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Design and Hardware Implementation of PI Controller with Perturb and Observe Algorithm for Enhancement of Performance of Photovoltaic System

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***Abstract* — these This paper will present the work on the Photovoltaic system as it is major renewable energy source to produce electricity and battery as a source of storage. This thesis also provides the theoretical and experimental results of the photovoltaic system. The output voltage of a PV is not sufficient enough for better performance of any type of Load devices to enhance the output voltage MPPT is used which supplies the maximum power from the PV panel to the load with Boost Converter which increases the efficiency of PV panel by matching output power with input power are used. From MPPT techniques perturb and observe (P&O) algorithm is implemented which is simulated by using MATLAB SIMULINK. In this method PV peak power, output voltage is properly improved and maximized, by using P&O algorithm with Proportional and integral gain by PI controller. 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 and battery source is used. For hardware implementation of PV panel with MPPT technique by boost converter and for P&O algorithm and PI controller Arduino microcontroller along with voltage and current sensors are used. The simulation and experimental results are compared and founded to be more efficient method to be used for maximum power for PV panel.**

***Index Terms*— Renewable Energy Systems, Power Control, Perturb and Observe (P&O), Proportional and Integral (PI) controller.**

I. INTRODUCTION

Recent energy production from fossil fuels and nuclear energy has environmental consequences, most notably for the ozone layer. These drawbacks include nuclear waste and pollution from fossil fuels, both of which contribute to global warming and climate change. [1]. In the future, there will be little room for massive wind power plants to be built, and hydro energy will be inefficient in meeting the rising generating need of these sources, which are a never-ending supply of energy in the cosmos. It is self-evident that an alternate and environmentally friendly source of energy must be developed. Solar energy is the most plentiful and cost-free resource on the planet. A photovoltaic (PV) system is a simple technique to convert solar energy to electricity.

A solar cell's efficiency is extremely low. Techniques must be used to appropriately balance the source and load in order to increase efficiency. Maximum Power Point Tracking is one such method (MPPT). I-V curve in solar systems is non-linear, making it difficult to power a load. For this purpose, some techniques with different tuning methods can be used. Sometimes PV system is not applicable for non-linear system, to exceed this drawback; the Perturb and Observe (P&O) algorithm with PI Controller is used for moving out a MPPT control [2]. A battery is a device that stores energy. The energy stored is as chemical energy and this can be turned into electrical energy when needed. Battery is made up of two metal plates called electrodes and a chemical called electrolyte.

II. METHODLOGY:

Firstly, reviewing the literature regarding integration of PV and Battery system performance then Analyze the problem with output power and voltage. Now design and simulate the PV and battery system using MATLAB SIMULINK and also PI controller for PV and Battery systems using MATLAB function and observe the PI controller alone with PV system. To enhance the performance of output Voltage MPPT technique with Boost Converter and to increase the performance of output peak power by PI controller. For enhancement of performance of photovoltaic system P&O Algorithm PI Controller is used. Now hardware of this project is implemented. The basic components of hardware are MPPT system, Arduino UNO, voltage sensor current sensor and DC-DC boost converter.

III. PROPOSED MODEL IN MATLAB

The complete model of photovoltaic system with boost converter is simulated using MATLAB SIMULINK as shown in figure 1.

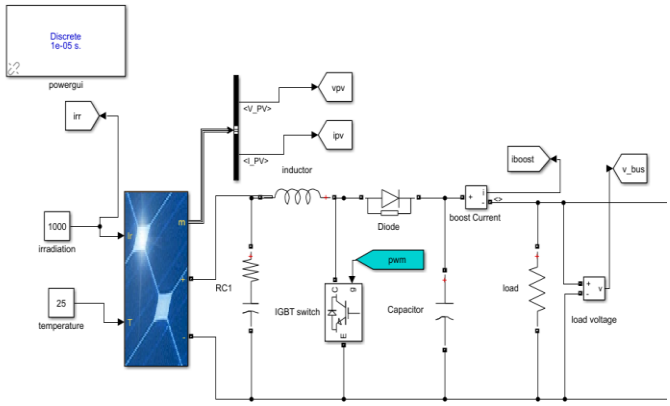

Fig 1: Simulation circuit for integration of solar and battery.

