12V Portable Battery Charging System.

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ABSTRACT

The essential use of 12V lead acid batteries in automobile engines to power incorporated electrical appliances, and also the sudden failure of vehicle charging systems that often give rise to a drain of battery cells has necessitated the construction of battery chargers suitable for fully restoring the lost charge into the required 12V battery cells. Most 12V battery charging devices built for commercial services are usually heavy and bulky and lack a protection circuit and a sensitized control circuit required for automatic deactivation of charging once the battery is fully charged. In this new design product, the size of the battery charger was made portable and light in weight to enable end users to convey it as easily as possible. Short circuits and current reverse protection were incorporated as well. A sensitized control circuit was implemented to ensure that charging is terminated immediately when the battery is fully charged. This is to avoid the possible occurrence of overcharging that may result in loss of electrolytes.

In this report the components used to actualize the design work were listed and the design specifications were tabulated with the circuit diagram well detailed. The operational principle of the built charger clearly explains how the design objectives were reached. An adopted formula with example on how to calculate the charging time of a battery when using the product was derived. Design limitations, recommendations, and conclusion were stated. Various relevant tests were conducted with its corresponding results tabulated. Finally, a well labeled image which lays out views of the completely constructed battery charger is attached in order to appreciate the effort and the value of the design work.

(Keywords: AC power supply, rectification, charging, deactivation, full charge)

INTRODUCTION

The life span of a battery mostly used by automobile drivers can be maximized by avoiding over loading, overcharging, and inputting charge current higher than battery manufacture's rated value. It was observed over time that most commercial battery charging service centers in town (Enugu, Nigeria) that are patronized by automobile drivers uses the conventional battery charger type that is built without an automatic charging cut-off circuit to provide charging services to their customers. The unavailability of this automatic charging cut-off circuit causes the operator to constantly be on manual check to determine when the connected battery is charged.

Irrespective of the discharge level of the battery received from customers, the service center operator often connects the battery and allows it to charge over night without monitoring. This frequent practice often leads to overcharging of the connected battery. Secondly, in an attempt to deliver quick service and satisfy the customer's expected time of need, they sometimes, adjust the charging setting of the charger to increase the charging current so as to reduce the charging time in order to get the battery charged within a short time. This kind of practice shortens the life span of the battery. However, these common problems had suggested the development and construction of a 12V portable battery charger with built-in automatic charging cut-off circuit in order to encourage domestic usage. This would help automobile drivers to avoid charging problems associated with commercial services centers.

Some components like a protection fuse and current reverse prevention diode were considered during development of this product to prevent problems that may result from short circuit current and reverse current.

Considering, the compact shape of the battery charger, with very low ventilation an extractor fan was incorporated to drive away hot air and moisture that would be generated inside the charger compartment during operation.

MATERIALS AND METHODS

List of Components

Table 1: Components Involved in the Design Construction.

S/N	Code Name	QTY	DESCRIPTION
1	R1	1	1K Resistor
2	R2	1	1.2K Resistor
3	R3	1	470Ω Resistor
4	R4	1	470Ω Resistor
5	R5	1	10K Resistor
6	C	1	10µF 25V Capacitor
7	D1	1	1N4001 Diode
8	D2	1	1N4005 Diode
9	D3	1	6.8V 0.5W Zener
10	TR	1	4.7K Trimmer
11	Q1	1	BT151 Thyristor
12	Q2	1	C106D SCR
13	BR	1	400V 8A Bridge Rectifier
14	T	1	220V/17V 4A Transformer
15	LD1	1	RED LED
16	LD2	1	GREEN LED
17	M	1	0-10A DC Ammeter
18	S	1	6A ON/OFF Switch
19	F	1	5A Fuse
20	FN	1	12V DC FAN
21	VR	1	LM7812 Voltage Regulator

Mode of Operation

With the presence of 220V AC mains supply, a 6A LED switch (S) is used to indicate and engage the presence of 220V AC supply in the transformer (T), where it is further stepped down to 17V AC to allow a current of 1A to 4A to flow.

