DESIGN AND MODELLING OF STANDALONE HYBRID POWER SYSTEM WITH MATLAB/SIMULINK

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ABSTRACT
This paper presents a standalone hybrid power system using wind/PV/diesel/Battery energy system with Matlab/Simulink environment. PV & Wind are the primary power sources of the system and battery is used as a backup for long run application. Here we have also compare the performance of PV/Wind/Battery connected system with PV/Wind/Diesel connected hybrid power system. The most frequently used renewable energy sources are those consisting of PV module and/or wind Turbine with/or Diesel generator, and some energy storage or backup system.

KEYWORDS – Hybrid power system, Photovoltaic module, diesel generator, battery, Matlab/Simulink.

I.   INTRODUCTION

The global environment conditions are getting worse day by day. The rapidly increasing energy consumption, limited resources of fossil fuel and the soaring cost of fuels increases the need of renewable energy sources. Renewable resources are natural resource. Renewable resources are basically a part of Earth's natural environment and one of the largest components of its atmosphere. Renewable energy is taken or extracted from natural resources such as sunlight, wind, biomass, green energy, tides, and geothermal energy. Common application of renewable energies is electricity generation.

Most renewable energy comes either directly or indirectly from the sun. Sunlight, or solar energy, which can be used directly for generating electricity, and also for hot water heating, and a variety of commercial and noncommercial uses. Renewable energy facilities generally require less maintenance than traditional generators.

Renewable energy produces zero or a very little amount of waste products such as carbon dioxide or other chemical pollutants, so has minimal impact on the environment.

Among all the renewable energy resources, the solar and wind energies have the great potential as a power generating energy source, because of their many advantage like low or zero emission of pollutant gases, low cost, inexhaustible sources and easy availability of these energy sources. But these systems have some disadvantages also like dependency on weather conditions. One of the major disadvantages with renewable energy is that it is difficult to generate the quantities of electricity that are as large as those produced by traditional fossil fuel generators. So we need to reduce the amount of energy we use or simply find alternated source of energy. The best solution to our energy problems may be to have a balance of many different power sources.

Another disadvantage of renewable energy sources is the dependency of supply like sun light or wind etc. Renewable energy often depends on the weather condition for its source of power input. For example a Hydro generator depends on rain to fill dams to supply flowing water. A wind turbine depends on wind to turn the blades to run the turbine, and a solar cell depends on the position of sun

to collect heat and make electricity. The supplies from these sources are highly unpredictable and inconsistent. The generation of current from renewable energy technology is also far in excess of traditional fossil fuel generation, this is because it has extremely large capital cost. We can reduce the dependency of solar or wind power system on weather conditions by using some backup supply like batteries. This paper presents an hybrid wind/PV/diesel/Battery energy system for standalone system using Matlab/Simulink environment.

II.   SYSTEM DESCRIPTION

In this section the Simulink model of hybrid power system based on PV module, wind turbine, and diesel generator set is described. The proposed system is consisting of a PV module, boost converter, inverters, wind turbine, synchronous generator, diesel generator set and battery.
In this paper we are also comparing the performance analysis of PV/wind/Diesel hybrid system with PV/wind/battery hybrid power system.

2.1 MODELING OF WIND TURBINE

The wind generator set consists of a wind turbine, synchronous generator, rectifier, and inverter to get an ac supply. Basically the wind turbine sends the wind's kinetic energy in the rotor which is mechanically coupled to generators**.**
The fundamental equation can be given as

$$PWIND = 0.5A\rho v3 \quad \ldots\ldots\ldots\ldots \quad (1)$$

The available energy part in wind is described by the power coefficient Cp.
The theoretical maximum value of this coefficient is 0.59 and this is called the Betz limit.

