Aluminum Capacitors
Axial Standard

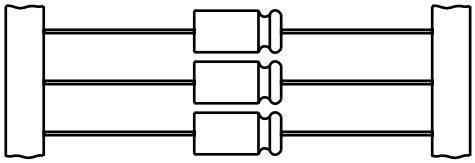
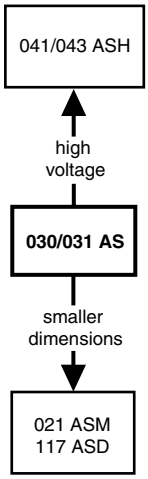


Fig.1 Component outlines



FEATURES

- Polarized aluminum electrolytic capacitors, non-solid electrolyte
- Axial leads, cylindrical aluminum case, insulated with a blue sleeve
- Taped version available for automatic insertion
- Charge and discharge proof
- Useful life: 3000 hours at 85 °C (case Ø D = 3.3 mm: 1500 hours)
- Standard dimensions
- Lead (Pb)-free versions are RoHS compliant

Pb-free
RoHS COMPLIANT

APPLICATIONS

- General purpose and industrial, automotive, telecommunication, audio-video
- Coupling, decoupling, timing, smoothing, filtering, buffering in SMPS
- Boards with restricted mounting height, vibration and shock resistant

MARKING

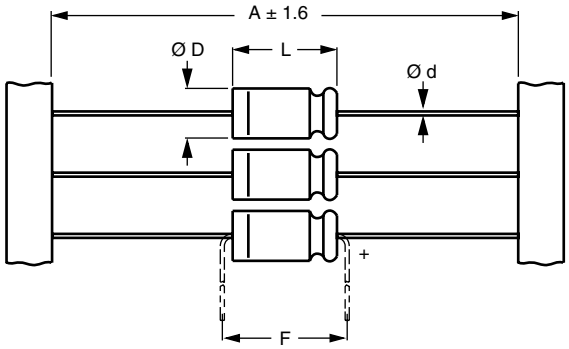
The capacitors are marked (where possible) with the following information:

- Rated capacitance (in µF)
- Tolerance on rated capacitance, code letter in accordance with IEC 60062 (T for - 10 to + 50 %)
- Rated voltage (in V)
- Date code in accordance with IEC 60062
- Code 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 (030 or 031)

QUICK REFERENCE DATA		
DESCRIPTION	**VALUE**	
Nominal case sizes (Ø D x L in mm)	3.3 x 11	4.5 x 10 to 10 x 25
Rated capacitance range, C_R	0.47 to 1000 µF	
Tolerance on C_R	- 10 to + 50 %	
Rated voltage, U_R	6.3 to 100 V	
Category temperature range	- 40 to + 85 °C	
Endurance test at 85 °C	1000 hours	2000 hours
Useful life at 85 °C	1500 hours	3000 hours
Useful life at 40 °C, 1.4 x I_R applied	40 000 hours	80 000 hours
Shelf life at 0 V, 85 °C	500 hours	
Based on sectional specification	IEC 60384-4/EN130300	
Climatic category IEC 60068	40/085/56	

SELECTION CHART FOR C_R, U_R AND RELEVANT NOMINAL CASE SIZES (Ø D x L in mm)							
C_R (µF)	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
	-	-	-	-	-	3.3 x 11	-
2.2	-	-	-	-	3.3 x 11	4.5 x 10	4.5 x 10
3.3	-	-	-	-	-	4.5 x 10	4.5 x 10
4.7	-	-	3.3 x 11	-	-	4.5 x 10	6 x 10
6.8	-	-	-	-	-	4.5 x 10	6 x 10
10	3.3 x 11	-	-	4.5 x 10	4.5 x 10	6 x 10	8 x 11
	-	-	-	-	-	-	6.5 x 18
15	-	-	-	-	4.5 x 10	6 x 10	-
22	-	-	-	4.5 x 10	6 x 10	8 x 11	8 x 18
	-	-	-	-	-	6.5 x 18	-
33	-	-	4.5 x 10	-	6 x 10	-	10 x 18
47	-	4.5 x 10	-	6 x 10	8 x 11	8 x 18	10 x 25
	-	-	-	-	6.5 x 18	-	-
68	4.5 x 10	-	6 x 10	-	-	10 x 18	-
100	-	6 x 10	-	8 x 11	8 x 18	10 x 25	-
	-	-	-	6.5 x 18	-	-	-
150	6 x 10	-	8 x 11	8 x 18	10 x 18	-	-
	-	-	6.5 x 18	-	-	-	-
220	-	8 x 11	8 x 18	10 x 18	10 x 25	-	-
	-	6.5 x 18	-	-	-	-	-
330	-	8 x 18	10 x 18	10 x 25	-	-	-
470	8 x 18	10 x 18	10 x 25	-	-	-	-
680	10 x 18	10 x 25	-	-	-	-	-
1000	10 x 25	-	-	-	-	-	-

