

## Aluminum Electrolytic Capacitors Radial Low Leakage Current

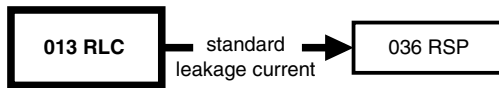


Fig. 1

| QUICK REFERENCE DATA   |   |
|--|---|
| DESCRIPTION  | VALUE   |
| Nominal case sizes (Ø D x L in mm)                             | 8.2 x 11  |
| Rated capacitance range, C <sub>R</sub>                        | 33 µF to 470 µF   |
| Tolerance on C <sub>R</sub>                                    | ± 20 %; ± 10 % on request   |
| Rated voltage range, U <sub>R</sub>                            | 6.3 V to 50 V   |
| Category temperature range                                     | -40 °C to +85 °C  |
| Leakage current after 2 min:<br>U <sub>R</sub> = 6.3 V to 25 V | 0.002 C <sub>R</sub> x U <sub>R</sub> or 0.7 µA, whichever is greater |
| U <sub>R</sub> = 35 V and 50 V                                 | 0.002 C <sub>R</sub> x U <sub>R</sub> + 1 µA                          |
| Endurance test at 85 °C  | 2000 h  |
| Useful life at 105 °C  | 750 h   |
| Useful life at 85 °C   | 3000 h  |
| Useful life at 40 °C, 1.4 x I <sub>R</sub> applied             | 80 000 h  |
| Shelf life at 0 V, 85 °C                                       | 500 h   |
| Based on sectional specification                               | IEC 60384-4 / EN 130300   |
| Climatic category IEC 60068                                    | 40 / 085 / 56   |

### FEATURES

- Useful life at +85 °C: 3000 h
- Low leakage current, low energy consumption
- Miniaturized, high CV-product per unit volume
- Natural pitch 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)



### APPLICATIONS

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

### MARKING

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

- Rated capacitance (in µF)
- Tolerance on rated capacitance, code letter in accordance with IEC 60062 (M for ± 20 %)
- Rated voltage (in V)
- Date code in accordance with IEC 60062
- Code indicating factory of origin
- Name of manufacturer
- “-”-sign on top to identify the negative terminal
- Series number (013)

| SELECTION CHART FOR C <sub>R</sub> , U <sub>R</sub> , AND RELEVANT NOMINAL CASE SIZES (Ø D x L in mm) |                    |          |          |          |          |          |
|---|--------------------|----------|----------|----------|----------|----------|
| C <sub>R</sub> (µF)   | U <sub>R</sub> (V) |          |          |          |          |          |
|   | 6.3                | 10       | 16       | 25       | 35       | 50       |
| 33  | -                  | -        | -        | -        | -        | 8.2 x 11 |
| 47  | -                  | -        | -        | 8.2 x 11 | -        | 8.2 x 11 |
| 68  | -                  | -        | -        | -        | -        | 8.2 x 11 |
| 100   | -                  | -        | 8.2 x 11 | -        | 8.2 x 11 | -        |
| 220   | -                  | 8.2 x 11 | -        | -        | -        | -        |
| 330   | 8.2 x 11           | -        | -        | -        | -        | -        |
| 470   | 8.2 x 11           | -        | -        | -        | -        | -        |

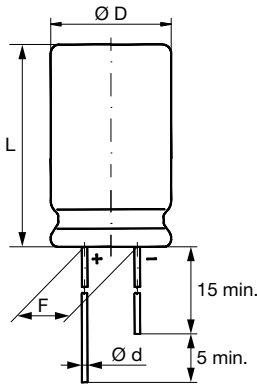
**DIMENSIONS in millimeters AND AVAILABLE FORMS**


