

# Resonance Tank Capacitor and Output Capacitor

## Table of contents

- [Resonance Tank Capacitor and Output Capacitor](#)
  - [Inputs and claculated parameters](#)
  - [Output capacitor Co](#)
    - [Formulas](#)
    - [Numerical Implementation of the Formulas](#)
    - [First proposition](#)
    - [Second proposition](#)
    - [Comparaision](#)
  - [Resonanat capacitor Cr](#)
    - [Chosing a capacitor for Cr](#)
    - [Understanding the Derating Curve of the Capacitors](#)
    - [Resonant capacitors configuration](#)
  - [References](#)

## Inputs and claculated parameters

V\_In\_min 360.0 V\_In\_max 400.0 Vo\_nom 48.0 Power 1200.0  
V\_In\_nom 380.0 Vo\_min 42.0 Vo\_max 54.0 f\_nom 100000.0

Lnc	3.000	Lm_uH	65.392	Ioe_rms	7.636	Re_110	22.637
Qec	0.550	fsw_min	60170.000	Ios_rms	30.545	Cr	0.0
Cr_nF	116.209	fsw_max	156220.000	Ir_rms	10.354	Lr	0.000022
n	4.000	Im_rms	6.992	L_second_uH	4.087	Lm	0.000065
Lr_uH	21.797	Io	25.000	Re_nom	24.901		

## Output capacitor Co

### Formulas

For a resistive load, the output capacitor is determined by

$$C_o \geq C_{o_{min}} = \frac{I_o}{8 \cdot f_{sw} \cdot \Delta V_{out}}$$

Where: -  $C_o$  : Output capacitance (Farads, F) -  $I_o$  : Output load current (Amperes, A) -  $f_{sw}$  : Switching frequency of the converter (Hertz, Hz) -  $\Delta V_{out}$  : Maximum allowed output voltage ripple (Volts, V)

$$ESR_{max} = \frac{\Delta V_{out}}{I_{rect\_peak}} = \frac{\Delta V_{out}}{\frac{\pi}{4} \cdot I_o \cdot 2}$$

$$I_{C_o} = I_o \sqrt{\frac{\pi^2}{8} - 1}$$

Where: -  $I_{C_o}$  : RMS current of the capacitor @  $f_{sw} = f_{nom}$  See page 26, 27 [

1

](#referencesID\_03\_1).

By default, you can found all formula of this chapeter in the same ref

For a resistive load, the output capacitor is determined by

$$C_o \geq C_{o_{min}}$$

$$C_{o_{min}} = \frac{I_o}{8 \cdot f_{sw} \cdot \Delta V_{outC}}$$

Where:

- $C_o$  : Output capacitance (Farads, F)
- $I_o$  : Output load current (Amperes, A)
- $f_{sw}$  : Switching frequency of the converter (Hertz, Hz)
- $\Delta V_{out}$  : Maximum allowed output voltage ripple (Volts, V)

$$ESR_{max} = \frac{\Delta V_{outR}}{I_{rect\_peak}}$$

$$I_{rect\_peak} = \frac{\pi}{4} \cdot I_o \cdot 2$$

$$I_{C_o} = I_o \sqrt{\frac{\pi^2}{8} - 1}$$

Where:

- $I_{C_o}$  : RMS current of the capacitor @  $f_{sw} = f_{nom}$

And the total ripple voltage can be:

- $V_{out} \approx V_{outR} + V_{outC}$

In this design we will verify:

- $V_{outR} < \frac{V_{outMax}}{2}$
- $V_{outC} < \frac{V_{outMax}}{2}$

See page 26, 27 [1].

By default, you can find all formulas of this chapter in the same reference.

## Numerical Implementation of the Formulas

**We must use fsw\_min to the worst case**

$$I_o = 25.000 \text{ (A)}$$

$$f_{sw_{min}} = 60170.000 \text{ (Hz)}$$

$$DV = 0.250 \text{ (vpp)}$$

$$\begin{aligned} C_{o_{min_{\mu F}}} &= 1 \times 10^6 \cdot \frac{I_o}{8 \cdot f_{sw_{min}} \cdot DV} \\ &= 1 \times 10^6 \cdot \frac{25.000}{8 \cdot 60170.000 \cdot 0.250} \\ &= 207.745 \text{ (}\mu\text{F)} \end{aligned}$$

$$\begin{aligned} ESR_{max_m} &= 1 \times 10^3 \cdot \frac{DV}{I_o \cdot \frac{\pi}{2}} \\ &= 1 \times 10^3 \cdot \frac{0.250}{25.000 \cdot \frac{3.142}{2}} \\ &= 6.366 \text{ (m}\Omega\text{)} \end{aligned}$$

$$\begin{aligned} I_{Co} &= I_o \cdot \sqrt{\frac{(\pi)^2}{8} - 1} \\ &= 25.000 \cdot \sqrt{\frac{(3.142)^2}{8} - 1} \\ &= 12.086 \text{ (Arms)} \end{aligned}$$

## First proposition

B40910A8127M000 aluminum electrolytic capacitors with Temp\_max = 150°C, Below a screenshot of the datasheet [\[2\]](#).

