Aluminum Capacitors
Radial Miniature Long Life

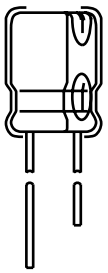
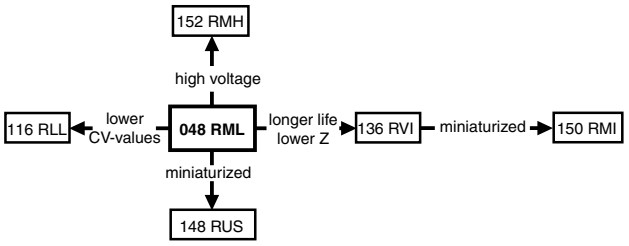


Fig.1 Component outline



QUICK REFERENCE DATA

DESCRIPTION	VALUE
Nominal case sizes (Ø D x L in mm)	10 x 12 to 18 x 35
Rated capacitance range, C_R	100 to 10 000 µF
Tolerance on C_R	± 20 %
Rated voltage range, U_R	6.3 to 63 V
Category temperature range	- 40 to + 105 °C
Endurance test at 105 °C	2000 hours
Useful life at 105 °C case Ø D = 10 and 12.5 mm case Ø D = 16 and 18 mm	 3000 hours 4000 hours
Useful life at 40 °C, 1.6 x I_R applied case Ø D = 10 and 12.5 mm case Ø D = 16 and 18 mm	 200 000 hours 260 000 hours
Shelf life at 0 V, 105 °C	1000 hours
Based on sectional specification	IEC 60384-4/EN130300
Climatic category IEC 60068	40/105/56

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
- Miniaturized, high CV-product per unit volume
- Very long useful life: 3000 to 4000 hours at 105 °C, high reliability
- Lead (Pb)-free versions are RoHS compliant

Pb-free
RoHS COMPLIANT

APPLICATIONS

- EDP, telecommunication, industrial, automotive and audio-video
- Smoothing, filtering, buffering in SMPS, timing
- Portable and mobile equipment (small size, low mass)

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 (048)

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	40	50	63
100	-	-	-	-	-	-	-	10 x 12
220	-	-	-	-	10 x 12	-	10 x 16	10 x 20
330	-	-	-	-	-	-	-	12.5 x 20
470	-	-	10 x 12	10 x 16	10 x 20	-	12.5 x 20	12.5 x 25
1000	-	10 x 16	10 x 20	12.5 x 20	12.5 x 25	-	16 x 25	16 x 31
2200	-	12.5 x 20	12.5 x 25	16 x 25	16 x 31	16 x 35	18 x 35	18 x 35
3300	-	12.5 x 25	16 x 25	16 x 31	18 x 35	18 x 35	18 x 35	-
4700	-	16 x 25	16 x 31	18 x 35	18 x 35	-	-	-
6800	16 x 25	16 x 31	16 x 35	-	-	-	-	-
10 000	16 x 35	18 x 35	18 x 35	-	-	-	-	-

For technical questions, contact: aluminumcaps1@vishay.com

DIMENSIONS in millimeters, **AND AVAILABLE FORMS**

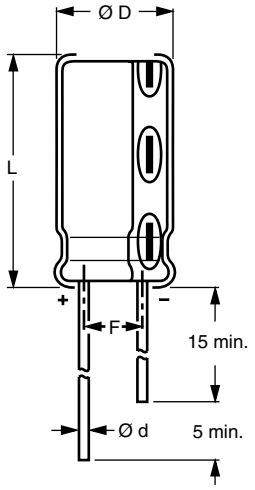


Fig.2 **Form CA**: Long leads

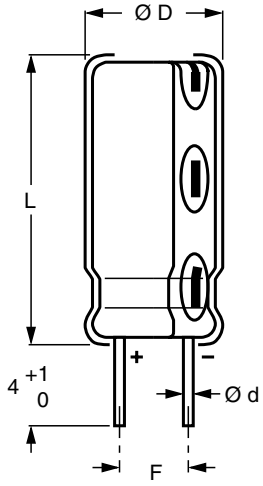


Fig.3 **Form CB**: Cut leads

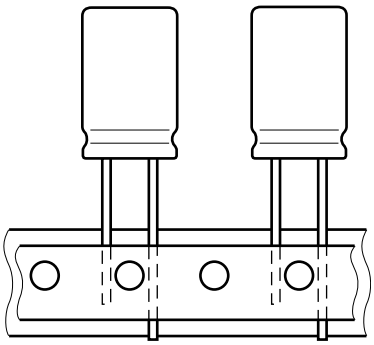


Fig.4 **Form TFA**: Taped in box (ammopack)

