

# CONTROL OF SOLAR LED STREET LIGHTING SYSTEM BASED ON CLIMATIC CONDITIONS AND OBJECT MOVEMENTS

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**ABSTRACT :** With the increased use of solar power, the solar LED (Light Emitting Diode) street lighting system plays a major role. Monitoring and controlling of street lights are utmost importance in order to reduce the power consumption and to increase the life of the battery. This paper presents a remote streetlight monitoring and controlling system based on LED and wireless sensor network. The present system is like, the street lights will be switched on in the evening after the sun sets and they are switched off the next day morning after there is sufficient light on the roads. This paper gives the best solution for electrical power wastage. In this paper the two sensors are used which are Light Dependent Resistor LDR (Light Dependent Resistor) sensor to indicate a day/night time and the photoelectric sensors to detect the movement on the street. The microcontroller PIC16F877A is used as brain to control the street light system. Furthermore, this system has auto-alarm function which will set off if any light is damaged and will show the serial number of the damaged light, thus it is easy to be found and repaired the damaged light.

**Keyword:** Street Lighting System, Light Emitting Diode (LED), Light Dependent Resistor (LDR), Photoelectric Sensor.

## 1. Introduction

The solar led street lighting system uses the solar radiation energy to charge the battery with the solar panel during day time, and offer energy to the LED light equipment at night. This system has a double advantage in both utilization of new energy and energy-saving.

### 1.1 Requirements on solar LED Street light and significance of design

The solar street light does not need to set up the transmission line or route the cable, and no any special management and control are required. It can be installed in the entire public place such as the square, the parking lot, the campus, the street or the highway etc. The street lighting is closely related to people's daily life. Following quick development in process of the global urbanization, the green, efficient, and long-life LED light gradually enters into our lives.

A good LED street lighting system is characterized with high efficiency, energy-saving, long-life, high color rendering index and environmental protection, which not only has a great significance on energy-saving of the city lighting, but also has close relationship with people's health and the economic development. So it is a noticeable issue how to design a reasonable LED street light system.

In general, following basic requirements on a qualified solar LED Street light

System shall met during design process,

- Learn general information of the meteorological conditions in the area.
- Select the cost-effective solar panel, the controller, the battery and a series of components.
- Adopt effective measures to protect the system.

These conditions ensure to design a reasonable solution and realize the significance and value of the existence of solar LED Street Light Street.

### 1.2 Basic components

Figure 1.1 shows the basic components of solar LED street lighting system. The system consists of,

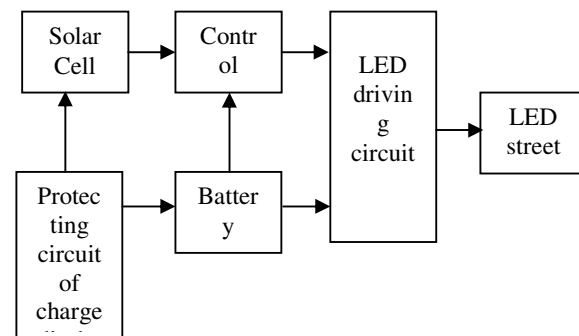


Figure 1.1 Block diagram of solar LED street lamp

- Solar cell
- LED lamps
- Control box (charger, controller, battery)

### 1.1.3 Operation principle

According to principle of photovoltaic effect, the solar panels receive solar radiation during the day time and then convert it into electrical energy through the charge and discharge controller, which is finally stored in the battery. When the light intensity reduced to about 10 lx during night and open circuit voltage of the solar panels reaches at a certain value, the controller has detected voltage value and then act, the Battery offer the energy to the LED light to drive the LED emits visible light at a certain direction. Battery discharges after certain time passes, the charge and discharge controller will act again to end the discharging of the battery in order to prepare next charging or discharging again.

## 1.2 CURRENT SITUATION AND DEVELOPMENT

From the current situation of the LED, there are still many problems which shall be further improved. For example, the quality of the LED chip, heating problem, package problem, power driver issue and the lifetime of the electronic components. LED lighting is a developing technology although its luminous efficiency is improving and cost is continuously reduced, but it still needs long time to completely replace the traditional high pressure sodium street lighting.

