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Aluminum Electrolytic Capacitors
SMD (Chip), High Temperature, Low Impedance



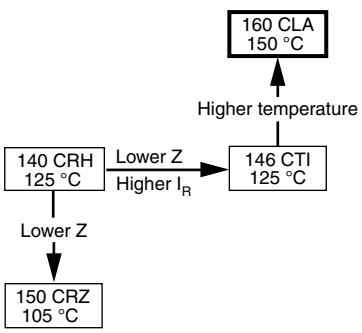


Fig. 1

QUICK REFERENCE DATA	
DESCRIPTION	**VALUE**
Nominal case sizes (L x W x H in mm)	12.5 x 12.5 x 13 to 18 x 18 x 21
Rated capacitance range, C_R	47 µF to 3300 µF
Tolerance on C_R	± 20 %
Rated voltage range, U_R	16 V to 80 V
Category temperature range	-55 °C to +150 °C
Endurance test at 150 °C	1000 h to 1500 h
Useful life at 150 °C	1000 h to 2000 h
Useful life at 40 °C 1.8 x I_R applied	300 000 h to 400 000 h
Shelf life at 0 V, 150 °C	1000 h
Based on sectional specification	IEC 60384-18 / CECC 32300
Climatic category IEC 60068	55 / 150 / 56

FEATURES

AUTOMOTIVE GRADE

Pb-free

RoHS COMPLIANT

- Useful life: up to 2000 h at 150 °C
- High reliability
- Low ESR
- Polarized aluminum electrolytic capacitors, non-solid electrolyte, self healing
- SMD-version with base plate, lead (Pb)-free reflow solderable
- Charge and discharge proof, no peak current limitation
- High temperature reflow soldering according to JEDEC® J-STD-020
- High temperature proof
- Vibration proof, 4-pin version and 6-pin version
- AEC-Q200 qualified
- Material categorization: for definitions of compliance please see www.vishay.com/doc?99912

APPLICATIONS

- SMD technology, for high temperature reflow soldering
- High temperature environment, high peak load
- Automotive, industrial
- Smoothing, filtering, buffering

MARKING

- Rated capacitance (in µF)
- Rated voltage (in V)
- Date code, in accordance with IEC 60062
- Black mark or “-” sign indicating the cathode (the anode is identified by bevelled edges)
- Code indicating group number (A)

PACKAGING

Supplied in blister tape on reel

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SELECTION CHART FOR C_R, U_R, AND RELEVANT NOMINAL CASE SIZES (L x W x H in mm)						
C_R (µF)	U_R (V)					
	16	25	35	50	63	80
47	→	→	→	→	12.5 x 12.5 x 13	-
68	→	→	→	→	12.5 x 12.5 x 13	12.5 x 12.5 x 13
100	→	→	→	12.5 x 12.5 x 13	12.5 x 12.5 x 13	12.5 x 12.5 x 16
150	→	→	→	12.5 x 12.5 x 13	12.5 x 12.5 x 16	16 x 16 x 16
220	→	→	12.5 x 12.5 x 13	12.5 x 12.5 x 16	16 x 16 x 16	18 x 18 x 16
330	→	12.5 x 12.5 x 13	12.5 x 12.5 x 13	16 x 16 x 16	18 x 18 x 16	18 x 18 x 21
470	12.5 x 12.5 x 13	12.5 x 12.5 x 13	16 x 16 x 16	18 x 18 x 16	16 x 16 x 21	-
680	12.5 x 12.5 x 13	16 x 16 x 16	18 x 18 x 16	16 x 16 x 21	18 x 18 x 21	-
1000	16 x 16 x 16	18 x 18 x 16	16 x 16 x 21	18 x 18 x 21	-	-
1500	18 x 18 x 16	16 x 16 x 21	18 x 18 x 21	-	-	-
2200	16 x 16 x 21	18 x 18 x 21	-	-	-	-
2700	18 x 18 x 21	-	-	-	-	-
3300	18 x 18 x 21	-	-	-	-	-

