

## Aluminum Electrolytic Capacitors Radial Miniature Long Life

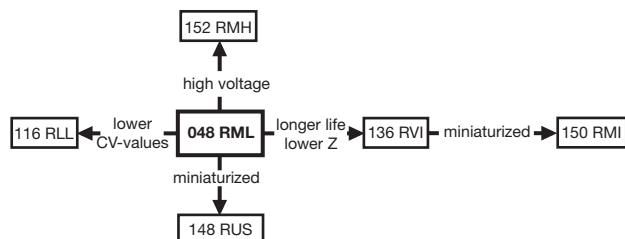


Fig. 1

### 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 <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          |

### 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](http://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)

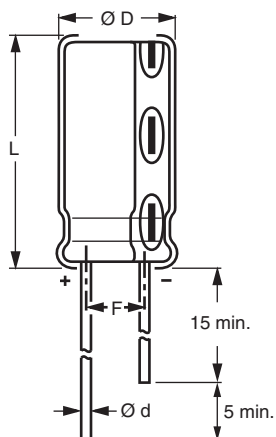
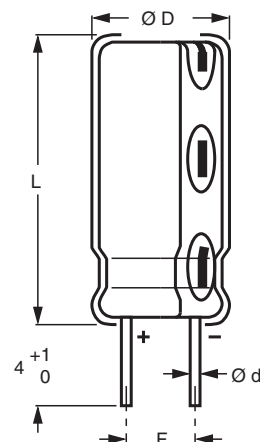
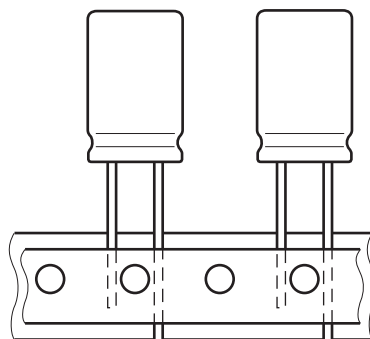
### MARKING

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<sub>R</sub>, U<sub>R</sub>, AND RELEVANT NOMINAL CASE SIZES (Ø D x L in mm)

| C <sub>R</sub><br>(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:** Longs leads

Fig. 3 - **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<br>CASE SIZE<br>Ø D x L  | CASE<br>CODE | Ø d | Ø D <sub>max.</sub> | L <sub>max.</sub> | F         | MASS<br>(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](http://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  $106\text{ kPa}$ ,  $RH = 45\%$  to  $75\%$ .

**Table 2**

| ELECTRICAL DATA AND ORDERING INFORMATION |                                      |  |                                   |  |                         |                                 |                              |                              |         |          |
|--|--------------------------------------|--|-----------------------------------|--|-------------------------|---------------------------------|------------------------------|------------------------------|---------|----------|
| $U_R$<br>(V)                             | $C_R$<br>100 Hz<br>( $\mu\text{F}$ ) | DIMENSIONS<br>$\varnothing D \times L$<br>(mm) | $I_R$<br>100 Hz<br>105 °C<br>(mA) | $I_{L1}$<br>1 min<br>( $\mu\text{A}$ ) | $\tan \delta$<br>100 Hz | $Z$<br>100 kHz<br>(m $\Omega$ ) | FREQ.<br>CODE <sup>(1)</sup> | 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**

- <sup>(1)</sup> Determines the applicable row in the table "Multiplier of Ripple Current ( $I_R$ ) as a Function of Frequency"

| 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 min at $U_R$   | $I_{L1} \leq 0.01 C_R \times U_R + 3 \mu A$  |
|                                    | After 5 min at $U_R$   | $I_{L5} \leq 0.002 C_R \times U_R + 3 \mu A$ |
| <b>Inductance</b>                  |  |  |
| Equivalent series inductance (ESL) | Case $\varnothing D = 10 mm$                                 | Typ. 16 nH                                   |
|                                    | Case $\varnothing D \geq 12.5 mm$                            | 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)

