

## Electrical Double Layer Energy Storage Capacitors Power and Energy Versions

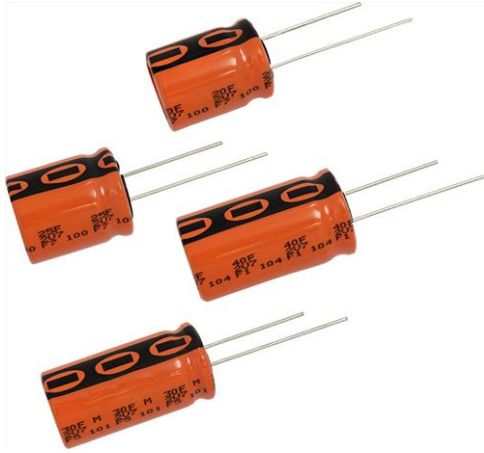


Image is not to scale


**RoHS  
COMPLIANT**

### FEATURES

- Polarized energy storage capacitor with high capacity and energy density
- Energy version with high stability available
- Rated voltage: 2.7 V
- Available in through-hole (radial) version
- Useful life: 1000 h at 85 °C
- Rapid charge and discharge
- Maintenance-free, no service necessary
- Material categorization: for definitions of compliance please see [www.vishay.com/doc?99912](http://www.vishay.com/doc?99912)

### APPLICATIONS

- Power backup
- Burst power support
- Storage device for energy harvesting
- Micro UPS power source
- Energy recovery

### MARKING

The capacitors are marked (where possible) with the following information:

- Rated capacitance (in F)
- Rated voltage (in V)
- Date code, in accordance with IEC 60062
- Code indicating factory of origin
- Logo of manufacturer
- Negative terminal identification
- Series number (220)

### PACKAGING

Supplied in ESD trays.

QUICK REFERENCE DATA	
DESCRIPTION	VALUE
Nominal case sizes (Ø D x L in mm)	16 x 20; 18 x 20; 16 x 25, 18 x 25; 16 x 31; <b>18 x 31</b> , 18 x 35, 18 x 40
Rated capacitance range, C <sub>R</sub>	15 F to 60 F
Rated voltage, U <sub>R</sub> (65 °C / 85 °C)	2.7 V / 2.3 V
Category temperature range	-40 °C to +85 °C
Endurance test at 85 °C	1000 h
Useful life at 85 °C	1000 h
Useful life at 20 °C	> 10 years
Shelf life at 20 °C	2 years
Cycle life	> 500 000 cycles

SELECTION CHART FOR C <sub>R</sub> , U <sub>R</sub> , AND RELEVANT NOMINAL CASE SIZES (Ø D x L in mm)	
C <sub>R</sub> (F)	U <sub>R</sub> (V) = 2.7 V
15	16 x 20
20	16 x 20; 16 x 25; 18 x 20
25	16 x 25; 18 x 20; 18 x 25
30	16 x 31; 18 x 25
35	16 x 31, <b>18 x 31</b> <sup>(1)</sup>
40	<b>18 x 31</b> <sup>(1)</sup>
45	18 x 35
50	18 x 35
55	18 x 40
60	18 x 40

#### Note

<sup>(1)</sup> Preferred case size.

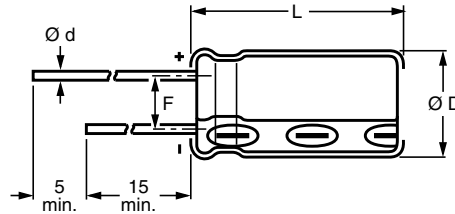
**DIMENSIONS in millimeters AND AVAILABLE FORMS**


Fig. 1 - Form CA: Long leads

Table 1

DIMENSIONS in millimeters, MASS, AND PACKAGING QUANTITIES							
NOMINAL CASE SIZE Ø D x L	CASE CODE	Ø d	Ø D <sub>max.</sub>	L <sub>max.</sub>	F	MASS (g)	PACKAGING QUANTITIES
							FORM CA IN TRAY
16 x 20	19a	0.8	16.5	22	7.5 ± 0.5	≈ 6.0	200
16 x 25	19	0.8	16.5	27	7.5 ± 0.5	≈ 8.0	200
18 x 20	1820	0.8	18.5	22	7.5 ± 0.5	≈ 7.0	200
18 x 25	1825	0.8	18.5	27	7.5 ± 0.5	≈ 10.0	200
16 x 31	20	0.8	16.5	33.5	7.5 ± 0.5	≈ 9.0	200
18 x 31	1831	0.8	18.5	33.5	7.5 ± 0.5	≈ 12.5	200
18 x 35	22	0.8	18.5	37.5	7.5 ± 0.5	≈ 14.5	200
18 x 40	1840	0.8	18.5	42.5	7.5 ± 0.5	≈ 16.5	150

