

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

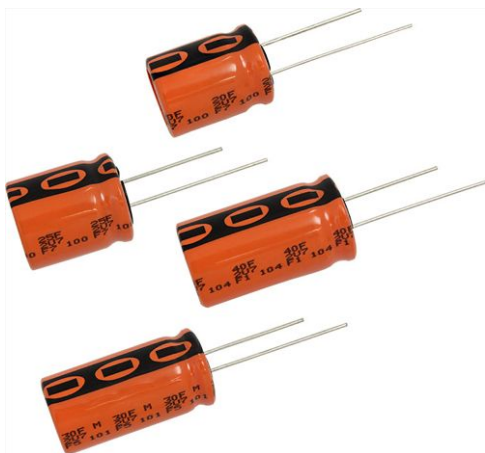


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### FEATURES

- 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](http://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 in ESD trays.

### QUICK REFERENCE DATA

| DESCRIPTION                                   | VALUE                                        |
|-----------------------------------------------|----------------------------------------------|
| Nominal case sizes (Ø D x L in mm)            | 16 x 20; 18 x 20;<br>16 x 31; <b>18 x 31</b> |
| Rated capacitance range, C <sub>R</sub>       | 15 F to 40 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; 18 x 20                       |
| 25                 | 18 x 20                                |
| 30                 | 16 x 31                                |
| 35                 | 16 x 31, <b>18 x 31</b> <sup>(1)</sup> |
| 40                 | <b>18 x 31</b> <sup>(1)</sup>          |

#### Note

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

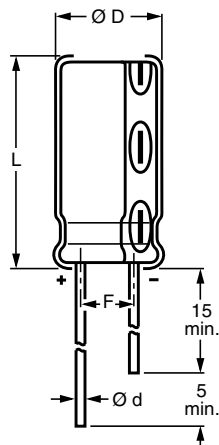
**DIMENSIONS in millimeters AND AVAILABLE FORMS**


Fig. 1 - Form CA: long leads

Table 1

| DIMENSIONS in millimeters, MASS, AND PACKAGING QUANTITIES |           |     |                     |                   |           |          |                                         |
|-----------------------------------------------------------|-----------|-----|---------------------|-------------------|-----------|----------|-----------------------------------------|
| NOMINAL CASE SIZE<br>Ø D x L                              | CASE CODE | Ø d | Ø D <sub>max.</sub> | L <sub>max.</sub> | F         | MASS (g) | PACKAGING QUANTITIES<br>FORM CA IN TRAY |
| 16 x 20                                                   | 19a       | 0.8 | 16.5                | 22                | 7.5 ± 0.5 | ≈ 6.0    | 200                                     |
| 18 x 20                                                   | 1820      | 0.8 | 18.5                | 22                | 7.5 ± 0.5 | ≈ 7.0    | 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 | ≈ 10.0   | 200                                     |

| 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 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 <sub>R</sub><br>(V)                                       | U <sub>CT</sub> <sup>(1)</sup><br>(V) | U <sub>S</sub><br>(V)<br>( $< 1\text{ s}$ ) | C <sub>R</sub> <sup>(2)</sup><br>100 Hz<br>(μF) | NOMINAL<br>CASE SIZE<br>Ø D x L<br>(mm) | MAX.<br>ESR <sub>DC</sub> <sup>(2)</sup><br>INITIAL<br>(mΩ) | MAX.<br>ESR <sub>AC</sub><br>INITIAL,<br>1 kHz<br>(mΩ) | I <sub>P</sub><br>MAX. PEAK<br>CURRENT<br>(A) |       | I <sub>L</sub><br>MAX.<br>LEAKAGE<br>CURRENT<br>AFTER<br>(mA) (μA) |      | STORED<br>ENERGY<br>E AT U <sub>R</sub><br>(Wh) |       | SPECIFIC<br>ENERGY<br>E <sub>d</sub> AT U <sub>R</sub><br>(Wh/kg) |       | ORDERING<br>CODE<br>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                                      | 18 x 20                                 | 38                                                          | 28                                                     | 25                                            | 20    | 6                                                                  | 75   | 0.020                                           | 0.015 | 2.9                                                               | 2.1   | 90004E3                          |
| 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                          |

