

Aluminum Capacitors

Radial, Ultra High CV per Volume, Semi-Professional

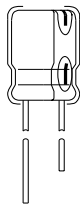
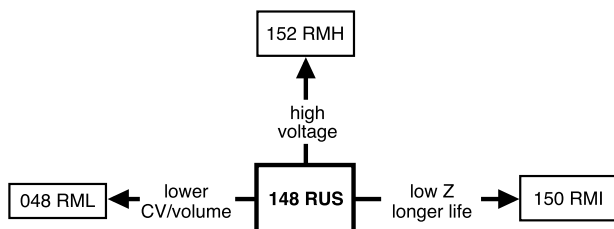


Fig.1 Component outline



FEATURES

- Polarized aluminum electrolytic capacitors, non-solid electrolyte
- Radial leads, cylindrical aluminum case with pressure relief, insulated with a blue vinyl sleeve
- Charge and discharge proof
- Miniaturized, ultra high CV-product per unit volume
- Very long useful life: 3000 hours at 105 °C, high reliability
- Lead (Pb)-free versions are RoHS compliant

RoHS
COMPLIANT

APPLICATIONS

- EDP, telecommunication, industrial, automotive and audio-video
- Smoothing, filtering, buffering in SMPS, timing
- Portable and mobile equipment (small size, low mass)

MARKING

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

- Rated capacitance value (in μF)
- 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 (148)

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	47 to 22 000 μF
Tolerance on C_R	$\pm 20\%$
Rated voltage range, U_R	6.3 to 100 V
Category temperature range	- 40 to + 105 °C
Endurance test at 105 °C:	
case $\varnothing D = 10$ mm	1000 hours
case $\varnothing D \geq 12.5$ mm	2000 hours
Useful life at 105 °C:	
case $\varnothing D = 10$ mm	2000 hours
case $\varnothing D \geq 12.5$ mm	3000 hours
Useful life at 40 °C, $1.6 \times I_R$ applied:	
case $\varnothing D = 10$ mm	140 000 hours
case $\varnothing D \geq 12.5$ mm	200 000 hours
Shelf life at 0 V, 105 °C	1000 hours
Based on sectional specification	IEC 60384-4/EN130300
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 (μF)	U_R (V)							
	6.3	10	16	25	35	50	63	100
47	-	-	-	-	-	-	-	10 x 12
68	-	-	-	-	-	-	-	10 x 16
100	-	-	-	-	-	-	10 x 12	10 x 20
150	-	-	-	-	-	-	-	12.5 x 20
220	-	-	-	-	-	10 x 12	10 x 16	12.5 x 25
	-	-	-	-	-	-	-	16 x 20
330	-	-	-	-	10 x 12	10 x 16	12.5 x 20	16 x 25
470	-	-	-	10 x 12	10 x 16	10 x 20	12.5 x 20	16 x 31
680	-	-	10 x 12	10 x 16	10 x 20	12.5 x 20	12.5 x 25	-
	-	-	-	-	-	-	16 x 20	-

SELECTION CHART FOR C_R , U_R AND RELEVANT NOMINAL CASE SIZES ($\varnothing D \times L$ in mm)								
C_R (μF)	U_R (V)							
	6.3	10	16	25	35	50	63	100
1000	-	10 x 12	10 x 16	10 x 20	12.5 x 20	12.5 x 25	16 x 25	-
1500	-	-	-	-	-	16 x 20	-	-
	-	10 x 16	10 x 20	12.5 x 20	12.5 x 25	16 x 25	16 x 31	-
2200	-	-	-	-	16 x 20	-	-	-
	10 x 16	10 x 20	12.5 x 20	12.5 x 25	16 x 25	16 x 31	18 x 35	-
3300	-	-	-	16 x 20	-	-	-	-
	-	12.5 x 20	12.5 x 25	16 x 25	16 x 31	18 x 35	-	-
4700	-	-	16 x 20	-	-	-	-	-
	12.5 x 20	12.5 x 25	16 x 25	16 x 31	18 x 35	-	-	-
6800	-	16 x 20	-	-	-	-	-	-
	16 x 20	16 x 25	16 x 31	18 x 35	-	-	-	-
10 000	16 x 25	16 x 31	18 x 35	-	-	-	-	-
15 000	16 x 31	18 x 35	-	-	-	-	-	-
22 000	18 x 35	-	-	-	-	-	-	-

