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RESEARCH ARTICLE

EFFICIENT SYSTEM FOR REDUCTION OF POWER USING ZIGBEE NETWORK AND SENSORS IN STREET LIGHTING

V. SIVA RAMA KRISHNA[1]
M.Tech Project scholar

K. RAGHAVA RAO[2]
Professor in CSE

[1,2]Department of Electronics and Computer Engineering, K L University, Guntur

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Corresponding Author

V.SIVA RAMA KRISHNA

Abstract

This paper proposes energy efficient system for reduction of power using zigbee network and sensor in street lighting. The main objective is to design energy efficient based street lamp via appropriate lighting levels control. This system consists of a arm controller, light sensor, motion sensor, current transformer to reduce the flow of current and a set of the light emitting module. While, the controlling and managing of the system is based on intensity of light. Different level of street light brightness has been used for lighting up the street. The system was programmed to automatically turn off or on during the hours of daylight based on the intensity of light and operate during the night. Several numbers of tests have been conducted to test and validate the proposed prototype in the different environment. As conclusion, reduction in power consumption can be achieved through this proposed system and can also know the amount of the time that street is working.
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I. Introduction

Especially in the public sector lighting systems, are still designed according to the old standards of reliability and they often do not take advantage of the latest technological developments. In many cases, this is related to the plant administrators who have not completed the return of the expenses derived from the construction of existing facilities yet. However, the recent increasing pressure related to the raw material costs and the greater social sensitivity to environmental issues are leading manufacturers to develop new techniques and technologies
which allow significant cost savings and a greater respect for the environment. We can find three possible solutions to these problems in the literature. The first one, and perhaps the most intuitive, is the use of new
Technologies for the sources of light. In this area, light-emitting diode (LED) technology is the best solution because it offers many benefits. Researchers have already considered this possibility, designing an advanced street lighting system based on LEDs.The second possible solution, and perhaps the most revolutionary, is the use of a remote-control system based on intelligent lamp posts that send information to a central control system, thus simplifying management and maintenance issues. Researchers have developed a street lamp system using the general-packet radio service (GPRS), power-line carrier, or Global Systems for Mobile Communications (GSM)
transmissions.Finally, the third possibility would be the use of renewable energy sources locally available, rather than conventional power sources, with a positive effect on the environment. Solar energy is the most important resource in this field. Our work aims at the unification of the three mentioned possibilities, creating an intelligent lamp post managed by a remote- controlled system which uses LED-based light sources and is powered by renewable energy (solar panel and battery). The control is implemented through a network of sensors to collect the relevant information related to the management and maintenance of the system, transferring the information via

wireless using the ZigBee protocol. The field of the ZigBee remote sensing and control system is widely present in the literature; we can also find ZigBee systems similar to (the) lighting systems in structure and management .
In this paper, we present our system, which is able to integrate the latest technologies, in order to describe an advanced and intelligentmanagement and control system of the street lighting.

II. Proposed System Design

The conceptual scheme of the proposed system. It consists of a group of observation stations on the street (one station for each lamp post) and a base station typically placed in a building located nearby. It is a modular system, easily extendable. The measuring stations monitor the street conditions and the intensity of sunlight and, based on them, they decide to turn the lamps on or off . The conditions depend on the pattern of the street where the lights are located and on the solar irradiation at a given point of the street, with frequent changes, depending on weather conditions, season, geographical location, and many other factors. For these reasons, we decided to make each lamp completely independent in the management of its own lighting. The on-street station also checks if the lamp is properly working and sends the information through the wireless network to the base station for processing data. If any malfunction is detected, the service engineer is informed through a graphical interface and can perform corrective actions.

A. Monitoring Stations

The monitoring station located in each lamp post consists of several modules: the presence sensor, the light sensor, the failure sensor, and an emergency switch. These devices work together and transfer all of the information to a microcontroller which processes the data and automatically sets the appropriate course of action. A priority in the transmission of information is assigned to each sensor, for example, the emergency switch takes precedence over any other device.

1) **Motion Sensor**: The task of the motion sensor is to identify the passage of a vehicle or pedestrian, giving an input to turn on a lamp or a group of lamps. This function depends on the pattern of the street; in case of a street without crossroads, a single sensor is sufficient (or one at each end in case of a two-way street), while for a street requiring more precise control, a solution with multiple presence detectors is necessary. This feature enables switching on the lamps only when necessary, avoiding a waste of energy. The main challenge with sucha sensor is its correct placement. The sensor should be placed at an optimal height, not too low (i.e., to avoid any erroneous detection of small animals) nor too high (for example, to avoid failure to detect children). A study of the sensor placement enables deciding the optimal height according to the user needs and considering the specific environment in which the system will work. We discovered that in field tests, the SE-10 PIR motion sensor offers good performance and is quite affordable.

