ANALYSIS AND SIMULATION OF SOLAR POWER SYSTEM AND ITS CONTROL TECHNIQUES

Renewable source

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***Abstract*—This paper presents a Renewable energy sources demand has been increasing rapidly due to their abundance in nature, environment friendly and also serves as decentralized power sources in rural areas. Solar energy is one such renewable energy source which produces electricity by means of photovoltaic effect. The disadvantage of solar energy is its output power depends on factors like temperature, intensity of sun light, sun angle of incidence and the efficiency is very low so MPPT technique is should be good to improvement of solar efficiency with boost converter**

MPPT technique should be good enough to track MPP in dynamic

Atmospheric conditions. Perturb and Observer (P & O) and Incremental conductance (INC) are widely used MPPT techniques, and also give batter output power.

In this dissertation work, MPPT algorithms, Perturb & Observe (P&O), Incremental Conductance (IC), Ripple Correlation Control (RCC) Fuzzy Logic Controller (FLC) and algorithms has been done in MATLAB/SIMULINK. I have done the model of P&O, IC, RCC and FLC with using Boost converters and, getting result of those algorithms model and compared to each other. By using these MPPT techniques, we get the more output current, voltage, power and efficiency. That whole dissertation works has done in MATLAB 2018a

***Index Terms*— Keyword- PV System, Boost converter, MPPT methods**

I. INTRODUCTION

The energy demand and the number of distributed generation systems are growing all over the world last years. For that reason, it is essential the use of renewable energy systems in addition to the conventional ones, [1]. Among renewable energy systems, solar energy is one of the most wide spread due to the fact that it is clean, inexhaustible and free.

The solar cell turns 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 PV module, obtaining output voltage or output current greater than a unique solar cell, a DC/DC converter to regulate the PV module output voltage in order to achieve the maximum power point and a DC/AC converter to transfer energy to the AC side[2].

There are various topologies of DC/DC converters, In this work, a boost converter is designed to regulate the solar module output voltage depending on the requirements, controlling the switch of the DC/DC converter to obtain the desired 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 MPP for each value of solar radiation and temperature and, in that point, the maximum power is extracted from the solar cells, If the PV system works at the MPP, the efficiency of the system is greater.

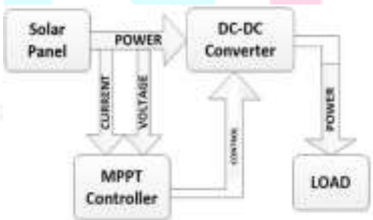


Fig: 1 Basic block diagram of MPPT in PV system

In order to improve the performance of the PV system and to extract the maximum power point under any environmental condition is necessary to track the maximum power point using control methods. The MPPT algorithm calculates the MPP in each instant of time for any irradiance and temperature. The MPP is changing because the environmental conditions are modifying as well. There are some techniques to implement the MPPT, [6-8], some of them are compared in this work. The most used method is the well-known Perturb and Observe (P&O), [9]. The P&O is based on the variation of the PV output voltage and observing the power obtained to modify the duty cycle of the DC/DC converter to reach the maximum power. Another control technique very used is the Fuzzy Logic Control method (FLC), [10]. A Ripple Correlation Control (RCC) MPPT algorithm, [11-12], 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/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.

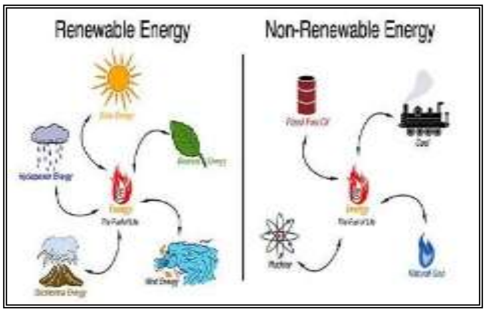


Fig: 2 RENEWABLE ENERGY AND NON-RENEWEBLE ENERGY

III. PV SYSTEM

This section describes the model of the photovoltaic system: the PV modules and the DC/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.

