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Design and Analysis of Hybrid Renewable Energy For Solar and Wind Energy Systems

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Abstract: This paper deals with the combination of two renewable energy systems solar and wind is known as hybrid renewable energy (HRES). This type of standalone hybrid energy system is suitable, for the availability of energy throughout the year in rural areas where grid connection is not possible. In this paper, a solar PV module irradiation level for different conditions using Incremental Conductance (IC) Method MPPT algorithm and wind speed control of PMSG Generator using a PI controller has been designed and analysed separately and interconnected as a hybrid system with energy back up to store excess energy and a both system are connected using a inverter to RL load which is a standalone system is designed and analysed using MATLAB/SIMULINK.

Keywords: Hybrid Renewable Energy System (HRES), Photo Voltaic (PV) Module, Incremental Conductance (IC) method Maximum Power Point Tracking (MPPT), Permanent Magnet Synchronous Generator (PMSG), Proportional Integral Controller (PI).

I. INTRODUCTION

Due to the demand of industrial fuels which include oil, gas and others, the development of renewable energy sources is continuously improving. This is the reason why renewable energy sources have become more important these days. The main advantages like abundant availability in nature, eco-friendly and recyclable. Among the different renewable sources solar and wind energy are the world's fastest growing energy resources. With no emission of pollutants, energy conversion is done through wind and PV cells.

Day by day, the demand for electricity is rapidly increasing. But the available base load plants are not able to supply electricity as per demand. So these energy sources can be used to bridge the gap between supply and demand during peak loads. This kind of small scale stand-alone power generating systems can also be used in remote areas where conventional power generation is impractical.

In this thesis, a wind-photovoltaic hybrid power generation system model is studied and simulated. A hybrid system is more advantageous as individual power generation system is not completely reliable. When any one of the system is shutdown the other can supply power. A block diagram of entire hybrid system is shown below.

II. PV MODULE DESIGN

A. SCHEMATIC DIAGRAM OF PV MODULE

Basically, a p-n junction is a thin fabricated wafer of semiconductor which is a solar cell. The electromagnetic radiation of solar energy can be converted to electricity directly through photovoltaic effect. Being cells are exposed to the sunlight radiation, the band-gap energy which is lesser than the photon energy of the semiconductor which creates some electron-hole pairs is proportional to the incident irradiation.

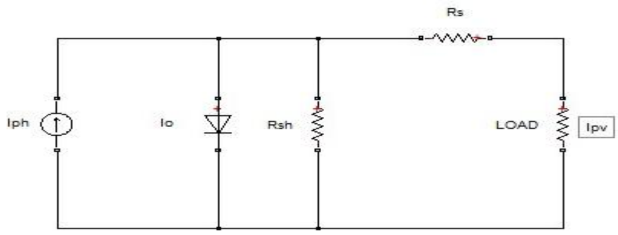


Figure 1.PV cell modeled as diode circuit

The current source Iph represents the cell photocurrent. Rsh and R s are the intrinsic shunt and series resistances of the cell, respectively. Usually the value of Rsh is very large and that of Rs is very small, hence they may be neglected to simplify the analysis. PV cells are grouped in larger units called PV modules which are further interconnected in a parallel-series configuration to form PV arrays. The photovoltaic panel can be modeled mathematically as given in equations (1)- (2) .

B.PV MODULE EQUATIONS

PV Module saturation current:

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

Current Output of PV Module:

$$\mathrm{Ipv} = \mathrm{Np} \times \mathrm{Iph} - \mathrm{Np} \times \mathrm{Io}\left[\exp\left\{q * \mathrm{Vpv} + \frac{\mathrm{IpvRs}}{\mathrm{NsAKT}}\right\} - 1\right] \quad (2)$$

III. DESIGN PROCEDURE FOR SOLAR PV MODULE

Different forms of renewable energies have been discussed along with the most important one, the solar energy. The concepts of a PV cell and its characteristics have been studied and obtained through its characteristic equation. Boost converter has been studied under both open loop and closed loop conditions [10]. The P-V, I-V, P-I curves have been obtained at varying irradiation levels and temperatures. Effects of partial shading on the Photovoltaic array have been demonstrated with the variations in the characteristics under these conditions. An MPPT model has been designed to extract maximum power from the photovoltaic array [15,16].

A. MPPT Algorithm

An overview of Maximum Power Point Tracking A typical solar panel converts only 30 to 40 percent of the incident solar irradiation into electrical energy. Maximum power point tracking technique is used to improve the efficiency of the solar panel. According to Maximum Power Transfer theorem, the power output of a circuit is maximum when the Thevenin impedance of the circuit (source impedance) matches with the load impedance [3]. Hence our problem of tracking the maximum power point reduces to an impedance matching problem. In the source side we are using a boost convertor connected to a solar panel in order to enhance the output voltage so that it can be used for different applications like motor load. By changing the duty cycle of the boost converter appropriately we can match the source impedance with that of the load impedance.

