Aluminum Electrolytic Capacitors
Radial Miniature Long Life

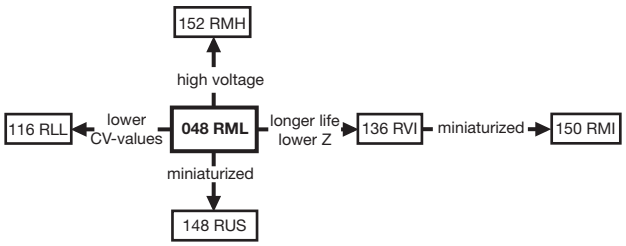


Fig. 1

FEATURES

- Very long useful life: 3000 h to 4000 h at 105 °C
- High reliability
- Miniaturized, high CV-product per unit volume
- Charge and discharge proof
- Polarized aluminum electrolytic capacitors, non-solid electrolyte
- Radial leads, cylindrical aluminum case with pressure relief, insulated with a blue sleeve
- Material categorization: for definitions of compliance please see www.vishay.com/doc?99912

Pb-free

RoHS COMPLIANT

APPLICATIONS

- EDP, telecommunication, industrial, automotive, and audio-video
- Smoothing, filtering, buffering in SMPS, timing
- Portable and mobile equipment (small size, low mass)

MARKING

The capacitors are marked (where possible) 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, in accordance with IEC 60062
- Code indicating factory of origin
- Name of manufacturer
- Upper category temperature (105 °C)
- Negative terminal identification
- Series number (048)

QUICK REFERENCE DATA	
DESCRIPTION	**VALUE**
Nominal case sizes (Ø D x L in mm)	10 x 12 to 18 x 35
Rated capacitance range, C_R	100 µF to 10 000 µF
Tolerance on C_R	± 20 %
Rated voltage range, U_R	6.3 to 63 V
Category temperature range	-40 °C to +105 °C
Endurance test at 105 °C	2000 h
Useful life at 105 °C Case Ø D = 10 mm and 12.5 mm Case Ø D = 16 mm and 18 mm	 3000 h 4000 h
Useful life at 40 °C, 1.6 x I_R applied Case Ø D = 10 mm and 12.5 mm Case Ø D = 16 mm and 18 mm	 200 000 h 260 000 h
Shelf life at 0 V, 105 °C	1000 h
Based on sectional specification	IEC 60384-4 / EN130300
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)							
	6.3	**10**	**16**	**25**	**35**	**40**	**50**	**63**
100	-	-	-	-	-	-	-	10 x 12
220	-	-	-	-	10 x 12	-	10 x 16	10 x 20
330	-	-	-	-	-	-	-	12.5 x 20
470	-	-	10 x 12	10 x 16	10 x 20	-	12.5 x 20	12.5 x 25
1000	-	10 x 16	10 x 20	12.5 x 20	12.5 x 25	-	16 x 25	16 x 31
2200	-	12.5 x 20	12.5 x 25	16 x 25	16 x 31	16 x 35	18 x 35	18 x 35
3300	-	12.5 x 25	16 x 25	16 x 31	18 x 35	18 x 35	18 x 35	-
4700	-	16 x 25	16 x 31	18 x 35	18 x 35	-	-	-
6800	16 x 25	16 x 31	16 x 35	-	-	-	-	-
10 000	16 x 35	18 x 35	18 x 35	-	-	-	-	-

