

Aluminum Electrolytic Capacitors Radial Long Life

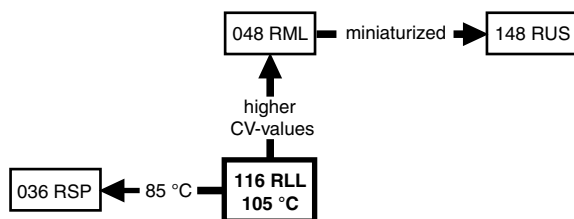
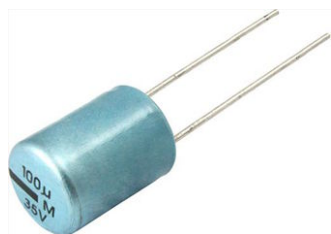


Fig. 1

FEATURES

- Long useful life: 2000 h at 105 °C
- Miniaturized, high CV-product per unit volume
- Natural pitch 2.5 mm and 5 mm
- Polarized aluminum electrolytic capacitors, non-solid electrolyte
- Radial leads, cylindrical aluminum case, all-insulated (light blue)
- Charge and discharge proof
- Material categorization: for definitions of compliance please see www.vishay.com/doc?99912


RoHS
COMPLIANT

APPLICATIONS

- Automotive, telecommunication, industrial and EDP
- Stand-by applications in audio and video equipment
- Coupling, decoupling, timing, smoothing, filtering and buffering in DC/DC converters
- Portable and mobile equipment (small size, low mass)

MARKING

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

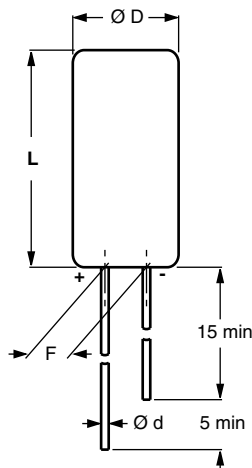
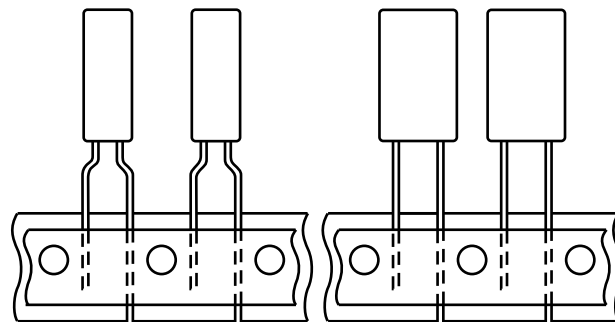
- Rated capacitance (in μF)
- Tolerance on rated capacitance, code letter in accordance with IEC 60062 (M for $\pm 20\%$)
- Rated voltage (in V)
- Date code in accordance with IEC 60062
- Code indicating factory of origin
- Name of manufacturer
- “-”-sign on top to identify the negative terminal
- Series number (116)

QUICK REFERENCE DATA

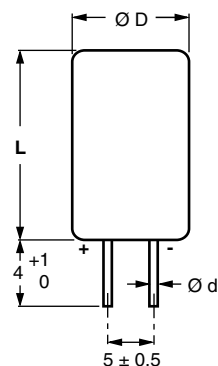
| DESCRIPTION | VALUE |
|--|--|
| Nominal case sizes ($\varnothing D \times L$ in mm) | 5 x 11 and 8.2 x 11 |
| Rated capacitance range, C_R | 1.5 μF to 470 μF |
| Tolerance on C_R | $\pm 20\%$ |
| Rated voltage range, U_R | 6.3 V to 100 V |
| Category temperature range | -55 °C to +105 °C |
| Endurance test at 105 °C | 1500 h |
| Endurance test at 85 °C | 5000 h |
| Useful life at 105 °C | 2000 h |
| Useful life at 40 °C, 1.3 x I_R applied | 200 000 h |
| Shelf life at 0 V, 105 °C | 1500 h |
| Based on sectional specification | IEC 60384-4 / EN 130300 |
| Climatic category IEC 60068 | 55 / 105 / 56 |

