

Aluminum Electrolytic Capacitors Radial Miniature, Low Impedance

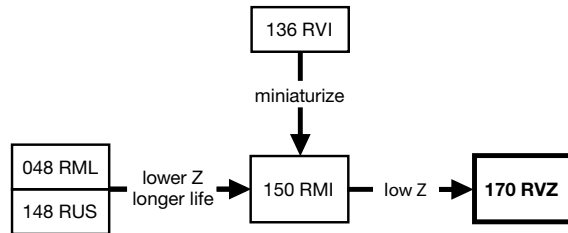
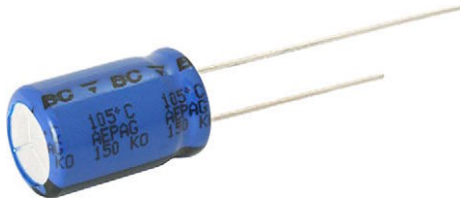


Fig. 1

| QUICK REFERENCE DATA | |
|--|------------------------|
| DESCRIPTION | VALUE |
| Nominal case sizes (Ø D x L in mm) | 10 x 12 to 18 x 40 |
| Rated capacitance range, C _R | 100 µF to 6800 µF |
| Tolerance on C _R | ± 20 % |
| Rated voltage range, U _R | 10 V to 63 V |
| Category temperature range | -40 °C to +105 °C |
| Endurance test at 105 °C | 3000 h to 6000 h |
| Useful life at 105 °C | 4000 h to 10 000 h |
| Useful life at 40 °C, 1.8 x I _R 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: 4000 h to 10 000 h at 105 °C, high stability, high reliability
- Very low impedance and low ESR in smaller case sizes than the 150 RMI series
- Excellent ripple current capability
- AEC-Q200 qualified
- 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

 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 (170)

| SELECTION CHART FOR C _R , U _R , AND RELEVANT NOMINAL CASE SIZES (Ø D x L in mm) | | | | | | |
|---|--------------------|-----------|-----------|-----------|-----------|-----------|
| C _R (µF) | U _R (V) | | | | | |
| | 10 | 16 | 25 | 35 | 50 | 63 |
| 100 | - | - | - | - | - | 10 x 12 |
| 150 | - | - | - | - | 10 x 12 | 10 x 16 |
| 220 | - | - | - | - | 10 x 16 | 10 x 20 |
| | - | - | - | 10 x 12 | - | - |
| 330 | - | - | 10 x 12 | 10 x 16 | 10 x 20 | 12.5 x 20 |
| 470 | - | - | 10 x 16 | 10 x 20 | 12.5 x 20 | 12.5 x 25 |
| | - | 10 x 12 | - | - | - | 16 x 20 |
| 680 | 10 x 12 | 10 x 16 | 10 x 20 | 12.5 x 20 | 12.5 x 25 | 16 x 20 |
| | - | - | - | - | - | 16 x 25 |
| 1000 | 10 x 16 | 10 x 20 | 12.5 x 20 | 12.5 x 25 | 16 x 25 | 16 x 31 |
| | - | - | - | 16 x 20 | - | - |
| 1200 | - | - | - | - | 16 x 31 | - |
| 1500 | - | 12.5 x 20 | 12.5 x 25 | 16 x 20 | 16 x 31 | - |
| 2200 | 12.5 x 20 | 12.5 x 25 | 16 x 20 | 16 x 31 | - | 18 x 40 |
| 3300 | 12.5 x 25 | 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 | - | - | - | - |

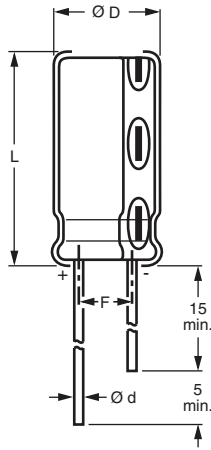
DIMENSIONS in millimeters AND AVAILABLE FORMS


