

## Aluminum Capacitors Axial Standard

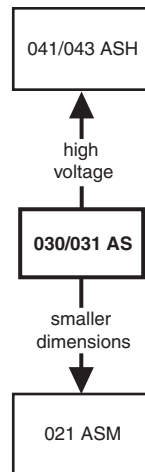
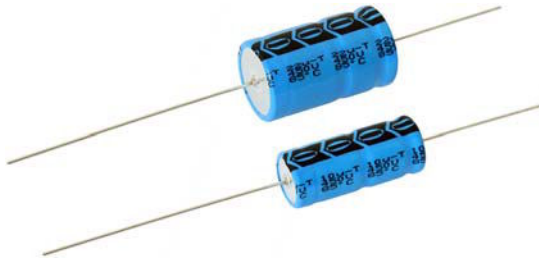


Fig. 1

QUICK REFERENCE DATA	
DESCRIPTION	VALUE
Nominal case sizes ( $\varnothing$ D x L in mm)	4.5 x 10 to 10 x 25
Rated capacitance range, $C_R$	0.47 $\mu$ F to 1000 $\mu$ F
Tolerance on $C_R$	- 10 % to + 50 %
Rated voltage, $U_R$	6.3 V to 100 V
Category temperature range	- 40 °C to + 85 °C
Endurance test at 85 °C	2000 h
Useful life at 85 °C	3000 h
Useful life at 40 °C, 1.4 x $I_R$ applied	80 000 h
Shelf life at 0 V, 85 °C	500 h
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
- Taped version available for automatic insertion
- Charge and discharge proof
- Useful life: 3000 h at 85 °C
- Standard dimensions
- Lead (Pb)-free versions are RoHS compliant
- Compliant to RoHS Directive 2002/95/EC


**RoHS  
COMPLIANT**

### APPLICATIONS

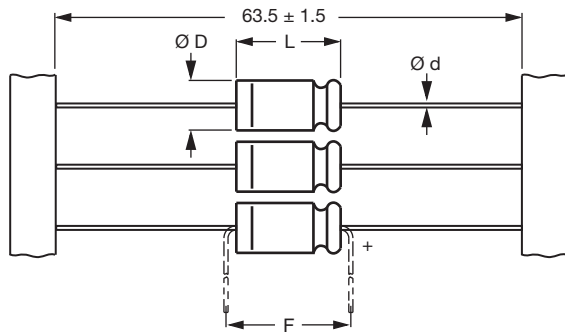
- General purpose and industrial, automotive, telecommunication, audio-video
- Coupling, decoupling, timing, smoothing, filtering, buffering in SMPS
- Boards with restricted mounting height, vibration and shock resistant

### MARKING

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

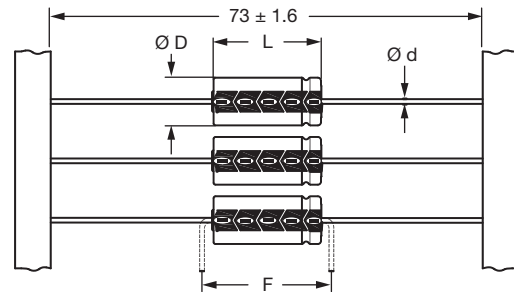
- Rated capacitance (in  $\mu$ F)
- Tolerance on rated capacitance, code letter in accordance with IEC 60062 (T for - 10 % to + 50 %)
- Rated voltage (in V)
- Date code in accordance with IEC 60062
- Code factory of origin
- Name of manufacturer
- Negative terminal identification
- Series number (030 or 031)

<b>SELECTION CHART FOR <math>C_R</math>, <math>U_R</math> AND RELEVANT NOMINAL CASE SIZES (<math>\varnothing D \times L</math> in mm)</b>							
$C_R$ ( $\mu F$ )	$U_R$ (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	4.5 x 10
4.7	-	-	-	-	-	4.5 x 10	6 x 10
6.8	-	-	-	-	-	4.5 x 10	6 x 10
10	-	-	-	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**


