# Hybrid Energy Storage Aluminum Capacitors

Image is not to scale

## FEATURES

- Polarized energy storage capacitor with high capacity and energy density
- Voltage flexibility: 1.4 V (single cell) to 2.8 V / 4.2 V / 5.6 V / 7.0 V / 8.4 V (multiple cells)
- Available in stacked through-hole (STH, radial), surface-mount flat (SMF) and lay flat configurations (LFC) with wire and connectors
- Useful life: 1000 h at 70 °C / 85 °C
- No cell balancing necessary
- Soft and low transient-voltage-controlled charging characteristic
- Non-hazardous electrolyte
- Maintenance-free, no service necessary
- Evaluation kits for engineering are available under ordering code: MAL219699001E3
- Material categorization: for definitions of compliance please see www.vishay.com/doc?99912

Pb-free

RoHS COMPLIANT

## APPLICATIONS

- Power backup for memory controller, flash backup, RAID systems, SRAM, DRAM
- Power failure and write cache protection for enterprise SSD and HDD
- Real time clock power source
- Burst power support for flash lights, wireless transmitters
- Backup power for industrial PC's and industrial controls
- Storage device for energy harvesting
- Emergency light and micro UPS power source

## MARKING

The capacitors are marked with the following information:

- Rated capacitance (in F)
- Rated voltage (in V)
- Date code
- Negative / positive terminal identification

## PACKAGING

Supplied in ESD trays only

## QUICK REFERENCE DATA

| DESCRIPTION | VALUE | | | | | |
|---|---|---|---|---|---|---|
| | SINGLE CELL | 2 CELLS | 3 CELLS | 4 CELLS | 5 CELLS | 6 CELLS |
| Nominal case size (Ø D x L in mm) Stacked Through-Hole (STH) | 7 x 2.5<br>12 x 2.5<br>- | 7 x 5<br>12 x 5<br>35 x 25 x 7.5 | 7 x 7.5<br>12 x 7.5<br>35 x 25 x 10 | 7 x 10<br>12 x 10<br>35 x 25 x 15 | 7 x 12.5<br>12 x 12.5<br>- | 7 x 15<br>12 x 15<br>- |
| Nominal case size (Ø W x L x H in mm) Surface-Mount Flat (SMF) | 7 x 7 x 2.5<br>12 x 12 x 2.5<br>- | 7 x 14 x 2.5<br>12 x 24 x 2.5<br>- | 13 x 14 x 2.5<br>22 x 24 x 2.5<br>- | 14 x 14 x 2.5<br>24 x 24 x 2.5<br>- | - | - |
| Nominal case size (W x L x H in mm) Lay Flat (LFC) | 14.5 x 12 x 2.5 | 14.5 x 24 x 2.5 | 14.5 x 36 x 2.5 | 14.5 x 48 x 2.5 | 14.5 x 60 x 2.5 | 14.5 x 72 x 2.5 |
| Rated capacitance range, $C_R$ | 4.0 F<br>15.0 F | 4.0 F<br>15.0 F<br>90.0 F | 4.0 F<br>15.0 F<br>90.0 F | 4.0 F<br>15.0 F<br>90.0 F | 4.0 F<br>15.0 F | 4.0 F<br>15.0 F |
| Tolerance on $C_R$ at 20 °C | -20 % to +80 % | | | | | |
| Rated voltage, $U_R$ | 1.4 V | 2.8 V | 4.2 V | 5.6 V | 7.0 V | 8.4 V |
| Maximum surge voltage, $U_S$ (max. 30 s) | 1.6 V | 3.2 V | 4.8 V | 6.4 V | 8.0 V | 9.6 V |
| Minimum stored energy | 4 Ws<br>17 Ws | 9 Ws<br>35 Ws<br>230 Ws | 13 Ws<br>52 Ws<br>345 Ws | 18 Ws<br>70 Ws<br>460 Ws | 22 Ws<br>87 Ws | 27 Ws<br>105 Ws |
| Energy density | 9 Ws/g to 13 Ws/g | | | | | |
| Category temperature range | 4.0 F: -20 °C to +70 °C | | | | | |
| | 15.0 F / 90.0 F: -20 °C to +85 °C | | | | | |
| Storage temperature range | -40 °C to +85 °C | | | | | |
| Useful life at $U_R$ | 4.0 F: at 70 °C: 1000 h<br>at 55 °C: 2800 h<br>at 45 °C: 5600 h | | | 15.0 F / 90.0 F: at 85 °C: 1000 h<br>at 70 °C: 2800 h<br>at 60 °C: 5600 h | | |
| Shelf life | 1000 h at upper category temperature | | | | | |
| Climatic category IEC 60068 | 25/085/21 | | | | | |



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| SELECTION CHART FOR $C_R$, $U_R$, AND FORM AT UPPER CATEGORY TEMPERATURE (UCT) | | | | | | | |
|---|---|---|---|---|---|---|---|
| $C_R$ (F) | FORM | $U_R$ (V) | | | | | |
| | | 1.4 | 2.8 | 4.2 | 5.6 | 7.0 | 8.4 |
| 4 | A2 | 7.0 x 2.5 | 7.0 x 5.0 | 7.0 x 7.5 | 7.0 x 10.0 | 7.0 x 12.5 | 7.0 x 15.0 |
| | B2 | 7.0 x 2.5 | 7.0 x 5.0 | 7.0 x 7.5 | 7.0 x 10.0 | 7.0 x 12.5 | 7.0 x 15.0 |
| | B3 | | | | | | |
| | C | 7.0 x 7.0 x 2.5 | - | - | - | - | - |
| | D | 7.0 x 7.0 x 2.5 | - | - | - | - | - |
| | E | - | 7.0 x 14.0 x 2.5 | 13.0 x 14.0 x 2.5 | 14.0 x 14.0 x 2.5 | - | - |
| 15 | A2 | 12.0 x 2.5 | 12.0 x 5.0 | 12.0 x 7.5 | 12.0 x 10.0 | 12.0 x 12.5 | 12.0 x 15.0 |
| | B2 | 12.0 x 2.5 | 12.0 x 5.0 | 12.0 x 7.5 | 12.0 x 10.0 | 12.0 x 12.5 | 12.0 x 15.0 |
| | B3 | | | | | | |
| | C | 12.0 x 12.0 x 2.5 | - | - | - | - | - |
| | D | 12.0 x 12.0 x 2.5 | - | - | - | - | - |
| | E | - | 12.0 x 24.0 x 2.5 | 22.0 x 24.0 x 2.5 | 24.0 x 24.0 x 2.5 | - | - |
| | F | 14.5 x 12.0 x 2.5 | 14.5 x 24.0 x 2.5 | 14.5 x 36.0 x 2.5 | 14.5 x 48.0 x 2.5 | 14.5 x 60.0 x 2.5 | 14.5 x 72.0 x 2.5 |
| 90 | G | - | 35 x 25 x 7.5 | 35 x 25 x 10 | 35 x 25 x 15 | - | - |
| | H | | | | | | |

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

### STACKED THROUGH HOLE CONFIGURATION (STH): Examples VERTICAL MOUNT

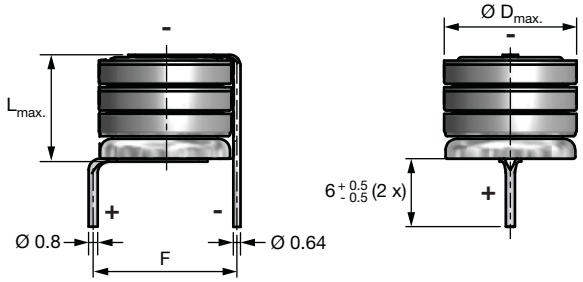


Fig. 1 - **Form A2:** Stacked Through Hole (example 4 cells, 2 pins) (1)

