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Mathematical Modeling and Performance Analysis of MPPT based Solar PV System

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ABSTRACT: This paper presents a analysis of control methods to extract the highest power and to track the maximum power point (MPP) from photovoltaic (PV) systems under changeable environmental conditions. The PV system consists of a solar module and a DC to DC converter, in this case a boost converter, connected to a load. The maximum power point tracking (MPPT) algorithms are the perturb and observe (P&O) method, and fuzzy logic control (FLC) technique .The parameters considered for the comparison are the efficiency of the MPPT algorithm taking into account the extracted power from the photovoltaic system, steady and dynamic response of the system under changeable conditions such as the temperature and the irradiance and the signals ripple. The methods have been used and the algorithm with the good results has been implemented in an MATLAB simulation platform.

KEYWORDS: PV System, Boost converter, MPPT methods

I. INTRODUCTION

The energy demand and the number of distributed generation systems are increase all over the world last few years. For that reason, it is necessary the use of renewable energy systems in addition to the conventional ones. Among renewable energy systems, solar energy is one of the topmost wide spread due to the fact that it is clean, and free.

The solar cell convert the solar light into electricity. There are two types of PV systems, the isolated systems and the grid connected systems. The PV system connected to the electrical network consists of solar cells connected together in series or parallel to get a Photovoltaic module, obtaining output voltage or current greater than a unique solar cell, a DC toDC converter to control the Photovoltaic module output voltage in order to achieve the highest power point and a DC to AC converter to transfer energy to the AC side.

There are many topologies of DC to DC converters, In this work, a boost converter is designed to control the solar module output voltage depending on the requirements, controlling the switch of the DC to DC converter to obtain the desirable input voltage value to track the MPP.

II. SYSTEM CONFIGURATION

The energy supplied by the PV panel depends on the environmental conditions, such as the irradiance and the temperature. Besides, there is only one maximum power point for each value of solar radiation and temperature and, in that point, the highest power is extracted from the solar cells, If the PV system works at the maximum power point , the efficiency of the system is increase.

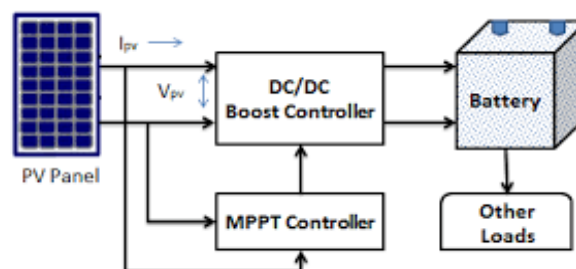


Fig:1 Basic block diagram of MPPT in PV system

In order to increase the performance of the PV system and to extract the highest power point under any environmental condition is necessary to track the maximum power point using control methods. The MPPT algorithm calculates the maximum power point in each instant of time for any irradiance and temperature. The maximum power point is changing because the environmental conditions are modifying as well. There are some techniques to implement the MPPT, some of them are compared in this work. The most used method is the well-known Perturb and Observe (P&O). The P&O is based on the variation of the PV O/P voltage and observing the power obtained to adjust the duty cycle of the DC to DC converter to reach the maximum power. Another control technique are used the Fuzzy Logic Control method . A Ripple Correlation Control (RCC) MPPT algorithm has been also implemented to compare the different methods.

The paper is organized as follows. Section III explains the PV system model, including the PV module and the DC to DC converter. Section IV describes the different MPPT techniques compared in this work. The simulation and results are developed in Section V. Finally, Section VI presents the main conclusions.

III. PV SYSTEM

This section describes the model of the photovoltaic system: the PV modules and the DC to DC converter, connected to a DC load, to regulate the voltage that gives the MPP.

A. Solar cells.

A solar cell converts the solar light to electricity by means of the photovoltaic effect. It is a p-n junction made with semiconductor material. The equivalent circuit model of the solar cell consists of electronic devices such as a current source, a diode and two resistors, one in series and one in parallel, as it is shown in Fig. 2.

