Development of Electronic Ballast for the Light Emitting Diode (LED) Lighting System

Mohammad Hafizi Bin Awang
Faculty of Electrical Engineering
UniversitiTeknologi MARA Malaysia
40450 Shah Alam, Selangor, Malaysia
E-mail: hurricane_bar69@yahoo.com

Abstract –**This paper describes a study and designs of electronic ballast which suitable to be used with light emitting diode (LED) as lighting system. The ballast can be operated with multi functions which are as charger and LED driver. The converter circuit need for this ballast is study and test. This system is design to replace the portable generator that commonly used by night market seller. The portable generator has more disadvantages other than advantages. The portable generator causes the air and noise pollution to the environment. Other than that, the operating and maintenance cost also high since it use fuel as working medium and engine to generate electricity. So this ballast is design to overcome this problem. This system use battery as working medium so instead of operates as driver to LED, this ballast also working as charger to charge the battery. Since the battery is used for supply the power, the conventional light bulb cannot be used as lighting system because it consumes large power to operate. So LED is choose as lighting system because it use less power to operate and produce light that comfortable to human eye.**

Keywords – LED, Converter Circuit, Electronic Ballast, Portable Generator

I. INTRODUCTION

The device that limit the current flow to the lamp during it operation is called ballast. Besides that, it also functions to regulate the voltage supply to the lamp. There are three types of ballast on the market for the lighting system which are magnetic ballast, hybrid ballast and electronic ballast. Magnetic ballast also knows as core and coil ballast. Magnetic core of several laminated steel plates wrapped with copper winding is contained in magnetic ballast while hybrid ballast which also called as cathode disconnect ballasts use a magnetic core and coil transformer and an electronic switch for the electrode heating unit. The electronic ballast is the most recommended ballast compare with the others because it is more efficiency and has less power loss [1].

The objective for this project is to study the Alternating Current (AC) to Direct Current (DC) converter that suite to charge the battery and the Direct Current (DC) to Direct Current (DC) converter that used as LED driver. Other than that, the objective also included to study the characteristic of this converter.

Nowadays the night market sellers used electric generator as the electricity supply to light up their stall. The function of electric generator is converting the mechanical energy to electrical energy. The portable electric generator is commonly used because it is easy to move and locate the generator at various positions.

The project is design to overcome the problem that faced by the sellers at night market. Instead of using the electric generators, the seller can used other alternative such as rechargeable battery to supply the electricity to their stall. The starting cost to buy the battery is less compare with the starting cost to buy the electric generator. Other than that, any extra cost such as cost to buy petrol or diesel can be eliminated when using the recharge battery. Furthermore, rechargeable battery also not produces either noise pollution or air pollution that release by the electrical generator. This could bring a lot of advantage to the seller also to the consumer and the environment. The energy also can be saved since the rechargeable battery not used fuel to operate.

When using rechargeable battery as the electrical energy supply, the power that delivers by the rechargeable battery is less compare to the electrical generator. So the lighting system on the stall is cannot use the conventional lighting which is light bulb. The light bulb used a lot of energy to operate depend on their output power (WATT). Due to that, the light bulbs can be replaced with the light emitting diodes (LED) which use less electrical energy to operate. LED allows a certain voltage only to operate, so the circuit converter that acting as electrical ballast must be design to allow the LED to function. The designed circuit not also allows the LED to operate but it also at the same time charge the batter to working with continuously.

LED not also save the electrical energy but it also provided the better quality of light. The light emitted by LED is more quality and comfortable to human eye compare with conventional bulb. The low light quality could bring harm to human eye.

II. METHODOLOGY

The whole system operation of the project is shown on the figure below. The charger circuit and the LED driver are combined on one circuit.

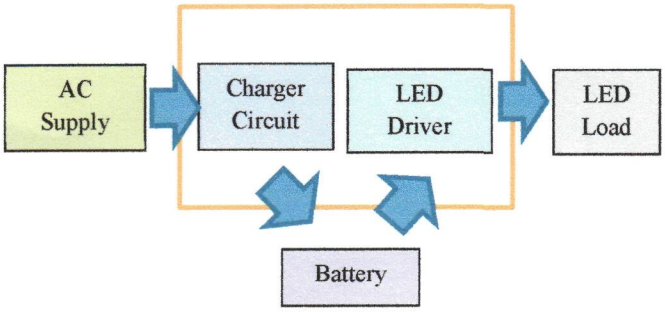

Figure 1. Basic topology of the system

The AC voltage from the supply is step down by transformer before enter the charger circuit. Then the regular will regulate the voltage and make sure there is enough voltage to charge the battery. The output voltage to charge the battery can be controlled by variable resistor either wants to increase or decrease the voltage depend on battery specification. After the battery is fully charge, it voltage will be used to light up the LED. Before that, the voltage must be regulate at the LED driver circuit so that the voltage that supply to LED is meet the specification need by LED and not blow up the LED. The function of the ballast can be assign by turn on the switch either operates as charger or driver. The LED driver which is DC to DC converter has been designed properly so it compatible with the white LED as lighting system.

The methodology for the whole circuit design is shown on the flow chart below. After the literature review, the simulation of the project is test on the breadboard first before it been implemented on the printed circuit board (PCB). This process is important so that the circuit must be test either operates well or not. The simulation of the project is done by using the Proteus software. The Proteus Virtual System Modelling will simulate and animated the component drawn on that so that the function of the circuit can be observed. The layout of the circuit also can design by using ARES which also included in Proteus Software. When all tests are done and obtain satisfied results, the prototyping process is proceeding. There is a lot of step need to be followed up to make sure this project is completely success and functional well.