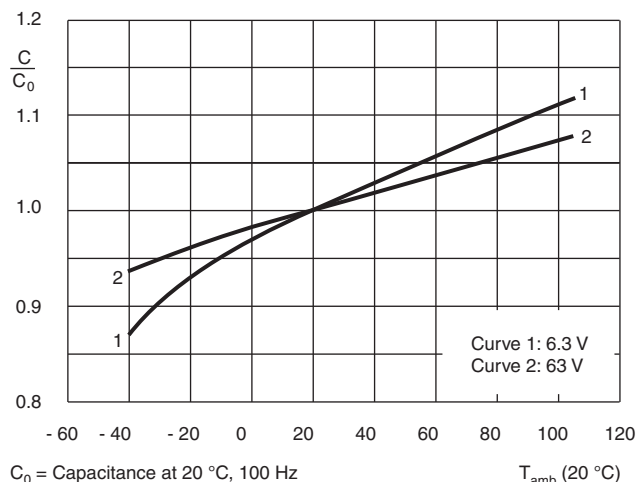


Fig. 5 - Typical multiplier of capacitance as a function of ambient temperature

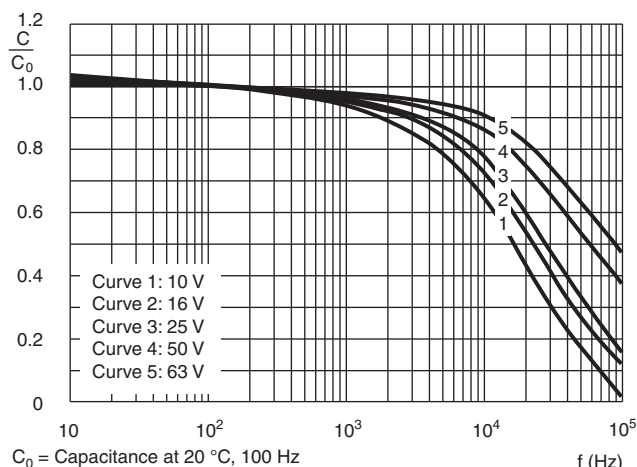


Fig. 6 - Typical multiplier of capacitance as a function of frequency

## EQUIVALENT SERIES RESISTANCE (ESR)

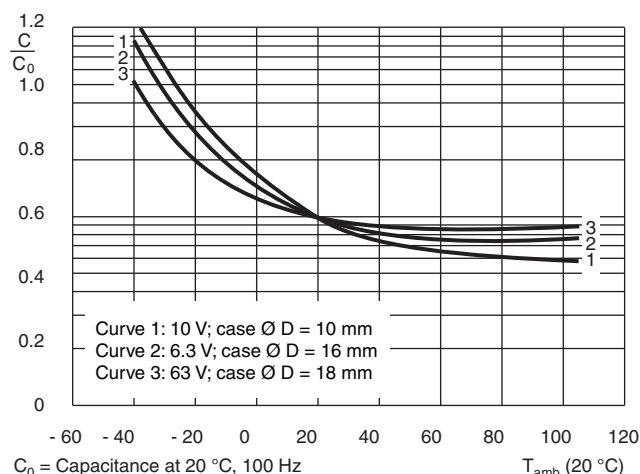


Fig. 7 - Typical multiplier of ESR as a function of ambient temperature

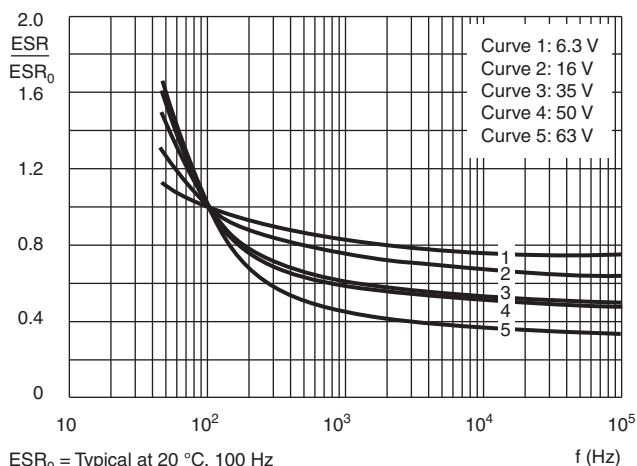


Fig. 8 - Typical multiplier of ESR as a function of frequency

# IMPEDANCE (Z)

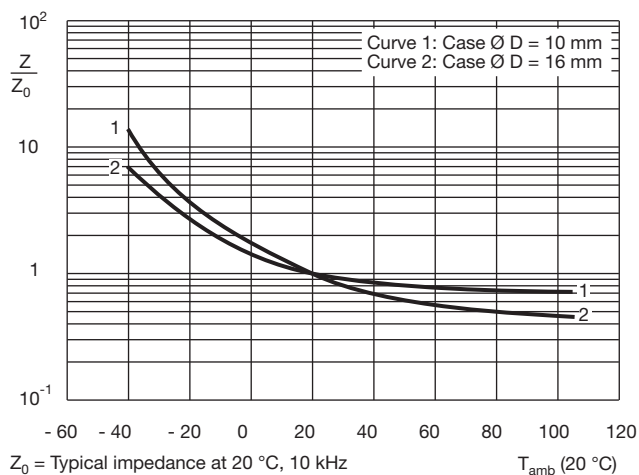


Fig. 9 - Typical multiplier of impedance as a function of ambient temperature

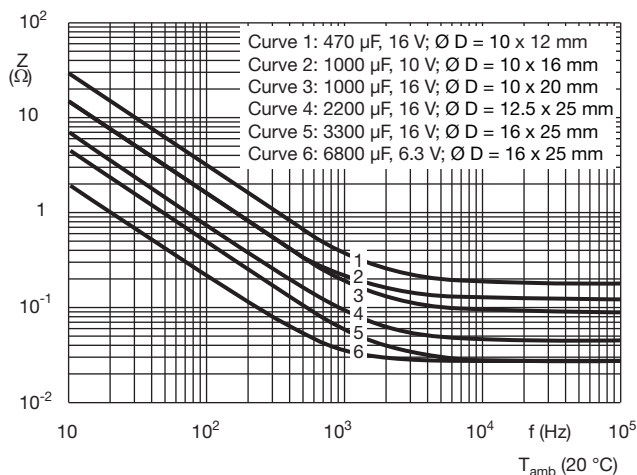


