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

## LINKS TO ADDITIONAL RESOURCES

SPICE
Models

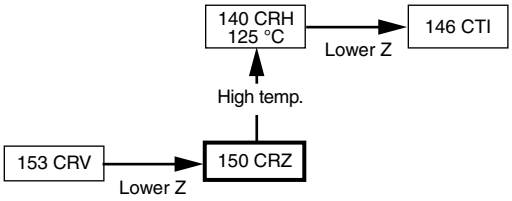


Fig. 1

| QUICK REFERENCE DATA | |
|---|---|
| **DESCRIPTION** | **VALUE** |
| Nominal case sizes (L x W x H in mm) | 8 x 8 x 10 to 18 x 18 x 21 |
| Rated capacitance range, $C_R$ | 4.7 µF to 10 000 µF |
| Tolerance on $C_R$ | ± 20 % |
| Rated voltage range, $U_R$ | 6.3 V to 100 V |
| Category temperature range<br>6.3 V to 63 V:<br>80 V to 100 V: | <br>-55 °C to +105 °C<br>-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; 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 specification | IEC 60384-18 / CECC 32300 |
| Climatic category IEC 60068<br>6.3 V to 63 V:<br>80 V to 100 V: | <br>55 / 105 / 56<br>40 / 105 / 56 |

## FEATURES

AUTOMOTIVE GRADE

Pb-free
RoHS COMPLIANT

- 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

## APPLICATIONS

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

## MARKING

- Rated capacitance (in µF)
- 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


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

| $C_R$ (µF) | $U_R$ (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 | - | - | - | - | - | - | - | - |

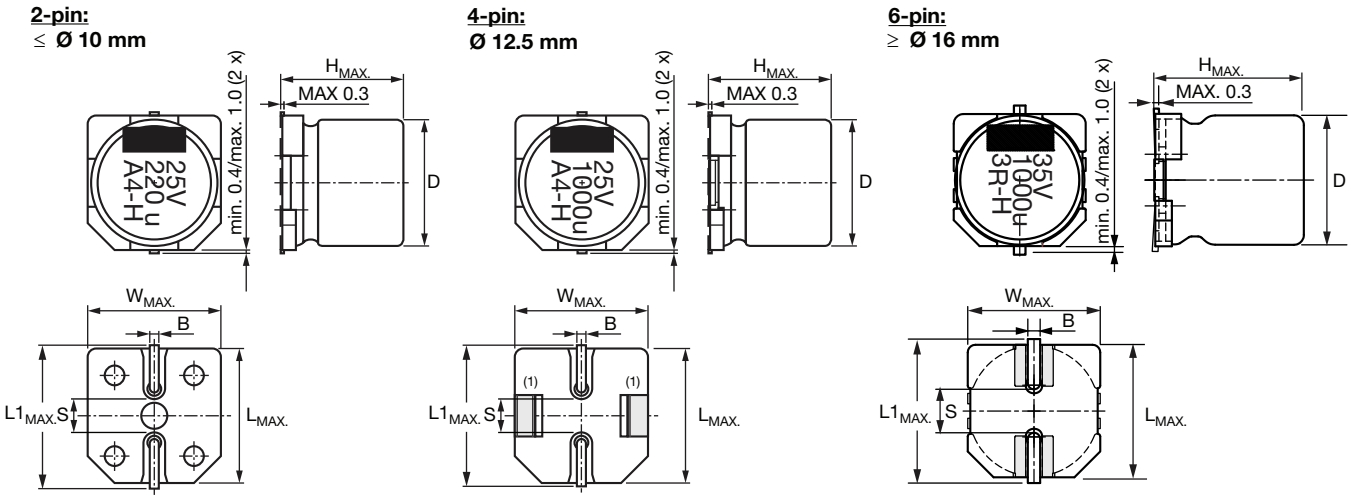


Fig. 2 - Dimensional outline

**Note**

(1) Additional dummy pins for mechanical stability, no electrical connection to pins or can


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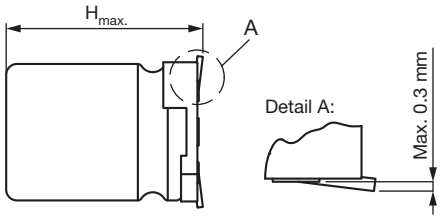


Fig. 3 - Coplanarity of pins

**Table 1**

| **DIMENSIONS** in millimeters **AND MASS** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **NOMINAL CASE SIZE L x W x H** | **CASE CODE** | **$L_{MAX.}$** | **$W_{MAX.}$** | **$H_{MAX.}$** | **Ø D** | **$B_{MAX.}$** | **S** | **$L1_{MAX.}$** | **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 L x W x H** | **CASE CODE** | **PITCH $P_1$** | **TAPE WIDTH W** | **TAPE THICKNESS $T_2$** | **REEL DIAMETER** | **PACKAGING QUANTITY 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”


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## 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. 4 and Table 3.

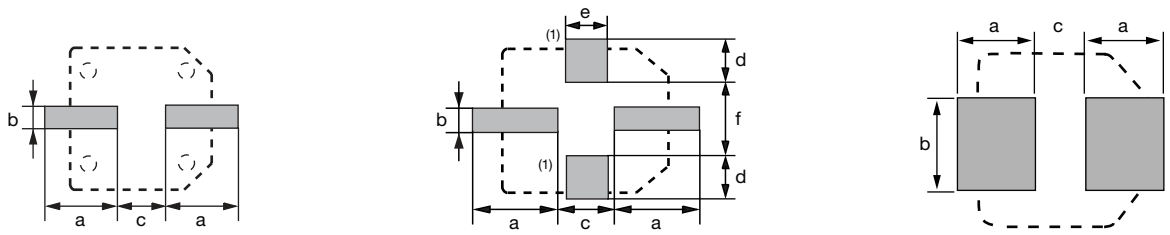
## SOLDERING

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. 5 or Fig. 6.

