

## Aluminum Capacitors Radial Standard Ultra Miniature

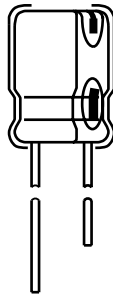
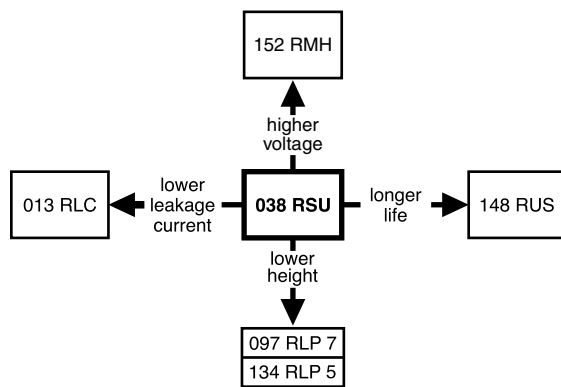


Fig.1 Component outline



### 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
- Compliant to RoHS directive 2002/95/EC


**RoHS  
COMPLIANT**

### APPLICATIONS

- General purpose, industrial, automotive, consumer, 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 18 x 40
Rated capacitance range, $C_R$	0.1 $\mu\text{F}$ to 22 000 $\mu\text{F}$
Tolerance on $C_R$	$\pm 20\%$
Rated voltage range, $U_R$	6.3 V to 100 V
Category temperature range	- 40 °C to + 85 °C
Endurance test at 85 °C:	
case size $\varnothing D \leq 8$ mm	2000 h
case size $\varnothing D \geq 10$ mm	3000 h
Useful life at 85 °C:	
case size $\varnothing D \leq 8$ mm	2500 h
case size $\varnothing D \geq 10$ mm	3500 h
Useful life at 40 °C, 1.4 x $I_R$ applied:	
case size $\varnothing D \leq 8$ mm	60 000 h
case size $\varnothing D \geq 10$ mm	90 000 h
Shelf life at 0 V, 85 °C	1000 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  $\mu\text{F}$ )
- 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 (038)

SELECTION CHART FOR C <sub>R</sub> , U <sub>R</sub> AND RELEVANT NOMINAL CASE SIZES (∅ D x L in mm)								
C <sub>R</sub> (μF)	U <sub>R</sub> (V)							
	6.3	10	16	25	35	50	63	100
0.1	-	-	-	-	-	-	5 x 11	-
0.22	-	-	-	-	-	-	5 x 11	-
0.33	-	-	-	-	-	-	5 x 11	-
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	6.3 x 11
22	-	-	-	-	-	5 x 11	5 x 11	6.3 x 11
33	-	-	-	-	-	5 x 11	6.3 x 11	8 x 11.5
47	-	-	-	-	5 x 11	6.3 x 11	6.3 x 11	10 x 12
100	-	5 x 11	5 x 11	6.3 x 11	6.3 x 11	8 x 11.5	10 x 12	10 x 20
220	5 x 11	5 x 11	6.3 x 11	8 x 11.5	8 x 11.5	10 x 12	10 x 16	13 x 25
330	6.3 x 11	6.3 x 11	8 x 11.5	8 x 11.5	10 x 12	10 x 16	10 x 20	13 x 25
470	6.3 x 11	6.3 x 11	8 x 11.5	10 x 12	10 x 16	10 x 20	13 x 20	16 x 25
1000	8 x 11.5	10 x 12	10 x 16	10 x 20	13 x 20	13 x 25	16 x 25	18 x 40
2200	10 x 16	10 x 20	13 x 20	13 x 25	16 x 25	16 x 31	18 x 35	-
3300	10 x 20	13 x 20	13 x 25	16 x 25	16 x 35	18 x 35	-	-
4700	13 x 20	13 x 25	16 x 25	16 x 31	18 x 35	-	-	-
6800	13 x 25	16 x 25	16 x 31	18 x 35	-	-	-	-
10 000	16 x 25	16 x 35	18 x 35	-	-	-	-	-
22 000	18 x 40	-	-	-	-	-	-	-

