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A Study of Super Capacitor Based Mobile Charging Units in Isolated Power Systems and Automobile Applications

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***Abstract*—** Super capacitors or super capacitors are special type of capacitors which have a high charge storage capacity than ordinary capacitors. It is a double layer capacitor (EDLC) used for high values of energy storage. Mobile charging units consists of generator, excitation system, transformer, storage batteries to provide energy to stand-alone /isolated power systems for medical and automobile applications. Super capacitor could store a large amount of charge for a long period of time. So it can be used for standalone isolated power systems. Solar power can be also incorporated with this unit for better performance. This will make the energy storage system more efficient, reliable and also the power factor can be improved. This method can also be used for reactive power compensation in FACTs controllers.

***Keywords*—** Super Capacitor, isolated/stand-alone power systems, FACTs, energy storage, mobile charging units

I. Introduction

Super capacitor is a high efficient energy storage capacitor which can store large amount of charge within short periods of time. Super capacitor or super capacitor can be used to store energy in standalone power systems. This paper introduces a simplified model of Super capacitor using constant current charging method. The detailed test procedure for 100 farad super capacitor and ordinary capacitor is analyzed.

II. Basic Design

Electrochemical capacitors (super capacitors) are a two electrode capacitor separated by an ion permeable membrane (separator) and an electrolyte electrically connecting both electrodes. When the electrodes are polarized with an applied voltage, ions in the electrolyte form electric double layers of opposite polarity to the electrode's polarity which means positively polarized electrodes will have a layer of negative ions form at the electrode/electrolyte interface along with a charge balancing layer of positive ions adsorbing onto the negative layer. The opposite is true for the negatively polarized electrode.

If capacitance values are equal then $C_{total}=0.5C_1$.The capacitances may be symmetric or asymmetric according to the length of parallel plate. If the electrolyte solvent is water then the influence of the high field strength creates permittivity ε of 6 (instead of 80 without an applied electric field) as activated carbon electrodes have a large surface area in the range of 10 to 40 μF/cm^2 and the extremely thin double layer distance is on the order of a few angstroms (0.3-0.8nm), the double layer capacitors have higher capacitance values than conventional capacitors.

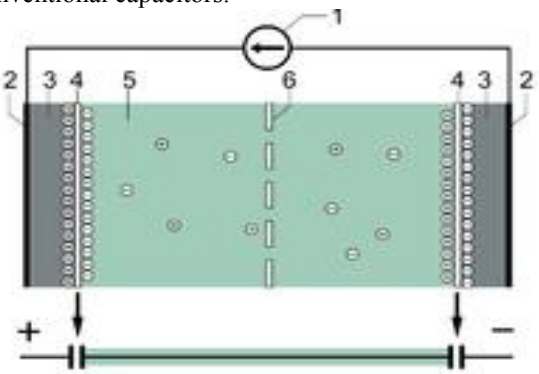

Fig 1. Typical Construction of super capacitor

As there are two layers the effective capacitance is

$$C_{total} = \frac{C_1 \cdot C_2}{C_1 + C_2} \quad (1)$$

III. Stand Alone Power Systems

Stand alone power systems are used in hospitals, flood affected areas and also in rural areas in which grid connectivity is very difficult. Stand alone power systems consist of a generator, dc excitation system, capacitor bank, storage batteries and transformer.(shown in Fig 2.(a) & (b).

The generator will generate electricity which is rectified and stored using storage batteries. DC link capacitor for stabilizing the voltage is a super capacitor. A super capacitor has several times capacity of an ordinary capacitor and can store more energy. This specialty of super capacitor is utilized in mobile charging units/stand alone power systems

A. Block Diagram

Generator may be of diesel generator (dc excitation) or solar cell or wind turbine generator. It will produce the power needed for the system.

B. Dual converter/ (Rectifier /Inverter)

It will convert AC-DC for storage and then DC-AC after the conversion. The capacitor used as dc link is a super capacitor which is described above.

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C. Storage battery

Storage battery may be fuel cell or Li-ion cells or Lead acid accumulator according to the need of the system.

D. Design of Stand Alone /Mobile charging unit.

The load to be fed determines the rating of generator, super capacitor and converter. Suppose the load is 10 KW at 0.9 pf, then the rating of generator is 1.5 k VA. The capacitor will be of 1.5 kV and power converter must be the same voltage and power. This can be also be designed by using a solar cell or wind turbine. This system will give uninterrupted power supply.

