# Aluminum Capacitors
# Radial Miniature Long Life

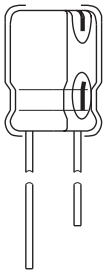
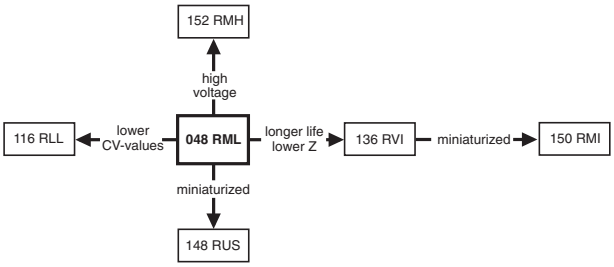


Fig.1 Component outline.




## 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.

Pb-free Available

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 (∅D × L in mm) | 10 × 12 to 18 × 35 |
| Rated capacitance range, $C_R$ | 100 to 10 000 μF |
| Tolerance on $C_R$ | ±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<br>case ∅D = 10 and 12.5 mm<br>case ∅D = 16 and 18 mm | <br>3000 hours<br>4000 hours |
| Useful life at 40 °C, 1.6 × $I_R$ applied<br>case ∅D = 10 and 12.5 mm<br>case ∅D = 16 and 18 mm | <br>200 000 hours<br>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 (ØD x L in mm)

| $C_R$ (μF) | $U_R$ (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 |
| 1000 | – | 10 × 16 | 10 × 20 | 12.5 × 20 | 12.5 × 25 | – | 16 × 25 | 16 × 31 |
| 2200 | – | 12.5 × 20 | 12.5 × 25 | 16 × 25 | 16 × 31 | 16 × 35 | 18 × 35 | 18 × 35 |
| 3300 | – | 12.5 × 25 | 16 × 25 | 16 × 31 | 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



For technical questions contact: aluminumcaps1@vishay.com

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

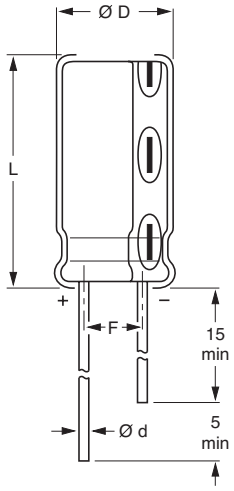



Fig.2 **Form CA**: Long leads.

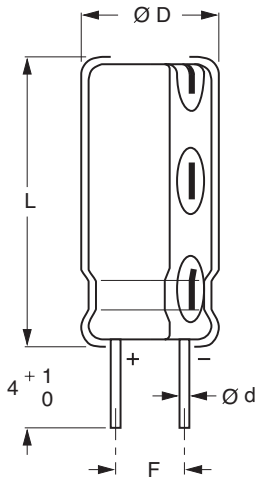



Fig.2 **Form CB**: Cut leads.

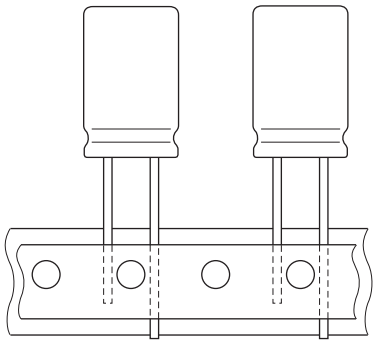


Fig.4 **Form TFA:** Taped in box (ammopack).

**Table 1**

| **DIMENSIONS** in millimeters, **MASS AND PACKAGING QUANTITIES** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **NOMINAL CASE SIZE ∅D × L** | **CASE CODE** | **∅d** | **∅$D_{max}$** | **$L_{max}$** | **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**

1. Detailed tape dimensions see section ‘PACKAGING’.

| 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 minute at $U_R$ |
| Tan δ | 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 °C, P = 86 to 106 kPa, RH = 45 to 75%.

## ORDERING EXAMPLE*

Electrolytic capacitor 048 series

2200 μF/16 V; ±20%

Nominal case size: ∅12.5 × 25 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.