Fig. 2 - Form CA: Long leads

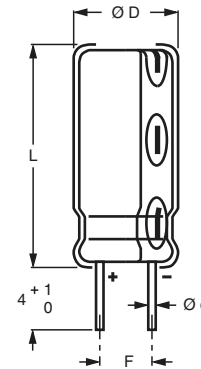


Fig. 3 - Form CB: Cut leads

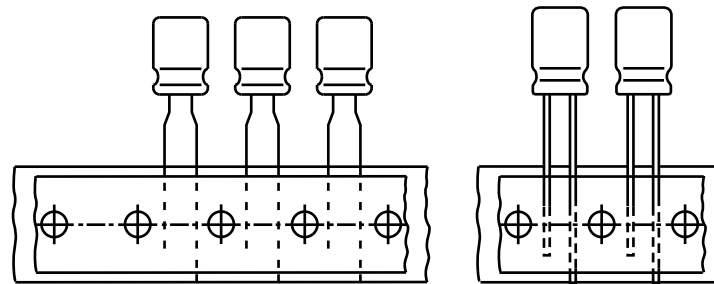

 Formed leads for $\text{Ø D} = 8 \text{ mm}$ with pitch $F = 5 \text{ mm}$

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

Table 1

| DIMENSIONS in millimeters, MASS AND PACKAGING QUANTITIES | | | | | | | | | |
|---|-----------|--------------|----------------------------|-------------------|---------------|----------------|----------------------|---------|----------|
| NOMINAL CASE SIZE $\text{Ø D} \times L$ | CASE CODE | Ø d | $\text{Ø D}_{\text{max.}}$ | $L_{\text{max.}}$ | 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 |
| 16 x 35 | 21 | 0.8 | 16.5 | 37.5 | 7.5 ± 0.5 | ≈ 11.0 | 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 ± 20 % |
| I _R | Rated RMS ripple current at 100 kHz, 105 °C |
| I _{L2} | Max. leakage current after 2 min at U _R |
| tan δ | 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 °C, P = 86 kPa to 106 kPa, RH = 45 % to 75 %

