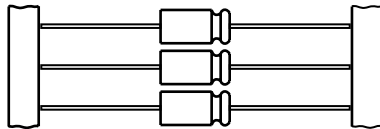
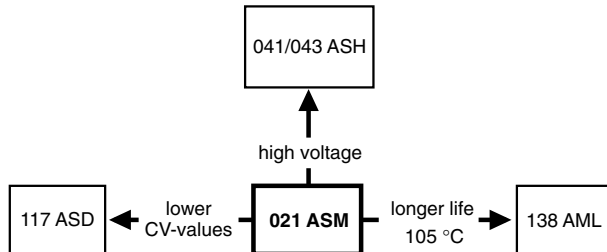


Aluminum Capacitors Axial Standard Miniature


Fig.1 Component outlines


QUICK REFERENCE DATA		
DESCRIPTION	VALUE	
Nominal case sizes (\varnothing D x L in mm)	4.5 x 10 to 10 x 25	10 x 30 to 21 x 38
Rated capacitance range, C_R	0.47 to 15 000 μ F	
Tolerance on C_R	\pm 20 %	
Rated voltage range, U_R	6.3 to 100 V	
Category temperature range	- 40 to + 85 °C	
Endurance test at 85 °C:		
$U_R = 6.3$ to 25 V	1000 hours	5000 hours
$U_R = 40$ to 100 V	2000 hours	5000 hours
Endurance test at 105 °C	-	2000 hours
Useful life at 85 °C	2500 hours	8000 hours
Useful life at 40 °C, 1.4 x I_R applied	70 000 hours	200 000 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	

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
- Charge and discharge proof
- Miniaturized, high CV-product per unit volume
- Lead (Pb)-free versions are RoHS compliant


**RoHS
COMPLIANT**
APPLICATIONS

- General purpose, industrial, automotive, audio-video
- Coupling, decoupling, smoothing, filtering, buffering
- Portable and mobile equipment (small size, low mass)
- Low mounting height boards, vibration and shock resistant

MARKING

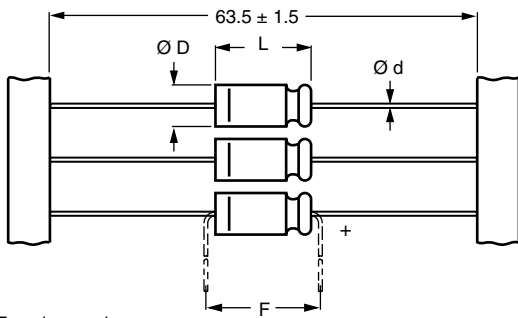
The capacitors are marked (where possible) with the following information:

- Rated capacitance (in μ F)
- Tolerance on rated capacitance, code letter in accordance with IEC 60062 (M for \pm 20 %)
- Rated voltage (in V)
- Upper category temperature (85 °C)
- Date code in accordance with IEC 60062
- Code for factory of origin
- Name of manufacturer
- Band to indicate the negative terminal
- "+" sign to identify the positive terminal (not for case sizes L < 18 mm)
- Series number (021)

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)						
	6.3	10	16	25	40	63	100
0.47	-	-	-	-	-	4.5 x 10	-
1.0	-	-	-	-	-	4.5 x 10	4.5 x 10
2.2	-	-	-	-	-	4.5 x 10	4.5 x 10
3.3	-	-	-	-	-	4.5 x 10	-
4.7	-	-	-	-	-	4.5 x 10	4.5 x 10
10	-	-	-	-	-	4.5 x 10	6 x 10
15	-	-	-	-	-	4.5 x 10	8 x 11
	-	-	-	-	-	-	6.5 x 18
22	-	-	-	-	4.5 x 10	6 x 10	8 x 11
	-	-	-	-	-	-	6.5 x 18
33	-	-	-	-	-	6 x 10	6.5 x 18