### STACKED THROUGH HOLE CONFIGURATION (STH): Examples HORIZONTAL MOUNT

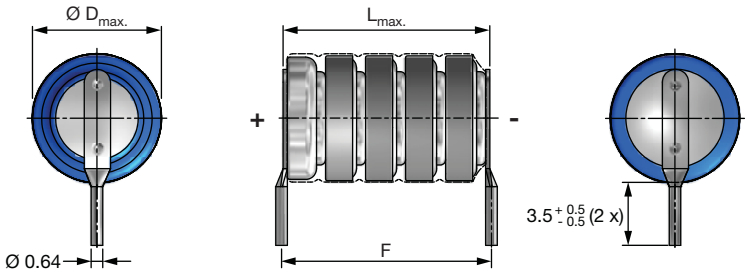


Fig. 2 - **Form B2:** Stacked Through Hole (example 5 cells, 2 pins) (1)

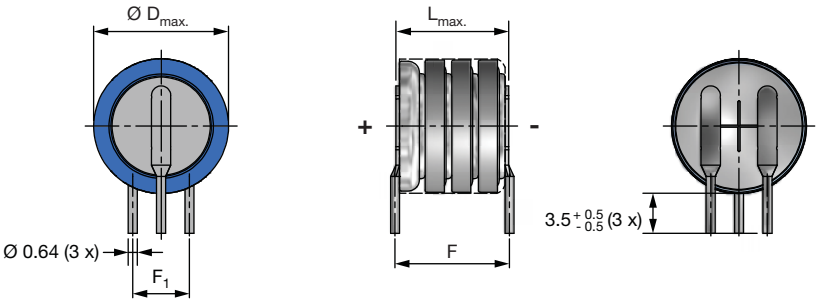


Fig. 3 - **Form B3:** Stacked Through Hole (example 4 cells, keyed polarity - 3 pins) (1)

**Note**

(1) Bottom and top are not isolated.



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

### SURFACE MOUNT FLAT CONFIGURATION (SMF): Examples

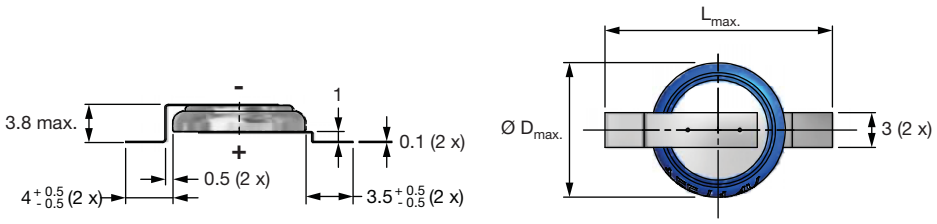


Fig. 4 - **Form C:** Surface Mount Flat (single cell, keyed polarity)

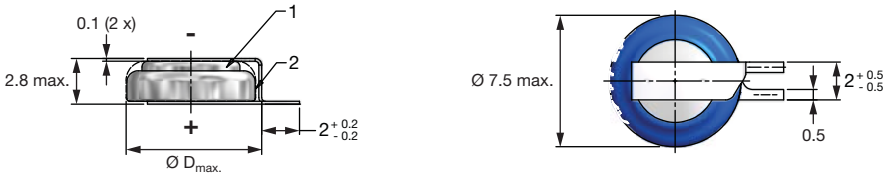


Fig. 5 - **Form D1:** Surface Mount Flat (single cell, keyed polarity)

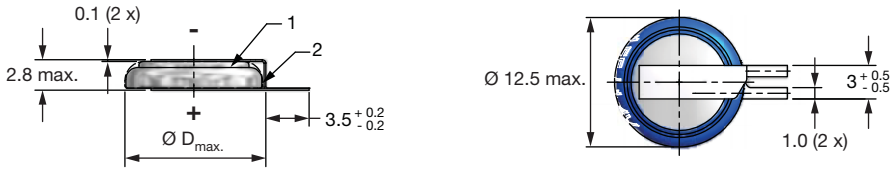


Fig. 6 - **Form D2:** Surface Mount Flat (single cell, keyed polarity)

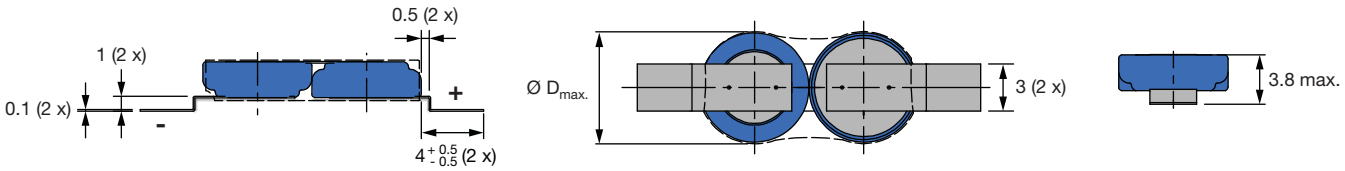


Fig. 7 - **Form E2:** Surface Mount Flat

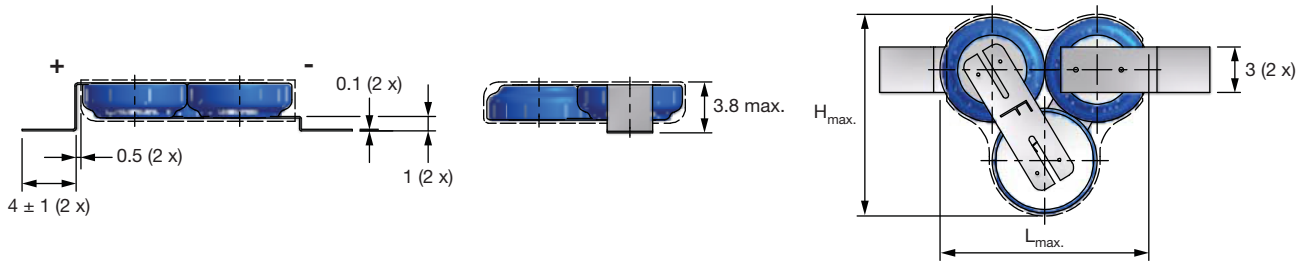


Fig. 8 - **Form E3:** Surface Mount Flat


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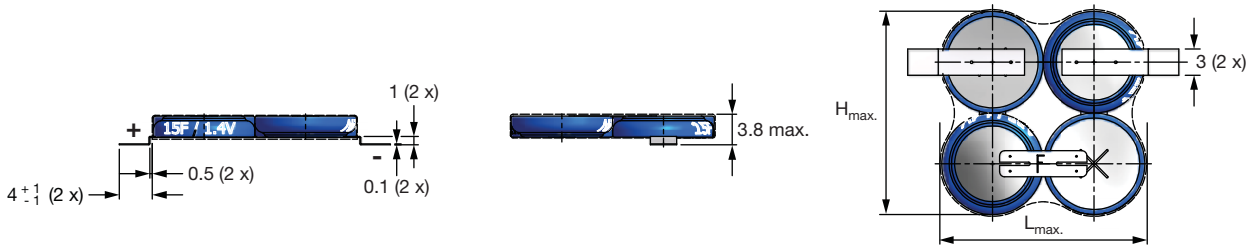


Fig. 9 - **Form E4:** Surface Mount Flat

**LAY FLAT CONFIGURATION (LFC) WITH CONNECTOR: Example 5 cells in series**

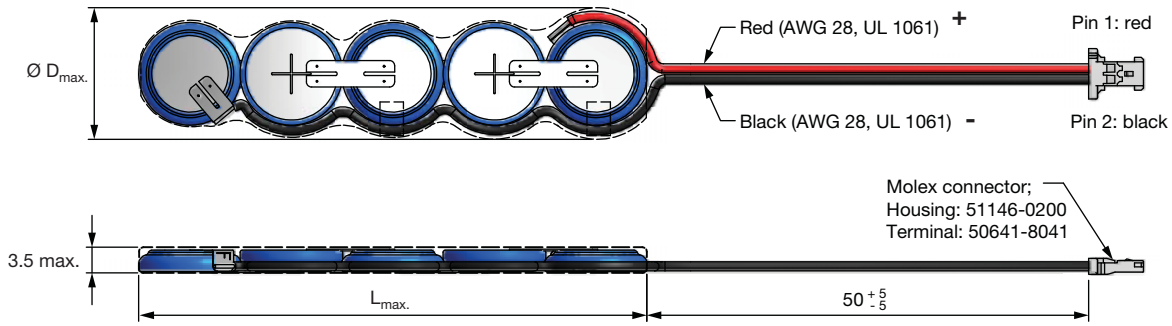


Fig. 10 - **Form F:** Lay Flat (example for 5 cells)

