

## Aluminum Capacitors Axial Miniature, Long-Life



Fig. 1

| QUICK REFERENCE DATA                               |                                   |                                   |
|--|-----------------------------------|-----------------------------------|
| DESCRIPTION  | VALUE                             |                                   |
| Nominal case sizes<br>( $\varnothing$ D x L in mm) | 6.3 x 12.7<br>to 10 x 25          | 10 x 30<br>to 21 x 38             |
| Rated capacitance range, $C_R$                     | 1.0 $\mu$ F to 15 000 $\mu$ 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                           | 1000 h                            | 5000 h                            |
| Useful life at 105 °C                              | 2000 h                            | 10 000 h                          |
| Useful life at 40 °C,<br>$I_R$ applied             | 1.3 x $I_R$ applied:<br>200 000 h | 1.8 x $I_R$ applied:<br>500 000 h |
| Shelf life at 0 V, 105 °C                          | 500 h                             |                                   |
| Based on sectional<br>specification                | IEC 60384-4/EN130 300             |                                   |
| Climatic category IEC 60068                        | 40/105/56                         |                                   |

### FEATURES

- Polarized aluminum electrolytic capacitors, non-solid electrolyte
- Axial leads, cylindrical aluminum case, insulated with a blue sleeve (case  $\varnothing$  6.3 mm x 12.7 mm and 7.7 mm x 12.7 mm are molded with flame retardant plastic material)
- Mounting ring version not available in insulated form
- Taped versions up to case  $\varnothing$  15 mm x 30 mm available for automatic insertion
- Charge and discharge proof
- Long useful life: 2000 h to 10 000 h at 105 °C, high reliability
- High ripple current capability
- Miniaturized, high CV-product per unit volume
- Material categorization: For definitions of compliance please see [www.vishay.com/doc?99912](http://www.vishay.com/doc?99912)


**RoHS  
COMPLIANT**

### APPLICATIONS

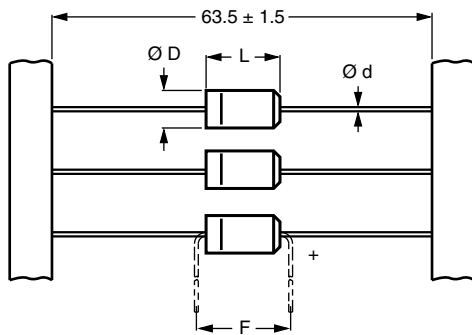
- Industrial, automotive, EDP and telecommunication
- Smoothing, filtering, buffering in SMPS; coupling, decoupling, timing
- Portable and mobile equipment (small size, low mass)
- Stand-by applications
- Low mounting height boards, vibration and shock resistant

### MARKING

The capacitors are marked (where possible) with the following information:

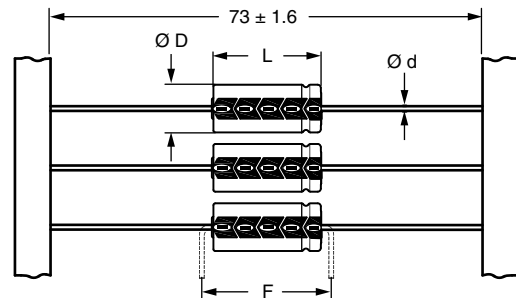
- Rated capacitance (in  $\mu$ F)
- Tolerance on rated capacitance, code letter in accordance with IEC 60062 (M for  $\pm$  20 %)
- Rated voltage (in V)
- Upper category temperature (105 °C)
- Date code, in accordance with IEC 60062
- Code for factory of origin
- Name of manufacturer
- Negative terminal identification
- Series number (138)

