

Aluminum Capacitors Radial High Temperature Standard

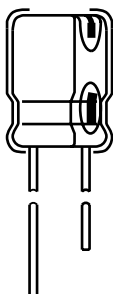
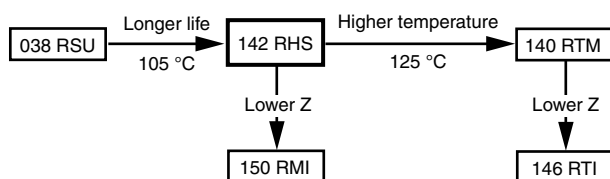


Fig.1 Component outline



QUICK REFERENCE DATA

DESCRIPTION	VALUE
Nominal case sizes (Ø D x L in mm)	5 x 11 to 18 x 40
Rated capacitance range, C _R	1 µF to 22 000 µF
Tolerance on C _R	± 20 %
Rated voltage range, U _R	10 V to 450 V
Category temperature range	- 40 °C to + 105 °C
Endurance test at 105 °C	2000 h
Useful life at 105 °C	2500 h
Useful life at 40 °C, 1.6 x I _R applied	140 000 h
Shelf life at 0 V, 105 °C	1000 h
Based on sectional specification	IEC 60384-4/EN130300
Climatic category IEC 60068	40/105/56

FEATURES

- Polarized aluminum electrolytic capacitors, non-solid electrolyte
- Radial leads, cylindrical aluminum case, insulated with a blue sleeve
- Pressure relief for case Ø D ≥ 6.3 mm
- Charge and discharge proof
- Miniaturized, high CV-product per unit volume
- Compliant to RoHS directive 2002/95/EC



RoHS
COMPLIANT

APPLICATIONS

- Industrial, telecom and domestic appliances
- Decoupling, smoothing, filtering, buffering in SMPS
- Portable and mobile equipment (small size, low mass)

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 (M for ± 20 %)
- Rated voltage (in V)
- Date code, in accordance with IEC 60062
- Code indicating factory of origin
- Name or logo of manufacturer
- Negative terminal identification
- Series number (142)

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

C_R (μ F)	U_R (V)						
	10	16	25	35	50	63	100
1.0	→	→	→	→	→	→	5 x 11
2.2	→	→	→	→	→	→	5 x 11
4.7	→	→	→	→	→	5 x 11	6.3 x 11
10	→	→	→	→	→	5 x 11	8 x 12
22	→	→	→	→	5 x 11	6.3 x 11	8 x 12
33	→	→	→	→	6.3 x 11	6.3 x 11	10 x 12
47	→	→	5 x 11	5 x 11	8 x 12	8 x 12	10 x 16
100	→	5 x 11	6.3 x 11	6.3 x 11	10 x 12	10 x 12	10 x 20
220	→	6.3 x 11	8 x 12	8 x 12	10 x 16	10 x 16	12.5 x 25
330	6.3 x 11	8 x 12	→	10 x 12	10 x 16	10 x 20	16 x 25
470	8 x 12	10 x 12	10 x 12	10 x 16	12.5 x 20	12.5 x 20	16 x 31
1000	10 x 12	10 x 16	10 x 20	12.5 x 20	12.5 x 25	16 x 25	18 x 40
2200	10 x 20	12.5 x 20	12.5 x 25	16 x 25	16 x 35	18 x 40	-
3300	→	12.5 x 25	16 x 25	16 x 31	18 x 35	-	-
4700	12.5 x 25	16 x 25	16 x 31	18 x 35	-	-	-
6800	16 x 25	16 x 31	18 x 35	-	-	-	-
10 000	16 x 31	18 x 31	-	-	-	-	-
22 000	18 x 40	-	-	-	-	-	-

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

C_R (μ F)	U_R (V)				
	200	250	350	400	450
1.0	5 x 11	5 x 11	6.3 x 11	6.3 x 11	8 x 12
2.2	6.3 x 11	6.3 x 11	8 x 12	8 x 12	10 x 12
4.7	8 x 12	8 x 12	10 x 12	10 x 12	10 x 16
10	10 x 12	10 x 12	10 x 16	10 x 20	12.5 x 20
22	10 x 16	10 x 20	12.5 x 20	12.5 x 25	16 x 20
33	→	12.5 x 20	→	→	16 x 25
47	12.5 x 20	12.5 x 25	16 x 25	16 x 31	16 x 35
100	16 x 25	16 x 31	18 x 35	18 x 40	-
220	18 x 35	-	-	-	-