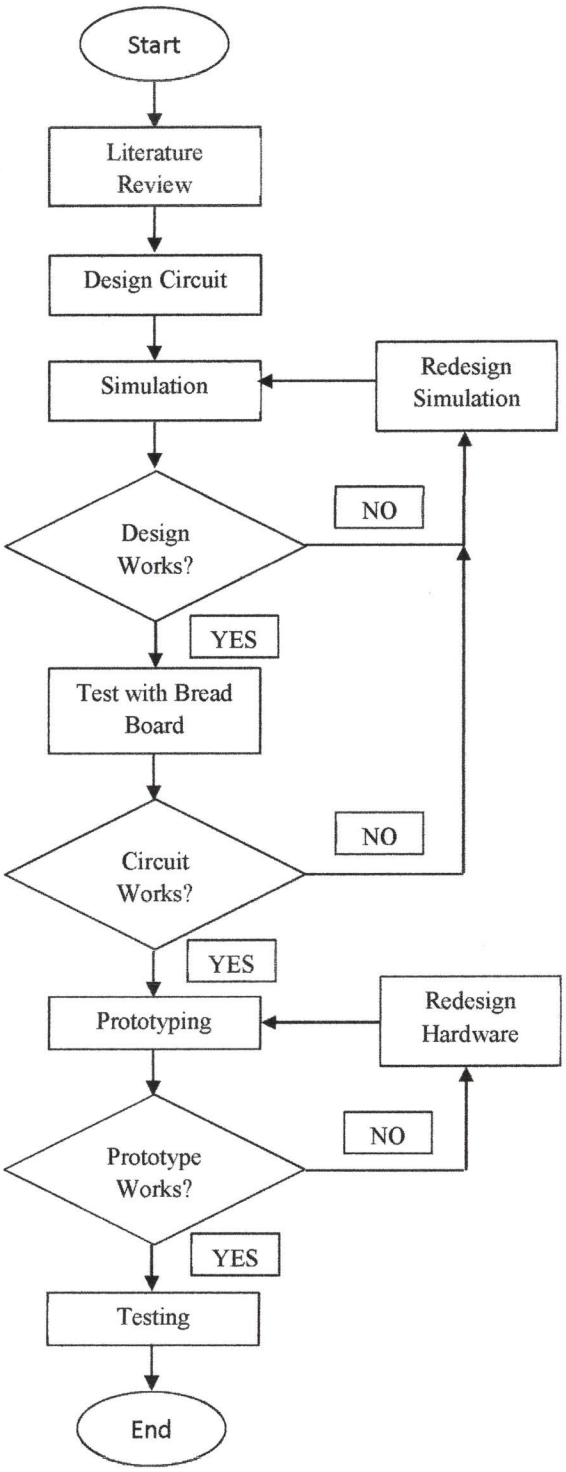

Figure 2. Flow chart of the project

III. CIRCUIT DESIGN

A. *Transformer*

Transformer is device that transfer electrical energy from one circuit to another either to decrease the voltage (step down) or increase the voltage (step up). The ratio of the voltage is controlled by the number of the turn on primary coil and the number of turn on secondary coil. Step down transformer refer to the number of turn on primary coil is greater that secondary coil. For this project, step down tranformer is used to drop the voltage from 230V of the supply to 18V so that compatible to input of charging circuit. To charge 12V battery, the voltage supply to battery must greater than 12V. The input for charging circuit is set 18V because the voltage will be drop when entering charging circuit.

B. *Rectifier*

The device that convert alternating current (AC) to direct current (DC) is called rectifier. Alternating currant flow in bidirectional which are forward and reverse, it must be rectified to flow in one direction only which is direct current. Four diode is used in rectifier circuit. Since diode only allow the current flow in one direction, so it is used as the rectifier components. The output from the diode is not completely DC so capacitor must be placed in parallel so that the output obtain is almost DC.

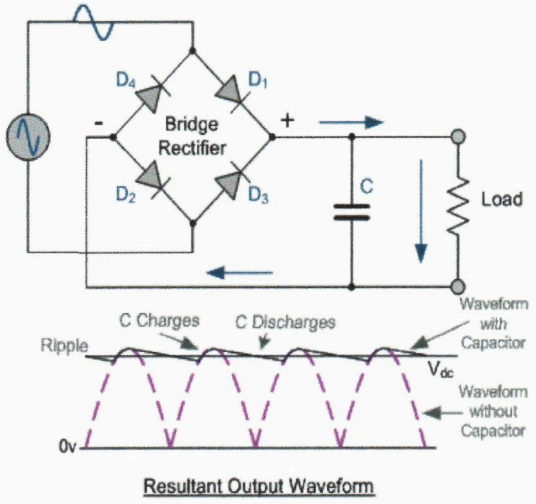

Figure 3. Rectifier Output Waveform

C. *Voltage regulator*

The linear voltage regulation LM 317 is used in the charging circuit to regulate the output voltage. It also can provide the adjustable output voltage over 1.2 to 37V range. and provide more than 1.5A from load current. Other than that, it also build up with complete series of protection which current limiting, thermal shutdown and safe area protection. The LM 317 is choose because it provide the correct charging voltage for the battery. The bipolar junction transistor, Q1 and resistor R3, R4 will control the charging current for battery while variable resistor is used to set the charging current. Other than that, voltage regulator also regulate the output voltage from rectifier and capacitor that almost DC to completely DC. Figure below shows the LM317 circuit connection

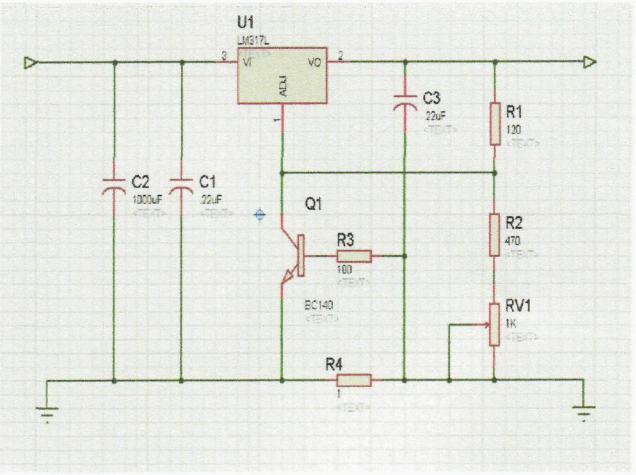

Figure 4. LM 317 Connection

For the LED driver circuit, L200 voltage regulator is used. This is due to L200 can regulate both voltage and current on the circuit. It will limit the current and voltage supply to LED so that no over current and over voltage occur that will blow or broke the LED. L200 voltage regulator has the adjustable output curent up to 2A and adjustable output voltage down to 2.85V. Other than that, it also also has input overvoltage protection up to 60V and has short circuit protection. This regulator hard to blow out proof since it is build with current limiting, power limiting and thermal shutdown. The voltage is limit by the resistor R1 and R2 which connected to the reference voltage terminal of the regulator. Figure below shows the L200 circuit connection.