**DIMENSIONS in millimeters AND AVAILABLE FORMS**

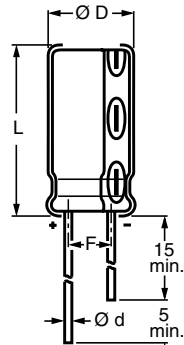


Fig.2 Form CA

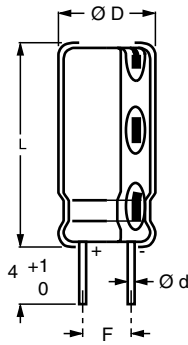


Fig.3 Form CB:  
Cut leads

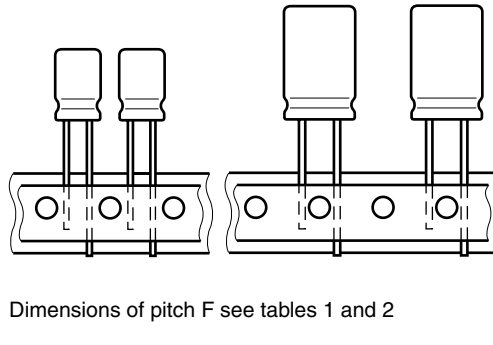


Fig.4 Form TNA, Form TFA:  
Taped in box (ammopack), straight leads

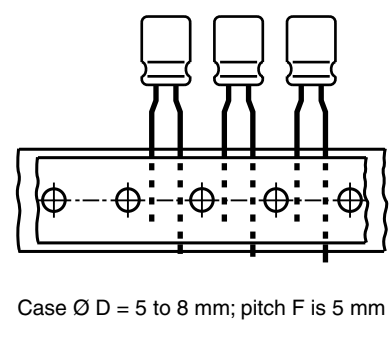


Fig.5 Form TFA:  
Taped in box (ammopack), formed leads

Table 1

DIMENSIONS in millimeters, MASS AND PACKAGING QUANTITIES									
NOMINAL CASE SIZE ∅ D x L	CASE CODE	∅ d	∅ D <sub>max.</sub>	L <sub>max.</sub>	F	MASS (g)	PACKAGING QUANTITIES		
							FORM CA	FORM CB	FORM TFA, TNA
5 x 11	11	0.5	5.5	12.5	2.0 ± 0.5	≈ 0.4	5000	-	2000
6.3 x 11	12	0.5	6.8	12.5	2.5 ± 0.5	≈ 0.6	5000	-	2000
8 x 11.5	13	0.6	8.5	12.5	3.5 ± 0.5	≈ 1.1	5000	-	1000
10 x 12	14	0.6	10.5	13.5	5.0 ± 0.5	≈ 1.6	3000	1000	500
10 x 16	15	0.6	10.5	17.5	5.0 ± 0.5	≈ 1.9	2500	1000	500
10 x 20	16	0.6	10.5	22.0	5.0 ± 0.5	≈ 2.2	2000	800	500
13 x 20	17	0.6	13.5	22.0	5.0 ± 0.5	≈ 4.0	1500	400	300
13 x 25	18	0.6	13.5	27.0	5.0 ± 0.5	≈ 5.0	1000	400	300
16 x 25	19	0.8	16.5	27.0	7.5 ± 0.5	≈ 8.0	750	200	200
16 x 31	20	0.8	16.5	33.5	7.5 ± 0.5	≈ 9.0	600	200	200
16 x 35	21	0.8	16.5	37.5	7.5 ± 0.5	≈ 11.0	500	200	-
18 x 35	22	0.8	18.5	37.5	7.5 ± 0.5	≈ 14.5	400	150	-
18 x 40	23	0.8	18.5	42.0	7.5 ± 0.5	≈ 16.0	400	150	-

**Note**

• Detailed tape dimensions see section 'PACKAGING'.

