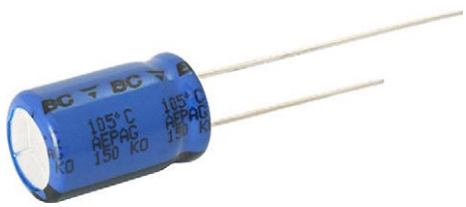
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Aluminum Electrolytic Capacitors
Radial Miniature, Low Impedance



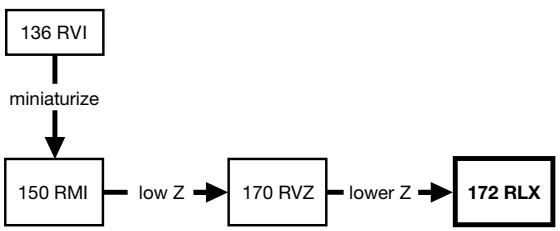


Fig. 1

FEATURES

- Very long useful life: 4000 h to 10 000 h at 105 °C, high stability, high reliability
- Very low impedance and low ESR in smaller case sizes than the 170 RVZ series
- Excellent ripple current capability
- AEC-Q200 qualified
- 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

AUTOMOTIVE GRADE

Pb-free

RoHS COMPLIANT

APPLICATIONS

- Power supplies (SMPS, DC/DC converters) for general industrial, EDP, audio-video, automotive, and telecommunications
- Smoothing, filtering, buffering

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 (172)

QUICK REFERENCE DATA

DESCRIPTION	VALUE
Nominal case sizes (Ø D x L in mm)	10 x 12 to 18 x 40
Rated capacitance range, C_R	150 µF to 15 000 µF
Tolerance on C_R	± 20 %
Rated voltage range, U_R	10 V to 50 V
Category temperature range	-40 °C to +105 °C
Endurance test at 105 °C	3000 h to 6000 h
Useful life at 105 °C	4000 h to 10 000 h
Useful life at 40 °C, 1.8 x I_R applied	200 000 h to 500 000 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)				
	10	16	25	35	50
150	→	→	→	→	10 x 12
220	→	→	→	→	10 x 16
270	→	→	→	10 x 12	-
330	→	→	→	→	10 x 20
390	→	→	→	10 x 16	-
470	→	→	10 x 12	10 x 20	-
560	→	→	→	→	12.5 x 20
680	→	10 x 12	10 x 16	→	12.5 x 25
820	→	→	10 x 20	12.5 x 20	16 x 20
1000	10 x 12	10 x 16	-	-	-
1200	→	10 x 20	→	12.5 x 25	18 x 20
1500	10 x 16	→	12.5 x 20	16 x 20	16 x 31
1800	10 x 20	→	12.5 x 25	18 x 20	16 x 35
2200	→	12.5 x 20	→	16 x 25	18 x 31
2700	→	12.5 x 25	16 x 20	16 x 31	18 x 35
3300	12.5 x 20	→	18 x 20	16 x 35	18 x 40
3900	12.5 x 25	16 x 20	16 x 25	18 x 35	-
4700	16 x 20	18 x 20	16 x 31	18 x 40	-
5600	18 x 20	16 x 25	18 x 31	-	-
6800	16 x 25	16 x 31	18 x 35	-	-
8200	18 x 25	16 x 35	18 x 40	-	-
10 000	16 x 31	18 x 35	-	-	-
12 000	16 x 35	18 x 40	-	-	-
15 000	18 x 40	-	-	-	-

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DIMENSIONS in millimeters AND AVAILABLE FORMS