| 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)  |            |            |            |            |            |            |            |
|   | 6.3        | 10         | 16         | 25         | 40         | 50         | 63         | 100        |
| 1.0   | -          | -          | -          | -          | -          | -          | -          | 6.3 x 12.7 |
| 2.2   | -          | -          | -          | -          | -          | -          | -          | 6.3 x 12.7 |
| 4.7   | -          | -          | -          | -          | -          | -          | 6.3 x 12.7 | 7.7 x 12.7 |
| 10  | -          | -          | -          | 6.3 x 12.7 | -          | 6.3 x 12.7 | 7.7 x 12.7 | 6.5 x 18   |
| 22  | -          | -          | 6.3 x 12.7 | 6.3 x 12.7 | -          | 7.7 x 12.7 | 6.5 x 18   | 8 x 18     |
| 33  | -          | -          | -          | 6.3 x 12.7 | 7.7 x 12.7 | -          | -          | -          |
| 47  | -          | -          | 6.3 x 12.7 | 7.7 x 12.7 | 6.5 x 18   | -          | 8 x 18     | 10 x 25    |
| 68  | -          | -          | -          | -          | -          | -          | -          | 10 x 30    |
| 100   | 6.3 x 12.7 | -          | 7.7 x 12.7 | 6.5 x 18   | 8 x 18     | 10 x 18    | 10 x 25    | 12.5 x 30  |
| 150   | -          | 7.7 x 12.7 | -          | -          | -          | -          | 10 x 30    | 15 x 30    |
| 220   | 7.7 x 12.7 | 6.5 x 18   | 8 x 18     | 10 x 18    | 10 x 25    | -          | 12.5 x 30  | 15 x 30    |
| 330   | -          | -          | -          | -          | 10 x 30    | -          | 12.5 x 30  | 18 x 30    |
| 470   | 6.5 x 18   | 8 x 18     | 10 x 18    | 10 x 25    | 12.5 x 30  | -          | 15 x 30    | 18 x 38    |
| 680   | -          | -          | -          | 10 x 30    | 12.5 x 30  | -          | 18 x 30    | 21 x 38    |
| 1000  | 10 x 18    | 10 x 25    | 10 x 30    | 12.5 x 30  | 15 x 30    | -          | 18 x 38    | -          |
| 1500  | -          | 10 x 30    | 12.5 x 30  | 15 x 30    | 18 x 30    | -          | 21 x 38    | -          |
| 2200  | 10 x 25    | 12.5 x 30  | 15 x 30    | 18 x 30    | 18 x 38    | -          | -          | -          |
| 3300  | -          | 15 x 30    | 18 x 30    | 18 x 38    | 21 x 38    | -          | -          | -          |
| 4700  | -          | 18 x 30    | 18 x 30    | 18 x 38    | -          | -          | -          | -          |
| 6800  | -          | 18 x 38    | 18 x 38    | 21 x 38    | -          | -          | -          | -          |
| 10 000  | -          | 18 x 38    | 21 x 38    | -          | -          | -          | -          | -          |
| 15 000  | -          | 21 x 38    | -          | -          | -          | -          | -          | -          |

**DIMENSIONS in millimeters AND AVAILABLE FORMS**


**Form BR:** Taped on reel  
**Form BA:** Taped in box (ammopack)  
 Case  $\varnothing D \times L = 6.3 \text{ mm} \times 12.7 \text{ mm}$  to  $7.7 \text{ mm} \times 12.7 \text{ mm}$

Fig. 2 - Forms BA and BR



**Form BR:** Taped on reel  
 Case  $\varnothing D \times L = 6.5 \text{ mm} \times 18 \text{ mm}$  to  $15 \text{ mm} \times 30 \text{ mm}$   
**Form BA:** Taped in box (ammopack)  
 Case  $\varnothing D \times L = 6.5 \text{ mm} \times 18 \text{ mm}$  to  $10 \text{ mm} \times 25 \text{ mm}$

Fig. 3 - Forms BA and BR



**Form AA:** Axial in box  
 Case  $\varnothing D \times L = 10 \text{ mm} \times 30 \text{ mm}$  to  $21 \text{ mm} \times 38 \text{ mm}$

Fig. 4 - Form AA

**Table 1**

| <b>AXIAL; DIMENSIONS</b> in millimeters, <b>MASS AND PACKAGING QUANTITIES</b> |           |                            |        |                     |                   |                   |          |                      |         |         |
|---|-----------|----------------------------|--------|---------------------|-------------------|-------------------|----------|----------------------|---------|---------|
| NOMINAL CASE SIZE<br>Ø D x L<br>(mm)  | CASE CODE | AXIAL: FORM AA, BA, AND BR |        |                     |                   |                   | MASS (g) | PACKAGING QUANTITIES |         |         |
|   |           | Ø d                        | l      | Ø D <sub>max.</sub> | L <sub>max.</sub> | F <sub>min.</sub> |          | FORM AA              | FORM BA | FORM BR |
| 6.3 x 12.7  | (2)       | 0.6                        | -      | 6.5                 | 12.9              | 17.5              | ≈ 1.1    | -                    | 1000    | 1000    |
| 7.7 x 12.7  | (3)       | 0.6                        | -      | 7.9                 | 12.9              | 17.5              | ≈ 1.3    | -                    | 500     | 500     |
| 6.5 x 18  | 4         | 0.8                        | -      | 6.9                 | 18.5              | 25                | ≈ 1.3    | -                    | 1000    | 1000    |
| 8 x 18  | 5         | 0.8                        | -      | 8.5                 | 18.5              | 25                | ≈ 1.7    | -                    | 500     | 500     |
| 10 x 18   | 6         | 0.8                        | -      | 10.5                | 18.5              | 25                | ≈ 2.5    | -                    | 500     | 500     |
| 10 x 25   | 7         | 0.8                        | -      | 10.5                | 25.5              | 30                | ≈ 3.3    | -                    | 500     | 500     |
| 10 x 30   | 00        | 0.8                        | 55 ± 1 | 10.5                | 30.5              | 35                | ≈ 4.8    | 340                  | -       | 500     |
| 12.5 x 30   | 01        | 0.8                        | 55 ± 1 | 13.0                | 30.5              | 35                | ≈ 7.4    | 260                  | -       | 400     |
| 15 x 30   | 02        | 0.8                        | 55 ± 1 | 15.5                | 30.5              | 35                | ≈ 11.7   | 200                  | -       | 250     |
| 18 x 30   | 03        | 0.8                        | 55 ± 1 | 18.5                | 30.5              | 35                | ≈ 12.9   | 120                  | -       | -       |
| 18 x 38   | 04        | 0.8                        | 34 ± 1 | 18.5                | 39.5              | 44                | ≈ 19.0   | 125                  | -       | -       |
| 21 x 38   | 05        | 0.8                        | 34 ± 1 | 21.5                | 39.5              | 44                | ≈ 24.0   | 100                  | -       | -       |

