

# **Aluminum Electrolytic Capacitors** SMD (Chip), High Voltage





Fig. 1

QUICK REFERENCE D	ATA					
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 <sub>R</sub>	2.2 μF to 33 μF					
Tolerance on C <sub>R</sub>	± 20 %					
Rated voltage range, U <sub>R</sub>	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 <sub>R</sub> 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					

#### **FEATURES**

- Extended useful life: up to 6000 h at 105 °C
- · Polarized aluminum electrolytic capacitors, non-solid electrolyte, self healing



RoHS

COMPLIANT

AUTOMOTIVE

· 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

#### **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

SELECTION CHART FOR $C_R$ , $U_R$ , and relevant nominal case sizes (L x W x H in mm)					
C <sub>R</sub>	U <sub>R</sub>	ı (V)			
(μ <b>F</b> )	400	450			
2.2	10 x 10 x 10	10 x 10 x 10			
3.9	10 x 10 x 10	-			
4.7	$\rightarrow$	12.5 x 12.5 x 13			
5.6	$\rightarrow$	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	$\rightarrow$	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			



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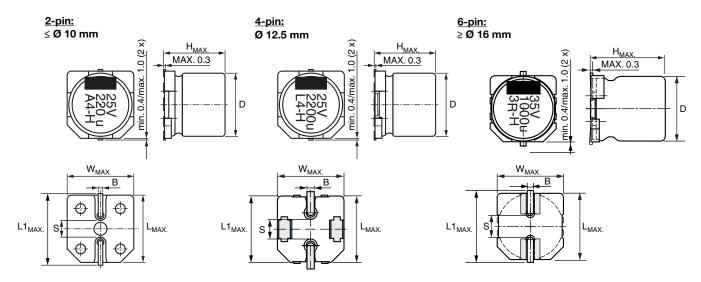


Fig. 2 - Dimensional outline

Table 1

DIMENSIONS in millimeters AND MASS									
NOMINAL CASE SIZE L x W x H	CASE CODE	L <sub>MAX.</sub>	W <sub>MAX.</sub>	H <sub>MAX.</sub>	ØD	B <sub>MAX.</sub>	s	L1 <sub>MAX.</sub>	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

NOMINAL CASE SIZE L x W x H	CASE CODE	PITCH P <sub>1</sub>	TAPE WIDTH W	TAPE THICKNESS T <sub>2</sub>	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"

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#### **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.

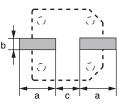
#### **SOLDERING**

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

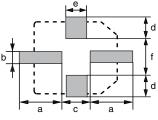
For maximum conditions refer to Fig. 4.

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

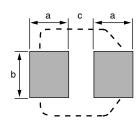
As a general principle, temperature and duration shall be the minimum necessary required to ensure good soldering connections. However, the specified maximum curves should never be exceeded.



Case size  $\emptyset$  D  $\leq$  10 mm



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	а	b	С	d	е	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

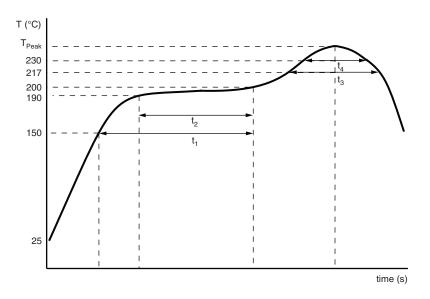


Fig. 4 - Maximum temperature load during reflow soldering

#### 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 <sub>Peak</sub>	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 <sub>1</sub> )	150 s	150 s	150 s				
Max. time from 190 °C to 200 °C (t <sub>2</sub> )	110 s	110 s	110 s				
Ramp up rate from 200 °C to T <sub>Peak</sub>	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 <sub>Liquidus</sub> (217 °C) (t <sub>3</sub> )	90 s	90 s	90 s				
Max. time above 230 °C (t <sub>4</sub> )	70 s	65 s	60 s				
Peak temperature T <sub>Peak</sub>	260 °C	250 °C	245 °C				
Max. time above T <sub>Peak</sub> minus 5 °C	40 s	30 s	30 s				
Ramp-down rate from T <sub>Liquidus</sub>	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



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ELECTRICAL DATA					
SYMBOL	DESCRIPTION				
C <sub>R</sub>	Rated capacitance at 100 Hz, tolerance ± 20 %				
I <sub>R</sub>	Rated RMS ripple current at 100 Hz, 105 °C				
$I_{L2}$	Max. leakage current after 2 min at U <sub>R</sub>				
tan δ	Max. dissipation factor at 100 Hz				
Z	Max. impedance at 100 kHz				

