Aluminum Electrolytic Capacitors
Power High Ripple Current Long Life Screw Terminals

LINKS TO ADDITIONAL RESOURCES

3D Models

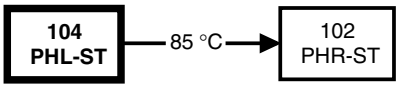


Fig. 1

FEATURES

- Long useful life: 5000 h at +105 °C
- High reliability
- Available in case sizes up to Ø 90 mm x 220 mm
- Polarized aluminum electrolytic capacitors, non-solid electrolyte
- Large types, cylindrical aluminum case, insulated with a blue sleeve
- Also available in bolt version (104 PHL-STB)
- Pressure relief in the sealing
- Material categorization: for definitions of compliance please see www.vishay.com/doc?99912

Pb-free

RoHS COMPLIANT

APPLICATIONS

- Telecom and industrial, high temperature systems
- Smoothing and filtering
- Standard and switched mode power supplies
- Energy storage in pulse systems
- Traction (subway, metro, light rail)

MARKING

The capacitors are marked with the following information:

- Rated capacitance (in µF)
- Tolerance on rated capacitance, code letter in accordance with IEC 60062 (± 20 %)
- 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
- "LL" for long life grade

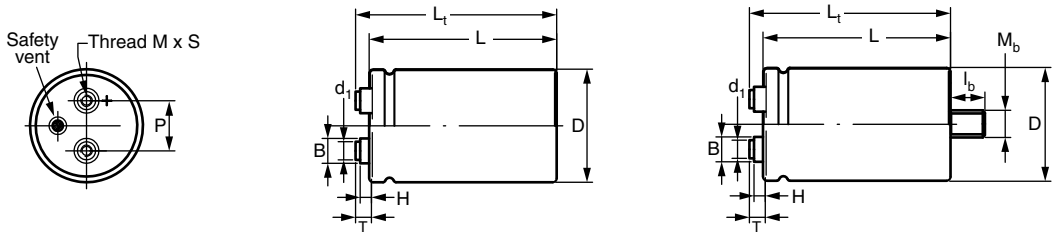
QUICK REFERENCE DATA	
DESCRIPTION	**VALUE**
Nominal case size (Ø D x L in mm)	35 x 60 to 90 x 220
Rated capacitance range (E6 series), C_R	150 µF to 33 000 µF
Tolerance on C_R	± 20 %
Rated voltage range, U_R	200 V to 450 V
Category temperature range	-40 °C to +105 °C
Endurance test at 105 °C	2000 h
Useful life at 105 °C	5000 h
Shelf life at 0 V, 105 °C	1000 h
Based on sectional specification	IEC 60384-4 / EN 130300
Climatic category IEC 60068	40 / 105 / 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)				
	200	**250**	**350**	**400**	**450**
150	-	-	-	-	35 x 60
220	-	-	-	35 x 60	35 x 80
330	-	-	35 x 60	35 x 80	35 x 105
470	-	-	35 x 80	35 x 80	50 x 80
680	35 x 60	35 x 60	35 x 105	50 x 80	50 x 105
	35 x 60	35 x 80	50 x 80	50 x 105	50 x 105
1000	35 x 80	35 x 105	-	-	65 x 105
	35 x 80	-	-	-	-
1500	35 x 80	35 x 105	50 x 105	50 x 105	65 x 105
	35 x 105	50 x 80	-	65 x 105	76 x 105
2200	35 x 105	50 x 80	65 x 105	65 x 105	76 x 105
	50 x 80	35 x 105	-	76 x 105	76 x 146

