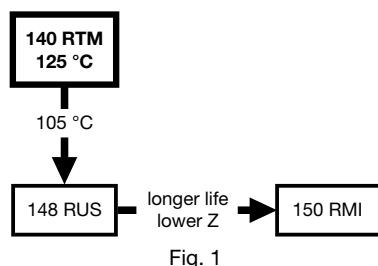


# Aluminum Electrolytic Capacitors Radial, High Temperature Miniature



## FEATURES

- Very long useful life: 2500 h to 4000 h at 125 °C
- High stability, high reliability
- AEC-Q200 qualified
- Extended temperature range up to 125 °C
- High ripple current capability
- Polarized aluminum electrolytic capacitors, non-solid electrolyte
- Radial leads, cylindrical aluminum case with pressure relief, 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

- EDP, telecommunication, industrial, automotive and military
- Smoothing, filtering, buffering in SMPS
- High ambient temperature environments

## MARKING

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

- Rated capacitance value (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 (125 °C)
- Negative terminal identification
- Series number (140)

## QUICK REFERENCE DATA

| DESCRIPTION                                        | VALUE                   |
|----------------------------------------------------|-------------------------|
| Nominal case sizes (Ø D x L in mm)                 | 10 x 12 to 18 x 31      |
| Rated capacitance range, C <sub>R</sub>            | 22 µF to 4700 µF        |
| Tolerance on C <sub>R</sub>                        | ± 20 %                  |
| Rated voltage range, U <sub>R</sub>                | 6.3 V to 63 V           |
| Category temperature range                         | -55 °C to +125 °C       |
| Endurance test at 125 °C                           | 2000 h                  |
| Useful life at 125 °C                              | 2500 h to 4000 h        |
| Useful life at 40 °C, 1.6 x I <sub>R</sub> applied | 300 000 h               |
| Shelf life at 0 V, 125 °C                          | 500 h                   |
| Based on sectional specification                   | IEC 60384-4 / EN 130300 |
| Climatic category IEC 60068                        | 55 / 125 / 56           |

## 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) |           |           |           |           |           |         |
|------------------------|--------------------|-----------|-----------|-----------|-----------|-----------|---------|
|                        | 6.3                | 10        | 16        | 25        | 35        | 50        | 63      |
| 22                     | -                  | -         | -         | -         | -         | -         | 10 x 12 |
| 47                     | -                  | -         | -         | -         | -         | 10 x 12   | 10 x 12 |
| 100                    | -                  | -         | -         | -         | 10 x 12   | 10 x 16   | 10 x 20 |
| 220                    | -                  | -         | 10 x 12   | 10 x 16   | 10 x 16   | 12.5 x 20 | 16 x 20 |
| 330                    | -                  | 10 x 12   | 10 x 16   | 10 x 20   | -         | 12.5 x 20 | 16 x 20 |
| 470                    | -                  | 10 x 16   | 10 x 16   | 10 x 20   | 12.5 x 20 | 12.5 x 25 | 16 x 25 |
|                        | -                  | -         | -         | -         | -         | 16 x 20   | -       |
| 1000                   | -                  | 10 x 20   | 12.5 x 20 | 12.5 x 25 | 16 x 25   | 16 x 31   | 18 x 31 |
|                        | -                  | -         | -         | 16 x 20   | -         | -         | -       |
| 1200                   | 10 x 16            | -         | -         | -         | -         | -         | -       |
| 2200                   | 10 x 20            | 12.5 x 25 | 16 x 25   | 16 x 31   | 18 x 31   | -         | -       |
|                        | -                  | 16 x 20   | -         | -         | -         | -         | -       |
| 3300                   | -                  | 16 x 25   | 16 x 31   | 18 x 31   | -         | -         | -       |
| 4700                   | -                  | 16 x 31   | 18 x 31   | -         | -         | -         | -       |