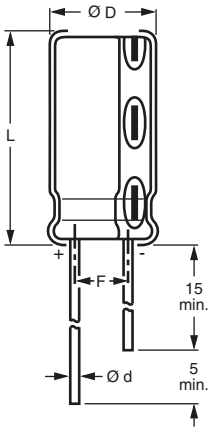


Fig. 2 - **Form CA:** Long leads

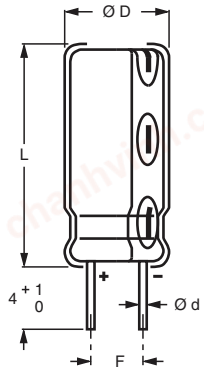


Fig. 3 - **Form CB:** Cut leads

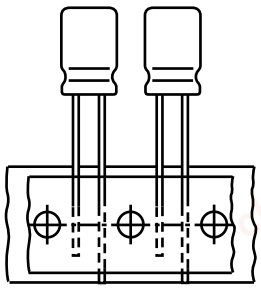


Fig. 4 - **Form TFA:** Taped in box (ammopack)

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
16 x 35	21	0.8	16.5	37.5	7.5 ± 0.5	≈ 11.0	100	100	-
18 x 20	1820	0.8	16.5	22.0	7.5 ± 0.5	≈ 8.0	100	100	250
18 x 25	1825	0.8	16.5	27.0	7.5 ± 0.5	≈ 10.0	100	100	250
18 x 31	1831	0.8	18.5	33.5	7.5 ± 0.5	≈ 12.5	100	100	-
18 x 35	22	0.8	18.5	37.5	7.5 ± 0.5	≈ 14.5	100	100	-
18 x 40	1840	0.8	18.5	42.5	7.5 ± 0.5	≈ 16.5	100	100	-

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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 kHz, 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 172 series

2200 µF / 16 V; ± 20 %

Nominal case size: Ø 12.5 mm x 20 mm; Form TFA

Ordering code: MAL217235222E3

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 kHz 105 °C (mA)	I_{L2} 2 min (µA)	tan δ 100 Hz	Z 100 kHz +20 °C (Ω)	Z 100 kHz -10 °C (Ω)	Z 100 kHz -40 °C (Ω)	ORDERING CODE MAL2172.....		
									BULK PACKAGING		TAPED
									FORM CA	FORM CB	FORM TFA
10	1000	10 x 12	1700	100	0.21	0.048	0.150	7.2	54102E3	64102E3	34102E3
	1500	10 x 16	2000	150	0.21	0.038	0.120	5.7	54152E3	64152E3	34152E3
	1800	10 x 20	2500	180	0.21	0.028	0.084	4.2	54182E3	64182E3	34182E3
	3300	12.5 x 20	2600	330	0.25	0.025	0.075	3.8	54332E3	64332E3	34332E3
	3900	12.5 x 25	3200	390	0.25	0.019	0.057	2.9	54392E3	64392E3	34392E3
	4700	16 x 20	3330	470	0.27	0.021	0.063	3.2	54472E3	64472E3	34472E3
	5600	18 x 20	3450	560	0.29	0.020	0.060	3.0	54562E3	64562E3	34562E3
	6800	16 x 25	3810	680	0.31	0.017	0.051	2.6	54682E3	64682E3	34682E3
	8200	18 x 25	3880	820	0.35	0.016	0.048	2.4	54822E3	64822E3	34822E3
	10 000	16 x 31	4100	1000	0.39	0.016	0.048	2.4	54103E3	64103E3	34103E3
	12 000	16 x 35	4280	1200	0.43	0.014	0.042	2.1	54123E3	64123E3	-
	15 000	18 x 40	4960	1500	0.49	0.011	0.033	1.7	54153E3	64153E3	-
16	680	10 x 12	1700	109	0.16	0.053	0.160	8.0	55681E3	65681E3	35681E3
	1000	10 x 16	2000	160	0.18	0.038	0.120	5.7	55102E3	65102E3	35102E3
	1200	10 x 20	2500	192	0.18	0.028	0.084	4.2	55122E3	65122E3	35122E3
	2200	12.5 x 20	2600	352	0.20	0.025	0.075	3.8	55222E3	65222E3	35222E3
	2700	12.5 x 25	3200	432	0.20	0.019	0.057	2.9	55272E3	65272E3	35272E3
	3900	16 x 20	3330	624	0.22	0.021	0.063	3.2	55392E3	65392E3	35392E3
	4700	18 x 20	3450	752	0.24	0.020	0.060	3.0	55472E3	65472E3	35472E3
	5600	16 x 25	3810	896	0.31	0.017	0.050	2.6	55562E3	65562E3	35562E3
	6800	16 x 31	4100	1088	0.28	0.016	0.048	2.4	55682E3	65682E3	35682E3
	8200	16 x 35	4280	1312	0.32	0.014	0.042	2.1	55822E3	65822E3	-
	10 000	18 x 35	4380	1600	0.36	0.012	0.036	1.8	55103E3	65103E3	-
	12 000	18 x 40	4960	1920	0.40	0.011	0.033	1.7	55123E3	65123E3	-
25	470	10 x 12	1700	118	0.14	0.048	0.150	7.2	56471E3	66471E3	36471E3
	680	10 x 16	2000	170	0.14	0.030	0.090	4.5	56681E3	66681E3	36681E3
	820	10 x 20	2500	205	0.14	0.028	0.084	4.2	56821E3	66821E3	36821E3
	1500	12.5 x 20	2600	375	0.16	0.025	0.075	3.8	56152E3	66152E3	36152E3
	1800	12.5 x 25	3200	450	0.16	0.019	0.057	2.9	56182E3	66182E3	36182E3
	2700	16 x 20	3330	675	0.18	0.021	0.063	3.2	56272E3	66272E3	36272E3
	3300	18 x 20	3450	825	0.20	0.020	0.060	3.0	56332E3	66332E3	36332E3
	3900	16 x 25	3810	975	0.20	0.017	0.051	2.6	56392E3	66392E3	36932E3
	4700	16 x 31	4100	1175	0.22	0.016	0.048	2.4	56472E3	66472E3	36472E3
	5600	18 x 31	4190	1400	0.24	0.014	0.042	2.1	56562E3	66562E3	-
	6800	18 x 35	4380	1700	0.26	0.012	0.036	1.8	56682E3	66682E3	-
	8200	18 x 40	4960	2050	0.30	0.011	0.033	1.7	56822E3	66822E3	-

