

## Aluminum Electrolytic Capacitors Axial Standard, High Voltage

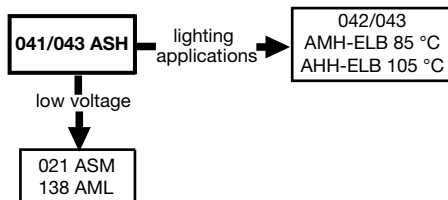


Fig. 1

### 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

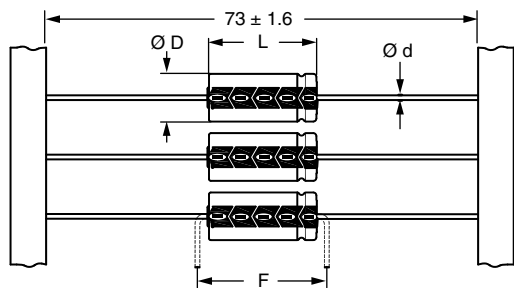
### MARKING

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)

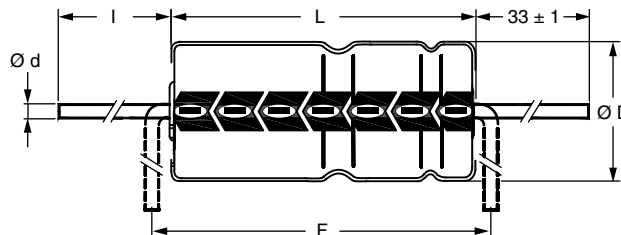
### SELECTION CHART FOR C<sub>R</sub>, U<sub>R</sub>, AND RELEVANT NOMINAL CASE SIZES (Ø D x L in mm)

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

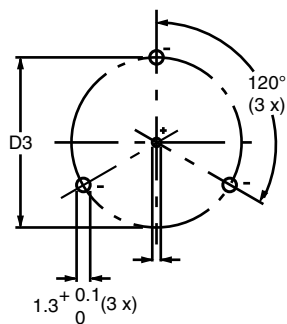
Fig. 3 - Form AA

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

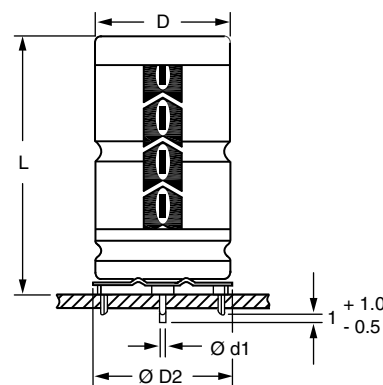
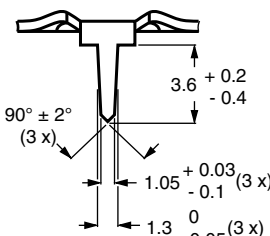

Fig. 4 - Mounting hole diagram and outline. **Form MR:** With mounting ring and pins

