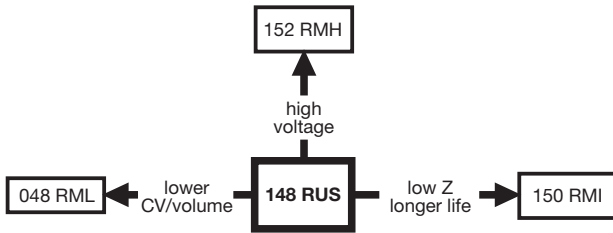


# Aluminum Electrolytic Capacitors

## Radial, Ultra High CV per Volume, Semi-Professional


**RoHS**  
COMPLIANT

### FEATURES

- Very long useful life: 3000 h at 105 °C
- Miniaturized, ultra high CV-product per unit volume
- Polarized aluminum electrolytic capacitors, non-solid electrolyte
- Radial leads, cylindrical aluminum case with pressure relief, insulated with a blue sleeve
- Charge and discharge proof
- Material categorization: for definitions of compliance please see [www.vishay.com/doc?99912](http://www.vishay.com/doc?99912)

### 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 value (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 (148)

| QUICK REFERENCE DATA                                 |  |
|--|--|
| DESCRIPTION  | VALUE                                    |
| Nominal case sizes ( $\varnothing D \times L$ in mm) | 10 x 12 to 18 x 35                       |
| Rated capacitance range, $C_R$                       | 47 $\mu\text{F}$ to 22 000 $\mu\text{F}$ |
| Tolerance on $C_R$                                   | $\pm 20\%$                               |
| Rated voltage range, $U_R$                           | 6.3 V to 100 V                           |
| Category temperature range                           | -40 °C to +105 °C                        |
| Endurance test at 105 °C:                            |  |
| Case $\varnothing D = 10$ mm                         | 1000 h                                   |
| Case $\varnothing D \geq 12.5$ mm                    | 2000 h                                   |
| Useful life at 105 °C:                               |  |
| Case $\varnothing D = 10$ mm                         | 2000 h                                   |
| Case $\varnothing D \geq 12.5$ mm                    | 3000 h                                   |
| Useful life at 40 °C, 1.6 x $I_R$ applied:           |  |
| Case $\varnothing D = 10$ mm                         | 140 000 h                                |
| Case $\varnothing D \geq 12.5$ mm                    | 200 000 h                                |
| Shelf life at 0 V, 105 °C                            | 1000 h                                   |
| Based on sectional specification                     | IEC 60384-4 / EN 130300                  |
| 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) |           |         |         |         |           |           |           |           |
|---|-----------|---------|---------|---------|-----------|-----------|-----------|-----------|
| $C_R$<br>( $\mu\text{F}$ )  | $U_R$ (V) |         |         |         |           |           |           |           |
|   | 6.3       | 10      | 16      | 25      | 35        | 50        | 63        | 100       |
| 47  | -         | -       | -       | -       | -         | -         | -         | 10 x 12   |
| 68  | -         | -       | -       | -       | -         | -         | -         | 10 x 16   |
| 100   | -         | -       | -       | -       | -         | -         | 10 x 12   | 10 x 20   |
| 150   | -         | -       | -       | -       | -         | -         | -         | 12.5 x 20 |
| 220   | -         | -       | -       | -       | -         | 10 x 12   | 10 x 16   | 12.5 x 25 |
|   | -         | -       | -       | -       | -         | -         | -         | 16 x 20   |
| 330   | -         | -       | -       | -       | 10 x 12   | 10 x 16   | 12.5 x 20 | 16 x 25   |
| 470   | -         | -       | -       | 10 x 12 | 10 x 16   | 10 x 20   | 12.5 x 20 | 16 x 31   |
| 680   | -         | -       | 10 x 12 | 10 x 16 | 10 x 20   | 12.5 x 20 | 12.5 x 25 | -         |
|   | -         | -       | -       | -       | -         | -         | 16 x 20   | -         |
| 1000  | -         | 10 x 12 | 10 x 16 | 10 x 20 | 12.5 x 20 | 12.5 x 25 | 16 x 25   | -         |
|   | -         | -       | -       | -       | -         | 16 x 20   | -         | -         |

| <b>SELECTION CHART FOR <math>C_R</math>, <math>U_R</math>, AND RELEVANT NOMINAL CASE SIZES (<math>\varnothing D \times L</math> in mm)</b> |           |           |           |           |           |         |         |     |
|--|-----------|-----------|-----------|-----------|-----------|---------|---------|-----|
| $C_R$<br>( $\mu F$ )   | $U_R$ (V) |           |           |           |           |         |         |     |
|  | 6.3       | 10        | 16        | 25        | 35        | 50      | 63      | 100 |
| 1500   | -         | 10 x 16   | 10 x 20   | 12.5 x 20 | 12.5 x 25 | 16 x 25 | 16 x 31 | -   |
|  | -         | -         | -         | -         | 16 x 20   | -       | -       | -   |
| 2200   | 10 x 16   | 10 x 20   | 12.5 x 20 | 12.5 x 25 | 16 x 25   | 16 x 31 | 18 x 35 | -   |
|  | -         | -         | -         | 16 x 20   | -         | -       | -       | -   |
| 3300   | -         | 12.5 x 20 | 12.5 x 25 | 16 x 25   | 16 x 31   | 18 x 35 | -       | -   |
|  | -         | -         | 16 x 20   | -         | -         | -       | -       | -   |
| 4700   | 12.5 x 20 | 12.5 x 25 | 16 x 25   | 16 x 31   | 18 x 35   | -       | -       | -   |
|  | -         | 16 x 20   | -         | -         | -         | -       | -       | -   |
| 6800   | 16 x 20   | 16 x 25   | 16 x 31   | 18 x 35   | -         | -       | -       | -   |
| 10 000   | 16 x 25   | 16 x 31   | 18 x 35   | -         | -         | -       | -       | -   |
| 15 000   | 16 x 31   | 18 x 35   | -         | -         | -         | -       | -       | -   |
| 22 000   | 18 x 35   | -         | -         | -         | -         | -       | -       | -   |

