

DC FILTERING

FFLI HV 1500V to 3800Vdc* RoHS Compliant



The FFLI series is specifically designed for DC filtering applications such as DC link. This high voltage range offers solutions for voltage from 1500V up to 3800V.

The **Controlled Self Healing Technology**, essential to ensure a safe and reliable behavior, is achieved using a wet solution with both polypropylene metallized film and oil (without free oil). 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 AVX representative.

PACKAGING MATERIAL

Aluminium cylindrical case filled polyurethane resin.

Self extinguishing polyurethane resin (VO: in accordance with UL94)

Self extinguishing plastic cover (VO: in accordance with UL94)
RoHS components

M6/10 Female connections or M8/20 Male connections

HOW TO ORDER

FFLI	6	L	0257	K	---
Series	Dielectric 6 = Polypropylene	Voltage Code R = 1500V S = 1750V N = 2000V T = 2250V P = 2500V W = 2750V X = 3000V Y = 3500V Z = 3800V	Capacitance EIA Code	Capacitance Tolerances K = ±10%	Terminal Code -- = Male Threaded JE = Female Threaded



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: Fire requirements

DEFINITIONS

C_n (µF)	capacitance	nominal value of the capacitance measured at $\theta_{amb} = 25 \pm 10^\circ\text{C}$
U_n (V)	rated DC voltage	maximum operating peak voltage of either polarity (non-reversing type waveform), for which the capacitor has been designed for continuous operation
U_w (V)	working voltage	value of the maximum operating recurrent voltage for a given hot spot temperature and an expected lifetime
U_r (V)	ripple voltage	peak-to-peak alternating component of the unidirectional voltage
L_s (nH)	parasitic inductance	capacitor series self-inductance
R_s (mΩ)	series resistance	capacitor series resistance due to galvanic circuit
I_{rms} (A)	RMS current	RMS current value for continuous operation under natural convection generating 30°C overheating
θ_{amb} (°C)	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
θ_{hs} (°C)	hot spot temperature	highest temperature obtained inside the case of the capacitor in thermal equilibrium
I^2t (A²s)	integral of action	maximum repetitive integral of action that galvanic circuit is able to withstand

CHARACTERISTICS

Capacitance range C_n	53µF to 1100µF
Tolerance on C_n	±10%
Rated DC voltage U_n	1500 to 3800V
Lifetime at U_n and 70°C hot-spot temperature and $\theta_{amb} / \theta_{hs} < 2\%$	100,000h
Parasitic inductance L_s	40 to 60nH
Maximum rms current I_{rms}	up to 92A _{rms}
Test voltage between terminals @ 25°C	1.5 x U_n for 10s
Test voltage between terminals and Case @ 25°C	9kV _{rms} @ 50Hz for 10s
Dielectric	polypropylene
Climatic Category	40 / 95 / 56 (IEC 60068)
Working temperature	-40°C / +95°C (according to the power dissipated)
Storage temperature	-40°C / +95°C
Caloric value	40 MJ/kg



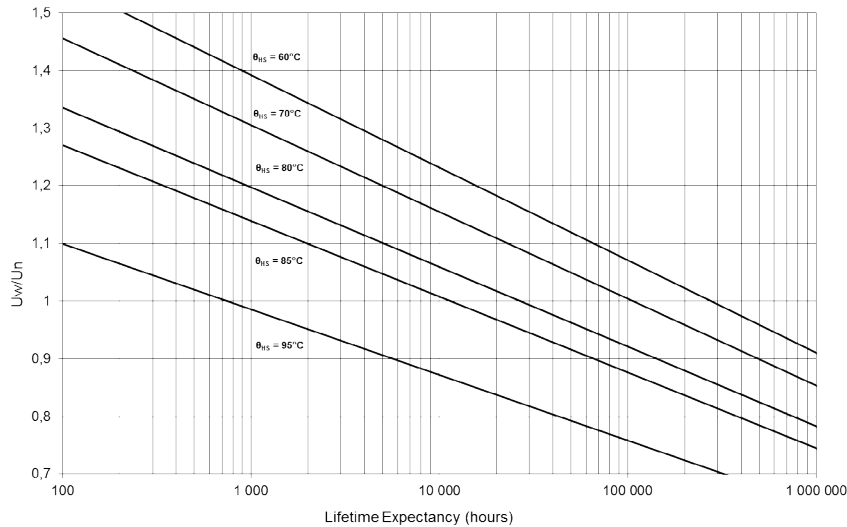
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LIFETIME EXPECTANCY VS HOT SPOT TEMPERATURE AND VOLTAGE



