

# DC FILTERING

FFLI 800V to 1400Vdc\* RoHS Compliant



The FFLI series is specifically designed for DC filtering applications such as DC link. This range offers solutions for voltage from 800V up to 1400V.

The Controlled Self Healing Technology, essential to ensure a safe and reliable behaviour, is achieved using a fully dry solution with polypropylene metallized and segmented film. Standard designs proposed in this catalogue are covering a wide range of voltage and capacitance values.

In case of specific requirements about shape and performances, please feel free to contact your local KYOCERA AVX representative.

**FFLI range is not recommended for new designs, KYOCERA AVX advises customers to review latest technology range - FFLK**

## STANDARDS

- IEC 61071: Power electronic capacitors
- IEC 61881: Railway applications, rolling stock equipment, capacitors for power electronics
- IEC 60068-2: Environmental testing
- IEC 61373: Shock and vibrations
- UL 94: Tests for Flammability of Plastic Materials for Parts in Devices and Appliances

## PACKAGING MATERIAL

- Aluminium cylindrical case filled with thermosetting resin.
- Self extinguishing thermosetting resin (V-0 : in accordance with UL94; certified classifications according to EN 45545-2)
- Self extinguishing plastic cover (V-0 : in accordance with UL94; certified classifications according to EN 45545-2)
- RoHS components
- M6/10 Female connections or M8/20 Male connections

## HOW TO ORDER

<b>FFLI</b>	<b>6</b>	<b>L</b>	<b>0337</b>	<b>K</b>	<b>--</b>	
Series	Dielectric 6 = Polypropylene	Voltage Code B = 800V L = 1000V U = 1150V Q = 1400V	Capacitance EIA Code	Capacitance Tolerances K = ±10%	Terminal Code -- = Male Threaded JE = Female Threaded	

## DEFINITIONS

<b>C<sub>n</sub> (μF)</b>	capacitance	nominal value of the capacitance measured at $\theta_{amb} = 25 \pm 10^{\circ}\text{C}$
<b>U<sub>n</sub> (V)</b>	rated DC voltage	maximum operating peak voltage of either polarity (non-reversing type waveform), for which the capacitor has been designed for continuous operation
<b>U<sub>w</sub> (V)</b>	working voltage	value of the maximum operating recurrent voltage for a given hot spot temperature and an expected lifetime
<b>U<sub>r</sub> (V)</b>	ripple voltage	peak-to-peak alternating component of the unidirectional voltage
<b>L<sub>s</sub> (nH)</b>	parasitic inductance	capacitor series self-inductance
<b>R<sub>s</sub> (mΩ)</b>	series resistance	capacitor series resistance due to galvanic circuit
<b>I<sub>rms</sub> (A)</b>	RMS current	RMS current value for continuous operation under natural convection generating 40°C overheating
<b>θ<sub>amb</sub> (°C)</b>	cooling air temperature	temperature of the cooling air measured at the hottest position of the capacitor, under steady-state conditions, midway between two units NOTE If only one unit is involved, it is the temperature measured at a point approximately 0.1 m away from the capacitor container and at two-thirds of the height from its base
<b>θ<sub>HS</sub> (°C)</b>	hot spot temperature	highest temperature obtained inside the case of the capacitor in thermal equilibrium
<b>I²t (A²s)</b>	integral of action	maximum repetitive integral of action that galvanic circuit is able to withstand

