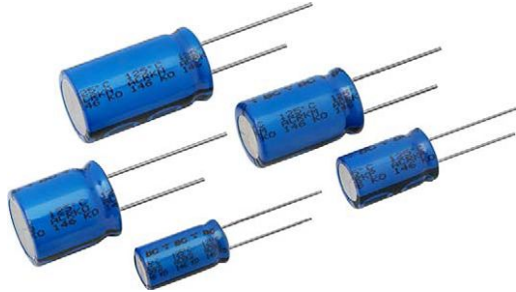


# Aluminum Electrolytic Capacitors

## Radial, Enhanced High Temperature, Low Impedance


**RoHS**  
COMPLIANT

**FEATURES**

- Useful life: up to 2000 h at 150 °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)

**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 (150 °C)
- Negative terminal identification
- Series number (160)

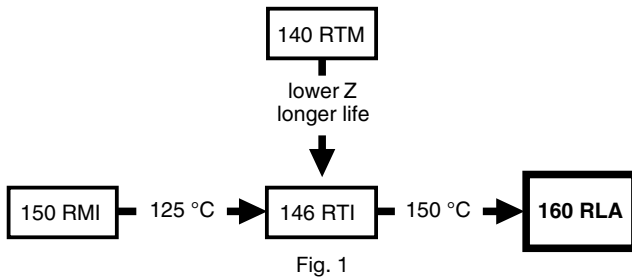


Fig. 1

QUICK REFERENCE DATA	
DESCRIPTION	VALUE
Nominal case sizes ( $\varnothing$ D x L in mm)	10 x 12 to 18 x 35
Rated capacitance range, $C_R$	33 $\mu\text{F}$ to 3300 $\mu\text{F}$
Tolerance on $C_R$	$\pm 20\%$
Rated voltage range, $U_R$	16 V to 50 V
Category temperature range	-55 °C to +150 °C
Endurance test at 150 °C	1000 h to 1500 h
Useful life at 150 °C	1000 h to 2000 h
Useful life at 40 °C, 1.8 x $I_R$ applied	200 000 h
Shelf life at 0 V, 150 °C	1000 h
Based on sectional specification	IEC 60384-4 / EN130300
Climatic category IEC 60068	55/150/56

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
33	→	→	→	10 x 12
47	→	→	10 x 12	10 x 12
100	→	10 x 12	10 x 16	10 x 16
220	10 x 16	12.5 x 20	12.5 x 20	10 x 20
330	10 x 20	12.5 x 25	12.5 x 25	12.5 x 20
470	12.5 x 20	16 x 25	18 x 20	12.5 x 25
680	12.5 x 25	→	16 x 31	16 x 25
1000	16 x 25	16 x 31	18 x 35	18 x 31
1500	18 x 20	18 x 31	-	-
2200	18 x 25	-	-	-
2700	18 x 31	-	-	-
3300	18 x 35	-	-	-

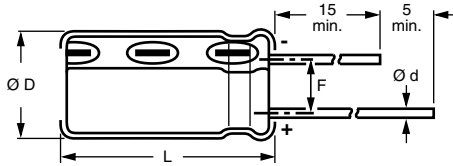
**DIMENSIONS in millimeters AND AVAILABLE FORMS**


Fig. 2 - Form CA: long leads

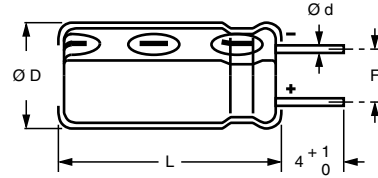


Fig. 3 - Form CB: cut leads

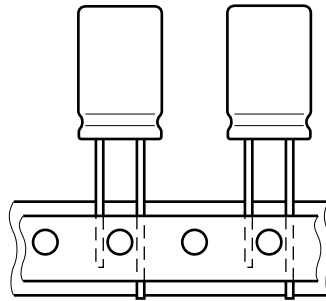


Fig. 4 - Form TFA: taped in box (ammopack)

