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

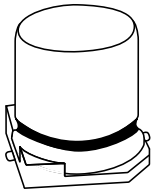
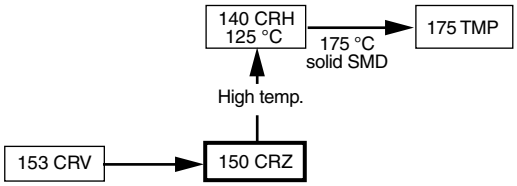


Fig.1 Component outline




## FEATURES

- 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
- Very long useful life: 5000 hours at 105 °C for case size ≥ 12.5 x 12.5 x 13
- Standard 4 pin-version for diameter ≥ 12.5 mm
- 4 pin-version for diameter 10 mm on request
- Charge and discharge proof, no peak current limitation
- Lead (Pb)-free and RoHS compliant
- ATTENTION: for maximum safe soldering conditions refer to Fig. 4

Pb-free

RoHS COMPLIANT

## APPLICATIONS

- SMD technology, for high mounting density
- Industrial and professional applications
- Automotive, general industrial
- Smoothing, filtering, buffering
- 4 pin-version for high vibration

## 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

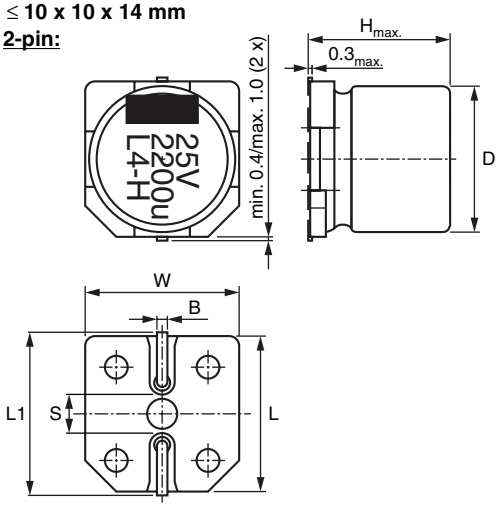
Supplied in blister tape on reel

| QUICK REFERENCE DATA | |
|---|---|
| **DESCRIPTION** | **VALUE** |
| Nominal case sizes (L x W x H in mm) | 8 x 8 x 10 to 12.5 x 12.5 x 16 |
| Rated capacitance range, $C_R$ | 33 to 2200 µF |
| Tolerance on $C_R$ | ± 20 % |
| Rated voltage range, $U_R$ | 6.3 to 63 V |
| Category temperature range | - 55 to + 105 °C |
| Endurance test at 105 °C:<br>case size ≤ 10 x 10 x 14<br>case size ≥ 12.5 x 12.5 x 13 | <br>2000 hours<br>3000 hours |
| Useful life at 105 °C:<br>case size ≤ 10 x 10 x 10<br>case size 10 x 10 x 14<br>case size ≥ 12.5 x 12.5 x 13 | <br>2500 hours<br>3000 hours<br>5000 hours |
| Useful life at 40 °C;<br>1.8 x $I_R$ applied:<br>case size ≤ 10 x 10 x 10<br>case size 10 x 10 x 14<br>case size ≥ 12.5 x 12.5 x 13 | <br><br>125 000 hours<br>150 000 hours<br>250 000 hours |
| Shelf life at 0 V, 105 °C | 1000 hours |
| Based on sectional specification | IEC 60384-18/CECC32300 |
| Climatic category IEC 60068 | 55/105/56 |

**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** |
| 33 | - | - | - | - | - | - | 8 x 8 x 10 |
| 47 | - | - | - | - | - | - | 8 x 8 x 10 |
| | - | - | - | - | - | - | 10 x 10 x 10 |
| 68 | - | - | - | - | - | 8 x 8 x 10 | 10 x 10 x 10 |
| 100 | - | - | - | - | 8 x 8 x 10 | 10 x 10 x 10 | 10 x 10 x 14 |
| 150 | - | - | - | 8 x 8 x 10 | - | - | 12.5 x 12.5 x 13 |
| 220 | - | - | 8 x 8 x 10 | 8 x 8 x 10 | 10 x 10 x 10 | 10 x 10 x 14 | 12.5 x 12.5 x 16 |
| 330 | - | 8 x 8 x 10 | 8 x 8 x 10 | 10 x 10 x 10 | 10 x 10 x 14 | 12.5 x 12.5 x 13 | - |
| 470 | 8 x 8 x 10 | 8 x 8 x 10 | 10 x 10 x 10 | 10 x 10 x 14 | 12.5 x 12.5 x 13 | - | - |
| 680 | - | 10 x 10 x 10 | 10 x 10 x 14 | 12.5 x 12.5 x 13 | 12.5 x 12.5 x 16 | - | - |
| 1000 | 10 x 10 x 10 | 10 x 10 x 14 | 12.5 x 12.5 x 13 | 12.5 x 12.5 x 16 | - | - | - |
| 1500 | - | 12.5 x 12.5 x 13 | 12.5 x 12.5 x 16 | - | - | - | - |
| 2200 | 12.5 x 12.5 x 13 | 12.5 x 12.5 x 16 | - | - | - | - | - |

