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Automatic Energy Saving System for Street Lighting Using Zigbee Network

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ABSTRACT

This paper introduces an intelligent street lighting system based on wireless sensor networks which controlling and monitoring electrical variables. The proposed street lighting is highly energy efficient and automated. It uses ZigBee based wireless device which enable street lamp system management. ZigBee network is connected to GSM system through computer which is located in base station. Sensor combination is used to control and guarantee the desired system parameters. The information is transferred to a control terminal using ZigBee network which is used to check the status of the street light. Appropriate action is taken whenever system fails.

KEYWORDS:-Automation,controlsystem,LED, lightingsystem,sensor,wirelessnetworks, ZigBee , etc.

I. LITERATURE REVIEW

Due to the increase of environmental concerns, lighting control systems will play an important role in the reduction of energy consumption of the lighting without impeding comfort goals. The energy is the single most important parameter to consider when assessing the impacts of technical systems on the environment. Energy related emissions are responsible for approximately 80% of air emissions (International Energy Agency 2001), and central to the most serious global environmental impacts and hazards, including climate change, acid deposition, smog and particulates. Lighting is often the largest electrical load in offices, but the cost of lighting energy consumption remains low when compared to the personnel costs. Thus its energy saving potential is often neglected. According to an International Energy Agency study (International Energy Agency 2006), global grid based electricity consumption for lighting was about 2650 TWh in 2005, which was an equivalent of 19% of total global electricity consumption. European office buildings dedicate about 50% of their electricity for lighting, whereas the share of electricity for lighting is around 20-30% in hospitals, 15% in factories, 10-15% in schools and 10% in residential buildings (European Commission 2007). Public lighting in streets, tunnels, city centers, ports and squares etc. can account for about 30% of the urban energy consumption. And the maintenance costs are very high. India is facing a huge energy crisis which has to be addressed to at the earliest using devices that are energy efficient. Based on

Environmental and economic factors, cities need smart energy management systems urgently for energy saving, maintenance costs reduction and CO2 emission reduction [1]. The proposed project presents an autonomous street lighting system based on solar angry as primary source, batteries as secondary source, and light emitting diodes (LEDs) as lighting source [4]. As LEDs lumen efficiency increases rapidly in recent years, many new LEDs illumination applications are emerging. LEDs have features such as long life, small and low power consumption [3]. The proposed system consists of ZigBee based wireless devices which enable most efficient street lamp system management, thanks to an advanced interface and control architecture. It uses a sensor combination to control and guarantee the desired system parameters, The information is transferred

point by point using ZigBee transmitter and receiver and is send to a control terminal used to check the state of the street lamps and to take appropriate measures in case of failure. The proposed remote control system can optimize management and efficiency of street lighting system [2]

1.1PROBLEM STATEMENT

Lighting systems, especially in the public sector, 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.

1.2 PROPOSED SOLUTION FOR THE ABOVE PROBLEM

We can need 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 o ers 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 [5]-[9] have developed a street lamp system using the general-packet radio service (GSM), 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 need ZigBee systems [9] similar to the lighting systems in structure and management In this project, we present our system, which is able to integrate the latest technologies, in order to describe an advanced and intelligent management and control system of the street lighting.

1.3 PROPOSED WORK

Proposed Methodology is divided into three parts. They are as follows:

1. Sensing system
2. Control System.
3. Communication System

Fig. 1. Schematic image of the system.

Fig. 1 shows 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 ends 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.

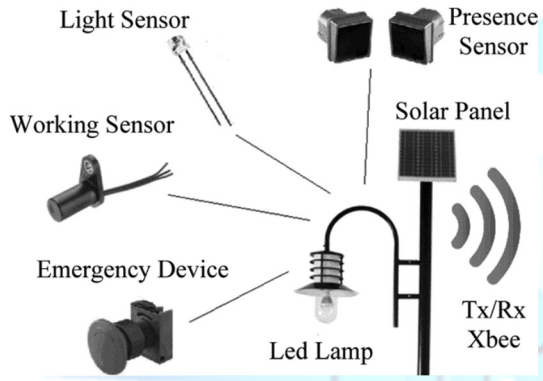

Fig. 2.Schematic image of an on-street station.

