10 kHz)* mΩ	Part number
1 µF	9	19	31.5	27.5	2	11	1	238.7	DCP4G041006A_____
2 „	9	19	31.5	27.5	2	22	1.5	119.4	DCP4G042006A_____
3 „	9	19	31.5	27.5	2	33	1.5	79.6	DCP4G043006A_____
4 „	9	19	31.5	27.5	2	44	2	59.7	DCP4G044006A_____
5 „	9	19	31.5	27.5	2	55	2	47.7	DCP4G045006A_____
7 „	9	19	31.5	27.5	2	77	2.5	34.1	DCP4G047006A_____
10 µF	11	21	31.5	27.5	2/4	110	3.5	23.9	DCP4G051006B_____
15 „	13	24	31.5	27.5	2/4	165	4.5	15.9	DCP4G051506D_____
20 „	15	26	31.5	27.5	2/4	220	5.5	11.9	DCP4G052006F_____
25 „	17	29	31.5	27.5	2/4	275	6.5	9.5	DCP4G052506G_____
30 „	17	34.5	31.5	27.5	2/4	330	7	8	DCP4G053006I_____
40 „	20	39.5	31.5	27.5	2/4	440	9.5	6	DCP4G054006J_____
50 „	20	39.5	41.5	37.5	2/4	400	11	5.4	DCP4G055007G_____
60 „	20	39.5	41.5	37.5	2/4	480	11.5	4.8	DCP4G056007G_____
70 „	24	45.5	41.5	37.5	2/4	560	15	3.6	DCP4G057007H_____
80 „	24	45.5	41.5	37.5	2/4	640	17	2.7	DCP4G058007H_____
90 „	24	45.5	41.5	37.5	2/4	720	17.5	2.6	DCP4G059007H_____
100 µF	31	46	41.5	37.5	2/4	800	19	2.5	DCP4G061007I_____
120 „	31	46	41.5	37.5	2/4	960	20	2.3	DCP4G061207I_____
140 „	35	50	41.5	37.5	2/4	1120	22.5	2.1	DCP4G061407J_____

Similar to other example in a smaller package.

Input Capacitor Type Summary

- Aluminum electrolytic capacitors are suitable for this application because of:
  - Low temperature operation;
  - No need for long life.
- If you remove the top off the the supply to look inside, you will see an electrolytic input capacitor.
- Film capacitors could be used if long life were a concern.
  - For instance, if you needed a similar supply installed inside a remote piece of test equipment that needs to last 10 – 15 years.
  - Instead of packaging 2 or 3 of the electrolytics, you could replace them with one of the film caps.

Output Capacitor - Electrolytic Type

For a flyback power supply, or any other converter with a high frequency output, low impedance and ESR are the most important trait.

Single-ended capacitors B41859

Very low impedance – 105 °C

Long-life grade capacitors

Applications

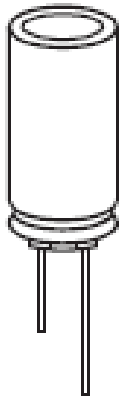
- Automotive electronics

Features

- Very low impedance at high frequency
- Very low ESR
- High ripple current capability
- RoHS-compatible

Construction

- Radial leads
- Charge-discharge proof, polar
- Aluminum case with PET insulating sleeve
- Minus pole marking on the insulating sleeve
- Case with safety vent