SELECTION CHART FOR C_R , U_R , AND RELEVANT NOMINAL CASE SIZES ($\varnothing D \times L$ in mm)

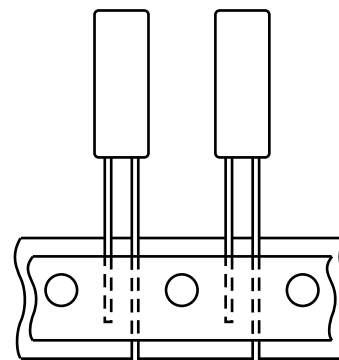
| C_R (μF) | U_R (V) | | | | | | | | |
|----------------------------|-----------|----------|----------|----------|----------|----------|----------|----------|----------|
| | 6.3 | 10 | 16 | 25 | 35 | 40 | 50 | 63 | 100 |
| 1.5 | - | - | - | - | - | - | 5 x 11 | - | - |
| 3.3 | - | - | - | - | - | - | 5 x 11 | - | - |
| 4.7 | - | - | - | - | - | - | 5 x 11 | - | 8.2 x 11 |
| 6.8 | - | - | - | - | - | - | 5 x 11 | - | - |
| 10 | - | - | - | - | - | - | 5 x 11 | 8.2 x 11 | 8.2 x 11 |
| 15 | - | - | - | - | - | - | 5 x 11 | - | - |
| 22 | - | - | - | - | - | - | 5 x 11 | 8.2 x 11 | - |
| 33 | - | - | - | - | 5 x 11 | 5 x 11 | 8.2 x 11 | - | - |
| 47 | - | - | - | 5 x 11 | - | - | 8.2 x 11 | - | - |
| 68 | - | - | 5 x 11 | - | - | - | 8.2 x 11 | - | - |
| 100 | - | 5 x 11 | - | - | 8.2 x 11 | 8.2 x 11 | - | - | - |
| 150 | 5 x 11 | - | - | 8.2 x 11 | - | - | - | - | - |
| 220 | - | - | 8.2 x 11 | - | - | - | - | - | - |
| 330 | - | 8.2 x 11 | - | - | - | - | - | - | - |
| 470 | 8.2 x 11 | - | - | - | - | - | - | - | - |

DIMENSIONS in millimeters **AND AVAILABLE FORMS**

Fig. 2 - **Form CA:** Long leads


Case $\varnothing D \times L = 5 \text{ mm} \times 11 \text{ mm}$ and $8.2 \text{ mm} \times 11 \text{ mm}$
Pitch $F = 5 \text{ mm}$

Fig. 3 - **Form TFA:** Taped in box (ammopack)


Case $\varnothing D \times L = 8.2 \text{ mm} \times 11 \text{ mm}$ only

Fig. 4 - **Form CB:** Cut leads


Case $\varnothing D \times L = 5 \text{ mm} \times 11 \text{ mm}$ only
Pitch $F = 2.5 \text{ mm}$

Fig. 5 - **Form TNA:** Taped in box (ammopack)

Table 1

| DIMENSIONS in millimeters, MASS, AND PACKAGING QUANTITIES | | | | | | | | |
|---|--------------|-----------------|-------------------------------|-------------------|---------------|---------------|----------------------|------------------|
| NOMINAL CASE SIZE $\varnothing D \times L$ | CASE CODE | $\varnothing d$ | $\varnothing D_{\text{max.}}$ | $L_{\text{max.}}$ | F | MASS (g) | PACKAGING QUANTITIES | |
| | | | | | | | FORM CA, CB | FORM TFA, TNA |
| 5 x 11 | 11 | 0.5 | 5.5 | 12 | 2.5 ± 0.5 | ≈ 0.4 | 1000 | 2000 |
| 8.2 x 11 | 13 | 0.6 | 8.7 | 12 | 5.0 ± 0.5 | ≈ 1.1 | 1000 | 1000 |

Note

- For detailed tape dimension 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, 105 °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 and 20 °C |

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% .