Table 1

DIMENSIONS in millimeters, MASS AND PACKAGING QUANTITIES									
NOMINAL CASE SIZE Ø D x L	CASE CODE	Ø d	Ø D <sub>max.</sub>	L <sub>max.</sub>	F	MASS (g)	PACKAGING QUANTITIES		
							FORM CA	FORM CB	FORM TFA
10 x 12	14	0.6	10.5	13.5	5.0 ± 0.5	≈ 1.6	1000	500	800
10 x 16	15	0.6	10.5	17.5	5.0 ± 0.5	≈ 1.9	500	500	800
10 x 20	16	0.6	10.5	22.0	5.0 ± 0.5	≈ 2.2	500	500	800
12.5 x 20	17	0.6	13.0	22.0	5.0 ± 0.5	≈ 4.0	500	500	500
12.5 x 25	18	0.6	13.0	27.0	5.0 ± 0.5	≈ 5.0	250	250	500
16 x 25	19	0.8	16.5	27.0	7.5 ± 0.5	≈ 8.0	250	250	250
16 x 31	20	0.8	16.5	33.5	7.5 ± 0.5	≈ 9.0	100	100	250
18 x 20	1820	0.8	18.5	22.0	7.5 ± 0.5	≈ 8.0	100	100	250
18 x 25	1825	0.8	18.5	27.0	7.5 ± 0.5	≈ 10.0	100	100	250
18 x 31	1831	0.8	18.5	33.5	7.5 ± 0.5	≈ 12.5	100	100	-
18 x 35	22	0.8	18.5	37.5	7.5 ± 0.5	≈ 14.5	100	100	-

ELECTRICAL DATA	
SYMBOL	DESCRIPTION
C <sub>R</sub>	Rated capacitance at 100 Hz, tolerance ± 20 %
I <sub>R</sub>	Rated RMS ripple current at 100 kHz, 150 °C
I <sub>L2</sub>	Maximum leakage current after 2 min at U <sub>R</sub>
tan δ	Maximum dissipation factor at 100 Hz
Z	Maximum impedance at 100 kHz

**Note**

- Unless otherwise specified, all electrical values in Table 2 apply at T<sub>amb</sub> = 20 °C, P = 86 kPa to 106 kPa, RH = 45 % to 75 %