Hybrid polymer aluminum electrolytic capacitors	B40910
Very high ripple current – up to 150 °C	

### Technical data and ordering codes

C <sub>R</sub> 120 Hz 20 °C μF	Case dimensions <sup>1)</sup> d x l mm	ESR <sub>max</sub> 100 kHz 20 °C Ω	I <sub>AC,R</sub> 100 kHz 125 °C A	I <sub>AC,max</sub> 100 kHz 135 °C A	Ordering code (composition see below)
V <sub>R</sub> = 63 V DC					
82	10 x 10.2   10 x 10.5	0.022	4.0	2.8	B40910A8826M***
100	10 x 10.2   10 x 10.5	0.022	4.0	2.8	B40910A8107M***
100	10 x 12.5   10 x 12.8	0.017	4.6	3.2	B40910B8107M***
120	10 x 12.5   10 x 12.8	0.017	4.6	3.2	B40910A8127M***
150	10 x 16.5   10 x 16.8	0.013	5.5	3.8	B40910A8157M***
180	10 x 16.5   10 x 16.8	0.013	5.5	3.8	B40910A8187M***

**Figure 1:** B40910A8127M000 aluminum electrolytic capacitors with Temp<sub>max</sub> = 150°C

Let's start with a configuration of 5 capacitors in parallel

$$Nb_{capa} = 6$$

$$C_{capa_{nom}} = 120 \text{ (}\mu\text{F)}$$

$$\text{Margin} = 20 \text{ (\%)}$$

$$C_{capa} = C_{capa_{nom}} \cdot \left(1 - \frac{\text{Margin}}{100}\right) = 120 \cdot \left(1 - \frac{20}{100}\right) = 96.000 \text{ (}\mu\text{F, Worst case)}$$

$$C_{eq} = C_{capa} \cdot Nb_{capa} = 96.000 \cdot 6 = 576.000 \text{ (}\mu\text{F} > 208\mu\text{F ok)}$$

$$ESR_{capa} = 17 \text{ (}\Omega \text{ @ 100kHz)}$$

$$ESR_{eq} = \frac{ESR_{capa}}{Nb_{capa}} = \frac{17}{6} = 2.833 \text{ (}\Omega < 6.36\text{m OK)}$$

$$I_{capa_{max}} = 4.600$$

$$\begin{aligned} I_{eq_{max}} &= I_{capa_{max}} \cdot Nb_{capa} \\ &= 4.600 \cdot 6 \\ &= 27.600 \text{ (@ Arms @ 125 °C 100kHz} > 12.08\text{Arms ok)} \end{aligned}$$

### Voltage ripples

$$\Delta_{V_{outC}} = \frac{I_o}{8 \cdot f_{sw_{min}} \cdot C_{eq} \cdot 1 \times 10^{-6}} = \frac{25.000}{8 \cdot 60170.000 \cdot 576.000 \cdot 1 \times 10^{-6}} = 0.090 \text{ (V)}$$

$$I_{rect_{peak}} = I_o \cdot \frac{\pi}{2} = 25.000 \cdot \frac{3.142}{2} = 39.270 \text{ (A)}$$

$$\Delta_{V_{outR}} = I_{rect_{peak}} \cdot ESR_{eq} \cdot 1 \times 10^{-3} = 39.270 \cdot 2.833 \cdot 1 \times 10^{-3} = 0.111$$

$$\Delta_{V_{out}} = \Delta_{V_{outR}} + \Delta_{V_{outC}} = 0.111 + 0.090 = 0.201 \text{ (< 0.25mV)}$$

## Self heating

### Power Dissipation of Each Capacitor

$$\begin{aligned} I_{each_{capa}} &= \frac{I_{Co}}{Nb_{capa}} \\ &= \frac{12.086}{6} \\ &= 2.014 \end{aligned}$$

$$\begin{aligned} P_{selfHeating} &= ESR_{capa} \cdot 1 \times 10^{-3} \cdot (I_{each_{capa}})^2 \\ &= 17 \cdot 1 \times 10^{-3} \cdot (2.014)^2 \\ &= 0.069 \text{ (W)} \end{aligned}$$

