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Wind and PV Hybrid Micro Grid Power Generation System

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Abstract: Demand for renewable energy (RES) systems is increasing, and research into wind and PV System has reached a pace in current years. Currently, the world is highly dependent on fossil fuels for energy needs, and these fossil fuels are on the brink of extinction. Demand for renewable energy will increase sharply in the coming years. Our work presents a hybrid system of energy generation with photovoltaic and wind system. Wind and PV system is connected to the grid as well as with each other. A control strategy is designed to maximize the benefits of such network interface system. The inverter is programmed to work as a multi-functional device with active power filtering capabilities. As a result the inverter is employed to power the RES energy in the network as a power converter. All analysis is performed and validated by the MATLAB / Simulink simulation, placing the system under dynamic load conditions.

Keywords: Renewable Energy, MPP, Converter, Inverter, Hybrid System, Permanent Magnet Synchronous Generator(PMSG)

I. INTRODUCTION

The rapid worldwide reduction of fossil fuels has created an alarming condition for tomorrow's energy needs. Solar, wind and hydroelectric power are the example of the alternative energy resources that are clean, that is, H. Environmentally benign and have a lot of promise.[1] In countries with good sunny days, photovoltaic energy can be used without problems. Non-renewable energy resources continuously and steadily provide the network. However, given the climatic conditions, variations of PV, wind and hybrid generation may occur, which can lead to problems such as extreme frequency change of the network. To achieve the reliability of a system, it must be connected to another power source to obtain continuous power generation.

II. PHOTO VOLTAIC SYSTEMS

A photovoltaic (PV) system switches light energy into electricity, and the photovoltaic cell is the system's basic unit. PV cells of this type can be joined or grouped to make photovoltaic panels or photovoltaic panels. Small loads, such as lighting systems and direct current motors, can be directly fed by the voltage and current available at the terminals of a photovoltaic device. [3]. Photovoltaic cells consist of different types of semiconductors that use different manufacturing processes. [3][4]The impact of light on the cell generates charge carriers that generate electric current when the cell is shorted. The photovoltaic array generates DC energy based on the amount of light it receives.[5][6] Direct current is converted to alternating current with phase and frequency using an inverter or a universal bridge. Figure 1 depicts the

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photovoltaic system's equivalent circuit.

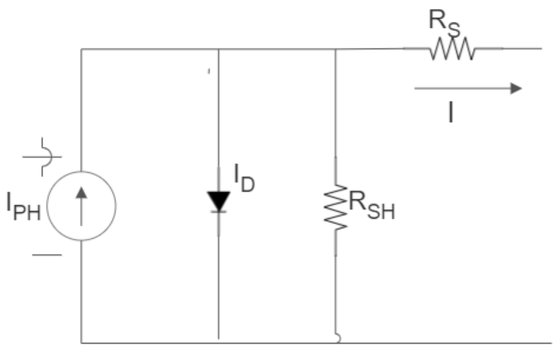

Figure 1: PV system equivalent circuit schematic with series and parallel resistance

This paper uses eight photovoltaic modules whose Simulink diagram is shown in Figure 2. Its electrical behavior and its properties depend on temperature and illumination.[9][10] Solar radiation is 1000 W / m2. The characteristic equation of the photovoltaic module is given as

$$I=I_L-I_0(e^{q(V+IRs)/nKT}-1) \quad (1)$$

Where I_L stands for photo current

I_0 for diode saturation current

R_S for series resistance, q for electron charge

T for temperature, and N for the number of PV modules.

This equation can be used to calculate the output power of a PV system.

$$P_{pv}(t)=Ins(t)*A*Eff_{(pv)} \quad (2)$$

Where

Ins (t) is the data on insolation at time t (kw/ m2)

A is the area of a single PV panel (m2)

Eff(pv) denotes the PV panels' and dc/dc converters' overall efficiency.

