

Energy Efficient Street Lighting Control System

¹S.Vijayakumar
Asst.Prof, TIFACCORE
Velammal Engineering College,
Chennai, India-600053

²S.Karthik srinivas
M.E. Mobile and Pervasive Computing
Velammal Engineering College,
Chennai, India-600053

Abstract

Energy conservation has become the need of the hour, especially in a developing country like India. In India 80% of power generated is wasted in lighting systems. The fossil fuels are depleting fast and alternate sources of energy have not reached expected levels even solar energy is costly. Thus the proposed system is based on ZIGBEE wireless technology involving zigbee coordinator, zigbee end-node interfaced with a microcontroller (ATMEGA16). The microcontroller is interfaced with

a GSM modem to achieve long distance communication. The street lights can be monitored and controlled from a centralized area (DTMF) and also controlled remotely via cell phone by a suitable street light application. Brightness of lights is adjusted using dimming control circuit (IRS2530D) at the lamp post. The brightness of the street light can also be adjusted with respect to surrounding ambience using sensor (LDR) at the microcontroller side.

1. Introduction

Energy is an important commodity for emerging India, thus important is its efficient usage. Currently, India is prominent among energy wasting countries for lack of any energy efficient planning. Some of the prominent areas of energy wastage in India:

1. Street Lighting.
2. Entertainment Lighting.
3. Home Lighting.
4. Industrial lighting

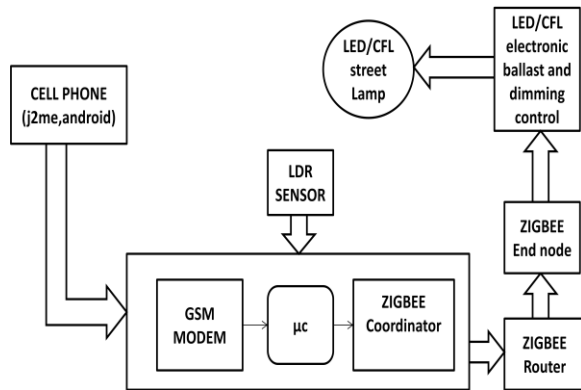
The most prominent area of wastage is street lighting. We propose an energy efficient system using zigbee wireless technology whereby a zigbee end node is mounted on the lamp post and connected to zigbee coordinator via a zigbee router in a wireless mesh

Topology. The end node is a reduced function device (RFD), it can only transmit or receive messages and cannot route it. The coordinator is a full function device (FFD); it is the heart of the zigbee network. Router is generally used when more number of nodes have to be connected with the coordinator and with increasing distances. The zigbee end node is connected to the dimming control circuit. The microcontroller is interfaced with zigbee coordinator and gsm modem. Cell phone is used to send information to the controller to switch on, off, adjust brightness of particular lights. The centralized control is achieved by Dual Tone Multi Frequency (DTMF) whereby microcontroller is programmed to automatically switch on, off or adjust brightness using available inputs.

2. System layout

The layout comprises of block consisting of cell phone (ANDROID/J2ME), another block comprises of GSM Modem, ATMEGA Microcontroller, zigbee coordinator and LDR sensor for ambience control, followed by individual blocks containing zigbee router, zigbee end node, dimming control circuit, the lamp used here is either CFL or LED. This is to attain maximum energy efficiency.

Layout architecture



3. System components

3.1. Cell phone

A cellular phone or mobile phone is a device that can make and receive telephone calls over a radio link whilst moving around a wide geographic area. It does so by connecting to a cellular network provided by a mobile phone operator, allowing access to the public telephone network.

3.2. Gsm modem

A GSM modem is a specialized type of modem which accepts a SIM card, and operates over a subscription to a mobile operator, just like a mobile phone. From the mobile operator perspective, a GSM modem looks just like a mobile phone. When a GSM modem is connected to a computer, this allows the computer to use the GSM modem to communicate over the mobile network. While these GSM modems are most frequently used to provide mobile internet connectivity, many of them can also be used for sending and receiving SMS and MMS messages.