Output Capacitor - Electrolytic Type

TDK

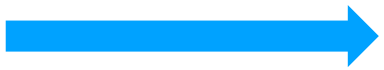
B41859

Very low impedance – 105 °C

Technical data and ordering codes

C_R 120 Hz 20 °C µF	Case dimensions d × l mm	Z_{max} 100 kHz −10 °C Ω	Z_{max} 100 kHz 20 °C Ω	$I_{AC,R}$ 100 kHz 105 °C mA	Ordering code (composition see below)
V_R = 16 V DC					
270	8 × 11.5	0.190	0.056	945	B41859C4277M***
330	8 × 11.5	0.190	0.056	945	B41859C4337M***
470	10 × 12.5	0.140	0.039	1330	B41859C4477M***
560	10 × 16	0.100	0.028	1760	B41859C4567M***
680	10 × 16	0.100	0.028	1760	B41859C4687M***
1000	10 × 20	0.060	0.020	1960	B41859C4108M***
1200	10 × 20	0.060	0.020	1960	B41859C4128M***
1500	12.5 × 20	0.043	0.017	2480	B41859C4158M***
1800	12.5 × 25	0.038	0.015	2900	B41859C4188M***
2200	12.5 × 25	0.038	0.015	2900	B41859C4228M***
2700	16 × 20	0.038	0.015	3250	B41859C4278M***
3300	16 × 25	0.035	0.013	3630	B41859C4338M***
V_R = 25 V DC					
180	8 × 11.5	0.190	0.056	945	B41859C5187M***
220	8 × 11.5	0.190	0.056	945	B41859C5227M***
270	10 × 12.5	0.140	0.039	1330	B41859C5277M***
330	10 × 12.5	0.140	0.039	1330	B41859C5337M***
470	10 × 16	0.100	0.028	1760	B41859C5477M***
560	10 × 16	0.100	0.028	1760	B41859C5567M***

- The schematic showed two 470 uF capacitors in parallel. Ripple current is 3.4 amps each.
- Taking into account comparable life and operating temperatures versus the input capacitor, this is a good candidate.



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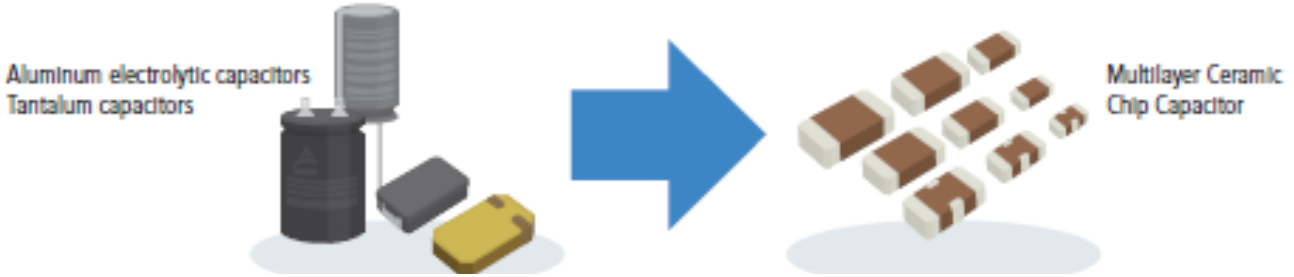
Output Capacitor Alternative - MLCC Type

- TDK has a solution guide that shows how you could replace electrolytics with multi-layer ceramic capacitors.
- There are caveats, though, in that the control circuit and other components may need adjusting or enhancing, so it is not necessarily just a simple swap.

TDK

MLCC Solutions Guide

How to select the optimal MLCC to replace an electrolytic capacitor.



Line Voltage

V ≦ 20V

Al Cap Value (μF)	Frequency		
	f ≧ 50kHz	f ≧ 100kHz	f ≧ 500kHz
1	C1608X7R1E105K	C1608X7R1E105K	C1005X7R1E224K
2.2	C2012X7R1E225K		C1608X7R1E474K
4.7			
10		C2012X7R1E225K	
22	C2012X7R1E475K		
47			
100			

Output Capacitor Alternative - MLCC Type

This is a small component

C2012X7R1E225K085AB

TDK Item Description : C2012X7R1E225KT****

Lead Free | Halogen Free | REACH | RoHS COMPLIANT

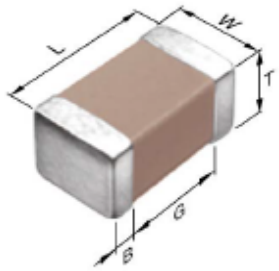
Characterization Sheet (Multilayer Ceramic Chip Capacitor)

Application & Main Feature

Commercial Grade (General (Up to 50V))

Series

C2012 [EIA 0805]



Dimensions

L	2.00mm +/-0.2mm
W	1.25mm +/-0.2mm
T	0.85mm +/-0.15mm
B	0.20mm Min.
G	0.50mm Min.

Temperature Characteristic

X7R (-55 to 125 degC +/-15%)

Rated Voltage

1E (25Vdc)

Capacitance

2.2uF

Capacitance Tolerance

K (+/-10%)

Dissipation Factor

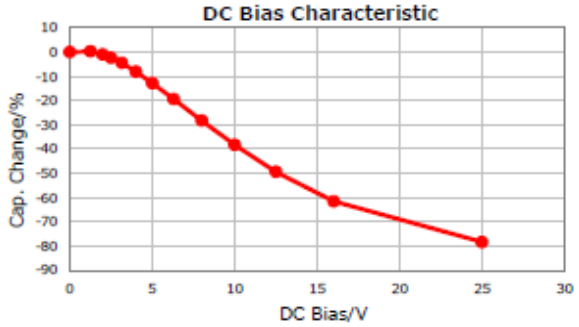
5% Max.

