

## Aluminum Capacitors Radial Very Low Impedance

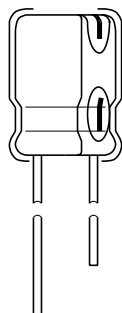
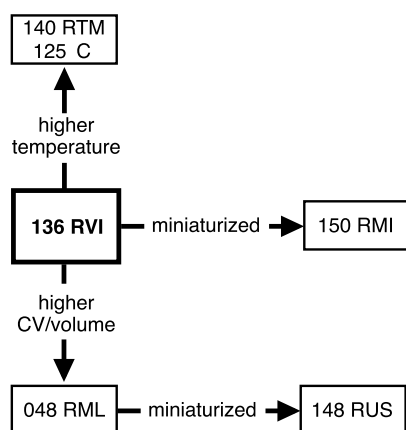


Fig.1 Component outline



### 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
- Very long useful life:  
4000 to 10 000 hours at 105 °C, very high reliability
- Very low impedance or ESR respectively,
- Excellent ripple current capability
- Lead (Pb)-free versions are RoHS compliant

### APPLICATIONS

- Power supplies (SMPS, DC/DC converters) for general industrial, EDP, audio-video, automotive and telecommunications
- Smoothing, filtering, buffering

### 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 (136)

| QUICK REFERENCE DATA                               |                                                      |
|----------------------------------------------------|------------------------------------------------------|
| DESCRIPTION                                        | VALUE                                                |
| Nominal case sizes<br>( $\varnothing$ D x L in mm) | 10 x 12<br>to 18 x 35                                |
| Rated capacitance range, $C_R$                     | 22 to 10000 $\mu\text{F}$                            |
| Tolerance on $C_R$                                 | $\pm 20\%$                                           |
| Rated voltage range, $C_R$                         | 10 to 100 V                                          |
| Category temperature range                         | - 55 to + 105 °C                                     |
| Endurance test at 105 °C                           | 3000 to 5000 hours<br>(dependent on case size)       |
| Useful life at 105 °C                              | 4000 to 10 000 hours<br>(dependent on case size)     |
| Useful life at 40 °C,<br>1.8 x $I_R$ applied       | 200 000 to 500 000 hours<br>(dependent on case size) |
| Shelf life at 0 V, 105 °C                          | 1000 hours                                           |
| Based on sectional specification                   | IEC 60384-4/EN130300                                 |
| Climatic category IEC 60068                        | 55/105/56                                            |



### SELECTION CHART FOR $C_R$ , $U_R$ AND RELEVANT NOMINAL CASE SIZES ( $\varnothing D \times L$ in mm)

| $C_R$<br>( $\mu F$ ) | $U_R$ (V) |           |           |           |           |           |           |
|----------------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
|                      | 10        | 16        | 25        | 35        | 50        | 63        | 100       |
| 22                   | -         | -         | -         | -         | -         | -         | 10 x 12   |
| 33                   | -         | -         | -         | -         | -         | -         | 10 x 12   |
| 47                   | -         | -         | -         | -         | -         | 10 x 12   | 10 x 16   |
| 56                   | -         | -         | -         | -         | -         | 10 x 12   | -         |
| 68                   | -         | -         | -         | -         | -         | 10 x 16   | 10 x 20   |
| 82                   | -         | -         | -         | -         | 10 x 12   | -         | -         |
| 100                  | -         | -         | -         | -         | 10 x 12   | 10 x 16   | 12.5 x 20 |
| 120                  | -         | -         | -         | 10 x 12   | 10 x 16   | 10 x 20   | -         |
|                      | -         | -         | -         | -         | -         | 12.5 x 16 | -         |
| 150                  | -         | -         | -         | 10 x 12   | 10 x 20   | 10 x 25   | 16 x 20   |
| 180                  | -         | -         | 10 x 12   | -         | 10 x 20   | 10 x 30   | -         |
|                      | -         | -         | -         | -         | 12.5 x 16 | -         | -         |
| 220                  | -         | -         | 10 x 12   | 10 x 16   | 10 x 25   | 12.5 x 20 | 16 x 25   |
| 270                  | -         | 10 x 12   | -         | -         | -         | 12.5 x 25 | -         |
| 330                  | -         | 10 x 12   | 10 x 16   | 10 x 20   | 10 x 30   | 16 x 20   | 16 x 31   |
|                      | -         | -         | -         | 12.5 x 16 | 12.5 x 20 | -         | -         |
| 390                  | 10 x 12   | -         | -         | 10 x 25   | -         | 12.5 x 31 | -         |
| 470                  | 10 x 12   | 10 x 16   | 10 x 20   | 12.5 x 20 | 12.5 x 25 | 16 x 25   | 16 x 35   |
|                      | -         | -         | 12.5 x 16 | -         | -         | -         | 18 x 31   |
| 560                  | -         | -         | 10 x 25   | 10 x 30   | 12.5 x 31 | -         | -         |
|                      | -         | -         | -         | 12.5 x 20 | -         | -         | -         |
| 680                  | 10 x 16   | 10 x 20   | -         | 12.5 x 25 | 16 x 20   | 16 x 31   | 18 x 35   |
|                      | -         | 12.5 x 16 | -         | -         | -         | 18 x 25   | -         |
| 820                  | -         | 10 x 25   | 10 x 30   | -         | 16 x 25   | 16 x 35   | -         |
|                      | -         | -         | 12.5 x 20 | -         | -         | -         | -         |
| 1000                 | 10 x 20   | 12.5 x 20 | 12.5 x 25 | 12.5 x 31 | 16 x 31   | 18 x 31   | -         |
|                      | 12.5 x 16 | -         | -         | 16 x 20   | 18 x 20   | -         | -         |
| 1200                 | 10 x 25   | 10 x 30   | -         | 16 x 25   | 16 x 35   | -         | -         |
|                      | -         | 12.5 x 20 | -         | -         | -         | -         | -         |
| 1500                 | 10 x 30   | 12.5 x 25 | 12.5 x 31 | 16 x 25   | 18 x 31   | 18 x 35   | -         |
|                      | 12.5 x 20 | -         | 16 x 20   | -         | -         | -         | -         |
| 1800                 | 12.5 x 20 | -         | 16 x 25   | 16 x 31   | -         | -         | -         |
| 2200                 | 12.5 x 25 | 12.5 x 31 | 16 x 31   | 16 x 35   | 18 x 35   | -         | -         |
|                      | -         | 16 x 20   | 18 x 20   | 18 x 31   | -         | -         | -         |
| 2700                 | 12.5 x 31 | 16 x 25   | 16 x 31   | -         | -         | -         | -         |
| 3300                 | 16 x 20   | 16 x 25   | 16 x 35   | 18 x 35   | -         | -         | -         |
|                      | -         | -         | 18 x 31   | -         | -         | -         | -         |
| 3900                 | 16 x 25   | 16 x 31   | -         | -         | -         | -         | -         |
| 4700                 | 16 x 31   | 16 x 35   | 18 x 35   | -         | -         | -         | -         |
|                      | -         | 18 x 31   | -         | -         | -         | -         | -         |
| 5600                 | 16 x 31   | -         | -         | -         | -         | -         | -         |
|                      | 18 x 25   | -         | -         | -         | -         | -         | -         |
| 6800                 | 16 x 35   | 18 x 35   | -         | -         | -         | -         | -         |
|                      | 18 x 31   | -         | -         | -         | -         | -         | -         |
| 10 000               | 18 x 35   | -         | -         | -         | -         | -         | -         |

