

## Energy Storage Double Layer Capacitors



### FEATURES

- Polarized capacitor with high charge density, alternative product to rechargeable backup batteries
- Dielectric: electric double layer
- Radial leads, cylindrical case, insulated with a blue sleeve
- Available in both vertical and low-profile versions
- Unlimited charge and discharge cycle numbers
- No charge-discharge control circuitry and no series resistor necessary
- Maintenance-free, no periodic replacement or service necessary
- Ecologically beneficial (no Cd, no Li)
- Material categorization: for definitions of compliance please see [www.vishay.com/doc?99912](http://www.vishay.com/doc?99912)


**RoHS**  
COMPLIANT

### APPLICATIONS

- Energy storage, for backup of semiconductor memories (CMOS) in all fields of electronics
- Telecommunication, audio-video, EDP
- General industrial, clock and timer systems

### MARKING

The capacitors are marked with the following information:

- Rated capacitance (in F)
- Rated voltage (in V)
- Date code, in accordance with IEC 60062
- Name of manufacturer
- Negative terminal identification
- Upper category temperature (at 85 °C types only)

| <b>QUICK REFERENCE DATA (Low Leakage Series)</b> |                                      |                          |                         |                         |
|--|--------------------------------------|--------------------------|-------------------------|-------------------------|
| DESCRIPTION                                      | VALUE                                |                          |                         |                         |
|  | STANDARD FORM A                      | HIGH TEMPERATURE FORM A  | STANDARD FORM B         | HIGH TEMPERATURE FORM B |
| Nominal case sizes (Ø D x L in mm)               | 13.5 x 7 and 20.5 x 8                | 13.5 x 7 and 20.5 x 10.5 | 11.5 x 13 and 19 x 20.5 | 11.5 x 13 and 19 x 20.5 |
| Rated capacitance range, C <sub>R</sub>          | 0.22 F to 1.5 F                      | 0.22 F to 1.5 F          | 0.22 F to 1.5 F         | 0.22 F to 1.5 F         |
| Tolerance on C <sub>R</sub> at 20 °C             | -20 % to +80 %                       |                          |                         |                         |
| Rated voltage, U <sub>R</sub>                    | 5.5 V                                | 5.5 V                    | 5.5 V                   | 5.5 V                   |
| Maximum surge voltage, U <sub>S</sub>            | 6.0 V                                | 6.0 V                    | 6.0 V                   | 6.0 V                   |
| Category temperature range                       | -25 °C to +70 °C                     | -25 °C to +85 °C         | -25 °C to +70 °C        | -25 °C to +85 °C        |
| Useful life at U <sub>R</sub> :                  |                                      |                          |                         |                         |
| at 85 °C   | -                                    | 1000 h                   | -                       | 1000 h                  |
| at 70 °C   | 1000 h                               | 2800 h                   | 1000 h                  | 2800 h                  |
| at 40 °C   | 8000 h                               | 23 000 h                 | 8000 h                  | 23 000 h                |
| at 25 °C   | 23 000 h                             | 64 000 h                 | 23 000 h                | 64 000 h                |
| Shelf life at 0 V                                | 1000 h at upper category temperature |                          |                         |                         |
| Climatic category IEC 60068                      | 25 / 070 / 21                        | 25 / 085 / 21            | 25 / 070 / 21           | 25 / 085 / 21           |



| <b>QUICK REFERENCE DATA (Standard Series)</b> |                                      |                         |                      |
|---|--------------------------------------|-------------------------|----------------------|
| DESCRIPTION                                   | VALUE                                |                         |                      |
|   | STANDARD FORM A                      | HIGH TEMPERATURE FORM A | VERTICAL FORM B      |
| Nominal case sizes (Ø D x L in mm)            | 13 x 7 and 21 x 7.5                  | 13 x 9 and 21 x 9       | 11.5 x 13 (vertical) |
| Rated capacitance range, C <sub>R</sub>       | 0.047 F to 1.0 F                     | 0.047 F to 0.68 F       | 0.047 F to 0.33 F    |
| Tolerance on C <sub>R</sub> at 20 °C          | -20 % to +80 %                       |                         |                      |
| Rated voltage, U <sub>R</sub>                 | 5.5 V                                | 5.5 V                   | 5.5 V                |
| Maximum surge voltage, U <sub>S</sub>         | 6.3 V                                | 6.3 V                   | 6.3 V                |
| Category temperature range                    | -25 °C to +70 °C                     | -25 °C to +85 °C        | -25 °C to +70 °C     |
| Useful life at U <sub>R</sub> :               |                                      |                         |                      |
| at 85 °C                                      | -                                    | 1000 h                  | -                    |
| at 70 °C                                      | 1000 h                               | 2800 h                  | 1000 h               |
| at 40 °C                                      | 8000 h                               | 23 000 h                | 8000 h               |
| at 25 °C                                      | 23 000 h                             | 64 000 h                | 23 000 h             |
| Shelf life at 0 V                             | 1000 h at upper category temperature |                         |                      |
| Climatic category IEC 60068                   | 25 / 070 / 21                        | 25 / 085 / 21           | 25 / 070 / 21        |