DIMENSIONS in millimeters AND AVAILABLE FORMS

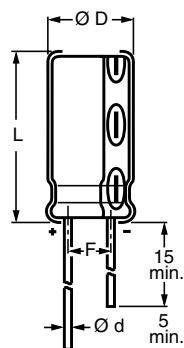


Fig.2 **Form CA**
Long leads

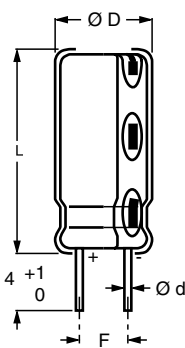
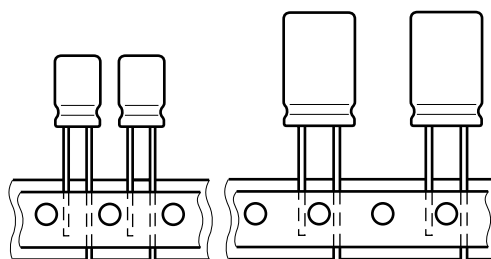
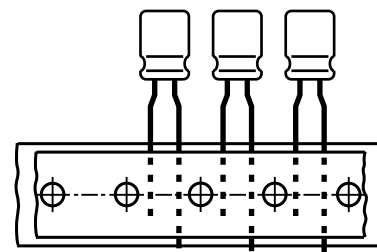


Fig.3 **Form CB**
Cut leads



Dimensions of lead space F see table 2

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



Case Ø D = 5 mm to 8 mm;
Lead space F is 5 mm

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

Table 1

DIMENSIONS in millimeters, MASS AND PACKAGING QUANTITIES									
NOMINAL CASE SIZE Ø D x L	CASE CODE	Ø d	Ø 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 ± 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 12	13	0.6	8.5	13.0	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
12.5 x 20	17	0.6	13.0	22.0	5.0 ± 0.5	≈ 4.0	1500	400	300
12.5 x 25	18	0.6	13.0	27.0	5.0 ± 0.5	≈ 5.0	1000	400	300
16 x 20	19a	0.8	16.5	22.0	7.5 ± 0.5	≈ 6.0	1000	200	200
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 31	1831	0.8	18.5	33.5	7.5 ± 0.5	≈ 12.5	400	150	-
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, 105 °C
I_{L2}	max. leakage current after 2 minutes at $U_R = 10\text{ V}$ to 100 V
I_{L5}	max. leakage current after 5 minutes at $U_R = 200\text{ V}$ to 450 V
$\tan \delta$	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 kPa, $RH = 45\%$ to 75 %.

ORDERING EXAMPLE

Electrolytic capacitor 142 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: MAL214236471E3

