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Hybrid, Low Cost, Sensor Based Smart Lighting for Rural Areas

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Abstract: Energy is important for the progress of a nation and it has to be saved or conserved. The most challenging task in the worldwide is reducing the energy demand in both residential and industrial sectors. Lighting systems are major source of electricity consumption in the cities and the rural areas. Technologies should be developed to produce energy in most user friendly manner and importance should be given to conserve energy. In the world lighting system consumes major source of electricity and huge amount of energy is wasted. Technologies are developed to use LED is offices, industries houses etc than traditional lights. Already installed lighting systems are outdated and energy inefficient. So in existing market lighting control systems are introduced. Because of high cost and maintenance, CO2 emission, the existing lighting systems are not efficiently applicable to be cooperative world. This paper introduces hybrid, low cost, wireless sensor based, adaptable smart LED lighting system to automatically control and adjust the light intensity to converse energy and to satisfy users. This system combines PIR sensor, light sensor and CO2 sensor to provide low power wireless solution. Communication is using zigbee transmitter and receiver. It also includes the facility of usage of renewable energy sources rather than the conventional power sources. Solar energy is the most importance renewable resource that can be used in case of failure to achieve the maximum efficiently. The paper represents the design and implementation of the proposed system in real time environment and it also focus on user preferences. It helps to provide more electricity to the rural people due to low power consumption.

Keywords: Lighting system, light emitting diode(LED), Sensors, Arduino, Energy saving, PIC16F877a, Zigbee.

I. INTRODUCTION

In the current research, energy saving and environmental awareness is an important topic. As we all know, lighting systems are a major source of energy consumption in cities and rural areas. The most crucial problem in the today's world is not getting the regular power because the power demand in consumer end is greater than the production of power. In many countries, especially rural areas, people are not getting the basic needs like lights, fan, TV etc. To balance the power demand, in particular area power will be cut and that area will be in dark. Rather than balancing the power in this way, the low power consuming equipments are allowed for particular time and high power consuming equipments are allowed for particular time. The most basic need is light. Wireless sensor network helps in controlling light. By reducing the energy consumption, efforts are made to satisfy the users. Also the environment is affected by the greenhouse gases like carbon dioxide, carbon monoxide methane etc. Radiation emitted by the sun is trapped by the atmosphere of the planet which is caused by the gases such as carbon dioxide, water vapour and methane. It allows incoming sunlight to pass through but heat radiated back from the surface of the planet is retained by it. Traditional light system emits more carbon dioxide (CO2) which is also the reason for energy consumption [1]. So the efforts are made to reduce the power consumption and CO2 emission by using Light emitting diodes (LED), light and sensors.

In the general lighting applications, the LEDs are used due to its longer lifetime, reduced power consumption, high intensity of light and having no mercury content when compared to the incandescent and fluorescent bulbs[2],[3]. Dimming control is also needed to save the energy. Novel driver systems are helpful to improve dimming AND ON/OFF control features. Using wireless sensor network (WSN), it is easier to control and monitor industries, buildings, houses and structures. WSN along with LED lights and drivers reduces the power consumption in several orders of units. It is possible to have low cost, high power saving system [4].

Smart lighting is a technology mainly designed and developed for energy efficiency. Automated controls are used to make adjustments based on the real time requirements such as occupancy or daylight availability. Smart lighting makes use of sensor networks, LED fixtures and different sensors to monitor and control the light. Data is collected for the same purpose so that energy can be saved. It is positioned to serve as infrastructure for space utilization and people tracking. Light management is known as smart lighting which provides many advantages such as energy saving, automatic control of light, long term constant lumen level and adjustable light levels [14].

II. LITERATURE SURVEY

Lot of work has been done in the said area. All the all issues are considered and idea behind this project paper is based on the same.