For technical questions, contact: aluminumcaps1@vishay.com

DIMENSIONS in millimeters **AND AVAILABLE FORMS**

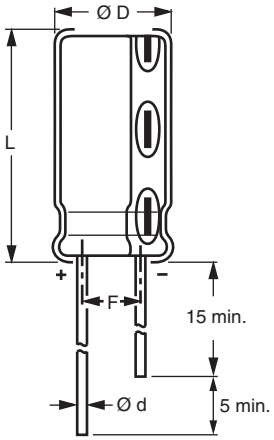


Fig. 2 - **Form CA:** Longs leads

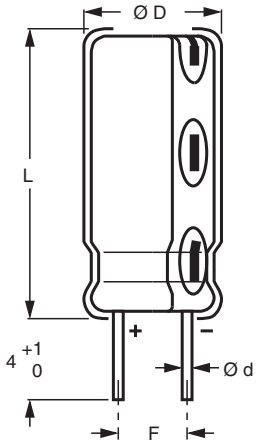


Fig. 3 - **Form CB:** Cut leads

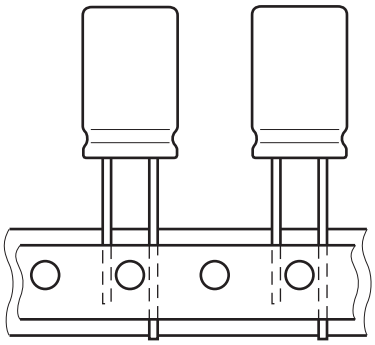


Fig. 4 - Form TFA: Taped in box (ammopack)

Table 1

DIMENSIONS in millimeters, **MASS AND PACKAGING QUANTITIES**									
NOMINAL CASE SIZE Ø D x L	**CASE CODE**	**Ø d**	**Ø $D_{max.}$**	**$L_{max.}$**	**F**	**MASS (g)**	**PACKAGING QUANTITIES**		
							FORM CA	**FORM CB**	**FORM TFA**
10 x 12	14	0.6	10.5	13.5	5.0 ± 0.5	≈ 1.6	1000	500	800
10 x 16	15	0.6	10.5	17.5	5.0 ± 0.5	≈ 1.9	500	500	800
10 x 20	16	0.6	10.5	22.0	5.0 ± 0.5	≈ 2.2	500	500	800
12.5 x 20	17	0.6	13.0	22.0	5.0 ± 0.5	≈ 4.0	500	500	500
12.5 x 25	18	0.6	13.0	27.0	5.0 ± 0.5	≈ 5.0	250	250	500
16 x 25	19	0.8	16.5	27.0	7.5 ± 0.5	≈ 8.0	250	250	250
16 x 31	20	0.8	16.5	33.5	7.5 ± 0.5	≈ 9.0	100	100	250
16 x 35	21	0.8	16.5	37.5	7.5 ± 0.5	≈ 11.5	100	100	-
18 x 35	22	0.8	18.5	37.5	7.5 ± 0.5	≈ 14.5	100	100	-

Note

- For detailed tape dimensions please refer to packaging information: www.vishay.com/doc?28360

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_{L1}	Max. leakage current after 1 min at U_R
tan δ	Max. dissipation factor at 100 Hz
Z	Max. impedance at 100 kHz

Note

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

ORDERING EXAMPLE

Electrolytic capacitor 048 series

2200 µF / 16 V; ± 20 %

Nominal case size: Ø 12.5 mm x 25 mm; Form TFA

Ordering code: MAL204835222E3
Former 12NC: 2222 048 35222

Table 2

ELECTRICAL DATA AND ORDERING INFORMATION

U_R (V)	C_R 100 Hz (µF)	DIMENSIONS Ø D x L (mm)	I_R 100 Hz 105 °C (mA)	I_{L1} 1 min (µA)	tan δ 100 Hz	Z 100 kHz (mΩ)	FREQ. CODE (1)	ORDERING NUMBER MAL2048.....		
								BULK PACKAGING		TAPED
								FORM CA	FORM CB	FORM TFA
6.3	6800	16 x 25	1350	430	0.32	56	MF1	53682E3	63682E3	33682E3
	10 000	16 x 35	1700	630	0.40	42	MF1	53103E3	63103E3	-
10	1000	10 x 16	470	100	0.19	180	MF1	54102E3	64102E3	34102E3
	2200	12.5 x 20	800	220	0.21	90	MF1	54222E3	64222E3	34222E3
	3300	12.5 x 25	1000	330	0.23	68	MF1	54332E3	64332E3	34332E3
	4700	16 x 25	1270	470	0.25	56	MF1	54472E3	64472E3	34472E3
	6800	16 x 31	1550	680	0.29	45	MF1	54682E3	64682E3	34682E3
	10 000	18 x 35	1870	1000	0.37	36	MF1	54103E3	64103E3	-
16	470	10 x 12	360	78	0.16	250	MF1	55471E3	65471E3	35471E3
	1000	10 x 20	600	160	0.16	140	MF1	55102E3	65102E3	35102E3
	2200	12.5 x 25	1000	360	0.18	70	MF1	55222E3	65222E3	35222E3
	3300	16 x 25	1220	530	0.20	56	MF1	55332E3	65332E3	35332E3
	4700	16 x 31	1500	760	0.22	45	MF1	55472E3	65472E3	35472E3
	6800	16 x 35	1690	1100	0.26	42	MF1	55682E3	65682E3	-
	10 000	18 x 35	1980	1600	0.34	34	MF1	55103E3	65103E3	-
25	470	10 x 16	440	120	0.14	180	MF1	56471E3	66471E3	36471E3
	1000	12.5 x 20	720	250	0.14	100	MF1	56102E3	66102E3	36102E3
	2200	16 x 25	1120	550	0.16	56	MF1	56222E3	66222E3	36222E3
	3300	16 x 31	1450	830	0.18	45	MF1	56332E3	66332E3	36332E3
	4700	18 x 35	1720	1200	0.20	36	MF1	56472E3	66472E3	-
35	220	10 x 12	310	80	0.12	280	MF2	50221E3	60221E3	30221E3
	470	10 x 20	500	170	0.12	150	MF2	50471E3	60471E3	30471E3
	1000	12.5 x 25	900	350	0.12	75	MF2	50102E3	60102E3	30102E3
	2200	16 x 31	1340	770	0.14	45	MF2	50222E3	60222E3	30222E3
	3300	18 x 35	1600	1200	0.16	36	MF2	50332E3	60332E3	-
	4700	18 x 35	1950	1600	0.18	34	MF2	50472E3	60472E3	-
40	2200	16 x 35	1500	880	0.13	45	MF2	57222E3	67222E3	-
	3300	18 x 35	1600	1300	0.15	36	MF2	57332E3	67332E3	-
50	220	10 x 16	340	110	0.10	250	MF3	51221E3	61221E3	31221E3
	470	12.5 x 20	620	240	0.10	110	MF3	51471E3	61471E3	31471E3
	1000	16 x 25	1030	500	0.10	60	MF3	51102E3	61102E3	31102E3
	2200	18 x 35	1500	1100	0.12	50	MF3	51222E3	61222E3	-
	3300	18 x 35	1900	1700	0.14	40	MF3	51332E3	61332E3	-
63	100	10 x 12	240	66	0.09	310	MF3	58101E3	68101E3	38101E3
	220	10 x 20	400	140	0.09	200	MF3	58221E3	68221E3	38221E3
	330	12.5 x 20	550	210	0.09	120	MF3	58331E3	68331E3	38331E3
	470	12.5 x 25	700	300	0.09	80	MF3	58471E3	68471E3	38471E3
	1000	16 x 31	1150	630	0.09	49	MF3	58102E3	68102E3	38102E3
	2200	18 x 35	1600	1400	0.11	45	MF3	58222E3	68222E3	-

Note

(1) Determines the applicable row in the table "Multiplier of Ripple Current (I_R) as a Function of Frequency"

ADDITIONAL ELECTRICAL DATA		
PARAMETER	**CONDITIONS**	**VALUE**
Voltage		
Surge voltage		$U_s \leq 1.15\ U_R$
Reverse voltage		$U_{rev} \leq 1\ V$
Current		
Leakage current	After 1 min at U_R	$I_{L1} \leq 0.01\ C_R \times U_R + 3\ \mu A$
	After 5 min at U_R	$I_{L5} \leq 0.002\ C_R \times U_R + 3\ \mu A$
Inductance		
Equivalent series inductance (ESL)	Case Ø D = 10 mm	Typ. 16 nH
	Case Ø D ≥ 12.5 mm	Typ. 18 nH
Resistance		
Equivalent series resistance (ESR)	Calculated from tan $\delta_{max.}$ and C_R (see Table 2)	ESR = tan $\delta/2\ \pi\ f\ C_R$

CAPACITANCE (C)

