Aluminum Capacitors
Radial Low Impedance

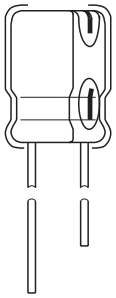
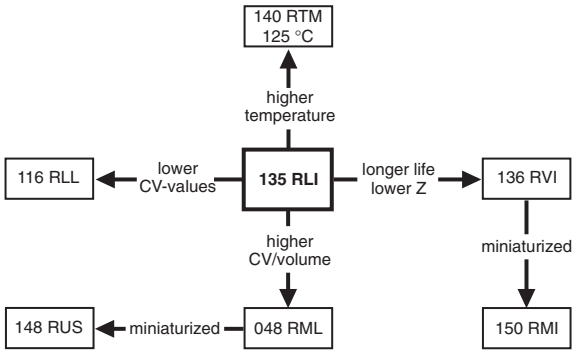


Fig.1 Component outline.



FEATURES

- Polarized aluminum electrolytic capacitors, non-solid electrolyte
- Radial leads, cylindrical aluminum case with pressure relief, insulated with a blue vinyl sleeve
- Charge and discharge proof
- Long useful life: 1500 to 2500 hours at 105 °C
- Low ESR, low impedance, high ripple current capability
- Lead (Pb)-free versions are RoHS compliant.

Pb-free Available

RoHS* COMPLIANT

APPLICATIONS

- General industrial, EDP, telecommunication and audio-video
- Smoothing, filtering, buffering in SMPS and DC/DC converters.

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.
- Upper category temperature (105 °C).
- Negative terminal identification.
- Series number (135).

QUICK REFERENCE DATA		
DESCRIPTION	VALUE	
Nominal case sizes (∅D × L in mm)	8 × 12 to 8 × 20	10 × 12 to 18 × 40
Rated capacitance range, C_R	22 to 10000 μF	
Tolerance on C_R	±20%	
Rated voltage range, U_R	6.3 to 100 V	
Category temperature range	–55 to +105 °C	
Endurance test at 105 °C	1000 hours	2000 hours
Useful life at 105 °C	1500 hours	2500 hours
Useful life at 40 °C, 1.3 × I_R applied	150000 hours	250000 hours
Shelf life at 0 V, 105 °C	1000 hours	1000 hours
Based on sectional specification	IEC 60384-4/EN130300	
Climatic category IEC 60068	55/105/56	

SELECTION CHART FOR C_R, U_R AND RELEVANT NOMINAL CASE SIZES (ØD x L in mm)

C_R (μF)	U_R (V)							
	6.3	10	16	25	35	50	63	100
22	–	–	–	–	–	–	–	8 × 12
47	–	–	–	–	–	–	8 × 12	–
100	–	–	–	–	8 × 12	10 × 16	–	12.5 × 20
220	–	–	8 × 12	8 × 15	8 × 20	10 × 25	12.5 × 20	16 × 25
330	–	–	8 × 15	–	10 × 20	12.5 × 20	–	16 × 31
	–	–	–	–	–	–	–	18 × 25

* Pb containing terminations are not RoHS compliant, exemptions may apply

SELECTION CHART FOR C_R, U_R AND RELEVANT NOMINAL CASE SIZES (ØD x L in mm)								
C_R (µF)	U_R (V)							
	6.3	**10**	**16**	**25**	**35**	**50**	**63**	**100**
470	10 × 12	8 × 15	8 × 20	10 × 20	10 × 30	12.5 × 25	16 × 25	16 × 40
	–	–	–	–	–	18 × 15	–	–
680	10 × 16	–	10 × 20	–	12.5 × 25	–	16 × 31	18 × 40
1000	–	12.5 × 16	10 × 30	12.5 × 25	12.5 × 31	16 × 31	16 × 40	–
	–	–	–	–	16 × 20	–	–	–
1500	–	10 × 30	12.5 × 25	12.5 × 31	12.5 × 40	16 × 40	–	–
2200	12.5 × 20	12.5 × 25	12.5 × 31	12.5 × 40	16 × 35	18 × 40	–	–
	–	18 × 15	16 × 20	18 × 20	18 × 31	–	–	–
3300	–	12.5 × 35	–	16 × 35	18 × 40	–	–	–
	–	16 × 20	–	18 × 31	–	–	–	–
4700	–	16 × 31	16 × 35	18 × 40	–	–	–	–
	–	18 × 25	18 × 31	–	–	–	–	–
6800	16 × 31	16 × 35	18 × 35	–	–	–	–	–
10000	18 × 31	18 × 40	–	–	–	–	–	–