### Estimation of Thermal Resistance Rth

$$\Delta_T = 150 - 125 = 25 \text{ (}^\circ\text{C)}$$

$$ESR = 0.017$$

$$I = 4.600 \text{ (Arms)}$$

$$\begin{aligned} P_{dissip} &= ESR \cdot (I)^2 \\ &= 0.017 \cdot (4.600)^2 \\ &= 0.360 \text{ (W)} \end{aligned}$$

$$\begin{aligned} R_{th} &= \frac{\Delta_T}{P_{dissip}} \\ &= \frac{25}{0.360} \\ &= 69.498 \text{ (}^\circ\text{C/W)} \end{aligned}$$

### The self heating estimation and the max ambient temp

$$\begin{aligned}
\Delta T &= P_{selfHeating} \cdot R_{th} \\
&= 0.069 \cdot 69.498 \\
&= 4.794 \text{ (}^\circ\text{C} \Rightarrow \text{low delta temp)}
\end{aligned}$$

$$\text{Margin} = 30 \text{ (}^\circ\text{C)}$$

$$T_{max} = 150$$

$$\begin{aligned}
T_{amb_{max}} &= T_{max} - \Delta T - \text{Margin} \\
&= 150 - 4.794 - 30 \\
&= 115.206 \text{ (}^\circ\text{C)}
\end{aligned}$$

### Voltage margin

$$V_{o_{max}} = 54.000 \text{ (VDC)}$$

$$V_{max_{datasheet}} = 63 \text{ (VDC)}$$

$$\begin{aligned}
\text{Voltage}_{Margin} &= 100 \cdot \frac{V_{max_{datasheet}} - V_{o_{max}}}{V_{max_{datasheet}}} \\
&= 100 \cdot \frac{63 - 54.000}{63} \\
&= 14.286 \text{ (\%)}
\end{aligned}$$

This solution is acceptable, but the voltage margin is limited.

## Second proposition

EMHS101ARA331MMN0S aluminum electrolytic capacitors with Temp\_max = 150°C, Below a screenshot of the datasheet [4].

WV (V <sub>ac</sub> )	Cap (μF)	Size code	ESR (Ω max./100kHz)		Rated ripple current (mA <sub>rms</sub> /125°C, 100kHz)	Part No.
			20°C	−40°C		
100	110	KE0	0.17	2.5	920	EMHS101□RA111MKE0S
	150	KG5	0.13	1.8	1,030	EMHS101□RA151MKG5S
	160	LH0	0.098	1.3	1,640	EMHS101□RA161MLH0S
	200	MH0	0.091	0.98	1,720	EMHS101□RA201MMH0S
	240	LN0	0.063	0.80	2,230	EMHS101□RA241MLN0S
	330	MN0	0.059	0.59	2,300	EMHS101□RA331MMN0S

**Figure 2:** EMHS101ARA331MMN0S aluminum electrolytic capacitors with Temp\_max = 150°C

Let's start with a configuration of 5 capacitors in parallel

$$Nb_{capa} = 10$$

$$C_{capa_{nom}} = 330 \text{ (uF)}$$

$$\text{Margin} = 20 \text{ (\%)}$$

$$C_{capa} = C_{capa_{nom}} \cdot \left(1 - \frac{\text{Margin}}{100}\right) = 330 \cdot \left(1 - \frac{20}{100}\right) = 264.000 \text{ (uF, Worst case)}$$

$$C_{eq} = C_{capa} \cdot Nb_{capa} = 264.000 \cdot 10 = 2640.000 \text{ (uF > 208uF ok)}$$

$$\text{ESR}_{capa} = 59 \text{ (\Omega @ 100kHz)}$$

$$\text{ESR}_{eq} = \frac{\text{ESR}_{capa}}{Nb_{capa}} = \frac{59}{10} = 5.900 \text{ (\Omega < 6.36m OK)}$$

$$I_{capa_{max}} = 2.300$$

$$I_{eq_{max}} = I_{capa_{max}} \cdot Nb_{capa} = 2.300 \cdot 10 = 23.000 \text{ (@ Arms)}$$

