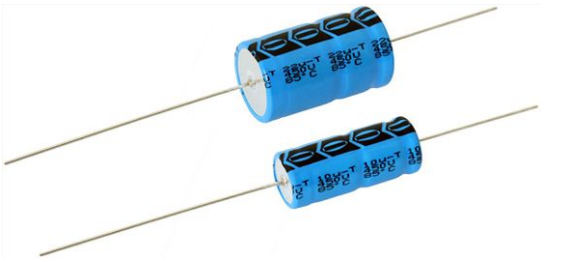
Aluminum Capacitors
Axial Standard



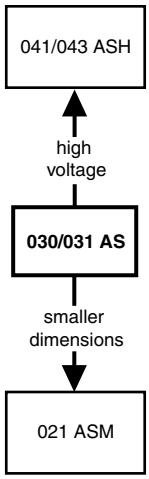


Fig. 1

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
- Material categorization: For definitions of compliance please see www.vishay.com/doc?99912

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
- Negative terminal identification
- Series number (030 or 031)

QUICK REFERENCE DATA	
DESCRIPTION	**VALUE**
Nominal case sizes (Ø D x L in mm)	4.5 x 10 to 10 x 25
Rated capacitance range, C_R	1 µF to 1000 µF
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

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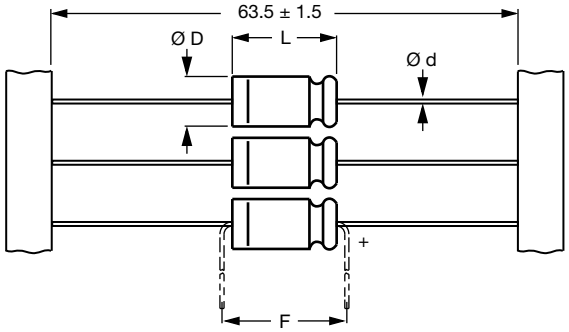
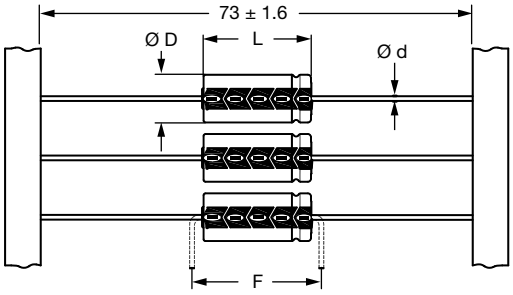
SELECTION CHART FOR C_R, U_R AND RELEVANT NOMINAL CASE SIZES (Ø D x L in mm)							
C_R (µF)	U_R (V)						
	6.3	10	16	25	40	63	100
1.0	-	-	-	-	-	4.5 x 10	4.5 x 10
2.2	-	-	-	-	-	4.5 x 10	4.5 x 10
3.3	-	-	-	-	-	4.5 x 10	4.5 x 10
4.7	-	-	-	-	-	4.5 x 10	6 x 10
6.8	-	-	-	-	-	4.5 x 10	6 x 10
10	-	-	-	4.5 x 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 Ø D x L = 4.5 mm x 10 mm to 8 mm x 11 mm

Fig. 2 - **Forms BA** and **BR**



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

Fig. 3 - **Forms BA** and **BR**

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	Ø $D_{max.}$	$L_{max.}$	$F_{min.}$		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”

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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 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 kPa to 106 kPa, RH = 45 % to 75 %.

ORDERING EXAMPLE

Electrolytic capacitor 031 series

330 µF/10 V; - 10 %/+ 50 %

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

Ordering code: MAL203134331E3

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	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

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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	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	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

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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 min at U_R: Case Ø D x L = 4.5 mm x 10 mm Case Ø D x L = 6 mm x 10 mm to 10 mm x 25 mm U_R = 100 V	 $I_{L1} \leq 0.05\ C_R \times U_R$ or 5 µA, whichever is greater I_{L1} for CV ≤ 1000: ≤ $0.01\ C_R \times U_R$ or 1 µA, whichever is greater I_{L1} for CV > 1000: ≤ $0.006\ C_R \times U_R$ + 4 µA $I_{L1} = 0.02\ C_R \times U_R$ + 4 µA
	After 5 min: U_R = 6.3 V to 63 V U_R = 100 V	 $I_{L5} \leq 0.002\ C_R \times U_R$ + 5 µA $I_{L5} \leq 0.006\ C_R \times U_R$ + 4 µA
Inductance		
Equivalent series inductance (ESL)	Case Ø D x L mm: 4.5 x 10 6 x 10 8 x 11 6.5 x 18 8 x 18 10 x 18 10 x 25	 typ. 10 nH typ. 22 nH typ. 85 nH typ. 25 nH typ. 40 nH typ. 61 nH 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)

