

# Aluminum Electrolytic Capacitors

## Radial Miniature, Low Impedance, High Vibration Capability

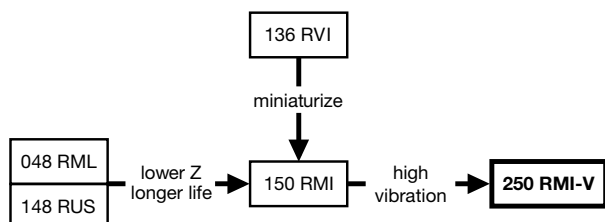


Fig. 1

### QUICK REFERENCE DATA

| DESCRIPTION                                        | VALUE                  |
|----------------------------------------------------|------------------------|
| Nominal case sizes (Ø D x L in mm)                 | 16 x 20 to 18 x 40     |
| Rated capacitance range, C <sub>R</sub>            | 330 µF to 8200 µF      |
| Tolerance on C <sub>R</sub>                        | ± 20 %                 |
| Rated voltage range, U <sub>R</sub>                | 10 V to 100 V          |
| Category temperature range                         | -55 °C to +105 °C      |
| Endurance test at 105 °C                           | 3000 h to 7000 h       |
| Useful life at 105 °C                              | 7000 h to 10 000 h     |
| Useful life at 40 °C, 1.8 x I <sub>R</sub> applied | 200 000 h to 500 000 h |
| Shelf life at 0 V, 105 °C                          | 1000 h                 |
| Based on sectional specification                   | IEC 60384-4 / EN130300 |
| Climatic category IEC 60068                        | 55 / 105 / 56          |

### FEATURES

- Very long useful life: 7000 h to 10 000 h at 105 °C, high stability, high reliability
- Very low impedance and low ESR in smaller case sizes than the 136 RVI series
- Excellent ripple current capability
- High vibration resistance up to 50 g
- AEC-Q200 qualified
- Polarized aluminum electrolytic capacitors, non-solid electrolyte
- Radial leads, cylindrical aluminum case, insulated with a blue sleeve
- Charge and discharge proof
- Material categorization: for definitions of compliance please see [www.vishay.com/doc?99912](http://www.vishay.com/doc?99912)

AUTOMOTIVE  
GRADE

RoHS  
COMPLIANT

### APPLICATIONS

- Power supplies (SMPS, DC/DC converters) for general industrial, EDP, audio-video, automotive, and telecommunications
- Smoothing, filtering, buffering

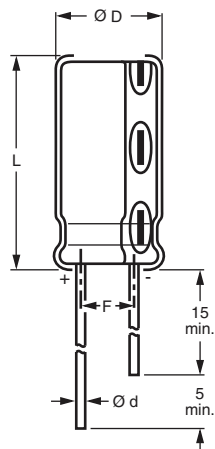
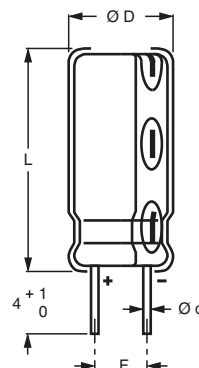
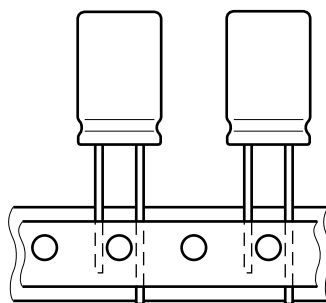
### MARKING

The capacitors are marked (where possible) with the following information:

- Rated capacitance (in µF)
- Tolerance on rated capacitance, code letter in accordance with IEC 60062 (M for ± 20 %)
- Rated voltage (in V)
- Date code, in accordance with IEC 60062
- Code indicating factory of origin
- Name of manufacturer
- Upper category temperature (105 °C)
- Negative terminal identification
- Series number (250)