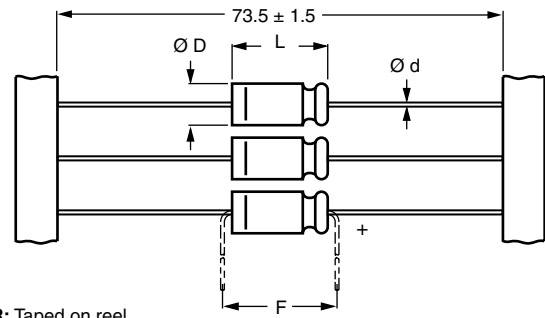
SELECTION CHART FOR C _R , U _R AND RELEVANT NOMINAL CASE SIZES (∅ D x L in mm)							
C _R (μF)	U _R (V)						
	6.3	10	16	25	40	63	100
47	-	-	-	4.5 x 10	6 x 10	8 x 11	8 x 18
68	-	-	4.5 x 10	-	-	8 x 11	10 x 18
100	-	4.5 x 10	-	6 x 10	8 x 11	8 x 18	10 x 25
150	-	-	6 x 10	8 x 11	8 x 18	10 x 18	12.5 x 30
220	-	6 x 10	8 x 11	6.5 x 18	10 x 18	10 x 25	12.5 x 30
330	-	8 x 11	6.5 x 18	8 x 18	10 x 25	12.5 x 30	15 x 30
470	8 x 11	6.5 x 18	8 x 18	10 x 18	10 x 25	12.5 x 30	18 x 30
680	-	8 x 18	10 x 18	10 x 25	12.5 x 30	15 x 30	18 x 38
1000	8 x 18	10 x 18	10 x 25	12.5 x 30	12.5 x 30	18 x 30	21 x 38
1500	-	10 x 25	12.5 x 30	12.5 x 30	15 x 30	18 x 38	-
2200	10 x 25	12.5 x 30	12.5 x 30	15 x 30	18 x 30	21 x 38	-
3300	-	12.5 x 30	15 x 30	18 x 30	18 x 38	-	-
4700	-	15 x 30	18 x 30	18 x 38	21 x 38	-	-
6800	-	18 x 30	18 x 38	21 x 38	-	-	-
10 000	-	18 x 38	21 x 38	-	-	-	-
15 000	-	21 x 38	-	-	-	-	-

DIMENSIONS in millimeters **AND AVAILABLE FORMS**



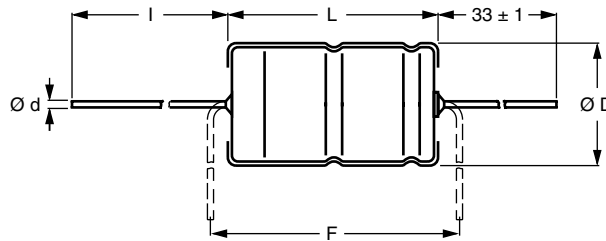
Form BR: Taped on reel
Form BA: Taped in box (ammopack)
Case ∅ D x L = 4.5 x 10 to 8 x 11 mm

Fig.2 Forms BA and BR



Form BR: Taped on reel
Case ∅ D x L = 6.5 x 18 to 15 x 30 mm
Form BA: Taped in box (ammopack)
Case ∅ D x L = 6.5 x 18 to 10 x 25 mm