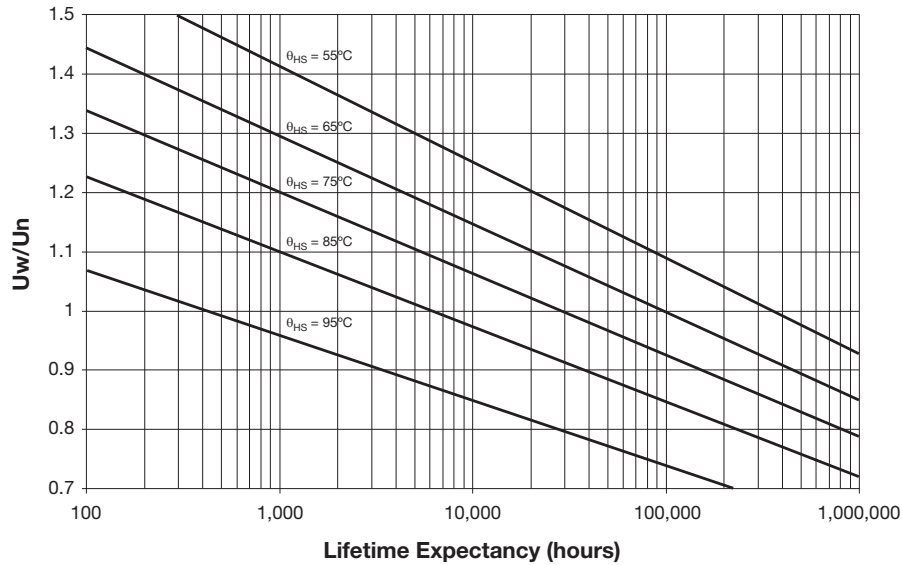
## CHARACTERISTICS

<b>Capacitance range C<sub>n</sub></b>	105μF to 3000μF
<b>Tolerance on C<sub>n</sub></b>	±10%
<b>Rated DC voltage U<sub>n</sub></b>	800 to 1400V
<b>Lifetime at U<sub>n</sub> and 65°C hot-spot temperature and ΔC / C &lt; 2%</b>	100,000h
<b>Parasitic inductance L<sub>s</sub></b>	35 to 60nH
<b>Maximum rms current I<sub>rms</sub></b>	up to 112A <sub>rms</sub>
<b>Test voltage between terminals @ 25°C</b>	1.5 x U <sub>n</sub> for 10s
<b>Test voltage between terminals and Case @ 25°C</b>	4kVrms @ 50Hz for 10s
<b>Dielectric</b>	polypropylene
<b>Climatic Category</b>	40 / 95 / 56 (IEC 60068)
<b>Working temperature</b>	-40°C / +95°C (according to the power dissipated)
<b>Storage temperature</b>	-40°C / +85°C
<b>Calorific value</b>	40 MJ/kg

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## LIFETIME EXPECTANCY VS HOT SPOT TEMPERATURE AND VOLTAGE



## HOW TO CHOSE THE RIGHT CAPACITOR

The capacitor lifetime depends on the working voltage and the hot spot temperature.

Our caps are designed to meet 100000 hours lifetime at rated voltage and 65°C hot spot temperature. In accordance with operating conditions, please calculate the hot spot temperature and deduce from this calculation if the obtained lifetime can suit the application.

### 1. From the tables, select a capacitor with required capacitance

$C_n$  and voltage  $U_n$ .

Calculate the maximum ripple voltage allowed for the selected cap:

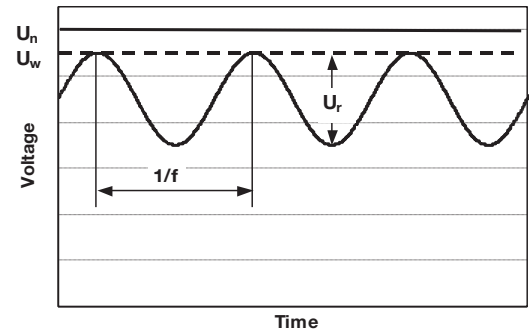
$$U_{rmax} = 0.2U_n$$

If  $U_r > U_{rmax}$ , select a capacitor with higher rated voltage

Make sure  $I_{rms}$  application  $<$   $I_{rms}$  table

Copy out:

- serial resistance ( $R_s$ ): see table of values
- thermal resistances  $R_{th}$



