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Design and Development of Cost Effective automatic cutoff PV Charge Controller with indicator

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Abstract**:** *In this paper, we present a design and development of a cost effective with efficient PV charge controller. This PV solar charge controller works with DC-DC converter topology for battery charging. The system is implemented using inexpensive and limited hardware components and the results for different PV cell and battery voltage levels. This PV charge controller module combined with regulated voltage and current, suitable for on and off automatic switch. To increase the life time of a recharge cycle of the storage battery is optimized and due to reduction of the recharge cycle the storage battery life time increase. Here regulated IC used to regulate voltage DC-DC converter. The proposed system uses resistive control to limit the output of the converter as to control the voltage or current limit. The design uses a back-up battery which is charged by the solar panel in times of absence or presence of a load battery and uses the charge stored to supply loads.*
Keywords: *Battery Charging, Buck converter, Resistive control*

I. Introduction

Solar power represents one of the most important sources of renewable energy to complement batteries in portable and autonomous devices. When connecting a solar panel to a rechargeable lead acid battery, a PV charge controller circuit usually necessary to use to prevent the battery from overcharging. As increase of technology PV Charge control can be performed with a number of different circuit types. The main function of a solar charge controller in a stand-alone PV system is to maintain the battery at highest possible state of charge while protecting it from overcharge and over discharge by the loads [1].

Important functions of solar charge controllers are to:

- Prevent Battery from Overcharge: to limit the energy supplied to the battery by the PV array when the battery becomes fully charged.
- Prevent Battery from Over-discharge: to disconnect the battery from electrical loads when the battery reaches low state of charge.

A series charge controller or series regulator disables further current flow into batteries when the battery is full. When the battery reaches a voltage near full charge, charge controllers turn off the charge and when the voltage drops about one volt (typically), turn it on , so as to protect the batteries in a solar electric system from being overcharged or being over-discharged. Batteries that are overcharged have a much shorter life time than well cared batteries since the electrolyte is boiled off as gas and lost [2].A PV charge controller is used to disconnect any load when the battery is discharged down to a safe cut off voltage because overly discharged lead acid batteries become permanently damaged. The primary objectives are compact and mostly hardware design, efficient operation to provide a regulated voltage output and ability to auto cutoff in case of full charging of battery. The paper is organized in the following way.

The design of PV charge controller is presented in Section II for hardware components and circuit diagram. Then we describe system architecture for regulated power supply with 14 volt and 3Amp output. After that a brief discussion is presented on the impact of resistive load to turnoff in full charging conditions and finally conclusion is given at last. The design of the buck converter has been given in Section 3. Section 4 gives a brief description of the hardware and the performance by testing of two different rechargeable batteries.

1.1 PV Voltage Controllers

A PV voltage controller is shown in Fig. 1. The converter regulates the solar PV voltage. Instantaneous change in solar radiations results change in solar PV current, solar PV voltage remains same due to the controller action. Characteristics of solar PV and converter are shown in Fig. 2.

Only one point of intersection exists. By writing differential equation for inductor, it is inferred that this operating point is stable. In summary, output voltage controller can make the system unstable. However, PV voltage controller ensures stable operation in all conditions which is realized by the PV voltage controller. [4]

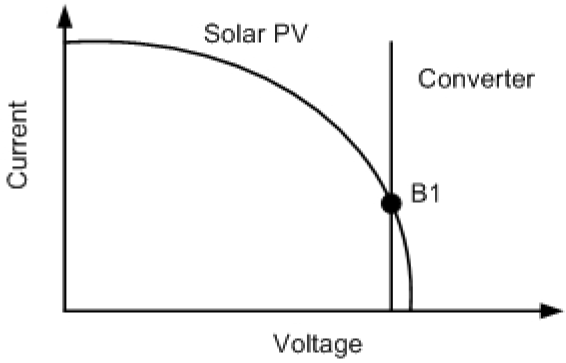

Fig.1: Characteristics of PV voltage controller

II. Design Of Proposed Controller PV Charge Controller

This solar charge control combines multiple features into a single design: 3A current rating, low dropout voltage (LDO), range of voltage adjustment (12V lead-acid batteries) and reverse polarity protection, low parts cost ($2.0) and low parts count. High performance is attributed to the application of the common LM358 op amp and Zener Diode as adjustable shunt voltage regulator.

The other features of this designed charge controller are listed as below.

- Solar charging current: 0 to 3 Amps continuous
- Nominal battery voltage: 12V
- Photovoltaic panel voltage ratings: 14 to 20 V (50W)
- Battery type: lead-acid (Tested with 12V@7Ah , 12V@17Ah and 12V@42Ah)
- Overcharge and over discharge protection by current comparisons in form of voltage
- Charge equalization
- Adjustable output voltage
- Reverse battery protection

3 LED indicators to show the status of the charge controller which are

- Red LED – Shows the output from the panel..
- Green LED ON – Charging of Battery.
- Green LED OFF– Battery is full Charged.

