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Performance Investigation & Utilization of Maximum Power Point Tracking (MPPT) Mechanism in Solar PV System

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Abstract—*MPPT (Maximum Power Point Tracking) is a technique of tracking the maximum power from PV system. For maximum power point tracking, many implementation methods have been used. The methods vary each other in complexity, convergence speed, sensors required, cost, range of effectiveness and hardware implementation. Semiconductor device, metal oxide field effect transistors (MOSFETs) are used in this design of MPPT circuits as a voltage switch. Microcontroller chip is used to generate gate signals for driving the MOSFETs. Since the gate pulses obtained from the microcontrollers are very low and are not enough to drive the MOSFETs continuously, so driver circuits are required and are interfaced between microcontroller and MOSFETs. The driver used in this project is designed by LM358. The pulse output from the microcontroller is controlled by varying the duty cycle of the pulse. The pulse width modulation (PWM) will control the output voltage. It is programmed in such a way that the duty cycle decreases as voltage crosses the MPP set point and increases when voltage falls down from the MPP set point. Thus, this project results a constant output voltage to the load.*

Keywords: *MPPT, MOSFETs, PWM*

1. INTRODUCTION

Solar energy has massive financial benefits. As we consume solar power for the electricity that we use to heating, cooling and to lighting our environment. In other words creating the use of solar energy seems to be one of the best options available. The usage of solar energy will only provide us with a clean environment, where we will not have to constantly worry about the ever so reducing resources to provide us with the basic comforts of human life. India ranks sixth in the world in total energy consumption. India has increased installed power capacity from 1,362MW to over 1, 62,366MW since independence. India has electrified more than 50,000 villages. India is the 11th largest economy in the world, in terms of purchasing power. Out of total electricity production, 65.8% comes from thermal power plants, 26.3% from hydroelectricity & only 3.1% from nuclear power. Renewable energy non-conventional sources like wind energy, solar constitute nearly 4.9%.

(As per NIC site on Ministry of Power) [1]. The power-starved North-Eastern (N-E) Region, comprising Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Tripura, Nagaland, Assam and, Sikkim is blessed with a huge hydro potential. The region also has abundant resource of oil, coal and gas for thermal power generation. According to the estimates of the North Eastern Electric Power Corporation (NEEPCO), the north-eastern region has the potential of about 58971 MW hydro powers i.e. almost 40% of the country's total hydro potential, but out of this only less than 2% (1095MW) has so far been harnessed. Among the NE states Arunachal Pradesh is the richest in hydroelectric power potential. Assam accounted for only a small fraction i.e. 0.16 per cent of the total generation of electricity in the country during 2000-2001.

The state of Manipur is endowed with plenty of hydropower potential (about 2000 MW) in its hilly streams and rivers. At present, Meghalaya has a total of five installed projects (hydel) with total installed capacity of 185.20 MW. Mizoram is also not having its own power generation worth mentioning. In Nagaland, out of requirement of 42 MW of power, Micro hydel stations and diesel stations generate 4.26 MW. Sikkim has a huge hydro power potential. Sikkim can look for developing and exploiting its huge hydro power potential, which has been assessed to 8000 MW peak with a firm base of 3000 MW(ref1). The power and energy scenario in Tripura is not satisfactory. At present, the state has a total of five installed projects under the state sector (two hydel, two thermal and a diesel) with total installed capacity of 85.35 MW [2].

1.1 Methods used for MPP Tracking

There're several methods to find the MPP. They are as follows-

1. Perturb and observation (P&O) method.
2. Modified perturb and observation (MP&O) method.
3. Incremental conductance method.
4. Sampling method.
5. Voltage sensing based MPPT.

In this project we are following the voltage sensing based MPPT. The classical P&O algorithm requires the use of both voltage and current sensors to track the MPP. This project work offers an algorithm involving simple computations and a single voltage sensor to arrive at and continuously track the maximum power point (MPP). In addition to changing atmospheric conditions, the proposed method MPPT also provides self-tuning, variable search step that improves steady-state and dynamics performance. Using a current sensor is very much costly and it also results oscillations. Using a single sensor is very much effective [3].

