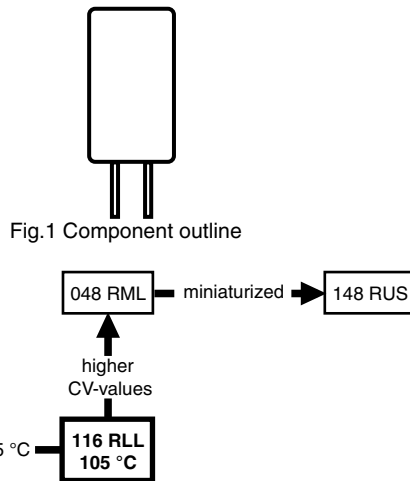


## Aluminum Capacitors Radial Long Life



### FEATURES

- Polarized aluminum electrolytic capacitors, non-solid electrolyte
- Radial leads, cylindrical aluminum case, all-insulated (light blue)
- Natural pitch 2.5 mm and 5 mm
- Charge and discharge proof
- Miniaturized, high CV-product per unit volume
- Long useful life: 2000 h at 105 °C, high reliability
- Lead (Pb)-free versions are RoHS compliant


**RoHS  
COMPLIANT**

### APPLICATIONS

- Automotive, telecommunication, industrial and EDP
- Stand-by applications in audio and video equipment
- Coupling, decoupling, timing; smoothing, filtering and buffering in dc-to-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
- Minus-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, $C_R$	0.47 to 470 $\mu\text{F}$
Tolerance on $C_R$	$\pm 20\%$
Rated voltage range, $U_R$	6.3 to 100 V
Category temperature range	- 55 to + 105 °C
Endurance test at 105 °C	1500 hours
Endurance test at 85 °C	5000 hours
Useful life at 105 °C	2000 hours
Useful life at 40 °C, $1.3 \times I_R$ applied	200 000 hours
Shelf life at 0 V, 105 °C	1500 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 ( $\varnothing$ D x L in mm)									
$C_R$ ( $\mu\text{F}$ )	$U_R$ (V)								
	6.3	10	16	25	35	40	50	63	100
0.47	-	-	-	-	-	-	5 x 11	-	-
1.0	-	-	-	-	-	-	5 x 11	-	-
1.5	-	-	-	-	-	-	5 x 11	-	-
2.2	-	-	-	-	-	-	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
15	-	-	-	-	-	-	8.2 x 11	-	-
22	-	-	-	-	-	-	5 x 11	-	-
33	-	-	-	-	-	-	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**

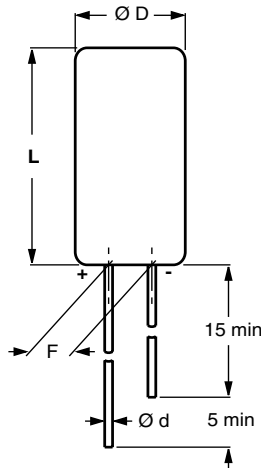
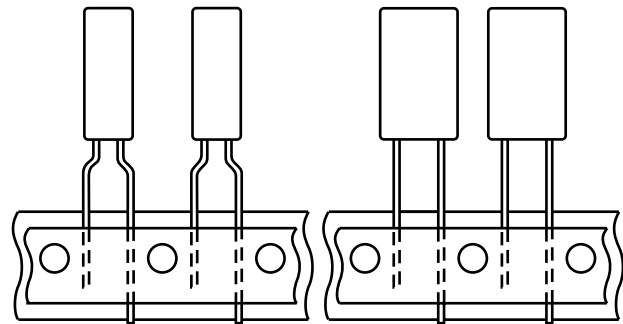
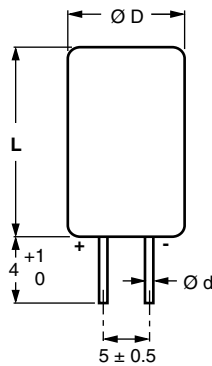


Fig.2 **Form CA:** Long leads



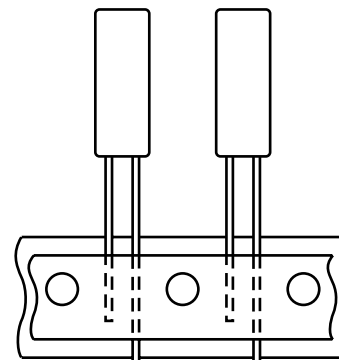
Case  $\text{Ø D} \times L = 5 \times 11$  and  $8.2 \times 11$  mm  
Pitch  $F = 5$  mm

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



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

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



Case  $\text{Ø D} \times L = 5 \times 11$  mm only  
Pitch  $F = 2.5$  mm

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

Table 1

DIMENSIONS in millimeters, MASS AND PACKAGING QUANTITIES								
NOMINAL CASE SIZE $\text{Ø D} \times L$	CASE CODE	$\text{Ø D}$	$\text{Ø D}_{\text{max.}}$	$L_{\text{max.}}$	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**

Tape dimension see section 'PACKAGING'.



