

Aluminum Capacitors Axial Standard, High Voltage

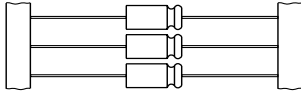
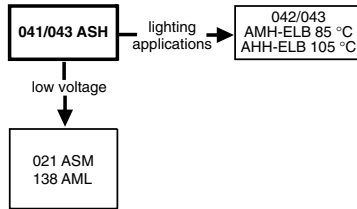


Fig. 1 Component outlines



FEATURES

- Polarized aluminum electrolytic capacitors, non-solid electrolyte
- Axial leads, cylindrical aluminum case, insulated with a blue sleeve
- Mounting ring version not available in insulated form
- Taped versions up to case \varnothing 15 x 30 mm available for automatic insertion
- Useful life: 5000 to 15 000 hours at 85 °C
- High rated voltage: up to 450 V
- Lead (Pb)-free versions are RoHS compliant



RoHS*
COMPLIANT

APPLICATIONS

- General purpose, industrial, power supply, audio-video
- Smoothing, filtering, buffering at high voltages
- Boards with restricted mounting height, vibration and shock resistant

MARKING

The capacitors are marked (where possible) with the following information:

- Rated capacitance (in μ F)
- Tolerance on rated capacitance, code letter in accordance with IEC 60062 (T for - 10 to + 50 %)
- Rated voltage (in V)
- Upper category temperature (85 °C)
- Date code, in accordance with IEC 60062
- Code indicating factory of origin
- Name of manufacturer
- Band to indicate the negative terminal
- '+' sign to identify the positive terminal
- Series number (041, 042 or 043)

QUICK REFERENCE DATA		
DESCRIPTION	VALUE	
Nominal case sizes (\varnothing D x L in mm)	6.5 x 18 to 10 x 25	10 x 30 to 21 x 38
Rated capacitance range, C_R	1 to 220 μ F	
Tolerance on C_R	- 10 to + 50 %	
Rated voltage range, U_R	160 to 450 V	
Category temperature range	- 40 to + 85 °C (450 V: - 25 to + 85 °C)	
Endurance test at 85 °C	2000 hours	8000 hours (450 V: 5000 hours)
Useful life at 85 °C	5000 hours	15 000 hours (450 V: 10 000 hours)
Useful life at 40 °C	1.4 x I_R applied: 120 000 hours	1.8 x I_R applied: 240 000 hours (450 V: 160 000 hours)
Shelf life at 0 V, 85 °C	500 hours	500 hours
Based on sectional specification	IEC 60384-4/EN130300	
Climatic category IEC 60068	40/085/56 (450 V: 25/085/56)	

SELECTION CHART FOR C_R , U_R AND RELEVANT NOMINAL CASE SIZES (\varnothing D x L in mm)						
C_R (μ F)	U_R (V)					
	160	250	350	385	400	450
1.0	-	-	-	6.5 x 18	-	-
2.2	-	6.5 x 18	-	8 x 18	-	-
4.7	6.5 x 18	8 x 18	10 x 18	10 x 25	-	-
6.8	-	-	10 x 30	10 x 30	10 x 30	10 x 30
10	8 x 18	10 x 25	12.5 x 30	12.5 x 30	12.5 x 30	12.5 x 30
	-	10 x 30	-	-	-	-
15	-	12.5 x 30	12.5 x 30	15 x 30	15 x 30	12.5 x 30
22	10 x 25	12.5 x 30	15 x 30	18 x 30	18 x 30	15 x 30
	10 x 30	-	-	-	-	-
33	12.5 x 30	15 x 30	18 x 30	18 x 38	18 x 38	18 x 30
47	15 x 30	18 x 30	18 x 38	18 x 38	18 x 38	18 x 38
68	15 x 30	18 x 38	21 x 38	21 x 38	21 x 38	21 x 38
100	18 x 30	21 x 38	-	-	-	-
150	18 x 38	-	-	-	-	-
220	21 x 38	-	-	-	-	-

* Pb containing terminations are not RoHS compliant, exemptions may apply

ELECTRICAL DATA	
SYMBOL	DESCRIPTION
C_R	rated capacitance at 100 Hz, tolerance - 10 to + 50
I_R	rated RMS ripple current at 100 Hz, 85 °C
I_{L1}	max. leakage current after 1 minute at U_R
I_{L5}	max. leakage current after 5 minutes at U_R
Tan δ	max. dissipation factor at 100 Hz
ESR	equivalent series resistance at 100 Hz (calculated from tan δ_{max} and C_R)
Z	max. impedance at 10 kHz

Note

1. Unless otherwise specified, all electrical values in Table 3 apply at $T_{amb} = 20\text{ °C}$, $P = 86$ to 106 kPa , $RH = 45$ to 75% .