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Adoniya Ben Sebtosi et al[5]. worked on the technology where white LED is used for rural rectification. It involves a quantum process to convert dc current to light. It has good life span than the incandescent light sources and it is best compared to fluorescent bulbs where there is time delay to get full brightness. But in this method, there is a possibility of leaking UV light to the laser so it is not much preferred.

R. Sankar et al[6]. identified the challenges faced by the people in rural area people who are unaware of the locally available resources. The same issue can be solved by utilizing alternate renewable energy sources. Solar energy is the best source for the rural rectification when power demand is high. When the reliable electricity is challenge to the developing and under developed countries, it is a cost effective method. But the cost of inverter and battery replacement is a limiting factor.

Daehi kim et al[7]. have proposed a smart Led lighting system based on the continuous human tracking using Ultrasonic and Infrared sensors. By using single sensor, it is not possible to continuously track data and to maintain efficiency. Depending on the result of the sensors, the LED control layer turns on or off the LED. In this approach, each LED in the specific area smartly emits the light. Energy saving is achieved in a considerable amount.

B.K. Subramanyam et al[8]. implemented solar based street light system which integrates many new technologies and also offers energy savings. Street lights are controlled by the graphical user interface(GUI) in the PC. Zigbee is also used for wireless communication. This system is suitable in urban and rural areas where traffic is low. It is versatile and adjustable to user needs.

Raja R et al[9]. used the sensor network with the lamp addressable controller to get high rate of energy saving in the building structure. LED has good switching time with handshaking capacity for the serial communication of DALI. It supports for the high information transfer between lamps and controller. The replacement of normal light by LED with controlling protocol helped to increase the power saving amount.

Sri Andari Husen et al[10]. studied the problem of controlling multiple lighting systems and tried to minimize the issues. They presented the load control methods in lighting systems which offers demand response services on smart grids. By this method the minimum illumination for all groups is allowed simultaneously.

R.F. Fernandes et al[11]. developed a system which helped in reduction of resource wastage. The smartness of the solutions stands on the communication infrastructure to move information from production to consumer points based on IEEE802.15.4 standard. So remote control of the system is achieved.

III.PROPOSED SYSTEM

The most popular alternative on the demand side energy management, monitoring and controlling homes, buildings and structures is by using wireless technology. It helps to overcome the installation cost issues. Wireless sensor technology enables energy control which is easier to install and implement than wired networks. By combining wireless sensor controls and DC grid powered LED lighting systems greater amount of energy can be saved at the demand side of the green smart buildings and in rural areas. The logic behind the lighting control system depends on the factors such as daylight intensity which can be measured by light sensitive sensors. The main goal is to reduce the cost of energy supply. This approach uses Zigbee standard which can control the LED driver so that the accuracy and reactivity of the system is increased. The usage of PyroelectricInfrared (PIR) sensor, Light sensor and CO2 sensor helps in monitoring and control of the smart lighting which helps to lower the energy consumption and makes the system reliable, practical and user convenient [12].

IV. PROPOSED SYSTEM ARCHITECTURE

(A). TRANSMITTER END

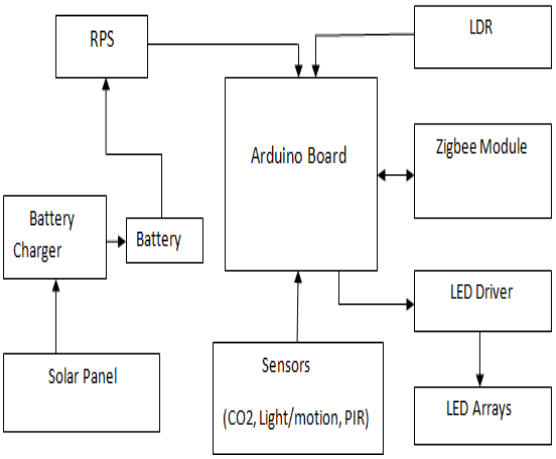

Figure 1: Architecture of transmitter end

The architecture of the transmitted end is shown in figure 1. It includes Arduino uno platform, solar panel, Light dependent resistors, sensors like CO2, light sensor and PyroelectricInfrared (PIR)sensor. Inclusion of Zigbee module helpful for wireless communication between transmitter and receiver end. Arduino uno R3 helps to process the data collected by the sensors which in turn gives the processed data to the Zigbee module for transmission.

