MAXIMUM POWER POINT TRACKING BASED SOLAR CHARGE CONTROLLER

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Abstract : ***In today's world consumption of the energy is exponentially increasing, the idea of exploring renewable energy sources has improved and modified by research works. Renewable energy sources include solar, wind, hydro, tidal and many more. This document mainly focuses on solar energy as it is easily and abundantly available in nature. But in spite of its greater availability, it has a drawback in achieving efficiency and extravagancy. In order to excel at these downsides, maximum power must be extracted from the solar panel using suitable techniques to optimize the efficiency of an overall system. Therefore, one such technique used here is Maximum Power Point Tracking (MPPT). This technique consists of many algorithms. As the solar cell gives a nonlinear current versus voltage (I–V) and power versus voltage (P–V) characteristics, the energy conversion efficiency of a photovoltaic system is too very low. These nonlinear characteristics are the functions of weather conditions such as solar irradiation and temperature of the solar panel. In order to maintain the efficiency, reliability, and a quick response, Incremental Conductance algorithm of maximum power point tracking is considered and implemented in Simulink platform. In order to prove its effectiveness, a suitable boost converter is also designed and integrated with the photovoltaic system. In addition, it is improvised by providing a User Interface.***

Index Terms – Maximum Power Point Tracking, current versus voltage, power versus voltage, Incremental Conductance, Charge Controller

I. INTRODUCTION

Electrical energy is a major influencing factor for the development in various sectors like Industrial, Commercial, Agriculture and Domestic. As per capita energy usage is one of the index of national development status, per capita energy consumption is almost about 600 units in India, 13,000 units in U.S.A, 1400 units in China, 6898 units in Germany and overall World average is almost about 2430 units.

The effectiveness in replacing the depleting sources can be achieved by the proper use of naturally available energies by tapping their natural flow based on our requirements. The above demerits gave birth to the research on renewable energy sources.

The main block diagram of proposed research work is shown in Figure 1, which consists of main components such as a DC-DC converter, PV panel, Controller, Inverter and Battery load. Each system is described below,

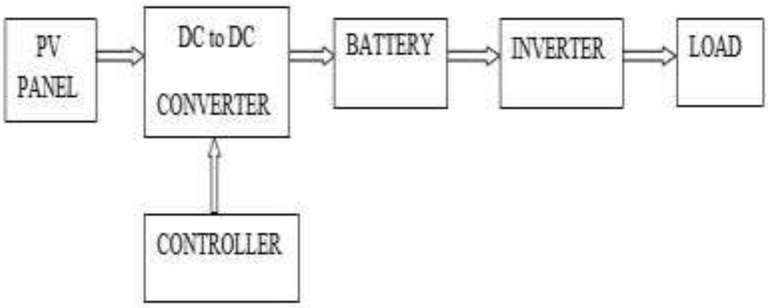

Figure.1 Block diagram of the solar charge controller

Photovoltaic is one of the methods of generating electrical power. This is done by converting the solar radiation into direct current electricity using some semiconductors that present the photovoltaic effect. This generation of power employs solar panels. These panels comprise the array of cells called photovoltaic cells. The PV generator is made by combining many PV cells. They can be connected either in series or in parallel to get the evident output voltage and current. As we get a variable voltage, the panel is connected to the DC-DC converter.

DC to DC converter is used for the conversion of variable input DC voltage from the panel into the fixed DC output voltage which is required for the battery. The output of the converter is fed to the battery. Battery here is considered as the charge storage device. As the input from the panel is variable it is converted to fixed voltage and then fed to the battery to store. This stored charge can be used directly by a DC load or can be inverted and then used by the AC loads as well. Inverter here is used for converting the DC voltage from the battery into AC voltage. This converted voltage can be used by AC loads.

Maximum Power Point Tracker is an algorithm, here charge controllers are used. Their useful for extracting maximum power that is possible from the PV module during certain conditions. The point at which the solar panel module can give out maximum power is called 'Maximum Power Point'. Maximum power is purely dependent on solar radiation, ambient temperature and solar cell temperature whose changes can affect the maximum power point.

The elementary objective of this work is to study various MPPT algorithms and successfully implement the best suited using the Simulink platform. To model the converter and the solar panel using Simulink, interfacing them with the selected MPPT algorithm and obtaining the maximum power point operation would be of prime importance. To design the boost converter for the required output and implement the same in hardware. To integrate the overall hardware circuit and obtain the required results.

