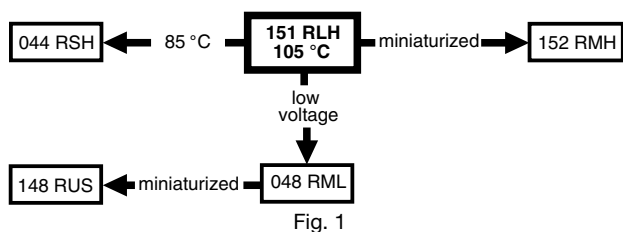




## Aluminum Capacitors Radial Long-Life, High Voltage



### FEATURES

- Long useful life: 3000 h to 4000 h at 105 °C
- High rated voltage, up to 450 V
- Charge and discharge proof
- Polarized aluminum electrolytic capacitors, non-solid electrolyte
- Radial leads, cylindrical aluminum case, insulated with a blue sleeve
- Pressure relief
- Material categorization: For definitions of compliance please see [www.vishay.com/doc?99912](http://www.vishay.com/doc?99912)



RoHS  
COMPLIANT

### APPLICATIONS

- Professional applications
- Lighting, monitors, consumer electronics, general industrial
- Filtering of high voltages in power supplies

### MARKING

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

- Rated capacitance value (in  $\mu\text{F}$ )
- 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
- Upper category temperature (105 °C)
- Negative terminal identification
- Series number (151)

| QUICK REFERENCE DATA                            |  |
|---|--|
| DESCRIPTION                                     | VALUE                                  |
| Nominal case sizes ( $\varnothing$ D x L in mm) | 10 x 12 to 18 x 35                     |
| Rated capacitance range, $C_R$                  | 2.2 $\mu\text{F}$ to 220 $\mu\text{F}$ |
| Tolerance on $C_R$                              | $\pm 20\%$                             |
| Rated voltage range, $U_R$                      | 160 V to 450 V                         |
| Category temperature range                      | -40 °C to +105 °C                      |
| Endurance test at 105 °C                        | 2000 h                                 |
| Useful life at 105 °C:                          |  |
| Case $\varnothing$ D = 10 mm and 12.5 mm        | 3000 h                                 |
| Case $\varnothing$ D = 16 mm and 18 mm          | 4000 h                                 |
| Useful life at 40 °C, 1.6 x $I_R$ applied:      |  |
| Case $\varnothing$ D = 10 mm and 12.5 mm        | 200 000 h                              |
| Case $\varnothing$ D = 16 mm and 18 mm          | 260 000 h                              |
| Shelf life at 0 V, 105 °C                       | 500 h                                  |
| Based on sectional specification                | IEC 60384-4/EN130300                   |
| Climatic category IEC 60068                     | 40/105/56                              |

| $C_R$<br>( $\mu\text{F}$ ) | $U_R$ (V) |           |           |           |           |           |
|----------------------------|-----------|-----------|-----------|-----------|-----------|-----------|
|                            | 160       | 200       | 250       | 350       | 400       | 450       |
| 2.2                        | -         | -         | -         | -         | 10 x 12   | 10 x 16   |
| 3.3                        | -         | -         | -         | 10 x 12   | 10 x 16   | 10 x 20   |
| 4.7                        | -         | 10 x 12   | 10 x 12   | 10 x 16   | 10 x 20   | 12.5 x 20 |
| 10                         | 10 x 16   | 10 x 16   | 10 x 20   | 12.5 x 20 | 12.5 x 20 | 16 x 20   |
| 22                         | 10 x 20   | 10 x 20   | 12.5 x 25 | 12.5 x 25 | 16 x 25   | 16 x 31   |
|                            | -         | -         | 16 x 20   | 16 x 20   | 18 x 20   | 18 x 25   |
| 33                         | 12.5 x 20 | 12.5 x 20 | 12.5 x 25 | 16 x 25   | 16 x 31   | 18 x 35   |
|                            | -         | -         | 16 x 20   | -         | 18 x 25   | -         |
| 47                         | 12.5 x 25 | 12.5 x 25 | 16 x 25   | 16 x 35   | 18 x 31   | -         |
|                            | 16 x 20   | 16 x 20   | 18 x 20   | 18 x 31   | -         | -         |
| 100                        | 16 x 25   | 16 x 31   | 16 x 31   | -         | -         | -         |
|                            | 18 x 20   | 18 x 25   | 18 x 25   | -         | -         | -         |
| 220                        | 18 x 35   | -         | -         | -         | -         | -         |



