Aluminum Capacitors
Power High Ripple Current Screw Terminals

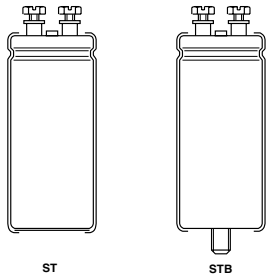


Fig. 1 Component outline

FEATURES

- Polarized aluminum electrolytic capacitors, non-solid electrolyte
- Large types, cylindrical aluminum case, insulated with a blue sleeve
- Pressure relief in the sealing
- Long useful life
- Compliant to RoHS directive 2002/95/EC

Pb-free
RoHS COMPLIANT

APPLICATIONS

- Computer, telecom, medical, and industrial systems
- Smoothing and filtering
- Standard and switched mode power supplies

MARKING

The capacitors are marked 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 (YYMM)
- 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

QUICK REFERENCE DATA

DESCRIPTION	VALUE	
	101	102
Nominal case size (Ø D x L in mm)	35 x 60 to 90 x 220	
Rated capacitance range (E6 series), C_R	220 µF to 1 F	
Tolerance on C_R	± 20 %	
Rated voltage range, U_R	25 V to 100 V	200 V to 450 V
Category temperature range	- 40 °C to + 85 °C	
Endurance test at 85 °C	2000 h	
Useful life at 85 °C	10 000 h (D ≤ 50 mm) 15 000 h (D ≥ 65 mm)	10 000 h
Useful life at 40 °C, 1.4 x IR applied	400 000 h (D ≤ 50 mm) 600 000 h (D ≥ 65 mm)	400 000 h
Shelf life at 0 V, 85 °C	500 h	
Based on sectional specification	IEC 60384-4/EN130300	
Climatic category IEC 60068	40/085/56	

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

C_R (µF)	U_R (V)									
	25	40	63	100	200	250	350	385	400	450
220	-	-	-	-	-	-	-	35 x 60	35 x 60	35 x 60
330	-	-	-	-	-	-	35 x 60	-	35 x 60	-
	-	-	-	-	-	-	-	-	35 x 80	-
470	-	-	-	-	-	35 x 60	-	35 x 80	35 x 80	-
	-	-	-	-	-	-	35 x 80	-	35 x 105	35 x 105
680	-	-	-	-	35 x 60	35 x 80	-	-	35 x 105	-
	-	-	-	-	-	-	-	-	50 x 80	50 x 80
1000	-	-	-	-	35 x 80	35 x 80	-	50 x 80	50 x 80	50 x 80
	-	-	-	-	35 x 105	35 x 105	-	-	50 x 105	50 x 105
1500	-	-	-	-	35 x 105	35 x 105	-	-	-	50 x 105
	-	-	-	-	50 x 80	50 x 80	50 x 105	50 x 105	50 x 105	65 x 105
2200	-	-	-	35 x 60	50 x 80	50 x 80	50 x 105	-	-	65 x 105
	-	-	-	-	-	50 x 105	65 x 105	65 x 105	65 x 105	-
3300	-	-	-	35 x 60	50 x 80	50 x 105	-	-	65 x 105	-
	-	-	-	35 x 80	50 x 105	65 x 105	65 x 105	76 x 105	-	76 x 146
4700	-	-	35 x 60	35 x 80	-	65 x 105	76 x 105	76 x 105	-	76 x 146
	-	-	-	35 x 105	65 x 105	76 x 105	76 x 146	76 x 146	76 x 146	-
5600	-	-	-	-	-	-	-	-	-	-

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

C_R (µF)	U_R (V)									
	25	**40**	**63**	**100**	**200**	**250**	**350**	**385**	**400**	**450**
6800	-	-	35 x 60	35 x 105	65 x 105	76 x 105	-	-	76 x 146	76 x 220
	-	-	35 x 80	50 x 80	76 x 105	76 x 146	76 x 146	76 x 146	-	90 x 146
10 000	-	35 x 60	35 x 80	50 x 80	76 x 105	76 x 105	76 x 220	-	-	-
	-	-	35 x 105	50 x 105	76 x 146	76 x 146	90 x 146	-	-	90 x 220
15 000	35 x 60	35 x 60	35 x 105	50 x 105	76 x 146	76 x 146	-	-	-	-
	-	35 x 80	50 x 80	-	-	-	90 x 220	-	-	-
22 000	35 x 60	35 x 80	50 x 80	65 x 105	76 x 220	76 x 220	-	-	-	-
	-	50 x 80	50 x 105	76 x 105	90 x 146	90 x 146	-	-	-	-
33 000	35 x 80	35 x 105	50 x 105	76 x 105	-	-	-	-	-	-
	50 x 80	50 x 80	65 x 105	76 x 146	90 x 220	90 x 220	-	-	-	-
47 000	35 x 105	50 x 80	65 x 105	-	-	-	-	-	-	-
	50 x 80	50 x 105	76 x 105	76 x 146	-	-	-	-	-	-
68 000	50 x 80	50 x 105	76 x 105	76 x 146	-	-	-	-	-	-
	50 x 105	65 x 105	76 x 146	-	-	-	-	-	-	-
100 000	50 x 105	65 x 105	-	76 x 220	-	-	-	-	-	-
	65 x 105	76 x 105	76 x 146	90 x 146	-	-	-	-	-	-
150 000	65 x 105	76 x 105	76 x 146	-	-	-	-	-	-	-
	76 x 105	76 x 146	-	90 x 220	-	-	-	-	-	-
220 000	65 x 105	-	76 x 220	-	-	-	-	-	-	-
	76 x 105	76 x 146	90 x 146	-	-	-	-	-	-	-
330 000	76 x 146	76 x 220	-	-	-	-	-	-	-	-
	-	90 x 146	90 x 220	-	-	-	-	-	-	-
470 000	76 x 220	-	-	-	-	-	-	-	-	-
	90 x 146	90 x 220	-	-	-	-	-	-	-	-
680 000	76 x 220	-	-	-	-	-	-	-	-	-
1 000 000	90 x 220	-	-	-	-	-	-	-	-	-

DIMENSIONS in millimeters AND AVAILABLE FORMS

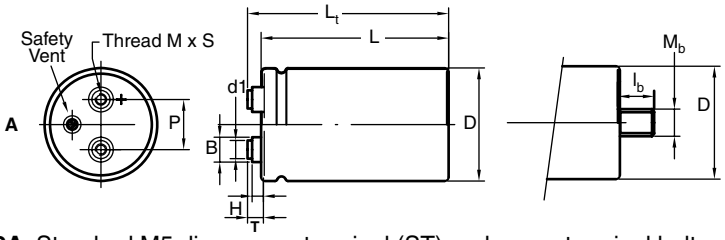


Fig. **2A**: Standard M5 disc: screw terminal (ST) and screw terminal bolt nut (STB)

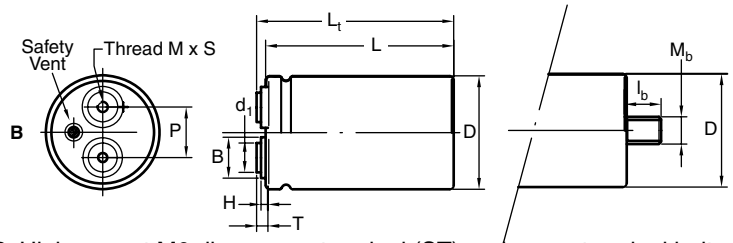


Fig. **2B**: High current M6 disc: screw terminal (ST) and screw terminal bolt nut (STB)

Maximum permissible torque which may be applied to the termination screws: 2 Nm for M5; 2.5 Nm for M6
For accessories refer to datasheet “Mounting Accessories”.
The capacitors are delivered with screws and washers.

Table 1

DIMENSIONS in millimeters, **MASS AND PACKAGING QUANTITIES**															
DESIGN	**DRAWING**	**L ± 1**	**L_t ± 1**	**D ± 1**	**P ± 0.3**	**T ± 0.2**	**H ± 0.3**	**B ± 0.3**	**d_1 ± 0.1**	**M**	**S - 0**	**Mb**	**l_b ± 0.1**	**MASS (g)**	**PACKAGING QUANTITIES**
35 x 60	2A	63.3	68.7	35.3	12.8	7.0	4.6	11.0	7.9	M5	9.5	M8	12.0	75	50
35 x 80	2A	81.3	86.7	35.3	12.8	7.0	4.6	11.0	7.9	M5	9.5	M8	12.0	95	50
35 x 105	2A	103.3	108.7	35.3	12.8	7.0	4.6	11.0	7.9	M5	9.5	M8	12.0	130	50
50 x 80	2A	82.8	88.8	51.0	22.2	7.1	4.8	11.0	7.9	M5	9.5	M12	16.0	200	25
50 x 105	2A	104.8	110.8	51.0	22.2	7.1	4.8	11.0	7.9	M5	9.5	M12	16.0	300	25
65 x 105	2A	104.8	110.7	65.0	28.5	7.0	4.6	11.9	7.9	M5	9.5	M12	16.0	480	16
65 x 105 HC	2B	104.8	109.2	65.0	28.5	5.5	3.5	18.0	13.0	M6	8.5	M12	16.0	480	16
76 x 105	2A	105.8	111.7	76.4	31.8	7.0	4.6	11.7	7.9	M5	9.5	M12	16.0	700	12
76 x 105 HC	2B	105.8	110.2	76.4	31.8	5.5	3.5	18.3	13.0	M6	8.5	M12	16.0	700	12
76 x 114	2A	115.8	121.7	76.4	31.8	7.0	4.6	11.7	7.9	M5	9.5	M12	16.0	800	12
76 x 114 HC	2B	115.8	120.2	76.4	31.8	5.5	3.5	18.3	13.0	M6	8.5	M12	16.0	800	12
76 x 146	2A	145.8	151.7	76.4	31.8	7.0	4.6	11.7	7.9	M5	9.5	M12	16.0	1000	12
76 x 146 HC	2B	145.8	150.2	76.4	31.8	5.5	3.5	18.3	13.0	M6	8.5	M12	16.0	1000	12
76 x 220	2A	219.8	225.7	76.4	31.8	7.0	4.6	11.7	7.9	M5	9.5	M12	16.0	1500	10
76 x 220 HC	2B	219.8	224.2	76.4	31.8	5.5	3.5	18.3	13.0	M6	8.5	M12	16.0	1500	10
90 x 146 HC	2B	150.1	155.4	89.4	31.8	7.9	0.0	13.0	13.0	M6	10.0	M12	16.0	1300	10
90 x 220 HC	2B	218.1	223.4	89.4	31.8	7.9	0.0	13.0	13.0	M6	10.0	M12	16.0	2000	10

Note

- For bolt version holds:

1. L = L standard - 0.5 mm
2. L_t = L_t standard - 0.5 mm

ELECTRICAL DATA	
SYMBOL	**DESCRIPTION**
C_R	rated capacitance at 100 Hz, tolerance ± 20 %
I_R	rated RMS ripple current at 100 Hz, 85 °C
I_{L5}	max. leakage current after 5 minutes at U_R
ESR	max. equivalent series resistance at 100 Hz
Z	max. impedance at 20 kHz

Note

- Unless otherwise specified, all electrical values in tables 2 and 3 apply at T_{amb} = 20 °C, P = 86 kPa to 106 kPa, RH = 45 % to 75 %.

