

# Aluminum Capacitors

## SMD (Chip) Long Life Vertical

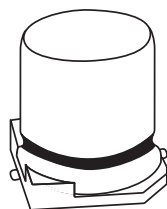
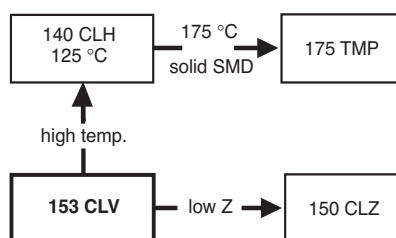


Fig.1 Component outline.



### QUICK REFERENCE DATA

| DESCRIPTION                                                                                             | VALUE                              |
|---------------------------------------------------------------------------------------------------------|------------------------------------|
| Nominal case sizes<br>(L × W × H in mm)                                                                 | 4.0 × 4.0 × 5.3<br>to 10 × 10 × 14 |
| Rated capacitance range, C <sub>R</sub>                                                                 | 0.47 to 1000 μF                    |
| Tolerance on C <sub>R</sub>                                                                             | ±20%                               |
| Rated voltage range, U <sub>R</sub>                                                                     | 6.3 to 100 V                       |
| Category temperature range                                                                              | −55 to +105 °C                     |
| Endurance test at 105 °C:<br>case sizes<br>4.0 × 4.0 × 5.3 to 6.3 × 6.3 × 5.3                           | 1000 hours                         |
| case sizes<br>8.0 × 8.0 × 6.5 to 10 × 10 × 14                                                           | 2000 hours                         |
| Useful life at 105 °C:<br>case sizes<br>4.0 × 4.0 × 5.3 to 6.3 × 6.3 × 5.3                              | 2000 hours                         |
| case sizes<br>8.0 × 8.0 × 6.5 to 10 × 10 × 14                                                           | 3000 hours                         |
| Useful life at 40 °C; 1.3 × I <sub>R</sub> applied:<br>case sizes<br>4.0 × 4.0 × 5.3 to 6.3 × 6.3 × 5.3 | 200000 hours                       |
| case sizes<br>8.0 × 8.0 × 6.5 to 10 × 10 × 14                                                           | 300000 hours                       |
| Shelf life at 0 V, 105 °C                                                                               | 1000 hours                         |
| Based on sectional specification                                                                        | IEC 60384-18/<br>CECC 32300        |
| Climatic category IEC 60068                                                                             | 55/105/56                          |

### FEATURES

- Polarized aluminum electrolytic capacitors, non-solid electrolyte, self healing
- SMD-version with base plate, vertical construction requiring minimum board space, reflow solderable
- High CV per unit volume
- Long useful life: 2000 to 3000 hours at 105 °C
- Charge and discharge proof, no peak current limitation
- Supplied in blister tape on reel.

### APPLICATIONS

- SMD technology, for high mounting density
- 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, in accordance with IEC 60062.
- Black mark or ‘−’ sign indicating the cathode (the anode is identified by bevelled edges).
- Code indicating group number (V).

### PACKAGING

Supplied in blister tape on reel.

