

SUPERCAPACITORS



Prepared by:-
HRISHIKESH H. DIXIT
TY(A)
T3414

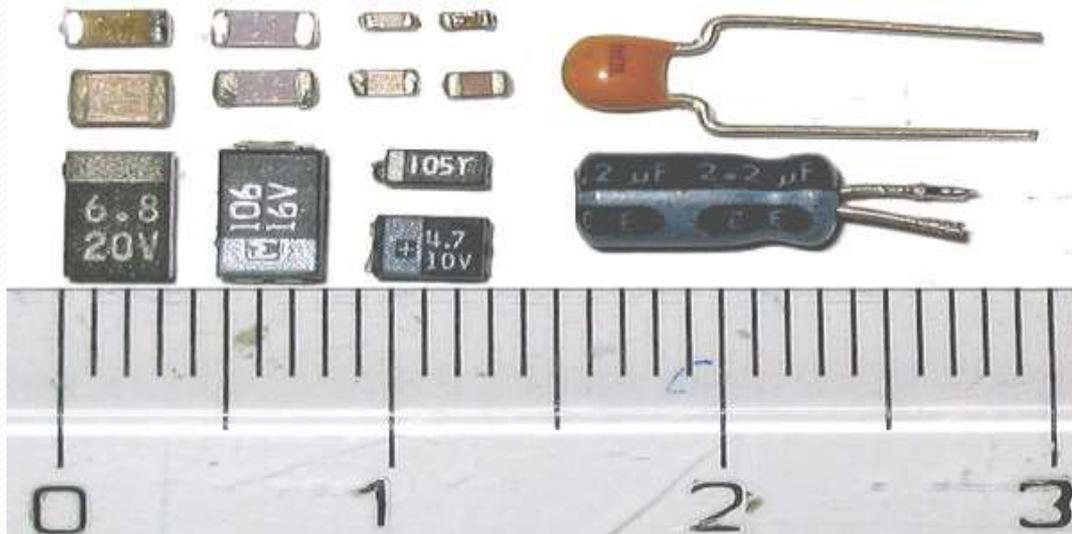
Guided by
Prof.Salve Madam

CONTENTS

- What is a Capacitor?
- What is a Super capacitor ?
- History of Super capacitor
- Basic Design
- Construction
- Working
- Technology used
- Why these substances used ?
- Charging and discharging time
- Features
- Comparison
- Applications
- Advantages
- Disadvantages
- Conclusion

CAPACITOR

- A **capacitor** (originally known as **condenser**) is a passive two-terminal electrical component used to store energy in its electric field.
- When a capacitor is attached across a battery, an electric field develops across the dielectric, causing positive charge $+Q$ to collect on one plate and negative charge $-Q$ to collect on the other plate.



SUPERCAPACITOR

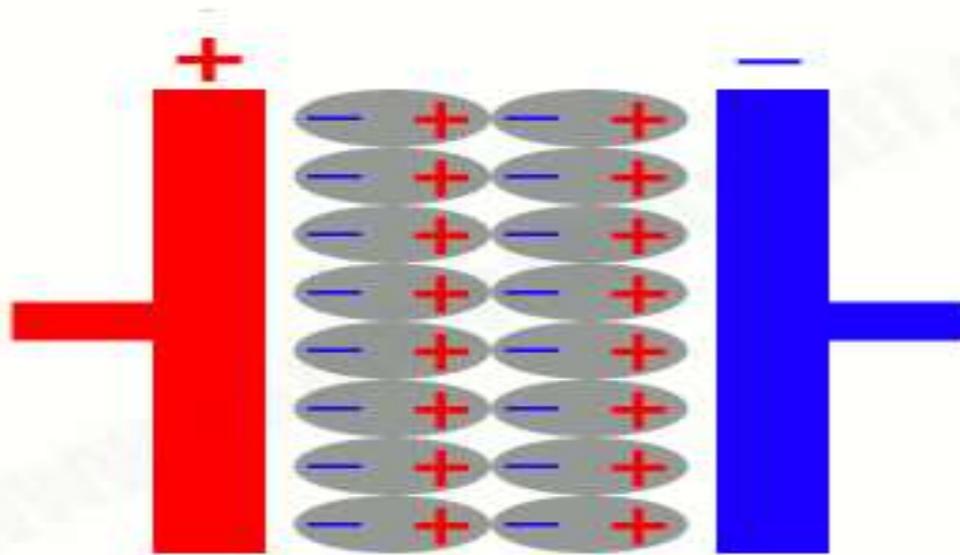
- A **supercapacitor** is an electrochemical capacitor that has a very high energy density as compared to common capacitors, about 100 times greater.
- Supercapacitor is also known as Electric Double Layer Capacitor(EDLC) or Ultracapacitor.
- The capacitance range is From 100 Farad to 5KFarad.

