

Aluminum Capacitors Radial Long Life

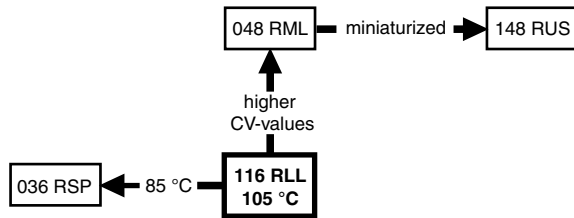
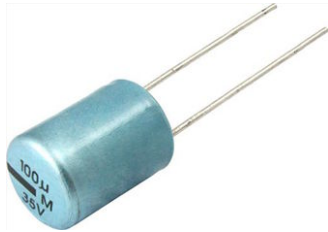


Fig. 1

| QUICK REFERENCE DATA | |
|--|-----------------------|
| DESCRIPTION | VALUE |
| Nominal case sizes (∅ D x L in mm) | 5 x 11 and 8.2 x 11 |
| Rated capacitance range, C _R | 0.47 µF to 470 µF |
| Tolerance on C _R | ± 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 |

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
- High reliability
- 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-to-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 ± 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)

| SELECTION CHART FOR C _R , U _R , AND RELEVANT NOMINAL CASE SIZES (∅ D x L in mm) | | | | | | | | | |
|---|--------------------|----------|----------|----------|----------|----------|----------|----------|----------|
| C _R (µF) | U _R (V) | | | | | | | | |
| | 6.3 | 10 | 16 | 25 | 35 | 40 | 50 | 63 | 100 |
| 0.47 | - | - | - | - | - | - | 5 x 11 | - | - |
| 1.0 | - | - | - | - | - | - | 5 x 11 | - | - |
| 1.5 | - | - | - | - | - | - | 5 x 11 | - | - |
| 2.2 | - | - | - | - | - | - | 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 |
| | - | - | - | - | - | - | 8.2 x 11 | - | - |
| 15 | - | - | - | - | - | - | 5 x 11 | - | - |
| 22 | - | - | - | - | - | - | 5 x 11 | 8.2 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 | - | - | - | - | - | - | - | - |

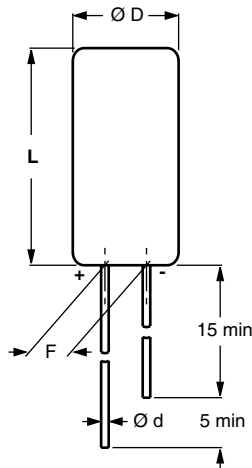
DIMENSIONS in millimeters AND AVAILABLE FORMS


Fig. 2 - Form CA: Long leads

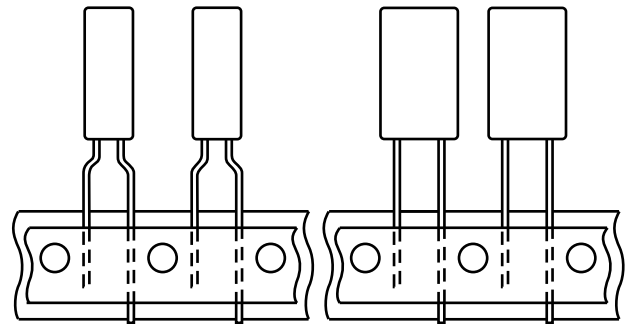

 Case $\varnothing D \times L = 5 \text{ mm} \times 11 \text{ mm}$ and $8.2 \text{ mm} \times 11 \text{ mm}$
 Pitch $F = 5 \text{ mm}$

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

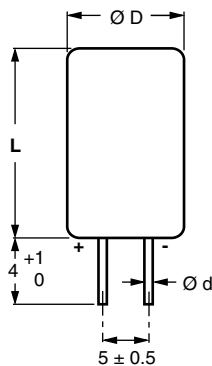

 Case $\varnothing D \times L = 8.2 \text{ mm} \times 11 \text{ mm}$ only

Fig. 4 - Form CB: Cut leads

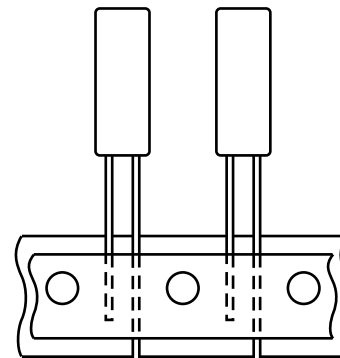

 Case $\varnothing D \times L = 5 \text{ mm} \times 11 \text{ mm}$ only
 Pitch $F = 2.5 \text{ mm}$

