International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 4 Issue 07, July-2015

Performance Enhancement of Voltage Compensators with Battery - Supercapacitor Combination

Remya A
M.Tech student
Dept. of EEE ASIET
Kalady

Chithra R
Assistant professor
Dept. of EEE ASIET
Kalady

***Abstract*— High reliability power supply is required in many industrial sectors especially for critical loads. There are several instants may happen which create voltage sags or complete interruption of power supply such as fault, load variations etc. During such instants the energy has to be supplied by local energy storage systems. Conventional energy storage systems for power supply are basically relying on the choice of good batteries. Batteries have a low-power density and limited charge/discharge cycles. During the load changes in the bus system the bus voltage fluctuations are balanced by supercapacitor and battery support. The power sharing between low equivalent series resistance (ESR) supercapacitors, and batteries is a promising solution for improving system performance, a method of storage in super capacitor reduce the battery stress .Using MATLAB the variation in bus voltage with and without using supercapacitor with a battery is analyzed.**

Keywords*— Energy storage systems, Hybrid power sources, Battery, Supercapacitor

I. INTRODUCTION

Due to deregulation, the electric power systems are facing dramatic changes in operational requirements with the integration of renewable energy and largely interconnected network leads to power system operation more complex and less secure. The introduction of the electronic loads has made the quality of power supply a critical issue. At the same time, inability of power generation and transmission to meet the new demand as a result of economic, environmental, technical and governmental regulation poses a serious issue.

Energy storage system appears to be an installation or method usually subjects to independent control, which is capable of storing and using energy in the power system when required. Energy storage allows the increased asset utilizations, facilitates the penetration of renewable, and improves the flexibility, reliability and efficiency due to instantaneous balancing between demand and supply [1]. With the proper controller, the natural intermittent characteristics of renewable resources can be smoothed out through energy storage devices. Because of the state of technological development and high price of energy storage devices, it hasn't expanded significantly.

Conventional energy storage systems (ESS) for power supply are basically relying on the choice of good batteries. An electric battery is a device consisting of one or more electrochemical cells that convert stored chemical energy into electrical energy. The battery saves money in peak energy costs, automatic switch over in blackouts for protected loads, putting in control of energy production and consumption. Batteries are mostly efficient when used to supply low, reasonably steady power levels .However there are some disadvantages for a battery used for storage. Batteries can be used for only a limited time. If the battery is a rechargeable then it can only be recharged at a certain number of times. Batteries have a limited life and have a low-power density. A cells effective series resistance indicates its ability to deliver current and voltage regulation. ESR characteristic of all cells depends on the cell type, size and state of charge. A high ESR reading may reveal damaged cells or a bad internal connection. The voltage across the terminals of a disposable battery driving a load decreases until it drops too low to be useful. This is largely due to an increase in internal resistance rather than a drop in the voltage of the equivalent source. The extracting pulsed power instead of average power from the battery makes a reduction in its life span[2].Pulsating current can cause reduction in battery runtime[3].When a severe load fluctuation occur, batteries cannot respond immediately and this cause battery under stress. So the batteries cannot respond immediately and it will be under high stress. This will again reflected as increase in charging and discharging cycles which finally leads to reduction in battery life span [4]

Supercapacitors also known as electrochemical double-layer capacitors (EDLC), electro-chemical capacitors or ultra-capacitors, store energy in the form of electrostatic charge and can offer considerably increased cycle-life (106 cycles) compared to lead-acid batteries.
Supercapacitors have high power density and can supply much higher currents than batteries. Supercapacitor have a lower energy density. Supercapacitor shares the characteristics of both batteries and conventional capacitors and has an energy density about 20 percent of a battery. Moreover, they have almost negligible losses and more lifespan than batteries. It is to investigate the use of super capacitor technology to reduce the stress in battery energy storage systems. Super capacitor ensures better performance of the system, a method of storage in super capacitor reduce the battery. This paper shows the bus voltage based sharing of battery and supercapacitor.

