

# Aluminum Capacitors Radial Miniature Long Life

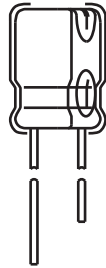
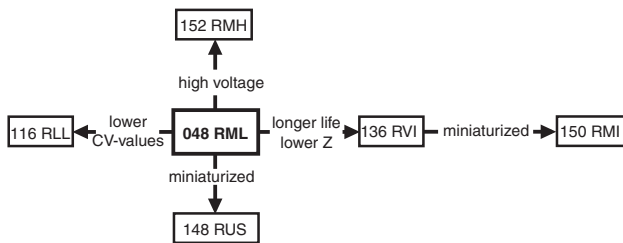


Fig.1 Component outline



## FEATURES

- Polarized aluminum electrolytic capacitors, non-solid electrolyte
- Radial leads, cylindrical aluminum case with pressure relief, insulated with a blue sleeve
- Charge and discharge proof
- Miniaturized, high CV-product per unit volume
- Very long useful life: 3000 h to 4000 h at 105 °C, high reliability
- Compliant to RoHS Directive 2002/95/EC



RoHS  
COMPLIANT

## APPLICATIONS

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

## 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 <sub>R</sub>	100 µF to 10 000 µF
Tolerance on C <sub>R</sub>	± 20 %
Rated voltage range, U <sub>R</sub>	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	3000 h
case Ø D = 16 mm and 18 mm	4000 h
Useful life at 40 °C, 1.6 x I <sub>R</sub> applied	
case Ø D = 10 mm and 12.5 mm	200 000 h
case Ø D = 16 mm and 18 mm	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

## 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)

## 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)							
	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	-	-	-	-	-

**DIMENSIONS** in millimeters, **AND AVAILABLE FORMS**

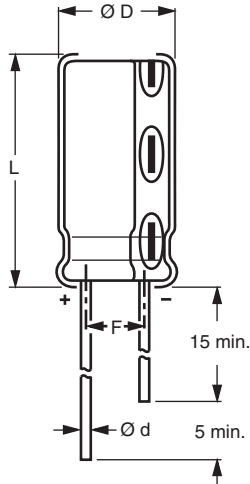


Fig.2 Form CA: Long leads

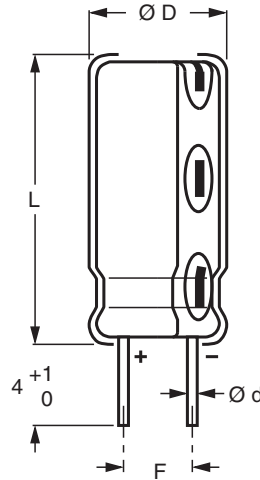


Fig.3 Form CB: Cut leads

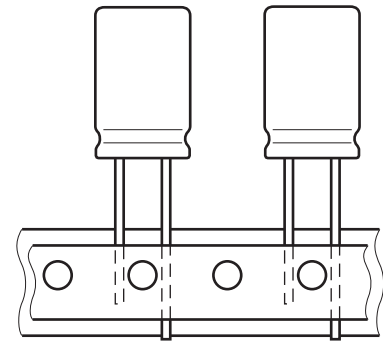


Fig.4 Form TFA: Taped in box (ammopack)

Table 1

DIMENSIONS in millimeters, MASS AND PACKAGING QUANTITIES									
NOMINAL CASE SIZE Ø D x L	CASE CODE	Ø d	Ø D <sub>max.</sub>	L <sub>max.</sub>	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**

Detailed tape dimensions see section 'PACKAGING'.

ELECTRICAL DATA	
SYMBOL	DESCRIPTION
$C_R$	rated capacitance at 100 Hz, tolerance $\pm 20\%$
$I_R$	rated RMS ripple current at 100 Hz, 105 °C
$I_{L1}$	max. leakage current after 1 minute at $U_R$
$\tan \delta$	max. dissipation factor at 100 Hz
Z	max. impedance at 100 kHz

**Note**

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

Table 2

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

**ORDERING EXAMPLE**

Electrolytic capacitor 048 series

2200  $\mu\text{F}/16\text{ V}$ ;  $\pm 20\%$ Nominal case size:  $\varnothing 12.5\text{ mm} \times 25\text{ mm}$ ; Form TFA