**DIMENSIONS** in millimeters **AND AVAILABLE FORMS**

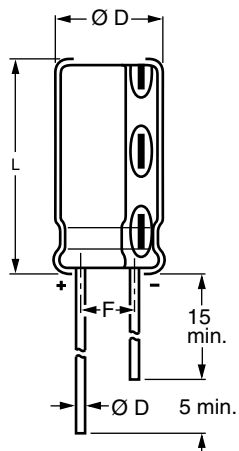


Fig. 2 - Form CA: Long leads

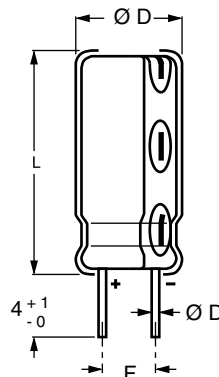


Fig. 3 - Form CB: Cut leads

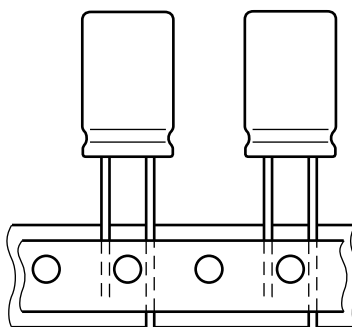


Fig. 4 - Form TFA: Taped in box (ammopack)

Table 1

| DIMENSIONS in millimeters, MASS AND PACKAGING QUANTITIES |           |     |                     |                   |           |          |                              |         |          |
|--|-----------|-----|---------------------|-------------------|-----------|----------|------------------------------|---------|----------|
| NOMINAL CASE SIZE<br>Ø D x L                             | CASE CODE | Ø d | Ø D <sub>max.</sub> | L <sub>max.</sub> | F         | MASS (g) | PACKAGING QUANTITIES PER BOX |         |          |
|  |           |     |                     |                   |           |          | 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  | 19 a      | 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 20  | 1820      | 0.8 | 18.5                | 22.0              | 7.5 ± 0.5 | ≈ 8.0    | 100                          | 100     | -        |
| 18 x 25  | 1825      | 0.8 | 18.5                | 27.0              | 7.5 ± 0.5 | ≈ 10.0   | 100                          | 100     | -        |
| 18 x 31  | 1831      | 0.8 | 18.5                | 33.5              | 7.5 ± 0.5 | ≈ 12.5   | 100                          | 100     | -        |
| 18 x 35  | 22        | 0.8 | 18.5                | 37.5              | 7.5 ± 0.5 | ≈ 14.5   | 100                          | 100     | -        |



| ELECTRICAL DATA |   |
|-----------------|---|
| SYMBOL          | DESCRIPTION                                       |
| $C_R$           | Rated capacitance at 100 Hz, tolerance $\pm 20\%$ |
| $I_R$           | Rated RMS ripple current at 100 Hz, 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 10 kHz                          |

**ORDERING EXAMPLE**

Electrolytic capacitor 151 series  
 4.7  $\mu$ F/400 V;  $\pm 20\%$   
 Nominal case size:  $\varnothing$  10 mm x 20 mm; Form TFA  
 Ordering code: MAL215136478E3  
 Former 12NC: 2222 151 36478

**Note**

- Unless otherwise specified, all electrical values in Table 2 apply at  $T_{amb} = 20\text{ °C}$ ,  $P = 86\text{ kPa}$  to  $106\text{ kPa}$ ,  $RH = 45\%$  to  $75\%$ .