Fig. 2 - Form CA: long leads

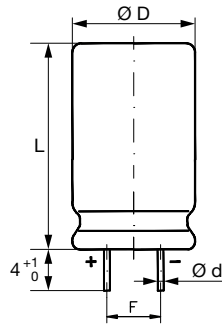


Fig. 3 - Form CB: cut leads

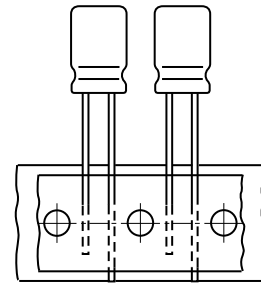

 Case  $\varnothing D \times L = 8.2 \text{ mm} \times 11 \text{ mm}$   
Pitch  $F = 5 \text{ mm}$ 

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

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

**Note**

- For detailed tape dimensions, 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 Hz, 85 °C          |
| $I_{L2}$        | Max. leakage current after 2 min at $U_R$          |
| $\tan \delta$   | Max. dissipation factor at 100 Hz                  |
| Z               | Max. impedance at 10 kHz and + 20 °C               |

**Note**

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

**ORDERING EXAMPLE**

Electrolytic capacitor 013 series

 100  $\mu\text{F}$  / 16 V;  $\pm 20 \%$ 

 Nominal case size:  $\varnothing 8.2 \text{ mm} \times 11 \text{ mm}$ ; Form TFA

Ordering code: MAL201335101E3

Former 12NC: 2222 013 35101

Table 1

| ELECTRICAL DATA AND ORDERING INFORMATION |                                |  |                         |                                  |                      |                       |                            |        |           |        |                |        |          |        |
|--|--------------------------------|--|-------------------------|----------------------------------|----------------------|-----------------------|----------------------------|--------|-----------|--------|----------------|--------|----------|--------|
| $U_R$ (V)                                | $C_R$ 100 Hz ( $\mu\text{F}$ ) | NOMINAL CASE SIZE<br>$\varnothing D \times L$ (mm) | $I_R$ 100 Hz 85 °C (mA) | $I_{L2}$ 2 min ( $\mu\text{A}$ ) | $\tan \delta$ 100 Hz | Z 10 kHz ( $\Omega$ ) | ORDERING CODE MAL2013..... |        |           |        |                |        |          |        |
|  |                                |  |                         |                                  |                      |                       | BULK PACKAGING             |        |           |        | TAPED AMMOPACK |        |          |        |
|  |                                |  |                         |                                  |                      |                       | LONG LEADS                 |        | CUT LEADS |        | FORM TFA       |        | F (mm)   |        |
|  |                                |  |                         |                                  |                      |                       | FORM CA                    | F (mm) | FORM CB   | F (mm) | FORM TFA       | F (mm) | FORM TFA | F (mm) |
| 6.3                                      | 330                            | 8.2 x 11   | 210                     | 4.2                              | 0.2                  | 0.9                   | 53331E3                    | 5.0    | 63331E3   | 5.0    | 33331E3        | 5.0    |          |        |
|  | 470                            | 8.2 x 11   | 250                     | 5.9                              | 0.2                  | 0.64                  | 53471E3                    | 5.0    | 63471E3   | 5.0    | 33471E3        | 5.0    |          |        |
| 10                                       | 220                            | 8.2 x 11   | 190                     | 4.4                              | 0.16                 | 0.9                   | 54221E3                    | 5.0    | 64221E3   | 5.0    | 34221E3        | 5.0    |          |        |
| 16                                       | 100                            | 8.2 x 11   | 150                     | 3.2                              | 0.13                 | 1.0                   | 55101E3                    | 5.0    | 65101E3   | 5.0    | 35101E3        | 5.0    |          |        |
| 25                                       | 47                             | 8.2 x 11   | 130                     | 2.4                              | 0.08                 | 1.3                   | 56479E3                    | 5.0    | 66479E3   | 5.0    | 36479E3        | 5.0    |          |        |
| 35                                       | 100                            | 8.2 x 11   | 150                     | 8.0                              | 0.13                 | 1.0                   | 50101E3                    | 5.0    | 60101E3   | 5.0    | 30101E3        | 5.0    |          |        |
| 50                                       | 33                             | 8.2 x 11   | 110                     | 4.3                              | 0.06                 | 1.4                   | 51339E3                    | 5.0    | 61339E3   | 5.0    | 31339E3        | 5.0    |          |        |
|  | 47                             | 8.2 x 11   | 130                     | 5.7                              | 0.08                 | 1.3                   | 51479E3                    | 5.0    | 61479E3   | 5.0    | 31479E3        | 5.0    |          |        |
|  | 68                             | 8.2 x 11   | 150                     | 7.8                              | 0.08                 | 1.2                   | 51689E3                    | 5.0    | 61689E3   | 5.0    | 31689E3        | 5.0    |          |        |



