Technology

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Intelligent Street Lighting Using a ZigBee Network of Devices and Sensors

Research Paper

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Intelligent Street Lighting Using a ZigBee Network of Devices and Sensors

Abstract— The lighting systems within the public sector are designed using the previous standards of reliability and they don't use the advancements of latest technological developments. In this paper, a wireless street lighting system is developed. It consists of set of sensors to detect the presence of humans and checks for the intensity of light and transmits the light in wireless.The proposed remote-control system can optimize management and efficiency of street lighting systems. It uses ZigBee-based wireless devices which enable more efficient street lamp-system management which is 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 transmitters and receivers and is sent to a control terminal used to check the state of the street lamps and take appropriate measures in case of failure. The use of renewable energy sources instead of typical power sources takes care of the environment, which is considered to be another advantage of this system.

Index Terms—Automation, control system, lighting system, sensors, wireless networks, ZigBee.

INTRODUCTION

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. Our project needs no manual operation for switching (ON and OFF).When there is need of light, it detects itself whether the light is need or not, based on the "Persistence of vision using Passive Infrared Sensor (PIR).When darkness rises to a certain value then automatically street light is switched ON.I.e., In day time, the street light gets OFF using Light Dependent resistor (LDR).The power consumption will be measured and displayed on a computer display to prove the power savings of the proposed project. In this new system, the system with LDR sensor, PIR sensor and Zigbee is used to intimate the status of human's use. Light intensity and street light ON/OFF status to the EB section is also enabled to avoid wastage of energy by glowing street lights in unwanted areas. The whole system is operated by using natural energy source called SOLAR and with battery backup the existing system is based on either LDR or checking for the evening time by using RTC. In this method the remote monitoring and controlling is not there. In this new system the system with LDR sensor, PIR sensor, GPS and Zigbee is used to intimate the status of humans use, light intensity and street light ON/OFF status to the EB section to avoid wastage of energy by glowing street lights in unwanted areas. The whole system is operated by using artificial energy source called solar and with battery backup. The PIR and LDR sensors sense the persons and light intensity of a particular place and transmits

Schematic image of the system.

The data in wireless to the EB section with its GPS section. Depend upon the data received the controller will turn ON/OFF the street light in wireless communication. For emergency purpose, if the particular light wants to ON means, the input should give from the PC side. That data will receive in Zigbee in street light section, According to that the light will ON.

Power Supply Unit:

The supply of 5V DC is given to the system which is converted from 230V AC supply. Firstly, the step down transformer will be used here for converting the 230V AC into 12V AC. The microcontroller will support only the DC supply, so the AC supply will be converted into DC using the bridge rectifier. The output of the rectifier will have ripples so we are using the 2200uf capacitor for filtering those ripples. The output from the filter is given to the 7805 voltage regulator which will convert the 12V DC into 5V DC. The output from the regulator will be filtered using the 1000uf capacitor, so the pure 5V DC is getting as the output from the power supply unit. Here we are using the pic microcontroller which will be capable of getting the supply of 5V DC so we have to convert the 230V AC supply into 5V DC supply.

Software is used to compile the coding of the desired application for the corresponding embedded system.

PIC16F877A: The PIC16F877A CMOS FLASH-based 8-bit microcontroller is upward compatible with the PIC16C5x, PIC12Cxxx and PIC16C7x devices. It features 200 ns instruction execution, 256 bytes of EEPROM data memory, self-programming, an ICD, 2 Comparators, 8 channels of 10-bit Analog-to-Digital (A/D) converter, 2 capture/compare/PWM functions, a synchronous serial port that can be configured as either 3-wire SPI or 2-wire I2C bus, a USART, and a Parallel Slave Port.

