

Efficient MPPT Technology for Low Power Indoor Solar System

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ABSTRACT: Requirement of electrical energy is increasing day by day. Thermal energy and nuclear energy are most widely used sources of electrical energy in modern days with high level of precautions. High level of precaution is essential because these methods generate more electricity and also they release lot of poisonous gases and heat to the environment. Also in these methods it may need one or other non renewable sources to produce energy. That is why harvesting of electricity is getting famous in day by day. That is why wind energy, solar energy and water energy related researches are getting promoted and each research tries to better the performance comparing to the previous research. This paper is for the solar indoor systems. In indoor systems also energy requirement will be constant throughout but the sun light is not constant throughout the day and it varies one place to other places inside the room. If we use a microcontroller it takes major part of energy to its functionality itself. Hence alternate to that by using 555, OPAMP and other simple components we can draw near maximum power from the solar panel.

KEYWORDS: PV Panel, MPPT, solar panel.

I. INTRODUCTION

For decades, electricity is a key driver of socio-economy development. Now a day in the context of competition there is a direct relationship between electricity generation and development of the country. The Paper [1] presents distinct use of a Photovoltaic array offering great potential as source of electricity. The energy that comes from the solar panel has to be utilized properly, for this MPPT technique is used. MPPT refers to the maximum power point tracking. Microcontrollers are used in such circuits which are very power hungry and it uses constant supply power for its functionality. In low power applications this may be the biggest burden over the supply source. The proposed model is an alternate to the microcontroller method. The paper [3] presents a two-phased tracking where PI-INC (Power increment aided Incremental Conductance) is used to get maximum power point tracking (MPPT) which improves the tracking behaviour of the conventional. In all the above mentioned models microcontrollers are used.

II. BLOCK DIAGRAM OF SYSTEM

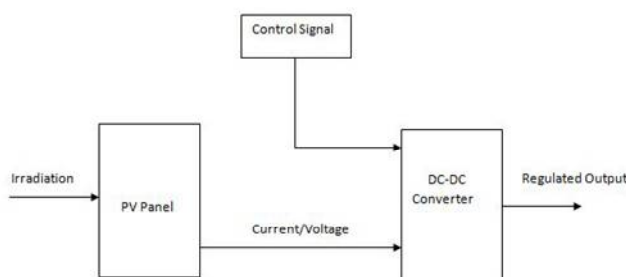


Figure 1: Block Diagram

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As shown in Figure 1 the PV panel generates the energy. This signal is given to the buckboost converter which regulates the input signal to the required level. The block diagram shows that there are mainly 3 important parts

- PV Panel
- Buckboost Converter
- Controller

III. SYSTEM DESIGN

PV PANEL

An infinite source of clean energy is solar energy and it is the most abundant source. Wind may not be blowing some time and in some geographical area. Water sources may get drained season by season. But sunlight is not like that, it will be available all over the world abundantly. Photovoltaic system is one of the renewable sources of electric power which is in forefront because it can generate direct current without any heavy environmental impact.

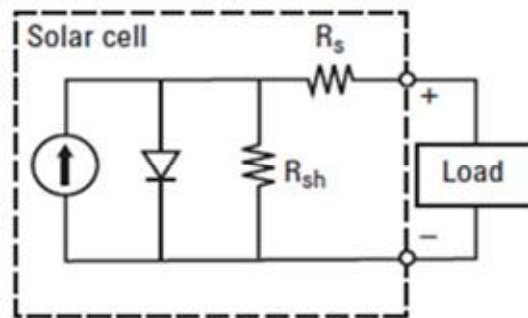


Figure 2: Single Diode model of the PV cell

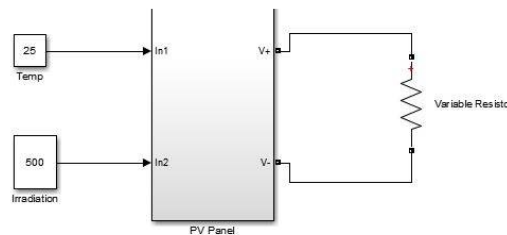


Figure 3: Simulink Model of PV Panel

Figure 2 shows the single diode model of the PV panel. Below mentioned formulas are used for the modelling of PV panel which is shown in the Figure 3. Figure 4 (a) & (b) gives the IV and PV characteristic of the PV panel.

