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Energy Control in AC Grid Integrated To Wind Energy Storage System with Reduced AC-DC-AC Wind Converter


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ABSTRACT

The use of energy storage equipment is considered a reasonable solution to suppress wind power fluctuations. An energy storage mode may have its disadvantages over the others, for example, capacity limits, dynamic response, higher prices or shorter lifetime. Wind power outputs fluctuate with the changing of wind speed. In this particular study, the power system consists of a power electronic converter supplied by a battery bank, which is used to form the AC grid. The main objective of this proposed strategy is to control the state of charge of the battery bank limiting the voltage on its terminals by controlling the power generated by the energy sources. Long-term energy is designed to meet the large-scale capacity requirement using Li-ion battery. The simulation results are presented to describe performance of proposed system.

INTRODUCTION

In recent years, wind power generation technology is developing rapidly and is becoming more mature. Wind velocity presents intermittent and stochastic characteristics, which leads to relatively large fluctuations of wind power. Power fluctuations can result in deviation of grid frequency and voltage, and affect stability and power quality of grid operation. If wind power does achieve 20% or more of total system power, peak capacity and safe operation of the grid will face enormous challenges. Nowadays, with a growing number of large-scale grid-connected wind farms and the continuous extension of installed capacity, the wind power ratio is becoming higher. Therefore, the fluctuations of windpower should be overcome urgently to avoid a degradation of the grid's performance.

All over the world, researchers have proposed several solutions to smooth wind power fluctuations. For example, for a given hour of the day, wind-deficient farms could be compensated by wind benefiting farms, so a general planning method was proposed to minimize the variance of aggregated wind farm power output by optimally distributing a predetermined number of wind turbines over a preselected number of potential wind farming sites, in which the objective is to facilitate high wind power penetration through the search for steadier overall power output. Kassem et al. proposed a hybrid power system by combining the continuously available diesel power and locally available, pollution-free wind energy, of which the main goal is to reduce fuel

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consumption and in this way to reduce system operating costs and environmental impact. A wind turbine generator was controlled with a voltage source converter to smooth power fluctuations, and pitch control of the turbine blades was employed for the same purpose, but their abilities and control ranges are limited due to reducing wind power acquisition. FACTS were also used to maintain grid voltage stability at the wind power access point by adjusting reactive power, but it cannot smooth active power fluctuations.

Large-scale energy storage technology provides an effective approach for large-scale grid-connected wind farms to improve the wind power quality [16–26], which not only can smooth active power but also can regulate reactive power. As a result, large-scale wind farms with energy storage systems (ESSs) can be easily and reliably connected to the conventional grid. There are many energy storage schemes for this purpose, for example, the compressed air energy storage (CAES) system is a mature and reliable bulk energy storage technique with promising potential to accommodate high wind power penetration in power systems. It operates with fast adaptability and low cost, but requires a suitable sealed underground geological cavern for air storage, as a result of that it is located far from user/load. Flywheel based ESS is used to improve power quality and stability of the wind farms. Superconducting magnetic-based ESS is achieved to smooth the fluctuations of wind power. Super-capacitors are employed to adjust wind farm output power. Practical applications of flywheel, super-conduction, and super-capacitors in the ESS for wind power are restrained due to their high cost or low capacity. At present, lead-acid batteries are widely used because of their mature technology and low price, but cycle life is very limited. Sodium sulfur batteries with their high energy density, high efficiency of charge/discharge and long cycle life, are primarily suitable for large-scale non-mobile applications such as grid energy storage. However, it requires a high operation temperature of 280–360 C and has the highly corrosive nature of sodium polysulfide. Also, hybrid power generation systems use ESS to improve power quality of the grid, for example, diesel generators and renewable energy sources (such as wind power and photovoltaic power units) are deployed at different locations of the system, and electric double layer capacitors as energy storage are utilized to play the main role to control the system's power quality and system frequency. Operation schedule of thermal generators, wind generators, photovoltaic power generation systems, and batteries are optimized through considering the transmission constraint to reduce operational cost of thermal units.

Wind based Grid Integration

The proposed hybrid system comprises of a WECS andlead acid battery bank. The system is designedfor a stand-alone dc load. The layout of the entire systemalong with the control strategy is shown in Fig. 1. The specificationsof the WT, PMSG, and battery bank are tabulated in theAppendix. TheWECS consists of horizontal axisWT,gear box with a gear ratio of 1:8 and a PMSG as theWTG.

