

## Aluminum Capacitors Radial Standard Ultra Miniature

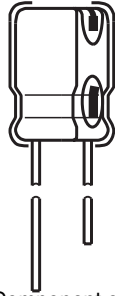
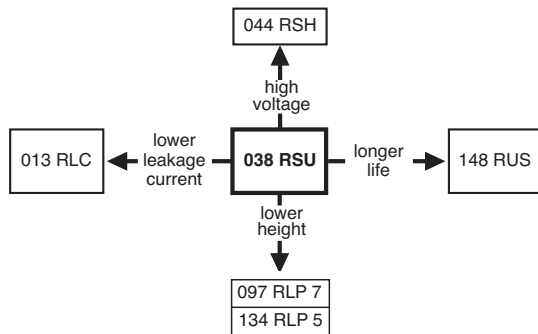


Fig.1 Component outline.



### 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.
- 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).

### MARKING

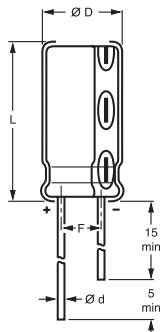
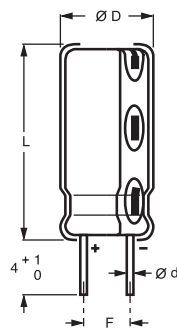
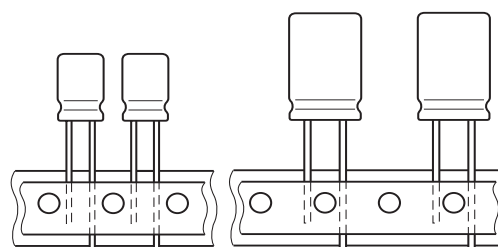
The capacitors are marked (where possible) with the following information:

- 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 (038).

QUICK REFERENCE DATA	
DESCRIPTION	VALUE
Nominal case sizes ( $\varnothing D \times L$ in mm)	5 × 11 to 18 × 40
Rated capacitance range, $C_R$	0.1 to 22000 $\mu F$
Tolerance on $C_R$	$\pm 20$ %
Rated voltage range, $U_R$	6.3 to 100 V
Category temperature range	- 40 to + 85 °C
Endurance test at 85 °C:	
case size $\varnothing D \leq 8$ mm	2000 hours
case size $\varnothing D \geq 10$ mm	3000 hours
Useful life at 85 °C:	
case size $\varnothing D \leq 8$ mm	2500 hours
case size $\varnothing D \geq 10$ mm	3500 hours
Useful life at 40 °C, $1.4 \times I_R$ applied:	
case size $\varnothing D \leq 8$ mm	60000 hours
case size $\varnothing D \geq 10$ mm	90000 hours
Shelf life at 0 V, 85 °C	1000 hours
Based on sectional specification	IEC 60384-4/EN130300
Climatic category IEC 60068	40/085/56

\* Pb containing terminations are not RoHS compliant, exemptions may apply

<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	50	63	100
0.1	-	-	-	-	-	-	5 × 11	-
0.22	-	-	-	-	-	-	5 × 11	-
0.33	-	-	-	-	-	-	5 × 11	-
0.47	-	-	-	-	-	-	5 × 11	5 × 11
1.0	-	-	-	-	-	-	5 × 11	5 × 11
2.2	-	-	-	-	-	-	5 × 11	5 × 11
3.3	-	-	-	-	-	-	5 × 11	5 × 11
4.7	-	-	-	-	-	-	5 × 11	5 × 11
10	-	-	-	-	-	-	5 × 11	6.3 × 11
22	-	-	-	-	-	5 × 11	5 × 11	6.3 × 11
33	-	-	-	-	-	5 × 11	6.3 × 11	8 × 11.5
47	-	-	-	-	5 × 11	6.3 × 11	6.3 × 11	10 × 12
100	-	5 × 11	5 × 11	6.3 × 11	6.3 × 11	8 × 11.5	10 × 12	10 × 20
220	5 × 11	5 × 11	6.3 × 11	8 × 11.5	8 × 11.5	10 × 12	10 × 16	13 × 25
330	6.3 × 11	6.3 × 11	8 × 11.5	8 × 11.5	10 × 12	10 × 16	10 × 20	13 × 25
470	6.3 × 11	6.3 × 11	8 × 11.5	10 × 12	10 × 16	10 × 20	13 × 20	16 × 25
1000	8 × 11.5	10 × 12	10 × 16	10 × 20	13 × 20	13 × 25	16 × 25	18 × 40
2200	10 × 16	10 × 20	13 × 20	13 × 25	16 × 25	16 × 31	18 × 35	-
3300	10 × 20	13 × 20	13 × 25	16 × 25	16 × 35	18 × 35	-	-
4700	13 × 20	13 × 25	16 × 25	16 × 31	18 × 35	-	-	-
6800	13 × 25	16 × 25	16 × 31	18 × 35	-	-	-	-
10000	16 × 25	16 × 35	18 × 35	-	-	-	-	-
22000	18 × 40	-	-	-	-	-	-	-