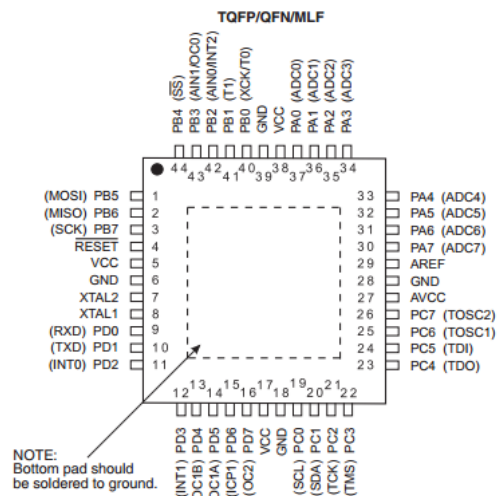
Gsm modem



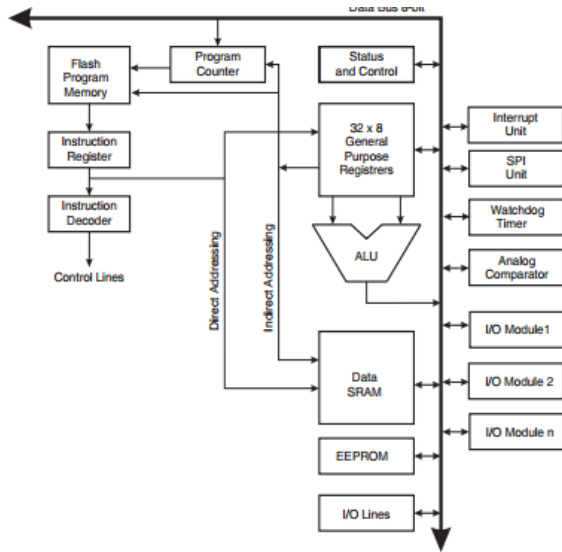
3.3. Avr microcontroller

ATMEGA16 is an 8-bit micro controller with 16k bytes in system programmable flash. It consumes low power as it is highly suitable for zigbee based applications. Based on Advanced RISC Architecture, consists 131 powerful instructions set, 32*8 general purpose registers. It has 512 bytes EEPROM, has the capacity to retain data at 85 Celsius for 20 years. The most important feature of AVR is security feature as it contains a programming lock to prevent software tampering.

Pin diagram

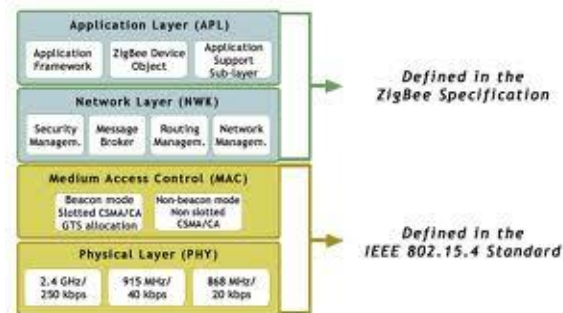


Avr architecture



3.4. ZIGBEE

Zigbee is a low power spin off of WiFi. It is a specification for small, low power radios based on IEEE 802.15.4 – 2003 Wireless Personal Area Networks standard. [1]The specification was accepted and ratified by the Zigbee alliance in December 2004. Zigbee Alliance is a group of more than 300 companies including industry majors like Philips, Mitsubishi Electric, Epson, Atmel, Texas Instruments etc. which are committed towards developing and promoting this standard. The alliance is responsible for publishing and maintaining the Zigbee specification and has updated it time and again after making it public for the first time in 2005.



3.4.1. Zigbee coordinator (ZC)

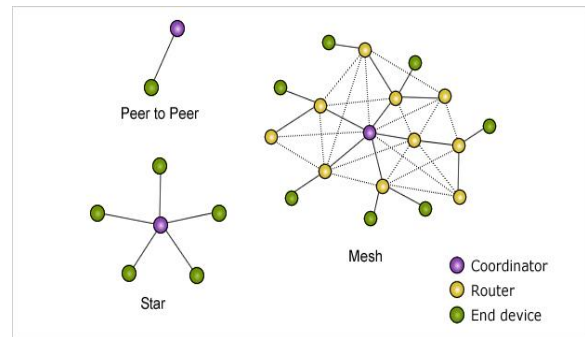
The most capable device, the coordinator forms the root of the network tree and might bridge to other networks. [1]There is exactly one ZigBee coordinator in each network since it is the device that started the network originally. It stores information about the network, including acting as the Trust Center & repository for security keys

3.4.2. Zigbee router (ZR)

As well as running an application function, a router can act as an intermediate router, passing on data from other devices. [1]Router is generally used when the number of end nodes to be connected to the coordinator increase further to increase the area of coverage and as a helping hand in routing.