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

**CAPACITANCE (C)**

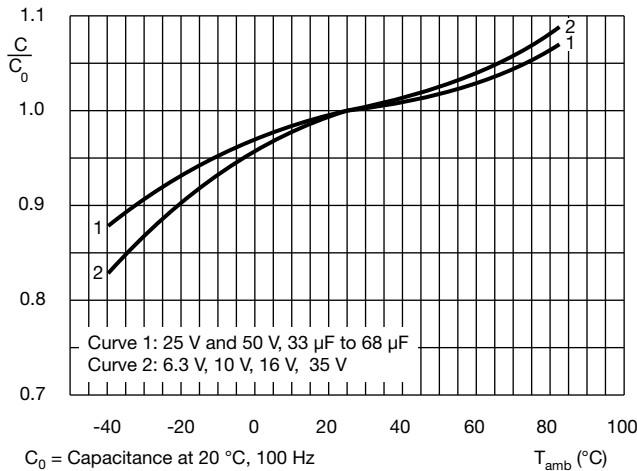


Fig. 5 - Typical multiplier of capacitance as a function of ambient temperature

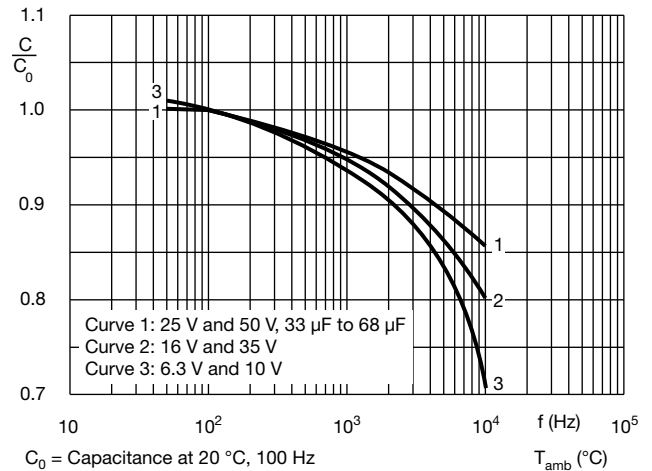


Fig. 6 - Typical multiplier of capacitance as a function of frequency

**LEAKAGE CURRENT**

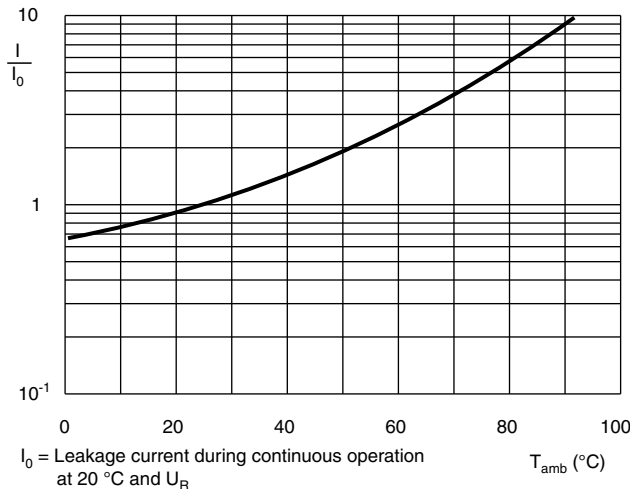


Fig. 7 - Typical multiplier of leakage current as a function of ambient temperature

