

## Electrical Double Layer Energy Storage Capacitors Up to 3 V Operating Voltage



Image is not to scale


**RoHS  
COMPLIANT**

### FEATURES

- Polarized energy storage capacitor with high capacity and energy density
- Rated voltage: 3.0 V
- Available in through-hole (radial) version
- Useful life: up to 2000 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 (230)

### PACKAGING

Supplied in ESD trays.

QUICK REFERENCE DATA	
DESCRIPTION	VALUE
Nominal case sizes (Ø D x L in mm)	16 x 20; 16 x 25; 18 x 20; 18 x 25; 16 x 31; <b>18 x 31</b> ; 18 x 35; 18 x 40
Rated capacitance range, C <sub>R</sub>	20 F to 60 F
Rated voltage, U <sub>R</sub> (65 °C / 85 °C)	3.0 V / 2.6 V
Category temperature range	-40 °C to +85 °C
Endurance test at 85 °C	Up to 1500 h
Useful life at 85 °C	Up to 2000 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	
C <sub>R</sub> (F)	Ø D x L (mm)
20	16 x 20
25	16 x 25; 18 x 20
30	18 x 25
35	16 x 31
40	<b>18 x 31</b> <sup>(1)</sup>
50	18 x 35
60	18 x 40

#### Note

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

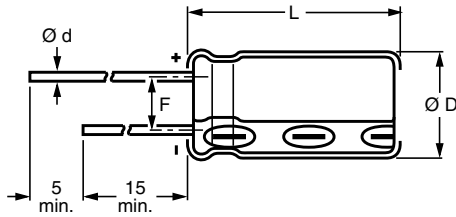
**DIMENSIONS in millimeters AND AVAILABLE FORMS**


Fig. 1 - Form CA: Long leads

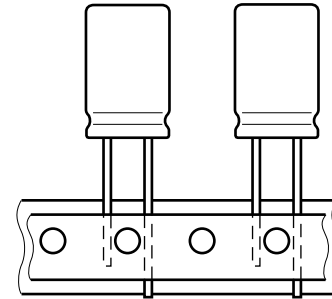


Fig. 2 - Form TFA: Taped in box (ammopack)

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	FORM TFA	FORM TRAY
16 x 20	19a	0.8	16.5	22.0	7.5 ± 0.5	≈ 6.0	250	250	200
16 x 25	19	0.8	16.5	27.0	7.5 ± 0.5	≈ 8.0	250	250	200
18 x 20	1820	0.8	18.5	22.0	7.5 ± 0.5	≈ 7.0	100	250	200
18 x 25	1825	0.8	18.5	27.0	7.5 ± 0.5	≈ 10.0	100	250	200
16 x 31	20	0.8	16.5	33.5	7.5 ± 0.5	≈ 9.0	100	250	200
18 x 31	1831	0.8	18.5	33.5	7.5 ± 0.5	≈ 12.5	100	250	200
18 x 35	22	0.8	18.5	37.5	7.5 ± 0.5	≈ 14.5	100	-	200
18 x 40	1840	0.8	18.5	42.5	7.5 ± 0.5	≈ 16.5	100	-	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>

