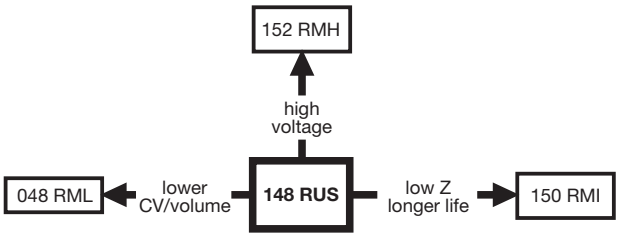
Aluminum Electrolytic Capacitors
Radial, Ultra High CV per Volume, Semi-Professional





FEATURES

- Very long useful life: 3000 h at 105 °C
- Miniaturized, ultra high CV-product per unit volume
- Polarized aluminum electrolytic capacitors, non-solid electrolyte
- Radial leads, cylindrical aluminum case with pressure relief, insulated with a blue sleeve
- Charge and discharge proof
- 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 / EN 130300
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	-
1000	-	10 x 12	10 x 16	10 x 20	12.5 x 20	12.5 x 25	16 x 25	-
	-	-	-	-	-	16 x 20	-	-

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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
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

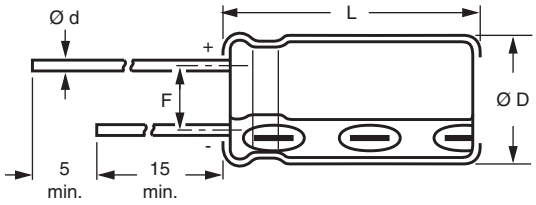

Fig. 2 - **Form CA:** Long leads

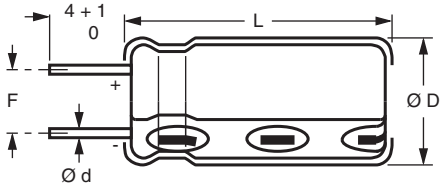

Fig. 3 - **Form CB:** Cut leads

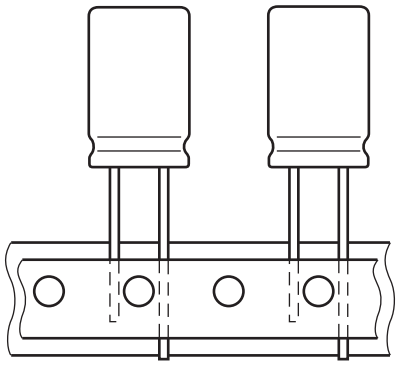

Fig. 4 - **Form TFA:** Taped in box (ammopack)