DIMENSIONS in millimeters **AND AVAILABLE FORMS**



Dimensional outline

Fig.2 **Form BR:** Taped on reel, non-preferred

Table 1

AXIAL; DIMENSIONS in millimeters, **MASS AND PACKAGING QUANTITIES**									
NOMINAL CASE SIZE Ø D x L	**CASE CODE**	**AXIAL FORM BA and BR**					**MASS (g)**	**PACKAGING QUANTITIES**	
		Ø d	**A**	**Ø $D_{max.}$**	**$L_{max.}$**	**$F_{min.}$**		**FORM BA**	**FORM BR**
3.3 x 11	1	0.6	63.5 ± 1.5	3.5	12	17.5	≈ 0.35	1000	4000
4.5 x 10	2	0.6	63.5 ± 1.5	5.0	10.5	15	≈ 0.5	1000	3000
6 x 10	3	0.6	63.5 ± 1.5	6.3	10.5	15	≈ 0.7	1000	1000
8 x 11	5a	0.6	63.5 ± 1.5	8.5	11.5	15	≈ 1.1	500	500
6.5 x 18	4	0.8	73 ± 1.6	6.9	18.5	25	≈ 1.3	1000	1000
8 x 18	5	0.8	73 ± 1.6	8.5	18.5	25	≈ 1.7	500	500
10 x 18	6	0.8	73 ± 1.6	10.5	18.5	25	≈ 2.5	500	500
10 x 25	7	0.8	73 ± 1.6	10.5	25.0	30	≈ 3.3	500	500

Note

Detailed tape dimensions see section ‘PACKAGING’.

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 $\delta_{max.}$ and C_R)
Z	max. impedance at 10 kHz

Note

Unless otherwise specified, all electrical values in Table 2 apply at T_{amb} = 20 °C, P = 86 to 106 kPa, RH = 45 to 75 %.

