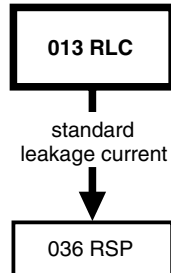


## Aluminum Capacitors Radial Low Leakage Current



Fig.1 Component outline



### 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
- Low leakage current, low energy consumption
- Lead (Pb)-free versions are RoHS compliant


**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

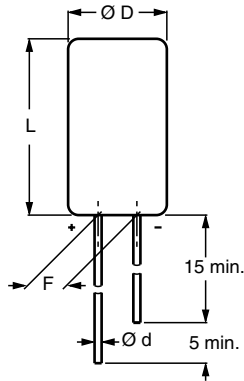
The capacitors are marked (where possible) with the following information:

- Rated capacitance (in  $\mu\text{F}$ )
- 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 (013)

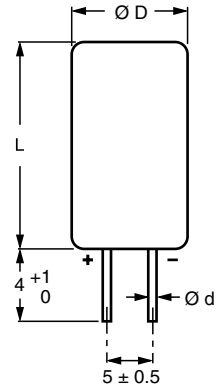
QUICK REFERENCE DATA	
DESCRIPTION	VALUE
Nominal case sizes ( $\varnothing D \times L$ in mm)	5 x 11 and 8.2 x 11
Rated capacitance range, $C_R$	0.47 to 470 $\mu\text{F}$
Tolerance on $C_R$	$\pm 20\%$ ; $\pm 10\%$ on request
Rated voltage range, $U_R$	6.3 to 50 V
Category temperature range	- 40 to + 85 °C
Leakage current after 2 minutes:  $U_R = 6.3$ to 25 V  $U_R = 35$ and 50 V	  0.002 $C_R \times U_R$ or 0.7 $\mu\text{A}$ , whichever is greater  0.002 $C_R \times U_R + 1 \mu\text{A}$
Endurance test at 85 °C	2000 hours
Useful life at 105 °C	750 hours
Useful life at 85 °C	3000 hours
Useful life at 40 °C, 1.4 x $I_R$ applied	80 000 hours
Shelf life at 0 V, 85 °C	500 hours
Based on sectional specification	IEC 60384-4/EN130300
Climatic category IEC 60068	40/085/56

SELECTION CHART FOR $C_R$ , $U_R$ AND RELEVANT NOMINAL CASE SIZES ( $\varnothing D \times L$ in mm)						
$C_R$ ( $\mu\text{F}$ )	$U_R$ (V)					
	6.3	10	16	25	35	50
0.47	-	-	-	-	-	5 x 11
1.0	-	-	-	5 x 11	-	5 x 11
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	-	-	-	-	-

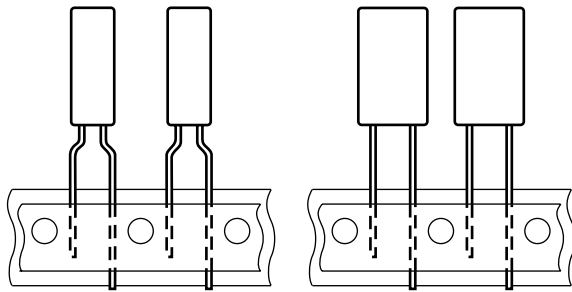
**DIMENSIONS** in millimeters **AND AVAILABLE FORMS**



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

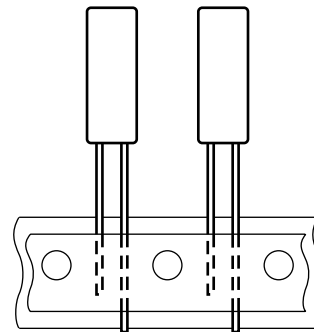


**Fig.3 Form CB: Cut leads**



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

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



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

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

<b>DIMENSIONS</b> in millimeters, <b>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**

Detailed tape dimensions see section 'PACKAGING'.



Aluminum Capacitors  
Radial Low Leakage Current

Vishay BCcomponents

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 minutes at $U_R$
$\tan \delta$	max. dissipation factor at 100 Hz
$Z$	max. impedance at 10 kHz and + 20 °C

**ORDERING EXAMPLE**

Electrolytic capacitor 013 series  
 100  $\mu$ F/16 V;  $\pm 20\%$   
 Nominal case size:  $\varnothing 8.2 \times 11$  mm; Form TFA  
 Ordering Code: MAL201335101E3  
 Former 12NC: 2222 013 35101

