

## Aluminum Electrolytic Capacitors SMD (Chip), High Temperature, Low Impedance

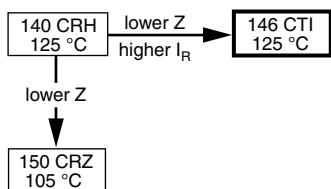


Fig. 1

AUTOMOTIVE  
GRADE

**RoHS**  
COMPLIANT

### FEATURES

- Extended useful life: up to 6000 h at 125 °C
- Polarized aluminum electrolytic capacitors, non-solid electrolyte, self healing
- SMD-version with base plate, lead (Pb)-free reflow solderable
- Charge and discharge proof, no peak current limitation
- Advanced temperature reflow soldering according to JEDEC® J-STD-020
- Vibration proof, 4-pin version and 6-pin version
- AEC-Q200 qualified
- High reliability
- Low ESR
- Material categorization: for definitions of compliance please see [www.vishay.com/doc?99912](http://www.vishay.com/doc?99912)

### APPLICATIONS

- SMD technology, for high temperature reflow soldering
- Industrial and professional applications
- Automotive, general industrial, telecom
- Smoothing, filtering, buffering

### MARKING

- Rated capacitance (in  $\mu\text{F}$ )
- Rated voltage (in V)
- Date code, in accordance with IEC 60062
- Black mark or “-” sign indicating the cathode (the anode is identified by bevelled edges)
- Code indicating group number (T)

### PACKAGING

Supplied in blister tape on reel

| QUICK REFERENCE DATA                        |                                        |
|---------------------------------------------|----------------------------------------|
| DESCRIPTION                                 | VALUE                                  |
| Nominal case sizes<br>(L x W x H in mm)     | 8 x 8 x 10<br>to 18 x 18 x 21          |
| Rated capacitance range, $C_R$              | 10 $\mu\text{F}$ to 4700 $\mu\text{F}$ |
| Tolerance on $C_R$                          | $\pm 20 \%$                            |
| Rated voltage range, $U_R$                  | 16 V to 100 V                          |
| Category temperature range                  | -55 °C to +125 °C                      |
| Endurance test at 125 °C                    | 1000 h to 5000 h                       |
| Useful life at 125 °C                       | 1500 h to 6000 h                       |
| Useful life at 40 °C<br>1.8 x $I_R$ applied | 150 000 h to 400 000 h                 |
| Shelf life at 0 V, 125 °C                   | 1000 h                                 |
| Based on sectional<br>specification         | IEC 60384-18 / CECC 32300              |
| Climatic category IEC 60068                 | 55 / 125 / 56                          |

**SELECTION CHART FOR  $C_R$ ,  $U_R$ , AND RELEVANT NOMINAL CASE SIZES (L x W x H in mm)**

| $C_R$<br>( $\mu F$ ) | $U_R$ (V)        |                  |                  |                  |                  |                  |                  |
|----------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|
|                      | 16               | 25               | 35               | 50               | 63               | 80               | 100              |
| 10                   | →                | →                | →                | →                | →                | 10 x 10 x 10     | 10 x 10 x 10     |
| 22                   | →                | →                | →                | →                | 10 x 10 x 10     | 10 x 10 x 10     | 10 x 10 x 10     |
| 33                   | →                | →                | 8 x 8 x 10       | →                | 10 x 10 x 10     | 10 x 10 x 10     | 10 x 10 x 12     |
| 47                   | →                | →                | 10 x 10 x 10     | 10 x 10 x 10     | 10 x 10 x 10     | 10 x 10 x 12     | 10 x 10 x 12     |
| 68                   | →                | →                | →                | 10 x 10 x 10     | 10 x 10 x 10     | 10 x 10 x 12     | 12.5 x 12.5 x 13 |
| 100                  | →                | 8 x 8 x 10       | 10 x 10 x 10     | 10 x 10 x 10     | 10 x 10 x 12     | 12.5 x 12.5 x 13 | 12.5 x 12.5 x 16 |
|                      |                  |                  |                  | 10 x 10 x 12     | 12.5 x 12.5 x 13 |                  |                  |
| 150                  | →                | →                | 10 x 10 x 10     | 10 x 10 x 12     | 12.5 x 12.5 x 13 | 12.5 x 12.5 x 16 | 16 x 16 x 16     |
| 220                  | 8 x 8 x 10       | 10 x 10 x 10     | 10 x 10 x 12     | 12.5 x 12.5 x 13 | 12.5 x 12.5 x 16 | 16 x 16 x 16     | 16 x 16 x 21     |
|                      |                  |                  |                  |                  |                  |                  | 18 x 18 x 16     |
| 330                  | 10 x 10 x 10     | 10 x 10 x 12     | 12.5 x 12.5 x 13 | 12.5 x 12.5 x 16 | 16 x 16 x 16     | 16 x 16 x 21     | 18 x 18 x 21     |
|                      |                  |                  |                  |                  |                  | 18 x 18 x 16     |                  |
| 470                  | 10 x 10 x 12     | 12.5 x 12.5 x 13 | 12.5 x 12.5 x 16 | 16 x 16 x 16     | 16 x 16 x 16     | 18 x 18 x 21     | -                |
| 680                  | 12.5 x 12.5 x 13 | 12.5 x 12.5 x 16 | 16 x 16 x 16     | 16 x 16 x 16     | 18 x 18 x 16     | -                | -                |
| 820                  | →                | →                | →                | →                | 16 x 16 x 21     | -                | -                |
| 1000                 | 12.5 x 12.5 x 16 | 16 x 16 x 16     | 16 x 16 x 16     | 16 x 16 x 21     | 18 x 18 x 21     | -                | -                |
|                      |                  |                  |                  | 18 x 18 x 16     |                  | -                | -                |
| 1200                 | →                | →                | 18 x 18 x 16     | 18 x 18 x 21     | -                | -                | -                |
| 1500                 | 16 x 16 x 16     | 16 x 16 x 16     | 16 x 16 x 21     | -                | -                | -                | -                |
| 1800                 | →                | →                | 18 x 18 x 21     | -                | -                | -                | -                |
| 2200                 | 16 x 16 x 16     | 16 x 16 x 21     | -                | -                | -                | -                | -                |
|                      |                  | 18 x 18 x 16     | -                | -                | -                | -                | -                |
| 2700                 | →                | 18 x 18 x 21     | -                | -                | -                | -                | -                |
| 3300                 | 16 x 16 x 21     | -                | -                | -                | -                | -                | -                |
|                      | 18 x 18 x 16     | -                | -                | -                | -                | -                | -                |
| 3900                 | 18 x 18 x 21     | -                | -                | -                | -                | -                | -                |
| 4700                 | 18 x 18 x 21     | -                | -                | -                | -                | -                | -                |

