SIMULATION OF SMART STREET LIGHT INTENSITY CONTROLLER: AN ENERGY SAVING APPROACH

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Abstract: It is very common these days that we see street light powered with solar panels. As the fossil fuels are degrading and also polluting the environment the use efficient power systems needs to be implemented. This paper presents a remote sense based street light system. This system can put effort to vary intensity according to the density of the traffic and pedestrians. Also the High Intensity Discharge lamp is replaced by LED's. The system can be easily implemented widely where there is need of timely control. This paper proposes energy efficient of smart- street lighting system using low cost microcontroller based Ardiuno. The main objective is to design energy efficient smart streetlight for energy conservation in existing streetlights of rural area, urban area and exclusively for smart cities. The system consists of LED luminaire, LED driver, PV panel, charge controller light sensor, motion sensor, Ardiuno. The smart streetlight is controlled on the basis of traffic on road and day/night time. The system is programmed to automatically turn off during the hours of daylight and only operate during the night and heavy raining or bad weather.
Keywords: LED, Energy Conservation, Audit, etc.

I. INTRODUCTION

Energy management is the primary and necessary step towards energy conservation. Saving energy has become one of the most important issues these days. The most waste of energy is caused by the inefficient use of the consumer electronics. Particularly, a light accounts for a great part of the total energy consumption. Various light control systems are introduced in current markets, because the installed lighting systems are outdated and energy-inefficient. However, due to architectural limitations, the existing light control systems cannot be successfully applied to home and office buildings. For any organization or industry, the main three top operating expenses are often found to be energy (both electrical and thermal), labor and materials. If one were to relate to the manageability of the cost or potential cost savings in each of the above components, energy would invariably emerge as a top ranker, and thus energy management function constitutes a strategic area for cost reduction. In most public indoor areas and offices, the light is used during the day time, but most of the times the amount of light intensity needed is almost half of the amount of power consumed for the lights, so by being able to control the suitable light intensity on various times, the consumed power will be reduced. The outline of the paper is as follows. Section II discuss the review for the problem identification and our motivations on developing the methods for HSAPF for power quality enhancement. In Section III, the working of HSAPF and controlling scheme is discussed using different topologies for voltage profile improvement. The controlling system development and modelling of proposed HSAPF also discussed in Section IV. Section V shows the Matlab simulation and results for proposed series APF for voltage profile enhancement and we also provide a discussion on simulation results. The conclusion remarks are in Section VI.

II. PROBLEM IDENTIFICATION AND OBJECTIVES OF HSAPF

Many researches on the lighting control system. Recently, attention has been paid to techniques and methods of save electricity, automated system, which improving efficiency and reduces size. The existing systems in industry consist of manual controls which need constant monitoring and maintenance. Considering the wastage of energy due to manual control many systems have been introduced. Time slot based systems consider the time slot as an advantage, but it actually is a drawback as it could not work in all conditions. Also, if any, hardware failure or error occurs, it could be expensive to solve it. Thus, another system is needed which overcomes these drawbacks.

Recently, an intelligent lighting control system using various sensors and communication modules are actively studied and developed in both university and industry. The objectives of this project are, to design and develop an optimal power usage for lighting system that will vary the power consumption depending on the surrounding's light intensity, to reduce electrical power consumption by reducing the light source intensity when necessary. All things considered, design goals of the new lighting control system are as follows:

- New device exploration
- Reduce electrical power consumption
- The new lighting control system should be designed to maximize the utilization of an LED and accurate and speedy configuration.
- The new intelligent lighting control system should be designed to have the communication capability and the control based on the situation awareness.
- Automated system so reduce maintenance and minimum human assistance
- The new intelligent lighting control system should be designed to enhance both energy efficiency and user satisfaction.
- Using a variable component such as a digital potentiometer and use of microcontroller based automated system allows designers to design systems that are flexible and multifunctional.