**Form BR:** Taped on reel  
**Form BA:** Taped in box (ammopack)  
 Case  $\varnothing D \times L = 4.5 \text{ mm} \times 10 \text{ mm}$  to  $8 \text{ mm} \times 11 \text{ mm}$

Fig. 2 - Forms BA and BR



**Form BR:** Taped on reel  
 Case  $\varnothing D \times L = 6.5 \text{ mm} \times 18 \text{ mm}$  to  $15 \text{ mm} \times 30 \text{ mm}$   
**Form BA:** Taped in box (ammopack)  
 Case  $\varnothing D \times L = 6.5 \text{ mm} \times 18 \text{ mm}$  to  $10 \text{ mm} \times 25 \text{ mm}$

Fig. 3 - Forms BA and BR

Table 1

<b>AXIAL; DIMENSIONS in millimeters, MASS AND PACKAGING QUANTITIES</b>								
NOMINAL CASE SIZE $\varnothing D \times L$	CASE CODE	AXIAL FORM BA AND BR				MASS (g)	PACKAGING QUANTITIES	
		$\varnothing d$	$\varnothing D_{max.}$	$L_{max.}$	$F_{min.}$		FORM BA	FORM BR
4.5 x 10	2	0.6	5.0	10.5	15	≈ 0.5	1000	3000
6 x 10	3	0.6	6.3	10.5	15	≈ 0.7	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	25.0	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 min at $U_R$
$I_{L5}$	Max. leakage current after 5 min at $U_R$
$\tan \delta$	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

