Aluminum Capacitors
Radial, Ultra High CV per Volume, Semi-Professional

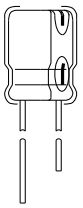
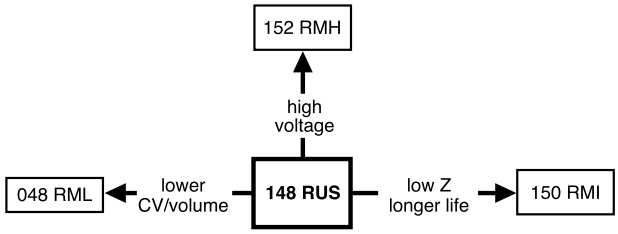


Fig.1 Component outline



FEATURES

- Polarized aluminum electrolytic capacitors, non-solid electrolyte
- Radial leads, cylindrical aluminum case with pressure relief, insulated with a blue sleeve
- Charge and discharge proof
- Miniaturized, ultra high CV-product per unit volume
- Very long useful life: 3000 h at 105 °C, high reliability
- Material categorization: For definitions of compliance please see www.vishay.com/doc?99912

Pb-free
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 ± 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 (Ø D x L in mm)	10 x 12 to 18 x 35
Rated capacitance range, C_R	47 µF to 22 000 µF
Tolerance on C_R	± 20 %
Rated voltage range, U_R	6.3 V to 100 V
Category temperature range	- 40 °C to + 105 °C
Endurance test at 105 °C: case Ø D = 10 mm case Ø D ≥ 12.5 mm	 1000 h 2000 h
Useful life at 105 °C: case Ø D = 10 mm case Ø D ≥ 12.5 mm	 2000 h 3000 h
Useful life at 40 °C, 1.6 x I_R applied: case Ø D = 10 mm case Ø D ≥ 12.5 mm	 140 000 h 200 000 h
Shelf life at 0 V, 105 °C	1000 h
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 (Ø D x 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	-

For technical questions contact: aluminumcaps1@vishay.com
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SELECTION CHART FOR C_R, U_R AND RELEVANT NOMINAL CASE SIZES (Ø D x 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	-
	-	-	-	-	-	16 x 20	-	-
1500	-	10 x 16	10 x 20	12.5 x 20	12.5 x 25	16 x 25	16 x 31	-
	-	-	-	-	16 x 20	-	-	-
2200	10 x 16	10 x 20	12.5 x 20	12.5 x 25	16 x 25	16 x 31	18 x 35	-
	-	-	-	16 x 20	-	-	-	-
3300	-	12.5 x 20	12.5 x 25	16 x 25	16 x 31	18 x 35	-	-
	-	-	16 x 20	-	-	-	-	-
4700	12.5 x 20	12.5 x 25	16 x 25	16 x 31	18 x 35	-	-	-
	-	16 x 20	-	-	-	-	-	-
6800	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

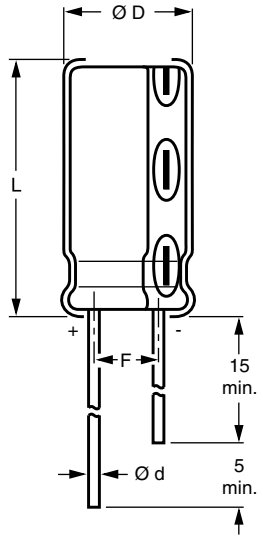


Fig.2 **Form CA**: Long leads

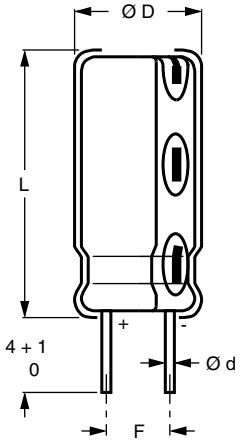


Fig.3 **Form CB**: Cut leads

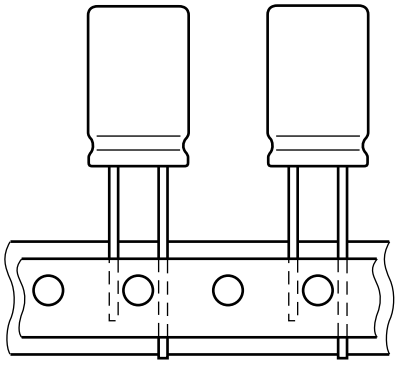


Fig.4 **Form TFA**: Taped in box (ammopack)

Table 1

DIMENSIONS in millimeters, MASS AND PACKAGING QUANTITIES									
Nominal CASE SIZE Ø D x L	CASE CODE	Ø d	Ø $D_{max.}$	$L_{max.}$	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

Tape dimensions see section ‘PACKAGING’.

