

Aluminum Electrolytic Capacitors Radial Low Leakage Current

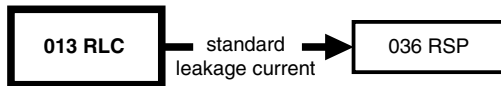


Fig. 1

| QUICK REFERENCE DATA | |
|----------------------------------------------------------------|-----------------------------------------------------------------------|
| DESCRIPTION | VALUE |
| Nominal case sizes (Ø D x L in mm) | 5 x 11 and 8.2 x 11 |
| Rated capacitance range, C _R | 2.2 µF to 470 µF |
| Tolerance on C _R | ± 20 %; ± 10 % on request |
| Rated voltage range, U _R | 6.3 V to 50 V |
| Category temperature range | -40 °C to +85 °C |
| Leakage current after 2 min: U _R = 6.3 V to 25 V | 0.002 C _R x U _R or 0.7 µA, whichever is greater |
| U _R = 35 V and 50 V | 0.002 C _R x U _R + 1 µA |
| Endurance test at 85 °C | 2000 h |
| Useful life at 105 °C | 750 h |
| Useful life at 85 °C | 3000 h |
| Useful life at 40 °C, 1.4 x I _R applied | 80 000 h |
| Shelf life at 0 V, 85 °C | 500 h |
| Based on sectional specification | IEC 60384-4 / EN 130300 |
| Climatic category IEC 60068 | 40 / 085 / 56 |

FEATURES

- Useful life at +85 °C: 3000 h
- Low leakage current, low energy consumption
- 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

- Telecommunication, automotive, audio-video, EDP and industrial
- Coupling, decoupling, buffering, timing, energy storage
- Portable and mobile equipment
- Low surface demand on printed-circuit board

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 (013)

| SELECTION CHART FOR C _R , U _R , AND RELEVANT NOMINAL CASE SIZES (Ø D x L in mm) | | | | | | |
|-------------------------------------------------------------------------------------------------------|--------------------|----------|--------|----------|----------|----------|
| C _R (µF) | U _R (V) | | | | | |
| | 6.3 | 10 | 16 | 25 | 35 | 50 |
| 2.2 | - | - | - | 5 x 11 | - | 5 x 11 |
| 3.3 | - | - | - | 5 x 11 | - | 5 x 11 |
| 4.7 | - | - | - | 5 x 11 | - | 5 x 11 |
| 10 | - | - | - | 5 x 11 | - | 5 x 11 |
| 22 | - | - | - | 5 x 11 | - | 5 x 11 |
| 33 | - | - | 5 x 11 | - | 5 x 11 | 8.2 x 11 |
| 47 | - | 5 x 11 | 5 x 11 | 8.2 x 11 | - | 8.2 x 11 |
| 68 | - | 5 x 11 | - | - | - | 8.2 x 11 |
| 100 | - | 5 x 11 | - | - | 8.2 x 11 | - |
| 220 | - | 8.2 x 11 | - | - | - | - |
| 330 | 8.2 x 11 | - | - | - | - | - |
| 470 | 8.2 x 11 | - | - | - | - | - |

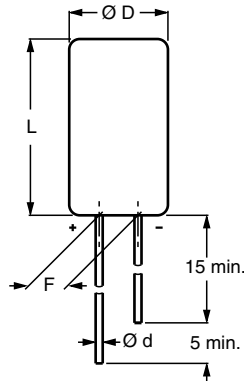
DIMENSIONS in millimeters AND AVAILABLE FORMS


