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Design and Simulation of Enhanced Adaptive Perturbation and Observe MPPT Algorithm for PV Fed DC to DC Boost Converter System

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Abstract*: *In this paper enhanced adaptive Perturb and Observe maximum power point tracking algorithm is presented for solar PV fed DC-DC to boost converter system. This proposed MPPT algorithm overcome the problem in conventional perturb and observe MPPT technique. The proposed system is modelled in MATLAB Simulink software package. System analyzed with various operating conditions and corresponding results are analyzed. The simulation results were compared with experimental results.

Keywords: **Solar PV, DC-DC converter, MPPT, P&O, MATLAB.**

I. INTRODUCTION

Most of the Photovoltaic system delivers power dependent on the temperature, irradiance and current drawn by the load. Maximum Power Point Tracking (MPPT) is method to acquire the maximum power from electrical systems. These techniques can be used to charging batteries, automotive electronics, and power supplies used in desktop computers & laptops. The photovoltaic system can deliver more power or less based on end application. The conversion of energy from source to load based on power generated in the system [1-2].

The MPPT system processes the voltage and current of the solar PV system to electrical resistive load to acquire maximum power at any ecological conditions. MPPT techniques are categories in five common areas to tract maximum power, the methods as follows: Fixed Voltage, Open circuit Voltage, Short circuit current, Perturb & observe, and Incremental Conductance method. Details the above methods are explained in the following proceeding section one by one [3-4].

Fixed voltage method:

It is the simplest method to acquire maximum power form solar PV system and which uses only one voltage sensor.

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To acquire Maximum power in the system which uses algorithm to tract the Maximum power according to the reference voltage on the account of varying environmental conditions. This algorithm adjusts the reference voltage automatically to get maximum power on all conditions [5].

Open circuit voltage method:

To extract maximum power by this method on basis of open circuit voltage of photovoltaic system generated from the source to determine the optimum operating voltage. After obtaining open circuit voltage value, voltage at maximum power is estimated by,

$$V_{MP} = A \times V_{OC}$$

The value of "A" is normally in the range of 0.7 to 0.8. In this method, algorithm works on the generation of open circuit voltage to deliver Maximum power [6].

Short Circuit Current Method:

This method is based on the generation of short circuit current of PV system, by this maximum power is tracked. It is also called as constant current method. To estimate current at maximum power by this method this is given by the following equation,

$$I_{MP} = A_1 \times I_{SC}$$

The value of "A1" is always less than one. The PV array of output current is more than 90% of the short circuit current means maximum power can be tracked [7].

Perturb & observe:

In this method, maximum power point controller regulates the output voltage of the DC-Dc converter from the PV panel input and tracks the maximum power. But this method has some disadvantage such maximum power acquire from thins method is oscillates around the maximum power point. This method will provide high efficiency with effective adaptive and predictive hill climbing strategy [8].

Incremental conductance:

In this maximum power is obtained at following condition is satisfied in the system,

$$\frac{dI_{PV}}{dV_{PV}} + \frac{I_{PV}}{V_{PV}} = 0$$

When, transient conductance $\left(\frac{dI_{PV}}{dV_{PV}}\right)$ is equal to negative slope conductance at stead state $\left(\frac{I_{PV}}{V_{PV}}\right)$.The IC utilizes an inquiry strategy that changes an obligation cycle or a reference, so that V_{PV} changes and check the conditions of the maximum power point. This method is useful for states of quickly shifting irradiance [9].

The organization of the paper as follows, Section 2 describes the overall system configuration of the proposed model. Section 3 explains the simulink model of the proposed system. Section 4 discusses simulation results. The experimental details provided in the section 5. Concluding remarks are provided in section 6.

II. PROPOSED SYSTEM

In distributed power generation, PV based power generating plant plays major role in power generation. Due to this, care should be taken for designing the maximum power point tracking controller for PV system. In this paper, enhanced adaptive perturb and observe maximum power point tracking algorithm is proposed to acquire the maximum power from the PV system. The proposed is system is shown in Figure 1.

