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Experimental Analysis of New Charge Controller for Solar PV Systems

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Abstract
Globally, abstraction rate of electrical energy has been increased from Renewable Energy Resource (RER). Because of, RER are ubiquitous, freely available and environmentally free. Besides, conventional fossil fuels are finite and also which are harming the environment. At present, the solar power plants are contributing more electrical energy that of others. Which is due to solar resources are available in a unique manner on all land areas as well as technically feasible. The heart of the solar PV system is charge controller which maintain the output of PV at desired level. Since it operating two modes such as buck and boost. According to the available solar irradiation it can operate. Hence, in this article proposed a new charge controller for PV system. The proposed system has a solar PV with capacity of 3W/6V, battery of 6V/4.5 AH. Moreover, the switching devices are made by MOSFET due to it offers very low switching loss. From experimental validation, the developed new charge controller working satisfactory.

Keywords: *Solar PV, Charge Controller, MPPT, Switching Loss.*

I. INTRODUCTION

Renewable energy resources are ubiquitous, freely obtainable and ecologically free. That includes solar, wind, hydro, etc. At present total installed capacity of renewable energy resource in India is 77.641 GW which is accounts 22% of total power generation. Moreover, the extraction rate of energy from solar resource is increased every year. India's land surface received 5000 trillion kWh/year, correspondingly, the majority of land surface receiving 4-7 kWh per sq.m per day. At present, total installed capacity of solar PV in India is 28679.21 of the MW as of 30.04.2018 (1). Though, GOI plan to generate 100 GW by 2022. Due to solar PV has mature technology and so installation cost per MW is drastically reduced. RanjitDeshmukh et al found technically as well as cost wise feasible generating of electricity from solar PV is 1300–5200 GW. Also, overall cost for energy generation per MWh is USD 47–52, respectively. However, the conversion efficiency of solar PV power plant has been low hence several research is involved for enhancing energy yield potential of solar PV panel, respectively [4], [5].

The critical parts of solar PV systems are energy conversion medium that solar panel, charge controller unit and battery unit. Globally, poly and mono crystalline and thin film solar PV panel used to convert useful sun radiation to electrical energy. Both the solar photovoltaic panels' principle operations were same, however mono crystalline panel make of single silicon material while poly crystalline making by silicon fragments melted together. Solar PV has nonlinear features and so the relation between current to voltage and voltage to power characteristics depends on the atmospheric condition. Hence, the maximum power generation has been fully contingent on the atmospheric water, temperature and irradiation, respectively. Hence, the charge controller is used to transfer maximum solar

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PV output to the battery which is done by keeping solar system operated with maximum power point. The key role of charge controllers is to track the maximum power irrespective of change in irradiations as well as reduced battery charging time. Furthermore, the charge controllers are enhancing the life time by limiting the battery over charging and discharging. In solar PV system to track the maximum power not an easy. Also, the tracking technique must have fast response to atmospheric changes such as irradiation or temperature[6].

Likewise, the MPPT algorithms have fast response under partial shading which happened due to object moving over the panels like a plane and cloud cross over. Such situation the output of PV falls down within fraction of seconds, hence developed MPPT technique should responses very fast manner. Commonly used solar charge controllers are shunt, series, pulse width modulation (PWM) and MPPT. In shunt type charge controller uses shunt regulator which controls charging of battery from solar panels. This is performed by short circuiting array internal to the controllers. Due to that shunt type charge controlling technique is not suitable for high current [7].

In shunt charge controller has relay act as a switching element. Which is sweet on or off depends on the pre-set value. Whereas, series type of charge controller utilizes the control circuit which is connected between PV and battery. This type of controller used in small scale system added with it suitable for high current system. In case of MPPT technique uses back to back DC converter, hence PV operated with maximum power [8]-[10]. Furthermore, MPPT has control circuit which is track the maximum power point and brief discussion about various solar PV MPPT techniques discussed in section 2.

Nevertheless, battery charge control classified as single stage and multistage. In first method any one of parameter keep constant for an example constant current method. While, constant voltage and power method is the best example for multistage. On compared to a single stage charging controller, the multistage charge controller has more efficiency. From be above literature we found that solar charge controller act as a key role in maintaining PV system at desired level [13]-[15]. The paper organizing in following ways (1) Introduction (2) Equivalent Circuit of Solar PV (3) Materials and Methods (4) Results and (5) discussion and conclusion.

