A Survey on Modelling Simulation & Performance Evaluation of Solar P-V Wind Hybrid Energy System

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Abstract— This paper describes the Simulation and analysis of hybrid energy system consisting of wind and solar PV system .The wind and solar PV system are connected to the common load through DCIDC Boost converter. Generally, in low radiation PV array system inverter gives the lower voltage than the rated voltage which affects the power quality. It is overcome by using Battery Energy Storage System. In the stand-alone mode the converter needs to maintain constant voltage and frequency regardless of load imbalance or the quality of the current, which can be highly distorted, if the load is nonlinear. The modeling and simulation of hybrid system along with the PI controllers are done using MA TLAB/SIMULINK. Simulation results show that the proposed hybrid system has the potential to meet the electricity demand of an isolated system.

Keywords: Renewable Energy, Photovoltaic, Wind Energy Conversion System, Hybrid Energy System, Inverter

I. Introduction

During the past few years renewable energy sources have received greater attention and considerable efforts have been made to develop efficient energy conversion and utilization system. The major goals of these approaches are to have reduced environmental damage, conservation of energy, exhaustible sources and increased safety. The renewable energy systems can be used to supply power either directly to a utility grid or to an isolated load. The stand -alone system find wider applications as water pumps, for village electrification, supply of power to isolated areas which are far away from the utility grid [2]. PV and Wind energy system are the most promising renewable energy technologies. A Photovoltaic (PV) system consists of a PV array, DCDC converter, DC-AC Inverter and load. The development of suitable algorithms to control the power converter is essential, for the efficient operation of the PV system. The use of the power control mechanism, called Maximum Power Point Tracking (MPPT) in a PV system, leads to an increase in the efficiency of operation of solar modules. The MPPT is basically an operating point matching between the PV array and the power converter. However, because of the non-linear P-V and I-V characteristics of the PV array, and the consequences of varying environment conditions, particularly irradiation and temperature, tracking the correct Maximum Power Point (MPP) is a challenging task. Using the information provided (MPP current or voltage) by MPPT, the duty cycle of the DC-DC converter is adjusted using PI controller to match the MPP, which in turn forces the converter to extract the maximum power from the PV array. Development of efficient control strategies to improve the steady state as well as dynamic behavior of DC-DC converter in terms of reaching its equilibrium condition, smoothly and quickly is necessary for the efficient operation of the PV system. The role of the inverter is to convert DC power into AC power at desired voltage and frequency.

II. Related Work

D.Hansen et.al [17] presented a number of approaches for modelling and simulation of stand-alone PV system with battery banle Wind power is another most competitive renewable technologies and, in developed countries with good wind resources, onshore wind is often competitive with fossil fuel fired generation. Wind power generation has experienced at remendous growth in the past decade, and has been recognized as an environmental friendly and economically competitive means of electric power generation. The wind energy system generates power in the form of AC with different voltage and frequency levels in case of variable speed operation. Solar energy system generates power in the form of dc voltage, the level of which varies depending on temperature and irradiation levels. Both these systems require power electronic interface for inter-connection with the grid. [18].The integration of renewable energy sources and energy storage systems have been one of the new trends in power electronic technology,
[lO]. Stand-alone wind with Solar Photovoltaic is known as the best hybrid combination of all renewable energy systems and suitable for most of the applications taking care of seasonal changes. They also complement each other during lean periods, for example additional energy production by wind during monsoon months compensate less output generated by solar. Similarly, in the post winter months when wind is dull, solar photovoltaic (SPV) takes over. This work proposes a solar PV and Wind.

