

## Aluminum Capacitors Radial, Standard Long-Life

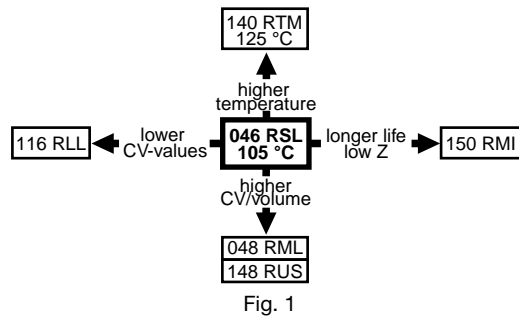
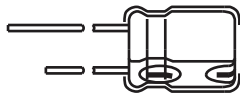


Fig. 1

### FEATURES

- Very long useful life: 3000 h to 4000 h at 105 °C
- High ripple current capability, low impedance, low ESR
- Charge and discharge proof
- Polarized aluminum electrolytic capacitors, non-solid electrolyte
- Radial leads, cylindrical aluminum case with pressure relief, insulated with a blue sleeve
- Material categorization: For definitions of compliance please see [www.vishay.com/doc?99912](http://www.vishay.com/doc?99912)



RoHS  
COMPLIANT

### APPLICATIONS

- Power conversion, EDP, telecommunication, industrial and audio-video
- Smoothing, filtering, buffering in SMPS, timing

### 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
- Name of manufacturer
- Upper category temperature (105 °C)
- Negative terminal identification
- Series number (046)

QUICK REFERENCE DATA	
DESCRIPTION	VALUE
Nominal case sizes ( $\varnothing D \times L$ in mm)	10 x 12 to 18 x 35
Rated capacitance range, $C_R$	22 $\mu\text{F}$ to 10 000 $\mu\text{F}$
Tolerance on $C_R$	$\pm 20\%$
Rated voltage range, $U_R$	6.3 V to 63 V
Category temperature range	-40 °C to +105 °C
Endurance test at 105 °C	2000 h
Useful life at 105 °C	
Case $\varnothing D = 10$ mm and 12.5 mm	3000 h
Case $\varnothing D = 16$ mm and 18 mm	4000 h
Useful life at 40 °C, $1.6 \times I_R$ applied	
Case $\varnothing D = 10$ mm and 12.5 mm	200 000 h
Case $\varnothing D = 16$ mm and 18 mm	260 000 h
Shelf life at 0 V, 105 °C	1000 h
Based on sectional specification	IEC 60384-4/EN 130300
Climatic category IEC 60068	40/105/56

SELECTION CHART FOR $C_R$ , $U_R$ , AND RELEVANT NOMINAL CASE SIZES ( $\varnothing D \times L$ in mm)								
$C_R$ ( $\mu\text{F}$ )	$U_R$ (V)							
	6.3	10	16	25	35	40	50	63
22	-	-	-	-	-	-	-	10 x 12
47	-	-	-	-	-	-	-	10 x 12
100	-	-	-	-	-	10 x 12	10 x 16	10 x 20
220	-	-	10 x 12	-	10 x 16	10 x 20	12.5 x 20	12.5 x 25
330	-	10 x 12	10 x 16	-	10 x 20	12.5 x 20	12.5 x 25	16 x 25
470	10 x 12	10 x 16	10 x 20	-	12.5 x 20	12.5 x 25	-	16 x 25
1000	10 x 20	12.5 x 20	12.5 x 25	12.5 x 25	16 x 25	-	16 x 31	18 x 35
2200	12.5 x 25	-	16 x 25	16 x 31	16 x 35	18 x 35	18 x 35	-
3300	16 x 25	-	16 x 31	18 x 35	-	18 x 35	-	-
4700	16 x 31	16 x 35	18 x 35	18 x 35	-	-	-	-
6800	16 x 35	18 x 35	18 x 35	-	-	-	-	-
10 000	18 x 35	18 x 35	-	-	-	-	-	-