The presence of a 5A fuse (F) in the output of the transformer is to ensure an open circuit once a current above its rated value attempt to flow through the circuit. The stepped down AC voltage flows into a bridge rectifier (BR), where it is converted to DC voltage. A certain amount of DC current flows through the current limiting resistor (R1) to emit the power indicating LED (LD1), which indicates the presence of power in the charging circuit.

The voltage regulator (VR) regulates the 17V DC at the output of the bridge rectifier to obtain the required 12V DC for suitable operation of the 12V DC FAN (FN) introduced in order to extract hot air generated inside the charger compartment during operation. Once a battery is connected, the voltage across the resistor (R3), forward biases the diode (D1), which triggers the gate of the thyristor (Q1), allowing current ranging from 1A to 4A to flow through the thyristor anode down to the positive charging terminal. This current that flows through is immediately measured by the connected 10A ammeter (M), to reveal the charging current of the charger. Before the battery terminals are connected initially, the voltage across the resistor (R4) causes the LED (LD2) to emit, which indicates that power is available at the charging circuit.

Following the adjustment of the trimmer (TR) to a predetermined cut-off voltage level, the charged LED indicator (LD2) stays ON, OFF or flickers when a single 12V battery is connected for charging. The status of the LED indicator (LD2) at this point depends on the charged or discharged level of the connected battery.

As the charging continues, the voltage built at the connected battery increases to a predetermined cut-off voltage level, enough to bias the zener diode (D3) to trigger the gate of the thyristor (Q2), enabling current to immediately flow through the anode of the thyristor (Q2) to the ground, which causes the thyristor (Q1) to be deactivated, thereby automatically cutting off the charging current to terminate further charging with the LED (LD2) off, to signal a battery full charge. The diode (D2) is a current reverse prevention diode used to prevent battery current from reversing back to the charging circuit to avoid battery drain during power outage.