III. PROPOSED WORK

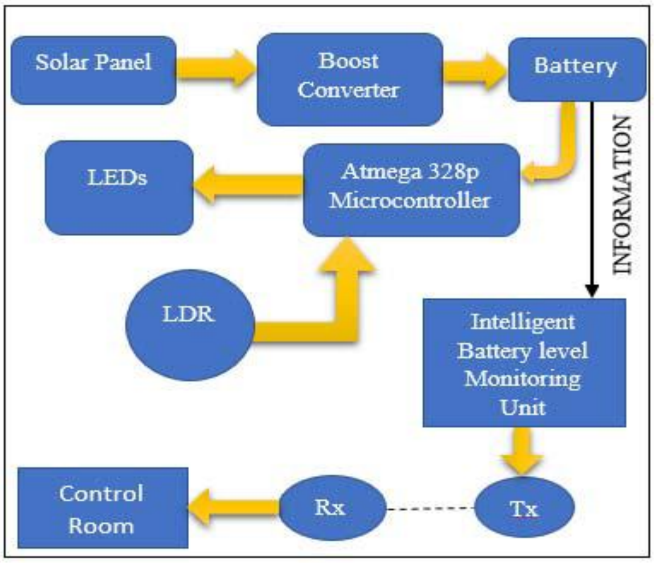

Fig.3.1: Block diagram representing the flow of control within the system

The dc supply given to the LED is first given to the filter which reduces the voltage spikes. Then the voltage regulator regulates the voltage and it is viewed by power indicator. Digital resistor includes digital potentiometer MCP41010 and serial interface communication RS232 and SPI protocol for LED controlling. The data received by the computer is given to the PIC microcontroller by communication port RS232. The output of the IR sensor is given to the microcontroller which is used to on/off the LED light. The digital resistor MCP41010 gives the programmable data to the switching regulator which is used to regulate dc supply of bulb or light so the intensity of the LED.

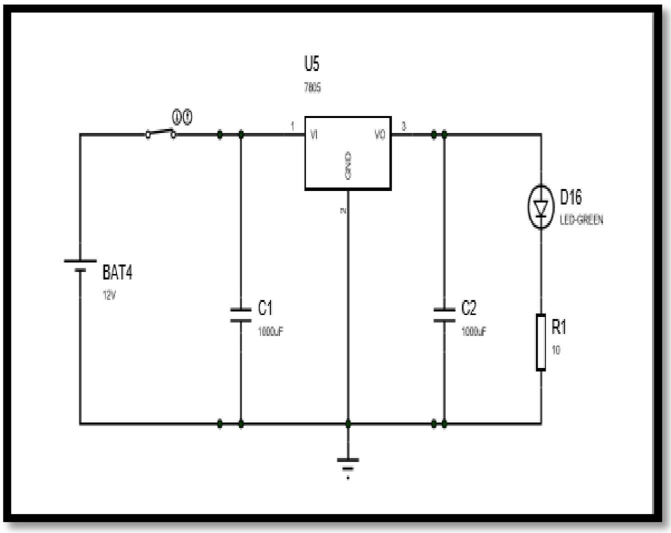

Fig.3.2.power supply conversion section

In the power conversion section the power supply is converted from 12V DC to 5V DC. The microcontroller uses 5V supply for its process. Also the 5V supply is given to the LED for power indication. The 5V supply is given to the LDR sensor, relay, LCD and digital resistor for its working. Here the 12 volt dc supply is used for the testing by using battery.