### SELECTION CHART FOR C<sub>R</sub>, U<sub>R</sub>, AND RELEVANT NOMINAL CASE SIZES (Ø D x L in mm)

| C <sub>R</sub><br>(µF) | U <sub>R</sub> (V) |         |         |         |         |         |         |
|------------------------|--------------------|---------|---------|---------|---------|---------|---------|
|                        | 10                 | 16      | 25      | 35      | 50      | 63      | 100     |
| 330                    | -                  | -       | -       | -       | -       | -       | 18 x 20 |
| 470                    | -                  | -       | -       | -       | -       | 16 x 20 | -       |
| 680                    | -                  | -       | -       | -       | -       | 16 x 20 | -       |
|                        | -                  | -       | -       | -       | -       | 16 x 25 | -       |
| 1000                   | -                  | -       | -       | -       | 16 x 25 | 16 x 31 | -       |
|                        | -                  | -       | -       | 16 x 20 | -       | -       | -       |
| 1200                   | -                  | -       | -       | -       | 16 x 31 | -       | -       |
| 1500                   | -                  | -       | -       | 16 x 20 | 16 x 31 | -       | -       |
| 2200                   | -                  | -       | 16 x 20 | 16 x 31 | -       | 18 x 40 | -       |
| 3300                   | -                  | 16 x 20 | 16 x 31 | 18 x 31 | 18 x 40 | -       | -       |
| 4700                   | 16 x 25            | 16 x 31 | 16 x 35 | 18 x 40 | -       | -       | -       |
| 6800                   | 16 x 31            | 16 x 35 | 18 x 40 | -       | -       | -       | -       |
| 8200                   | -                  | 18 x 40 | -       | -       | -       | -       | -       |

**DIMENSIONS** in millimeters **AND AVAILABLE FORMS**

Fig. 2 - **Form CA:** Long leads

Fig. 3 - **Form CB:** Cut leads

Fig. 4 - **Form TFA:** Taped in box (ammopack)

**Table 1**

| <b>DIMENSIONS</b> in millimeters, <b>MASS AND PACKAGING QUANTITIES</b> |              |     |                     |                   |           |             |                      |            |             |
|------------------------------------------------------------------------|--------------|-----|---------------------|-------------------|-----------|-------------|----------------------|------------|-------------|
| NOMINAL<br>CASE SIZE<br>Ø D x L                                        | CASE<br>CODE | Ø d | Ø D <sub>max.</sub> | L <sub>max.</sub> | F         | MASS<br>(g) | PACKAGING QUANTITIES |            |             |
|                                                                        |              |     |                     |                   |           |             | FORM<br>CA           | FORM<br>CB | FORM<br>TFA |
| 16 x 20                                                                | 19a          | 0.8 | 16.5                | 22.0              | 7.5 ± 0.5 | ≈ 6.0       | 250                  | 250        | 250         |
| 16 x 25                                                                | 19           | 0.8 | 16.5                | 27.0              | 7.5 ± 0.5 | ≈ 8.0       | 250                  | 250        | 250         |
| 16 x 31                                                                | 20           | 0.8 | 16.5                | 33.5              | 7.5 ± 0.5 | ≈ 9.0       | 100                  | 100        | 250         |
| 16 x 35                                                                | 21           | 0.8 | 16.5                | 37.5              | 7.5 ± 0.5 | ≈ 11.0      | 100                  | 100        | -           |
| 18 x 20                                                                | 1820         | 0.8 | 18.5                | 22.0              | 7.5 ± 0.5 | ≈ 8.0       | 100                  | 100        | -           |
| 18 x 31                                                                | 1831         | 0.8 | 18.5                | 33.5              | 7.5 ± 0.5 | ≈ 12.5      | 100                  | 100        | -           |
| 18 x 40                                                                | 1840         | 0.8 | 18.5                | 42.5              | 7.5 ± 0.5 | ≈ 16.5      | 100                  | 100        | -           |



| ELECTRICAL DATA |                                                   |
|-----------------|---------------------------------------------------|
| SYMBOL          | DESCRIPTION                                       |
| $C_R$           | Rated capacitance at 100 Hz, tolerance $\pm 20\%$ |
| $I_R$           | Rated RMS ripple current at 100 kHz, 105 °C       |
| $I_{L2}$        | Maximum leakage current after 2 min at $U_R$      |
| $\tan \delta$   | Maximum dissipation factor at 100 Hz              |
| $Z$             | Maximum impedance at 100 kHz                      |

**Note**

- Unless otherwise specified, all electrical values in Table 2 apply at  $T_{amb} = 20\text{ °C}$ ,  $P = 86\text{ kPa}$  to  $106\text{ kPa}$ ,  $RH = 45\%$  to  $75\%$ .

