BATTERY AND SUPER CAPACITOR BASED HYBRID ENERGY STORAGE SYSTEM

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Abstract: The aim of this paper includes that battery and super capacitor devices as key storage technology for their excellent properties in terms of power density, energy density, charging and discharging cycles, life span and a wide operative temperature rang etc. Proposed Hybrid Energy Storage System (HESS) by battery and super capacitor has the advantages compare to conventional battery energy storage system (BESS). HESS stores the excess of energy and reuses it when really needed. This paper describes the hybrid energy storage system that is suitable for use in renewable sources like solar, wind and can be used for remote or backup energy storage systems in absence of a working power grid. In order to get the highest efficiency from this system, super capacitors will be used in parallel with the battery and a pulsed load. Along with the above information this paper also presents Modeling of Battery and Super Capacitor based Hybrid Energy Storage System using MATLAB/Simulink software.

Index Terms **- Hybrid Energy Storage System (HESS), Battery Energy Storage System (BESS), Energy Storage System (ESS), Photovoltaic (PV), Super Capacitor (SC), Super Capacitor Energy Storage System (SCESS) System, Battery-Super capacitor based hybrid energy storage system (BSHESS).**

I. INTRODUCTION

Conversion of the excess electricity into the different form of energy which can be reconverted into electrical energy known as energy storage system (ESS). Energy storage system (ESS) stored in the form of mechanical energy, electrostatic, electrochemical energy, thermal energy etc. and we can use the stored energy whenever the need arises, it can be applied to both conventional source of electricity and renewable energy sources, but among them we focus on battery and super capacitor energy storage systems. When demand is high compare to supply then un-uniformity between demand and supply, due to this power system is unbalanced and many problems introduced in power grid like decrease power quality, decrease efficiency, decrease reliability and stability of system and introduces many losses which is reduced by ESS system.

1.1 Advantages of energy storage system (ESS)

A. Increase dispatch ability
B. Makes power available on demand
C. Reduce gap between supply and demand
D. Compensated for intermittency of renewable energy such as solar and wind
E. Electricity stored during the off peak time can be used during on peak hours. Energy storage system (ESS) integrated with photovoltaic can maximize consumption of the solar energy by using electricity stored peak.

Energy storage system (ESS) offers various benefits of improved efficiency, reliability, availability and cost effectiveness for wide range of application including power grid, renewable power sources, Electric vehicle/Hybrid electric vehicle and so on, energy storage keeping smart grids in balance .The Field of electrical energy is deeply affected by the push for cleaner energy and transportation for the energy storage to become a complete solution these flows have to be addressed. The advent of new, high energy storage capacitors (i.e. super capacitors) with higher power density, lighter rechargeable batteries, with greater energy density has allowed new development in the clean energy sector.

II. RESEARCH METHODOLOGY

2.1 BATTERY ENERGY STRORAGE SYSTEM (BESS)

Renewable energy sources such as wind energy, photovoltaic (PV) energy, are widely used as standalone power system supplying different electrical loads in rural and remote areas. These sources of intermittent nature and, therefore the stand alone power systems should include storage battery bank the storage battery banks improves the reliability of the systems because the excess energy stored in the battery bank, this energy is delivered to the load bank when the solar or wind energy is not available or not sufficient. Mostly lithium ion and lead acid batteries are used as a storage battery bank. Battery energy storage system (BESS) requires regular battery replacement after hundreds of charging discharging cycles or cycle efficiency is poor.

2.1.1. Lead Acid Battery

Lead-Acid has its strengths in the energy storage system (ESS) industry of its high energy density, efficiency, good battery life, low cost and eco- friendly. Lead Acid batteries have a relatively low cost per energy and so they are suitable for large scale energy storages. Lead acid batteries can be used in case of pulsating power load and constant power load.

2.1.2. Lithium Ion Battery

Lithium ion batteries have greater energy density, high life span ,high efficiency, weight loss, eco-friendly compare to lead acid batteries and but it is of higher cost. Lithium ion batteries are widely used for mobiles and automobiles applications etc.

2.2 HYBRID ENERGY STORAGE SYSTEM (HESS)

Combination of the two or more energy storage system is known as hybrid energy storage system. In this paper we used battery energy storage system (BESS) and super capacitor energy storage system (SCESS). Combination of the battery energy storage system (BESS) and super capacitor energy storage system (SCESS) provide the photovoltaic system with advantages such as ability of providing energy during night time and sunless periods, ability to meet momentary peak power demands and stabilizing the system voltage and improve the capabilities of the system etc. means battery-super capacitor based hybrid energy storage system (BSHESS) increase the efficiency of the system. Battery-Super Capacitor based hybrid energy storage system (HESS) are cost prohibitive for a large scale deployment makes peak load demand and load demand uniform. When a super capacitor is introduced change in system efficiency and create a valid model for simulation, we can say hybrid storage system can achieve higher specific power then battery storage system (BSS). Super capacitor has a greater power density which allows the super capacitor to provide more power for a short period of time or super capacitor can supply peak power for a short duration, means we can say charging capacity of hybrid storage system increase. The main role of super capacitor (SC) in hybrid energy storage system (HESS) to increase the Buffer level. Peak power requirement of load are supplied by the super capacitor and battery supplies the lower continuous power requirement, resulting in a reduction in the battery pack size for large storage .Battery has a much higher density due to this battery store more energy and release it over a long period of time means we can say battery increase the storage capacity of system and decrease the discharging capacity of hybrid system.