However, there is a need for a battery backup to meet the loaddemand during the period of unavailability of sufficient windpower. This hybrid wind-battery system requires suitable controllogic for interfacing with the load. The uncontrolled dc outputof the rectifier is applied to the charge controller circuit of thebattery. The charge controller is a dc–dc buck converter whichdetermines the charging and discharging rate of the battery.

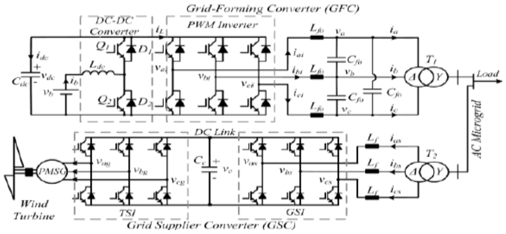

Fig 1: Grid Integrated WECS using BESS

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The battery bank connected to the system can either act as asource or load depending on whether it is charging or discharging.However, regardless of this the battery ensures that theload terminal voltage is regulated. Further, as shown in Fig. 1,the charging of the battery bank is achieved by MPPT logic,while the pitch controller limits the mechanical and electricalparameters within the rated value. The integrated action of thebattery charge and pitch controller ensures reliable operation ofthe stand-alone WECS.

Control System

The wind flow is erratic in nature. Therefore, a WECS isintegrated with the load by means of anDC–DC–AC converterto avoid voltage flicker and harmonic generation. The controlscheme for a stand-alone hybrid wind-battery system includesthe charge controller circuit for battery banks and pitch controllogic to ensureWT operation within the rated value. The controllogic ensures effective control of the WECS against all possibledisturbances.

The implementation of the charge control logic as shown inFig. 2 is carried out by three nested control loops. The outermost control loop operates the turbine following MPPT logicwith battery SoC limit. To implement the MPPT logic, the actualtip speed ratio (TSR) of turbine is compared with the optimumvalue. The error is tuned by a PI controller to generate the batterycurrent demand as long as the battery SoC is below the CCmode limit.

Beyond this point, the SoC control logic tries tomaintain constant battery charging voltage. This in turn reducesthe battery current demand and thus prevents the battery bankfrom overcharging. The buck converter inductor current commandis generated in the intermediate control loop. To designthe controller, it is essential to model the response of the battery current with respect to the inductor current.

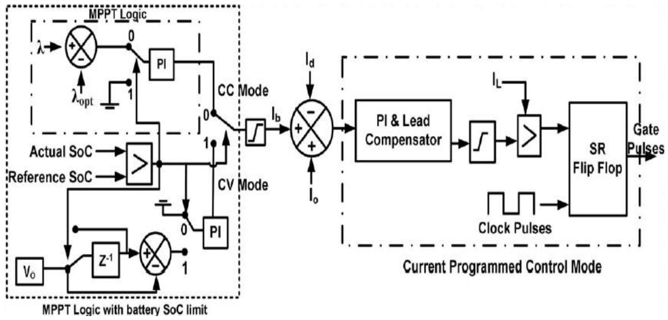

Fig 2: Control Strategy of dc-dc-ac converter

Pitch Control Scheme

As seen thep.u. value of each input is compared with 1 to calculate theerror. The errors are tuned by PI controller.

The "MAX" blockchooses the maximum output from each PI controller which isthen passed on to a limiter to generate the pitch command for theWT. The actual pitch command is compared with the limitedvalue. The lower limit of the pitch command is set at zero.There arises an error when the actual pitch command goes aboveor below the specified limit. This is multiplied with the errorobtained from each of the comparator. The product is comparedwith zero to determine the switching logic for integrator. Thistechnique is carried out to avoid integrator saturation. The pitchcontroller changes the pitch command owing to variation inturbine rotation speed, power, and output voltage of rectifier,which ensures safe operation of the WECS.

In standalone and distributed renewable energy systems, there is no commercial or conventional grid to absorb any surplus power generated internally in the microgrid. Therefore, the generated power needs to be controlled when the load power is less than the amount of power that could be generated by the energy sources. This is necessary to keep the energy balance in the microgrid under control and to keep the battery bank voltage below or equal its maximum allowable value. This is necessary since voltages higher than the gasification voltage can

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decrease the lifespan of batteries or even damage them irreversibly.