**Note**

- For detailed tape dimensions refer to packaging information: [www.vishay.com/doc?28361](http://www.vishay.com/doc?28361)


 Fig. 5 - Mounting hole diagram and outline; **Form MR:** With mounting ring and pins

**Table 2**

| <b>MOUNTING RING; DIMENSIONS</b> in millimeters, <b>MASS AND PACKAGING QUANTITIES</b> |           |                        |           |                   |                      |            |                   |          |                      |
|---|-----------|------------------------|-----------|-------------------|----------------------|------------|-------------------|----------|----------------------|
| NOMINAL CASE SIZE<br>Ø D x L  | CASE CODE | MOUNTING RING: FORM MR |           |                   |                      |            |                   | MASS (g) | PACKAGING QUANTITIES |
|   |           | Ø d1                   | Ø d2      | D <sub>max.</sub> | Ø D <sub>2max.</sub> | D3         | L <sub>max.</sub> |          |                      |
| 15 x 30   | 02        | 0.8                    | 1.0 + 0.4 | 15.5              | 17.5                 | 16.5 ± 0.2 | 33                | ≈ 11.7   | 200                  |
| 18 x 30   | 03        | 0.8                    | 1.0 + 0.4 | 18.5              | 19.5                 | 18.5 ± 0.2 | 33                | ≈ 12.9   | 240                  |
| 18 x 38   | 04        | 0.8                    | 1.0 + 0.4 | 18.5              | 19.5                 | 18.5 ± 0.2 | 42                | ≈ 19.0   | 100                  |
| 21 x 38   | 05        | 0.8                    | 1.0 + 0.4 | 21.5              | 22.5                 | 21.5 ± 0.2 | 42                | ≈ 24.0   | 100                  |



| ELECTRICAL DATA |   |
|-----------------|---|
| SYMBOL          | DESCRIPTION   |
| $C_R$           | Rated capacitance at 100 Hz, tolerance $\pm 20\%$                                       |
| $I_R$           | Rated RMS ripple current at 100 Hz, 105 °C  |
| $I_{L5}$        | Max. leakage current after 5 min at $U_R$   |
| $\tan \delta$   | Max. dissipation factor at 100 Hz   |
| ESR             | Equivalent series resistance at 100 Hz (calculated from $\tan \delta_{max}$ and $C_R$ ) |
| Z               | Max. impedance at 10 kHz or 100 kHz   |

**ORDERING EXAMPLE**

Electrolytic capacitor 138 series  
 470  $\mu\text{F}/10\text{ V}$ ;  $\pm 20\%$   
 Nominal case size:  $\varnothing 8\text{ mm} \times 18\text{ mm}$ ; Form BA  
 Ordering code: MAL213834471E3  
 Former 12 NC: 2222 138 34471

**Note**

- Unless otherwise specified, all electrical values in Table 3 apply at  $T_{amb} = 20\text{ °C}$ ,  $P = 86\text{ kPa}$  to 106 kPa,  $RH = 45\%$  to 75 %.