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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 kHz 105 °C (mA)	I_{L2} 2 min (µA)	tan δ 100 Hz	Z 100 kHz +20 °C (Ω)	Z 100 kHz -10 °C (Ω)	Z 100 kHz -40 °C (Ω)	ORDERING CODE MAL2172.....		
									BULK PACKAGING		TAPED
									FORM CA	FORM CB	FORM TFA
35	270	10 x 12	1700	95	0.12	0.053	0.160	8.0	50271E3	60271E3	30271E3
	390	10 x 16	2000	137	0.12	0.038	0.120	5.7	50391E3	60391E3	30391E3
	470	10 x 20	2500	165	0.12	0.028	0.084	4.2	50471E3	60471E3	30471E3
	820	12.5 x 20	2600	287	0.12	0.025	0.075	3.8	50821E3	60821E3	30821E3
	1200	12.5 x 25	3200	420	0.14	0.019	0.057	2.9	50122E3	60122E3	30122E3
	1500	16 x 20	3330	525	0.14	0.021	0.063	3.2	50152E3	60152E3	30152E3
	1800	18 x 20	3450	630	0.14	0.020	0.060	3.0	50182E3	60182E3	30182E3
	2200	16 x 25	3810	770	0.16	0.017	0.051	2.6	50222E3	60222E3	30222E3
	2700	16 x 31	4100	945	0.16	0.016	0.048	2.4	50272E3	60272E3	30272E3
	3300	18 x 31	4280	1155	0.18	0.014	0.042	2.1	50332E3	60332E3	-
	3900	18 x 35	4380	1365	0.18	0.012	0.036	1.8	50392E3	60392E3	-
	4700	18 x 40	4960	1645	0.20	0.011	0.033	1.7	50472E3	60472E3	-
50	150	10 x 12	1280	75	0.10	0.073	0.220	11.0	51151E3	61151E3	31151E3
	220	10 x 16	1650	110	0.10	0.053	0.160	8.0	51221E3	61221E3	31221E3
	330	10 x 20	2060	165	0.10	0.038	0.120	5.7	51331E3	61331E3	31331E3
	560	12.5 x 20	2300	280	0.10	0.032	0.100	4.8	51561E3	61561E3	31561E3
	680	12.5 x 25	2800	340	0.10	0.025	0.080	3.8	51681E3	61681E3	31681E3
	820	16 x 20	3070	410	0.10	0.026	0.084	3.9	51821E3	61821E3	31821E3
	1200	16 x 25	3510	600	0.12	0.022	0.070	3.3	51122E3	61122E3	31122E3
	1500	16 x 31	4030	750	0.12	0.019	0.057	3.2	51152E3	61152E3	31152E3
	1800	16 x 35	4220	900	0.12	0.016	0.048	2.4	51182E3	61182E3	-
	2200	18 x 31	4080	1100	0.14	0.016	0.048	2.4	51222E3	61222E3	-
	2700	18 x 35	4270	1350	0.14	0.013	0.039	2.0	51272E3	61272E3	-
	3300	18 x 40	4850	1650	0.16	0.012	0.036	1.8	51332E3	61332E3	-