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.




Case size Ø D ≤ 10 mm | Case size Ø D = 12.5 mm | Case size Ø D ≥ 16 mm

Fig. 4 - Recommended soldering pad dimensions

**Note**

(1) Additional solder pads, can be connected to GND or open

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

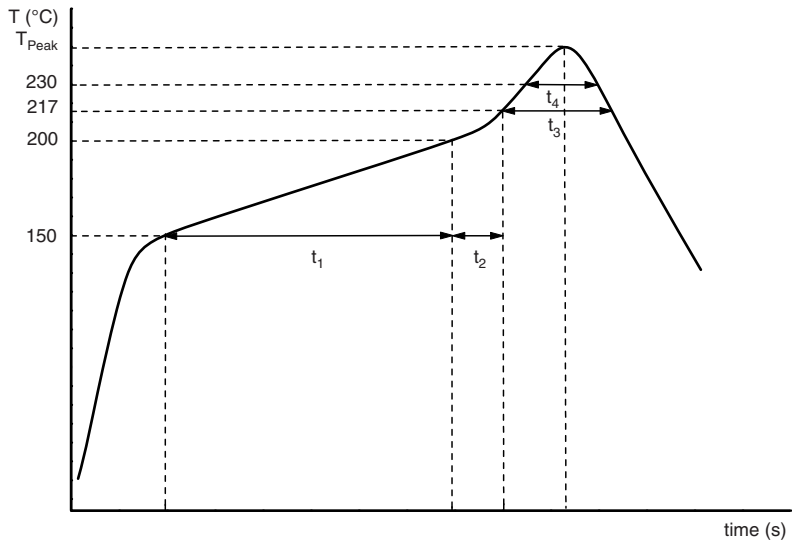


Fig. 5 - Maximum temperature load during reflow soldering

**Table 4**

| **REFLOW SOLDERING CONDITIONS** for MAL215097xxxE3 | | |
|---|---|---|
| **PROFILE FEATURES** | **CASE CODE 0810 TO 1014** | **CASE CODE 1213 TO 1216** |
| 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


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

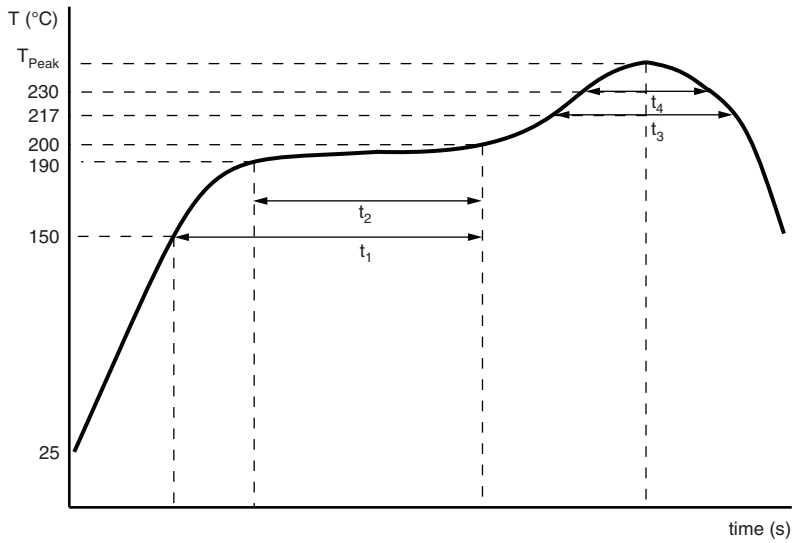


Fig. 6 - Maximum temperature load during reflow soldering

**Table 5**

| **REFLOW SOLDERING CONDITIONS** for MAL215099xxxE3 | | | |
|---|---|---|---|
| **PROFILE FEATURES** | **CASE CODE 1010 TO 1012** | **CASE CODE 1213 TO 1216** | **CASE CODE 1616 TO 1821** |
| 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


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| ELECTRICAL DATA | |
|---|---|
| SYMBOL | DESCRIPTION |
| $C_R$ | Rated capacitance at 100 Hz, tolerance ± 20 % |
| $I_R$ | Rated RMS ripple current at 100 kHz, 105 °C |
| $I_{L2}$ | Max. leakage current after 2 min at $U_R$ |
| tan δ | 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 °C, P = 86 kPa to 106 kPa, RH = 45 % to 75 %

