

## Aluminum Capacitors SMD (Chip), Very Low Z

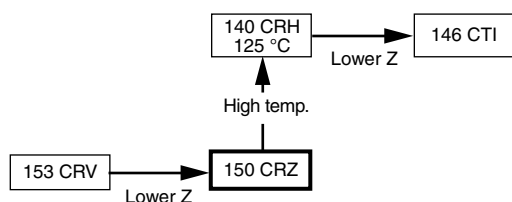


Fig. 1

### 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, $C_R$               | 4.7 $\mu$ F to 10 000 $\mu$ F |
| Tolerance on $C_R$                           | $\pm 20 \%$                   |
| Rated voltage range, $U_R$                   | 6.3 V to 100 V                |
| Category temperature range                   |                               |
| 6.3 V to 63 V:                               | -55 °C to +105 °C             |
| 80 V to 100 V:                               | -40 °C to +105 °C             |
| Endurance test at 105 °C                     | 2000 h to 8000 h              |
| Useful life at 105 °C                        | 2500 h to 10 000 h            |
| Useful life at 40 °C;<br>1.8 x $I_R$ applied | 125 000 h to 500 000 h        |
| Shelf life at 0 V, 105 °C                    | 1000 h                        |
| Based on sectional<br>specification          | IEC 60384-18/CECC 32300       |
| Climatic category IEC 60068                  |                               |
| 6.3 V to 63 V:                               | 55/105/56                     |
| 80 V to 100 V:                               | 40/105/56                     |

### FEATURES

- Extended useful life: Up to 10 000 h at 105 °C for MAL215099...E3 parts
- Polarized aluminum electrolytic capacitors, non-solid electrolyte, self healing
- SMD-version with base plate, lead (Pb)-free reflow solderable
- Very low impedance, very high ripple current
- Charge and discharge proof, no peak current limitation
- Parts for advanced high 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)

AUTOMOTIVE  
GRADE

RoHS  
COMPLIANT

### APPLICATIONS

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

### MARKING

- Rated capacitance (in  $\mu$ 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 (Z)

### PACKAGING

Supplied in blister tape on reel

| SELECTION CHART FOR C <sub>R</sub> , U <sub>R</sub> , AND RELEVANT NOMINAL CASE SIZES (L x W x H in mm) |                    |                  |                  |                  |                  |                  |                  |                  |                  |
|---------------------------------------------------------------------------------------------------------|--------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|
| C <sub>R</sub><br>(μF)                                                                                  | U <sub>R</sub> (V) |                  |                  |                  |                  |                  |                  |                  |                  |
|                                                                                                         | 6.3                | 10               | 16               | 25               | 35               | 50               | 63               | 80               | 100              |
| 4.7                                                                                                     | →                  | →                | →                | →                | →                | →                | →                | →                | 10 x 10 x 10     |
| 10                                                                                                      | →                  | →                | →                | →                | →                | →                | →                | →                | 10 x 10 x 10     |
| 22                                                                                                      | →                  | →                | →                | →                | →                | →                | →                | →                | 10 x 10 x 10     |
| 33                                                                                                      | →                  | →                | →                | →                | →                | →                | 8 x 8 x 10       | →                | 10 x 10 x 10     |
| 47                                                                                                      | →                  | →                | →                | →                | →                | →                | 8 x 8 x 10       | 10 x 10 x 10     | 10 x 10 x 12     |
|                                                                                                         | →                  | →                | →                | →                | →                | →                | 10 x 10 x 10     |                  | -                |
| 68                                                                                                      | →                  | →                | →                | →                | →                | 8 x 8 x 10       | 10 x 10 x 10     | →                | 12.5 x 12.5 x 13 |
| 100                                                                                                     | →                  | →                | →                | →                | 8 x 8 x 10       | 10 x 10 x 10     | 10 x 10 x 12     | 10 x 10 x 12     | 12.5 x 12.5 x 13 |
|                                                                                                         |                    |                  |                  |                  |                  |                  | 10 x 10 x 14     |                  | -                |
| 150                                                                                                     | →                  | →                | →                | 8 x 8 x 10       | →                | →                | 12.5 x 12.5 x 13 | 12.5 x 12.5 x 13 | 12.5 x 12.5 x 16 |
| 220                                                                                                     | →                  | →                | 8 x 8 x 10       | 8 x 8 x 10       | 10 x 10 x 10     | 10 x 10 x 12     | 12.5 x 12.5 x 16 | 12.5 x 12.5 x 16 | 16 x 16 x 16     |
|                                                                                                         |                    |                  |                  |                  |                  | 10 x 10 x 14     |                  |                  | -                |
| 330                                                                                                     | →                  | 8 x 8 x 10       | 8 x 8 x 10       | 10 x 10 x 10     | 10 x 10 x 12     | 12.5 x 12.5 x 13 | 16 x 16 x 16     | 16 x 16 x 16     | 16 x 16 x 21     |
|                                                                                                         |                    |                  |                  |                  | 10 x 10 x 14     |                  |                  |                  | 18 x 18 x 16     |
| 470                                                                                                     | 8 x 8 x 10         | 8 x 8 x 10       | 10 x 10 x 10     | 10 x 10 x 12     | 12.5 x 12.5 x 13 | →                | 16 x 16 x 21     | 16 x 16 x 21     | 18 x 18 x 21     |
|                                                                                                         |                    |                  |                  | 10 x 10 x 14     |                  |                  | 18 x 18 x 16     | 18 x 18 x 16     | -                |
| 680                                                                                                     | →                  | 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     | 18 x 18 x 21     | 18 x 18 x 21     | -                |
|                                                                                                         |                    |                  | 10 x 10 x 14     |                  |                  |                  |                  |                  | -                |
| 1000                                                                                                    | 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     | -                | -                | -                |
|                                                                                                         |                    | 10 x 10 x 14     |                  |                  |                  | 18 x 18 x 16     | -                | -                | -                |
| 1500                                                                                                    | →                  | 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     | -                | -                | -                | -                |
| 2200                                                                                                    | 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     | -                | -                | -                | -                | -                |
| 3300                                                                                                    | →                  | 16 x 16 x 16     | 16 x 16 x 21     | 18 x 18 x 21     | -                | -                | -                | -                | -                |
|                                                                                                         |                    |                  | 18 x 18 x 16     | -                | -                | -                | -                | -                | -                |
| 4700                                                                                                    | 16 x 16 x 16       | 16 x 16 x 21     | 18 x 18 x 21     | -                | -                | -                | -                | -                | -                |
|                                                                                                         |                    | 18 x 18 x 16     | -                | -                | -                | -                | -                | -                | -                |
| 6800                                                                                                    | 16 x 16 x 21       | 18 x 18 x 21     | -                | -                | -                | -                | -                | -                | -                |
|                                                                                                         | 18 x 18 x 16       | -                | -                | -                | -                | -                | -                | -                | -                |
| 10 000                                                                                                  | 18 x 18 x 21       | -                | -                | -                | -                | -                | -                | -                | -                |

