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SOLAR-WIND HYBRID ELECTRICAL POWER SYSTEM

Mergu Chandramouly[1], A Raghuram[2]

Abstract: A grid connected hybrid scheme integrated photo-voltaic (PV) array and a wind-driven induction generator has been Jawaharlal Nehru Technological University,proposed in this project. This new grid-connected configuration employs a closed loop controller at the inverter interfaced to Hyderabad, India.the PV array to regulate the current fed to the grid. By varying the reference current to the controller the PV array meets the reactive power needs of the induction generator (IG) and also acts as a source of real power to the grid. In hybrid power systems, a number of power generators and storage components are combined to meet the energy demand of remote or rural area, or even a whole community. In addition to PV generators, wind generators, small hydro plants, and others sources of electrical energy can be added as needed to meet the energy demand in a way that fits the local geography and other specifics. Before developing a hybrid electric system for a specific site, it is essential to know the particular energy demand and the resources available at that site. Therefore, energy planners must study the solar energy, wind, and other potential resources at the site, in addition to the energy demand. This will allow them to design the kind of hybrid power system that meets the demands of the facility at best.
Keywords: Hybrid System, Grid-connected, Photo-voltaic, and PV array, solar energy, hybrid power system.

1. INTRODUCTION

In this present modern world, one cannot assume life without electric power, as everyone is habituated to use electrical power for all the applications. As the population is increasing day by day, the electrical power demand is also increasing. But the conventional sources such as coal, diesel and gas are depleting. The need of non-
conventional energy sources or renewable power sources becomes important in this context. Many renewable energy technologies today are well developed, reliable, and cost competitive with the conventional fuel generators. The cost of renewable energy technologies is on a falling trend as demand and production increases. There are many renewable energy sources such as solar, biomass, wind, and tidal power.

Electric power can be generated by conventional thermal power plants (using fossil fuels, or nuclear energy), hydro power stations and other alternative power generating units (such as wind turbine generators, photovoltaic arrays, fuel cells, biomass power plants, geo thermal power stations etc.,).Fossil fuels (including coal, oil and natural gas) and nuclear energy are not renewable, and their resources are limited. These renewable/alternative power generation systems normally have modular structure and can be installed close to load centers as distributed generation sources (except large wind and PV farms). Therefore no high voltage transmission lines are needed for them to supply.

In general, due to the ever increasing energy consumption, the rising public awareness for environmental protection, the exhausting density of fossil-fuel, and the intensive political and social concerns upon the nuclear power safety, alternative(i.e., renewable and fuel cell based) power generation systems have attracted increased interest. The term “alternative energy” is referred to the energy produced in an environmental friendly way. And sooner or later, today’s alternatives will become tomorrow’s main sources for electricity.

2. PROPOSED HYBRID SYSTEM

An Integrated Solar-Wind Hybrid Electrical Power Systems connected to the isolated load is simulated using MATLAB software. The operation can be reached by different controllers for different quantities (power, current, voltage). All this necessitates a development and analyzing of different models for different power system elements including controller’s modeling. As shown in Fig.2.1, the system is very simple and consists of a PV module, a DC-DC Boost converter and voltage sourced three phase bridge inverter and hysteresis controller and induction generator. The system including the subsystems will be simulated to verify the functionalities. Systems based on either wind or solar energy is unreliable due to seasonal and diurnal variations of these resources. Earlier, wind-diesel systems were employed to overcome the diluteness of the renewable resources, but the recurring need of the diesel oil and frequent maintenance requirement of the diesel-generators made such a system to be inappropriate for off-grid supplies. The control of such a scheme is also far from straightforward, especially where there is a high wind penetration. Furthermore, it decreases the advantage of clean and non-pollution energy achieved from the renewable sources. A system that is based fully on renewable resources but at the same time reliable is necessary and hybrid wind and solar systems with small battery storage to meet these requirements.

[1] Department of Electrical and Electronics Engineering, Jawaharlal Nehru Technological University, Hyderabad, India.
[2] Professor, Department of, Electrical and Electronics Engineering

The block schematic of the proposed scheme is shown in Fig. 2.1, where the PV array voltage is fed to a dc-dc boost converter and then to three-phase, six step Current-Controlled Voltage Source Inverter (CC-VSI). This CC-VSI is connected to the grid through an inductor [1].