Table 2

| ELECTRICAL DATA AND ORDERING INFORMATION |                               |   |                                   |                                 |                         |                             |                               |         |          |
|--|-------------------------------|---|-----------------------------------|---------------------------------|-------------------------|-----------------------------|-------------------------------|---------|----------|
| $U_R$<br>(V)                             | $C_R$<br>100 Hz<br>( $\mu$ F) | NOMINAL<br>CASE SIZE<br>$\varnothing$ D x L<br>(mm) | $I_R$<br>100 Hz<br>105 °C<br>(mA) | $I_{L1}$<br>1 min<br>( $\mu$ A) | $\tan \delta$<br>100 Hz | Z<br>10 kHz<br>( $\Omega$ ) | ORDERING CODE<br>MAL2151..... |         |          |
|  |                               |   |                                   |                                 |                         |                             | BULK PACKAGING                |         | TAPED    |
|  |                               |   |                                   |                                 |                         |                             | FORM CA                       | FORM CB | FORM TFA |
| 160                                      | 10                            | 10 x 16   | 95                                | 118                             | 0.12                    | 6.3                         | 51109E3                       | 61109E3 | 31109E3  |
|  | 22                            | 10 x 20   | 145                               | 176                             | 0.12                    | 3.2                         | 51229E3                       | 61229E3 | 31229E3  |
|  | 33                            | 12.5 x 20   | 190                               | 228                             | 0.12                    | 2.3                         | 51339E3                       | 61339E3 | 31339E3  |
|  | 47                            | 12.5 x 25   | 280                               | 296                             | 0.12                    | 1.7                         | 51479E3                       | 61479E3 | 31479E3  |
|  | 47                            | 16 x 20   | 280                               | 296                             | 0.12                    | 1.7                         | 91475E3                       | 91476E3 | 91473E3  |
|  | 100                           | 16 x 25   | 380                               | 550                             | 0.12                    | 1.1                         | 51101E3                       | 61101E3 | 31101E3  |
|  | 100                           | 18 x 20   | 380                               | 550                             | 0.12                    | 1.1                         | 91105E3                       | 91106E3 | -        |
|  | 220                           | 18 x 35   | 630                               | 1126                            | 0.12                    | 0.8                         | 51221E3                       | 61221E3 | -        |
| 200                                      | 4.7                           | 10 x 12   | 60                                | 96                              | 0.12                    | 13.0                        | 52478E3                       | 62478E3 | 32478E3  |
|  | 10                            | 10 x 16   | 95                                | 130                             | 0.12                    | 6.3                         | 52109E3                       | 62109E3 | 32109E3  |
|  | 22                            | 10 x 20   | 145                               | 202                             | 0.12                    | 3.2                         | 52229E3                       | 62229E3 | 32229E3  |
|  | 33                            | 12.5 x 20   | 190                               | 268                             | 0.12                    | 2.3                         | 52339E3                       | 62339E3 | 32339E3  |
|  | 47                            | 12.5 x 25   | 280                               | 352                             | 0.12                    | 1.7                         | 52479E3                       | 62479E3 | 32479E3  |
|  | 47                            | 16 x 20   | 280                               | 352                             | 0.12                    | 1.7                         | 92475E3                       | 92476E3 | 92473E3  |
|  | 100                           | 16 x 31   | 410                               | 670                             | 0.12                    | 1.1                         | 52101E3                       | 62101E3 | 32101E3  |
|  | 100                           | 18 x 25   | 410                               | 670                             | 0.12                    | 1.1                         | 92105E3                       | 92106E3 | -        |
| 250                                      | 4.7                           | 10 x 12   | 60                                | 105                             | 0.12                    | 13.0                        | 53478E3                       | 63478E3 | 33478E3  |
|  | 10                            | 10 x 20   | 105                               | 145                             | 0.12                    | 6.3                         | 53109E3                       | 63109E3 | 33109E3  |
|  | 22                            | 12.5 x 25   | 180                               | 235                             | 0.12                    | 3.2                         | 53229E3                       | 63229E3 | 33229E3  |
|  | 22                            | 16 x 20   | 180                               | 235                             | 0.12                    | 3.2                         | 93225E3                       | 93226E3 | 93223E3  |
|  | 33                            | 12.5 x 25   | 250                               | 318                             | 0.12                    | 2.3                         | 53339E3                       | 63339E3 | 33339E3  |
|  | 33                            | 16 x 20   | 250                               | 318                             | 0.12                    | 2.3                         | 93335E3                       | 93336E3 | 93333E3  |
|  | 47                            | 16 x 25   | 300                               | 423                             | 0.12                    | 1.7                         | 53479E3                       | 63479E3 | 33479E3  |
|  | 47                            | 18 x 20   | 300                               | 423                             | 0.12                    | 1.7                         | 93475E3                       | 93476E3 | -        |
|  | 100                           | 16 x 31   | 410                               | 820                             | 0.12                    | 1.1                         | 53101E3                       | 63101E3 | 33101E3  |
|  | 100                           | 18 x 25   | 410                               | 820                             | 0.12                    | 1.1                         | 93105E3                       | 93106E3 | -        |
| 350                                      | 3.3                           | 10 x 12   | 50                                | 105                             | 0.15                    | 22.0                        | 55338E3                       | 65338E3 | 35338E3  |
|  | 4.7                           | 10 x 16   | 65                                | 119                             | 0.15                    | 16.0                        | 55478E3                       | 65478E3 | 35478E3  |
|  | 10                            | 12.5 x 20   | 120                               | 175                             | 0.15                    | 7.6                         | 55109E3                       | 65109E3 | 35109E3  |
|  | 22                            | 12.5 x 25   | 180                               | 301                             | 0.15                    | 3.8                         | 55229E3                       | 65229E3 | 35229E3  |
|  | 22                            | 16 x 20   | 180                               | 301                             | 0.15                    | 3.8                         | 95225E3                       | 95226E3 | 95223E3  |
|  | 33                            | 16 x 25   | 210                               | 417                             | 0.15                    | 2.6                         | 55339E3                       | 65339E3 | 35339E3  |
|  | 47                            | 16 x 35   | 300                               | 564                             | 0.15                    | 2.0                         | 55479E3                       | 65479E3 | -        |
|  | 47                            | 18 x 31   | 300                               | 564                             | 0.15                    | 2.0                         | 95475E3                       | 95476E3 | -        |



