

Aluminum Electrolytic Capacitors Axial High Temperature, High Ripple Current



Fig. 1

| QUICK REFERENCE DATA | |
|--|--------------------------|
| DESCRIPTION | VALUE |
| Nominal case sizes (Ø D x L in mm) | 10 x 30 to 21 x 38 |
| Rated capacitance range, C _R | 47 µF to 6800 µF |
| Tolerance on C _R | ± 20 % |
| Rated voltage range, U _R | 16 V to 100 V |
| Category temperature range | -40 °C to +125 °C |
| Endurance test at 150 °C | 1000 h |
| Endurance test at 125 °C | 4000 h |
| Useful life at 125 °C | 8000 h |
| Useful life at 85 °C, 1.4 x I _R applied | 40 000 h |
| Shelf life at 0 V, 125 °C | 1000 h (100 V: 500 h) |
| Shelf life at 0 V, 150 °C | ≤ 63 V: 500 h |
| Based on sectional specification | IEC 60384-4 / EN 130300 |
| Climatic category IEC 60068 | 40 / 125 / 56 |

FEATURES

- Extra long useful life: up to 8000 h at 125 °C
- Extended temperature range: usable up to 150 °C
- Low ESR levels provide very high ripple current capability
- Miniaturized, high CV-product per unit volume
- Polarized aluminum electrolytic capacitors, non-solid electrolyte
- Axial leads, cylindrical aluminum case, insulated with a blue sleeve
- Taped versions up to case Ø 15 mm x 30 mm available for automatic insertion
- Lead diameter Ø d = 1.0 mm, available on request
- AEC-Q200 qualified
- Material categorization: for definitions of compliance please see www.vishay.com/doc?99912


**RoHS
COMPLIANT**

APPLICATIONS

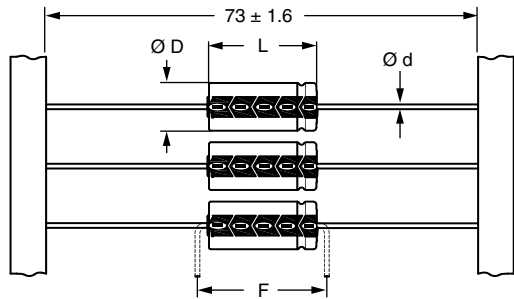
- Automotive, industrial, and telecommunication
- Smoothing, filtering, buffering
- Low mounting height applications, vibration and shock resistant
- SMPS and standard power supplies

MARKING

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

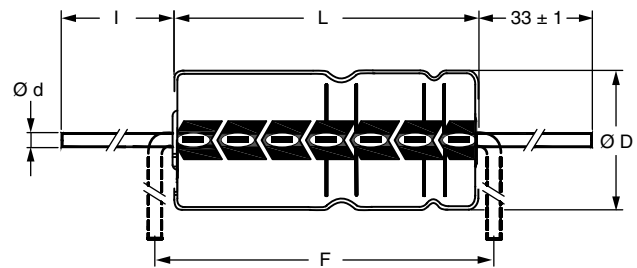
- Rated capacitance (in µF)
- Tolerance on rated capacitance, code letter in accordance with IEC 60062 (M for ± 20 %)
- Rated voltage (in V)
- Upper category temperature (125 °C)
- Date code in accordance with IEC 60062
- Code for factory of origin
- Name of manufacturer
- Negative terminal identification
- Series number (120)