At first, a low cost and low power consuming based charge controller is shown in figure 2 while maintaining the methodology of charging control; such as overcharge, undercharge and without random charging the battery to reduce the recharge cycle so as to increase the overall system lifetime. The design paves to simplicity and facilitates component availability with low power consumption.

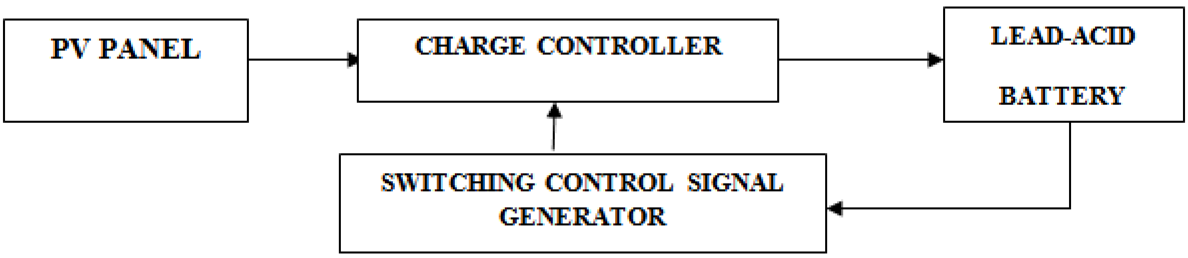

Fig.2: Simplified Hardware Block Diagram of a Solar Charging Station

III. Circuit Operation –

Here first of all 3.0 A, Step-Down (Buck Converter) using LM2596 regulator ic. It has many features like Adjustable Output Voltage Range 1.23 V − 37 V, Guaranteed 3.0 Amp Output Load Current, Wide Input Voltage Range up to 40 V.[3] With a point of buck application a complete circuit diagram of LM2596 shown in figure 2.