## ORDERING EXAMPLE

Electrolytic capacitor 150 CRZ series

470 µF / 35 V; ± 20 %

Nominal case size: 12.5 mm x 12.5 mm x 13 mm; taped on reel

Ordering code: MAL215099012E3

**Table 6**

**ELECTRICAL DATA AND ORDERING INFORMATION**

| $U_R$ (V) | $C_R$ (µF) | NOMINAL CASE SIZE L x W x H (mm) | $I_R$ 105 °C 100 kHz (mA) | $I_L$ 2 min (µA) | tan δ 100 Hz | Z 100 kHz 20 °C (Ω) | Z 100 kHz -40 °C (Ω) | LIFE CODE [3] | ORDERING CODE [1] MAL2150... | ORDERING CODE [2] MAL2150... |
|---|---|---|---|---|---|---|---|---|---|---|
| 6.3 | 470 | 8 x 8 x 10 | 435 | 30 | 0.24 | 0.250 | 2.00 | L1 | 97311E3 | - |
| | 1000 | 10 x 10 x 10 | 670 | 63 | 0.24 | 0.130 | 1.10 | L2 | 97301E3 | 99301E3 |
| | 2200 | 12.5 x 12.5 x 13 | 905 | 139 | 0.26 | 0.077 | 0.60 | L3 | 97312E3 | - |
| | 2200 | 12.5 x 12.5 x 13 | 905 | 139 | 0.26 | 0.077 | 0.60 | L4 | - | 99312E3 |
| | 4700 | 16 x 16 x 16 | 1350 | 296 | 0.28 | 0.050 | 0.40 | L6 | - | 99313E3 |
| | 6800 | 16 x 16 x 21 | 1666 | 428 | 0.30 | 0.035 | 0.28 | L6 | - | 99314E3 |
| | 6800 | 18 x 18 x 16 | 1400 | 428 | 0.32 | 0.050 | 0.40 | L6 | - | 99315E3 |
| | 10 000 | 18 x 18 x 21 | 1756 | 630 | 0.34 | 0.035 | 0.28 | L6 | - | 99316E3 |
| 10 | 330 | 8 x 8 x 10 | 435 | 33 | 0.20 | 0.250 | 2.00 | L1 | 97411E3 | - |
| | 470 | 8 x 8 x 10 | 435 | 47 | 0.20 | 0.250 | 2.00 | L1 | 97412E3 | - |
| | 680 | 10 x 10 x 10 | 670 | 68 | 0.20 | 0.130 | 1.10 | L2 | 97401E3 | 99401E3 |
| | 1000 | 10 x 10 x 12 | 850 | 100 | 0.20 | 0.100 | 0.80 | L2 | - | 99403E3 |
| | 1000 | 10 x 10 x 14 | 850 | 100 | 0.20 | 0.100 | 0.80 | L2 | 97402E3 | - |
| | 1500 | 12.5 x 12.5 x 13 | 905 | 150 | 0.22 | 0.077 | 0.60 | L3 | 97413E3 | - |
| | 1500 | 12.5 x 12.5 x 13 | 905 | 150 | 0.22 | 0.077 | 0.60 | L4 | - | 99413E3 |
| | 2200 | 12.5 x 12.5 x 16 | 1007 | 220 | 0.22 | 0.060 | 0.48 | L3 | 97414E3 | - |
| | 2200 | 12.5 x 12.5 x 16 | 1007 | 220 | 0.22 | 0.060 | 0.48 | L5 | - | 99414E3 |
| | 3300 | 16 x 16 x 16 | 1350 | 330 | 0.24 | 0.050 | 0.40 | L6 | - | 99415E3 |
| | 4700 | 16 x 16 x 21 | 1666 | 470 | 0.26 | 0.035 | 0.28 | L6 | - | 99416E3 |
| | 4700 | 18 x 18 x 16 | 1400 | 470 | 0.26 | 0.050 | 0.40 | L6 | - | 99417E3 |
| | 6800 | 18 x 18 x 21 | 1756 | 680 | 0.28 | 0.035 | 0.28 | L6 | - | 99418E3 |
| 16 | 220 | 8 x 8 x 10 | 435 | 35 | 0.16 | 0.250 | 2.00 | L1 | 97511E3 | - |
| | 330 | 8 x 8 x 10 | 435 | 53 | 0.16 | 0.250 | 2.00 | L1 | 97512E3 | - |
| | 470 | 10 x 10 x 10 | 670 | 75 | 0.16 | 0.130 | 1.10 | L2 | 97501E3 | 99501E3 |
| | 680 | 10 x 10 x 12 | 850 | 109 | 0.16 | 0.100 | 0.80 | L2 | - | 99503E3 |
| | 680 | 10 x 10 x 14 | 850 | 109 | 0.16 | 0.100 | 0.80 | L2 | 97502E3 | - |
| | 1000 | 12.5 x 12.5 x 13 | 905 | 160 | 0.18 | 0.077 | 0.60 | L3 | 97513E3 | - |
| | 1000 | 12.5 x 12.5 x 13 | 905 | 160 | 0.18 | 0.077 | 0.60 | L4 | - | 99513E3 |
| | 1500 | 12.5 x 12.5 x 16 | 1007 | 240 | 0.18 | 0.060 | 0.48 | L3 | 97514E3 | - |
| | 1500 | 12.5 x 12.5 x 16 | 1007 | 240 | 0.18 | 0.060 | 0.48 | L5 | - | 99514E3 |
| | 2200 | 16 x 16 x 16 | 1350 | 352 | 0.20 | 0.050 | 0.40 | L6 | - | 99515E3 |
| | 3300 | 16 x 16 x 21 | 1666 | 528 | 0.22 | 0.035 | 0.28 | L6 | - | 99516E3 |
| | 3300 | 18 x 18 x 16 | 1400 | 528 | 0.22 | 0.050 | 0.40 | L6 | - | 99517E3 |
| | 4700 | 18 x 18 x 21 | 1756 | 752 | 0.26 | 0.035 | 0.28 | L6 | - | 99518E3 |

**Notes**

(1) Standard reflow soldering profile, see Fig. 5 and Table 4
(2) Advanced reflow soldering profile, according to JEDEC J-STD-020, see Fig. 6 and Table 5
(3) Determines the applicable row in the table “Endurance Test Duration and Useful Life”