DIMENSIONS in millimeters **AND AVAILABLE FORMS**

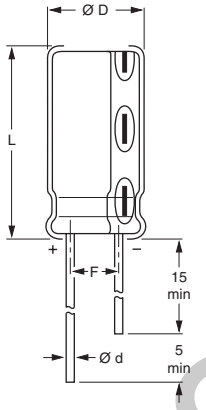


Fig.2 **Form CA**: Long leads.

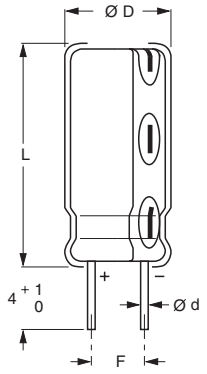
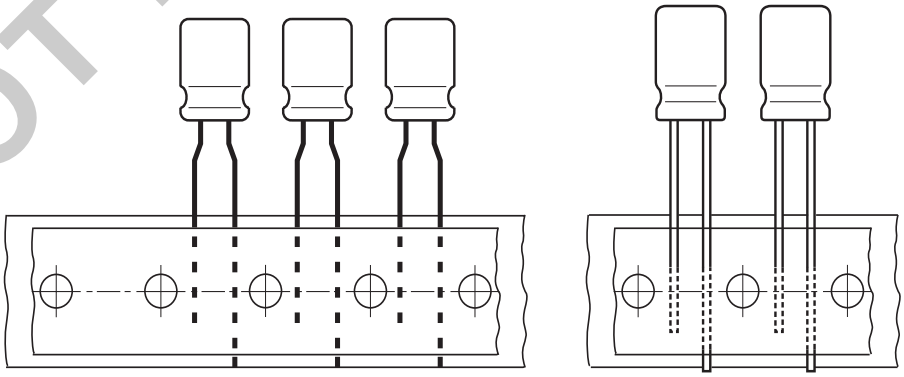


Fig.3 **Form CB**: Cut leads.