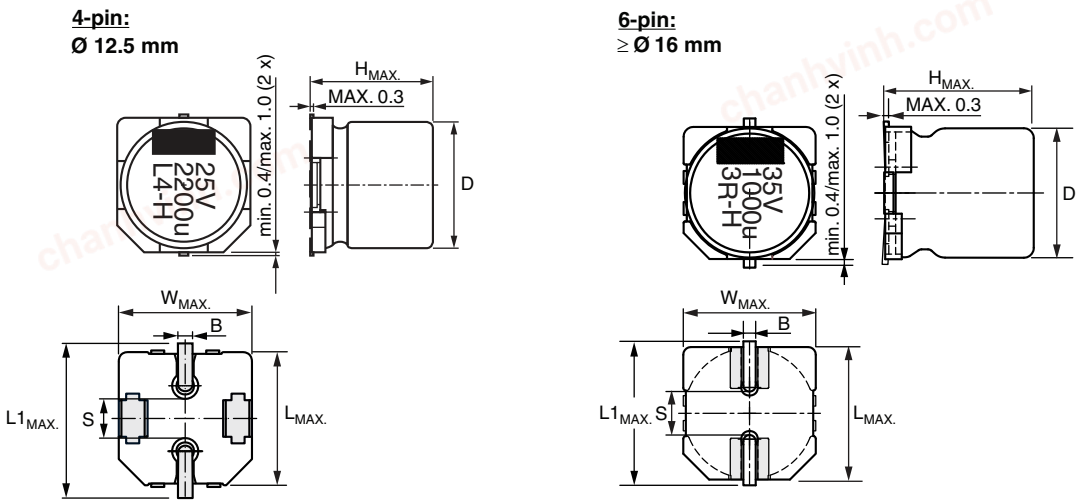


Fig. 2 - Dimensional outline

Table 1

DIMENSIONS in millimeters AND MASS									
NOMINAL CASE SIZE L x W x H	CASE CODE	$L_{MAX.}$	$W_{MAX.}$	$H_{MAX.}$	Ø D	$B_{MAX.}$	S	$L1_{MAX.}$	MASS (g)
12.5 x 12.5 x 13	1213	12.9	12.9	14.0	12.5	1.3	3.6	14.9	≈ 2.9
12.5 x 12.5 x 16	1216	12.9	12.9	16.5	12.5	1.3	3.6	14.9	≈ 3.2
16 x 16 x 16	1616	16.6	16.6	17.5	16.0	1.3	6.5	18.6	≈ 5.8
16 x 16 x 21	1621	16.6	16.6	22.0	16.0	1.3	6.5	18.6	≈ 7.1
18 x 18 x 16	1816	19.0	19.0	17.5	18.0	1.3	6.5	21.0	≈ 8.0
18 x 18 x 21	1821	19.0	19.0	22.0	18.0	1.3	6.5	21.0	≈ 9.3

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Table 2

TAPE AND REEL DIMENSIONS in millimeters, PACKAGING QUANTITIES						
NOMINAL CASE SIZE L x W x H	CASE CODE	PITCH P_1	TAPE WIDTH W	TAPE THICKNESS T_2	REEL DIAMETER	PACKAGING QUANTITY PER REEL
12.5 x 12.5 x 13	1213	20	24	16.2	380	250
12.5 x 12.5 x 16	1216	24	32	18.5	380	200
16 x 16 x 16	1616	28	44	18.9	380	150
16 x 16 x 21	1621	28	44	23.4	380	100
18 x 18 x 16	1816	32	44	18.9	380	125
18 x 18 x 21	1821	32	44	23.4	380	100

Note

- Detailed tape dimensions see section “PACKAGING”

MOUNTING

The capacitors are designed for automatic placement on to printed-circuit boards.

Optimum dimensions of soldering pads depend amongst others on soldering method, mounting accuracy, print layout and / or adjacent components.

For recommended soldering pad dimensions, refer to Fig. 3 and Table 3.