Fig. 10 - Typical impedance as a function of frequency

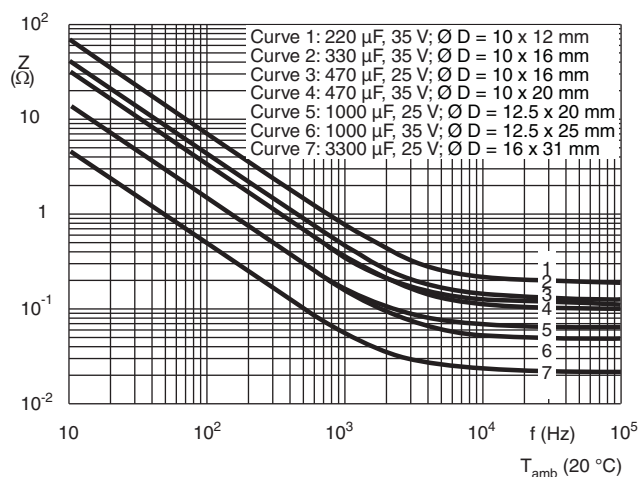


Fig. 11 - Typical impedance as a function of frequency

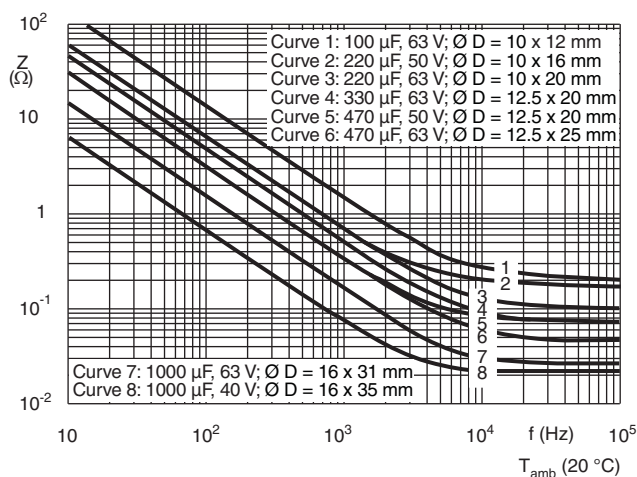


Fig. 12 - Typical impedance as a function of frequency

## RIPPLE CURRENT AND USEFUL LIFE

Table 3

| ENDURANCE TEST DURATION AND USEFUL LIFE |                               |                                 |
|---|-------------------------------|---------------------------------|
| NOMINAL CASE SIZE<br>Ø D x L<br>(mm)    | ENDURANCE<br>AT 105 °C<br>(h) | USEFUL LIFE<br>AT 105 °C<br>(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

