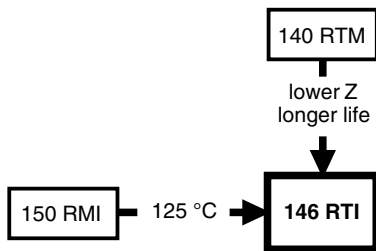
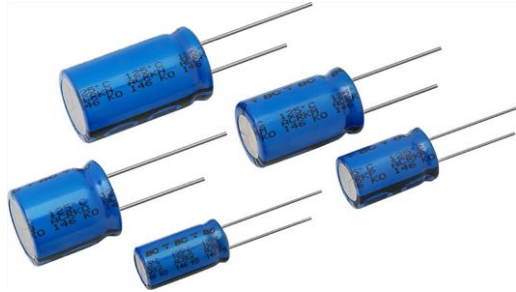


## Aluminum Capacitors Radial, High Temperature, Low Impedance



### FEATURES

- Very long useful life: 2500 h to 6000 h at 125 °C
- High stability, high reliability
- Very low ESR
- AEC-Q200 qualified
- Excellent ripple current capability
- Polarized aluminum electrolytic capacitors, non-solid electrolyte
- Radial leads, cylindrical aluminum case with pressure relief, insulated with a blue PET sleeve
- Charge and discharge proof
- Material categorization: for definitions of compliance please see [www.vishay.com/doc?99912](http://www.vishay.com/doc?99912)


**RoHS  
COMPLIANT**

### APPLICATIONS

- Power supplies (SMPS, DC/DC converters) for industrial, automotive, telecommunications and military
- Smoothing, filtering and buffering

### 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
- Logo of manufacturer
- Upper category temperature (125 °C)
- Negative terminal identification
- Series number (146)

QUICK REFERENCE DATA	
DESCRIPTION	VALUE
Nominal case sizes ( $\varnothing$ D x L in mm)	10 x 12 to 18 x 40
Rated capacitance range, $C_R$	68 $\mu\text{F}$ to 8200 $\mu\text{F}$
Tolerance on $C_R$	$\pm 20\%$
Rated voltage range, $U_R$	16 V to 63 V
Category temperature range	-55 °C to +125 °C
Endurance test at 125 °C	2000 h to 5000 h
Useful life at 125 °C	2500 h to 6000 h
Useful life at 40 °C, 1.8 x $I_R$ applied	400 000 h
Shelf life at 0 V, 125 °C	1000 h
Based on sectional specification	IEC 60384-4 / EN130300
Climatic category IEC 60068	55 / 125 / 56

SELECTION CHART FOR $C_R$ , $U_R$ , AND RELEVANT NOMINAL CASE SIZES ( $\varnothing$ D x L in mm)					
$C_R$ ( $\mu\text{F}$ )	$U_R$ (V)				
	16	25	35	50	63
68	-	-	-	-	10 x 20
100	-	-	-	10 x 12	10 x 16
150	-	-	-	-	10 x 20
220	-	-	10 x 12	10 x 16	12.5 x 20
330	-	10 x 12	10 x 16	10 x 20	12.5 x 25
390	-	-	-	-	16 x 20
470	10 x 12	10 x 16	10 x 20	12.5 x 20	18 x 20
560	-	-	-	-	16 x 25
680	10 x 16	10 x 20	12.5 x 20	12.5 x 25	18 x 25
	-	-	-	-	16 x 31
820	-	-	-	16 x 20	16 x 35
1000	10 x 20	12.5 x 20	12.5 x 25	18 x 20	18 x 31
	-	-	-	16 x 25	-

