

Aluminum Electrolytic Capacitors Radial Long Life

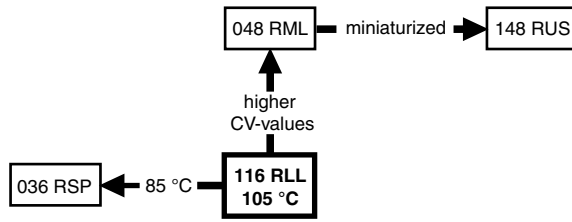
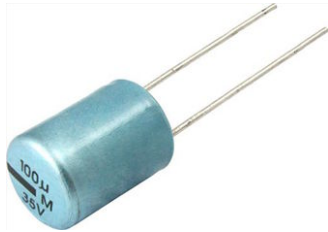


Fig. 1


**RoHS
COMPLIANT**
FEATURES

- Long useful life: 2000 h at 105 °C
- 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

APPLICATIONS

- Automotive, telecommunication, industrial and EDP
- Stand-by applications in audio and video equipment
- Coupling, decoupling, timing, smoothing, filtering and buffering in DC/DC converters
- 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 $\pm 20\%$)
- 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 (116)

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	1.5 μF to 470 μF
Tolerance on C_R	$\pm 20\%$
Rated voltage range, U_R	6.3 V to 100 V
Category temperature range	-55 °C to +105 °C
Endurance test at 105 °C	1500 h
Endurance test at 85 °C	5000 h
Useful life at 105 °C	2000 h
Useful life at 40 °C, $1.3 \times I_R$ applied	200 000 h
Shelf life at 0 V, 105 °C	1500 h
Based on sectional specification	IEC 60384-4 / EN 130300
Climatic category IEC 60068	55 / 105 / 56

SELECTION CHART FOR C_R , U_R , AND RELEVANT NOMINAL CASE SIZES (\varnothing D x L in mm)									
C_R (μF)	U_R (V)								
	6.3	10	16	25	35	40	50	63	100
1.5	-	-	-	-	-	-	5 x 11	-	-
3.3	-	-	-	-	-	-	5 x 11	-	-
4.7	-	-	-	-	-	-	5 x 11	-	8.2 x 11
6.8	-	-	-	-	-	-	5 x 11	-	-
10	-	-	-	-	-	-	5 x 11	8.2 x 11	8.2 x 11
	-	-	-	-	-	-	8.2 x 11	-	-
15	-	-	-	-	-	-	5 x 11	-	-
22	-	-	-	-	-	-	5 x 11	8.2 x 11	-
	-	-	-	-	-	-	8.2 x 11	-	-
33	-	-	-	-	5 x 11	5 x 11	8.2 x 11	-	-
47	-	-	-	5 x 11	-	-	8.2 x 11	-	-
68	-	-	5 x 11	-	-	-	8.2 x 11	-	-
100	-	5 x 11	-	-	8.2 x 11	8.2 x 11	-	-	-
150	5 x 11	-	-	8.2 x 11	-	-	-	-	-
220	-	-	8.2 x 11	-	-	-	-	-	-
330	-	8.2 x 11	-	-	-	-	-	-	-
470	8.2 x 11	-	-	-	-	-	-	-	-

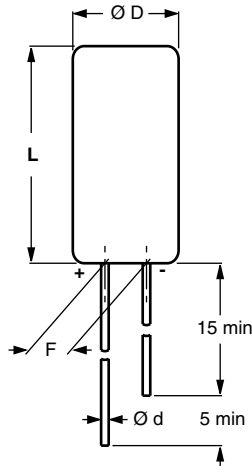
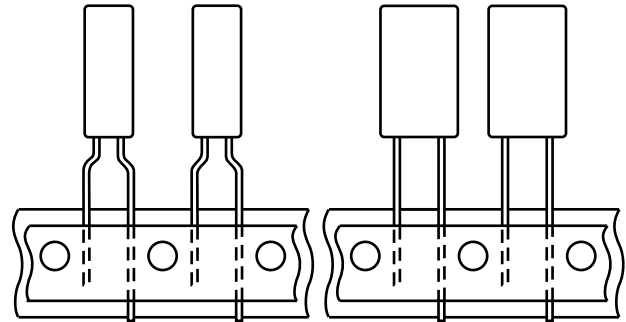
DIMENSIONS in millimeters AND AVAILABLE FORMS

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

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

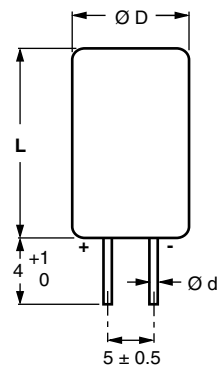
 Fig. 3 - **Form TFA:** Taped in box (ammopack)

 Case $\varnothing D \times L = 8.2 \text{ mm} \times 11 \text{ mm}$ only

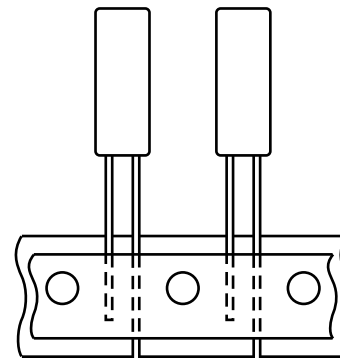
 Fig. 4 - **Form CB:** Cut leads

 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)

Table 1

DIMENSIONS in millimeters, MASS, AND PACKAGING QUANTITIES								
NOMINAL CASE SIZE $\varnothing D \times L$	CASE CODE	$\varnothing d$	$\varnothing D_{\text{max}}$	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 dimension 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 kHz, 105 °C
I_{L1}	Max. leakage current after 1 min at U_R
$\tan \delta$	Max. dissipation factor at 100 Hz
Z	Max. impedance at 100 kHz and 20 °C

ORDERING EXAMPLE

Electrolytic capacitor 116 series
 220 μF / 16 V; $\pm 20\%$
 Nominal case size: $\varnothing 8.2\text{ mm} \times 11\text{ mm}$; form TFA
 Ordering code: MAL211635221E3
 Former 12NC: 2222 116 35221

Note

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

Table 2

ELECTRICAL DATA AND ORDERING INFORMATION														
U_R (V)	C_R 100 Hz (μF)	NOMINAL CASE SIZE $\varnothing D \times L$ (mm)	I_R 100 kHz 105 °C (mA)	I_{L1} 1 min (μA)	$\tan \delta$ 100 Hz	Z 100 kHz (Ω)	ORDERING CODE MAL2116							
							BULK PACKAGING				TAPED AMMOPACK			
							LONG LEADS		CUT LEADS		FORM TFA		FORM TNA	
							FORM CA	F (mm)	FORM CB	F (mm)	FORM TFA	F (mm)	FORM TNA	F (mm)
6.3	150	5 x 11	130	8.7	0.25	1.3	53151E3	2.5	-	-	33151E3	5.0	73151E3	2.5
	470	8.2 x 11	300	21	0.25	0.45	53471E3	5.0	63471E3	5.0	33471E3	5.0	-	-
10	100	5 x 11	130	9.0	0.20	1.4	54101E3	2.5	-	-	34101E3	5.0	74101E3	2.5
	330	8.2 x 11	280	23	0.20	0.45	54331E3	5.0	64331E3	5.0	34331E3	5.0	-	-
16	68	5 x 11	130	9.5	0.16	1.5	55689E3	2.5	-	-	35689E3	5.0	75689E3	2.5
	220	8.2 x 11	280	24	0.16	0.5	55221E3	5.0	65221E3	5.0	35221E3	5.0	-	-
25	47	5 x 11	120	10	0.14	1.6	56479E3	2.5	-	-	36479E3	5.0	76479E3	2.5
	150	8.2 x 11	260	26	0.14	0.5	56151E3	5.0	66151E3	5.0	36151E3	5.0	-	-
35	33	5 x 11	110	9.9	0.12	1.7	50339E3	2.5	-	-	30339E3	5.0	70339E3	2.5
	100	8.2 x 11	240	24	0.12	0.55	50101E3	5.0	60101E3	5.0	30101E3	5.0	-	-
40	33	5 x 11	110	10.9	0.12	1.7	57339E3	2.5	-	-	37339E3	5.0	77339E3	2.5
	100	8.2 x 11	240	27	0.12	0.55	57101E3	5.0	67101E3	5.0	37101E3	5.0	-	-
50	1.5	5 x 11	50	3.5	0.09	4.0	51158E3	2.5	-	5.0	31158E3	5.0	71158E3	2.5
	2.2	5 x 11	60	3.7	0.09	3.5	51228E3	2.5	-	5.0	31228E3	5.0	71228E3	2.5
	3.3	5 x 11	65	4.0	0.09	3.1	51338E3	2.5	-	5.0	31338E3	5.0	71338E3	2.5
	4.7	5 x 11	70	4.4	0.09	2.8	51478E3	2.5	-	5.0	31478E3	5.0	71478E3	2.5
	6.8	5 x 11	75	5.0	0.09	2.5	51688E3	2.5	-	5.0	31688E3	5.0	71688E3	2.5
	10	5 x 11	80	6.0	0.09	2.2	51109E3	2.5	-	5.0	31109E3	5.0	71109E3	2.5
	10	8.2 x 11	160	6.0	0.05	1.0	90084E3	5.0	90085E3	5.0	90036E3	5.0	-	-
	15	5 x 11	90	7.5	0.09	2.0	51159E3	2.5	-	5.0	31159E3	5.0	71159E3	2.5
	22	5 x 11	110	9.6	0.09	1.9	51229E3	2.5	-	5.0	31229E3	5.0	71229E3	2.5
	22	8.2 x 11	190	9.6	0.06	0.9	90025E3	5.0	90086E3	5.0	90039E3	5.0	-	-
63	33	8.2 x 11	190	13	0.09	0.77	51339E3	5.0	61339E3	5.0	31339E3	5.0	-	-
	47	8.2 x 11	210	17	0.09	0.65	51479E3	5.0	61479E3	5.0	31479E3	5.0	-	-
	68	8.2 x 11	240	23	0.09	0.55	51689E3	5.0	61689E3	5.0	31689E3	5.0	-	-
	10	8.2 x 11	160	7.0	0.06	1.3	58109E3	5.0	68109E3	5.0	38109E3	5.0	-	-
	22	8.2 x 11	190	11	0.06	0.9	58229E3	5.0	68229E3	5.0	38229E3	5.0	-	-
100	4.7	8.2 x 11	75	5.8	0.07	3.5	59478E3	5.0	69478E3	5.0	39478E3	5.0	-	-
	10	8.2 x 11	100	9.0	0.08	3.0	59109E3	5.0	69109E3	5.0	39109E3	5.0	-	-