Formed leads for ØD=8mm with pitch F = 5mm

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

Table 1

DIMENSIONS in millimeters, **MASS AND PACKAGING QUANTITIES**									
NOMINAL CASE SIZE ∅D × L	**CASE CODE**	**∅d**	**∅D_{max}**	**L_{max}**	**F**	**MASS (g)**	**PACKAGING QUANTITIES**		
							FORM CA	**FORM CB**	**FORM TFA**
8 × 12	13	0.6	8.5	13.0	3.5 ±0.5	≈1.1	1000	2000	1000
8 × 15	13L	0.6	8.5	16.0	3.5 ±0.5	≈1.3	1000	1000	1000
8 × 20	13LL	0.6	8.5	21.0	3.5 ±0.5	≈1.5	1000	1000	1000
10 × 12	14	0.6	10.5	13.5	5 ±0.5	≈1.6	1000	500	800
10 × 16	15	0.6	10.5	17.5	5 ±0.5	≈1.9	500	500	800
10 × 20	16	0.6	10.5	22.0	5 ±0.5	≈2.2	500	500	800
10 × 25	16L	0.6	10.5	27.0	5 ±0.5	≈3.0	1000	1500	800
10 × 30	16LL	0.6	10.5	32.0	5 ±0.5	≈3.5	1000	750	–
12.5 × 16	17a	0.6	13.0	17.5	5 ±0.5	≈2.7	1000	1500	500
12.5 × 20	17	0.6	13.0	22.0	5 ±0.5	≈4.0	500	500	500
12.5 × 25	18	0.6	13.0	27.0	5 ±0.5	≈5.0	250	250	500
12.5 × 31	18L	0.6	13.0	33.5	5 ±0.5	≈5.5	1000	750	–
12.5 × 35	18LL	0.6	13.0	37.5	5 ±0.5	≈6.0	500	750	–
12.5 × 40	1240	0.6	13.0	42.0	5 ±0.5	≈7.5	500	750	–
16 × 20	19a	0.8	16.5	22.0	7.5 ±0.5	≈6.0	250	250	250
16 × 25	19	0.8	16.5	27.0	7.5 ±0.5	≈8.0	250	250	250
16 × 31	20	0.8	16.5	33.5	7.5 ±0.5	≈9.0	100	100	250
16 × 35	21	0.8	16.5	37.5	7.5 ±0.5	≈11.0	100	100	–
16 × 40	21L	0.8	16.5	42.0	7.5 ±0.5	≈13.0	250	500	–
18 × 15	1815	0.8	18.5	17.0	7.5 ±0.5	≈6.0	500	500	–
18 × 20	1820	0.8	18.5	22.0	7.5 ±0.5	≈8.0	100	100	–
18 × 25	1825	0.8	18.5	27.0	7.5 ±0.5	≈10.0	100	100	–
18 × 31	1831	0.8	18.5	33.5	7.5 ±0.5	≈12.5	100	100	–
18 × 35	22	0.8	18.5	37.5	7.5 ±0.5	≈14.5	100	100	–
18 × 40	23	0.8	18.5	42.0	7.5 ±0.5	≈16.0	250	500	–

Note

1. Detailed tape dimensions see section ‘PACKAGING’.

ELECTRICAL DATA	
SYMBOL	**DESCRIPTION**
C_R	rated capacitance at 120 Hz, tolerance ± 20%
I_R	rated RMS ripple current at 100 kHz, 105 °C
I_{L2}	max. leakage current after 2 minutes at U_R
Tan δ	max. dissipation factor at 120 Hz
Z	max. impedance at 100 kHz

Note

1. Unless otherwise specified, all electrical values in Table 2 apply at T_{amb} = 20 °C, P = 86 to 106 kPa, RH = 45 to 75%.

ORDERING EXAMPLE*

Electrolytic capacitor 135 series

1000 μF/16V; ±20%

Nominal case size: ∅10 × 30 mm; Form CB

Catalog number: 2222 135 65102

* To ensure delivery of lead (Pb)-free parts during the transition period, please contact your Vishay sales agent.

