Aluminum Electrolytic Capacitors
SMD (Chip), High Temperature

FEATURES
- Extended useful life: up to 6000 h at 125 °C for MAL214099...E3 parts
- Parts for advanced high temperature reflow soldering according to JEDEC® J-STD-020 available
- Vibration proof, 4-pin version and 6-pin version
- AEC-Q200 qualified
- Polarized aluminum electrolytic capacitors, non-solid electrolyte, self healing
- SMD-version with base plate, lead (Pb)-free reflow solderable
- Charge and discharge proof, no peak current limitation
- High reliability
- Material categorization: for definitions of compliance please see www.vishay.com/doc?99912

APPLICATIONS
- SMD technology, for high temperature reflow soldering
- Industrial and professional applications
- Automotive, general industrial, telecom
- Smoothing, filtering, buffering

MARKING
- Rated capacitance (in µF)
- Rated voltage (in V)
- Date code, in accordance with IEC 60062
- Black mark or "-" sign indicating the cathode (the anode is identified by beveled edges)
- Code indicating group number (H)

PACKAGING
Supplied in blister tape on reel

QUICK REFERENCE DATA

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>VALUE</th>
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<tbody>
<tr>
<td>Nominal case sizes (L x W x H in mm)</td>
<td>8 x 8 x 10 to 18 x 18 x 21</td>
</tr>
<tr>
<td>Rated capacitance range, $C_R$</td>
<td>10 µF to 4700 µF</td>
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<td>Tolerance on $C_R$</td>
<td>± 20 %</td>
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<tr>
<td>Rated voltage range, $U_R$</td>
<td>6.3 V to 63 V</td>
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<tr>
<td>Category temperature range</td>
<td>-55 °C to +125 °C</td>
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<tr>
<td>Endurance test at 125 °C</td>
<td>1000 h to 5000 h</td>
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<tr>
<td>Useful life at 125 °C</td>
<td>1500 h to 6000 h</td>
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<tr>
<td>Useful life at 40 °C 1.8 x $I_R$ applied</td>
<td>150 000 h to 500 000 h</td>
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<tr>
<td>Shelf life at 0 V, 125 °C</td>
<td>1000 h</td>
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<tr>
<td>Based on sectional specification</td>
<td>IEC 60384-18 / CECC 32300</td>
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<tr>
<td>Climatic category IEC 60068</td>
<td>55 / 125 / 56</td>
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## SELECTION CHART FOR CR, UR, AND RELEVANT NOMINAL CASE SIZES (L x W x H in mm)

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<thead>
<tr>
<th>CR (μF)</th>
<th>UR (V)</th>
<th>6.3</th>
<th>10</th>
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<th>50</th>
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<td>18 x 18 x 16</td>
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<td>1000</td>
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<td>→</td>
<td>16 x 16 x 21</td>
<td>18 x 18 x 16</td>
<td>-</td>
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<td>1500</td>
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</table>

### Dimensions

**2-pin:** ≤ Ø 10 mm

**4-pin:** Ø 12.5 mm

**6-pin:** ≥ Ø 16 mm

![Fig. 2 - Dimensional outline](image-url)
Table 1

<table>
<thead>
<tr>
<th>NOMINAL CASE SIZE L x W x H</th>
<th>CASE CODE</th>
<th>L_MAX.</th>
<th>W_MAX.</th>
<th>H_MAX.</th>
<th>Ø D</th>
<th>B_MAX.</th>
<th>S</th>
<th>L1_MAX.</th>
<th>MASS (g)</th>
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<td>8.5</td>
<td>10.5</td>
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<td>≈ 1.0</td>
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<tr>
<td>10 x 10 x 10</td>
<td>1010</td>
<td>10.5</td>
<td>10.5</td>
<td>10.5</td>
<td>10.0</td>
<td>1.0</td>
<td>3.5</td>
<td>12.1</td>
<td>≈ 1.3</td>
</tr>
<tr>
<td>10 x 10 x 14</td>
<td>1014</td>
<td>10.5</td>
<td>10.5</td>
<td>14.3</td>
<td>10.0</td>
<td>1.0</td>
<td>3.5</td>
<td>12.1</td>
<td>≈ 1.5</td>
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<tr>
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<td>12.9</td>
<td>12.9</td>
<td>14.0</td>
<td>12.5</td>
<td>1.3</td>
<td>3.6</td>
<td>14.9</td>
<td>≈ 2.6</td>
</tr>
<tr>
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<td>1216</td>
<td>12.9</td>
<td>12.9</td>
<td>16.5</td>
<td>12.5</td>
<td>1.3</td>
<td>3.6</td>
<td>14.9</td>
<td>≈ 2.8</td>
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<td>17.5</td>
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<td>18.6</td>
<td>≈ 6.0</td>
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<td>17.5</td>
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<td>1.3</td>
<td>6.5</td>
<td>21.0</td>
<td>≈ 8.0</td>
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<td>19.0</td>
<td>19.0</td>
<td>22.0</td>
<td>18.0</td>
<td>1.3</td>
<td>6.5</td>
<td>21.0</td>
<td>≈ 8.3</td>
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</table>

