Simulation Modelling of Solar And Wind Energy System

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Abstract - *In present situation electrical energy is playing a crucial role in development of any nation. Enormous consumption of resources like coal, oil etc. has created demand for renewable energy. Due to the current requirements for the use of renewable energy as sources of electrical energy, solar energy and wind energy is getting much interest all over the world. This paper consist the simulation modeling of solar and wind energy system using MATLAB.*

***Key Words*: PV Panel, MPPT, Boost Converter, Wind Turbine, Permanent Synchronous Generator.**

1. INTRODUCTION

Today most of the researches in power system are going on the development of conventional energy based power generation. But the issues like international oil crisis, limited availability of non renewable sources and environmental pollution effect forced the researcher to think about an alternative source of energy that can be the solution for the above issues.. So conventional sources of energy acquire growing importance due to its enormous consumption and exhaustion of fossil fuel. The various forms of renewable energy sources like wind energy, solar energy, biogas energy, hydro energy, tidal energy etc. can be a probable solution to this. All these sources of renewable energy are plentifully available in nature, are recyclable and almost available free of cost. Moreover, solar energy and wind energy is the best among all the renewable energy sources. Energy provided by the sun in one hour is equivalent to the amount of energy necessary by the human in one year. Photo voltaic arrays are used in various applications such as battery charging ,water pumping, street lighting in rural town, and grid connected PV systems. Solar energy is non conventional, everlasting and vital source of energy. If used in a suitable way, it has a capacity to satisfy many energy needs of the world. The power from the sun captured by earth is nearly 2631MW. Thus Even though the PV system is modeled to its high capital fabrication cost and small conversion efficiency, the sky rocketing oil prices make solar energy naturally viable energy supply with potentially long-term benefits. [1] Power-Voltage curve of a solar panel, there is an optimal operating point such that the PV provides the maximum possible power to the load. The optimum operating point varied with solar irradiation and cell temperature. This paper describe the Perturb And Observe MPPT algorithm method.

Wind power, as an alternative to fossil fuel is exist plentifully, renewable, largely distributed, unpolluted, produces zero greenhouse gas throughout operation and uses diminutive land for its installation.In year 1887 firstly when wind power was used for producing electricity. Later that wind energy was used to generate power at small scale. In the year 1973, when the oil price crisis increases the research of non-petroleum energy and investigators started doing research on wind based power generation for more use. Wind power station can work in both in standalone mode as well as grid connected mode. In wind energy conversion systems (WECSs), the main technologies contain wind turbine technology, permanent magnet synchronous generator (PMSG) modeling technology, power electronics technology and system control technology. This paper describe the control algorithm of direct-driven wind turbine PMSG system and simulated. The direct-drive wind turbine PMSG do not have the gearbox between the wind turbine and rotor shaft, which evade the mechanical power losses occurred by gearbox. Also the elimination of gearbox also helps in decreasing the cost of the system. The kinetic energy of the wind is transformed into mechanical energy by the turbine by mode of shaft and gearbox arrangement as of the different operating speed ranges of the wind turbine rotor and generator. The generator transforms this mechanical energy into electrical energy. Though, as wind is an irregular renewable source, the wind source take out by a wind turbine is therefore not constant. [2] Due to this, the wavering of wind power results in wavered power output from wind turbine generator. From the point of view of utilities, due to the wavering of generator output, it's not suitable for the generator to be straight connected to the power grid. In order to attain the condition that the generator output power is appropriate for grid-connection, it is required to use a controller to manage the output generated by the wind turbine generator.