Ordering code: MAL204835222E3

Former 12NC: 2222 048 35222

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

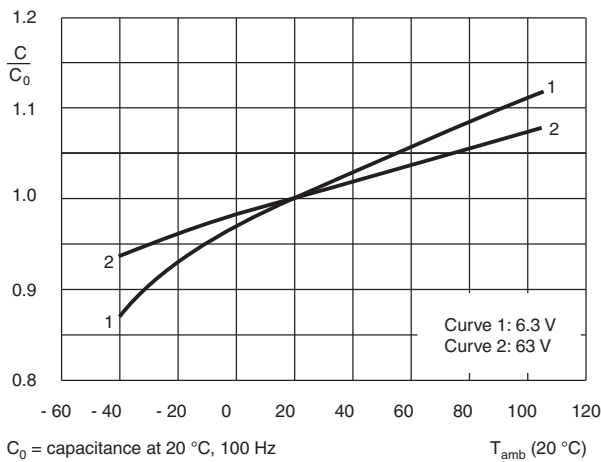
**CAPACITANCE (C)**


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

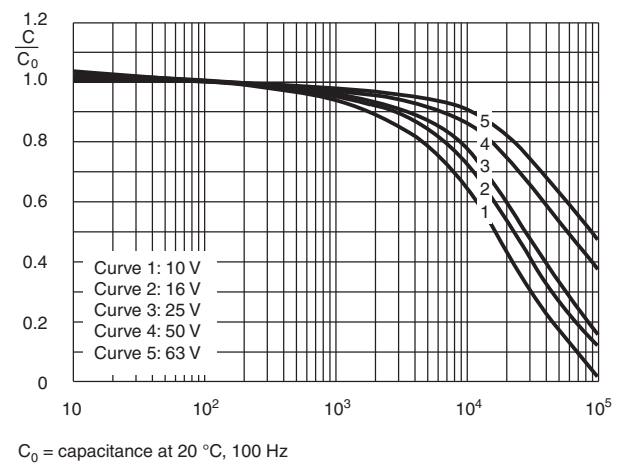


Fig.6 Typical multiplier of capacitance as a function of frequency

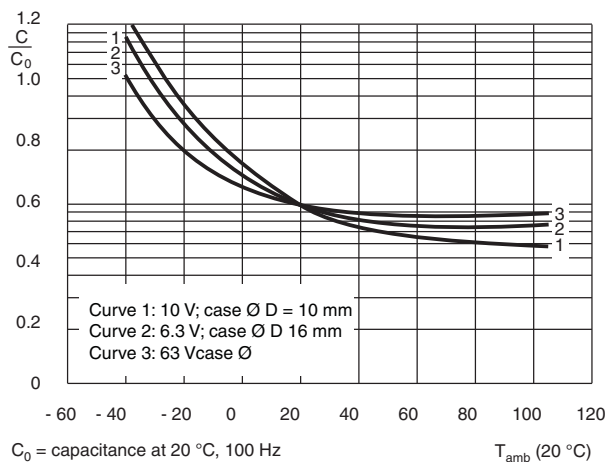
**EQUIVALENT SERIES RESISTANCE (ESR)**


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