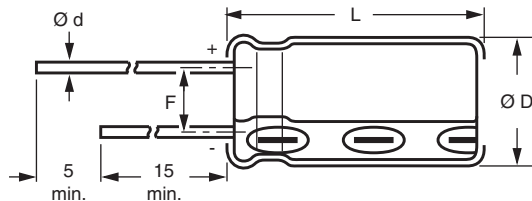
**DIMENSIONS in millimeters, AND AVAILABLE FORMS**


Fig. 2 - Form CA: Long leads

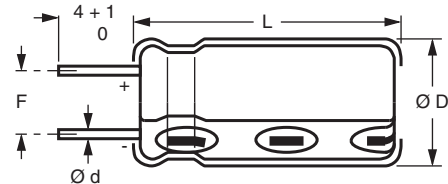


Fig. 3 - Form CB: Cut leads

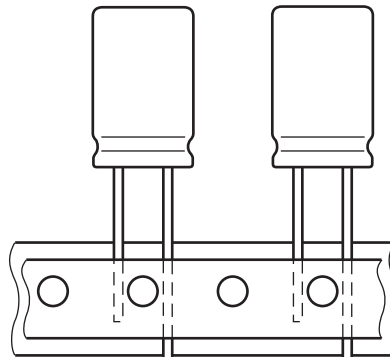


Fig. 4 - Form TFA: Taped in box (ammopack)

**Table 1**

| <b>DIMENSIONS in millimeters, MASS, AND PACKAGING QUANTITIES</b> |           |                 |                        |            |               |                |                      |         |          |
|--|-----------|-----------------|------------------------|------------|---------------|----------------|----------------------|---------|----------|
| NOMINAL CASE SIZE<br>$\varnothing D \times L$                    | CASE CODE | $\varnothing d$ | $\varnothing D_{max.}$ | $L_{max.}$ | F             | MASS (g)       | PACKAGING QUANTITIES |         |          |
|  |           |                 |                        |            |               |                | FORM CA              | FORM CB | FORM TFA |
| 10 x 12  | 14        | 0.6             | 10.5                   | 13.5       | $5.0 \pm 0.5$ | $\approx 1.6$  | 1000                 | 500     | 800      |
| 10 x 16  | 15        | 0.6             | 10.5                   | 17.5       | $5.0 \pm 0.5$ | $\approx 1.9$  | 500                  | 500     | 800      |
| 10 x 20  | 16        | 0.6             | 10.5                   | 22.0       | $5.0 \pm 0.5$ | $\approx 2.2$  | 500                  | 500     | 800      |
| 12.5 x 20  | 17        | 0.6             | 13.0                   | 22.0       | $5.0 \pm 0.5$ | $\approx 4.0$  | 500                  | 500     | 500      |
| 12.5 x 25  | 18        | 0.6             | 13.0                   | 27.0       | $5.0 \pm 0.5$ | $\approx 5.0$  | 250                  | 250     | 500      |
| 16 x 20  | 19a       | 0.8             | 16.5                   | 22.0       | $7.5 \pm 0.5$ | $\approx 6.0$  | 250                  | 250     | 250      |
| 16 x 25  | 19        | 0.8             | 16.5                   | 27.0       | $7.5 \pm 0.5$ | $\approx 8.0$  | 250                  | 250     | 250      |
| 16 x 31  | 20        | 0.8             | 16.5                   | 33.5       | $7.5 \pm 0.5$ | $\approx 9.0$  | 100                  | 100     | 250      |
| 18 x 35  | 22        | 0.8             | 18.5                   | 37.5       | $7.5 \pm 0.5$ | $\approx 14.5$ | 100                  | 100     | -        |

**Note**

- For detailed tape dimensions, please see [www.vishay.com/doc?28360](http://www.vishay.com/doc?28360)



| ELECTRICAL DATA |  |
|-----------------|--|
| SYMBOL          | DESCRIPTION  |
| C <sub>R</sub>  | Rated capacitance at 100 Hz, tolerance ± 20 %      |
| I <sub>R</sub>  | Rated RMS ripple current at 100 Hz, 105 °C         |
| I <sub>L2</sub> | Max. leakage current after 2 min at U <sub>R</sub> |
| tan δ           | Max. dissipation factor at 100 Hz                  |
| Z               | Max. impedance at 100 kHz                          |

**ORDERING EXAMPLE**

Electrolytic capacitor 148 series  
 470 µF / 25 V; ± 20 %  
 Nominal case size: Ø 10 mm x 12 mm; form TFA  
 Ordering code: MAL214836471E3  
 Former 12NC: 2222 148 36471

**Note**

- Unless otherwise specified, all electrical values in Table 2 apply at T<sub>amb</sub> = 20 °C, P = 86 kPa to 106 kPa, RH = 45 % to 75 %.

