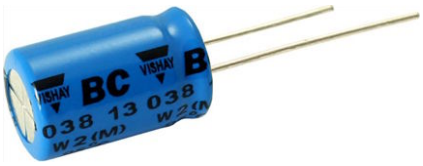
Aluminum Electrolytic Capacitors
Radial Standard Ultra Miniature



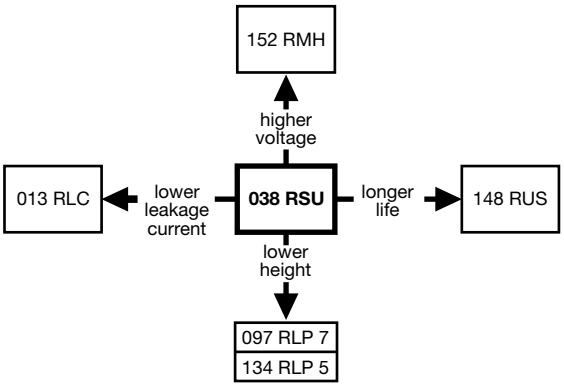


Fig. 1

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	2.2 µF to 22 000 µF
Tolerance on C_R	± 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 Ø D ≤ 8 mm	2000 h
Case size Ø D ≥ 10 mm	3000 h
Useful life at 85 °C:	
Case size Ø D ≤ 8 mm	2500 h
Case size Ø D ≥ 10 mm	3500 h
Useful life at 40 °C, 1.4 x I_R applied:	
Case size Ø D ≤ 8 mm	60 000 h
Case size Ø D ≥ 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

FEATURES

Pb-free
RoHS COMPLIANT

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

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)

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 of manufacturer
- Negative terminal identification
- Series number (038)

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	35	50	63	100
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	6 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

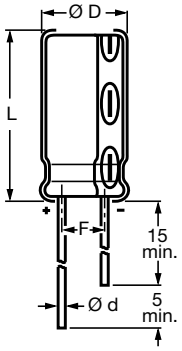


Fig. 2 - **Form CA**

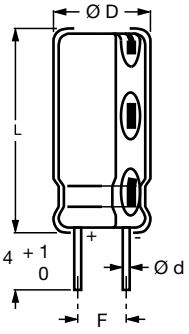
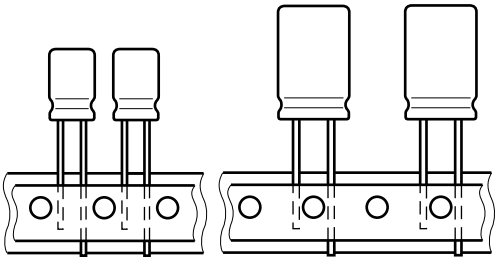
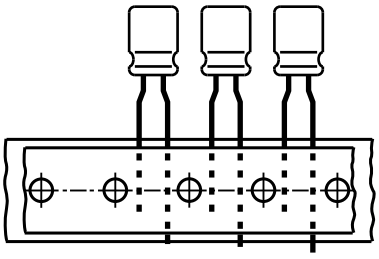


Fig. 3 - **Form CB:**
Cut leads



Dimensions of pitch F see Table 1 and Table 2

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



Case Ø D = 5 mm to 8 mm; pitch 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 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 ± 20 %
I_R	Rated RMS ripple current at 100 Hz, 85 °C
I_{L2}	Max. leakage current after 2 min at U_R
tan δ	Max. dissipation factor at 100 Hz

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 038 series

470 µF / 25 V; ± 20 %

Nominal case size: Ø 10 mm x 12 mm; form TFA

Ordering code: MAL2 038 36471 E3
Former 12NC: 2222 038 36471

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 85 °C (mA)	I_{L2} 2 min (µA)	tan δ 100 Hz	ORDERING CODE MAL2038							
						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	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_R (V)	C_R 100 Hz (µF)	NOMINAL CASE SIZE Ø D x L (mm)	I_R 100 Hz 85 °C (mA)	I_{L2} 2 min (µA)	tan δ 100 Hz	ORDERING CODE MAL2038							
						BULK PACKAGING				TAPED AMMOPACK			
						LONG LEADS		CUT LEADS					
						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	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	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**
Voltage		
Surge voltage		$U_s \leq 1.15 \times U_R$
Reverse voltage		$U_{rev} \leq 1$ V
Current		
Leakage current	After 2 min at U_R	$I_{L2} \leq 0.01\ C_R \times U_R$ or 3 µA, whichever is greater
	After 5 min at U_R	$I_{L5} \leq 0.002\ C_R \times U_R + 3$ µA
Inductance		
Equivalent series inductance (ESL)	Case Ø D ≤ 8 mm	Typ. 13 nH
	Case Ø D = 10 mm	Typ. 16 nH
	Case Ø D ≥ 12.5 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)