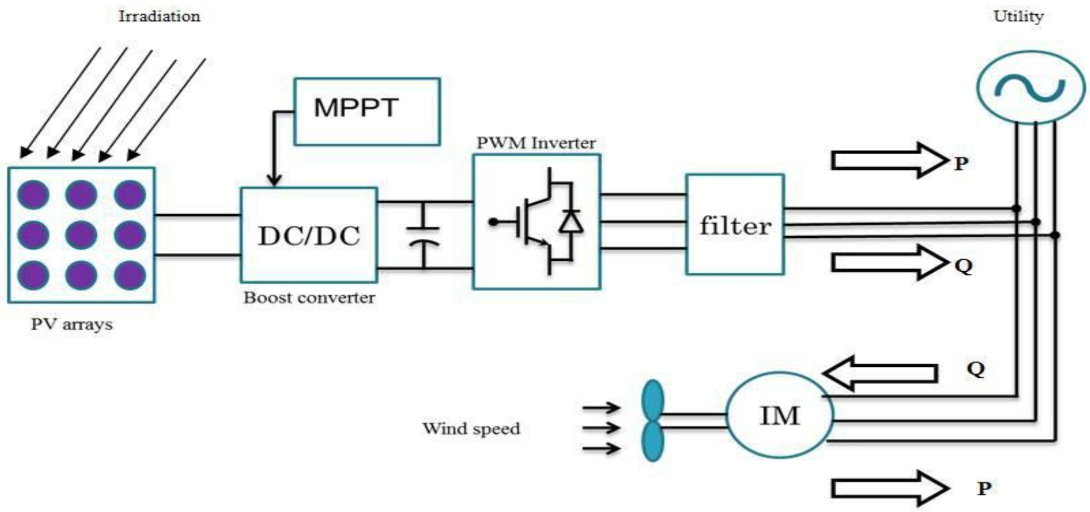

Fig.2.1.Block diagram of HEPS

2.1 Working Principle of the Proposed Scheme:

The above block diagram shows the proposed Integrated Wind-Solar Hybrid Electrical Power Systems connected to the utility. During day time whenever sun rays fall on the PV panel, through photo voltaic effect, DC electrical power will be generated. Since this PV panel is connected to the DC-DC boost converter, DC voltage will be boosted up and will be given as input to the voltage sourced, current controlled inverter and the inverted AC power is fed to the grid through simple inductor. This voltage sourced inverter is controlled by hysteresis current controller. Wind driven induction generator also connected to the same utility to supply the active power to the grid. But the reactive power is needed for the induction generator to supply the active power. By changing the reference current magnitude, we can change the amount of active power fed to the grid and by changing the reference current phase, we can change the amount of reactive power fed to the grid [2]. By employing sufficient number of PV panels we can supply the total reactive power required by the induction generator. MPPT algorithm is also employed to track the maximum power for every irradiation. Different blocks in the proposed scheme are described in detail in the following lines.

2.2 DC-DC Boost Converter

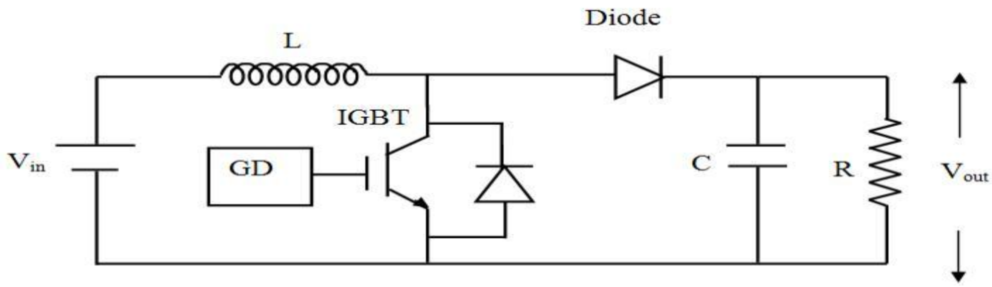

Fig.2.2.DC-DC Boost Converter

The above circuit shows the DC-DC boost converter. According to the irradiation variation, the duty ratio of the boost converter is controlled by MPPT algorithm, to extract the maximum power at the respective irradiation. The design of Boost converter parameters is carried out as follows.