Sign	Operating Point
dP/dV>0	Left to MPP
dP/dV<0	Right to MPP
dP/dV=0	At MPP

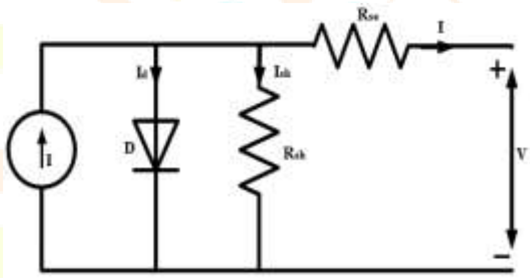


Fig: 3 Basic solar cell circuit

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

$$I = I_{Ph} - I_O \left[\mathrm{Exp}\left((V + I R_S) / V_T \right) - 1 \right] - \left[(V + I R_S) / R_P \right]$$

Where, Iph = The PV module saturation current (A)
I = Output Current of a PV modules (A)
I0 = Reverse Saturation Current
V = Output Voltage of a PV modules (V)
Rs = Series Resistance of PV modules
Rp = Parallel Resistance
VT = Thermal Voltage

Being V the voltage of the solar cell in V, Iph the light generated by the photons and Io is the saturation current, both in A. In order to adjust the model with the losses, two resistors have been added, Rs represents the ohmic losses and Rsh models the current leak in a parallel way, both measured in Ω.

The voltage generated by a solar cell is about 1 V and it is essential to connect cells in series and in parallel to create PV modules in order to supply the desired power.

B. DC/DC Boost Converter

A topology of the DC boost converter is shown in Fig. 3. It is modelled in two modes of operation, which are given by the operation state of the switch. The output variables are inductor current Il and the capacitor voltage Vc [6].

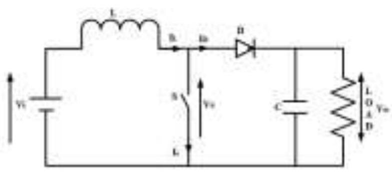


Fig: 4 Basic circuit of Boost Converter

When the switch is on (closed), the inductor stores the energy from PV array and the load is supplied only by the capacitor

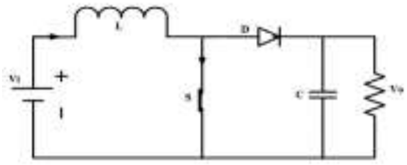


Fig : 5 Operation of Boost Converter (switch on)

When the switch if off (open), the inductor current flows to the load and the stored energy of the inductor is transferred to the capacitor and the load (Fig. 5) [5].

The MPPT algorithms are responsible for achieving the maximum power point 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, is compared with the RCC and FLC.

A. Perturb and Observe (P&O)

The advantage of this method is that it is simple and easy to implement and it is the most used algorithm. The P&O is based on the variation of the PV module output voltage, controlling the duty cycle of the DC/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, [9]. If the power of the current cycle is greater than the previous one, the voltage must be modified in the same way, increasing or decreasing it, whereas if the power is lower than the previous power, then the voltage must be varied in the opposite way, increasing or decreasing it as well. When the MPP is reached, the control algorithm oscillates around the maximum power. The flowchart of the P&O is shown in Fig. 6.

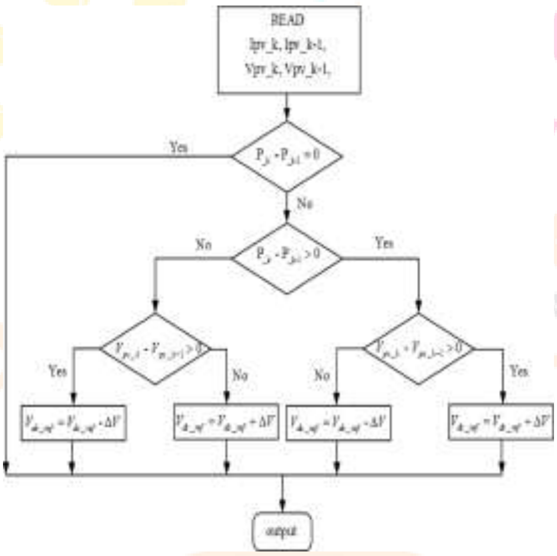


Fig : 7 Flow Chart of Perturb and Observe

The disadvantage of this technique is energy losses due to the oscillation around the MPP even when the maximum power is achieved, reducing the efficiency of the PV system.