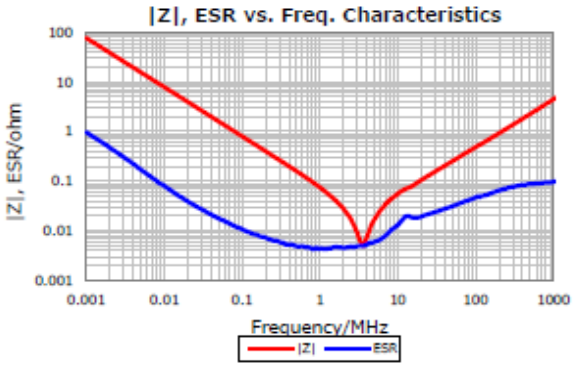
Insulation Resistance

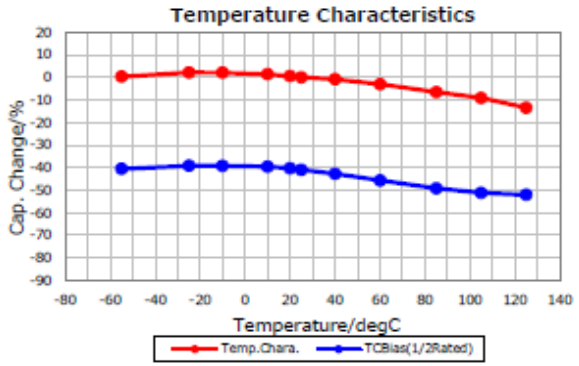
227Mohm Min.

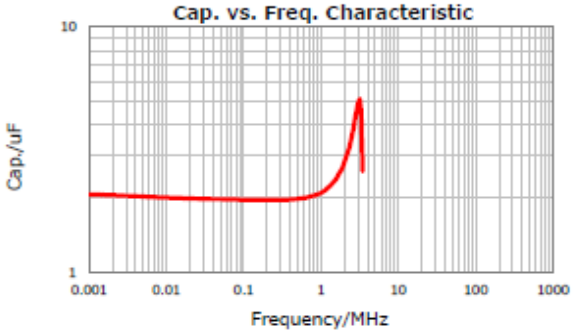
AEC-Q200

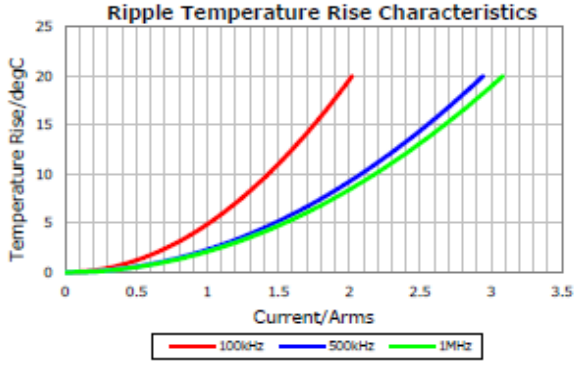
Not Applicable











TDK

All specifications are subject to change without notice.

