

## Aluminum Capacitors Axial Standard

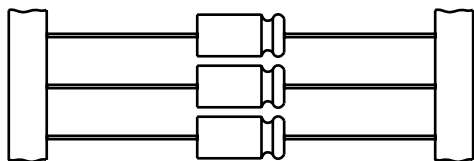
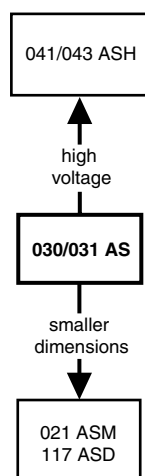


Fig.1 Component outlines



### FEATURES

- Polarized aluminum electrolytic capacitors, non-solid electrolyte
- Axial leads, cylindrical aluminum case, insulated with a blue sleeve
- Taped version available for automatic insertion
- Charge and discharge proof
- Useful life: 3000 hours at 85 °C (case Ø D = 3.3 mm: 1500 hours)
- Standard dimensions
- Lead (Pb)-free versions are RoHS compliant



**RoHS**  
COMPLIANT

### APPLICATIONS

- General purpose and industrial, automotive, telecommunication, audio-video
- Coupling, decoupling, timing, smoothing, filtering, buffering in SMPS
- 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)
- Date code in accordance with IEC 60062
- Code factory of origin
- Name of manufacturer
- Band to indicate the negative terminal
- '+' sign to identify the positive terminal (not for case sizes L < 18 mm)
- Series number (030 or 031)

### QUICK REFERENCE DATA

| DESCRIPTION                                           | VALUE                |                        |
|-------------------------------------------------------|----------------------|------------------------|
| Nominal case sizes<br>(Ø D x L in mm)                 | 3.3 x 11             | 4.5 x 10<br>to 10 x 25 |
| Rated capacitance range, C <sub>R</sub>               | 0.47 to 1000 µF      |                        |
| Tolerance on C <sub>R</sub>                           | - 10 to + 50 %       |                        |
| Rated voltage, U <sub>R</sub>                         | 6.3 to 100 V         |                        |
| Category temperature range                            | - 40 to + 85 °C      |                        |
| Endurance test at 85 °C                               | 1000 hours           | 2000 hours             |
| Useful life at 85 °C                                  | 1500 hours           | 3000 hours             |
| Useful life at 40 °C,<br>1.4 x I <sub>R</sub> applied | 40 000 hours         | 80 000 hours           |
| Shelf life at 0 V, 85 °C                              | 500 hours            |                        |
| Based on sectional specification                      | IEC 60384-4/EN130300 |                        |
| Climatic category IEC 60068                           | 40/085/56            |                        |

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

| $C_R$<br>( $\mu F$ ) | $U_R$ (V) |          |          |          |          |          |          |
|----------------------|-----------|----------|----------|----------|----------|----------|----------|
|                      | 6.3       | 10       | 16       | 25       | 40       | 63       | 100      |
| 0.47                 | -         | -        | -        | -        | -        | -        | 4.5 x 10 |
| 1.0                  | -         | -        | -        | -        | -        | 4.5 x 10 | 4.5 x 10 |
|                      | -         | -        | -        | -        | -        | 3.3 x 11 | -        |
| 2.2                  | -         | -        | -        | -        | 3.3 x 11 | 4.5 x 10 | 4.5 x 10 |
| 3.3                  | -         | -        | -        | -        | -        | 4.5 x 10 | 4.5 x 10 |
| 4.7                  | -         | -        | 3.3 x 11 | -        | -        | 4.5 x 10 | 6 x 10   |
| 6.8                  | -         | -        | -        | -        | -        | 4.5 x 10 | 6 x 10   |
| 10                   | 3.3 x 11  | -        | -        | 4.5 x 10 | 4.5 x 10 | 6 x 10   | 8 x 11   |
|                      | -         | -        | -        | -        | -        | -        | 6.5 x 18 |
| 15                   | -         | -        | -        | -        | 4.5 x 10 | 6 x 10   | -        |
| 22                   | -         | -        | -        | 4.5 x 10 | 6 x 10   | 8 x 11   | 8 x 18   |
|                      | -         | -        | -        | -        | -        | 6.5 x 18 | -        |
| 33                   | -         | -        | 4.5 x 10 | -        | 6 x 10   | -        | 10 x 18  |
| 47                   | -         | 4.5 x 10 | -        | 6 x 10   | 8 x 11   | 8 x 18   | 10 x 25  |
|                      | -         | -        | -        | -        | 6.5 x 18 | -        | -        |
| 68                   | 4.5 x 10  | -        | 6 x 10   | -        | -        | 10 x 18  | -        |
| 100                  | -         | 6 x 10   | -        | 8 x 11   | 8 x 18   | 10 x 25  | -        |
|                      | -         | -        | -        | 6.5 x 18 | -        | -        | -        |
| 150                  | 6 x 10    | -        | 8 x 11   | 8 x 18   | 10 x 18  | -        | -        |
|                      | -         | -        | 6.5 x 18 | -        | -        | -        | -        |
| 220                  | -         | 8 x 11   | 8 x 18   | 10 x 18  | 10 x 25  | -        | -        |
|                      | -         | 6.5 x 18 | -        | -        | -        | -        | -        |
| 330                  | -         | 8 x 18   | 10 x 18  | 10 x 25  | -        | -        | -        |
| 470                  | 8 x 18    | 10 x 18  | 10 x 25  | -        | -        | -        | -        |
| 680                  | 10 x 18   | 10 x 25  | -        | -        | -        | -        | -        |
| 1000                 | 10 x 25   | -        | -        | -        | -        | -        | -        |

