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An Efficient Control Strategy for Power Fluctuations Using Wind and BESS Approaches

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ABSTRACT: The battery energy storage station (BESS) is the current and typical means of smoothing wind- or solar-power generation fluctuations. Such BESS -based hybrid power systems necessitate an appropriate control strategy that can meritoriously regulate power output levels and battery state of charge (SOC). This paper presents the results of a wind/photovoltaic (PV)/BESS hybrid power system simulation analysis carry out to progress the smoothing performance of wind/PV/BESS hybrid power generation and the usefulness of battery SOC control.The effectiveness of the proposed technique is validated using MATLAB/SIMULINK software.

KEYWORDS: PV, WT, MPPT-IC, DFIG, BESS

I. INTRODUCTION

Renewable Energy Sources are those energy sources which are not demolished when their energy is harnessed. Human use of renewable energy requires technologies that harness natural occurrences, such as sunlight, wind, waves, water flow, and biological processes such as anaerobic digestion, biological hydrogen production and geothermal heat. Amongst the above stated sources of energy there has been a lot of expansion in the technology for harnessing energy from the wind.Wind is the motion of air masses produced by the irregular heating of the earth’s surface by sun. These differences consequently create forces that push air masses around for balancing the global temperature or, on a much smaller scale, the temperature between land and sea or between mountains.Wind energy is not a constant source of energy. It varies continuously and gives energy in sudden bursts. About 50% of the entire energy is given out in just 15% of the operating time. Wind strengths vary and thus cannot guarantee continuous power. It is best used in the context of a system that has significant reserve capacity such as hydro, or reserve load, such as a desalination plant, to mitigate the economic effects of resource variability.

The global environmental conservation is the main excuse foremployment of wind turbine (WTs) and photovoltaic (PV) cellsas the most important renewable energy generator. The windvelocity and solar radiation changes, is a big drawback forachieving a secure power source. The distributed generation(DG) has absorbed most considerations these days, since powertransmission network for remote areas is over-priced and overcomplicated. Solar and wind energy systems are taking thebiggest share from this trend [1], so PV and WT powergenerations play an important role as clean electric powersupplies among renewable power generators. The outputs of PVand WT system operations may deeply experience somedrawbacks, for instance diversion in frequency and changes involtage (voltage instability) [2]. A method in order to reach theacceptable reliability is to use both of the mentioned systemscooperatively [3-4]. Furthermore, the appropriate solution forinstability conditions in both the wind speed and solarirradiation has to be storing the energy using a storage device

In the literature, the energy management of hybrid powersystem with the conventional approaches been proven it’s instability in handling various changes in weatherconditions [5]. Some advanced controlling techniques (such as geneticalgorithms, fuzzy logic, and artificial neuralnetworks) exist, which can readily incorporate human intelligence in

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complicated control systems.

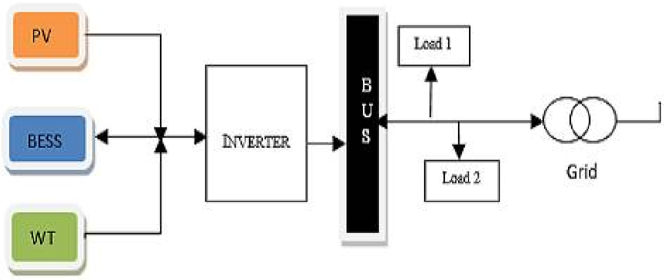

Fig-1 PV/WT/BESS hybrid power generation system.

Fig.1 as shown above is block diagram of a system which comprises photo voltaic (PV) and wind turbine (WT) assource of energy and BESS as flexible energy management solution, which auxiliaryprogresses the quality of outputpower along with the inverter and grid connected load1 and load2. These all components are connected to a commonBUS that is Point of Common Coupling (PCC). Solar and Wind energies are controlled to obtain maximum energyoutput using maximum power point (MPP) technique for solar power system and pitch control technique for doubly fedinduction generator (DFIG) based WT system. BESS along with SOC is used for smoothing of the output voltagefluctuations for both PV and WT systems.

II. LITERATURE SURVEY

Several PV/FC combined power systemshave been proposed and discussed [6].Not many PVsystems are gaining popularity due to relatively high costcompared with other traditional energy sources. Also PVarray output voltage versus the current follows a non-linearrelationship and requires maximum power point trackingto ensure maximum utilization and the array varies withsolar radiation.[7].Fuel cell has also several shortcomingssuch as it cannot store energy, slow response, its outputfluctuates with the load and it is difficult to cold start[8].

Infact, wind power and battery are complementary to someextent since strong winds are mostly occur during nighttime and cloudy days whereas battery due to its dynamicresponse and peak power capacity compensates the load bycharging and discharging and enhance power generationcapability. Hence a Wind-Battery hybrid generation systemcan offer high reliability to maintain continuous poweroutput than any other individual/hybrid power generationsystems. [9]

Whenusing BESS to control PV and wind power fluctuations,there is a trade- off between battery effort and the degreeof smoothness. That is, if one is willing to accept a lesssmooth output, the battery can be spared some effort.Thus far, although various effective BESS-based methodsof smoothing power fluctuations in renewable powergeneration systems have been proposed [10], [10], [12],smoothing targets for grid-connected wind and PV farmsgenerally have not been formulated.Smoothing control byway of power fluctuation rate limits, for such systems, hasrarely even been discussed.