Fig.3 Forms BA and BR



Form AA: Axial in box
Case ∅ D x L = 10 x 30 to 21 x 38 mm

Fig.4 Form AA

Table 1

AXIAL; DIMENSIONS in millimeters, MASS AND PACKAGING QUANTITIES										
NOMINAL CASE SIZE Ø D x L	CASE CODE	AXIAL: FORM AA, BA, and BR					MASS (g)	PACKAGING QUANTITIES		
		Ø d	l	Ø D _{max.}	L _{max.}	F _{min.}		FORM AA	FORM BA	FORM BR
4.5 x 10	2	0.6	-	5.0	10.5	15	≈ 0.50	-	1000	3000
6 x 10	3	0.6	-	6.3	10.5	15	≈ 0.70	-	1000	1000
8 x 11	5a	0.6	-	8.5	11.5	15	≈ 1.1	-	500	500
6.5 x 18	4	0.8	-	6.9	18.5	25	≈ 1.3	-	1000	1000
8 x 18	5	0.8	-	8.5	18.5	25	≈ 1.7	-	500	500
10 x 18	6	0.8	-	10.5	18.5	25	≈ 2.5	-	500	500
10 x 25	7	0.8	-	10.5	25.5	30	≈ 3.3	-	500	500
10 x 30	00	0.8	55 ± 1	10.5	30.5	35	≈ 4.8	340	-	500
12.5 x 30	01	0.8	55 ± 1	13.0	30.5	35	≈ 7.4	260	-	400
15 x 30	02	0.8	55 ± 1	15.5	30.5	35	≈ 11.7	200	-	250
18 x 30	03	0.8	55 ± 1	18.5	30.5	35	≈ 12.9	120	-	-
18 x 38	04	0.8	34 ± 1	18.5	39.5	44	≈ 19.0	125	-	-
21 x 38	05	0.8	34 ± 1	21.5	39.5	44	≈ 24.0	100	-	-

Note

- Detailed tape dimensions see section "PACKAGING".

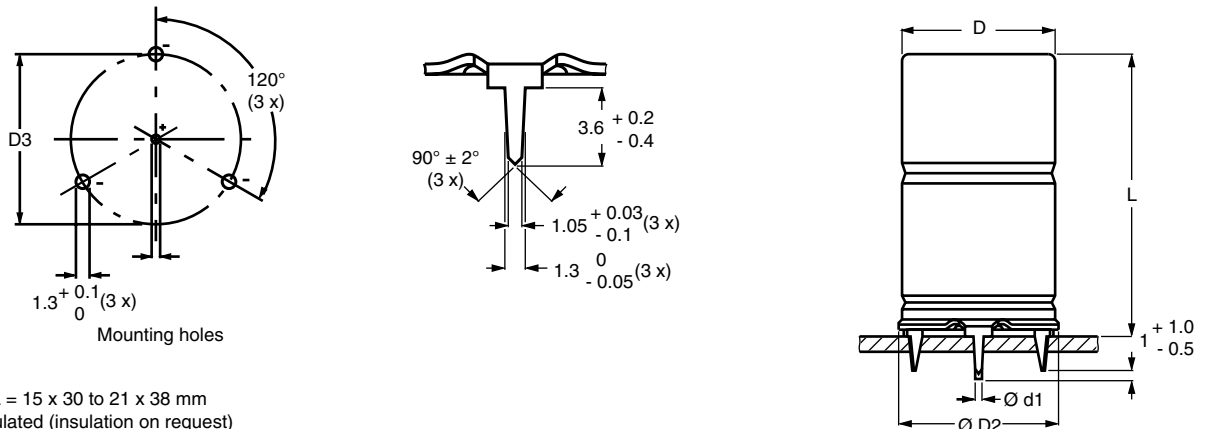

Fig.5 Mounting hole diagram and outline. **Form MR:** with mounting ring and pins

Table 2

MOUNTING RING; DIMENSIONS in millimeters, MASS AND PACKAGING QUANTITIES								
NOMINAL CASE SIZE Ø D x L	CASE CODE	MOUNTING RING: FORM MR					MASS (g)	PACKAGING QUANTITIES
		Ø d1	Ø d2	Ø D2 _{max.}	D3	L _{max.}		
15 x 30	02	0.8	1.0 + 0.4	17.5	16.5 ± 0.2	33	≈ 11.7	200
18 x 30	03	0.8	1.0 + 0.4	19.5	18.5 ± 0.2	33	≈ 12.9	240
18 x 38	04	0.8	1.0 + 0.4	19.5	18.5 ± 0.2	42	≈ 19.0	100
21 x 38	05	0.8	1.0 + 0.4	22.5	21.5 ± 0.2	42	≈ 24.0	100



ELECTRICAL DATA	
SYMBOL	DESCRIPTION
C _R	rated capacitance at 100 Hz, tolerance ± 20 %
I _R	rated RMS ripple current at 100 Hz, 85 °C
I _{L5}	max. leakage current after 5 min 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

