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RESEARCH ARTICLE

Design of Smart Street Lighting System

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Abstract— Our model is intended to propose a model that can overcome flaws in the present street lighting system. The conventional street lamps presently using are build high intensity discharge tubes that possess major disadvantages such as hefty levels of power consumption and low efficiency. The proposed model provides a better solution with optimized management and efficiency. It uses LEDs and multiple sensors interconnected with ZigBee protocol that helps in designing energy efficient method for controlling the street lights from a remote location; the information is transmitted point-to-point via ZigBee based transmitters and receivers which are controlled by a centralized server. It enables checking in case of system failure. This model is also equipped with unique functions like sensing frequency of persons passing by and with sensing devices like gas sensors and LDR. The main purpose of this project is to design a smart and efficient street lighting system that results in maximum energy savings by employing new technology.

Keywords— lighting system, CO_2 emissions, ZigBee

I. INTRODUCTION

Now-a-days, street lighting is one of the important parts of a city's infrastructure where the main function is to illuminate the city's streets during dark hours of the day. Lighting is often the largest electrical load in offices, but the cost of lighting energy consumption is low when compared to the personnel costs. Thus its energy saving potential is often neglected. According to Frost and Sullivan study about 4400MW of power is alone spent in India on public lightning. Previously, the number of streets in the town and city is very small. Therefore, the street lamps are relatively simple but with the development of urbanization, the number of streets increases rapidly with high traffic density.

Based on the aforementioned considerations, innovation in efficient streetlight management systems is a must. We propose a scalable, holistic and efficient solution that provides lighting only when necessary (according to the instant weather conditions or the presence of persons and vehicles) with the objective of reducing the related cost in the municipalities, helping the economic recovery. The illumination level will be conveniently regulated, thus avoiding over lighting and glare. The installation cost will be reduced to the minimum, using wireless communications and autonomous performance modes. The predictive monitoring of each spotlight would also reduce the price of the streetlight installation maintenance. All these improvements have to be considered in order to achieve a significant reduction of the energy consumption in lighting and consequently contribute to sustainable development.

a) Smart Street Lighting: Requirements analysis

The main problem of mercury and sodium steam bulbs, used in common street lighting systems up to now is their long switching interval time – it takes some time to reach the full light intensity, and once switched off, it requires a pause of several minutes before it is possible to turn them on again. This disadvantage is no longer an issue when using the new LED technology. Beside its main characteristics, as they are low-power consumption and long durability, they:

- offer (very) short switching times;
- are almost unaffected from numerous switching (w.r.t. to their life time);
- can be switched back on right after they have been switched off;
- are dimmable (from zero to 100 percent intensity and back to 0 percent); and
- Can produce different colors.

All these listed characteristics (expect the capability of lighting in different colors) are absolutely necessary requirements for a flexible, dynamic operating, Smart Street Lighting (SSL) system.

b) LED technology – one step towards energy saving.

LED is considered a promising solution to modern street lighting system due to it is behavior and advantages. A part from that, the advantages of LED are likely to replace the traditional street lamps such as the incandescent lamp, fluorescent lamp and High Pressure Sodium Lamp in future but LED technology is an extremely difficult process that requires a combination of advanced production lines, top quality materials and high-precision manufacturing process. Therefore, this paper highlights the energy efficiency of street lighting design using LED lamps through intelligent sensor interface for controlling and managing. Recent progress in LED-lamp technology research has led to mass production, cheaper unit prices and thus, an increasing market penetration. Conventional street lighting systems installed by municipality governments are today more and more replaced by economic LED-based light sources. The installation costs are lower than the savings generated from reduced energy consumption – the investment pays for itself. Even less developed countries can now take advantage of solutions. They will replace light bulbs in private homes with energy saving lamps free of charge. This is made possible by a project of the United Nations – the reduction in CO_2 emissions is converted into emission certificates that pay for the investment (Siemens, 2007b). Nevertheless, and even with broad usage of energy conserving LED systems, further energy consumption (and CO_2 emission) reduction is still a big issue for public-lighting systems in order to help governments to reach the ambitious CO_2 threshold values as set, for instance, by the European Commission. The SSL system presented in this works should help to reach this goal by switching street lights only on if passersby are in vicinity, and off all the remaining time.