HISTORY OF SUPERCAPACITORS

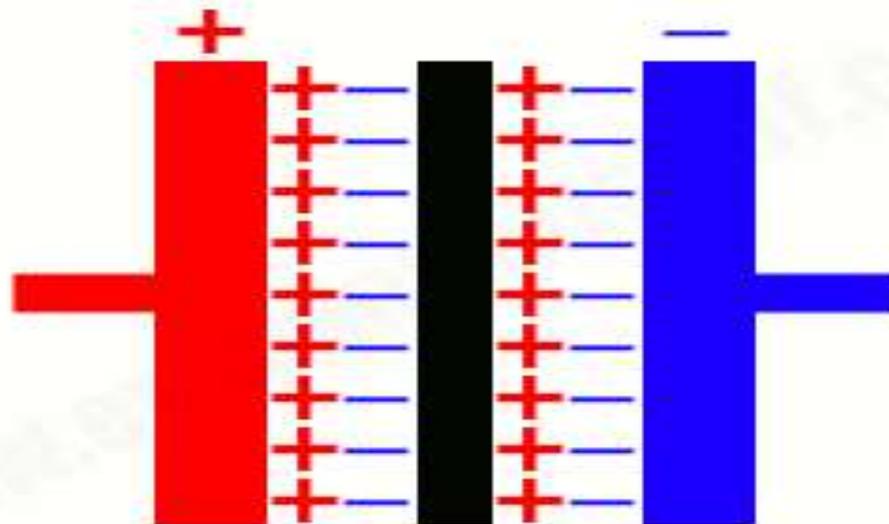
- In 1950s General Electric Engineers started experimenting components using porous carbon electrodes for fuel cells and rechargeable batteries.
- In 1957 H. Becker developed a "Low voltage electrolytic capacitor with porous carbon electrodes".
- That capacitor came to known as Supercapacitor as it stored very high amount of energy.

Basic Design

- Electrochemical capacitors (supercapacitors) consist of two electrodes separated by an ion permeable membrane (separator), and an electrolyte electrically connecting both electrodes. When the voltage is applied, ions in the electrolyte form electric double layers of opposite polarity to the electrode's polarity.
- For example, positive electrodes will have a layer of negative ions and negative electrodes will have a layer of positive ions.