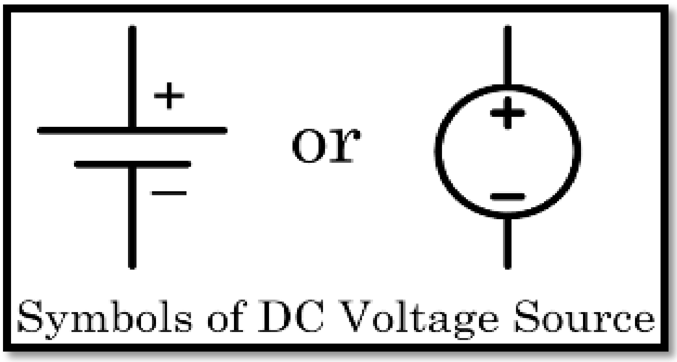

Fig.3.3: DC voltage source

A light-emitting diode (LED) is a two-lead semiconductor light source. It is a p–n junction diode that emits light when activated. When a suitable current is applied to the leads, electrons are able to recombine with electron holes within the device, releasing energy in the form of photons. This effect is called electroluminescence, and the color of the light (corresponding to the energy of the photon) is determined by the energy band gap of the semiconductor. LEDs are typically small (less than 1 mm2) and integrated optical components may be used to shape the radiation pattern. LEDs have many advantages over incandescent light sources, including lower energy consumption, longer lifetime, improved physical robustness, smaller size, and faster switching. Light-emitting diodes are used in applications as diverse as aviation lighting, automotive headlamps, advertising, general lighting, traffic signals, camera flashes, lighted wallpaper and medical devices. They are also significantly more energy efficient and, arguably, have fewer environmental concerns linked to their disposal. A P-N junction can convert absorbed light energy into a proportional electric current. The same process is reversed here (i.e. the P-N junction emits light when electrical energy is applied to it). This phenomenon is generally called electroluminescence, which can be defined as the emission of light from a semiconductor under the influence of an electric field. The charge carriers recombine in a forward-biased P-N junction as the electrons cross from the N-region and recombine with the holes existing in the P-region. Free electrons are in the conduction band of energy levels, while holes are in the valence energy band. Thus the energy level of the holes is less than the energy levels of the electrons. Some portion of the energy must be dissipated to recombine the electrons and the holes. This energy is emitted in the form of heat and light.

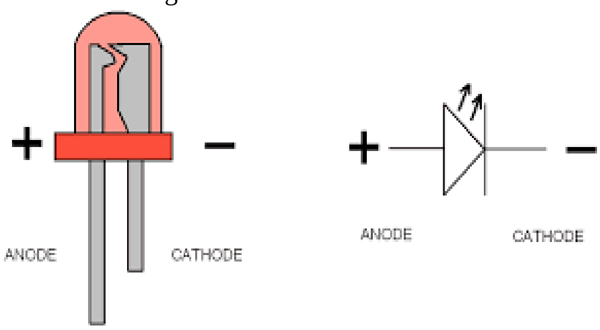

Fig.3.4: LED light

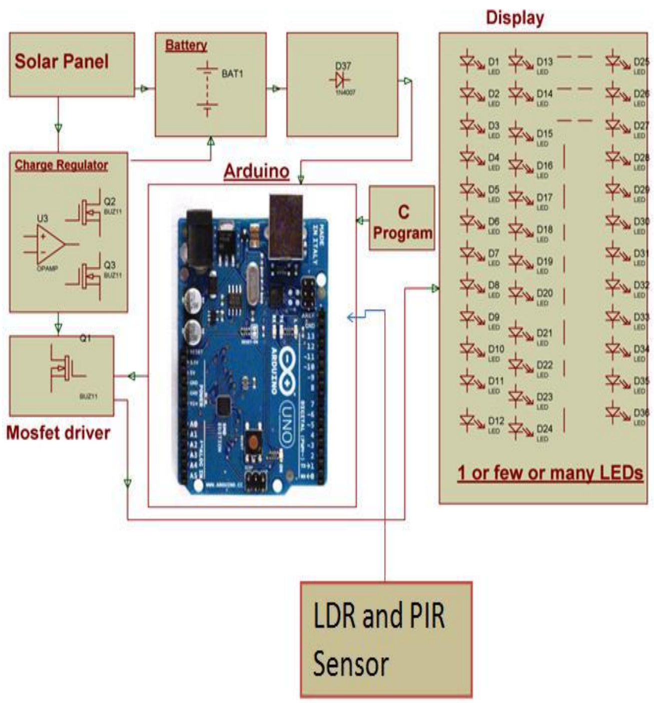

Figure-3.5: Block diagram of proposed system

1) Arduino:
Arduino Uno R3 [4] specifications are ATmega328 microcontroller, operating voltage at 5v, input voltage 7 to 12v, input voltage limit up to 20v, digital I/O pins 14, analog pins 6, DC current 40mA, flash memory 32KB including 0.5KB used by boot loader. SRAM of 2KB, EEPROM of 1KB and clock speed of 16 MHz some of the Features of Arduino UNO are power: can be USB connection or external power supply, with 7 to 12 volts recommended. The Arduino UNO provides power pins for other devices, the variants are 5v, 3.3v and Vin IOREF pin for optional power.