D = Duty ratio

fsw = Switching Frequency vout $\frac{vin}{1\ D}$

T = 1/f = Time Period RDT 2

L = Inductance

C = Capacitance

R = Load Resistance

Vin = Input Voltage

Vout = Output Voltage

Lcr 1 D

2

$$C = \frac{DT \; V_{out}}{R \cdot \Delta V_{out}}$$

2.3 Hysteresis Current Controller:

As the three controllers are similar, the conventional hysteresis controller is discussed for single phase with the aid of Fig.2.2. The converter output voltage is positive when S1and S4 are given gate pulses and this duration is treated as ON-time (TON) and it is negative when S2and S3 are given gate pulses and this period is considered as OFF-time (TOFF). The following nomenclature is adopted in developing the expression for average switching frequency.

Vd = DC source voltage

Vconv= Vab = Converter output voltage

Vg = Grid voltage

ir= Reference current (average current)

io = Output current

Δir = Ripple current

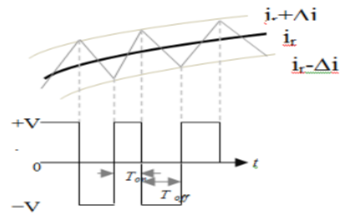

Fig.2.3. Reference and actual current during Ton and Toff

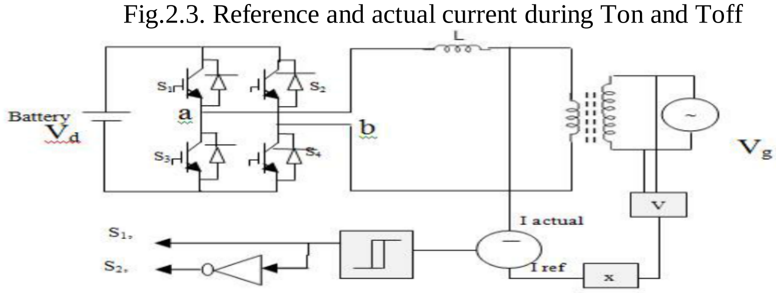

Fig.2.4 Schematic of the proposed system

3. SIMULATION OF THE HYBRID SYSTEM

This chapter discusses the overall proposed HEPS connected to the utility grid for various wind speeds and irradiation levels. And the reactive power compensation to the induction generator by controlling the reference current of inverter controller also discussed.

 SYSTEM DATA: The ratings of the PV panel and Induction Generators are given below.

 PV Panel Boost Converter

Open Circuit Voltage = 22V Parameters

Short Circuit Current = 4.7A Inductance (L) =45.6 mH

Standard Temperature = 25°C Capacitance (C) =39.66 μF

Standard Irradiation = 1000 kW/m2 Switching frequency (fsw) =5000Hz Number of strings connected in series = 4

Number of strings connected in parallel =2

Total number of PV panels used = 8
Induction
Generator Parameters
r1 = 1.3Ω
r2 = 1.75Ω
x1 = 2.6Ω
x2 = 2.6Ω
xm = 47.04Ω
rm = 2245Ω
P =3.7 Kw
V (line to line rms) = 400 V
f = 50Hz
p = 4

The complete simulation schematic diagram of the proposed system is shown in fig.3.1. The model for boost converter and MPPT controller are given in fig.3.2 and fig.3.3 respectively.