ORDERING EXAMPLE

Electrolytic capacitor 031 series

330 µF/10 V; - 10/+ 50 %

Nominal case size: Ø 8 x 18 mm; Form BA

Ordering code: MAL203134331E3
Former 12 NC: 2222 031 34331

Table 2

ELECTRICAL DATA AND ORDERING INFORMATION

U_R (V)	C_R 100 Hz (µF)	NOMINAL CASE SIZE Ø 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)	ORDERING CODE MAL2.....	
										TAPED ON REEL FORM BR	TAPED IN BOX FORM BA
6.3	10	3.3 x 11	1	15	5	5.1	0.30	47.8	20	03023109E3	03033109E3
	68	4.5 x 10	2	75	22	5.9	0.25	5.86	2.9	03023689E3	03033689E3
	150	6 x 10	3	120	10	6.9	0.25	2.66	1.3	03023151E3	03033151E3
	470	8 x 18	5	330	22	11	0.25	0.85	0.43	03123471E3	03133471E3
	680	10 x 18	6	430	30	14	0.25	0.59	0.29	03123681E3	03133681E3
	1000	10 x 25	7	560	42	18	0.25	0.40	0.20	03123102E3	03133102E3
10	47	4.5 x 10	2	70	24	5.9	0.20	6.78	3.4	03024479E3	03034479E3
	100	6 x 10	3	110	10	7.0	0.20	3.19	1.6	03024101E3	03034101E3
	220	8 x 11	5a	210	18	9.4	0.20	1.45	0.73	03124221E3	03034221E3
	220	6.5 x 18	4	210	18	9.4	0.20	1.45	0.73	03124221E3	03134221E3
	330	8 x 18	5	310	24	12	0.20	0.97	0.48	03124331E3	03134331E3
	470	10 x 18	6	410	33	14	0.20	0.68	0.34	03124471E3	03134471E3
	680	10 x 25	7	510	45	19	0.20	0.47	0.24	03124681E3	03134681E3
16	4.7	3.3 x 11	1	15	5	5.1	0.20	67.8	26	03025478E3	03035478E3
	33	4.5 x 10	2	65	27	6.1	0.16	7.72	3.6	03025339E3	03035339E3
	68	6 x 10	3	110	11	7.2	0.16	3.75	1.8	03025689E3	03035689E3
	150	8 x 11	5a	200	19	9.8	0.16	1.70	0.80	03025151E3	03035151E3
	150	6.5 x 18	4	200	19	9.8	0.16	1.70	0.80	03125151E3	03135151E3
	220	8 x 18	5	270	26	12	0.16	1.16	0.55	03125221E3	03135221E3
	330	10 x 18	6	410	36	16	0.16	0.78	0.36	03125331E3	03135331E3
	470	10 x 25	7	480	49	20	0.16	0.55	0.26	03125471E3	03135471E3
25	10	4.5 x 10	2	50	13	5.5	0.14	22.3	9	03026109E3	03036109E3
	22	4.5 x 10	2	60	28	6.1	0.14	10.2	4.1	03026229E3	03036229E3
	47	6 x 10	3	100	12	7.4	0.14	4.8	1.9	03026479E3	03036479E3
	100	8 x 11	5a	160	19	10	0.14	2.23	0.90	03026101E3	03036101E3
	100	6.5 x 18	4	160	19	10	0.14	2.23	0.90	03126101E3	03136101E3
	150	8 x 18	5	240	27	13	0.14	1.49	0.60	03126151E3	03136151E3
	220	10 x 18	6	350	37	16	0.14	1.02	0.41	03126221E3	03136221E3
	330	10 x 25	7	460	54	22	0.14	0.68	0.27	03126331E3	03136331E3

