

## Aluminum Electrolytic Capacitors, Power High Ripple for Traction, Screw Terminals



### LINKS TO ADDITIONAL RESOURCES



QUICK REFERENCE DATA	
DESCRIPTION	VALUE
Nominal case size (Ø D x L in mm)	76 x 146 to 76 x 220 <sup>(1)</sup>
Rated capacitance range (E6 series), C <sub>R</sub>	6000 µF <sup>(1)</sup>
Tolerance on C <sub>R</sub>	-10 % / +30 %
Rated voltage range, U <sub>R</sub>	250 V to 450 V <sup>(1)</sup>
Category temperature range	-40 °C to +85 °C
Endurance test at 85 °C	2000 h
Useful life at 85 °C	> 10 000 h
Useful life at 70 °C	> 40 000 h
Useful life at 40 °C, 1.4 x I <sub>R</sub> applied	> 400 000 h
Shelf life at 0 V, 85 °C	500 h
Based on sectional specification	IEC 60384-4 / EN 130300
Climatic category IEC 60068	40 / 085 / 056

**Note**

<sup>(1)</sup> Other values available on request

SELECTION CHART FOR C <sub>R</sub> , U <sub>R</sub> , AND RELEVANT NOMINAL CASE SIZES (Ø D x L in mm)					
C <sub>R</sub> (µF)	U <sub>R</sub> (V)				
	250	300	350	400	450
6000	76 x 146	76 x 220	76 x 220	76 x 220	76 x 220

**Note**

• Other values available on request

### FEATURES

- Long useful life: > 10 000 h at +85 °C
- Available in case sizes up to Ø 90 mm x 220 mm
- Low ESR
- Polarized aluminum electrolytic capacitors, non-solid electrolyte
- Large types, cylindrical aluminum case, insulated with a blue sleeve
- Pressure relief in the sealing
- Material categorization: for definitions of compliance please see [www.vishay.com/doc?99912](http://www.vishay.com/doc?99912)



### APPLICATIONS

- Traction (metro / subway, light rail, streetcars / tram)
- Heavy duty applications
- Various industrial applications

### MARKING

The capacitors are marked with the following information:

- Rated capacitance (in µF)
- Tolerance on rated capacitance, code letter in accordance with IEC 60062 (Q for -10 % / +30 %)
- Rated voltage (in V)
- Date code
- Name of manufacturer
- Code for factory of origin
- “-” sign to identify the negative terminal, visible from the top and side of the capacitor
- Code number
- Climatic category in accordance with IEC 60068

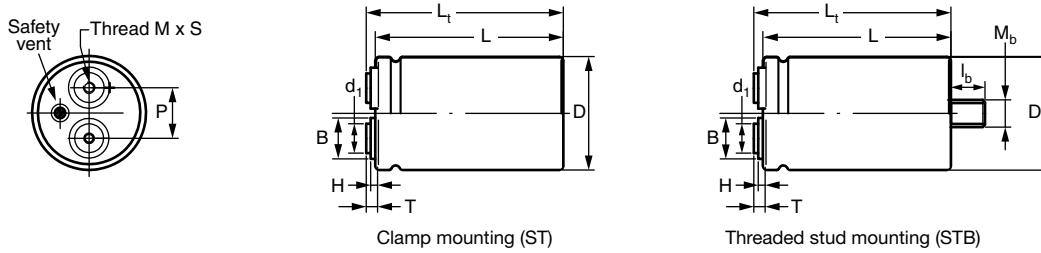
**DIMENSIONS in millimeters AND AVAILABLE FORMS**


Fig. 1A - High current M5 and M6-13 mm disc: Screw Terminal (ST) and Screw Terminal Bolt nut (STB)  
For details refer to Table 1

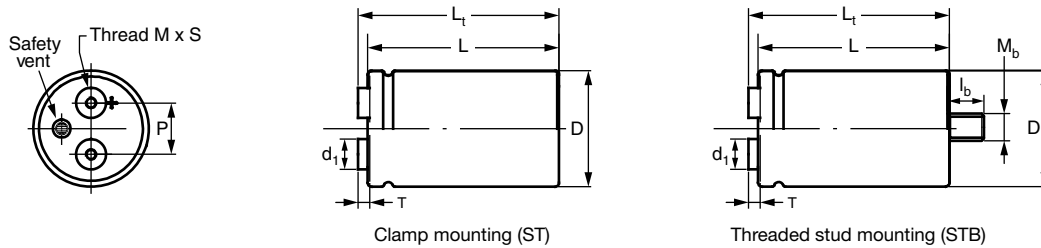


Fig. 1B - High current M6-18 mm disc and 1/4-28 UNF disc: Screw Terminal (ST) and Screw Terminal Bolt nut (STB)  
For details refer to Table 1