Table 2

ELECTRICAL DATA AND ORDERING INFORMATION													
U _R (V)	C _R 100 Hz (μF)	NOMINAL CASE SIZE Ø D x L (mm)	I _R 100 Hz 105 °C (mA)	I _{L2} 2 min (μA)	tan δ 100 Hz	ORDERING CODE MAL2142...							
						BULK PACKAGING				TAPED AMMOPACK			
						LONG LEADS		CUT LEADS					
						FORM CA	F (mm)	FORM CB	F (mm)	FORM TNA	F (mm)	FORM TFA	F (mm)
10	330	6.3 x 11	200	33	0.20	54331E3	2.5	-	-	74331E3	2.5	34331E3	5.0
	470	8 x 12	290	47	0.20	54471E3	3.5	-	-	74471E3	3.5	34471E3	5.0
	1000	10 x 12	460	100	0.20	54102E3	5.0	64102E3	5.0	-	-	34102E3	5.0
	2200	10 x 20	760	220	0.22	54222E3	5.0	64222E3	5.0	-	-	34222E3	5.0
	4700	12.5 x 25	1260	470	0.26	54472E3	5.0	64472E3	5.0	-	-	34472E3	5.0
	6800	16 x 25	1690	680	0.28	54682E3	7.5	64682E3	7.5	-	-	34682E3	7.5
	10 000	16 x 31	2120	1000	0.30	54103E3	7.5	64103E3	7.5	-	-	34103E3	7.5
	22 000	18 x 40	3100	2200	0.32	54223E3	7.5	64223E3	7.5	-	-	-	-
	16	100	5 x 11	110	16	0.16	55101E3	2.0	-	-	75101E3	2.5	35101E3
220		6.3 x 11	190	35	0.16	55221E3	2.5	-	-	75221E3	2.5	35221E3	5.0
330		8 x 12	270	53	0.16	55331E3	3.5	-	-	75331E3	3.5	35331E3	5.0
470		10 x 12	370	75	0.16	55471E3	5.0	65471E3	5.0	-	-	35471E3	5.0
1000		10 x 16	560	160	0.16	55102E3	5.0	65102E3	5.0	-	-	35102E3	5.0
2200		12.5 x 20	920	352	0.18	55222E3	5.0	65222E3	5.0	-	-	35222E3	5.0
3300		12.5 x 25	1170	528	0.20	55332E3	5.0	65332E3	5.0	-	-	35332E3	5.0
4700		16 x 25	1480	752	0.22	55472E3	7.5	65472E3	7.5	-	-	35472E3	7.5
6800		16 x 31	1930	1088	0.24	55682E3	7.5	65682E3	7.5	-	-	35682E3	7.5
10 000		18 x 31	2330	1600	0.26	55103E3	7.5	65103E3	7.5	-	-	-	-
25	47	5 x 11	97	12	0.14	56479E3	2.0	-	-	76479E3	2.5	36479E3	5.0
	100	6.3 x 11	142	25	0.14	56101E3	2.5	-	-	76101E3	2.5	36101E3	5.0
	220	8 x 12	236	55	0.14	56221E3	3.5	-	-	76221E3	3.5	36221E3	5.0
	470	10 x 12	380	118	0.14	56471E3	5.0	66471E3	5.0	-	-	36471E3	5.0
	1000	10 x 20	680	250	0.14	56102E3	5.0	66102E3	5.0	-	-	36102E3	5.0
	2200	12.5 x 25	1110	550	0.16	56222E3	5.0	66222E3	5.0	-	-	36222E3	5.0
	3300	16 x 25	1440	825	0.18	56332E3	7.5	66332E3	7.5	-	-	36332E3	7.5
	4700	16 x 31	1710	1175	0.20	56472E3	7.5	66472E3	7.5	-	-	36472E3	7.5
	6800	18 x 35	2160	1700	0.22	56682E3	7.5	66682E3	7.5	-	-	-	-