**≤ 10 x 10 x 14 mm**
**2-pin:**




**≥ 12.5 x 12.5 x 13 mm**
**4-pin:**

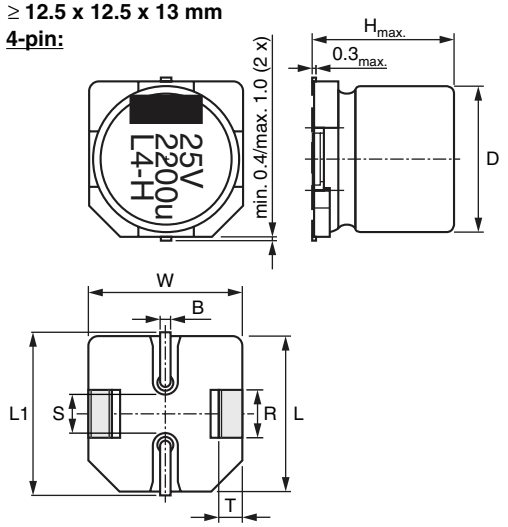



Fig.2 Dimensional Outline

**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** | **$L1_{max.}$** | **R ± 0.1** | **T ± 0.1** | **MASS (g)** |
| 8 x 8 x 10 | 0810 | 8.5 | 8.5 | 10.5 | 8.0 | 1.0 | 2.2 | 9.9 | - | - | ≈ 1.0 |
| 10 x 10 x 10 | 1010 | 10.5 | 10.5 | 10.5 | 10.0 | 1.0 | 3.5 | 11.8 | - | - | ≈ 1.3 |
| 10 x 10 x 14 | 1014 | 10.5 | 10.5 | 14.3 | 10.0 | 1.0 | 3.5 | 11.8 | - | - | ≈ 1.5 |
| 12.5 x 12.5 x 13 | 1213 | 12.8 | 12.8 | 14.0 | 12.5 | 1.3 | 3.6 | 14.9 | 3.7 | 2.4 | ≈ 2.6 |
| 12.5 x 12.5 x 16 | 1216 | 12.8 | 12.8 | 16.5 | 12.5 | 1.3 | 3.6 | 14.9 | 3.7 | 2.4 | ≈ 2.8 |

**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 | 11.3 | 380 | 500 |
| 10 x 10 x 10 | 1010 | 16 | 24 | 11.3 | 380 | 500 |
| 10 x 10 x 14 | 1014 | 16 | 24 | 14.8 | 330 | 250 |
| 12.5 x 12.5 x 13 | 1213 | 20 | 24 | 15.5 | 380 | 250 |
| 12.5 x 12.5 x 16 | 1216 | 24 | 32 | 17.5 | 380 | 200 |

**Note**
Detailed tape dimensions see section 'PACKAGING'.

## MOUNTING

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

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

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

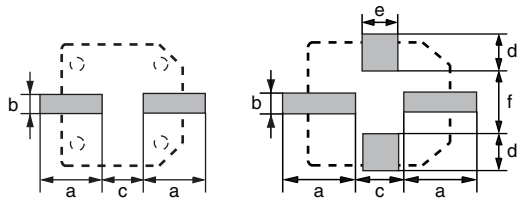
## SOLDERING

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

For maximum conditions refer to Fig.4.

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

AS A GENERAL PRINCIPLE, TEMPERATURE AND DURATION SHALL BE THE **MINIMUM** NECESSARY REQUIRED TO ENSURE GOOD SOLDERING CONNECTIONS. HOWEVER, THE SPECIFIED MAXIMUM CURVES SHOULD NEVER BE EXCEEDED.




