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Fuzzy Logic Based Hybrid Energy Storage System for Wind Generating Plant

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Abstract- **This paper discusses a hybrid energy storage system for isolated operation of permanent magnet synchronous generator based wind turbine. The hybrid energy storage system consisting of battery storage and a super capacitor, the battery and super capacitor provide high energy and power requirements respectively. The super capacitor ensures a healthy operation of the battery storage by preventing it to operate in high Depth of Discharge regions and to operate at low frequency power regions. The system provides the solution for power wasted by the turbine when the battery is in full charge condition .A fuzzy logic is proposed for the hybrid energy storage with a view to improve the performance of the battery storage and to improve the system stability. The simulation results using MATLAB simulink of the proposed method is capable of achieving voltage and frequency regulation, effective management of the hybrid storage system without dump load and maximum power extraction from wind.**

Keywords- **Battery Storage, Energy Storage System, Remote Area Power Supply, Super Capacitor And Fuzzy Controller .**

I. INTRODUCTION

Energy storage systems are becoming popular for remote area power generation applications due to advances in energy storage technologies. An energy storage system usually consists of two or more energy storage devices used together to provide increased system efficiency as well as greater balance in energy supply. Variable nature of wind make the operation of wind based power systems challenging, particularly when they operate in standalonemode. For a wind turbine based remote area power supply system(RAPS), an ideal energy storage system should be able to provide both high energy and power capacity to handle situations such as wind fluctuations or sudden load variations which may exist for a few seconds or even longer. An energy storage system (ESS) in a wind farm is required to be able to absorb wind power surges during gusts, and have sufficient energy storage capacity to level wind fluctuations. A RAPS system consisting of a Permanent Magnet Synchronous Generator (PMSG), an energy storage, and a mains load is considered in this paper. However, among all the energy storage options available, a single type of energy storage is not able to manage both power and energy requirements of the RAPS system thus requiring the combination of two or more energy storage systems. The energy storage system in this paper consists of battery storage and a supercapacitor. This proposed system is suitable for standalone system, ex- hill station, island, forest area, rural area. A fuzzy logic is proposed for the energy storage with a view to improve the performance of the battery storage and utilization of inverter as a dump load. In this project, the performance of the components of a hybrid RAPS system is investigated using mat lab simulation. Fuzzy controller is used to manage the stored energy and the load demand. Integration of an Energy Storage System (ESS) into a wind based power system provides an opportunity for better voltage and frequency response, especially during wind and load demand variations. The proposed method is capable of achieving robust voltage and frequency regulation, effective management of the hybrid storage system, and maximum power extraction from wind.

II. BLOCK DIAGRAM OF PROPOSED SYSTEM

The use of the wind as an energy source is increasing worldwide. For a wind turbine based remote area power supply system an ideal energy storage system should be able to provide high energy and power capacity to handle sudden load variations. A single type of energy storage is not seen to satisfy both power and energy requirements of the RAPS system thus requiring the combination of two or more energy storage systems to perform in a hybrid manner. The system implements a new methodology called Segmented Storage Energy System. The system provides the solution for power wasted by the turbine when the battery is in full charge condition. The system can use two or more number of batteries which is integrated with the inverter hence the power can distributed to the batteries one by one and it is stored. Instead of using dump load, an additional battery is used to store the excessive power. Fuzzy logic control strategy is implemented in the proposed system. To

maintain the stable dc output from Super Capacitor and Battery here the DC to DC converter is connected. The DC link voltage of the RAPS system is regulated using a DC/DC converter. For the converter MOSFET is used. The electrical power obtained from the wind energy is converted into DC by using a rectifier. The output of rectifier is fed to battery super capacitor unit. To make the output stable a DC to DC converter is used. LSC in the block diagram indicates the load side converter, basically LSC is the inverter. LSC converts DC to AC for the distribution line and load. If the load needs stored power, fuzzy controller controls the flow of flower and pulse is generated using PWM generation. PWM generation is used to allow the control of power supplied to electrical devices. PMSG is used to convert mechanical output of the wind turbine into electrical power. PMSG performs as the main source of energy and is interfaced with line side converter before connecting to the mains load. The control objective of the LSC is to regulate the magnitude and frequency of the load side voltage. A gate driver accepts a low-power input from a controller IC and produces a high-current drive input for the gate of a high-power transistor such as an IGBT or power MOSFET.

