A Hybrid Wind & Solar Energy System for Different Load Variations Using Hysteresis Controller

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Abstract**:** **The system introduced in this paper adapts various power-control strategies of a grid-connected hybrid generation system with versatile power transfer. With this hybrid system the freely available renewable energy sources like wind and photovoltaic energies can be utilized effectively. For this, an adaptive MPPT algorithm along with standard perturbs will be used for the system. Also, this configuration allows the two sources to supply power to the load either separately or simultaneously depending on the availability of the energy sources. The turbine rotor speed is the main determinant of mechanical output from wind energy and Solar cell operating voltage in the case of solar energy for output power. Permanent Magnet Synchronous Generator is coupled with wind turbine for attaining wind energy conversion system. This hybrid system operates under normal conditions which include normal room temperature in the case of solar energy and normal wind speed at plain area in the case of wind energy. A PWM Controller is used for inverter which is replaced with Hysteresis controller. The simulation results are presented to illustrate reliability of this proposed system.**

Keywords**: The area, delay, error feedback, MASH, power Sigma Delta DAC.**

I. INTRODUCTION

With increasing concern of global warming and the depletion of fossil fuel reserves, many are looking at sustainable energy solutions to preserve the earth for the future generations. Other than hydro power, wind and photovoltaic energy holds the most potential to meet our energy demands. Wind energy alone can meet the electric power demand if and only if wind energy available is constant through out the day. But the wind energy levels can't be predicted, so we may or may not be able to meet the power demand. Similarly, solar energy exists throughout the day but the solar irradiation levels vary due to sun intensity and unpredictable shadows caused by clouds, birds, trees, etc.. So by combining wind and solar systems and by introducing maximum power point tracking (MPPT) algorithms, the system's power transfer efficiency and reliability can be improved significantly. The integration of renewable energy sources and energy-storage systems has been one of the new trends in power-electronic technology. The increasing number of renewable energy sources and distributed generators requires new strategies for their operations in order to maintain or improve the power-supply stability and quality. Combining multiple renewable resources via a common dc bus of a power converter has been prevalent because of convenience in integrated monitoring and control and consistency in the structure of controllers as

compared with a common ac type. Dynamic performance of a wind and solar system is analyzed. A wind turbine system model was developed and compared with a real system. Several methodologies for optimal design or unit sizing. Most applications are for stand-alone operation, where the main control target is to balance local loads. A few grid-connected systems consider the grid as just a back-up means to use when there is insufficient supply from renewable sources. They are originally designed to meet local load demands with a loss of power-supply probability of a specific period. Such hybrid systems, focusing on providing sustainable power to their loads, do not care much about the quality or flexibility of power delivered to the grid. From the perspective of utility, however, a hybrid system with less fluctuating power injection or with the capability of flexibly regulating its power is more desirable. In addition, users will prefer a system that can provide multiple options for power transfer since it will be favourable in system operation and management. Control strategies of such a hybrid system should be quite different from those of conventional systems. This project addresses dynamic modelling and control of a grid-connected wind–PV–battery hybrid system with versatile power transfer. The hybrid system, unlike conventional systems, considers the stability and dispatch-ability of its power injection into the grid. The hybrid system can operate in three different modes, which include normal operation without use of battery, dispatch operation, and averaging operation. In order to effectively achieve such modes of operation, two modified techniques are applied; a

modified hysteresis control strategy for a battery charger/discharger and a power averaging technique using a low-pass filter. The concept and principle of the hybrid system and its supervisory control are described. Wind turbine control can be achieved by extracting maximum power from PV array. In order to extract maximum power from PV array we need to apply MPPT techniques. Dynamic simulations were carried out using Power System Computer Aided Design/Electromagnetic Transients Program for DC (PSCAD/EMTDC), power-system transient-analysis software. The program was based on Dommel's algorithm, specifically developed for the simulation of high-voltage direct current systems and efficient for the transient simulation of power system under power-electronic control.