SIMULATION RESULTS

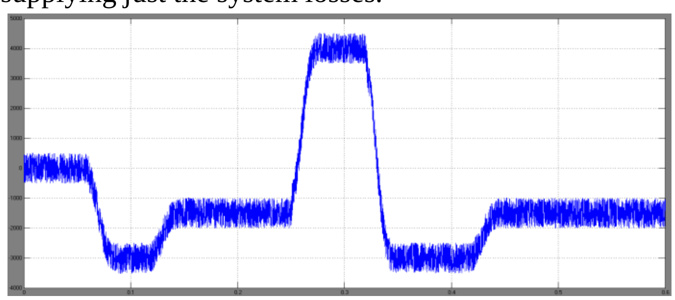
This includes the charge control logic and the pitch control logic.The charge controller regulates the charging and discharging rate of the battery bank while the pitch controller controls the WT action during high wind speed conditions or in case of a power mismatch.A WECS needs to be efficient to ensure continuous powerflowto the load.TheWT parameterslike shaft speed, TSR, blade pitch and output power are analyzedwith variation in wind speed conditions.

The current profile ofthe converter, load, and the battery are also monitored with the wind profile. The effectiveness can be achieved by integratingthe hybrid wind-battery system with suitable control logic. Both the control strategy are integrated withthe hybrid system and simulated with various wind profiles tovalidate the efficacy of the system. The system is connected to aload profile varying in steps from 0 to 4 kW. To ensure uninterrupted power flow, load demandis givenmore priority over battery charging.

Simulation Grid Supplier Converter:

Under Constant Wind Speed

The wind speed was considered constant and equal to 9.2 m/s. Before the tests, the battery bank was fully charged, and its open circuit voltage is 258 V. At instant 0 *s* the GFC is turned on and the microgrid is at no load, supplying just the system losses.



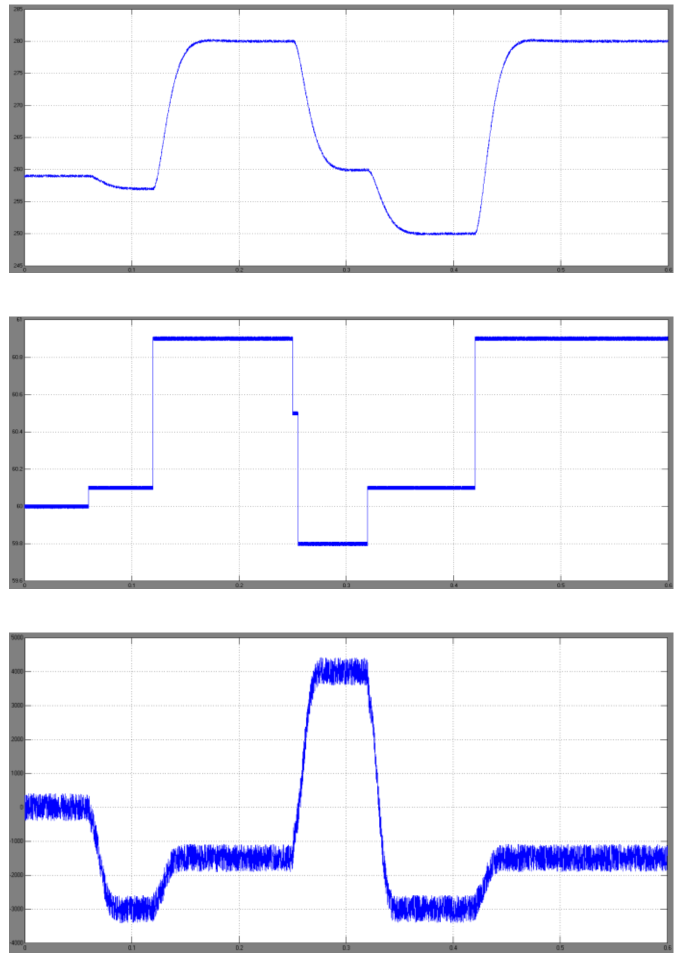
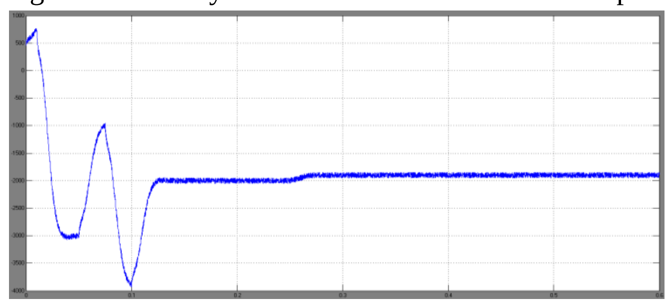


Fig 3: Operation with a constant wind speed of 9.2 m/s: (a) power at the GFC terminals; (b) battery bank voltage; (c) microgrid frequency, and (d) battery current.

