

# Aluminum Electrolytic Capacitors

## Axial Miniature, Long-Life

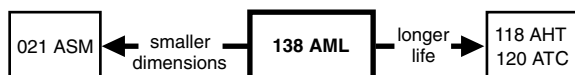
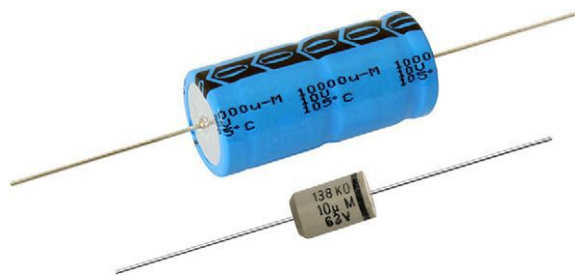


Fig. 1

| QUICK REFERENCE DATA                            |                                            |                                            |
|-------------------------------------------------|--------------------------------------------|--------------------------------------------|
| DESCRIPTION                                     | VALUE                                      |                                            |
| Nominal case sizes<br>(Ø 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 <sub>R</sub>         | 2.2 µF to 15 000 µF                        |                                            |
| Tolerance on C <sub>R</sub>                     | ± 20 %                                     |                                            |
| Rated voltage range, U <sub>R</sub>             | 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 <sub>R</sub> applied | 1.3 x I <sub>R</sub> applied:<br>200 000 h | 1.8 x I <sub>R</sub> 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 Ø 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 Ø 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

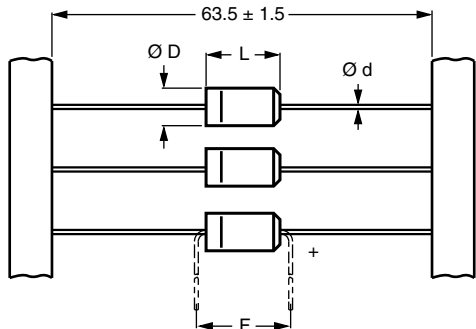
### MARKING

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

- Rated capacitance (in µF)
- Tolerance on rated capacitance, code letter in accordance with IEC 60062 (M for ± 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)

| <b>SELECTION CHART FOR <math>C_R</math>, <math>U_R</math>, AND RELEVANT NOMINAL CASE SIZES (<math>\varnothing D \times L</math> in mm)</b> |            |            |            |            |            |            |            |            |
|--------------------------------------------------------------------------------------------------------------------------------------------|------------|------------|------------|------------|------------|------------|------------|------------|
| $C_R$<br>( $\mu F$ )                                                                                                                       | $U_R$ (V)  |            |            |            |            |            |            |            |
|                                                                                                                                            | 6.3        | 10         | 16         | 25         | 40         | 50         | 63         | 100        |
| 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                                                                                                                                         | -          | -          | -          | -          | 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

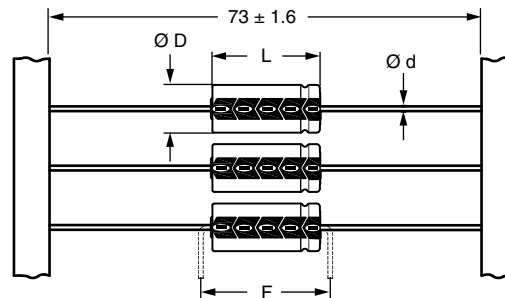


**Form BR:** Taped on reel

**Form BA:** Taped in box (ammpack)

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



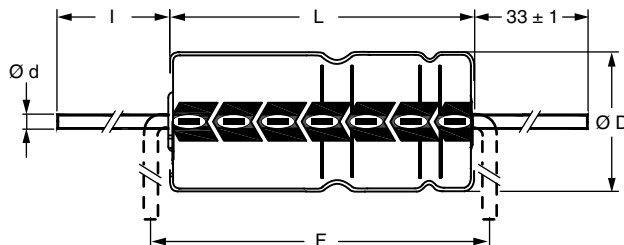
**Form BR:** Taped on reel

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 (ammpack)

