

## Aluminum Electrolytic Capacitors Radial Low Leakage Current

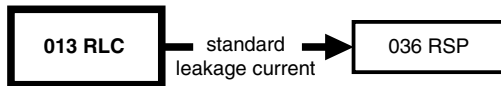


Fig. 1

QUICK REFERENCE DATA	
DESCRIPTION	VALUE
Nominal case sizes (Ø D x L in mm)	5 x 11 and 8.2 x 11
Rated capacitance range, C <sub>R</sub>	2.2 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: 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 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

- 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
2.2	-	-	-	5 x 11	-	5 x 11
3.3	-	-	-	5 x 11	-	5 x 11
4.7	-	-	-	5 x 11	-	5 x 11
10	-	-	-	5 x 11	-	5 x 11
22	-	-	-	5 x 11	-	5 x 11
33	-	-	5 x 11	-	5 x 11	8.2 x 11
47	-	5 x 11	5 x 11	8.2 x 11	-	8.2 x 11
68	-	5 x 11	-	-	-	8.2 x 11
100	-	5 x 11	-	-	8.2 x 11	-
220	-	8.2 x 11	-	-	-	-
330	8.2 x 11	-	-	-	-	-
470	8.2 x 11	-	-	-	-	-

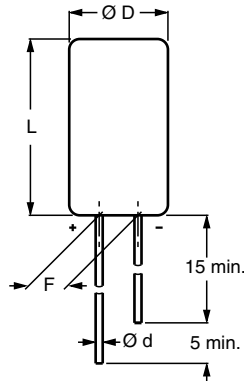
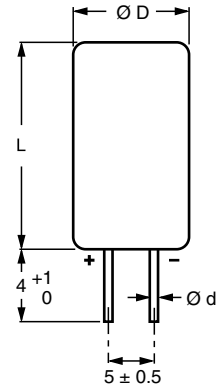
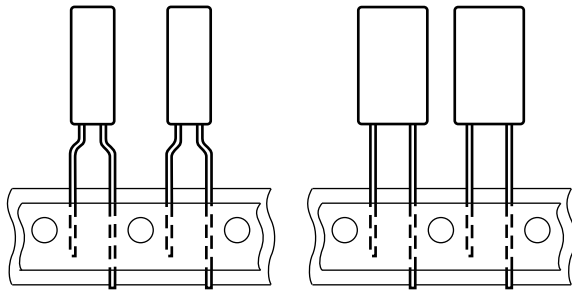
**DIMENSIONS in millimeters AND AVAILABLE FORMS**

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

 Fig. 3 - **Form CB:** Cut leads

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

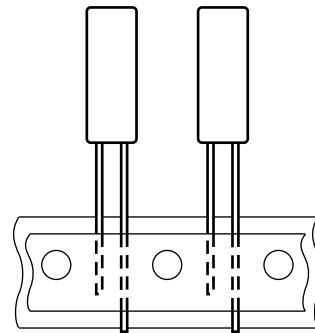
 Fig. 4 - **Form TFA:** Taped in box (ammopack)

 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)

<b>DIMENSIONS in millimeters, MASS AND PACKAGING QUANTITIES</b>								
NOMINAL CASE SIZE $\varnothing D \times L$	CASE CODE	$\varnothing d$	$\varnothing D_{max.}$	$L_{max.}$	F	MASS (g)	PACKAGING QUANTITIES	
							FORM CA, CB	FORM 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 dimensions, please see [www.vishay.com/doc?28360](http://www.vishay.com/doc?28360).



ELECTRICAL DATA	
SYMBOL	DESCRIPTION
C <sub>R</sub>	Rated capacitance at 100 Hz, tolerance ± 20 %
I <sub>R</sub>	Rated RMS ripple current at 100 Hz, 85 °C
I <sub>L2</sub>	Max. leakage current after 2 min at U <sub>R</sub>
tan δ	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<sub>amb</sub> = 20 °C, P = 86 kPa to 106 kPa, RH = 45 % to 75 %.