1. SENSING SYSTEM

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.

I) PRESENCE SENSOR: The task of the presence 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 such a 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 systemwill work. We discovered that in field tests, the SE-10 PIR motion sensor offers good performance and is quite affordable.

II) 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.* [19]). 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 (by Vishay Semiconductors) 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 Fig. 3. Control software flowchart. 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.

III) OPERATING CONTROL: This sensor is useful to improve fault management and system maintenance. Thanks to this sensor (in this case, aHall sensor), itis possible to recognize when the lamp is switched on. The system is able to recognize false positives, because identified parameters are compared with the stored data (e.g., lamps are switched off during daylight and the sensor incorrectly detects a fault, but the microcontroller does not report the malfunction because of additional logic functions). The information is reported through the ZigBee network to the station control unit, where the operator is informed about the location of the broken-down lamp and can send a technician to replace it. The system current is 1.5 A, so a sensor suited to detect this current is necessary. An appropriate threshold value to detect the operation of the lamp has been set between 1 and 1.5 A. The chosen sensor is the ACS756 [20] of the Allegro Microsystems, an economical and precise solution for ac or dc currentsensing, particularly suitable for communication systems.

Thanks to this sensor, it is possible to store in the microcontroller's memory the current value which flows in the LED lamp in normal operating conditions, enabling the online power consumption measurement.

IV) EMERGENCY DEVICE: The system has an emergency button, which can be useful in case of an emergency. This device excludes the entire sensor system with the objective to immediately turn on the lamp. The light will remain on for a preset time. After that, the button must be pressed again. This prevents the system from being accidentally active even when the necessity ends. Obviously, this device does not work during the day, when there is no need for artificial light.

V) CONTROL UNIT: The sensors transfer the collected information to a controller which runs the software to analyze the system. Fig. 3 shows the control software flowchart. After the initial setting, the system is controlled by the light sensor which activates themicrocontroller only if the sunlight illumination islower than a fixed threshold. In this case, the system reads thestate of the emergency button, and switches on the lamp if thisis activated. The same happens in case of a vehicle or a pedestrian.

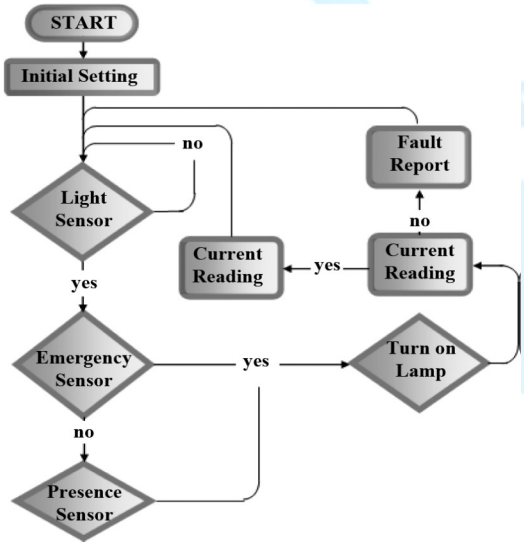

Fig.3. Control software flowchart.

Once the lamp has been switched on, the operating sensor starts the monitoring and, in case of fault detection, an alarm is sent to the control center. If no fault is detected, the microcontroller measures the current flux by the Hall sensor memorizing the current values.

The entire operation is regulated by a timer which enables the system to work for the predetermined time. At the stop input, thelamp is turned off and the cycle restarted. The algorithm has been written in Pic Basic and runs on the microcontroller.