ADDITIONAL ELECTRICAL DATA

PARAMETER	CONDITIONS	VALUE
Voltage		
Surge voltage		$U_s \leq 1.15 \times U_R$
Reverse voltage		$U_{rev} \leq 1$ V
Current		
Leakage current	After 2 min at U_R	$I_{L2} \leq 0.01\ C_R \times U_R$
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 $\delta/2\ \pi\ f\ C_R$

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CAPACITANCE (C)

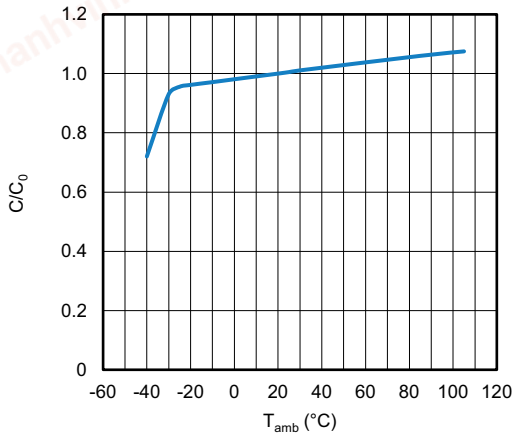


Fig. 5 - Typical multiplier of capacitance as a function of ambient temperature (C_0 = typical capacitance at 20 °C, 100 Hz)

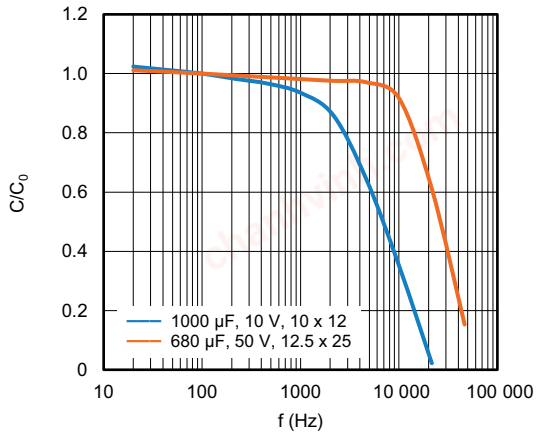


Fig. 6 - Typical multiplier of capacitance as a function of frequency (C_0 = typical capacitance at 20 °C, 100 Hz; T_{amb} = 20 °C)

EQUIVALENT SERIES RESISTANCE (ESR)

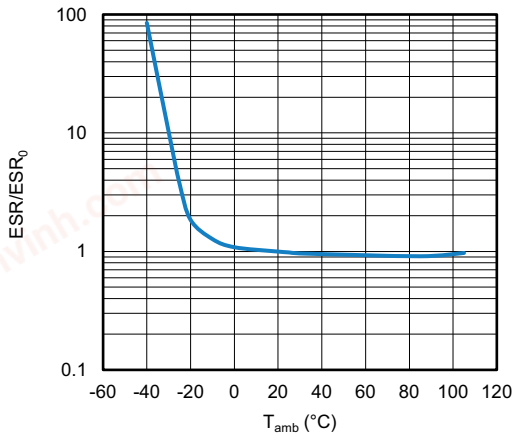


Fig. 7 - Typical multiplier of ESR as a function of ambient temperature (ESR_0 = typical ESR at 20 °C, 100 Hz)