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  $21 \text{ mm} \times 38 \text{ mm}$

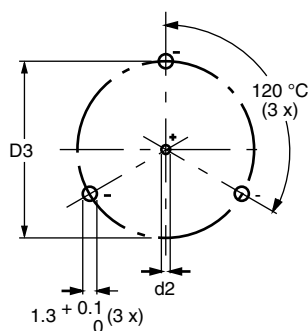
Fig. 4 - Form AA

**Table 1**

| <b>AXIAL; DIMENSIONS in millimeters, MASS AND PACKAGING QUANTITIES</b> |              |                            |        |                     |                   |                   |             |                      |            |            |
|------------------------------------------------------------------------|--------------|----------------------------|--------|---------------------|-------------------|-------------------|-------------|----------------------|------------|------------|
| NOMINAL<br>CASE SIZE<br>Ø D x L<br>(mm)                                | CASE<br>CODE | AXIAL: FORM AA, BA, AND BR |        |                     |                   |                   | MASS<br>(g) | PACKAGING QUANTITIES |            |            |
|                                                                        |              | Ø d                        | l      | Ø D <sub>max.</sub> | L <sub>max.</sub> | F <sub>min.</sub> |             | FORM<br>AA           | FORM<br>BA | FORM<br>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**

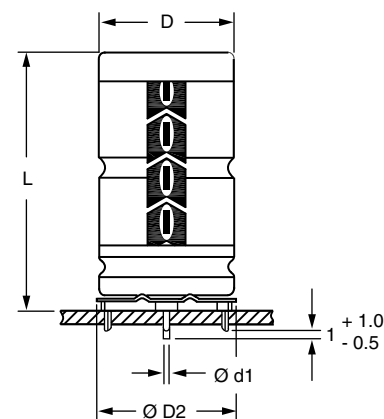
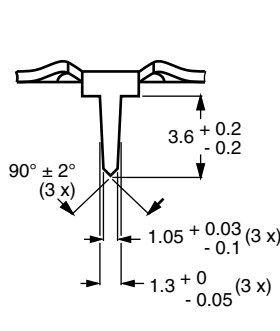
- For detailed tape dimensions refer to packaging information: [www.vishay.com/doc?28361](http://www.vishay.com/doc?28361)



Mounting holes

Case Ø D x L = 15 mm x 30 mm to 21 mm x 38 mm

Especially for applications with severe shocks and vibrations


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

**Table 2**

| <b>MOUNTING RING; DIMENSIONS in millimeters, MASS AND PACKAGING QUANTITIES</b> |              |                        |           |                   |                      |            |                   |             |                         |
|--------------------------------------------------------------------------------|--------------|------------------------|-----------|-------------------|----------------------|------------|-------------------|-------------|-------------------------|
| NOMINAL<br>CASE SIZE<br>Ø D x L                                                | CASE<br>CODE | MOUNTING RING: FORM MR |           |                   |                      |            |                   | MASS<br>(g) | PACKAGING<br>QUANTITIES |
|                                                                                |              | Ø d1                   | Ø d2      | D <sub>max.</sub> | Ø D2 <sub>max.</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                                                     |

**Note**

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

**Table 3**

| ELECTRICAL DATA AND ORDERING INFORMATION |                                  |                                         |                                            |                                  |                 |                      |                    |                     |                            |                             |                            |                             |
|------------------------------------------|----------------------------------|-----------------------------------------|--------------------------------------------|----------------------------------|-----------------|----------------------|--------------------|---------------------|----------------------------|-----------------------------|----------------------------|-----------------------------|
| U <sub>R</sub><br>(V)                    | C <sub>R</sub><br>100 Hz<br>(μF) | NOMINAL<br>CASE SIZE<br>Ø D x L<br>(mm) | I <sub>R</sub><br>100 Hz<br>105 °C<br>(mA) | I <sub>L5</sub><br>5 min<br>(μA) | tan δ<br>100 Hz | ESR<br>100 Hz<br>(Ω) | Z<br>10 kHz<br>(Ω) | Z<br>100 kHz<br>(Ω) | 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                    | -                           |
|                                          | 47                               | 7.7 x 12.7                              | 96                                         | 6.4                              | 0.14            | 4.700                | 2.600              | 1.000               | -                          | 26479E3                     | 36479E3                    | -                           |