RESULTS AND DISCUSSION

Parameters

Transformer type: Single phase step down Insulation transformer

Voltage rating: Output voltage (V_2) = 17V AC

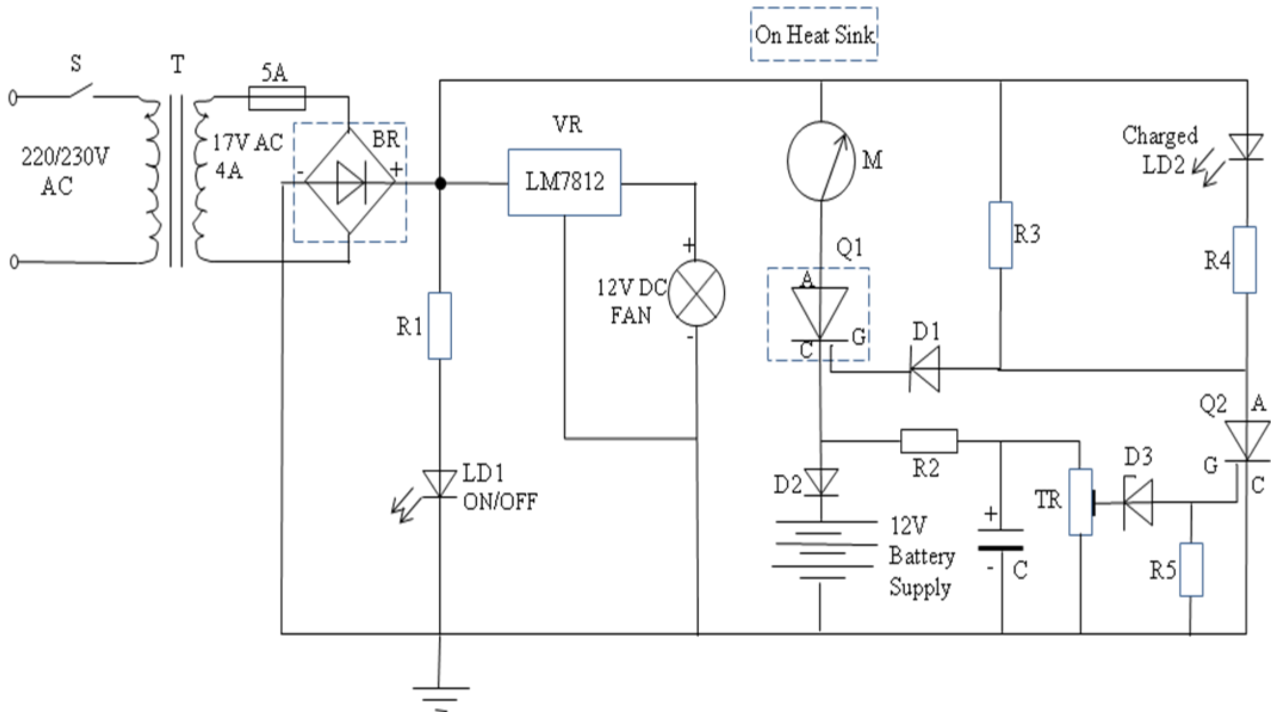

Figure 1: Circuit Diagram of the 12V, 3.5A Battery Charging Circuit.

Input voltage (V_1) = 230V AC

Turns ratio (N_1/N_2) = V_1/V_2 = 230/17 = 13.5

Current Rating:

Output current (I_2) = 4A

Input current (I_1)= V_2I_2/V_1 = 17x4/230 = 68/230 = 0.296A = 0.3A approx.

Power Rating:

Output power (P_o) **=** $V_1.I_1$
=$V_2.I_2$ = 230x0.3 = 17x4 = 68W

Charging Duration:

The length of time taken to recharge a battery depends on the battery amp-hour (AH) rating and the charger output current. To calculate an approximate total charge time, a good rule of thumb is to take the amp-hour rating of the battery and divide it by the charger rating. For example, to fully charge a 12V, 75AH battery using the constructed 12V 3.5AH charger. The charging time can be calculated using the formula as follows:

Charging Time of battery = Battery AH rating / Charging Current of the charger

T = AH / A

T = 75AH / 3.5A = 21hrs approx. if the battery was fully discharged

At battery full discharge, the terminal voltage is usually 10.5V and at full charge the terminal voltage is expected to be 13.2V mostly for lead acid type of batteries.

The recommended charging current for a 75AH battery is 10% of its AH rating, which is obtained as 75x10/100 = 7.5A.

This 12V DC 3.5A charger has been built with a low charging current that would admit long charging time on the required automobile batteries. Therefore, it is not suitable for industrial and commercial use.

Table 2: Design Specification.

Description	12V 3.5A Battery Charger
Input Voltage	220/230V AC
Output Voltage	12V DC
Input current	0.3A AC
Output current	3.5A DC
Charging mode	Constant voltage
Charger type	Automatic
Charged/cut-off voltage limit	13.0V DC
Operation frequency	50-60Hz
Cooling mode	Extractor fan
Charging time	22hrs for a single discharged 12V, 75AH Battery
Protection	Short circuit
Indicators	Power, operation and charged
Casing dimensions	18cm x 14cm x 8cm

Table 3: Test and Corresponding Results.

<table>
<tr><th>Test</th><th colspan="2">Result</th><th>Remarks</th></tr>
<tr><td>Transformer voltage test</td><td colspan="2">Output voltage yielded 18V AC when 230V AC was supplied to the primary.</td><td>Pass</td></tr>
<tr><td>Open circuit test</td><td colspan="2">No open circuit found</td><td>Pass</td></tr>
<tr><td>Short circuit test</td><td colspan="2">No short circuit found</td><td>Pass</td></tr>
<tr><td>Continuity test</td><td colspan="2">Circuit connection were continuous</td><td>Pass</td></tr>
<tr><td>Charging test</td><td colspan="2">Ammeter measured the output current when the battery terminal were connected</td><td>Pass</td></tr>
<tr><td colspan="4">Comprehensive charging test of the charger using a 12V,75AH battery</td></tr>
<tr><th>Time (Hrs)</th><th>Charging current (A)</th><th>Cell voltage before charging (V)</th><th>Cell voltage after charging (V)</th></tr>
<tr><td>2</td><td>3.5</td><td>11.92</td><td>12.18</td></tr>
<tr><td>4</td><td>3.5</td><td>12.18</td><td>12.44</td></tr>
<tr><td>6</td><td>3.5</td><td>12.44</td><td>12.70</td></tr>
<tr><td>8</td><td>3.5</td><td>12.70</td><td>12.96</td></tr>
<tr><td>10</td><td>3.5</td><td>12.96</td><td>13.22</td></tr>
<tr><td>12</td><td><0.5</td><td>13.22</td><td>13.23</td></tr>
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The following relevant tests were conducted using multimeter as the measuring instrument to ensure operational compliance and accountability.