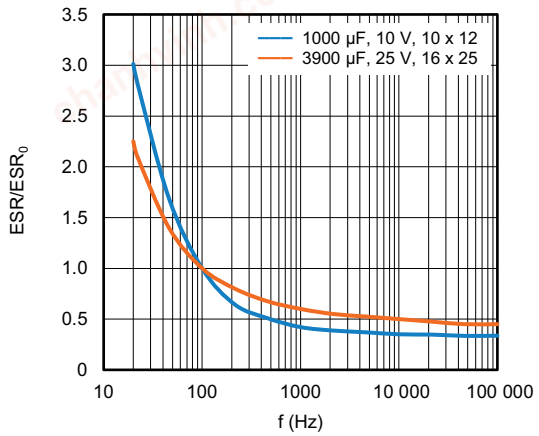


Fig. 8 - Typical multiplier of ESR as a function of frequency (ESR_0 = typical ESR at 20 °C, 100 Hz; T_{amb} = 20 °C)

IMPEDANCE (Z)

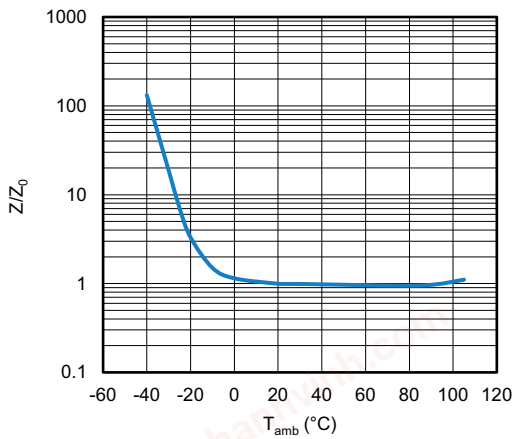


Fig. 9 - Typical impedance as a function of ambient temperature (Z_0 = typical impedance at 20 °C, 100 kHz)

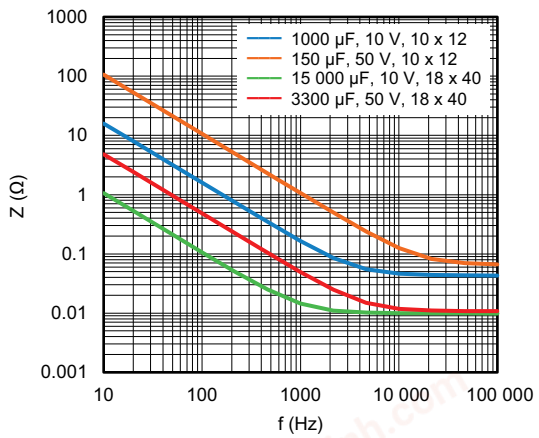


Fig. 10 - Typical impedance as a function of frequency (T_{amb} = 20 °C)

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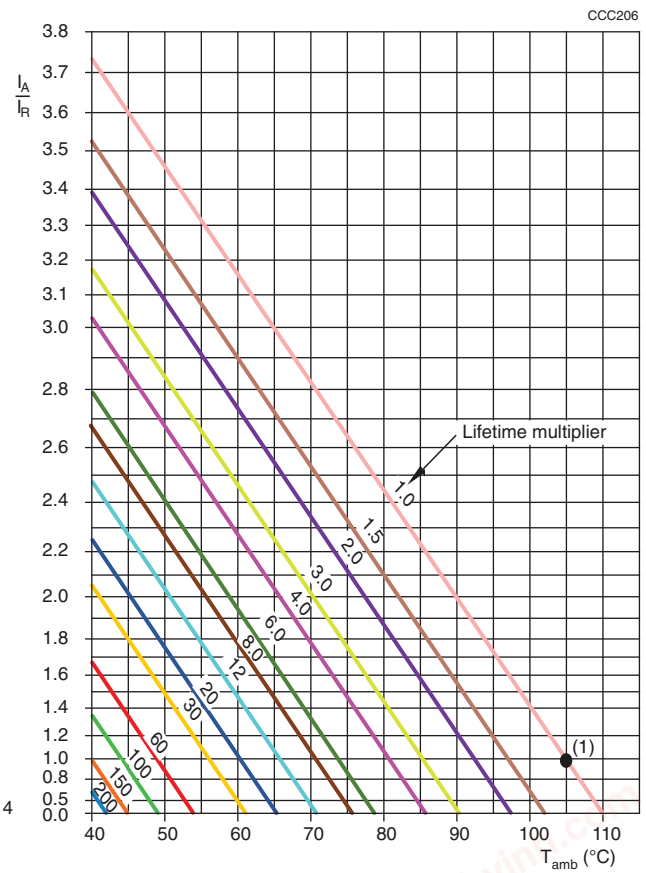
RIPPLE CURRENT AND USEFUL LIFE