$$i_{cell} = i_{ph} - i_d - i_{sh} \quad (1)$$

$$i_{cell} = i_{ph} + \left[\alpha \frac{q}{kT} (T_c - T_{ref}) + \left(\frac{q}{kT} - 1 \right) i_{sc} \right] \quad (2)$$

$$V_{cell} = -\beta (T_c - T_{ref}) - r_s \Delta i + V_T \quad (3)$$

$$\Delta i = \left[\alpha \frac{q}{kT} (T_c - T_{ref}) + \left(\frac{q}{kT} - 1 \right) i_{sc} \right] \quad (4)$$

$$V_m = n_{sc} * V_{cell} \quad (5)$$

$$i_m = n_{pc} * i_{cell} \quad (6)$$

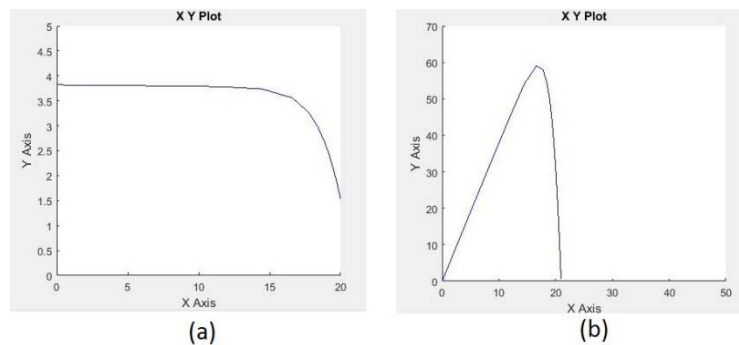


Figure 4: Waveforms (a) IV Curve (b) PV

Model shown above in Figure 3 is replica of the formulas mentioned above. Output of photovoltaic panel is given to a variable resistor to plot the characteristics as shown in the Figure 4. In current characteristic Y-axis refers to current and X-axis refers to voltage. Current is constant initially and slops down after a cut off. In Power characteristic Y-axis refers power and X-axis refers to voltage. Figure 4 (b) shows that there is a peak operating point for particular voltage level. MPPT will search that peak point and offers to work nearer to that operating point. If we observe the Figure 4 (b) the graph shows a peak power of approximately around 60Watts, this is for one particular irradiation. Similarly we can get the graph for different range of irradiations for particular PV Panel which will help us in getting the peak power. MPPT controller will search automatically that peak operating point and keeps the device to operate around that point.

BUCKBOOST CONVERTER

Buckboost converter regulates the output voltage to the required level which takes the input from the PV Panel. The output of this converter is varied based on the PWM input given to it. Buckboost converter acts in buck mode if PWM has duty ratio less than 0.5 and acts in boost mode if the duty ratio is greater than the 0.5. This is the beneficial part of using the buckboost converter. In case of MPPT technology peak power is obtained by controlling the duty ratio for the converter. Controller continuously keeps monitoring the power through the feedback. Therefore it must be a closed loop system in some cases.

