

# Aluminum Capacitors Radial Standard Miniature

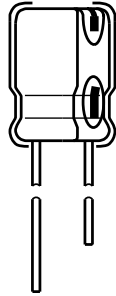
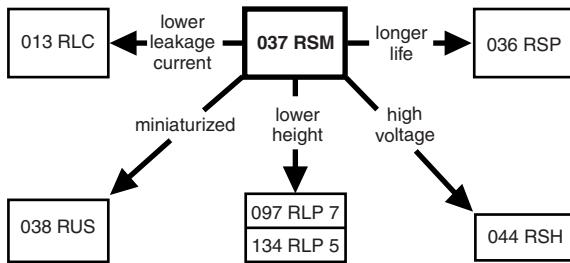


Fig.1 Component outline



## FEATURES

- Polarized aluminum electrolytic capacitors, non-solid electrolyte
- Radial leads, cylindrical aluminum case, insulated with a blue vinyl sleeve
- Pressure relief for case  $\varnothing D \geq 6.3$  mm.
- 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 and audio-video
- Coupling, decoupling, timing, smoothing, filtering, buffering in SMPS
- Portable and mobile equipment (small size, low mass)

## QUICK REFERENCE DATA

DESCRIPTION	VALUE
Nominal case sizes ( $\varnothing D \times L$ in mm)	5 x 11 to 16 x 31
Rated capacitance range, $C_R$	0.47 to 10 000 $\mu F$
Tolerance on $C_R$	$\pm 20\%$ ; $\pm 10\%$ on request
Rated voltage range, $U_R$	6.3 to 100 V
Category temperature range	- 40 to + 85 °C
Endurance test at 85 °C	2000 h
Useful life at 85 °C	2500 h
Useful life at 40 °C, $1.4 \times I_R$ applied	70 000 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

## 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 (M for  $\pm 20\%$ )
- Rated voltage (in V)
- Date code in accordance with IEC 60062
- Code indicating factory of origin
- Name of manufacturer
- Negative terminal identification
- Series number (037)

## SELECTION CHART FOR $C_R$ , $U_R$ AND RELEVANT NOMINAL CASE SIZES ( $\varnothing D \times L$ in mm)

$C_R$ ( $\mu F$ )	$U_R$ (V)								
	6.3	10	16	25	35	40	50	63	100
0.47	-	-	-	-	-	-	-	5 x 11	5 x 11
1.0	-	-	-	-	-	-	-	5 x 11	5 x 11
2.2	-	-	-	-	-	-	-	5 x 11	5 x 11
3.3	-	-	-	-	-	-	-	5 x 11	5 x 11
4.7	-	-	-	-	-	-	-	5 x 11	5 x 11
10	-	-	-	-	-	-	5 x 11	5 x 11	6.3 x 11
22	-	-	-	-	-	-	5 x 11	6.3 x 11	8 x 12
33	-	-	-	-	5 x 11	-	-	6.3 x 11	10 x 12
47	-	-	-	5 x 11	-	-	6.3 x 11	8 x 12	10 x 16
68	-	-	5 x 11	6.3 x 11	-	-	8 x 12	10 x 12	-
100	-	5 x 11	6.3 x 11	6.3 x 11	-	-	8 x 12	10 x 12	10 x 20
150	-	6.3 x 11	-	8 x 12	-	10 x 12	-	10 x 16	-
220	-	6.3 x 11	8 x 12	8 x 12	10 x 12	-	10 x 16	10 x 20	12.5 x 2

<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	35	40	50	63	100
330	6.3 x 11	–	8 x 12	10 x 12	10 x 16	–	10 x 20	12.5 x 20	16 x 25
470	–	8 x 12	10 x 12	10 x 16	10 x 20	12.5 x 20	12.5 x 20	12.5 x 25	16 x 31
680	–	–	10 x 16	–	12.5 x 20	12.5 x 25	12.5 x 25	16 x 25	–
1000	10 x 12	10 x 16	10 x 20	12.5 x 20	12.5 x 25	16 x 25	16 x 25	16 x 31	–
1500	10 x 20	–	12.5 x 20	12.5 x 25	16 x 25	–	–	–	–
2200	12.5 x 20	12.5 x 20	12.5 x 25	16 x 25	16 x 31	–	–	–	–
3300	12.5 x 20	12.5 x 25	16 x 25	16 x 31	–	–	–	–	–
4700	–	16 x 25	16 x 31	–	–	–	–	–	–
6800	–	16 x 31	–	–	–	–	–	–	–
10 000	16 x 31	–	–	–	–	–	–	–	–

