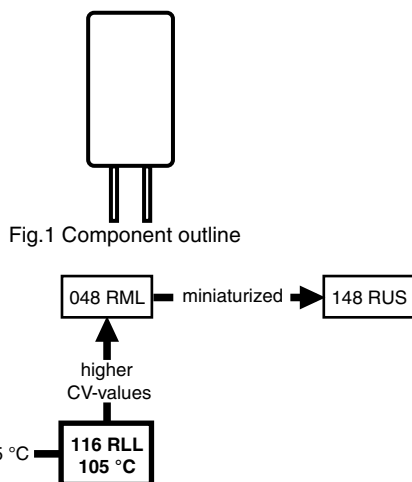


## Aluminum Capacitors Radial Long Life



### FEATURES

- Polarized aluminum electrolytic capacitors, non-solid electrolyte
- Radial leads, cylindrical aluminum case, all-insulated (light blue)
- Natural pitch 2.5 mm and 5 mm
- Charge and discharge proof
- Miniaturized, high CV-product per unit volume
- Long useful life: 2000 h at 105 °C, high reliability
- Lead (Pb)-free versions are RoHS compliant


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  $\mu\text{F}$ )
- 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
- Minus-sign on top to identify the negative terminal
- Series number (116)

### QUICK REFERENCE DATA

| DESCRIPTION                                     | VALUE                     |
|-------------------------------------------------|---------------------------|
| Nominal Case sizes ( $\varnothing$ D x L in mm) | 5 x 11 and 8.2 x 11       |
| Rated capacitance range, $C_R$                  | 0.47 to 470 $\mu\text{F}$ |
| Tolerance on $C_R$                              | $\pm 20\%$                |
| Rated voltage range, $U_R$                      | 6.3 to 100 V              |
| Category temperature range                      | - 55 to + 105 °C          |
| Endurance test at 105 °C                        | 1500 hours                |
| Endurance test at 85 °C                         | 5000 hours                |
| Useful life at 105 °C                           | 2000 hours                |
| Useful life at 40 °C, $1.3 \times I_R$ applied  | 200 000 hours             |
| Shelf life at 0 V, 105 °C                       | 1500 hours                |
| Based on sectional specification                | IEC 60384-4/EN130300      |
| Climatic category IEC 60068                     | 55/105/56                 |

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

| $C_R$<br>( $\mu\text{F}$ ) | $U_R$ (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 |
| 15                         | -         | -        | -        | -        | -        | -        | 8.2 x 11 | -        | -        |
| 22                         | -         | -        | -        | -        | -        | -        | 5 x 11   | -        | -        |
| 33                         | -         | -        | -        | -        | -        | -        | 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  | -        | -        | -        | -        | -        | -        | -        | -        |

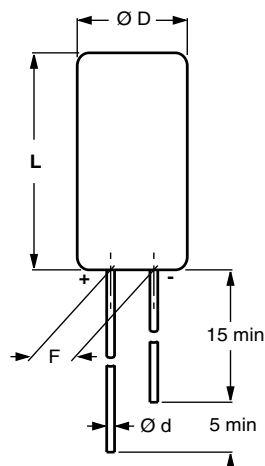
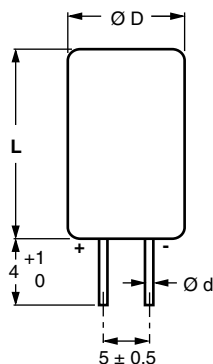
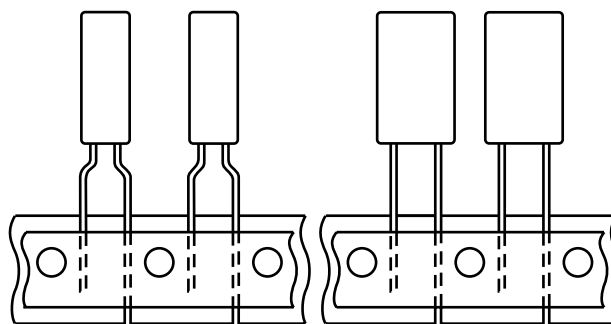
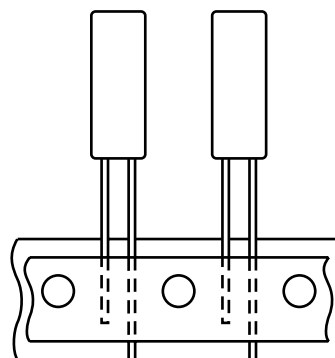
**DIMENSIONS** in millimeters **AND AVAILABLE FORMS**Fig.2 **Form CA:** Long leadsCase  $\varnothing D \times L = 8.2 \times 11$  mm onlyFig.4 **Form CB:** Cut leadsCase  $\varnothing D \times L = 5 \times 11$  and  $8.2 \times 11$  mm  
Pitch  $F = 5$  mmFig.3 **Form TFA:** Taped in box (ammopack)Case  $\varnothing D \times L = 5 \times 11$  mm only  
Pitch  $F = 2.5$  mmFig.5 **Form TNA:** Taped in box (ammopack)

Table 1

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

**Note**

Tape dimension see section 'PACKAGING'.

