



Ruggedized Electrical Double Layer Energy Storage Capacitors



Image is not to scale

QUICK REFERENCE DATA	
DESCRIPTION	VALUE
Nominal case sizes (Ø D x L in mm)	16 x 20, 16 x 25, 16 x 31, 18 x 25, 18 x 20, 18 x 31 , 18 x 35, 18 x 40
Rated capacitance range, C _R	20 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
Biased humidity at 85 °C / 85 % RH	1500 h
Useful life at 85 °C	2000 h
Useful life at 20 °C	> 10 years
Shelf life at 20 °C	2 years
Cycle life	> 500 000 cycles

FEATURES

- Polarized energy storage capacitor with high capacity and energy density
- Rated voltage: 2.7 V
- Available in through-hole (radial) version
- Useful life: 2000 h at 85 °C
- Ruggedized for high humidity operation
- Rapid charge and discharge
- Maintenance-free, no service necessary
- AEC-Q200 qualified available (on request)
- Material categorization: for definitions of compliance please see www.vishay.com/doc?99912



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 (225)

PACKAGING

Supplied in ESD trays.

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
20	16 x 20
25	16 x 25; 18 x 20
30	18 x 25
35	16 x 31
40	18 x 31 ⁽¹⁾
50	18 x 35
60	18 x 40

Note

(1) Preferred case size

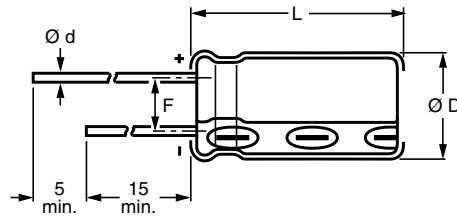
DIMENSIONS in millimeters AND AVAILABLE FORMS


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 225 EDLC-R

40 F / 2.7 V

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

Ordering code: MAL222591001E3

Table 2

ELECTRICAL DATA AND ORDERING INFORMATION															
U _R (V)	U _{CT} ⁽¹⁾ (V)	U _S (V) (< 1 s)	C _R ⁽²⁾ 100 Hz (F)	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		STORED ENERGY E AT U _R (Wh)		SPECIFIC ENERGY E _d AT U _R (Wh/kg)		ORDERING CODE MAL2225.....
							65 °C	85 °C	0.5 h	72 h	65 °C	85 °C	65 °C	85 °C	
2.7	2.3	2.85	20	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	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	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	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	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	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	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	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}



Table 3

RUGGEDIZED FOR HIGH HUMIDITY - BIASED HUMIDITY TESTING		
PARAMETER	PROCEDURE (AT RATED VOLTAGE)	REQUIREMENTS
Humidity (relative)	85 %	After loading the capacitor for the specified time at maximum category temperature $T_{max.} = 85\text{ °C}$ and 85 % relative humidity, and related permissible maximum operating voltage $U_R = 2.3\text{ V}$, following parameters are valid within a timeframe of 1000 h: No visible damage No leakage of electrolyte $\Delta C/C$: within $\pm 30\%$ of minimum initial specified value ESR: less than 3 x initial specified value Leakage: less than initial specified value
Temperature	85 °C	

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 $0.5 \times U_R$. 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 for specified time at maximum category temperature $T_{max.} = 85\text{ °C}$ and related permissible maximum operating voltage $U_R = 2.3\text{ V}$, following parameters are valid within a timeframe of 1000 h:	
	Capacitance	Within $\pm 30\%$ of minimum initial specified value
	ESR	Less than 3 x initial specified value
	Leakage	Within specified value
Useful life	After loading the capacitor for specified time at maximum category temperature $T_{max.} = 85\text{ °C}$ and related permissible maximum operating voltage $U_R = 2.3\text{ V}$, following parameters are valid within a timeframe of 2000 h:	
	Capacitance	Within $\pm 50\%$ 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 $T_{max.} = 85\text{ °C}$ and without charge and under 40 % RH, following parameters are valid within a timeframe of 1000 h:	
	Capacitance	Within $\pm 30\%$ 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 $\pm 30\%$ of minimum initial specified value
	ESR	Less than 3 x initial specified value
Stored energy E_s , specific energy E_d and E_v	$E [Wh] = \frac{1}{2} \times C \times (U_R)^2 \times 1/3600$ $E_d [Wh/kg] = \frac{1}{2} \times C \times (U_R)^2 \times 1/3600 \times 1/mass$ $E_v [Wh/L] = \frac{1}{2} \times C \times (U_R)^2 \times 1/3600 \times 1/volume$	
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"> temperatures outside specified range high humidity atmospheres; except series 225 which is ruggedized for high humidity 85 °C and 85 % RH 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, $0.8 \times U_R$ in V
U_2	Ending voltage, $0.4 \times U_R$ 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

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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