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Design and Implementation of a 12v Automatic Battery Charger

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Abstract: ***Despite the fact most modern electrical appliances receive their power directly from the utility grid, a growing number of devices require electrical power from batteries in order to achieve greater mobility and convenience. Also the sudden failure of vehicle charging systems often gives rise to drain of battery cell. Rechargeable batteries store electricity from the grid for later use and can be conveniently recharged when their energy has been drained. Thus, the objective of this paper is to designand construct an effective automatic battery charger for efficient and sustained power optimization.The designed device consists of a circuit which perform charging, a circuit for current reverse protection, and a circuit displaying battery charge level during or resting state of charging. This particular charger has an inbuilt protection unit and is fully automatic to protect the battery from being over charged as overcharging damages the battery plate. The Fully-charge control monitors the fully charged condition of the cell or battery when the battery has charged up to 13.5volts. At this level, the battery is fully charged and is automatically disconnected.The design is simulated by proteus simulation software, and the prototype of the battery charger has been implemented; and results from its operational test are satisfactory. Adequate care has been taken in its design and construction to ensure that the resultant battery charger is both reliable and easy to use.***

Keywords: Charging, Current reverse protection, Power optimization, Rechargeable battery

1. Introduction

Battery is very important in both electrical and electronics circuits. Battery needs to be recharged once its charge has dropped below a certain level.

It is observed that irrespective of the level of discharge, most battery service centers often connect the batteries and allow them to charge without a means to automatically disconnect them when they are fully charged in order to prevent over-charge and possible explosion [1].

In some cases, in an effort to deliver quick service and meet customer demand, the charge setting of the battery charger is adjusted to increase the charging current so as to reduce the charging time.Such practices shorten the life time of the battery [1]. This article introduces one of the simplest 12V battery charger with automatic cutoff. The design is simple and uses easily available electronic components which are cheap and can be easily found. The circuit is tested in Proteus ISIS for verification.

2. Typical Automatic battery charger arrangement

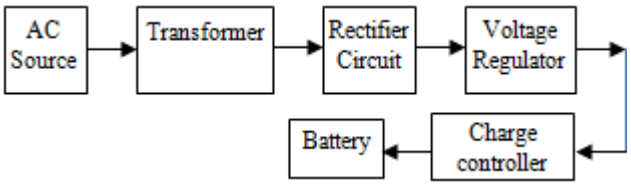

Figure 1: Block Diagram of Automatic battery charger

- **The Transformer:** The purpose of the transformer is to bring the ac voltage down to a safe level.
- **The Rectifier Circuit:** The rectifier circuit converts ac voltage to dc voltage because battery is a dc component and it needs dc voltage to charge it.
- **Voltage Regulator voltage Regulator:** The voltage regulator provides the constant voltage to charge the battery.
- **Auto Cutoff Arrangement:** It saves the battery from damage caused by overcharging.

3. Components List

X_1 = 220 AC primary to 25V, 8 A Secondary
IC = LM317 EMP Adjustable Voltage Regulator
D_1-D_5 = 1N4007 Rectifier Diodes
C_1 = 470 µF 25V Electrolytic Capacitor
C_2 = 0.22 µF Ceramic
R_s = (R_0 = 2200Ω, R_1 = 240 Ω, R_2= 2700Ω, R_3 = 240Ω and R_4 = 800Ω)
VR_1 = 1KΩ Potmeter
R_2 = Ro + Part of VR_1
ZD = Zener Diode ZPD12RL
T = Transistor BD139
Relay = 12V relay

The above components are connected in the Fig. 2 to make automatic battery charger.