$$Pturbine = 0.5Cp\ Av3 \quad \ldots\ldots\ldots \quad (2)$$

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

$$\lambda = r\ \Omega/V \quad \ldots\ldots..(3)$$

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

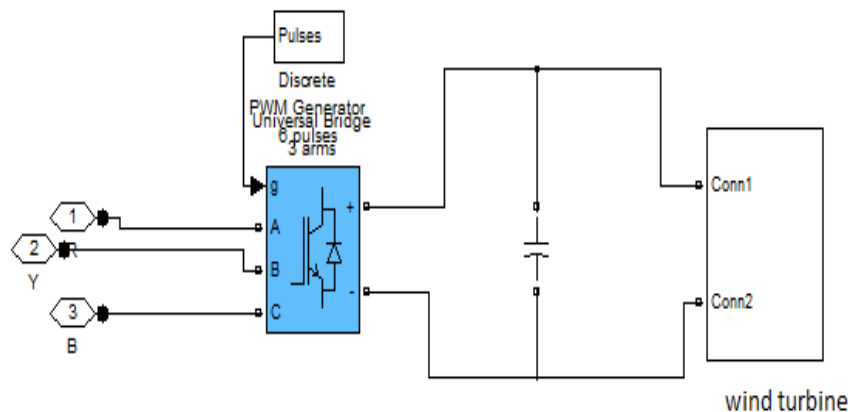The Simulink model for wind turbine is shown in Fig. 1.
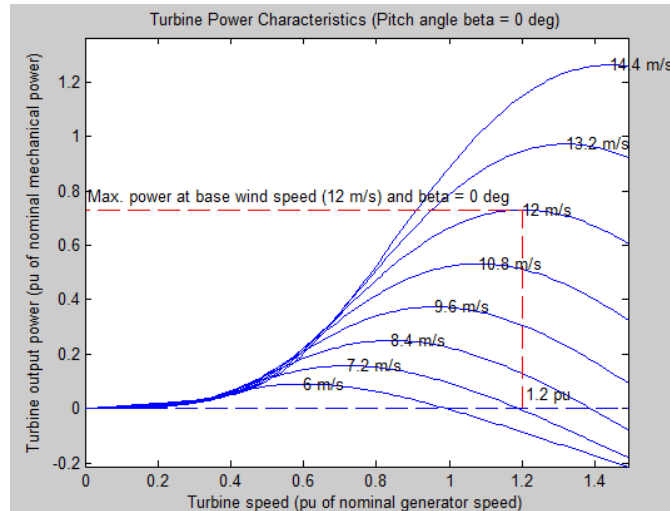

Fig. 1 Simulink model of wind turbine

Fig 2. Characteristics of wind turbine

2.2 MODELLING OF PV MODULE

Solar cell is basically a p-n junction with a thin layer of semiconductor device.
Photo current is generated when solar radiations are fall on the PV panels.
PV system naturally exhibits a nonlinear I-V and P-V characteristics which vary with the radiant intensity and cell temperature.[1]
The voltage-current characteristic equation of a solar cell is given as

$$I = I_{PH} - I_S \left[\exp \left(q(V + I_{RS}) / kT_C A \right) - 1 \right] - (V + I_{RS}) / R_{SH}$$

Where I_{ph} is photocurrent, I_s is the cell saturation of dark current, q $(= 1.6 \times 10{-}19C)$ is an electron charge, k $(= 1.38 \times 10{-}23 J/K)$ is a Boltzmann's constant, T_c is the
Working temperature of the solar cell, A is an ideality factor of the diode, R_{sh} is a shunt resistance, and R_s is a series resistance.
With the help of the above equation we designed a Simulink model of PV module, with boost converter to convert variable dc in to constant dc supply and an inverter to convert this dc supply into ac supply.
The Simulink model of PV module is shown in the Fig. 3
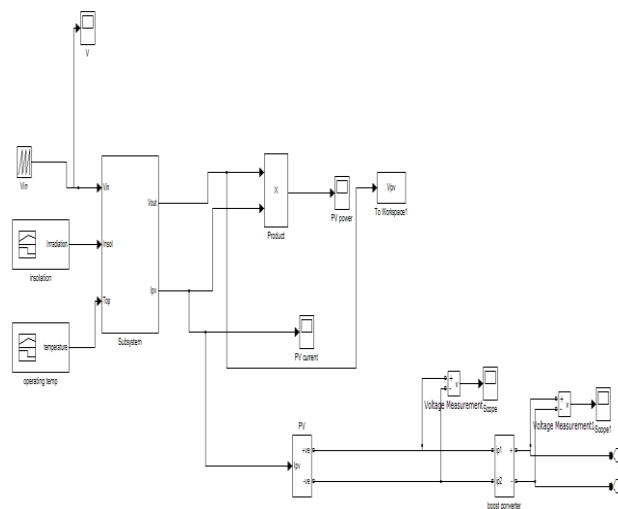
Fig. 3 Simulink model of PV module