# **ORDERING EXAMPLE**

Electrolytic capacitor 152 CME series

33  $\mu F$  / 450 V;  $\pm$  20 %

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

ree

Ordering code: MAL215299706E3

#### Note

 Unless otherwise specified, all electrical values in Table 5 apply at T<sub>amb</sub> = 20 °C, P = 86 kPa to 106 kPa, RH = 45 % to 75 %

#### Table 5

ELECTI	ELECTRICAL DATA AND ORDERING INFORMATION								
U <sub>R</sub> (V)	C <sub>R</sub> (μF)	NOMINAL CASE SIZE L x W x H (mm)	I <sub>R</sub> 105 °C 100 Hz (mA)	I <sub>L1</sub> 1 min (μΑ)	tan δ 100 Hz	Z 10 kHz 20 °C (Ω)	LIFE CODE (1)	ORDERING CODE MAL2152	
	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	
400	10	12.5 x 12.5 x 16	80	190	0.15	3.5	L3	99604E3	
400	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	
	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	
450	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

• 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	$U_s \le 1.10 \times U_R$					
Reverse voltage for short periods IEC 60384-18, subclause 4.16; $T_A \le 105$ °C $U_{rev} \le 1 \text{ V}$							
Current							
Leakage current	After 1 min at U <sub>R</sub>	$I_{L1} \le 0.03 \ x \ C_R \ x \ U_R + 70 \ \mu A$					
Leakage Current	After 5 min at U <sub>R</sub>	$I_{L5} \leq 0.015 \; x \; C_R \; x \; U_R + 30 \; \mu A$					
Inductance							
Equivalent period industance (ESL)	Ø D = 10 mm	Typ. 16 nH					
Equivalent series inductance (ESL)	Ø D ≥ 12.5 mm	Typ. 18 nH					
Resistance							
Equivalent series resistance (ESR) at 100 Hz	Calculated from tan $\delta_{\text{max.}}$ and $C_{\text{R}}$ (see Table 5)	ESR = $\tan \delta/2\pi fC_R$					



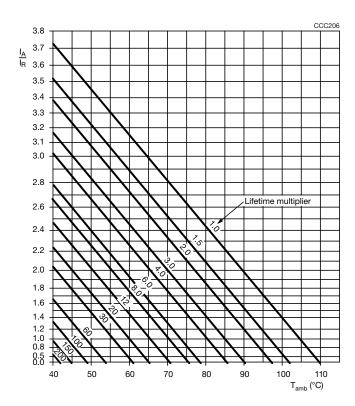
# **RIPPLE CURRENT AND USEFUL LIFE**

# 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 <sub>R</sub> 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. 5 - Multiplier of useful life as a function of ambient temperature and ripple current load

# Table 8

MULTIPLIER OF RIPPLE CURRENT (I <sub>R</sub> ) AS A FUNCTION OF FREQUENCY							
U <sub>R</sub>	FREQUENCY (Hz)						
(V)	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



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# Table 9

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TEST PROCEDURES AND REQUIREMENTS						
	TEST	PROCEDURE	REQUIREMENTS			
NAME OF TEST	REFERENCE	(quick reference)	NEQUINEMENTS			
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"	$\Delta C/C$ : ± 5 % tan $\delta$ ≤ spec. limit $I_{L2}$ ≤ spec. limit			
Endurance	IEC 60384-18 / CECC 32300, subclause 4.15	T <sub>amb</sub> = 105 °C; U <sub>R</sub> applied; for test duration see Table 7	$\begin{array}{l} U_R \geq 400 \text{ V; } \Delta C/C\text{: } \pm 20 \text{ \%} \\ \tan\delta \leq 2 \text{ x spec. limit} \\ I_{L2} \leq \text{spec. limit} \end{array}$			
Useful life	CECC 30301, subclause 1.8.1	$T_{amb}$ = 105 °C; $U_{R}$ and $I_{R}$ applied; for test duration see Table 7	$\begin{array}{l} \Delta C/C: \pm 50 \ \% \\ tan \ \delta \leq 3 \ x \ spec. \ limit \\ I_{L2} \leq spec. \ limit \\ no \ short \ or \ open \ circuit \\ total \ failure \ percentage: \leq 1 \ \% \end{array}$			
Shelf life (storage at high temperature)	IEC 60384-18 / CECC 32300, subclause 4.17	T <sub>amb</sub> = 105 °C; no voltage applied; 1000 h after test: U <sub>R</sub> 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 <sub>amb</sub> = 105 °C: 125 h at U = -1.0 V, followed by 125 h at U <sub>R</sub>	$\Delta$ C/C: ± 15 % tan $\delta$ ≤ 1.5 x spec. limit $I_{L2}$ ≤ spec. limit			

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