ORDERING EXAMPLE

Electrolytic capacitor 101 series

10 000 µF/40 V; ± 20 %

Nominal case size: Ø 35 mm x 60 mm;
ST version, high post M5 disc

Ordering code: MAL2 101 17103 E3

Former 12NC: 2222 101 17103

Table 2

ELECTRICAL DATA AND ORDERING INFORMATION FOR 101 SERIES										
U_R (V)	C_R 100 Hz (µF)	NOMINAL CASE SIZE Ø D x L (mm)	I_R 100 Hz 85 °C (A)	I_{L5} 5 min (mA)	ESR max. 100 Hz (mΩ)	Z max. 20 kHz (mΩ)	STANDARD HIGH POST M5 DISC		HIGH CURRENT M6 DISC	
							ST ORDERING CODE MAL2101.....	ST BOLT NUT ORDERING CODE MAL2101.....	ST ORDERING CODE MAL2101.....	ST BOLT NUT ORDERING CODE MAL2101.....
	15 000	35 x 60	7.7	0.75	29	22	16153E3	56153E3	-	-
	22 000	35 x 60	8.3	1.10	27	22	16223E3	56223E3	-	-
	33 000	35 x 80	9.0	1.65	19	17	16333E3	56333E3	-	-
	33 000	50 x 80	10.0	1.65	17	14	26333E3	66333E3	-	-
	47 000	35 x 105	12.1	2.35	15	13	16473E3	56473E3	-	-
	47 000	50 x 80	14.8	2.35	12	10	26473E3	66473E3	-	-
	68 000	50 x 80	12.8	3.40	15	13	16683E3	56683E3	-	-
	68 000	50 x 105	17.1	3.40	9	8	26683E3	66683E3	-	-
	100 000	50 x 105	14.7	5.00	12	11	16104E3	56104E3	-	-
25	100 000	65 x 105	19.6	5.00	7	6	26104E3	66104E3	46104E3	86104E3
	150 000	65 x 105	17.6	7.50	8	7	16154E3	56154E3	36154E3	76154E3
	150 000	76 x 105	21.4	7.50	6	5	26154E3	66154E3	46154E3	86154E3
	220 000	65 x 105	20.2	11.0	6	5	16224E3	56224E3	36224E3	76224E3
	220 000	76 x 105	22.5	11.0	6	5	26224E3	66224E3	46224E3	86224E3
	330 000	76 x 146	25.8	16.5	4	4	26334E3	66334E3	46334E3	86334E3
	470 000	76 x 220	29.9	23.5	5	5	16474E3	56474E3	36474E3	76474E3
	470 000	90 x 146	38.2	23.5	5	5	-	-	46474E3	86474E3
	680 000	76 x 220	29.0	34.0	5	5	16684E3	56684E3	36684E3	76684E3
	1 000 000	90 x 220	46.6	50.0	5	5	-	-	46105E3	86105E3
	10 000	35 x 60	7.1	0.80	31	23	17103E3	57103E3	-	-
	15 000	35 x 60	7.8	1.20	28	22	17153E3	57153E3	-	-
	15 000	35 x 80	8.7	1.20	22	17	27153E3	67153E3	-	-
	22 000	35 x 80	9.4	1.76	20	17	17223E3	57223E3	-	-
	22 000	50 x 80	11.2	1.76	19	15	27223E3	67223E3	-	-
	33 000	35 x 105	11.0	2.64	15	13	17333E3	57333E3	-	-
	33 000	50 x 80	13.7	2.64	13	10	27333E3	67333E3	-	-
	47 000	50 x 80	14.6	3.76	12	10	17473E3	57473E3	-	-
	47 000	50 x 105	15.9	3.76	10	8	27473E3	67473E3	-	-
40	68 000	50 x 105	16.9	5.44	9	8	17683E3	57683E3	-	-
	68 000	65 x 105	18.1	5.44	7	6	27683E3	67683E3	47683E3	87683E3
	100 000	65 x 105	19.2	8.0	7	6	17104E3	57104E3	37104E3	77104E3
	100 000	76 x 105	21.3	8.0	7	6	27104E3	67104E3	47104E3	87104E3
	150 000	76 x 105	20.5	12.0	7	6	17154E3	57154E3	37154E3	77154E3
	150 000	76 x 146	24.0	12.0	5	5	27154E3	67154E3	47154E3	87154E3
	220 000	76 x 146	24.5	17.6	5	5	27224E3	67224E3	47224E3	87224E3
	330 000	76 x 220	28.2	26.4	5	5	17334E3	57334E3	37334E3	77334E3
	330 000	90 x 146	38.6	26.4	5	5	-	-	47334E3	87334E3
	470 000	90 x 220	41.5	37.6	5	5	-	-	47474E3	87474E3

ELECTRICAL DATA AND ORDERING INFORMATION FOR 101 SERIES

U_R (V)	C_R 100 Hz (µF)	NOMINAL CASE SIZE Ø D x L (mm)	I_R 100 Hz 85 °C (A)	I_{L5} 5 min (mA)	ESR max. 100 Hz (mΩ)	Z max. 20 kHz (mΩ)	STANDARD HIGH POST M5 DISC		HIGH CURRENT M6 DISC	
							ST ORDERING CODE MAL2101.....	ST BOLT NUT ORDERING CODE MAL2101.....	ST ORDERING CODE MAL2101.....	ST BOLT NUT ORDERING CODE MAL2101.....
63	4700	35 x 60	5.9	0.59	42	25	18472E3	58472E3	-	-
	6800	35 x 60	6.6	0.86	38	25	18682E3	58682E3	-	-
	6800	35 x 80	7.3	0.86	30	19	28682E3	68682E3	-	-
	10 000	35 x 80	8.1	1.26	27	19	18103E3	58103E3	-	-
	10 000	35 x 105	8.8	1.26	22	14	28103E3	68103E3	-	-
	15 000	35 x 105	9.7	1.89	19	14	18153E3	58153E3	-	-
	15 000	50 x 80	12.1	1.89	16	11	28153E3	68153E3	-	-
	22 000	50 x 80	11.1	2.77	19	15	18223E3	58223E3	-	-
	22 000	50 x 105	14.3	2.77	12	9	28223E3	68223E3	-	-
	33 000	50 x 105	12.9	4.16	14	12	18333E3	58333E3	-	-
	33 000	65 x 105	16.5	4.16	9	6	28333E3	68333E3	48333E3	88333E3
	47 000	65 x 105	15.6	5.92	10	8	18473E3	58473E3	38473E3	78473E3
	47 000	76 x 105	18.6	5.92	8	6	28473E3	68473E3	48473E3	88473E3
	68 000	76 x 105	20.0	8.57	7	6	18683E3	58683E3	38683E3	78683E3
	68 000	76 x 146	21.9	8.57	6	5	28683E3	68683E3	48683E3	88683E3
	100 000	76 x 146	23.4	12.6	5	5	28104E3	68104E3	48104E3	88104E3
	150 000	76 x 146	22.2	18.9	6	5	18154E3	58154E3	38154E3	78154E3
	220 000	76 x 220	27.0	27.7	5	5	18224E3	58224E3	38224E3	78224E3
	220 000	90 x 146	36.5	27.7	5	5	-	-	48224E3	88224E3
	330 000	90 x 220	42.9	41.6	5	5	-	-	48334E3	88334E3
100	2200	35 x 60	5.2	0.44	50	29	19222E3	59222E3	-	-
	3300	35 x 60	6.0	0.66	42	27	19332E3	59332E3	-	-
	3300	35 x 80	6.6	0.66	35	21	29332E3	69332E3	-	-
	4700	35 x 80	7.3	0.94	31	20	19472E3	59472E3	-	-
	4700	35 x 105	7.9	0.94	26	16	29472E3	69472E3	-	-
	6800	35 x 105	8.8	1.36	23	15	19682E3	59682E3	-	-
	6800	50 x 80	10.9	1.36	19	12	29682E3	69682E3	-	-
	10 000	50 x 80	10.5	2.00	21	15	19103E3	59103E3	-	-
	10 000	50 x 105	13.1	2.00	14	9	29103E3	69103E3	-	-
	15 000	50 x 105	12.3	3.00	16	12	19153E3	59153E3	-	-
	22 000	65 x 105	14.8	4.40	11	8	19223E3	59223E3	39223E3	79223E3
	22 000	76 x 105	17.4	4.40	9	6	29223E3	69223E3	49223E3	89223E3
	33 000	76 x 105	19.0	6.60	8	6	19333E3	59333E3	39333E3	79333E3
	33 000	76 x 146	20.7	6.60	7	5	29333E3	69333E3	49333E3	89333E3
	47 000	76 x 146	22.4	9.40	6	5	29473E3	69473E3	49473E3	89473E3
	68 000	76 x 146	25.6	13.6	6	5	19683E3	59683E3	39683E3	79683E3
	100 000	76 x 220	31.2	20.0	5	5	19104E3	59104E3	39104E3	79104E3
	100 000	90 x 146	41.5	20.0	5	5	-	-	49104E3	89104E3
	150 000	90 x 220	49.1	30.0	5	5	-	-	49154E3	89154E3

