

## Aluminum Capacitors Axial Standard, High Voltage

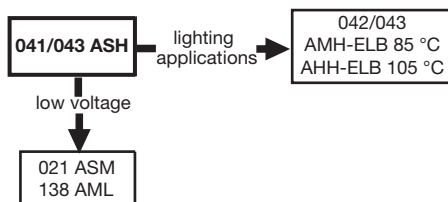


Fig. 1

### QUICK REFERENCE DATA

| DESCRIPTION                             | VALUE                                         |                                                                  |
|-----------------------------------------|-----------------------------------------------|------------------------------------------------------------------|
| Nominal case sizes<br>(Ø D x L in mm)   | 8 x 18<br>to 10 x 25                          | 10 x 30<br>to 21 x 38                                            |
| Rated capacitance range, C <sub>R</sub> | 6.8 µF to 220 µF                              |                                                                  |
| Tolerance on C <sub>R</sub>             | -10 % to +50 %                                |                                                                  |
| Rated voltage range, U <sub>R</sub>     | 160 V to 450 V                                |                                                                  |
| Category temperature range              | -40 °C to +85 °C<br>(450 V: -25 °C to +85 °C) |                                                                  |
| Endurance test at 85 °C                 | 2000 h                                        | 8000 h<br>(450 V: 5000 h)                                        |
| Useful life at 85 °C                    | 5000 h                                        | 15 000 h<br>(450 V: 10 000 h)                                    |
| Useful life at 40 °C                    | 1.4 x I <sub>R</sub><br>applied:<br>120 000 h | 1.8 x I <sub>R</sub> applied:<br>240 000 h<br>(450 V: 160 000 h) |
| Shelf life at 0 V, 85 °C                | 500 h                                         |                                                                  |
| Based on sectional<br>specification     | IEC 60384-4/EN130300                          |                                                                  |
| Climatic category IEC 60068             | 40/085/56 (450 V: 25/085/56)                  |                                                                  |

### FEATURES

- Useful life: 5000 h to 15 000 h at 85 °C
- High rated voltage: up to 450 V
- Taped versions up to case Ø 15 mm x 30 mm available for automatic insertion
- Polarized aluminum electrolytic capacitors, non-solid electrolyte
- Axial leads, cylindrical aluminum case, insulated with a blue sleeve
- Mounting ring version not available in insulated form
- Material categorization: for definitions of compliance please see [www.vishay.com/doc?99912](http://www.vishay.com/doc?99912)


**RoHS  
COMPLIANT**

### APPLICATIONS

- General purpose, industrial, power supply, audio-video
- Smoothing, filtering, buffering at high voltages
- Boards with restricted mounting height, vibration and shock resistant

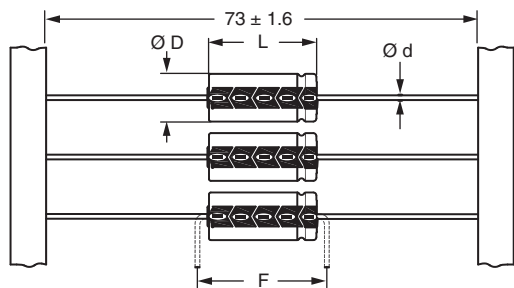
### MARKING

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 (T for -10 % to +50 %)
- Rated voltage (in V)
- Upper category temperature (85 °C)
- Date code, in accordance with IEC 60062
- Code indicating factory of origin
- Name of manufacturer
- Negative terminal identification
- Series number (041, 042 or 043)

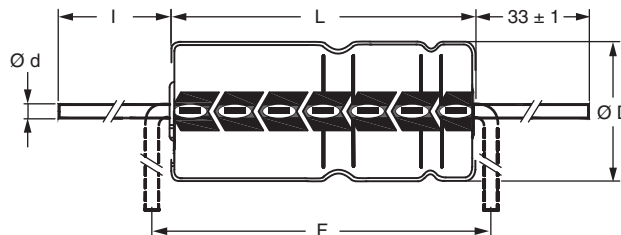
### SELECTION CHART FOR C<sub>R</sub>, U<sub>R</sub>, AND RELEVANT NOMINAL CASE SIZES (Ø D x L in mm)

| C <sub>R</sub><br>(µF) | U <sub>R</sub> (V) |           |           |           |           |           |
|------------------------|--------------------|-----------|-----------|-----------|-----------|-----------|
|                        | 160                | 250       | 350       | 385       | 400       | 450       |
| 6.8                    | -                  | -         | 10 x 30   | 10 x 30   | 10 x 30   | 10 x 30   |
| 10                     | 8 x 18             | -         | 12.5 x 30 | 12.5 x 30 | 12.5 x 30 | 12.5 x 30 |
|                        | -                  | 10 x 30   | -         | -         | -         | -         |
| 15                     | -                  | 12.5 x 30 | 12.5 x 30 | 15 x 30   | 15 x 30   | 12.5 x 30 |
| 22                     | 10 x 25            | 12.5 x 30 | 15 x 30   | 18 x 30   | 18 x 30   | 15 x 30   |
|                        | 10 x 30            | -         | -         | -         | -         | -         |
| 33                     | 12.5 x 30          | 15 x 30   | 18 x 30   | 18 x 38   | 18 x 38   | 18 x 30   |
| 47                     | 15 x 30            | 18 x 30   | 18 x 38   | 18 x 38   | 18 x 38   | 18 x 38   |
| 68                     | 15 x 30            | 18 x 38   | 21 x 38   | 21 x 38   | 21 x 38   | 21 x 38   |
| 100                    | 18 x 30            | 21 x 38   | -         | -         | -         | -         |
| 150                    | 18 x 38            | -         | -         | -         | -         | -         |
| 220                    | 21 x 38            | -         | -         | -         | -         | -         |