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

- For detailed tape dimensions, please see www.vishay.com/doc?28360

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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)	FREQ. CODE (1)	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	MF1	53222E3	63222E3	33222E3
	4700	12.5 x 20	1100	296	0.34	0.085	0.60	MF1	53472E3	63472E3	33472E3
	6800	16 x 20	1210	428	0.38	0.060	0.30	MF1	53682E3	63682E3	33682E3
	10 000	16 x 25	1660	630	0.46	0.045	0.25	MF1	53103E3	63103E3	33103E3
	15 000	16 x 31	2050	945	0.56	0.033	0.15	MF1	53153E3	63153E3	33153E3
	22 000	18 x 35	2350	1386	0.66	0.032	0.15	MF1	53223E3	63223E3	-
10	1000	10 x 12	460	100	0.24	0.240	3.00	MF1	54102E3	64102E3	34102E3
	1500	10 x 16	620	150	0.24	0.170	1.90	MF1	54152E3	64152E3	34152E3
	2200	10 x 20	750	220	0.26	0.130	1.50	MF1	54222E3	64222E3	34222E3
	3300	12.5 x 20	1010	330	0.28	0.085	0.60	MF1	54332E3	64332E3	34332E3
	4700	12.5 x 25	1260	470	0.30	0.065	0.50	MF1	54472E3	64472E3	34472E3
	4700	16 x 20	1260	470	0.30	0.060	0.30	MF1	94475E3	94476E3	94473E3
	6800	16 x 25	1590	680	0.34	0.045	0.25	MF1	54682E3	64682E3	34682E3
	10 000	16 x 31	1910	1000	0.42	0.033	0.15	MF1	54103E3	64103E3	34103E3
	15 000	18 x 35	2200	1500	0.52	0.032	0.15	MF1	54153E3	64153E3	-
16	680	10 x 12	450	109	0.20	0.240	3.00	MF1	55681E3	65681E3	35681E3
	1000	10 x 16	570	160	0.20	0.180	2.00	MF1	55102E3	65102E3	35102E3
	1500	10 x 20	720	240	0.20	0.130	1.50	MF1	55152E3	65152E3	35152E3
	2200	12.5 x 20	930	352	0.22	0.090	0.60	MF1	55222E3	65222E3	35222E3
	3300	12.5 x 25	1180	528	0.24	0.065	0.50	MF1	55332E3	65332E3	35332E3
	3300	16 x 20	1120	528	0.24	0.060	0.30	MF1	95335E3	95336E3	95333E3
	4700	16 x 25	1480	752	0.26	0.045	0.25	MF1	55472E3	65472E3	35472E3
	6800	16 x 31	1790	1088	0.30	0.035	0.20	MF1	55682E3	65682E3	35682E3
	10 000	18 x 35	2100	1600	0.36	0.032	0.20	MF1	55103E3	65103E3	-
25	470	10 x 12	410	118	0.16	0.260	3.20	MF1	56471E3	66471E3	36471E3
	680	10 x 16	550	170	0.16	0.190	2.10	MF1	56681E3	66681E3	36681E3
	1000	10 x 20	690	250	0.16	0.130	1.50	MF1	56102E3	66102E3	36102E3
	1500	12.5 x 20	850	375	0.16	0.100	0.70	MF1	56152E3	66152E3	36152E3
	2200	12.5 x 25	1110	550	0.18	0.070	0.50	MF1	56222E3	66222E3	36222E3
	2200	16 x 20	1050	550	0.18	0.060	0.30	MF1	96225E3	96226E3	96223E3
	3300	16 x 25	1420	825	0.20	0.045	0.25	MF1	56332E3	66332E3	36332E3
	4700	16 x 31	1750	1175	0.22	0.035	0.20	MF1	56472E3	66472E3	36472E3
	6800	18 x 35	2050	1700	0.26	0.033	0.20	MF1	56682E3	66682E3	-

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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)	FREQ. CODE (1)	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	MF2	50331E3	60331E3	30331E3
	470	10 x 16	480	165	0.14	0.190	2.10	MF2	50471E3	60471E3	30471E3
	680	10 x 20	580	238	0.14	0.140	1.60	MF2	50681E3	60681E3	30681E3
	1000	12.5 x 20	810	350	0.14	0.100	0.70	MF2	50102E3	60102E3	30102E3
	1500	12.5 x 25	950	525	0.14	0.070	0.50	MF2	50152E3	60152E3	30152E3
	1500	16 x 20	970	525	0.14	0.063	0.30	MF2	90155E3	90156E3	90153E3
	2200	16 x 25	1270	770	0.16	0.045	0.25	MF2	50222E3	60222E3	30222E3
	3300	16 x 31	1620	1155	0.18	0.037	0.20	MF2	50332E3	60332E3	30332E3
	4700	18 x 35	1930	1645	0.20	0.033	0.20	MF2	50472E3	60472E3	-
50	220	10 x 12	330	110	0.12	0.280	3.40	MF3	51221E3	61221E3	31221E3
	330	10 x 16	420	165	0.12	0.200	2.20	MF3	51331E3	61331E3	31331E3
	470	10 x 20	530	235	0.12	0.140	1.60	MF3	51471E3	61471E3	31471E3
	680	12.5 x 20	720	340	0.12	0.100	0.70	MF3	51681E3	61681E3	31681E3
	1000	12.5 x 25	950	500	0.12	0.070	0.50	MF3	51102E3	61102E3	31102E3
	1000	16 x 20	880	500	0.12	0.068	0.35	MF3	91105E3	91106E3	91103E3
	1500	16 x 25	1180	750	0.12	0.047	0.30	MF3	51152E3	61152E3	31152E3
	2200	16 x 31	1520	1100	0.14	0.039	0.20	MF3	51222E3	61222E3	31222E3
	3300	18 x 35	1810	1650	0.16	0.035	0.20	MF3	51332E3	61332E3	-
63	100	10 x 12	230	63	0.10	0.320	3.90	MF3	58101E3	68101E3	38101E3
	220	10 x 16	350	139	0.10	0.240	2.70	MF3	58221E3	68221E3	38221E3
	330	12.5 x 20	540	208	0.10	0.130	0.90	MF3	58331E3	68331E3	38331E3
	470	12.5 x 20	540	296	0.10	0.130	0.90	MF3	58471E3	68471E3	38471E3
	680	12.5 x 25	760	428	0.10	0.085	0.65	MF3	58681E3	68681E3	38681E3
	680	16 x 20	820	428	0.10	0.070	0.50	MF3	98685E3	98686E3	98683E3
	1000	16 x 25	980	630	0.10	0.049	0.25	MF3	58102E3	68102E3	38102E3
	1500	16 x 31	1390	945	0.10	0.042	0.20	MF3	58152E3	68152E3	38152E3
	2200	18 x 35	1670	1386	0.12	0.038	0.20	MF3	58222E3	68222E3	-
100	47	10 x 12	165	47	0.08	0.640	19.20	MF3	59479E3	69479E3	39479E3
	68	10 x 16	190	68	0.08	0.580	17.40	MF3	59689E3	69689E3	39689E3
	100	10 x 20	260	100	0.08	0.380	11.40	MF3	59101E3	69101E3	39101E3
	150	12.5 x 20	360	150	0.08	0.260	7.80	MF3	59151E3	69151E3	39151E3
	220	12.5 x 25	440	220	0.08	0.170	5.10	MF3	59221E3	69221E3	39221E3
	220	16 x 20	590	220	0.08	0.140	4.20	MF3	99225E3	99226E3	99223E3
	330	16 x 25	630	330	0.08	0.120	3.60	MF3	59331E3	69331E3	39331E3
	470	16 x 31	750	470	0.08	0.100	3.00	MF3	59471E3	69471E3	39471E3