2. DESIGN AND WORKING OF MPPT CIRCUIT

A typical MPPT system consists of PV panels, sensors, regulators, batteries and an inverter. The regulator connects the PV panel to the batteries and prevents them from over charging. Here the MOSFET is used as regulator, which will control the charging and discharging of battery with the help of the PWM signals from the microcontroller. The MPP can be found at the knee point of the V-I curve. The V-I and P-V curves can be shown as below-

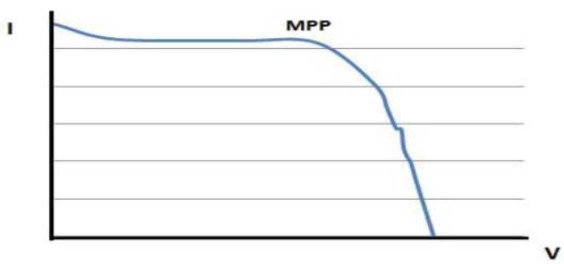

Fig. 1: I-V characteristics.

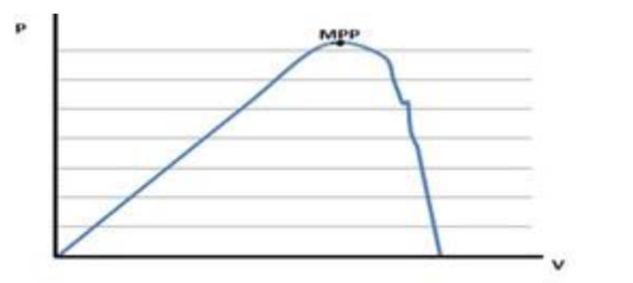

Fig. 2: P-V characteristics.

Study of I-V characteristics curve for three days to find MPP at local area at various times and weather conditions-

(Horizontal axis for voltage and vertical axis for current)

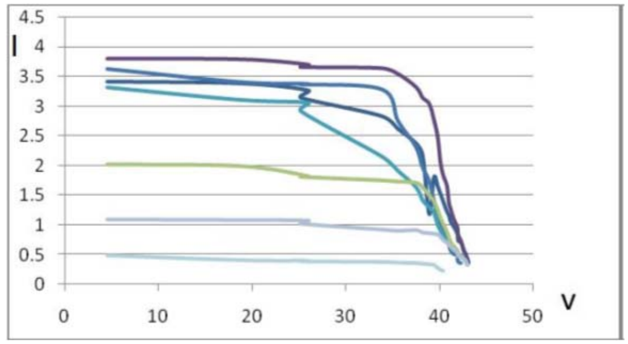

Fig. 3.I: V characteristics(day-1).

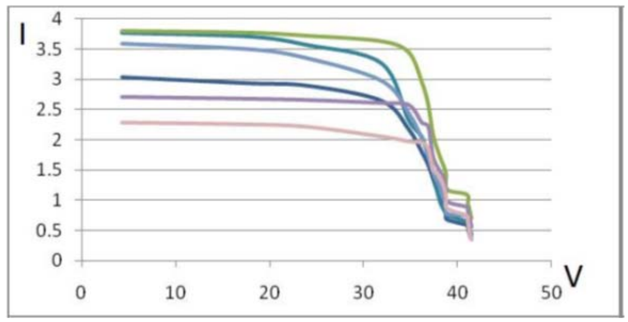

Fig. 4.I: V characteristics(day-2).

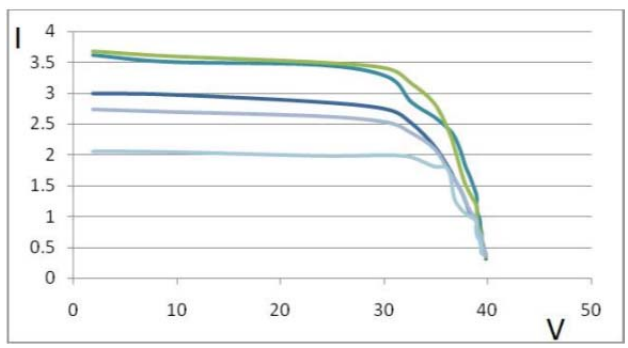

Fig. 5.I: V characteristics(day-3).