2) Solar panel:
As the name implies, these are cells that are grown from a single crystal. The Mon crystalline solar PV panel is more efficient than polycrystalline panel. Efficiency is about 18%. High Efficient Mon crystalline solar panel generates electricity during day time and it is stored in battery.

3) Battery:
It is a type of rechargeable battery, which uses lithium ion Phosphate as a cathode material. Li ion Ph batteries have somewhat high energy density, light weight offer longer lifetime. Inherently safer hence lithium ion Phosphate is popular among all storage batteries.

4) Sensors:
LDR (Light Dependent Resistor):
Light Dependent Resistor as the name suggests the resistance is dependent upon the light incident on it. The LDR resistance changes with intensity of light, with increase in light intensity the resistance offered by the sensor decreases. LDR sensor gives analog input value to control circuit. This value can be used to automatically turn on/off the LED streetlight.

Charge Controller:
Charge controller is the interface between Solar Array and battery bank. It protects the battery from overcharging and moderate charging at finishing end of charge of battery bank. Therefore it enhances the life of the battery bank. It also indicates the charging status of batteries like battery undercharged, overcharged or deep discharged through LEDs indications. Some switches and MCBs are also provided for manual or accidental cut-off of charging. In some charge controllers load terminals are also provided through a low battery charge cut-off device so that it can protect the battery bank from deep discharge.

5) LED driver:
It is basically coverts the inputs AC supply into DC supply with appropriate voltage level required to LED array. There is much research is going on for improving the lifespan of LED driver. The lifespan can increased by reducing the load on LED driver that is by means of smart controlling of intensity level as proposed in this paper.