2) **Light Sensor:** A light sensor can measure the brightness of the sunlight and provides information. The purpose of this measurement is to ensure a minimum level of illumination of the street, as required by regulations (see CIE et al. The sensor must have high sensitivity in the visible spectrum, providing a photocurrent high enough for low light luminance levels. For this reason, the phototransistor TEPT5700 has been selected. Based on the measured luminance, the microcontroller drives the lamp in order to maintain a constant level of illumination. This action is obviously not required during daylight time, but it is desirable in the early morning and at dusk, when it is not necessary to operate the lamp at full power but simply as a “support” to the sunlight. This mode enables saving electric power supplied to the lamp because the lamp is regulated by the combined action of the sensor and the microcontroller to ensure the minimum illumination required.

3) **CurrentTransformer:**A current transformer (CT) is used for measurement of alternating electric currents. Current transformers, together with voltage transformers (VT) (potential transformers (PT)), are known as instrument transformers. When current in a circuit is too high to apply directly to measuring instruments, a current transformer produces a reduced current accurately proportional to the current in the circuit, which can be conveniently connected to measuring and recording instruments. A current transformer isolates the measuring instruments from what may be very high voltage in the monitored circuit.

4) Ldr Arrays: A photo resistor or light-dependent resistor (LDR) or photocell is a light-controlled variable resistor. The resistance of a photo resistor decreases with increasing incident light intensity; in other words, it exhibits photo conductivity. A photo resistor can be applied in light-sensitive detector circuits, and light- and dark-activated switching circuits

B. Base Control Station

The base control station is the hub of the system since it allows the visualization of the entire lighting system. The transmission system consists of a ZigBee device that receives information on the state of the lamps and sends it to a terminal. The processing unit consists of a terminal with a serial Universal Asynchronous Receiver-Transmitter (UART) interface which receives information about the state of the lamps provided by a ZigBee device. The terminal is required for a graphical display of the results. Moreover, data on lamps' operation are associated with the lamp address; consequently, all faults are easily identified. The graphical interface enables monitoring the state of the system with the state of the lights and the power consumption of each lamp.The operator will have a graphical representation of the lamp location within the area where the system is installed.
Pressing the button "Power Consumption Data," a second window appears where power consumption and working time of any lamp are given. The program is also equipped with a management system that acts in case of no communication from the lamp posts well explained in Section III-E after the description of the entire system.

C. ZigBee Network

ZigBee is a wireless communication technology based on the IEEE802.15.4 standard for communication among multiple devices in a wireless personal-area network (WPAN). ZigBee is designed to be more affordable than other WPANs (such as, for example, Bluetooth) in terms of costs and, above all, energy consumption. A ZigBee personal-area network (ZBPAN) consists of at least one coordinator, one (or more) end device(s) and, if required, one (or more) router(s). The network is created when a coordinator selects a channel and starts the communication, henceforth, a router or an end device can join the network. The typical distance of a ZigBee transmission range, depending on the environment conditions and the transmission power, shifts from tens to hundreds of meters, and the transmission power is deliberately kept as low as possible to maintain the lowest energy consumption.

In the proposed system, the network is built to transfer information from the lamp posts to the base station control. Information is transferred point by point, from one lamppost to another where each lamp post has a unique address in the system. Each lamp post can only send the information to the nearest one, until the information reaches the base station. Thus, transmission power is limited to the required low value and the signals sent by the lampposts do not interfere with each other. In case of failure of one lamp, the chosen transmission distance between the lampposts ensures that the signal can reach the next operational lamp post without breaking the chain. The ZigBee wireless communication network has been implemented with the use of Digi-MaxStream radio-frequency modules called XBee modules, which are available in Standard and Pro versions (pin-to-pin compatible). The Standard Xbee modules have an operation range of tens of meters indoors and hundreds of meters outdoors, while the XBee Pro modules have a wider spread range in the order of hundreds of meters indoors and of about 1.5 km outdoors,
because the Pro modules have higher transmission power, butimply higher consumption (about three times the consumption of the Standard version).The receiver has very high sensitivity and a low probability of receiving corrupted packets (less than 1%). The modules should be supplied by 3 V from a dc source; the current consumption is in the order of 50 mA (for XBee) and 150–200 mA (for XBee PRO) in uplink and in the order of 50 mA in downlink (identical for both versions); moreover, they support a sleep mode where consumption is less than 10 A. The XBee modules are distributed
in three versions of antennas: with an on-chip antenna, a wire antenna, and with an integrated connector for an external antenna.

