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Design and Implementation of Microcontroller Based Solar Tracking System with Forward Converter

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ABSTRACT: Reduction of energy consumption is one of the most important concerns in the recent days. Especially in lighting applications as they represent approximately 20% electrical energy in consumption. An efficient way to reduce the energy consumption is done by most of the conventional light bulbs which have been replaced by LEDs. Solar panel is the fundamental solar energy conversion component which is fixed at a certain angle and is not able to track the direction of sunlight during seasonal changes. This limits the efficiency of the tracking system and sun exposure on solar panels. The system consists of combination of micro controller, LDR, and MPPT technique particularly using Perturb &observe algorithm. This paper proposes a forward flyback converter applied to a street light with photo voltaic (PV)system. The proposed system can be implemented in public areas with relatively low cost.

KEYWORDS: Street lighting, Solar (PV) panel, LDR, forward flybackconverter, (Maximum Power Point Tracking) MPPT, Microcontroller.

I. INTRODUCTION

For large number of purposes energy is required. Some traditional energy used from coal, oil, natural gas, nuclear energy is exhaustible and polluting. So an alternating source that is renewable energy resource is used. Solar energy is used as it is a good option and the electricity produced is clean, reduced cost and long lasting. The growth of solar in the past years have been expanded the importance of photo voltaic panels.the power conversion fundamental is represented by a PV panel unit of a PV generator system. The solar isolation of a PV module is responsible for the output characteristics since it has some linear characteristics. it is necessary to design and model for the applications which require it. C.Nagarajan et al [5,6,7] obtain the maximum power from the solar panel a algorithm used is maximum power point tracking technique. The voltage output from the solar panel is regulated from a DC-DC converter. The basic block diagram of a pv system is given below

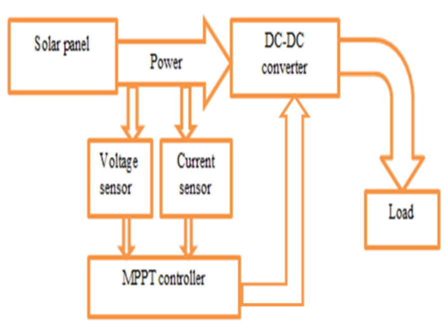

Fig-1Basic PV system configuration.

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1.1 PHOTOVOLTAIC MODEL:

A photo voltaic cell is device which generates electric power by using solar cells to convert energy from the sun into a flow of electrons.. A PV Module refers to a number of cells connected in series in a photo voltaicarray, modules are connected both in series and parallel. Environmental problems such as green house and polluting emissions to the atmosphere are reduced by large use of photovoltaic (PV) cells. voltage-current(V-I) curves, voltage-power (V-P) curves, maximum power point values, current in short-circuit and voltage in open-circuit across a area of irradiation levels and cell temperatures are accurately predicted.The linear curve depending on irradiation and temperature. Both V-I and V-P curves have a maximum mount which is often called as Maximum Power Point (MPP).

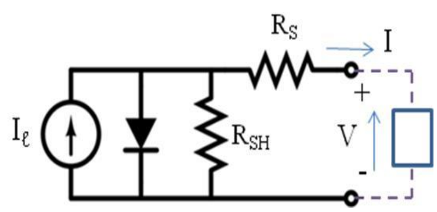

Fig-1(a) simplified PV cell

The output voltage of a PV Cell is basically a function of the photon current which is determined by load current mainly depending on solar irradiation level during the operation.

II. TRACKING MAXIMUM POWER POINT

An essential part of a PV array in a PV system is to track its maximum power point. With the variation of the solar irradiance and temperature the PV module changes its power output. From the figure 2 it is clear that there exists a maximum power which corresponds to the current and voltage. it is desirable to operate the module at its maximum power since the solar cell has 8-15% of its efficiency. so maximum power can be transmitted to the load with varying temperature and irradiance levels MPPT is an electronic algorithm which enables the PV system to store the maximum power in any conditions[2].various MPPT algorithms are present among them perturb & observe method is the most popular one. The peturb & observe algorithm is discussed below

