

Aluminum Electrolytic Capacitors Radial, High Temperature Miniature

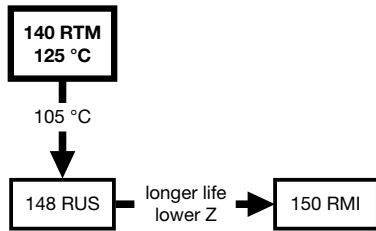


Fig. 1

 AUTOMOTIVE
GRADE

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

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 $\pm 20\%$)
- 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 μF to 4700 μF |
| 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 x 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 (μF) | 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 | - | - | - | - |

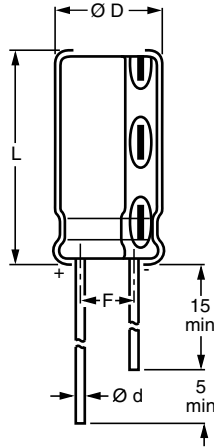
DIMENSIONS in millimeters **AND AVAILABLE FORMS**


Fig. 2 - Form CA: Long leads

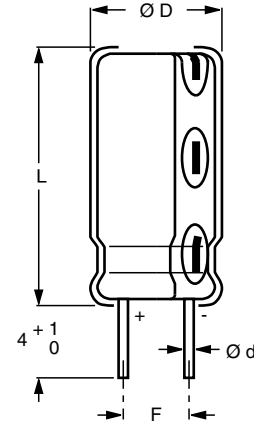


Fig. 3 - Form CB: Cut leads

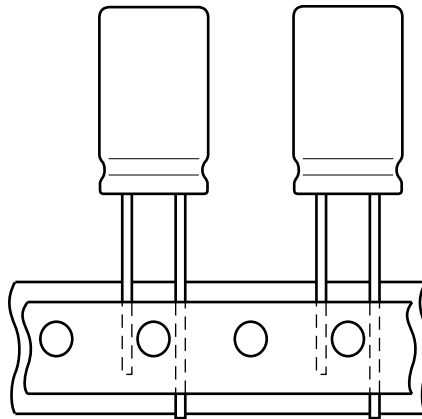


Fig. 4 - Form TFA: Taped in box (ammopack)

Table 1

| DIMENSIONS in millimeters, MASS , AND PACKAGING QUANTITIES | | | | | | | | | |
|---|-----------|-----|---------------------|-------------------|-----------|----------|----------------------|---------|----------|
| NOMINAL CASE SIZE Ø D x L | CASE CODE | Ø d | Ø D _{max.} | L _{max.} | 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



| 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 kPa , $RH = 45\%$ to 75%

ORDERING EXAMPLE

Electrolytic capacitor 140 series

220 μF / 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 (V) | C_R 100 Hz (μF) | NOMINAL CASE SIZE $\varnothing D \times L$ (mm) | I_R 100 kHz 125 °C (mA) | I_{L1} 1 min (μA) | $\tan \delta$ 100 Hz | Z 100 kHz + 20 °C (Ω) | Z 100 kHz - 40 °C (Ω) | ORDERING CODE 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 |
| Voltage | | |
| Surge voltage | | $U_s \leq 1.15 \times U_R$ |
| Reverse voltage | | $U_{rev} \leq 1 \text{ V}$ |
| Current | | |
| 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 | $I_{L5} \leq 0.002 C_R \times U_R + 3 \mu\text{A}$ |
| Inductance | | |
| Equivalent series inductance (ESL) | Case $\varnothing D = 10 \text{ mm}$ | Typ. 16 nH |
| | Case $\varnothing D \geq 12.5 \text{ mm}$ | Typ. 18 nH |
| Resistance | | |
| Equivalent series resistance (ESR) | Calculated from $\tan \delta_{max.}$ and C_R (see Table 2) | $ESR = \tan \delta / 2 \pi f C_R$ |