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                    | $1.0 \pm 0.4$    | 15.5                          | 17.5                           | $16.5 \pm 0.2$ | 33                | ≈ 11.7   | 200                  |
| 18 x 30                                                                        | 03        | 0.8                    | $1.0 \pm 0.4$    | 18.5                          | 19.5                           | $18.5 \pm 0.2$ | 33                | ≈ 12.9   | 240                  |
| 18 x 38                                                                        | 04        | 0.8                    | $1.0 \pm 0.4$    | 18.5                          | 19.5                           | $18.5 \pm 0.2$ | 42                | ≈ 19.0   | 100                  |
| 21 x 38                                                                        | 05        | 0.8                    | $1.0 \pm 0.4$    | 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 <sub>R</sub><br>(V)                    | C <sub>R</sub><br>100 Hz<br>(μF) | NOMINAL<br>CASE<br>SIZE<br>Ø D x L<br>(mm) | CASE<br>CODE | I <sub>R</sub><br>100 Hz<br>85 °C<br>(mA) | I <sub>L1</sub><br>1 min<br>(μA) | 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) | LIFE<br>CODE <sup>(1)</sup> | 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                 | L1                          | -                       | 04121109E3                  | 04131109E3                 | -                           |
|                                          | 22                               | 10 x 25                                    | 7            | 150                                       | 130                              | 25                               | 0.15            | 11                   | 5.5                | L1                          | -                       | 04121229E3                  | 04131229E3                 | -                           |
|                                          | 22                               | 10 x 30                                    | 00           | 190                                       | 42                               | 25                               | 0.10            | 6.8                  | 5.5                | L2                          | 04211229E3              | 04221229E3                  | -                          | -                           |
|                                          | 33                               | 12.5 x 30                                  | 01           | 270                                       | 58                               | 36                               | 0.10            | 4.5                  | 3.1                | L2                          | 04211339E3              | 04221339E3                  | -                          | -                           |
|                                          | 47                               | 15 x 30                                    | 02           | 350                                       | 78                               | 49                               | 0.10            | 3.2                  | 2.1                | L2                          | 04211479E3              | 04221479E3                  | -                          | 04241479E3                  |
|                                          | 68                               | 15 x 30                                    | 02           | 420                                       | 110                              | 69                               | 0.10            | 2.2                  | 1.4                | L2                          | 04211689E3              | 04221689E3                  | -                          | 04241689E3                  |
|                                          | 100                              | 18 x 30                                    | 03           | 580                                       | 150                              | 100                              | 0.10            | 1.5                  | 1.0                | L2                          | 04211101E3              | -                           | -                          | 04241101E3                  |
|                                          | 150                              | 18 x 38                                    | 04           | 760                                       | 230                              | 150                              | 0.10            | 1.0                  | 0.7                | L2                          | 04311151E3              | -                           | -                          | 04341151E3                  |
|                                          | 220                              | 21 x 38                                    | 05           | 940                                       | 330                              | 220                              | 0.10            | 0.7                  | 0.5                | L2                          | 04311221E3              | -                           | -                          | 04341221E3                  |
| 250                                      | 10                               | 10 x 30                                    | 00           | 130                                       | 33                               | 19                               | 0.10            | 15                   | 11                 | L2                          | 04213109E3              | 04223109E3                  | -                          | -                           |
|                                          | 15                               | 12.5 x 30                                  | 01           | 180                                       | 44                               | 27                               | 0.10            | 10                   | 7.4                | L2                          | 04213159E3              | 04223159E3                  | -                          | -                           |
|                                          | 22                               | 12.5 x 30                                  | 01           | 220                                       | 60                               | 37                               | 0.10            | 6.8                  | 5.0                | L2                          | 04213229E3              | 04223229E3                  | -                          | -                           |
|                                          | 33                               | 15 x 30                                    | 02           | 290                                       | 84                               | 54                               | 0.10            | 4.5                  | 3.4                | L2                          | 04213339E3              | 04223339E3                  | -                          | 04243339E3                  |
|                                          | 47                               | 18 x 30                                    | 03           | 400                                       | 120                              | 75                               | 0.10            | 3.2                  | 2.3                | L2                          | 04213479E3              | -                           | -                          | 04243479E3                  |
|                                          | 68                               | 18 x 38                                    | 04           | 520                                       | 160                              | 110                              | 0.10            | 2.2                  | 1.7                | L2                          | 04313689E3              | -                           | -                          | 04343689E3                  |
|                                          | 100                              | 21 x 38                                    | 05           | 650                                       | 240                              | 150                              | 0.10            | 1.5                  | 1.1                | L2                          | 04313101E3              | -                           | -                          | 04343101E3                  |
| 350                                      | 6.8                              | 10 x 30                                    | 00           | 110                                       | 32                               | 18                               | 0.10            | 22                   | 14                 | L2                          | 04215688E3              | 04225688E3                  | -                          | -                           |
|                                          | 10                               | 12.5 x 30                                  | 01           | 150                                       | 42                               | 25                               | 0.10            | 15                   | 10                 | L2                          | 04215109E3              | 04225109E3                  | -                          | -                           |
|                                          | 15                               | 12.5 x 30                                  | 01           | 180                                       | 57                               | 36                               | 0.10            | 10                   | 6.7                | L2                          | 04215159E3              | 04225159E3                  | -                          | -                           |
|                                          | 22                               | 15 x 30                                    | 02           | 250                                       | 79                               | 50                               | 0.10            | 6.8                  | 4.5                | L2                          | 04215229E3              | 04225229E3                  | -                          | 04245229E3                  |
|                                          | 33                               | 18 x 30                                    | 03           | 350                                       | 110                              | 73                               | 0.10            | 4.5                  | 3.1                | L2                          | 04215339E3              | -                           | -                          | 04245339E3                  |
|                                          | 47                               | 18 x 38                                    | 04           | 450                                       | 160                              | 100                              | 0.10            | 3.2                  | 2.1                | L2                          | 04315479E3              | -                           | -                          | 04345479E3                  |
|                                          | 68                               | 21 x 38                                    | 05           | 560                                       | 220                              | 150                              | 0.10            | 2.2                  | 1.4                | L2                          | 04315689E3              | -                           | -                          | 04345689E3                  |
| 385                                      | 6.8                              | 10 x 30                                    | 00           | 110                                       | 34                               | 20                               | 0.10            | 22                   | 14                 | L2                          | 04218688E3              | 04228688E3                  | -                          | -                           |
|                                          | 10                               | 12.5 x 30                                  | 01           | 150                                       | 45                               | 27                               | 0.10            | 15                   | 10                 | L2                          | 04218109E3              | 04228109E3                  | -                          | -                           |
|                                          | 15                               | 15 x 30                                    | 02           | 210                                       | 62                               | 39                               | 0.10            | 10                   | 6.0                | L2                          | 04218159E3              | 04228159E3                  | -                          | 04248159E3                  |
|                                          | 22                               | 18 x 30                                    | 03           | 290                                       | 86                               | 55                               | 0.10            | 6.8                  | 4.1                | L2                          | 04218229E3              | -                           | -                          | 04248229E3                  |
|                                          | 33                               | 18 x 38                                    | 04           | 380                                       | 120                              | 80                               | 0.10            | 4.5                  | 2.7                | L2                          | 04318339E3              | -                           | -                          | 04348339E3                  |
|                                          | 47                               | 18 x 38                                    | 04           | 450                                       | 170                              | 110                              | 0.10            | 3.2                  | 2.1                | L2                          | 04318479E3              | -                           | -                          | 04348479E3                  |
|                                          | 68                               | 21 x 38                                    | 05           | 570                                       | 250                              | 160                              | 0.10            | 2.2                  | 1.4                | L2                          | 04318689E3              | -                           | -                          | 04348689E3                  |