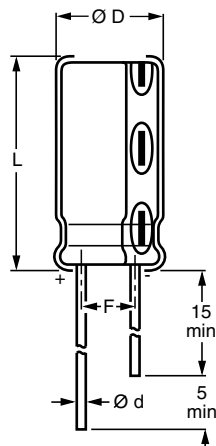
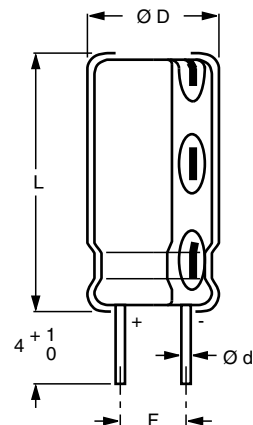
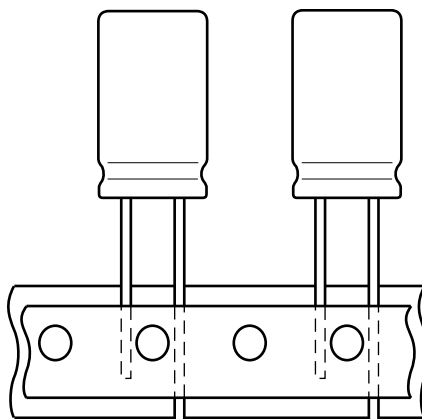
**DIMENSIONS** in millimeters **AND AVAILABLE FORMS**

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 |
| 10 x 12                                                                 | 14           | 0.6 | 10.5                | 13.5              | 5.0 ± 0.5 | ≈ 1.6       | 1000                 | 500        | 800         |
| 10 x 16                                                                 | 15           | 0.6 | 10.5                | 17.5              | 5.0 ± 0.5 | ≈ 1.9       | 500                  | 500        | 800         |
| 10 x 20                                                                 | 16           | 0.6 | 10.5                | 22.0              | 5.0 ± 0.5 | ≈ 2.2       | 500                  | 500        | 800         |
| 12.5 x 20                                                               | 17           | 0.6 | 13.0                | 22.0              | 5.0 ± 0.5 | ≈ 4.0       | 500                  | 500        | 500         |
| 12.5 x 25                                                               | 18           | 0.6 | 13.0                | 27.0              | 5.0 ± 0.5 | ≈ 5.0       | 250                  | 250        | 500         |
| 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         |
| 18 x 31                                                                 | 1831         | 0.8 | 18.5                | 33.5              | 7.5 ± 0.5 | ≈ 12.5      | 100                  | 100        | -           |

**Note**

- For detailed tape dimensions please see [www.vishay.com/doc?28360](http://www.vishay.com/doc?28360)



| ELECTRICAL DATA |                                                   |
|-----------------|---------------------------------------------------|
| SYMBOL          | DESCRIPTION                                       |
| $C_R$           | Rated capacitance at 100 Hz, tolerance $\pm 20\%$ |
| $I_R$           | Rated RMS ripple current at 100 kHz, 125 °C       |
| $I_{L1}$        | Max. leakage current after 1 min at $U_R$         |
| $\tan \delta$   | Max. dissipation factor at 100 Hz                 |
| $Z$             | Max. 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  $75\%$

**ORDERING EXAMPLE**

Electrolytic capacitor 140 series

220  $\mu\text{F}$  / 25 V;  $\pm 20\%$ Nominal case size:  $\varnothing 10\text{ mm} \times 16\text{ mm}$ ; form TFA