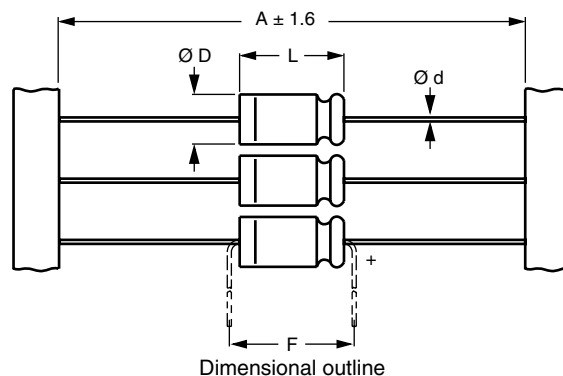
**DIMENSIONS in millimeters AND AVAILABLE FORMS**Fig.2 **Form BR:** Taped on reel, non-preferred

Table 1

| <b>AXIAL; DIMENSIONS in millimeters, MASS AND PACKAGING QUANTITIES</b> |              |                      |            |                        |            |            |             |                      |         |
|------------------------------------------------------------------------|--------------|----------------------|------------|------------------------|------------|------------|-------------|----------------------|---------|
| NOMINAL CASE SIZE<br>$\varnothing D \times L$                          | CASE<br>CODE | AXIAL FORM BA and BR |            |                        |            |            | MASS<br>(g) | PACKAGING QUANTITIES |         |
|                                                                        |              | $\varnothing d$      | A          | $\varnothing D_{max.}$ | $L_{max.}$ | $F_{min.}$ |             | FORM BA              | FORM BR |
| 3.3 x 11                                                               | 1            | 0.6                  | 63.5 ± 1.5 | 3.5                    | 12         | 17.5       | ≈ 0.35      | 1000                 | 4000    |
| 4.5 x 10                                                               | 2            | 0.6                  | 63.5 ± 1.5 | 5.0                    | 10.5       | 15         | ≈ 0.5       | 1000                 | 3000    |
| 6 x 10                                                                 | 3            | 0.6                  | 63.5 ± 1.5 | 6.3                    | 10.5       | 15         | ≈ 0.7       | 1000                 | 1000    |
| 8 x 11                                                                 | 5a           | 0.6                  | 63.5 ± 1.5 | 8.5                    | 11.5       | 15         | ≈ 1.1       | 500                  | 500     |
| 6.5 x 18                                                               | 4            | 0.8                  | 73 ± 1.6   | 6.9                    | 18.5       | 25         | ≈ 1.3       | 1000                 | 1000    |
| 8 x 18                                                                 | 5            | 0.8                  | 73 ± 1.6   | 8.5                    | 18.5       | 25         | ≈ 1.7       | 500                  | 500     |
| 10 x 18                                                                | 6            | 0.8                  | 73 ± 1.6   | 10.5                   | 18.5       | 25         | ≈ 2.5       | 500                  | 500     |
| 10 x 25                                                                | 7            | 0.8                  | 73 ± 1.6   | 10.5                   | 25.0       | 30         | ≈ 3.3       | 500                  | 500     |

**Note**

Detailed tape dimensions see section 'PACKAGING'.

Aluminum Capacitors  
Axial Standard

Vishay BCcomponents

| 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 minute at $U_R$                                                |
| $I_{L5}$        | max. leakage current after 5 minutes at $U_R$                                               |
| $\tan \delta$   | max. dissipation factor at 100 Hz                                                           |
| ESR             | equivalent series resistance at 100 Hz<br>(calculated from $\tan \delta_{\max}$ and $C_R$ ) |
| Z               | max. impedance at 10 kHz                                                                    |