When To Consider An Hybrid Solar-Wind System:
Even during the same day, in many regions worldwide or in some periods of the year, there are different and opposite wind and solar resource patterns. And those different patterns can make the hybrid systems the best option for electricity production.

The Combination:
The combined operation of solar and wind energy systems leads to following advantages: 1) For example to meet an energy demand of 120 kWh per month we can use a single 3kW wind turbine (instead of a 6kW one.) and a solar system with a smaller size panels. 2) System is reliable, i.e if the intensity of sun is more than the wind, then we can meet the demand with solar system and vice-versa

Hybrid wind-solar electricity production system Size And Price
An hybrid wind-solar electric system demands an higher initial investment than single larger systems. A part from the initial investment the hybrid systems are best in meeting demand and in improving efficiency.
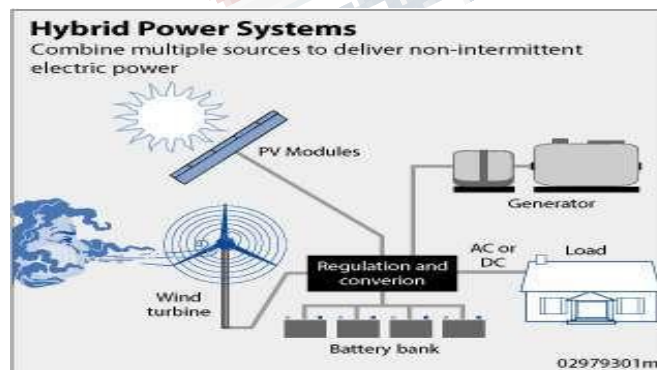

Fig 1.1:General Hybrid System

When Hybrid Solar-Wind Systems Aren't Suitable

Hybrid Solar-Wind Systems are not suitable in non-windy locations, urban and suburban areas. However solar system can be widely used in urban and suburban area for water heating and for charging inverter batteries.

II. SOLAR AND WIND

The principle of photovoltaic effect is used in generating electricity from PV Panels. Mono crystalline silicon, polycrystalline silicon, amorphous silicon, cadmium telluride, and copper indium are the commonly used materials for manufacturing PV panels.[1]. PV systems can be installed either on to the ground or can be installed on the roof of walls of a building. This kind of systems can be called as Building Integrated Photo-voltaics, in short form BIPV. The photovoltaic effect is the generation of a voltage (or a corresponding electric current) in a material upon exposure to light. Though the photovoltaic effect is directly related to the photo electric effect, the two processes are different and should be distinguished. In the photoelectric effect, electrons are ejected from a material's surface upon exposure to radiation of sufficient energy. The photovoltaic effect is different in that the generated electrons are transferred between different bands (i.e. from the valence to conduction bands) within the material, resulting in the build up of a voltage between two electrodes. In most photovoltaic applications the radiation is sunlight and for this reason the devices are known as solar cells. In the case of a p-n junction solar cell, illumination of the material results in the generation of an electric current as excited electrons and the remaining holes are swept in different directions by the built-in electric field of the depletion region. The photovoltaic effect was first observed by Alexandre-Edmond Becquerel in 1839.
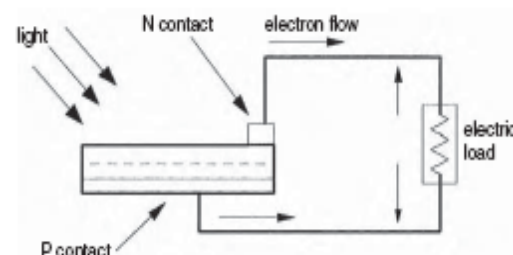

Fig 2.1: PV effect converts the photon energy into voltage across the pn junction

