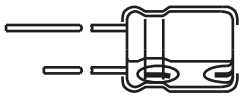
Aluminum Capacitors
Radial, Standard Long-Life



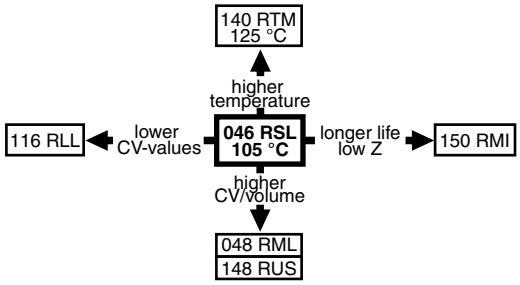


Fig. 1

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

Pb-free
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 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 (046)

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	22 µF to 10 000 µF
Tolerance on C_R	± 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 Ø D = 10 mm and 12.5 mm Case Ø D = 16 mm and 18 mm	 3000 h 4000 h
Useful life at 40 °C, 1.6 x I_R applied Case Ø D = 10 mm and 12.5 mm Case Ø D = 16 mm and 18 mm	 200 000 h 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 (Ø D x L in mm)

C_R (µF)	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	-	-	-	-	-	-

For technical questions, contact: aluminumcaps1@vishay.com
THIS DOCUMENT IS SUBJECT TO CHANGE WITHOUT NOTICE. THE PRODUCTS DESCRIBED HEREIN AND THIS DOCUMENT ARE SUBJECT TO SPECIFIC DISCLAIMERS, SET FORTH AT www.vishay.com/doc?91000

DIMENSIONS in millimeters, **AND AVAILABLE FORMS**

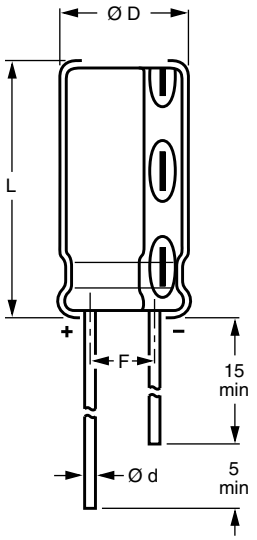


Fig. 2 - **Form CA:** Long leads

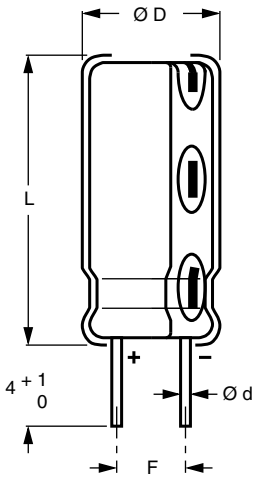
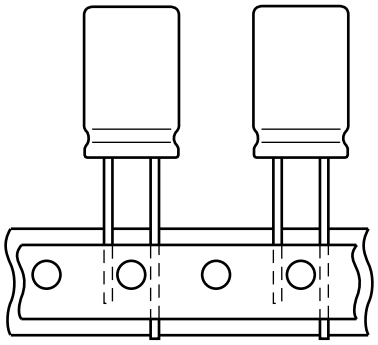


Fig. 3 - **Form CB:** Cut leads



Case Ø D x L ≤ 16 x 31 mm

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 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
16 x 35	21	0.8	16.5	37.5	7.5 ± 0.5	≈ 11.5	100	100	-
18 x 35	22	0.8	18.5	37.5	7.5 ± 0.5	≈ 14.5	300	1000	-

Note

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

For technical questions, contact: aluminumcaps1@vishay.com
THIS DOCUMENT IS SUBJECT TO CHANGE WITHOUT NOTICE. THE PRODUCTS DESCRIBED HEREIN AND THIS DOCUMENT ARE SUBJECT TO SPECIFIC DISCLAIMERS, SET FORTH AT www.vishay.com/doc?91000

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_{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 δ	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 °C, P = 86 kPa to 106 kPa, RH = 45 % to 75 %.