### 2. Hot spot temperature calculation

Total losses are calculated as follow:  $P_t = P_j + P_d$

Joule losses:  $P_j = R_s \times I_{rms}^2$

Dielectric losses:  $P_d = Q \times \text{tg} \delta_0$  with

•  $Q$  (reactive power) =  $\frac{I_{rms}^2}{C\omega}$  for a sinusoidal waveform

•  $\text{tg} \delta_0 = 2 \times 10^{-4}$  (dielectric losses of polypropylene)

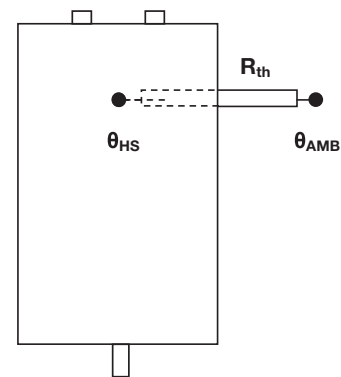
Hot spot temperature will be:

$$\theta_{HS} = \theta_{amb} + (P_j + P_d) \times R_{th}$$

$\theta_{HS}$  **absolute maximum is 95°C**

If temperature is higher than 95°C, come back to #1 and start again with another selection.

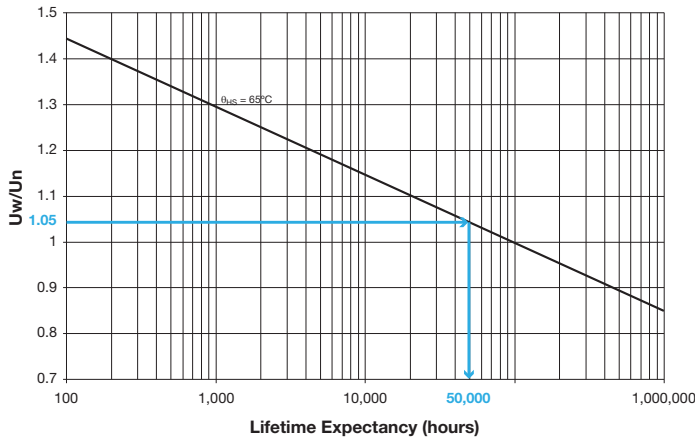
$R_{th}$ : thermal resistance between case and ambient air



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### 3. Refer to the curve and deduce the lifetime vs $U_w/U_n$ ratio



eg: rated voltage 1000V  
 working voltage 1050V  
 $\rho = 1.05 \Rightarrow$  lifetime 50,000 hours  
 @ 65°C hot spot temperature

Please, find a calculation form at the end of the catalog

## MTBF CALCULATION

Based on Return Of Experience from the field of more than 30 years, we have established the following relation. The failure rate  $\lambda_B$  depends on hot spot temperature  $\theta_{HS}$  and charge ratio  $\rho$ .

$$\rho = U_w/U_n$$

$$\lambda_B = 3 \times 10^{2.75(\rho-1)} \times e^{\left(3.2 \left(\frac{\theta_{HS} + 273}{358}\right)^{30}\right)} \times 10^{-9} \text{ in failures/hour}$$

## GENERAL FAILURE RATE

$\lambda = \lambda_B \times \pi_Q \times \pi_B \times \pi_E$  failures/hour •  $\pi_Q$ ,  $\pi_B$  and  $\pi_E$  see following tables

Qualification	Qualification factor $\pi_Q$
Product qualified on IEC61071 and internal qualification	1
Product qualified on IEC61071	2
Product answering on another norm	5
Product without qualification	15

Environment	Environment factor $\pi_E$
On ground (good conditions)	1
On ground (fixed materials)	2
On ground (on board)	4
On ship	9
On plane	15

Environment	Environment factor $\pi_B$
Favorable	1
Unfavourable	5

## MEAN TIME BETWEEN FAILURE (MTBF)

MTBF =  $1/\lambda$  hours

## SURVIVAL FUNCTION

$$N = N_0 \times \exp(-\lambda t)$$

N is the number of pieces still working after t hours.