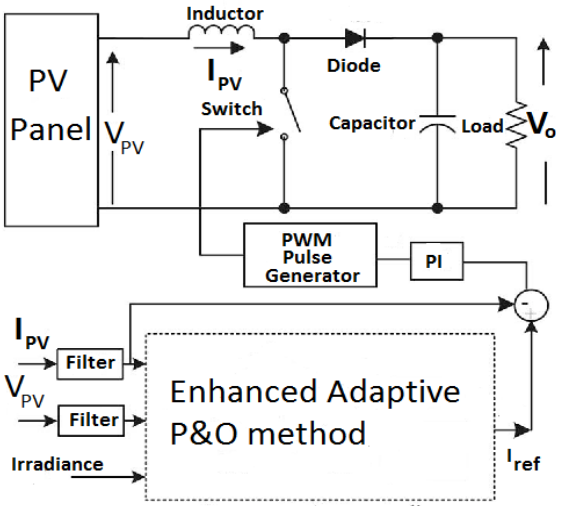


Fig. 1.Enhanced Adaptive Perturbation and Observe MPPT Algorithm for PV Fed DC to DC Boost Converter System

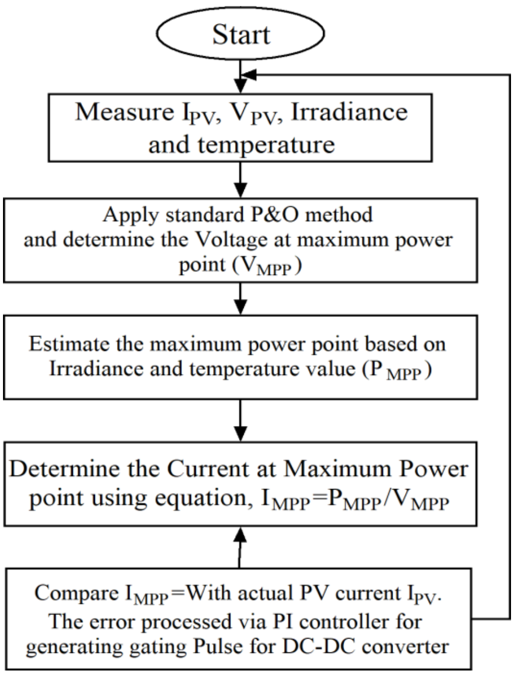


Fig. 2.FlowChart for Enhanced Adaptive Perturbation and Observe MPPT Algorithm

The system consists of PV panel. DC-DC boost converter, measurement system for current, voltage, irradiance and temperature, enhanced adaptive P&O algorithm, PI controller and PWM pulse generator. In this system, current, voltage and irradiance of the system is proceed via proposed adaptive P&O method and it generate the reference current for next stage. In next stage, reference current is compared with actual PV panel current. The error current from the comparator is processed via proportional integral controller and it generate the necessary duty cycle for PWM generator [10-27]. The PWM generator supplies the pulses to the switch for acquiring maximum power from the PV panel. The flowchart for the proposed enhanced adaptive P&O method is shown in Figure 2.

III. SIMULATION CIRCUIT

The proposed system is created and tested using MATLAB simulation software. The Simulink model of the proposed system is shown in Figure 3.

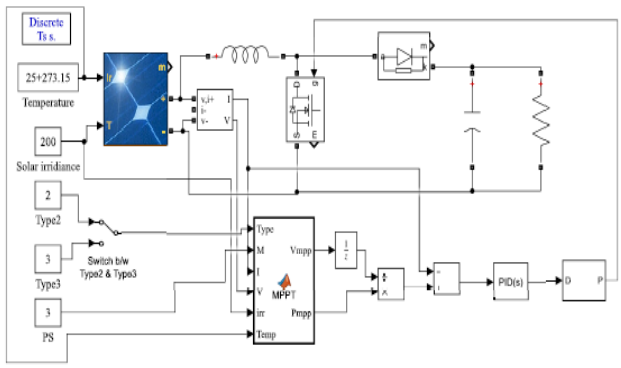


Fig. 3.Simulation circuit of proposed system

The Simulink model of the adaptive P&O and pulse generation circuit is shown in Figure 4.