Under Variable Wind Speed

Fig 4 shows the system behavior for variable wind speed.



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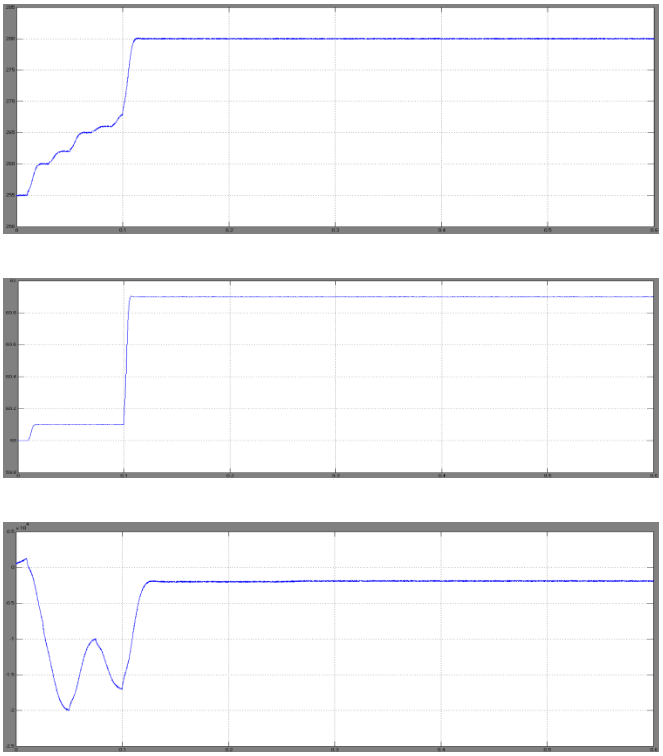

Fig 4: Operation with variable wind speed: (a) power at the GFC terminals; (b) battery bank voltage; (c) microgrid frequency, and (d) battery current

Without Grid Supplier Converter:

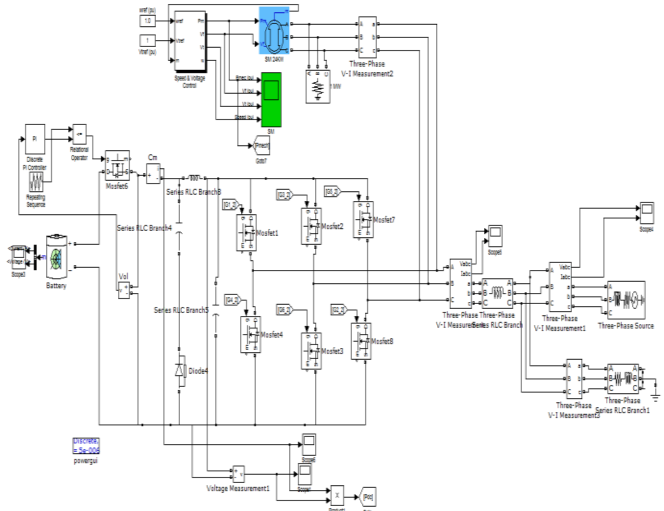

Fig 5: simulation circuit proposed system without GSC

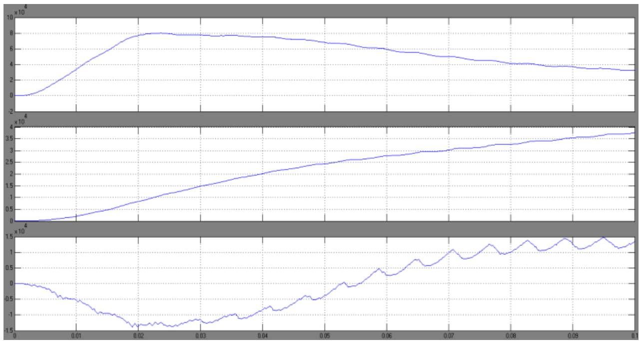

Fig 6: Wind Active Power, DC power, Wind Reactive power

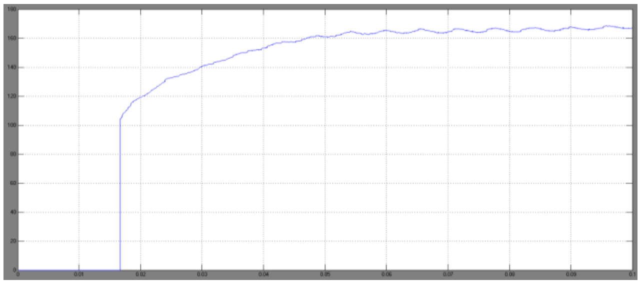

Fig 7: DC Voltage

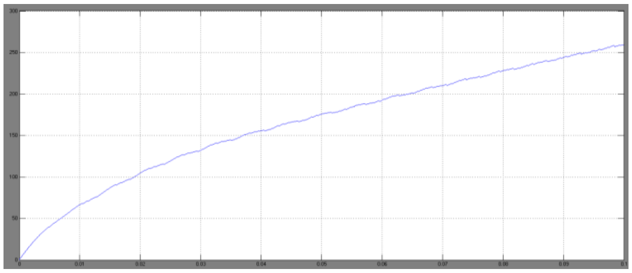

Fig 8: DC current

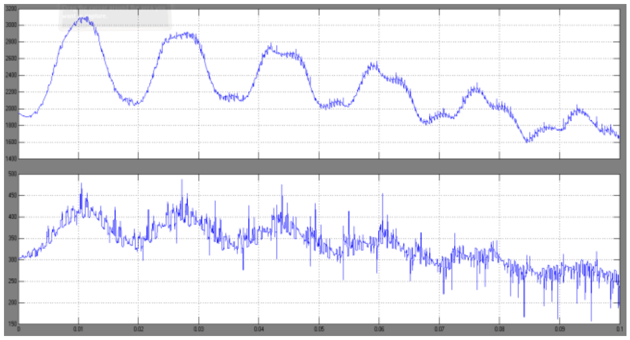

Fig 9: Load Active and Reactive power

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CONCLUSION

The power quality issues and its consequences on the consumer and electric utility are presented.The project presents the power quality improvement in grid connected wind generating system and non li-near unbalanced load from wind-based control scheme.It has a capability to cancel out the harmonic parts of the source current. It maintains the source voltage and current in-phase and support the reactive power demand for the wind generator and load at PCC in the grid system, thus it gives an opportunity WECS with BESS have shown the outstanding performance.The operation of the control system developed for the wind-BESS in MAT-LAB/Simulink software.

REFERENCES

[1]A. Sannino, ―Global power systems for sustaina-ble development,‖ in IEEE General Meeting, Denver, CO, Jun. 2004.

[2] K. S. Hook, Y. Liu, and S. Atcitty, ―Mitigation of the wind generation integration related power quality issues by energy storage,‖ EPQU J. ,vol. XII, no. 2, 2006.

[3] R. Billinton and Y. Gao, ―Energy conversion sys-tem models for adequacy assessment of generating systems incorporating wind energy,‖ IEEE Trans. on E. Conv., vol. 23, no. 1, pp. 163–169, 2008, Multis-tate.

[4] Wind Turbine Generating System—Part 21, Inter-national standard-IEC 61400-21, 2001.

[5] J. Manel, ―Power electronic system for grid inte-gration of renewable energy source: A survey,‖IEEE Trans. Ind. Electron., vol. 53, no. 4, pp. 1002–1014, 2006, Carrasco.

[6] D. L. Yao, S. S. Choi, K. J. Tseng, and T. T. Lie, ―A statistical approach to the design of a dispatchable wind power—Battery energy storage system,‖ IEEE Trans. Energy Conv., vol. 24, no. 4, Dec. 2009.

[7] F. Zhou, G. Joos, and C. Abhey, ―Voltage stabil-ity in weak connection wind farm,‖ in IEEE PES Gen. Meeting, 2005, vol. 2, pp. 1483–1488.

[8] T. Kinjo and T. Senjyu, ― Output leveling of renewable energy by electric double layer capacitor applied for energy storage system,‖ IEEE Trans. Energy Conv., vol. 21, no. 1, Mar. 2006.

[9] R. S.Bhatia, S. P. Jain, D. K. Jain, and B. Singh, ―Battery energy storage system for power condition-ing of renewable energy sources,‖ in Proc. Int. Conf. Power Electron Drives System, Jan. 2006, vol. 1, pp.501–506.

[10] S. W. Mohod and M. V. Aware, ― Grid power quality with variable speed wind energy conversion,‖ in Proc.IEEE Int. Conf. Power Electronic Drives and Energy System (PEDES), Delhi, Dec. 2006.