

IMPLEMENTATION OF STANDALONE HYBRID POWER SYSTEM USING MATLAB/SIMULINK

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Abstract: This paper presents a standalone hybrid power system using PV and wind energy system with MATLAB/SIMULINK environment. Hybrid power system is the ideal for rural electrification and to provide reliable form of energy to consumer. The amount of power generated from PV system depends on Radiation and Temperature. PV panel provide maximum power at a particular point called Maximum Power Point and to produce maximum power and to get maximum efficiency PV panel must have to operate at a MPP only. The Simulink model of PV panel, boost converter, MPP algorithm, converter are modelled and analysed and results are verified. Also this paper describes that how the variable speed wind turbine can be used to generate fixed voltage using synchronous generator. The Simulink model of wind system, converter, synchronous machine are modelled and analysed and results are verified.

Key Words: PV, wind system, hybrid power, Simulink model.

I. INTRODUCTION

The environmental conditions of the earth are getting worse day by day. The rapidly increasing demand and limited resources of nonconventional energy sources increases the need of renewable energy sources. Renewable energy sources are natural resources and it is part of Earth's natural environment. Renewable energy is generated from natural resources such as solar, wind, tidal and geothermal. One of the most important application of renewable energy is electricity generation. Renewable energy facilities generally requires less maintenance than traditional generator also it is pollution free and it has less impact on environment. Among all renewable energy sources, the solar and wind energy sources having high potential, because of their many advantages like pollutant free, easy availability, low cost and very less or zero emission of pollutant gases. 'Hybrid

renewable energy' system is the best option for the electrification. Hybrid renewable energy system is a combination of two or more renewable energy sources and connected to the conventional energy system through grid to meet the required load.

II. WORK OBJECTIVE

The main objective of this work is to contribute to the topic of distributed generator sources modelling and controlled by developing an accurate model of PV cell, Wind power generator and Energy storage bank and based on this model contemplate the control issues. The scientific objective of this research includes the following.

1. Modelling and dynamic behaviour of investigation of the mechanical and electrical part of PV cell and wind system.
2. Design of the overall Hybrid system integrated with the grid.

III. DESIGN OF HYBRID POWER SYSTEM

Hybrid energy system consist if the proposed DC grid consist of uncontrolled DG's such as wind power a photo-voltaic generation, battery bank, capacitor, DC load and grid tied DC/AC or AC/DC converter. [3]

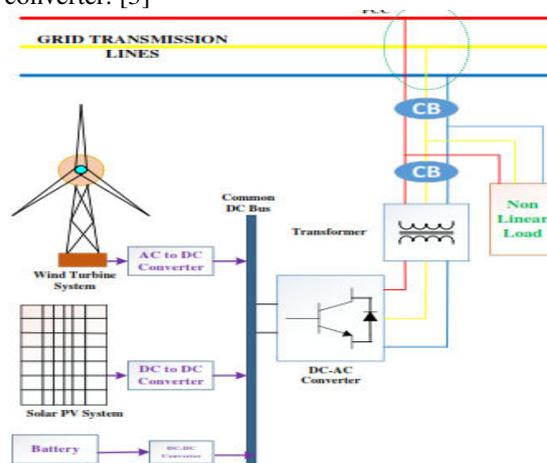


Figure 1. circuit diagram of Hybrid Energy system

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A.PV System:

Sizing of PV system can be depend on different factors these are;

- i. The solar radiation of the site and generally the Metrological data
- ii. The daily power consumption (Wh) and types of the electric loads
- iii. The storage system to contribute to the system's energy independence for a certain period of time.

Photovoltaic cell is a semiconductor device that absorb and converts the energy of light into electricity by photovoltaic effect. Generation of potential when light radiation strikes the region in on near the built in barrier of a semiconductor P-N junction. Sizing a photovoltaic system is an important task in the system's design. Solar cell is connected in series and parallel to set the PV array. Schematic diagram of solar cell as shown in fig.3 PV System can be act as a non linear current source. The generated current is mainly depend on temperature, irradiation, material and age of solar cell. DC to DC Boost converter is widely used in standalone solar system because it is cheaper, simple in construction and high conversion efficiency. Efficiency of boost converter is up to 90%. [6]

The PV generator is oversized it will have a big impact in the final cost and the price of the power produced and in the other hand, the PV-generator is undersized, problems might occur in meeting the power demand at any time.