| SELECTION CHART FOR C _R , U _R , AND RELEVANT NOMINAL CASE SIZE (Ø D x L in mm) | | | | | |
|--|--------------------|-----------|-----------|-----------|-----------|
| C _R (µF) | U _R (V) | | | | |
| | 16 | 25 | 40 | 63 | 100 |
| 47 | - | - | - | - | 10 x 30 |
| 68 | - | - | - | - | 12.5 x 30 |
| 100 | - | - | - | 10 x 30 | 12.5 x 30 |
| 150 | - | - | - | 12.5 x 30 | 15 x 30 |
| 220 | - | - | 10 x 30 | 12.5 x 30 | 18 x 30 |
| 330 | - | - | 12.5 x 30 | 15 x 30 | 18 x 38 |
| 470 | - | 10 x 30 | 12.5 x 30 | 18 x 30 | 21 x 38 |
| 680 | 10 x 30 | 12.5 x 30 | 15 x 30 | 18 x 38 | - |
| 1000 | 12.5 x 30 | 12.5 x 30 | 18 x 30 | 21 x 38 | - |
| 1500 | 12.5 x 30 | 15 x 30 | 18 x 38 | - | - |
| 2200 | 15 x 30 | 18 x 30 | 21 x 38 | - | - |
| 3300 | 18 x 30 | 18 x 38 | - | - | - |
| 4700 | 18 x 38 | 21 x 38 | - | - | - |
| 6800 | 21 x 38 | - | - | - | - |

DIMENSIONS in millimeters AND AVAILABLE FORMS


Form BR: Taped on reel
Case $\varnothing D \times L = 6.5 \text{ mm} \times 18 \text{ mm}$ to $15 \text{ mm} \times 30 \text{ mm}$

Fig. 2 - Form BR



Form AA: Axial in box
Case $\varnothing D \times L = 10 \text{ mm} \times 30 \text{ mm}$ to $21 \text{ mm} \times 38 \text{ mm}$

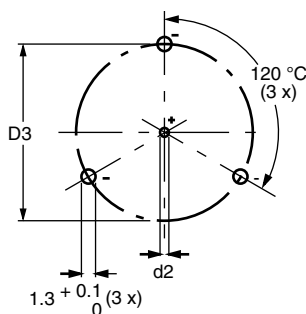
Fig. 3 - Form AA

Table 1

| AXIAL; DIMENSIONS in millimeters, MASS, AND PACKAGING QUANTITIES | | | | | | | | |
|--|-----------------------|------------|-------------------------------|-------------------|-------------------|----------------|----------------------|---------|
| NOMINAL CASE SIZE $\varnothing D \times L$ (mm) | AXIAL: FORM AA AND BR | | | | | MASS (g) | PACKAGING QUANTITIES | |
| | $\varnothing d$ (1) | l | $\varnothing D_{\text{max.}}$ | $L_{\text{max.}}$ | $F_{\text{min.}}$ | | FORM AA | FORM BR |
| 10 x 30 | 0.8 | 55 ± 1 | 10.5 | 30.5 | 35 | ≈ 4.8 | 340 | 500 |
| 12.5 x 30 | 0.8 | 55 ± 1 | 13.0 | 30.5 | 35 | ≈ 7.4 | 260 | 400 |
| 15 x 30 | 0.8 | 55 ± 1 | 15.5 | 30.5 | 35 | ≈ 11.7 | 200 | 250 |
| 18 x 30 | 0.8 | 55 ± 1 | 18.5 | 30.5 | 35 | ≈ 12.9 | 120 | - |
| 18 x 38 | 0.8 | 34 ± 1 | 18.5 | 39.5 | 44 | ≈ 19.0 | 125 | - |
| 21 x 38 | 0.8 | 34 ± 1 | 21.5 | 39.5 | 44 | ≈ 24.0 | 100 | - |

Notes

- For detailed tape dimensions, please see www.vishay.com/doc?28361
- (1) Lead diameter $\varnothing d = 1.0 \text{ mm}$, available on request



Mounting holes

Case $\varnothing D \times L = 15 \text{ mm} \times 30 \text{ mm}$ to $21 \text{ mm} \times 38 \text{ mm}$
Especially for applications with severe shocks and vibrations