| ELECTRICAL DATA AND ORDERING INFORMATION |                                  |   |  |                                  |                 |                    |                               |         |          |
|--|----------------------------------|---|--|----------------------------------|-----------------|--------------------|-------------------------------|---------|----------|
| U <sub>R</sub><br>(V)                    | C <sub>R</sub><br>100 Hz<br>(μF) | NOMINAL<br>CASE SIZE<br>Ø D x L<br>(mm) | I <sub>R</sub><br>100 Hz<br>105 °C<br>(mA) | I <sub>L1</sub><br>1 min<br>(μA) | tan δ<br>100 Hz | Z<br>10 kHz<br>(Ω) | ORDERING CODE<br>MAL2151..... |         |          |
|  |                                  |   |  |                                  |                 |                    | BULK PACKAGING                |         | TAPED    |
|  |                                  |   |  |                                  |                 |                    | FORM CA                       | FORM CB | FORM TFA |
| 400                                      | 2.2                              | 10 x 12                                 | 40   | 93                               | 0.15            | 33.0               | 56228E3                       | 66228E3 | 36228E3  |
|  | 3.3                              | 10 x 16                                 | 50   | 110                              | 0.15            | 22.0               | 56338E3                       | 66338E3 | 36338E3  |
|  | 4.7                              | 10 x 20                                 | 70   | 126                              | 0.15            | 16.0               | 56478E3                       | 66478E3 | 36478E3  |
|  | 10                               | 12.5 x 20                               | 120  | 190                              | 0.15            | 7.6                | 56109E3                       | 66109E3 | 36109E3  |
|  | 22                               | 16 x 25                                 | 200  | 334                              | 0.15            | 3.8                | 56229E3                       | 66229E3 | 36229E3  |
|  | 22                               | 18 x 20                                 | 200  | 334                              | 0.15            | 3.8                | 96225E3                       | 96226E3 | -        |
|  | 33                               | 16 x 31                                 | 245  | 466                              | 0.15            | 2.6                | 56339E3                       | 66339E3 | 36339E3  |
|  | 33                               | 18 x 25                                 | 245  | 466                              | 0.15            | 2.6                | 96335E3                       | 96336E3 | -        |
| 450                                      | 47                               | 18 x 31                                 | 300  | 634                              | 0.15            | 2.0                | 56479E3                       | 66479E3 | -        |
|  | 2.2                              | 10 x 16                                 | 45   | 99                               | 0.2             | 43.0               | 57228E3                       | 67228E3 | 37228E3  |
|  | 3.3                              | 10 x 20                                 | 65   | 115                              | 0.2             | 29.0               | 57338E3                       | 67338E3 | 37338E3  |
|  | 4.7                              | 12.5 x 20                               | 80   | 133                              | 0.2             | 20.0               | 57478E3                       | 67478E3 | 37478E3  |
|  | 10                               | 16 x 20                                 | 140  | 205                              | 0.2             | 10.0               | 57109E3                       | 67109E3 | 37109E3  |
|  | 22                               | 16 x 31                                 | 220  | 367                              | 0.2             | 4.6                | 57229E3                       | 67229E3 | 37229E3  |
|  | 22                               | 18 x 25                                 | 220  | 367                              | 0.2             | 4.6                | 97225E3                       | 97226E3 | -        |
|  | 33                               | 18 x 35                                 | 280  | 516                              | 0.2             | 3.4                | 57339E3                       | 67339E3 | -        |

