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Three-point MPPT technique for photovoltaic systems

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***Abstract*—Renewable energy is generally defined as energy that comes from resources which are naturally replenished on a human timescale, such as sunlight, wind, rain, tides, waves, and geothermal heat. Of all the renewable sources of energy, one of the most easily trappable is the solar energy. This project aims at designing a solar panel that taps the maximum output power through a maximum power tracking technique. The solar panel has been designed by taking the diode equivalent circuit of a PV cell and connecting these individual cells in a combination to generate the required power output. Through 3 point Maximum Power Tracking Technique, the maximum output is fed to boost converter that steps up the voltage to the value as determined by the design of the boost. This design is simulated in Mat lab Simulink.**

Index terms- MPPT, boost converter, Mat lab.

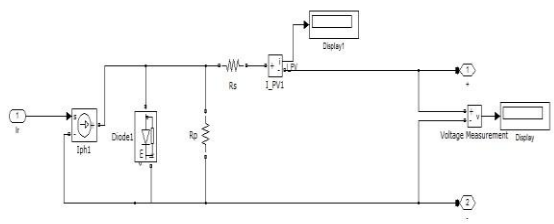
I. INTRODUCTION

With the ever increasing energy demands, tapping alternative sources of energy is crucial. It will increase energy security through reliance on an indigenous, inexhaustible and mostly import-independent resource. It enhances sustainability, lowers the costs of mitigating global warming, and keeps fossil fuel prices lower than otherwise. Sun produces 100 watts of solar energy per square foot. Tapping this solar energy not only reduces dependency on fossil fuels but also paves a path for a cleaner source of energy and hence a cleaner future. Of all the applications of solar energy, converting it to electrical energy efficiently has been the area of utmost interest for decades. India being a tropical country has an abundance of solar energy and this widens our opportunities in this sector.

This project aims at harnessing solar energy with high efficiency. The simulated photovoltaic system consists of a group of solar cells connected in series and parallel where each PV cell is modelled using an electrical equivalent circuit called the practical single diode model. The array is driven by the varying irradiation that is fed as the input. The output from the PV array is fed into the MPPT system. The MPPT system uses 3 point MPPT technique to track the maximum power point. The tracked maximum power is given to the boost converter where it is stepped up to a desirable stable voltage to charge a battery.

II. PV ARRAY

To electrically analyse the characteristics of a PV charge cell the 'Practical single diode model' was used as in (1). This is most appealing in terms of simplicity in implementation and the iteration speed. The PV cell is a diode which undergoes photoelectric effect hence the equivalent electrical circuit consists of a light generated current source connected in parallel to a p-n junction diode. Simulation of a solar cell or a complete photovoltaic (PV) system at various solar intensities is possible using this principle. Equivalent circuit of one PV cell is given below.



R_{sh}	415.405 ohms
R_s	0.221 ohms

Each PV cell is connected in a combination of series and parallel. Six cells are connected in series and six such in parallel. This forms a subsystem of 36 cells whose characteristics for an insolation of 1000 W/m^2 are as below:

Open circuit voltage, Voc=10.8V

Short circuit current, Isc=48.65A

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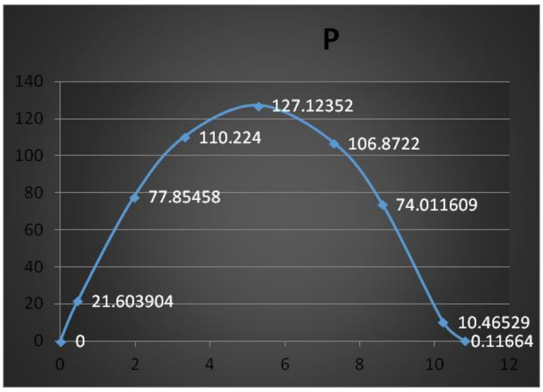
Peak Voltage, Vpv =5.288V Peak

Current, Ipv=24.04A Peak power,

Ppv=127.1235W

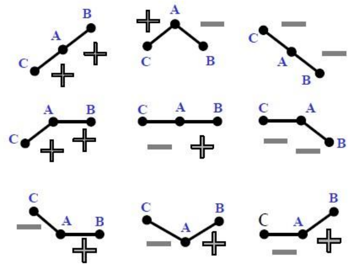


III. MPPT

Maximum power point tracking is a technique used to maximise power output of a PV array (3). Solar cells have a complex relationship between temperature, irradiance and total resistance that produces a non-linear output efficiency which can be analyzed based on the I-V curve. It is the purpose of the MPPT system to sample the output of the PV cells and apply the proper resistance (load) to obtain maximum power for any given environmental conditions. MPPT devices are typically integrated into an electric power converter system that provides voltage or current conversion, filtering, and regulation for driving various loads, including power grids, batteries, or motors. Here the MPPT is integrated into the boost system.