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## ELECTRICAL DATA AND ORDERING INFORMATION

| $U_R$ (V) | $C_R$ (µF) | NOMINAL CASE SIZE L x W x H (mm) | $I_R$ 105 °C 100 kHz (mA) | $I_L$ 2 min (µA) | tan δ 100 Hz | Z 100 kHz 20 °C (Ω) | Z 100 kHz -40 °C (Ω) | LIFE CODE [3] | ORDERING CODE [1] MAL2150... | ORDERING CODE [2] MAL2150... |
|---|---|---|---|---|---|---|---|---|---|---|
| 25 | 150 | 8 x 8 x 10 | 420 | 38 | 0.14 | 0.280 | 2.24 | L1 | 97611E3 | - |
| | 220 | 8 x 8 x 10 | 420 | 55 | 0.14 | 0.280 | 2.24 | L1 | 97612E3 | - |
| | 330 | 10 x 10 x 10 | 640 | 83 | 0.14 | 0.140 | 1.12 | L2 | 97601E3 | 99601E3 |
| | 470 | 10 x 10 x 12 | 820 | 118 | 0.14 | 0.110 | 0.88 | L2 | - | 99603E3 |
| | 470 | 10 x 10 x 14 | 820 | 118 | 0.14 | 0.110 | 0.88 | L2 | 97602E3 | - |
| | 680 | 12.5 x 12.5 x 13 | 905 | 170 | 0.16 | 0.077 | 0.60 | L3 | 97613E3 | - |
| | 680 | 12.5 x 12.5 x 13 | 905 | 170 | 0.16 | 0.077 | 0.60 | L4 | - | 99613E3 |
| | 1000 | 12.5 x 12.5 x 16 | 1007 | 250 | 0.16 | 0.060 | 0.48 | L3 | 97614E3 | - |
| | 1000 | 12.5 x 12.5 x 16 | 1007 | 250 | 0.16 | 0.060 | 0.48 | L5 | - | 99614E3 |
| | 1500 | 16 x 16 x 16 | 1350 | 375 | 0.16 | 0.050 | 0.40 | L6 | - | 99615E3 |
| | 2200 | 16 x 16 x 21 | 1666 | 550 | 0.18 | 0.035 | 0.28 | L6 | - | 99616E3 |
| | 2200 | 18 x 18 x 16 | 1400 | 550 | 0.18 | 0.050 | 0.40 | L6 | - | 99617E3 |
| | 3300 | 18 x 18 x 21 | 1756 | 825 | 0.20 | 0.035 | 0.28 | L6 | - | 99618E3 |
| 35 | 100 | 8 x 8 x 10 | 405 | 35 | 0.12 | 0.300 | 2.40 | L1 | 97011E3 | - |
| | 220 | 10 x 10 x 10 | 630 | 77 | 0.12 | 0.150 | 1.20 | L2 | 97001E3 | 99001E3 |
| | 330 | 10 x 10 x 12 | 790 | 116 | 0.12 | 0.120 | 0.96 | L2 | - | 99003E3 |
| | 330 | 10 x 10 x 14 | 790 | 116 | 0.12 | 0.120 | 0.96 | L2 | 97002E3 | - |
| | 470 | 12.5 x 12.5 x 13 | 905 | 165 | 0.14 | 0.077 | 0.60 | L3 | 97012E3 | - |
| | 470 | 12.5 x 12.5 x 13 | 905 | 165 | 0.14 | 0.077 | 0.60 | L4 | - | 99012E3 |
| | 680 | 12.5 x 12.5 x 16 | 1007 | 238 | 0.14 | 0.060 | 0.48 | L3 | 97013E3 | - |
| | 680 | 12.5 x 12.5 x 16 | 1007 | 238 | 0.14 | 0.060 | 0.48 | L5 | - | 99013E3 |
| | 1000 | 16 x 16 x 16 | 1350 | 350 | 0.14 | 0.050 | 0.40 | L6 | - | 99014E3 |
| | 1500 | 16 x 16 x 21 | 1666 | 525 | 0.14 | 0.035 | 0.28 | L6 | - | 99015E3 |
| | 1500 | 18 x 18 x 16 | 1400 | 525 | 0.14 | 0.050 | 0.40 | L6 | - | 99016E3 |
| | 2200 | 18 x 18 x 21 | 1756 | 770 | 0.16 | 0.035 | 0.28 | L6 | - | 99017E3 |
| 50 | 68 | 8 x 8 x 10 | 333 | 34 | 0.12 | 0.480 | 3.84 | L1 | 97111E3 | - |
| | 100 | 10 x 10 x 10 | 490 | 50 | 0.12 | 0.240 | 1.92 | L2 | 97101E3 | 99101E3 |
| | 220 | 10 x 10 x 12 | 620 | 110 | 0.12 | 0.190 | 1.52 | L2 | - | 99103E3 |
| | 220 | 10 x 10 x 14 | 620 | 110 | 0.12 | 0.190 | 1.52 | L2 | 97102E3 | - |
| | 330 | 12.5 x 12.5 x 13 | 690 | 165 | 0.12 | 0.130 | 1.04 | L3 | 97112E3 | - |
| | 330 | 12.5 x 12.5 x 13 | 690 | 165 | 0.12 | 0.130 | 1.04 | L4 | - | 99112E3 |
| | 680 | 16 x 16 x 16 | 1035 | 340 | 0.12 | 0.085 | 0.68 | L6 | - | 99114E3 |
| | 1000 | 16 x 16 x 21 | 1100 | 500 | 0.12 | 0.080 | 0.64 | L6 | - | 99115E3 |
| | 1000 | 18 x 18 x 16 | 1074 | 500 | 0.12 | 0.085 | 0.68 | L6 | - | 99116E3 |
| | 1500 | 18 x 18 x 21 | 1470 | 750 | 0.12 | 0.080 | 0.64 | L6 | - | 99117E3 |
| 63 | 33 | 8 x 8 x 10 | 270 | 21 | 0.10 | 0.650 | 5.20 | L1 | 97812E3 | - |
| | 47 | 8 x 8 x 10 | 270 | 30 | 0.10 | 0.650 | 5.20 | L1 | 97811E3 | - |
| | 47 | 10 x 10 x 10 | 390 | 30 | 0.10 | 0.380 | 3.00 | L2 | 97801E3 | 99801E3 |
| | 68 | 10 x 10 x 10 | 390 | 43 | 0.10 | 0.380 | 3.00 | L2 | 97802E3 | 99802E3 |
| | 100 | 10 x 10 x 12 | 507 | 63 | 0.10 | 0.290 | 2.32 | L2 | - | 99804E3 |
| | 100 | 10 x 10 x 14 | 507 | 63 | 0.10 | 0.290 | 2.32 | L2 | 97803E3 | - |
| | 150 | 12.5 x 12.5 x 13 | 507 | 97 | 0.10 | 0.250 | 2.00 | L3 | 97821E3 | - |
| | 150 | 12.5 x 12.5 x 13 | 507 | 97 | 0.10 | 0.250 | 2.00 | L4 | - | 99821E3 |
| | 220 | 12.5 x 12.5 x 16 | 637 | 141 | 0.10 | 0.200 | 1.60 | L3 | 97815E3 | - |
| | 220 | 12.5 x 12.5 x 16 | 637 | 141 | 0.10 | 0.200 | 1.60 | L5 | - | 99815E3 |
| | 330 | 16 x 16 x 16 | 910 | 208 | 0.10 | 0.150 | 1.20 | L6 | - | 99816E3 |
| | 470 | 16 x 16 x 21 | 987 | 296 | 0.10 | 0.120 | 0.96 | L6 | - | 99817E3 |
| | 470 | 18 x 18 x 16 | 944 | 296 | 0.10 | 0.150 | 1.20 | L6 | - | 99818E3 |
| | 680 | 18 x 18 x 21 | 1160 | 428 | 0.10 | 0.120 | 0.96 | L6 | - | 99819E3 |