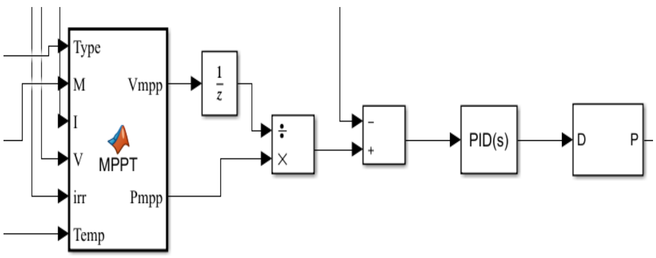


Fig. 4.Simulation model of the adaptive P&O MPPT technique and pulse generation circuit

In simulation, current, voltage and irradiance measured and processed via proposed controller and controller provide gating pulses for boost converter. Figure 5 shows the subsystem model of the proposed P&O. The parameter used for Solar PV panel is shown in Table I.

Table- I: Parameter of the Solar PV Panel

Power (W)	Open circuit voltage (Volts)	Sort circuit current (A)	Voltage at maximum power point (Volts)	Current at maximum power point (A)
60.5	21.1	3.8	17.05	3.55

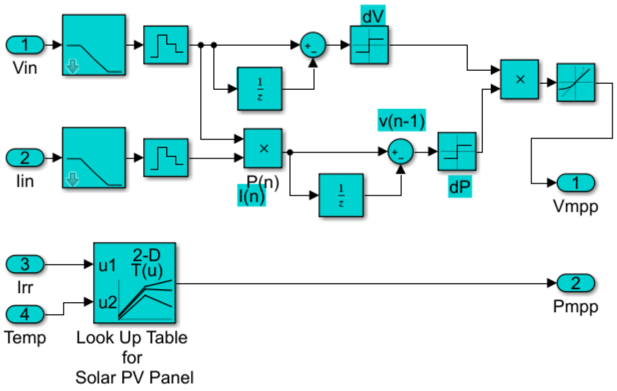


Fig. 5.Subsystem Simulation model of the Normal P&O MPPT

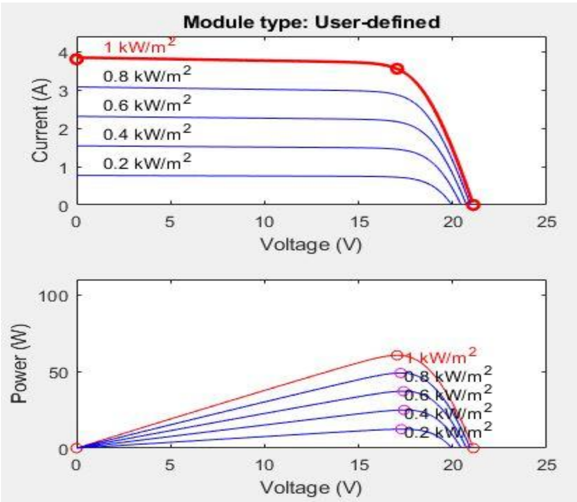


Fig. 6.I-V and P-V characteristics of the Solar PV panel

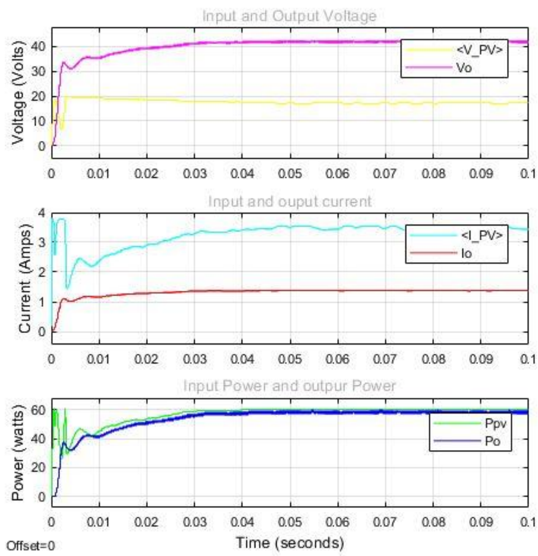


Fig. 7.Input and output voltage, current and power of the system under 1000 W/m^2.