Following progressing of the technology, the LED lights can use more low-power products to achieve same effect as the traditional lighting, and the price will decreased significantly in the coming year. The significant progress of the LED must make it completely replace the traditional street lights.

## 2. CONTROL CIRCUIT FOR SOLAR STREET LIGHT

Monitoring and controlling of street lights is utmost importance in developing country like India to reduce the power consumption. The idea of designing a new system for the streetlight that do not consume huge amount of electricity and illuminate large areas with the highest intensity of light is concerning each engineer working in this field.

Providing street lighting is one of the most important and expensive responsibilities of a city. Lighting can account for 10–38% of the total energy bill in typical cities worldwide Street lighting is a particularly critical concern for public authorities in developing countries because of its strategic importance for economic and social stability. Inefficient lighting wastes significant financial resources every year, and poor lighting creates unsafe conditions. Energy efficient technologies and design mechanism can reduce cost of the street lighting drastically.

There are various numbers of control strategy and methods in controlling the street light system are

used among them the control circuit of solar LED street lighting system which depends on climatic conditions and object movement.

In this work, two kinds of sensors will be used which are light sensor and InfraRed (IR) sensor. The light sensor will detect darkness to activate the ON/OFF switch, so the streetlights will be ready to turn on and the IR sensor will detect movement to activate the streetlights. Light Dependent Resistor (LDR), which varies according to the amount of light falling on its surface, this gives an inductions for whether it is a day-night time, the IR sensors are placed on the side of the road, which can be controlled by microcontroller (PIC16f877A). The IR will be activated only on the night time. If any object crosses the IR beam, a particular light will be automatically ON. By using this as a basic principle, the intelligent system can be designed for the perfect usage of streetlights in any place.

The block diagram of street light system as shown in Figure.2.1 consists of microcontroller, LDR, and IR sensor.

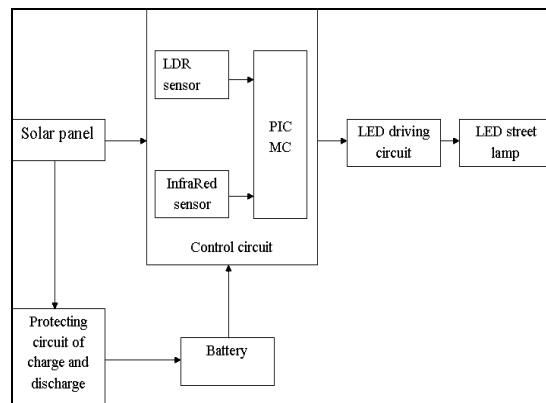


Figure 2.1 Block diagram of automatic solar street light intensity control circuit

By using the LDR we can operate the lights, i.e. when the light is available then it will be in the OFF state and when it is dark the light will be in ON state, it means LDR is inversely proportional to light. When the light falls on the LDR it sends the commands to the microcontroller that it should be in the OFF state then it switch OFF the light, the IR sensor will be used to adjust the brightness of the light according to the presence or absent of the object.

All these commands are sent to the controller then according to that the device operates.

### 2.1 AUTOMATIC STREET LIGHT CIRCUIT DESIGN

The system basically consists of a LDR, IR sensor, Power supply and Micro controller.

#### 2.1.1 LDR

The theoretical concept of the light sensor lies behind, which is used in this circuit as a darkness detector. The LDR is a resistor as shown in Figure 2.2, and its resistance varies according to the amount of light falling on its surface. When the LDR detect light its resistance will get decreased, thus if it detects darkness its resistance will increase.

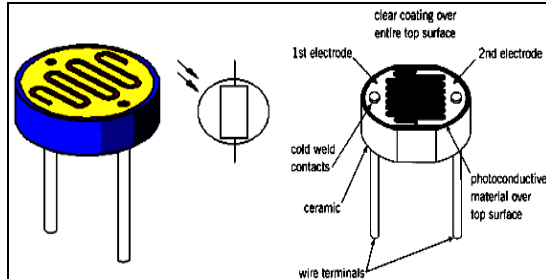


Figure 2.2 LDR

### 2.1.2 Microcontroller(PIC16F877A)

A microcontroller is a computer control system on a single chip. It has many electronic circuits built into it, which can decode written instructions and convert them to electrical signals.