**ORDERING EXAMPLE**

Electrolytic capacitor 160 RLA series

470 µF / 25 V; ± 20 %

Nominal case size: Ø 10 mm x 16 mm; Form TFA

Ordering code: MAL216036471E3



Table 2

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 150 °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 MAL2160.....		
								BULK PACKAGING		TAPED
								FORM CA	FORM CB	FORM TFA
16	220	10 x 16	300	38	0.14	0.075	0.450	55221E3	65221E3	35221E3
	330	10 x 20	400	56	0.14	0.065	0.390	55331E3	65331E3	35331E3
	470	12.5 x 20	600	78	0.14	0.048	0.288	55471E3	65471E3	35471E3
	680	12.5 x 25	700	112	0.14	0.040	0.240	55681E3	65681E3	35681E3
	1000	16 x 25	800	163	0.16	0.029	0.174	55102E3	65102E3	35102E3
	1500	18 x 20	750	243	0.16	0.035	0.210	55152E3	65152E3	35152E3
	2200	18 x 25	1200	355	0.18	0.028	0.168	55222E3	65222E3	35222E3
	2700	18 x 31	1600	435	0.18	0.025	0.150	55272E3	65272E3	35272E3
3300	18 x 35	2000	531	0.20	0.023	0.132	55332E3	65332E3	-	
25	100	10 x 12	250	28	0.12	0.120	0.750	56101E3	66101E3	36101E3
	220	12.5 x 20	600	58	0.12	0.048	0.288	56221E3	66221E3	36221E3
	330	12.5 x 25	700	86	0.12	0.040	0.240	56331E3	66331E3	36331E3
	470	16 x 25	800	121	0.12	0.029	0.174	56471E3	66471E3	36471E3
	1000	16 x 31	1000	253	0.12	0.027	0.162	56102E3	66102E3	36102E3
	1500	18 x 31	1600	378	0.14	0.025	0.150	56152E3	66152E3	36152E3
35	47	10 x 12	250	19	0.10	0.120	0.750	50479E3	60479E3	30479E3
	100	10 x 16	400	38	0.10	0.075	0.450	50101E3	60101E3	30101E3
	220	12.5 x 20	600	80	0.10	0.048	0.288	50221E3	60221E3	30221E3
	330	12.5 x 25	700	119	0.10	0.040	0.240	50331E3	60331E3	30331E3
	470	18 x 20	750	168	0.10	0.035	0.210	50471E3	60471E3	30471E3
	680	16 x 31	1000	241	0.10	0.027	0.162	50681E3	60681E3	30681E3
	1000	18 x 35	1200	353	0.10	0.024	0.144	50102E3	60102E3	-
	50	33	10 x 12	160	20	0.10	0.380	2.280	51339E3	61339E3
47		10 x 12	180	27	0.10	0.360	2.160	51479E3	61479E3	31479E3
100		10 x 16	270	53	0.10	0.260	1.560	51101E3	61101E3	31101E3
220		10 x 20	360	113	0.10	0.170	1.020	51221E3	61221E3	31221E3
330		12.5 x 20	400	168	0.10	0.115	0.690	51331E3	61331E3	31331E3
470		12.5 x 25	600	238	0.10	0.095	0.570	51471E3	61471E3	31471E3
680		16 x 25	700	343	0.10	0.069	0.414	51681E3	61681E3	31681E3
1000		18 x 31	1000	503	0.10	0.062	0.372	51102E3	61102E3	31102E3

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> ≤ 0.5 V
<b>Current</b>		
Leakage current	After 2 min 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)**

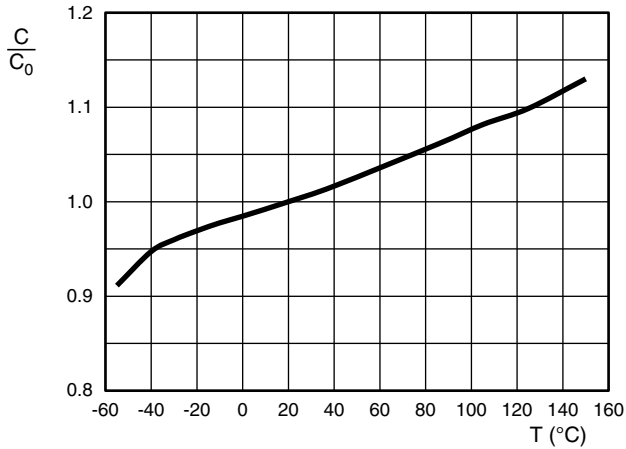


Fig. 5 - Typical multiplier of capacitance at 100 Hz as a function of temperature ( $C_0 = C$  at 20 °C)

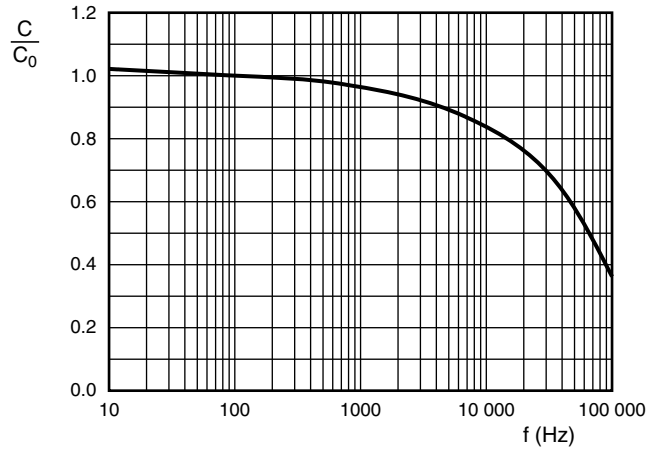


Fig. 6 - Typical multiplier of capacitance as a function of frequency at 20 °C ( $C_0 = C$  at 100 Hz)