II. PRESENTATION OF STUDIED BATTERY-SUPERCAPACITOR HYBRID SYSTEM CONNECTED TO LOAD

A. Modeling of battery

The energy stored in the batteries is in the form of electrochemical. They are the one of the most cost-effective energy storage technologies available. When a potential applied to the terminals they undergo an internal chemical reaction and they are "charged". They "discharge" or deliver the absorbed energy when they reverse the chemical reaction.. Most of the energy storage system uses Lead acid batteries .Here it is modeled by using a simple controlled voltage source in series with a constant resistance. The nonlinear battery model is shown in figure 1.

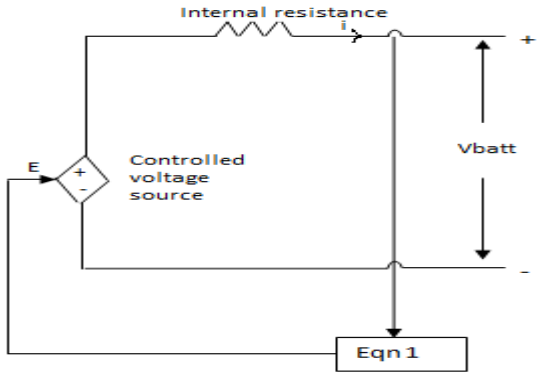

Fig 1: A nonlinear model of a battery

Here the battery is modeled as a non linear voltage source using the following equation in [5].

$$E = E_0 - K\frac{Q}{Q - \int i\,dt} + Ae^{-B\int i\,dt} \quad (1)$$

$$V_{batt} = E - Ri \quad (2)$$

Where i and V_{batt} are the terminal current and voltage of battery and other parameter can be get through the specification in [5].

B. Modeling of supercapacitor

When compared to electrolytic capacitor the SC has high capacitance. The SC stores energy by means of static energy rather than electrochemical process in battery.SC has huge number of charge discharge cycle and long life span. It has also little wear and tear induced by cycling and age doesn't affect SC much when compared to battery Figure 2 shows the three branch model of supercapacitor. Here ESR is the Equivalent Series Resistance, which is a frequency variable measure of the total lossiness of a capacitor. The C_1 is the main capacitance responsible for energy storage and charge handling. The Rp and Cp are responsible for the fast dynamic behavior of SCs. The R_1 is responsible for the self discharge effect. Procedure to determine the parameters are represented in [6].

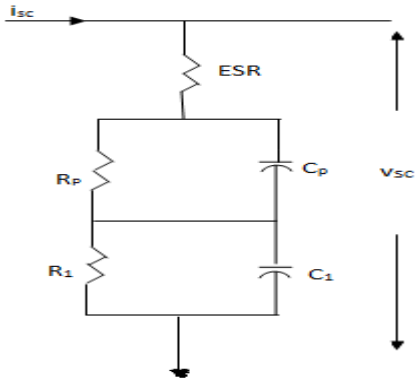

Fig 2 : Equivalent circuit of supercapacitor

C. System under study

Super capacitor is used to reduce the battery stress. The bus voltage fluctuation during the load changes when battery alone connected is balanced. When the battery is connected to the system having no super capacitor there will be large drop in voltage when a load is introduced suddenly. This will create a great financial as well as productive loss in high tech industries. In order to avoid such situation and to regain the battery performance the super capacitor is connected. There are several topologies for connecting the super capacitor with battery. Here the super capacitor and battery are connected.

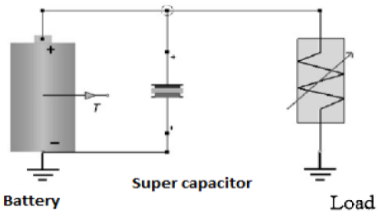

Fig 3: Battery and super capacitor connected to a load

Here the system is working in enhanced and in normal mode. In enhanced mode the battery and supercapacitor are working. In normal mode the battery alone is working .The below shown flowchart 1 shows the switching strategy of battery and supercapacitor in enhanced mode.

