

Simulation And Analysis of Solar PV System With Hybrid Operation of Wind Power Plant With Battery Operated Charge Controller

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Abstract-Renewable energy is derived from natural processes that are replenished constantly. The different renewable energy sources which are generally used are solar, wind, ocean, hydropower, biomass, geothermal energy, etc. Each of these sources has unique characteristics which influence how and where they are used. For fulfilling the global energy demand hybrid energy system is the better option. The importance of hybrid systems has grown as they appeared to be the right solution for a clean and distributed energy production. So that new implementations of hybrid systems require special attention on analysis and modelling. This paper deals theoretical study of hybrid systems, based on renewable energy is the availability of models, which can be used to study the behaviour of hybrid systems and most important, software simulation environments. In this paper we present several models which can be used for the simulation purposes of hybrid power systems.

I. INTRODUCTION

India currently has a peak demand shortage of around 14% and an energy deficit of 8.4%. India is facing an acute energy scarcity that hampers the country's industrial growth and economic progress and setting up of new power plants is inevitably dependent on import of highly volatile fossil fuels. The increasing consumption of conventional fuels coupled with environmental degradation has led to the development of eco-friendly renewable energy sources. The development of remote rural areas could not take place even after more than 50 years independence, as the grid could not be extended due to its high cost, capacity shortage and difficult terrain and environmental considerations. It becomes necessary to take up electrification of remote villages through non-conventional energy sources such as solar, micro-hydro and wind systems. Hybrid power systems consist of a Combination of renewable energy sources as photovoltaic (PV), wind generators, hydro(etc) to charge batteries and provide power to meet the energy demand, considering the local geography and other details of installation. The solar power we are taking directly from sun, wind energy is obtained from the air movement on the earth's surface determined by the difference in speed and pressure. Small hydroelectric power plants harness the falling water kinetic energy to generate electricity.

II. 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 consists 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].

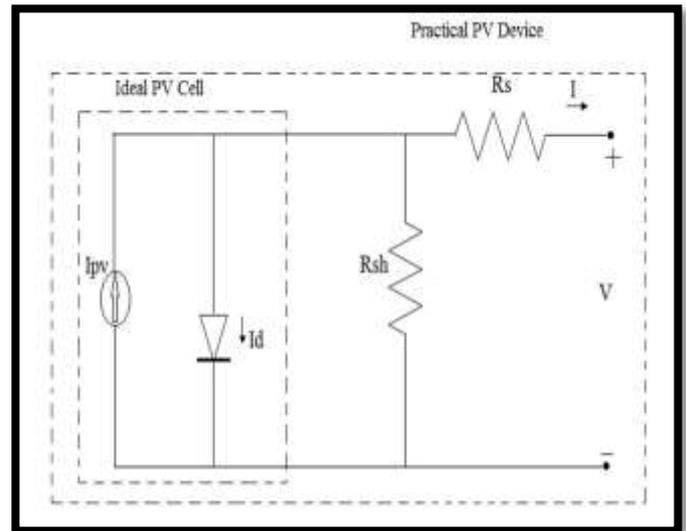


Fig.1: Equivalent circuit of a practical PV device

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,

$$I = I_{pv} - I_d - I_{Rsh} \quad (1)$$

$$I = I_{pv} - I_0 \left[\exp\left(\frac{V+IR_s}{a}\right) - 1 \right] - \left(\frac{V+IR_s}{R_p}\right) \quad (2)$$

$$\text{Where, } a = \frac{NS.A.K.Tc}{q} = NS.A.V_T \frac{I_{sc} + K_v * dT}{\exp\left(\frac{V_{oc} + K_v * dT}{a * V}\right) - 1}$$

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 I₀. 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 Boltzmann's constant is K (1.38

$\times 10^{-23}$ J/K). Ambient temperature (in Kelvin) is T and charge constant is q (1.607×10^{-19} C).