ELECTRICAL DATA	
SYMBOL	DESCRIPTION
$C_R$	rated capacitance at 100 Hz, tolerance $\pm 20\%$
$I_R$	rated RMS ripple current at 100 Hz, 85 °C
$I_{L2}$	max. leakage current after 2 min at $U_R$
$\tan \delta$	max. dissipation factor at 100 Hz

**Note**

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

**ORDERING EXAMPLE**

Electrolytic capacitor 038 series

 470  $\mu\text{F}/25\text{ V}$ ;  $\pm 20\%$ 

 Nominal case size:  $\varnothing 10\text{ mm} \times 12\text{ mm}$ ; Form TFA

Ordering Code: MAL203836471E3

Former 12NC: 2222 038 36471

Table 2

ELECTRICAL DATA AND ORDERING INFORMATION																	
$U_R$ (V)	$C_R$ 100 Hz ( $\mu\text{F}$ )	NOMINAL CASE SIZE $\varnothing D \times L$ (mm)	$I_R$ 100 Hz 85 °C (mA)	$I_{L2}$ 2 min ( $\mu\text{A}$ )	$\tan \delta$ 100 Hz	ORDERING CODE MAL2038 .....											
						BULK PACKAGING				TAPED AMMOPACK							
						LONG LEADS		CUT LEADS		FORM TFA		F (mm)		FORM TNA		F (mm)	
						FORM CA	F (mm)	FORM CB	F (mm)	FORM TFA	F (mm)	FORM TNA	F (mm)				
6.3	220	5 x 11	200	14	0.23	53221E3	2.0	-	-	33221E3	5.0	73221E3	2.5				
	330	6.3 x 11	270	21	0.23	53331E3	2.5	-	-	33331E3	5.0	73331E3	2.5				
	470	6.3 x 11	320	30	0.23	53471E3	2.5	-	-	33471E3	5.0	73471E3	2.5				
	1000	8 x 11.5	540	63	0.23	53102E3	3.5	-	-	33102E3	5.0	73102E3	3.5				
	2200	10 x 16	785	139	0.25	53222E3	5.0	63222E3	5.0	33222E3	5.0	-	-				
	3300	10 x 20	1185	208	0.27	53332E3	5.0	63332E3	5.0	33332E3	5.0	-	-				
	4700	13 x 20	1545	296	0.29	53472E3	5.0	63472E3	5.0	33472E3	5.0	-	-				
	6800	13 x 25	1880	428	0.33	53682E3	5.0	63682E3	5.0	33682E3	5.0	-	-				
	10 000	16 x 25	2330	630	0.41	53103E3	7.5	63103E3	7.5	33103E3	7.5	-	-				
	22 000	18 x 40	3320	1386	0.65	53223E3	7.5	63223E3	7.5	-	-	-	-				
10	100	5 x 11	145	10	0.20	54101E3	2.0	-	-	34101E3	5.0	74101E3	2.5				
	220	5 x 11	160	22	0.20	54221E3	2.0	-	-	34221E3	5.0	74221E3	2.5				
	330	6.3 x 11	290	33	0.20	54331E3	2.5	-	-	34331E3	5.0	74331E3	2.5				
	470	6.3 x 11	350	47	0.20	54471E3	2.5	-	-	34471E3	5.0	74471E3	2.5				
	1000	10 x 12	650	100	0.20	54102E3	5.0	64102E3	5.0	34102E3	5.0	-	-				
	2200	10 x 20	1070	220	0.22	54222E3	5.0	64222E3	5.0	34222E3	5.0	-	-				
	3300	13 x 20	1420	330	0.24	54332E3	5.0	64332E3	5.0	34332E3	5.0	-	-				
	4700	13 x 25	1780	470	0.26	54472E3	5.0	64472E3	5.0	34472E3	5.0	-	-				
	6800	16 x 25	2220	680	0.30	54682E3	7.5	64682E3	7.5	34682E3	7.5	-	-				
	10 000	16 x 35	2760	1000	0.38	54103E3	7.5	64103E3	7.5	-	-	-	-				
16	100	5 x 11	160	16	0.16	55101E3	2.0	-	-	35101E3	5.0	75101E3	2.5				
	220	6.3 x 11	260	35	0.16	55221E3	2.5	-	-	35221E3	5.0	75221E3	2.5				
	330	8 x 11.5	370	53	0.16	55331E3	3.5	-	-	35331E3	5.0	75331E3	3.5				
	470	8 x 11.5	440	75	0.16	55471E3	3.5	-	-	35471E3	5.0	75471E3	3.5				
	1000	10 x 16	785	160	0.16	55102E3	5.0	65102E3	5.0	35102E3	5.0	-	-				
	2200	13 x 20	1295	352	0.18	55222E3	5.0	65222E3	5.0	35222E3	5.0	-	-				
	3300	13 x 25	1655	528	0.20	55332E3	5.0	65332E3	5.0	35332E3	5.0	-	-				
	4700	16 x 25	2090	752	0.22	55472E3	7.5	65472E3	7.5	35472E3	7.5	-	-				
	6800	16 x 31	2520	1088	0.26	55682E3	7.5	65682E3	7.5	35682E3	7.5	-	-				
	10 000	18 x 35	2920	1600	0.34	55103E3	7.5	65103E3	7.5	-	-	-	-				
25	100	6.3 x 11	190	25	0.14	56101E3	2.5	-	-	36101E3	5.0	76101E3	2.5				
	220	8 x 11.5	320	55	0.14	56221E3	3.5	-	-	36221E3	5.0	76221E3	3.5				
	330	8 x 11.5	440	83	0.14	56331E3	3.5	-	-	36331E3	5.0	76331E3	3.5				
	470	10 x 12	545	118	0.14	56471E3	5.0	66471E3	5.0	36471E3	5.0	-	-				
	1000	10 x 20	955	250	0.14	56102E3	5.0	66102E3	5.0	36102E3	5.0	-	-				
	2200	13 x 25	1540	550	0.16	56222E3	5.0	66222E3	5.0	36222E3	5.0	-	-				
	3300	16 x 25	1975	825	0.18	56332E3	7.5	66332E3	7.5	36332E3	7.5	-	-				
	4700	16 x 31	2420	1175	0.20	56472E3	7.5	66472E3	7.5	36472E3	7.5	-	-				
	6800	18 x 35	2880	1700	0.24	56682E3	7.5	66682E3	7.5	-	-	-	-				