Table 3

ELECTRICAL DATA AND ORDERING INFORMATION													
U_R (V)	C_R 100 Hz (μF)	NOMINAL CASE SIZE $\varnothing D \times L$ (mm)	CASE CODE	I_R 100 Hz 85 °C (mA)	I_{L1} 1 min (μA)	I_{L5} 5 min (μA)	Tan δ 100 Hz	ESR 100 Hz (Ω)	Z 10 kHz (Ω)	CATALOG NUMBER 2222			
										IN BOX FORM AA	TAPED ON REEL FORM BR	TAPED IN BOX FORM BA	MOUNTING RING FORM MR
160	4.7	6.5 x 18	4	50	38	8	0.15	51	26	-	041 21478	041 31478	-
	10	8 x 18	5	70	68	14	0.15	24	12	-	041 21109	041 31109	-
	22	10 x 25	7	150	130	25	0.15	11	5.5	-	041 21229	041 31229	-
	22	10 x 30	00	190	42	25	0.10	6.8	5.5	042 11229	042 21229	-	-
	33	12.5 x 30	01	270	58	36	0.10	4.5	3.1	042 11339	042 21339	-	-
	47	15 x 30	02	350	78	49	0.10	3.2	2.1	042 11479	042 21479	-	042 41479
	68	15 x 30	02	420	110	69	0.10	2.2	1.4	042 11689	042 21689	-	042 41689
	100	18 x 30	03	580	150	100	0.10	1.5	1.0	042 11101	-	-	042 41101
	150	18 x 38	04	760	230	150	0.10	1.0	0.7	043 11151	-	-	043 41151
	220	21 x 38	05	940	330	220	0.10	0.7	0.5	043 11221	-	-	043 41221
250	2.2	6.5 x 18	4	35	28	6	0.10	72	50	-	041 23228	041 33228	-
	4.7	8 x 18	5	55	55	11	0.10	34	23	-	041 23478	041 33478	-
	10	10 x 25	7	90	95	19	0.10	16	11	-	041 23109	041 33109	-
	10	10 x 30	00	130	33	19	0.10	15	11	042 13109	042 23109	-	-
	15	12.5 x 30	01	180	44	27	0.10	10	7.4	042 13159	042 23159	-	-
	22	12.5 x 30	01	220	60	37	0.10	6.8	5.0	042 13229	042 23229	-	-
	33	15 x 30	02	290	84	54	0.10	4.5	3.4	042 13339	042 23339	-	042 43339
	47	18 x 30	03	400	120	75	0.10	3.2	2.3	042 13479	-	-	042 43479
	68	18 x 38	04	520	160	110	0.10	2.2	1.7	043 13689	-	-	043 43689
	100	21 x 38	05	650	240	150	0.10	1.5	1.1	043 13101	-	-	043 43101
350	4.7	10 x 18	6	60	69	14	0.10	34	22	-	041 25478	041 35478	-
	6.8	10 x 30	00	110	32	18	0.10	22	14	042 15688	042 25688	-	-
	10	12.5 x 30	01	150	42	25	0.10	15	10	042 15109	042 25109	-	-
	15	12.5 x 30	01	180	57	36	0.10	10	6.7	042 15159	042 25159	-	-
	22	15 x 30	02	250	79	50	0.10	6.8	4.5	042 15229	042 25229	-	042 45229
	33	18 x 30	03	350	110	73	0.10	4.5	3.1	042 15339	-	-	042 45339
	47	18 x 38	04	450	160	100	0.10	3.2	2.1	043 15479	-	-	043 45479
	68	21 x 38	05	560	220	150	0.10	2.2	1.4	043 15689	-	-	043 45689
385	1	6.5 x 18	4	20	19	4	0.10	160	100	-	041 28108	041 38108	-
	2.2	8 x 18	5	40	42	8	0.10	72	45	-	041 28228	041 38228	-
	4.7	10 x 25	7	70	71	15	0.10	34	22	-	041 28478	041 38478	-
	6.8	10 x 30	00	110	34	20	0.10	22	14	042 18688	042 28688	-	-
	10	12.5 x 30	01	150	45	27	0.10	15	10	042 18109	042 28109	-	-
	15	15 x 30	02	210	62	39	0.10	10	6.0	042 18159	042 28159	-	042 48159
	22	18 x 30	03	290	86	55	0.10	6.8	4.1	042 18229	-	-	042 48229
	33	18 x 38	04	380	120	80	0.10	4.5	2.7	043 18339	-	-	043 48339
	47	18 x 38	04	450	170	110	0.10	3.2	2.1	043 18479	-	-	043 48479
	68	21 x 38	05	570	250	160	0.10	2.2	1.4	043 18689	-	-	043 48689