## Note

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

Table 2

| ELECTRICAL DATA AND ORDERING INFORMATION |                                      |                                                          |              |                                  |                                        |                                        |                         |                               |                             |                             |                         |
|------------------------------------------|--------------------------------------|----------------------------------------------------------|--------------|----------------------------------|----------------------------------------|----------------------------------------|-------------------------|-------------------------------|-----------------------------|-----------------------------|-------------------------|
| $U_R$<br>(V)                             | $C_R$<br>100 Hz<br>( $\mu\text{F}$ ) | NOMINAL<br>CASE SIZE<br>$\varnothing D \times L$<br>(mm) | 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<br>MAL2.....  |                         |
|                                          |                                      |                                                          |              |                                  |                                        |                                        |                         |                               |                             | TAPED ON<br>REEL<br>FORM BR | TAPED IN BOX<br>FORM BA |
| 6.3                                      | 10                                   | 3.3 x 11                                                 | 1            | 15                               | 5                                      | 5.1                                    | 0.30                    | 47.8                          | 20                          | 03023109E3                  | 03033109E3              |
|                                          | 68                                   | 4.5 x 10                                                 | 2            | 75                               | 22                                     | 5.9                                    | 0.25                    | 5.86                          | 2.9                         | 03023689E3                  | 03033689E3              |
|                                          | 150                                  | 6 x 10                                                   | 3            | 120                              | 10                                     | 6.9                                    | 0.25                    | 2.66                          | 1.3                         | 03023151E3                  | 03033151E3              |
|                                          | 470                                  | 8 x 18                                                   | 5            | 330                              | 22                                     | 11                                     | 0.25                    | 0.85                          | 0.43                        | 03123471E3                  | 03133471E3              |
|                                          | 680                                  | 10 x 18                                                  | 6            | 430                              | 30                                     | 14                                     | 0.25                    | 0.59                          | 0.29                        | 03123681E3                  | 03133681E3              |
|                                          | 1000                                 | 10 x 25                                                  | 7            | 560                              | 42                                     | 18                                     | 0.25                    | 0.40                          | 0.20                        | 03123102E3                  | 03133102E3              |
| 10                                       | 47                                   | 4.5 x 10                                                 | 2            | 70                               | 24                                     | 5.9                                    | 0.20                    | 6.78                          | 3.4                         | 03024479E3                  | 03034479E3              |
|                                          | 100                                  | 6 x 10                                                   | 3            | 110                              | 10                                     | 7.0                                    | 0.20                    | 3.19                          | 1.6                         | 03024101E3                  | 03034101E3              |
|                                          | 220                                  | 8 x 11                                                   | 5a           | 210                              | 18                                     | 9.4                                    | 0.20                    | 1.45                          | 0.73                        | 03124221E3                  | 03034221E3              |
|                                          | 220                                  | 6.5 x 18                                                 | 4            | 210                              | 18                                     | 9.4                                    | 0.20                    | 1.45                          | 0.73                        | 03124221E3                  | 03134221E3              |
|                                          | 330                                  | 8 x 18                                                   | 5            | 310                              | 24                                     | 12                                     | 0.20                    | 0.97                          | 0.48                        | 03124331E3                  | 03134331E3              |
|                                          | 470                                  | 10 x 18                                                  | 6            | 410                              | 33                                     | 14                                     | 0.20                    | 0.68                          | 0.34                        | 03124471E3                  | 03134471E3              |
| 16                                       | 680                                  | 10 x 25                                                  | 7            | 510                              | 45                                     | 19                                     | 0.20                    | 0.47                          | 0.24                        | 03124681E3                  | 03134681E3              |
|                                          | 4.7                                  | 3.3 x 11                                                 | 1            | 15                               | 5                                      | 5.1                                    | 0.20                    | 67.8                          | 26                          | 03025478E3                  | 03035478E3              |
|                                          | 33                                   | 4.5 x 10                                                 | 2            | 65                               | 27                                     | 6.1                                    | 0.16                    | 7.72                          | 3.6                         | 03025339E3                  | 03035339E3              |
|                                          | 68                                   | 6 x 10                                                   | 3            | 110                              | 11                                     | 7.2                                    | 0.16                    | 3.75                          | 1.8                         | 03025689E3                  | 03035689E3              |
|                                          | 150                                  | 8 x 11                                                   | 5a           | 200                              | 19                                     | 9.8                                    | 0.16                    | 1.70                          | 0.80                        | 03025151E3                  | 03035151E3              |
|                                          | 150                                  | 6.5 x 18                                                 | 4            | 200                              | 19                                     | 9.8                                    | 0.16                    | 1.70                          | 0.80                        | 03125151E3                  | 03135151E3              |
|                                          | 220                                  | 8 x 18                                                   | 5            | 270                              | 26                                     | 12                                     | 0.16                    | 1.16                          | 0.55                        | 03125221E3                  | 03135221E3              |
|                                          | 330                                  | 10 x 18                                                  | 6            | 410                              | 36                                     | 16                                     | 0.16                    | 0.78                          | 0.36                        | 03125331E3                  | 03135331E3              |
| 25                                       | 470                                  | 10 x 25                                                  | 7            | 480                              | 49                                     | 20                                     | 0.16                    | 0.55                          | 0.26                        | 03125471E3                  | 03135471E3              |
|                                          | 10                                   | 4.5 x 10                                                 | 2            | 50                               | 13                                     | 5.5                                    | 0.14                    | 22.3                          | 9                           | 03026109E3                  | 03036109E3              |
|                                          | 22                                   | 4.5 x 10                                                 | 2            | 60                               | 28                                     | 6.1                                    | 0.14                    | 10.2                          | 4.1                         | 03026229E3                  | 03036229E3              |
|                                          | 47                                   | 6 x 10                                                   | 3            | 100                              | 12                                     | 7.4                                    | 0.14                    | 4.8                           | 1.9                         | 03026479E3                  | 03036479E3              |
|                                          | 100                                  | 8 x 11                                                   | 5a           | 160                              | 19                                     | 10                                     | 0.14                    | 2.23                          | 0.90                        | 03026101E3                  | 03036101E3              |
|                                          | 100                                  | 6.5 x 18                                                 | 4            | 160                              | 19                                     | 10                                     | 0.14                    | 2.23                          | 0.90                        | 03126101E3                  | 03136101E3              |
|                                          | 150                                  | 8 x 18                                                   | 5            | 240                              | 27                                     | 13                                     | 0.14                    | 1.49                          | 0.60                        | 03126151E3                  | 03136151E3              |
|                                          | 220                                  | 10 x 18                                                  | 6            | 350                              | 37                                     | 16                                     | 0.14                    | 1.02                          | 0.41                        | 03126221E3                  | 03136221E3              |
| 330                                      | 330                                  | 10 x 25                                                  | 7            | 460                              | 54                                     | 22                                     | 0.14                    | 0.68                          | 0.27                        | 03126331E3                  | 03136331E3              |