Case size Ø D ≤ 10 mm  Case size Ø D ≥ 12.5 mm

Fig.3 Recommended soldering pad dimensions

**Table 3**

| **RECOMMENDED SOLDERING PAD DIMENSIONS** in millimeters | | | | | | |
|---|---|---|---|---|---|---|
| **CASE CODE** | **a** | **b** | **c** | **d** | **e** | **f** |
| 0810 | 3.5 | 2.5 | 3.0 | - | - | - |
| 1010 | 4.3 | 2.5 | 4.0 | - | - | - |
| 1014 | 4.3 | 2.5 | 4.0 | - | - | - |
| 1213 | 5.5 | 2.5 | 4.0 | 4.2 | 5.0 | 5.6 |
| 1216 | 5.5 | 2.5 | 4.0 | 4.2 | 5.0 | 5.6 |

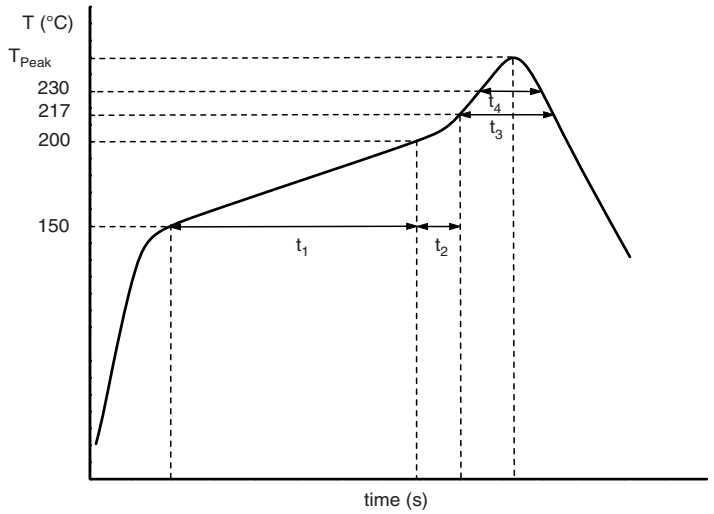



Fig.4 Maximum temperature load during reflow soldering

**Table 4**

| **REFLOW SOLDERING CONDITIONS** | | |
|---|---|---|
| **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 - 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 $T_{Liquidus}$ | 6 K/s | 6 K/s |

**Note**

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

| 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 minutes 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 5 apply at $T_{amb}$ = 20 °C, P = 86 to 106 kPa, RH = 45 to 75 %

