

Aluminum Electrolytic Capacitors Radial Low Leakage Current

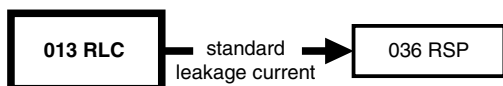


Fig. 1

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	2.2 μ F to 470 μ F
Tolerance on C_R	$\pm 20\%$; $\pm 10\%$ on request
Rated voltage range, U_R	6.3 V to 50 V
Category temperature range	-40 °C to +85 °C
Leakage current after 2 min: $U_R = 6.3$ V to 25 V	0.002 $C_R \times U_R$ or 0.7 μ A, whichever is greater
$U_R = 35$ V and 50 V	0.002 $C_R \times U_R + 1$ μ A
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_R 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


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

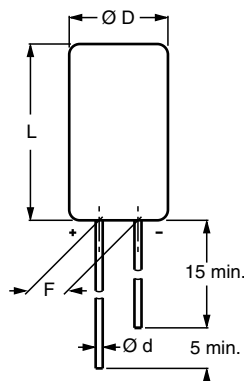
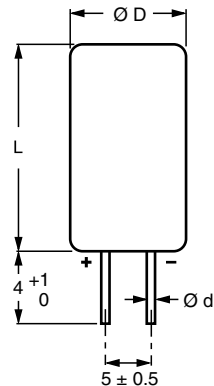
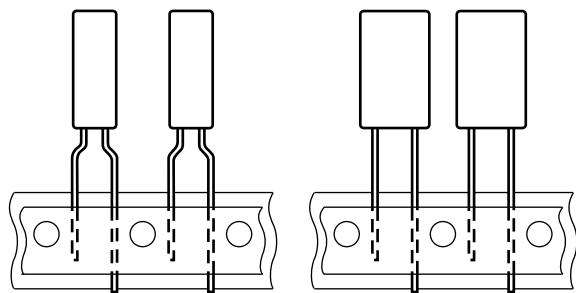
MARKING

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

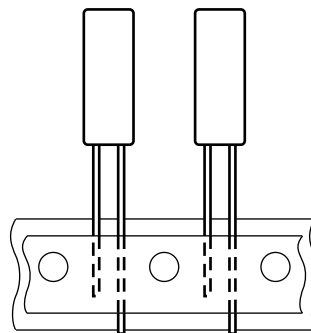
- Rated capacitance (in μ F)
- Tolerance on rated capacitance, code letter in accordance with IEC 60062 (M for $\pm 20\%$)
- Rated voltage (in V)
- Date code in accordance with IEC 60062
- Code indicating factory of origin
- Name of manufacturer
- “-”-sign on top to identify the negative terminal
- Series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

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

C_R (μ F)	U_R (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)

DIMENSIONS in millimeters, MASS AND PACKAGING QUANTITIES								
NOMINAL CASE SIZE $\varnothing D \times L$	CASE CODE	$\varnothing d$	$\varnothing D_{\text{max.}}$	$L_{\text{max.}}$	F	MASS (g)	PACKAGING QUANTITIES	
							FORM CA, CB	FORM TFA, TNA
5 x 11	11	0.5	5.5	12	2.5 ± 0.5	≈ 0.4	1000	2000
8.2 x 11	13	0.6	8.7	12	5.0 ± 0.5	≈ 1.1	1000	1000

Note

- For detailed tape dimensions, please see 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 kPa , $RH = 45\%$ to 75% .

Table 1

ELECTRICAL DATA AND ORDERING INFORMATION														
U _R (V)	C _R 100 Hz (μF)	NOMINAL CASE SIZE Ø D x L (mm)	I _R 100 Hz 85 °C (mA)	I _{L2} 2 min (μA)	tan δ 100 Hz	Z 10 kHz (Ω)	ORDERING CODE MAL2013.....							
							BULK PACKAGING				TAPED AMMOPACK			
							LONG LEADS		CUT LEADS					
							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	-	-

ORDERING EXAMPLE

Electrolytic capacitor 013 series

100 μF / 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

ADDITIONAL ELECTRICAL DATA		
PARAMETER	CONDITIONS	VALUE
Voltage		
Surge voltage		$U_s \leq 1.3 \times U_R$
Reverse voltage		$U_{rev} \leq 1 \text{ V}$
Current		
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 $I_{L2} \leq 0.002 C_R \times U_R + 1 \mu\text{A}$
Inductance		
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
Resistance		
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)