Aluminum Capacitors  
Radial Long Life

Vishay BCcomponents

| 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 minutes 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  
 $T_{amb} = 20\text{ °C}$ ,  $P = 86\text{ to }106\text{ kPa}$ ,  $RH = 45\text{ to }75\%$ .

Table 2

| ELECTRICAL DATA AND ORDERING INFORMATION |                                  |                                            |                                             |                                  |                 |                     |                             |           |            |           |                |           |             |           |
|------------------------------------------|----------------------------------|--------------------------------------------|---------------------------------------------|----------------------------------|-----------------|---------------------|-----------------------------|-----------|------------|-----------|----------------|-----------|-------------|-----------|
| U <sub>R</sub><br>(V)                    | C <sub>R</sub><br>100 Hz<br>(μF) | NOMINAL<br>CASE<br>SIZE<br>Ø D x L<br>(mm) | I <sub>R</sub><br>100 kHz<br>105 °C<br>(mA) | I <sub>L1</sub><br>1 min<br>(μA) | tan δ<br>100 Hz | Z<br>100 kHz<br>(Ω) | ORDERING CODE MAL2116 ..... |           |            |           |                |           |             |           |
|                                          |                                  |                                            |                                             |                                  |                 |                     | BULK PACKAGING              |           |            |           | TAPED AMMOPACK |           |             |           |
|                                          |                                  |                                            |                                             |                                  |                 |                     | LONG LEADS                  |           | CUT LEADS  |           |                |           |             |           |
|                                          |                                  |                                            |                                             |                                  |                 |                     | FORM<br>CA                  | F<br>(mm) | FORM<br>CB | F<br>(mm) | FORM<br>TFA    | F<br>(mm) | FORM<br>TNA | F<br>(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                                | 0.2             | 1.4                 | 54101E3                     | 2.5       | -          | -         | 34101E3        | 5.0       | 74101E3     | 2.5       |
|                                          | 330                              | 8.2 x 11                                   | 280                                         | 23                               | 0.2             | 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                   | 51108E3                     | 2.5       | -          | 5.0       | 31108E3        | 5.0       | 71108E3     | 2.5       |
|                                          | 1.5                              | 5 x 11                                     | 50                                          | 3.5                              | 0.09            | 4                   | 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                                | 0.09            | 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                                | 0.09            | 2.5                 | 51688E3                     | 2.5       | -          | 5.0       | 31688E3        | 5.0       | 71688E3     | 2.5       |
|                                          | 10                               | 5 x 11                                     | 80                                          | 6                                | 0.09            | 2.2                 | 51109E3                     | 2.5       | -          | 5.0       | 31109E3        | 5.0       | 71109E3     | 2.5       |
|                                          | 10                               | 8.2 x 11                                   | 160                                         | 6                                | 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                                | 0.06            | 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                   | 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                                | 0.08            | 3                   | 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:  $\varnothing 8.2 \times 11\text{ mm}$ ; Form TFA

Ordering code: MAL211635221E3

Former 12NC: 2222 116 35221

| ADDITIONAL ELECTRICAL DATA         |                                                              |                                              |
|------------------------------------|--------------------------------------------------------------|----------------------------------------------|
| PARAMETER                          | CONDITIONS                                                   | VALUE                                        |
| <b>Voltage</b>                     |                                                              |                                              |
| Surge voltage                      |                                                              | $U_S \leq 1.3 U_R$                           |
| Reverse voltage                    |                                                              | $U_{rev} \leq 1 V$                           |
| <b>Current</b>                     |                                                              |                                              |
| Leakage current                    | After 1 minutes at $U_R$                                     | $I_{L1} \leq 0.006 C_R \times U_R + 3 \mu A$ |
|                                    | After 5 minutes at $U_R$                                     | $I_{L5} \leq 0.001 C_R \times U_R + 3 \mu A$ |
| <b>Inductance</b>                  |                                                              |                                              |
| Equivalent series inductance (ESL) | Case $\varnothing D \times L = 5 \times 11 \text{ mm}$       | typ. 13 nH                                   |
|                                    | Case $\varnothing D \times L = 8.2 \times 11 \text{ mm}$     | typ. 16 nH                                   |
| <b>Resistance</b>                  |                                                              |                                              |
| Equivalent series resistance (ESR) | Calculated from $\tan \delta_{max.}$ and $C_R$ (see Table 2) | $ESR = \tan \delta / 2 \pi f C_R$            |

