

## Aluminum Capacitors Radial Miniature, Low Impedance

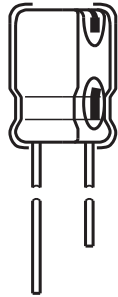
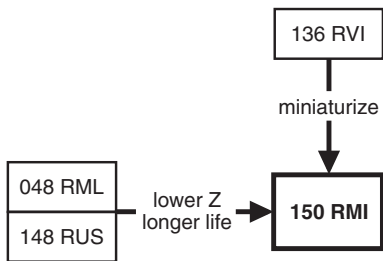


Fig.1 Component outline



### FEATURES

- Polarized aluminum electrolytic capacitors, non-solid electrolyte
- Radial leads, cylindrical aluminum case with pressure relief, insulated with a blue sleeve
- Charge and discharge proof
- Very long useful life: 4000 h to 10 000 h at 105 °C, high stability, high reliability
- Very low impedance or ESR respectively, at smaller case sizes than the 136 RVI series
- Excellent ripple current capability
- AEC-Q200 qualified
- Compliant to RoHS Directive 2002/95/EC



**RoHS**  
COMPLIANT

### APPLICATIONS

- Power supplies (SMPS, DC/DC converters) for general industrial, EDP, audio-video, automotive and telecommunications
- Smoothing, filtering, buffering

### QUICK REFERENCE DATA

DESCRIPTION	VALUE
Nominal case sizes (Ø D x L in mm)	8 x 12 to 18 x 31
Rated capacitance range, C <sub>R</sub>	100 µF to 6800 µF
Tolerance on C <sub>R</sub>	± 20 %
Rated voltage range, U <sub>R</sub>	10 V to 100 V
Category temperature range	- 55 °C to + 105 °C
Endurance test at 105 °C	3000 h to 5000 h
Useful life at 105 °C	4000 h to 10 000 h
Useful life at 40 °C, 1.8 x I <sub>R</sub> applied	200 000 h to 500 000 h
Shelf life at 0 V, 105 °C	1000 h
Based on sectional specification	IEC 60384-4/EN130300
Climatic category IEC 60068	55/105/56

### 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
- Upper category temperature (105 °C)
- Negative terminal identification
- Series number (150)

### SELECTION CHART FOR C<sub>R</sub>, U<sub>R</sub> AND RELEVANT NOMINAL CASE SIZES (Ø D x L in mm)

C <sub>R</sub> (µF)	U <sub>R</sub> (V)						
	10	16	25	35	50	63	100
22	-	-	-	-	-	-	8 x 12
47	-	-	-	-	-	8 x 12	-
100	-	-	-	8 x 12	-	10 x 12	-
150	-	-	-	-	10 x 12	10 x 16	-
220	-	8 x 12	8 x 12	8 x 15	10 x 16	10 x 20	-
	-	-	-	10 x 12	-	-	-
330	-	8 x 12	10 x 12	10 x 16	10 x 20	12.5 x 20	18 x 20
470	8 x 12	8 x 15	10 x 16	10 x 20	12.5 x 20	12.5 x 25	-
	-	10 x 12	-	-	-	16 x 20	-
680	10 x 12	10 x 16	10 x 20	12.5 x 20	12.5 x 25	16 x 20	-
	-	-	-	-	-	16 x 25	-
1000	10 x 16	10 x 20	12.5 x 20	12.5 x 25	16 x 25	16 x 31	-
	-	-	-	16 x 20	-	-	-

<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)						
	10	16	25	35	50	63	100
1200	-	-	-	-	16 x 31	-	-
1500	-	12.5 x 20	12.5 x 25	16 x 20	16 x 31	-	-
	-	-	-	12.5 x 35	-	-	-
2200	12.5 x 20	12.5 x 25	16 x 20	16 x 31	-	-	-
	-	-	12.5 x 35	-	-	-	-
3300	12.5 x 25	16 x 20	16 x 31	18 x 31	-	-	-
4700	16 x 25	16 x 31	16 x 35	-	-	-	-
6800	16 x 31	16 x 35	-	-	-	-	-