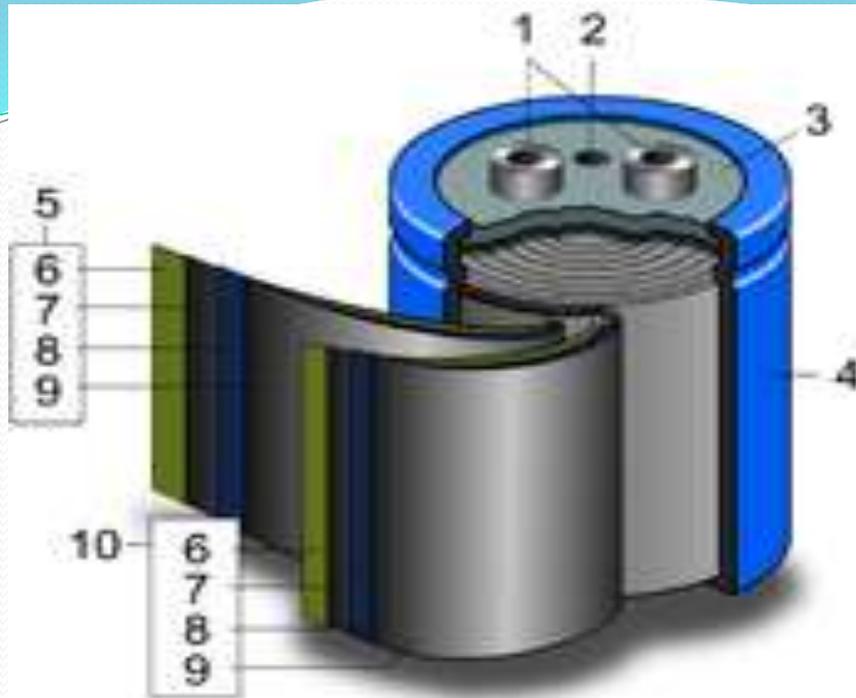


www.explainthatstuff.com

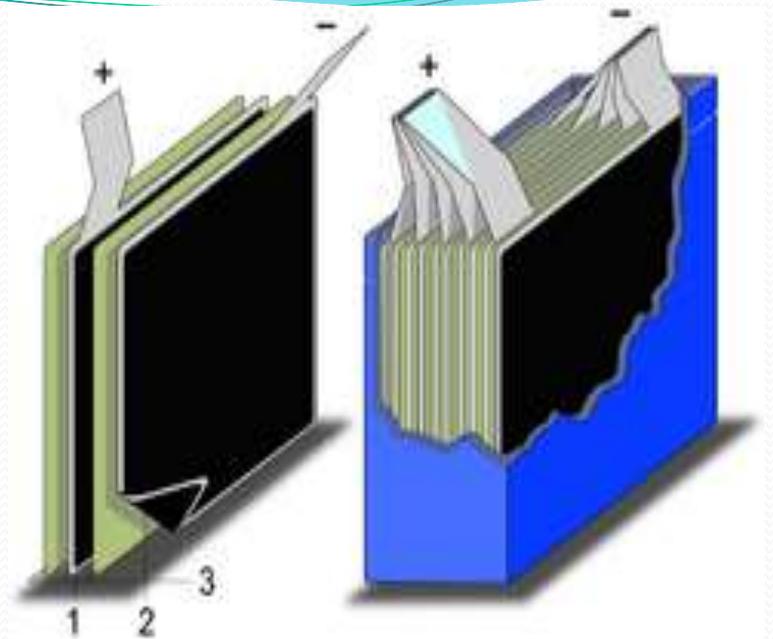


CONSTRUCTION

- Supercapacitors are constructed with two metal foils, each coated with an electrode material such as activated carbon.
- The electrodes are kept apart by an ion-permeable membrane (separator) used as an insulator to protect the electrodes against short circuits.
- The construction is subsequently rolled or folded into a cylindrical or rectangular shape and is packed in an aluminium can.