Table 2**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 105 °C (mA) | I_{L1} 1 min (μA) | $\tan \delta$ 100 Hz | Z 100 kHz (Ω) | ORDERING CODE MAL2116 | | | | | | | |
|--------------|--------------------------------------|--|------------------------------------|--|-------------------------|------------------------------|-----------------------------|-----------|------------|-----------|----------------|-----------|-------------|-----------|
| | | | | | | | BULK PACKAGING | | | | TAPED AMMOPACK | | | |
| | | | | | | | LONG LEADS | | CUT LEADS | | | | | |
| | | | | | | | FORM CA | F (mm) | FORM CB | F (mm) | FORM TFA | F (mm) | FORM TNA | F (mm) |
| 6.3 | 150 | 5 x 11 | 130 | 8.7 | 0.25 | 1.3 | 53151E3 | 2.5 | - | - | 33151E3 | 5.0 | 73151E3 | 2.5 |
| | 470 | 8.2 x 11 | 300 | 21 | 0.25 | 0.45 | 53471E3 | 5.0 | 63471E3 | 5.0 | 33471E3 | 5.0 | - | - |
| 10 | 100 | 5 x 11 | 130 | 9.0 | 0.20 | 1.4 | 54101E3 | 2.5 | - | - | 34101E3 | 5.0 | 74101E3 | 2.5 |
| | 330 | 8.2 x 11 | 280 | 23 | 0.20 | 0.45 | 54331E3 | 5.0 | 64331E3 | 5.0 | 34331E3 | 5.0 | - | - |
| 16 | 68 | 5 x 11 | 130 | 9.5 | 0.16 | 1.5 | 55689E3 | 2.5 | - | - | 35689E3 | 5.0 | 75689E3 | 2.5 |
| | 220 | 8.2 x 11 | 280 | 24 | 0.16 | 0.5 | 55221E3 | 5.0 | 65221E3 | 5.0 | 35221E3 | 5.0 | - | - |
| 25 | 47 | 5 x 11 | 120 | 10 | 0.14 | 1.6 | 56479E3 | 2.5 | - | - | 36479E3 | 5.0 | 76479E3 | 2.5 |
| | 150 | 8.2 x 11 | 260 | 26 | 0.14 | 0.5 | 56151E3 | 5.0 | 66151E3 | 5.0 | 36151E3 | 5.0 | - | - |
| 35 | 33 | 5 x 11 | 110 | 9.9 | 0.12 | 1.7 | 50339E3 | 2.5 | - | - | 30339E3 | 5.0 | 70339E3 | 2.5 |
| | 100 | 8.2 x 11 | 240 | 24 | 0.12 | 0.55 | 50101E3 | 5.0 | 60101E3 | 5.0 | 30101E3 | 5.0 | - | - |
| 40 | 33 | 5 x 11 | 110 | 10.9 | 0.12 | 1.7 | 57339E3 | 2.5 | - | - | 37339E3 | 5.0 | 77339E3 | 2.5 |