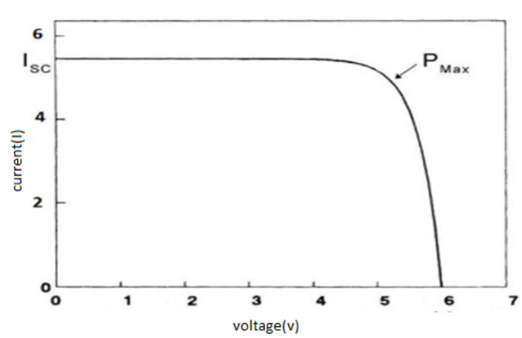

Fig-1(c) V-I characteristics

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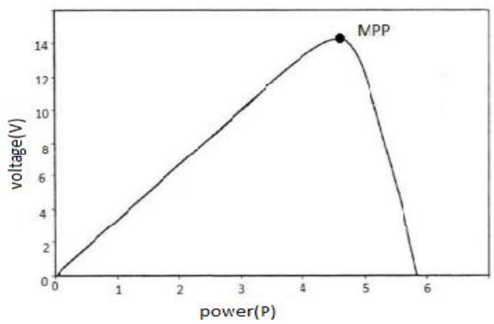

Fig-**1(**d) V-P characteristics

2.1 perturb &observe method:

The main drawback of the P&O algorithm is that the operating point in the steady state oscillates around the maximum power point (MPP) which gives rise to some amount of available energy which is considerably waste. Thealgorithm can be confused during time intervals characterized by rapidly changing atmospheric conditions is well known in this method. To control the negative effects associated to the above drawbacks, the Maximum Power Point Tracking P&O parameter must be personalized to the changing behavior of the specific converter adopted in the system.

MPPT BOOST CONVERTER:

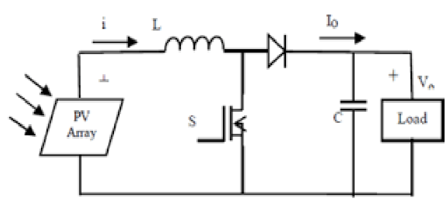

Fig-3(a) MPPT Boost converter

III. DC-DC CONVERTER

The process of the DC-DC converter is to convert the DC input power from the PV array into DC output power.the DC-DC converter is used in the MPP to adjust the PV voltage at its maximum power.There are different types of converters, an isolated DC-DC converter is preferred due to the following advantages.

- Between an input and output circuit by means of a high frequency transformer Isolated DC to DC converters provide full dielectric isolation.
- In the case of any internal failure isolation prevents input voltage from transferring to output

3.1 SERIES CONNECTED FORWARD FLYBACK CONVERTER:

Many lighting systems with distributed photovoltaic micro generation have been proposed as a suitable solution for some specific cases. A flyback converter is used for the conversion of DC-DC with dynamic isolation between inputs and any outputs. A common transformer is used to merge flyback converter and a forward converter.the flyback converter operates only when the input voltage becomes lower than the reflected output voltage.both the converters are operated in the case to share the output power in the rest region.the traditional forward converter consists of dead zones which exists in the ac input current are eliminated and a high power factor can be achieved in it.

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IV. STREET LIGHT INTEGRATED SYSTEM

The main objective of this paper is to develop an automatic street light system for remote places,with increased efficiency and long lifetime using alternative energy sources. In autonomous street light system, the solution is using solar energy to reduce nonrenewable resources affecting the environment. by using solar energy the system can increase its efficiency and it can be easily installed even in urban areas. A converter is placed between the pv panel and the dc link which is used to track the maximum power point. The flyback converter is used both in distributed generation and street light system. the proposed system comprises two types of sensor. The light sensor which is used to detect darkness to activate the ON/OFF switch , the photoelectric sensor turns on and activates the street light when it detects the movement. LDR is used to measure the intensity of light which also varies the amount of light falling on the surface gives an inductions for whether it is a day time or night time, the photoelectric sensors are placed on the road sides, The battery rating will be of 12V, 75 Ah (at C/10 discharge rate).75 % of the rated capacity of the battery should be fully charged and in load cut off conditions.the entire system can be controlled by microcontroller PIC16f877A.

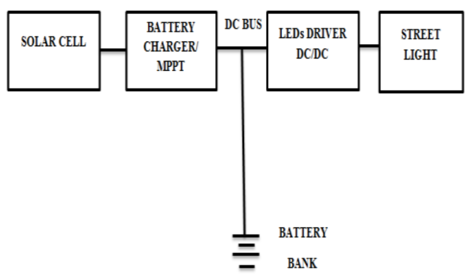

Fig-4Block diagram of street light integrated system

V. HARDWARE IMPLEMENTATION:

The main challenge in designing a hardware part is to design the parameters to meet its requirements and to increase the maximum system efficiency. The PV panel is connected to the boost converter and the MPPT controller. the converter used is DC-DC boost converter which shares the transformer to increase the utilization factor and to boost the energy produced. The produced voltage is isolated and controlled DC voltage. the maximum power point tracking method with the P&O algorithm integrated with the open circuit voltage is connected with the pv panel to speed up the tracking speed. Battery used with the nominal voltage of 12V and capacity 7AH for long service life. The converted power is given to the load placed at the end of the circuit.