Table 2

ELECTRICAL DATA AND ORDERING INFORMATION

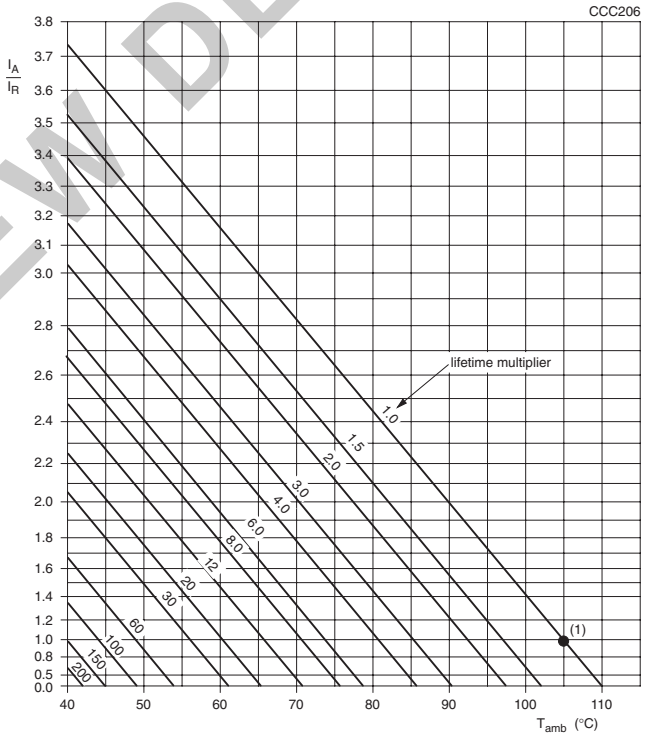
U_R (V)	C_R 120 Hz (μF)	NOMINAL CASE SIZE ∅D × L (mm)	I_R 100 kHz 105 °C (mA)	I_{L2} 2 min (μA)	Tan δ 120 Hz	Z 100 kHz (Ω)	CATALOG NUMBER 2222 135					
							BULK PACKAGING				TAPED	
							LONG LEADS		CUT LEADS			
							FORM CA	F (mm)	FORM CB	F (mm)	FORM TFA	F (mm)
6.3	470	10 × 12	510	30	0.22	0.28	53471	5.0	63471	5.0	33471	5.0
	680	10 × 16	640	43	0.22	0.22	53681	5.0	63681	5.0	33681	5.0
	2200	12.5 × 20	1100	140	0.24	0.089	53222	5.0	63222	5.0	33222	5.0
	6800	16 × 31	1800	430	0.32	0.055	53682	7.5	63682	7.5	33682	7.5
	10000	18 × 31	2000	630	0.40	0.047	53103	7.5	63103	7.5	–	–
10	470	8 × 15	500	47	0.19	0.24	54471	3.5	84471	3.5	34471	5.0
	1000	12.5 × 16	970	100	0.19	0.12	54102	5.0	64102	5.0	34102	5.0
	1500	10 × 30	1200	150	0.19	0.093	54152	5.0	64152	5.0	–	–
	2200	12.5 × 25	1300	220	0.21	0.073	54222	5.0	64222	5.0	34222	5.0
	2200	18 × 15	1300	220	0.21	0.080	90001	7.5	90002	7.5	–	–
	3300	12.5 × 35	1800	330	0.23	0.052	54332	5.0	64332	5.0	–	–
	3300	16 × 20	1400	330	0.23	0.075	90025	7.5	90026	7.5	90042	7.5
	4700	16 × 31	1800	470	0.25	0.054	54472	7.5	64472	7.5	34472	7.5
	4700	18 × 25	1800	470	0.25	0.053	90003	7.5	90004	7.5	–	–
	6800	16 × 35	2000	680	0.29	0.046	54682	7.5	64682	7.5	–	–
	10000	18 × 40	2500	1000	0.37	0.037	54103	7.5	64103	7.5	–	–
16	220	8 × 12	400	35	0.16	0.33	55221	3.5	85221	3.5	35221	5.0
	330	8 × 15	500	53	0.16	0.23	55331	3.5	85331	3.5	35331	5.0
	470	8 × 20	650	75	0.16	0.18	55471	3.5	85471	3.5	35471	5.0
	680	10 × 20	860	110	0.16	0.14	55681	5.0	65681	5.0	35681	5.0
	1000	10 × 30	1200	160	0.16	0.091	55102	5.0	65102	5.0	–	–
	1500	12.5 × 25	1300	240	0.16	0.072	55152	5.0	65152	5.0	35152	5.0
	2200	12.5 × 31	1500	350	0.18	0.063	55222	5.0	65222	5.0	–	–
	2200	16 × 20	1400	350	0.18	0.073	90007	7.5	90008	7.5	90043	7.5
	4700	16 × 35	2000	750	0.22	0.046	55472	7.5	65472	7.5	–	–
	4700	18 × 31	2000	750	0.22	0.046	90009	7.5	90011	7.5	–	–
	6800	18 × 35	2200	1100	0.26	0.040	55682	7.5	65682	7.5	–	–