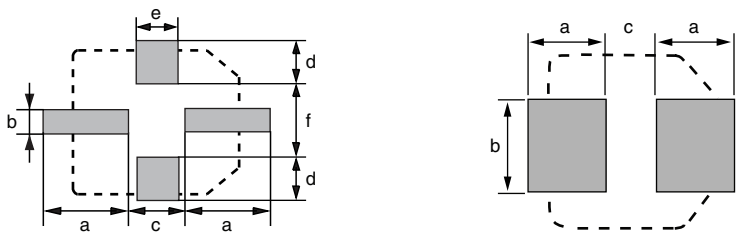
SOLDERING

Soldering conditions are defined by the curve, temperature versus time, where the temperature is that measured on the component during processing.

For maximum conditions refer to Fig. 4.

Any temperature versus time curve which does not exceed the specified maximum curves may be applied.

As a general principle, temperature and duration shall be the **minimum** necessary required to ensure good soldering connections. However, the specified maximum curves should never be exceeded.



Case size Ø D = 12.5 mm Case size Ø D ≥ 16 mm

Fig. 3 - Recommended soldering pad dimensions

Table 3

RECOMMENDED SOLDERING PAD DIMENSIONS in millimeters						
CASE CODE	a	b	c	d	e	f
1213	6.3	2.5	4.0	4.2	5.0	5.6
1216	6.3	2.5	4.0	4.2	5.0	5.6
1616	7.8	9.6	4.7	-	-	-
1621	7.8	9.6	4.7	-	-	-
1816	8.8	9.6	4.7	-	-	-
1821	8.8	9.6	4.7	-	-	-

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ADVANCED SOLDERING PROFILE FOR LEAD (Pb)-FREE REFLOW PROCESS ACCORDING TO JEDEC J-STD-020

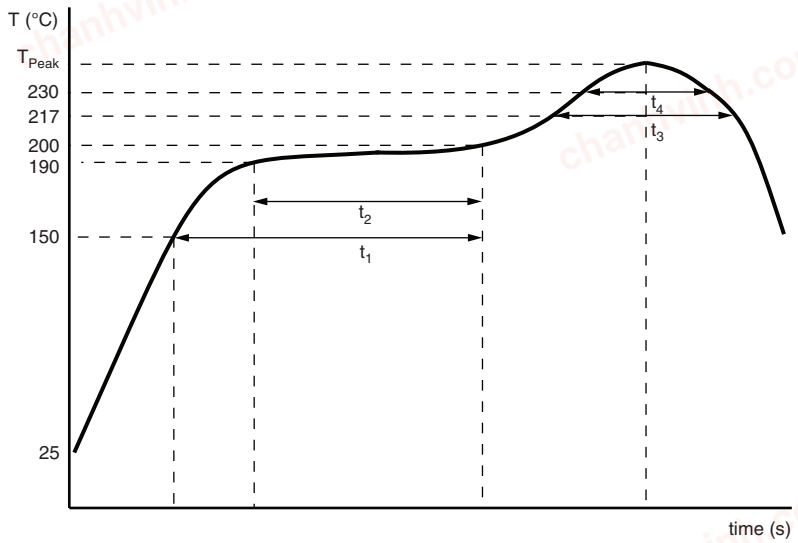


Fig. 4 - Maximum temperature load during reflow soldering

Table 4

REFLOW SOLDERING CONDITIONS for MAL216099xxxE3		
PROFILE FEATURES	**CASE CODE 1213 TO 1216**	**CASE CODE 1616 TO 1821**
Max. time from 25 °C to T_{Peak}	300 s	300 s
Max. ramp-up rate to 150 °C	3 K/s	3 K/s
Max. time from 150 °C to 200 °C (t_1)	150 s	150 s
Max. time from 190 °C to 200 °C (t_2)	110 s	110 s
Ramp up rate from 200 °C to T_{Peak}	0.5 K/s to 3 K/s	0.5 K/s to 3 K/s
Max. time above $T_{Liquidus}$ (217 °C) (t_3)	90 s	90 s
Max. time above 230 °C (t_4)	65 s	60 s
Peak temperature T_{Peak}	250 °C	245 °C
Max. time above T_{Peak} minus 5 °C	30 s	30 s
Ramp-down rate from $T_{Liquidus}$	3 K/s to 6 K/s	3 K/s to 6 K/s

Notes

- Temperature measuring point on top of the case and on terminals.
- Max. 2 runs with pause of min. 30 min in between.

