# Aluminum Capacitors
# SMD (Chip) Long Life Vertical

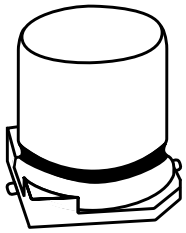
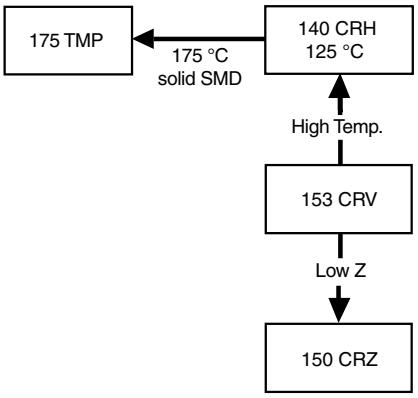


Fig.1 Component outline




## FEATURES

- Polarized aluminum electrolytic capacitors, non-solid electrolyte, self healing
- SMD-version with base plate, vertical construction requiring minimum board space, lead (Pb)-free reflow solderable
- High CV per unit volume
- Long useful life: 2000 to 3000 h at 105 °C
- Charge and discharge proof, no peak current limitation
- Supplied in blister tape on reel
- Lead (Pb)-free and RoHS compliant
- ATTENTION: for maximum safe soldering conditions refer to Fig.4

Pb-free
RoHS COMPLIANT

## APPLICATIONS

- SMD technology, in compliance with RoHS
- Coupling, decoupling, smoothing, filtering, buffering, timing
- Telecommunications, general industrial, EDP, automotive, portable and lightweight equipment

## MARKING

- Rated capacitance (in µF)
- Rated voltage (in V)
- Date code
- Black mark or '-' sign indicating the cathode (the anode is identified by bevelled edges)

## PACKAGING

- Supplied in blister tape on reel

| QUICK REFERENCE DATA | |
|---|---|
| **DESCRIPTION** | **VALUE** |
| Nominal case sizes (L x W x H in mm) | 4.0 x 4.0 x 5.3 to 10 x 10 x 14 |
| Rated capacitance range, $C_R$ | 0.47 to 1000 µF |
| Tolerance on $C_R$ | ± 20 % |
| Rated voltage range, $U_R$ | 6.3 to 100 V |
| Category temperature range | - 55 to + 105 °C |
| Endurance test at 105 °C: | |
| case sizes 4.0 x 4.0 x 5.3 to 6.3 x 6.3 x 5.3 | 1000 hours |
| case sizes 8.0 x 8.0 x 6.5 to 10 x 10 x 14 | 2000 hours |
| Useful life at 105 °C: | |
| case sizes 4.0 x 4.0 x 5.3 to 6.3 x 6.3 x 5.3 | 2000 hours |
| case sizes 8.0 x 8.0 x 6.5 to 10 x 10 x 14 | 3000 hours |
| Useful life at 40 °C; 1.3 x $I_R$ applied: | |
| case sizes 4.0 x 4.0 x 5.3 to 6.3 x 6.3 x 5.3 | 200 000 hours |
| case sizes 8.0 x 8.0 x 6.5 to 10 x 10 x 14 | 300 000 hours |
| Shelf life at 0 V, 105 °C | 1000 hours |
| Based on sectional specification | IEC 60384-18/ CECC 32300 |
| 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 | 100 |
| 0.47 | - | - | - | - | - | 4.0 x 4.0 x 5.3 | - | - |
| 1.0 | - | - | - | - | - | 4.0 x 4.0 x 5.3 | - | - |
| 2.2 | - | - | - | - | - | 4.0 x 4.0 x 5.3 | - | - |
| 3.3 | - | - | - | - | - | 4.0 x 4.0 x 5.3 | - | - |
| 4.7 | - | - | - | - | 4.0 x 4.0 x 5.3 | 5.0 x 5.0 x 5.3 | - | - |
| 10 | - | - | 4.0 x 4.0 x 5.3 | - | 5.0 x 5.0 x 5.3 | 6.3 x 6.3 x 5.3 | - | 10 x 10 x 12 |
| 22 | 4.0 x 4.0 x 5.3 | - | 5.0 x 5.0 x 5.3 | - | 6.3 x 6.3 x 5.3 | 8.0 x 8.0 x 6.5 | - | 10 x 10 x 12 |
| 33 | - | 5.0 x 5.0 x 5.3 | - | 6.3 x 6.3 x 5.3 | 8.0 x 8.0 x 6.5 | 8.0 x 8.0 x 10 | - | 10 x 10 x 14 |
| 47 | 5.0 x 5.0 x 5.3 | - | 6.3 x 6.3 x 5.3 | 8.0 x 8.0 x 6.5 | - | 8.0 x 8.0 x 10 | 10 x 10 x 12 | - |
| 100 | 6.3 x 6.3 x 5.3 | - | 8.0 x 8.0 x 6.5 | 8.0 x 8.0 x 10 | - | 10 x 10 x 10 | 10 x 10 x 14 | - |
| | - | - | - | - | - | 10 x 10 x 12 | - | - |
| 220 | - | 8.0 x 8.0 x 10 | 10 x 10 x 10 | 10 x 10 x 12 | 10 x10 x 12 | - | - | - |
| 330 | 8.0 x 8.0 x 10 | 10 x 10 x 10 | 10 x 10 x 12 | 10 x 10 x 14 | - | - | - | - |
| 470 | 10 x 10 x 10 | 10 x 10 x 12 | 10 x 10 x 14 | - | - | - | - | - |
| 680 | 10 x 10 x 12 | 10 x 10 x 14 | - | - | - | - | - | - |
| 1000 | 10 x 10 x 14 | - | - | - | - | - | - | - |