<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)				
	16	25	35	50	63
1200	-	-	16 x 20	18 x 25	18 x 35
	-	-	-	16 x 31	-
1500	12.5 x 20	12.5 x 25	18 x 20	16 x 35	18 x 40
1800	-	16 x 20	16 x 25	18 x 31	-
2200	12.5 x 25	-	18 x 25	18 x 35	-
	-	-	16 x 31	-	-
2700	16 x 20	18 x 20	16 x 35	18 x 40	-
	-	16 x 25	18 x 31	-	-
3300	18 x 20	16 x 31	18 x 35	-	-
3900	16 x 25	18 x 25	-	-	-
4700	18 x 25	16 x 35	18 x 40	-	-
	16 x 31	18 x 31	-	-	-
5600	16 x 35	18 x 35	-	-	-
6800	18 x 31	18 x 40	-	-	-
8200	18 x 40	-	-	-	-

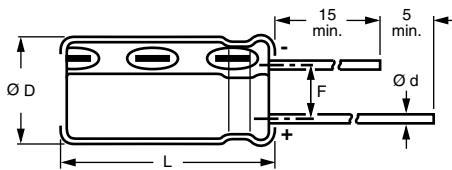
**DIMENSIONS in millimeters AND AVAILABLE FORMS**


Fig. 2 - Form CA: long leads

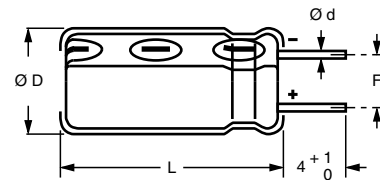


Fig. 3 - Form CB: cut leads

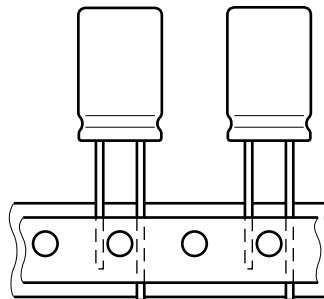


Fig. 4 - Form TFA: taped in box (ammopack)