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 70°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:

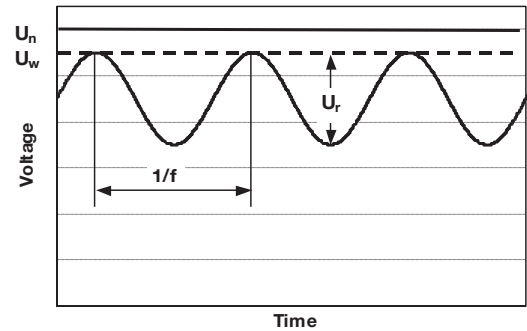
$$U_{max} = 0.2U_n$$

If $U_r > U_{max}$, 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: $P_d = Q \times \text{tg } \delta$ with

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

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

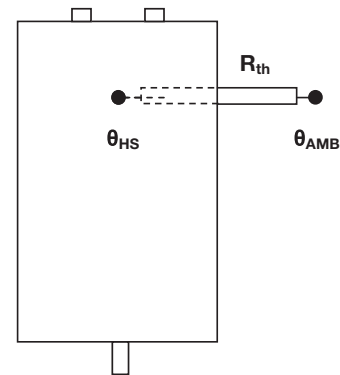
Hot spot temperature will be:

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

θ_{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} : between case and ambient air

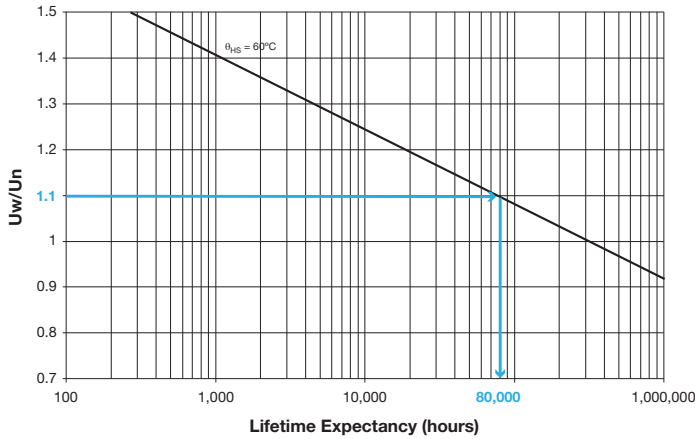


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3. Refer to the curve and deduce the lifetime vs U_w/U_n ratio



eg: rated voltage 2000V
 working voltage 2200V
 = 1.1 \Rightarrow lifetime 80,000 hours @ 60°C hot spot temperature

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

MTBF CALCULATION

The failure rate λ_B depends on hot spot temperature θ_{HS} and charge ratio U_w/U_n .

$$= U_w/U_n$$

$$\lambda_B = 3 \times 10^{2,75(\rho-1)} \times e^{\left(3,2 \left(\frac{\theta_{HS} + 273}{358}\right)^{30}\right)} \times 10^{-9} \text{ in failures/hour}$$

GENERAL FAILURE RATE

$\lambda_B \times Q \times B \times E$ failures/hour • Q , B and E see following tables

Qualification	Qualification factor πQ
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 πE
On ground (good conditions)	1
On ground (fixed materials)	2
On ground (on board)	4
On ship	9
On plane	15

Environment	Environment factor πB
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 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**.



