Charger for Lead-Acid Batteries

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Abstract— In this paper some important charging method for rechargeable batteries and its charging circuits are introduced. A smart battery charger circuit of about (225 watt) based on a dc/dc half-bridge converter is presented, designed and analyzed in this research.

This charger is able to control the values of the load voltage and current and then, maintain them at a desirable value. A first converter is used to convert the grid 50 Hz electrical quantities into dc quantities. A second converter adjusts the levels to the values required by the battery and moreover, provides a galvanic isolation.

MATLAB/Simulink program is used to simulate the presented charging circuit, and model of lead-acid battery is used to simulate the battery performance. The main results which obtained from applying the constant voltage method, constant current constant voltage method, and modified constant current constant voltage method are highlighted and investigated.

Index Terms— Rechargeable batteries, charger ,Battery Charging Method , Matlab simulation.

I. INTRODUCTION

Rechargeable batteries are extensively utilized in many applications, including renewable energy generation systems, electrical vehicles, uninterruptible power supplies, laptop computers, personal digital assistants, cell phones, and digital cameras [1]. Since these appliances continuously consume electric energy, they need charging circuits for rechargeable batteries. The life and capacity of the rechargeable batteries depend on several factors, e.g., charge mode, maintenance, temperature, and age. Among these factors, the charge mode has a great impact on battery life and capacity. The rechargeable batteries should be charged with current and voltage levels with low ripple. Therefore, a high-performance battery charger is necessary in a battery energy storage system. In addition, the basic requirements of battery chargers with switching regulators are small sized and high efficiency. High switching frequency is necessary to achieve a small size, the charging time and lifetime of the rechargeable battery depend strongly on the properties of the charger circuit. Conventional battery chargers with linear power regulators can handle only low power levels, have a very low efficiency, and have a low power density, since they stipulated low-frequency transformers and filters. Conversely, modern battery chargers require high quality, small size, light weight, high reliability, and highly efficient energy conversions. Consequently, pulse width-modulated (PWM) dc–dc converters for battery charger, employing semiconductor power switches, have developed rapidly in recent years [2].

Manuscript received October, 2013.
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II. MAIN CIRCUIT

This paper uses the half-bridge DC-DC converter shown in Fig.1 as the battery charger main circuit, which is composed of half-bridge inverter, high frequency transformer and output rectifier filter. The advantage of using this circuit is that the voltage on switches is power supply voltage, which is suitable for high supply voltage occasions. A and B are the single-phase aviation input power, T is the step-down transformer, which has the function of isolation between charging circuit and power grid, what's more, it also can present a certain degree of resistance, thus the risk of battery to absorb of peak current is reduced.

The design of the charger main circuit includes transformer, power switches, input capacitance and rectifier diodes. To reduce the wear and tear, the charger's switching frequency is selected to be 31kHz. According to the input voltage, output voltage and secondary side peak current of transformer, the voltage and current values of transformer on both sides is calculated, thus the transformer parameters is determined. The EC-35 core is selected by calculating, variable ratio of transformer is 36:7, and Its input capacitor is 560µF/200V electrolytic capacitor. Based on the rectifier diode's current RMS and inverse voltage, the 6A/800V diode (GBU6K) is used in the first stage rectifier. The diodes of second stage rectifier select Ultra Fast Recovery Diodes 200V 20A.

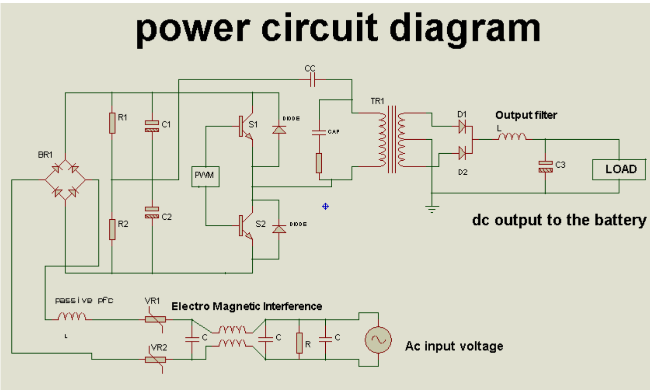


Figure 1. The main circuit of the charger.

