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Smart Parking System Based on Wireless Sensor Network and Light Emitting Diode Technology

نظام المواقف الذكي بواسطة شبكة الاستشعار اللاسلكية وتقنية ثنائي الباعث الضوئي

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الآية

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DEDICATION

To My Family

with Love

ABSTRACT

With the rapid proliferation of vehicle availability and usage in recent years, finding a vacant car parking space is becoming more difficult, resulting in a number of practical conflicts. Parking problems are becoming ubiquitous and ever growing at an alarming rate in every major city. Wide usage of wireless technologies with the recent advances in wireless applications for parking, manifests that digital data dissemination could be the key to solve emerging parking problems. Wireless sensor network technologies have attracted increased attention and are rapidly emerging due to their enormous application potential in diverse fields. This field is expected to provide an efficient and cost-effective solution to the effluent car parking problems. This thesis proposes a smart parking management system based on wireless sensor network and light emitting diode technology to assist drivers to find vacant spaces in a car park in a shorter time. The proposed system includes vacant parking space detection using IR sensors, and directional indicators toward vacant parking spaces through the use of specific LEDs. The obtained results show the reliability, integrity and flexibility of the WSN in managing the parking lots.

المستخلص

مع الانتشار السريع لتوافر السيارات وإستخدامها في السنوات الأخيرة، أصبح إيجاد مساحة شاغرة فى مواقف السيارات أكثر صعوبة، مما أدى إلى عدد من المشكلات العملية و التي تتزايد بمعدل ينذر بالخطر في كل مدينة من المدن الكبرى. الإستخدام الواسع للتكنولوجيا اللاسلكية و التقدم الحثيث في تطبيقاتها والتي من ضمنها مواقف السيارات يقرب من كون حل مشاكل مواقف السيارات يكمن في نشر بياناتها رقميا. أن شبكة الإستشعار اللاسلكية جذبت اهتماما متزايدا مؤخرا وأخذت في التنامي بسرعة بسبب إمكانات التطبيق الهائلة في مختلف المجالات. يتوقع أن تقوم الشبكة بتقديم حل فعال من حيث التكلفة والمرونة لمشكلة مواقف السيارات. يقترح هذا البحث نظام لإدارة مواقف السيارات على أساس شبكة الاستشعار اللاسلكية وتكنولوجيا ثنائي الباعث الضوئي لمساعدة السائقين للعثور على أماكن شاغرة في مواقف السيارات في وقت أقصر وبكلفة تشغيل أقل. يشمل النظام المقترح كاشف لأماكن مواقف السيارات الشاغرة بواسطة الأشعة تحت الحمراء، وشاشة عرض بمدخل الموقف لتحديد العنوان الشاغر للموقف مع إرشاد السائق بواسطة إضاءة لمبات ثنائي الباعث الضوئي على طول مسارة الي محل الركن. التصميم المختبر يبرز أهمية وسهولة إستخدام شبكة الاستشعار اللاسلكية في إدارة الموقف مع تقليل كلفة التشغيل والصيانة.

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LIST OF ABBREVIATIONS

AC	Alternative Current
ADC	Analog to Digital Converter
CCTV	Closed-Circuit Television
CDMA	Code Division Multiple Access
CU	Control Unit
DU	Display Unit
FPGA	Field Programmable Gate Array
FSM	Finite State Machine
GSM	Global System Mobile Communication
HDL	High Descriptive Language
HID	High Intensity Discharge
HPS	High Pressure Sodium
IR	Infrared Sensor
LCD	Liquid Crystal Display
LED	Light-Emitting Diode
LPS	Low Pressure Sodium
LR-WPAN	Low-Rate Wireless Personal Area Networks
LSAE	Luminous System Application Efficiency
MCU	Micro Controller Unit
MH	Metal Halide
MTU	Maximum Transmission Unit
MV	Mercury Vapor
PGIS	Parking Guidance and Information System
PIR	Passive Infrared Sensors
PLC	Power Line Carrier
PLC	Programmable Logic Controller

PSDU	Parking Status Display Unit
PWM	Phase Width Modulation
RF	Radio Frequency
RISC	Reduced Instruction Set Computing
SMS	Short Message Service
SPAS	Smart Parking Assistant System
SPS	Smart Parking System
UART	Universal Asynchronous Receiver-Transmitter
USB	Universal Serial Bus
UV	Ultra Violet
WPANs	Wireless Personal Area Networks
WSN	Wireless Sensor Network
ZC	ZigBee Coordinator
ZED	ZigBee End device
ZR	ZigBee Router