Ordering code: MAL214036221E3

Former 12NC: 2222 140 36221

| 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>125 °C<br>(mA) | I <sub>L1</sub><br>1 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>MAL2140 ..... |         |          |
|                                          |                                  |                                         |                                             |                                  |                 |                                |                                | BULK PACKAGING                 |         | TAPED    |
|                                          |                                  |                                         |                                             |                                  |                 |                                |                                | FORM CA                        | FORM CB | FORM TFA |
| 6.3                                      | 1200                             | 10 x 16                                 | 760                                         | 79                               | 0.28            | 0.150                          | 1.10                           | 53122E3                        | 63122E3 | 33122E3  |
|                                          | 2200                             | 10 x 20                                 | 850                                         | 142                              | 0.28            | 0.120                          | 0.85                           | 53222E3                        | 63222E3 | 33222E3  |
| 10                                       | 330                              | 10 x 12                                 | 480                                         | 36                               | 0.20            | 0.200                          | 1.40                           | 54331E3                        | 64331E3 | 34331E3  |
|                                          | 470                              | 10 x 16                                 | 760                                         | 50                               | 0.20            | 0.150                          | 1.10                           | 54471E3                        | 64471E3 | 34471E3  |
|                                          | 1000                             | 10 x 20                                 | 850                                         | 103                              | 0.20            | 0.120                          | 0.85                           | 54102E3                        | 64102E3 | 34102E3  |
|                                          | 2200                             | 12.5 x 25                               | 1400                                        | 223                              | 0.24            | 0.050                          | 0.40                           | 94225E3                        | 94226E3 | 94223E3  |
|                                          | 2200                             | 16 x 20                                 | 1400                                        | 223                              | 0.24            | 0.050                          | 0.40                           | 54222E3                        | 64222E3 | 34222E3  |
|                                          | 3300                             | 16 x 25                                 | 1900                                        | 333                              | 0.24            | 0.034                          | 0.25                           | 54332E3                        | 64332E3 | 34332E3  |
|                                          | 4700                             | 16 x 31                                 | 2200                                        | 473                              | 0.24            | 0.030                          | 0.20                           | 54472E3                        | 64472E3 | 34472E3  |
| 16                                       | 220                              | 10 x 12                                 | 480                                         | 38                               | 0.16            | 0.200                          | 1.40                           | 55221E3                        | 65221E3 | 35221E3  |
|                                          | 330                              | 10 x 16                                 | 760                                         | 56                               | 0.16            | 0.150                          | 1.10                           | 55331E3                        | 65331E3 | 35331E3  |
|                                          | 470                              | 10 x 16                                 | 760                                         | 78                               | 0.16            | 0.150                          | 1.10                           | 55471E3                        | 65471E3 | 35471E3  |
|                                          | 1000                             | 12.5 x 20                               | 1200                                        | 163                              | 0.16            | 0.073                          | 0.50                           | 55102E3                        | 65102E3 | 35102E3  |
|                                          | 2200                             | 16 x 25                                 | 1900                                        | 355                              | 0.18            | 0.034                          | 0.25                           | 55222E3                        | 65222E3 | 35222E3  |
|                                          | 3300                             | 16 x 31                                 | 2200                                        | 531                              | 0.18            | 0.030                          | 0.20                           | 55332E3                        | 65332E3 | 35332E3  |
|                                          | 4700                             | 18 x 31                                 | 2200                                        | 755                              | 0.18            | 0.030                          | 0.20                           | 55472E3                        | 65472E3 | -        |
| 25                                       | 220                              | 10 x 16                                 | 750                                         | 58                               | 0.14            | 0.150                          | 1.10                           | 56221E3                        | 66221E3 | 36221E3  |
|                                          | 330                              | 10 x 20                                 | 850                                         | 86                               | 0.14            | 0.120                          | 0.85                           | 56331E3                        | 66331E3 | 36331E3  |
|                                          | 470                              | 10 x 20                                 | 850                                         | 121                              | 0.14            | 0.120                          | 0.85                           | 56471E3                        | 66471E3 | 36471E3  |
|                                          | 1000                             | 12.5 x 25                               | 1400                                        | 253                              | 0.14            | 0.050                          | 0.40                           | 96105E3                        | 96106E3 | 96103E3  |