IV. HARDWARE IMPLEMENTATION

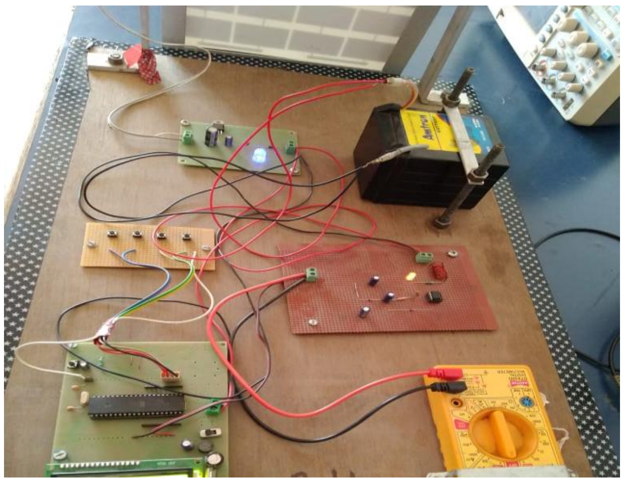

Fig 4.1- Solar PV System with Boost Converter

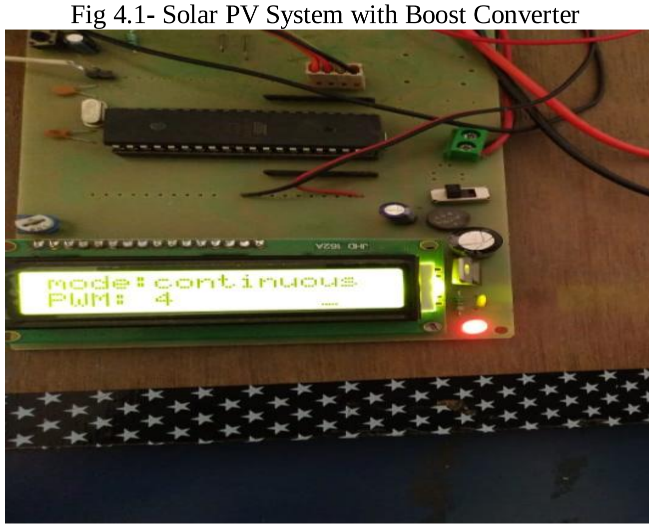

Fig 4.2- PWM of Boost Converter

Fig 4.3- Output Voltage of Boost Converter

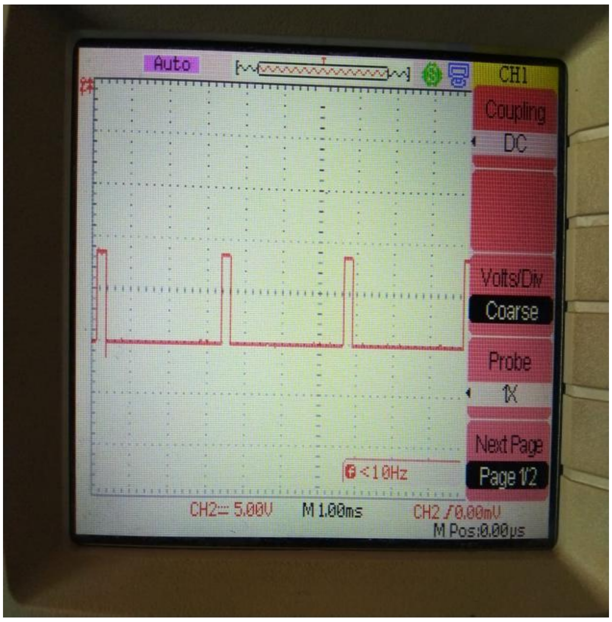

Fig 4.4- Triggering Pulses for Boost Converter

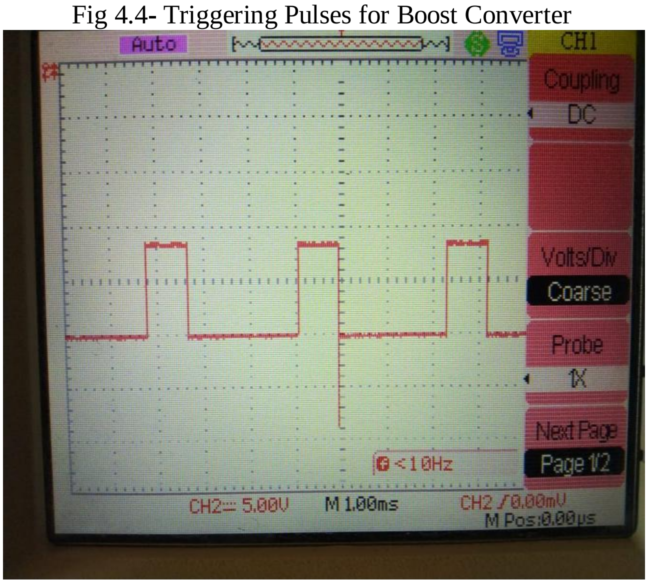

Fig 4.5- Triggering Pulses for Boost Converter

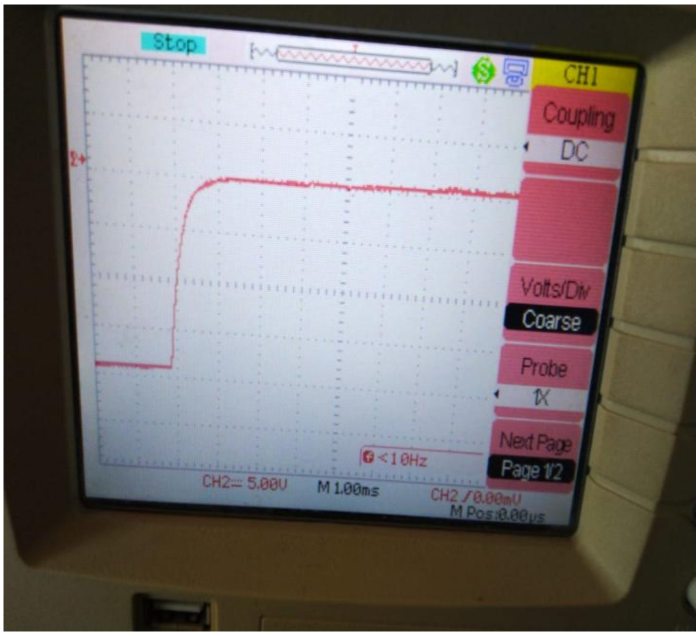

Fig 4.6- D.C output voltage of Boost Converter

V. SIMULATION AND RESULT DISCUSSION

Solar PV with Droop Control Simulation

Voltage droop is the intentional loss in output voltage from a device as it drives a load. Employing droop in a voltage regulation circuit increases the headroom for load transients. Although it may seem counterproductive, a series resistor is included between the regulator output and the load.