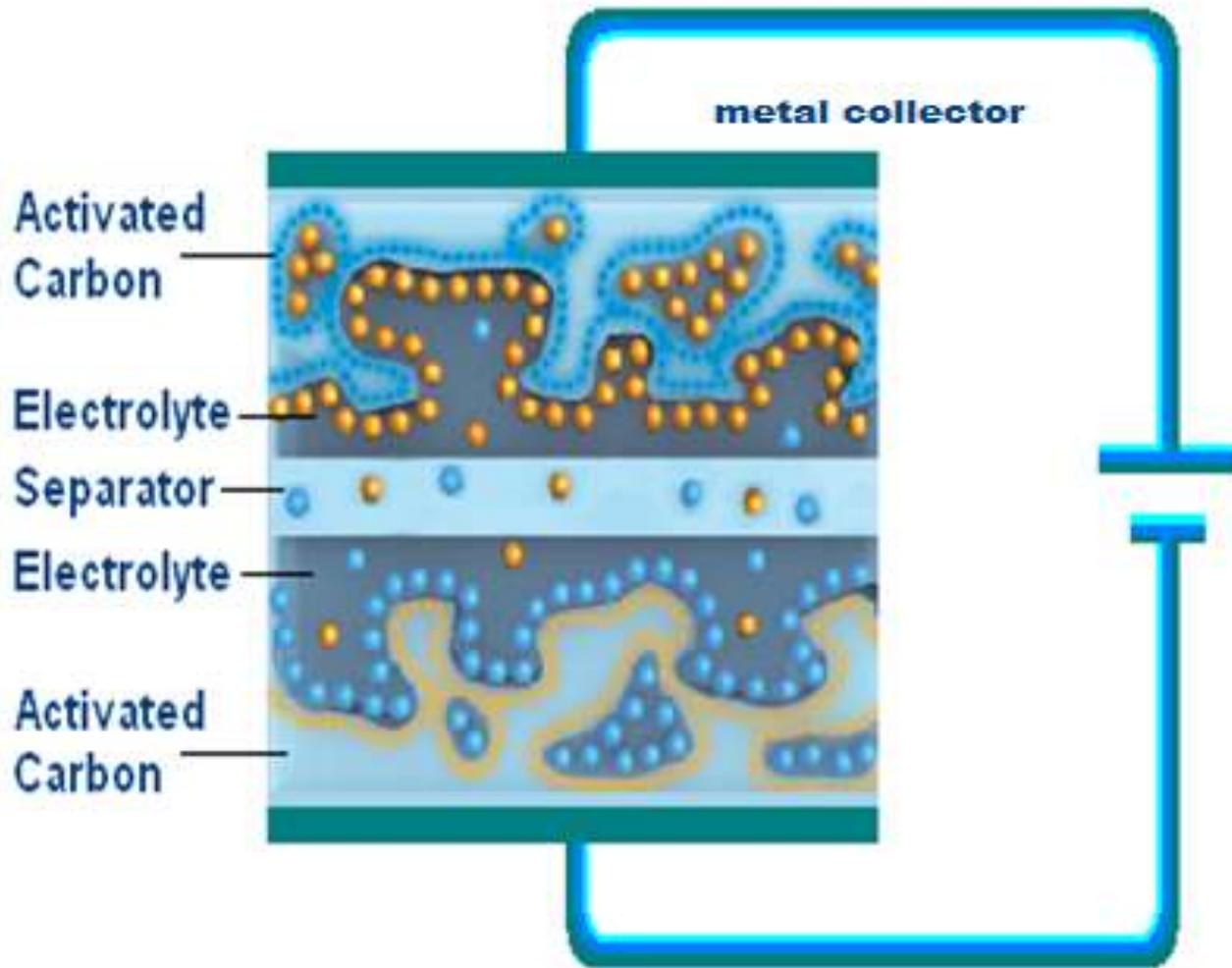
- 4. Aluminum can
- 5. Positive pole
- 6. Separator
- 7. Carbon electrode
- 8. Collector
- 9. Carbon electrode
- 10. Negative pole