ELECTRICAL DATA AND ORDERING INFORMATION

U_R (V)	C_R 100 Hz (µF)	NOMINAL CASE SIZE Ø 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)	ORDERING CODE MAL2.....	
										TAPED ON REEL FORM BR	TAPED IN BOX FORM BA
40	2.2	3.3 x 11	1	15	5	5.1	0.15	109	32	03027228E3	03037228E3
	10	4.5 x 10	2	50	20	5.8	0.11	17.6	7	03027109E3	03037109E3
	15	4.5 x 10	2	55	30	6.2	0.11	11.7	4.7	03027159E3	03037159E3
	22	6 x 10	3	75	9	6.8	0.11	8.0	3.2	03027229E3	03037229E3
	33	6 x 10	3	95	12	7.7	0.11	5.31	2.1	03027339E3	03037339E3
	47	8 x 11	5a	150	16	8.8	0.11	3.73	1.5	03027479E3	03037479E3
	47	6.5 x 18	4	150	16	8.8	0.11	3.73	1.5	03127479E3	03137479E3
	100	8 x 18	5	220	28	13	0.11	1.75	0.70	03127101E3	03137101E3
	150	10 x 18	6	300	40	17	0.11	1.17	0.47	03127151E3	03137151E3
	220	10 x 25	7	430	57	23	0.11	0.80	0.32	03127221E3	03137221E3
63	1.0	3.3 x 11	1	10	5	5.1	0.12	191	55	03090067E3	03090068E3
	1.0	4.5 x 10	2	13	5	5.1	0.09	143	55	03028108E3	03038108E3
	2.2	4.5 x 10	2	25	7	5.3	0.09	65.2	25	03028228E3	03038228E3
	3.3	4.5 x 10	2	35	11	5.4	0.09	46.5	17	03028338E3	03038338E3
	4.7	4.5 x 10	2	40	15	5.6	0.09	30.5	12	03028478E3	03038478E3
	6.8	4.5 x 10	2	46	22	5.9	0.09	21.1	8.1	03028688E3	03038688E3
	10	6 x 10	3	70	7	6.3	0.08	12.8	5.5	03028109E3	03038109E3
	15	6 x 10	3	79	10	6.9	0.08	8.5	3.7	03028159E3	03038159E3
	22	8 x 11	5a	110	13	7.8	0.08	5.79	2.5	03028229E3	03038229E3
	22	6.5 x 18	4	110	13	7.8	0.08	5.79	2.5	03128229E3	03138229E3
	47	8 x 18	5	190	22	11	0.08	2.71	1.2	03128479E3	03138479E3
	68	10 x 18	6	250	30	14	0.08	1.88	0.81	03128689E3	03138689E3
	100	10 x 25	7	300	42	18	0.08	1.28	0.55	03128101E3	03138101E3
100	0.47	4.5 x 10	2	9	5	4.3	0.08	271	96	03029477E3	03039477E3
	1.0	4.5 x 10	2	20	5	4.6	0.08	128	45	03029108E3	03039108E3
	2.2	4.5 x 10	2	30	11	5.3	0.08	57.9	21	03029228E3	03039228E3
	3.3	4.5 x 10	2	40	17	6.0	0.08	38.6	14	03029338E3	03039338E3
	4.7	6 x 10	3	50	13	6.8	0.07	23.7	9.6	03029478E3	03039478E3
	6.8	6 x 10	3	70	18	8.0	0.07	16.4	6.6	03029688E3	03039688E3
	10	8 x 11	5a	90	24	10	0.07	11.2	4.5	03029109E3	03039109E3
	10	6.5 x 18	4	90	24	10	0.07	11.2	4.5	03129109E3	03139109E3
	22	8 x 18	5	120	48	18	0.07	5.07	2.1	03129229E3	03139229E3
	33	10 x 18	6	200	70	24	0.07	3.38	1.4	03129339E3	03139339E3
	47	10 x 25	7	260	98	33	0.07	2.37	0.96	03129479E3	03139479E3

ADDITIONAL ELECTRICAL DATA		
PARAMETER	**CONDITIONS**	**VALUE**
Voltage		
Surge voltage		$U_s \leq 1.15 \times U_R$
Reverse voltage		$U_{rev} \leq 1$ V
Current		
Leakage current	After 1 minute at U_R:	
	Case Ø D x L = 3.3 x 11 and 4.5 x 10 mm	$I_{L1} \leq 0.05\ C_R \times U_R$ or 5 µA, whichever is greater
	Case Ø D x L = 6 x 10 to 10 x 25 mm	I_{L1} for CV ≤ 1000: $\leq 0.01\ C_R \times U_R$ or 1 µA, whichever is greater
		I_{L1} for CV > 1000: $\leq 0.006\ C_R \times U_R + 4$ µA
	U_R = 100 V	$I_{L1} = 0.02\ C_R \times U_R + 4$ µA
	After 5 minutes:	
	U_R = 6.3 to 63 V	$I_{L5} \leq 0.002\ C_R \times U_R + 5$ µA
	U_R = 100 V	$I_{L5} \leq 0.006\ C_R \times U_R + 4$ µA
Inductance		
Equivalent series inductance (ESL)	Case Ø D x L mm:	
	3.3 x 11	typ. 11 nH
	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
Resistance		
Equivalent series resistance (ESR)	Calculated from tan $\delta_{max.}$ and C_R (see Table 2)	ESR = tan $\delta/2\ \pi\ f\ C_R$

CAPACITANCE (C)