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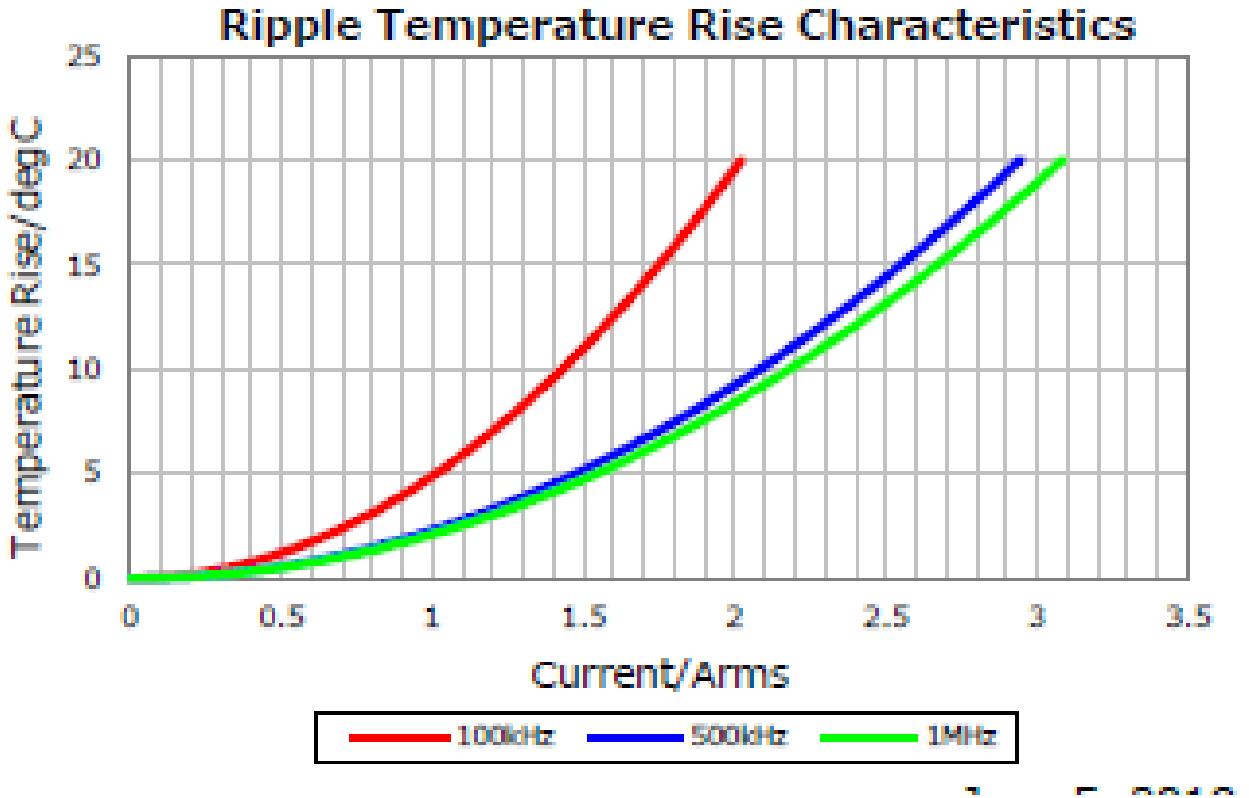
Output Capacitor Alternative - MLCC Type

- For our application current (6.8 a rms), 4 of these in parallel would generate a modest temperature rise.
- Careful attention will need to be made to board layout so that only minimal inductance is introduced.



Output Capacitor Alternative - Tantalum Type

KEMET Organic Capacitor (KO-CAP®)

T52X/T530 Polymer Electrolytic Capacitors

Electronic Components KEMET CHARGED.

Overview

KO-CAP Polymer Capacitors

The KEMET Organic Capacitor (KO-CAP) is a solid electrolytic capacitor with a conductive polymer cathode capable of delivering very low ESR and improved capacitance retention at high frequencies. KO-CAP combines the low ESR of multilayer ceramic, the high capacitance of aluminum electrolytic, and the volumetric efficiency of tantalum into a single surface mount package. Unlike liquid electrolyte-based capacitors, KO-CAP has a very long operational life and high ripple current capabilities.

The T52X/T530 provides the widest range of voltages, capacitance and case size options in the KO-CAP family and is suitable for general purpose DC applications for up to 48 volt DC voltage rails.

Benefits

- ESR values down to 5 mΩ
- Stable capacitance across temperature and voltage
- No aging effects
- High ripple handling
- Volumetrically efficient
- High frequency capacitance retention
- 100% accelerated steady state aging
- 100% surge current tested
- Halogen-free epoxy and RoHS compliant

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Output Capacitor Alternative - Tantalum Type

KEMET Organic Capacitor (KO-CAP®)

T52x/T530 Polymer Electrolytic Capacitors

Electronic Components KEMET CHARGED

Table 1 – Ratings & Part Number Reference cont.

