AN APPROACH TO ACHIEVE MAXIMUMPOWER POINT TRACKING USING PV SYSTEM FOR BUCK CONVERTER

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Abstract— A solar cell is a non-linear power source and its output power depends on the terminal operating voltage. As the intensity of light falling on the panel varies, its voltage as well as its internal resistance both varies. It is necessary to operate a solar photovoltaic panel at its maximum power point to achieve high efficiency and maximum power transfer. Maximum power point trackers (MPPT) are used to operate a photovoltaic panel at its maximum power point. To extract maximum power from the panel, the load resistance should be equal to the internal resistance of the panel. This Paper represents a simple an systematic approach to achieve an Maximum power transfer in solar micro grid applications by impedance matching with a dc–dc converter with maximum power point tracking by the perturb and observe method. The MPPT is simulated and studied using MATLAB/SIMULINK

Index Terms—Photovoltaic panel, maximum power point tracker, perturb and observe method

1. INTRODUCTION

THE renewable energy sources offer great potential in meeting future global requirements. The production of power from renewable energies will lead to a significant reduction in the rate of environmental pollution, thus gaining renewed attention due to advance in technology, environmental concerns and a growing energy demand. Photovoltaic systems in particular have great potential when compared to other renewable energies. Solar photovoltaic panel (SPV) uses free and non-exhaustible sunlight as the fuel. They are highly reliable, flexible and can be expanded at any time to meet our requirements.

Power output of a Solar PV module changes with change in direction of sun, changes in solar insolation level and with varying temperature. There exists a peak power corresponding to a particular voltage and current. Maximization of power improves the utilization of the solar PV module. Since the module efficiency is low it is desirable to operate the module at the peak power point so that the maximum power can be delivered to the load under varying temperature and insolation conditions.

A maximum power point tracker (MPPT) is used for extracting the maximum power from the SPV module and transferring that power to the load. DC-DC converter acts as MPPT. By changing the duty cycle, the load impedance as seen by the source is varied and matched at the point of the peak power with the source so as to transfer the maximum power.

The proposed MPPT must be able to accurately track the maximum power in order to increase the efficiency of the solar cell.

2. CHARACTERISTICS OF A SOLAR CELL

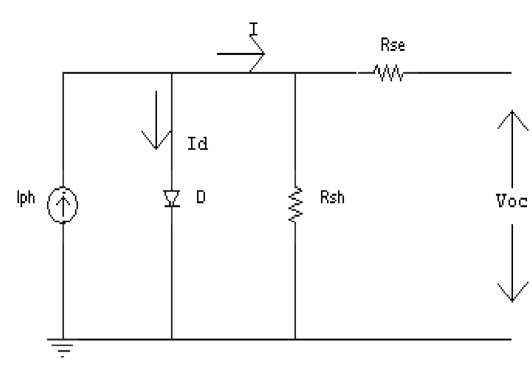


Fig.1. Equivalent circuit of a solar cell

The V-I and P-V characteristics of a solar cell are highly non-linear. Using the equivalent circuit of Fig.1, the non-linear V-I characteristics of a solar cell can be expressed by the following equation

$$I = I_{Ph} - I_D = I_{Ph} - I_S\left[\exp\left(\frac{V}{mV_T}\right) - 1\right] \quad (1)$$

Where, I_{ph} is the short–circuit current,
I_d is the diode current,
I_s is the diode reverse saturation current,
m is the diode ideal factor,
V_T is the thermal voltage.

By using the equation (1), equivalent circuit of a solar cell is modeled for this work. Fig.2 shows the V-I and P-V characteristics of a solar cell and Fig.3 & Fig.4 shows the simulated V-I and P-V characteristics of a solar cell. This characteristic varies drastically with the solar insolation and the temperature.

When many such cells are connected in series, we get a solar PV module.