ORDERING EXAMPLE

Electrolytic capacitor 021 series

1000 µF/16 V; ± 20 %

Nominal case size: Ø 10 x 25 mm; Form BA

Ordering code: MAL202190518E3

Former 12NC: 2222 021 90518

Note

1. Unless otherwise specified, all electrical values in Table 3 apply at T_{amb} = 20 °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 Ø D x L (mm)	I _R 100 Hz 85 °C (mA)	I _{L5} 5 min (µA)	tanδ 100 Hz	ESR 100 Hz (Ω)	Z 10 kHz (Ω)	ORDERING CODE MAL2021				
								IN BOX FORM AA	TAPED ON REEL FORM BR	TAPED IN BOX FORM BA	MOUNTING RING FORM MR	
6.3	470	8 x 11	260	10	0.25	0.85	0.64	-	23471E3	33471E3	-	
	1000	8 x 18	440	17	0.25	0.4	0.5	-	23102E3	33102E3	-	
	2200	10 x 25	710	32	0.29	0.21	0.16	-	90588E3	90589E3	-	
10	100	4.5 x 10	100	6	0.20	3.2	2.0	-	24101E3	34101E3	-	
	220	6 x 10	160	8.4	0.20	1.5	0.91	-	24221E3	34221E3	-	
	330	8 x 11	230	11	0.20	1.0	0.61	-	24331E3	34331E3	-	
	470	6.5 x 18	310	13	0.20	0.68	0.43	-	24471E3	34471E3	-	
	680	8 x 18	400	18	0.20	0.47	0.29	-	24681E3	34681E3	-	
	1000	10 x 18	550	24	0.20	0.32	0.20	-	24102E3	34102E3	-	
	1500	10 x 25	690	34	0.23	0.25	0.18	-	90524E3	90525E3	-	
	1500	10 x 30	740	34	0.23	0.245	0.18	14152E3	24152E3	-	-	
	2200	12.5 x 30	980	48	0.25	0.177	0.095	14222E3	24222E3	-	-	
	3300	12.5 x 30	1090	70	0.27	0.128	0.095	14332E3	24332E3	-	-	
	4700	15 x 30	1320	98	0.29	0.100	0.07	14472E3	24472E3	-	44472E3	
	6800	18 x 30	1590	140	0.34	0.079	0.065	14682E3	-	-	44682E3	
	10 000	18 x 38	2090	204	0.40	0.064	0.04	14103E3	-	-	44103E3	
	15 000	21 x 38	2250	304	0.50	0.054	0.035	14153E3	-	-	44153E3	
16	68	4.5 x 10	90	6.2	0.16	3.8	2.4	-	25689E3	35689E3	-	
	150	6 x 10	140	8.8	0.16	1.7	1.1	-	25151E3	35151E3	-	
	220	8 x 11	210	11	0.16	1.2	0.73	-	25221E3	35221E3	-	
	330	6.5 x 18	290	15	0.16	0.77	0.48	-	25331E3	35331E3	-	
	470	8 x 18	380	19	0.16	0.55	0.34	-	25471E3	35471E3	-	
	680	10 x 18	500	26	0.16	0.38	0.24	-	25681E3	35681E3	-	
	1000	10 x 25	660	36	0.16	0.26	0.18	-	90517E3	90518E3	-	
	1000	10 x 30	700	36	0.16	0.260	0.175	15102E3	25102E3	-	-	
	1500	12.5 x 30	950	52	0.19	0.205	0.095	15152E3	25152E3	-	-	
	2200	12.5 x 30	1040	74	0.21	0.150	0.095	15222E3	25222E3	-	-	
	3300	15 x 30	1290	110	0.23	0.111	0.07	15332E3	25332E3	-	45332E3	
	4700	18 x 30	1560	154	0.25	0.087	0.065	15472E3	-	-	45472E3	
	6800	18 x 38	2040	222	0.30	0.070	0.04	15682E3	-	-	45682E3	
	10 000	21 x 38	2170	324	0.36	0.058	0.035	15103E3	-	-	45103E3	
25	47	4.5 x 10	80	6.4	0.14	4.8	2.6	-	26479E3	36479E3	-	
	100	6 x 10	150	9	0.14	2.3	1.2	-	26101E3	36101E3	-	
	150	8 x 11	190	12	0.14	1.5	0.80	-	90534E3	90535E3	-	
	150	6.5 x 18	210	12	0.14	1.5	0.80	-	26151E3	36151E3	-	
	220	6.5 x 18	250	15	0.14	1.0	0.55	-	26221E3	36221E3	-	
	330	8 x 18	340	21	0.14	0.68	0.36	-	26331E3	36331E3	-	
	470	10 x 18	450	28	0.14	0.48	0.26	-	26471E3	36471E3	-	
	680	10 x 25	560	38	0.14	0.33	0.18	-	90527E3	90528E3	-	
	680	10 x 30	640	38	0.14	0.323	0.175	16681E3	26681E3	-	-	
	1000	12.5 x 30	840	54	0.14	0.220	0.095	16102E3	26102E3	-	-	
	1500	12.5 x 30	950	79	0.17	0.179	0.095	16152E3	26152E3	-	-	