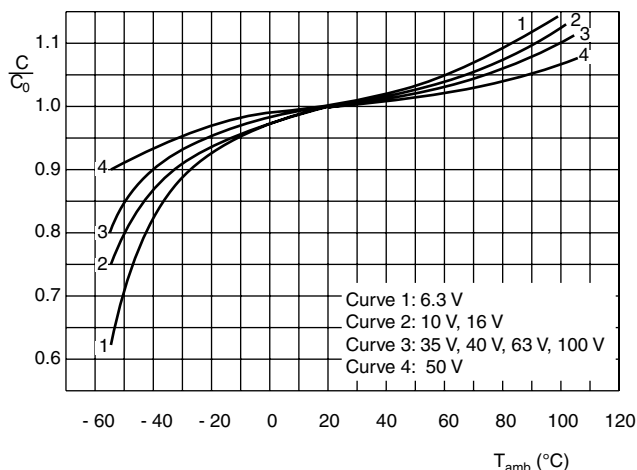
**CAPACITANCE (C)**

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

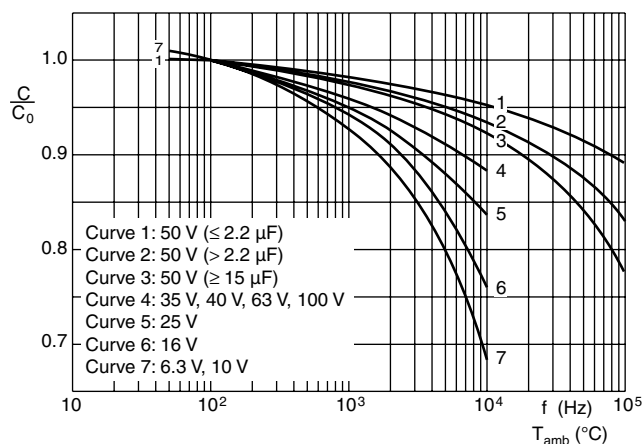


Fig.7 Typical multiplier of capacitance as a function of ambient frequency

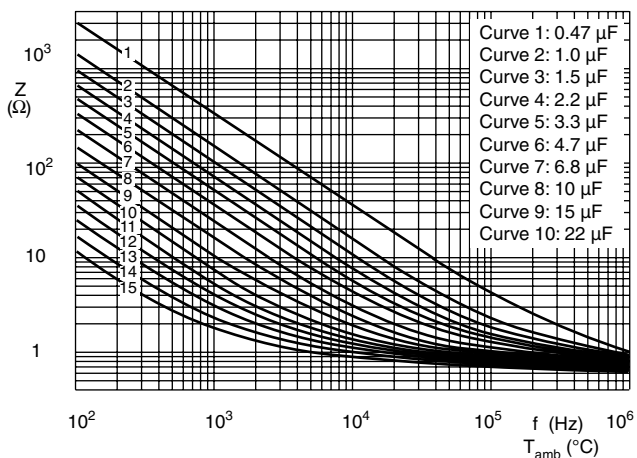
**IMPEDANCE (Z)**

Fig.8 Typical impedance as a function of frequency

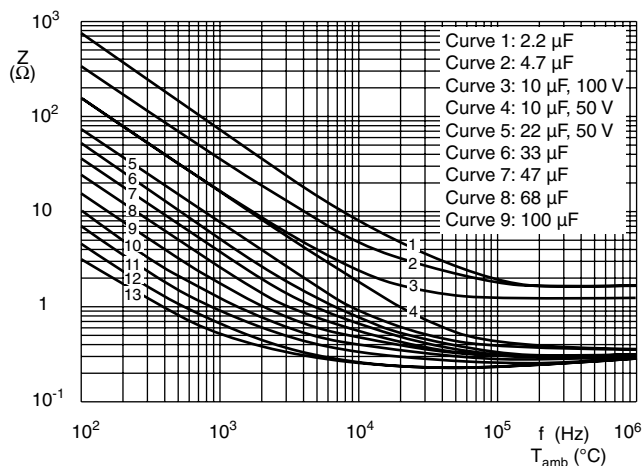


Fig.9 Typical impedance as a function of frequency

**RIPPLE CURRENT AND USEFUL LIFE**

$I_A$  = actual ripple current at 100 Hz  
 $I_R$  = rated ripple current at 100 Hz, 105 °C  
<sup>(1)</sup> = useful life at 105 °C and  $I_R$  applied: 2000 h