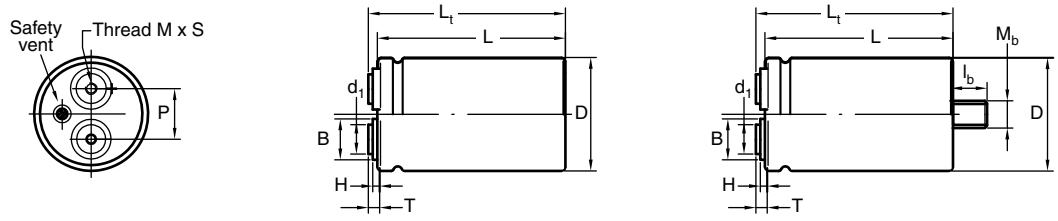
SELECTION CHART FOR C_R, U_R, AND RELEVANT NOMINAL CASE SIZES (Ø D x L in mm)					
C_R (µF)	U_R (V)				
	200	250	350	400	450
3300	50 x 80	50 x 105	-	76 x 105	76 x 146
	50 x 105	65 x 105	-	76 x 146	-
4700	50 x 105	65 x 105	-	76 x 146	76 x 220
	65 x 105	76 x 105	76 x 146	-	90 x 146
6800	65 x 105	76 x 105	76 x 146	76 x 220	90 x 220
	76 x 105	76 x 146	-	90 x 146	-
10 000	76 x 105	76 x 146	76 x 220	90 x 220	-
	76 x 146	-	90 x 146	-	-
15 000	76 x 146	76 x 220	90 x 220	-	-
	-	90 x 146	-	-	-
22 000	76 x 220	90 x 220	-	-	-
	90 x 146	-	-	-	-
33 000	90 x 220	-	-	-	-

DIMENSIONS in millimeters AND AVAILABLE FORMS



Standard M5 disc | Clamp mounting (ST) | Threaded stud mounting (STB)

Fig. 2A - Mechanical drawings for standard M5 disc versions.
For details refer to Table 1



High current M6 disc | Clamp mounting (ST) | Threaded stud mounting (STB)

Fig. 2B - Mechanical drawings for high current M6 disc versions.
For details refer to Table 1

Notes

- Maximum permissible torque which may be applied to the termination screws: 2 Nm for M5; 2.5 Nm for M6
  For accessories refer to document “Mounting Accessories”, see www.vishay.com/doc?28348
  The capacitors are delivered with screws and washers
- High current disc with 1/4 28 UNF (US) thread is available on request

Table 1

DIMENSIONS in millimeters **AND MASS**														
DESIGN	**DRAWING**	**L ± 1**	**L_t ± 1**	**D ± 1**	**P ± 0.3**	**T ± 0.2**	**H ± 0.3**	**B ± 0.3**	**D1 ± 0.1**	**M**	**S - 0**	**M_b**	**l_b ± 0.1**	**MASS (g)**
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
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
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 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
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
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
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
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
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
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
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
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
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
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
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

PACKAGING QUANTITIES AND DIMENSIONS in millimeters		
DESIGN	**PACKAGING QUANTITIES (units per box)**	**CARDBOARD BOX DIMENSIONS L x W x H**
35 x 60	50	377 x 375 x 88
35 x 80	50	377 x 375 x 123
35 x 105	50	377 x 375 x 129
50 x 80	25	377 x 375 x 123
50 x 105	25	377 x 375 x 129
65 x 105	16	377 x 375 x 129
65 x 105 HC	16	377 x 375 x 129
76 x 105	12	377 x 375 x 129
76 x 105 HC	12	377 x 375 x 129
76 x 146	12	377 x 375 x 168
76 x 146 HC	12	377 x 375 x 168
76 x 220	12	377 x 375 x 242
76 x 220 HC	12	377 x 375 x 242
90 x 146 HC	8	377 x 375 x 168
90 x 220 HC	8	377 x 375 x 242

Note

- For STB version holds:
  H of cardbox box: + 10 mm

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_{L5}	Max. leakage current after 5 min at U_R
ESR	Max. equivalent series resistance at 100 Hz
Z	Impedance at 20 kHz