ELECTRICAL DATA	
SYMBOL	**DESCRIPTION**
C_R	rated capacitance at 100 Hz, tolerance ± 20 %
I_R	rated RMS ripple current at 100 Hz, 105 °C
I_{L2}	max. leakage current after 2 min at U_R
tan δ	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 °C, P = 86 kPa to 106 kPa, RH = 45 % to 75 %.

ORDERING EXAMPLE

Electrolytic capacitor 148 series

470 µF/25 V; ± 20 %

Nominal case size: Ø 10 mm x 12 mm; Form TFA

Ordering Code: MAL214836471E3
Former 12NC: 2222 148 36471

Table 2

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
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	-

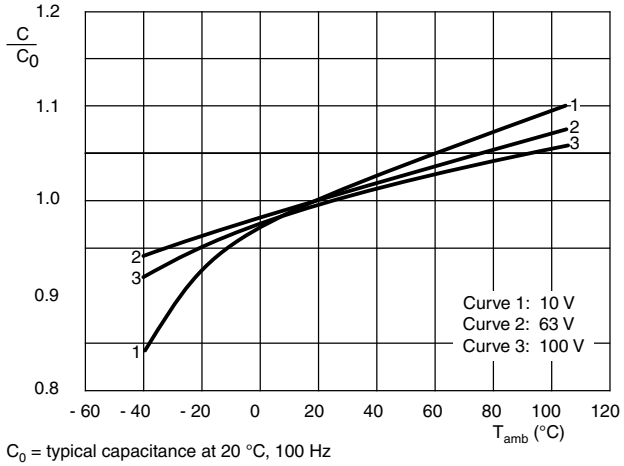
ELECTRICAL DATA AND ORDERING INFORMATION

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

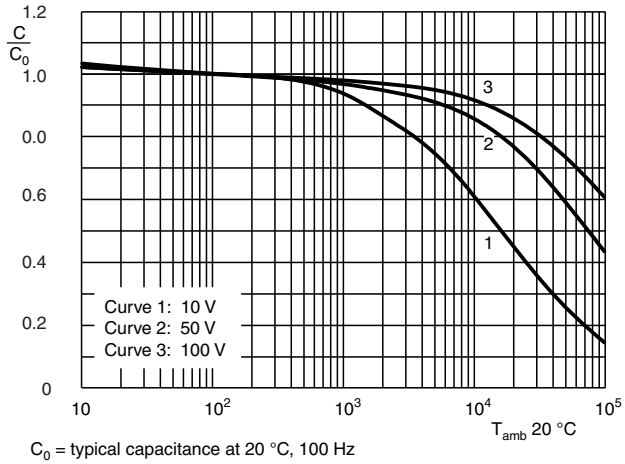
PARAMETER	CONDITIONS	VALUE
Voltage		
Surge voltage		$U_s \leq 1.15\ U_R$
Reverse voltage		$U_{rev} \leq 1$ V
Current		
Leakage current	After 2 minutes at U_R	$I_{L2} \leq 0.01\ C_R \times U_R$
	After 5 minutes at U_R	$I_{L5} \leq 0.002\ C_R \times U_R$
Inductance		
Equivalent series inductance (ESL)	Case ∅ D = 10 mm	typ. 16 nH
	Case ∅ 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)



C_0 = typical capacitance at 20 °C, 100 Hz

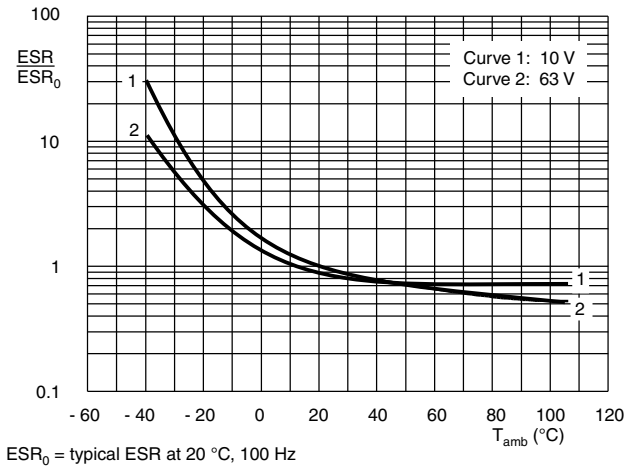
Fig.5 Typical multiplier of capacitance as a function of ambient temperature