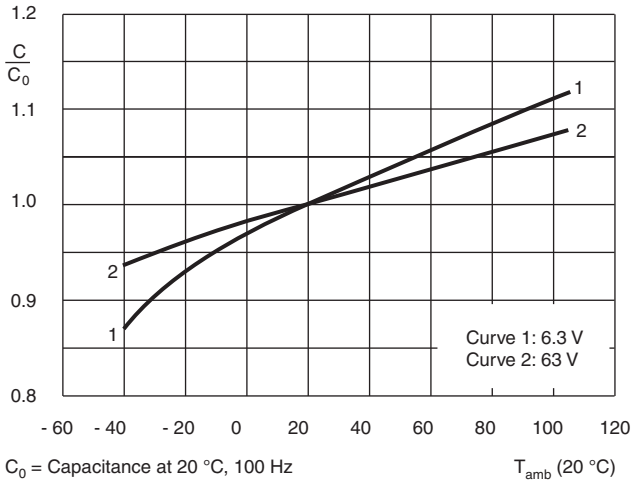


Fig. 5 - Typical multiplier of capacitance as a function of ambient temperature

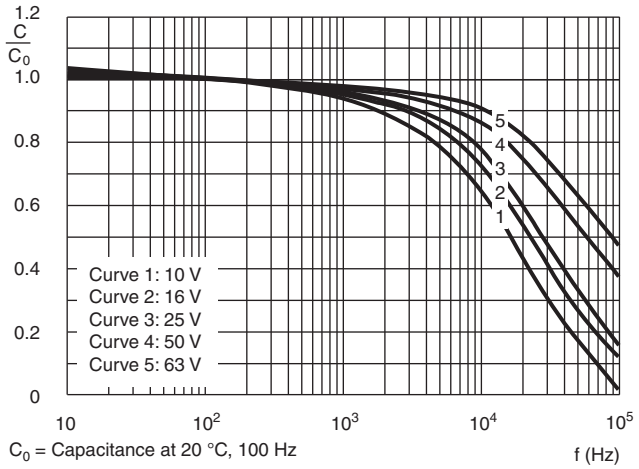


Fig. 6 - Typical multiplier of capacitance as a function of frequency

EQUIVALENT SERIES RESISTANCE (ESR)

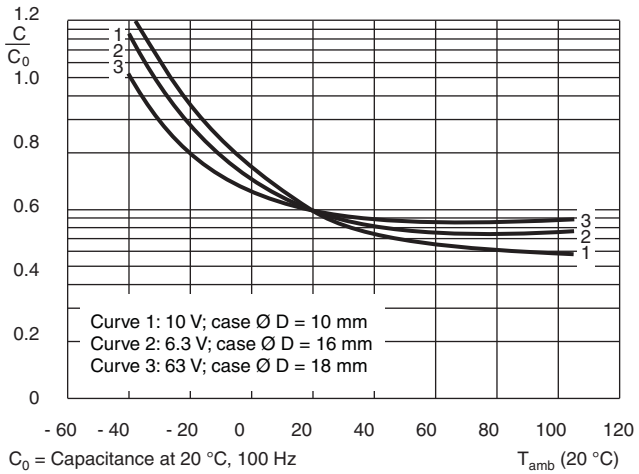


Fig. 7 - Typical multiplier of ESR as a function of ambient temperature

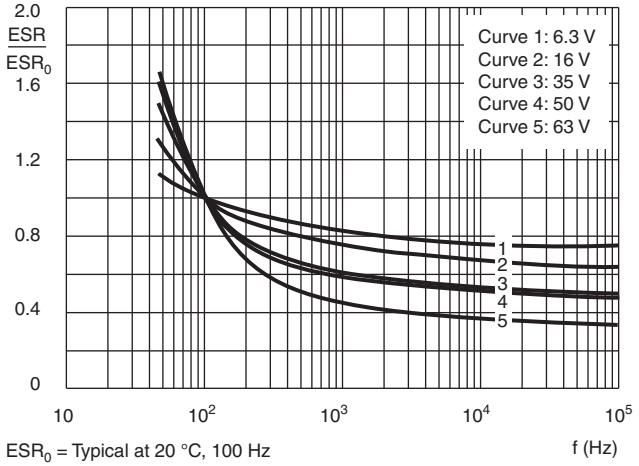


Fig. 8 - Typical multiplier of ESR as a function of frequency

IMPEDANCE (Z)