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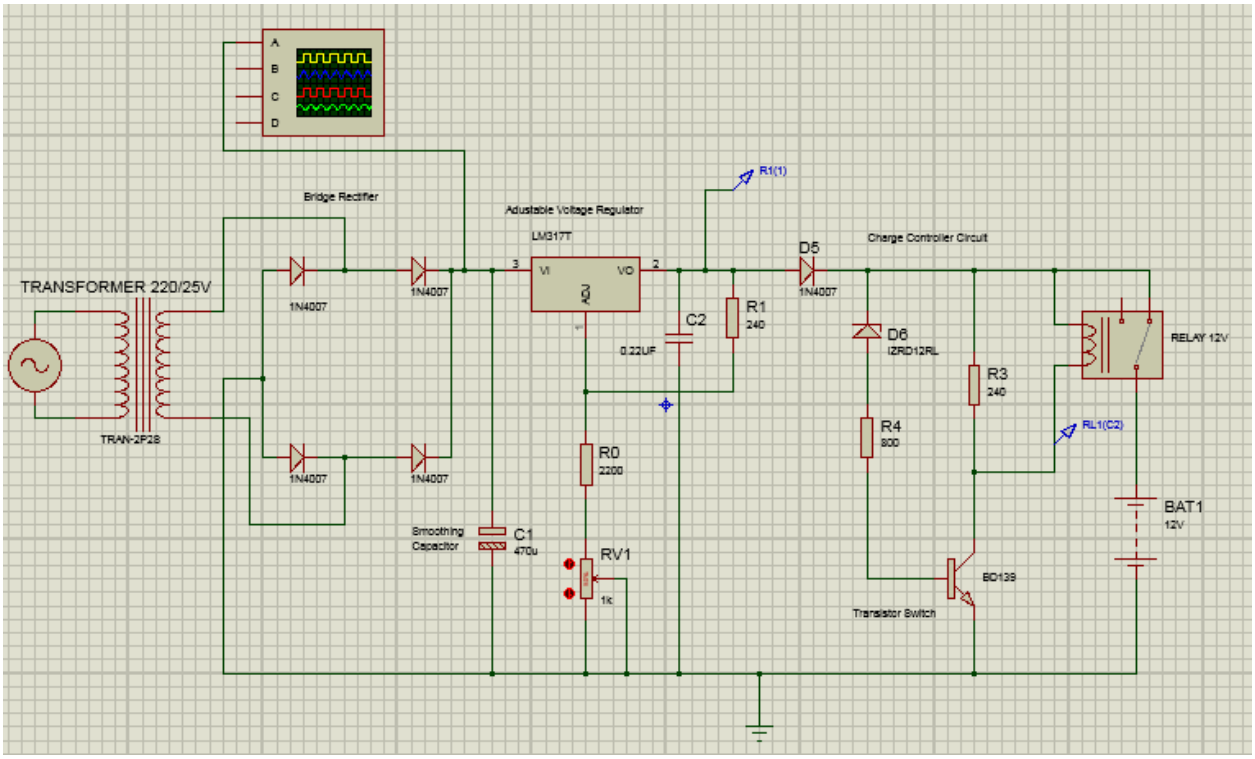

Figure 2: Circuit Diagram of the 12V Automatic Battery Charging Circuit.

4. Mode of Operation of the Automatic Battery Charger

A 220V/25V transformer is used to bring voltage down. For 12V battery charger, the voltage on the secondary side should be in between 15V and 25V so that it can be adjusted around 12V via regulator. The bridge rectifier circuit is used to convert AC into DC [2]. The output of rectifier is pulsating DC as shown in Fig.3.

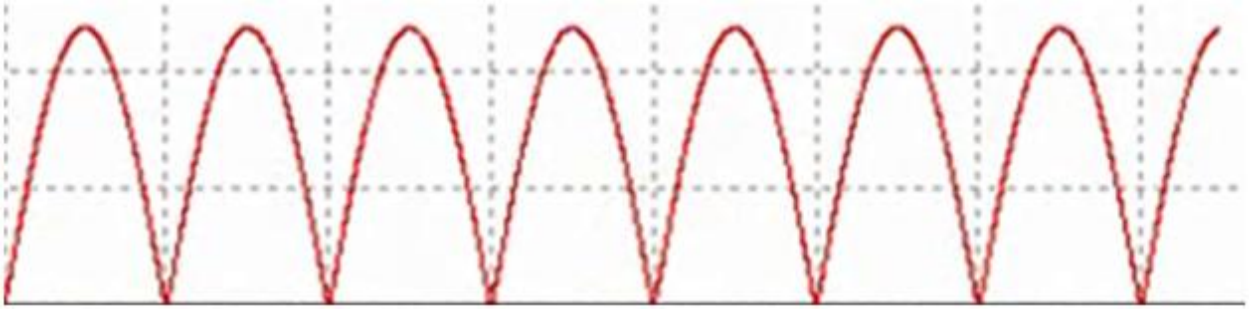

Figure 3: Pulsating DC

The smoothing capacitor C_1 is connected at the output of bridge rectifier, sopure DC is then given to the voltage regulator LM317. The output of LM317 can be adjusted using equation 1.

$$V_0 = 1.25\left(1+\frac{R_2}{R_1}\right)[3] \quad (1)$$

Where R_2 = Ro + Part of VR_1

For this charger the output of the regulator is calculated as follows

$$V_0 = 1.25\left(1+\frac{2700}{240}\right)$$

= 1.25 (1 + 11.25)

= 1.25 x 12.25

= 15.31 V

In series with R_0, a variable resistor RV_1 is connected so that the output voltage of regulator can be adjusted.