ADDITIONAL ELECTRICAL DATA		
PARAMETER	CONDITIONS	VALUE
Voltage		
Surge voltage		$U_s \leq 1.3 U_R$
Reverse voltage		$U_{rev} \leq 1 V$
Current		
Leakage current	After 1 min at U_R	$I_{L1} \leq 0.006 C_R \times U_R + 3 \mu A$
	After 5 min at U_R	$I_{L5} \leq 0.001 C_R \times U_R + 3 \mu A$
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 2)	$ESR = \tan \delta / 2 \pi f C_R$

CAPACITANCE (C)

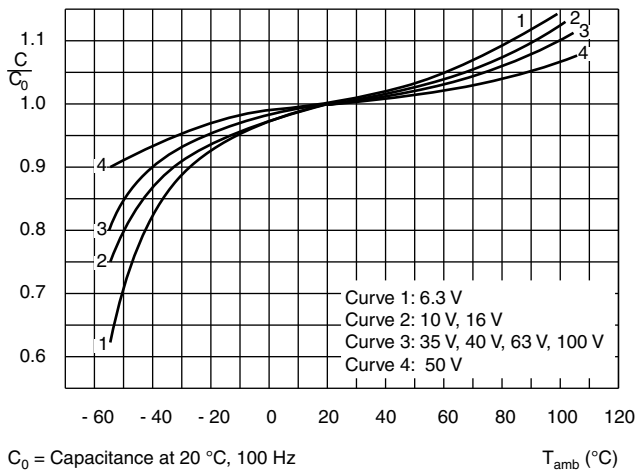


Fig. 6 - Typical multiplier of capacitance as a function of ambient temperature

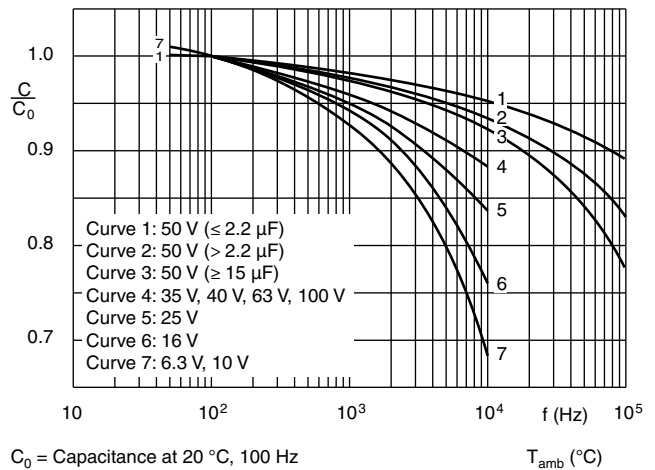


Fig. 7 - Typical multiplier of capacitance as a function of ambient frequency

IMPEDANCE (Z)