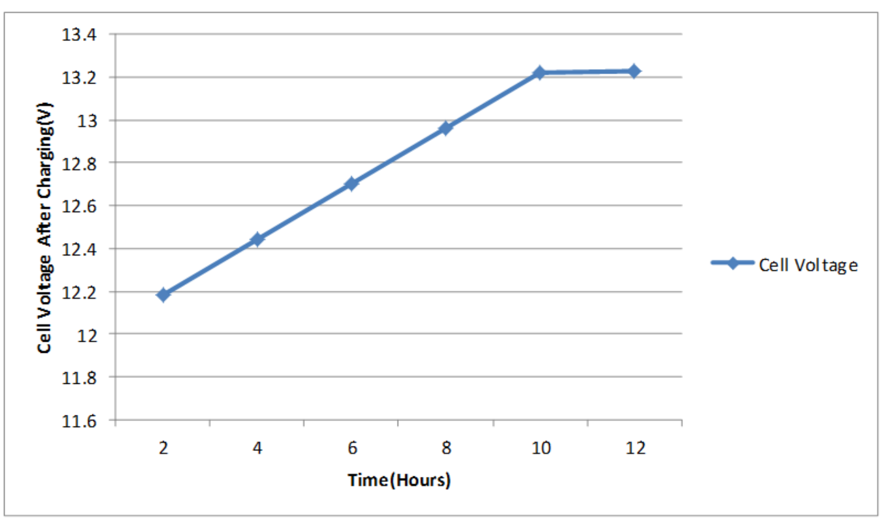


Figure 2: A Graph of Cell Voltage After Charging (V) Against Time (Hours).

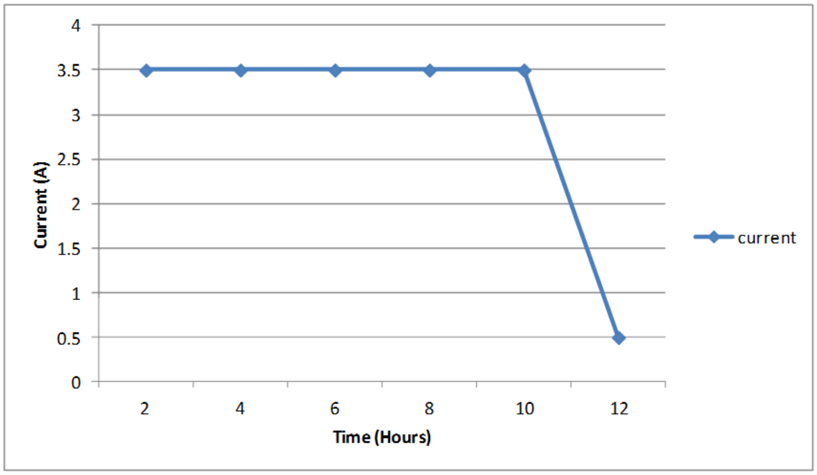


Figure 3: A Graph of Current (A) versus Time (Hours).