C. Incremental Conductance

The Incremental conductance method uses two voltage and current sensors to sense the output voltage and current of the PV array. At MPP the slope of the PV curve is 0.

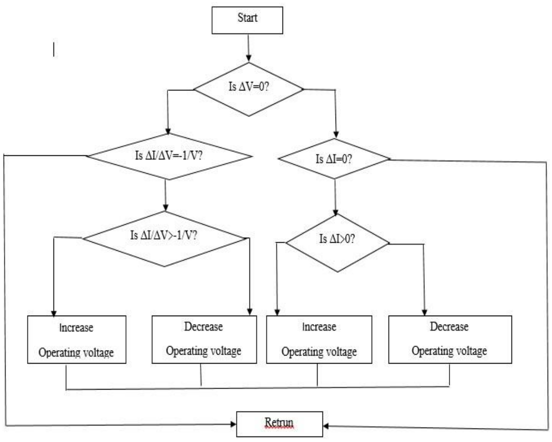
$$(dP/dV)_{MPP}=d(VI)/dV \quad (3)$$

$$0=I+V dI/dV_{MPP} \quad (4)$$

$$dI/dV_{MPP} = - I/V \quad (5)$$

The left hand side is the instantaneous conductance of the solar panel. When this instantaneous conductance equals the conductance of the solar then MPP is reached. Here we are sensing both the voltage and current simultaneously. Hence the error due to change in irradiance is eliminated [8]. However complexity and the cost of implementation increases. As we go down the list of algorithms the complexity and the cost of implementation goes on increasing which may be suitable for a highly complicated system. This is the reason that Perturb and Observe and Incremental Conductance method are the most widely used algorithms and the mathematical equations (3)-(5)

D .Flow Chart of IC Method



IV. SIMULATION RESULTS AND DISCUSSIONS

CASE 1: Subsytem of PVmodule

From the simulation design of PV module a radiation from sun that fall on the solar panel produces photovoltaic current and insolation that is interconnected with MPPT algorithm

CASE 2: Design of IC Method (MPPT)

The simulation design of MPPT Incremental conductance method with buck converter for for dc-ac and discrete mean value with relational operator, pulse generator

CASE 3: Subsytem for regulation with boost converter

The effect on efficiency of PV module due to different load applied by user. The PV module power reduces if the load is not properly match with the characteristics resistance of the PV module. This problem can be solved by applying DC-DC converter in between PV module & Load

CASE 4: Subsystem model of PI Controller

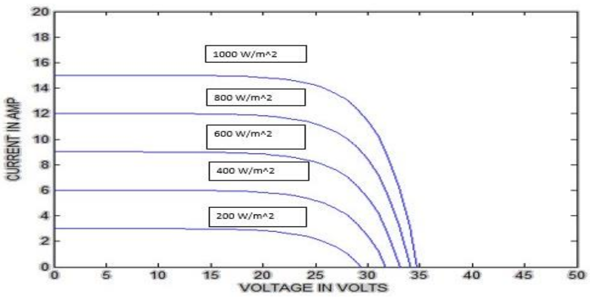
The effect on efficiency of PV module due to different load applied by user. The PV module power reduces if the load is not properly match with the characteristics resistance of the PV module. This problem can be solved by applying DC-DC converter in between PV module & Load.

CASE 5:Overall design of solar pv module

The Overall design of PV module it maintain constant power for various irradiation levels upto 0.49sec the irradiation level will be in 300W/m^2 when it reaches 0.5sec the irradiation level will reach to 500W/m^2 .

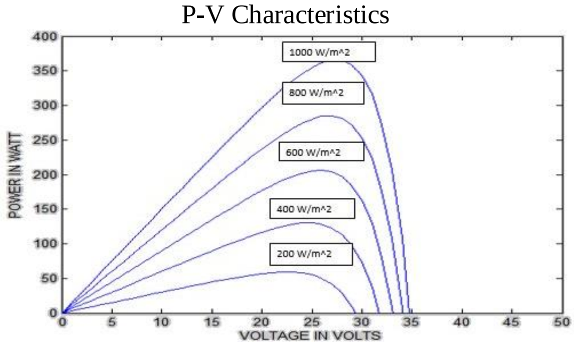
CASE 6: SIMULINK DESIGN OF PV MODULEBLOCK TO ATTAIN PV ARRAY CHARACTERISTICS

I-V Characteristics



Fig(a)

P-V Characteristics



Fig(b)