III. BATTERY CHARGING CONTROL METHODS

The battery charging techniques include constant current, constant voltage , Two-step, Pulse charging, and Reflexm charging[3].

A. Constant current charging

This is a simple charging method using constant currents for battery charging and the charging currents for the series connected batteries are equal. However, battery overcharging will result in the degradation of battery life. Small charging current will prolong the charging time. Fig. 2(a) gives the charging curves for constant current charging.

B. Constant voltage charging

This constant voltage charging for battery can be easily implemented with simple and controls. During the initial stage of charging the possible large charging currents need to be limited to protect devices. When the battery voltage reaches the default value. charging voltage is hold and charging current decreases with time. The charging will cause temperature rise and degradation of the battery life. Fig. 2(b) shows the battery charging characteristics for constant voltage charging.

C. Two-step charging

Two-step charging method combines the constant current and constant voltage charging. In the first stage of charging, the batteries are charged by a constant current until the battery voltage reaches a preset voltage. In the second stage, a constant voltage is applied for battery charging. Fig. 2(c) shows the charging curves for the two-step charging.

D. Pulse charging

A pulse current is applied to the battery periodically, this provides the battery a relax time in charging process. The electrochemical reaction and neutralization of battery internal electrolyte are helpful to enhance the life cycle of battery. Using a large pulse current will shorten the battery charging time. Fig. 2(d) shows the current waveform of pulse charging method.

E. ReflexrTM charging

The Reflex^{TM} charging method is an improvement on the pulse charging. A charging period consists of a positive pulse, a negative pulse. and a relax interval. Fig. 2(e) shows the current waveform of Reflex^{TM} charging.

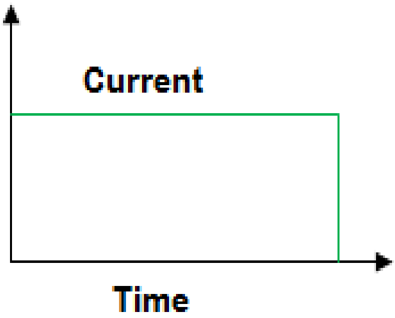


Figure.2,a Constant Current

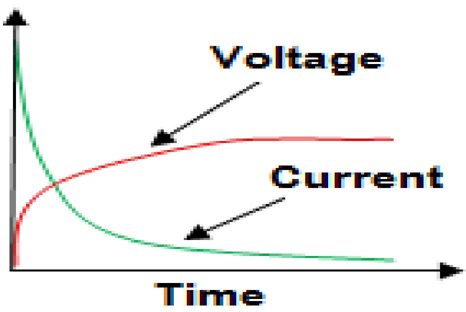


Figure.2,b Constant Voltage

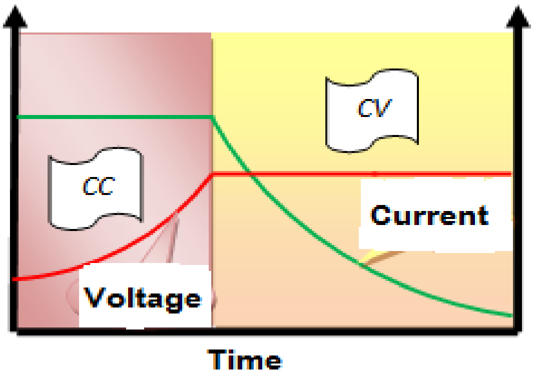


Figure2,c, Constant Current Constant Voltage (CC CV)