Table 2

| ELECTRICAL DATA AND ORDERING INFORMATION |                                  |                                         |                                             |                                  |                 |                               |                               |                               |         |          |
|------------------------------------------|----------------------------------|-----------------------------------------|---------------------------------------------|----------------------------------|-----------------|-------------------------------|-------------------------------|-------------------------------|---------|----------|
| U <sub>R</sub><br>(V)                    | C <sub>R</sub><br>100 Hz<br>(μF) | NOMINAL<br>CASE SIZE<br>Ø D x L<br>(mm) | I <sub>R</sub><br>100 kHz<br>105 °C<br>(mA) | I <sub>L2</sub><br>2 min<br>(μA) | tan δ<br>100 Hz | Z<br>100 kHz<br>+20 °C<br>(Ω) | Z<br>100 kHz<br>-40 °C<br>(Ω) | ORDERING CODE<br>MAL2250..... |         |          |
|                                          |                                  |                                         |                                             |                                  |                 |                               |                               | BULK PACKAGING                |         | TAPED    |
|                                          |                                  |                                         |                                             |                                  |                 |                               |                               | FORM CA                       | FORM CB | FORM TFA |
| 10                                       | 4700                             | 16 x 25                                 | 2390                                        | 473                              | 0.23            | 0.022                         | 0.150                         | 54472E3                       | 64472E3 | 34472E3  |
|                                          | 6800                             | 16 x 31                                 | 2890                                        | 683                              | 0.25            | 0.019                         | 0.130                         | 54682E3                       | 64682E3 | 34682E3  |
| 16                                       | 3300                             | 16 x 20                                 | 1840                                        | 531                              | 0.20            | 0.028                         | 0.200                         | 55332E3                       | 65332E3 | 35332E3  |
|                                          | 4700                             | 16 x 31                                 | 2890                                        | 755                              | 0.22            | 0.019                         | 0.130                         | 55472E3                       | 65472E3 | 35472E3  |
|                                          | 6800                             | 16 x 35                                 | 3100                                        | 1091                             | 0.24            | 0.018                         | 0.130                         | 55682E3                       | 65682E3 | -        |
|                                          | 8200                             | 18 x 40                                 | 3500                                        | 1315                             | 0.28            | 0.018                         | 0.130                         | 55822E3                       | 65822E3 | -        |
| 25                                       | 2200                             | 16 x 20                                 | 1840                                        | 553                              | 0.16            | 0.028                         | 0.200                         | 56222E3                       | 66222E3 | 36222E3  |
|                                          | 3300                             | 16 x 31                                 | 2890                                        | 828                              | 0.16            | 0.019                         | 0.130                         | 56332E3                       | 66332E3 | 36332E3  |
|                                          | 4700                             | 16 x 35                                 | 3100                                        | 1178                             | 0.18            | 0.018                         | 0.130                         | 56472E3                       | 66472E3 | -        |
|                                          | 6800                             | 18 x 40                                 | 3500                                        | 1703                             | 0.22            | 0.018                         | 0.130                         | 56682E3                       | 66682E3 | -        |
