

## Aluminum Electrolytic Capacitors Radial Long Life

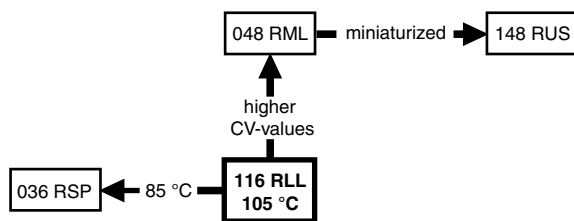
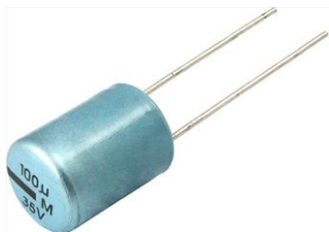


Fig. 1

### FEATURES

- Long useful life: 2000 h at 105 °C
- Miniaturized, high CV-product per unit volume
- Natural pitch 2.5 mm and 5 mm
- Polarized aluminum electrolytic capacitors, non-solid electrolyte
- Radial leads, cylindrical aluminum case, all-insulated (light blue)
- Charge and discharge proof
- Material categorization: for definitions of compliance please see [www.vishay.com/doc?99912](http://www.vishay.com/doc?99912)


**RoHS**  
COMPLIANT

### APPLICATIONS

- Automotive, telecommunication, industrial and EDP
- Stand-by applications in audio and video equipment
- Coupling, decoupling, timing, smoothing, filtering and buffering in DC/DC converters
- Portable and mobile equipment (small size, low mass)

### MARKING

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

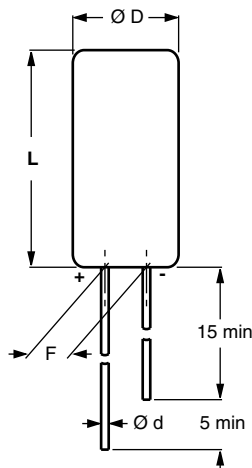
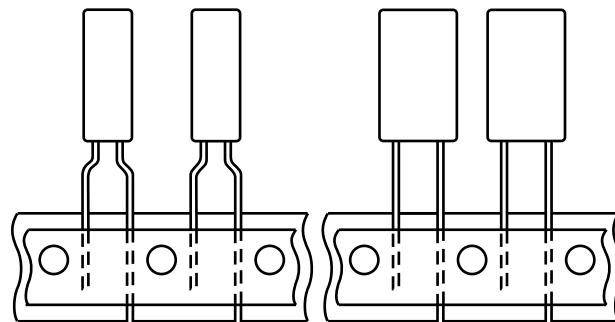
- Rated capacitance (in  $\mu\text{F}$ )
- Tolerance on rated capacitance, code letter in accordance with IEC 60062 (M for  $\pm 20\%$ )
- Rated voltage (in V)
- Date code in accordance with IEC 60062
- Code indicating factory of origin
- Name of manufacturer
- “-”-sign on top to identify the negative terminal
- Series number (116)

### QUICK REFERENCE DATA

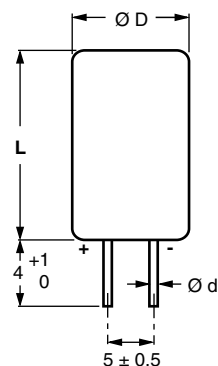
| DESCRIPTION                                          | VALUE                                  |
|------------------------------------------------------|----------------------------------------|
| Nominal case sizes ( $\varnothing D \times L$ in mm) | 5 x 11 and 8.2 x 11                    |
| Rated capacitance range, $C_R$                       | 1.5 $\mu\text{F}$ to 470 $\mu\text{F}$ |
| Tolerance on $C_R$                                   | $\pm 20\%$                             |
| Rated voltage range, $U_R$                           | 6.3 V to 100 V                         |
| Category temperature range                           | -55 °C to +105 °C                      |
| Endurance test at 105 °C                             | 1500 h                                 |
| Endurance test at 85 °C                              | 5000 h                                 |
| Useful life at 105 °C                                | 2000 h                                 |
| Useful life at 40 °C, 1.3 x $I_R$ applied            | 200 000 h                              |
| Shelf life at 0 V, 105 °C                            | 1500 h                                 |
| Based on sectional specification                     | IEC 60384-4 / EN 130300                |
| Climatic category IEC 60068                          | 55 / 105 / 56                          |

