Development of Solar Power Intelligent Street Lights System

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Abstract- The lack of natural light during night time in the urban environment has always been a problem. From people not being able to see where they are going, to the greater chance of being attacked or mugged at night which as we all know is a problem that has been in existence since humans started living together. The main advantage of this system exists in the reduction of costs related to energy consumption by the street light by integrating a vehicle/human detection algorithm into the system. The introduction of this vehicle/human detection algorithm further reduces the power consumption costs. In this project, solar PV is used to supply the energy to charge the battery. The battery later powers the operation of the whole system. The 12-17V of the solar is buck to a steady 12V for battery charging. A light sensor is connected to the microcontroller that sense the light during day time, when the presence of day light is sensed the microcontroller turns ON the mosfet of the buck converter. If the voltage of the solar PV is greater than 12V, it charges the battery and switches off the load transistor. But at dawn, when the solar PV voltage is less than 12V the microcontroller turn OFF the buck converter mosfet and switch ON the load transistor. When no vehicle or human is detected for 10mins the microcontroller dims the LED lamp. If vehicle or human is detected the microcontroller brighten the LED lamp and inform the next microcontroller to brighten its LED lamp. If the next street light did not detect a vehicle or human after 10 mins it dims the lamp but if it detects a vehicle or human the lamp remain brightened. The microcontroller uses the ultrasonic sensor to detect object and the PIR sensor to detect human. The RF module is used for communication between the microcontrollers to inform each other the presence of vehicle or human.

Index Terms- PIR, Ultrasonic, LDR, microcontroller, Buck converter, street Light and control

I. Introduction

Street Light or Lamp is a source of light raised on the edge of a road, pathway or walkway to illuminate its environment in the event of night time or bad weather conditions. Most street lights of today are designed to automatically turn ON/OFF when needed: dusk, dawn, or the onset of dark weather. The goal of this project is to design a circuit that makes an automatic street light intelligent enough to dim it's light during the wee hours of the night while also having the capability of brighten it's light during the same hours of the night on the detection of any vehicular or human movement thus reducing energy consumption by the street lights while increasing their life span.

II. LITERATURE REVIEW

There are several attempts to control the road lighting for saving energy and to reduce light pollution. In [1, 2] a road lighting intelligent control system was proposed. The system was based on wireless network control that can implement real-time monitoring for road lighting. The proposed system uses the Zigbee wireless networks and GPRS standard to monitor the status of the lamps. Similar work using zigbee, solar panel, IR sensor, air velocity sensor, and rain sensor are given in Kavitha and Thiyagarajan [17].

In order to monitor and control each street light, the Wireless Sensor Network (WSN) was developed in [3].The system consists of sensor node, Remote Terminal Unit (RTU) and control centre. The sensor nodes were installed at each lighting pole and make up a network with RTUs. The sensor senses the status of the lamp and the light intensity. Using the Power Line Communication (PLC) [3-4], the status and the control signals can be sent from the RTU and the control centre or vice versa. Another related work that uses the WSN is given in [5].Similar works that uses PLC to remote control the terminal nodes (of the lamps) are given in [1, 4].

Another system for controlling the road lighting is proposed in [6] where the streets are divided into regions. By using vehicle-detection loops in each region, the number of vehicles entering that region can be obtained. Thus, using a dedicated network and control system, any region can be switched on or off depending on whether there are vehicles detected in that region or not. This system can save 23.7% power if put to use.

Siliang [7] described a street lighting system based on a wireless sensor network which could run automatically and controls street lights in accordance to sunrise and sunset algorithm as well as light intensity. This system integrates a temperature-humidity sensor which is digital in nature and also monitors the street lights in real time.

Kalaiarasan [8] described a solar energy based street light capable of fully maximizing power output from solar panels by the use of a sun auto-tracking system. The system utilizes an AT89C51 microcontroller which integrates all other constituent circuits to fully control and power street lights automatically without the need of any manual operation.