**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
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
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	250
18 x 25	1825	0.8	18.5	27.0	$7.5 \pm 0.5$	$\approx 10.0$	100	100	250
18 x 31	1831	0.8	18.5	33.5	$7.5 \pm 0.5$	$\approx 12.5$	100	100	250
18 x 35	22	0.8	18.5	37.5	$7.5 \pm 0.5$	$\approx 14.5$	100	100	-
18 x 40	1840	0.8	18.5	42.5	$7.5 \pm 0.5$	$\approx 16.5$	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, 125 °C
$I_{L2}$	Max. leakage current after 2 min 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 125 °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 MAL2146.....		
								BULK PACKAGING		TAPED
								FORM CA	FORM CB	FORM TFA
16	470	10 x 12	620	78	0.16	0.120	0.750	55471E3	65471E3	35471E3
	680	10 x 16	1100	112	0.16	0.075	0.450	55681E3	65681E3	35681E3
	1000	10 x 20	1250	163	0.16	0.060	0.360	55102E3	65102E3	35102E3
	1500	12.5 x 20	1600	243	0.16	0.043	0.258	55152E3	65152E3	35152E3
	2200	12.5 x 25	2000	355	0.18	0.033	0.198	55222E3	65222E3	35222E3
	2700	16 x 20	1900	435	0.18	0.034	0.204	55272E3	65272E3	35272E3
	3300	18 x 20	2000	531	0.20	0.033	0.198	55332E3	65332E3	35332E3
	3900	16 x 25	2500	627	0.20	0.024	0.144	55392E3	65392E3	35392E3
	4700	18 x 25	2800	755	0.22	0.025	0.150	55472E3	65472E3	35472E3
	4700	16 x 31	3000	755	0.22	0.021	0.126	95475E3	95476E3	95473E3
	5600	16 x 35	3200	899	0.24	0.018	0.108	55562E3	65562E3	-
	6800	18 x 31	3100	1091	0.24	0.022	0.132	55682E3	65682E3	35682E3
8200	18 x 40	3300	3300							
25	330	10 x 12	620	85	0.14	0.120	0.750	56331E3	66331E3	36331E3
	470	10 x 16	1100	121	0.14	0.075	0.450	56471E3	66471E3	36471E3
	680	10 x 20	1250	173	0.14	0.060	0.360	56681E3	66681E3	36681E3
	1000	12.5 x 20	1600	253	0.14	0.043	0.258	56102E3	66102E3	36102E3
	1500	12.5 x 25	2000	378	0.14	0.033	0.198	56152E3	66152E3	36152E3
	1800	16 x 20	1900	453	0.14	0.034	0.204	56182E3	66182E3	36182E3
	2700	18 x 20	2000	678	0.16	0.033	0.198	56272E3	66272E3	36272E3
	2700	16 x 25	2500	678	0.16	0.024	0.144	96275E3	96276E3	96273E3
	3300	16 x 31	3000	828	0.18	0.021	0.126	56332E3	66332E3	36332E3
	3900	18 x 25	2800	978	0.18	0.025	0.150	56392E3	66392E3	36392E3
	4700	16 x 35	3200	1178	0.20	0.018	0.108	56472E3	66472E3	-
	4700	18 x 31	3100	1178	0.20	0.022	0.132	96475E3	96476E3	96473E3
5600	18 x 35	3100	1403	0.22	0.019	0.114	56562E3	66562E3	-	
6800	18 x 40	3300	3300							
35	220	10 x 12	620	80	0.12	0.120	0.750	50221E3	60221E3	30221E3
	330	10 x 16	1100	119	0.12	0.075	0.450	50331E3	60331E3	30331E3
	470	10 x 20	1250	168	0.12	0.060	0.360	50471E3	60471E3	30471E3
	680	12.5 x 20	1600	241	0.12	0.043	0.258	50681E3	60681E3	30681E3
	1000	12.5 x 25	2000	353	0.12	0.033	0.198	50102E3	60102E3	30102E3
	1200	16 x 20	1900	423	0.12	0.034	0.204	50122E3	60122E3	30122E3
	1500	18 x 20	2000	528	0.12	0.033	0.198	50152E3	60152E3	30152E3
	1800	16 x 25	2500	633	0.12	0.024	0.144	50182E3	60182E3	30182E3
	2200	18 x 25	2800	773	0.14	0.025	0.150	50222E3	60222E3	30222E3
	2200	16 x 31	3000	773	0.14	0.021	0.126	90225E3	90226E3	90223E3
	2700	16 x 35	3200	948	0.14	0.018	0.108	50272E3	60272E3	-
	2700	18 x 31	3100	948	0.14	0.022	0.132	90275E3	90276E3	90273E3
3300	18 x 35	3100	1158	0.16	0.019	0.114	50332E3	60332E3	-	
4700	18 x 40	3300	3300							