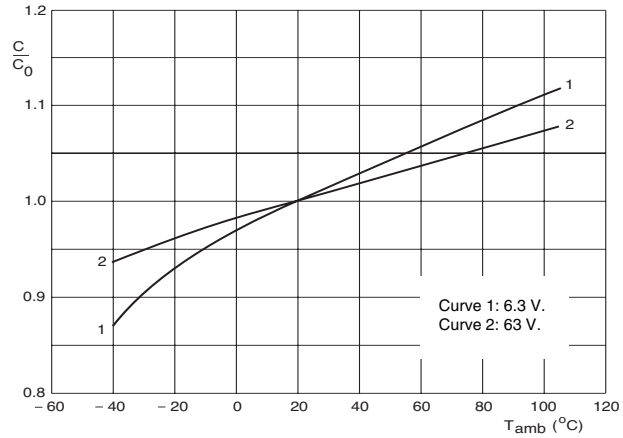
**Table 2**

**ELECTRICAL DATA AND ORDERING INFORMATION**

| $U_R$ (V) | $C_R$ 100 Hz (μF) | NOMINAL CASE SIZE ∅D × L (mm) | $I_R$ 100 Hz 105 °C (mA) | $I_{L1}$ 1 min (μA) | Tan δ 100 Hz | Z 100 kHz (mΩ) | 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 | – |

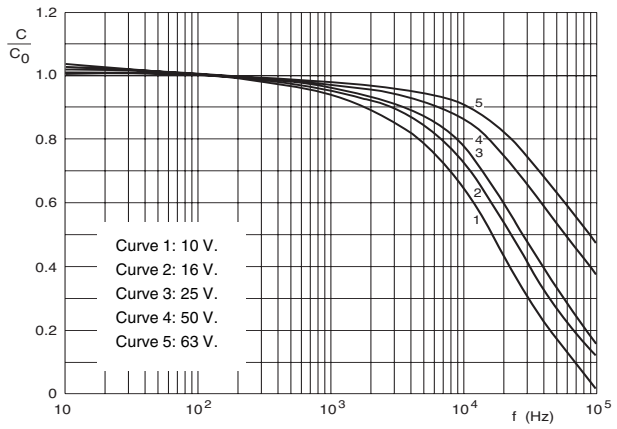
| ADDITIONAL ELECTRICAL DATA | | |
|---|---|---|
| **PARAMETER** | **CONDITIONS** | **VALUE** |
| **Voltage** | | |
| Surge voltage | | $U_s \leq 1.15\ U_R$ |
| Reverse voltage | | $U_{rev} \leq 1$ V |
| **Current** | | |
| Leakage current | after 1 minute at $U_R$ | $I_{L1} \leq 0.01\ C_R \times U_R + 3\ \mu A$ |
| | after 5 minutes at $U_R$ | $I_{L5} \leq 0.002\ C_R \times U_R + 3\ \mu A$ |
| **Inductance** | | |
| Equivalent series inductance (ESL) | case ∅D = 10 mm | typ. 16 nH |
| | case ∅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)




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

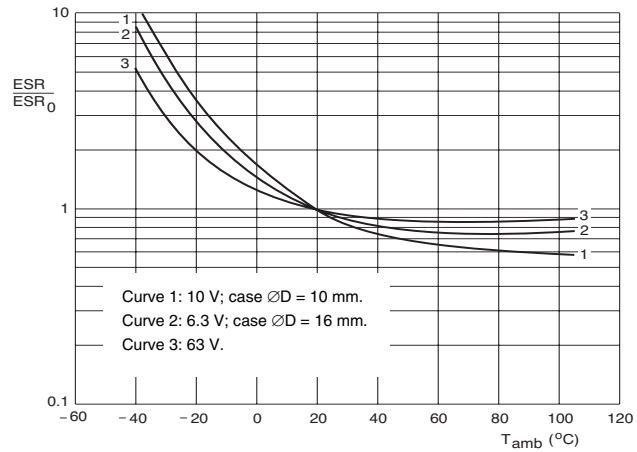
Fig.5 Typical multiplier of capacitance as a function of ambient temperature.




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

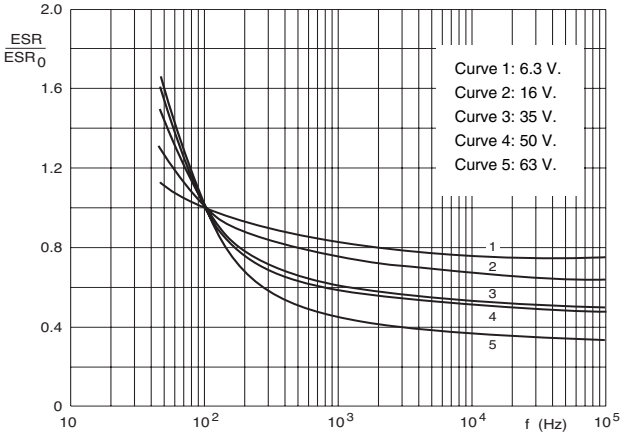
Fig.6 Typical multiplier of capacitance as a function of frequency.