The amount of solar radiation at a site at any time, either it is expressed as solar intensity (W/m²) or solar radiation in MJ or Wh, The amount of electrical energy produced by a PV-array depends primarily on the radiation at a given location and time. [7,8,9]

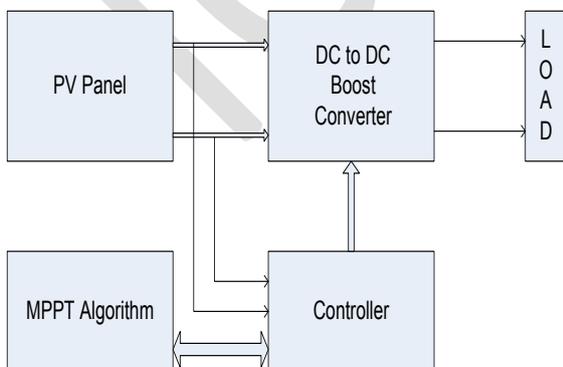


Figure 2.circuit diagram of PV system

1. Modelling of Solar (PV) System:

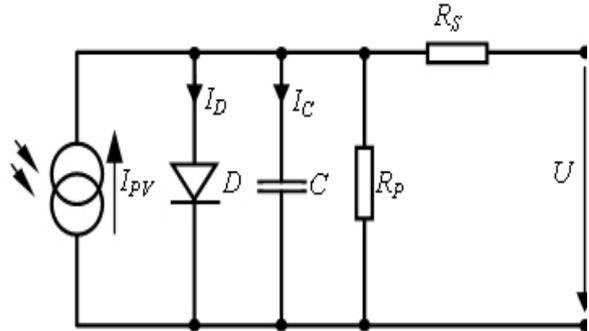


Figure 3. Equivalent circuit diagram of a solar cell

The basic Equation from the theory of semiconductors that mathematically describes I-V characteristics of PVcell is given by,

$$I = I_{pv,cell} - I_D \quad (1)$$

Where $I_{pv,cell}$ is the current generated by incident light and I_D is the diode current.

The equation for saturation current I_0 given below,

$$I_0 = \frac{I_{scn} + KI\Delta T}{\exp((V_{oc} + KV\Delta T)/aVt) - 1} \quad (2)$$

Equation for photovoltaic panel I_{pv} is given below,

$$I_{pv} = (I_{pvn} + KI\Delta T) \frac{G}{G_n} \quad (3)$$

Figure 3 shows the mathematical model for current I_m shown in the following equation,

$$I_m = I_{pv} - I_0 \left[\exp\left(\frac{V + IR_s}{aVt}\right) - 1 \right] \quad (4)$$

Where:

k - Boltzmann constant ($1.3806 \cdot 10^{-23}$ J/K);

T - Reference temperature of solar cell;

q - Elementary charge ($1.6021 \cdot 10^{-19}$ As);

V - Solar cell voltage (V);

I_0 - saturation current of the diode (A);

I_{pv} - Photovoltaic current (A).

A MATLAB Simulink model based on the equations mentioned above, was developed for the PV Cell module. This model is shown in below figure4.

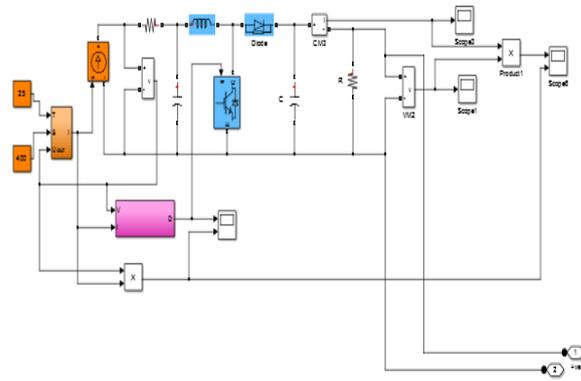


Figure 4.MATLAB Simulink model of PV system

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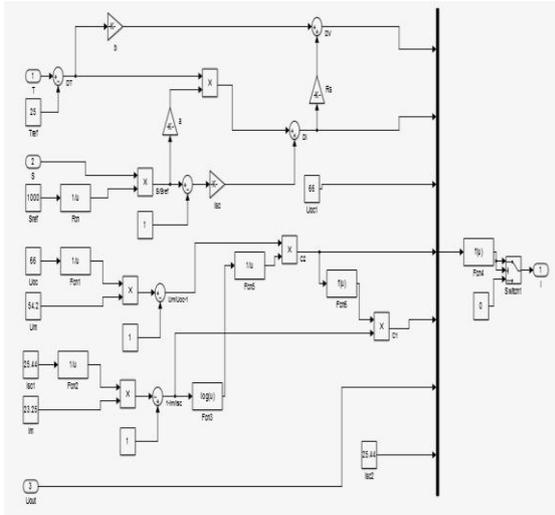