**ORDERING EXAMPLE**

Electrolytic capacitor 146 series

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

Nominal case size:  $\varnothing 10\text{ mm} \times 16\text{ mm}$ ; Form TFA

Ordering code: MAL214636471E3



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 125 °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 MAL2146.....		
								BULK PACKAGING		TAPED
								FORM CA	FORM CB	FORM TFA
50	100	10 x 12	420	53	0.10	0.190	1.330	51101E3	61101E3	31101E3
	220	10 x 16	900	113	0.10	0.120	0.720	51221E3	61221E3	31221E3
	330	10 x 20	1000	168	0.10	0.090	0.540	51331E3	61331E3	31331E3
	470	12.5 x 20	1250	238	0.10	0.065	0.390	51471E3	61471E3	31471E3
	680	12.5 x 25	1700	343	0.10	0.050	0.300	51681E3	61681E3	31681E3
	820	16 x 20	1650	413	0.10	0.047	0.282	51821E3	61821E3	31821E3
	1000	18 x 20	1800	503	0.10	0.039	0.234	51102E3	61102E3	31102E3
	1000	16 x 25	2100	503	0.10	0.031	0.186	91105E3	91106E3	91103E3
	1200	18 x 25	2400	603	0.10	0.030	0.180	51122E3	61122E3	31122E3
	1200	16 x 31	2550	603	0.10	0.027	0.162	91125E3	91126E3	91123E3
	1500	16 x 35	2800	753	0.10	0.022	0.132	51152E3	61152E3	-
	1800	18 x 31	2700	903	0.10	0.026	0.156	51182E3	61182E3	31182E3
	2200	18 x 35	3000	1103	0.12	0.022	0.132	51222E3	61222E3	-
2700	18 x 40	3200								
63	68	10 x 12	400	46	0.10	0.360	2.160	58689E3	68689E3	38689E3
	100	10 x 16	600	66	0.10	0.220	1.320	58101E3	68101E3	38101E3
	150	10 x 20	750	98	0.10	0.150	0.900	58151E3	68151E3	38151E3
	220	12.5 x 20	1000	142	0.10	0.098	0.950	58221E3	68221E3	38221E3
	330	12.5 x 25	1300	211	0.10	0.076	0.456	58331E3	68331E3	38331E3
	390	16 x 20	1250	249	0.10	0.075	0.450	58391E3	68391E3	38391E3
	470	18 x 20	1500	299	0.10	0.055	0.330	58471E3	68471E3	38471E3
	560	16 x 25	1800	356	0.10	0.048	0.288	58561E3	68561E3	38561E3
	680	18 x 25	2100	431	0.10	0.041	0.246	58681E3	68681E3	38681E3
	680	16 x 31	2200	431	0.10	0.036	0.216	98685E3	98686E3	98683E3
	820	16 x 35	2500	520	0.10	0.029	0.174	58821E3	68821E3	-
	1000	18 x 31	2400	633	0.10	0.032	0.192	58102E3	68102E3	38102E3
	1200	18 x 35	2600	759	0.10	0.029	0.174	58122E3	68122E3	-
	1500	18 x 40	2800							

ADDITIONAL ELECTRICAL DATA		
PARAMETER	CONDITIONS	VALUE
<b>Voltage</b>		
Surge voltage		$U_s \leq 1.15 \times U_R$
Reverse voltage		$U_{rev} \leq 0.5 V$
<b>Current</b>		
Leakage current	After 2 min at $U_R$	$I_{L2} \leq 0.01 C_R \times U_R + 3 \mu A$
<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 $\tan \delta_{max}$ and $C_R$ (see Table 2)	$ESR = \tan \delta / 2 \pi f C_R$

**CAPACITANCE (C)**

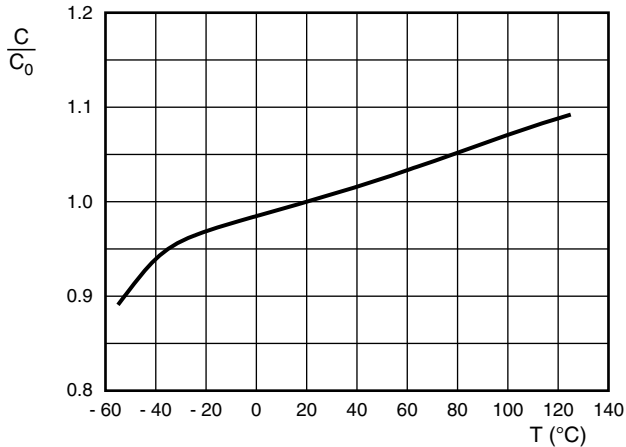


Fig. 5 - Typical multiplier of capacitance at 100 Hz as a function of temperature ( $C_0 = C$  at 20 °C)