| SELECTION CHART FOR $C_R$ , $U_R$ AND RELEVANT NOMINAL CASE SIZES (L × W × H in mm) |                    |                    |                    |                    |                    |                    |                 |                 |
|-------------------------------------------------------------------------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|-----------------|-----------------|
| $C_R$<br>( $\mu F$ )                                                                | $U_R$ (V)          |                    |                    |                    |                    |                    |                 |                 |
|                                                                                     | 6.3                | 10                 | 16                 | 25                 | 35                 | 50                 | 63              | 100             |
| 0.47                                                                                | –                  | –                  | –                  | –                  | –                  | 4.0 ×<br>4.0 × 5.3 | –               | –               |
| 1.0                                                                                 | –                  | –                  | –                  | –                  | –                  | 4.0 ×<br>4.0 × 5.3 | –               | –               |
| 2.2                                                                                 | –                  | –                  | –                  | –                  | –                  | 4.0 ×<br>4.0 × 5.3 | –               | –               |
| 3.3                                                                                 | –                  | –                  | –                  | –                  | –                  | 4.0 ×<br>4.0 × 5.3 | –               | –               |
| 4.7                                                                                 | –                  | –                  | –                  | –                  | 4.0 ×<br>4.0 × 5.3 | 5.0 ×<br>5.0 × 5.3 | –               | –               |
| 10                                                                                  | –                  | –                  | 4.0 ×<br>4.0 × 5.3 | –                  | 5.0 ×<br>5.0 × 5.3 | 6.3 ×<br>6.3 × 5.3 | –               | 10 ×<br>10 × 12 |
| 22                                                                                  | 4.0 ×<br>4.0 × 5.3 | –                  | 5.0 ×<br>5.0 × 5.3 | –                  | 6.3 ×<br>6.3 × 5.3 | 8.0 ×<br>8.0 × 6.5 | –               | 10 ×<br>10 × 12 |
| 33                                                                                  | –                  | 5.0 ×<br>5.0 × 5.3 | –                  | 6.3 ×<br>6.3 × 5.3 | 8.0 ×<br>8.0 × 6.5 | 8.0 ×<br>8.0 × 10  | –               | 10 ×<br>10 × 14 |
| 47                                                                                  | 5.0 ×<br>5.0 × 5.3 | –                  | 6.3 ×<br>6.3 × 5.3 | 8.0 ×<br>8.0 × 6.5 | –                  | 8.0 ×<br>8.0 × 10  | 10 ×<br>10 × 12 | –               |
| 100                                                                                 | 6.3 ×<br>6.3 × 5.3 | –                  | 8.0 ×<br>8.0 × 6.5 | 8.0 ×<br>8.0 × 10  | –                  | 10 ×<br>10 × 10    | 10 ×<br>10 × 14 | –               |
|                                                                                     | –                  | –                  | –                  | –                  | –                  | 10 ×<br>10 × 12    | –               | –               |
| 220                                                                                 | –                  | 8.0 ×<br>8.0 × 10  | 10 ×<br>10 × 10    | 10 ×<br>10 × 12    | 10 ×<br>10 × 12    | –                  | –               | –               |
| 330                                                                                 | 8.0 ×<br>8.0 × 10  | 10 ×<br>10 × 10    | 10 ×<br>10 × 12    | 10 ×<br>10 × 14    | –                  | –                  | –               | –               |
| 470                                                                                 | 10 ×<br>10 × 10    | 10 ×<br>10 × 12    | 10 ×<br>10 × 14    | –                  | –                  | –                  | –               | –               |
| 680                                                                                 | 10 ×<br>10 × 12    | 10 ×<br>10 × 14    | –                  | –                  | –                  | –                  | –               | –               |
| 1000                                                                                | 10 ×<br>10 × 14    | –                  | –                  | –                  | –                  | –                  | –               | –               |

Table 1

| TAPE AND REEL DIMENSIONS in millimeters AND PACKAGING QUANTITIES |                |                   |                         |           |                                   |
|------------------------------------------------------------------|----------------|-------------------|-------------------------|-----------|-----------------------------------|
| CASE CODE                                                        | PITCH<br>$P_1$ | TAPE WIDTH<br>$W$ | TAPE THICKNESS<br>$T_2$ | REEL DIA. | PACKAGING<br>QUANTITY<br>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**