ELECTRICAL DATA AND ORDERING INFORMATION											
U _R (V)	C _R 100 Hz (μF)	NOMINAL CASE SIZE Ø D x L (mm)	I _R 100 Hz 85 °C (mA)	I _{L5} 5 min (μA)	tanδ 100 Hz	ESR 100 Hz (Ω)	Z 10 kHz (Ω)	ORDERING CODE MAL2021			
								IN BOX FORM AA	TAPED ON REEL FORM BR	TAPED IN BOX FORM BA	MOUNTING RING FORM MR
25	2200	15 x 30	1180	114	0.19	0.132	0.07	16222E3	26222E3	-	46222E3
	3300	18 x 30	1470	169	0.21	0.099	0.065	16332E3	-	-	46332E3
	4700	18 x 38	1920	239	0.23	0.079	0.04	90062E3	-	-	46472E3
	6800	21 x 38	2070	344	0.28	0.064	0.035	16682E3	-	-	46682E3
40	22	4.5 x 10	60	5.8	0.11	8.0	3.2	-	27229E3	37229E3	-
	47	6 x 10	110	7.8	0.11	3.8	1.5	-	27479E3	37479E3	-
	100	8 x 11	170	12	0.11	1.8	0.70	-	90537E3	90538E3	-
	100	6.5 x 18	190	12	0.11	1.8	0.70	-	27101E3	37101E3	-
	150	8 x 18	250	16	0.11	1.1	0.47	-	27151E3	37151E3	-
	220	10 x 18	330	22	0.11	0.8	0.32	-	27221E3	37221E3	-
	330	10 x 25	430	30	0.11	0.53	0.21	-	27331E3	37331E3	-
	470	10 x 25	520	42	0.11	0.37	0.18	-	90514E3	90515E3	-
	470	10 x 30	590	42	0.12	0.404	0.175	17471E3	27471E3	-	-
	680	12.5 x 30	800	58	0.12	0.297	0.110	17681E3	27681E3	-	-
	1000	12.5 x 30	900	84	0.12	0.190	0.110	17102E3	90064E3	-	-
	1500	15 x 30	1120	124	0.15	0.159	0.07	17152E3	27152E3	-	47152E3
	2200	18 x 30	1390	180	0.17	0.118	0.065	17222E3	-	-	47222E3
	3300	18 x 38	1810	268	0.19	0.090	0.04	17332E3	-	-	47332E3
4700	21 x 38	1940	380	0.21	0.072	0.035	17472E3	-	-	47472E3	
63	0.47	4.5 x 10	8	4.1	0.09	310	120	-	28477E3	38477E3	-
	1	4.5 x 10	12	4.1	0.09	150	55	-	28108E3	38108E3	-
	2.2	4.5 x 10	21	4.3	0.09	65	25	-	28228E3	38228E3	-
	3.3	4.5 x 10	25	4.4	0.09	44	17	-	28338E3	38338E3	-
	4.7	4.5 x 10	31	4.6	0.09	31	12	-	28478E3	38478E3	-
	10	4.5 x 10	50	5.3	0.08	13	5.5	-	28109E3	38109E3	-
	15	4.5 x 10	55	5.9	0.08	8.5	3.7	-	28159E3	38159E3	-
	22	6 x 10	90	6.8	0.08	5.8	2.5	-	28229E3	38229E3	-