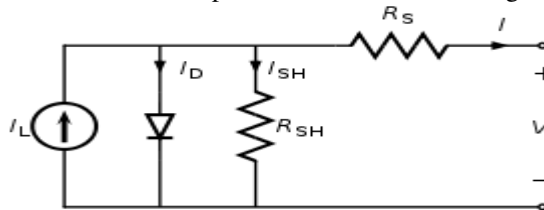


Fig:2 Basic solar cell circuit

The equation that describes the I-V characteristic curve of a solar cell is :

$$I = I_{ph} - I_0 \left[\exp \left(\frac{V + I R_S}{V_T} \right) - 1 \right] - \frac{V + I R_S}{R_P}$$

Where, I_{ph} = The PV module saturation current (Amp)

I = Output Current of a PV modules (Amp)

I_0 = Reverse Saturation Current

V = Output Voltage of a PV modules (Volt)

R_s = Series Resistance of PV modules

R_p = Parallel Resistance

V_T = Thermal Voltage

Being V the voltage of the solar cell in Volt, I_{ph} the light developed by the photons and I_0 is the saturation current, both in Amp.

In order to adjust the model with the losses, two resistors have been added, R_s define the ohmic losses and R_{sh} models the current leak in a parallel path, both measured in Ω . The voltage generated by a solar cell is about 1 Volt and it is essential to connect cells in series and in parallel to create photovoltaic modules in order to supply the desired power.

B. DC/DC Boost Converter

A topology of the DC boost converter is shown Fig. 3. It is divided in two modes of operation, which are given by the operation state of the switch. The output variables are inductor current and the capacitor voltage V_c .

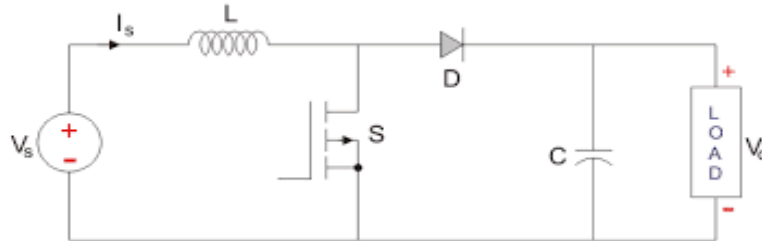


Fig: 3 Basic Circuit of Boost Converter

When the switch is on (closed), the inductor stores the energy from photovoltaic array and the load is supplied only by the capacitor. When the switch off (open), the inductor current flows to the load and the stored energy in the inductor is transferred to the capacitor and the load.

IV. MPPT ALGORITHMS

The MPPT algorithms are responsible for achieving the MPP even when there are changeable environmental conditions in order to increase the efficiency of the PV system. There are plenty of techniques for the tracking, the most used method, the P&O.

A. Perturb and Observe (P&O) The advantage of this method

The P&O is based on the variation of the PV module output voltage, controlling the duty cycle of the DC to DC converter, and comparing the power supplied by the solar cells in the current instant of time with the power obtained in the previous instant of time. The flowchart of the P&O is shown in fig 4.