|                                          | 1000                             | 16 x 20                                 | 1400                                        | 253                              | 0.14            | 0.050                          | 0.40                           | 56102E3                        | 66102E3 | 36102E3  |
|                                          | 2200                             | 16 x 31                                 | 2200                                        | 553                              | 0.16            | 0.030                          | 0.20                           | 56222E3                        | 66222E3 | 36222E3  |
|                                          | 3300                             | 18 x 31                                 | 2200                                        | 828                              | 0.16            | 0.030                          | 0.20                           | 56332E3                        | 66332E3 | -        |
| 35                                       | 100                              | 10 x 12                                 | 480                                         | 38                               | 0.12            | 0.200                          | 1.40                           | 50101E3                        | 60101E3 | 30101E3  |
|                                          | 220                              | 10 x 16                                 | 760                                         | 80                               | 0.12            | 0.150                          | 1.10                           | 50221E3                        | 60221E3 | 30221E3  |
|                                          | 470                              | 12.5 x 20                               | 1200                                        | 168                              | 0.12            | 0.073                          | 0.50                           | 50471E3                        | 60471E3 | 30471E3  |
|                                          | 1000                             | 16 x 25                                 | 1500                                        | 353                              | 0.12            | 0.034                          | 0.25                           | 50102E3                        | 60102E3 | 30102E3  |
|                                          | 2200                             | 18 x 31                                 | 2200                                        | 773                              | 0.14            | 0.030                          | 0.20                           | 50222E3                        | 60222E3 | -        |
| 50                                       | 47                               | 10 x 12                                 | 300                                         | 27                               | 0.10            | 0.300                          | 2.00                           | 51479E3                        | 61479E3 | 31479E3  |
|                                          | 100                              | 10 x 16                                 | 380                                         | 53                               | 0.10            | 0.200                          | 1.40                           | 51101E3                        | 61101E3 | 31101E3  |
|                                          | 220                              | 12.5 x 20                               | 580                                         | 113                              | 0.10            | 0.120                          | 0.85                           | 51221E3                        | 61221E3 | 31221E3  |
|                                          | 330                              | 12.5 x 20                               | 870                                         | 168                              | 0.10            | 0.120                          | 0.85                           | 51331E3                        | 61331E3 | 31331E3  |
|                                          | 470                              | 12.5 x 25                               | 1100                                        | 238                              | 0.10            | 0.085                          | 0.60                           | 91475E3                        | 91476E3 | 91473E3  |
|                                          | 470                              | 16 x 20                                 | 1100                                        | 238                              | 0.10            | 0.085                          | 0.60                           | 51471E3                        | 61471E3 | 31471E3  |
|                                          | 1000                             | 16 x 31                                 | 1700                                        | 503                              | 0.10            | 0.045                          | 0.30                           | 51102E3                        | 61102E3 | 31102E3  |
| 63                                       | 22                               | 10 x 12                                 | 380                                         | 17                               | 0.10            | 0.300                          | 2.00                           | 58229E3                        | 68229E3 | 38229E3  |
|                                          | 47                               | 10 x 12                                 | 380                                         | 33                               | 0.10            | 0.300                          | 2.00                           | 58479E3                        | 68479E3 | 38479E3  |
|                                          | 100                              | 10 x 20                                 | 650                                         | 66                               | 0.10            | 0.160                          | 1.10                           | 58101E3                        | 68101E3 | 38101E3  |
|                                          | 220                              | 16 x 20                                 | 1100                                        | 142                              | 0.10            | 0.085                          | 0.60                           | 58221E3                        | 68221E3 | 38221E3  |
|                                          | 330                              | 16 x 20                                 | 1100                                        | 211                              | 0.10            | 0.085                          | 0.60                           | 58331E3                        | 68331E3 | 38331E3  |
|                                          | 470                              | 16 x 25                                 | 1500                                        | 299                              | 0.10            | 0.055                          | 0.40                           | 58471E3                        | 68471E3 | 38471E3  |
|                                          | 1000                             | 18 x 31                                 | 1800                                        | 633                              | 0.10            | 0.040                          | 0.28                           | 58102E3                        | 68102E3 | -        |

