

# Aluminum Capacitors Radial Miniature Long Life

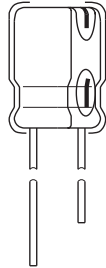
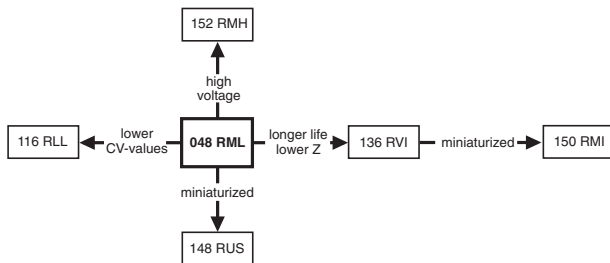


Fig.1 Component outline.



## FEATURES

- Polarized aluminum electrolytic capacitors, non-solid electrolyte
- Radial leads, cylindrical aluminum case with pressure relief, insulated with a blue vinyl sleeve
- Charge and discharge proof
- Miniaturized, high CV-product per unit volume
- Very long useful life: 3000 to 4000 hours at 105 °C, high reliability
- Lead (Pb)-free versions are RoHS compliant.



**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  $\mu\text{F}$ ).
- Tolerance on rated capacitance, code letter in accordance with IEC 60062 (M for  $\pm 20\%$ ).
- 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 ( $\varnothing D \times L$ in mm)	10 × 12 to 18 × 35
Rated capacitance range, $C_R$	100 to 10 000 $\mu\text{F}$
Tolerance on $C_R$	$\pm 20\%$
Rated voltage range, $U_R$	6.3 to 63 V
Category temperature range	-40 to +105 °C
Endurance test at 105 °C	2000 hours
Useful life at 105 °C	
case $\varnothing D = 10$ and 12.5 mm	3000 hours
case $\varnothing D = 16$ and 18 mm	4000 hours
Useful life at 40 °C, $1.6 \times I_R$ applied	
case $\varnothing D = 10$ and 12.5 mm	200 000 hours
case $\varnothing D = 16$ and 18 mm	260 000 hours
Shelf life at 0 V, 105 °C	1000 hours
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 ( $\varnothing D \times L$ in mm)									
$C_R$ ( $\mu\text{F}$ )	$U_R$ (V)								
	6.3	10	16	25	35	40	50	63	
100	-	-	-	-	-	-	-	-	10 × 12
220	-	-	-	-	10 × 12	-	10 × 16	-	10 × 20
330	-	-	-	-	-	-	-	-	12.5 × 20
470	-	-	10 × 12	10 × 16	10 × 20	-	12.5 × 20	12.5 × 25	12.5 × 25
1000	-	10 × 16	10 × 20	12.5 × 20	12.5 × 25	-	16 × 25	16 × 31	16 × 31
2200	-	12.5 × 20	12.5 × 25	16 × 25	16 × 31	16 × 35	18 × 35	18 × 35	18 × 35
3300	-	12.5 × 25	16 × 25	16 × 31	18 × 35	18 × 35	18 × 35	18 × 35	-
4700	-	16 × 25	16 × 31	18 × 35	18 × 35	-	-	-	-
6800	16 × 25	16 × 31	16 × 35	-	-	-	-	-	-
10000	16 × 35	18 × 35	18 × 35	-	-	-	-	-	-

\* Pb containing terminations are not RoHS compliant, exemptions may apply

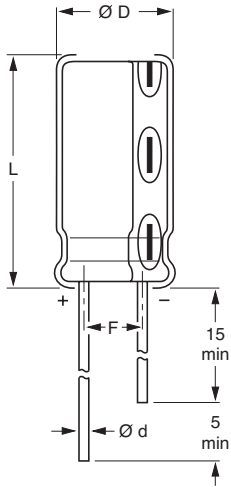
**DIMENSIONS** in millimeters, **AND AVAILABLE FORMS**


Fig.2 Form CA: Long leads.