As of October 2010, the largest photovoltaic (PV) power plants in the world are the Sarnia Photovoltaic Power Plant (Canada, 80 MW), the Olmedilla Photovoltaic Park (Spain, 60 MW), the Strasskirchen Solar Park (Germany, 54 MW), the Lieberose Photovoltaic Park (Germany, 53 MW), the Puertollano Photovoltaic Park (Spain, 50 MW), the Moura

photovoltaic power station (Portugal, 46 MW), and the Waldpolenz Solar Park (Germany, 40 MW).
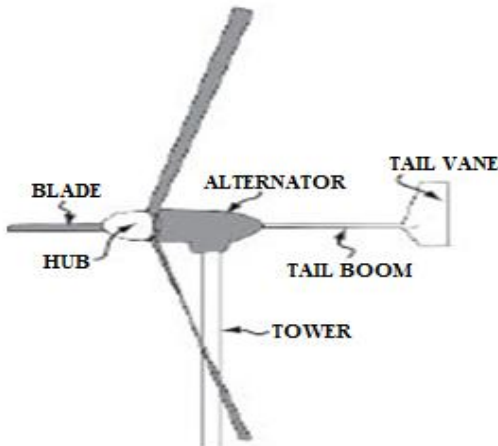

Fig 2.2: Wind turbine

III. BATTERY STORAGE

Electricity is more versatile in use than other types of power, because it is a highly ordered form of energy that can be converted efficiently into other forms. For example, it can be converted into mechanical form with efficiency near 100% or into heat with 100% efficiency. Heat energy, on the other hand, cannot be converted into electricity with such high efficiency, because it is a disordered form of energy in atoms. For this reason, the overall thermal-to-electrical conversion efficiency of a typical fossil thermal power plant is less than 50%. Disadvantage of electricity is that it cannot be easily stored on a large scale. Almost all electric energy used today is consumed as it is generated. This poses no hardship in conventional power plants, in which fuel consumption is continuously varied with the load requirement. Wind and photovoltaic's (PVs), both being intermittent sources of power, cannot meet the load demand at all times, 24 h a day, 365 d a year.

3.1 Battery control
The primary goal of the battery converter is to regulate the common dc-bus voltage. The battery load current rapidly changes according to changes in weather conditions and power command for grid inverter in dispatching or averaging mode of operation. Common dc-bus voltage must be regulated to stay within a stable region regardless of the battery-current variation. To do this, a modified hysteresis-control strategy is applied. The concept of this strategy is to regulate the common dc

voltage within a specific band, for example, a hysteresis band. Therefore, the charging and discharging of a battery is controlled by defining upper and lower limits on dc bus. Vdc_up and Vdc_lw, are upper and lower respectively as shown in the figure. The battery buck–booster operates according to the scheme as below:

$$\text{If } V_{dc} \gtrsim V_{dc_{up}}, \quad \text{then charging} \to V_{dc} = V_{dc_{up}}$$

$$\text{If } V_{dc} \lesssim V_{dc_{up}}, \quad \text{then discharging} \to V_{dc} = V_{dc_{lw}}$$

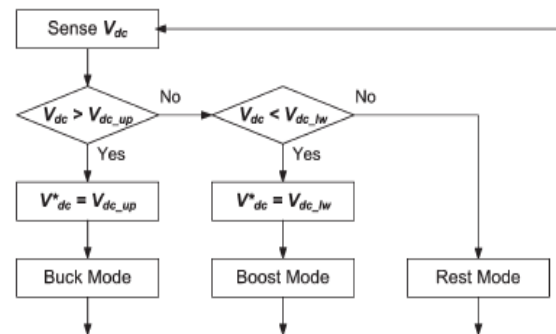$$\text{If } V_{dc_{lw}} \leq V_{dc} \leq V_{dc_{up}} \quad \text{then no control (rest)}$$

Fig. 3.1. Battery-mode control block (modified hysteresis).

