Simulation and Analysis of Various Techniques Used for MPPT Solar Charge Controller

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***Abstract*—In this paper various Maximum Power Point Tracking (MPPT) techniques are proposed. Maximum power point tracking is used for extracting the maximum power from the Solar photovoltaic module (SPV). Maximum power point tracking (MPPT) algorithms are used for achieving maximum power point. Microcontroller is used for control of the MPPT algorithm. Perturb & Observe method is used to operate the PV system at maximum power point. The Perturb & Observe method tracks Maximum power point (MPP) steadily and calculate the operating point at which battery is capable to produce maximum power. The project aims to design Buck converter & development of MPPT algorithm using Microcontroller programming.**

***Keywords*—Constant Current Method, Maximum Power Point (MPP), Maximum Power Point Tracking (MPPT), P & O Method, Synchronous Buck Converter Method.**

I. INTRODUCTION

Maximum Power Point Tracking (MPPT) is a technique which is used to extract maximum power from solar photovoltaic module. MPPT is used to maximize array efficiency of PV system.MPPT is also used to check the output of PV module then compares it with battery voltage and decides about the best power that PV module can produces to charge battery. MPPT is used to reduce the cost of energy generated by PV panels.MPPT of photovoltaic array is used to continuously deliever highest possible power to the load when variation in solar radiation and temperature occurs. Maximum power point tracking is an electronic tracking [1].
The block diagram of MPPT is shown in Fig. 1.The Solar panel is considered as input source.Solar panel produces voltage in the range of 12 V to 21 V. The voltage rating of solar panel is taken as 20 V. The output of solar panel is applied to DC-DC converter. Two sensors are taken into consideration which are current sensor and voltage sensor. The power produces by solar panel is given to MPPT controller throughvoltage sensor and current sensor. The output of MPPT controller is given to DC-DC converter through Digital to Analog Conversion (DAC).The DC-DC converter is usedto produceoutput power that is given to the load.

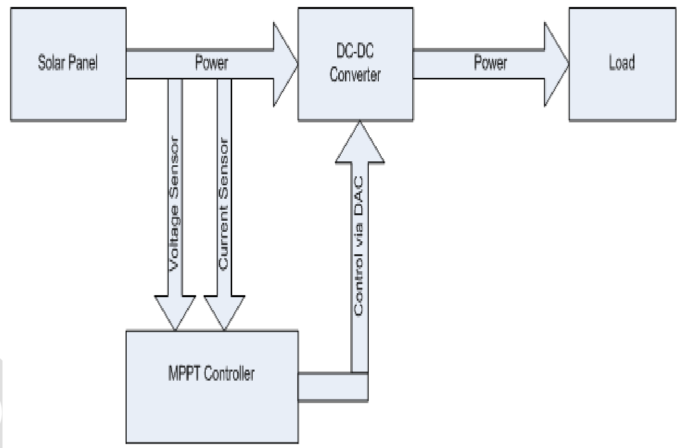

Fig. 1. Block Diagram of MPPT

II MPPT SOLAR CHARGE CONTROLLER

A MPPT solar charge controller is the charge controller embedded with MPPT algorithm to maximize the amount of current delivered to the battery from PV module. MPPT solar charge controller is operated by taking DC input voltage from PV module, converting it to AC and then converting it back to different DC voltage and current. MPPT solar charge controller is also used to exactly match the PV module voltage to the battery voltage. MPPT solar charge controller is mainly DC to DC converter [1].

III. TECHNIQUES FOR MPPT SOLAR CHARGE CONTROLLER

There are various techniques used for MPPT Solar Charge Controller. The techniques are as below.