**Table 3**

| 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 Hz<br>105 °C<br>(mA) | $I_{L5}$<br>5 min<br>( $\mu\text{A}$ ) | $\tan \delta$<br>100 Hz | ESR<br>100 Hz<br>( $\Omega$ ) | Z<br>10 kHz<br>( $\Omega$ ) | Z<br>100 kHz<br>( $\Omega$ ) | ORDERING CODE MAL2138..... |                             |                            |                             |
|  |                                      |  |                                   |  |                         |                               |                             |                              | IN BOX<br>FORM AA          | TAPED<br>ON REEL<br>FORM BR | TAPED<br>IN BOX<br>FORM BA | MOUNTING<br>RING<br>FORM MR |
| 6.3                                      | 100                                  | 6.3 x 12.7   | 99                                | 5.3                                    | 0.24                    | 3.800                         | 3.000                       | 1.800                        | -                          | 23101E3                     | 33101E3                    | -                           |
|  | 220                                  | 7.7 x 12.7   | 160                               | 6.8                                    | 0.24                    | 1.700                         | 1.400                       | 0.950                        | -                          | 23221E3                     | 33221E3                    | -                           |
|  | 470                                  | 6.5 x 18   | 250                               | 9.9                                    | 0.24                    | 0.810                         | 0.640                       | 0.500                        | -                          | 23471E3                     | 33471E3                    | -                           |
|  | 1000                                 | 10 x 18  | 430                               | 17                                     | 0.24                    | 0.380                         | 0.300                       | 0.240                        | -                          | 23102E3                     | 33102E3                    | -                           |
|  | 2200                                 | 10 x 25  | 640                               | 32                                     | 0.29                    | 0.210                         | 0.180                       | 0.150                        | -                          | 23222E3                     | 33222E3                    | -                           |
| 10                                       | 150                                  | 7.7 x 12.7   | 140                               | 7.0                                    | 0.2                     | 2.100                         | 1.300                       | 0.950                        | -                          | 24151E3                     | 34151E3                    | -                           |
|  | 220                                  | 6.5 x 18   | 190                               | 8.4                                    | 0.2                     | 1.400                         | 0.910                       | 0.500                        | -                          | 24221E3                     | 34221E3                    | -                           |
|  | 470                                  | 8 x 18   | 300                               | 13                                     | 0.2                     | 0.680                         | 0.430                       | 0.350                        | -                          | 24471E3                     | 34471E3                    | -                           |
|  | 1000                                 | 10 x 25  | 520                               | 24                                     | 0.2                     | 0.320                         | 0.200                       | 0.160                        | -                          | 24102E3                     | 34102E3                    | -                           |
|  | 1500                                 | 10 x 30  | 670                               | 34                                     | 0.28                    | 0.320                         | 0.260                       | 0.260                        | 14152E3                    | 24152E3                     | -                          | -                           |
|  | 2200                                 | 12.5 x 30  | 890                               | 48                                     | 0.29                    | 0.220                         | 0.190                       | 0.190                        | 14222E3                    | 24222E3                     | -                          | -                           |
|  | 3300                                 | 15 x 30  | 1140                              | 70                                     | 0.30                    | 0.160                         | 0.130                       | 0.150                        | 14332E3                    | 24332E3                     | -                          | 44332E3                     |
|  | 4700                                 | 18 x 30  | 1450                              | 98                                     | 0.33                    | 0.120                         | 0.110                       | 0.130                        | 14472E3                    | -                           | -                          | 44472E3                     |
|  | 6800                                 | 18 x 38  | 1880                              | 140                                    | 0.34                    | 0.085                         | 0.074                       | 0.110                        | 14682E3                    | -                           | -                          | 44682E3                     |
|  | 10 000                               | 18 x 38  | 1980                              | 200                                    | 0.41                    | 0.070                         | 0.062                       | 0.100                        | 14103E3                    | -                           | -                          | 44103E3                     |
| 15 000                                   | 21 x 38                              | 2200   | 300                               | 0.55                                   | 0.063                   | 0.058                         | 0.099                       | 14153E3                      | -                          | -                           | 44153E3                    |                             |
| 16                                       | 22                                   | 6.3 x 12.7   | 58                                | 4.7                                    | 0.12                    | 8.700                         | 7.300                       | 2.700                        | -                          | 25229E3                     | 35229E3                    | -                           |
|  | 47                                   | 6.3 x 12.7   | 83                                | 5.5                                    | 0.16                    | 5.400                         | 3.400                       | 1.900                        | -                          | 25479E3                     | 35479E3                    | -                           |
|  | 100                                  | 7.7 x 12.7   | 130                               | 7.2                                    | 0.16                    | 2.500                         | 1.600                       | 1.000                        | -                          | 25101E3                     | 35101E3                    | -                           |
|  | 220                                  | 8 x 18   | 230                               | 11                                     | 0.16                    | 1.200                         | 0.730                       | 0.350                        | -                          | 25221E3                     | 35221E3                    | -                           |
|  | 470                                  | 10 x 18  | 360                               | 19                                     | 0.16                    | 0.540                         | 0.340                       | 0.250                        | -                          | 25471E3                     | 35471E3                    | -                           |
|  | 1000                                 | 10 x 30  | 630                               | 36                                     | 0.20                    | 0.340                         | 0.270                       | 0.260                        | 15102E3                    | 25102E3                     | -                          | -                           |
|  | 1500                                 | 12.5 x 30  | 860                               | 52                                     | 0.20                    | 0.230                         | 0.190                       | 0.190                        | 15152E3                    | 25152E3                     | -                          | -                           |
|  | 2200                                 | 15 x 30  | 1090                              | 74                                     | 0.21                    | 0.170                         | 0.140                       | 0.150                        | 15222E3                    | 25222E3                     | -                          | 45222E3                     |
|  | 3300                                 | 18 x 30  | 1420                              | 110                                    | 0.24                    | 0.120                         | 0.100                       | 0.130                        | 15332E3                    | -                           | -                          | 45332E3                     |
|  | 4700                                 | 18 x 30  | 1480                              | 150                                    | 0.28                    | 0.100                         | 0.090                       | 0.120                        | 15472E3                    | -                           | -                          | 45472E3                     |
| 6800                                     | 18 x 38                              | 1930   | 220                               | 0.28                                   | 0.072                   | 0.062                         | 0.100                       | 15682E3                      | -                          | -                           | 45682E3                    |                             |
| 10 000                                   | 21 x 38                              | 2100   | 320                               | 0.38                                   | 0.065                   | 0.057                         | 0.098                       | 15103E3                      | -                          | -                           | 45103E3                    |                             |
| 25                                       | 10                                   | 6.3 x 12.7   | 46                                | 4.5                                    | 0.09                    | 14.000                        | 12.000                      | 2.800                        | -                          | 26109E3                     | 36109E3                    | -                           |
|  | 22                                   | 6.3 x 12.7   | 61                                | 5.1                                    | 0.14                    | 10.000                        | 5.500                       | 2.500                        | -                          | 26229E3                     | 36229E3                    | -                           |
|  | 33                                   | 6.3 x 12.7   | 74                                | 5.7                                    | 0.14                    | 6.800                         | 3.600                       | 1.900                        | -                          | 26339E3                     | 36339E3                    | -                           |
|  | 47                                   | 7.7 x 12.7   | 96                                | 6.4                                    | 0.14                    | 4.700                         | 2.600                       | 1.000                        | -                          | 26479E3                     | 36479E3                    | -                           |