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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, 150 °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 5 apply at T_{amb} = 20 °C, P = 86 kPa to 106 kPa, RH = 45 % to 75 %

ORDERING EXAMPLE

Electrolytic capacitor 160 CLA series

220 µF / 50 V; ± 20 %

Nominal case size: 12.5 mm x 12.5 mm x 16 mm; taped on reel

Ordering code: MAL216099103E3

Table 5

ELECTRICAL DATA AND ORDERING INFORMATION									
U_R (V)	C_R (µF)	NOMINAL CASE SIZE L x W x H (mm)	I_R 150 °C 100 kHz (mA)	I_{L2} 2 min (µA)	tan δ 100 Hz	Z 100 kHz 20 °C (Ω)	Z 100 kHz -40 °C (Ω)	LIFE CODE [1]	ORDERING CODE MAL2160...
16	470	12.5 x 12.5 x 13	750	75	0.16	0.080	0.70	L2	99501E3
	680	12.5 x 12.5 x 13	800	109	0.16	0.080	0.70	L2	99502E3
	1000	16 x 16 x 16	850	160	0.16	0.050	0.45	L3	99503E3
	1500	18 x 18 x 16	900	240	0.16	0.050	0.45	L3	99504E3
	2200	16 x 16 x 21	1100	352	0.18	0.035	0.32	L5	99505E3
	2700	18 x 18 x 21	1350	432	0.18	0.035	0.32	L5	99506E3
	3300	18 x 18 x 21	1400	528	0.20	0.035	0.32	L5	99507E3
25	330	12.5 x 12.5 x 13	650	83	0.14	0.080	0.70	L2	99601E3
	470	12.5 x 12.5 x 13	700	118	0.14	0.080	0.70	L2	99602E3
	680	16 x 16 x 16	800	170	0.14	0.050	0.45	L3	99603E3
	1000	18 x 18 x 16	830	250	0.14	0.050	0.45	L3	99604E3
	1500	16 x 16 x 21	1050	375	0.14	0.035	0.32	L5	99605E3
	2200	18 x 18 x 21	1350	550	0.16	0.035	0.32	L5	99606E3
35	220	12.5 x 12.5 x 13	550	77	0.12	0.080	0.70	L2	99001E3
	330	12.5 x 12.5 x 13	650	116	0.12	0.080	0.70	L2	99002E3
	470	16 x 16 x 16	800	165	0.12	0.050	0.45	L3	99003E3
	680	18 x 18 x 16	830	238	0.12	0.050	0.45	L3	99004E3
	1000	16 x 16 x 21	1000	350	0.12	0.035	0.32	L5	99005E3
	1500	18 x 18 x 21	1350	525	0.12	0.035	0.32	L5	99006E3
50	100	12.5 x 12.5 x 13	420	50	0.10	0.130	1.20	L2	99101E3
	150	12.5 x 12.5 x 13	450	75	0.10	0.120	1.10	L2	99102E3
	220	12.5 x 12.5 x 16	550	110	0.10	0.085	0.76	L2	99103E3
	330	16 x 16 x 16	700	165	0.10	0.072	0.65	L3	99104E3
	470	18 x 18 x 16	720	235	0.10	0.070	0.63	L3	99105E3
	680	16 x 16 x 21	800	340	0.10	0.052	0.47	L5	99106E3
	1000	18 x 18 x 21	1100	500	0.10	0.049	0.44	L5	99107E3
63	47	12.5 x 12.5 x 13	300	30	0.10	0.240	2.16	L1	99801E3
	68	12.5 x 12.5 x 13	320	43	0.10	0.240	2.16	L1	99802E3
	100	12.5 x 12.5 x 13	320	63	0.10	0.240	2.16	L1	99803E3
	150	12.5 x 12.5 x 16	400	95	0.10	0.160	1.44	L2	99804E3
	220	16 x 16 x 16	500	139	0.10	0.100	0.90	L3	99805E3
	330	18 x 18 x 16	520	208	0.10	0.095	0.86	L3	99806E3
	470	16 x 16 x 21	600	296	0.10	0.075	0.68	L5	99807E3
	680	18 x 18 x 21	700	428	0.10	0.072	0.65	L5	99808E3
80	68	12.5 x 12.5 x 13	270	54	0.12	0.780	6.24	L1	99701E3
	100	12.5 x 12.5 x 16	320	80	0.12	0.650	5.20	L1	99702E3
	150	16 x 16 x 16	430	120	0.12	0.390	3.12	L3	99703E3
	220	18 x 18 x 16	430	176	0.12	0.390	3.12	L3	99704E3
	330	18 x 18 x 21	520	264	0.12	0.300	2.40	L4	99705E3