**ELECTRICAL DATA AND ORDERING INFORMATION**

| U <sub>R</sub><br>(V) | C <sub>R</sub><br>100 Hz<br>(μF) | NOMINAL<br>CASE<br>SIZE<br>Ø D x L<br>(mm) | CASE<br>CODE | I <sub>R</sub><br>100 Hz<br>85 °C<br>(mA) | I <sub>L1</sub><br>1 min<br>(μA) | 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) | LIFE<br>CODE <sup>(1)</sup> | 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                | L2                          | 04216688E3              | 04226688E3                  | -                          | -                           |
|                       | 10                               | 12.5 x 30                                  | 01           | 150                                       | 240                              | 110                              | 0.055           | 7.5                  | 4.6                | L2                          | 04216109E3              | 04226109E3                  | -                          | -                           |
|                       | 15                               | 15 x 30                                    | 02           | 210                                       | 250                              | 110                              | 0.055           | 5.0                  | 3.1                | L2                          | 04216159E3              | 04226159E3                  | -                          | 04246159E3                  |
|                       | 22                               | 18 x 30                                    | 03           | 290                                       | 280                              | 120                              | 0.055           | 3.5                  | 2.1                | L2                          | 04216229E3              | -                           | -                          | 04246229E3                  |
|                       | 33                               | 18 x 38                                    | 04           | 380                                       | 320                              | 130                              | 0.055           | 2.3                  | 1.4                | L2                          | 04316339E3              | -                           | -                          | 04346339E3                  |
|                       | 47                               | 18 x 38                                    | 04           | 450                                       | 370                              | 140                              | 0.055           | 1.7                  | 1.1                | L2                          | 04316479E3              | -                           | -                          | 04346479E3                  |
|                       | 68                               | 21 x 38                                    | 05           | 560                                       | 440                              | 150                              | 0.055           | 1.2                  | 0.7                | L2                          | 04316689E3              | -                           | -                          | 04346689E3                  |
| 450                   | 6.8                              | 10 x 30                                    | 00           | 110                                       | 230                              | 110                              | 0.10            | 22                   | 14                 | L3                          | 04217688E3              | 04227688E3                  | -                          | -                           |
|                       | 10                               | 12.5 x 30                                  | 01           | 150                                       | 240                              | 110                              | 0.10            | 15                   | 10                 | L3                          | 04217109E3              | 04227109E3                  | -                          | -                           |
|                       | 15                               | 12.5 x 30                                  | 01           | 180                                       | 260                              | 110                              | 0.10            | 10                   | 6.0                | L3                          | 04217159E3              | 04227159E3                  | -                          | -                           |
|                       | 22                               | 15 x 30                                    | 02           | 240                                       | 290                              | 120                              | 0.10            | 6.8                  | 4.1                | L3                          | 04217229E3              | 04227229E3                  | -                          | 04247229E3                  |
|                       | 33                               | 18 x 30                                    | 03           | 350                                       | 330                              | 130                              | 0.10            | 4.5                  | 2.7                | L3                          | 04217339E3              | -                           | -                          | 04247339E3                  |
|                       | 47                               | 18 x 38                                    | 04           | 440                                       | 390                              | 140                              | 0.10            | 3.2                  | 2.1                | L3                          | 04317479E3              | -                           | -                          | 04347479E3                  |
|                       | 68                               | 21 x 38                                    | 05           | 550                                       | 460                              | 160                              | 0.10            | 2.2                  | 1.4                | L3                          | 04317689E3              | -                           | -                          | 04347689E3                  |