**ORDERING EXAMPLE**

Electrolytic capacitor 031 series

330  $\mu$ F/10 V; - 10 %/+ 50 %

Nominal case size:  $\varnothing$  8 mm x 18 mm; form BA

Ordering code: MAL203134331E3

**Note**

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

Table 2

ELECTRICAL DATA AND ORDERING INFORMATION											
$U_R$ (V)	$C_R$ 100 Hz ( $\mu$ F)	NOMINAL CASE SIZE $\varnothing$ D x L (mm)	CASE CODE	$I_R$ 100 Hz 85 °C (mA)	$I_{L1}$ 1 min ( $\mu$ A)	$I_{L5}$ 5 min ( $\mu$ A)	$\tan \delta$ 100 Hz	ESR 100 Hz ( $\Omega$ )	Z 10 kHz ( $\Omega$ )	ORDERING CODE MAL2.....	
										TAPED ON REEL FORM BR	TAPED IN BOX FORM BA
6.3	68	4.5 x 10	2	75	22	5.9	0.25	5.86	2.90	03023689E3	03033689E3
	150	6 x 10	3	120	10	6.9	0.25	2.66	1.30	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	3.40	03024479E3	03034479E3
	100	6 x 10	3	110	10	7.0	0.20	3.19	1.60	03024101E3	03034101E3
	220	8 x 11	5a	210	18	9.4	0.20	1.45	0.73	03024221E3	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	33	4.5 x 10	2	65	27	6.1	0.16	7.72	3.60	03025339E3	03035339E3
	68	6 x 10	3	110	11	7.2	0.16	3.75	1.80	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	9.00	03026109E3	03036109E3
	22	4.5 x 10	2	60	28	6.1	0.14	10.2	4.10	03026229E3	03036229E3
	47	6 x 10	3	100	12	7.4	0.14	4.80	1.90	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 <sub>R</sub> (V)	C <sub>R</sub> 100 Hz (μF)	NOMINAL CASE SIZE Ø D x L (mm)	CASE CODE	I <sub>R</sub> 100 Hz 85 °C (mA)	I <sub>L1</sub> 1 min (μA)	I <sub>L5</sub> 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	10	4.5 x 10	2	50	20	5.8	0.11	17.6	7.00	03027109E3	03037109E3
	15	4.5 x 10	2	55	30	6.2	0.11	11.7	4.70	03027159E3	03037159E3
	22	6 x 10	3	75	9	6.8	0.11	8.00	3.20	03027229E3	03037229E3
	33	6 x 10	3	95	12	7.7	0.11	5.31	2.10	03027339E3	03037339E3
	47	8 x 11	5a	150	16	8.8	0.11	3.73	1.50	03027479E3	03037479E3
	47	6.5 x 18	4	150	16	8.8	0.11	3.73	1.50	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	4.5 x 10	2	13	5	5.1	0.09	143	55.0	03028108E3	03038108E3
	2.2	4.5 x 10	2	25	7	5.3	0.09	65.2	25.0	03028228E3	03038228E3
	3.3	4.5 x 10	2	35	11	5.4	0.09	46.5	17.0	03028338E3	03038338E3
	4.7	4.5 x 10	2	40	15	5.6	0.09	30.5	12.0	03028478E3	03038478E3
	6.8	4.5 x 10	2	46	22	5.9	0.09	21.1	8.10	03028688E3	03038688E3
	10	6 x 10	3	70	7	6.3	0.08	12.8	5.50	03028109E3	03038109E3
	15	6 x 10	3	79	10	6.9	0.08	8.50	3.70	03028159E3	03038159E3
	22	8 x 11	5a	110	13	7.8	0.08	5.79	2.50	03028229E3	03038229E3
	22	6.5 x 18	4	110	13	7.8	0.08	5.79	2.50	03128229E3	03138229E3
	47	8 x 18	5	190	22	11	0.08	2.71	1.20	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	96.0	03029477E3	03039477E3
	1.0	4.5 x 10	2	20	5	4.6	0.08	128	45.0	03029108E3	03039108E3
	2.2	4.5 x 10	2	30	11	5.3	0.08	57.9	21.0	03029228E3	03039228E3
	3.3	4.5 x 10	2	40	17	6.0	0.08	38.6	14.0	03029338E3	03039338E3
	4.7	6 x 10	3	50	13	6.8	0.07	23.7	9.60	03029478E3	03039478E3
	6.8	6 x 10	3	70	18	8.0	0.07	16.4	6.60	03029688E3	03039688E3
	10	8 x 11	5a	90	24	10	0.07	11.2	4.50	03029109E3	03039109E3
	10	6.5 x 18	4	90	24	10	0.07	11.2	4.50	03129109E3	03139109E3
	22	8 x 18	5	120	48	18	0.07	5.07	2.10	03129229E3	03139229E3
	33	10 x 18	6	200	70	24	0.07	3.38	1.40	03129339E3	03139339E3
	47	10 x 25	7	260	98	33	0.07	2.37	0.96	03129479E3	03139479E3

