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Modeling and Simulation of Photovoltaic/Wind/Diesel/Battery Hybrid Power Generation System

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ABSTRACT: In today's date, India is a large consumer of fossil fuel such as coal, crude oil, natural gas etc. The rapid increase in use of Nonrenewable energies such as fossil fuel, oil, natural gas has created problems of demand & supply. Because of which, the future of Nonrenewable energies is becoming uncertain The increasing concern towards global warming and rapidly reducing conventional energy sources have created the need of an alternate energy sources. The importance of hybrid system has grown as they are non-conventional energy sources and they are more energy efficient, decrease the global warming and pollution. In this paper the hybrid system is designed and modeled using Matlab/Simulink environment. The combination of Photo voltaic (PV) array system, Wind turbine system, battery system and Diesel generator system are used for power generation . Blocks like wind model, PV model, Diesel generator, energy conversion system and load are implemented and the results and simulation are also presented.

Keywords : Renewable Energy, Hybrid System, Simulink/ Matlab.

I. INTRODUCTION

It is now a globally accepted reality that electrical energy is fundamental for social and economic development. In recent years the major concern is about global warming and the harmful after effects of conventional energy sources. All these concerns have created a surge to find a source of energy which is renewable, sustainable and cheap. Renewable energy sources are those who does not destroyed when their energy is harnessed, like sun, wind, tidal, geothermal etc. Among all the non-conventional & renewable sources of energy sun and wind have experienced the biggest growth in the past few years, not only because they are pollution free resources and have an inexhaustible potential but also because it's low cost and easy availability.

A combination of two or more renewable energy sources is more effective than the single source system in terms of cost, efficiency and reliability. We can easily reduce the need of fossil fuel by properly choose the combination of renewable energy source.

The combination of two or more energy sources is known as Hybrid energy system. The main advantage of hybrid energy system is the enhancement of reliability of the hybrid energy system and cost benefit of the system.

Hybrid systems provide a high level of energy security through the mix of generation methods and often will incorporate a storage system (battery & fuel cell) or small fossil fueled generator to ensure maximum supply reliability & security. Wind turbines & Solar panels are the most well-known of the renewable energy devices used in hybrid power systems.

However with all these advantages electric power system consisting of solar and wind as a primary sources poses some technical difficulties also due to uncontrollable weather data like wind speed fluctuation and to the day & night , summer & winter sun conditions. As a consequence of this the power supply continuity should maintained by or backed up by alternate reliable and non-fluctuant energy sources, such as diesel generator, battery or fuel cell etc. Thus we can ensure the reliable supply to the consumers with this type of hybrid power system.

In this paper the hybrid system is designed and modeled using Matlab/Simulink environment. The combination of Photo voltaic (PV) array system, Wind turbine system and Diesel generator system are used for power generation. Blocks like wind model, PV model, Diesel generator, battery, energy conversion system and load are implemented and the results and simulation are also presented.

II. MODELLING THE COMPONENTS OF THE HYBRID POWER SYSTEM

A. Modeling of PV Module

Photovoltaic or PV cells, known commonly as solar cells, basically converts the energy from sunlight into DC electricity, and then we can convert this DC into AC with DC-DC converters and inverters. The PV module is consisting of various parts like combination of solar cells connection etc. Solar cells are basically a semiconductor cell usually made of silicon, which are specially treated to form an electric field which is positive on one side and negative on other. Electric current is developed when solar radiation hits the solar cell. The model of solar cell is represented by an equivalent circuit shown in Fig.1.

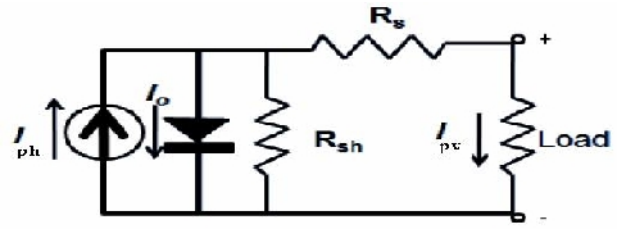


Fig. 1.Equivalent circuit diagram of a solar cell.