III Experimental Results

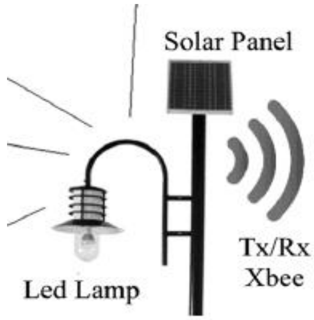


Figure 1: Schematic image of an on-street station.

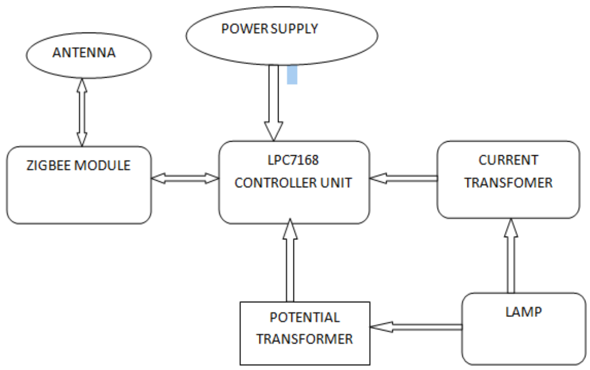


Figure 2: Remote street light control terminal

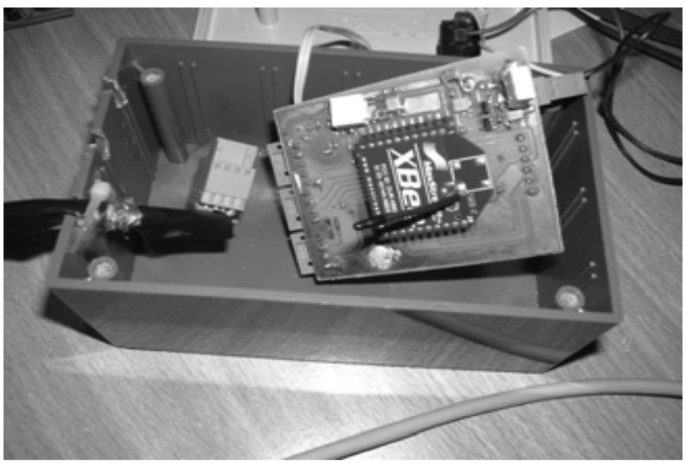


Figure 3: Prototype module

A. Prototype Model : The prototype has been tested in variable real-life conditions to verify the overall functionality and seek better performance. The measurements collected during the test phase allow calculating energy savings so that it is possible to estimate cost savings also for larger systems using approximations. A. Range Tests To test the reliability of the communication between two or more ZigBee modules in the following environmental conditions:

1) open field in line of sight between modules;
2) open field out of the line of sight where the obstacle is a big tree or a hill;
3) indoor test.

Figure 4: Tested system

B. Power Management in Designed System: The system was designed to be stand alone, supplied by solar panel energy, with relevant advantages resulting from this kind of power supply. It is possible to avoid the tedious and expensive wiring of the supply power network, with considerable savings and ease of implementation. The control circuit is designed to consume the lowest possible power, minimizing the battery capacity and the energy supplied by the solar panel. These goals were achieved through the use of the XBee module for transmitting and receiving information, using LED lamps as a replacement for standard lamps and using special power-saving solutions for microcontrollers and radio modules. The program, which controls the system, is designed primarily to save energy. First, since the system only works at night, avoiding wasting energy during daylight hours occurs when the only active device is the solar panel recharging the battery. Second, various sensors allow the system to work only when necessary. Third, the system implies highly efficient LEDs to ensure proper illumination and ensure energy savings.