Sa'ad [9] described an automatic street lighting system that can be switched ON during the night and OFF during the day. This can be implemented by the use of a Light Dependent Resistor (LDR), a photoelectric sensor and a micro-controller. The LDR controls the ON/OFF switch; the photoelectric sensor detects vehicular movements to activate street lights placed on each side of the road which is controlled by the micro-controller.

Costa [10] examined a solar panel based LED street lighting system. Here the lighting system comprises a solar panel as a primary source, battery as a secondary source and LED consider as a lighting source. Using DC converter, batteries are charged during day time through solar panel. DC converter is controlled by Maximum Power Point Tracker (MPPT) algorithm; through this the system can attain reducing power consumption.

Yongqing [11] discussed controlling solar LED street lights utilizing programmed control circuit. This system consists of three working modes such as light control delay, delay quenching and delay plus low power. Light control delay is used to turn OFF lights in daytime and turn ON light after sunset. Delay quenching mode is used to turn ON/OFF lights automatically based on setting time. Delay plus low power is used to changing the pulsed lighting power based on setting time. The above three working mode scan be used in different situations flexibly and conveniently. This system can be used for the place such as streets, shops and so on.

Hemalatha [12] proposed street light control system utilizing PIC microcontroller and GSM technology. The street lights turn ON/OFF automatically based on the RTC (Real Time Clock). Information about the street lights and street light maintenances are transmitted through GSM.

Vijayakumar and Srinivas [13] proposed an energy efficient street lighting system based on ZIGBEE wireless technology, GSM modem, and LDR sensor interface with (ATMEGA16) microcontroller. The streetlights can be controlled using mobile phones, the option in the mobile phones is ON/OFF/DIMMING. Utilizing ZIGBEE technology the power consumption is reduced. Similar work using LDR, IR, Motion, Humidity and Temperature sensor with a PIC16F micro-controller is given in Archana [15]

Rajput [14] presented on intelligent street lighting system based on GSM/GPRS technology and wireless sensor network integrated with a C8051F350 microcontroller. Using GPRS Technology, the location of the street lights can be identified and the information of street lights is gathered by sensors. It is fully based on location aware application and WSN application. The system always needs internet connection for sending street light information to the maintenance team. Automatic Street light control systems based on IR sensor, LDR sensor is interfaced with 89S52 microcontroller. The system provides power saving, cost effective and 90%, reduce of manual work.

Subramanyam and Reddy [16] suggested an efficient management of street lights in manual mode controlled through a Graphical User Interface (GUI). The ZIGBEE wireless technology can be used for monitoring and controlling at PC end. This can save 60%-70% power using LDR, IR sensors and LED light.

III. MATERIALS AND METHODS

The block diagram of the intelligent street light is shown in figure 1. Figure 1 illustrates how the different units components are connected together to achieve the design of this system.

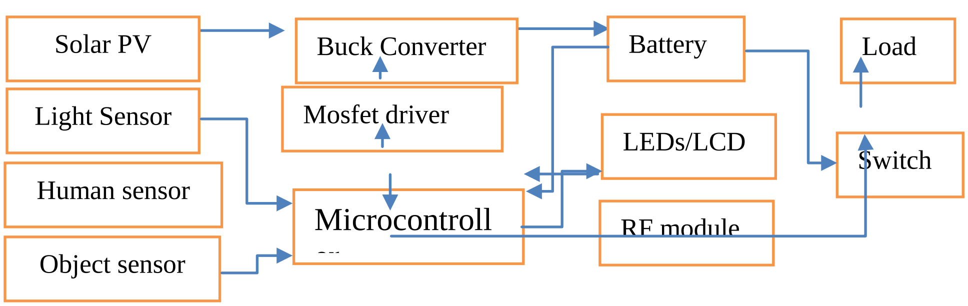


Figure 1: Block diagram of Intelligent Street Lights system.