**Table 2**

| ELECTRICAL DATA AND ORDERING INFORMATION |                                  |   |  |                                  |                 |                              |                               |                              |                               |         |          |
|--|----------------------------------|---|--|----------------------------------|-----------------|------------------------------|-------------------------------|------------------------------|-------------------------------|---------|----------|
| U <sub>R</sub><br>(V)                    | C <sub>R</sub><br>100 Hz<br>(µF) | NOMINAL<br>CASE SIZE<br>Ø D x L<br>(mm) | I <sub>R</sub><br>100 Hz<br>105 °C<br>(mA) | I <sub>L2</sub><br>2 min<br>(µA) | tan δ<br>100 Hz | Z<br>100 kHz<br>20 °C<br>(Ω) | Z<br>100 kHz<br>-40 °C<br>(Ω) | FREQ.<br>CODE <sup>(1)</sup> | ORDERING CODE<br>MAL2148..... |         |          |
|  |                                  |   |  |                                  |                 |                              |                               |                              | BULK PACKAGING                |         | TAPED    |
|  |                                  |   |  |                                  |                 |                              |                               |                              | FORM CA                       | FORM CB | FORM TFA |
| 6.3                                      | 2200                             | 10 x 16                                 | 720  | 139                              | 0.30            | 0.170                        | 1.90                          | MF1                          | 53222E3                       | 63222E3 | 33222E3  |
|  | 4700                             | 12.5 x 20                               | 1100                                       | 296                              | 0.34            | 0.085                        | 0.60                          | MF1                          | 53472E3                       | 63472E3 | 33472E3  |
|  | 6800                             | 16 x 20                                 | 1210                                       | 428                              | 0.38            | 0.060                        | 0.30                          | MF1                          | 53682E3                       | 63682E3 | 33682E3  |
|  | 10 000                           | 16 x 25                                 | 1660                                       | 630                              | 0.46            | 0.045                        | 0.25                          | MF1                          | 53103E3                       | 63103E3 | 33103E3  |
|  | 15 000                           | 16 x 31                                 | 2050                                       | 945                              | 0.56            | 0.033                        | 0.15                          | MF1                          | 53153E3                       | 63153E3 | 33153E3  |
|  | 22 000                           | 18 x 35                                 | 2350                                       | 1386                             | 0.66            | 0.032                        | 0.15                          | MF1                          | 53223E3                       | 63223E3 | -        |
| 10                                       | 1000                             | 10 x 12                                 | 460  | 100                              | 0.24            | 0.240                        | 3.00                          | MF1                          | 54102E3                       | 64102E3 | 34102E3  |
|  | 1500                             | 10 x 16                                 | 620  | 150                              | 0.24            | 0.170                        | 1.90                          | MF1                          | 54152E3                       | 64152E3 | 34152E3  |
|  | 2200                             | 10 x 20                                 | 750  | 220                              | 0.26            | 0.130                        | 1.50                          | MF1                          | 54222E3                       | 64222E3 | 34222E3  |
|  | 3300                             | 12.5 x 20                               | 1010                                       | 330                              | 0.28            | 0.085                        | 0.60                          | MF1                          | 54332E3                       | 64332E3 | 34332E3  |
|  | 4700                             | 12.5 x 25                               | 1260                                       | 470                              | 0.30            | 0.065                        | 0.50                          | MF1                          | 54472E3                       | 64472E3 | 34472E3  |
|  | 4700                             | 16 x 20                                 | 1260                                       | 470                              | 0.30            | 0.060                        | 0.30                          | MF1                          | 94475E3                       | 94476E3 | 94473E3  |
|  | 6800                             | 16 x 25                                 | 1590                                       | 680                              | 0.34            | 0.045                        | 0.25                          | MF1                          | 54682E3                       | 64682E3 | 34682E3  |
|  | 10 000                           | 16 x 31                                 | 1910                                       | 1000                             | 0.42            | 0.033                        | 0.15                          | MF1                          | 54103E3                       | 64103E3 | 34103E3  |
| 15 000                                   | 18 x 35                          | 2200                                    | 1500                                       | 0.52                             | 0.032           | 0.15                         | MF1                           | 54153E3                      | 64153E3                       | -       |          |
| 16                                       | 680                              | 10 x 12                                 | 450  | 109                              | 0.20            | 0.240                        | 3.00                          | MF1                          | 55681E3                       | 65681E3 | 35681E3  |
|  | 1000                             | 10 x 16                                 | 570  | 160                              | 0.20            | 0.180                        | 2.00                          | MF1                          | 55102E3                       | 65102E3 | 35102E3  |
|  | 1500                             | 10 x 20                                 | 720  | 240                              | 0.20            | 0.130                        | 1.50                          | MF1                          | 55152E3                       | 65152E3 | 35152E3  |
|  | 2200                             | 12.5 x 20                               | 930  | 352                              | 0.22            | 0.090                        | 0.60                          | MF1                          | 55222E3                       | 65222E3 | 35222E3  |
|  | 3300                             | 12.5 x 25                               | 1180                                       | 528                              | 0.24            | 0.065                        | 0.50                          | MF1                          | 55332E3                       | 65332E3 | 35332E3  |
|  | 3300                             | 16 x 20                                 | 1120                                       | 528                              | 0.24            | 0.060                        | 0.30                          | MF1                          | 95335E3                       | 95336E3 | 95333E3  |
|  | 4700                             | 16 x 25                                 | 1480                                       | 752                              | 0.26            | 0.045                        | 0.25                          | MF1                          | 55472E3                       | 65472E3 | 35472E3  |
|  | 6800                             | 16 x 31                                 | 1790                                       | 1088                             | 0.30            | 0.035                        | 0.20                          | MF1                          | 55682E3                       | 65682E3 | 35682E3  |
|  | 10 000                           | 18 x 35                                 | 2100                                       | 1600                             | 0.36            | 0.032                        | 0.20                          | MF1                          | 55103E3                       | 65103E3 | -        |
|  | 10 000                           | 18 x 35                                 | 2100                                       | 1600                             | 0.36            | 0.032                        | 0.20                          | MF1                          | 55103E3                       | 65103E3 | -        |
| 25                                       | 470                              | 10 x 12                                 | 410  | 118                              | 0.16            | 0.260                        | 3.20                          | MF1                          | 56471E3                       | 66471E3 | 36471E3  |
|  | 680                              | 10 x 16                                 | 550  | 170                              | 0.16            | 0.190                        | 2.10                          | MF1                          | 56681E3                       | 66681E3 | 36681E3  |
|  | 1000                             | 10 x 20                                 | 690  | 250                              | 0.16            | 0.130                        | 1.50                          | MF1                          | 56102E3                       | 66102E3 | 36102E3  |
|  | 1500                             | 12.5 x 20                               | 850  | 375                              | 0.16            | 0.100                        | 0.70                          | MF1                          | 56152E3                       | 66152E3 | 36152E3  |
|  | 2200                             | 12.5 x 25                               | 1110                                       | 550                              | 0.18            | 0.070                        | 0.50                          | MF1                          | 56222E3                       | 66222E3 | 36222E3  |
|  | 2200                             | 16 x 20                                 | 1050                                       | 550                              | 0.18            | 0.060                        | 0.30                          | MF1                          | 96225E3                       | 96226E3 | 96223E3  |
|  | 3300                             | 16 x 25                                 | 1420                                       | 825                              | 0.20            | 0.045                        | 0.25                          | MF1                          | 56332E3                       | 66332E3 | 36332E3  |
|  | 4700                             | 16 x 31                                 | 1750                                       | 1175                             | 0.22            | 0.035                        | 0.20                          | MF1                          | 56472E3                       | 66472E3 | 36472E3  |
| 6800                                     | 18 x 35                          | 2050                                    | 1700                                       | 0.26                             | 0.033           | 0.20                         | MF1                           | 56682E3                      | 66682E3                       | -       |          |