**DIMENSIONS in millimeters AND AVAILABLE FORMS**


**Form BR:** Taped on reel  
Case  $\varnothing D \times L = 8 \text{ mm} \times 18 \text{ mm}$  to  $15 \text{ mm} \times 30 \text{ mm}$   
**Form BA:** Taped in box (ammopack)  
Case  $\varnothing D \times L = 8 \text{ mm} \times 18 \text{ mm}$  to  $10 \text{ mm} \times 25 \text{ mm}$

Fig. 2 - Forms BA and BR



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

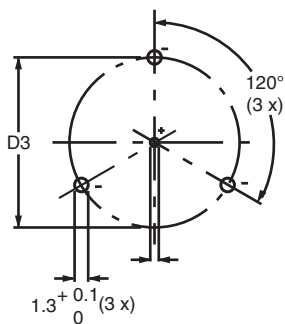
Fig. 3 - Form AA

Table 1

| <b>AXIAL; DIMENSIONS in millimeters, MASS AND PACKAGING QUANTITIES</b> |           |                            |            |                               |                   |                   |          |                      |         |         |
|------------------------------------------------------------------------|-----------|----------------------------|------------|-------------------------------|-------------------|-------------------|----------|----------------------|---------|---------|
| NOMINAL CASE SIZE<br>$\varnothing D \times L$                          | CASE CODE | AXIAL: FORM AA, BA, AND BR |            |                               |                   |                   | MASS (g) | PACKAGING QUANTITIES |         |         |
|                                                                        |           | $\varnothing d$            | L          | $\varnothing D_{\text{max.}}$ | $L_{\text{max.}}$ | $F_{\text{min.}}$ |          | FORM AA              | FORM BA | FORM BR |
| 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                        | $55 \pm 1$ | 10.5                          | 30.5              | 35                | ≈ 4.8    | 340                  | -       | 500     |
| 12.5 x 30                                                              | 01        | 0.8                        | $55 \pm 1$ | 13.0                          | 30.5              | 35                | ≈ 7.4    | 260                  | -       | 400     |
| 15 x 30                                                                | 02        | 0.8                        | $55 \pm 1$ | 15.5                          | 30.5              | 35                | ≈ 11.7   | 200                  | -       | 250     |
| 18 x 30                                                                | 03        | 0.8                        | $55 \pm 1$ | 18.5                          | 30.5              | 35                | ≈ 12.9   | 120                  | -       | -       |
| 18 x 38                                                                | 04        | 0.8                        | $34 \pm 1$ | 18.5                          | 39.5              | 44                | ≈ 19.0   | 125                  | -       | -       |
| 21 x 38                                                                | 05        | 0.8                        | $34 \pm 1$ | 21.5                          | 39.5              | 44                | ≈ 24.0   | 100                  | -       | -       |

**Note**

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



**Form MR:**  
Case  $\varnothing D \times L = 15 \text{ mm} \times 30 \text{ mm}$  to  $21 \text{ mm} \times 38 \text{ mm}$   
Especially for applications with severe shocks and vibrations

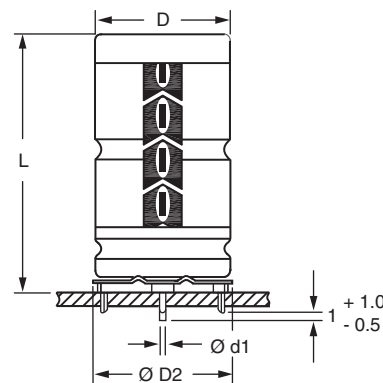
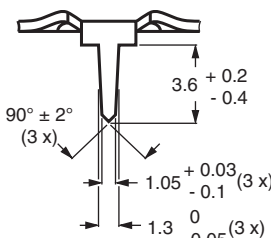

Fig. 4 - Mounting hole diagram and outline. **Form MR:** with mounting ring and pins

Table 2

| <b>MOUNTING RING; DIMENSIONS in millimeters, MASS AND PACKAGING QUANTITIES</b> |           |                        |                  |                               |                                |                |                   |          |                      |
|--------------------------------------------------------------------------------|-----------|------------------------|------------------|-------------------------------|--------------------------------|----------------|-------------------|----------|----------------------|
| NOMINAL CASE SIZE<br>$\varnothing D \times L$                                  | CASE CODE | MOUNTING RING: FORM MR |                  |                               |                                |                |                   | MASS (g) | PACKAGING QUANTITIES |
|                                                                                |           | $\varnothing d1$       | $\varnothing d2$ | $\varnothing D_{\text{max.}}$ | $\varnothing D2_{\text{max.}}$ | D3             | $L_{\text{max.}}$ |          |                      |
| 15 x 30                                                                        | 02        | 0.8                    | $1.0 + 0.4$      | 15.5                          | 17.5                           | $16.5 \pm 0.2$ | 33                | ≈ 11.7   | 200                  |
| 18 x 30                                                                        | 03        | 0.8                    | $1.0 + 0.4$      | 18.5                          | 19.5                           | $18.5 \pm 0.2$ | 33                | ≈ 12.9   | 240                  |
| 18 x 38                                                                        | 04        | 0.8                    | $1.0 + 0.4$      | 18.5                          | 19.5                           | $18.5 \pm 0.2$ | 42                | ≈ 19.0   | 100                  |
| 21 x 38                                                                        | 05        | 0.8                    | $1.0 + 0.4$      | 21.5                          | 22.5                           | $21.5 \pm 0.2$ | 42                | ≈ 24.0   | 100                  |



