International Journal of Recent Development in Engineering and Technology
Website: www.ijrdet.com (ISSN 2347 - 6435 (Online) Volume 13, Issue 4, April 2024)

Supercapacitors-Able to Replace Batteries

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ABSTRACT:
This research paper is based on one of the modern-day energy-storing devices i.e. Supercapacitors, it includes the structure, applications, and components connected to it, and how supercapacitors could aid in the advancement of technology in the future. We will be able to know about the current position of supercapacitors, all the basics, and the potential outcomes in the future.
Keywords- Supercapacitors, Hybrid vehicles, phones batteries, Stop and Start System, Supercapacitor vs. Batteries.

I. INTRODUCTION

Nowadays a large number of people use battery-powered devices. Everyone is familiar with gadgets like phones, cars, tablets, computers, smart watches, remotes, etc. These devices no doubt have made our life easier, but the very first requirement for all these devices to work is their batteries. Generally, the batteries that power these gadgets are lithium-ion batteries, these are from the family of rechargeable battery types in which lithium ions move from the negative electrode to the positive electrode during discharge and back when the device is on charging. But there are some limitations in these batteries, they have less charging, less life span, needs maintenance, are less eco-friendly, etc.

But supercapacitors are something that has many advantages as compared to typical batteries.

Supercapacitors are also known as ultracapacitors, these are high-capacity capacitors with a capacitance value much higher than the other capacitors. They can store 10 to 100 times more energy, can accept and deliver charge much faster than batteries, and are able to tolerate many more charge and discharge cycles than rechargeable batteries.[1][2]

II. LITERATURE REVIEW

In order to understand the upcoming future scopes of supercapacitors and opportunities that can be gained

from them, a search of the literature was conducted to fulfill useful information, pertaining to the paper. The internet was used for acquiring useful research papers, having a connection with the objectives of this paper. The internet (and Google Scholar) and some data from the college library were used as a resource for acquiring research papers having a connection with the objectives of this paper. Search keywords used for this purpose were Supercapacitors, are supercapacitors able to replace batteries, supercapacitors benefits, drawbacks, supercapacitors in upcoming future, supercapacitors in vehicles, phones, laptops, challenges in the advancement of supercapacitors.

At present Supercapacitors are not that advanced. Many researchers are working to make supercapacitors more advance and more comparable to batteries. There are a few companies that are manufacturing different supercapacitors with different qualities like:

TDK- Tokyo Denki Kagaku Kogyo K.K, is a Japanese electronics corporation that manufactures electronic components. TDK'S high capacitance and low-profile supercapacitors expand the possibilities of application development.

Eaton is an american irish multinational power manage agency. Eaton's XLR supercapacitors modules provide energy storage for high-power, frequent charge/discharge systems in hybrid or electronic vehicles, public transport, material handling, heavy equipment, and marine systems. The XLR modules reduce the size and weight or replace batteries along together depending upon the load profile, which results in fuel savings, noise reduction, and a more stable electrical system.

Maxwell Technologies is an American developer and manufacturer headquartered in California, it focuses on developing energy storage and power delivery products.This company is also making and developing supercapacitors.

Supercapacitors are still a new technology so there are only a few research papers available on the internet which are directly related to the objective of this paper. Therefore, to identify the future scopes and comparison between the batteries and supercapacitors papers were discovered by searching, using keywords and were then considered more in detail and the final selection was made for the purpose of literature review, based on the factors –

1) Identification of papers that were addressing the current situation of supercapacitors and technologies running with their help.
2) The papers which have content that compares batteries and supercapacitors.
3) The papers were relevant with reference to the primary objective of the paper and did not divert the focus on matters.
4) The papers include the process of working of supercapacitors and Batteries.