Table 3

ELECTRICAL DATA AND ORDERING INFORMATION FOR 102 SERIES

U_R (V)	C_R 100 Hz (µF)	NOMINAL CASE SIZE Ø D x L (mm)	I_R 100 Hz 85 °C (A)	I_{L5} 5 min (mA)	ESR max. 100 Hz (mΩ)	Z max. 20 kHz (mΩ)	HIGH POST M5 DISC		HIGH CURRENT M6 DISC	
							ST ORDERING CODE MAL2102.....	ST BOLT NUT ORDERING CODE MAL2102.....	ST ORDERING CODE MAL2102.....	ST BOLT NUT ORDERING CODE MAL2102.....
	680	35 x 60	3.5	0.27	207	136	12681E3	52681E3	-	-
	1000	35 x 80	4.4	0.40	144	95	12102E3	52102E3	-	-
	1000	35 x 105	4.7	0.40	140	91	22102E3	62102E3	-	-
	1500	35 x 105	5.5	0.60	100	67	12152E3	52152E3	-	-
	1500	50 x 80	6.2	0.60	106	74	22152E3	62152E3	-	-
	2200	50 x 80	8.0	0.88	67	44	12222E3	52222E3	-	-
	3300	50 x 80	8.9	1.32	50	35	12332E3	52332E3	-	-
	3300	50 x 105	9.9	1.32	46	32	22332E3	62332E3	-	-
200	4700	65 x 105	12.5	1.88	37	26	22472E3	62472E3	42472E3	82472E3
	6800	65 x 105	15.2	2.72	25	18	12682E3	52682E3	32682E3	72682E3
	6800	76 x 105	16.9	2.72	25	18	22682E3	62682E3	42682E3	82682E3
	10 000	76 x 105	19.9	4.00	18	13	12103E3	52103E3	32103E3	72103E3
	10 000	76 x 146	20.4	4.00	18	13	22103E3	62103E3	42103E3	82103E3
	15 000	76 x 146	24.1	6.00	12	9	12153E3	52153E3	32153E3	72153E3
	22 000	76 x 220	29.5	8.8	9	7	12223E3	52223E3	32223E3	72223E3
	22 000	90 x 146	34.1	8.8	8	6	-	-	42223E3	82223E3
	33 000	90 x 220	41.7	13.2	6	5	-	-	42333E3	82333E3
	470	35 x 60	3.1	0.24	250	152	13471E3	53471E3	-	-
	680	35 x 80	3.8	0.34	175	107	13681E3	53681E3	-	-
	1000	35 x 80	4.4	0.50	128	82	13102E3	53102E3	-	-
	1000	35 x 105	4.8	0.50	122	76	23102E3	63102E3	-	-
	1500	35 x 105	5.4	0.75	90	58	13152E3	53152E3	-	-
	1500	50 x 80	7.0	0.75	81	50	23152E3	63152E3	-	-
	2200	50 x 80	8.0	1.10	60	39	13222E3	53222E3	-	-
	2200	50 x 105	8.7	1.10	57	35	23222E3	63222E3	-	-
	3300	50 x 105	9.8	1.65	42	28	13332E3	53332E3	-	-
250	3300	65 x 105	11.4	1.65	42	28	23332E3	63332E3	43332E3	83332E3
	4700	65 x 105	13.8	2.35	29	19	13472E3	53472E3	33472E3	73472E3
	4700	76 x 105	15.3	2.35	29	19	23472E3	63472E3	43472E3	83472E3
	6800	76 x 105	18.1	3.40	21	14	13682E3	53682E3	33682E3	73682E3
	6800	76 x 146	18.6	3.40	21	14	23682E3	63682E3	43682E3	83682E3
	10 000	76 x 105	19.3	5.00	17	12	13103E3	53103E3	33103E3	73103E3
	10 000	76 x 146	22.0	5.00	15	10	23103E3	63103E3	43103E3	83103E3
	15 000	76 x 146	23.3	7.5	12	10	13153E3	53153E3	33153E3	73153E3
	22 000	76 x 220	29.1	11.0	9	7	13223E3	53223E3	33223E3	73223E3
	22 000	90 x 146	35.3	11.0	7	5	-	-	43223E3	83223E3
	33 000	90 x 220	43.2	16.5	5	5	-	-	43333E3	83333E3
	330	35 x 60	2.5	0.23	435	305	15331E3	55331E3	-	-
	470	35 x 80	3.1	0.33	308	216	25471E3	65471E3	-	-
	680	35 x 105	3.8	0.48	216	152	25681E3	65681E3	-	-
	1000	50 x 80	5.6	0.70	145	102	25102E3	65102E3	-	-
	1500	50 x 80	6.5	1.05	102	74	15152E3	55152E3	-	-
	1500	50 x 105	7.0	1.05	99	70	25152E3	65152E3	-	-
	2200	50 x 105	8.0	1.54	72	52	15222E3	55222E3	-	-
350	2200	65 x 105	9.3	1.54	72	52	25222E3	65222E3	45222E3	85222E3
	3300	65 x 105	11.4	2.31	48	35	25332E3	65332E3	45332E3	85332E3
	4700	76 x 105	15.0	3.29	34	25	15472E3	55472E3	35472E3	75472E3
	4700	76 x 146	15.4	3.29	34	25	25472E3	65472E3	45472E3	85472E3
	6800	76 x 146	18.3	4.76	24	18	25682E3	65682E3	45682E3	85682E3
	10 000	76 x 220	23.2	7.0	15	12	15103E3	55103E3	35103E3	75103E3
	10 000	90 x 146	25.1	7.0	15	12	-	-	45103E3	85103E3
	15 000	90 x 220	31.2	10.5	10	8	-	-	45153E3	85153E3

ELECTRICAL DATA AND ORDERING INFORMATION FOR 102 SERIES

U_R (V)	C_R 100 Hz (µF)	NOMINAL CASE SIZE Ø D x L (mm)	I_R 100 Hz 85 °C (A)	I_{L5} 5 min (mA)	ESR max. 100 Hz (mΩ)	Z max. 20 kHz (mΩ)	HIGH POST M5 DISC		HIGH CURRENT M6 DISC	
							ST ORDERING CODE MAL2102.....	ST BOLT NUT ORDERING CODE MAL2102.....	ST ORDERING CODE MAL2102.....	ST BOLT NUT ORDERING CODE MAL2102.....
385	220	35 x 60	2.1	0.17	575	380	18221E3	58221E3	-	-
	330	35 x 80	2.7	0.26	386	257	18331E3	58331E3	-	-
	470	35 x 80	3.1	0.37	279	188	18471E3	58471E3	-	-
	680	35 x 105	3.9	0.53	196	133	18681E3	58681E3	-	-
	1000	50 x 80	5.6	0.77	132	89	18102E3	58102E3	-	-
	1500	50 x 105	7.1	1.16	90	61	18152E3	58152E3	-	-
	2200	65 x 105	10.0	1.70	61	42	18222E3	58222E3	38222E3	78222E3
	3300	76 x 105	13.4	2.55	42	29	18332E3	58332E3	38332E3	78332E3
	4700	76 x 105	15.0	3.62	31	22	18472E3	58472E3	38472E3	78472E3
	4700	76 x 146	16.3	3.62	29	20	28472E3	68472E3	48472E3	88472E3
	6800	76 x 146	18.3	5.24	22	16	18682E3	58682E3	38682E3	78682E3
400	220	35 x 60	2.1	0.18	557	363	16221E3	56221E3	-	-
	330	35 x 60	2.5	0.26	383	254	16331E3	56331E3	-	-
	330	35 x 80	2.7	0.26	374	245	26331E3	66331E3	-	-
	470	35 x 80	3.1	0.38	271	180	16471E3	56471E3	-	-
	470	35 x 105	3.3	0.38	265	175	26471E3	66471E3	-	-
	680	35 x 105	3.9	0.55	191	128	16681E3	56681E3	-	-
	680	50 x 80	4.5	0.54	199	136	26681E3	66681E3	-	-
	1000	50 x 80	5.7	0.80	128	86	16102E3	56102E3	-	-
	1000	50 x 105	6.0	0.80	125	83	26102E3	66102E3	-	-
	1500	50 x 105	7.1	1.20	88	59	26152E3	66152E3	-	-
	2200	65 x 105	10.0	1.76	60	40	26222E3	66222E3	46222E3	86222E3
	3300	65 x 105	12.1	2.64	40	27	16332E3	56332E3	36332E3	76332E3
	3300	76 x 105	13.4	2.64	40	27	26332E3	66332E3	46332E3	86332E3
	4700	76 x 105	15.0	3.76	31	21	16472E3	56472E3	36472E3	76472E3
	4700	76 x 146	16.4	3.76	28	19	26472E3	66472E3	46472E3	86472E3
	6800	76 x 146	18.3	5.44	22	15	26682E3	66682E3	46682E3	86682E3
	10000	76 x 220	22.1	8.0	14	11	16103E3	56103E3	36103E3	76103E3
450	220	35 x 60	2.1	0.20	503	313	17221E3	57221E3	-	-
	330	35 x 80	2.7	0.30	339	212	27331E3	67331E3	-	-
	470	35 x 105	3.4	0.42	241	151	27471E3	67471E3	-	-
	680	50 x 80	4.9	0.61	159	98	27681E3	67681E3	-	-
	1000	50 x 80	5.7	0.90	118	75	17102E3	57102E3	-	-
	1000	50 x 105	6.1	0.90	114	72	27102E3	67102E3	-	-
	1500	50 x 105	7.1	1.35	81	52	17152E3	57152E3	-	-
	1500	65 x 105	8.3	1.35	81	52	27152E3	67152E3	47152E3	87152E3
	2200	65 x 105	10.1	1.98	55	35	17222E3	57222E3	37222E3	77222E3
	2200	76 x 105	11.2	1.98	55	35	27222E3	67222E3	47222E3	87222E3
	3300	76 x 105	13.5	2.97	37	24	17332E3	57332E3	37332E3	77332E3
	3300	76 x 146	13.9	2.97	37	24	27332E3	67332E3	47332E3	87332E3
	4700	76 x 146	16.4	4.23	26	17	17472E3	57472E3	37472E3	77472E3
	5600	76 x 146	17.3	5.04	23	15	17562E3	57562E3	37562E3	77562E3
	6800	76 x 220	19.8	6.1	25	20	17682E3	57682E3	37682E3	77682E3
	6800	90 x 146	21.3	6.1	24	19	-	-	47682E3	87682E3
	10 000	90 x 220	26.5	9.0	17	14	-	-	47103E3	87103E3

ADDITIONAL ELECTRICAL DATA		
PARAMETER	**CONDITIONS**	**VALUE**
Voltage		
Surge voltage	≤ 250 V versions	$U_s = 1.15 \times U_R$
	≥ 350 V versions	$U_s = 1.1 \times U_R$
Reverse voltage		$U_{rev} \leq 1$ V
Current		
Leakage current in µA	After 1 minute at U_R	$I_{L1} \leq 0.006\ C_R \times U_R$
	After 5 minutes at U_R	$I_{L5} \leq 0.002\ C_R \times U_R$
Inductance		
Equivalent series inductance (ESL)	Case Ø D = 35 mm	Typ. 13 nH
	Case Ø D = 50 mm	Typ. 16 nH
	Case Ø D = 65 mm	Typ. 19 nH (1)
	Case Ø D = 76 mm	Typ. 20 nH (1)
	Case Ø D = 90 mm	Typ. 21 nH (1)