### Voltage ripples

$$\Delta V_{outC} = \frac{I_o}{8 \cdot f_{sw_{min}} \cdot C_{eq} \cdot 1 \times 10^{-6}} = \frac{25.000}{8 \cdot 60170.000 \cdot 2640.000 \cdot 1 \times 10^{-6}} = 0.020$$

$$I_{rect_{peak}} = I_o \cdot \frac{\pi}{2} = 25.000 \cdot \frac{3.142}{2} = 39.270$$

$$\Delta V_{outR} = I_{rect_{peak}} \cdot \text{ESR}_{eq} \cdot 1 \times 10^{-3} = 39.270 \cdot 5.900 \cdot 1 \times 10^{-3} = 0.232$$

$$\begin{aligned} \Delta V_{out} &= \Delta V_{outR} + \Delta V_{outC} \\ &= 0.232 + 0.020 \\ &= 0.251 \text{ (clause to 0.25mV)} \end{aligned}$$

### Self heating

#### Power Dissipation of Each Capacitor

$$I_{each_{capa}} = \frac{I_{Co}}{Nb_{capa}} = \frac{12.086}{10} = 1.209$$

$$\begin{aligned} P_{selfHeating} &= \text{ESR}_{capa} \cdot 1 \times 10^{-3} \cdot (I_{each_{capa}})^2 \\ &= 59 \cdot 1 \times 10^{-3} \cdot (1.209)^2 \\ &= 0.086 \text{ (W)} \end{aligned}$$

#### Estimation of Thermal Resistance Rth

$$\Delta_T = 150 - 125 = 25 \text{ (}^\circ\text{C)}$$

$$\begin{aligned} P_{dissip} &= ESR_{capa} \cdot 1 \times 10^{-3} \cdot (I_{capa_{max}})^2 \\ &= 59 \cdot 1 \times 10^{-3} \cdot (2.300)^2 \\ &= 0.312 \text{ (W)} \end{aligned}$$

$$R_{th} = \frac{\Delta_T}{P_{dissip}} = \frac{25}{0.312} = 80.100 \text{ (}^\circ\text{C/W)}$$

### The self heating estimation and the max ambient temp

$$\Delta_T = P_{selfHeating} \cdot R_{th} = 0.086 \cdot 80.100 = 6.903 \text{ (}^\circ\text{C} \Rightarrow \text{low delta temp)}$$

$$\text{Margin} = 30 \text{ (}^\circ\text{C)}$$

$$T_{max} = 150$$

$$T_{amb_{max}} = T_{max} - \Delta_T - \text{Margin} = 150 - 6.903 - 30 = 113.097 \text{ (}^\circ\text{C)}$$

$$V_{o_{max}} = 54.000 \text{ (VDC)}$$

$$V_{max_{datasheet}} = 100 \text{ (VDC)}$$

$$\text{Voltage}_{Margin} = 100 \cdot \frac{V_{max_{datasheet}} - V_{o_{max}}}{V_{max_{datasheet}}} = 100 \cdot \frac{100 - 54.000}{100} = 46.000 \text{ (\%)}$$

## Comparaison

	requirements	Solutio1	Solutio2
<b>ESR_eq</b>	6.37	2.83	5.90
<b>C_eq</b>	207.74	576.00	2640.00
<b>Ieq_max</b>	12.09	27.60	23.00
<b>VmaxDC</b>	54.00	63.00	100.00
<b>Delta_V_out</b>	0.25	0.20	0.25
<b>C_capa</b>	NaN	96.00	264.00
<b>Nb_capa</b>	NaN	6.00	10.00
<b>P_selfHeating</b>	NaN	0.07	0.09
<b>T_amb_max</b>	NaN	115.21	113.10
<b>Voltage_Margin</b>	NaN	14.29	46.00

The voltage margin in the first solution is limited (16% in the worst case). However, I propose we proceed with this option, given the number of parallel capacitors. Care must be taken in control to prevent any



overshoot or transient voltage, especially when Vout is at Vout\_max.

## Resonant capacitor Cr

### Choosing a capacitor for Cr

#### The inputs data

$$Cr_{nF} = 116.209 \text{ (nF)}$$

$$V_{In_{max}} = 400.000 \text{ (V)}$$

$$f_{sw_{min}} = 60170.000 \text{ (Hz)}$$

#### The RMS voltage of the resonant capacitor

$$\begin{aligned} X_{Cr} &= \frac{1}{2 \cdot \pi \cdot f_{sw_{min}} \cdot Cr_{nF} \cdot 1 \times 10^{-9}} \\ &= \frac{1}{2 \cdot 3.142 \cdot 60170.000 \cdot 116.209 \cdot 1 \times 10^{-9}} \\ &= 22.761 \text{ (Ohm)} \end{aligned}$$

$$V_{Cr} = I_{rms} \cdot X_{Cr} = 10.354 \cdot 22.761 = 235.672 \text{ (V)}$$

$$V_{Cr_{rms}} = \sqrt{\left(\frac{V_{In_{max}}}{2}\right)^2 + (V_{Cr})^2} = \sqrt{\left(\frac{400.000}{2}\right)^2 + (235.672)^2} = 309.098 \text{ (vrms)}$$

Starting with the **B3267\*L** film capacitors, the maximum rated DC voltage is 2000V. [\[2\]](#).