**DIMENSIONS in millimeters AND AVAILABLE FORMS**

 Fig.2 Form CA:  
 Long leads.

 Fig.3 Form CB:  
 Cut leads.


Dimensions of pitch F see tables 1 and 2.

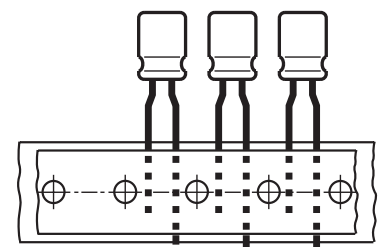

 Case  $\varnothing D = 5$  to 8 mm; pitch  $F = 5$  mm.

 Fig.4 Form TFA: Taped in box  
 (ammpack), formed 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 × 11	11	0.5	5.5	12.5	2.0 ±0.5	≈0.4	5000	-	2000
6.3 × 11	12	0.5	6.8	12.5	2.5 ±0.5	≈0.6	5000	-	2000
8 × 11.5	13	0.6	8.5	12.5	3.5 ±0.5	≈1.1	5000	-	1000
10 × 12	14	0.6	10.5	13.5	5.0 ±0.5	≈1.6	3000	1000	500
10 × 16	15	0.6	10.5	17.5	5.0 ±0.5	≈1.9	2500	1000	500
10 × 20	16	0.6	10.5	22.0	5.0 ±0.5	≈2.2	2000	800	500
13 × 20	17	0.6	13.5	22.0	5.0 ±0.5	≈4.0	1500	400	300
13 × 25	18	0.6	13.5	27.0	5.0 ±0.5	≈5.0	1000	400	300
16 × 25	19	0.8	16.5	27.0	7.5 ±0.5	≈8.0	750	200	200
16 × 31	20	0.8	16.5	33.5	7.5 ±0.5	≈9.0	600	200	200
16 × 35	21	0.8	16.5	37.5	7.5 ±0.5	≈11.0	500	200	-
18 × 35	22	0.8	18.5	37.5	7.5 ±0.5	≈14.5	400	150	-
18 × 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 minutes at $U_R$
Tan $\delta$	max. dissipation factor at 100 Hz

**Note**

1. Unless otherwise specified, all electrical values in Table 2 apply at  
 $T_{amb} = 20\text{ °C}$ ,  $P = 86$  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:  $\varnothing 10 \times 12\text{ mm}$ ; Form TFA

Catalog number: 2222 038 36471.

\* To ensure delivery of lead (Pb)-free parts during the transition period, please contact your Vishay sales agent.