Table 2

<table>
<thead>
<tr>
<th>NOMINAL CASE SIZE L x W x H</th>
<th>CASE CODE</th>
<th>PITCH P1</th>
<th>TAPE WIDTH W</th>
<th>TAPE THICKNESS T2</th>
<th>REEL DIAMETER</th>
<th>PACKAGING QUANTITY PER REEL</th>
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<tr>
<td>8 x 8 x 10</td>
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<td>16</td>
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<td>10 x 10 x 10</td>
<td>1010</td>
<td>16</td>
<td>24</td>
<td>11.6</td>
<td>380</td>
<td>500</td>
</tr>
<tr>
<td>10 x 10 x 14</td>
<td>1014</td>
<td>16</td>
<td>24</td>
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<td>20</td>
<td>24</td>
<td>16.2</td>
<td>380</td>
<td>250</td>
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<td>24</td>
<td>32</td>
<td>18.5</td>
<td>380</td>
<td>200</td>
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<td>28</td>
<td>44</td>
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<td>380</td>
<td>150</td>
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<td>16 x 16 x 21</td>
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<td>44</td>
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<td>380</td>
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<td>18.9</td>
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<td>32</td>
<td>44</td>
<td>23.4</td>
<td>380</td>
<td>100</td>
</tr>
</tbody>
</table>

Note
- For detailed tape dimensions please refer to packaging information: [www.vishay.com/doc?28359](http://www.vishay.com/doc?28359)
MOUNTING
The capacitors are designed for automatic placement on to printed-circuit boards.
Optimum dimensions of soldering pads depend amongst others on soldering method, mounting accuracy, print layout and / or adjacent components.
For recommended soldering pad dimensions, refer to Fig. 3 and Table 3.

SOLDERING
Soldering conditions are defined by the curve, temperature versus time, where the temperature is that measured on the component during processing.
For maximum conditions refer to Fig. 4 or Fig. 5.
Any temperature versus time curve which does not exceed the specified maximum curves may be applied.
As a general principle, temperature and duration shall be the minimum necessary required to ensure good soldering connections. However, the specified maximum curves should never be exceeded.

Table 3

<table>
<thead>
<tr>
<th>CASE CODE</th>
<th>a</th>
<th>b</th>
<th>c</th>
<th>d</th>
<th>e</th>
<th>f</th>
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<td>2.5</td>
<td>4.0</td>
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<td>-</td>
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<td>1014</td>
<td>4.4</td>
<td>2.5</td>
<td>4.0</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>1213</td>
<td>6.3</td>
<td>2.5</td>
<td>4.0</td>
<td>4.2</td>
<td>5.0</td>
<td>5.6</td>
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<td>2.5</td>
<td>4.0</td>
<td>4.2</td>
<td>5.0</td>
<td>5.6</td>
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<td>9.6</td>
<td>4.7</td>
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<td>1621</td>
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<td>4.7</td>
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<td>1816</td>
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<td>9.6</td>
<td>4.7</td>
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<td>9.6</td>
<td>4.7</td>
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</tr>
</tbody>
</table>

Fig. 3 - Recommended soldering pad dimensions
STANDARD SOLDERING PROFILE FOR LEAD (Pb)-FREE REFLOW PROCESS

![Graph showing temperature profile during reflow soldering](https://example.com/temperature_profile.png)