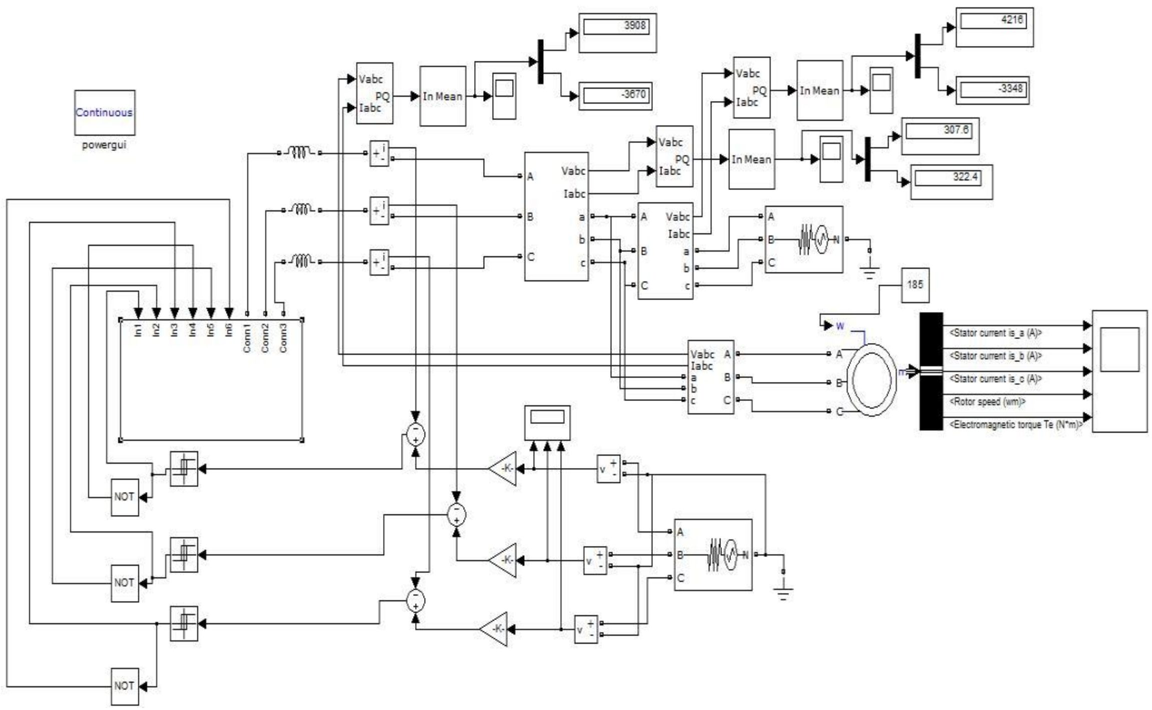

Fig 3.1 Simulation model of the Proposed Scheme

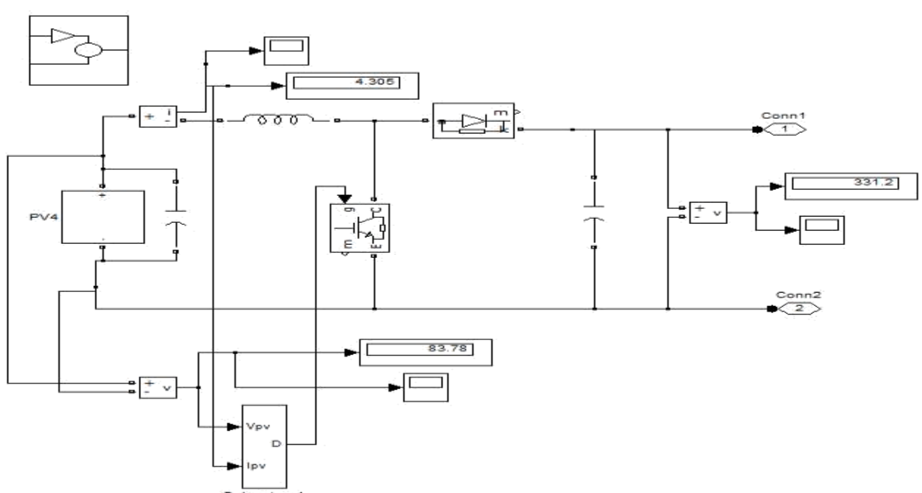

Fig 3.2 Simulation model of Boost Converter

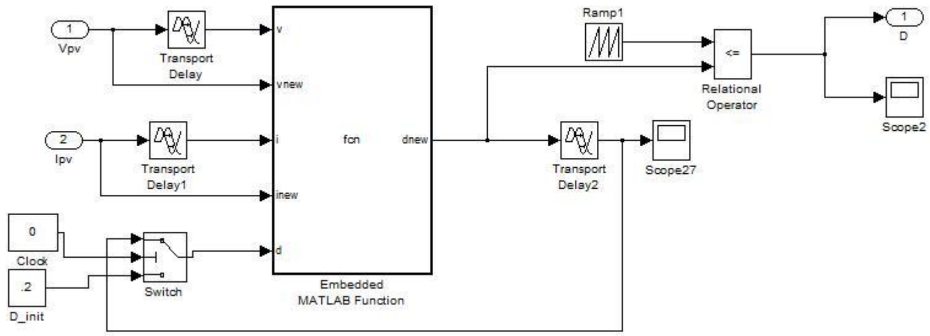

Fig 3.3 P&O MPPT Simulation Diagram

4. SIMULATION RESULTS

The model presented in the previous section was simulated and the results were presented in the following figures. Fig.4.1 and Fig.4.2 show the boost converter output voltage for