SJIF Impact Factor 2021: 8.013| ISI I.F.Value:1.241| Journal DOI: 10.36713/epra2016 ISSN: 2455-7838(Online)
EPRA International Journal of Research and Development (IJRD)
Volume: 6 | Issue: 6 | June 2021 - Peer Reviewed Journal

SUPERCAPACITOR TECHNOLOGY

Vishal V. Mehtre[1], Kunwar Pratoon Singh[2]

[1]*Assistant Professor, Department of Electrical Engineering, Bharati Vidyapeeth (Deemed to be University) College of Engineering, Pune, Maharashtra, India*

[2]*Student, Department of Electrical Engineering, Bharati Vidyapeeth (Deemed to be University) College of Engineering, Pune, Maharashtra, India*

ABSTRACT

Battery technology is well-established and widely used technology, but they offer several disadvantages such as weight, volume, high internal resistance, power density, short-term negative feedback. A new technology is rising in this area i.e., the supercapacitor, it has a very effective capability to come up in major advances in energy storage. Supercapacitors are controlled by the same basic as conventional capacitors but use a greater number of electrodes and smaller dielectrics to obtain greater power. They offer short-term response, power, low weight, low volume, and low internal resistance that make them suitable for most applications. This paper summarizes the different types of supercapacitors, the relevant quantitative modeling areas, and the future of supercapacitor research and development.

KEYWORDS: *Supercapacitor, Batteries, capacitor, constant current, constant voltage, Equivalent Charge Resistance, Electrostatic Double Layer Capacitance.*

1. INTRODUCTION

In response to the current change in global landscape, energy has become a focus for the major world powers and scientific community. The world has a interest in developing and refining more efficient energy storage devices. One such device is the supercapacitor it has matured significantly over the last few years and emerged with the future in the energy storage area. Batteries are well established and widely used in toys to medical implants. There are few downsides with batteries i.e., lower lifecycle, less power density, higher charging time, heating problem and they are not environmentally safe. The supercapacitors are special type of capacitors with a huge capacitance, they have the properties of batteries and capacitors into a single device, as compared to other type of batteries and capacitors they charge frequently but discharges like a normal battery the most important thing is they are eco-friendly.

2. SUPERCAPACITOR WORKING AND CONSTRUCTION

Normally capacitor have two conducting electrodes separated by an insulating dielectric material. When a specific voltage is given to a capacitor, opposite charges are gathered on the surfaces of each electrode, these charges are kept separate by the dielectric material which,

SJIF Impact Factor 2021: 8.013| ISI I.F.Value:1.241| Journal DOI: 10.36713/epra2016 ISSN: 2455-7838(Online)
EPRA International Journal of Research and Development (IJRD)
Volume: 6 | Issue: 6 | June 2021 - Peer Reviewed Journal

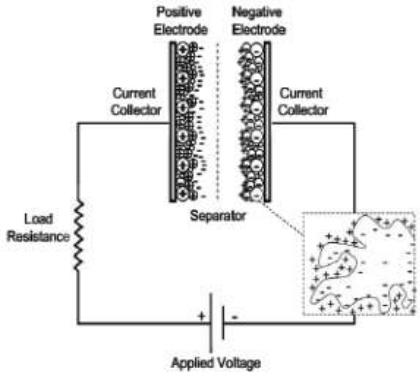
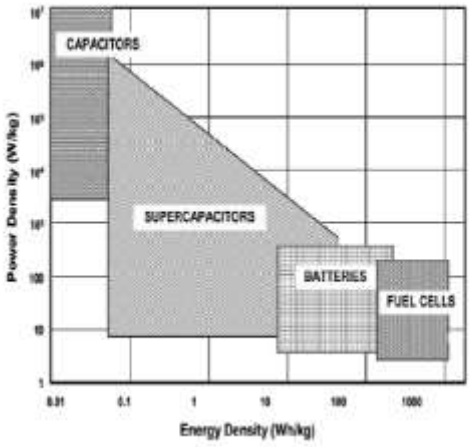


Figure 1. Schematic of a Capacitor

helps in producing electric field which allows the capacitor to store energy. On the other hand Supercapacitors are governed by the same basic principle as of a conventional capacitor, but supercapacitor based on carbon materials has a higher surface area, where phenomena known as electric double layer store charges . Super capacitors involving metal oxide or polymeric materials, pseudo-capacitance is the dominant charge storage mechanism. Though supercapacitors and electrolytic capacitors are governed by the same capacitance equations, supercapacitors can achieve higher capacitance because of thinner dielectric and higher surface area of electrodes due to this power density is greater than battery and energy density will be greater than capacitors, as shown in Graph 1 shows a ―Ragone plot, it shows the performance of various energy storage devices. supercapacitors occupy space between batteries and capacitors, this presents a unique advantage that makes them efficient and reliable for applications which require high power delivered in a short time. Supercapacitors uses a dielectric material to split up two carbon-based electrodes, which not only acts an insulator but also has electrical properties that affect the functioning of supercapacitors



Graph 1. Ragone plot for different energy storage device

In supercapacitors there is no transfer of charges, instead, charges are stored electrostatically. When a voltage is applied across the terminals, an electrical field is made within the electrolyte and since of this electrolyte is polarized. This causes ions to disperse through the dielectric to the porous electrodes of opposite charges. Thus, electric double layer is made at each electrode, as a result, distance between electrodes decreases and area of electrode increases. The energy storage capacity depends on the active material utilized in the electrolyte, the area of electrode and utilization rate of micro-holes within the porous electrode.