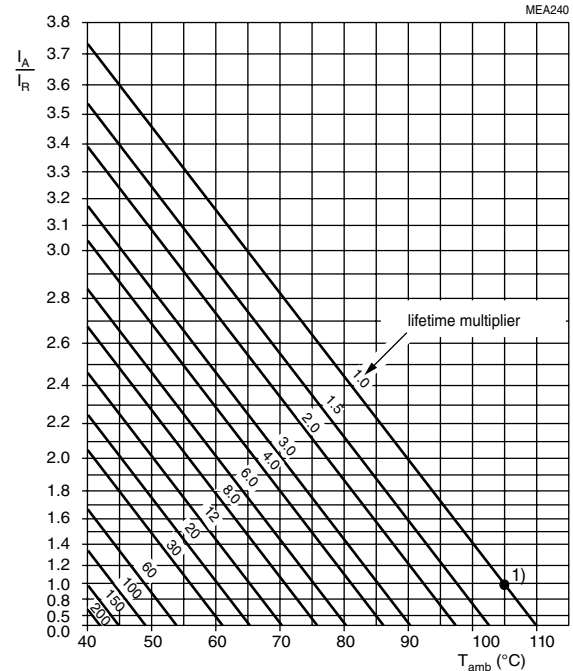


Fig.10 Multiplier of useful life as a function of ambient temperature and ripple current load

Table 3

| <b>MULTIPLIER OF RIPPLE CURRENT (<math>I_R</math>) AS A FUNCTION OF FREQUENCY</b> |                                                    |                                                   |                                                                                     |
|-----------------------------------------------------------------------------------|----------------------------------------------------|---------------------------------------------------|-------------------------------------------------------------------------------------|
| <b>FREQUENCY<br/>(Hz)</b>                                                         | <b><math>I_R</math> MULTIPLIER</b>                 |                                                   |                                                                                     |
|                                                                                   | <b><math>U_R = 6.3</math> to <math>10</math> V</b> | <b><math>U_R = 16</math> to <math>35</math> V</b> | <b><math>U_R = 40</math> to <math>100</math> V (<math>C_R \geq 10 \mu F</math>)</b> |
| 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                                                                                |
| 10 to 100 k                                                                       | 1.00                                               | 1.00                                              | 1.00                                                                                |

Table 4

| <b>TEST PROCEDURES AND REQUIREMENTS</b>        |                                            |                                                                                                                                   |                                                                                                                                                                                                                                                                 |
|------------------------------------------------|--------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>TEST</b>                                    |                                            | <b>PROCEDURE<br/>(quick reference)</b>                                                                                            | <b>REQUIREMENTS</b>                                                                                                                                                                                                                                             |
| <b>NAME OF TEST</b>                            | <b>REFERENCE</b>                           |                                                                                                                                   |                                                                                                                                                                                                                                                                 |
| Endurance                                      | IEC 60384-4/<br>EN130300<br>subclause 4.13 | $T_{amb} = 105$ °C; $U_R$ applied;<br>1500 h                                                                                      | $U_R \leq 6.3$ V; $\Delta C/C: +15/-30$ %<br>$U_R > 6.3$ V; $\Delta C/C: \pm 15$ %<br>$\tan \delta \leq 1.3 \times$ spec. limit<br>$Z \leq 2 \times$ spec. limit<br>$I_{L5} \leq$ spec. limit                                                                   |
| Useful life                                    | CECC 30301<br>subclause 1.8.1              | $T_{amb} = 105$ °C; $U_R$ and $I_R$ applied;<br>2000 h                                                                            | $U_R \leq 6.3$ V; $\Delta C/C: +45/-50$ %<br>$U_R > 6.3$ V; $\Delta C/C: \pm 45$ %<br>$\tan \delta \leq 3 \times$ spec. limit<br>$Z \leq 3 \times$ spec. limit<br>$I_{L5} \leq$ spec. limit<br>no short or open circuit<br>total failure percentage: $\leq 1\%$ |
| Shelf life<br>(storage at<br>high temperature) | IEC 60384-4/<br>EN130300<br>subclause 4.17 | $T_{amb} = 105$ °C; no voltage applied;<br>1500 h<br>after test: $U_R$ to be applied for 30 min, 24 to 48 h<br>before measurement | $\Delta C/C$ , $\tan \delta$ , $Z$ :<br>for requirements<br>see 'Endurance test' above<br>$I_{L5} \leq 2 \times$ spec. limit                                                                                                                                    |



### Disclaimer

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Электрон  
Связь**

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Благодаря сотрудничеству с мировыми поставщиками мы осуществляем комплексные и плановые поставки широчайшего спектра электронных компонентов.

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