Table 2

| ELECTRICAL DATA AND ORDERING INFORMATION | | | | | | | | | | |
|--|----------------------------------|---|---|----------------------------------|-----------------|-------------------------------|-------------------------------|-------------------------------|---------|----------|
| U _R (V) | C _R 100 Hz (µF) | NOMINAL CASE SIZE Ø D x L (mm) | I _R 100 kHz 105 °C (mA) | I _{L2} 2 min (µA) | tan δ 100 Hz | Z 100 kHz +20 °C (Ω) | Z 100 kHz -40 °C (Ω) | ORDERING CODE MAL2170..... | | |
| | | | | | | | | BULK PACKAGING | | TAPED |
| | | | | | | | | FORM CA | FORM CB | FORM TFA |
| 10 | 680 | 10 x 12 | 770 | 71 | 0.19 | 0.092 | 0.660 | 54681E3 | 64681E3 | 34681E3 |
| | 1000 | 10 x 16 | 1100 | 103 | 0.19 | 0.062 | 0.450 | 54102E3 | 64102E3 | 34102E3 |
| | 2200 | 12.5 x 20 | 1760 | 223 | 0.21 | 0.033 | 0.240 | 54222E3 | 64222E3 | 34222E3 |
| | 3300 | 12.5 x 25 | 2200 | 333 | 0.21 | 0.027 | 0.190 | 54332E3 | 64332E3 | 34332E3 |
| | 4700 | 16 x 25 | 2630 | 473 | 0.23 | 0.020 | 0.140 | 54472E3 | 64472E3 | 34472E3 |
| | 6800 | 16 x 31 | 3300 | 683 | 0.25 | 0.017 | 0.120 | 54682E3 | 64682E3 | 34682E3 |
| 16 | 470 | 10 x 12 | 770 | 78 | 0.16 | 0.092 | 0.660 | 55471E3 | 65471E3 | 35471E3 |
| | 680 | 10 x 16 | 1100 | 112 | 0.16 | 0.062 | 0.450 | 55681E3 | 65681E3 | 35681E3 |
| | 1000 | 10 x 20 | 1260 | 163 | 0.16 | 0.046 | 0.330 | 55102E3 | 65102E3 | 35102E3 |
| | 1500 | 12.5 x 20 | 1760 | 243 | 0.16 | 0.033 | 0.240 | 55152E3 | 65152E3 | 35152E3 |
| | 2200 | 12.5 x 25 | 2200 | 355 | 0.18 | 0.027 | 0.190 | 55222E3 | 65222E3 | 35222E3 |
| | 3300 | 16 x 20 | 2100 | 531 | 0.20 | 0.020 | 0.140 | 55332E3 | 65332E3 | 35332E3 |
| | 4700 | 16 x 31 | 3300 | 755 | 0.22 | 0.017 | 0.120 | 55472E3 | 65472E3 | 35472E3 |
| | 6800 | 16 x 35 | 3550 | 1091 | 0.24 | 0.017 | 0.120 | 55682E3 | 65682E3 | - |
| 8200 | 18 x 40 | 3800 | 1315 | 0.28 | 0.017 | 0.120 | 55822E3 | 65822E3 | - | |
| 25 | 330 | 10 x 12 | 770 | 86 | 0.14 | 0.092 | 0.660 | 56331E3 | 66331E3 | 36331E3 |
| | 470 | 10 x 16 | 1100 | 121 | 0.14 | 0.062 | 0.450 | 56471E3 | 66471E3 | 36471E3 |
| | 680 | 10 x 20 | 1260 | 173 | 0.14 | 0.046 | 0.330 | 56681E3 | 66681E3 | 36681E3 |
| | 1000 | 12.5 x 20 | 1760 | 253 | 0.14 | 0.033 | 0.240 | 56102E3 | 66102E3 | 36102E3 |
| | 1500 | 12.5 x 25 | 2200 | 378 | 0.14 | 0.027 | 0.190 | 56152E3 | 66152E3 | 36152E3 |
| | 2200 | 16 x 20 | 2100 | 553 | 0.16 | 0.020 | 0.140 | 56222E3 | 66222E3 | 36222E3 |
| | 3300 | 16 x 31 | 3300 | 828 | 0.16 | 0.017 | 0.120 | 56332E3 | 66332E3 | 36332E3 |
| | 4700 | 16 x 35 | 3550 | 1178 | 0.18 | 0.017 | 0.120 | 56472E3 | 66472E3 | - |
| 6800 | 18 x 40 | 3800 | 1703 | 0.22 | 0.017 | 0.120 | 56682E3 | 66682E3 | - | |
| 35 | 220 | 10 x 12 | 770 | 80 | 0.12 | 0.092 | 0.660 | 50221E3 | 60221E3 | 30221E3 |
| | 330 | 10 x 16 | 1100 | 118 | 0.12 | 0.062 | 0.450 | 50331E3 | 60331E3 | 30331E3 |
| | 470 | 10 x 20 | 1260 | 167 | 0.12 | 0.046 | 0.330 | 50471E3 | 60471E3 | 30471E3 |
| | 680 | 12.5 x 20 | 1760 | 241 | 0.12 | 0.033 | 0.240 | 50681E3 | 60681E3 | 30681E3 |
| | 1000 | 12.5 x 25 | 2200 | 353 | 0.12 | 0.027 | 0.190 | 50102E3 | 60102E3 | 30102E3 |
| | 1000 | 16 x 20 | 2100 | 353 | 0.12 | 0.020 | 0.140 | 90105E3 | 90106E3 | 90103E3 |
| | 1500 | 16 x 20 | 2100 | 528 | 0.12 | 0.020 | 0.140 | 50152E3 | 60152E3 | 30152E3 |
| | 2200 | 16 x 31 | 3300 | 773 | 0.14 | 0.017 | 0.120 | 50222E3 | 60222E3 | 30222E3 |
| | 3300 | 18 x 31 | 3300 | 1155 | 0.16 | 0.017 | 0.120 | 50332E3 | 60332E3 | - |
| | 4700 | 18 x 40 | 3700 | 1648 | 0.18 | 0.017 | 0.120 | 50472E3 | 60472E3 | - |



