

# Simulation and Realization of a Battery Charge Regulator

B. Nasri, and M. Bensaada

**Abstract**—We present a simulation and realization of a battery charge regulator (BCR) in microsatellite earth observation. The tests were performed on battery pack 12volt, capacity 24Ah and the solar array open circuit voltage of 100 volt and optimum power of about 250 watt. The battery charge is made by solar module. The principle is to adapt the output voltage of the solar module to the battery by using the technique of pulse width modulation (PWM). Among the different techniques of charge battery, we opted for the technique of the controller ON/OFF is a standard technique and simple, it's easy to be board executed validation will be made by simulation "Proteus Isis Professional software ". The circuit and the program of this prototype are based on the PIC16F877 microcontroller, a serial interface connecting a PC is also realized, to view and save data and graphics in real time, for visualization of data and graphs we develop an interface tool "visual basic.net (VB)".

**Keywords**—Battery Charge Regulator, Batteries, Buck converter, Power System, Power Conditioning, Power Distribution, Solar arrays.

## I. INTRODUCTION

THE Controller design for any subsystem in the spatial domain needs knowledge about system behavior. Usually this involves a mathematical description of the relation among inputs to the process, state variables, and output. This description in the form of mathematical equations which describe behavior of the system (process) is called model of the system.

The DC/DC converters are widely used in regulated switch mode DC power supplies. The input of these converters is an unregulated DC voltage, which is obtained by PV array and therefore it will be fluctuated due to changes in radiation and temperature. In these converters the average DC output voltage must be controlled to be equated to the desired value although the input voltage is changing. From the energy point of view, output voltage regulation in the DC/DC converter is achieved by constantly adjusting the amount of energy absorbed from the source and that injected into the load, which is in turn controlled by the relative durations of the absorption and injection intervals.

These two basic processes of energy absorption and injection constitute a switching cycle. Intuitively speaking, if

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the energy storage capacity of the converter is too small or the switching period is relatively too long, then the converter would have transmitted all the stored energy to the load before the next cycle begins. This introduces an idling period immediately following the injection interval, during which the converter is not performing any specific task [1, 2, 3]. We find the block diagram of controller battery charge.

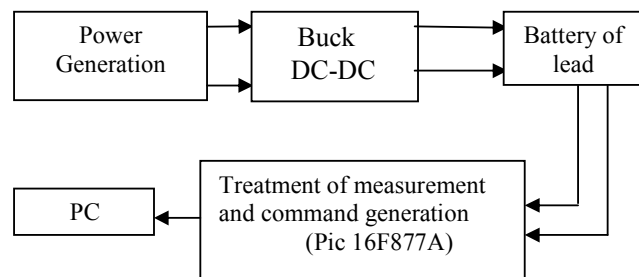


Fig. 1 Controller battery charge

### A. Converter Modeling

The buck converter with ideal switching devices will be considered here which is operating with the switching period of  $T$  and duty cycle  $D$  Fig. 2, [4]. The state equations corresponding to the converter in continuous conduction mode (CCM) can be easily understood by applying Kirchhoff's voltage law on the loop containing the inductor and Kirchhoff's current law on the node with the capacitor branch connected to it. When the ideal switch is ON, the dynamics of the inductor current  $i_L(t)$  and the capacitor voltage  $V_c(t)$  are given by:

$$\begin{aligned} \frac{di_L}{dt} &= \frac{1}{L} (V_{in} - v_0) \\ \frac{dv_0}{dt} &= \frac{1}{C} \left( i_L - \frac{v_0}{R} \right) \end{aligned} \quad (1)$$

,  $0 < t < dT, Q: ON$

and when the switch is OFF are presented by,

$$\begin{aligned} \frac{di_L}{dt} &= \frac{1}{L} (-v_0) \\ \frac{dv_0}{dt} &= \frac{1}{C} \left( i_L - \frac{v_0}{R} \right) \end{aligned} \quad (2)$$

$dT < t < T, Q: OFF$

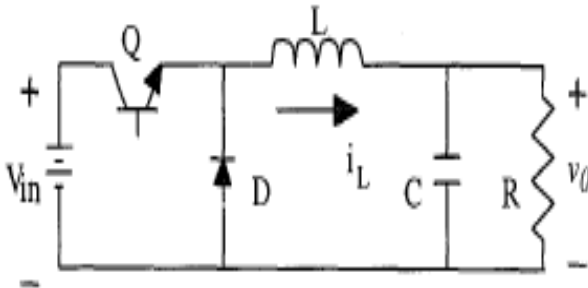


Fig. 2 DC-DC Buck Converter

TABLE I  
THE VALUES THE BUCK CONVERTER

Parameter	Quantity	Value
Vin	Input Voltage	42V
Vout	Output Voltage	13V
D	Duty Cycle	1 -99%
F	Switching Frequency	100KHz
L	Inductor	125mH
C	Capacitor	250µF
R	Load Resistor	15Ω

**B. Software Development of the Control Regulator**

The organization associated with the proposed control algorithm is described in Fig. 3. During charging, the IRF740 (mosfet) bloc load behaves like a short circuit and the whole current of the solar array is used for battery charging. Once the Voltage reaches the regulation voltage (Voltage Regulation Setpoint) [2], the microcontroller will act on the mosfet the charging current and maintain consequently the battery voltage. This operation allows the regulator to protect the battery against overcharging. The battery is enabled again when the voltage drops below the value (Voltage Regulation Reconnect Setpoint). [5].