**Note**

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

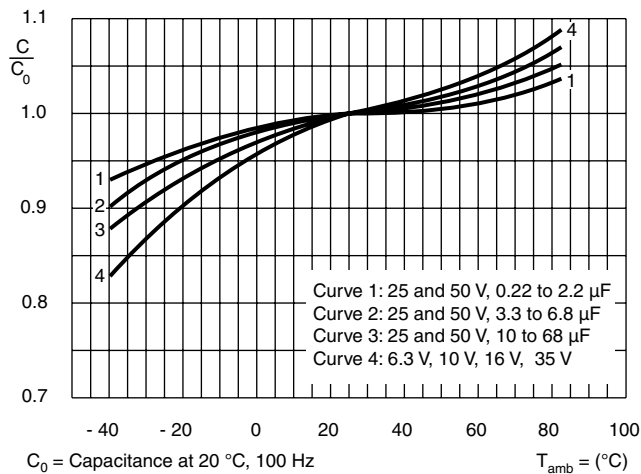
Table 1

ELECTRICAL DATA AND ORDERING INFORMATION																
$U_R$ (V)	$C_R$ 100 Hz ( $\mu$ F)	NOMINAL CASE SIZE $\varnothing D \times L$ (mm)	$I_R$ 100 Hz 85 °C (mA)	$I_{L2}$ 2 min ( $\mu$ A)	$\tan \delta$ 100 Hz	$Z$ 10 kHz ( $\Omega$ )	ORDERING CODE MAL2013.....									
							BULK PACKAGING				TAPED AMMOPACK					
							LONG LEADS		CUT LEADS		FORM TFA		FORM TNA		FORM F	
							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	1.0	5 x 11	5	0.7	0.06	40	56108E3	2.5	-	-	36108E3	5.0	76108E3	2.5		
	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	5.0	-	-	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	0.47	5 x 11	5	1.1	0.06	85	51477E3	2.5	-	-	31477E3	5.0	71477E3	2.5		
	1.0	5 x 11	10	1.1	0.06	40	51108E3	2.5	-	-	31108E3	5.0	71108E3	2.5		
	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	-	-		

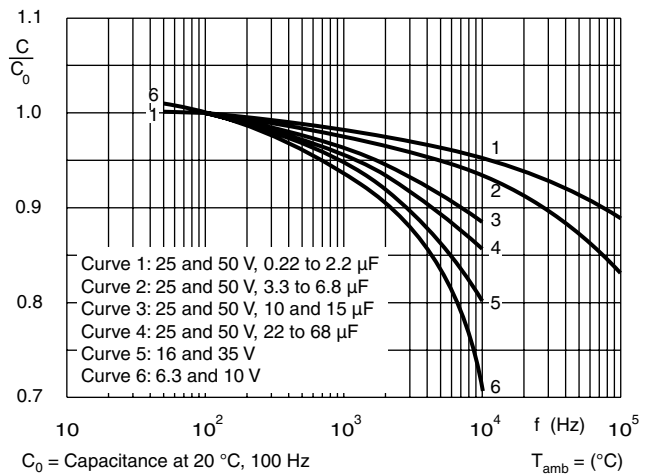


ADDITIONAL ELECTRICAL DATA		
PARAMETER	CONDITIONS	VALUE
<b>Voltage</b>		
Surge voltage		$U_s \leq 1.3 \times U_R$
Reverse voltage		$U_{rev} \leq 1 \text{ V}$
<b>Current</b>		
Leakage current	After 2 minutes at $U_R$ : $U_R = 6.3$ to $25 \text{ V}$ $U_R = 35$ and $50 \text{ V}$	$I_{L2} \leq 0.002 C_R \times U_R$ 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 $\varnothing D \times L = 5 \times 11 \text{ mm}$	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 1)	$ESR = \tan \delta / 2 \pi f C_R$