ORDERING EXAMPLE*

Electrolytic capacitor 041 series

10 $\mu\text{F}/250\text{ V}$; - 10/+ 50 %Nominal case size: $\varnothing 10 \times 25\text{ mm}$; Form BA

Catalog number: 2222 041 33109

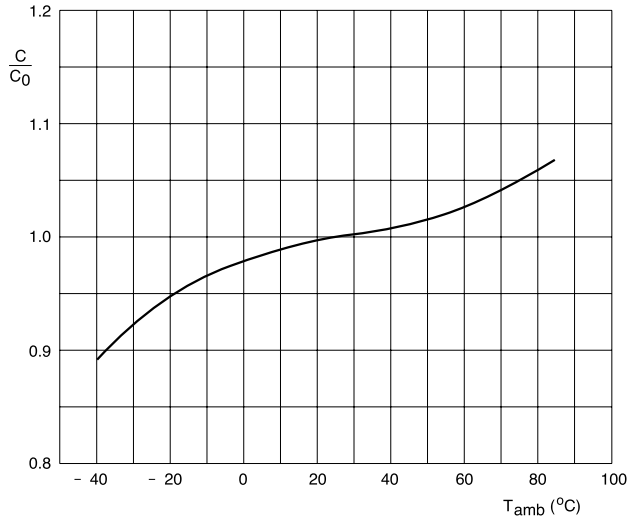
*Note: To ensure delivery of lead (Pb)-free parts during the transition period, please contact your Vishay sales agent.



ELECTRICAL DATA AND ORDERING INFORMATION													
U _R (V)	C _R 100 Hz (μF)	NOMINAL CASE SIZE ∅ D x L (mm)	CASE CODE	I _R 100 Hz 85 °C (mA)	I _{L1} 1 min (μA)	I _{L5} 5 min (μA)	Tan δ 100 Hz	ESR 100 Hz (Ω)	Z 10 kHz (Ω)	CATALOG NUMBER 2222			
										IN BOX FORM AA	TAPED ON REEL FORM BR	TAPED IN BOX FORM BA	MOUNTING RING FORM MR
400	6.8	10 x 30	00	110	220	110	0.055	11.5	7.3	042 16688	042 26688	-	-
	10	12.5 x 30	01	150	240	110	0.055	7.5	4.6	042 16109	042 26109	-	-
	15	15 x 30	02	210	250	110	0.055	5.0	3.1	042 16159	042 26159	-	042 46159
	22	18 x 30	03	290	280	120	0.055	3.5	2.1	042 16229	-	-	042 46229
	33	18 x 38	04	380	320	130	0.055	2.3	1.4	043 16339	-	-	043 46339
	47	18 x 38	04	450	370	140	0.055	1.7	1.1	043 16479	-	-	043 46479
	68	21 x 38	05	560	440	150	0.055	1.2	0.7	043 16689	-	-	043 46689
450	6.8	10 x 30	00	110	230	110	0.10	22	14	042 17688	042 27688	-	-
	10	12.5 x 30	01	150	240	110	0.10	15	10	042 17109	042 27109	-	-
	15	12.5 x 30	01	180	260	110	0.10	10	6	042 17159	042 27159	-	-
	22	15 x 30	02	240	290	120	0.10	6.8	4.1	042 17229	042 27229	-	042 47229
	33	18 x 30	03	350	330	130	0.10	4.5	2.7	042 17339	-	-	042 47339
	47	18 x 38	04	440	390	140	0.10	3.2	2.1	043 17479	-	-	043 47479
	68	21 x 38	05	550	460	160	0.10	2.2	1.4	043 17689	-	-	043 47689

