



# User Manual

## 1. Background

Film capacitors store charge by means of two layers of conductive film that are separated by a dielectric material. The charge accumulates on both conductive film layers, yet remains separated due to the dielectric between the conductive films.

Electrolytic capacitors are composed of metal to which is added a thin layer of non-conductive metal oxide which serves as the dielectric.

These capacitors have an inherently larger capacitance than that of standard film capacitors.

In both cases the capacitance is generated by electronic charge and therefore the power capability of these types of capacitors is relatively high while the energy density is much lower.

The Electrochemical Double Layer Capacitor (EDLC) or Super Capacitor is a form of hybrid between conventional capacitors and the battery.

The electrochemical capacitor is based on the double layer phenomena occurring between a conductive solid and a solution interphase.

The capacitance, coined the "double layer capacitance", is the result of charge separation in the interphase. On the solid electrode, electronic charge is accumulated and in the solution counter charge is accumulated in the form of ionic charge.

The EDLC embodies high power and high energy density (Fig. 1).

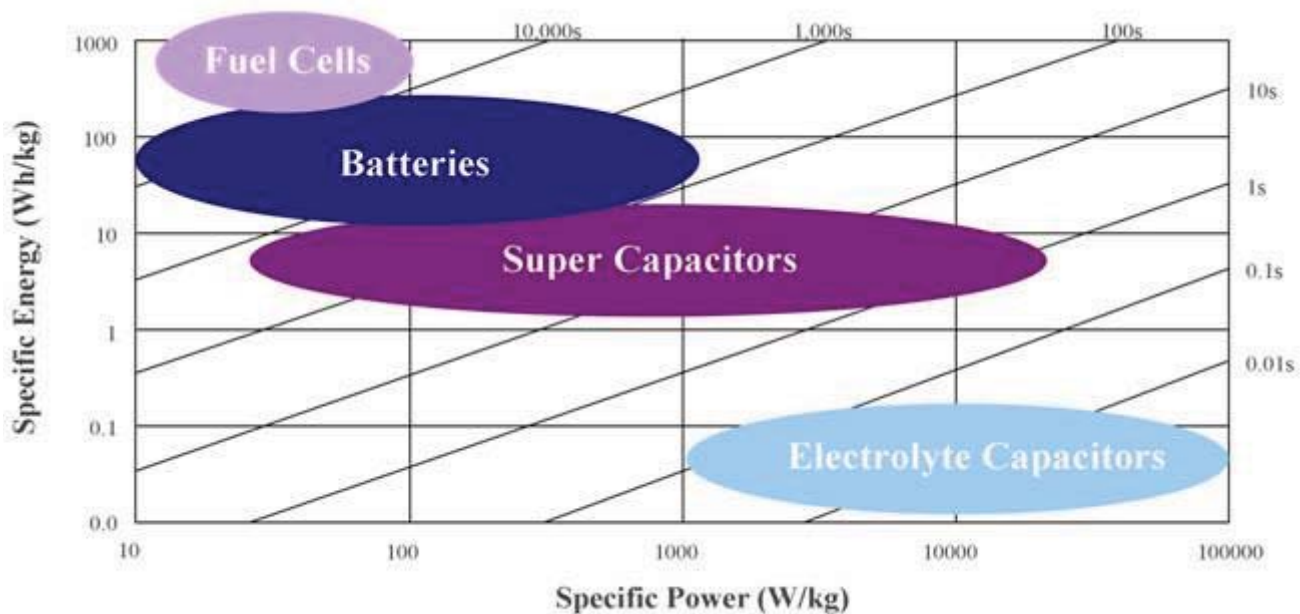


Fig. 1



Ph: 847-675-1865  
 Fax: 847-675-3345  
 Email: [sales@icd-sales.com](mailto:sales@icd-sales.com)  
 Website: [www.icd-sales.com](http://www.icd-sales.com)



## Electrochemical Capacitors

The operating principle of the super capacitor is similar to that of a battery. Pairs of electrodes are separated by an ionic conductive, yet electrically insulating, separator (Fig. 2). When a super capacitor is charged, electronic charge accumulates on the electrodes (conductive carbon) and ions (from the electrolyte) of opposite charge approach the electronic charge.