II. Methodology

2.1 Incremental Conductance method

This method uses the photovoltaic array's incremental sign of dP/dV. When dI/dV is equal and opposite to the value of I/V (where dP/dV = 0) the algorithm knows that the maximum power point is reached and thus it terminates and returns the corresponding value of operating voltage for MPP. This method tracks rapidly changing irradiation conditions more accurately than P&O method. One complexity of this method is that it requires many sensors to operate and hence is economically less efficient. P= V*I

Differentiating with respect to voltage dP/dV = d (V*I)/dV

dP/dV = I * (dV/dV) + V * (dI/dV)
dP/dV = I + V * (dI/dV)

when the maximum power point is reached the slope dP/dV=0.
Thus, condition would be dP/dV = 0

I + V * (dI/dV) = 0 dI/dV = - (I/V)

2.2 Open and Closed loop charge controller using Simulink

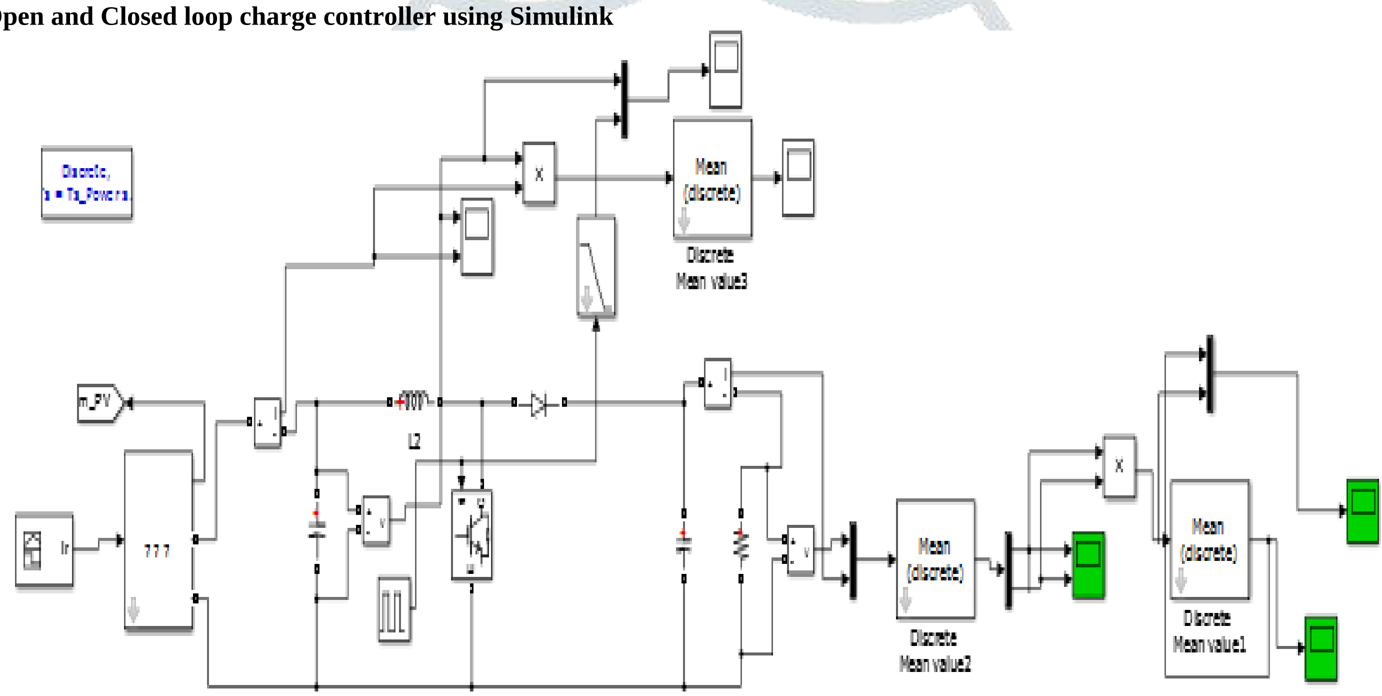

Figure.2 simulation circuit of open loop charge controller

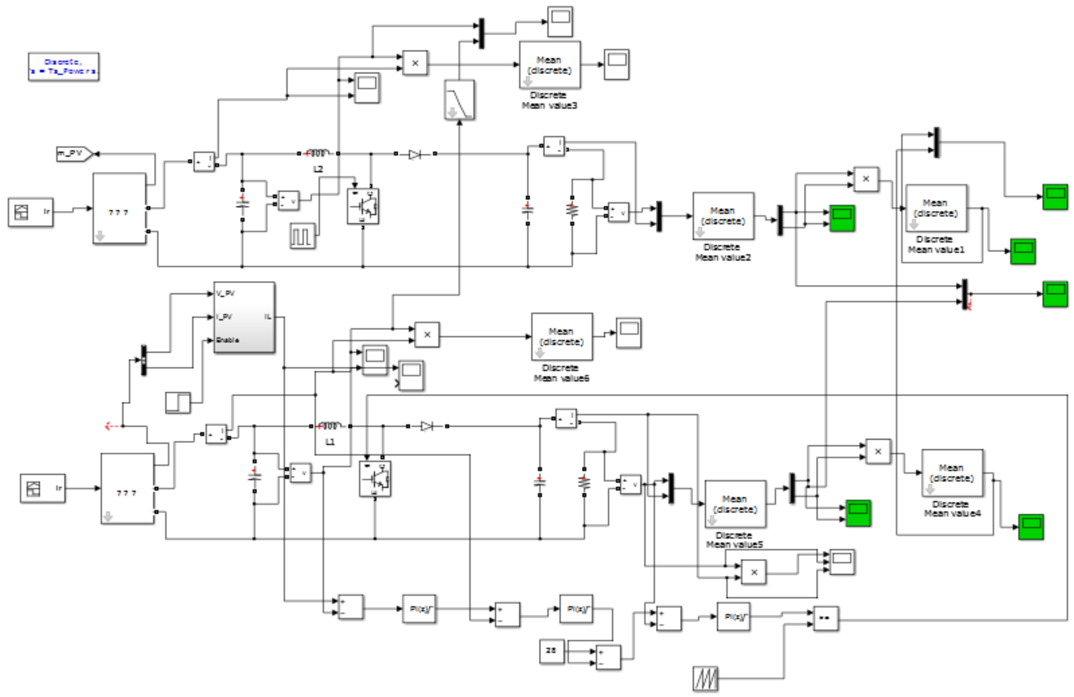

Figure.3 Closed loop charge controller using Simulink

The closed-loop simulation work carried out is as shown in figure.3. In closed loop charge controller MPPT algorithm, incremental conductance is used. This helps in achieving constant output with better efficiency when compared to the open loop charge controller as shown in figure2.

Here the PV array is used as the input along with the irradiance block. The output variable voltage from the solar array is fed to MPPT block. The maximum power point is tracked by using the algorithm. A reference voltage is generated and that reference is tallied with the input voltage. The error after the tally is fed to the proportional integrated controller and current reference is with the constants is fed to the other controller. The constant output of the controller and positive sawtooth wave is compared and the pulses are given as feedback to the MOSFET switch. Here it is not required to vary the duty cycle for every change in input values. This is the advantage of closed loop charge controller. This also results in very less dip in voltage and gives out maximum power.