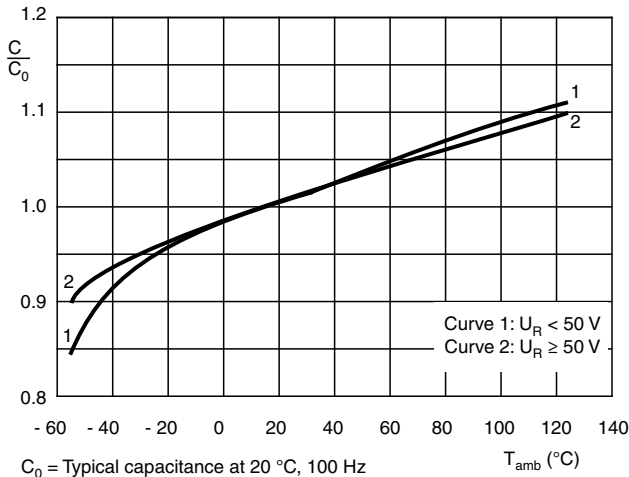
CAPACITANCE (C)


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

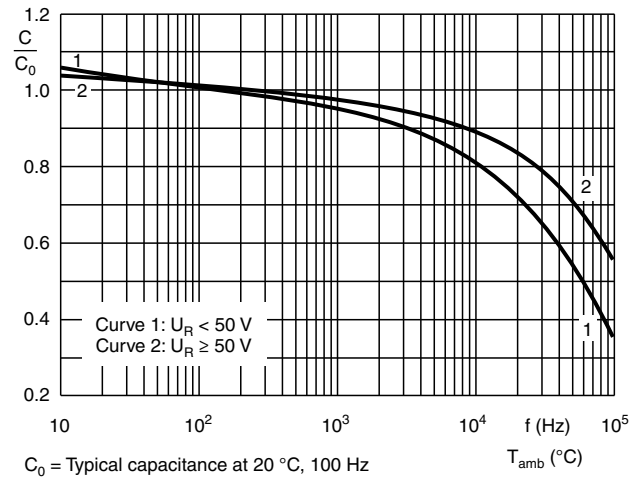


Fig. 6 - Typical multiplier of capacitance as a function of frequency

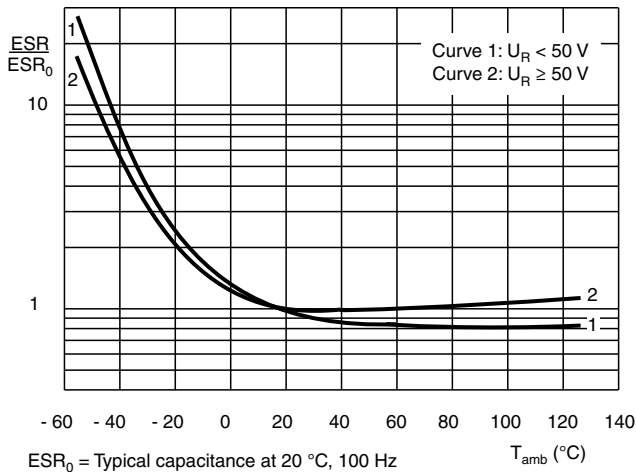
EQUIVALENT SERIES RESISTANCE (ESR)


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

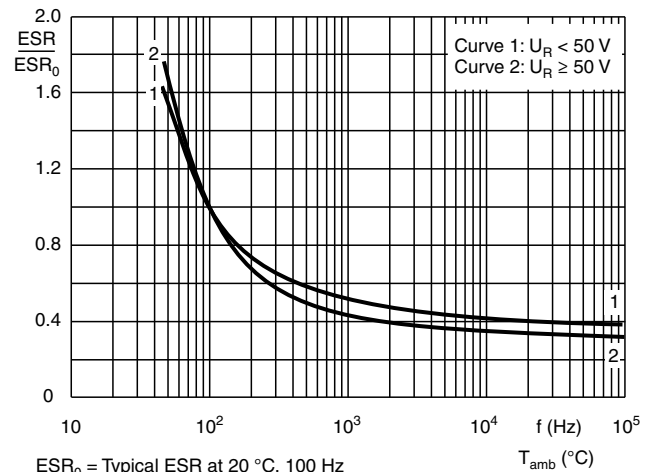


Fig. 8 - Typical multiplier of ESR as a function of frequency

RIPPLE CURRENT AND USEFUL LIFE

Table 2

| ENDURANCE TEST DURATION AND USEFUL LIFE | | | |
|---|-----------|------------------------------------|---------------------------------|
| NOMINAL CASE SIZE Ø D x L (mm) | CASE CODE | ENDURANCE TEST AT 125 °C (h) | USEFUL LIFE AT 125 °C (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