| ELECTRICAL DATA AND ORDERING INFORMATION |                            |                                |                                   |                            |              |                |              |               |                            |                       |                      |                       |
|--|----------------------------|--------------------------------|-----------------------------------|----------------------------|--------------|----------------|--------------|---------------|----------------------------|-----------------------|----------------------|-----------------------|
| U <sub>R</sub> (V)                       | C <sub>R</sub> 100 Hz (μF) | NOMINAL CASE SIZE Ø D x L (mm) | I <sub>R</sub> 100 Hz 105 °C (mA) | I <sub>L5</sub> 5 min (μA) | tan δ 100 Hz | ESR 100 Hz (Ω) | Z 10 kHz (Ω) | Z 100 kHz (Ω) | ORDERING CODE MAL2138..... |                       |                      |                       |
|  |                            |                                |                                   |                            |              |                |              |               | IN BOX FORM AA             | TAPED ON REEL FORM BR | TAPED IN BOX FORM BA | MOUNTING RING FORM MR |
| 25                                       | 100                        | 6.5 x 18                       | 160                               | 9.0                        | 0.13         | 2.100          | 1.200        | 0.550         | -                          | 26101E3               | 36101E3              | -                     |
|  | 220                        | 10 x 18                        | 270                               | 15                         | 0.13         | 0.940          | 0.550        | 0.270         | -                          | 26221E3               | 36221E3              | -                     |
|  | 470                        | 10 x 25                        | 440                               | 28                         | 0.13         | 0.440          | 0.260        | 0.170         | -                          | 26471E3               | 36471E3              | -                     |
|  | 680                        | 10 x 30                        | 580                               | 38                         | 0.14         | 0.360          | 0.260        | 0.250         | 16681E3                    | 26681E3               | -                    | -                     |
|  | 1000                       | 12.5 x 30                      | 790                               | 54                         | 0.15         | 0.250          | 0.180        | 0.190         | 16102E3                    | 26102E3               | -                    | -                     |
|  | 1500                       | 15 x 30                        | 1020                              | 79                         | 0.15         | 0.170          | 0.130        | 0.150         | 16152E3                    | 26152E3               | -                    | 46152E3               |
|  | 2200                       | 18 x 30                        | 1320                              | 110                        | 0.17         | 0.130          | 0.100        | 0.130         | 16222E3                    | -                     | -                    | 46222E3               |
|  | 3300                       | 18 x 38                        | 1720                              | 170                        | 0.17         | 0.090          | 0.071        | 0.110         | 16332E3                    | -                     | -                    | 46332E3               |
|  | 4700                       | 18 x 38                        | 1840                              | 240                        | 0.21         | 0.076          | 0.063        | 0.100         | 16472E3                    | -                     | -                    | 46472E3               |
|  | 6800                       | 21 x 38                        | 2100                              | 340                        | 0.27         | 0.068          | 0.058        | 0.099         | 16682E3                    | -                     | -                    | 46682E3               |
| 40                                       | 33                         | 7.7 x 12.7                     | 91                                | 6.6                        | 0.11         | 5.300          | 2.700        | 1.000         | -                          | 27339E3               | 37339E3              | -                     |
|  | 47                         | 6.5 x 18                       | 120                               | 7.8                        | 0.10         | 3.400          | 1.900        | 0.650         | -                          | 27479E3               | 37479E3              | -                     |
|  | 100                        | 8 x 18                         | 180                               | 12                         | 0.10         | 1.600          | 0.900        | 0.400         | -                          | 27101E3               | 37101E3              | -                     |
|  | 220                        | 10 x 25                        | 350                               | 22                         | 0.10         | 0.720          | 0.410        | 0.200         | -                          | 27221E3               | 37221E3              | -                     |
|  | 330                        | 10 x 30                        | 490                               | 30                         | 0.09         | 0.470          | 0.320        | 0.300         | 17331E3                    | 27331E3               | -                    | -                     |
|  | 470                        | 12.5 x 30                      | 650                               | 42                         | 0.09         | 0.340          | 0.230        | 0.220         | 17471E3                    | 27471E3               | -                    | -                     |
|  | 680                        | 12.5 x 30                      | 750                               | 58                         | 0.10         | 0.250          | 0.180        | 0.180         | 17681E3                    | 27681E3               | -                    | -                     |
|  | 1000                       | 15 x 30                        | 970                               | 84                         | 0.10         | 0.170          | 0.120        | 0.140         | 17102E3                    | 27102E3               | -                    | 47102E3               |
|  | 1500                       | 18 x 30                        | 1250                              | 120                        | 0.12         | 0.130          | 0.098        | 0.120         | 17152E3                    | -                     | -                    | 47152E3               |
|  | 2200                       | 18 x 38                        | 1640                              | 180                        | 0.12         | 0.093          | 0.069        | 0.100         | 17222E3                    | -                     | -                    | 47222E3               |
| 3300                                     | 21 x 38                    | 1810                           | 270                               | 0.15                       | 0.079        | 0.061          | 0.100        | 17332E3       | -                          | -                     | 47332E3              |                       |
| 50                                       | 10                         | 6.3 x 12.7                     | 51                                | 5.0                        | 0.09         | 14.00          | 7.000        | 2.700         | -                          | 21109E3               | 31109E3              | -                     |
|  | 22                         | 7.7 x 12.7                     | 82                                | 6.2                        | 0.09         | 6.500          | 3.002        | 1.100         | -                          | 21229E3               | 31229E3              | -                     |
|  | 100                        | 10 x 18                        | 230                               | 14                         | 0.08         | 1.300          | 0.700        | 0.300         | -                          | 21101E3               | 31101E3              | -                     |
| 63                                       | 4.7                        | 6.3 x 12.7                     | 35                                | 4.6                        | 0.09         | 30.00          | 17.000       | 5.000         | -                          | 28478E3               | 38478E3              | -                     |
|  | 10                         | 7.7 x 12.7                     | 59                                | 5.3                        | 0.08         | 13.00          | 8.000        | 1.800         | -                          | 28109E3               | 38109E3              | -                     |
|  | 22                         | 6.5 x 18                       | 100                               | 6.8                        | 0.07         | 5.100          | 3.600        | 0.850         | -                          | 28229E3               | 38229E3              | -                     |
|  | 47                         | 8 x 18                         | 150                               | 9.9                        | 0.07         | 2.400          | 1.700        | 0.500         | -                          | 28479E3               | 38479E3              | -                     |
|  | 100                        | 10 x 25                        | 280                               | 17                         | 0.07         | 1.100          | 0.800        | 0.270         | -                          | 28101E3               | 38101E3              | -                     |
|  | 150                        | 10 x 30                        | 410                               | 23                         | 0.11         | 0.730          | 0.440        | 0.400         | 18151E3                    | 28151E3               | -                    | -                     |
|  | 220                        | 12.5 x 30                      | 560                               | 32                         | 0.11         | 0.500          | 0.310        | 0.290         | 18221E3                    | 28221E3               | -                    | -                     |
|  | 330                        | 12.5 x 30                      | 660                               | 46                         | 0.12         | 0.370          | 0.230        | 0.220         | 18331E3                    | 28331E3               | -                    | -                     |
|  | 470                        | 15 x 30                        | 860                               | 63                         | 0.12         | 0.260          | 0.160        | 0.160         | 18471E3                    | 28471E3               | -                    | 48471E3               |
|  | 680                        | 18 x 30                        | 1130                              | 90                         | 0.12         | 0.190          | 0.120        | 0.140         | 18681E3                    | -                     | -                    | 48681E3               |
| 1000                                     | 18 x 38                    | 1460                           | 130                               | 0.12                       | 0.130        | 0.086          | 0.110        | 18102E3       | -                          | -                     | 48102E3              |                       |
| 1500                                     | 21 x 38                    | 1680                           | 190                               | 0.13                       | 0.100        | 0.072          | 0.110        | 18152E3       | -                          | -                     | 48152E3              |                       |
| 100                                      | 1.0                        | 6.3 x 12.7                     | 16                                | 4.2                        | 0.09         | 140.0          | 55.000       | 10.00         | -                          | 29108E3               | 39108E3              | -                     |
|  | 2.2                        | 6.3 x 12.7                     | 24                                | 4.4                        | 0.09         | 65.00          | 25.000       | 8.000         | -                          | 29228E3               | 39228E3              | -                     |
|  | 4.7                        | 7.7 x 12.7                     | 40                                | 4.9                        | 0.08         | 27.00          | 17.000       | 5.000         | -                          | 29478E3               | 39478E3              | -                     |
|  | 10                         | 6.5 x 18                       | 67                                | 6.0                        | 0.07         | 11.00          | 8.000        | 2.400         | -                          | 29109E3               | 39109E3              | -                     |
|  | 22                         | 8 x 18                         | 100                               | 8.4                        | 0.07         | 5.100          | 3.600        | 1.400         | -                          | 29229E3               | 39229E3              | -                     |
|  | 47                         | 10 x 25                        | 190                               | 13                         | 0.07         | 2.400          | 1.700        | 0.670         | -                          | 29479E3               | 39479E3              | -                     |
|  | 68                         | 10 x 30                        | 300                               | 18                         | 0.07         | 1.700          | 1.100        | 0.970         | 19689E3                    | 29689E3               | -                    | -                     |
|  | 100                        | 12.5 x 30                      | 410                               | 24                         | 0.07         | 1.100          | 0.770        | 0.670         | 19101E3                    | 29101E3               | -                    | -                     |
|  | 150                        | 15 x 30                        | 550                               | 34                         | 0.07         | 0.780          | 0.520        | 0.460         | 19151E3                    | 29151E3               | -                    | 49151E3               |
|  | 220                        | 15 x 30                        | 650                               | 48                         | 0.07         | 0.540          | 0.370        | 0.330         | 19221E3                    | 29221E3               | -                    | 49221E3               |
|  | 330                        | 18 x 30                        | 880                               | 70                         | 0.08         | 0.380          | 0.270        | 0.240         | 19331E3                    | -                     | -                    | 49331E3               |
|  | 470                        | 18 x 38                        | 1130                              | 98                         | 0.08         | 0.270          | 0.190        | 0.170         | 19471E3                    | -                     | -                    | 49471E3               |
|  | 680                        | 21 x 38                        | 1330                              | 140                        | 0.09         | 0.210          | 0.140        | 0.140         | 19681E3                    | -                     | -                    | 49681E3               |