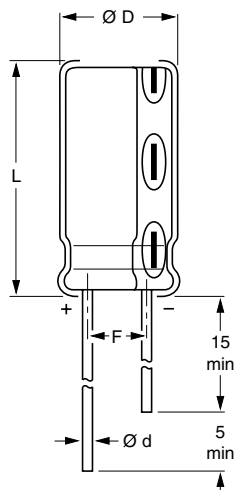
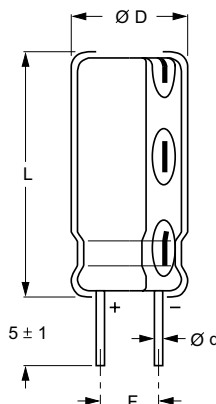
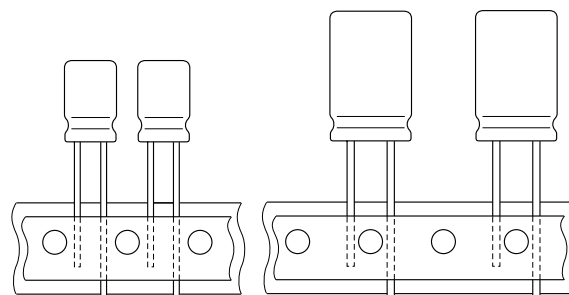
**DIMENSIONS** in millimeters **AND AVAILABLE FORMS**Fig.2 **Form CA:** Long leadsFig.3 **Form CB:** Cut leadsFig.4 **Form TFA:** Taped in box (ammopack)

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<br>CA           | FORM<br>CB | FORM<br>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         |
| 10 x 25                                                                | 16L          | 0.6 | 10.5                | 27.0              | 5.0 ± 0.5 | ≈ 3.0       | 1000                 | 1500       | 800         |
| 10 x 30                                                                | 16LL         | 0.6 | 10.5                | 32.0              | 5.0 ± 0.5 | ≈ 3.5       | 1000                 | 750        | -           |
| 12.5 x 16                                                              | 17a          | 0.6 | 13.0                | 17.5              | 5.0 ± 0.5 | ≈ 2.7       | 1000                 | 1500       | 500         |
| 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         |
| 12.5 x 31                                                              | 18L          | 0.6 | 13.0                | 33.5              | 5.0 ± 0.5 | ≈ 5.5       | 1000                 | 750        | -           |
| 16 x 20                                                                | 19a          | 0.8 | 16.5                | 22.0              | 7.5 ± 0.5 | ≈ 6.0       | 250                  | 250        | 250         |
| 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 | ≈ 11.0      | 100                  | 100        | -           |
| 18 x 20                                                                | 1820         | 0.8 | 18.5                | 22.0              | 7.5 ± 0.5 | ≈ 8.0       | 100                  | 100        | -           |
| 18 x 25                                                                | 1825         | 0.8 | 18.5                | 27.0              | 7.5 ± 0.5 | ≈ 10.0      | 100                  | 100        | -           |
| 18 x 31                                                                | 1831         | 0.8 | 18.5                | 33.5              | 7.5 ± 0.5 | ≈ 12.5      | 100                  | 100        | -           |
| 18 x 35                                                                | 22           | 0.8 | 18.5                | 37.5              | 7.5 ± 0.5 | ≈ 14.5      | 100                  | 100        | -           |

**Note**

1. Detailed tape dimensions see section 'PACKAGING'.

Aluminum Capacitors  
Radial Very Low Impedance

Vishay BCcomponents

| ELECTRICAL DATA |                                                   |
|-----------------|---------------------------------------------------|
| SYMBOL          | DESCRIPTION                                       |
| $C_R$           | rated capacitance at 100 Hz, tolerance $\pm 20\%$ |
| $I_R$           | rated RMS ripple current at 100 kHz, 105 °C       |
| $I_{L2}$        | max. leakage current after 2 minutes at $U_R$     |
| $\tan \delta$   | max. dissipation factor at 100 Hz                 |
| $Z$             | max. impedance at 100 kHz                         |

## ORDERING EXAMPLE

Electrolytic capacitor 136 series

1000  $\mu\text{F}/25\text{ V}$ ;  $\pm 20\%$ Nominal case size:  $\varnothing 12.5 \times 25\text{ mm}$ ; Form TFA