III. MODELLING THE WIND SYSTEM

Modelling of the wind energy converter is made considering the following assumption:-

- frictionless
- stationary wind flow
- constant, shear-free wind flow
- rotation-free flow
- incompressible flow ($\rho=1.22$ kg/m³)
- free wind flow around the wind energy converter

On the above condition the maximum physically achievable wind energy conversion can be derived by a theoretical model that is independent from the technical construction of a wind energy converter. Energy of the flow air mass has certain energy. This energy is obtained from the air movement on the earth surface determined by difference of speed and pressure. The wind turbines use this energy as the main energy for obtaining electric power. The kinetic energy W taken from air mass flow m at speed v₁ in front of wind turbine pales and in the backside of pales at speed v₂ is illustrated by following equation:-

$$W = \frac{1}{2} m(v_1^2 - v_2^2) \dots\dots\dots (3)$$

The Matlab modelling of PMSG type wind power plant is shown in the fig.2 below. The Excitation system and Wind turbine section is provided with synchronous generator. The simulation results shows the output voltage of wind turbine and also shows the different parameters output like stator voltage, excitation voltage and other mechanical parameters also. The Matlab model of wind power plant includes the subsystem of wind turbine and PMSG generator at input side and the models of DFT and Hysteresis controller for wind power generation controlling are also shown in the below section figures of different blocks subsystems.