ORDERING EXAMPLE

Electrolytic capacitor 046 series

2200 μF/16 V; ± 20 %

Nominal case size: Ø 16 mm x 25 mm; form TFA

Ordering code: MAL204635222E3
Former 12NC: 2222 046 35222

Table 2

ELECTRICAL DATA AND ORDERING INFORMATION

U_R (V)	C_R 100 Hz (μF)	NOMINAL CASE SIZE Ø D x L (mm)	CASE CODE	I_R 100 Hz 105 °C (mA)	I_{RH} 100 kHz 105 °C (mA)	I_{L1} 1 min (μA)	I_{L5} 5 min (μA)	tan δ 100 Hz	ESR 100 Hz (Ω)	Z 10 kHz (Ω)	Z 100 kHz (Ω)	ORDERING NUMBER MAL2046..... BULK PACKAGING FORM CA	BULK PACKAGING FORM CB	TAPED 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	-

For technical questions, contact: aluminumcaps1@vishay.com
THIS DOCUMENT IS SUBJECT TO CHANGE WITHOUT NOTICE. THE PRODUCTS DESCRIBED HEREIN AND THIS DOCUMENT ARE SUBJECT TO SPECIFIC DISCLAIMERS, SET FORTH AT www.vishay.com/doc?91000

ELECTRICAL DATA AND ORDERING INFORMATION

U_R (V)	C_R 100 Hz (µF)	NOMINAL CASE SIZE Ø D x L (mm)	CASE CODE	I_R 100 Hz 105 °C (mA)	I_{RH} 100 kHz 105 °C (mA)	I_{L1} 1 min (µA)	I_{L5} 5 min (µA)	tan δ 100 Hz	ESR 100 Hz (Ω)	Z 10 kHz (Ω)	Z 100 kHz (Ω)	ORDERING NUMBER MAL2046..... BULK PACKAGING FORM CA	BULK PACKAGING FORM CB	TAPED 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
Voltage		
Surge voltage		$U_s \leq 1.15\ U_R$
Reverse voltage		$U_{rev} \leq 1$ V
Current		
Leakage current	After 1 min at U_R	$I_{L1} \leq 0.01\ C_R \times U_R + 3$ µA
	After 5 min at U_R	$I_{L5} \leq 0.002\ C_R \times U_R + 3$ µA
Inductance		
Equivalent series inductance (ESL)	Case Ø D = 10 mm	Typ. 16 nH
	Case Ø D ≥ 12.5 mm	Typ. 18 nH

CAPACITANCE (C)

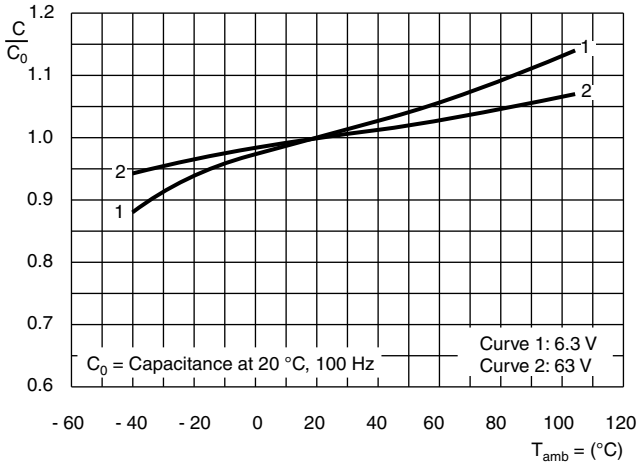


Fig. 5 - Typical multiplier of capacitance as a function of ambient temperature

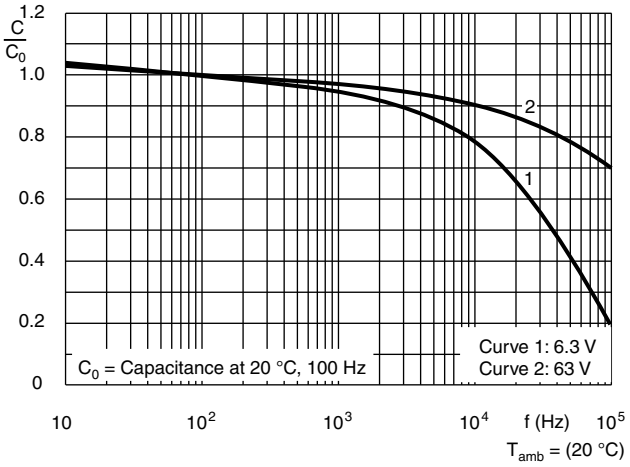


Fig. 6 - Typical multiplier of capacitance as a function of frequency

For technical questions, contact: aluminumcaps1@vishay.com
THIS DOCUMENT IS SUBJECT TO CHANGE WITHOUT NOTICE. THE PRODUCTS DESCRIBED HEREIN AND THIS DOCUMENT ARE SUBJECT TO SPECIFIC DISCLAIMERS, SET FORTH AT www.vishay.com/doc?91000