**ORDERING EXAMPLE**

Electrolytic capacitor 138 series

470  $\mu\text{F}$  / 10 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



| ELECTRICAL DATA AND ORDERING INFORMATION |                                  |                                         |                                            |                                  |                 |                      |                    |                     |                            |                             |                            |                             |
|------------------------------------------|----------------------------------|-----------------------------------------|--------------------------------------------|----------------------------------|-----------------|----------------------|--------------------|---------------------|----------------------------|-----------------------------|----------------------------|-----------------------------|
| U <sub>R</sub><br>(V)                    | C <sub>R</sub><br>100 Hz<br>(μF) | NOMINAL<br>CASE SIZE<br>Ø D x L<br>(mm) | I <sub>R</sub><br>100 Hz<br>105 °C<br>(mA) | I <sub>L5</sub><br>5 min<br>(μA) | tan δ<br>100 Hz | ESR<br>100 Hz<br>(Ω) | Z<br>10 kHz<br>(Ω) | Z<br>100 kHz<br>(Ω) | 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 |
| 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                               | 0.10            | 0.470                | 0.320              | 0.300               | 17331E3                    | 27331E3                     | -                          | -                           |
|                                          | 470                              | 12.5 x 30                               | 650                                        | 42                               | 0.10            | 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                | 3.200              | 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                                      | 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 |
| Voltage                            |                                                                                                                   |                                                    |               |
| Surge voltage                      |                                                                                                                   | $U_s \leq 1.15 \times U_R$                         |               |
| Reverse voltage                    |                                                                                                                   | $U_{rev} \leq 1 \text{ V}$                         |               |
| Current                            |                                                                                                                   |                                                    |               |
| 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 $U_R$                                                                                              | $I_{L5} \leq 0.002 C_R \times U_R + 4 \mu\text{A}$ |               |
| Inductance                         |                                                                                                                   |                                                    |               |
| 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)