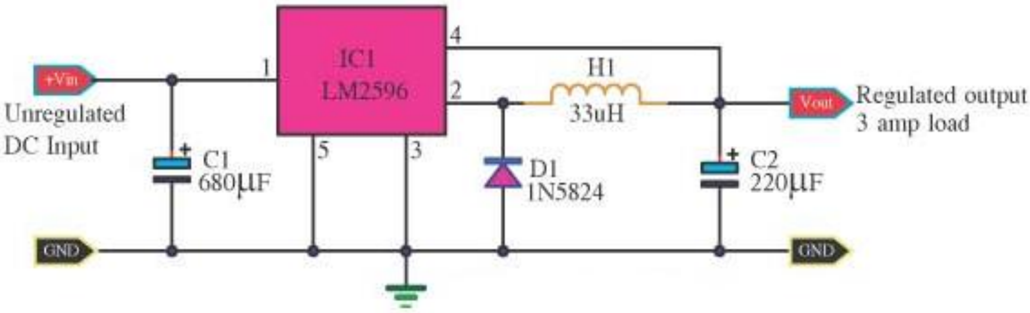

Fig3. -1.2 to 35 V Adjustable 3.0 A Power Supply with Low Output Ripple

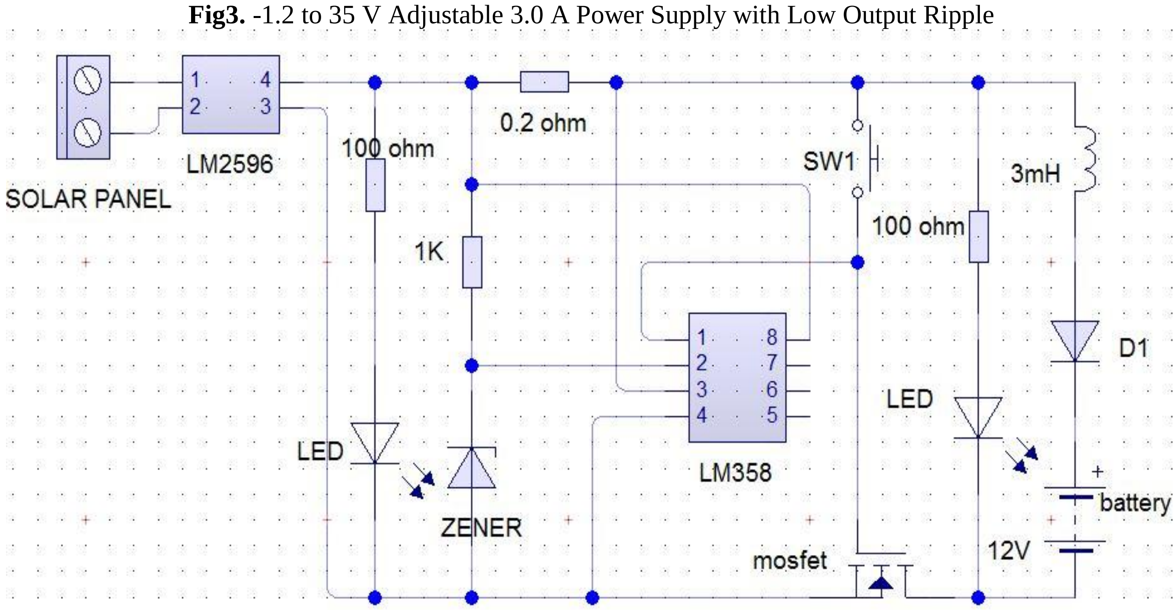

Fig.4: Complete diagram of cost efficient solar PV charge controller

Normally solar charge controller has been made on the basis of voltage control but in this paper solar charge controller made according to the accurate performance of battery charging characteristics. Recharging battery characteristics is that when charging is on and charging has been done by constant voltage or constant current methods. Here in this paper charging method done by constant voltage method. In this method as the charging start first battery voltage has been increased from low level to high level and current reduced from high level to low level. For example starting discharged battery level is 10.50volt for 12 volt battery and as the charging is on voltage level first increased from 10.5volt to rated charged voltage (14.5Volts).As the charging started current 1Amp drawn to battery and it will be go down as the battery charged. As battery voltage reached 14.5Volts then current to the battery will be sharply decreased to milliamps (50 milliamps).This circuit will be automatic cut to the battery from panel.

MOSFET is used as a switch. Switching of MOSFET is controlled by the Opamp which is use as a comparator. Opamp compare two inputs one is reference voltage generated by zener diode and second is battery current in the form of variable voltage.

IV. Experimental Results:

Panel Specification= 50 watt,
Vm= 17volt, Im= 2.3 Amp

Time	Solar Panel Output		Battery Charging Status	
	Vp (Voltage output)in volt	Ip(Current Output) in Amp	Vb(Voltage output)in volt	Ib(Current Output) in Amp
11:00 AM	19.0	1.2	11.8	.8
12:00 PM	19.5	1.3	12.5	.7
1:00 PM	19.9	1.3	13.2	.6
2:00 PM	20.0	1.5	13.4	.5
3:00 PM	16.0	.8	13.4	.3
4:00 PM	15.0	.7	13.42	.1

Fig.5: Charging testing of Battery (12V@17Ah)

Panel Specification= 50 watt,

Vm= 17volt, Im= 2.3 Amp

Time	Solar Panel Output		Battery Charging Status	
	Vp (Voltage output)in volt	Ip(Current Output) in Amp	Vb(Voltage output)in volt	Ib(Current Output) in Amp
10:00 AM	19.0	1.2	10.90	.7
11:00 AM	19.5	1.3	11.80	.6
12:00 PM	19.9	1.3	12.50	.6
1:00 PM	20.0	1.5	12.90	.5
2:00 PM	16.0	1.4	13.40	.3
3:00 PM	15.0	1.2	13.48	.1
4:00PM	14.5	.9	13.72	.05

Fig.6: Charging Testing with Battery (12V@7Ah)

V. Conclusion

The overall cost of a PV charge controller can be reduced with proper battery-charging control techniques, which achieve high battery state of charge and lifetime, under continuously varying atmospheric conditions, which give rise to intermittent PV energy production. In this paper, a novel battery charging regulation system has been presented, consisting of a DC/DC converter controlled by a current comparison. Advantages of the proposed method are:

(a) The proper regulation of charge controller assures maximization of the energy transferred to the battery bank, and thus a better exploitation of the PV source is achieved.

(b) The lifetime of battery is increased because the battery is operating at a higher state of charge.
The testing results verify that the use of the proposed method results in better exploitation of the available PV energy.

References

[1]. Nowshad Amin , Lam Zi Yi and Kamaruzzaman Sopian , "Microcontroller based smart charge controller for standalone photovoltaic power system" 978-1-4244-2950-9/09/2009IEEE.

[2]. J.H.Lee, H.S.Bae & B.H.Cho, 'Resistive control for a photovoltaic battery charging system using a microcontroller', IEEE transactions on Industrial Electronics,Vol 55, No.7, pp. 2767-2775, July 2008.

[3]. X. Jiang, J. Polastre, and D. Culler, "Perpetual Environmentally Powered Sensor Networks," Proc. 4th Int'l Conf. Information Processing in Sensor Networks/Special Track on Platform Tools and Design Methods for NetworkEmbedded Sensors (IPSN/SPOTS), Los Angeles, CA, Apr. 2005.

[4]. Anand, S.; Farswan, R.S.; Mangu, B.; Fernandes, B.G., "Optimal charging of battery using solar pv in standalone dc system," Power Electronics, Machines and Drives (PEMD 2012), 6th IET International Conference on , vol., no., pp.1,6, 27-29 March 2012

[5]. http://onsemi.com/LM2596-datasheet.

[6]. P.S. Bhimra" Power Electronics, Dr. (4^{th} Edition)".

[7]. Muhammad H. Rashid,"Power Electronics Devices, Circuit and Applications, (4^{th} Edition)".