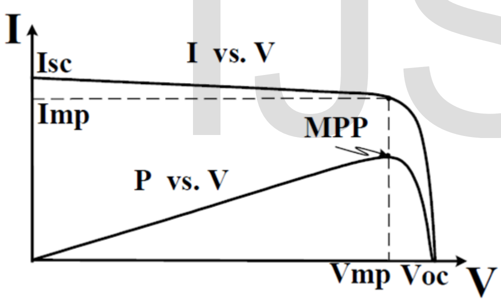


Fig.2. V-I and P-V characteristics of a solar cell

3. SYSTEM CONFIGURATION

To use the solar array effectively, it is mandatory to match the PV source with the load so as to draw maximum power at the current solar irradiance level. In this regard, a switching DC-DC converter controlled by means of a maximum power point tracking (MPP) strategy is suitable to ensure the source-load matching. Any efficient maximum power point tracker (MPPT) must be able to detect the voltage and current value corresponding to the maximum power that can be delivered by the source.

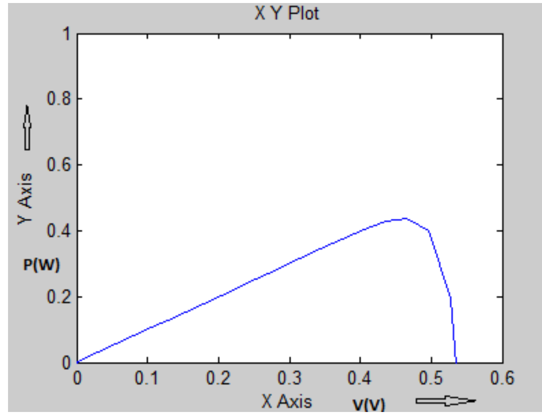


Fig.3. V-I characteristics of a solar cell

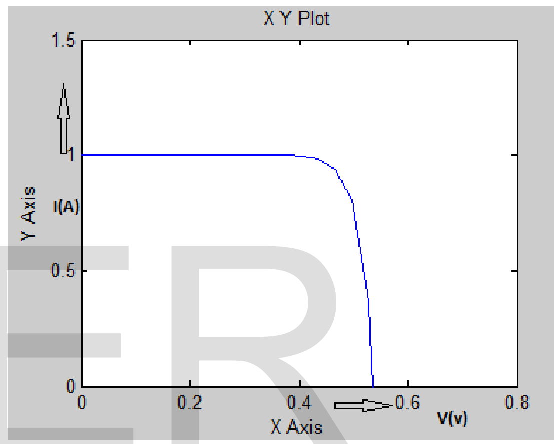


Fig.4. P-V characteristics of a solar cell

The MPPT accepts a DC input voltage and outputs a DC voltage higher, lower or the same as the input voltage. This capability of the converter makes it ideal for converting the solar panel maximum power point voltage to the load operating voltage.

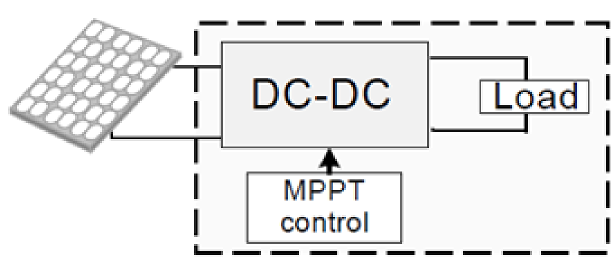


Fig.5. Block diagram of a typical MPPT system

Most MPPT charge controllers are based on either the buck converter (step-down), boost convert (step-up) or buck-boost converter. Fig.5 shows the block diagram of a typical MPPT system. The present work describes the maximum power point tracker (MPPT) for the SPV module connected to a resistive load.

4. THE PROPOSED MPPT SCHEM

4.1 Buck converter

The MPPT in this paper is the DC-DC Buck converter that steps down the solar panel output voltage to the desired load voltage. The basic circuit for the Buck converter is shown in Fig.6. To ensure that the solar module operates at the maximum operating point, the input impedance of the DC-DC converter must be adapted to force the solar module to work at its maximum power point. The Buck converter uses energy storage components such as inductors and capacitors to control the energy flow from the solar module to the load by continuously opening and closing a switch. The switch is actually a MOSFET that is controlled by a PWM signal.