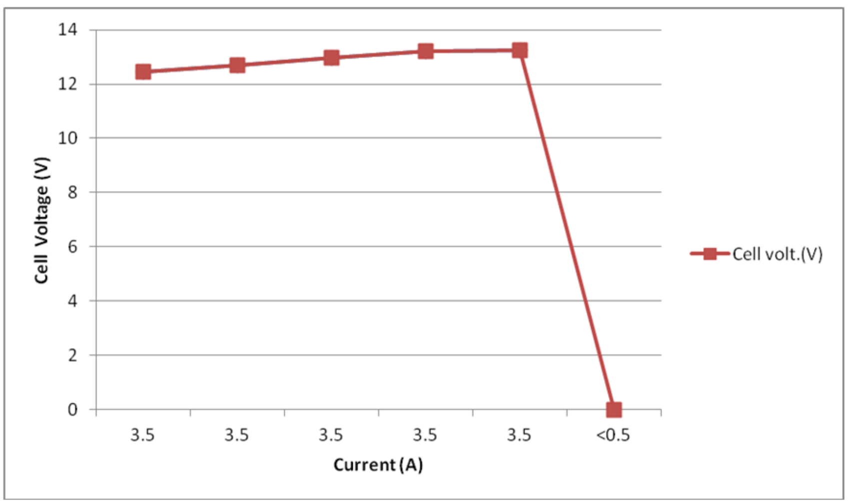


Figure 4: A Graph of Cell Voltage (V) versus Current (A).

The cell voltage increased gradually as the Time (hours) increases. The initial cell battery voltage was 11.92V before charging but it increased to 12.18V after charging for 2 hours. The maximum cell voltage obtained was 13.23V after charging for 12 hours. The current after 10 hours dropped to less than 0.5A, which is an indication that the battery is at its full charge.

DESIGN LIMITATION

● The AC to DC conversion here uses only the rectifier and may contain AC ripples as there is no filter.

● This 12V DC 3.5A charger has been built with a low charging current that would admit long charging time.

● It has been built to charge only 12V batteries.

● Not suitable for charging more than one 12V battery at a time. Therefore, it's not recommended for industrial and commercial purpose.

PRODUCT'S IMAGE LAYOUT

Extractor Fan

Power ON Switch

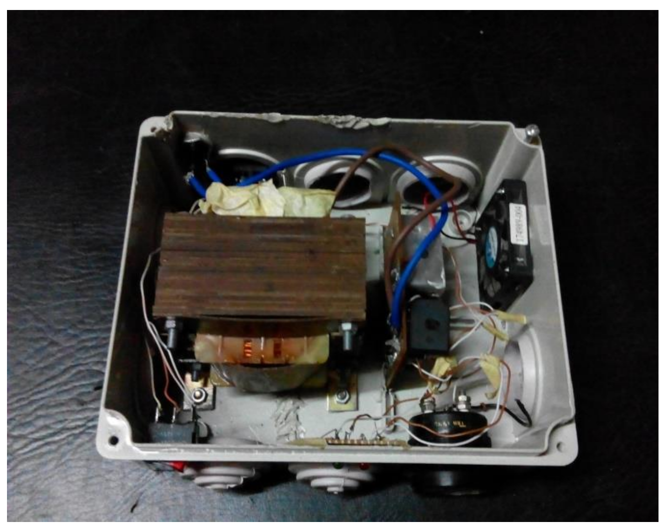
Charged LED Indicator

Rectifier LED Indicator

DC Ammeter

5A Fuse Link

220V AC Input/Charging Output Port



Internal view showing physical connections.

CONCLUSION AND RECOMMENDATIONS

The overall features of the battery charger certify it safe, convenient, and suitable for private home use. It is practically user friendly and does not require constant supervision during operation. The product is affordable and is recommended to every private vehicle owner who requires battery charging service at convenience.

The product would encourage innovation and development of other related products in a technical research environment. This product can be used to motivate students on industrial training when demonstrated. It has a promotional impact to any research or technical establishment. This product is capable of attracting the attention of sponsors and investors from different part of the country, if its functionality and appearance are intermittently improved with proper exhibition conducted. The importance of a portable battery charger of this kind to the society at large cannot be overemphasized since it practically eliminates issues associated with overcharging, short circuit and provides charging at convenience.

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