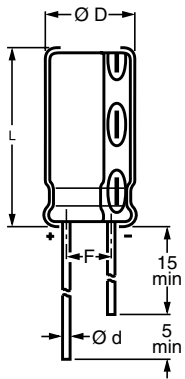
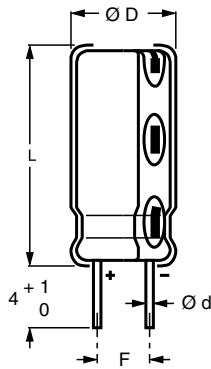
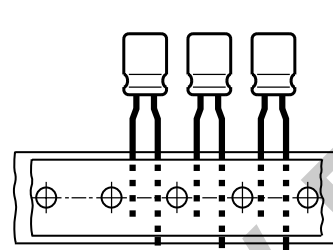
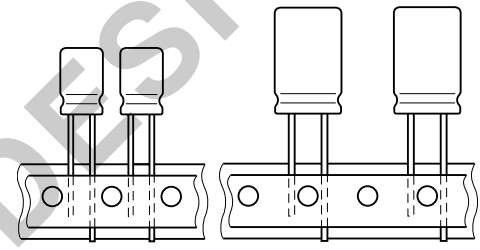
**DIMENSIONS in millimeters AND AVAILABLE FORMS**

 Fig.2 **Form CA:**  
 Long leads

 Fig.3 **Form CB:**  
 Cut leads

 Case  $\varnothing D = 5$  to 8 mm; pitch  $F = 5$  mm

 Pitch  $F$  see tables 1 and 2

 Fig.5 **Form TNA, Form TFA:** Taped in box  
 (ammopack), straight leads

Table 1

<b>DIMENSIONS in millimeters, MASS AND PACKAGING QUANTITIES</b>									
NOMINAL CASE SIZE $\varnothing D \times L$	CASE CODE	$\varnothing d$	$\varnothing D_{max}$	$L_{max}$	F	MASS (g)	PACKAGING QUANTITIES		
							FORM CA	FORM CB	FORM TFA, TNA
5 x 11	11	0.5	5.5	12.5	$2.0 \pm 0.5$	$\approx 0.4$	3000	–	2000
6.3 x 11	12	0.5	6.8	12.5	$2.5 \pm 0.5$	$\approx 0.6$	2000	–	2000
8 x 12	13	0.6	8.5	13.0	$3.5 \pm 0.5$	$\approx 1.1$	1000	–	1000
10 x 12	14	0.6	10.5	13.5	$5.0 \pm 0.5$	$\approx 1.6$	1000	1000	500
10 x 16	15	0.6	10.5	17.5	$5.0 \pm 0.5$	$\approx 1.9$	1000	1000	500
10 x 20	16	0.6	10.5	22.0	$5.0 \pm 0.5$	$\approx 2.2$	1000	500	500
12.5 x 20	17	0.6	13.0	22.0	$5.0 \pm 0.5$	$\approx 4.0$	1000	2000	500
12.5 x 25	18	0.6	13.0	27.0	$5.0 \pm 0.5$	$\approx 5.0$	500	2000	500
16 x 25	19	0.8	16.5	27.0	$7.5 \pm 0.5$	$\approx 8.0$	500	1000	250
16 x 31	20	0.8	16.5	33.5	$7.5 \pm 0.5$	$\approx 9.0$	200	1000	250

**Note**

- Detailed tape dimensions see section 'PACKAGING'.



ELECTRICAL DATA	
SYMBOL	DESCRIPTION
C <sub>R</sub>	rated capacitance at 100 Hz, tolerance ± 20 %
I <sub>R</sub>	rated RMS ripple current at 100 Hz, 85 °C
I <sub>L1</sub>	max. leakage current after 1 min at U <sub>R</sub>
Tan δ	max. dissipation factor at 100 Hz
Z	max. impedance at 10 kHz

**ORDERING EXAMPLE**

Electrolytic capacitor 037 series  
 1000 µF/16 V; ± 20 %  
 Nominal case size: Ø 10 × 20 mm; Form TFA  
 Ordering Code: MAL203735102  
 Former 12NC: 2222 037 35102

**Note**

1. Unless otherwise specified, all electrical values in Table 2 apply at T<sub>amb</sub> = 20 °C, P = 86 to 106 kPa, RH = 45 to 75 %.