**Table 1**

| TAPE AND REEL DIMENSIONS in millimeters AND PACKAGING QUANTITIES | | | | | |
|---|---|---|---|---|---|
| CASE CODE | PITCH $P_1$ | TAPE WIDTH W | TAPE THICKNESS $T_2$ | REEL DIAMETER | PACKAGING QUANTITY PER REEL |
| 0405 | 8 | 12 | 5.8 | 380 | 2000 |
| 0505 | 12 | 12 | 5.8 | 380 | 1000 |
| 0605 | 12 | 16 | 5.8 | 380 | 1000 |
| 0807 | 12 | 16 | 6.8 | 380 | 1000 |
| 0810 | 16 | 24 | 11.3 | 380 | 500 |
| 1010 | 16 | 24 | 11.3 | 380 | 500 |
| 1012 | 16 | 24 | 12.8 | 330 | 250 |
| 1014 | 16 | 24 | 14.8 | 330 | 250 |

**Note**

Detailed tape dimensions see section ‘PACKAGING’.

**Table 2**

| **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** | **MASS (g)** |
| 4.0 x 4.0 x 5.3 | 0405 | 4.5 | 4.5 | 5.5 | 4.0 | 0.8 | 1.0 | ≈ 0.13 |
| 5.0 x 5.0 x 5.3 | 0505 | 5.5 | 5.5 | 5.5 | 5.0 | 0.8 | 1.4 | ≈ 0.20 |
| 6.3 x 6.3 x 5.3 | 0605 | 6.8 | 6.8 | 5.5 | 6.3 | 0.8 | 2.0 | ≈ 0.30 |
| 8.0 x 8.0 x 6.5 | 0807 | 8.6 | 8.6 | 6.8 | 8.0 | 0.8 | 2.3 | ≈ 0.50 |
| 8.0 x 8.0 x 10 | 0810 | 8.6 | 8.6 | 10.5 | 8.0 | 1.1 | 3.1 | ≈ 1.00 |
| 10 x 10 x 10 | 1010 | 10.6 | 10.6 | 10.5 | 10.0 | 1.1 | 4.7 | ≈ 1.30 |
| 10 x 10 x 12 | 1012 | 10.6 | 10.6 | 12.3 | 10.0 | 1.2 | 4.5 | ≈ 1.40 |
| 10 x 10 x 14 | 1014 | 10.6 | 10.6 | 14.3 | 10.0 | 1.2 | 4.5 | ≈ 1.50 |

