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Modelling of Subsystems of Solar-Wind Hybrid Power Generation System by Simulation/Matlab

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***Abstract*— Due to rapid expansion in energy issue, the developments of renewable energy source are becoming more popular and attractive. The commonly used renewable sources are solar photovoltaic and wind energy systems have received a great acceptance in field of power generation for pollution free performance, free availability and for great reliability. And for further development and for effective use of natural resources, the hybrid systems are developed. Hybrid Systems can give better output and better performance than the standalone solar power systems and standalone wind energy systems. The effectiveness of renewable energy hybrid system is increased; though primarily those are not conventional or non conventional energy resources & secondarily it decreases global warming and pollution which is a vital issue now-a-days. In this Paper, the designing and modelling of solar photovoltaic system and wind energy system are done by MATLAB/Simulation.**

Keywords—Hybrid System, Solar Photovoltaic System, Wind Energy System, Simulation/MATLAB

I. INTRODUCTION

The rapid decreasing in fossil fuel and natural gas are alarming us to think about alternative sources of energy. Renewable energy is a better solution to this problem. Different technologies have been developed day by day to mitigate the required output of the hybrid system. Standalone Hybrid system generally consists of two or more integration of different renewable sources (solar PV-Wind hybrid, diesel-wind hybrid), fossil fuel generator, energy storage system and power conditioning devices. It has the ability to provide 24-hour grid quality electricity to the load. It has also flexibility of planning, environmental benefits, low maintenance and long term project revenue. Apart from mobility of the system, it has also longer life cycle.

Most well-known renewable energy systems that are used for hybrid system are solar photovoltaic system and wind energy system. Even though, there are advantages in electrical power generation system comprising of solar and wind as foremost resources of energy, many troubles are faced for intermittent properties and fluctuations in weather data in day, night, winter and summer. Due to which the power supply continuity should be maintained by some other reliable source such as battery & diesel generator.
In this paper the solar photovoltaic model and wind energy model are designed by simulation/MATLAB and their corresponding results are also presented in this paper.

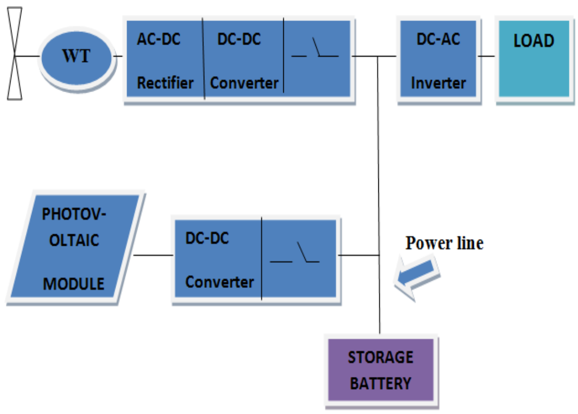

Fig.1 Wind – solar PV Hybrid System

II. SOLAR PHOTOVOLTAIC SYSTEM

The solar cells are well identified as Photovoltaic cells. It generally converts direct sunlight into Direct current & further it is converted to AC by DC-DC converter (here, buck-boost conv. is used) and inverter. Photovoltaic cells are generally a semiconductor usually made up of **Si** (silicon), those are especially used for creating an electric field that is +ve on one side and -ve on other side. Direct current is produced when the sun ray or radiation falls on the cell. Solar module basic equations are given by;

Solar Module photo current is given by;

$$Iph = [Isc + Kp(T\text{-}298)]*\lambda /1000 \quad ...... (1)$$

Solar Module reverse current Irs is given by ;

$$Irs = Isc / [exp (q\ Voc/ Ns\ k\ AT)\text{-}1] \quad ...... (2)$$

The saturation current Io deviates with the temperature of solar cell & is given by,

$$Io= Irs \left[\frac{T}{Tr}\right]^3 exp \left[q* \frac{Ego}{Bk}\left(\frac{1}{Tr} - \frac{1}{T}\right)\right] \quad ...... (3)$$

The output current of PV module is given by,

$$Ipv = Np* Iph – Np* Io[exp\{\frac{q*(Vpv+IpvRs)}{NsAkT}\}\text{-}1] \quad ...... (4)$$

Where Vpv=Voc= open circuit voltage
Vpv, Ipv=output voltage and current of a PV Module

Tr = mentioned Temperature
T= operating temperature
Iph=photo current in PV module
Io= solar module saturation current
A,B = ideal factor= 1.5
K= Boltzmann's constant = 1.38×10^{-23} J/K
q= Charge of electron = 1.6×10^{-19} C
Isc = short circuit current of the module at constant temperature 25℃ and at constant irradiation 1000 W/m^2= 2.55A
Kp = short circuit current temperature co-efficient= 0.0017 A/℃
λ= module illumination (1000W/m^2)
Ego= band gap for silicon = 1.1eV
Ns, Np= number of solar cells connected in series and parallel respectively.