II. DESIGN METHODOLOGY

In this proposed model solar panel can be used for generating power and it will be stored into the rechargeable battery, from that we are giving power supply to the street lights using relays. Operation of the model can be studied under two modes as auto & manual modes respectively.

a) Auto

In this automatic mode operation the LDR Sensor (Light Dependent Resistor) can be used for measuring light intensity for switched ON or OFF the street light using relays. The main principle of LDR is when the light intensity is low; light is going to be ON otherwise it's going to be OFF. For the efficient reduction of power wastage IR (Infrared) Sensor is integrated. If any vehicle or obstacle is detected using IR sensor at that time it will check the light intensity level using LDR sensor then light will go ON or OFF.

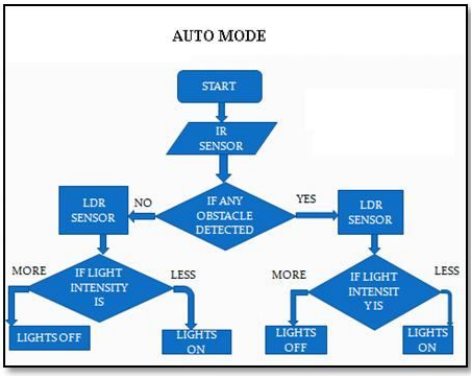

Figure. 1 Flow Chart for Auto mode operation

b) Manual

In this manual mode, the street lights are controlled through a specially designed Graphical User Interface (GUI) in the PC. The ZigBee technology can be used for the street lights monitoring and controlling at the PC end. The system consists of a group of measuring stations in the street. (One station located in each lamppost) and a base station located nearby. The system is designed as a modular system, easily extendable. The LDR Sensors are used to observe street conditions as the light intensity of daylight and, depending on the conditions they activate or off the lamps. Other factors influencing the activation are: climatic conditions, seasons, geographical location, and many possible alternative factors. For these reasons every lamp is designed independent to decide about the activation of light.

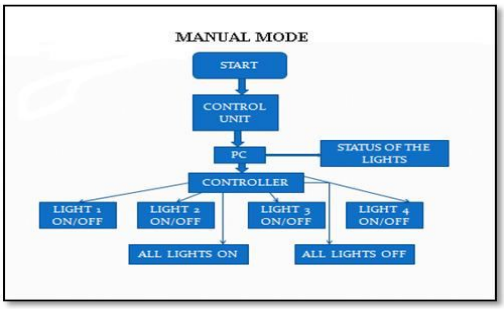

Figure. 2 Flow Chart for Manual mode operation

c) Devices and methods

The Figure. 3 shows the prototype 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, seasons, 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.

Figure. 3 Prototype of Proposed model

c) 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. Fig.4 shows the devices to be employed the model.

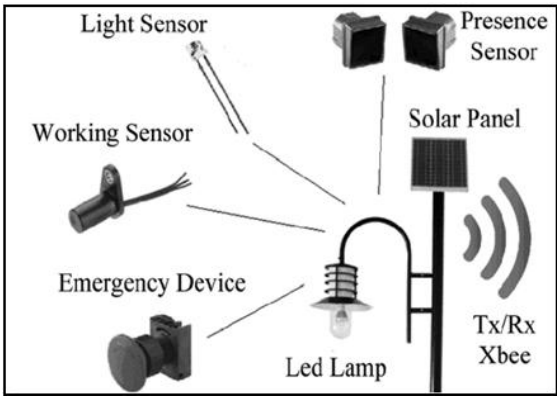

Figure. 4 Schematic image of an on street station

d) Control unit

The Control unit controls all the lighting system through a graphical user interface (GUI) application window we can control all the lights and we can monitor and status of the lights. The sensors transfer the collected information to a PC. The Control unit can be extended so that other electrical Systems, not solely lampposts are connected, and might send data regarding power consumptions to a central system. The working of this control unit can be represented in a flow chart as shown in Figure.5.

