

## Aluminum Electrolytic Capacitors Radial, High Temperature Miniature

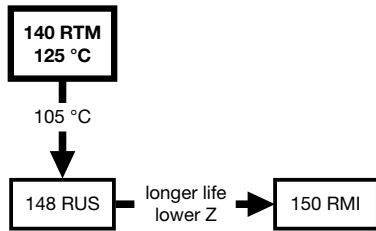


Fig. 1


**RoHS  
COMPLIANT**

### 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)

### 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  $\mu\text{F}$ )
- Tolerance on rated capacitance, code letter in accordance with IEC 60062 (M for  $\pm 20\%$ )
- 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 ( $\varnothing$ D x L in mm) | 10 x 12 to 18 x 31                     |
| Rated capacitance range, $C_R$                  | 22 $\mu\text{F}$ to 4700 $\mu\text{F}$ |
| Tolerance on $C_R$                              | $\pm 20\%$                             |
| Rated voltage range, $U_R$                      | 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, $1.6 \times I_R$ 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 $C_R$ , $U_R$ , AND RELEVANT NOMINAL CASE SIZES ( $\varnothing$ D x L in mm) |           |           |           |           |           |           |         |
|--|-----------|-----------|-----------|-----------|-----------|-----------|---------|
| $C_R$<br>( $\mu\text{F}$ )   | $U_R$ (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   | -         | -         | -         | -       |

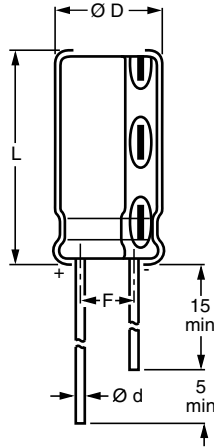
**DIMENSIONS** in millimeters **AND AVAILABLE FORMS**


Fig. 2 - Form CA: Long leads

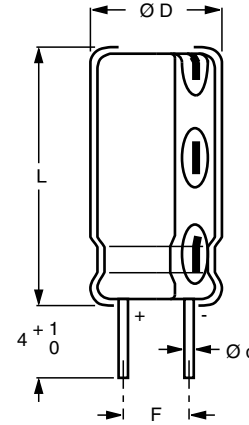


Fig. 3 - Form CB: Cut leads

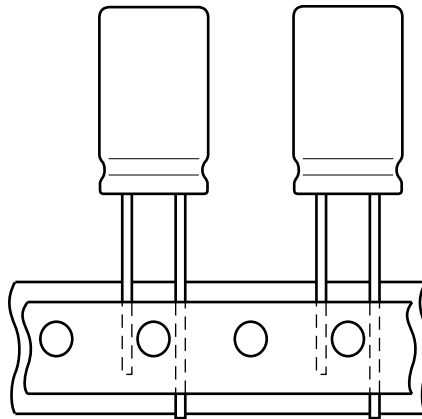


Fig. 4 - Form TFA: Taped in box (ammopack)

Table 1

| DIMENSIONS in millimeters, MASS, AND PACKAGING QUANTITIES |           |     |                     |                   |           |          |                      |         |          |
|---|-----------|-----|---------------------|-------------------|-----------|----------|----------------------|---------|----------|
| NOMINAL CASE SIZE<br>Ø D x L                              | CASE CODE | Ø d | Ø D <sub>max.</sub> | L <sub>max.</sub> | F         | MASS (g) | PACKAGING QUANTITIES |         |          |
|   |           |     |                     |                   |           |          | FORM CA              | FORM CB | FORM 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 |                                      |  |                                    |  |                         |   |   |                                |         |          |
|--|--------------------------------------|--|------------------------------------|--|-------------------------|---|---|--------------------------------|---------|----------|
| $U_R$<br>(V)                             | $C_R$<br>100 Hz<br>( $\mu\text{F}$ ) | NOMINAL<br>CASE SIZE<br>$\varnothing D \times L$<br>(mm) | $I_R$<br>100 kHz<br>125 °C<br>(mA) | $I_{L1}$<br>1 min<br>( $\mu\text{A}$ ) | $\tan \delta$<br>100 Hz | Z<br>100 kHz<br>+ 20 °C<br>( $\Omega$ ) | Z<br>100 kHz<br>- 40 °C<br>( $\Omega$ ) | 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  |
| 16                                       | 4700                                 | 16 x 31  | 2200                               | 473                                    | 0.24                    | 0.030                                   | 0.20                                    | 54472E3                        | 64472E3 | 34472E3  |
|  | 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  |
| 25                                       | 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 | -        |
|  | 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  |
| 35                                       | 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 | -        |
|  | 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  |
| 50                                       | 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 | -        |
|  | 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  |
| 63                                       | 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  |
|  | 22                                   | 10 x 12  | 380                                | 17                                     | 0.10                    | 0.300                                   | 2.00                                    | 58229E3                        | 68229E3 | 38229E3  |
| 63                                       | 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) | $ESR = \tan \delta / 2 \pi f C_R$                  |