Figure 2 shows the circuit diagram of the Intelligent Street Lights. The solar voltage is stepped down by using voltage divider principle to give a maximum 5v which is the equivalent of the solar 17v. The voltage from the voltage divider is fed into pin 2 of the PIC16f877a microcontroller [17] which converts the analogue voltage values to digital values. This digital values is compared with the equivalent 12v stored in the memory of the PIC16f877a, so that if the solar voltage is greater than 12v the PIC16f877a continuously turn on and off the buck converter mosfet in such a way that a steady 12v is supply at the load to charge the battery but if the solar voltage is less than 12v the PIC16f877a stops switching on/off the buck converter mosfet. LDR sensor [18] is used to detect light presence, during the day the PIC16f877a uses the LDR connected to pin 4 to senses the presence of light by detecting high voltage. When light is sensed the PIC16f877a turn off the load transistor that is connected to pin 21, but when it is night the LDR gives low voltage and the PIC16f877a turn on the load transistor to switch on the LED lamp. The charged battery is expected to power the system through the night, but the PIC16f877a also read the battery voltage via the second voltage divider which is connected to pin 3. If the voltage of the battery is greater than 10V the load transistor will remain turn ON but if the battery voltage goes below 9v the load transistor will be turned OFF. The HC-04 ultrasonic [19] and PIR sensor [20] that are connected to pin 19 and 20 are to detect the presence of object and human respectively. The RF module [21] connected to pin 25 and 26 and they used for communication with other street light PIC16f877a. The transmitter module transmits string to inform the next microcontroller of the incoming presence of vehicle or human while the receiver module is accept the string inform of the street light before it of the presence of vehicle or human. When this string of information is received the PIC16f877a either brightens or dims the LED lamp depending on the presence or absence of vehicle/human after 10mins. LCD is used in the simulation to display the information but the implementation only need LEDs.