## ORDERING EXAMPLE

Electrolytic capacitor 031 series

330  $\mu\text{F}/10\text{ V}$ ; - 10/+ 50 %Nominal case size:  $\varnothing 8 \times 18\text{ mm}$ ; Form BA

Ordering code: MAL203134331E3

Former 12 NC: 2222 031 34331

**ELECTRICAL DATA AND ORDERING INFORMATION**

| U <sub>R</sub><br>(V) | C <sub>R</sub><br>100 Hz<br>(μF) | NOMINAL<br>CASE SIZE<br>Ø D x L<br>(mm) | 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) | ORDERING CODE<br>MAL2.....  |                         |
|-----------------------|----------------------------------|-----------------------------------------|--------------|-------------------------------------------|----------------------------------|----------------------------------|-----------------|----------------------|--------------------|-----------------------------|-------------------------|
|                       |                                  |                                         |              |                                           |                                  |                                  |                 |                      |                    | TAPED ON<br>REEL<br>FORM BR | TAPED IN BOX<br>FORM BA |
| 40                    | 2.2                              | 3.3 x 11                                | 1            | 15                                        | 5                                | 5.1                              | 0.15            | 109                  | 32                 | 03027228E3                  | 03037228E3              |
|                       | 10                               | 4.5 x 10                                | 2            | 50                                        | 20                               | 5.8                              | 0.11            | 17.6                 | 7                  | 03027109E3                  | 03037109E3              |
|                       | 15                               | 4.5 x 10                                | 2            | 55                                        | 30                               | 6.2                              | 0.11            | 11.7                 | 4.7                | 03027159E3                  | 03037159E3              |
|                       | 22                               | 6 x 10                                  | 3            | 75                                        | 9                                | 6.8                              | 0.11            | 8.0                  | 3.2                | 03027229E3                  | 03037229E3              |
|                       | 33                               | 6 x 10                                  | 3            | 95                                        | 12                               | 7.7                              | 0.11            | 5.31                 | 2.1                | 03027339E3                  | 03037339E3              |
|                       | 47                               | 8 x 11                                  | 5a           | 150                                       | 16                               | 8.8                              | 0.11            | 3.73                 | 1.5                | 03027479E3                  | 03037479E3              |
|                       | 47                               | 6.5 x 18                                | 4            | 150                                       | 16                               | 8.8                              | 0.11            | 3.73                 | 1.5                | 03127479E3                  | 03137479E3              |
|                       | 100                              | 8 x 18                                  | 5            | 220                                       | 28                               | 13                               | 0.11            | 1.75                 | 0.70               | 03127101E3                  | 03137101E3              |
|                       | 150                              | 10 x 18                                 | 6            | 300                                       | 40                               | 17                               | 0.11            | 1.17                 | 0.47               | 03127151E3                  | 03137151E3              |
|                       | 220                              | 10 x 25                                 | 7            | 430                                       | 57                               | 23                               | 0.11            | 0.80                 | 0.32               | 03127221E3                  | 03137221E3              |
| 63                    | 1.0                              | 3.3 x 11                                | 1            | 10                                        | 5                                | 5.1                              | 0.12            | 191                  | 55                 | 03090067E3                  | 03090068E3              |
|                       | 1.0                              | 4.5 x 10                                | 2            | 13                                        | 5                                | 5.1                              | 0.09            | 143                  | 55                 | 03028108E3                  | 03038108E3              |
|                       | 2.2                              | 4.5 x 10                                | 2            | 25                                        | 7                                | 5.3                              | 0.09            | 65.2                 | 25                 | 03028228E3                  | 03038228E3              |
|                       | 3.3                              | 4.5 x 10                                | 2            | 35                                        | 11                               | 5.4                              | 0.09            | 46.5                 | 17                 | 03028338E3                  | 03038338E3              |
|                       | 4.7                              | 4.5 x 10                                | 2            | 40                                        | 15                               | 5.6                              | 0.09            | 30.5                 | 12                 | 03028478E3                  | 03038478E3              |
|                       | 6.8                              | 4.5 x 10                                | 2            | 46                                        | 22                               | 5.9                              | 0.09            | 21.1                 | 8.1                | 03028688E3                  | 03038688E3              |
|                       | 10                               | 6 x 10                                  | 3            | 70                                        | 7                                | 6.3                              | 0.08            | 12.8                 | 5.5                | 03028109E3                  | 03038109E3              |
|                       | 15                               | 6 x 10                                  | 3            | 79                                        | 10                               | 6.9                              | 0.08            | 8.5                  | 3.7                | 03028159E3                  | 03038159E3              |
|                       | 22                               | 8 x 11                                  | 5a           | 110                                       | 13                               | 7.8                              | 0.08            | 5.79                 | 2.5                | 03028229E3                  | 03038229E3              |
|                       | 22                               | 6.5 x 18                                | 4            | 110                                       | 13                               | 7.8                              | 0.08            | 5.79                 | 2.5                | 03128229E3                  | 03138229E3              |
|                       | 47                               | 8 x 18                                  | 5            | 190                                       | 22                               | 11                               | 0.08            | 2.71                 | 1.2                | 03128479E3                  | 03138479E3              |
|                       | 68                               | 10 x 18                                 | 6            | 250                                       | 30                               | 14                               | 0.08            | 1.88                 | 0.81               | 03128689E3                  | 03138689E3              |
|                       | 100                              | 10 x 25                                 | 7            | 300                                       | 42                               | 18                               | 0.08            | 1.28                 | 0.55               | 03128101E3                  | 03138101E3              |
| 100                   | 0.47                             | 4.5 x 10                                | 2            | 9                                         | 5                                | 4.3                              | 0.08            | 271                  | 96                 | 03029477E3                  | 03039477E3              |
|                       | 1.0                              | 4.5 x 10                                | 2            | 20                                        | 5                                | 4.6                              | 0.08            | 128                  | 45                 | 03029108E3                  | 03039108E3              |
|                       | 2.2                              | 4.5 x 10                                | 2            | 30                                        | 11                               | 5.3                              | 0.08            | 57.9                 | 21                 | 03029228E3                  | 03039228E3              |
|                       | 3.3                              | 4.5 x 10                                | 2            | 40                                        | 17                               | 6.0                              | 0.08            | 38.6                 | 14                 | 03029338E3                  | 03039338E3              |
|                       | 4.7                              | 6 x 10                                  | 3            | 50                                        | 13                               | 6.8                              | 0.07            | 23.7                 | 9.6                | 03029478E3                  | 03039478E3              |
|                       | 6.8                              | 6 x 10                                  | 3            | 70                                        | 18                               | 8.0                              | 0.07            | 16.4                 | 6.6                | 03029688E3                  | 03039688E3              |
|                       | 10                               | 8 x 11                                  | 5a           | 90                                        | 24                               | 10                               | 0.07            | 11.2                 | 4.5                | 03029109E3                  | 03039109E3              |
|                       | 10                               | 6.5 x 18                                | 4            | 90                                        | 24                               | 10                               | 0.07            | 11.2                 | 4.5                | 03129109E3                  | 03139109E3              |
|                       | 22                               | 8 x 18                                  | 5            | 120                                       | 48                               | 18                               | 0.07            | 5.07                 | 2.1                | 03129229E3                  | 03139229E3              |
|                       | 33                               | 10 x 18                                 | 6            | 200                                       | 70                               | 24                               | 0.07            | 3.38                 | 1.4                | 03129339E3                  | 03139339E3              |
|                       | 47                               | 10 x 25                                 | 7            | 260                                       | 98                               | 33                               | 0.07            | 2.37                 | 0.96               | 03129479E3                  | 03139479E3              |