| ELECTRICAL DATA AND ORDERING INFORMATION |                                  |   |  |                                  |                 |                              |                               |                              |                               |         |          |
|--|----------------------------------|---|--|----------------------------------|-----------------|------------------------------|-------------------------------|------------------------------|-------------------------------|---------|----------|
| U <sub>R</sub><br>(V)                    | C <sub>R</sub><br>100 Hz<br>(μF) | NOMINAL<br>CASE SIZE<br>Ø D x L<br>(mm) | I <sub>R</sub><br>100 Hz<br>105 °C<br>(mA) | I <sub>L2</sub><br>2 min<br>(μA) | tan δ<br>100 Hz | Z<br>100 kHz<br>20 °C<br>(Ω) | Z<br>100 kHz<br>-40 °C<br>(Ω) | FREQ.<br>CODE <sup>(1)</sup> | ORDERING CODE<br>MAL2148..... |         |          |
|  |                                  |   |  |                                  |                 |                              |                               |                              | BULK PACKAGING                |         | TAPED    |
|  |                                  |   |  |                                  |                 |                              |                               |                              | FORM CA                       | FORM CB | FORM TFA |
| 35                                       | 330                              | 10 x 12                                 | 350  | 116                              | 0.14            | 0.270                        | 3.30                          | MF2                          | 50331E3                       | 60331E3 | 30331E3  |
|  | 470                              | 10 x 16                                 | 480  | 165                              | 0.14            | 0.190                        | 2.10                          | MF2                          | 50471E3                       | 60471E3 | 30471E3  |
|  | 680                              | 10 x 20                                 | 580  | 238                              | 0.14            | 0.140                        | 1.60                          | MF2                          | 50681E3                       | 60681E3 | 30681E3  |
|  | 1000                             | 12.5 x 20                               | 810  | 350                              | 0.14            | 0.100                        | 0.70                          | MF2                          | 50102E3                       | 60102E3 | 30102E3  |
|  | 1500                             | 12.5 x 25                               | 950  | 525                              | 0.14            | 0.070                        | 0.50                          | MF2                          | 50152E3                       | 60152E3 | 30152E3  |
|  | 1500                             | 16 x 20                                 | 970  | 525                              | 0.14            | 0.063                        | 0.30                          | MF2                          | 90155E3                       | 90156E3 | 90153E3  |
|  | 2200                             | 16 x 25                                 | 1270                                       | 770                              | 0.16            | 0.045                        | 0.25                          | MF2                          | 50222E3                       | 60222E3 | 30222E3  |
|  | 3300                             | 16 x 31                                 | 1620                                       | 1155                             | 0.18            | 0.037                        | 0.20                          | MF2                          | 50332E3                       | 60332E3 | 30332E3  |
| 4700                                     | 18 x 35                          | 1930                                    | 1645                                       | 0.20                             | 0.033           | 0.20                         | MF2                           | 50472E3                      | 60472E3                       | -       |          |
| 50                                       | 220                              | 10 x 12                                 | 330  | 110                              | 0.12            | 0.280                        | 3.40                          | MF3                          | 51221E3                       | 61221E3 | 31221E3  |
|  | 330                              | 10 x 16                                 | 420  | 165                              | 0.12            | 0.200                        | 2.20                          | MF3                          | 51331E3                       | 61331E3 | 31331E3  |
|  | 470                              | 10 x 20                                 | 530  | 235                              | 0.12            | 0.140                        | 1.60                          | MF3                          | 51471E3                       | 61471E3 | 31471E3  |
|  | 680                              | 12.5 x 20                               | 720  | 340                              | 0.12            | 0.100                        | 0.70                          | MF3                          | 51681E3                       | 61681E3 | 31681E3  |
|  | 1000                             | 12.5 x 25                               | 950  | 500                              | 0.12            | 0.070                        | 0.50                          | MF3                          | 51102E3                       | 61102E3 | 31102E3  |
|  | 1000                             | 16 x 20                                 | 880  | 500                              | 0.12            | 0.068                        | 0.35                          | MF3                          | 91105E3                       | 91106E3 | 91103E3  |
