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Hybrid Energy Storage System Using Wind Power System With Battery/Supercapacitor

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Abstract *–This paper presents a renewable generation, batteries used in renewable-power systems can undergo many irregular, partial charge/discharge cycles. A stand-alone wind power system mainly consists of a wind turbine, a permanent magnet synchronous generator, hybrid energy storage devices based on a vanadium redox flow battery and a supercapacitor, an AC/DC converter, two bidirectional DC/DC converters, a DC/AC converter and a variable load. This strategy avoids the necessity of measuring wind velocity, obtaining models or parameters of the wind turbine and calculating the differentials of the power generated from the wind power system and from the speed of the generator. The battery charge/discharge control maintains a constant DC bus voltage. When the battery charging/discharging current reaches the setting threshold, the charge/discharge control of the supercapacitor is triggered to limit the charging/discharging current of the battery. The simulation results show that the proposed method can rapidly respond to variations in wind velocity and load power.*

Keywords*: Batteries, energy storage, super capacitors, wind power generation.*

I. Introduction

To develop a system to prolong expected battery life, so reducing battery-replacement prices. This will be a big advantage, significantly in remote areas, wherever access may be tough and costly. In contrast to secondary batteries, super capacitors additionally referred to as "electrochemical double-layer capacitors" (EDLC), or "ultra capacitors," supply higher power density and increased cycle life (of the order of 106 cycles) however have a significantly lower energy density Super capacitors presently notice use as short-run power buffers or secondary energy storage devices in renewable energy power systems and transport applications Combining 2 or a lot of energy storage systems permits the useful attributes from every device to be used. Secondary lead-acid batteries could have a typical service lifetime of but a thousand full-cycles and sometimes constitute an oversized proportion of the entire price of a renewable energy project.

The aim of this study is to utilize the inherently high cycle lifetime of super capacitances during a battery/super capacitor hybrid energy storage system to enhance battery life. Have shown that the active coupling of batteries and super capacitors will yield an improvement within the overall energy storage system power handling. Wei et al. have incontestable that a battery-super capacitance hybrid has lower battery prices, a general increase in battery life and better overall system efficiency. Haihua et. al. have planned a composite energy storage system with each high power density and energy density for small grid applications. One similarity between these studies et al. is that the battery is used to supply the low-frequency element of total power demand whereas the super capacitance provides the short-run or high-frequency element.

This has the effect of reducing transient fluctuations within the battery power profile. The work conferred here additionally adopts this approach, and extends previous studies by providing new results that quantify the potential increase in battery cycle lifetime because of the addition of super capacitance energy storage, and describes a method of system implementation and analysis.

The planned system and analysis also can be applied to systems within which the low-voltage battery is interfaced with a regulated dc bus at the next voltage for power transfer but, to demonstrate the underlying principle of the system.

II. Theory

II.1. Wind power generation

Wind power is extracted from air flow using wind turbines or sails to provide mechanical or electric power. Windmills are used for their mechanical power, wind pumps for water pumping, and sails to propel hips. Wind generation as another to fossil fuels, is plentiful, renewable, widely distributed, clean, produces no greenhouse emission emissions throughout operation, and uses very little land. Internet effects on the surroundings are so much less problematic than those of nonrenewable power sources.

Wind power is extremely consistent from year to year however has important variation over shorter time scales. It's so utilized in conjunction with different electrical power sources to offer a reliable provide. Because the proportion of wind power during a region will increase, a requirement to upgrade the grid and a down ability to replace typical production will occur. Power management techniques like having excess capability, geographically distributed turbines, dispatch able backing sources, sufficient hydroelectric power, exportation and importation power to neighboring areas, using vehicle-to-grid methods or reducing demand once wind production is low, will in several cases overcome these issues. Additionally, weather forecasting permits the electricity network to be readied for the predictable variations in production that occur.

II.2. Energy storage

Energy storage is accomplished by devices or physical media that store energy to perform useful processes at a later time. A tool that stores energy is typically known as an accumulator. Many sorts of energy turn out useful work, heating or cooling to satisfy societal needs. These energy forms include energy, gravitational P.E., electrical potential, electricity, temperature variations, latent heat, and K.E.. Energy storage involves changing energy from forms that are difficult to store (electricity, K.E., etc.) to additional handily or economically storable forms. Some technologies offer only short-run energy storage, and others will be very long-run like power to gas using hydrogen or methane series and also the storage of heat or cold between opposing seasons in deep aquifers or bedrock. A wind-up clock stores P.E. (in this case mechanical, within the spring tension), are chargeable battery stores readily convertible energy to control a mobile, and electricity dam stores energy during a reservoir as gravitational P.E.. Ice storage tanks store ice (thermal energy within the type of latent heat) in the dark to fulfill peak demand for cooling. Fossil fuels like coal and gasolene store ancient energy derived from sunlight by organisms that later died, became buried and over time were then converted into these fuels. Even food (which kind by a similar method as fossil fuels) could be a type of energy keeps in chemical form.