A small capacitor C_2 is connected at the output of voltage regulator whose purpose is to ground the fundamental component (low frequency) of the ripple voltage not filtered by capacitor C_1.A diode D_5 is connected after the resistor at the output of regulator. The purpose of this diode is to protect the regulator LM317 against reverse voltages and isolate the charge controller circuit and the battery load. It also protects the battery from being discharged through the regulator. If the battery voltage is below 12V, then the current from LM317 IC flows through the diode D_5 to the battery. At this time zener diode will not conduct because battery takes all the current for charging. When the battery voltage rises to 13.5 V, which is the set breakdown voltage of the Zener diode, current flows through R_4 to the base of the transistor

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BC139. The transistor switches suddenly and, in turn, switches the contacts of the relay and disconnects the battery.

As a result, the collector of transistor which was previously at 12V (due to cutoff) isnow at ground level (or near to ground level). The resistor R_4 connected at the base of transistor controls the sensitivity of the cutoff switch. Low value of this resistance will operate the switch as soon as zener starts conducting while higher value will operate the switch when voltage goes beyond 13.5V. When relay operates, battery is isolated from the automatic battery charger. And remains in this state until when the battery discharges below a set value.

5. Result and Discussion

Parameters
Transformer type: single phase step down transformer
Input voltage 220/230V, 50Hz
Output voltage 25V AC

$$\text{Turn ratio } \frac{N_1}{N_2}\,[4] \qquad (2)$$

= 220/25 = 8.8
Current rating
Output current I_2 = 8A

$$\text{Input current } I_1 = N_2 \text{ x } \frac{I_2}{N_1}\,[4] \qquad (3)$$

$$= \left(25 \text{ x } \frac{8}{220}\right) = 0.91 \text{ A}$$

Power rating:

$$\text{Output power Po} = V_1 \text{ x } I_1 = V_2 \text{ x } I_2 \qquad (4)$$

= 220 x 0.91 = 25 x 8 = 200W.

Charging Time
Charging time of battery = battery Ah rating/charging current of the charger

$$T = \frac{AH}{A}\,[5] \qquad (5)$$

$\frac{75}{8}$ = 9.4hrs. if the battery is to be fully charged.

However the recommend charging current for a 75 Ah battery is 10% of its AH rating, which is obtained as

$$\left(75 \text{ x } \frac{10}{100}\right) = 7.5\text{A}$$

Test and Results

Test	Result	Remarks
Open circuit test	No open circuit detected	Pass
Short circuit test	No circuit short detected	Pass
Continuity test	Circuit connection were continuous	Pass

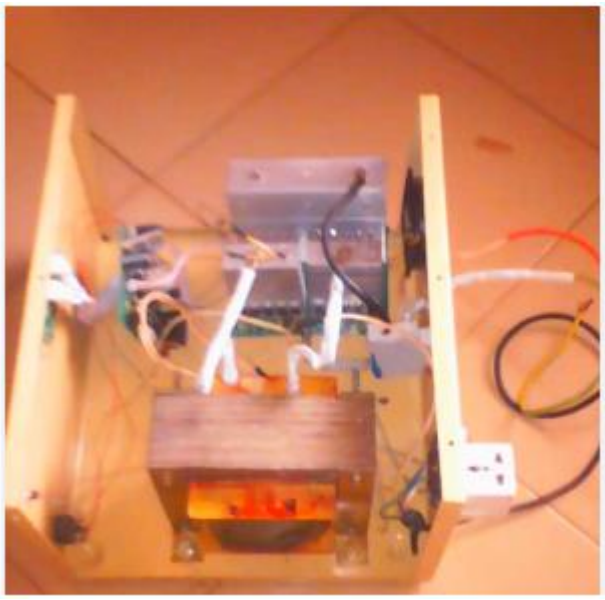

Figure 4: Internal View Showing Physical Connections

6. Conclusion

The implementation of automatic battery charger has been designed successfully. The battery is safe, convenient and suitable to use. It is quite efficient and reduced the manpower, maintenance and complexity. There is no need to continuously monitor the battery and switch off from charging. The product is affordable and is recommended to people who are in the business of charging batteries.

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