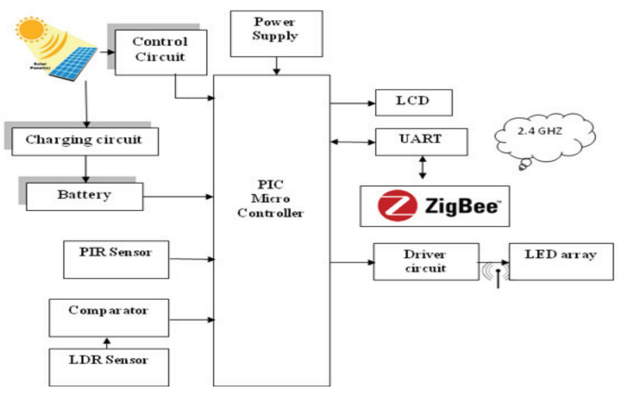
SOLAR PANEL:

Solar cells are devices that convert light into electricity, but they do not store electric power. In addition, since the actual amount of power produced varies depending on factors such as the installation conditions and location, as well as the weather, there are a few requirements which must be borne in mind when designing a system. Research conducted by Panasonic over many years on solar cells and the application of this new technology culminated in 1984 with the successful development of the world's first thin-film solar cell using compound semiconductors. The company named these cells Sunceram II. The Sunceram II cells have good weather-proof properties and high spectral sensitivity characteristics over a wide Wavelength range. Furthermore, since the entire film-forming process involves only screen printing and since belt sintering is employed, these cells are very amenable to mass production. It also means that high-voltage type solar cells can be formed at a high density on a single glass substrate, and that it is easy to produce them with larger surface areas. Besides developing compact and lightweight Sunceram II modules for outdoor use which maintain a stable performance over prolonged periods, Panasonic has developed compact, high-performance Sunceram II sign units which are used in combination with the company's own coin-type rechargeable batteries. With its sights firmly fixed on power sources for the new forms of soft energy which will be abundant in the twenty-first century, Panasonic is committed to developing new products which will fill the needs of the market.

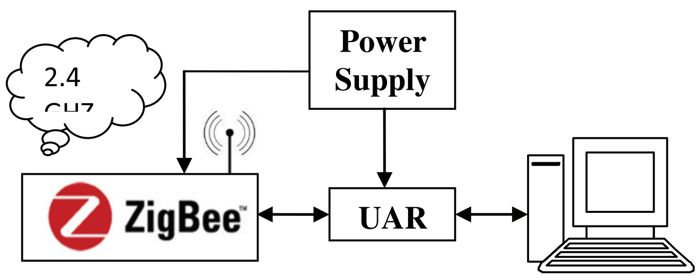
PIR sensor:

A **Passive Infrared sensor(PIR sensor)** is an electronic device that measures infrared (IR) light radiating from objects in its field of view. PIR sensors are often used in the construction of PIR-based motion detectors. Apparent motion is detected when an infrared source with one temperature, such as a human, passes in front of an infrared source with another temperature, such as a wall. All objects emit what is known as black body radiation. It is usually infrared radiation that is invisible to the human eye but can be detected by electronic devices designed for such a purpose. The term passive in this instance means that the PIR device does not emit an infrared beam but merely passively accepts incoming infrared radiation. "Infra" meaning below our ability to detect it visually, and "Red" because this color represents the lowest energy level that our eyes can sense before it becomes invisible. Thus, infrared means below the energy level of the color red, and applies to many sources of invisible energy. Infrared radiation enters through the front of the sensor, known as the sensor face. At the core of a PIR sensor is a solid state sensor or set of sensors, made from an approximately 1/4 inch square of natural or artificial pyro electric materials, usually in the form of a thin film, out of gallium nitride (GaN), cesium nitrate ($CsNO_3$), polyvinyl fluorides, derivatives of phenylpyrazine, and cobaltphthalocyanine. Lithium tantalate ($LiTaO_3$) is a crystal exhibiting both piezoelectric and pyro electric properties.

The sensor is often manufactured as part of an integrated circuit and may consist of one (1), two (2) or four (4) 'pixels' of equal areas of the pyro electric material. Pairs of the sensor pixels may be wired as opposite inputs to a differential amplifier. In such a configuration, the PIR measurements cancel each other so that the average temperature of the field of view is removed from the electrical signal; an increase of IR energy across the entire sensor is self-cancelling and will not trigger the device. This allows the device to resist false indications of change in the event of being exposed to flashes of light or field-wide illumination. (Continuous bright light could still saturate the sensor materials and render the sensor unable to register further information.) At the same time, this differential arrangement minimizes common-mode interference, allowing the device to resist triggering due to nearby electric fields. However, a differential pair of sensors cannot measure temperature in that configuration and therefore this configuration is specialized for motion detector. This PIR (Passive Infra-Red) Sensor is a pyro electric device that detects motion by measuring changes in the infrared (heat) levels emitted by surrounding objects. This motion can be detected by checking for a sudden change in the surrounding IR patterns. When motion is detected the PIR sensor outputs a high signal on its output pin. This logic signal can be read by a microcontroller or used to drive a transistor to switch a higher current load.