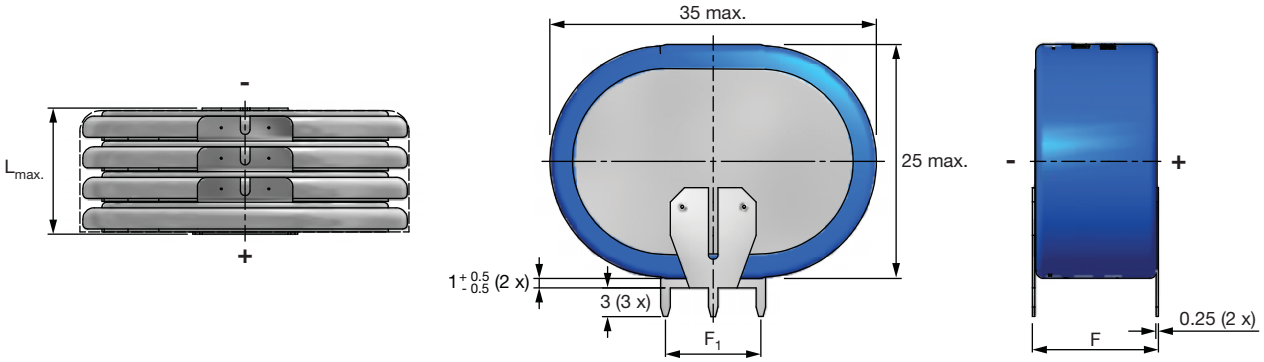


Fig. 11 - **Form G:** Stacked Through Hole Oval (PCBD)

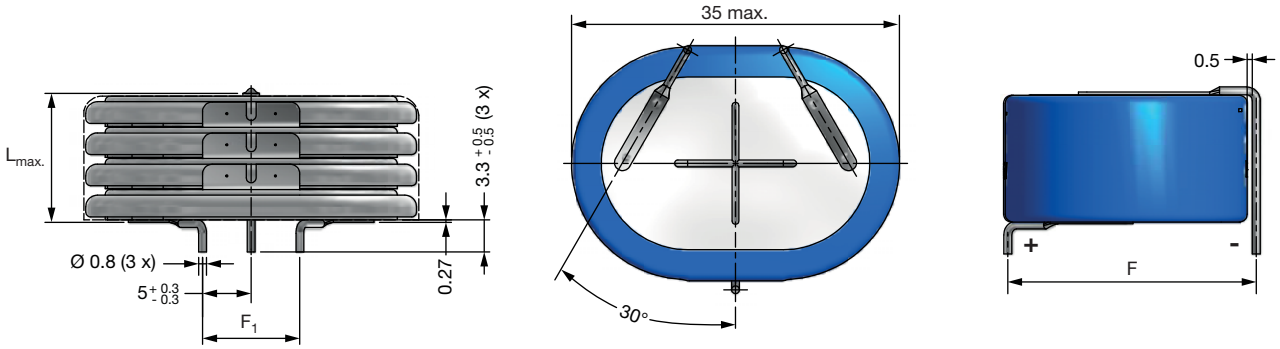


Fig. 12 - **Form H:** Stacked Through Hole Oval Horizontal


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**Table 1**

| **DIMENSIONS** in millimeters, **MASS AND PACKAGING QUANTITIES** | | | | | | |
|---|---|---|---|---|---|---|
| **NOMINAL CASE SIZE D x L x H (mm)** | **FORM** | **Ø $D_{max.}$** | **$L_{max.}$** | **$L1_{max.}$** | **$H_{max.}$** | **MASS (g)** |
| 7.0 x 7.0 x 2.5 | A2, B2, B3 | 7.5 | 2.3 + 0.3 | 7.0 + 0.5 | - | 0.5 |
| 7.0 x 7.0 x 2.5 | C | 7.5 | 7.0 | 7.0 + 8.0 | - | 0.5 |
| 7.0 x 7.0 x 2.5 | D1 | 7.5 | 7.0 | 7.0 + 4.0 | - | 0.5 |
| 7.0 x 7.0 x 5.0 | A2, B2, B3 | 7.5 | 4.2 | 4.2 + 0.5 | - | 0.8 |
| 7.0 x 7.0 x 7.5 | A2, B2, B3 | 7.5 | 7.5 | 7.8 + 0.5 | - | 1.5 |
| 7.0 x 7.0 x 10.0 | A2, B2, B3 | 7.5 | 10.5 | 10.2 + 0.5 | - | 1.8 |
| 7.0 x 7.0 x 12.5 | A2, B2, B3 | 7.5 | 12.5 | 12.4 + 0.5 | - | 2.5 |
| 7.0 x 7.0 x 15.0 | A2, B2, B3 | 7.5 | 14.8 | 14.8 + 0.5 | - | 3.0 |
| 12.0 x 12.0 x 2.5 | A2, B2, B3 | 12.5 | 2.3 | 2.3 + 0.5 | - | 1.2 |
| 12.0 x 12.0 x 2.5 | C | 12.5 | 12.5 | 12.5 + 8.0 | - | 1.0 |
| 12.0 x 12.0 x 2.5 | D2 | 12.5 | 12.5 | 12.5 + 4.0 | - | 1.0 |
| 12.0 x 12.0 x 5.0 | A2, B2, B3 | 12.5 | 4.2 | 4.2 + 0.5 | - | 2.2 |
| 12.0 x 12.0 x 7.5 | A2, B2, B3 | 12.5 | 8.0 | 7.8 + 0.5 | - | 3.3 |
| 12.0 x 12.0 x 10.0 | A2, B2, B3 | 12.5 | 10.5 | 10.5 + 0.5 | - | 4.0 |
| 12.0 x 12.0 x 12.5 | A2, B2, B3 | 12.5 | 12.5 | 12.5 + 0.5 | - | 5.4 |
| 12.0 x 12.0 x 15.0 | A2, B2, B3 | 12.5 | 14.8 | 14.8 + 0.5 | - | 6.5 |
| 7.0 x 14.0 x 2.5 | E2 | 7.5 | 14.8 | 14.8 + 8.0 | - | 1.0 |
| 12.0 x 24.0 x 2.5 | E2 | 12.5 | 24.0 | 24.0 + 8.0 | - | 2.0 |
| 13.0 x 14.0 x 2.5 | E3 | 14.0 | 15.0 | 14.8 + 8.0 | 14.0 | 1.2 |
| 22.0 x 24.0 x 2.5 | E3 | 24.0 | 24.0 | 24.8 + 8.0 | 15.0 | 3.3 |
| 14.0 x 14.0 x 2.5 | E4 | 15.0 | 15.0 | 14.8 + 8.0 | 22.5 | 1.5 |
| 24.0 x 24.0 x 2.5 | E4 | 24.0 | 24.0 | 24.8 + 8.0 | 24.0 | 4.4 |
| 14.5 x 12.0 x 2.5 | F | 14.5 | 12.0 | 12.0 + 50.0 | - | 1.0 |
| 14.5 x 24.0 x 2.5 | F | 14.5 | 24.0 | 24.0 + 50.0 | - | 3.0 |
| 14.5 x 36.0 x 2.5 | F | 14.5 | 36.0 | 36.0 + 50.0 | - | 4.0 |
| 14.5 x 48.0 x 2.5 | F | 14.5 | 48.0 | 48.0 + 50.0 | - | 6.0 |
| 14.5 x 60.0 x 2.5 | F | 14.5 | 60.0 | 60.0 + 50.0 | - | 7.5 |
| 14.5 x 72.0 x 2.5 | F | 14.5 | 72.0 | 72.0 + 50.0 | - | 9.0 |
| 35 x 25 x 7.5 | G, H | 35 x 25 | 7.5 | 7.5 + 0.5 | - | 15.0 |
| 35 x 25 x 10.0 | G, H | 35 x 25 | 10.5 | 10.5 + 0.5 | - | 22.5 |
| 35 x 25 x 15.0 | G, H | 35 x 25 | 15.5 | 15.0 + 0.5 | - | 30.0 |

| **ELECTRICAL DATA** | |
|---|---|
| **SYMBOL** | **DESCRIPTION** |
| $C_R$ | Rated capacitance, tolerance -20 %/+80 %, measured by constant current discharge method |
| UCT | Upper category temperature |
| $I_L$ | Max. leakage current after 24 h at $U_R$ |
| $R_I$ | Max. internal resistance at 1 kHz |