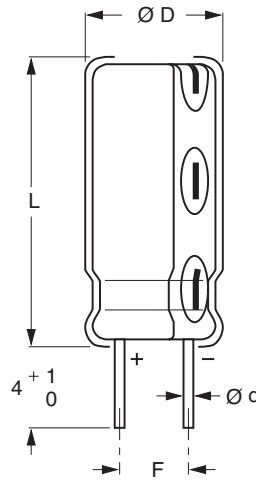


Fig.2 Form CB: Cut leads.

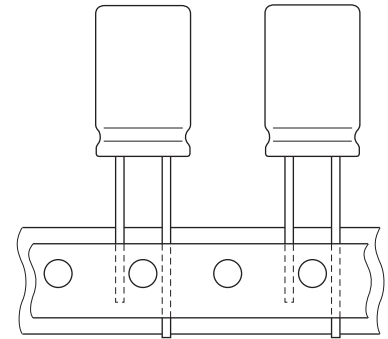


Fig.4 Form TFA: Taped in box (ammopack).

Table 1

<b>DIMENSIONS</b> in millimeters, <b>MASS AND PACKAGING QUANTITIES</b>									
NOMINAL CASE SIZE ØD × L	CASE CODE	Ød	ØD <sub>max</sub>	L <sub>max</sub>	F	MASS (g)	PACKAGING QUANTITIES		
							FORM CA	FORM CB	FORM TFA
10 × 12	14	0.6	10.5	13.5	5.0 ±0.5	≈1.6	1000	500	800
10 × 16	15	0.6	10.5	17.5	5.0 ±0.5	≈1.9	500	500	800
10 × 20	16	0.6	10.5	22.0	5.0 ±0.5	≈2.2	500	500	800
12.5 × 20	17	0.6	13.0	22.0	5.0 ±0.5	≈4.0	500	500	500
12.5 × 25	18	0.6	13.0	27.0	5.0 ±0.5	≈5.0	250	250	500
16 × 25	19	0.8	16.5	27.0	7.5 ±0.5	≈8.0	250	250	250
16 × 31	20	0.8	16.5	33.5	7.5 ±0.5	≈9.0	100	100	250
16 × 35	21	0.8	16.5	37.5	7.5 ±0.5	≈11.5	100	100	–
18 × 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**