When sunlight strikes the photovoltaic panel, energy is created and transferred to the boost converter. The boost converter raises the voltage while lowering the current. The MPPT technique is used the keep the PV panel's operating point at its MPP and extract the maximum power possible in the PV panel

The suggested MPPT system employs P&O algorithm with a PI controller. This algorithm modifies the operating voltage to assure that the PV panel produces the maximum amount of power and enhance by using proportional and integral control gains.

This simulation circuit for integration of solar and battery uses the Photovoltaic model (PV) which is consists of 10 parallel strings and 1 series connect modules per string to produce the power output of 80W and output voltage up to 27V.

PV control model to analyze the matlab function with P&O Algorithm coding and PI controller as shown in Figure 2. The algorithm are written in MATLAB programming language with integral and proportional gains in controller block.

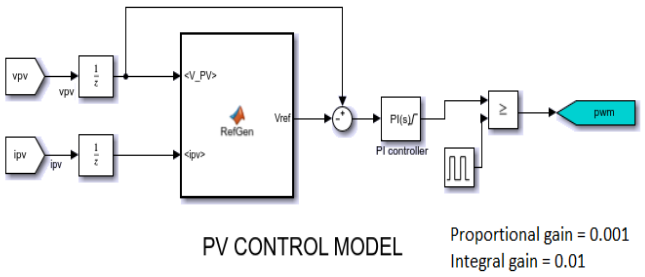

Fig 2: PV control model

The model of battery source connected in series with PV system is also simulated using MATLAB SIMULINK as shown in figure 3

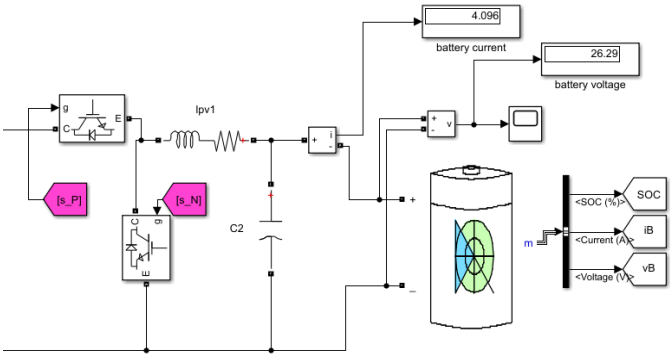

Fig 3: Simulation circuit of battery source.

The battery source is used as a standby storage system when the PV output is not sufficient to produce the required output voltage during uneven weather conditions this battery source can be used with output voltage 26V.

The MPPT is designed in order to keep the battery's output voltage remains constant. Lithium-ion battery is used for this analysis purpose.

Input power and voltage of the Photovoltaic (PV) in figure 4 shows when the MPPT and P&O with PI controller is not applied which is about 67.62W and 16.1V.

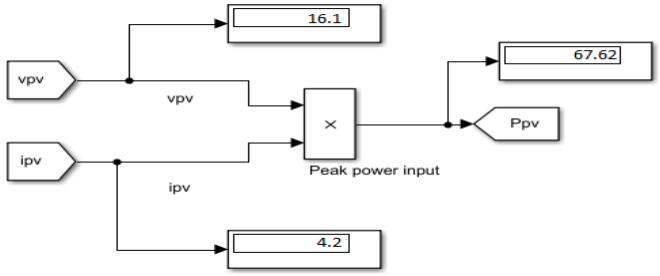

Fig 4: Simulation circuit for solar without MPPT and P&O with PI controller to analyze input Power and voltage.

Output power and voltage of the Photovoltaic (PV) in figure 5 shows when the MPPT and P&O with PI controller is applied which is about 74.4W and 31.0V.

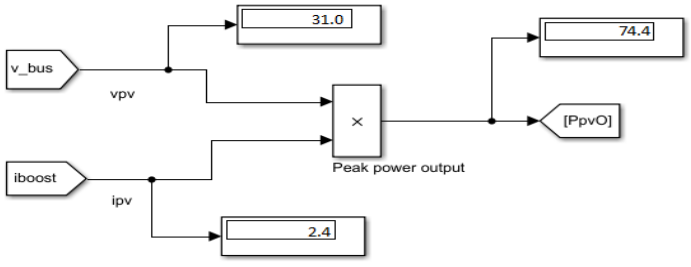

Fig 5: Simulation circuit for solar to analyze output power and voltgae with MPPT and P&O and with PI controller.