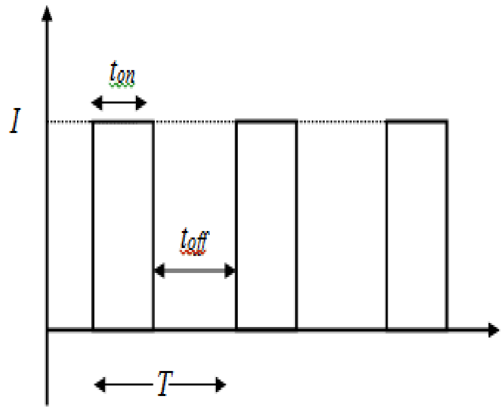
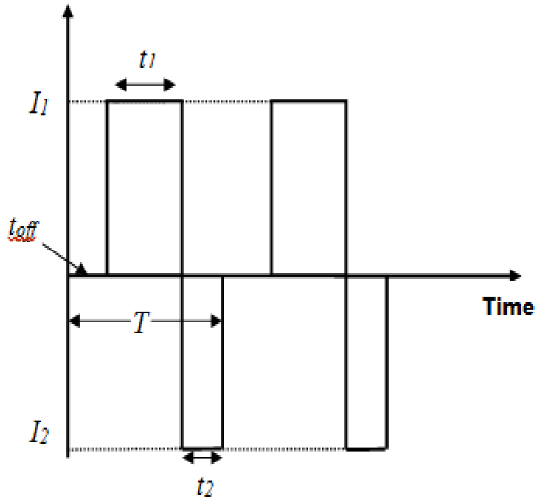