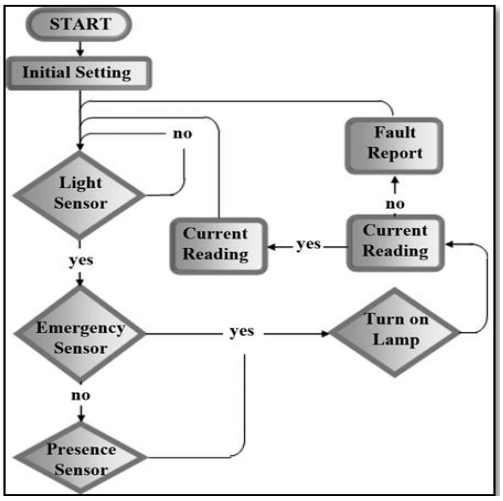

Figure. 5 Control Software Flowchart

e) ZigBee Network

ZigBee is wireless communication technology primarily based on IEEE 802.15.4 norm for communication among multiple devices in a WPAN (Wireless Personal space Network). ZigBee is intended to be less complicated than other WPANs (such as Bluetooth) in terms of price and consumption of energy. The ZigBee Personal space Network consists of a minimum of one Coordinator, one (or more) Devices and, if necessary, of one (or more) Router. The bit rate of transmission depends on the frequency band. ZigBee transmission vary, depending on the atmospheric conditions and therefore the transmission power, ranges from tens to hundred meters since the transmission power is deliberately kept as low as necessary (in the order of few mW) to keep up very low energy consumption. In proposed system, the network is made to transfer data from the lampposts to the central station. Data is transferred purpose by purpose, from one lamppost to another one where every lamppost has a distinctive address within the system. The chosen transmission distance between the lampposts assures that in case of failure of one lamp within the chain, the signalwill reach other operational lamppost while not breaking the chain.

Table I. Zigbee VS other wireless technologies

	Zigbee	WI-FI	Bluetooth
IEEE standard	802.15.04	802.11bgn	802.15.01
Main application	Control	Broadband	Mobile devices
No. network devices	Up to 65000	32	7
Bit rate	20 - 250 kb/s	11/54/300 Mb/s	720 kb/s
Range	100 m	100 m	10 m
Battery life	100 - 1000 days	1 - 5 days	1 - 7 days

ZigBee wireless communication network has been implemented with the utilization of radio frequency modules. They operate within the ISM band at the frequency of 2.4 GHz. The receiver sensitivity is high and therefore the chance of receiving bad packets is low (about 1%). The modules ought to be provided by 3V DC supply, and then the power consumption is within the order of 50mA. The module supports sleep mode where consumption is smaller than 10μA.

III. CONCLUSION

In this paper a proposal of design of smart street lighting system describes how new trends in technology can help us in saving the energy. This is obtained by using the highly economical lamp post technology supplied by renewable energy provided by the solar panels and by using the intelligent control unit of the lampposts. The system works solely in the darkness, avoiding waste of energy throughout sunlight hours when the sole active device is the solar panel that recharges battery. Sensors enable the system to operate solely when necessary. System employs highly economical LEDs to ensure correct illumination and assure energy savings. Another advantage obtained by the control system is the intelligent management of the lamp posts by sending data to a central station by ZigBee wireless communication. The system maintenance can be easily and efficiently planned from the central station, allowing additional savings. Finally we can conclude that we can save 70-75% of energy by using this technology and can increase the life time of street lighting.

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