V. SIMULATION RESULTS

A. Perturb and Observe (P&O)

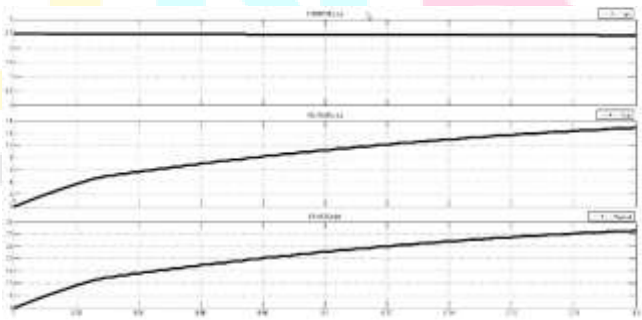


Fig : 13 Output current/voltage/power for P&O Controller

B. Incremental Conductance (IC)

Fig : 13 Output current/voltage/power for IC Controller

B Ripple correlation control

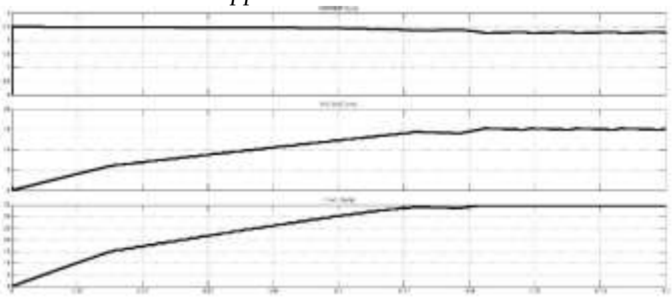


Fig : 13 Output current/voltage/power with RCC Controller

C. Fuzzy Logic Control (FLC)

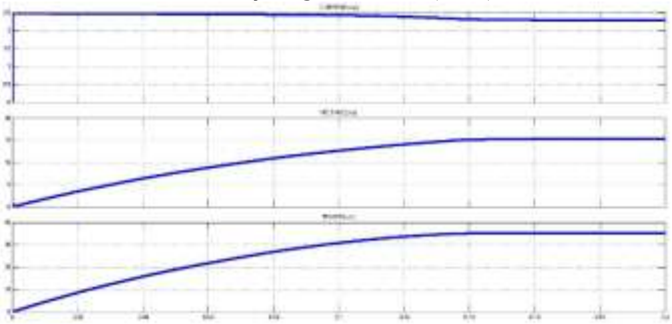
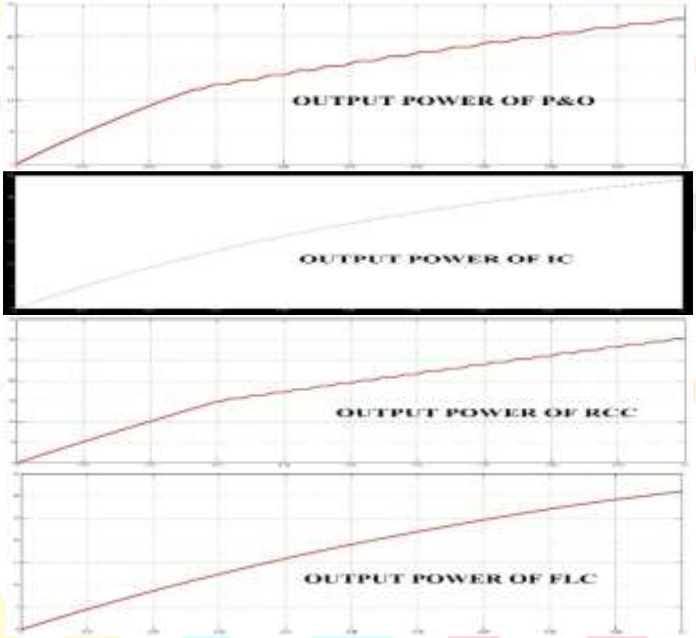
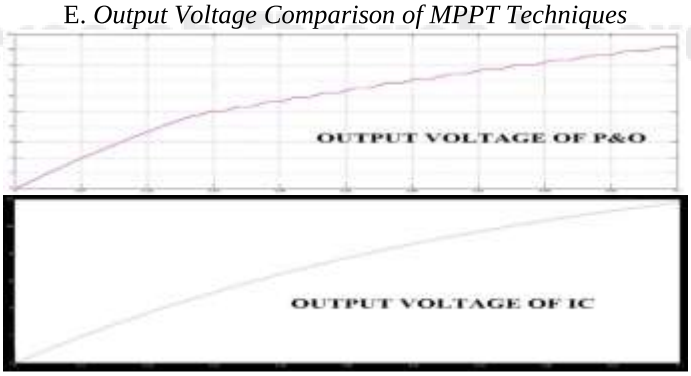