**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

Hybrid Storage Capacitor

15 F/1.4 V

Nominal case size: Ø 12.0 mm x 2.5 mm; Form B3

Ordering code: MAL219691211E3



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**Table 2**

| ELECTRICAL DATA AND ORDERING INFORMATION | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $U_R$ (V) | $C_R$ (µF) | NOMINAL CASE SIZE Ø D x L D x L x H (mm) | CASE CODE | FORM | F (mm) | F1 (mm) | UCT (°C) | $I_L$ 24 h (mA) | ESR AC (1) 1 kHz (Ω) | ESR DC (2) (Ω) | MIN. STORAGE ENERGY (Ws) | PACKAGING QUANTITIES | ORDERING CODE |
| **STACKED THROUGH HOLE CONFIGURATION (STH) - VERTICAL MOUNT** | | | | | | | | | | | | | |
| 1.4 | 4 000 000 | 7.0 x 2.5 | 2 pin | A2 | 7.5 | - | 70 | 0.03 | 2.5 | 7.5 | 4.6 | 80 | MAL219691101E3 |
| 2.8 | 4 000 000 | 7.0 x 5.0 | 2 pin | A2 | 7.5 | - | 70 | 0.03 | 5.0 | 15.0 | 9.2 | 80 | MAL219691102E3 |
| 4.2 | 4 000 000 | 7.0 x 7.5 | 2 pin | A2 | 7.5 | - | 70 | 0.03 | 7.5 | 22.5 | 13.8 | 80 | MAL219691103E3 |
| 5.6 | 4 000 000 | 7.0 x 10.0 | 2 pin | A2 | 7.5 | - | 70 | 0.03 | 10.0 | 30.0 | 18.4 | 80 | MAL219691104E3 |
| 7.0 | 4 000 000 | 7.0 x 12.5 | 2 pin | A2 | 7.5 | - | 70 | 0.03 | 12.5 | 37.5 | 23.0 | 84 | MAL219691105E3 |
| 8.4 | 4 000 000 | 7.0 x 15.0 | 2 pin | A2 | 7.5 | - | 70 | 0.03 | 15.0 | 45.0 | 27.6 | 84 | MAL219691106E3 |
| 1.4 | 15 000 000 | 12.0 x 2.5 | 2 pin | A2 | 12.5 | - | 85 | 0.12 | 0.6 | 2.5 | 17.5 | 80 | MAL219691201E3 |
| 2.8 | 15 000 000 | 12.0 x 5.0 | 2 pin | A2 | 12.5 | - | 85 | 0.12 | 1.2 | 5.0 | 35.0 | 80 | MAL219691202E3 |
| 4.2 | 15 000 000 | 12.0 x 7.5 | 2 pin | A2 | 12.5 | - | 85 | 0.12 | 1.8 | 7.5 | 52.5 | 80 | MAL219691203E3 |
| 5.6 | 15 000 000 | 12.0 x 10.0 | 2 pin | A2 | 12.5 | - | 85 | 0.12 | 2.4 | 10.0 | 70.0 | 80 | MAL219691204E3 |
| 7.0 | 15 000 000 | 12.0 x 12.5 | 2 pin | A2 | 12.5 | - | 85 | 0.12 | 3.0 | 12.5 | 87.5 | 90 | MAL219691205E3 |
| 8.4 | 15 000 000 | 12.0 x 15.0 | 2 pin | A2 | 12.5 | - | 85 | 0.12 | 3.6 | 15.0 | 105.0 | 90 | MAL219691206E3 |
| **STACKED THROUGH HOLE CONFIGURATION (STH) - HORIZONTAL MOUNT** | | | | | | | | | | | | | |
| 1.4 | 4 000 000 | 7.0 x 2.5 | 2 pin | B2 | 3.2 | - | 70 | 0.03 | 2.5 | 7.5 | 4.6 | 100 | MAL219691121E3 |
| 2.8 | 4 000 000 | 7.0 x 5.0 | 2 pin | B2 | 5.4 | - | 70 | 0.03 | 5.0 | 15.0 | 9.2 | 100 | MAL219691122E3 |
| 4.2 | 4 000 000 | 7.0 x 7.5 | 2 pin | B2 | 7.5 | - | 70 | 0.03 | 7.5 | 22.5 | 13.8 | 96 | MAL219691123E3 |
| 5.6 | 4 000 000 | 7.0 x 10.0 | 2 pin | B2 | 8.8 | - | 70 | 0.03 | 10.0 | 30.0 | 18.4 | 96 | MAL219691124E3 |
| 7.0 | 4 000 000 | 7.0 x 12.5 | 2 pin | B2 | 12 | - | 70 | 0.03 | 12.5 | 37.5 | 23.0 | 40 | MAL219691125E3 |
| 8.4 | 4 000 000 | 7.0 x 15.0 | 2 pin | B2 | 14.5 | - | 70 | 0.03 | 15.0 | 45.0 | 27.6 | 40 | MAL219691126E3 |
| 1.4 | 15 000 000 | 12.0 x 2.5 | 2 pin | B2 | 3.2 | - | 85 | 0.12 | 0.6 | 2.5 | 17.5 | 100 | MAL219691221E3 |
| 2.8 | 15 000 000 | 12.0 x 5.0 | 2 pin | B2 | 5.8 | - | 85 | 0.12 | 1.2 | 5.0 | 35.0 | 100 | MAL219691222E3 |
| 4.2 | 15 000 000 | 12.0 x 7.5 | 2 pin | B2 | 8.3 | - | 85 | 0.12 | 1.8 | 7.5 | 52.5 | 80 | MAL219691223E3 |
| 5.6 | 15 000 000 | 12.0 x 10.0 | 2 pin | B2 | 11.0 | - | 85 | 0.12 | 2.4 | 10.0 | 70.0 | 80 | MAL219691224E3 |
| 7.0 | 15 000 000 | 12.0 x 12.5 | 2 pin | B2 | 13.4 | - | 85 | 0.12 | 3.0 | 12.5 | 87.5 | 40 | MAL219691225E3 |
| 8.4 | 15 000 000 | 12.0 x 15.0 | 2 pin | B2 | 15.7 | - | 85 | 0.12 | 3.6 | 15.0 | 105.0 | 40 | MAL219691226E3 |
| 1.4 | 4 000 000 | 7.0 x 2.5 | 3 pin | B3 | 2.8 | 2.5 | 70 | 0.03 | 2.5 | 7.5 | 4.6 | 100 | MAL219691111E3 |
| 2.8 | 4 000 000 | 7.0 x 5.0 | 3 pin | B3 | 5.1 | 2.5 | 70 | 0.03 | 5.0 | 15.0 | 9.2 | 100 | MAL219691112E3 |
| 4.2 | 4 000 000 | 7.0 x 7.5 | 3 pin | B3 | 7.5 | 2.5 | 70 | 0.03 | 7.5 | 22.5 | 13.8 | 88 | MAL219691113E3 |
| 5.6 | 4 000 000 | 7.0 x 10.0 | 3 pin | B3 | 10.0 | 2.5 | 70 | 0.03 | 10.0 | 30.0 | 18.4 | 88 | MAL219691114E3 |
| 7.0 | 4 000 000 | 7.0 x 12.5 | 3 pin | B3 | 12.0 | 2.5 | 70 | 0.03 | 12.5 | 37.5 | 23.0 | 40 | MAL219691115E3 |
| 8.4 | 4 000 000 | 7.0 x 15.0 | 3 pin | B3 | 14.5 | 2.5 | 70 | 0.03 | 15.0 | 45.0 | 27.6 | 40 | MAL219691116E3 |
| 1.4 | 15 000 000 | 12.0 x 2.5 | 3 pin | B3 | 3.2 | 5.0 | 85 | 0.12 | 0.6 | 2.5 | 17.5 | 100 | MAL219691211E3 |
| 2.8 | 15 000 000 | 12.0 x 5.0 | 3 pin | B3 | 5.8 | 5.0 | 85 | 0.12 | 1.2 | 5.0 | 35.0 | 100 | MAL219691212E3 |
| 4.2 | 15 000 000 | 12.0 x 7.5 | 3 pin | B3 | 8.0 | 5.0 | 85 | 0.12 | 1.8 | 7.5 | 52.5 | 80 | MAL219691213E3 |
| 5.6 | 15 000 000 | 12.0 x 10.0 | 3 pin | B3 | 11.0 | 5.0 | 85 | 0.12 | 2.4 | 10.0 | 70.0 | 25 | MAL219691214E3 |
| 7.0 | 15 000 000 | 12.0 x 12.5 | 3 pin | B3 | 13.0 | 5.0 | 85 | 0.12 | 3.0 | 12.5 | 87.5 | 40 | MAL219691215E3 |
| 8.4 | 15 000 000 | 12.0 x 15.0 | 3 pin | B3 | 16.0 | 5.0 | 85 | 0.12 | 3.6 | 15.0 | 105.0 | 40 | MAL219691216E3 |