| <b>SELECTION CHART FOR C<sub>R</sub>, U<sub>R</sub>, AND FORM AT UPPER CATEGORY TEMPERATURE (UCT)</b> |      |                        |             |                    |             |
|---|------|------------------------|-------------|--------------------|-------------|
| C <sub>R</sub> (F)  | FORM | U <sub>R</sub> = 5.5 V |             |                    |             |
|   |      | STANDARD SERIES        |             | LOW LEAKAGE SERIES |             |
|   |      | UCT = 85 °C            | UCT = 70 °C | UCT = 85 °C        | UCT = 70 °C |
| 0.047   | A    | 13 x 9                 | 13 x 7      | -                  | -           |
|   | B    | -                      | 11.5 x 13   | -                  | -           |
| 0.1   | A    | 13 x 9                 | 13 x 7      | -                  | -           |
|   | B    | -                      | 11.5 x 13   | -                  | -           |
| 0.22  | A    | -                      | 13 x 7      | 13.5 x 7           | 13.5 x 7    |
|   | B    | -                      | 11.5 x 13   | 11.5 x 13          | 11.5 x 13   |
| 0.33  | A    | -                      | 13 x 7      | 13.5 x 7           | 13.5 x 7    |
|   | B    | -                      | 11.5 x 13   | 11.5 x 13          | 11.5 x 13   |
| 0.47  | A    | 21 x 9                 | 21 x 7.5    | 13.5 x 7           | 13.5 x 7    |
|   | B    | -                      | -           | 11.5 x 13          | 11.5 x 13   |
| 0.68  | A    | 21 x 9                 | -           | 20.5 x 10.5        | -           |
|   | B    | -                      | -           | -                  | -           |
| 1.0   | A    | -                      | 21 x 7.5    | 20.5 x 8           | 20.5 x 8    |
|   | B    | -                      | -           | 19 x 20.5          | 19 x 20.5   |
| 1.5   | A    | -                      | -           | 20.5 x 8           | 20.5 x 8    |
|   | B    | -                      | -           | 19 x 20.5          | 19 x 20.5   |

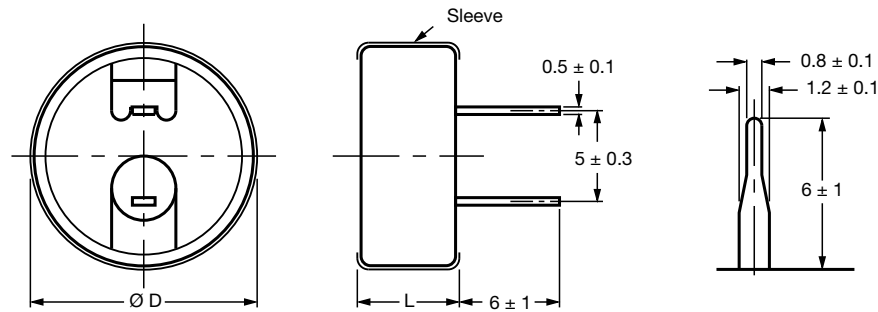
**DIMENSIONS** in millimeters **AND AVAILABLE FORMS**


Fig. 1 - Form A: Low profile

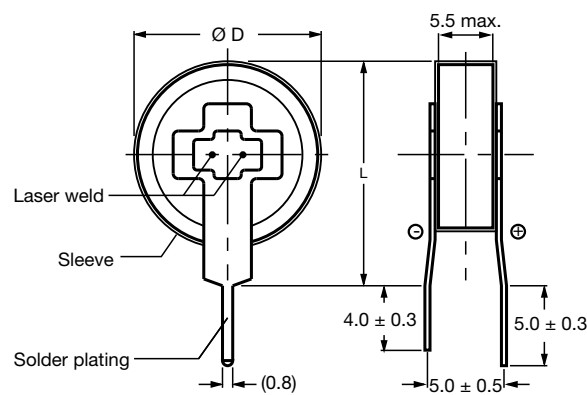


Fig. 2 - Form B: Vertical

| <b>DIMENSIONS</b> in millimeters, <b>MASS AND PACKAGING QUANTITIES</b> (Low Leakage Series) |           |      |                               |                   |          |                      |
|---|-----------|------|-------------------------------|-------------------|----------|----------------------|
| NOMINAL CASE SIZE<br>$\varnothing D \times L$ (mm)  | CASE CODE | FORM | $\varnothing D_{\text{max.}}$ | $L_{\text{max.}}$ | MASS (g) | PACKAGING QUANTITIES |
| 11.5 x 13   | 6         | B    | 12.0                          | 14.0              | ≈ 1.6    | 2000                 |
| 19 x 20.5   | 7         | B    | 19.5                          | 21.5              | ≈ 4.0    | 800                  |
| 13.5 x 7  | 8         | A    | 14.0                          | 7.5               | ≈ 3.5    | 1000                 |
| 20.5 x 8  | 9         | A    | 21.0                          | 8.5               | ≈ 9.0    | 1000                 |
| 20.5 x 10   | 10        | A    | 21.0                          | 11.0              | ≈ 10.0   | 600                  |

| <b>DIMENSIONS</b> in millimeters, <b>MASS AND PACKAGING QUANTITIES</b> (Standard Series) |           |      |                               |                   |          |                      |
|--|-----------|------|-------------------------------|-------------------|----------|----------------------|
| NOMINAL CASE SIZE<br>$\varnothing D \times L$ (mm)                                       | CASE CODE | FORM | $\varnothing D_{\text{max.}}$ | $L_{\text{max.}}$ | MASS (g) | PACKAGING QUANTITIES |
| 11.5 x 13  | 1         | B    | 11.8                          | 13.5              | ≈ 1.5    | 1000                 |
| 13 x 7   | 2         | A    | 13.5                          | 7.5               | ≈ 2.8    | 1000                 |
| 13 x 9   | 3         | A    | 13.5                          | 9.5               | ≈ 3.4    | 1000                 |
| 21 x 7.5   | 4         | A    | 21.5                          | 8.0               | ≈ 7.1    | 500                  |
| 21 x 9   | 5         | A    | 21.5                          | 9.5               | ≈ 8.8    | 500                  |

**Note**

- Packaging: bulk in box



| ELECTRICAL DATA |   |
|-----------------|---|
| SYMBOL          | DESCRIPTION   |
| C <sub>R</sub>  | Rated capacitance, tolerance -20 % / +80 %, measured by constant current discharge method |
| UCT             | Upper category temperature  |
| I <sub>L</sub>  | Max. leakage current after 30 min at U <sub>R</sub>                                       |
| R <sub>I</sub>  | Max. internal resistance at 1 kHz   |

**Note**

- Unless otherwise specified, all electrical values in Table 1 apply at T<sub>amb</sub> = 20 °C, P = 86 kPa to 106 kPa and RH = 45 % to 75 %

**ORDERING EXAMPLE**

Double layer capacitor 196 series

1.0 F / 5.5 V

Nominal case size: Ø 20.5 mm x 8 mm; form A

Ordering code: MAL219642105E3

**Table 1**

| ELECTRICAL DATA AND ORDERING INFORMATION (Low Leakage Series) <sup>(1)</sup> |                       |   |              |      |             |                                  |                                |                |
|--|-----------------------|---|--------------|------|-------------|----------------------------------|--------------------------------|----------------|
| U <sub>R</sub><br>(V)  | C <sub>R</sub><br>(F) | NOMINAL<br>CASE SIZE<br>Ø D x L<br>(mm) | CASE<br>CODE | FORM | UCT<br>(°C) | I <sub>L</sub><br>30 min<br>(µA) | R <sub>I</sub><br>1 kHz<br>(Ω) | ORDERING CODE  |
| <b>STANDARD SERIES</b>   |                       |   |              |      |             |                                  |                                |                |
| 5.5  | 0.22                  | 13.5 x 7                                | 8            | A    | 70          | 3                                | 75                             | MAL219642224E3 |
|  | 0.33                  | 13.5 x 7                                | 8            | A    | 70          | 5                                | 50                             | MAL219642334E3 |
|  | 0.47                  | 13.5 x 7                                | 8            | A    | 70          | 5                                | 50                             | MAL219642474E3 |
|  | 1.0                   | 20.5 x 8                                | 9            | A    | 70          | 8                                | 30                             | MAL219642105E3 |
|  | 1.5                   | 20.5 x 8                                | 9            | A    | 70          | 8                                | 30                             | MAL219642155E3 |
| <b>STANDARD SERIES, VERTICAL</b>   |                       |   |              |      |             |                                  |                                |                |
| 5.5  | 0.22                  | 11.5 x 13                               | 6            | B    | 70          | 3                                | 75                             | MAL219652224E3 |
|  | 0.33                  | 11.5 x 13                               | 6            | B    | 70          | 5                                | 50                             | MAL219652334E3 |
|  | 0.47                  | 11.5 x 13                               | 6            | B    | 70          | 5                                | 50                             | MAL219652474E3 |
|  | 1.0                   | 19 x 20.5                               | 7            | B    | 70          | 8                                | 30                             | MAL219652105E3 |
|  | 1.5                   | 19 x 20.5                               | 7            | B    | 70          | 8                                | 30                             | MAL219652155E3 |
| <b>HIGH TEMPERATURE SERIES</b>   |                       |   |              |      |             |                                  |                                |                |
| 5.5  | 0.22                  | 13.5 x 7                                | 8            | A    | 85          | 3                                | 75                             | MAL219662224E3 |
|  | 0.33                  | 13.5 x 7                                | 8            | A    | 85          | 3                                | 50                             | MAL219662334E3 |
|  | 0.47                  | 13.5 x 7                                | 8            | A    | 85          | 5                                | 50                             | MAL219662474E3 |
|  | 0.68                  | 20.5 x 10.5                             | 10           | A    | 85          | 8                                | 30                             | MAL219662684E3 |
|  | 1.0                   | 20.5 x 8                                | 9            | A    | 85          | 8                                | 30                             | MAL219662105E3 |
|  | 1.5                   | 20.5 x 8                                | 9            | A    | 85          | 8                                | 30                             | MAL219662155E3 |
| <b>HIGH TEMPERATURE SERIES, VERTICAL</b>                                     |                       |   |              |      |             |                                  |                                |                |
| 5.5  | 0.22                  | 11.5 x 13                               | 6            | B    | 85          | 3                                | 75                             | MAL219672224E3 |
|  | 0.33                  | 11.5 x 13                               | 6            | B    | 85          | 5                                | 50                             | MAL219672334E3 |
|  | 0.47                  | 11.5 x 13                               | 6            | B    | 85          | 5                                | 50                             | MAL219672474E3 |
|  | 1.0                   | 19 x 20.5                               | 7            | B    | 85          | 8                                | 30                             | MAL219672105E3 |
|  | 1.5                   | 19 x 20.5                               | 7            | B    | 85          | 8                                | 30                             | MAL219672155E3 |