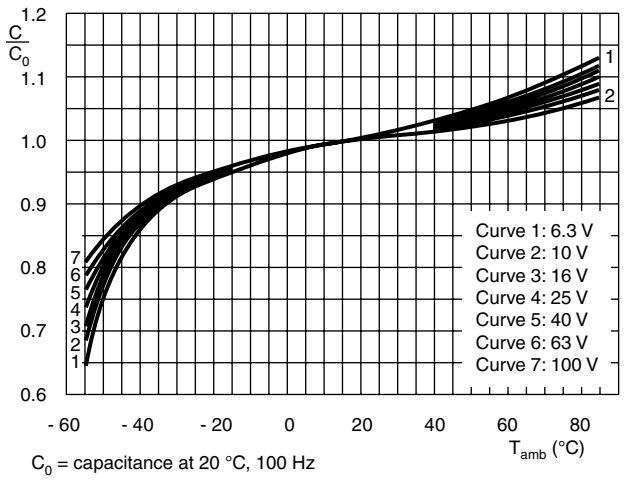


Fig.3 Typical multiplier of capacitance as a function of ambient temperature

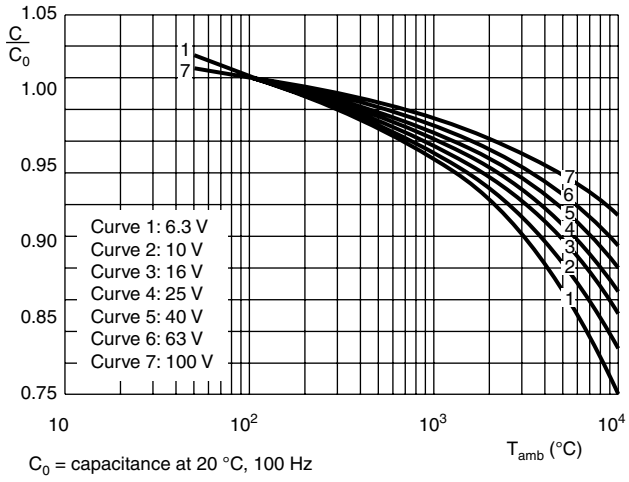


Fig.4 Typical multiplier of capacitance as a function of frequency

EQUIVALENT SERIES RESISTANCE (ESR)

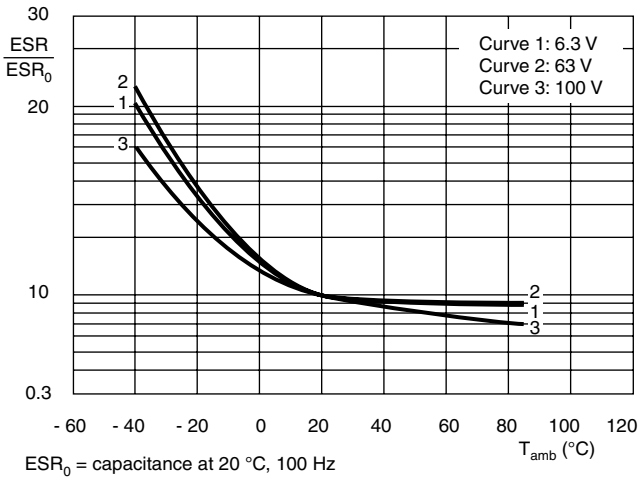


Fig.5 Typical multiplier of ESR as a function of ambient temperature

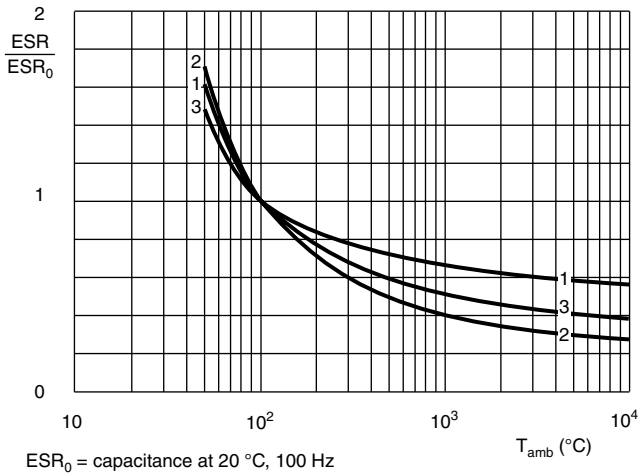


Fig.6 Typical multiplier of ESR as a function of frequency

IMPEDANCE (Z)