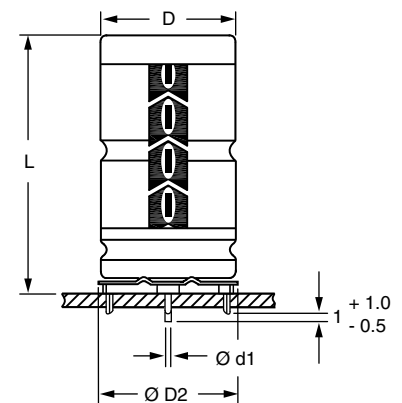
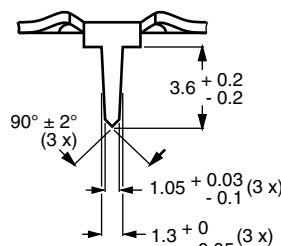

 Fig. 4 - Mounting hole diagram and outline; **form MR:** With mounting ring and pins

Table 2

| MOUNTING RING; DIMENSIONS in millimeters, MASS, AND PACKAGING QUANTITIES | | | | | | | | | |
|--|-----------|------------------------|------------------|-------------------------------|--------------------------------|----------------|-------------------|----------------|----------------------|
| NOMINAL CASE SIZE $\varnothing D \times L$ | CASE CODE | MOUNTING RING: FORM MR | | | | | | MASS (g) | PACKAGING QUANTITIES |
| | | $\varnothing d1$ | $\varnothing d2$ | $\varnothing D_{\text{max.}}$ | $\varnothing D2_{\text{max.}}$ | D3 | $L_{\text{max.}}$ | | |
| 15 x 30 | 02 | 0.8 | $1.0 + 0.4$ | 15.5 | 17.5 | 16.5 ± 0.2 | 33 | ≈ 8.6 | 200 |
| 18 x 30 | 03 | 0.8 | $1.0 + 0.4$ | 18.5 | 19.5 | 18.5 ± 0.2 | 33 | ≈ 11.5 | 240 |
| 18 x 38 | 04 | 0.8 | $1.0 + 0.4$ | 18.5 | 19.5 | 18.5 ± 0.2 | 42 | ≈ 14.0 | 100 |
| 21 x 38 | 05 | 0.8 | $1.0 + 0.4$ | 21.5 | 22.5 | 21.5 ± 0.2 | 42 | ≈ 19.2 | 100 |



| ELECTRICAL DATA | |
|-----------------|---|
| SYMBOL | DESCRIPTION |
| C_R | Rated capacitance at 100 Hz, tolerance $\pm 20\%$ |
| I_R | Rated RMS ripple current at 10 kHz, 125 °C |
| I_{L1} | Max. leakage current after 1 min at U_R |
| I_{L5} | Max. leakage current after 5 min at U_R |
| ESR | Equivalent series resistance at 100 Hz (calculated from $\tan \delta_{max}$ and C_R) |
| Z | Max. impedance at 10 kHz |

Note

- Unless otherwise specified, all electrical values in Table 3 apply at $T_{amb} = 20\text{ °C}$, $P = 86\text{ kPa}$ to 106 kPa , $RH = 45\%$ to 75%