Ordering code: MAL213636102E3

Former 12NC: 2222 136 36102

## Note

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

Table 2

| ELECTRICAL DATA AND ORDERING INFORMATION |                                      |                                                          |                                    |                                        |                         |                                            |                                            |                               |            |             |
|------------------------------------------|--------------------------------------|----------------------------------------------------------|------------------------------------|----------------------------------------|-------------------------|--------------------------------------------|--------------------------------------------|-------------------------------|------------|-------------|
| $U_R$<br>(V)                             | $C_R$<br>100 Hz<br>( $\mu\text{F}$ ) | NOMINAL<br>CASE SIZE<br>$\varnothing D \times L$<br>(mm) | $I_R$<br>100 kHz<br>105 °C<br>(mA) | $I_{L2}$<br>2 min<br>( $\mu\text{A}$ ) | $\tan \delta$<br>100 Hz | $Z$<br>100 kHz<br>+ 20 °C<br>(m $\Omega$ ) | $Z$<br>100 kHz<br>- 10 °C<br>(m $\Omega$ ) | ORDERING CODE<br>MAL2136..... |            |             |
|                                          |                                      |                                                          |                                    |                                        |                         |                                            |                                            | BULK PACKAGING                |            | TAPED       |
|                                          |                                      |                                                          |                                    |                                        |                         |                                            |                                            | FORM<br>CA                    | FORM<br>CB | FORM<br>TFA |
| 10                                       | 390                                  | 10 x 12                                                  | 630                                | 39                                     | 0.19                    | 120                                        | 240                                        | 54391E3                       | 64391E3    | 34391E3     |
|                                          | 470                                  | 10 x 12                                                  | 630                                | 47                                     | 0.19                    | 120                                        | 240                                        | 54471E3                       | 64471E3    | 34471E3     |
|                                          | 680                                  | 10 x 16                                                  | 830                                | 68                                     | 0.19                    | 84                                         | 170                                        | 54681E3                       | 64681E3    | 34681E3     |
|                                          | 1000                                 | 10 x 20                                                  | 1000                               | 100                                    | 0.19                    | 62                                         | 130                                        | 54102E3                       | 64102E3    | 34102E3     |
|                                          | 1000                                 | 12.5 x 16                                                | 940                                | 100                                    | 0.19                    | 76                                         | 160                                        | 94105E3                       | 94106E3    | 94103E3     |
|                                          | 1200                                 | 10 x 25                                                  | 1300                               | 120                                    | 0.19                    | 52                                         | 110                                        | 54122E3                       | 64122E3    | 34122E3     |
|                                          | 1500                                 | 10 x 30                                                  | 1400                               | 150                                    | 0.19                    | 44                                         | 88                                         | 94155E3                       | 94156E3    | -           |
|                                          | 1500                                 | 12.5 x 20                                                | 1300                               | 150                                    | 0.19                    | 46                                         | 92                                         | 54152E3                       | 64152E3    | 34152E3     |
|                                          | 1800                                 | 12.5 x 20                                                | 1340                               | 180                                    | 0.19                    | 46                                         | 92                                         | 54182E3                       | 64182E3    | 34182E3     |
|                                          | 2200                                 | 12.5 x 25                                                | 1700                               | 220                                    | 0.21                    | 34                                         | 68                                         | 54222E3                       | 64222E3    | 34222E3     |
|                                          | 2700                                 | 12.5 x 31                                                | 2000                               | 270                                    | 0.21                    | 30                                         | 60                                         | 54272E3                       | 64272E3    | -           |
|                                          | 3300                                 | 16 x 20                                                  | 1600                               | 330                                    | 0.23                    | 38                                         | 76                                         | 54332E3                       | 64332E3    | 34332E3     |
|                                          | 3900                                 | 16 x 25                                                  | 2100                               | 390                                    | 0.23                    | 28                                         | 56                                         | 54392E3                       | 64392E3    | 34392E3     |
|                                          | 4700                                 | 16 x 31                                                  | 2400                               | 470                                    | 0.25                    | 25                                         | 50                                         | 54472E3                       | 64472E3    | 34472E3     |
|                                          | 5600                                 | 16 x 31                                                  | 2400                               | 560                                    | 0.27                    | 25                                         | 50                                         | 54562E3                       | 64562E3    | 34562E3     |
|                                          | 5600                                 | 18 x 25                                                  | 2270                               | 560                                    | 0.27                    | 25                                         | 50                                         | 94565E3                       | 94566E3    | -           |
|                                          | 6800                                 | 16 x 35                                                  | 2600                               | 680                                    | 0.29                    | 22                                         | 44                                         | 54682E3                       | 64682E3    | -           |
|                                          | 6800                                 | 18 x 31                                                  | 2760                               | 680                                    | 0.29                    | 23                                         | 46                                         | 94685E3                       | 94686E3    | -           |
|                                          | 10 000                               | 18 x 35                                                  | 3180                               | 1000                                   | 0.31                    | 21                                         | 42                                         | 54103E3                       | 64103E3    | -           |
| 16                                       | 270                                  | 10 x 12                                                  | 630                                | 43                                     | 0.16                    | 120                                        | 240                                        | 55271E3                       | 65271E3    | 35271E3     |
|                                          | 330                                  | 10 x 12                                                  | 630                                | 53                                     | 0.16                    | 120                                        | 240                                        | 55331E3                       | 65331E3    | 35331E3     |
|                                          | 470                                  | 10 x 16                                                  | 830                                | 75                                     | 0.16                    | 84                                         | 170                                        | 55471E3                       | 65471E3    | 35471E3     |
|                                          | 680                                  | 10 x 20                                                  | 1000                               | 110                                    | 0.16                    | 62                                         | 130                                        | 55681E3                       | 65681E3    | 35681E3     |
|                                          | 680                                  | 12.5 x 16                                                | 940                                | 110                                    | 0.16                    | 76                                         | 160                                        | 95685E3                       | 95686E3    | 95683E3     |
|                                          | 820                                  | 10 x 25                                                  | 1300                               | 130                                    | 0.16                    | 52                                         | 110                                        | 55821E3                       | 65821E3    | 35821E3     |
|                                          | 1000                                 | 12.5 x 20                                                | 1300                               | 160                                    | 0.16                    | 48                                         | 96                                         | 55102E3                       | 65102E3    | 35102E3     |
|                                          | 1200                                 | 10 x 30                                                  | 1400                               | 190                                    | 0.16                    | 44                                         | 88                                         | 95125E3                       | 95126E3    | -           |
|                                          | 1200                                 | 12.5 x 20                                                | 1300                               | 190                                    | 0.16                    | 46                                         | 92                                         | 55122E3                       | 65122E3    | 35122E3     |
|                                          | 1500                                 | 12.5 x 25                                                | 1700                               | 240                                    | 0.16                    | 34                                         | 68                                         | 55152E3                       | 65152E3    | 35152E3     |
|                                          | 2200                                 | 12.5 x 31                                                | 2000                               | 350                                    | 0.18                    | 30                                         | 60                                         | 95225E3                       | 95226E3    | -           |
|                                          | 2200                                 | 16 x 20                                                  | 1600                               | 350                                    | 0.18                    | 38                                         | 76                                         | 55222E3                       | 65222E3    | 35222E3     |
|                                          | 2700                                 | 16 x 25                                                  | 2100                               | 430                                    | 0.18                    | 28                                         | 56                                         | 55272E3                       | 65272E3    | 35272E3     |
|                                          | 3300                                 | 16 x 25                                                  | 2100                               | 530                                    | 0.20                    | 28                                         | 56                                         | 55332E3                       | 65332E3    | 35332E3     |
|                                          | 3900                                 | 16 x 31                                                  | 2400                               | 620                                    | 0.20                    | 25                                         | 50                                         | 55392E3                       | 65392E3    | 35392E3     |
|                                          | 4700                                 | 16 x 35                                                  | 2600                               | 750                                    | 0.22                    | 22                                         | 44                                         | 55472E3                       | 65472E3    | -           |
|                                          | 4700                                 | 18 x 31                                                  | 2560                               | 750                                    | 0.22                    | 23                                         | 46                                         | 95475E3                       | 95476E3    | -           |
|                                          | 6800                                 | 18 x 35                                                  | 3000                               | 1090                                   | 0.24                    | 21                                         | 42                                         | 55682E3                       | 65682E3    | -           |

