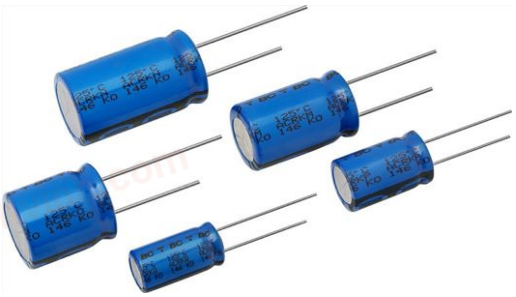
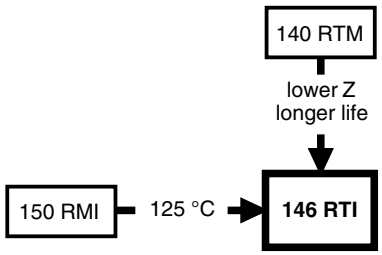
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Aluminum Capacitors
Radial, High Temperature, Low Impedance





FEATURES

- Very long useful life: 2500 h to 6000 h at 125 °C
- High stability, high reliability
- Very low ESR
- AEC-Q200 qualified
- Excellent ripple current capability
- Polarized aluminum electrolytic capacitors, non-solid electrolyte
- Radial leads, cylindrical aluminum case with pressure relief, insulated with a blue PET sleeve
- Charge and discharge proof
- Material categorization: For definitions of compliance please see www.vishay.com/doc?99912

Pb-free
RoHS COMPLIANT

APPLICATIONS

- Power supplies (SMPS, DC/DC converters) for industrial, automotive, telecommunications and military
- Smoothing, filtering and 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
- Logo of manufacturer
- Upper category temperature (125 °C)
- Negative terminal identification
- Series number (146)

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	68 µF to 6800 µF
Tolerance on C_R	± 20 %
Rated voltage range, U_R	16 V to 63 V
Category temperature range	- 55 °C to + 125 °C
Endurance test at 125 °C	2000 h to 5000 h
Useful life at 125 °C	2500 h to 6000 h
Useful life at 40 °C, 1.8 x I_R applied	400 000 h
Shelf life at 0 V, 125 °C	1000 h
Based on sectional specification	IEC 60384-4/EN130300
Climatic category IEC 60068	55/125/56

SELECTION CHART FOR C_R, U_R, AND RELEVANT NOMINAL CASE SIZES (Ø D x L in mm)

C_R (µF)	U_R (V)				
	16	**25**	**35**	**50**	**63**
68	-	-	-	-	10 x 20
100	-	-	-	10 x 12	10 x 16
150	-	-	-	-	10 x 20
220	-	-	10 x 12	10 x 16	12.5 x 20
330	-	10 x 12	10 x 16	10 x 20	12.5 x 25
390	-	-	-	-	16 x 20
470	10 x 12	10 x 16	10 x 20	12.5 x 20	18 x 20
560	-	-	-	-	10 x 20
680	10 x 16	10 x 20	12.5 x 20	12.5 x 25	18 x 25
	-	-	-	-	16 x 31
820	-	-	-	16 x 20	16 x 35
1000	10 x 20	12.5 x 20	12.5 x 25	18 x 20	18 x 31
	-	-	-	16 x 25	-

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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)				
	16	25	35	50	63
1200	-	-	16 x 20	18 x 25	18 x 35
	-	-	-	16 x 31	-
1500	12.5 x 20	12.5 x 25	18 x 20	16 x 35	-
1800	-	16 x 20	16 x 25	18 x 31	-
2200	12.5 x 25	-	18 x 25	18 x 35	-
	-	-	16 x 31	-	-
2700	16 x 20	18 x 20	16 x 35	-	-
	-	16 x 25	18 x 31	-	-
3300	18 x 20	16 x 31	18 x 35	-	-
3900	16 x 25	18 x 25	-	-	-
4700	18 x 25	16 x 35	-	-	-
	16 x 31	18 x 31	-	-	-
5600	16 x 35	18 x 35	-	-	-
6800	18 x 31	-	-	-	-