2.3 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].
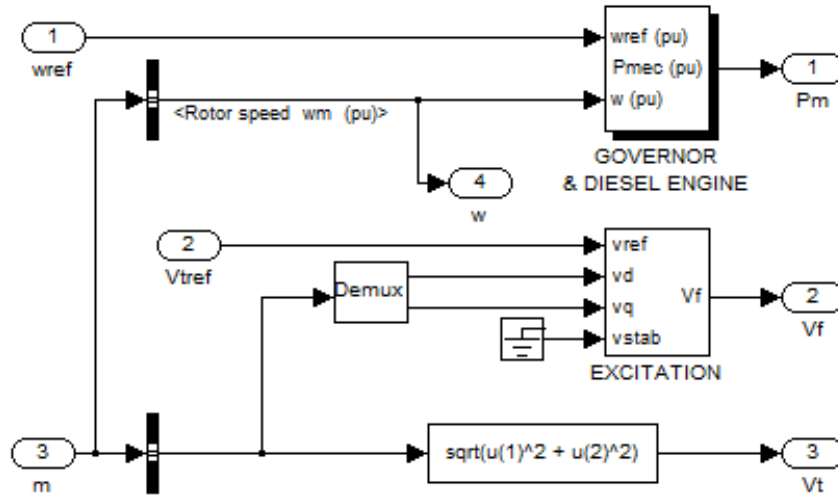Fig.4 shows the Simulink diagram of diesel generator set.

Fig 4. Simulink model of diesel generator

2.4 MODELING OF HYBRID POWER SYSTEM

Using the Simulink environment the stand alone hybrid power system is developed here. The two hybrid systems are consists of PV/wind/diesel and PV/wind/battery connected power system**.** Fig.5 & fig.6 shows simulation both hybrid system.
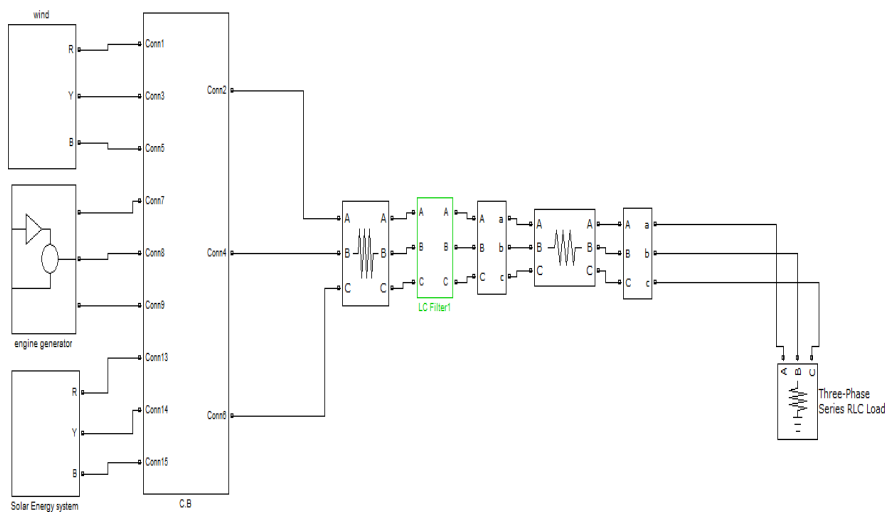
Fig .5 Simulink model of PV/wind/diesel system
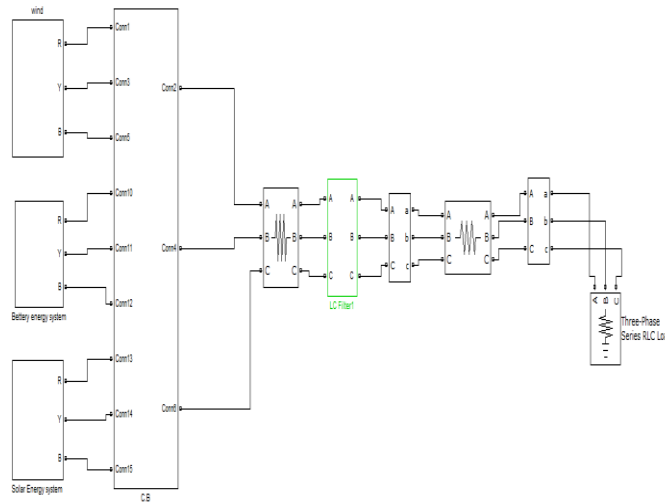
Fig .6 Simulink model of PV/wind/battery system

III.   SIMULINK RESULTS

Fig. 7 shows the load characteristics of PV/wind /diesel hybrid power system
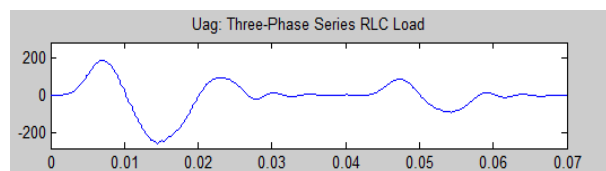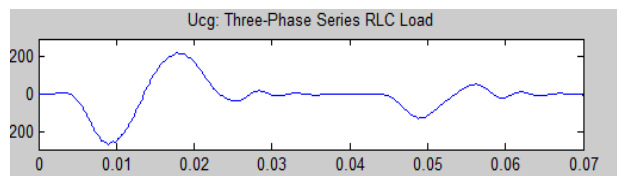