**CAPACITANCE (C)**

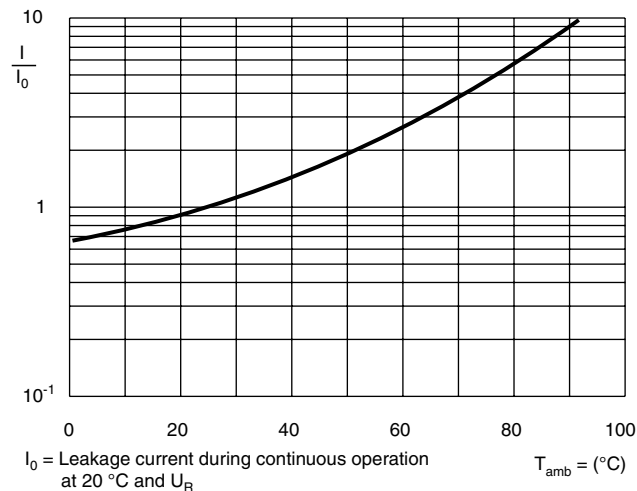


**Fig.6** Typical multiplier of capacitance as a function of ambient temperature

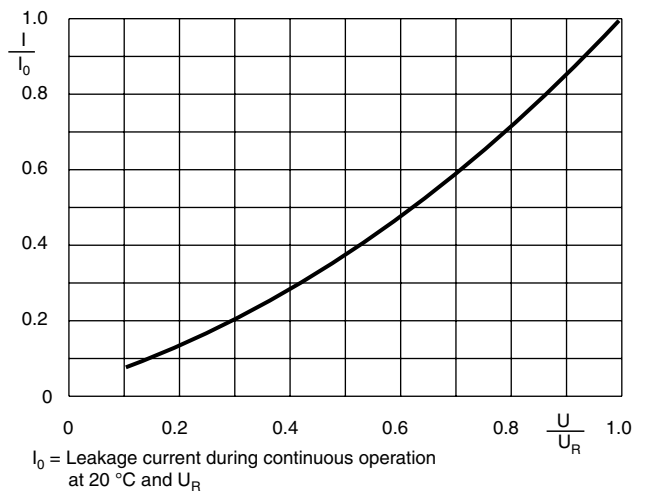


**Fig.7** Typical multiplier of capacitance as a function of frequency

**LEAKAGE CURRENT**

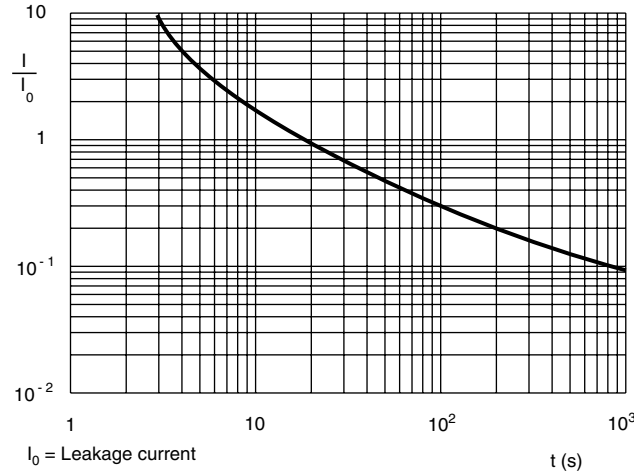


**Fig.8** Typical multiplier of leakage current as a function of ambient temperature



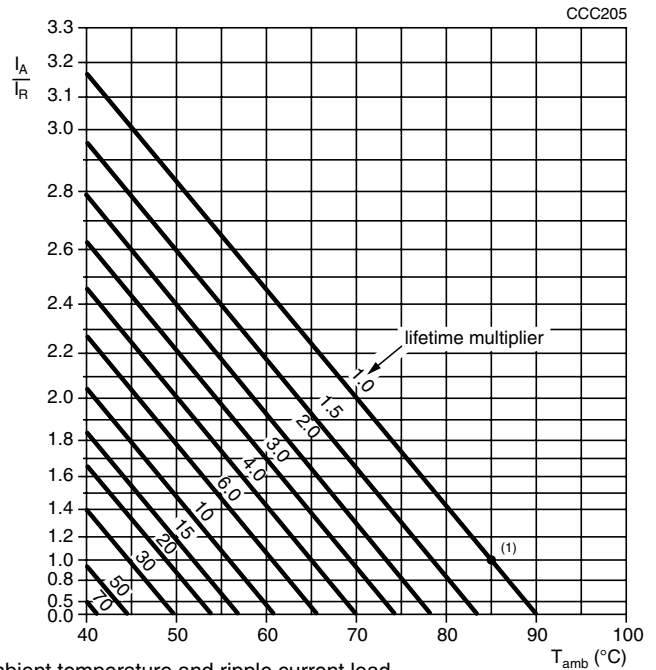
**Fig.9** Typical multiplier of leakage current as a function of time

**LEAKAGE CURRENT**



**Fig.10** Typical multiplier of leakage current a function of time

**RIPPLE CURRENT AND USEFUL LIFE**



$I_A$  = Actual ripple current at 100 Hz  
 $I_R$  = Ripple current at 85 °C, 100 Hz  
 (1) Useful life at 85 °C and  $I_R$  ripple current load

**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, 16 \text{ and } 35 V</math></b>	<b><math>U_R = 25 \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

<b>TEST PROCEDURES AND REQUIREMENTS</b>			
<b>TEST</b>		<b>PROCEDURE</b>	<b>REQUIREMENTS</b>
<b>NAME OF TEST</b>	<b>REFERENCE</b>		
Endurance	IEC 60384-4/ EN130300, subclause 4.13	$T_{amb} = 85\text{ }^{\circ}\text{C}$ ; $U_R$ applied; 2000 hours	$U_R \leq 6.3\text{ V}$ ; $\Delta C/C$ : + 15/- 30 % $U_R > 6.3\text{ V}$ ; $\Delta C/C$ : $\pm 15\%$ $\tan \delta \leq 1.3 \times \text{spec. limit}$ $Z \leq 2 \times \text{spec. limit}$ $I_{L2} \leq \text{spec. limit}$
Useful life	CECC 30301, subclause 1.8.1	$T_{amb} = 85\text{ }^{\circ}\text{C}$ ; $U_R$ and $I_R$ applied; 3000 hours	$U_R \leq 6.3\text{ V}$ ; $\Delta C/C$ : + 45/- 50 % $U_R > 6.3\text{ V}$ ; $\Delta C/C$ : $\pm 45\%$ $\tan \delta \leq 3 \times \text{spec. limit}$ $Z \leq 3 \times \text{spec. limit}$ $I_{L2} \leq \text{spec. limit}$ no short or open circuit total failure percentage: $\leq 1\%$
Shelf life (storage at high temperature)	IEC 60384-4/ EN130300, subclause 4.17	$T_{amb} = 85\text{ }^{\circ}\text{C}$ ; no voltage applied; 500 hours after test: $U_R$ to be applied for 30 minutes, 24 to 48 hours 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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