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Designing An Intelligent Street Lighting system using a Zigbee Network

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Abstract: The planned remote-control system will optimize management and potency of street lighting systems. It uses ZigBee-based wireless devices that modify additional efficient street lamp-system management, due to a complicated interface and control design. It uses a device combination to manage and guarantee the specified system parameters. This information is transferred point by point using ZigBee transmitters and receivers and it is sent to a control terminal used to check the state of the street lamps. 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 the solar panel is not working properly, the lamp will be off condition, and directly takes energy from the electric grid after the lamp will be on condition. The solar panel tilts to the direction where energy obtained is maximum.

Keywords: Sensors , Zigbee , GPRS, LED , PIC

I. Introduction

Lighting systems, particularly within the public sector, are still designed in step with the recent standards of dependableness and they usually don't benefit of the most recent technological developments. In several cases, this can be associated with the plant directors who haven't completed the come back of the expenses derived from the development of existing facilities however. However, the recent increasing pressure associated with the stuff costs and therefore the larger social sensitivity to environmental problems are leading makers to develop new techniques and technologies which allow vital price savings and a larger respect for the surroundings. We will realize 3 attainable solutions to these issues within the literature. The first one, and maybe the foremost intuitive, is that the use of recent technologies for the sources of light. During this space, light-emitting diode (LED) technology is that the best resolution as a result of it offers many advantages. Researchers [1]–[4] have already thought of this possibility, coming up with a sophisticated street lighting system based mostly on LEDs. The second attainable resolution, and maybe the foremost revolutionary, is the use of a remote-control system based on intelligent lamp posts that send data to a central management system, therefore simplifying management and maintenance problems. Researchers have developed a lamp system using the general-packet radio service (GPRS), power-line carrier, or global Systems for Mobile Communications (GSM) transmissions.

Finally, the third risk would be the utilization of renewable energy sources regionally offered, instead of standard power sources, with a positive result on the surroundings. Solar energy is that the most vital resource during this field. Our work aims at the unification of the 3 mentioned potentialities, creating associate degree intelligent lamp post managed by a remote- controlled system that uses LED-based light-weight sources and is high-powered by renewable energy (solar panel and battery).The management is enforced through a network of sensors to collect the relevant info associated with the management and maintenance of the system, transferring the data via wireless exploitation the ZigBee protocol. The sphere of the ZigBee remote sensing and system is wide gift within the literature; we can additionally notice ZigBee systems like (the) lighting systems in structure and management. In this paper, we tend to gift our system, that is in a position to integrate the latest technologies, so as to explain a sophisticated and intelligent management and system of the road lighting.

II. DEVICES AND METHODS

Figure 1 shows the abstract theme of the planned system. It consists of a bunch of observation stations on the road one station for every lamp post and a base station generally placed in a building situated near. It's a standard system, easily extendable. The activity stations monitor the road conditions and also the intensity of daylight and, supported them, they plan to flip the lamps on or off. The conditions rely upon the pattern of the street wherever the lights are situated and on the star irradiation at a given purpose of the road, with frequent changes, depending on weather, season, geographical location, and many other factors. For these reasons, we tend to determined to create every lamp utterly independent within the management of its own lighting. The on-street station additionally checks if the lamp is correctly operating and sends the knowledge through the wireless

network to the base station for process knowledge. If any malfunction is detected, the service engineer is well-read through a graphical interface and can perform corrective actions

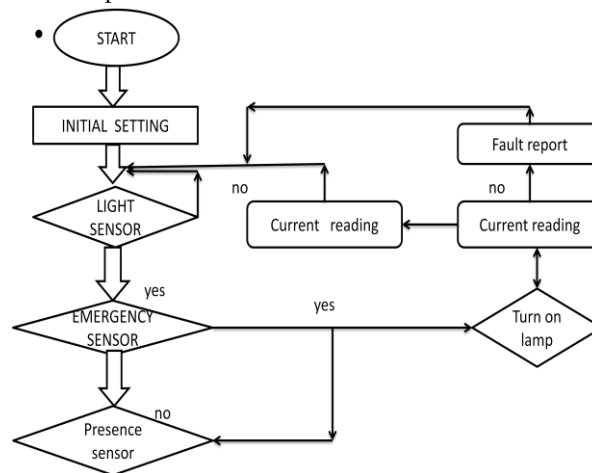


Fig. 1. Flow chart

A. OBSERVANCE STATIONS

1) PRESENCE SENSOR:

The task of the presence sensing element is to identify the passage of a vehicle or pedestrian, giving associate degree input to turn on a lamp or a bunch of lamps. This perform depends on the pattern of the street; just in case of a street while not crossroads, a single sensing element is ample (or one at every finish just in case of a two-way street), while for a street requiring a lot of precise management, a solution with multiple presence detectors is important. This feature allows change on the lamps only necessary, avoiding a waste of energy. The most challenge with such a sensing element is its correct placement. The sensing element ought to be placed at associate degree best height, not too low (i.e., to avoid any incorrect detection of little animals) nor too high (for example, to avoid failure to observe children). A study of the sensing element placement allows deciding the best height in line with the user desires and considering the particular setting during which the system will work. We tend to discovered that in field tests, the SE-10 PIR motion sensor offers sensible performance and is kind of reasonable.

2) LIGHT-WEIGHT SENSOR:

A lightweight sensing element will live the brightness of the daylight and provides data. The aim of this measurement is to make sure a minimum level of illumination of the street, as needed by rules. The sensing element should have high sensitivity within the spectrum, providing a photocurrent high enough for low light-weight brightness level levels. For this reason, the phototransistor TEPT5700 has been elite. Based on the measured brightness level, the microcontroller drives the lamp so as to take care of a continuing level of illumination. This action is clearly not needed throughout daylight time, but it is fascinating within the early morning and at time of day, once it's not necessary to work the lamp at full power however merely as a "support" to the daylight.

3) OPERATIVE CONTROL

This sensing element is beneficial to enhance fault management and system maintenance. Due to this sensing element (in this case, a Hall sensor), it is potential to acknowledge once the lamp is switched on. The system is in a position to acknowledge false positives, because known parameters are compared with the hold on knowledge (e.g., lamps are converted throughout daylight and also the sensing element incorrectly detects a fault, however the microcontroller doesn't report the malfunction attributable to extra logic functions). The information is rumored through the ZigBee network to the station management unit, wherever the operator is well-read concerning the location of the broken-down lamp and might send a technician to replace it. The system current is one .5 A, therefore a sensing element suited to detect this current is important. Associate degree applicable threshold worth to observe the operation of the lamp has been set between one and zero.

4) EMERGENCY DEVICE

The system has associate degree emergency button, which can be helpful just in case of associate degree emergency. This device excludes the entire sensing element system with the target to instantly turn on the lamp. The sunshine can stay on for a predetermined time. After that, the button should be ironed once more. This prevents the system from being accidentally active even once the need ends. Obviously, this device doesn't work throughout the day, when there is no would like for artificial light-weight.

5) MANAGEMENT UNIT

The sensors transfer the collected data to a controller that runs the software package to investigate the system. Fig. three shows the management software package flow chart. After the initial setting, the system is controlled by the sunshine sensing element.

C. ZIGBEE NETWORK

In the projected system, the network is made to transfer info from the lamp posts to the bottom station management. Info is transferred purpose by purpose, from one post to a different where every lamp post encompasses a distinctive address within the system. Each lamp post will solely send the data to the closest one, until the data reaches the bottom station. Thus, transmission power is proscribed to the specified low price and also the signals sent by the lampposts don't interfere with one another.

D. DETAILS AND BUILDUP

- The voltage controllers which give power to all or any different devices.
- The microcontroller (U2, semiconductor PIC 16f688), which manages the system wherever the microcode is uploaded;
- The XBeemodule;
- Connectors for programming the pic (ProgPort), for elective serial electronic transistor|electronic transistor|semiconductor device|semiconductor unit|semiconductor} transistor logic (TTL), for an external reference voltage, necessary for the proper activity of the PIC digitiser (ADC), and for the input/output (I/O) ports.

III. TEST AND RESULTS

The image has been tested in variable real-life conditions to verify the general practicality and obtain higher performance. The measurements collected throughout the take a look at section permit calculative energy savings so it's potential to estimate price savings also for larger systems victimization approximations.

A. VARY TESTS

The first tests on the Xbee modules performance were done at the Electric and Electronic Measurements Laboratory of Roma Tree University, to check the responsibility of the communication between two or a lot of ZigBee modules within the following environmental conditions:

- 1) open field in line of sight between modules;
- 2) open field out of the road of sight wherever the obstacle may be a big tree or a hill;
- 3) indoor take a look at.