2. MODELLING OF PHOTOVOLTAIC CELL

Solar cells are joined in series and parallel to build the solar array. Solar cell will generate dc voltage when the sunlight fall on it. Fig. 1 shows the equivalent electrical circuit for a solar cell. Solar cell can be considered as a non-linear current source. Its produced current depends on the properties of the material, age of solar cell, irradiation and temperature.

$$I = I_L - I_0 \left\{ \exp\left[\frac{q(V + IR_S)}{nkT}\right] - 1 \right\} - \frac{V + IR_S}{R_{SH}}.$$

Above equation defines the I-V characteristics of the PV model.[3]

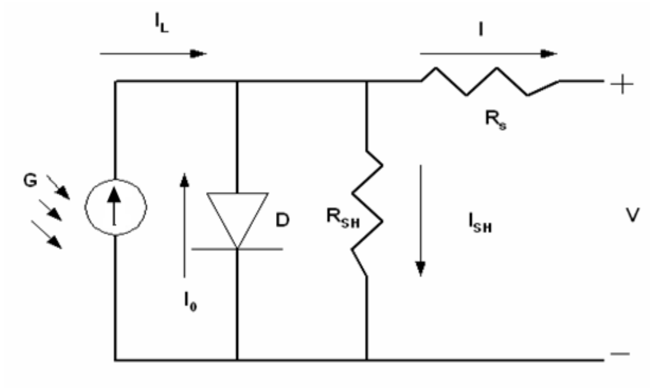

Fig-1: Photovoltic Cell

Where, IL is the light produced current (A), Io the PV cell saturation current (A), q the electron charge (q = 1,602 10.19 C), k the Boltzman constant (k = 1,38 10-23 J/OK), T the cell temperature. Rp and Rsh are pure dependent resistances characterizing respectively parallel current leakage and series connecting circuit.

3. MAXIMUM POWER POINT TRACKING

The position of the MPP in the I-V curve of PV module is not known previously and all the time modify animatedly hang on irradiance and temperature. Hence, the MPP requires to be placed by tracking algorithm, which is the heart of MPPT controller. The motive of the MPPT is to equal the load resistance RL to the output resistance of PV module. The MPPT used in this work is termed:[4] "output sensing method", it measures the power alteration of PV at the output side of converter and uses the duty cycle as a control variable [2]. This control method is the Perturbation and Observation (P&O) algorithm to positioned the MPP. The flowchart of algorithm is shown in **Fig2**. To accommodate duty cycle as a control variable, the P&O algorithm [23] used here is a somewhat modified, but the idea how it works is the same. The algorithm perturbs the duty cycle and find the output power of converter. If the power is rised the duty cycle is further perturbed in the similar direction; else the direction will be reversed.[5] When the output power of the converter is reached at the peak, the PV module is supposed to be operating at MPP .

3.1 Perturb and Observe algorithm (P&O)

The P&O algorithm is mostly used because it is easy to use ans simple to implement.. As per its name indicates, this method works by disturbing the system and observing the effect on power output of PV module. If the operating voltage is disturbed in a given direction and that the power rises (dP/dV > 0) then it is clear that the disturbance has moved the operating point toward the MPP. The P&O algorithm will remain to disturb the voltage in the similar direction. If the power decrease (dP/dV < 0), [6]then the disturbance has moved the operating point distant from the MPP. The algorithm will reverse the direction of following disturbance.

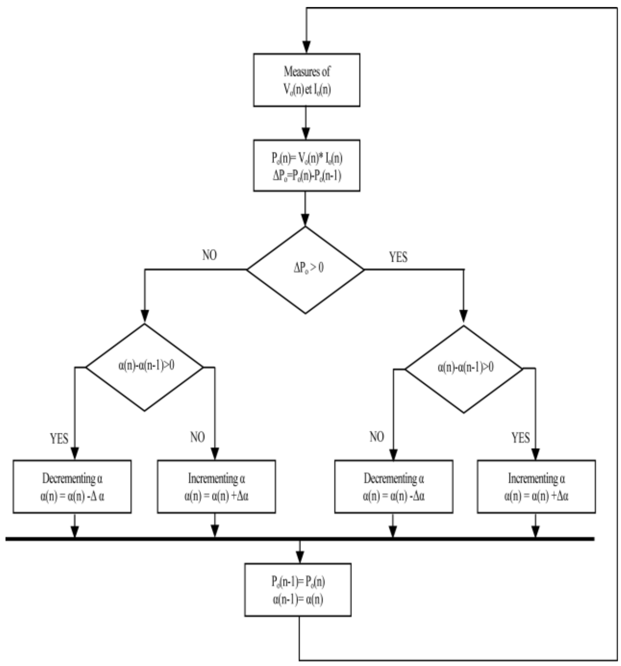

Fig-2: Flowchart of P&O algorithm with the output sensing method.