| ELECTRICAL DATA |                                                                                          |
|-----------------|------------------------------------------------------------------------------------------|
| SYMBOL          | DESCRIPTION                                                                              |
| $C_R$           | Rated capacitance at 100 Hz, tolerance -10 % to +50 %                                    |
| $I_R$           | Rated RMS ripple current at 100 Hz, 85 °C                                                |
| $I_{L1}$        | Max. leakage current after 1 min at $U_R$                                                |
| $I_{L5}$        | 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                                                                 |

**Note**

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

**ORDERING EXAMPLE**

Electrolytic capacitor 041 series

10  $\mu\text{F}$ /250 V; -10 %/+50 %Nominal case size:  $\varnothing 10\text{ mm} \times 25\text{ mm}$ ; Form BA

Ordering code: MAL204133109E3

Former 12NC: 2222 041 33109

| ELECTRICAL DATA AND ORDERING INFORMATION |                                      |                                                             |              |                                  |                                        |                                        |                         |                               |                             |                         |                             |                            |                             |
|------------------------------------------|--------------------------------------|-------------------------------------------------------------|--------------|----------------------------------|----------------------------------------|----------------------------------------|-------------------------|-------------------------------|-----------------------------|-------------------------|-----------------------------|----------------------------|-----------------------------|
| $U_R$<br>(V)                             | $C_R$<br>100 Hz<br>( $\mu\text{F}$ ) | NOMINAL<br>CASE<br>SIZE<br>$\varnothing D \times L$<br>(mm) | CASE<br>CODE | $I_R$<br>100 Hz<br>85 °C<br>(mA) | $I_{L1}$<br>1 min<br>( $\mu\text{A}$ ) | $I_{L5}$<br>5 min<br>( $\mu\text{A}$ ) | $\tan \delta$<br>100 Hz | ESR<br>100 Hz<br>( $\Omega$ ) | Z<br>10 kHz<br>( $\Omega$ ) | ORDERING CODE MAL2..... |                             |                            |                             |
|                                          |                                      |                                                             |              |                                  |                                        |                                        |                         |                               |                             | 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 |
| 160                                      | 10                                   | 8 x 18                                                      | 5            | 70                               | 68                                     | 14                                     | 0.15                    | 24                            | 12                          | -                       | 04121109E3                  | 04131109E3                 | -                           |
|                                          | 22                                   | 10 x 25                                                     | 7            | 150                              | 130                                    | 25                                     | 0.15                    | 11                            | 5.5                         | -                       | 04121229E3                  | 04131229E3                 | -                           |
|                                          | 22                                   | 10 x 30                                                     | 00           | 190                              | 42                                     | 25                                     | 0.10                    | 6.8                           | 5.5                         | 04211229E3              | 04221229E3                  | -                          | -                           |
|                                          | 33                                   | 12.5 x 30                                                   | 01           | 270                              | 58                                     | 36                                     | 0.10                    | 4.5                           | 3.1                         | 04211339E3              | 04221339E3                  | -                          | -                           |
|                                          | 47                                   | 15 x 30                                                     | 02           | 350                              | 78                                     | 49                                     | 0.10                    | 3.2                           | 2.1                         | 04211479E3              | 04221479E3                  | -                          | 04241479E3                  |
|                                          | 68                                   | 15 x 30                                                     | 02           | 420                              | 110                                    | 69                                     | 0.10                    | 2.2                           | 1.4                         | 04211689E3              | 04221689E3                  | -                          | 04241689E3                  |
|                                          | 100                                  | 18 x 30                                                     | 03           | 580                              | 150                                    | 100                                    | 0.10                    | 1.5                           | 1.0                         | 04211101E3              | -                           | -                          | 04241101E3                  |
|                                          | 150                                  | 18 x 38                                                     | 04           | 760                              | 230                                    | 150                                    | 0.10                    | 1.0                           | 0.7                         | 04311151E3              | -                           | -                          | 04341151E3                  |
| 250                                      | 220                                  | 21 x 38                                                     | 05           | 940                              | 330                                    | 220                                    | 0.10                    | 0.7                           | 0.5                         | 04311221E3              | -                           | -                          | 04341221E3                  |
|                                          | 10                                   | 10 x 30                                                     | 00           | 130                              | 33                                     | 19                                     | 0.10                    | 15                            | 11                          | 04213109E3              | 04223109E3                  | -                          | -                           |
|                                          | 15                                   | 12.5 x 30                                                   | 01           | 180                              | 44                                     | 27                                     | 0.10                    | 10                            | 7.4                         | 04213159E3              | 04223159E3                  | -                          | -                           |
|                                          | 22                                   | 12.5 x 30                                                   | 01           | 220                              | 60                                     | 37                                     | 0.10                    | 6.8                           | 5.0                         | 04213229E3              | 04223229E3                  | -                          | -                           |