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

Table 2

ELECTRICAL DATA AND ORDERING INFORMATION									
$U_R$ (V)	$C_R$ 100 Hz ( $\mu\text{F}$ )	NOMINAL CASE SIZE $\varnothing D \times L$ (mm)	$I_R$ 100 Hz 105 °C (mA)	$I_{L1}$ 1 min ( $\mu\text{A}$ )	$\tan \delta$ 100 Hz	Z 100 kHz (m $\Omega$ )	CATALOG NUMBER 2222 048 .....		
							BULK PACKAGING		TAPED
							FORM CA	FORM CB	FORM TFA
6.3	6800	16 × 25	1350	430	0.32	56	53682	63682	33682
	10000	16 × 35	1700	630	0.40	42	53103	63103	–
10	1000	10 × 16	470	100	0.19	180	54102	64102	34102
	2200	12.5 × 20	800	220	0.21	90	54222	64222	34222
	3300	12.5 × 25	1000	330	0.23	68	54332	64332	34332
	4700	16 × 25	1270	470	0.25	56	54472	64472	34472
	6800	16 × 31	1550	680	0.29	45	54682	64682	34682
	10000	18 × 35	1870	1000	0.37	36	54103	64103	–
16	470	10 × 12	360	78	0.16	250	55471	65471	35471
	1000	10 × 20	600	160	0.16	140	55102	65102	35102
	2200	12.5 × 25	1000	360	0.18	70	55222	65222	35222
	3300	16 × 25	1220	530	0.20	56	55332	65332	35332
	4700	16 × 31	1500	760	0.22	45	55472	65472	35472
	6800	16 × 35	1690	1100	0.26	42	55682	65682	–
	10000	18 × 35	1980	1600	0.34	34	55103	65103	–
25	470	10 × 16	440	120	0.14	180	56471	66471	36471
	1000	12.5 × 20	720	250	0.14	100	56102	66102	36102
	2200	16 × 25	1120	550	0.16	56	56222	66222	36222
	3300	16 × 31	1450	830	0.18	45	56332	66332	36332
	4700	18 × 35	1720	1200	0.20	36	56472	66472	–
35	220	10 × 12	310	80	0.12	280	50221	60221	30221
	470	10 × 20	500	170	0.12	150	50471	60471	30471
	1000	12.5 × 25	900	350	0.12	75	50102	60102	30102
	2200	16 × 31	1340	770	0.14	45	50222	60222	30222
	3300	18 × 35	1600	1200	0.16	36	50332	60332	–
	4700	18 × 35	1950	1600	0.18	34	50472	60472	–
40	2200	16 × 35	1500	880	0.13	45	57222	67222	–
	3300	18 × 35	1600	1300	0.15	36	57332	67332	–
50	220	10 × 16	340	110	0.10	250	51221	61221	31221
	470	12.5 × 20	620	240	0.10	110	51471	61471	31471
	1000	16 × 25	1030	500	0.10	60	51102	61102	31102
	2200	18 × 35	1500	1100	0.12	50	51222	61222	–
	3300	18 × 35	1900	1700	0.14	40	51332	61332	–
63	100	10 × 12	240	66	0.09	310	58101	68101	38101
	220	10 × 20	400	140	0.09	200	58221	68221	38221
	330	12.5 × 20	550	210	0.09	120	58331	68331	38331
	470	12.5 × 25	700	300	0.09	80	58471	68471	38471
	1000	16 × 31	1150	630	0.09	49	58102	68102	38102
	2200	18 × 35	1600	1400	0.11	45	58222	68222	–

**ORDERING EXAMPLE\***

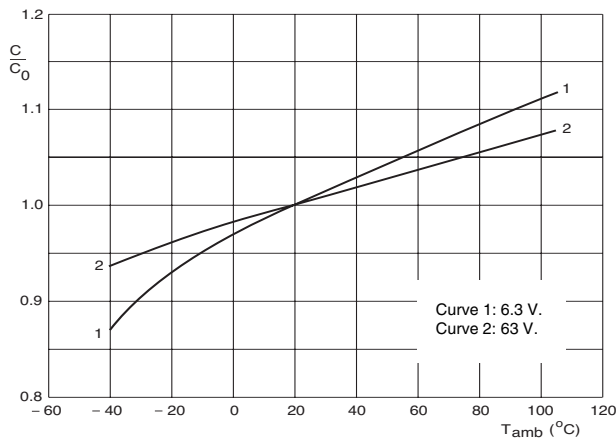
Electrolytic capacitor 048 series

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

Catalog number: 2222 048 35222.

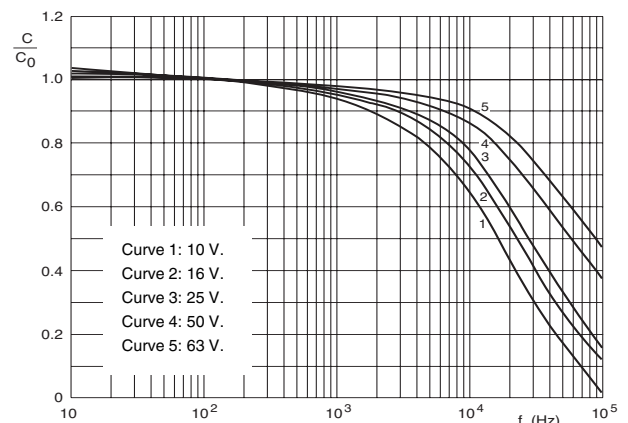
\* To ensure delivery of lead (Pb)-free parts during the transition period, please contact your Vishay sales agent.