Table 1

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	Form CB	Form TFA
10 x 12	14	0.6	10.5	13.5	5.0 ± 0.5	≈ 1.6	1000	500	800
10 x 16	15	0.6	10.5	17.5	5.0 ± 0.5	≈ 1.9	500	500	800
10 x 20	16	0.6	10.5	22.0	5.0 ± 0.5	≈ 2.2	500	500	800
12.5 x 20	17	0.6	13.0	22.0	5.0 ± 0.5	≈ 4.0	500	500	500
12.5 x 25	18	0.6	13.0	27.0	5.0 ± 0.5	≈ 5.0	250	250	500
16 x 25	19	0.8	16.5	27.0	7.5 ± 0.5	≈ 8.0	250	250	250
16 x 31	20	0.8	16.5	33.5	7.5 ± 0.5	≈ 9.0	100	100	250
16 x 35	21	0.8	16.5	37.5	7.5 ± 0.5	≈ 11.5	100	100	-
18 x 35	22	0.8	18.5	37.5	7.5 ± 0.5	≈ 14.5	100	100	-

Note

Detailed tape dimensions see section ‘PACKAGING’.

ELECTRICAL DATA	
SYMBOL	**DESCRIPTION**
C_R	rated capacitance at 100 Hz, tolerance ± 20 %
I_R	rated RMS ripple current at 100 Hz, 105 °C
I_{L1}	max. leakage current after 1 minute at U_R
tan δ	max. dissipation factor at 100 Hz
Z	max. impedance at 100 kHz

Note

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 048 series

2200 µF/16 V; ± 20 %

Nominal case size: Ø 12.5 x 25 mm; Form TFA

Ordering code: MAL204835222E3
Former 12NC: 2222 048 35222

Table 2

ELECTRICAL DATA AND ORDERING INFORMATION

U_R (V)	C_R 100 Hz (µF)	DIMENSIONS Ø D x L (mm)	I_R 100 Hz 105 °C (mA)	I_{L1} 1 min (µA)	tan δ 100 Hz	Z 100 kHz (mΩ)	ORDERING NUMBER MAL2048.....		
							BULK PACKAGING		TAPED
							Form CA	Form CB	Form TFA
6.3	6800	16 x 25	1350	430	0.32	56	53682E3	63682E3	33682E3
	10 000	16 x 35	1700	630	0.40	42	53103E3	63103E3	-
10	1000	10 x 16	470	100	0.19	180	54102E3	64102E3	34102E3
	2200	12.5 x 20	800	220	0.21	90	54222E3	64222E3	34222E3
	3300	12.5 x 25	1000	330	0.23	68	54332E3	64332E3	34332E3
	4700	16 x 25	1270	470	0.25	56	54472E3	64472E3	34472E3
	6800	16 x 31	1550	680	0.29	45	54682E3	64682E3	34682E3
	10 000	18 x 35	1870	1000	0.37	36	54103E3	64103E3	-
16	470	10 x 12	360	78	0.16	250	55471E3	65471E3	35471E3
	1000	10 x 20	600	160	0.16	140	55102E3	65102E3	35102E3
	2200	12.5 x 25	1000	360	0.18	70	55222E3	65222E3	35222E3
	3300	16 x 25	1220	530	0.20	56	55332E3	65332E3	35332E3
	4700	16 x 31	1500	760	0.22	45	55472E3	65472E3	35472E3
	6800	16 x 35	1690	1100	0.26	42	55682E3	65682E3	-
	10 000	18 x 35	1980	1600	0.34	34	55103E3	65103E3	-
25	470	10 x 16	440	120	0.14	180	56471E3	66471E3	36471E3
	1000	12.5 x 20	720	250	0.14	100	56102E3	66102E3	36102E3
	2200	16 x 25	1120	550	0.16	56	56222E3	66222E3	36222E3
	3300	16 x 31	1450	830	0.18	45	56332E3	66332E3	36332E3
	4700	18 x 35	1720	1200	0.20	36	56472E3	66472E3	-
35	220	10 x 12	310	80	0.12	280	50221E3	60221E3	30221E3
	470	10 x 20	500	170	0.12	150	50471E3	60471E3	30471E3
	1000	12.5 x 25	900	350	0.12	75	50102E3	60102E3	30102E3
	2200	16 x 31	1340	770	0.14	45	50222E3	60222E3	30222E3
	3300	18 x 35	1600	1200	0.16	36	50332E3	60332E3	-
	4700	18 x 35	1950	1600	0.18	34	50472E3	60472E3	-
40	2200	16 x 35	1500	880	0.13	45	57222E3	67222E3	-
	3300	18 x 35	1600	1300	0.15	36	57332E3	67332E3	-
50	220	10 x 16	340	110	0.10	250	51221E3	61221E3	31221E3
	470	12.5 x 20	620	240	0.10	110	51471E3	61471E3	31471E3
	1000	16 x 25	1030	500	0.10	60	51102E3	61102E3	31102E3
	2200	18 x 35	1500	1100	0.12	50	51222E3	61222E3	-
	3300	18 x 35	1900	1700	0.14	40	51332E3	61332E3	-
63	100	10 x 12	240	66	0.09	310	58101E3	68101E3	38101E3
	220	10 x 20	400	140	0.09	200	58221E3	68221E3	38221E3
	330	12.5 x 20	550	210	0.09	120	58331E3	68331E3	38331E3
	470	12.5 x 25	700	300	0.09	80	58471E3	68471E3	38471E3
	1000	16 x 31	1150	630	0.09	49	58102E3	68102E3	38102E3
	2200	18 x 35	1600	1400	0.11	45	58222E3	68222E3	-