|                                          | 33                                   | 15 x 30                                                     | 02           | 290                              | 84                                     | 54                                     | 0.10                    | 4.5                           | 3.4                         | 04213339E3              | 04223339E3                  | -                          | 04243339E3                  |
|                                          | 47                                   | 18 x 30                                                     | 03           | 400                              | 120                                    | 75                                     | 0.10                    | 3.2                           | 2.3                         | 04213479E3              | -                           | -                          | 04243479E3                  |
|                                          | 68                                   | 18 x 38                                                     | 04           | 520                              | 160                                    | 110                                    | 0.10                    | 2.2                           | 1.7                         | 04313689E3              | -                           | -                          | 04343689E3                  |
|                                          | 100                                  | 21 x 38                                                     | 05           | 650                              | 240                                    | 150                                    | 0.10                    | 1.5                           | 1.1                         | 04313101E3              | -                           | -                          | 04343101E3                  |
| 350                                      | 6.8                                  | 10 x 30                                                     | 00           | 110                              | 32                                     | 18                                     | 0.10                    | 22                            | 14                          | 04215688E3              | 04225688E3                  | -                          | -                           |
|                                          | 10                                   | 12.5 x 30                                                   | 01           | 150                              | 42                                     | 25                                     | 0.10                    | 15                            | 10                          | 04215109E3              | 04225109E3                  | -                          | -                           |
|                                          | 15                                   | 12.5 x 30                                                   | 01           | 180                              | 57                                     | 36                                     | 0.10                    | 10                            | 6.7                         | 04215159E3              | 04225159E3                  | -                          | -                           |
|                                          | 22                                   | 15 x 30                                                     | 02           | 250                              | 79                                     | 50                                     | 0.10                    | 6.8                           | 4.5                         | 04215229E3              | 04225229E3                  | -                          | 04245229E3                  |
|                                          | 33                                   | 18 x 30                                                     | 03           | 350                              | 110                                    | 73                                     | 0.10                    | 4.5                           | 3.1                         | 04215339E3              | -                           | -                          | 04245339E3                  |
|                                          | 47                                   | 18 x 38                                                     | 04           | 450                              | 160                                    | 100                                    | 0.10                    | 3.2                           | 2.1                         | 04315479E3              | -                           | -                          | 04345479E3                  |
| 385                                      | 68                                   | 21 x 38                                                     | 05           | 560                              | 220                                    | 150                                    | 0.10                    | 2.2                           | 1.4                         | 04315689E3              | -                           | -                          | 04345689E3                  |
|                                          | 6.8                                  | 10 x 30                                                     | 00           | 110                              | 34                                     | 20                                     | 0.10                    | 22                            | 14                          | 04218688E3              | 04228688E3                  | -                          | -                           |
|                                          | 10                                   | 12.5 x 30                                                   | 01           | 150                              | 45                                     | 27                                     | 0.10                    | 15                            | 10                          | 04218109E3              | 04228109E3                  | -                          | -                           |
|                                          | 15                                   | 15 x 30                                                     | 02           | 210                              | 62                                     | 39                                     | 0.10                    | 10                            | 6.0                         | 04218159E3              | 04228159E3                  | -                          | 04248159E3                  |
|                                          | 22                                   | 18 x 30                                                     | 03           | 290                              | 86                                     | 55                                     | 0.10                    | 6.8                           | 4.1                         | 04218229E3              | -                           | -                          | 04248229E3                  |
|                                          | 33                                   | 18 x 38                                                     | 04           | 380                              | 120                                    | 80                                     | 0.10                    | 4.5                           | 2.7                         | 04318339E3              | -                           | -                          | 04348339E3                  |
| 385                                      | 47                                   | 18 x 38                                                     | 04           | 450                              | 170                                    | 110                                    | 0.10                    | 3.2                           | 2.1                         | 04318479E3              | -                           | -                          | 04348479E3                  |
|                                          | 68                                   | 21 x 38                                                     | 05           | 570                              | 250                                    | 160                                    | 0.10                    | 2.2                           | 1.4                         | 04318689E3              | -                           | -                          | 04348689E3                  |