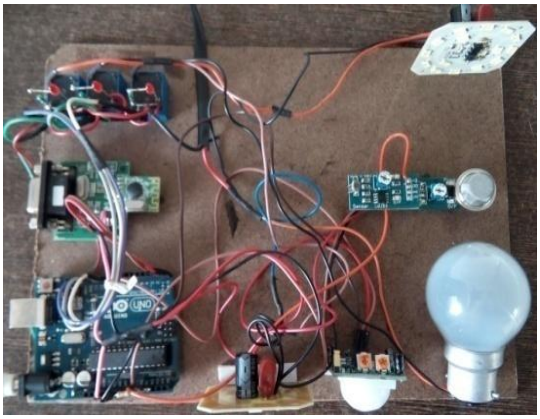

Figure 2: Constructed Transmitter end

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PIR sensor
Passive infrared sensor also named as pyroelectricInfrared sensor which detects infrared rays radiated from moving human body in its coverage area. This sensor is housed in a sealed metal to enhance the immunity against noise/temperature or humidity. This module also detects other heat sources other than human temperature. But it can't detect any obstacles which are not in motion. It detects infrared rays by Fresnel lens. In strong shock or vibration, rapid environmental changes in these conditions it is not preferable to use. It is small, low power, not much expensive so it finds in business and home appliances. In projects it is much preferable to use to detect the presence of a person inside the room. These sensors are easy to interface also[15].

CO2 sensor
The CO2 concentration/amount is measured in parts per million (ppm). Carbon dioxide sensor is used the measurement of CO2 gas. It works on the principle of infrared gas sensors and chemical gas sensors. It is important to measure the indoor air quality. Here it is used measure CO2 gas by incandescent and LED light. The measured concentration is displayed on the LCD display[13].

Light sensor
Light sensors are photo-resistors or light dependent resistors. They changes its resistance according to the intensity of light. Here intensity of light and its resistance is inversely proportional to each other. The intensity of LED light and incandescent bulb is calculated and comparison level of intensity is displayed in LCD display at receiver end.

LED Driver
An LED driver is a electronic device used to regulate the power to an LED arrays. It provides constant power to LEDs. Its output matches the electrical properties of LEDs. By using pulse width modulation circuits it helps in dimming of light. It helps in maintaining the power level of LEDS. Without the proper driver, LED may become too hot and unstable which may therefore cause poor performance.

RF Tx-Rx (Zigbee module)
Now a days, Wireless communication is more preferred than wired network communication to simplify the circuitry. Zigbee is highly used in industries and is because of demand from consumer end for wireless applications. Some of its good features are low data rate, lower duty cycle, longer battery life, reliable data transfer, simple design, shorter range, low cost solutions and a simple protocol. It also provides good security capabilities.

Arduino Uno
It is microcontroller board based on ATmega 328. It has got 14 input/output pins out of which 6 are used as analog input pins and 6 can be used as PWM outputs. It is a open source physical computing platform. Programming is simple here[17].