| 35                                       | 1000                             | 16 x 20                                 | 1840                                        | 353                              | 0.12            | 0.028                         | 0.200                         | 90105E3                       | 90106E3 | 90103E3  |
|                                          | 1500                             | 16 x 20                                 | 1840                                        | 528                              | 0.12            | 0.028                         | 0.200                         | 50152E3                       | 60152E3 | 30152E3  |
|                                          | 2200                             | 16 x 31                                 | 2890                                        | 773                              | 0.14            | 0.019                         | 0.130                         | 50222E3                       | 60222E3 | 30222E3  |
|                                          | 3300                             | 18 x 31                                 | 3000                                        | 1155                             | 0.16            | 0.019                         | 0.130                         | 50332E3                       | 60332E3 | -        |
|                                          | 4700                             | 18 x 40                                 | 3300                                        | 1648                             | 0.18            | 0.018                         | 0.130                         | 50472E3                       | 60472E3 | -        |
| 50                                       | 1000                             | 16 x 25                                 | 1800                                        | 503                              | 0.10            | 0.034                         | 0.240                         | 51102E3                       | 61102E3 | 31102E3  |
|                                          | 1200                             | 16 x 31                                 | 2200                                        | 603                              | 0.10            | 0.027                         | 0.190                         | 51122E3                       | 61122E3 | 31122E3  |
|                                          | 1500                             | 16 x 31                                 | 2200                                        | 753                              | 0.10            | 0.027                         | 0.190                         | 51152E3                       | 61152E3 | 31152E3  |
|                                          | 3300                             | 18 x 40                                 | 3200                                        | 1653                             | 0.14            | 0.024                         | 0.168                         | 51332E3                       | 61332E3 | -        |
| 63                                       | 470                              | 16 x 20                                 | 1100                                        | 299                              | 0.10            | 0.074                         | 0.520                         | 98475E3                       | 98476E3 | 98473E3  |
|                                          | 680                              | 16 x 20                                 | 1100                                        | 431                              | 0.10            | 0.074                         | 0.520                         | 58681E3                       | 68681E3 | 38681E3  |
|                                          | 680                              | 16 x 25                                 | 1500                                        | 431                              | 0.10            | 0.054                         | 0.380                         | 98685E3                       | 98686E3 | 98683E3  |
|                                          | 1000                             | 16 x 31                                 | 1900                                        | 633                              | 0.10            | 0.042                         | 0.295                         | 58102E3                       | 68102E3 | 38102E3  |
|                                          | 2200                             | 18 x 40                                 | 3100                                        | 1389                             | 0.12            | 0.033                         | 0.231                         | 58222E3                       | 68222E3 | -        |
| 100                                      | 330                              | 18 x 20                                 | 1700                                        | 330                              | 0.07            | 0.074                         | 2.0                           | 90183E3                       | 90185E3 | -        |