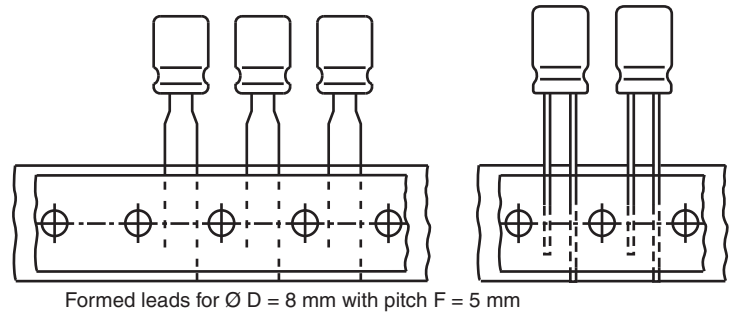
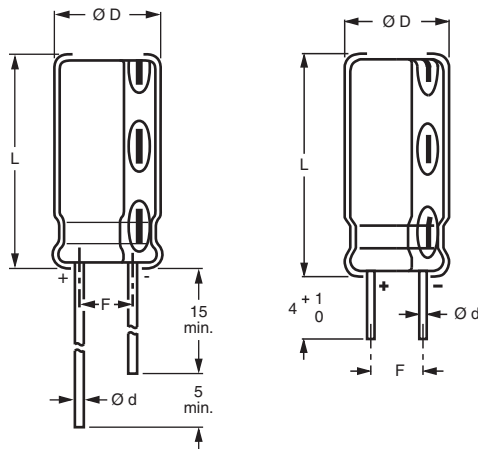
**DIMENSIONS in millimeters AND AVAILABLE FORMS**


Fig.2 Form CA: Long leads

Fig.3 Form CB: Cut leads

Fig.4 Form TFA: Taped in box (ammopack)

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
8 x 12	13	0.6	8.5	13.0	$3.5 \pm 0.5$	$\approx 1.1$	5000	5000	1000
8 x 15	13L	0.6	8.5	16.0	$3.5 \pm 0.5$	$\approx 1.3$	5000	5000	1000
10 x 12	14	0.6	10.5	13.5	$5.0 \pm 0.5$	$\approx 1.6$	1000	500	800
10 x 16	15	0.6	10.5	17.5	$5.0 \pm 0.5$	$\approx 1.9$	500	500	800
10 x 20	16	0.6	10.5	22.0	$5.0 \pm 0.5$	$\approx 2.2$	500	500	800
12.5 x 20	17	0.6	13.0	22.0	$5.0 \pm 0.5$	$\approx 4.0$	500	500	500
12.5 x 25	18	0.6	13.0	27.0	$5.0 \pm 0.5$	$\approx 5.0$	250	250	500
12.5 x 35	18LL	0.6	13.0	37.5	$5.0 \pm 0.5$	$\approx 6.0$	250	250	-
16 x 20	19a	0.8	16.5	22.0	$7.5 \pm 0.5$	$\approx 6.0$	250	250	250
16 x 25	19	0.8	16.5	27.0	$7.5 \pm 0.5$	$\approx 8.0$	250	250	250
16 x 31	20	0.8	16.5	33.5	$7.5 \pm 0.5$	$\approx 9.0$	100	100	250
16 x 35	21	0.8	16.5	37.5	$7.5 \pm 0.5$	$\approx 11.0$	100	100	-
18 x 20	1820	0.8	18.5	22.0	$7.5 \pm 0.5$	$\approx 8.0$	100	100	-
18 x 31	1831	0.8	18.5	33.5	$7.5 \pm 0.5$	$\approx 12.5$	100	100	-



ELECTRICAL DATA	
SYMBOL	DESCRIPTION
$C_R$	rated capacitance at 100 Hz , tolerance $\pm 20\%$
$I_R$	rated RMS ripple current at 100 kHz , 105 °C
$I_{L2}$	max. leakage current after 2 minutes at $U_R$
$\tan \delta$	max. dissipation factor at 100 Hz
$Z$	max. impedance at 100 kHz