EQUIVALENT SERIES RESISTANCE (ESR)

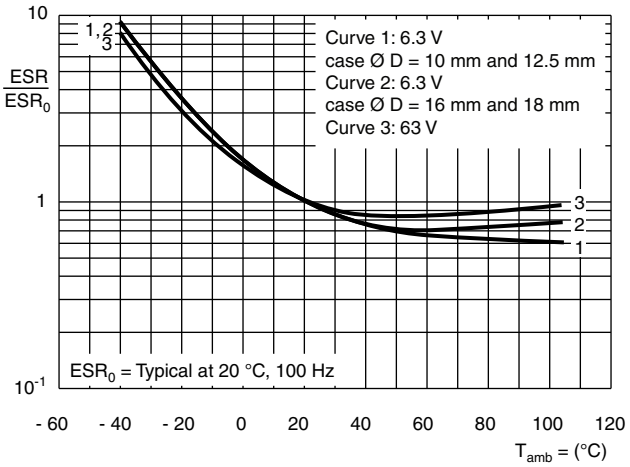


Fig. 7 - Typical multiplier of ESR as a function of ambient temperature

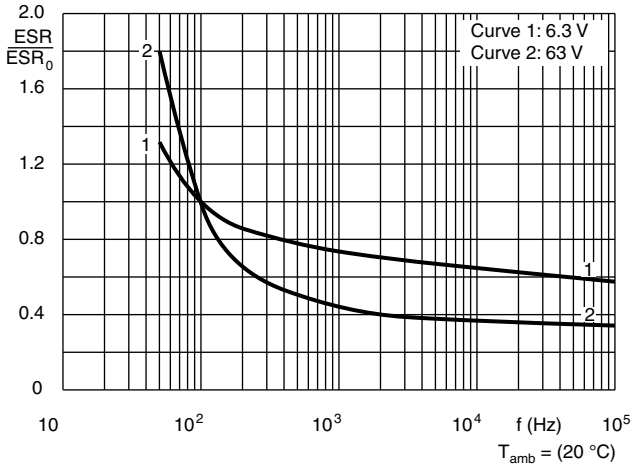


Fig. 8 - Typical multiplier of ESR as a function of frequency

IMPEDANCE (Z)