DIMENSIONS in millimeters, AND AVAILABLE FORMS

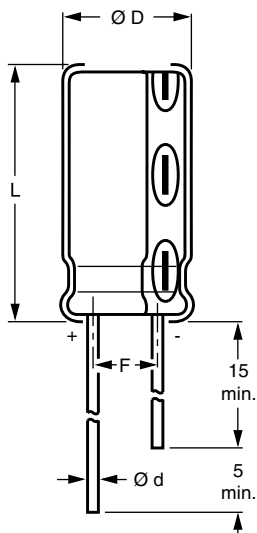


Fig. 2 Form CA: Long leads

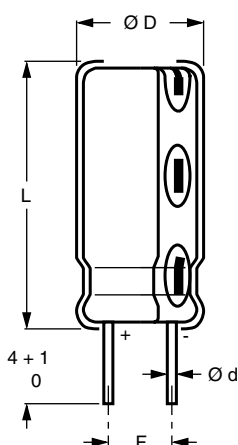


Fig.3 Form CB: Cut leads

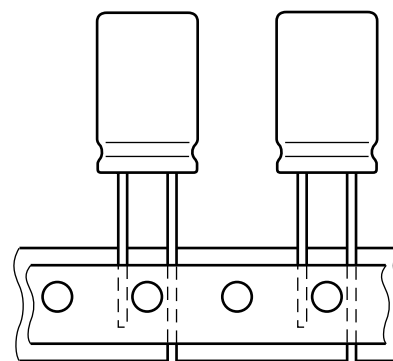


Fig.4 Form TFA: Taped in box (ammopack)

Table 1

DIMENSIONS in millimeters, MASS AND PACKAGING QUANTITIES									
NOMINAL CASE SIZE $\varnothing D \times L$	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 ± 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 20	19a	0.8	16.5	22.0	7.5 ± 0.5	≈ 6.0	250	250	250
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 35	22	0.8	18.5	37.5	7.5 ± 0.5	≈ 14.5	100	100	-

Note

1. 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, 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
 $T_{amb} = 20\text{ °C}$, $P = 86$ to 106 kPa , $RH = 45$ to 75% .