Note

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

ORDERING EXAMPLE

Electrolytic capacitor 104 PHL-ST series

4700 µF / 250 V; ± 20 %

Nominal case size: Ø 65 mm x 105 mm; ST version

Ordering code: MAL2 104 13472 E3
Former 12NC: 2222 104 13472

Table 2

ELECTRICAL DATA AND ORDERING INFORMATION										
U_R (V)	C_R 100 Hz (µF)	NOMINAL CASE SIZE Ø D x L (mm)	I_R 100 Hz 105 °C (A)	I_{L5} 5 MIN (mA)	ESR MAX. 100 Hz (mΩ)	Z MAX. 20 kHz (mΩ)	STANDARD M5 DISC		HIGH CURRENT M6 DISC	
							ST ORDERING CODE MAL2104.....	STB ORDERING CODE MAL2104.....	ST ORDERING CODE MAL2104.....	STB ORDERING CODE MAL2104.....
200	680	35 x 60	2.9	0.28	197	117	12681E3	52681E3	-	-
	1000	35 x 60	3.3	0.40	148	94	12102E3	52102E3	-	-
	1000	35 x 80	3.7	0.40	137	83	22102E3	62102E3	-	-
	1500	35 x 80	4.1	0.60	102	66	12152E3	52152E3	-	-
	1500	35 x 105	4.6	0.60	95	59	22152E3	62152E3	-	-
	2200	35 x 105	5.0	0.88	74	49	12222E3	52222E3	-	-
	2200	50 x 80	6.7	0.88	63	39	22222E3	62222E3	-	-
	3300	50 x 80	8.2	1.32	42	26	12332E3	52332E3	-	-
	3300	50 x 105	8.2	1.32	44	28	22332E3	62332E3	-	-
	4700	50 x 105	9.9	1.88	31	19	12472E3	52472E3	-	-
	4700	65 x 105	11.6	1.88	31	19	22472E3	62472E3	42472E3	82472E3
	6800	65 x 105	13.7	2.72	22	14	12682E3	52682E3	32682E3	72682E3
	6800	76 x 105	15.2	2.72	22	14	22682E3	62682E3	42682E3	82682E3
	10 000	76 x 105	16.4	4.0	17	12	12103E3	52103E3	32103E3	72103E3
	10 000	76 x 146	16.9	4.0	17	12	22103E3	62103E3	42103E3	82103E3
	15 000	76 x 146	19.9	6.0	12	9	12153E3	52153E3	32153E3	72153E3
	22 000	76 x 220	24.6	8.8	9	7	12223E3	52223E3	32223E3	72223E3
	22 000	90 x 146	28.5	8.8	8	6	-	-	42223E3	82223E3
	33 000	90 x 220	34.8	13.2	5	5	-	-	42333E3	82333E3
250	680	35 x 60	2.9	0.34	176	99	13681E3	53681E3	-	-
	1000	35 x 80	3.7	0.50	123	70	13102E3	53102E3	-	-
	1000	35 x 105	4.0	0.50	116	63	23102E3	63102E3	-	-
	1500	35 x 105	4.5	0.75	86	51	13152E3	53152E3	-	-
	1500	50 x 80	5.9	0.75	76	41	23152E3	63152E3	-	-
	2200	50 x 80	6.6	1.10	58	34	13222E3	53222E3	-	-
	2200	50 x 105	7.3	1.10	54	30	23222E3	63222E3	-	-
	3300	50 x 105	8.9	1.65	36	20	13332E3	53332E3	-	-
	3300	65 x 105	10.4	1.65	36	20	23332E3	63332E3	43332E3	83332E3
	4700	65 x 105	11.4	2.35	28	17	13472E3	53472E3	33472E3	73472E3
	4700	76 x 105	12.7	2.35	28	17	23472E3	63472E3	43472E3	83472E3
	6800	76 x 105	15.0	3.40	20	12	13682E3	53682E3	33682E3	73682E3
	6800	76 x 146	15.4	3.40	20	12	23682E3	63682E3	43682E3	83682E3
	10 000	76 x 146	18.2	5.0	14	9	13103E3	53103E3	33103E3	73103E3
	15 000	76 x 220	22.7	7.5	10	7	13153E3	53153E3	33153E3	73153E3
	15 000	90 x 146	25.8	7.5	9	6	-	-	43153E3	83153E3
	22 000	90 x 220	30.4	11.0	7	5	-	-	43223E3	83223E3
350	330	35 x 60	2.1	0.26	396	243	15331E3	55331E3	-	-
	470	35 x 80	2.6	0.33	280	172	15471E3	55471E3	-	-
	680	35 x 105	3.2	0.48	197	122	15681E3	55681E3	-	-
	1000	50 x 80	4.7	0.70	132	82	15102E3	55102E3	-	-
	1500	50 x 105	5.9	1.05	90	57	15152E3	55152E3	-	-
	2200	65 x 105	8.4	1.54	61	38	15222E3	55222E3	35222E3	75222E3
	3300	65 x 105	10.1	2.31	42	26	15332E3	55332E3	35332E3	75332E3
	3300	76 x 105	11.2	2.31	42	26	25332E3	65332E3	45332E3	85332E3
	4700	76 x 105	12.6	3.29	32	21	15472E3	55472E3	35472E3	75472E3
	4700	76 x 146	13.7	3.29	30	19	25472E3	65472E3	45472E3	85472E3
	6800	76 x 146	15.4	4.76	22	15	15682E3	55682E3	35682E3	75682E3
	10 000	76 x 220	18.5	7.0	20	18	15103E3	55103E3	35103E3	75103E3
	10 000	90 x 146	20.5	7.0	19	17	-	-	45103E3	85103E3
	15 000	90 x 220	25.6	10.5	13	12	-	-	45153E3	85153E3