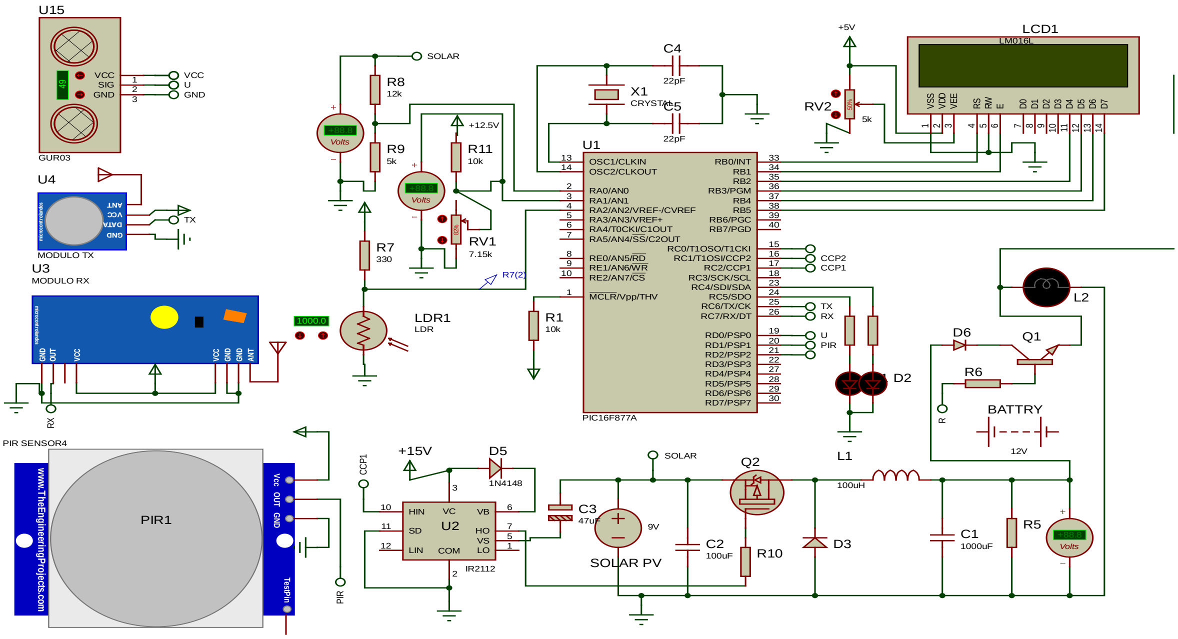
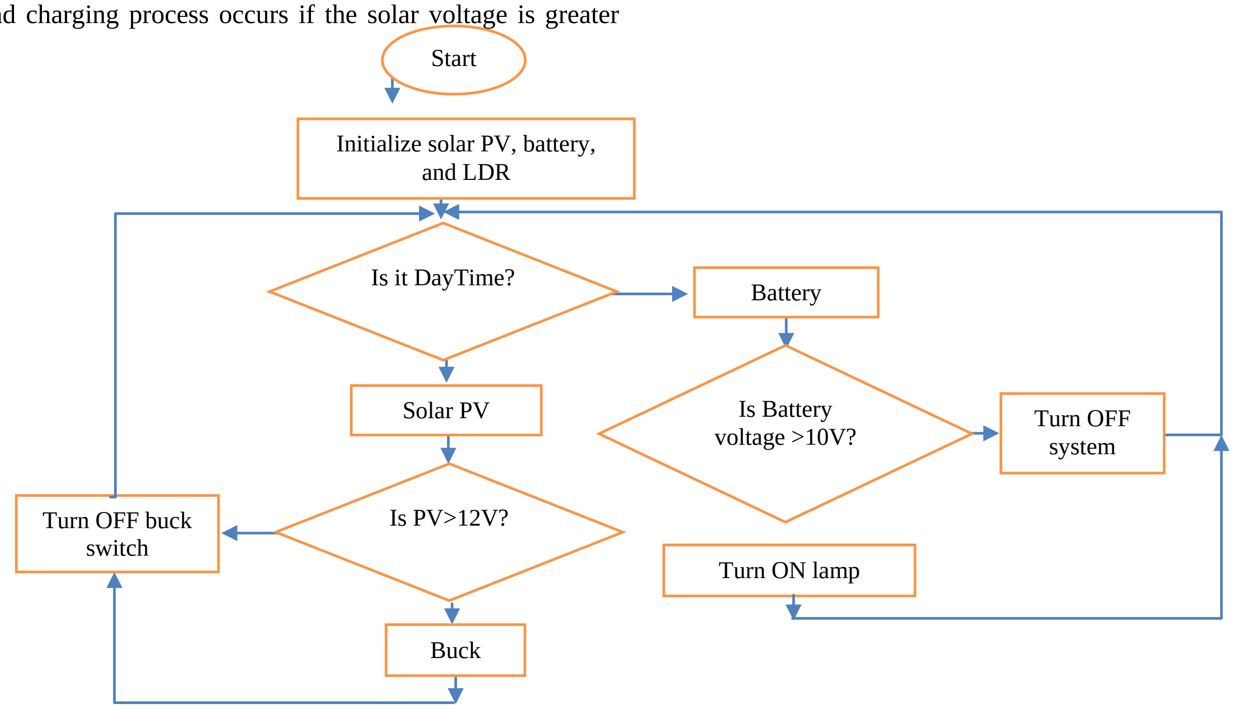


Figure 2: Circuit Diagram of the Intelligent Street Lights system.