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  $75\%$

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 kHz 105 °C (mA)	$I_{L2}$ 2 min ( $\mu\text{A}$ )	$\tan \delta$ 100 Hz	$Z$ 100 kHz + 20 °C ( $\Omega$ )	$Z$ 100 kHz - 40 °C ( $\Omega$ )	ORDERING CODE MAL2150.....		
								BULK PACKAGING		TAPED
								FORM CA	FORM CB	FORM TFA
10	470	8 x 12	555	47	0.19	0.117	0.870	54471E3	84471E3	34471E3
	680	10 x 12	730	71	0.19	0.097	0.680	54681E3	64681E3	34681E3
	1000	10 x 16	950	103	0.19	0.066	0.460	54102E3	64102E3	34102E3
	2200	12.5 x 20	1460	223	0.21	0.037	0.260	54222E3	64222E3	34222E3
	3300	12.5 x 25	1950	333	0.21	0.029	0.200	54332E3	64332E3	34332E3
	4700	16 x 25	2390	473	0.23	0.022	0.150	54472E3	64472E3	34472E3
	6800	16 x 31	2890	683	0.25	0.019	0.130	54682E3	64682E3	34682E3
16	220	8 x 12	555	35	0.16	0.117	0.870	55221E3	85221E3	35221E3
	330	8 x 12	555	53	0.16	0.117	0.870	55331E3	85331E3	35331E3
	470	8 x 15	730	78	0.16	0.085	0.750	95475E3	95478E3	95473E3
	470	10 x 12	730	78	0.16	0.097	0.680	55471E3	65471E3	35471E3
	680	10 x 16	950	112	0.16	0.066	0.460	55681E3	65681E3	35681E3
	1000	10 x 20	1180	163	0.16	0.049	0.340	55102E3	65102E3	35102E3
	1500	12.5 x 20	1460	243	0.16	0.037	0.260	55152E3	65152E3	35152E3
	2200	12.5 x 25	1950	355	0.18	0.029	0.200	55222E3	65222E3	35222E3
	3300	16 x 20	1840	531	0.20	0.028	0.200	55332E3	65332E3	35332E3
25	4700	16 x 31	2890	755	0.22	0.019	0.130	55472E3	65472E3	35472E3
	6800	16 x 35	3100	1091	0.24	0.018	0.130	55682E3	65682E3	-
	220	8 x 12	555	55	0.14	0.117	0.870	56221E3	86221E3	36221E3
	330	10 x 12	730	86	0.14	0.097	0.680	56331E3	66331E3	36331E3
	470	10 x 16	950	121	0.14	0.066	0.460	56471E3	66471E3	36471E3
	680	10 x 20	1180	173	0.14	0.049	0.340	56681E3	66681E3	36681E3
	1000	12.5 x 20	1460	253	0.14	0.037	0.260	56102E3	66102E3	36102E3
	1500	12.5 x 25	1950	378	0.14	0.029	0.200	56152E3	66152E3	36152E3
	2200	12.5 x 35	2510	553	0.16	0.028	0.200	96225E3	96226E3	-
35	2200	16 x 20	1840	553	0.16	0.028	0.200	56222E3	66222E3	36222E3
	3300	16 x 31	2890	828	0.16	0.019	0.130	56332E3	66332E3	36332E3
	4700	16 x 35	3100	1178	0.18	0.018	0.130	56472E3	66472E3	-
	100	8 x 12	555	35	0.12	0.117	0.870	50101E3	80101E3	30101E3
	220	8 x 15	730	77	0.12	0.085	0.750	90225E3	90228E3	90223E3
	220	10 x 12	730	80	0.12	0.097	0.680	50221E3	60221E3	30221E3
	330	10 x 16	950	118	0.12	0.066	0.460	50331E3	60331E3	30331E3
	470	10 x 20	1180	167	0.12	0.049	0.340	50471E3	60471E3	30471E3
	680	12.5 x 20	1460	241	0.12	0.037	0.260	50681E3	60681E3	30681E3
50	1000	12.5 x 25	1950	353	0.12	0.029	0.200	50102E3	60102E3	30102E3
	1000	16 x 20	1840	353	0.12	0.028	0.200	90105E3	90106E3	90103E3
	1500	12.5 x 35	2510	528	0.12	0.028	0.200	90186E3	90187E3	-
	1500	16 x 20	1840	528	0.12	0.028	0.200	50152E3	60152E3	30152E3
	2200	16 x 31	2890	773	0.14	0.019	0.130	50222E3	60222E3	30222E3
	3300	18 x 31	3000	1155	0.16	0.019	0.130	50332E3	60332E3	-
	150	10 x 12	500	78	0.10	0.200	1.400	51151E3	61151E3	31151E3
	220	10 x 16	700	113	0.10	0.120	0.840	51221E3	61221E3	31221E3
	330	10 x 20	900	168	0.10	0.090	0.630	51331E3	61331E3	31331E3
50	470	12.5 x 20	1100	238	0.10	0.062	0.430	51471E3	61471E3	31471E3
	680	12.5 x 25	1400	343	0.10	0.048	0.340	51681E3	61681E3	31681E3
	1000	16 x 25	1800	503	0.10	0.034	0.240	51102E3	61102E3	31102E3
	1200	16 x 31	2200	603	0.10	0.027	0.190	51122E3	61122E3	31122E3
	1500	16 x 31	2200	753	0.10	0.027	0.190	51152E3	61152E3	31152E3