TRANSMITTER SECTION

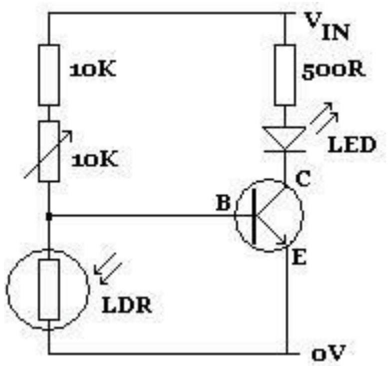


RECEIVER SECTION

LDR:

A **Light Dependent Resistor** (aka LDR, photoconductor, or photocell) is a device which has a resistance which varies according to the amount of light falling on its surface. A typical light dependent resistor is pictured above together with (on the right hand side) its circuit diagram symbol. Different LDR's have different specifications, however the **LDR**'s we sell in the REUK Shop are fairly standard and have a resistance in total darkness of 1MOhm, and a resistance of a couple of ohm in bright light (10-20kOhm @ 10 lux, 2-4kOhm @ 100 lux).Light dependent resistors are a vital component in any electric circuit which is to be turned on and off automatically according to the level of ambient light - for example, solar powered garden lights, and night security lighting.

An LDR can even be used in a simple remote control circuit using the backlight of a mobile phone to turn on a device - call the mobile from anywhere in the world, it lights up the LDR, and lighting (or a garden sprinkler) can be turned on remotely. There are two basic circuits using **light dependent resistors** - the first is activated by darkness, the second is activated by light. The two circuits are very similar and just require an **LDR**, some standard resistors, a variable resistor (aka potentiometer), and any small signal transistor

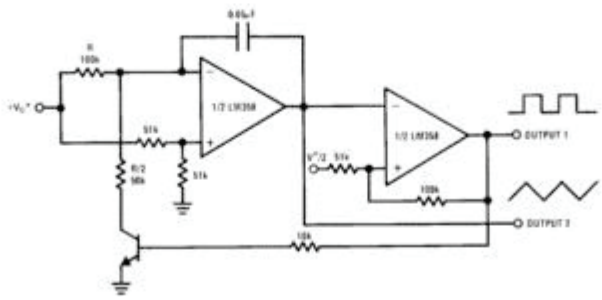


LDR

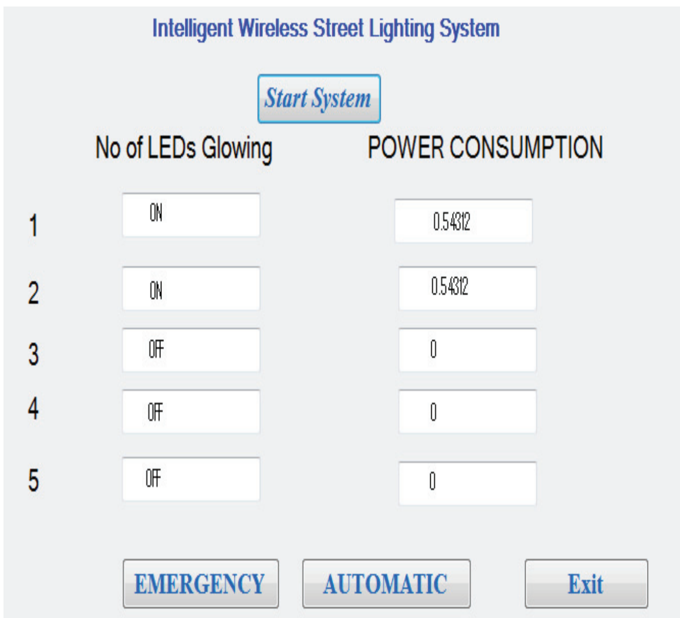
In the circuit diagram above, the LED lights up whenever the LDR is in darkness. The 10K variable resistor is used to fine-tune the level of darkness required before the LED lights up. The 10K standard resistor can be changed as required to achieve the desired effect, although any replacement must be at least 1K to protect the transistor from being damaged by excessive current. By swapping the LDR over with the 10K and 10K variable resistors (as shown above), the circuit will be activated instead by light. Whenever sufficient light falls on the LDR (manually fine-tuned using the 10K variable resistor), the LED will light up. The circuits shown above are not practically useful. In a real world circuit, the LED (and resistor) between the positive voltage input (Vin) and the collector (C) of the transistor would be replaced with the device to be powered. Typically a relay is used - particularly when the low voltage light detecting circuit is used to switch on (or off) a 240V mains powered device. A diagram of that part of the circuit is shown above. When darkness falls (if the LDR circuit is configured that way around), the relay is triggered and the 240V device - for example a security light - switches on