The flow chart of the program for the Intelligent Street Lights system is shown in figure 3. Figure 3a shows the flowchart of solar, battery and LDR sensor combined while figure 3b shows the flowchart ultrasonic/PIR sensor

The flowchart of solar, battery and LDR sensor initializes the solar Pv, battery and LDR. The LDR is used to sense day light and charging process occurs if the solar voltage is greater than 12v. When it is night the operation will be ON if the battery voltage is greater than 10V. The ultrasonic/PIR sensor flowchart senses the presence of vehicle/human, if no vehicle/human for 10mins the system dim the lamp. But if vehicle/human is detected the lamp is brightened up and message is sent to the next system to brighten up their lamp and the process continues



(a): LDR, solar Pv and battery Flowchart.
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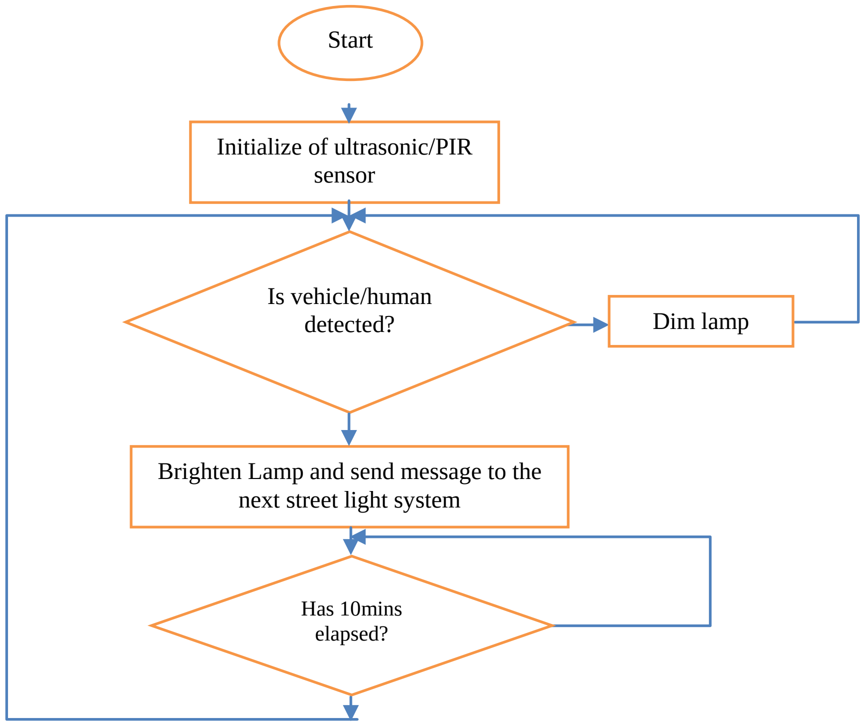
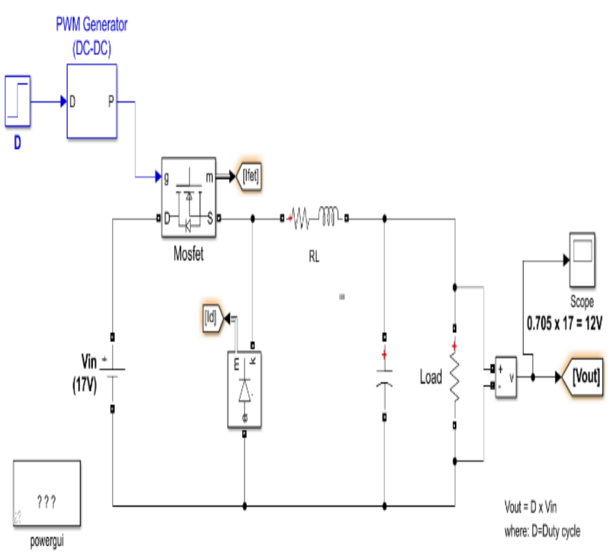
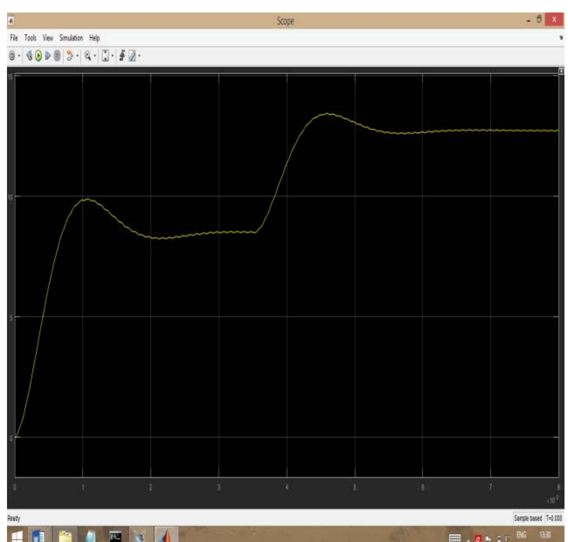