| | 100 | 8.2 x 11 | 240 | 27 | 0.12 | 0.55 | 57101E3 | 5.0 | 67101E3 | 5.0 | 37101E3 | 5.0 | - | - |
| 50 | 1.5 | 5 x 11 | 50 | 3.5 | 0.09 | 4.0 | 51158E3 | 2.5 | - | 5.0 | 31158E3 | 5.0 | 71158E3 | 2.5 |
| | 2.2 | 5 x 11 | 60 | 3.7 | 0.09 | 3.5 | 51228E3 | 2.5 | - | 5.0 | 31228E3 | 5.0 | 71228E3 | 2.5 |
| | 3.3 | 5 x 11 | 65 | 4.0 | 0.09 | 3.1 | 51338E3 | 2.5 | - | 5.0 | 31338E3 | 5.0 | 71338E3 | 2.5 |
| | 4.7 | 5 x 11 | 70 | 4.4 | 0.09 | 2.8 | 51478E3 | 2.5 | - | 5.0 | 31478E3 | 5.0 | 71478E3 | 2.5 |
| | 6.8 | 5 x 11 | 75 | 5.0 | 0.09 | 2.5 | 51688E3 | 2.5 | - | 5.0 | 31688E3 | 5.0 | 71688E3 | 2.5 |
| | 10 | 5 x 11 | 80 | 6.0 | 0.09 | 2.2 | 51109E3 | 2.5 | - | 5.0 | 31109E3 | 5.0 | 71109E3 | 2.5 |
| | 10 | 8.2 x 11 | 160 | 6.0 | 0.05 | 1.0 | 90084E3 | 5.0 | 90085E3 | 5.0 | 90036E3 | 5.0 | - | - |
| | 15 | 5 x 11 | 90 | 7.5 | 0.09 | 2.0 | 51159E3 | 2.5 | - | 5.0 | 31159E3 | 5.0 | 71159E3 | 2.5 |
| | 22 | 5 x 11 | 110 | 9.6 | 0.09 | 1.9 | 51229E3 | 2.5 | - | 5.0 | 31229E3 | 5.0 | 71229E3 | 2.5 |
| | 22 | 8.2 x 11 | 190 | 9.6 | 0.06 | 0.9 | 90025E3 | 5.0 | 90086E3 | 5.0 | 90039E3 | 5.0 | - | - |
| | 33 | 8.2 x 11 | 190 | 13 | 0.09 | 0.77 | 51339E3 | 5.0 | 61339E3 | 5.0 | 31339E3 | 5.0 | - | - |
| | 47 | 8.2 x 11 | 210 | 17 | 0.09 | 0.65 | 51479E3 | 5.0 | 61479E3 | 5.0 | 31479E3 | 5.0 | - | - |
| | 68 | 8.2 x 11 | 240 | 23 | 0.09 | 0.55 | 51689E3 | 5.0 | 61689E3 | 5.0 | 31689E3 | 5.0 | - | - |
| 63 | 10 | 8.2 x 11 | 160 | 7.0 | 0.06 | 1.3 | 58109E3 | 5.0 | 68109E3 | 5.0 | 38109E3 | 5.0 | - | - |
| | 22 | 8.2 x 11 | 190 | 11 | 0.06 | 0.9 | 58229E3 | 5.0 | 68229E3 | 5.0 | 38229E3 | 5.0 | - | - |
| 100 | 4.7 | 8.2 x 11 | 75 | 5.8 | 0.07 | 3.5 | 59478E3 | 5.0 | 69478E3 | 5.0 | 39478E3 | 5.0 | - | - |
| | 10 | 8.2 x 11 | 100 | 9.0 | 0.08 | 3.0 | 59109E3 | 5.0 | 69109E3 | 5.0 | 39109E3 | 5.0 | - | - |