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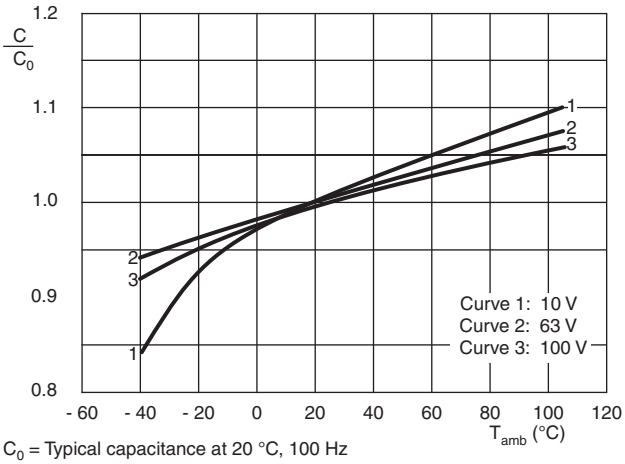
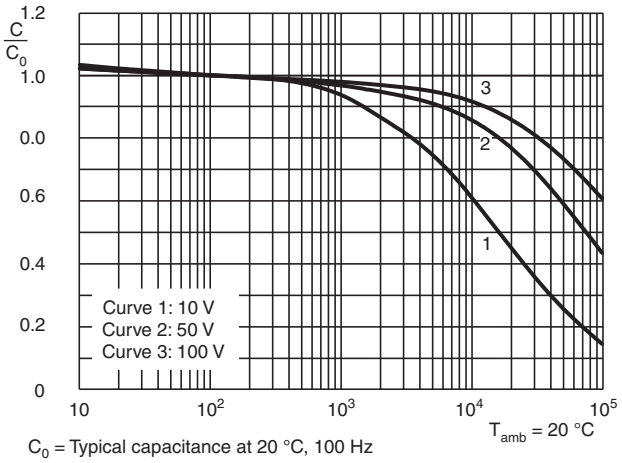
ADDITIONAL ELECTRICAL DATA		
PARAMETER	**CONDITIONS**	**VALUE**
Voltage		
Surge voltage		$U_s \leq 1.15\ U_R$
Reverse voltage		$U_{rev} \leq 1$ V
Current		
Leakage current	After 2 min at U_R	$I_{L2} \leq 0.01\ C_R \times U_R$
	After 5 min at U_R	$I_{L5} \leq 0.002\ C_R \times U_R$
Inductance		
Equivalent 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)