|  | 1500                             | 16 x 25                                 | 1180                                       | 750                              | 0.12            | 0.047                        | 0.30                          | MF3                          | 51152E3                       | 61152E3 | 31152E3  |
|  | 2200                             | 16 x 31                                 | 1520                                       | 1100                             | 0.14            | 0.039                        | 0.20                          | MF3                          | 51222E3                       | 61222E3 | 31222E3  |
| 3300                                     | 18 x 35                          | 1810                                    | 1650                                       | 0.16                             | 0.035           | 0.20                         | MF3                           | 51332E3                      | 61332E3                       | -       |          |
| 63                                       | 100                              | 10 x 12                                 | 230  | 63                               | 0.10            | 0.320                        | 3.90                          | MF3                          | 58101E3                       | 68101E3 | 38101E3  |
|  | 220                              | 10 x 16                                 | 350  | 139                              | 0.10            | 0.240                        | 2.70                          | MF3                          | 58221E3                       | 68221E3 | 38221E3  |
|  | 330                              | 12.5 x 20                               | 540  | 208                              | 0.10            | 0.130                        | 0.90                          | MF3                          | 58331E3                       | 68331E3 | 38331E3  |
|  | 470                              | 12.5 x 20                               | 540  | 296                              | 0.10            | 0.130                        | 0.90                          | MF3                          | 58471E3                       | 68471E3 | 38471E3  |
|  | 680                              | 12.5 x 25                               | 760  | 428                              | 0.10            | 0.085                        | 0.65                          | MF3                          | 58681E3                       | 68681E3 | 38681E3  |
|  | 680                              | 16 x 20                                 | 820  | 428                              | 0.10            | 0.070                        | 0.50                          | MF3                          | 98685E3                       | 98686E3 | 98683E3  |
|  | 1000                             | 16 x 25                                 | 980  | 630                              | 0.10            | 0.049                        | 0.25                          | MF3                          | 58102E3                       | 68102E3 | 38102E3  |
|  | 1500                             | 16 x 31                                 | 1390                                       | 945                              | 0.10            | 0.042                        | 0.20                          | MF3                          | 58152E3                       | 68152E3 | 38152E3  |
| 2200                                     | 18 x 35                          | 1670                                    | 1386                                       | 0.12                             | 0.038           | 0.20                         | MF3                           | 58222E3                      | 68222E3                       | -       |          |
| 100                                      | 47                               | 10 x 12                                 | 165  | 47                               | 0.08            | 0.640                        | 19.20                         | MF3                          | 59479E3                       | 69479E3 | 39479E3  |
|  | 68                               | 10 x 16                                 | 190  | 68                               | 0.08            | 0.580                        | 17.40                         | MF3                          | 59689E3                       | 69689E3 | 39689E3  |
|  | 100                              | 10 x 20                                 | 260  | 100                              | 0.08            | 0.380                        | 11.40                         | MF3                          | 59101E3                       | 69101E3 | 39101E3  |
|  | 150                              | 12.5 x 20                               | 360  | 150                              | 0.08            | 0.260                        | 7.80                          | MF3                          | 59151E3                       | 69151E3 | 39151E3  |
|  | 220                              | 12.5 x 25                               | 440  | 220                              | 0.08            | 0.170                        | 5.10                          | MF3                          | 59221E3                       | 69221E3 | 39221E3  |
|  | 220                              | 16 x 20                                 | 590  | 220                              | 0.08            | 0.140                        | 4.20                          | MF3                          | 99225E3                       | 99226E3 | 99223E3  |
|  | 330                              | 16 x 25                                 | 630  | 330                              | 0.08            | 0.120                        | 3.60                          | MF3                          | 59331E3                       | 69331E3 | 39331E3  |
|  | 470                              | 16 x 31                                 | 750  | 470                              | 0.08            | 0.100                        | 3.00                          | MF3                          | 59471E3                       | 69471E3 | 39471E3  |