III. PROPOSED ALGORITHM

Fig.2 shows block diagram of proposed grid connected hybrid generation systemconsisting of PV array, wind turbine(WT) as power sources and battery energy storage system (BESS) with SOC as energy storage. A hybrid system hasbeen designed to operate in grid connected mode, through power electronic interface. The power electronic interfacehas the ability to maintain the hybrid generation system parameters like voltage, frequency etc., at prescribed(acceptable) levels which is essential for the stable operation. To achieve this it is essential to have a good control overthe power angle and the voltage level, and it has been achieved by means of an inverter which constitutes the mainblock of the power control system (PCS). Controlling of the inverter’s output voltage and the power

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anglecontrol theflow of real power and reactive power into the system. Power converter system (PCS) includes various converters ateach stage like DC-DC boost converter at PV side, AC-DC converter at WTsideas shown in Fig-2 to deliver morestable output power to the loads as well as to the grid. It also improves the quality of power and reduces voltage andharmonic variations of overall system.

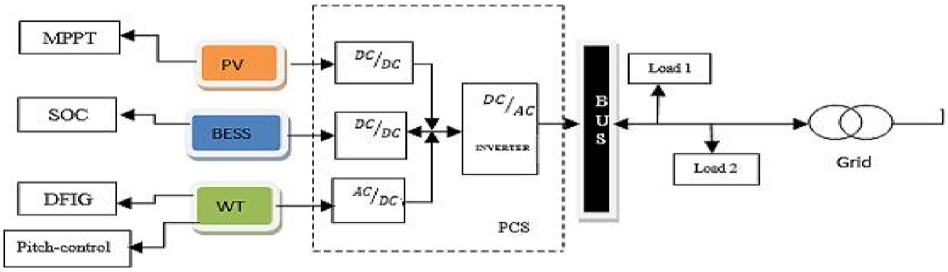

Fig-2:System configuration with PCS.

A.Modelling of PV system.

PV cells are assembled in larger unit called PV modules which are supplementary connected in series-parallel configuration toform PV arrays [3]. A 100kW, 25kV, PV module is taken as reference model for the simulation. To progress theefficiency and to regulate the amount of power drawn by photovoltaic panel, it is forced to operate at maximum powerpoint (MPP) condition. This is accomplished by using MPPT, incremental conductance (IC) algorithm which controls theDC-DC converter [4]. Henceforth maximum power with condensed fluctuations can be obtained at converter side.

B. Modelling of Wind system.

A doubly fed induction generator (DFIG) based wind turbine (WT) system is modelled for wind speed of 13m/s, 25kVvoltage and power of 100kW. DFIG based wind turbine is popular wind turbine system with its advanced controlstrategy to have high energy efficiency. To optimize the power extraction of WT and to evade over power production,Pitch Angle controller is used in the simulation. Detailed pitch control scheme and pitch servo is explained in [13].When speed of the generator exceeds rated speed pitch control is activated and pitch angle is turned on so that turbinepower can be limited to the rated values.

C. Modelling of BESS.

A capacity of 31.02Ah at nominal voltage, 250V lithium iron phosphate (LiFePO4) BESS is considered for thesimulation. In hybrid system, interfacing battery/BESS to the grid is the key to guarantee the reliability and stability ofthe power supply to the loads. When generation is insufficient battery works as power supply and when ample ofenergy is available, battery gets charged.

D.SOC Estimation

For smoothing of Wind and PV power fluctuations a new control strategy is used i.e. feedbackcontrol of SOC. In order to operate the BESS without interruption, the battery SOC needs to be controlled with in arange. SOC estimation is calculated using various methods [1][6].

IV. SIMULATION RESULTS

The proposed control schemes were implemented to the system model shown in Fig.3 using MATLAB/SIMULINK environment.