**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 kHz<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>(mΩ) | Z<br>100 kHz<br>- 10 °C<br>(mΩ) | ORDERING CODE<br>MAL2136..... |            |             |
|-----------------------|----------------------------------|-----------------------------------------|---------------------------------------------|----------------------------------|-----------------|---------------------------------|---------------------------------|-------------------------------|------------|-------------|
|                       |                                  |                                         |                                             |                                  |                 |                                 |                                 | BULK PACKAGING                |            | TAPED       |
|                       |                                  |                                         |                                             |                                  |                 |                                 |                                 | FORM<br>CA                    | FORM<br>CB | FORM<br>TFA |
| 25                    | 180                              | 10 x 12                                 | 630                                         | 45                               | 0.14            | 120                             | 240                             | 56181E3                       | 66181E3    | 36181E3     |
|                       | 220                              | 10 x 12                                 | 630                                         | 55                               | 0.14            | 120                             | 240                             | 56221E3                       | 66221E3    | 36221E3     |
|                       | 330                              | 10 x 16                                 | 830                                         | 83                               | 0.14            | 84                              | 170                             | 56331E3                       | 66331E3    | 36331E3     |
|                       | 470                              | 10 x 20                                 | 1000                                        | 120                              | 0.14            | 62                              | 130                             | 56471E3                       | 66471E3    | 36471E3     |
|                       | 470                              | 12.5 x 16                               | 940                                         | 120                              | 0.14            | 76                              | 160                             | 96475E3                       | 96476E3    | 96473E3     |
|                       | 560                              | 10 x 25                                 | 1300                                        | 140                              | 0.14            | 52                              | 110                             | 56561E3                       | 66561E3    | 36561E3     |
|                       | 820                              | 10 x 30                                 | 1400                                        | 210                              | 0.14            | 44                              | 88                              | 96825E3                       | 96826E3    | -           |
|                       | 820                              | 12.5 x 20                               | 1300                                        | 210                              | 0.14            | 46                              | 92                              | 56821E3                       | 66821E3    | 36821E3     |
|                       | 1000                             | 12.5 x 25                               | 1700                                        | 250                              | 0.14            | 34                              | 68                              | 56102E3                       | 66102E3    | 36102E3     |
|                       | 1500                             | 12.5 x 31                               | 2000                                        | 380                              | 0.14            | 30                              | 60                              | 96155E3                       | 96156E3    | -           |
|                       | 1500                             | 16 x 20                                 | 1700                                        | 380                              | 0.14            | 38                              | 76                              | 56152E3                       | 66152E3    | 36152E3     |
|                       | 1800                             | 16 x 25                                 | 2100                                        | 450                              | 0.14            | 28                              | 56                              | 56182E3                       | 66182E3    | 36182E3     |
|                       | 2200                             | 16 x 31                                 | 2400                                        | 550                              | 0.16            | 25                              | 50                              | 56222E3                       | 66222E3    | 36222E3     |
|                       | 2200                             | 18 x 20                                 | 1680                                        | 550                              | 0.16            | 28                              | 56                              | 96225E3                       | 96226E3    | -           |
|                       | 2700                             | 16 x 31                                 | 2400                                        | 680                              | 0.16            | 25                              | 50                              | 56272E3                       | 66272E3    | 36272E3     |
|                       | 3300                             | 16 x 35                                 | 2600                                        | 830                              | 0.18            | 22                              | 44                              | 56332E3                       | 66332E3    | -           |
|                       | 3300                             | 18 x 31                                 | 2490                                        | 830                              | 0.18            | 27                              | 54                              | 96335E3                       | 96336E3    | -           |
|                       | 4700                             | 18 x 35                                 | 3000                                        | 1180                             | 0.20            | 21                              | 42                              | 56472E3                       | 66472E3    | -           |
| 35                    | 120                              | 10 x 12                                 | 630                                         | 42                               | 0.12            | 120                             | 240                             | 50121E3                       | 60121E3    | 30121E3     |
|                       | 150                              | 10 x 12                                 | 630                                         | 53                               | 0.12            | 120                             | 240                             | 50151E3                       | 60151E3    | 30151E3     |
|                       | 220                              | 10 x 16                                 | 830                                         | 77                               | 0.12            | 84                              | 170                             | 50221E3                       | 60221E3    | 30221E3     |
|                       | 330                              | 10 x 20                                 | 1000                                        | 120                              | 0.12            | 62                              | 130                             | 50331E3                       | 60331E3    | 30331E3     |
|                       | 330                              | 12.5 x 16                               | 940                                         | 120                              | 0.12            | 76                              | 160                             | 90335E3                       | 90336E3    | 90333E3     |
|                       | 390                              | 10 x 25                                 | 1300                                        | 140                              | 0.12            | 52                              | 110                             | 50391E3                       | 60391E3    | 30391E3     |
|                       | 470                              | 12.5 x 20                               | 1300                                        | 170                              | 0.12            | 48                              | 96                              | 50471E3                       | 60471E3    | 30471E3     |
|                       | 560                              | 10 x 30                                 | 1400                                        | 200                              | 0.12            | 44                              | 88                              | 90565E3                       | 90566E3    | -           |
|                       | 560                              | 12.5 x 20                               | 1300                                        | 200                              | 0.12            | 46                              | 92                              | 50561E3                       | 60561E3    | 30561E3     |
|                       | 680                              | 12.5 x 25                               | 1700                                        | 240                              | 0.12            | 34                              | 68                              | 50681E3                       | 60681E3    | 30681E3     |
|                       | 1000                             | 12.5 x 31                               | 2000                                        | 350                              | 0.12            | 30                              | 60                              | 90105E3                       | 90106E3    | -           |
|                       | 1000                             | 16 x 20                                 | 1700                                        | 350                              | 0.12            | 38                              | 76                              | 50102E3                       | 60102E3    | 30102E3     |
|                       | 1200                             | 16 x 25                                 | 2100                                        | 420                              | 0.12            | 28                              | 56                              | 50122E3                       | 60122E3    | 30122E3     |
|                       | 1500                             | 16 x 25                                 | 2100                                        | 530                              | 0.12            | 28                              | 56                              | 50152E3                       | 60152E3    | 30152E3     |
|                       | 1800                             | 16 x 31                                 | 2400                                        | 630                              | 0.12            | 25                              | 50                              | 50182E3                       | 60182E3    | 30182E3     |
|                       | 2200                             | 16 x 35                                 | 2600                                        | 770                              | 0.14            | 22                              | 44                              | 50222E3                       | 60222E3    | -           |
|                       | 2200                             | 18 x 31                                 | 2320                                        | 770                              | 0.14            | 27                              | 54                              | 90225E3                       | 90226E3    | -           |
|                       | 3300                             | 18 x 35                                 | 2890                                        | 1160                             | 0.16            | 21                              | 42                              | 50332E3                       | 60332E3    | -           |
| 50                    | 82                               | 10 x 12                                 | 480                                         | 41                               | 0.10            | 200                             | 400                             | 51829E3                       | 61829E3    | 31829E3     |
|                       | 100                              | 10 x 12                                 | 480                                         | 50                               | 0.10            | 200                             | 400                             | 51101E3                       | 61101E3    | 31101E3     |
|                       | 120                              | 10 x 16                                 | 760                                         | 60                               | 0.10            | 100                             | 200                             | 51121E3                       | 61121E3    | 31121E3     |
|                       | 150                              | 10 x 20                                 | 850                                         | 75                               | 0.10            | 90                              | 180                             | 51151E3                       | 61151E3    | 31151E3     |
|                       | 180                              | 10 x 20                                 | 950                                         | 90                               | 0.10            | 75                              | 150                             | 51181E3                       | 61181E3    | 31181E3     |
|                       | 180                              | 12.5 x 16                               | 780                                         | 90                               | 0.10            | 59                              | 120                             | 91185E3                       | 91186E3    | 91183E3     |
|                       | 220                              | 10 x 25                                 | 1200                                        | 110                              | 0.10            | 63                              | 130                             | 51221E3                       | 61221E3    | 31221E3     |
|                       | 330                              | 10 x 30                                 | 1300                                        | 170                              | 0.10            | 54                              | 110                             | 91335E3                       | 91336E3    | -           |
|                       | 330                              | 12.5 x 20                               | 1200                                        | 170                              | 0.10            | 59                              | 120                             | 51331E3                       | 61331E3    | 31331E3     |
|                       | 470                              | 12.5 x 25                               | 1500                                        | 240                              | 0.10            | 44                              | 88                              | 51471E3                       | 61471E3    | 31471E3     |
|                       | 560                              | 12.5 x 31                               | 1700                                        | 280                              | 0.10            | 39                              | 78                              | 51561E3                       | 61561E3    | -           |
|                       | 680                              | 16 x 20                                 | 1400                                        | 340                              | 0.10            | 50                              | 100                             | 51681E3                       | 61681E3    | 31681E3     |
|                       | 820                              | 16 x 25                                 | 1900                                        | 410                              | 0.10            | 34                              | 68                              | 51821E3                       | 61821E3    | 31821E3     |
|                       | 1000                             | 16 x 31                                 | 2200                                        | 500                              | 0.10            | 30                              | 60                              | 51102E3                       | 61102E3    | 31102E3     |
|                       | 1000                             | 18 x 20                                 | 1510                                        | 500                              | 0.10            | 41                              | 82                              | 91105E3                       | 91106E3    | -           |
|                       | 1200                             | 16 x 35                                 | 2300                                        | 600                              | 0.10            | 27                              | 54                              | 51122E3                       | 61122E3    | -           |
|                       | 1500                             | 18 x 31                                 | 2200                                        | 750                              | 0.10            | 31                              | 62                              | 51152E3                       | 61152E3    | -           |
|                       | 2200                             | 18 x 35                                 | 2650                                        | 1100                             | 0.12            | 27                              | 54                              | 51222E3                       | 61222E3    | -           |