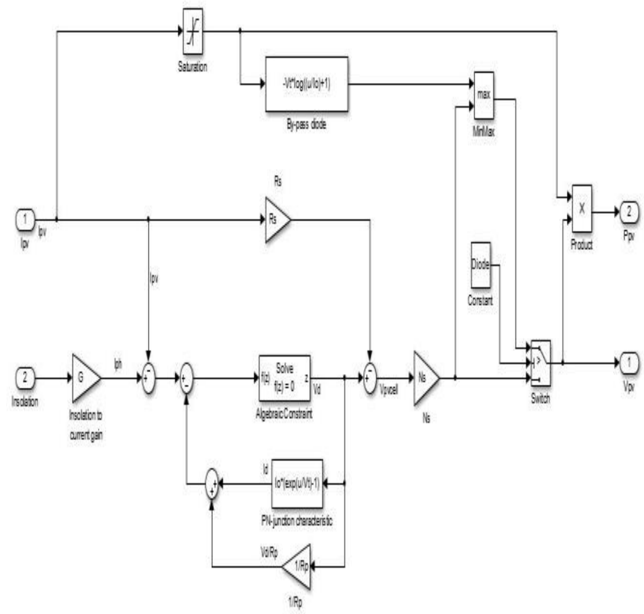

Figure 2: Simulink of Photovoltaic System

III. WIND ENERGY SYSTEM

The kinetic energy of a rotor with numerous blades is detected and converted into electrical energy by a wind turbine. This procedure can be carried out using wind energy to power a windmill, which then activates a generator to generate electricity [4]. In this situation, the windmill is referred to as a wind turbine. This turbine converts wind energy into mechanical energy, which is then transferred into electrical energy via a generator. The wind energy conversion system [5] is a system that combines wind generators, wind turbines, and wind turbines.[9][11] Based on the axis around which the turbine revolves, wind turbines can be divided into two categories.. Turbines that revolve horizontally are extremely efficient. The wind

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turbine's components are depicted in the diagram.

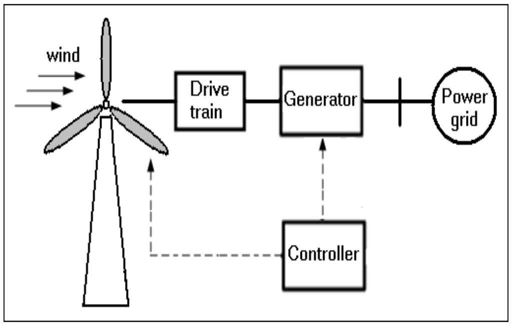

Figure 3: Wind energy system components

The wind turbine's output power equation is as follows:

$$\mathbf{P_m=C_P(\beta,\lambda)\rho A/2(V_w)^3} \qquad \mathbf{(3)}$$

Where Pm stands for Turbine mechanical output power

C_p stands for turbine's Performance coefficient

ρ stands for Air density Kg/m^3

λ= speed ratio

A stands for turbine's swept area

B stands for blade's pitch angle

V_w stands for speed of wind in m/s

PMSG is used for greater performance and efficiency. Figure 4 depicts the model of a wind turbine.