duty ratio equal to 75% and real and reactive powers fed to the grid respectively.

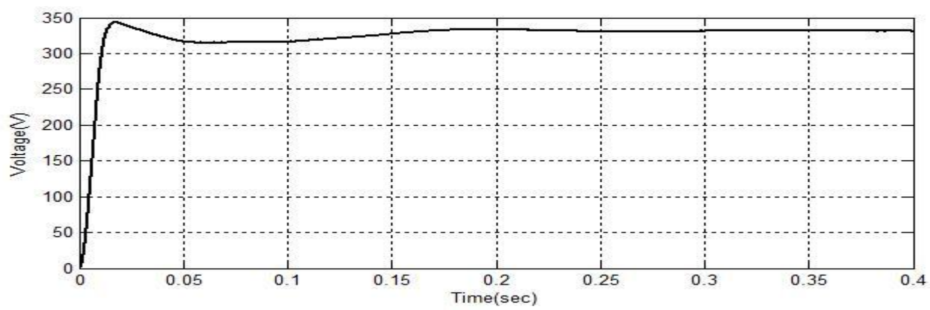

Fig4.1.Boost Converter output voltage for duty ratio =75%

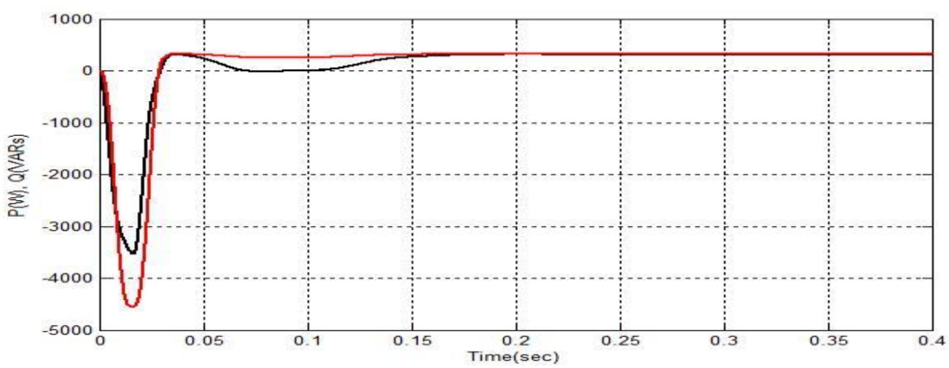

Fig. 4.2 Real and reactive powers from PV array fed to the grid.

Figures 4.3, 4.4 and 4.5 show the inverter currents, total powers (real and reactive) of the proposed scheme and the power by induction generator fed into the grid.