| 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 2 min at $U_R$  | $I_{L2} \leq 0.01 C_R \times U_R$  |
|                                    | After 5 min at $U_R$  | $I_{L5} \leq 0.002 C_R \times U_R$ |
| <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)**

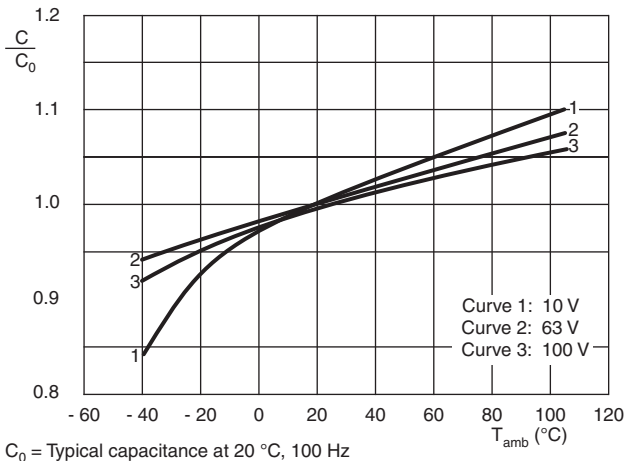


Fig. 5 - Typical multiplier of capacitance as a function of ambient temperature

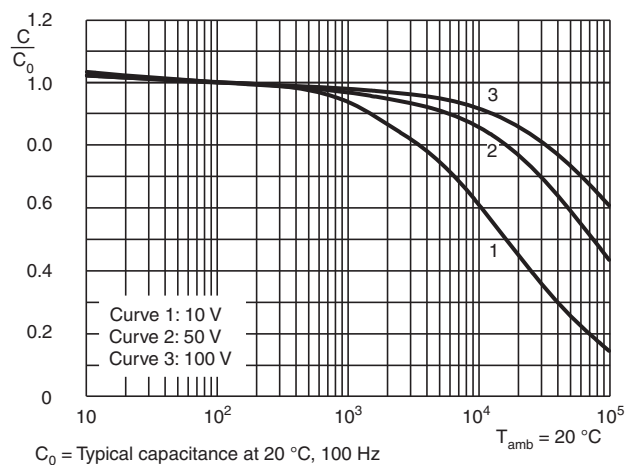


Fig. 6 - Typical multiplier of capacitance as a function of frequency

**EQUIVALENT SERIES RESISTANCE (ESR)**

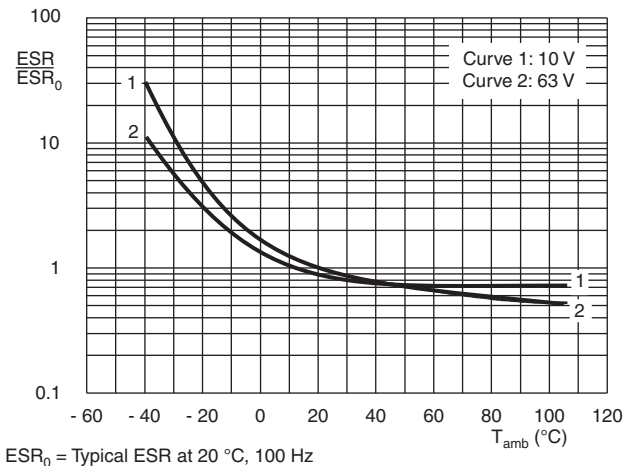


Fig. 7 - Multiplier of ESR as a function of ambient temperature

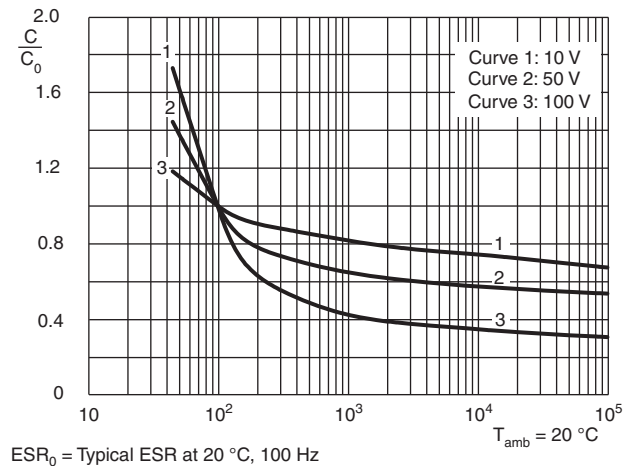
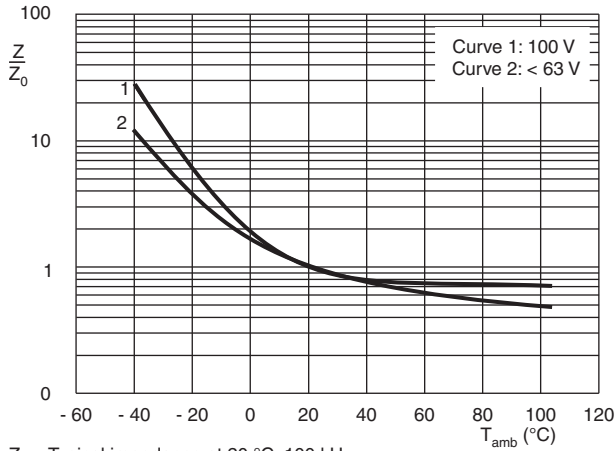