**Note**

- Maximum permissible torque which may be applied to the termination screws: 2 Nm for M5; 2.5 Nm for M6 and 1/4-28 UNF. For accessories refer to document "Mounting Accessories", see [www.vishay.com/doc?28348](http://www.vishay.com/doc?28348)  
The capacitors are delivered with screws and washers

**Table 1**

<b>DIMENSIONS in millimeters, MASS, AND PACKAGING QUANTITIES</b>														
DESIGN	DRAWING	$L \pm 1$	$L_t \pm 1$	$D \pm 1$	$P \pm 0.3$	$T \pm 0.2$	$H \pm 0.3$	$B \pm 0.3$	$d_1 \pm 0.1$	M	$S \pm 1$	$M_b$	$l_b \pm 0.1$	MASS (g)
76 x 146 M5-13 mm	1A	145.8	150.2	76.4	31.8	5.5	3.5	18.3	13.0	M5	9.5	M12	16	1000
76 x 146 M6-13 mm	1A	145.8	150.2	76.4	31.8	5.5	3.5	18.3	13.0	M6	9.5	M12	16	1000
76 x 146 M6-18 mm	1B	145.8	153.0	76.4	31.8	8.3	n/a	n/a	17.3	M6	10.0	M12	16	1000
76 x 146 1/4-28 UNF	1B	145.8	153.0	76.4	31.8	8.3	n/a	n/a	17.3	1/4-28 UNF	10.0	M12	16	1000
76 x 220 M5-13 mm	1A	219.8	224.2	76.4	31.8	5.5	3.5	18.3	13.0	M5	9.5	M12	16	1500
76 x 220 M6-13 mm	1A	219.8	224.2	76.4	31.8	5.5	3.5	18.3	13.0	M6	9.5	M12	16	1500
76 x 220 M6-18 mm	1B	219.8	227.0	76.4	31.8	8.3	n/a	n/a	17.3	M6	10.0	M12	16	1500
76 x 220 1/4-28 UNF	1B	219.8	227.0	76.4	31.8	8.3	n/a	n/a	17.3	1/4-28 UNF	10.0	M12	16	1500

<b>DIMENSIONS in millimeters, MASS AND PACKAGING QUANTITIES</b>		
DESIGN	PACKAGING QUANTITIES (units per box)	CARDBOX DIMENSIONS L x W x H (mm)
76 x 146	12	377 x 375 x 168
76 x 220	12	377 x 375 x 242

**Note**

- For STB version holds:  
H cardboard box: +10 mm



ELECTRICAL DATA	
SYMBOL	DESCRIPTION
C <sub>R</sub>	Rated capacitance at 100 Hz, tolerance -10 % / +30 %
I <sub>R</sub>	Rated RMS ripple current at 100 Hz, 85 °C
I <sub>L5</sub>	Max. leakage current after 5 min at U <sub>R</sub>
ESR	Max. equivalent series resistance at 100 Hz
Z	Max. impedance at 20 kHz

**Note**

- Unless otherwise specified, all electrical values in Table 2 apply at T<sub>amb</sub> = 20 °C, P = 86 kPa to 106 kPa, RH = 45 % to 75 %