ELECTRICAL DATA AND ORDERING INFORMATION

U_R (V)	C_R 120 Hz (µF)	NOMINAL CASE SIZE ∅D × L (mm)	I_R 100 kHz 105 °C (mA)	I_{L2} 2 min (µA)	Tan δ 120 Hz	Z 100 kHz (Ω)	CATALOG NUMBER 2222 135					
							BULK PACKAGING				TAPED	
							LONG LEADS		CUT LEADS			
							FORM CA	F (mm)	FORM CB	F (mm)	FORM TFA	F (mm)
25	220	8 × 15	500	55	0.14	0.23	56221	3.5	86221	3.5	36221	5.0
	470	10 × 20	860	120	0.14	0.14	56471	5.0	66471	5.0	36471	5.0
	1000	12.5 × 25	1300	250	0.14	0.071	56102	5.0	66102	5.0	36102	5.0
	1500	12.5 × 31	1500	380	0.14	0.062	56152	5.0	66152	5.0	–	–
	2200	12.5 × 40	2000	550	0.16	0.044	56222	5.0	66222	5.0	–	–
	2200	18 × 20	1600	550	0.16	0.060	90012	7.5	90013	7.5	–	–
	3300	16 × 35	2000	830	0.18	0.045	56332	7.5	66332	7.5	–	–
	3300	18 × 31	2000	830	0.18	0.045	90014	7.5	90015	7.5	–	–
	4700	18 × 40	2500	1200	0.20	0.036	56472	7.5	66472	7.5	–	–
35	100	8 × 12	400	35	0.12	0.32	50101	3.5	80101	3.5	30101	5.0
	220	8 × 20	650	77	0.12	0.18	50221	3.5	80221	3.5	30221	5.0
	330	10 × 20	860	120	0.12	0.13	50331	5.0	60331	5.0	30331	5.0
	470	10 × 30	1200	160	0.12	0.089	50471	5.0	60471	5.0	–	–
	680	12.5 × 25	1300	240	0.12	0.070	50681	5.0	60681	5.0	30681	5.0
	1000	12.5 × 31	1500	350	0.12	0.061	50102	5.0	60102	5.0	–	–
	1000	16 × 20	1370	350	0.12	0.071	90016	7.5	90017	7.5	90044	7.5
	1500	12.5 × 40	2000	530	0.12	0.043	50152	5.0	60152	5.0	–	–
	2200	16 × 35	2000	770	0.14	0.044	50222	7.5	60222	7.5	–	–
	2200	18 × 31	2000	770	0.14	0.044	90018	7.5	90019	7.5	–	–
	3300	18 × 40	2500	1200	0.16	0.035	50332	7.5	60332	7.5	–	–
50	100	10 × 16	640	50	0.10	0.20	51101	5.0	61101	5.0	31101	5.0
	220	10 × 25	1000	110	0.10	0.11	51221	5.0	61221	5.0	31221	5.0
	330	12.5 × 20	1100	170	0.10	0.081	51331	5.0	61331	5.0	31331	5.0
	470	12.5 × 25	1300	240	0.10	0.068	51471	5.0	61471	5.0	31471	5.0
	470	18 × 15	1300	240	0.10	0.074	90021	7.5	90022	7.5	–	–
	1000	16 × 31	1800	500	0.10	0.050	51102	7.5	61102	7.5	31102	7.5
	1500	16 × 40	2300	750	0.10	0.035	51152	7.5	61152	7.5	–	–
	2200	18 × 40	2500	1100	0.12	0.034	51222	7.5	61222	7.5	–	–
63	47	8 × 12	300	30	0.08	0.56	58479	3.5	88479	3.5	38479	5.0
	220	12.5 × 20	890	140	0.08	0.16	58221	5.0	68221	5.0	38221	5.0
	470	16 × 25	1400	300	0.08	0.091	58471	7.5	68471	7.5	38471	7.5
	680	16 × 31	1800	430	0.08	0.065	58681	7.5	68681	7.5	38681	7.5
	1000	16 × 40	2200	630	0.08	0.049	58102	7.5	68102	7.5	–	–
100	22	8 × 12	310	22	0.07	0.53	59229	3.5	89229	3.5	39229	5.0
	100	12.5 × 20	890	100	0.07	0.15	59101	5.0	69101	5.0	39101	5.0
	220	16 × 25	1400	220	0.07	0.086	59221	7.5	69221	7.5	–	–
	330	16 × 31	1800	330	0.07	0.062	59331	7.5	69331	7.5	–	–
	330	18 × 25	1700	330	0.07	0.074	90023	7.5	90024	7.5	–	–
	470	16 × 40	2200	470	0.07	0.047	59471	7.5	69471	7.5	–	–
	680	18 × 40	2400	680	0.07	0.043	59681	7.5	69681	7.5	–	–

