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Microcontroller Based MPPT Technique Using Novel Algorithm for Solar Panel

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Abstract-Photovoltaic Cell (PV) is an environment friendly source for electric power generation. This is relatively costly as compared to the other available sources of energy. The maximum power point tracking (MPPT) for the PV system application provides PV generated power for all irradiation conditions to have the maximum output power. MPPT is important unit in photovoltaic power systems because it increases the system efficiency by increasing the output power.
The perturb and observe (P&O) MPPT algorithm is the most commonly used method for tracking maximum power ,but it has some drawbacks such as the oscillation of the operating point around the maximum power point (MPP) at steady state which consumes a portion of the available energy. Also, the P&O algorithm can be confused due to the rapidly changing atmospheric conditions that can lead into unstable system. Incremental conductance algorithm, on the other hand, requires differentiation, division circuitry and a relatively complex decision making process, and therefore requires a more complex microcontroller with more memory.
The above problem will be overcome by using novel algorithm for maximum power point tracking and also it can increase the speed, accuracy, and efficiency of the PV module.
Keywords-Maximum power point tracking (MPPT), Maximum Power Point (MPP), Photovoltaic (PV), perturb and observe (P&O), Incremental Conductance (IncCond)

I. INTRODUCTION

Solar energy is one of the most important renewable energy sources that have been gaining increased attention in recent years. Solar energy is plentiful; it has the greatest availability compared to other energy sources. Solar energy is clean and free of emissions, since it does not produce harmful products to nature. The conversion of solar energy into electrical energy has many application fields. Solar to electrical energy conversion can be done in two ways solar thermal and solar photovoltaic. Solar thermal is similar to conventional AC electricity generation by steam turbine excepting that instead of fossil fuel; heat extracted from concentrated solar ray is used to produce steam and apart is stored in thermally insulated tanks. Solar photovoltaic cells are made up of silicon or certain types of semiconductor materials which convert the light energy into electric energy.
Recently, research and development of low cost flat-panel solar panels, thin-film devices, concentrator systems, and many innovative concepts have increased. In the near future, the costs of small solar-power modular units and solar-power plants will be economically feasible for large-scale production and use of solar energy.

1.1. Maximum Power Point Tracking

For extracting maximum power from the photovoltaic solar panel some method needs to be implemented. Therefore most feasible way to increase the efficiency of a solar panel is to use a Maximum Power point Tracker (MPPT), a power electronic device that significantly increases the system efficiency. By using it the system operates at the Maximum Power Point (MPP) and produces its maximum power output. Thus, an MPPT maximizes the array efficiency, thereby reducing the overall system cost.

In addition, design here A Novel algorithm for MPPT Charge controller for PV application system by using the algorithm for MPPT. This is “Perturb and Observe with reference voltage based” and implements it by using a DC- DC Converter. We have found various types of DC-DC converter. Among them we have selected the most suitable converter which is “BUCK-BOOST” converter, for our design. PV generation systems generally use a microcontroller based charge controller connected to a PV and the load. A charge controller is used to maintain the proper charging voltage on the batteries.

Microcontroller based designs are able to provide more intelligent control and thus increases the efficiency of the system. For extracting maximum power from the photovoltaic solar panel’s operation some method needs to be implemented. Therefore most feasible way to increase the efficiency of a solar panel is to use a Maximum Power point Tracker (MPPT), a power electronic device that significantly increases the system efficiency.

II. RESEARCH PROBLEM

Photovoltaic panel exhibit nonlinear I-V characteristics that vary with solar irradiation and temperature. Premature failure of batteries is therefore a big challenge and attributes to very high share of the running cost. Maximum Power Point Tracking (MPPT) algorithms are necessary in PV applications because the MPP of a solar panel varies with the irradiation and temperature. By observing the perturb and observe (P&O) and incremental conductance algorithms, it is found that each has some limitations on extracting power from photovoltaic cells.