| ADDITIONAL ELECTRICAL DATA         |                                                                                                                                                                                                    |                                                                                                                                                                                                                                                                                                               |
|------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| PARAMETER                          | CONDITIONS                                                                                                                                                                                         | VALUE                                                                                                                                                                                                                                                                                                         |
| <b>Voltage</b>                     |                                                                                                                                                                                                    |                                                                                                                                                                                                                                                                                                               |
| Surge voltage                      |                                                                                                                                                                                                    | $U_S \leq 1.15 \times U_R$                                                                                                                                                                                                                                                                                    |
| Reverse voltage                    |                                                                                                                                                                                                    | $U_{rev} \leq 1 \text{ V}$                                                                                                                                                                                                                                                                                    |
| <b>Current</b>                     |                                                                                                                                                                                                    |                                                                                                                                                                                                                                                                                                               |
| Leakage current                    | After 1 minute at $U_R$ :<br>Case $\varnothing D \times L = 3.3 \times 11$ and $4.5 \times 10$ mm<br>Case $\varnothing D \times L = 6 \times 10$ to $10 \times 25$ mm<br><br>$U_R = 100 \text{ V}$ | $I_{L1} \leq 0.05 C_R \times U_R$ or $5 \mu\text{A}$ , whichever is greater<br>$I_{L1}$ for $CV \leq 1000$ : $\leq 0.01 C_R \times U_R$ or $1 \mu\text{A}$ , whichever is greater<br>$I_{L1}$ for $CV > 1000$ : $\leq 0.006 C_R \times U_R + 4 \mu\text{A}$<br>$I_{L1} = 0.02 C_R \times U_R + 4 \mu\text{A}$ |
|                                    | After 5 minutes:<br>$U_R = 6.3$ to $63 \text{ V}$<br>$U_R = 100 \text{ V}$                                                                                                                         | $I_{L5} \leq 0.002 C_R \times U_R + 5 \mu\text{A}$<br>$I_{L5} \leq 0.006 C_R \times U_R + 4 \mu\text{A}$                                                                                                                                                                                                      |
| <b>Inductance</b>                  |                                                                                                                                                                                                    |                                                                                                                                                                                                                                                                                                               |
| Equivalent series inductance (ESL) | Case $\varnothing D \times L$ mm:<br>3.3 x 11<br>4.5 x 10<br>6 x 10<br>8 x 11<br>6.5 x 18<br>8 x 18<br>10 x 18<br>10 x 25                                                                          | typ. 11 nH<br>typ. 10 nH<br>typ. 22 nH<br>typ. 85 nH<br>typ. 25 nH<br>typ. 40 nH<br>typ. 61 nH<br>typ. 38 nH                                                                                                                                                                                                  |
| <b>Resistance</b>                  |                                                                                                                                                                                                    |                                                                                                                                                                                                                                                                                                               |
| Equivalent series resistance (ESR) | Calculated from $\tan \delta_{max.}$ and $C_R$ (see Table 2)                                                                                                                                       | $ESR = \tan \delta / 2 \pi f C_R$                                                                                                                                                                                                                                                                             |