4. BUCK BOOST CONVERTER

It gives an output voltage that may be greater than or less than the input voltage therefore the name "buck-boost" the output voltage polarity is reverse to that of the input voltage. This regulator is known as an inverting regulator.[7]

During Mode 1, IGBT is switch on and diode D is reversed biased. The rising input current , ,flows through inductor L and IGBT. During mode 2 , IGBT is turn off and the current would flow through L,C , diode and load. Energy stored in inductor L would be transmitted to the load and the inductor current would decrease until IGBT is turn on again in the next cycle.[8]

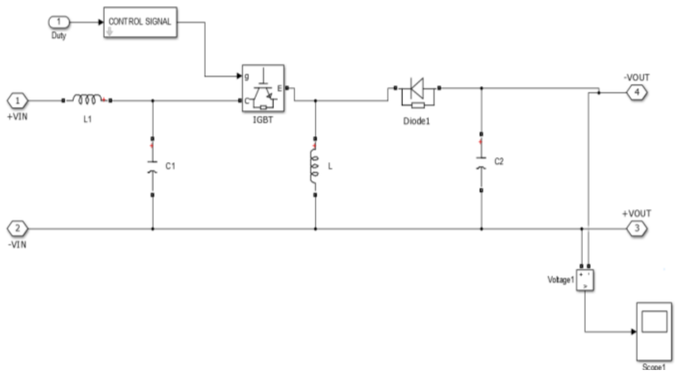

Fig-3: Buck boost converter

5. SIMULATION AND RESULTS OF SOLAR PANEL MPPT BUCK BOOST CONVERTER

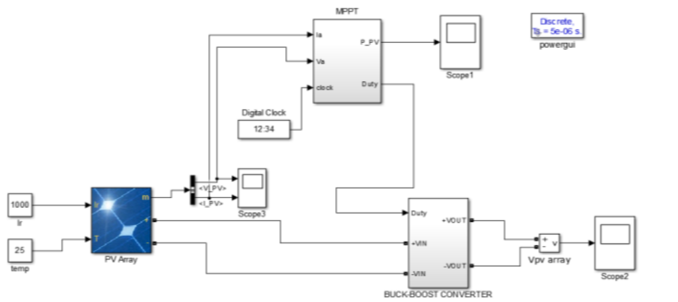

Fig-4: Simulation of PV panel with MPPT

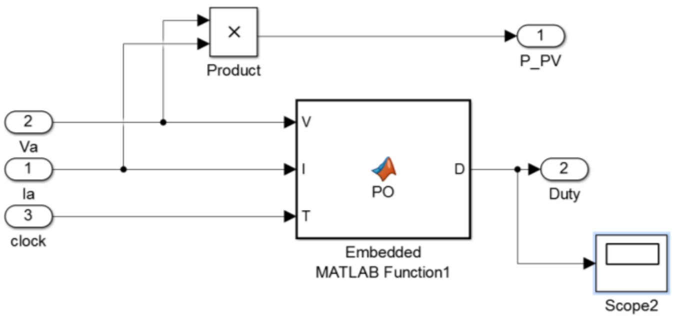

Fig-6: Simulation of P&O algorithm

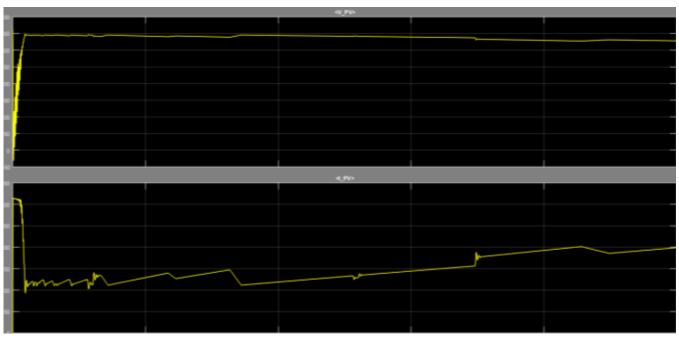

Fig-7: Waveform of PV voltage and current

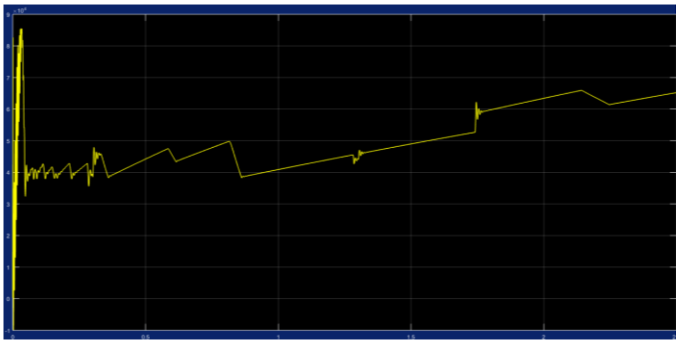

Fig-7: Waveform of solar PV power

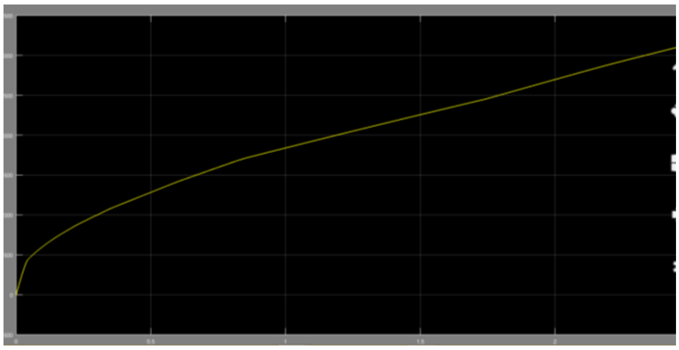

Fig-8: Waveform of buck- boost converter output

6. WIND ENERGY AND WIND TURBINE

The motion of air in the atmosphere is initiated by the non - uniform heating of the earth's surface by sun. In general, throughout the day the air above the land mass be likely to heat up more quickly than the air over water. In coastline regions this exhibits itself in a robust onshore wind. At night the process is reversed because the air cools down more quickly over the land and the wind blows off shore.[9]