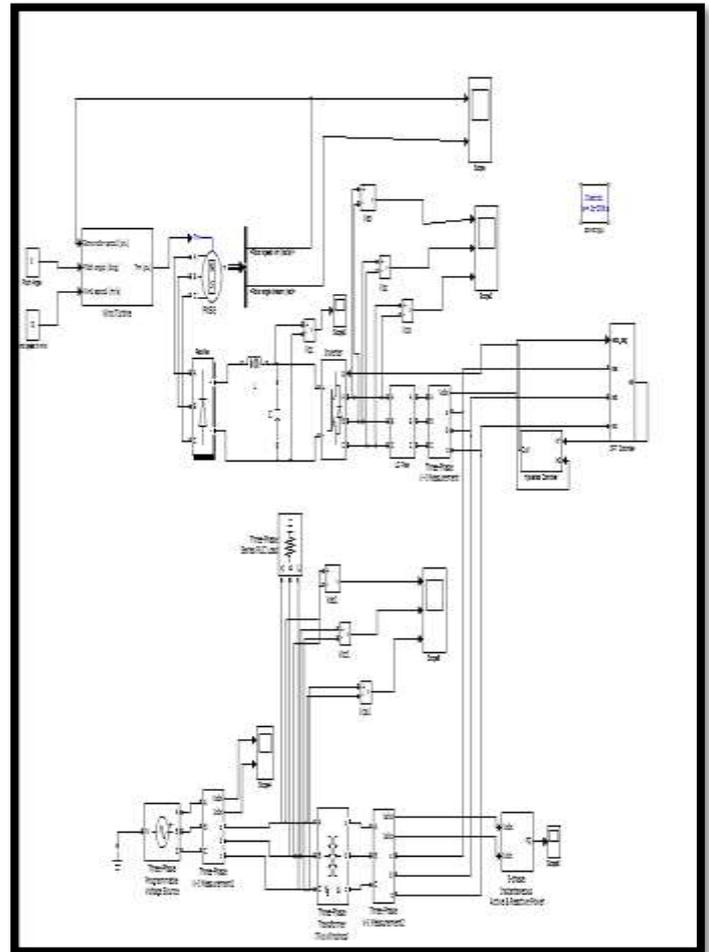


Fig.2- Wind Power Plant Matlab Simulink model

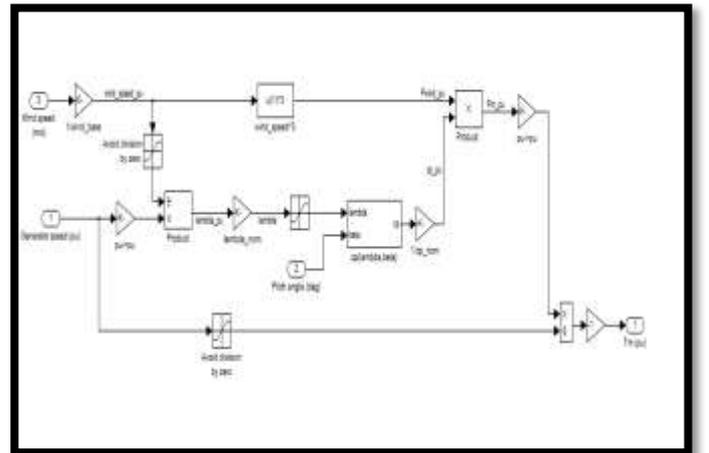


Fig.3- Subsystem of wind turbine

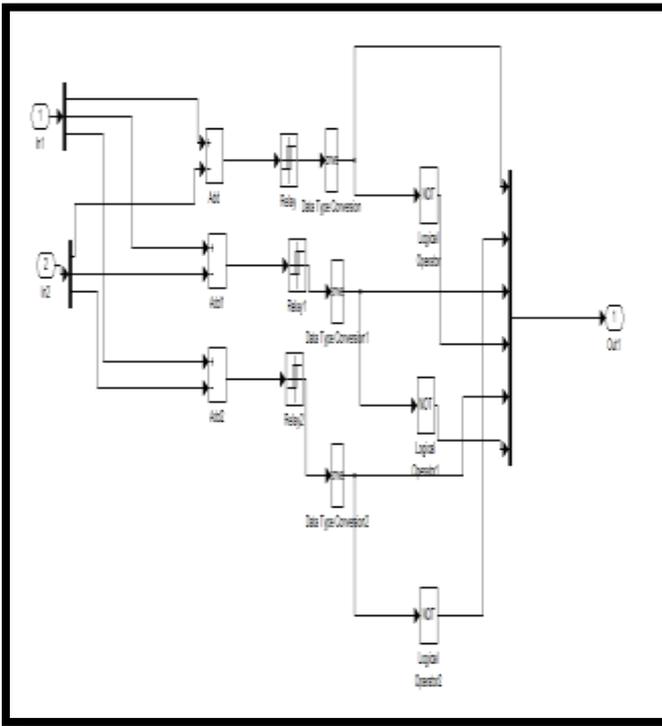


Fig.4- Hysteresis controller subsystem

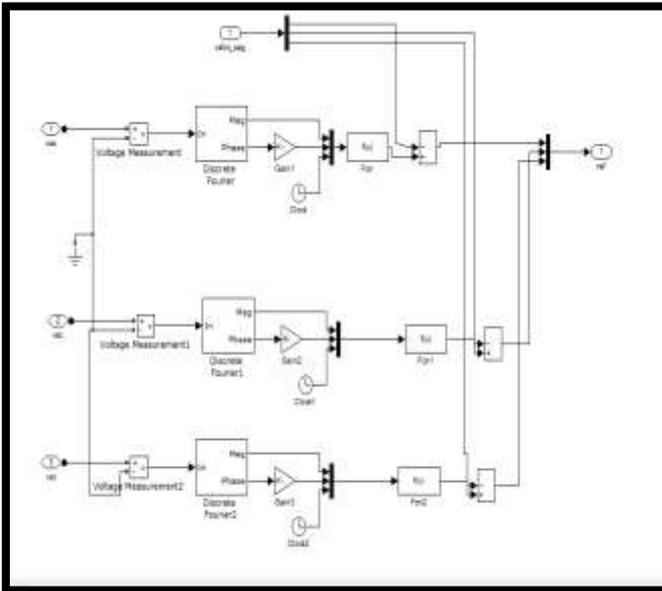


Fig.5- DFT controller subsystem

For harmonics mitigation in the proposed system we have providing the LC filter also in the system. So the Matlab subsystem of LC filter is shown in the fig.6 below:-