Aluminum Capacitors  
Radial Very Low Impedance

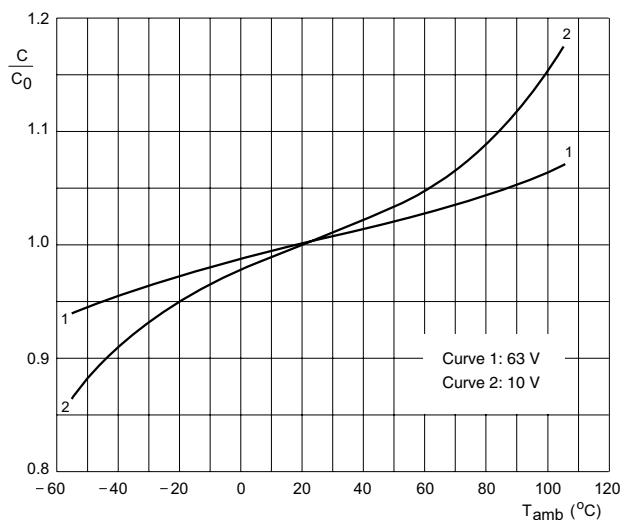
Vishay BCcomponents

**ELECTRICAL DATA AND ORDERING INFORMATION**

| $U_R$<br>(V) | $C_R$<br>100 Hz<br>( $\mu$ F) | NOMINAL<br>CASE SIZE<br>$\varnothing D \times L$<br>(mm) | $I_R$<br>100 kHz<br>105 °C<br>(mA) | $I_{L2}$<br>2 min<br>( $\mu$ A) | $\tan \delta$<br>100 Hz | $Z$<br>100 kHz<br>+ 20 °C<br>(m $\Omega$ ) | $Z$<br>100 kHz<br>- 10 °C<br>(m $\Omega$ ) | ORDERING CODE<br>MAL2136..... |            |             |
|--------------|-------------------------------|----------------------------------------------------------|------------------------------------|---------------------------------|-------------------------|--------------------------------------------|--------------------------------------------|-------------------------------|------------|-------------|
|              |                               |                                                          |                                    |                                 |                         |                                            |                                            | BULK PACKAGING                |            | TAPED       |
|              |                               |                                                          |                                    |                                 |                         |                                            |                                            | FORM<br>CA                    | FORM<br>CB | FORM<br>TFA |
| 63           | 47                            | 10 x 12                                                  | 380                                | 30                              | 0.10                    | 300                                        | 750                                        | 58479E3                       | 68479E3    | 38479E3     |
|              | 56                            | 10 x 12                                                  | 420                                | 35                              | 0.10                    | 270                                        | 680                                        | 58569E3                       | 68569E3    | 38569E3     |
|              | 68                            | 10 x 16                                                  | 520                                | 43                              | 0.10                    | 210                                        | 530                                        | 58689E3                       | 68689E3    | 38689E3     |
|              | 100                           | 10 x 16                                                  | 580                                | 63                              | 0.10                    | 190                                        | 480                                        | 58101E3                       | 68101E3    | 38101E3     |
|              | 120                           | 10 x 20                                                  | 650                                | 76                              | 0.10                    | 160                                        | 400                                        | 58121E3                       | 68121E3    | 38121E3     |
|              | 120                           | 12.5 x 16                                                | 610                                | 76                              | 0.10                    | 180                                        | 450                                        | 98125E3                       | 98126E3    | 98123E3     |
|              | 150                           | 10 x 25                                                  | 780                                | 95                              | 0.10                    | 130                                        | 330                                        | 58151E3                       | 68151E3    | 38151E3     |
|              | 180                           | 10 x 30                                                  | 960                                | 110                             | 0.10                    | 100                                        | 250                                        | 58181E3                       | 68181E3    | -           |
|              | 220                           | 12.5 x 20                                                | 870                                | 140                             | 0.10                    | 110                                        | 280                                        | 58221E3                       | 68221E3    | 38221E3     |
|              | 270                           | 12.5 x 25                                                | 1200                               | 170                             | 0.10                    | 74                                         | 190                                        | 58271E3                       | 68271E3    | 38271E3     |
|              | 330                           | 16 x 20                                                  | 1100                               | 210                             | 0.10                    | 85                                         | 220                                        | 58331E3                       | 68331E3    | 38331E3     |
|              | 390                           | 12.5 x 31                                                | 1300                               | 250                             | 0.10                    | 68                                         | 170                                        | 58391E3                       | 68391E3    | -           |
|              | 470                           | 16 x 25                                                  | 1500                               | 300                             | 0.10                    | 55                                         | 140                                        | 58471E3                       | 68471E3    | 38471E3     |
|              | 680                           | 16 x 31                                                  | 1700                               | 430                             | 0.10                    | 46                                         | 120                                        | 58681E3                       | 68681E3    | 38681E3     |
|              | 680                           | 18 x 25                                                  | 1470                               | 430                             | 0.10                    | 54                                         | 108                                        | 98685E3                       | 98686E3    | -           |
|              | 820                           | 16 x 35                                                  | 1900                               | 520                             | 0.10                    | 40                                         | 100                                        | 58821E3                       | 68821E3    | -           |
|              | 1000                          | 18 x 31                                                  | 1950                               | 630                             | 0.10                    | 39                                         | 78                                         | 58102E3                       | 68102E3    | -           |
|              | 1500                          | 18 x 35                                                  | 2350                               | 950                             | 0.10                    | 33                                         | 66                                         | 58152E3                       | 68152E3    | -           |
| 100          | 22                            | 10 x 12                                                  | 300                                | 22                              | 0.07                    | 450                                        | 2300                                       | 59229E3                       | 69229E3    | 39229E3     |
|              | 33                            | 10 x 12                                                  | 320                                | 33                              | 0.07                    | 390                                        | 2000                                       | 59339E3                       | 69339E3    | 39339E3     |
|              | 47                            | 10 x 16                                                  | 450                                | 47                              | 0.07                    | 320                                        | 1600                                       | 59479E3                       | 69479E3    | 39479E3     |
|              | 68                            | 10 x 20                                                  | 520                                | 68                              | 0.07                    | 240                                        | 1200                                       | 59689E3                       | 69689E3    | 39689E3     |
|              | 100                           | 12.5 x 20                                                | 800                                | 100                             | 0.07                    | 150                                        | 750                                        | 59101E3                       | 69101E3    | 39101E3     |
|              | 150                           | 16 x 20                                                  | 1000                               | 150                             | 0.07                    | 110                                        | 550                                        | 59151E3                       | 69151E3    | 39151E3     |
|              | 220                           | 16 x 25                                                  | 1300                               | 220                             | 0.07                    | 81                                         | 400                                        | 59221E3                       | 69221E3    | 39221E3     |
|              | 330                           | 16 x 31                                                  | 1600                               | 330                             | 0.07                    | 58                                         | 290                                        | 59331E3                       | 69331E3    | 39331E3     |
|              | 470                           | 16 x 35                                                  | 1800                               | 470                             | 0.07                    | 45                                         | 230                                        | 59471E3                       | 69471E3    | -           |
|              | 470                           | 18 x 31                                                  | 1800                               | 470                             | 0.07                    | 45                                         | 230                                        | 99475E3                       | 99476E3    | -           |
|              | 680                           | 18 x 35                                                  | 2000                               | 680                             | 0.07                    | 39                                         | 200                                        | 59681E3                       | 69681E3    | -           |