## ORDERING EXAMPLE

Electrolytic capacitor 150 CRZ series

220 µF/50 V; ± 20 %

Nominal case size: 10 x 10 x 14 mm; taped on reel

Ordering Code: MAL215097102E3
Former 12 NC: 2222 150 97102

**Table 5**

**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) | $I_{L2}$ 2 min (µA) | tan δ 100 Hz | Z 100 kHz 20 °C (Ω) | Z 100 kHz - 40 °C (Ω) | ORDERING CODE MAL2150..... |
|---|---|---|---|---|---|---|---|---|
| 6.3 | 470 | 8 x 8 x 10 | 435 | 30 | 0.24 | 0.250 | 2.000 | 97311E3 |
| | 1000 | 10 x 10 x 10 | 670 | 63 | 0.24 | 0.130 | 1.100 | 97301E3 |
| | 2200 | 12.5 x 12.5 x 13 | 905 | 139 | 0.26 | 0.077 | 0.600 | 97312E3 |
| 10 | 330 | 8 x 8 x 10 | 435 | 33 | 0.20 | 0.250 | 2.000 | 97411E3 |
| | 470 | 8 x 8 x 10 | 435 | 47 | 0.20 | 0.250 | 2.000 | 97412E3 |
| | 680 | 10 x 10 x 10 | 670 | 68 | 0.20 | 0.130 | 1.100 | 97401E3 |
| | 1000 | 10 x 10 x 14 | 850 | 100 | 0.20 | 0.100 | 0.800 | 97402E3 |
| | 1500 | 12.5 x 12.5 x 13 | 905 | 150 | 0.22 | 0.077 | 0.600 | 97413E3 |
| | 2200 | 12.5 x 12.5 x 16 | 1007 | 220 | 0.22 | 0.060 | 0.480 | 97414E3 |
| 16 | 220 | 8 x 8 x 10 | 435 | 35 | 0.16 | 0.250 | 2.000 | 97511E3 |
| | 330 | 8 x 8 x 10 | 435 | 53 | 0.16 | 0.250 | 2.000 | 97512E3 |
| | 470 | 10 x 10 x 10 | 670 | 75 | 0.16 | 0.130 | 1.100 | 97501E3 |
| | 680 | 10 x 10 x 14 | 850 | 109 | 0.16 | 0.100 | 0.800 | 97502E3 |
| | 1000 | 12.5 x 12.5 x 13 | 905 | 160 | 0.18 | 0.077 | 0.600 | 97513E3 |
| | 1500 | 12.5 x 12.5 x 16 | 1007 | 240 | 0.18 | 0.060 | 0.480 | 97514E3 |
| 25 | 150 | 8 x 8 x 10 | 420 | 38 | 0.14 | 0.280 | 2.240 | 97611E3 |
| | 220 | 8 x 8 x 10 | 420 | 55 | 0.14 | 0.280 | 2.240 | 97612E3 |
| | 330 | 10 x 10 x 10 | 640 | 83 | 0.14 | 0.140 | 1.120 | 97601E3 |
| | 470 | 10 x 10 x 14 | 820 | 118 | 0.14 | 0.110 | 0.880 | 97602E3 |
| | 680 | 12.5 x 12.5 x 13 | 905 | 170 | 0.16 | 0.077 | 0.600 | 97613E3 |
| | 1000 | 12.5 x 12.5 x 16 | 1007 | 250 | 0.16 | 0.060 | 0.480 | 97614E3 |
| 35 | 100 | 8 x 8 x 10 | 405 | 35 | 0.12 | 0.300 | 2.400 | 97011E3 |
| | 220 | 10 x 10 x 10 | 630 | 77 | 0.12 | 0.150 | 1.200 | 97001E3 |
| | 330 | 10 x 10 x 14 | 790 | 116 | 0.12 | 0.120 | 0.960 | 97002E3 |
| | 470 | 12.5 x 12.5 x 13 | 905 | 165 | 0.14 | 0.077 | 0.600 | 97012E3 |
| | 680 | 12.5 x 12.5 x 16 | 1007 | 238 | 0.14 | 0.060 | 0.480 | 97013E3 |
| 50 | 68 | 8 x 8 x 10 | 333 | 34 | 0.12 | 0.480 | 3.840 | 97111E3 |
| | 100 | 10 x 10 x 10 | 490 | 50 | 0.12 | 0.240 | 1.920 | 97101E3 |
| | 220 | 10 x 10 x 14 | 620 | 110 | 0.12 | 0.190 | 1.520 | 97102E3 |
| | 330 | 12.5 x 12.5 x 13 | 690 | 165 | 0.12 | 0.130 | 1.040 | 97112E3 |
| 63 | 33 | 8 x 8 x 10 | 270 | 21 | 0.10 | 0.650 | 5.200 | 97812E3 |
| | 47 | 8 x 8 x 10 | 270 | 30 | 0.10 | 0.650 | 5.200 | 97811E3 |
| | 47 | 10 x 10 x 10 | 390 | 30 | 0.10 | 0.380 | 3.000 | 97801E3 |
| | 68 | 10 x 10 x 10 | 390 | 43 | 0.10 | 0.380 | 3.000 | 97802E3 |
| | 100 | 10 x 10 x 14 | 507 | 63 | 0.10 | 0.290 | 2.320 | 97803E3 |
| | 150 | 12.5 x 12.5 x 13 | 507 | 97 | 0.10 | 0.250 | 2.000 | 97821E3 |
| | 220 | 12.5 x 12.5 x 16 | 637 | 141 | 0.10 | 0.200 | 1.600 | 97815E3 |

| ADDITIONAL ELECTRICAL DATA | | |
|---|---|---|
| **PARAMETER** | **CONDITIONS** | **VALUE** |
| **Voltage** | | |
| Surge voltage for short periods | IEC 60384-18, subclause 4.14 | $U_s \leq 1.15 \times U_R$ |
| Reverse voltage for short periods | IEC 60384-18, subclause 4.16 | $U_{rev} \leq 1$ V |
| **Current** | | |
| Leakage current | After 2 minutes 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 5) | ESR = tan $\delta/2\,\pi\,f\,C_R$ |