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Vishay BCcomponents

ELECTRICAL DATA AND ORDERING INFORMATION

U _R (V)	C _R 100 Hz (μF)	NOMINAL CASE SIZE Ø D x L (mm)	I _R 100 Hz 105 °C (mA)	I _{L2} 2 min (μA)	tan δ 100 Hz	ORDERING CODE MAL2142...							
						BULK PACKAGING				TAPED AMMOPACK			
						LONG LEADS		CUT LEADS		FORM TNA		FORM TFA	
						FORM CA	F (mm)	FORM CB	F (mm)	FORM TNA	F (mm)	FORM TFA	F (mm)
35	47	5 x 11	90	16	0.12	50479E3	2.0	-	-	70479E3	2.5	30479E3	5.0
	100	6.3 x 11	150	35	0.12	50101E3	2.5	-	-	70101E3	2.5	30101E3	5.0
	220	8 x 12	270	77	0.12	50221E3	3.5	-	-	70221E3	3.5	30221E3	5.0
	330	10 x 12	350	116	0.12	50331E3	5.0	60331E3	5.0	-	-	30331E3	5.0
	470	10 x 16	460	165	0.12	50471E3	5.0	60471E3	5.0	-	-	30471E3	5.0
	1000	12.5 x 20	810	350	0.12	50102E3	5.0	60102E3	5.0	-	-	30102E3	5.0
	2200	16 x 25	1260	770	0.14	50222E3	7.5	60222E3	7.5	-	-	30222E3	7.5
	3300	16 x 31	1420	1155	0.16	50332E3	7.5	60332E3	7.5	-	-	30332E3	7.5
	4700	18 x 35	1900	1645	0.18	50472E3	7.5	60472E3	7.5	-	-	-	-
50	22	5 x 11	78	11	0.10	51229E3	2.0	-	-	71229E3	2.5	31229E3	5.0
	47	6.3 x 11	120	24	0.10	51479E3	2.5	-	-	71479E3	2.5	31479E3	5.0
	100	8 x 12	188	50	0.10	51101E3	3.5	-	-	71101E3	3.5	31101E3	5.0
	220	10 x 12	240	110	0.10	51221E3	5.0	61221E3	5.0	-	-	31221E3	5.0
	330	10 x 16	410	165	0.10	51331E3	5.0	61331E3	5.0	-	-	31331E3	5.0
	470	12.5 x 20	530	235	0.10	51471E3	5.0	61471E3	5.0	-	-	31471E3	5.0
	1000	12.5 x 25	950	500	0.10	51102E3	5.0	61102E3	5.0	-	-	31102E3	5.0
	2200	16 x 35	1470	1100	0.12	51222E3	7.5	61222E3	7.5	-	-	-	-
	3300	18 x 35	1770	1650	0.14	51332E3	7.5	61332E3	7.5	-	-	-	-
63	4.7	5 x 11	36	3	0.09	58478E3	2.0	-	-	78478E3	2.5	38478E3	5.0
	10	5 x 11	54	6	0.09	58109E3	2.0	-	-	78109E3	2.5	38109E3	5.0
	22	6.3 x 11	86	14	0.09	58229E3	2.5	-	-	78229E3	2.5	38229E3	5.0
	33	6.3 x 11	100	21	0.09	58339E3	2.5	-	-	78339E3	2.5	38339E3	5.0
	47	8 x 12	141	30	0.09	58479E3	3.5	-	-	78479E3	3.5	38479E3	5.0
	100	10 x 12	235	63	0.09	58101E3	5.0	68101E3	5.0	-	-	38101E3	5.0
	220	10 x 16	335	139	0.09	58221E3	5.0	68221E3	5.0	-	-	38221E3	5.0
	330	10 x 20	510	208	0.09	58331E3	5.0	68331E3	5.0	-	-	38331E3	5.0
	470	12.5 x 20	640	296	0.09	58471E3	5.0	68471E3	5.0	-	-	38471E3	5.0
	1000	16 x 25	930	630	0.09	58102E3	7.5	68102E3	7.5	-	-	38102E3	7.5
100	2200	18 x 40	2340	1380	0.09	58222E3	7.5	68222E3	7.5	-	-	-	-
	1.0	5 x 11	15	3	0.08	59108E3	2.0	-	-	79108E3	2.5	39108E3	5.0
	2.2	5 x 11	30	3	0.08	59228E3	2.0	-	-	79228E3	2.5	39228E3	5.0
	4.7	6.3 x 11	40	5	0.08	59478E3	2.5	-	-	79478E3	2.5	39478E3	5.0
	10	8 x 12	66	10	0.08	59109E3	3.5	-	-	79109E3	3.5	39109E3	5.0
	22	8 x 12	99	22	0.08	59229E3	3.5	-	-	79229E3	3.5	39229E3	5.0
	33	10 x 12	148	33	0.08	59339E3	5.0	69339E3	5.0	-	-	39339E3	5.0
	47	10 x 16	180	47	0.08	59479E3	5.0	69479E3	5.0	-	-	39479E3	5.0
	100	10 x 20	265	100	0.08	59101E3	5.0	69101E3	5.0	-	-	39101E3	5.0
	220	12.5 x 25	440	220	0.08	59221E3	5.0	69221E3	5.0	-	-	39221E3	5.0
	330	16 x 25	540	330	0.08	59331E3	7.5	69331E3	7.5	-	-	39331E3	7.5
	470	16 x 31	715	470	0.08	59471E3	7.5	69471E3	7.5	-	-	39471E3	7.5
	1000	18 x 40	985	1000	0.08	59102E3	7.5	69102E3	7.5	-	-	-	-