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	CATALOG NUMBER 2222 038 .....							
						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)
6.3	220	5 × 11	200	14	0.23	53221	2.0	–	–	33221	5.0	73221	2.5
	330	6.3 × 11	270	21	0.23	53331	2.5	–	–	33331	5.0	73331	2.5
	470	6.3 × 11	320	30	0.23	53471	2.5	–	–	33471	5.0	73471	2.5
	1000	8 × 11.5	540	63	0.23	53102	3.5	–	–	33102	5.0	73102	3.5
	2200	10 × 16	785	139	0.25	53222	5.0	63222	5.0	33222	5.0	–	–
	3300	10 × 20	1185	208	0.27	53332	5.0	63332	5.0	33332	5.0	–	–
	4700	13 × 20	1545	296	0.29	53472	5.0	63472	5.0	33472	5.0	–	–
	6800	13 × 25	1880	428	0.33	53682	5.0	63682	5.0	33682	5.0	–	–
	10000	16 × 25	2330	630	0.41	53103	7.5	63103	7.5	33103	7.5	–	–
	22000	18 × 40	3320	1386	0.65	53223	7.5	63223	7.5	–	–	–	–
	10	100	5 × 11	145	10	0.20	54101	2.0	–	–	34101	5.0	74101
220		5 × 11	160	22	0.20	54221	2.0	–	–	34221	5.0	74221	2.5
330		6.3 × 11	290	33	0.20	54331	2.5	–	–	34331	5.0	74331	2.5
470		6.3 × 11	350	47	0.20	54471	2.5	–	–	34471	5.0	74471	2.5
1000		10 × 12	650	100	0.20	54102	5.0	64102	5.0	34102	5.0	–	–
2200		10 × 20	1070	220	0.22	54222	5.0	64222	5.0	34222	5.0	–	–
3300		13 × 20	1420	330	0.24	54332	5.0	64332	5.0	34332	5.0	–	–
4700		13 × 25	1780	470	0.26	54472	5.0	64472	5.0	34472	5.0	–	–
6800		16 × 25	2220	680	0.30	54682	7.5	64682	7.5	34682	7.5	–	–
10000		16 × 35	2760	1000	0.38	54103	7.5	64103	7.5	–	–	–	–
16		100	5 × 11	160	16	0.16	55101	2.0	–	–	35101	5.0	75101
	220	6.3 × 11	260	35	0.16	55221	2.5	–	–	35221	5.0	75221	2.5
	330	8 × 11.5	370	53	0.16	55331	3.5	–	–	35331	5.0	75331	3.5
	470	8 × 11.5	440	75	0.16	55471	3.5	–	–	35471	5.0	75471	3.5
	1000	10 × 16	785	160	0.16	55102	5.0	65102	5.0	35102	5.0	–	–
	2200	13 × 20	1295	352	0.18	55222	5.0	65222	5.0	35222	5.0	–	–
	3300	13 × 25	1655	528	0.20	55332	5.0	65332	5.0	35332	5.0	–	–
	4700	16 × 25	2090	752	0.22	55472	7.5	65472	7.5	35472	7.5	–	–
	6800	16 × 31	2520	1088	0.26	55682	7.5	65682	7.5	35682	7.5	–	–
	10000	18 × 35	2920	1600	0.34	55103	7.5	65103	7.5	–	–	–	–
	25	100	6.3 × 11	190	25	0.14	56101	2.5	–	–	36101	5.0	76101
220		8 × 11.5	320	55	0.14	56221	3.5	–	–	36221	5.0	76221	3.5
330		8 × 11.5	440	83	0.14	56331	3.5	–	–	36331	5.0	76331	3.5
470		10 × 12	545	118	0.14	56471	5.0	66471	5.0	36471	5.0	–	–
1000		10 × 20	955	250	0.14	56102	5.0	66102	5.0	36102	5.0	–	–
2200		13 × 25	1540	550	0.16	56222	5.0	66222	5.0	36222	5.0	–	–
3300		16 × 25	1975	825	0.18	56332	7.5	66332	7.5	36332	7.5	–	–
4700		16 × 31	2420	1175	0.20	56472	7.5	66472	7.5	36472	7.5	–	–
6800		18 × 35	2880	1700	0.24	56682	7.5	66682	7.5	–	–	–	–