The microcontroller will then step through these instructions and execute them one by one. As an example of this a microcontroller we can use it to controller the lighting of a street by using the exact procedures. Microcontrollers are now changing electronic designs.

Instead of hard wiring a number of logic gates together to perform some function we now use instructions to wire the gates electronically. The list of these instructions given to the microcontroller is called a program.

There are different types of microcontroller, this work focus only on the PIC16F877A Microcontroller where it's pins as shown in Figure2.3.

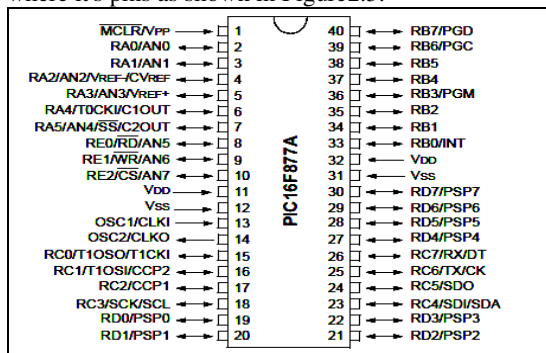


Figure 2.3 Pin diagram of PIC16F877A microcontroller

### 2.1.3 IR sensor circuit

An infrared sensor circuit is one of the basic and popular sensor modules in an electronic device. This sensor is analogous to human's visionary senses, which can be used to detect obstacles and it is one of

the common applications in real time. This circuit comprises of the following components

- LM358 IC 2 IR transmitter and receiver pair
- Resistors of the range of kilo ohms.
- Variable resistors.

The figure 3.4 shows the circuit diagram of the IR sensor.

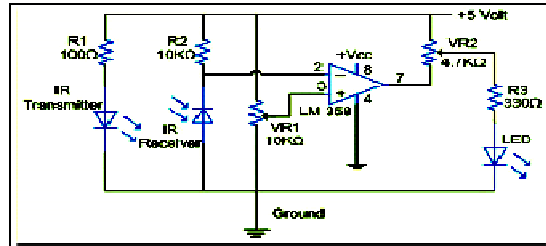


Figure 2.4 IR sensor circuit diagram

## 2.2 HARDWARE DESIGN OF CONTROL CIRCUIT

The hardware module of automatic light intensity control circuit can be designed with the help of the schematic diagram as shown in figure 2.5

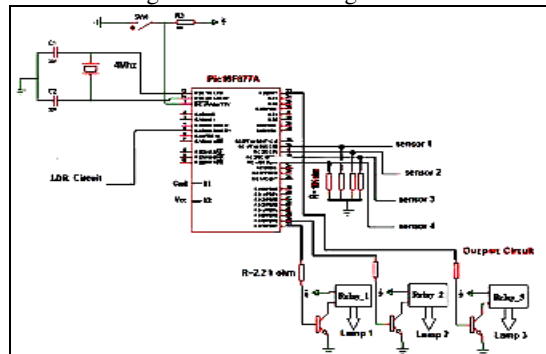


Figure 2.5 schematic diagram of the control circuit

The proposed street lights control system is shown in Figure 3.5. Consists of power supply, microcontroller PIC 16F877A, Light Dependent Resistor circuit (Day & night sensor), infrared motion detector circuit. The schematic diagram explains the simple working of the whole system developed. The power supply circuit provides the 5V regulated power supply for revitalizing the microcontroller module.

The core of the system is a PIC16F877A microcontroller. It is preferred because of the following features, it is a low power, high-performance enhanced flash 8-bit microcontroller with 8K Bytes of in-system programmable Flash memory, 256 bytes of Random Access Memory (RAM), 32 I/O lines, three 16-bit timer/counters, a full duplex serial port, on-chip oscillator, and supports two software selectable power saving modes: low power Idle and Power-down mode.