| ADDITIONAL ELECTRICAL DATA         |  |   |
|------------------------------------|--|---|
| PARAMETER                          | CONDITIONS   | VALUE   |
| <b>Voltage</b>                     |  |   |
| Surge voltage                      | IEC 60384-4, subclause 4.14:<br>U <sub>R</sub> = 160 V to 250 V<br>U <sub>R</sub> = 350 V to 400 V | U <sub>s</sub> ≤ 1.15 x U <sub>R</sub><br>U <sub>s</sub> ≤ 1.10 x U <sub>R</sub>  |
| Reverse voltage                    | IEC 60384-4, subclause 4.15  | U <sub>rev</sub> ≤ 1 V  |
| <b>Current</b>                     |  |   |
| Leakage current                    | After 1 min at U <sub>R</sub> :<br>CV ≤ 1000 μC<br>CV > 1000 μC                                    | I <sub>L1</sub> ≤ 0.06 C <sub>R</sub> x U <sub>R</sub> + 40 μA<br>I <sub>L1</sub> ≤ 0.03 C <sub>R</sub> x U <sub>R</sub> + 70 μA  |
|                                    | After 5 min at U <sub>R</sub> :<br>CV ≤ 1000 μC<br>CV > 1000 μC                                    | I <sub>L5</sub> ≤ 0.03 C <sub>R</sub> x U <sub>R</sub> + 15 μA<br>I <sub>L5</sub> ≤ 0.015 C <sub>R</sub> x U <sub>R</sub> + 30 μA |
| <b>Inductance</b>                  |  |   |
| Equivalent series inductance (ESL) | Case Ø D = 10 mm   | Typ. 16 nH  |
|                                    | Case Ø D ≥ 12.5 mm   | Typ. 18 nH  |
| <b>Resistance</b>                  |  |   |
| Equivalent series resistance (ESR) | Calculated from tan δ <sub>max</sub> and C <sub>R</sub> (see Table 2)                              | ESR = tan δ/2 πf C <sub>R</sub>   |