ORDERING EXAMPLE

Electrolytic capacitor 120 series

1000 μF / 16 V; $\pm 20\%$

Nominal case size: $\varnothing 12.5\text{ mm} \times 30\text{ mm}$; form BR

Ordering code: MAL212025102E3

Former 12NC: 2222 120 25102

Table 3

| ELECTRICAL DATA AND ORDERING INFORMATION | | | | | | | | | | | | | | |
|--|--------------------------------------|--|-----------------------------------|--|--|--|--|--|--|--------------------------------------|------------------------------|----------------------------|-----------------------------|-----------------------------|
| U_R (V) | C_R 100 Hz (μF) | NOMINAL CASE SIZE $\varnothing D \times L$ (mm) | I_R 10 kHz 125 °C (mA) | I_{L1} 1 min (μA) | I_{L5} 5 min (μA) | TYP. ESR 100 Hz (m Ω) | MAX. ESR 100 Hz (m Ω) | TYP. ESR 10 kHz (m Ω) | MAX. ESR 10 kHz (m Ω) | Z MAX. 10 kHz (m Ω) | FREQ. CODE ⁽¹⁾ | ORDERING CODE MAL2120..... | | |
| | | | | | | | | | | | | IN BOX FORM AA | TAPED ON REEL FORM BR | MOUNTING RING FORM MR |
| 16 | 680 | 10 x 30 | 2100 | 171 | 84 | 106 | 177 | 44 | 74 | 78 | MF1 | 15681E3 | 25681E3 | - |
| | 1000 | 12.5 x 30 | 2550 | 232 | 104 | 77 | 128 | 35 | 58 | 61 | MF1 | 15102E3 | 25102E3 | - |
| | 1500 | 12.5 x 30 | 2650 | 328 | 136 | 60 | 100 | 32 | 53 | 53 | MF1 | 15152E3 | 25152E3 | - |
| | 2200 | 15 x 30 | 2940 | 462 | 181 | 48 | 79 | 28 | 46 | 46 | MF1 | 15222E3 | 25222E3 | 45222E3 |
| | 3300 | 18 x 30 | 3430 | 674 | 251 | 41 | 68 | 26 | 43 | 43 | MF2 | 15332E3 | - | 45332E3 |
| | 4700 | 18 x 38 | 4350 | 942 | 341 | 27 | 45 | 18 | 29 | 29 | MF2 | 15472E3 | - | 45472E3 |
| | 6800 | 21 x 38 | 4590 | 1346 | 475 | 26 | 43 | 18 | 29 | 29 | MF2 | 15682E3 | - | 45682E3 |
| 25 | 470 | 10 x 30 | 2100 | 181 | 87 | 112 | 187 | 45 | 74 | 84 | MF1 | 16471E3 | 26471E3 | - |
| | 680 | 12.5 x 30 | 2550 | 244 | 108 | 81 | 136 | 35 | 59 | 64 | MF1 | 16681E3 | 26681E3 | - |
| | 1000 | 12.5 x 30 | 2600 | 340 | 140 | 64 | 107 | 32 | 53 | 55 | MF1 | 16102E3 | 26102E3 | - |
| | 1500 | 15 x 30 | 2890 | 490 | 190 | 49 | 82 | 28 | 46 | 46 | MF1 | 16152E3 | 26152E3 | 46152E3 |
| | 2200 | 18 x 30 | 3310 | 700 | 260 | 43 | 71 | 27 | 44 | 44 | MF2 | 16222E3 | - | 46222E3 |
| | 3300 | 18 x 38 | 4350 | 1030 | 370 | 28 | 47 | 18 | 29 | 29 | MF2 | 16332E3 | - | 46332E3 |