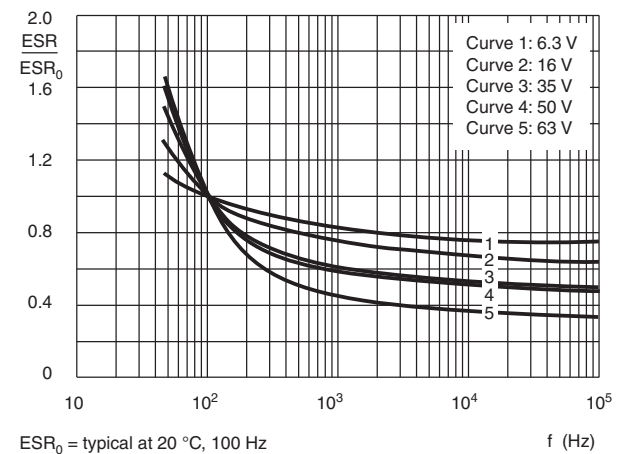


Fig.8 Typical multiplier of ESR as a function of frequency

**IMPEDANCE (Z)**

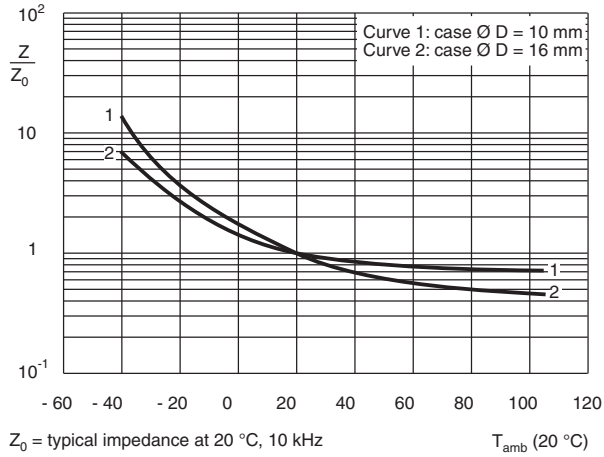


Fig.9 Typical multiplier of impedance as a function of ambient temperature

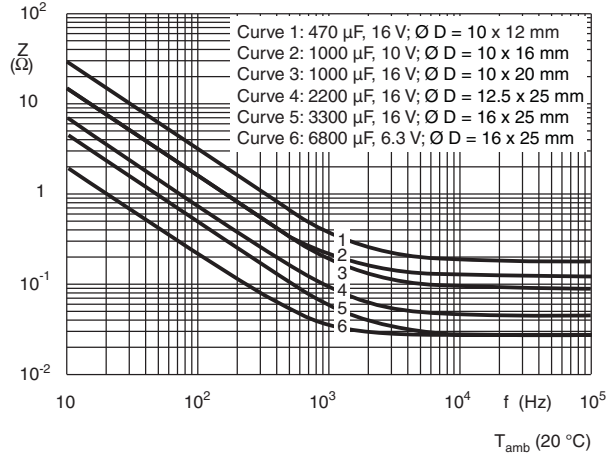


Fig.10 Typical impedance as a function of frequency

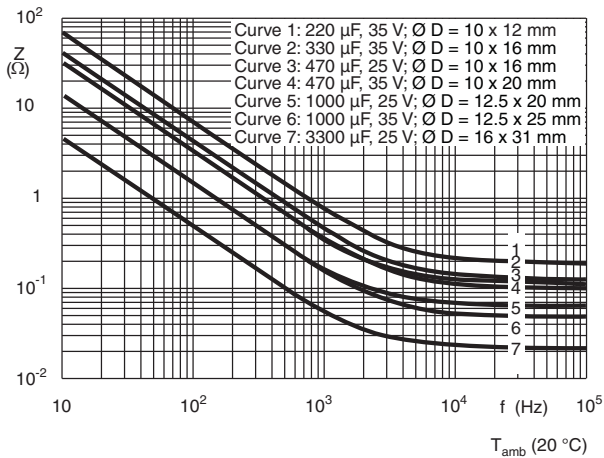


Fig.11 Typical impedance as a function of frequency

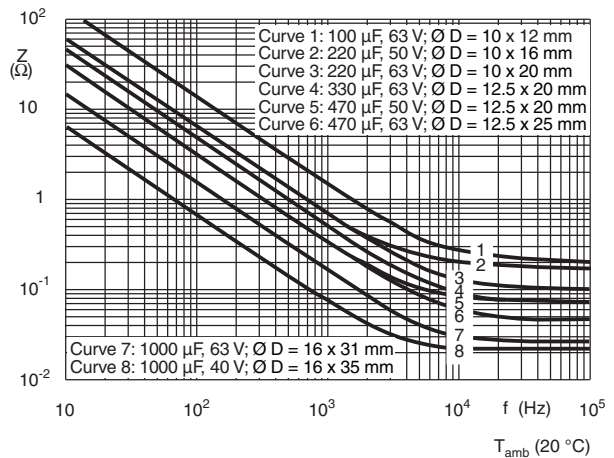
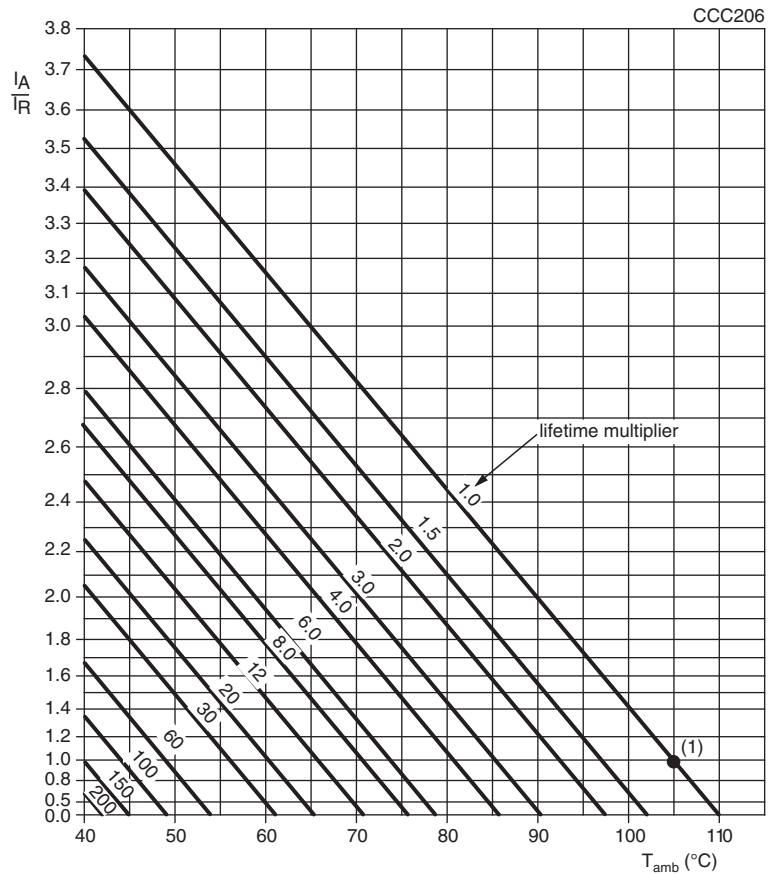