- Constant Current Method
- Perturb and Observe Method
- Synchronous Buck Converter Method

A. Constant Current Method

In Constant Current Method, the charging current is regulated to a constant value under all conditions. The block diagram of constant current method is shown in Fig. 2. In this method the solar panel is taken as input source. The voltage rating of solar panel is considered as 20 V. The input capacitor is used as filter and provide stiffness to d.c link. The output of filter is given to buck converter and buck converter is used to step down the voltage from d.c link. The output of buck converter is given to battery. The current sensor will sense the current and when battery's maximum charging current is 2.16 Amp then battery's output will be 1. The output of current sensor is given to PI controller. The PI controller is used to producezero error and its output is given to buck converter.

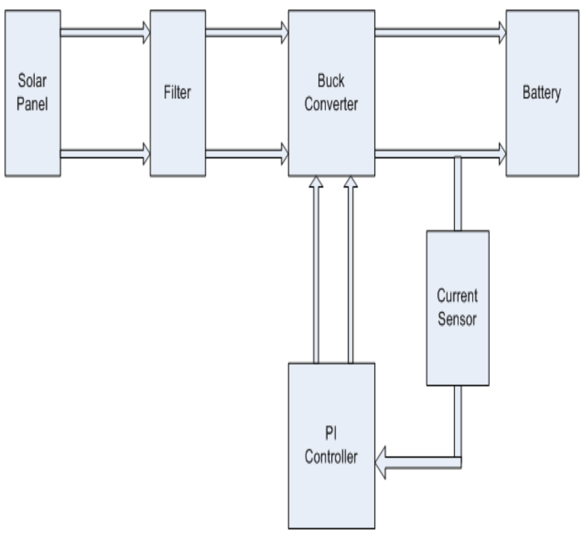

Fig. 2. Block Diagram of Constant Current Method

B. Perturb And Observe Method

The Perturb and Observe Method is used to calculate the power at PV array by determining value of voltage and current. The Perturb and Observe Method is most commonly used technique for MPPT solar charge controller and it has high reliability [2, 3]. The block diagram of Perturb and Observe Method is shown in Fig. 3.In this method the solar panel is considered as input source. The voltage rating of solar panel is taken as 20 V. The input capacitor is used as filter and provide stiffness to d.c link. The output of solar panel is given to filter. The output of filter is given to buck converter and buck converter is used to step down the voltage from d.c link. The output of buck converter is given to battery. The voltage sensor will sense the voltage and when battery's maximum chargingvoltage is 14 V then battery'soutput will be 1. The output of voltage sensor is given to PI controller. The PI controller produces zero error and its output is given to buck converter.

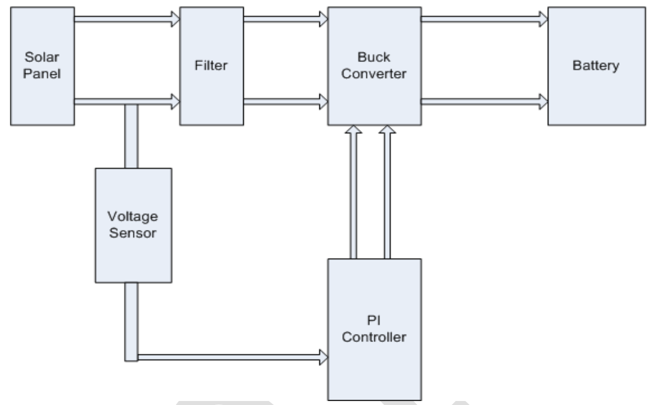

Fig. 3. Block Diagram of Perturb and Observe Method

C. Synchronous Buck Converter Method

The synchronous buck converter is one type of buck converter in which the maximum efficiency is obtained and also Maximum Power Point Tracking (MPPT) can be done. The efficiency obtained by synchronous buck converter is approximately 98 %. In synchronous buck converter topology twoMOSFETs are used. The block diagram of synchronous buck converter method is shown in Fig. 4. In this method solar panel is taken as input source. The voltage rating of solar panel is considered as 20 V. The input capacitor is used as filter and it provides stiffness to the d.c link. The current sensor is used to sense the current and when battery's maximum charging current is 2.16 Amp then battery's output will be 1. The voltage sensor will sense the voltage and when battery's maximum charging voltage is 14 V then battery's output will be 1. The output of both current and voltage sensor is given to controller. The output of filter is given to synchronous buck converter. The output of synchronous buck converter is given to battery.

