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Remotely Control Automatic Street Lighting System Using Solar Tracking System

Priti Lahoti[1], Anil Wanare[2]

[1] Dr. D.Y.Patil School of Engineering, Lohegaon, Pune University, Pune, India

[2]Professor, Dr. D.Y.Patil School of Engineering, Lohegaon, Pune University, Pune, India

Abstract: ***In our country most of the energy get wasted in street lighting i.e. unnecessary lighting of the street lamps continuously. To avoid this condition we proposed remotely control automatic street lighting system. The proposed system in this project uses combination of sensors, zigbee, solar inverter and solar tracking system. Use of LED lamps and solar tracking system together increases energy efficiency of the system by 50 to 60%. Zigbee transmitter and receiver transfers all the information of the system to base station so that proper action can be taken in case of failure, Thus Automatic fault detection feature is achieved which ultimately reduces the maintenance of the system. The system is also characterized with auto switching feature between power sources that is, if voltage of solar powered battery falls below system threshold voltage level then it automatically switches to ac supply.***

Keywords: Zigbee, Solar Inverter, Solar Tracking System, LED, Sensors, Automatic Fault Detection

1. Introduction

Most of the times street lighting systems in the public sector are designed as per old standards. They do not take the benefit of latest developed technology. Many times the main reason for this is plant administrators. They did not utilize the money to develop or replace existing facilities with latest advanced technology. But, nowadays people become more curious about raw material and designing cost which results in increasing pressure on plant administrators. The social sensitivity regarding environmental issues and safety of environment also increased these days. This ultimately enforced administrators to use new techniques and latest developed technologies. This design will achieve Ecofriendly and cost effective system implementation. To achieve this we can find three solutions in the literature.

The first one is use of new lighting source which has long life, consumes less energy and eco-friendly. Light Emitting Diode is the best solution on this as it does not emit any poisonous gaseous which are harmful to the environment. It is clean lighting source. Some of the researchers [1-4] already proposed designing of the advanced intelligent high efficient street lighting system using LEDs as a lighting source.

The second solution is use of automatic system which can be remotely control or monitored. Status of the system and lamps can be controlled and monitored remotely using base station. The base station can be designed using combination of Zigbee receiver, microcontroller and Graphical Liquid Crystal Display. Many of the researchers [5-8] already developed the automatic street lighting system using power line communication, Global systems for Mobile communication (GSM) and General packet radio service (GPRS).

The third and last important solution is use of eco friendly power source. In other words we can say that use of renewable energy source as a power source. Solar energy is the best renewable energy source for such condition as it is eco-friendly, economical and easily available.

The main objective of my project is to combine all these three solutions and reduced the maintenance of the system, achieves the automatic fault detection of the system, increase the energy efficiency of the system using LEDs and solar tracking system. This remotely controlled automatic high energy efficient street lighting system which is developed uses solar powered battery as a primary power source. But, if the voltage level of the battery falls below the threshold voltage of the system i.e. minimum voltage which is required to drive the microcontroller then instead of keeping the system off it should automatically switch its power supply to AC mains.

The design and development of remotely control system is achieved using sensors and Zigbee communication protocol. This communication protocol is used to collect and transfer the relevant data between street light module and base station regarding status of the system.

Figure 1: Schematic image of the street lighting system [1]

If we look into the literature then we can easily find that many researchers had already developed the street lighting system based on Zigbee and sensors. Not only street lighting systems but other lighting systems also used sensors and Zigbee in their implementation. [9-11]. In this paper I am demonstrating the implementation of advanced and intelligent street lighting system in detail which is the ideal combination of all latest technical advancement mentioned above.

2. Working of Devices and Proposed Methodology

Schematic image of the street lighting system is shown in the figure 1. This schematic shows base station which is used to control and monitor the system and on street monitoring station which ultimately includes Zigbee Transmitter, microcontroller, IR sensor pairs, LDR, LED lamps and Solar tracking system. The entire project can be divided into following three modules.

A. Street Lighting Module
B. Base Station
C. Energy Section or Inverter circuit with auto-switching Feature.

A. Street Lighting Module

Figure 2 shows the block diagram of the street lighting module which consists of Zigbee transmitter, solar tracking system, 4 IR sensor pairs, LDR, microcontroller and emergency switch.

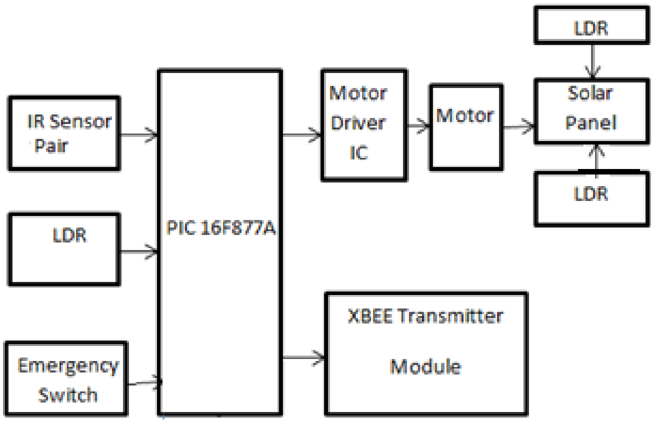

Figure 2: Block Diagram of Street Lighting Module

1) IR Sensor pairs

In this project 4 pairs of IR sensor pairs are used. To design the IR sensor pair we have used LED, photodiode and resistance. LED along with resistance act as an IR transmitter and photo diode along with resistance acts as an IR receiver. Such 4 pairs of IR transmitter and receiver are designed. These IR sensor pairs will be mounted on two sides of road. The work of these pairs is to detect presence of any obstacle or passage of any pedestrian on the road and gives the signal to microcontroller so that microcontroller can decide which action needs to be taken i.e. whether to turn on the lamps or turn off the lamps. The IR sensor pairs are mounted at some distance before the lamp so that when pedestrian comes near to sensor pairs the lamp next to that pair will be turned on. As pedestrian passes, the lamps in the forward direction are turning on and the lamps in the backward direction are turning off. The main and most important thing about this sensor pair is its correct placement. These pairs should be placed at proper height not too high and not too low. If it is mounted at very low level then it can't detect the presence of the children.

2) LDR (Light Emitting diode)

It is used as a light intensity sensor. This sensor is used to sense the light intensity of the sunlight in the surrounding environment and gives the input to the microcontroller. The measurement of sunlight intensity is to check the exact illumination of the street so that microcontroller can take proper action of turning on or turning off the lamp and maintain the minimum illumination on the street.

3) Emergency Switch

This is simple one way switch which is used for to on or off all the lamps in case of emergency. When we press this switch all lamps will be switch on or switch off simultaneously by escaping the entire system.

4) Zigbee Transmitter

Zigbee transmitter is used to transmit the data regarding status of the lamp and status of the system. The data regarding fault in the lamp i.e. whether lamp is faulty or working and the data regarding fault in the LDR is transferred along this transmitter to base station.

5) Solar Tracking System

LDR pair, solar panel, motor and Motor Driver IC interfaced with microcontroller together form the solar tracking system.
Only microcontroller output is not sufficient to drive the motor so motor driver IC is needed to interface the motor with microcontroller. We used LM293D IC as an interfacing IC. The main aim of this automated solar tracking system is to get the maximum solar energy output and to increase the efficiency of the overall system. The LDR is use to track the sun. A transparent coating is use around the LDR so as to detect the difference between its resistance under sun and under shadow. Automatically it will provide us the voltage difference across LDR in shadow as well as in sunlight. When LDR is exactly facing the sun the maximum light will enter into the LDR and its resistance changes accordingly. Since we are using NTC type of LDR i.e. LDR having negative temperature coefficient of resistance definitely its resistance decreases with incidence of solar radiations. In series with the LDR one resistance is connected. The common point between LDR and resistor is connected to positive terminal of OP-AMP LM-358.This OP-AMP is used as comparator. One trimmer which is going to change the sensitivity is connected to negative terminal of OP-AMP. This trimmer acts just like a potentiometer. The voltage provided at negative input terminal of OP-AMP can be change by moving screw at its top. If the voltage across positive terminal exceeds negative terminal voltage then OP-AMP provides 5V output and it will provide 0V in reverse case. So in short we can say that OP-AMP here act as ADC and gives us digital i.e. either 5V or 0V output depending on input conditions. The output of this OP-AMP is given to the microcontroller. When OP-AMP output is high the microcontroller turned on and it will rotate the motor through the desire angle. DC motor with 30 rpm is used. The microcontroller is programmed in such a way that solar panel is always able to maintain perpendicular profile with the incident solar radiations. As sun moves from East to west,

solar panel will follow the sun and track the sun. The output of solar panel is given to the rechargeable battery through diode. Solar panel will convert the solar radiations which incident on its surface into electrical energy and provide us DC voltage. Using this DC voltage our rechargeable battery is charged which we later used to design solar inverter. We use Lead Acid 12V, 1.3mAH rechargeable battery in our project. Thus using solar tracking system we charged our lead acid battery which acts as a primary power supply or we can say primary source of power supply for our system.

B. Base Station

Now, let's talk about 2nd module of the project which is base station. Base station or control station is designed to remotely monitor and control the system. Figure 3 shows the block diagram of the base station of the system. Base station mainly consists of Zigbee receiver module, microcontroller, 128*64 Graphical LCD for GUI purpose and emergency switch. Zigbee Receiver module receives the data transmitted by Zigbee transmitter about status of the system and displays it on the graphical LCD. It displays the data where lamp is on or off. If the lamp is on then it displays the power consumption of the lamp and if the lamp is off due to fault in the lamp then it displays the fault in the lamp. Microcontroller at the transmitter end is programmed in such a way that it can recognize 4 types of lamp faults which are High Current, Low Current, Short Circuit and Open Circuit. These faults are displayed on GLCD as HC, LC, S, and O respectively. If LDRs used in the system are faulty then it will display the message as 'LDR not working properly'. On pressing emergency switch all the lamps will be turn on or off simultaneously by escaping entire system.

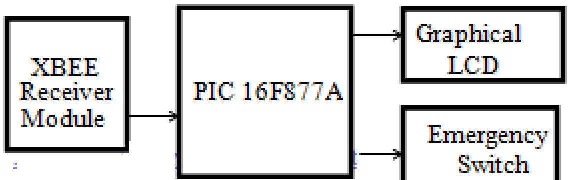

Figure 3: Block Diagram of Base Station

C. Energy Section or Inverter Circuit with Auto-Switching Feature

The third and most important module of the project is solar inverter and auto-switching feature between power supplies. By using solar tracking system we charged Lead Acid Battery of 12V. This DC voltage is converted to 230V AC using inverter. The DC battery charged using solar energy is our primary power source for the system. If the charging level of the battery falls below the threshold voltage of the system then instead of stopping the system our auto-switching board will switch the power supply to AC supply. Lets discuss about software flow of the system so that we can go through the flow chart of the entire system and also we can go through the block diagram of this third inverter module of the project. It will be shown as figure 5on next page.

D. Software Flow of the System

If the emergency switch is pressed either from transmitter side or from receiver side it will escape the entire system and turns on all the lamps simultaneously. In other words we can say that emergency switch takes precedence over all other switches or sensors in the system. If no input is received from emergency switch then microcontroller checks the input from IR sensor pairs and LDR and depending on these two inputs microcontroller will decide which action to be taken i.e. whether to turn on the lamp or to turn off the lamp. The current flowing through the street lamps during normal operating condition is stored in the memory of microcontroller. Microcontroller will compare the current flowing through all the street lamps with this value of the current saved in the memory of the microcontroller and depending on this comparison it will detect four faults as high current when current flowing through lamp is exceeding memory current value, low current when current through street lamp is less than memory current value , short circuit when current through lamp is too much excess than memory current value and lastly open circuit when there is no current through street lamp. If any fault is detected in any lamp then microcontroller turns off to safeguard the entire system. Figure 4 shows the flow chart of the system.

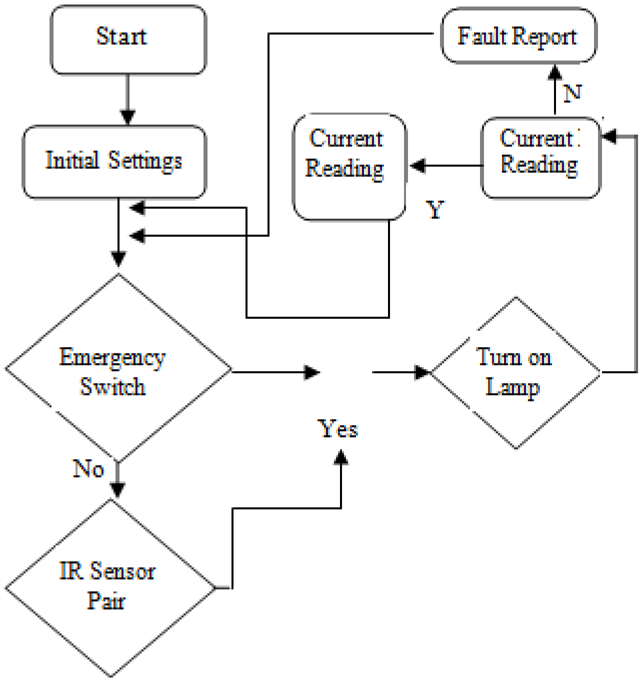

Figure 4: Software Flow Chart of the System

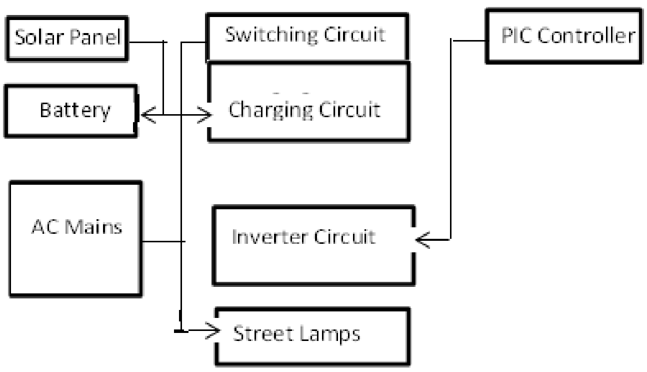

Figure 5: Block Diagram of Energy section or inverter with auto-switching feature

3. Results

The proposed automatic street lighting system increases the energy efficiency by 50 to 60% by using solar tracking system and LED lamps. The tables below shows these results more clearly

.

Table1: Solar panel Output voltage with and without tracking

Time	*Output Voltage without Tracking*	*Output Voltage with Tracking*
11:00 AM	10.3V	15.2V
12:00 PM	12.7V	16.8V
01: 00 PM	12.5 V	16.5 V
02:00 PM	12.1V	16.1V
03:00 PM	11.7 V	15.3 V

Table 2: Comparison Chart for LED, CFL and Ordinary Bulb

Characteristics	*LED*	*CFL*	*Ordinary Bulb*
Life (in Hrs)	50,000	8000	1200
Watt	3	5-6	40-50
Cost	180	325	60
Sensitivity to Temperature	No	Yes	Some

4. Conclusion

We have proposed remotely controlled automated high energy efficient street lighting system through this paper. This system increases energy efficiency of the system by 50 to 60%. It achieves the automatic fault detection and ultimately reduces the maintenance. Uses solar energy as primary power source and it is economical. This system can be further modularized to combine with traffic controller or can add feature of dynamic routing to transfer data at a larger distance.

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