Our main aim is to solve above problems using a Novel algorithm for MPPT Charger based on microcontroller. It will track maximum power based on source voltage and also improves speed, accuracy and efficiency of PV array.

III. MPPT CONTROL TECHNIQUE

There are number of algorithms that are able to track MPPs for all the conditions of Photovoltaic system. Some of them are simple such as, only voltage and current feedback system. The perturbation and observation (P&O)is a simple method whereas, the incremental conductance (Inc Cond) method are more complicated which requires number of sensors, speed of convergence, cost, range of operation, popularity, ability to detect multiple local maxima, and their applications [4]–[6]. Among the recommended methods, hill climbing and P&O [7],[19] are the algorithms that operates in the centre of consideration because of their simplicity and easy implementation. Hill climbing is Perturbation in the duty ratio of the power converter, and the P&O method [10], [24] is perturbation in the operating voltage of the PV array. However, the P&O algorithm compares the previous power and present power and respectively tracks output result of steady-state oscillations at MPPT hence waste the available energy [4].On the other hand, another MPPTs are more fast and accurate and thus, more effective, which needs additional special design with specific subjects such as fuzzy logic [14] methods. Table I shows comparative chart of various algorithm [15].

Table 1. Comparison of Various Algorithms

MPPT Technique	Speed	Complexity	Reliability	Implementation
Fractional Isc	Medium	Medium	Low	Analog/Digital
Fractional Voc	Medium	Low	Low	Analog/Digital
IncCond	Varies	Medium	Medium	Digital
P&O	Varies	Low	Medium	Analog/Digital
Fuzzy Logic	Fast	High	Medium	Digital

IV.PROPOSED TECHNIQUE

A Novel control system and tracking algorithm based on input voltage sensing control algorithm is implemented. The block diagram of proposed control system is illustrated in Fig.1.

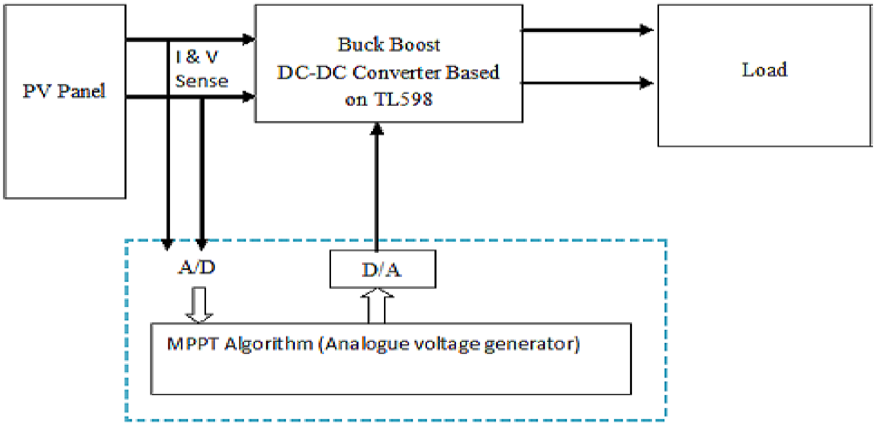

Figure 1.Block diagram of proposed control method

The main difference of proposed control system with existing ones is, after finding the peak unique point PWM signal latch that peak point and monitor source voltage for change of input voltage due to change in environmental condition. Accordingly takes the decision-making action against increasing or decreasing of duty cycle of DC-DC converter. However, problem on wastage of energy due to steady state oscillation at MPP is totally solves.

The TL598 based DC-DC Converter is a PWM control 16 pin IC, it has two high gain error amplifiers. One amplifier used for maintain constant output voltage another for output current for protection against over current. This converter has dead time control Pin (DTCON) that can directly control duty cycle. When we apply adjustable DAC output voltage to this pin get directly control duty cycle. Flowchart of tracking algorithm is illustrated Fig.2.