6.1 Power in wind energy

The power in the wind can be calculated by using the theory of kinetics. The wind mill works on the principal of transforming kinetic of the wind to mechanical energy [10]. As power is equal to energy per unit time. The energy obtainable is the kinetic energy of the wind. The kinetic energy of one particle is equal to one half its mass times the square of its velocity (½ mv2).The quantity of air passing in unit time, over an area A, with velocity V, is A.V, and its mass m is equal to its volume multiplied by its density of ρ air, or

$$m = \rho A V$$

Put this value of the mass in the expression for the kinetic energy,

$$K.E = 1/2\ \rho AV3\ \text{WATT}$$

Equations convey that the wind power is proportional to the capture area. Therefore an aero-turbine with great swept area has greater power than a smaller area machine [11][12] Since the area is usually circular of radius r in horizontal axis aero-turbine, the $A = \pi r^2$

So the equation of wind power is transformed to

Wind power=1/2ρπr^2V3

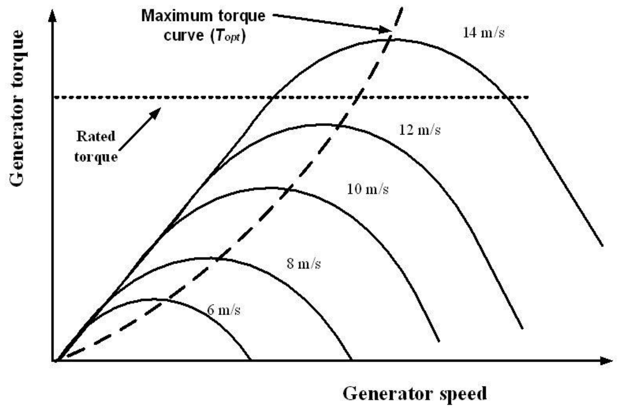

Fig -9: Characteristics of Wind Turbine

6.2 Wind Speed Model

A model is essential that can properly simulate the three-dimensional effect of wind behavior, containing gusting, rapid (ramp) changes, and background noise.[13] The wind speed is exhibited as the sum of the four components listed above.