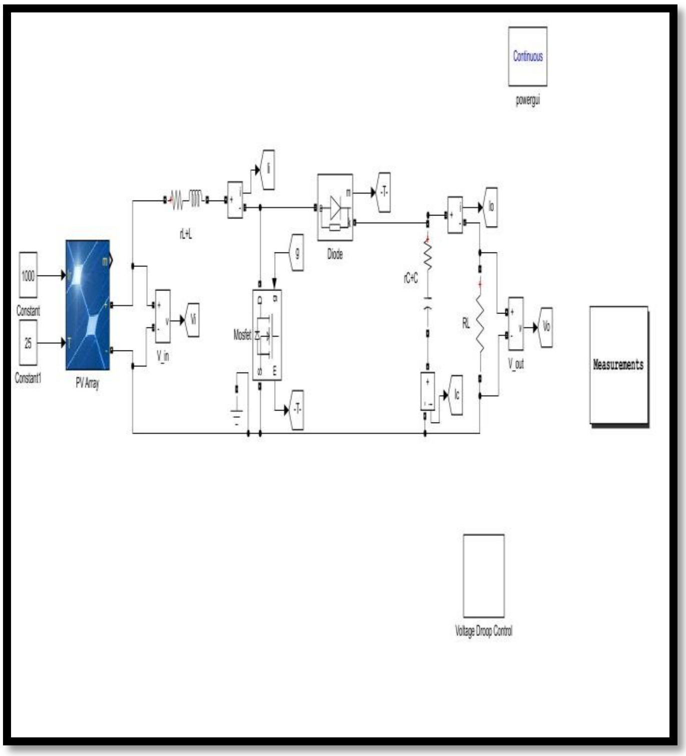

Fig 5.1- Matlab Simulation of Solar PV with voltage droop control subsystem

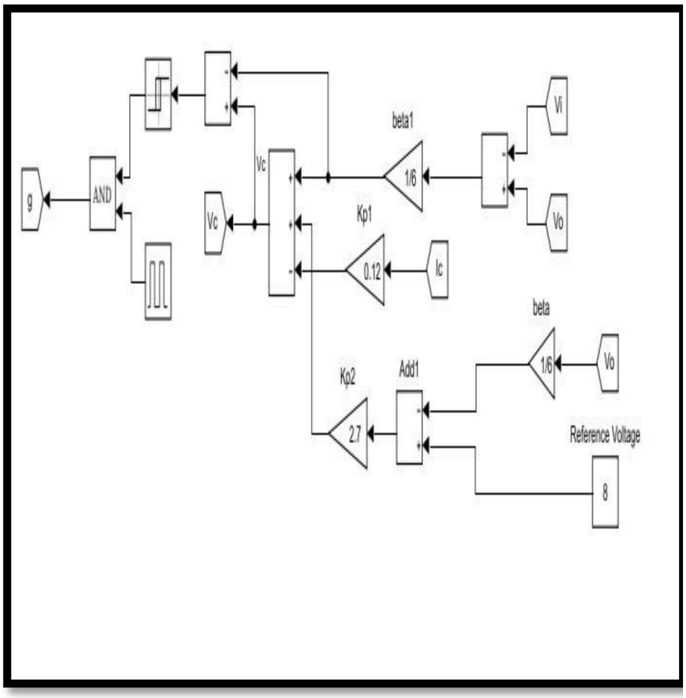

Fig 5.2- Voltage Droop control subsystem

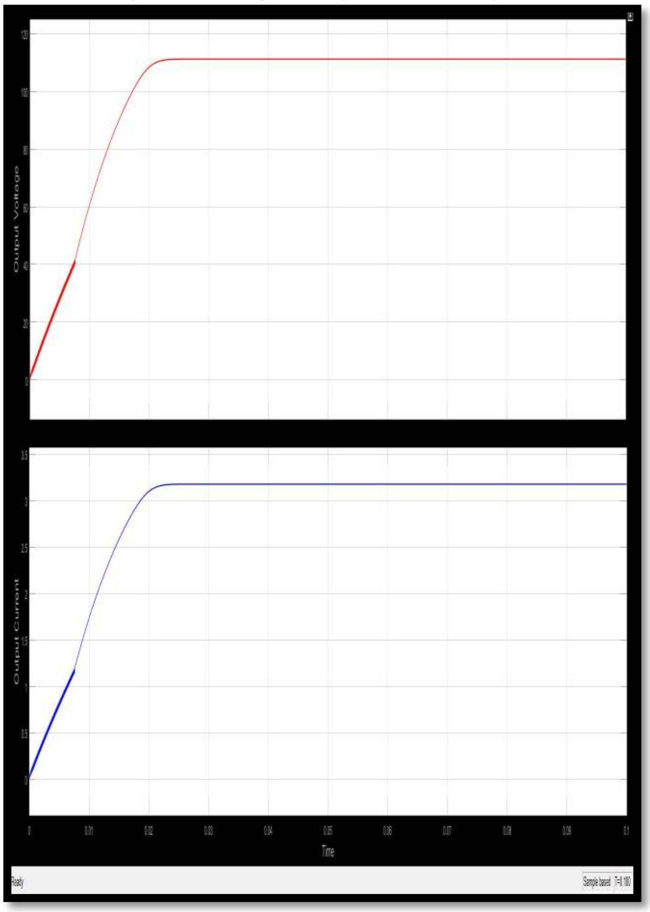

Fig 5.3- Output Voltage and Current of Solar with Droop control

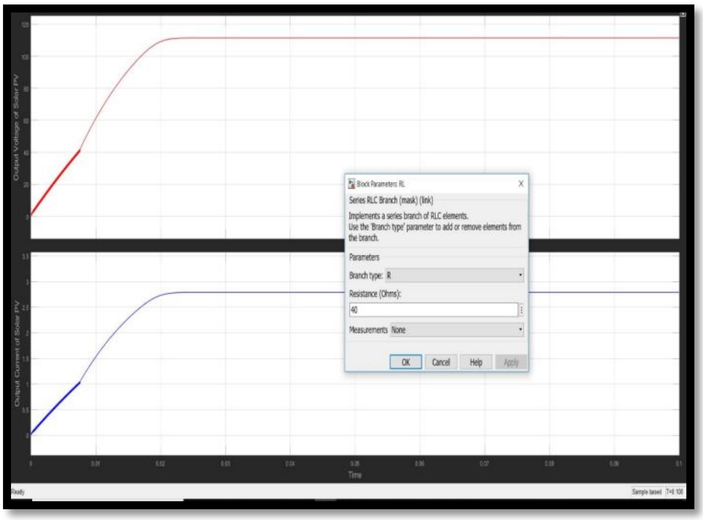