2.1 Block Diagram

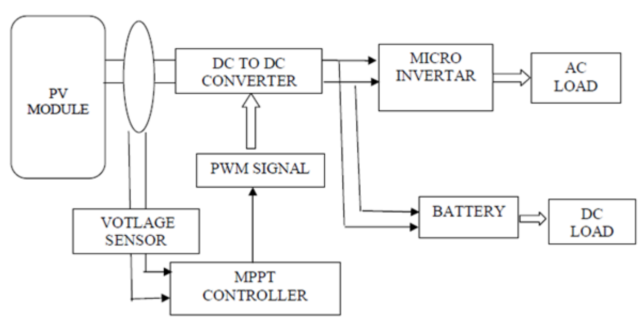

Fig. 6: Block diagram.

The block diagram shows the utilization of MPPT circuit to drive a DC battery and an inverter. It consists of PV module, voltage sensor, micro controller, buck converter, battery and a micro inverter. The voltage divider circuit is used as voltage sensor. The PWM output from the microcontroller, drives the MOSFET using an amplifier circuit. Since the voltage output from the microcontroller is very small it is not able to drive the MOSFET directly. The voltage output needs to be amplified. LM 358 op-amp is used as MOSFET driver IC. It amplifies the voltage output from the microcontroller. The microcontroller is programmed in such a way that when input voltage from PV panel crosses the MPP point the duty cycle of the PWM output from the microcontroller decreases to maintain the output voltage at MPP and vice versa. The PWM output is then fed to the gate of the MOSFET. The MOSFET works as a switch. It is then connected to a buck converter which results 12v that is enough to drive a micro inverter. DC to DC converter is converter whose input is a dc signal and output is also a dc signal. Here we are using a buck converter. The buck converter is the type of a dc to dc converter whose input voltage is comparably higher than the output voltage. The MOSFET controls the charging and discharging of the battery. The output PWM signal from microcontroller allows controlling the behavior of the converter. A capacitor is used improve the efficiency of the buck converter to reduce the drift error. The Inductor L2 reduces the reverse recovery peak current through diode D1and consequently maximizes di/dt. Capacitor C2 limits the voltage increasing ratio (dv/dt) during turning off.

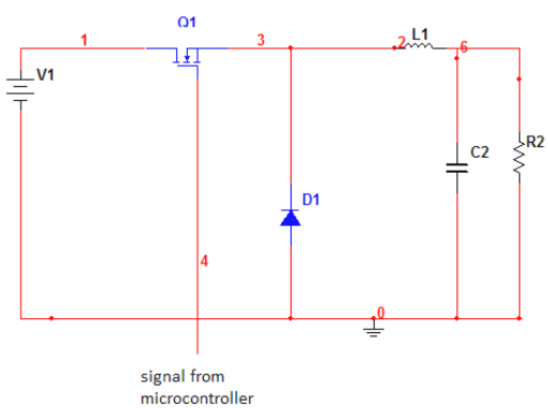

Fig. 7: Buck converter circuit in multisim.

The DC output can be fed to a battery for charging it. Thus, using this circuit AC loads and DC loads can be drive with the help of an inverter and a DC/DC converter respectively.

2.2 Flow Chart

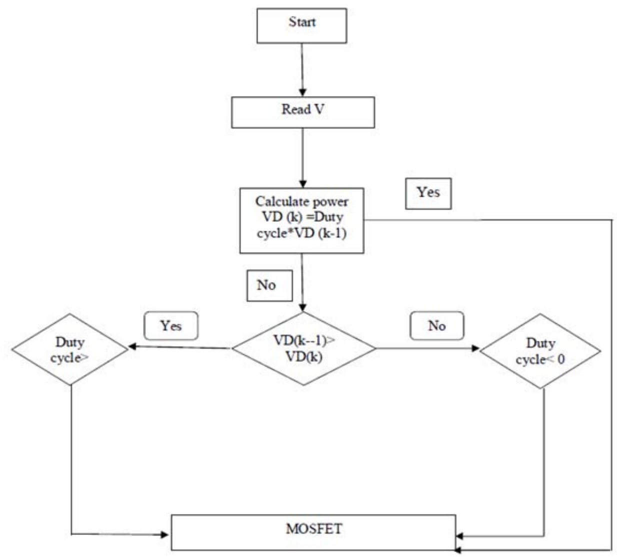

Fig. 8: Flow chart.