As people are shifting more and more to the technical side and working on making everything compact in size, easy to use, and time-saving. Phones, laptops, electric vehicles, digital cameras, videogames, remote controls, and many more things which run on the battery are at hype nowadays, but the major drawback for them is that they get discharged and take time to get charged again. Batteries had a shorter lifespan, limited cycling capability, and limited ability to power multiple accessories. supercapacitors are unlike batteries they have many advantages but for now, their limitations are not overcome. On seeing the development in the technological field, we can easily predict that in the upcoming future supercapacitors are definitely going to replace batteries, they had already replaced lead acid batteries because they are lighter, faster to charge, safer and non-toxic for the environment. In most electrical devices Lithium-ion batteries are used, these have few better qualities than supercapacitors, their size is small and weight is less, have higher energy density than other batteries.[1][4][3]

Structure and Working of Li-ion Batteries and Supercapacitor:

These capacitors also follow the same fundamental equation of capacitors:

$$C = \varepsilon \frac{A}{d}.$$

- C is the greatest capacitance.
- A is the electrode plate surface area.
- D is the distance between the plates.
- ε is the permittivity.

Both batteries and supercapacitors are storage methods. Li-ion batteries rely on chemical reactions, they have a positive (anode) and a negative (cathode) side the ones factors are submerged in a liquid electrolyte and separated through a micro-perforated separator, which simplest lets in ions to pass via. During charging, the ions are supposed to move back and forth between the anode and cathode. When this ion movement occurs, the battery gets heated up,

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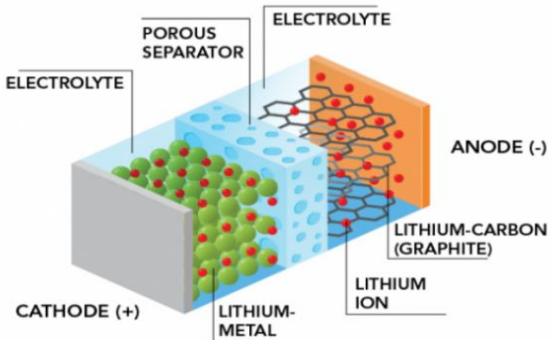
expands, and then contracts. These reactions gradually result in a reduced lifespan of batteries.
however supercapacitors do no longer rely upon chemical reactions, they store capacity strength electrostatically inside them. In supercapacitors, there is a membrane (dielectric or insulator) present between their plates which separates the collection of positive and negative charge on each side of the plates, because of this separation supercapacitors are able to store and release the energy quickly. It essentially captures static power for future use.

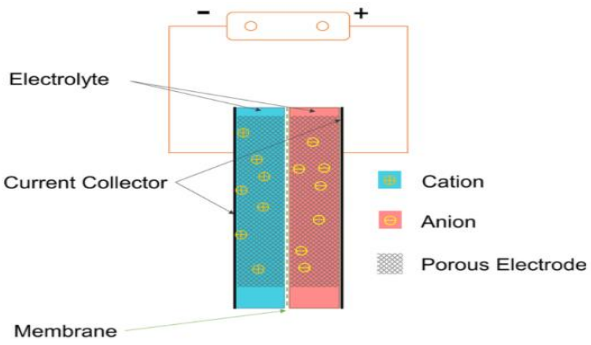
Comparison between Battery and Supercapacitor:

- comparison between Battery and Supercapacitor: The most great benefit of the SCs is that a 3V capacitor now will nevertheless be a 3V capacitor in 15-two decades, however in. batteries, the voltage capacity gets less over time.
- SCs have high power throughput, which implies they can charge and discharge in a fraction of the time, but they have less specific energy as compared to batteries.
- Batteries are more suited for higher energy density applications like a device that needs to run for a long period of time on a single charge. alternatively, supercapacitors have a far better electricity density than batteries. it makes SCs best for high-drain programs like powering an electric powered automobile.
- A battery can best take care of around 2000-3000 price and discharge cycles,whilst supercapacitors can normally preserve extra than one million. It helps in saving the material and costs.
- Supercapacitors with the same weight as any battery can hold more control, it's watts/KG (control thickness) is up to 10 times superior than the Li-ion batteries. Batteries have the ability to slowly discharge unlike SCs are unable to do so.

supercapacitors are advanced to all different capacitors because of their ability to save and launch power, however nonetheless, they're not able to update li-ion batteries. The main reason for not taking place of batteries is the energy density (Li-ion batteries– 250 watt-hour/kg,supercapacitors–20 watt-hour/kg).[5][6]



Li-ion Battery [6]



Supercapacitor or Ultracapacitor [6]

III. TYPES OF SUPERCAPACITORS

1. Electrostatic double-layer capacitors (EDLCs)
2. Pseudo-capacitors
3. Hybrid capacitors

In **EDLCs,** carbon electrodes or their derivatives are used with much higher electrostatic double-layer capacitance than electrochemical pseudo capacitance.
In **Pseudo capacitors,** metal oxides and conducting polymers are used with a high amount of electrochemical pseudo capacitance in addition to the double-layer capacitance.
In **Hybrid capacitors,** things like lithium-ion capacitors are used with different characteristics.