$N_0$  is the number of pieces at the origin (t = 0)

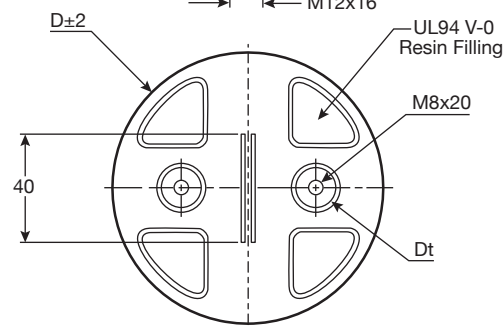
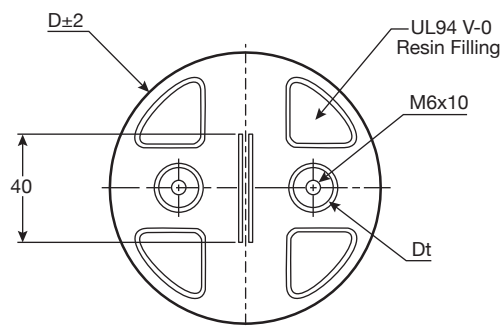
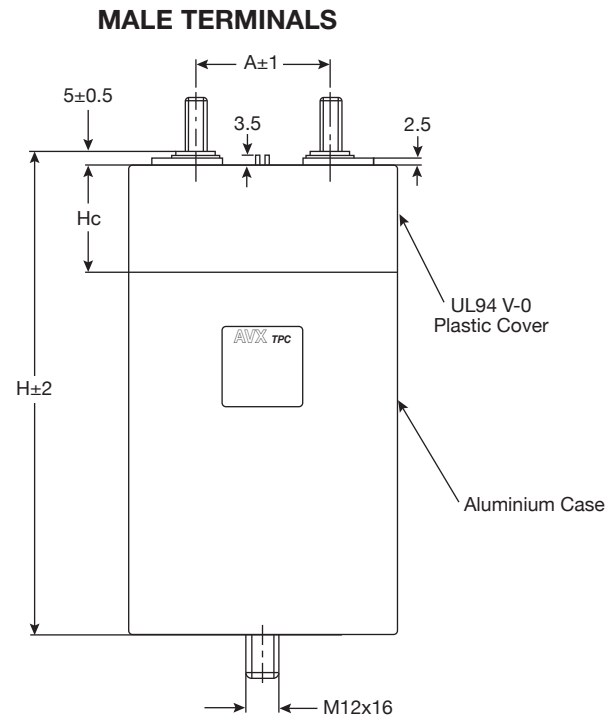
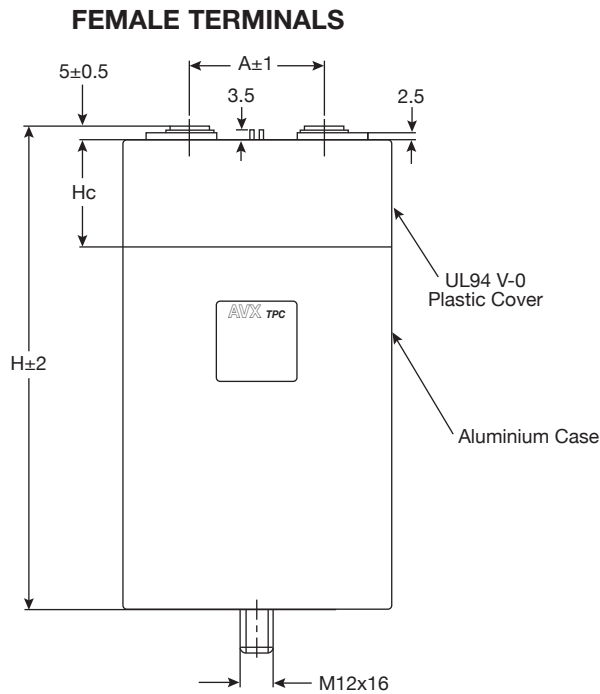
## FAILURE MODE

Main failure mode due to KYOCERA AVX's **Controlled Self-Healing Technology** is only losses of capacitance. Thanks to **Controlled Self-Healing solution** to interrupt self-healing process in order to prevent avalanche effect due to polypropylene molecular cracking producing gas and potential explosion in confined box for none **Controlled Self-Healing capacitors**.