Table 2

ELECTRICAL DATA AND ORDERING INFORMATION														
U <sub>R</sub> (V)	C <sub>R</sub> 100 Hz (µF)	NOMINAL CASE SIZE Ø D × L (mm)	I <sub>R</sub> 100 Hz 85 °C (mA)	I <sub>L1</sub> 1 min (µA)	Tan δ 100 Hz	Z 10 kHz z (Ω)	ORDERING CODE MAL2037.....							
							BULK PACKAGING				TAPED AMMOPACK			
							LONG LEADS		CUT LEADS					
							FORM CA	F (mm)	FORM CB	F (mm)	FORM TFA	F (mm)	FORM TNA	F (mm)
6.3	330	6.3 x 11	280	24	0.24	1.8	90021E6	2.5	-	-	90027E6	5.0	90028E6	2.5
	1000	10 x 12	530	66	0.24	0.6	53102E3	5.0	63102E3	5.0	33102E3	5.0	-	-
	1500	10 x 20	730	98	0.25	0.4	53152E3	5.0	63152E3	5.0	33152E3	5.0	-	-
	2200	12.5 x 20	990	140	0.26	0.27	53222E3	5.0	63222E3	5.0	33222E3	5.0	-	-
	3300	12.5 x 20	1150	210	0.28	0.18	53332E3	5.0	63332E3	5.0	33332E3	5.0	-	-
	10 000	16 x 31	2250	630	0.42	0.07	53103E3	7.5	63103E3	7.5	33103E3	7.5	-	-
10	100	5 x 11	140	13	0.20	4.5	54101E6	2.0	-	-	34101E6	5.0	74101E6	2.5
	150	6.3 x 11	180	18	0.20	3.0	54151E6	2.5	-	-	34151E6	5.0	74151E6	2.5
	220	6.3 x 11	250	25	0.20	2.0	90029E6	2.5	-	-	90036E6	5.0	90037E6	2.5
	470	8 x 12	410	50	0.20	0.96	54471E6	3.5	-	-	34471E6	5.0	74471E6	3.5
	1000	10 x 16	630	100	0.20	0.45	54102E3	5.0	64102E3	5.0	34102E3	5.0	-	-
	2200	12.5 x 20	1050	220	0.22	0.20	54222E3	5.0	64222E3	5.0	34222E3	5.0	-	-
	3300	12.5 x 25	1350	330	0.24	0.14	54332E3	5.0	64332E3	5.0	34332E3	5.0	-	-
	4700	16 x 25	1800	470	0.28	0.10	54472E3	7.5	64472E3	7.5	34472E3	7.5	-	-
6800	16 x 31	2200	680	0.32	0.07	54682E3	7.5	64682E3	7.5	34682E3	7.5	-	-	
16	68	5 x 11	130	14	0.16	4.7	55689E6	2.0	-	-	35689E6	5.0	75689E6	2.5
	100	6.3 x 11	180	19	0.16	3.2	55101E6	2.5	-	-	35101E6	5.0	75101E6	2.5
	220	8 x 12	300	38	0.16	1.5	55221E6	3.5	-	-	35221E6	5.0	75221E6	3.5
	330	8 x 12	370	56	0.16	0.97	90038E6	3.5	-	-	90045E6	5.0	90046E6	3.5
	470	10 x 12	420	78	0.16	0.68	55471E3	5.0	65471E3	5.0	35471E3	5.0	-	-
	680	10 x 16	520	110	0.16	0.47	55681E3	5.0	65681E3	5.0	35681E3	5.0	-	-
	1000	10 x 20	740	160	0.16	0.32	55102E3	5.0	65102E3	5.0	35102E3	5.0	-	-
	1500	12.5 x 20	900	240	0.17	0.21	55152E3	5.0	65152E3	5.0	35152E3	5.0	-	-
	2200	12.5 x 25	1200	360	0.18	0.15	55222E3	5.0	65222E3	5.0	35222E3	5.0	-	-
	3300	16 x 25	1650	530	0.20	0.10	55332E3	7.5	65332E3	7.5	35332E3	7.5	-	-
	4700	16 x 31	2100	760	0.24	0.07	55472E3	7.5	65472E3	7.5	35472E3	7.5	-	-
25	47	5 x 11	120	15	0.14	4.7	56479E6	2.0	-	-	36479E6	5.0	76479E6	2.5
	68	6.3 x 11	130	20	0.14	3.2	56689E6	2.5	-	-	36689E6	5.0	76689E6	2.5
	100	6.3 x 11	190	28	0.14	2.2	90047E6	2.5	-	-	90054E6	5.0	90055E6	2.5
	150	8 x 12	230	41	0.14	1.5	56151E6	3.5	-	-	36151E6	5.0	76151E6	3.5
	220	8 x 12	320	58	0.14	1.0	56221E6	3.5	-	-	36221E6	5.0	76221E6	3.5
	330	10 x 12	410	86	0.14	0.67	56331E3	5.0	66331E3	5.0	36331E3	5.0	-	-
	470	10 x 16	510	120	0.14	0.47	56471E3	5.0	66471E3	5.0	36471E3	5.0	-	-
	1000	12.5 x 20	910	250	0.14	0.22	56102E3	5.0	66102E3	5.0	36102E3	5.0	-	-
	1500	12.5 x 25	1100	380	0.15	0.15	56152E3	5.0	66152E3	5.0	36152E3	5.0	-	-
	2200	16 x 25	1500	550	0.16	0.10	56222E3	7.5	66222E3	7.5	36222E3	7.5	-	-
	3300	16 x 31	1900	830	0.18	0.07	56332E3	7.5	66332E3	7.5	36332E3	7.5	-	-