Note
(1) Low ESL designs available on request

RIPPLE CURRENT AND USEFUL LIFE

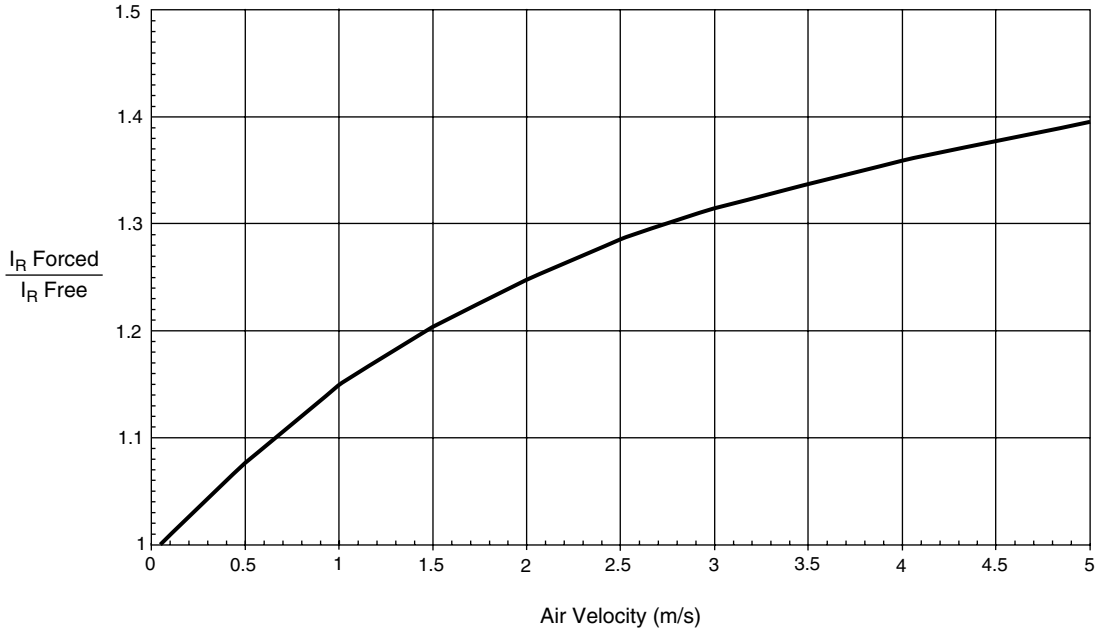
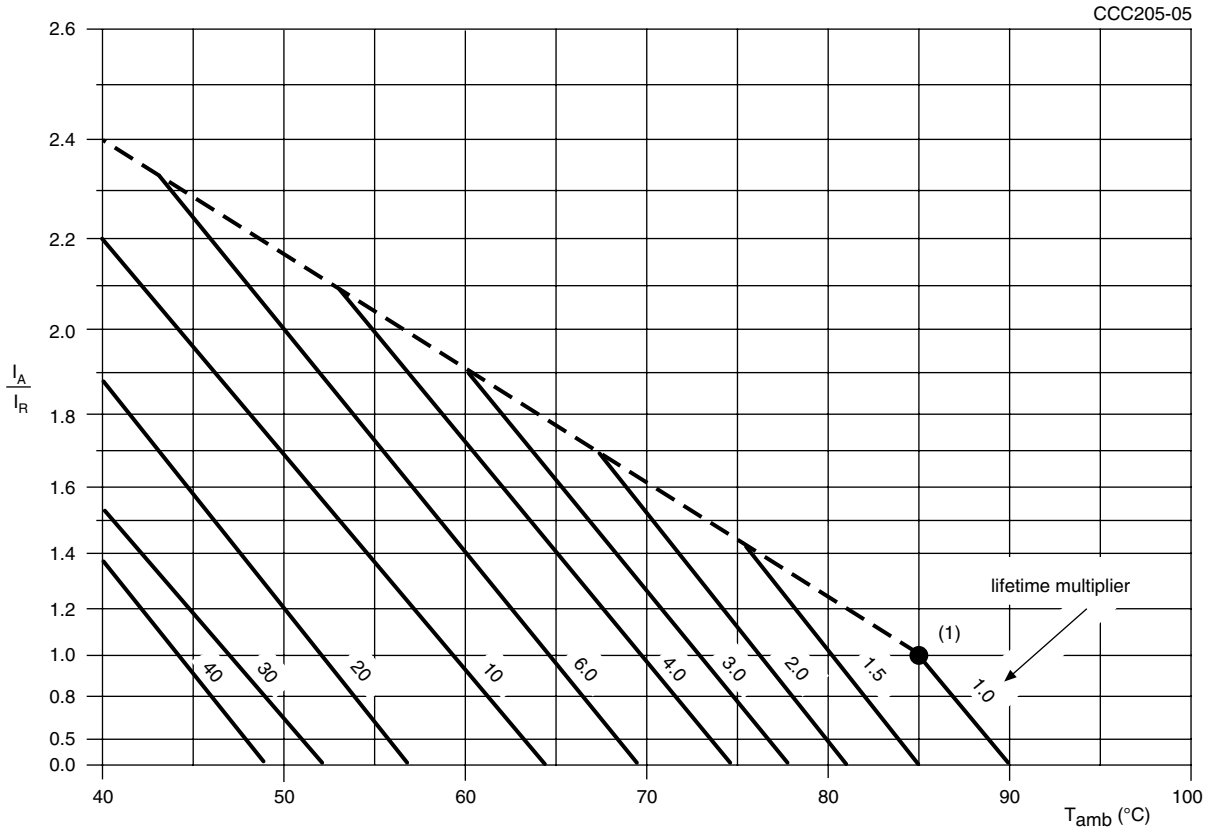


Fig.3 Multiplier of ripple current (I_R) as a function of air flow

MAXIMUM RIPPLE CURRENT			
PARAMETER	**CONDITION**	**MAXIMUM RIPPLE CURRENT MULTIPLIER**	**VALUE**
Ambient temperature (T_{amb})	70 °C	From nomogram; see fig. 4	1.6
Operating frequency (f)	400 Hz	From frequency; table 4	1.3
Air flow	2 m/s	From air-flow; see fig. 3	1.25

Note
• Calculation example for 102 series. Maximum ripple current multiplier = 1.6 x 1.3 x 1.25 = 2.6



I_A = actual ripple current at 100 Hz
I_R = rated ripple current at 100 Hz and 85 °C
(1) Useful life at 85 °C and I_R applied:
101 series: case Ø D ≤ 50: 10 000 h
case Ø D ≥ 65: 15 000 h
102 series: 10 000 h

Fig.4 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	
	101	102
50	0.85	0.90
100	1.00	1.00
200	1.10	1.20
400	1.15	1.30
1000	1.20	1.40
10 000	1.30	1.50

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} = 85 °C; U_R applied; 2000 hours	$U_R \leq 100$ V; ΔC/C: ± 15 % $U_R > 100$ V; ΔC/C: ± 10 % tan δ ≤ 1.3 x spec. limit Z ≤ 2 x spec. limit IL5 ≤ spec. limit
Useful life	CECC 30301 subclause 1.8.1	T_{amb} = 85 x C; U_R and I_R applied; 101 series: Case Ø D ≤ 50: 10 000 hours Case Ø D ≥ 65: 15 000 hours 102 series: 10 000 hours	$U_R \leq 100$ V; ΔC/C: ± 45 % $U_R > 100$ V; ΔC/C: ± 30 % tan δ ≤ 3 x spec. limit Z ≤ 3 x spec. limit I_{L5} ≤ spec. limit No short or open circuit, No visible damage Total failure percentage: $U_R \leq$ 100 V: ≤ 1 %; $U_R >$ 100 V: ≤ 3 %
Shelf life (storage at high temperature)	IEC 60384-4/ EN130300 subclause 4.17	T_{amb} = 85 x C; no voltage applied; 500 hours After test: U_R to be applied for 30 minutes, 24 hours to 48 hours before measurement	ΔC/C: ± 10 % tan δ ≤ 1.2 x spec. limit I_{L5} ≤ 2 x spec. limit

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Aluminum Capacitors

INTRODUCTION

For unambiguous processing of customer orders, a component supplier defines a system of product codes to uniquely identify a component, including its packaging. Two systems can be used:

1. Cleartext type
2. Index type

Cleartext Type

In this system the letters/digits in the product code are grouped. Each group has a predefined interpretation. This could be something like “positions number 6 and 7 describe product dimensions”. The accompanying table provides the reserved codes, e.g. “CF” for a radial product corresponds to dimensions 8.5 x 22 mm. The predefined interpretations give a direct link between the product code and the component’s parameters.

Index Type

In this system the product code is the index or sequence number of a record in a database. This record contains all information describing and uniquely identifying the component. Therefore this system does not require a relation between the product code and the component’s parameters.

VISHAY BCCOMPONENTS PRODUCT CODE

The Vishay BCcomponents Product Code, formerly known as 12NC, is an Index type product code. Although this system allows to use random product codes, a systematic approach is used to generate the bulk of the codenumbers. Unfortunately, the number of component variations is larger than the number of variations possible in this system. Therefore the interpretation described below covers about 80 % of the aluminum capacitor product codes found in the datasheets.

	PRODUCT CODE													
GROUP	1				2			3	4	5			6	
DIGIT	1	2	3	4	5	6	7	8	9	10	11	12	13	14
ORDER CODE	M	A	L	2	0	3	8	3	1	4	7	9	E	3
FORMER 12NC	2	2	2	2	0	3	8	3	1	4	7	9		

Note

The order code (MAL....) was introduced in 2007 to accommodate a change in the logistic system. To minimize errors when converting from the former 12NC to the new order code, or vice versa, only six conversion schemes are used:

ORDER CODE	FORMER 12NC	COMMENT
MAL2xxxyyyyyE3	2222 xxx yyyyy	
MAL2xxxyyyyy	2222 xxx yyyyy	For non lead (Pb)-free versions, e.g. 123 SAL-A
MAL2xxxyyyyyE3	2281 xxx yyyyy	See explanation of Group 1
MAL2xxxyyyyyE6	2222 xxx yyyyy	See explanation of Group 6
MAL5xxxyyyyyE3	2215 xxx yyyyy	See explanation of Group 1
MAL8xxxyyyyy	4322 xxx yyyyy	For Accessories

Group 1

This group consists of 4 digits, positions 1 - 4. It can have the following values:

ORDER CODE	FORMER 12NC	
MAL2	2222	Most common. No special meaning
MAL2	2281	Lead (Pb)-free, RoHS compliant product. Only used for specific series.
MAL5	2215	Lead (Pb)-free, RoHS compliant product. Only used for specific series.
MAL8	4322	Accessories

Group 2

This group consists of 3 digits, positions 5 - 7. This group identifies the series.
The digits are the same as those in the series name. In some cases a series name contains two groups of three digits. In that case the first group in the series name identifies components with rated voltage ≤ 100 V and the second group the components with rated voltage > 100 V.

Examples

038	Component from 038 RSU series
056	≤ 100 V rated component from 056/057 PSM-SI series
057	> 100 V rated component from 056/057 PSM-SI series

Group 3

This group consists of 1 digit, position 8. This group describes packaging, termination type, case size and tolerance. Due to its many functions, there is no single interpretation.

Example, for radial products

3	Form TFA, taped, wide lead pitch, in ammopack
5	Form CA, bulk packaging, long leads
6	Form CB, bulk packaging, short leads
7	Form TNA, taped, narrow lead pitch, in ammopack

For a non-catalogue component, a.k.a. “special”, the digits for Group 3 and Group 4 are “90”, as in e.g. MAL203890012E3

Group 4

This group consists of 1 digit, position 9. This group describes the rated voltage. The interpretation of the digit is linked to the coding of Group 2.