| ELECTRICAL DATA AND ORDERING INFORMATION | | | | | | | | | | |
|--|----------------------------------|---|---|----------------------------------|-----------------|-------------------------------|-------------------------------|-------------------------------|---------|----------|
| U _R (V) | C _R 100 Hz (μF) | NOMINAL CASE SIZE Ø D x L (mm) | I _R 100 kHz 105 °C (mA) | I _{L2} 2 min (μA) | tan δ 100 Hz | Z 100 kHz +20 °C (Ω) | Z 100 kHz -40 °C (Ω) | ORDERING CODE MAL2170..... | | |
| | | | | | | | | BULK PACKAGING | | TAPED |
| | | | | | | | | FORM CA | FORM CB | FORM TFA |
| 50 | 150 | 10 x 12 | 560 | 78 | 0.10 | 0.155 | 1.300 | 51151E3 | 61151E3 | 31151E3 |
| | 220 | 10 x 16 | 900 | 113 | 0.10 | 0.114 | 0.820 | 51221E3 | 61221E3 | 31221E3 |
| | 330 | 10 x 20 | 1000 | 168 | 0.10 | 0.086 | 0.620 | 51331E3 | 61331E3 | 31331E3 |
| | 470 | 12.5 x 20 | 1320 | 238 | 0.10 | 0.059 | 0.420 | 51471E3 | 61471E3 | 31471E3 |
| | 680 | 12.5 x 25 | 1550 | 343 | 0.10 | 0.045 | 0.320 | 51681E3 | 61681E3 | 31681E3 |
| | 1000 | 16 x 25 | 2100 | 503 | 0.10 | 0.031 | 0.220 | 51102E3 | 61102E3 | 31102E3 |
| | 1200 | 16 x 31 | 2550 | 603 | 0.10 | 0.025 | 0.180 | 51122E3 | 61122E3 | 31122E3 |
| | 1500 | 16 x 31 | 2550 | 753 | 0.10 | 0.025 | 0.180 | 51152E3 | 61152E3 | 31152E3 |
| 63 | 3300 | 18 x 40 | 3380 | 1653 | 0.14 | 0.022 | 0.160 | 51332E3 | 61332E3 | - |
| | 100 | 10 x 12 | 445 | 66 | 0.10 | 0.260 | 1.860 | 58101E3 | 68101E3 | 38101E3 |
| | 150 | 10 x 16 | 615 | 97 | 0.10 | 0.181 | 1.290 | 58151E3 | 68151E3 | 38151E3 |
| | 220 | 10 x 20 | 770 | 141 | 0.10 | 0.140 | 1.010 | 58221E3 | 68221E3 | 38221E3 |
| | 330 | 12.5 x 20 | 1115 | 211 | 0.10 | 0.072 | 0.520 | 58331E3 | 68331E3 | 38331E3 |
| | 470 | 12.5 x 25 | 1320 | 299 | 0.10 | 0.064 | 0.460 | 58471E3 | 68471E3 | 38471E3 |
| | 470 | 16 x 20 | 1200 | 299 | 0.10 | 0.071 | 0.510 | 98475E3 | 98476E3 | 98473E3 |
| | 680 | 16 x 20 | 1200 | 431 | 0.10 | 0.071 | 0.510 | 58681E3 | 68681E3 | 38681E3 |
| | 680 | 16 x 25 | 1800 | 431 | 0.10 | 0.048 | 0.350 | 98685E3 | 98686E3 | 98683E3 |
| | 1000 | 16 x 31 | 2200 | 633 | 0.10 | 0.040 | 0.290 | 58102E3 | 68102E3 | 38102E3 |
| | 2200 | 18 x 40 | 3260 | 1389 | 0.12 | 0.031 | 0.220 | 58222E3 | 68222E3 | - |

