Aluminum Electrolytic Capacitors
SMD (Chip), High Voltage

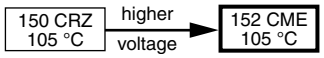


Fig. 1

FEATURES

- Extended useful life: up to 6000 h at 105 °C
- 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
- Advanced temperature reflow soldering according to JEDEC® J-STD-020
- Vibration proof, 4-pin version and 6-pin version
- AEC-Q200 qualified
- High reliability
- Material categorization: for definitions of compliance please see www.vishay.com/doc?99912

AUTOMOTIVE GRADE

Pb-free

RoHS COMPLIANT

APPLICATIONS

- SMD technology, for high temperature reflow soldering
- Industrial and professional applications
- Automotive, general industrial, telecom
- 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 beveled edges)
- Code indicating group number (E)

PACKAGING

Supplied in blister tape on reel

QUICK REFERENCE DATA	
DESCRIPTION	**VALUE**
Nominal case sizes (L x W x H in mm)	10 x 10 x 10 to 18 x 18 x 21
Rated capacitance range, C_R	2.2 µF to 33 µF
Tolerance on C_R	± 20 %
Rated voltage range, U_R	400 V to 450 V
Category temperature range	-40 °C to +105 °C
Endurance test at 105 °C	1000 h to 5000 h
Useful life at 105 °C	1500 h to 6000 h
Useful life at 40 °C 1.8 x I_R applied	75 000 h to 300 000 h
Shelf life at 0 V, 105 °C	1000 h
Based on sectional specification	IEC 60384-18 / CECC 32300
Climatic category IEC 60068	40 / 105 / 56

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)	
	400	**450**
2.2	10 x 10 x 10	10 x 10 x 10
3.9	10 x 10 x 10	-
4.7	→	12.5 x 12.5 x 13
5.6	→	12.5 x 12.5 x 16
6.8	12.5 x 12.5 x 13	-
10	12.5 x 12.5 x 16	16 x 16 x 16
15	→	16 x 16 x 21
18	16 x 16 x 16	-
22	16 x 16 x 21 18 x 18 x 16	18 x 18 x 16
33	18 x 18 x 21	18 x 18 x 21

