

# Zigbee based Smart Street Lighting System

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**Abstract**— Street light, a raised source of light that is commonly used along walkways and streets when the surrounding turns dark. Currently, various street lighting control systems technology have been developed to control and maintain these systems more economically. However, most of these systems developed have contributed some drawbacks. They have been considered to be outdated due to lack of communication capabilities, not allowing a system feedback. Hence, Zigbee communication technology is deployed so as to ensure a higher efficiency and overcome current drawbacks. The system will be able to detect fault and apprise the control room about it.

**Keywords**— outdated communication, feedback, Zigbee

## I. INTRODUCTION

Street lights, a raised source of light, installed along walkways and street that are used to provide some amount of brightness when the surrounding environment has turned dark. The fixtures of street lights indirectly have assisted the public and government in reduction of crime rate and accidents in the area. However, most of the time the street lights go faulty and not much initiative is taken to get it repaired unless a complaint is made or when patrolling is done by the higher authorities to check on the street light's health [1]. Even when a complaint is made to the higher authorities, not much response is given [2] and tremendous amount of paper works are involved in getting the street light repaired. This in turn wastes time whereby people in the neighborhood need to wait for days before the street light can actually function again.

Due to the faulty street light, walking along the streets in the dark environment can be daunting to anyone. This scenario can happen in many housing areas, along pedestrian walkways and streets. The street becomes too dark that the pedestrian and other road users are susceptible to any kind of dangers such as theft, kidnapping, accidents and etc. This is due to the internal fixtures used in the conventional street light that do not counteract to any fault detected within its system. Conventional street lights are not equipped with any communication capabilities whereby they only rely on photoelectric relays to turn ON/OFF the lights and there are no other alternatives to transfer control commands if the street light happens to be faulty [3]. Faulty street lights being left ignored could in turn waste an incredible amount of power and increase maintenance costs. Besides that, due to faulty street lights there are potential rise in crime rate and accidents. Thus, with the implementation of Zigbee wireless communication technology the drawbacks of conventional street lighting system can be overcome. Perhaps the major criterion of the street light development was to reduce night-

time accident rate as visual performance is poorer at night compared to daytime [4].

Under the cluster of WPAN (Wireless Personal Area Network) comes the technology known as Zigbee. Zigbee is a type of wireless communication standard defined by IEEE 802.15.4 as a set of communication protocols that consists of low data rate and is widely used for short range wireless networking [5]. Zigbee can be used in 868MHz, 915MHz and 2.4GHz unlicensed ISM (Industrial Scientific Medical) frequency band that varies according to continents. The main use of Zigbee is limited to battery powered applications whereby low data rate, low power and longer battery life are of main prioritization [5]. The key principle of Zigbee technology is to control and monitor applications in which that reflects the Zigbee based smart street lighting system.

## II. BACKGROUND

### A. Conventional Street Lighting

The conventional street light may be mounted on steel or wooden pole that is fed by an underground cable line that connects to the nearest distribution line [6]. At the beginning of the development of the street lighting system, the lights were turned ON manually at dusk and turned OFF manually at dawn [7]. Sooner after that, a smart based controller in the form of timer was used to turn ON and OFF the lights at dusk and dawn based on a pre-set time within the street light. With the invention of sensors, the street lighting system evolved to a higher level with the use of light detecting sensors such as photodiode, photo resistor and photo relays. These sensors are mounted on top of the street light to detect surrounding ambient lighting and turn ON and OFF according to how much light intensity are sensed.

The structure of the conventional street light consists of a lamp, ballast, capacitor, starter (ignitor) and a photo resistor. Fig. 1 below shows the architecture of a conventional street light.

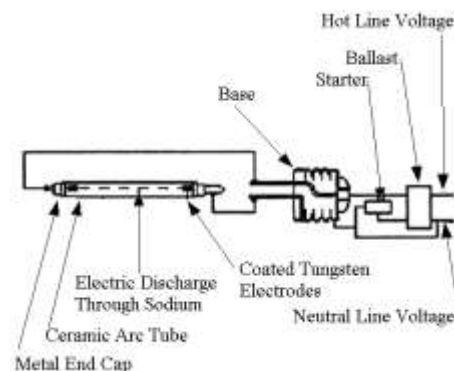


Fig. 1 Conventional street light architecture

The lamp is the one that emits luminous light and normally consists of a metal halide type of lamp. When the photo resistor detects the surrounding as dark, it sends a signal to invoke the starter. The starter functions as a time delay switch whereby it heats up the coated tungsten electrodes at both ends. The ionization by the mixture of gasses and the electrodes heated up results in formation of charges. The capacitor then holds the charge to be released and that will start the arc and start up the lamp. Here, the ballast function to maintain the current of the light which has been turned ON by limiting the current to an appropriate amount suitable for the lamp.

*B. Zigbee enabled street light*

Zigbee -enabled street light is based on the wireless sensor network application that utilizes Zigbee communication protocol to enhance the technology of street lighting system by providing communication capabilities. Zigbee - enabled street light are mostly battery powered, hence there is no need of laying underground cable connection. Fig. 2 below shows the Zigbee - enabled street light system.