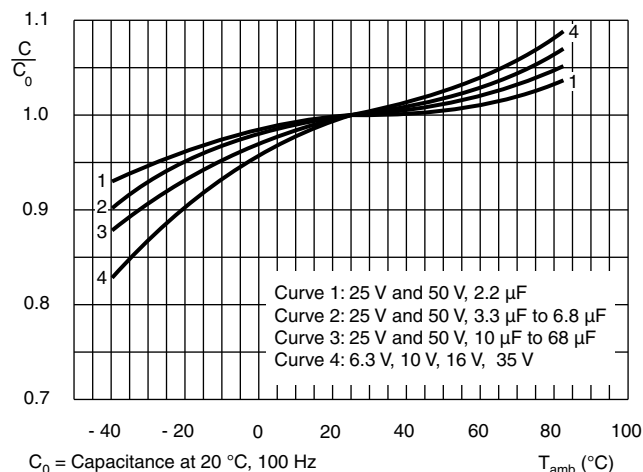


Fig. 6 - Typical multiplier of capacitance as a function of ambient temperature

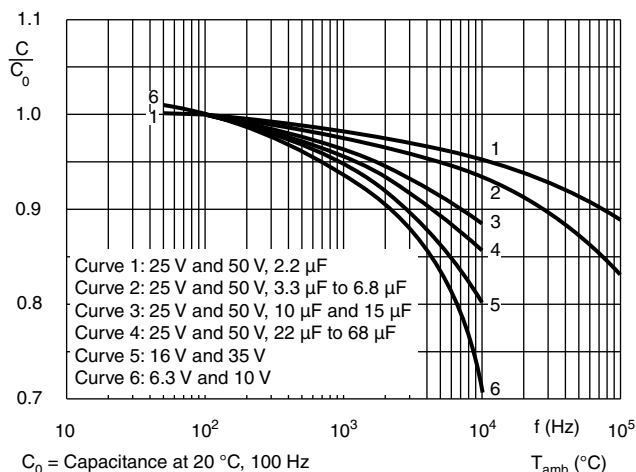


Fig. 7 - Typical multiplier of capacitance as a function of frequency

LEAKAGE CURRENT

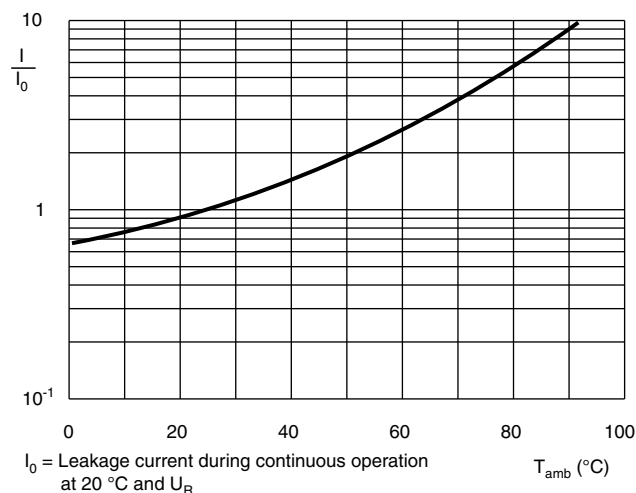


Fig. 8 - Typical multiplier of leakage current as a function of ambient temperature