**Fig. 4 - Maximum temperature load during reflow soldering**

### Table 4

**REFLOW SOLDERING CONDITIONS for MAL214097xxxE3**

<table>
<thead>
<tr>
<th>PROFILE FEATURES</th>
<th>CASE CODE 0810 TO 1014</th>
<th>CASE CODE 1213 TO 1216</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max. time from 25 °C to T\text{Peak}</td>
<td>240 s</td>
<td>200 s</td>
</tr>
<tr>
<td>Max. ramp-up rate to 150 °C</td>
<td>3 K/s</td>
<td>3 K/s</td>
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<tr>
<td>Max. time from 150 °C to 200 °C (t\text{1})</td>
<td>150 s</td>
<td>120 s</td>
</tr>
<tr>
<td>Ramp up rate from 200 °C to T\text{Peak}</td>
<td>0.5 K/s to 3 K/s</td>
<td>0.5 K/s to 3 K/s</td>
</tr>
<tr>
<td>Max. time from 200 °C to 217 °C (t\text{2})</td>
<td>60 s</td>
<td>60 s</td>
</tr>
<tr>
<td>Max. time above T\text{Liquidus} (217 °C) (t\text{3})</td>
<td>90 s</td>
<td>60 s</td>
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<tr>
<td>Max. time above 230 °C (t\text{4})</td>
<td>40 s</td>
<td>30 s</td>
</tr>
<tr>
<td>Peak temperature T\text{Peak}</td>
<td>250 °C</td>
<td>240 °C</td>
</tr>
<tr>
<td>Max. time above T\text{Peak} minus 5 °C</td>
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<td>10 s</td>
</tr>
<tr>
<td>Max. ramp-down rate from T\text{Liquidus}</td>
<td>3 K/s to 6 K/s</td>
<td>3 K/s to 6 K/s</td>
</tr>
</tbody>
</table>

**Notes**
- Temperature measuring point on top of the case and on terminals
- Max. 2 runs with pause of min. 30 min in between
ADVANCED SOLDERING PROFILE FOR LEAD (Pb)-FREE REFLOW PROCESS
ACCORDING TO JEDEC J-STD-020

Fig. 5 - Maximum temperature load during reflow soldering

Table 5

<table>
<thead>
<tr>
<th>REFLOW SOLDERING CONDITIONS for MAL214099xxxE3</th>
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<tbody>
<tr>
<td>PROFILE FEATURES</td>
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<td>Max. time from 25 °C to T_{Peak}</td>
</tr>
<tr>
<td>Max. ramp-up rate to 150 °C</td>
</tr>
<tr>
<td>Max. time from 150 °C to 200 °C (t_{1})</td>
</tr>
<tr>
<td>Max. time from 190 °C to 200 °C (t_{2})</td>
</tr>
<tr>
<td>Ramp up rate from 200 °C to T_{Peak}</td>
</tr>
<tr>
<td>Max. time above T_{Liquidus} (217 °C) (t_{3})</td>
</tr>
<tr>
<td>Max. time above 230 °C (t_{4})</td>
</tr>
<tr>
<td>Peak temperature T_{Peak}</td>
</tr>
<tr>
<td>Max. time above T_{Peak} minus 5 °C</td>
</tr>
<tr>
<td>Ramp-down rate from T_{Liquidus}</td>
</tr>
</tbody>
</table>

Notes
- Temperature measuring point on top of the case and on terminals
- Max. 2 runs with pause of min. 30 min in between
Note
• Unless otherwise specified, all electrical values in Table 6 apply at $T_{amb} = 20\, ^\circ\mathrm{C}$, $P = 86\, \text{kPa}$ to $106\, \text{kPa}$, $\text{RH} = 45\%$ to $75\%$

ORDERING EXAMPLE
Electrolytic capacitor 140 CRH series
220 $\mu$F / 50 V; $\pm\, 20\%$
Nominal case size: 12.5 mm x 12.5 mm x 13 mm; taped on reel
Ordering code: MAL214099111E3