**Note**

<sup>(1)</sup> Determines the applicable row in the table "Endurance Test Duration and Useful Life"

**ADDITIONAL ELECTRICAL DATA**

| ADDITIONAL ELECTRICAL DATA         |                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                                                                                                                                                                                         |               |
|------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------|
| PARAMETER                          | CONDITIONS                                                                                                                                                                                                                                                                                                                                                                              | VALUE                                                                                                                                                                                                                                                                                   |               |
|                                    |                                                                                                                                                                                                                                                                                                                                                                                         | AXIAL                                                                                                                                                                                                                                                                                   | MOUNTING RING |
| Voltage                            |                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                                                                                                                                                                                         |               |
| Surge voltage                      | $U_R = 160\text{ V to }250\text{ V}$                                                                                                                                                                                                                                                                                                                                                    | $U_s \leq 1.15 \times U_R$                                                                                                                                                                                                                                                              |               |
|                                    | $U_R = 350\text{ V to }450\text{ V}$                                                                                                                                                                                                                                                                                                                                                    | $U_s \leq 1.1 \times U_R$                                                                                                                                                                                                                                                               |               |
| Reverse voltage                    |                                                                                                                                                                                                                                                                                                                                                                                         | $U_{rev} \leq 1\text{ V}$                                                                                                                                                                                                                                                               |               |
| Current                            |                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                                                                                                                                                                                         |               |
| Leakage current                    | After 1 min:<br>case $\varnothing D \times L = 8\text{ mm} \times 18\text{ mm to }10\text{ mm} \times 25\text{ mm}$ :<br>$CV \leq 1000\text{ }\mu\text{C}$<br>$CV > 1000\text{ }\mu\text{C}$<br>case $\varnothing D \times L = 10\text{ mm} \times 30\text{ mm to }21\text{ mm} \times 38\text{ mm}$ :<br>$U_R = 160\text{ V to }385\text{ V}$<br>$U_R = 400\text{ V and }450\text{ V}$ | $I_{L1} \leq 0.05 C_R \times U_R \text{ or } 5\text{ }\mu\text{A}$ , whichever is greater<br>$I_{L1} \leq 0.03 C_R \times U_R + 20\text{ }\mu\text{A}$<br><br>$I_{L1} \leq 0.009 C_R \times U_R + 10\text{ }\mu\text{A}$<br>$I_{L1} \leq 0.009 C_R \times U_R + 200\text{ }\mu\text{A}$ |               |
|                                    | After 5 min:<br>$U_R = 160\text{ V to }385\text{ V}$ :<br>$CV \leq 1000\text{ }\mu\text{C}$<br>$CV > 1000\text{ }\mu\text{C}$<br>$U_R = 400\text{ V and }450\text{ V}$                                                                                                                                                                                                                  | $I_{L5} \leq 0.01 C_R \times U_R \text{ or } 1\text{ }\mu\text{A}$ , whichever is greater<br>$I_{L5} \leq 0.006 C_R \times U_R + 4\text{ }\mu\text{A}$<br>$I_{L5} \leq 0.002 C_R \times U_R + 100\text{ }\mu\text{A}$                                                                   |               |
| Inductance                         |                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                                                                                                                                                                                         |               |
| Equivalent series inductance (ESL) | Case $\varnothing D \times L\text{ mm}$ :                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                                                                                                                                                                         |               |
|                                    | 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)