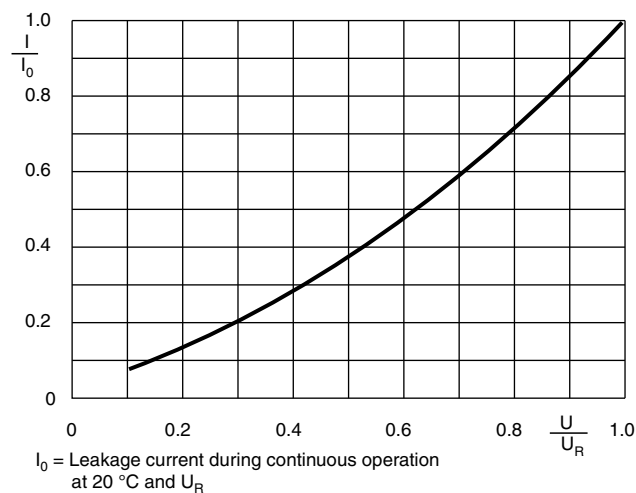


Fig. 9 - Typical multiplier of leakage current as a function of time

LEAKAGE CURRENT

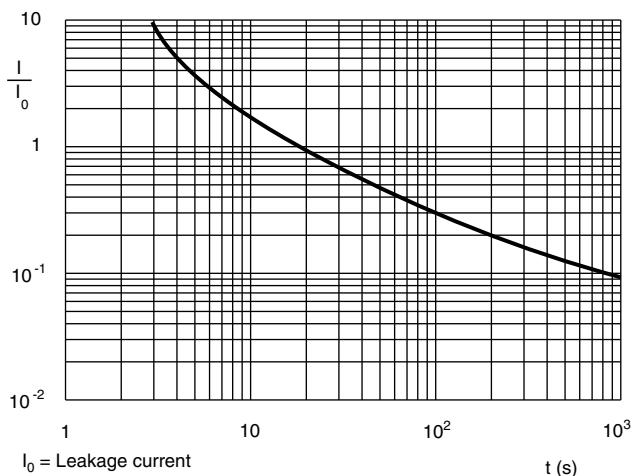


Fig. 10 - Typical multiplier of leakage current as a function of time

RIPPLE CURRENT AND USEFUL LIFE

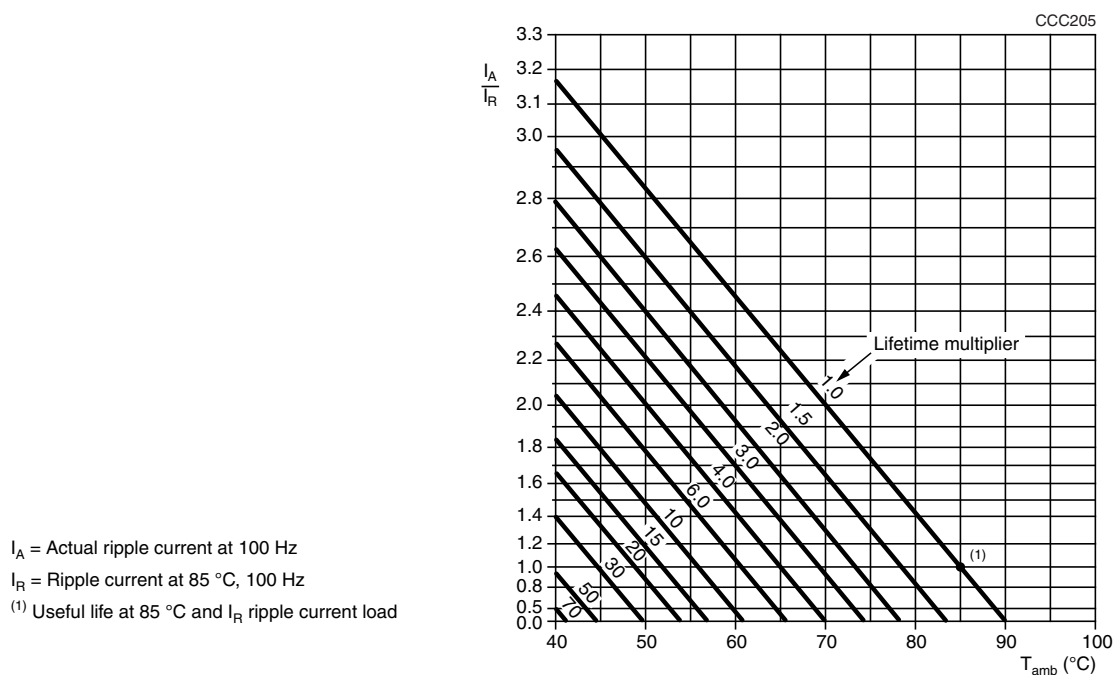


Fig. 11 - Multiplier of useful life as a function of ambient temperature and ripple current load

Table 2

MULTIPLIER OF RIPPLE CURRENT (I_R) AS A FUNCTION OF FREQUENCY			
FREQUENCY (Hz)	I_R MULTIPLIER		
	$U_R = 6.3 \text{ V}$	$U_R = 10 \text{ V, } 16 \text{ V, and } 35 \text{ V}$	$U_R = 25 \text{ V and } 50 \text{ V}$
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 $I_{L2} \leq 2 \times \text{spec. limit}$

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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