III. Proposed Hybrid System

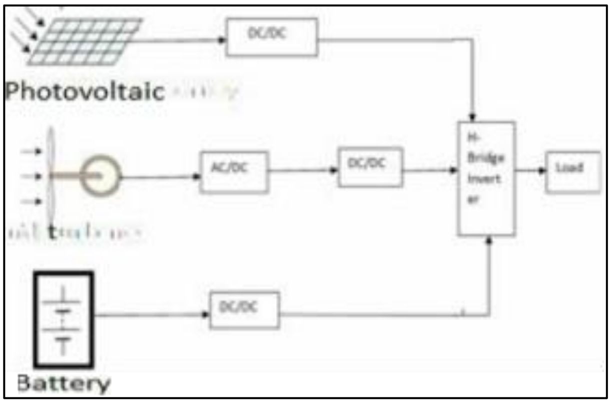

Fig. 1: Schematic Diagram of Hybrid System

The proposed system consists of a PV array and Induction generator-driven Wind energy conversion system meeting a common load. The PV system consists of PV arrays and corresponding DC/AC converter modules. Generally, according to the sunlight conditions, the maximum power point tracking control mode is adopted for PV system, which aims to utilization of solar energy [4]. A H-Bridge inverter is used to connect the load to the hybrid system. Batteries are used as backup option to store the power when the power production exceeds the demand. Thesupply from the battery is needed during peak hours when power demand is higher than the production.

IV. MODELLING OF VARIOUS RENEWABLE

A. Energy Systems

This section presents mathematical models of energy sources and power electronic converters used in the proposed hybrid energy system A. Modelling of Photo voltaic System

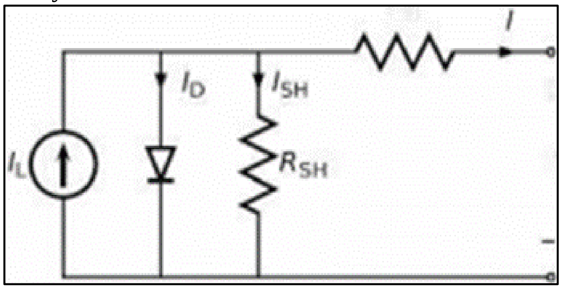

Fig. 2: Equivalent Circuit of Photovoltaic System

The PV system consists of PV arrays and corresponding DC/AC converter modules. Generally, according to the sunlight conditions, the maximum power point tracking control mode is adopted for PV system, which aims to utilization of solar energy. [4]. When exposed to sunlight, photons which energy greater than the band gap energy of the semiconductor are absorbed and create some electron hole - pair proportional to the incident radiation. The equations of the output current is given by

I = Ipv – ID (1)

Where
(I)

v To = To [exp- - 1] (2) AVT

Then equation (1) becomes

v 1= Tpv - Io[exp - - 1] (3) AVT

The I-V characteristics of a solar cell is given by

1= [exp (lpVv+-/l'oR,Vs T) - 1] (4)

P = V {Tsc - To [exp (□) - 1]} (5) AVT

IPV is the current generated by the incident of light, 10 is the diode reverse bias saturation current, VT = NS.K.T is the thermal Q voltage of PV module having Number of cells (S) connected in series; Rs starting resistance, Isc is the short circuit current, q is the electron charge; K = 1.38xl0-23 is the Boltzmann constant; T is the temperature of the p-n junction and A = 2 is the diode ideality factor. The output of the current source is directly proportional to light falling on the cell. Naturally PV system exhibits a non-linear Current – Voltage (I-V) and Power - Voltage (P-V) characteristics which vary with the radiant intensity and cell temperature. The dependence of power generated by a PV array with changing atmospheric conditions can readily be seen in the I-V and the P-V characteristics of PV arrays. B. Modelling of Wind System: The wind turbine depending on the flow of air in the rotor consists of two or three blades mechanically coupled to an electric generator. The power captured by the wind turbine is given by relation

Pw= 1 3) '2Cpp.A.Vw (6)

P is the air density, which is equal to 1.225 kglm3, Cp is the power coefficient, Vw is the wind speed in (m/s) and A is the area swept by the rotor inC m2). The amount of aerodynamic torque Tw in (N-m) is given by the ratio between Ihe power extracted from the wind Pw and turbine rotor speed Ww in (rad Is) as follows

Tw = Pwww (7)

B. Modelling of Battery

The storage capacity at any given time (t) is expressed as

Cbat (t) =Cbat(t-l)+ ppv(t) + P wg(t)- PlQaa(t).lIcad !1t·l1b (8)

Where Cbat (t) and Cbat(t_l) is the available battery capacityat time (t) and (t-I).Ppvis power generated by Photovoltaicsystem ,Pwg is power generated by wind turbine generator,P10ad (t) is power consumed at load t, t is simulation step (□t =thrs), I1cad is efficiency of AC/DC converter and l1b is batterycharging efficiency which depends upon charging current andmay vary from 0.65 - 0.135. When wind alone cannot meet the power demand but combining with PV can, i.e., l1invPwgCt) +Ppv(C) □ P'oad (t). In such case the excess power ifavailable is used in cbarging the battery. Battery storagecapacity in such case is given by:

C' ((Pload(t)-PWg(t))) Cbat(t) Cbat t - 1) Pp.,Ct) lIinv M·l1b (9)

C. DC-DC Boost Converter

DC-DC boost converter is a most efficient topology which ensures good efficiency along with low cost. A DC-DC boost converter is connected next to full-wave bridge rectifier to raise the voltage of the diode rectifier. A capacitor C 1 is connected across rectifier to lessen the variation the rectified AC output voltage waveform from the bridge. Figure 3 shows the arrangement of the DC-DC boost converter circuit.l D

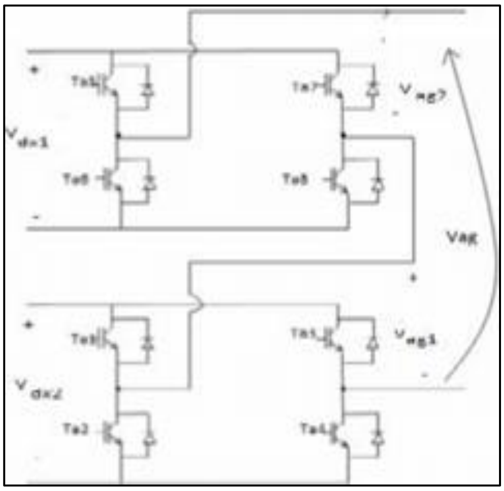
Fig. 3: DC-DC Boost Converter Circuit

The model of the boost converter is needed to simulate andanalyze the behaviour. The input and output voltage of theboost converter under an ideal condition can be related as

Vi= Vo * (1 - D) (10)

Vi is the input voltage, Vo is the output voltage and 0 is duty cycle. Given the value of 0, it is possible to find the minimum values for inductance and capacitance using the equations given below.

(l-D)O Ro (11)

Lmin = --2{ ---.::.
C DVo (12)
min = VrR of

Where, Vr is the ripple voltage, Ro is the output resistance and f is the switching frequency. An important consideration in DC-DC converters is the use of synchronous switching which replaces the flywheel diode with a power IGBT with low "on" resistance, thereby reducing switching losses. This is achieved by using a Pulse Width Modulation (PWM) switched mode control design or PWM. The PWM performs the control and regulation of the total output voltage. If the semiconductor device is in the off-state, its current is zero, and hence, its power dissipation is zero. If the device is in the on state, the voltage drop across it will be close to zero, and hence, the dissipated power will be very small. The most common strategy for controlling the power transmitted to the load is the Pulse Width Modulation (PWM).

D. Three Level H- Bridge Inverter

Figure 3 shows the a-phase of a Cascaded H - Bridge inverter utilizing two three level cells. The b - and C- phases are identical to the a-phase. Here H - Bridge inverter will be designated according to the voltage levels. In terms of the general mathematical description, it can be noted that p = 2, n l= 3, and 112 = 3. If the dc voltage of each cell i set to tbe same value (VdX1 = VdX2 = E) when VdX1,vdx2 are inverter input voltage., then the resulting inverter can operate with five voltage levels, and two output voltages Vag1,vag2 and Vag is the total H-Level inverter output voltage. Table I shows the zero and positive voltage levels obtainable from this inverteras well as the voltage levels from the individual H - bridge cells. The positive levels of E and 2E are possible output voltages as well as O. Due to the inverter symmetry, it is also possible to have negative output voltages of -E and -2E for a total of five voltage levels.

V. CONCLUSION

This paper has described a hybrid energy system with variable speed wind generation, photovoltaic system with power electronic interface under stand-alone mode. Computer simulation was conducted using MATLAB/SIMULINK. In the stand-alone mode the performance of the system is evaluated for various wind speeds and various irradiation levels and the performance was analyzed. Due to variations in wind speed and solar irradiation AC voltage varies. Battery system is used to maintain the balance between the source and load. The performance of the developed system is evaluated in

MATLAB/SIMULINK platform and the results are presented.

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