DIMENSIONS in millimeters AND AVAILABLE FORMS

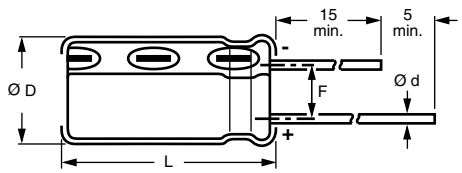


Fig. 2 - **Form CA**: Long leads

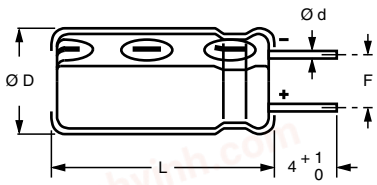


Fig. 3 - **Form CB:** Cut leads

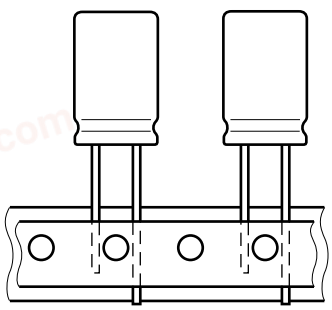


Fig. 4 - **Form TFA**: Taped in box (ammopack)

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	18.5	22.0	7.5 ± 0.5	≈ 8.0	100	100	250
18 x 25	1825	0.8	18.5	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	250
18 x 35	22	0.8	18.5	37.5	7.5 ± 0.5	≈ 14.5	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, 125 °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 146 series

470 µF/25 V; ± 20 %

Nominal case size: Ø 10 mm x 16 mm; Form TFA

Ordering Code: MAL214636471E3

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 125 °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 MAL2146.....		
								BULK PACKAGING		TAPED
								FORM CA	FORM CB	FORM TFA
16	470	10 x 12	620	78	0.16	0.120	0.750	55471E3	65471E3	35471E3
	680	10 x 16	1100	112	0.16	0.075	0.450	55681E3	65681E3	35681E3
	1000	10 x 20	1250	163	0.16	0.060	0.360	55102E3	65102E3	35102E3
	1500	12.5 x 20	1600	243	0.16	0.043	0.258	55152E3	65152E3	35152E3
	2200	12.5 x 25	2000	355	0.18	0.033	0.198	55222E3	65222E3	35222E3
	2700	16 x 20	1900	435	0.18	0.034	0.204	55272E3	65272E3	35272E3
	3300	18 x 20	2000	531	0.20	0.033	0.198	55332E3	65332E3	35332E3
	3900	16 x 25	2500	627	0.20	0.024	0.144	55392E3	65392E3	35392E3
	4700	18 x 25	2800	755	0.22	0.025	0.150	55472E3	65472E3	35472E3
	4700	16 x 31	3000	755	0.22	0.021	0.126	95475E3	95476E3	95473E3
	5600	16 x 35	3200	899	0.24	0.018	0.108	55562E3	65562E3	-
	6800	18 x 31	3100	1091	0.24	0.022	0.132	55682E3	65682E3	35682E3
25	330	10 x 12	620	85	0.14	0.120	0.750	56331E3	66331E3	36331E3
	470	10 x 16	1100	121	0.14	0.075	0.450	56471E3	66471E3	36471E3
	680	10 x 20	1250	173	0.14	0.060	0.360	56681E3	66681E3	36681E3
	1000	12.5 x 20	1600	253	0.14	0.043	0.258	56102E3	66102E3	36102E3
	1500	12.5 x 25	2000	378	0.14	0.033	0.198	56152E3	66152E3	36152E3
	1800	16 x 20	1900	453	0.14	0.034	0.204	56182E3	66182E3	36182E3
	2700	18 x 20	2000	678	0.16	0.033	0.198	56272E3	66272E3	36272E3
	2700	16 x 25	2500	678	0.16	0.024	0.144	96275E3	96276E3	96273E3
	3300	16 x 31	3000	828	0.18	0.021	0.126	56332E3	66332E3	36332E3
	3900	18 x 25	2800	978	0.18	0.025	0.150	56392E3	66392E3	36392E3
	4700	16 x 35	3200	1178	0.20	0.018	0.108	56472E3	66472E3	-
	4700	18 x 31	3100	1178	0.20	0.022	0.132	96475E3	96476E3	96473E3
	5600	18 x 35	3100	1403	0.22	0.019	0.114	56562E3	66562E3	-
35	220	10 x 12	620	80	0.12	0.120	0.750	50221E3	60221E3	30221E3
	330	10 x 16	1100	119	0.12	0.075	0.450	50331E3	60331E3	30331E3
	470	10 x 20	1250	168	0.12	0.060	0.360	50471E3	60471E3	30471E3
	680	12.5 x 20	1600	241	0.12	0.043	0.258	50681E3	60681E3	30681E3
	1000	12.5 x 25	2000	353	0.12	0.033	0.198	50102E3	60102E3	30102E3
	1200	16 x 20	1900	423	0.12	0.034	0.204	50122E3	60122E3	30122E3
	1500	18 x 20	2000	528	0.12	0.033	0.198	50152E3	60152E3	30152E3
	1800	16 x 25	2500	633	0.12	0.024	0.144	50182E3	60182E3	30182E3
	2200	18 x 25	2800	773	0.14	0.025	0.150	50222E3	60222E3	30222E3
	2200	16 x 31	3000	773	0.14	0.021	0.126	90225E3	90226E3	90223E3
	2700	16 x 35	3200	948	0.14	0.018	0.108	50272E3	60272E3	-
	2700	18 x 31	3100	948	0.14	0.022	0.132	90275E3	90276E3	90273E3
	3300	18 x 35	3100	1158	0.16	0.019	0.114	50332E3	60332E3	-