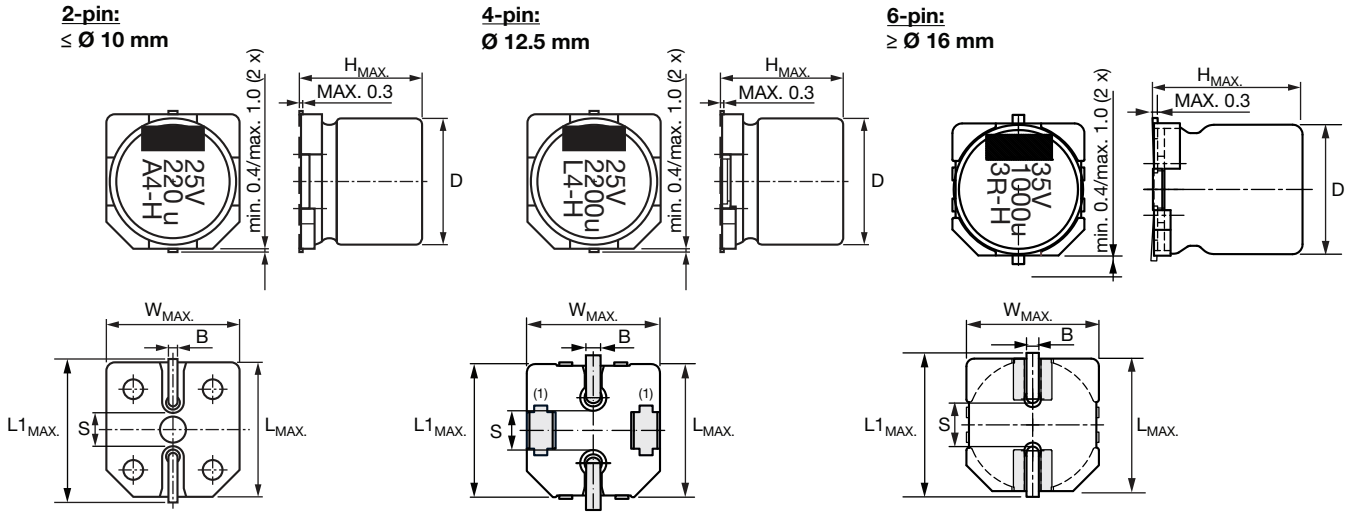


Fig. 2 - Dimensional outline

Note

(1) Additional dummy pins for mechanical stability, no electrical connection to pins or can

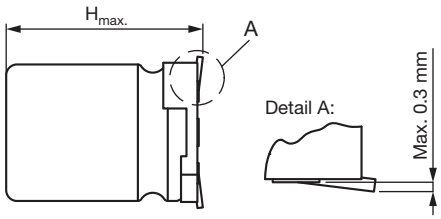


Fig. 3 - Coplanarity of pins

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)**
10 x 10 x 10	1010	10.5	10.5	10.5	10.0	1.0	3.5	12.1	≈ 1.3
12.5 x 12.5 x 13	1213	12.9	12.9	14.0	12.5	1.3	3.6	14.9	≈ 2.6
12.5 x 12.5 x 16	1216	12.9	12.9	16.5	12.5	1.3	3.6	14.9	≈ 2.8
16 x 16 x 16	1616	16.6	16.6	17.5	16.0	1.3	6.5	18.6	≈ 5.5
16 x 16 x 21	1621	16.6	16.6	22.0	16.0	1.3	6.5	18.6	≈ 6.0
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	≈ 8.3

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
10 x 10 x 10	1010	16	24	11.6	380	500
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. 4 and Table 3.

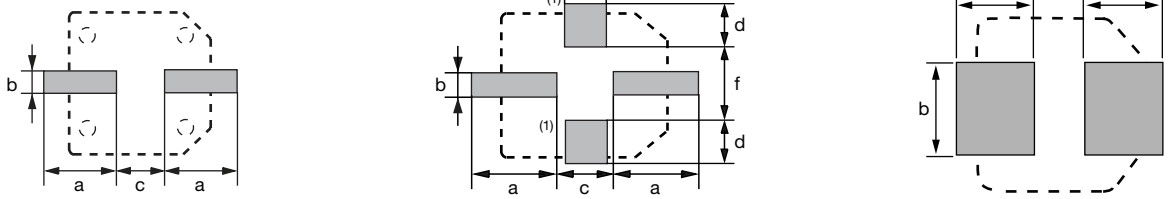
SOLDERING

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. 5.

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 ≤ 10 mm | Case size Ø D = 12.5 mm | Case size Ø D ≥ 16 mm

Fig. 4 - Recommended soldering pad dimensions

Note

(1) Additional solder pads, can be connected to GND or open

Table 3

RECOMMENDED SOLDERING PAD DIMENSIONS in millimeters						
CASE CODE	a	b	c	d	e	f
1010	4.4	2.5	4.0	-	-	-
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	-	-	-