Table 3

| EXTENDED VIBRATION SPECIFICATIONS |                                                                                                                                       |                                                                                                                                      |
|-----------------------------------|---------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------|
| PARAMETER                         | PROCEDURE                                                                                                                             | REQUIREMENTS                                                                                                                         |
| Vibration specifications          | From 10 g to 50 g                                                                                                                     | No visible damage;<br>no leakage of electrolyte;<br>marking legible<br>$\Delta C/C: \pm 5\%$ with respect to<br>initial measurements |
| Vibration frequency range         | 10 Hz to 2 kHz                                                                                                                        |                                                                                                                                      |
| Vibration profile                 | <ul style="list-style-type: none"> <li>Constant sinus sweep (1 oct./min.)</li> <li>3 directions</li> <li>8 h per direction</li> </ul> |                                                                                                                                      |

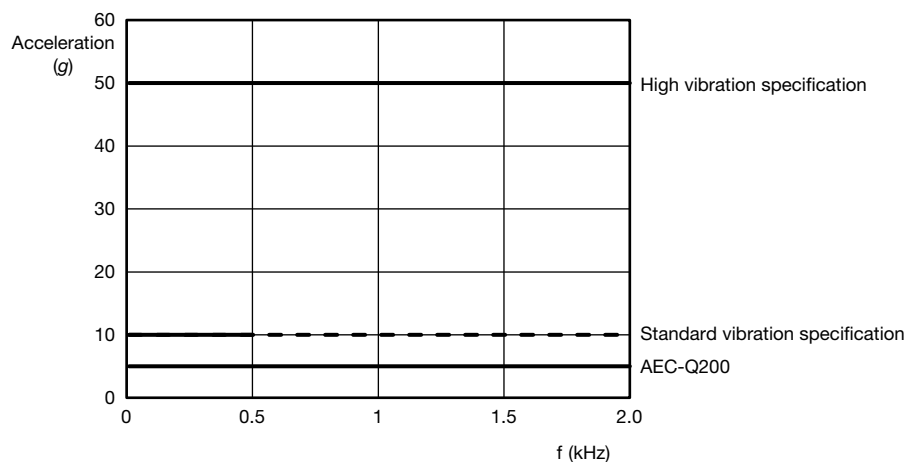


Fig. 5 - Vibration profile

Table 4

| ADDITIONAL ELECTRICAL DATA         |                                                             |                                                   |
|------------------------------------|-------------------------------------------------------------|---------------------------------------------------|
| PARAMETER                          | CONDITIONS                                                  | VALUE                                             |
| <b>Voltage</b>                     |                                                             |                                                   |
| Surge voltage                      |                                                             | $U_s \leq 1.15 \times U_R$                        |
| Reverse voltage                    |                                                             | $U_{rev} \leq 1 \text{ V}$                        |
| <b>Current</b>                     |                                                             |                                                   |
| Leakage current                    | After 2 min at $U_R$                                        | $I_{L2} \leq 0.01 C_R \times U_R + 3 \mu\text{A}$ |
| <b>Inductance</b>                  |                                                             |                                                   |
| Equivalent series inductance (ESL) | Case $\varnothing D \geq 16 \text{ mm}$                     | Typ. 18 nH                                        |
| <b>Resistance</b>                  |                                                             |                                                   |
| Equivalent series resistance (ESR) | Calculated from $\tan \delta_{max}$ and $C_R$ (see Table 2) | $ESR = \tan \delta / 2 \pi f C_R$                 |