Rated Voltage VDC at 105°C	Rated Capacitance	Case Code/ Case Size	KEMET Part Number	DC Leakage	DF	ESR	Maximum Allowable Ripple Current	MSL	Maximum Operating Temperature
Not all parts are 105°C rated	µF	KEMET/EIA	(See below for part options)	µA at 25°C Maximum/ 5 Minutes	% at 25°C 120 Hz Maximum	mΩ at 25°C 100 kHz Maximum	(rms) mA at +45°C 100 kHz	Reflow Temp ≤ 260°C	°C
25	100	D/7343-31	T521D107M025A(1)E040	250	10	40	2,400	3	105
25	100	D/7343-31	T521D107M025A(1)E050	250	10	50	2,100	3	125
25	100	D/7343-31	T521D107M025A(1)E060	250	10	60	1,900	3	105
25	100	X/7343-43	T521X107M025A(1)E030	250	10	30	2,900	3	105
25	100	X/7343-43	T521X107M025A(1)E060	250	10	60	2,000	3	105

4 of these will suffice.

Case Size		Component Dimensions											
KEMET	EIA	L	W	H	F ±0.1 ±(0.004)	S ±0.3 ±(0.012) S1 ±0.4 (0.0157) S2 ±0.2 (0.00)	B ±0.15 (Ref) ±0.006	X (Ref)	P (Ref)	R (Ref)	T (Ref)	A (Min)	Typical Weight (mg)
A	3216-18	3.2 ±0.2 (0.126 ±0.008)	1.6 ±0.2 (0.063 ±0.008)	1.6 ±0.2 (0.063 ±0.008)	1.2 (0.047)	0.8 (0.032)	N/A	0.10 ±0.10 (0.004 ±0.004)	0.4 (0.016)	0.4 (0.016)	0.13 (0.005)	1.2 (0.047)	53
B	3528-21	3.5 ±0.2 (0.138 ±0.008)	2.8 ±0.2 (0.110 ±0.008)	1.9 ±0.1[*3] (0.075 ±0.008)	2.2 (0.087)	0.8 (0.032) S1 = 0.8 (0.032)[*2] S2 = 0.8 (0.032)[*2]	0.4 (0.016)	0.10 ±0.10 (0.004 ±0.004)	0.5 (0.020)	1.0 (0.039)	0.13 (0.005)	1.9 (0.075)	95
C	6032-28	6.0 ±0.3 (0.236 ±0.012)	3.2 ±0.2 (0.126 ±0.008)	2.5 ±0.3 (0.098 ±0.012)	2.2 (0.087)	1.30 (0.051)	0.5 (0.020)	0.10 ±0.10 (0.004 ±0.004)	0.9 (0.035)	1.0 (0.039)	0.13 (0.005)	2.9 (0.114)	184
D	7343-31	7.3 ±0.3 (0.287 ±0.012)	4.3 ±0.3 (0.169 ±0.012)	2.8 ±0.3 (0.110 ±0.012)	2.4 (0.094)	1.30 (0.051)	0.5 (0.020)	0.10 ±0.10 (0.004 ±0.004)	0.9 (0.035)	1.0 (0.039)	0.13 (0.005)	3.6 (0.142)	435

Larger than the MLCC, but a lot shorter than the Al electrolytic.

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Output Capacitor Type Summary

- Similar to the input side, Aluminum electrolytic capacitors are suitable for this application because of:
  - Low temperature operation;
  - No need for long life.
- If you remove the top off the supply to look inside, you will see 2 electrolytic output capacitors.
- MLCCs or tantalum capacitors could be used to save on packaging volume and board space.