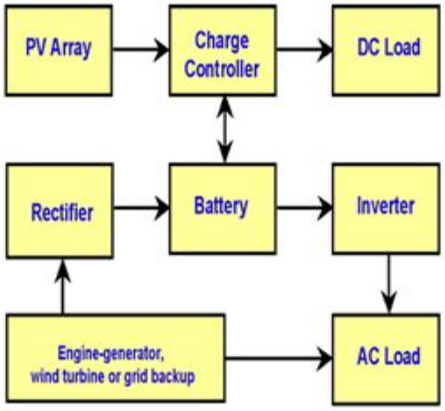

Fig .2(a). Stand alone power system block diagram

IV. EQUIVALENT CIRCUIT OF SUPER CAPACITOR

Fig 3.shows equivalent circuit of super capacitor which consists of R& C combination with a controlled current source. The charge can be controlled by varying the distance between parallel plates. Super capacitor stores more charges than ordinary capacitor or storage battery

A. Simulation of super capacitor based storage system

Fig 3. shows the application of super capacitor based energy storage in automobile traction. The energy can be stored to charge the automobile braking/starting system and also in electric or hybrid vehicle.

Fig 5.Shows the Simulation diagram of super capacitor based stand-alone power system. Simulation diagram consists of a generator connected to a resistive load through a dual converter.The converter is swiched by PWM modulation method.The super capacitor will enhance the capacity to stabilise the voltage.

B. Simulation parameters

Operating Voltage=1.5 K V
Current= 50 A
Power Rating= 75 K VA
Capacitor Rating=1.5 K V;5000μF
Load= 1.1 K W
Converter= Dual Converter
Modulation= Pulse Width Modulation