**RIPPLE CURRENT AND USEFUL LIFE**

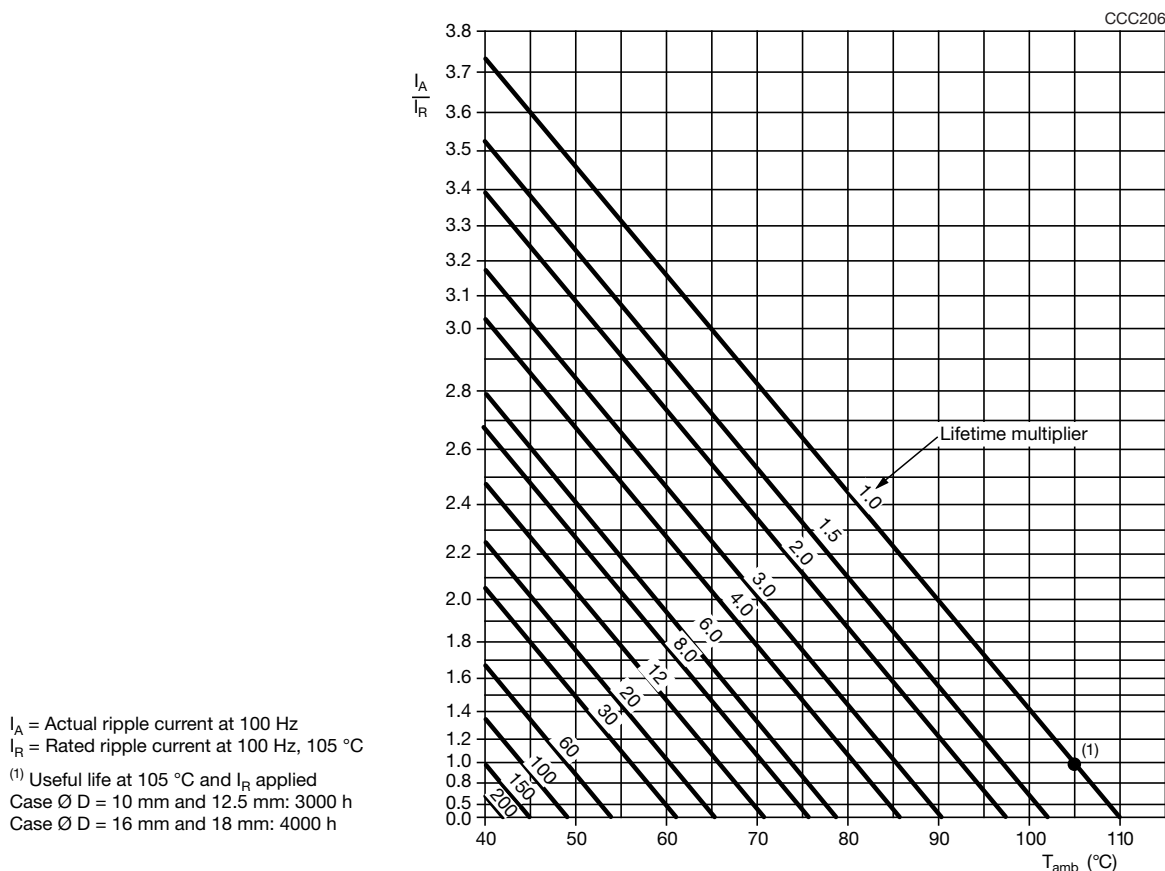


Fig. 5 - Multiplier of useful life as a function of ambient temperature and ripple current load

Table 3

| MULTIPLIER OF RIPPLE CURRENT ( $I_R$ ) AS A FUNCTION OF FREQUENCY |                  |
|---|------------------|
| FREQUENCY (Hz)  | $I_R$ MULTIPLIER |
| 50  | 0.75             |
| 100   | 1.00             |
| 300   | 1.20             |
| 1000  | 1.35             |
| 3000  | 1.45             |
| $\geq 10\ 000$  | 1.50             |



Table 4

| TEST PROCEDURES AND REQUIREMENTS               |  |   |  |
|--|--|---|--|
| TEST   |  | PROCEDURE<br>(quick reference)  | REQUIREMENTS   |
| NAME OF TEST                                   | REFERENCE                                  |   |  |
| Endurance                                      | IEC 60384-4/<br>EN130300<br>subclause 4.15 | $T_{amb} = 105\text{ }^{\circ}\text{C}$ ; $U_R$ applied;<br>2000 h  | $\Delta C/C: \pm 20\%$<br>$\tan \delta \leq 2 \times \text{spec. limit}$<br>$Z \leq 2 \times \text{spec. limit}$<br>$I_{L5} \leq \text{spec. limit}$   |
| Useful life                                    | CECC 30301<br>subclause 1.8.1              | $T_{amb} = 105\text{ }^{\circ}\text{C}$ ; $U_R$ and $I_R$ applied;<br>Case $\varnothing D = 10\text{ mm}$ and $12.5\text{ mm}$ : 3000 h;<br>Case $\varnothing D = 16\text{ mm}$ and $18\text{ mm}$ : 4000 h | $\Delta C/C: \pm 50\%$<br>$\tan \delta \leq 3 \times \text{spec. limit}$<br>$Z \leq 3 \times \text{spec. limit}$<br>$I_{L5} \leq \text{spec. limit}$<br>No short or open circuit<br>Total failure percentage: $\leq 1\%$ |
| Shelf life<br>(storage at high<br>temperature) | IEC 60384-4/<br>EN130300<br>subclause 4.17 | $T_{amb} = 105\text{ }^{\circ}\text{C}$ ; no voltage applied;<br>500 h<br>After test: $U_R$ to be applied for 30 min, 24 h to 48 h<br>before measurement  | $\Delta C/C: \pm 20\%$<br>$\tan \delta \leq 2 \times \text{spec. limit}$<br>$Z \leq 2 \times \text{spec. limit}$<br>$I_{L5} \leq 2 \times \text{spec. limit}$  |



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**Please note that some Vishay documentation may still make reference to RoHS Directive 2002/95/EC. We confirm that all the products identified as being compliant to Directive 2002/95/EC conform to Directive 2011/65/EU.**

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