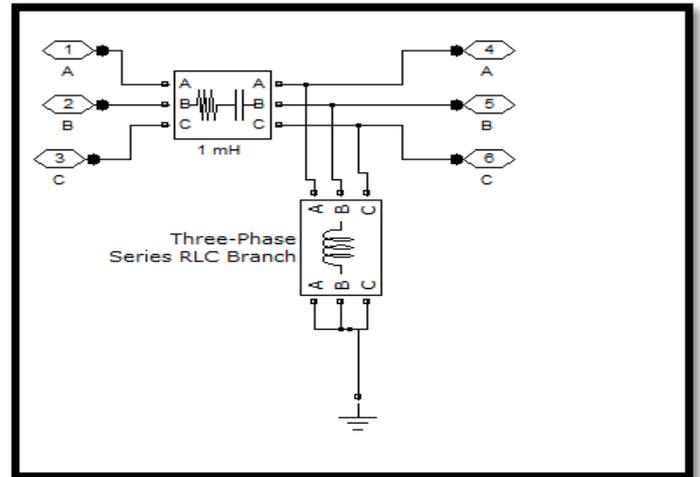


Fig.6- LC-Filter subsystem

Now the simulation results of output voltage, current, active and reactive power and other characteristics of wind speed and angle is shown in the fig below:-