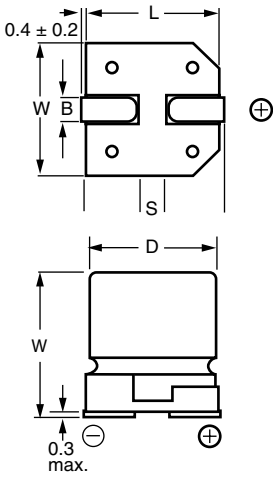



Fig.2 Dimensional outline

## 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.

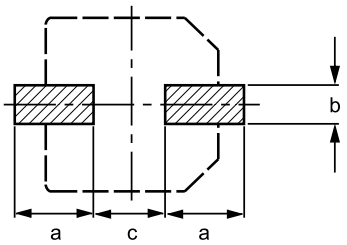



Fig.3 Recommended soldering pad dimensions

## SOLDERING

Soldering conditions are defined by the curve, temperature versus time, where the temperature is that measured on the soldering pad and on top of the case during processing.

For maximum conditions refer to Fig.4.
Maximum 2 runs with pause of minimum 30 min between.

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.

**Table 3**

| **RECOMMENDED SOLDERING PAD DIMENSIONS** in millimeters | | | |
|---|---|---|---|
| **CASE CODE** | **a** | **b** | **c** |
| 0405 | 2.6 | 1.6 | 1.0 |
| 0505 | 3.0 | 1.6 | 1.4 |
| 0605 | 3.5 | 1.6 | 1.9 |
| 0807 | 4.0 | 1.6 | 2.1 |
| 0810 | 3.5 | 2.5 | 3.0 |
| 1010 | 4.0 | 2.5 | 4.0 |
| 1012 | 4.3 | 2.5 | 4.0 |
| 1014 | 4.3 | 2.5 | 4.0 |

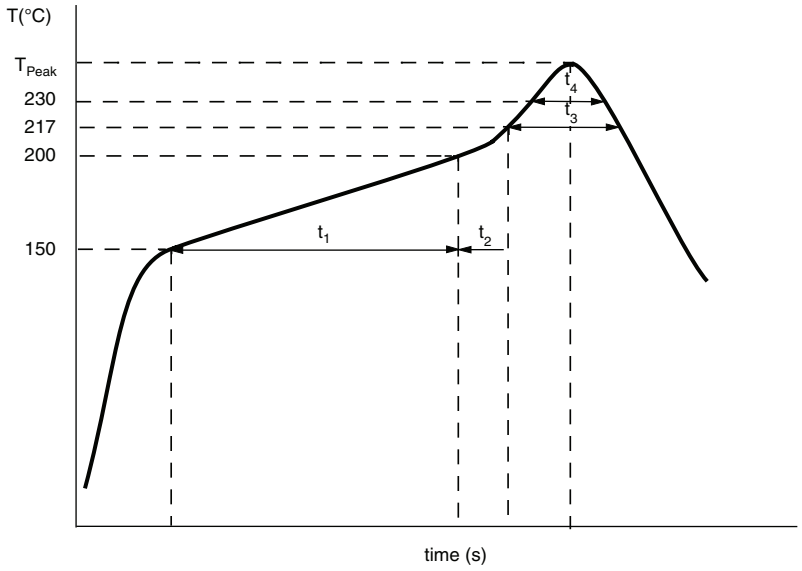



Fig.4 Maximum temperature load during reflow soldering measured on capacitors soldering pad and top of the case