Table 2

ELECTRICAL DATA AND ORDERING INFORMATION										
U <sub>R</sub> (V)	C <sub>R</sub> 100 Hz (µF)	CASE SIZE Ø D x L (mm)	I <sub>R</sub> 100 Hz 85 °C (A)	I <sub>L</sub> 5 min (mA)	ESR (mΩ)		Z (mΩ)		ORDERING CODE <sup>(1)</sup>	
					MAX.	TYP.	MAX.	TYP.	ST	STB
250	6000	76 x 146	18.35	3.0	17.6	9.7	11.5	6.9	MAL21101 <u>3</u> 602E3	MAL21102 <u>3</u> 602E3
									MAL21103 <u>3</u> 602E3	MAL21104 <u>3</u> 602E3
									MAL21105 <u>3</u> 602E3	MAL21106 <u>3</u> 602E3
									MAL21107 <u>3</u> 602E3	MAL21108 <u>3</u> 602E3
300	6000	76 x 220	18.35	3.6	25.3	13.9	20.0	12.0	MAL21101 <u>0</u> 602E3	MAL21102 <u>0</u> 602E3
									MAL21103 <u>0</u> 602E3	MAL21104 <u>0</u> 602E3
									MAL21105 <u>0</u> 602E3	MAL21106 <u>0</u> 602E3
									MAL21107 <u>0</u> 602E3	MAL21108 <u>0</u> 602E3
350	6000	76 x 220	18.49	4.2	24.0	13.2	18.6	11.2	MAL21101 <u>5</u> 602E3	MAL21102 <u>5</u> 602E3
									MAL21103 <u>5</u> 602E3	MAL21104 <u>5</u> 602E3
									MAL21105 <u>5</u> 602E3	MAL21106 <u>5</u> 602E3
									MAL21107 <u>5</u> 602E3	MAL21108 <u>5</u> 602E3
400	6000	76 x 220	18.45	4.8	23.8	13.1	18.6	11.2	MAL21101 <u>6</u> 602E3	MAL21102 <u>6</u> 602E3
									MAL21103 <u>6</u> 602E3	MAL21104 <u>6</u> 602E3
									MAL21105 <u>6</u> 602E3	MAL21106 <u>6</u> 602E3
									MAL21107 <u>6</u> 602E3	MAL21108 <u>6</u> 602E3
450	6000	76 x 220	19.76	5.4	19.1	10.5	13.6	8.2	MAL21101 <u>7</u> 602E3	MAL21102 <u>7</u> 602E3
									MAL21103 <u>7</u> 602E3	MAL21104 <u>7</u> 602E3
									MAL21105 <u>7</u> 602E3	MAL21106 <u>7</u> 602E3
									MAL21107 <u>7</u> 602E3	MAL21108 <u>7</u> 602E3

**Note**

- (1) Underlined 8<sup>th</sup> digit determines form: for details see “Part Number Explanation” table

PART NUMBER EXPLANATION (Example: 350 V, 6000 µF, M6-13 mm disc)						
1 2 3 4	5 6 7	8	9	10 11 12	13 14	
<b>MAL2</b>	<b>110</b>	<b>3</b>	<b>5</b>	<b>602</b>	<b>E3</b>	
PREFIX	SERIES NAME	FORM	VOLTAGE	CAPACITANCE	Lead (Pb)-free (RoHS-compliant)	
		<ul style="list-style-type: none"> <li>1 = high current M5-13 mm disc (ST)</li> <li>2 = high current M5-13 mm disc, with mounting bolt (STB)</li> <li>3 = high current M6-13 mm disc (ST)</li> <li>4 = high current M6-13 mm disc, with mounting bolt (STB)</li> <li>5 = high current M6-18 mm disc (ST)</li> <li>6 = high current M6-18 mm disc, with mounting bolt (STB)</li> <li>7 = US tread 1/4-28 UNF (ST)</li> <li>8 = US tread 1/4-28 UNF, with mounting bolt (STB)</li> </ul>	<ul style="list-style-type: none"> <li>3 = 250 V</li> <li>0 = 300 V</li> <li>5 = 350 V</li> <li>6 = 400 V</li> <li>7 = 450 V</li> </ul>	<ul style="list-style-type: none"> <li>602 = 6000 µF</li> </ul>		

**Note**

- Other values or designs are available on request. For more information, please visit the “Product Coding” page: [www.vishay.com/doc?28394](http://www.vishay.com/doc?28394)



ADDITIONAL ELECTRICAL DATA		
PARAMETER	CONDITIONS	VALUE
<b>Voltage</b>		
Surge voltage		$U_S = 1.1 \times U_R$
Reverse voltage		$U_{rev} \leq 1 \text{ V}$
<b>Current</b>		
Leakage current	After 1 min at $U_R$	$I_{L1} \leq 0.006 C_R \times U_R$
	After 5 min at $U_R$	$I_{L5} \leq 0.002 C_R \times U_R$
<b>Inductance</b>		
Equivalent series inductance (ESL)		Typ. 20 nH <sup>(1)</sup>