## EQUIVALENT SERIES RESISTANCE (ESR)




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

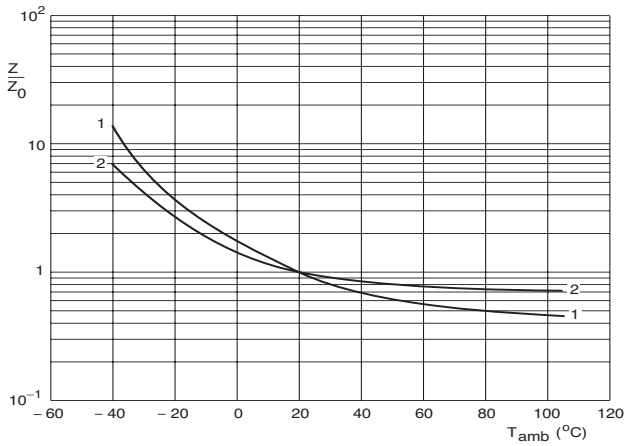
Fig.7 Multiplier of ESR as a function of ambient temperature.




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

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

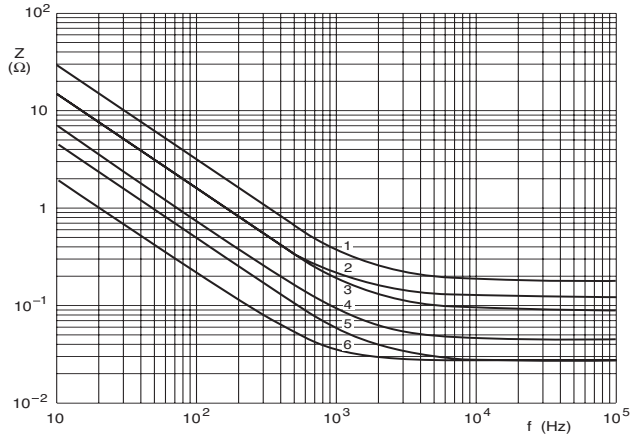
## IMPEDANCE (Z)




Curve 1: case ∅D = 10 mm.
Curve 2: case ∅D = 16 mm.

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

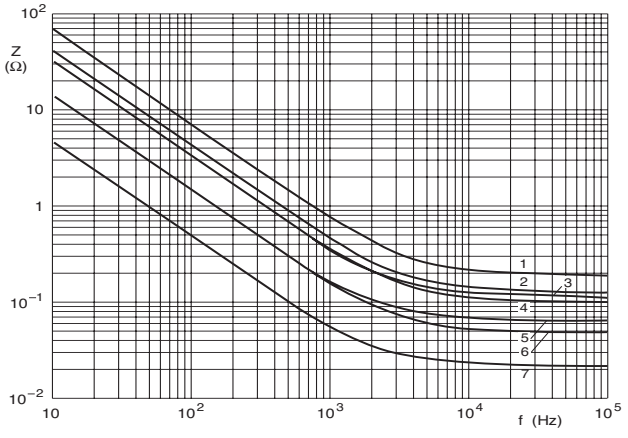
Fig.9 Typical multiplier of impedance as a function of ambient temperature.




$T_{amb}$ = 20 °C.

Curve 1: 470 µF, 16 V; ∅10 × 12 mm.
Curve 2: 1000 µF, 10 V; ∅10 × 16 mm.
Curve 3: 1000 µF, 16 V; ∅10 × 20 mm.
Curve 4: 2200 µF, 16 V; ∅12.5 × 25 mm.
Curve 5: 3300 µF, 16 V; ∅16 × 25 mm.
Curve 6: 6800 µF, 6.3 V; ∅16 × 25 mm.

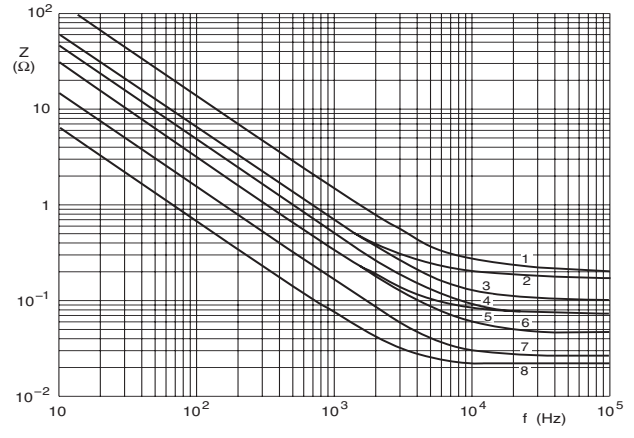
Fig.10 Typical impedance as a function of frequency.