3.4.3. Zigbee end node (ZED)

Contains just enough functionality to talk to the parent node (either the coordinator or a router); it cannot relay data from other devices. [1]This relationship allows the node to be asleep a significant amount of the time thereby giving long battery life. A ZED requires the least amount of memory, and therefore can be less expensive to manufacture than a ZR or ZC.



3.5. Ldr sensor

LDR means light dependant resistor.[5] There is no resistance at the presence of light. When darkness falls its resistance increases. Maximum resistance is achieved under no light conditions. Normally the resistance of an LDR is very high, sometimes as high

as 1000 000 ohms, but when they are illuminated with light resistance drops dramatically.

3.5.1. Ambience sensing

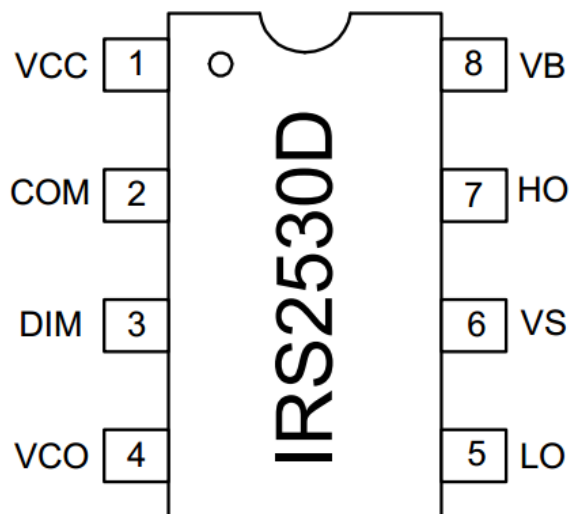
The street lighting system can be made to react to the surrounding ambience by connecting a sensor (LDR) to the microcontroller (ATMEGA16). [5]The LDR sensor will have no resistance in the presence of light and very high resistance of 1000 000 ohms so the resistance values can be sent to the microcontroller's ADC, converted into digital values. So accordingly

3.6 Electronic ballast

Electronic ballast uses solid state electronic circuitry to provide the proper starting and operating electrical conditions to power discharge lamps. [2]It is very necessary for the electronic ballast to provide the starting voltage and current and also maintain the required current and voltage levels for the efficient operation of an LED or CFL lamp.

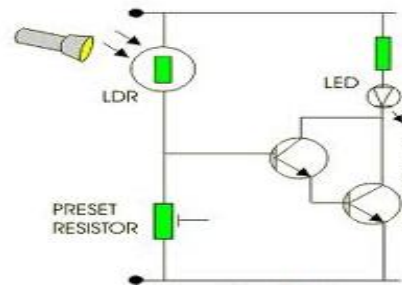
3.6.1. Dimming control circuit

Dimming control circuit is generally used to control the brightness of the street light; dimming principle states that the brightness of a CFL or LED lamp can be controlled by controlling the current flowing to the lamp, which can be achieved by usage of potentiometer, tank circuit. It uses a special driver ic IR2530D.



3.7. Cfl lamp

the brightness level of lamp is computed and adjusted.



A compact fluorescent lamp (CFL), also called compact fluorescent light, energy-saving light, and compact fluorescent tube, is a fluorescent lamp designed to replace an incandescent lamp; some types fit into light fixtures formerly used for incandescent lamps. The lamps use a tube which is curved or folded to fit into the space of an incandescent bulb, and a compact electronic ballast in the base of the lamp. Compared to general-service incandescent lamps giving the same amount of visible light, CFLs use one-fifth to one-third the electric power, and last eight to fifteen times longer. A CFL has a higher purchase price than an incandescent lamp, but can save over five times its purchase price in electricity costs over the lamp's lifetime. Like all fluorescent lamps, CFLs contain mercury, which complicates their disposal. In many countries, governments have established recycling schemes for CFLs and glass generally. CFLs radiate a spectral power distribution that is different from that of incandescent lamps. Improved phosphor formulations have improved the perceived colour of the light emitted by CFLs, such that some sources rate the best "soft white" CFLs as subjectively similar in colour to standard incandescent lamps.