Fig 5.4- 40 ohm Load condition output at Voltage Droop

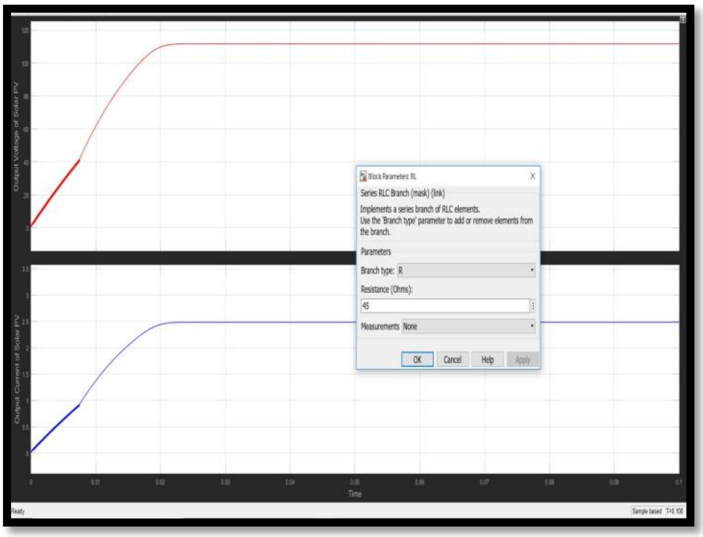

Fig 5.5- 45 ohm Load condition output at Voltage Droop

Results and Discussion

The results were obtained in term of voltage variation within time, there were two led light bulb named bulb A and bulb B. The one beside the window was bulb A, the results are shown in the tables below.