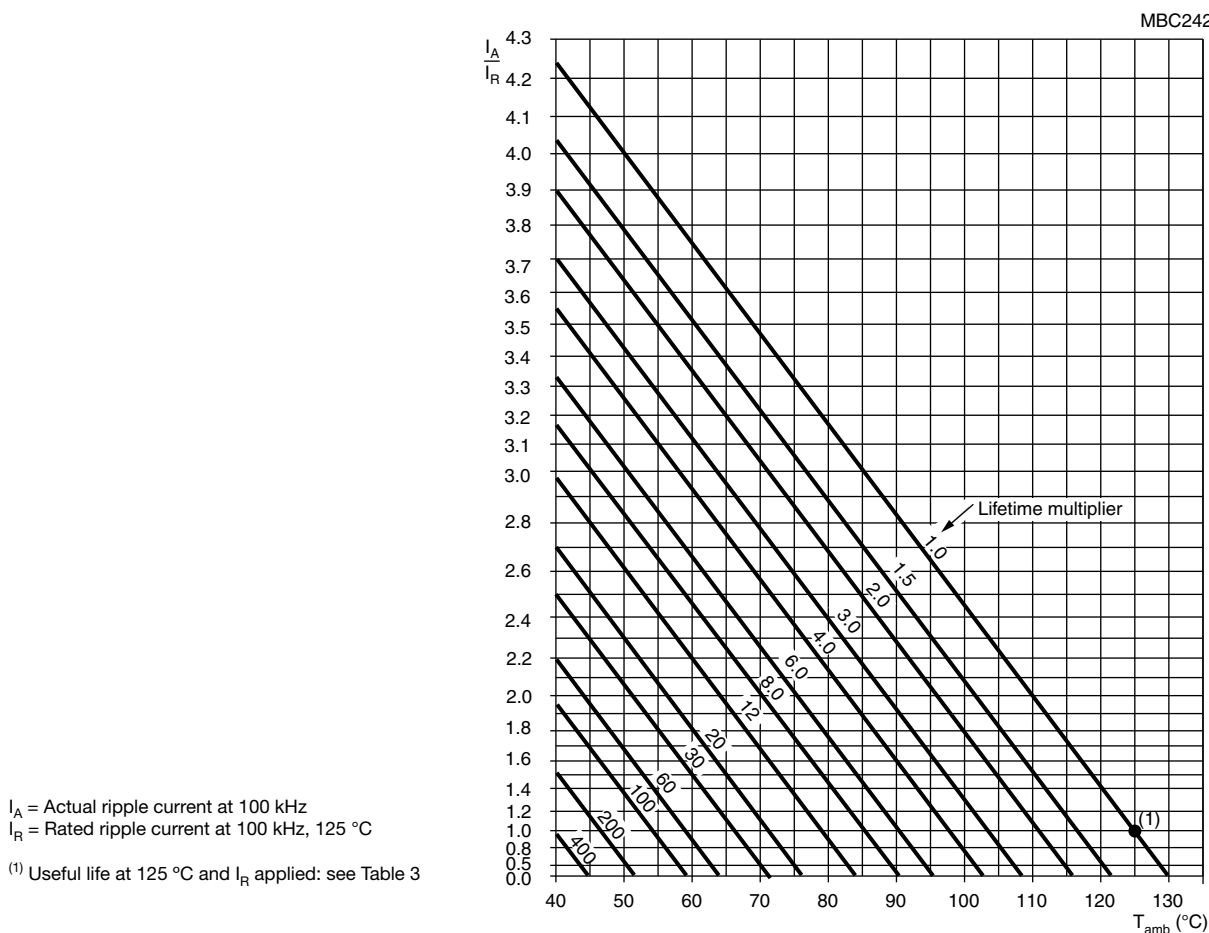


Fig. 9 - Multiplier of useful life as a function of ambient temperature and ripple current load



