Impact Factor (SJIF): 4.542

International Journal of Advance Research in Engineering, Science & Technology

e-ISSN: 2393-9877, p-ISSN: 2394-2444

Volume 4, Issue 4, April-2017

COORDINATION OF BATTERY ENERGY STORAGE STATION WITH HYBRID PV/WIND ENERGY SYSTEM

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Abstract — ***This paper is present a smoothing the output power fluctuation of PV and WIND generation. Battery energy storage station is current and typical means smoothing WIND or Solar power generation fluctuation. In this paper present the results of a wind/photovoltaic (PV)/BESS hybrid power system simulation. DC output of solar energy conversion system (SECS) and rectified dc output of wind energy conversion system (WECS) is fed to the boost converter. The output of boost converter is feed to the common dc link which is connected to the voltage source inverter, which converts its dc input to AC output. The simulation of whole hybrid model is done in SIMULINK/MATLAB***

I. INTRODUCTION

In recent years, electricity generation by photovoltaic (PV) or wind power (WP) has received considerable attention worldwide. Solar-PV (Photo-Voltaic) array and WECS (Wind Energy Conversion System) are gaining attention due to their environment friendly nature, low cost and availability for rural applications. Stand-alone systems are used for isolated operation i.e. not connected with the grid. Stand alone solar-PV and WECS are prominently used for electricity generation in rural areas [1].However, the solar and wind energy systems both have their own drawbacks as they greatly depend on the weather conditions, while solar energy can be tap only during daylight. Integration of these renewable energy sources with a competent system has massive potential to furnish a reliable energy source for the consumers than a system based only on solar or wind energy. Thus the hybrid energy sources based on solar-PV and WECS are prominently being a subject of research [2-5].

The objective of this paper is to propose a hybrid PV/Wind/BESS power system model. Battery energy storage systems recently have begun to be utilized for multiple applications such as frequency regulation, grid stabilization, transmission loss reduction, diminished congestion, increased reliability, wind and solar energy smoothing, spinning reserve, peak-shaving, load leveling ,uninterruptible power sources, grid services, electric vehicle (EV) charging stations, and others.

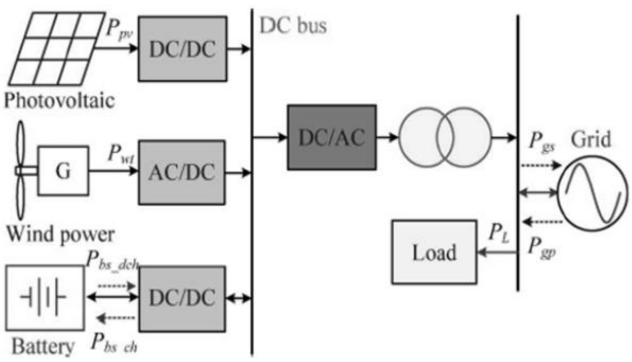

Figure 1 Wind/PV/BESS hybrid power generation system.[14]

These days, the issue of how power fluctuations in PV and wind power generation are to be smoothed has attracted widespread interest and attention. And even as this issue is being resolved, another one, that of the application of an energy storage system such as BESS, has arisen. When using BESS to control PV and wind power fluctuations, there is a trade-off between battery effort and the degree of smoothness.

II. Modelling of Wind Energy Conversion System

Wind results from the air in motion. Wind causes by the uneven heating of the land and the water. The aero turbine is used to converter the wind energy into mechanical energy. The turbines are of horizontal and vertical axis turbine. The pitch control and yaw control is used in the aero turbine.

The wind turbine is selected as 7 KW rated power and it is modeled using its power characteristics equation given a (1), which shows the rated power generated by wind turbine [8].The rated wind velocity for this turbine is 10m/sand the rotor diameter is 6m. The output power of a wind turbine is dependent on the wind velocity and expressed as,

$$P = 1/2 C_p(\lambda,\beta)\rho A V_w^2 \tag{1}$$

Where, the air density ρ is 1.22. The area of rotor (A) is calculated as (πr2) 32 m2. The value of power coefficient C is function of blade pitch angle (ß) and tip speed ratio (λ), is obtained as,

$$C_P(\lambda,\beta) = C_1\left\{C_2\left(\frac{1}{\lambda_i}\right) - C_3\beta - C_4\right\}e^{-C_5/\lambda_i} + C_6\lambda \tag{2}$$

$$\frac{1}{\lambda_i} = \frac{1}{\lambda+0.08\beta} - \frac{0.035}{\beta^3+1} \tag{3}$$

III. Modelling of Solar-PV System

A 30 KW panel is considered as consisting of 24,080 solar cells arranged in 344X70 combinations. The solar array onsists of number of panels connected in series-parallel configuration and a panel consists of number of cells. The power characteristics of the solar cell are formulated using its equivalent circuit. The equivalent circuit of the cell is presented as a current source in parallel with diode and a parallel resistance with a series resistance [6]