(b) Ultrasonic/PIR Flowchart.
Figure 3: Flow Chart of the Intelligent Street Lights system.

IV. RESULTS AND DISCUSSION

The matlab simulation of the buck converter was done in Matlab IDE [22] to ascertain the response time of the buck as shown in Figure 4(a) and (b). Figure 4a is the simulated circuit while 4b is the result of the simulation.





(a): Matlab Simulation of the buck converter. (b): Results of Simulation of the buck converter.

Figure 4: Buck converter simulation

The program for the microcontroller was written in C language and was then compiled into an executable file using the mickroC IDE [23]. The executable file was next imported into the Proteus Design Suite IDE [24] where the hardware circuit was designed and simulated as shown in Figure 2. Figures 5 to 9 show the proteus simulation results of the Intelligent Street Lights system.

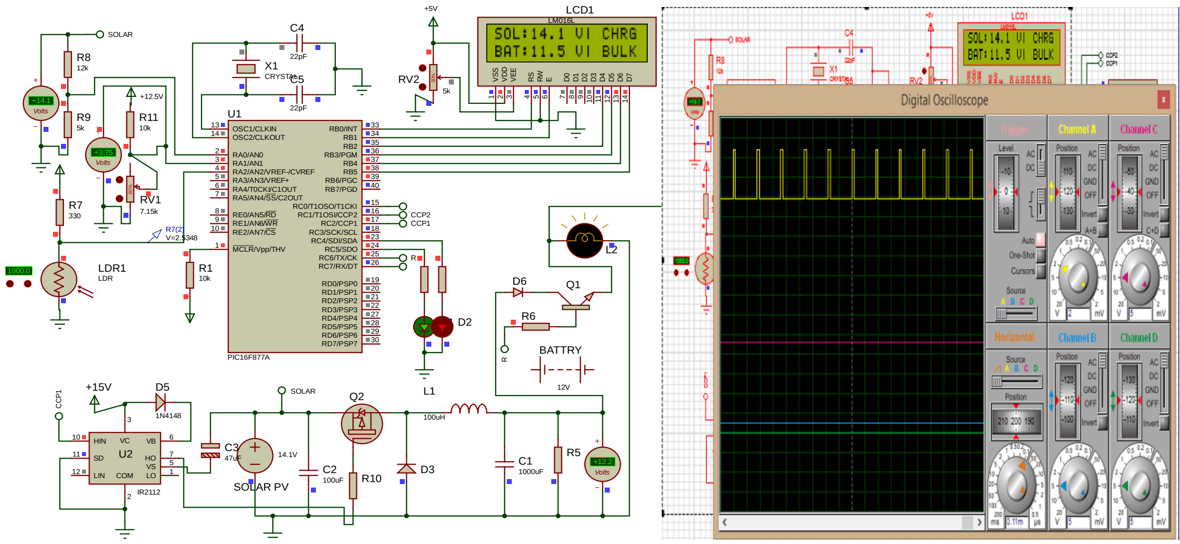


Figure 5: when solar PV voltage is greater than 12V and battery voltage is greater than 10V