| ADDITIONAL ELECTRICAL DATA | | |
|------------------------------------|---|---|
| PARAMETER | CONDITIONS | VALUE |
| Voltage | | |
| Surge voltage | | $U_s \leq 1.15 \times U_R$ |
| Reverse voltage | | $U_{rev} \leq 1 V$ |
| Current | | |
| Leakage current | After 2 min at U _R | $I_{L2} \leq 0.01 C_R \times U_R + 3 \mu A$ |
| Inductance | | |
| Equivalent series inductance (ESL) | Case Ø D ≤ 10 mm | Typ. 16 nH |
| | Case Ø D ≥ 12.5 mm | Typ. 18 nH |
| Resistance | | |
| Equivalent series resistance (ESR) | Calculated from tan δ _{max} and C _R (see Table 2) | $ESR = \tan \delta / 2 \pi f C_R$ |

CAPACITANCE (C)

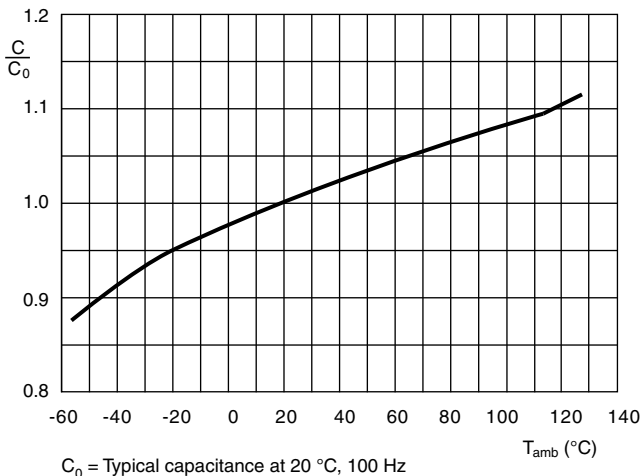


Fig. 5 - Typical multiplier of capacitance as a function of ambient temperature

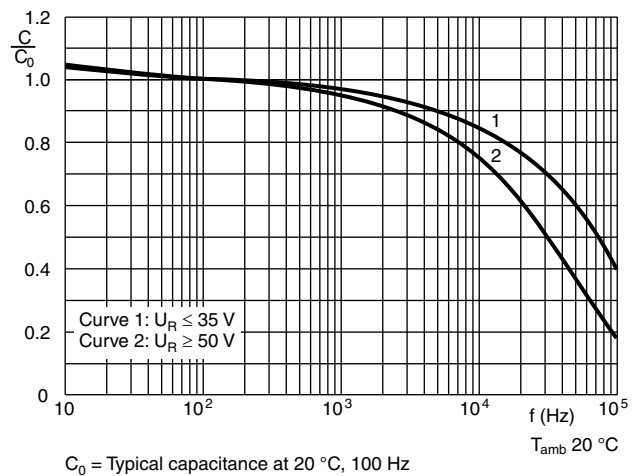


Fig. 6 - Typical multiplier of capacitance as a function of frequency

EQUIVALENT SERIES RESISTANCE (ESR)