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)	I <sub>R</sub> 100 Hz 85 °C (mA)	I <sub>L2</sub> 2 min (μA)	tan δ 100 Hz	ORDERING CODE MAL2038 .....											
						BULK PACKAGING				TAPED AMMOPACK							
						LONG LEADS		CUT LEADS		FORM TFA		F (mm)		FORM TNA		F (mm)	
						FORM CA	F (mm)	FORM CB	F (mm)	FORM TFA	F (mm)	FORM TNA	F (mm)				
35	47	5 x 11	130	17	0.12	50479E3	2.0	-	-	30479E3	5.0	70479E3	2.5				
	100	6.3 x 11	210	35	0.12	50101E3	2.5	-	-	30101E3	5.0	70101E3	2.5				
	220	8 x 11.5	385	77	0.12	50221E3	3.5	-	-	30221E3	5.0	70221E3	3.5				
	330	10 x 12	490	116	0.12	50331E3	5.0	60331E3	5.0	30331E3	5.0	-	-				
	470	10 x 16	740	165	0.12	50471E3	5.0	60471E3	5.0	30471E3	5.0	-	-				
	1000	13 x 20	1145	350	0.12	50102E3	5.0	60102E3	5.0	30102E3	5.0	-	-				
	2200	16 x 25	1785	770	0.14	50222E3	7.5	60222E3	7.5	30222E3	7.5	-	-				
	3300	16 x 35	2275	1155	0.16	50332E3	7.5	60332E3	7.5	-	-	-	-				
4700	18 x 35	2700	1645	0.18	50472E3	7.5	60472E3	7.5	-	-	-	-					
50	22	5 x 11	95	11	0.10	51229E3	2.0	-	-	31229E3	5.0	71229E3	2.5				
	33	5 x 11	125	17	0.10	51339E3	2.0	-	-	31339E3	5.0	71339E3	2.5				
	47	6.3 x 11	165	24	0.10	51479E3	2.5	-	-	31479E3	5.0	71479E3	2.5				
	100	8 x 11.5	260	50	0.10	51101E3	3.5	-	-	31101E3	5.0	71101E3	3.5				
	220	10 x 12	455	110	0.10	51221E3	5.0	61221E3	5.0	31221E3	5.0	-	-				
	330	10 x 16	585	165	0.10	51331E3	5.0	61331E3	5.0	31331E3	5.0	-	-				
	470	10 x 20	755	235	0.10	51471E3	5.0	61471E3	5.0	31471E3	5.0	-	-				
	1000	13 x 25	1340	500	0.10	51102E3	5.0	61102E3	5.0	31102E3	5.0	-	-				
2200	16 x 31	1885	1100	0.12	51222E3	7.5	61222E3	7.5	31222E3	7.5	-	-					
3300	18 x 35	2500	1650	0.14	51332E3	7.5	61332E3	7.5	-	-	-	-					
63	0.10	5 x 11	3.0	3.0	0.09	58107E3	2.0	-	-	38107E3	5.0	78107E3	2.5				
	0.22	5 x 11	4.5	3.0	0.09	58227E3	2.0	-	-	38227E3	5.0	78227E3	2.5				
	0.33	5 x 11	7.5	3.0	0.09	58337E3	2.0	-	-	38337E3	5.0	78337E3	2.5				
	0.47	5 x 11	9.5	3.0	0.09	58477E3	2.0	-	-	38477E3	5.0	78477E3	2.5				
	1.0	5 x 11	17	3.0	0.09	58108E3	2.0	-	-	38108E3	5.0	78108E3	2.5				