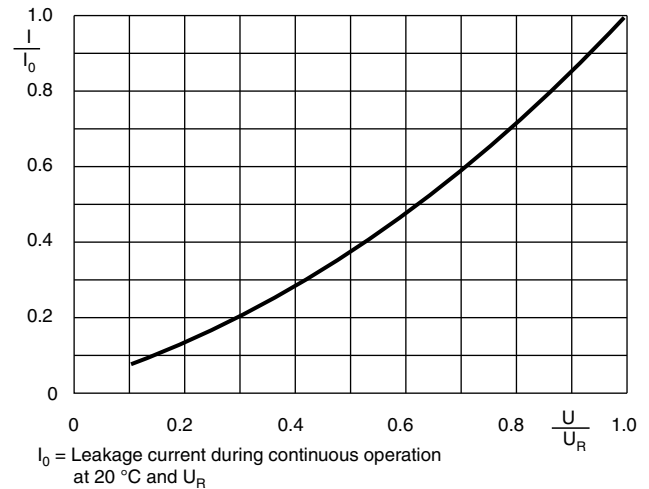


Fig. 8 - Typical multiplier of leakage current as a function of time

**LEAKAGE CURRENT**

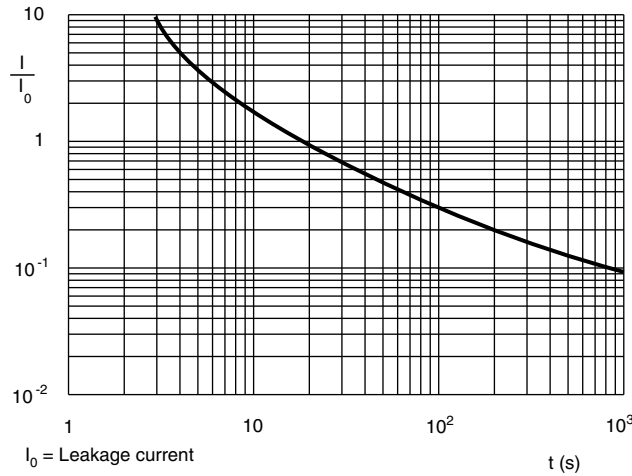


Fig. 9 - Typical multiplier of leakage current as a function of time

**RIPPLE CURRENT AND USEFUL LIFE**

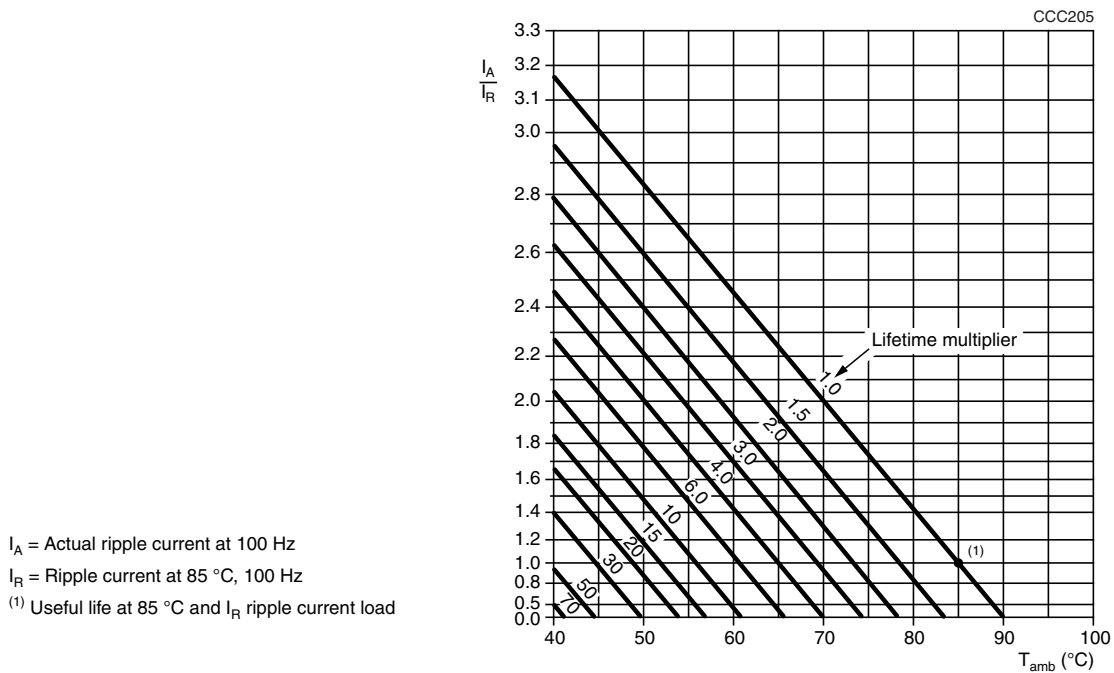


Fig. 10 - Multiplier of useful life as a function of ambient temperature and ripple current load

Table 2

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



Table 3

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

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.



## **Disclaimer**

ALL PRODUCT, PRODUCT SPECIFICATIONS AND DATA ARE SUBJECT TO CHANGE WITHOUT NOTICE TO IMPROVE RELIABILITY, FUNCTION OR DESIGN OR OTHERWISE.

Vishay Intertechnology, Inc., its affiliates, agents, and employees, and all persons acting on its or their behalf (collectively, "Vishay"), disclaim any and all liability for any errors, inaccuracies or incompleteness contained in any datasheet or in any other disclosure relating to any product.

Vishay makes no warranty, representation or guarantee regarding the suitability of the products for any particular purpose or the continuing production of any product. To the maximum extent permitted by applicable law, Vishay disclaims (i) any and all liability arising out of the application or use of any product, (ii) any and all liability, including without limitation special, consequential or incidental damages, and (iii) any and all implied warranties, including warranties of fitness for particular purpose, non-infringement and merchantability.

Statements regarding the suitability of products for certain types of applications are based on Vishay's knowledge of typical requirements that are often placed on Vishay products in generic applications. Such statements are not binding statements about the suitability of products for a