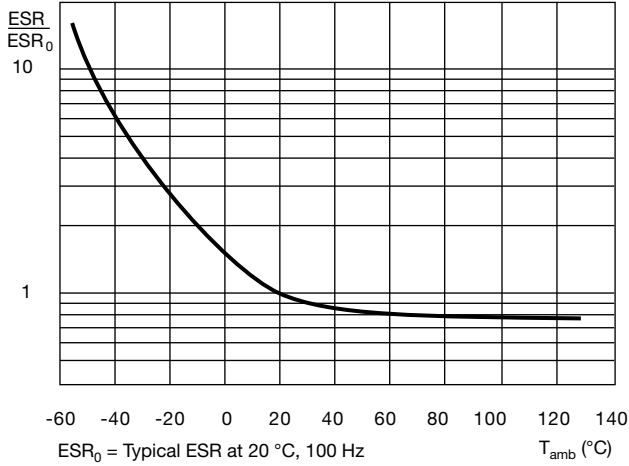


Fig. 7 - Typical multiplier of ESR as a function of ambient temperature

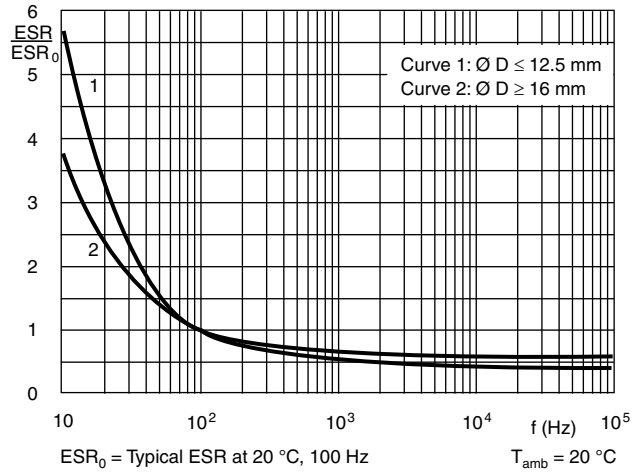


Fig. 8 - Typical multiplier of ESR as a function of frequency

IMPEDANCE (Z)