**Notes**

(1) Standard reflow soldering profile, see Fig. 5 and Table 4
(2) Advanced reflow soldering profile, according to JEDEC J-STD-020, see Fig. 6 and Table 5
(3) Determines the applicable row in the table “Endurance Test Duration and Useful Life”


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| ELECTRICAL DATA AND ORDERING INFORMATION | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| $U_R$ (V) | $C_R$ (µF) | NOMINAL CASE SIZE L x W x H (mm) | $I_R$ 105 °C 100 kHz (mA) | $I_L$ 2 min (µA) | tan δ 100 Hz | Z 100 kHz 20 °C (Ω) | Z 100 kHz -40 °C (Ω) | LIFE CODE (3) | ORDERING CODE (1) MAL2150... | ORDERING CODE (2) MAL2150... |
| 80 | 47 | 10 x 10 x 10 | 240 | 38 | 0.10 | 0.800 | 6.40 | L2 | 97701E3 | 99701E3 |
| | 100 | 10 x 10 x 12 | 300 | 80 | 0.10 | 0.620 | 4.96 | L2 | - | 99702E3 |
| | 150 | 12.5 x 12.5 x 13 | 670 | 120 | 0.10 | 0.350 | 2.80 | L3 | - | 99703E3 |
| | 220 | 12.5 x 12.5 x 16 | 750 | 176 | 0.10 | 0.250 | 2.00 | L3 | - | 99704E3 |
| | 330 | 16 x 16 x 16 | 1000 | 264 | 0.10 | 0.180 | 1.44 | L3 | - | 99705E3 |
| | 470 | 16 x 16 x 21 | 1400 | 376 | 0.10 | 0.120 | 0.96 | L3 | - | 99706E3 |
| | 470 | 18 x 18 x 16 | 1050 | 376 | 0.10 | 0.160 | 1.28 | L3 | - | 99707E3 |
| | 680 | 18 x 18 x 21 | 1450 | 544 | 0.10 | 0.110 | 0.88 | L3 | - | 99708E3 |
| 100 | 4.7 | 10 x 10 x 10 | 210 | 5 | 0.10 | 0.800 | 6.40 | L2 | 97901E3 | - |
| | 10 | 10 x 10 x 10 | 240 | 10 | 0.10 | 0.800 | 6.40 | L2 | 97902E3 | 99902E3 |
| | 22 | 10 x 10 x 10 | 240 | 22 | 0.10 | 0.800 | 6.40 | L2 | 97903E3 | 99903E3 |
| | 33 | 10 x 10 x 10 | 250 | 33 | 0.10 | 0.800 | 6.40 | L2 | 97904E3 | 99904E3 |
| | 47 | 10 x 10 x 12 | 270 | 47 | 0.10 | 0.620 | 4.96 | L2 | - | 99905E3 |
| | 68 | 12.5 x 12.5 x 13 | 660 | 68 | 0.10 | 0.350 | 2.80 | L3 | - | 99906E3 |
| | 100 | 12.5 x 12.5 x 13 | 660 | 100 | 0.10 | 0.350 | 2.80 | L3 | - | 99907E3 |
| | 150 | 12.5 x 12.5 x 16 | 750 | 150 | 0.10 | 0.250 | 2.00 | L3 | - | 99908E3 |
| | 220 | 16 x 16 x 16 | 1000 | 220 | 0.10 | 0.180 | 1.44 | L3 | - | 99909E3 |
| | 330 | 16 x 16 x 21 | 1400 | 330 | 0.10 | 0.120 | 0.96 | L3 | - | 99911E3 |
| | 330 | 18 x 18 x 16 | 1050 | 330 | 0.10 | 0.160 | 1.28 | L3 | - | 99912E3 |
| | 470 | 18 x 18 x 21 | 1450 | 470 | 0.10 | 0.110 | 0.80 | L3 | - | 99913E3 |