Table 3

IMPEDANCE VS. CAPACITANCE VALUES AT 10 kHz							
T_{amb}	$Z \times C_R$ (Ω x µF)						
	6.3 V	10 V	16 V	25 V	40 V	63 V	100 V
+ 20 °C	≤ 200	≤ 160	≤ 120	≤ 90	≤ 70	≤ 55	≤ 45
- 25 °C	≤ 1200	≤ 750	≤ 560	≤ 400	≤ 300	≤ 180	≤ 130
- 40 °C	≤ 3200	≤ 2000	≤ 1500	≤ 1100	≤ 900	≤ 500	≤ 350

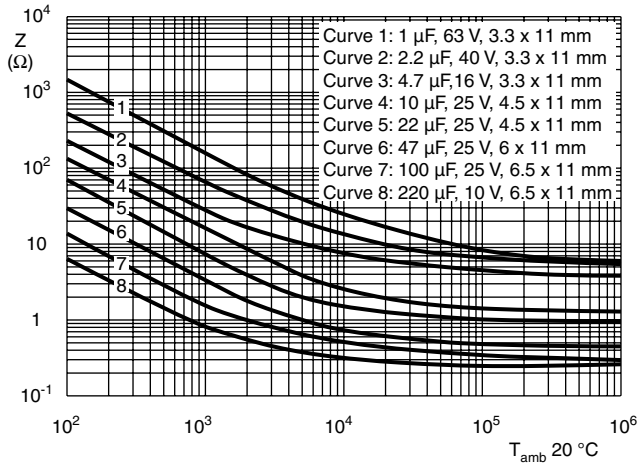


Fig.7 Typical impedance as a function of frequency

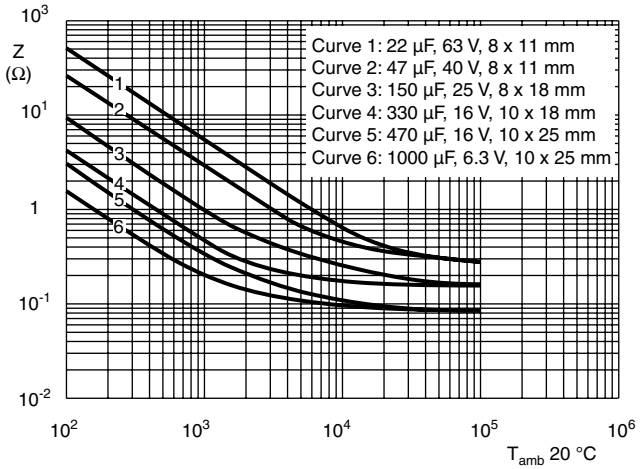
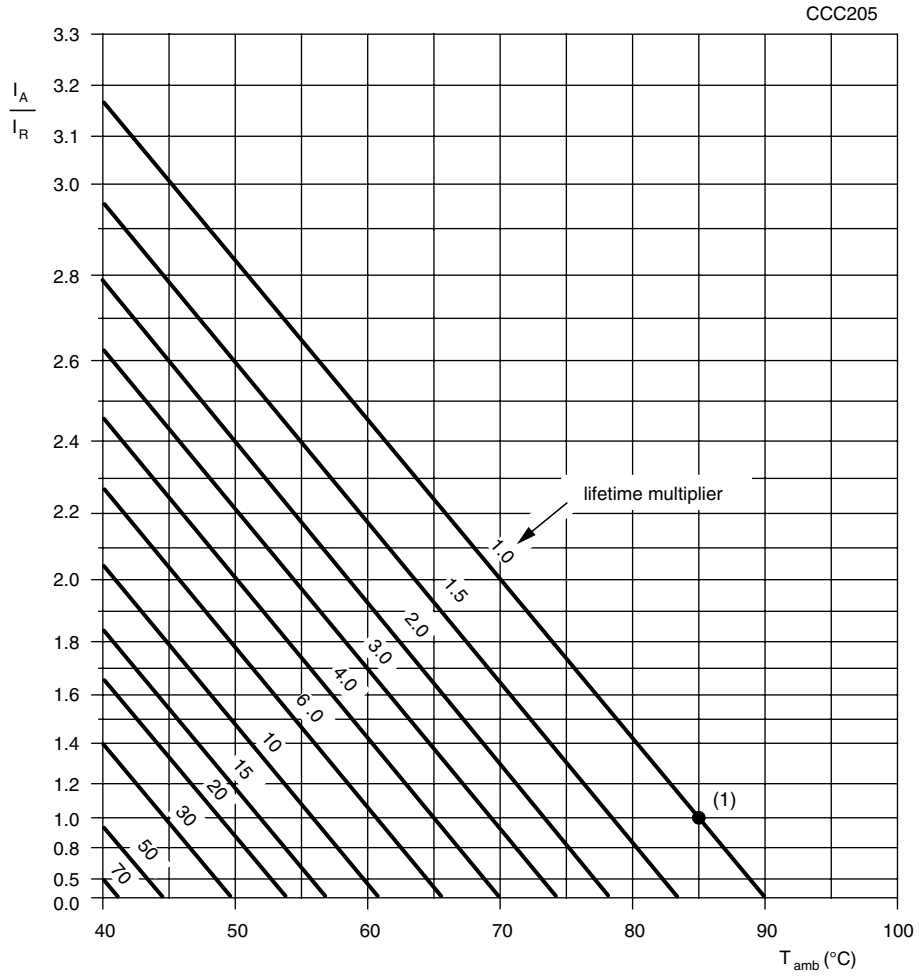