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## DIMENSIONS



D (mm)	75	85	100	116
A (mm)	32	32	50	50
Dt (mm)	12	12	15	15
Hc (mm)	30	30	40	40

	Max Torque (Nm)
M6	4.5
M8	8.5
M12	15

D (mm)	Distance terminal to terminal (mm)		Distance terminal to case (mm)	
	creepage	clearance	creepage	clearance
75	40	19	47	45
85	40	19	52	50
100	55	34	59	57
116	55	34	67	65

## MECHANICAL MOUNTING

Capacitors enclosure presents a M12 x 16 bolt in order to fix the capacitor. Over height (H) more than 1.5 x D (diameter of tube), we recommend to clamp (constraint < 35daN), just below the plastic cover, the capacitor in order to limit oscillations in case of potential Shock&Vibration stress.

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## RATINGS AND PART NUMBER REFERENCE

Part Number	Capacitance (μF)	D	H	I <sub>rms</sub> (A)	I <sup>2</sup> t (A <sup>2</sup> s)	Typical L <sub>s</sub> (nH)	Typical R <sub>s</sub> (mΩ)	R <sub>th</sub> (°C/W)	Typical Weight (g)
<b>U<sub>n</sub>dc 800V</b>									
FFLI6B0297K**	290	75	105	54	13	35	3.1	4.5	600
FFLI6B0397K**	390	85	105	66	24	35	2.3	4.0	700
FFLI6B0687K**	680	85	155	59	24	50	3.1	3.7	1100
FFLI6B1007K**	1000	100	155	73	52	50	2.2	3.4	1500
FFLI6B1207K**	1200	100	180	70	52	60	2.5	3.3	1800
FFLI6B1357K**	1350	116	155	86	95	50	1.7	3.2	2000
FFLI6B1607K**	1600	116	180	80	95	60	2.0	3.1	2400
FFLI6B3007K**	3000	116	340	109	320	60	1.4	2.4	4500
<b>U<sub>n</sub>dc 1000V</b>									
FFLI6L0197K**	190	75	105	49	8	35	3.7	4.5	600
FFLI6L0267K**	260	85	105	60	16	35	2.8	4.0	700
FFLI6L0337K**	330	75	155	45	8	50	4.9	4.0	850
FFLI6L0457K**	450	85	155	54	16	50	3.7	3.7	1100
FFLI6L0657K**	650	100	155	66	33	50	2.7	3.4	1500
FFLI6L0907K**	900	116	155	79	66	50	2.0	3.2	2000
FFLI6L1107K**	1100	116	180	75	66	60	2.3	3.1	2400
FFLI6L2007K**	2000	116	340	102	210	60	1.6	2.4	4500
<b>U<sub>n</sub>dc 1150V</b>									
FFLI6U0157K**	150	75	105	46	7	35	4.2	4.5	600
FFLI6U0437K**	430	85	180	50	12	60	4.7	3.4	1300
FFLI6U0537K**	530	100	155	64	27	50	2.9	3.4	1500
FFLI6U0637K**	630	100	180	61	27	60	3.3	3.3	1800
FFLI6U0867K**	860	116	180	72	51	60	2.5	3.1	2400
FFLI6U1607K**	1600	116	340	99	160	60	1.7	2.4	4500
<b>U<sub>n</sub>dc 1400V</b>									
FFLI6Q1056K**	105	75	105	43	5	35	4.9	4.5	600
FFLI6Q0147K**	140	85	105	51	9	35	3.8	4.0	700
FFLI6Q0257K**	250	85	155	47	9	50	4.8	3.7	1100
FFLI6Q0607K**	600	116	180	66	36	60	3.0	3.1	2400
FFLI6Q1107K**	1100	116	340	91	120	60	2.0	2.4	4500