This phenomenon is coined "the double layer phenomenon".

The distance between the electronic and the ionic charges is very small, roughly 1 nanometer, yet electronic tunneling does not occur.

Between charging and discharging, ions and electrons shift locations.

In the charged state a high concentration of ions will be located along the electronically charged carbon surface (electrodes).

As the electrons flow through an external discharge circuit, slower moving ions will shift away from the double layer. During EDLC cycling electrons and ions constantly move in the capacitor, yet no chemical reaction occurs.

Therefore electrochemical capacitors can undergo millions of charge and discharge cycles. This phenomenon which occurs with carbon electrodes of very high surface area and a three-dimensional structure, leads to incredibly high capacitance as compared to standard capacitors.

One can envision the model of the EDLC as two capacitors formed by the solid (carbon) liquid (electrolyte) interphase separated by a conductive ionic membrane. An equivalent electronic model is two capacitors in a series connection (Fig. 3) where  $C_{dl}$  is the capacitance of each electrode;  $R_p$  is the parallel resistance to the electrode,  $R_s$  is the resistance of the separator.

We conclude that the energy density of electrochemical capacitors is higher than that of electrolytic capacitors, and therefore they have applicability for systems with lower frequency requirements.

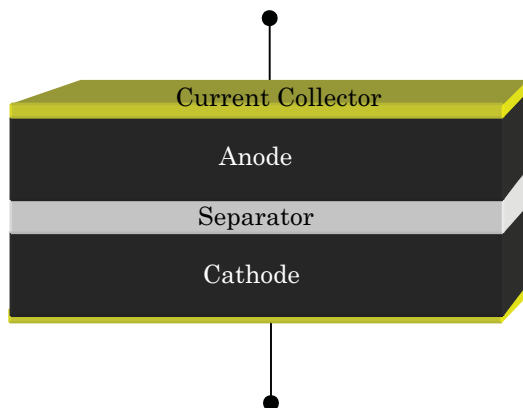


Fig. 2

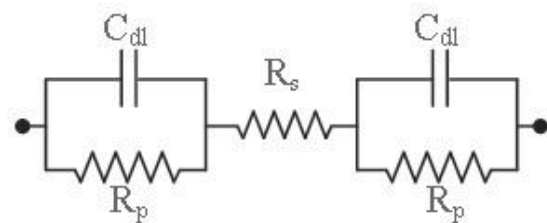


Fig. 3



Ph: 847-675-1865

Fax: 847-675-3345

Email: sales@icd-sales.com

Website: www.icd-sales.com



## Cellergy's Technology

By use of a unique patented production and manufacturing process, Cellergy has developed a small footprint, low Equivalent Series Resistance (ESR), high frequency EDLC capable of storing relatively large amounts of energy.

The development is based on an innovative printing technology allowing the production of EDLC's in many different sizes with varied dimensions and shapes.

In fact, Cellergy produces one of the smallest low ESR footprint EDLC's on the market today.

Since the patented printing technology is based on conventional printing techniques, the manufacturing process is simple and unique, and it is possible to manufacture large wafers of EDLC's.

The basis of the technology is a printable aqueous electrode paste based on a high surface area carbon paste that is printed in an electrode matrix structure on an electronically conductive film.

The electrodes are then encapsulated with a porous ionic conducting separator and another electrode matrix is then printed on the separator. This bipolar printing process is repeated as many times as required enabling us to tailor our product to the specifications of the end user.

The finished wafer is then cut into individual EDLC's that are then packaged.

Cellergy's EDLC's boasts low equivalent series resistance as well as a low leakage current due to our unique encapsulation technology and electrode composition.

Cellergy's EDLC's require no cell balancing or de-rating.

The combination of the separator and carbon paste lead to the capability of very high power bursts within low milli-second pulse widths.

