Aluminum Capacitors
Radial Low Leakage Current

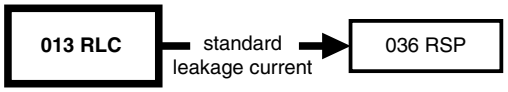


Fig. 1

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

Pb-free

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)

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_R	0.47 µF to 470 µF
Tolerance on C_R	± 20 %; ± 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 U_R = 35 V and 50 V	 0.002 C_R x U_R or 0.7 µA, whichever is greater 0.002 C_R x U_R + 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_R applied	80 000 h
Shelf life at 0 V, 85 °C	500 h
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 (Ø D x L in mm)

C_R (µF)	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**

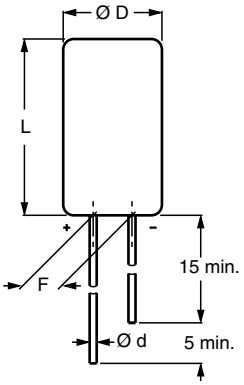


Fig. 2 - **Form CA:** Long leads

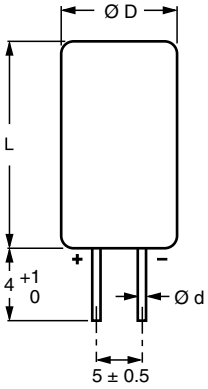
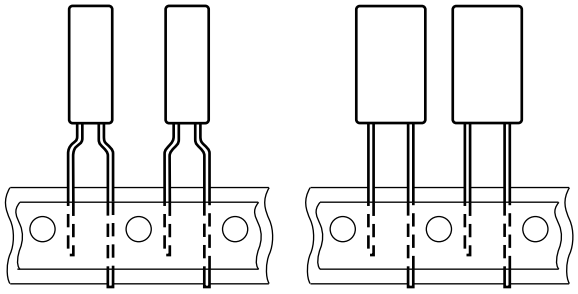
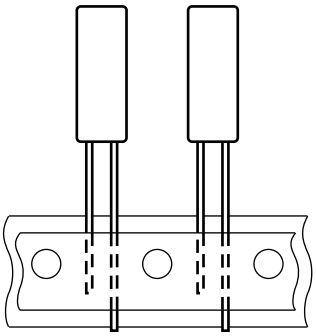


Fig. 3 - **Form CB:** Cut leads



Case Ø D x L = 5 mm x 11 mm and 8.2 mm x 11 mm
Pitch F = 5 mm

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



Case Ø D x L = 5 mm x 11 mm only
Pitch F = 2.5 mm

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

DIMENSIONS in millimeters, **MASS AND PACKAGING QUANTITIES**								
NOMINAL CASE SIZE Ø D x L	**CASE CODE**	**Ø d**	**Ø $D_{max.}$**	**$L_{max.}$**	**F**	**MASS (g)**	**PACKAGING QUANTITIES**	
							FORM CA, CB	**FORM TFA, TNA**
5 x 11	11	0.5	5.5	12	2.5 ± 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 ± 20 %
I_R	Rated RMS ripple current at 100 Hz, 85 °C
I_{L2}	Max. leakage current after 2 min at U_R
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_{amb} = 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_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	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	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	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**
Voltage		
Surge voltage		$U_s \leq 1.3 \times U_R$
Reverse voltage		$U_{rev} \leq 1$ V
Current		
Leakage current	After 2 min at U_R: U_R = 6.3 V to 25 V U_R = 35 V and 50 V	 $I_{L2} \leq 0.002\ C_R \times U_R$ or 0.7 µA, whichever is greater $I_{L2} \leq 0.002\ C_R \times U_R + 1$ µA
Inductance		
Equivalent series inductance (ESL)	Case Ø D x L = 5 mm x 11 mm	Typ. 13 nH
	Case Ø D x L = 8.2 mm x 11 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)