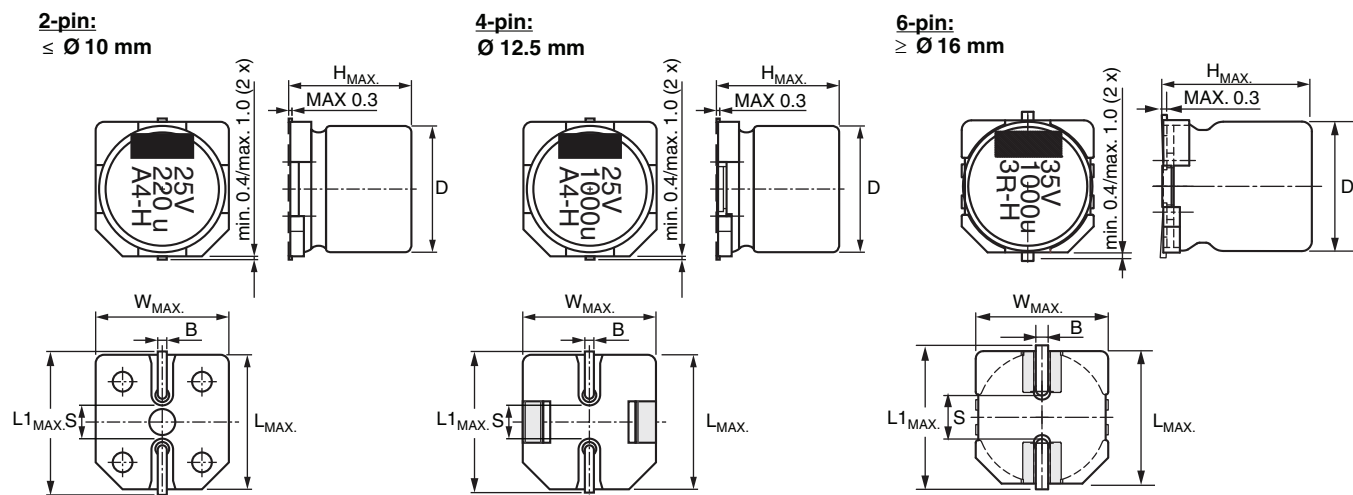


Fig. 2 - Dimensional outline



Table 1

| DIMENSIONS in millimeters AND MASS |           |                   |                   |                   |      |                   |     |                    |          |
|------------------------------------|-----------|-------------------|-------------------|-------------------|------|-------------------|-----|--------------------|----------|
| NOMINAL CASE SIZE<br>L x W x H     | CASE 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 (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    |
| 10 x 10 x 14                       | 1014      | 10.5              | 10.5              | 14.3              | 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

| TAPE AND REEL DIMENSIONS in millimeters, PACKAGING QUANTITIES |           |                         |                 |                                  |               |                                |
|---------------------------------------------------------------|-----------|-------------------------|-----------------|----------------------------------|---------------|--------------------------------|
| NOMINAL CASE SIZE<br>L x W x H                                | CASE CODE | PITCH<br>P <sub>1</sub> | TAPE WIDTH<br>W | TAPE THICKNESS<br>T <sub>2</sub> | REEL DIAMETER | PACKAGING 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                            |
| 10 x 10 x 14                                                  | 1014      | 16                      | 24              | 15.4                             | 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 or Fig. 5.

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.

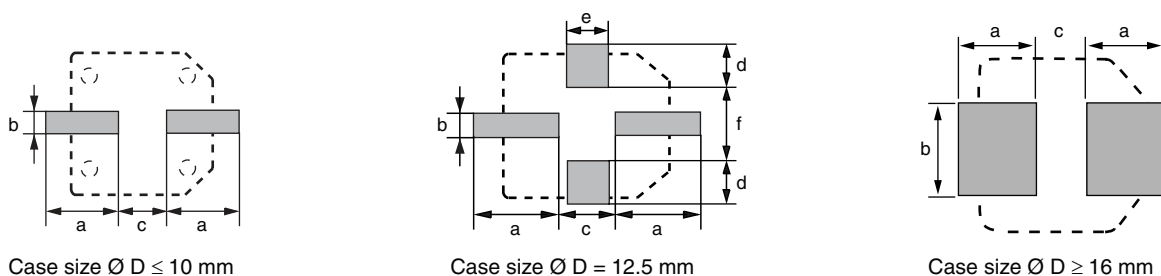


Fig. 3 - Recommended soldering pad dimensions

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 | -   | -   | -   |
| 1014                                                | 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 | -   | -   | -   |

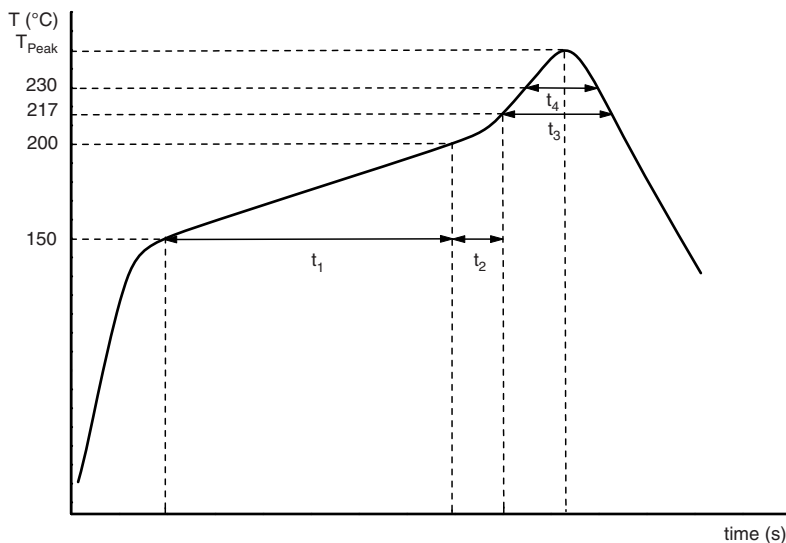
**STANDARD SOLDERING PROFILE FOR LEAD (Pb)-FREE REFLOW PROCESS**


Fig. 4 - Maximum temperature load during reflow soldering

**Table 4**

| <b>REFLOW SOLDERING CONDITIONS</b> for MAL215097xxxE3 |                                   |                                   |
|-------------------------------------------------------|-----------------------------------|-----------------------------------|
| <b>PROFILE FEATURES</b>                               | <b>CASE CODE<br/>0810 TO 1014</b> | <b>CASE CODE<br/>1213 TO 1216</b> |
| Max. time from 25 °C to $T_{peak}$                    | 240 s                             | 200 s                             |
| Max. ramp-up rate to 150 °C                           | 3 K/s                             | 3 K/s                             |
| Max. time from 150 °C to 200 °C ( $t_1$ )             | 150 s                             | 120 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                  |
| Max. time from 200 °C to 217 °C ( $t_2$ )             | 60 s                              | 60 s                              |
| Max. time above $T_{Liquidus}$ (217 °C) ( $t_3$ )     | 90 s                              | 60 s                              |
| Max. time above 230 °C ( $t_4$ )                      | 40 s                              | 30 s                              |
| Peak temperature $T_{peak}$                           | 250 °C                            | 240 °C                            |
| Max. time above $T_{peak}$ minus 5 °C                 | 5 s                               | 10 s                              |
| Max. ramp-down rate from $T_{Liquidus}$               | 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.