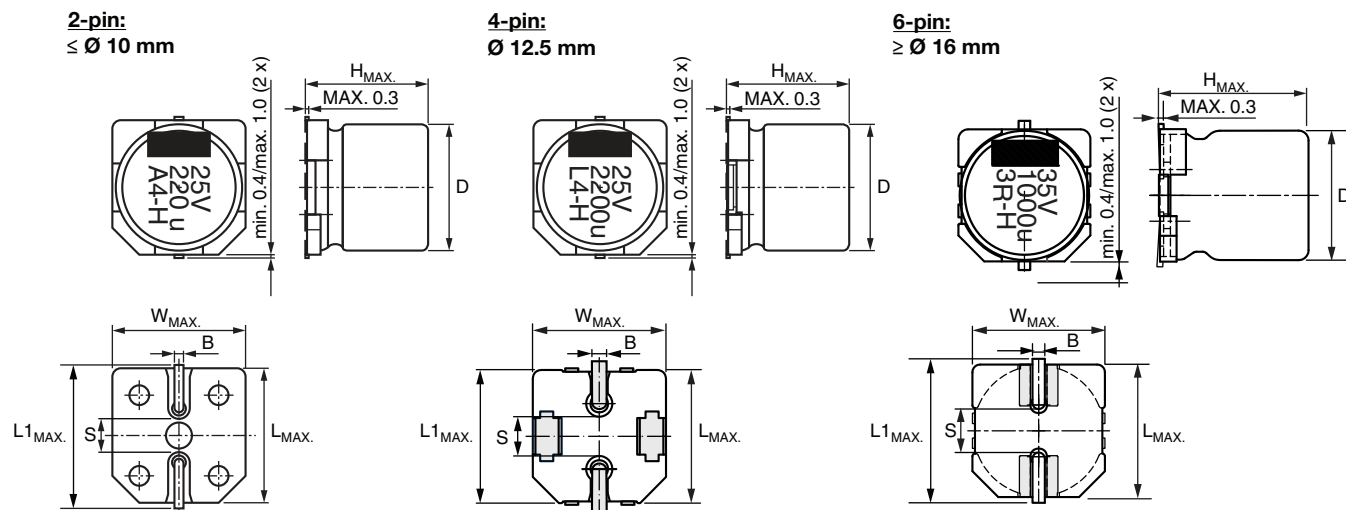


Fig. 2 - Dimensional outline



Table 1

| <b>DIMENSIONS in millimeters AND MASS</b> |              |                   |                   |                   |      |                   |     |                    |             |
|-------------------------------------------|--------------|-------------------|-------------------|-------------------|------|-------------------|-----|--------------------|-------------|
| NOMINAL<br>CASE SIZE<br>L x W x H         | CASE<br>CODE | L <sub>MAX.</sub> | W <sub>MAX.</sub> | H <sub>MAX.</sub> | Ø D  | B <sub>MAX.</sub> | S   | L1 <sub>MAX.</sub> | MASS<br>(g) |
| 8 x 8 x 10                                | 0810         | 8.5               | 8.5               | 10.5              | 8.0  | 1.0               | 2.2 | 10.2               | ≈ 1.0       |
| 10 x 10 x 10                              | 1010         | 10.5              | 10.5              | 10.5              | 10.0 | 1.0               | 3.5 | 12.1               | ≈ 1.3       |
| 10 x 10 x 12                              | 1012         | 10.5              | 10.5              | 12.5              | 10.0 | 1.0               | 3.5 | 12.1               | ≈ 1.5       |
| 12.5 x 12.5 x 13                          | 1213         | 12.9              | 12.9              | 14.0              | 12.5 | 1.3               | 3.6 | 14.9               | ≈ 2.6       |
| 12.5 x 12.5 x 16                          | 1216         | 12.9              | 12.9              | 16.5              | 12.5 | 1.3               | 3.6 | 14.9               | ≈ 2.8       |
| 16 x 16 x 16                              | 1616         | 16.6              | 16.6              | 17.5              | 16.0 | 1.3               | 6.5 | 18.6               | ≈ 5.5       |
| 16 x 16 x 21                              | 1621         | 16.6              | 16.6              | 22.0              | 16.0 | 1.3               | 6.5 | 18.6               | ≈ 6.0       |
| 18 x 18 x 16                              | 1816         | 19.0              | 19.0              | 17.5              | 18.0 | 1.3               | 6.5 | 21.0               | ≈ 8.0       |
| 18 x 18 x 21                              | 1821         | 19.0              | 19.0              | 22.0              | 18.0 | 1.3               | 6.5 | 21.0               | ≈ 8.3       |

Table 2

| <b>TAPE AND REEL DIMENSIONS in millimeters, PACKAGING QUANTITIES</b> |              |                         |                 |                                     |               |                                   |
|----------------------------------------------------------------------|--------------|-------------------------|-----------------|-------------------------------------|---------------|-----------------------------------|
| NOMINAL<br>CASE SIZE<br>L x W x H                                    | CASE<br>CODE | PITCH<br>P <sub>1</sub> | TAPE WIDTH<br>W | TAPE<br>THICKNESS<br>T <sub>2</sub> | REEL DIAMETER | PACKAGING<br>QUANTITY<br>PER REEL |
| 8 x 8 x 10                                                           | 0810         | 16                      | 24              | 11.6                                | 380           | 500                               |
| 10 x 10 x 10                                                         | 1010         | 16                      | 24              | 11.6                                | 380           | 500                               |
| 10 x 10 x 12                                                         | 1012         | 16                      | 24              | 12.8                                | 330           | 250                               |
| 12.5 x 12.5 x 13                                                     | 1213         | 20                      | 24              | 16.2                                | 380           | 250                               |
| 12.5 x 12.5 x 16                                                     | 1216         | 24                      | 32              | 18.5                                | 380           | 200                               |
| 16 x 16 x 16                                                         | 1616         | 28                      | 44              | 18.9                                | 380           | 150                               |
| 16 x 16 x 21                                                         | 1621         | 28                      | 44              | 23.4                                | 380           | 100                               |
| 18 x 18 x 16                                                         | 1816         | 32                      | 44              | 18.9                                | 380           | 125                               |
| 18 x 18 x 21                                                         | 1821         | 32                      | 44              | 23.4                                | 380           | 100                               |

**Note**

- Detailed tape dimensions see section "PACKAGING"

## MOUNTING

The capacitors are designed for automatic placement on to printed-circuit boards.

Optimum dimensions of soldering pads depend amongst others on soldering method, mounting accuracy, print layout and / or adjacent components.

For recommended soldering pad dimensions, refer to Fig. 3 and Table 3.