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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 125 °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 MAL2146.....		
								BULK PACKAGING		TAPED
								FORM CA	FORM CB	FORM TFA
50	100	10 x 12	420	53	0.10	0.190	1.330	51101E3	61101E3	31101E3
	220	10 x 16	900	113	0.10	0.120	0.720	51221E3	61221E3	31221E3
	330	10 x 20	1000	168	0.10	0.090	0.540	51331E3	61331E3	31331E3
	470	12.5 x 20	1250	238	0.10	0.065	0.390	51471E3	61471E3	31471E3
	680	12.5 x 25	1700	343	0.10	0.050	0.300	51681E3	61681E3	31681E3
	820	16 x 20	1650	413	0.10	0.047	0.282	51821E3	61821E3	31821E3
	1000	18 x 20	1800	503	0.10	0.039	0.234	51102E3	61102E3	31102E3
	1000	16 x 25	2100	503	0.10	0.031	0.186	91105E3	91106E3	91103E3
	1200	18 x 25	2400	603	0.10	0.030	0.180	51122E3	61122E3	31122E3
	1200	16 x 31	2550	603	0.10	0.027	0.162	91125E3	91126E3	91123E3
	1500	16 x 35	2800	753	0.10	0.022	0.132	51152E3	61152E3	-
	1800	18 x 31	2700	903	0.10	0.026	0.156	51182E3	61182E3	31182E3
	2200	18 x 35	3000	1103	0.12	0.022	0.132	51222E3	61222E3	-
63	68	10 x 12	400	46	0.10	0.360	2.160	58689E3	68689E3	38689E3
	100	10 x 16	600	66	0.10	0.220	1.320	58101E3	68101E3	38101E3
	150	10 x 20	750	98	0.10	0.150	0.900	58151E3	68151E3	38151E3
	220	12.5 x 20	1000	142	0.10	0.098	0.950	58221E3	68221E3	38221E3
	330	12.5 x 25	1300	211	0.10	0.076	0.456	58331E3	68331E3	38331E3
	390	16 x 20	1250	249	0.10	0.075	0.450	58391E3	68391E3	38391E3
	470	18 x 20	1500	299	0.10	0.055	0.330	58471E3	68471E3	38471E3
	560	16 x 25	1800	356	0.10	0.048	0.288	58561E3	68561E3	38561E3
	680	18 x 25	2100	431	0.10	0.041	0.246	58681E3	68681E3	38681E3
	680	16 x 31	2200	431	0.10	0.036	0.216	98685E3	98686E3	98683E3
	820	16 x 35	2500	520	0.10	0.029	0.174	58821E3	68821E3	-
	1000	18 x 31	2400	633	0.10	0.032	0.192	58102E3	68102E3	38102E3
	1200	18 x 35	2600	759	0.10	0.029	0.174	58122E3	68122E3	-

ADDITIONAL ELECTRICAL DATA

PARAMETER	CONDITIONS	VALUE
Voltage		
Surge voltage		$U_s \leq 1.15 \times U_R$
Reverse voltage		$U_{rev} \leq 0.5$ V
Current		
Leakage current	After 2 min at U_R	$I_{L2} \leq 0.01\ C_R \times U_R + 3$ µA
Inductance		
Equivalent series inductance (ESL)	Case Ø D = 10 mm	Typ. 16 nH
	Case Ø D ≥ 12.5 mm	Typ. 18 nH
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)