Cellergy's technology is based on aqueous components that are all environmentally friendly and non-toxic. Though the system is water based, the capacitor can work at temperatures between -40°C and 70°C.

This working temperature range is achieved by the unique water based electrolyte that impregnates the high surface carbon.

Because the chemistry of the system is based on water, the performance of Cellergy's EDLC's is not affected by humidity.



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Website: [www.icd-sales.com](http://www.icd-sales.com)



## Application Notes for EDLC

Cellergy's super capacitors offer high power and high energy. This characteristic coupled with a battery offer the designer a unique opportunity to solve power related issues.

The following table lists the characteristics of the EDLC (Table 1):

Characteristics	
Working Voltage	1-12 volts
De-rating	Not required
Capacitance	10-100's of mF
Foot print	Selectable down to 17mm by 17 mm
Operating Temperatures	-40°C to +70°C
SMT	Under development.
ESR	10's-100's mΩ
Expected life	50,000 hours
Safety	Environmentally friendly materials, No toxic fumes upon burning
Power	10's of amps, short pulse widths
Polarity	No polarity
Number of cycles	Not limited

Table 1



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## Voltage Drop

Two main factors affect the voltage drop of all capacitors including EDLC's.

The first voltage drop is defined as the **Ohmic voltage drop**.

The capacitor has an internal resistance defined as ESR (Equivalent Series Resistance).

As current flows through the capacitor, a voltage drop occurs that obeys Ohms law. This voltage drop is instantaneous and will diminish the moment that no current is drawn.

The second voltage drop (**capacitance related voltage drop**) is due to capacitor discharge.

The voltage of the capacitor is directly proportional to the charge accumulated in the capacitor. During current discharge, capacitance is consumed (current emitting from the capacitor) thus causing a linear voltage decrease in the capacitor. When the current is stopped, the voltage of the capacitor indicates the charge left in the capacitor. The combination of the Ohmic related voltage drop and the capacitance related voltage drop determine the actual **working voltage window** of an EDLC under drain conditions (Fig. 4).

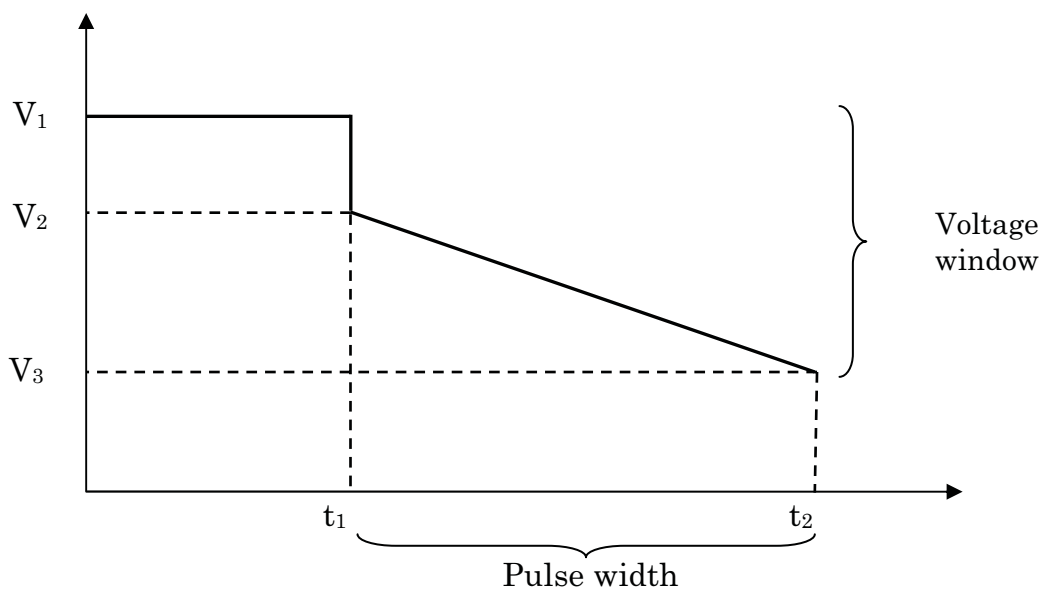


Fig. 4

$$\text{Ohmic voltage drop} = V_1 - V_2 = I_{\text{pulse}} * \text{ESR}$$

$$\text{Capacitance related voltage drop} = V_2 - V_3 = I_{\text{pulse}} * (t_2 - t_1) / C$$

$$\text{Working voltage window} = V_1 - V_3 = I_{\text{pulse}} * \text{ESR} + I_{\text{pulse}} * (t_2 - t_1) / C$$