ELECTRICAL DATA	
SYMBOL	DESCRIPTION
C <sub>R</sub>	Rated capacitance, tolerance -20 % / +50 %
I <sub>P</sub>	Max. peak current
I <sub>L</sub>	Max. leakage current after 0.5 h / 72 h at U <sub>R</sub>

**ORDERING EXAMPLE**

Capacitor series 220 EDLC

40 F / 2.7 V

Nominal case size: Ø 18 mm x 31 mm; Form CA

Ordering code: MAL222091001E3

**Note**

- Unless otherwise specified, all electrical values in Table 2 apply at T<sub>amb</sub> = 20 °C, P = 86 kPa to 106 kPa and RH = 45 % to 75 %.

Table 2

ELECTRICAL DATA AND ORDERING INFORMATION FOR ENERGY VERSION															
U <sub>R</sub> (V)	U <sub>CT</sub> <sup>(1)</sup> (V)	U <sub>S</sub> (V) (< 1 s)	C <sub>R</sub> <sup>(2)</sup> 100 Hz (µF)	NOMINAL CASE SIZE Ø D x L (mm)	MAX. ESR <sub>DC</sub> <sup>(2)</sup> INITIAL (mΩ)	MAX. ESR <sub>AC</sub> INITIAL, 1 kHz (mΩ)	I <sub>P</sub> MAX. PEAK CURRENT (A)		I <sub>L</sub> MAX. LEAKAGE CURRENT AFTER		STORED ENERGY E AT U <sub>R</sub> (Wh)		SPECIFIC ENERGY E <sub>d</sub> AT U <sub>R</sub> (Wh/kg)		ORDERING CODE MAL2220.....
							65 °C	85 °C	0.5 h	72 h	65 °C	85 °C	65 °C	85 °C	
2.7	2.3	2.85	15 000 000	16 x 20	40	30	25	20	6	75	0.015	0.011	2.5	1.8	90003E3
2.7	2.3	2.85	20 000 000	16 x 25	38	28	25	20	6	75	0.020	0.015	2.5	1.8	90006E3
2.7	2.3	2.85	20 000 000	18 x 20	38	28	25	20	6	75	0.020	0.015	2.9	2.1	90004E3
2.7	2.3	2.85	25 000 000	18 x 25	36	26	25	20	11	115	0.025	0.018	2.5	1.8	90007E3
2.7	2.3	2.85	30 000 000	16 x 31	36	26	25	20	15	150	0.030	0.022	3.4	2.5	90002E3
2.7	2.3	2.85	35 000 000	18 x 31	35	25	25	20	15	150	0.035	0.029	3.5	2.6	90001E3
2.7	2.3	2.85	45 000 000	18 x 35	30	21	25	20	20	200	0.046	0.033	3.2	2.3	90008E3
2.7	2.3	2.85	55 000 000	18 x 40	25	18	25	20	25	250	0.056	0.040	3.4	2.5	90009E3

**Notes**

- U<sub>CT</sub> = rated voltage at upper category temperature
- Rated capacitance C<sub>R</sub> and ESR<sub>DC</sub>