| REFLOW SOLDERING CONDITIONS | | | | |
|---|---|---|---|---|
| **PROFILE FEATURES** | **CASE CODE 0405 to 0605** | **CASE CODE 0807 to 1010** | **CASE CODE 1012 to 1014 ≤ 63 V** | **CASE CODE 1012 to 1014 100 V** |
| Max. time from 25 °C to $T_{peak}$ | 240 s | 240 s | 300 s | 270 s |
| Max. ramp-up rate to 150 °C | 3 K/s | 3 K/s | 3 K/s | 3 K/s |
| Max. time from 150 °C to 200 °C (t1) | 120 s | 120 s | 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 | 0.5 K/s to 3 K/s | 0.5 K/s to 3 K/s |
| Max. time from 200 °C - 217 °C, (t2) | 20 s | 20 s | 60 s | 60 s |
| Max. time above $T_{Liquidus}$ (217 °C), (t3) | 60 s | 60 s | 90 s | 60 s |
| Max. time above 230 °C (t4) | 30 s | 20 s | 40 s | 30 s |
| Peak temperature $T_{peak}$ | 250 °C | 240 °C | 250 °C | 240 °C |
| Max. time above $T_{peak}$ minus 5 °C | 5 s | 5 s | 5 s | 10 s |
| Max. ramp-down rate from $T_{Liquidus}$ | 6 K/s | 6 K/s | 6 K/s | 6 K/s |

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

## ELECTRICAL DATA

| SYMBOL | DESCRIPTION |
|---|---|
| $C_R$ | rated capacitance at 100 or 120 Hz, tolerance ± 20 % |
| $I_R$ | rated RMS ripple current at 100 or 120 Hz, 105 °C |
| $I_{L2}$ | max. leakage current after 2 minutes at $U_R$ |
| **tan** $\delta$ | max. dissipation factor at 100 or 120 Hz |
| **ESR** | equivalent series resistance at 100 kHz |

**Note**

Unless otherwise specified, all electrical values in Table 4 apply at $T_{amb}$ = 20 °C, P = 86 to 106 kPa, RH = 45 to 75 %.