ADDITIONAL ELECTRICAL DATA			
PARAMETER	CONDITIONS	VALUE	
		AXIAL	MOUNTING RING
Voltage			
Surge voltage	U _R = 160 to 250 V	U _s ≤ 1.15 x U _R	
	U _R = 350 to 450 V	U _s ≤ 1.1 x U _R	
Reverse voltage		U _{rev} ≤ 1 V	
Current			
Leakage current	after 1 minute: case ∅ D x L = 6.5 x 18 to 10 x 25 mm: CV ≤ 1000 μC CV > 1000 μC case ∅ D x L = 10 x 30 to 21 x 38 mm: U _R = 160 to 385 V U _R = 400 and 450 V	I _{L1} ≤ 0.05 C _R x U _R or 5 μA, whichever is greater I _{L1} ≤ 0.03 C _R x U _R + 20 μA I _{L1} ≤ 0.009 C _R x U _R + 10 μA I _{L1} ≤ 0.009 C _R x U _R + 200 μA	
	after 5 minutes: U _R = 160 to 385 V: CV ≤ 1000 μC CV > 1000 μC U _R = 400 and 450 V	I _{L5} ≤ 0.01 C _R x U _R or 1 μA, whichever is greater I _{L5} ≤ 0.006 C _R x U _R + 4 μA I _{L5} ≤ 0.002 C _R x U _R + 100 μA	
Inductance			
Equivalent series inductance (ESL)	case ∅ D x L mm:		
	6.5 x 18	typ. 15 nH	-
	8 x 18	typ. 35 nH	-
	10 x 18	typ. 69 nH	-
	10 x 25	typ. 38 nH	-
	10 x 30	typ. 38 nH	-
	12.5 x 30	typ. 46 nH	-
	15 x 30	typ. 48 nH	typ. 39 nH
	18 x 30	typ. 50 nH	typ. 39 nH
	18 x 38	typ. 54 nH	typ. 39 nH
21 x 38	typ. 59 nH	typ. 39 nH	

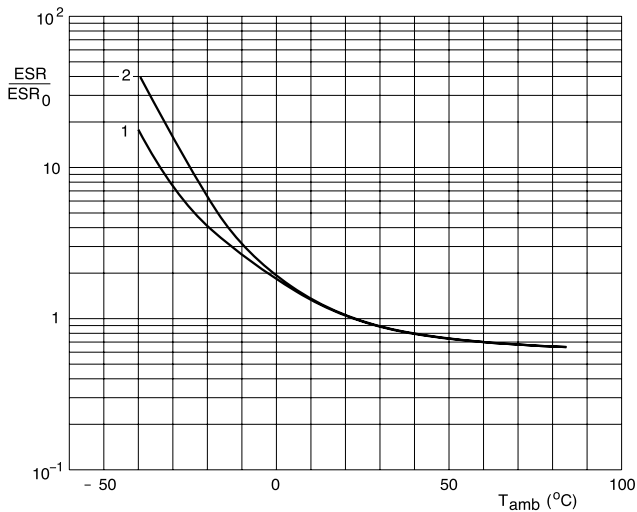
CAPACITANCE (C)