Fig. 8 - Multiplier of ESR as a function of frequency

**IMPEDANCE (Z)**



$Z_0$  = Typical impedance at 20 °C, 100 kHz

Fig. 9 - Multiplier of impedance as a function of ambient temperature

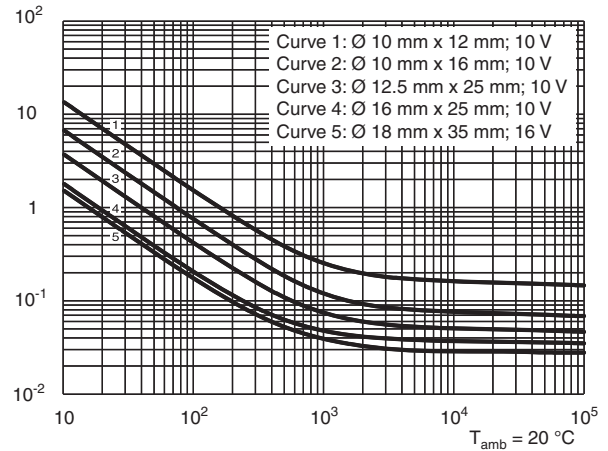


Fig. 10 - Typical impedance as a function of frequency

**IMPEDANCE (Z)**

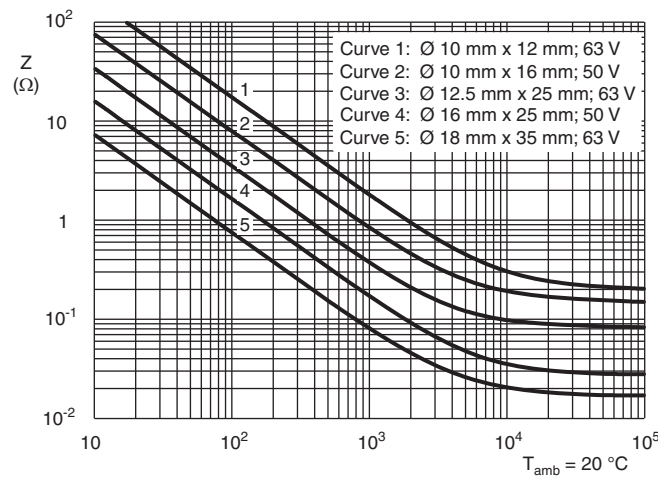


Fig. 11 - Typical impedance as a function of frequency

**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                                 | 1000                          | 2000                            |
| 10 x 16                                 | 1000                          | 2000                            |
| 10 x 20                                 | 1000                          | 2000                            |
| 12.5 x 20                               | 2000                          | 3000                            |
| 12.5 x 25                               | 2000                          | 3000                            |
| 16 x 20                                 | 2000                          | 3000                            |
| 16 x 25                                 | 2000                          | 3000                            |
| 16 x 31                                 | 2000                          | 3000                            |
| 18 x 35                                 | 2000                          | 3000                            |