3. CLASSIFICATION OF SUPER CAPACITORS

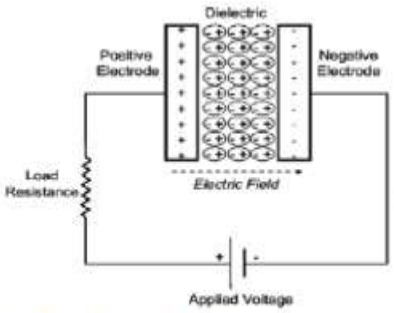
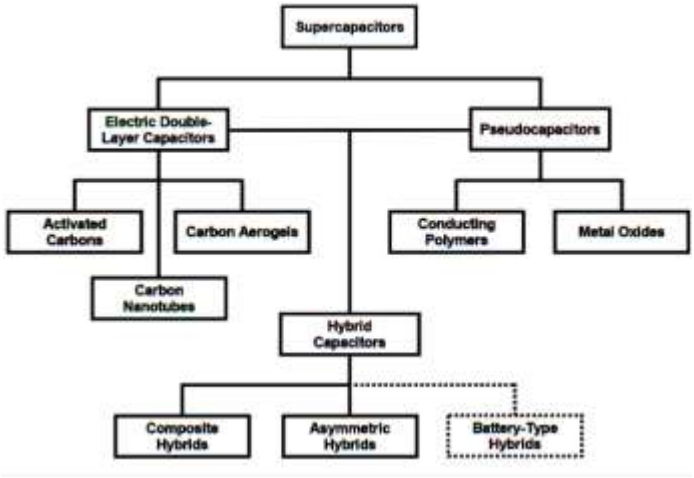


Figure 2. Schematic of a conventional electrochemical double-layer capacitor

SJIF Impact Factor 2021: 8.013| ISI I.F.Value:1.241| Journal DOI: 10.36713/epra2016 ISSN: 2455-7838(Online)
EPRA International Journal of Research and Development (IJRD)
Volume: 6 | Issue: 6 | June 2021 - Peer Reviewed Journal

Based upon research and development trends supercapacitors are mainly divided into three types:-

1.) Electrochemical double-layer capacitors (EDLC)
2.) Pseudo-capacitors
3.) Hybrid capacitors



Based upon storage technique they can be classified as:

1.) Faradaic Supercapacitors.
2.) Non-Faradaic Supercapacitors
3.) Faradic and Non-Faradic combination.

Figure 3. Block Diagram of types of Supercapacitors

4. SUPERCAPACITORS VS OTHER STORAGE DEVICES

With the upcoming advancement in technology the supercapacitor must prove its value in the market with the present competitor i.e., Battery or electrolytic capacitors. Supercapacitors has a higher energy density; higher power density and it has small in size and weight distribution is also good as compared to other devices. Supercapacitors have a long life and when compared to batteries it is around 500000 times. Supercapacitors can support various power level than batteries but has lower energy to weight ratio. In the upcoming time there is requirement of high-power rating, which has led to the manufacturing of batteries with high power and affecting the energy density and life cycle. Similar thing is happening with the capacitors, as they are suffering from low energy density and a huge self-discharge. Comparing with individual supercapacitors and battery, hybrid energy storage system will achieve better energy and power performance. There are various hybrid models which shows superiority over battery only systems. Battery-supercapacitor, fuel cell - hybrid models are some examples.

Storage Device Characteristics	Super Capacitor	Capacitor	Battery
Charging Time	1-30 s	$10^{-1} < t < 10$ S	$J < t < 5$ h
Discharging Time	1-30 s	$10^{-3} < t < 10^{6}$ s	$T > 0.3$ h
Energy Density (Wh/kg)	1-10	< 0.1	10-100
Lifetime (Cycle no.)	10^6	10^6	1000
Power Density (W/kg)	10,000	> 1,000,000	< 1000
Charge /Discharge Efficiency	0.85-0.98	> 0.95	0.7-0.85

Table 1. Comparisons of supercapacitors, capacitor, and battery performance.

5. ADVANTAGES AND FUTURE SCOPES

Batteries are dangerous when not properly treated, overheating of the batteries may lead to explode. Supercapacitors do not overheat because of their low internal resistance property. The time span of batteries is low, when compared to supercapacitors which have a long life, which make super capacitors useful where it is subjected to frequent charging and discharging cycles.