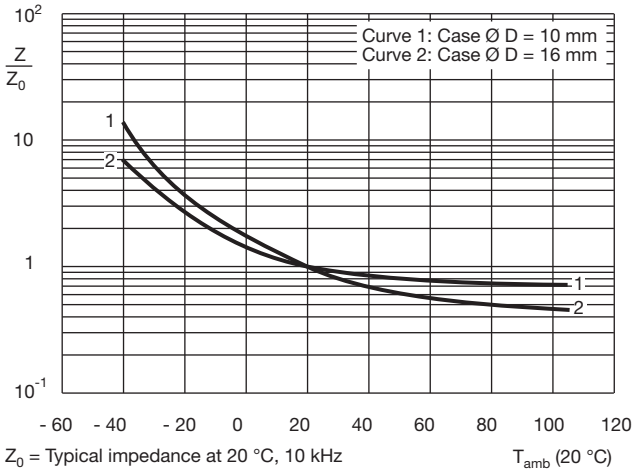


Fig. 9 - Typical multiplier of impedance as a function of ambient temperature

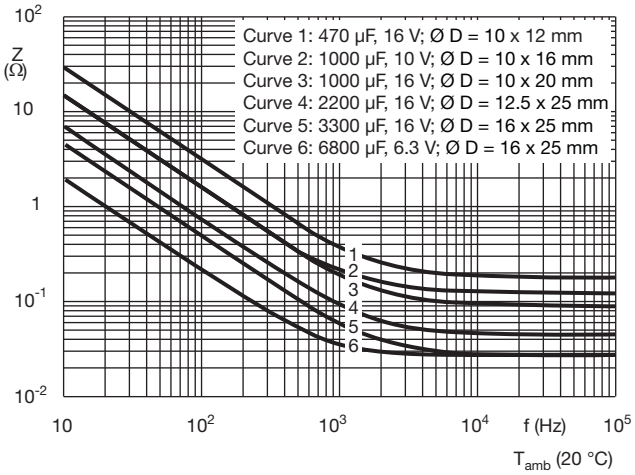


Fig. 10 - Typical impedance as a function of frequency

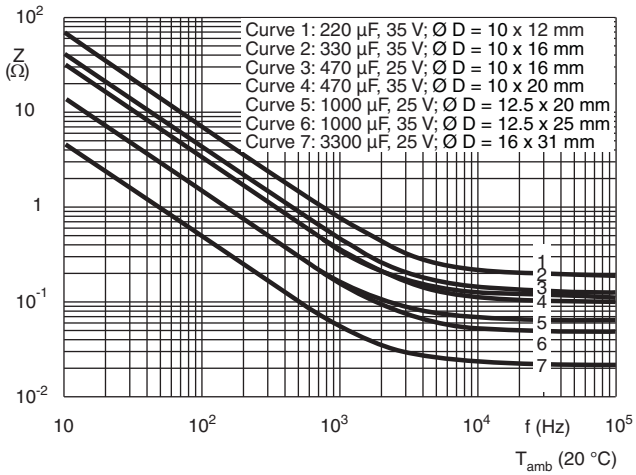


Fig. 11 - Typical impedance as a function of frequency

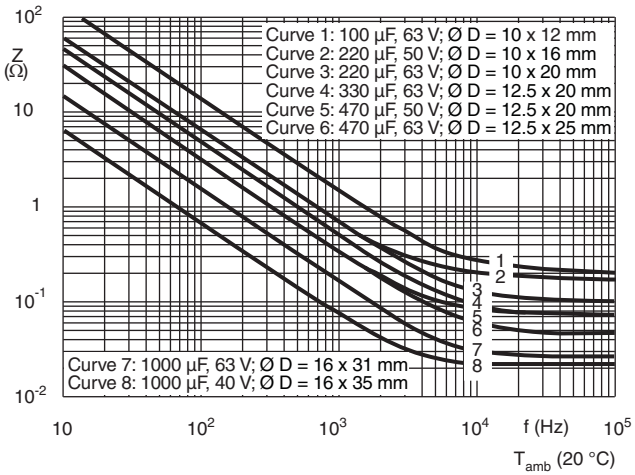


Fig. 12 - Typical impedance as a function of frequency

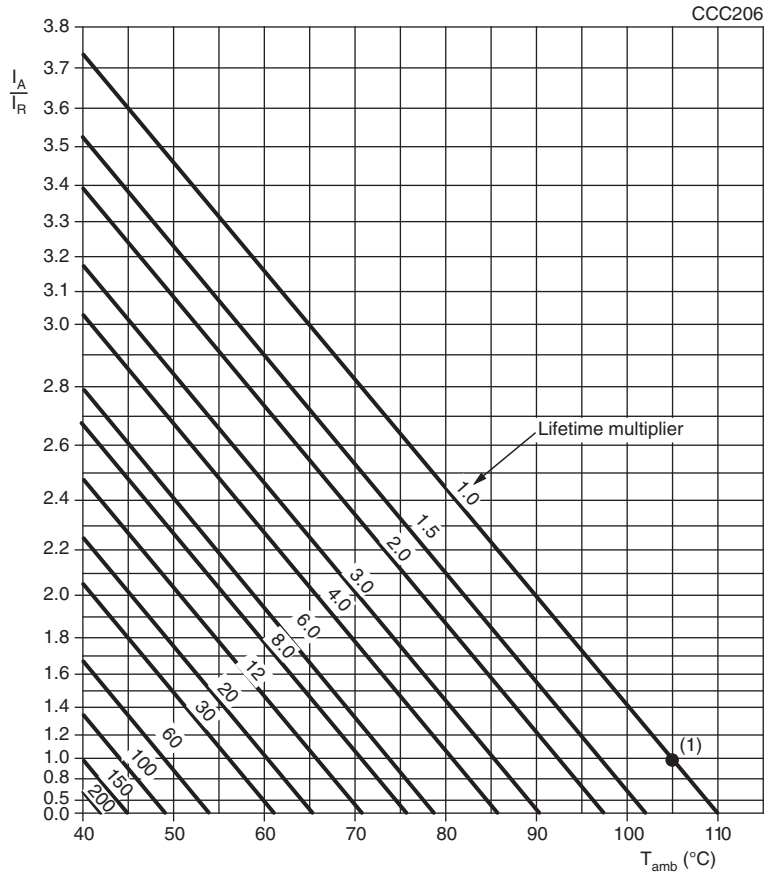
RIPPLE CURRENT AND USEFUL LIFE

Table 3

ENDURANCE TEST DURATION AND USEFUL LIFE		
NOMINAL CASE SIZE Ø D x L (mm)	**ENDURANCE AT 105 °C (h)**	**USEFUL LIFE AT 105 °C (h)**
10 x 12	2000	3000
10 x 16	2000	3000
10 x 20	2000	3000
12.5 x 20	2000	3000
12.5 x 25	2000	3000
16 x 25	2000	4000
16 x 31	2000	4000
16 x 35	2000	4000
18 x 35	2000	4000

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
(1) Useful life at 105 °C and I_R applied (see Table 4)

Fig. 13 - 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						
FREQ. CODE	FREQUENCY (Hz)					
	50	100	300	1000	3000	≥ 100 000
	I_R MULTIPLIER					