ELECTRICAL DATA AND ORDERING INFORMATION

U_R (V)	C_R 100 Hz (μF)	NOMINAL CASE SIZE $\varnothing D \times L$ (mm)	I_R 100 Hz 105 °C (mA)	I_{L2} 2 min (μA)	$\tan \delta$ 100 Hz	ORDERING CODE MAL2142...							
						BULK PACKAGING				TAPED AMMOPACK			
						LONG LEADS		CUT LEADS					
						FORM CA	F (mm)	FORM CB	F (mm)	FORM TNA	F (mm)	FORM TFA	F (mm)
200	1.0	5 x 11	18	21	0.14	52108E3	2.0	-	-	72108E3	2.5	32108E3	5.0
	2.2	6.3 x 11	30	28	0.14	52228E3	2.5	-	-	72228E3	2.5	32228E3	5.0
	4.7	8 x 12	54	43	0.14	52478E3	3.5	-	-	72478E3	3.5	32478E3	5.0
	10	10 x 12	94	65	0.14	52109E3	5.0	62109E3	5.0	-	-	32109E3	5.0
	22	10 x 16	142	113	0.14	52229E3	5.0	62229E3	5.0	-	-	32229E3	5.0
	47	12.5 x 20	250	213	0.14	52479E3	5.0	62479E3	5.0	-	-	32479E3	5.0
	100	16 x 25	485	425	0.14	52101E3	7.5	62101E3	7.5	-	-	32101E3	7.5
	220	18 x 35	835	905	0.14	52221E3	7.5	62221E3	7.5	-	-	-	-
250	1.0	5 x 11	16	23	0.17	51083E3	2.0	-	-	71083E3	2.5	31083E3	5.0
	2.2	6.3 x 11	35	32	0.17	52283E3	2.5	-	-	72283E3	2.5	32283E3	5.0
	4.7	8 x 12	60	50	0.17	54783E3	3.5	-	-	74783E3	3.5	34783E3	5.0
	10	10 x 12	92	75	0.17	51093E3	5.0	61093E3	5.0	-	-	31093E3	5.0
	22	10 x 20	215	135	0.17	52293E3	5.0	62293E3	5.0	-	-	32293E3	5.0
	33	12.5 x 20	315	190	0.17	53393E3	5.0	63393E3	5.0	-	-	33393E3	5.0
	47	12.5 x 25	350	260	0.17	54793E3	5.0	64793E3	5.0	-	-	34793E3	5.0
	100	16 x 31	530	525	0.17	51013E3	7.5	61013E3	7.5	-	-	31013E3	7.5
350	1.0	6.3 x 11	23	26	0.20	51085E3	2.5	-	-	71085E3	2.5	31085E3	5.0
	2.2	8 x 12	41	38	0.20	52285E3	3.5	-	-	72285E3	3.5	32285E3	5.0
	4.7	10 x 12	65	58	0.20	54785E3	5.0	64785E3	5.0	-	-	34785E3	5.0
	10	10 x 16	105	95	0.20	51095E3	5.0	61095E3	5.0	-	-	31095E3	5.0
	22	12.5 x 20	210	179	0.20	52295E3	5.0	62295E3	5.0	-	-	32295E3	5.0
	47	16 x 25	365	354	0.20	54795E3	7.5	64795E3	7.5	-	-	34795E3	7.5
	100	18 x 35	505	725	0.20	51015E3	7.5	61015E3	7.5	-	-	-	-
400	1.0	6.3 x 11	21	27	0.25	51086E3	2.5	-	-	71086E3	2.5	31086E3	5.0
	2.2	8 x 12	39	41	0.25	52286E3	3.5	-	-	72286E3	3.5	32286E3	5.0
	4.7	10 x 12	70	63	0.25	54786E3	5.0	64786E3	5.0	-	-	34786E3	5.0
	10	10 x 20	125	105	0.25	51096E3	5.0	61096E3	5.0	-	-	31096E3	5.0
	22	12.5 x 25	235	201	0.25	52296E3	5.0	62296E3	5.0	-	-	32296E3	5.0
	47	16 x 31	390	401	0.25	54796E3	7.5	64796E3	7.5	-	-	34796E3	7.5
	100	18 x 40	530	825	0.25	51016E3	7.5	61016E3	7.5	-	-	-	-
450	1.0	8 x 12	27	29	0.25	57108E3	3.5	-	-	77108E3	3.5	37108E3	5.0
	2.2	10 x 12	48	45	0.25	57228E3	5.0	67228E3	5.0	-	-	37228E3	5.0
	4.7	10 x 16	75	67	0.25	57478E3	5.0	67478E3	5.0	-	-	37478E3	5.0
	10	12.5 x 20	145	115	0.25	57109E3	5.0	67109E3	5.0	-	-	37109E3	5.0
	22	16 x 20	245	223	0.25	57229E3	7.5	67229E3	7.5	-	-	37229E3	7.5
	33	16 x 25	325	322	0.25	57339E3	7.5	67339E3	7.5	-	-	37339E3	7.5
	47	16 x 35	420	448	0.25	57479E3	7.5	67479E3	7.5	-	-	-	-