Vw(t)= Vb(t)+Vr(t)+Vg(t)+Vn(t)

Where Vb is the base (constant) wind component, Vr is the ramp wind component, Vg is the gust wind component and Vn is the base noise wind component, all of them in m/s. The present work studies a constant wind speed equal to 12m/s.[16]

6.3 Wind Turbine Model

The wind turbine examined is a standard three-bladed horizontal-axis (main shaft) wind turbine design with the analogous pitch controller. The output mechanical power accessible from a wind turbine can be represented through the algebraic relation,

$$P_m = C_p(\lambda, \beta)\frac{\rho A}{2}v_{\text{wind}}^3$$

Where, ρ - air density V – Wind Speed Cp – Coefficient of Performance (or Power Coefficient) of the wind turbine A – Area swept by the rotor blades of the wind turbine .

The wind power captured by wind turbine relay on its power co-efficient (Cp) which is given by

$$C_p(\lambda, \beta) = 0.5\left(116\frac{1}{\lambda_i} - 0.4\beta - 5\right)e^{-\left(\frac{21}{\lambda_i}\right)}$$

$$\frac{1}{\lambda_i} = \frac{1}{\lambda + 0.08\beta} - \frac{0.035}{1+\beta^3}$$

The torque of the wind turbine would be expressed as

$$\tau_t = \frac{1}{2}\rho A v^2 c_t(\lambda)$$

6.4 Pitch Controller

The turbine has a pitch control system for every blade. Every pitch control system is a servo loop which will create the pitch follow a given reference as speedily as possible and with enough damping. The pitch controller is a non-linear controller which pays for the dead band and the curbs in the proportional valve. When the wind velocities are greater than rated, the maximum energy taken must be limited using pitch control by changing β the pitch angle will rise until the machine is at the rated speed [11].

6.5 Generator

WECS require a low-speed gearless generator, mainly for off-shore wind applications, where the geared doubly fed induction generator will need consistent maintenance due to the reason of tearing wearing in brushes and gear box [5][6]. Both the brushes and [14]the gear box can be removed from WECS by using directly coupled low speed generators. Additionally, the removal of the gear box can rise the efficiency of wind turbine by 10%.[15]

The low-speed PMSG requires:

1. Higher number of poles to take suitable frequency at low speed;

2. Big rotor diameter for the high wind turbine torque

6.6 Equivalent Circuit of PMSG:

As the back-EMF is the function of rotor position in stationary reference frame, so, it is convenient to model PMSG in this frame.

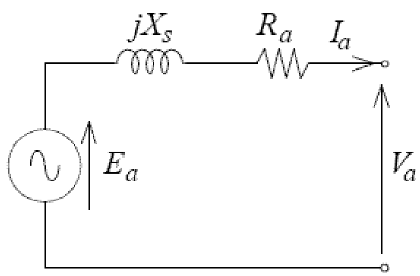

Fig -10: Equivalent circuit diagram of PMSM

6.7 Power electronics interference

The projected system contain completely controlled converters decoupled by a dc-link [17].The converters have been modeled by using six switches for converter. The thyristors need small reactors in series to control the rate of rise of currents [11][12].