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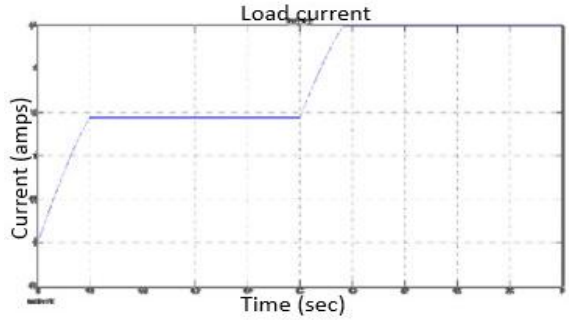
I-V and P-V characteristics the parameters were obtained for a generalized solar cell fig(a). The plot is similar to the theoretically known plot of the solar cell voltage and current. The peak power is denoted by a circle in the plot fig(b). Since only one solar cell in series is considered, hence the solar output voltage is less in this case.

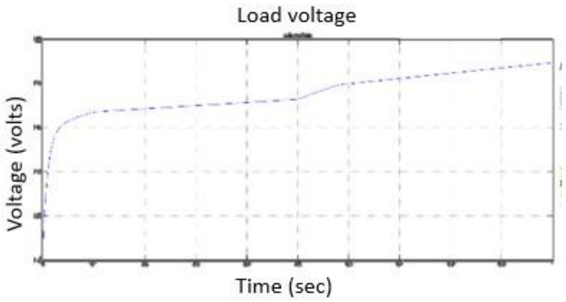
A.LOAD CURRENT



Fig(a)

From the above fig(a) R load current response is comparing between time in milli sec and current in milli amps it maintain constant power for various irradiation levels upto 0.49sec the irradiation level will be in 300W/m^2 when it reaches 0.5sec the irradiation level will reach to 500W/m^2

B.LOAD VOLTAGE



Fig(b)

From the above fig(b) R load output voltage response is comparing between time in milli sec and current in volts it maintain constant power for various irradiation levels upto 0.49sec the irradiation level will be in 300W/m^2 when it reaches 0.5sec the irradiation level will reach to 500W/m^2

C.OUTPUT POWER FROM PV UNIT

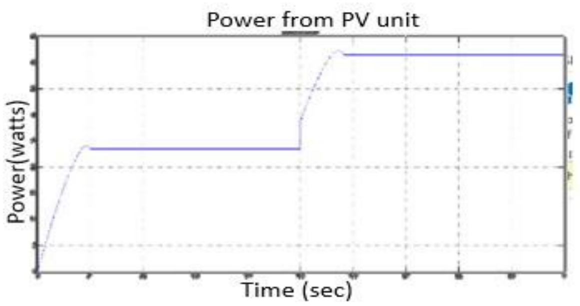


Fig (c)

V.WIND ENERGY SYSTEM

A.MODEL EQUATIONS OF WIND ENERGY

$$Pm=.\frac{1}{2}Cp(\lambda,\beta).\rho.A.v^3 \quad (1)$$

$$TSR=\frac{\omega R}{v} \quad (2)$$

B.PARAMETERS OF WIND TURBINE

- Pitch angle
- Air density
- Wind speed
- Rotor radius
- Generator speed

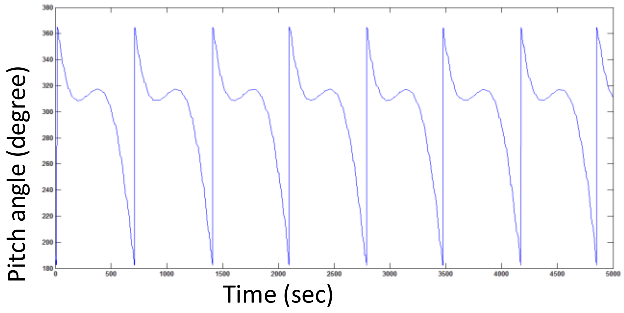


Fig.1 Output response of pitch angle

From the above pitch angle plot depend upon the rotation of blade the wind flow will be in horizontal direction

D.WIND SPEED RESPONSE

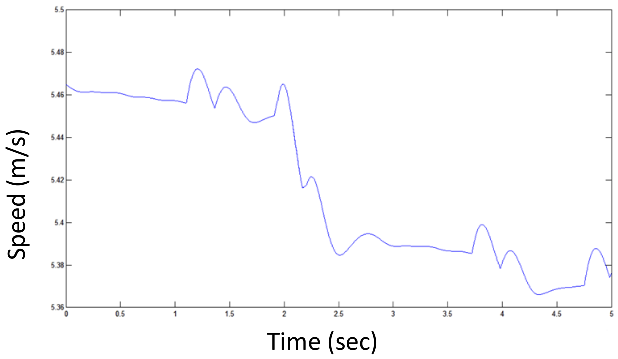


Fig.2 Wind speed response

From the above response the wind speed due to wind flow the energy will rectify using ac-dc rectifier