## CAPACITANCE

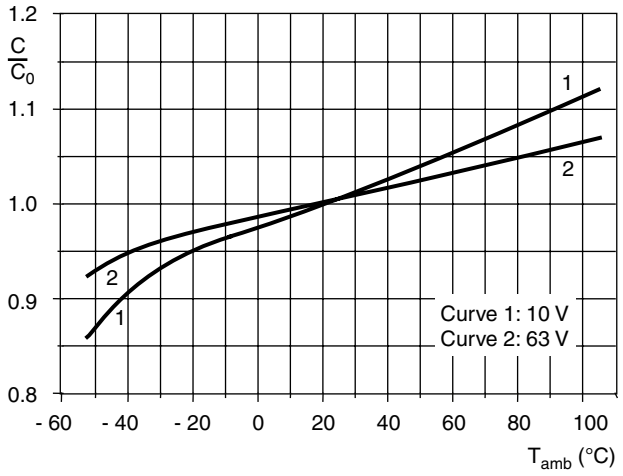



Fig.5 Typical multiplier of capacitance C as a function of temperature at 100 Hz
$C_0$ = typical capacitance C at 20 °C, 100 Hz

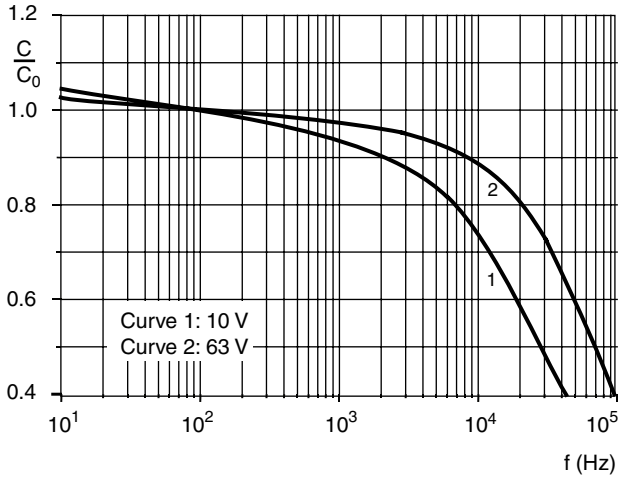



Fig.6 Typical multiplier of capacitance as a function of frequency at 20 °C
$C_0$ = typical capacitance at 20 °C, 100 Hz

## EQUIVALENT SERIES RESISTANCE (ESR)

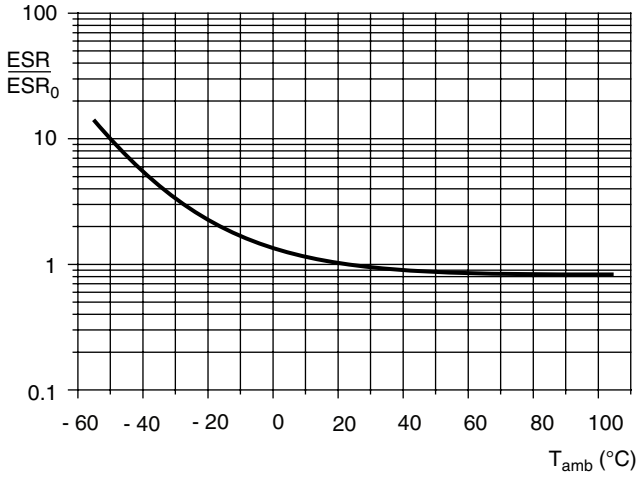



Fig.7 Typical multiplier of ESR as a function of temperature at 100 Hz
$ESR_0$ = typical ESR at 20 °C, 100 Hz

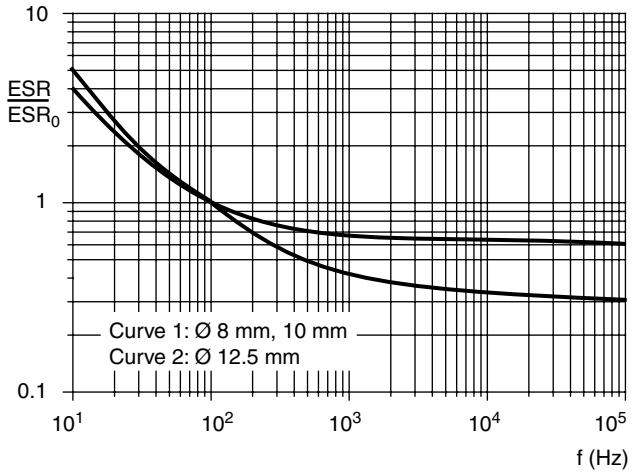



Fig.8 Typical multiplier ESR as a function of frequency at 20 °C
$ESR_0$ = typical ESR at 20 °C, 100 Hz