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

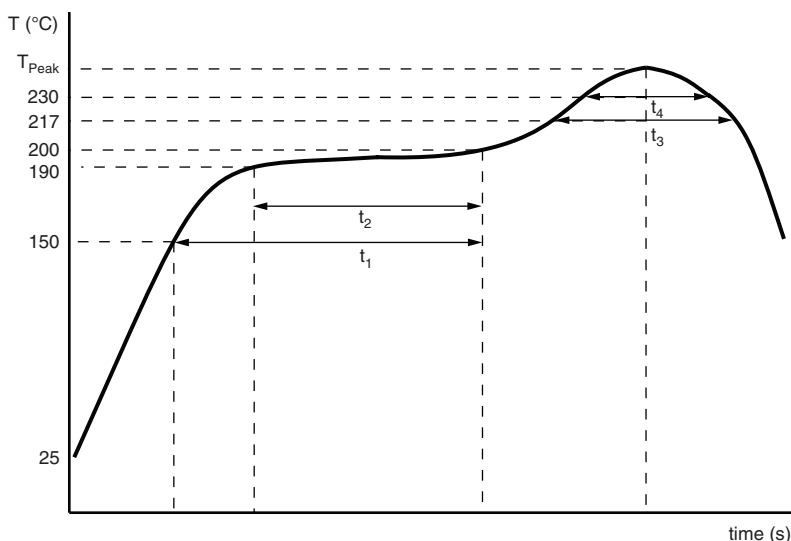


Fig. 5 - Maximum temperature load during reflow soldering

Table 5

| <b>REFLOW SOLDERING CONDITIONS</b> for MAL215099xxxE3 |                                   |                                   |                                   |
|-------------------------------------------------------|-----------------------------------|-----------------------------------|-----------------------------------|
| <b>PROFILE FEATURES</b>                               | <b>CASE CODE<br/>1010 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, 105 °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 6 apply at  $T_{amb} = 20\text{ °C}$ ,  $P = 86\text{ kPa}$  to  $106\text{ kPa}$ ,  $RH = 45\%$  to  $75\%$

Table 6

| ELECTRICAL DATA AND ORDERING INFORMATION |                            |                                        |                                 |                                     |                         |                                         |                                          |                                               |                                               |
|------------------------------------------|----------------------------|----------------------------------------|---------------------------------|-------------------------------------|-------------------------|-----------------------------------------|------------------------------------------|-----------------------------------------------|-----------------------------------------------|
| $U_R$<br>(V)                             | $C_R$<br>( $\mu\text{F}$ ) | NOMINAL CASE SIZE<br>L x W x H<br>(mm) | $I_R$ 105 °C<br>100 kHz<br>(mA) | $I_L$<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>( $\Omega$ ) | ORDERING<br>CODE <sup>(1)</sup><br>MAL2150... | ORDERING<br>CODE <sup>(2)</sup><br>MAL2150... |
| 6.3                                      | 470                        | 8 x 8 x 10                             | 435                             | 30                                  | 0.24                    | 0.250                                   | 2.00                                     | 97311E3                                       | -                                             |
|                                          | 1000                       | 10 x 10 x 10                           | 670                             | 63                                  | 0.24                    | 0.130                                   | 1.10                                     | 97301E3                                       | 99301E3                                       |
|                                          | 2200                       | 12.5 x 12.5 x 13                       | 905                             | 139                                 | 0.26                    | 0.077                                   | 0.60                                     | 97312E3                                       | 99312E3                                       |
|                                          | 4700                       | 16 x 16 x 16                           | 1350                            | 296                                 | 0.28                    | 0.050                                   | 0.40                                     | -                                             | 99313E3                                       |
|                                          | 6800                       | 16 x 16 x 21                           | 1666                            | 428                                 | 0.30                    | 0.035                                   | 0.28                                     | -                                             | 99314E3                                       |
|                                          | 6800                       | 18 x 18 x 16                           | 1400                            | 428                                 | 0.32                    | 0.050                                   | 0.40                                     | -                                             | 99315E3                                       |
|                                          | 10 000                     | 18 x 18 x 21                           | 1756                            | 630                                 | 0.34                    | 0.035                                   | 0.28                                     | -                                             | 99316E3                                       |
| 10                                       | 330                        | 8 x 8 x 10                             | 435                             | 33                                  | 0.20                    | 0.250                                   | 2.00                                     | 97411E3                                       | -                                             |
|                                          | 470                        | 8 x 8 x 10                             | 435                             | 47                                  | 0.20                    | 0.250                                   | 2.00                                     | 97412E3                                       | -                                             |
|                                          | 680                        | 10 x 10 x 10                           | 670                             | 68                                  | 0.20                    | 0.130                                   | 1.10                                     | 97401E3                                       | 99401E3                                       |
|                                          | 1000                       | 10 x 10 x 12                           | 850                             | 100                                 | 0.20                    | 0.100                                   | 0.80                                     | -                                             | 99403E3                                       |
|                                          | 1000                       | 10 x 10 x 14                           | 850                             | 100                                 | 0.20                    | 0.100                                   | 0.80                                     | 97402E3                                       | -                                             |
|                                          | 1500                       | 12.5 x 12.5 x 13                       | 905                             | 150                                 | 0.22                    | 0.077                                   | 0.60                                     | 97413E3                                       | 99413E3                                       |
|                                          | 2200                       | 12.5 x 12.5 x 16                       | 1007                            | 220                                 | 0.22                    | 0.060                                   | 0.48                                     | 97414E3                                       | 99414E3                                       |
|                                          | 3300                       | 16 x 16 x 16                           | 1350                            | 330                                 | 0.24                    | 0.050                                   | 0.40                                     | -                                             | 99415E3                                       |
|                                          | 4700                       | 16 x 16 x 21                           | 1666                            | 470                                 | 0.26                    | 0.035                                   | 0.28                                     | -                                             | 99416E3                                       |
|                                          | 4700                       | 18 x 18 x 16                           | 1400                            | 470                                 | 0.26                    | 0.050                                   | 0.40                                     | -                                             | 99417E3                                       |
| 16                                       | 6800                       | 18 x 18 x 21                           | 1756                            | 680                                 | 0.28                    | 0.035                                   | 0.28                                     | -                                             | 99418E3                                       |