3.8. Led lamp

An LED lamp (or LED light bulb) is a solid-state lamp that uses light-emitting diodes (LEDs) as the

source of light. LED lamps offer long life and high energy efficiency, but initial costs are higher than fluorescent and incandescent lamps. Chemical decomposition of LED chips reduces luminous flux over life cycle as with conventional lamps. [3]The LEDs involved conventional semiconductor light-emitting diodes, organic LEDs (OLED), or polymer light-emitting diodes (PLED) devices. However, PLED technologies are not commercially available. Diode technology improves steadily.LED lamps can be made interchangeable with other types of lamps. Assemblies of high power light-emitting diodes can be used to replace incandescent or fluorescent lamps. Some LED lamps are made with identical bases so that they are directly interchangeable with incandescent bulbs. Since the luminous efficacy (amount of visible light produced per unit of electrical power input) varies widely between LED

and incandescent lamps, lamps are usefully marked with their lumen output to allow comparison with

4. User interface

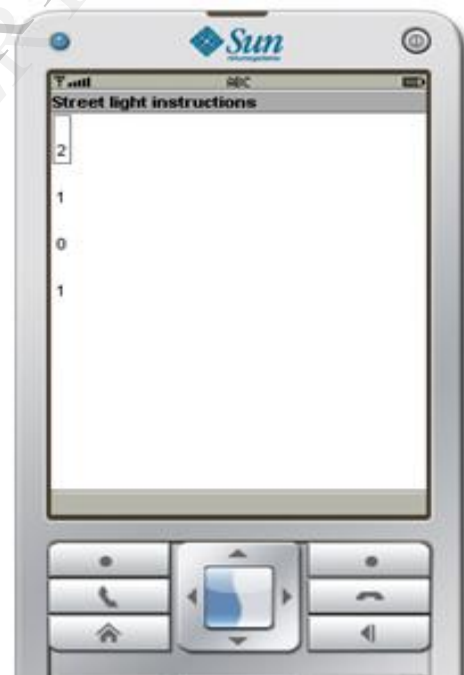
An model interface is developed using j2me, it has options for ON, OFF and DIMMING .

Street light application



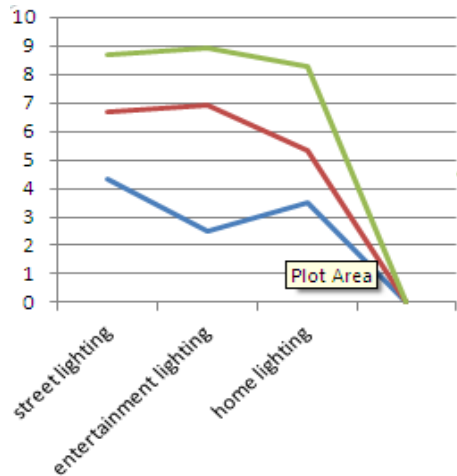
Street light interface

other types of lamps.[3] LED lamps are sometimes marked to show the watt rating of an incandescent lamp with approximately the same lumen output, for consumer reference in purchasing a lamp that will provide a similar level of illumination.



5. Energy comparison

Scale: y-axis=1cm=1000 watts



Street lighting (watts/day) = (8800 watts/day)

Entertainment lighting (watts/day) = (6700 watts/day)

Home lighting (watts/day) = (4300 watts/day)

6. Conclusion

An efficient and effective street light control system with maximum energy efficiency, maintainability is achieved tailor-made for sub continental conditions. There is both remote as well as centralized control so there is option to fall back upon if either one of the control systems fail. The proposed system can be extended to other areas of lighting as well. The power consumption of the system is lowest among existing systems due to the use zigbee wireless network, so false activations as in the case of sensor based systems is ruled out. There is further scope of increase in the system capacity with improvements in zigbee technology. The scope of future up gradations is bright.

Acknowledgment

1. Atmel corporation
2. Philips corporation.
3. Dr. R.S.kumar, principal, velammal engineering college, Chennai

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