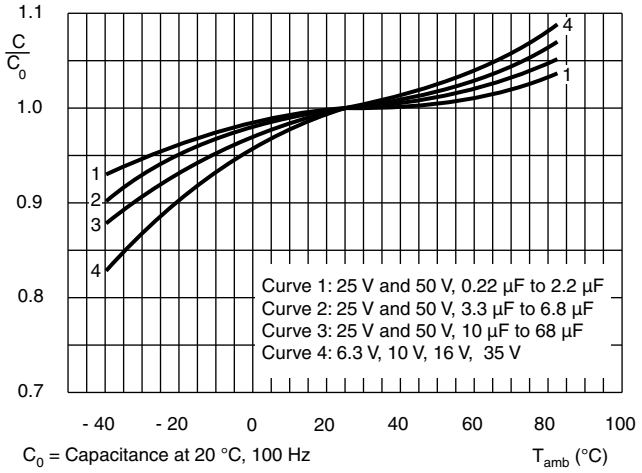


Fig. 6 - Typical multiplier of capacitance as a function of ambient temperature

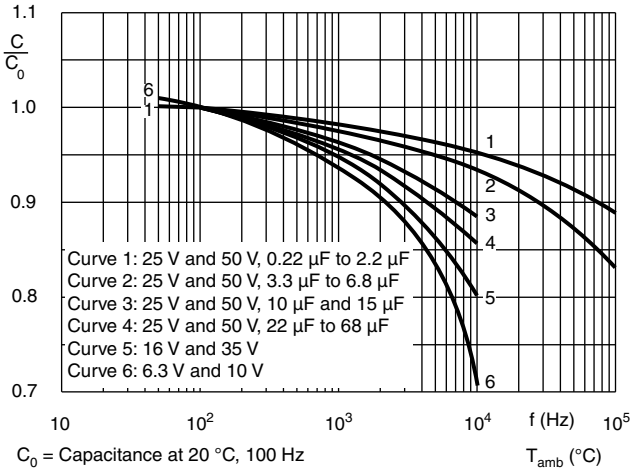


Fig. 7 - Typical multiplier of capacitance as a function of frequency

LEAKAGE CURRENT

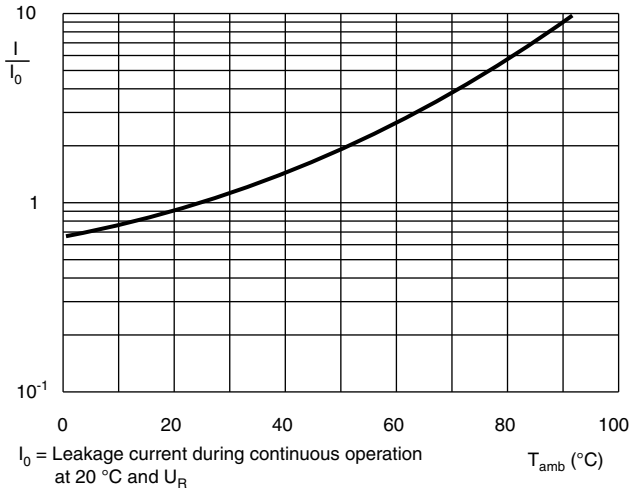


Fig. 8 - Typical multiplier of leakage current as a function of ambient temperature