C₀ = capacitance at 20 °C, 100 Hz

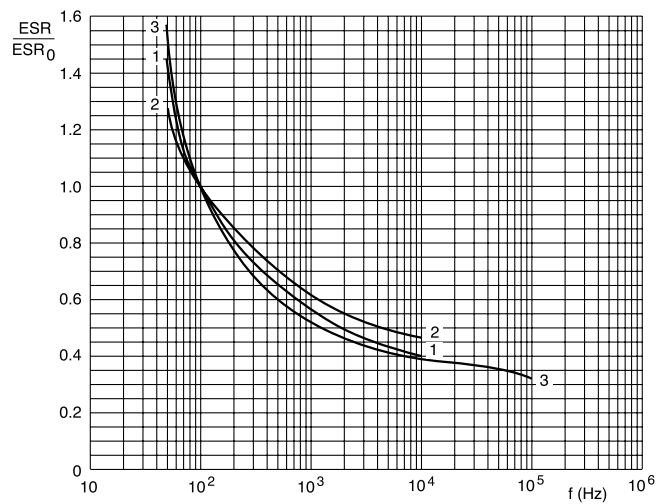
Fig. 5 Typical multiplier of capacitance as a function of ambient temperature

EQUIVALENT SERIES RESISTANCE (ESR)



Curve 1: case Ø D x L = 10 x 30 to 21 x 38 mm
 Curve 2: case Ø D x L = 6.5 x 18 to 10 x 25 mm
 ESR₀ = typical at 20 °C, 100 Hz

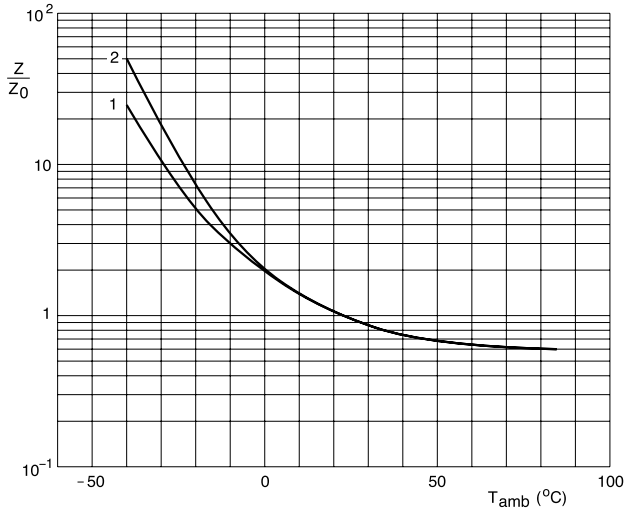
Fig. 6 Typical multiplier of ESR as a function of ambient temperature



Curve 1: case Ø D x L = 10 x 30 mm
 Curve 2: case Ø D x L = 21 x 38 mm
 Curve 3: case Ø D x L = 6.5 x 18 to 10 x 25 mm
 ESR₀ = typical at 20 °C, 100 Hz

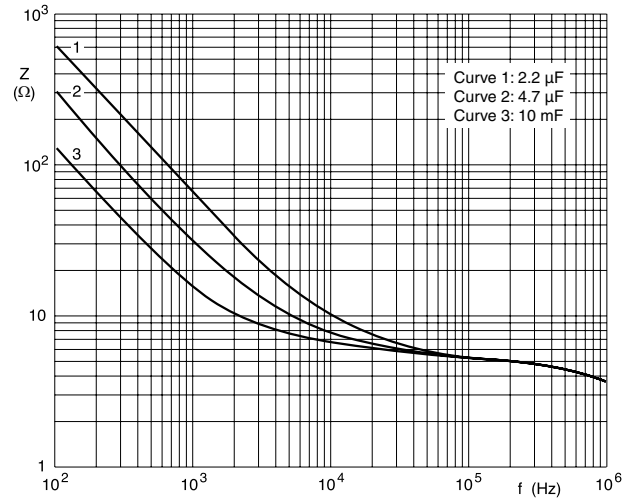
Fig. 7 Typical multiplier of ESR as a function of frequency

IMPEDANCE (Z)