ELECTRICAL DATA AND ORDERING INFORMATION

U_R (V)	C_R 100 Hz (µF)	NOMINAL CASE SIZE Ø D x L (mm)	I_R 100 Hz 105 °C (A)	I_{L5} 5 MIN (mA)	ESR MAX. 100 Hz (mΩ)	Z MAX. 20 kHz (mΩ)	STANDARD M5 DISC		HIGH CURRENT M6 DISC	
							ST ORDERING CODE MAL2104.....	STB ORDERING CODE MAL2104.....	ST ORDERING CODE MAL2104.....	STB ORDERING CODE MAL2104.....
400	220	35 x 60	1.8	0.18	519	290	16221E3	56221E3	-	-
	330	35 x 80	2.3	0.27	349	196	16331E3	56331E3	-	-
	470	35 x 80	2.6	0.38	254	148	16471E3	56471E3	-	-
	680	50 x 80	4.1	0.55	170	96	26681E3	66681E3	-	-
	1000	50 x 105	5.1	0.80	117	67	16102E3	56102E3	-	-
	1500	50 x 105	6.0	1.20	83	49	16152E3	56152E3	-	-
	1500	65 x 105	6.9	1.20	83	49	26152E3	66152E3	46152E3	86152E3
	2200	65 x 105	8.4	1.76	56	33	16222E3	56222E3	36222E3	76222E3
	2200	76 x 105	9.4	1.76	56	33	26222E3	66222E3	46222E3	86222E3
	3300	76 x 105	11.3	2.64	38	23	16332E3	56332E3	36332E3	76332E3
	3300	76 x 146	11.6	2.64	38	23	26332E3	66332E3	46332E3	86332E3
	4700	76 x 146	13.8	3.76	27	17	16472E3	56472E3	36472E3	76472E3
	6800	76 x 220	16.5	5.4	25	20	16682E3	56682E3	36682E3	76682E3
	6800	90 x 146	17.7	5.4	25	20	-	-	46682E3	86682E3
	10 000	90 x 220	22.1	8.0	17	14	-	-	46103E3	86103E3
450	150	35 x 60	1.5	0.14	735	404	17151E3	57151E3	-	-
	220	35 x 80	1.9	0.20	503	278	17221E3	57221E3	-	-
	330	35 x 105	2.4	0.30	339	189	17331E3	57331E3	-	-
	470	50 x 80	3.3	0.43	253	148	17471E3	57471E3	-	-
	680	50 x 105	4.3	0.62	165	92	17681E3	57681E3	-	-
	1000	50 x 105	5.1	0.90	117	67	17102E3	57102E3	-	-
	1000	65 x 105	5.9	0.90	116	66	27102E3	67102E3	47102E3	87102E3
	1500	65 x 105	7.3	1.35	77	44	17152E3	57152E3	37152E3	77152E3
	1500	76 x 105	8.1	1.35	77	44	27152E3	67152E3	47152E3	87152E3
	2200	76 x 105	9.7	1.98	53	31	17222E3	57222E3	37222E3	77222E3
	2200	76 x 146	10.0	1.98	53	31	27222E3	67222E3	47222E3	87222E3
	3300	76 x 146	12.1	2.97	36	21	17332E3	57332E3	37332E3	77332E3
	4700	76 x 220	14.1	4.2	33	25	17472E3	57472E3	37472E3	77472E3
	4700	90 x 146	15.3	4.2	31	24	-	-	47472E3	87472E3
	6800	90 x 220	18.9	6.1	22	17	-	-	47682E3	87682E3