The LDR circuit detects the external light intensity. The street lamps still consume a lot of electricity when merely a few vehicles are driving around the road. Thus, there is a great necessity to develop a

control system based on the traffic flow density. Whenever there is no traffic i.e. density of traffic is zero, there is no need of street light to be glow on highways which saves power consumption to a greater extent. The lights of a particular area should glow only when a vehicle enters that area on highways. For this purpose, the infrared detection circuit has been used. It consists of IR sensor (presence sensor) which has the task of identifying the passage of a vehicle or pedestrian causing the switching ON/OFF of street lamps.

This feature permits to activate lamps solely when necessary, avoiding wastage of energy. The load which is street-light lamps is connected to microcontroller. Using power transistors and solid state dual relays, the street-lamps are switched ON/OFF. The solid state relays accept the triggering voltage from power transistors which in turn are triggered by microcontroller on reception of activation signals from the sensors. Pulse width Modulation (PWM) is one of the powerful techniques used in control systems today.

They are not only employed in wide range of control application which includes, speed control, power control, measurement and communication. This PWM technique switches the power supply 5v to 3.3v for dimming purpose. These dimming purposes save the great amount of power consumption.

The sensors transfer the collected information to a controller that runs the software to manage the system.

The hardware module of automatic light intensity control circuit as shown in figure 2.6

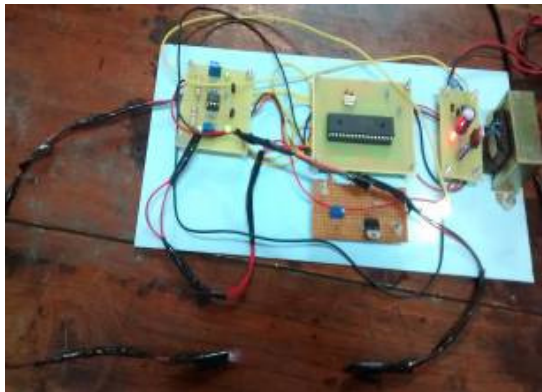


Figure 2.6 Hardware module of automatic intensity control circuit.

### 3. SIMULATION AND HARDWARE RESULTS AND DISCUSSION

The present system is like, the street lights will be switched on in the evening after the sun sets and they are switched off the next day morning.

This work aims at designing and executing the advanced development in embedded systems for energy saving of street lights, which gives the best solution for electrical power wastage. This work,

presents a remote streetlight controlling system based on LED and sensors. The system can be set to run in automatic mode, which control streetlight. This control can make a reasonable adjustment according to the seasonal variation. This street light system also includes a time cut-out function and an automatic control pattern for even more electricity conserving, namely when any objects pass by, the light will glow bright automatically, later it will again dim.

### 3.1 SIMULATION DESIGN OF SOLAR PANEL

The solar panel is designed with the help of MATLAB/Simulink model. This is rated at the voltage of 21 V with the current rating of 0.5A, as shown in figure 3.1.

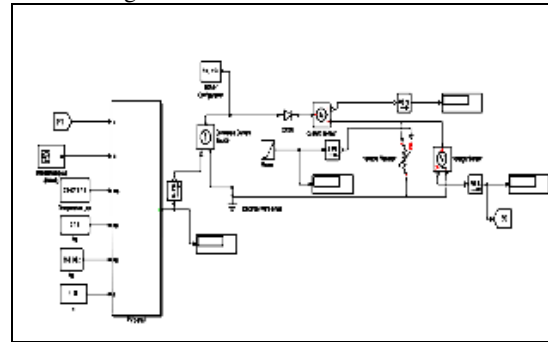


Figure 3.1 Design of solar panel using MATLAB/SIMULINK

The V-I characteristics of the solar panel designed in the above circuit is as shown in figure 3.2 and the P-V characteristics of the solar panel is as shown in the figure 3.3.