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

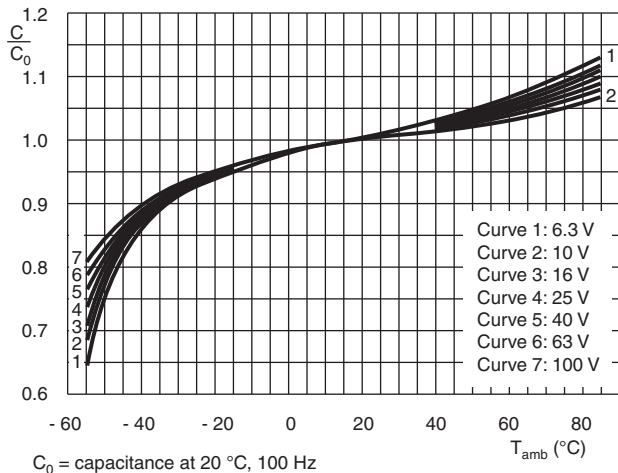
**CAPACITANCE (C)**


Fig. 4 - Typical multiplier of capacitance as a function of ambient temperature

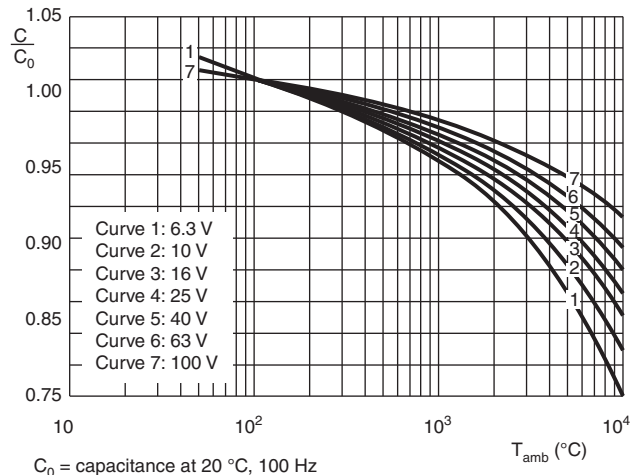


Fig. 5 - Typical multiplier of capacitance as a function of frequency

**EQUIVALENT SERIES RESISTANCE (ESR)**

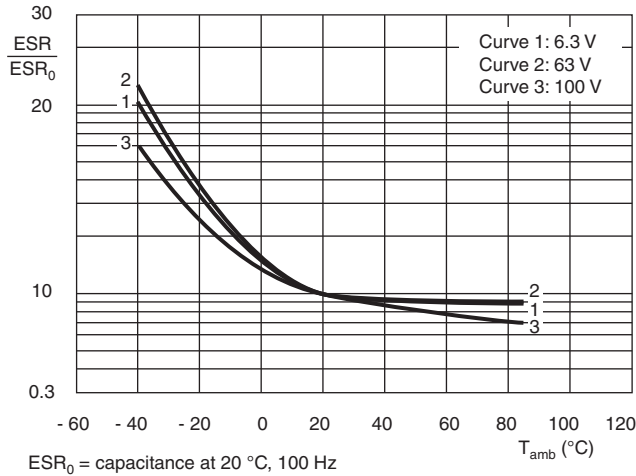


Fig. 6 - Typical multiplier of ESR as a function of ambient temperature

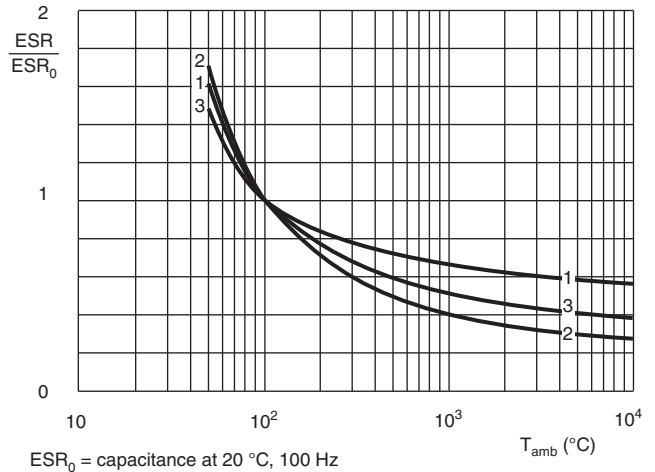


Fig. 7 - Typical multiplier of ESR as a function of frequency

**IMPEDANCE (Z)**

Table 3

IMPEDANCE VS. CAPACITANCE VALUES AT 10 kHz							
T <sub>amb</sub>	Z x C <sub>R</sub> (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