| 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 1 min at $U_R$                                        | $I_{L1} \leq 0.01 C_R \times U_R + 3 \mu\text{A}$  |
|                                    | After 5 min at $U_R$                                        | $I_{L5} \leq 0.002 C_R \times U_R + 3 \mu\text{A}$ |
| <b>Inductance</b>                  |                                                             |                                                    |
| Equivalent series inductance (ESL) | Case $\varnothing D = 10 \text{ mm}$                        | Typ. 16 nH                                         |
|                                    | Case $\varnothing D \geq 12.5 \text{ mm}$                   | 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)

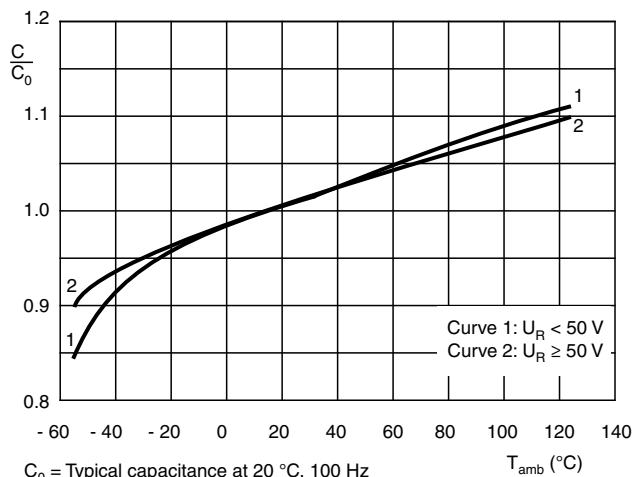


Fig. 5 - Typical multiplier of capacitance as a function of ambient temperature

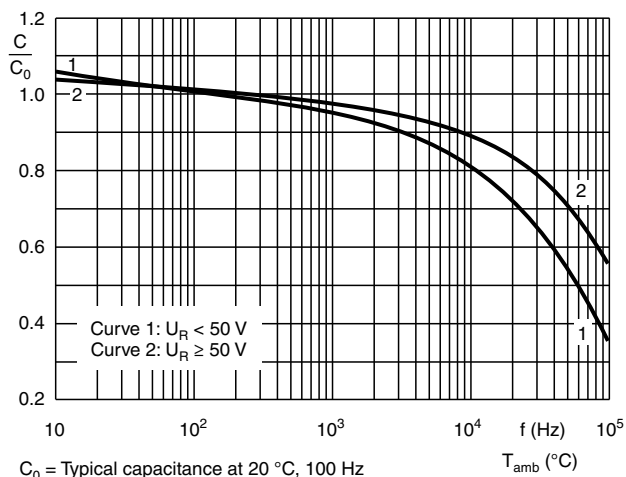


Fig. 6 - Typical multiplier of capacitance as a function of frequency

## EQUIVALENT SERIES RESISTANCE (ESR)

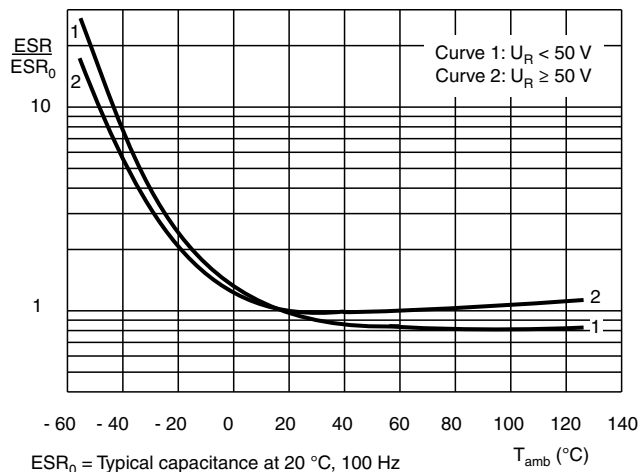


Fig. 7 - Typical multiplier of ESR as a function of ambient temperature

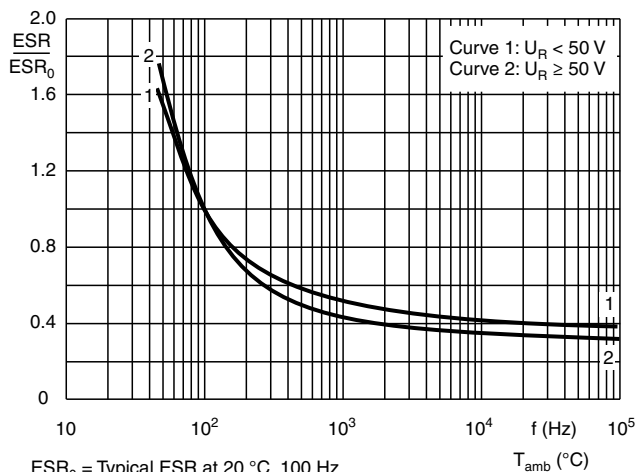


Fig. 8 - Typical multiplier of ESR as a function of frequency

## RIPPLE CURRENT AND USEFUL LIFE

Table 2

| ENDURANCE TEST DURATION AND USEFUL LIFE |           |                                    |                                 |
|-----------------------------------------|-----------|------------------------------------|---------------------------------|
| NOMINAL CASE SIZE<br>Ø D x L<br>(mm)    | CASE CODE | ENDURANCE TEST<br>AT 125 °C<br>(h) | USEFUL LIFE<br>AT 125 °C<br>(h) |
| 10 x 12                                 | 14        | 2000                               | 2500                            |
| 10 x 16                                 | 15        | 2000                               | 3000                            |
| 10 x 20                                 | 16        | 2000                               | 3000                            |
| 12.5 x 20                               | 17        | 2000                               | 3000                            |
| 12.5 x 25                               | 18        | 2000                               | 3000                            |
| 16 x 20                                 | 19a       | 2000                               | 3000                            |
| 16 x 25                                 | 19        | 2000                               | 4000                            |
| 16 x 31                                 | 20        | 2000                               | 4000                            |
| 18 x 31                                 | 1831      | 2000                               | 4000                            |