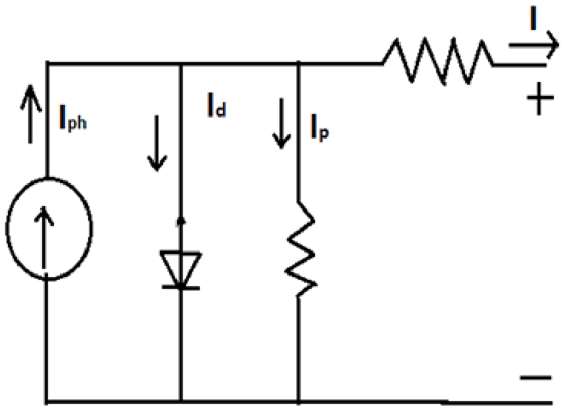

Figure 2: Equivalent circuit of a practical PV device

The output current can be measured by subtracting the diode currents and current through resistance from the light generated current. From this circuit, the output current of the cell is expressed as,

$$I = I_{ph} - I_d - I_p \tag{4}$$

Where, Iph = photocurrent, Id = diode current, Ip = current leak in parallel resistor

$$I_{ph} = \frac{G}{G_{ref}}(I_{ph,ref} + \mu_{sc}\ \Delta T) \tag{5}$$

Where,G = Irradiance (w/m^2), Gref = Irradiance 1000 (w/m^2), µ = coefficient temperature of short circuit current , ΔT = Tc –Tref, Tref = cell temperature 25 + 273 = 298 k.

$$I_d = I_o\left[\exp\left(\frac{V}{A\,N_S\,V_T}\right) - 1\right] \tag{6}$$

Where, A=ideality factor, Ns=number of PV cells, Vt= Thermal voltage, Io = leakage current of diode

Ns is the number of PV cells connected in series.
A is the ideality factor. It depends on photovoltaic cell technique

$$Ip = Io,ref\left(\frac{Tc}{Tc,ref}\right)^3 \exp\left[\left(\frac{q\,eG}{A\,K}\right)\left(\frac{1}{Tc,ref} - \frac{1}{Tc}\right)\right] \quad (7)$$

Where, eG: Material band gap energy (eV)
The model is not get into account the internal losses of the current. A diode is connected in anti-parallel with the light generated current source.

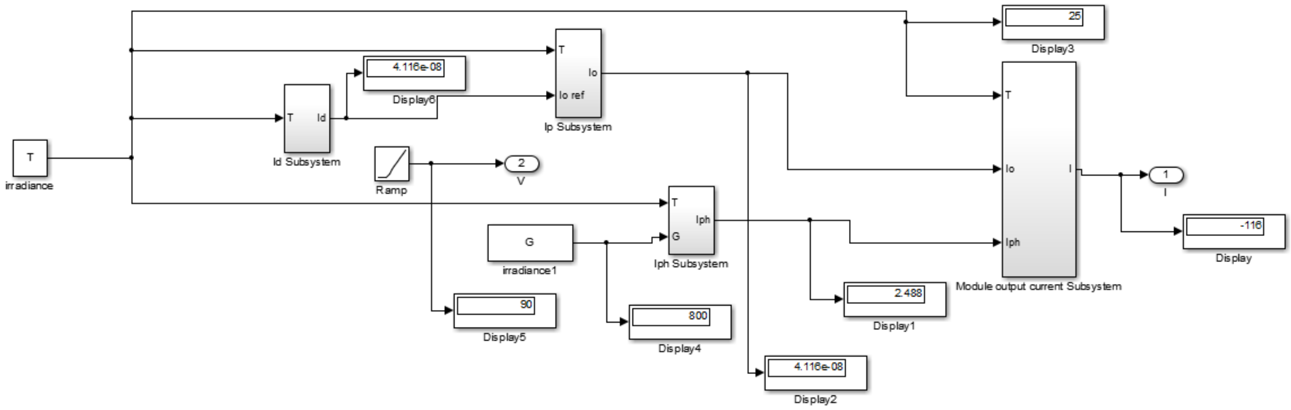

Figure 3: Simulink model of a PV device

Where, ns are numbers of cells connected in series. The output current of the solar panel is I. The light generated current is Ipv. Saturation currents through diodes are I_0. The voltage at output of panel is V Series resistance of cell is Rs which represents the internal resistance of cell and it is considered as 0.55 Ω. The Boltzman's constant is K (1.38 X 10^{-23} J/K). Ambient temperature (in Kelvin) is T and charge constant is q (1.607 X 10^{-19}C). A 30 KW solar-PV array is realized considering 24,080 cells (344×70 dimensions) using (4). A MATLAB model for the same is developed