≤ 100 V

0	35 V	5	16 V
1	50 V	6	25 V
2	4.0 V/80 V	7	40 V
3	6.3 V	8	63 V
4	10 V	9	100 V

> 100 V

0	Reserved	5	350 V
1	160 V	6	400 V
2	200 V	7	450 V
3	250 V	8	385 V
4	420 V	9	500 V

For a non-catalogue component, a.k.a. “special”, the digits for Group 3 and Group 4 are “90”, as in e.g. MAL203890012E3

Group 5

This group consists of 3 digits, positions 10 - 12. This group reflects the capacitance value in µF. The first two digits represent the value, the third digit represents the multiplier, e.g. 479 means 47 x 1 = 47 µF.

Multiplier (position 12)

0	Not used	5	x 100 000
1	x 10	6	x 1 000 000
2	x 100	7	x 0.01
3	x 1000	8	x 0.1
4	x 10 000	9	x 1

For a non-catalogue component, a.k.a. "special", the digits for Group 5 are sequential numbers.

Group 6

This group consists of 2 alphanumeric characters, positions 13 - 14. It enables to differentiate, between a lead (Pb)-free, RoHS compliant version and non lead (Pb)-free, non RoHs compliant version, when both could exist. It can have following values:

	Non lead (Pb)-free, non RoHS compliant product
E3	Lead (Pb)-free, RoHS compliant product.
E6	Lead (Pb)-free, RoHS compliant product. Bismuth, Bi, containing solder finish.

REPLACEMENT SERIES TABLE				
WITHDRAWN SERIES		DESIGN	REMARK	REPLACEMENT SERIES
ORDERING CODE	FORMER PARTNUMBER			
-	2222 054 …..	Snap-In	General purpose, 85 °C	056/057 PSM-SI
-	2222 055 …..	Snap-In	General purpose, 85 °C	056/057 PSM-SI
-	2222 086 …..	Screw Terminal	General purpose, 85 °C	101/102 PHR-ST
-	2222 087 …..	Screw Terminal	General purpose, 85 °C	101/102 PHR-ST
-	2222 088 …..	Screw Terminal	General purpose, 85 °C	101/102 PHR-ST
-	2222 089 …..	Screw Terminal	General purpose, 85 °C	101/102 PHR-ST
-	2222 111 …..	Screw Terminal	General purpose, 85 °C	101/102 PHR-ST
-	2222 112 …..	Screw Terminal	General purpose, 85 °C	101/102 PHR-ST
-	2222 114 …..	Screw Terminal	Long Life, 85 °C	106 PED-ST
-	2222 115 …..	Screw Terminal	Long Life, 85 °C	101/102 PHR-ST
-	2222 154 …..	Screw Terminal	Long Life, 85 °C	101/102 PHR-ST
-	2222 155 …..	Screw Terminal	Long Life, 85 °C	101/102 PHR-ST
-	2222 166 …..	4 Terminal Snap-In	Long Life, 85 °C	Contact sales
-	2222 167 …..	4 Terminal Snap-In	Long Life, 85 °C	Contact sales
-	2222 168 …..	4 Terminal Snap-In	Long Life, 105 °C	Contact sales
-	2222 169 …..	4 Terminal Snap-In	Long Life, 105 °C	Contact sales
-	3148…….	Screw Terminal	High Ripple ≤ 75 V, 105 °C	Contact sales
-	3173…….	Screw Terminal	Long Life, 85 °C	101/102 PHR-ST
-	3186…….	Screw Terminal	General purpose, 85 °C	101/102 PHR-ST
-	3188…….	Screw Terminal	General purpose, 85 °C	101/102 PHR-ST
-	3191…….	Screw Terminal	General purpose, 85 °C	101/102 PHR-ST
-	3198…….	Screw Terminal	General purpose, 105 °C	104 PHL-ST
-	3199…….	Screw Terminal	General purpose, 85 °C	101/102 PHR-ST
-	3500…….	Screw Terminal	Motor Start	No replacement
MALTEYE……..	EYE……..	Screw Terminal	General purpose, 85 °C	101/102 PHR-ST
MALTEYM……..	EYM……..	Screw Terminal	General purpose, 85 °C	101/102 PHR-ST
MALTEYP……..	EYP……..	Screw Terminal	General purpose, 85 °C	101/102 PHR-ST
MALIEYS……..	EYS……..	Snap-In	General purpose ≤ 100 V, 105 °C	EYH
MALIEYS……..	EYS……..	Snap-In	General purpose > 100 V, 85 °C	093 PMG-SI

Aluminum Capacitors

WARNING

Correct application and strict adherence to the important information listed below will ensure optimum performance of the capacitors over their entire specified useful life.

Please note that ignoring these rules may reduce the equipment lifetime or even destroy the capacitor, together with parts of the equipment or property involved. The consequences may be a short or open circuit of the component, leakage of electrolyte or heat generation. Opening of the case or vent (danger of injury) may be regarded as hazardous and cause liquids, vapors or dust to be released. Similar precautions should be taken when testing aluminum capacitors.

Please consult your local Vishay sales organization, if one or more of these limits cannot be adhered to.

GUIDELINES

PARAMETER	IMPORTANT INFORMATION - PRODUCT SAFETY	MORE DETAILS
DESIGN		
VOLTAGE	**Do not apply a voltage exceeding the capacitor's voltage rating.** Check the maximum voltage across the capacitor that may occur over the whole equipment life. In normal operation the rated voltage of the capacitor shall not be exceeded; if so, early failures may occur. However, for short periods the voltage may be raised up to surge voltage value (see Detail Specification); for conditions and maximum parameter changes, see section *"Tests and Requirements"*.	Detail Specification TESTS AND REQUIREMENTS
RIPPLE LOAD	**Do not allow excessive ripple current to pass.** The rated ripple current as calculated for the application conditions (see section "Introduction"), shall not be exceeded. If so, early failure may result. **Keep ripple voltage within ratings.** The sum of DC-bias and maximum amplitude of ripple voltage shall be within rated voltage and 0 V. Aluminum capacitors are not normally designed for AC application.	Detail Specification INTRODUCTION
TEMPERATURE CHANGE	**Use capacitors within specified temperature range.** Applicable temperature range is given in the relevant detail specification. A general principle is that lower ambient temperature means longer life; therefore, wherever possible, aluminum capacitors should be placed at the coolest positions on the board (please ensure that aluminum capacitors are placed away from 'heating' components such as power resistors, switching diodes/transistors or transformers). Exceeding the permitted temperature range may cause early failures.	Detail Specification
CHARGE-DISCHARGE	**Observe charge-discharge limitations.** Frequent charge-discharge load via low resistance may cause capacitance drop or destroy the capacitor. Under well defined conditions (see section *"Tests and Requirements")* frequent charge-discharge operation is allowed. The resulting current through the capacitor must not exceed the ripple current limit. Standard aluminum capacitors are not suitable for flash applications.	TESTS AND REQUIREMENTS
SERIES/ PARALLEL CONNECTIONS	**When connecting in series/parallel, apply corresponding design rules.** Connecting aluminum capacitors in series/parallel is possible, provided that balancing resistors are applied to each capacitor, in order to stabilize the voltage over each individual capacitor. Rules for correct design are given in section "Introduction".	INTRODUCTION
PC BOARD DESIGN	Conducting tracks or lands should not be located under upright mounted aluminum capacitors; short circuits under the capacitor with danger of fire could be the result.	
INSULATION	**The capacitor case is not insulated from the cathode terminal.** Axial capacitors have a direct contact between case and cathode terminal; radial and power capacitors exhibit an indeterminate resistance between the cathode terminal and the metal case. Metal parts other than terminals should never make contact with conducting tracks or metal parts of other components. Dummy pins should be connected to the cathode.	
MOUNTING		
POLARITY, REVERSE VOLTAGE	**Aluminum capacitors for DC applications require polarization.** Check the polarity of each capacitor: both in circuit design and in mounting (polarity is clearly indicated on the capacitor). For short periods a limited reverse voltage is allowed (see Detail Specification); for conditions and maximum parameter changes, see section "*Tests and Requirements"*. Exceeding reverse voltage may result in early failures.	Detail Specification TESTS AND REQUIREMENTS

GUIDELINES		
PARAMETER	**IMPORTANT INFORMATION - PRODUCT SAFETY**	**MORE DETAILS**
PLACEMENT	**Avoid excessive stress to the lead wires or terminals.** Excessive stress can be caused by component processing machines if lead wires are not sufficiently fixed during bending, cutting, cropping or inserting operations. Other possible reasons are incorrect hole distance on the printed circuit or bending of the component after soldering. Care should be taken when the manual bending of terminals or mounted capacitors is required. For maximum allowed mechanical load and time of application, see section *"Tests and Requirements"*. Mechanically damaged capacitors may not be used. Pressure relief should have enough space to function correctly.	TESTS AND REQUIREMENTS
SOLDERING	**Keep soldering temperature and time under control.** For maximum soldering conditions, see section *"Tests and Requirements"*. Additional temperature load e.g. for curing the glue of Surface Mount Devices (SMDs) are allowed to a certain limit, which depends on series and exact details. Please apply to your sales engineer for your specific conditions. Molten solder or the soldering iron should not make contact with the capacitor's insulation. Reflow soldering is only suitable for SMD components.	TESTS AND REQUIREMENTS
BOARD CLEANING	**No guarantees can be given with regard to solvents based on halogenated hydrocarbons or ozone depleting chemicals (ODCs).** **Warning: such solvents are hazardous to the environment.** Component cleaning using solvents such as demineralized or distilled water, isopropanol, methanol, ethanol and propanol would not normally have any detrimental effects and therefore do not require any special precautions. Aqueous cleaning methods may be used in conjunction with saponification using a neutral detergent like calgonite at 20 g/l. It is recommended that immediate drying of the component in hot air is carried out at approximately 85 °C (or 70 °C for products with an upper category temperature of 70 °C) for at least 5 minutes. For further information regarding the application of solvent temperatures exceeding the temperature mentioned in *"IEC 60068-2-45"*, consult your local Vishay sales organization.	
ADHESIVES, COATING MATERIALS	**Some adhesives and coating materials affect capacitors adversely.** For varnishing, coating, lacquering, embedding or gluing at the capacitor's sealing, ensure that the materials used are halogene-free in all their constituent parts (base material, thinners, binders, reacting agents, propellants, additives). For reasons see 'BOARD CLEANING' above. When applying such materials, ensure that non-aluminum parts, e.g. the rubber area, are not completely sealed off.	
STORAGE AND TRANSPORT		
STORAGE CONDITIONS, HANDLING	**Excessive storage time or conditions may have adverse effects on capacitors.** Capacitors should be stored at room temperature, low humidity and out of direct sunlight. Storage at elevated temperature and/or high relative humidity may have a negative influence on taping accuracy, solderability, leakage current and life expectancy. Packages with aluminum capacitors should be handled with care, otherwise bent leads and/or incorrect taping dimensions could be the result.	INTRODUCTION TESTS AND REQUIREMENTS
HIGH AIR PRESSURE	**Do not expose capacitors to overpressure.** Maximum operating pressure is 150 kPa. Higher pressure may cause a short circuit.	
LOW AIR PRESSURE	**The capacitors may be used up to an altitude of ≤ 12 000 m.** Minimum air pressure: 8.5 kPa for short periods (in accordance with *"IEC 60384-4, sub clause 4.11.4"*).	TESTS AND REQUIREMENTS
DISINFECTING E.G. FOR SARS	**No guarantees can be given when disinfectants are/have been used.** Disinfectants may contain halogens like chlorine, fluorine, bromine etc. and alkaline solutions. Disinfectants should not be used near or on the capacitor. Over time they can cause corrosive reactions to capacitors resulting in reduced capacitance, open circuits etc. For further information please consult your local Vishay sales organization	
EMERGENCY		
PERSONNEL SAFETY	**WARNING NOTE.** Non-solid aluminum capacitors may contain chemicals which can be regarded as hazardous if handled incorrectly. Caution is necessary if the outer case is fractured; vapors or dust particles should not be inhaled (good ventilation is essential); skin, eye or clothing contact with liquids should be avoided. In case of such contact, flush thoroughly with running water as soon as possible, then wash skin or clothing with soap and water or a mild detergent. Any possible discoloration of the wetted skin will disappear after a few days. In the event of fire, the organic parts of aluminum capacitors may release such constituents as carbon monoxide, nitric oxides or dust particles; take caution when breathing-in.	
END OF LIFE		
DISPOSAL	**Aluminum capacitors are subject to special waste regulations.** Aluminum capacitors are free from PCB- or PBDE-containing substances. Dioxines or furanes are not constituent parts of aluminum capacitors. However, because of other polluting ingredients, larger quantities (in weight) of aluminum capacitors are subject to special waste regulations in accordance with the relevant national laws; please consult your local Vishay sales organization. In general, disposal of aluminum capacitors must take place under controlled circumstances in a high temperature incinerator at minimum 900 °C.	