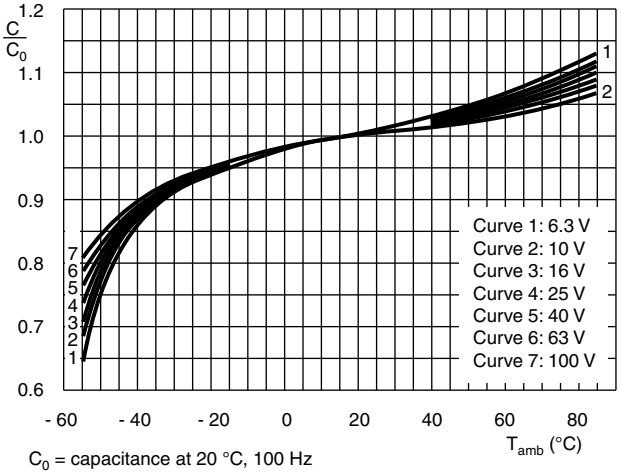

Fig. 4 - Typical multiplier of capacitance as a function of ambient temperature

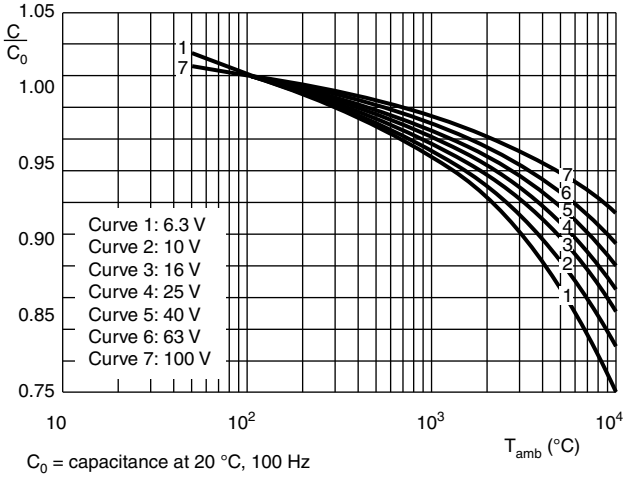

Fig. 5 - Typical multiplier of capacitance as a function of frequency

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EQUIVALENT SERIES RESISTANCE (ESR)

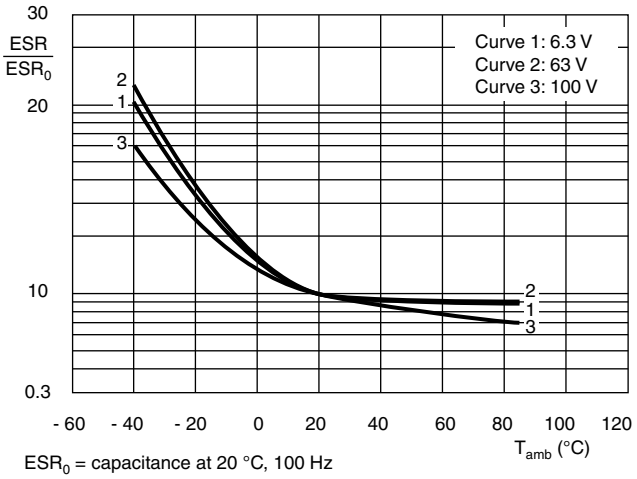

Fig. 6 - Typical multiplier of ESR as a function of ambient temperature

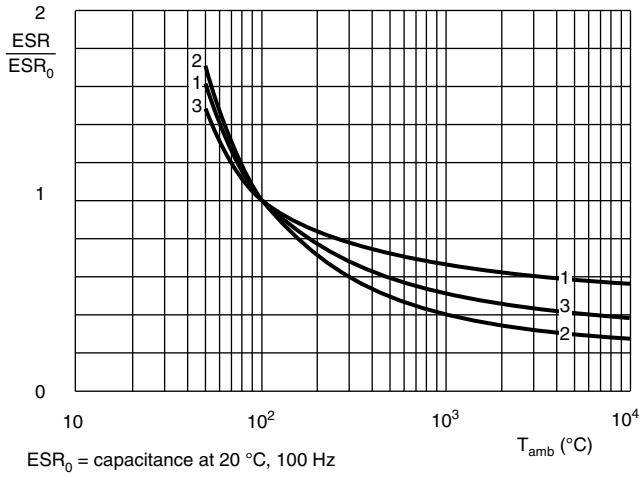

Fig. 7 - Typical multiplier of ESR as a function of frequency

IMPEDANCE (Z)

Table 3

IMPEDANCE VS. CAPACITANCE VALUES AT 10 kHz							
T_{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