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)**


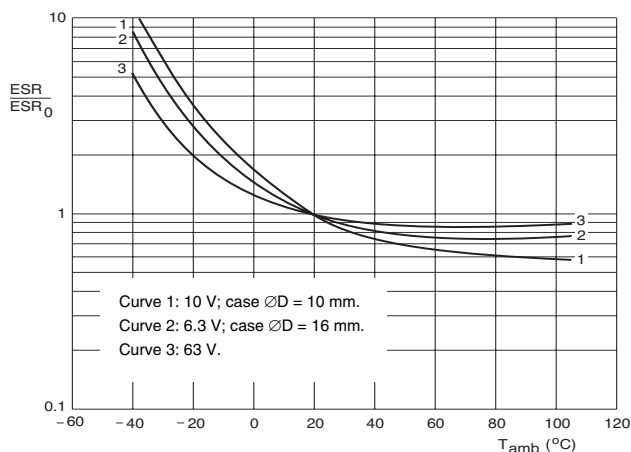
$C_0$  = typical capacitance at 20 °C, 100 Hz.

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



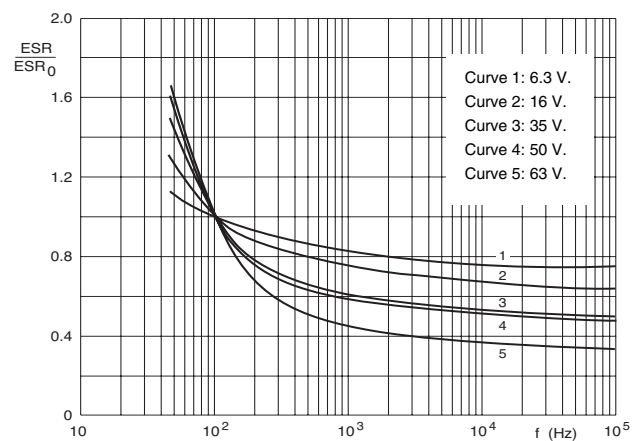
$C_0$  = typical capacitance at 20 °C, 100 Hz.  $T_{amb} = 20 \text{ °C}$ .

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

**EQUIVALENT SERIES RESISTANCE (ESR)**


$ESR_0$  = typical ESR at 20 °C, 100 Hz.

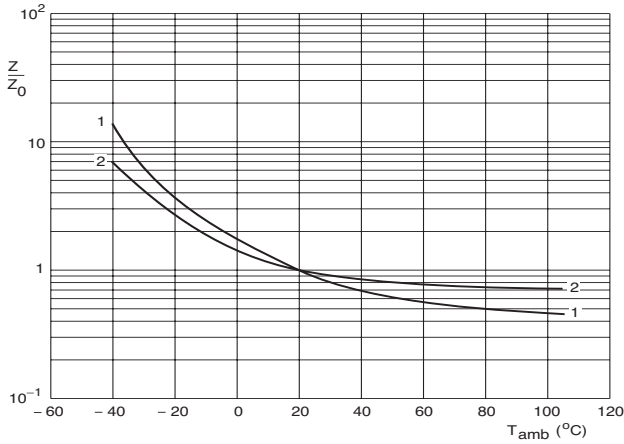
Fig.7 Multiplier of ESR as a function of ambient temperature.



$ESR_0$  = typical ESR at 20 °C, 100 Hz.

Fig.8 Multiplier of ESR as a function of frequency.

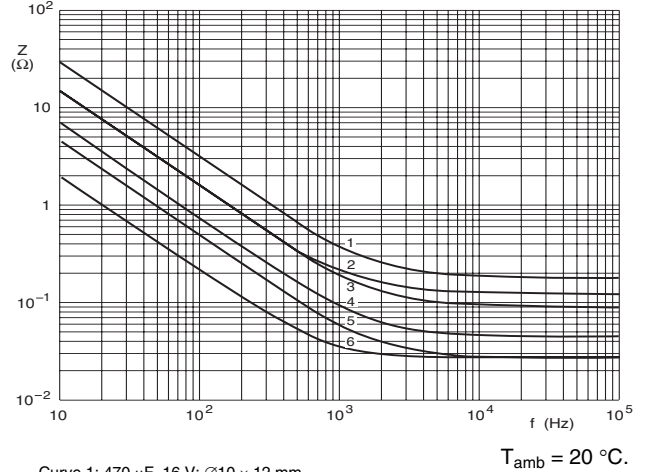
**IMPEDANCE (Z)**



Curve 1: case  $\varnothing D = 10$  mm.  
Curve 2: case  $\varnothing D = 16$  mm.