CHAPTER ONE

INTRODUCTION

1.1 General Back Ground

With the development of people's living standard, and the development of automobile industry, the owners of the vehicles are increasing sharply. So the parking issue is becoming more and more serious in most major cities. The limited availability of parking results in traffic congestion, air pollution, as well as driver frustration. The price for parking expansion is usually prohibitive or extremely high. To address this problem, Smart Parking a system that helps to park many vehicles within a limited amount of space is being used in developed countries [1]. Many researches and developments are being done all over the world to implement better and smarter parking management mechanisms. Widespread use of wireless technologies paired with the recent advances in wireless applications for parking, manifests that digital data dissemination could be the key to solve emerging parking problems. Wireless Sensor Network (WSN) technologies has attracted and increased attention and are rapidly emerging due to their enormous application potential in diverse fields. This technology is expected to provide an efficient and cost-effective solution to the efficient car parking problems and guide drivers to park the vehicle at the appropriate parking slot within a minimum time [2].

The most commonly used lamps in parking lot and area lighting applications are High-Intensity Discharge (HID) lamps. These include High Pressure Sodium (HPS), Metal Halide (MH), and Mercury Vapor (MV). However MV lamps are not recommended by energy efficiency groups, because they are inefficient and their luminous flux output decreases over time to the point that they emit little useful light but still appear to be lighted. Although phosphor coated MH lamps are sometimes used for their improved color properties, the performance of a

luminaries optical system will suffer if a coated lamp is used because the larger, coated outer jacket (bulb) alters the optical size of the lamp. Low pressure sodium lamps are sometimes used for parking lot lighting. A few manufacturers offer parking lot and area lighting luminaries that use incandescent or fluorescent lamps. Among the fluorescent types of lamps is the induction lamp, a type of fluorescent technology that operates without the use of electrodes. This electrode less lamp may become an important light source for parking lot and area lighting applications in the future because of its ruggedness, good color properties, and long life. With advancements in light emitting diode (LED) technology, low wattage LED streetlights are also becoming available. As the efficacy of LEDs improves, it may also become an important light source for parking lot and area lighting [3]. LEDs have the potential for reduced maintenance, reduced operating cost, and lower energy usage than other technologies [4].

Ten years ago, many people didn't even know what an LED was. Today, they're the new hot item on the shelves – and everyone wants to use them. Recently they have become more popular and practical for general lighting purposes. A Light Emitting Diode is an electronic device that produces light when an electrical current is passed through it. The wavelength (or color) of light that is emitted is dependent on the materials from which the LED is made. LEDs are available in many colors, including red, blue, amber, green, with lumen outputs ranging from 10 lumens to 200 lumens. LED lamps use half the energy and last around five times longer than conventional lamps like HID. However, the upfront cost of LED lamps is also greater. Even with this heavy initial cost, LED lights provide big savings and a relatively short payback period [5].

1.2 Problem Statement

There is admiring need for, intelligent, efficient and reliable parking system which can be used for searching the unoccupied parking facility. Most of the

driver might spend a lot of time just to find an empty parking space. From previous studies we find that the main problems statement of parking that contain:

- Difficulty in Finding Vacant Spaces: Quickly finding a vacant space in a multilevel parking lot is difficult if not impossible, especially on weekends or public holidays, so insufficient car park spaces\lead to traffic congestion and driver frustration.
- Improper parking: If a car is parked in such a way that it occupies two parking slots rather than one, this is called improper parking. Improper parking can happen when a driver is not careful about another driver's rights. Sometimes improper parking occurs when a driver parks on or a bit outside of the lines of a parking space.
- Cost of energy: Especially electricity, Efficiency can be one of the main ways to save energy in the world. Lighting consumes for around 20% of the world's total Electrical energy .therefore, the efficient lighting can save lots of energy.

1.3 Objectives

The main objective of this research is to design a smart parking system based on WSN as well as reduce the energy consumption in the parking by using the LED, which is integrated with the parking management algorithm. This may include:

- Reduce the searching time and management for vacant and occupied spaces using the Zigbee technology
- Enhance the power consumption in the parking by utilizing the LEDs as the lighting components as well as implementing an efficient management algorithm.
- Reduce the cost of installing wired connection for sensors by using Zigbee technology.

1.4 Methodology

To achieve the above mentioned objective, the following method/approach can be followed:

- Developed a smart parking assist system based on wireless sensor network to provide convenient parking services to drivers in parking lots. The scheme is characterized by employing microcontroller to manage the whole parking lot through wireless communication.
- Developed real time parking service to driver in large parking lots. With real time parking service, drivers can quickly know the parking status at the entrance itself whether the parking space is available in the parking garage or not.
- Integrated the LED with the lighting system as well as with management system in the parking.
- Provided friendly parking information services to the moving vehicles. With this friendly parking information, the microcontroller can provided information to the drivers regarding the parking lot nearest to the incoming vehicle just after the display of vacant parking spaces. Therefore gasoline and the time wasted in searching for the vacant parking space nearest to the vehicle can be effectively reduced.
- Simulated, test, and optimized the whole system as well as its individual components.