## SOLDERING

Soldering conditions are defined by the curve, temperature versus time, where the temperature is that measured on the component during processing.

For maximum conditions refer to Fig. 4.

Any temperature versus time curve which does not exceed the specified maximum curves may be applied.

As a general principle, temperature and duration shall be the **minimum** necessary required to ensure good soldering connections. However, the specified maximum curves should never be exceeded.

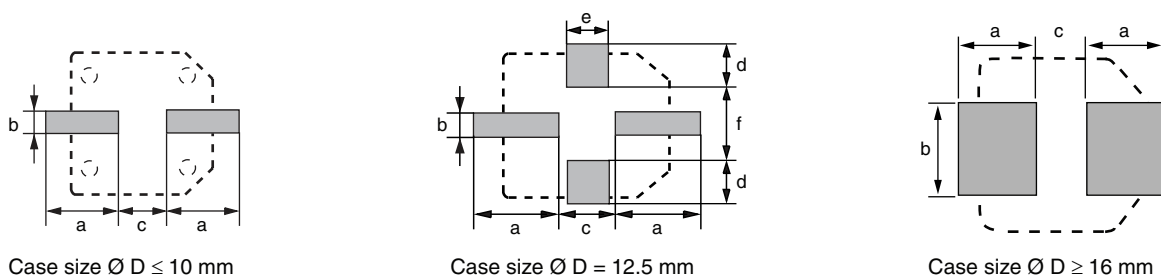


Fig. 3 - Recommended soldering pad dimensions

Table 3

| RECOMMENDED SOLDERING PAD DIMENSIONS in millimeters |     |     |     |     |     |     |
|-----------------------------------------------------|-----|-----|-----|-----|-----|-----|
| CASE CODE                                           | a   | b   | c   | d   | e   | f   |
| 0810                                                | 4.4 | 2.5 | 3.0 | -   | -   | -   |
| 1010                                                | 4.4 | 2.5 | 4.0 | -   | -   | -   |
| 1012                                                | 4.4 | 2.5 | 4.0 | -   | -   | -   |
| 1213                                                | 6.3 | 2.5 | 4.0 | 4.2 | 5.0 | 5.6 |
| 1216                                                | 6.3 | 2.5 | 4.0 | 4.2 | 5.0 | 5.6 |
| 1616                                                | 7.8 | 9.6 | 4.7 | -   | -   | -   |
| 1621                                                | 7.8 | 9.6 | 4.7 | -   | -   | -   |
| 1816                                                | 8.8 | 9.6 | 4.7 | -   | -   | -   |
| 1821                                                | 8.8 | 9.6 | 4.7 | -   | -   | -   |

# **ADVANCED SOLDERING PROFILE FOR LEAD (Pb)-FREE REFLOW PROCESS ACCORDING TO JEDEC J-STD-020**

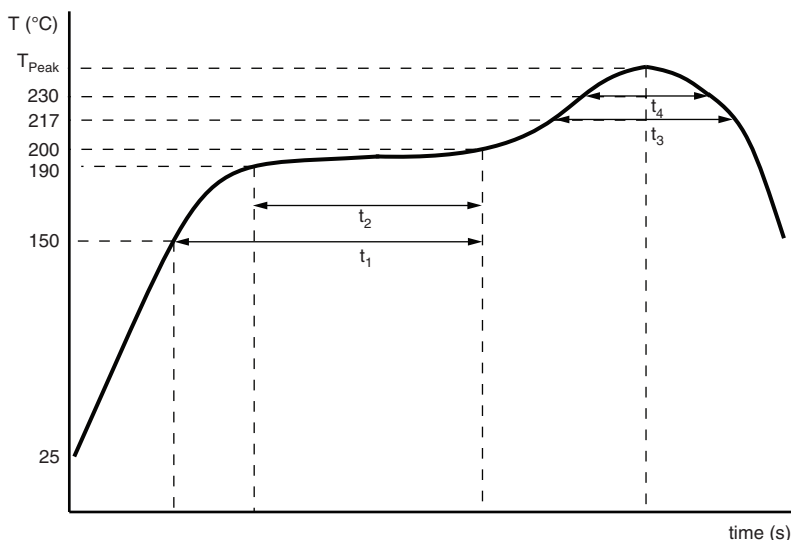


Fig. 4 - Maximum temperature load during reflow soldering

Table 4

| <b>REFLOW SOLDERING CONDITIONS</b> for MAL214699xxxE3 |                                   |                                   |                                   |
|-------------------------------------------------------|-----------------------------------|-----------------------------------|-----------------------------------|
| <b>PROFILE FEATURES</b>                               | <b>CASE CODE<br/>0810 TO 1012</b> | <b>CASE CODE<br/>1213 TO 1216</b> | <b>CASE CODE<br/>1616 TO 1821</b> |
| Max. time from 25 °C to $T_{Peak}$                    | 300 s                             | 300 s                             | 300 s                             |
| Max. ramp-up rate to 150 °C                           | 3 K/s                             | 3 K/s                             | 3 K/s                             |
| Max. time from 150 °C to 200 °C ( $t_1$ )             | 150 s                             | 150 s                             | 150 s                             |
| Max. time from 190 °C to 200 °C ( $t_2$ )             | 110 s                             | 110 s                             | 110 s                             |
| Ramp up rate from 200 °C to $T_{Peak}$                | 0.5 K/s to 3 K/s                  | 0.5 K/s to 3 K/s                  | 0.5 K/s to 3 K/s                  |
| Max. time above $T_{Liquidus}$ (217 °C) ( $t_3$ )     | 90 s                              | 90 s                              | 90 s                              |
| Max. time above 230 °C ( $t_4$ )                      | 70 s                              | 65 s                              | 60 s                              |
| Peak temperature $T_{Peak}$                           | 260 °C                            | 250 °C                            | 245 °C                            |
| Max. time above $T_{Peak}$ minus 5 °C                 | 40 s                              | 30 s                              | 30 s                              |
| Ramp-down rate from $T_{Liquidus}$                    | 3 K/s to 6 K/s                    | 3 K/s to 6 K/s                    | 3 K/s to 6 K/s                    |

## **Notes**

- Temperature measuring point on top of the case and on terminals.
- Max. 2 runs with pause of min. 30 min in between.



| ELECTRICAL DATA |                                                   |
|-----------------|---------------------------------------------------|
| SYMBOL          | DESCRIPTION                                       |
| $C_R$           | Rated capacitance at 100 Hz, tolerance $\pm 20\%$ |
| $I_R$           | Rated RMS ripple current at 100 kHz, 125 °C       |
| $I_{L2}$        | Max. leakage current after 2 min at $U_R$         |
| $\tan \delta$   | Max. dissipation factor at 100 Hz                 |
| Z               | Max. impedance at 100 kHz                         |