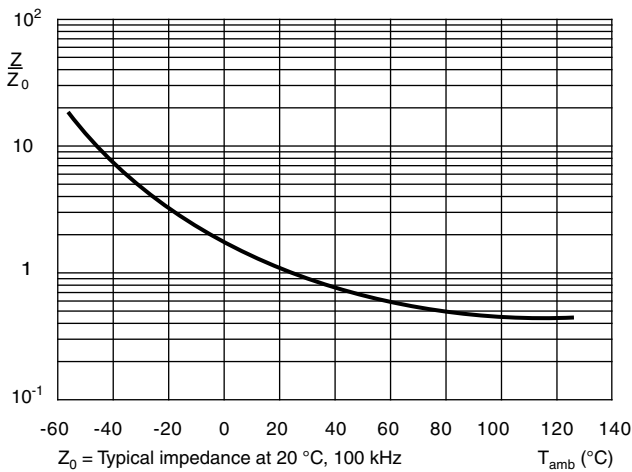


Fig. 9 - Typical multiplier of impedance as a function of ambient temperature

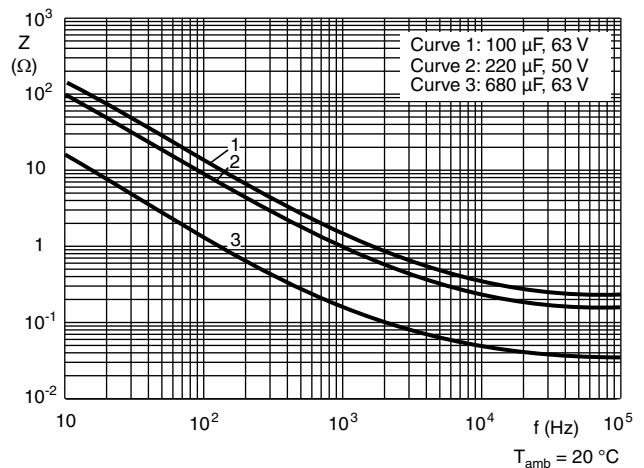


Fig. 10 - Typical impedance as a function of frequency

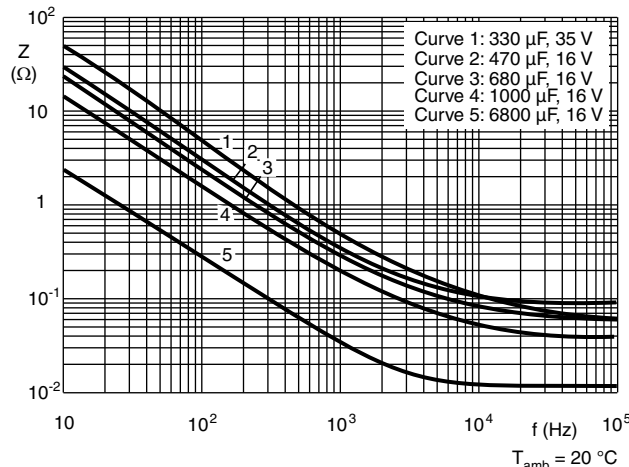


Fig. 11 - Typical impedance as a function of frequency

RIPPLE CURRENT AND USEFUL LIFE

Table 3

| ENDURANCE TEST DURATION AND USEFUL LIFE | | | |
|---|-----------|-------------------------------|---------------------------------|
| NOMINAL CASE SIZE Ø D x L (mm) | CASE CODE | ENDURANCE AT 105 °C (h) | USEFUL LIFE AT 105 °C (h) |
| 10 x 12 | 14 | 3000 | 4000 |
| 10 x 16 | 15 | 3000 | 6000 |
| 10 x 20 | 16 | 3000 | 6000 |
| 12.5 x 20 | 17 | 3000 | 7000 |
| 12.5 x 25 | 18 | 5000 | 8000 |
| 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 31 | 1831 | 6000 | 10 000 |
| 18 x 40 | 1840 | 8000 | 10 000 |

Note

- Multiplier of useful life code: CCC206

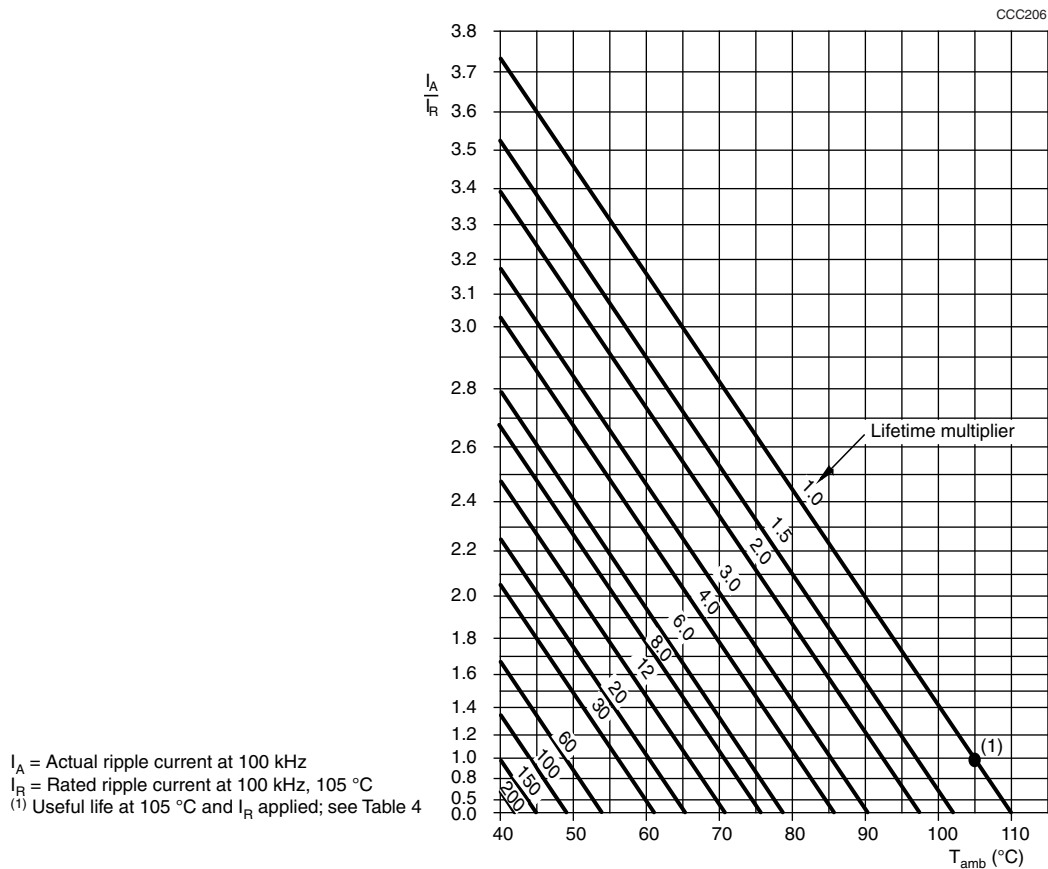


Fig. 12 - Multiplier of useful life as a function of ambient temperature and ripple current load