ORDERING EXAMPLE

Electrolytic capacitor 150 series

470  $\mu\text{F}$ /16 V;  $\pm 20\%$

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

Ordering Code: MAL215035471E3

Former 12NC: 2222 150 35471



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 kHz 105 °C (mA)	I <sub>L2</sub> 2 min (µA)	tan δ 100 Hz	Z 100 kHz + 20 °C (Ω)	Z 100 kHz - 40 °C (Ω)	ORDERING CODE MAL2150.....		
								BULK PACKAGING		TAPED
								FORM CA	FORM CB	FORM TFA
63	47	8 x 12	405	30	0.09	0.342	2.350	58479E3	88479E3	38479E3
	100	10 x 12	420	66	0.10	0.270	1.890	58101E3	68101E3	38101E3
	150	10 x 16	560	97	0.10	0.190	1.330	58151E3	68151E3	38151E3
	220	10 x 20	700	141	0.10	0.150	1.050	58221E3	68221E3	38221E3
	330	12.5 x 20	930	211	0.10	0.095	0.670	58331E3	68331E3	38331E3
	470	12.5 x 25	1200	299	0.10	0.067	0.470	58471E3	68471E3	38471E3
	470	16 x 20	1100	299	0.10	0.074	0.520	98475E3	98476E3	98473E3
	680	16 x 20	1100	431	0.10	0.074	0.520	58681E3	68681E3	38681E3
	680	16 x 25	1500	431	0.10	0.054	0.380	98685E3	98686E3	98683E3
	1000	16 x 31	1900	633	0.10	0.042	0.295	58102E3	68102E3	38102E3
100	22	8 x 12	230	22	0.08	0.68	27.0	59229E3	89229E3	39229E3
	330	18 x 20	1700	330	0.07	0.074	2.0	90183E3	90185E3	-

ADDITIONAL ELECTRICAL DATA		
PARAMETER	CONDITIONS	VALUE
<b>Voltage</b>		
Surge voltage		U <sub>s</sub> ≤ 1.15 x U <sub>R</sub>
Reverse voltage		U <sub>rev</sub> ≤ 1 V
<b>Current</b>		
Leakage current	After 2 minutes at U <sub>R</sub>	I <sub>L2</sub> ≤ 0.01 C <sub>R</sub> x U <sub>R</sub> + 3 µA
<b>Inductance</b>		
Equivalent series inductance (ESL)	Case Ø D ≤ 10 mm	typ. 16 nH
	Case Ø D ≥ 12.5 mm	typ. 18 nH
<b>Resistance</b>		
Equivalent series resistance (ESR)	Calculated from tan δ <sub>max</sub> and C <sub>R</sub> (see Table 2)	ESR = tan δ/2 π f C <sub>R</sub>