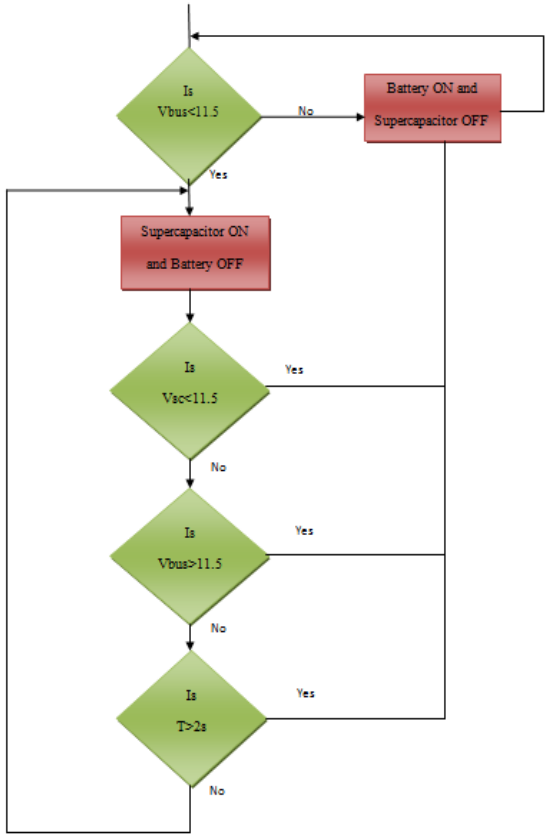

Fig 4:Flow chart showing the switching criterion for battery and supercapacitor

In normal mode, the battery alone is feeding the systems. If the sudden voltage is in given there won't be any effect of super capacitor on the system. In enhanced mode the hybrid system will be there .i.e., both the battery and super capacitor will be feeding the load based on condition given. If the sudden load is introduced, that transient period will be feeding by super capacitor. Otherwise the battery will only be connected in enhanced mode.

As the sudden load is introduced in this system, there will be a drop in bus voltage. When the bus voltage is less than a particular value (say 11.5V), then the super capacitor will be ON and battery will be OFF .i.e., the super capacitor will be providing energy to the load at that instant. Otherwise the battery will be feeding the load the battery will be ON and super capacitor will be OFF.

D. Simulation results

Here the battery used is lead acid battery of 12V,6A. Supercapacitor rated voltage of 13V,60F. A diode can be provided to prevent the reverse flow.LC Filtering is also provided. If the super capacitor voltage is less than 11.5V also the same state will be taken. A delay of 2s can be applied using monostable multivibrator.A non linear load with a push pull inverter is introduced here to know the variation of bus voltage. The variation of bus voltage with sudden introduction of load in battery alone connected system and battery–supercapacitor hybrid system at .1 sec. It draws high amount of current causes the bus voltage to reduce about 40 percent in normal mode, it can be seen in figure 5 and figure 6 respectively.

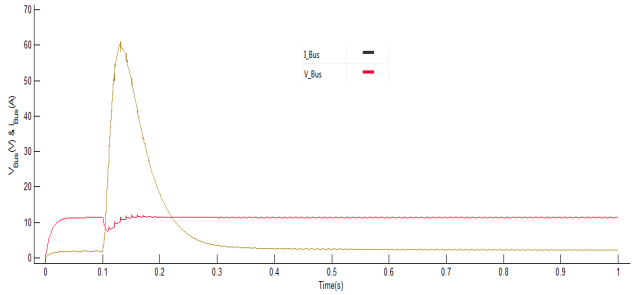

Fig 5: Bus voltage and current variation during normal mode

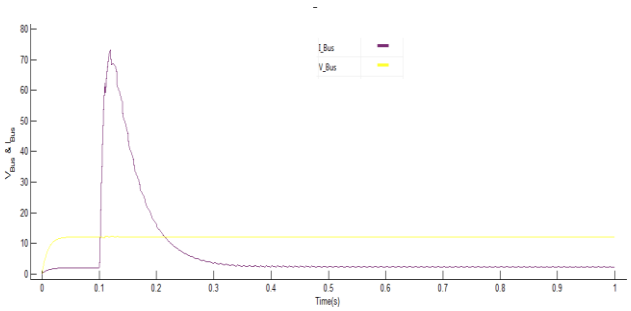

Fig 6**:** Bus voltage and current variation during enhanced mode

In the enhanced mode even though load draws high amount of current there is no reduction in the bus voltage.bus voltage and power variation in the system with battery alone system and with battery-supercapacitor hybrid system comparison is shown in figure 7 and figure 8 respectively.

