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To Design the Pi Controller for Enhancement of Performance of Hybrid Power Generation System

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***Abstract* — Abstract: This paper will present the work on the Photovoltaic system and wind turbine system as they are major renewable energy source to produce electricity and battery as a source of storage. The output voltage of a PV is not sufficient enough for better performance of any type of Load devices to improve the output voltage MPPT with Boost Converter along with Perturb and Observe (P&O) algorithm is first observed In this method PV peak power is improved but not properly improved and maximized, to maximize and improve the peak power output PI controller is used also the performance of output voltage shows non-linear curve which can be improved by using fuzzy logic with PI. As there is no consistency of load during night time and in case of overload or in bad weather conditions for this purpose integration of PV with Battery and Wind Turbine System is used. The results are simulated by using MATLAB SIMULINK.**

***Index Terms*— Hybrid Renewable Energy Systems, Power Control, Fuzzy Logic, Proportional, Integral and Derivative (PID) controller.**

I. INTRODUCTION

There are many environmental problems caused due to renewable energy production from fossil fuel, biomass, geothermal energy and nuclear reaction [1]. Other than wind energy and solar energy, Hydro energy is not so much efficient to fulfill the increasing generation demand so it is necessary that an environmental sustainable source of energy must be invented. The solar energy and wind energy are the most abundant resources and free of cost available on earth. The easy way to convert solar energy and wind energy to electrical energy is photovoltaic (PV) system and wind turbine system respectively.

Presently available solar cell is not very much good in efficiency. So, it is necessary to build-up the efficiency of solar cell, different techniques/methods are employed. Like Maximum Power Point Tracking (MPPT) also voltage and power output of photovoltaic system is not maximized and improved, thus making it challenging to be used to power load. PI technique is used with perturb and observe tuning method. PI control is not suitable for non-linear system, to exceed this drawback; it can be achieved by the PI-Fuzzy logics Control (FLC) for moving out a MPPT control [2].

Wind turbine system converts the kinetic energy into electrical energy by the process when the wind turns the wind turbine's blades, a rotor takes the kinetic energy of the wind and converts it into rotary motion to drive the through a dynamic contact with the electrical generator which transforms this mechanical energy to electrical energy. Wind energy can be used as the stand-by source with Photovoltaic system as it is pollution free and with recent technology it can be taken efficiently [3].

A battery is a temporary source used to store and supply power. The energy stored is in the formed of chemical energy and this can be converted into electrical energy. Battery is made up of two metal plates called electrodes and a chemical called electrolyte. When cathode negative metal plate is connected with external circuit electrons starts flowing towards anode positive metal plates and produces a chemical force which sends power to an external device. Battery life depends on the cells storage capacity and load.

The PI controller is used to correct the error between a preferred set point & output variable by calculating & then output of a controller action that can correct the process according to the desired set point. As the PI controller is comprises of two different parameters, Proportional (P), and the Integral (I) values for calculations. The Proportional (P) value is directly proportional to current error. The Integral (I) value determines integral of current error based on closed feedback loop which provides improved efficiency or optimization for linear systems [4]

II. METHODLOGY

The hybrid power generation system consists of Photovoltaic system (PV), Battery and Wind turbine system. To design and simulate the PV and battery system MATLAB SIMULINK is used. PI controller is used for PV and Battery systems. Observe the PI controller alone with PV system to enhance the performance of output voltage using MPPT technique with boost converter and to increase the performance of output peak power by PI controller. Peak power and output voltage of PV can be further improved and maximized by Fuzzy logic. Hybrid power generation system of PV with Battery and wind turbine is used for consistency of load during night time and in case of overload or in bad weather conditions.

TABLE I: Integration of PV with Battery and Wind Turbine System

Collected	data
Irradiation	500w/M^2
Temperature	25˚C
Power Output	5KW
Voltage Input	250-300V
Proportional Gain	0.001
Integral Gain	0.1
Nominal Battery Voltage	24V
Wind Speed	100m/S
Pitch Angle	3˚C

III. PROPOSED MODEL AND RESULTS

This simulation circuit for integration of solar and battery uses the Photovoltaic model (PV) which is consists of 47 strings and 10 parallel modules to produce the power output of 5KW and voltage up to 305V. To maximize the output voltage of PV the boost converter with maximum power point tracking (MPPT) technique is used. The battery source is used as a standby storage system when the PV output is not sufficient to produce the required output voltage this battery source can be used.

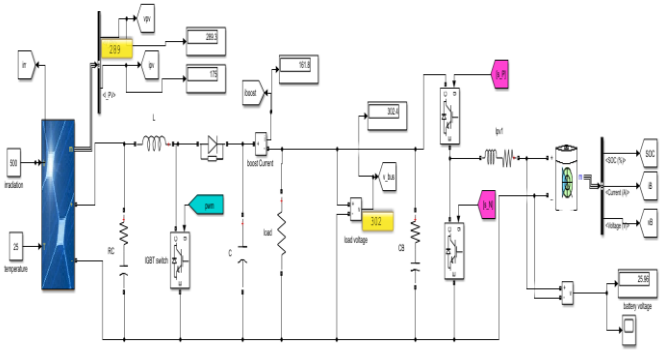

Figure 1: Simulation circuit for integration of solar and battery.