A. MODELLING OF SOLAR MODULE

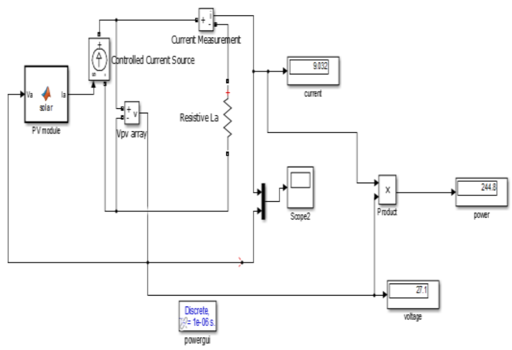

Fig.2 simulation of solar module

RESULT:

Fig.3 simulation result of solar module having constant temperature 298K and constant irradiation 1000W/sqm and Np=2 and Ns=24, V= 27.4volt, I= 9.0A (approx.)

B. MODELLING OF DC-DC (BUCK-BOOST) CONVERTER:

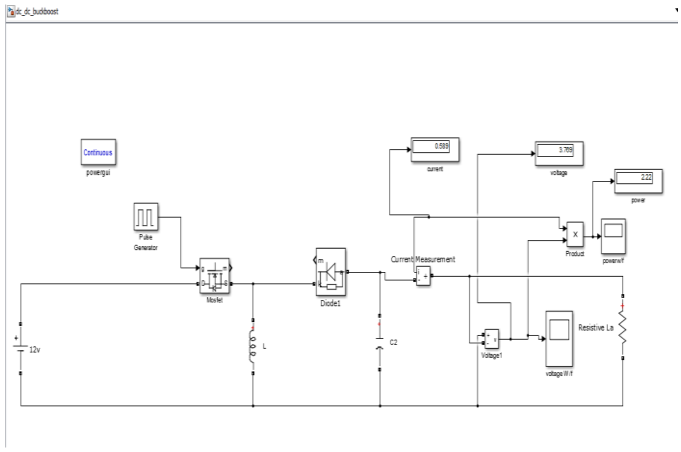

Fig.4 Simulation of DC-DC (buck-boost) converter

RESULT:

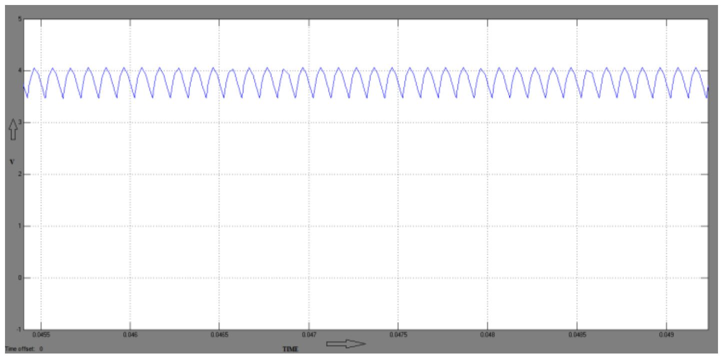

Fig.5 Simulation result of DC-DC converter (Voltage Vs. Time)

C. MODELLING OF INTEGRATION OF SOLAR MODULE AND DC-DC CONVERTER:

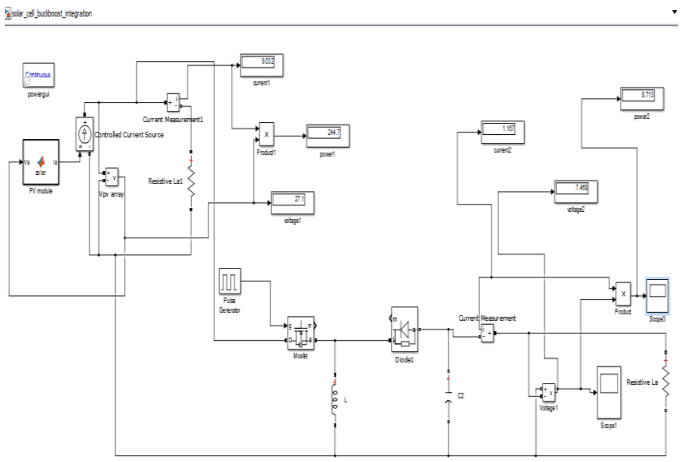

Fig.6 Simulation of integration solar pv module and DC-DC converter

RESULT:

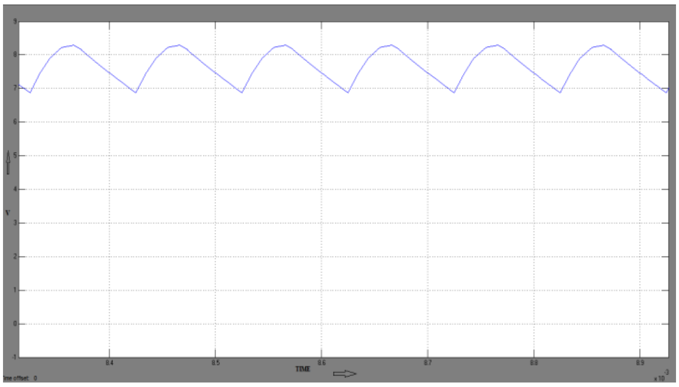

Fig.7 Simulation result of solar pv module and DC-DC converter (Voltage vs. Time)

III. WIND ENERGY SYSTEM:

Generally, wind energy systems convert kinetic energy of wind into other forms of energy like electricity. The applications of Wind energy conversion system have so increased in the world that the efficiency of the wind energy conversion system is getting vital. However, the optimum efficiency of a WT is theoretically taken as 59.1% (Approx.), the usable conversion efficiency comes about (40-45)% in modified WT type. Wind energy conversion system generally consists of wind turbine, Permanent magnet synchronous machine (PMSM) rectifier, DC-DC converter (buck converter is used here) and 3 Ø inverter (SPWM).

a. MODELLING OF WIND CONVERSION ENERGY SYSTEM:

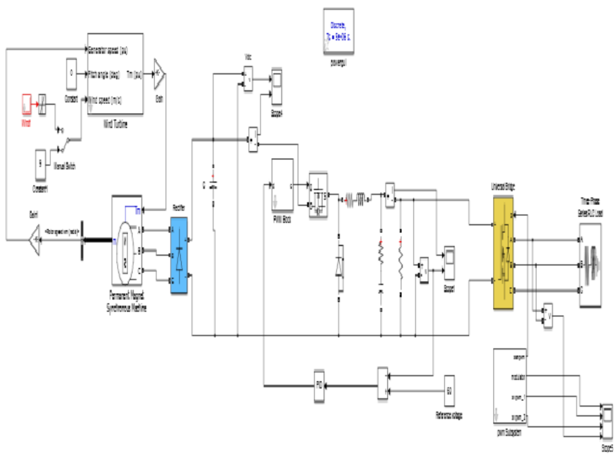

Fig.8 Simulation diagram of WECS

RESULT:

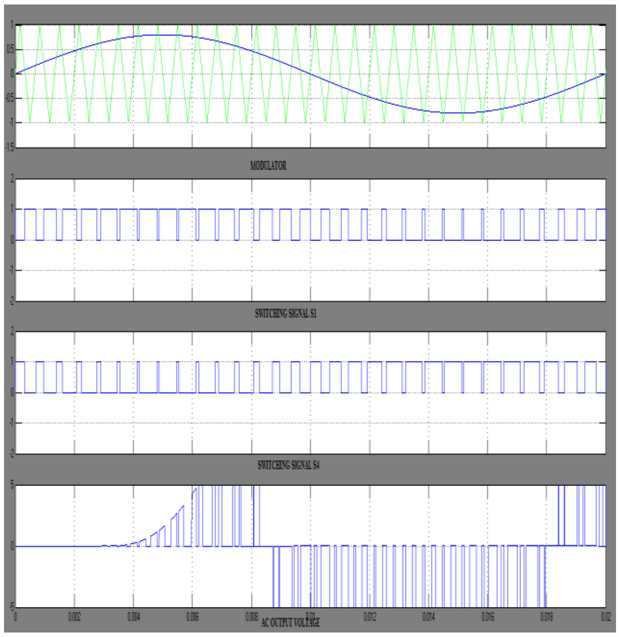

Fig.9 Sinusoidal PWM graphs for three phase inverter

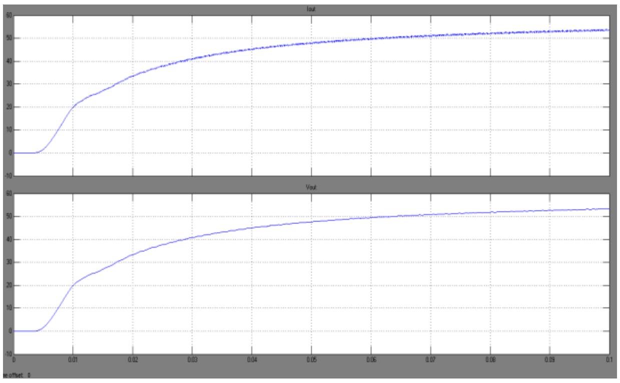

Fig.10 regulated current output and voltage output WECS

IV. CONCLUSION

The field of study introduced in the above paper proposes the solar-wind hybrid system working principle in particular. Here, the solar photovoltaic subsystem and wind energy conversion subsystem are simulated separately. Solar PV module is modelled according to their basic solar equations. WECS has been simulated in this paper and its graphical output has been presented. The working cost of the hybrid power generation unit is cheaper when installed in proper location as compared to any conventional fuel system.

V. REFERENCES

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