## CAPACITANCE (C)

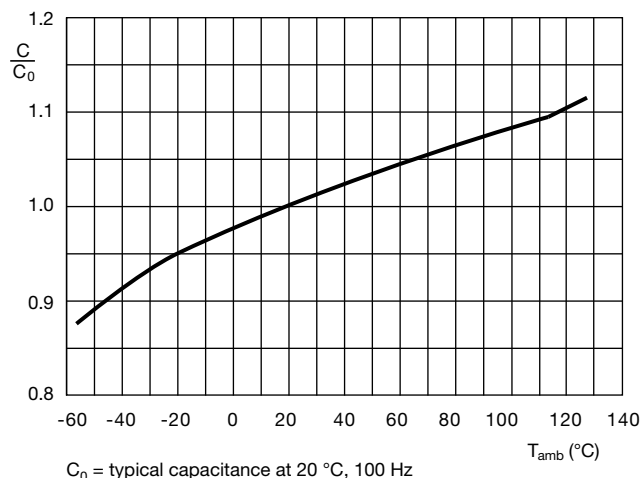


Fig. 6 - Typical multiplier of capacitance as a function of ambient temperature

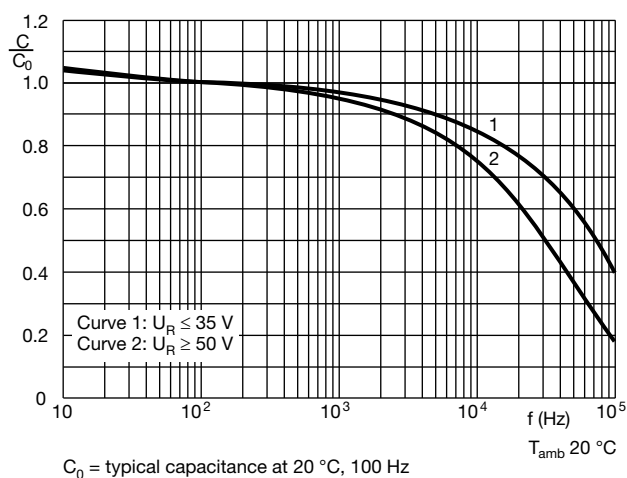


Fig. 7 - Typical multiplier of capacitance as a function of frequency

### EQUIVALENT SERIES RESISTANCE (ESR)

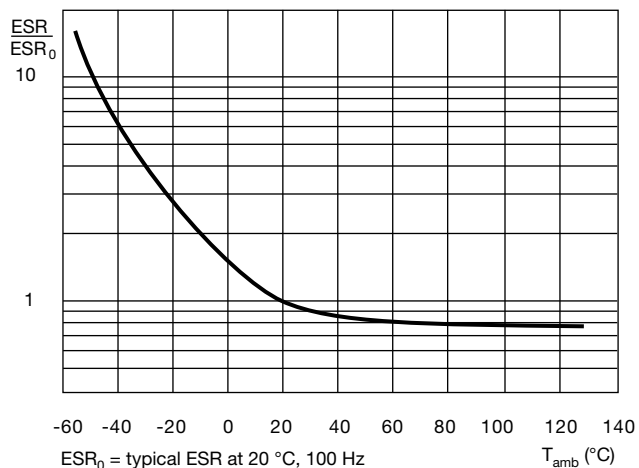


Fig. 8 - Typical multiplier of ESR as a function of ambient temperature

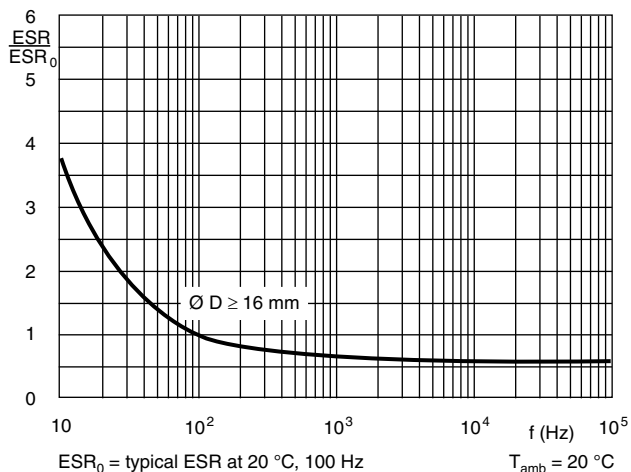


Fig. 9 - Typical multiplier of ESR as a function of frequency

### IMPEDANCE (Z)

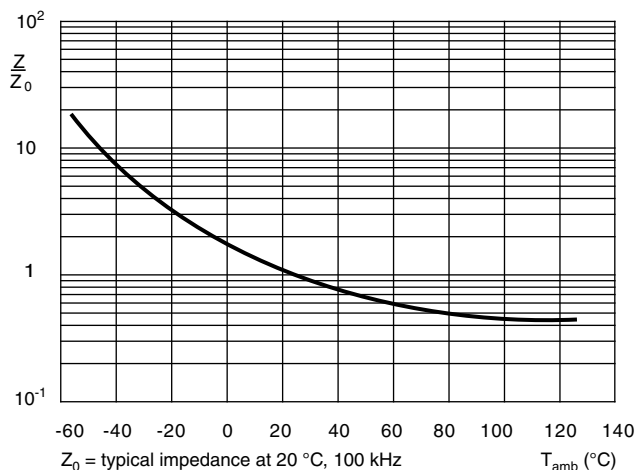


Fig. 10 - Typical multiplier of impedance as a function of ambient temperature

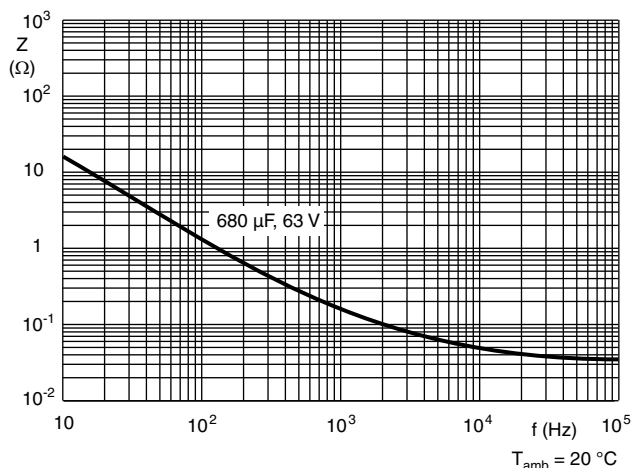


Fig. 11 - Typical impedance as a function of frequency

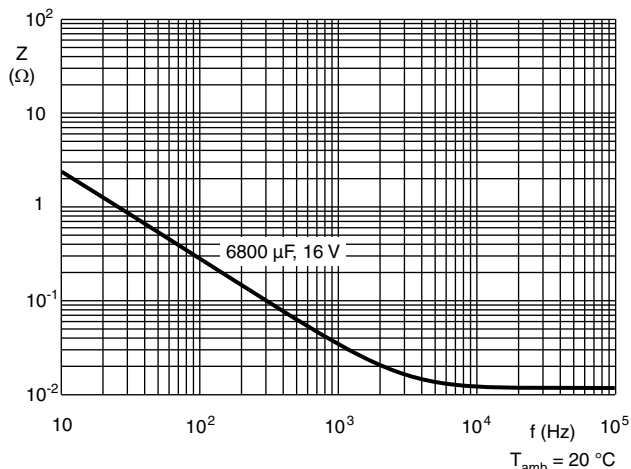


Fig. 12 - Typical impedance as a function of frequency

## RIPPLE CURRENT AND USEFUL LIFE

Table 5

| ENDURANCE TEST DURATION AND USEFUL LIFE AS A FUNCTION OF CASE SIZE |           |                               |                                 |
|--------------------------------------------------------------------|-----------|-------------------------------|---------------------------------|
| NOMINAL CASE SIZE<br>Ø D x L<br>(mm)                               | CASE CODE | ENDURANCE<br>AT 105 °C<br>(h) | USEFUL LIFE<br>AT 105 °C<br>(h) |
| 16 x 20                                                            | 19a       | 3000                          | 7000                            |
| 16 x 25                                                            | 19        | 5000                          | 10 000                          |
| 16 x 31                                                            | 20        | 5000                          | 10 000                          |
| 16 x 35                                                            | 21        | 5000                          | 10 000                          |
| 18 x 20                                                            | 1820      | 3000                          | 7000                            |
| 18 x 31                                                            | 1831      | 6000                          | 10 000                          |
| 18 x 40                                                            | 1840      | 8000                          | 10 000                          |