**Notes**
<sup>(1)</sup> U<sub>CT</sub> = rated voltage at upper category temperature

<sup>(2)</sup> 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><br>(V)                                      | U <sub>CT</sub> <sup>(1)</sup><br>(V) | U <sub>S</sub><br>(V)<br>( $< 1$ s) | C <sub>R</sub> <sup>(2)</sup><br>100 Hz<br>(μF) | NOMINAL<br>CASE SIZE<br>Ø D x L<br>(mm) | MAX.<br>ESR <sub>DC</sub> <sup>(2)</sup><br>INITIAL<br>(mΩ) | MAX.<br>ESR <sub>AC</sub><br>INITIAL,<br>1 kHz<br>(mΩ) | I <sub>P</sub><br>MAX.<br>PEAK<br>CURRENT<br>(A) |       | I <sub>L</sub><br>MAX.<br>LEAKAGE<br>CURRENT<br>AFTER |      | STORED<br>ENERGY<br>E AT U <sub>R</sub><br>(Wh) |       | SPECIFIC<br>ENERGY<br>Ed AT U <sub>R</sub><br>(Wh/kg) |       | ORDERING<br>CODE<br>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                                      | 18 x 20                                 | 20                                                          | 15                                                     | 25                                               | 20    | 8                                                     | 75   | 0.025                                           | 0.018 | 3.6                                                   | 2.6   | 91004E3                          |
| 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                          |

**Notes**

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

(2) Rated capacitance  $C_R$  and ESR<sub>DC</sub>

| TEST PROCEDURES AND REQUIREMENTS <sup>(1)</sup>     |                                                                                                                                                                                                                                                                                                                                                |
|-----------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| NAME OF TEST                                        | PROCEDURE<br>(quick reference)                                                                                                                                                                                                                                                                                                                 |
| Capacitance $C_R$ and ESR <sub>DC</sub>             | Measured by DC discharging method as described in "Measuring of Characteristics". <sup>(2)</sup>                                                                                                                                                                                                                                               |
| Maximum peak current                                | Non-repetitive current for maximum 1 s at specified operating temperature.<br>Maximum operating voltage (refer to derating table) must not be exceeded.<br>Usually to be tested with constant current discharge from $U_R$ to 0.5 x $U_R$ .<br>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 $\pm 30$ % of minimum initial specified value                                                                                                                                                                                                                                                                          |
|                                                     | ESR                Less than 3 x initial specified value                                                                                                                                                                                                                                                                                       |
|                                                     | Leakage           Within specified value                                                                                                                                                                                                                                                                                                       |
| Useful life                                         | After loading the capacitor the specified time at maximum category temperature $T_{MAX}$ , and related permissible maximum operating voltage $U_R$ :                                                                                                                                                                                           |
|                                                     | 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 the specified time at maximum storage temperature $T_{MAX}$ , without charge and under 40 % RH:                                                                                                                                                                                                                    |
|                                                     | 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.<br>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 $E$ , specific energy $E_d$ and $E_v$ | $E$ [Wh] = $\frac{1}{2} \times C \times (U_R)^2 \times 1/3600$<br>$E_d$ [Wh/kg] = $\frac{1}{2} \times C \times (U_R)^2 \times 1/3600 \times 1/\text{mass}$<br>$E_v$ [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.<br>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  $C_R$  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

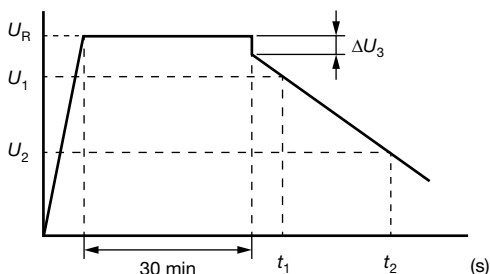


Fig. 2 - Voltage Diagram for Capacitance Measurement

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 ( $ESR_{DC}$ )

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



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- Изготовление тестовой платы монтаж и пусконаладочные работы.



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