III. Discussions of Test Results

3.1 Output voltage of open loop charge controller (without MPPT)

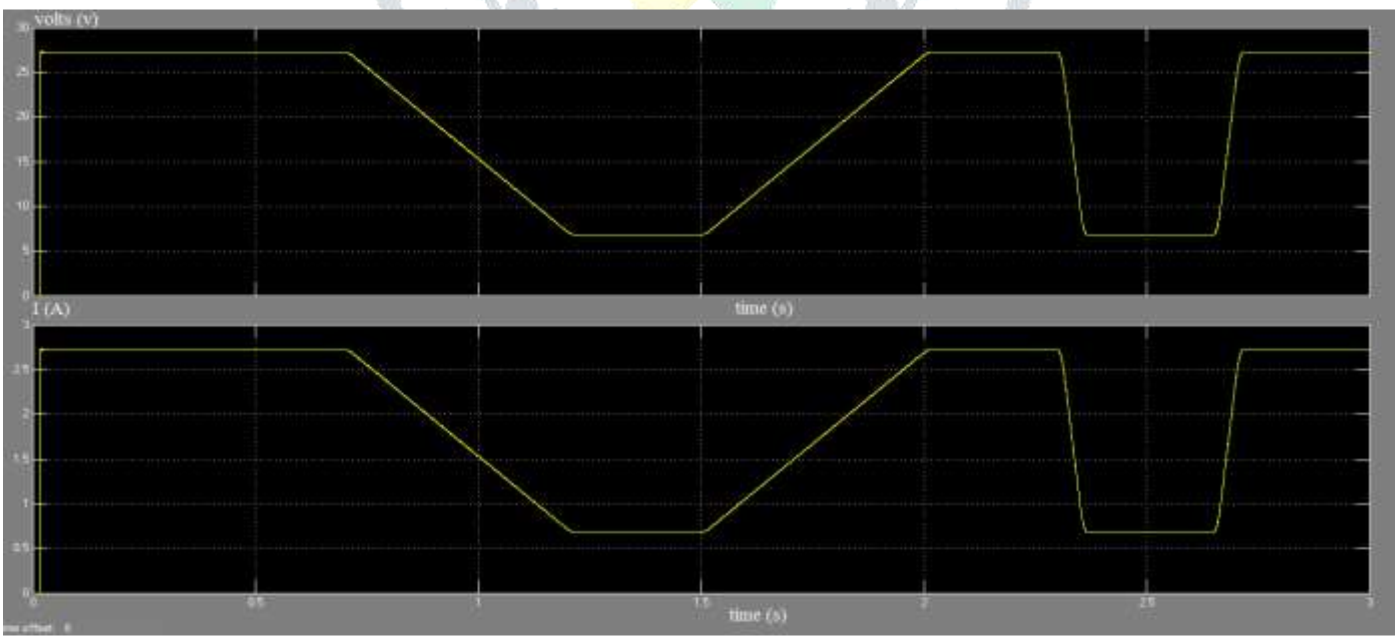

Figure.4 Output voltage & current of open loop charge controller with respect to time without using MPPT technique

The result shown in figure 4, the voltage and current waveforms with respect to time is obtained from the open loop charge controller where no MPPT techniques were used. The obtained result clearly explains that there is a heavy dip in voltage every now and then, this also results in the less efficient output. Therefore MPPT technique plays a vital role in achieving almost constant output voltage.