| ADDITIONAL ELECTRICAL DATA         |   |  |               |
|------------------------------------|---|--|---------------|
| PARAMETER                          | CONDITIONS  | VALUE  |               |
|                                    |   | AXIAL  | MOUNTING RING |
| <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 1 min at $U_R$ :  |  |               |
|                                    | Case $\varnothing D \times L = 6.3 \text{ mm} \times 12.7 \text{ mm}$ and $7.7 \text{ mm} \times 12.7 \text{ mm}$ | $I_{L1} \leq 0.02 C_R \times U_R + 3 \mu\text{A}$  |               |
|                                    | Case $\varnothing D \times L = 6.5 \text{ mm} \times 18 \text{ mm}$ to $21 \text{ mm} \times 38 \text{ mm}$       | $I_{L1} \leq 0.006 C_R \times U_R + 4 \mu\text{A}$ |               |
|                                    | After 5 min at $U_R$  | $I_{L5} \leq 0.002 C_R \times U_R + 4 \mu\text{A}$ |               |
| <b>Inductance</b>                  |   |  |               |
| Equivalent series inductance (ESL) | Case $\varnothing D \times L$ mm:   |  |               |
|                                    | 6.3 x 12.7  | Typ. 20 nH   | -             |
|                                    | 7.7 x 12.7  | Typ. 30 nH   | -             |
|                                    | 6.5 x 18  | Typ. 15 nH   | -             |
|                                    | 8 x 18  | Typ. 35 nH   | -             |
|                                    | 10 x 18   | Typ. 69 nH   | -             |
|                                    | 10 x 25   | Typ. 38 nH   | -             |
|                                    | 10 x 30   | Typ. 38 nH   | -             |
|                                    | 12.5 x 30   | Typ. 46 nH   | -             |
|                                    | 15 x 30   | Typ. 48 nH   | Typ. 39 nH    |
|                                    | 18 x 30   | Typ. 50 nH   | Typ. 39 nH    |
|                                    | 18 x 38   | Typ. 54 nH   | Typ. 39 nH    |
| 21 x 38                            | Typ. 59 nH  | Typ. 39 nH   |               |