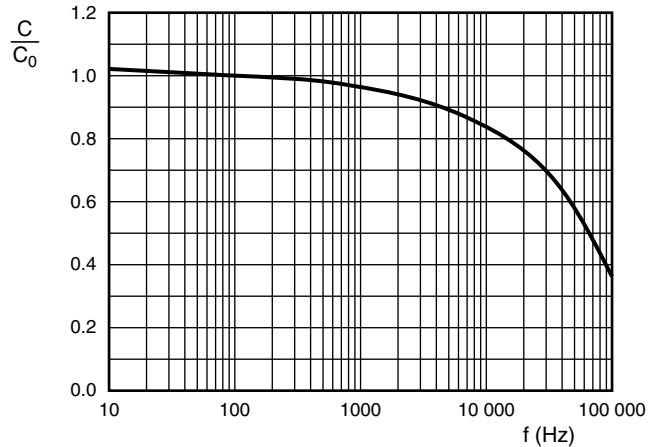


Fig. 6 - Typical multiplier of capacitance as a function of frequency at 20 °C ( $C_0 = C$  at 100 Hz)

**EQUIVALENT SERIES RESISTANCE (ESR)**

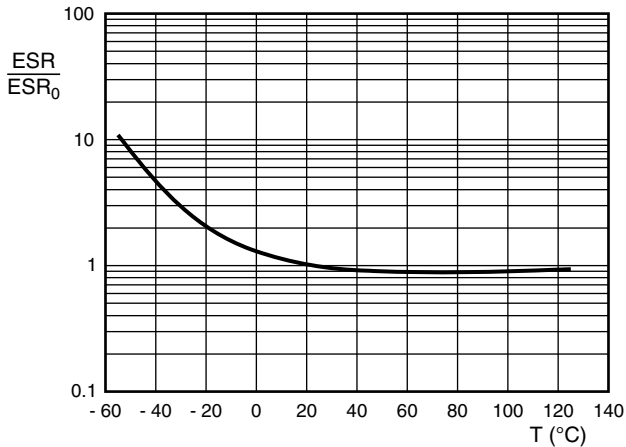


Fig. 7 - Typical multiplier of ESR at 100 Hz as a function of temperature ( $ESR_0 = ESR$  at 20 °C)

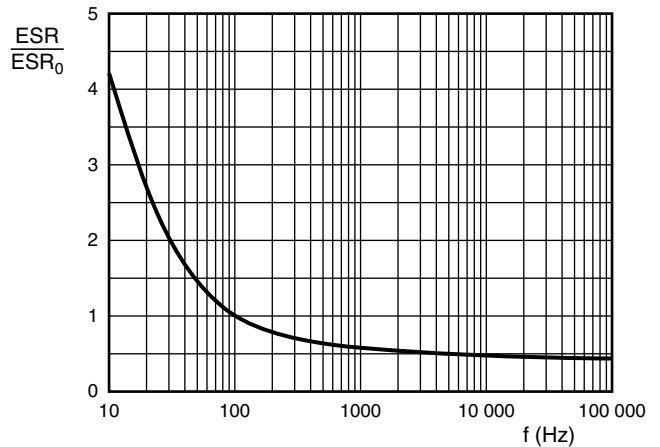


Fig. 8 - Typical multiplier of ESR at 20 °C as a function of frequency ( $ESR_0 = ESR$  at 100 Hz)

**IMPEDANCE (Z)**

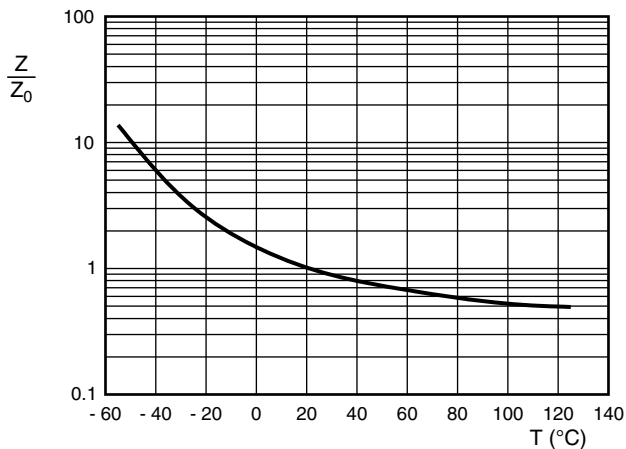


Fig. 9 - Typical multiplier of impedance at 100 kHz as a function of temperature ( $Z_0 = Z$  at 20 °C)