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	$I_{L1} \leq 0.01\ C_R \times U_R + 3\ \mu A$
	After 5 minutes at U_R	$I_{L5} \leq 0.002\ C_R \times U_R + 3\ \mu A$
Inductance		
Equivalent series inductance (ESL)	Case Ø D = 10 mm	typ. 16 nH
	Case Ø D ≥ 12.5 mm	typ. 18 nH
Resistance		
Equivalent series resistance (ESR)	Calculated from tan $\delta_{max.}$ and C_R (see Table 2)	ESR = tan $\delta/2\ \pi\ f\ C_R$

CAPACITANCE (C)

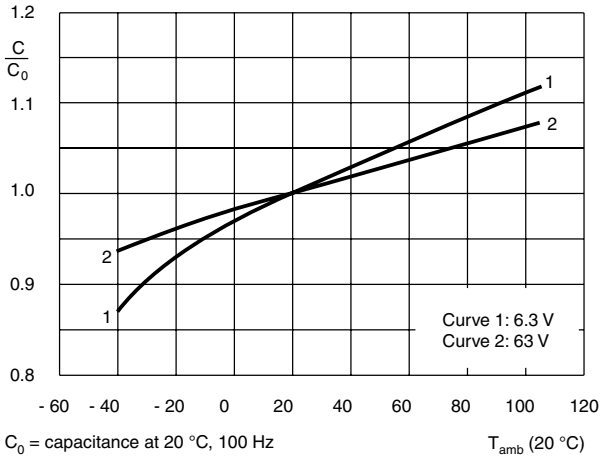


Fig.5 Typical multiplier of capacitance as a function of ambient temperature

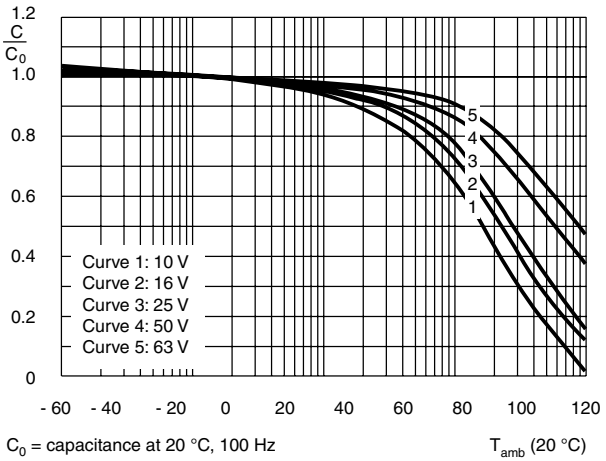


Fig.6 Typical multiplier of capacitance as a function of ambient temperature

EQUIVALENT SERIES RESISTANCE (ESR)