\*Where C is Capacitance



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## EDLC and Battery Coupling

Under drain conditions, a battery undergoes a voltage drop similarly to the EDLC. Because of many physical and chemical constraints, the battery often cannot supply the power required while still retaining its open circuit voltage.

The working voltage of the battery reflects the load on the battery, thus the larger the voltage drop of the battery the larger the load on the battery.

Many difficulties are encountered by the designer planning the online power demand of a system, mainly because the power of the batteries is limited.

If the battery must supply high power at short pulse widths, the voltage drop may be too great to supply the power and voltage required by the end product (cutoff voltage).

The large load on the battery may decrease the useful energy stored in the battery and even may harm the battery and shorten its work life.

This problem may be resolved by connecting the battery in parallel to an EDLC (Fig. 5).

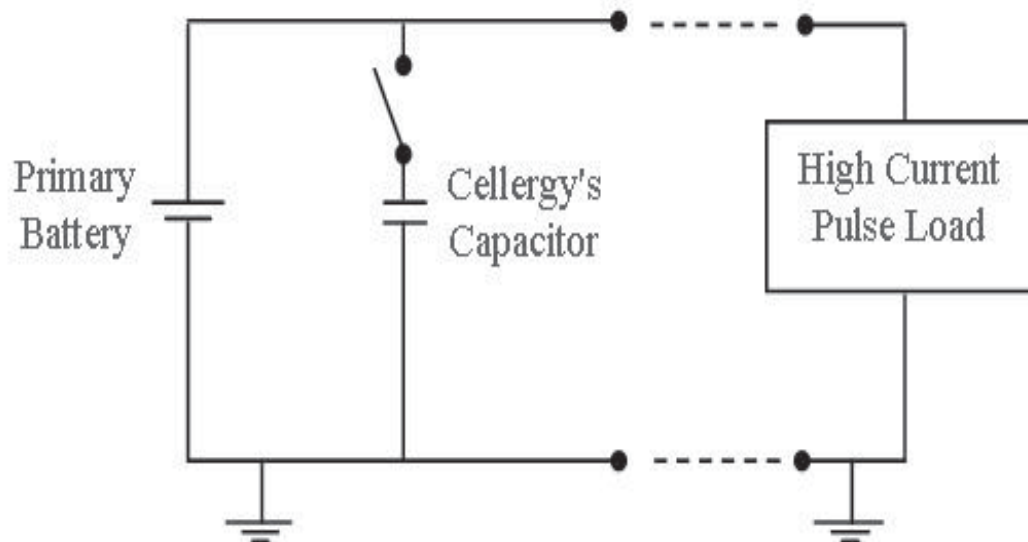


Fig. 5



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## EDLC and Battery Coupling (Continued)