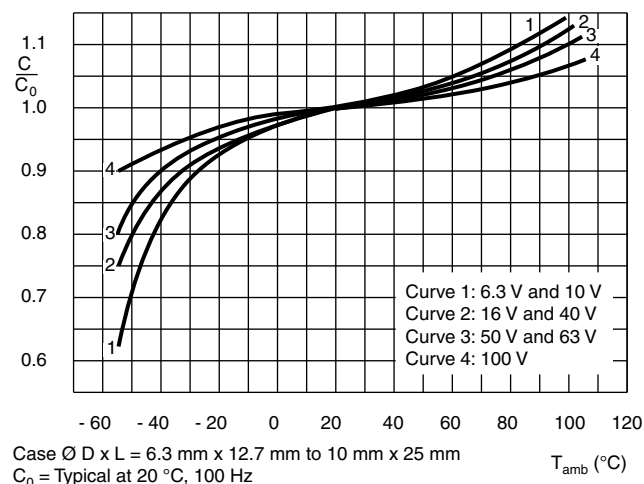


Fig. 6 - Typical multiplier of capacitance as a function of ambient temperature

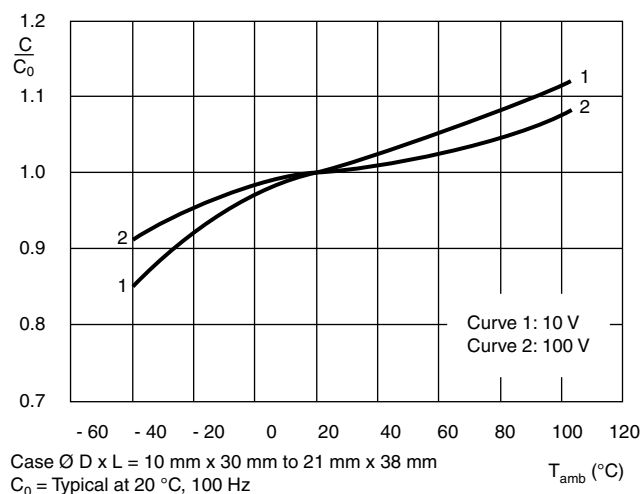


Fig. 7 - Typical multiplier of capacitance as a function of ambient temperature

# EQUIVALENT SERIES RESISTANCE (ESR)

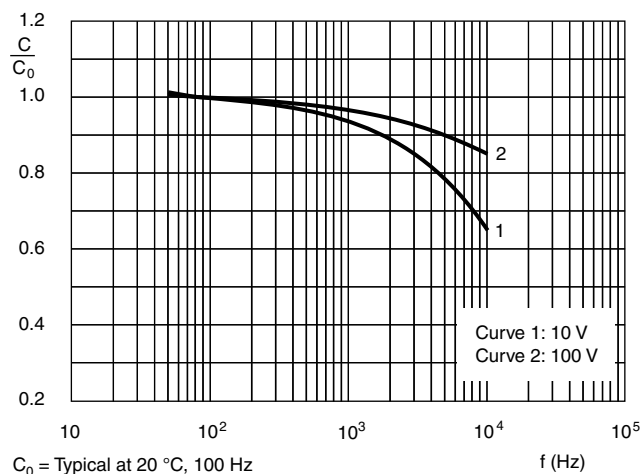


Fig. 8 - Typical multiplier of capacitance as a function of frequency

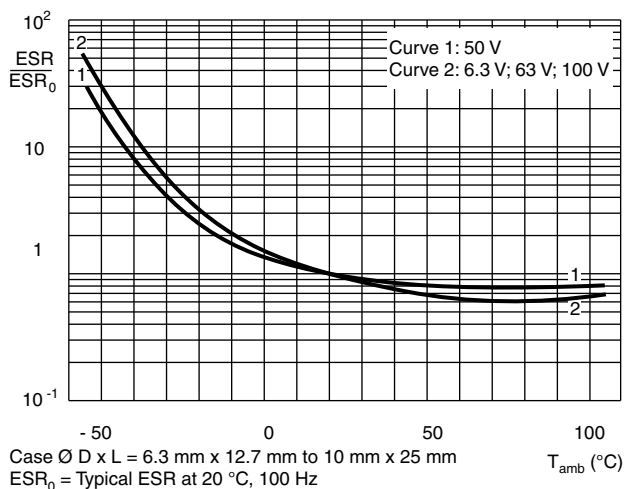


Fig. 9 - Typical multiplier of ESR as a function of ambient temperature

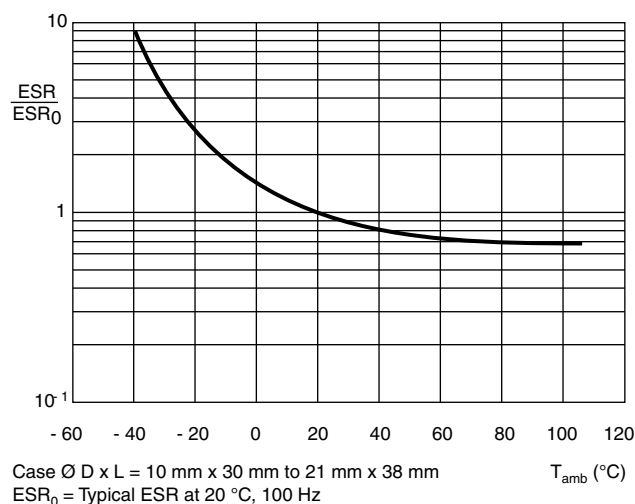