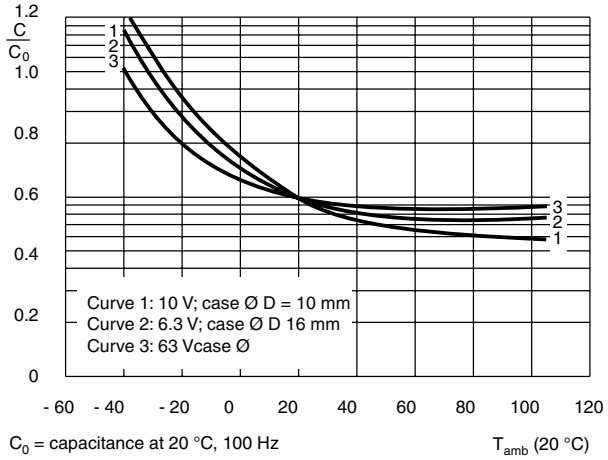


Fig.7 Typical multiplier of ESR as a function of ambient temperature

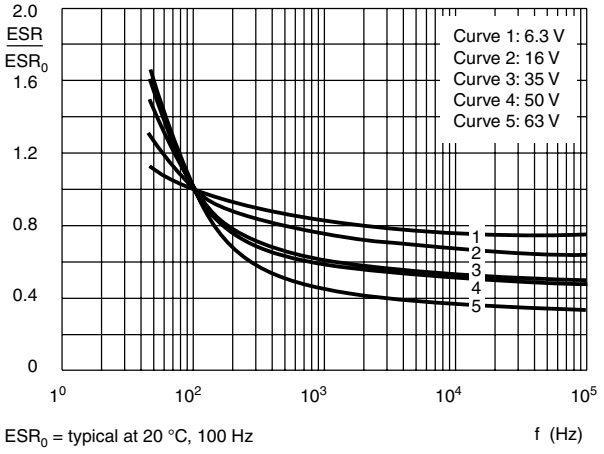


Fig.8 Typical multiplier of ESR as a function of frequency

IMPEDANCE (Z)