When the common dc voltage Vdc becomes larger than the upper limit, charging mode begins with the voltage command Vdc equal to the upper limit and continues until the dc voltage reaches the limit. If Vdc goes below the lower limit, then the voltage target is bound at the lower limit and the converter starts operating in boost mode.

IV. PWM AND HYSTERESIS CURRENT CONTROL

The devices (FETs, GTOs, or IGBTs) used in single-phase, and three-phase bridges will get firing pulses from PWM generator block. The firing pulses required to trigger the devices can be generated by comparing a triangular carrier waveform with reference modulating signal. The amplitude (modulation), phase, and frequency of the reference signals need to be defined to control the output voltage (on the AC terminals) of the bridge connected to the PWM Generator block. The two devices in the single arm bridge gets their firing pulses in complementary fashion. i e. if upper device is on, lower device in the same arm will be off and vice-versa. The following figure displays the two pulses generated by the PWM Generator block when it is programmed to control a one-arm bridge
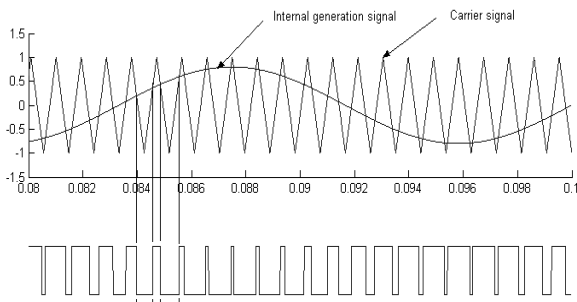
Fig:4.1   Waveform of pwm current controller

The hysteresis current control (HCC) is the easiest control method to implement; it was developed by Brod and Novotny in 1985. The shunt APF is implemented with three phase current controlled VSI and is connected to the ac mains for compensating the current harmonics. The VSI gate control signals are brought out from hysteresis band current controller
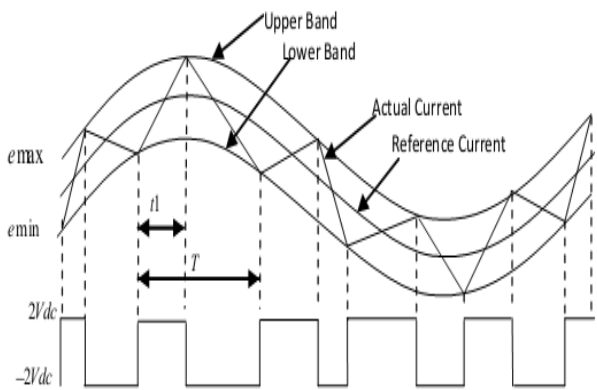

Fig:4.2   Waveform of Hysteresis current controller

A hysteresis current controller is implemented with a closed loop control system and waveforms are shown in Fig 4.4. An error signal I_{aerr} is used to control the switches in a voltage source inverter. This error is the difference between the desired current I_a and the current being injected by the inverter I_a . If the error exceeds the upper limit of the hysteresis band, the upper switch of the inverter arm is turned off and the lower switch is turned on. So that the current starts decaying and if the error crosses the lower limit of the hysteresis band, the lower switch of the inverter arm is turned off and the upper switch is turned on. Hence the current level falls between th levels specified in the hysteresis band. Let emin and emax are the minimum and maximum values of the error signals respectively. The range of the error signal e max -

emin directly controls the amount of ripple in the output current from the VSI.