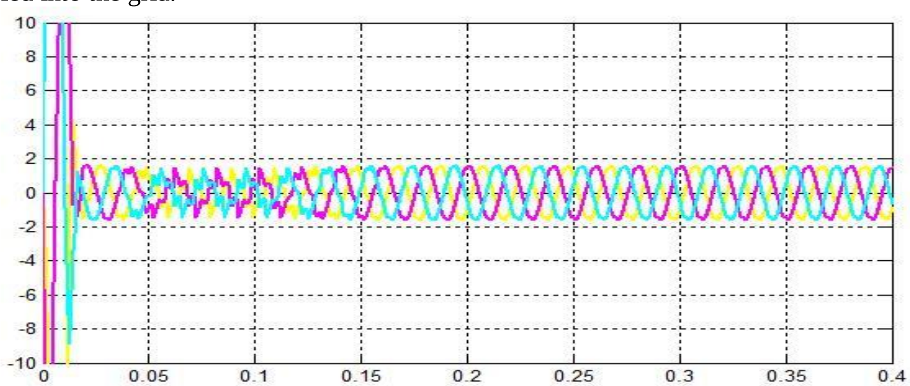

Fig.4.3 Inverter Current Waveforms

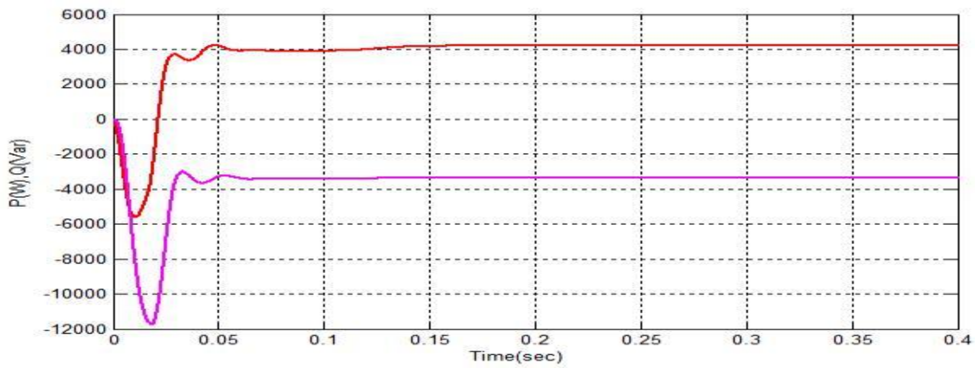

Fig.4.4 Total power of the HEPS fed into the grid for wind speed=185rps and irradiation=1p.u

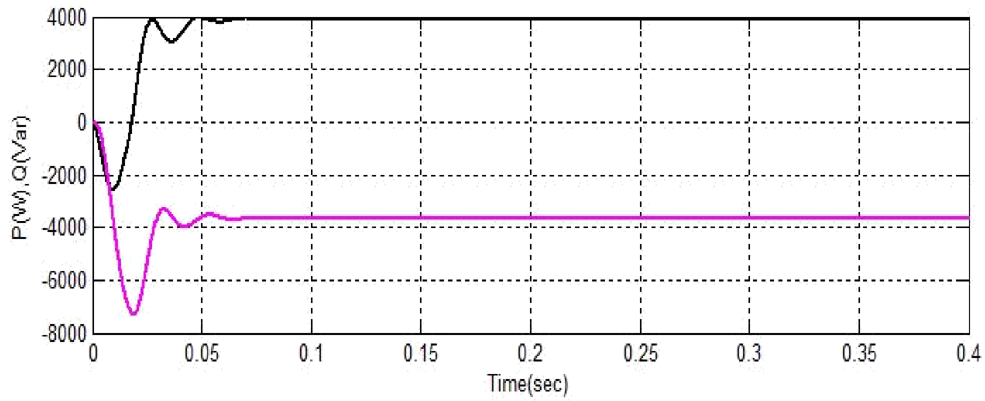

Fig 4.5 Power from induction generator for wind speed=185rps

5. CONCLUSION

A hybrid scheme based on PV and wind driven induction generator has been proposed. The scheme has been modeled and simulated. The simulation results confirm the supply of real power from both PV panel and induction generator. Further, the reactive power requirement of the induction generator was suitably met by the inverter fed from the PV array. For a given irradiation level, the real power fed from the PV array decreases with increase in reactive power demand of the induction generator. A controller to automatically adjust the inverter current for varying reactive power demand is also presented in this work.

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