**ORDERING EXAMPLE**

Electrolytic capacitor 013 series

100 µF / 16 V; ± 20 %

Nominal case size: Ø 8.2 mm x 11 mm; Form TFA

Ordering Code: MAL201335101E3

Former 12NC: 2222 013 35101

Table 1

ELECTRICAL DATA AND ORDERING INFORMATION														
U <sub>R</sub> (V)	C <sub>R</sub> 100 Hz (µF)	NOMINAL CASE SIZE Ø D x L (mm)	I <sub>R</sub> 100 Hz 85 °C (mA)	I <sub>L2</sub> 2 min (µA)	tan δ 100 Hz	Z 10 kHz (Ω)	ORDERING CODE MAL2013.....							
							BULK PACKAGING				TAPED AMMOPACK			
							LONG LEADS		CUT LEADS		FORM TFA		FORM TNA	
							FORM CA	F (mm)	FORM CB	F (mm)	FORM TFA	F (mm)	FORM TNA	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	47	5 x 11	75	1.0	0.16	2.8	54479E3	2.5	-	-	34479E3	5.0	74479E3	2.5
	68	5 x 11	90	1.4	0.16	2.5	54689E3	2.5	-	-	34689E3	5.0	74689E3	2.5
	100	5 x 11	110	2.0	0.16	1.7	54101E3	2.5	-	-	34101E3	5.0	74101E3	2.5
	220	8.2 x 11	190	4.4	0.16	0.9	54221E3	5.0	64221E3	5.0	34221E3	5.0	-	-
16	33	5 x 11	70	1.1	0.13	2.8	55339E3	2.5	-	-	35339E3	5.0	75339E3	2.5
	47	5 x 11	85	1.5	0.13	2.1	55479E3	2.5	-	-	35479E3	5.0	75479E3	2.5
	100	8.2 x 11	150	3.2	0.13	1.0	55101E3	5.0	65101E3	5.0	35101E3	5.0	-	-
25	2.2	5 x 11	10	0.7	0.06	18	56228E3	2.5	-	-	36228E3	5.0	76228E3	2.5
	3.3	5 x 11	18	0.7	0.06	12	56338E3	2.5	-	-	36338E3	5.0	76338E3	2.5
	4.7	5 x 11	25	0.7	0.06	8.5	56478E3	2.5	-	-	36478E3	5.0	76478E3	2.5
	10	5 x 11	50	0.7	0.06	4.0	56109E3	2.5	-	-	36109E3	5.0	76109E3	2.5
	22	5 x 11	75	1.1	0.08	2.7	56229E3	2.5	-	-	36229E3	5.0	76229E3	2.5
	47	8.2 x 11	130	2.4	0.08	1.3	56479E3	5.0	66479E3	5.0	36479E3	5.0	-	-
35	33	5 x 11	70	3.3	0.13	2.8	50339E3	2.5	-	-	30339E3	5.0	70339E3	2.5
	100	8.2 x 11	150	8.0	0.13	1.0	50101E3	5.0	60101E3	5.0	30101E3	5.0	-	-
50	2.2	5 x 11	20	1.2	0.06	18	51228E3	2.5	-	-	31228E3	5.0	71228E3	2.5
	3.3	5 x 11	32	1.3	0.06	12	51338E3	2.5	-	-	31338E3	5.0	71338E3	2.5
	4.7	5 x 11	38	1.5	0.06	8.5	51478E3	2.5	-	-	31478E3	5.0	71478E3	2.5
	10	5 x 11	55	2.0	0.06	4.0	51109E3	2.5	-	-	31109E3	5.0	71109E3	2.5
	22	5 x 11	75	3.2	0.08	2.7	51229E3	2.5	-	-	31229E3	5.0	71229E3	2.5
	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 $U_R$ : $U_R = 6.3 \text{ V to } 25 \text{ V}$ $U_R = 35 \text{ V and } 50 \text{ V}$	$I_{L2} \leq 0.002 C_R \times U_R$ or $0.7 \mu\text{A}$ , whichever is greater $I_{L2} \leq 0.002 C_R \times U_R + 1 \mu\text{A}$
<b>Inductance</b>		
Equivalent series inductance (ESL)	Case $\varnothing D \times L = 5 \text{ mm} \times 11 \text{ mm}$	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 1)	$ESR = \tan \delta / 2 \pi f C_R$

