RENEWABLE ENERGY BASED HYBRID POWER SYSTEM WITH RELIABILITY ENHANCEMENT

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Abstract : Recent developments in renewable energy sources have shown that they can contribute more to the grid along with conventional sources. In order to synchronize with the grid and to meet the ever increasing load demands during varying atmospheric conditions, various renewable energy sources needs to be integrated with each other. This paper describes modeling and simulation of a renewable energy based hybrid system connected to the grid through a intermediate DC bus. To optimize the power output from each of the renewable energy sources, Maximum power point tracking (MPPT), algorithm is used along with a buck boost converter to obtain a stable voltage. The output from the dc bus is used to drive a DC motor coupled with an alternator to supply ac power, which can be either connected to the grid or directly to the loads. The renewable energy sources used are wind turbine, and a PV cell. The design of the proposed hybrid system will effectively manage the optimal utilization of both the energy sources and ensures reliability in power supply during varying atmospheric as well as load conditions.

***IndexTerms* - Hybrid system, Renewable energy Sources, DC Motor- alternator, grid.**

I. INTRODUCTION

Nowadays energy demand is steadily increasing, due to increase in loads. It is very much essential to meet the continuous increase in demand of electric energy. The solution to meet the increase in load demand can be obtained from the recent development in alternative energy sources which has excellent potential to contribute together with conventional power generation systems. The renewable energy source offers many advantages over conventional power generation systems, such as low pollution, diversity of fuels, reusability of exhausts, and onsite installation [1]. Hybrid systems combine two or more energy conversion devices, when integrated overcome the limitations inherent in each other source. In this system, the output from the renewable energy source cannot be fed to the loads directly because of voltage fluctuations, which may reduce the lifetime of the connected loads. Hence power supply from renewable energy system needs to be conditioned, before being connected to the dc bus. A control algorithm needs to be developed which will optimize energy from each renewable energy source [2]. In this paper power optimization is done with the help of Maximum power point tracking (MPPT), algorithm. The output from each renewable energy source is then fed to a boost converter, to obtain a constant dc voltage [3]. The dc voltage can be maintained at the required values and specified limits by varying the duty ratio of the converters, and then connecting to the DC bus [4]. The dynamic behaviour of the proposed system is simulated by changing wind speed, solar radiation and varying load conditions.

II. PROPOSED SYSTEM

The block diagram of the proposed system is shown in figure.1. The DC bus is used for integrating the entire renewable energy sources. To have an optimum, efficient and reliable operation of each source, MPPT algorithm is used. A boost converter is connected at the output of each renewable energy source. Modeling and simulations are conducted using MATLAB/ Simulink [1] to verify the effectiveness of the proposed system.

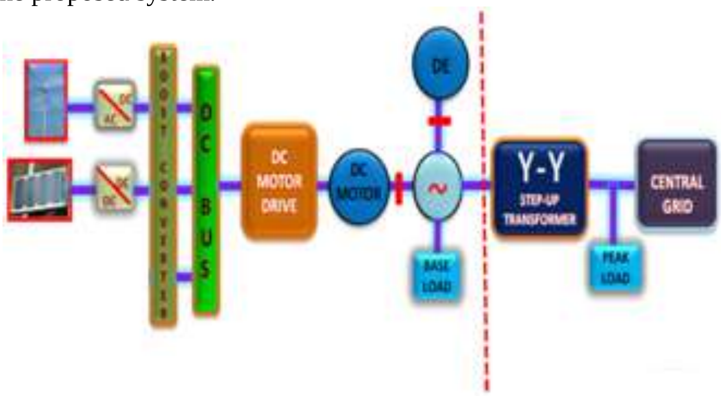

Figure 1: proposed hybrid Renewable System Block diagram

III. MODELING AND SIMULATION

a. PV Panel

Photovoltaic/solar cell is the device which converts sunlight into electricity directly in which magnitude of current and voltage depends on many factors like temperature, solar irradiation, and wave length of incident photon etc [5]. The output from the solar cell is a DC voltage. The one diode electrical equivalent circuit shown in figure 2 is commonly used for cell based or module based analysis. It consists of a diode, a current source, a series resistance and a parallel resistance [6]. The current source generates the photo-current which is a function of the incident solar cell radiation and temperature [7], [8]. The PV array VI characteristic is shown in figure 3.

In the circuit model, the voltage loss is expressed by a series resistance (R_s) and the leakage currents are expressed by a parallel resistance (R_{sh}). Nevertheless, the series resistance is very small and the parallel resistance is very large [8]. Hence R_s and R_{sh} can be neglected.

