International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 9 Issue 11, November-2020

# Designing of an Efficient Online Solar Charge Controller for 24V System

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***Abstract*—This paper presents a very simple solar controller with system voltage of 24V for PV energy system. The mechanisms for voltage regulation, over-charging protection and over-discharging protection are proposed in this paper. The voltage variation at the output of solar panel are fed to the charge controller circuit so that the circuit prevents overcharging of the battery and helps to increase lifespan of battery. The over-discharging of the battery is also protected by disconnecting the current flowing path to battery. The entire model is implemented in Proteus software and simulated results are observed and analyzed to examine the capability of the solar charge controller.**

***Keywords—Solar charge controller; proteus; discharging; over charging; battery***

## I. INTRODUCTION

The arresting feature of PV is that it produces electric energy from a free inexhaustible source, the sun, creating no pollution or greenhouse gases during the power generation.

We have increasing demand of energy as we use power faster than we produce it. Nowadays, people prefer nonconventional sources of energy over conventional sources as conventional source of energy causes ecological problems such as global warming. We all know that energy produced from the sun light is most reliable and cleanest form of renewable energy available. Solar powered panel convert the sun's rays into electricity by exciting electrons in the silicon cells using photons of light from the sun [1].

Solar energy is one of the most important renewable energy sources that have been gaining increased attention in recent years. Solar energy is abundant; it has the greatest availability compared to other energy sources. The amount of energy supplied to the earth in one day by the sun is sufficient to power the total energy needs of the earth for one year. Solar energy is clean, sustainable and natural energy and it does not produce pollutants harmful to nature [2].

A Photovoltaic (PV) system consists of a PV array which absorbs sun light and converts it to electricity. Throughout the day depending on temperature and solar irradiance level the voltage generated from the output of PV panel varies drastically. In PV module voltage can be generated only in day time. Therefore, PV module based standalone system needs energy storage device to store energy during day time so it can be used at night. A charge controller controls the rate of flow of current to or from a battery while charging and discharging condition. It prevents overcharging to limit the energy supplied to the battery by the PV array. It also prevents undercharging to disconnect the battery from electrical loads when the battery contains very less charge [3].

The main goal of this work is to design an efficient and very simple, user friendly and low-cost solar charge controller and simulate it on proteus software.

## II. RELATED WORKS

Myriad of researches have been accomplished so far around the whole world relating to the battery protection and number of solar charge controllers have been designed for commercial purposes. But the researchers are not fully content and the research is not finished yet. For this, we have studied several journal papers, thesis works, books, web documents etc. related to this paper.

Muhammad Riazul Hamid, Jakaria Rahimi, Sabrina Chowdhury, T.M. Moniruzzaman Sunny in their research paper "Design and Development of a Maximum Power Point Tracking (MPPT) charge controller for Photo-Voltaic (PV) power generation system", published in American Journal of Engineering Research (AJER) describe how to implement MPPT using the most popular switching power supply topology [4].

In the paper "A Digital MPPT Control for the Optimization of a Photovoltaic System as a Battery Charger", researcher Catherine T. J. presents the functioning and improvement of the performance of a Photovoltaic system adopting a digital MPPT controller [5].

Wenjie Zhu, Fei Rong, An Luo, Yong Xu, Anping Hu in the paper "Grid-connected Control Strategy based on Fixed MI Coefficient for Single-Phase Photovoltaic System" presents a grid-connected control strategy for single-phase photovoltaic (PV) system [6].

In the review paper titled "A Review of Single-Phase Grid-Connected Inverters for Photovoltaic Modules" Soeren Baekhoej Kjaer, John K. Pedersen, and Frede Blaabjerg focuses on inverter technologies for connecting photovoltaic (PV) modules to a single-phase grid [7].

G. D. Rai has written the book "Solar Energy Utilization". Salient feature of this book is that it has a dedicated chapter on "Solar Photovoltaic Electric Power Generation" [8].

John A. Duffie and William A. Beckman in their book "Solar Engineering of Thermal Processes" wrote a chapter about the design process of different photovoltaic systems [9].

In the paper titled "An Efficient MPPT Solar Charge Controller," maximum power point tracker battery charger is

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proposed by Dr. Anil S. Hiwale, Mugdha V. Patil, Hemangi Vinchurkar for extracting maximum power from a photovoltaic panel to charge the battery [2].

In our paper, we are designing a very simple charge controller. The charge controller constantly monitors battery voltage, and disconnects the array in series once the battery reaches the highest voltage set point. When battery voltage drops to the lowest set point, the array and battery are reconnected, and the cycle repeats. Assume that the battery is fully charged when the terminal voltage reaches 25 volts with a specific charging current.