IV. SIMULATION RESULTS

Simulation result of PV Input voltage is shown in Figure 6

This simulation results in figure shows the Input voltage of

Photovoltaic panel which is starting from T=0s and reaches upto 16.1V and stabilized at T=0.016s.

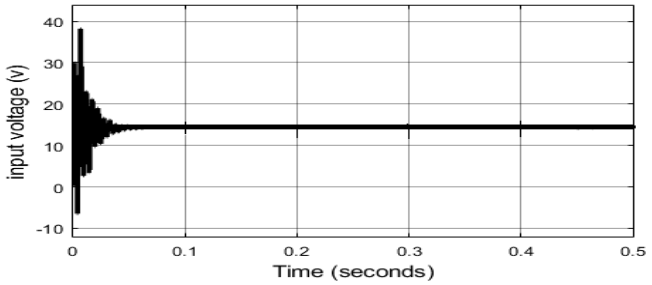

Fig 6: Simulation result of PV Input voltage.

This simulation results in figure 7 shows the output voltage of Photovoltaic panel which is starting from T=0s and reaches upto 31.0V 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.

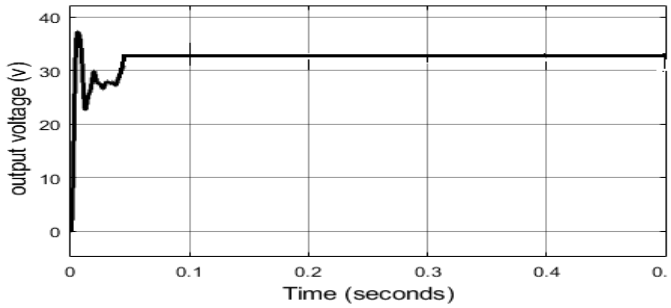

Fig: Simulation result of PV output voltage.

This simulation result in figure 8 shows the input peak power of Photovoltaic panel which is starting from T=0s and reaches upto 67.62 W and stabilized at T=0.01s.

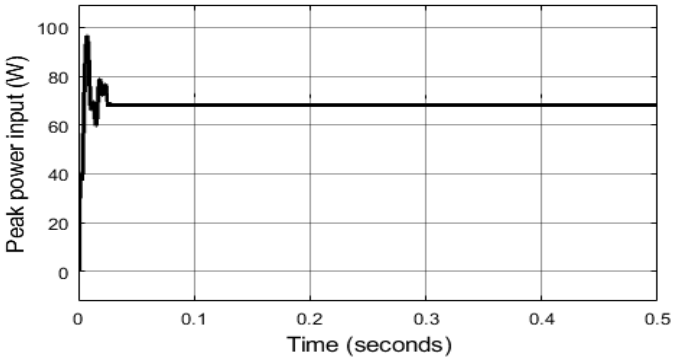

Fig 8: Simulation result of PV input Peak Power.

This simulation result in figure 9 shows the output peak power of Photovoltaic panel which is starting from T=0s and reaches upto 74.4 W and stabilized at T=0.01s. This simulation results shows that the peak power of Photovoltaic panel which is maximized and improved by PI controller with Perturb and Observe (P&O) algorithm further it can also be imporved by using fuzzy logic algorithm.

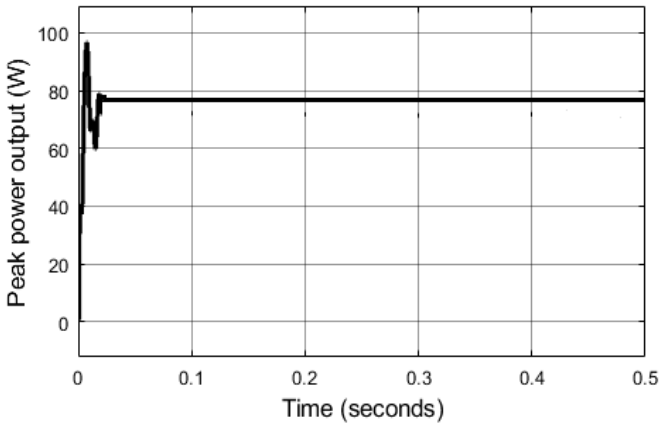

Fig 9: Simulation result of PV output Peak Power.