**DIMENSIONS** in millimeters, **AND AVAILABLE FORMS**

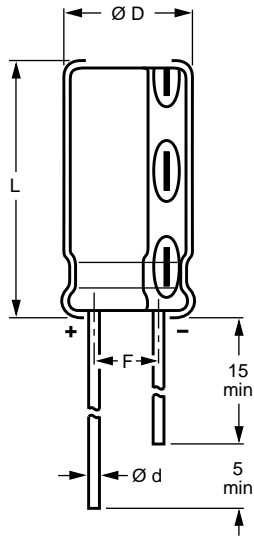


Fig. 2 - Form CA: Long leads

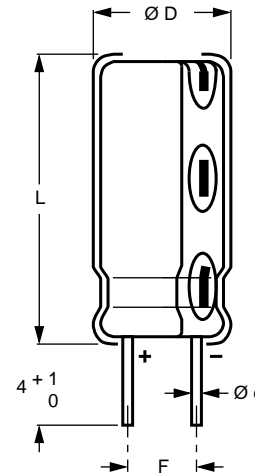
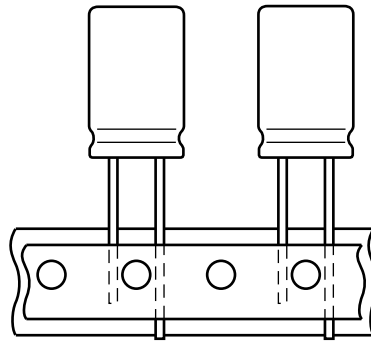


Fig. 3 - Form CB: Cut leads



Case  $\varnothing D \times L \leq 16 \times 31$  mm

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

Table 1

DIMENSIONS in millimeters, MASS, AND PACKAGING QUANTITIES									
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 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	$7.5 \pm 0.5$	$\approx 11.5$	100	100	-
18 x 35	22	0.8	18.5	37.5	$7.5 \pm 0.5$	$\approx 14.5$	300	1000	-

**Note**

- For detailed tape dimensions please see [www.vishay.com/doc?28360](http://www.vishay.com/doc?28360)