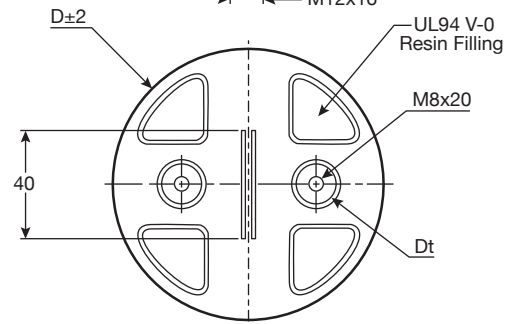
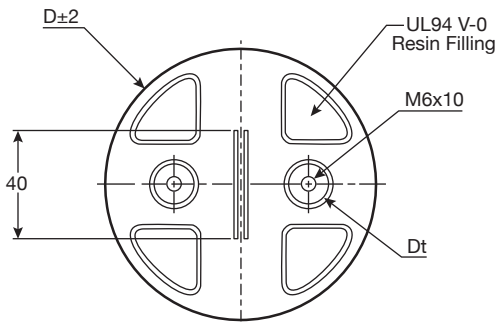
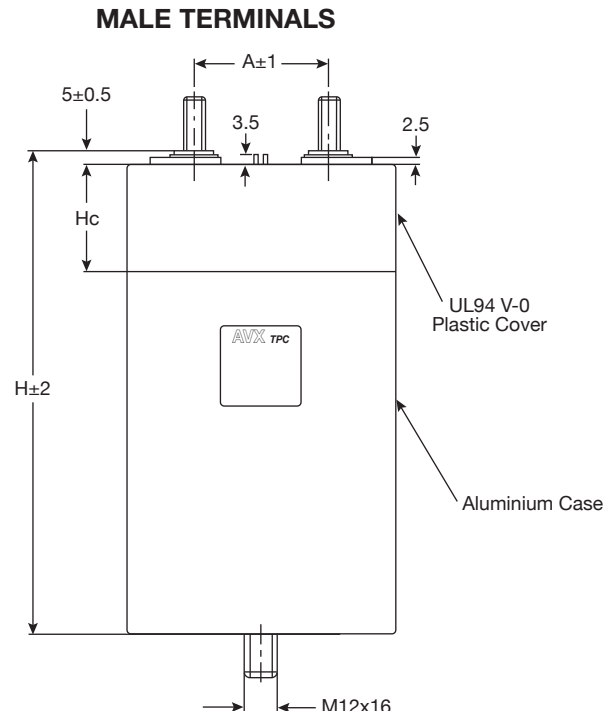
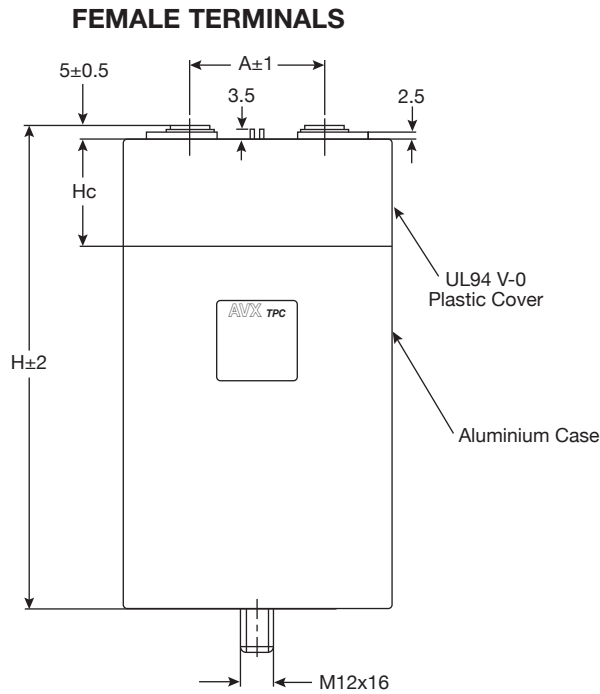
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DIMENSIONS