**Note**

<sup>(1)</sup> Low ESL designs available on request

**RIPPLE CURRENT AND USEFUL LIFE**

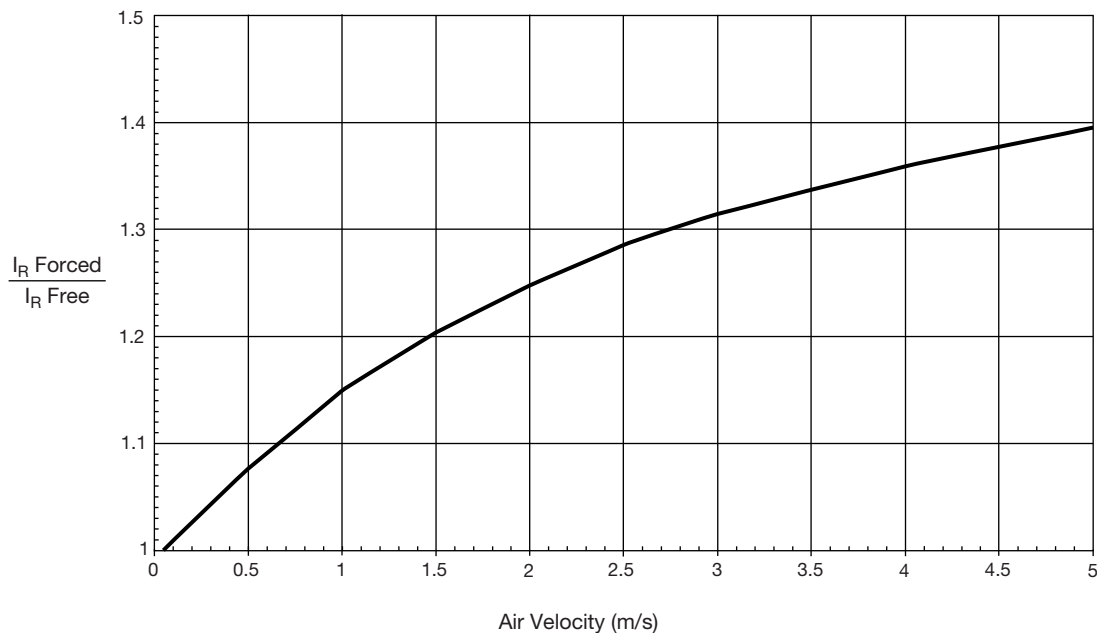


Fig. 2 - Multiplier of ripple current ( $I_R$ ) as a function of air flow

MAXIMUM RIPPLE CURRENT			
PARAMETER	CONDITION	MAXIMUM RIPPLE CURRENT MULTIPLIER	VALUE
Ambient temperature ( $T_{amb}$ )	70 °C	From nomogram; see Fig. 3	1.6
Operating frequency (f)	400 Hz	From frequency; see Table 3	1.3
Air flow	2 m/s	From air flow; see Fig. 2	1.25

**Note**

- Calculation example for 110 series. maximum ripple current multiplier = 1.6 x 1.3 x 1.25 = 2.6