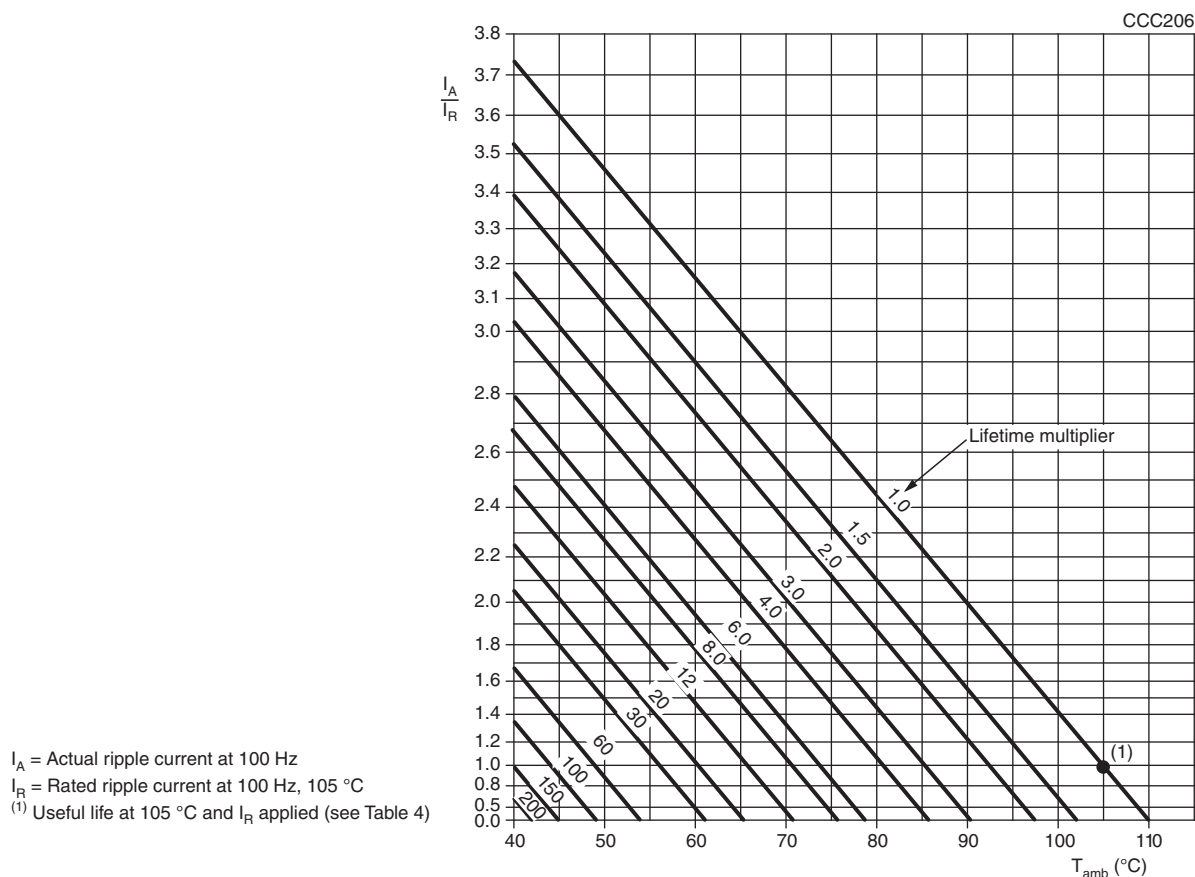


Fig. 13 - Multiplier of useful life as a function of ambient temperature and ripple current load

Table 4

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

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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