D (mm)	85	100	116	116
A (mm)	32	50	50	50
Dt (mm)	12	15	15	15
Hc (mm)	30	40	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
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 _{rms} (A)	I ² t (A ² s)	Typical L _s (nH)	Typical R _s (mΩ)	R _{th} (°C/W)	Typical Weight (g)
U_n = 1500V									
FFLI6R0257K**	250	85	155	51	11	50	3.2	3.6	1100
FFLI6R0317K**	310	85	180	49	11	60	3.8	3.3	1300
FFLI6R0377K**	370	100	155	62	24	50	2.3	3.3	1500
FFLI6R0457K**	450	100	180	59	24	60	2.7	3.1	1800
FFLI6R0517K**	510	116	155	74	45	50	1.8	3.1	2000
FFLI6R0627K**	620	116	180	70	45	60	2.1	2.9	2400
FFLI6R0707K**	700	116	240	92	140	40	1.1	3.2	3200
FFLI6R0907K**	900	116	290	90	140	50	1.3	2.9	3900
FFLI6R1107K**	1100	116	340	89	140	60	1.5	2.5	4500
U_n = 1750Vdc									
FFLI6S1856K**	185	85	155	48	8	50	3.7	3.6	1100
FFLI6S2256K**	225	85	180	46	8	60	4.4	3.3	1300
FFLI6S0277K**	270	100	155	58	18	50	2.6	3.3	1500
FFLI6S0337K**	330	100	180	56	18	60	3.1	3.1	1800
FFLI6S0377K**	370	116	155	69	33	50	2.0	3.1	2000
FFLI6S0457K**	450	116	180	65	33	60	2.4	2.9	2400
FFLI6S0527K**	520	116	240	89	108	40	1.2	3.2	3200
FFLI6S0677K**	670	116	290	86	108	50	1.4	2.9	3900
FFLI6S0827K**	820	116	340	85	108	60	1.7	2.5	4500
U_n = 2000Vdc									
FFLI6N0147K**	140	85	155	45	6	50	4.2	3.6	1100
FFLI6N0177K**	170	85	180	43	6	60	5.0	3.3	1300
FFLI6N2056K**	205	100	155	55	13	50	3.0	3.3	1500
FFLI6N0257K**	250	100	180	52	13	60	3.5	3.1	1800
FFLI6N0287K**	280	116	155	65	25	50	2.3	3.1	2000
FFLI6N0357K**	350	116	180	62	25	60	2.6	2.9	2400
FFLI6N0407K**	400	116	240	85	82	40	1.3	3.2	3200
FFLI6N0517K**	510	116	290	82	82	50	1.5	2.9	3900
FFLI6N0627K**	620	116	340	81	82	60	1.8	2.5	4500
U_n = 2250Vdc									
FFLI6T0117K**	110	85	155	43	5	50	4.7	3.6	1100
FFLI6T1356K**	135	85	180	41	5	60	5.5	3.3	1300
FFLI6T0167K**	160	100	155	52	10	50	3.3	3.3	1500
FFLI6T0187K**	195	100	180	49	10	60	4.0	3.1	1800
FFLI6T0227K**	220	116	155	62	20	50	2.5	3.1	2000
FFLI6T0277K**	270	116	180	59	20	60	3.0	2.9	2400
FFLI6T0317K**	310	116	240	81	64	40	1.4	3.2	3200
FFLI6T0407K**	400	116	290	79	64	50	1.7	2.9	3900
FFLI6T0497K**	490	116	340	78	64	60	2.0	2.5	4500
U_n = 2500Vdc									
FFLI6P0856K**	85	85	155	40	4	50	5.2	3.6	1100
FFLI6P1056K**	105	85	180	39	4	60	6.1	3.3	1300
FFLI6P0127K**	120	100	155	49	8	50	3.8	3.3	1500
FFLI6P0157K**	150	100	180	47	8	60	4.4	3.1	1800
FFLI6P0177K**	170	116	155	59	16	50	2.8	3.1	2000
FFLI6P0217K**	210	116	180	56	16	60	3.3	2.9	2400
FFLI6P0237K**	230	116	240	77	50	40	1.6	3.2	3200
FFLI6P0307K**	300	116	290	75	50	50	1.9	2.9	3900
FFLI6P0387K**	380	116	340	75	50	60	2.2	2.5	4500
U_n = 2750Vdc									
FFLI6W0706K**	70	85	155	39	3.3	50	5.7	3.6	1100
FFLI6W0856K**	85	85	180	37	3.3	60	6.8	3.3	1300
FFLI6W0107K**	100	100	155	47	7	50	4.1	3.3	1500
FFLI6W1256K**	125	100	180	45	7	60	4.8	3.1	1800
FFLI6W0147K**	140	116	155	56	13	50	3.0	3.1	2000
FFLI6W0177K**	170	116	180	53	13	60	3.6	2.9	2400
FFLI6W0197K**	190	116	240	74	42	40	1.7	3.2	3200
FFLI6W0257K**	250	116	290	73	42	50	2.0	2.9	3900
FFLI6W0317K**	310	116	340	72	42	60	2.4	2.5	4500
U_n = 3000Vdc									
FFLI6X0586K**	58	85	155	37	2.7	50	6.3	3.6	1100
FFLI6X0706K**	70	85	180	35	2.7	60	7.6	3.3	1300
FFLI6X0856K**	85	100	155	45	6	50	4.4	3.3	1500
FFLI6X1056K**	105	100	180	43	6	60	5.2	3.1	1800
FFLI6X1156K**	115	116	155	54	11	50	3.3	3.1	2000
FFLI6X1456K**	145	116	180	51	11	60	3.9	2.9	2400
FFLI6X0167K**	160	116	240	72	35	40	1.8	3.2	3200
FFLI6X0217K**	210	116	290	70	35	50	2.1	2.9	3900
FFLI6X0267K**	260	116	340	69	35	60	2.5	2.5	4500
U_n = 3500Vdc									
FFLI6Y0606K**	60	100	155	60	17	50	2.5	3.3	1500
FFLI6Y0756K**	75	100	180	58	17	60	2.9	3.1	1800
FFLI6Y0856K**	85	116	155	72	34	50	1.9	3.1	2000
FFLI6Y1056K**	105	116	180	68	34	60	2.2	3.0	2400
FFLI6Y1156K**	115	116	240	89	110	40	1.2	3.3	3200
FFLI6Y0157K**	150	116	290	88	106	50	1.3	2.9	3900
FFLI6Y0197K**	190	116	340	88	110	60	1.6	2.5	4500
U_n = 3800Vdc									
FFLI6Z0536K**	53	100	155	59	15	50	2.6	3.3	1500
FFLI6Z0666K**	66	100	180	56	15	60	3.0	3.1	1800
FFLI6Z0726K**	72	116	155	69	28	50	2.0	3.1	2000
FFLI6Z0906K**	90	116	188	66	28	60	2.3	3.0	2400
FFLI6Z0107K**	100	116	240	88	95	40	1.2	3.3	3200
FFLI6Z0137K**	130	116	290	86	92	50	1.4	2.9	3900
FFLI6Z1656K**	165	116	340	87	95	60	1.5	2.5	4500