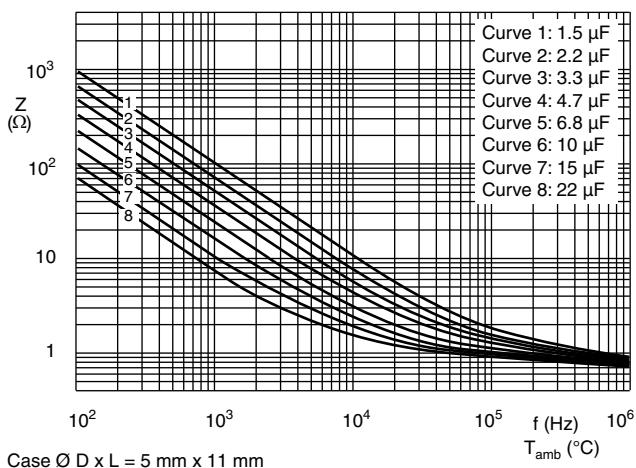


Fig. 8 - Typical impedance as a function of frequency

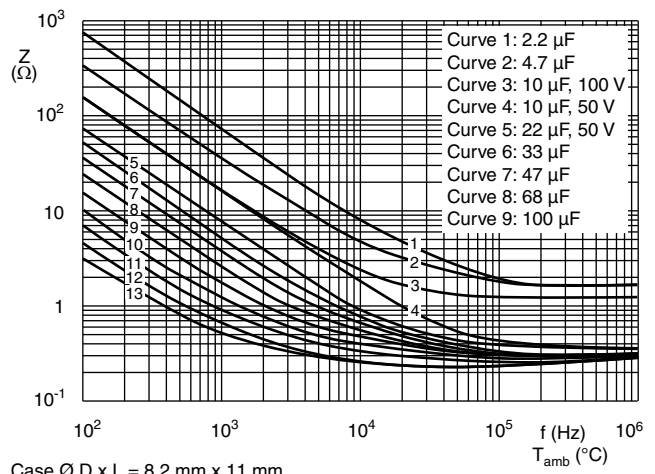
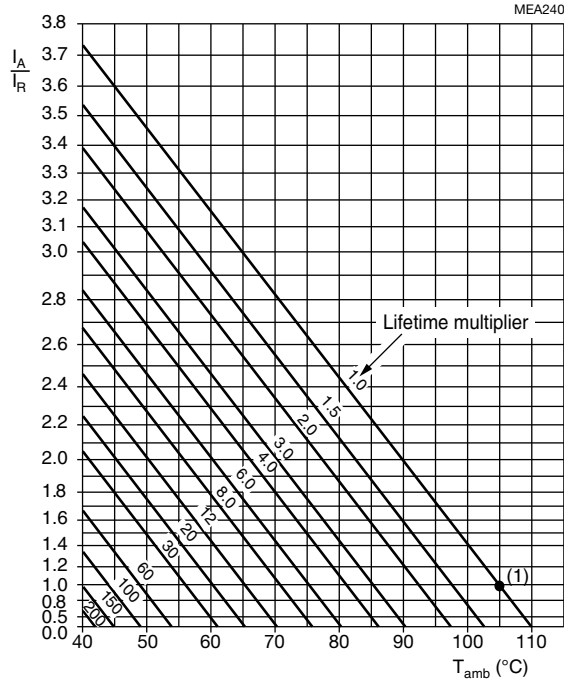


Fig. 9 - Typical impedance as a function of frequency

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: 2000 h

Fig. 10 - 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		
	$U_R = 6.3 \text{ V TO } 10 \text{ V}$	$U_R = 16 \text{ V TO } 35 \text{ V}$	$U_R = 40 \text{ V TO } 100 \text{ V (} C_R \geq 10 \mu\text{F)}$
50	0.70	0.60	0.50
100	0.77	0.71	0.63
300	0.86	0.85	0.78
1000	0.92	0.93	0.88
3000	0.96	0.96	0.94
10K to 100K	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 / EN 130300 subclause 4.13	$T_{amb} = 105 \text{ °C}$; U_R applied; 1500 h	$U_R \leq 6.3 \text{ V}$; $\Delta C/C$: +15 % / -30 % $U_R > 6.3 \text{ V}$; $\Delta C/C$: $\pm 15 \%$ $\tan \delta \leq 1.3 \times \text{spec. limit}$ $Z \leq 2 \times \text{spec. limit}$ $I_{L5} \leq \text{spec. limit}$
Useful life	CECC 30301 subclause 1.8.1	$T_{amb} = 105 \text{ °C}$; U_R and I_R applied; 2000 h	$U_R \leq 6.3 \text{ V}$; $\Delta C/C$: +45 % / -50 % $U_R > 6.3 \text{ V}$; $\Delta C/C$: $\pm 45 \%$ $\tan \delta \leq 3 \times \text{spec. limit}$ $Z \leq 3 \times \text{spec. limit}$ $I_{L5} \leq \text{spec. limit}$ no short or open circuit total failure percentage: $\leq 1\%$
Shelf life (storage at high temperature)	IEC 60384-4 / EN 130300 subclause 4.17	$T_{amb} = 105 \text{ °C}$; no voltage applied; 1500 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 $I_{L5} \leq 2 \times \text{spec. limit}$

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