Figure 5. MATLAB Simulink model of Subsystem

2.MPPT Control:

On the I-V curve, there is a point where PV cell generates the maximum power this point always locates at the knee of the curve and it is called maximum power point. There are various methods used for tracking MPP. The P&O method is broadly used because it is very easy to implement. The MATLAB simulation of P&O method is shown in fig.6.

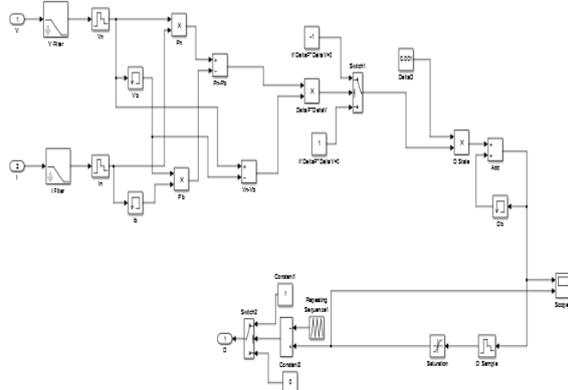


Figure 6. MATLAB Simulink model of MPPT Control

The MPP tracker operates by periodically incrementing and decrementing the solar array voltage. If the given perturbation leads to an increase in the output power of PV, then the subsequent perturbation generated in the same direction and if the given perturbation leads to a decrease in the output power of PV, then the subsequent perturbation generated in the opposite direction. The P&O algorithm is as shown in fig.7.[4]

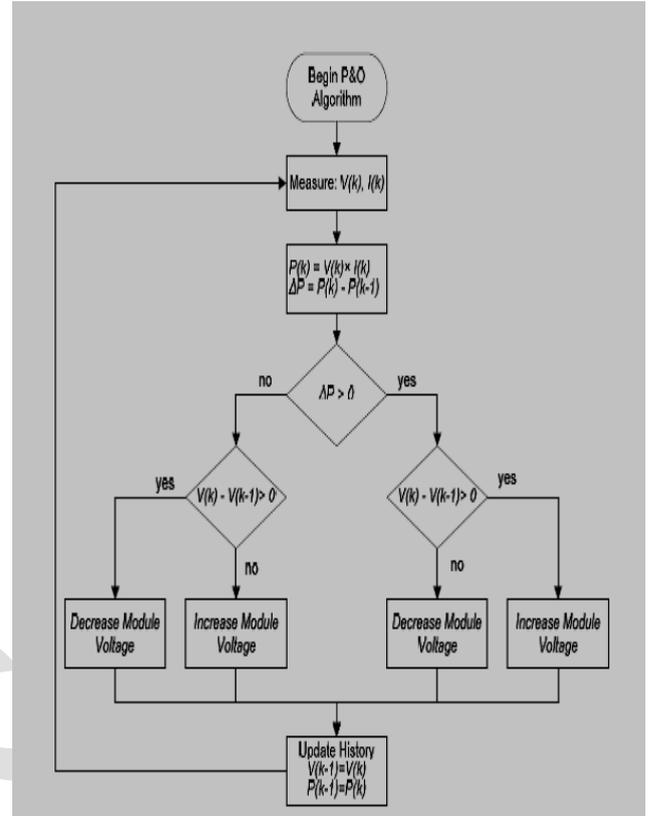


Figure 7. MPPT P& O Algorithm

B.Wind Energy System:

Wind energy sources have the potential to significantly reduce fuel costs, greenhouse gas emissions, and natural habitat disturbances associated with conventional energy generation. Wind turbine generators are an ideal choice in developing countries where the most urgent need is to supply basic electricity in rural or isolated areas without any power infrastructure. Wind energy has become competitive with conventional forms of energy. Power system deregulation has opened opportunities for many private energy producers. Wind energy is a potential choice for smaller energy producers due to relatively short installation times, easy operating procedures, and different available incentives for investment in wind energy.