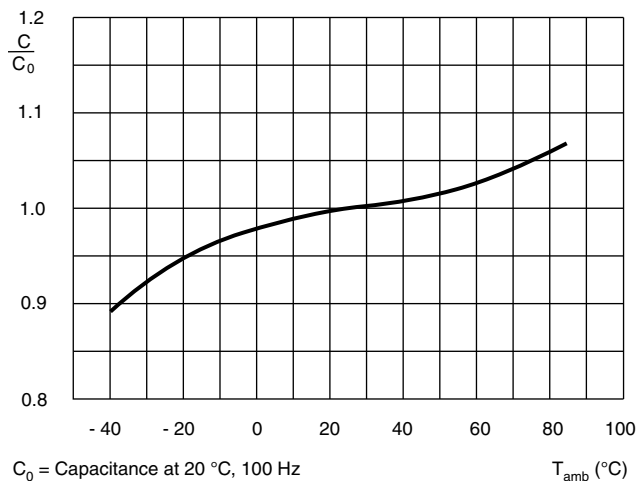


Fig. 5 - Typical multiplier of capacitance as a function of ambient temperature

## EQUIVALENT SERIES RESISTANCE (ESR)

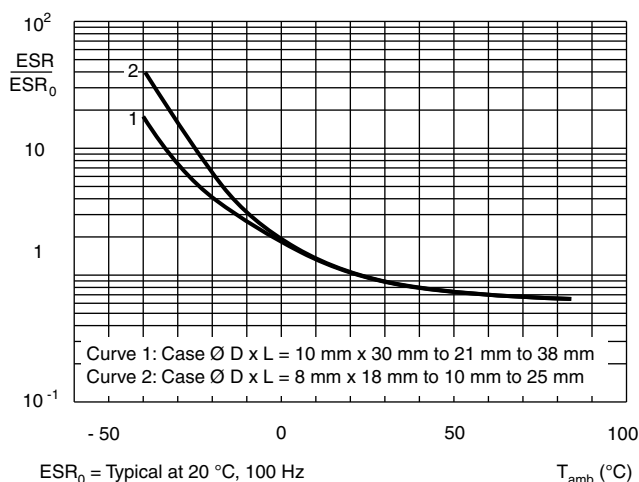


Fig. 6 - Typical multiplier of ESR as a function of ambient temperature

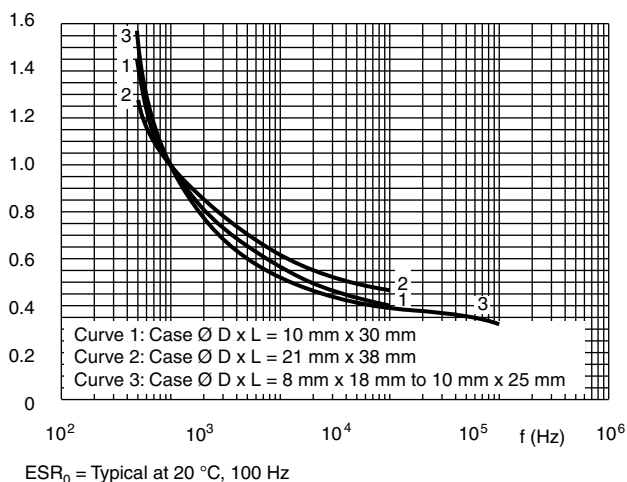


Fig. 7 - Typical multiplier of ESR as a function of frequency

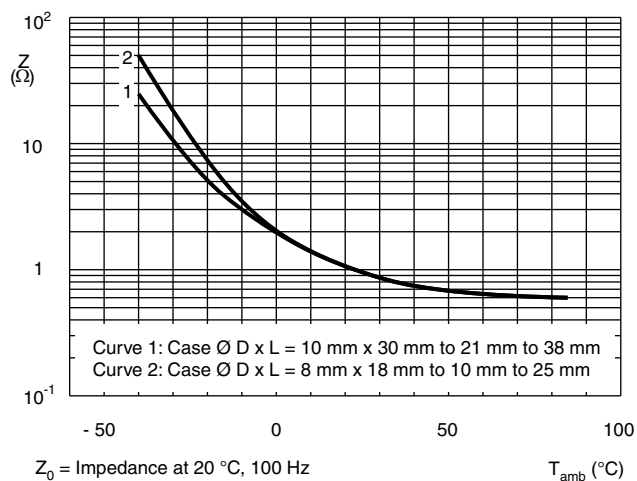
**IMPEDANCE (Z)**


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

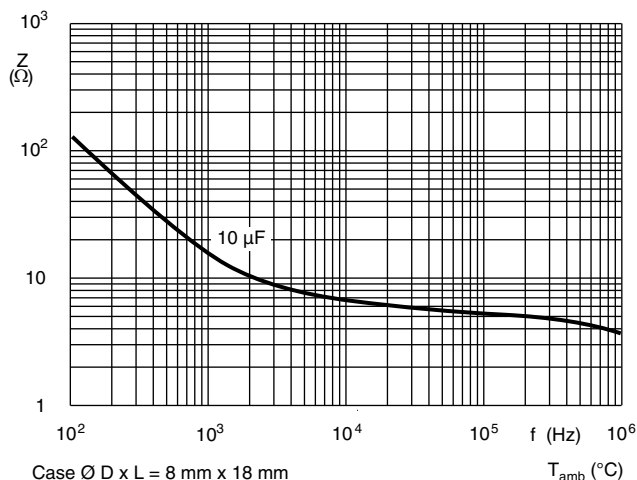


Fig. 9 - Typical impedance as a function of frequency

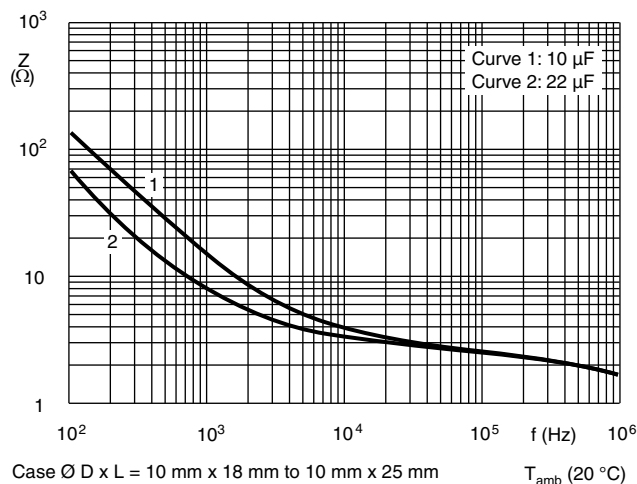


Fig. 10 - Typical impedance as a function of frequency

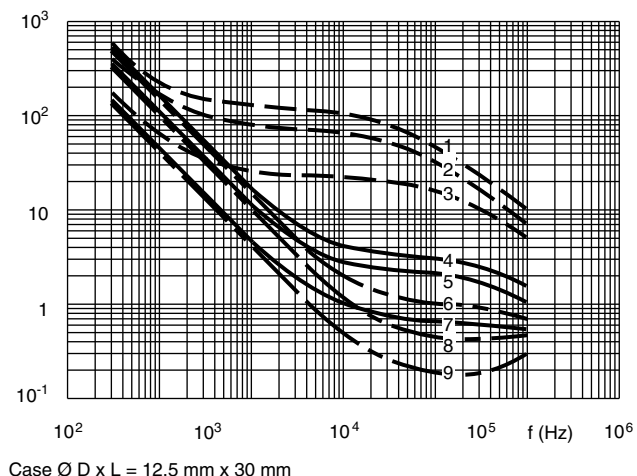


Fig. 11 - Typical impedance as a function of frequency at different ambient temperatures

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**

Table 3

| ENDURANCE TEST DURATION AND USEFUL LIFE |                        |                          |
|-----------------------------------------|------------------------|--------------------------|
| LIFE CODE                               | ENDURANCE AT 85 °C (h) | USEFUL LIFE AT 85 °C (h) |
| L1                                      | 2000                   | 5000                     |
| L2                                      | 8000                   | 15 000                   |
| L3                                      | 5000                   | 10 000                   |