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

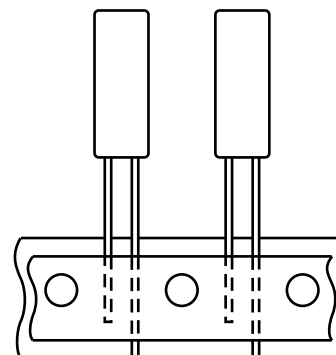
| $C_R$<br>( $\mu\text{F}$ ) | $U_R$ (V) |          |          |          |          |          |          |          |          |
|----------------------------|-----------|----------|----------|----------|----------|----------|----------|----------|----------|
|                            | 6.3       | 10       | 16       | 25       | 35       | 40       | 50       | 63       | 100      |
| 1.5                        | -         | -        | -        | -        | -        | -        | 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                         | -         | -        | -        | -        | -        | -        | 5 x 11   | -        | -        |
| 22                         | -         | -        | -        | -        | -        | -        | 5 x 11   | 8.2 x 11 | -        |
| 33                         | -         | -        | -        | -        | 5 x 11   | 5 x 11   | 8.2 x 11 | -        | -        |
| 47                         | -         | -        | -        | 5 x 11   | -        | -        | 8.2 x 11 | -        | -        |
| 68                         | -         | -        | 5 x 11   | -        | -        | -        | 8.2 x 11 | -        | -        |
| 100                        | -         | 5 x 11   | -        | -        | 8.2 x 11 | 8.2 x 11 | -        | -        | -        |
| 150                        | 5 x 11    | -        | -        | 8.2 x 11 | -        | -        | -        | -        | -        |
| 220                        | -         | -        | 8.2 x 11 | -        | -        | -        | -        | -        | -        |
| 330                        | -         | 8.2 x 11 | -        | -        | -        | -        | -        | -        | -        |
| 470                        | 8.2 x 11  | -        | -        | -        | -        | -        | -        | -        | -        |

**DIMENSIONS in millimeters AND AVAILABLE FORMS**

Fig. 2 - **Form CA:** Long leads


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

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


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

Fig. 4 - **Form CB:** Cut leads


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

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

**Table 1**

| <b>DIMENSIONS in millimeters, MASS, AND PACKAGING QUANTITIES</b> |              |                 |                               |                   |               |               |                      |                  |
|------------------------------------------------------------------|--------------|-----------------|-------------------------------|-------------------|---------------|---------------|----------------------|------------------|
| NOMINAL<br>CASE SIZE<br>$\varnothing D \times L$                 | CASE<br>CODE | $\varnothing d$ | $\varnothing D_{\text{max.}}$ | $L_{\text{max.}}$ | F             | MASS<br>(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**

- For detailed tape dimension please see [www.vishay.com/doc?28360](http://www.vishay.com/doc?28360)

**ELECTRICAL DATA**

| SYMBOL        | DESCRIPTION                                       |
|---------------|---------------------------------------------------|
| $C_R$         | Rated capacitance at 100 Hz, tolerance $\pm 20\%$ |
| $I_R$         | Rated RMS ripple current at 100 kHz, 105 °C       |
| $I_{L1}$      | Max. leakage current after 1 min at $U_R$         |
| $\tan \delta$ | Max. dissipation factor at 100 Hz                 |
| Z             | Max. impedance at 100 kHz and 20 °C               |