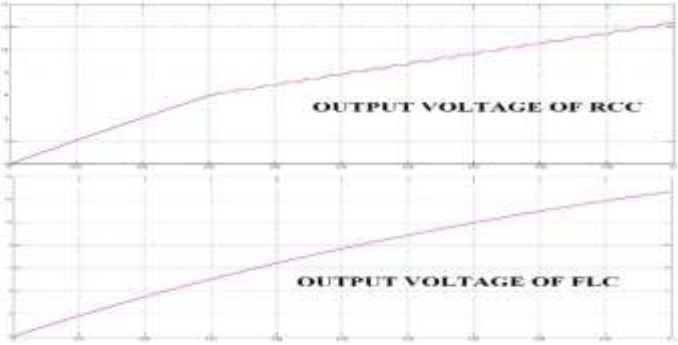
Fig : 13 Output current/voltage/power with FL Controller

D. Output Power Comparison of MPPT Techniques



E. *Output Voltage Comparison of MPPT Techniques*





VI. CONCLUSION

In this work, three MPPT algorithms have been simulated to be compared, the P&O algorithm, IC , the RCC control and the fuzzy logic (FLC) controller.

All the methods have rapidly tracking under changeable environmental conditions. The P&O has two disadvantages, the signals ripple involves small oscillation about the MPP voltage leading to power losses and it can reach a local maximum instead of a global maximum in some cases. The other two methods avoid local maximum and have smooth transient response and gives the more output power compare than P&O. Incremental Conductance (IC), Ripple correlation control (RCC) gives slightly better result than P&O. Regarding the efficiency of the MPPT, the fuzzy logic control (FLC) achieves better result compare than other methods.

VII. APPENDICES

A. Parameters for Solar Photovoltaic System

Number of cells	36
Ns and Np	1
Open circuit voltage	19.1 volts
Short circuit current	2.5 Amp.
Series Resistance	0.18 Ohms
Shunt Resistance	360.002 Ohms
Ideality factor	1.36
Temperature	25°C
Irradiance	1000 W/m2

B. Parameters for DC-DC Boost converter

R	10 Ohms
L	0.005 H
C	12000 µF
fsh	10 kHz
D	0.86

C. Comparison an output results

Output	***P&O***	***IC***	***RCC***	***FLC***
Current	2.476	2.458	2.452	2.443
Voltage	9.197	11.77	12.30	12.69
Power	22.77	28.93	30.15	31.01

VIII. ACKNOWLEDGMENT

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