1. Detailed tape dimensions see section 'PACKAGING'.

Table 2

| DIMENSIONS in millimeters AND MASS |           |                  |                  |                  |      |                  |     |          |          |
|------------------------------------|-----------|------------------|------------------|------------------|------|------------------|-----|----------|----------|
| NOMINAL CASE SIZE<br>L × W × H     | CASE CODE | L <sub>max</sub> | W <sub>max</sub> | H <sub>max</sub> | ØD   | B <sub>max</sub> | S   | C        | MASS (g) |
| 4.0 × 4.0 × 5.3                    | 0405      | 4.5              | 4.5              | 5.5              | 4.0  | 0.8              | 1.0 | 2.0 ±0.2 | ≈0.13    |
| 5.0 × 5.0 × 5.3                    | 0505      | 5.5              | 5.5              | 5.5              | 5.0  | 0.8              | 1.4 | 2.3 ±0.2 | ≈0.20    |
| 6.3 × 6.3 × 5.3                    | 0605      | 6.8              | 6.8              | 5.5              | 6.3  | 0.8              | 2.0 | 2.7 ±0.2 | ≈0.30    |
| 8.0 × 8.0 × 6.5                    | 0807      | 8.6              | 8.6              | 6.8              | 8.0  | 0.8              | 2.3 | 3.4 ±0.2 | ≈0.50    |
| 8.0 × 8.0 × 10                     | 0810      | 8.6              | 8.6              | 10.5             | 8.0  | 1.1              | 3.1 | 3.0 ±0.2 | ≈1.00    |
| 10 × 10 × 10                       | 1010      | 10.6             | 10.6             | 10.5             | 10.0 | 1.1              | 4.7 | 3.3 ±0.2 | ≈1.30    |
| 10 × 10 × 12                       | 1012      | 10.6             | 10.6             | 12.3             | 10.0 | 1.2              | 4.5 | 3.9 ±0.2 | ≈1.40    |
| 10 × 10 × 14                       | 1014      | 10.6             | 10.6             | 14.3             | 10.0 | 1.2              | 4.5 | 3.9 ±0.2 | ≈1.50    |

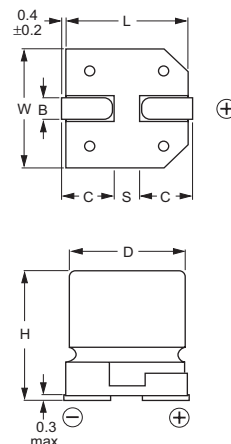


Fig.2 Dimensional outline.

## 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.

## SOLDERING

Soldering conditions are defined by the curve, temperature versus time, where the temperature is that measured on the soldering pad 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.

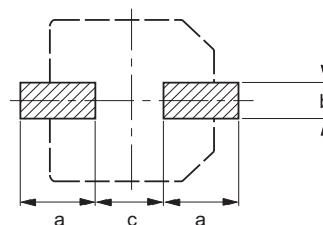


Fig.3 Recommended soldering pad dimensions.

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 |

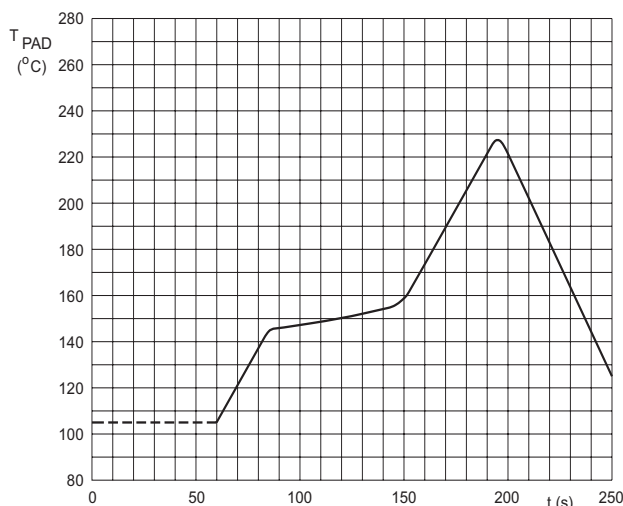


Fig.4 Maximum temperature load during infrared reflow soldering measured on the soldering pad.

| ELECTRICAL DATA |                                                          |
|-----------------|----------------------------------------------------------|
| SYMBOL          | DESCRIPTION                                              |
| $C_R$           | rated capacitance at 100 or 120 Hz, tolerance $\pm 20\%$ |
| $I_R$           | 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**