3.2 Output voltage of closed loop charge controller (with MPPT)

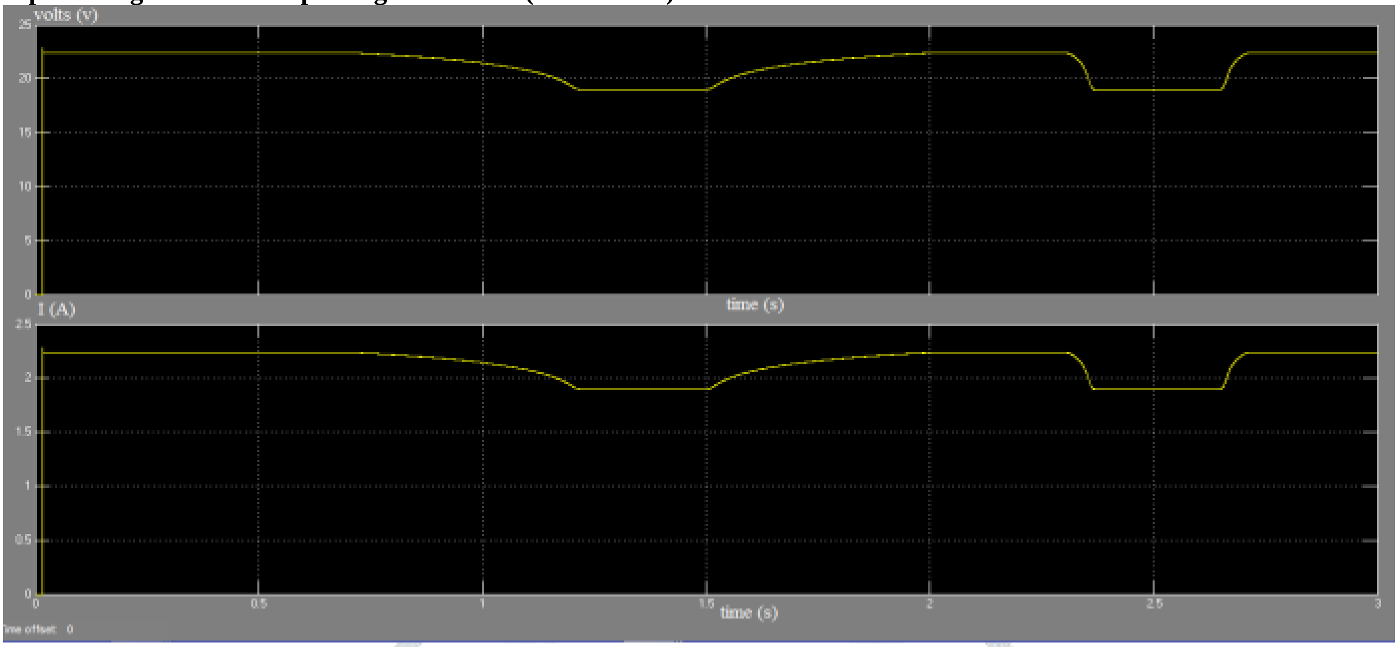

Figure.5 Output voltage & current of closed loop charge controller with respect to time using MPPT technique

The above result, voltage and current waveforms with respect to time are obtained from the closed loop charge controller where we use MPPT algorithm (Internal conductance). The obtained result clearly explains that there is a minor dip in voltage when compared to open loop charge controller, this also results in more efficient output and increases the total lifespan of the battery. Therefore MPPT technique plays a vital role in achieving almost constant output voltage. This is shown in figure 4.

3.3 Comparison of results for various inputs

The solar input is not constant every time. Therefore, we need a charge controller including a converter which converts variable dc input to the fixed dc output. In order to verify the operation of the simulated circuit, the different cases were tested by giving different inputs. The requirement was to achieve fixed boosted output. The results for different cases are shown below, by considering 15V, 18V and 20V as case1, case2, and case3 respectively.

Case 1: When the DC input considered as 15V.

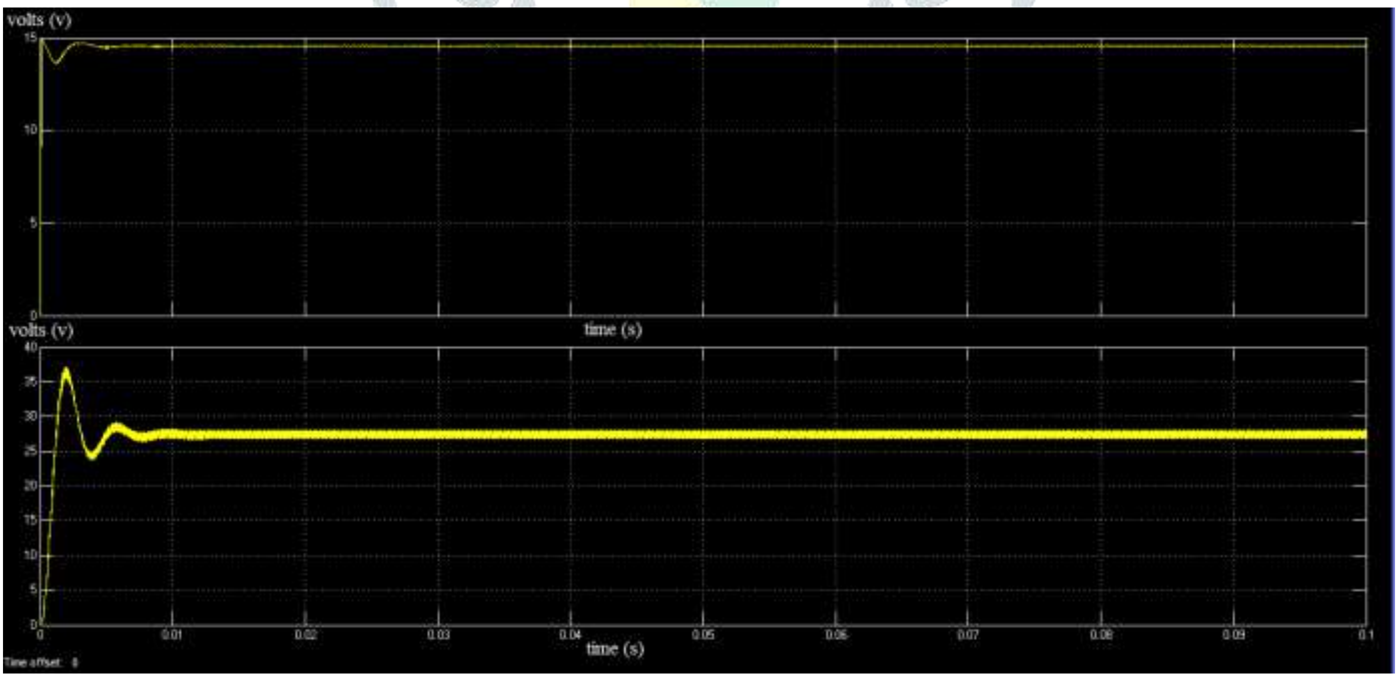

Figure.6 Voltage with respect to the time constant boosted 28V output for 15V input