**Notes**
(1) Standard reflow soldering profile, see Fig. 5 and Table 4
(2) Advanced reflow soldering profile, according to JEDEC J-STD-020, see Fig. 6 and Table 5
(3) Determines the applicable row in the table “Endurance Test Duration and Useful Life”

**Table 7**

| ADDITIONAL ELECTRICAL DATA | | |
|---|---|---|
| **PARAMETER** | **CONDITIONS** | **VALUE** |
| **Voltage** | | |
| 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 | $U_{rev} \leq 1$ V |
| **Current** | | |
| Leakage current | After 2 min at $U_R$ | $I_{L2} \leq 0.01 \times C_R \times U_R$ |
| **Inductance** | | |
| Equivalent series inductance (ESL) | Ø D = 8 mm | Typ. 6 nH |
| | Ø D = 10 mm | Typ. 8 nH |
| | Ø D ≥ 12.5 mm | Typ. 11 nH |
| **Resistance** | | |
| Equivalent series resistance (ESR) at 100 Hz | Calculated from tan $\delta_{max.}$ and $C_R$ (see Table 6) | ESR = tan $\delta/2\pi f C_R$ |


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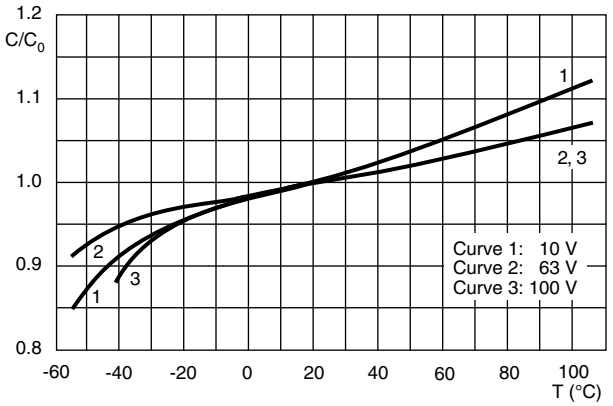
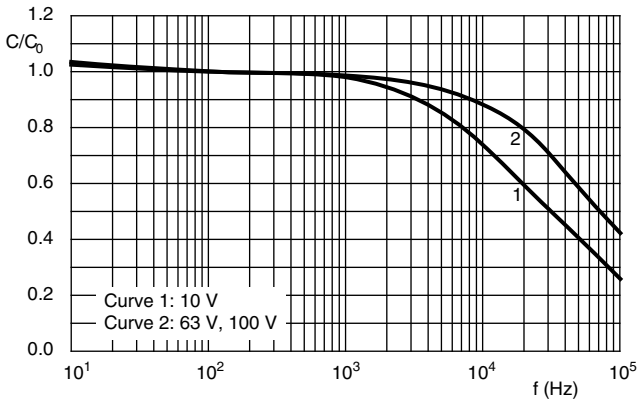
## CAPACITANCE




$C_0$ = Capacitance at 20 °C, 100 Hz

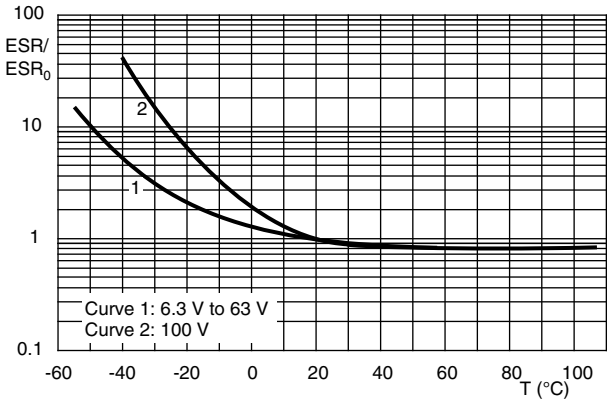
Fig. 7 - Typical multiplier of capacitance as a function of temperature at 100 Hz




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

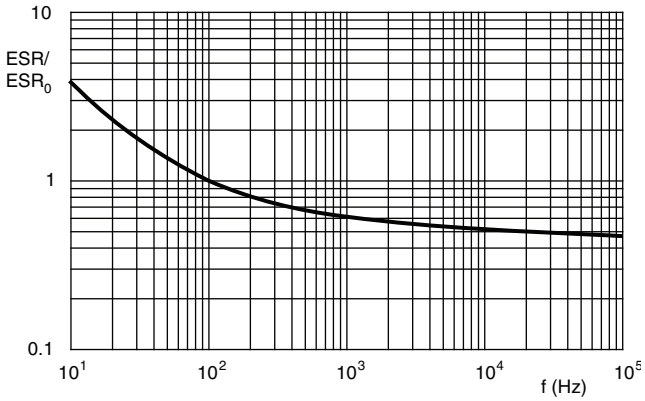
Fig. 8 - Typical multiplier of capacitance as a function of frequency at 20 °C

