

## Aluminum Electrolytic Capacitors Radial Long Life

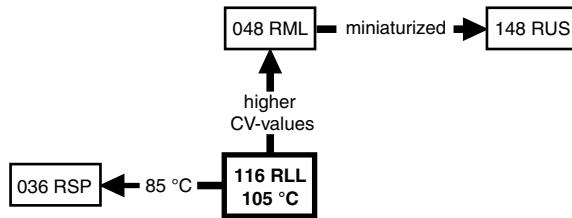
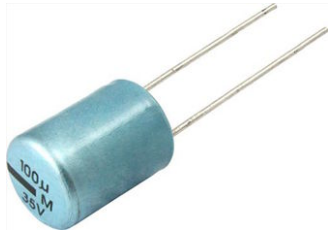


Fig. 1


**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](http://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  $\mu\text{F}$ )
- 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 (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 $\mu\text{F}$ to 470 $\mu\text{F}$
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)									
$C_R$ ( $\mu\text{F}$ )	$U_R$ (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	-	-	-	-	-	-	-	-

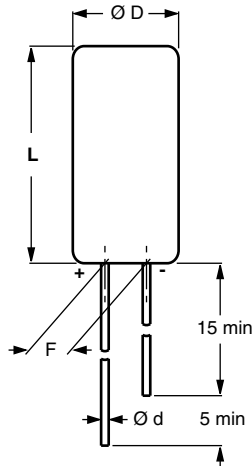
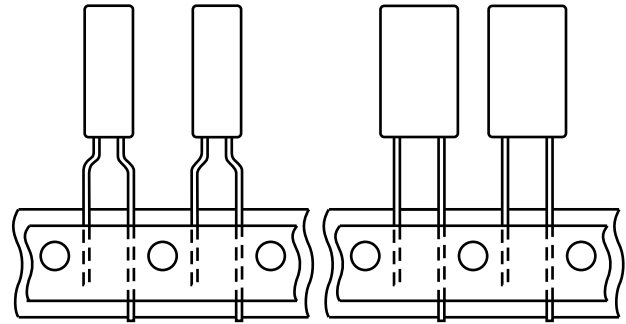
**DIMENSIONS in millimeters AND AVAILABLE FORMS**

 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  $F = 5 \text{ mm}$ 

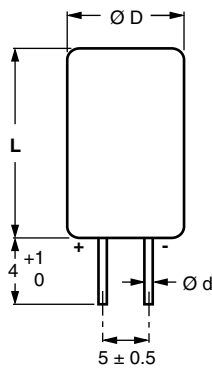
 Fig. 3 - **Form TFA:** Taped in box (ammopack)

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

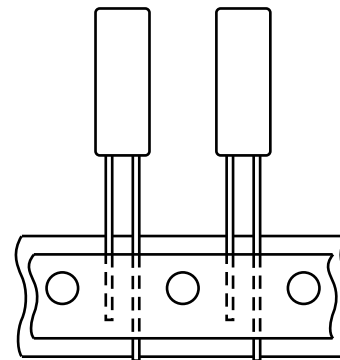
 Fig. 4 - **Form CB:** Cut leads

 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	$\varnothing d$	$\varnothing D_{\text{max}}$	$L_{\text{max}}$	F	MASS (g)	PACKAGING QUANTITIES	
							FORM CA, CB	FORM TFA, TNA
5 x 11	11	0.5	5.5	12	$2.5 \pm 0.5$	$\approx 0.4$	1000	2000
8.2 x 11	13	0.6	8.7	12	$5.0 \pm 0.5$	$\approx 1.1$	1000	1000

**Note**

- For detailed tape dimension please see [www.vishay.com/doc?28360](http://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  $\mu\text{F}$  / 16 V;  $\pm 20\%$   
 Nominal case size:  $\varnothing 8.2$  mm x 11 mm; form TFA  
 Ordering code: MAL211635221E3  
 Former 12NC: 2222 116 35221

**Note**

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

Table 2

ELECTRICAL DATA AND ORDERING INFORMATION														
$U_R$ (V)	$C_R$ 100 Hz ( $\mu\text{F}$ )	NOMINAL CASE SIZE $\varnothing D \times L$ (mm)	$I_R$ 100 kHz 105 °C (mA)	$I_{L1}$ 1 min ( $\mu\text{A}$ )	$\tan \delta$ 100 Hz	Z 100 kHz ( $\Omega$ )	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
<b>Voltage</b>		
Surge voltage		$U_s \leq 1.3 U_R$
Reverse voltage		$U_{rev} \leq 1 V$
<b>Current</b>		
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 $U_R$	$I_{L5} \leq 0.001 C_R \times U_R + 3 \mu A$
<b>Inductance</b>		
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
<b>Resistance</b>		
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)**