ELECTRICAL DATA	
SYMBOL	DESCRIPTION
$C_R$	Rated capacitance at 100 Hz, tolerance $\pm 20\%$
$I_R$	Rated RMS ripple current at 100 Hz, 105 °C
$I_{RH}$	Rated RMS ripple current at 100 kHz, 105 °C
$I_{L1}$	Max. leakage current after 1 min at $U_R$
$I_{L5}$	Max. leakage current after 5 min at $U_R$
$\tan \delta$	Max. dissipation factor at 100 Hz
ESR	Equivalent series resistance at 100 Hz (calculated from $\tan \delta_{max.}$ and $C_R$ )
Z	Max. impedance at 10 kHz or 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)	CASE CODE	$I_R$ 100 Hz 105 °C (mA)	$I_{RH}$ 100 kHz 105 °C (mA)	$I_{L1}$ 1 min ( $\mu\text{A}$ )	$I_{L5}$ 5 min ( $\mu\text{A}$ )	$\tan \delta$ 100 Hz	ESR 100 Hz ( $\Omega$ )	Z 10 kHz ( $\Omega$ )	Z 100 kHz ( $\Omega$ )	ORDERING NUMBER MAL2046.....		
												BULK PACKAGING		TAPED
												FORM CA	FORM CB	FORM TFA
6.3	470	10 x 12	14	360	600	33	9	0.19	0.64	0.32	0.28	53471E3	63471E3	33471E3
	1000	10 x 20	16	600	1000	66	16	0.19	0.30	0.15	0.14	53102E3	63102E3	33102E3
	2200	12.5 x 25	18	950	1500	140	31	0.23	0.17	0.08	0.07	53222E3	63222E3	33222E3
	3300	16 x 25	19	1200	1700	210	45	0.25	0.12	0.06	0.06	53332E3	63332E3	33332E3
	4700	16 x 31	20	1400	2000	300	62	0.27	0.09	0.05	0.05	53472E3	63472E3	33472E3
	6800	16 x 35	21	1600	2100	430	89	0.31	0.07	0.05	0.05	53682E3	63682E3	-
	10 000	18 x 35	22	1800	2300	630	130	0.39	0.06	0.04	0.04	53103E3	63103E3	-
10	330	10 x 12	14	370	620	36	10	0.15	0.72	0.38	0.31	54331E3	64331E3	34331E3
	470	10 x 16	15	460	800	50	12	0.15	0.51	0.27	0.22	54471E3	64471E3	34471E3
	1000	12.5 x 20	17	770	1100	100	23	0.15	0.24	0.13	0.12	54102E3	64102E3	34102E3
	4700	16 x 35	21	1600	2300	470	97	0.23	0.08	0.04	0.04	54472E3	64472E3	-
	6800	18 x 35	22	1800	2500	680	140	0.27	0.06	0.03	0.03	54682E3	64682E3	-
	10 000	18 x 35	22	2000	2600	1000	200	0.35	0.06	0.03	0.03	54103E3	64103E3	-
16	220	10 x 12	14	350	620	38	10	0.13	0.94	0.40	0.31	55221E3	65221E3	35221E3
	330	10 x 16	15	430	800	56	14	0.13	0.63	0.30	0.22	55331E3	65331E3	35331E3
	470	10 x 20	16	560	920	78	18	0.13	0.44	0.21	0.18	55471E3	65471E3	35471E3
	1000	12.5 x 25	18	900	1500	160	35	0.13	0.21	0.10	0.10	55102E3	65102E3	35102E3
	2200	16 x 25	19	1300	1800	360	73	0.17	0.12	0.06	0.05	55222E3	65222E3	35222E3
	3300	16 x 31	20	1600	2200	530	110	0.19	0.09	0.04	0.04	55332E3	65332E3	35332E3
	4700	18 x 35	22	1800	2500	760	150	0.21	0.07	0.03	0.03	55472E3	65472E3	-
	6800	18 x 35	22	2000	2600	1100	220	0.25	0.06	0.03	0.03	55682E3	65682E3	-
25	1000	12.5 x 25	18	900	1500	250	53	0.11	0.18	0.09	0.08	56102E3	66102E3	36102E3
	2200	16 x 31	20	1600	2100	550	110	0.15	0.11	0.04	0.04	56222E3	66222E3	36222E3
	3300	18 x 35	22	1900	2500	830	170	0.17	0.08	0.03	0.03	56332E3	66332E3	-
	4700	18 x 35	22	2000	2600	1200	240	0.19	0.06	0.03	0.03	56472E3	66472E3	-
35	220	10 x 16	15	400	740	80	18	0.10	0.72	0.30	0.23	50221E3	60221E3	30221E3
	330	10 x 20	16	510	880	120	26	0.10	0.48	0.26	0.16	50331E3	60331E3	30331E3
	470	12.5 x 20	17	650	1000	170	36	0.10	0.34	0.14	0.11	50471E3	60471E3	30471E3
	1000	16 x 25	19	1200	1600	350	73	0.10	0.16	0.07	0.06	50102E3	60102E3	30102E3
	2200	16 x 35	21	1800	2000	770	160	0.12	0.10	0.04	0.04	50222E3	60222E3	-
40	100	10 x 12	14	300	560	43	11	0.09	1.43	0.60	0.35	57101E3	67101E3	-
	220	10 x 20	16	450	850	91	21	0.09	0.65	0.27	0.17	57221E3	67221E3	37221E3
	330	12.5 x 20	17	590	1000	140	29	0.09	0.43	0.18	0.13	57331E3	67331E3	37331E3
	470	12.5 x 25	18	750	1300	190	41	0.09	0.30	0.13	0.08	57471E3	67471E3	37471E3
	2200	18 x 35	22	1900	2500	880	180	0.11	0.08	0.03	0.03	57222E3	67222E3	-
	3300	18 x 35	22	2100	2600	1300	270	0.12	0.06	0.03	0.03	57332E3	67332E3	-