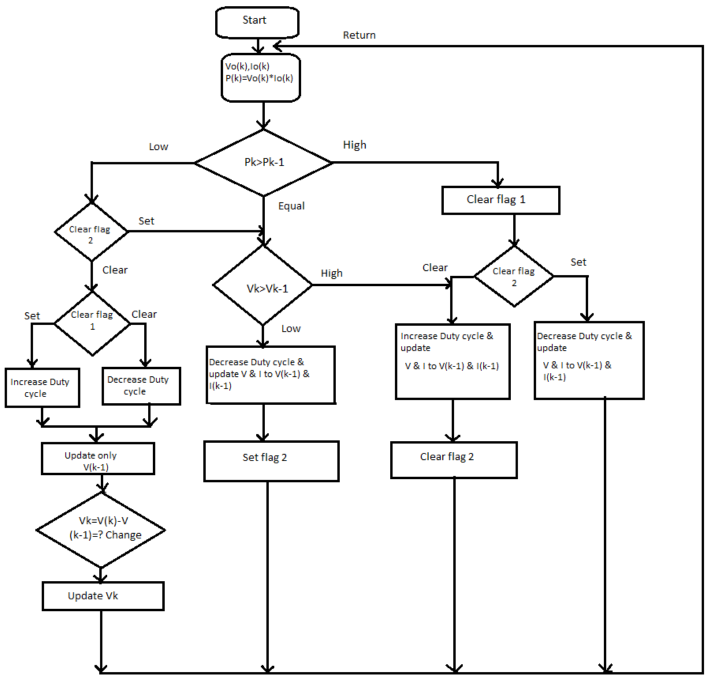

Figure 2.Flowchart for proposed tracking algorithm.

V.CONVERTER DESIGN

5.1. Topologies

There are various topologies used in DC-DC converter. They are isolated or non-isolated topologies. High frequency ferrite core transformer based converters are mostly preferred where electrical isolation is required. This provides DC isolation between input and output. By changing the transformer turn ratio, we can obtain low or high output voltage. In PV applications, the grid-tied systems often use isolated topologies when electrical isolation is preferred for safety reasons. Non-isolated topologies do not have output isolation transformers. They are a mostly used in DC motor drives. The topologies are classified into three types:

I. Step down (Buck)
II. Step up (Boost) and
III. Step up & down (Buck-Boost).

In PV applications, the buck type converter is normally used for charging batteries whereas; the boost topologies are used for stepping up the voltage. In the application of PV system with batteries, the commercial MPPT and PV module is set above the charging voltage of batteries for all combinations of irradiance and temperature changes. Normally buck converter can operate at the MPP under some conditions. But it cannot operate every time when the MPP goes below the battery charging voltage under a low irradiance and high-temperature conditions. Thus, such additional buck-boost converter can operate in these conditions with the overall efficiency.

5.2. Control Techniques

The MPPT algorithm directs a MPPT controller how to track the operating peak voltage in order extract maximum power. Then, it is MPPT controller's task to continuously track Vmp voltage to a desired level. The different methods often used for MPPT are:

5.2.1. PI control - In this method MPPT controller takes measurement of PV voltage and current, and then use of tracking algorithm calculates the reference voltage (Vref) where the PV operating voltage should be moved for tracking.

5.2.2.Direct control - This control method is very simple which use only one control loop, and it makes the adjustment of duty cycle of DC-DC converter within the MPP tracking algorithm.