**Note**

- <sup>(1)</sup> Preferred for ordering



Table 2

| <b>ELECTRICAL DATA AND ORDERING INFORMATION</b> (Standard Series) |              |  |              |      |             |                                |                                |                |
|---|--------------|--|--------------|------|-------------|--------------------------------|--------------------------------|----------------|
| $U_R$<br>(V)  | $C_R$<br>(F) | NOMINAL<br>CASE SIZE<br>$\varnothing D \times L$<br>(mm) | CASE<br>CODE | FORM | UCT<br>(°C) | $I_L$<br>30 min<br>( $\mu A$ ) | $R_1$<br>1 kHz<br>( $\Omega$ ) | ORDERING CODE  |
| <b>STANDARD SERIES</b>  |              |  |              |      |             |                                |                                |                |
| 5.5   | 0.047        | 13 x 7   | 2            | A    | 70          | 69                             | 120                            | MAL219612473E3 |
|   | 0.10         | 13 x 7   | 2            | A    | 70          | 100                            | 75                             | MAL219612104E3 |
|   | 0.22         | 13 x 7   | 2            | A    | 70          | 135                            | 75                             | MAL219612224E3 |
|   | 0.33         | 13 x 7   | 2            | A    | 70          | 182                            | 75                             | MAL219612334E3 |
|   | 0.47         | 21 x 7.5   | 4            | A    | 70          | 216                            | 30                             | MAL219612474E3 |
|   | 1.0          | 21 x 7.5   | 4            | A    | 70          | 315                            | 30                             | MAL219612105E3 |
| <b>HIGH TEMPERATURE SERIES</b>                                    |              |  |              |      |             |                                |                                |                |
| 5.5   | 0.047        | 13 x 9   | 3            | A    | 85          | 69                             | 300                            | MAL219622473E3 |
|   | 0.10         | 13 x 9   | 3            | A    | 85          | 100                            | 200                            | MAL219622104E3 |
|   | 0.47         | 21 x 9   | 5            | A    | 85          | 216                            | 50                             | MAL219622474E3 |
|   | 0.68         | 21 x 9   | 5            | A    | 85          | 260                            | 50                             | MAL219622684E3 |
| <b>VERTICAL, MINIATURIZED SERIES</b>                              |              |  |              |      |             |                                |                                |                |
| 5.5   | 0.047        | 11.5 x 13  | 1            | B    | 70          | 69                             | 120                            | MAL219632473E3 |
|   | 0.10         | 11.5 x 13  | 1            | B    | 70          | 100                            | 75                             | MAL219632104E3 |
|   | 0.22         | 11.5 x 13  | 1            | B    | 70          | 135                            | 75                             | MAL219632224E3 |
|   | 0.33         | 11.5 x 13  | 1            | B    | 70          | 182                            | 75                             | MAL219632334E3 |

**MEASURING OF CHARACTERISTICS**

**CAPACITANCE (C)**

Capacitance shall be measured by constant current discharge method.

| DISCHARGE CURRENT AS A FUNCTION OF RATED CAPACITANCE |       |     |      |      |      |      |     |     |      |
|--|-------|-----|------|------|------|------|-----|-----|------|
| PARAMETER  | VALUE |     |      |      |      |      |     |     | UNIT |
| Rated capacitance, C <sub>R</sub>                    | 0.047 | 0.1 | 0.22 | 0.33 | 0.47 | 0.68 | 1.0 | 1.5 | F    |
| Discharge current, I <sub>D</sub>                    | 0.1   |     |      | 1.0  |      |      |     |     | mA   |

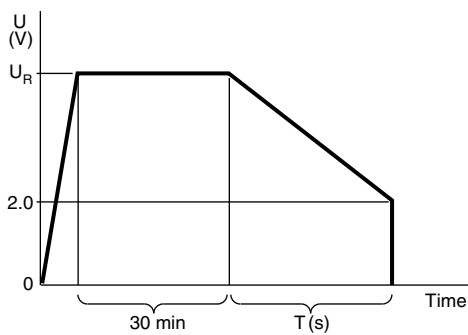


Fig. 3 - Voltage diagram for capacitance measurement

Capacitance value C<sub>R</sub> is given by discharge current I<sub>D</sub>, time T and rated voltage U<sub>R</sub>, according to the following equation:

$$C(F) = \frac{I_D(mA) \times 10^{-3} \times T(s)}{U_R(V) - 2}$$

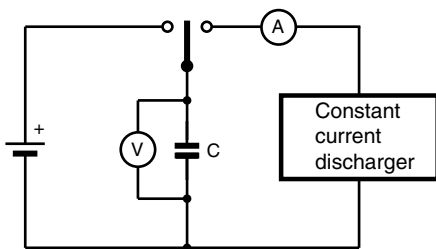


Fig. 4 - Test circuit for capacitance measurement

**INTERNAL RESISTANCE (R<sub>I</sub>) AT 1 kHz**

$$R_I(\Omega) = \frac{V_C(V)}{10^{-3}}$$

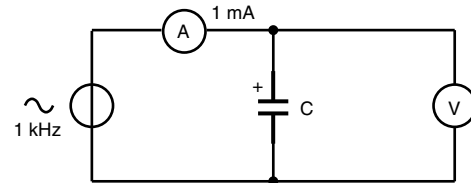


Fig. 5 - Test circuit for R<sub>I</sub> measurement

**LEAKAGE CURRENT (I<sub>L</sub>)**

Leakage current shall be measured after 30 min application of rated voltage U<sub>R</sub>:

$$I_L(\mu A) = \frac{V(V)}{10^{-4}}$$

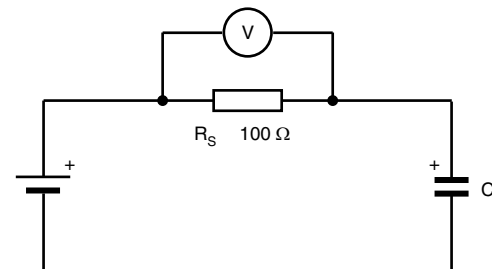


Fig. 6 - Test circuit for leakage current

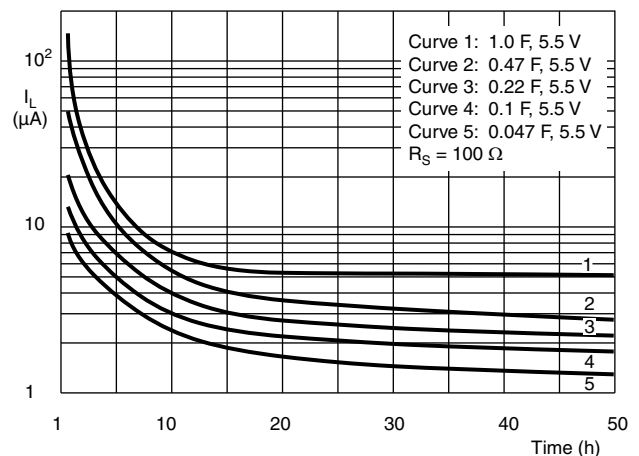


Fig. 7 - Typical leakage current as a function of time

**DISCHARGE CHARACTERISTICS**

Backup time of 196 DLC series capacitors depends on minimum memory holding voltage and discharge current (corresponding with the current consumption of the load). For minimum backup times of standard and vertical miniaturized series see Figures 8 and 9 (charging time  $\geq 24$  h).

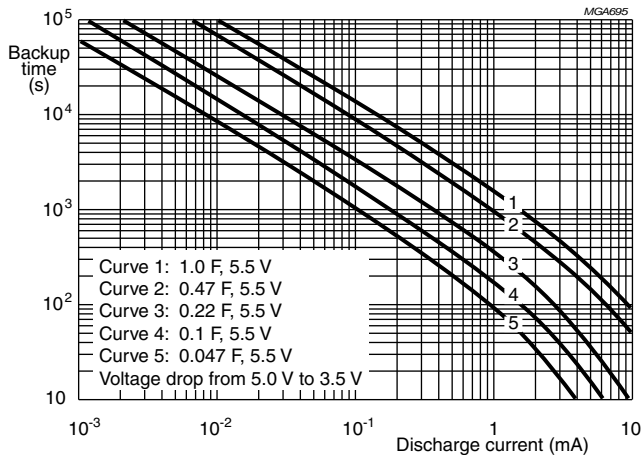


Fig. 8 - Typical backup time as a function of discharge current

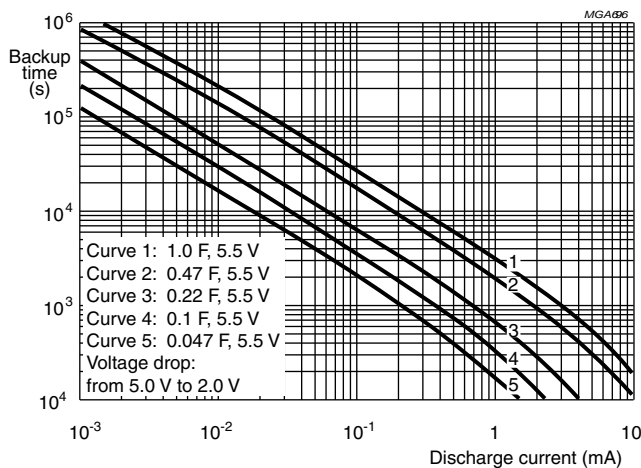


Fig. 9 - Typical backup time as a function of discharge current

Figure 10 shows the backup time when a 196 DLC capacitor is discharged by a constant resistance (charging time  $\geq 24$  h).

The horizontal axis shows the initial value of discharge current if 5 V is connected to the capacitor via a fixed series resistor.

**Example: 1  $\mu$ A corresponds to 5 M $\Omega$  and 0.1  $\mu$ A corresponds to 50 M $\Omega$**

The vertical axis shows that period of time during which the voltage drops from 5 V to 2 V.