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

Table 4

| ELECTRICAL DATA AND ORDERING INFORMATION |                            |                                                         |                         |                                        |               |                                |                                  |
|------------------------------------------|----------------------------|---------------------------------------------------------|-------------------------|----------------------------------------|---------------|--------------------------------|----------------------------------|
| $U_R$<br>(V)                             | $C_R$<br>( $\mu\text{F}$ ) | NOMINAL<br>CASE SIZE<br>L $\times$ W $\times$ H<br>(mm) | $I_R$<br>105 °C<br>(mA) | $I_{L2}$<br>2 min<br>( $\mu\text{A}$ ) | $\tan \delta$ | ESR<br>100 kHz<br>( $\Omega$ ) | CATALOG NUMBER<br>2222 153 ..... |
| 6.3                                      | 22                         | 4.0 $\times$ 4.0 $\times$ 5.3                           | 21                      | 3.0                                    | 0.30          | 8                              | 63229                            |
|                                          | 47                         | 5.0 $\times$ 5.0 $\times$ 5.3                           | 36                      | 3.0                                    | 0.30          | 4                              | 63479                            |
|                                          | 100                        | 6.3 $\times$ 6.3 $\times$ 5.3                           | 61                      | 6.3                                    | 0.30          | 2                              | 63101                            |
|                                          | 330                        | 8.0 $\times$ 8.0 $\times$ 10                            | 180                     | 21                                     | 0.30          | 0.5                            | 63331                            |
|                                          | 470                        | 10 $\times$ 10 $\times$ 10                              | 320                     | 30                                     | 0.30          | 0.3                            | 63471                            |
|                                          | 680                        | 10 $\times$ 10 $\times$ 12                              | 340                     | 43                                     | 0.24          | 0.29                           | 63681                            |
|                                          | 1000                       | 10 $\times$ 10 $\times$ 14                              | 400                     | 63                                     | 0.24          | 0.24                           | 63102                            |
| 10                                       | 33                         | 5.0 $\times$ 5.0 $\times$ 5.3                           | 31                      | 3.3                                    | 0.26          | 4                              | 64339                            |
|                                          | 220                        | 8.0 $\times$ 8.0 $\times$ 10                            | 180                     | 22                                     | 0.26          | 0.5                            | 64221                            |
|                                          | 330                        | 10 $\times$ 10 $\times$ 10                              | 320                     | 33                                     | 0.26          | 0.3                            | 64331                            |
|                                          | 470                        | 10 $\times$ 10 $\times$ 12                              | 330                     | 47                                     | 0.19          | 0.29                           | 64471                            |
|                                          | 680                        | 10 $\times$ 10 $\times$ 14                              | 380                     | 68                                     | 0.19          | 0.24                           | 64681                            |
| 16                                       | 10                         | 4.0 $\times$ 4.0 $\times$ 5.3                           | 16                      | 3.0                                    | 0.22          | 8                              | 65109                            |
|                                          | 22                         | 5.0 $\times$ 5.0 $\times$ 5.3                           | 28                      | 3.5                                    | 0.22          | 4                              | 65229                            |
|                                          | 47                         | 6.3 $\times$ 6.3 $\times$ 5.3                           | 47                      | 7.5                                    | 0.22          | 2.2                            | 65479                            |
|                                          | 100                        | 8.0 $\times$ 8.0 $\times$ 6.5                           | 110                     | 16                                     | 0.22          | 1.2                            | 65101                            |
|                                          | 220                        | 10 $\times$ 10 $\times$ 10                              | 320                     | 35                                     | 0.22          | 0.3                            | 65221                            |
|                                          | 330                        | 10 $\times$ 10 $\times$ 12                              | 330                     | 53                                     | 0.16          | 0.29                           | 65331                            |
|                                          | 470                        | 10 $\times$ 10 $\times$ 14                              | 370                     | 75                                     | 0.16          | 0.25                           | 65471                            |
| 25                                       | 33                         | 6.3 $\times$ 6.3 $\times$ 5.3                           | 44                      | 8.3                                    | 0.16          | 2.2                            | 66339                            |
|                                          | 47                         | 8.0 $\times$ 8.0 $\times$ 6.5                           | 110                     | 12                                     | 0.16          | 1.2                            | 66479                            |