| | 4700 | 21 x 38 | 4470 | 1450 | 510 | 27 | 44 | 18 | 29 | 29 | MF2 | 16472E3 | - | 46472E3 |
| 40 | 220 | 10 x 30 | 1990 | 146 | 75 | 192 | 320 | 52 | 87 | 124 | MF1 | 17221E3 | 27221E3 | - |
| | 330 | 12.5 x 30 | 2430 | 198 | 93 | 130 | 216 | 37 | 62 | 83 | MF1 | 17331E3 | 27331E3 | - |
| | 470 | 12.5 x 30 | 2550 | 266 | 115 | 101 | 169 | 35 | 58 | 70 | MF1 | 17471E3 | 27471E3 | - |
| | 680 | 15 x 30 | 2840 | 366 | 149 | 75 | 125 | 30 | 50 | 55 | MF1 | 17681E3 | 27681E3 | 47681E3 |
| | 1000 | 18 x 30 | 3150 | 520 | 200 | 59 | 99 | 28 | 47 | 49 | MF2 | 17102E3 | - | 47102E3 |
| | 1500 | 18 x 38 | 4130 | 760 | 280 | 39 | 65 | 19 | 31 | 32 | MF2 | 17152E3 | - | 47152E3 |
| | 2200 | 21 x 38 | 4170 | 1096 | 392 | 34 | 56 | 19 | 31 | 31 | MF2 | 17222E3 | - | 47222E3 |
| 63 | 100 | 10 x 30 | 1560 | 116 | 65 | 297 | 495 | 92 | 154 | 249 | MF3 | 18101E3 | 28101E3 | - |
| | 150 | 12.5 x 30 | 2050 | 153 | 78 | 195 | 325 | 61 | 102 | 162 | MF3 | 18151E3 | 28151E3 | - |
| | 220 | 12.5 x 30 | 2150 | 206 | 95 | 149 | 249 | 55 | 92 | 126 | MF3 | 18221E3 | 28221E3 | - |
| | 330 | 15 x 30 | 2510 | 289 | 123 | 105 | 175 | 44 | 73 | 91 | MF3 | 18331E3 | 28331E3 | 48331E3 |
| | 470 | 18 x 30 | 2860 | 395 | 158 | 81 | 135 | 38 | 64 | 74 | MF4 | 18471E3 | - | 48471E3 |
| | 680 | 18 x 38 | 3720 | 554 | 211 | 55 | 92 | 26 | 43 | 49 | MF4 | 18681E3 | - | 48681E3 |
| | 1000 | 21 x 38 | 3780 | 796 | 292 | 44 | 74 | 25 | 41 | 43 | MF4 | 18102E3 | - | 48102E3 |
| 100 | 47 | 10 x 30 | 760 | 96 | 59 | 760 | 1269 | 349 | 581 | 720 | MF3 | 19479E3 | 29479E3 | - |
| | 68 | 12.5 x 30 | 1030 | 122 | 67 | 531 | 885 | 246 | 410 | 503 | MF3 | 19689E3 | 29689E3 | - |
| | 100 | 12.5 x 30 | 1140 | 160 | 80 | 389 | 648 | 196 | 327 | 381 | MF3 | 19101E3 | 29101E3 | - |
| | 150 | 15 x 30 | 1480 | 220 | 100 | 266 | 443 | 137 | 229 | 262 | MF3 | 19151E3 | 29151E3 | 49151E3 |
| | 220 | 18 x 30 | 1960 | 304 | 128 | 181 | 302 | 95 | 158 | 179 | MF4 | 19221E3 | - | 49221E3 |
| | 330 | 18 x 38 | 2550 | 436 | 172 | 120 | 200 | 62 | 104 | 117 | MF4 | 19331E3 | - | 49331E3 |
| | 470 | 21 x 38 | 2800 | 604 | 228 | 92 | 154 | 52 | 86 | 94 | MF4 | 19471E3 | - | 49471E3 |