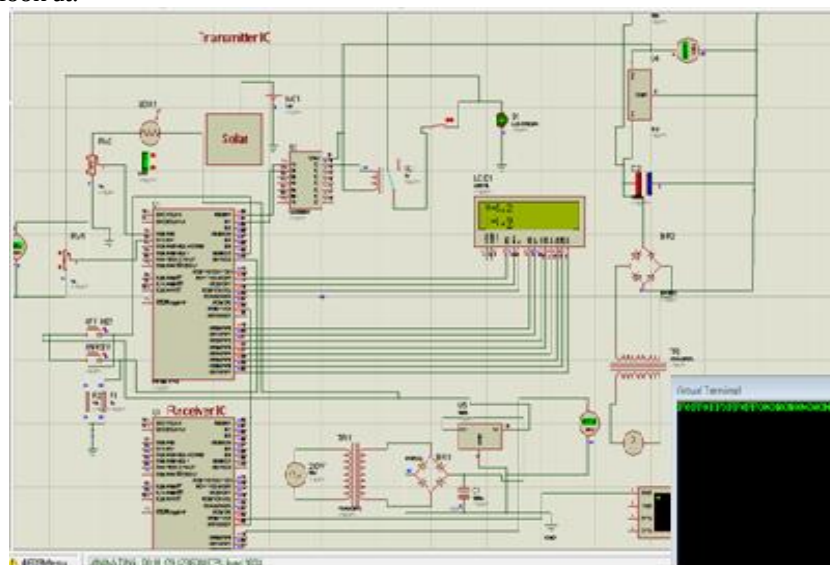


Fig. 2: Simulation output of Transmitter and Receiver

B. POWER MANAGEMENT

The system was designed to be stand alone, provided by star panel energy, with relevant blessings ensuing from this type of power provide. It's attainable to avoid the tedious and high-priced wiring of the availability power network, with significant savings and easy implementation. The negative feedback circuit is meant to consume the bottom attainable power, minimizing the battery capability and the energy provided by the solar array. These goals were achieved through the utilization of the XBee module for transmittal and receiving info, mistreatment crystal rectifier lamps as a replacement for standard lamps and mistreatment special power-saving solutions for microcontrollers and radio modules. The program, which controls the system, is meant primarily to avoid wasting energy. First, since the system solely works at midnight, avoiding wasting energy throughout daylight

happens once the sole active device is the solar array recharging the battery. Second, various sensors enable the system to figure only if necessary. Third, the system implies extremely economical LEDs to make sure correct illumination and guarantee energy savings. For our work, a 84-lm/W.

C. MEASUREMENTS

The system provides associate degree correct reading of the switch-on times of the road lamps and of the absorbed currents. Both are stored within the memory of the microcontroller and square measure sent to the control center once daily. The transmission of a giant frame of data could lead on to the collision between information and to memory management issues. This case happens once 2 or additional lamp posts send quite great amount of knowledge at the same time. This matter may be resolved exploitation the transmission methodology that sends information from the farthest lamp post to a different and, hence, down to the centre, storing all of the cumulated information in every lamp post. The high capability memory desires would be incompatible with the parts and devices chosen for the system, leading to higher hardware prices and package complexness. To solve this issue, information were sent from a given post only when asked by the centre. An additional correct analysis of power consumption is shown in Table I, supported the information collected throughout the months of March and April 2011. The average consumptions of current (I) square measure pictured in Table II; switch-on time variations square measure as a result of the take a look at of emergency conditions on the second lamp post in March, while in April, a failure was simulated to verify the third street lightweight maintenance conditions. Given the time, this, and the cost of a kWh of energy, totally different for every supplier, it's doable to determine the important energy price savings versus different systems. For instance, lamp posts put in with a classical system square measure active for regarding ten h/day throughout March and April, with a complete of regarding three hundred monthly operating hours, versus the expected 108. Table III shows the current consumption and operational time of lamp posts h in March and eighty seven h in April for the projected system, with a savings of regarding sixty six of the time within the 1st month and seventy one in the second. Table III shows the new processed information for might and Gregorian calendar month 2011. As we will see, this consumption decreases in sunny months. Finally, table IV shows the current consumption and operational time of recent and previous lamp posts.