Fig. 2 - Form CA: Long leads

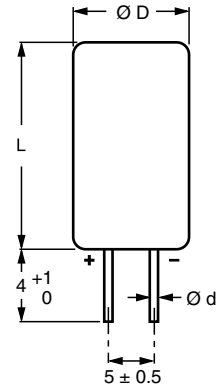


Fig. 3 - Form CB: Cut leads

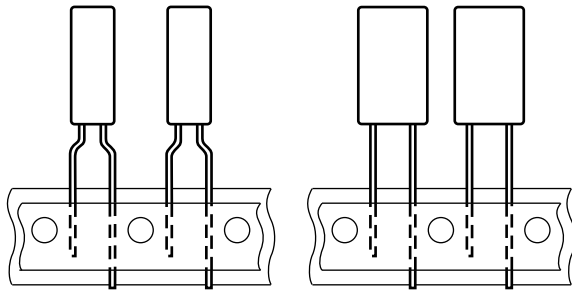

 Case $\varnothing D \times L = 5 \text{ mm} \times 11 \text{ mm}$ and $8.2 \text{ mm} \times 11 \text{ mm}$
 Pitch $F = 5 \text{ mm}$

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

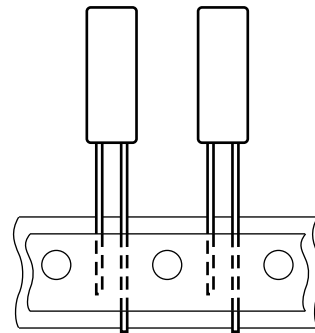

 Case $\varnothing D \times L = 5 \text{ mm} \times 11 \text{ mm}$ only
 Pitch $F = 2.5 \text{ mm}$

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

| DIMENSIONS in millimeters, MASS AND PACKAGING QUANTITIES | | | | | | | | |
|----------------------------------------------------------|-----------|-----------------|------------------------|------------|---------------|---------------|----------------------|---------------|
| NOMINAL CASE SIZE $\varnothing D \times L$ | CASE CODE | $\varnothing d$ | $\varnothing D_{max.}$ | $L_{max.}$ | 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 dimensions, please see www.vishay.com/doc?28360.



| ELECTRICAL DATA | |
|-----------------|----------------------------------------------------|
| SYMBOL | DESCRIPTION |
| C _R | Rated capacitance at 100 Hz, tolerance ± 20 % |
| I _R | Rated RMS ripple current at 100 Hz, 85 °C |
| I _{L2} | Max. leakage current after 2 min at U _R |
| tan δ | Max. dissipation factor at 100 Hz |
| Z | Max. impedance at 10 kHz and + 20 °C |

ORDERING EXAMPLE

Electrolytic capacitor 013 series
 100 µF / 16 V; ± 20 %
 Nominal case size: Ø 8.2 mm x 11 mm; Form TFA
 Ordering Code: MAL201335101E3
 Former 12NC: 2222 013 35101

Note

- Unless otherwise specified, all electrical values in Table 1 apply at T_{amb} = 20 °C, P = 86 kPa to 106 kPa, RH = 45 % to 75 %.