ADDITIONAL ELECTRICAL DATA		
PARAMETER	CONDITIONS	VALUE
Voltage		
Surge voltage		$U_s \leq 1.15 \times U_R$
Reverse voltage		$U_{rev} \leq 1 \text{ V}$
Current		
Leakage current	After 2 minutes at $U_R = 10 \text{ V}$ to 100 V	$I_{L2} \leq 0.01 C_R \times U_R$ or $3 \mu\text{A}$, whichever is greater
	After 5 minutes at $U_R = 200 \text{ V}$ to 450 V	$I_{L5} \leq 0.03 C_R \times U_R + 15 \mu\text{A}$ ($C_R \times U_R \leq 1000$) $I_{L5} \leq 0.02 C_R \times U_R + 25 \mu\text{A}$ ($C_R \times U_R > 1000$)
Inductance		
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
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)

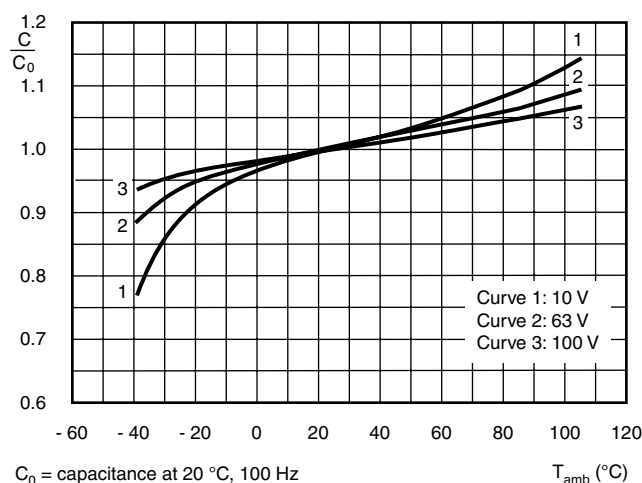


Fig.6 Typical multiplier of capacitance as a function of ambient temperature

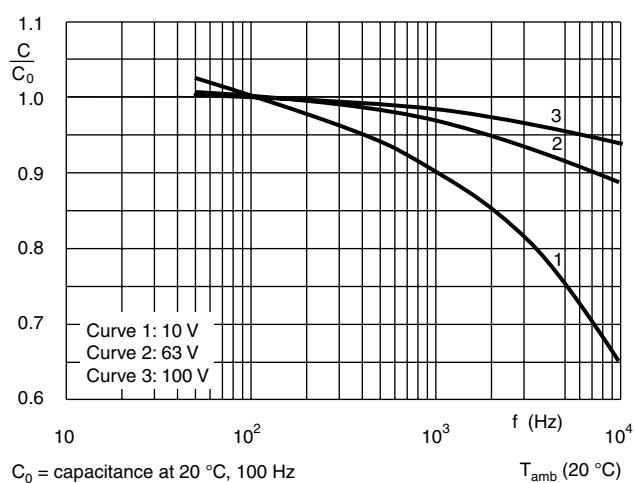


Fig.7 Typical multiplier of capacitance as a function of frequency

RIPPLE CURRENT AND USEFUL LIFE

I_A = actual ripple current at 100 Hz, 105 °C
 I_R = rated ripple current at 100 Hz, 105 °C
 Useful life at 105 °C and I_R applied