5.3. Proper Converter Selection

At the time of proposing an MPP tracker, the important job was to choose and design a highly efficient converter, which was supposed to operate as the heart of the MPPT. Most of the applications switch mode DC-DC converters power supplies are well designing for proper function with high efficiency. Among all the available topologies, buck–boost converters provides to step up or step down voltage compared with input voltage. This configuration is cheaper and the higher efficiency with isolation from load. It can also provide a better output voltage-current characteristic. Thus, requires the proper converter in designing the MPPT. This paper proposed a power circuit of a Push pull converter based on TL598 control circuit. The MPPT controller has a task of measuring instantaneous analog voltage and current of the PV module using current and voltage sensor, which convert them to digital form using ADC. Processing the obtained information in a microcontroller with defined algorithm, and generating a valid analogue voltage by use of DAC for adjusting duty cycle of converter to achieve MPP maximum power level point all the time, and the main program continues to track the MPPs. In this paper, we select push-pull high frequency converter using TL598 as PWM generator and control circuitry. The output from programmed microcontroller is applied to Pin 4 DTCON of TL598, this varies duty cycle, which is function of algorithm. For Design of proper converter select the solar panel voltage of 75Wp,1000W/m2.

5.3.1. DC-DC Converter Design

5.3.1.1. Design of Ferrite Transformer Turns Calculation for High-Frequency Converter

To design a DC-DC converter the first step is to design high frequency transformer. In high-frequency converters, the ferrite core transformer is uses for stepping up or down stage. In this paper, low voltage DC from the PV is step up voltage DC i.e. from 12V to 28V to charge two 12V batteries. The used ferrite core is ETD39. Transformer secondary output will be high frequency AC.The required DC output obtained after rectification using ultrafast recovery diodes by use of rectifier and filtration circuit. The electrical parameter specifications tabulated in Table 2.

Table 2. Electric Parameters

Minimum Input voltage (Vmin)	13.5Volts
Maximum Input voltage (Vmax)	22.2Volts
Nominal voltage (Vnom)	18 Volts
Switching frequency (Fosc)	22000Hz
Maximum Output voltage (Vout)	28 Volts
Maximum Output current (Isc)	4 Amp

$$NPri = \frac{Vin(nom)10^8}{4.f.Bmax.Ac} \quad \text{-------- (1)}$$

Where,
NPri – No. of Primary turns.
NSec - No. of Secondary turns.
Vin(nom) - Nominal Input Voltage.
Fosc - Operating switching frequency in Hertz.
Bmax - Maximum flux density in Gauss (1500).
Ac - Effective Cross-Sectional Area in cm2.
Ac - 1.25 for ETD39.
Npri = 10.9 = 11 turns.

For the PWM control circuit, assume maximum duty cycle to be 98%. At minimum input voltage (i.e. Vin =13.5V), duty cycle will be maximum. At maximum duty cycle = 98%, voltage to transformer = 0.98 * 13.5V =13.23V.
Thus, voltage ratio V2:V1 (secondary: primary) =28V:13.23V =2.1. Since voltage ratio = 2.1, turns ratio (V2:V1) must also be 2.1 as turns ratio (V2: V1) = voltage ratioV2:V1). N. designates turns ratio.So,in our case,N=2.1.

Nsec = N x Npri = 2.1 x 11 -------- (2)
Nsec = 23 turns

Thus, 23 turns are required for the secondary. With proper implementation of feedback, a constant 28VDC output will obtained throughout the entire input voltage range of 13.5V to 22.2V.

5.3.1.2. PWM Control Circuit

For the generation of PWM signal IC TL598 is a complete Pulse-Width Modulation (PWM) Power-Control circuitry, Uncommitted Outputs for Single-Ended or Push Pull Applications, Totem output, Low Standby Current 8mA typical. Fig. 7 show a practical push pull converter, which are use as power stage interface between the PV module and the load. The power circuit of the proposed system consists of a push-pull converter based on TL598, and the control of the duty cycle is done using the voltage and current feedback control circuit and also from DTCON pin which is controlled from MPP algorithm. The change of voltage at DTCON pin from 0 to 3.3V can adjust output power from maximum to minimum.