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| ELECTRICAL DATA AND ORDERING INFORMATION | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $U_R$ (V) | $C_R$ (µF) | NOMINAL CASE SIZE Ø D x L D x L x H (mm) | CASE CODE | FORM | F (mm) | F1 (mm) | UCT (°C) | $I_L$ 24 h (mA) | ESR AC (1) 1 kHz (Ω) | ESR DC (2) (Ω) | MIN. STORAGE ENERGY (Ws) | PACKAGING QUANTITIES | ORDERING CODE |
| **SURFACE MOUNT FLAT CONFIGURATION (SMF)** | | | | | | | | | | | | | |
| 1.4 | 4 000 000 | 7.0 x 7.0 x 2.5 | 2 pin | C | - | - | 70 | 0.03 | 2.5 | 7.5 | 4.6 | 100 | MAL219691131E3 |
| 1.4 | 15 000 000 | 12.0 x 12.0 x 2.5 | 2 pin | C | - | - | 85 | 0.12 | 0.6 | 2.5 | 17.5 | 100 | MAL219691231E3 |
| 1.4 | 4 000 000 | 7.0 x 7.0 x 2.5 | 2 pin | D1 | - | - | 70 | 0.03 | 2.5 | 7.5 | 4.6 | 100 | MAL219691141E3 |
| 1.4 | 15 000 000 | 12.0 x 12.0 x 2.5 | 2 pin | D2 | - | - | 85 | 0.12 | 0.6 | 2.5 | 17.5 | 100 | MAL219691241E3 |
| 2.8 | 4 000 000 | 7.0 x 14.0 x 2.5 | 2 pin | E2 | - | - | 70 | 0.03 | 5.0 | 15.0 | 9.2 | 100 | MAL219691152E3 |
| 2.8 | 15 000 000 | 12.0 x 24.0 x 2.5 | 2 pin | E2 | - | - | 85 | 0.12 | 1.2 | 5.0 | 35.0 | 50 | MAL219691252E3 |
| 4.2 | 4 000 000 | 13.0 x 14.0 x 2.5 | 3 pin | E3 | - | - | 70 | 0.03 | 7.5 | 22.5 | 13.8 | 40 | MAL219691153E3 |
| 4.2 | 15 000 000 | 22.0 x 24.0 x 2.5 | 3 pin | E3 | - | - | 85 | 0.12 | 1.8 | 7.5 | 52.5 | 40 | MAL219691253E3 |
| 5.6 | 4 000 000 | 14.0 x 14.0 x 2.5 | 4 pin | E4 | - | - | 70 | 0.03 | 10.0 | 30.0 | 18.4 | 40 | MAL219691154E3 |
| 5.6 | 15 000 000 | 24.0 x 24.0 x 2.5 | 4 pin | E4 | - | - | 85 | 0.12 | 2.4 | 10.0 | 70.0 | 40 | MAL219691254E3 |
| **LAY FLAT CONFIGURATION (LFC)** | | | | | | | | | | | | | |
| 1.4 | 15 000 000 | 14.5 x 12.0 x 2.5 | 2 pin | F | - | - | 85 | 0.12 | 0.6 | 2.5 | 17.5 | 40 | MAL219691261E3 |
| 2.8 | 15 000 000 | 14.5 x 24.0 x 2.5 | 2 pin | F | - | - | 85 | 0.12 | 1.2 | 5.0 | 35.0 | 40 | MAL219691262E3 |
| 4.2 | 15 000 000 | 14.5 x 36.0 x 2.5 | 2 pin | F | - | - | 85 | 0.12 | 1.8 | 7.5 | 52.5 | 40 | MAL219691263E3 |
| 5.6 | 15 000 000 | 14.5 x 48.0 x 2.5 | 2 pin | F | - | - | 85 | 0.12 | 2.4 | 10.0 | 70.0 | 20 | MAL219691264E3 |
| 7.0 | 15 000 000 | 14.5 x 60.0 x 2.5 | 2 pin | F | - | - | 85 | 0.12 | 3.6 | 12.5 | 87.5 | 20 | MAL219691265E3 |
| 8.4 | 15 000 000 | 14.5 x 72.0 x 2.5 | 2 pin | F | - | - | 85 | 0.12 | 4.8 | 15.0 | 105.0 | 20 | MAL219691266E3 |
| **STACKED THROUGH HOLE OVAL** | | | | | | | | | | | | | |
| 2.8 | 90 000 000 | 35 x 25 x 7.5 | 3 pin | G | 7 | 10 | 85 | 0.5 | 0.03 | 0.090 | 230.0 | 25 | MAL219690103E3 |
| 4.2 | 90 000 000 | 35 x 25 x 10 | 3 pin | G | 10 | 10 | 85 | 0.5 | 0.04 | 0.135 | 345.0 | 25 | MAL219690101E3 |
| 5.6 | 90 000 000 | 35 x 25 x 15 | 3 pin | G | 15 | 10 | 85 | 0.5 | 0.06 | 0.180 | 460.0 | 25 | MAL219690102E3 |
| **STACKED THROUGH HOLE OVAL HORIZONTAL** | | | | | | | | | | | | | |
| 2.8 | 90 000 000 | 35 x 25 x 7.5 | 3 pin | H | 25 | 10 | 85 | 0.5 | 0.03 | 0.090 | 230.0 | 25 | MAL219690113E3 |
| 4.2 | 90 000 000 | 35 x 25 x 10 | 3 pin | H | 25 | 10 | 85 | 0.5 | 0.04 | 0.135 | 345.0 | 25 | MAL219690111E3 |
| 5.6 | 90 000 000 | 35 x 25 x 15 | 3 pin | H | 25 | 10 | 85 | 0.5 | 0.06 | 0.180 | 460.0 | 25 | MAL219690112E3 |

**Notes**

(1) ESR AC 1 kHz are typical values.