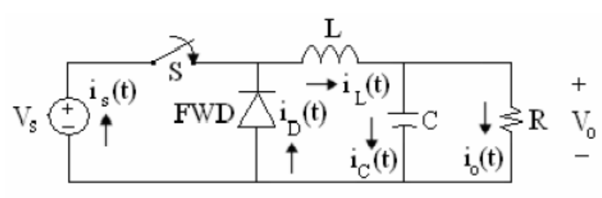


Fig.6. Basic buck converter

The duty cycle can be adjusted to set the output voltage of the converter to the desired value. The duty cycle is set by means of a pulse width modulation (PWM) signal used to control the MOSFET on and off states.

4.2 P&O ALGORITHM

There are many algorithms that are used to control the MPPT. The proposed Perturbation and Observation (P&O) tracking method has a simple feedback structure and fewer measured parameters. Fig.7 shows the flowchart of perturb and observe method. This method operates by periodically perturbing (i.e. incrementing or decreasing) the array terminal voltage and comparing the PV output power with that of the previous perturbation cycle. If the perturbation leads to an increase (decrease) in array power, the subsequent perturbation is made in the same (opposite) direction. By using the P&O control action given in Fig.8, the peak power tracker continuously seeks the peak power condition. A drawback of PAO method is that the operating point oscillates around the MPP. Moreover, in rapidly changing atmospheric conditions, the MPPT takes considerable time to track the MPP.

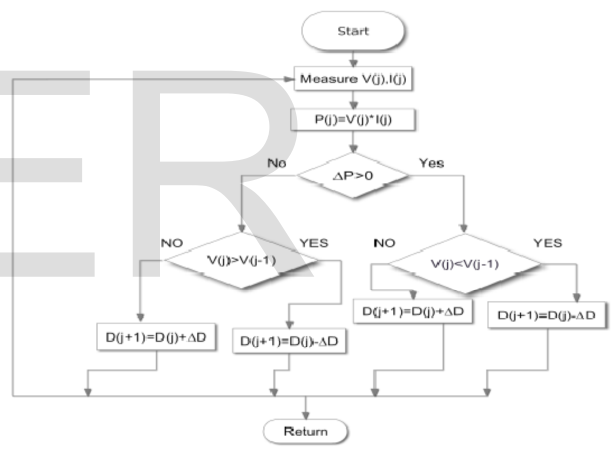
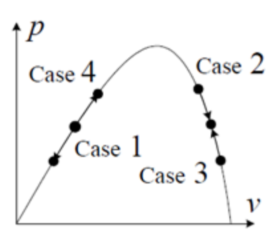


Fig.7. Flowchart of Perturb and Observe method



Case	dP	dV	Action
1	< 0	< 0	+
2	< 0	> 0	-
3	> 0	< 0	-
4	> 0	> 0	+

Fig.8. P&O control action

The Solar PV panel developed was used as the source for the DC-DC converter. The Buck Converter circuit is designed to be compatible with the given resistive load to achieve maximum power transfer from the solar panel. The MPPT control uses the P&O algorithm and a PI controller to generate PWM signal, which is used as gate signal for the MOSFET of buck converter. Fig.9 shows the block diagram of the proposed MPPT scheme.

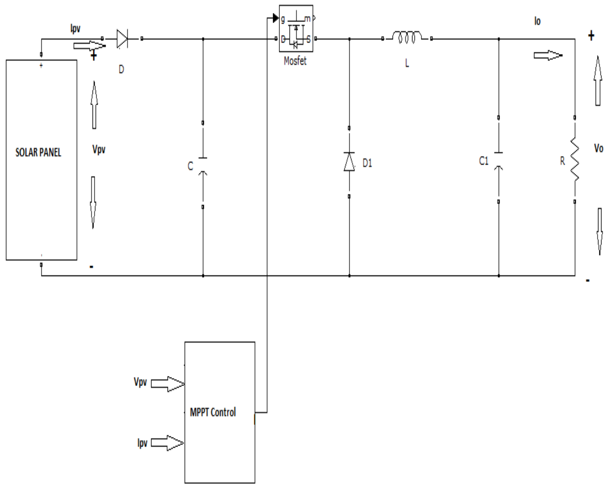


Fig.9. Block diagram of proposed MPPT Scheme

5. SIMULATION OF PERTURB AND OBSERVE BASED MPPT METHOD

The MATLAB/SIMULINK software is used to realize the proposed Perturb & Observe based Maximum power point tracking method indicated in Fig.10. For the solar panel the sub systems are created as block called PV panel. The panel voltage and current are obtained from the PV panel and are used as a control element in P & O algorithm and the output error signal is fed into the PI controller for processing. The output of the PI controller is compared with the high frequency carrier signal in PWM block to produce Pulse Width Modulated (PWM) output which is used to drive the MOSFET of a step down dc-dc converter. The duty cycle of the converter changes till the load is matched with the source.