**ELECTRICAL DATA AND ORDERING INFORMATION**

| $U_R$<br>(V) | $C_R$<br>100 Hz<br>( $\mu$ F) | NOMINAL<br>CASE<br>SIZE<br>$\varnothing$ D x L<br>(mm) | CASE<br>CODE | $I_R$<br>100 Hz<br>85 °C<br>(mA) | $I_{L1}$<br>1 min<br>( $\mu$ A) | $I_{L5}$<br>5 min<br>( $\mu$ A) | $\tan \delta$<br>100 Hz | ESR<br>100 Hz<br>( $\Omega$ ) | Z<br>10 kHz<br>( $\Omega$ ) | ORDERING CODE MAL2..... |                             |                            |                             |
|--------------|-------------------------------|--------------------------------------------------------|--------------|----------------------------------|---------------------------------|---------------------------------|-------------------------|-------------------------------|-----------------------------|-------------------------|-----------------------------|----------------------------|-----------------------------|
|              |                               |                                                        |              |                                  |                                 |                                 |                         |                               |                             | 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 |
| 400          | 6.8                           | 10 x 30                                                | 00           | 110                              | 220                             | 110                             | 0.055                   | 11.5                          | 7.3                         | 04216688E3              | 04226688E3                  | -                          | -                           |
|              | 10                            | 12.5 x 30                                              | 01           | 150                              | 240                             | 110                             | 0.055                   | 7.5                           | 4.6                         | 04216109E3              | 04226109E3                  | -                          | -                           |
|              | 15                            | 15 x 30                                                | 02           | 210                              | 250                             | 110                             | 0.055                   | 5.0                           | 3.1                         | 04216159E3              | 04226159E3                  | -                          | 04246159E3                  |
|              | 22                            | 18 x 30                                                | 03           | 290                              | 280                             | 120                             | 0.055                   | 3.5                           | 2.1                         | 04216229E3              | -                           | -                          | 04246229E3                  |
|              | 33                            | 18 x 38                                                | 04           | 380                              | 320                             | 130                             | 0.055                   | 2.3                           | 1.4                         | 04316339E3              | -                           | -                          | 04346339E3                  |
|              | 47                            | 18 x 38                                                | 04           | 450                              | 370                             | 140                             | 0.055                   | 1.7                           | 1.1                         | 04316479E3              | -                           | -                          | 04346479E3                  |
|              | 68                            | 21 x 38                                                | 05           | 560                              | 440                             | 150                             | 0.055                   | 1.2                           | 0.7                         | 04316689E3              | -                           | -                          | 04346689E3                  |
| 450          | 6.8                           | 10 x 30                                                | 00           | 110                              | 230                             | 110                             | 0.10                    | 22                            | 14                          | 04217688E3              | 04227688E3                  | -                          | -                           |
|              | 10                            | 12.5 x 30                                              | 01           | 150                              | 240                             | 110                             | 0.10                    | 15                            | 10                          | 04217109E3              | 04227109E3                  | -                          | -                           |
|              | 15                            | 12.5 x 30                                              | 01           | 180                              | 260                             | 110                             | 0.10                    | 10                            | 6.0                         | 04217159E3              | 04227159E3                  | -                          | -                           |
|              | 22                            | 15 x 30                                                | 02           | 240                              | 290                             | 120                             | 0.10                    | 6.8                           | 4.1                         | 04217229E3              | 04227229E3                  | -                          | 04247229E3                  |
|              | 33                            | 18 x 30                                                | 03           | 350                              | 330                             | 130                             | 0.10                    | 4.5                           | 2.7                         | 04217339E3              | -                           | -                          | 04247339E3                  |
|              | 47                            | 18 x 38                                                | 04           | 440                              | 390                             | 140                             | 0.10                    | 3.2                           | 2.1                         | 04317479E3              | -                           | -                          | 04347479E3                  |
|              | 68                            | 21 x 38                                                | 05           | 550                              | 460                             | 160                             | 0.10                    | 2.2                           | 1.4                         | 04317689E3              | -                           | -                          | 04347689E3                  |

**ADDITIONAL ELECTRICAL DATA**

| PARAMETER                          | CONDITIONS                                                                                                                                                                                                             | VALUE                                                                                                                                                                                                                                                                                             |               |
|------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------|
|                                    |                                                                                                                                                                                                                        | AXIAL                                                                                                                                                                                                                                                                                             | MOUNTING RING |
| Voltage                            |                                                                                                                                                                                                                        |                                                                                                                                                                                                                                                                                                   |               |
| Surge voltage                      | U <sub>R</sub> = 160 V to 250 V                                                                                                                                                                                        | U <sub>s</sub> ≤ 1.15 x U <sub>R</sub>                                                                                                                                                                                                                                                            |               |
|                                    | U <sub>R</sub> = 350 V to 450 V                                                                                                                                                                                        | U <sub>s</sub> ≤ 1.1 x U <sub>R</sub>                                                                                                                                                                                                                                                             |               |
| Reverse voltage                    |                                                                                                                                                                                                                        | U <sub>rev</sub> ≤ 1 V                                                                                                                                                                                                                                                                            |               |
| Current                            |                                                                                                                                                                                                                        |                                                                                                                                                                                                                                                                                                   |               |
| Leakage current                    | After 1 min:<br>case Ø D x L = 8 mm x 18 mm to 10 mm x 25 mm:<br>CV ≤ 1000 µC<br>CV > 1000 µC<br>case Ø D x L = 10 mm x 30 mm to 21 mm x 38 mm:<br>U <sub>R</sub> = 160 V to 385 V<br>U <sub>R</sub> = 400 V and 450 V | I <sub>L1</sub> ≤ 0.05 C <sub>R</sub> x U <sub>R</sub> or 5 µA, whichever is greater<br>I <sub>L1</sub> ≤ 0.03 C <sub>R</sub> x U <sub>R</sub> + 20 µA<br><br>I <sub>L1</sub> ≤ 0.009 C <sub>R</sub> x U <sub>R</sub> + 10 µA<br>I <sub>L1</sub> ≤ 0.009 C <sub>R</sub> x U <sub>R</sub> + 200 µA |               |
|                                    | After 5 min:<br>U <sub>R</sub> = 160 V to 385 V:<br>CV ≤ 1000 µC<br>CV > 1000 µC<br>U <sub>R</sub> = 400 V and 450 V                                                                                                   | I <sub>L5</sub> ≤ 0.01 C <sub>R</sub> x U <sub>R</sub> or 1 µA, whichever is greater<br>I <sub>L5</sub> ≤ 0.006 C <sub>R</sub> x U <sub>R</sub> + 4 µA<br>I <sub>L5</sub> ≤ 0.002 C <sub>R</sub> x U <sub>R</sub> + 100 µA                                                                        |               |
| Inductance                         |                                                                                                                                                                                                                        |                                                                                                                                                                                                                                                                                                   |               |
| Equivalent series inductance (ESL) | Case Ø D x L mm:                                                                                                                                                                                                       |                                                                                                                                                                                                                                                                                                   |               |
|                                    | 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)