	33	6 x 10	100	8.2	0.08	3.9	1.7	-	28339E3	38339E3	-
	47	8 x 11	140	10	0.08	2.7	1.2	-	90541E3	90542E3	-
	47	6.5 x 18	150	10	0.08	2.7	1.2	-	28479E3	38479E3	-
	68	8 x 11	160	13	0.08	1.9	0.81	-	90544E3	90545E3	-
	68	6.5 x 18	170	13	0.08	1.9	0.81	-	28689E3	38689E3	-
	100	8 x 18	250	17	0.08	1.3	0.55	-	28101E3	38101E3	-
	150	10 x 18	320	23	0.08	0.85	0.37	-	28151E3	38151E3	-
	220	10 x 25	430	32	0.08	0.60	0.25	-	90511E3	90512E3	-
	220	10 x 30	480	32	0.08	0.614	0.26	18221E3	28221E3	-	-
	330	12.5 x 30	610	46	0.08	0.409	0.19	18331E3	28331E3	-	-
	470	12.5 x 30	700	63	0.08	0.287	0.13	18471E3	28471E3	-	-
	680	15 x 30	890	90	0.08	0.199	0.095	18681E3	28681E3	-	48681E3
1000	18 x 30	1170	130	0.08	0.135	0.075	18102E3	-	-	48102E3	
1500	18 x 38	1530	193	0.11	0.122	0.045	18152E3	-	-	48152E3	
2200	21 x 38	1780	281	0.13	0.099	0.040	18222E3	-	-	48222E3	
100	1	4.5 x 10	14	4.2	0.08	130	90	-	29108E3	39108E3	-
	2.2	4.5 x 10	20	4.4	0.08	58	41	-	29228E3	39228E3	-
	4.7	4.5 x 10	30	4.9	0.08	27	19	-	29478E3	39478E3	-
	10	6 x 10	65	6	0.08	13	9	-	29109E3	39109E3	-
	15	8 x 11	77	7	0.08	8.5	6	-	90547E3	90548E3	-
	15	6.5 x 18	85	7	0.08	8.5	6	-	29159E3	39159E3	-
	22	8 x 11	95	8.4	0.08	5.8	4.1	-	90551E3	90552E3	-
	22	6.5 x 18	100	8.4	0.08	5.8	4.1	-	29229E3	39229E3	-
	33	6.5 x 18	120	10.6	0.08	3.9	2.7	-	29339E3	39339E3	-
	47	8 x 18	160	13.4	0.08	2.7	1.9	-	29479E3	39479E3	-
	68	10 x 18	220	17.6	0.08	1.9	1.3	-	29689E3	39689E3	-
	100	10 x 25	300	24	0.08	1.3	0.9	-	90531E3	90532E3	-
	100	10 x 30	340	24	0.07	1.150	1.0	19101E3	29101E3	-	-
	150	12.5 x 30	490	34	0.07	0.645	0.61	19151E3	29151E3	-	-
	220	12.5 x 30	560	48	0.08	0.610	0.56	19221E3	29221E3	-	-
	330	15 x 30	740	70	0.09	0.420	0.40	19331E3	29331E3	-	49331E3
	470	18 x 30	980	98	0.09	0.310	0.29	19471E3	-	-	49471E3
	680	18 x 38	1260	140	0.09	0.195	0.18	19681E3	-	-	49681E3
1000	21 x 38	1470	204	0.10	0.160	0.15	19102E3	-	-	49102E3	