COMPARATOR (LM358):

The LM158 series consists of two independent, high gains; internally frequency compensated operational amplifiers which were designed specifically to operate from a single power supply over a wide range of voltages. Operation from split power supplies is also possible and the low power supply current drain is independent of the magnitude of the power supply voltage. Application areas include transducer amplifiers, dc gain blocks and all the conventional op amp circuits which now can be more easily implemented in single power supply systems. For example, the LM158 series can be directly operated off of the standard +5V power supply voltage which is used in digital systems and will easily provide the required interface electronics without requiring the additional ±15V power supplies. The LM358 and LM2904 are available in a chip sized package (8-Bump micro SMD) using National's micro SMD package technology.



Comparator



Receiver window

Zig bee:

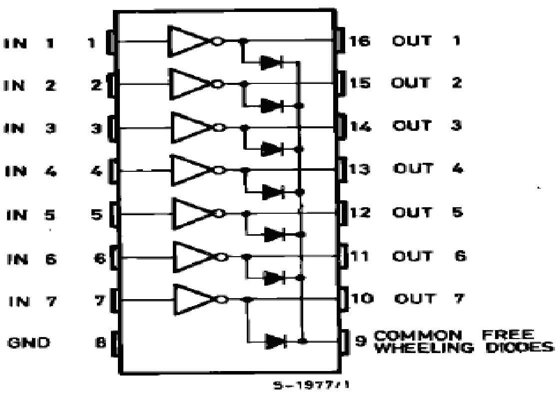
Zigbee is a wireless technology developed as an open global standard to address the unique needs of low-cost, low-power, wireless sensor networks. The standard takes full advantage of the IEEE 802.15.4 physical radio specification and operates in unlicensed bands worldwide at the following frequencies: 2.400–2.484 GHz, 902-928 MHz and 868.0–868.6 MHz.The power levels (down from 5v to 3.3v) to power the zigbee module. The communication lines (TX, RX, DIN and DOUT) to the appropriate voltages. The Zigbee module acts as both transmitter and receiver. The Rx and Tx pins of ZIGBEE are connected to Tx and Rx of 8051 microcontroller respectively. The data's from microcontroller is serially transmitted to Zigbee module via UART port. Then Zigbee transmits the data to another Zigbee. The data's from Zigbee transmitted from Dout pin. The Zigbee from other side receives the data via Din pin.

Driver circuit

The ULN2003 is a monolithic high voltage and high current Darlington transistor arrays. It consists of seven NPN Darlington pairs that feature high-voltage outputs with common-cathode clamp diode for switching inductive loads. The collector-current rating of a single Darlington pair is 500mA. The Darlington pairs may be paralleled for higher current capability. Applications include relay drivers, hammer drivers, lamp drivers, display drivers (LED gas discharge), line drivers, and logic buffers.

The ULN2003 has a 2.7kW series base resistor for each Darlington pair for operation directly with TTL or 5V CMOS devices.

FEATURES: 500mA rated collector current (Single output) High-voltage outputs: 50V, Inputs compatible with various types of logic, Relay driver application.