**EQUIVALENT SERIES RESISTANCE (ESR)**

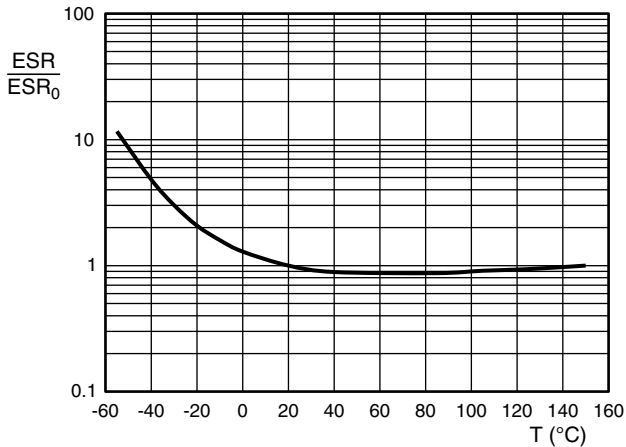


Fig. 7 - Typical multiplier of ESR at 100 Hz as a function of temperature ( $ESR_0 = ESR$  at 20 °C)

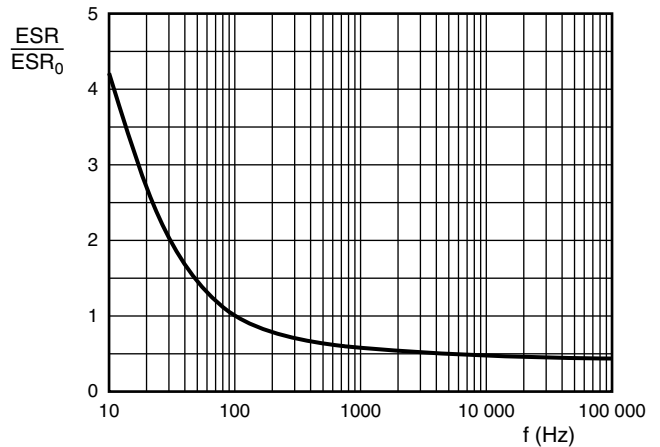


Fig. 8 - Typical multiplier of ESR at 20 °C as a function of frequency ( $ESR_0 = ESR$  at 100 Hz)

**IMPEDANCE (Z)**

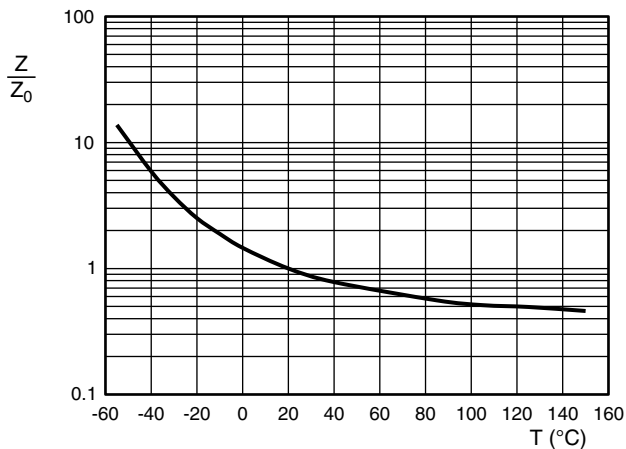


Fig. 9 - Typical multiplier of impedance at 100 kHz as a function of temperature ( $Z_0 = Z$  at 20 °C)