**CAPACITANCE (C)**

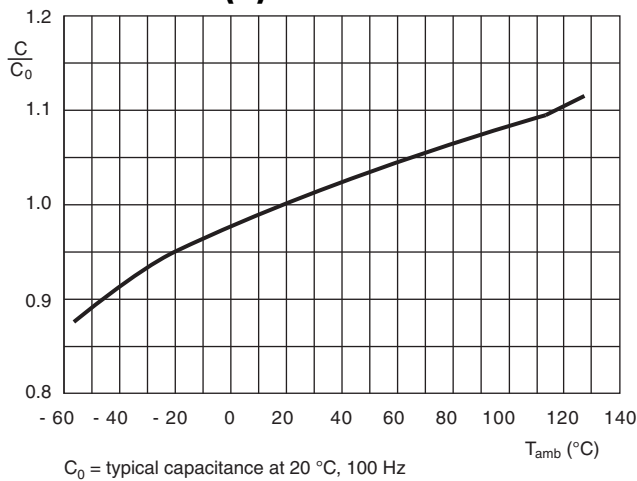


Fig.5 Typical multiplier of capacitance as a function of ambient temperature

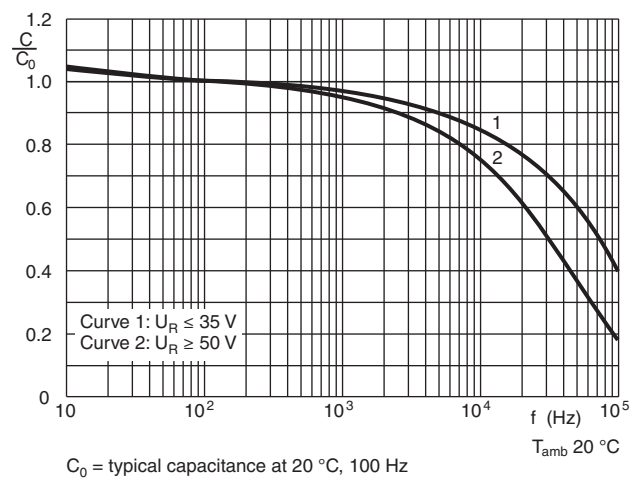


Fig.6 Typical multiplier of capacitance as a function of frequency

**EQUIVALENT SERIES RESISTANCE (ESR)**

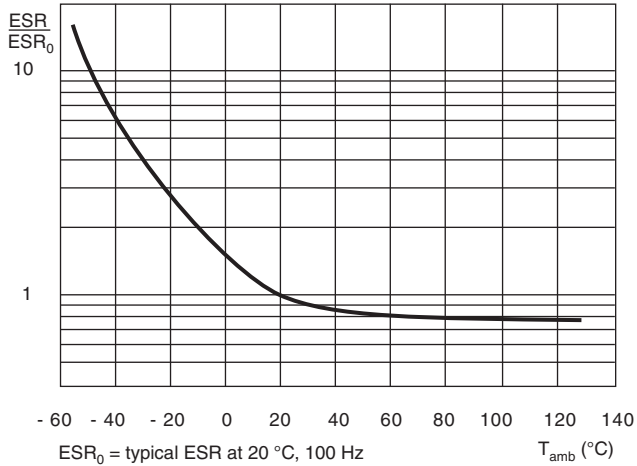


Fig.7 Typical multiplier of ESR as a function of ambient temperature

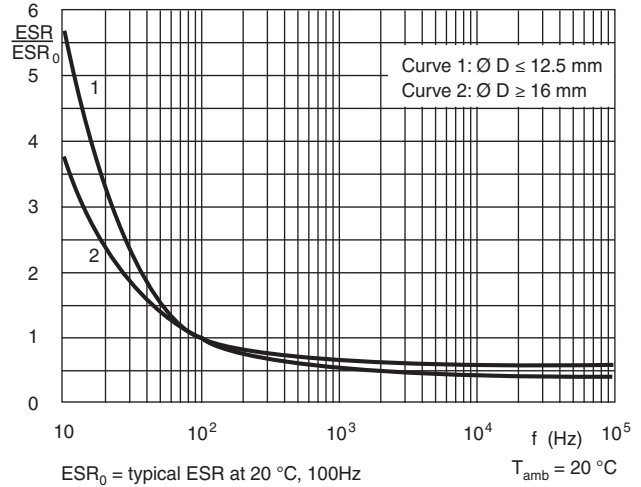


Fig.8 Typical multiplier of ESR as a function of frequency

**IMPEDANCE (Z)**

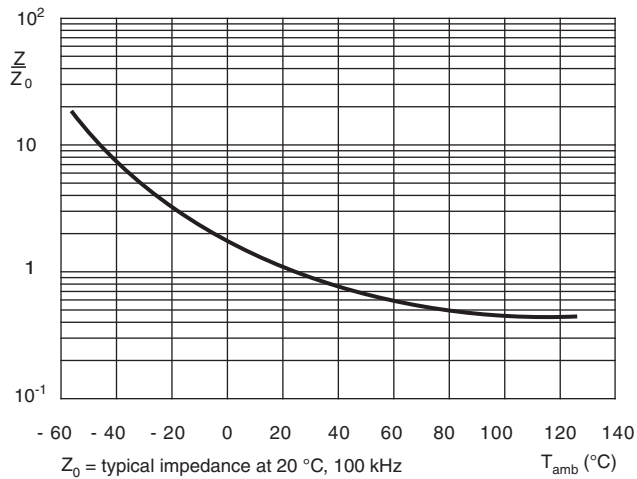


Fig.9 Typical multiplier of impedance as a function of ambient temperature

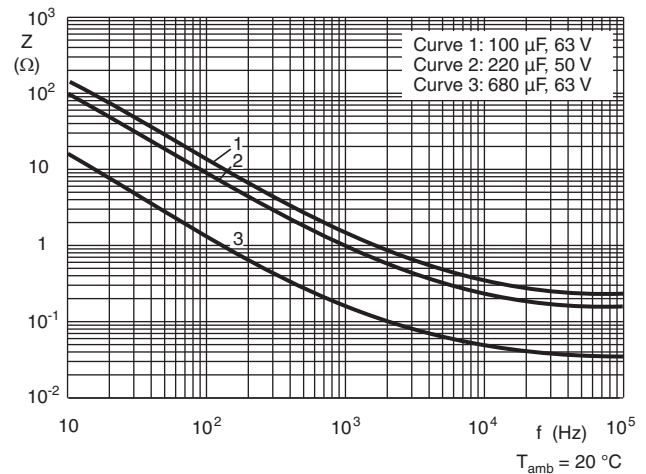


Fig.11 Typical impedance as a function of frequency

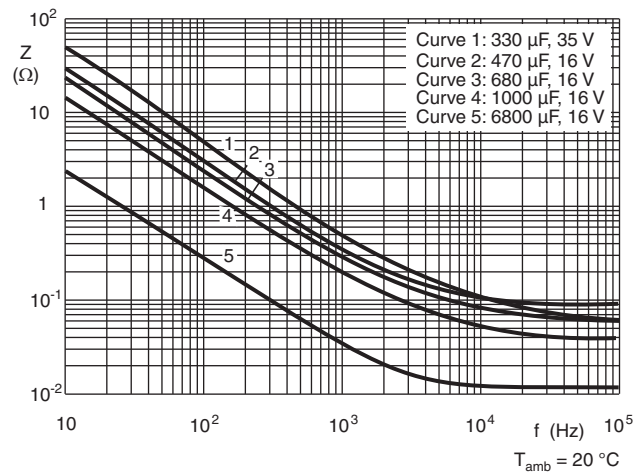
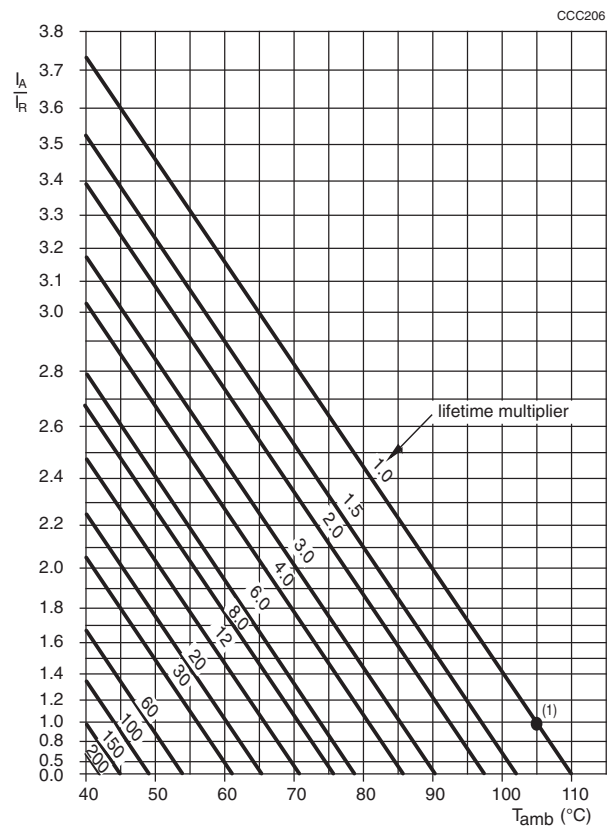