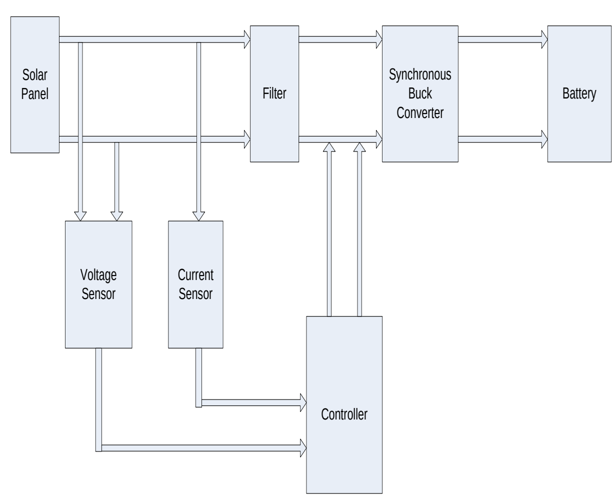

Fig. 4. MPPT Using Synchronous Buck Converter

IV. SIMULATIONOF PROPOSED MPPT TECHNIQUES

Simulation models of various MPPT techniques vis. constant current method, perturb and observe method and synchronous buck converter method are as shown below.

1. *Constant Current Method*

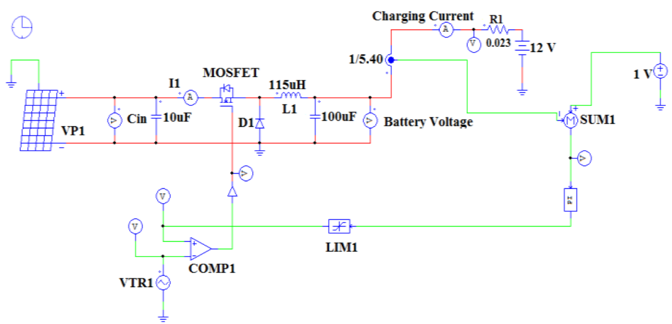

Fig. 5. Simulation Model of Constant Current Method for MPPT Solar Charge Controller

2. *Perturb And Observe Method*

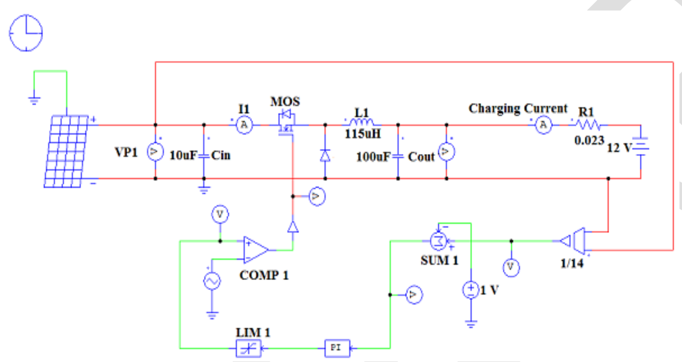

Fig. 6. Simulation Model of Perturb and Observe Method for MPPT Solar Charge Controller