Note

[1] Determines the applicable row in the table “Endurance Test Duration and Useful Life”

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Table 6

ADDITIONAL ELECTRICAL DATA		
PARAMETER	**CONDITIONS**	**VALUE**
Voltage		
Surge voltage for short periods	IEC 60384-18, subclause 4.14	$U_s \leq 1.15 \times U_R$
Reverse voltage for short periods	IEC 60384-18, subclause 4.16; $T_A \leq 150$ °C	$U_{rev} \leq 1$ V
Current		
Leakage current	After 2 min at U_R	$I_{L2} \leq 0.01 \times C_R \times U_R$
Inductance		
Equivalent series inductance (ESL)	Ø D ≥ 12.5 mm	Typ. 11 nH
Resistance		
Equivalent series resistance (ESR) at 100 Hz	Calculated from tan $\delta_{max.}$ and C_R (see Table 5)	ESR = tan $\delta/2\pi f C_R$

CAPACITANCE (C)

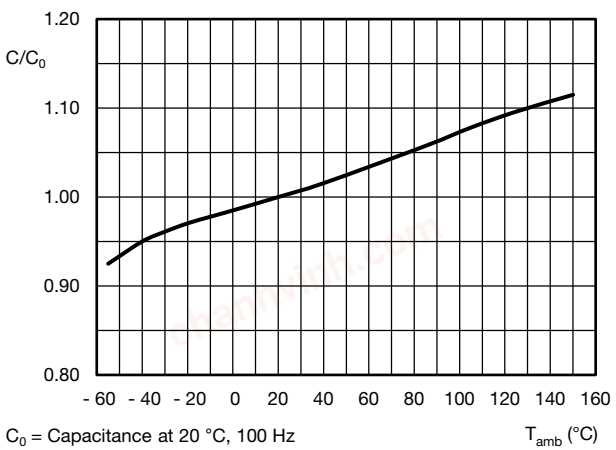


Fig. 5 - Typical multiplier of capacitance as a function of ambient temperature

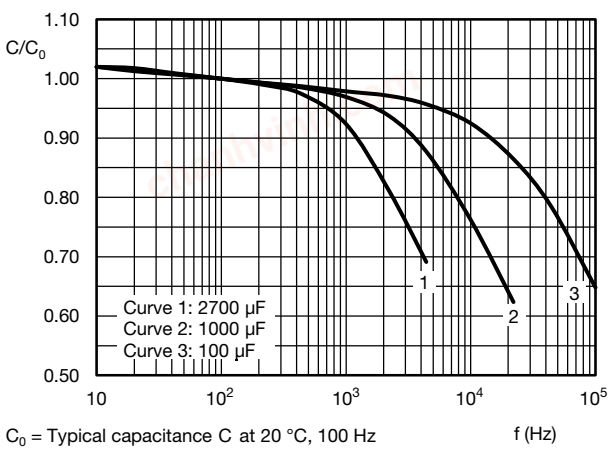


Fig. 6 - Typical multiplier of capacitance as a function of frequency

DISSIPATION FACTOR (tan δ)