Some of the features of supercapacitors are:

i) Low ESR.
ii)Low leakage current.
iii)Higher life cycle.
iv)A wide range of operating temperature. v)Higher useable capacity.

In the upcoming time we can use supercapacitors in these fields: -

1. In Transmission Lines.
2. Computer Application like Supercapacitor UPS, Hybrid Ups SC and battery can complement each other in their shortcoming which would reduce battery cycling, in turn, increasing battery life.

SJIF Impact Factor 2021: 8.013| ISI I.F.Value:1.241| Journal DOI: 10.36713/epra2016 ISSN: 2455-7838(Online)
EPRA International Journal of Research and Development (IJRD)
Volume: 6 | Issue: 6 | June 2021 - Peer Reviewed Journal

3. To get more stability and frequency in system.
4. They can be used as an energy storage device in a micro source system connected to microgrid.
5. Wind Turbine System.
6. Hybrid electric vehicle use battery alone system to drive the vehicle through motor and inverter. If along with battery which is rich in energy density, supercapacitor which is rich in power density is used together, the transient requirement i.e., a pulse of current during acceleration is supplied by SC and during deceleration or breaking the energy will be returned back to the SC. An appreciable amount of energy used during acceleration will be regained.

6. CONCLUSION

In this paper, some of the characteristics of the supercapacitors have been discussed which will be helpful to select supercapacitor and design energy storage system using it. With high power density, short charging time, large discharging time, long life and environmentally friendly properties supercapacitor may be chosen as an alternative for battery or other energy storage devices in the upcoming times.

7. REFERENCES

1. *Chukwuka C, Folly K. A, "Batteries and Super-capacitors", IEEE PES PowerAfrica, pp. 1-6,2012*
2. *A. Armutlulu, J. K. Kim, M. Kim, S. A. Bidstrup Allen, M. G. Allen, " Nickel-oxide- based supercapacitors with high aspect ratio concentric cylindrical electrodes", Transducers &Eurosensors , pp. 1480 - 1483, 2013.*
3. *IonutCioc an, CristianFarca, AlinGrama, Adrian Tulbure, " An Improved Method for the Electrical Parameters Identification of a Simplified PspiceSupercapacitor Model", IEEE SIITME, pp. 171 - 174, 2016*
4. *S. D. G. Jayasinghe, D. M. Vilathgamuwa, U. K. Madawala, " A New Method of Interfacing Battery/ Supercapacitor Energy Storage Systems for Distributed Energy Sources", Conference Proceedings IPEC, pp. 1211 - 1216, 2010.*
5. *A. K. Saonerkar, A Thakre, A. Podey, A. Chimote, P. Kadao , P. Kadu , R. Satpute, " S ingle Phase Residential Multilevel Inverter Using Supercapacitor", International Conference on Inventive Computation Technologies, Vol. 3, pp. l - 4, 2016.*
6. *Andrew F. Burke, "Batteries and Ultracapacitors for Electric, Hybrid, and Fuel Cell Vehicles", Proceedings of the IEEE, Vol. 95, pp. 806 - 820, 2007*
7. *Jayathu Fernando, Nihal Kularatna, Howell Round, SadhanaTalele , "Implementation of the supercapacitor-assisted surge absorber (SCASA) technique in a practical surge protector", Annual Conference of the IEEE Industrial Electronics Society, pp. 5191 - 5195, 2014.*
8. *Lakshmikant M. Bopche, Ank.-ush A. Deosant, Muneeb Ahmad, " Combination of Parallel Connected Supercapacitor& Battery for Enhancing Battery Life", International Conference on Automatic Control and Dynamic Optimization Techniques , pp. 77 - 82, 2016.*
9. *C. M. Krislma, "Managing Battery and Supercapacitor Resources For Real-Time Sporadic Workloads", IEEE Embedded Systems Letters, Vol. 3, pp. 32 - 36 2011.*
10. *Hamid Gua lous , HichamChaoui , Roland Gallay, "Supercapacitor Calendar Aging for Teleco1mnunication Applications ", IEEE INTELEC , pp. 1 - 5, 2016.*

8. BIOGRAPHIES

Mr. Vishal Mehtre *has completed his Master in Electrical Engineering (Power Systems) from Bharati Vidyapeeth (Deemed to be University) College of Engineering, Pune. He is currently working as Assistant Professor in department of Electrical Engineering. He has an industrial experience of about 2 years in Suzlon Power Infrastructure Pvt. Ltd. as Engineer in Power Evacuation department and has an teaching experience of more than 5 years. His area of interest is Renewable sources of energy specially Wind and solar with its analysis, optimization and power quality.*

Mr. Kunwar Pratoon Singh *currently Pursuing Bachelor of Technology Degree in Electrical Engineering from Bharati vidyapeeth (Deemed to be University) College of Engineering, Pune***.**