**CAPACITANCE (C)**

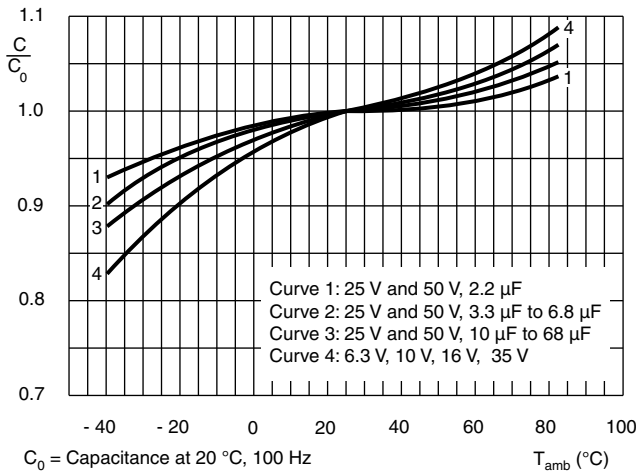


Fig. 6 - Typical multiplier of capacitance as a function of ambient temperature

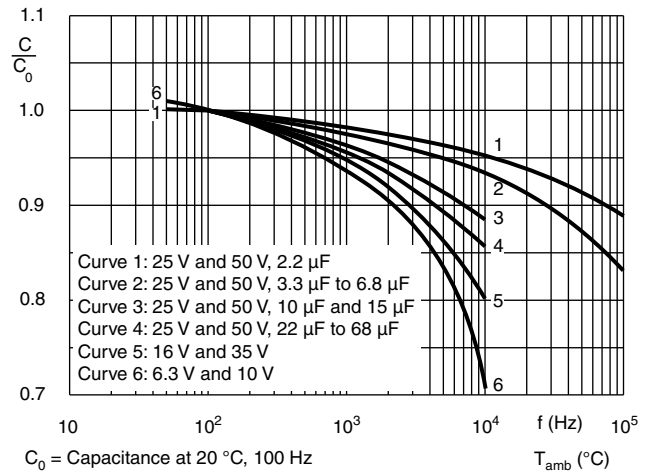


Fig. 7 - Typical multiplier of capacitance as a function of frequency

**LEAKAGE CURRENT**

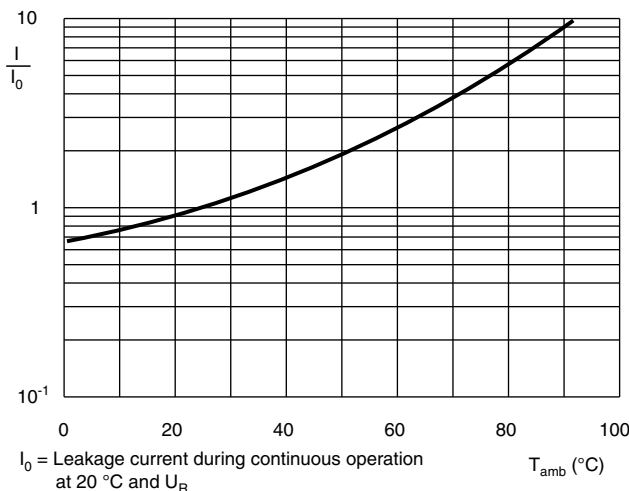


Fig. 8 - Typical multiplier of leakage current as a function of ambient temperature