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



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CALCULATION FORM SPECIFICATION

Capacitance	C (μF)	
Working voltage	U _w (V)	
Rms current	I _{rms} (Arms)	
Frequency	f (Hz)	
Ripple voltage	U _r (V)	
Ambient temperature	T _{amb} (°C)	
Lifetime @ U _w , I _{rms} and T _{amb}	hours	
Parasitic inductance	L (nH)	

Your choice

PN		
Capacitance	C (μF)	
Rated voltage	U _n (V)	
Serial resistance	R _s (m Ω)	
between hot spot and case	R _{th} (°C/W)	

CALCULATIONS

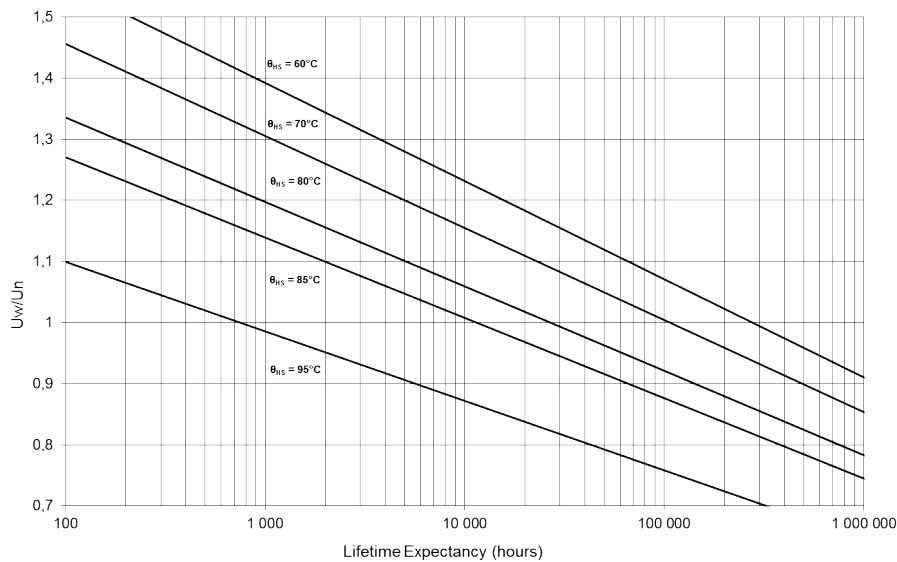
Maximum ripple voltage	U _{rmax} = 0.2 U _n	U _{rmax} =	V
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The maximum ripple voltage of the selected capacitor must be in any case higher than the ripple voltage of your application

Ratio U _w /U _n	= U _w /U _n	=	
Joule losses	P _j = R _s × I _{rms} ²	P _j =	W
Dielectric losses	P _d = Q × tg δ = Q × 2.10 ⁻⁴	P _d =	W
Hot spot temperature	T _{HS} = T _{amb} + (P _j + P _d) × R _{th}	T _{HS} =	°C

The hot spot temperature must be in any case lower than 95°C

LIFETIME EXPECTANCY VS HOT SPOT TEMPERATURE AND VOLTAGE



Expected lifetime at hot spot calculated at U _w	
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