3. RESULT AND DISCUSSION

Finally, the project on MPPT shows the best result to run a micro inverter.20V is supplied from the solar panel and it carries 6 A current. The PWM output is generated from the microcontroller. It is shown in the figure. This signal is then fed to the gate of the MOSFET with the help of a driver circuit. The MOSFET then works as a switch. This switch excites the buck converter. The output of the converter is about 12V. This voltage is sufficient enough to run a micro inverter. This whole circuit works at the maximum power delivered by the solar panel. This circuit can be also used to produce more voltage using a boost converter.

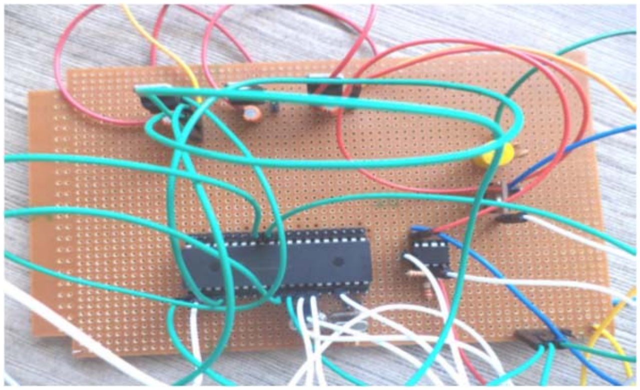

Fig. 9: Top view of the circuit.

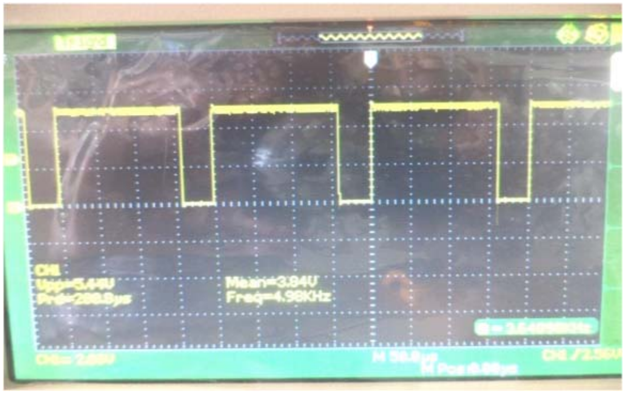

Fig. 10: Picture of Duty cycle (voltage v/s time for MPPT).

3.1 Conclusion

Output power of module is improves by using MPPT system. By observing it is found that the module gives the output maximum power at noon. Temperature of the module is an important parameter. The temperature has effect on the maximum Power. Power output should be increased by increasing the current rating. To increase the power, biasing power should be decreased. Due to the increase in temperature the power output decreases very sharply. The power output of the module changes by about 0.5% for every degree rise in temperature. The position of module placement also plays an important role in power output.

3.2 Advantages

1. This design has good linearity.

2. Efficiency is very high.

3. It has good speed of response.

4. This project work offers an algorithm involving simple computations and a single voltage sensor.

5. It continuously tracks the maximum power point (MPP).

6. It provides self-tuning, variable search step that considerably improves dynamics and steady-state performance.

7. Using a current sensor is very much costly and it also results oscillations.

8. Using a single sensor is very much effective.

3.3 Disadvantages

1. According to the size of the solar panel an appropriate designed of MPPT is required.

2. It is more expensive.

3.4 Applications

1. Applicable to solar charger.

2. Applicable to run ac loads such as a micro inverter.

3. Applicable to the plants where high voltage is required.

4. It offers great flexibility for the system growth.

4. ACKNOWLEDGEMENT

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