### Note

- Multiplier of useful life code: MBC242

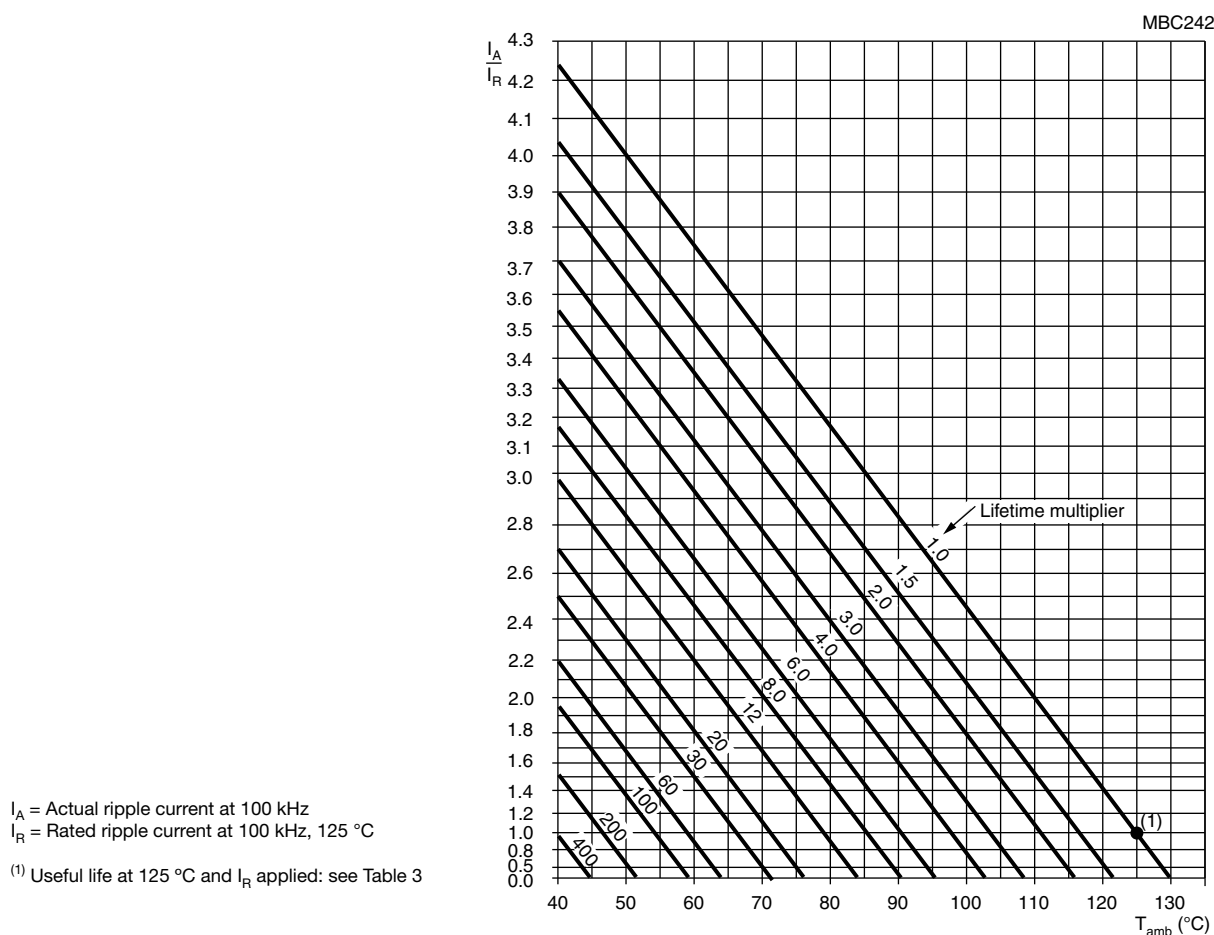


Fig. 9 - Multiplier of useful life as a function of ambient temperature and ripple current load

**Table 3**

| <b>MULTIPLIER OF RIPPLE CURRENT (<math>I_R</math>) AS A FUNCTION OF FREQUENCY</b> |                  |      |      |      |      |        |         |
|-----------------------------------------------------------------------------------|------------------|------|------|------|------|--------|---------|
| $U_R$<br>(V)                                                                      | FREQUENCY (Hz)   |      |      |      |      |        |         |
|                                                                                   | 50               | 100  | 300  | 1000 | 3000 | 10 000 | 100 000 |
|                                                                                   | $I_R$ MULTIPLIER |      |      |      |      |        |         |
| 6.3                                                                               | 0.60             | 0.70 | 0.85 | 0.90 | 0.95 | 1.00   | 1.00    |
| 10                                                                                | 0.60             | 0.70 | 0.85 | 0.90 | 0.95 | 1.00   | 1.00    |
| 16                                                                                | 0.60             | 0.70 | 0.85 | 0.90 | 0.95 | 1.00   | 1.00    |
| 25                                                                                | 0.60             | 0.70 | 0.85 | 0.90 | 0.95 | 1.00   | 1.00    |
| 35                                                                                | 0.50             | 0.65 | 0.80 | 0.85 | 0.90 | 0.95   | 1.00    |
| 50                                                                                | 0.35             | 0.50 | 0.65 | 0.80 | 0.90 | 0.90   | 1.00    |
| 63                                                                                | 0.35             | 0.50 | 0.65 | 0.80 | 0.90 | 0.90   | 1.00    |

**Table 4**

| <b>TEST PROCEDURES AND REQUIREMENTS</b> |                                              |                                                                                                                                            |                                                                                                                                                                                                                          |