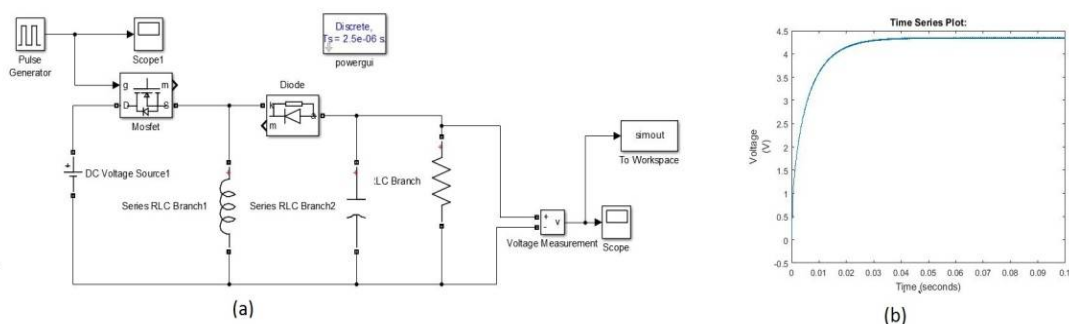


Figure 5: (a) Buckboost Converter (b) Output wave form of buckboost converter

IV. SIMULATION AND IMPLEMENTATION

Controller is the part which decides duty ratio of the PWM input to the buckboost converter. The PWM can also be generated using 555 timer IC or an OPAMP and to set the duty ratio open circuit voltage (Voc) of Photovoltaic panel is

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used. Open circuit voltage will be different for different irradiation. Open circuit voltage is stored in the capacitor by disconnecting the load end by using switch and timer, and in the mean time connecting the capacitor which gets charged to its peak that is V_{oc} . Therefore a sampling is required to connect and disconnect capacitor meanwhile disconnect and connect the converter.

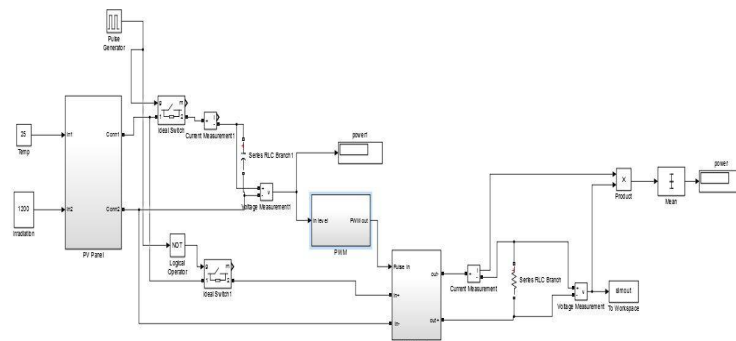


Figure 6: Simulink Model of the System

Large capacitor has to be selected such that there should not be much variation in the capacitor value during its sampling. Sampling time must be appropriate such that charging of the capacitor should be maximum for the irradiation to which panel is operating at that particular time. Sampling time must be appropriate, it should not be too long or should not be too short. If it is too long even if the irradiation is changed the PWM will be according to the previous sample. If the sampling time is too short then much time will be wasted in sampling itself. Simulation is performed using the MATLAB software.

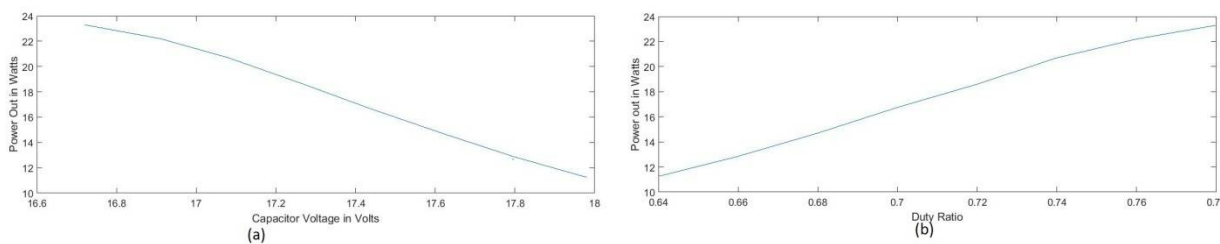


Figure 7: (a) Power Versus capacitor Voltage Graph (b) Power versus Duty Ratio Graph

Two figures Figure 7 (a) and (b) are drawn by the varying irradiation from 500 to 1200 keeping temperature constant at 25 degree Celsius. The graph shows a linier relationship between the irradiation, capacitor voltage and the duty ratio. Figure 7 (a) shows as we increase the irradiation, capacitor voltage is getting reduced linearly but output voltage is increasing. That is at irradiation 500 capacitor voltage is around 18 volts where as output power is 11.25 watt and at irradiation 1200 capacitor voltage is 16.72 where as output power is 23 watts. Similarly if we observe graph in Figure 7 (b) as we increase irradiation at regular interval of duty ratio we can get the near maximum power. That is for irradiation 500 for duty ratio of 0.64 we have near maximum output whereas for 1200 we have a near maximum output at duty ratio of 0.78. The linier relationship between of capacitor voltage, duty ratio and output power is utilized. A large capacitor is thus connected across the output of panel to hold the open circuit voltage which varies linearly for different irradiation level.

