

Aluminum Electrolytic Capacitors Radial Miniature Long Life

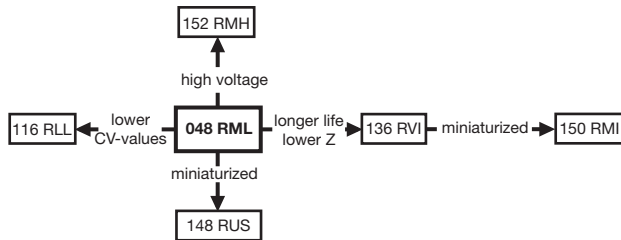


Fig. 1

| 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 | 3000 h |
| Case Ø D = 16 mm and 18 mm | 4000 h |
| Useful life at 40 °C, 1.6 x I _R 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 |

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


**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)

| 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 | - | - | - | - | - |

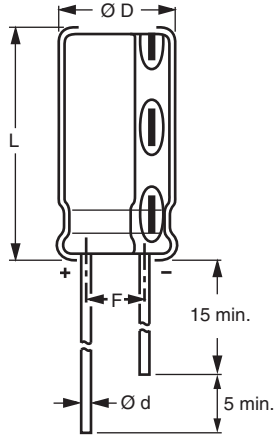
DIMENSIONS in millimeters AND AVAILABLE FORMS


Fig. 2 - Form CA: Longs leads

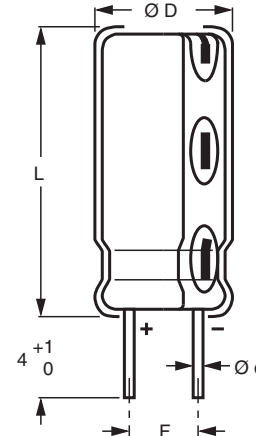


Fig. 3 - Form CB: Cut leads

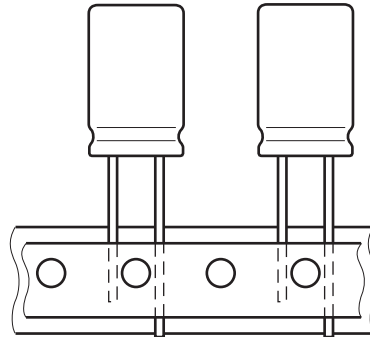


Fig. 4 - Form TFA: Taped in box (ammopack)

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 $\pm 20\%$ |
| I_R | Rated RMS ripple current at 100 Hz, 105 °C |
| I_{L1} | Max. leakage current after 1 min 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 kPa , $RH = 45\%$ to 75% .

Table 2

| ELECTRICAL DATA AND ORDERING INFORMATION | | | | | | | | | | |
|--|--------------------------------------|--|-----------------------------------|--|-------------------------|-------------------------------|------------------------------|------------------------------|---------|----------|
| U_R (V) | C_R 100 Hz (μF) | DIMENSIONS $\varnothing D \times L$ (mm) | I_R 100 Hz 105 °C (mA) | I_{L1} 1 min (μA) | $\tan \delta$ 100 Hz | Z 100 kHz (m Ω) | 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 | - |
| 25 | 10 000 | 18 x 35 | 1980 | 1600 | 0.34 | 34 | MF1 | 55103E3 | 65103E3 | - |
| | 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”

ORDERING EXAMPLE

Electrolytic capacitor 048 series

2200 μF / 16 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 |
| 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 $\varnothing D = 10 \text{ mm}$ | Typ. 16 nH |
| | Case $\varnothing D \geq 12.5 \text{ mm}$ | 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)