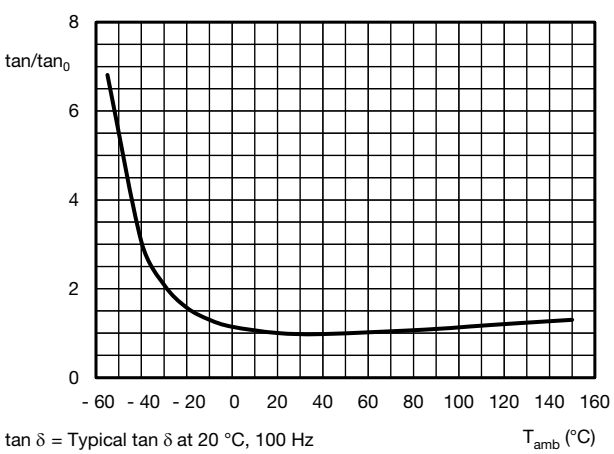


Fig. 7 - Typical multiplier of dissipation factor (tan δ) as a function of ambient temperature

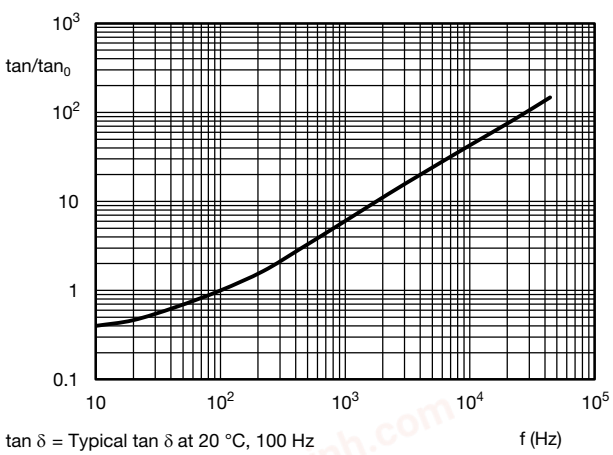


Fig. 8 - Typical multiplier of dissipation factor (tan δ) as a function of frequency

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EQUIVALENT SERIES RESISTANCE (ESR)

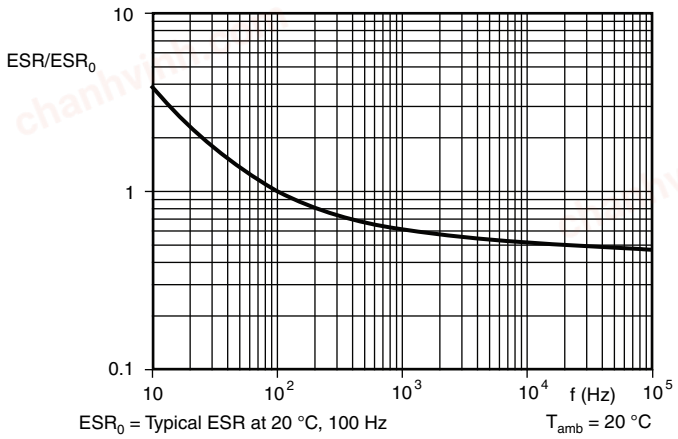


Fig. 9 - Typical multiplier of ESR as a function of frequency

IMPEDANCE (Z)