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_{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 TFA | | FORM TNA | |
| | | | | | | | 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 | 0.47 | 5 x 11 | 30 | 3.1 | 0.09 | 10 | 51477E3 | 2.5 | - | 5.0 | 31477E3 | 5.0 | 71477E3 | 2.5 |
| | 1.0 | 5 x 11 | 40 | 3.3 | 0.09 | 6.0 | 51108E3 | 2.5 | - | 5.0 | 31108E3 | 5.0 | 71108E3 | 2.5 |
| | 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 | 2.2 | 8.2 x 11 | 60 | 4.3 | 0.06 | 4.0 | 59228E3 | 5.0 | 69228E3 | 5.0 | 39228E3 | 5.0 | - | - |
| | 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 $\mu\text{F}/16\text{ V}$; $\pm 20\%$

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)

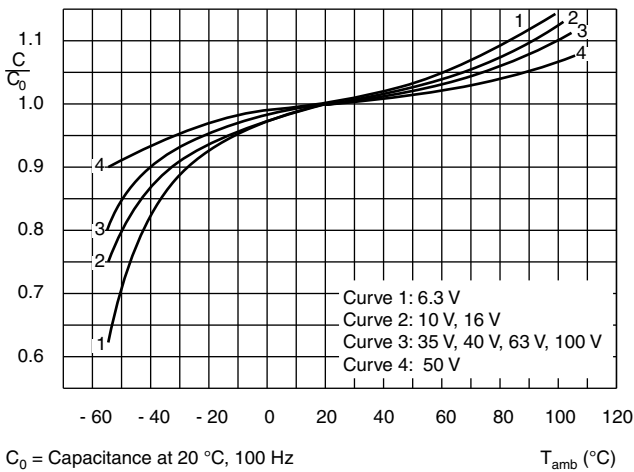


Fig. 6 - Typical multiplier of capacitance as a function of ambient temperature

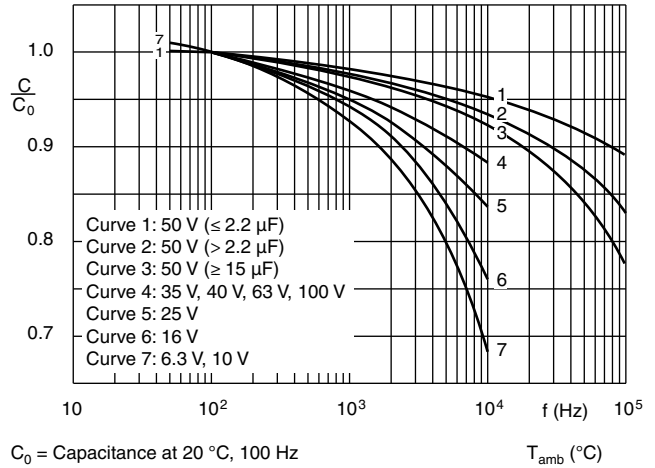


Fig. 7 - Typical multiplier of capacitance as a function of ambient frequency

IMPEDANCE (Z)