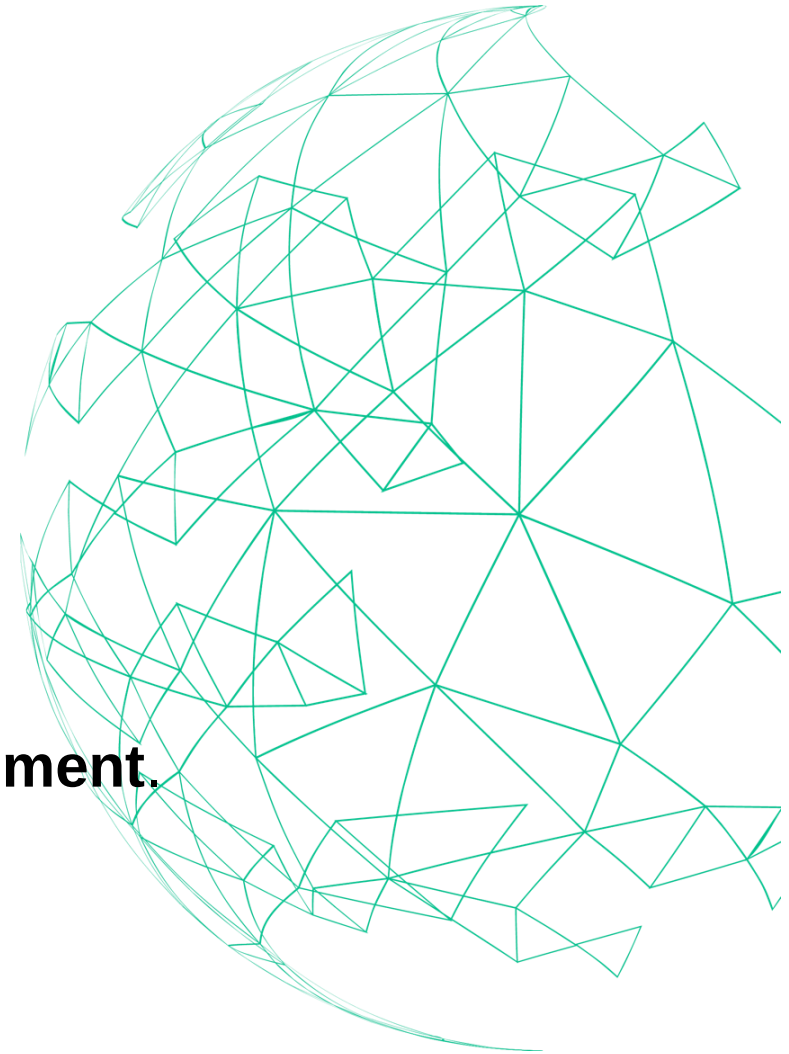
Wrap Up

- In this presentation, we looked at:
- A common device as an application;
- The differing roles for capacitors in the application;
- The most common capacitor types and their operating regions;
- Types and data sheets for input and output bulk filter capacitors.

Final Questions & Thank You

Please take the survey

We appreciate any ideas or suggestions for improvement.



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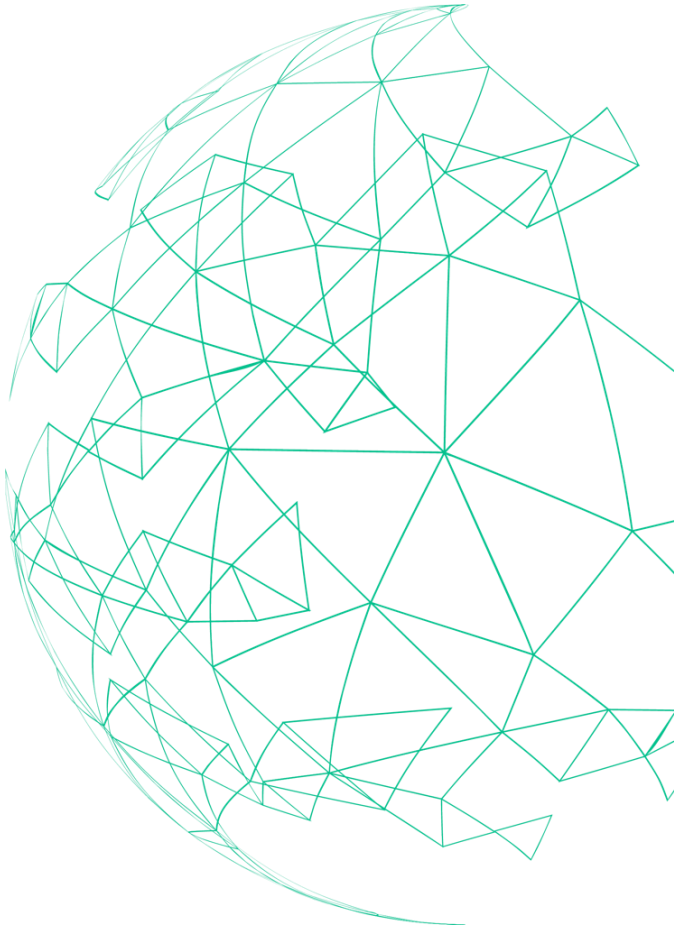

Thank You and hope you have enjoyed the webinar

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"Individual commitment to a group effort--that is what makes a team work, a company work, a society work, a civilization work." --Vince Lombardi