Development of Battery Charge/Discharge Regulator for Photovoltaic Systems

DianguinaDiarisso, Mamadou Saliou Diallo, Amadou Diao, Ousmane Sow, Idrissa Gaye, Fabé Idrissa Barro, Grégoire Sissoko

***Abstract*—This work present the development of a battery charge/discharge regulator for photovoltaic systems. The system is designed to operate at 12V and accept solar panel up to 100W.**

The charge/discharge regulator is an analog one with protections respectively against battery deep discharge and overcharge, thermal drift, short circuit and polarity inversion.

The proposed regulator has been realized and tested in a solar home system (SHS) composed with AC lamps and DC/AC inverter

***Index Terms*—Battery, charge/discharge,regulator, SHS.**

I. INTRODUCTION

Photovoltaic solar systems are more and more used not only in village but also in modern cities. Given that solar irradiation is not accessible in the night, it becomes necessary to store the energy for last use for example in the night. That is why batteries are used because they can store electrical energy coming from solar panel in the form of chemical energy and restore this stored energy in its original form.

Actually, lead –acid batteries are the most used but are very sensitive to both deep discharge and overcharge [1], [2]. It becomes necessary to protect the battery so that charging and discharging processes are controlled; these tasks involve to the battery charge/discharge regulator.

Many technologies like shunt and series regulators have been designed [3], [4] with various command schemes: PWM, MPPT… [5] - [7]. Depending on the implemented technology, the cost of solar regulator could not be negligible mainly if the system is microprocessor or microcontroller based.

The aim of this work is to develop a cheap but good performance battery charge/discharge regulator. We will first present an overview of a common photovoltaic solar system followed by the functional block and the flowchart describing the battery charge/discharge regulator.

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II. PRESENTATION AND IMPLEMENTATION

Low and intermediate power photovoltaic solar energy system are generally presented in the following form [3]:

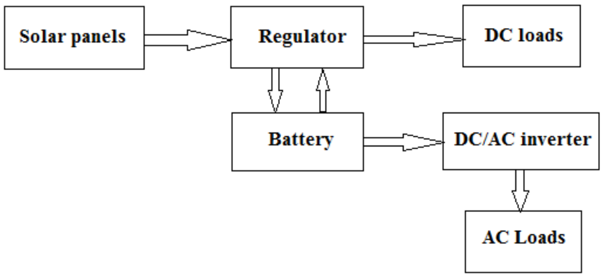

Figure 1: Typical photovoltaic solar energy system

Solar panels charge the batteries through the charge/discharge regulator and the batteries are loaded by both DC loads and the DC/AC inverter for AC loads.

Different types of charge /discharge regulators exist [5] - [7] but we choose to develop a series type with pulse width modulation technique [8]. Figure 2 presents the functional blocks of the developed regulator.

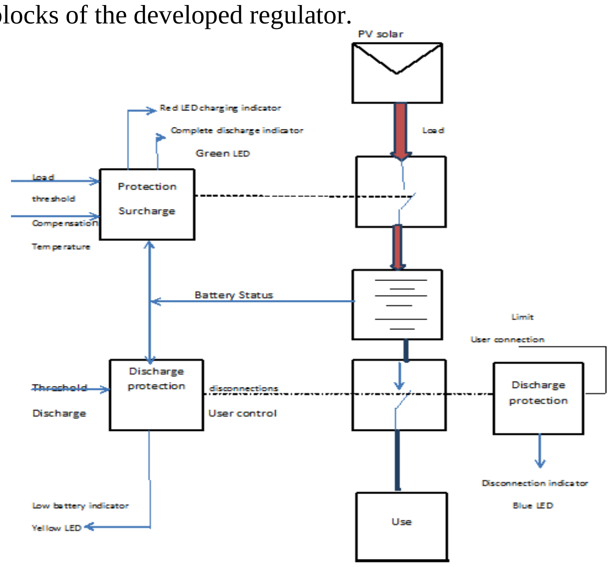

Figure 2: Functional blocks of the charge/discharge regulator.

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The state of charge of the battery is determined by the three protection blocks (against deep discharge and overvoltage); given the measured state of charge, they decide to connect either solar panels or DC loads.

These protection blocks use as references the threshold levels of charge and discharge as well as temperature compensation.