Table 2

ELECTRICAL DATA AND ORDERING INFORMATION										
U_R (V)	C_R 100 Hz (μF)	NOMINAL CASE SIZE $\varnothing D \times L$ (mm)	I_R 100 Hz 105 °C (mA)	I_{L2} 2 min (μA)	$\tan \delta$ 100 Hz	Z 100 kHz 20 °C (Ω)	Z 100 kHz - 40 °C (Ω)	ORDERING CODE MAL2148.....		
								BULK PACKAGING		TAPED
								FORM CA	FORM CB	FORM TFA
6.3	2200	10 x 16	720	139	0.30	0.170	1.90	53222E3	63222E3	33222E3
	4700	12.5 x 20	1100	296	0.34	0.085	0.60	53472E3	63472E3	33472E3
	6800	16 x 20	1210	428	0.38	0.060	0.30	53682E3	63682E3	33682E3
	10000	16 x 25	1660	630	0.46	0.045	0.25	53103E3	63103E3	33103E3
	15000	16 x 31	2050	945	0.56	0.033	0.15	53153E3	63153E3	33153E3
	22000	18 x 35	2350	1386	0.66	0.032	0.15	53223E3	63223E3	-
10	1000	10 x 12	460	100	0.24	0.240	3.00	54102E3	64102E3	34102E3
	1500	10 x 16	620	150	0.24	0.170	1.90	54152E3	64152E3	34152E3
	2200	10 x 20	750	220	0.26	0.130	1.50	54222E3	64222E3	34222E3
	3300	12.5 x 20	1010	330	0.28	0.085	0.60	54332E3	64332E3	34332E3
	4700	12.5 x 25	1260	470	0.30	0.065	0.50	54472E3	64472E3	34472E3
	4700	16 x 20	1260	470	0.30	0.060	0.30	94475E3	94476E3	94473E3
	6800	16 x 25	1590	680	0.34	0.045	0.25	54682E3	64682E3	34682E3
	10000	16 x 31	1910	1000	0.42	0.033	0.15	54103E3	64103E3	34103E3
	15000	18 x 35	2200	1500	0.52	0.032	0.15	54153E3	64153E3	-
16	680	10 x 12	450	109	0.20	0.240	3.00	55681E3	65681E3	35681E3
	1000	10 x 16	570	160	0.20	0.180	2.00	55102E3	65102E3	35102E3
	1500	10 x 20	720	240	0.20	0.130	1.50	55152E3	65152E3	35152E3
	2200	12.5 x 20	930	352	0.22	0.090	0.60	55222E3	65222E3	35222E3
	3300	12.5 x 25	1180	528	0.24	0.065	0.50	55332E3	65332E3	35332E3
	3300	16 x 20	1120	528	0.24	0.060	0.30	95335E3	95336E3	95333E3
	4700	16 x 25	1480	752	0.26	0.045	0.25	55472E3	65472E3	35472E3
	6800	16 x 31	1790	1088	0.30	0.035	0.20	55682E3	65682E3	35682E3
	10000	18 x 35	2100	1600	0.36	0.032	0.20	55103E3	65103E3	-
25	470	10 x 12	410	118	0.16	0.260	3.20	56471E3	66471E3	36471E3
	680	10 x 16	550	170	0.16	0.190	2.10	56681E3	66681E3	36681E3
	1000	10 x 20	690	250	0.16	0.130	1.50	56102E3	66102E3	36102E3
	1500	12.5 x 20	850	375	0.16	0.100	0.70	56152E3	66152E3	36152E3
	2200	12.5 x 25	1110	550	0.18	0.070	0.50	56222E3	66222E3	36222E3
	2200	16 x 20	1050	550	0.18	0.060	0.30	96225E3	96226E3	96223E3
	3300	16 x 25	1420	825	0.20	0.045	0.25	56332E3	66332E3	36332E3
	4700	16 x 31	1750	1175	0.22	0.035	0.20	56472E3	66472E3	36472E3
	6800	18 x 35	2050	1700	0.26	0.033	0.20	56682E3	66682E3	-