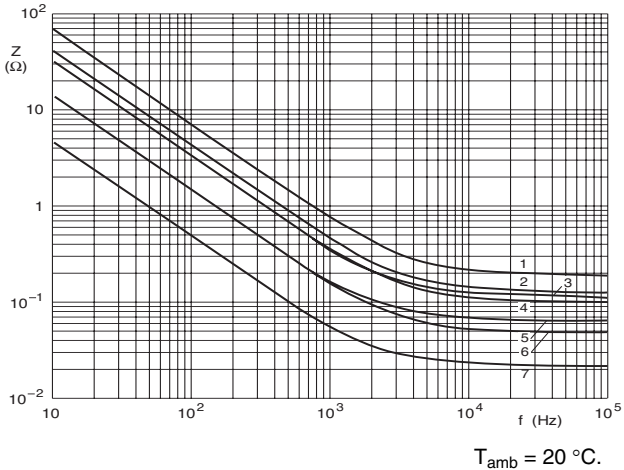
$Z_0$  = typical impedance at 20 °C, 10 kHz.

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



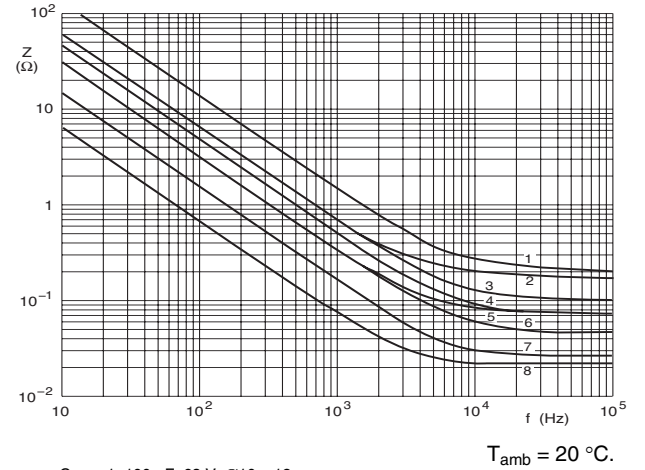
Curve 1: 470  $\mu$ F, 16 V;  $\varnothing 10 \times 12$  mm.  
Curve 2: 1000  $\mu$ F, 10 V;  $\varnothing 10 \times 16$  mm.  
Curve 3: 1000  $\mu$ F, 16 V;  $\varnothing 10 \times 20$  mm.  
Curve 4: 2200  $\mu$ F, 16 V;  $\varnothing 12.5 \times 25$  mm.  
Curve 5: 3300  $\mu$ F, 16 V;  $\varnothing 16 \times 25$  mm.  
Curve 6: 6800  $\mu$ F, 6.3 V;  $\varnothing 16 \times 25$  mm.

Fig.10 Typical impedance as a function of frequency.