## CAPACITANCE (C)

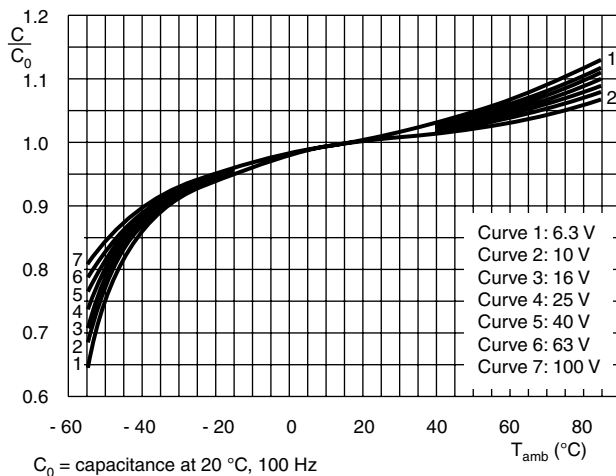


Fig.3 Typical multiplier of capacitance as a function of ambient temperature

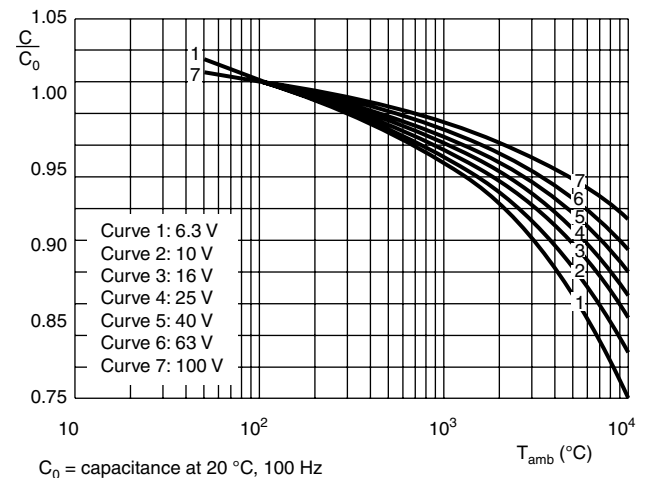


Fig.4 Typical multiplier of capacitance as a function of frequency

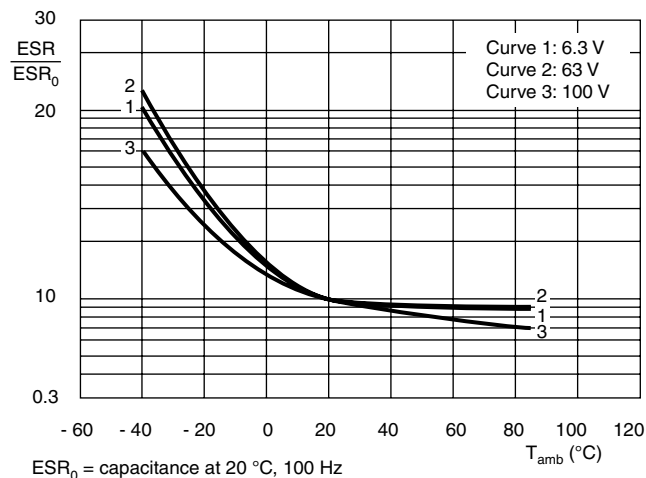
**EQUIVALENT SERIES RESISTANCE (ESR)**

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

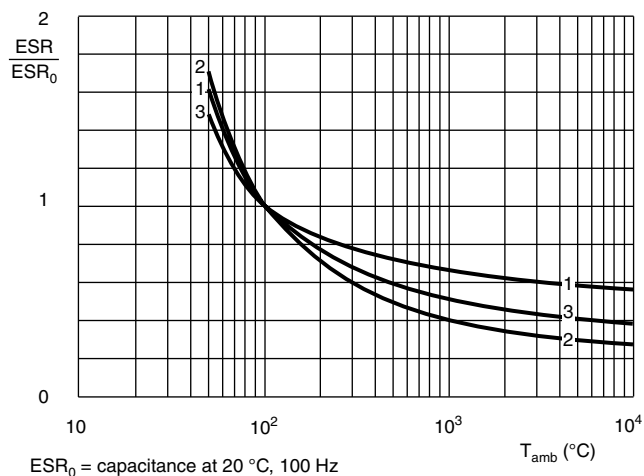


Fig.6 Typical multiplier of ESR as a function of frequency

**IMPEDANCE (Z)**

Table 3

| <b>IMPEDANCE VS. CAPACITANCE VALUES AT 10 kHz</b> |                             |        |        |        |       |       |       |
|---------------------------------------------------|-----------------------------|--------|--------|--------|-------|-------|-------|
| T <sub>amb</sub>                                  | Z x C <sub>R</sub> (Ω x μF) |        |        |        |       |       |       |
|                                                   | 6.3 V                       | 10 V   | 16 V   | 25 V   | 40 V  | 63 V  | 100 V |
| + 20 °C                                           | ≤ 200                       | ≤ 160  | ≤ 120  | ≤ 90   | ≤ 70  | ≤ 55  | ≤ 45  |
| - 25 °C                                           | ≤ 1200                      | ≤ 750  | ≤ 560  | ≤ 400  | ≤ 300 | ≤ 180 | ≤ 130 |
| - 40 °C                                           | ≤ 3200                      | ≤ 2000 | ≤ 1500 | ≤ 1100 | ≤ 900 | ≤ 500 | ≤ 350 |