<table>
<thead>
<tr>
<th>$U_R$ (V)</th>
<th>$C_R$ ($\mu$F)</th>
<th>NOMINAL CASE SIZE L x W x H (mm)</th>
<th>$I_R$ 100 kHz 125 °C (mA)</th>
<th>$I_{L2}$ 2 min (mA)</th>
<th>$\tan \delta$ 100 Hz</th>
<th>$Z$ 100 kHz 20 °C (Ω)</th>
<th>LIFE CODE (2)</th>
<th>ORDERING CODE (1) MAL2140...</th>
<th>ORDERING CODE (2) MAL2140...</th>
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<td>21</td>
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<td>0.40</td>
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<tr>
<td>470</td>
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<td>30</td>
<td>0.30</td>
<td>0.25</td>
<td>L1</td>
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<td>220</td>
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<td>0.26</td>
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Notes
(1) Standard reflow soldering profile, see Fig. 4 and Table 4
(2) Advanced reflow soldering profile, according to JEDEC J-STD-020, see Fig. 5 and Table 5
(3) Determines the applicable row in the table “Endurance Test Duration and Useful Life”
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<td></td>
</tr>
<tr>
<td>330</td>
<td>16 x 16 x 21</td>
<td>750 208 0.10 0.15 L5</td>
<td>99018E3</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>470</td>
<td>16 x 16 x 16</td>
<td>750 296 0.10 0.15 L5</td>
<td>99018E3</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>470</td>
<td>18 x 18 x 16</td>
<td>750 296 0.10 0.15 L5</td>
<td>99018E3</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>470</td>
<td>18 x 18 x 16</td>
<td>750 296 0.10 0.15 L5</td>
<td>99018E3</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>680</td>
<td>18 x 18 x 21</td>
<td>900 296 0.10 0.15 L5</td>
<td>99018E3</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes
(1) Standard reflow soldering profile, see Fig. 4 and Table 4
(2) Advanced reflow soldering profile, according to JEDEC J-STD-020, see Fig. 5 and Table 5
(3) Determines the applicable row in the table “Endurance Test Duration and Useful Life”
Table 7

<table>
<thead>
<tr>
<th>ADDITIONAL ELECTRICAL DATA</th>
</tr>
</thead>
<tbody>
<tr>
<td>PARAMETER</td>
</tr>
<tr>
<td>Voltage</td>
</tr>
<tr>
<td>Surge voltage for short periods</td>
</tr>
<tr>
<td>Reverse voltage for short periods</td>
</tr>
<tr>
<td>Current</td>
</tr>
<tr>
<td>Leakage current</td>
</tr>
<tr>
<td>Inductance</td>
</tr>
<tr>
<td>Equivalent series inductance (ESL)</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Resistance</td>
</tr>
<tr>
<td>Equivalent series resistance (ESR) at 100 Hz</td>
</tr>
</tbody>
</table>

### CAPACITANCE (C)

![Capacitance Graph](image1)

$C_T = \text{Capacitance at } 20 \degree \text{C}, 100 \text{ Hz}$

- Curve 1: 10 V
- Curve 2: 63 V

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

### DISSIPATION FACTOR ($\tan \delta$)

![Dissipation Factor Graph](image2)

$\tan \delta_0 = \text{Typical } \tan \delta \text{ at } 20 \degree \text{C}, 100 \text{ Hz}$

Fig. 7 - Typical multiplier of dissipation factor ($\tan \delta$) as a function of ambient temperature
EQUIVALENT SERIES RESISTANCE (ESR)

![Graph showing Equivalent Series Resistance (ESR)](image)

**Fig. 8** - Typical multiplier of ESR as a function of frequency

**IMPEDANCE (Z)**

![Graph showing Impedance (Z)](image)

**Fig. 9** - Typical impedance as a function of frequency

**Fig. 10** - Typical impedance as a function of frequency

RIPPLE CURRENT AND USEFUL LIFE

Table 8

<table>
<thead>
<tr>
<th>LIFE CODE</th>
<th>ENDURANCE AT 125 °C (h)</th>
<th>USEFUL LIFE AT 125 °C (h)</th>
<th>USEFUL LIFE AT 40 °C 1.8 x I&lt;sub&gt;R&lt;/sub&gt; APPLIED (h)</th>
</tr>
</thead>
<tbody>
<tr>
<td>L1</td>
<td>1000</td>
<td>1500</td>
<td>150 000</td>
</tr>
<tr>
<td>L2</td>
<td>2000</td>
<td>3000</td>
<td>300 000</td>
</tr>
<tr>
<td>L3</td>
<td>3000</td>
<td>3500</td>
<td>350 000</td>
</tr>
<tr>
<td>L4</td>
<td>4000</td>
<td>5000</td>
<td>400 000</td>
</tr>
<tr>
<td>L5</td>
<td>5000</td>
<td>6000</td>
<td>500 000</td>
</tr>
</tbody>
</table>

**Note**
- Multiplier of useful life code: MBC242
Fig. 11 - Multiplier of useful life as a function of ambient temperature and ripple current load

