

Electrical Double Layer Energy Storage Capacitors Power and Energy Versions



Image is not to scale

| QUICK REFERENCE DATA | |
|--|---|
| DESCRIPTION | VALUE |
| Nominal case sizes (\varnothing D x L in mm) | 12.5 x 20; 12.5 x 25; 12.5 x 30; 12.5 x 40; 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 | 8 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 |

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
- 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 (220)

PACKAGING

Supplied loose in box and in ESD trays

| SELECTION CHART FOR C_R , U_R , AND RELEVANT NOMINAL CASE SIZES (\varnothing D x L in mm) | |
|--|--|
| C_R (F) | U_R (V) = 2.7 V |
| 8 | 12.5 x 20 |
| 12 | 12.5 x 25 |
| 15 | 12.5 x 30; 16 x 20 |
| 20 | 16 x 20; 16 x 25; 18 x 20 |
| 22 | 12.5 x 40 |
| 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

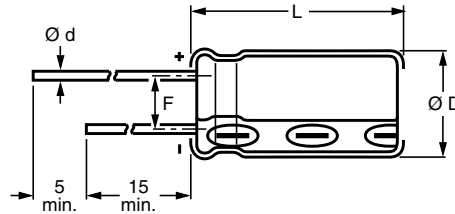
DIMENSIONS in millimeters AND AVAILABLE FORMS


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 | FORM TRAY |
| 12.5 x 20 | 17 | 0.6 | 13.0 | 22 | 5.0 ± 0.5 | ≈ 4.0 | 500 | - |
| 12.5 x 25 | 18 | 0.6 | 13.0 | 27 | 5.0 ± 0.5 | ≈ 5.0 | 250 | - |
| 12.5 x 30 | 18L | 0.8 | 13.0 | 33.5 | 5.0 ± 0.5 | ≈ 5.5 | 250 | - |
| 12.5 x 40 | 18LL | 0.8 | 13.0 | 42.5 | 5.0 ± 0.5 | ≈ 7.0 | 250 | - |
| 16 x 20 | 19a | 0.8 | 16.5 | 22 | 7.5 ± 0.5 | ≈ 6.0 | 250 | 200 |
| 16 x 25 | 19 | 0.8 | 16.5 | 27 | 7.5 ± 0.5 | ≈ 8.0 | 250 | 200 |
| 18 x 20 | 1820 | 0.8 | 18.5 | 22 | 7.5 ± 0.5 | ≈ 7.0 | 100 | 200 |
| 18 x 25 | 1825 | 0.8 | 18.5 | 27 | 7.5 ± 0.5 | ≈ 10.0 | 100 | 200 |
| 16 x 31 | 20 | 0.8 | 16.5 | 33.5 | 7.5 ± 0.5 | ≈ 9.0 | 100 | 200 |
| 18 x 31 | 1831 | 0.8 | 18.5 | 33.5 | 7.5 ± 0.5 | ≈ 12.5 | 100 | 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 _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 tray