2.3 Advantages of battery-super capacitor based hybrid energy storage system (BSHESS)

A. Thrust for renewable energy sources
B .Long cycle life
C. Energy Buffering
D. Increase Reliability
E. High Cycle efficiency
F. Low self-discharge rate
G. High energy and power density
H. Improve the uniformity and efficiency
I. Improve the electricity system performance
J. Low cost and light weight for large scale deployment

2.4 MODELLING OF BATTERY/SUPER CAPACITOR HYBRID ENERGY STORAGE SYSTEM (HESS)

A useful and systematic model of a hybrid system by battery and super capacitor is designed on MATLAB/Simulink software. The model takes following to account battery model, super capacitor model, DC Voltage source (PV cell model), converter circuits, load and internal losses. All model of the battery/super capacitor hybrid system has been validated by simulation on the software MATLAB/Simulink detailed evaluation results have shown that our battery and super capacitor system model can accurately estimate real-world hybrid system energy usage.

2.4.1 Modeling of battery energy storage system (BESS)

Battery performance depends on the PV system design and operation and the type of battery technology employed. Lead- acid battery is the technology of choice for most PV application. A Fundamental based battery model has been developed and integrated into the PV module.

Modeling of the BESS using MATLAB/Simulink as shown in figure 1.

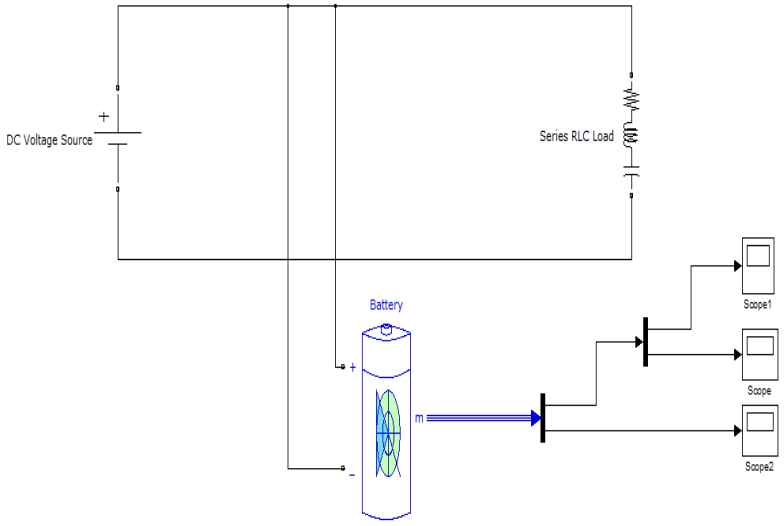

Figure 1: Modeling of Battery

Battery (Lead acid/Lithium ion) is in parallel with DC voltage source and load (R/RL/RLC) , we can choose different values of DC voltage source, load, battery after simulation analyze the outputs {voltage from input source, discharge current and state of charge (SOC)}of the designed model in MATLAB/Simulink software.

2.4.2 Modeling of Battery-Super Capacitor HESS

Modeling of Battery-Super Capacitor based hybrid energy storage system using MATLAB as shown in figure 2.

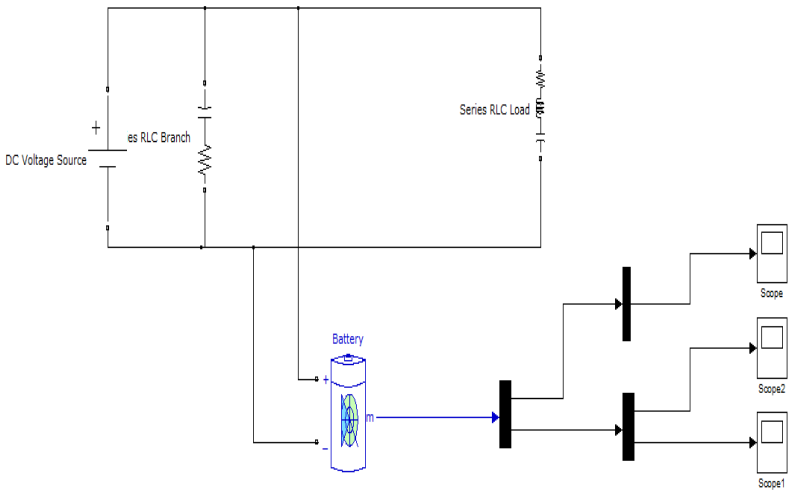

Figure 2: Modeling of Battery-Super capacitor

In the above figure high capacity capacitor is connected in parallel with DC voltage source, load and battery. According to the requirement we can choose the different values of DC voltage source, load, battery after simulation analyze the outputs {voltage from source connected, discharge current and state of charge (SOC)} of the designed model in MATLAB/Simulink software.