Features of Arduino Uno
- ATmega328 microcontroller
- Input voltage - 7-12V
- Operating voltage- 5V
- 14 Digital I/O Pins (6 PWM outputs)
- 6 Analog Inputs
- 16Mhz Crystal Oscillator
- 32kB Flash Memory

(B). RECEIVER END

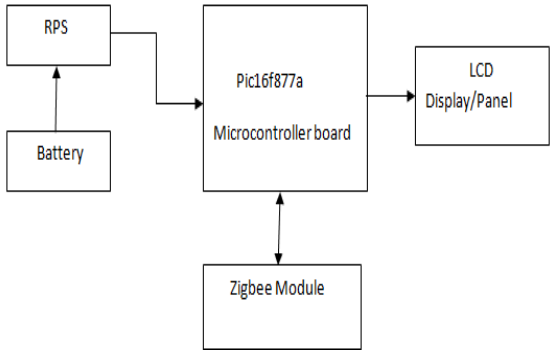

Figure 3: Architecture of receiver end


Figure 4: Constructed Receiver end

Liquid Crystal Display (LCD)
LCD is used in this project to visualize the comparative values obtained by the LED and incandescent bulbs such as power consumption, intensity and CO2 concentration. We have used 16×2 LCD. It indicates 2 rows and 16columns. In each line 16 characters can be written. Total of 32 characters can be displayed on it. It is used to check the output of the different modules interfaced with microcontroller.

PIC16F877A Microcontroller
PIC16F877a is CMOS flash based 8 bit microcontroller. It possess 256 bytes of EEPROM data memory, an ICD, comparators(2), self programming,8 channels of 10 bit Analaog-to-Digital converter, capture/compare/PWM functions(2) and synchronous serial port. At the receiver end PIC is used for linear programming. Measured values received from the Zigbee are processed by the microcontroller which in further displays the results on the LCD[16].

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V. RESULTS

Prototype has been developed, tested and can be deployed in variable real time conditions to verify its functionality, performance and its results. The solar energy is used to conserve energy which is renewable energy source. The results are obtained by comparing incandescent bulb and LED light. To evaluate the power consumption, intensity and CO2 the corresponding sensors are used which senses the values and those measured valued are processed by arduino platform, it is sent and received by Zigbee a wireless communication. The resulting values are again processed by the PIC microcontroller. The comparison values are finally displayed on the LCD display. The on/off control of light is also achieved by using PIR sensor. Whenever the human body movement is detected the heat (infrared rays) is absorbed by the sensor and it finally helps to turn on the LED. In the absence LED is off which helps in energy saving and cost. Result shows that the intensity of light is higher in LED than incandescent bulb.

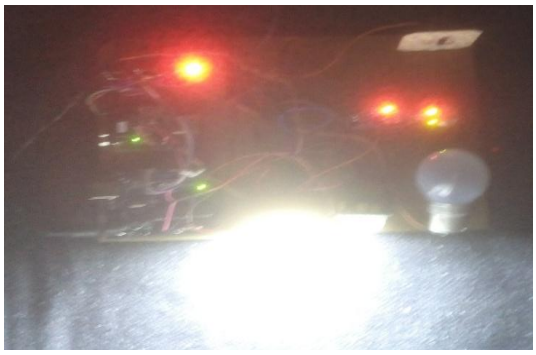

Figure 5: Automatic on/off control using PIR sensor

Figure 6:Intensity of light and CO2 emission(in ppm) when 5W Incandescent bulb is used

Figure 7: Intensity of light and CO2 emission (in ppm) when 5W LED bulb is used.

VI. CONCLUSSION AND FUTURE SCOPE

The proposed novel system is helpful to monitor and control LED lighting with low cost and low power wireless sensor network. This method involves the deployment of sensors together with Zigbee which is responsible for generating PWM signal to control the existing LED drivers. It helps in reduction of the power consumption of LED lighting. The use of CO2 sensor, light sensor and PIR sensor together with user preferences allows distributed intelligence to save energy by reducing intensity of light. LED lighting is environment friendly because of the reduction in CO2 emission compared to other conventional lighting system. LED also produces less heat. Colour range and effects are also high. LEDs needs no maintenance. This system also gives the idea to make use of the renewable energy source like solar energy to conserve energy. In future efforts can be made to reduce the cost of inverter by simplifying the circuit and battery replacement. As a future work efforts can be done to dim only selected light in a large group and similar to load reduction, load restoration may be considered

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