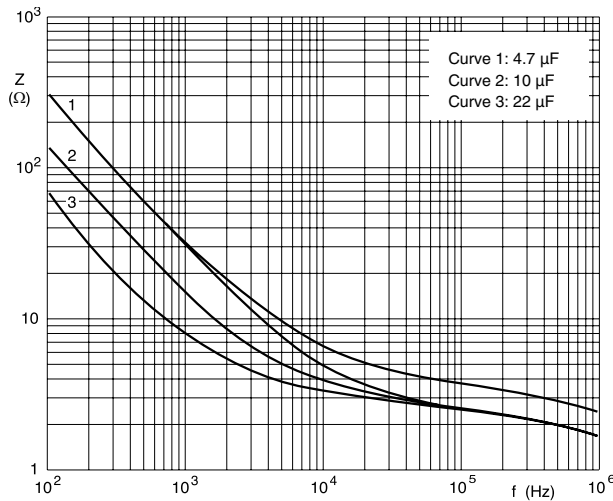
Curve 1: case $\varnothing D \times L = 10 \times 30$ to 21×38 mm
 Curve 2: case $\varnothing D \times L = 6.5 \times 18$ to 10×25 mm
 Z_0 = impedance at 20 °C, 10 kHz

Fig. 8 Typical multiplier of impedance as a function of ambient temperature



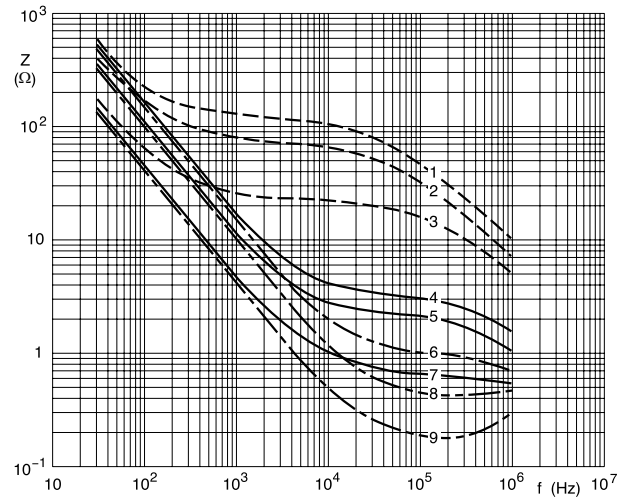
Case $\varnothing D \times L = 8 \times 18$ mm $T_{amb} = 20$ °C