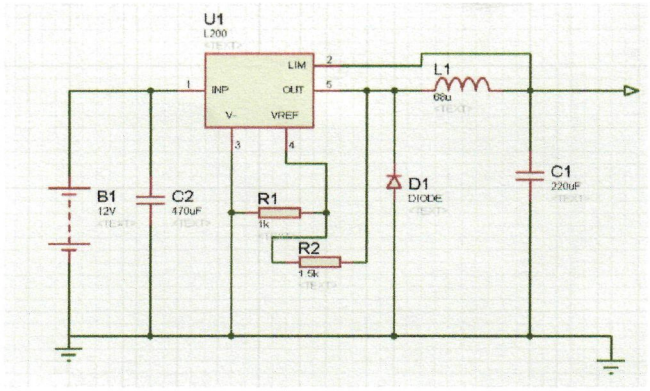

Figure 5. L200 Connection

D. *Light Emitting Diode (LED)*

The electronic semiconductor device that emits lights when an electric current flows through it is called Light Emitting Diode (LED). The LEDs are hard and rarely burns component if no over current flow through it and also have greater efficiency that incandescent bulb. They are often used as an indicator lamps in many devices and are increasingly used for other lighting[2].Electrons are able to recombine with electron holes within the device when LED is at forward-biased condition (switched on) and also releasing energy in the form of photons through this process. This effect is called electroluminescence and the energy gap of the semiconductor is determined the colour of the light [3]. LED is used as the lighting system of this project because it consume less energy and can light up the night market all night long to battery as power supply. Figure below shows the LED construction.

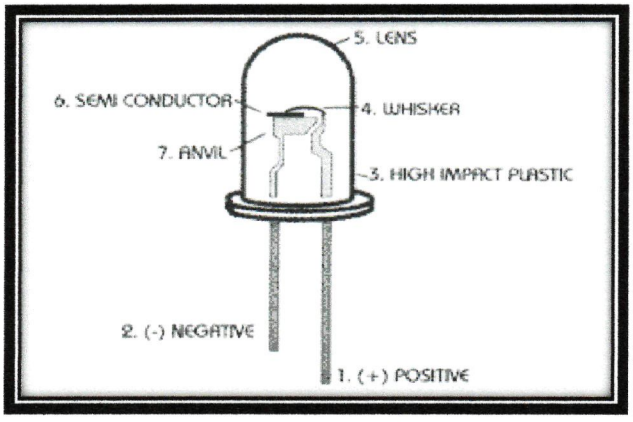

Figure 6. LED Dimension

E. *Full Circuit Design*

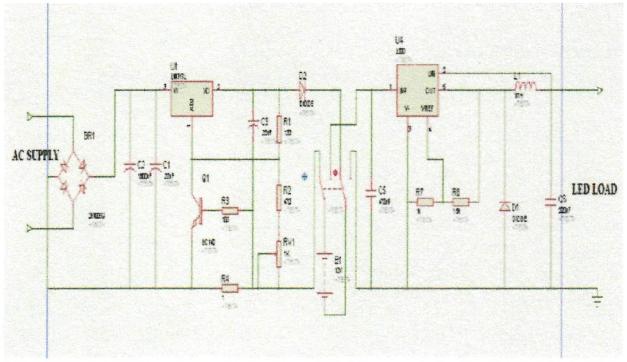

Figure 7. Full Circuit connection

The figure above showed the whole circuit of the ballast. The AC supply is from secondary winding of the transformer which is 18V. Both regulators which are L 200 and LM 317 are used to stabilise the voltage in the circuit. The switch is located at the middle of the circuit which function to switch the battery from charger circuit to the LED driver.

IV. RESULTS AND DISCUSSIONS

A. *Hardware*

Figure 8. Hardware Design

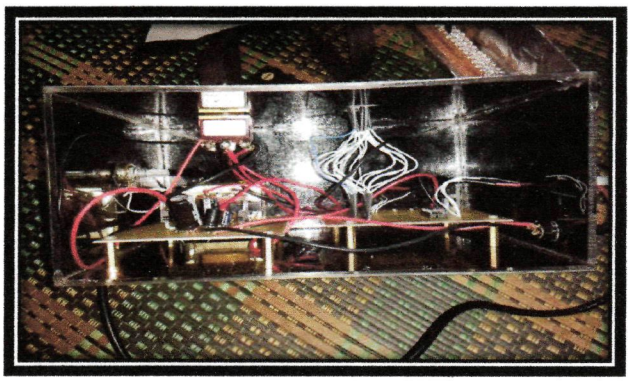

Figure 9. Internal Circuit

Figures above shows that the hardware that has been designed. Both charger and driver circuit that has been combine is located on the box that made by the Perspex. The Perspex then is wrapped by the carbon sticker so that it look solid, tidy and interesting .The shape of the model does not means anything other than just as a casing to protect the circuit so that it is easy to be move and locate to different location and place without damage the circuit. One side of the box is left unclosed so that it easy to troubleshoot if the problems occur.

B. Ballast Characteristic

a. Charger Results

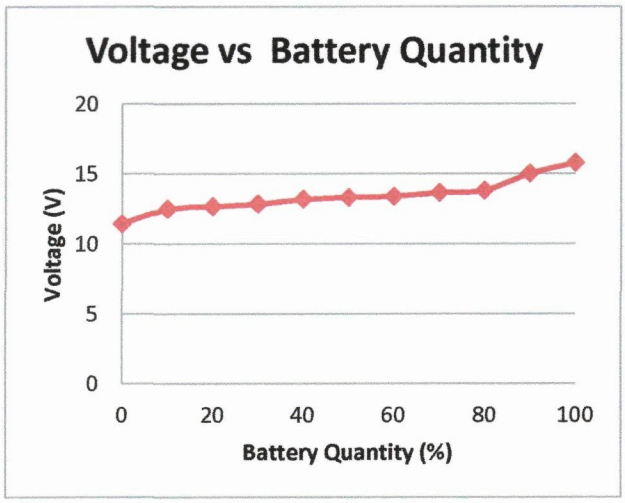

Figure 10. Voltage vs. Battery Quantity while battery is under charge

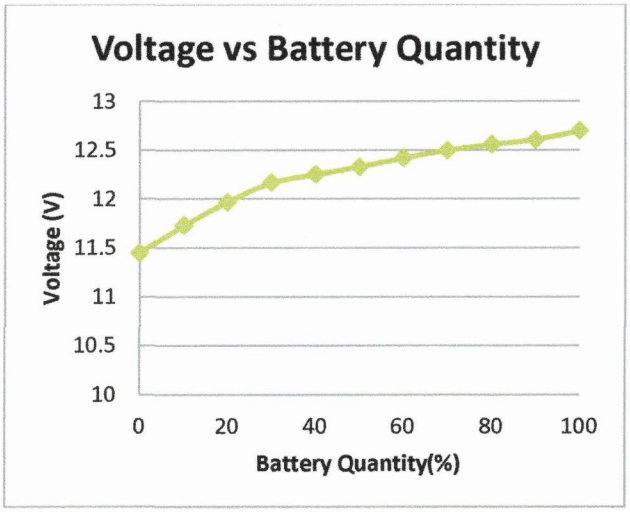

Figure 11. Voltage vs. Battery Quantity while battery at rest

Both graphs show that voltage is increase when battery quantity is increase. This is due to current that flow through the cell of the battery when the battery is charged. When there is current flow to the battery, the cell voltage of the battery will rise due to internal cell resistance of the battery resulted from the moving current. From the both graph, it can be observed that there is different characteristic of the voltage when the battery is under charge and battery is at rest. Battery quantity at fully charged has higher voltage when battery is under charge which is 15.8V compare to when battery at rest which is only 12.7V. This is due to when the battery is under charge there is variation of voltage resulted from current moving while when battery at rest there is no current flowing. Battery quantity when battery at rest is more accurate compares to when batter undercharge.