The current source Iph represents the photocurrent of the cell. Rsh and Rs are the intrinsic shunt and series resistances of the solar cell, respectively. The value of Rsh is very large and that of Rs is very small, hence they can be neglected to simplify the analysis [1].
Module photo-current is given by:

$$I_{ph} = [I_{SCr} + K_i (T - 298)] * \lambda / 100 \quad \ldots(1)$$

Module reverses saturation current – Irs is given by:

$$I_{rs} = I_{SCr} / [\exp(qV_{OC} / N_S kAT) - 1] \ldots\ldots(2)$$

The current output of PV module is given by

$$I_{PV} = N_P * I_{ph} - N_P * I_0 \{\exp[q*(V_{PV} + I_{PV} * R_s)/N_s AkT)] - 1\} \ldots(3)$$

Where Iph is a light-generated current or photocurrent, Irs is the cell saturation of dark current, q (= 1.6 ×10^{-19C}) is an electron charge,
k (= 1.38 ×10^{-23} J/K) is a Boltzmann's constant,
T is the cell's working temperature
A is an ideal factor of the diode.
λ is the PV module illumination (W/m^2) = 1000W/m^2
Equation (2) & (3) leads to the development of a Simulink model for the PV module. The Simulink model is presented in Fig. 2.

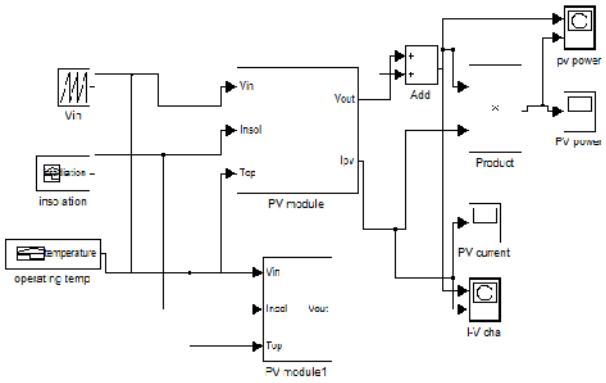


Fig. 2. Simulink model of PV module.

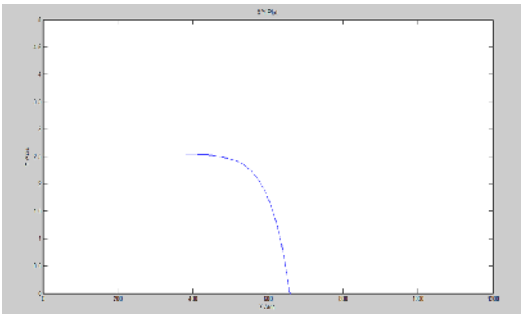


Fig. 3. I-V Characteristics of PV Module.

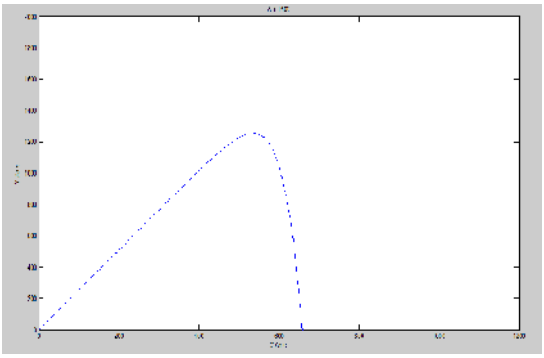


Fig. 4. P-V Characteristics of PV module.

B. Modeling of Wind Conversion System
Wind energy system converts the kinetic energy of the wind and then to electrical energy. This can be done by wind energy conversion system (WECS). WECS Composed of a wind turbine, a generator, power electronic converters and the Control system. The wind energy is a renewable source of energy .The wind turbine converts the kinetic energy of wind into mechanical power P_{wind} and then into electrical power.