ELECTRICAL DATA AND ORDERING INFORMATION																	
U <sub>R</sub> (V)	C <sub>R</sub> 100 Hz (μF)	NOMINAL CASE SIZE ØD × L (mm)	I <sub>R</sub> 100 Hz 85 °C (mA)	I <sub>L2</sub> 2 min (μA)	Tan δ 100 Hz	CATALOG NUMBER 2222 038 .....											
						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 × 11	130	17	0.12	50479	2.0	–	–	30479	5.0	70479	2.5				
	100	6.3 × 11	210	35	0.12	50101	2.5	–	–	30101	5.0	70101	2.5				
	220	8 × 11.5	385	77	0.12	50221	3.5	–	–	30221	5.0	70221	3.5				
	330	10 × 12	490	116	0.12	50331	5.0	60331	5.0	30331	5.0	–	–				
	470	10 × 16	740	165	0.12	50471	5.0	60471	5.0	30471	5.0	–	–				
	1000	13 × 20	1145	350	0.12	50102	5.0	60102	5.0	30102	5.0	–	–				
	2200	16 × 25	1785	770	0.14	50222	7.5	60222	7.5	30222	7.5	–	–				
	3300	16 × 35	2275	1155	0.16	50332	7.5	60332	7.5	–	–	–	–				
	4700	18 × 35	2700	1645	0.18	50472	7.5	60472	7.5	–	–	–	–				
50	22	5 × 11	95	11	0.10	51229	2.0	–	–	31229	5.0	71229	2.5				
	33	5 × 11	125	17	0.10	51339	2.0	–	–	31339	5.0	71339	2.5				
	47	6.3 × 11	165	24	0.10	51479	2.5	–	–	31479	5.0	71479	2.5				
	100	8 × 11.5	260	50	0.10	51101	3.5	–	–	31101	5.0	71101	3.5				
	220	10 × 12	455	110	0.10	51221	5.0	61221	5.0	31221	5.0	–	–				
	330	10 × 16	585	165	0.10	51331	5.0	61331	5.0	31331	5.0	–	–				
	470	10 × 20	755	235	0.10	51471	5.0	61471	5.0	31471	5.0	–	–				
	1000	13 × 25	1340	500	0.10	51102	5.0	61102	5.0	31102	5.0	–	–				
	2200	16 × 31	1885	1100	0.12	51222	7.5	61222	7.5	31222	7.5	–	–				
3300	18 × 35	2500	1650	0.14	51332	7.5	61332	7.5	–	–	–	–					
63	0.10	5 × 11	3.0	3.0	0.09	58107	2.0	–	–	38107	5.0	78107	2.5				
	0.22	5 × 11	4.5	3.0	0.09	58227	2.0	–	–	38227	5.0	78227	2.5				
	0.33	5 × 11	7.5	3.0	0.09	58337	2.0	–	–	38337	5.0	78337	2.5				
	0.47	5 × 11	9.5	3.0	0.09	58477	2.0	–	–	38477	5.0	78477	2.5				
	1.0	5 × 11	17	3.0	0.09	58108	2.0	–	–	38108	5.0	78108	2.5				
	2.2	5 × 11	28	3.0	0.09	58228	2.0	–	–	38228	5.0	78228	2.5				
	3.3	5 × 11	34	3.0	0.09	58338	2.0	–	–	38338	5.0	78338	2.5				
	4.7	5 × 11	45	3.0	0.09	58478	2.0	–	–	38478	5.0	78478	2.5				
	10	5 × 11	70	6.3	0.09	58109	2.0	–	–	38109	5.0	78109	2.5				
	22	5 × 11	105	14	0.09	58229	2.0	–	–	38229	5.0	78229	2.5				
	33	6.3 × 11	140	21	0.09	58339	2.5	–	–	38339	5.0	78339	2.5				
	47	6.3 × 11	170	30	0.09	58479	2.5	–	–	38479	5.0	78479	2.5				
	100	10 × 12	320	63	0.09	58101	5.0	68101	5.0	38101	5.0	–	–				
	220	10 × 16	490	139	0.09	58221	5.0	68221	5.0	38221	5.0	–	–				
	330	10 × 20	710	208	0.09	58331	5.0	68331	5.0	38331	5.0	–	–				
	470	13 × 20	900	296	0.09	58471	5.0	68471	5.0	38471	5.0	–	–				
1000	16 × 25	1560	630	0.09	58102	7.5	68102	7.5	38102	7.5	–	–					
2200	18 × 35	1950	1386	0.11	58222	7.5	68222	7.5	–	–	–	–					
100	0.47	5 × 11	12	3.0	0.08	59477	2.0	–	–	39477	5.0	79477	2.5				
	1.0	5 × 11	22	3.0	0.08	59108	2.0	–	–	39108	5.0	79108	2.5				
	2.2	5 × 11	33	3.0	0.08	59228	2.0	–	–	39228	5.0	79228	2.5				
	3.3	5 × 11	40	3.3	0.08	59338	2.0	–	–	39338	5.0	79338	2.5				
	4.7	5 × 11	48	4.7	0.08	59478	2.0	–	–	39478	5.0	79478	2.5				
	10	6.3 × 11	80	10	0.08	59109	2.5	–	–	39109	5.0	79109	2.5				
	22	6.3 × 11	115	22	0.08	59229	2.5	–	–	39229	5.0	79229	2.5				
	33	8 × 11.5	145	33	0.08	59339	3.5	–	–	39339	5.0	79339	3.5				
	47	10 × 12	235	47	0.08	59479	5.0	69479	5.0	39479	5.0	–	–				
	100	10 × 20	370	100	0.08	59101	5.0	69101	5.0	39101	5.0	–	–				
	220	13 × 25	675	220	0.08	59221	5.0	69221	5.0	39221	5.0	–	–				
	330	13 × 25	825	330	0.08	59331	5.0	69331	5.0	39331	5.0	–	–				
	470	16 × 25	1070	470	0.08	59471	7.5	69471	7.5	39471	7.5	–	–				
1000	18 × 40	2410	1000	0.08	59102	7.5	69102	7.5	–	–	–	–					