(2) ESR DC are typical values.

**Table 3**

| LOAD CURRENTS AND VOLTAGES | | | | |
|---|---|---|---|---|
| $C_R$ (µF) | RECOMMENDED CHARGE CURRENT | MAX. CHARGE CURRENT | MAX. DISCHARGE CURRENT | LOWEST DISCHARGE VOLTAGE (1) |
| 4 000 000 | 2 mA to 8 mA | 14 mA | 25 mA | n x 0.8 V |
| 15 000 000 | 5 mA to 20 mA | 50 mA | 70 mA | n x 0.8 V |
| 90 000 000 | 0.3 A to 1 A | 1.5 A | 3 A | n x 0.8 V |

**Note**

(1) n... number of cells, permanent operation below lowest discharge voltage is not permitted.



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## 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, $C_R$ | 4 | 15 | 90 | F |
| Discharge current, $I_D$ | 4 | 15 | 90 | mA |

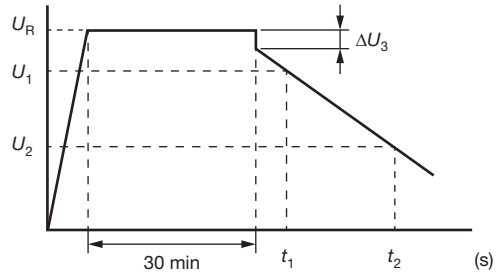


Fig. 13 - Voltage Diagram for Capacitance Measurement

Capacitance value $C_R$ is given by discharge current $I_D$, time t and rated voltage $U_R$, according to the following equation:

| | |
|---|---|
| $C_R$ | Rated capacitance, in F |
| $U_R$ | Rated voltage, in V |
| $U_1$ | Starting voltage, in V |
| $U_2$ | Ending voltage, 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 |
| $I_D$ | Discharge current, in A |

$$C_R(F) = \frac{I_D(A) \times (t_2(s) - t_1(s))}{U_1(V) - U_2(V)}$$

For $I_D$, $U_1$, and $U_2$ the following definitions have to be used:

**Table 4**

| CAPACITANCE | | | | | | |
|---|---|---|---|---|---|---|
| C (F) | $I_D$ (A) | $U_R$ (V) | $U_1$ (V) | $U_2$ (V) | $t_1$ (s) | $t_2$ (s) |
| 4 | 0.004 | 1.4 | 1.3 | 0.7 | 5 | > 600 |
| 4 | 0.004 | 2.8 | 2.7 | 1.9 | 5 | > 600 |
| 4 | 0.004 | 4.2 | 4.0 | 3.1 | 5 | > 600 |
| 4 | 0.004 | 5.6 | 5.4 | 4.4 | 5 | > 600 |
| 4 | 0.004 | 7.0 | 6.7 | 5.6 | 5 | > 600 |
| 4 | 0.004 | 8.4 | 8.1 | 6.9 | 5 | > 600 |
| 15 | 0.015 | 1.4 | 1.3 | 0.7 | 5 | > 600 |
| 15 | 0.015 | 2.8 | 2.7 | 1.9 | 5 | > 600 |
| 15 | 0.015 | 4.2 | 4.0 | 3.1 | 5 | > 600 |
| 15 | 0.015 | 5.6 | 5.4 | 4.4 | 5 | > 600 |
| 15 | 0.015 | 7.0 | 6.7 | 5.6 | 5 | > 600 |
| 15 | 0.015 | 8.4 | 8.1 | 6.9 | 5 | > 600 |
| 90 | 0.090 | 2.8 | 2.7 | 1.9 | 5 | > 600 |
| 90 | 0.090 | 4.2 | 4.0 | 3.1 | 5 | > 600 |
| 90 | 0.090 | 5.6 | 5.4 | 4.4 | 5 | > 600 |

**Note**

- For $U_2$ see also Table 5.

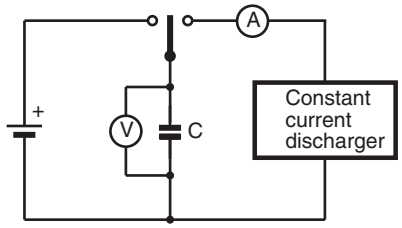


Fig. 14 - Test Circuit for Capacitance Measurement

### INTERNAL RESISTANCE ($R_I$) AT 1 kHz

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

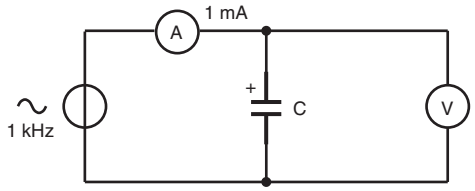


Fig. 15 - Test Circuit for $R_I$ Measurement

### LEAKAGE CURRENT ($I_L$)

Leakage current shall be measured after 30 min application of rated voltage $U_R$:

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

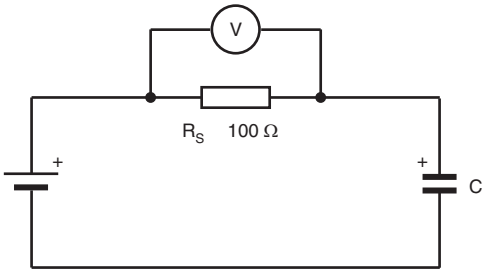


Fig. 16 - Test Circuit for Leakage Current

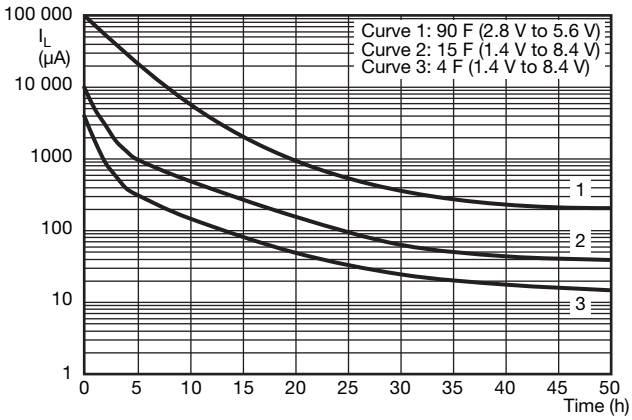


Fig. 17 - Typical Leakage Current at $R_T$ as a Function of Time



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**Table 5**

| VOLTAGE TO BE USED FOR SERIES CONNECTION | | | |
|---|---|---|---|
| N CELLS IN SERIES | $U_R$ (V) | $U_1$ (V) | $U_2$ (V) |
| 1 | 1.4 | 1.3 | 0.7 |
| 2 | 2.8 | 2.7 | 1.9 |
| 3 | 4.2 | 4.0 | 3.1 |
| 4 | 5.6 | 5.4 | 4.4 |
| 5 | 7.0 | 6.7 | 5.6 |
| 6 | 8.4 | 8.1 | 6.9 |

## DISCHARGE CHARACTERISTICS

Backup time of 196 HVC 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 figure 18 to figure 20 (charging time ≥ 24 h and CC-CV charging according to table 3).