The wind generator set consists of a wind turbine, synchronous generator, rectifier and inverter to get a suitable supply. Basically wind turbine sends the wind's kinetic energy in the rotor which is mechanically coupled to generators.[1]

1.Modelling of Wind Energy System:

Modelling the wind energy converter is made considering the following assumptions;

- Friction is neglected;
- Stationary wind flow;
- Rotation-free flow;

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the battery is represented by C. The current I_a is taken as positive if discharging and negative otherwise.[11]

The equation for the circuit model is:

$$V_p = \frac{1}{C} \left[\left(\frac{V_o - V_a}{R_1} \right) - I_b \right] \quad (9)$$

$$V_b = V_p - I_b R_b \quad (10)$$

Based on this model and the equations above, a MATLAB Simulink model was developed for the battery storage device. This model is shown in Figure 11,

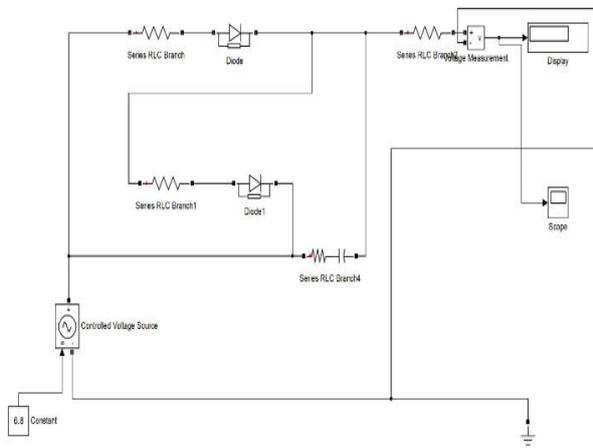


Figure 11 - The MATLAB Simulink model of the battery storage device

IV.RESULT

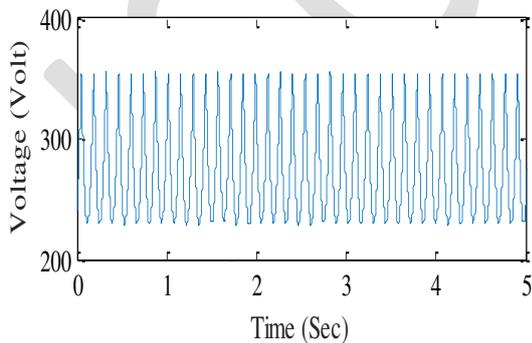


Figure 12.Voltage waveform of Solar System

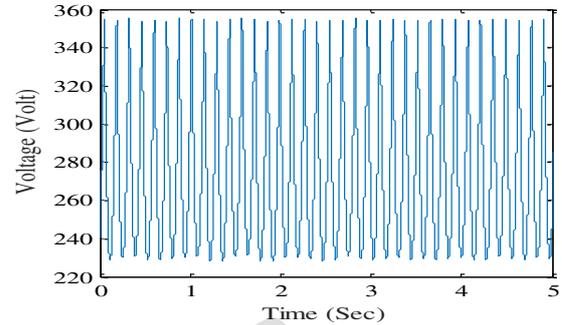


Figure 13.Power waveform of Solar System

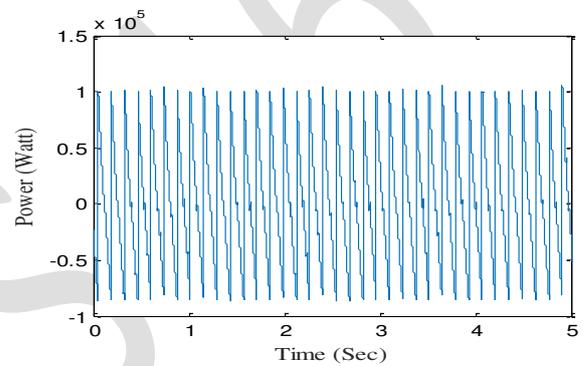


Figure 14.Voltage waveform of Wind System

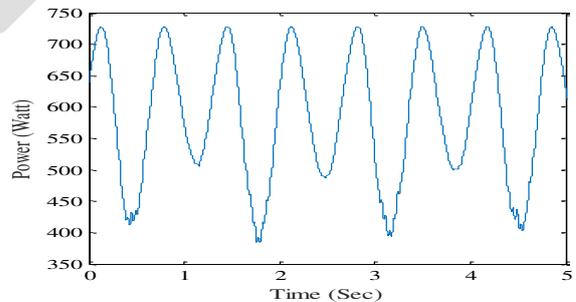


Figure 15.Power waveform of Wind System

IV.CONCLUSION

This paper proposed simple and robust technique for implementation of Hybrid Energy System by using MATLAB/Simulink. A hybrid energy system increases the energy efficiency and reliability. The hybrid renewable energy system provide mobile form of energy to consumer and relief the grid to some extend during peak load. A model gives a promising environment for rural electrification and control of power flow to the load. It's going to increase the per capita consumption of electricity of India. Simulation result have verified that the proposed power

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management method insures a secured power supply and efficient operation. Control method have been incorporated to harness the maximum power from dc and ac sources and to coordinate power exchange between ac and dc grid.

REFERENCES

[1] Sachin Khajuria, Jaspreet Kaur, "Implimentation of Pitch Control of Wind using Simulink(MATLAB)", ISSN:2278-1323, International Journal of Advance Research in Computer Engineering and Technology, Volume 1, Issue 4, June 2012.

[2] Aparna Pachori, Payal Suhane, "Design and Modelling of Standalone Hybrid Power System with Matlab/Simulink", International Journal of Scientific Research and Management Studies (IJSRMS), Vol.1, Issue 2, Page 65-71, ISSN:2349-3771.