IV. SIMULATION RESULTS AND DISCUSSIONS

In order to test the effectiveness of the proposed enhanced adaptive P&O method for Solar PV fed DC-DC booster converter system, MATLAB simulation have been developed in 2.1 GHz Intel i5 processor personal computer. The overall MATLAB simulation circuit is shown in Fig.3. The proposed model is tested for different operating conditions such as constant irradiance, step change in irradiance and ramp change irradiance level.

Constant irradiance level:

The proposed system is tested with 1000 W/m^2, 600 W/m^2 and 200 W/m^2 (Constant temperature = 25 °C). The simulation results are presented in the Figure 7, Figure 8, and Figure 9.

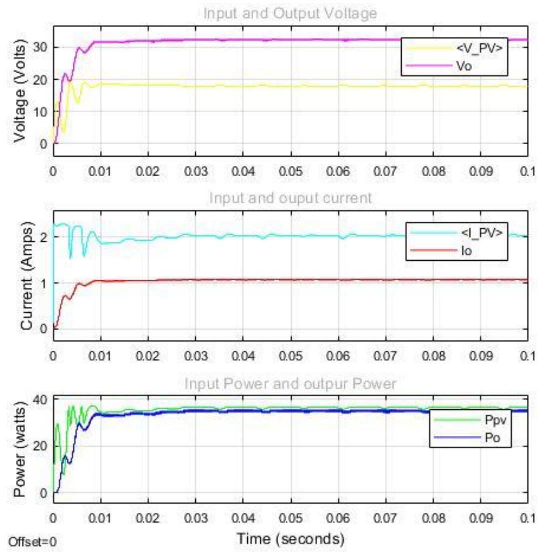


Fig. 8.Input and output voltage, current and power of the system under 600 W/m^2.

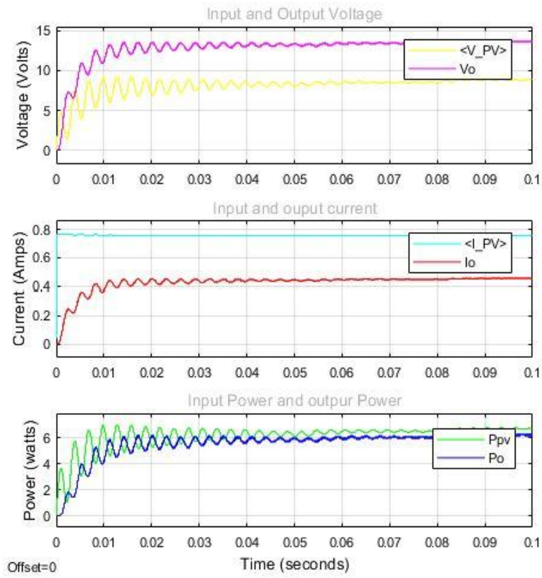


Fig. 9.Input and output voltage, current and power of the system under 200 W/m^2.

From the test results, maximum power extracted from the PV panel is 60 W, 35 W and 6 W for 1000 w/m^2 and 600 W/m^2 and 200 W/m^2 respectively. The input voltage is 19 volts, 18 volts and 9 volts. The output voltage is 40 volts, 35 volts and 13 volts. The input current is 3.5 Amps, 2 Amps and 0.75 Amps. The output power is 57 W, 32 W and 5 W. from these results, proposed MPPT algorithm effectively extract the maximum power from solar PV panel. The proposed system is tested with step change in irradiance and ramp change in irradiance and corresponding results are shown in Figure 10 and Figure 11.