- 1. Positive electrode
- 2. Separator
- 3. Negative electrode

WORKING OF SUPERCAPACITOR

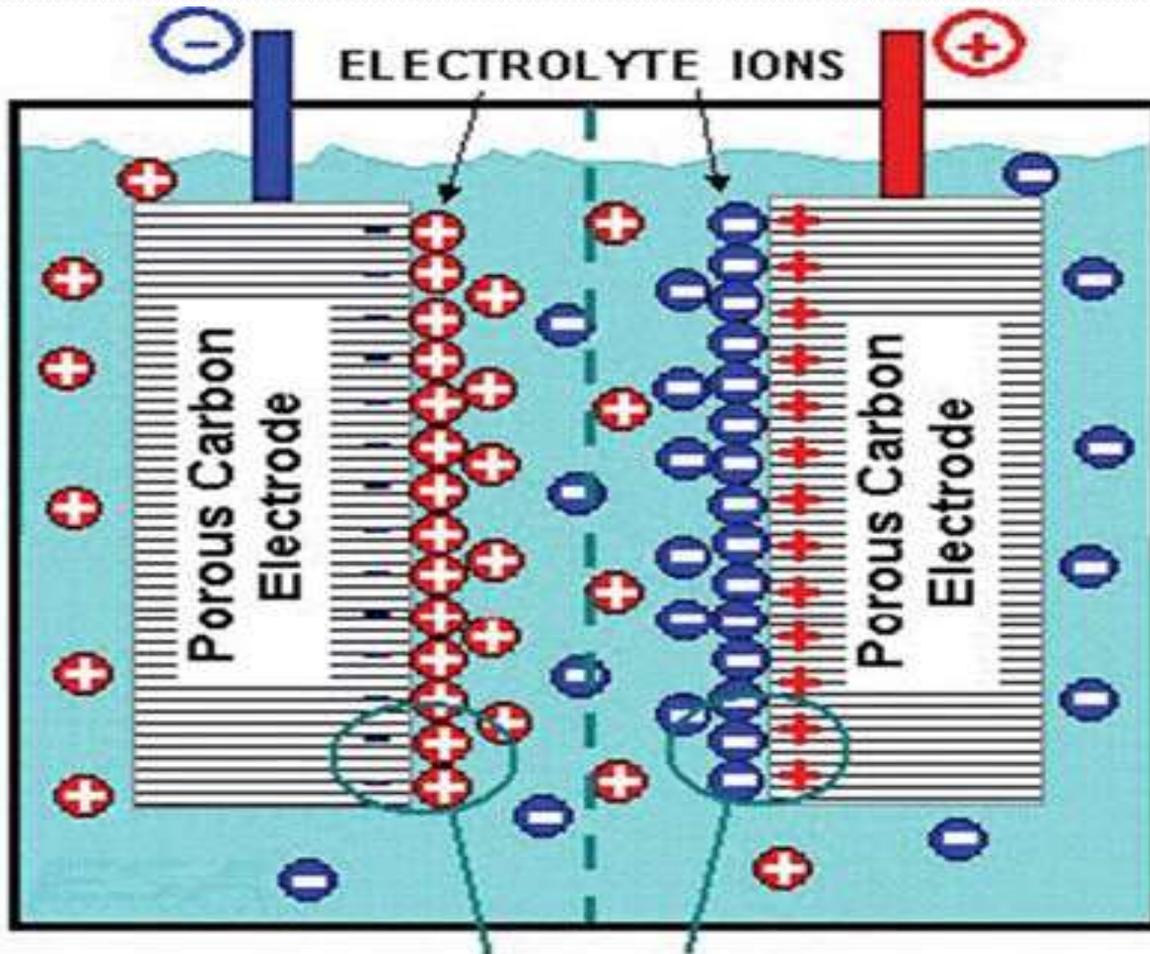
- In a supercapacitor, there is no conventional dielectric. Both plates are soaked in an electrolyte and separated by a very thin insulator. When the plates are charged, an opposite charge forms on either side of the separator, creating what's called an electric **double-layer**. This is why supercapacitors are often referred to as double-layer capacitors.



ELECTRIC DOUBLE LAYER

- Electrochemical capacitor has two electrodes, separated by a separator, which are electrically connected to each other via the electrolyte.
- When voltage is applied, and plates get charged, an opposite charge forms on the either side of the separator creating a electric double layer.

STRUCTURE OF EDLC



**Double Layer Capacitors
(Adsorbed layers of ions and solvated ions)**

TECHNOLOGY USED

- Carbon nano tubes, carbon aerogels are used for supercapacitors plates or electrodes.
- Sodium perchlorate (NaClO_4) or lithium perchlorate (LiClO_4) are used as electrolytes.
- Polyacrylonitrile($\text{C}_3\text{H}_3\text{N}$)_n is used as a separator(thickness 0.3-0.8 nm).
- Aluminium as a packing component.

WHY THESE SUBSTANCES USED

- Electrodes:-

- 1) Carbon nanotubes greatly improve capacitor performance, due to the highly wettable surface area and high conductivity.
- 2) Highly porous.