Fig.12 Typical impedance as a function of frequency

**RIPPLE CURRENT AND USEFUL LIFE**



$I_A$  = 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 3

MULTIPLIER OF RIPPLE CURRENT ( $I_R$ ) AS A FUNCTION OF FREQUENCY			
FREQUENCY (Hz)	$I_R$ MULTIPLIER		
	$U_R = 6.3$ to $25$ V	$U_R = 35$ and $40$ V	$U_R = 50$ and $63$ V
50	0.95	0.85	0.80
100	1.00	1.00	1.00
300	1.07	1.20	1.25
1000	1.12	1.30	1.40
3000	1.15	1.35	1.50
$\geq 10\ 000$	1.20	1.40	1.60

**TEST PROCEDURES AND REQUIREMENTS**

TEST		PROCEDURE (quick reference)	REQUIREMENTS
NAME OF TEST	REFERENCE		
Endurance	IEC 60384-4/ EN130300 subclause 4.13	$T_{amb} = 105\text{ }^{\circ}\text{C}$ ; $U_R$ applied; 2000 hours	$U_R \leq 6.3\text{ V}$ ; $\Delta C/C$ : + 15/- 30 % $U_R > 6.3\text{ V}$ ; $\Delta C/C$ : $\pm 15\%$ $\tan \delta \leq 1.3 \times \text{spec. limit}$ $Z \leq 2 \times \text{spec. limit}$ $I_{L5} \leq \text{spec. limit}$
Useful life	CECC 30301 subclause 1.8.1	$T_{amb} = 105\text{ }^{\circ}\text{C}$ ; $U_R$ and $I_R$ applied; case $\varnothing D = 10$ and 12.5 mm: 3000 hours case $\varnothing D = 16$ and 18 mm: 4000 hours	$U_R \leq 6.3\text{ V}$ ; $\Delta C/C$ : + 45/- 50 % $U_R > 6.3\text{ V}$ ; $\Delta C/C$ : $\pm 45\%$ $\tan \delta \leq 3 \times \text{spec. limit}$ $Z \leq 3 \times \text{spec. limit}$ $I_{L5} \leq \text{spec. limit}$ no short or open circuit total failure percentage: $\leq 1\%$
Shelf life (storage at high temperature)	IEC 60384-4/ EN130300 subclause 4.17	$T_{amb} = 105\text{ }^{\circ}\text{C}$ ; no voltage applied; 1000 hours after test: $U_R$ to be applied for 30 minutes, 24 to 48 hours before measurement	$U_R \leq 6.3\text{ V}$ ; $\Delta C/C$ : + 15/- 30 % $U_R > 6.3\text{ V}$ ; $\Delta C/C$ : $\pm 15\%$ $\tan \delta \leq 1.3 \times \text{spec. limit}$ $Z \leq 2 \times \text{spec. limit}$ $I_{L5} \leq 2 \times \text{spec. limit}$



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