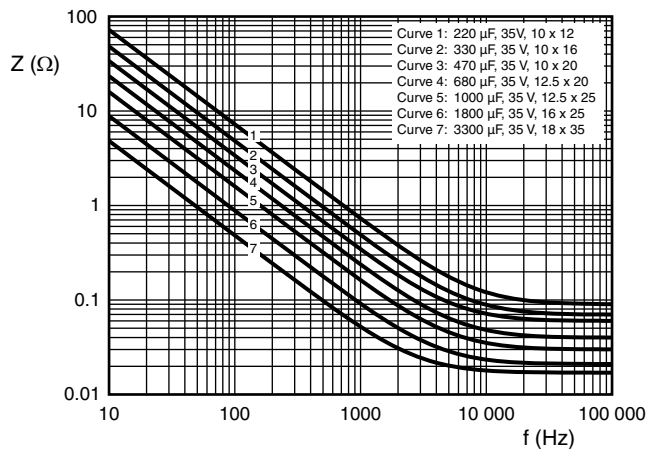


Fig. 10 - Typical impedance Z at 20 °C as a function of frequency

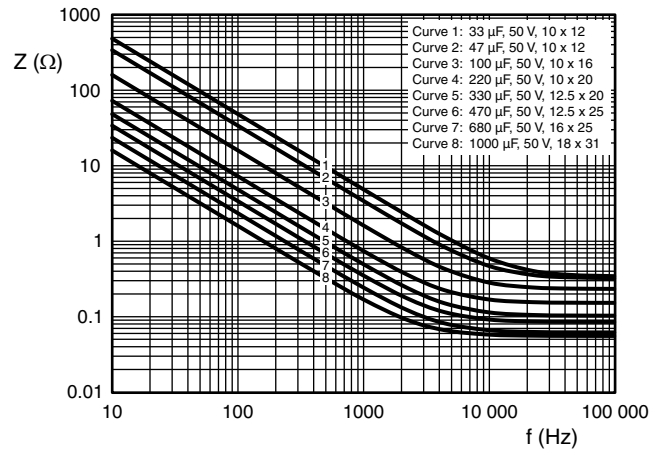


Fig. 11 - Typical impedance Z at 20 °C as a function of frequency

**Table 3**

<b>ENDURANCE TEST DURATION AND USEFUL LIFE AS A FUNCTION OF CASE SIZE</b>			
<b>NOMINAL CASE SIZE Ø D x L (mm)</b>	<b>CASE CODE</b>	<b>ENDURANCE AT 150 °C (h)</b>	<b>USEFUL LIFE AT 150 °C (h)</b>
10 x 12	14	1000	1000
10 x 16	15	1000	1000
10 x 20	16	1000	1000
12.5 x 20	17	1000	1000
12.5 x 25	18	1000	1000
16 x 25	19	1500	2000
16 x 31	20	1500	2000
18 x 20	1820	1500	2000
18 x 25	1825	1500	2000
18 x 31	1831	1500	2000
18 x 35	22	1500	2000