**Note**

- Unless otherwise specified, all electrical values in Table 5 apply at  $T_{amb} = 20\text{ °C}$ ,  $P = 86\text{ kPa}$  to  $106\text{ kPa}$ ,  $RH = 45\%$  to  $75\%$

Table 5

| ELECTRICAL DATA AND ORDERING INFORMATION |                            |                                           |                                    |                                        |                         |                                       |                                        |                             |                             |
|------------------------------------------|----------------------------|-------------------------------------------|------------------------------------|----------------------------------------|-------------------------|---------------------------------------|----------------------------------------|-----------------------------|-----------------------------|
| $U_R$<br>(V)                             | $C_R$<br>( $\mu\text{F}$ ) | NOMINAL<br>CASE SIZE<br>L x W x H<br>(mm) | $I_R$<br>125 °C<br>100 kHz<br>(mA) | $I_{L2}$<br>2 min<br>( $\mu\text{A}$ ) | $\tan \delta$<br>100 Hz | Z<br>100 kHz<br>20 °C<br>( $\Omega$ ) | Z<br>100 kHz<br>-40 °C<br>( $\Omega$ ) | LIFE<br>CODE <sup>(1)</sup> | ORDERING CODE<br>MAL2146... |
| 16                                       | 220                        | 8 x 8 x 10                                | 650                                | 35                                     | 0.16                    | 0.300                                 | 2.40                                   | L1                          | 99512E3                     |
|                                          | 330                        | 10 x 10 x 10                              | 750                                | 53                                     | 0.16                    | 0.150                                 | 1.35                                   | L1                          | 99501E3                     |
|                                          | 470                        | 10 x 10 x 12                              | 900                                | 75                                     | 0.16                    | 0.097                                 | 0.87                                   | L2                          | 99502E3                     |
|                                          | 680                        | 12.5 x 12.5 x 13                          | 1100                               | 109                                    | 0.16                    | 0.075                                 | 0.68                                   | L4                          | 99503E3                     |
|                                          | 1000                       | 12.5 x 12.5 x 16                          | 1300                               | 160                                    | 0.16                    | 0.058                                 | 0.52                                   | L5                          | 99504E3                     |
|                                          | 1500                       | 16 x 16 x 16                              | 1400                               | 240                                    | 0.16                    | 0.050                                 | 0.45                                   | L6                          | 99505E3                     |
|                                          | 2200                       | 16 x 16 x 16                              | 1400                               | 352                                    | 0.18                    | 0.050                                 | 0.45                                   | L6                          | 99506E3                     |
|                                          | 3300                       | 16 x 16 x 21                              | 1660                               | 528                                    | 0.20                    | 0.035                                 | 0.32                                   | L7                          | 99507E3                     |
|                                          | 3300                       | 18 x 18 x 16                              | 1500                               | 528                                    | 0.20                    | 0.050                                 | 0.45                                   | L6                          | 99508E3                     |
|                                          | 3900                       | 18 x 18 x 21                              | 1750                               | 624                                    | 0.20                    | 0.035                                 | 0.32                                   | L7                          | 99509E3                     |
| 25                                       | 4700                       | 18 x 18 x 21                              | 1750                               | 752                                    | 0.22                    | 0.035                                 | 0.32                                   | L7                          | 99511E3                     |
|                                          | 100                        | 8 x 8 x 10                                | 650                                | 25                                     | 0.14                    | 0.300                                 | 2.40                                   | L1                          | 99611E3                     |
|                                          | 220                        | 10 x 10 x 10                              | 750                                | 55                                     | 0.14                    | 0.150                                 | 1.35                                   | L1                          | 99601E3                     |
|                                          | 330                        | 10 x 10 x 12                              | 900                                | 83                                     | 0.14                    | 0.097                                 | 0.87                                   | L2                          | 99602E3                     |
|                                          | 470                        | 12.5 x 12.5 x 13                          | 1100                               | 118                                    | 0.14                    | 0.075                                 | 0.68                                   | L4                          | 99603E3                     |
|                                          | 680                        | 12.5 x 12.5 x 16                          | 1300                               | 170                                    | 0.14                    | 0.058                                 | 0.52                                   | L5                          | 99604E3                     |
|                                          | 1000                       | 16 x 16 x 16                              | 1400                               | 250                                    | 0.14                    | 0.050                                 | 0.45                                   | L6                          | 99605E3                     |
|                                          | 1500                       | 16 x 16 x 16                              | 1400                               | 375                                    | 0.14                    | 0.050                                 | 0.45                                   | L6                          | 99606E3                     |
|                                          | 2200                       | 16 x 16 x 21                              | 1660                               | 550                                    | 0.16                    | 0.035                                 | 0.32                                   | L7                          | 99607E3                     |
|                                          | 2200                       | 18 x 18 x 16                              | 1500                               | 550                                    | 0.16                    | 0.050                                 | 0.45                                   | L6                          | 99608E3                     |
| 35                                       | 2700                       | 18 x 18 x 21                              | 1750                               | 675                                    | 0.16                    | 0.035                                 | 0.32                                   | L7                          | 99609E3                     |
|                                          | 33                         | 8 x 8 x 10                                | 650                                | 12                                     | 0.12                    | 0.300                                 | 2.40                                   | L1                          | 99013E3                     |
|                                          | 47                         | 10 x 10 x 10                              | 750                                | 17                                     | 0.12                    | 0.150                                 | 1.35                                   | L1                          | 99001E3                     |
|                                          | 100                        | 10 x 10 x 10                              | 750                                | 35                                     | 0.12                    | 0.150                                 | 1.35                                   | L1                          | 99002E3                     |
|                                          | 150                        | 10 x 10 x 10                              | 750                                | 53                                     | 0.12                    | 0.150                                 | 1.35                                   | L1                          | 99003E3                     |
|                                          | 220                        | 10 x 10 x 12                              | 900                                | 77                                     | 0.12                    | 0.097                                 | 0.87                                   | L2                          | 99004E3                     |
|                                          | 330                        | 12.5 x 12.5 x 13                          | 1100                               | 116                                    | 0.12                    | 0.075                                 | 0.68                                   | L4                          | 99005E3                     |
|                                          | 470                        | 12.5 x 12.5 x 16                          | 1300                               | 165                                    | 0.12                    | 0.058                                 | 0.52                                   | L5                          | 99006E3                     |
|                                          | 680                        | 16 x 16 x 16                              | 1400                               | 238                                    | 0.12                    | 0.050                                 | 0.45                                   | L6                          | 99007E3                     |
|                                          | 1000                       | 16 x 16 x 16                              | 1400                               | 350                                    | 0.12                    | 0.050                                 | 0.45                                   | L6                          | 99008E3                     |
| 50                                       | 1200                       | 18 x 18 x 16                              | 1500                               | 420                                    | 0.12                    | 0.050                                 | 0.45                                   | L6                          | 99009E3                     |
|                                          | 1500                       | 16 x 16 x 21                              | 1660                               | 525                                    | 0.12                    | 0.035                                 | 0.32                                   | L7                          | 99011E3                     |
|                                          | 1800                       | 18 x 18 x 21                              | 1750                               | 630                                    | 0.12                    | 0.035                                 | 0.32                                   | L7                          | 99012E3                     |
|                                          | 47                         | 10 x 10 x 10                              | 600                                | 24                                     | 0.10                    | 0.240                                 | 2.16                                   | L1                          | 99101E3                     |
|                                          | 68                         | 10 x 10 x 10                              | 600                                | 34                                     | 0.10                    | 0.240                                 | 2.16                                   | L1                          | 99102E3                     |
|                                          | 100                        | 10 x 10 x 10                              | 600                                | 50                                     | 0.10                    | 0.240                                 | 2.16                                   | L1                          | 99103E3                     |
|                                          | 100                        | 10 x 10 x 12                              | 700                                | 50                                     | 0.10                    | 0.170                                 | 1.53                                   | L2                          | 99104E3                     |
|                                          | 150                        | 10 x 10 x 12                              | 700                                | 75                                     | 0.10                    | 0.170                                 | 1.53                                   | L2                          | 99105E3                     |
|                                          | 220                        | 12.5 x 12.5 x 13                          | 900                                | 110                                    | 0.10                    | 0.120                                 | 1.08                                   | L4                          | 99106E3                     |
|                                          | 330                        | 12.5 x 12.5 x 16                          | 1100                               | 165                                    | 0.10                    | 0.085                                 | 0.76                                   | L5                          | 99107E3                     |
|                                          | 470                        | 16 x 16 x 16                              | 1300                               | 235                                    | 0.10                    | 0.072                                 | 0.65                                   | L6                          | 99108E3                     |
|                                          | 680                        | 16 x 16 x 16                              | 1300                               | 340                                    | 0.10                    | 0.072                                 | 0.65                                   | L6                          | 99109E3                     |
|                                          | 1000                       | 16 x 16 x 21                              | 1500                               | 500                                    | 0.10                    | 0.052                                 | 0.47                                   | L7                          | 99111E3                     |
|                                          | 1000                       | 18 x 18 x 16                              | 1300                               | 500                                    | 0.10                    | 0.070                                 | 0.63                                   | L6                          | 99112E3                     |
|                                          | 1200                       | 18 x 18 x 21                              | 1600                               | 600                                    | 0.10                    | 0.049                                 | 0.44                                   | L7                          | 99113E3                     |