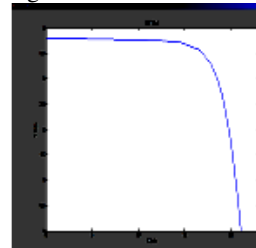


Figure 4.2 V-I characteristics

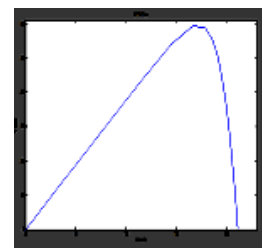


Figure 4.3 P-V characteristics

The V-I characteristics curve shows that the current is increased with respect to the voltage during the day time. It gets gradually decreased when the solar energy gets down during the evening time.

The P-V characteristics curve shows that the power is increased with respect voltage, the power of the solar panel reached the maximum power at the noon and slowly decreased with the constant voltage in the evening time. The maximum power point of the panel is achieved by the algorithm called maximum power point tracking algorithm.

#### 4.2 HARDWARE DESIGN OF LED DRIVING CIRCUIT

The driver circuit is used to regulate the power given to the LED. The hardware design of the driving circuit is as shown in figure 3.4.



Figure 3.4 LED driving circuit

LED driving circuit consists of NE555 and the peripheral circuit. When potentiometer RP4 is on the middle position, the charge time is approximately equal to the discharge time and the duty cycle of pulse is approximately 50%. When regulating RP4, the duty cycle is changed. If the duty cycle D is minimum the LED light consumes the required power for turn ON, else it will be maximum it doesn't consume any power it will later turn OFF.

#### 3.4 HARDWARE DESIGN OF CHARGE CONTROLLER

The charge controller is a device which is used to control the battery charging and discharging, as shown in figure 3.5. When the voltage of battery is higher than the voltage of the set over voltage (14.4V), the voltage of the non-inverting input end is changed higher than the voltage of the inverted input end. Then the output voltage of U4 is high level, transistor Q2 conducts saturably, relay RY operates, and the charging circuit breaks preventing battery over voltage.

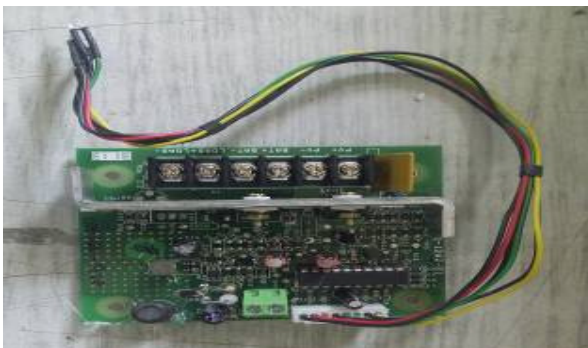


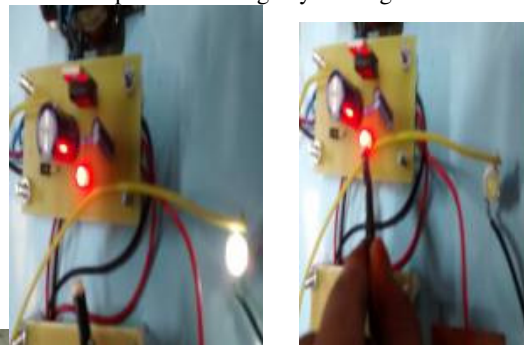
Figure 3.5 Charge controller

When the voltage of battery is lower than the voltage of the set under voltage (10.8V), the voltage of the non-inverting input end of U1 is higher than the inverted input end, the output voltage of U1 is high level, under voltage indicating lamp LED1 lights, the output voltage of U2 is low level, and LED driving circuit does not work to prevent the battery continue discharging.

#### 3.4 AUTOMATIC CONTROL OF SOLAR LED STREET LIGHT SYSTEM BASED ON CLIMATIC CONDITION

An automatic control circuit of LED street lamp is designed. The circuit is supplied with solar cell and stored electric energy with battery. It has three working modes of light control, delay quenching and delay plus low power. Under the light control mode, the LED street lamp is turned off in daytime and lit at night automatically. Under the delay quenching mode, the LED street lamp is turned off in daytime. It would be lit at night automatically and turned off after the setting time. Under the delay plus low power mode, the LED street lamp is lit at night automatically and changed into pulsed lighting in low power after the setting time. It would be turned off in daytime. The circuit also has the functions of protecting the battery from the over voltage or under voltage and automatic restoration of charging.