## DISSIPATION FACTOR (tan δ)

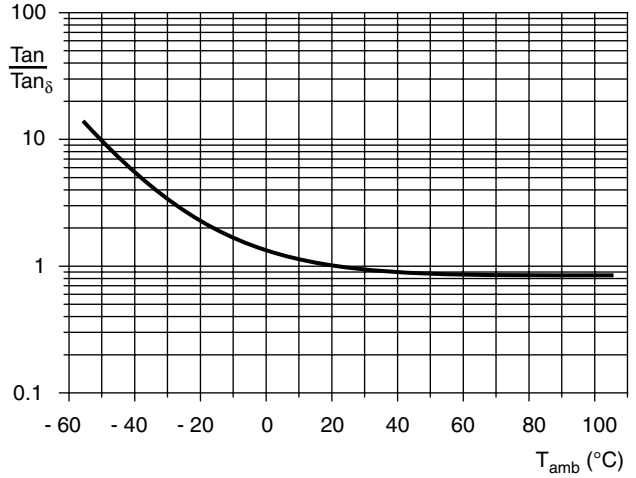



Fig.9 Typical multiplier of dissipation factor tan $_\delta$ as a function of temperature at °C 20 at 100 Hz
tan $\delta_0$ = typical tan δ at 20 °C, 100 Hz

## IMPEDANCE (Z)

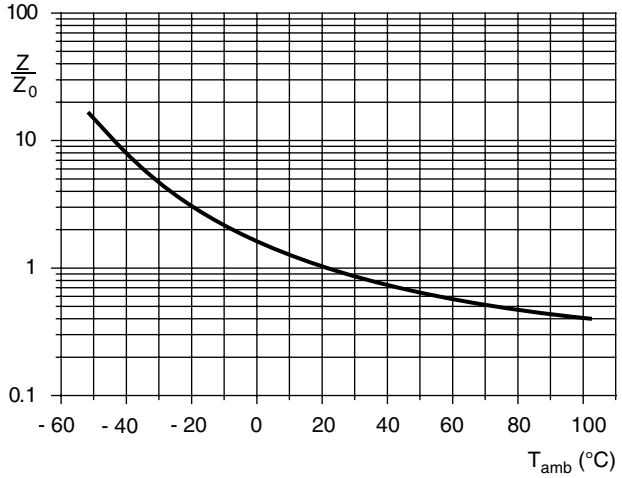



Fig.10 Typical multiplier of impedance Z as a function of temperature at 100 kHz
$Z_0$ = typical impedance Z at 20 °C, 100 kHz