V. HARDWARE IMPLEMENTATION OF PROPOSED MODEL

The maximum power point tracking in this project is implemented by using an Arduino uno, which implements the Perturb and observe technique and PI controller gains. PV panel current and voltage are monitored using a current and voltage sensor. These readings are sent to Arduino through input pins. To extract the maximum power, the Arduino uno performs the MPPT algorithm and modifies the duty cycle of the DC-DC boost converter accordingly. Vero board is utilized for the hardware implementation of the proposed MPPT system. Figure 10 shows the hardware implementation of proposed MPPT system.

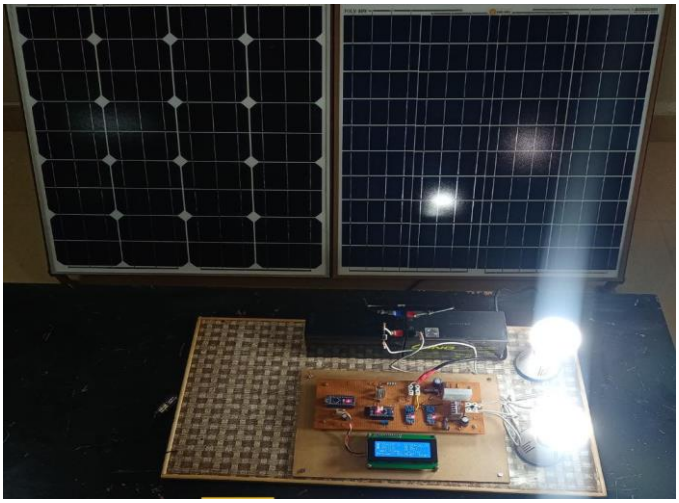

Fig 10: Hardware implementation of PV system

After the hardware implementations of proposed PV system, it is tested under different environmental and compared with simulation results

This figure 11 shoes the display module which shows the input voltage and current of PV system which is 15.2V and 1.5A current which gives output voltage and current of 27.2V and 0.9A.

Fig 11: Display module of PV system

Bar chart in figure 12 shows the comparison of hardware and simulation results when PV system is connected with the load. This shows that simulations results are more accurate than hardware results as there are some interruption due to environmental conditions. But this hardware model shows that by using P&O algorithm with PI controller along with MPPT techniques the performance of photovoltaic system is enhanced.

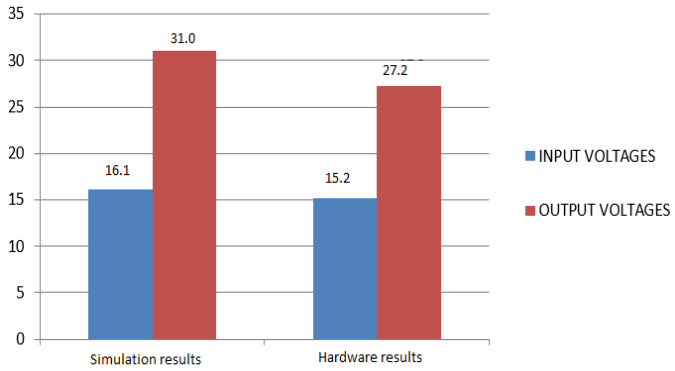

Fig 12: Bar chart showing comparison of simulation and hardware results of PV system

VI. CONCLUSION:

The complete model of photovoltaic system is simulated in MATLAB SIMULINK and also hardware implemented. The simulation results were compared with experimental results and found to be more efficient of renewable energy sources. By using different techniques of MPPT with boost converter to extract maximum power from PV panel with improved efficiency. In this project Perturb and Observe algorithm is found to be most significant in tracking maximum power from PV panel. Along with P&O algorithm to track the maximum efficiency for reliable use PI controller is used with suitable Proportional and integral gains.

Battery source is used as standby source in case of power outage from photovoltaic system due to bad weather conditions, during nighttime, or any fault occurring to facilitate consumer.

FUTURE WORK AND RECOMMENDATIONS

The more efficient technique of MPPT can be used to enhance the performance of peak power output and output voltage photovoltaic system by using Fuzzy logic controller. The hardware implementation of wind turbine system can also be fabricated for efficient and longer time without power outage. Also, the compact size of microcontroller used the cost of the system can be economical.

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