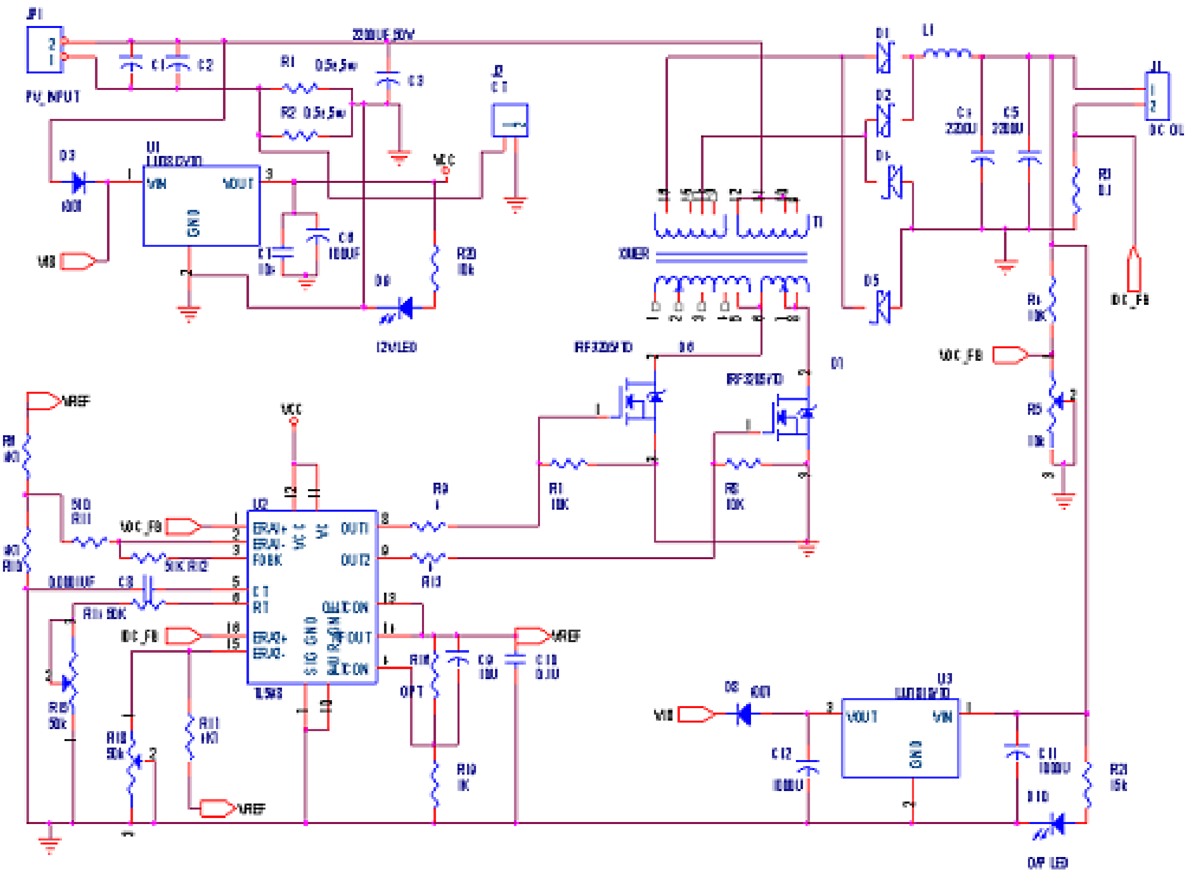

Figure 3.Circuit diagram of DC-DC converter.

VI. CONCLUSION

This paper presents a source voltage information based MPPT controller. By use of Novel algorithm technique the proposed MPPT algorithm adopts it perturbation and observe power with increase or decrease duty cycle of DC-DC Converter for achieving peak power. Where, duty cycle of DC-DC converter is latched. At the same time it achieve a stable output power and monitors only source voltage information for sensing any change in environment for operation of obtaining maximum power all the times. For validate the performance of proposed MPPT controller. The experimental results show that the proposed MPPT algorithm is accurate and simple method. It has fast dynamic response and high efficiency under various environmental conditions. Also it does not oscillate at peak point. However, the proposed method attempts to extract maximum power from the PV by use of DC-DC converter with direct control method.

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