- Electrolytes:-

- 1) Wide working temperature (-90°C to 400°C).
- 2) Non flammable and low toxic.
- 3) Non-corrosive to electrode & packing components.

- Separator:-

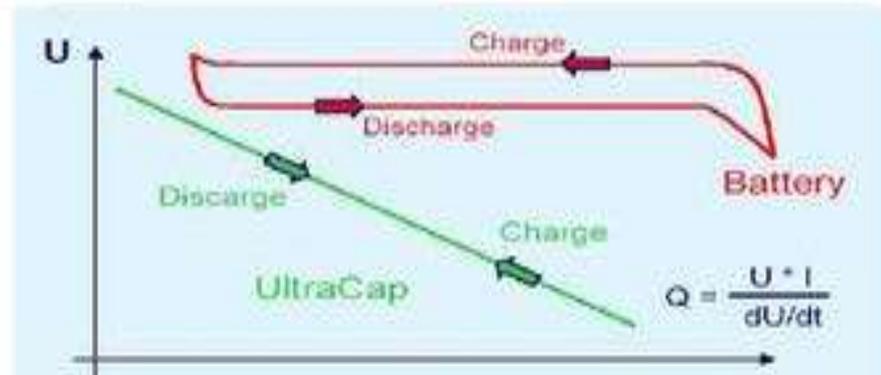
- 1) Unique tensile strength (10³ MegaPascals).
- 2) Electrical conductivity (1.5x10⁴ S/m).
- 3) Not degraded easily.

CHARGING & DISCHARGING TIME



Technology Comparison

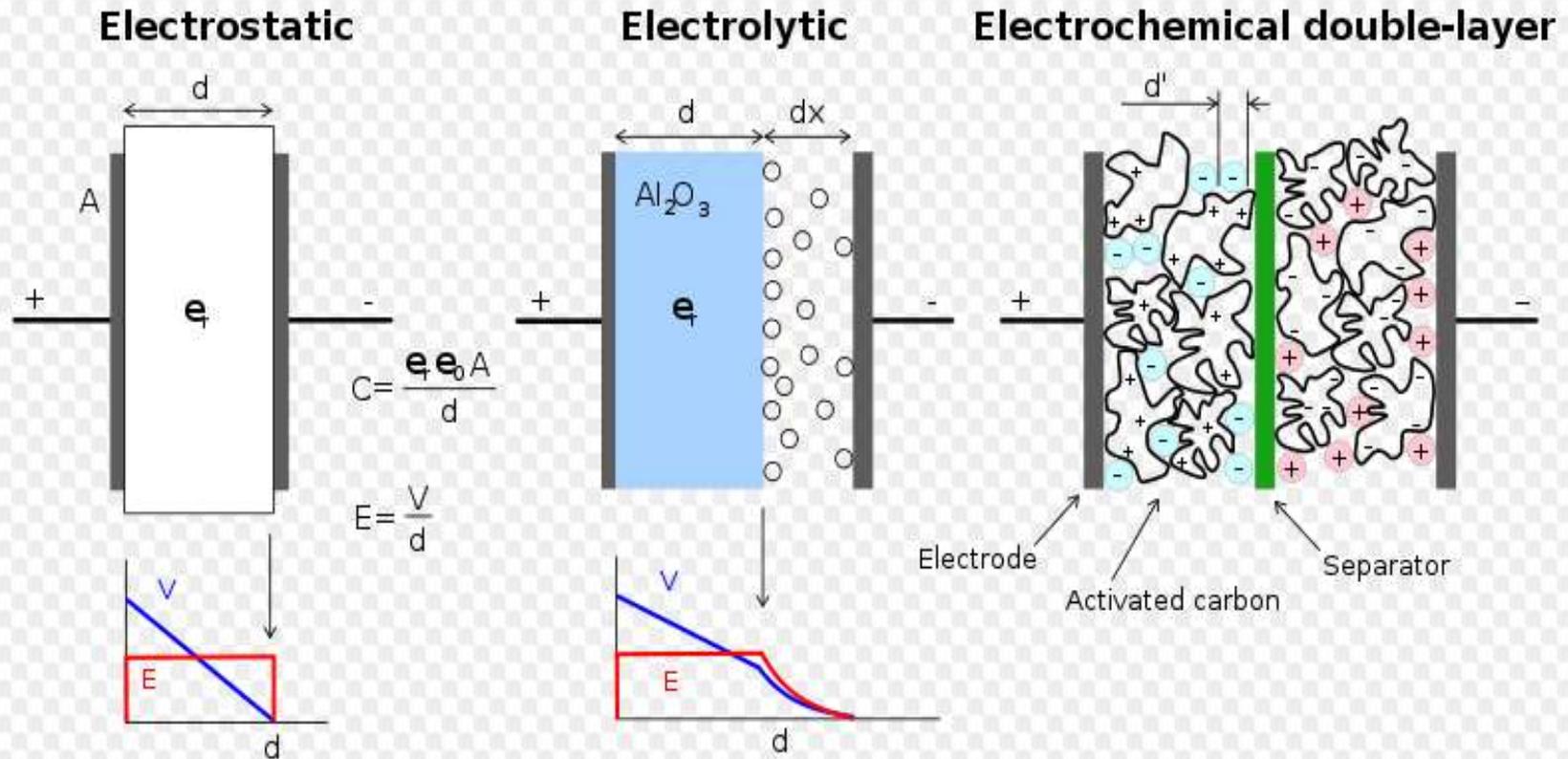
Available Performance	Lead Acid Battery	Ultracapacitor	Conventional Capacitor
Charge Time	1 to 5 hrs	0.3 to 30 s	10^{-3} to 10^{-6} s
Discharge Time	0.3 to 3 hrs	0.3 to 30 s	10^{-3} to 10^{-6} s
Energy (Wh/kg)	10 to 100	1 to 10	< 0.1
Cycle Life	1,000	>500,000	>500,000
Specific Power (W/kg)	<1000	<10,000	<100,000
Charge/discharge efficiency	0.7 to 0.85	0.85 to 0.98	>0.95