This figure 2 shows the output power of the Photovoltaic (PV) when the Proportional and Integral (PI) controller is not applied the peak output power is which is about 4.88W.

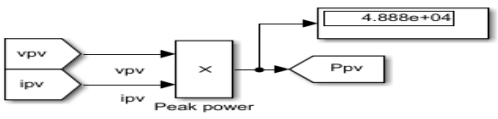

Figure 2: Simulation circuit for solar without PI to analyze Peak Power.

This figure 3 shows the output power of the Photovoltaic (PV) when the Proportional and Integral (PI) controller is applied the peak output power is which is about 48.89W.

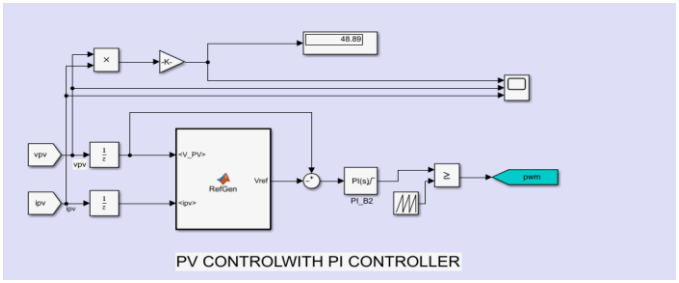

Figure 3: PV control model for MATLAB function to analyze peak power with PI controller.

This Simulink model of Wind turbine system shown in figure 4 is made up of Permanent Magnet Synchronous Machine (PMSM) and a three-phase rectifier bridge to convert the AC supply of wind turbine to DC Supply. The Pitch angle 3 degree and wind speed 1000m/s is used in the Simulink model to produce the rotor speed of 238rpm and output voltage of 305V. This wind turbine is a standby source in case of overloading conditions so it can used to fulfill the required power demand by load.

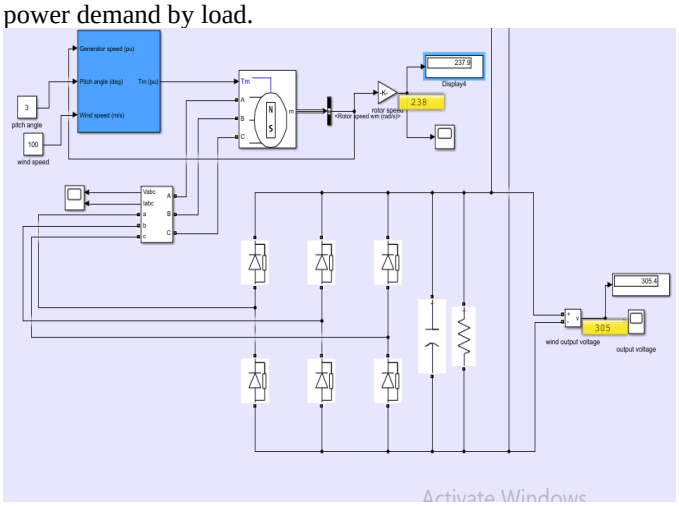

Figure 4: Simulink model of wind turbine system.

This simulation results in figure 5 shows the Rotor speed of the wind turbine which is starting at T=0s and reaches up to 238rpm and stabilized at T=0.0125s.

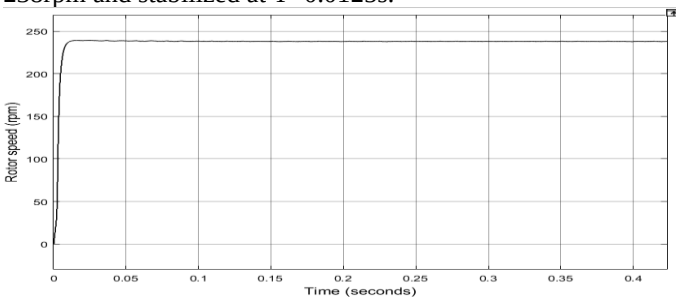

Figure 5: Simulation results of wind turbine rotor speed.

This simulation results in figure 6 shows the output voltage of the wind turbine which is starting at T=0s and reaches up to 305V and stabilized at T=0.15s.

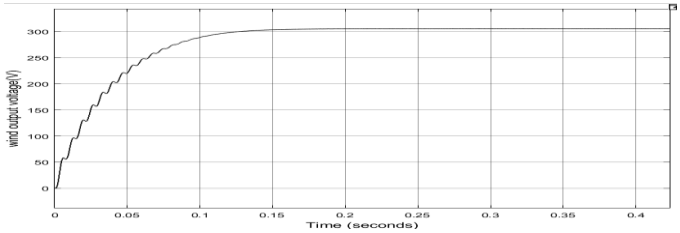

Figure 6: Simulation results of wind turbine output voltage.

This simulation results in figure 7 shows the irradiation of the Photovoltaic Panel which is fixed 500W/m2.