**Table 3**

ENDURANCE TEST DURATION AND USEFUL LIFE	
ENDURANCE AT 85 °C (h)	USEFUL LIFE AT 85 °C (h)
2000	> 10 000

**Note**

- Multiplier of useful life code: CCC205-05

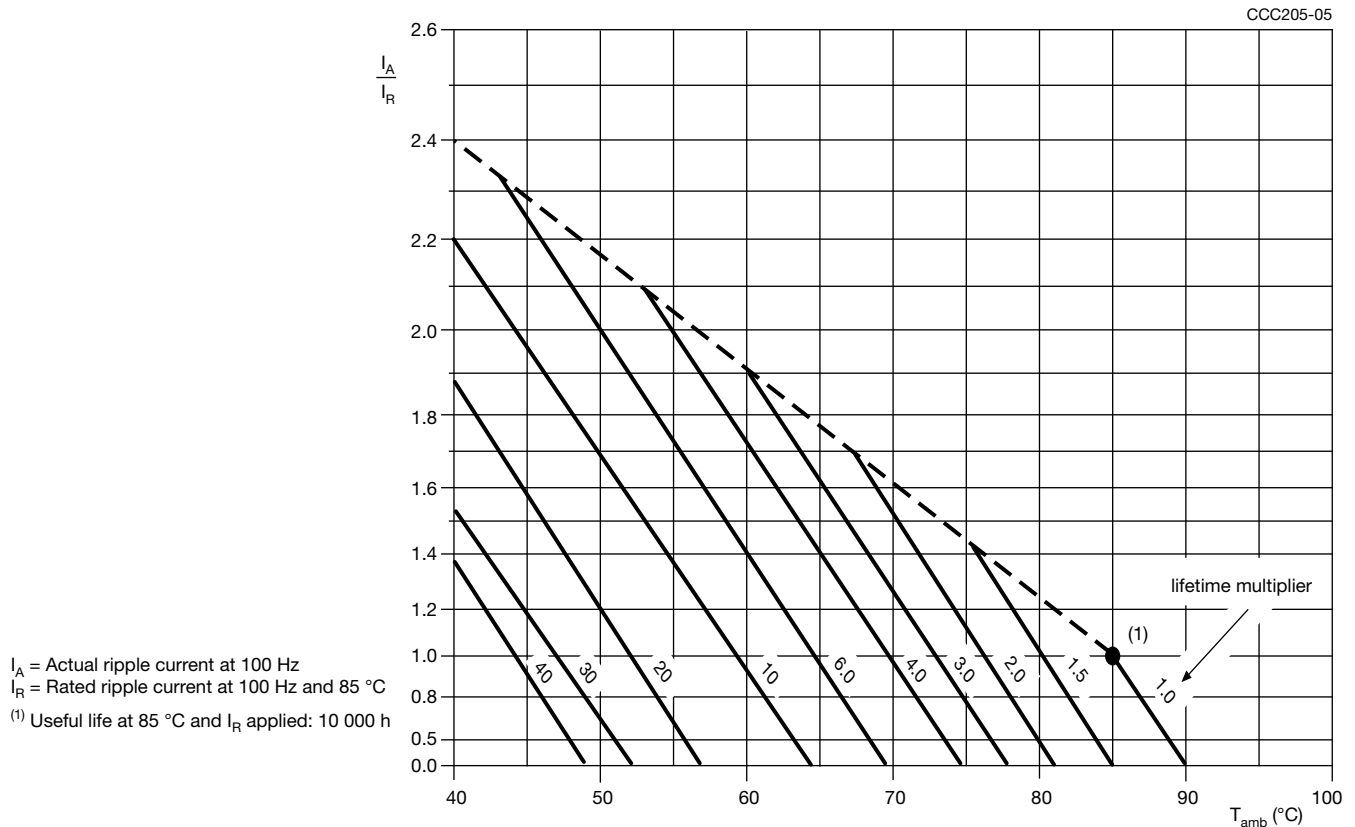


Fig. 3 - Multiplier of useful life as a function of ambient temperature and ripple current load

**Table 4**

MULTIPLIER OF RIPPLE CURRENT ( $I_R$ ) AS A FUNCTION OF FREQUENCY					
FREQUENCY (Hz)					
50	100	200	400	1000	10 000
$I_R$ MULTIPLIER					
0.90	1.00	1.20	1.30	1.40	1.50



Table 5

TEST PROCEDURES AND REQUIREMENTS			
TEST		PROCEDURE (quick reference)	REQUIREMENTS
NAME OF TEST	REFERENCE		
Endurance	IEC 60384-4 / EN 130300 subclause 4.13	T <sub>amb</sub> = 85 °C; U <sub>R</sub> applied; 2000 h	ΔC/C: ± 10 % tan δ ≤ 1.3 x spec. limit Z ≤ 2 x spec. limit I <sub>L5</sub> ≤ spec. limit
Useful life	CECC 30301 subclause 1.8.1	T <sub>amb</sub> = 85 °C; U <sub>R</sub> and I <sub>R</sub> applied	ΔC/C: ± 30 % tan δ ≤ 3 x spec. limit Z ≤ 3 x spec. limit I <sub>L5</sub> ≤ spec. limit no short or open circuit, no visible damage Total failure percentage: ≤ 3 %
Shelf life (storage at high temperature)	IEC 60384-4 / EN 130300 subclause 4.17	T <sub>amb</sub> = 85 °C; no voltage applied; 500 h  after test: U <sub>R</sub> to be applied for 30 min, 24 h to 48 h before measurement	ΔC/C: ± 10 % tan δ ≤ 1.2 x spec. limit I <sub>L5</sub> ≤ 2 x 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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