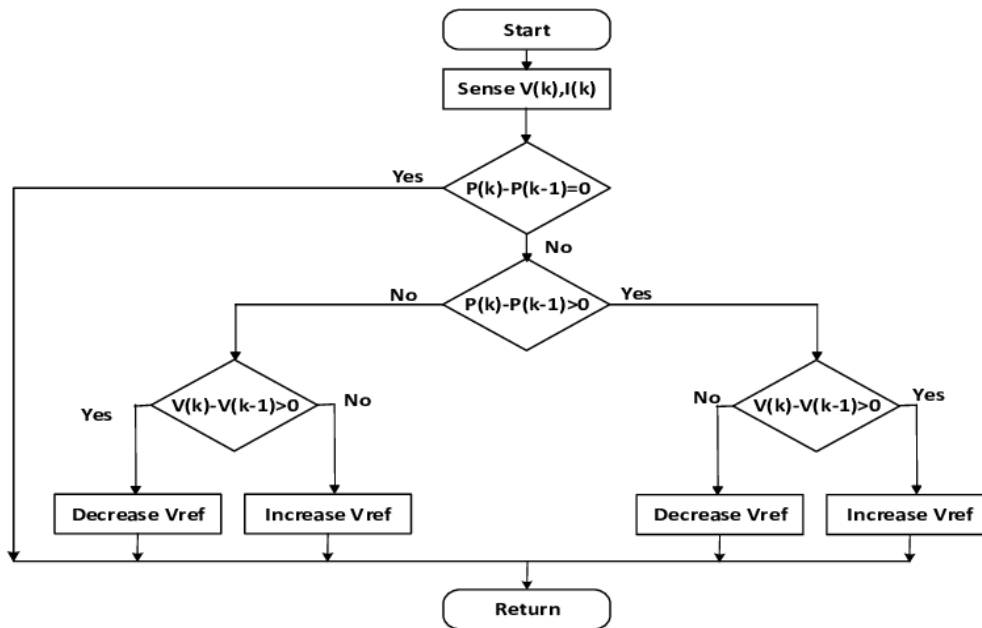


Fig:4 Flow Chart of Perturb and Observe

V. SIMULATION

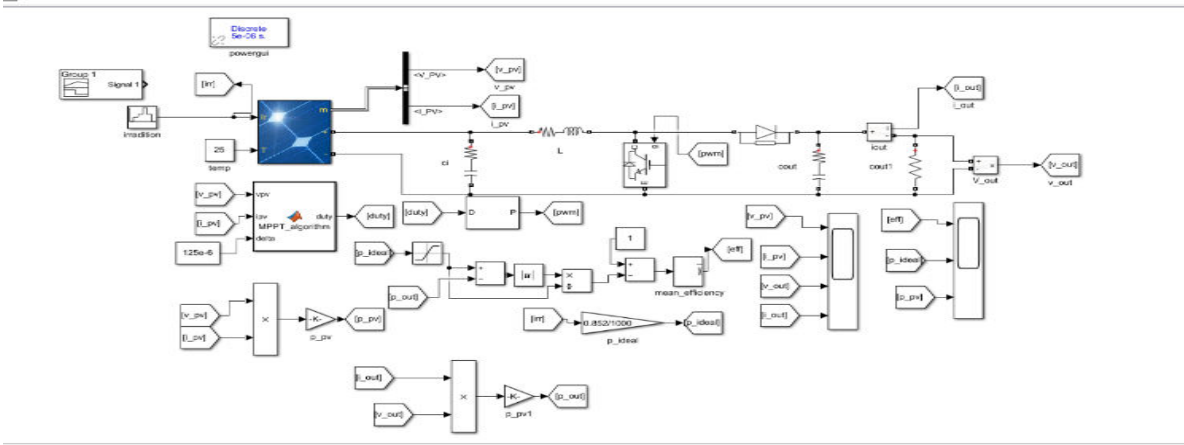


Fig :5 Simulation Block

VI. SIMULATION RESULT

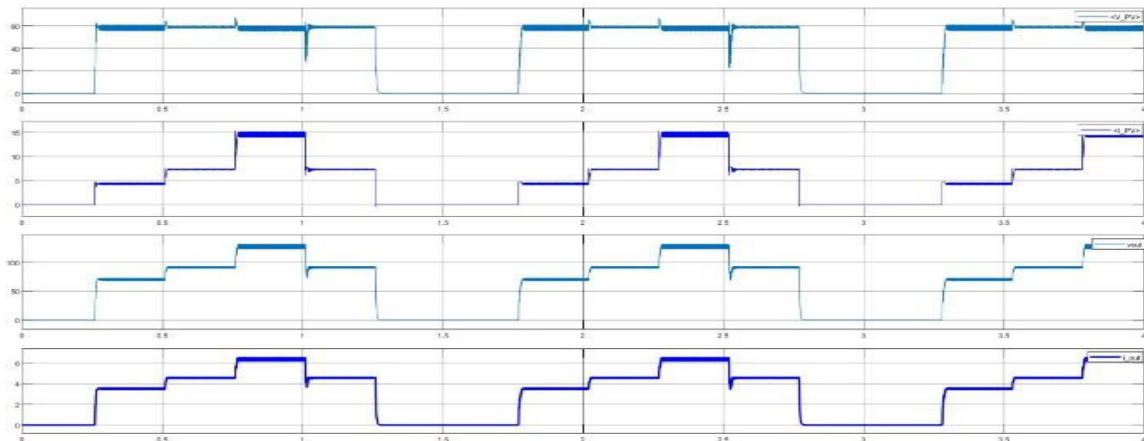


Fig :6 Output Current and Voltage for P&O Controller

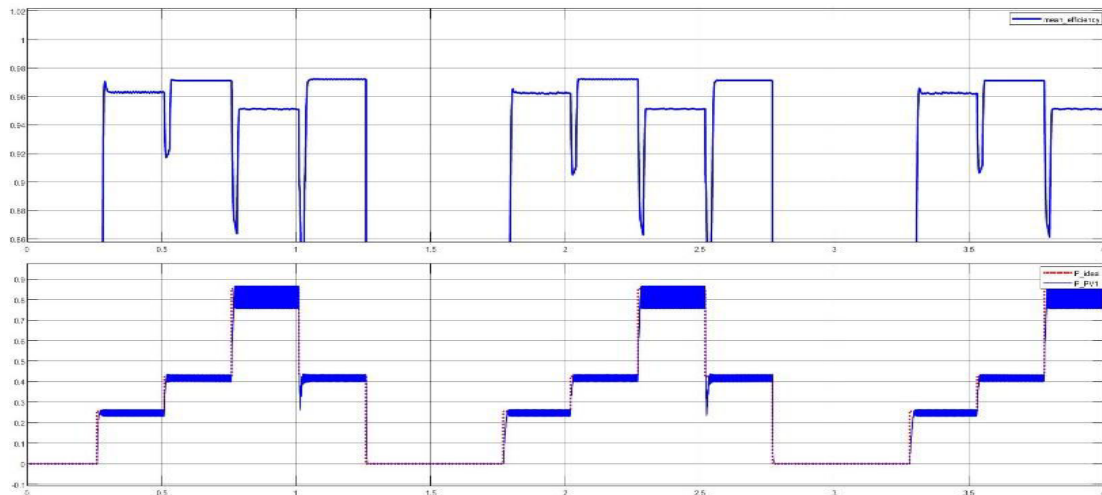


fig: 7 overall system efficiency



VII. CONCLUSION

This paper has presented the Mathematical Modeling of photovoltaic(PV)and then compare of MPPT and without MPPT. Hence withthe use of MPPT, we increase the efficiency and improve the waveform. Output characteristic of PV system depends on environmental conditions. Requires less simulation time and gives quickly dynamic output. Hence MPPT are critical to performance of PV system. Comparison is done between under different value of irradiation and temperature stage to validate the effectiveness of the model. The P&O algorithm for MPPT gives better efficiency for quickly changed environment conditions whereas without MPPT is less useful.

APPENDIX

Table 1. Electrical parameter of solar PV at 25 Cand 1000W/m

Parameter	N0
No. of cells per module	60
No. of series connected module per string	2
No. of parallel string	2

Table 2. Simulation block parameter

S.No	EQUIPMENTS	SPECIFICATION/RATINGS
1.	RC Circuit	R:1e-4; C:100e-6H
2.	RL Circuit	R:0.1 ohms; L:2e-4H
3.	Diode	R:0.001ohms; Forward voltage 250e-9volt Snubber Resistance:500 ohms
4.	IGBT	Internal Resistance:1e-3; Snubber Resistance:1e-5
5.	PWM Generator(DC-DC)	Switching frequency:500Hz Sample time:5e-6
6.	Powergui (Discrete)	Sample time:5e-6

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