Lamp ID	March		April	
	Time (h)	I (A)	Time (h)	I (A)
Lamp 1	108.14	1.47	87	1.44
Lamp 2	108.33	1.51	87	1.50
Lamp 3	108.14	1.48	86.64	1.47
Lamp 4	108.14	1.53	87	1.44

Table: I

Lamp ID	May		June	
	Time (h)	I (A)	Time (h)	I (A)
Lamp 1	80.14	1.48	77.02	1.45
Lamp 2	80.14	1.50	77.02	1.50
Lamp 3	80.14	1.48	77.02	1.47
Lamp 4	80.14	1.51	77.02	1.49

Table: II

Lamp ID	July		kWh	Cost h X kWh (0.200 €)	Plant Costs				
	Time (h)	I (A)			Battery type and cost	Solar Panel type and cost	Battery Recharger	Cost € (lamp)	Power supplier
New Lamp (L1)	75.12	1.48	1.334	0	5 A – 16 €	19 W – 50 €	10 €	18	0
New Lamp without light sensor (L2)	263	1.49	4.702	0	20 A – 25 €	80 W – 220 €	10 €	18	0
New Lamp without presence sensor and supplied by electrical net (L3)	263	0.09	5.260	0.9404	None	None	0	18	30
Mercury Vapor Technology without presence sensor and supplied by electrical net (L4)	263.1	0.22	13.155	2.631	None	None	0	15	40

TABLE III

	L1	L2	L3	L4
L1	-	Always more convenient	After 53 months	After 19 months
L2	Never more convenient	-	After 250 months	After 87 months
L3	Before 53 months	Before 250 months	-	After 2 months
L4	Before 19 months	Before 87 months	Before 2 months	-

TABLE IV

It is doable to contemplate the worth of kWh constant. Considering a particular month like Gregorian calendar month, once the number of kWh is low so the savings square measure even lower, Table V shows the break-even time between the various selections. It's doable to note because the answer L1 is clearly continuously additional convenient than L2 and reaches the reach against the L4 with classical technology in barely nineteen months, it conjointly becomes additional convenient than the third solutions when fifty three months. Obviously, employing a month additional convenient for pure mathematics, the break-even may be quickly reached. That is, between the analyzed months, March is the most convenient. For it, L1 is often more convenient than L2, reaches the break-even against L4 in only ten months and becomes additional convenient than the third solutions after twenty nine months.

E. MANAGEMENT OF LAMP POST FAULT

One of the needs of our work was to form the system available to tell the remote central just in case of a lamp post fault in order that a restore operation would be quickly doable. In case of the ZigBee communication fault, if the n-ism lamp post doesn't 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 measurement and storing information into the EEPROM and random-access memory (RAM) (with a capacity of 512 B) of the microcontroller. thus if we have a tendency to contemplate a sampling each five min and a lamp post switch on for eight h/day (as a very stern case), the system can store information for regarding 3 days consecutively. however if the system isn't improved within 3 days and that we need to grasp the consumption information, a PIC with higher storage capability, or maybe associate degree SIM card, is critical. If the PIC isn't high-powered by the battery of the system any longer, a 4.5-V backup battery is integrated within the box and provides the required energy. subsequent unharness of the system are going to be changed within the microcode, providing the reading of the voltage of the battery on the microcontroller pin, so if the voltage is zero, electric battery fault signal are going to be sent to the remote central.

IV. CONCLUSION

This paper describes a replacement intelligent street lighting system which integrates new technologies out there on the market to offer higher potency and goodly savings. this will be achieved exploitation the extremely economical crystal rectifier technology provided by renewable energy of star panels, that the value of energy is freelance from the facility provider costs, combined to associate degree intelligent management of the lamp posts derived by an effect system switch on the sunshine only if necessary, increasing the lamps' lifespan. Another advantage obtained by the system is that the intelligent management of the lamp posts by causation information to a central station by ZigBee wireless communication. The system maintenance may be simply and with efficiency planned from the central station, permitting extra savings. The projected system is especially appropriate for street lighting in urban and rural areas wherever the traffic is low at a given vary of time. The freelance nature of the power-supply network enables implementing the system in remote areas wherever the classical installations square measure prohibitively costly. The system is always versatile, extendable, and totally variable to user desires. The simplicity of ZigBee, the responsibility of electronic parts, the feature of the device network, the process speed, the reduced prices, and also the simple installation square measure the options that characterize the projected system, that presents itself as an interesting engineering and industrial answer because the comparison with different technologies incontestable . The system may be adopted within the future for hundreds provided by the power system that allows the observance of energy consumption.

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