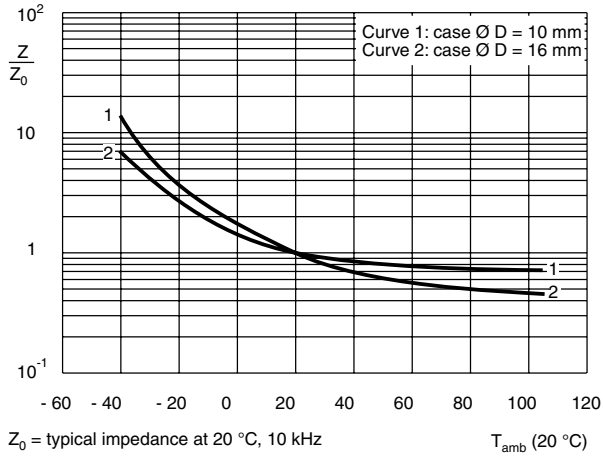


Fig.9 Typical multiplier of impedance as a function of ambient temperature

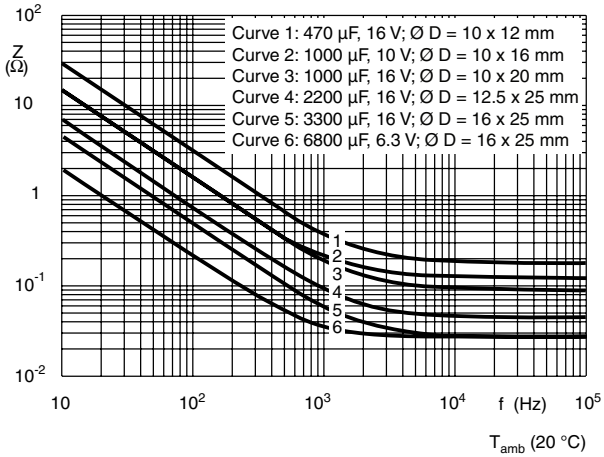


Fig.10 Typical impedance as a function of frequency

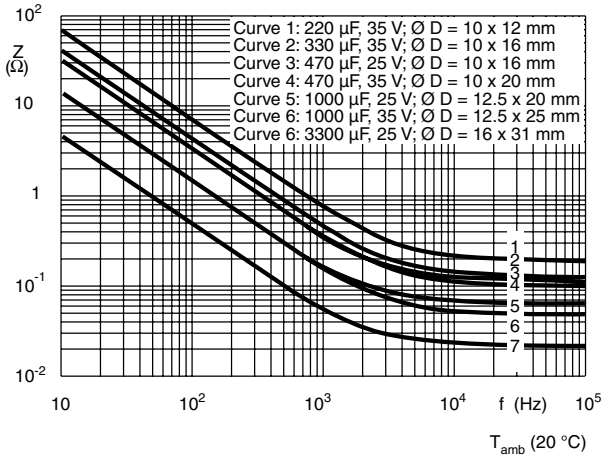


Fig.11 Typical impedance as a function of frequency

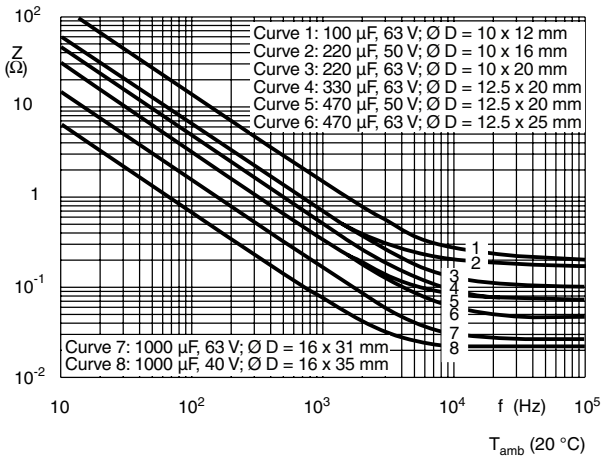
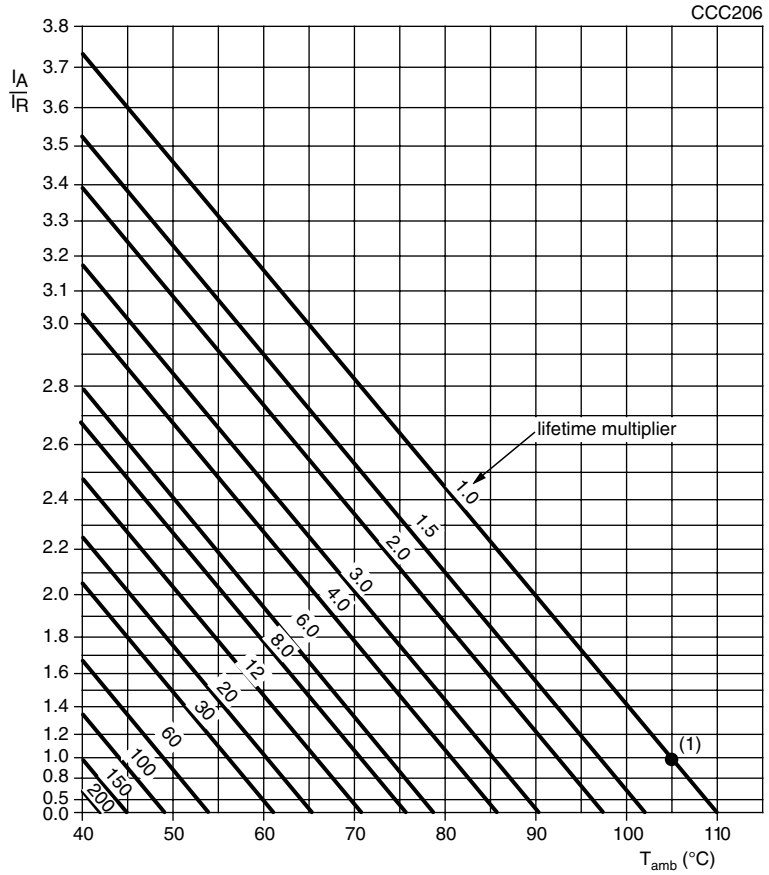


Fig.12 Typical impedance as a function of frequency

RIPPLE CURRENT AND USEFUL LIFE



I_A = actual ripple current at 100 Hz
I_R = rated ripple current at 100 Hz, 105 °C
(1) Useful life at 105 °C and I_R applied (see table 4)

Fig.13 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		
	U_R = 6.3 to 25 V	U_R = 35 and 40 V	U_R = 50 and 63 V
50	0.95	0.85	0.80
100	1.00	1.00	1.00
300	1.07	1.20	1.25
1000	1.12	1.30	1.40
3000	1.15	1.35	1.50
≥ 10 000	1.20	1.40	1.60

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; 2000 hours	$U_R \leq 6.3$ 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 $I_{L5} \leq$ spec. limit
Useful life	CECC 30301 subclause 1.8.1	T_{amb} = 105 °C; U_R and I_R applied; case Ø D = 10 and 12.5 mm: 3000 hours case Ø D = 16 and 18 mm: 4000 hours	$U_R \leq 6.3$ 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 $I_{L5} \leq$ 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} = 105 °C; no voltage applied; 1000 hours after test: U_R to be applied for 30 minutes, 24 to 48 hours before measurement	$U_R \leq 6.3$ 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 $I_{L5} \leq 2$ x spec. limit

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