|                                          | 220                        | 8 x 8 x 10                             | 435                             | 35                                  | 0.16                    | 0.250                                   | 2.00                                     | 97511E3                                       | -                                             |
|                                          | 330                        | 8 x 8 x 10                             | 435                             | 53                                  | 0.16                    | 0.250                                   | 2.00                                     | 97512E3                                       | -                                             |
|                                          | 470                        | 10 x 10 x 10                           | 670                             | 75                                  | 0.16                    | 0.130                                   | 1.10                                     | 97501E3                                       | 99501E3                                       |
|                                          | 680                        | 10 x 10 x 12                           | 850                             | 109                                 | 0.16                    | 0.100                                   | 0.80                                     | -                                             | 99503E3                                       |
|                                          | 680                        | 10 x 10 x 14                           | 850                             | 109                                 | 0.16                    | 0.100                                   | 0.80                                     | 97502E3                                       | -                                             |
|                                          | 1000                       | 12.5 x 12.5 x 13                       | 905                             | 160                                 | 0.18                    | 0.077                                   | 0.60                                     | 97513E3                                       | 99513E3                                       |
|                                          | 1500                       | 12.5 x 12.5 x 16                       | 1007                            | 240                                 | 0.18                    | 0.060                                   | 0.48                                     | 97514E3                                       | 99514E3                                       |
|                                          | 2200                       | 16 x 16 x 16                           | 1350                            | 352                                 | 0.20                    | 0.050                                   | 0.40                                     | -                                             | 99515E3                                       |
|                                          | 3300                       | 16 x 16 x 21                           | 1666                            | 528                                 | 0.22                    | 0.035                                   | 0.28                                     | -                                             | 99516E3                                       |
| 25                                       | 3300                       | 18 x 18 x 16                           | 1400                            | 528                                 | 0.22                    | 0.050                                   | 0.40                                     | -                                             | 99517E3                                       |
|                                          | 4700                       | 18 x 18 x 21                           | 1756                            | 752                                 | 0.26                    | 0.035                                   | 0.28                                     | -                                             | 99518E3                                       |
|                                          | 150                        | 8 x 8 x 10                             | 420                             | 38                                  | 0.14                    | 0.280                                   | 2.24                                     | 97611E3                                       | -                                             |
|                                          | 220                        | 8 x 8 x 10                             | 420                             | 55                                  | 0.14                    | 0.280                                   | 2.24                                     | 97612E3                                       | -                                             |
|                                          | 330                        | 10 x 10 x 10                           | 640                             | 83                                  | 0.14                    | 0.140                                   | 1.12                                     | 97601E3                                       | 99601E3                                       |
|                                          | 470                        | 10 x 10 x 12                           | 820                             | 118                                 | 0.14                    | 0.110                                   | 0.88                                     | -                                             | 99603E3                                       |
|                                          | 470                        | 10 x 10 x 14                           | 820                             | 118                                 | 0.14                    | 0.110                                   | 0.88                                     | 97602E3                                       | -                                             |
|                                          | 680                        | 12.5 x 12.5 x 13                       | 905                             | 170                                 | 0.16                    | 0.077                                   | 0.60                                     | 97613E3                                       | 99613E3                                       |
|                                          | 1000                       | 12.5 x 12.5 x 16                       | 1007                            | 250                                 | 0.16                    | 0.060                                   | 0.48                                     | 97614E3                                       | 99614E3                                       |
|                                          | 1500                       | 16 x 16 x 16                           | 1350                            | 375                                 | 0.16                    | 0.050                                   | 0.40                                     | -                                             | 99615E3                                       |
| 25                                       | 2200                       | 16 x 16 x 21                           | 1666                            | 550                                 | 0.18                    | 0.035                                   | 0.28                                     | -                                             | 99616E3                                       |
|                                          | 2200                       | 18 x 18 x 16                           | 1400                            | 550                                 | 0.18                    | 0.050                                   | 0.40                                     | -                                             | 99617E3                                       |
|                                          | 3300                       | 18 x 18 x 21                           | 1756                            | 825                                 | 0.20                    | 0.035                                   | 0.28                                     | -                                             | 99618E3                                       |