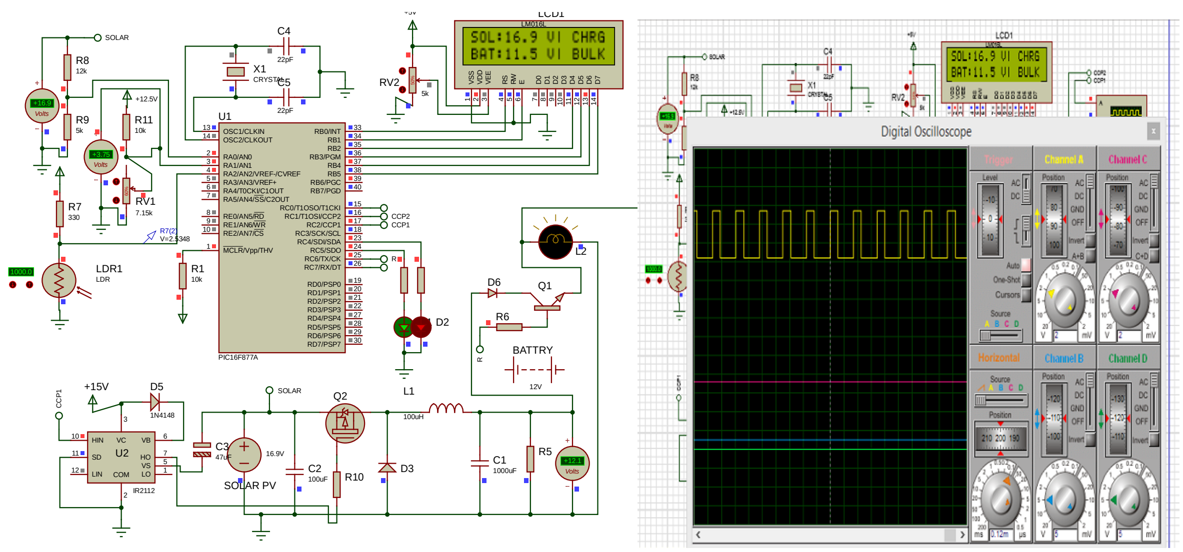


Figure 6: when solar PV voltage is greater than 12V and battery voltage is greater than 10V

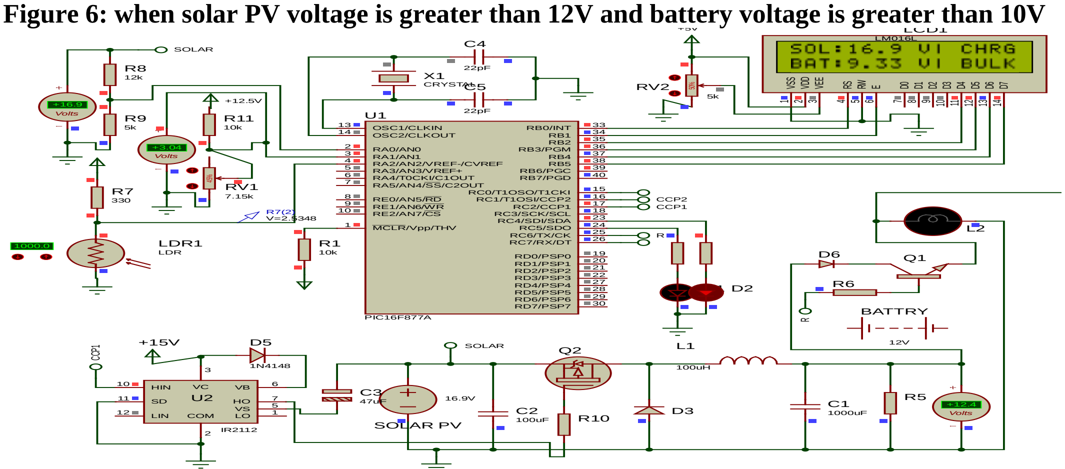


Figure 7: when solar PV voltage is greater than 12V and battery voltage is less than 10V