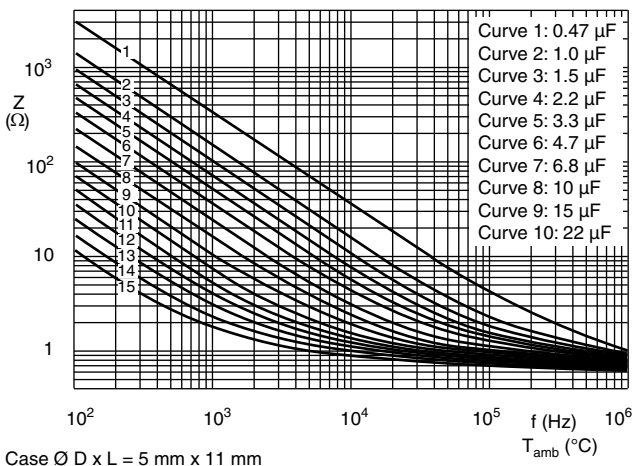


Fig. 8 - Typical impedance as a function of frequency

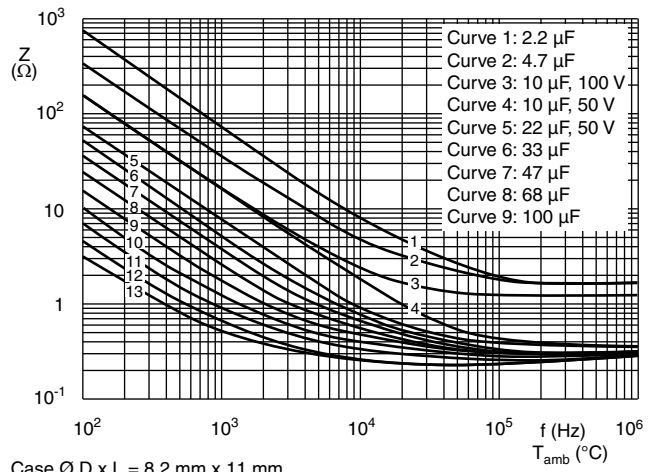


Fig. 9 - Typical impedance as a function of frequency

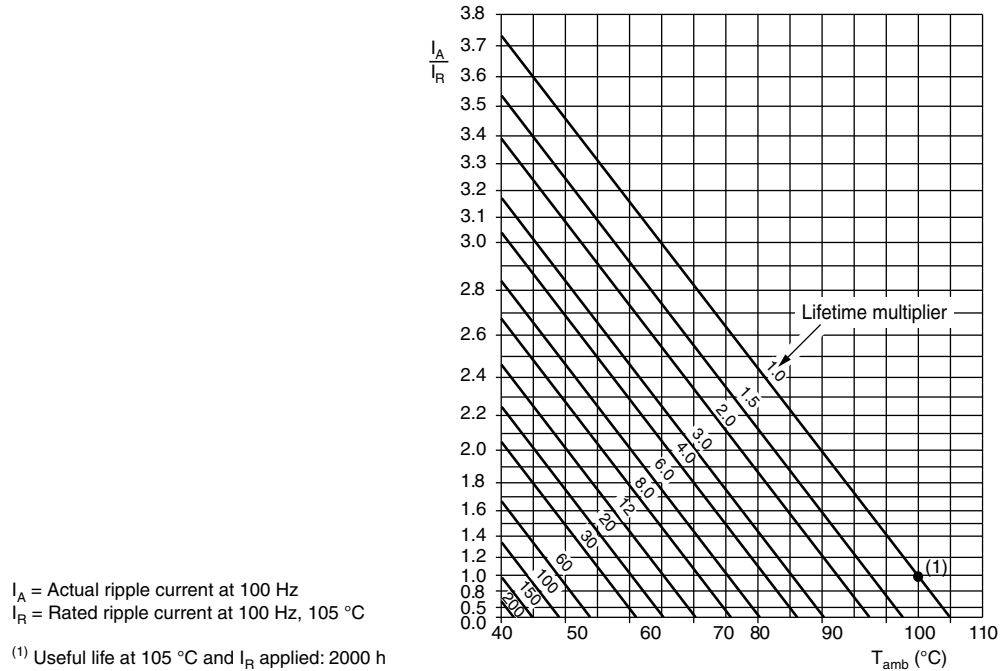
RIPPLE CURRENT AND USEFUL LIFE


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 | $T_{amb} = 105 \text{ }^\circ\text{C}$; 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 | $T_{amb} = 105 \text{ }^\circ\text{C}$; 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 | $T_{amb} = 105 \text{ }^\circ\text{C}$; 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 $I_{L5} \leq 2 \times \text{spec. limit}$ |



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