II. Equivalent Circuit of Solar PV

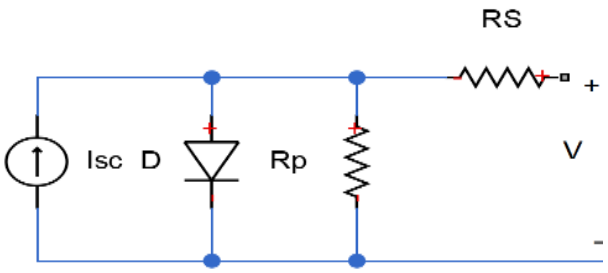

Fig 1. Equivalent circuit of PV

The corresponding circuit of solar PV is shown in figure1. It has a current source, a diode, series and shunt resistance, respectively. Whereas, the series resistance represents the metal portions of panel, connection leads out and parallel resistance due to leakage current (1) to (3) shows relation between output current, diode current, respectively.

$$Iout = Isc - ID \quad (1)$$

$$I_D = Io * \left(e^{q} \frac{(V + IRs)}{nKT} - 1 \right) \quad (2)$$

$$I_{out} = I_L * \left(e^{q} \frac{(V + IRs)}{nKT} - 1 \right) - \frac{(V + IRs)}{Rp} \quad (3)$$

The individual cell capacity is one to one point five watts. These cells are grouped together according to the requirement make and solar module. The module is connected series, which is used to make a solar panel, respectively.

III. Methodology

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Fig 1. Solar PV cell

Fig 2. Sealed Rechargeable Battery

In this project we use polycrystalline solar PV panel with 3W/6V as shown in figure 1. Then Sealed Rechargeable Battery with a rating of 6V, 4.5AH as shown in Figure 2 and LM 324 as a comparator. Adding with three types of transistor has been used such as SL 100 it can be used as a switch. It can be used in a common emitter configuration. Second transistor BC 547 which is used for amplifying the current. Additionally, IRF 630 MOSFET has been used as a switching device since it offers very low switching losses, respectively.

In this proposed system has a set of operational amplifier which is used to monitor panel voltage as well as current, respectively. Besides, three LED's used to indicate under and deep charging, overload. Likewise, the switching devices MOSFET are used to trip the load under battery low and so over load. Whenever, battery is fully charged in this instant the generated electricity from solar PV cell is diverted to dummy loads through the transistor.

IV. HARDWARE IMPLEMENTATION

Once irradiation is falling on solar panels, it observes the photon and excite the electron that is electrical energy. This electrical energy has been stored in battery through limiting diode. This is allowing power from solar PV to the battery, moreover, it acts as an open switch under reverse current flow which is due to lower radiation.

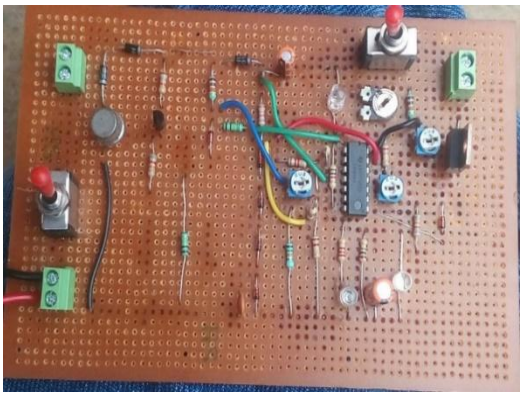

Fig 3. Control circuit

Fig 4. Hardware implementation

When battery is fully charged, then two set of transistors is used to divert the PV generated electric energy to the load. The hardware implementation of Control circuit as shown in fig 3. Also, whole proposed prototype model as shown in fig 4. Consequently, battery over charging has been prevented. And so, when battery voltage is going below the desired voltage level, which detected automatically by a comparator unit. Suppose, the comparator output is high subsequently MOSFET gate open. Hence, battery prevented from under voltage.

V. CONCLUSION

In this paper a new charge controller has been developed and validated. It's working based on the battery charge level. Whenever, battery is fully charged the generated electricity from solar PV has been diverted to the load. Whereas, under charging, the generated electric energy directly fed to solar battery. Furthermore, in this control circuit, we can use MOSFET for switching devices, hence switching loss has been reduced. From the experimental validation, the proposed control circuit has been working satisfactorily.

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