## III. SOLAR CHARGE CONTROLLER IN BRIEF

A photovoltaic system converts the sun's radiation into usable electricity. It comprises the solar array, solar charge controller, power converting system and battery.

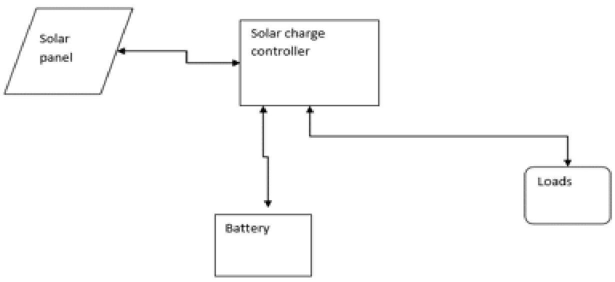


Fig.1. Block diagram of Photovoltaic Solar system

The main part of this paper is the designing of the solar charge controller as the controller protects battery from being damage. A charge controller or alternatively a charge regulator regulates the voltage and current coming from the solar panels and going to the battery. It limits the rate at which electric current is added to or drawn from electric batteries. It prevents overcharging and may prevent against overvoltage. It may also prevent completely draining a battery, or perform controlled discharges, depending on the battery technology, to protect battery life. Simple charge controllers stop charging a battery when they exceed a set high voltage level, and re-enable charging when battery voltage drops back below that level. Simple charge controllers stop charging a battery when they exceed a set high voltage level, and re-enable charging when battery voltage drops back below that level [1, 10].

The two types of charge controllers most commonly used in today's solar power systems. These are:

- ➢ Pulse Width Modulation (PWM) and
- ➢ Maximum Power Point Tracking (MPPT)

Pulse width modulation (PWM) charge controller is the most effective means to achieve constant voltage for battery charging by adjusting the duty ratio of the switches.

Technological advancement has helped PV cells achieving the highest efficiency of 20%. To charge batteries from solar panel, a charge controller is needed. An efficient charge controller needs to charge the battery as quickly as possible by harnessing the maximum power available at the solar panel. For extracting maximum available power, the solar panel needs to be operated at its maximum power point. MPPT systems adjust the duty cycle of a DC-DC converter in such a way that the operating voltage of the panel is consistently maintained at its maximum operating point [11].

## IV. CIRCUIT IMPLEMENTATION AND SIMULATION

Many researches have been done so fur around the world relating the solar charge controllers and many more designs have been published in various research journals. But research is not finished yet. However, the works in this paper are very simple as described below with proper practical circuits on proteus software.

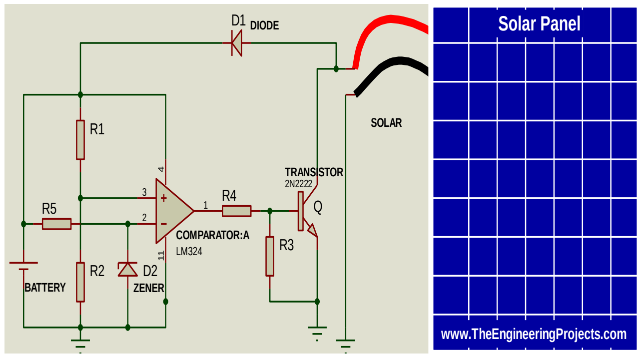


Fig.2. Simple circuit diagram of solar charge controller

In Fig.2, the voltage divider is used to control the upper cut-off and lower cut-off. The reference voltage in this case is 4.7V, which is done using a zener diode.

In the above figure, the output voltage, Vout become:

$$Vout = Vin \times \frac{R2}{R1 + R2}$$

In this paper, simulation is done by proteus software and is explained below:

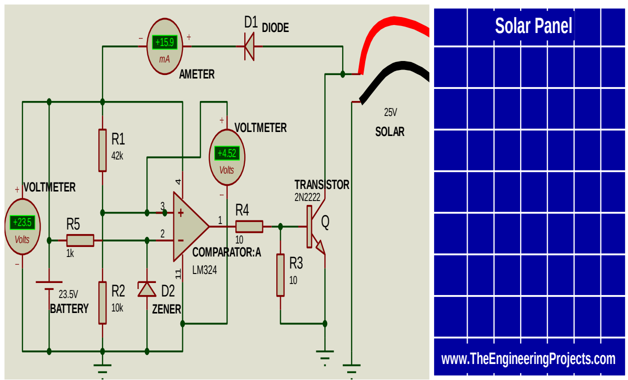


Fig.3. Output of charge controller when battery voltage is 23.5V

Fig.3 shows that a current of 15.9 mA from solar panel flows in battery through the diode as the battery is being charged at 23.5V.