Note

- ⁽¹⁾ Determines the applicable row in the table "Multiplier of Ripple Current (I_R) as a Function of Frequency"

| ADDITIONAL ELECTRICAL DATA | | | |
|------------------------------------|------------------------------|---|---------------|
| PARAMETER | CONDITIONS | VALUE | |
| | | AXIAL | MOUNTING RING |
| 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 | $I_{L1} \leq 0.012 C_R \times U_R + 40 \mu\text{A}$ | |
| | After 5 min at U_R | $I_{L5} \leq 0.004 C_R \times U_R + 40 \mu\text{A}$ | |
| Inductance | | | |
| Equivalent series inductance (ESL) | Case \varnothing D x L mm: | | |
| | 10 x 30 | Typ. 38 nH | |
| | 12.5 x 30 | Typ. 46 nH | |
| | 15 x 30 | Typ. 48 nH | Typ. 39 nH |
| | 18 x 30 | Typ. 50 nH | Typ. 39 nH |
| | 18 x 38 | Typ. 54 nH | Typ. 39 nH |
| | 21 x 38 | Typ. 59 nH | Typ. 39 nH |

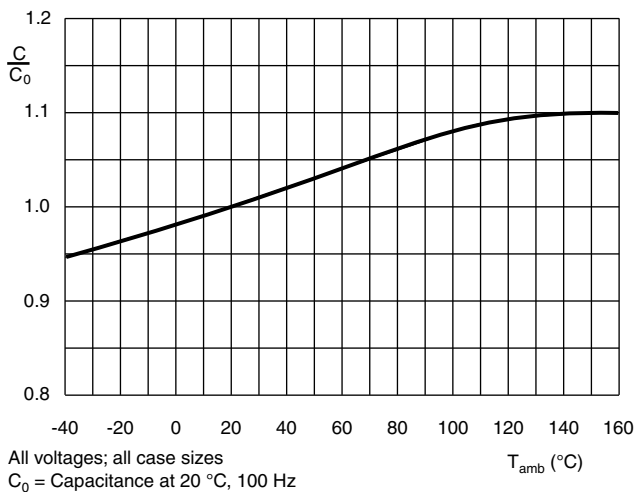
CAPACITANCE (C)


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

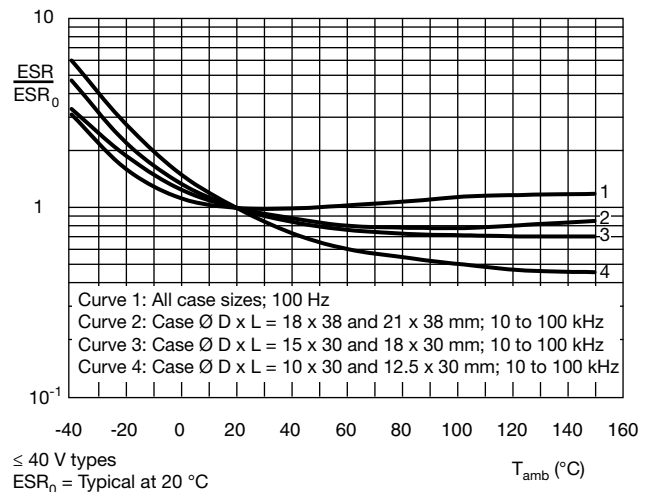
EQUIVALENT SERIES RESISTANCE (ESR)


Fig. 6 - Typical multiplier of ESR as a function of ambient temperature at different frequencies

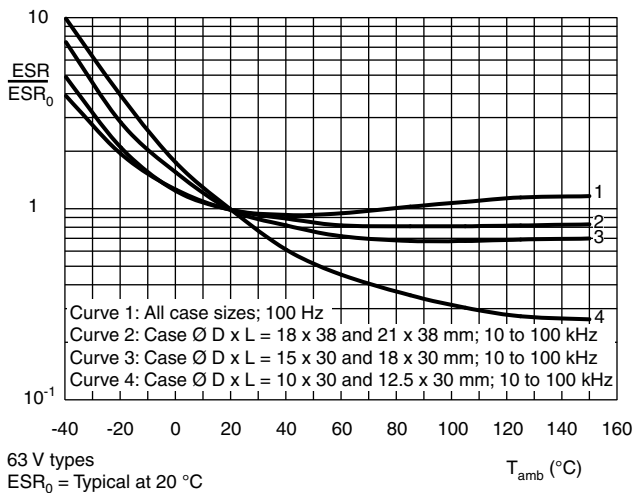


Fig. 7 - Typical multiplier of ESR as a function of ambient temperature at different frequencies