C_0 = typical capacitance at 20 °C, 100 Hz

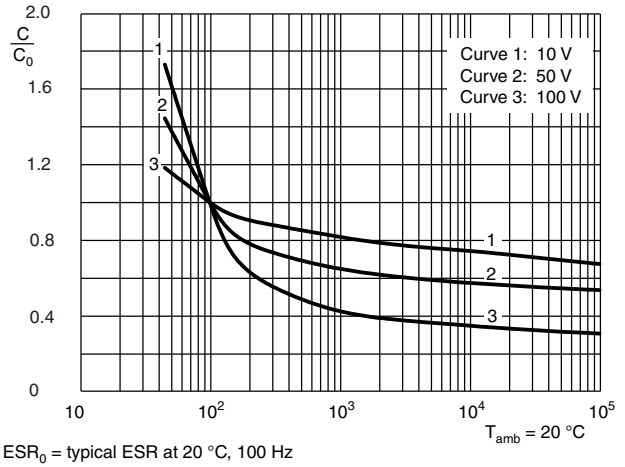
Fig.6 Typical multiplier of capacitance as a function of frequency

EQUIVALENT SERIES RESISTANCE (ESR)



ESR_0 = typical ESR at 20 °C, 100 Hz

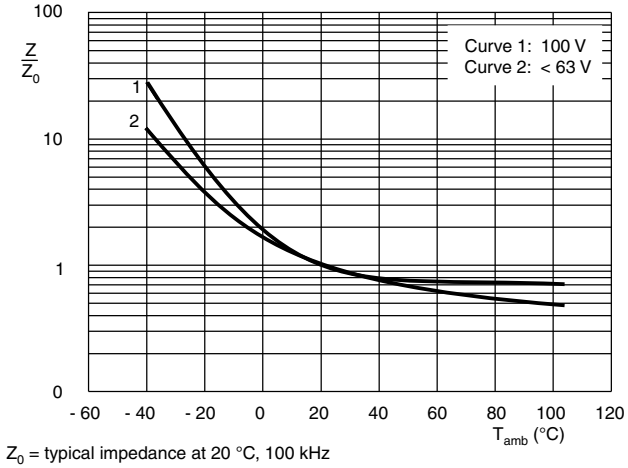
Fig.7 Multiplier of ESR as a function of ambient temperature



ESR_0 = typical ESR at 20 °C, 100 Hz

Fig.8 Multiplier of ESR as a function of frequency

IMPEDANCE (Z)



Z_0 = typical impedance at 20 °C, 100 kHz

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

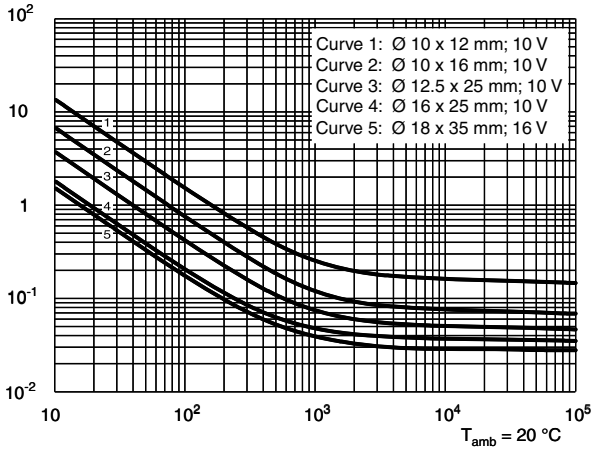


Fig.10 Typical impedance as a function of frequency

IMPEDANCE (Z)