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)	CASE CODE	I <sub>R</sub> 100 Hz 105 °C (mA)	I <sub>RH</sub> 100 kHz 105 °C (mA)	I <sub>L1</sub> 1 min (μA)	I <sub>L5</sub> 5 min (μA)	tan δ 100 Hz	ESR 100 Hz (Ω)	Z 10 kHz (Ω)	Z 100 kHz (Ω)	ORDERING NUMBER MAL2046.....		
												BULK PACKAGING		TAPED
												FORM CA	FORM CB	FORM TFA
50	100	10 x 16	15	310	610	53	13	0.07	1.11	0.50	0.28	51101E3	61101E3	31101E3
	220	12.5 x 20	17	500	980	110	25	0.07	0.51	0.23	0.13	51221E3	61221E3	31221E3
	330	12.5 x 25	18	680	1200	170	36	0.07	0.34	0.15	0.09	51331E3	61331E3	31331E3
	1000	16 x 31	20	1400	1800	500	100	0.07	0.11	0.05	0.05	51102E3	61102E3	31102E3
	2200	18 x 35	22	2000	2600	1100	220	0.09	0.07	0.03	0.03	51222E3	61222E3	-
63	22	10 x 12	14	170	310	17	9	0.06	4.3	1.6	0.7	58229E3	68229E3	38229E3
	47	10 x 12	14	230	430	33	9	0.06	2.03	0.96	0.40	58479E3	68479E3	38479E3
	100	10 x 20	16	360	710	66	16	0.06	0.95	0.45	0.20	58101E3	68101E3	38101E3
	220	12.5 x 25	18	610	1100	140	31	0.06	0.43	0.20	0.11	58221E3	68221E3	38221E3
	330	16 x 25	19	750	1300	210	45	0.06	0.29	0.14	0.08	58331E3	68331E3	38331E3
	470	16 x 25	19	950	1600	300	62	0.06	0.20	0.10	0.06	58471E3	68471E3	38471E3
	1000	18 x 35	22	1500	2100	630	130	0.06	0.10	0.04	0.04	58102E3	68102E3	-

ADDITIONAL ELECTRICAL DATA		
PARAMETER	CONDITIONS	VALUE
<b>Voltage</b>		
Surge voltage		U <sub>s</sub> ≤ 1.15 U <sub>R</sub>
Reverse voltage		U <sub>rev</sub> ≤ 1 V
<b>Current</b>		
Leakage current	After 1 min at U <sub>R</sub>	I <sub>L1</sub> ≤ 0.01 C <sub>R</sub> × U <sub>R</sub> + 3 μA
	After 5 min at U <sub>R</sub>	I <sub>L5</sub> ≤ 0.002 C <sub>R</sub> × 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