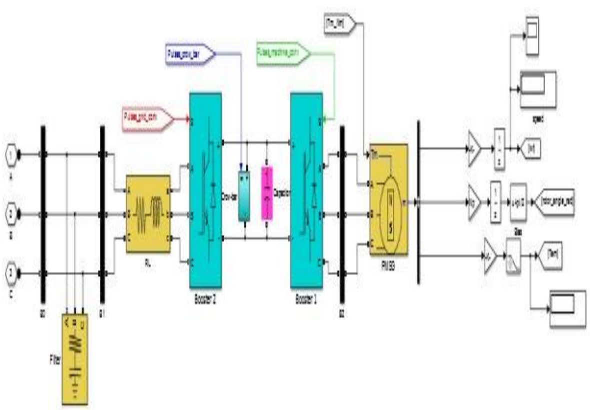

Figure 4: Model of wind energy system using PMSG

IV. PROPOSED MODEL

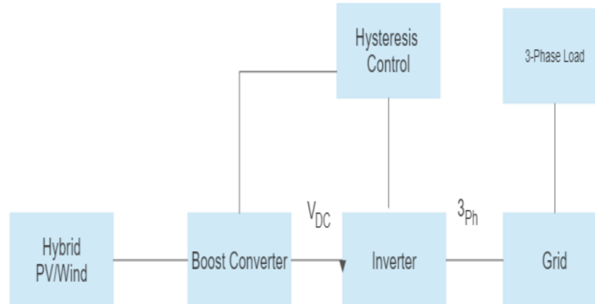

Figure 5: Proposed Model Block diagram

Figure 5 depicts the Renewable energy generation system with wind and Photo voltaic as main source. [12][3]The power generated by photo voltaic is generally a low voltage D.C and the power generated by wind is generally variable A.C. so a power conditioning required a.c-dc or d.c-d.c to create a D.C. link out of both to make a hybrid system.[1][2] The PID controller tunes the Vdc at 800 volts by controlling the D.C link voltage after boost converter conditioning. The three-level inverter converts dc voltage to three-phase AC and synchronizes the AC. voltage generated with the grid voltage levels using the phase locked loop referencing and hysteresis control.

A. Control Strategy

Because Renewable Energy Systems are intermittent, the amount of electricity generated varies. The DC link is essential for transmitting fluctuating energy from a RES to the grid. RES is represented by power sources connected to a network inverter's DC link. The Simulink model for tweaking and stabilizing the CC link DC voltage is shown in Figure 6.The desired tuned D.C value is 780 volts which is fed as the reference voltage and subtracted from the current

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value of the VDC to get the error and fed to the PID controller. Furthermore, PID controller decides the duty ratio of the IGBT of the boost converter to tune the Voltage level to its desired value.

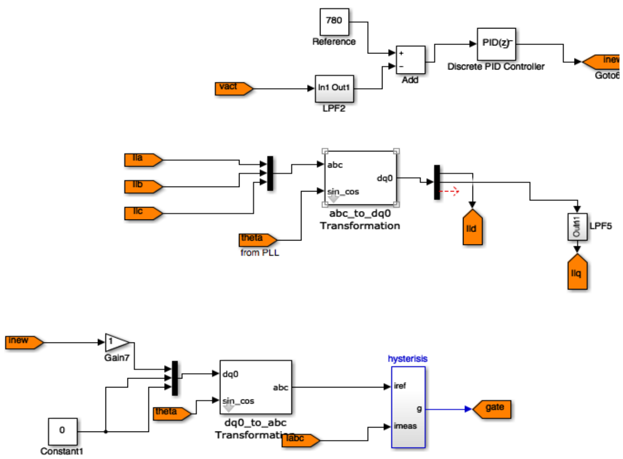

Figure 6: Control Strategy Simulink block

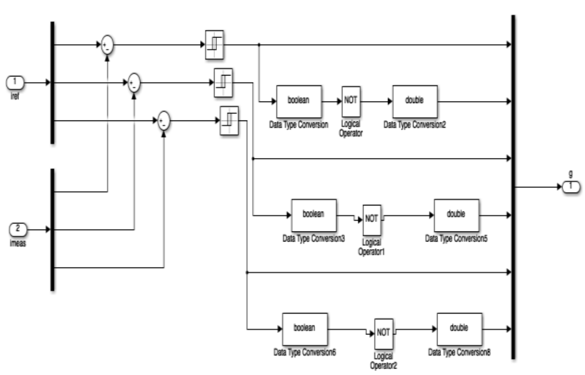

Figure 7: Hysteresis Control Simulink blocks

The hysteresis controller extracts the line voltage and current source reference and compares them with the measured voltages and currents of the inverterIf the load connected to the line side is not linear, unbalanced, or both, the control strategy compensates for harmonics, unbalance, and neutral current. In one power cycle, the duty cycle of the inverter switches is modified in order to feed the load and inverter combination. Figure 7 shows the Simulink hysteresis control model to provide gate pulses to the inverter.