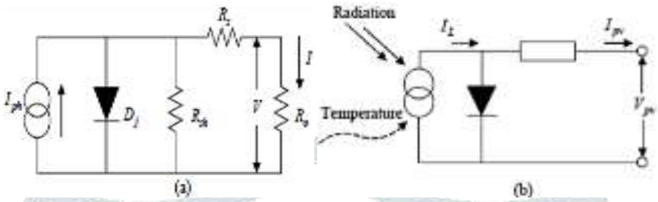

Figure 2: solar cell (a) equivalent circuit (b) simplified circuit

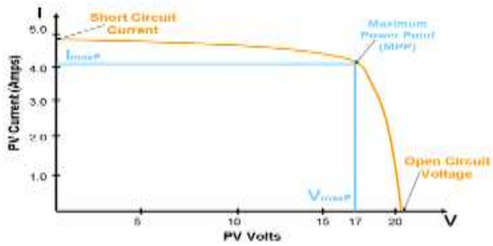

Figure 3: PV array V-I characteristics

The Simulink model of the PV panel is depicted in figure 4. The modeling equations used to develop the PV panel are given by equations 1-4.

$$I_{PV}(t) = I_{sc}\left\{1 - C1\left[\exp\left(\frac{Vmp}{C2Voc}\right) - 1\right]\right\} + \frac{Ett(t)}{Est}[\alpha(Ta(t) + 0.002Ett(t) + 1] - Imp \quad (1)$$

Where $i_{py}(t)$ is the solar current.

The PV cell voltage equation are given by

$$V_{PV} = V_{mp}\left[1 + 0.0539log\left(\frac{Ett(t)}{Est}\right)\right] + \beta(T_a(t) + 0.02E_{tt}(t)) \quad (2)$$

$$C_1 = \left(1 - \frac{Vmp}{Isc}\right)\exp\left[\frac{-Vmp}{C2*Voc}\right] \quad (3)$$

$$C_2 = \frac{\frac{Vmp}{Voc} - 1}{\ln(1 - \frac{Imp}{Isc})} \quad (4)$$

Using the above equations PV cell is modeled in Simulink.

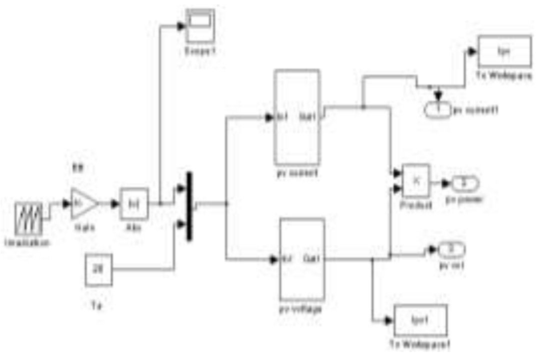

Figure 4 Simulink model of PV panel

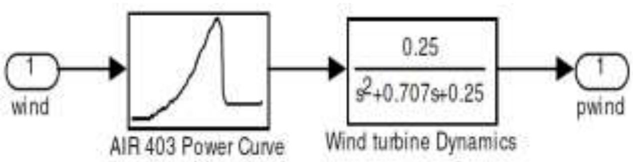

Figure 5 Simulink model of Wind turbine

IV. CONTROL SYSTEM

The power output from the wind turbine is related to the wind speed with a cubic ratio. The power curve from the wind turbine AIR 403 obtained is nonlinear [9] [10], is used to model it in Simulink as shown in figure 5. The first order moment of inertia (J) and a friction based dynamic model for the wind turbine rotor, and a first order model for the permanent magnet generator is used for simulation. The dynamics of the wind turbine due to its rotor inertia and generator are considered in the wind turbine response as a second order slightly under-damped system [11], [12]. Using this simple approach, small wind turbine dynamic is modeled as

$$P_g(s)/P_{wt}(s) = 0.25/\ (s^2+0.707s+0.25) \quad (5)$$

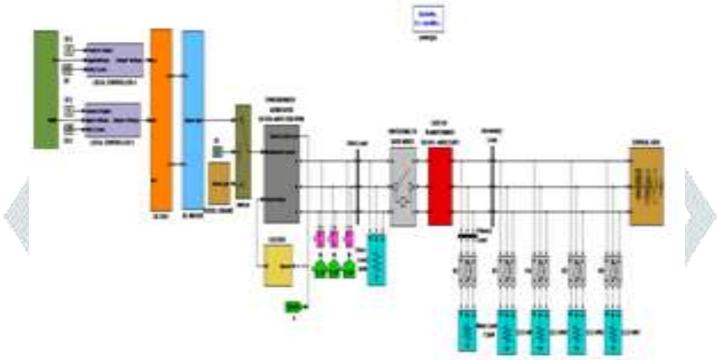

Figure 6 Proposed Hybrid power system model using Simulink

To control the power output from the renewable energy sources, a special MPPT controller is required. The proposed system is operated with MPPT and a boost converter to boosts the variable DC voltage output of solar/wind and to bring the dc output voltage to 220 V dc. Maximum power can be extracted from a PV/WT system when MPPT is done on each one of them. Individual tracking systems are implemented for PV/WT to ensure the maximization of system's efficiency.

Boost converters gives a output voltage higher than the input voltage i.e., acts as step-up converters. In the proposed work, boost converter is used to control the output voltage and current of the PV module. The output voltage of the boost converter has an output that is equivalent to the input voltage divided by the duty cycle.