The charge controller conceived also protects the battery against deep discharge. Once the nominal battery voltage and rated capacity, reaches a value to low (Low Voltage Disconnect Setpoint) [6], where the discharge current is assumed to be negative, the microcontroller will act on the IRF740 the bloc limiting discharge to disconnect the battery usage and stop his defense accordingly when the battery has taken a correct voltage level (Low Voltage reconnect Setpoint) [7].

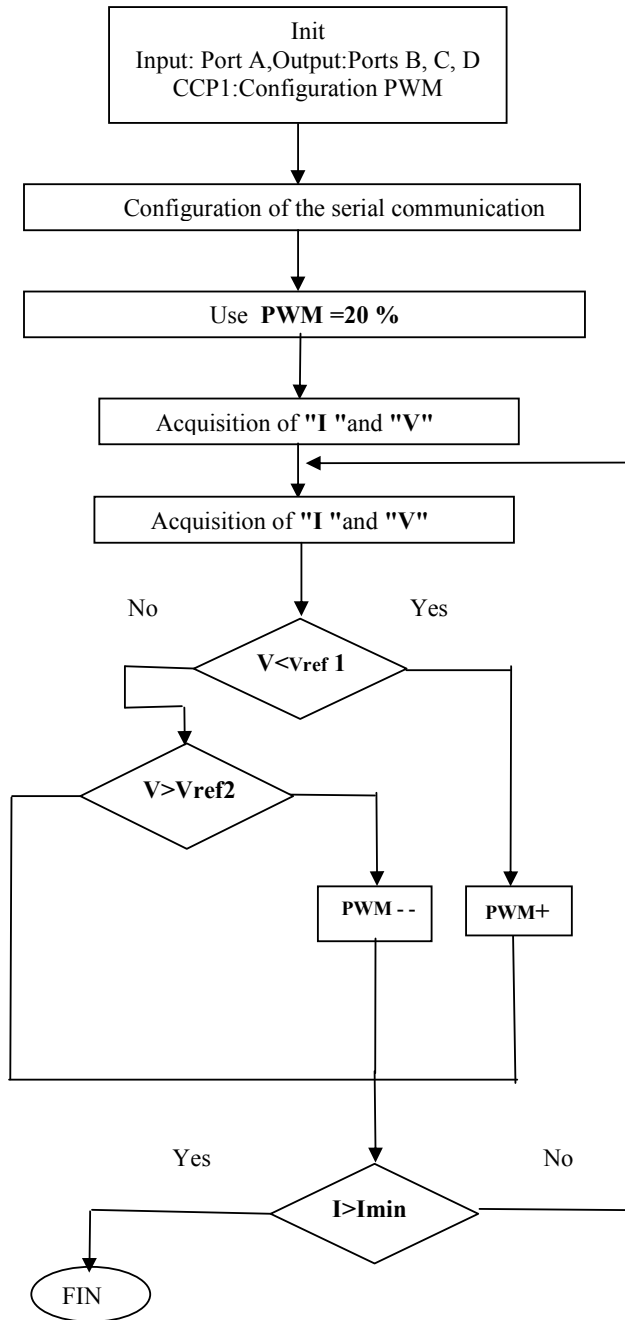


Fig. 3 Flowchart of the control algorithm proposed

**C. Hardware Implementation**

A detailed block diagram of the proposed system is shown in Fig. 5. The buck-type DC/DC converter is designed according to the system power capability requirements, as analyzed in [8]. The control unit in Fig. 4 consists of microcontroller 16F877A and interface circuits required to lead the battery voltage, and current signals to the microcontroller. The microcontroller on-chip 8-bit pulse width modulation (PWM) generator output drives the DC/DC

converter, according to the battery charging algorithm analyzed below. The control unit has its power supply from the battery, which is charged by the DC/DC converter. The battery voltage is measured by means of a voltage divider interfaced to an op-amp-based voltage-follower, and a Hall-effect based sensor is used to measure the battery current [9]. The components used are given in Table II.