| ELECTRICAL DATA AND ORDERING INFORMATION |                     |                                           |                                    |                                 |                         |                                       |                                        |                             |                             |
|------------------------------------------|---------------------|-------------------------------------------|------------------------------------|---------------------------------|-------------------------|---------------------------------------|----------------------------------------|-----------------------------|-----------------------------|
| $U_R$<br>(V)                             | $C_R$<br>( $\mu$ F) | NOMINAL<br>CASE SIZE<br>L x W x H<br>(mm) | $I_R$<br>125 °C<br>100 kHz<br>(mA) | $I_{L2}$<br>2 min<br>( $\mu$ A) | $\tan \delta$<br>100 Hz | Z<br>100 kHz<br>20 °C<br>( $\Omega$ ) | Z<br>100 kHz<br>-40 °C<br>( $\Omega$ ) | LIFE<br>CODE <sup>(1)</sup> | ORDERING CODE<br>MAL2146... |
| 63                                       | 22                  | 10 x 10 x 10                              | 400                                | 14                              | 0.10                    | 0.430                                 | 3.90                                   | L1                          | 99801E3                     |
|                                          | 33                  | 10 x 10 x 10                              | 470                                | 21                              | 0.10                    | 0.380                                 | 3.40                                   | L1                          | 99802E3                     |
|                                          | 47                  | 10 x 10 x 10                              | 470                                | 30                              | 0.10                    | 0.380                                 | 3.40                                   | L1                          | 99803E3                     |
|                                          | 68                  | 10 x 10 x 10                              | 470                                | 43                              | 0.10                    | 0.380                                 | 3.40                                   | L1                          | 99804E3                     |
|                                          | 100                 | 10 x 10 x 12                              | 550                                | 63                              | 0.10                    | 0.290                                 | 2.61                                   | L2                          | 99805E3                     |
|                                          | 100                 | 12.5 x 12.5 x 13                          | 650                                | 63                              | 0.10                    | 0.210                                 | 1.89                                   | L4                          | 99806E3                     |
|                                          | 150                 | 12.5 x 12.5 x 13                          | 650                                | 95                              | 0.10                    | 0.210                                 | 1.89                                   | L4                          | 99807E3                     |
|                                          | 220                 | 12.5 x 12.5 x 16                          | 800                                | 139                             | 0.10                    | 0.160                                 | 1.44                                   | L5                          | 99808E3                     |
|                                          | 330                 | 16 x 16 x 16                              | 1050                               | 208                             | 0.10                    | 0.100                                 | 0.90                                   | L6                          | 99809E3                     |
|                                          | 470                 | 16 x 16 x 16                              | 1050                               | 296                             | 0.10                    | 0.100                                 | 0.90                                   | L6                          | 99811E3                     |
|                                          | 680                 | 18 x 18 x 16                              | 1150                               | 428                             | 0.10                    | 0.095                                 | 0.86                                   | L6                          | 99812E3                     |
|                                          | 820                 | 16 x 16 x 21                              | 1300                               | 517                             | 0.10                    | 0.075                                 | 0.68                                   | L7                          | 99813E3                     |
| 80                                       | 1000                | 18 x 18 x 21                              | 1400                               | 630                             | 0.10                    | 0.072                                 | 0.65                                   | L7                          | 99814E3                     |
|                                          | 10                  | 10 x 10 x 10                              | 240                                | 8                               | 0.12                    | 0.800                                 | 6.40                                   | L2                          | 99701E3                     |
|                                          | 22                  | 10 x 10 x 10                              | 240                                | 18                              | 0.12                    | 0.800                                 | 6.40                                   | L2                          | 99702E3                     |
|                                          | 33                  | 10 x 10 x 10                              | 240                                | 26                              | 0.12                    | 0.800                                 | 6.40                                   | L2                          | 99703E3                     |
|                                          | 47                  | 10 x 10 x 12                              | 270                                | 38                              | 0.12                    | 0.620                                 | 4.96                                   | L2                          | 99704E3                     |
|                                          | 68                  | 10 x 10 x 12                              | 270                                | 54                              | 0.12                    | 0.620                                 | 4.96                                   | L2                          | 99705E3                     |
|                                          | 100                 | 12.5 x 12.5 x 13                          | 580                                | 80                              | 0.12                    | 0.350                                 | 2.80                                   | L3                          | 99706E3                     |
|                                          | 150                 | 12.5 x 12.5 x 16                          | 630                                | 120                             | 0.12                    | 0.250                                 | 2.00                                   | L3                          | 99707E3                     |
|                                          | 220                 | 16 x 16 x 16                              | 900                                | 176                             | 0.12                    | 0.180                                 | 1.44                                   | L3                          | 99708E3                     |
|                                          | 330                 | 16 x 16 x 21                              | 1100                               | 264                             | 0.12                    | 0.120                                 | 0.96                                   | L3                          | 99709E3                     |
| 100                                      | 330                 | 18 x 18 x 16                              | 900                                | 264                             | 0.12                    | 0.160                                 | 1.28                                   | L3                          | 99711E3                     |
|                                          | 470                 | 18 x 18 x 21                              | 1100                               | 376                             | 0.12                    | 0.110                                 | 0.88                                   | L3                          | 99712E3                     |
|                                          | 10                  | 10 x 10 x 10                              | 200                                | 10                              | 0.12                    | 1.200                                 | 9.50                                   | L2                          | 99901E3                     |
|                                          | 22                  | 10 x 10 x 10                              | 200                                | 22                              | 0.12                    | 1.200                                 | 9.50                                   | L2                          | 99902E3                     |
|                                          | 33                  | 10 x 10 x 12                              | 230                                | 33                              | 0.12                    | 0.930                                 | 7.40                                   | L2                          | 99903E3                     |
|                                          | 47                  | 10 x 10 x 12                              | 230                                | 47                              | 0.12                    | 0.930                                 | 7.40                                   | L2                          | 99904E3                     |
|                                          | 68                  | 12.5 x 12.5 x 13                          | 390                                | 68                              | 0.12                    | 0.650                                 | 5.20                                   | L3                          | 99905E3                     |
|                                          | 100                 | 12.5 x 12.5 x 16                          | 420                                | 100                             | 0.12                    | 0.500                                 | 4.00                                   | L3                          | 99906E3                     |
|                                          | 150                 | 16 x 16 x 16                              | 650                                | 150                             | 0.12                    | 0.300                                 | 2.40                                   | L3                          | 99907E3                     |
|                                          | 220                 | 16 x 16 x 21                              | 810                                | 220                             | 0.12                    | 0.230                                 | 1.80                                   | L3                          | 99908E3                     |
|                                          | 220                 | 18 x 18 x 16                              | 650                                | 220                             | 0.12                    | 0.300                                 | 2.40                                   | L3                          | 99909E3                     |
|                                          | 330                 | 18 x 18 x 21                              | 810                                | 330                             | 0.12                    | 0.230                                 | 1.80                                   | L3                          | 99911E3                     |