Fig.7(a)
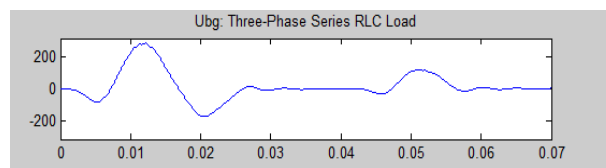
Fig.7(b)

Fig7(c)

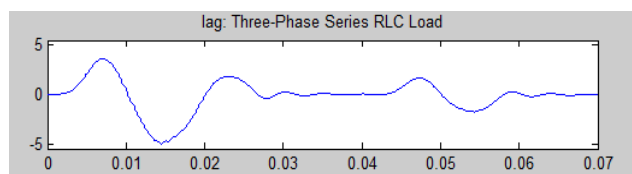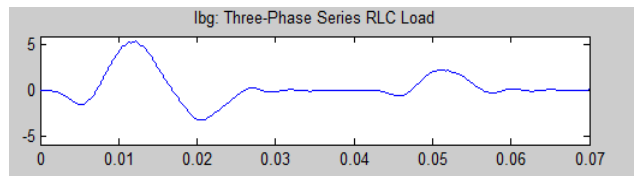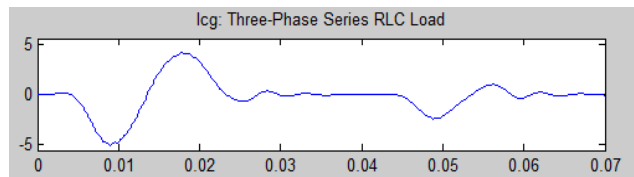Figure 7(a), 7(b) & 7(c) Characteristics of load current

Fig7(d)

Fig7(e)

Fig7(f)

Figure 7(d), 7(e) & 7(f) Characteristics of load voltage

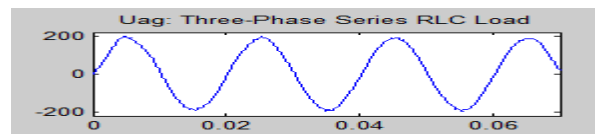Fig. 7 shows the load characteristics of PV/wind /battery hybrid power system.
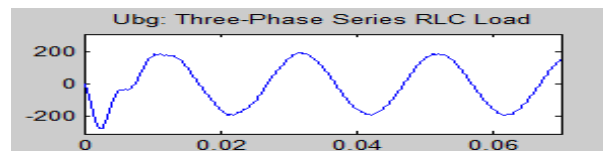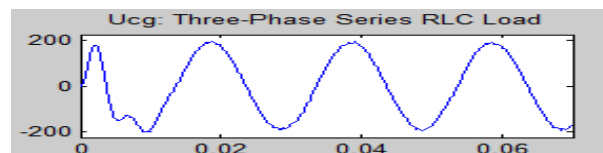

Fig.8(a)

Fig.8(b)

Fig.8(c)

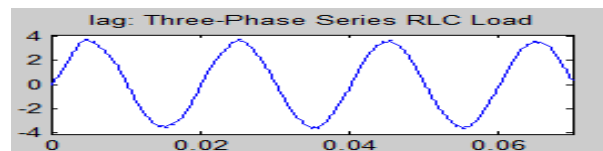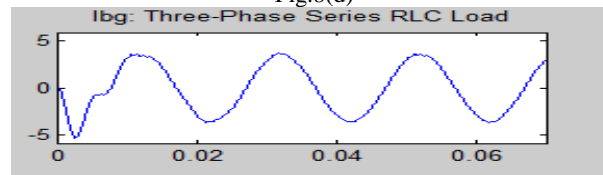Figure 8(a), 8(b) & 8(c) Characteristics of load current

Fig.8(d)

Fig.8(e)

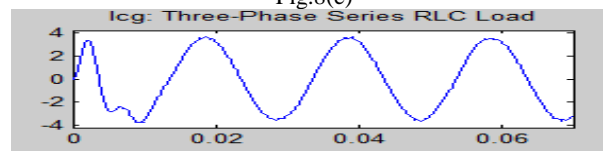
Fig.8(f)

Figure 8(d), 8(e) & 8(f) Characteristics of load voltage

IV.   CONCLUSION

This paper presents an hybrid wind/PV/diesel/Battery energy system for standalone system using Matlab/Simulink environment. The standalone hybrid system is better than a single energy source. Here we have compare the two system PV/wind/battery hybrid system and PV/wind/diesel hybrid system. From the simulation results we can say that hybrid connected system with battery perform better in some ways than the diesel connected system.

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