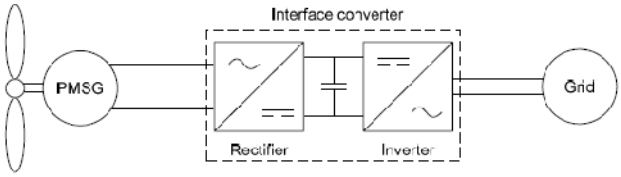


Fig. 5. Block Diagram of WECS.

$$P_{WIND} = 0.5A\rho v^3 \quad \ldots(1)$$

Only a part of the total wind energy can be used or extrcred. The available energy part in wind is described by the power coefficient C_p. The theoretical maximum value of this coefficient is 0.59 and this is called the Betz limit.

$$P_{turbine} = 0.5C_p\, Av^3 \quad \ldots(2)$$

The practical values of Cp lies between the value of 0.4 and 0.5 for industrial wind turbines. This power coefficient is a function of the tip-speed ratio λ

$$\lambda = r\,\Omega / V \qquad \ldots(3)$$

where r is the rotor radius and Ω is known as the angular otc speed.

The simulation diagram of WECS is shown in the Fig. 6.

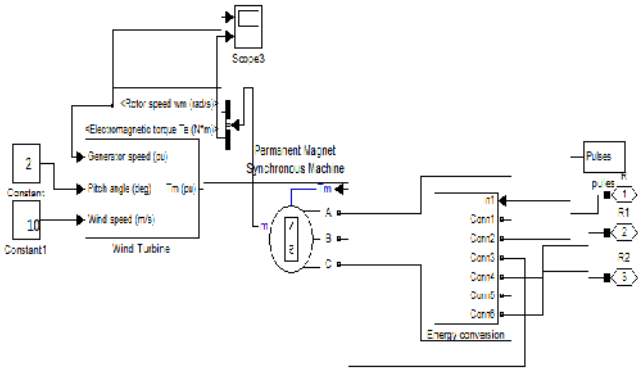


Fig. 6. Simulink Model of WECS.

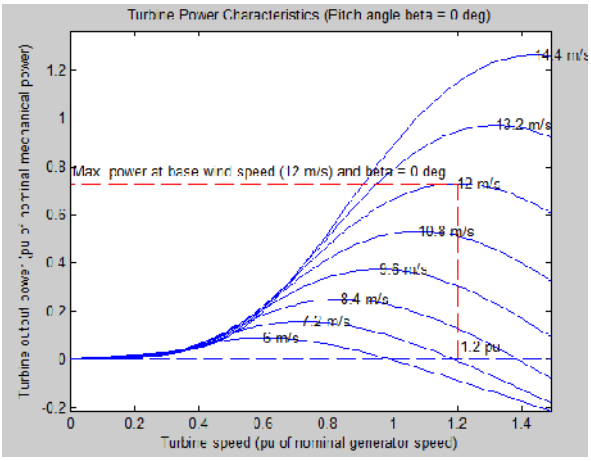


Fig. 7. Wind turbine power characteristics.

C. Modeling of Diesel Generator

Diesel generator sets convert fuel energy (diesel or bio-diesel) into mechanical energy by means of an internal combustion engine, and then into electric energy by means of an electric machine working as generator [3]. Fig. 8 shows the Simulink diagram of diesel generator set.

D. Proposed Simulink Model

Fig. 9 shows the proposed hybrid system Simulink diagram .this system consist of wind generator , Pv module , battery system and diesel generator.

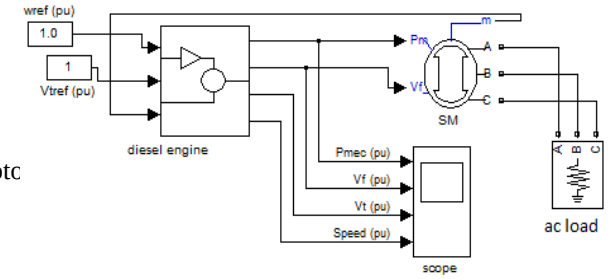


Fig. 8. Simulink diagram of Diesel generator.