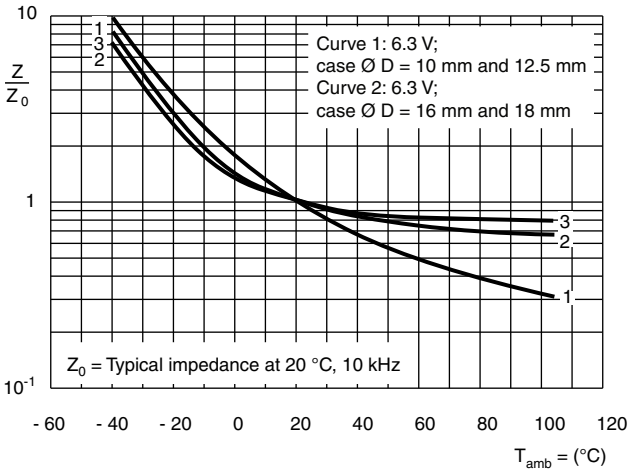


Fig. 9 - Typical multiplier of impedance as a function of ambient temperature

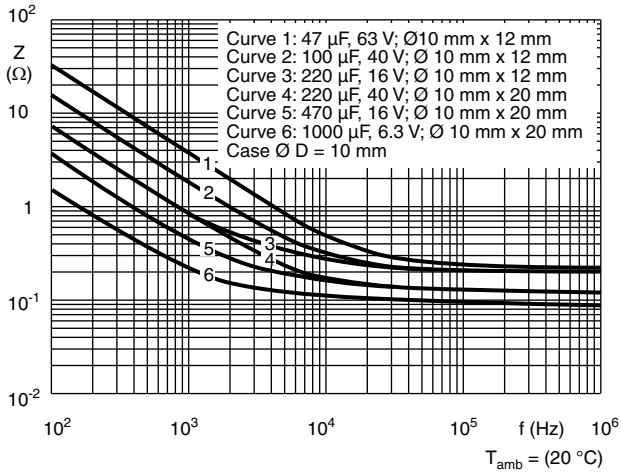


Fig. 10 - Typical impedance as a function of frequency

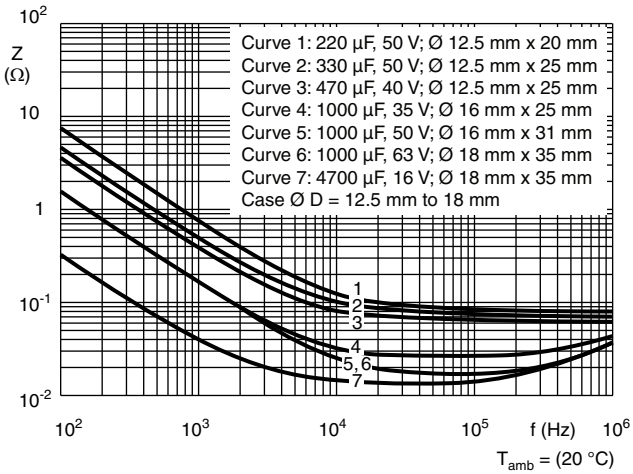
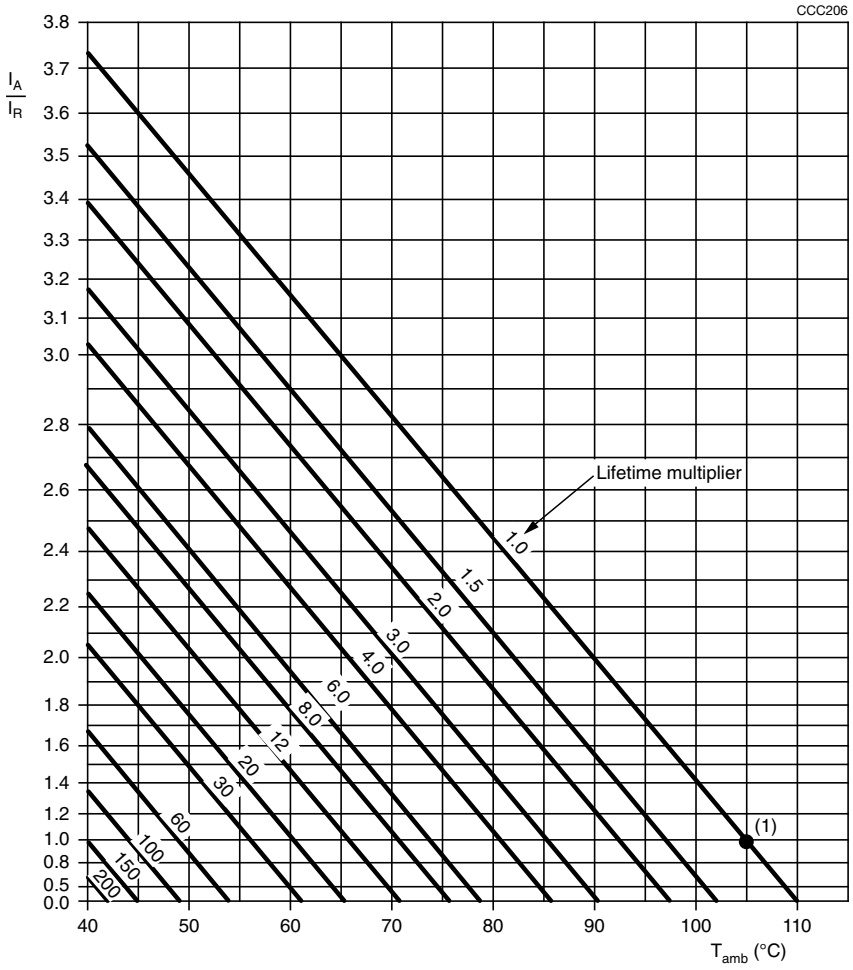