The result in figure 6 shows the input and output of the boost converter. The result is voltage with respect to time. The top signal refers to the input voltage and the second signal refers to the output of the boost converter.

Case 2: When the DC input considered as 18V.

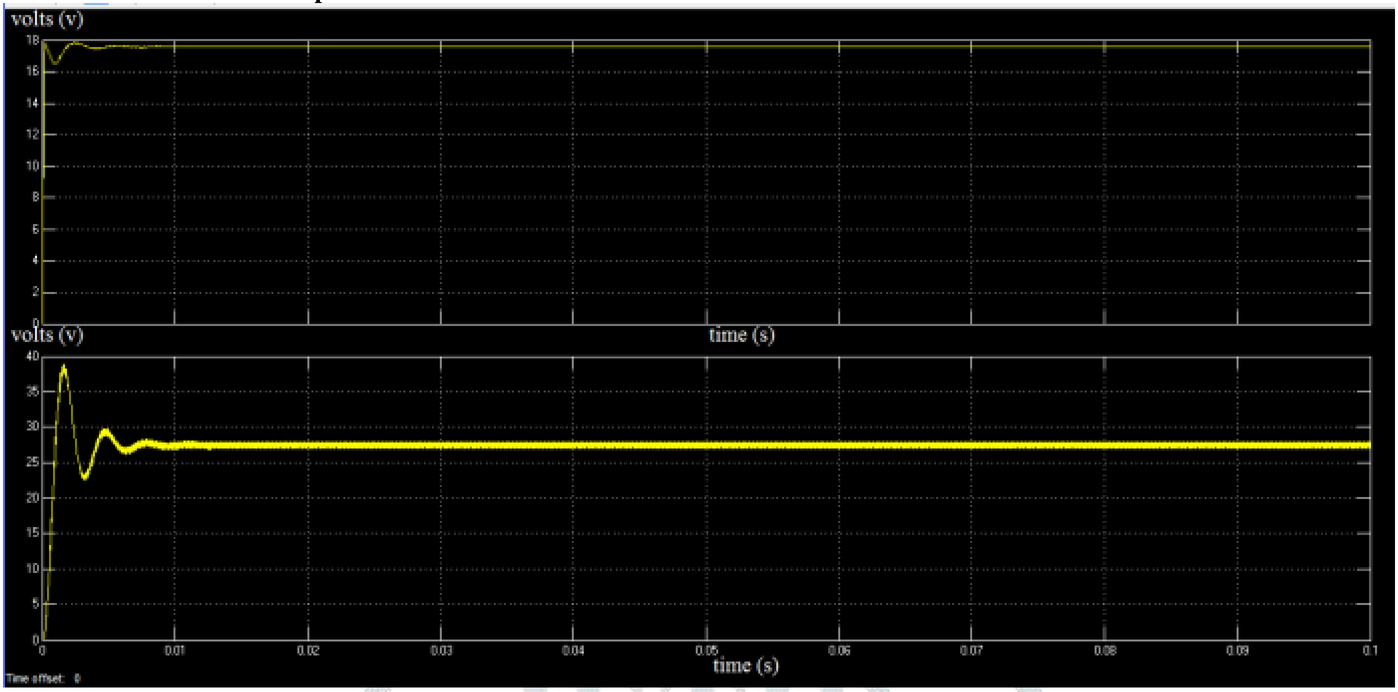

Figure.7 Voltage with respect to the time constant boosted 28V output for 18V input

Case 3: When the DC input considered as 20V.