|                                          | 100                        | 8.0 $\times$ 8.0 $\times$ 10                            | 180                     | 25                                     | 0.16          | 0.5                            | 66101                            |
|                                          | 220                        | 10 $\times$ 10 $\times$ 12                              | 270                     | 55                                     | 0.14          | 0.29                           | 66221                            |
|                                          | 330                        | 10 $\times$ 10 $\times$ 14                              | 300                     | 83                                     | 0.14          | 0.27                           | 66331                            |
| 35                                       | 4.7                        | 4.0 $\times$ 4.0 $\times$ 5.3                           | 14                      | 3.0                                    | 0.13          | 8                              | 60478                            |
|                                          | 10                         | 5.0 $\times$ 5.0 $\times$ 5.3                           | 23                      | 3.5                                    | 0.13          | 4                              | 60109                            |
|                                          | 22                         | 6.3 $\times$ 6.3 $\times$ 5.3                           | 50                      | 7.7                                    | 0.13          | 2.2                            | 60229                            |
|                                          | 33                         | 8.0 $\times$ 8.0 $\times$ 6.5                           | 110                     | 12                                     | 0.13          | 1.2                            | 60339                            |
|                                          | 220                        | 10 $\times$ 10 $\times$ 12                              | 270                     | 77                                     | 0.12          | 0.29                           | 60221                            |
| 50                                       | 0.47                       | 4.0 $\times$ 4.0 $\times$ 5.3                           | 5                       | 3.0                                    | 0.12          | 12                             | 61477                            |
|                                          | 1.0                        | 4.0 $\times$ 4.0 $\times$ 5.3                           | 7                       | 3.0                                    | 0.12          | 12                             | 61108                            |
|                                          | 2.2                        | 4.0 $\times$ 4.0 $\times$ 5.3                           | 10                      | 3.0                                    | 0.12          | 12                             | 61228                            |
|                                          | 3.3                        | 4.0 $\times$ 4.0 $\times$ 5.3                           | 12                      | 3.0                                    | 0.12          | 12                             | 61338                            |
|                                          | 4.7                        | 5.0 $\times$ 5.0 $\times$ 5.3                           | 17                      | 3.0                                    | 0.12          | 6                              | 61478                            |
|                                          | 10                         | 6.3 $\times$ 6.3 $\times$ 5.3                           | 26                      | 5.0                                    | 0.12          | 3                              | 61109                            |
|                                          | 22                         | 8.0 $\times$ 8.0 $\times$ 6.5                           | 110                     | 11                                     | 0.12          | 1.2                            | 61229                            |
|                                          | 33                         | 8.0 $\times$ 8.0 $\times$ 10                            | 180                     | 17                                     | 0.12          | 0.5                            | 61339                            |
|                                          | 47                         | 8.0 $\times$ 8.0 $\times$ 10                            | 180                     | 24                                     | 0.12          | 0.5                            | 61479                            |
|                                          | 100                        | 10 $\times$ 10 $\times$ 10                              | 320                     | 50                                     | 0.12          | 0.3                            | 61101                            |
|                                          | 100                        | 10 $\times$ 10 $\times$ 12                              | 230                     | 50                                     | 0.12          | 0.29                           | 91106                            |
| 63                                       | 47                         | 10 $\times$ 10 $\times$ 12                              | 220                     | 30                                     | 0.09          | 0.29                           | 68479                            |
|                                          | 100                        | 10 $\times$ 10 $\times$ 14                              | 240                     | 63                                     | 0.09          | 0.41                           | 68101                            |
| 100                                      | 10                         | 10 $\times$ 10 $\times$ 12                              | 150                     | 10                                     | 0.07          | 0.9                            | 69109                            |
|                                          | 22                         | 10 $\times$ 10 $\times$ 12                              | 150                     | 25                                     | 0.07          | 0.9                            | 69229                            |
|                                          | 33                         | 10 $\times$ 10 $\times$ 14                              | 170                     | 33                                     | 0.07          | 0.65                           | 69339                            |