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

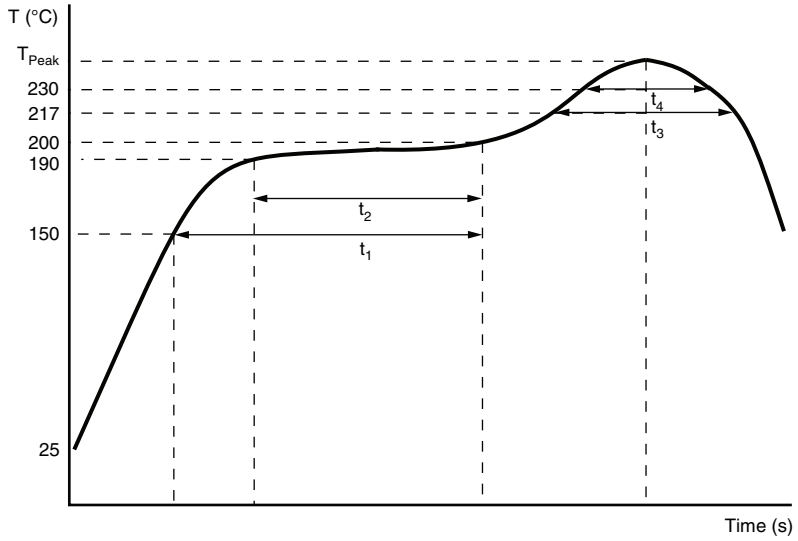


Fig. 5 - Maximum temperature load during reflow soldering

Table 4

REFLOW SOLDERING CONDITIONS for MAL215299xxxE3			
PROFILE FEATURES	**CASE CODE 1010**	**CASE CODE 1213 TO 1216**	**CASE CODE 1616 TO 1821**
Max. time from 25 °C to T_{Peak}	300 s	300 s	300 s
Max. ramp-up rate to 150 °C	3 K/s	3 K/s	3 K/s
Max. time from 150 °C to 200 °C (t_1)	150 s	150 s	150 s
Max. time from 190 °C to 200 °C (t_2)	110 s	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	0.5 K/s to 3 K/s
Max. time above $T_{Liquidus}$ (217 °C) (t_3)	90 s	90 s	90 s
Max. time above 230 °C (t_4)	70 s	65 s	60 s
Peak temperature T_{Peak}	260 °C	250 °C	245 °C
Max. time above T_{Peak} minus 5 °C	40 s	30 s	30 s
Ramp-down rate from $T_{Liquidus}$	3 K/s to 6 K/s	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

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

ORDERING EXAMPLE

Electrolytic capacitor 152 CME series

33 µF / 450 V; ± 20 %

Nominal case size: 18 mm x 18 mm x 21 mm; blister tape on reel

Ordering code: MAL215299706E3

Table 5

ELECTRICAL DATA AND ORDERING INFORMATION								
U_R (V)	C_R (µF)	NOMINAL CASE SIZE L x W x H (mm)	I_R 105 °C 100 Hz (mA)	I_{L1} 1 min (µA)	tan δ 100 Hz	Z 10 kHz 20 °C (Ω)	LIFE CODE (1)	ORDERING CODE MAL2152.....
400	2.2	10 x 10 x 10	30	97	0.15	13.0	L1	99601E3
	3.9	10 x 10 x 10	50	117	0.15	8.5	L1	99602E3
	6.8	12.5 x 12.5 x 13	60	152	0.15	4.7	L2	99603E3
	10	12.5 x 12.5 x 16	80	190	0.15	3.5	L3	99604E3
	18	16 x 16 x 16	100	286	0.15	2.1	L4	99605E3
	22	16 x 16 x 21	130	334	0.15	1.5	L5	99606E3
	22	18 x 18 x 16	140	334	0.15	1.5	L4	99607E3
	33	18 x 18 x 21	190	466	0.15	1.1	L5	99608E3
450	2.2	10 x 10 x 10	30	100	0.20	14.5	L1	99701E3
	4.7	12.5 x 12.5 x 13	50	134	0.20	5.9	L2	99702E3
	5.6	12.5 x 12.5 x 16	65	146	0.20	5.2	L3	99703E3
	10	16 x 16 x 16	90	205	0.20	2.9	L4	99704E3
	15	16 x 16 x 21	110	273	0.20	2.1	L5	99705E3
	22	18 x 18 x 16	120	367	0.20	1.7	L4	99706E3
	33	18 x 18 x 21	160	516	0.20	1.1	L5	99707E3

Note

(1) Determines the applicable row in the table “Endurance Test Duration and Useful Life”