7. SIMULATION MODEL AND RESULTS OF WIND TURBINE WITH PMSG

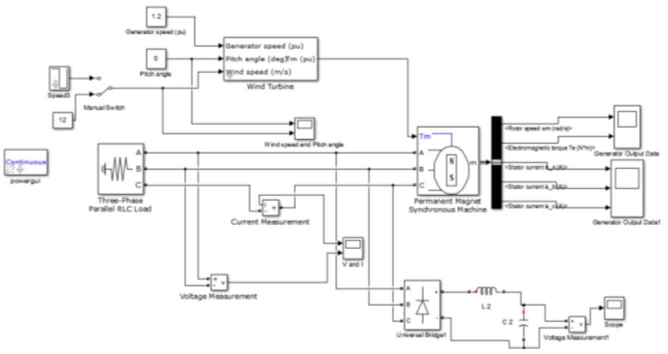

Fig -11: Simulation of wind turbine with PMSG

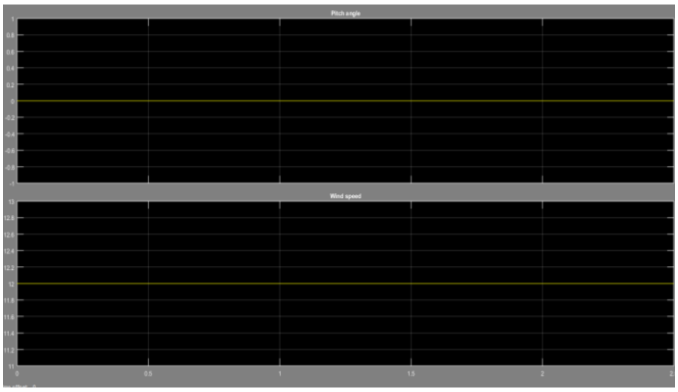

Fig -12: Waveform of wind speed and pitch angle

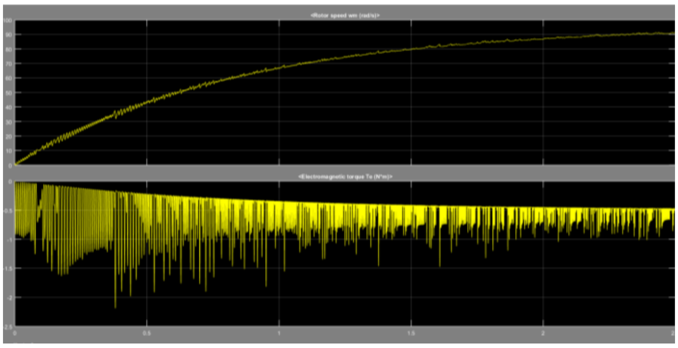

Fig -13: Waveform of rotor speed and electromagnetic torque

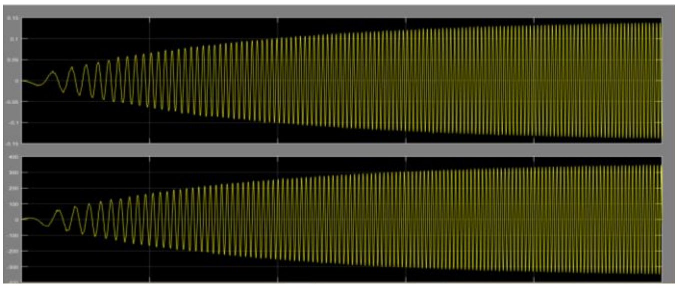

Fig-14: waveform of wind voltage and current

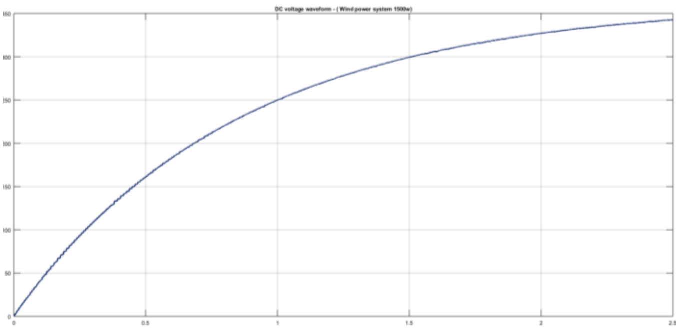

Fig -15: dc output voltage waveform

VII. CONCLUSION

The modeling of a solar PV Panel with MPPT and buck boost converter and wind turbine with a permanent magnet synchronous generator has been treated. This study analyzes the control strategies as well as models and designs and simulates the whole autonomous system of PMSG wind turbine feeding AC power to the universal bridge and solar PV panel wth MPPT. The model has been realized in MATLAB/Simulink in order to validate it.

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