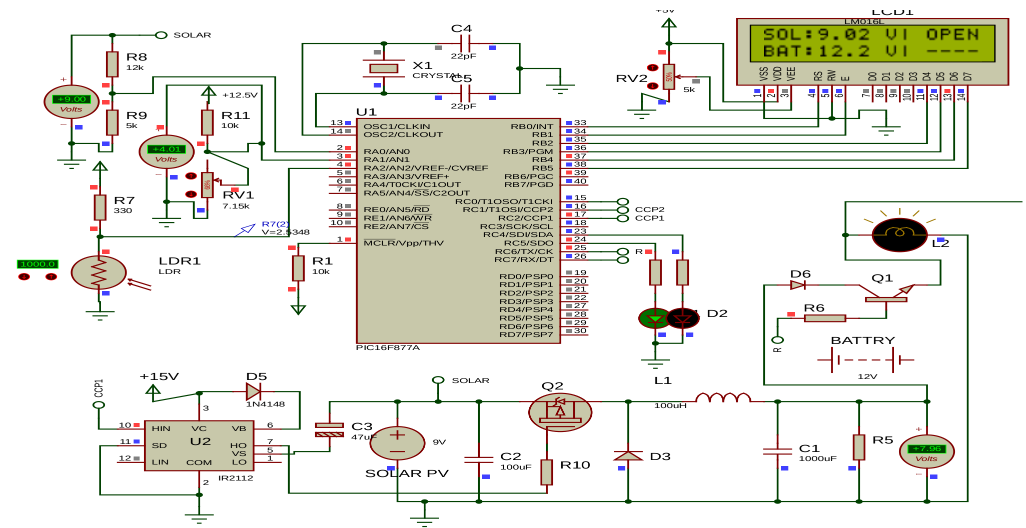


Figure 8: when solar PV voltage is less than 12V and battery voltage is greater than 10V

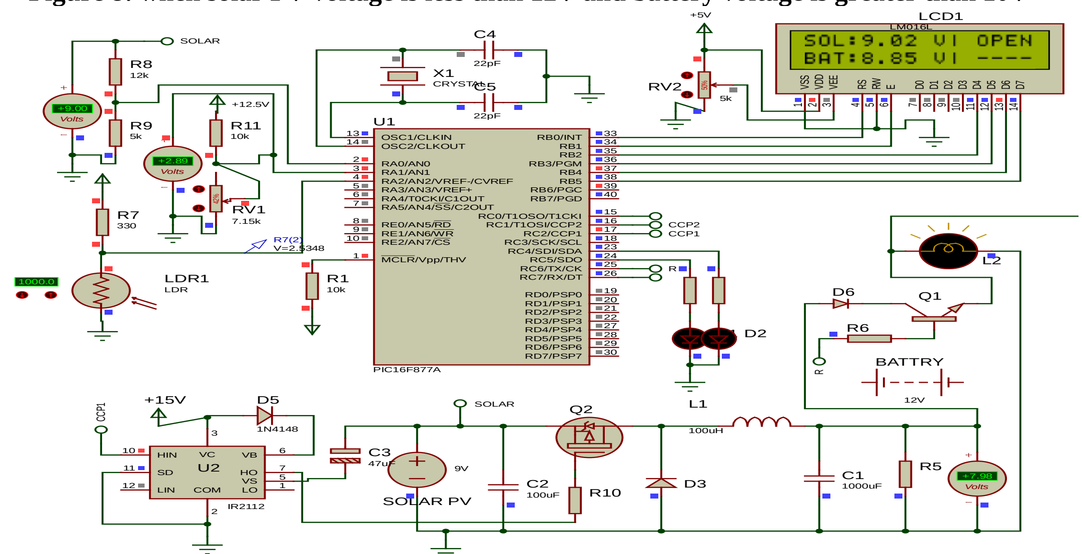


Figure 9: when solar PV voltage is less than 12V and battery voltage is less than 10V

V. CONCLUSION

The design, construction and implementation of intelligent street lights was realized from the basic principles of digital electronics. The basic components used are the PIC16f876a Micro-controller. The entire circuitry and its realization gives an automated control of streets lights based on predefined settings.

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