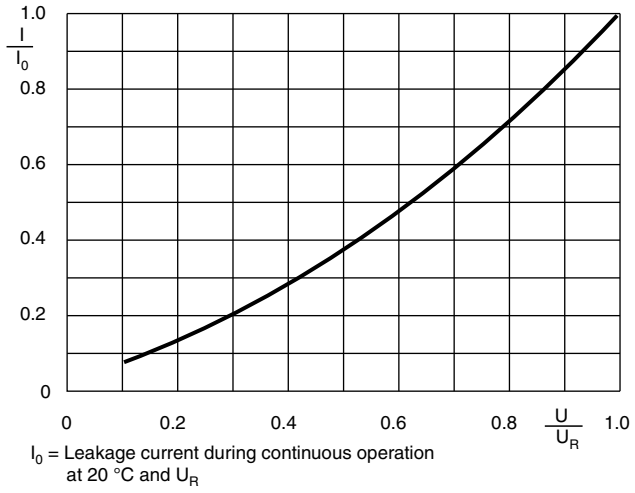


Fig. 9 - Typical multiplier of leakage current as a function of time

LEAKAGE CURRENT

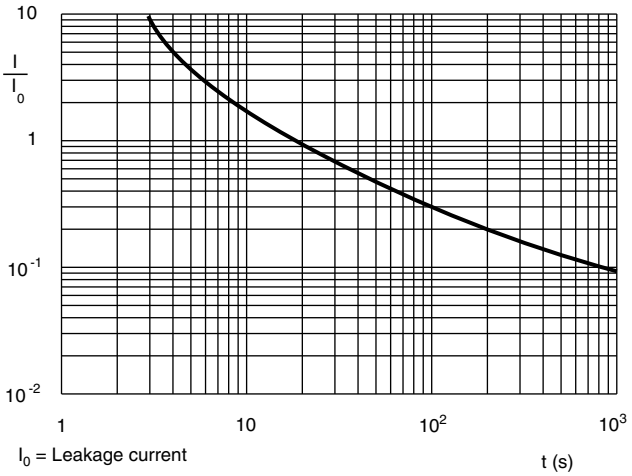
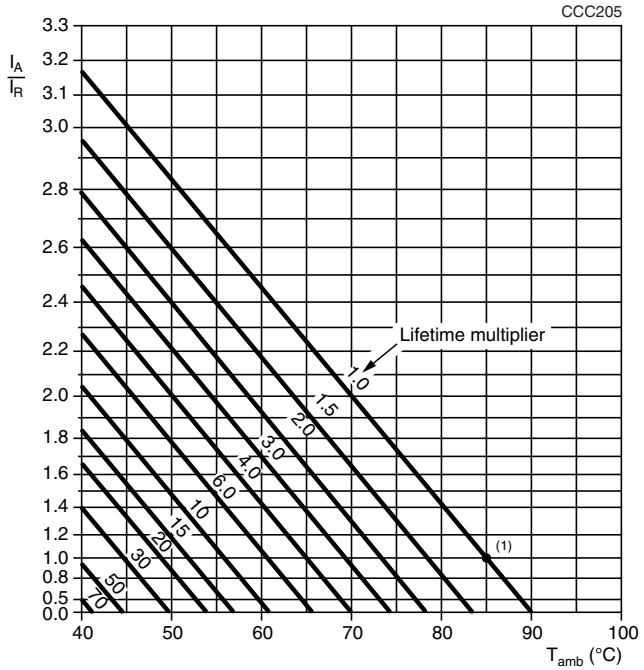


Fig. 10 - Typical multiplier of leakage current as a function of time

RIPPLE CURRENT AND USEFUL LIFE



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

MULTIPLIER OF RIPPLE CURRENT (I_R) AS A FUNCTION OF FREQUENCY			
FREQUENCY (Hz)	I_R MULTIPLIER		
	U_R = 6.3 V	U_R = 10 V, 16 V and 35 V	U_R = 25 V and 50 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
≥ 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 °C; U_R applied; 2000 h	$U_R \leq 6.3$ V; $\Delta C/C$: + 15 %/- 30 % $U_R > 6.3$ V; $\Delta C/C$: ± 15 % tan $\delta \leq 1.3$ x spec. limit $Z \leq 2$ x spec. limit $I_{L2} \leq$ spec. limit
Useful life	CECC 30301, subclause 1.8.1	T_{amb} = 85 °C; U_R and I_R applied; 3000 h	$U_R \leq 6.3$ V; $\Delta C/C$: + 45 %/- 50 % $U_R > 6.3$ V; $\Delta C/C$: ± 45 % tan $\delta \leq 3$ x spec. limit $Z \leq 3$ x spec. limit $I_{L2} \leq$ spec. limit no short or open circuit total failure percentage: ≤ 1 %
Shelf life (storage at high temperature)	IEC 60384-4/ EN130300, subclause 4.17	T_{amb} = 85 °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 δ, Z: For requirements see “Endurance test” above $I_{L2} \leq 2$ x spec. limit

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