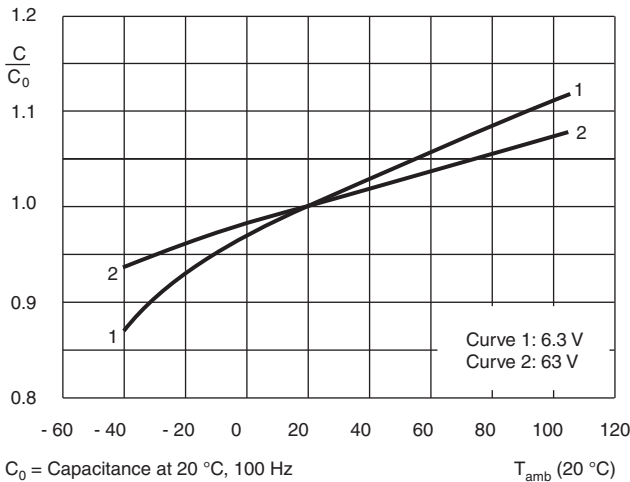


Fig. 5 - Typical multiplier of capacitance as a function of ambient temperature

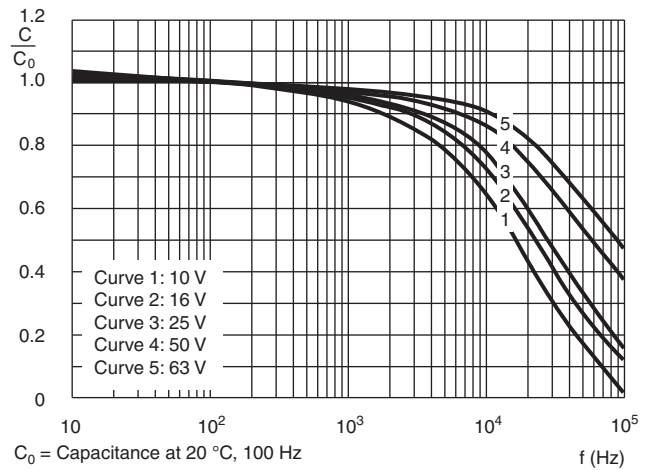


Fig. 6 - Typical multiplier of capacitance as a function of frequency

EQUIVALENT SERIES RESISTANCE (ESR)

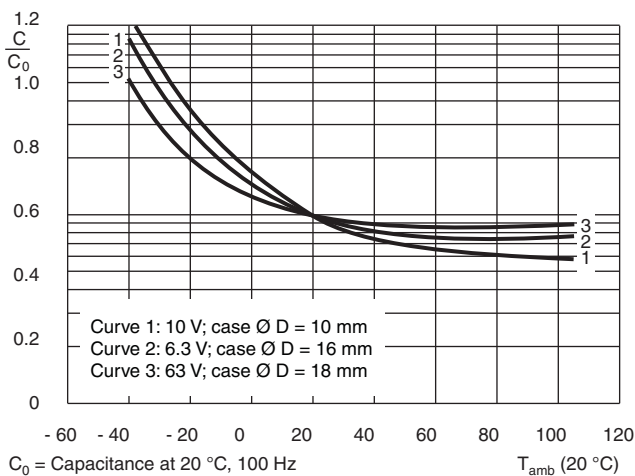


Fig. 7 - Typical multiplier of ESR as a function of ambient temperature

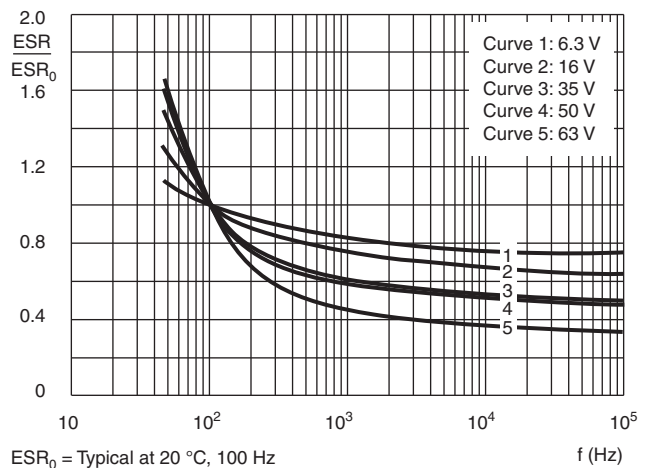


Fig. 8 - Typical multiplier of ESR as a function of frequency

IMPEDANCE (Z)