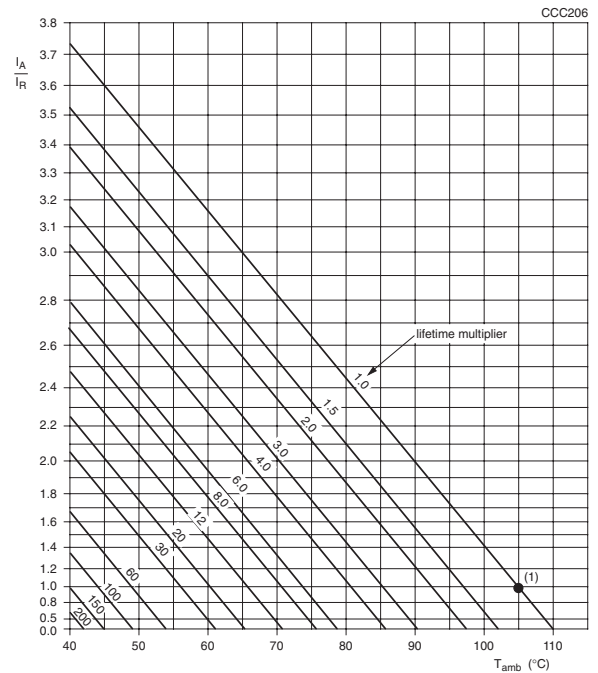
Curve 1: 220  $\mu$ F, 35 V;  $\varnothing 10 \times 12$  mm.  
Curve 2: 330  $\mu$ F, 35 V;  $\varnothing 10 \times 16$  mm.  
Curve 3: 470  $\mu$ F, 25 V;  $\varnothing 10 \times 16$  mm.  
Curve 4: 470  $\mu$ F, 35 V;  $\varnothing 10 \times 20$  mm.  
Curve 5: 1000  $\mu$ F, 25 V;  $\varnothing 12.5 \times 20$  mm.  
Curve 6: 1000  $\mu$ F, 35 V;  $\varnothing 12.5 \times 25$  mm.  
Curve 7: 3300  $\mu$ F, 25 V;  $\varnothing 16 \times 31$  mm.

Fig.10 Typical impedance as a function of frequency.



Curve 1: 100  $\mu$ F, 63 V;  $\varnothing 10 \times 12$  mm.  
Curve 2: 220  $\mu$ F, 50 V;  $\varnothing 10 \times 16$  mm.  
Curve 3: 220  $\mu$ F, 63 V;  $\varnothing 10 \times 20$  mm.  
Curve 4: 330  $\mu$ F, 63 V;  $\varnothing 12.5 \times 20$  mm.  
Curve 5: 470  $\mu$ F, 50 V;  $\varnothing 12.5 \times 20$  mm.  
Curve 6: 470  $\mu$ F, 63 V;  $\varnothing 12.5 \times 25$  mm.  
Curve 7: 1000  $\mu$ F, 63 V;  $\varnothing 16 \times 31$  mm.  
Curve 8: 2200  $\mu$ F, 40 V;  $\varnothing 16 \times 35$  mm.

Fig.11 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

<b>MULTIPLIER OF RIPPLE CURRENT (<math>I_R</math>) AS A FUNCTION OF FREQUENCY</b>			
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
$\geq 10000$	1.20	1.40	1.60

Table 4

<b>TEST PROCEDURES AND REQUIREMENTS</b>			
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 hours	$U_R \leq 6.3$ V; $\Delta C/C$ : +15/-30% $U_R > 6.3$ V; $\Delta C/C$ : $\pm 15\%$ $\tan \delta \leq 1.3 \times$ spec. limit $Z \leq 2 \times$ spec. limit $I_{L5} \leq$ spec. limit
Useful life	CECC 30301 subclause 1.8.1	$T_{amb} = 105$ °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	$U_R \leq 6.3$ V; $\Delta C/C$ : +45/-50% $U_R > 6.3$ V; $\Delta C/C$ : $\pm 45\%$ $\tan \delta \leq 3 \times$ spec. limit $Z \leq 3 \times$ spec. limit $I_{L5} \leq$ 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	$T_{amb} = 105$ °C; no voltage applied; 1000 hours after test: $U_R$ to be applied for 30 minutes, 24 to 48 hours before measurement	$U_R \leq 6.3$ V; $\Delta C/C$ : +15/-30% $U_R > 6.3$ V; $\Delta C/C$ : $\pm 15\%$ $\tan \delta \leq 1.3 \times$ spec. limit $Z \leq 2 \times$ spec. limit $I_{L5} \leq 2 \times$ spec. limit



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