Table 3

ELECTRICAL DATA AND ORDERING INFORMATION FOR POWER VERSION															
U <sub>R</sub> (V)	U <sub>CT</sub> <sup>(1)</sup> (V)	U <sub>S</sub> (V) (< 1 s)	C <sub>R</sub> <sup>(2)</sup> 100 Hz (μF)	NOMINAL CASE SIZE Ø D x L (mm)	MAX. ESR <sub>DC</sub> <sup>(2)</sup> INITIAL (mΩ)	MAX. ESR <sub>AC</sub> INITIAL, 1 kHz (mΩ)	I <sub>p</sub> MAX. PEAK CURRENT (A)		I <sub>L</sub> MAX. LEAKAGE CURRENT AFTER (mA) (μA)		STORED ENERGY E AT U <sub>R</sub> (Wh)		SPECIFIC ENERGY Ed AT U <sub>R</sub> (Wh/kg)		ORDERING CODE MAL2220.....
							65 °C	85 °C	0.5 h	72 h	65 °C	85 °C	65 °C	85 °C	
2.7	2.3	2.85	20 000 000	16 x 20	24	18	25	20	8	75	0.020	0.015	3.4	2.3	91003E3
2.7	2.3	2.85	25 000 000	16 x 25	22	16	25	20	8	75	0.025	0.018	3.2	2.3	91006E3
2.7	2.3	2.85	25 000 000	18 x 20	20	15	25	20	8	75	0.025	0.018	3.6	2.6	91004E3
2.7	2.3	2.85	30 000 000	18 x 25	19	13	30	25	12	140	0.030	0.022	3.0	2.2	91007E3
2.7	2.3	2.85	35 000 000	16 x 31	20	14	30	25	15	200	0.035	0.026	3.8	2.9	91002E3
2.7	2.3	2.85	40 000 000	18 x 31	18	12	35	30	20	200	0.041	0.029	4.1	3.0	91001E3
2.7	2.3	2.85	50 000 000	18 x 35	15	10	35	30	25	250	0.051	0.037	3.5	2.6	91008E3
2.7	2.3	2.85	60 000 000	18 x 40	13	9	35	30	30	300	0.061	0.044	3.7	2.7	91009E3

Notes

- (1) U<sub>CT</sub> = rated voltage at upper category temperature
- (2) Rated capacitance C<sub>R</sub> and ESR<sub>DC</sub>

TEST PROCEDURES AND REQUIREMENTS (1)		
NAME OF TEST	PROCEDURE (quick reference)	
Capacitance C <sub>R</sub> and ESR <sub>DC</sub>	Measured by DC discharging method as described in "Measuring of Characteristics". (2)	
Maximum peak current	Non-repetitive current for maximum 1 s at specified operating temperature. Maximum operating voltage (refer to derating table) must not be exceeded. Usually to be tested with constant current discharge from U <sub>R</sub> to 0.5 x U <sub>R</sub> . Maximum current should not be used in normal operation and is only provided as reference value.	
Leakage current I <sub>L</sub>	Measured at U <sub>R</sub> . Capacitor is charged to the rated voltage at 20 °C. Leakage current is the current at specified time that is required to keep the capacitor charged at the rated voltage.	
Endurance	After loading the capacitor the specified time at maximum category temperature T <sub>MAX</sub> and related permissible maximum operating voltage U <sub>R</sub> :	
	Capacitance	Within ± 30 % of minimum initial specified value
	ESR	Less than 3 x initial specified value
Useful life	After loading the capacitor the specified time at maximum category temperature T <sub>MAX</sub> and related permissible maximum operating voltage U <sub>R</sub> :	
	Capacitance	Within ± 30 % of minimum initial specified value
	ESR	Less than 3 x initial specified value
Storage at upper category temperature	After loading the capacitor the specified time at maximum storage temperature T <sub>MAX</sub> without charge and under 40 % RH:	
	Capacitance	Within ± 30 % of minimum initial specified value
	ESR	Less than 3 x initial specified value
Shelf life	Stored uncharged at 20 °C.	
	Parameter within initial specification	
Cycle life	Cycles at 20 °C between rated voltage and half of rated voltage U <sub>R</sub> with constant current 3 A and 1 s rest between charge and discharge: > 500 000 cycles	
	Capacitance	Within ± 30 % of minimum initial specified value
	ESR	Less than 3 x initial specified value
Stored energy E, specific energy Ed and Ev	$E [Wh] = \frac{1}{2} \times C \times (U_R)^2 \times 1/3600$ $Ed [Wh/kg] = \frac{1}{2} \times C \times (U_R)^2 \times 1/3600 \times 1/mass$ $Ev [Wh/L] = \frac{1}{2} \times C \times (U_R)^2 \times 1/3600 \times 1/volume$	
Soldering	Hand or wave soldering allowed. For details refer to soldering requirements for radial aluminum electrolytic capacitors in supplementary document.	
Cleaning	For printed circuit board cleaning apply non-aggressive cleaning agents only. For details refer to cleaning requirements for aluminum electrolytic capacitors in supplementary document.	
Environmental conditions	Do not expose capacitors to <ul style="list-style-type: none"> <li>temperatures outside specified range</li> <li>high humidity atmospheres</li> <li>corrosive atmospheres, e.g. halogenides, sulphurous or nitrous gases, acid or alkaline solutions, etc.</li> <li>environments containing oil and grease</li> </ul>	