C_0 = Typical capacitance at 20 °C, 100 Hz

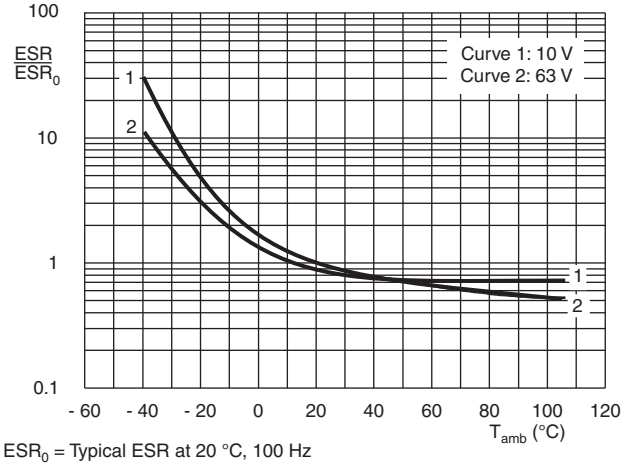
Fig. 5 - Typical multiplier of capacitance as a function of ambient temperature



C_0 = Typical capacitance at 20 °C, 100 Hz

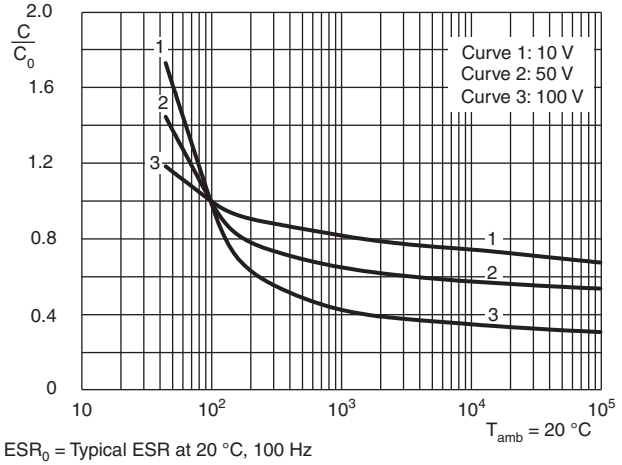
Fig. 6 - Typical multiplier of capacitance as a function of frequency

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

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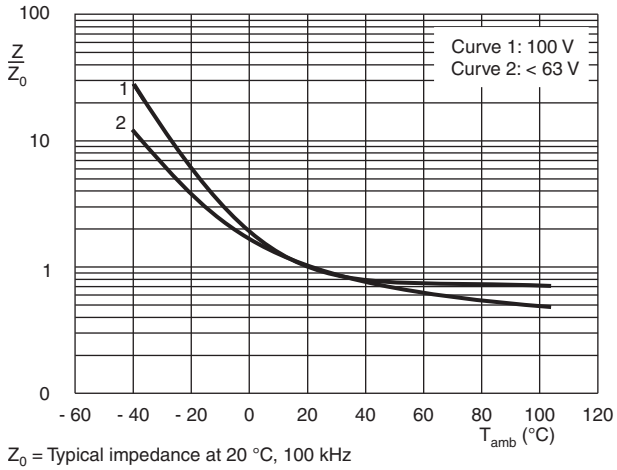
IMPEDANCE (Z)



Z_0 = Typical impedance at 20 °C, 100 kHz

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

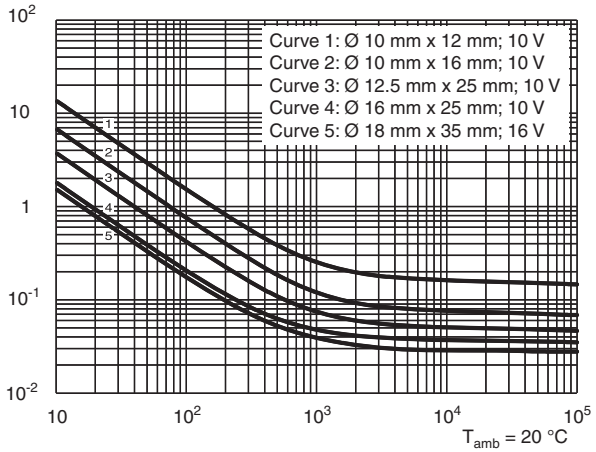


Fig. 10 - Typical impedance as a function of frequency

IMPEDANCE (Z)