Table 1

| ELECTRICAL DATA AND ORDERING INFORMATION | | | | | | | | | | | | | | |
|------------------------------------------|----------------------------------|--------------------------------------------|-------------------------------------------|----------------------------------|-----------------|--------------------|----------------------------|-----------|------------|-----------|----------------|-----------|-------------|-----------|
| U _R (V) | C _R 100 Hz (µF) | NOMINAL CASE SIZE Ø D x L (mm) | I _R 100 Hz 85 °C (mA) | I _{L2} 2 min (µA) | tan δ 100 Hz | Z 10 kHz (Ω) | ORDERING CODE MAL2013..... | | | | | | | |
| | | | | | | | 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 | 330 | 8.2 x 11 | 210 | 4.2 | 0.2 | 0.9 | 53331E3 | 5.0 | 63331E3 | 5.0 | 33331E3 | 5.0 | - | - |
| | 470 | 8.2 x 11 | 250 | 5.9 | 0.2 | 0.64 | 53471E3 | 5.0 | 63471E3 | 5.0 | 33471E3 | 5.0 | - | - |
| 10 | 47 | 5 x 11 | 75 | 1.0 | 0.16 | 2.8 | 54479E3 | 2.5 | - | - | 34479E3 | 5.0 | 74479E3 | 2.5 |
| | 68 | 5 x 11 | 90 | 1.4 | 0.16 | 2.5 | 54689E3 | 2.5 | - | - | 34689E3 | 5.0 | 74689E3 | 2.5 |
| | 100 | 5 x 11 | 110 | 2.0 | 0.16 | 1.7 | 54101E3 | 2.5 | - | - | 34101E3 | 5.0 | 74101E3 | 2.5 |
| | 220 | 8.2 x 11 | 190 | 4.4 | 0.16 | 0.9 | 54221E3 | 5.0 | 64221E3 | 5.0 | 34221E3 | 5.0 | - | - |
| 16 | 33 | 5 x 11 | 70 | 1.1 | 0.13 | 2.8 | 55339E3 | 2.5 | - | - | 35339E3 | 5.0 | 75339E3 | 2.5 |
| | 47 | 5 x 11 | 85 | 1.5 | 0.13 | 2.1 | 55479E3 | 2.5 | - | - | 35479E3 | 5.0 | 75479E3 | 2.5 |
| | 100 | 8.2 x 11 | 150 | 3.2 | 0.13 | 1.0 | 55101E3 | 5.0 | 65101E3 | 5.0 | 35101E3 | 5.0 | - | - |
| 25 | 2.2 | 5 x 11 | 10 | 0.7 | 0.06 | 18 | 56228E3 | 2.5 | - | - | 36228E3 | 5.0 | 76228E3 | 2.5 |
| | 3.3 | 5 x 11 | 18 | 0.7 | 0.06 | 12 | 56338E3 | 2.5 | - | - | 36338E3 | 5.0 | 76338E3 | 2.5 |
| | 4.7 | 5 x 11 | 25 | 0.7 | 0.06 | 8.5 | 56478E3 | 2.5 | - | - | 36478E3 | 5.0 | 76478E3 | 2.5 |
| | 10 | 5 x 11 | 50 | 0.7 | 0.06 | 4.0 | 56109E3 | 2.5 | - | - | 36109E3 | 5.0 | 76109E3 | 2.5 |
| | 22 | 5 x 11 | 75 | 1.1 | 0.08 | 2.7 | 56229E3 | 2.5 | - | - | 36229E3 | 5.0 | 76229E3 | 2.5 |
| | 47 | 8.2 x 11 | 130 | 2.4 | 0.08 | 1.3 | 56479E3 | 5.0 | 66479E3 | 5.0 | 36479E3 | 5.0 | - | - |
| 35 | 33 | 5 x 11 | 70 | 3.3 | 0.13 | 2.8 | 50339E3 | 2.5 | - | - | 30339E3 | 5.0 | 70339E3 | 2.5 |
| | 100 | 8.2 x 11 | 150 | 8.0 | 0.13 | 1.0 | 50101E3 | 5.0 | 60101E3 | 5.0 | 30101E3 | 5.0 | - | - |
| 50 | 2.2 | 5 x 11 | 20 | 1.2 | 0.06 | 18 | 51228E3 | 2.5 | - | - | 31228E3 | 5.0 | 71228E3 | 2.5 |
| | 3.3 | 5 x 11 | 32 | 1.3 | 0.06 | 12 | 51338E3 | 2.5 | - | - | 31338E3 | 5.0 | 71338E3 | 2.5 |
| | 4.7 | 5 x 11 | 38 | 1.5 | 0.06 | 8.5 | 51478E3 | 2.5 | - | - | 31478E3 | 5.0 | 71478E3 | 2.5 |
| | 10 | 5 x 11 | 55 | 2.0 | 0.06 | 4.0 | 51109E3 | 2.5 | - | - | 31109E3 | 5.0 | 71109E3 | 2.5 |
| | 22 | 5 x 11 | 75 | 3.2 | 0.08 | 2.7 | 51229E3 | 2.5 | - | - | 31229E3 | 5.0 | 71229E3 | 2.5 |
| | 33 | 8.2 x 11 | 110 | 4.3 | 0.06 | 1.4 | 51339E3 | 5.0 | 61339E3 | 5.0 | 31339E3 | 5.0 | - | - |
| | 47 | 8.2 x 11 | 130 | 5.7 | 0.08 | 1.3 | 51479E3 | 5.0 | 61479E3 | 5.0 | 31479E3 | 5.0 | - | - |
| | 68 | 8.2 x 11 | 150 | 7.8 | 0.08 | 1.2 | 51689E3 | 5.0 | 61689E3 | 5.0 | 31689E3 | 5.0 | - | - |