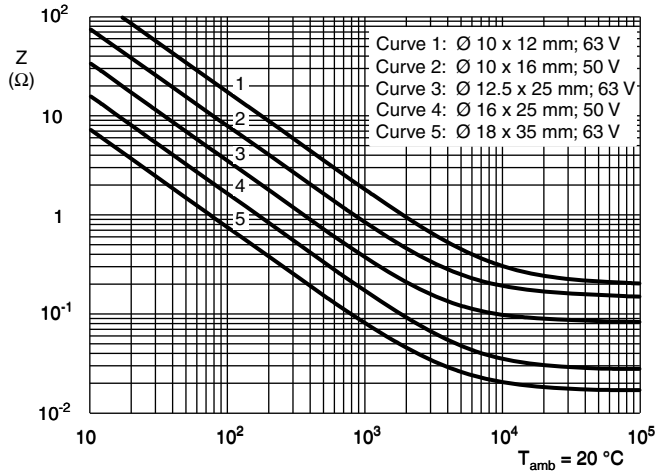


Fig.11 Typical impedance as a function of frequency

RIPPLE CURRENT AND USEFUL LIFE

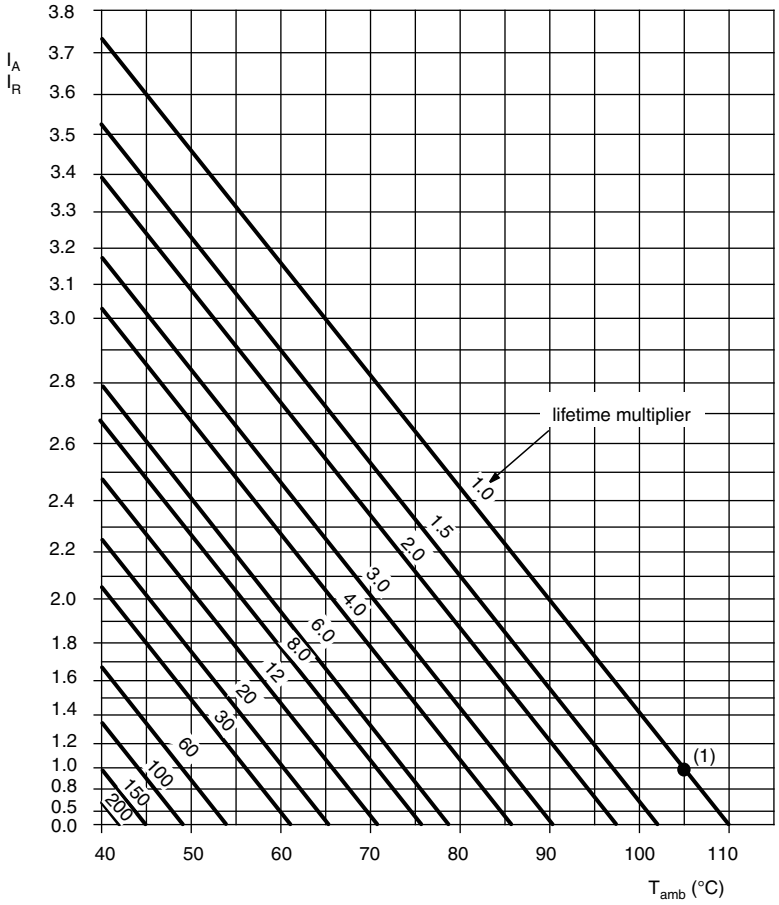


Fig.12 Mulyiplier of useful life as a function of ambient ripple current load

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

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
≥ 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 °C; U_R applied case Ø D = 10 mm: 1000 h case Ø D ≥ 12.5 mm: 2000 h	U_R = 6.3 V; ΔC/C: + 15/- 30 % U_R ≥ 10 V; ΔC/C: ± 20 % tan δ ≤ 2 x spec. limit Z ≤ 2 x spec. limit I_{L5} ≤ spec. limit
Useful life	CECC 30301 subclause 1.8.1	T_{amb} = 105 °C; U_R and I_R applied case Ø D = 10 mm: 2000 h case Ø D ≥ 12.5 mm: 3000 h	U_R = 6.3 V; ΔC/C: + 45/- 50 % U_R ≥ 10 V; ΔC/C: ± 45 % tan δ ≤ 3 x spec. limit Z ≤ 3 x spec. limit I_{L5} ≤ spec. limit no short or open circuit total failure percentage: ≤ 1 %
Shelf life (storage at high temperature)	IEC 60384-4/ EN130300 subclause 4.17	T_{amb} = 105 °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 V; ΔC/C: + 15/- 30 % U_R ≥ 10 V; ΔC/C: ± 20 % tan δ ≤ 2 x spec. limit Z ≤ 2 x spec. limit I_{L5} ≤ 2 x spec. limit
Surge	IEC 60384-4/ EN130300 subclause 4.14	from source of 1.15 x U_R: RC = 0.1 ± 0.05 s; 1000 cycles of 30 s on, 330 s off, at 105 °C	ΔC/C: ± 20 % tan δ ≤ 1.5 x spec. limit I_{L5} ≤ spec. limit
Reverse voltage	IEC 60384-4/ EN130300 subclause 4.15	T_{amb} = 105 °C: 125 h at U = - 1 V, followed by 125 h at U_R	ΔC/C: ± 15 % tan δ ≤ 1.5 x spec. limit I_{L5} ≤ spec. limit

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