ORDERING EXAMPLE

Electrolytic capacitor 148 series

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

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

Ordering Code: MAL214836471E3

Former 12NC: 2222 148 36471

**ELECTRICAL DATA AND ORDERING INFORMATION**

U _R (V)	C _R 100 Hz (μF)	NOMINAL CASE SIZE Ø D x L (mm)	I _R 100 Hz 105 °C (mA)	I _{L2} 2 min (μA)	tan δ 100 Hz	Z 100 kHz 20 °C (Ω)	Z 100 kHz - 40 °C (Ω)	ORDERING CODE MAL2148.....		
								BULK PACKAGING		TAPED
								FORM CA	FORM CB	FORM TFA
35	330	10 x 12	350	116	0.14	0.270	3.30	50331E3	60331E3	30331E3
	470	10 x 16	480	165	0.14	0.190	2.10	50471E3	60471E3	30471E3
	680	10 x 20	580	238	0.14	0.140	1.60	50681E3	60681E3	30681E3
	1000	12.5 x 20	810	350	0.14	0.100	0.70	50102E3	60102E3	30102E3
	1500	12.5 x 25	950	525	0.14	0.070	0.50	50152E3	60152E3	30152E3
	1500	16 x 20	970	525	0.14	0.063	0.30	90155E3	90156E3	90153E3
	2200	16 x 25	1270	770	0.16	0.045	0.25	50222E3	60222E3	30222E3
	3300	16 x 31	1620	1155	0.18	0.037	0.20	50332E3	60332E3	30332E3
	4700	18 x 35	1930	1645	0.20	0.033	0.20	50472E3	60472E3	-
50	220	10 x 12	330	110	0.12	0.280	3.40	51221E3	61221E3	31221E3
	330	10 x 16	420	165	0.12	0.200	2.20	51331E3	61331E3	31331E3
	470	10 x 20	530	235	0.12	0.140	1.60	51471E3	61471E3	31471E3
	680	12.5 x 20	720	340	0.12	0.100	0.70	51681E3	61681E3	31681E3
	1000	12.5 x 25	950	500	0.12	0.070	0.50	51102E3	61102E3	31102E3
	1000	16 x 20	880	500	0.12	0.068	0.35	91105E3	91106E3	91103E3
	1500	16 x 25	1180	750	0.12	0.047	0.30	51152E3	61152E3	31152E3
	2200	16 x 31	1520	1100	0.14	0.039	0.20	51222E3	61222E3	31222E3
	3300	18 x 35	1810	1650	0.16	0.035	0.20	51332E3	61332E3	-
63	100	10 x 12	230	63	0.10	0.320	3.90	58101E3	68101E3	38101E3
	220	10 x 16	350	139	0.10	0.240	2.70	58221E3	68221E3	38221E3
	330	12.5 x 20	540	208	0.10	0.130	0.90	58331E3	68331E3	38331E3
	470	12.5 x 20	540	296	0.10	0.130	0.90	58471E3	68471E3	38471E3
	680	12.5 x 25	760	428	0.10	0.085	0.65	58681E3	68681E3	38681E3
	680	16 x 20	820	428	0.10	0.070	0.50	98685E3	98686E3	98683E3
	1000	16 x 25	980	630	0.10	0.049	0.25	58102E3	68102E3	38102E3
	1500	16 x 31	1390	945	0.10	0.042	0.20	58152E3	68152E3	38152E3
	2200	18 x 35	1670	1386	0.12	0.038	0.20	58222E3	68222E3	-
100	47	10 x 12	165	47	0.08	0.640	19.20	59479E3	69479E3	39479E3
	68	10 x 16	190	68	0.08	0.580	17.40	59689E3	69689E3	39689E3
	100	10 x 20	260	100	0.08	0.380	11.40	59101E3	69101E3	39101E3
	150	12.5 x 20	360	150	0.08	0.260	7.80	59151E3	69151E3	39151E3
	220	12.5 x 25	440	220	0.08	0.170	5.10	59221E3	69221E3	39221E3
	220	16 x 20	590	220	0.08	0.140	4.20	99225E3	99226E3	99223E3
	330	16 x 25	630	330	0.08	0.120	3.60	59331E3	69331E3	39331E3
	470	16 x 31	750	470	0.08	0.100	3.00	59471E3	69471E3	39471E3

ADDITIONAL ELECTRICAL DATA

PARAMETER	CONDITIONS	VALUE
Voltage		
Surge voltage		$U_s \leq 1.15 U_R$
Reverse voltage		$U_{rev} \leq 1 V$
Current		
Leakage current	After 2 minutes at U_R	$I_{L2} \leq 0.01 C_R \times U_R$
	After 5 minutes at U_R	$I_{L5} \leq 0.002 C_R \times U_R$
Inductance		
Equivalent series inductance (ESL)	Case Ø D = 10 mm	typ. 16 nH
	Case Ø D ≥ 12.5 mm	typ. 18 nH
Resistance		
Equivalent series resistance (ESR)	calculated from $\tan \delta_{max.}$ and C_R (see Table 2)	$ESR = \tan \delta / 2 \pi f C_R$

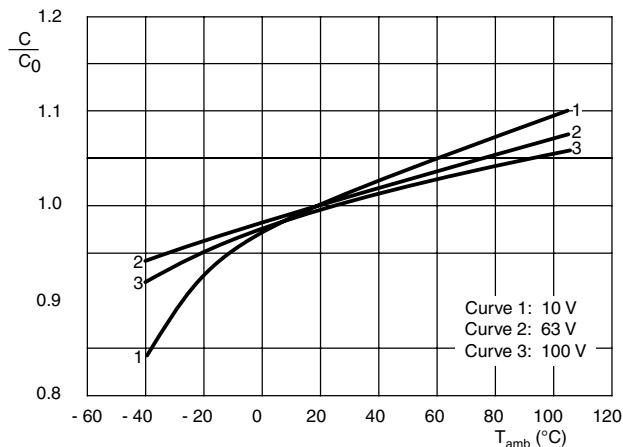
CAPACITANCE (C)