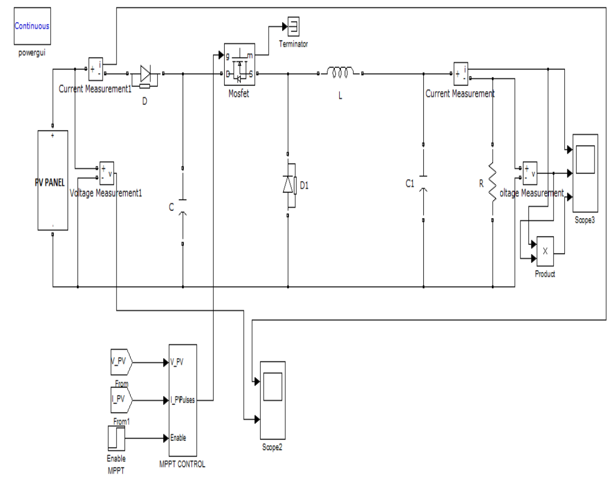


Fig.10. P&O based MPPT using Buck converter

The subsystems of P&O algorithm and MPPT control are shown in Fig.11 and Fig.12.

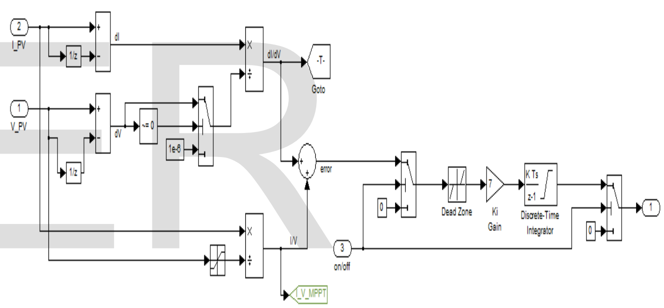


Fig.11. Subsystem of P&O algorithm

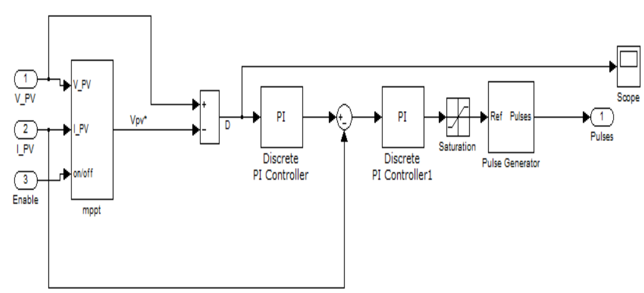


Fig.12. Subsystem of MPPT control

For the simulation of the MPPT system, a buck converter (step down converter model is developed in simulink using power systems block set. The converter circuit parameters are shown in Table I.

TABLE I- PARAMETER VALUES FOR BUCK CONVERTER

L	25µH
C	1µF
C_1	1500mF
S(Switch) - MOSFET *fs*- 20KHz	

6. SIMULATION RESULTS

Fig.13 shows the computed Voltage, Current and Power characteristics across the resistive load with P&O based MPPT. The captured maximum power is approximately 330W (Fig.13.c), which shows that maximum power is transferred to the load via the MPPT excluding the power loss in the converter.