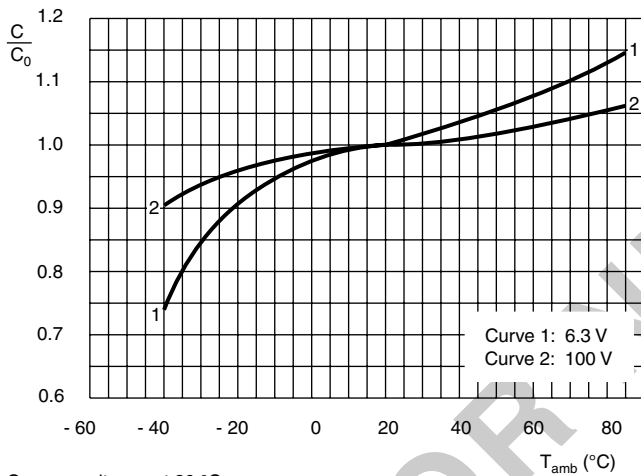
Aluminum Capacitors  
Radial Standard Miniature

Vishay BCcomponents

ELECTRICAL DATA AND ORDERING INFORMATION														
U <sub>R</sub> (V)	C <sub>R</sub> 100 Hz (μF)	NOMINAL CASE SIZE ∅ D × L (mm)	I <sub>R</sub> 100 Hz 85 °C (mA)	I <sub>L1</sub> 1 min (μA)	Tan δ 100 Hz	Z 10 kHz z (Ω)	ORDERING CODE MAL2037.....							
							BULK PACKAGING				TAPED AMMOPACK			
							LONG LEADS		CUT LEADS		FORM TFA		FORM TNA	
							FORM CA	F (mm)	FORM CB	F (mm)	FORM TFA	F (mm)	FORM TNA	F (mm)
35	33	5 x 11	110	15	0.12	4.5	50339E6	2.0	-	-	30339E6	5.0	70339E6	2.5
	220	10 x 12	330	80	0.12	0.68	50221E3	5.0	60221E3	5.0	30221E3	5.0	-	-
	330	10 x 16	450	120	0.12	0.45	50331E3	5.0	60331E3	5.0	30331E3	5.0	-	-
	470	10 x 20	590	170	0.12	0.32	50471E3	5.0	60471E3	5.0	30471E3	5.0	-	-
	680	12.5 x 20	830	240	0.12	0.22	50681E3	5.0	60681E3	5.0	30681E3	5.0	-	-
	1000	12.5 x 25	1050	350	0.12	0.15	50102E3	5.0	60102E3	5.0	30102E3	5.0	-	-
	1500	16 x 25	1400	530	0.13	0.10	50152E3	7.5	60152E3	7.5	30152E3	7.5	-	-
	2200	16 x 31	1750	770	0.14	0.07	50222E3	7.5	60222E3	7.5	30222E3	7.5	-	-
40	150	10 x 12	250	63	0.12	0.87	57151E3	5.0	67151E3	5.0	37151E3	5.0	-	-
	470	12.5 x 20	670	190	0.12	0.28	57471E3	5.0	67471E3	5.0	37471E3	5.0	-	-
	680	12.5 x 25	850	280	0.12	0.19	57681E3	5.0	67681E3	5.0	37681E3	5.0	-	-
	1000	16 x 25	1200	400	0.12	0.13	57102E3	7.5	67102E3	7.5	37102E3	7.5	-	-
50	10	5 x 11	65	8	0.10	9.5	51109E6	2.0	-	-	31109E6	5.0	71109E6	2.5
	22	5 x 11	95	14	0.10	4.3	90056E6	2.0	-	-	90063E6	5.0	90064E6	2.5
	47	6.3 x 11	150	27	0.10	2.0	90065E6	2.5	-	-	90072E6	5.0	90073E6	2.5
	68	8 x 12	190	37	0.10	1.4	51689E6	3.5	-	-	31689E6	5.0	71689E6	3.5
	100	8 x 12	260	53	0.10	0.95	51101E6	3.5	-	-	31101E6	5.0	71101E6	3.5
	220	10 x 16	400	110	0.10	0.43	51221E3	5.0	61221E3	5.0	31221E3	5.0	-	-
	330	10 x 20	580	170	0.10	0.29	51331E3	5.0	61331E3	5.0	31331E3	5.0	-	-
	470	12.5 x 20	740	240	0.10	0.20	51471E3	5.0	61471E3	5.0	31471E3	5.0	-	-
	680	12.5 x 25	950	340	0.10	0.14	51681E3	5.0	61681E3	5.0	31681E3	5.0	-	-
	1000	16 x 25	1350	500	0.10	0.10	51102E3	7.5	61102E3	7.5	31102E3	7.5	-	-