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	After 1 min at U_R	$I_{L1} \leq 0.006\ C_R \times U_R + 4$ µA
	After 5 min at U_R	$I_{L5} \leq 0.002\ C_R \times U_R + 4$ µA
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

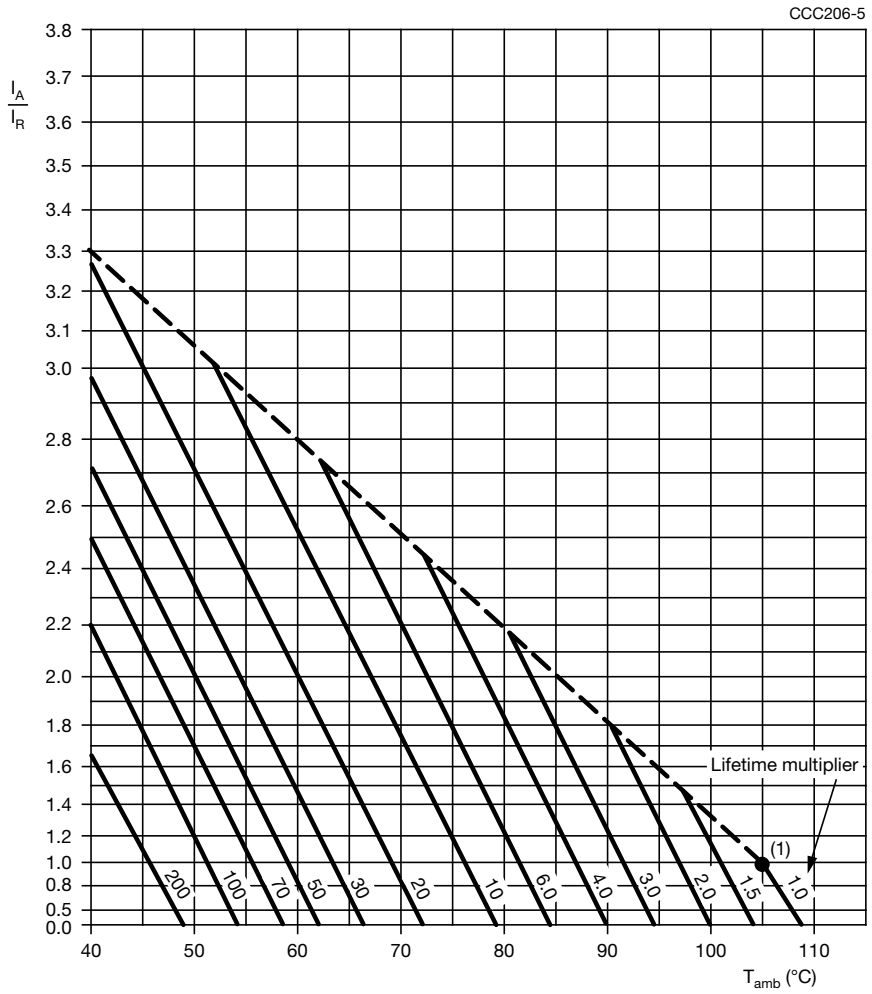
RIPPLE CURRENT AND USEFUL LIFE

Table 3

ENDURANCE TEST DURATION AND USEFUL LIFE	
ENDURANCE AT 105 °C (h)	USEFUL LIFE AT 105 °C (h)
2000	5000

Note

- Multiplier of useful life code: CCC206-5



I_A = Actual ripple current at 100 Hz
I_R = Actual ripple current at 100 Hz and 105 °C
With an absolute maximum of 50 A at 105 °C

(1) Useful life at 105 °C and I_R applied: 5000 h

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_{amb} = 105 °C; U_R applied; 2000 h	ΔC/C: ± 10 % ESR ≤ 1.3 x spec. limit Z ≤ 2 x spec. limit I_{L5} ≤ spec. limit
Useful life	CECC 30301 subclause 4.13	T_{amb} = 105 °C; U_R and I_R applied; 5000 h	ΔC/C: ± 30 % ESR ≤ 3 x spec. limit Z ≤ 3 x spec. limit I_{L5} ≤ 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_{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	ΔC/C: ± 10 % ESR ≤ 1.2 x spec. limit I_{L5} ≤ 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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