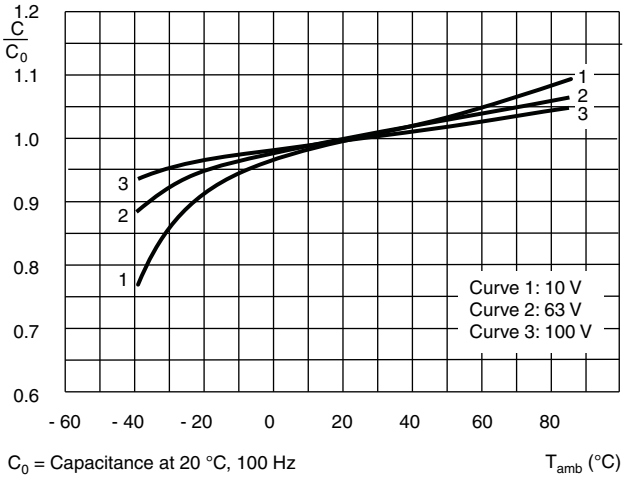


Fig. 6 - Typical multiplier of capacitance as a function of ambient temperature

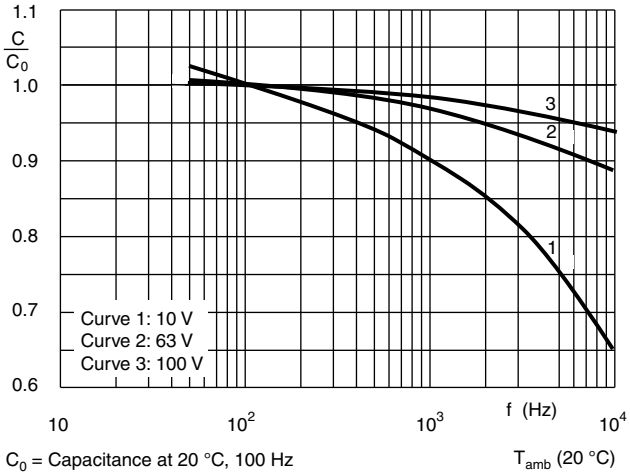


Fig. 7 - Typical multiplier of capacitance as a function of frequency

RIPPLE CURRENT AND USEFUL LIFE

I_A = Actual ripple current at 100 Hz
I_R = Rated ripple current at 100 Hz, 85 °C
Useful life at 85 °C and I_R applied:
Case Ø D ≤ 8 mm: 2500 h
Case Ø D ≥ 10 mm: 3500 h

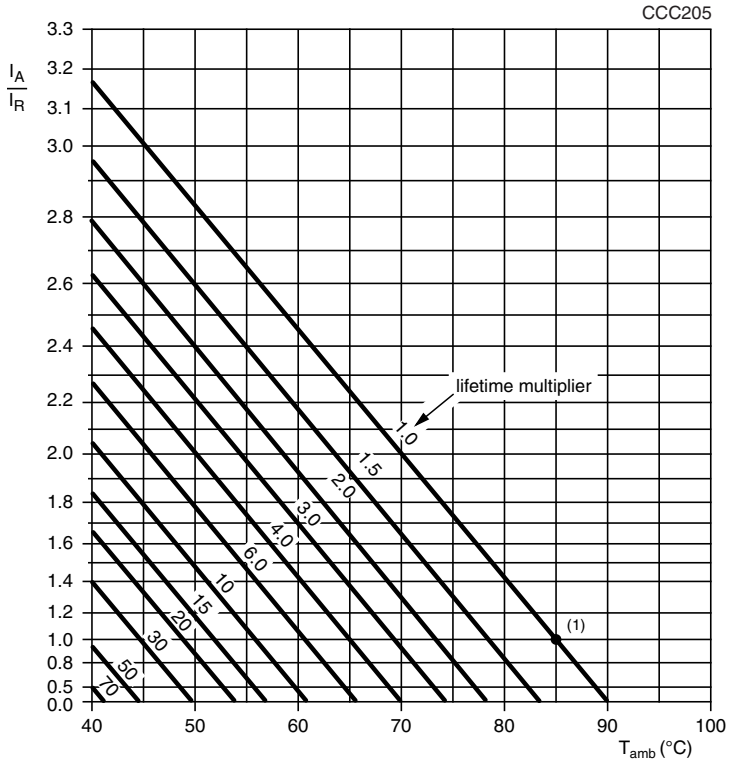


Fig. 8 - Multiplier of useful life as a function of ambient temperature and ripple current load

Table 3

MULTIPLIER OF RIPPLE CURRENT (I_R) AS A FUNCTION OF FREQUENCY			
FREQUENCY (Hz)	I_R MULTIPLIER		
	C_R < 100 µF	C_R = 100 µF TO 1000 µF	C_R > 1000 µF
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
≥ 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 Ø ≤ 8 mm: 2000 h Case Ø ≥ 10 mm: 3000 h	ΔC/C: ± 20 % tan δ ≤ 2 x spec. limit I_{L5} ≤ spec. limit
Useful life	CECC 30301 subclause 1.8.1	T_{amb} = 85 °C; U_R and I_R applied; Case Ø ≤ 8 mm: 2500 h Case Ø ≥ 10 mm: 3500 h	ΔC/C: ± 50 % tan δ ≤ 3 x spec. limit I_{L5} ≤ spec. limit no short or open circuit total failure percentage: ≤ 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 h to 48 h before measurement	ΔC/C: ± 20 % tan δ ≤ 2 x spec. limit I_{L5} ≤ 3 x spec. limit
Surge	IEC 60384-4 / EN130300 subclause 4.14	From source of 1.15 x U_R: RC = 0.1 s ± 0.05 s; 1000 cycles of 30 s on, 330 s off, at 85 °C	ΔC/C: ± 25 % tan δ ≤ 1.5 x spec. limit I_{L5} ≤ spec. limit

Statements about product lifetime are based on calculations and internal testing. They should only be interpreted as estimations. Also due to external factors, the lifetime in the field application may deviate from the calculated lifetime. In general, nothing stated herein shall be construed as a guarantee of durability.

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