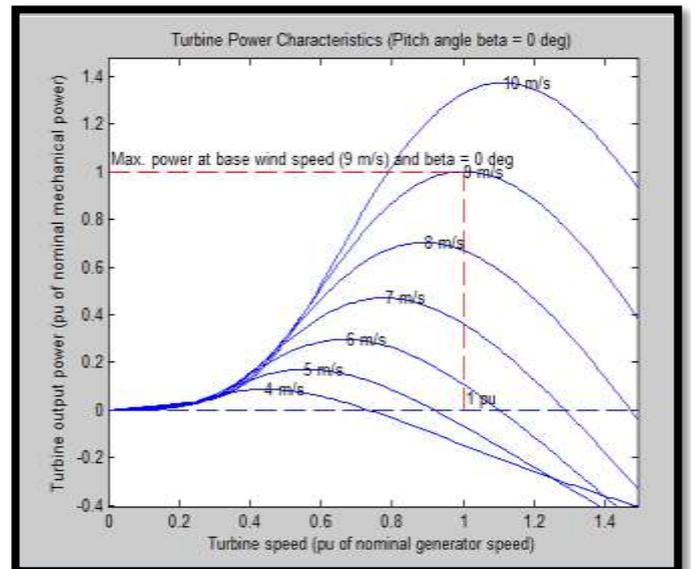


Fig.7- Turbine speed and mechanical output power relation



Fig.8- Constant output active power

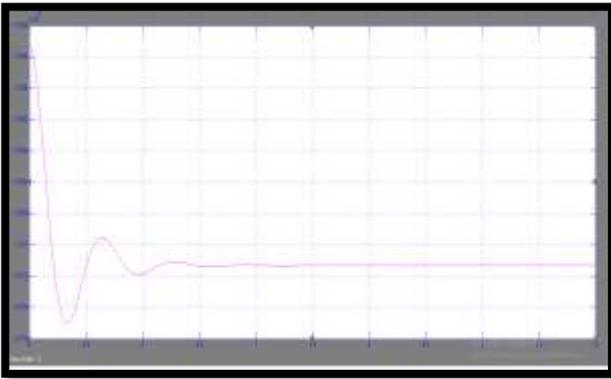


Fig.9- Reactive power

Modelling and Results of Solar –Wind Hybrid System

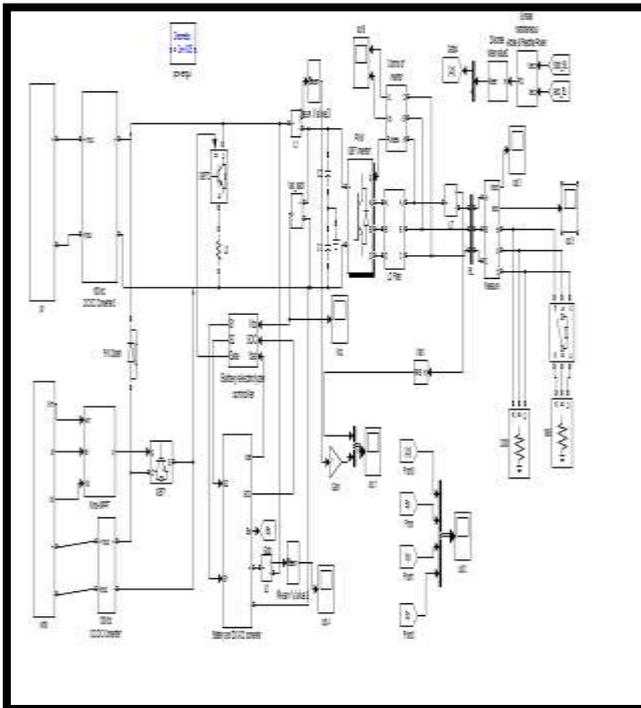


Fig.10- Hybrid of solar & wind System

The Matlab simulation of Solar PV and wind based Hybrid power system is shown in fig.10 above. The Hybrid system includes simulation model of Solar PV, Wind, Battery, and DC- DC converter. The subsystems and the output parameters and simulation results of that hybrid system are shown in the below fig:-