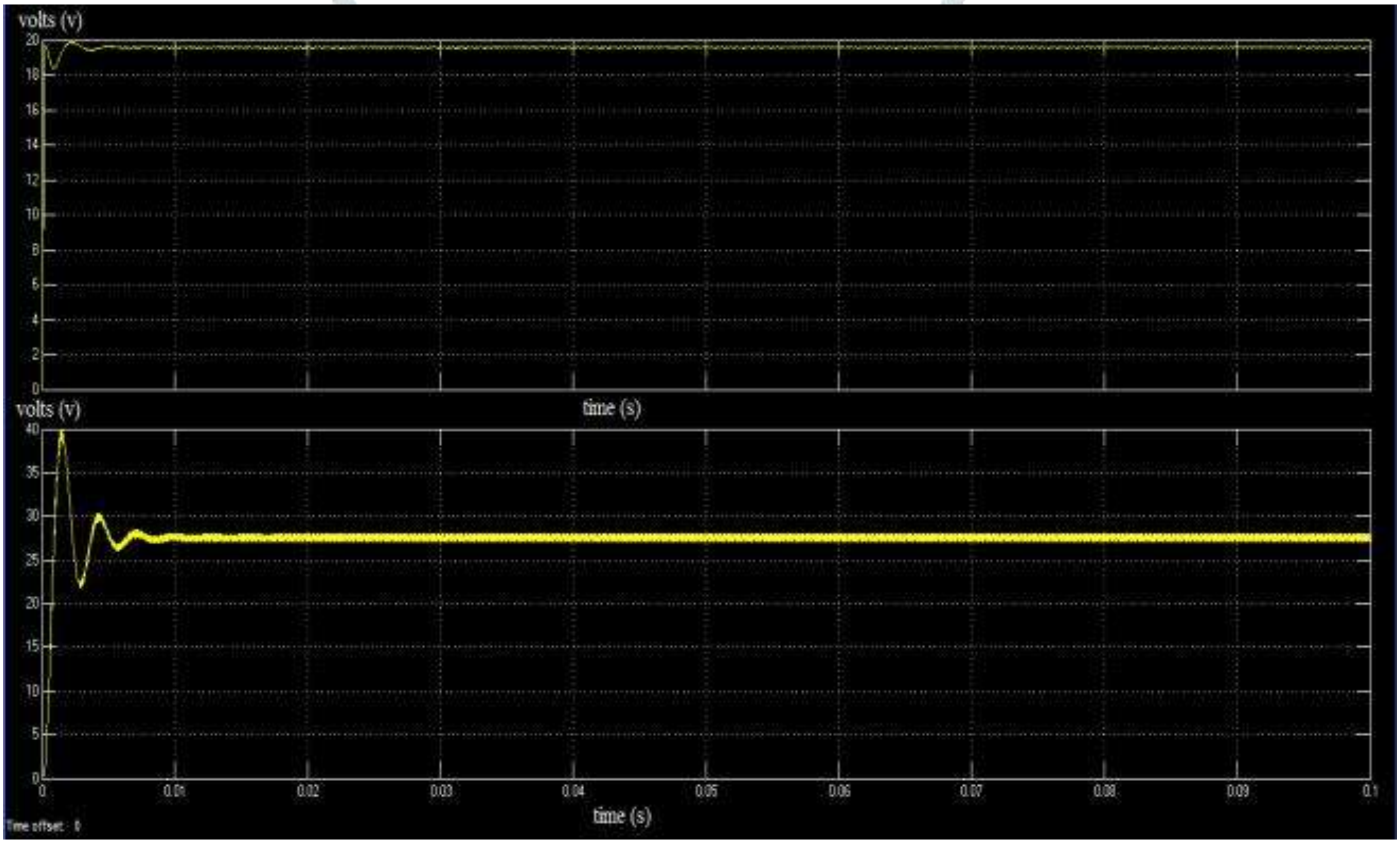

Figure.8 Voltage with respect to the time constant boosted 28V output for 20V input

From the figures, 6, 7 and 8 results can be clearly noticed that for every change in input voltage the constant boosted output voltage is achieved. This also helps in achieving the better efficiency.

IV. CONCLUSIONS

This study represents a simple but efficient photovoltaic system with maximum power point tracker. Description of each component like a solar panel, DC-DC converter, and charge controller are presented here. As the aim was to design a system which can extract maximum output power, it is been achieved through an efficient charge controller and a boost converter. This work explained even about maximum power point and maximum power point tracker. Study of different MPPT algorithms and their significance along with the drawbacks has been explored. Finally, the expected output is achieved with the proper analysis and literature survey. Compared output results of the conventional method and with MPPT method (Implemented) has enhanced the understanding of concepts. As a result, the improvement in the overall performance of the system is obtained.

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