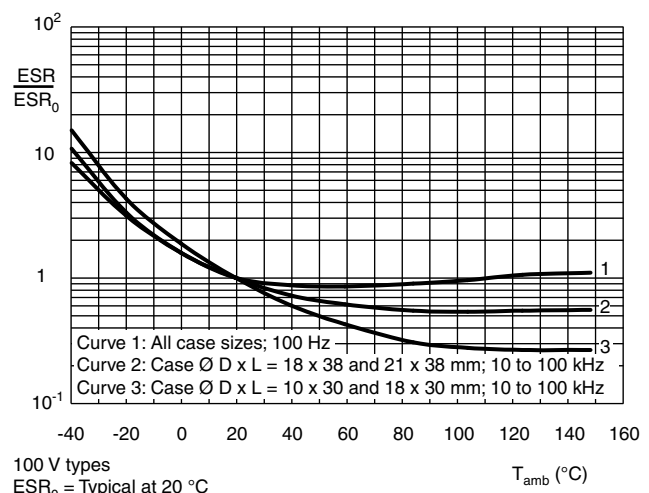


Fig. 8 - Typical multiplier of ESR as a function of ambient temperature at different frequencies

RIPPLE CURRENT AND USEFUL LIFE

Table 4

| ENDURANCE TEST DURATION AND USEFUL LIFE | |
|---|---------------------------|
| ENDURANCE AT 125 °C (h) | USEFUL LIFE AT 125 °C (h) |
| 4000 | 8000 |

Note

- Multiplier of useful life code: JW64


 I_A = Actual ripple current at 10 kHz

 I_R = Rated ripple current at 10 kHz, 125 °C

 (1) Useful life at 125 °C and I_R applied: 8000 h

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

Table 5

| MULTIPLIER OF RIPPLE CURRENT (I_R) AS A FUNCTION OF FREQUENCY | | | | | | |
|---|----------------|------|------|------|------|----------|
| FREQ. CODE | FREQUENCY (Hz) | | | | | |
| | 50 | 100 | 300 | 1000 | 3000 | ≥ 10 000 |
| I_R MULTIPLIER | | | | | | |
| MF1 | 0.37 | 0.48 | 0.69 | 0.86 | 0.96 | 1.00 |
| MF2 | 0.54 | 0.63 | 0.75 | 0.81 | 0.87 | 1.00 |
| MF3 | 0.23 | 0.32 | 0.53 | 0.77 | 0.93 | 1.00 |
| MF4 | 0.44 | 0.56 | 0.76 | 0.88 | 0.94 | 1.00 |

Table 6

| TEST PROCEDURES AND REQUIREMENTS | | | |
|--|--|---|---|
| TEST | | PROCEDURE (quick reference) | REQUIREMENTS |
| NAME OF TEST | REFERENCE | | |
| Endurance | IEC 60384-4 / EN 130300 subclause 4.13 | $T_{amb} = 125\text{ °C}$; U_R applied; 4000 h $T_{amb} = 150\text{ °C}$; U_R applied; 1000 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 | $T_{amb} = 125\text{ °C}$; U_R and I_R applied; 8000 h | $\Delta C/C$: $\pm 45\%$ $\tan \delta \leq 3 \times \text{spec. limit}$ $Z \leq 3 \times \text{spec. limit}$ $I_{L5} \leq \text{spec. limit}$ no short or open circuit total failure percentage: $\leq 1\%$ |
| Shelf life (storage at high temperature) | IEC 60384-4 / EN 130300 subclause 4.17 | $T_{amb} = 125\text{ °C}$; no voltage applied; 1000 h (100 V: 500 h) $T_{amb} = 150\text{ °C}$; no voltage applied; 500 h for voltages: $\leq 63\text{ V}$ After test: U_R to be applied for 30 min, 24 h to 48 h before measurement | $\Delta C/C$, $\tan \delta$, Z : for requirements see "Endurance test" above $I_{L5} \leq 2 \times \text{spec. limit}$ |
| Reverse voltage | IEC 60384-4 / EN 130300 subclause 4.15 | $T_{amb} = 125\text{ °C}$: 125 h at $U = -1\text{ V}$ Followed by 125 h at U_R | $\Delta C/C$: $\pm 20\%$ $\tan \delta \leq \text{spec. limit}$ $I_{L5} \leq \text{spec. limit}$ |

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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