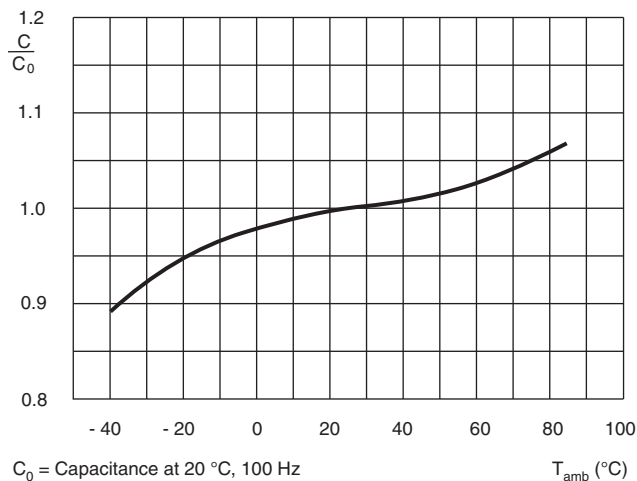


Fig. 5 - Typical multiplier of capacitance as a function of ambient temperature

## EQUIVALENT SERIES RESISTANCE (ESR)

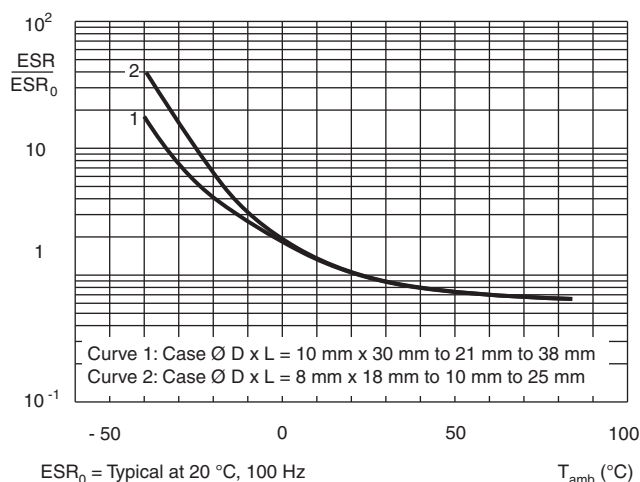


Fig. 6 - Typical multiplier of ESR as a function of ambient temperature

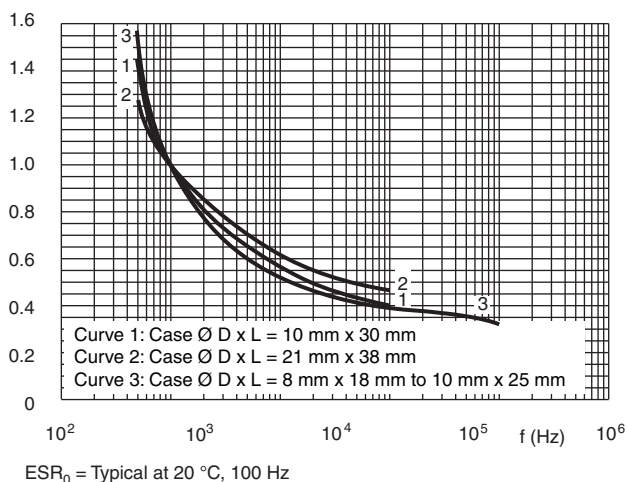


Fig. 7 - Typical multiplier of ESR as a function of frequency



## IMPEDANCE (Z)

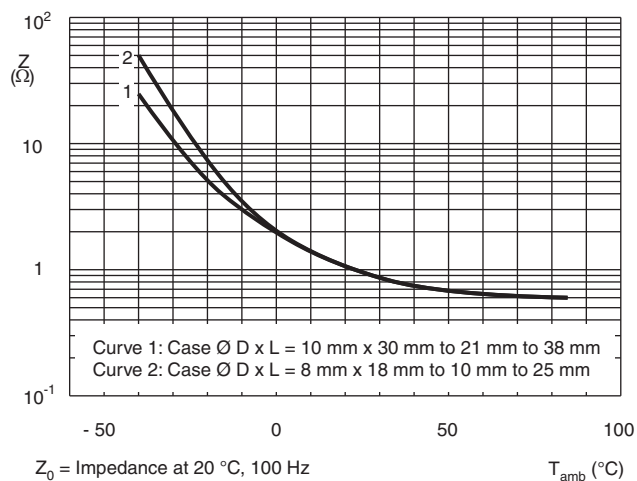


Fig. 8 - Typical impedance of capacitance as a function of ambient temperature

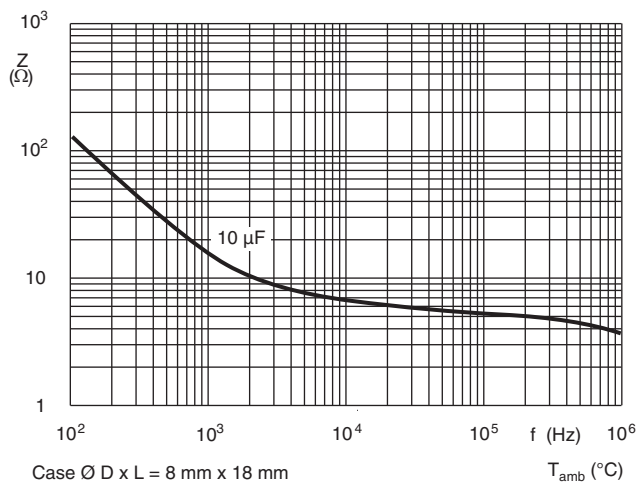