When the battery is 24V, as shown from voltmeter across battery, 4.38mA current flows in battery via the charge controller from solar panel (Fig.5).

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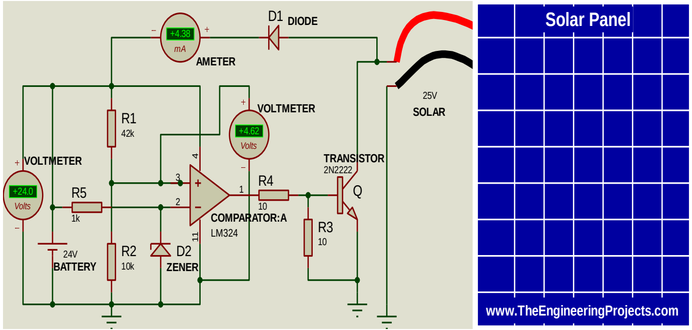


Fig.4. Output of charge controller when battery voltage is 24V

In following figure, the voltmeter output across the battery is 24.25V and at this stage the current flowing is of 0.56 mA from solar panel to the battery.

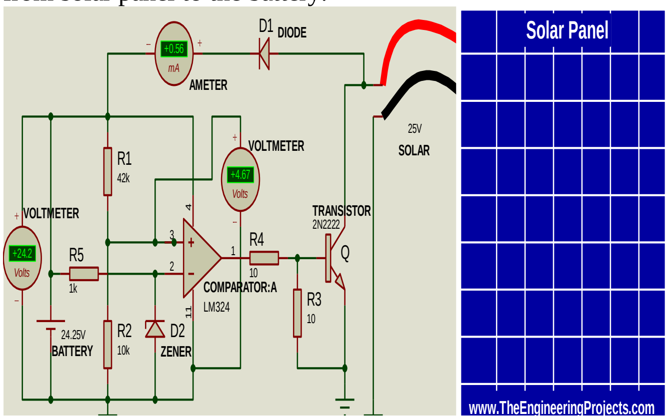


Fig.5. Output of charge controller when battery voltage is 24.25V

When the battery is 24.45V as shown from voltmeter across battery, 0.00mA current flows in battery via the charge controller from solar panel (Fig.8).

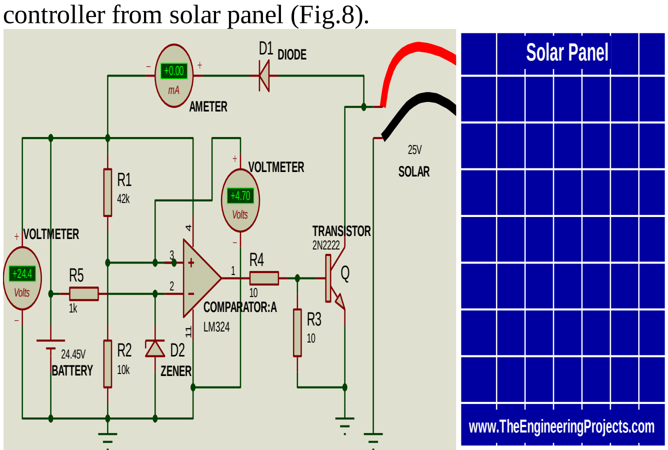


Fig.8. Output of charge controller when battery voltage is 24.45V

Table 2 summarizes the result obtained above.

**Table 2**

| Battery Voltage (V) | Charging Current (mA) |
|---|---|
| 23.5 | 15.9 |
| 24 | 4.38 |
| 24.25 | 0.56 |
| 24.44 | 0.01 |
| 24.45 | 0.00 |

From the table above its clear that as the battery voltage increases charging current, from solar panel, decreases gradually. And the charge controller circuit stops charging the battery when the battery voltage reaches 24.45V. It is the upper threshold voltage for the designed charge controller which is very low.

## V. CONCLUSION

As the solar energy is everlasting source of renewable energy, different countries tried to take the use of such resources but they faced many difficulties in actually implementing the technology. So, every country tried to make to control the battery charging. The life of the battery mainly depends on charge controller. The charge controller in this paper has a very simple circuit but can properly determine the state of charge of the battery. In this work, we just designed a stand-alone solar charge controller circuit theoretically and simulated it on proteus software. In future, further research can be done and can be implemented on hardware properly to get an efficient, user friendly and low cost solar charge controller device.

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