IV. EXPERIMENTATION RESULTS

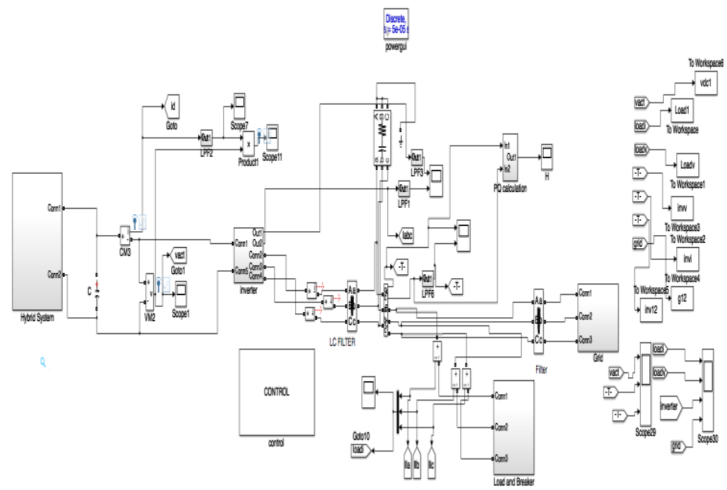

Figure 8: Final Simulink model

Figure 8 shows the final proposed Matlab Simulink model where the Hybrid system maximum capacity is **10KW** with **6KW** capacity of PV and **4KW** capacity wind generation system. The VDc is set to 780 volts, and the hybrid system generates 8 KW of power.

The Load variation is done to display the dynamic stability of the system under variable load. The load values taken are **12KW** and **9KW**. The first priority to provided power is from renewable source and the remaining one will be taken from grid. and the synchronization of the grid and inverter is done using PLL and hysteresis control.

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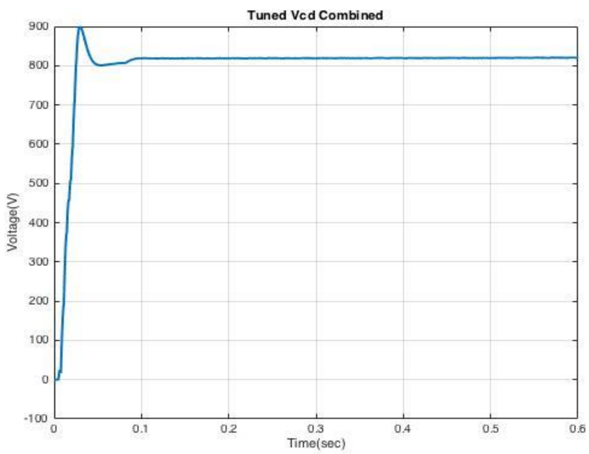

Figure 9: Tuned Vdc

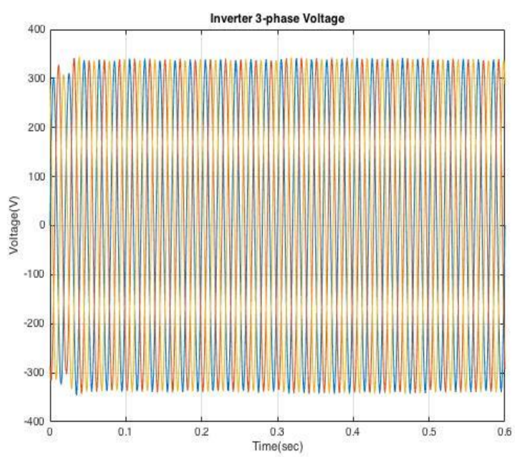

Figure 10: 3-Phase Inverter Voltage

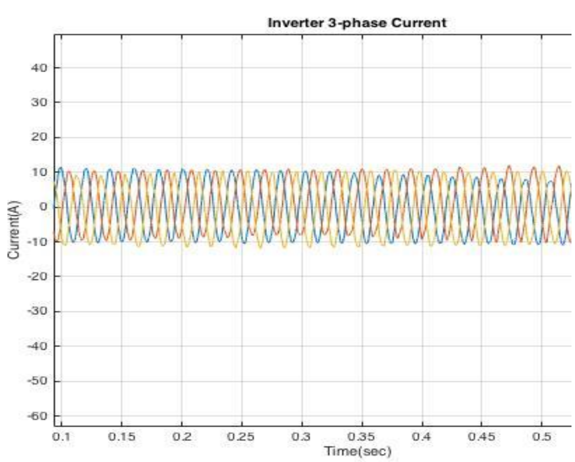

Figure 11: 3-phase Inverter current

Figure 10 and 11 displays the 3-phase voltage and currents of the inverter respectively. [12]The voltages and currents of the inverter are stable and in phase with the grid shows the proper synchronization with the grid.