Fig. 9 - Typical impedance as a function of frequency

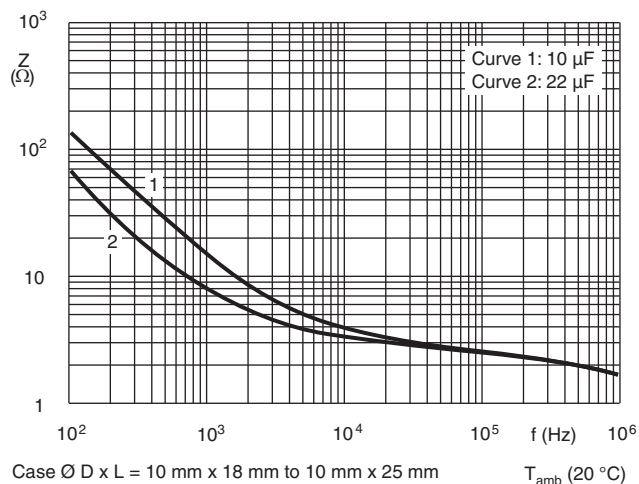


Fig. 10 - Typical impedance as a function of frequency

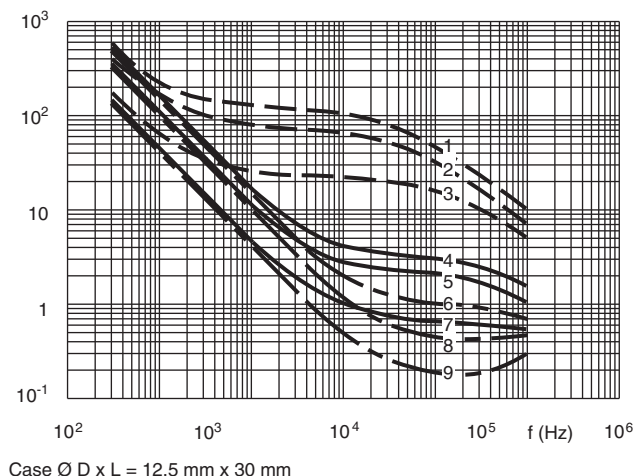


Fig. 11 - Typical impedance as a function of frequency at different ambient temperatures

Curve 1: 10 µF, 350 V and 385 V; - 40 °C  
Curve 2: 15 µF, 250 V; - 40 °C  
Curve 3: 33 µF, 160 V; - 40 °C  
Curve 4: 10 µF, 350 V and 385 V; 20 °C  
Curve 5: 15 µF, 250 V; 20 °C  
Curve 6: 33 µF, 160 V; 20 °C  
Curve 7: 10 µF, 350 V and 385 V; 85 °C  
Curve 8: 15 µF, 250 V; 85 °C  
Curve 9: 33 µF, 160 V; 85 °C