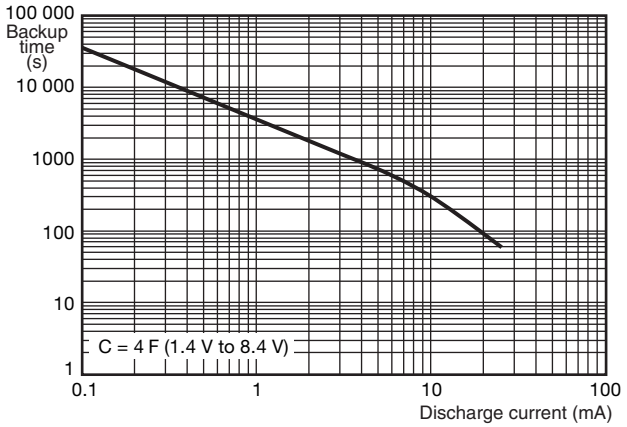


Fig. 18 - Typical Backup Time as a Function of Discharge Current

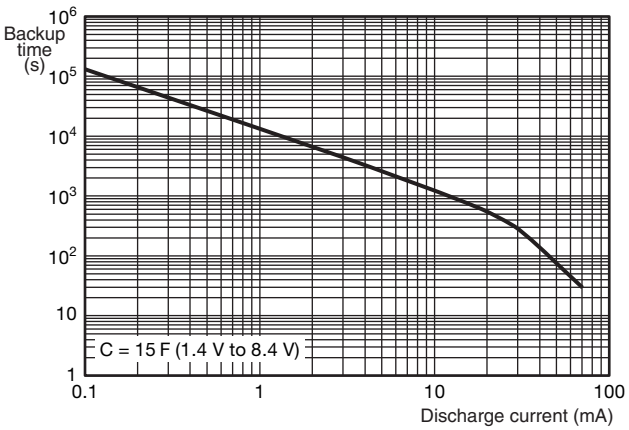


Fig. 19 - Typical Backup Time as a Function of Discharge Current

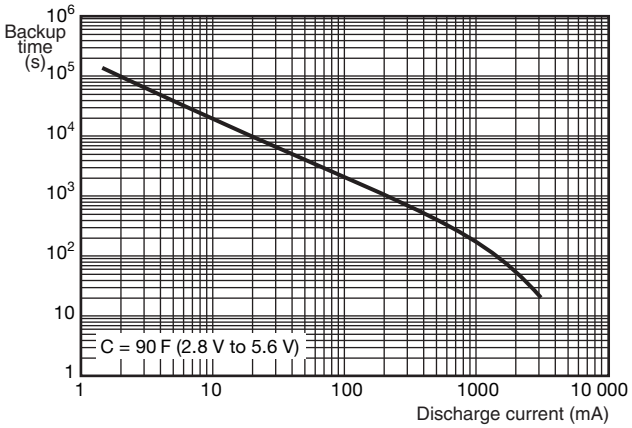


Fig. 20 - Typical Backup Time as a Function of Discharge Current


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## CHARGE CHARACTERISTICS

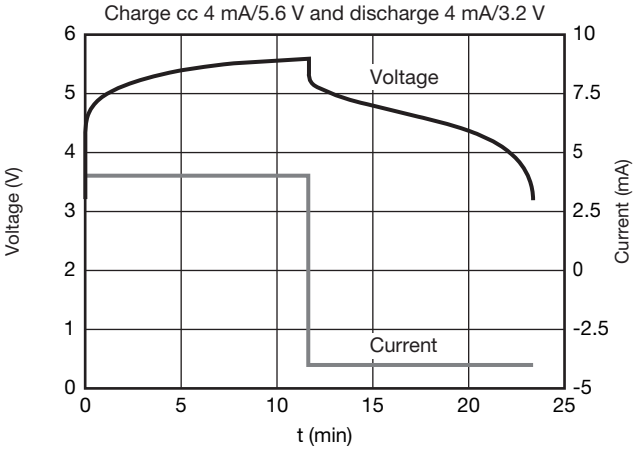


Fig. 21 - Constant Current (CC) with V-Limit Charging Method at RT
Typical Charge/Discharge Characteristics at RT: 4 F/5.6 V

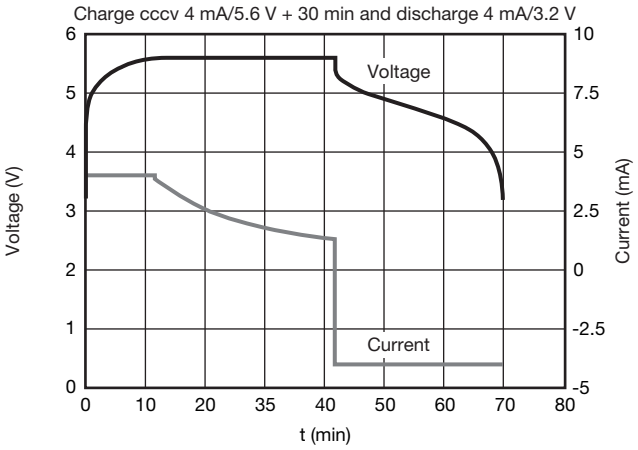


Fig. 22 - Constant Current (CC)-Constant Voltage (CV)
Charging Method at RT
Typical Charge/Discharge Characteristics at RT: 4 F/5.6 V

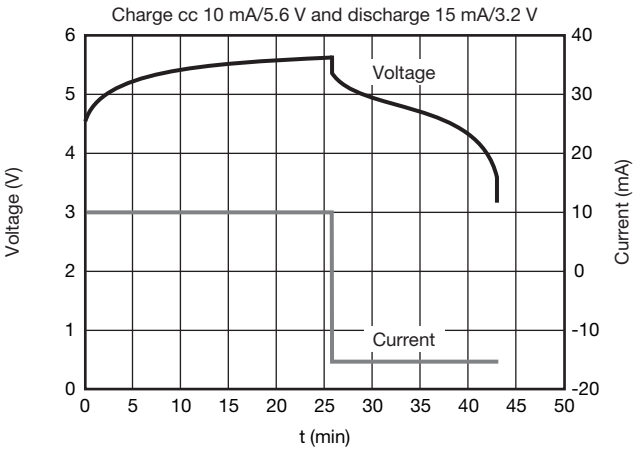


Fig. 23 - Constant Current (CC) with V-Limit Charging Method at RT
Typical Charge/Discharge Characteristics at RT: 15 F/5.6 V

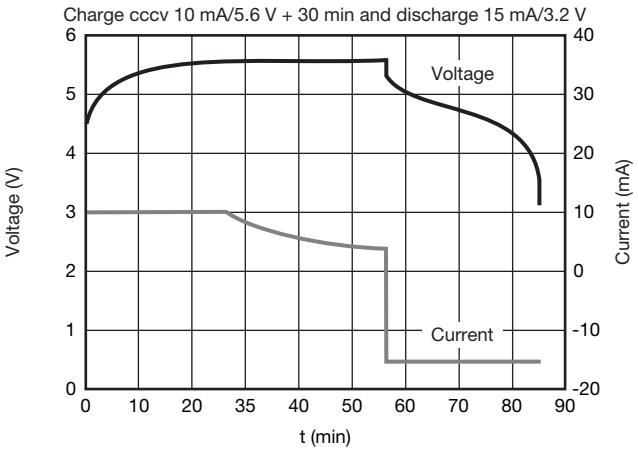


Fig. 24 - Constant Current (CC)-Constant Voltage (CV)
Charging Method at RT
Typical Charge/Discharge Characteristics at RT: 15 F/5.6 V

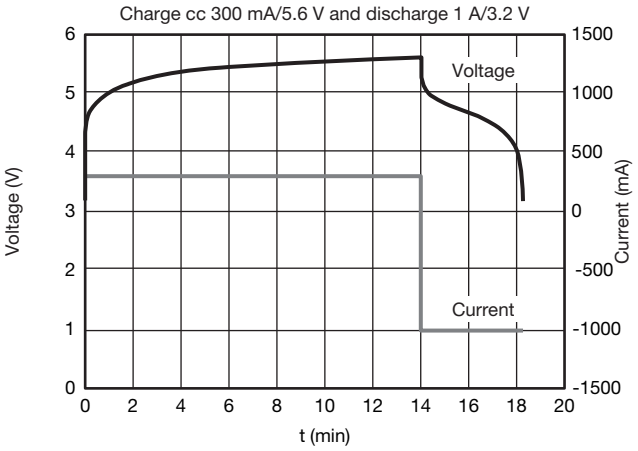


Fig. 25 - Constant Current (CC) with V-Limit Charging Method at RT
Typical Charge/Discharge Characteristics at RT: 90 F/5.6 V

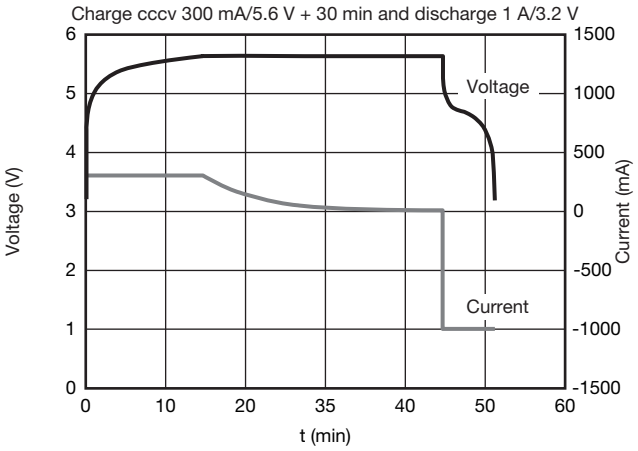


Fig. 26 - Constant Current (CC)-Constant Voltage (CV)
Charging Method at RT
Typical Charge/Discharge Characteristics at RT: 90 F/5.6 V

**Note**

- Charge and discharge cycles at room temperature - maximal 50 000 cycles at room temperature allowed!