b. Discharged Results

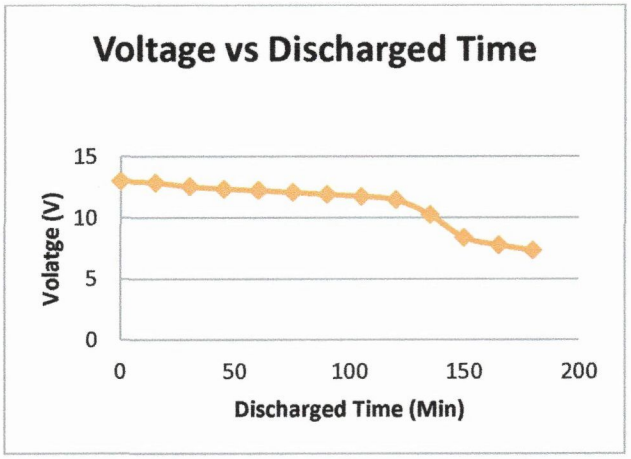

Figure 12. Voltage vs. Discharged Time

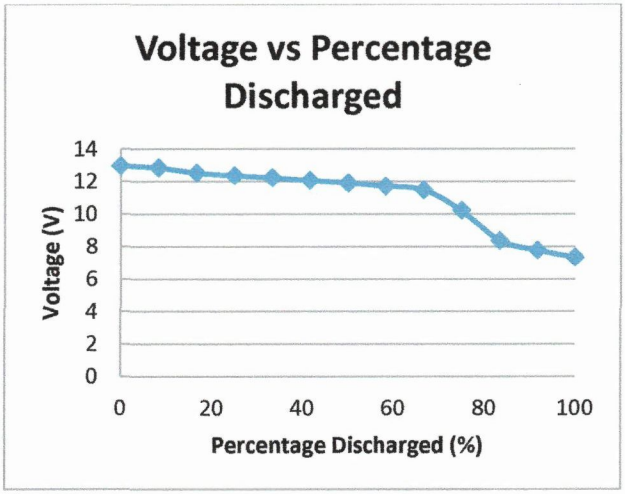

Figure 13. Voltage vs. Percentage Discharged

For this analysis, 30 white LED has been used as LED load to show the discharging time for the battery. From the graph it can be concluded that the voltage is drop continuously until the battery is out of charge. This is due to the constant LED load that we used. The white LED consume same amount on energy to operate all the time. The graph also indicates how much current is drawn from the battery. Small voltage drop across the internal resistance of battery occur when current is drown from battery. The current used by LED is small so it takes a lot of time for the current is completely drawn from battery. The battery can be assumed out of charge when the LED is dimmed when it reach below than 7V voltage. The battery can stand until 3 hours before it out of charge because the Ampere-Hours (AH) for the battery used is small which is only 1.2Ah. The Ampere-Hours (AH) indicates the amount of the power available in battery. This condition is valid since the project is just a model and the load used also small which only 30 white LED.

V. CONCLUSION AND RECOMMENDATIONS

The ballast that was design is able to functional well and achieves the objective needed. Both circuit which are charger circuit (AC to DC converter) and LED driver (DC to DC converter) is able to be combined on one circuit and functional well. The LED loads manage to be light up by using the LED driver that has been designed and the charger also can charged 12V and meet specification needed. The characteristic of the ballast also can be observed and study through this project.

Since this project just the model to be study, there is a lot of thing can be improved. Provided suggestion is to build the actual prototype so that this idea can be commercialised and installed on the night market to replace the existed system. Other than that, the controller also can be added to charger circuit so that it will automatically stop to charge the battery when it is fully charged. This is important since the overcharge of the battery will reduce it life span. The amount of LED used also must be carefully calculated so that it will able to light up the stall.

It can be concluded that this project is completely success and able to achieve the objective needed.

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