III. Method

III.1. Battery Model

The dynamic battery model described was used to represent battery voltage and state of charge (SOC) variations. a close description of the modeling-parameter identification method is For the aim of this simulation, the battery parameters provided for charge and discharge simulations given in are used .The number of series battery cells was set to 12, giving battery voltage of 24 V at the nominal cell capability. The governing equations of the lead-acid battery model shown in Fig. 1 from are given later like battery-cell model Parameters.

$$C(I,\theta) = \frac{K_c C_0 \left(1+\frac{\theta}{-\theta_f}\right)^{\varepsilon}}{1+(K_c-1)(I/I^*_{nom})^k} \quad (1)$$

Where K_c, k, and ε are the modeling parameters, Im nom is the battery nominal discharge current, θ is the electrolyte temperature, and θ_f is the electrolyte freezing temperature (◦C). State of charge (SOC) and depth of charge (DOC) are defined as:

$$SOC = 1 - \frac{Q_c}{C(0,\theta)} \; where \; Q_c = \int_0^t -I_m(t) \quad (2)$$

$$DOC = 1 - \frac{Q_c}{C(I_{fil},\theta)} \; where \; I_{fil} = \frac{I_m}{1+\tau_{bs}} \quad (3)$$

Where τbs is a battery modeling time constant

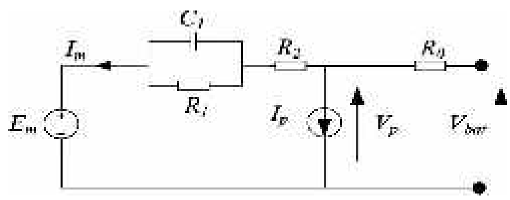

Fig. 1 Dynamic lead-acid battery model

III.2. Super capacitor Model

Please Super capacitance effective capacitance is represented by a nonlinear function of terminal voltage but, The effective capacitance C*, the leakage resistance R_{leak}, and also the series resistance R_{esr} terms is determined by measure or derived from manufacturer's information, as during this simulation Super capacitance voltage is then represented as.

$$V_{sc} = \frac{1}{C^*}\int (I_{sc} - \frac{V_{sc}}{R_{leak}})\,dt + I_{sc}R_{esr} \quad (4)$$

The required supercapacitor energy storage capability determined empirically by simulation. The supercapacitor module was then designed using a combination of normal commercially-available supercapacitor cells with parameters. The effective total capacitance C∗ and series and leakage resistances (Rleak and Resr) were calculated supported the amount of series/parallel supercapacitor cells. The supercapacitor module was designed to offer a most operational voltage of 120 Vdc. to confirm that the supercapacitor voltage is maintained at a better level than the battery voltage the least bit times, a lower limit was placed on the supercapacitor in operation voltage of 30 Vdc.

IV. Result

The simulation was run with battery energy storage only and with the battery sized such that the load is met at all times. The rain-flow counting algorithm was used to determine the number of cycles experienced by the battery over the week-long simulation period. Figure 2 shows the battery current, SOC, and the results of the rain-flow cycle counting.

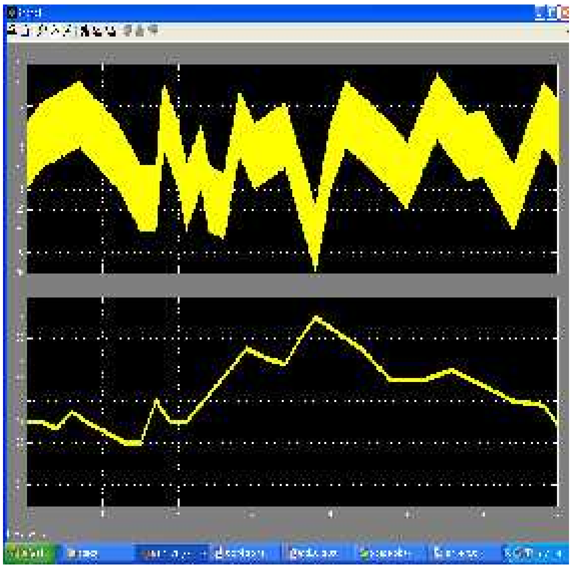

Fig. 2 Battery current, soc (conventional)