## EQUIVALENT SERIES RESISTANCE (ESR)




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

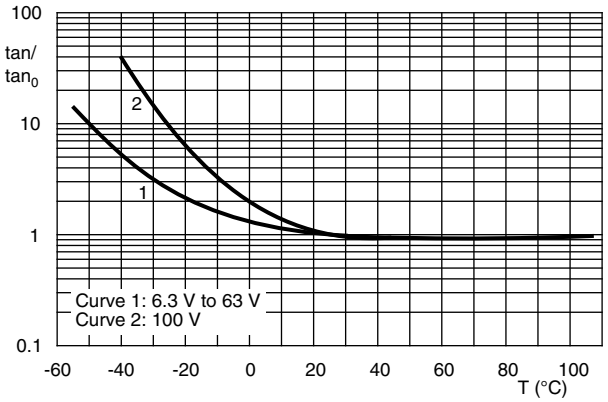
Fig. 9 - Typical multiplier of ESR as a function of temperature at 100 Hz




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

Fig. 10 - Typical multiplier ESR as a function of frequency at 20 °C

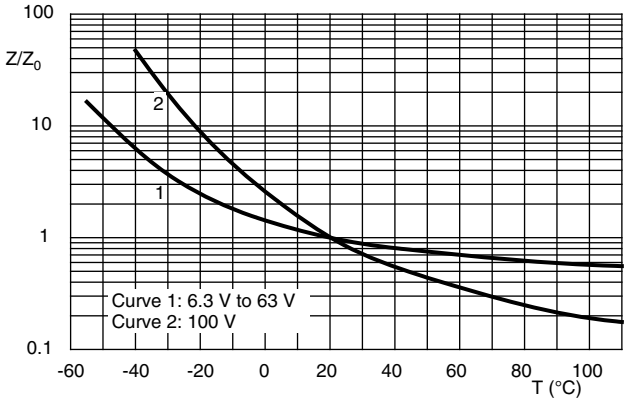
## DISSIPATION FACTOR (tan δ)




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

Fig. 11 - Typical multiplier of dissipation factor tan δ as a function of temperature at 20 °C at 100 Hz

## IMPEDANCE (Z)




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

Fig. 12 - Typical multiplier of impedance Z as a function of temperature at 100 kHz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## IMPEDANCE (Z)

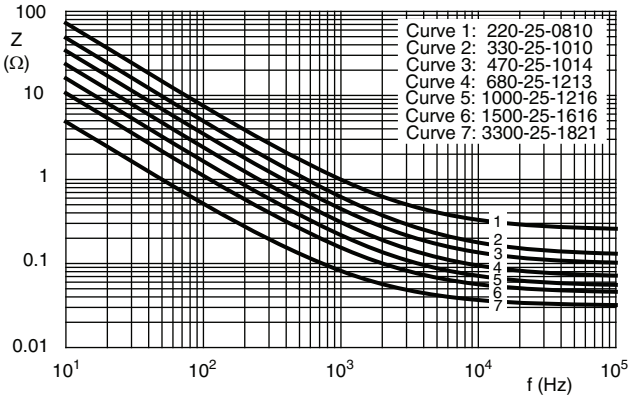


Fig. 13 - Typical impedance Z as a function of frequency at 20 °C

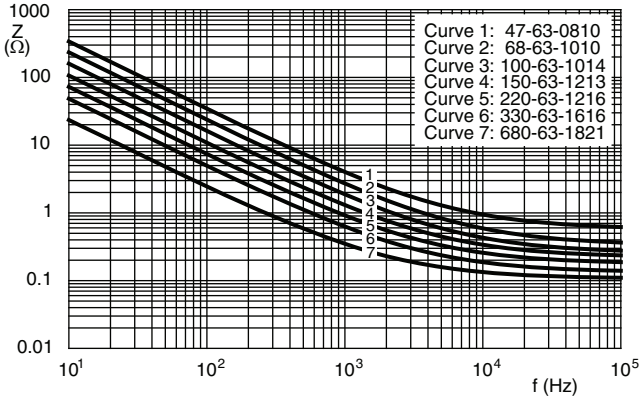


Fig. 14 - Typical impedance Z as a function of frequency at 20 °C

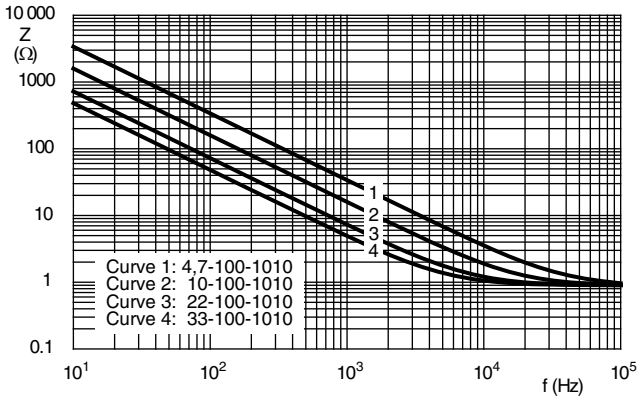


Fig. 15 - Typical impedance Z as a function of frequency at 20 °C

## RIPPLE CURRENT AND USEFUL LIFE

**Table 8**

| ENDURANCE TEST DURATION AND USEFUL LIFE | | | |
|---|---|---|---|
| **LIFE CODE** | **ENDURANCE AT 105 °C (h)** | **USEFUL LIFE AT 105 °C (h)** | **USEFUL LIFE AT 40 °C 1.8 x $I_R$ APPLIED (h)** |
| L1 | 2000 | 2500 | 125 000 |
| L2 | 2000 | 3000 | 150 000 |
| L3 | 3000 | 5000 | 250 000 |
| L4 | 5000 | 6000 | 300 000 |
| L5 | 6500 | 7500 | 375 000 |
| L6 | 8000 | 10 000 | 500 000 |