**Notes**

<sup>(1)</sup> Standard reflow soldering profile, see Fig. 4 and Table 4

<sup>(2)</sup> Advanced reflow soldering profile, according to JEDEC J-STD-020, see Fig. 5 and Table 5



| ELECTRICAL DATA AND ORDERING INFORMATION |                     |                                        |                                 |                              |                         |                                       |                                        |                                               |                                               |
|------------------------------------------|---------------------|----------------------------------------|---------------------------------|------------------------------|-------------------------|---------------------------------------|----------------------------------------|-----------------------------------------------|-----------------------------------------------|
| $U_R$<br>(V)                             | $C_R$<br>( $\mu$ F) | NOMINAL CASE SIZE<br>L x W x H<br>(mm) | $I_R$ 105 °C<br>100 kHz<br>(mA) | $I_L$<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>( $\Omega$ ) | ORDERING<br>CODE <sup>(1)</sup><br>MAL2150... | ORDERING<br>CODE <sup>(2)</sup><br>MAL2150... |
| 35                                       | 100                 | 8 x 8 x 10                             | 405                             | 35                           | 0.12                    | 0.300                                 | 2.40                                   | 97011E3                                       | -                                             |
|                                          | 220                 | 10 x 10 x 10                           | 630                             | 77                           | 0.12                    | 0.150                                 | 1.20                                   | 97001E3                                       | 99001E3                                       |
|                                          | 330                 | 10 x 10 x 12                           | 790                             | 116                          | 0.12                    | 0.120                                 | 0.96                                   | -                                             | 99003E3                                       |
|                                          | 330                 | 10 x 10 x 14                           | 790                             | 116                          | 0.12                    | 0.120                                 | 0.96                                   | 97002E3                                       | -                                             |
|                                          | 470                 | 12.5 x 12.5 x 13                       | 905                             | 165                          | 0.14                    | 0.077                                 | 0.60                                   | 97012E3                                       | 99012E3                                       |
|                                          | 680                 | 12.5 x 12.5 x 16                       | 1007                            | 238                          | 0.14                    | 0.060                                 | 0.48                                   | 97013E3                                       | 99013E3                                       |
|                                          | 1000                | 16 x 16 x 16                           | 1350                            | 350                          | 0.14                    | 0.050                                 | 0.40                                   | -                                             | 99014E3                                       |
|                                          | 1500                | 16 x 16 x 21                           | 1666                            | 525                          | 0.14                    | 0.035                                 | 0.28                                   | -                                             | 99015E3                                       |
|                                          | 1500                | 18 x 18 x 16                           | 1400                            | 525                          | 0.14                    | 0.050                                 | 0.40                                   | -                                             | 99016E3                                       |
| 50                                       | 2200                | 18 x 18 x 21                           | 1756                            | 770                          | 0.16                    | 0.035                                 | 0.28                                   | -                                             | 99017E3                                       |
|                                          | 68                  | 8 x 8 x 10                             | 333                             | 34                           | 0.12                    | 0.480                                 | 3.84                                   | 97111E3                                       | -                                             |
|                                          | 100                 | 10 x 10 x 10                           | 490                             | 50                           | 0.12                    | 0.240                                 | 1.92                                   | 97101E3                                       | 99101E3                                       |
|                                          | 220                 | 10 x 10 x 12                           | 620                             | 110                          | 0.12                    | 0.190                                 | 1.52                                   | -                                             | 99103E3                                       |
|                                          | 220                 | 10 x 10 x 14                           | 620                             | 110                          | 0.12                    | 0.190                                 | 1.52                                   | 97102E3                                       | -                                             |
|                                          | 330                 | 12.5 x 12.5 x 13                       | 690                             | 165                          | 0.12                    | 0.130                                 | 1.04                                   | 97112E3                                       | 99112E3                                       |
|                                          | 680                 | 16 x 16 x 16                           | 1035                            | 340                          | 0.12                    | 0.085                                 | 0.68                                   | -                                             | 99114E3                                       |
|                                          | 1000                | 16 x 16 x 21                           | 1100                            | 500                          | 0.12                    | 0.080                                 | 0.64                                   | -                                             | 99115E3                                       |
|                                          | 1000                | 18 x 18 x 16                           | 1074                            | 500                          | 0.12                    | 0.085                                 | 0.68                                   | -                                             | 99116E3                                       |
| 63                                       | 1500                | 18 x 18 x 21                           | 1470                            | 750                          | 0.12                    | 0.080                                 | 0.64                                   | -                                             | 99117E3                                       |
|                                          | 33                  | 8 x 8 x 10                             | 270                             | 21                           | 0.10                    | 0.650                                 | 5.20                                   | 97812E3                                       | -                                             |
|                                          | 47                  | 8 x 8 x 10                             | 270                             | 30                           | 0.10                    | 0.650                                 | 5.20                                   | 97811E3                                       | -                                             |
|                                          | 47                  | 10 x 10 x 10                           | 390                             | 30                           | 0.10                    | 0.380                                 | 3.00                                   | 97801E3                                       | 99801E3                                       |
|                                          | 68                  | 10 x 10 x 10                           | 390                             | 43                           | 0.10                    | 0.380                                 | 3.00                                   | 97802E3                                       | 99802E3                                       |
|                                          | 100                 | 10 x 10 x 12                           | 507                             | 63                           | 0.10                    | 0.290                                 | 2.32                                   | -                                             | 99804E3                                       |
|                                          | 100                 | 10 x 10 x 14                           | 507                             | 63                           | 0.10                    | 0.290                                 | 2.32                                   | 97803E3                                       | -                                             |
|                                          | 150                 | 12.5 x 12.5 x 13                       | 507                             | 97                           | 0.10                    | 0.250                                 | 2.00                                   | 97821E3                                       | 99821E3                                       |
|                                          | 220                 | 12.5 x 12.5 x 16                       | 637                             | 141                          | 0.10                    | 0.200                                 | 1.60                                   | 97815E3                                       | 99815E3                                       |
| 80                                       | 330                 | 16 x 16 x 16                           | 910                             | 208                          | 0.10                    | 0.150                                 | 1.20                                   | -                                             | 99816E3                                       |
|                                          | 470                 | 16 x 16 x 21                           | 987                             | 296                          | 0.10                    | 0.120                                 | 0.96                                   | -                                             | 99817E3                                       |
|                                          | 470                 | 18 x 18 x 16                           | 944                             | 296                          | 0.10                    | 0.150                                 | 1.20                                   | -                                             | 99818E3                                       |
|                                          | 680                 | 18 x 18 x 21                           | 1160                            | 428                          | 0.10                    | 0.120                                 | 0.96                                   | -                                             | 99819E3                                       |
|                                          | 47                  | 10 x 10 x 10                           | 240                             | 38                           | 0.10                    | 0.800                                 | 6.40                                   | 97701E3                                       | 99701E3                                       |
|                                          | 100                 | 10 x 10 x 12                           | 300                             | 80                           | 0.10                    | 0.620                                 | 4.96                                   | -                                             | 99702E3                                       |
|                                          | 150                 | 12.5 x 12.5 x 13                       | 670                             | 120                          | 0.10                    | 0.350                                 | 2.80                                   | -                                             | 99703E3                                       |
|                                          | 220                 | 12.5 x 12.5 x 16                       | 750                             | 176                          | 0.10                    | 0.250                                 | 2.00                                   | -                                             | 99704E3                                       |
|                                          | 330                 | 16 x 16 x 16                           | 1000                            | 264                          | 0.10                    | 0.180                                 | 1.44                                   | -                                             | 99705E3                                       |
| 100                                      | 470                 | 16 x 16 x 21                           | 1400                            | 376                          | 0.10                    | 0.120                                 | 0.96                                   | -                                             | 99706E3                                       |
|                                          | 470                 | 18 x 18 x 16                           | 1050                            | 376                          | 0.10                    | 0.160                                 | 1.28                                   | -                                             | 99707E3                                       |
|                                          | 680                 | 18 x 18 x 21                           | 1450                            | 544                          | 0.10                    | 0.110                                 | 0.88                                   | -                                             | 99708E3                                       |
|                                          | 4.7                 | 10 x 10 x 10                           | 210                             | 5                            | 0.10                    | 0.800                                 | 6.40                                   | 97901E3                                       | -                                             |
|                                          | 10                  | 10 x 10 x 10                           | 240                             | 10                           | 0.10                    | 0.800                                 | 6.40                                   | 97902E3                                       | 99902E3                                       |
|                                          | 22                  | 10 x 10 x 10                           | 240                             | 22                           | 0.10                    | 0.800                                 | 6.40                                   | 97903E3                                       | 99903E3                                       |
|                                          | 33                  | 10 x 10 x 10                           | 250                             | 33                           | 0.10                    | 0.800                                 | 6.40                                   | 97904E3                                       | 99904E3                                       |
|                                          | 47                  | 10 x 10 x 12                           | 270                             | 47                           | 0.10                    | 0.620                                 | 4.96                                   | -                                             | 99905E3                                       |
|                                          | 68                  | 12.5 x 12.5 x 13                       | 660                             | 68                           | 0.10                    | 0.350                                 | 2.80                                   | -                                             | 99906E3                                       |
|                                          | 100                 | 12.5 x 12.5 x 13                       | 660                             | 100                          | 0.10                    | 0.350                                 | 2.80                                   | -                                             | 99907E3                                       |
|                                          | 150                 | 12.5 x 12.5 x 16                       | 750                             | 150                          | 0.10                    | 0.250                                 | 2.00                                   | -                                             | 99908E3                                       |
|                                          | 220                 | 16 x 16 x 16                           | 1000                            | 220                          | 0.10                    | 0.180                                 | 1.44                                   | -                                             | 99909E3                                       |
|                                          | 330                 | 16 x 16 x 21                           | 1400                            | 330                          | 0.10                    | 0.120                                 | 0.96                                   | -                                             | 99911E3                                       |
|                                          | 330                 | 18 x 18 x 16                           | 1050                            | 330                          | 0.10                    | 0.160                                 | 1.28                                   | -                                             | 99912E3                                       |
|                                          | 470                 | 18 x 18 x 21                           | 1450                            | 470                          | 0.10                    | 0.110                                 | 0.80                                   | -                                             | 99913E3                                       |