$T_{amb}$ = 20 °C.

Curve 1: 220 µF, 35 V; ∅10 × 12 mm.
Curve 2: 330 µF, 35 V; ∅10 × 16 mm.
Curve 3: 470 µF, 25 V; ∅10 × 16 mm.
Curve 4: 470 µF, 35 V; ∅10 × 20 mm.
Curve 5: 1000 µF, 25 V; ∅12.5 × 20 mm.
Curve 6: 1000 µF, 35 V; ∅12.5 × 25 mm.
Curve 7: 3300 µF, 25 V; ∅16 × 31 mm.

Fig.10 Typical impedance as a function of frequency.

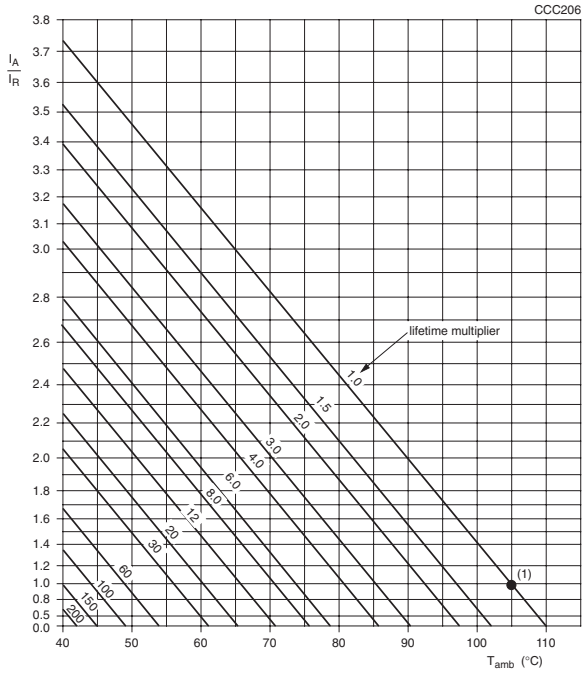



$T_{amb}$ = 20 °C.

Curve 1: 100 µF, 63 V; ∅10 × 12 mm.
Curve 2: 220 µF, 50 V; ∅10 × 16 mm.
Curve 3: 220 µF, 63 V; ∅10 × 20 mm.
Curve 4: 330 µF, 63 V; ∅12.5 × 20 mm.
Curve 5: 470 µF, 50 V; ∅12.5 × 20 mm.
Curve 6: 470 µF, 63 V; ∅12.5 × 25 mm.
Curve 7: 1000 µF, 63 V; ∅16 × 31 mm.
Curve 8: 2200 µF, 40 V; ∅16 × 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**

| 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 |
| ≥10000 | 1.20 | 1.40 | 1.60 |

**Table 4**

| 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 hours | $U_R \leq 6.3$ V; $\Delta C/C$: +15/–30%<br>$U_R > 6.3$ V; $\Delta C/C$: ±15%<br>tan $\delta \leq 1.3 \times$ spec. limit<br>$Z \leq 2 \times$ spec. limit<br>$I_{L5} \leq$ spec. limit |
| Useful life | CECC 30301 subclause 1.8.1 | $T_{amb}$ = 105 °C; $U_R$ and $I_R$ applied;<br>case ØD = 10 and 12.5 mm: 3000 hours<br>case ØD = 16 and 18 mm: 4000 hours | $U_R \leq 6.3$ V; $\Delta C/C$: +45/–50%<br>$U_R > 6.3$ V; $\Delta C/C$: ±45%<br>tan $\delta \leq 3 \times$ spec. limit<br>$Z \leq 3 \times$ spec. limit<br>$I_{L5} \leq$ spec. limit<br>no short or open circuit<br>total failure percentage: ≤ 1% |
| Shelf life (storage at high temperature) | IEC 60384-4/ EN130300 subclause 4.17 | $T_{amb}$ = 105 °C; no voltage applied;<br>1000 hours<br>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%<br>$U_R > 6.3$ V; $\Delta C/C$: ±15%<br>tan $\delta \leq 1.3 \times$ spec. limit<br>$Z \leq 2 \times$ spec. limit<br>$I_{L5} \leq 2 \times$ spec. limit |

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