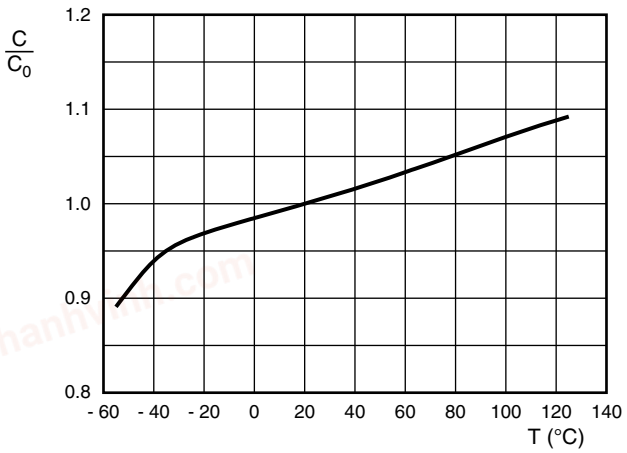


Fig. 5 - Typical multiplier of capacitance at 100 Hz as a function of temperature (C_0 = C at 20 °C)

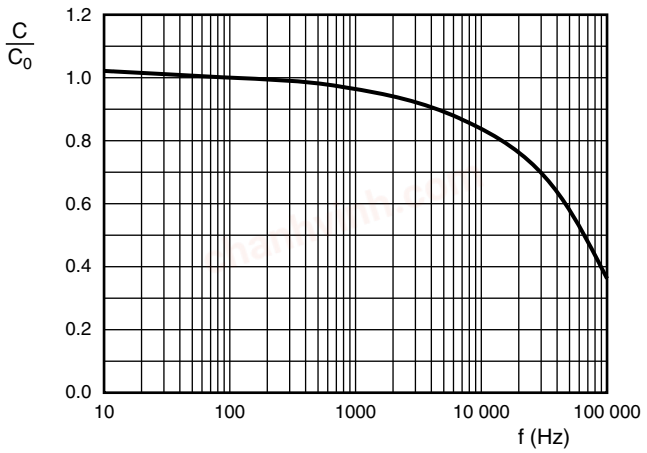


Fig. 6 - Typical multiplier of capacitance as a function of frequency at 20 °C (C_0 = C at 100 Hz)

EQUIVALENT SERIES RESISTANCE (ESR)

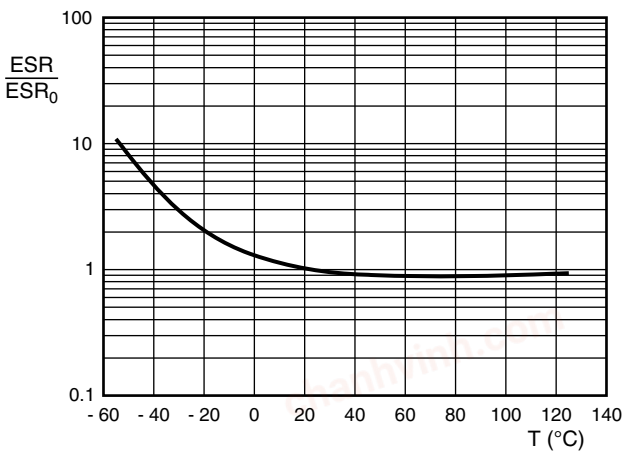


Fig. 7 - Typical multiplier of ESR at 100 Hz as a function of temperature (ESR_0 = ESR at 20 °C)

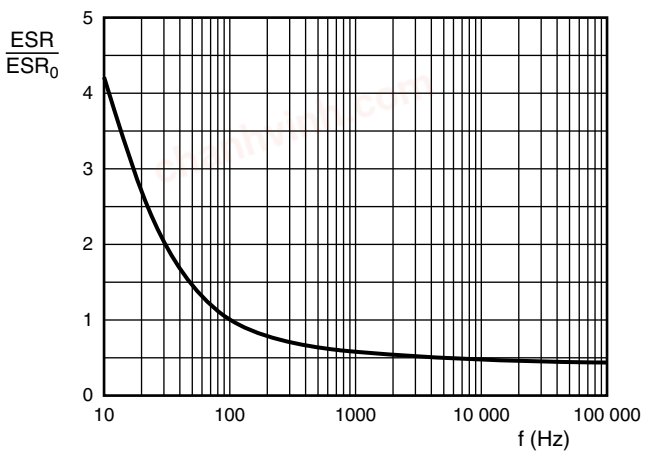


Fig. 8 - Typical multiplier of ESR at 20 °C as a function of frequency (ESR_0 = ESR at 100 Hz)