Table 6

ADDITIONAL ELECTRICAL DATA		
PARAMETER	CONDITIONS	VALUE
Voltage		
Surge voltage for short periods	IEC 60384-18, subclause 4.14	$U_s \leq 1.10 \times U_R$
Reverse voltage for short periods	IEC 60384-18, subclause 4.16; $T_A \leq 105$ °C	$U_{rev} \leq 1$ V
Current		
Leakage current	After 1 min at U_R	$I_{L1} \leq 0.03 \times C_R \times U_R + 70$ µA
	After 5 min at U_R	$I_{L5} \leq 0.015 \times C_R \times U_R + 30$ µA
Inductance		
Equivalent series inductance (ESL)	Ø D = 10 mm	Typ. 16 nH
	Ø D ≥ 12.5 mm	Typ. 18 nH
Resistance		
Equivalent series resistance (ESR) at 100 Hz	Calculated from tan $\delta_{max.}$ and C_R (see Table 5)	ESR = tan $\delta/2\pi f C_R$

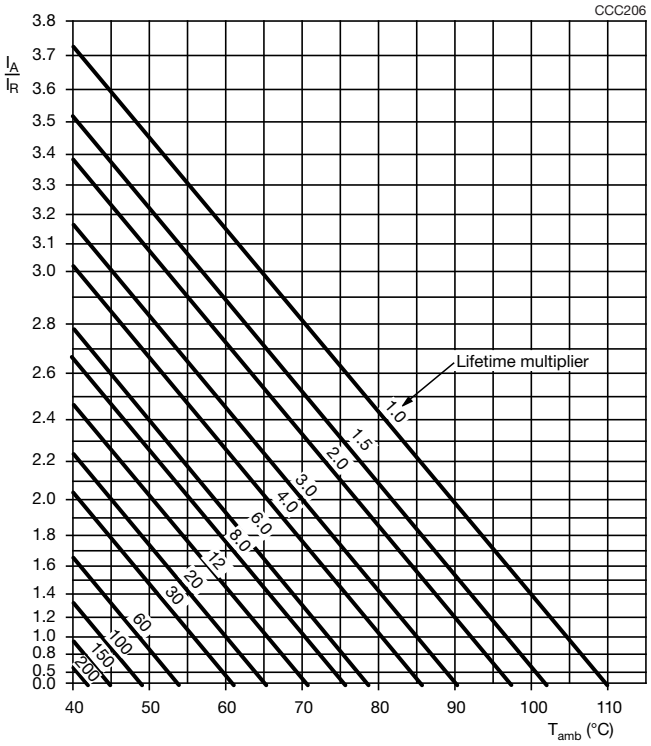
RIPPLE CURRENT AND USEFUL LIFE

Table 7

ENDURANCE TEST DURATION AND USEFUL LIFE			
LIFE CODE	ENDURANCE AT 105 °C (h)	USEFUL LIFE AT 105 °C (h)	USEFUL LIFE AT 40 °C 1.8 x I_R APPLIED (h)
L1	1000	1500	75 000
L2	2500	3000	150 000
L3	3000	4000	200 000
L4	4000	5000	250 000
L5	5000	6000	300 000

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

Fig. 6 - Multiplier of useful life as a function of ambient temperature and ripple current load

Table 8

MULTIPLIER OF RIPPLE CURRENT (I_R) AS A FUNCTION OF FREQUENCY							
U_R (V)	FREQUENCY (Hz)						
	50	100	300	1000	3000	10 000	≥ 30 000
400	0.75	1.00	1.30	1.60	1.90	2.20	2.50
450	0.75	1.00	1.30	1.60	1.90	2.20	2.50

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} = 105 °C; U_R applied; for test duration see Table 7	U_R ≥ 400 V; 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 7	ΔC/C: ± 50 % 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} = 105 °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} = 105 °C: 125 h at U = -1.0 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.

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.