**CAPACITANCE (C)**

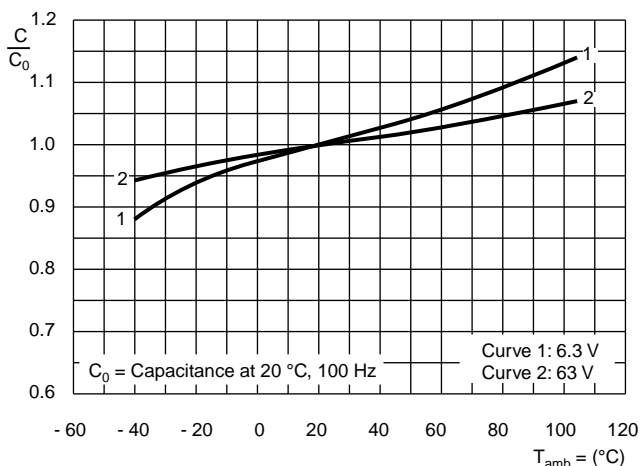


Fig. 5 - Typical multiplier of capacitance as a function of ambient temperature

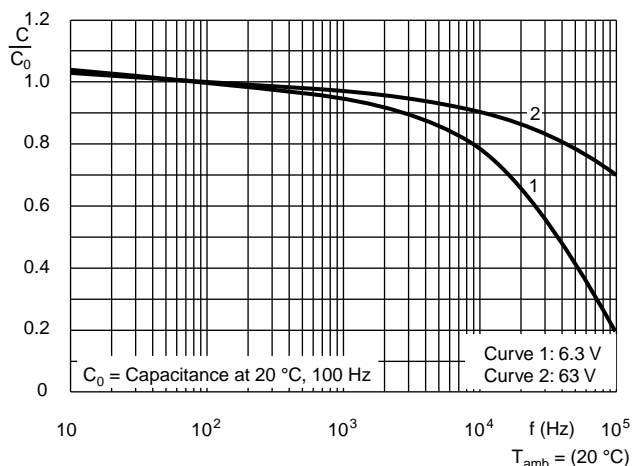


Fig. 6 - Typical multiplier of capacitance as a function of frequency



**EQUIVALENT SERIES RESISTANCE (ESR)**

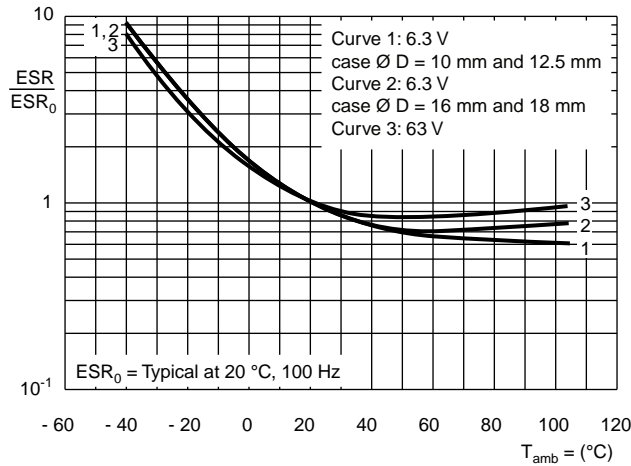


Fig. 7 - Typical multiplier of ESR as a function of ambient temperature