| ADDITIONAL ELECTRICAL DATA | | |
|------------------------------------|------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------|
| PARAMETER | CONDITIONS | VALUE |
| Voltage | | |
| Surge voltage | | $U_s \leq 1.3 \times U_R$ |
| Reverse voltage | | $U_{rev} \leq 1 \text{ V}$ |
| Current | | |
| Leakage current | After 2 min at U_R : $U_R = 6.3 \text{ V to } 25 \text{ V}$ $U_R = 35 \text{ V and } 50 \text{ V}$ | $I_{L2} \leq 0.002 C_R \times U_R$ or $0.7 \mu\text{A}$, whichever is greater $I_{L2} \leq 0.002 C_R \times U_R + 1 \mu\text{A}$ |
| 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 1) | $ESR = \tan \delta / 2 \pi f C_R$ |

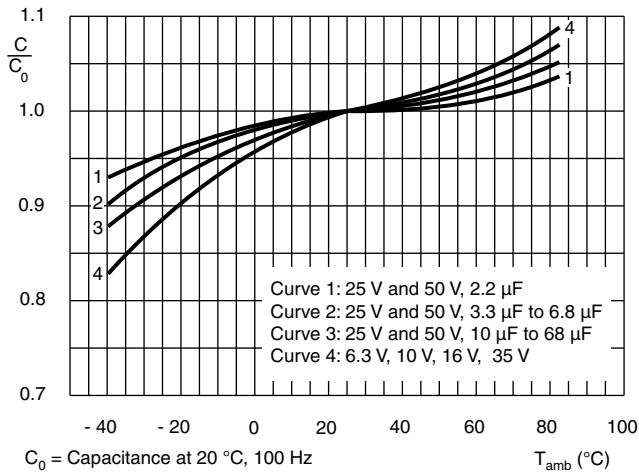
CAPACITANCE (C)


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

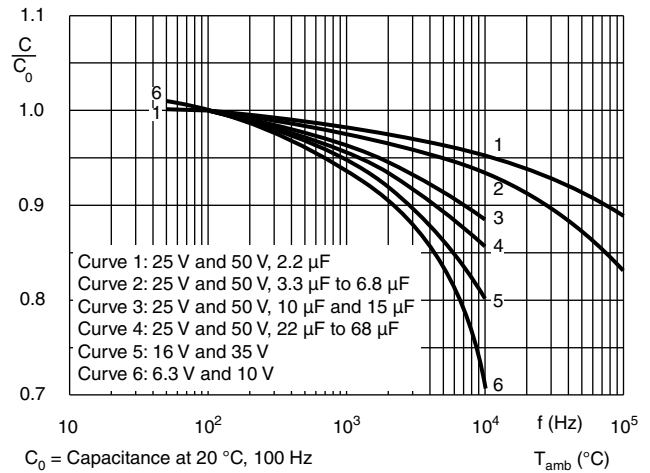


Fig. 7 - Typical multiplier of capacitance as a function of frequency

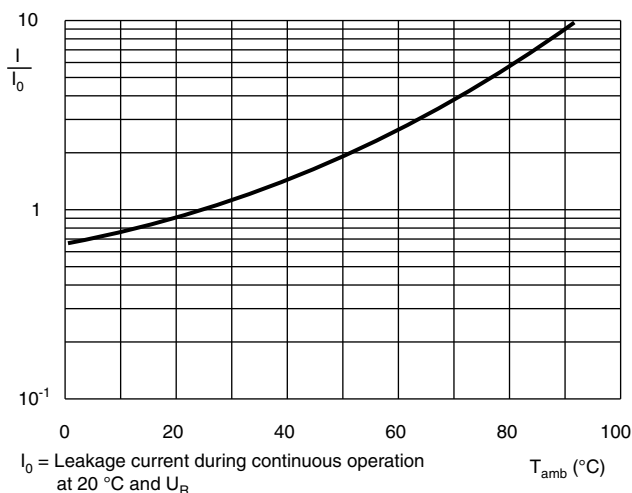
LEAKAGE CURRENT


Fig. 8 - Typical multiplier of leakage current as a function of ambient temperature