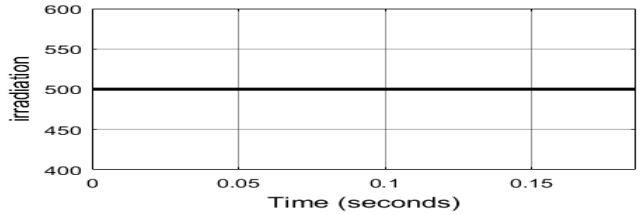

Figure 7: Simulation result of Irradiations.

This simulation results in figure 8 shows the Battery voltage which is starting at T=0s and reaches up to 26V and stabilized at T=0.0125s.

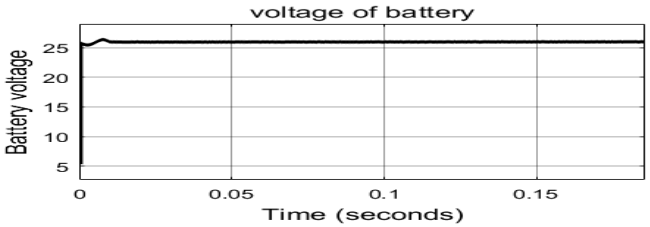

Figure 8: Simulation result of Battery voltage.

This simulation results in figure 9 shows the Input voltage of Photovoltaic panel which is starting from T=0s and reaches up to 289V and stabilized at T=0.016s. This simulation results shows the harmonics in the input voltage of Photovoltaic panel which can be improved by PI controller with Perturb and Observe (P&O) algorithm.

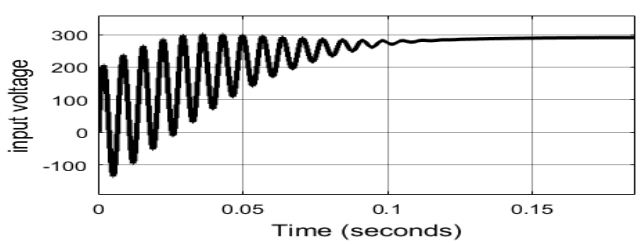

Figure 9: Simulation result of PV Input voltage.

This simulation results in figure 10 shows the output voltage of Photovoltaic panel which is starting from T=0s and reaches up to 305V and stabilized at T=0.016s. This simulation results shows that the output voltage is maximized by MPPT Boost converter and the harmonics are improved by the PI controller with Perturb and Observe (P&O) algorithm but still there are harmonics which can be further tuned by Fuzzy logic.

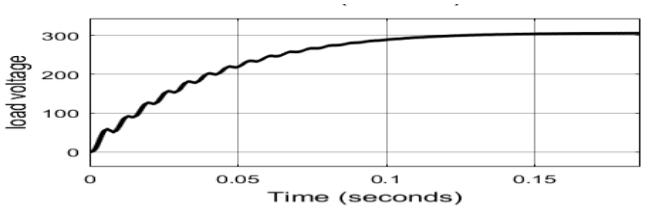

Figure 10: Simulation result of PV output voltage.

This simulation results in figure 11 shows the peak power of Photovoltaic panel which is starting from T=0s and reaches up to 4.8W and stabilized at T=0.01s. This simulation results shows the harmonics in the peak power of Photovoltaic panel which can be improved by PI controller with Perturb and Observe (P&O) algorithm.

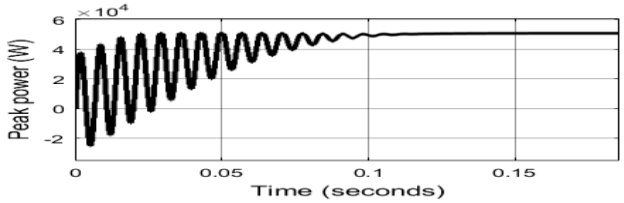

Figure 11: Simulation result of Peak Power without PI Controller.

This simulation results in figure 12 shows the peak power of Photovoltaic panel which is starting from T=0s and reaches up to 48W and stabilized at T=0.01s. This simulation results shows that the peak power of Photovoltaic panel is maximized and improved by PI controller with Perturb and Observe (P&O) algorithm and it can further be improved by Fuzzy logic.

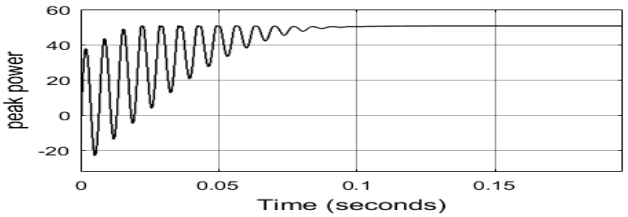

Figure 12: Simulation result of Peak Power with PI Controller.

IV. CONCLUSION

This study is to enhance the performance of PV system using PI controllers for maximum power point tracking. As the P-V panel characteristic is a non-linear that output power differs in utility of the irradiance and the temperature. Employing Fuzzy logic -PI controller, the performance of the voltage and peak power can be enhanced for non-linear output. And energy efficiency of PV system will be improved.

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