A. Weighted cumulative 3 point method

The MPPT technique used is called ***3 point method***. This is a modified P and O algorithm (4). This method is more efficient because here three points are compared instead of two. The algorithm of the three-point comparison is run periodically by continuously storing the 3 consecutive solar array terminal voltages as it is measured. The powers calculated of these 3 points are compared. These three points are the current operating point B, the perturbed previous point A and the doubly perturbed previous point C. On comparison, according to the pattern they follow, the duty cycle is either incremented or decremented. This is more efficient because this algorithm ignores any sudden changes in insolation.

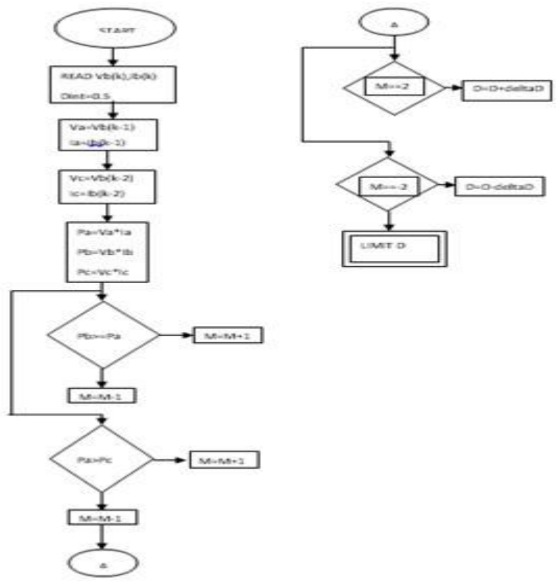


The conditions for positive weighting are:

$W_B >= W_A$ and $W_C < W_A$

Otherwise the status is assigned negative weighting. If both the comparisons result in positive weighting then the duty cycle of the boost is incremented and vice versa. If it so happens that one of the conditions are positive weighted and the other is negative weighted, then the MPP is reached or the solar radiation has changed rapidly and the duty cycle is not to be changed.

In these cases, for the point A and B if the Wattage of point B is greater than or equal to that of point A, the status is assigned a positive weighting. Otherwise, the status is assigned a negative weighting. And, for the point A and C, when the wattage of point C is smaller than that of point A, the status is assigned a positive weighting. Otherwise, the status is assigned a negative weighting. Of the three measured points, if two are positively weighted, the duty cycle of the converter should be increased. On the contrary, when two are negatively weighted, the duty cycle of the converter should be decreased. In the other cases with one positive and one negative weighting, the duty cycle is retained as its older value.



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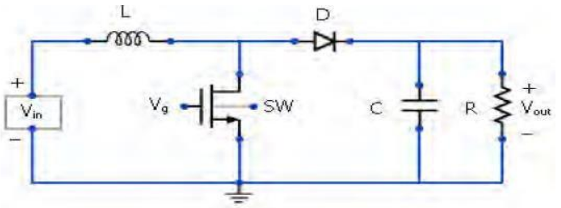
IV. BOOST CONVERTER



Schematic of Boost converter

To extract the maximum power, you must adjust the load to match the current and voltage of the solar panel. The converter must be designed to be connected directly to the photovoltaic panel and perform operation to search the maximum power point (MPPT). A boost converter is used along with the MPPT to physically implement the MPPT (2) and (6).

The MPPT sustains the operating point at around 5V which is then stepped up to 24 V by the designed BOOST circuit as seen below.

Design equations of BOOST

$$D = 1 - ((Vin(min) * EFFICIENCY)/Vout)$$

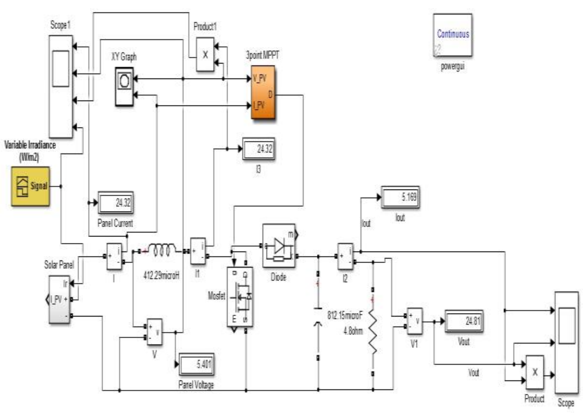
$$\Delta IL = (Vin(min) * D)/(fs * L)$$

$$L = Vin * (Vout - Vin)/(\Delta IL * fs * Vout)$$

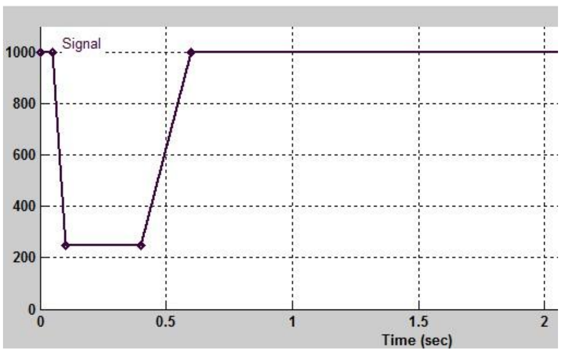
$$Cout(min) = Iout(max) * D/(fS * \Delta Vout)$$