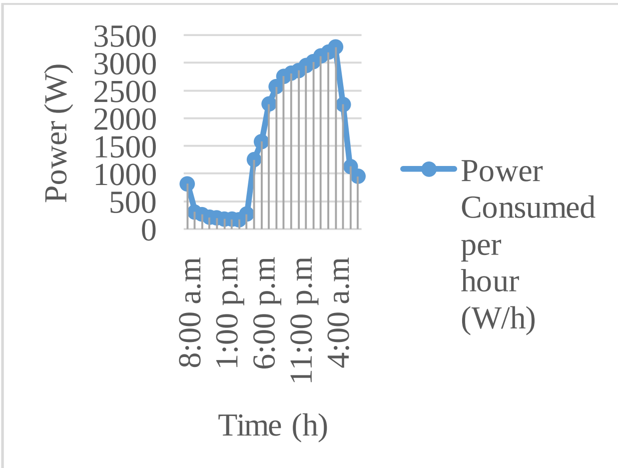

Fig.5.6 Bulb A power consumption against time

The prototype room was placed in a way that its window was facing the sunrise to obtain the maximum external light source which is the sun. As it is observed in the graph in Fig.5.6, at 8.00am the external light source is slightly low, so the power consumption is a bit high, but within that time the sun starts to rise and a sufficient amount of light passes through the window, the system to reduce the light intensity. Thus, power consumption will be reduced. Then the graph will maintain until 2.00pm and the consumption starts to increase, this is because the position of the sun was vertical above the room, only slight amount sunlight passed through the window. The more the sun moves toward sunset, the darker it gets, the power consumption will be higher. At 5.00 pm the power consumption increases rapidly due to the absence of external light sources. It can be noticed that at 7.00pm the incremental rapidity reduces, this is because the street lights were turned on, hence, street light can be considered as external light sources that helps to reduce the power consumption. The shape of graph in Fig.5.7 is similar to the shape of the graph of bulb A in Fig.5.6, except that the power consumption of bulb B is slightly higher, this is because the bulb B is further from the window compared to bulb A, the external light source does not reach it's lighting spread area as much as it reaches the lighting spread area of bulb A.

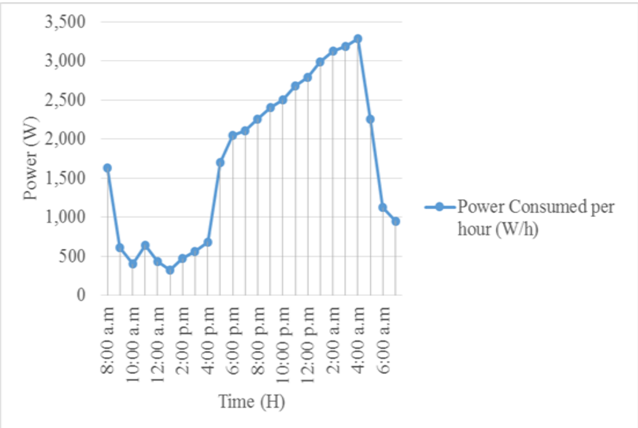

Fig 5.7-Bulb B power consumption against time

For comparison purpose a test of bulb power consumption of the bulb without applying the system was also carried out. The result for this is described in the graph shown in Fig 5.8.

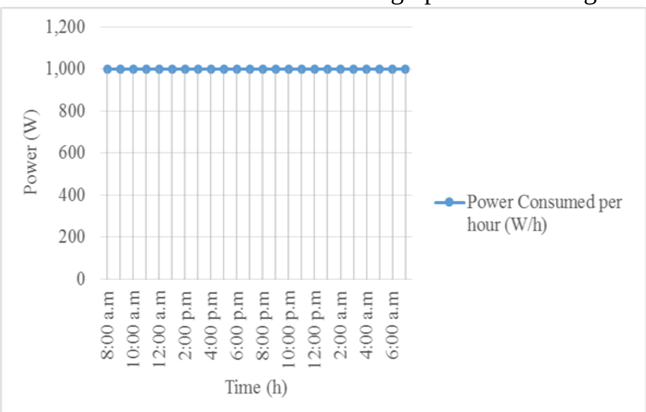

Fig.5.8Bulb's power consumption without applying the system

Power consumed at each instant is one watt when the system is not applied, this is the reason the graph is horizontal without any fluctuation.

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