**Note**

- Multiplier of useful life code: CCC206


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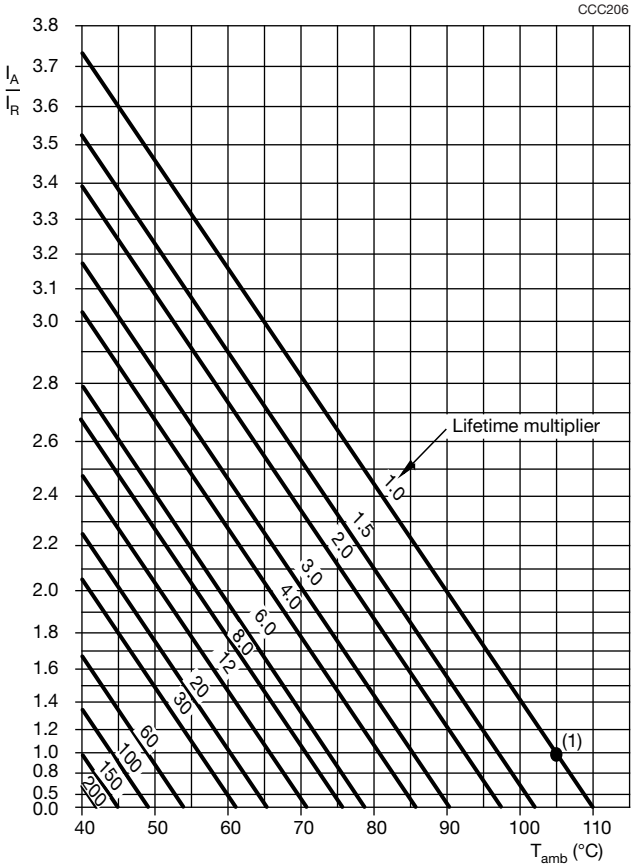


$I_A$ = actual ripple current at 100 kHz
$I_R$ = rated ripple current at 100 kHz, 105 °C
(1) Useful life at 105 °C and $I_R$ applied: see Table 7

Fig. 16 - Multiplier of useful life as a function of ambient temperature and ripple current load

**Table 9**

| MULTIPLIER OF RIPPLE CURRENT ($I_R$) AS A FUNCTION OF FREQUENCY | | | | | | | |
|---|---|---|---|---|---|---|---|
| $V_R$ (V) | FREQUENCY (Hz) | | | | | | |
| | 100 | 300 | 1000 | 3000 | 10 000 | 30 000 | 100 000 |
| | $I_R$ MULTIPLIER | | | | | | |
| 6.3 | 0.70 | 0.80 | 0.85 | 0.93 | 0.95 | 0.97 | 1.00 |
| 10 | 0.70 | 0.80 | 0.85 | 0.93 | 0.95 | 0.97 | 1.00 |
| 16 | 0.70 | 0.80 | 0.85 | 0.93 | 0.95 | 0.97 | 1.00 |
| 25 | 0.70 | 0.80 | 0.85 | 0.93 | 0.95 | 0.97 | 1.00 |
| 35 | 0.65 | 0.80 | 0.85 | 0.93 | 0.95 | 0.97 | 1.00 |
| 50 | 0.60 | 0.75 | 0.85 | 0.93 | 0.95 | 0.97 | 1.00 |
| 63 | 0.60 | 0.75 | 0.85 | 0.93 | 0.95 | 0.97 | 1.00 |
| 80 | 0.60 | 0.75 | 0.85 | 0.93 | 0.95 | 0.97 | 1.00 |
| 100 | 0.60 | 0.75 | 0.85 | 0.93 | 0.95 | 0.97 | 1.00 |


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**Table 10**

| TEST PROCEDURES AND REQUIREMENTS | | | |
|---|---|---|---|
| TEST | | PROCEDURE (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” | $\Delta C/C$: ± 5 %<br>tan $\delta \leq$ spec. limit<br>$I_{L2} \leq$ spec. limit |
| Endurance | IEC 60384-18 / CECC32300, subclause 4.15 | $T_{amb}$ = 105 °C; $U_R$ applied; for test duration see Table 8 | $U_R$ = 6.3 V; $\Delta C/C$: ± 25 %<br>$U_R \geq$ 10 V; $\Delta C/C$: ± 20 %<br>tan $\delta \leq$ 2 x spec. limit<br>$I_{L2} \leq$ spec. limit |
| Useful life | CECC 30301, subclause 1.8.1 | $T_{amb}$ = 105 °C; $U_R$ and $I_R$ applied; for test duration see Table 8 | $\Delta C/C$: ± 30 %<br>tan $\delta \leq$ 3 x spec. limit<br>$I_{L2} \leq$ spec. limit<br>no short or open circuit<br>total failure percentage: ≤ 1 % |
| Shelf life (storage at high temperature) | IEC 60384-18 / CECC32300, subclause 4.17 | $T_{amb}$ = 105 °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 |

*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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