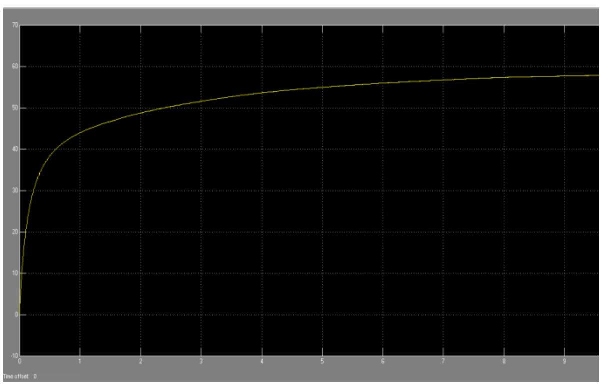


Fig.13.a. shows the computed Voltage characteristics across the resistive load with P&O based MPPT.

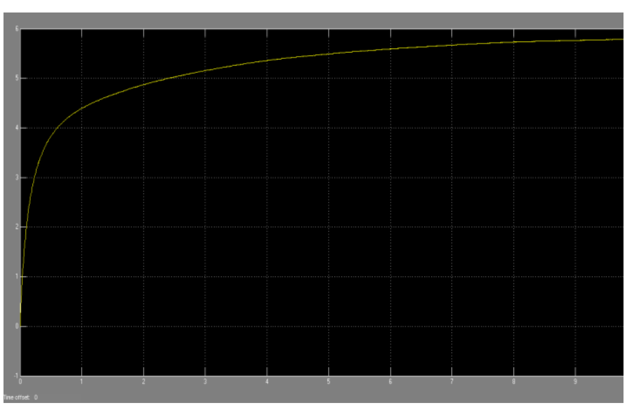


Fig.13.b. shows the computed current characteristics across the resistive load with P&O based MPPT.

The inductor current of the buck converter is shown in Fig.14.

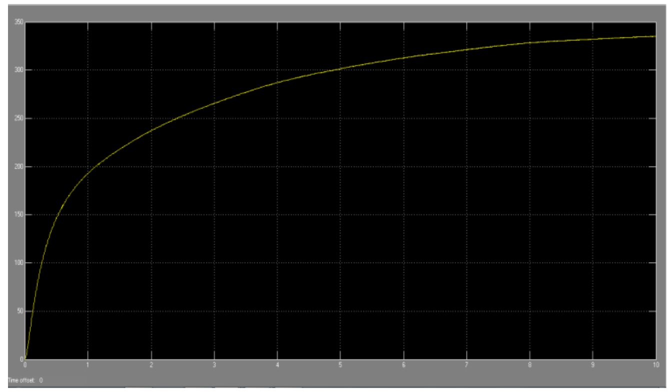


Fig.13.c. shows the computed power characteristics across the resistive load with P&O based MPPT.

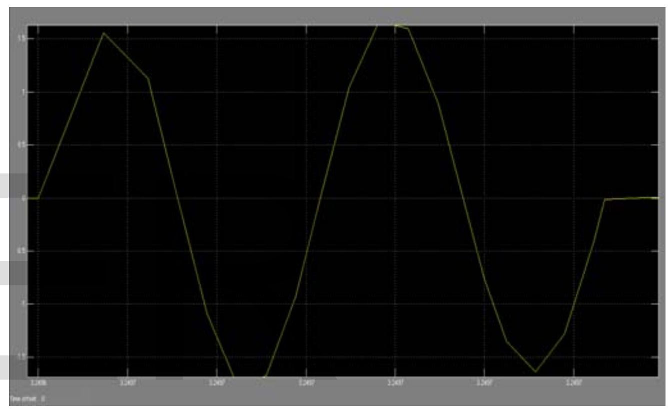


Fig.14. Inductor current of the buck converter

7. CONCLUSION

In this paper, Perturb and Observe based maximum power point tracker using buck converter has been simulated using MATLAB/SIMULINK software. The range of operation can be extended for low light levels or partially shaded solar panels. The step response for change in solar input is stable. The following conclusions are drawn:

1. Interfacing an MPPT chopper between SPV panel and the load maximize the power input to the load excluding the power loss of the converter.
2. The size of the step determines the size of deviation while oscillating about the MPP.
3. Perturb & Observe based MPPT method is simple and fast method used for MPP

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estimation of PV system under all insolation and temperature conditions.

4. Simplicity and robustness are the main advantages, but the panel operating voltage naturally oscillates about the MPP.

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