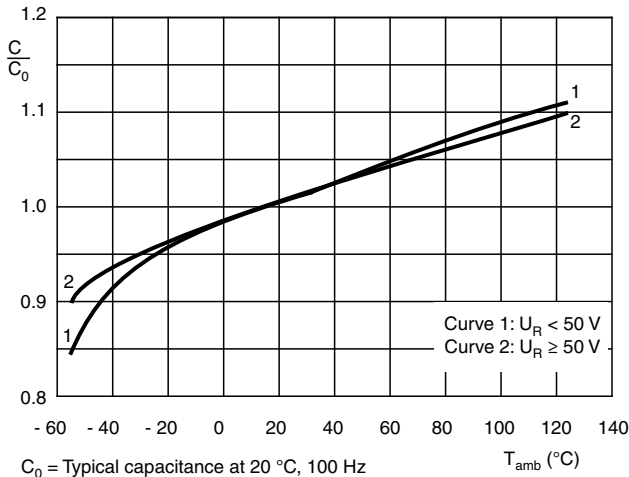
**CAPACITANCE (C)**


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

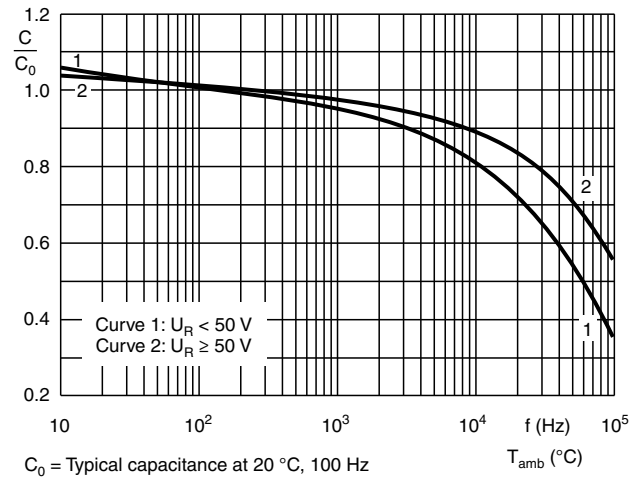


Fig. 6 - Typical multiplier of capacitance as a function of frequency

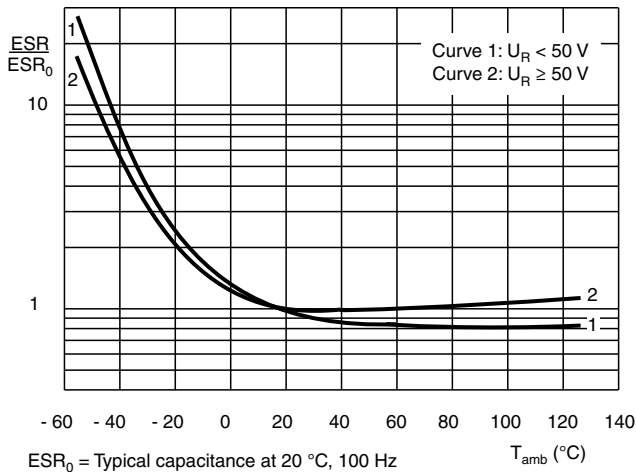
**EQUIVALENT SERIES RESISTANCE (ESR)**


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

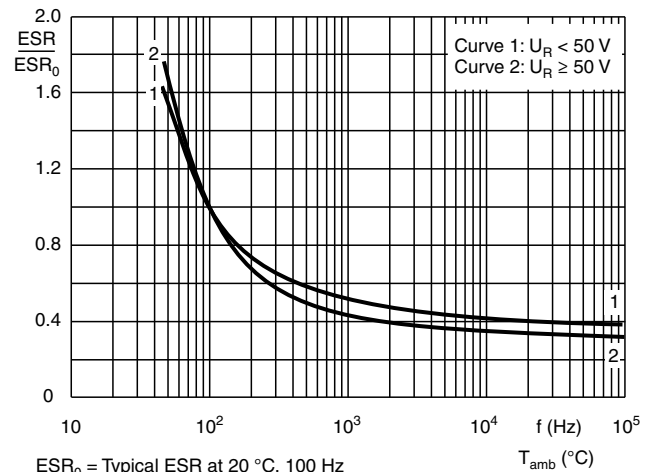


Fig. 8 - Typical multiplier of ESR as a function of frequency

**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

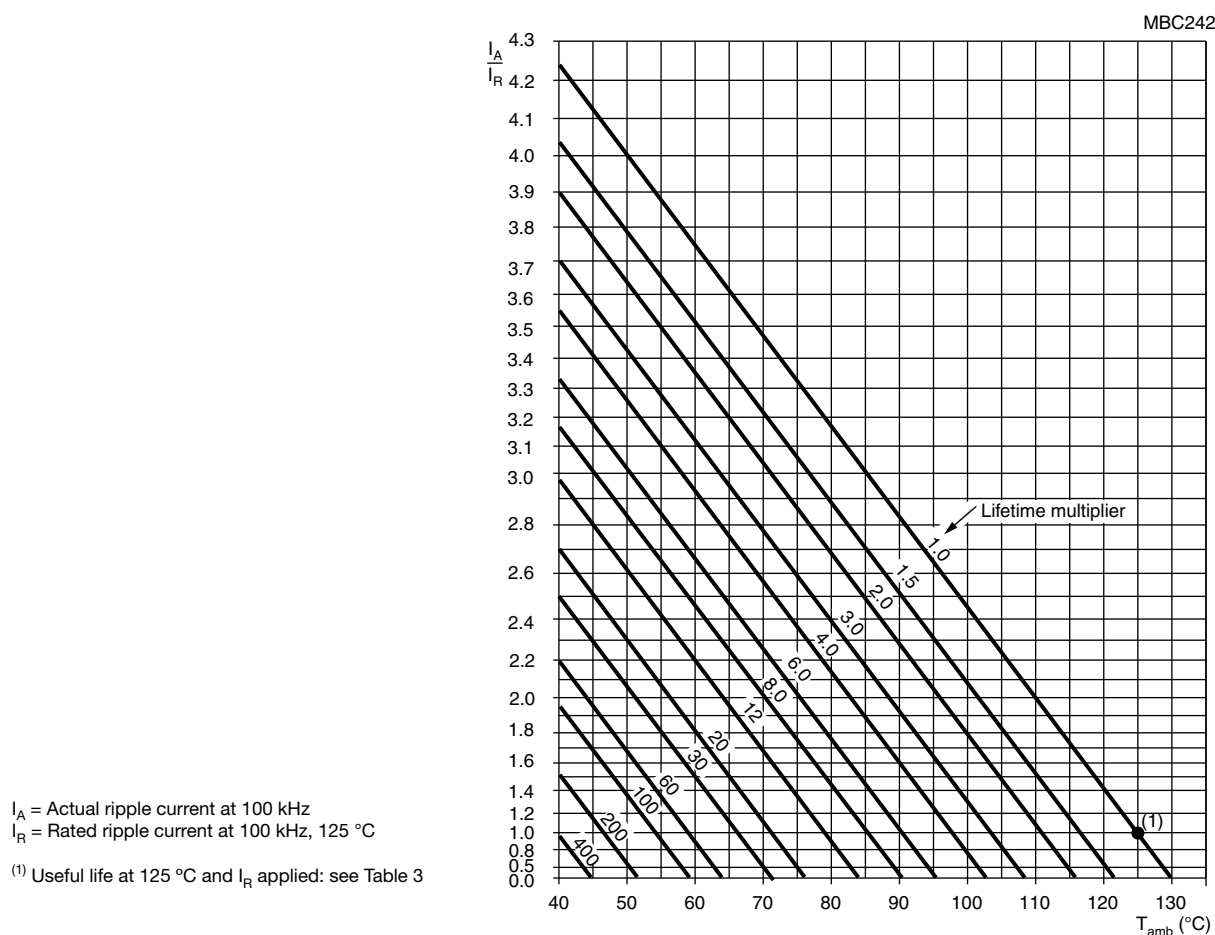


Fig. 9 - Multiplier of useful life as a function of ambient temperature and ripple current load



Table 3

| MULTIPLIER OF RIPPLE CURRENT ( $I_R$ ) AS A FUNCTION OF FREQUENCY |                  |      |      |      |      |        |         |
|---|------------------|------|------|------|------|--------|---------|
| $U_R$<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

| TEST PROCEDURES AND REQUIREMENTS |  |  |  |
|----------------------------------|--|--|--|
| 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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