	63	0.47	5 x 11	11	3.3	0.09	170	58477E6	2.0	-	-	38477E6	5.0	78477E6
1.0		5 x 11	16	3.6	0.09	80	58108E6	2.0	-	-	38108E6	5.0	78108E6	2.5
2.2		5 x 11	29	4.4	0.09	36	58228E6	2.0	-	-	38228E6	5.0	78228E6	2.5
3.3		5 x 11	35	5.1	0.09	24	58338E6	2.0	-	-	38338E6	5.0	78338E6	2.5
4.7		5 x 11	45	6.0	0.09	17	58478E6	2.0	-	-	38478E6	5.0	78478E6	2.5
10		5 x 11	70	9.3	0.09	8.0	58109E6	2.0	-	-	38109E6	5.0	78109E6	2.5
22		6.3 x 11	110	17	0.09	3.6	58229E6	2.5	-	-	38229E6	5.0	78229E6	2.5
33		6.3 x 11	140	24	0.09	2.4	90074E6	2.5	-	-	90081E6	5.0	90082E6	2.5
47		8 x 12	190	33	0.09	1.7	58479E6	3.5	-	-	38479E6	5.0	78479E6	3.5
68		10 x 12	200	46	0.09	1.2	58689E3	5.0	68689E3	5.0	38689E3	5.0	-	-
100		10 x 12	260	66	0.09	0.80	58101E3	5.0	68101E3	5.0	38101E3	5.0	-	-
150		10 x 16	320	98	0.09	0.53	58151E3	5.0	68151E3	5.0	38151E3	5.0	-	-
220		10 x 20	460	140	0.09	0.36	58221E3	5.0	68221E3	5.0	38221E3	5.0	-	-
330		12.5 x 20	650	210	0.09	0.24	58331E3	5.0	68331E3	5.0	38331E3	5.0	-	-
470		12.5 x 25	850	300	0.09	0.17	58471E3	5.0	68471E3	5.0	38471E3	5.0	-	-
680		16 x 25	1150	430	0.09	0.12	58681E3	7.5	68681E3	7.5	38681E3	7.5	-	-
1000		16 x 31	1550	630	0.09	0.08	58102E3	7.5	68102E3	7.5	38102E3	7.5	-	-
100	0.47	5 x 11	12	3.5	0.07	130	59477E6	2.0	-	-	39477E6	5.0	79477E6	2.5
	1.0	5 x 11	22	4	0.07	60	59108E6	2.0	-	-	39108E6	5.0	79108E6	2.5
	2.2	5 x 11	33	5.2	0.07	27	59228E6	2.0	-	-	39228E6	5.0	79228E6	2.5
	3.3	5 x 11	40	6.3	0.07	18	59338E6	2.0	-	-	39338E6	5.0	79338E6	2.5
	4.7	5 x 11	48	7.7	0.07	13	59478E6	2.0	-	-	39478E6	5.0	79478E6	2.5
	10	6.3 x 11	80	13	0.07	6.0	59109E6	2.5	-	-	39109E6	5.0	79109E6	2.5
	22	8 x 12	130	25	0.07	2.7	59229E6	3.5	-	-	39229E6	5.0	79229E6	3.5
	33	10 x 12	160	36	0.07	1.8	59339E3	5.0	69339E3	5.0	39339E3	5.0	-	-
	47	10 x 16	210	50	0.07	1.3	59479E3	5.0	69479E3	5.0	39479E3	5.0	-	-
	100	10 x 20	350	100	0.07	0.60	59101E3	5.0	69101E3	5.0	39101E3	5.0	-	-
	220	12.5 x 25	580	220	0.07	0.27	59221E3	5.0	69221E3	5.0	39221E3	5.0	-	-
	330	16 x 25	710	330	0.07	0.18	59331E3	7.5	69331E3	7.5	39331E3	7.5	-	-
	470	16 x 31	900	470	0.07	0.13	59471E3	7.5	69471E3	7.5	39471E3	7.5	-	-