**ORDERING EXAMPLE**

Electrolytic capacitor 153 series

100  $\mu\text{F}$ /25 V;  $\pm 20\%$ 

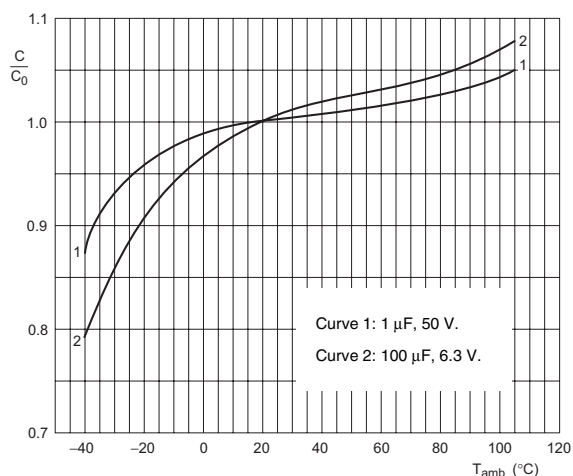
Nominal case size:

8  $\times$  8  $\times$  10 mm; taped on reel

Catalog number: 2222 153 66101.

| ADDITIONAL ELECTRICAL DATA         |                              |                                                                                    |
|------------------------------------|------------------------------|------------------------------------------------------------------------------------|
| PARAMETER                          | CONDITIONS                   | VALUE                                                                              |
| <b>Voltage</b>                     |                              |                                                                                    |
| Surge voltage                      | IEC 60384-18, subclause 4.14 | $U_s \leq 1.15 \times U_R$                                                         |
| Reverse voltage                    | IEC 60384-18, subclause 4.16 | $U_{rev} \leq 1 \text{ V}$                                                         |
| <b>Current</b>                     |                              |                                                                                    |
| Leakage current                    | after 2 minutes at $U_R$     | $I_{L2} \leq 0.01 \times C_R \times U_R$ or $3 \mu\text{A}$ , whichever is greater |
| <b>Inductance</b>                  |                              |                                                                                    |
| Equivalent series inductance (ESL) | case codes 0405 to 0605      | typ. 10 nH                                                                         |
|                                    | case codes 0807 to 1010      | typ. 15 nH                                                                         |
|                                    | case codes 1012 and 1014     | typ. 16 nH                                                                         |

## CAPACITANCE (C)



$C_0$  = capacitance at 20 °C.

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

## EQUIVALENT SERIES RESISTANCE (ESR)

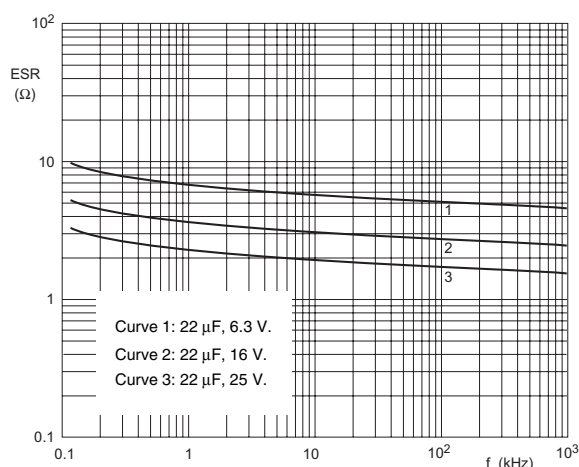


Fig.6 Typical ESR as a function of frequency at 20 °C.

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

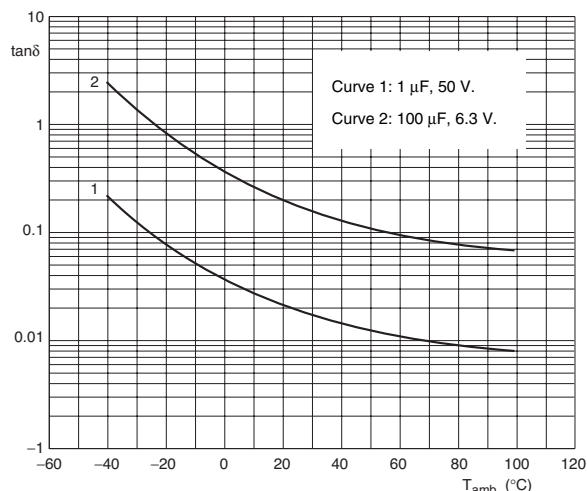


Fig.7 Typical dissipation factor ( $\tan \delta$ ) at 100 or 120 Hz as a function of ambient temperature.