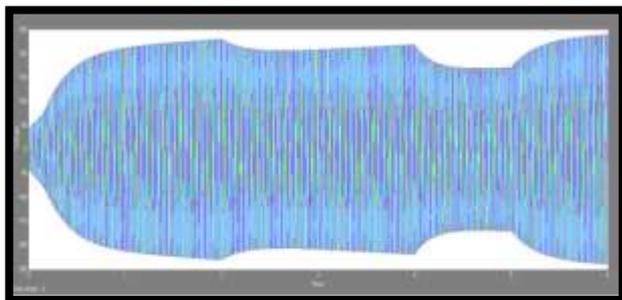


Fig 11-Output Voltage of Hybrid System

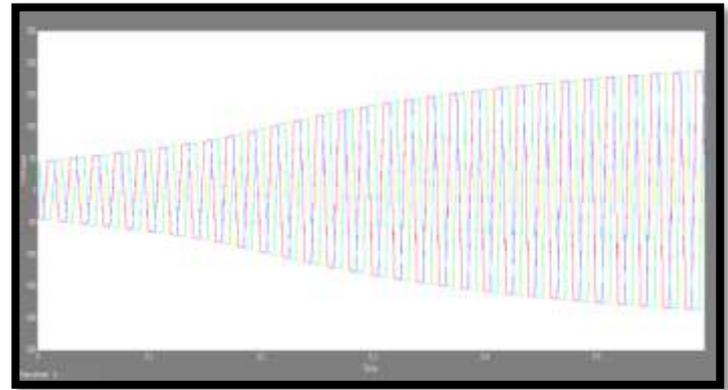


Fig 12-Output Voltage of Hybrid System with range

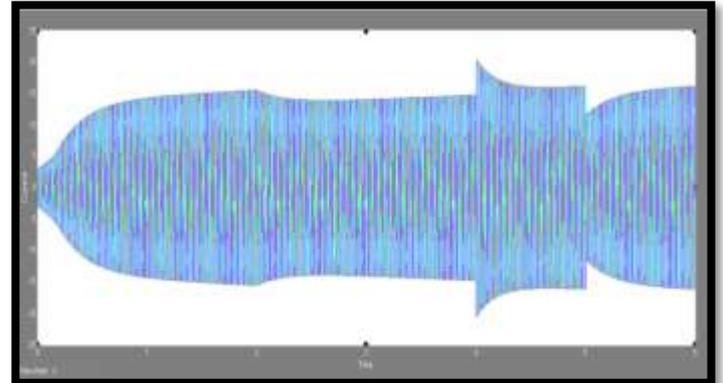


Fig 13-Output Current of Hybrid System

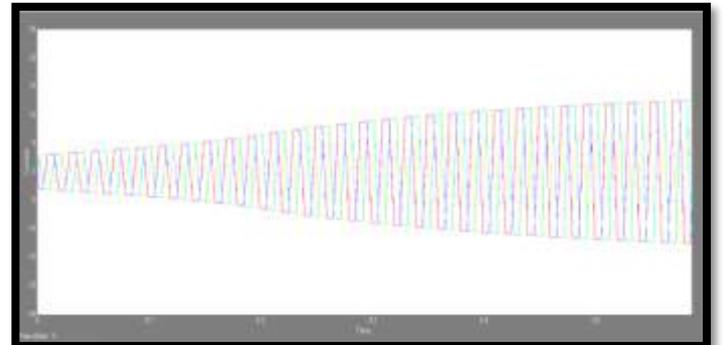


Fig 14-Output Current of Hybrid System with range

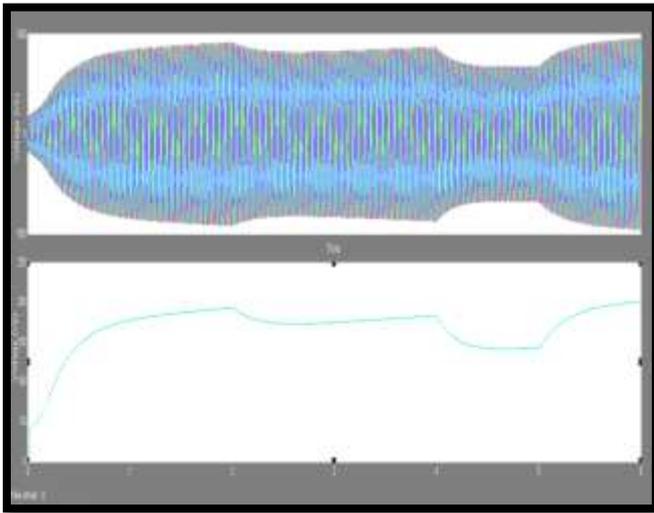


Fig 15- Output VL and VP waveform

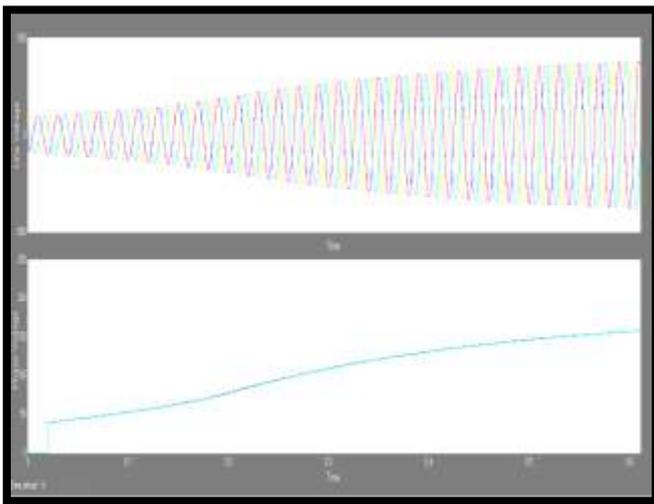


Fig 16- Output VL and VP waveform with range

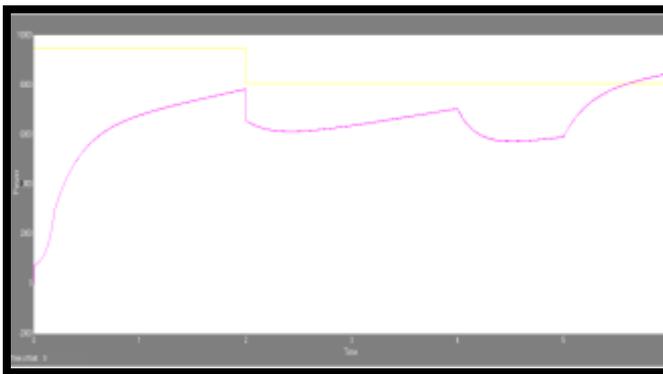


Fig 17- Output power of Solar PV with MPPT and without



Fig 18- Output voltage of Battery

IV. SOLAR-WIND HYBRID WITH GRID INTEGRATION

The Matlab simulation of Solar PV and wind based Hybrid power system is integrated with grid is shown in fig 19 below. The Hybrid system includes simulation model of Solar PV, Wind, Battery, and DC- DC converter and grid integration. The subsystems and the output parameters and simulation results of that hybrid system are shown in the below fig:-