This operation can be achieved by using Light Dependent Resistors are very useful especially in light/dark sensor circuits. Normally the resistance of an LDR is very high, sometimes as high as 1000 ohms, but when they are illuminated with light resistance drops dramatically. The figure 3.6 shows the LDR operation during day and night



(a)

(b)

Figure 3.6 (a) LED glows when LDR senses no light (night time), (b) LED turns off when the LDR senses the light (day time)

In above circuit R1 can be used to adjust the sensitivity. And the working of the circuit is very simple. The LDR will have very low resistance during day time so the transistor Q1 will be in OFF condition. And during night time the resistance will

be very high so automatically the transistor Q1 will be ON.

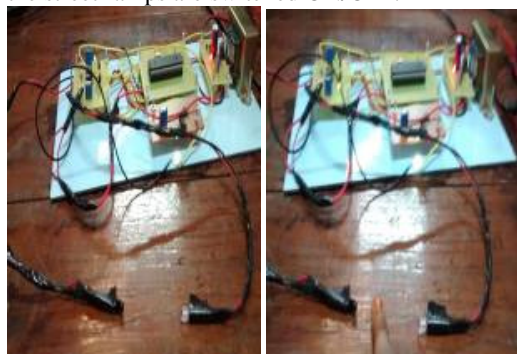
The Q1 is PNP transistor and the emitter of Q1 is given to base of Q2. So the Q2 transistor will be ON only if the transistor Q1 is ON. The Triode for Alternating Current (TRIAC) is used in the circuit to make is circuit complete. As the TRIAC will allow voltage to pass from either direction only when there is a certain threshold voltage in gate terminal. And the gate of TRIAC is controlled by transistor Q2. So totally the lamp will be ON during night time and will be again switched off during day light.

### **3.5 AUTOMATIC CONTROL OF SOLAR LED STREET LIGHT SYSTEM BASED ON OBJECT MOVEMENT**

The street light intensity can be automatically controlled according to the object movement by using IR sensors. The figure 3.7 shows the operation of IR sensor based on object movement.

IR sensor (presence sensor) which has the task of identifying the passage of any objects causing the light glows dim to maximum intensity of street lamps. This feature permits to activate lamps solely when necessary, avoiding wastage of energy. The load which is street-light lamps is connected to microcontroller.

Using power transistors and solid state dual relays, the street-lamps are switched ON/OFF.



(a)

(b)

Figure 3.7 (a) IR sensors detects no object movement, so the LED glows dim, (b) when the sensor detects the object, the LED glows brightly.

The solid state relays accept the triggering voltage from power transistors which in turn are triggered by microcontroller on reception of activation signals from the sensors. Pulse width Modulation (PWM) is one of the powerful techniques used in control systems today. They are not only employed in wide range of control application which includes: speed control, power control, measurement and communication. This PWM technique switches the power supply 5v to 3.3v for dimming purpose. These dimming purposes save the great amount of power consumption.

### **CONCLUSION**

This work elaborates the design and construction of automatic street control system circuit. This Circuit Works properly to turn street light ON/OFF. LDR sensor and the IR sensors are the two main conditions in working the circuit. If the two conditions have been satisfied the circuit will do the desired work according to specific program. The street light has been successfully controlled by microcontroller. With commands from the controller the lights will be glow bright in the places of the movement.

This work aims to reduce the drawbacks of the current street lighting system, and find a solution to save power. This is done by replacing sodium vapor lamps by LED and adding dimming technology to it. It also provides an effective measure to save energy by preventing unnecessary wastage of electricity, caused due to manual switching of street-lights when it is not required.

Compare with the normal street lighting systems, one lamp is switched on for 3650 hours per year. One streetlight has a median consumption of 200 W yearly. With the system presented in this work, every lamp uses about 20-25 W (95% of energy consumed by the LEDs). The proposed circuit is active for about 10 hours daily and the total number of working hours is about 300 per month, savings of about 66% to 71% are achieved. This system is versatile, extendable and totally adjustable to user needs.

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