particular application. It is the customer's responsibility to validate that a particular product with the properties described in the product specification is suitable for use in a particular application. Parameters provided in datasheets and / or specifications may vary in different applications and performance may vary over time. All operating parameters, including typical parameters, must be validated for each customer application by the customer's technical experts. Product specifications do not expand or otherwise modify Vishay's terms and conditions of purchase, including but not limited to the warranty expressed therein.

Hyperlinks included in this datasheet may direct users to third-party websites. These links are provided as a convenience and for informational purposes only. Inclusion of these hyperlinks does not constitute an endorsement or an approval by Vishay of any of the products, services or opinions of the corporation, organization or individual associated with the third-party website. Vishay disclaims any and all liability and bears no responsibility for the accuracy, legality or content of the third-party website or for that of subsequent links.

Vishay products are not designed for use in life-saving or life-sustaining applications or any application in which the failure of the Vishay product could result in personal injury or death unless specifically qualified in writing by Vishay. Customers using or selling Vishay products not expressly indicated for use in such applications do so at their own risk. Please contact authorized Vishay personnel to obtain written terms and conditions regarding products designed for such applications.

No license, express or implied, by estoppel or otherwise, to any intellectual property rights is granted by this document or by any conduct of Vishay. Product names and markings noted herein may be trademarks of their respective owners.