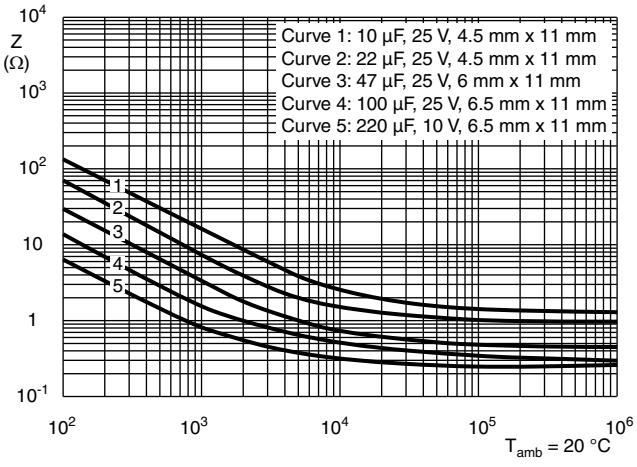

Fig. 8 - Typical impedance as a function of frequency

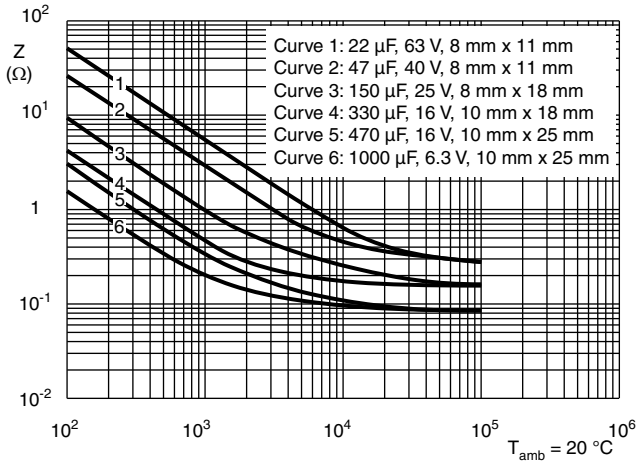

Fig. 9 - Typical impedance as a function of frequency

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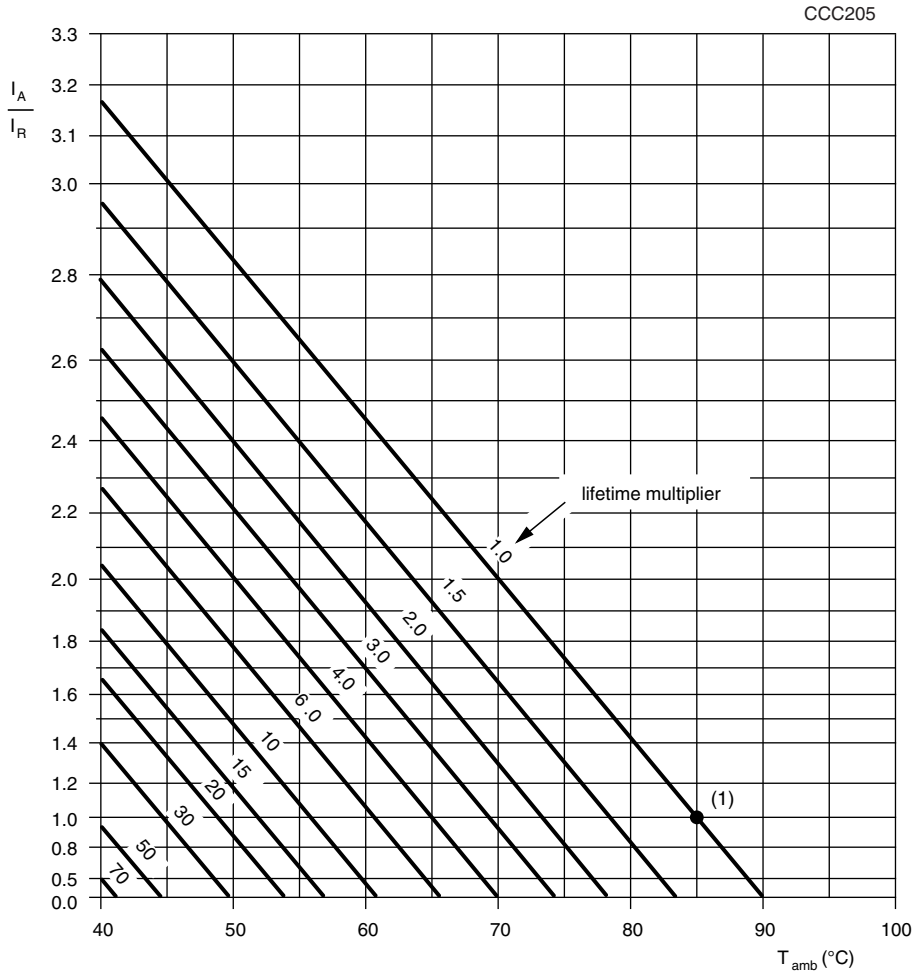
RIPPLE CURRENT AND USEFUL LIFE



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 I_R applied:
case Ø D x L = 4.5 mm x 10 mm to
10 mm x 25 mm: 3000 h

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 V TO 10 V	U_R = 16 V TO 25 V	U_R = 40 V 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

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Table 5

TEST PROCEDURES AND REQUIREMENTS			
TEST		**PROCEDURE (quick reference)**	**REQUIREMENTS**
NAME OF TEST	**REFERENCE**		
Case Ø 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 °C; U_R applied; 2000 h	$U_R \leq$ 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 $I_L \leq$ spec. limit
Useful life	CECC 30301 subclause 1.8.1	T_{amb} = 85 °C; U_R and I_R applied; 3000 h	$U_R \leq$ 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 $I_L \leq$ 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 h After test: U_R to be applied for 30 min, 24 h to 48 h before measurement	ΔC/C, tan δ, Z: for requirements see “Endurance test” above $I_L \leq$ 2 x spec. limit

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