V. SIMULATION DESIGN

5.1 SIMULINK MODEL OF HYSTERESIS CURRENT CONTROL
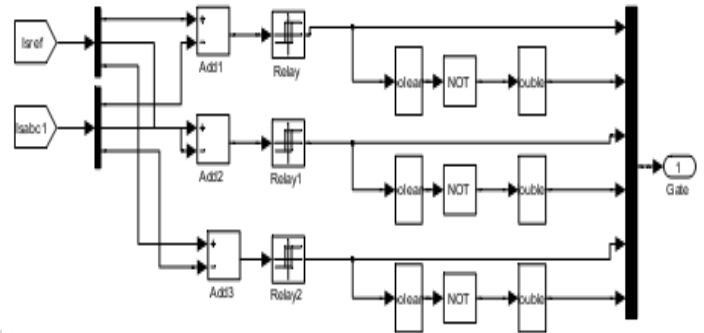

Fig. 5.1 Simulink Model of Hysteresis Current Control
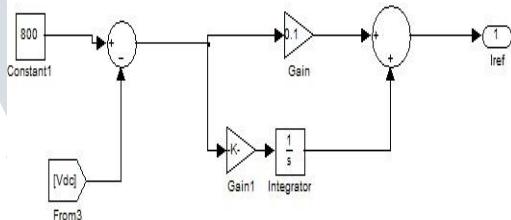

Fig.5.2 MATLAB Simulink model of PI control

We can visualize the system by viewing signals with the displays and scopes provided in Simulink software. Alternatively, we can build ourr own custom displays using MATLAB® visualization and GUI development tools. We can also log signals for post-processing.
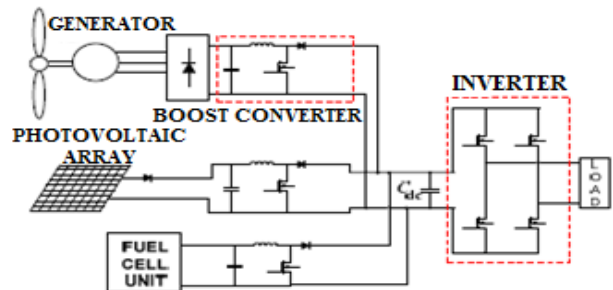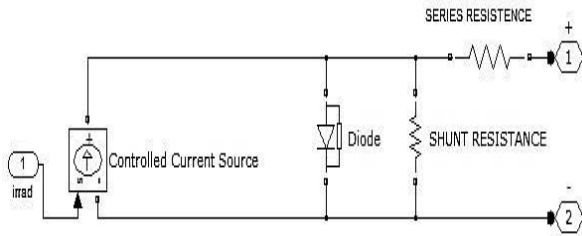

Fig 5.3Model of Proposed Hybrid Circuit

Fig 5.4 Basic Structure Of PV-Cell

The basic PV cell is built with the current supplied from the solar energy and then it is fed forward with the use of diode. There are two resistances both in shunt and series connection to enhance the working of the PV cell.
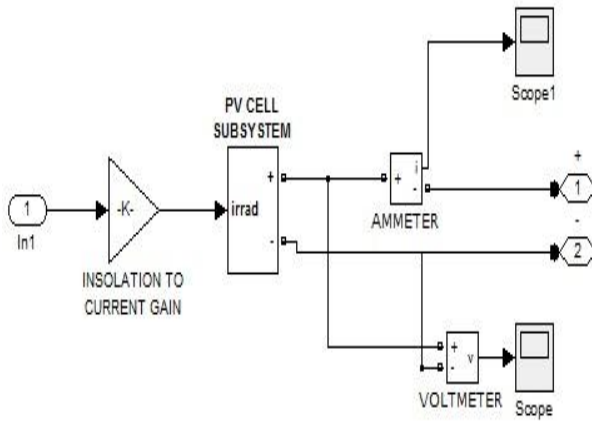