The Pulse Width Modulation (PWM) technique of the boost converter is obtained by comparing the reference and measured voltages. The error signal is then compared with the carrier signal to obtain the switching PWM signals. MPPT algorithm using Perturb-and-observe (P&O) strategy is used to generate the duty cycle of the switches in the boost converter. MPPT algorithm calculates the maximum available power from the solar/ wind system, and then compares the calculated power with the actual drawn power for generating the switching signals of the DC-DC boost converter. Further a DC-DC boost converter is connected after the MPPT to maintain the voltage level of the DC bus at 230 Volt dc to ensure continuous power supply to the DC motor.

The work of MPPT algorithm in Wind energy system is the control of the output voltage of a diode bridge rectifier attached to the permanent magnet generator. When the speed is less, the dc output voltage is lowered to prevent the dc link from reverse biasing the diode rectifier. Since the current output from WT is proportional to torque, the DC-DC boost converter will provide control over the speed of the turbine.

V. SIMULATION RESULTS

The proposed model shown in figure 6 is simulated using MATLAB/Simulink [14]. The simulation results of the proposed hybrid system are depicted in figures 7, 8 and 9. To perform simulation and to study the performance of the system, various loads are added to the system at 0.1s, 0.175s, 0.26s, 0.33 and 0.42 sec respectively. From figure 7 it can be seen that the output voltage from individual renewable energy source will remain constant irrespective of load additions, with the help of MPPT algorithm and boost converter. The output ac voltage remains constant for addition of different loads as depicted in figure 8 and the increase in currents and power for raise in load can also be observed in figure 8. The THD values remain at a lower value as illustrated in figure 9. The values of increase in load and efficiency are shown in figure 10.

The sum of power generated by both renewable sources is designed to meet the required DC bus voltage as the output power of solar and wind system fluctuates with irradiation and wind speed.

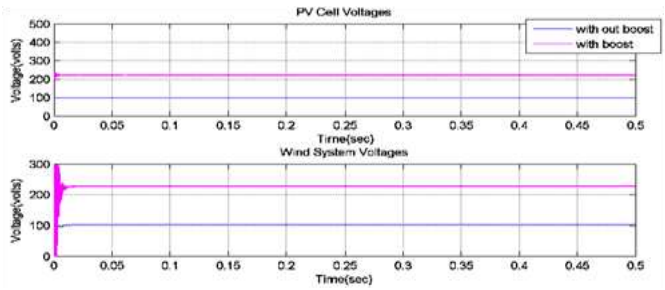

Figure 7 Voltages at Dc bus with and without Boost Converter

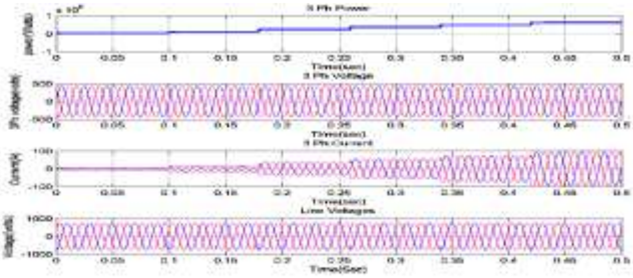

Figure 8. 3-Φ Power, Phase Voltages, Currents & Line Voltage

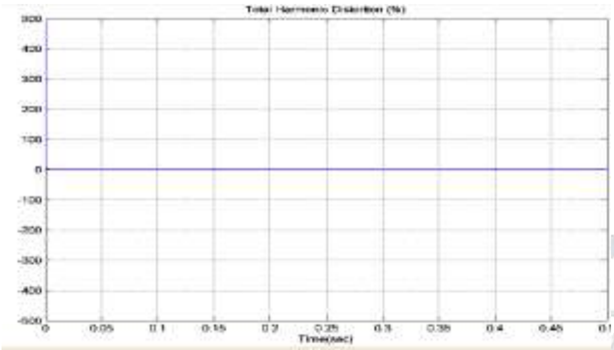

Figure 9 Total Harmonic Distortion of Proposed system

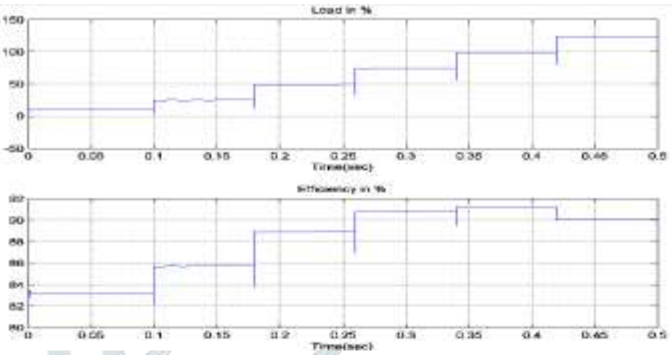

Figure 10 Load and Efficiency of Proposed system

V. CONCLUSION

In this paper, a reliable renewable energy based hybrid system is proposed. The system is modeled for a grid connected system, with the method of using DC Motor-Alternator setup instead of using static converters. The proposed system facilitates improvement in voltage profile, which ensures continuous and reliable power supply to loads. The voltage and THD values are found to be within the acceptable range as discussed in the results section. Hence, this system can adjust to the changes in loads and environmental conditions, and suppress the effects of these fluctuations and provides optimum utilization of available resources.

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