**Note**

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

**Table 2****ELECTRICAL DATA AND ORDERING INFORMATION**

| $U_R$<br>(V) | $C_R$<br>100 Hz<br>( $\mu\text{F}$ ) | NOMINAL<br>CASE SIZE<br>$\varnothing D \times L$<br>(mm) | $I_R$<br>100 kHz<br>105 °C<br>(mA) | $I_{L1}$<br>1 min<br>( $\mu\text{A}$ ) | $\tan \delta$<br>100 Hz | Z<br>100 kHz<br>( $\Omega$ ) | 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                                    | 0.20                    | 1.4                          | 54101E3                     | 2.5       | -          | -         | 34101E3        | 5.0       | 74101E3     | 2.5       |
|              | 330                                  | 8.2 x 11                                                 | 280                                | 23                                     | 0.20                    | 0.45                         | 54331E3                     | 5.0       | 64331E3    | 5.0       | 34331E3        | 5.0       | -           | -         |
| 16           | 68                                   | 5 x 11                                                   | 130                                | 9.5                                    | 0.16                    | 1.5                          | 55689E3                     | 2.5       | -          | -         | 35689E3        | 5.0       | 75689E3     | 2.5       |
|              | 220                                  | 8.2 x 11                                                 | 280                                | 24                                     | 0.16                    | 0.5                          | 55221E3                     | 5.0       | 65221E3    | 5.0       | 35221E3        | 5.0       | -           | -         |
| 25           | 47                                   | 5 x 11                                                   | 120                                | 10                                     | 0.14                    | 1.6                          | 56479E3                     | 2.5       | -          | -         | 36479E3        | 5.0       | 76479E3     | 2.5       |
|              | 150                                  | 8.2 x 11                                                 | 260                                | 26                                     | 0.14                    | 0.5                          | 56151E3                     | 5.0       | 66151E3    | 5.0       | 36151E3        | 5.0       | -           | -         |
| 35           | 33                                   | 5 x 11                                                   | 110                                | 9.9                                    | 0.12                    | 1.7                          | 50339E3                     | 2.5       | -          | -         | 30339E3        | 5.0       | 70339E3     | 2.5       |
|              | 100                                  | 8.2 x 11                                                 | 240                                | 24                                     | 0.12                    | 0.55                         | 50101E3                     | 5.0       | 60101E3    | 5.0       | 30101E3        | 5.0       | -           | -         |
| 40           | 33                                   | 5 x 11                                                   | 110                                | 10.9                                   | 0.12                    | 1.7                          | 57339E3                     | 2.5       | -          | -         | 37339E3        | 5.0       | 77339E3     | 2.5       |
|              | 100                                  | 8.2 x 11                                                 | 240                                | 27                                     | 0.12                    | 0.55                         | 57101E3                     | 5.0       | 67101E3    | 5.0       | 37101E3        | 5.0       | -           | -         |
| 50           | 1.5                                  | 5 x 11                                                   | 50                                 | 3.5                                    | 0.09                    | 4.0                          | 51158E3                     | 2.5       | -          | 5.0       | 31158E3        | 5.0       | 71158E3     | 2.5       |
|              | 2.2                                  | 5 x 11                                                   | 60                                 | 3.7                                    | 0.09                    | 3.5                          | 51228E3                     | 2.5       | -          | 5.0       | 31228E3        | 5.0       | 71228E3     | 2.5       |
|              | 3.3                                  | 5 x 11                                                   | 65                                 | 4.0                                    | 0.09                    | 3.1                          | 51338E3                     | 2.5       | -          | 5.0       | 31338E3        | 5.0       | 71338E3     | 2.5       |