**CAPACITANCE (C)**



Fig. 6 - Typical multiplier of capacitance as a function of ambient temperature

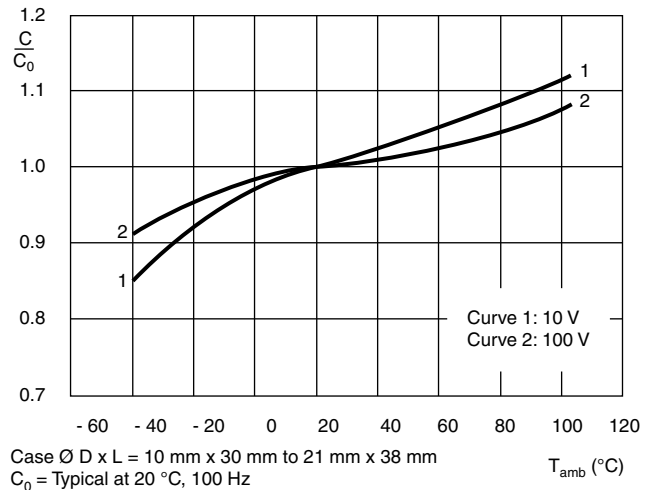


Fig. 7 - Typical multiplier of capacitance as a function of ambient temperature

**EQUIVALENT SERIES RESISTANCE (ESR)**



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



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



Fig. 10 - Typical multiplier of ESR as a function of ambient temperature



Fig. 11 - Typical multiplier ESR as a function of frequency

**EQUIVALENT SERIES RESISTANCE (ESR)**



Fig. 12 - Typical multiplier ESR as a function of frequency

**IMPEDANCE (Z)**

Table 4

| IMPEDANCE VS. CAPACITANCE VALUES (Case $\varnothing$ D x L = 6.3 mm x 12.7 mm to 10 mm x 25 mm) |  |        |        |        |        |       |        |        |
|---|--|--------|--------|--------|--------|-------|--------|--------|
| $T_{amb}$   | $Z \times C_R (\Omega \times \mu F)$ AT 10 kHz |        |        |        |        |       |        |        |
|   | 6.3 V  | 10 V   | 16 V   | 25 V   | 40 V   | 50 V  | 63 V   | 100 V  |
| + 20 °C   | ≤ 300  | ≤ 200  | ≤ 160  | ≤ 120  | ≤ 90   | ≤ 70  | ≤ 80   | ≤ 80   |
| - 25 °C   | ≤ 2000   | ≤ 1200 | ≤ 750  | ≤ 560  | ≤ 450  | ≤ 300 | ≤ 550  | ≤ 550  |
| - 40 °C   | ≤ 5500   | ≤ 3200 | ≤ 2000 | ≤ 1500 | ≤ 1200 | ≤ 900 | ≤ 1500 | ≤ 1500 |