ADDITIONAL ELECTRICAL DATA			
PARAMETER	CONDITIONS	VALUE	
		AXIAL	MOUNTING RING
Voltage			
Surge voltage		$U_s \leq 1.15 \times U_R$	
Reverse voltage		$U_{rev} \leq 1 \text{ V}$	
Current			
Leakage current	after 1 min at U_R	$I_{L1} \leq 0.006 C_R \times U_R + 4 \mu\text{A}$	
	after 5 min at U_R	$I_{L5} \leq 0.002 C_R \times U_R + 4 \mu\text{A}$	
Inductance			
Equivalent series inductance (ESL)	case $\varnothing D \times L$ mm:		
	4.5 x 10	typ. 10 nH	-
	6 x 10	typ. 22 nH	-
	8 x 11	typ. 85 nH	-
	6.5 x 18	typ. 25 nH	-
	8 x 18	typ. 40 nH	-
	10 x 18	typ. 61 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

RIPPLE CURRENT AND USEFUL LIFE

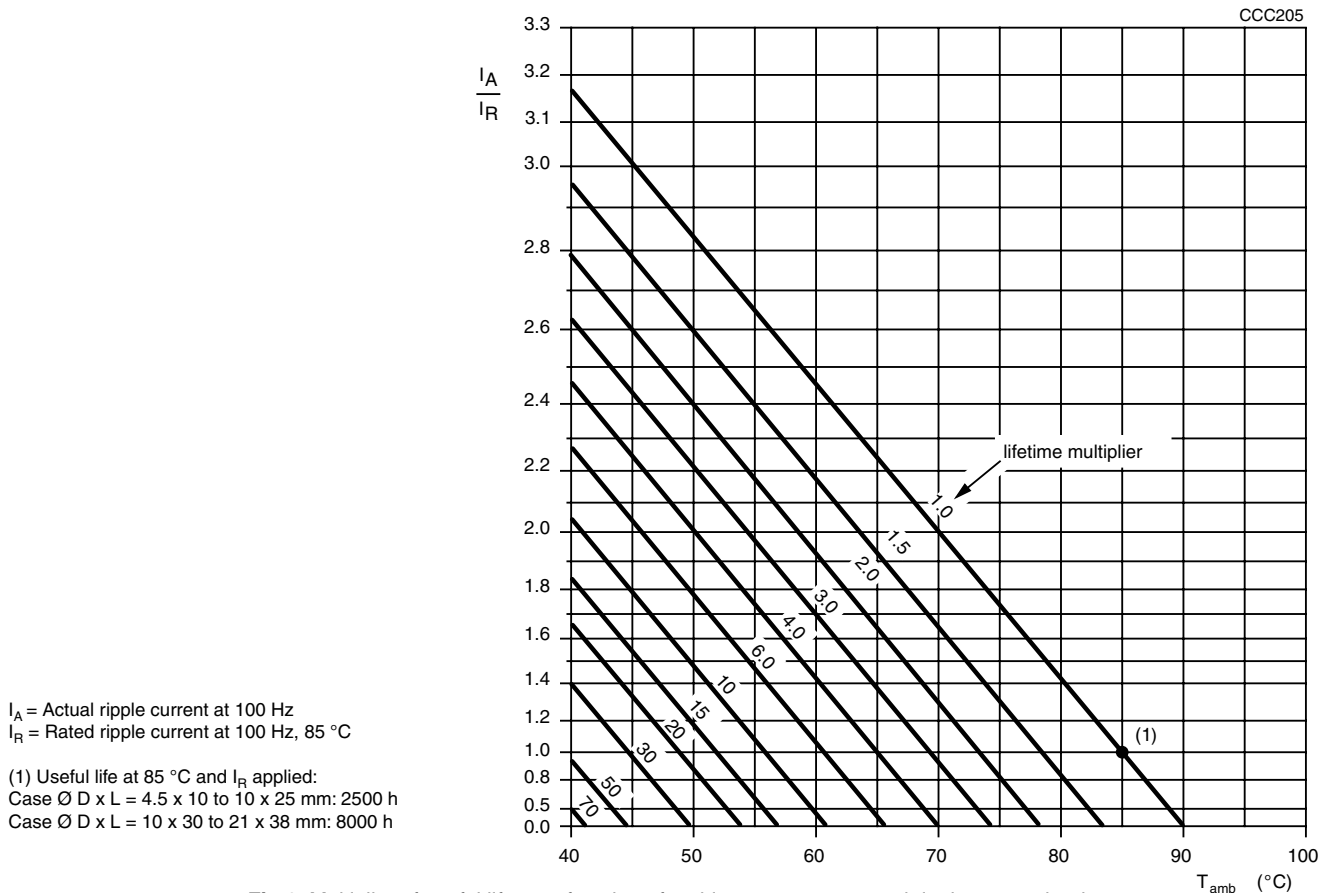


Fig.6 Multiplier of useful life as a function of ambient temperature and ripple current load

Table 4

MULTIPLIER OF RIPPLE CURRENT (I_R) AS A FUNCTION OF FREQUENCY			
FREQUENCY (Hz)	I_R MULTIPLIER		
	$U_R = 6.3$ to 16 V	$U_R = 25$ to 40 V	$U_R = 63$ to 100 V
50	0.95	0.90	0.85
100	1.00	1.00	1.00
300	1.07	1.12	1.20
1000	1.12	1.20	1.30
3000	1.15	1.25	1.35
$\geq 10\ 000$	1.20	1.30	1.40

Table 5

TEST PROCEDURES AND REQUIREMENTS			
TEST		PROCEDURE (quick reference)	REQUIREMENTS
NAME OF TEST	REFERENCE		