**RIPPLE CURRENT AND USEFUL LIFE**

MBC245

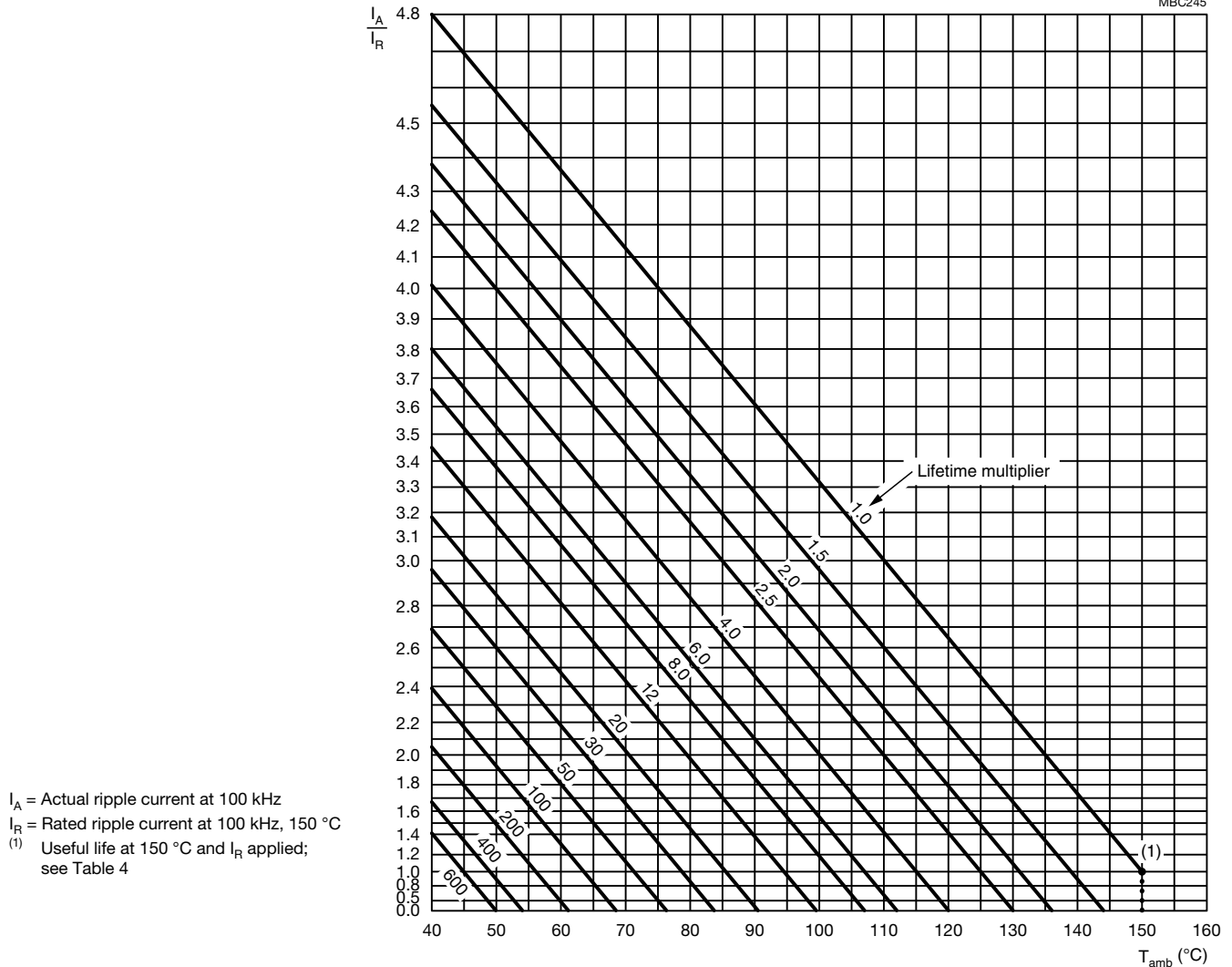


Fig. 12 - Multiplier of useful life as a function of ambient temperature and ripple current load

**Table 4**

<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>U_R = 16\text{ V to }25\text{ V}</math></b>	<b><math>U_R = 35\text{ V}</math></b>	<b><math>U_R = 50\text{ V}</math></b>
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 <sub>amb</sub> = 150 °C; U <sub>R</sub> applied; for test duration see Table 3	ΔC/C: ± 15 % tan δ ≤ 1.3 x spec. limit I <sub>L2</sub> ≤ spec. limit
Useful life	CECC 30301 subclause 1.8.1	T <sub>amb</sub> = 150 °C; U <sub>R</sub> and I <sub>R</sub> applied; for test duration see Table 3	ΔC/C: ± 30 % tan δ ≤ 3 x spec. limit I <sub>L2</sub> ≤ spec. limit no short or open circuit total failure percentage: ≤ 1 %
Shelf life	IEC 60384-4 / EN130300 subclause 4.17	T <sub>amb</sub> = 150 °C; no voltage applied; 1000 h after test: U <sub>R</sub> to be applied for 30 min, 24 h o 48 h before measurement	ΔC/C: ± 15 % tan δ ≤ 1.3 x spec. limit I <sub>L2</sub> ≤ spec. limit



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