\*\*Insert - for male terminals or JE for female terminals

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## CALCULATION FORM SPECIFICATION

Capacitance	C (μF)	
Working voltage	U <sub>w</sub> (V)	
Rms current	I <sub>rms</sub> (A <sub>rms</sub> )	
Frequency	f (Hz)	
Ripple voltage	U <sub>r</sub> (V)	
Ambient temperature	θ <sub>amb</sub> (°C)	
Lifetime @ U <sub>w</sub> , I <sub>rms</sub> and θ <sub>amb</sub>	hours	
Parasitic inductance	L (nH)	
Cooling conditions		

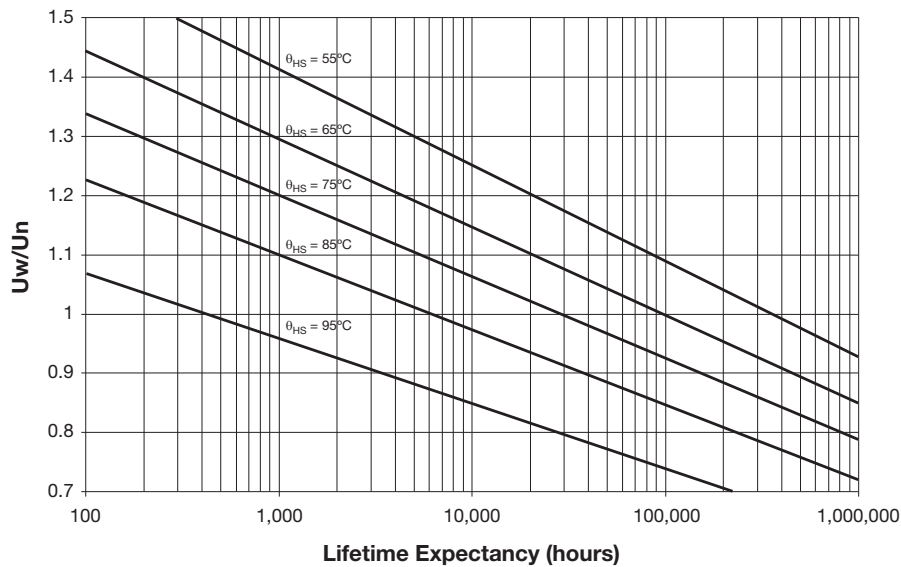
### Your choice

PN		
Capacitance	C (μF)	
Rated voltage	U <sub>n</sub> (V)	
Serial resistance	R <sub>s</sub> (mΩ)	
between hot spot and case	R <sub>th</sub> (°C/W)	

## CALCULATIONS

Maximum ripple voltage	$U_{rmax} = 0.2 U_n$	$U_{rmax} =$	V
<i>The maximum ripple voltage of the selected capacitor must be in any case higher than the ripple voltage of your application</i>			
Ratio U <sub>w</sub> /U <sub>n</sub>	$\rho = U_w/U_n$	$\rho =$	
Joule losses	$P_j = R_s \times I_{rms}^2$	$P_j =$	W
Dielectric losses	$P_d = Q \times \text{tg}\delta = Q \times 2.10^{-4}$	$P_d =$	W
Hot spot temperature	$\theta_{HS} = \theta_{amb} + (P_j + P_d) \times R_{th}$	$\theta_{HS} =$	°C
<i>The hot spot temperature must be in any case lower than 95°C</i>			

## LIFETIME EXPECTANCY VS HOT SPOT TEMPERATURE AND VOLTAGE



Expected lifetime at hot spot calculated and $U = U_w$	
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