|              | 4.7                                  | 5 x 11                                                   | 70                                 | 4.4                                    | 0.09                    | 2.8                          | 51478E3                     | 2.5       | -          | 5.0       | 31478E3        | 5.0       | 71478E3     | 2.5       |
|              | 6.8                                  | 5 x 11                                                   | 75                                 | 5.0                                    | 0.09                    | 2.5                          | 51688E3                     | 2.5       | -          | 5.0       | 31688E3        | 5.0       | 71688E3     | 2.5       |
|              | 10                                   | 5 x 11                                                   | 80                                 | 6.0                                    | 0.09                    | 2.2                          | 51109E3                     | 2.5       | -          | 5.0       | 31109E3        | 5.0       | 71109E3     | 2.5       |
|              | 10                                   | 8.2 x 11                                                 | 160                                | 6.0                                    | 0.05                    | 1.0                          | 90084E3                     | 5.0       | 90085E3    | 5.0       | 90036E3        | 5.0       | -           | -         |
|              | 15                                   | 5 x 11                                                   | 90                                 | 7.5                                    | 0.09                    | 2.0                          | 51159E3                     | 2.5       | -          | 5.0       | 31159E3        | 5.0       | 71159E3     | 2.5       |
|              | 22                                   | 5 x 11                                                   | 110                                | 9.6                                    | 0.09                    | 1.9                          | 51229E3                     | 2.5       | -          | 5.0       | 31229E3        | 5.0       | 71229E3     | 2.5       |
|              | 22                                   | 8.2 x 11                                                 | 190                                | 9.6                                    | 0.06                    | 0.9                          | 90025E3                     | 5.0       | 90086E3    | 5.0       | 90039E3        | 5.0       | -           | -         |
|              | 33                                   | 8.2 x 11                                                 | 190                                | 13                                     | 0.09                    | 0.77                         | 51339E3                     | 5.0       | 61339E3    | 5.0       | 31339E3        | 5.0       | -           | -         |
|              | 47                                   | 8.2 x 11                                                 | 210                                | 17                                     | 0.09                    | 0.65                         | 51479E3                     | 5.0       | 61479E3    | 5.0       | 31479E3        | 5.0       | -           | -         |
|              | 68                                   | 8.2 x 11                                                 | 240                                | 23                                     | 0.09                    | 0.55                         | 51689E3                     | 5.0       | 61689E3    | 5.0       | 31689E3        | 5.0       | -           | -         |
| 63           | 10                                   | 8.2 x 11                                                 | 160                                | 7.0                                    | 0.06                    | 1.3                          | 58109E3                     | 5.0       | 68109E3    | 5.0       | 38109E3        | 5.0       | -           | -         |
|              | 22                                   | 8.2 x 11                                                 | 190                                | 11                                     | 0.06                    | 0.9                          | 58229E3                     | 5.0       | 68229E3    | 5.0       | 38229E3        | 5.0       | -           | -         |
| 100          | 4.7                                  | 8.2 x 11                                                 | 75                                 | 5.8                                    | 0.07                    | 3.5                          | 59478E3                     | 5.0       | 69478E3    | 5.0       | 39478E3        | 5.0       | -           | -         |
|              | 10                                   | 8.2 x 11                                                 | 100                                | 9.0                                    | 0.08                    | 3.0                          | 59109E3                     | 5.0       | 69109E3    | 5.0       | 39109E3        | 5.0       | -           | -         |