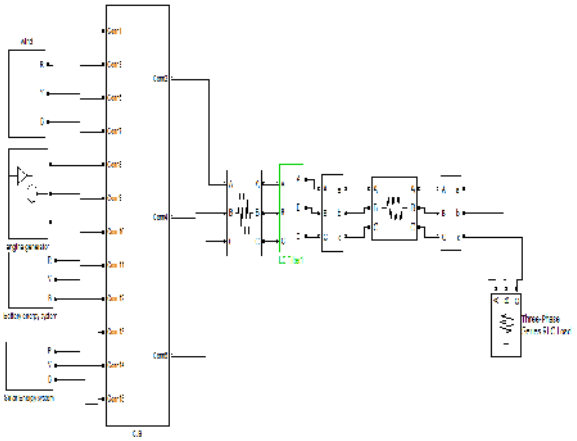
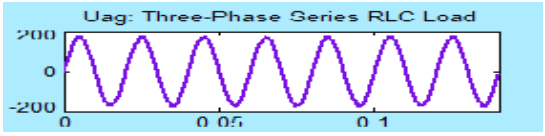
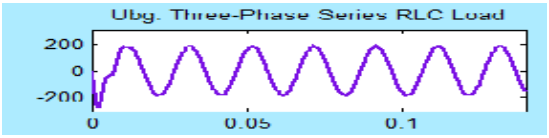


Fig. 9. Simulink Diagram of Hybrid power system.

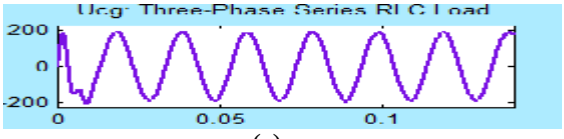
III. SIMULATION RESULT OF HYBRID POWER SYSTEM



(a)



(b)



(c)

Fig. 10. Different characteristics of load voltage.

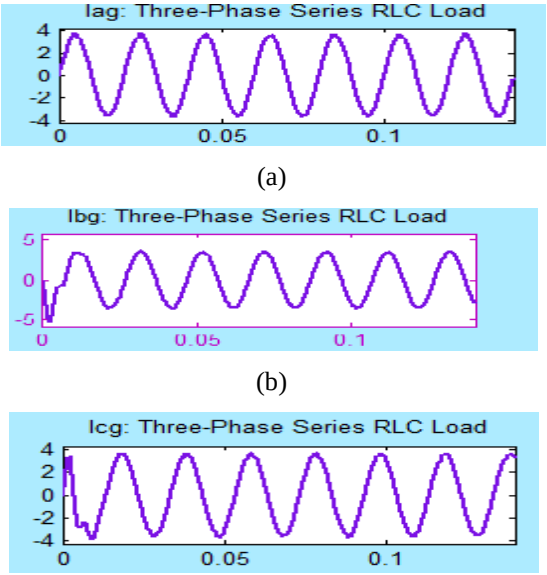


Fig. 11. Different characteristic of load current.

IV. CONCULSION

The simulation model of the proposed hybrid system has developed in this paper using Simulink/Matlab environment. It has been discussed here that the standalone hybrid system consisting of PV module, Wind generator, diesel generator & battery system. The modeling of PV module has been done by their general equation. A battery model is also developed to provide the backup supply. Compared to any fossil fuel based power system the running cost of this system is very low when installed in proper location.

REFRENCES

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

[2]. Sandeep Kumar1, Vijay Garg," 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.

[3]. Tiberiu Tudorache, Cristian Roman, "The Numerical Modeling of Transient Regimes of Diesel Generator Sets", *Acta Polytechnica Hungarica*. Vol. **7**, No. 2, 2010.

[4]. Natarajan Pandiarajan, Ramabadran Ramaprabha, and RanganathMuthu,"Application of Circuit Model for Photovoltaic Energy Conversion System Hindawi publishing *Corporation International Journal of Photoenergy* Volume 2012.

[5]. Binayak Bhandari, Shiva Raj Poudel, Kyung-Tae Lee, and Sung-Hoon Ahn," Mathematical Modeling of Hybrid Renewable Energy System: A Review on Small Hydro-Solar-Wind Power generation", *International Journal of precision engineering and manufacturing-green technology* vol. **1**, no. 2, pp. 157-173.

[6]. Dali, M., Belhadj, J., and Roboam, X., "Hybrid solar–Wind System with Battery Storage Operating in Grid-Connected and Standalone Mode: *Control and Energy Management – Experimental Investigation," Energy*, Vol. **35**, No. 6, pp. 2587-2595, 2010.