FEATURES

- Stores high amount of energy.
- Have high capacitance.
- High rates of charge and discharge.
- Little degradation over thousands of cycles.
- Low toxicity.
- High cycle efficiency (95%)

COMPARISON BETWEEN CAPACITORS



APPLICATIONS

- In start up mechanism for Automobiles.
- Used in Diesel engine start up in submarines & tanks.
- China is experimenting with a new form of electric bus that runs without powerlines but runs on power stored in large supercapacitors, which are quickly recharged whenever the electric bus stops at any bus stop, and get fully charged in the terminus. A few prototypes were being tested in Shanghai in early 2005. In 2006 two commercial bus routes began to use supercapacitor buses, one of them is route 11 in Shanghai.
- Backup power system in missiles.
- Power source for laptops, flash in cameras.
- Voltage stabilizer.



Bus operated on Supercapacitor in Shanghai



Supercapacitor
installed in bus



Supercapacitors

ADVANTAGES

- High energy storage.
- Wide working temperature(-40°C to 60°C).
- Eco-friendly.
- Quick charging time.
- Maximum life cycle.
- High cycle efficiency (95%).
- High specific power up to 17 kW/kg.
- Extremely low internal resistance.
- Safe.

DISADVANTAGES

- Low energy density; usually holds $1/5 - 1/10$ of a battery.
- Cannot use the full energy spectrum for some applications.
- The voltage varies with the energy stored.
- Have high self-discharge rate.
- Individual cells have low voltages, and so serial connections are needed to obtain higher voltages.
- Requires expert electronic control.
- Cannot be used in AC and high frequency circuits.
- High cost.

CONCLUSION

- Supercapacitors may be used where high power or energy storage is required.
- Supercapacitors can be used widely because of their long life & short charging time.
- On the other hand it has limitations due to its high cost, self discharge, packaging problems etc.