	2.2	5 x 11	28	3.0	0.09	58228E3	2.0	-	-	38228E3	5.0	78228E3	2.5				
	3.3	5 x 11	34	3.0	0.09	58338E3	2.0	-	-	38338E3	5.0	78338E3	2.5				
	4.7	5 x 11	45	3.0	0.09	58478E3	2.0	-	-	38478E3	5.0	78478E3	2.5				
	10	5 x 11	70	6.3	0.09	58109E3	2.0	-	-	38109E3	5.0	78109E3	2.5				
	22	5 x 11	105	14	0.09	58229E3	2.0	-	-	38229E3	5.0	78229E3	2.5				
	33	6.3 x 11	140	21	0.09	58339E3	2.5	-	-	38339E3	5.0	78339E3	2.5				
	47	6.3 x 11	170	30	0.09	58479E3	2.5	-	-	38479E3	5.0	78479E3	2.5				
	100	10 x 12	320	63	0.09	58101E3	5.0	68101E3	5.0	38101E3	5.0	-	-				
	220	10 x 16	490	139	0.09	58221E3	5.0	68221E3	5.0	38221E3	5.0	-	-				
330	10 x 20	710	208	0.09	58331E3	5.0	68331E3	5.0	38331E3	5.0	-	-					
470	13 x 20	900	296	0.09	58471E3	5.0	68471E3	5.0	38471E3	5.0	-	-					
1000	16 x 25	1560	630	0.09	58102E3	7.5	68102E3	7.5	38102E3	7.5	-	-					
2200	18 x 35	1950	1386	0.11	58222E3	7.5	68222E3	7.5	-	-	-	-					
100	0.47	5 x 11	12	3.0	0.08	59477E3	2.0	-	-	39477E3	5.0	79477E3	2.5				
	1.0	5 x 11	22	3.0	0.08	59108E3	2.0	-	-	39108E3	5.0	79108E3	2.5				
	2.2	5 x 11	33	3.0	0.08	59228E3	2.0	-	-	39228E3	5.0	79228E3	2.5				
	3.3	5 x 11	40	3.3	0.08	59338E3	2.0	-	-	39338E3	5.0	79338E3	2.5				
	4.7	5 x 11	48	4.7	0.08	59478E3	2.0	-	-	39478E3	5.0	79478E3	2.5				
	10	6.3 x 11	80	10	0.08	59109E3	2.5	-	-	39109E3	5.0	79109E3	2.5				
	22	6.3 x 11	115	22	0.08	59229E3	2.5	-	-	39229E3	5.0	79229E3	2.5				
	33	8 x 11.5	145	33	0.08	59339E3	3.5	-	-	39339E3	5.0	79339E3	3.5				
	47	10 x 12	235	47	0.08	59479E3	5.0	69479E3	5.0	39479E3	5.0	-	-				
	100	10 x 20	370	100	0.08	59101E3	5.0	69101E3	5.0	39101E3	5.0	-	-				
	220	13 x 25	675	220	0.08	59221E3	5.0	69221E3	5.0	39221E3	5.0	-	-				
	330	13 x 25	825	330	0.08	59331E3	5.0	69331E3	5.0	39331E3	5.0	-	-				
	470	16 x 25	1070	470	0.08	59471E3	7.5	69471E3	7.5	39471E3	7.5	-	-				
	1000	18 x 40	2410	1000	0.08	59102E3	7.5	69102E3	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 2 min at $U_R$	$I_{L2} \leq 0.01 C_R \times U_R$ or $3 \mu\text{A}$ , whichever is greater
	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)	$ESR = \tan \delta / 2 \pi f C_R$