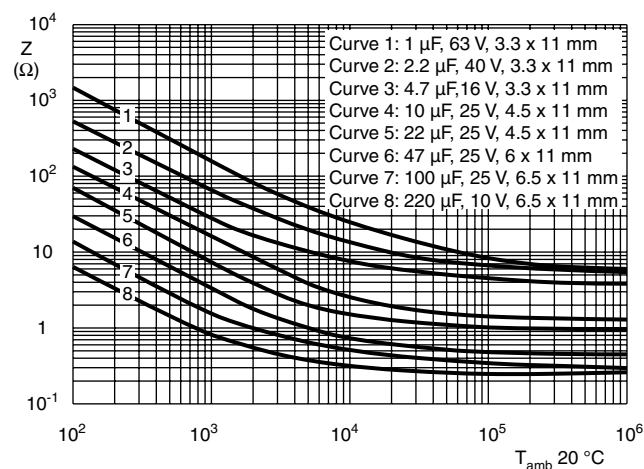


Fig.7 Typical impedance as a function of frequency

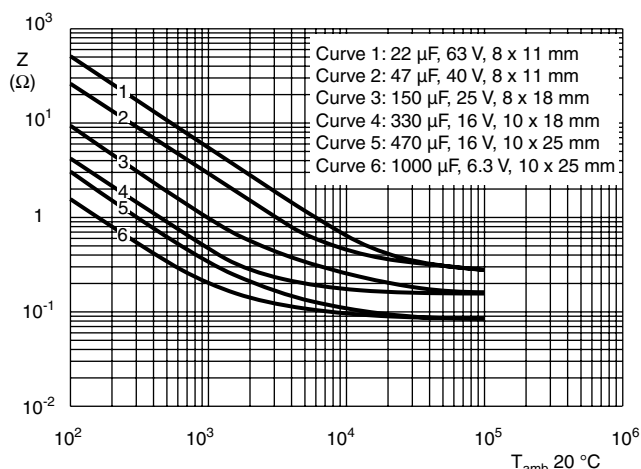


Fig.8 Typical impedance as a function of frequency

## RIPPLE CURRENT AND USEFUL LIFE

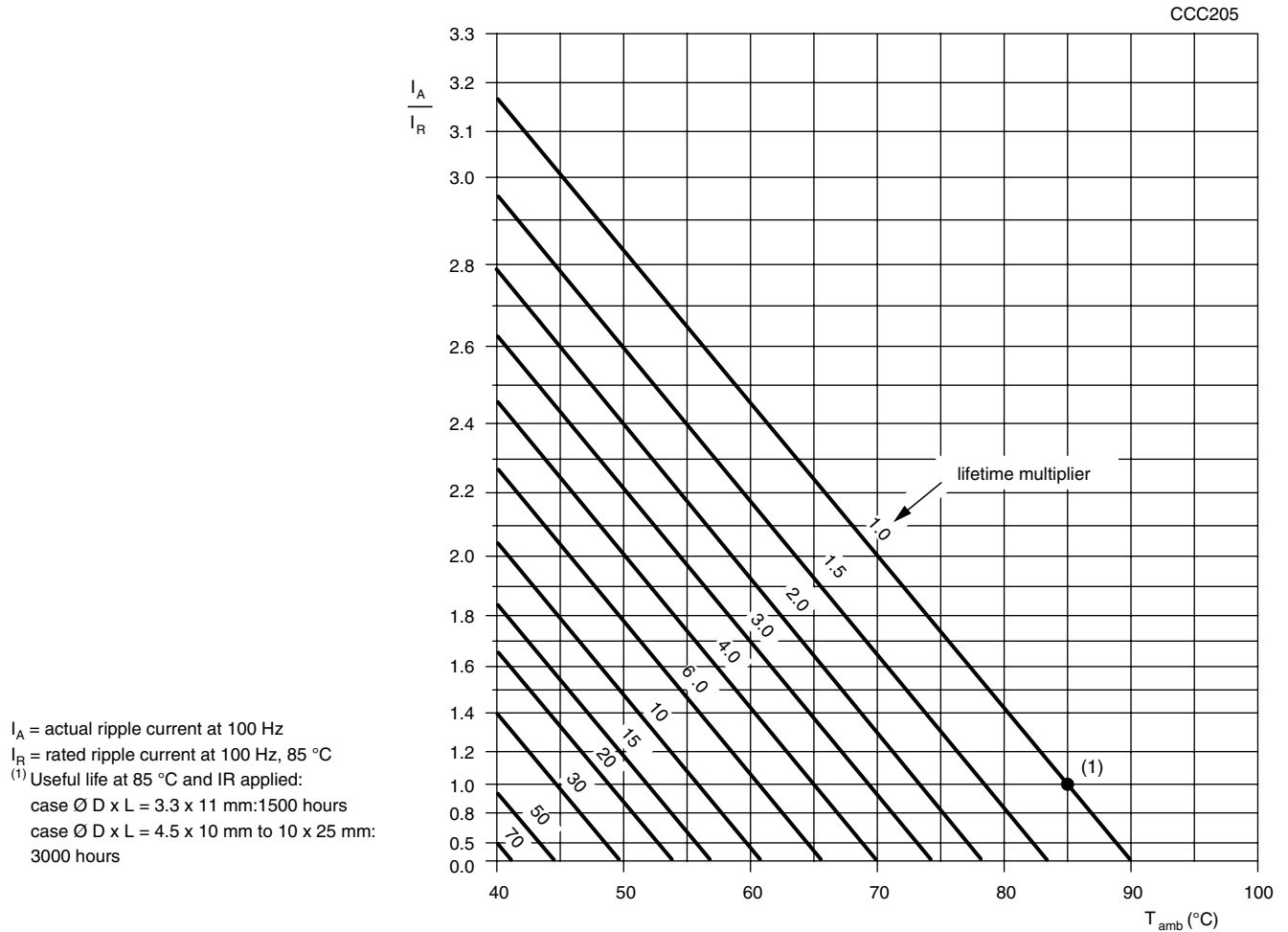


Fig.9 Multiplier of useful life as a function of ambient temperature and ripple current load

Table 4

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

Table 5

| TEST PROCEDURES AND REQUIREMENTS               |                                          |                                                                                                                                                                 |                                                                                                                                                                                                                                                            |
|------------------------------------------------|------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| TEST                                           |                                          | PROCEDURE<br>(quick reference)                                                                                                                                  | REQUIREMENTS                                                                                                                                                                                                                                               |
| NAME OF TEST                                   | REFERENCE                                |                                                                                                                                                                 |                                                                                                                                                                                                                                                            |
| Case Ø D x L = 3.3 x 11 mm                     |                                          |                                                                                                                                                                 |                                                                                                                                                                                                                                                            |
| Endurance                                      | IEC 384-4/<br>EN130300<br>subclause 4.13 | T <sub>amb</sub> = 85 °C ; U <sub>R</sub> applied;<br>1000 hours                                                                                                | ΔC/C: ± 20 %<br><br>tan δ ≤ 2 x spec. limit<br><br>Z ≤ 3 x spec. limit<br><br>I <sub>L</sub> ≤ spec. limit                                                                                                                                                 |