Aluminum Capacitors

TESTS AND REQUIREMENTS

This datasheet contains an abridged version of tests and requirements given in *"IEC 60384-4"* or *"EN130300"* respectively. Correct sequence of measurement for electrical parameters in accordance with *"IEC 60384-4"*:

1. Leakage current
2. Capacitance
3. Tan δ or ESR
4. Impedance

Table 1

NON-SOLID ALUMINUM TYPES				
NAME OF TEST	**IEC 60384-4/ EN130300 subclause**	**IEC 60068-2 TEST METHOD**	**PROCEDURE (quick reference)**	**REQUIREMENTS**
Robustness of terminations:	4.4			
Tensile strength		Ua	leaded types: loading force 10 N for 10 s power types: loading force 20 N for 10 s	no visible damage
Bending		Ub	leaded types: loading force 5 N two consecutive bends	no visible damage
Torsion		Uc	leaded types, axial: two successive rotations of 180° in opposite direction; 5 s per rotation	no visible damage
Torque on nut (stud)		Ud	power types/screw terminal: torque of 176 Nm gradually applied	no visible damage
Resistance to soldering heat	4.5	Tb (method 1A)	solder bath: 260 °C; 10 s	no visible damage; marking legible $\Delta C/C$: ± 5 %
Solderability	4.6	Ta	solder bath: 235 °C; 2 s; immersed up to 2 mm from the body; non activated flux	no visible damage; marking legible ≥ 95 % tinning
Rapid change of temperature	4.7	Na	for Snap-In, DIN-PW and Screw Terminal capacitors: 5 cycles of 3 h at lower and upper category temperature for axial, radial and SMD capacitors: 5 cycles of 30 min at lower and upper category temperature	no visible damage; no leakage of electrolyte
Vibration (note 1)	4.8	Fc	10 Hz to 500 Hz; 0.75 mm or 10 g (whichever is less); 3 directions; 2 h per direction form MR or ST types: 10 Hz to 55 Hz; 0.75 mm or 10 g (whichever is less); 3 directions; 2 h per direction	no visible damage; no leakage of electrolyte; marking legible $\Delta C/C$: ± 5 % with respect to initial measurements
Bump (note 1)	4.9	Eb	40 g; 2 directions; 4000 bumps total form MR: 40 g; 2 directions; 1000 bumps total	no visible damage; no leakage of electrolyte $\Delta C/C$: ± 5 % with respect to initial measurement
Climatic sequence:	4.11			
Dry heat	4.11.1	Ba	16 h at upper category temperature; no voltage applied	no visible damage; no leakage of electrolyte
Damp heat, cyclic	4.11.2	Db	1 cycle (55 °C → 25 °C) of 24 h; RH 95 % to 100 %; no voltage applied	
Cold	4.11.3	Aa	2 h at lower category temperature; no voltage applied	no visible damage; no leakage of electrolyte

Table 1 (continued)

NON-SOLID ALUMINUM TYPES				
NAME OF TEST	**IEC 60384-4/ EN130300 subclause**	**IEC 60068-2 TEST METHOD**	**PROCEDURE (quick reference)**	**REQUIREMENTS**
Low air pressure	4.11.4	M	5 min at 25 °C ± 10 °C; at atmospheric pressure of 8.5 kPa; U_R applied during last min	no visible damage; no evidence of breakdown or flashover
Damp heat, cyclic	4.11.5	Db	5 cycles (55 °C → 25 °C) of 24 h each; RH 95 % to 100 %; no voltage applied	
Sealing	4.11.6	Qc	1 min in water at 90 °C	no continuous chain of bubbles
	4.11.7		final measurement after climatic sequence	no visible damage; no leakage of electrolyte; marking legible leakage current ≤ stated limit tan δ ≤ 1.2 x stated limit ΔC/C: ± 10 %
Insulation resistance	4.3.5		insulation sleeve: foil method	insulation resistance ≥ 100 MΩ
Voltage proof	4.3.6		insulation sleeve: foil method; 1000 V for 1 min	no breakdown or flashover
Damp heat, steady state	4.12	Ca	56 d at 40 °C; RH 90 % to 95 %; no voltage applied	no visible damage; no leakage of electrolyte; marking legible leakage current ≤ stated limit tan δ ≤ 1.2 x stated limit insulation resistance > 100 MΩ; no breakdown or flashover below 1000 V ΔC/C: ± 10 %
Endurance	4.13		for test duration, refer to the relevant data sheet in this data handbook; at upper category temperature; U_R applied	no visible damage; no leakage of electrolyte; marking legible leakage current ≤ stated limit insulation resistance > 100 MΩ; no breakdown or flashover below 1000 V U_R ≤ 6.3 V; ΔC/C: + 15 %/- 30 %; 6.3 V < U_R < 200 V; ΔC/C: ± 15 %; U_R ≥ 200 V; ΔC/C: ± 10 % tan δ ≤ 1.3 x stated limit impedance ≤ 2 x stated limit
Surge	4.14		from source of 1.15 x U_R for U_R ≤ 315 V or 1.1 x U_R for U_R > 315 V RC = 0.1 s ± 0.05 s 1000 cycles of 30 s on, 330 s off, at upper category temperature	no visible damage; no leakage of electrolyte leakage current ≤ stated limit tan δ ≤ stated limit ΔC/C: ± 15 %

Table 1 (continued)

NON-SOLID ALUMINUM TYPES				
NAME OF TEST	**IEC 60384-4/ EN130300 subclause**	**IEC 60068-2 TEST METHOD**	**PROCEDURE (quick reference)**	**REQUIREMENTS**
Reverse voltage	4.15		1 V in reverse polarity followed by U_R in forward polarity, both for 125 h at upper category temperature	leakage current ≤ stated limit tan δ ≤ stated limit ΔC/C: ± 10 %
Pressure relief (only for types with vent)	4.16		DC voltage applied in reverse direction producing a current of 1 A to 10 A	pressure relief opens prior to danger of explosion or fire
Storage at upper category temperature	4.17	Ba	test duration 500 h at upper category temperature; for longer test duration (shelf life), refer to the relevant data sheet in this data handbook	no visible damage; no leakage of electrolyte leakage current ≤ 2 x stated limit tan δ ≤ 1.2 x stated limit ΔC/C: ± 10 %
Storage at low temperature	4.18	Ab	72 h at the lower category temperature	no visible damage; no leakage of electrolyte leakage current ≤ stated limit tan δ ≤ stated limit ΔC/C: ± 10 %
Characteristics at high and low temperatures	4.19		step 1: reference measurement of impedance at 20 °C and 100 Hz	
		Aa	step 2: measurement at lower category temperature	impedance at 100 Hz: ≤ 7 x value of step 1 for U_R ≤ 6.3 V or U_R > 160 V; ≤ 5 x value of step 1 for 6.3 V < U_R ≤ 16 V; ≤ 4 x value of step 1 for 16 V U_R 160 V
		Ba	step 3: measurement at upper category temperature	leakage current: ≤ 10 x stated limit at 125 °C; ≤ 8 x stated limit at 105 °C; ≤ 5 x stated limit at 85 °C; ≤ 3 x stated limit at 70 °C
Charge and discharge	4.20		for U_R ≤ 160 V: 10^6 cycles of 0.5 s charge to U_R (RC = 0.1 s) and 0.5 s discharge (RC = 0.1 s); for U_R > 160 V: under consideration	no visible damage; no leakage of electrolyte ΔC/C: ± 10 %
Additional tests in accordance with IEC 60384-1 and EN 130000				
Solvent resistance	4.31	Xa	immersion: 5 min ± 0.5 min with or without ultrasonic at 55 °C ± 0.5 °C solvents: demineralized water and/or calgonite solution (20 g/l)	visual appearance not affected
Passive flammability	4.38	IEC 60695-2-2	needle flame test	category of flammability: B

Notes

For vibration and bump testing, the components shall be mounted by their terminations (with mounting accessories where applicable).
The following capacitors shall also be clamped by their body:

a) Radial types: Ø D_{nom} ≥ 12.5 mm; L_{nom} ≥ 15 mm

b) Axial types: Ø D_{nom} ≥ 12.5 mm; L_{nom} ≥ 30 mm.

