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Supercapacitors: The Future Batteries

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***Abstract:* - supercapacitors or ultracapacitors are becoming increasingly popular as alternatives for the conventional and traditional battery sources. This brief overview focuses on the different types of super capacitors, the relevant quantitative modeling areas and the future of supercapacitors research and development. Supercapacitors may emerge as the solution for many application-specific power systems. Especially, there has been great interest in developing supercapacitors for electric vehicle hybrid power systems, pulses power applications, as well as backup and emergency power supplies, because of their flexibility, however, supercapacitors can be adapted to serve in roles for which electrochemical that make them ideally suited to specialized roles and applications that complement the strengths of batteries. In particular, supercapacitors have great potential for applications that require a combinations of high power, short charging time, high cycling stability and long shelf life. Hence supercapacitors are the future batteries of life-long batteries that can be charge up almost anything and everything within seconds.**

I. INTRODUCTION

A capacitor (originally known as a conductor) is defined as a passive terminal electrical used to store energy electro statically in an electric field separated by a dielectric (i.e. insulator). So the super capacitor is the capacitor or a device that as matured significantly over the last decade and emerged with the potential to facilitate major advances in energy storage. This paper presents a brief overview of supercapacitors based on a broad survey of supercapacitors research and development. Following to the introduction, methodology is provided with respect to the fundamentals of conventional capacitors and supercapacitors including taxonomy of supercapacitors, different classes of supercpacitors and illustrates the supercapacitors energy storage approaches.

When battery was invented, it was one of the most remarkable and a novel discovery in the last 400 years was electricity. In 1800's Volta discovered certain fluids would generate a continuous flow of electric power when used as a conductor. This discovery led to the invention of the first voltaic cell, more commonly known as battery. In 1836 an English chemist JOHN F.DANEIL developed an improved battery that produced a steadier current than earlier devices. Until this time, all batteries were primary, meaning they could not be recharged. In 1859, the French physist GASTON PLANTE invented the first rechargeable battery. It was based on lead acid, a system that is still used today. In 1899, EALDMAR JUNGNER from Sweden invented the nickel-cadmium battery (NiCad), which uses nickel as a positive electrode (cathode) and cadmium as a negative electrode (anode). High material costs compared to lead acid limited its usage, two years later THOMAS ALVA EDISON produced an alternative design by replacing cadmium with iron, poor performance at low temperature and high self-discharge limited the success of the nickel-iron battery.
BENJAMIN FRANKLIN invented stove, bifocal eyeglasses and the lighting rod. He was unequaled in American history as an inventor until THOMAS ALVA EDISON emerged. EDISON was a good businessman who may have taken credit for inventions others had made. Country to popular belief, Edison did not invent the light bulb ; he improved upon a 50-year-old idea by using a small, carbonized filament lit up in a batter vacuum. Although a number of people had worked on this idea before, Edison gained the financial reward by making the concept commercially viable to the public

Table1: performance comparison between supercapacitor and li-ion battery

FUNCTION	SUPERCAPCITOR	LI-ION BATTERY
Charge time	1-10 sec	10-60 min
Cycle life	30,000	500 and higher
Cell voltage	2.2 to 2.75V	3.6 to 3.7V
Specific energy (wh/kg)	5	100-200
Specific power (wh/kg)	Up to 10,000	100 to 3000
Cost per w/hrs	$20(typical)	$ 0.50 - $1(typical)
Service life (in vehicle)	10-15 years	5 to 10 years
Charge temperature	-40 to 65^0 C	0 to 45^{0}C
Discharge temperature	-40 to 65^0 C	-20 to 60^{0}C

II. METHODOLOGY

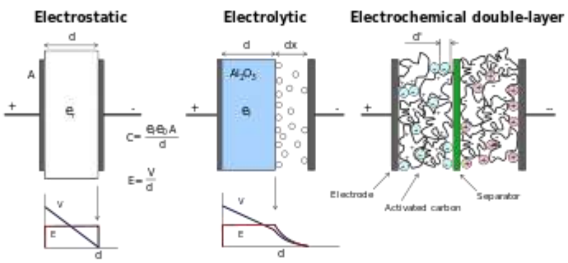

Fig1.supercapacitor diagram

The super capacitor differs from a regular capacitor in that it has a very high capacitance. A capacitor stores energy by mean of static charge as opposed to an electrochemical reaction. Applying a voltage differential ion the positive and negative plates charges the capacitor. This is similar to the buildup of electrical charge when walking on a carpet. Touching an object releases the energy through the finger.

The supercapacitor, rated in farads, which is again thousands of time higher than the electrolytic capacitor. The supercapacitor is ideal for energy storage that under goes frequent charge and discharge cycle at high current and short duration. Rather than operating as a standalone energy storage device, supercapacitors work well as low maintenance memory backup to bridge short power interruption. Supercapacitors have also made critical in roads into electric power trains. A charge cycle of supercapacitors is about 10 seconds; the self discharge of supercapacitor is substantially higher than that of an electrostatic capacitor and somewhat higher than the electrochemical battery. The organic electrolyte contributes to this the stored energy of a supercapacitor decreases to 50% in 30-40 days. A nickel based battery self discharges 10-15% per month but li-ion battery disgorges only 5% per month.

PRINCIPLE: in a conventional capacitor, energy stored is by moving charge carriers, typically electrons, from one metal plate to another. This charge separation creates potential between the two plates, which can be harnessed in a external circuit. The total energy stored in this fashion increases with both the amount of charge stored and the potential between the plates. The amount of charge stored per unit voltage is essentially a function a of the size, the distance and the material properties of the plates and the materials in between the plates, while the potential between the plates is limited by the breakdown field strength of the dielectric. The dielectric controls the capacitors voltage. Optimizing the material leads to higher energy density of a given size.