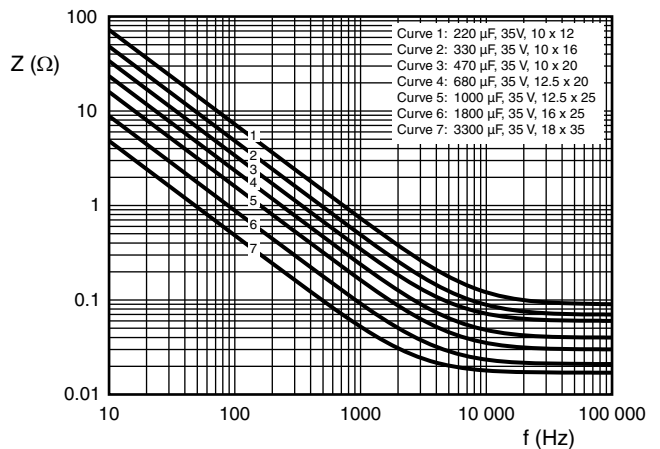


Fig. 10 - Typical impedance  $Z$  at 20 °C as a function of frequency

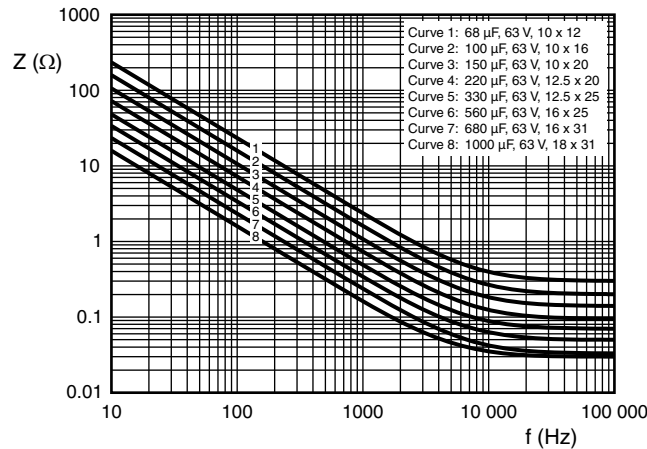


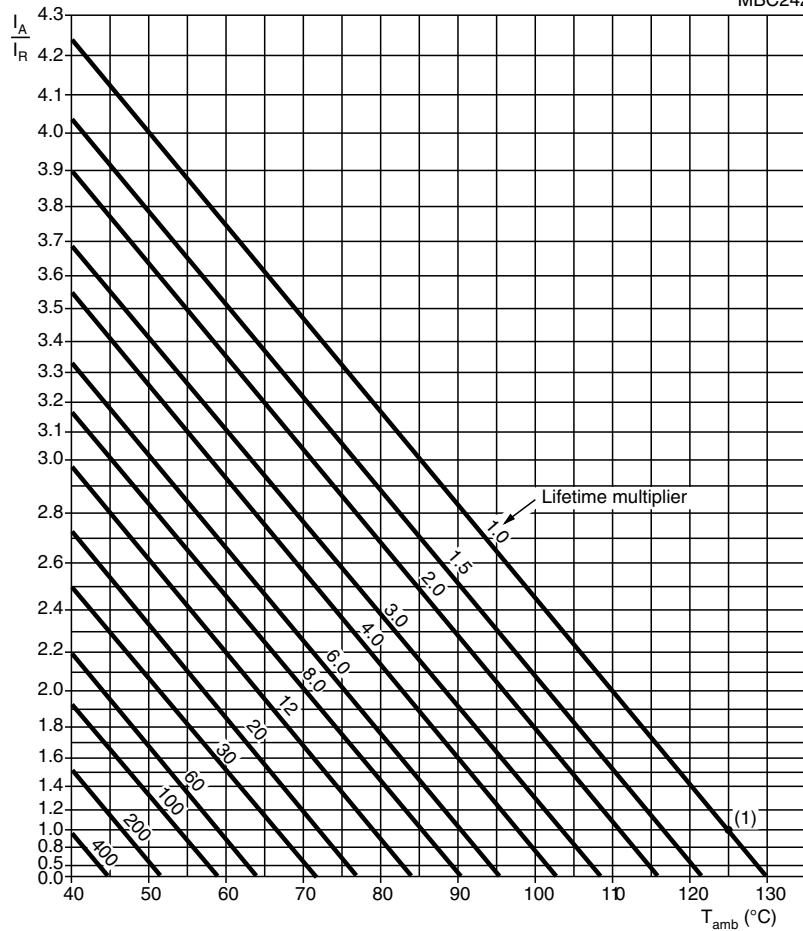
Fig. 11 - Typical impedance Z at 20 °C as a function of frequency