Supercapacitors are mostly used in transportation and energy solutions.

Tecate Group's (a global manufacturer and supplier of electronic components and assemblies) HC Series of supercapacitors are rated up to 150 F of capacitance, a voltage of 2.7, and a maximum peak current of 65 A.

Murata (manufacturer of ceramic passive electronic components, primarily capacitors) has developed a supercapacitor (EDLC) DMF Series, it exhibits the world's highest output power with a discharge of 50 W per piece.

One of the coolest applications of supercapacitors is ABB's rapid charging station, which allows electric buses to be fully charged in less than 10 minutes.[2][7]

IV. BENIFITS OF SUPERCAPACITOR

Benefits:

- They offer fast charging
- Longer life span
- No gas emissions and safe for the environment
- stops energy flow when fully charged
- Provides high Power density value

V. LIMITATION OF SUPERCAPACITOR

Limitations:

- They are more costly than batteries
- Power supplies for a short duration
- Dielectric absorption is high
- They have a high self-discharge rate

VI. FUTURE SCOPE

By reading the paper till now, we get the idea that what are supercapacitors, their structure, their types, which kinds of batteries can be replaced by them, and the limitations which are preventing them from being widely used right now.

- **Stop and Start System**
  In our vehicles, when we get stuck in traffic jams or we have to stop for a little amount of time then we let the vehicles ON, which results in a lot of waste of fuel and money. In the stop-start system as soon as we stop the vehicle it automatically stops the engine and as soon as we press the clutch paddle to engage the engine with the gearbox engine starts automatically. By using this stop-start system we will be able to save 5-8% of fuel. Supercapacitors will help in the immediate starting and stopping of the engine.

- **Hybrid Vehicles**
  We can also use supercapacitors and batteries together in heavy vehicles like trains. We can use Li-ion battery banks (these are costly but better than lead-acid batteries) which will help to run the vehicle smoothly when the speed is constant, but when the peak load is applied then these batteries will go under pressure. So, this pressure can be handled by supercapacitors.

- **Phone Batteries**
  Generally, in phones, **Li-ion batteries** are used, and they come in different sizes, shapes, and types. These batteries can store lots of charge and energy despite being small and light in size, but they take more time to get charged after getting discharged, and as the years pass the working of batteries gets slower. **Capacitors** have a longer lifespan and they have the ability to get quickly charged and discharged but, the drawback of capacitors is that, relative to their size, they store extremely little charge. This is the main cause of a smartphone's inability to be powered by capacitors, so, **supercapacitors** play a great role here because they occupy the position between batteries and capacitors due to their properties, they can store a reasonable amount of charge. Supercapacitors may have a hundred times more energy capacity than regular capacitors, it is far from that of a battery. It provides us many

advantages like they can charge quickly and won't degrade as quickly as batteries also they have a great tolerance for extremely high temperatures. For now, supercapacitors are not that advanced so they have not able to take the place of batteries in smartphones. But, In the near future with the advancement of technologies, this can be a reality and if it happens then everyone is using a smartphone that can charge within seconds and work flawlessly even after a decade of use. [3][6][2]

VII. CONCLUSION

Supercapacitors or ultracapacitors are a new type of green and efficient storage device, they are showing their best in some industries and in the near future they will get more popular in all industries, they may replace car batteries and phone batteries because in phones Lithium-ion batteries are used, which require huge supplies of cobalt. The mining of this rare metal is not a green symbol for the environment. We all know that as new energy devices become more and more popular, people are switching from conventional to electric equipment. So, it is an important goal to expand the application field of supercapacitors because they are going to reduce cost and improve energy density. Also, the basic details (definitions, types, structures, etc) about the Supercapacitors are presented in this paper.

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