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 minutes 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  $\mu\text{F}/16\text{ V}$ ;  $\pm 20\%$

Nominal case size:  $\varnothing 8.2 \times 11\text{ mm}$ ; Form TFA

Ordering code: MAL211635221E3

Former 12NC: 2222 116 35221

**Note**

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

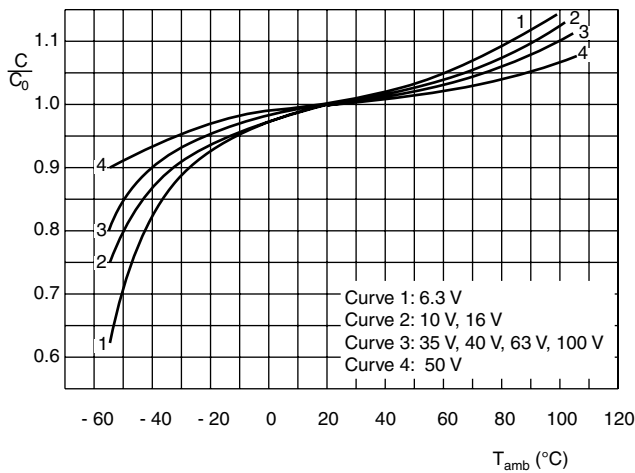
Table 2

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	0.2	1.4	54101E3	2.5	-	-	34101E3	5.0	74101E3	2.5
	330	8.2 x 11	280	23	0.2	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	0.47	5 x 11	30	3.1	0.09	10	51477E3	2.5	-	5.0	31477E3	5.0	71477E3	2.5
	1.0	5 x 11	40	3.3	0.09	6	51108E3	2.5	-	5.0	31108E3	5.0	71108E3	2.5
	1.5	5 x 11	50	3.5	0.09	4	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	0.09	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	0.09	2.5	51688E3	2.5	-	5.0	31688E3	5.0	71688E3	2.5
	10	5 x 11	80	6	0.09	2.2	51109E3	2.5	-	5.0	31109E3	5.0	71109E3	2.5
	10	8.2 x 11	160	6	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	-	-
	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	-	-	
63	10	8.2 x 11	160	7	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	2.2	8.2 x 11	60	4.3	0.06	4	59228E3	5.0	69228E3	5.0	39228E3	5.0	-	-
	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	0.08	3	59109E3	5.0	69109E3	5.0	39109E3	5.0	-	-



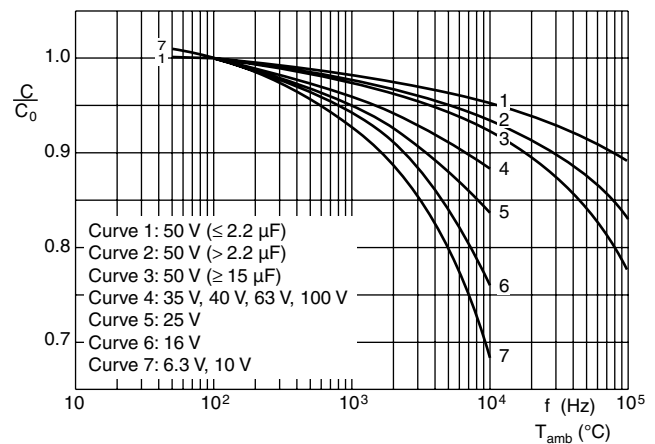
ADDITIONAL ELECTRICAL DATA		
PARAMETER	CONDITIONS	VALUE
<b>Voltage</b>		
Surge voltage		$U_s \leq 1.3 U_R$
Reverse voltage		$U_{rev} \leq 1 V$
<b>Current</b>		
Leakage current	After 1 minutes at $U_R$	$I_{L1} \leq 0.006 C_R \times U_R + 3 \mu A$
	After 5 minutes at $U_R$	$I_{L5} \leq 0.001 C_R \times U_R + 3 \mu A$
<b>Inductance</b>		
Equivalent series inductance (ESL)	Case $\varnothing D \times L = 5 \times 11 \text{ mm}$	typ. 13 nH
	Case $\varnothing D \times L = 8.2 \times 11 \text{ mm}$	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)**



$C_0$  = Capacitance at 20 °C, 100 Hz

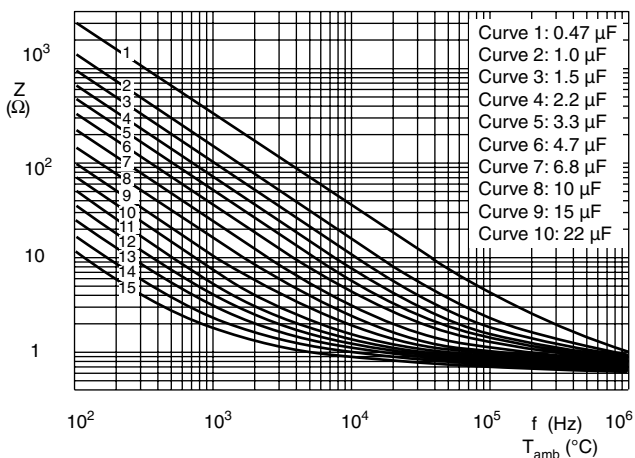
Fig.6 Typical multiplier of capacitance as a function of ambient temperature