Table 3

ENDURANCE TEST DURATION AND USEFUL LIFE			
NOMINAL CASE SIZE Ø D x L (mm)	CASE CODE	ENDURANCE AT 105 °C (h)	USEFUL LIFE AT 105 °C (h)
10 x 12	14	3000	4000
10 x 16	15	3000	6000
10 x 20	16	3000	6000
12.5 x 20	17	3000	7000
12.5 x 25	18	5000	8000
16 x 20	19a	3000	7000
16 x 25	19	5000	10 000
16 x 31	20	5000	10 000
16 x 35	21	5000	10 000
18 x 20	1820	3000	7000
18 x 25	1825	5000	10 000
18 x 31	1831	6000	10 000
18 x 35	22	6000	10 000
18 x 40	1840	6000	10 000

Note

- Multiplier of useful life code: CCC206



I_A = actual ripple current at 100 kHz
I_R = rated ripple current at 100 kHz, 105 °C
(1) Useful life at 105 °C and I_R applied; see Table 4

Fig. 11 - Multiplier of useful life as a function of ambient temperature and ripple current load

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Table 4

MULTIPLIER OF RIPPLE CURRENT (I_R) AS A FUNCTION OF FREQUENCY							
NOMINAL CASE SIZE Ø D x L (mm)	FREQUENCY (Hz)						
	100	300	1000	3000	10 000	30 000	100 000
	I_R MULTIPLIER						
10 x 12	0.65	0.76	0.85	0.89	0.90	0.97	1.00
10 x 16	0.65	0.76	0.85	0.89	0.90	0.97	1.00
10 x 20	0.65	0.76	0.85	0.89	0.90	0.97	1.00
12.5 x 20	0.65	0.76	0.85	0.89	0.90	0.97	1.00
12.5 x 25	0.65	0.76	0.85	0.89	0.90	0.97	1.00
16 x 20	0.76	0.85	0.91	0.94	0.96	0.98	1.00
16 x 25	0.76	0.85	0.91	0.94	0.96	0.98	1.00
16 x 31	0.76	0.85	0.91	0.94	0.96	0.98	1.00
16 x 35	0.76	0.85	0.91	0.94	0.96	0.98	1.00
18 x 20	0.76	0.85	0.91	0.94	0.96	0.98	1.00
18 x 25	0.76	0.85	0.91	0.94	0.96	0.98	1.00
18 x 31	0.76	0.85	0.91	0.94	0.96	0.98	1.00
18 x 35	0.76	0.85	0.91	0.94	0.96	0.98	1.00
18 x 40	0.76	0.85	0.91	0.94	0.96	0.98	1.00

Table 5

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; for test duration see Table 3	ΔC/C: ± 20 % tan δ ≤ 2 x spec. limit I_{L2} ≤ spec. limit
Useful life	CECC 30301 subclause 1.8.1	T_{amb} = 105 °C; U_R and I_R applied; for test duration see Table 3	ΔC/C: ± 30 % tan δ ≤ 3 x spec. limit I_{L2} ≤ 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	ΔC/C: ± 20 % tan δ ≤ 2 x spec. limit I_{L2} ≤ 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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