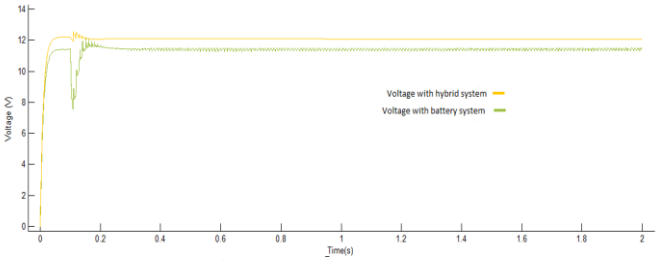

Fig 7: Comparison of bus voltage during enhanced and normal mode

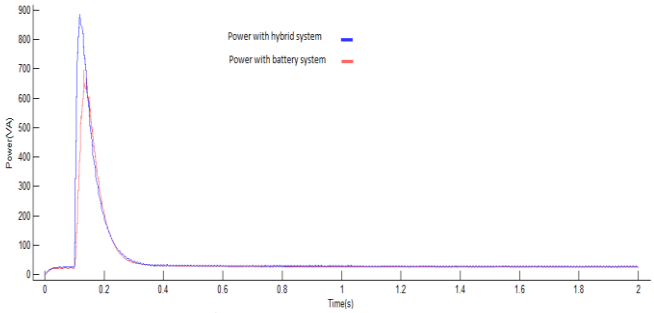

Fig 8: Comparison of power during enhanced and normal mode

Bus voltage fluctuation has been reduced in enhanced mode than in normal mode. During enhanced the power is improved than in normal mode as the bus voltage is improved.

III. CONCLUSIONS

Energy storage device provide improved system reliability, dynamic stability, enhanced power quality enhancement of transmission capacity in power system. In industrial sectors, high reliability power supply is required for critical loads. Conventional ESS for power supply are basically relying on the choice of good batteries. Because of drawbacks associated with batteries such as low-power density, limited charge/discharge cycles and extracting pulsed power instead of average power from the battery can decrease its lifespan. The super capacitors are connected along with the battery to increase the performance of systems. The super capacitors are used as high-power storage devices to smooth the peak power applied to the battery during backup time and to deliver full power during short grid outages. During the load changes in the bus system, the bus voltage fluctuations are balanced by super capacitor and battery support. There by the power is also improved by battery-super capacitor combination and thereby the battery stress is also reduced

REFERENCES

[1] Variability of Wind Power and other Renewables: Management Options and Strategies,International Energy Agency Publications, June 2005

[2] A. M. Van Voorden, L. M. R Elizondo, G. C. Paap, J. Verboomen, and L. Van der Sluis, "The application of super capacitors to relieve batterystorage systems in autonomous renewable energy systems," in *Proc. IEEE Power Tech.*, Lausanne, Switzerland, Jul. 1–5, 2007, pp. 479–484

[3] R. A. Dougal, S. Liu, and R. E. White, "Power and life extension of battery–ultracapacitor hybrids," *IEEE Trans. Compon. Packag.*, vol. 25,no. 1, pp. 120–131, Mar. 2002.

[4] W.Li and G.Joos, "A power electronic interface for a battery supercapacitor hybrid energy storage system for wind application," in *Proc.2008 IEEE Power Electronics Specialists Conference,pp.1-4*

[5] O. Tremblay,L.-A. Dessaint, and A.-I. Dekkiche,"A generic battery model for the dynamic simulation of hybrid electric vehicle," in *IEEE Vehicle Power and Propulsion Conference*,VPPC 2007,Sept.2007,pp.284-289

[6] C. Farcas, D.Petreus, I.Ciocan,and N. Palaghita," Modelling and simulation of supercapacitors," in *15th International Symposium for Design and Technology of Electronics Packages,(SIITME)*,Sept.2009,pp.195-200