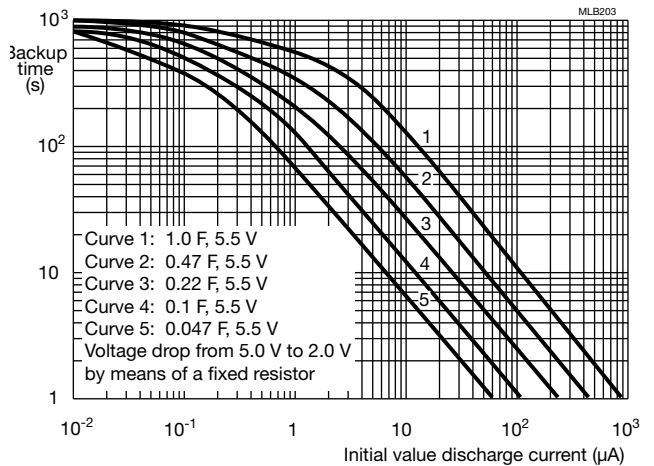


Fig. 10 - Typical backup time as a function of initial discharge current



Table 3

| <b>TEST PROCEDURES AND REQUIREMENTS</b> for standard and vertical miniaturized series (5.5 V; 70 °C) |   |   |   |
|--|---|---|---|
| <b>NAME OF TEST</b>  | <b>IEC 60384-4 / EN130300 SUBCLAUSE</b> | <b>PROCEDURE (quick reference)</b>  | <b>REQUIREMENTS</b>   |
| Robustness of terminations   | 4.4                                     | Tensile strength; application of loading force for 10 s:<br>20 N (standard series)<br>5 N (vertical miniaturized series)  | No breaks   |
| Resistance to soldering heat   | 4.5                                     | Solder bath; 260 °C; 5 s  | $\Delta C/C: \pm 10 \%$<br>$R_I$ and $I_L \leq \text{spec. limit}$  |
| Solderability  | 4.6                                     | Solder bath; 235 °C; 2 s  | $\geq 75 \%$ tinning  |
| Vibration  | 4.8                                     | 10 Hz to 55 Hz; 1.5 mm; 3 directions;<br>2 h per direction  | $\Delta C/C: \pm 10 \%$<br>$R_I$ and $I_L \leq \text{spec. limit}$  |
| Damp heat, steady state  | 4.12                                    | 500 h at 55 °C; RH 90 % to 95 %;<br>no voltage applied  | $\Delta C/C: \pm 30 \%$<br>$R_I \leq 4 \times \text{spec. limit}$<br>$I_L \leq 2 \times \text{spec. limit}$   |
| Endurance  | 4.13                                    | $T_{\text{amb}} = 70 \text{ °C}$ ; 5.5 V applied;<br>1000 h   | $\Delta C/C: \pm 30 \%$<br>$R_I \leq 4 \times \text{spec. limit}$<br>$I_L \leq 2 \times \text{spec. limit}$   |
| Useful life  | -                                       | $T_{\text{amb}} = 70 \text{ °C}$ ; 5.5 V applied;<br>1000 h   | $\Delta C/C: \pm 30 \%$<br>$R_I \leq 4 \times \text{spec. limit}$<br>$I_L \leq 2 \times \text{spec. limit}$   |
| Storage at upper category temperature  | 4.17                                    | $T_{\text{amb}} = 70 \text{ °C}$ ;<br>no voltage applied;<br>1000 h   | $\Delta C/C: \pm 30 \%$<br>$R_I \leq 4 \times \text{spec. limit}$<br>$I_L \leq 2 \times \text{spec. limit}$   |
| Self discharge   | -                                       | 24 h storage at room temperature after application of 5 V for 1 h   | Remaining voltage: $\geq 4 \text{ V}$   |
| Characteristics at high and low temperature  | 4.19                                    | Step 1: reference measurement at +20 °C of C, $R_I$ and $I_L$<br>Step 2: measurement at -25 °C<br>Step 3: measurement at +20 °C<br>Step 4: measurement at +70 °C<br>Step 5: measurement at +20 °C | $\Delta C/C: \pm 30 \%$ of +20 °C value<br>$R_I \leq 5 \times \text{the } +20 \text{ °C value}$<br>$I_L \leq 4 \times \text{the } +20 \text{ °C value}$ |

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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