Notes

- General remark: temperatures to be measured at capacitor case
- (1) Conditions: electrical measurements at 20 °C, unless otherwise specified
- (2) Rated capacitance C<sub>R</sub> and ESR<sub>DC</sub>

**MEASURING OF CHARACTERISTICS**
**CAPACITANCE (C)**

Capacitance shall be measured by constant current discharge method.

- Constant current charge with 10 mA/F to  $U_R$
- Constant voltage charge at  $U_R$  for 5 min
- Constant current discharge with 10 mA/F to 0.1 V

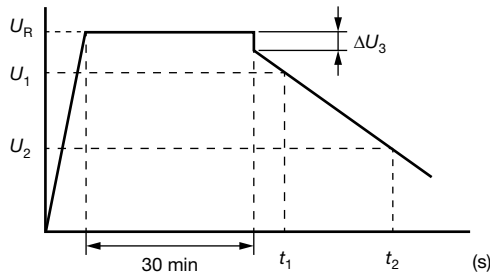


Fig. 2 - Voltage Diagram for Capacitance Measurement

Capacitance value  $C_R$  is given by discharge current  $I_D$ , time  $t$  and rated voltage  $U_R$ , according to the following equation:

$$C_R [F] = \frac{I_D [A] \times (t_2 [s] - t_1 [s])}{U_1 [V] - U_2 [V]}$$

$C_R$	Rated capacitance, in F
$U_R$	Rated voltage, in V
$U_1$	Starting voltage, $0.8 \times U_R$ in V
$U_2$	Ending voltage, $0.4 \times U_R$ in V
$\Delta U_3$	Voltage drop at internal resistance, in V
$t_1$	Time from start of discharge until voltage $U_1$ is reached, in s
$t_2$	Time from start of discharge until voltage $U_2$ is reached, in s
$I_D$	Absolute value of discharge current, in A

**EQUIVALENT SERIES RESISTANCE (ESR<sub>DC</sub>)**

- Constant current charge to  $U_R$
- Constant voltage charge at  $U_R$  for 5 min
- Constant current discharge to 0.1 V

$$ESR_{DC} [\Omega] = \frac{\Delta U_3 [V]}{I_D [A]}$$

$ESR_{DC}$	Equivalent series resistance, in $\Omega$
$\Delta U_R$	Voltage drop at internal resistance, in V
$I_D$	Absolute value of discharge current, in A

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.



## **Disclaimer**

ALL PRODUCT, PRODUCT SPECIFICATIONS AND DATA ARE SUBJECT TO CHANGE WITHOUT NOTICE TO IMPROVE RELIABILITY, FUNCTION OR DESIGN OR OTHERWISE.

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 in any datasheet or in any other disclosure relating to any product.

Vishay makes no warranty, representation or guarantee regarding the suitability of the products for any particular purpose or the continuing production of any product. To the maximum extent permitted by applicable law, Vishay disclaims (i) any and all liability arising out of the application or use of any product, (ii) any and all liability, including without limitation special, consequential or incidental damages, and (iii) any and all implied warranties, including warranties of fitness for particular purpose, non-infringement and merchantability.

Statements regarding the suitability of products for certain types of applications are based on Vishay's knowledge of typical requirements that are often placed on Vishay products in generic applications. Such statements are not binding statements about the suitability of products for a particular application. It is the customer's responsibility to validate that a particular product with the properties described in the product specification is suitable for use in a particular application. Parameters provided in datasheets and / or specifications may vary in different applications and performance may vary over time. All operating parameters, including typical parameters, must be validated for each customer application by the customer's technical experts. Product specifications do not expand or otherwise modify Vishay's terms and conditions of purchase, including but not limited to the warranty expressed therein.

Except as expressly indicated in writing, Vishay products are not designed for use in medical, life-saving, or life-sustaining applications or for any other application in which the failure of the Vishay product could result in personal injury or death. Customers using or selling Vishay products not expressly indicated for use in such applications do so at their own risk. Please contact authorized Vishay personnel to obtain written terms and conditions regarding products designed for such applications.

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