## ORDERING EXAMPLE

Electrolytic capacitor 153 CRV series

100 µF/25 V; ± 20 %

Nominal case size:
8 x 8 x 10 mm; taped on reel

Ordering Code: MAL215376101E3

Former 12NC: 2222 153 76101

**Table 4**

## ELECTRICAL DATA AND ORDERING INFORMATION

| $U_R$ (V) | $C_R$ (µF) | NOMINAL CASE SIZE L x W x H (mm) | $I_R$ 105 °C (mA) | $I_{L2}$ 2 min (µA) | tan $\delta$ 100 Hz | ESR 100 kHz (Ω) | ORDERING CODE MAL2153..... |
|---|---|---|---|---|---|---|---|
| 6.3 | 22 | 4.0 x 4.0 x 5.3 | 21 | 3.0 | 0.30 | 8 | 73229E3 |
| | 47 | 5.0 x 5.0 x 5.3 | 36 | 3.0 | 0.30 | 4 | 73479E3 |
| | 100 | 6.3 x 6.3 x 5.3 | 61 | 6.3 | 0.30 | 2 | 73101E3 |
| | 330 | 8.0 x 8.0 x 10 | 180 | 21 | 0.30 | 0.5 | 73331E3 |
| | 470 | 10 x 10 x 10 | 320 | 30 | 0.30 | 0.3 | 73471E3 |
| | 680 | 10 x 10 x 12 | 340 | 43 | 0.24 | 0.29 | 73681E3 |
| | 1000 | 10 x 10 x 14 | 400 | 63 | 0.24 | 0.24 | 73102E3 |
| 10 | 33 | 5.0 x 5.0 x 5.3 | 31 | 3.3 | 0.26 | 4 | 74339E3 |
| | 220 | 8.0 x 8.0 x 10 | 180 | 22 | 0.26 | 0.5 | 74221E3 |
| | 330 | 10 x 10 x 10 | 320 | 33 | 0.26 | 0.3 | 74331E3 |
| | 470 | 10 x 10 x 12 | 330 | 47 | 0.19 | 0.29 | 74471E3 |
| | 680 | 10 x 10 x 14 | 380 | 68 | 0.19 | 0.24 | 74681E3 |
| 16 | 10 | 4.0 x 4.0 x 5.3 | 16 | 3.0 | 0.22 | 8 | 75109E3 |
| | 22 | 5.0 x 5.0 x 5.3 | 28 | 3.5 | 0.22 | 4 | 75229E3 |
| | 47 | 6.3 x 6.3 x 5.3 | 47 | 7.5 | 0.22 | 2.2 | 75479E3 |
| | 100 | 8.0 x 8.0 x 6.5 | 110 | 16 | 0.22 | 1.2 | 75101E3 |
| | 220 | 10 x 10 x 10 | 320 | 35 | 0.22 | 0.3 | 75221E3 |
| | 330 | 10 x 10 x 12 | 330 | 53 | 0.16 | 0.29 | 75331E3 |
| | 470 | 10 x 10 x 14 | 370 | 75 | 0.16 | 0.25 | 75471E3 |
| 25 | 33 | 6.3 x 6.3 x 5.3 | 44 | 8.3 | 0.16 | 2.2 | 76339E3 |
| | 47 | 8.0 x 8.0 x 6.5 | 110 | 12 | 0.16 | 1.2 | 76479E3 |
| | 100 | 8.0 x 8.0 x 10 | 180 | 22 | 0.16 | 0.5 | 76101E3 |
| | 220 | 10 x 10 x 12 | 270 | 55 | 0.14 | 0.29 | 76221E3 |
| | 330 | 10 x 10 x 14 | 300 | 83 | 0.14 | 0.27 | 76331E3 |
| 35 | 4.7 | 4.0 x 4.0 x 5.3 | 14 | 3.0 | 0.13 | 8 | 70478E3 |
| | 10 | 5.0 x 5.0 x 5.3 | 23 | 3.5 | 0.13 | 4 | 70109E3 |
| | 22 | 6.3 x 6.3 x 5.3 | 50 | 7.7 | 0.13 | 2.2 | 70229E3 |
| | 33 | 8.0 x 8.0 x 6.5 | 110 | 12 | 0.13 | 1.2 | 70339E3 |
| | 220 | 10 x 10 x 12 | 270 | 77 | 0.12 | 0.29 | 70221E3 |
| 50 | 0.47 | 4.0 x 4.0 x 5.3 | 5 | 3.0 | 0.12 | 12 | 71477E3 |
| | 1.0 | 4.0 x 4.0 x 5.3 | 7 | 3.0 | 0.12 | 12 | 71108E3 |
| | 2.2 | 4.0 x 4.0 x 5.3 | 10 | 3.0 | 0.12 | 12 | 71228E3 |
| | 3.3 | 4.0 x 4.0 x 5.3 | 12 | 3.0 | 0.12 | 12 | 71338E3 |
| | 4.7 | 5.0 x 5.0 x 5.3 | 17 | 3.0 | 0.12 | 6 | 71478E3 |
| | 10 | 6.3 x 6.3 x 5.3 | 26 | 5.0 | 0.12 | 3 | 71109E3 |
| | 22 | 8.0 x 8.0 x 6.5 | 110 | 11 | 0.12 | 1.2 | 71229E3 |
| | 33 | 8.0 x 8.0 x 10 | 180 | 17 | 0.12 | 0.5 | 71339E3 |
| | 47 | 8.0 x 8.0 x 10 | 180 | 24 | 0.12 | 0.5 | 71479E3 |
| | 100 | 10 x 10 x 10 | 320 | 50 | 0.12 | 0.3 | 71101E3 |
| | 100 | 10 x 10 x 12 | 230 | 50 | 0.12 | 0.29 | 91107E3 |
| 63 | 47 | 10 x 10 x 12 | 220 | 30 | 0.09 | 0.39 | 78479E3 |
| | 100 | 10 x 10 x 14 | 240 | 63 | 0.09 | 0.34 | 78101E3 |
| 100 | 10 | 10 x 10 x 12 | 150 | 10 | 0.07 | 1.4 | 79109E3 |
| | 22 | 10 x 10 x 12 | 150 | 25 | 0.07 | 1.4 | 79229E3 |
| | 33 | 10 x 10 x 14 | 170 | 33 | 0.07 | 1.3 | 79339E3 |