$C_0$  = Capacitance at 20 °C, 100 Hz

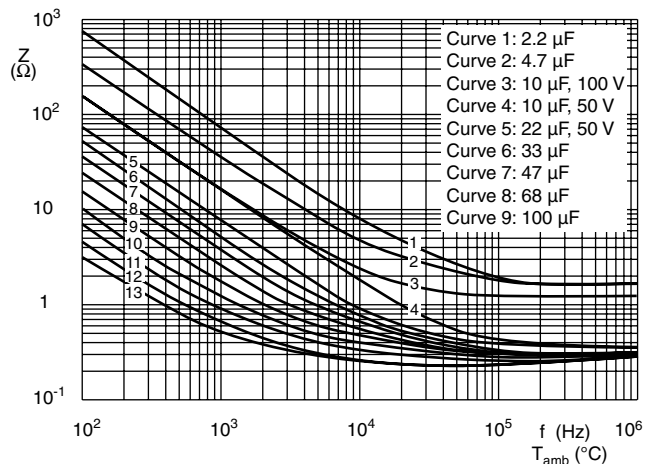
Fig.7 Typical multiplier of capacitance as a function of ambient frequency

**IMPEDANCE (Z)**



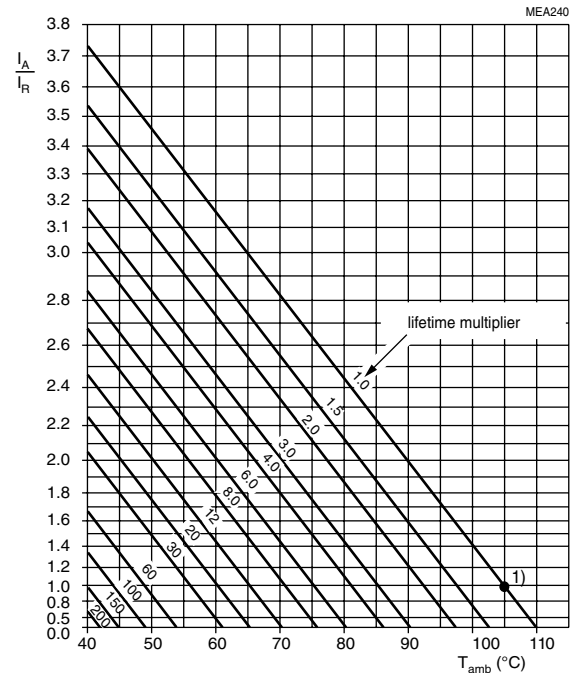
Case  $\varnothing D \times L = 5 \times 11 \text{ mm}$

Fig.8 Typical impedance as a function of frequency



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

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		
	$U_R = 6.3$ to $10$ V	$U_R = 16$ to $35$ V	$U_R = 40$ to $100$ V ( $C_R \geq 10 \mu F$ )
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
10 to 100 k	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/ EN130300 subclause 4.13	$T_{amb} = 105$ °C; $U_R$ applied; 1500 h	$U_R \leq 6.3$ V; $\Delta C/C$ : + 15/- 30 % $U_R > 6.3$ V; $\Delta C/C$ : $\pm 15$ % $\tan \delta \leq 1.3$ 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; 2000 h	$U_R \leq 6.3$ V; $\Delta C/C$ : + 45/- 50 % $U_R > 6.3$ V; $\Delta C/C$ : $\pm 45$ % $\tan \delta \leq 3$ x spec. limit $Z \leq 3$ x spec. limit $I_{L5} \leq$ spec. limit no short or open circuit total failure percentage: $\leq 1\%$
Shelf life (storage at high temperature)	IEC 60384-4/ EN130300 subclause 4.17	$T_{amb} = 105$ °C; no voltage applied; 1500 h after test: $U_R$ to be applied for 30 min, 24 to 48 h before measurement	$\Delta C/C$ , $\tan \delta$ , $Z$ : for requirements see 'Endurance test' above $I_{L5} \leq 2$ x spec. limit



## Disclaimer

All product specifications and data are subject to change without notice.

Vishay Intertechnology, Inc., its affiliates, agents, and employees, and all persons acting on its or their behalf (collectively, "Vishay"), disclaim any and all liability for any errors, inaccuracies or incompleteness contained herein or in any other disclosure relating to any product.

Vishay disclaims any and all liability arising out of the use or application of any product described herein or of any information provided herein to the maximum extent permitted by law. The product specifications do not expand or otherwise modify Vishay's terms and conditions of purchase, including but not limited to the warranty expressed therein, which apply to these products.

No license, express or implied, by estoppel or otherwise, to any intellectual property rights is granted by this document or by any conduct of Vishay.

The products shown herein are not designed for use in medical, life-saving, or life-sustaining applications unless otherwise expressly indicated. Customers using or selling Vishay products not expressly indicated for use in such applications do so entirely at their own risk and agree to fully indemnify Vishay for any damages arising or resulting from such use or sale. Please contact authorized Vishay personnel to obtain written terms and conditions regarding products designed for such applications.

Product names and markings noted herein may be trademarks of their respective owners.