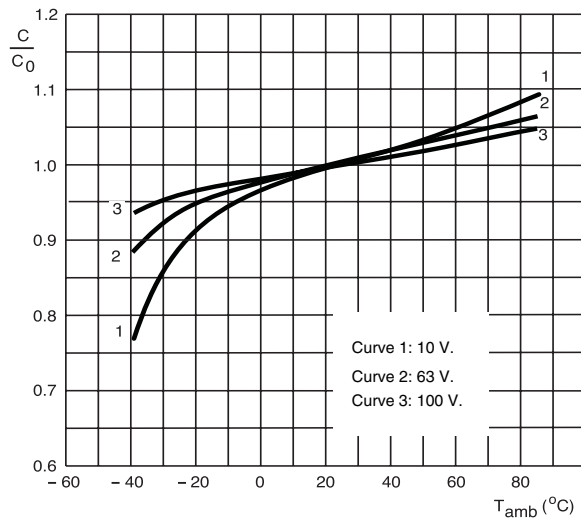


ADDITIONAL ELECTRICAL DATA		
PARAMETER	CONDITIONS	VALUE
<b>VOLTAGE</b>		
Surge voltage		$U_s \leq 1.15 \times U_R$
Reverse voltage		$U_{rev} \leq 1 \text{ V}$
<b>CURRENT</b>		
Leakage current	after 2 minutes at $U_R$	$I_{L2} \leq 0.01 C_R \times U_R$ or $3 \mu\text{A}$ , whichever is greater
	after 5 minutes 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)**

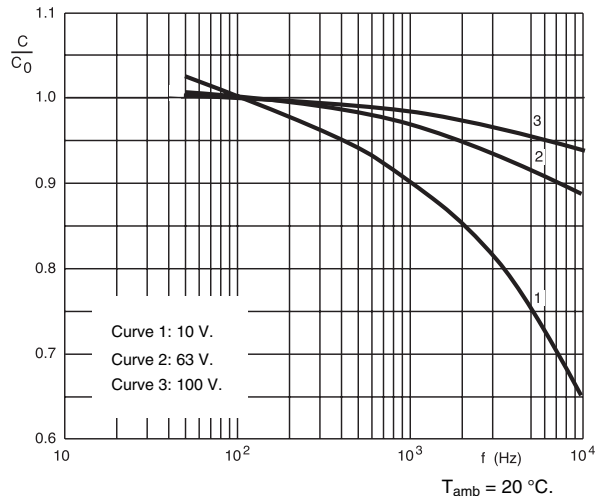
$C_0$  = capacitance at 20 °C, 100 Hz.

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.



**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  $\varnothing \leq 8$  mm: 2 500 hours;  
 case  $\varnothing \geq 10$  mm: 3 500 hours.