The design value of Cr is 116.2 nF

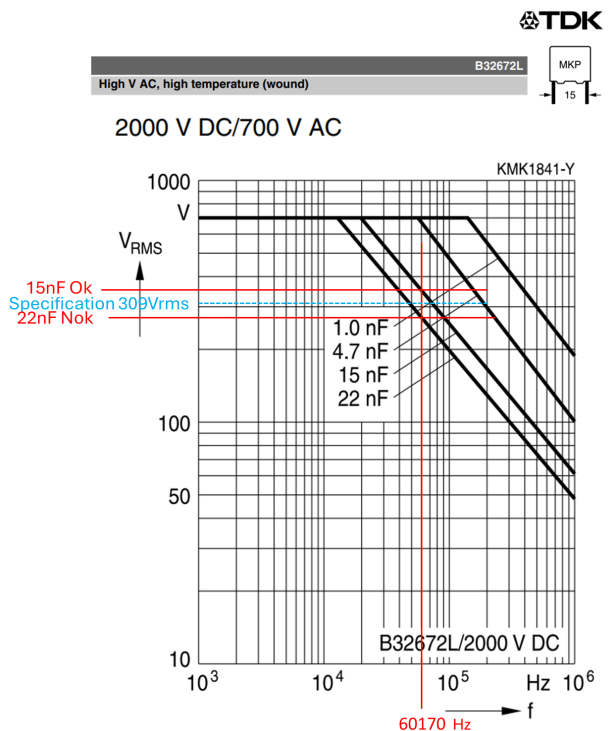
Below are some possible combinations for constructing this resonant capacitor:

	Nominal_capa_nF	Nb capas in parallel	total capa nF	error %
0	6.2	19	117.8	1.4
1	6.8	17	115.6	-0.5
2	8.2	14	114.8	-1.2
3	10.0	12	120.0	3.3
4	12.0	10	120.0	3.3
5	15.0	8	120.0	3.3
6	22.0	5	110.0	-5.3
7	33.0	4	132.0	13.6
8	47.0	2	94.0	-19.1
9	56.0	2	112.0	-3.6
10	68.0	2	136.0	17.0

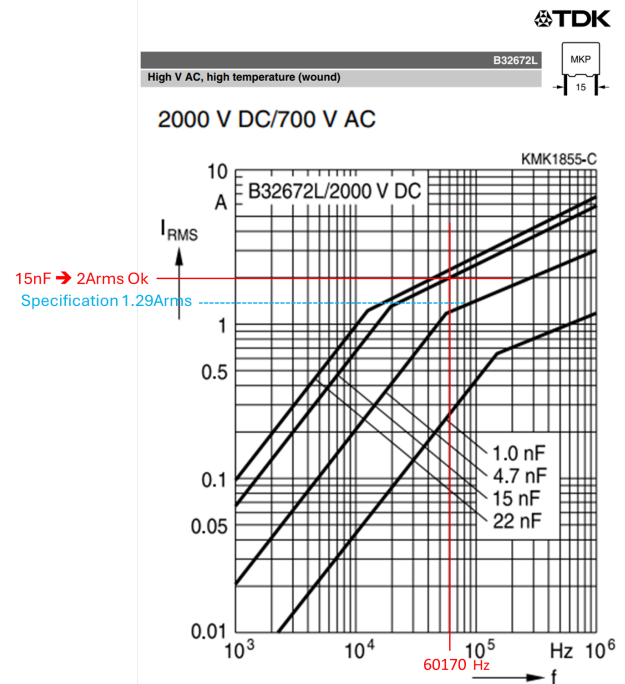
## The current of each element capacitor

$$I_{r_{ms1}} = 1.294$$

The 15 nF, 15 mm, 2000 VDC TDK MKP capacitor meets both the  $V_{rms}$  and  $I_{rms}$  requirements.