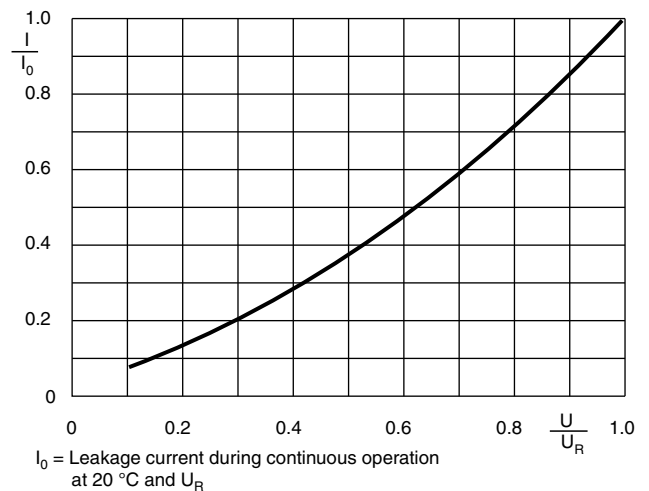


Fig. 9 - Typical multiplier of leakage current as a function of time

**LEAKAGE CURRENT**

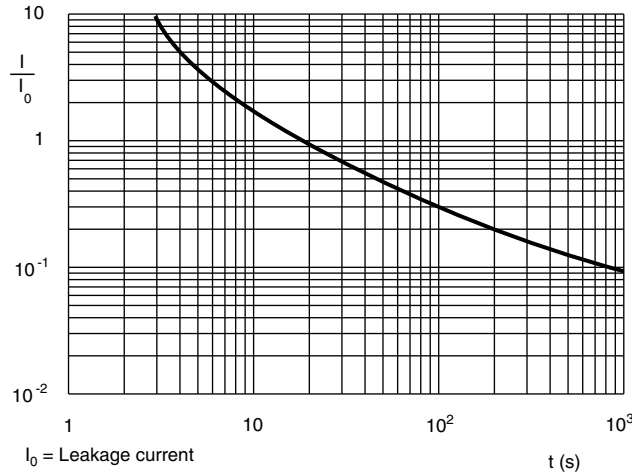


Fig. 10 - Typical multiplier of leakage current as a function of time

**RIPPLE CURRENT AND USEFUL LIFE**

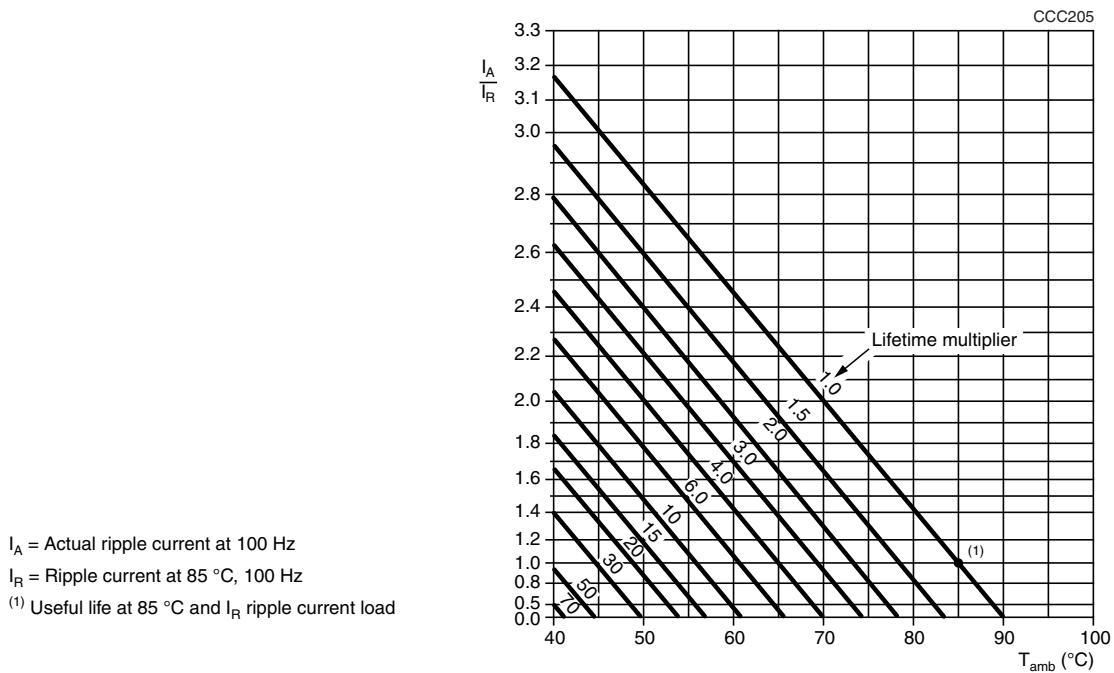


Fig. 11 - Multiplier of useful life as a function of ambient temperature and ripple current load

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 % $U_R > 6.3\text{ V}$ ; $\Delta C/C$ : $\pm 15\text{ }%$ $\tan \delta \leq 1.3 \times \text{spec. limit}$ $Z \leq 2 \times \text{spec. limit}$ $I_{L2} \leq \text{spec. limit}$
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 % $U_R > 6.3\text{ V}$ ; $\Delta C/C$ : $\pm 45\text{ }%$ $\tan \delta \leq 3 \times \text{spec. limit}$ $Z \leq 3 \times \text{spec. limit}$ $I_{L2} \leq \text{spec. limit}$ no short or open circuit total failure percentage: $\leq 1\text{ }%$
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 After test: $U_R$ to be applied for 30 min, 24 h to 48 h before measurement	$\Delta C/C$ , $\tan \delta$ , $Z$ : For requirements see "Endurance test" above $I_{L2} \leq 2 \times \text{spec. limit}$

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