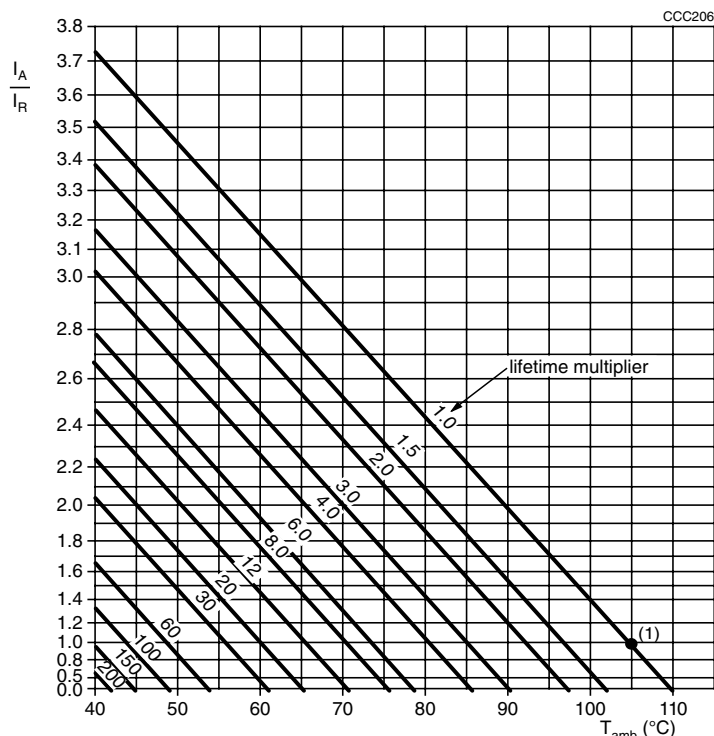


Fig.8 Multiplier of useful life as a function of ambient temperature and ripple current load

Table 3

MULTIPLIER OF RIPPLE CURRENT (I_R) AS A FUNCTION OF FREQUENCY			
FREQUENCY (Hz)	I_R MULTIPLIER		
	$C_R < 100 \mu F$	$C_R = 100 \mu F$ 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	$T_{amb} = 105\text{ °C}$; U_R applied; 2000 h	$\Delta C/C: \pm 20\%$ $\tan \delta \leq 2 \times \text{spec. limit}$ $I_{L5} \leq \text{spec. limit}$
Useful life	CECC 30301 subclause 1.8.1	$T_{amb} = 105\text{ °C}$; U_R and I_R applied; 2500 h	$\Delta C/C: \pm 30\%$ $\tan \delta \leq 3 \times \text{spec. limit}$ $I_{L5} \leq \text{spec. limit}$ no short or open circuit total failure percentage: $\leq 1\%$
Shelf life (storage at high temperature)	IEC 60384-4/ EN130300 subclause 4.17	$T_{amb} = 105\text{ °C}$; no voltage applied; 1000 h after test: U_R to be applied for 30 min, 24 h to 48 h before measurement	$\Delta C/C: \pm 20\%$ $\tan \delta \leq 2 \times \text{spec. limit}$ $I_{L5} \leq \text{spec. limit}$
Surge	IEC 60384-4/ EN130300 subclause 4.14	from source of $1.15 \times U_R$: $RC = 0.1 \text{ s} \pm 0.05 \text{ s}$; 1000 cycles of 30 s on, 330 s off, at 105 °C	$\Delta C/C: \pm 25\%$ $\tan \delta \leq 1.5 \times \text{spec. limit}$ $I_{L5} \leq \text{spec. limit}$



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