Led indicators indicate in real time the operating state of the system.

Fig.3 shows the flowchart describing step by step the operation of the charge/discharge regulator.

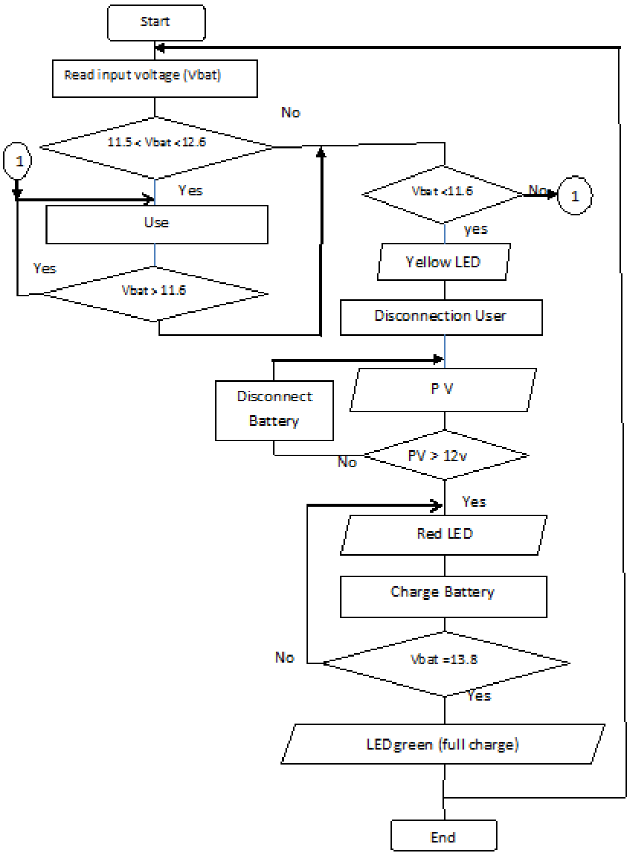

Figure 3: Regulator's flowchart

The battery voltage and temperature are first measured; the battery voltage is then compared to four threshold values [2]: V1 (load disconnect), V2 (load connect), V3 (solar panels connect) and V4 (solar panels disconnect). The compensation is made by LM324 operational amplifier and the result is used to drive power fets Q1 for solar panels, Q3 for DC loads; simultaneously leds are lit correspondingly, indicating the operating state of the battery charge/discharge regulator.

III. EXPERIMENTAL RESULTS AND DISCUSSIONS

The following pictures (Fig.4) present the developed charge/discharge regulator.

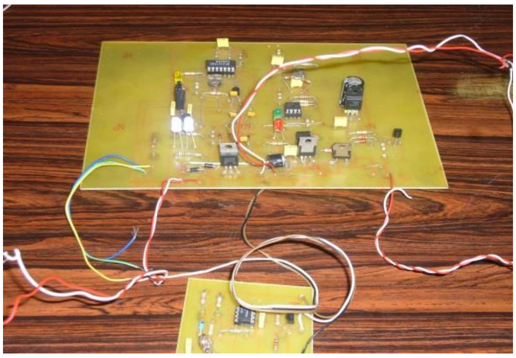

Figure 4a:Automatic switch, command and power boards

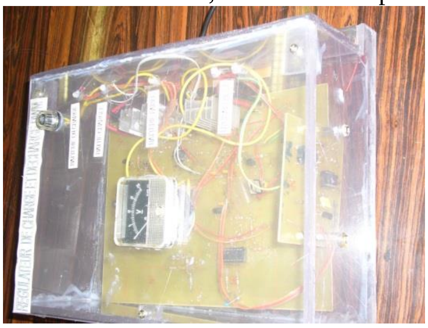

Figure 4b:The assembled prototype

Figure 4c:The associated DC/AC inverter

Figure 4d: The whole system during the test (battery, regulator, AC and DC lamps, DC/AC inverter

The regulator has been realized with two boards: the automatic connect/disconnect board on one hand and the command and power board at other hand. The maximum DC load is 10A and the maximum allowed solar panels power is 100W. The temperature compensation is based on a thermistor. Fig.5 presents some experimental results from the regulator; we have plotted the DC load state and the solar panels connect/disconnect state versus battery voltage. The battery voltage was recorded as same as DC output voltage during charge/discharge cycle; simultaneously, we noted if solar panels where connected or not.