**Notes**<sup>(1)</sup> Standard reflow soldering profile, see Fig. 4 and Table 4<sup>(2)</sup> Advanced reflow soldering profile, according to JEDEC J-STD-020, see Fig. 5 and Table 5



Table 7

| ADDITIONAL ELECTRICAL DATA                   |                                                              |                                          |
|----------------------------------------------|--------------------------------------------------------------|------------------------------------------|
| PARAMETER                                    | CONDITIONS                                                   | VALUE                                    |
| <b>Voltage</b>                               |                                                              |                                          |
| Surge voltage for short periods              | IEC 60384-18, subclause 4.14                                 | $U_s \leq 1.1 \times U_R$                |
| Reverse voltage for short periods            | IEC 60384-18, subclause 4.16                                 | $U_{rev} \leq 1 \text{ V}$               |
| <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)           | $\varnothing D = 8 \text{ mm}$                               | Typ. 6 nH                                |
|                                              | $\varnothing D = 10 \text{ mm}$                              | Typ. 8 nH                                |
|                                              | $\varnothing D \geq 12.5 \text{ mm}$                         | Typ. 11 nH                               |
| <b>Resistance</b>                            |                                                              |                                          |
| Equivalent series resistance (ESR) at 100 Hz | Calculated from $\tan \delta_{max.}$ and $C_R$ (see Table 6) | $ESR = \tan \delta / 2\pi f C_R$         |

## CAPACITANCE

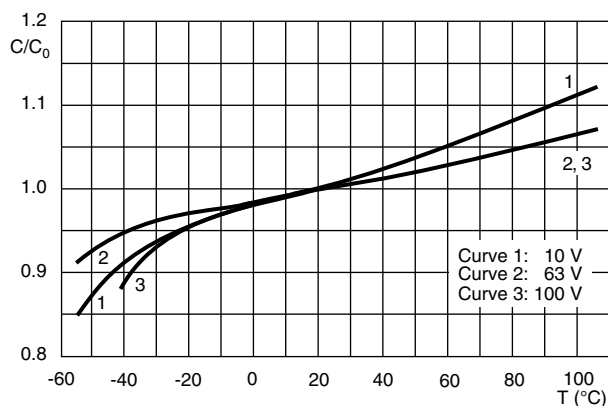

 $C_0$  = Capacitance at 20 °C, 100 Hz

Fig. 6 - Typical multiplier of capacitance as a function of temperature at 100 Hz

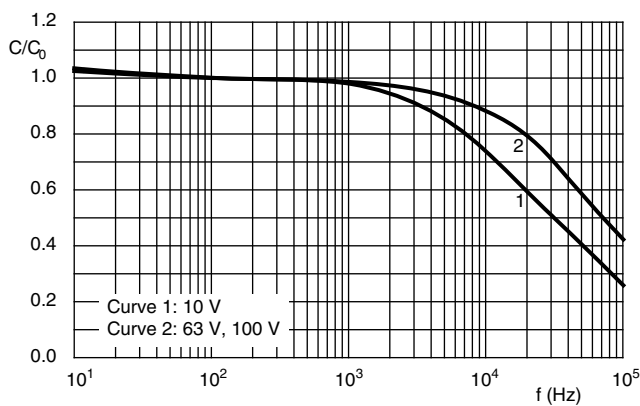

 $C_0$  = Typical capacitance at 20 °C, 100 Hz

Fig. 7 - Typical multiplier of capacitance as a function of frequency at 20 °C

## EQUIVALENT SERIES RESISTANCE (ESR)

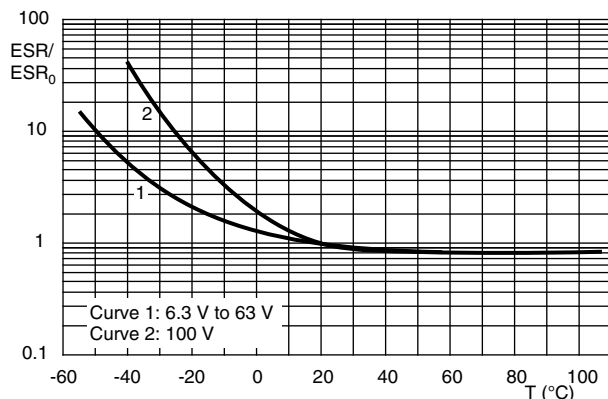

 $ESR_0$  = Typical ESR at 20 °C, 100 Hz

Fig. 8 - Typical multiplier of ESR as a function of temperature at 100 Hz

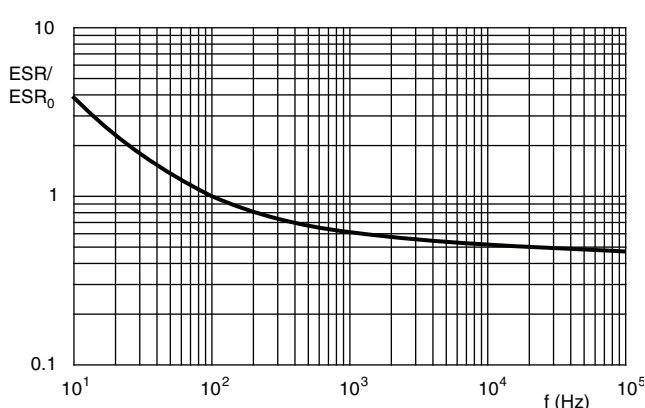
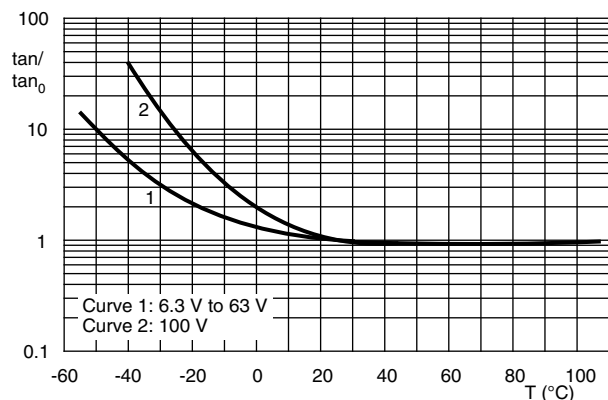

 $ESR_0$  = Typical ESR at 20 °C, 100 Hz

Fig. 9 - Typical multiplier ESR as a function of frequency at 20 °C

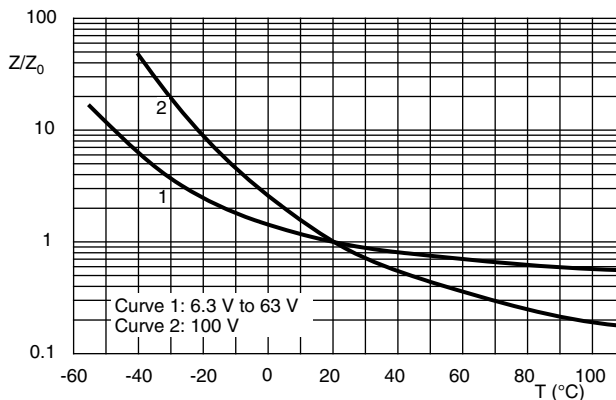
### DISSIPATION FACTOR ( $\tan \delta$ )