Table 3

| MULTIPLIER OF RIPPLE CURRENT (I_R) AS A FUNCTION OF FREQUENCY | | | | | | | |
|---|------------------|------|------|------|------|--------|---------|
| U_R (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 (quick reference) | REQUIREMENTS |
| NAME OF TEST | REFERENCE | | |
| Endurance | IEC 60384-4 / EN 130300 subclause 4.13 | $T_{amb} = 125\text{ }^\circ\text{C}$; U_R applied; 2000 h | $\Delta C/C: \pm 15\%$ $\tan \delta \leq 1.3 \times \text{spec. limit}$ $Z \leq 2 \times \text{spec. limit}$ $I_{L5} \leq \text{spec. limit}$ |
| Useful life | CECC 30301 subclause 1.8.1 | $T_{amb} = 125\text{ }^\circ\text{C}$; U_R and I_R applied; for test duration see Table 3 | $\Delta C/C: \pm 30\%$ $\tan \delta \leq 3 \times \text{spec. limit}$ $Z \leq 3 \times \text{spec. limit}$ $I_{L5} \leq \text{spec. limit}$ no short or open circuit total failure percentage: $\leq 1\%$ |
| Shelf life | IEC 60384-4 / EN 130300 subclause 4.17 | $T_{amb} = 125\text{ }^\circ\text{C}$; no voltage applied; 500 h After test: U_R to be applied for 30 min, 24 h to 48 h before measurement | $\Delta C/C: \pm 15\%$ $\tan \delta \leq 1.3 \times \text{spec. limit}$ $Z \leq 2 \times \text{spec. limit}$ $I_{L5} \leq 2 \times \text{spec. limit}$ |

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.



Disclaimer

ALL PRODUCT, PRODUCT SPECIFICATIONS AND DATA ARE SUBJECT TO CHANGE WITHOUT NOTICE TO IMPROVE RELIABILITY, FUNCTION OR DESIGN OR OTHERWISE.

Vishay Intertechnology, Inc., its affiliates, agents, and employees, and all persons acting on its or their behalf (collectively, "Vishay"), disclaim any and all liability for any errors, inaccuracies or incompleteness contained in any datasheet or in any other disclosure relating to any product.

Vishay makes no warranty, representation or guarantee regarding the suitability of the products for any particular purpose or the continuing production of any product. To the maximum extent permitted by applicable law, Vishay disclaims (i) any and all liability arising out of the application or use of any product, (ii) any and all liability, including without limitation special, consequential or incidental damages, and (iii) any and all implied warranties, including warranties of fitness for particular purpose, non-infringement and merchantability.

Statements regarding the suitability of products for certain types of applications are based on Vishay's knowledge of typical requirements that are often placed on Vishay products in generic applications. Such statements are not binding statements about the suitability of products for a particular application. It is the customer's responsibility to validate that a particular product with the properties described in the product specification is suitable for use in a particular application. Parameters provided in datasheets and / or specifications may vary in different applications and performance may vary over time. All operating parameters, including typical parameters, must be validated for each customer application by the customer's technical experts. Product specifications do not expand or otherwise modify Vishay's terms and conditions of purchase, including but not limited to the warranty expressed therein.

Hyperlinks included in this datasheet may direct users to third-party websites. These links are provided as a convenience and for informational purposes only. Inclusion of these hyperlinks does not constitute an endorsement or an approval by Vishay of any of the products, services or opinions of the corporation, organization or individual associated with the third-party website. Vishay disclaims any and all liability and bears no responsibility for the accuracy, legality or content of the third-party website or for that of subsequent links.

Except as expressly indicated in writing, Vishay products are not designed for use in medical, life-saving, or life-sustaining applications or for any other application in which the failure of the Vishay product could result in personal injury or death. Customers using or selling Vishay products not expressly indicated for use in such applications do so at their own risk. Please contact authorized Vishay personnel to obtain written terms and conditions regarding products designed for such applications.

No license, express or implied, by estoppel or otherwise, to any intellectual property rights is granted by this document or by any conduct of Vishay. Product names and markings noted herein may be trademarks of their respective owners.