| Useful life                                    | CECC 30301<br>subclause 1.8.1            | T <sub>amb</sub> = 85 °C; U <sub>R</sub> and I <sub>R</sub> applied;<br>1500 hours                                                                              | ΔC/C: ± 50 %<br><br>tan δ ≤ 3 x spec. limit<br><br>Z ≤ 3 x spec. limit<br><br>I <sub>L</sub> ≤ spec. limit<br><br>no short or open circuit<br><br>total failure percentage: ≤ 3 %                                                                          |
| Shelf life<br>(storage at<br>high temperature) | IEC 384-4/<br>EN130300<br>subclause 4.17 | T <sub>amb</sub> = 85 °C; no voltage applied;<br>500 hours<br><br>After test: U <sub>R</sub> to be applied for 30 minutes,<br>24 to 48 hours before measurement | ΔC/C, tan δ, Z:<br>for requirements<br>see 'Endurance test' above<br><br>I <sub>L</sub> ≤ 2 x spec. limit                                                                                                                                                  |
| Case Ø D L = 4.5 x 10 to 10 x 25 mm            |                                          |                                                                                                                                                                 |                                                                                                                                                                                                                                                            |
| Endurance                                      | IEC 384-4/<br>EN130300<br>subclause 4.13 | T <sub>amb</sub> = 85 °C; U <sub>R</sub> applied;<br>2000 hours                                                                                                 | U <sub>R</sub> ≤ 6.3 V; ΔC/C: + 15/- 30 %<br><br>U <sub>R</sub> > 6.3 V; ΔC/C: ± 15 %<br><br>tan δ ≤ 1.3 x spec. limit<br><br>Z ≤ 2 x spec. limit<br><br>I <sub>L</sub> ≤ spec. limit                                                                      |
| Useful life                                    | CECC 30301<br>subclause 1.8.1            | T <sub>amb</sub> = 85 °C; U <sub>R</sub> and I <sub>R</sub> applied;<br>3000 hours                                                                              | U <sub>R</sub> ≤ 6.3 V; ΔC/C: + 45/- 50 %<br><br>U <sub>R</sub> > 6.3 V; ΔC/C: ± 45 %<br><br>tan δ ≤ 3 x spec. limit<br><br>Z ≤ 3 x spec. limit<br><br>I <sub>L</sub> ≤ spec. limit<br><br>no short or open circuit<br><br>total failure percentage: ≤ 1 % |
| Shelf life<br>(storage at<br>high temperature) | IEC 384-4/<br>EN130300<br>subclause 4.17 | T <sub>amb</sub> = 85 °C; no voltage applied;<br>500 hours<br><br>After test: U <sub>R</sub> to be applied for 30 minutes,<br>24 to 48 hours before measurement | ΔC/C, tan δ, Z:<br>for requirements<br>see 'Endurance test' above<br><br>I <sub>L</sub> ≤ 2 x spec. limit                                                                                                                                                  |



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