$\tan \delta_0$  = Typical  $\tan \delta$  at 20 °C, 100 Hz

Fig. 10 - Typical multiplier of dissipation factor  $\tan \delta$  as a function of temperature at 20 °C at 100 Hz

### IMPEDANCE (Z)



$Z_0$  = Typical impedance Z at 20 °C, 100 kHz

Fig. 11 - Typical multiplier of impedance Z as a function of temperature at 100 kHz

### IMPEDANCE (Z)

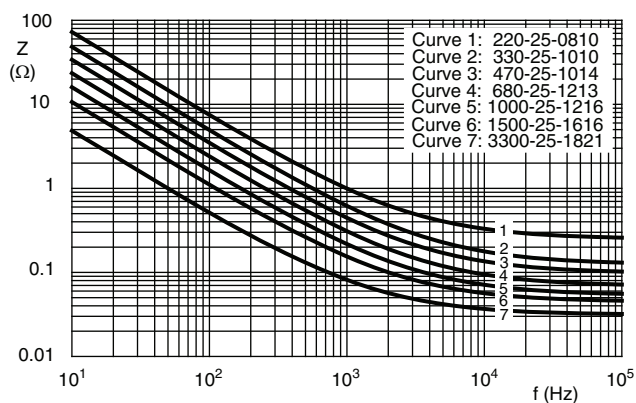


Fig. 12 - Typical impedance Z as a function of frequency at 20 °C

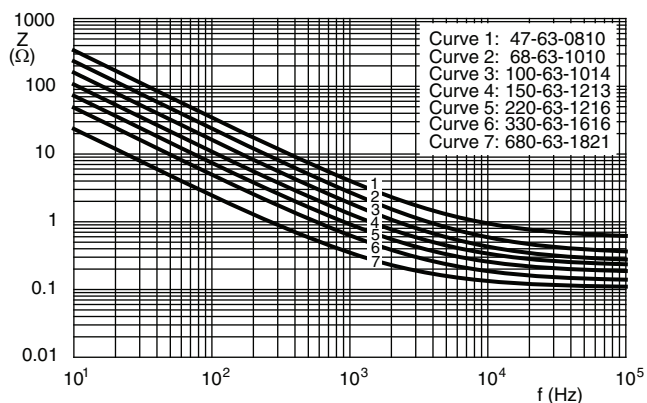


Fig. 13 - Typical impedance Z as a function of frequency at 20 °C

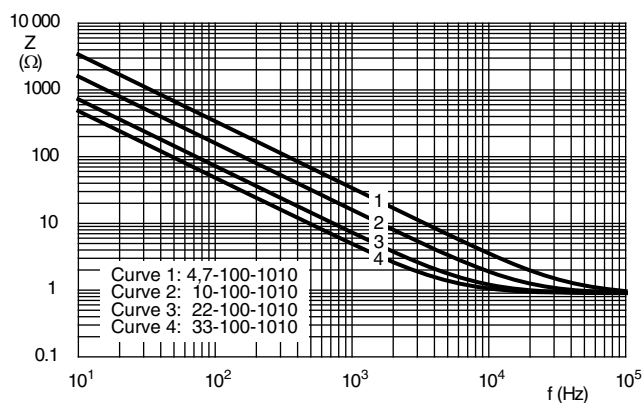


Fig. 14 - Typical impedance Z as a function of frequency at 20 °C

# RIPPLE CURRENT AND USEFUL LIFE

Table 8

| ENDURANCE TEST DURATION AND USEFUL LIFE |              |                               |                                    |                                                                  |                                                 |                                    |                                                                  |                                                  |                                    |                                                                  |
|-----------------------------------------|--------------|-------------------------------|------------------------------------|------------------------------------------------------------------|-------------------------------------------------|------------------------------------|------------------------------------------------------------------|--------------------------------------------------|------------------------------------|------------------------------------------------------------------|
| NOMINAL<br>CASE SIZE<br>D x L<br>(mm)   | CASE<br>CODE | MAL215097...                  |                                    |                                                                  | MAL215099... $U_R = 16\text{ V TO }63\text{ V}$ |                                    |                                                                  | MAL215099... $U_R = 80\text{ V TO }100\text{ V}$ |                                    |                                                                  |
|                                         |              | ENDURANCE<br>AT 105 °C<br>(h) | USEFUL<br>LIFE<br>AT 105 °C<br>(h) | USEFUL<br>LIFE<br>AT 40 °C<br>$1.8 \times I_R$<br>APPLIED<br>(h) | ENDURANCE<br>AT 105 °C<br>(h)                   | USEFUL<br>LIFE<br>AT 105 °C<br>(h) | USEFUL<br>LIFE<br>AT 40 °C<br>$1.8 \times I_R$<br>APPLIED<br>(h) | ENDURANCE<br>AT 105 °C<br>(h)                    | USEFUL<br>LIFE<br>AT 105 °C<br>(h) | USEFUL<br>LIFE<br>AT 40 °C<br>$1.8 \times I_R$<br>APPLIED<br>(h) |
| 8 x 8 x 10                              | 0810         | 2000                          | 2500                               | 125 000                                                          | -                                               | -                                  | -                                                                | -                                                | -                                  | -                                                                |
| 10 x 10 x 10                            | 1010         | 2000                          | 3000                               | 150 000                                                          | 2000                                            | 3000                               | 150 000                                                          | 2000                                             | 3000                               | 150 000                                                          |
| 10 x 10 x 12                            | 1012         | -                             | -                                  | -                                                                | 2000                                            | 3000                               | 150 000                                                          | 2000                                             | 3000                               | 150 000                                                          |
| 10 x 10 x 14                            | 1014         | 2000                          | 3000                               | 150 000                                                          | -                                               | -                                  | -                                                                | -                                                | -                                  | -                                                                |
| 12.5 x 12.5 x 13                        | 1213         | 3000                          | 5000                               | 250 000                                                          | 5000                                            | 6000                               | 300 000                                                          | 3000                                             | 5000                               | 250 000                                                          |
| 12.5 x 12.5 x 16                        | 1216         | 3000                          | 5000                               | 250 000                                                          | 6500                                            | 7500                               | 375 000                                                          | 3000                                             | 5000                               | 250 000                                                          |
| 16 x 16 x 16                            | 1616         | -                             | -                                  | -                                                                | 8000                                            | 10 000                             | 500 000                                                          | 3000                                             | 5000                               | 250 000                                                          |
| 16 x 16 x 21                            | 1621         | -                             | -                                  | -                                                                | 8000                                            | 10 000                             | 500 000                                                          | 3000                                             | 5000                               | 250 000                                                          |
| 18 x 18 x 16                            | 1816         | -                             | -                                  | -                                                                | 8000                                            | 10 000                             | 500 000                                                          | 3000                                             | 5000                               | 250 000                                                          |
| 18 x 18 x 21                            | 1821         | -                             | -                                  | -                                                                | 8000                                            | 10 000                             | 500 000                                                          | 3000                                             | 5000                               | 250 000                                                          |

