

Ambient temperature/ life expectancy

The standard operating temperature range for EDLC capacitors is between -40°C to +70°C depending on the product line. Over time the EDLC like an aluminum electrolytic capacitor will dry out causing the ESR to increase, a decreased capacitance and eventually to end of life. End of life is defined as a specified increase in ESR and decrease in capacitance. Exposure to temperatures above 20°C or high voltage or current will lead to accelerated increase in ESR and reduced capacitance leading to the capacitors life being shorter.

Life expectancy of an EDLC is similar to an aluminum electrolytic capacitor with the liquid electrolyte eventually drying out of the capacitor leading to the capacitor failing.

Voltage

If the applied voltage exceeds the rated voltage the resulting life time will be reduced. If the rated voltage is exceeded for a prolonged period of time an abnormal amount of gas will be generated within the capacitor leading to the capacitor rupturing or electrolyte leaking out of the capacitor. Voltages exceeding the rated voltage of the capacitor are to be avoided.

Polarity

EDLC capacitors are polarized except where noted. Applying a reverse voltage to the EDLC is not recommended and should be avoided. Applying reverse voltage can shorten the life of the capacitor.

Discharge

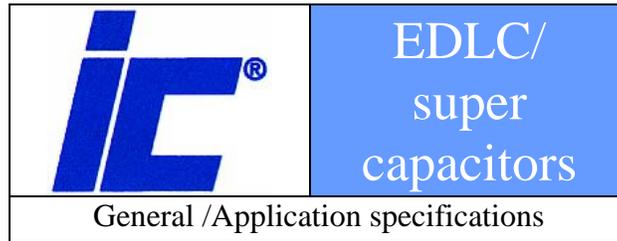
It is important in selecting an EDLC that both the capacitive and resistive components are taken into consideration. In high current applications the resistive component is critical and in long duration low current applications the capacitive component is most critical.

The following formula used for determining the voltage drop (V_d) during a discharge current (I) for t seconds is:

$$V_d = I(R + t/C)$$

To minimize the voltage drop in a pulse application, use an EDLC with a low ESR.

To minimize the voltage drop in a low current application select an EDLC with a large capacitance.



Charging

EDLC's can be charged using various methods including constant current, constant power, constant voltage.

If an EDLC is charged by a battery, a low value series resistance should be used to maintain battery life. The maximum charging current I for an EDLC is:

$I = V_w / 5R$ where V_w is the charging voltage and R is the ESR of the EDLC.

Applying an over current or overvoltage to the EDLC during charging can damage the capacitor and is to be avoided.

Leakage current and self discharge

Leakage current and self-discharge current are similar terms. An EDLC has a high internal resistance so a small current is needed to keep the charge on the capacitor. This charge maintaining current is known as leakage current. When the capacitor is disconnected from the charging source the capacitor will begin to loose charge due to the high internal resistance. This is called discharge current.

In order to get a realistic measure of the leakage and self discharge currents the capacitors need to be charged for several hours (typically 72 to 100 hours).

Series connections

When connecting EDLC's in series it is important to keep the voltage applied to any EDLC at or below the rated voltage for the EDLC or else the capacitor will become damaged.

Voltage imbalance comes from the differences in the capacitance and leakage currents of the capacitors. Higher capacitance parts will have lower voltage stresses on them when EDLC's are in series. For example: two 1F/2.5V EDLC's are connected in series. 1 capacitor is at the +20% tolerance and the other at the -20% tolerance.

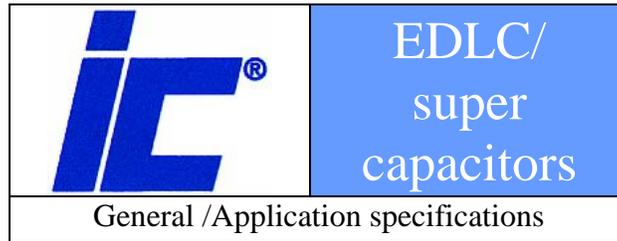
$$V_{cap2} = V_{supply} * (C_{cap1} / (C_{cap1} + C_{cap2})) = V_{supply} * (1.2 / (1.2 + 0.8)) = V_{supply} * (0.6)$$

$$\text{IF } V_{supply} = 5V \text{ } V_{cap2} = 5 * 0.6 = 3V$$

To avoid voltage imbalances it is necessary to incorporate some type of voltage balancing is required.

Passive voltage balancing

Passive voltage balancing is done by placing a resistor in parallel with each capacitor. The resistors will have a higher current flow through them which will cause the voltages across the capacitors to be equal.



The minimum current the resistors are to conduct needs to be greater than the leakage current of the EDLC's. As a guide it is suggested that the current used be 50 times higher than the leakage current of the EDLC.

Passive voltage balancing should only be used in applications where charge/discharge cycling occurs on a regular basis or where the additional load current from the balancing resistors can be tolerated.

Active voltage balancing

Active balancing circuits force the voltage at the nodes of series connected EDLC's to be the same as a fixed reference voltage. Active circuits typically draw lower currents in steady state and only require larger currents when the capacitor voltages go out of balance.

Active balancing is ideal for applications where charge/discharge cycling of the EDLC occurs on a frequent basis and where the charging source has a finite amount of energy like a battery.

Soldering

Supercapacitors can only be soldered using hand soldering and wave soldering techniques.

Flat pack supercapacitors can only be hand soldered. Solder iron temperature should be less than 435°C with a 3 second maximum exposure time.

All other leaded termination types can be hand soldered or wave soldered. Hand solder iron temperature is to be limited to 350°C with a maximum exposure time of 3.5 seconds.

For wave soldering the preheat should be limited to 170°C with a solder bath temperature of 260°C with an exposure time of 2~3 seconds.

Storage Temperature

Supercapacitors should be stored at temperatures ranging from -25°C to +60°C for brief periods without damage. Storage should be limited to 2 years maximum.