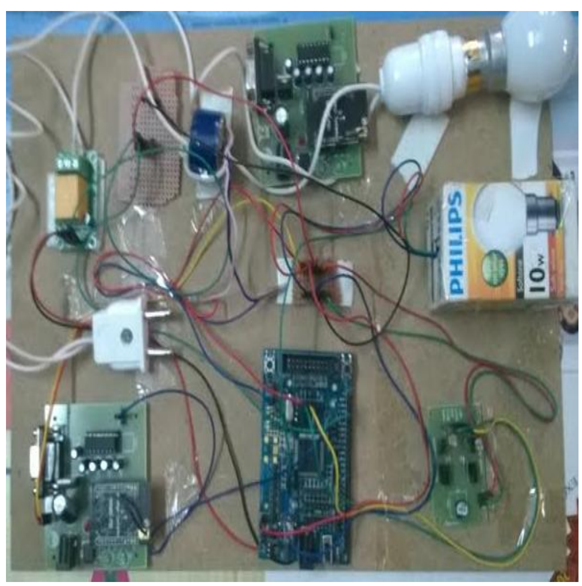
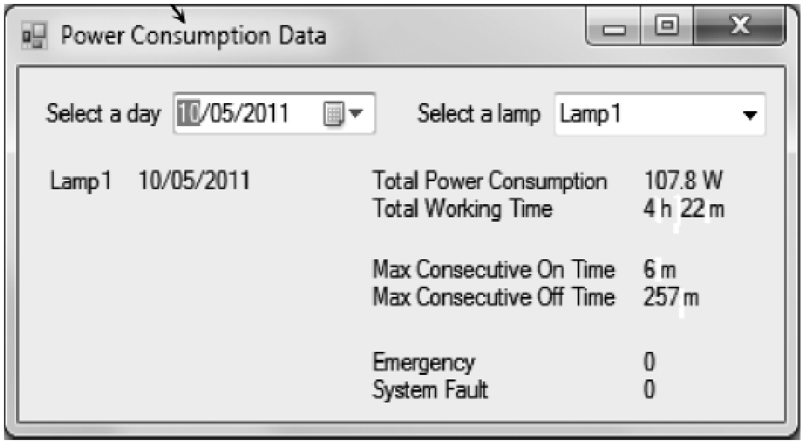


Figure 5:Tested for the system

C.Management of Lamp Post Fault : One of the purposes of our work was to make the system available to inform the remote central in case of a lamp post fault so that a restore operation would be quickly possible. In case of the ZigBee communication fault, if the n ism lamppost does not react to the inquiry of the central, the program sends a notification of a breakdown to the graphics interface. In this case, the system goes on measuring and storing data into the EEPROM and random-access memory (RAM) (with a capacity of 512 B) of the microcontroller. So if we consider a sampling every 5 min and a lamp post switching on for 8 h/day (as a particularly demanding case), the system will store data for about three days consecutively. But if the system is not restored within three days and we want to know the consumption information.



Fiure g 7: Result after system tested

IV. CONCLUSION

This paper describes a new intelligent street lighting system which integrates new technologies available on the market to offer higher efficiency and considerable savings. This can be achieved using the highly efficient LED technology supplied by renewable energy of solar panels, for which the cost of energy is independent from the power supplier prices, combined to an intelligent management of the lamp posts derived by a control system switching on the light only when necessary, increasing the lamps' lifetime. The system can be adopted in the future for loads supplied by the power system, which enables the monitoring of energy consumption.

V. Acknowledgements

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Authors Profile

[1]V.Siva Rama Krishna ,is Post Graduate Project scholar. As part of his Master of Technology thesis work , he has been done this work and implemented in working model and which can further enhanced to be a real model product. He has done several presentations and projects in area of Embedd Systems and wireless Sensor Networks.

[2]K.Raghava Rao, Professor in CSE, is having 15 years of experience in teaching for UG and PG engineering students and 3 years of Software Development experience in Singapore. He received B.E(CSE) from MG State University, M.Tech(CSE) from RVP University, Udaipur and Ph.D(CSE) from Mahatma Gandhi University (Kasi Vidyapeeth), Varanasi, in the years 1995, 2005 and 2009 respectively. He published several papers in national & international conferences and journals. He published 3 text books on Core Java, Design & Analysis of Algorithms and Data Mining and currently he is carrying a DST funded project in the area of Wireless Sensor Networks-Sensor Web Enablement. His research interests are Wireless Sensor Networks, Embedded Networks and Sensor Web Services. He is a recipient of best research paper award from DST Secretary and Best Teacher award from KL University in 2011 and 2012 respectively.