MF1	0.95	1.00	1.07	1.12	1.15	1.20
MF2	0.85	1.00	1.20	1.30	1.35	1.40
MF3	0.80	1.00	1.25	1.40	1.50	1.60

TEST PROCEDURES AND REQUIREMENTS			
TEST		PROCEDURE (quick reference)	REQUIREMENTS
NAME OF TEST	REFERENCE		
Endurance	IEC 60384-4 / EN130300 subclause 4.13	T_{amb} = 105 °C; U_R applied; 2000 h	$U_R \leq$ 6.3 V; ΔC/C: +15 % / -30 % $U_R >$ 6.3 V; ΔC/C: ± 15 % tan δ ≤ 1.3 x spec. limit Z ≤ 2 x spec. limit I_{L5} ≤ spec. limit
Useful life	CECC 30301 subclause 1.8.1	T_{amb} = 105 °C; U_R and I_R applied; Case Ø D = 10 mm and 12.5 mm: 3000 h Case Ø D = 16 mm and 18 mm: 4000 h	$U_R \leq$ 6.3 V; ΔC/C: +45 % / -50 % $U_R >$ 6.3 V; ΔC/C: ± 45 % tan δ ≤ 3 x spec. limit Z ≤ 3 x spec. limit I_{L5} ≤ spec. limit No short or open circuit Total failure percentage: ≤ 1 %
Shelf life (storage at high temperature)	IEC 60384-4 / EN130300 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	$U_R \leq$ 6.3 V; ΔC/C: +15 % / -30 % $U_R >$ 6.3 V; ΔC/C: ± 15 % tan δ ≤ 1.3 x spec. limit Z ≤ 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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