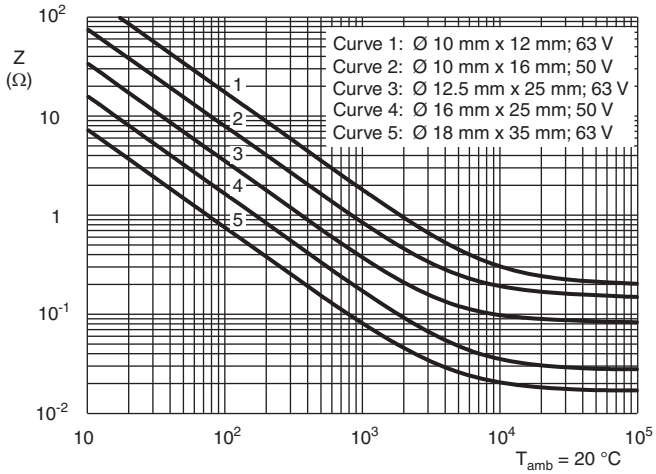


Fig. 11 - Typical impedance as a function of frequency

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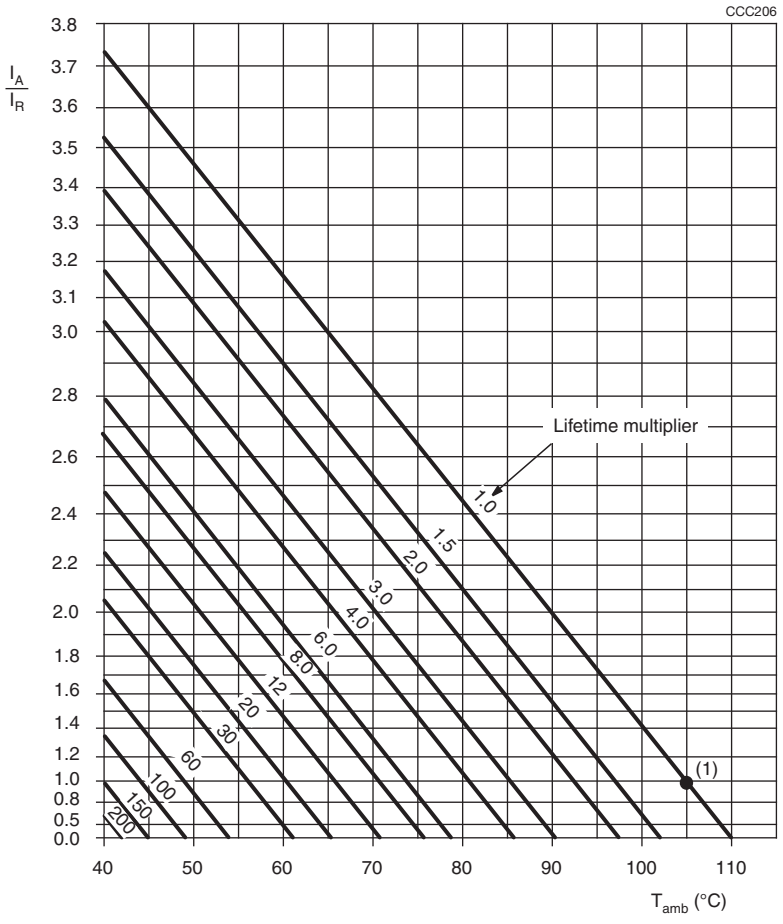
RIPPLE CURRENT AND USEFUL LIFE

Table 3

ENDURANCE TEST DURATION AND USEFUL LIFE		
NOMINAL CASE SIZE Ø D x L (mm)	ENDURANCE AT 105 °C (h)	USEFUL LIFE AT 105 °C (h)
10 x 12	1000	2000
10 x 16	1000	2000
10 x 20	1000	2000
12.5 x 20	2000	3000
12.5 x 25	2000	3000
16 x 20	2000	3000
16 x 25	2000	3000
16 x 31	2000	3000
18 x 35	2000	3000

Note

- Multiplier of useful life code: CCC206



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

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Table 4

MULTIPLIER OF RIPPLE CURRENT (I_R) AS A FUNCTION OF FREQUENCY						
FREQ. CODE	FREQUENCY (Hz)					
	50	100	300	1000	3000	≥ 10 000
	I_R MULTIPLIER					
MF1	0.95	1.00	1.07	1.12	1.15	1.20
MF2	0.85	1.00	1.20	1.30	1.35	1.40
MF3	0.80	1.00	1.25	1.40	1.50	1.60

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 °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 / EN 130300 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 / EN 130300 subclause 4.14	From source of 1.15 x U_R: RC = 0.1 s ± 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 / EN 130300 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

Statements about product lifetime are based on calculations and internal testing. They should only be interpreted as estimations. Also due to external factors, the lifetime in the field application may deviate from the calculated lifetime. In general, nothing stated herein shall be construed as a guarantee of durability.

For technical questions, contact: aluminumcaps1@vishay.com
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