## IMPEDANCE (Z)

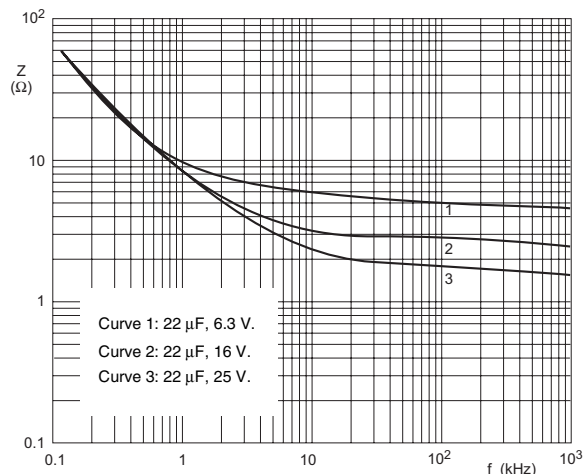


Fig.8 Typical impedance as a function of frequency at 20 °C.

# RIPPLE CURRENT AND USEFUL LIFE

CCC206

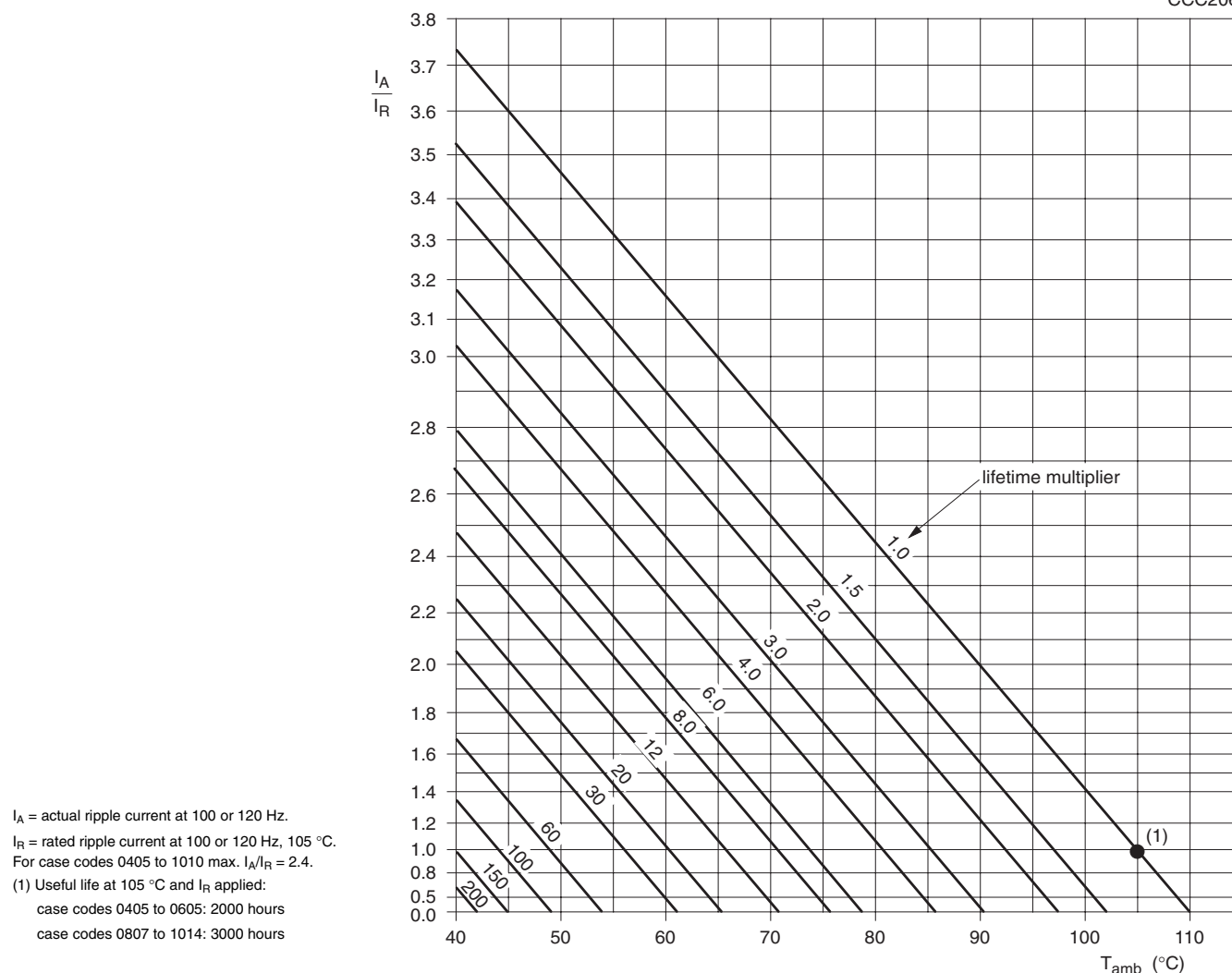


Fig.9 Multiplier of useful life as a function of ambient temperature and ripple current load.

Table 5

| MULTIPLIER OF RIPPLE CURRENT ( $I_R$ ) AS A FUNCTION OF FREQUENCY |                     |                    |                     |
|-------------------------------------------------------------------|---------------------|--------------------|---------------------|
| FREQUENCY<br>(Hz)                                                 | $I_R$ MULTIPLIER    |                    |                     |
|                                                                   | $U_R = 6.3$ to 16 V | $U_R = 25$ or 35 V | $U_R = 50$ 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                |
| $\geq 10000$                                                      | 1.25                | 1.40               | 1.50                |



Table 6

| TEST PROCEDURES AND REQUIREMENTS            |                                                |                                                                                                                                                                      |                                                                                                                                                                                  |
|---------------------------------------------|------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| TEST                                        |                                                | PROCEDURE<br>(quick reference)                                                                                                                                       | REQUIREMENTS                                                                                                                                                                     |