**Figure 3:**  $V_{rms}$  15 nF, 15 mm, 2000 VDC TDK MKP



**Figure 4:**  $I_{rms}$  15 nF, 15 mm, 2000 VDC TDK MKP

Below is a screenshot from the B32672L datasheet. The ref **B32672L8153** is a 15 nF capacitor.

B32672L

MKP

15

High V AC, high temperature (wound)

Ordering codes and packing units (lead spacing 15 mm)

V <sub>RMS</sub> f ≤1 kHz V AC	V <sub>R</sub> V DC	C <sub>R</sub> nF	Max. dimensions w × h × l mm	Ordering code (composition see below)	Ammo pack pcs./MOQ	Reel pcs./MOQ	Untaped pcs./MOQ
700	2000	1.0	5.0 × 10.5 × 18.0	B32672L8102+***	4680	5200	4000
		1.2	5.0 × 10.5 × 18.0	B32672L8122+***	4680	5200	4000
		1.5	5.0 × 10.5 × 18.0	B32672L8152+***	4680	5200	4000
		2.2	5.0 × 10.5 × 18.0	B32672L8222+***	4680	5200	4000
		2.7	5.0 × 10.5 × 18.0	B32672L8272+***	4680	5200	4000
		3.3	5.0 × 10.5 × 18.0	B32672L8332+***	4680	5200	4000
		3.9	5.0 × 10.5 × 18.0	B32672L8392+***	4680	5200	4000
		4.7	5.0 × 10.5 × 18.0	B32672L8472+***	4680	5200	4000
		5.6	6.0 × 11.0 × 18.0	B32672L8562+***	3840	4400	4000
		6.2	6.0 × 11.0 × 18.0	B32672L8622+***	3840	4400	4000
		6.8	6.0 × 11.0 × 18.0	B32672L8682+***	3840	4400	4000
		8.2	6.0 × 12.0 × 18.0	B32672L8822+***	3840	4400	4000
		10	7.0 × 12.5 × 18.0	B32672L8103+***	3320	3600	4000
		12	8.5 × 14.5 × 18.0	B32672L8123+***	2720	2800	2000
		15	8.5 × 14.5 × 18.0	B32672L8153+***	2720	2800	2000
		22	9.0 × 17.5 × 18.0	B32672L8223+***	2560	2800	2000
		33	11.0 × 18.5 × 18.0	B32672L8333+***	—	2200	1200

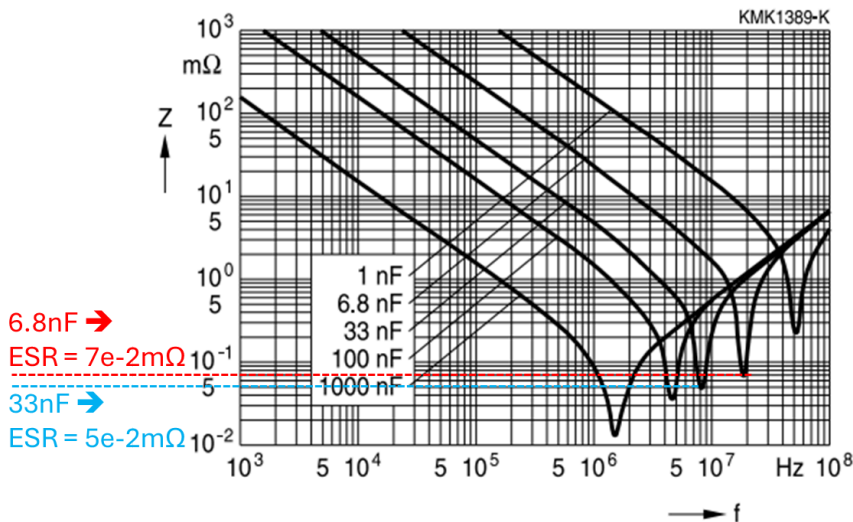
Figure 5: B32672L8153 is a 15 nF capacitor.