Table 2

SOLID ALUMINUM TYPES, SAL				
NAME OF TEST	**IEC 60384-4/ EN130300 subclause**	**IEC 60068-2 TEST METHOD**	**PROCEDURE (quick reference)**	**REQUIREMENTS**
Robustness of terminations:	4.4			
Tensile strength (note 1)		Ua	loading force; 10 N for 10 s	no visible damage
Bending (note 1)		Ub	loading force; 5 N; two consecutive bends	no visible damage
Torsion (axial types)		Uc	two successive rotations of 180° in opposite direction; 5 s duration per rotation	no visible damage
Resistance to soldering heat	4.5	Tb (method 1A)	radial types: solder bath: 260 °C; 10 s	no visible damage; markings legible $\Delta C/C$: ± 5 % with respect to initial measurement
		Tb (method 1B)	axial types: solder bath 350 °C for 3.5 s	
Solderability	4.6	Ta (method 1)	solder bath: 235 °C; 2 s immersed up to 2 mm from the body; non activated flux	no visible damage; marking legible ≥ 95 % tinning
Rapid change of temperature	4.7	Na	5 cycles of 30 min at lower and upper category temperature	no visible damage leakage current tan δ and $Z \leq$ stated limit
Vibration (note 2)	4.8	Fc	10 Hz to 500 Hz; 0.75 mm or 10 g (whichever is less severe); in 3 directions; 2 h per direction	no visible damage; markings legible $\Delta C/C$: ± 5 % with respect to initial measurement
			128 SAL-RPM: 10 Hz to 2000 Hz; 1.5 mm or 20 g (whichever is less severe); in 3 directions; 2 h per direction	no visible damage; markings legible $\Delta C/C$: ± 5 % with respect to initial measurement
Bump (note 2)	4.9	Eb	40 g; 2 directions; 4000 bumps total	no visible damage $\Delta C/C$: ± 5 % with respect to initial measurement
Shock (note 2)	4.10	Ea	123 SAL-AG: acceleration: 29400 m/s^2 or 3000 g; duration of pulse: 0.2 ms; total number of shocks: 18	no visible damage $\Delta C/C$: ± 5 % with respect to initial measurement

Table 2 (continued)

SOLID ALUMINUM TYPES, SAL				
NAME OF TEST	**IEC 60384-4/ EN130300 subclause**	**IEC 60068-2 TEST METHOD**	**PROCEDURE (quick reference)**	**REQUIREMENTS**
Climatic sequence:	4.11			
Dry heat	4.11.1	Ba	16 h at upper category temperature; no voltage applied	
Damp heat, cyclic	4.11.2	Db	1 cycle (55 °C → 25 °C) of 24 h; RH 95 % to 100 %; no voltage applied	no breakdown, flashover, or harmful deformation of case
Cold	4.11.3	Aa	2 h at lower category temperature; no voltage applied	
Low air pressure	4.11.4	M	5 min at 25 °C ± 10 °C; atmospheric pressure: 8.5 kPa; U_R applied during last min of test	
Damp heat, cyclic	4.11.5	Db	5 cycles (55 °C → 25 °C) of 24 h each; 25 °C; RH 95 % to 100 %; no voltage applied	
	4.11.7		final measurements after climatic sequence	no visible damage; markings legible
				leakage current ≤ stated limit
				tan δ and Z ≤ 1.2 x stated limit
				axial types: ΔC/C: ± 5 % with respect to initial measurement
				radial types: ΔC/C: ± 10 % with respect to initial measurement
Damp heat, steady state	4.12	Ca	56 d at 40 °C: RH 90 % to 95 %; no voltage applied	no visible damage; markings legible
				leakage current ≤ stated limit
				tan δ and Z ≤ 1.2 x stated limit
				ΔC/C: ± 10 % of initial measurement
Insulation resistance	4.3.5		insulation sleeve: foil method	insulation resistance ≥ 100 MΩ
Voltage proof	4.3.6		insulation sleeve: foil method; 1000 V for 1 min	no breakdown or flashover
Endurance	4.13		for test duration, refer to the relevant data sheet in this data handbook; at upper category temperature; U_R applied (note 3)	no visible damage; markings legible
				leakage current ≤ stated limit
				ΔC/C: ± 10 % with respect to initial measurement
				tan δ and Z ≤ 1.2 x stated limit
				axial types: insulation resistance ≥ 100 MΩ; no breakdown or flashover at 1000 V
Endurance (additional)			2000 h at 175 °C; maximum 0.63 x U_R applied	leakage current ≤ stated limit
				ΔC/C: ± 20 % with respect to initial measurement
				tan δ ≤ 1.5 x stated limit
				Z ≤ 2.5 x stated limit

Table 2 (continued)

SOLID ALUMINUM TYPES, SAL				
NAME OF TEST	**IEC 60384-4/ EN130300 subclause**	**IEC 60068-2 TEST METHOD**	**PROCEDURE (quick reference)**	**REQUIREMENTS**
Surge	4.14		applied voltage source of 1.15 x U_R (note 3) at 125 °C; 1000 cycles; 30 s on, 330 s off	no visible damage leakage current ≤ stated limit tan δ ≤ stated limit
				axial types: ΔC/C: ± 5 % with respect to initial measurement
				radial types: ΔC/C: ± 10 % with respect to initial measurement
Reverse voltage	4.15		0.15 x U_R (note 3) in reverse polarity at 125 °C for 125 h, followed by U_R (note 3) in forward polarity at 125 °C for 125 h	leakage current ≤ stated limit ΔC/C: ± 10 % with respect to initial measurement tan δ and Z ≤ stated limit
Reverse voltage (additional): Radial types			0.30 x U_R (note 3) in reverse polarity at 125 °C for 125 h, followed by U_R (note 3) in forward polarity at 125 °C for 125 h	leakage current ≤ stated limit ΔC/C: ± 10 % with respect to initial measurement tan δ and Z ≤ stated limit
Reverse voltage (additional): Axial types			0.30 x U_R in reverse polarity at 125 °C for 2000 h	leakage current ≤ stated limit ΔC/C: ± 10 % with respect to initial measurement tan δ and Z ≤ stated limit
Storage at upper category temperature	4.17	Ba	500 h at upper category temperature	no visible damage leakage current ≤ stated limit ΔC/C: ± 10 % with respect to initial measurement
Long storage ≥ 1 year (additional)			at ambient temperature	leakage current ≤ stated limit
Characteristics at high and low temperature	4.19		step 1: reference measurement at 20 °C of capacitance, tan δ and impedance at 100 Hz	
			step 2: measurement at - 55 °C; tan δ and impedance at 100 Hz	ΔC/C: ± 20 % with respect to value in step 1 impedance ratio (100 Hz) ≤ 2 x the value of step 1 tan δ ≤ 2 x the stated limit
			step 3: measurement at 125 °C capacitance, leakage current and tan δ	leakage current ≤ 15 x the stated limit; (notes 4 and 5) ΔC/C: ± 20 % of the value measured in step 1 tan δ ≤ stated limit
Charge and discharge	4.20		10^6 cycles charging to U_R for 0.5 s, and then discharging for 0.5 s	no visible damage ΔC/C: ± 5 % with respect to initial measurement

Table 2 (continued)

SOLID ALUMINUM TYPES, SAL				
NAME OF TEST	**IEC 60384-4/ EN130300 subclause**	**IEC 60068-2 TEST METHOD**	**PROCEDURE (quick reference)**	**REQUIREMENTS**
Additional tests in accordance with IEC 60384-1 and EN130000				
Solvent resistance	4.31	Xa	immersion: 5 min ± 0.5 min with or without ultrasonic at 55 °C ± 0.5 °C solvents: demineralized water and/or calgonite solution (20 g/l)	visual appearance not affected
Passive flammability	4.38	IEC 60695-2-2	needle flame test	category of flammability: B

Notes

1. SPECIAL PLIERS MUST BE USED TO PROTECT THE CELL BODY AND CONSEQUENTLY KEEP THE BENDING LOCATION UNDER CONTROL.
2. Axial capacitors shall be mounted by clamping both the body and the leads.
3. U_R at 125 °C is 25 V for 35 V and 40 V versions.
4. For radial types, 40 V version: < 8 x the stated limit.
5. Leakage current for axial types: $\leq 1.5 \times U_R \times C_R$.

Aluminum Capacitors

MECHANICAL DATA

CLAMPS FOR ST TYPES

To facilitate vertical mounting, a series of rigid clamps is available. These are made of zinc plated steel, chromium(III) passivated, or stainless steel (Ø D = 76 mm).

The clamps have either two or three mounting lugs, may be easily slipped over the capacitor and then clamped with a nut and bolt. Five types of clamps are available, one for each case diameter.

They are delivered without nuts or bolts, except for Ø D = 90 mm, where they are included.

To avoid damaging the insulation sleeve, do not overtighten the clamp screw.

DIMENSIONS in millimeters AND AVAILABLE FORMS

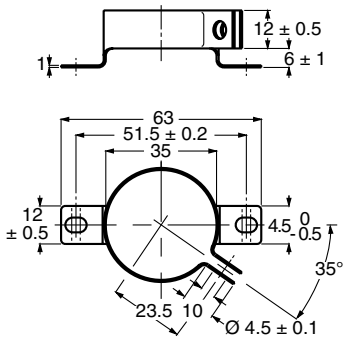


Fig.1 Dimensional outline of clamp for case Ø D = 35 mm

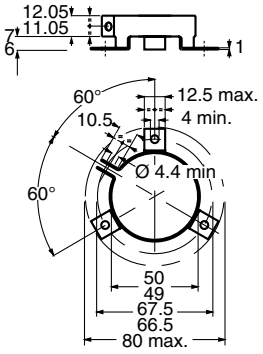


Fig.2 Dimensional outline of clamp for case Ø D = 50 mm

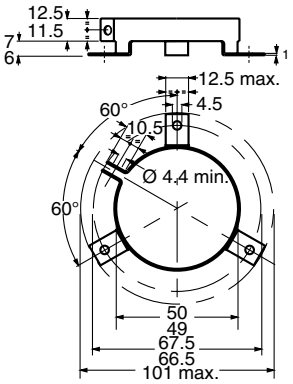


Fig.3 Dimensional outline of clamp for case Ø D = 65 mm

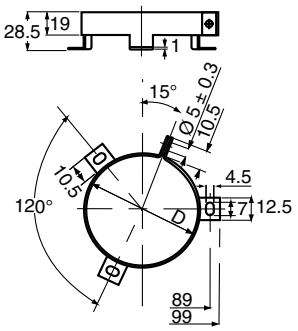


Fig.4 Dimensional outline of clamp for case Ø D = 76 mm

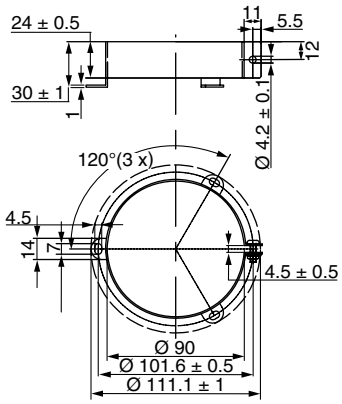


Fig.5 Dimensional outline of clamp for case Ø D = 90 mm

Table 1

MOUNTING CLAMPS FOR SCREW TERMINALS	
CASE DIAMETER	**ORDERING CODE**
35	MAL804324031E3
50	MAL804324051E3
65	MAL804324061E3
76	MAL804323321E3
90	MAL804324921E3

NUTS AND WASHERS FOR STB-VERSIONS

When mounting with the bolt, which is an integral part of the case, standard metal M8 and M12 nuts and washers may be used; the maximum permissible torque is 4 Nm for M8 nuts and 10 Nm for M12 nuts.