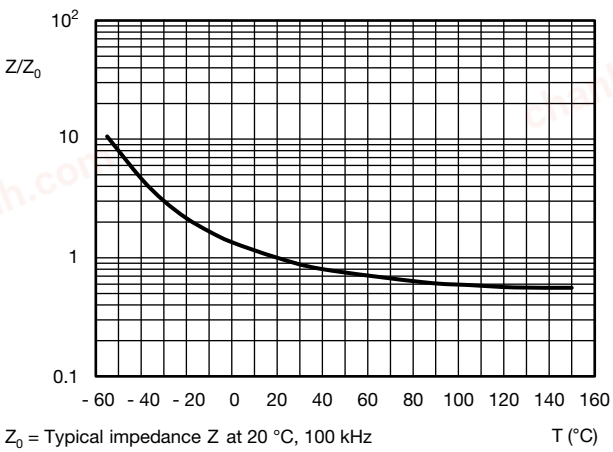


Fig. 10 - Typical multiplier of impedance as a function of temperature

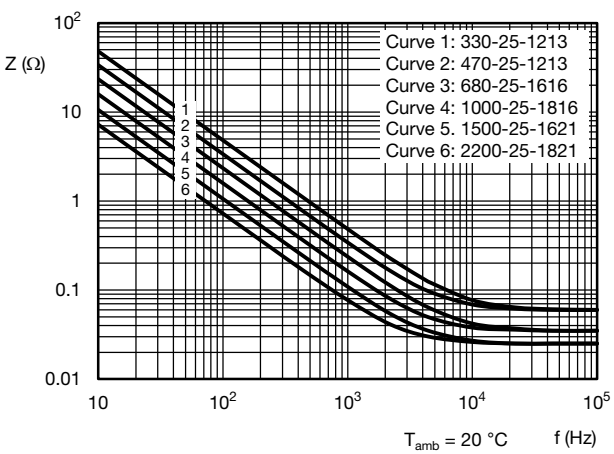


Fig. 11 - Typical impedance as a function of frequency

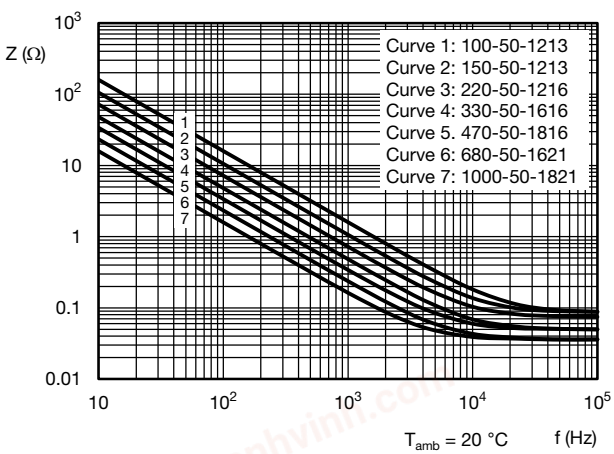


Fig. 12 - Typical impedance as a function of frequency

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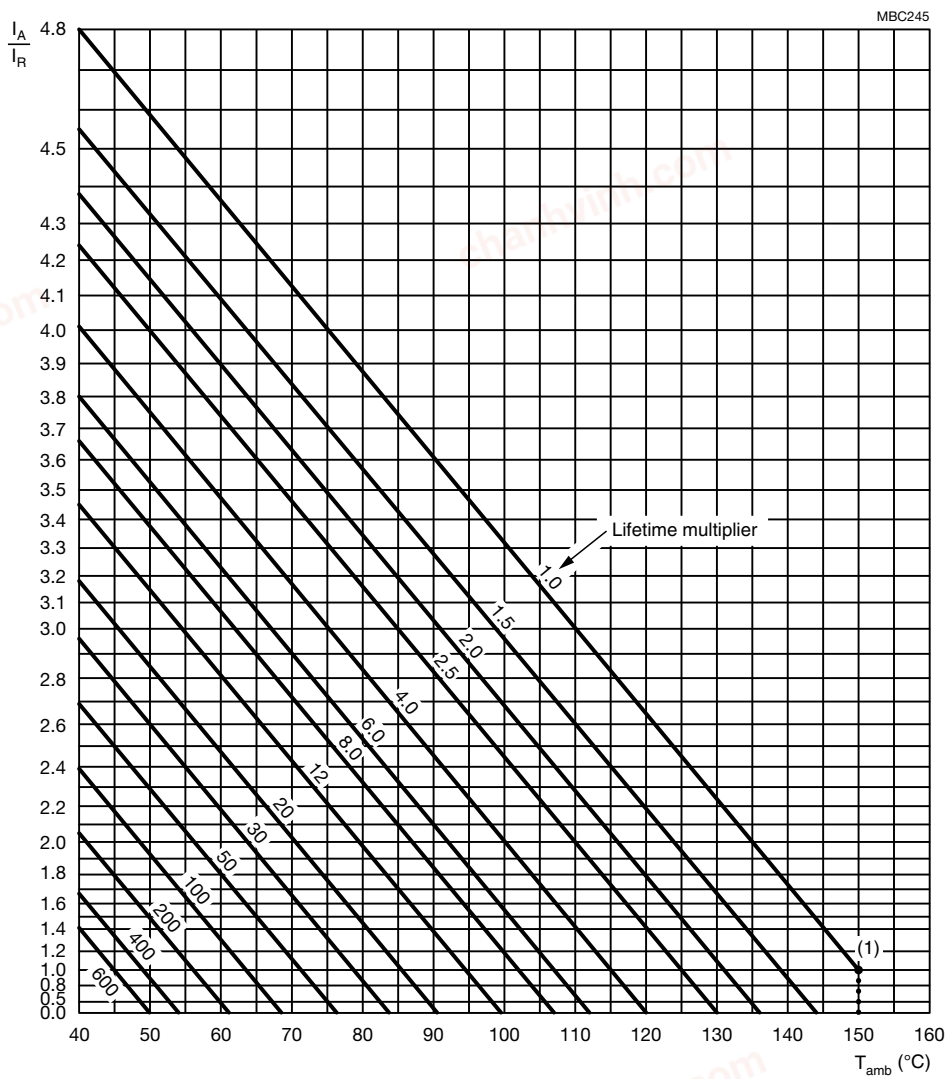
RIPPLE CURRENT AND USEFUL LIFE