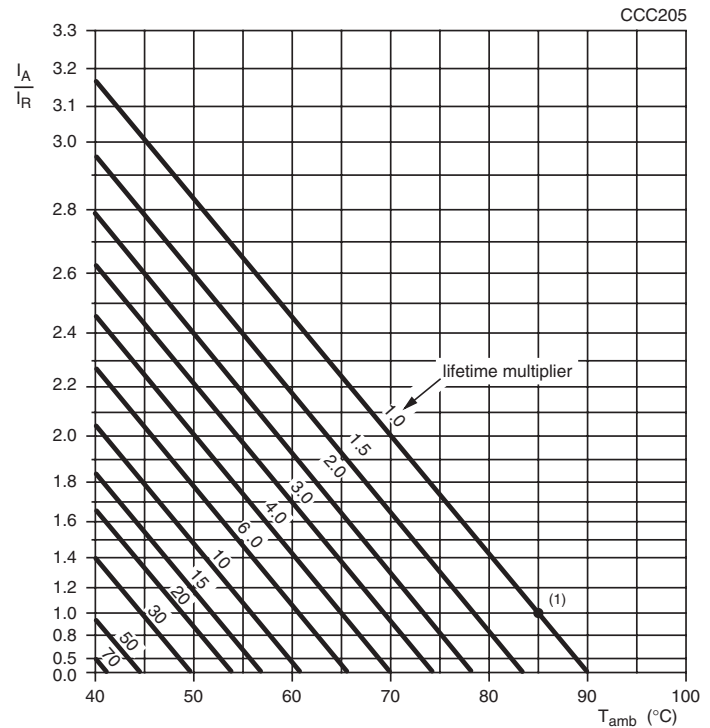


Fig.8 Multiplier of useful life as a function of ambient temperature and ripple current load.

Table 3

<b>MULTIPLIER OF RIPPLE CURRENT (<math>I_R</math>) AS A FUNCTION OF FREQUENCY</b>			
<b>FREQUENCY (Hz)</b>	<b><math>I_R</math> MULTIPLIER</b>		
	<b><math>C_R &lt; 100 \mu\text{F}</math></b>	<b><math>C_R = 100</math> to <math>1000 \mu\text{F}</math></b>	<b><math>C_R &gt; 1000 \mu\text{F}</math></b>
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
$\geq 10000$	1.50	1.35	1.15

Table 4

<b>TEST PROCEDURES AND REQUIREMENTS</b>			
<b>TEST</b>		<b>PROCEDURE (QUICK REFERENCE)</b>	<b>REQUIREMENTS</b>
<b>NAME OF TEST</b>	<b>REFERENCE</b>		
Endurance	IEC 60384-4/ EN130300 subclause 4.13	$T_{\text{amb}} = 85 \text{ }^\circ\text{C}$ ; $U_R$ applied; case $\varnothing \leq 8$ mm: 2000 hours case $\varnothing \geq 10$ mm: 3000 hours	$\Delta C/C: \pm 20 \%$ $\tan \delta \leq 2 \times \text{spec. limit}$ $I_{L5} \leq \text{spec. limit}$
Useful life	CECC 30301 subclause 1.8.1	$T_{\text{amb}} = 85 \text{ }^\circ\text{C}$ ; $U_R$ and $I_R$ applied; case $\varnothing \leq 8$ mm: 2500 hours case $\varnothing \geq 10$ mm: 3500 hours	$\Delta C/C: \pm 50 \%$ $\tan \delta \leq 3 \times \text{spec. limit}$ $I_{L5} \leq \text{spec. limit}$ no short or open circuit total failure percentage: $\leq 1 \%$
Shelf life (storage at high temperature)	IEC 60384-4/ EN130300 subclause 4.17	$T_{\text{amb}} = 85 \text{ }^\circ\text{C}$ ; no voltage applied; 1000 hours after test: $U_R$ to be applied for 30 minutes, 24 to 48 hours before measurement	$\Delta C/C: \pm 20 \%$ $\tan \delta \leq 2 \times \text{spec. limit}$ $I_{L5} \leq 3 \times \text{spec. limit}$
Surge	IEC 60384-4/ EN130300 subclause 4.14	from source of $1.15 \times U_R$ : $RC = 0.1 \pm 0.05 \text{ s}$ ; 1000 cycles of 30 s on, 330 s off, at $85 \text{ }^\circ\text{C}$	$\Delta C/C: \pm 25 \%$ $\tan \delta \leq 1.5 \times \text{spec. limit}$ $I_{L5} \leq \text{spec. limit}$



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