IMPEDANCE (Z)

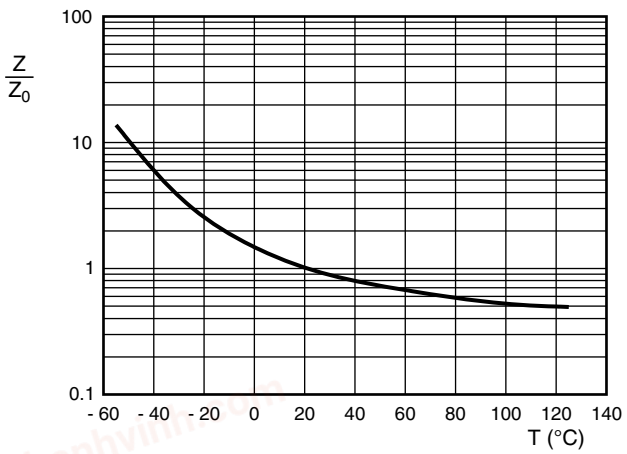


Fig. 9 - Typical multiplier of impedance at 100 kHz as a function of temperature (Z_0 = Z at 20 °C)

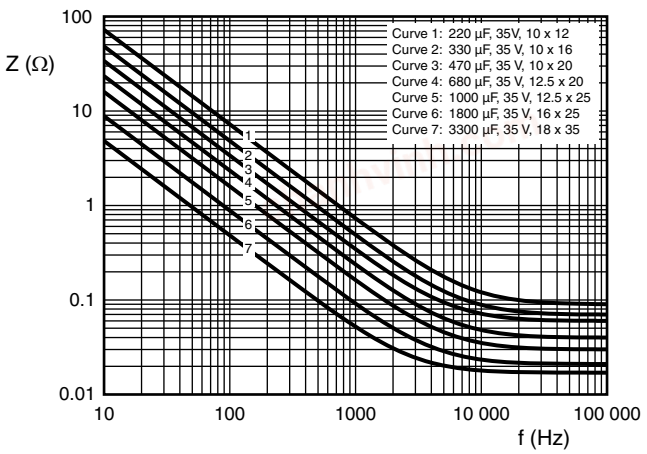


Fig. 10 - Typical impedance Z at 20 °C as a function of frequency

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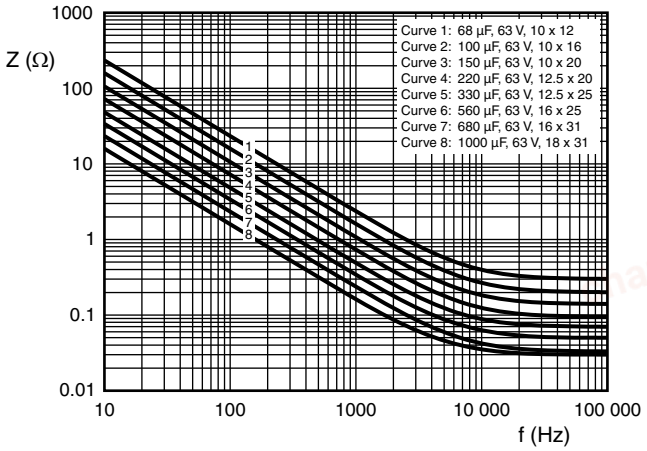