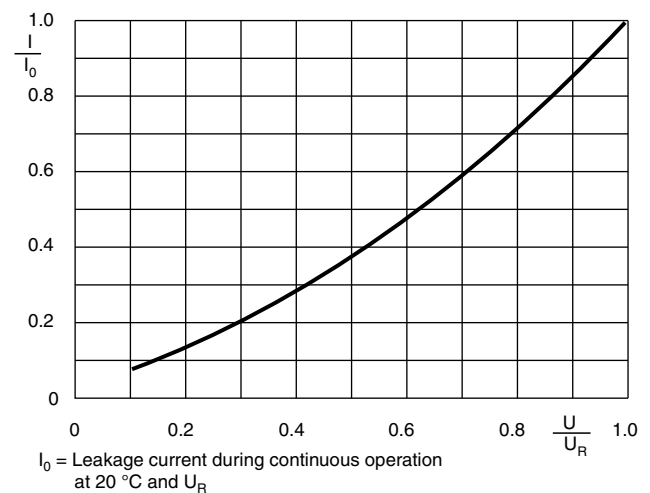


Fig. 9 - Typical multiplier of leakage current as a function of time

LEAKAGE CURRENT

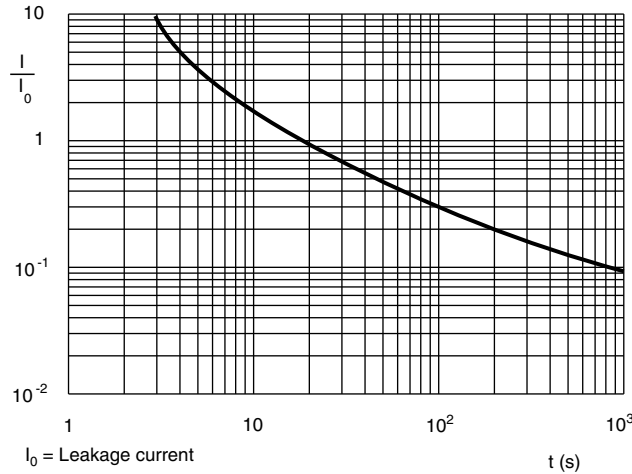
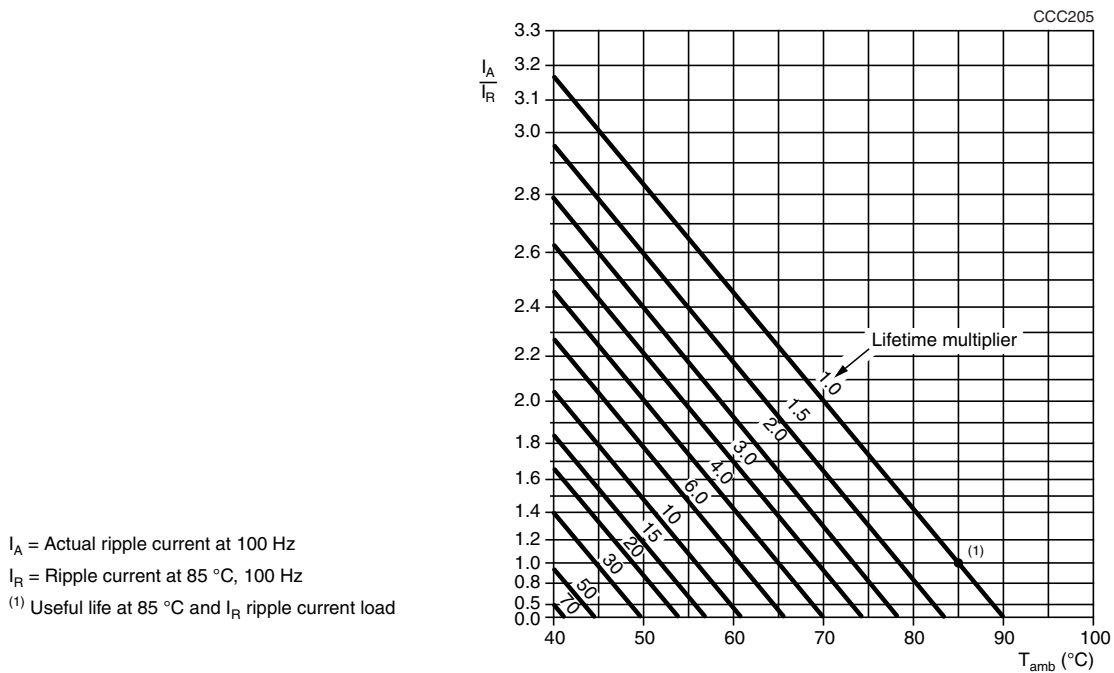