## The ESR and Power dissipation



### Capacitors for Snubbing, Resonant Circuits, Power Factor Correction (PFC) B3267\*L High V AC, high temperature (wound)

#### Impedance Z versus frequency f (typical values)



$$I_{RMS}(T_A) = I_{RMS, T_A \leq 100^\circ C} \cdot F_T(T_A)$$

$$V_{RMS}(T_A) = V_{RMS, T_A \leq 100^\circ C} \cdot F_T(T_A)$$

And  $F_T$  is given by the following curve:

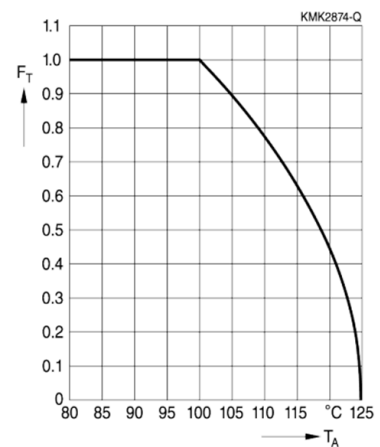


Figure 6: ESR and Thermal derating

From the below

6.8nF ESR=70μΩ

33nF ESR=50μΩ

By linear interpolation, the ESR of a 15 nF capacitor can be estimated as 63.74 μΩ

### The power dissipation of each capacitor

$$ESR_u = 63.740 \text{ (}\mu\Omega\text{)}$$

$$I_{rms_1} = 1.294 \text{ (Arms)}$$

$$I_{rms_{max}} = 2 \text{ (Arms)}$$

$$PD_{uW} = ESR_u \cdot (I_{rms_1})^2 = 63.740 \cdot (1.294)^2 = 106.771 \text{ (uW)}$$

### The Rth estimation

$$T_{max} = 125$$

$$T_{100} = 100$$

$$\Delta_T = T_{max} - T_{100} = 125 - 100 = 25$$

$$PD_{uW_{max}} = ESR_u \cdot (I_{rms_{max}})^2 = 63.740 \cdot (2)^2 = 254.962$$

$$R_{TH} = \frac{\Delta_T}{PD_{uW_{max}}} = \frac{25}{254.962} = 0.098 \text{ (}^\circ\text{C/uW)}$$

### Each capacitor's self-heating and the maximum permissible ambient temperature.

$$\Delta_T = PD_{uW} \cdot R_{TH} = 106.771 \cdot 0.098 = 10.469 \text{ (}^\circ\text{C)}$$

$$T_{amb_{max}} = 125 - \Delta_T = 125 - 10.469 = 114.531 \text{ (}^\circ\text{C)}$$