**Note**

- Determines the applicable row in the table "Endurance Test Duration and Useful Life"

**Table 6**

| ADDITIONAL ELECTRICAL DATA                   |                                                             |                                          |
|----------------------------------------------|-------------------------------------------------------------|------------------------------------------|
| PARAMETER                                    | CONDITIONS                                                  | VALUE                                    |
| <b>Voltage</b>                               |                                                             |                                          |
| Surge voltage for short periods              | IEC 60384-18, subclause 4.14                                | $U_S \leq 1.15 \times U_R$               |
| Reverse voltage for short periods            | IEC 60384-18, subclause 4.16; $T_A \leq 105$ °C             | $U_{rev} \leq 1$ V                       |
| <b>Current</b>                               |                                                             |                                          |
| Leakage current                              | After 2 min at $U_R$                                        | $I_{L2} \leq 0.01 \times C_R \times U_R$ |
| <b>Inductance</b>                            |                                                             |                                          |
| Equivalent series inductance (ESL)           | $\varnothing D = 8$ mm                                      | Typ. 6 nH                                |
|                                              | $\varnothing D = 10$ mm                                     | Typ. 8 nH                                |
|                                              | $\varnothing D \geq 12.5$ mm                                | Typ. 11 nH                               |
| <b>Resistance</b>                            |                                                             |                                          |
| Equivalent series resistance (ESR) at 100 Hz | Calculated from $\tan \delta_{max}$ and $C_R$ (see Table 5) | $ESR = \tan \delta / 2\pi f C_R$         |

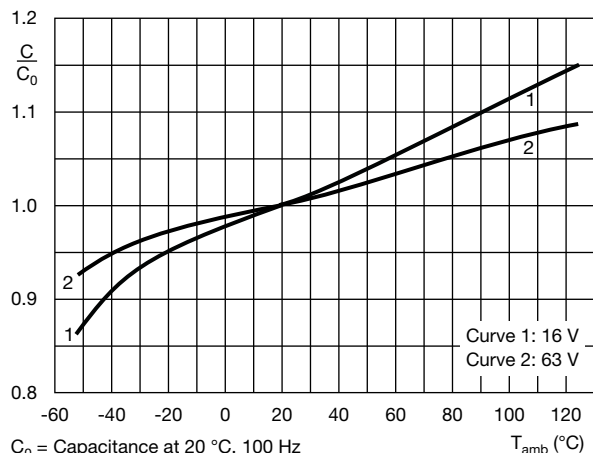
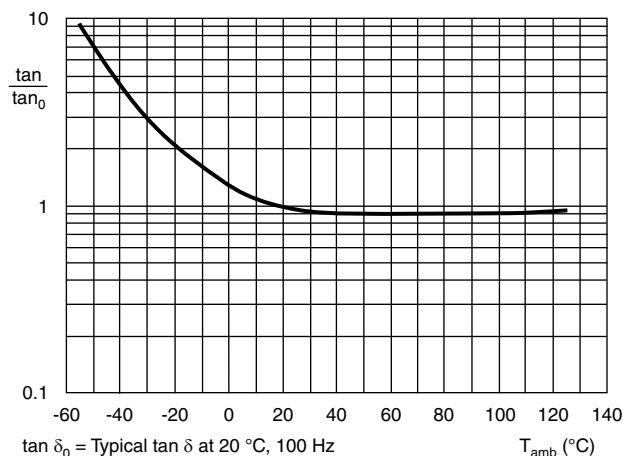
**CAPACITANCE (C)**