Figure.2,d.Pulse charging

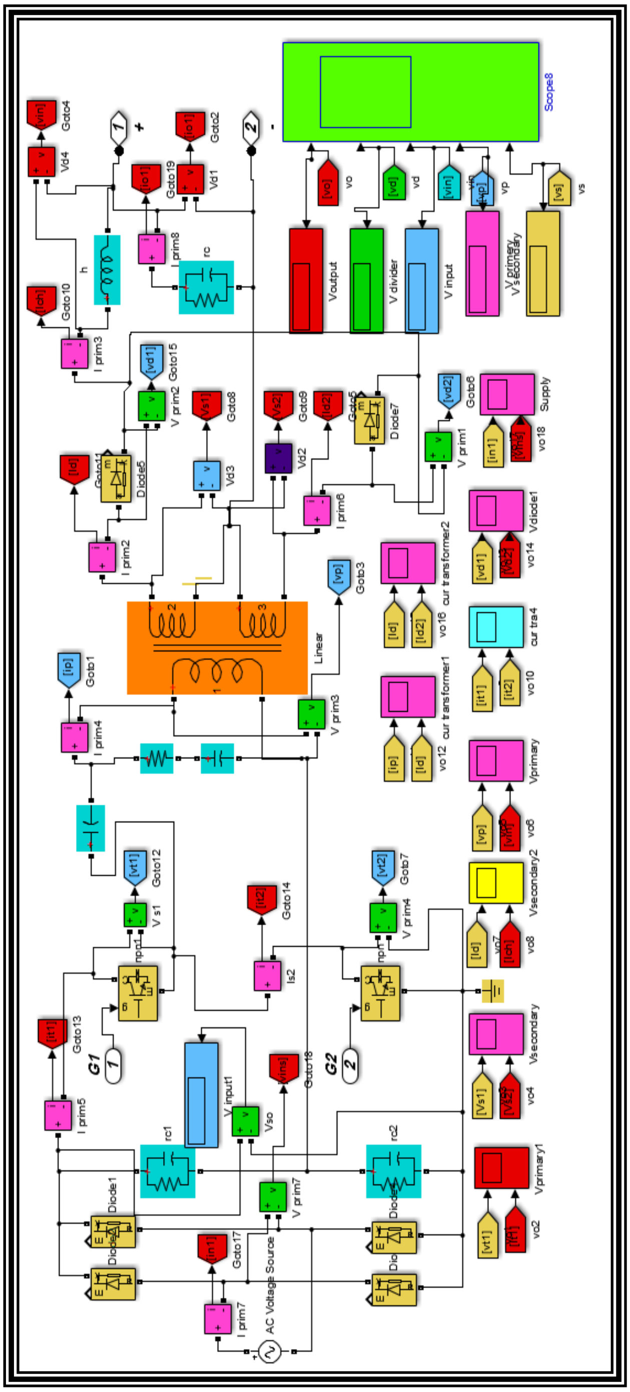


Figure,2,e Reflax^{Tm} charging

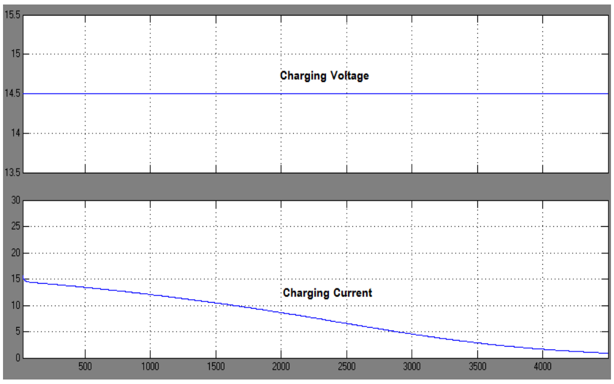
IIII. RESULTS

A. Simulation Results.

Fig. 3.0 is the schematic diagram of the proposed system designed with Matlab Simulink software complete with control loop. Fig. 4.0 shows the constant current charging,. Fig. 5.0 shows the constant current constant voltage charging, While Fig.6.0 shows the constant current constant voltage method



(a)



Figur4. Constant Voltage Charging

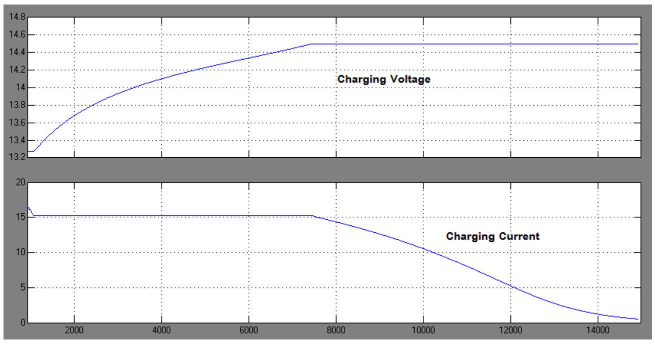


Figure 5.Constant Current Constant Voltage Charging

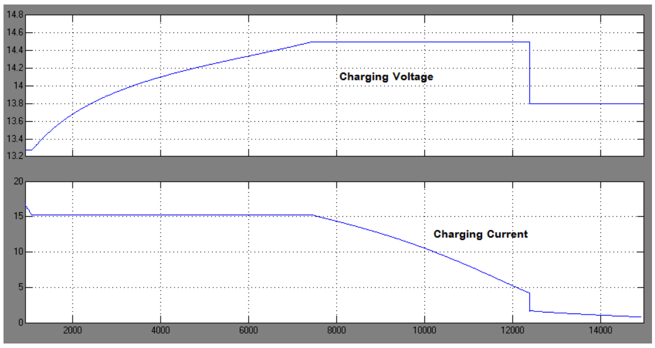


Figure 6. Modified Constant Current Constant Voltage Charging

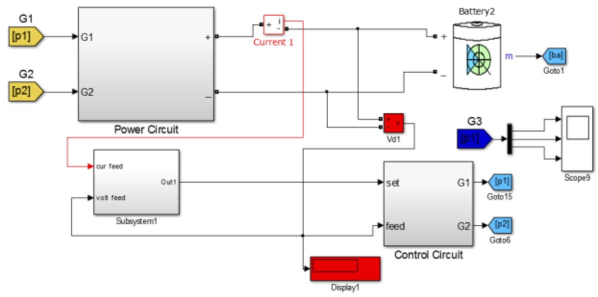


Fig. 3.0: The proposed system design in

CONCLUSIONS

The battery is an electrochemical system in the complex and difficult behavior representation and modeling are accurate; influenced by a few of the physical and chemical factors, environmental and others. However mathematical model is used in the program MATLAB MATLAB / PSB Simulink from the nearest simulation models used in the disposal of the battery practical, although adopted in his work on a set of assumption.

The simulated circuit proves through the result the algorithms charging. Showed the use of functions (Embedded Mat lab functions) high flexibility in the implementation of shipping methods applied in this research, as was written by a group of police functions (IF: then) to control the value of the voltage and charging current .

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