## Understanding the Derating Curve of the Capacitors

### One point calculation

$$T_a = 105$$

$$\Delta_T = T_{max} - T_a = 125 - 105 = 20$$

$$PD_{uW_{max}} = \frac{\Delta_T}{R_{TH}} = \frac{20}{0.098} = 203.969$$

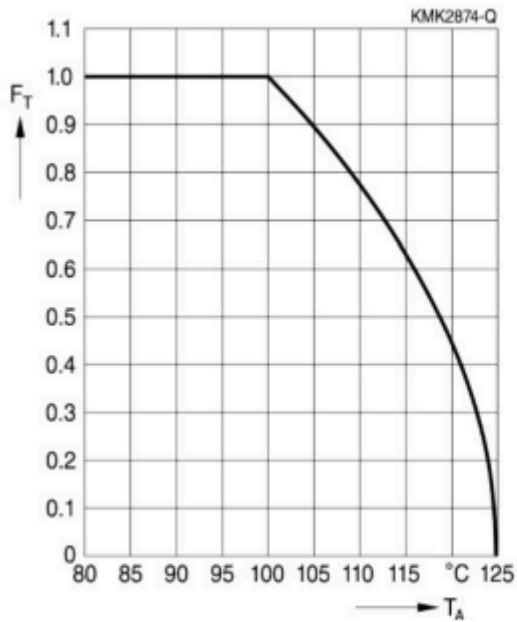
$$I_{rms_{max_{Ta}}} = 1.789$$

$$Fa = \frac{I_{rms_{max_{Ta}}}}{I_{rms_{max}}} = \frac{1.789}{2} = 0.894$$

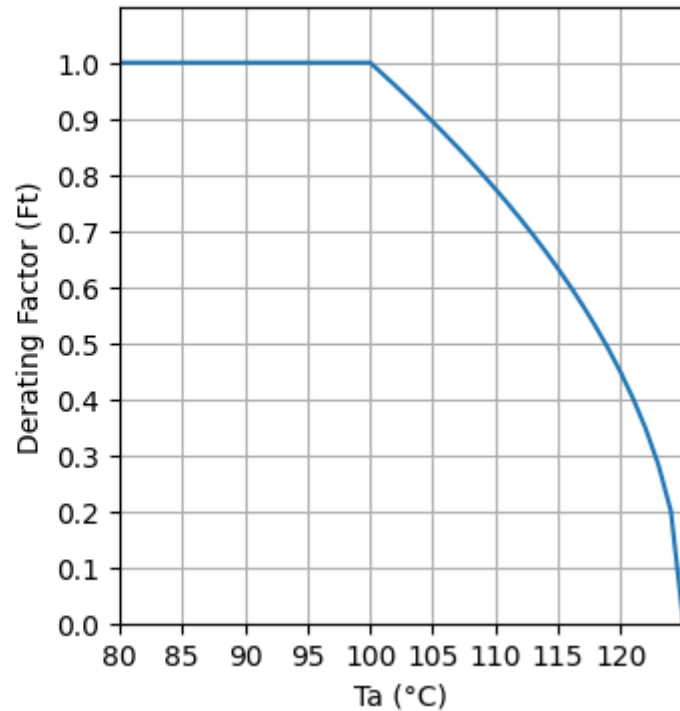
The same calculation is repeated to construct the derating curve.

(80.0, 125.0)

### Thermal Derating from datasheet



### Calculated Thermal Derating



## Resonant capacitors configuration

There are two possible configurations for the resonant capacitors:

- All capacitors in parallel:

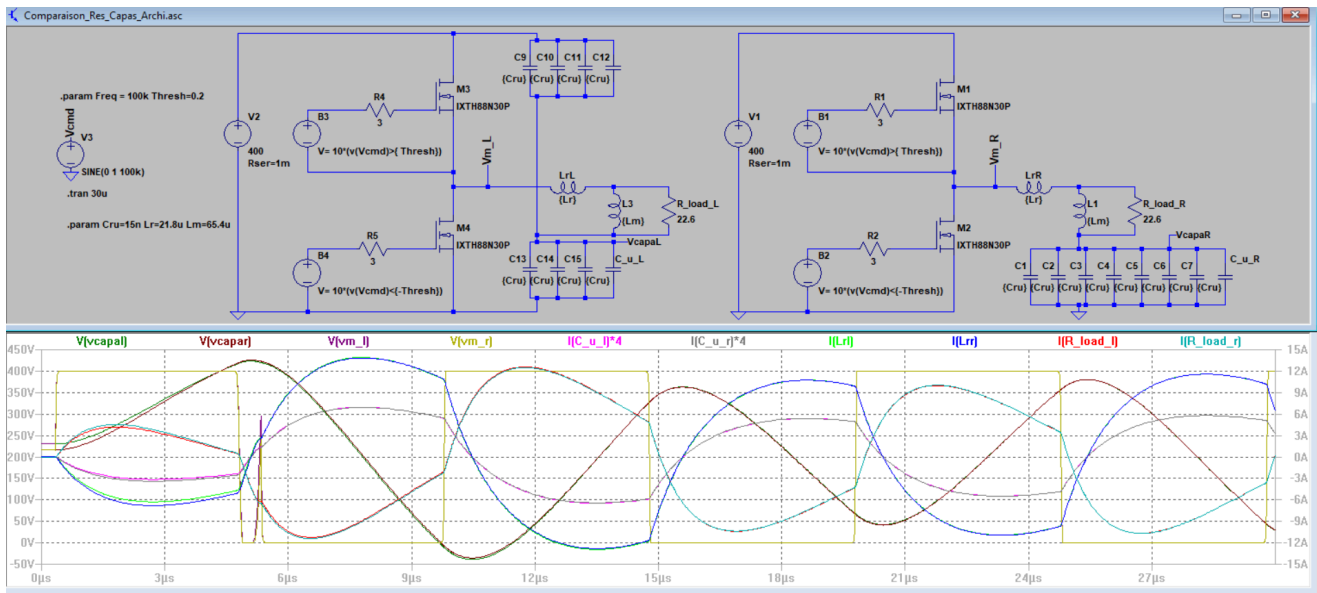
which is the classic LLC configuration and offers simplicity in layout.

- Dividing the capacitors between the high side and low side:

which helps balance HV+ and HV-.

Below is a simulation of both solutions. We can see that the voltage and current of each capacitor are almost identical in both configurations, and all other voltages and currents are also very similar.

You can download the LTSPICE file using this [Link](#).



**Figure 7:** Simulation of resonant capacitor configurations

## References

- [1] Hong Huang, *Designing an LLC Resonant Half-Bridge Power Converter*. Available: <https://bbs.dianyuan.com/upload/community/2013/12/01/1385867010-65563.pdf>
- [2] B40910 Aluminum electrolytic capacitors datasheet
- [3] B3267\*L Film Capacitors
- [4] EMHS Aluminum electrolytic capacitors datasheet