Table 3

ENDURANCE TEST DURATION AND USEFUL LIFE AS A FUNCTION OF CASE SIZE			
NOMINAL CASE SIZE $\varnothing$ D x L (mm)	CASE CODE	ENDURANCE AT 125 °C (h)	USEFUL LIFE AT 125 °C (h)
10 x 12	14	2000	2500
10 x 16	15	2000	2500
10 x 20	16	2000	3000
12.5 x 20	17	2000	3000
12.5 x 25	18	3000	5000
16 x 20	19a	3000	4000
16 x 25	19	3000	5000
16 x 31	20	4000	6000
16 x 35	21	5000	6000
18 x 20	1820	3000	4000
18 x 25	1825	3000	5000
18 x 31	1831	4000	6000
18 x 35	22	5000	6000
18 x 40	1840	5000	6000

**RIPPLE CURRENT AND USEFUL LIFE**

MBC242



$I_A$  = Actual ripple current at 100 kHz  
 $I_R$  = Rated ripple current at 100 kHz, 125 °C

(1) Useful life at 125 °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		
	$U_R = 16\text{ V to }25\text{ V}$	$U_R = 35\text{ V}$	$U_R = 50\text{ V to }63\text{ V}$
50	0.60	0.50	0.35
100	0.70	0.65	0.50
300	0.85	0.80	0.65
1000	0.90	0.85	0.80
3000	0.95	0.90	0.90
10 000	1.00	0.95	0.90
100 000	1.00	1.00	1.00

Table 5

<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	$T_{amb} = 125\text{ °C}$ ; $U_R$ applied; for test duration see Table 3	$\Delta C/C: \pm 15\%$ $\tan \delta \leq 1.3 \times \text{spec. limit}$ $Z \leq 2 \times \text{spec. limit}$ $I_{L2} \leq \text{spec. limit}$
Useful life	CECC 30301 subclause 1.8.1	$T_{amb} = 125\text{ °C}$ ; $U_R$ and $I_R$ applied; for test duration see Table 3	$\Delta C/C: \pm 30\%$ $\tan \delta \leq 3 \times \text{spec. limit}$ $Z \leq 3 \times \text{spec. limit}$ $I_{L2} \leq \text{spec. limit}$ no short or open circuit total failure percentage: $\leq 1\%$
Shelf life	IEC 60384-4 / EN130300 subclause 4.17	$T_{amb} = 125\text{ °C}$ ; no voltage applied; 1000 h after test: $U_R$ to be applied for 30 min, 24 h o 48 h before measurement	$\Delta C/C: \pm 15\%$ $\tan \delta \leq 1.3 \times \text{spec. limit}$ $Z \leq 3 \times \text{spec. limit}$ $I_{L2} \leq \text{spec. limit}$





## Disclaimer

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