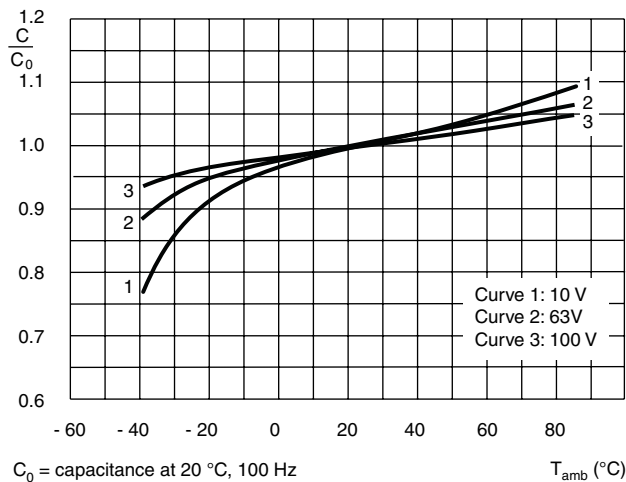
**CAPACITANCE (C)**


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

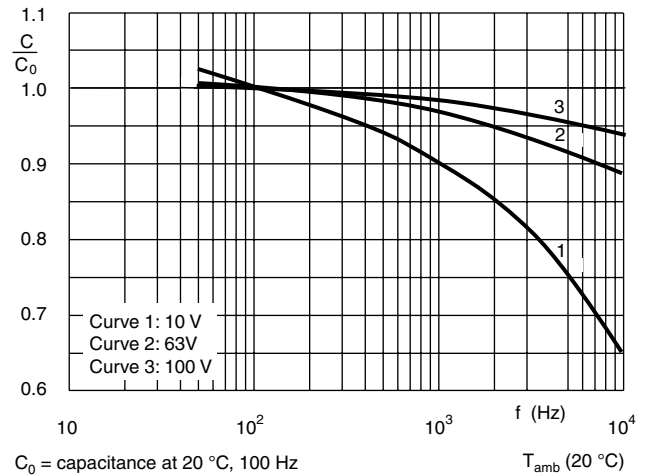
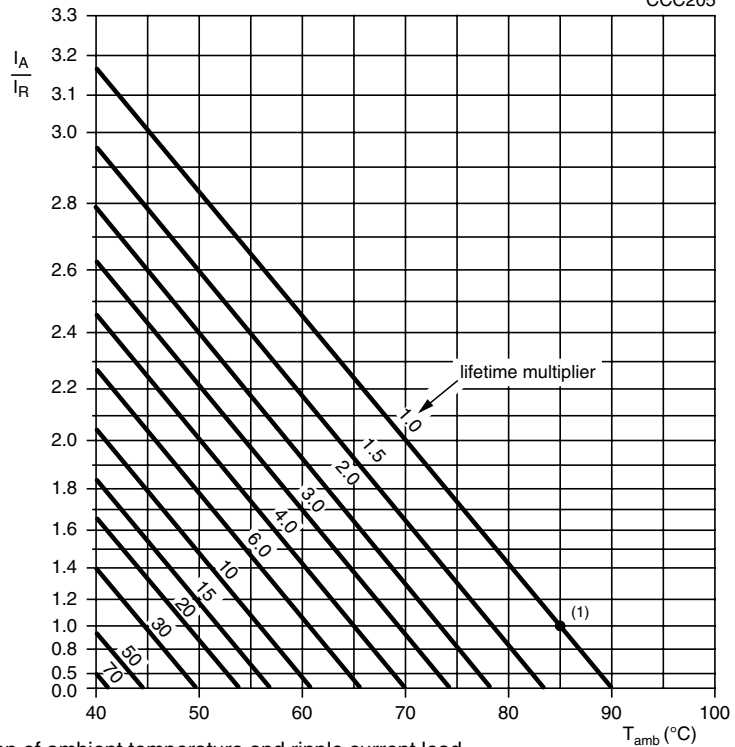