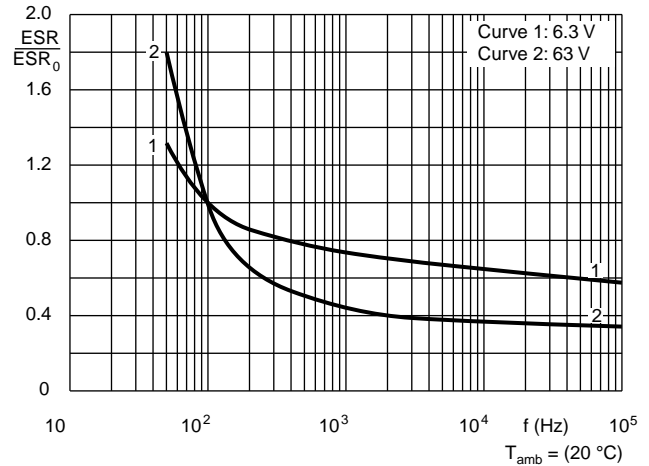


Fig. 8 - Typical multiplier of ESR as a function of frequency

**IMPEDANCE (Z)**

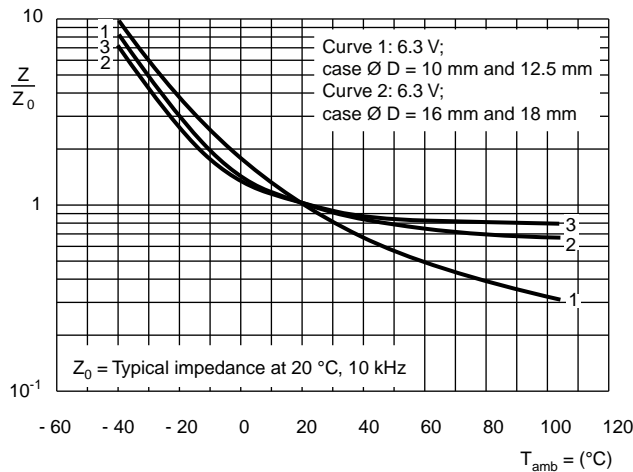


Fig. 9 - Typical multiplier of impedance as a function of ambient temperature

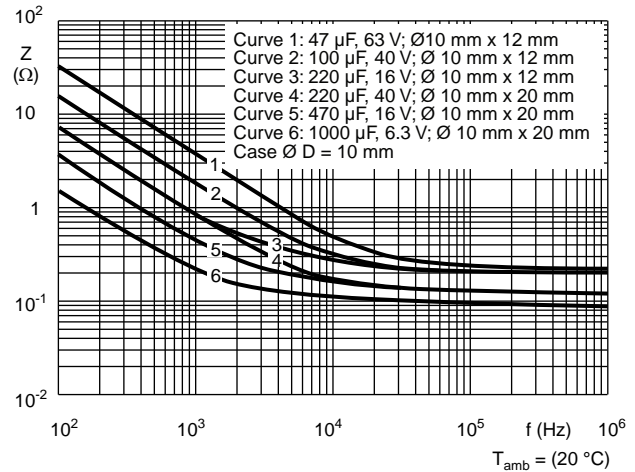


Fig. 10 - Typical impedance as a function of frequency

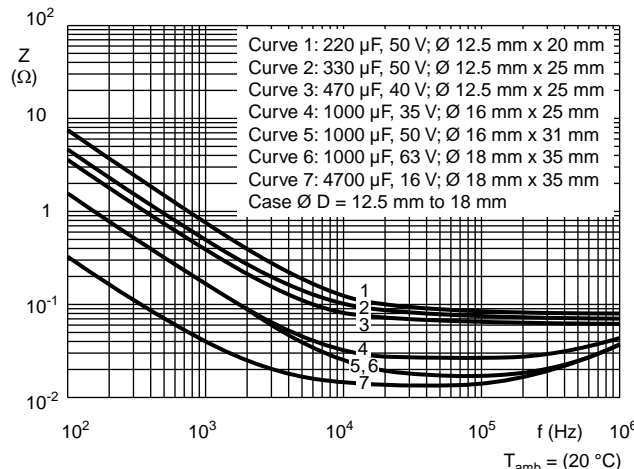
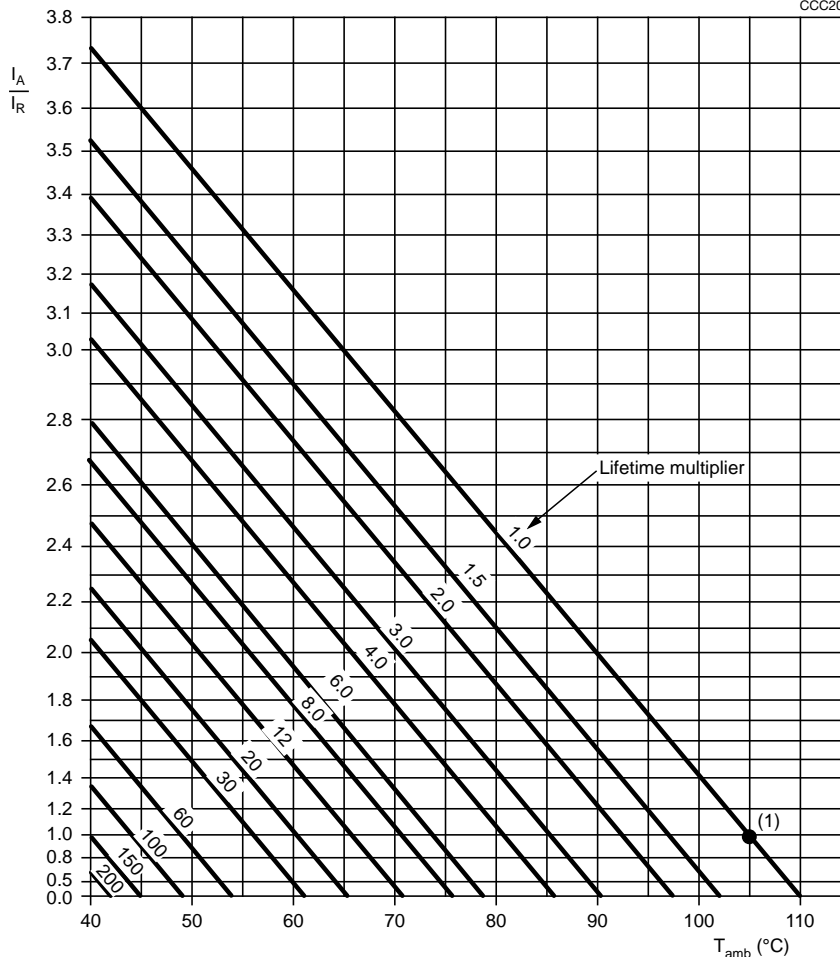