[3] F. Valenciaga and P. F. Puleston, "Supervisor Control for a Stand- Alone Hybrid Generation System Using Wind and Photovoltaic Energy," IEEE Transaction Energy Conversion, vol. 20, no. 2, pp. 398-405, June 2005.

[4] Ishaque, K., Z. Salam, M. Amjad And S. Mekhilef, "An Improved Particle Swarm Optimization (PSO)-Based MPPT For PV With Reduced Steady-State Oscillation", IEEE Transaction Power Electronics, 27: 3627-3638. DOI: 10.1109/Tpel.2012.2185713.

[5] E. Koutroulis and K. Kalaitzakis, "Design of a Maximum Power Tracking System for Wind-Energy-Conversion Applications", IEEE Transactions on Industrial Electronics, vol. 53, April 2006.

[6] Patil Sahebrao N. and R.C. Prasad, "Design and simulation of MPPT algorithm for solar energy system using simulink model", International Journal of research in Engineering and Applied Sciences.

[7] Kinal Kachhiya, makarandlokhande and Mukesh Patel, "MATLAB/Simulation of Solar PV Module and MPPT Algorithm", National Conference of Recent trends in Engineering and Technology.

[8] M. Lokanadham and K. Vijaya Bhaskar, "Incremental Conductance based Maximum Power Point Tracking (MPPT) for Photovoltaic System, International Journal of Engineering Research and Application, ISSN:2248-9622.

[9] N. Pandiarajan and Ranganath Muthu, "Mathematical Modeling of Photovoltaic Module with Simulink", International Conference on Electrical Energy Systems (ICEES 2011), 3-5 Jan 2011.

[10] Sandeep kumar¹, Vijay garg², "HYBRID SYSTEM OF PV SOLAR / WIND & FUEL CELL", International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering (An ISO 3297: 2007 Certified Organization) Vol. 2, Issue 8, August 2013.

[11] Samson Gebre "M. Optimal Load Sharing Strategy in a Hybrid Power System based on PV/Fuel Cell/ Battery/Super-capacitor", Undeland (IEEE Fellow).

[12] M. R. Patel, "Wind and Solar Power systems, Design, Analysis and Operation", 2nd ed. Taylor & Francis, New York, 2006.

[13] Yogesh Tiwari and Chitesh Dubey "To design solar (photovoltaic) - Wind hybrid power generation system", International Journal of Emerging Trends & technology in computer science (IJETTCS), Volume 1, Issue 4, November - December 2012, ISSN 2278-6856

[14] Mahmud Abdul Matin Bhuiyan, Anik Deb and Arefin Nasir "Optimum Planning of Hybrid Energy System using HOMER for Rural Electrification" International Journal of Computer Applications (0975 - 8887) Volume 66- No.13, March 2013.]

[15] A.P. Yadav, S. Thirumaliah and G. Harith. "Comparison of MPPT Algorithms for DC-DC Converters Based PV Systems" International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering Vol. 1, Issue 1, July 2012.