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

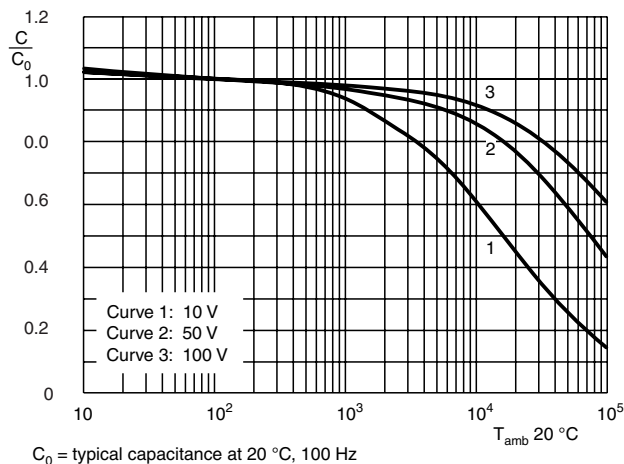


Fig. 6 Typical multiplier of capacitance as a function of frequency

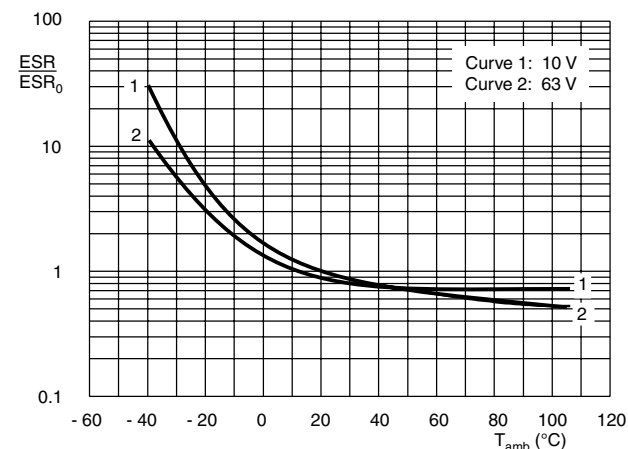
EQUIVALENT SERIES RESISTANCE (ESR)

Fig. 7 Multiplier of ESR as a function of ambient temperature

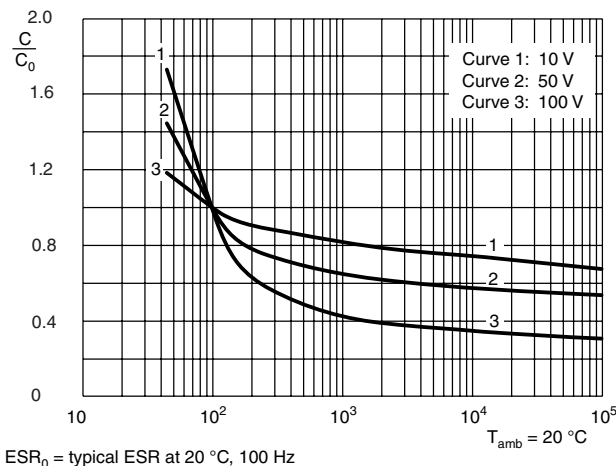


Fig. 8 Multiplier of ESR as a function of frequency

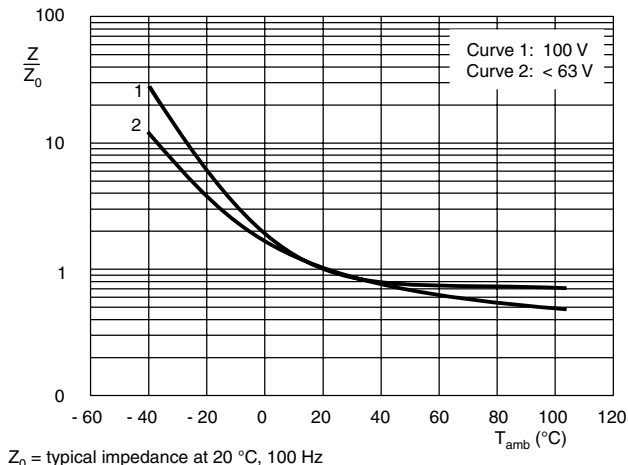
IMPEDANCE (Z)