Table 4

| MULTIPLIER OF RIPPLE CURRENT (I_R) AS A FUNCTION OF FREQUENCY | | | | | | | |
|---|------------------|------|------|------|--------|--------|---------|
| NOMINAL CASE SIZE $\varnothing D \times L$ (mm) | FREQUENCY (Hz) | | | | | | |
| | 100 | 300 | 1000 | 3000 | 10 000 | 30 000 | 100 000 |
| | I_R MULTIPLIER | | | | | | |
| 10 x 12 | 0.65 | 0.76 | 0.85 | 0.89 | 0.90 | 0.97 | 1.00 |
| 10 x 16 | 0.65 | 0.76 | 0.85 | 0.89 | 0.90 | 0.97 | 1.00 |
| 10 x 20 | 0.65 | 0.76 | 0.85 | 0.89 | 0.90 | 0.97 | 1.00 |
| 12.5 x 20 | 0.65 | 0.76 | 0.85 | 0.89 | 0.90 | 0.97 | 1.00 |
| 12.5 x 25 | 0.65 | 0.76 | 0.85 | 0.89 | 0.90 | 0.97 | 1.00 |
| 16 x 20 | 0.76 | 0.85 | 0.91 | 0.94 | 0.96 | 0.98 | 1.00 |
| 16 x 25 | 0.76 | 0.85 | 0.91 | 0.94 | 0.96 | 0.98 | 1.00 |
| 16 x 31 | 0.76 | 0.85 | 0.91 | 0.94 | 0.96 | 0.98 | 1.00 |
| 16 x 35 | 0.76 | 0.85 | 0.91 | 0.94 | 0.96 | 0.98 | 1.00 |
| 18 x 31 | 0.76 | 0.85 | 0.91 | 0.94 | 0.96 | 0.98 | 1.00 |
| 18 x 40 | 0.76 | 0.85 | 0.91 | 0.94 | 0.96 | 0.98 | 1.00 |

Table 5

| TEST PROCEDURES AND REQUIREMENTS | | | |
|--|--|--|--|
| TEST | | PROCEDURE (quick reference) | REQUIREMENTS |
| NAME OF TEST | REFERENCE | | |
| Endurance | IEC 60384-4 / EN130300 subclause 4.13 | $T_{amb} = 105 \text{ }^\circ\text{C}$; U_R applied; for test duration see Table 3 | $\Delta C/C: \pm 20 \%$ $\tan \delta \leq 2 \times \text{spec. limit}$ $I_{L2} \leq \text{spec. limit}$ |
| Useful life | CECC 30301 subclause 1.8.1 | $T_{amb} = 105 \text{ }^\circ\text{C}$; U_R and I_R applied; for test duration see Table 3 | $\Delta C/C: \pm 30 \%$ $\tan \delta \leq 3 \times \text{spec. limit}$ $I_{L2} \leq \text{spec. limit}$ no short or open circuit total failure percentage: $\leq 1 \%$ |
| Shelf life (storage at high temperature) | IEC 60384-4 / EN130300 subclause 4.17 | $T_{amb} = 105 \text{ }^\circ\text{C}$; no voltage applied; 1000 h after test: U_R to be applied for 30 min., 24 h to 48 h before measurement | $\Delta C/C: \pm 20 \%$ $\tan \delta \leq 2 \times \text{spec. limit}$ $I_{L2} \leq \text{spec. limit}$ |

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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