Fig.10 Typical impedance as a function of frequency

**RIPPLE CURRENT AND USEFUL LIFE**

Table 3

<b>ENDURANCE TEST DURATION AND USEFUL LIFE AS A FUNCTION OF CASE SIZE</b>			
NOMINAL CASE SIZE Ø D x L (mm)	CASE CODE	ENDURANCE at 105 °C (h)	USEFUL LIFE at 105 °C (h)
8 x 12	13	3000	4000
8 x 15	13L	3000	4000
10 x 12	14	3000	4000
10 x 16	15	3000	6000
10 x 20	16	3000	6000
12.5 x 20	17	3000	7000
12.5 x 25	18	5000	8000
12.5 x 35	18LL	5000	8000
16 x 20	19a	3000	7000
16 x 25	19	5000	10 000
16 x 31	20	5000	10 000
16 x 35	21	5000	10 000
18 x 20	1820	3000	7000
18 x 31	1831	6000	10 000



$I_A$  = actual ripple current at 100 kHz  
 $I_R$  = rated ripple current at 100 kHz, 105 °C  
 (1) Useful life at 105 °C and  $I_R$  applied; see Table 4

Fig.12 Multiplier of useful life as a function of ambient temperature and ripple current load

Table 4

MULTIPLIER OF RIPPLE CURRENT ( $I_R$ ) AS A FUNCTION OF FREQUENCY		
FREQUENCY (Hz)	$I_R$ MULTIPLIER	
	$\varnothing = 8 \text{ mm to } 12.5 \text{ mm}$	$\varnothing = 16 \text{ mm and } 18 \text{ mm}$
100	0.65	0.76
300	0.76	0.85
1000	0.85	0.91
3000	0.89	0.94
10 000	0.90	0.96
30 000	0.97	0.98
100 000	1.00	1.00

Table 5

TEST PROCEDURES AND REQUIREMENTS			
TEST		PROCEDURE (quick reference)	REQUIREMENTS
NAME OF TEST	REFERENCE		
Endurance	IEC 60384-4/ EN130300 subclause 4.13	$T_{amb} = 105 \text{ }^\circ\text{C}$ ; $U_R$ applied; for test duration see Table 3	$\Delta C/C: \pm 20 \%$ $\tan \delta \leq 2 \times \text{spec. limit}$ $I_{L2} \leq \text{spec. limit}$
Useful life	CECC 30301 subclause 1.8.1	$T_{amb} = 105 \text{ }^\circ\text{C}$ ; $U_R$ and $I_R$ applied; for test duration see Table 3	$\Delta C/C: \pm 30 \%$ $\tan \delta \leq 3 \times \text{spec. limit}$ $I_{L2} \leq \text{spec. limit}$ no short or open circuit total failure percentage: $\leq 1 \%$
Shelf life (storage at high temperature)	IEC 60384-4/ EN130300 subclause 4.17	$T_{amb} = 105 \text{ }^\circ\text{C}$ ; no voltage applied; 1000 h after test: $U_R$ to be applied for 30 min., 24 h to 48 h before measurement	$\Delta C/C: \pm 20 \%$ $\tan \delta \leq 2 \times \text{spec. limit}$ $I_{L2} \leq \text{spec. limit}$



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