**Note**

- Multiplier of useful life code: CCC206

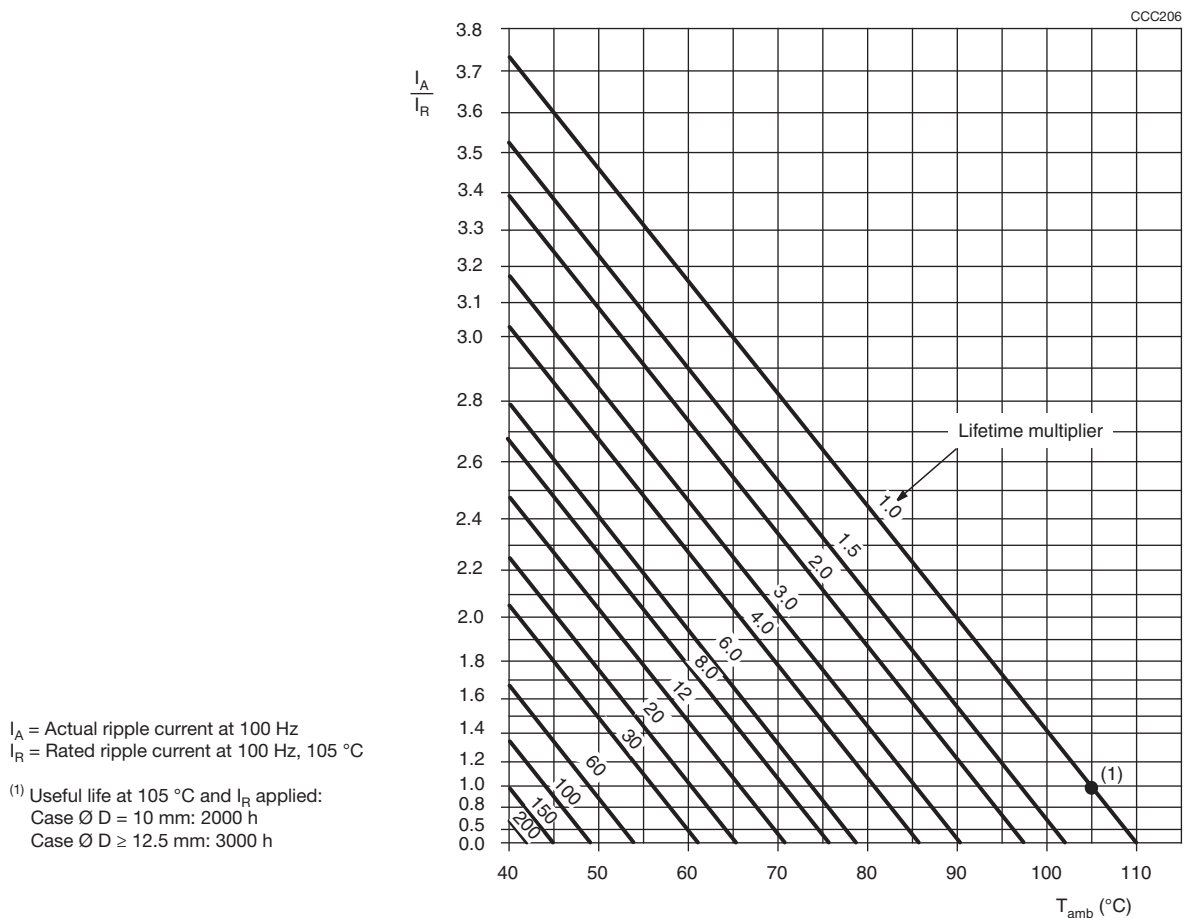


Fig. 12 - Multiplier of useful life as a function of ambient ripple current load

Table 4

| <b>MULTIPLIER OF RIPPLE CURRENT (<math>I_R</math>) AS A FUNCTION OF FREQUENCY</b> |                |      |      |      |      |          |
|---|----------------|------|------|------|------|----------|
| FREQ. CODE  | FREQUENCY (Hz) |      |      |      |      |          |
|   | 50             | 100  | 300  | 1000 | 3000 | ≥ 10 000 |
| <b><math>I_R</math> MULTIPLIER</b>  |                |      |      |      |      |          |
| 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     |

| <b>TEST PROCEDURES AND REQUIREMENTS</b>     |  |  |   |
|---|--|--|---|
| TEST  |  | PROCEDURE<br>(quick reference)   | REQUIREMENTS  |
| NAME OF TEST                                | REFERENCE                              |  |   |
| Endurance                                   | IEC 60384-4 / EN 130300 subclause 4.13 | $T_{amb} = 105\text{ °C}$ ; $U_R$ applied<br>Case $\varnothing D = 10\text{ mm}$ : 1000 h<br>Case $\varnothing D \geq 12.5\text{ mm}$ : 2000 h           | $U_R = 6.3\text{ V}$ ; $\Delta C/C$ : +15 % / -30 %<br>$U_R \geq 10\text{ V}$ ; $\Delta C/C$ : $\pm 20\%$<br>$\tan \delta \leq 2 \times \text{spec. limit}$<br>$Z \leq 2 \times \text{spec. limit}$<br>$I_{L5} \leq \text{spec. limit}$   |
| Useful life                                 | CECC 30301 subclause 1.8.1             | $T_{amb} = 105\text{ °C}$ ; $U_R$ and $I_R$ applied<br>Case $\varnothing D = 10\text{ mm}$ : 2000 h<br>Case $\varnothing D \geq 12.5\text{ mm}$ : 3000 h | $U_R = 6.3\text{ V}$ ; $\Delta C/C$ : +45 % / -50 %<br>$U_R \geq 10\text{ V}$ ; $\Delta C/C$ : $\pm 45\%$<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 high temperature) | IEC 60384-4 / EN 130300 subclause 4.17 | $T_{amb} = 105\text{ °C}$ ; 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              | $U_R = 6.3\text{ V}$ ; $\Delta C/C$ : +15 % / -30 %<br>$U_R \geq 10\text{ V}$ ; $\Delta C/C$ : $\pm 20\%$<br>$\tan \delta \leq 2 \times \text{spec. limit}$<br>$Z \leq 2 \times \text{spec. limit}$<br>$I_{L5} \leq 2 \times \text{spec. limit}$  |
| Surge                                       | IEC 60384-4 / EN 130300 subclause 4.14 | From source of $1.15 \times U_R$ :<br>$RC = 0.1 \pm 0.05\text{ s}$ ; 1000 cycles of 30 s on,<br>330 s off, at $105\text{ °C}$                            | $\Delta C/C$ : $\pm 20\%$<br>$\tan \delta \leq 1.5 \times \text{spec. limit}$<br>$I_{L5} \leq \text{spec. limit}$   |
| Reverse voltage                             | IEC 60384-4 / EN 130300 subclause 4.15 | $T_{amb} = 105\text{ °C}$ :<br>125 h at $U = -1\text{ V}$ , followed by 125 h at $U_R$   | $\Delta C/C$ : $\pm 15\%$<br>$\tan \delta \leq 1.5 \times \text{spec. limit}$<br>$I_{L5} \leq \text{spec. limit}$   |

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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