Table 9

<table>
<thead>
<tr>
<th>$U_R$ (V)</th>
<th>50</th>
<th>100</th>
<th>300</th>
<th>1000</th>
<th>3000</th>
<th>10000</th>
<th>30000</th>
<th>100000</th>
</tr>
</thead>
<tbody>
<tr>
<td>$I_R$ MULTIPLIER</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.3</td>
<td>0.60</td>
<td>0.70</td>
<td>0.80</td>
<td>0.85</td>
<td>0.90</td>
<td>0.95</td>
<td>0.97</td>
<td>1.00</td>
</tr>
<tr>
<td>10</td>
<td>0.60</td>
<td>0.70</td>
<td>0.80</td>
<td>0.85</td>
<td>0.90</td>
<td>0.95</td>
<td>0.97</td>
<td>1.00</td>
</tr>
<tr>
<td>16</td>
<td>0.60</td>
<td>0.70</td>
<td>0.80</td>
<td>0.85</td>
<td>0.90</td>
<td>0.95</td>
<td>0.97</td>
<td>1.00</td>
</tr>
<tr>
<td>25</td>
<td>0.60</td>
<td>0.70</td>
<td>0.80</td>
<td>0.85</td>
<td>0.90</td>
<td>0.95</td>
<td>0.97</td>
<td>1.00</td>
</tr>
<tr>
<td>35</td>
<td>0.45</td>
<td>0.60</td>
<td>0.75</td>
<td>0.85</td>
<td>0.90</td>
<td>0.95</td>
<td>0.97</td>
<td>1.00</td>
</tr>
<tr>
<td>50</td>
<td>0.45</td>
<td>0.60</td>
<td>0.75</td>
<td>0.85</td>
<td>0.90</td>
<td>0.95</td>
<td>0.97</td>
<td>1.00</td>
</tr>
<tr>
<td>63</td>
<td>0.40</td>
<td>0.55</td>
<td>0.70</td>
<td>0.85</td>
<td>0.90</td>
<td>0.95</td>
<td>0.97</td>
<td>1.00</td>
</tr>
</tbody>
</table>

$I_A$ = Actual ripple current at 100 kHz  
$I_R$ = Rated ripple current at 100 kHz, 125 °C  
(1) Useful life at 125 °C and $I_R$ applied; see Table 8
## TEST PROCEDURES AND REQUIREMENTS

<table>
<thead>
<tr>
<th>TEST</th>
<th>PROCEDURE (quick reference)</th>
<th>REQUIREMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mounting</td>
<td>Shall be performed prior to tests mentioned below; reflow soldering; for maximum temperature load refer to chapter “Mounting”</td>
<td>$\Delta C/C: \pm 5%$ tan $\delta \leq \text{spec. limit}$ $I_{L2} \leq \text{spec. limit}$</td>
</tr>
<tr>
<td>Endurance</td>
<td>$T_{\text{amb}} = 125^\circ\text{C}; U_R$ applied; for test duration see Table 8</td>
<td>$U_R = 6.3, \text{V}; \Delta C/C: \pm 25%$ $U_R \geq 10, \text{V}; \Delta C/C: \pm 20%$ tan $\delta \leq 2 \times \text{spec. limit}$ $I_{L2} \leq \text{spec. limit}$</td>
</tr>
<tr>
<td>Useful life</td>
<td>$T_{\text{amb}} = 125^\circ\text{C}; U_R$ and $I_R$ applied; for test duration see Table 8</td>
<td>$\Delta C/C: \pm 30%$ tan $\delta \leq 3 \times \text{spec. limit}$ $I_{L2} \leq \text{spec. limit}$ no short or open circuit total failure percentage: $\leq 1%$</td>
</tr>
<tr>
<td>Shelf life (storage at high temperature)</td>
<td>$T_{\text{amb}} = 125^\circ\text{C};$ no voltage applied; 1000 h after test: $U_R$ to be applied for 30 min, 24 h to 48 h before measurement</td>
<td>For requirements see “Endurance test” above</td>
</tr>
<tr>
<td>Reverse voltage</td>
<td>$T_{\text{amb}} = 125^\circ\text{C};$ 125 h at $U = -0.5, \text{V}$, followed by 125 h at $U_R$</td>
<td>$\Delta C/C: \pm 15%$ tan $\delta \leq 1.5 \times \text{spec. limit}$ $I_{L2} \leq \text{spec. limit}$</td>
</tr>
</tbody>
</table>

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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