**ORDERING EXAMPLE**

Electrolytic capacitor 116 series

220  $\mu\text{F}$  / 16 V;  $\pm 20\%$ Nominal case size:  $\varnothing 8.2\text{ mm} \times 11\text{ mm}$ ; form TFA

Ordering code: MAL211635221E3

Former 12NC: 2222 116 35221

| ADDITIONAL ELECTRICAL DATA         |                                                                     |                                              |
|------------------------------------|---------------------------------------------------------------------|----------------------------------------------|
| PARAMETER                          | CONDITIONS                                                          | VALUE                                        |
| <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 min at $U_R$                                                | $I_{L1} \leq 0.006 C_R \times U_R + 3 \mu A$ |
|                                    | After 5 min at $U_R$                                                | $I_{L5} \leq 0.001 C_R \times U_R + 3 \mu A$ |
| <b>Inductance</b>                  |                                                                     |                                              |
| 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                                   |
| <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)

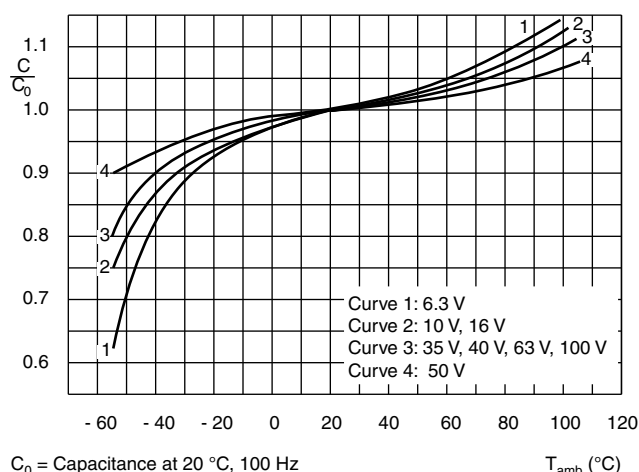


Fig. 6 - Typical multiplier of capacitance as a function of ambient temperature

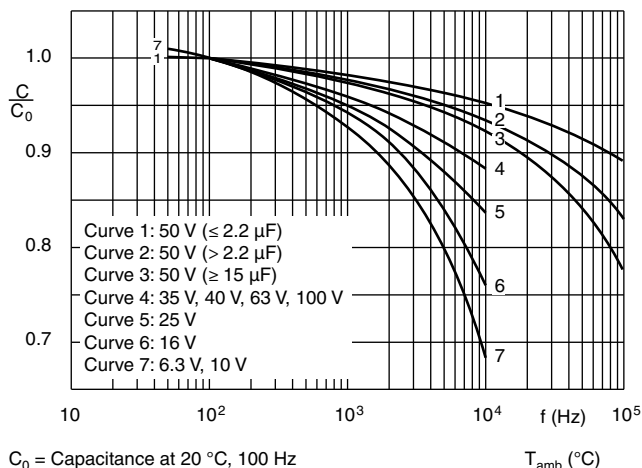


Fig. 7 - Typical multiplier of capacitance as a function of ambient frequency

## IMPEDANCE (Z)

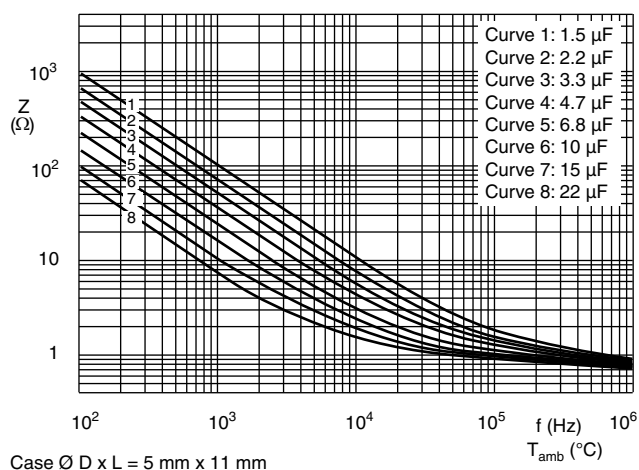


Fig. 8 - Typical impedance as a function of frequency

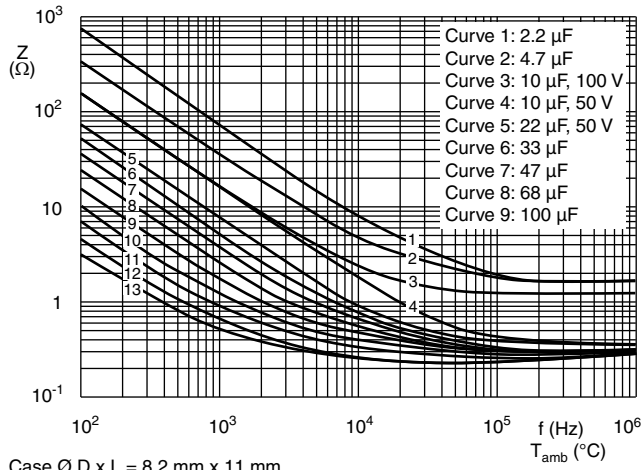


Fig. 9 - Typical impedance as a function of frequency

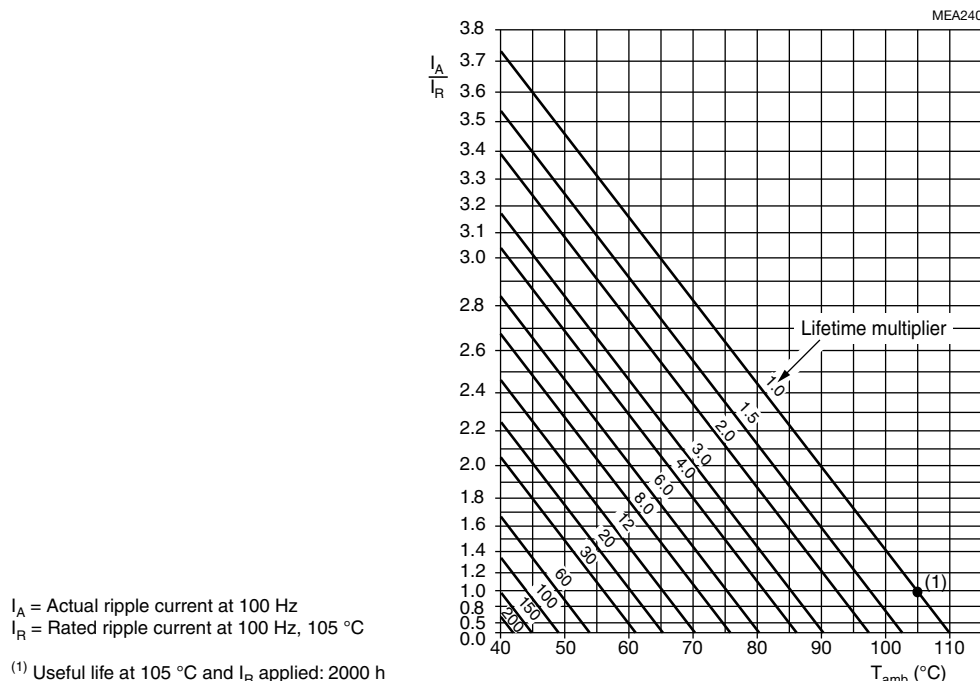