Fig. 10 - Typical multiplier of ESR as a function of ambient temperature

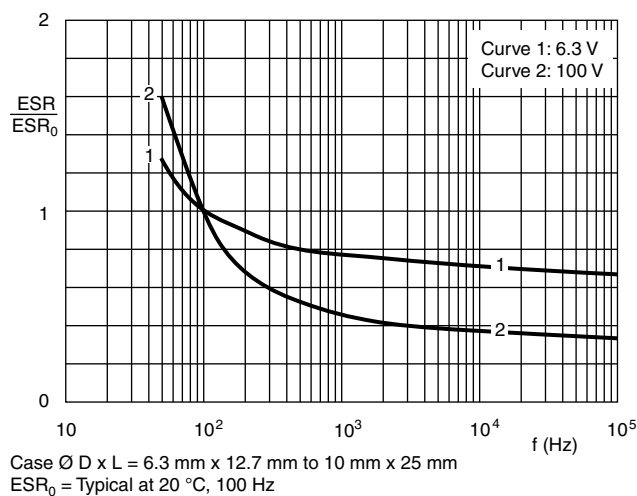


Fig. 11 - Typical multiplier ESR as a function of frequency

## EQUIVALENT SERIES RESISTANCE (ESR)

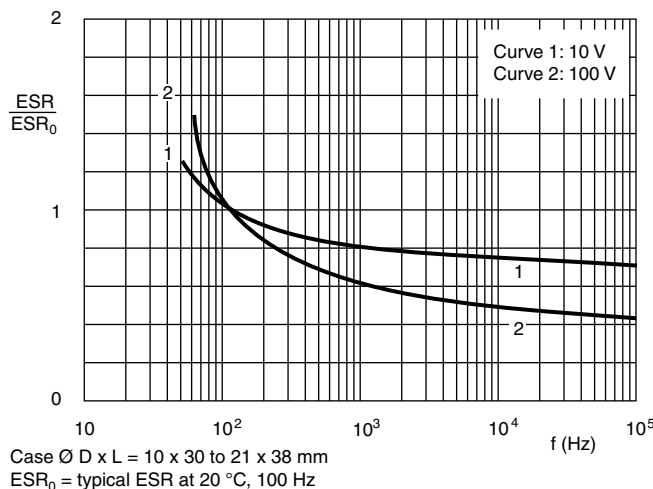


Fig. 12 - Typical multiplier ESR as a function of frequency

## IMPEDANCE (Z)

Table 4

| IMPEDANCE VS. CAPACITANCE VALUES (Case $\varnothing D \times L = 6.3$ 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 |

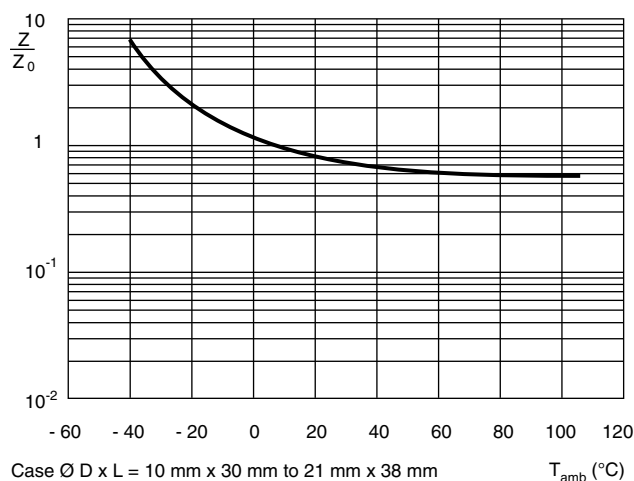


Fig. 13 - Typical multiplier of ESR as a function of ambient temperature at 10 kHz

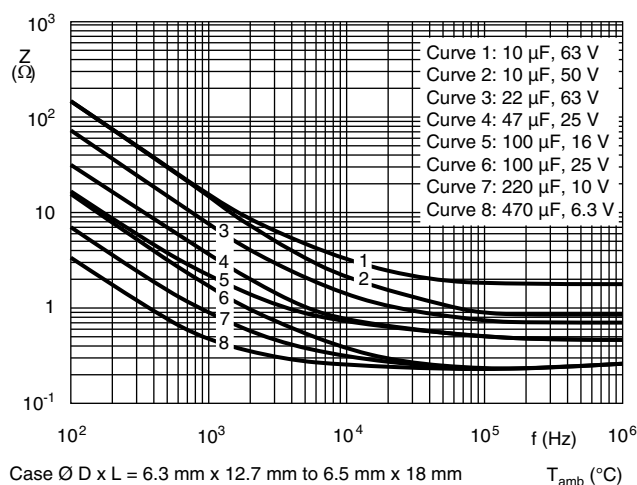


Fig. 14 - Typical impedance as a function of frequency

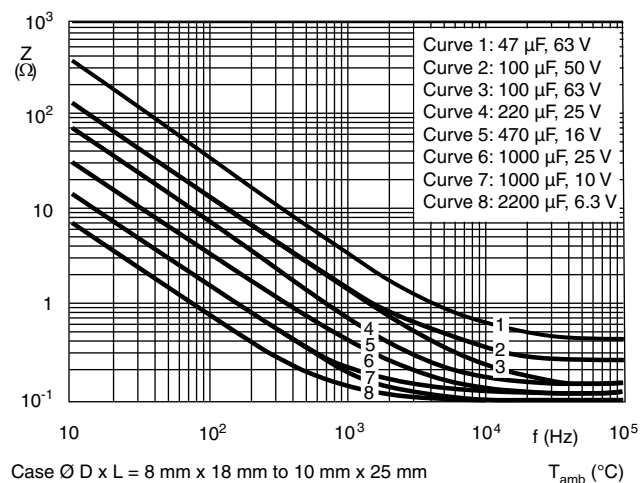


Fig. 15 - Typical impedance as a function of frequency

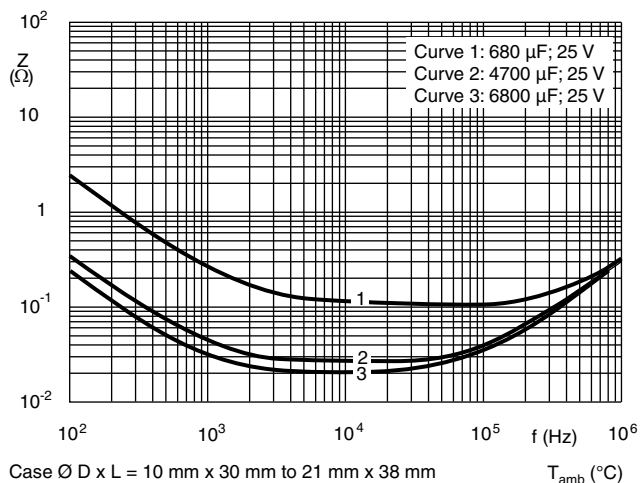


Fig. 16 - Typical impedance as a function of frequency

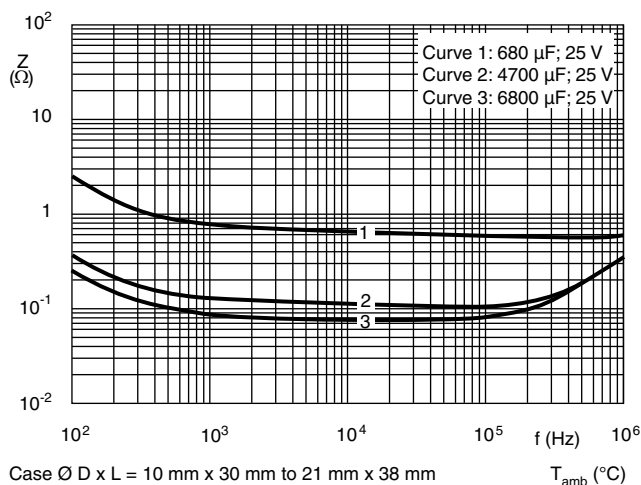


Fig. 17 - Typical impedance as a function of frequency

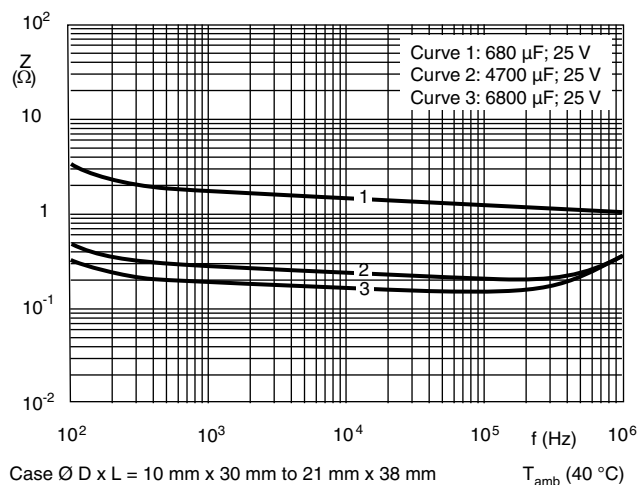


Fig. 18 - Typical impedance as a function of frequency

# RIPPLE CURRENT AND USEFUL LIFE

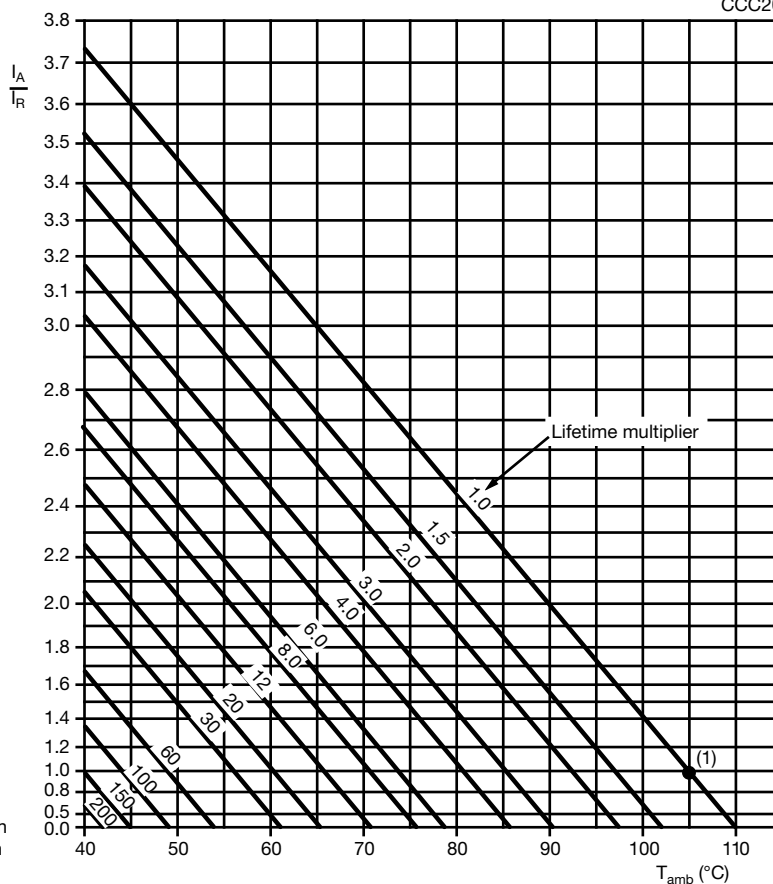
Table 5

| ENDURANCE TEST DURATION AND USEFUL LIFE |                               |                                 |
|-----------------------------------------|-------------------------------|---------------------------------|
| NOMINAL CASE SIZE<br>Ø D x L<br>(mm)    | ENDURANCE<br>AT 105 °C<br>(h) | USEFUL LIFE<br>AT 105 °C<br>(h) |
| 6.3 x 12.7                              | 1000                          | 2000                            |
| 7.7 x 12.7                              | 1000                          | 2000                            |
| 6.5 x 18                                | 1000                          | 2000                            |
| 8 x 18                                  | 1000                          | 2000                            |
| 10 x 18                                 | 1000                          | 2000                            |
| 10 x 25                                 | 1000                          | 2000                            |
| 10 x 30                                 | 5000                          | 10 000                          |
| 12.5 x 30                               | 5000                          | 10 000                          |
| 15 x 30                                 | 5000                          | 10 000                          |
| 18 x 30                                 | 5000                          | 10 000                          |
| 18 x 38                                 | 5000                          | 10 000                          |
| 21 x 38                                 | 5000                          | 10 000                          |

## Note

- Multiplier of useful life code: CCC206

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 Ø D x L = 6.3 mm x 12.7 mm to 10 mm x 25 mm: 2000 h  
Case Ø D x L = 10 mm x 30 mm to 21 mm x 38 mm: 10 000 h