Fig. 11 - Typical impedance at as a function of frequency

For technical questions, contact: aluminumcaps1@vishay.com
THIS DOCUMENT IS SUBJECT TO CHANGE WITHOUT NOTICE. THE PRODUCTS DESCRIBED HEREIN AND THIS DOCUMENT ARE SUBJECT TO SPECIFIC DISCLAIMERS, SET FORTH AT www.vishay.com/doc?91000

RIPPLE CURRENT AND USEFUL LIFE



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 Ø D = 10 mm and 12.5 mm; 3000 h
Case Ø 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 °C; U_R applied; 2000 h	U_R = 6.3 V; ΔC/C: +15 %/-30 % U_R > 6.3 V; ΔC/C: ± 15 % tan δ ≤ 1.3 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; 3000 h, case Ø D = 10 mm and 12.5 mm; 4000 h, case Ø D = 16 mm and 18 mm	U_R = 6.3 V; ΔC/C: +45 %/-50 % U_R > 6.3 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 > 6.3 V; ΔC/C: ± 15 % tan δ ≤ 1.3 x spec. limit Z ≤ 2 x spec. limit I_{L5} ≤ 2 x spec. limit

For technical questions, contact: aluminumcaps1@vishay.com
THIS DOCUMENT IS SUBJECT TO CHANGE WITHOUT NOTICE. THE PRODUCTS DESCRIBED HEREIN AND THIS DOCUMENT ARE SUBJECT TO SPECIFIC DISCLAIMERS, SET FORTH AT www.vishay.com/doc?91000

Disclaimer

ALL PRODUCT, PRODUCT SPECIFICATIONS AND DATA ARE SUBJECT TO CHANGE WITHOUT NOTICE TO IMPROVE RELIABILITY, FUNCTION OR DESIGN OR OTHERWISE.

Vishay Intertechnology, Inc., its affiliates, agents, and employees, and all persons acting on its or their behalf (collectively, “Vishay”), disclaim any and all liability for any errors, inaccuracies or incompleteness contained in any datasheet or in any other disclosure relating to any product.

Vishay makes no warranty, representation or guarantee regarding the suitability of the products for any particular purpose or the continuing production of any product. To the maximum extent permitted by applicable law, Vishay disclaims (i) any and all liability arising out of the application or use of any product, (ii) any and all liability, including without limitation special, consequential or incidental damages, and (iii) any and all implied warranties, including warranties of fitness for particular purpose, non-infringement and merchantability.

Statements regarding the suitability of products for certain types of applications are based on Vishay's knowledge of typical requirements that are often placed on Vishay products in generic applications. Such statements are not binding statements about the suitability of products for a particular application. It is the customer's responsibility to validate that a particular product with the properties described in the product specification is suitable for use in a particular application. Parameters provided in datasheets and / or specifications may vary in different applications and performance may vary over time. All operating parameters, including typical parameters, must be validated for each customer application by the customer's technical experts. Product specifications do not expand or otherwise modify Vishay's terms and conditions of purchase, including but not limited to the warranty expressed therein.

Hyperlinks included in this datasheet may direct users to third-party websites. These links are provided as a convenience and for informational purposes only. Inclusion of these hyperlinks does not constitute an endorsement or an approval by Vishay of any of the products, services or opinions of the corporation, organization or individual associated with the third-party website. Vishay disclaims any and all liability and bears no responsibility for the accuracy, legality or content of the third-party website or for that of subsequent links.

Except as expressly indicated in writing, Vishay products are not designed for use in medical, life-saving, or life-sustaining applications or for any other application in which the failure of the Vishay product could result in personal injury or death. Customers using or selling Vishay products not expressly indicated for use in such applications do so at their own risk. Please contact authorized Vishay personnel to obtain written terms and conditions regarding products designed for such applications.

No license, express or implied, by estoppel or otherwise, to any intellectual property rights is granted by this document or by any conduct of Vishay. Product names and markings noted herein may be trademarks of their respective owners.

© 2024 VISHAY INTERTECHNOLOGY, INC. ALL RIGHTS RESERVED