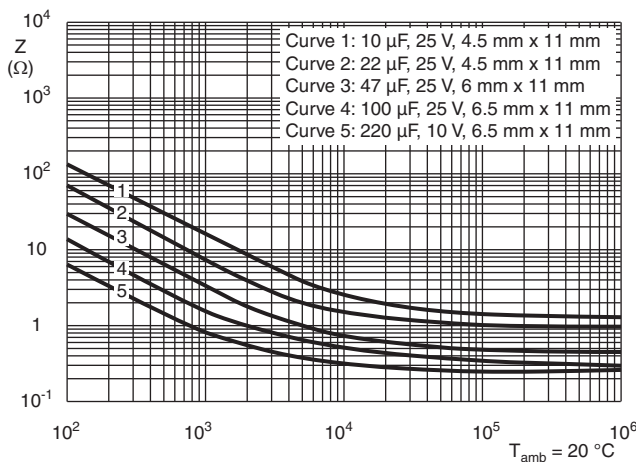


Fig. 8 - Typical impedance as a function of frequency

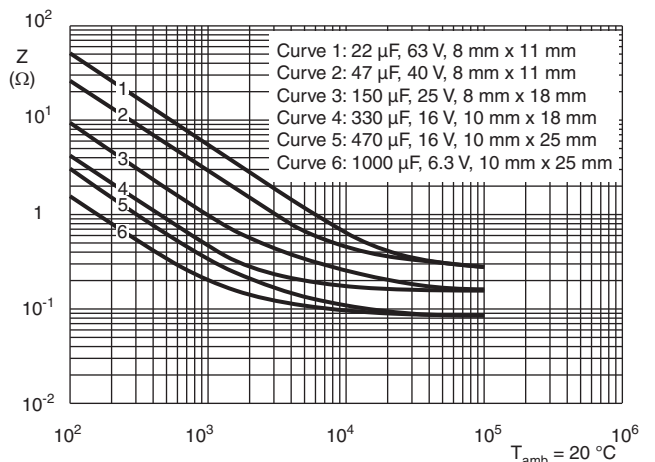


Fig. 9 - Typical impedance as a function of frequency

**RIPPLE CURRENT AND USEFUL LIFE**

CCC205

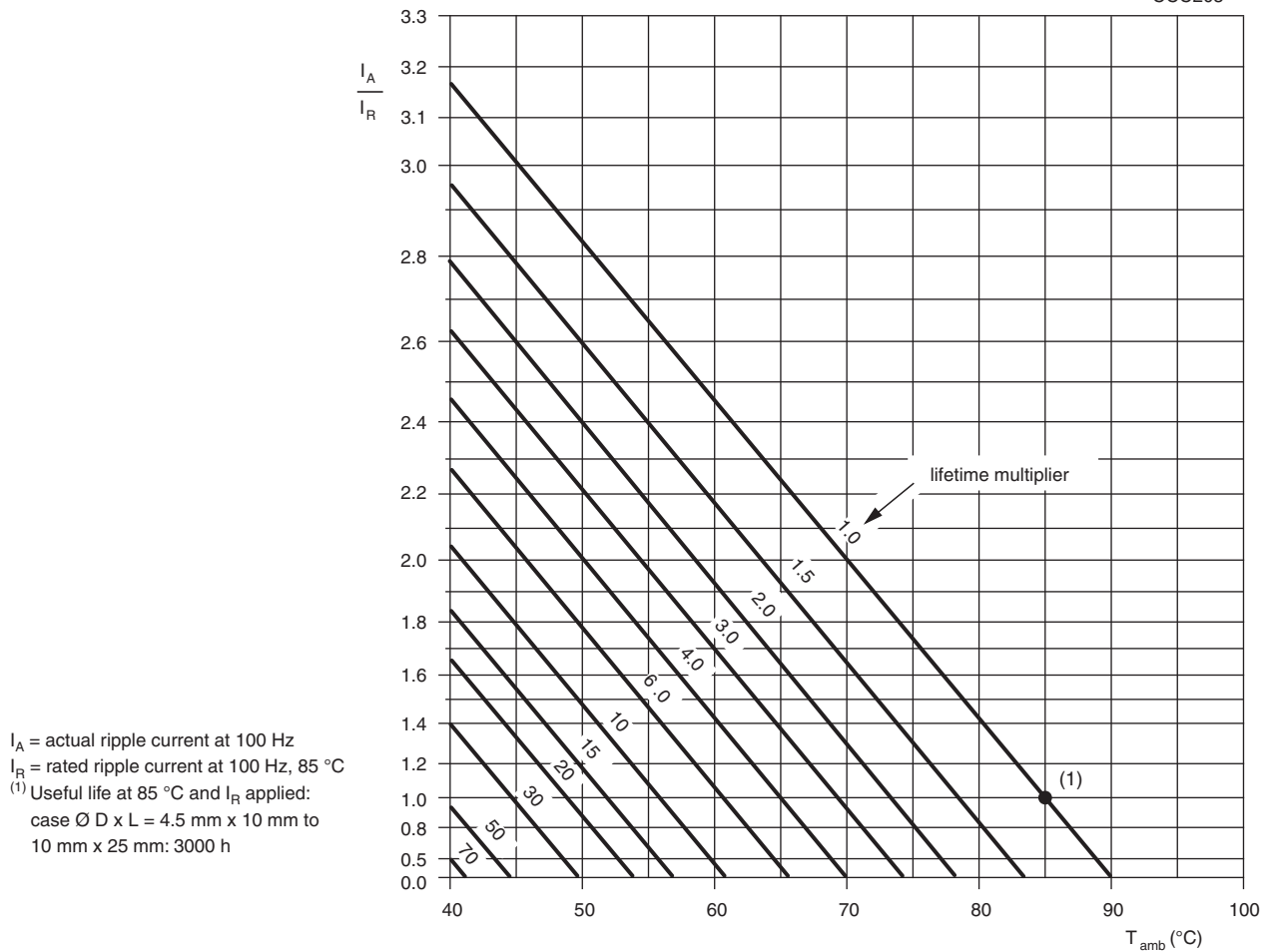


Fig. 10 - Multiplier of useful life as a function of ambient temperature and ripple current load

Table 4

MULTIPLIER OF RIPPLE CURRENT ( $I_R$ ) AS A FUNCTION OF FREQUENCY			
FREQUENCY (Hz)	$I_R$ MULTIPLIER		
	$U_R = 6.3 \text{ V TO } 10 \text{ V}$	$U_R = 16 \text{ V TO } 25 \text{ V}$	$U_R = 40 \text{ V TO } 100 \text{ V}$
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		
Case $\varnothing$ D x L = 4.5 mm x 10 mm to 10 mm x 25 mm			
Endurance	IEC 384-4/ EN130300 subclause 4.13	$T_{amb} = 85\text{ }^{\circ}\text{C}$ ; $U_R$ applied; 2000 h	$U_R \leq 6.3\text{ V}$ ; $\Delta C/C$ : + 15 %/- 30 % $U_R > 6.3\text{ V}$ ; $\Delta C/C$ : $\pm 15\text{ }%$ $\tan \delta \leq 1.3 \times \text{spec. limit}$ $Z \leq 2 \times \text{spec. limit}$ $I_L \leq \text{spec. limit}$
Useful life	CECC 30301 subclause 1.8.1	$T_{amb} = 85\text{ }^{\circ}\text{C}$ ; $U_R$ and $I_R$ applied; 3000 h	$U_R \leq 6.3\text{ V}$ ; $\Delta C/C$ : + 45 %/- 50 % $U_R > 6.3\text{ V}$ ; $\Delta C/C$ : $\pm 45\text{ }%$ $\tan \delta \leq 3 \times \text{spec. limit}$ $Z \leq 3 \times \text{spec. limit}$ $I_L \leq \text{spec. limit}$ no short or open circuit total failure percentage: $\leq 1\text{ }%$
Shelf life (storage at high temperature)	IEC 384-4/ EN130300 subclause 4.17	$T_{amb} = 85\text{ }^{\circ}\text{C}$ ; no voltage applied; 500 h  After test: $U_R$ to be applied for 30 min, 24 h to 48 h before measurement	$\Delta C/C$ , $\tan \delta$ , Z: for requirements see "Endurance test" above $I_L \leq 2 \times \text{spec. limit}$





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