ADDITIONAL ELECTRICAL DATA		
PARAMETER	**CONDITIONS**	**VALUE**
Voltage		
Surge voltage		$U_s \leq 1.15\ U_R$
Reverse voltage		$U_{rev} \leq 1\ V$
Current		
Leakage current	after 1 minute at U_R	$I_{L1} \leq 0.03\ C_R \times U_R$
	after 2 minutes at U_R	$I_{L2} \leq 0.01\ C_R \times U_R$
Capacitance (C)		
Ratio of capacitance at 120 Hz	U_R = 6.3 V	$C_{-55\ °C}/C_{20\ °C} \geq 0.7$
	U_R = 10 to 100 V	$C_{-55\ °C}/C_{20\ °C} \geq 0.8$
Impedance (Z)		
Ratio of impedance at 120 Hz		$Z_{-55\ °C}/Z_{20\ °C} \leq 3$
Resistance		
Equivalent series resistance (ESR)	calculated from tan δ_{max} and C_R (see Table 2)	ESR = tan δ / $2\pi f C_R$

RIPPLE CURRENT AND USEFUL LIFE



I_A = actual ripple current at 100 kHz.
I_R = rated ripple current at 100 kHz, 105 °C.
(1) Useful life at 105 °C and I_R applied:
∅D = 8 mm: 1500 hours
∅D ≥ 10 mm: 2500 hours.

Fig.5 Multiplier of useful life as a function of ambient temperature and ripple current load.

Table 3

MULTIPLIER OF RIPPLE CURRENT (I_R) AS A FUNCTION OF FREQUENCY				
FREQUENCY (Hz)	**I_R MULTIPLIER**			
	22 µF	**33 to 330 µF**	**470 to 1 000 µF**	**>1 000 µF**
50	0.40	0.60	0.65	0.80
120	0.50	0.70	0.80	0.90
300	0.60	0.80	0.90	0.95
1000	0.80	0.90	0.98	0.98
10000	0.90	0.95	1.00	1.00
100000	1.00	1.00	1.00	1.00

Table 4

TEST PROCEDURES AND REQUIREMENTS			
TEST		**PROCEDURE (quick reference)**	**REQUIREMENTS**
NAME OF TEST	**REFERENCE**		
Endurance	IEC 60384-4/ EN130300 subclause 4.13	T_{amb} = 105 °C; U_R applied; ∅D = 8 mm: 1000 hours ∅D ≥ 10 mm: 2000 hours	ΔC/C: ±20% tan δ ≤ 2 × spec. limit I_{L2} ≤ spec. limit
Useful life	CECC 30301 subclause 1.8.1	T_{amb} = 105 °C; U_R and I_R applied; ∅D = 8 mm: 1500 hours ∅D ≥ 10 mm: 2500 hours	ΔC/C: ±50% tan δ ≤ 3 × spec. limit Z ≤ 3 × spec. limit I_{L2} ≤ spec. limit no short or open circuit total failure percentage: ≤ 1%
Shelf life (storage at high temperature)	IEC 60384-4/ EN130 300, subclause 4.17	T_{amb} = 105 °C; no voltage applied; 1000 hours after test: U_R to be applied for 30 minutes, 24 to 48 hours before measurement	ΔC/C: ±20% tan δ ≤ 1.5 × spec. limit I_{L2} ≤ spec. limit