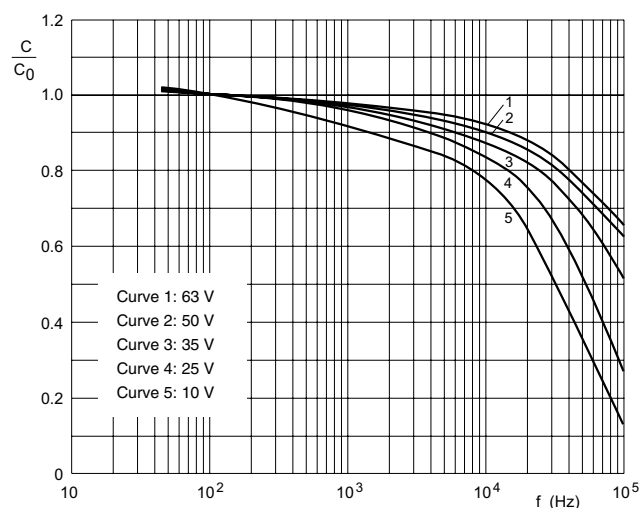
**ADDITIONAL ELECTRICAL DATA**

| PARAMETER                          | CONDITIONS                                                  | VALUE                             |
|------------------------------------|-------------------------------------------------------------|-----------------------------------|
| <b>Voltage</b>                     |                                                             |                                   |
| Surge voltage                      |                                                             | $U_S \leq 1.15 \times U_R$        |
| Reverse voltage                    |                                                             | $U_{rev} \leq 1 \text{ V}$        |
| <b>Current</b>                     |                                                             |                                   |
| Leakage current                    | After 2 minutes at $U_R$                                    | $I_{L2} \leq 0.01 C_R \times U_R$ |
| <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)**

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

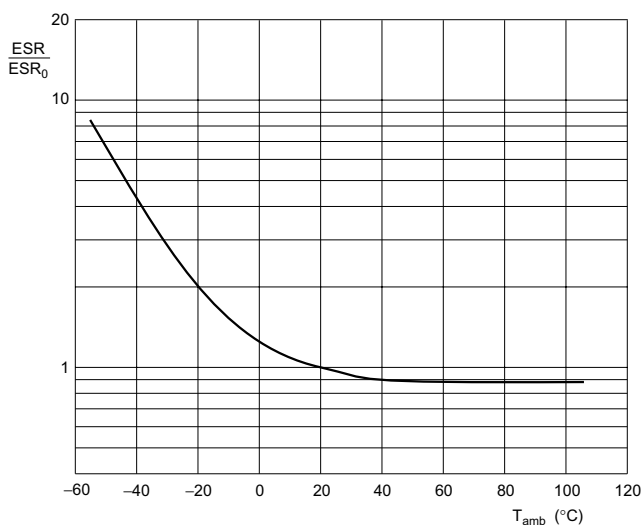
Fig.5 Typical multiplier of capacitance as a function of ambient temperature



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

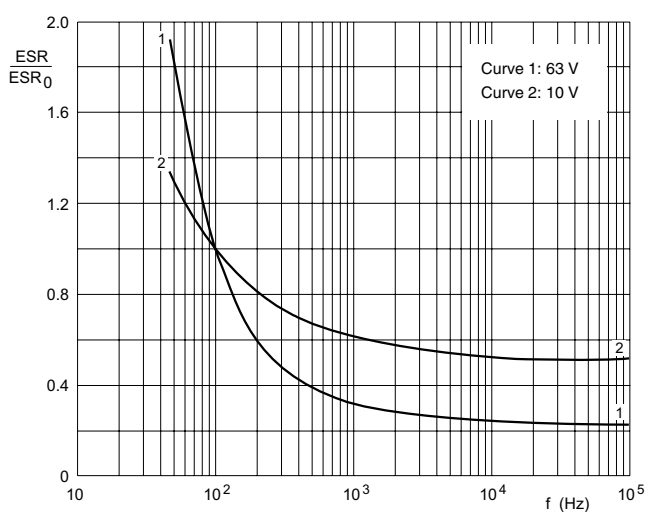
$T_{amb} = 20\text{ °C}$

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

**EQUIVALENT SERIES RESISTANCE (ESR)**

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

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



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

$T_{amb} = 20\text{ °C}$

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

# IMPEDANCE (Z)

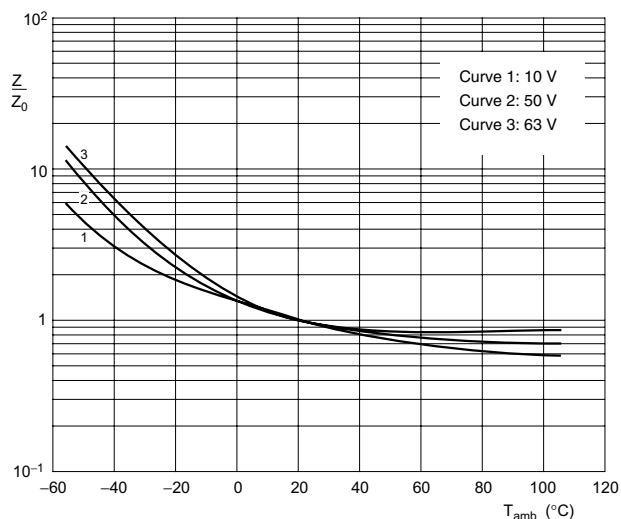

 $Z_0$  = typical impedance at 20 °C, 100 kHz

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

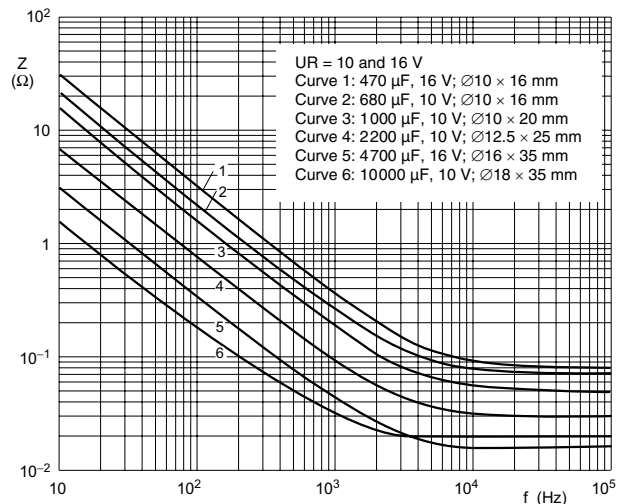

 $T_{amb} = 20\text{ °C}$ 

Fig.10 Typical impedance as a function of frequency

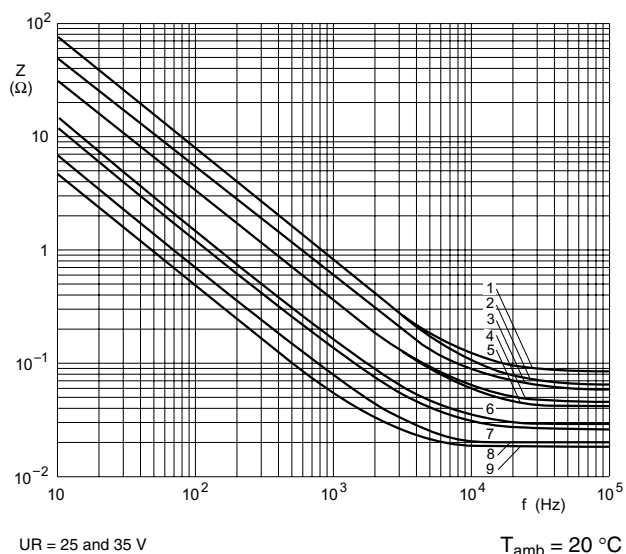

 $T_{amb} = 20\text{ °C}$ 

Fig.11 Typical impedance as a function of frequency

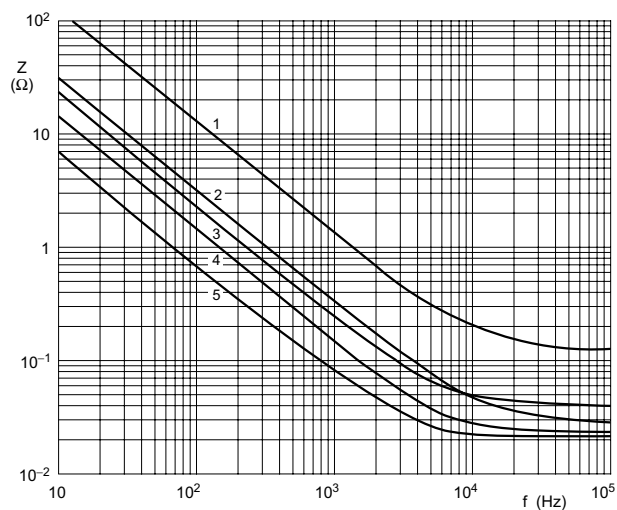
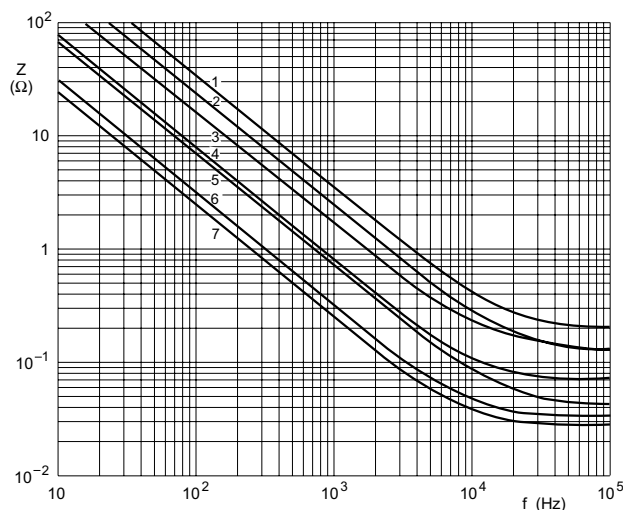

 $T_{amb} = 20\text{ °C}$ 

Fig.12 Typical impedance as a function of frequency

UR = 63 V  
 Curve 1: 47  $\mu$ F, 63 V;  $\varnothing$  10 x 12 mm  
 Curve 2: 68  $\mu$ F, 63 V;  $\varnothing$  10 x 16 mm  
 Curve 3: 100  $\mu$ F, 63 V;  $\varnothing$  10 x 20 mm  
 Curve 4: 220  $\mu$ F, 63 V;  $\varnothing$  12.5 x 20 mm  
 Curve 5: 270  $\mu$ F, 63 V;  $\varnothing$  12.5 x 25 mm  
 Curve 6: 470  $\mu$ F, 63 V;  $\varnothing$  16 x 25 mm  
 Curve 7: 680  $\mu$ F, 63 V;  $\varnothing$  16 x 31 mm