Table 7

ENDURANCE TEST DURATION AND USEFUL LIFE			
LIFE CODE	ENDURANCE AT 150 °C (h)	USEFUL LIFE AT 150 °C (h)	USEFUL LIFE AT 40 °C 1.8 x I_R APPLIED (h)
L1	1000	1000	300 000
L2	1000	1250	325 000
L3	1000	1500	350 000
L4	1500	1500	350 000
L5	1500	2000	400 000

Note

- Multiplier of useful life code: MBC245



I_A = Actual ripple current at 100 kHz
I_R = Rated ripple current at 100 kHz, 150 °C
(1) Useful life at 150 °C and I_R applied; see Table 7

Fig. 13 - Multiplier of useful life as a function of ambient temperature and ripple current load

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Table 8

MULTIPLIER OF RIPPLE CURRENT (I_R) AS A FUNCTION OF FREQUENCY							
FREQUENCY (Hz)							
50	100	300	1000	3000	10 000	30 000	100 000
I_R MULTIPLIER							
0.40	0.60	0.75	0.80	0.90	0.95	0.97	1.00

Table 9

TEST PROCEDURES AND REQUIREMENTS			
TEST		PROCEDURE (quick reference)	REQUIREMENTS
NAME OF TEST	REFERENCE		
Mounting	IEC 60384-18, subclause 4.3	Shall be performed prior to tests mentioned below; reflow soldering; for maximum temperature load refer to chapter “Mounting”	ΔC/C: ± 5 % tan δ ≤ spec. limit I_{L2} ≤ spec. limit
Endurance	IEC 60384-18 / CECC 32300, subclause 4.15	T_{amb} = 150 °C; U_R applied; for test duration see Table 7	ΔC/C: ± 20 % tan δ ≤ 2 x spec. limit I_{L2} ≤ spec. limit
Useful life	CECC 30301, subclause 1.8.1	T_{amb} = 150 °C; U_R and I_R applied; for test duration see Table 7	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 60384-18 / CECC 32300, subclause 4.17	T_{amb} = 150 °C; no voltage applied; 1000 h After test: U_R to be applied for 30 min, 24 h to 48 h before measurement	For requirements see “Endurance test” above
Reverse voltage	IEC 60384-18 / CECC 32300, subclause 4.16	T_{amb} = 150 °C: 125 h at U = -0.5 V, followed by 125 h at U_R	ΔC/C: ± 15 % tan δ ≤ 1.5 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.

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