**Note**

- Multiplier of useful life code: CCC205

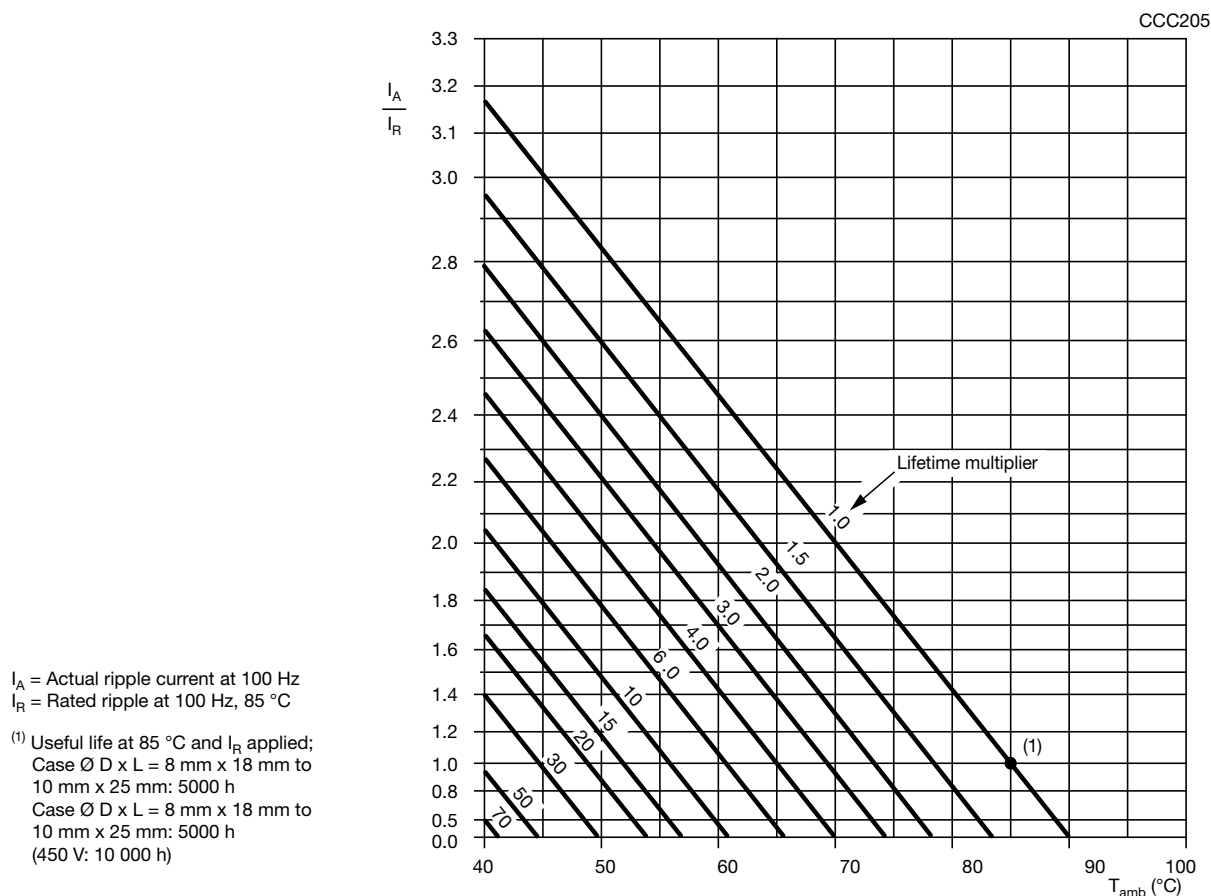


Fig. 12 - Multiplier of useful life as a function of ambient temperature and ripple current load

Table 4

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


**Table 5**

| <b>TEST PROCEDURE REQUIREMENTS</b>             |                                             |                                                                                                                                                                                                                    |                                                                                                                                                                                                                                                                                                                |
|------------------------------------------------|---------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>TEST</b>                                    |                                             | <b>PROCEDURE<br/>(quick reference)</b>                                                                                                                                                                             | <b>REQUIREMENTS</b>                                                                                                                                                                                                                                                                                            |
| <b>NAME OF TEST</b>                            | <b>REFERENCE</b>                            |                                                                                                                                                                                                                    |                                                                                                                                                                                                                                                                                                                |
| Endurance                                      | IEC 60384-4 /<br>EN130300<br>subclause 4.13 | $T_{amb} = 85\text{ }^{\circ}\text{C}$ ; $U_R$ 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>$I_{L5} \leq 2 \times \text{spec. limit}$                                                                                                                                                                            |

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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