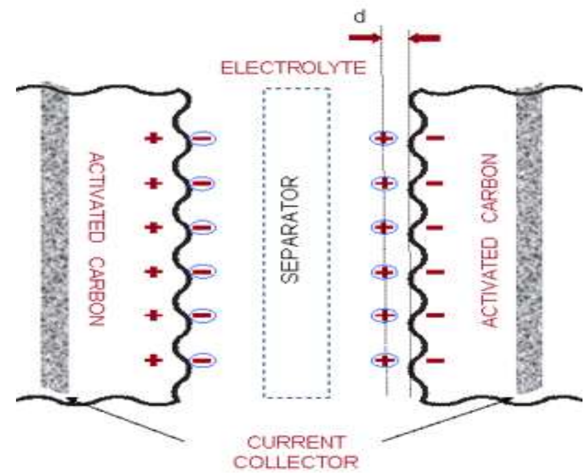

Fig2.schematic diagram of supercapacitor

Types of supercapacitors:

- Electrostatic double-layer capacitance
- Electrochemical pseudocapacitance
- Hybrid capacitors

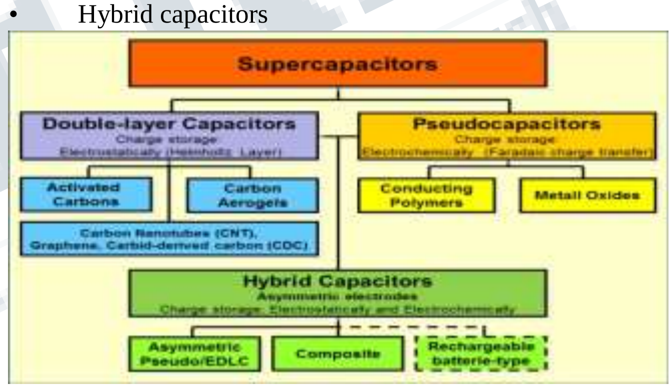

Fig3. Types of supercapacitors

Electrical energy is stored in super capacitors via two storage principles:

Double-layer capacitors (EDLCs) – with activated carbon electrodes or derivatives with much higher electrostatic double-layer capacitance than electrochemical pseudocapacitance

Pseudocapacitors – with transition metal oxide or polymer electrodes with a high electrochemical pseudocapacitance

Hybrid capacitors – with asymmetric electrodes, one of which exhibits mostly electrostatic and the other mostly electrochemical capacitance, such as lithium-ion capacitors

Construction details of wound and stacked supercapacitors with activated carbon electrodes

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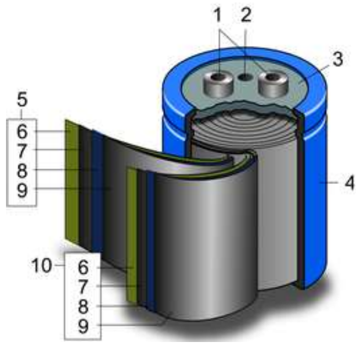

Fig4. Schematic construction of a wound supercapacitor

1. Terminals 2. Safety vent, 3. Sealing disc, 4. Aluminum cans 5. Positive pole, 6. Separator, 7. Carbon electrode, 8. Collector, 9. carbon electrode, 10. Negative pole.

III. RESULTS/FINDINGS

This paper has covered an overview of supercapacitors. The structure and characteristics of these power systems has been described, while research in the physical implementations and the quantitative modeling of supercapacitors has been surveyed. The advantages and limitations are discussed below.

ADAVANTAGES:

- virtually unlimited cycle life; can be cycled millions of time.
- High specific power; low resistances enables high load currents.
- Charges in seconds; no end-of-charge termination required.
- Simple charging; draws only what it needs; not subject to overcharge.
- Safe; forgiving if abused.
- Excellent low-temperature charge and discharge performance.

LIMITATIONS:

- low specific energy; holds a fractions of a regular battery.
- Linear discharge voltage prevents using the full energy spectrum.
- High self-discharge; higher than most batteries.
- Low cell voltage; requires serial connections with voltage balancing
- High cost per watt.

Supercapacitors find many applications in consumer, public and industrial sectors and they are also vital in medical aviation, military, transport,(hybrid electric vehicle, trains, buses, light rails, cranks, aerial lifts, forklifts, tractors and even motor-racing cars) services, energy recovery and renewable energy technologies. For past two years, the southeastern Pennsylvania transit authority has been capturing its braking energy and then selling it back into the power grid. SEPTA’s initial project has been successful enough that it is launching into a second phase, with future expansions, already being planned. Other electric modes of transportation, such as electric cars and trucks are also participating in frequency regulation markets in PJM and ERCOT and finally with help from supercapacitors, trains are providing new services to the grid.

IV. CONCLUSIONS/DISCUSSION

In every at least two smart phones that are do overused and require more, and still more charging. Supercapacitors really seem a truly convincing option. Because of their flexibility, supercapacitors can be adapted to serve in roles for which electrochemical batteries are not as well suited. Also, supercapacitors have some intrinsic characteristics that makes that make them ideally suited specialized roles and applications that complement the strengths of batteries. in particular, supercapacitors have great potential for applications that require a combination of high power, short charging time, high cycling stability, and long shelf life. Thus supercapacitors may emerge as the solution for many application specific power systems. So, it can be concluded that supercapacitors are indeed the very near future for all of us on earth.

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