Fig. 13 - Typical multiplier of ESR as a function of ambient temperature at 10 kHz



Fig. 14 - Typical impedance as a function of frequency





Fig. 15 - Typical impedance as a function of frequency



Fig. 16 - Typical impedance as a function of frequency



Fig. 17 - Typical impedance as a function of frequency



Fig. 18 - Typical impedance as a function of frequency

**RIPPLE CURRENT AND USEFUL LIFE**

CCC206



$I_A$  = Actual ripple current at 100 Hz  
 $I_R$  = Rated ripple current at 100 Hz, 105 °C

(1) Useful life at 105 °C and  $I_R$  applied:  
 Case  $\varnothing D \times L = 6.3 \text{ mm} \times 12.7 \text{ mm}$  to  $10 \text{ mm} \times 25 \text{ mm}$ : 2000 h  
 Case  $\varnothing D \times L = 10 \text{ mm} \times 30 \text{ mm}$  to  $21 \text{ mm} \times 38 \text{ mm}$ : 10 000 h

Fig. 19 - Multiplier of useful life as a function of ambient temperature and ripple current load

Table 5

| <b>MULTIPLIER OF RIPPLE CURRENT (<math>I_R</math>) AS A FUNCTION OF FREQUENCY</b> |  |   |  |
|---|--|---|--|
| <b>FREQUENCY (Hz)</b>   | <b><math>I_R</math> MULTIPLIER</b>                       |   |  |
|   | <b><math>U_R = 6.3 \text{ V TO } 10 \text{ V}</math></b> | <b><math>U_R = 16 \text{ V TO } 25 \text{ V}</math></b> | <b><math>U_R = 40 \text{ V TO } 100 \text{ V}</math></b> |
| 50  | 0.95   | 0.90  | 0.85   |
| 100   | 1.00   | 1.00  | 1.00   |
| 300   | 1.07   | 1.12  | 1.20   |
| 1000  | 1.12   | 1.20  | 1.30   |
| 3000  | 1.15   | 1.25  | 1.35   |
| $\geq 10\ 000$  | 1.20   | 1.30  | 1.40   |

Table 6

| <b>TEST PROCEDURES AND REQUIREMENTS</b>        |   |   |   |
|--|---|---|---|
| <b>TEST</b>                                    |   | <b>PROCEDURE<br/>(quick reference)</b>  | <b>REQUIREMENTS</b>   |
| <b>NAME OF TEST</b>                            | <b>REFERENCE</b>                            |   |   |
| Endurance                                      | IEC 60384-4/<br>EN130300<br>subclause 4.13  | $T_{amb} = 105\text{ }^{\circ}\text{C}$ ; $U_R$ applied;<br>Case $\emptyset D \times L$ :<br>6.3 mm x 12.7 mm to 10 mm x 25 mm: 1000 h;<br>10 mm x 30 mm to 21 mm x 38 mm: 5000 h             | $U_R \leq 6.3\text{ V}$ ; $\Delta C/C$ : + 15 %/- 30 %<br>$U_R > 6.3\text{ V}$ ; $\Delta C/C$ : $\pm 15\%$<br>$\tan \delta \leq 1.3 \times \text{spec. limit}$<br>$Z \leq 2 \times \text{spec. limit}$<br>$I_{L5} \leq \text{spec. limit}$  |
| Useful life                                    | CECC 30301<br>subclause 1.8.1               | $T_{amb} = 105\text{ }^{\circ}\text{C}$ ; $U_R$ and $I_R$ applied;<br>Case $\emptyset D \times L$ :<br>6.3 mm x 12.7 mm to 10 mm x 25 mm: 2000 h;<br>10 mm x 30 mm to 21 mm x 38 mm: 10 000 h | $U_R \leq 6.3\text{ V}$ ; $\Delta C/C$ : + 45 %/- 50 %<br>$U_R > 6.3\text{ V}$ ; $\Delta C/C$ : $\pm 45\%$<br>$\tan \delta \leq 3 \times \text{spec. limit}$<br>$Z \leq 3 \times \text{spec. limit}$<br>$I_{L5} \leq \text{spec. limit}$<br>no short open circuit<br>total failure percentage: $\leq 1\%$ |
| Shelf life<br>(storage at<br>high temperature) | IEC 60384-4/<br>EN130300,<br>subclause 4.17 | $T_{amb} = 105\text{ }^{\circ}\text{C}$ ; no voltage applied;<br>500 h<br>After test: $U_R$ to be applied for 30 min,<br>24 h to 48 h before measurement                                      | $\Delta C/C$ , $\tan \delta$ , $Z$ :<br>For requirements<br>see "Endurance test" above<br>$I_{L5} \leq 2 \times \text{spec. limit}$   |



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