### Note

- Multiplier of useful life code: CCC206

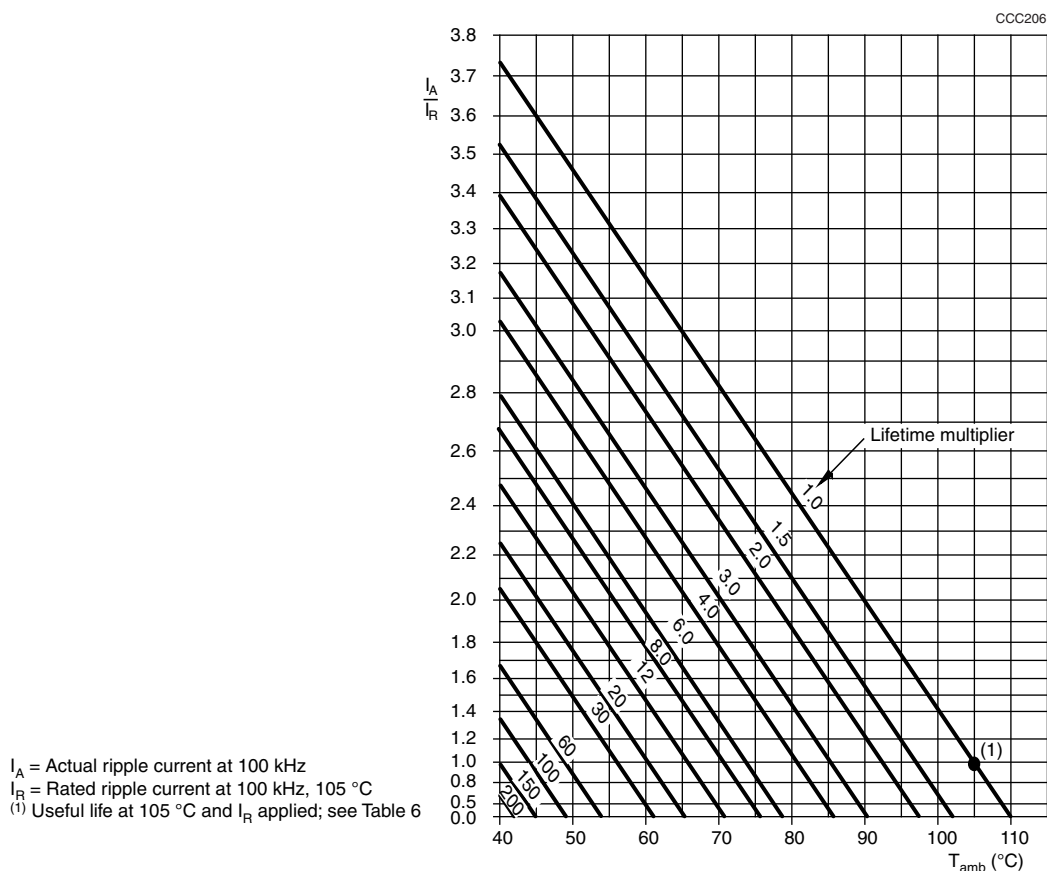


Fig. 13 - Multiplier of useful life as a function of ambient temperature and ripple current load



Table 6

| MULTIPLIER OF RIPPLE CURRENT ( $I_R$ ) AS A FUNCTION OF FREQUENCY |      |      |      |        |        |         |
|-------------------------------------------------------------------|------|------|------|--------|--------|---------|
| FREQUENCY (Hz)                                                    |      |      |      |        |        |         |
| 100                                                               | 300  | 1000 | 3000 | 10 000 | 30 000 | 100 000 |
| $I_R$ MULTIPLIER                                                  |      |      |      |        |        |         |
| 0.76                                                              | 0.85 | 0.91 | 0.94 | 0.96   | 0.98   | 1.00    |

Table 7

| TEST PROCEDURES AND REQUIREMENTS               |                                             |                                                                                                                                           |                                                                                                                                                                                  |
|------------------------------------------------|---------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| TEST                                           |                                             | PROCEDURE<br>(quick reference)                                                                                                            | REQUIREMENTS                                                                                                                                                                     |
| NAME OF TEST                                   | REFERENCE                                   |                                                                                                                                           |                                                                                                                                                                                  |
| Endurance                                      | IEC 60384-4 /<br>EN130300<br>subclause 4.13 | $T_{amb} = 105\text{ °C}$ ; $U_R$ applied;<br>for test duration see Table 3                                                               | $\Delta C/C: \pm 20\%$<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               | $T_{amb} = 105\text{ °C}$ ; $U_R$ and $I_R$ applied;<br>for test duration see Table 3                                                     | $\Delta C/C: \pm 30\%$<br>$\tan \delta \leq 3 \times \text{spec. limit}$<br>$I_{L2} \leq \text{spec. limit}$<br>no short or open circuit<br>total failure percentage: $\leq 1\%$ |
| Shelf life<br>(storage at high<br>temperature) | IEC 60384-4 /<br>EN130300<br>subclause 4.17 | $T_{amb} = 105\text{ °C}$ ; no voltage applied; 1000 h<br>after test: $U_R$ to be applied for 30 min., 24 h to 48 h<br>before measurement | $\Delta C/C: \pm 20\%$<br>$\tan \delta \leq 2 \times \text{spec. limit}$<br>$I_{L2} \leq \text{spec. limit}$                                                                     |

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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