Endurance	IEC 60384-4/ EN130300 subclause 4.13	$T_{amb} = 85\ ^\circ\text{C}$; U_R applied; case $\varnothing D \times L = 4.5 \times 10$ to 10×25 mm: $U_R = 6.3$ to 25 V: 1000 h; $U_R = 40$ to 100 V: 2000 h; case $\varnothing D \times L = 10 \times 30$ to 21×38 mm: $U_R = 6.3$ to 100 V: 5000 h	$U_R \leq 6.3$ V; $\Delta C/C$: + 15/- 30 % $U_R > 6.3$ V; $\Delta C/C$: ± 15 % $\tan \delta \leq 1.3 \times$ spec. limit $Z \leq 2 \times$ spec. limit $I_{L5} \leq$ spec. limit
		$T_{amb} = 105\ ^\circ\text{C}$; U_R applied; case $\varnothing D \times L = 10 \times 30$ to 21×38 mm: 2000 h	$\Delta C/C$: $\leq \pm 20$ % $\tan \delta \leq 1.6 \times$ spec. limit $Z \leq 2 \times$ spec. limit $I_{L5} \leq$ spec. limit
Useful life	CECC 30301 subclause 1.8.1	$T_{amb} = 85\ ^\circ\text{C}$; U_R and I_R applied; case $\varnothing D \times L = 4.5 \times 10$ to 10×25 mm: 2500 h; case $\varnothing D \times L = 10 \times 30$ to 21×38 mm: 8000 h	$U_R \leq 6.3$ V; $\Delta C/C$: + 45/- 50 % $U_R > 6.3$ V; $\Delta C/C$: ± 45 % $\tan \delta \leq 3 \times$ spec. limit $Z \leq 3 \times$ spec. limit $I_{L5} \leq$ spec. limit no short or open circuit total failure percentage: ≤ 1 %
Shelf life (storage at high temperature)	IEC 60384-4/ EN130300 subclause 4.17	$T_{amb} = 85\ ^\circ\text{C}$; no voltage applied; 500 h after test: U_R to be applied for 30 min, 24 to 48 h before measurement	$\Delta C/C$, $\tan \delta$, Z : for requirements see 'Endurance test' above $I_{L5} \leq 2 \times$ spec. limit



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