Fig. 10 - Typical multiplier of leakage current as a function of time

RIPPLE CURRENT AND USEFUL LIFE



I_A = Actual ripple current at 100 Hz
 I_R = Ripple current at 85 °C, 100 Hz
 (1) Useful life at 85 °C and I_R ripple current load

Fig. 11 - Multiplier of useful life as a function of ambient temperature and ripple current load

Table 2

| MULTIPLIER OF RIPPLE CURRENT (I_R) AS A FUNCTION OF FREQUENCY | | | |
|-----------------------------------------------------------------------------------|------------------------------------|---------------------------------------------------------|--------------------------------------------------|
| FREQUENCY (Hz) | I_R MULTIPLIER | | |
| | $U_R = 6.3 V$ | $U_R = 10 V, 16 V, \text{ and } 35 V$ | $U_R = 25 V \text{ and } 50 V$ |
| 50 | 0.90 | 0.85 | 0.80 |
| 100 | 1.00 | 1.00 | 1.00 |
| 300 | 1.12 | 1.20 | 1.25 |
| 1000 | 1.20 | 1.30 | 1.40 |
| 3000 | 1.25 | 1.35 | 1.50 |
| $\geq 10\ 000$ | 1.30 | 1.40 | 1.60 |



Table 3

| TEST PROCEDURES AND REQUIREMENTS | | | |
|---------------------------------------------|----------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| TEST | | PROCEDURE | REQUIREMENTS |
| NAME OF TEST | REFERENCE | | |
| Endurance | IEC 60384-4 / EN130300, subclause 4.13 | $T_{amb} = 85\text{ }^{\circ}\text{C}$; U_R applied; 2000 h | $U_R \leq 6.3\text{ V}$; $\Delta C/C$: +15 % / -30 % $U_R > 6.3\text{ V}$; $\Delta C/C$: $\pm 15\text{ }%$ $\tan \delta \leq 1.3 \times \text{spec. limit}$ $Z \leq 2 \times \text{spec. limit}$ $I_{L2} \leq \text{spec. limit}$ |
| Useful life | CECC 30301, subclause 1.8.1 | $T_{amb} = 85\text{ }^{\circ}\text{C}$; U_R and I_R applied; 3000 h | $U_R \leq 6.3\text{ V}$; $\Delta C/C$: +45 % / -50 % $U_R > 6.3\text{ V}$; $\Delta C/C$: $\pm 45\text{ }%$ $\tan \delta \leq 3 \times \text{spec. limit}$ $Z \leq 3 \times \text{spec. limit}$ $I_{L2} \leq \text{spec. limit}$ no short or open circuit total failure percentage: $\leq 1\text{ }%$ |
| Shelf life (storage at high temperature) | IEC 60384-4 / EN130300, subclause 4.17 | $T_{amb} = 85\text{ }^{\circ}\text{C}$; no voltage applied; 500 h After test: U_R to be applied for 30 min, 24 h to 48 h before measurement | $\Delta C/C$, $\tan \delta$, Z : For requirements see "Endurance test" above $I_{L2} \leq 2 \times \text{spec. limit}$ |

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