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

**DISSIPATION FACTOR ( $\tan \delta$ )**

Fig. 6 - Typical multiplier of dissipation factor ( $\tan \delta$ ) as a function of ambient temperature

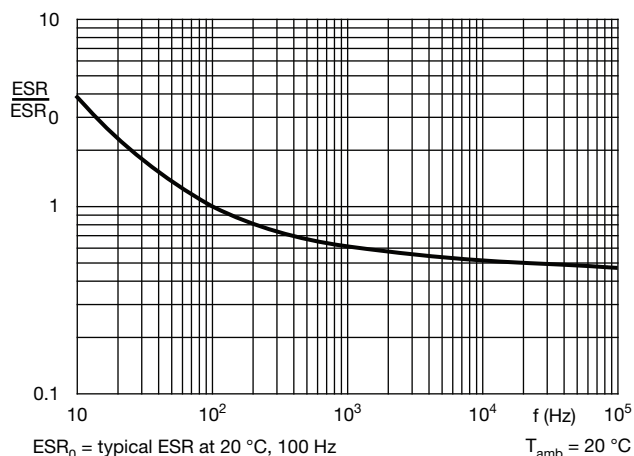
**EQUIVALENT SERIES RESISTANCE (ESR)**


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

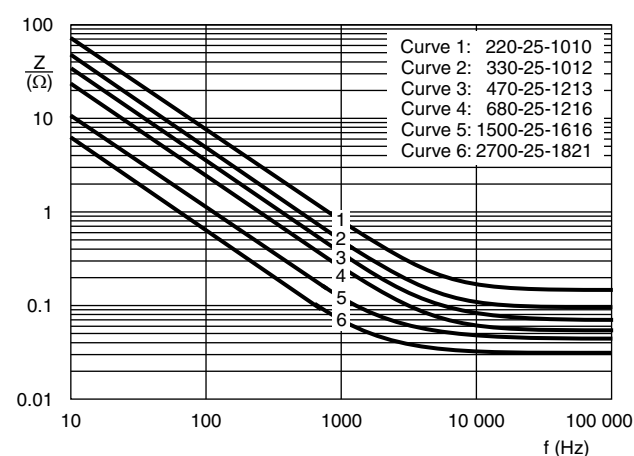
**IMPEDANCE (Z)**


Fig. 8 - Typical impedance as a function of frequency

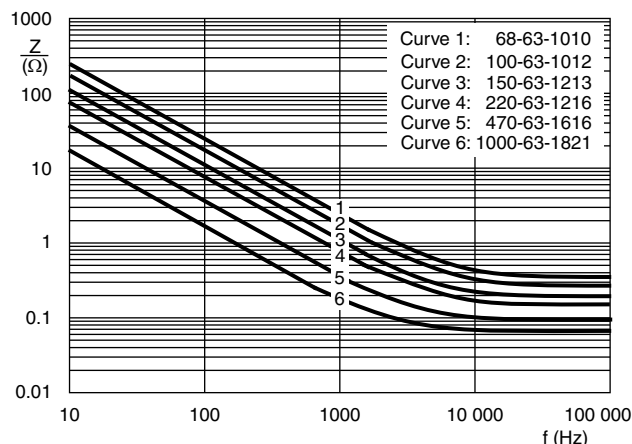
**IMPEDANCE (Z)**


Fig. 9 - Typical impedance as a function of frequency

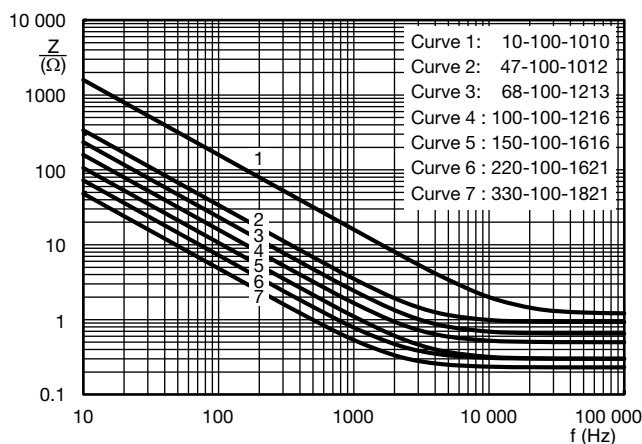


Fig. 10 - Typical impedance as a function of frequency

## RIPPLE CURRENT AND USEFUL LIFE

Table 7

| ENDURANCE TEST DURATION AND USEFUL LIFE |                         |                           |                                                       |
|-----------------------------------------|-------------------------|---------------------------|-------------------------------------------------------|
| LIFE CODE                               | ENDURANCE AT 125 °C (h) | USEFUL LIFE AT 125 °C (h) | USEFUL LIFE AT 40 °C 1.8 x I <sub>R</sub> APPLIED (h) |
| L1                                      | 1000                    | 1500                      | 150 000                                               |
| L2                                      | 1500                    | 2000                      | 200 000                                               |
| L3                                      | 2000                    | 2500                      | 250 000                                               |
| L4                                      | 2500                    | 3000                      | 300 000                                               |
| L5                                      | 3000                    | 4000                      | 325 000                                               |
| L6                                      | 4000                    | 5000                      | 350 000                                               |
| L7                                      | 5000                    | 6000                      | 400 000                                               |