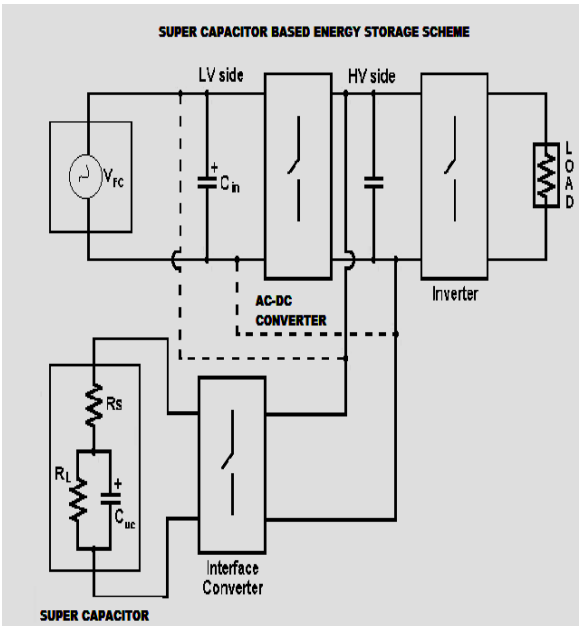

Fig 2.(b).Stand alone power system block diagram

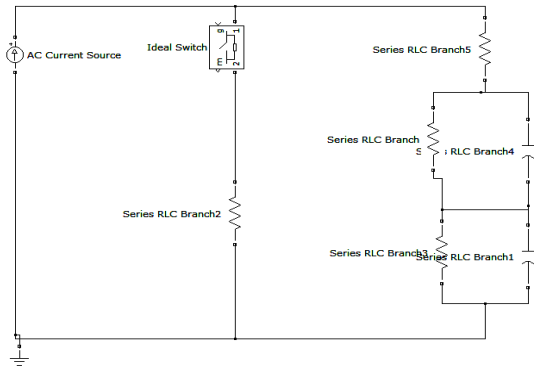

Fig .3.Equivalent circuit of super capacitor

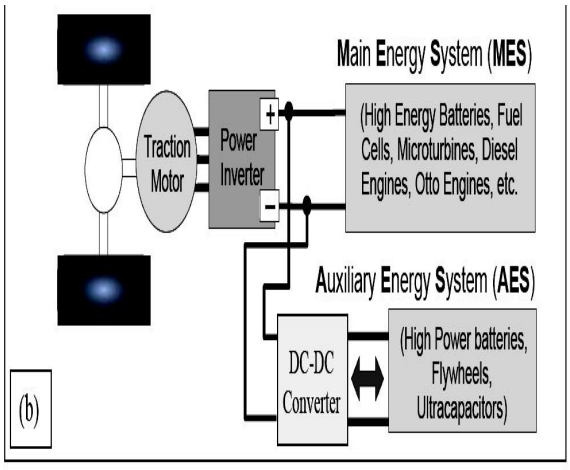

Fig. 4. Block diagram of super capacitor based automobile control system

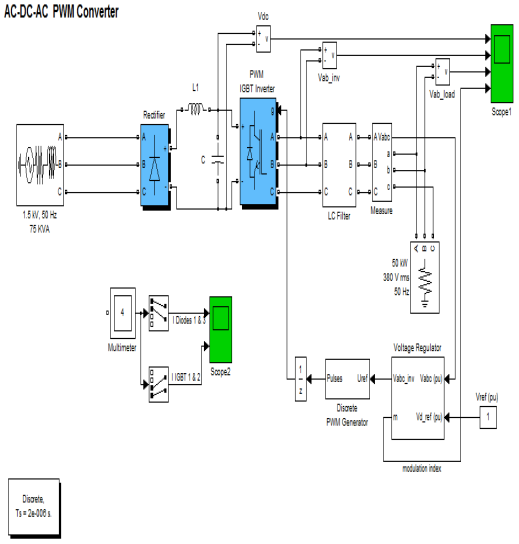

Fig. 5. Simulation diagram of super capacitor based stand-alone power system

V. RESULTS

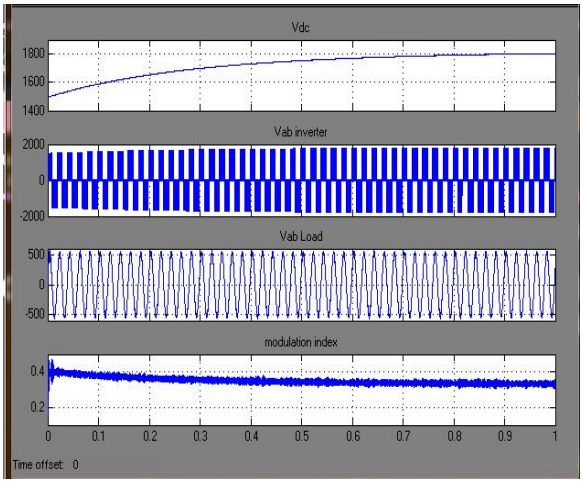

Fig. 6. Simulation results of super capacitor based stand-alone power system

The above Fig. shows the simulation results of a super capacitor based power stabilisation scheme. It is shown in the results that the output power is stablised by a capacitor.The stand alone power system will deliver constant power ,constant voltage,accordng to the need of the load consumed.

VI. ADVANTAGES

- Extends battery run time
- Provides backup power
- Enables design to meet current specifications
- Cuts pulse current noise
- Lessens RF noise by eliminating DC/DC
- Allows low/high temperature operation
- Minimizes space requirements
- Reduces battery size
- Enhances load balancing when used in parallel with a battery
- Meets environmental standards

A. Engineering Characteristics Super Capacitor

Charge/Discharge Time	Milliseconds to seconds
Operating Temperature	C -40 ° to +75 °
Operating Voltage Aqueous	1.1 V; Organic 2.5 V
Capacitance	100 mF to > 1000 F
Life	3,000 to 50,000 hrs
Power Density	0.01 to 10 3 kW/kg
Energy Density	0.05 to 10 Wh/kg
Pulse Load	0.1 to 100 A
Pollution Potential	Aqueous electrolyte is highly corrosive

VII. APPLICATIONS

Super capacitors find a wide range of applications such as electric vehicles,hybrid vehicles,stand alone power suppy stem,uninterrupted power systems,medical application including make shift hospitals.

VIII. CONCLUSION

The super capacitor based standalone power systems/mobile charging units are helpful for better storage capacity,uninterrupted power supply,high efficiency,high power factor and less reactive power loss.

IX. FUTURE WORK

The study of super capacitor based power systems, power factor improvement,FACTs controllers, and their real time hardware control module and its installation in residential and industries etc must be done with thorough research ,analysis and simulation.

REFERENCES

[1] A.S. Samosir and A. H. M. Yatim "Dynamic Evolution Control of Bidirectional DC-DC Converter for Interfacing Ultra capacitor Energy Storage to Fuel Cell Electric Vehicle System"2008 Australasian Universities Power Engineering Conference (AUPEC'08). Paper P-113. page 1

[2] Benyahia N.a,*, Denoun H.a, Zaouia M.a, Tamalouzt S.b, Bouheraoua M.a,Benamrouche N.a, Rekioua T.b, Haddad S.a "Characterization and Control of Supercapacitors Bank for Stand-Alone Photovoltaic Energy" Energy Procedia. Sciverse Science Direct 00 (2013)00-00.

[3] Andrew C. Baisden, Student Member, IEEE, and Ali Emadi, Senior Member, IEEE "ADVISOR-Based Model of a Battery and an Ultra-Capacitor Energy Source for Hybrid Electric Vehicles" IEEE Transactions on Vehicular Technology, vol. 53, no. 1, January 2004

[4] M.G. Molina ,P.E. Mercado, " Modeling Of a D-STATCOM With Ultra-Capacitor Energy Storage For Power Distribution System Applications" XIII Eriacdécimo Tercer Encuentro Regional Ibero Americano De Cigré 24 al 28 de mayo de 2009