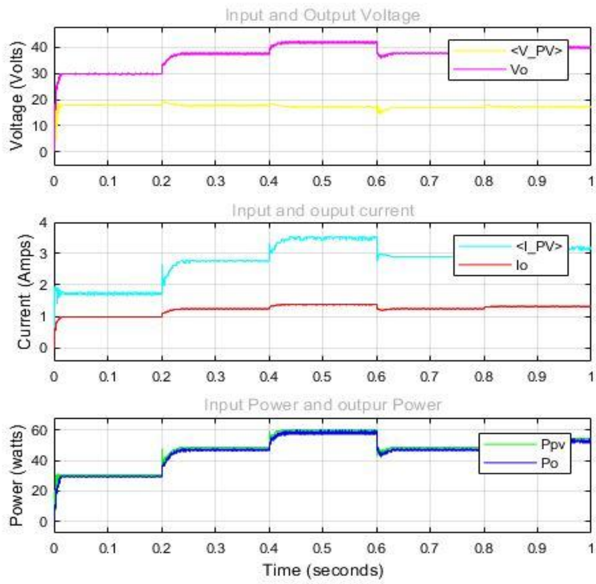


Fig. 10. Input and output voltage, current and power of the system under step change in irradiance level.

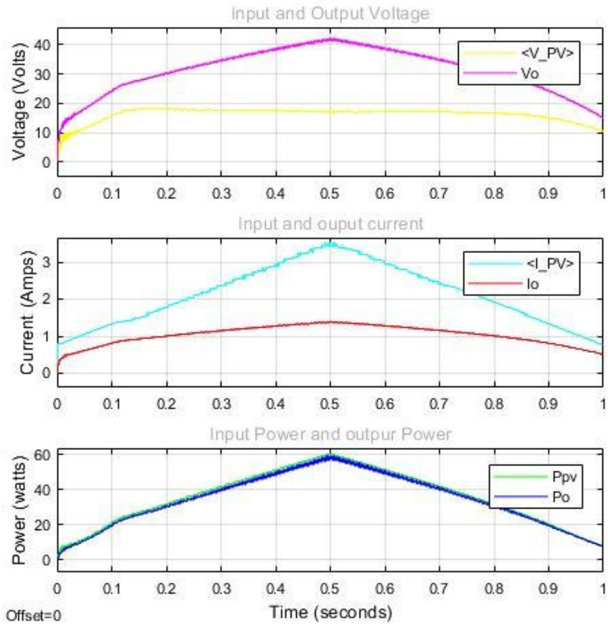


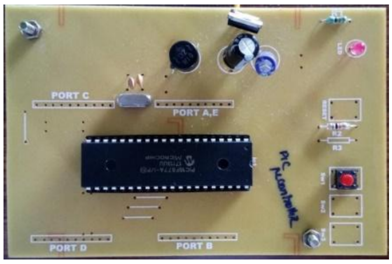
Fig. 11. Input and output voltage, current and power of the system under ramp change in irradiance level.

Examine the results of the Figure 10 and Figure 11, the proposed MPPT accurately tract the maximum power for the both conditions. The experimental verification of the proposed model is presented in the next section.

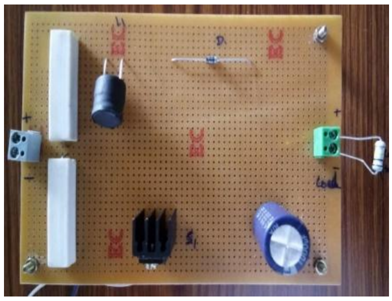
V. EXPERIMENTAL VERIFICATION

In order to verify the effectiveness of the proposed algorithm, experimental setup is developed and tested with different operating conditions. The experimental setup of the proposed method is shown in the Figure 12.

(a) Overall setup



(b) PIC microcontroller



(c) DC-DC boost converter

Fig. 12. Snapshot of the experimental setup

The Enhanced Adaptive P&O Algorithm is implemented in the PIC Microcontroller to generate the gate pulses. The pulses generated from the microcontroller were sent to the driver circuit. This is used for switching the MOSFET of the DC-DC boost converter. Due to switching, maximum power from the PV panel is extracted.

VI. CONCLUSION

This paper proposes the enhanced adaptive P&O method for PV fed DC-DC converter system. The simulation carried out in the MATLAB Simulink. The developed systems are tested for different operating conditions. The proposed method extracts 95 % maximum power from PV panel. The proposed method also verified experimentally. Similar results were obtained in simulation and hardware.

The proposed MPPT is suitable method for extract the maximum power from the PV panel.

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