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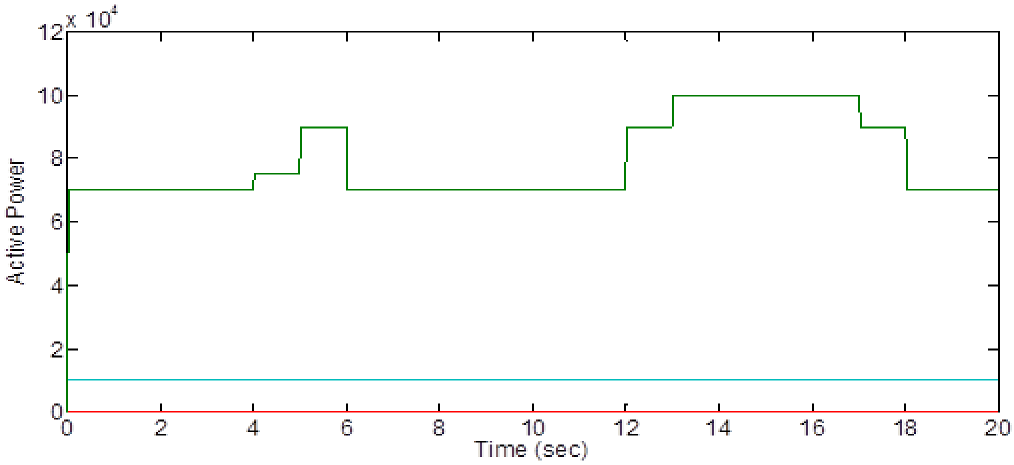

Fig-3

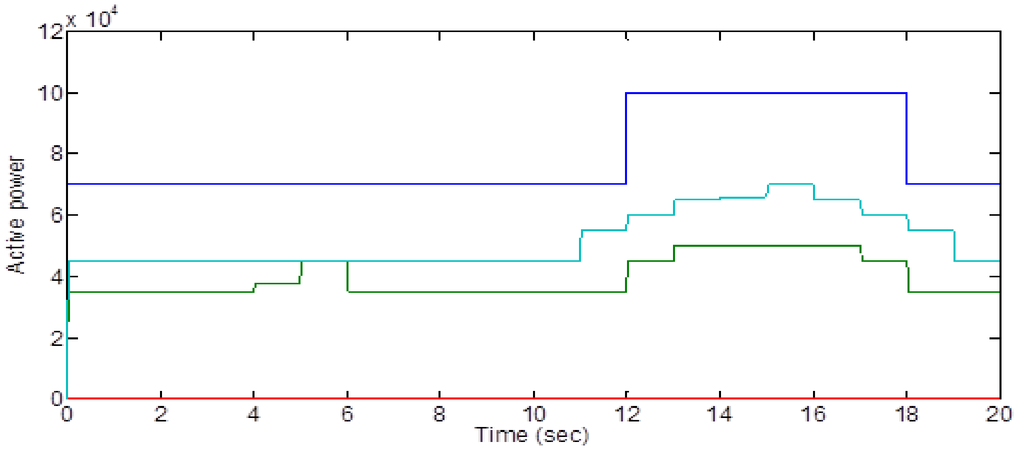

Fig-4 Operating strategy of the whole system with WIND and BESS system

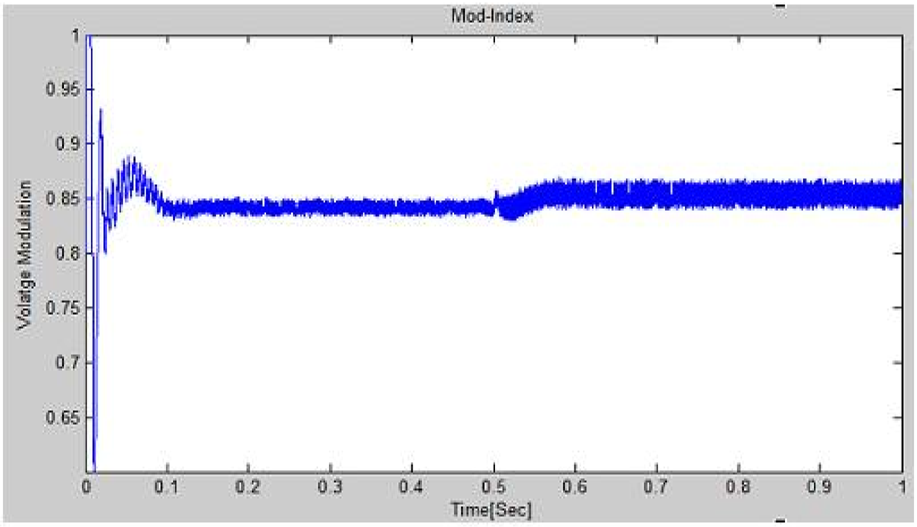

Fig.5 Battery Voltage (V_o), representing fluctuation reduction.

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Since battery SOC feedback control has been used in the hybrid system, voltage (V_o) fluctuations has been greatly reduced to maximum amount as shown in Fig-5. At the BESS side initially voltage fluctuation is maximum till 0.1sec, as time increases rate of fluctuation gradually reduces. Like this source voltage fluctuation has been reduced and fed to inverter. Therefore overall variation of voltage has been reduced to maximum extent.

V. CONCLUSION

In this paper incorporation of photovoltaic power generation system (PVGS) and Wind power Generation system (WPGS) with BESS diminishes the unstable power output and negative impact on utility and grid operation. Also in this paper a novel SOC-based control strategy for smoothing the fluctuation of output voltage of PV and WT has been proposed. This paper also suggests various case studies by which uninterruptable power is supplied to load at all conditions which enriches the power quality to the loads and improves efficiency.

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