3. *Synchronous Buck Converter Method*

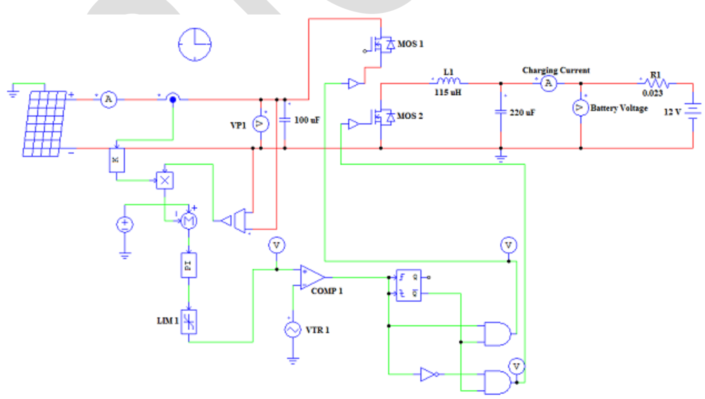

Fig. 7. Simulation Model of MPPT Using Synchronous Buck Converter Method

V.SIMULATION RESULTSOF VARIOUS MPPT TECHNIQUES

1. *Constant Current Method :-*

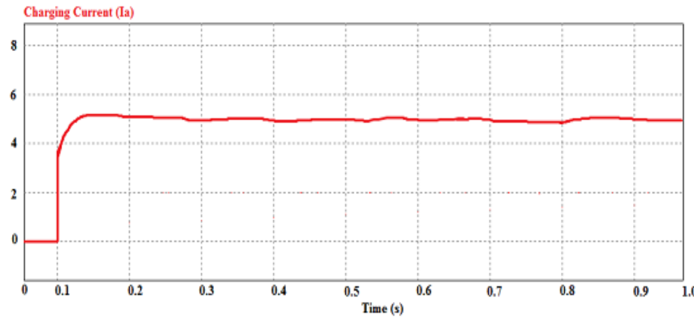

Fig. 8 (a)Charging Current versus Time

Charging Current versus Time waveform of ConstantCurrent Method is shown in Fig. 8 (a). Intiallycharging current is zero when MOSFET switch is off. When MOSFET switch is on charging current suddenly increases. Charging currentattains 5.17 A at output and it remains constant at this value.

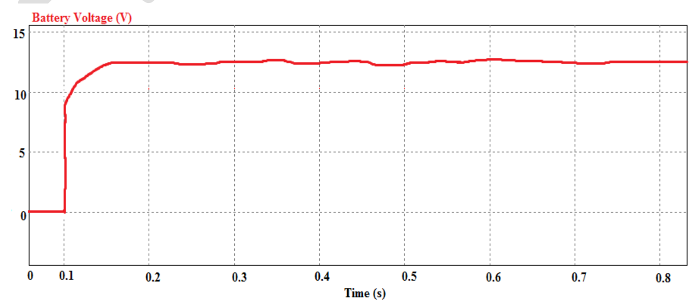

Fig. 8 (b)Battery Voltage versus Time

Battery voltage versus Time waveform is shown in Fig. 8 (b). Intially battery voltage is zerowhen MOSFET switch is off. When MOSFET switch is on, battery voltage suddenly increases. Battery voltage reaches approximetaly 12 V at output and it remains constant at this value.

2. *Perturb And Observe Method :-*

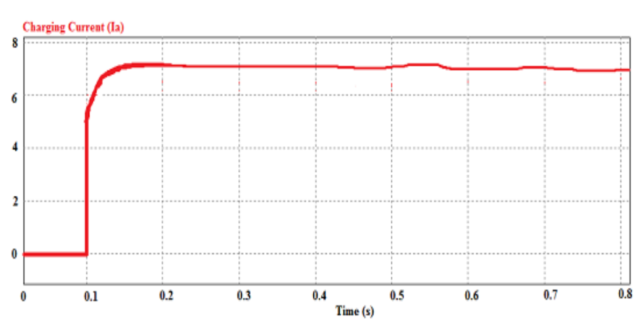

Fig. 9 (a) Charging Current versusTime

Charging Current versus Time waveform for Perturb And Observe method is shown in Fig. 9 (a). Intially charging current is zerowhen MOSFET switch is off. When MOSFET switch is on charging current increases. Charging current attains 7.39 A at output and it remains constant at this value.