## IMPEDANCE (Z)

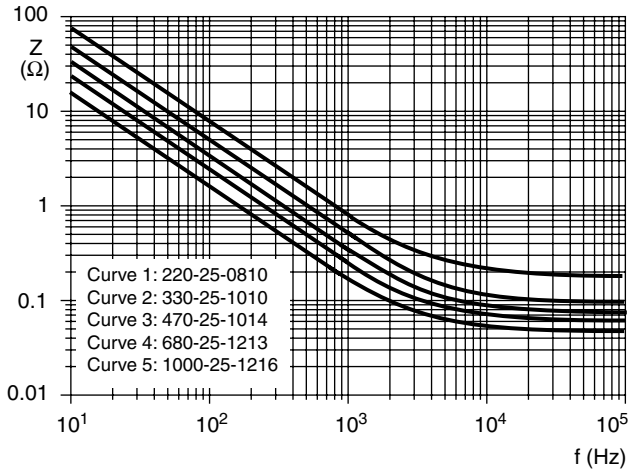



Fig.11 Typical impedance Z as a function of frequency at 20 °C

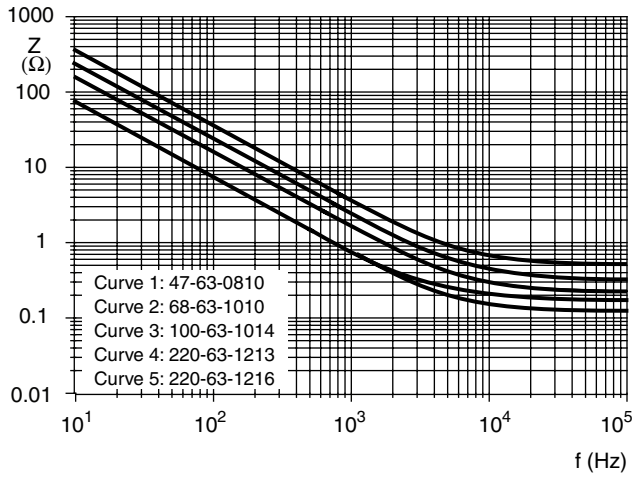
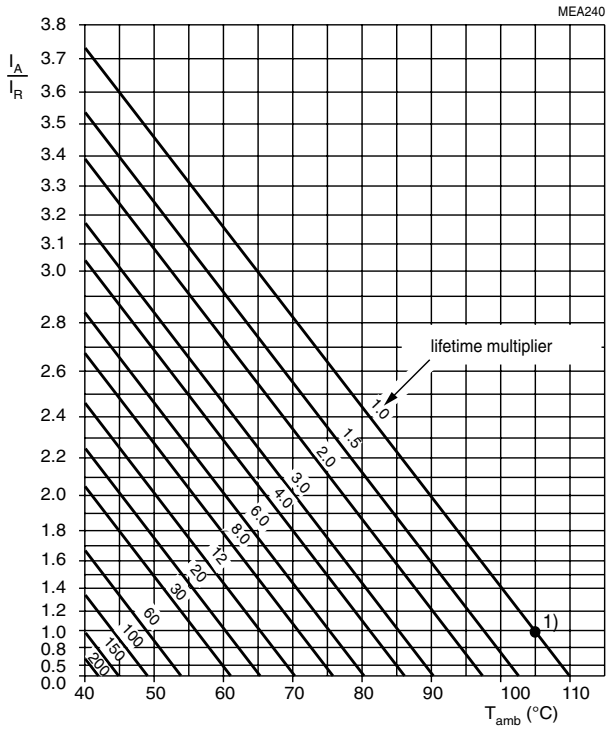



Fig.12 Typical impedance Z as a function of frequency at 20 °C

## RIPPLE CURRENT AND USEFUL LIFE




$I_A$ = actual ripple current at 100 Hz
$I_R$ = rated ripple current at 100 Hz, 105 °C
(1) = useful life at 105 °C and $I_R$ applied: 2000 h

Fig.13 Multiplier of useful life as a function of ambient temperature and ripple current load

**Table 6**

| MULTIPLIER OF RIPPLE CURRENT ($I_R$) AS A FUNCTION OF FREQUENCY | | | |
|---|---|---|---|
| FREQUENCY (Hz) | $I_R$ MULTIPLIER | | |
| | $U_R$ = 6.3 to 25 V | $U_R$ = 35 V | $U_R$ = 50 to 63 V |
| 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 7**

| 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;<br>reflow soldering;<br>for maximum temperature load<br>refer to chapter “Mounting” | ΔC/C: ± 5 %<br>tan δ ≤ spec. limit<br>$I_{L2}$ ≤ spec. limit |
| Endurance | IEC 60384-18/ CECC32300, subclause 4.15 | $T_{amb}$ = 105 °C; $U_R$ applied;<br>case size ≤ 10 x 10 x 14: 2000 hours<br>case size ≥ 12.5 x 12.5 x 13: 3000 hours | $U_R$ = 6.3 V; ΔC/C: ± 25 %<br>$U_R$ ≥ 10 V; ΔC/C: ± 20 %<br>tan δ ≤ 2 x spec. limit<br>$I_{L2}$ ≤ spec. limit |
| Useful life | CECC 30301, subclause 1.8.1 | $T_{amb}$ = 105 °C; $U_R$ and $I_R$ applied;<br>case size ≤ 10 x 10 x 10: 2500 hours<br>case size = 10 x 10 x 14: 3000 hours<br>case size ≥ 12.5 x 12.5 x 13: 5000 hours | ΔC/C: ± 30 %<br>tan δ ≤ 3 x spec. limit<br>$I_{L2}$ ≤ 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;<br>1000 hours<br>after test: $U_R$ to be applied for 30 minutes,<br>24 to 48 hours before measurement | for requirements<br>see ‘Endurance test’ above |

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