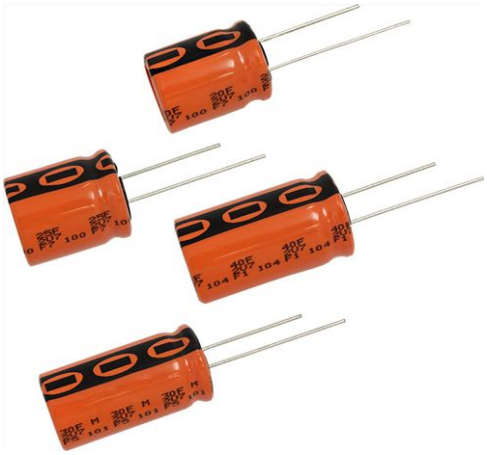
Electrical Double Layer Energy Storage Capacitors
Power and Energy Versions



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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

Pb-free

RoHS COMPLIANT

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; **18 x 31**, 18 x 35, 18 x 40
Rated capacitance range, C_R	15 F to 60 F
Rated voltage, U_R (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_R, U_R, AND RELEVANT NOMINAL CASE SIZES (Ø D x L in mm)	
C_R (F)	**U_R (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, **18 x 31** (1)
40	**18 x 31** (1)
45	18 x 35
50	18 x 35
55	18 x 40
60	18 x 40

Note

(1) Preferred case size.

DIMENSIONS in millimeters AND AVAILABLE FORMS

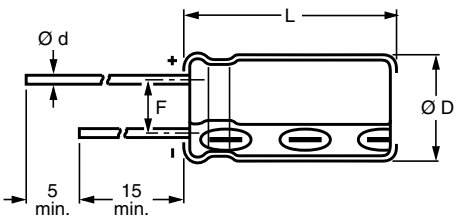

Fig. 1 - **Form CA:** Long leads

Table 1

DIMENSIONS in millimeters, MASS, AND PACKAGING QUANTITIES							
NOMINAL CASE SIZE Ø D x L	CASE CODE	Ø d	Ø $D_{max.}$	$L_{max.}$	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_R	Rated capacitance, tolerance -20 % / +50 %
I_P	Max. peak current
I_L	Max. leakage current after 0.5 h / 72 h at U_R

Note

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

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

Table 2

ELECTRICAL DATA AND ORDERING INFORMATION FOR ENERGY VERSION															
U_R (V)	U_{CT} (1) (V)	U_S (V) (< 1 s)	C_R (2) 100 Hz (µF)	NOMINAL CASE SIZE Ø D x L (mm)	MAX. ESR_{DC} (2) INITIAL (mΩ)	MAX. ESR_{AC} INITIAL, 1 kHz (mΩ)	I_P MAX. PEAK CURRENT (A)		I_L MAX. LEAKAGE CURRENT AFTER (mA) (µA)		STORED ENERGY E AT U_R (Wh)		SPECIFIC ENERGY Ed AT U_R (Wh/kg)		ORDERING CODE MAL2220.....
65 °C	85 °C						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

(1) U_{CT} = rated voltage at upper category temperature

(2) Rated capacitance C_R and ESR_{DC}

Table 3

ELECTRICAL DATA AND ORDERING INFORMATION FOR POWER VERSION															
U_R (V)	U_{CT} (1) (V)	U_S (V) (< 1 s)	C_R (2) 100 Hz (µF)	NOMINAL CASE SIZE Ø D x L (mm)	MAX. ESR_{DC} (2) INITIAL (mΩ)	MAX. ESR_{AC} INITIAL, 1 kHz (mΩ)	I_P MAX. PEAK CURRENT (A)		I_L MAX. LEAKAGE CURRENT AFTER (mA) (µA)		STORED ENERGY E AT U_R (Wh)		SPECIFIC ENERGY Ed AT U_R (Wh/kg)		ORDERING CODE MAL2220.....
65 °C	85 °C						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_{CT} = rated voltage at upper category temperature
(2) Rated capacitance C_R and ESR_{DC}

TEST PROCEDURES AND REQUIREMENTS (1)		
NAME OF TEST	**PROCEDURE (quick reference)**	
Capacitance C_R and ESR_{DC}	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_R to 0.5 x U_R. Maximum current should not be used in normal operation and is only provided as reference value.	
Leakage current I_L	Measured at U_R. 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 $T_{MAX.}$ and related permissible maximum operating voltage U_R:	
	Capacitance	Within ± 30 % of minimum initial specified value
	ESR	Less than 3 x initial specified value
	Leakage	Within specified value
Useful life	After loading the capacitor the specified time at maximum category temperature $T_{MAX.}$ and related permissible maximum operating voltage U_R:	
	Capacitance	Within ± 30 % of minimum initial specified value
	ESR	Less than 3 x initial specified value
	Leakage	Within specified value
Storage at upper category temperature	After loading the capacitor the specified time at maximum storage temperature $T_{MAX.}$ without charge and under 40 % RH:	
	Capacitance	Within ± 30 % of minimum initial specified value
	ESR	Less than 3 x initial specified value
	Leakage	Within 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_R 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] = ½ x C x $(U_R)^2$ x 1/3600 Ed [Wh/kg] = ½ x C x $(U_R)^2$ x 1/3600 x 1/mass Ev [Wh/L] = ½ x C x $(U_R)^2$ x 1/3600 x 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 • temperatures outside specified range • high humidity atmospheres • corrosive atmospheres, e.g. halogenides, sulphurous or nitrous gases, acid or alkaline solutions, etc. • environments containing oil and grease	

Notes
• General remark: temperatures to be measured at capacitor case
(1) Conditions: electrical measurements at 20 °C, unless otherwise specified
(2) Rated capacitance C_R and ESR_{DC}

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

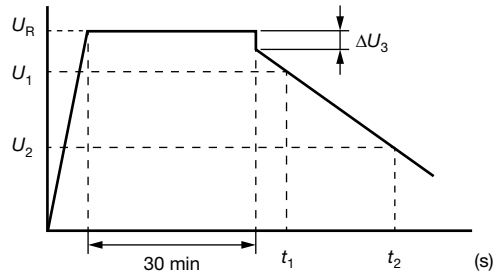

Fig. 2 - Voltage Diagram for Capacitance Measurement

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 x U_R in V
U_2	Ending voltage, 0.4 x U_R in V
ΔU_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_{DC})

- 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 Ω
ΔU_R	Voltage drop at internal resistance, in V
I_D	Absolute value of discharge current, in A

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