Fig. 11 - Typical impedance Z at 20 °C as a function of frequency

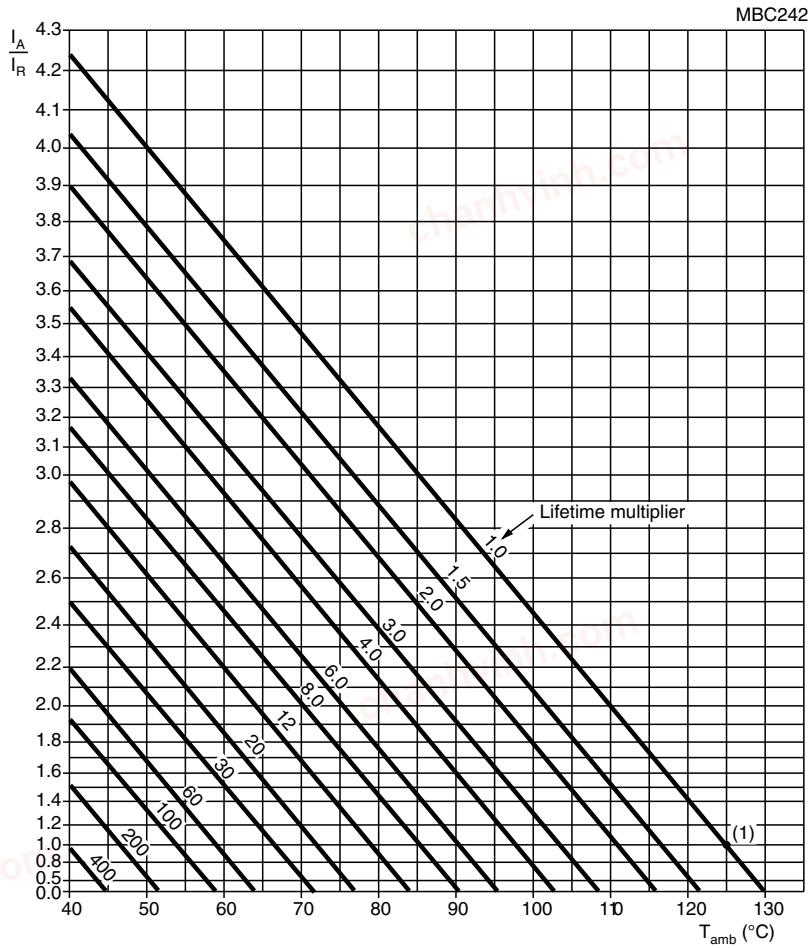
Table 3

ENDURANCE TEST DURATION AND USEFUL LIFE AS A FUNCTION OF CASE SIZE			
NOMINAL CASE SIZE Ø D x L (mm)	**CASE CODE**	**ENDURANCE AT 125 °C (h)**	**USEFUL LIFE AT 125 °C (h)**
10 x 12	14	2000	2500
10 x 16	15	2000	2500
10 x 20	16	2000	3000
12.5 x 20	17	2000	3000
12.5 x 25	18	3000	5000
16 x 20	19a	3000	4000
16 x 25	19	3000	5000
16 x 31	20	4000	6000
16 x 35	21	5000	6000
18 x 20	1820	3000	4000
18 x 25	1825	3000	5000
18 x 31	1831	4000	6000
18 x 35	22	5000	6000

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RIPPLE CURRENT AND USEFUL LIFE



I_A = Actual ripple current at 100 kHz
I_R = Rated ripple current at 100 kHz, 125 °C

(1) Useful life at 125 °C and I_R applied; see Table 4

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

Table 4

MULTIPLIER OF RIPPLE CURRENT (I_R) AS A FUNCTION OF FREQUENCY			
FREQUENCY (Hz)	I_R MULTIPLIER		
	U_R = 16 V to 25 V	U_R = 35 V	U_R = 50 V to 63 V
50	0.60	0.50	0.35
100	0.70	0.65	0.50
300	0.85	0.80	0.65
1000	0.90	0.85	0.80
3000	0.95	0.90	0.90
10 000	1.00	0.95	0.90
100 000	1.00	1.00	1.00

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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} = 125 °C; U_R applied; for test duration see Table 3	ΔC/C: ± 15 % tan δ ≤ 1.3 x spec. limit Z ≤ 2 x spec. limit I_{L2} ≤ spec. limit
Useful life	CECC 30301 subclause 1.8.1	T_{amb} = 125 °C; U_R and I_R applied; for test duration see Table 3	ΔC/C: ± 30 % tan δ ≤ 3 x spec. limit Z ≤ 3 x spec. limit I_{L2} ≤ spec. limit no short or open circuit total failure percentage: ≤ 1 %
Shelf life	IEC 60384-4/ EN130300 subclause 4.17	T_{amb} = 125 °C; no voltage applied; 1000 h after test: U_R to be applied for 30 min, 24 h o 48 h before measurement	ΔC/C: ± 15 % tan δ ≤ 1.3 x spec. limit Z ≤ 3 x spec. limit I_{L2} ≤ spec. limit

For technical questions, contact: aluminumcaps1@vishay.com
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