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

Table 6

| <b>MULTIPLIER OF RIPPLE CURRENT (<math>I_R</math>) AS A FUNCTION OF FREQUENCY</b> |                  |      |      |      |      |                |
|-----------------------------------------------------------------------------------|------------------|------|------|------|------|----------------|
| $U_R$<br>(V)                                                                      | FREQUENCY (Hz)   |      |      |      |      |                |
|                                                                                   | 50               | 100  | 300  | 1000 | 3000 | $\geq 10\,000$ |
|                                                                                   | $I_R$ MULTIPLIER |      |      |      |      |                |
| 6.3                                                                               | 0.95             | 1.00 | 1.07 | 1.12 | 1.15 | 1.20           |
| 10                                                                                | 0.95             | 1.00 | 1.07 | 1.12 | 1.15 | 1.20           |
| 16                                                                                | 0.90             | 1.00 | 1.12 | 1.20 | 1.25 | 1.30           |
| 25                                                                                | 0.90             | 1.00 | 1.12 | 1.20 | 1.25 | 1.30           |
| 40                                                                                | 0.85             | 1.00 | 1.20 | 1.30 | 1.35 | 1.40           |
| 50                                                                                | 0.85             | 1.00 | 1.20 | 1.30 | 1.35 | 1.40           |
| 63                                                                                | 0.85             | 1.00 | 1.20 | 1.30 | 1.35 | 1.40           |
| 100                                                                               | 0.85             | 1.00 | 1.20 | 1.30 | 1.35 | 1.40           |

Table 7

| <b>TEST PROCEDURES AND REQUIREMENTS</b>        |                                              |                                                                                                                                                                                         |                                                                                                                                                                                                                                                                                                           |
|------------------------------------------------|----------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| TEST                                           |                                              | PROCEDURE<br>(quick reference)                                                                                                                                                          | REQUIREMENTS                                                                                                                                                                                                                                                                                              |
| NAME OF TEST                                   | REFERENCE                                    |                                                                                                                                                                                         |                                                                                                                                                                                                                                                                                                           |
| Endurance                                      | IEC 60384-4 /<br>EN130300<br>subclause 4.13  | $T_{amb} = 105\,^{\circ}\text{C}$ ; $U_R$ applied;<br>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                | $T_{amb} = 105\,^{\circ}\text{C}$ ; $U_R$ 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 | $T_{amb} = 105\,^{\circ}\text{C}$ ; 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>$I_{L5} \leq 2 \times \text{spec. limit}$                                                                                                                                                                       |

Statements about product lifetime are based on calculations and internal testing. They should only be interpreted as estimations. Also due to external factors, the lifetime in the field application may deviate from the calculated lifetime. In general, nothing stated herein shall be construed as a guarantee of durability.



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