|-----------------------------------------|----------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| TEST                                    |                                              | PROCEDURE<br>(quick reference)                                                                                                             | REQUIREMENTS                                                                                                                                                                                                             |
| NAME OF TEST                            | REFERENCE                                    |                                                                                                                                            |                                                                                                                                                                                                                          |
| Endurance                               | IEC 60384-4 /<br>EN 130300<br>subclause 4.13 | $T_{amb} = 125\text{ °C}$ ; $U_R$ applied;<br>2000 h                                                                                       | $\Delta C/C: \pm 15\%$<br>$\tan \delta \leq 1.3 \times \text{spec. limit}$<br>$Z \leq 2 \times \text{spec. limit}$<br>$I_{L5} \leq \text{spec. limit}$                                                                   |
| Useful life                             | CECC 30301<br>subclause 1.8.1                | $T_{amb} = 125\text{ °C}$ ; $U_R$ 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>$Z \leq 3 \times \text{spec. limit}$<br>$I_{L5} \leq \text{spec. limit}$<br>no short or open circuit<br>total failure percentage: $\leq 1\%$ |
| Shelf life                              | IEC 60384-4 /<br>EN 130300<br>subclause 4.17 | $T_{amb} = 125\text{ °C}$ ; no voltage applied;<br>500 h<br>After test: $U_R$ to be applied for 30 min,<br>24 h to 48 h before measurement | $\Delta C/C: \pm 15\%$<br>$\tan \delta \leq 1.3 \times \text{spec. limit}$<br>$Z \leq 2 \times \text{spec. limit}$<br>$I_{L5} \leq 2 \times \text{spec. limit}$                                                          |

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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