The GSM and ZigBee interface module of road lighting intelligent control system's programming idea is the same as the terminal controller of road lighting intelligent control system. This program also include ZigBee protocol stack and application program. The ZigBee protocol is the same as the terminal controller of road lighting intelligent control system.

2. CONTROL SYSTEM

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 (upper section of Fig. 4) with the state of the lights and the power consumption of each lamp (lower section of Fig. 4).

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.

The GSM and ZigBee interface module of road lighting intelligent control system's programming idea is the same as the terminal

controller of road lighting intelligent control system. This program also include ZigBee protocol stack and application program. The ZigBee protocol is the same as the terminal controller of road lighting intelligent control system. Below, application program is discussed. First, the microprocessor initializes all register and function module, such as watchdog, timer, interrupt, SCImodule,I/O port and GSM module etc.

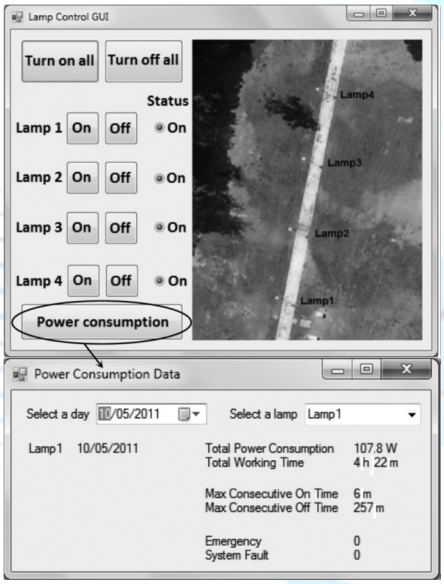

Fig.4.Lamp control system and measurement of power consumption.

Second, going to the main cycle wait for valid data from the ZigBee network and GSM network. And then, the received data are processed and analyzed. Finally, valid data transmit to corresponding network (GSM or ZigBee).

3. ZIGBEE NETWORK

ZigBee is a wireless communication technology based on theIEEE802.15.4 standard for communication among multiple devicesin a wireless personal-area network (WPAN). ZigBee isdesigned to be more affordable than other WPANs (such as,for example, Bluetooth) in terms of costs and, above all, energyconsumption. 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 createdwhen a coordinator selects a channel and starts the communication, henceforth, a router or an end device can join thenetwork. The typical distance of a ZigBee transmission range,depending on the environment conditions and the transmissionpower, shifts from tens to hundreds of meters, and the transmissionpower is deliberately kept as low as possible (in the orderof a few milliwatts) to maintain the lowest energy consumption[1]–[5].

In the proposed system, the network is built to transfer informationfrom the lamp posts to the base station control. Informationis transferred point by point; from one lamppost to anotherwhere 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, transmissionpower is limited to the required low value and the signalssent by the lampposts do not interfere with each other.In case of failure of one lamp, the chosen transmissiondistance between the lampposts ensures that the signal canreach the next operational lamp post without breaking the chain. The Standard Xbee modules have an operation range of tens ofmeters indoors and hundreds of meters outdoors, while theXBee Pro modules have a wider spread range in the orderof 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 consumptionof the Standard version).

The receiver has very high sensitivity and a low probability ofreceiving corrupted packets (less than 1%). The modules shouldbe supplied by 3 V from a dc source; the current consumption isinthe order of 50 mA (for XBee) and 150–200 mA (for XBeePRO) in uplink and in the order of 50 mA in downlink (identicalfor both versions); moreover, they support a sleep mode whereconsumption 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.

II. 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.

This system operated at solar energy so we can save more energy our government also passes some rules for saving energies like using a star rating in electronics product. Zigbee communication network is simple and accurate. The efficiency of a network is also better by zigbee. And the maintenance of the system is also very easy by GUI unit at the base station.Here one major Advantage is the use of GSM network.

The main aim of our work is to make system better for performance. In our system the all lamp post connected through a base station when the fault is begin on a control panel and we can send person for repair at that lamppost.

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