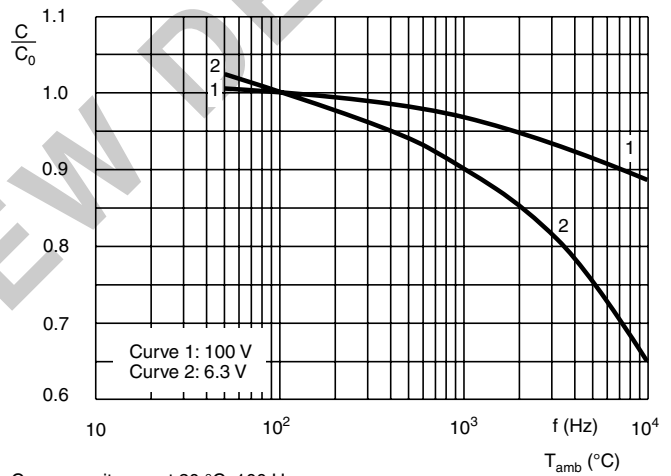
ADDITIONAL ELECTRICAL DATA		
PARAMETER	CONDITIONS	VALUE
<b>Voltage</b>		
Surge voltage		$U_s \leq 1.15 \times U_R$
Reverse voltage		$U_{rev} \leq 1 \text{ V}$
<b>Current</b>		
Leakage current	after 1 min at $U_R$	$I_{L1} \leq 0.01 C_R \times U_R + 3 \mu\text{A}$
	after 5 min at $U_R$	$I_{L5} \leq 0.002 C_R \times U_R + 3 \mu\text{A}$
<b>Inductance</b>		
Equivalent series inductance (ESL)	case $\varnothing D \leq 8 \text{ mm}$	typ. 13 nH
	case $\varnothing D = 10 \text{ mm}$	typ. 16 nH
	case $\varnothing D \geq 12.5 \text{ mm}$	typ. 18 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)**



$C_0$  = capacitance at 20 °C

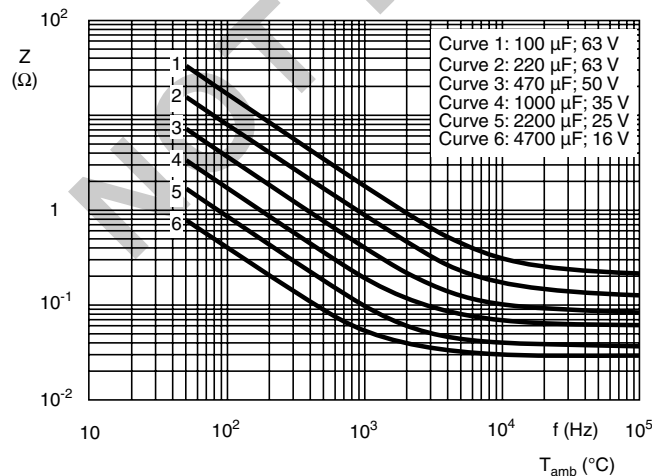
Fig. 6 Typical multiplier of capacitance as a function of ambient temperature