| ADDITIONAL ELECTRICAL DATA | | |
|---|---|---|
| **PARAMETER** | **CONDITIONS** | **VALUE** |
| **Voltage** | | |
| Surge voltage | IEC 6084-18, subclause 4.14 | $U_s \leq 1.15 \times U_R$ |
| Reverse voltage | IEC 60384-18, subclause 4.16 | $U_{rev} \leq 1$ V |
| **Current** | | |
| Leakage current | After 2 minutes at $U_R$ | $I_{L2} \leq 0.01 \times C_R \times U_R$ or 3 µA, whichever is greater |
| **Inductance** | | |
| Equivalent series inductance (ESL) | Case codes 0405 to 0605 | typ. 10 nH |
| | Case codes 0807 to 1014 | typ. 15 nH |

## CAPACITANCE (C)

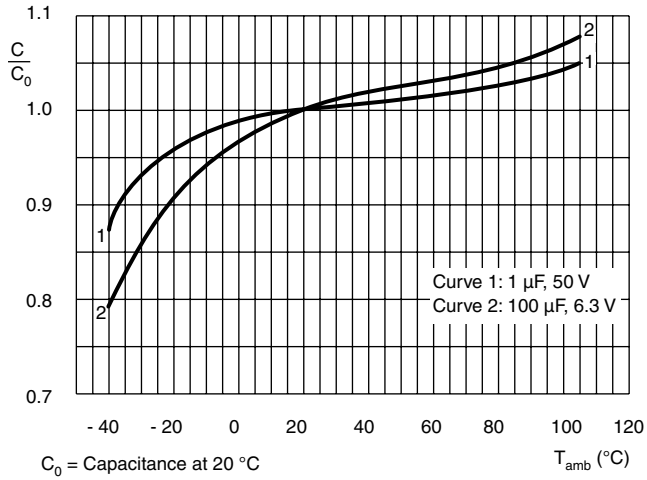



Fig.5 Typical multiplier of capacitance at 100 or 120 Hz as a function of ambient temperature