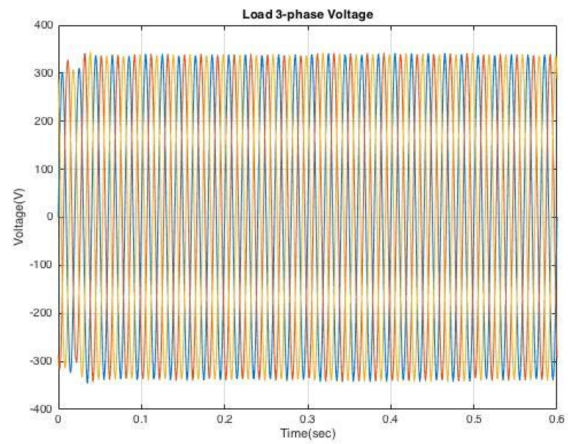

Figure 12: 3-phase LoadVoltage

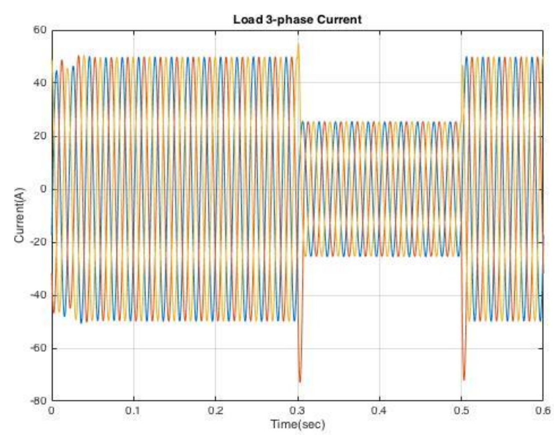

Figure 13: 3-phase Load current

Figures 12 and 13 illustrate the load voltages and currents, respectively. The voltage is smooth, as can be seen in the graph,the current variation is there at 0.3 seconds till 0.5 seconds due to the change in the load demand on the run time which was reduced from 12KW to 9 KW in that duration. [8][9]It can be noted that in the variation of load also the current level doesn't show any unbalancing and not much of spikes reflects in the stable system.

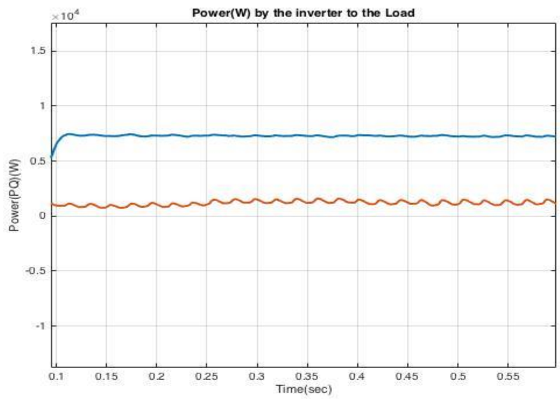

Figure 14: Inverter Power to Load

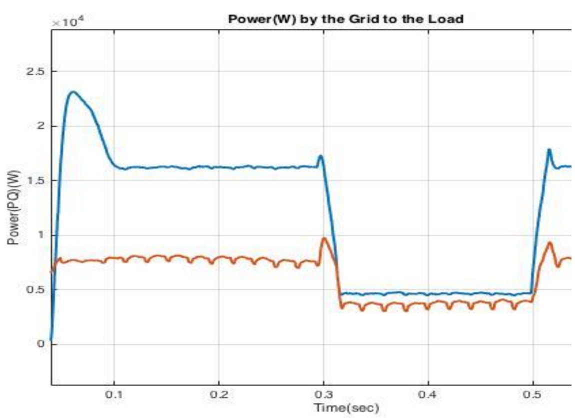

Figure 15: Grid Power to Load

Figure 14 and 15 shows the sharing of the power provided to the load by two generating sources inverter and Grid respectively. The inverter the supplying the constant 8KW power to the loads shown in figure 14 and the rest reaming is provided by the grid.

V. CONCLUSION

Hybrid wind-photovoltaic system has been successfully established. The tuned Vdc is achieved using the PID controller. The inverter output is synchronized with the GIRD using the Phase Locked Loop (PLL) with current hysteresis control. The power quality is improved and the stability of the system is also visible on the interchanging of the load in the run time.

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