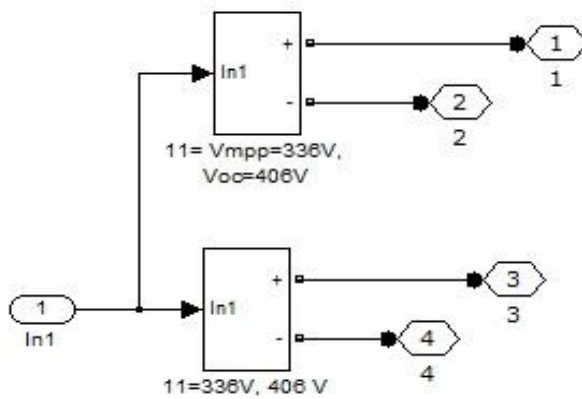*Fig 5.5 Transition of Insolation into Current Gain*
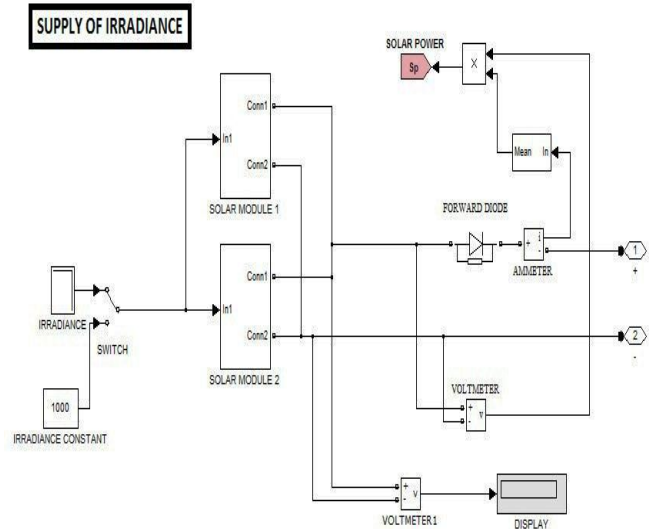

Fig 5.6 Parallel Connection Of Solar Cell

Fig 5.7 Simulation Model Showing The Utilization Of Irradiance And Solar Modules

There are two modules of PV cells in the designed PV Array. There are two rows of 11 cells in each PV module. The voltage developed at the parallel connection between the parallel connection of the PV modules is measured here with the inclusion of the Display block of simulink.
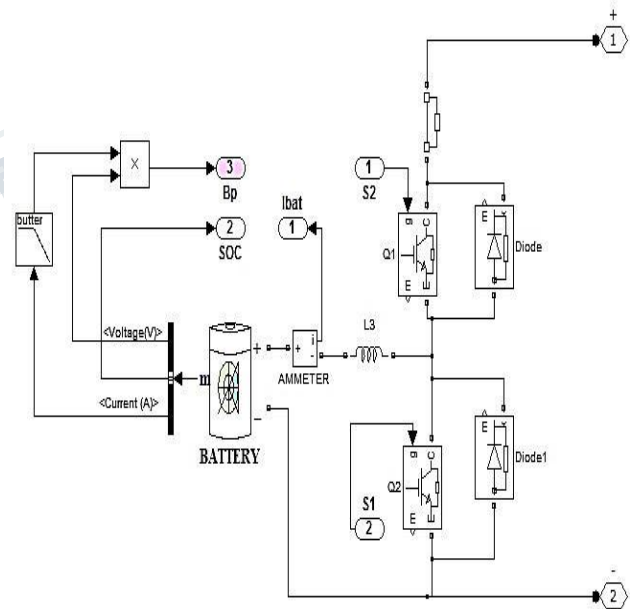

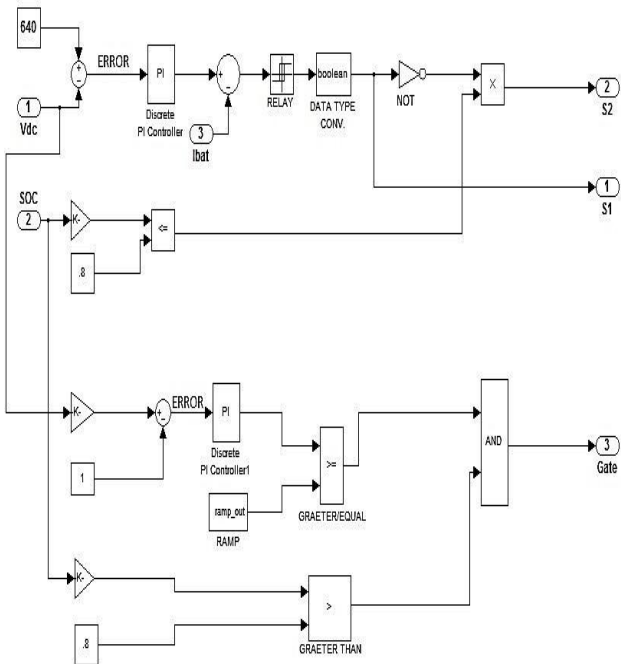*Fig 5.8 Battery Operation features sufficient supply to load*