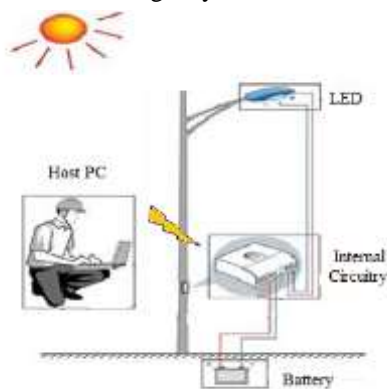


Fig. 2 Zigbee-enabled street light architecture

Within the street light, only three types of circuitry are involved mainly the sensor circuit (above the street light), Zigbee module, microcontroller and an LED (Light Emitting Diode) circuit. The microcontroller behaves as the 'brain' of the overall system controlling the in and out of the data. When the microcontroller senses the street light surrounding as dark or bright, it sends a signal to the microcontroller. The microcontroller immediately sends a high (1) or low (0) to turn ON and OFF the LED lamp. With the help of the Zigbee transceiver, the microcontroller reports every action and status of the street light to the control station wirelessly. In this case the host at the control station is able to monitor and control the street light all the time.

III. RESULTS

TABLE I  
STREET LIGHT STATUS CORRESPONDING TO ADC VALUE

ADC Value	Lamp State	Environment	Status
0-199	ON	Dark	Healthy
200-399	OFF	Dark	Unhealthy
400-599	OFF	Dark/Bright	Error
600-899	ON	Bright	Unhealthy
900-1023	OFF	Bright	Healthy



Fig. 3 Graphical user interface for 'unhealthy' status



Fig. 4 Graphical user interface for 'faulty' status

IV. DISCUSSION

As the surrounding gets darker, the resistance of the LDR (Light Dependent Resistor) increases, the voltage yielded will be high and a large ADC (Analog to Digital Converter) value will be obtained. The ADC value can be as low as 0 for very bright environment and as far as 1023 for a dark environment. The ADC value obtained is directly proportional to the voltage divider value of both the LDR and the potentiometer in series with each other. A slightest change in the resistance of the LDR can give a difference to the ADC value. The microcontroller used in the system is of 10-bit, hence produces as much as  $2^{10} = 1023$  values.

The LDR with a resistance of  $1M\Omega$  (value used in this circuit) has the capabilities of yielding a resistance as low as few hundreds of ohms in a bright light while resistance of Mega ohms in the dark. The resistance of the LDR mainly depends on the surrounding ambient lighting. As the brightness increases, the resistance of the LDR drops. As the resistance drops, the illuminance value defined as lux increases. Lux is a parameter used to define the light intensity.

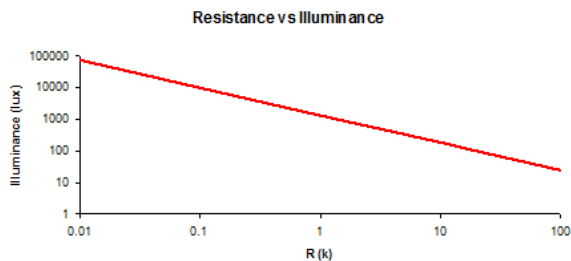


Fig. 5 Relationship between resistance and illuminance

The street lighting system in this project is reflected by three different cases which includes healthy, unhealthy and faulty. In a healthy condition, the street light operates in a normal working condition by turning ON and OFF automatically for night and day light respectively. However, in an unhealthy condition, the street light does not turn ON or OFF and in return sends a feedback message to the control room to notify the host. With the use of GUI (graphical user interface) at the host computer, the host is able to turn ON or OFF the street light located a distance away manually and wirelessly as depicted in Fig. 3 and Fig. 4. In a faulty condition, the street light is believed to have malfunctioned and sends an error message as seen in Fig. 4 to the control room to alert the host regarding the matter. The host is notified and further actions are taken to carry out repair works.

Compared to the conventional street lighting system, Zigbee based street lighting system offers high reliability and low maintenance with the deployment of feedback system. The feedback system allows the street light to communicate or 'respond' with the control room reporting its daily status and condition. Besides, it involves the use of miniature circuitry that includes wireless monitoring and control with maximum 5V to power up the LED lights.

## V. FUTURE WORK

Further development can be done to increase the system efficiency by deploying GSM (Global System for Mobile Communications) system to send automatic text message to host at the control station, to increase the range of Zigbee communication with the use of RF (Radio Frequency) amplifiers, to increase the number of nodes (capacity) in the network by implementing higher class topologies and to have

an internal database (date, time, location and status) to keep track of the street light activity for reference and maintenance purposes. Besides, to reduce power wastage, a motion sensor can be installed so as to turn ON only when there is a sense of movement while the rest of time to be in OFF state.

## VI. CONCLUSION

An application for the purpose of controlling and monitoring was developed through the use of Zigbee wireless communication protocol. Zigbee communication protocol enabled street light to communicate with microcontroller and control station wirelessly without the need of laying down cables. Besides, compared to the conventional street lighting system, with the use of Zigbee protocol, enable to develop a much more energy efficient based street lighting system which is time plus cost saving. Furthermore, the developed application used embedded programming to control the behaviour of the overall system. The developed application has communication capabilities to provide system feedback which allow for robust communication in different environment.

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