**RIPPLE CURRENT AND USEFUL LIFE**


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 \text{ V TO } 10 \text{ V}</math></b> | <b><math>U_R = 16 \text{ V TO } 35 \text{ V}</math></b> | <b><math>U_R = 40 \text{ V TO } 100 \text{ V (C}_R \geq 10 \mu\text{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                                                                               |
| 10K to 100K                                                                       | 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>EN 130300<br>subclause 4.13 | $T_{amb} = 105 \text{ °C}$ ; $U_R$ applied;<br>1500 h                                                                                        | $U_R \leq 6.3 \text{ V}$ ; $\Delta C/C$ : +15 % / -30 %<br>$U_R > 6.3 \text{ V}$ ; $\Delta C/C$ : $\pm 15 \%$<br>$\tan \delta \leq 1.3 \times \text{spec. limit}$<br>$Z \leq 2 \times \text{spec. limit}$<br>$I_{L5} \leq \text{spec. limit}$                                                                   |
| Useful life                                    | CECC 30301<br>subclause 1.8.1                | $T_{amb} = 105 \text{ °C}$ ; $U_R$ and $I_R$ applied;<br>2000 h                                                                              | $U_R \leq 6.3 \text{ V}$ ; $\Delta C/C$ : +45 % / -50 %<br>$U_R > 6.3 \text{ V}$ ; $\Delta C/C$ : $\pm 45 \%$<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<br>high temperature) | IEC 60384-4 /<br>EN 130300<br>subclause 4.17 | $T_{amb} = 105 \text{ °C}$ ; no voltage applied;<br>1500 h<br>After test: $U_R$ to be applied for 30 min, 24 h to 48 h<br>before measurement | $\Delta C/C$ , $\tan \delta$ , $Z$ :<br>For requirements see<br>"Endurance test" above<br>$I_{L5} \leq 2 \times \text{spec. limit}$                                                                                                                                                                             |

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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