Supercapacitor Frequently Asked Questions

What is a Supercapacitor?

Supercapacitors also known ultracapacitors and electric double layer capacitors (EDLC) are capacitors with capacitance values greater than any other capacitor type available today. Supercapacitors are breakthrough energy storage and delivery devices that offer millions of times more capacitance than traditional capacitors. They deliver rapid, reliable bursts of power for hundreds of thousands to millions of duty cycles – even in demanding conditions.

What is a hybrid supercapacitor (LIC)?

Offers increased voltage (3.8V) and energy density of batteries along with the rapid charge/discharge, environmental friendliness, longevity, and safety of supercapacitors.

Are supercapacitors safe?

Cornell Dubilier supercapacitors have successfully passed UL810A testing and are UL recognized components under file number MH64760.

How is Energy Stored in supercapacitors?

Supercapacitor construction leverages highly porous carbon materials to form electrodes that store electric charge electrostatically on its surface area. The electrode material offers a surface area of up to 3000 m^2/g, which gives supercapacitors much higher energy density than that of traditions capacitors.

Can supercapacitors handle high current?

Supercapacitors inherently have very low equivalent series resistance (ESR), allowing them to deliver and absorb very high current. The low ESR of supercapacitors allows them to be charged quickly. The fundamental characteristics of the supercapacitor allow it to be charged and discharged at the same rates, something no battery chemistry can tolerate.

What is the operating voltage of a supercapacitor?

Supercapacitors are not restricted to a narrow voltage window. Designers need only consider the voltage range of the system, which can be much wider than the narrow voltage range required by a battery. The supercapacitor can operate at any voltage below its maximum continuous operating voltage. The possible operating voltage extends from the maximum rated voltage down to 0 volts. To achieve higher voltages, multiple cells are placed in series, and are operated at or below their total series maximum voltage. There is no risk of over-discharging the supercapacitor.

What is the operating temperature of a supercapacitor?

Supercapacitors can operate without relying on chemical reactions, so they can operate over a wide range of temperatures. On the high side, they can operate up to 85°C, and without risk of thermal runaway. On the low side, they can deliver power (with slightly increased resistive losses) as cold as -

40°C, well below the cold performance threshold of batteries.

How do I calculate life of the supercapacitor?

Life of supercapacitors is most often measured in calendar years and is dependent on two primary factors: voltage and temperature. The life expectancy of supercapacitors is similar to aluminum electrolytic capacitors. The life of supercapacitors will double for every 10°C decrease in temperature or voltage by 0.1V.

$$L_2=L_1*2^X*2^Y \quad X=\frac{Tm-Ta}{2} \quad Y=\frac{Vr-Va}{0.2}$$

L_1= Load life rating of the super capacitor (typically 1000 hours at rated temperature).
L= expected life at operating condition.
Tm= Maximum temperature rating of the supercapacitor.
Ta= Ambient temperature the supercapacitor is going to be exposed to in the application.
Vr= rated voltage of capacitor.
Va= applied voltage to capacitor

How do I size/calculate my application requirements properly?

Determination of the proper supercapacitor and number of capacitors is dependent on the intended application. For sizing the system correctly, a number of factors should be known. These factors include:

1. maximum and minimum operating voltage of the application
2. average current or power
3. peak current or power
4. operating environment temperature
5. run time required for the application
6. required life of the application.

Since supercapacitors are low voltage devices, the rated voltage is generally less than the application voltage required. Knowing the maximum application voltage (Vmax) will determine how many capacitor cells are required to be series connected. The number of series connected cells is determined by:

$$\#\text{ series cells} = \frac{V_{max}}{V_R}$$

Next, the average current (I) in amps, the required run time (dt) in seconds and the minimum working voltage (Vmin), an approximate system capacitance can be calculated.

$$Csys = I \bullet \frac{dt}{dV} = I \bullet \frac{dt}{(V_{max} - V_{min})}$$

The total system capacitance is comprised of the capacitance of all the series connected capacitors for achieving Vmax. For capacitors connected in series the capacitance of the individual cells is determined by:

$$\frac{1}{Csys} = \frac{1}{C1} + \frac{1}{C2} + \ldots + \frac{1}{Cn}$$

For capacitors connected in parallel to achieve the required energy, the capacitance is determined by:

$$C = C1 + C2 + \ldots + Cn$$

Note: There are many other items to consider for properly sizing the application. This includes the internal resistance of the capacitor to account for the sudden voltage drop associated with an applied current, the ambient operating temperature which affects the internal resistance and the capacitor life, and the life of the application. The supercapacitor performance requirement at end of life of the application is necessary to ensure proper initial sizing of the system

Leakage Current

The current that the supercapacitor will continue to draw from a source once it is at full voltage. The value drops over time and typically measured after the supercapacitor has been on charge for 72 hours.

Self-Discharge

The rate of voltage decline when the supercapacitor is not connected to any circuit. The rate of self-discharge is dependent on the state of charge it was held at before being disconnected from the circuit. A part that is quickly charged and left to sit will discharge faster than one that is held on charge for many hours. The rate of discharge also changes as the voltage decreases.

Equation:

I = C dv/dt or time = cap value * voltage change/ current.

What is the failure mode of a supercapacitor?

Supercapacitors do not have a hard end of life like batteries. End of life (EOL) is defined as when the capacitance and/or ESR has degraded beyond the application's needs. The failure mode of supercapacitors is a premature end of life condition where the product will degrade to a virtual open circuit. There are no short circuit or other catastrophic failure modes.

How to integrate sells in series or parallel?

Supercapacitor integration is primarily focused on keeping the supercapacitor within its wide operating limits of voltage and temperature. Supercapacitors can be placed in series or in parallel. Due to the low voltage characteristics of a single supercapacitor cell, most applications require multiple cells in series to achieve the voltage required. Because each cell will have a slight tolerance in capacitance and resistance it is necessary to balance, or prevent, individual cells from exceeding its rated voltage.

Passive Balancing

Passive balancing implies no variation in the voltage regulation as a function of the ultracapacitor condition. The most typical method of passive balancing utilizes resistors. The concept of resistive balancing employs resistors in parallel with the ultracapacitors.

Active Balancing

Active voltage balancing is preferred for applications with a limited energy source or high level of cycling. An active circuit typically draws much lower current in steady state and only requires larger currents when the cell voltage is out of balance. The maximum current varies by product

What are the maintenance requirements for supercapacitors?

Supercapacitors are fundamentally maintenance-free. They have no memory effects, cannot be over-discharged, and can be held at any voltage at or below their rating. If kept within their wide operating ranges of voltage and temperature, there is no recommended maintenance.

North America / EU – Tel: 1-508-996-8561 – Email: cdena@cde.com

Asia – Phone: 852-2793-0931 - Email: cdasia@cde.com