## EQUIVALENT SERIES RESISTANCE (ESR)

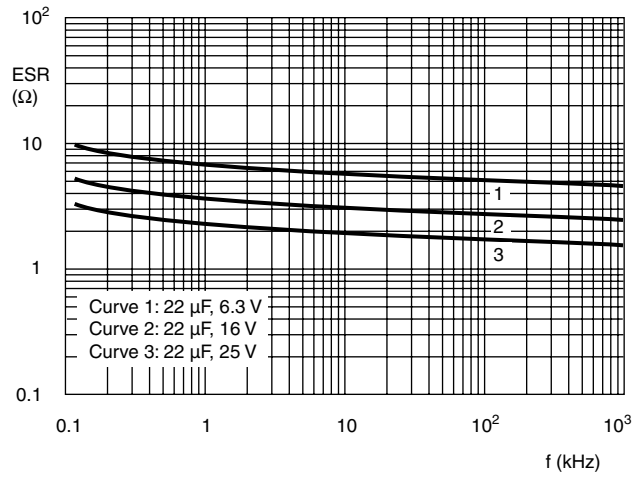



Fig.6 Typical ESR as a function of frequency at 20 °C

## DISSIPATION FACTOR (tan δ)

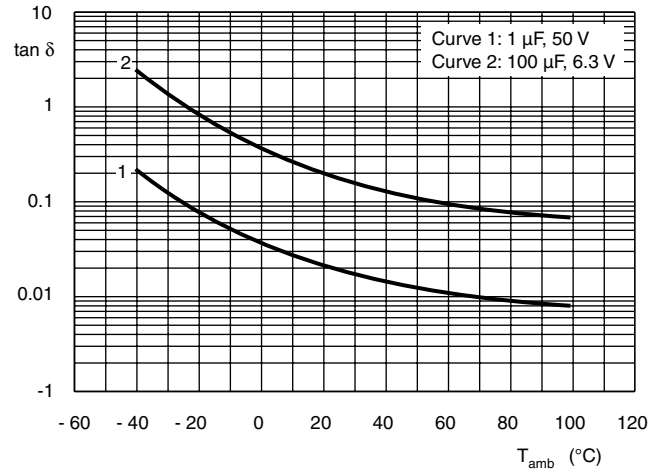



Fig.7 Typical dissipation factor (tan δ) at 100 Hz or 120 Hz as a function of ambient temperature

## IMPEDANCE (Z)

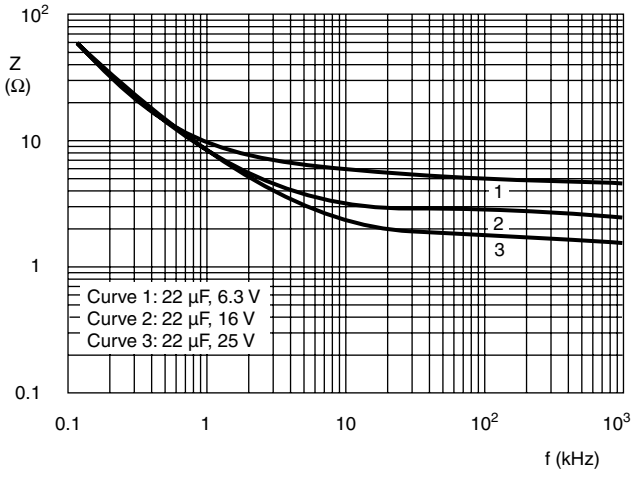
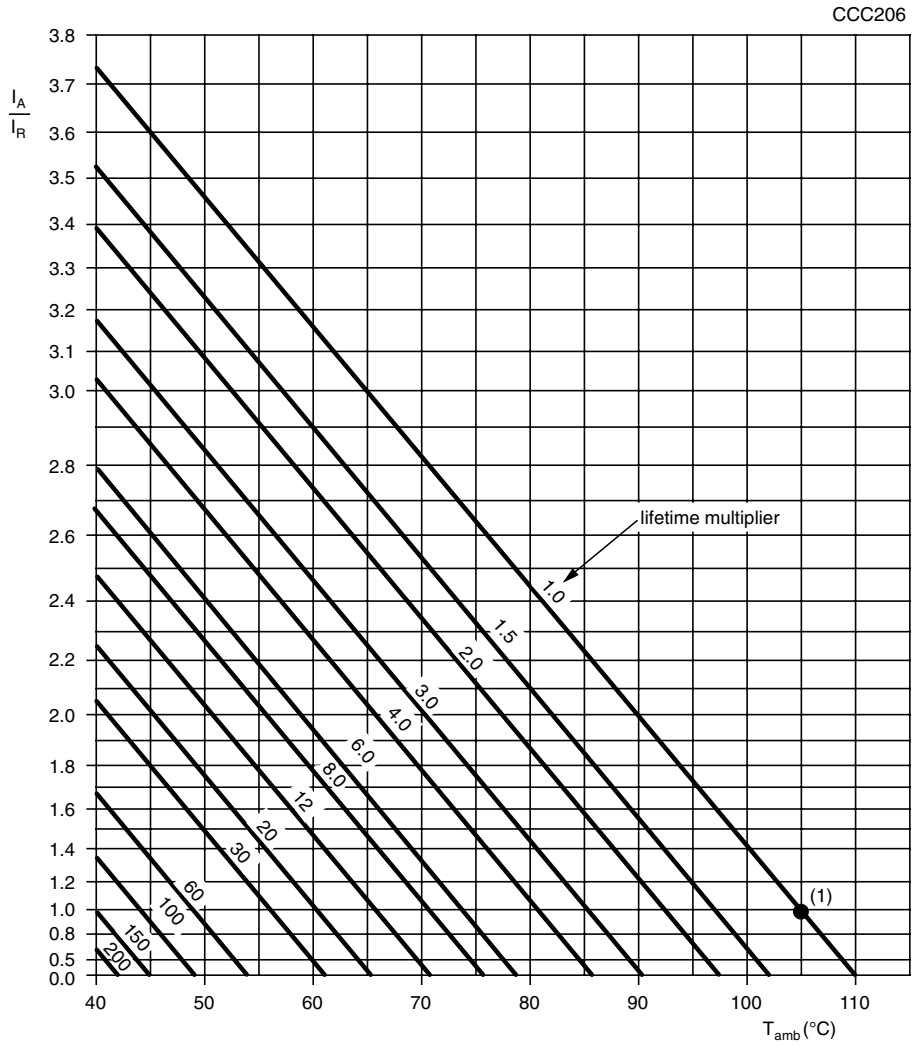