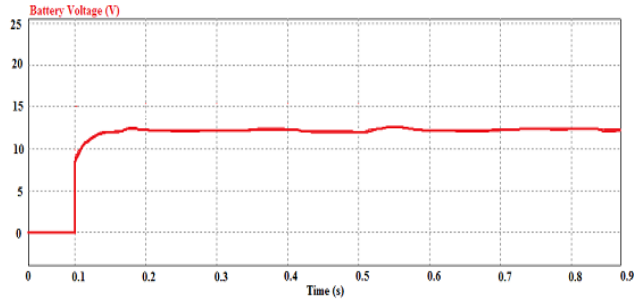

Fig. 9 (b)   Battery Voltage versus Time

The Battery Voltage versus Time waveform for Perturb And Observe Method is shown in Fig. 9 (b).Initially battery voltage is zerowhen the MOSFET switch is off. When MOSFET switch is on the battery voltage increases. Battery voltage attains 12.17 V at output and it remains constant at this value.

3. *Synchronous Buck Converter Method :-*

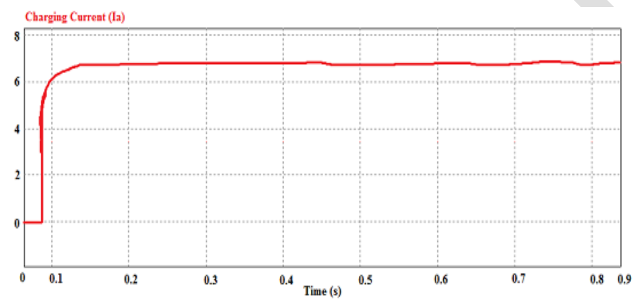

Fig. 10 (a)   Charging Current versus Time

Charging Current vs Time waveform for Synchronous Buck Converter method is shown in Fig. 10 (a). MOS 1switch and MOS 2 switch are complementary switches.Intially charging current is zero.The instant at which MOS 2 switch is on, MOS 1 switch is off. When MOS 1 switch is on charging current suddenly increases. Charging currentattains 6.86 A at output and it remains constant at this value.

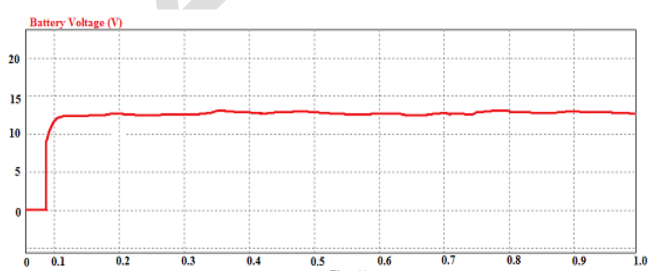

Fig. 10 (b)   Battery Voltage versus Time

Battery Voltage versus Time waveform for Synchronous Buck Converter method is shown in Fig. 10 (b). MOS 1 switch and MOS 2 switch are complementary switches. Intially battery voltage is zero. Battery voltage is zero when MOS 2 switch is on and at that time MOS 1 switch is off. When MOS 1 switch is on battery voltage suddenly increases. Battery voltageattains 12.15 V at output and it remains constant at this value.

VI. ANALYSIS OF VARIOUS MPPT METHODS

Table IComparison ofperformance Parameters of Three MPPT Techniques

MPPT Techniques	Constant Current Method	Perturb & Observe Method	Synchronous Buck Converter Method
Input Power to DC-DC Converter (W)	99.76	68.08	89.81
Output Power (W)	62.09	61.20	88.03
Efficiency (η) in %	62.24	89.10	98.02

The comparison table of performance parameters of various MPPT techniques is shown in Table I.From this table it can be shown that maximum power can be extracted from solar panel usingSynchronous Buck Converter Method. Maximum efficiency can be obtained usingthis method. The Synchronous Buck Converter Method is used to achieve efficiency about 98 %.

VII. CONCLUSION

The simulation of all three MPPT techniques viz.Constant Current Method,Perturb &Observe Method and Synchronous Buck Converter Method has been done. It is concluded that maximum power can be extracted from the solar photovoltaic panel using the synchronous buck converter method. Also, maximum efficiency can be obtained by Synchronous Buck Converter Method.

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