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Fig 5.11 Inverter control using PWM

Fig 5.9 Working Logic of Battery Operation
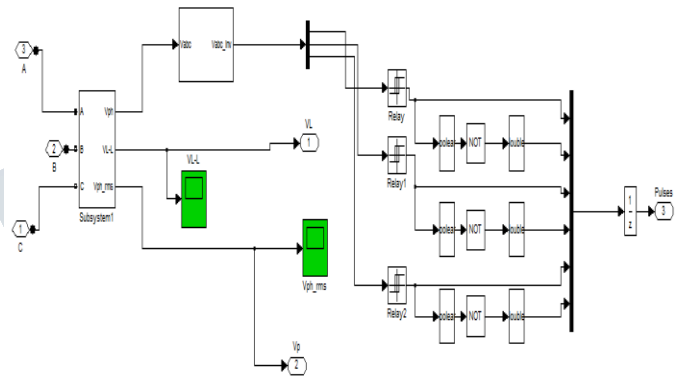
Fig 5.12 Inverter control using Hysteresis

Fig 5.10 Composite Simulation Model of Proposed Hybrid System
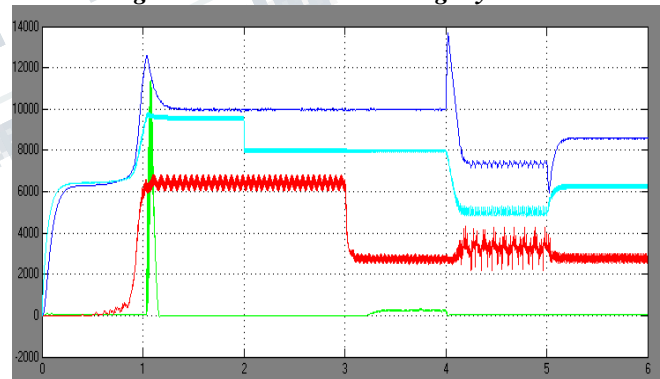
Fig 5.13 Simulation result with PWM control
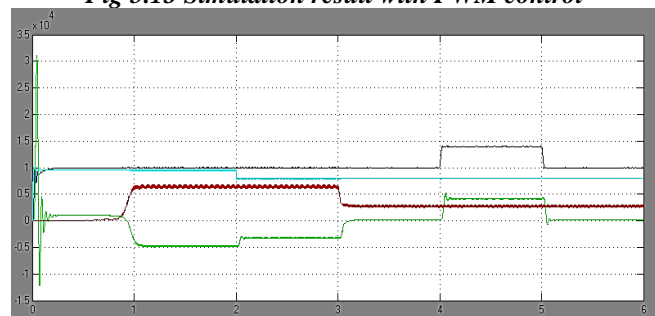
Fig 5.14 Simulation result with hysteresis control

V. CONCLUSION

The Hybrid Energy System is giving supply to load based on the changing conditions of Wind Speed and Solar Irradiation parameters. Battery is supporting the simultaneous operation of Solar and Wind Energy System. Battery is working as a Auxiliary Source of Supply to the load at the time of need. While comparing with PWM controller HYSTERESIS control gives better performance for inverter control.

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