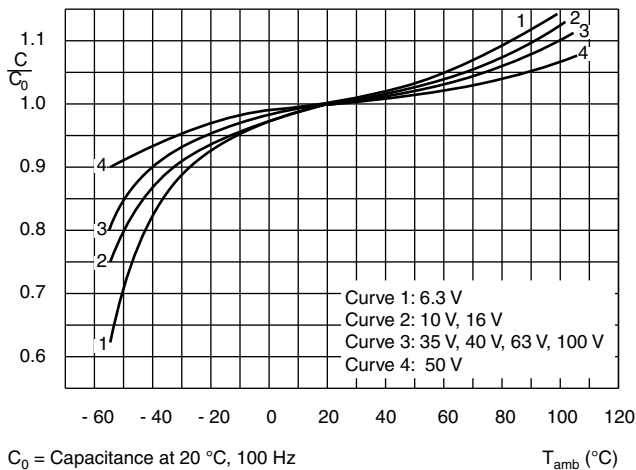


Fig. 6 - Typical multiplier of capacitance as a function of ambient temperature

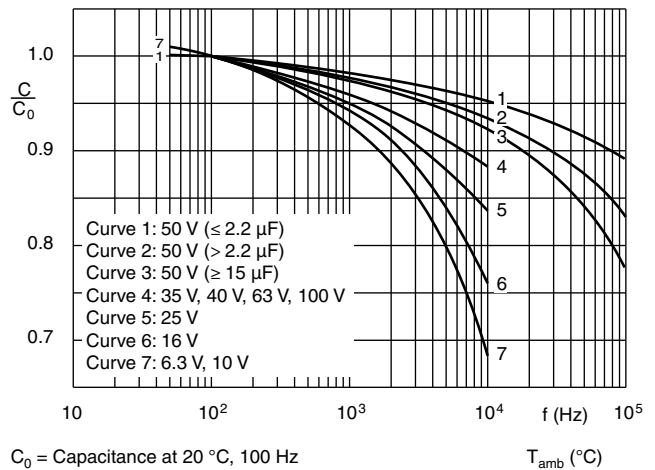


Fig. 7 - Typical multiplier of capacitance as a function of ambient frequency

**IMPEDANCE (Z)**

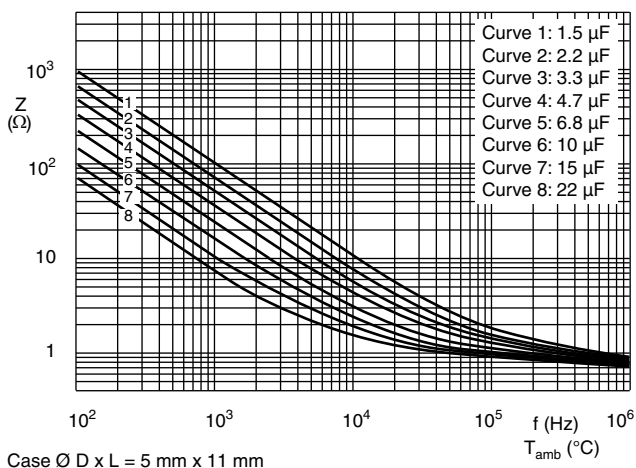


Fig. 8 - Typical impedance as a function of frequency

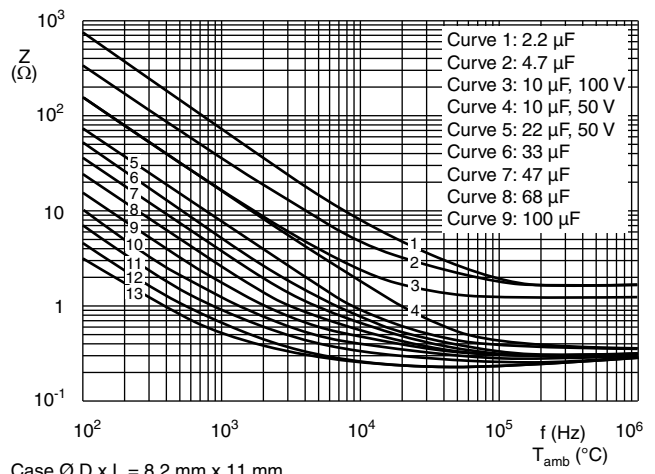
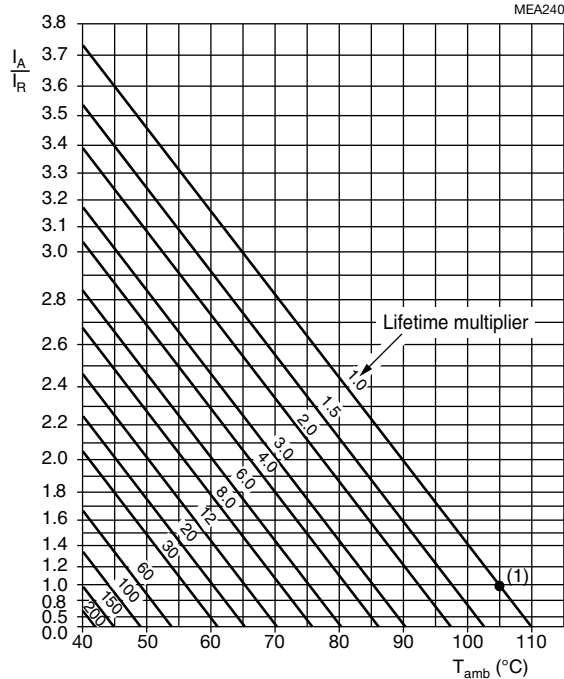


Fig. 9 - Typical impedance as a function of frequency

**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

<b>MULTIPLIER OF RIPPLE CURRENT (<math>I_R</math>) AS A FUNCTION OF FREQUENCY</b>			
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

<b>TEST PROCEDURES AND REQUIREMENTS</b>			
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 $I_{L5} \leq 2 \times \text{spec. limit}$

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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