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| CHARGING VOLTAGE AT DIFFERENT TEMPERATURES | | | | |
|---|---|---|---|---|
| OPERATING TEMPERATURE RANGE | 0 °C UP TO +45 °C | | +45 °C UP TO +60 °C | +60 °C UP TO +70 °C/+85 °C |
| Charge voltage | 1 cell | $U_R$ + 0.03 V | $U_R$ | $U_R$ - n [1] x 0.0015 x (T[°C] - 45) |
| | 2 cells | $U_R$ + 0.06 V | | |
| | 3 cells | $U_R$ + 0.09 V | | |
| | > 4 cells | $U_R$ + 0.10 V | | |

**Notes**

- Capacitor is polarized, product will be damaged if reverse charged.
- Voltages higher than specified need to be avoided; otherwise reduction of life time, internal gas generation or damage of HVC hybrid capacitor will occur.
- For other operating temperatures, a temperature derating factor has to be considered for correct charging voltage.
- Surge voltage is only allowed a few seconds per day, but not as a charging process.

(1) n... number of cells

## DERATING

Working voltage at temperatures above 60 °C should be below rated voltage $U_R$. A derating-factor of -1.5 mV/°C per cell is recommended.

## PRODUCT AND MOUNTING CHARACTERISTICS

**Attention: parts are pre-charged at delivery - handle appropriate.**

At delivery products are pre-charged and voltage over terminals is near nominal voltage. Short circuiting of product terminals is permitted. Do not short circuit permanently. Short circuiting of charged cells may heat up the cells. Cells will fulfill UL 2054 - $T_{cell}$ < 150 °C due to self heating in case of short circuiting.

For printed circuit board mounting it has to be taken into account, that for certain form factors top and bottom of products may not be insulated.

Capacitor disposal methods should be in accordance with local and state regulations.

**Table 6.1**

| TEST PROCEDURES AND REQUIREMENTS | | | |
|---|---|---|---|
| NAME OF TEST | IEC 60384-4/ EN 130300 SUBCLAUSE | PROCEDURE (quick reference) | REQUIREMENTS |
| Damp heat, steady state | 4.12 | 500 h at 55 °C; RH 90 % to 95 %; no voltage applied | ΔC/C: ± 30 %<br>$R_I$ ≤ 4 x spec. limit<br>$I_L$ ≤ 2 x spec. limit |
| Endurance | 4.13 | $T_{amb}$ = 70 °C / 85 °C; rated voltage $U_R$ applied; 1000 h | ΔC/C: ± 30 %<br>$R_I$ ≤ 4 x spec. limit<br>$I_L$ ≤ 2 x spec. limit |
| Shelf at upper category temperature | 4.17 | $T_{amb}$ = 70 °C / 85 °C; no voltage applied; 1000 h | ΔC/C: ± 30 %<br>$R_I$ ≤ 4 x spec. limit<br>$I_L$ ≤ 2 x spec. limit |
| Shelf discharge | - | 24 h storage at room temperature after application of n x $U_R$ | Remaining voltage: ≥ n x ($U_R$ x 0.1) |
| 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 -20 °C<br>Step 3: measurement at +20 °C<br>Step 2: measurement at +70 °C<br>Step 4: measurement at +20 °C | ΔC/C: ± 30 % of +20 °C value<br>$R_I$ ≤ 5 x the +20 °C value<br>$I_L$ ≤ 4 x the +20 °C value |
| Surge voltage | - | Max. 30 s at room temperature<br>$U_S$ = n [1] x 1.6 V | No change of parameter!<br>After surge voltage, discharge product below rated voltage |

**Note**

(1) n... number of cells


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**Table 6.2: Stacked Through Hole configuration (STH), Surface Mount Flat configuration (SMF), and Lay Flat configuration with Connector**

| TEST PROCEDURES AND REQUIREMENTS | | | |
|---|---|---|---|
| **NAME OF TEST** | **IEC 60384-4/ EN 130300 SUBCLAUSE** | **PROCEDURE (quick reference)** | **REQUIREMENTS** |
| Robustness of terminations | 4.4 | Tensile strength; application of load 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 | ΔC/C: ± 10 %<br>$R_I$ and $I_L$ ≤ spec. limit |
| Solderability | 4.6 | Solder bath; 236 °C; 2 s | ≥ 75 % tinning |
| Vibration | 4.8 | 10 Hz to 55 Hz; 1.5 mm; 3 directions;<br>2 h per direction | ΔC/C: ± 10 %<br>$R_I$ and $I_L$ ≤ spec. limit |

**Notes**

- Robustness - bending limited to ± 15°, force in direction of tab.
- Solder bath test: max. allowed case temperature during test is e.g. 85 °C or immersion of one (1) pad only.
- Wave soldering allowed.

## SOLDERING

As a general principle, temperature and duration shall be the minimum necessary required to ensure good soldering connections. However, the maximum specified soldering time and case temperature should never be exceeded.

## EVALUATION KIT

Evaluation kits are available under ordering code: MAL219699001E3. The engineering kit includes a charge and discharge demo board with different 196 HVC capacitor samples.

For further details, please contact aluminumcaps1@vishay.com.


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LifeElectronics
Живое партнерство

**ООО «ЛайфЭлектроникс»** **“LifeElectronics” LLC**

*ИНН 7805602321 КПП 780501001 Р/С 40702810122510004610 ФАКБ "АБСОЛЮТ БАНК" (ЗАО) в г.Санкт-Петербурге К/С 30101810900000000703 БИК 044030703*

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*С конца 2013 года компания активно расширяет линейку поставок компонентов по направлению коаксиальный кабель, кварцевые генераторы и конденсаторы (керамические, пленочные, электролитические), за счёт заключения дистрибьюторских договоров*

*Мы предлагаем:*

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- *Специальные условия для постоянных клиентов.*
- *Подбор аналогов.*
- *Поставку компонентов в любых объемах, удовлетворяющих вашим потребностям.*

- *Приемлемые сроки поставки, возможна ускоренная поставка.*
- *Доставку товара в любую точку России и стран СНГ.*
- *Комплексную поставку.*
- *Работу по проектам и поставку образцов.*
- *Формирование склада под заказчика.*

- *Сертификаты соответствия на поставляемую продукцию (по желанию клиента).*
- *Тестирование поставляемой продукции.*
- *Поставку компонентов, требующих военную и космическую приемку.*
- *Входной контроль качества.*
- *Наличие сертификата ISO.*

*В составе нашей компании организован Конструкторский отдел, призванный помогать разработчикам, и инженерам.*

*Конструкторский отдел помогает осуществить:*

- *Регистрацию проекта у производителя компонентов.*
- *Техническую поддержку проекта.*
- *Защиту от снятия компонента с производства.*
- *Оценку стоимости проекта по компонентам.*
- *Изготовление тестовой платы монтаж и пусконаладочные работы.*

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