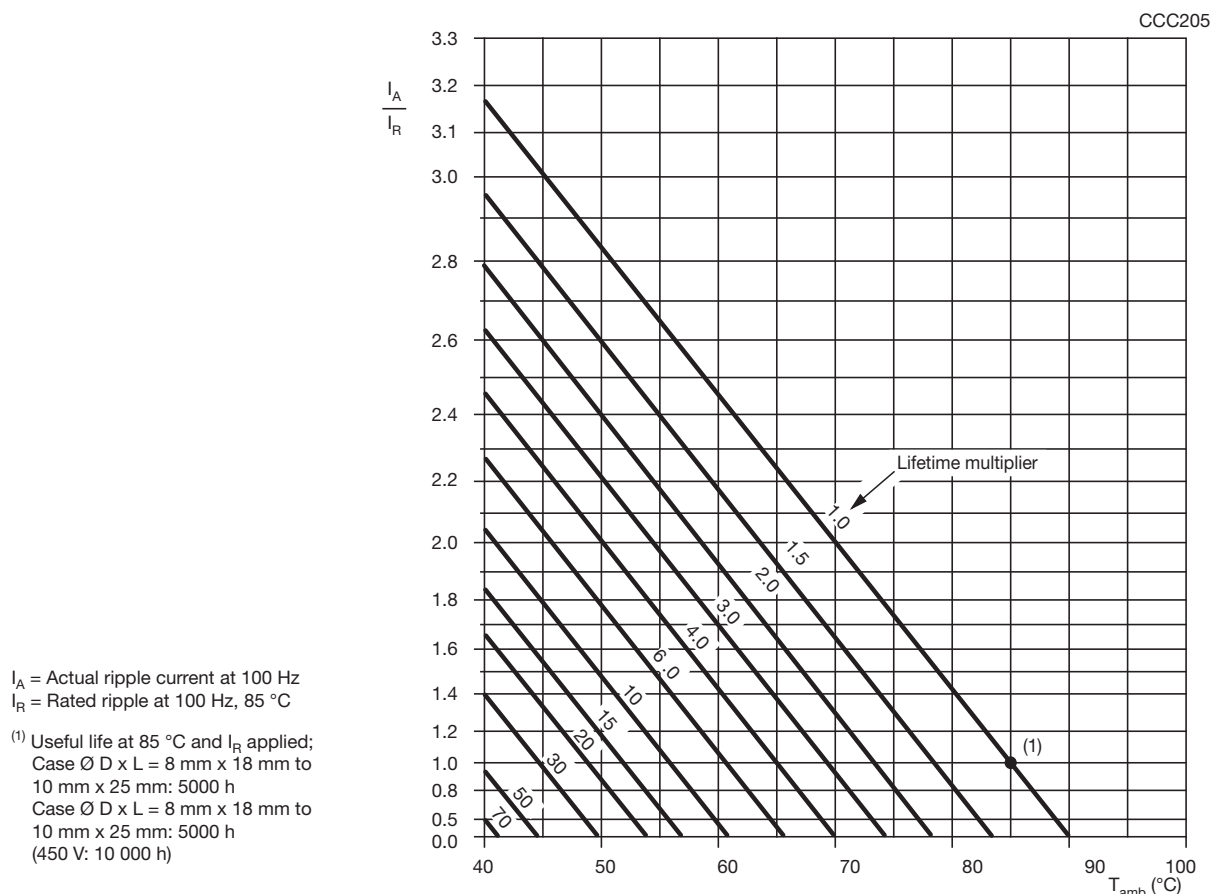
**RIPPLE CURRENT AND USEFUL LIFE**


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

**Table 3**

| <b>MULTIPLIER OF RIPPLE CURRENT (<math>I_R</math>) AS A FUNCTION OF FREQUENCY</b> |                                    |
|-----------------------------------------------------------------------------------|------------------------------------|
| <b>FREQUENCY<br/>(Hz)</b>                                                         | <b><math>I_R</math> MULTIPLIER</b> |
| 50                                                                                | 0.75                               |
| 100                                                                               | 1.00                               |
| 300                                                                               | 1.15                               |
| 1000                                                                              | 1.30                               |
| 3000                                                                              | 1.40                               |
| ≥ 10 000                                                                          | 1.50                               |



Table 4

| TEST PROCEDURE REQUIREMENTS                    |                                            |                                                                                                                                                                                                                    |                                                                                                                                                                                                                                                                                                                |
|------------------------------------------------|--------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| TEST                                           |                                            | PROCEDURE<br>(quick reference)                                                                                                                                                                                     | REQUIREMENTS                                                                                                                                                                                                                                                                                                   |
| NAME OF TEST                                   | REFERENCE                                  |                                                                                                                                                                                                                    |                                                                                                                                                                                                                                                                                                                |
| Endurance                                      | IEC 60384-4/<br>EN130300<br>subclause 4.13 | $T_{amb} = 85\text{ }^{\circ}\text{C}$ ; $U_R$ applied;<br>Case $\varnothing D \times L$ :<br>8 mm x 18 mm to 10 mm x 25 mm:<br>2000 h;<br>10 mm x 30 mm to 21 mm x 38 mm:<br>8000 h (450 V: 5000 h)               | $U_R = 160\text{ V}$ ; $\Delta C/C$ : $\pm 15\%$<br>$U_R = 250\text{ V}$ to 450 V; $\Delta C/C$ : $\pm 10\%$<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              | $T_{amb} = 85\text{ }^{\circ}\text{C}$ ; $U_R$ and $I_R$ applied;<br>Case $\varnothing D \times L$ :<br>8 mm x 18 mm to 10 mm x 25 mm:<br>5000 h;<br>10 mm x 30 mm to 21 mm x 38 mm:<br>15 000 h (450 V: 10 000 h) | $U_R = 160\text{ V}$ ; $\Delta C/C$ : $\pm 45\%$<br>$U_R = 250\text{ V}$ to 450 V; $\Delta C/C$ : $\pm 30\%$<br>$\tan \delta \leq 3 \times \text{spec. limit}$<br>$Z \leq 3 \times \text{spec. limit}$<br>$I_{L5} \leq \text{spec. limit}$<br>No short or open circuit<br>Total failure percentage: $\leq 3\%$ |
| Shelf life<br>(storage at high<br>temperature) | IEC 60384-4/<br>EN130300<br>subclause 4.17 | $T_{amb} = 85\text{ }^{\circ}\text{C}$ ; 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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