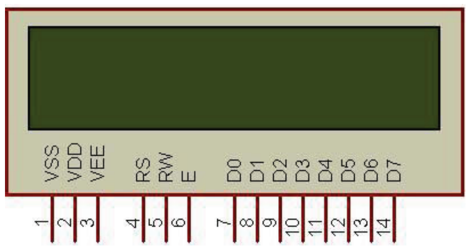
Driver circuit

The ULN2003 series input resistors selected for operation directly with 5 V TTL or CMOS. These devices will handle numerous interface needs particularly those beyond the capabilities of standard logic buffers. The ULN2003 have series input resistors for operation directly from 6 V to 15 VCMOS or PMOS logic outputs. The ULN 2003 is the standard Darlington arrays. The outputs are capable of sinking 500mA and will withstand at least 50 V in the OFF state. Outputs may be paralleled for higher load current capability. The ULx2823A/LW and ULx2824A/LW will withstand 95 V in the OFF state. These Darlington arrays are furnished in 18-pin dual in-line plastic packages (suffix 'A') or 18-lead small-outline plastic packages (suffix 'LW'). All devices are pinned with outputs opposite inputs to facilitate ease of circuit board layout. Prefix 'ULN' devices are rated for operation over the temperature range of -20   C to +85   C; prefix 'ULQ' devices are rated for operation to -40   C.

LCD:

The most commonly used Character based LCDs are based on Hitachi's HD44780 controller or other which are compatible with HD44580. In this tutorial, we will discuss about character based LCDs, their interfacing with various microcontrollers, various interfaces (8-bit/4-bit), programming, special stuff and tricks you can do with these simple looking LCDs which can give a new look to your application.

The most commonly used LCDs found in the market today are 1 Line, 2 Line or 4 Line LCDs which have only 1 controller and support at most of 80 characters, whereas LCDs supporting more than 80 characters make use of 2 HD44780 controllers.Most LCDs with 1 controller has 14 Pins and LCDs with 2 controller has 16 Pins (two pins are extra in both for back-light LED connections). Pin description is shown in the table below.



Character LCD type HD44780 Pin diagram

usually these days you will find single controller LCD modules are used more in the market. So in the tutorial we will discuss more about the single controller LCD, the operation and everything else is same for the double controller too. Let's take a look at the basic information which is there in every LCD.

BF - Busy Flag: Busy Flag is an status indicator flag for LCD. When we send a command or data to the LCD for processing, this flag is set (i.e. BF =1) and as soon as the instruction is executed successfully this flag is cleared (BF = 0). This is helpful in producing and exact amount of delay. For the LCD processing. To read Busy Flag, the condition RS = 0 and R/W = 1 must be met and The MSB of the LCD data bus (D7) act as busy flag. When BF = 1 means LCD is busy and will not accept next command or data and BF = 0 means LCD is ready for the next command or data to process.

Instruction Register (IR) and Data Register (DR): There are two 8-bit registers in HD44780 controller Instruction and Data register. Instruction register corresponds to the register where you send commands to LCD e.g LCD shift command, LCD clear, LCD address etc. and Data register is used for storing data which is to be displayed on LCD. When send the enable signal of the LCD is asserted, the data on the pins is latched in to the data register and data is then moved automatically to the DDRAM and hence is displayed on the LCD. Data Register is

Not only used for sending data to DDRAM but also for CGRAM, the address where you want to send the data is decided by the instruction you send to LCD. We will discuss more on LCD instruction set further in this tutorial.

Commands and Instruction set: Only the instruction register (IR) and the data register (DR) of the LCD can be controlled by the MCU. Before starting the internal operation of the LCD, control information is temporarily stored into these registers to allow interfacing with various MCUs, which operate at different speeds, or various peripheral control devices. The internal operation of the LCD is determined by signals sent from the MCU. These signals, which include register selection signal (RS), read/write signal (R/W), and the data bus (DB0 to DB7), make up the LCD instructions (Table 3). Designate LCD functions, such as display format, data length, etc. Set internal RAM addresses. Perform data transfer with internal RAM. Perform miscellaneous functions

Although looking at the table you can make your own commands and test them. Below is a brief list of useful commands which are used frequently while working on the LCD.

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