Fig. 11 - Typical impedance as a function of frequency



**RIPPLE CURRENT AND USEFUL LIFE**

CCC206



$I_A$  = Actual ripple current at 100 Hz or 100 kHz  
 $I_R$  = Rated ripple current at 100 Hz or 100 kHz, 105 °C

(1) Useful life at 105 °C and  $I_R$  applied:  
 Case  $\varnothing$  D = 10 mm and 12.5 mm; 3000 h  
 Case  $\varnothing$  D = 16 mm and 18 mm; 4000 h

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

Table 3

TEST PROCEDURES AND REQUIREMENTS			
TEST		PROCEDURE (QUICK REFERENCE)	REQUIREMENTS
NAME OF TEST	REFERENCE		
Endurance	IEC 60384-4/ EN 130300 subclause 4.13	$T_{amb} = 105\text{ °C}$ ; $U_R$ applied; 2000 h	$U_R = 6.3\text{ V}$ ; $\Delta C/C: +15\%/-30\%$ $U_R > 6.3\text{ V}$ ; $\Delta C/C: \pm 15\%$ $\tan \delta \leq 1.3 \times \text{spec. limit}$ $Z \leq 2 \times \text{spec. limit}$ $I_{L5} \leq \text{spec. limit}$
Useful life	CECC 30301 subclause 1.8.1	$T_{amb} = 105\text{ °C}$ ; $U_R$ and $I_R$ applied; 3000 h, case $\varnothing$ D = 10 mm and 12.5 mm; 4000 h, case $\varnothing$ D = 16 mm and 18 mm	$U_R = 6.3\text{ V}$ ; $\Delta C/C: +45\%/-50\%$ $U_R > 6.3\text{ V}$ ; $\Delta C/C: \pm 45\%$ $\tan \delta \leq 3 \times \text{spec. limit}$ $Z \leq 3 \times \text{spec. limit}$ $I_{L5} \leq \text{spec. limit}$ no short or open circuit total failure percentage: $\leq 1\%$
Shelf life (storage at high temperature)	IEC 60384-4/ EN 130300 subclause 4.17	$T_{amb} = 105\text{ °C}$ ; no voltage applied; 1000 h  After test: $U_R$ to be applied for 30 min, 24 h to 48 h before measurement	$U_R = 6.3\text{ V}$ ; $\Delta C/C: +15\%/-30\%$ $U_R > 6.3\text{ V}$ ; $\Delta C/C: \pm 15\%$ $\tan \delta \leq 1.3 \times \text{spec. limit}$ $Z \leq 2 \times \text{spec. limit}$ $I_{L5} \leq 2 \times \text{spec. limit}$



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