ORDERING EXAMPLE

Electrolytic capacitor 116 series

220 μF / 16 V; $\pm 20\%$ Nominal case size: $\varnothing 8.2\text{ mm} \times 11\text{ mm}$; form TFA

Ordering code: MAL211635221E3

Former 12NC: 2222 116 35221

| ADDITIONAL ELECTRICAL DATA | | |
|------------------------------------|---|--|
| PARAMETER | CONDITIONS | VALUE |
| Voltage | | |
| Surge voltage | | $U_s \leq 1.3 U_R$ |
| Reverse voltage | | $U_{rev} \leq 1 V$ |
| Current | | |
| Leakage current | After 1 min at U_R | $I_{L1} \leq 0.006 C_R \times U_R + 3 \mu A$ |
| | After 5 min at U_R | $I_{L5} \leq 0.001 C_R \times U_R + 3 \mu A$ |
| Inductance | | |
| Equivalent series inductance (ESL) | Case $\varnothing D \times L = 5 \text{ mm} \times 11 \text{ mm}$ | Typ. 13 nH |
| | Case $\varnothing D \times L = 8.2 \text{ mm} \times 11 \text{ mm}$ | Typ. 16 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)

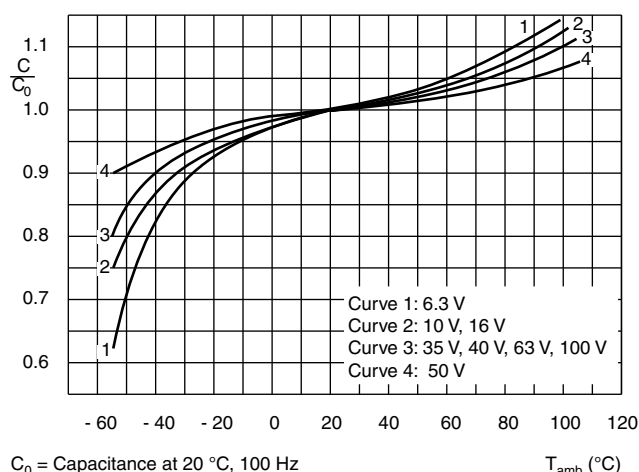


Fig. 6 - Typical multiplier of capacitance as a function of ambient temperature

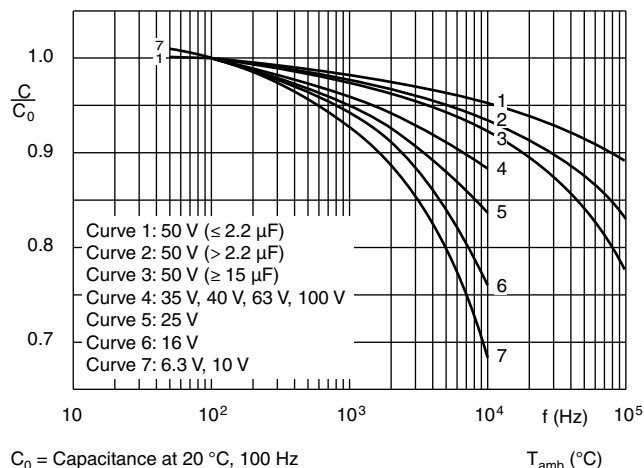


Fig. 7 - Typical multiplier of capacitance as a function of ambient frequency

IMPEDANCE (Z)