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 (F) | NOMINAL CASE SIZE Ø D x L (mm) | MAX. ESR _{DC} ⁽²⁾ INITIAL (mΩ) | MAX. ESR _{AC} ⁽²⁾ 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 E _d 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 | FORM CA | FORM TRAY |
| 2.7 | 2.3 | 2.85 | 15 | 16 x 20 | 40 | 30 | 25 | 20 | 6 | 75 | 0.015 | 0.011 | 2.5 | 1.8 | 50003E3 | 90003E3 | |
| 2.7 | 2.3 | 2.85 | 20 | 16 x 25 | 38 | 28 | 25 | 20 | 6 | 75 | 0.020 | 0.015 | 2.5 | 1.8 | 50006E3 | 90006E3 | |
| 2.7 | 2.3 | 2.85 | 20 | 18 x 20 | 38 | 28 | 25 | 20 | 6 | 75 | 0.020 | 0.015 | 2.9 | 2.1 | 50004E3 | 90004E3 | |
| 2.7 | 2.3 | 2.85 | 25 | 18 x 25 | 36 | 26 | 25 | 20 | 11 | 115 | 0.025 | 0.018 | 2.5 | 1.8 | 50007E3 | 90007E3 | |
| 2.7 | 2.3 | 2.85 | 30 | 16 x 31 | 36 | 26 | 25 | 20 | 15 | 150 | 0.030 | 0.022 | 3.4 | 2.5 | 50002E3 | 90002E3 | |
| 2.7 | 2.3 | 2.85 | 35 | 18 x 31 | 35 | 25 | 25 | 20 | 15 | 150 | 0.035 | 0.029 | 3.5 | 2.6 | 50001E3 | 90001E3 | |
| 2.7 | 2.3 | 2.85 | 45 | 18 x 35 | 30 | 21 | 25 | 20 | 20 | 200 | 0.046 | 0.033 | 3.2 | 2.3 | 50008E3 | 90008E3 | |
| 2.7 | 2.3 | 2.85 | 55 | 18 x 40 | 25 | 18 | 25 | 20 | 25 | 250 | 0.056 | 0.040 | 3.4 | 2.5 | 50009E3 | 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 (F) | NOMINAL CASE SIZE Ø D x L (mm) | MAX. ESR _{DC} ⁽²⁾ INITIAL (mΩ) | MAX. ESR _{AC} ⁽²⁾ 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 E _d 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 | FORM CA | FORM TRAY |
| 2.7 | 2.3 | 2.85 | 8 | 12.5 x 20 | 28 | 21 | 15 | 12 | 4 | 40 | 0.008 | 0.006 | 2.0 | 1.5 | 51014E3 | - | |
| 2.7 | 2.3 | 2.85 | 12 | 12.5 x 25 | 26 | 19 | 17 | 14 | 5 | 55 | 0.011 | 0.008 | 2.2 | 1.6 | 51015E3 | - | |
| 2.7 | 2.3 | 2.85 | 15 | 12.5 x 30 | 23 | 16 | 20 | 17 | 6 | 70 | 0.015 | 0.011 | 2.7 | 2.0 | 51016E3 | - | |
| 2.7 | 2.3 | 2.85 | 20 | 16 x 20 | 24 | 18 | 25 | 20 | 8 | 75 | 0.020 | 0.015 | 3.4 | 2.3 | 51003E3 | 91003E3 | |
| 2.7 | 2.3 | 2.85 | 22 | 12.5 x 40 | 18 | 11 | 25 | 20 | 9 | 75 | 0.021 | 0.015 | 3.0 | 2.1 | 51017E3 | - | |
| 2.7 | 2.3 | 2.85 | 25 | 16 x 25 | 22 | 16 | 25 | 20 | 8 | 75 | 0.025 | 0.018 | 3.2 | 2.3 | 51006E3 | 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 | 51004E3 | 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 | 51007E3 | 91007E3 | |
| 2.7 | 2.3 | 2.85 | 35 | 16 x 31 | 20 | 14 | 30 | 25 | 15 | 200 | 0.035 | 0.026 | 3.9 | 2.9 | 51002E3 | 91002E3 | |
| 2.7 | 2.3 | 2.85 | 40 | 18 x 31 | 18 | 12 | 35 | 30 | 20 | 200 | 0.041 | 0.029 | 3.3 | 2.3 | 51001E3 | 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 | 51008E3 | 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 | 51009E3 | 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 $0.5 \times U_R$. 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 of 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 of 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 |
| 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 | $E \text{ [Wh]} = \frac{1}{2} \times C \times (U_R)^2 \times 1/3600$ $E_d \text{ [Wh/kg]} = \frac{1}{2} \times C \times (U_R)^2 \times 1/3600 \times 1/\text{mass}$ $E_v \text{ [Wh/L]} = \frac{1}{2} \times C \times (U_R)^2 \times 1/3600 \times 1/\text{volume}$ | |
| 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 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

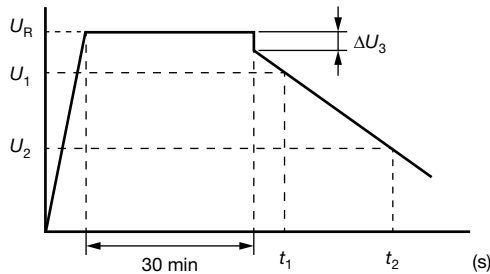


Fig. 2 - Voltage Diagram for Capacitance Measurement

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.



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.