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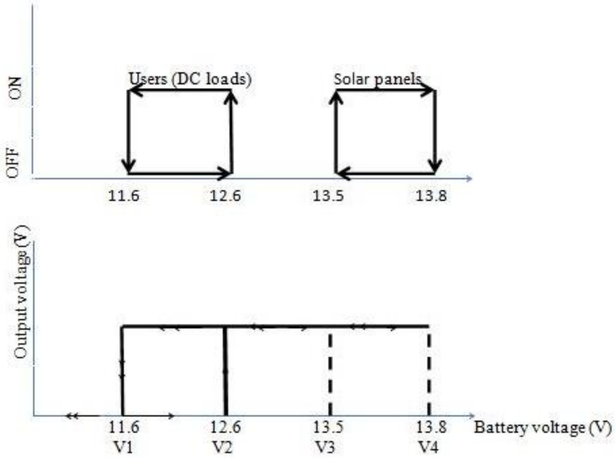

Figure 5: DC load voltage versus battery voltage and connect/disconnect state of the solar panels.

This figure shows that the different thresholds are in a good agreement with the theoretical ones:

The table below resumes the experimental values and the corresponding theoretical threshold.

Table I: Experimental and theoretical thresholds

Theoretical threshold (V)	Experimental thresholds (V)
11.6	**11.54**
12.6	**12.65**
13.5	**13.48**
13.8	**13.84**

We present on figure 6 the battery charge current and battery voltage versus charging time.

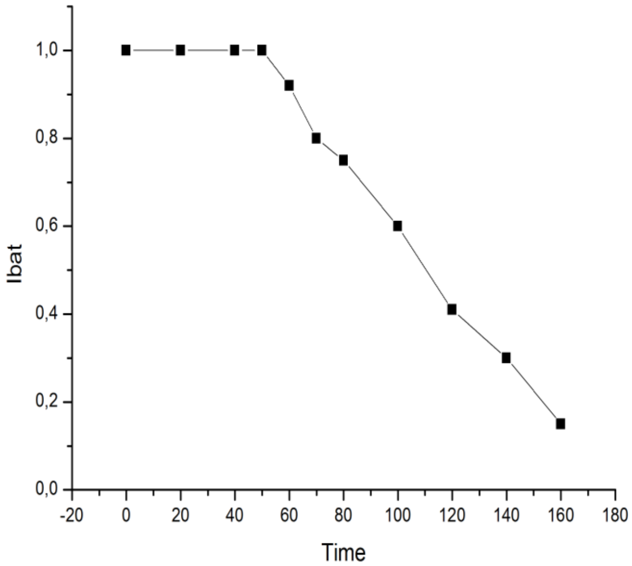

Figure 6a: Battery charging current versus charging time

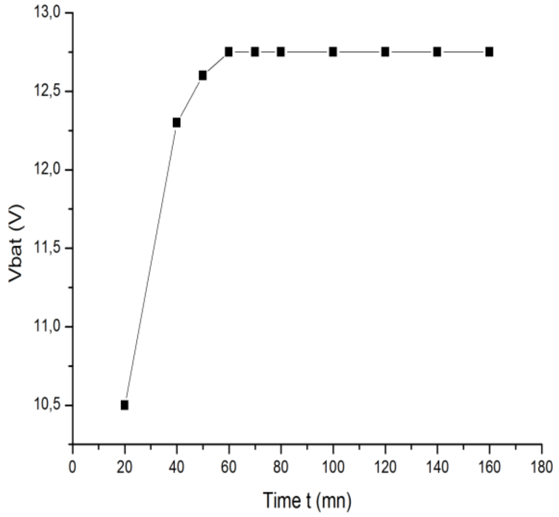

Figure 6b: Battery charging voltage versus charging time

We can see that the battery charging process is ok with a high charging current decreasing with increasing battery voltage or time. This decrease is well controlled through the PWM signal driving the power FET Q1.

IV. CONCLUSION

We presented in this paper a battery charge/discharge regulator for photovoltaic solar energy systems. The proposed regulator is very easy to build and very cheap and also has very good performance as proved by the experimentation in a solar home system.

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