| NAME OF TEST                                | REFERENCE                                      |                                                                                                                                                                      |                                                                                                                                                                                  |
| Mounting                                    | IEC 60384-18,<br>subclause 4.3                 | shall be performed prior to tests mentioned below;<br>reflow soldering;<br>for maximum temperature load refer to chapter "Mounting"                                  | $\Delta C/C: \pm 10\%$<br>$\tan \delta \leq \text{spec. limit}$<br>$I_{L2} \leq \text{spec. limit}$                                                                              |
| Endurance                                   | IEC 60384-18/<br>CECC 32300,<br>subclause 4.15 | $T_{\text{amb}} = 105^\circ\text{C}$ ; $U_R$ applied;<br>1000 hours, case codes 0405 to 0605<br>2000 hours, case codes 0807 to 1014                                  | $\Delta C/C: \pm 20\%$<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                 | $T_{\text{amb}} = 105^\circ\text{C}$ ; $U_R$ and $I_R$ applied;<br>2000 hours, case codes 0405 to 0605<br>3000 hours, case codes 0807 to 1014                        | $\Delta C/C: \pm 50\%$<br>$\tan \delta \leq 3 \times \text{spec. limit}$<br>$I_{L2} \leq \text{spec. limit}$<br>no short or open circuit<br>total failure percentage: $\leq 1\%$ |
| Shelf life<br>(storage at high temperature) | IEC 60384-18/<br>CECC 32300,<br>subclause 4.17 | $T_{\text{amb}} = 105^\circ\text{C}$ ; no voltage applied;<br>1000 hours<br><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                                                                                                                                   |