R	4.8 ohms
C	812.15microF
L	412.29microH
fs	20kHz
efficiency	assumed 100%

V. SIMULATION MODEL



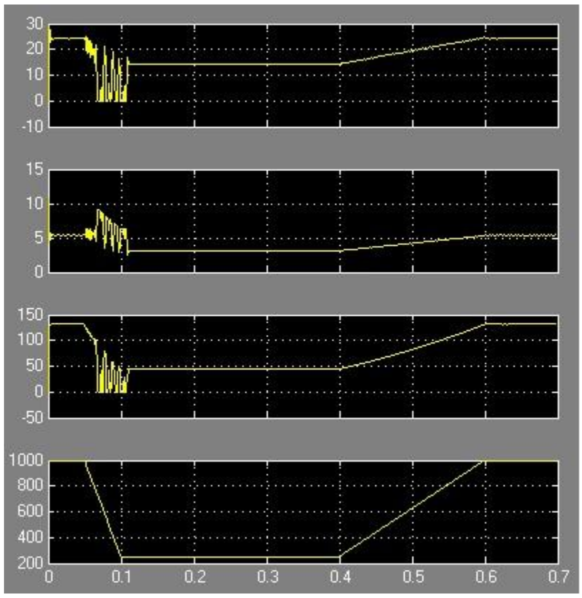
The irradiance is a generated signal by a signal generator in Mat lab.



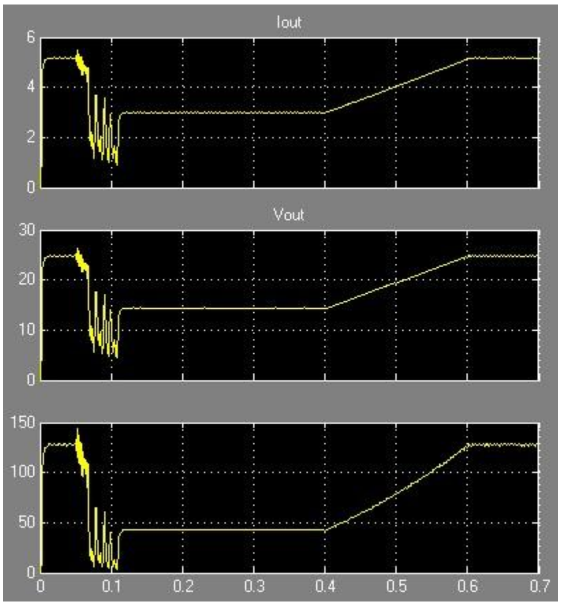
VI. RESULTS

According to the characteristics of the PV array, at 1000 W/m^2, the MPP lies at 24A and 5.2 V. As the irradiance changes the MPP varies and the 3 point MPPT operates the PV array at this point. At 1000 W/m^2 this operating voltage is stabilized at 24V using the Boost converter to suit the load applications.

A. *Input*



B. Output



These graphs indicate the output I, V and P from the Boost converter. It indicates how the input has been boosted to the shown values at each irradiance.

Note that the input and the output power remain almost same.

VII. CONCLUSION

Solar energy is abundantly available naturally. It is an inexhaustible and a clean source of energy. As solar energy is the future of alternative source of energy, this project was aimed at converting solar energy into Electrical energy. This was achieved by modelling PV array in Matlab Simulink and fed to a load through a Boost converter. To achieve higher efficiencies and reduce the loss of power, three-point MPP tracking technique was modelled and integrated to the Boost converter. The output power obtained was found to be ideal to connect to various suitable loads.

The used MPPT is cumulative with respect to the duty cycle as opposed to the 3 point technique in (5) which has only two states for the duty cycle. This makes the cumulative method more accurate. This method is better than P and O method because it reduces oscillations about the MPP.

The disadvantages of this method are that it is very time consuming depending on the sampling time and more complex than Hill climbing and P and O methods.

VIII. FUTURE SCOPE

By varying the step size the 3 point technique can be further made more adaptive to load and radiation changes. Also, instead of a boost converter, a buck boost or a cuk converter can be used to enhance the flexibility of the system. If physically implemented, this circuit can be used to charge a battery which can then be used for further applications.

IX. ACKNOWLEDGEMENT

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