### Note

- Multiplier of useful life code: MBC242

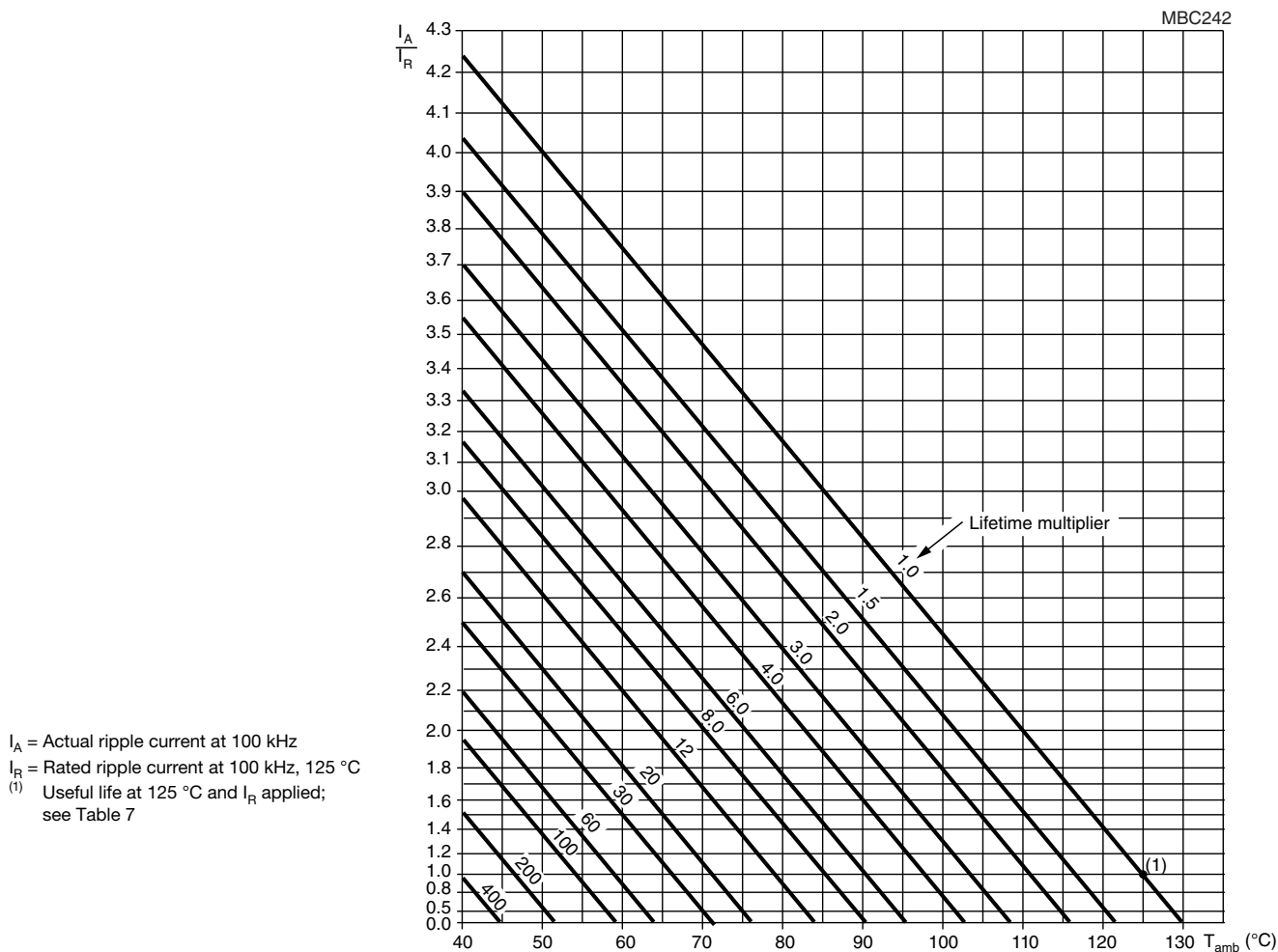


Fig. 11 - Multiplier of useful life as a function of ambient temperature and ripple current load

**Table 8**

| <b>MULTIPLIER OF RIPPLE CURRENT (<math>I_R</math>) AS A FUNCTION OF FREQUENCY</b> |                |      |      |      |      |        |        |         |
|-----------------------------------------------------------------------------------|----------------|------|------|------|------|--------|--------|---------|
| $U_R$<br>(V)                                                                      | FREQUENCY (Hz) |      |      |      |      |        |        |         |
|                                                                                   | 50             | 100  | 300  | 1000 | 3000 | 10 000 | 30 000 | 100 000 |
| 16                                                                                | 0.60           | 0.70 | 0.80 | 0.85 | 0.90 | 0.95   | 0.97   | 1.00    |
| 25                                                                                | 0.60           | 0.70 | 0.80 | 0.85 | 0.90 | 0.95   | 0.97   | 1.00    |
| 35                                                                                | 0.45           | 0.65 | 0.80 | 0.85 | 0.90 | 0.95   | 0.97   | 1.00    |
| 50                                                                                | 0.40           | 0.60 | 0.75 | 0.82 | 0.90 | 0.95   | 0.97   | 1.00    |
| 63                                                                                | 0.40           | 0.60 | 0.75 | 0.82 | 0.90 | 0.95   | 0.97   | 1.00    |
| 80                                                                                | 0.40           | 0.60 | 0.75 | 0.82 | 0.90 | 0.95   | 0.97   | 1.00    |
| 100                                                                               | 0.40           | 0.60 | 0.75 | 0.82 | 0.90 | 0.95   | 0.97   | 1.00    |

**Table 9**

| <b>TEST PROCEDURES AND REQUIREMENTS</b>     |                                           |                                                                                                                                                  |                                                                                                                                                                                    |
|---------------------------------------------|-------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| TEST                                        |                                           | PROCEDURE<br>(quick reference)                                                                                                                   | REQUIREMENTS                                                                                                                                                                       |
| NAME OF TEST                                | REFERENCE                                 |                                                                                                                                                  |                                                                                                                                                                                    |
| Mounting                                    | IEC 60384-18, subclause 4.3               | Shall be performed prior to tests mentioned below; reflow soldering; for maximum temperature load refer to chapter "Mounting"                    | $\Delta C/C: \pm 5 \%$<br>$\tan \delta \leq \text{spec. limit}$<br>$I_{L2} \leq \text{spec. limit}$                                                                                |
| Endurance                                   | IEC 60384-18 / CECC 32300, subclause 4.15 | $T_{\text{amb}} = 125^\circ\text{C}$ ; $U_R$ applied; for test duration see Table 7                                                              | $U_R \geq 16 \text{ V}$ ; $\Delta C/C: \pm 20 \%$<br>$\tan \delta \leq 2 \times \text{spec. limit}$<br>$I_{L2} \leq \text{spec. limit}$                                            |
| Useful life                                 | CECC 30301, subclause 1.8.1               | $T_{\text{amb}} = 125^\circ\text{C}$ ; $U_R$ and $I_R$ applied; for test duration see Table 7                                                    | $\Delta C/C: \pm 30 \%$<br>$\tan \delta \leq 3 \times \text{spec. limit}$<br>$I_{L2} \leq \text{spec. limit}$<br>no short or open circuit<br>total failure percentage: $\leq 1 \%$ |
| Shelf life<br>(storage at high temperature) | IEC 60384-18 / CECC 32300, subclause 4.17 | $T_{\text{amb}} = 125^\circ\text{C}$ ; no voltage applied; 1000 h<br>after test: $U_R$ to be applied for 30 min, 24 h to 48 h before measurement | For requirements see "Endurance test" above                                                                                                                                        |
| Reverse voltage                             | IEC 60384-18 / CECC 32300, subclause 4.16 | $T_{\text{amb}} = 125^\circ\text{C}$ :<br>125 h at $U = -0.5 \text{ V}$ , followed by 125 h at $U_R$                                             | $\Delta C/C: \pm 15 \%$<br>$\tan \delta \leq 1.5 \times \text{spec. limit}$<br>$I_{L2} \leq \text{spec. limit}$                                                                    |

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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