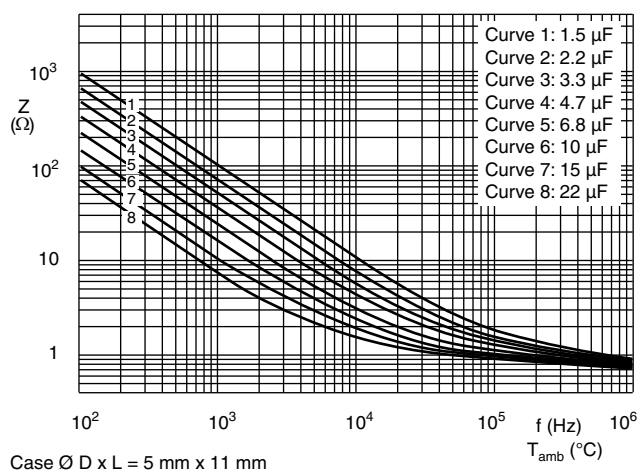


Fig. 8 - Typical impedance as a function of frequency

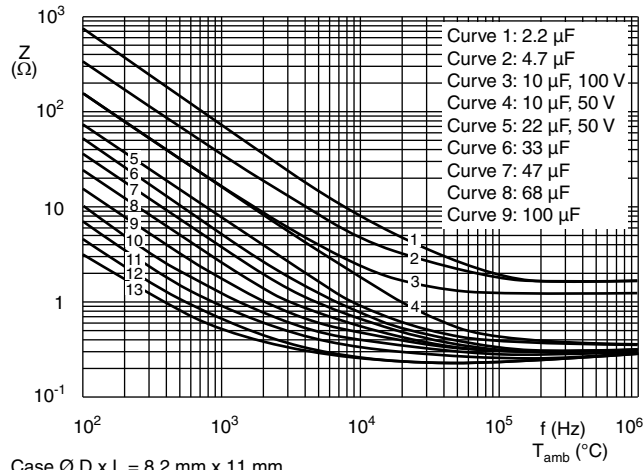


Fig. 9 - Typical impedance as a function of frequency

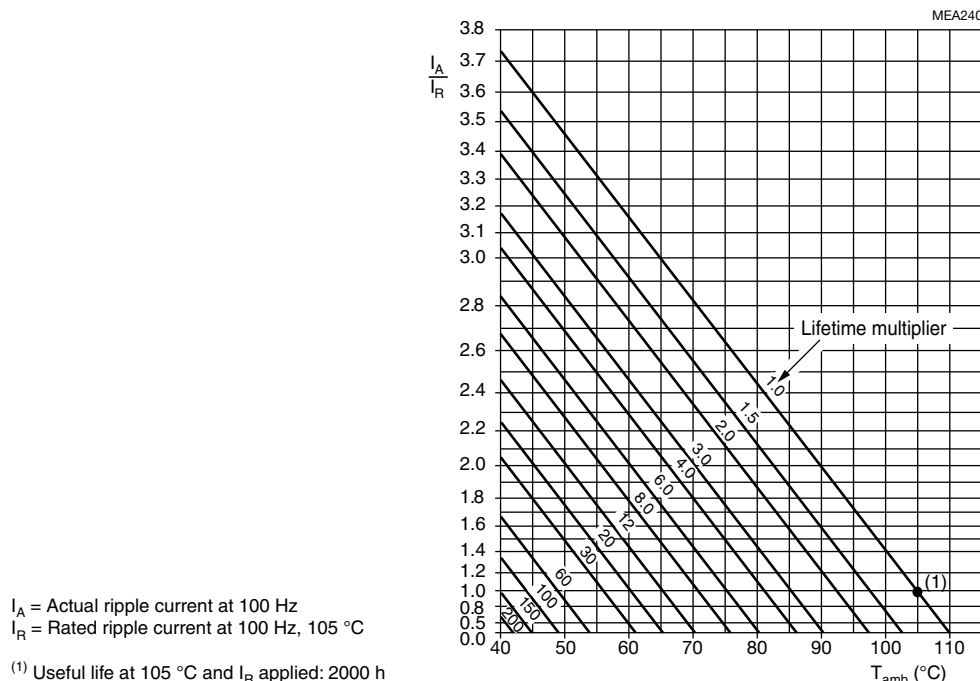
RIPPLE CURRENT AND USEFUL LIFE


Fig. 10 - 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 | | | |
|---|--|---|--|
| FREQUENCY (Hz) | I_R MULTIPLIER | | |
| | $U_R = 6.3 \text{ V TO } 10 \text{ V}$ | $U_R = 16 \text{ V TO } 35 \text{ V}$ | $U_R = 40 \text{ V TO } 100 \text{ V (C}_R \geq 10 \mu\text{F)}$ |
| 50 | 0.70 | 0.60 | 0.50 |
| 100 | 0.77 | 0.71 | 0.63 |
| 300 | 0.86 | 0.85 | 0.78 |
| 1000 | 0.92 | 0.93 | 0.88 |
| 3000 | 0.96 | 0.96 | 0.94 |
| 10K to 100K | 1.00 | 1.00 | 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 | $T_{amb} = 105 \text{ °C}$; U_R applied; 1500 h | $U_R \leq 6.3 \text{ V}$; $\Delta C/C$: +15 % / -30 % $U_R > 6.3 \text{ V}$; $\Delta C/C$: $\pm 15 \%$ $\tan \delta \leq 1.3 \times \text{spec. limit}$ $Z \leq 2 \times \text{spec. limit}$ $I_{L5} \leq \text{spec. limit}$ |
| Useful life | CECC 30301 subclause 1.8.1 | $T_{amb} = 105 \text{ °C}$; U_R and I_R applied; 2000 h | $U_R \leq 6.3 \text{ V}$; $\Delta C/C$: +45 % / -50 % $U_R > 6.3 \text{ V}$; $\Delta C/C$: $\pm 45 \%$ $\tan \delta \leq 3 \times \text{spec. limit}$ $Z \leq 3 \times \text{spec. limit}$ $I_{L5} \leq \text{spec. limit}$ no short or open circuit total failure percentage: $\leq 1\%$ |
| Shelf life (storage at high temperature) | IEC 60384-4 / EN 130300 subclause 4.17 | $T_{amb} = 105 \text{ °C}$; no voltage applied; 1500 h 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 $I_{L5} \leq 2 \times \text{spec. limit}$ |

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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