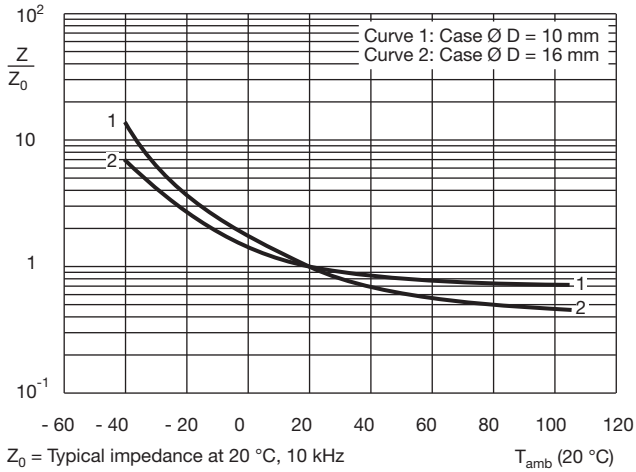


Fig. 9 - Typical multiplier of impedance as a function of ambient temperature

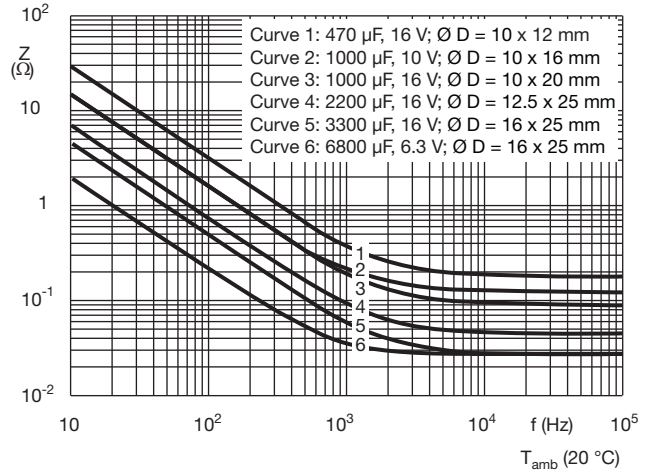


Fig. 10 - Typical impedance as a function of frequency

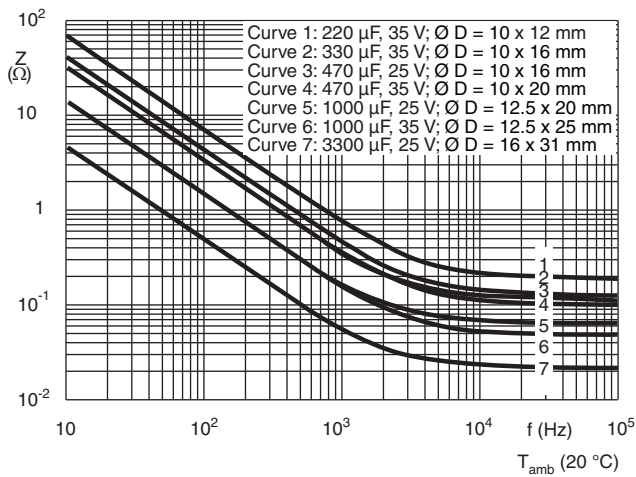


Fig. 11 - Typical impedance as a function of frequency

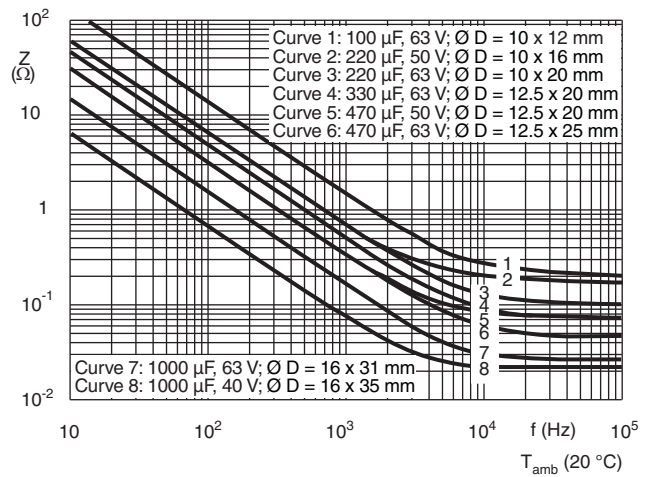


Fig. 12 - Typical impedance as a function of frequency

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

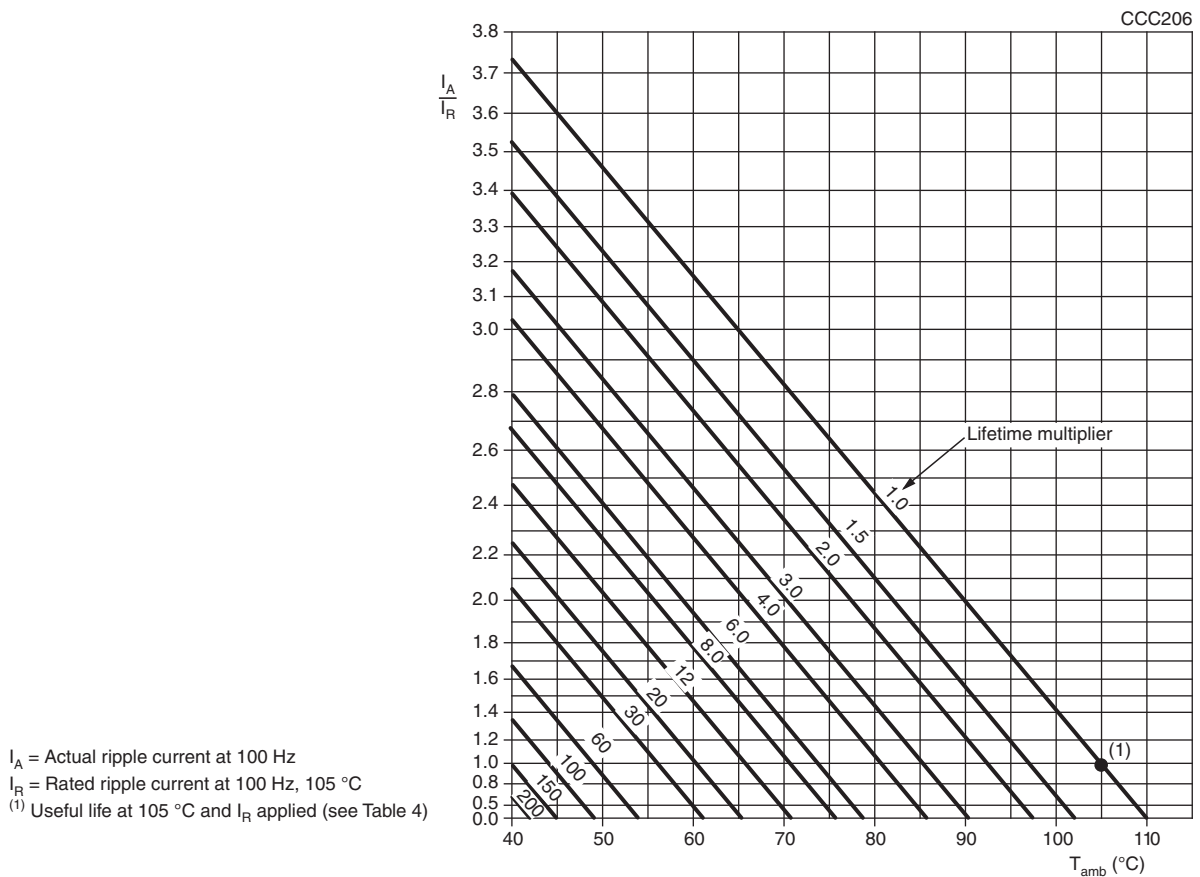


Fig. 13 - Multiplier of useful life as a function of ambient temperature and ripple current load

Table 4

| MULTIPLIER OF RIPPLE CURRENT (I_R) AS A FUNCTION OF FREQUENCY | | | | | | |
|---|------------------|------|------|------|------|-----------------|
| FREQ. CODE | FREQUENCY (Hz) | | | | | |
| | 50 | 100 | 300 | 1000 | 3000 | $\geq 100\ 000$ |
| | 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 | $T_{amb} = 105\ ^\circ\text{C}$; U_R applied; 2000 h | $U_R \leq 6.3\ \text{V}$; $\Delta C/C$: +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 | $T_{amb} = 105\ ^\circ\text{C}$; U_R and I_R applied; Case $\varnothing D = 10\ \text{mm}$ and $12.5\ \text{mm}$: 3000 h Case $\varnothing D = 16\ \text{mm}$ and $18\ \text{mm}$: 4000 h | $U_R \leq 6.3\ \text{V}$; $\Delta C/C$: +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 | $T_{amb} = 105\ ^\circ\text{C}$; no voltage applied; 1000 h After test: U_R to be applied for 30 min, 24 h to 48 h before measurement | $U_R \leq 6.3\ \text{V}$; $\Delta C/C$: +15 % / -30 % $U_R > 6.3\ \text{V}$; $\Delta C/C$: $\pm 15\ \%$ $\tan \delta \leq 1.3 \times \text{spec. limit}$ $Z \leq 2 \times \text{spec. limit}$ $I_{L5} \leq 2 \times \text{spec. limit}$ |

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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