Fig.8 Typical impedance as a function of frequency

RIPPLE CURRENT AND USEFUL LIFE



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 IR applied:
case Ø D x L = 3.3 x 11 mm:1500 hours
case Ø D x L = 4.5 x 10 mm to 10 x 25 mm:
3000 hours

Fig.9 Multiplier of useful life as a function of ambient temperature and ripple current load

Table 4

MULTIPLIER OF RIPPLE CURRENT (IR) AS A FUNCTION OF FREQUENCY			
FREQUENCY (Hz)	I_R MULTIPLIER		
	U_R = 6.3 to 10 V	U_R = 16 to 25 V	U_R = 40 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
≥ 10 000	1.20	1.30	1.40

Table 5

TEST PROCEDURES AND REQUIREMENTS			
TEST		**PROCEDURE (quick reference)**	**REQUIREMENTS**
NAME OF TEST	**REFERENCE**		
Case Ø D x L = 3.3 x 11 mm			
Endurance	IEC 384-4/ EN130300 subclause 4.13	T_{amb} = 85 °C ; U_R applied; 1000 hours	ΔC/C: ± 20 % tan δ ≤ 2 x spec. limit Z ≤ 3 x spec. limit I_L ≤ spec. limit
Useful life	CECC 30301 subclause 1.8.1	T_{amb} = 85 °C; U_R and I_R applied; 1500 hours	ΔC/C: ± 50 % tan δ ≤ 3 x spec. limit Z ≤ 3 x spec. limit I_L ≤ spec. limit no short or open circuit total failure percentage: ≤ 3 %
Shelf life (storage at high temperature)	IEC 384-4/ 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_L ≤ 2 x spec. limit
Case Ø D L = 4.5 x 10 to 10 x 25 mm			
Endurance	IEC 384-4/ EN130300 subclause 4.13	T_{amb} = 85 °C; U_R applied; 2000 hours	U_R ≤ 6.3 V; ΔC/C: + 15/- 30 % U_R > 6.3 V; ΔC/C: ± 15 % tan δ ≤ 1.3 x spec. limit Z ≤ 2 x spec. limit I_L ≤ spec. limit
Useful life	CECC 30301 subclause 1.8.1	T_{amb} = 85 °C; U_R and I_R applied; 3000 hours	U_R ≤ 6.3 V; ΔC/C: + 45/- 50 % U_R > 6.3 V; ΔC/C: ± 45 % tan δ ≤ 3 x spec. limit Z ≤ 3 x spec. limit I_L ≤ spec. limit no short or open circuit total failure percentage: ≤ 1 %
Shelf life (storage at high temperature)	IEC 384-4/ 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_L ≤ 2 x spec. limit

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