$T_{amb} = 20\text{ }^{\circ}\text{C}$

Fig.13 Typical impedance as a function of frequency

## RIPPLE CURRENT AND USEFUL LIFE

Table 3

| ENDURANCE TEST AND USEFUL LIFE AS A FUNCTION OF CASE SIZE |              |                                    |                                 |
|-----------------------------------------------------------|--------------|------------------------------------|---------------------------------|
| NOMINAL CASE SIZE<br>$\varnothing$ D x L<br>(mm)          | CASE<br>CODE | ENDURANCE TEST<br>AT 105 °C<br>(h) | USEFUL LIFE<br>AT 105 °C<br>(h) |
| 10 x 12                                                   | 14           | 3000                               | 4000                            |
| 10 x 16                                                   | 15           | 3000                               | 6000                            |
| 10 x 20                                                   | 16           | 3000                               | 6000                            |
| 10 x 25                                                   | 16L          | 5000                               | 7000                            |
| 10 x 30                                                   | 16LL         | 5000                               | 7000                            |
| 12.5 x 16                                                 | 17a          | 3000                               | 5000                            |
| 12.5 x 20                                                 | 17           | 3000                               | 7000                            |
| 12.5 x 25                                                 | 18           | 5000                               | 8000                            |
| 12.5 x 31                                                 | 18L          | 5000                               | 8000                            |
| 16 x 20                                                   | 19a          | 3000                               | 7000                            |
| 16 x 25                                                   | 19           | 5000                               | 10 000                          |
| 16 x 31                                                   | 20           | 5000                               | 10 000                          |
| 16 x 35                                                   | 21           | 5000                               | 10 000                          |
| 18 x 20                                                   | 1820         | 3000                               | 7000                            |
| 18 x 25                                                   | 1825         | 5000                               | 10 000                          |
| 18 x 31                                                   | 1831         | 5000                               | 10 000                          |
| 18 x 35                                                   | 22           | 5000                               | 10 000                          |

$I_A$  = actual ripple current at 100 kHz  
 $I_R$  = rated ripple current at 100 kHz, 105 °C  
 (1) Useful life at 105 °C and  $I_R$  applied; see Table 3

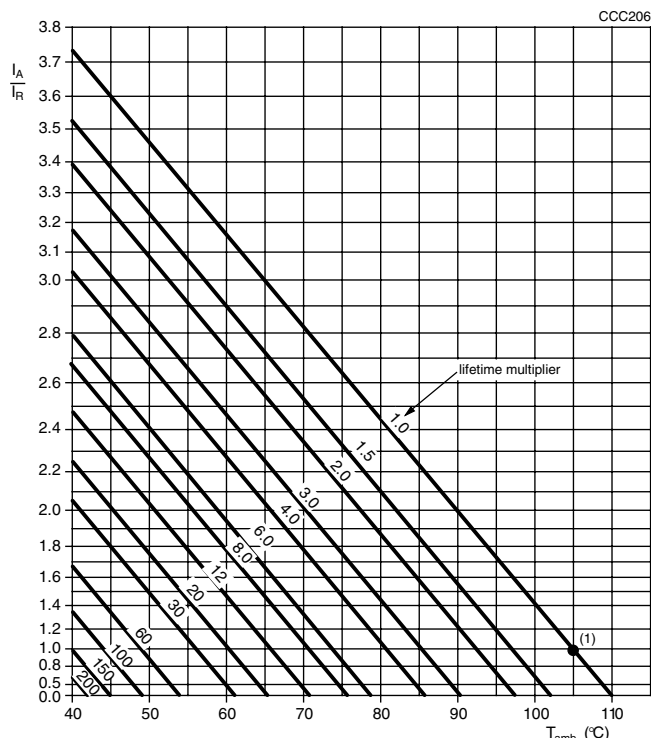


Fig.14 Multiplier of useful life as a function of ambient temperature and ripple current load

Table 4

| MULTIPLIER OF RIPPLE CURRENT ( $I_R$ ) AS A FUNCTION OF FREQUENCY |                         |                       |                                   |                       |                                   |                       |                                    |                       |
|-------------------------------------------------------------------|-------------------------|-----------------------|-----------------------------------|-----------------------|-----------------------------------|-----------------------|------------------------------------|-----------------------|
| FREQUENCY<br>(Hz)                                                 | $I_R$ MULTIPLIER        |                       |                                   |                       |                                   |                       |                                    |                       |
|                                                                   | $U_R = 10\text{ V}$     |                       | $U_R = 16\text{ and }25\text{ V}$ |                       | $U_R = 35\text{ and }50\text{ V}$ |                       | $U_R = 63\text{ and }100\text{ V}$ |                       |
|                                                                   | $\varnothing \leq 12.5$ | $\varnothing \geq 16$ | $\varnothing \leq 12.5$           | $\varnothing \geq 16$ | $\varnothing \leq 12.5$           | $\varnothing \geq 16$ | $\varnothing \leq 12.5$            | $\varnothing \geq 16$ |
| 100                                                               | 0.70                    | 0.83                  | 0.63                              | 0.69                  | 0.50                              | 0.60                  | 0.35                               | 0.50                  |
| 300                                                               | 0.80                    | 0.90                  | 0.72                              | 0.79                  | 0.61                              | 0.71                  | 0.51                               | 0.64                  |
| 1000                                                              | 0.88                    | 0.95                  | 0.80                              | 0.87                  | 0.72                              | 0.80                  | 0.66                               | 0.74                  |
| 3000                                                              | 0.92                    | 0.98                  | 0.88                              | 0.92                  | 0.81                              | 0.88                  | 0.76                               | 0.83                  |
| 10 000                                                            | 0.96                    | 0.99                  | 0.92                              | 0.96                  | 0.88                              | 0.93                  | 0.85                               | 0.90                  |
| 30 000                                                            | 0.99                    | 1.00                  | 0.98                              | 0.99                  | 0.94                              | 0.96                  | 0.92                               | 0.95                  |
| 100 000                                                           | 1.00                    | 1.00                  | 1.00                              | 1.00                  | 1.00                              | 1.00                  | 1.00                               | 1.00                  |

Table 5

| TEST PROCEDURES AND REQUIREMENTS               |                                            |                                                                                                                                                       |                                                                                                                                                                                  |
|------------------------------------------------|--------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| TEST                                           |                                            | PROCEDURE<br>(QUICK REFERENCE)                                                                                                                        | REQUIREMENTS                                                                                                                                                                     |
| NAME OF TEST                                   | REFERENCE                                  |                                                                                                                                                       |                                                                                                                                                                                  |
| Endurance                                      | IEC 60384-4/<br>EN130300<br>subclause 4.13 | $T_{amb} = 105\text{ °C}$ ; $U_R$ applied;<br>for test duration see Table 3                                                                           | $\Delta C/C: \pm 20\%$<br>$\tan \delta \leq 2 \times \text{spec. limit}$<br>$I_{L2} \leq \text{spec. limit}$                                                                     |
| Useful life                                    | CECC 30301<br>subclause 1.8.1              | $T_{amb} = 105\text{ °C}$ ; $U_R$ and $I_R$ applied;<br>for test duration see Table 3                                                                 | $\Delta C/C: \pm 30\%$<br>$\tan \delta \leq 3 \times \text{spec. limit}$<br>$I_{L2} \leq \text{spec. limit}$<br>no short or open circuit<br>total failure percentage: $\leq 1\%$ |
| Shelf life<br>(storage at high<br>temperature) | IEC 60384-4/<br>EN130300<br>subclause 4.17 | $T_{amb} = 105\text{ °C}$ ; no voltage applied;<br>1000 hours<br>after test: $U_R$ to be applied for 30 minutes,<br>24 to 48 hours before measurement | $\Delta C/C: \pm 20\%$<br>$\tan \delta \leq 2 \times \text{spec. limit}$<br>$I_{L2} \leq \text{spec. limit}$                                                                     |



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