# RIPPLE CURRENT AND USEFUL LIFE

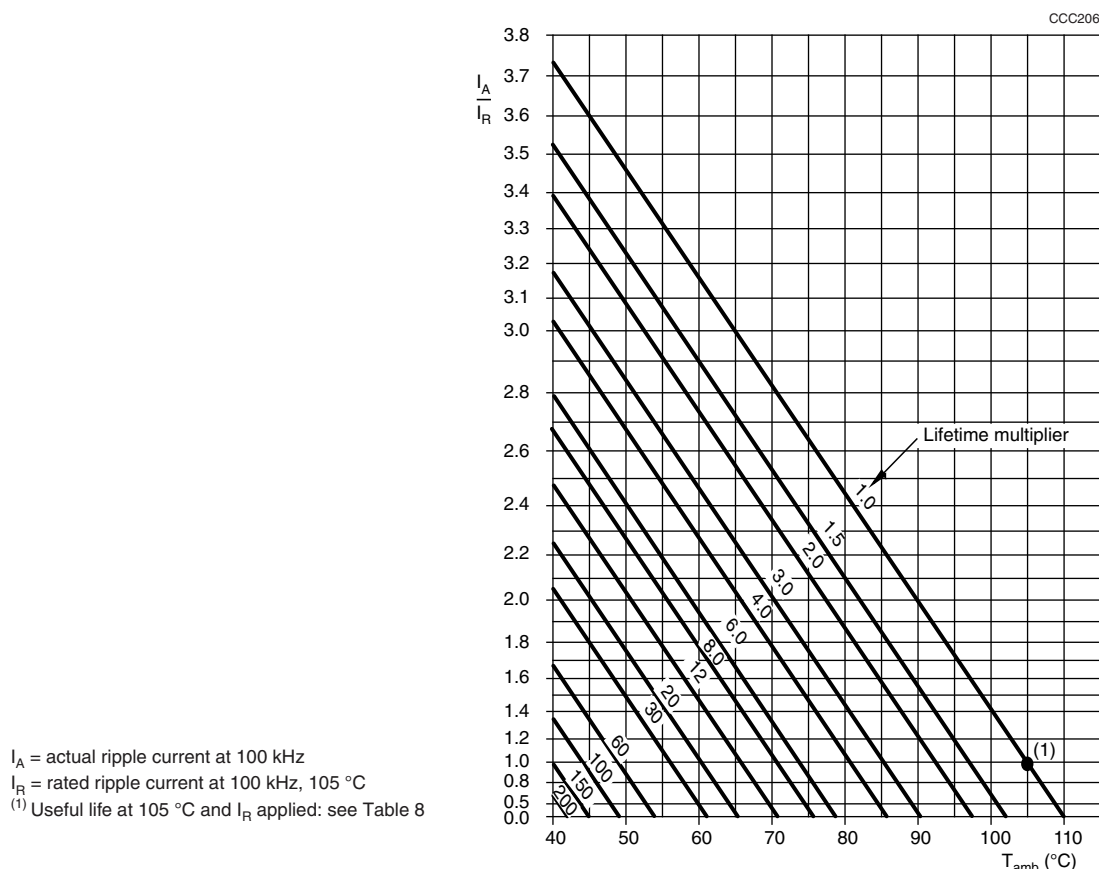


Fig. 15 - Multiplier of useful life as a function of ambient temperature and ripple current load

Table 9

| <b>MULTIPLIER OF RIPPLE CURRENT (<math>I_R</math>) AS A FUNCTION OF FREQUENCY</b> |                                                          |                                        |                                                          |
|-----------------------------------------------------------------------------------|----------------------------------------------------------|----------------------------------------|----------------------------------------------------------|
| <b>FREQUENCY<br/>(Hz)</b>                                                         | <b><math>I_R</math> MULTIPLIER</b>                       |                                        |                                                          |
|                                                                                   | <b><math>U_R = 6.3 \text{ V TO } 25 \text{ V}</math></b> | <b><math>U_R = 35 \text{ V}</math></b> | <b><math>U_R = 50 \text{ V TO } 100 \text{ V}</math></b> |
| 100                                                                               | 0.70                                                     | 0.65                                   | 0.60                                                     |
| 300                                                                               | 0.80                                                     | 0.80                                   | 0.75                                                     |
| 1000                                                                              | 0.85                                                     | 0.85                                   | 0.85                                                     |
| 3000                                                                              | 0.93                                                     | 0.93                                   | 0.93                                                     |
| 10 000                                                                            | 0.95                                                     | 0.95                                   | 0.95                                                     |
| 30 000                                                                            | 0.97                                                     | 0.97                                   | 0.97                                                     |
| 100 000                                                                           | 1.00                                                     | 1.00                                   | 1.00                                                     |

Table 10

| <b>TEST PROCEDURES AND REQUIREMENTS</b>        |                                               |                                                                                                                                                                 |                                                                                                                                                                                            |
|------------------------------------------------|-----------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>TEST</b>                                    |                                               | <b>PROCEDURE<br/>(quick reference)</b>                                                                                                                          | <b>REQUIREMENTS</b>                                                                                                                                                                        |
| <b>NAME OF TEST</b>                            | <b>REFERENCE</b>                              |                                                                                                                                                                 |                                                                                                                                                                                            |
| Mounting                                       | IEC 60384-18,<br>subclause 4.3                | Shall be performed prior to tests mentioned below;<br>reflow soldering;<br>for maximum temperature load<br>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/CECC32300,<br>subclause 4.15     | $T_{\text{amb}} = 105 \text{ }^\circ\text{C}$ ; $U_R$ applied;<br>for test duration see Table 8                                                                 | $U_R = 6.3 \text{ V}$ ; $\Delta C/C: \pm 25 \%$<br>$U_R \geq 10 \text{ V}$ ; $\Delta C/C: \pm 20 \%$<br>$\tan \delta \leq 2 \times \text{spec. limit}$<br>$I_{L2} \leq \text{spec. limit}$ |
| Useful life                                    | CECC 30301,<br>subclause 1.8.1                | $T_{\text{amb}} = 105 \text{ }^\circ\text{C}$ ; $U_R$ and $I_R$ applied;<br>for test duration see Table 8                                                       | $\Delta C/C: \pm 30 \%$<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<br>temperature) | IEC 60384-18/<br>CECC32300,<br>subclause 4.17 | $T_{\text{amb}} = 105 \text{ }^\circ\text{C}$ ; no voltage applied;<br>1000 h<br>after test: $U_R$ to be applied for 30 min,<br>24 h to 48 h before measurement | For requirements<br>see "Endurance test" above                                                                                                                                             |



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