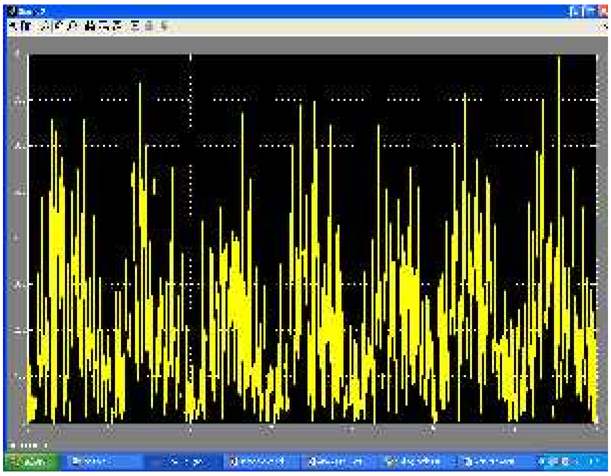

Fig.3 Load power Prrofile

In figure 3 the demultiplexed form of the load power is given after the application of the wind power storage in the battery

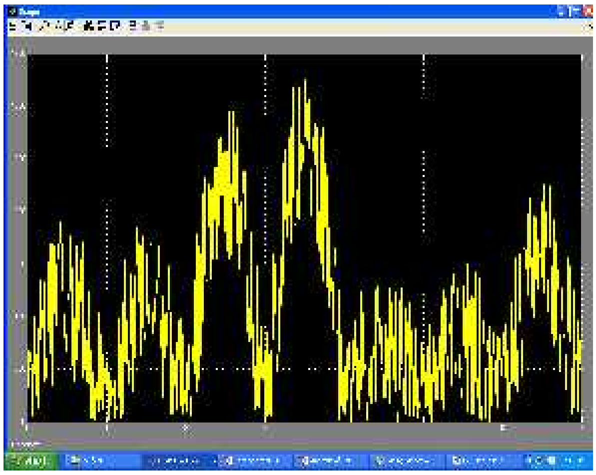

Fig.4 Wind-power profile

In figure 4 the output of the demultiplexed form is given by the wind power Three-phase instantaneous voltage (V) Iabc input: Three-phase instantaneous current (A) PQ output: Active and reactive power [P(W) Q(var)]

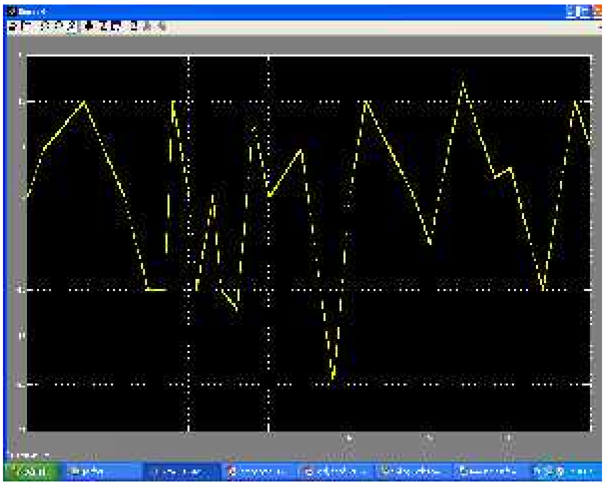

Fig.5 battery state of charge of battery only system result

In figure 6.4 the current output of the battery is in the multiplexing and the output of the battery is multiplexed with other wind power outputs

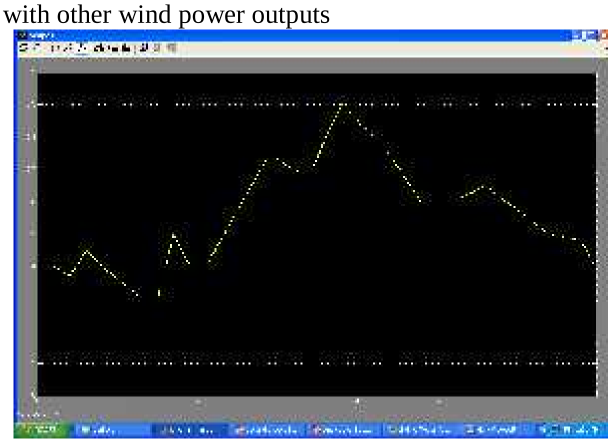

Fig.6 battery state of charge of hybrid system

V. Conclusion

In this project planned has investigated the utilization of super capacitors to enhance expected battery life cycle over a representative weeklong power-profile typical of a little, remote-area wind-energy conversion system. The suitability of super capacitors to expand the safe operating window of a wind-membrane system was examined in a very systematic manner. The super capacitors were able to give sufficient energy during times of no wind (intermittency) and enhance the power quality delivered to the membrane by absorbing turbulent wind (fluctuations). As a result, system shut-down and compromised permeate quality because of reduced TMP were avoided. The uses of super capacitors to produce constant power resulted during a 40 to extend within the average flux and 15 august 1945 increase in permeate quality under intermittent operation over one hour. The enhancements within the average flux and permeate quality underneath fluctuating conditions because of increased power quality were 85 try to 40 the concerns, severally. Whereas the SOC of the super capacitance bank was higher than the minimum threshold price of 27 the concerns, the membrane system operated as underneath steady-state conditions regardless of the wind speed and power output from the turbine.

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