Fig. 9 Multiplier of impedance as a function of ambient temperature

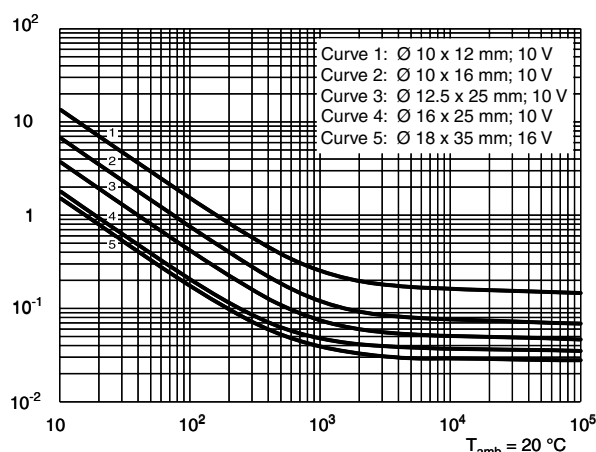


Fig. 10 Typical impedance as a function of frequency

IMPEDANCE (Z)

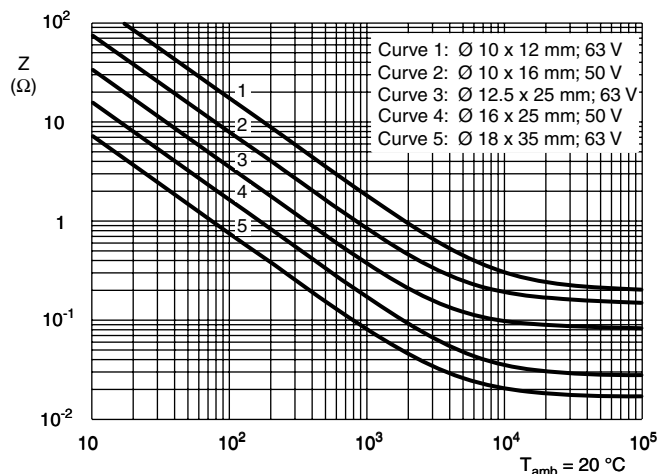
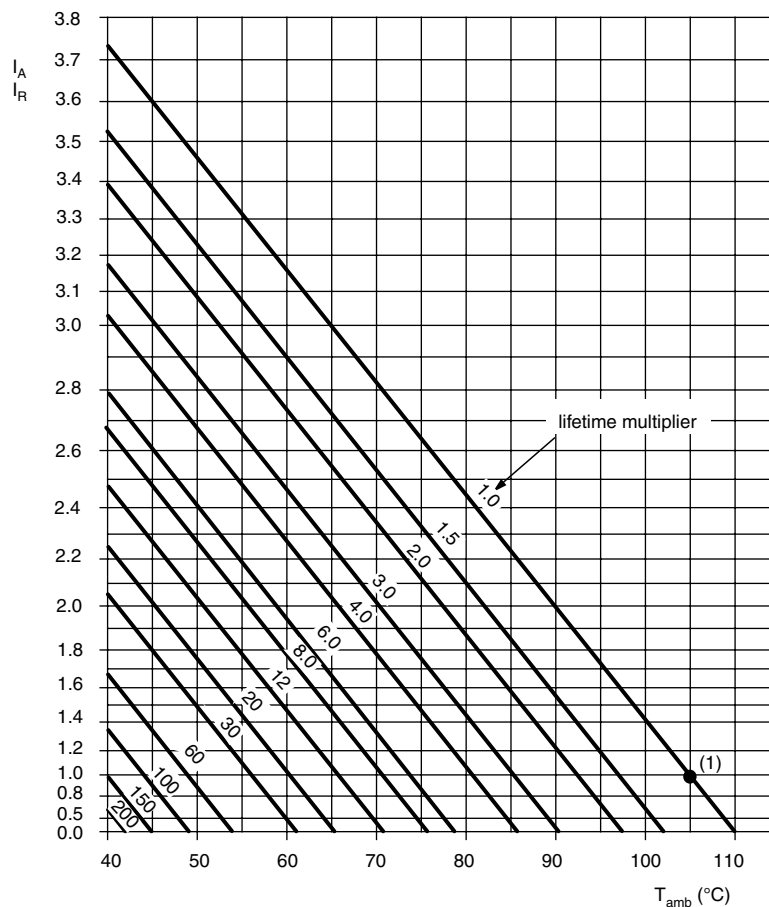