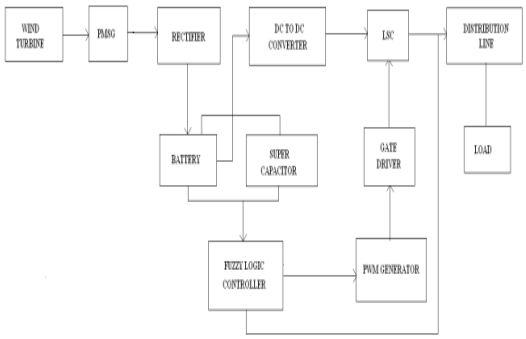

Fig 1: Block diagram

III. CIRCUIT DIAGRAM

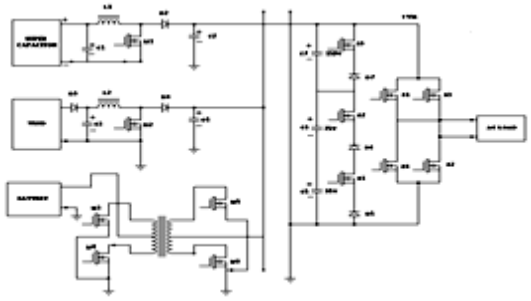

Fig 2: Circuit Diagram

IV. SIMULATION DIAGRAM

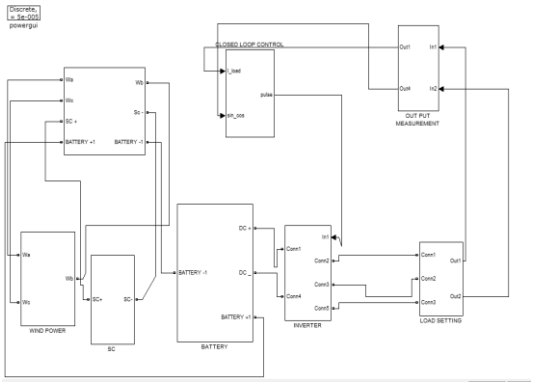

Fig 3: Overall Simulation Diagram

From the above simulation diagram it can be seen that the rectified wind power is connected to the super capacitor and battery. For rectification purpose diodes are used. In the simulation model load setting is shown, RL load is used for the simulation. MOSFTET used as the inverter, which converts the dc output to ac for load. A fuzzy control system is a control system based on fuzzy logical mathematical system that analyzes analog input values in terms of logical variables that take on continuous values between 0 and 1, in contrast to classical or digital logic, which operates on discrete values of either 1 or 0 (true or false, respectively).The system has faster response time by using the Fuzzy controller and is less sensitive to input. In Fuzzy logic everything is a matter of degree. Any logical system can be fuzzified.

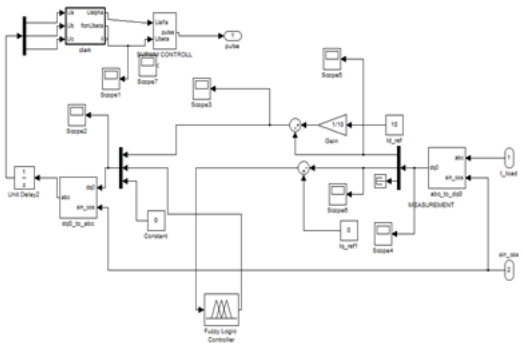

Fig 4: Simulation model of proposed system with Fuzzy logic controller

Fuzzy controllers are very simple conceptually. They consist of an input stage, a processing stage, and an output stage. The input stage converts inputs to the appropriate membership functions and truth values.The processing stage invokes each appropriate rule and generates a result for each, then combines the results of the rules. Finally, the output stage converts the combined result back into a specific control output value. The processing stage is based on a collection of logic rules in the form of IF-THEN statements, where the IF part is called the antecedent and the THEN part is called the consequent.

V. OUTPUT WAVEFORMS

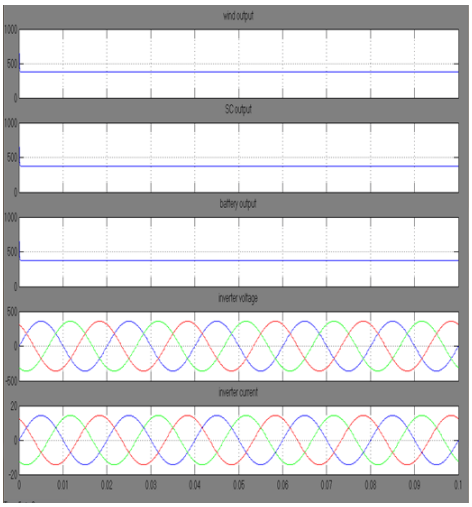

Fig 5: Output waveform of proposed system

The output waveform of wind, battery, super capacitor and inverter with time are shown in above figure. The output voltage of battery and super capacitor obtained is stable. Also the output of inverter is sinusoidal waveform. The simulation time is 0.01second.

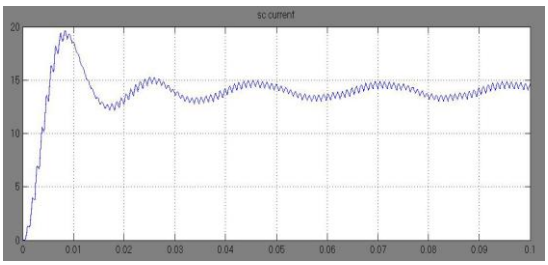

Fig 6: Output current of supercapacitor

VI. CONCLUSION

This paper investigated the standalone operation of a PMSG with energy storage system consisting of battery storage and a super capacitor, without a dump load.The proposed strategy was implemented with the detailed model of the MATLAB Simulink and also with the highly accurate models of the system components. Also, the performance of the battery storage is improved with the proposed energy storage system, as super capacitor absorbs the ripple or high frequency power. Moreover, the super capacitor helps in avoiding battery operation in high rate of depth of discharge regions.When the battery is fullycharged condition, the dump load absorb the excess power. So that the excess of power generated by wind turbine is simply wasted. It will affects the system efficiency. The proposed system is able to extract the maximum power output from the wind throughout its entire operation.

VII. REFERENCES

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