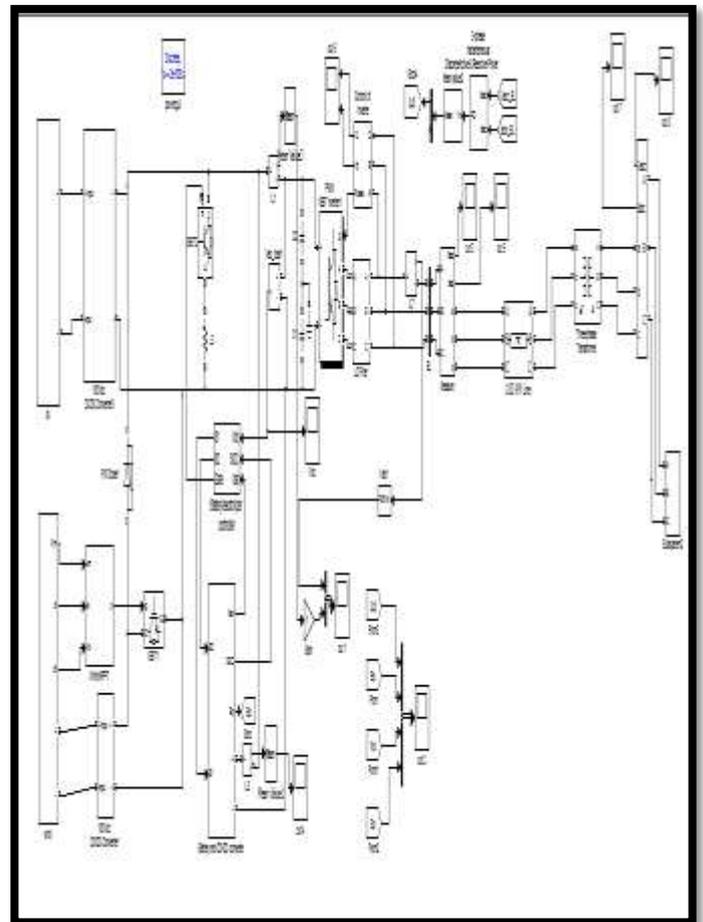


Fig 19- Grid Integration of Solar-wind hybrid System

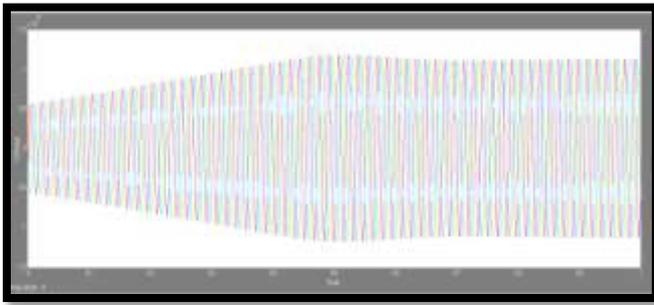


Fig 20- Grid Side A.C Voltage

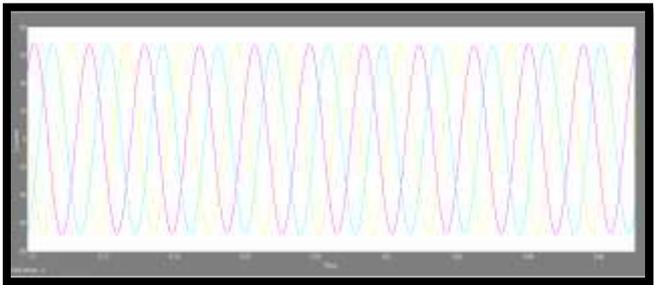


Fig 21- Grid Side A.C Current

V. CONCLUSION

This paper presents a hybrid wind/PV energy system for standalone system. The standalone hybrid system is better than a single energy source. The wind energy systems may not be technically viable at all sites because of low wind speeds and being more unpredictable than solar energy. The combined utilization of these renewable energy sources is therefore becoming increasingly attractive. This Project also highlights the future developments, which have the potential to increase the economic attractiveness of such systems and their acceptance by the user. This Project also represents the modelling and Simulation of Solar PV System using MATLAB-SIMULINK software. The Simulation results show the ideal I-V and P-V characteristics of the solar PV system. The wind power plant simulation and results are also discussed. The Hybrid system of Solar and Wind is simulated and results shows the performance is better in hybrid compare to standalone system.

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