Fig.8 Typical impedance as a function of frequency at 20 °C

## RIPPLE CURRENT AND USEFUL LIFE




$I_A$ = actual ripple current at 100 Hz or 120 Hz
$I_R$ = rated ripple current at 100 Hz or 120 Hz at 105 °C
For case codes 0405 to 1010 max. $I_A/I_R$ = 2.4
(1) Useful life at 105 °C and $I_R$ applied:
case codes 0405 to 0605: 2000 h
case codes 0807 to 1014: 3000 h

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

**Table 5**

| MULTIPLIER OF RIPPLE CURRENT ($I_R$) AS A FUNCTION OF FREQUENCY | | | |
|---|---|---|---|
| FREQUENCY (Hz) | $I_R$ MULTIPLIER | | |
| | $U_R$ = 6.3 to 16 V | $U_R$ = 25 or 35 V | $U_R$ = 50 V to 100 V |
| 50 or 60 | 0.80 | 0.80 | 0.80 |
| 100 or 120 | 1.00 | 1.00 | 1.00 |
| 300 | 1.10 | 1.15 | 1.20 |
| 1000 | 1.15 | 1.25 | 1.35 |
| 3000 | 1.20 | 1.35 | 1.45 |
| ≥ 10 000 | 1.25 | 1.40 | 1.50 |

**Table 6**

| 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 refer to chapter “Mounting” | ΔC/C: ± 10 %<br>tan δ ≤ spec. limit<br>$I_{L2}$ ≤ spec. limit |
| Endurance | IEC 60384-18/ CECC 32300, subclause 4.15 | $T_{amb}$ = 105 °C; $U_R$ applied;<br>1000 hours, case codes 0405 to 0605<br>2000 hours, case codes 0807 to 1014 | 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>2000 hours, case codes 0405 to 0605<br>3000 hours, case codes 0807 to 1014 | ΔC/C: ± 50 %<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/ CECC 32 300, subclause 4.17 | $T_{amb}$ = 105 °C; no voltage applied;<br>1000 hours<br>after test: $U_R$ to be applied for 30 minutes, 24 to 48 hours before measurement | for requirements see ‘Endurance test’ above |

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