**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 %

**ORDERING EXAMPLE**

Capacitor series 230 EDLC-HV

40 F / 3.0 V

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

Ordering code: MAL223091001E3

Table 2

ELECTRICAL DATA AND ORDERING INFORMATION																		
U <sub>R</sub> (V)	U <sub>MT</sub> <sup>(1)</sup> (V)	U <sub>CT</sub> <sup>(2)</sup> (V)	U <sub>s</sub> (V) (< 1 s)	C <sub>R</sub> <sup>(3)</sup> 100 Hz (F)	NOMINAL CASE SIZE Ø D x L (mm)	MAX. ESR <sub>DC</sub> <sup>(3)</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 (µA)		STORED ENERGY E AT U <sub>R</sub> (Wh)		SPECIFIC ENERGY E <sub>d</sub> AT U <sub>R</sub> (Wh/kg)		ORDERING CODE MAL2230.....		
								65 °C	85 °C	0.5 h	72 h	65 °C	85 °C	65 °C	85 °C	FORM CA	FORM TFA	FORM TRAY
3.0	2.8	2.6	3.15	20	16 x 20	28	22	25	20	8	75	0.020	0.015	3.4	2.3	51003E3	31003E3	91003E3
3.0	2.8	2.6	3.15	25	16 x 25	26	20	25	20	8	75	0.025	0.018	3.2	2.3	51006E3	31006E3	91006E3
3.0	2.8	2.6	3.15	25	18 x 20	24	19	25	20	8	75	0.025	0.018	3.6	2.6	51004E3	31004E3	91004E3
3.0	2.8	2.6	3.15	30	18 x 25	23	17	30	25	12	140	0.030	0.022	3.0	2.2	51007E3	31007E3	91007E3
3.0	2.8	2.6	3.15	35	16 x 31	24	18	30	25	15	200	0.035	0.026	3.8	2.9	51002E3	31002E3	91002E3
3.0	2.8	2.6	3.15	40	18 x 31	22	16	35	30	20	200	0.041	0.029	4.1	3.0	51001E3	31001E3	91001E3
3.0	2.8	2.6	3.15	50	18 x 35	19	14	35	30	25	250	0.051	0.037	3.5	2.6	51008E3	-	91008E3
3.0	2.8	2.6	3.15	60	18 x 40	17	13	35	30	30	300	0.061	0.044	3.7	2.7	51009E3	-	91009E3

**Notes**

- U<sub>MT</sub> = rated voltage at 75 °C
- U<sub>CT</sub> = rated voltage at upper category temperature
- Rated capacitance C<sub>R</sub> and ESR<sub>DC</sub>



Table 3

ENDURANCE AND USEFUL LIFE - VOLTAGES AND TEMPERATURES					
PARAMETER	U <sub>R</sub> (V)				U <sub>S</sub> (V) (< 1 s)
	55 °C	65 °C	75 °C	85 °C	
	3.0	3.0	2.8	2.6	
Endurance (h)	1500	1000	1000	1500	3.15
Useful life (h)	2000	1500	1500	2000	

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 of specified time at maximum category temperature T <sub>max.</sub> = 85 °C and related permissible maximum operating voltage U <sub>R</sub> = 2.6 V, following parameters are valid within a timeframe as specified in Table 3:	
	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 of specified time at maximum category temperature T <sub>max.</sub> = 85 °C and related permissible maximum operating voltage U <sub>R</sub> = 2.6 V, following parameters are valid within a timeframe as specified in Table 3:	
	Capacitance	Within ± 50 % of minimum initial specified value
	ESR	Less than 4 x initial specified value
	Leakage	Within specified value
Storage at upper category temperature	After loading the capacitor of specified time at maximum category temperature T <sub>max.</sub> = 85 °C and without charge and under 40 % RH, following parameters are valid within a timeframe of 1000 h:	
	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 <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] = ½ x C x (U <sub>R</sub> ) <sup>2</sup> x 1/3600 Ed [Wh/kg] = ½ x C x (U <sub>R</sub> ) <sup>2</sup> x 1/3600 x 1/mass Ev [Wh/L] = ½ x C x (U <sub>R</sub> ) <sup>2</sup> 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 <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

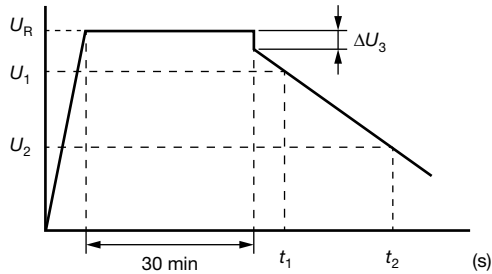


Fig. 3 - Voltage Diagram for Capacitance Measurement

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 $\Omega$
$\Delta U_3$	Voltage drop at internal resistance, in V
$I_D$	Absolute value of discharge current, in A

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