Fig.11 Typical impedance as a function of frequency

RIPPLE CURRENT AND USEFUL LIFE


 I_A = actual ripple current at 100 Hz

 I_R = rated ripple current at 100 Hz, 105 °C

⁽¹⁾Useful life at 105 °C and I_R applied:

case Ø D = 10 mm: 2000 h

case Ø D ≥ 12.5 mm: 3000 h

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

MULTIPLIER OF RIPPLE CURRENT (I_R) AS A FUNCTION OF FREQUENCY

FREQUENCY (Hz)	I_R MULTIPLIER		
	$U_R = 6.3$ to 25 V	$U_R = 35$ V	$U_R = 50$ to 100 V
50	0.95	0.85	0.80
100	1.00	1.00	1.00
300	1.07	1.20	1.25
1000	1.12	1.30	1.40
3000	1.15	1.35	1.50
$\geq 10\,000$	1.20	1.40	1.60

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 case $\varnothing D = 10$ mm: 1000 hours case $\varnothing D \geq 12.5$ mm: 2000 hours	$U_R = 6.3$ V; $\Delta C/C: +15\text{ }/-30\%$ $U_R \geq 10$ V; $\Delta C/C: \pm 20\%$ $\tan \delta \leq 2 \times \text{spec. limit}$ $Z \leq 2 \times \text{spec. limit}$ $I_{L5} \leq \text{spec. limit}$
Useful life	CECC 30301 subclause 1.8.1	$T_{amb} = 105\text{ }^{\circ}\text{C}$; U_R and I_R applied case $\varnothing D = 10$ mm: 2000 hours case $\varnothing D \geq 12.5$ mm: 3000 hours	$U_R = 6.3$ V; $\Delta C/C: +45\text{ }/-50\%$ $U_R \geq 10$ 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/ EN130300 subclause 4.17	$T_{amb} = 105\text{ }^{\circ}\text{C}$; no voltage applied; 1000 hours after test: U_R to be applied for 30 minutes, 24 to 48 hours before measurement	$U_R = 6.3$ V; $\Delta C/C: +15\text{ }/-30\%$ $U_R \geq 10$ V; $\Delta C/C: \pm 20\%$ $\tan \delta \leq 2 \times \text{spec. limit}$ $Z \leq 2 \times \text{spec. limit}$ $I_{L5} \leq 2 \times \text{spec. limit}$
Surge	IEC 60384-4/ EN130300 subclause 4.14	from source of $1.15 \times U_R$: $RC = 0.1 \pm 0.05$ s; 1000 cycles of 30 s on, 330 s off, at $105\text{ }^{\circ}\text{C}$	$\Delta C/C: \pm 20\%$ $\tan \delta \leq 1.5 \times \text{spec. limit}$ $I_{L5} \leq \text{spec. limit}$
Reverse voltage	IEC 60384-4/ EN130300 subclause 4.15	$T_{amb} = 105\text{ }^{\circ}\text{C}$: 125 h at $U = -1$ V, followed by 125 hours at U_R	$\Delta C/C: \pm 15\%$ $\tan \delta \leq 1.5 \times \text{spec. limit}$ $I_{L5} \leq \text{spec. limit}$



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