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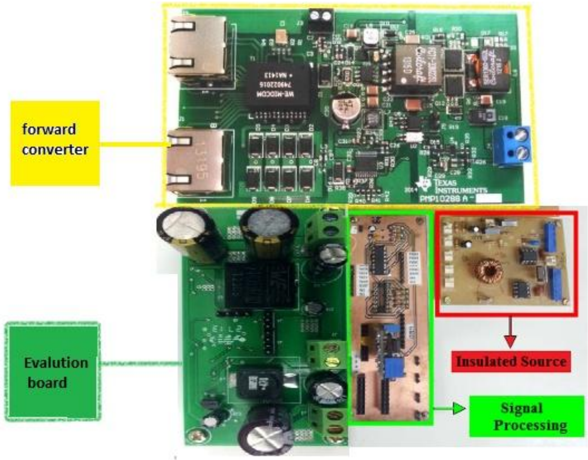

Fig-5 Hardware part of the solar tracking system

VI. SIMULATION RESULT

The overall system consist of Maximum Power Point Tracking circuit and a forward converter circuit. The overall system control are realized by a microcontroller. After implementing the prototype the experimental results are used to conform the proposed function. From the experiment two modules consisting of Maximum power point tracking circuit of the solar cell is implemented. To build a solar power system two modules are combined with the battery. One bidirectional charge/discharge controller and a battery used. The proposed simulation model is given below:

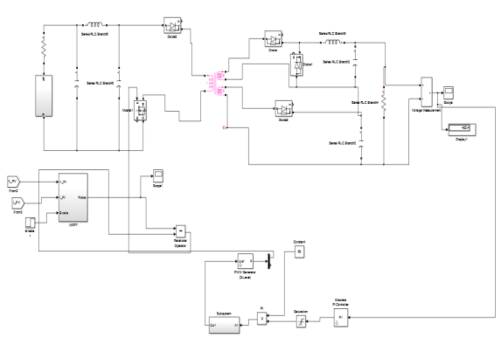

Fig-6(a) proposed simulation model

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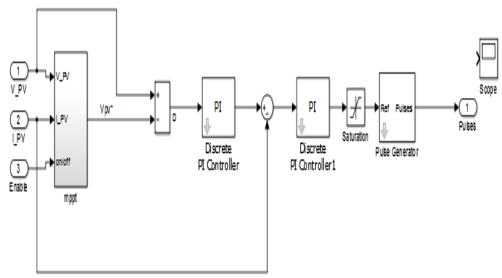

Fig-6(b) MPPT simulation model

Fig-6(c) output waveform 1 for photovoltaic cell

Fig-6(d) output waveform 2 for photovoltaic cell

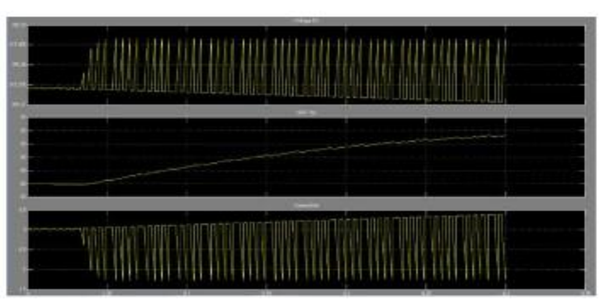

Fig-6(e) battery charging waveform

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VII. CONCLUSION

PV module design and simulation is done using MATLAB/Simulink. Perturb & Observe algorithm used in the MPPT method. The efficiency obtained from the simulation is 92.38% The LED driver circuit for the system which can achieve maximum power efficiency up to 91.9% at a current of 1.06A. the implementation of a Microcontroller based solar tracking system gives a design that using 32-bit microprocessor chip as a controller, to attain the automatic sun tracking by controlling the vertical and horizontal directions through the program.Thus the LED driver circuit produces maximum efficiency of 94.7% as compared to the previous methods in the literature.Hence 98% efficiency can be obtained in the future.Thus the low power LED street light system can be installed with a low cost even in urban areas.

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