2.4.3Modeling of BSHESS with Converters

Converter is used in HESS for voltage regulation and work as an energy transduction. Designed model of the BSHESS with converter in MATLAB 2010 as shown in figure 3

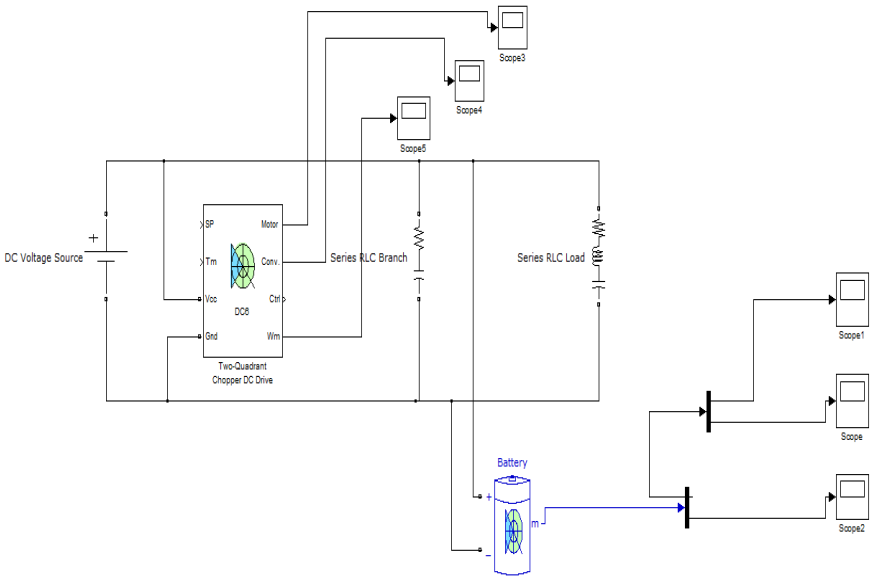

Figure 3: Modeling of Battery-Super Capacitor with Converter

Battery and Super Capacitor are connected in parallel with DC voltage source and load connected and converters are also used in this system, according to the requirement we can choose the different values of DC voltage source, load, battery after simulation analyze the outputs {voltage from source connected, discharge current and state of charge (SOC)} of the designed model in MATLAB.

2.5RATING OF BATTERY AND SUPER CAPACITOR

We can calculate Rating of Battery and Super Capacitor for given PV system according to the requirement of consumer load and demand hours. The shown below calculation gives an idea for calculating Rating of Battery and Super Capacitor for given PV system.

2.6 CALCULATION FOR 80 Watt SOLAR PV SYSTEM FOR 10hr LOAD

Total load consumption = Volt*Ampere*Hours
= V*I*h
= 80*10
=800W or0.8KWh

Battery Rating
Let the Battery Rating = 12V/75Ah
= 12V*75Ah
= 900VAh or 0.9KWh (approx.)

Super Capacitor Rating
We know that Q = C*V
We know that Q = Ampere* Time
C = Q/V
C = 75/12
C = 6.25 Farad

Therefore super capacitor rating is 6F/12V (approx.)

Solar panel calculation
Total voltage of solar panel = 17.0 volts
Amperage of it = 4.7 to 5 Amp.
Power of panel = V*I= 17x 4.7 = 79.9 Watt
= 80 Watt (approx.)

2.7 Application of HESS

A. Load labeling
B. Peak Saving
C. Voltage Regulation
D. Capacitive Firming

E. Frequency Regulation
F. Power Quality
G. Spinning Reserve

III. FUTURE SCOPE

Hybrid energy storage system by battery and super capacitor will replace the conventional battery energy storage system (BESS). Many areas like rooftop solar power plant, street solar lights, electrical vehicles, inverters in houses, govt. projects, renewable energy storage, solar companies etc. this hybrid energy storage system could be implemented in small as well as large scale deployment. Government Initiatives in India in which proposed HESS by Battery-Super Capacitor is required to be implemented:-
1) Ministry of Power has approved National Smart Grid Mission (NSGM) which has set aggressive targets for Micro grids which will require energy storage technologies.
2) The Govt. of India has launched Nation Electric Mobility Mission (NEMM) in April 2015 with a target of 6-7 million Electric Vehicles by 2022.
3) Net Metering Policy which gives consumer a provision to install Rooftop PV at their premises. Most systems will involve inverters with batteries.
4) Renewable Energy Targets has set by GoI. Integration of renewable energy will require energy storage technologies to achieve these Renewable Energy Targets.

IV. COCLUSION

To provide a BSHESS. Modeling of BESS and modeling of HESS by Battery-Super Capacitors and with Convertors is carried out by the MATLAB/Simulink. In order to get highest efficiency from this hybrid system, super capacitor will be used in parallel with the battery and a pulse load. Model of this hybrid system is designed on MATLAB/Simulink. This proposed system reduces the disadvantages of BESS by using super capacitor in parallel with battery and load. Rating of battery and super capacitor can be calculated and used for remote or backup energy storage system if the power output and demand hours are given for any PV system or any power grid.

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