If insulated mounting is required, synthetic nuts and rubber washers are available; for these nuts the maximum permissible torque is 2 Nm (M8) and 4 Nm (M12).

DIMENSIONS in millimeters AND AVAILABLE FORMS

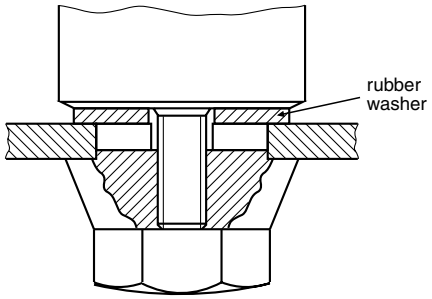


Fig.6 Insulated mounting

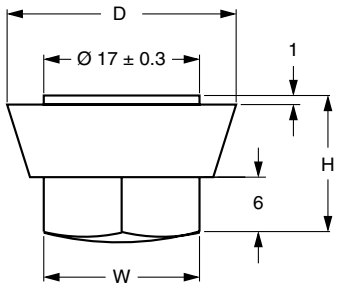


Fig. 7 Synthetic cap nut; see Table 2 for dimensions D, H and W

Table 2

SYNTHETIC CAP NUTS						
CASE DIAMETER (mm)	**THREAD**	**D (mm)**	**H (mm)**	**W (1) (mm)**	**MIN. THREADED DEPTH (mm)**	**ORDERING CODE**
35	M8	25	15	17	11.5	MAL804305561E3
≥ 50	M12	30	20	19	15.5	MAL804305571E3

Note

(1) Dimension W is measured across flats.

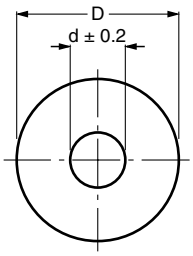


Fig.8 Rubber washer; thickness 2 mm

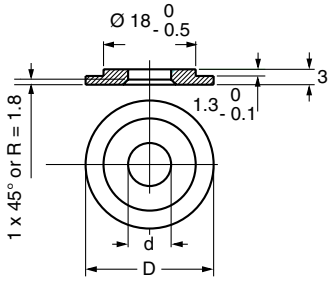


Fig.9 Insulating shouder disk

RUBBER WASHERS		
D (mm)	**d (mm)**	**ORDERING CODE**
34	8.4	MAL804305591E3
49	13.0	MAL804305531E3
64	13.0	MAL804305521E3
74	13.0	MAL804313001E3

INSULATING SHOULDER DISKS		
D (mm)	**d (mm)**	**ORDERING CODE**
25	8.4	MAL804320381E3
30	12.5	MAL804320391E3

CLAMPS FOR SL-VERSIONS, Ø D = 25, 30, 35 and 40 mm

Pb-free
RoHS COMPLIANT

To facilitate vertical mounting, a series of rigid clamps made of zinc plated steel is available. These are made of zinc plated steel, chromium(III) passivated.

The clamps have two mounting lugs, may be easily slipped over the capacitor and then clamped with a nut and bolt. Four types of clamps are available, one for each case diameter.

They are delivered without nuts or bolts.

To avoid damaging the insulation sleeve, do not overtighten the clamp screw.

DIMENSIONS in millimeters

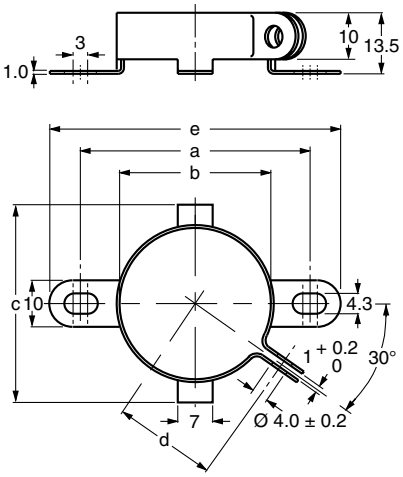


Fig.10 Dimensional outline of clamp for case Ø D = 25, 30 and 40 mm

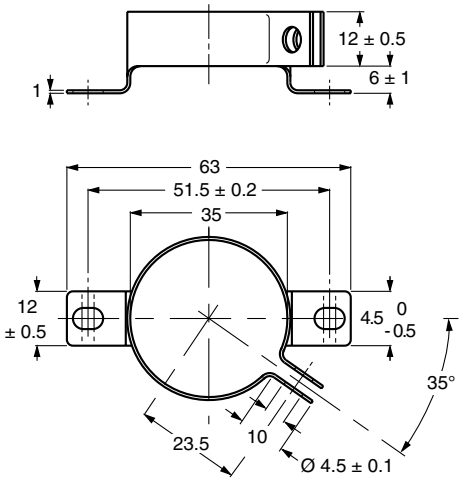
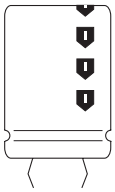


Fig.11 Dimensional outline of clamp for case Ø D = 35 mm

Table 3

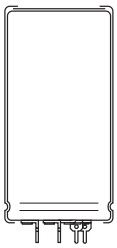
MOUNTING CLAMPS FOR SOLDER LUGS						
CASE DIAMETER	a	b	c	d	e	ORDERING CODE
25	41.5 ± 0.2	25	35	18.5	56	MAL804324011E3
30	46.5 ± 0.2	30	40	21	61	MAL804324021E3
35	51.5 ± 0.2	35	-	23.5	63	MAL804324031E3
40	56.5 ± 0.2	40	50	26	71	MAL804324041E3

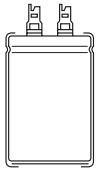
Large and Screw Terminal Series



Standard Ranges, SNAP-IN	
85 °C	105 °C
056/057 PSM-SI **197 PGP-SI** **EYN** **80D** **82D**	**058/059 PLL-SI** **199 PEL-SI** **EYH** **81D**

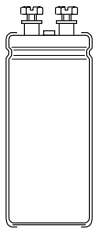
High CU/Vol	
85 °C	105 °C
156 PUM-SI **157 PUM-SI** **093 PMG-SI** **82DA**	**090 PUL-SI** **158 PUL-SI** **159 PUL-SI** **094 PME-SI** **EYC** **81DA**

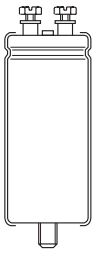




Larger Size, SOLDER PIN/SOLDER LUG	
85 °C	105 °C
096 PLL-4TSI **095 PLL-4TSI** **051/053 PEC-PW** **EYD** **EYK** **050/052 PED-PW** **EYV** **EY**	**162/163 PLL-PW** **EYZ**

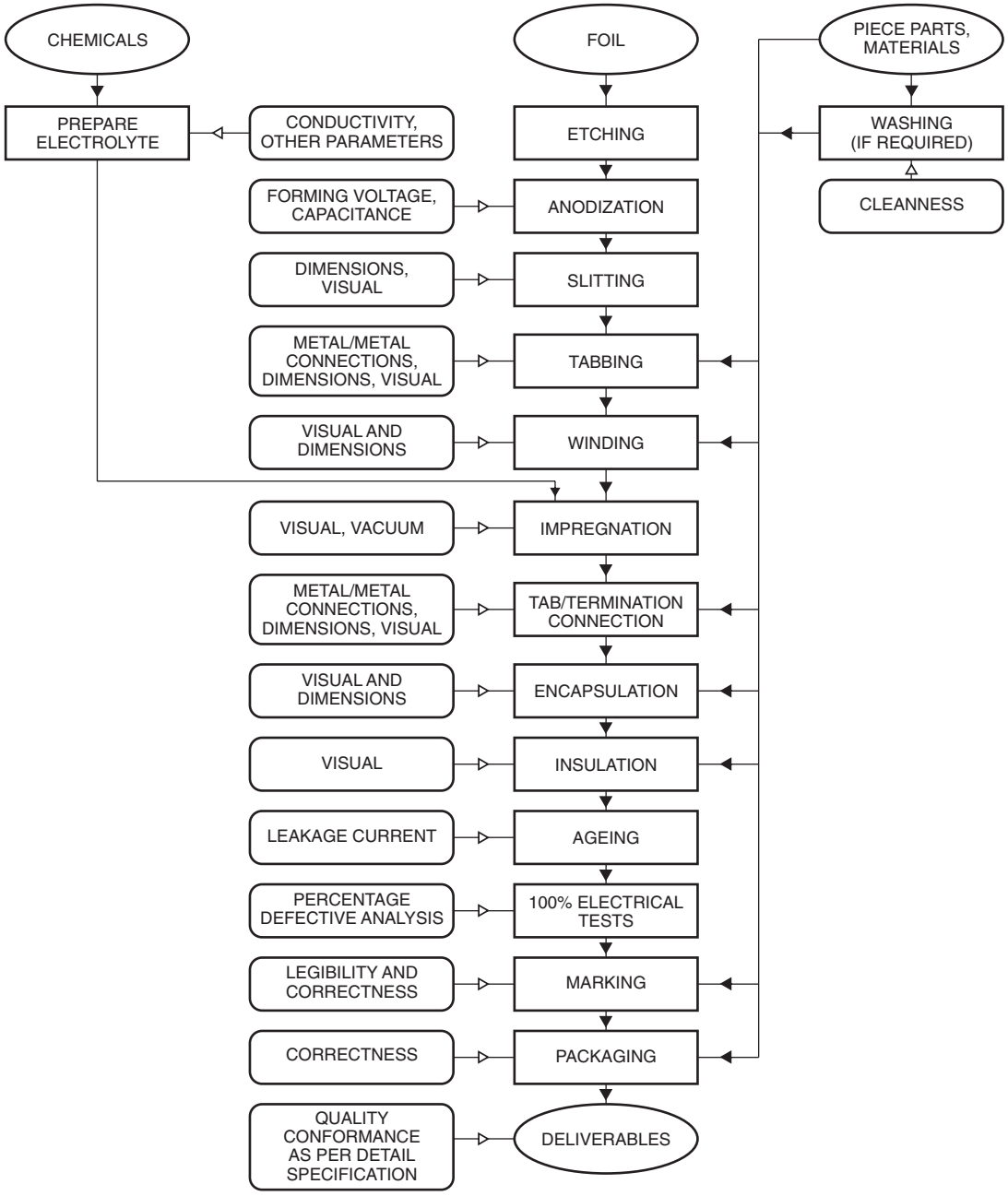
High Ripple Current
85 °C
198 PHR-SI





Larger Size, SCREW TERMINAL	
85 °C	105 °C
500 PGP-ST **101/102 PHR-ST** **106 PED-ST** **36DY** **36D, 36DE, 36DX** **36DA**	**104 PHL-ST**

Generic Quality Flowchart for Non-Solid Electrolytic Capacitors



Lay-out and wording are based on CECC 210 011 (Technology Approval Schedule Electrolytic Capacitors).