The hardware is tested initially part by part separately that is charging circuit, PWM generation using 555 timer, buckboost converter and sample and hold circuit are tested separately. A large capacitor is used to hold the open circuit voltage. Same voltage of this large capacitor is used to set the level in the PWM generation. Thus PWM generator has 2

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inputs one from sawtooth wave generator and other from the capacitor. According to these two inputs it will generate a PWM which is appropriate to the near maximum power. PWM out is given to the buckboost converter which provides the supply for the entire load. Generating sawtooth wave and then generating a PWM though it is perfect method of generating a PWM, but it adds up components in the schematic. Instead of that a 555 timer circuit is slightly modified as shown in Figure 8 . The 555 timer generates PWM and duty ratio is maintained by the two resistors R1 and R2 combinations. But there is a diode across the R2 which makes the difference in off period of the PWM. Inputs to these two resistors are coming from the capacitor that is sample and hold capacitor which holds the open circuit voltage. Therefore as this voltage varies the PWM varies and that PWM is used to manipulate required high power at the load end.

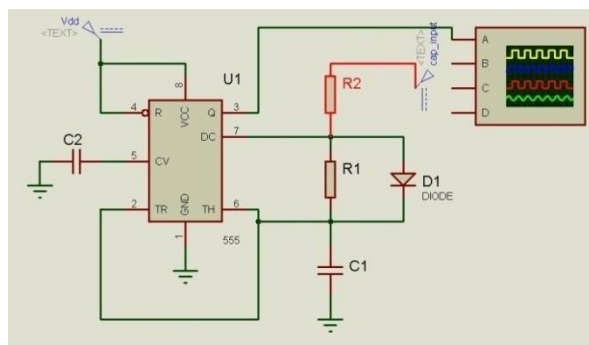


Figure 8: PWM Generator circuit

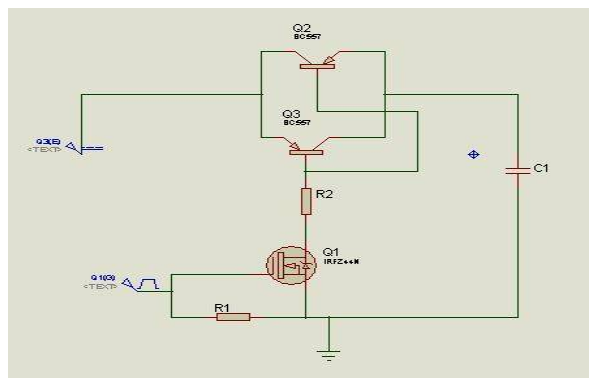


Figure 9: Capacitor charging circuit

The charging circuit as shown in Figure 9 has 2 anti-parallel PNP transistor and N channel MOSFET. Large capacitor acts as a hold circuit. The input signal is sampled at a low sampling rate say 1 sample per one second. Same charge is given as an input to set the level in PWM generator. Figure 10 shows the experimental setup. Figure 11 shows the boost operation of the buckboost converter connected to the solar panel. The panel connected in the set up is low watt panel hence the output seems to be very low. If the panel with better wattage and better performance are connected output will be still better.

IV. RESULTS AND DISCUSSION

MPPT that uses microcontroller is not suitable for indoor systems, it is suitable only for outdoor applications where control of the system, normally necessitating the use of a microcontroller. If the load is constant and load is known then instead of microcontroller we can have alternate circuits. Microcontroller senses the maximum operating point and

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keeps the circuit to operate around that region. The methods explained in this paper may not operate at maximum point but operates in reasonably near maximum point with added benefit of lower power consumption at generator side.



Figure 10: Test set up of the system



Figure 11: Output waveform of the buckboost

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