Fig.7 Typical multiplier of capacitance as a function of frequency

**RIPPLE CURRENT AND USEFUL LIFE**

CCC205



$I_A$  = actual ripple current at 100 Hz  
 $I_R$  = rated ripple current at 100 Hz, 85 °C  
 Useful life at 85 °C and  $I_R$  applied:  
 case  $\varnothing D \leq 8$  mm: 2500 h  
 case  $\varnothing D \geq 10$  mm: 3500 h

Fig.8 Multiplier of useful life as a function of ambient temperature and ripple current load

Table 3

MULTIPLIER OF RIPPLE CURRENT ( $I_R$ ) AS A FUNCTION OF FREQUENCY			
FREQUENCY (Hz)	$I_R$ MULTIPLIER		
	$C_R < 100 \mu F$	$C_R = 100$ to $1000 \mu F$	$C_R > 1000 \mu F$
50	0.70	0.75	0.80
100	1.00	1.00	1.00
500	1.30	1.20	1.10
1000	1.40	1.30	1.12
$\geq 10\ 000$	1.50	1.35	1.15

Table 4

TEST PROCEDURES AND REQUIREMENTS			
TEST		PROCEDURE (quick reference)	REQUIREMENTS
NAME OF TEST	REFERENCE		
Endurance	IEC 60384-4/ EN130300 subclause 4.13	$T_{amb} = 85$ °C; $U_R$ applied; case $\varnothing \leq 8$ mm: 2000 h case $\varnothing \geq 10$ mm: 3000 h	$\Delta C/C: \pm 20$ % $\tan \delta \leq 2$ x 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; case $\varnothing \leq 8$ mm: 2500 h case $\varnothing \geq 10$ mm: 3500 h	$\Delta C/C: \pm 50$ % $\tan \delta \leq 3$ x spec. limit $I_{L5} \leq$ spec. limit no short or open circuit total failure percentage: $\leq 1$ %
Shelf life (storage at high temperature)	IEC 60384-4/ EN130300 subclause 4.17	$T_{amb} = 85$ °C; no voltage applied; 1000 h after test: $U_R$ to be applied for 30 min, 24 to 48 h before measurement	$\Delta C/C: \pm 20$ % $\tan \delta \leq 2$ x spec. limit $I_{L5} \leq 3$ x spec. limit
Surge	IEC 60384-4/ EN130300 subclause 4.14	from source of $1.15 \times U_R$ ; $RC = 0.1 \pm 0.05$ s; 1000 cycles of 30 s on, 330 s off, at 85 °C	$\Delta C/C: \pm 25$ % $\tan \delta \leq 1.5$ x spec. limit $I_{L5} \leq$ spec. limit



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