

## Principles

Electric double-layer capacitors are based on the operating principle of the electric double-layer that is formed at the interface between activated charcoal and an electrolyte.

Activated charcoal is used as an electrode, and the principle behind the capacitor is shown in Figure 1. Activated charcoal is used in its solid form, and the electrolytic fluid is liquid. When these materials come in contact with each other, the positive and negative poles are distributed relative to each other over an extremely short distance. Such a phenomenon is known as an electrical double-layer. When an external electric field is applied, the electrical double-layer that is formed in the vicinity of the activated charcoal's surface within the electrolytic fluid is used as the fundamental capacitor structure.

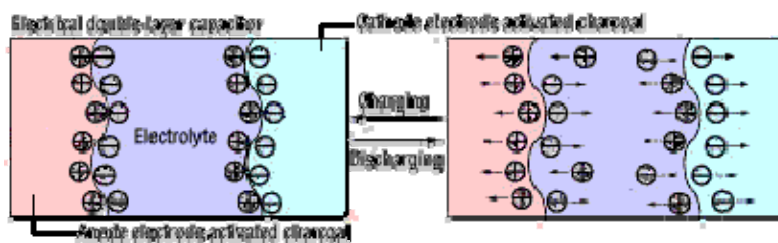


Figure 1: The Operating Principle in Electrical Double-layer Capacitors

## Benefits

The electrical double-layer design does not have the solid dielectric that is used in previous designs, nor does it have the chemical reactions such as are found in batteries during charging and discharging. Rather this design has the following characteristics:

### Benefits

1. This design allows farad-order capacitance in a small device. (When activated charcoal, with its large surface area, is used the thickness of the dielectric is extremely thin.)
2. There is no need for special charging circuits or for control during discharge.
3. Overcharging or over-discharging does not have a negative effect on the lifespan, as it does with batteries.
4. This technology is extremely "clean energy" in terms of environmental friendliness.
5. Because the electronic parts can be soldered, there are no problems with unstable contacts as there are with batteries.

### Weaknesses

1. The lifespan is limited because of the use of electrolyte.
2. The electrolyte may leak if the capacitor is used incorrectly.
3. When compared to aluminum electrolytic capacitors, these capacitors have high internal resistances and thus cannot be used in AC circuits.

## Application Examples

Taking advantage of the benefits described above, electrical double-layer capacitors are used broadly in applications such as the following:

1. Memory backup for timers, programs, etc., in video and audio equipment.
2. Backup power sources when changing batteries for portable electronic equipment.
3. Power sources for equipment that uses solar cells, such as watches and display lights.
4. Starters for small motors and cell motors.

## Comparison of Electric Double-layer Capacitors, Batteries, & Aluminum Electrolytic Capacitors

This table shows a comparison of the performance and the basic materials in electric double-layer capacitors:

	Electric Double-layer Capacitor	Aluminum Electrolytic Capacitor	Ni-Cd Battery	Lead Sealed Battery
Temperature range	-25 to +70°C	-55 to +125°C	-20 to +60°C	-40 to +60°C
Electrode materials	Activated charcoal	Aluminum	(+)NiOOH (-)Cd	(+)PbO <sub>2</sub> (-)Pb
Electrolytic fluid	Organic solvent	Organic solvent	KOH	H <sub>2</sub> SO <sub>4</sub>
Method of electromotive force	Naturally occurring electrical double-layer effect as the dielectric	Aluminum oxide as the dielectric	Chemical reaction	Chemical reaction
Pollution	None	None	Cd	Pb
Number of charge/discharge cycles	>100,000 times	>100,000 times	500 times	200 to 1000 times
Capacity per unit volume	1	1/1000	100	100

A comparison of the capacitance of the electrical double-layer capacitor is shown below:

