Design of Traffic Flow based Street Light Control System

Vipasha
Centre for Development of Advanced Computing, Mohali, Punjab, India

Preeti Abrol
Centre for Development of Advanced Computing, Mohali, Punjab, India

ABSTRACT
Monitoring of street lights and controlling is of utmost importance in developing country like India to reduce the power consumption. This paper presents a street light control system which combines various technologies: a timer, Liquid Crystal Display (LCD), a statistics of traffic flow magnitude, a photosensitive detector (LDR), infrared photoelectric control, Light Emitting Diodes (LED), power transistors, dual relays and wireless communication (ZigBee). This system contains light sensor to observe the day and night detection to turn lamps on, merely during night time. It also includes infrared detectors to turn light on automatically when vehicles, pedestrians pass by, later turn off after a certain predefined delay for even more energy conserving. This system also includes fault detection and feedback circuit to indicate the present state of the control system. The intact information regarding these various aspects is transferred to nearby control terminal (base station) by using ZigBee communication to visualize the state of the system by creation of Graphical User Interface (GUI) there. It allows substantial energy savings with increased performance and maintainability.

Keywords
GUI-Graphical User Interface, ZigBee, Infrared detection, photosensitive

1. INTRODUCTION
Automation, Power consumption and Cost Effectiveness are the important considerations in the present field of electronics and electrical related technologies. Industry of street lighting systems are growing rapidly and going to complex with rapid growth of industry and cities. To control and maintain complex street lighting system more economically, various street light control systems are developed. These systems are developed to control and reduce energy consumption of a town's public lighting system using different technologies. These range from controlling a circuit of street lights and/or individual lights with specific ballasts and network operating protocols. They may include sending and receiving instructions via separate data networks, at high frequency over the top of the low voltage supply or wireless. Various protocols have been developed as well as compatible hardware for most types of lighting. A multi-functional street light control system, which is more electricity conserving and convenient, is presented here in this paper. Main goal of the proposed work is to control switching of street light automatically according to light intensity, to develop traffic flow based dynamic control statistics using infrared detection technology and maintain wireless communication among lampposts and control terminal using ZigBee wireless protocol.

This proposed system utilizes the latest technology for the sources of light as LED Lamps instead of generally used street lamps such as High Pressure Sodium Lamps, etc. The LED technology is preferred as it offers several advantages over other traditional technologies like energy saving due to high current luminous efficiency, low maintenance cost, high color rendering index, rapid startup speed, long working life etc. This proposed system makes use of infrared photoelectric sensor (G12-3C3PA) for vehicle detection.

Figure 1: G12- 3C3PA

Specifications of IR Photoelectric sensor Used:

- Model no: G12 -3C3PA
- Detection distance: 3m
- Operating voltage: DC10-30V
- Output method: PNP transistor o/p
- Output status : NO (light -on)
- Detection method : Through beam
- Response time : < 2ms

Some of the advantages of infrared detectors are that they can be operated during both day and night, and they can be mounted in both side and overhead configurations. In this developed prototype, they are mounted in side configurations. The developed system uses (wireless) ZigBee communication to send information from lampposts through microcontroller to a nearby control terminal (base station), thus provides the availability of simplification for the management of the system and offers ease of maintenance at the operator end.

2. RELATED WORKS

Energy savings are of utmost importance today. The goal is therefore, the reduction of operating prices of street lighting with the creation of a system characterized by straightforward installation and low power consumption. A multi-functional street lights control system based on AT89S52 was presented. This system included a time cut-out function and an automatic control pattern for electricity conservation. This design can save a great amount of electricity compared to street lamps that keep alight during nights. 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 [2]. In this paper, a simpler, multipurpose, cost-effective design to control the on-off mechanism of street lights via Short Message Service (SMS) and GSM module has been developed [3].This paper discusses a new intelligent control terminal of solar street light. It combines of current General Street light charge and discharge management, controller and wireless communication technology. It employs fuzzy control theory to control the uncertain system to achieve reasonable battery charge or discharge. The terminal has the feature of running on the network and off the network independently, so it ensures the stability of the system [8]. In order to reach a high performance level in a street lighting control system, two important aspects must be taken into account: the selection of the adequate communication protocol, on the one hand, and the selection of the network topology that supports the architecture, on the other hand. Taking into consideration these circumstances, this paper focuses on an assessment of the performance of the mesh and tree network topologies which, along with the ZigBee communication protocol, can be implemented in a street lighting control architecture. As a result of the simulations that have been conducted, the data reveals that the tree topology is much more efficient than the mesh topology[9].An innovative wireless street lighting system with optimized management and efficiency has been presented in this paper. Wireless communication based ZigBee wireless devices which allow more efficient street lamp system management; advanced interface and control architecture are used. The Information is transferred point-by-point using ZigBee transmitters and receivers to a control terminal to diagnose different conditions of street lights. [10].

3. BLOCK DIAGRAM OF PROPOSED SYSTEM

The block diagram of proposed street lights control system is shown in Figure 2 (a) and Figure 2 (b). The transmitter end consists of power supply, microcontroller AT89S52, photosensitive detection circuit (Day & night sensor), infrared vehicle detector, feedback circuit, fault detection circuit, LCD display and ZigBee transmitter module. The receiver part consists of ZigBee receiver module, MAX232, RS232 and PC. The block 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 an AT89S52 microcontroller. It is preferred because of the following features:- it is a low-power, high-performance CMOS 8-bit microcontroller with 8K Bytes of in-system programmable Flash memory, 256 bytes of 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 photosensitive detection circuit consists of Day & night sensor to determine the external light intensity. The threshold (reference) illumination level is set initially. The photoelectric sensor with set threshold intensity is used to observe street conditions as the intensity of daylight and, depending on the conditions they activate or off the lamps. 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. The fault detection circuit indicates the LED lamp failure as well as wire fault along with lamp and wire number when the lamps are firstly turned on, on sensing the night. Through feedback circuit the malfunctioning message is transmitted to the controller which displays it on the LCD and also transmitted wirelessly through ZigBee module to the control terminal. The LCD display is used to show different conditional messages like day, night, light testing, wire fault, LED failure, etc. The sensors transfer the collected information to a controller that runs the software to manage the system.

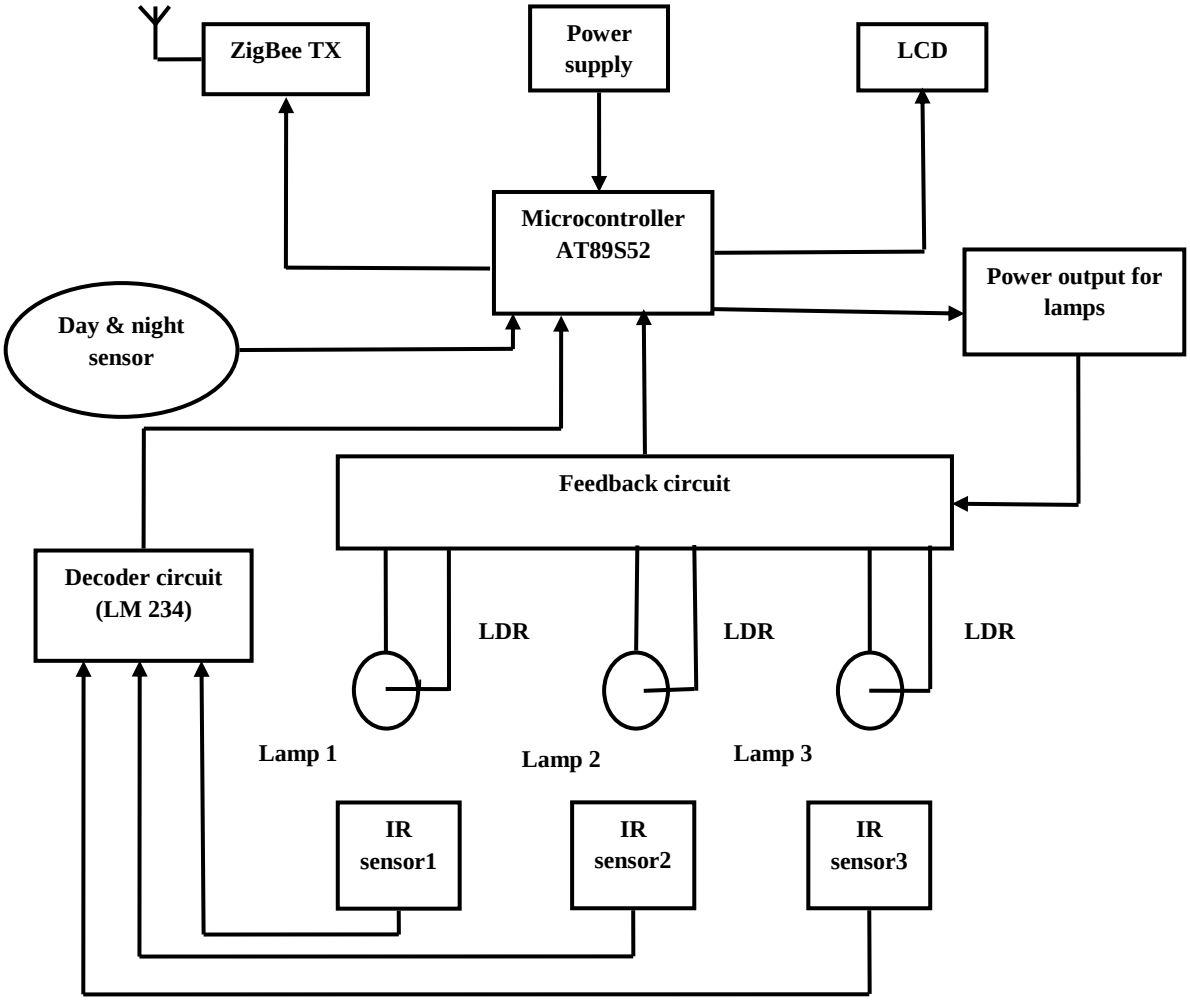

Figure 2 (a): Transmitter end diagram

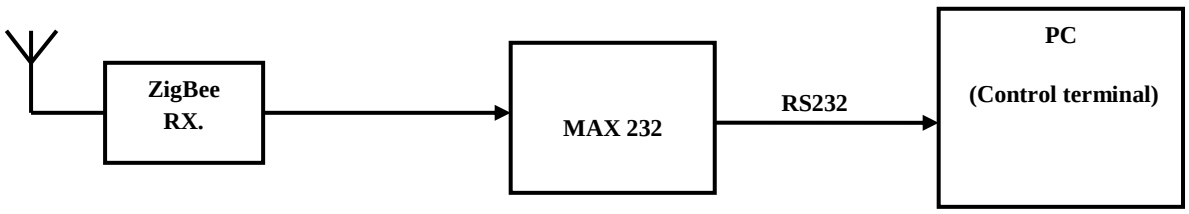

Figure 2 (b): Receiver end diagram

All the operation is regulated by a timing management that permits the system is set for predestined time. The ZigBee transmission module (Series S2) connected to microcontroller receives data of the state of the lamps and sends it to a ZigBee receiver module which is connected with control terminal processing unit (base station). The operating voltage required for ZigBee module is 3.3V. It is achieved by using low dropout voltage regulator LM2950 which uses 5V as input from regulated power supply section and provides 3.3V output to energize the ZigBee

module. The processing unit consists of a terminal with a serial UART (RS232) interface that receives data regarding the state of the lamps provided by a ZigBee receiver module, connected to the UART interface. The terminal is needed for graphical presentation of the system results. The graphical interface permits to visualize the state of the system with the state of the lights and the power consumption of every lamp (Power Consumption Data graph). The basic block diagram plays an important role in building the project completely and to provide a basic understanding of the working of the system. All blocks in the diagram are implemented in the circuit level. The minimal circuit of system is as shown in the Figure 3.

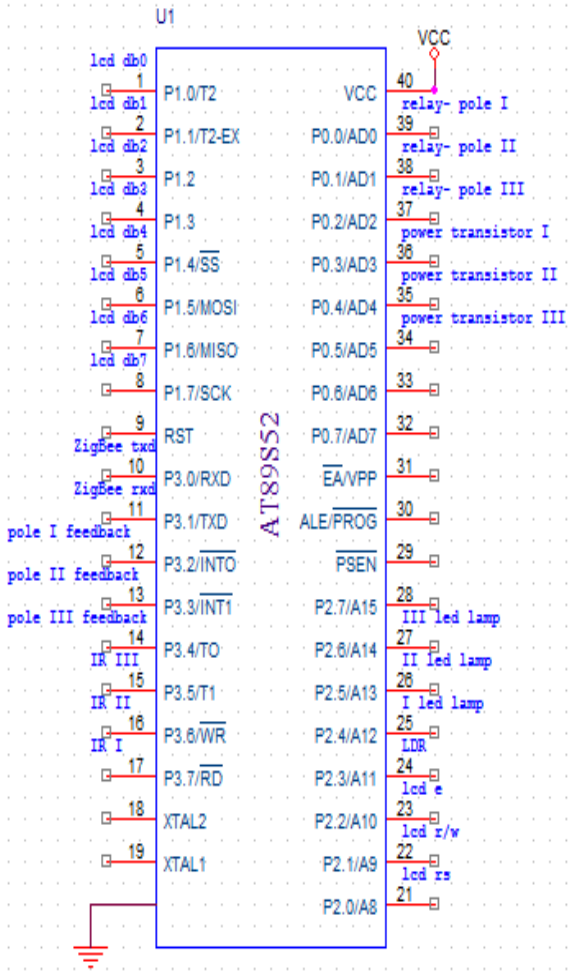

Figure 3: The minimal circuit diagram

4. STREET LIGHT AUTOMATIC CONTROL METHODOLOGY

The street light control system adopts a dynamic control methodology. According to this, the initial state of the lights is set as off. Street light schematic is shown in Figure 4 and control flow in Figure 5. When the signal is detected at the point S, the state of lamp A switched (On to Off or Off to On), when the signal gets detected at the point B, the states of lamp A and lamp C are switched on or off simultaneously, while point D detects the signal, lamp C and lamp E are switched on or off simultaneously, while S' detects the signal, lamp E is switched on or off.

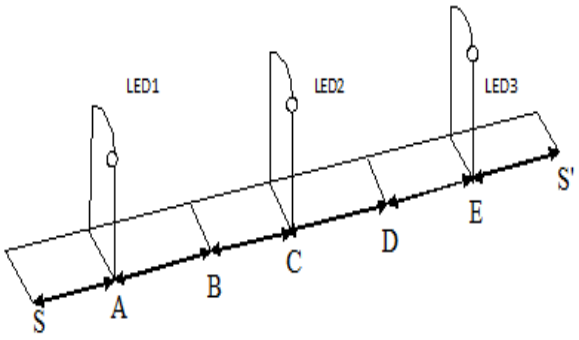

Figure 4: Streetlights schematic

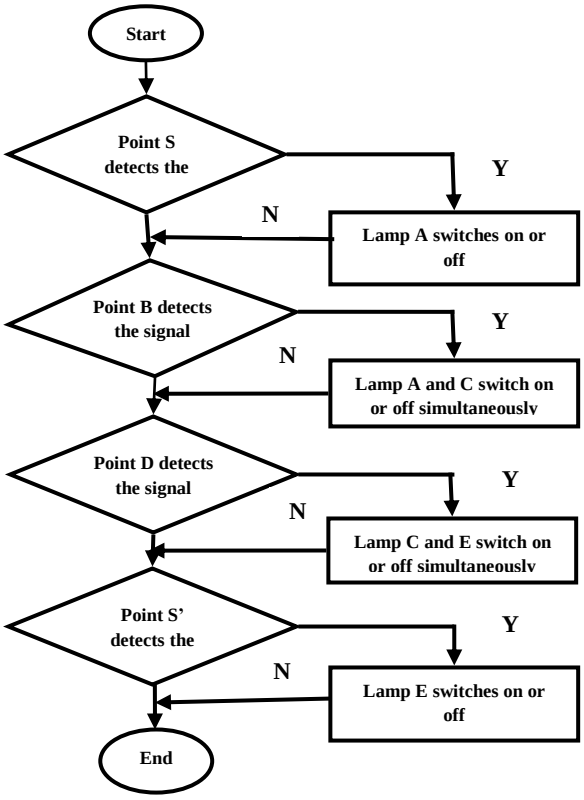

Figure 5: The control flow chart

5. ZIGBEE COMMUNICATION

The **ZigBee** is a specification for a suite of high level communication protocols using small, low-power digital radios based on an IEEE 802.15.4 standard for wireless personal area networks. ZigBee is targeted at applications that require a low data rate, long battery life, and secure networking. ZigBee has a defined rate of 250 Kbit/s, best suited for periodic or intermittent data or a single signal transmission from a sensor or input device. ZigBee specification is intended to be simpler and less expensive than other WPANs, such as Bluetooth in terms of price and consumption of energy. The bit rate of transmission depends on frequency band.

Table 1: Comparison of ZigBee with other wireless technologies

	ZIGBEE	WI-FI	BLUETOOTH
IEEE standard	802.15.04	802.11bgn	802.15.01
Main application	Control	Broadband	Mobile devices
Number of Network devices	Up to 65000	32	7
Bit Range	20-250 kb/s	11/54/300Mb/s	720 kb/s
Range	100 m	100 m	10 m
Battery life	100-1000 days	1-5 days	1-7 days

On 2.4 GHz band the typical bit rate is of 250 kb/s, 40 kb/s at 915MHz and 20 kb/s at 868 MHz The standard distance of ZigBee transmission vary, depending on the atmospheric conditions and therefore the transmission power, ranges from tens to hundred meters since the transmission power is deliberately kept as low as necessary (in the order of few mW) to keep up very low energy consumption. In proposed system, the ZigBee transmitter module is used to transfer data from microcontroller to ZigBee receiver module interfaced to control terminal (PC). ZigBee wireless communication network has been implemented with the utilization of Series S2 radio frequency modules with 100 m outdoor range. They operate within the ISM band at the frequency of 2.4 GHz. The receiver sensitivity is high. The modules ought to be provided by 3.3V DC supply, and then the power consumption is within the order of 50 mA. The module supports sleep mode where consumption is smaller than 10µA. ZigBee is configured by the use of X-CTU software.

5. RESULTS AND ANALYSIS

The GUI at the control terminal (base station) for the presentation of the state of the system is constructed using MATLAB as shown in the Figure 6.

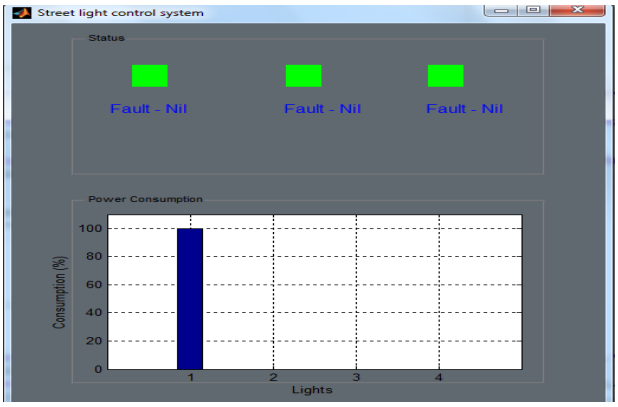

Figure 6: Exemplary GUI of street light control system

The results of different failure conditions i.e. of wire fault and lamp malfunction are presented in Figure 7 and Figure 8.

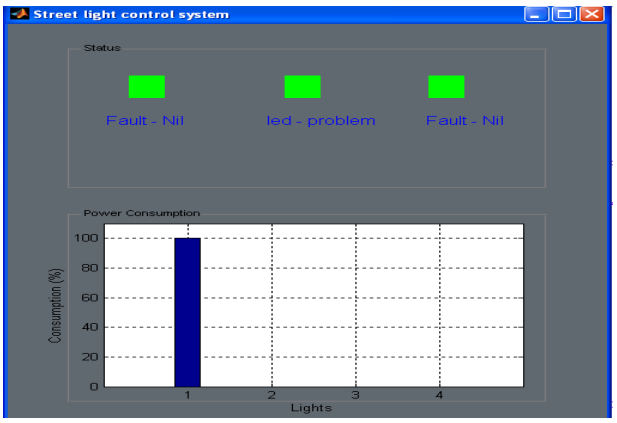

Figure 7: Fault condition due to lamp failure

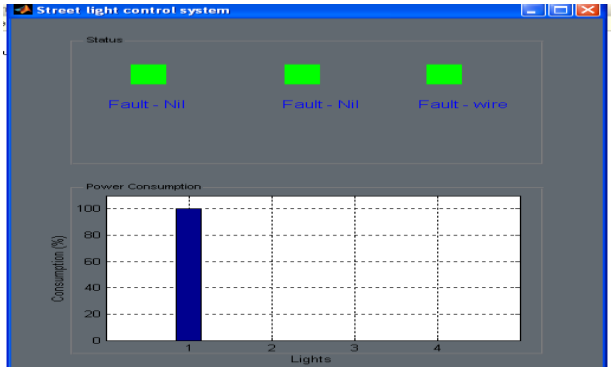

Figure 8: Wire fault condition

Power consumption of lamps and power savings is depicted by Figure 9. The first bar of the graph is showing 100% power consumption of lamp (taken as reference) when it remains on whole night. As shown in figure second lamp consumes only 40% power as it is turned on only when vehicle/ pedestrian is detected by IR sensor.

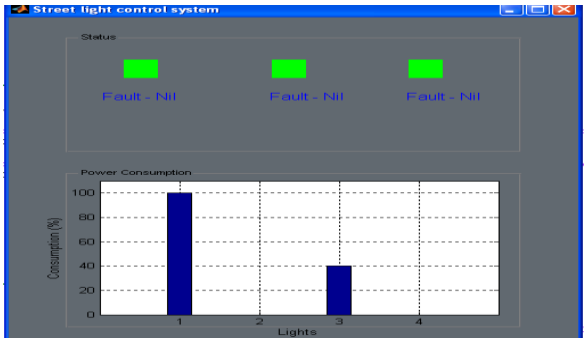

Figure 9: Power consumption of second street lamp

6. CONCLUSION

Street-lights are a large consumer of energy for cities, using up to 50 percent of a city's energy budget. If every city installs the proposed system then a lot of power can be saved. Proposed system is power saving mechanism for street lights by using LED lamps as replacement of normal lamps and using special power savings mechanism for microcontroller and ZigBee modules. It turns out most reliable and time efficient way to switch ON/OFF street-lights. It provides an effective measure to save energy by preventing unnecessary wastage of electricity, caused due to manual switching or lighting of street-lights when it is not required. It adopts a dynamic control methodology for traffic flow. The proposed system is especially appropriate for street lighting in remote urban and rural areas where the traffic is low at times. The system is versatile, extendable and totally adjustable to user needs.

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