VI. SIMULATION RESULTS

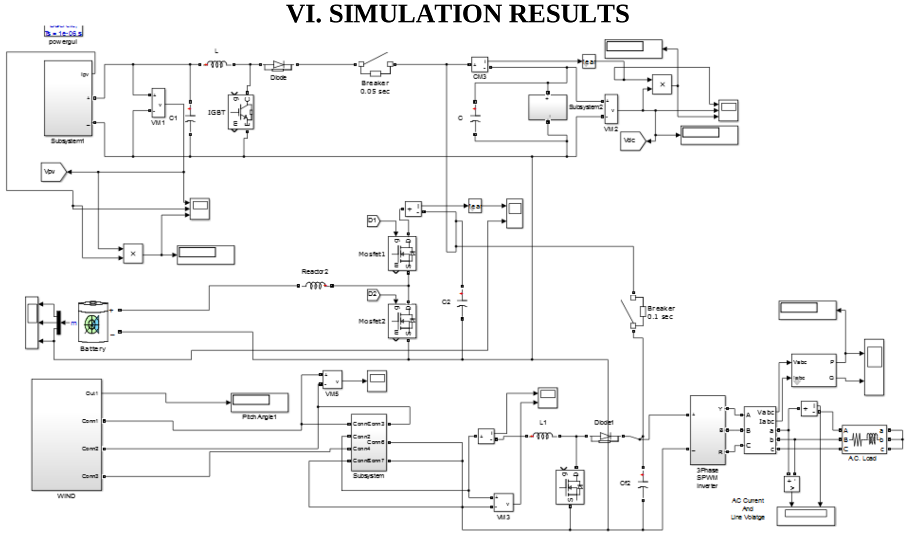

Figure 4: PV/WIND/BATTERY simulation

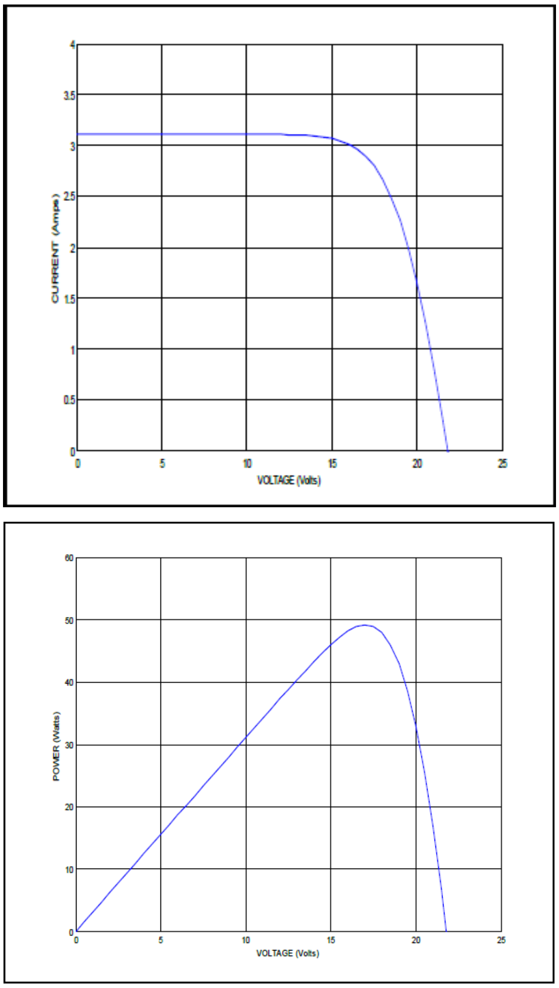

Figure 5: I-V and P-V characteristics of solar PV module at nominal condition

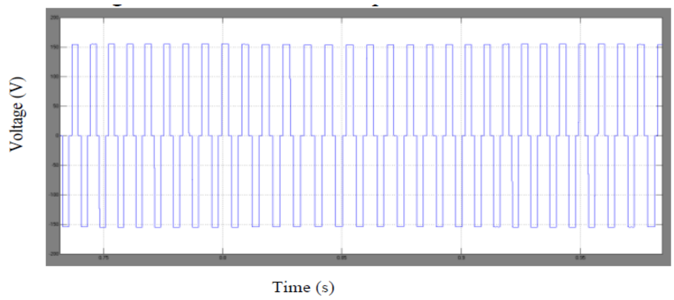

Figure 6: Voltage of wind turbine

Inverter output

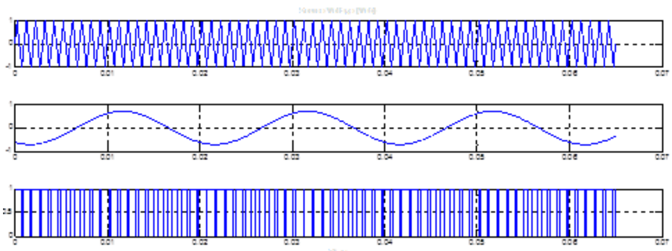

Figure 7: output of inverter

Dc link voltage.

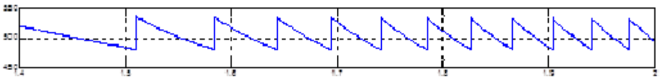

Figure 8: dc link voltage

V. CONCLUSION

this paper was mainly focused on some filtering on the BESS charge and discharge power have been achieved by using a power fluctuation rate constraint as the smoothing control target to prevent excessive excursions to “chase down” every PV or wind power output fluctuation. In addition, the control strategies of BESS and smoothing based on battery capacity established conditions was focused.

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