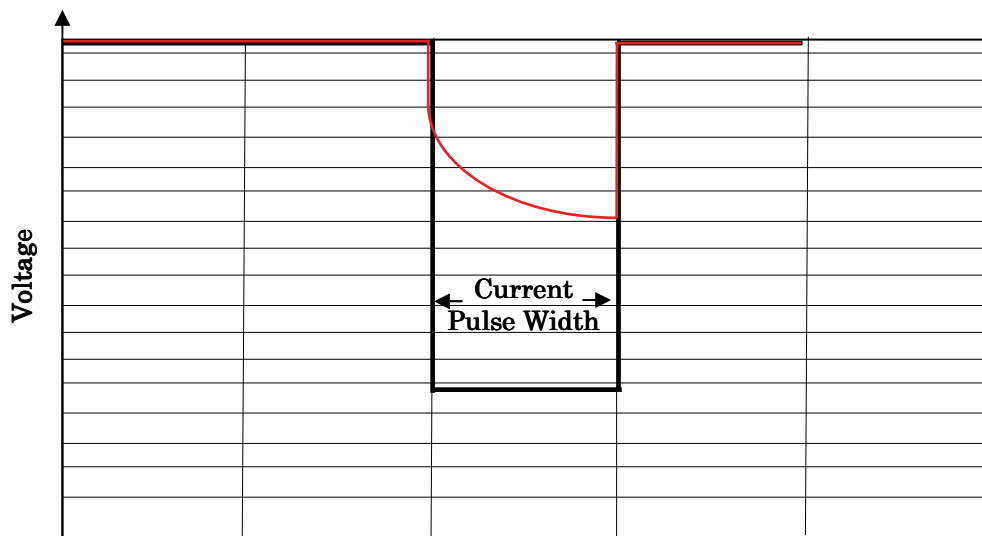
Under conditions of high power and short duration current pulses, a *voltage damping effect* will be achieved. The voltage drop of the battery will be decreased resulting in better energy management and superior energy density of the battery (Fig. 6).

The power supplied will be produced by both the EDLC and the battery, and each will supply the relative power inversely to its own ESR. The inefficiency of batteries at lower temperatures is well known. The capacitance of most batteries decreases with decreasing temperatures.

This decrease is due to the slow kinetics of the chemical reaction in the battery which increases the internal resistance of the battery.

At low temperatures, the voltage drop of the battery increases and reduces the usefulness of the battery. This voltage drop can be reduced greatly by coupling of the battery and the EDLC.

In conclusion, coupling the battery and EDLC results in superior power management for many short interval and high power applications.



— Battery Alone    - Battery +Cellergy's Capacitor

Fig. 6



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## Distinct Applications for Cellergy's Super Capacitors

- Extending battery lifetimes – by connecting a primary battery in parallel to Cellergy's capacitor, the designer can reduce the voltage drop during a high current pulse.
- Extending secondary battery operation - Reducing voltage drop at low temperatures (-40°C).
- CF, PCMCIA Cards - Cellergy's EDLC overcome the current limitation encountered when connecting boards in an application utilizing batteries.
- Backup or current booster for mechanical applications such as a DC motor.
- Extending the battery lifetime of digital cameras.
- Rechargeable backup power source for microprocessors, static RAM's and DAT.
- AMR – Automatic Meter Readings.
- GPS-GSM Modules.



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## Manual Soldering

Upon using a soldering iron, it should not touch the cell body.

Temperature of the soldering iron should be less than  $360 \pm 5^\circ\text{C}$ .

Soldering time for terminals should be less than  $8 \pm 0.3$  seconds.



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## Handling Cautions

- 1) Do not apply more than rated voltage.  
If you apply more than rated voltage, Cellergy electrolyte will be electrolyzed and the super capacitors ESR may increase.
- 2) Do not use Cellergy for ripple absorption.
- 3) Operating temperature and life  
Generally, Cellergy has a lower leakage current, longer back-up time and longer life in the low temperature range i.e. the room temperature. It will have a higher leakage current and a shorter life at elevated temperatures.  
Please design the Cellergy such that is not adjacent to heat emitting elements.
- 4) Short-circuit Cellergy  
You can short-circuit between terminals of Cellergy without a resistor. However when you short-circuit frequently, please consult us.
- 5) Storage  
In long term storage, please store Cellergy in following condition:
  - 1) TEMP. : 15 ~ 25 °C
  - 2) HUMIDITY: 45 ~ 75 %RH
  - 3) NON-DUST
- 6) Do not disassemble Cellergy. It contains electrolyte.
- 7) The tips of Cellergy terminals are very sharp. Please handle with care.
- 8) Reflow process is not recommended for Cellergy capacitors.

### *Note*

*The Cellergy EDLC is a water based component. Extended use of the EDLC at elevated temperatures may cause evaporation of water leading to ESR increase.*



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