E.TIP-SPEED RATIO

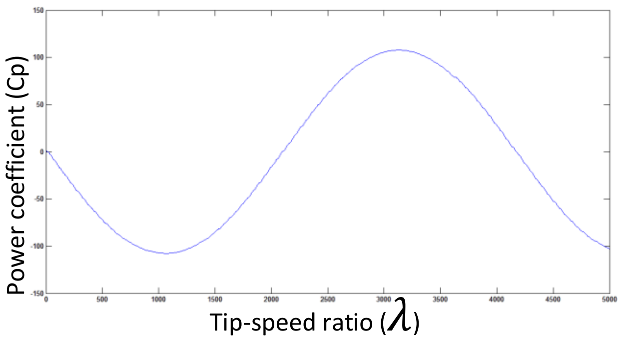


Fig.3

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From the response the power coefficient is a function of the tip- speed ratio and the efficiency of wind turbine is a function of the TSR. Higher tip speed result in higher noise

OVERALL BLOCK DIAGRAM OF HYBRID RENEWABLE ENERGY SYSTEM:

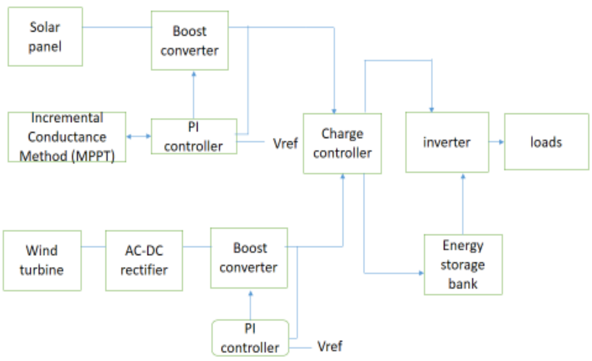

Fig.4 Block Diagram

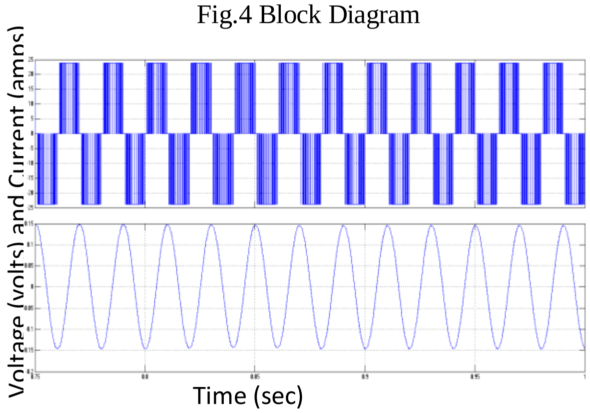

Fig.5 Inverter Output response Voltage and current

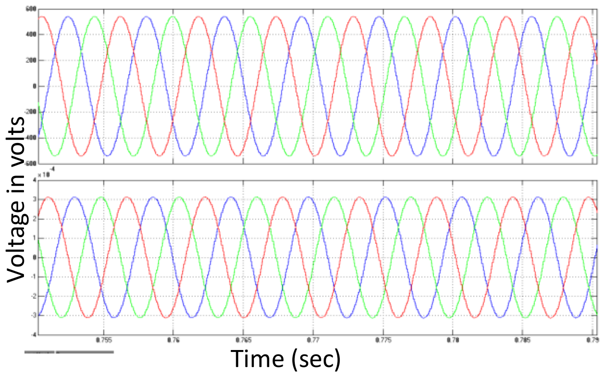

Fig 6.Three phase line voltage of wind energy system

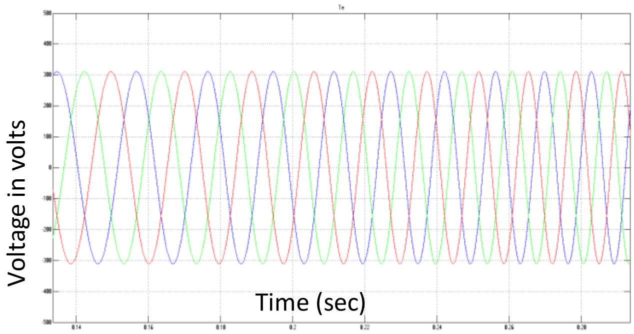

Fig 7. Three phase output voltage of PMSG

VI. CONCLUSION

Thus the proposed work of hybrid renewable energy system using solar and wind has been designed and modelled using MATLAB/Simulink which is a standalone system connected to RL load. In this work, a solar is tested for various conditions and a wind energy uses a PMSG generator, in which a wind speed is controlled by PI controller. In order overcome the disadvantage of single energy system the HRES has been used for continuous flow power when any one of the system has been failed the energy given through other system.

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