Fig. 9 Typical impedance as a function of frequency



Case $\varnothing D \times L = 10 \times 18$ and 10×25 mm $T_{amb} = 20$ °C

Fig. 10 Typical impedance as a function of frequency

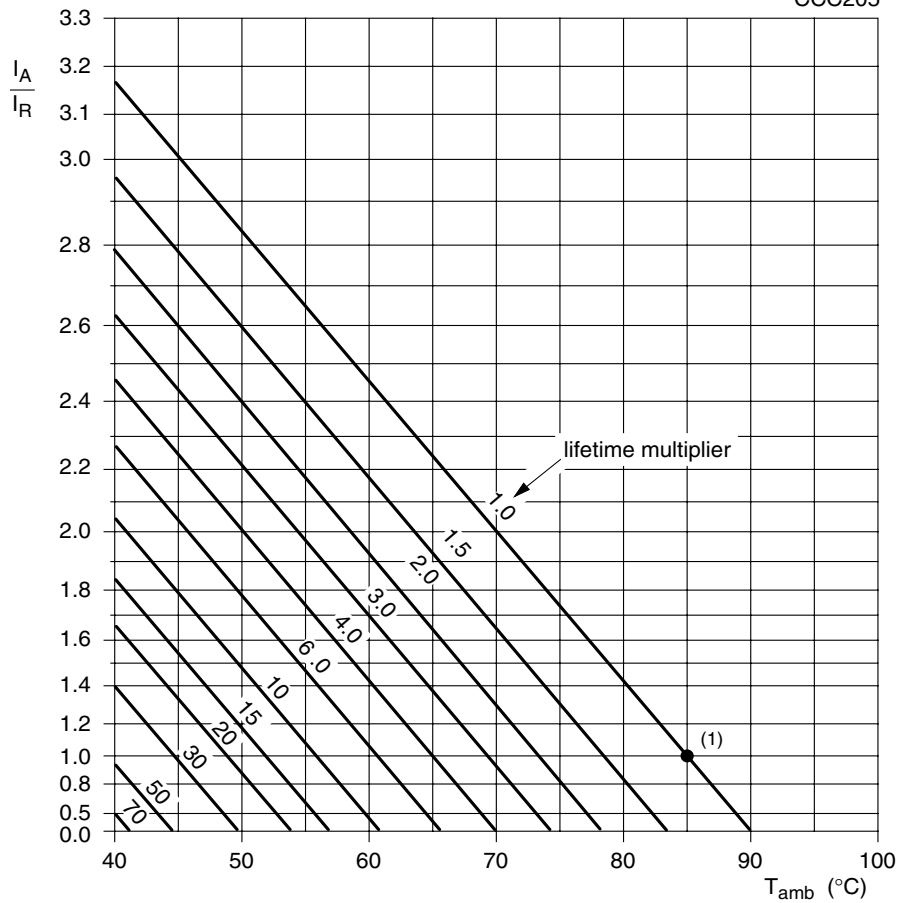


Case $\varnothing D \times L = 12.5 \times 30$ mm
 Curve 1: 10 μ F, 350 and 385 V; - 40 °C
 Curve 2: 15 μ F, 250 V; - 40 °C
 Curve 3: 33 μ F, 160 V; - 40 °C
 Curve 4: 10 μ F, 350 and 385 V; 20 °C
 Curve 5: 15 μ F, 250 V; 20 °C
 Curve 6: 33 μ F, 160 V; 20 °C
 Curve 7: 10 μ F, 350 and 385 V; 85 °C
 Curve 8: 15 μ F, 250 V; 85 °C
 Curve 9: 33 μ F, 160 V; 85 °C

Fig. 11 Typical impedance as a function of frequency at different ambient temperatures

RIPPLE CURRENT AND USEFUL LIFE

CCC205



I_A = actual ripple current at 100 Hz

I_R = rated ripple current at 100 Hz, 85 °C

(1) Useful life at 85 °C and I_R applied;

case $\varnothing D \times L = 6.5 \times 18$ to 10×25 mm: 5000 hours

case $\varnothing D \times L = 10 \times 30$ to 21×38 mm: 15000 hours (450 V: 10000 hours)

Fig. 12 Multiplier of useful life as a function of ambient temperature and ripple current load

Table 4

MULTIPLIER OF RIPPLE CURRENT (I_R) AS A FUNCTION OF FREQUENCY	
FREQUENCY (Hz)	I_R MULTIPLIER
50	0.75
100	1.00
300	1.15
1000	1.30
3000	1.40
$\geq 10\ 000$	1.50



Table 5

TEST PROCEDURES AND REQUIREMENTS			
TEST		PROCEDURE (quick reference)	REQUIREMENTS
NAME OF TEST	REFERENCE		
Endurance	IEC 60384-4/ EN130300 subclause 4.13	T _{amb} = 85 °C; U _R applied; case Ø D x L: 6.5 x 18 to 10 x 25 mm: 2000 hours; 10 x 30 to 21 x 38 mm 8000 hours (450 V: 5000 hours)	U _R = 160 V; ΔC/C: ± 15 % U _R = 250 to 450 V; ΔC/C: ± 10 % tan δ ≤ 1.3 x spec. limit Z ≤ 2 x spec. limit I _{L5} ≤ spec. limit
Useful life	CECC 30301 subclause 1.8.1	T _{amb} = 85 °C; U _R and I _R applied; case Ø D x L: 6.5 x 18 to 10 x 25 mm: 5000 hours; 10 x 30 to 21 x 38 mm: 15 000 hours (450 V: 10 000 hours)	U _R = 160 V; ΔC/C: ± 45 % U _R = 250 to 450 V; ΔC/C: ± 30 % tan δ ≤ 3 x spec. limit Z ≤ 3 x spec. limit I _{L5} ≤ spec. limit no short or open circuit total failure percentage: ≤ 3 %
Shelf life (storage at high temperature)	IEC 60384-4/ EN130300 subclause 4.17	T _{amb} = 85 °C; no voltage applied; 500 hours after test: U _R to be applied for 30 minutes, 24 to 48 hours before measurement	ΔC/C, tan δ, Z: for requirements see 'Endurance test' above I _{L5} ≤ 2 x spec. limit



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