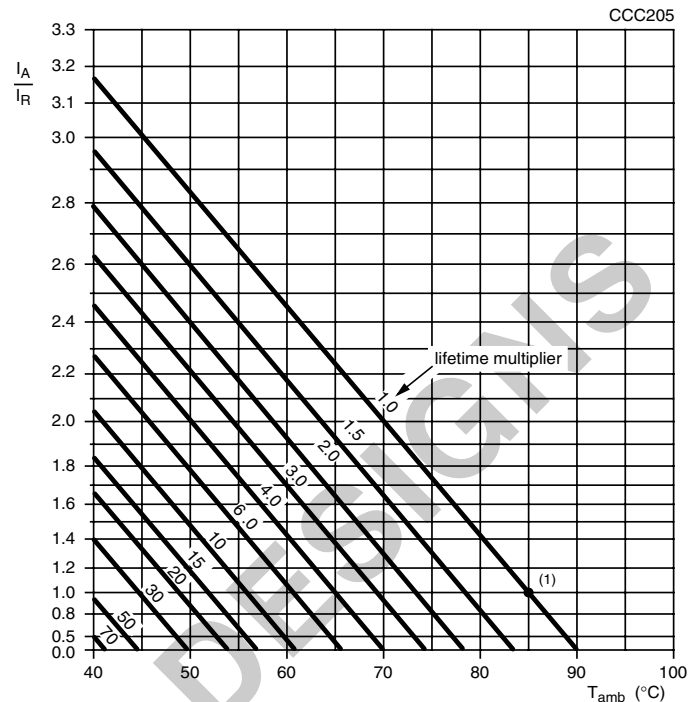


$C_0$  = capacitance at 20 °C, 100 Hz

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

**IMPEDANCE (Z)**



**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: 2500 h

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

**Table 3**

<b>MULTIPLIER OF RIPPLE CURRENT (<math>I_R</math>) AS A FUNCTION OF FREQUENCY</b>			
FREQUENCY (Hz)	$I_R$ MULTIPLIER		
	$U_R = 6.3$ to $10$ V	$U_R = 16$ to $35$ V	$U_R = 40$ to $100$ V
50	0.90	0.85	0.80
100	1.00	1.00	1.00
500	1.12	1.20	1.25
1000	1.20	1.30	1.40
3000	1.25	1.35	1.50
$\geq 10\ 000$	1.30	1.40	1.60

**Table 4**

<b>TEST PROCEDURES AND REQUIREMENTS</b>			
TEST		PROCEDURE (quick reference)	REQUIREMENTS
NAME OF TEST	REFERENCE		
Endurance	IEC 60384-4/ EN130300 subclause 4.13	$T_{amb} = 85$ °C; $U_R$ applied; 2000 h	$U_R \leq 6.3$ V; $\Delta C/C$ : + 15 / - 30 % $U_R > 6.3$ V; $\Delta C/C$ : $\pm 20$ % $\tan \delta \leq 1.5 \times$ spec. limit $Z \leq 3 \times$ spec. limit $I_{L5} \leq$ spec. limit
Useful life	CECC 30301 subclause 1.8.1	$T_{amb} = 85$ °C; $U_R$ and $I_R$ applied; 2500 h	$U_R \leq 6.3$ V; $\Delta C/C$ : + 45 / - 50 % $U_R > 6.3$ V; $\Delta C/C$ : $\pm 50$ % $\tan \delta \leq 3 \times$ spec. limit $Z \leq 3 \times$ spec. limit $I_{L5} \leq$ spec. limit no short or open circuit total failure percentage: $\leq 3$ %
Shelf life (storage at high temperature)	IEC 60384-4/ EN130300 subclause 4.17	$T_{amb} = 85$ °C; no voltage applied; 500 h after test: $U_R$ to be applied for 30 min, 24 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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