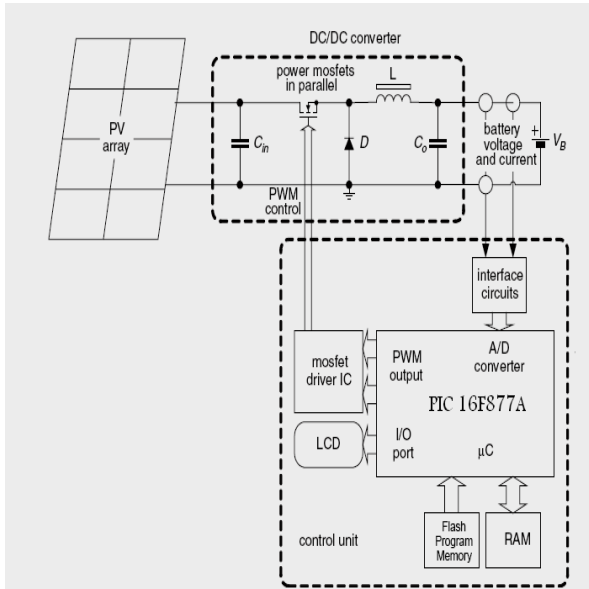


Fig. 4 Detailed diagram of the proposed system

TABLE II  
THE COMPONENTS USED IN THE CONTROL BOARD

Parameter	Reference
Voltage divider	TL082
Low pass filter	TL082
Current divider	LA100P
Optocoupler	4N35
Driver	4049
Voltage divider	TL082
Low pass filter	15Ω

D. Preliminary Result Obtained

A software program in visual basic.net for windows was developed for the microcontroller sent data via the RS232 serial ports. Information received in the PC is displayed numerically and graphically.

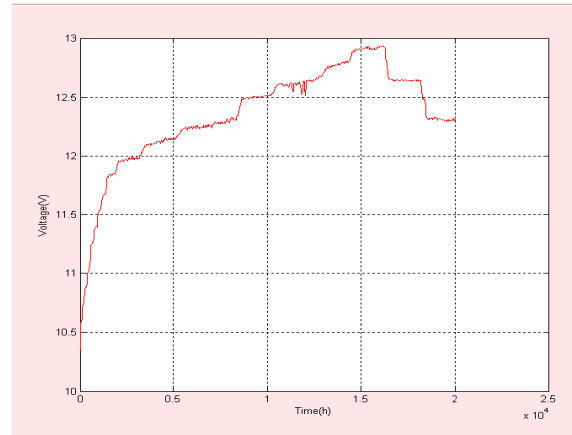


Fig. 5 Battery Voltage

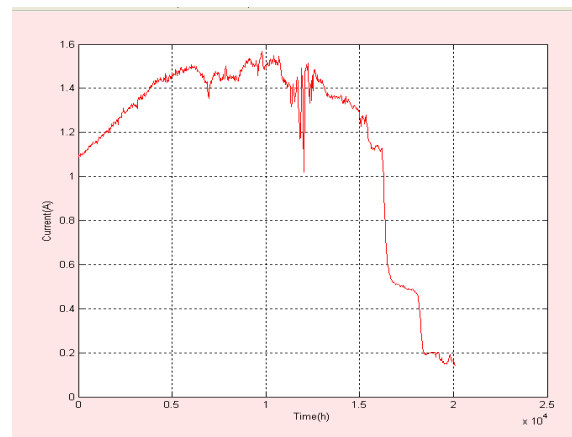


Fig. 6 Battery Current

II. CONCLUSION

Objective was the realization of a charge controller of battery acid-plomb in a photovoltaic system. The prototype is card based 16f877 microcontroller and a power card consists of a buck DC-DC. The ON / OFF algorithm was used to charge the battery when the end of life equipment in the satellite can patch the threshold voltage, the initial values of the battery in the microcontroller. The experimental results ensure the maximization of the energy transferred to the battery, with a long life and less time to charge the battery.

REFERENCES

- [1] Konstantin P. Louganski, "Modeling and Analysis of A DC Power Distribution System In 21st Century Airlifters", M.Sc. Electrical Engineering Dept., Faculty of the Virginia Polytechnic Institute and State University, September 30, 1999, Blacksburg, Virginia.
- [2] Jaber Abu-Qahouq and Issa Batarseh, "Generalized Analysis of Soft-Switching DC-DC Converters", ISCAS 2000 – IEEE International Symposium on Circuits and Systems, May 28-31, 2000, Geneva, Switzerland, pp. 507-510.
- [3] Woywode, O.; Guldner, H. "Application of Statistical Analysis to DC-DC Converter" International Power Electronics Conference, IPEC 2000, Tokyo, Japan 2000.

- [4] J.Mahdavi, A.Emadi, H.A.Toliat, Application of State Space Averaging Method to Sliding Mode Control of PWM DC/DC Converters, IEEE Industry Applications Society October 1997.
- [5] E.P. Usher and M.M.D. Ross, 'Recommended Practices for Charge Controllers', Report IEA PVPS T3-05, August 1998.
- [6] E. Koutroulis and K. Kalaitzakis, 'Novel Battery Charging Regulation System for Photovoltaic Applications', IEE Proc. Electr. Power Appl., Vol. 151 N°2, pp.191 - 197, March 2004.
- [7] C. Tavernier, 'Applications Industrielles des PIC', Ed. Dunod, Paris, 2001.
- [8] Mohan, N., Undeland, T., and Robbins, W.: 'Power electronics - Converters, Applications and Design' (Wiley, New York, USA, 1995,2nd Edn.).
- [9] E. Koutroulis and K. Kalaitzakis Novel battery charging regulation system for photovoltaic applications- IEEE.