1.5 Thesis Outline

This thesis is organized as follow: Chapter Two introduces the needed for smart parking garage, and widespread use of wireless technologies paired with the recent advances in wireless applications for parking. In addition, some of the previous embedded Smart parking System designs were reviewed. Chapter Three as well as demonstrated the design and implementation of smart parking system

based on wireless sensor network and light emitting diode. In Chapter Four, the simulation results were showed and discussed. In Chapter Five, the conclusion and recommendation were drawn and suggested respectively.

CHAPTER TWO

EMBEDDED-BASED SMART PARKING STSTEM

2.1 Introduction

Recent advancement in the automobile industry has opted many people to use their own vehicle for travelling. This has increased effect on car ownership. But to park all these cars in the major cities is quite tedious and difficult. Parking problems are becoming ubiquitous and ever growing at an alarming rate in every major city. The price for parking expansion is extremely high. Smart parking is a parking/ garage system that utilize various technologies to efficiently manage the garage [6]. There are mainly two kinds of parking systems, named as single layered car parking system and multilayered car parking system. Multilayered car parking system can be categorized according to their physical structure such as puzzle car parks and parallel car parks. Automated car parks (smart car parks) rely on similar technology that is used for mechanical handling and document retrieval as shown in Figure 2.1.

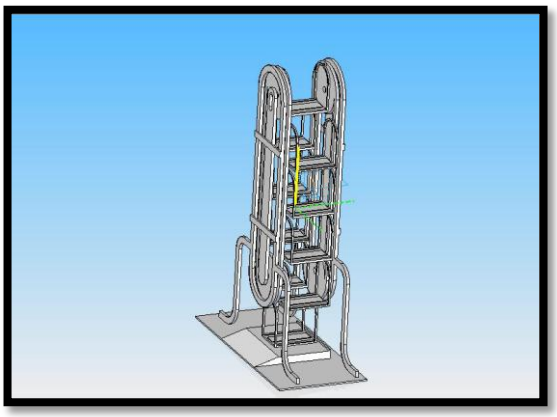


Figure 2.1: Assembly of automated smart parking system

The user leaves the car at the entrance. Then the car is shifted to a parking spot by a robot trolley or an elevator. For the user, the process of parking is reduced for leaving the car inside an entrance module. Single layered car parks are self-

serviced car parks but with minimum hardware components and minimum cost [1].

2.2 Smart Parking Systems (Single Layered)

Smart Parking System based on wireless Sensor Network it is the parking technology that guides and provides information about availability of parking spaces located in parking lots and availability of parking slot for the incoming vehicle. Therefore it becomes possible for parking guidance systems to track parking space occupancy and guide drivers to find empty parking spaces in large parking slots through wireless communication. Most of the existing parking management systems rarely address the issues of parking space management such as vehicle guidance, and parking lot reservation. Majority of these systems have control at the entrance and exit and use vehicle detectors as an essential element to provide smart parking. Though inductive loop is one of the most widely used detectors today, it includes various problems in installation and maintenance which might disturb the normal operations of parking. The widespread use of wireless technologies paired with the advancement in wireless applications for parking implies that digital data dissemination could be the key for resolving the growing parking challenges. WSNs have a great potential towards providing an easy and cost effective solution to this credible application for various reasons, easy of deployment in existing parking lots without excavation and expensive cable installations has increased our attention towards wireless sensor network technology, flexibility to couple with sophisticated but cheap sensors that can accurately detect vehicles makes WSN a natural candidate to solve the emerging car parking problems.

2.3 Wireless Sensor Network

A wireless sensor network consists of a large number of low-cost sensor nodes which can be self-organized to establish an ad hoc network via the wireless

communication module equipped on the nodes. Each sensor node is also equipped with various kinds of sensors, computation units, and storage devices. These functional parts enable sensor nodes to be easily and rapidly deployed to cooperatively collect, process and transmit information, compared with the existing parking management systems [7]. As sensor nodes, WSN are designed to operate on extremely low power, they usually run on battery power, which makes wireless sensor networks especially useful in monitoring applications where AC electricity is not available [8].

2.4 Wireless Sensor Network Architecture

Generally, the wireless sensor network consists of nodes and sinks /gateways. The sensor node is considered the simplest component in the network. Sinks or gateways are considered to be more complex than sensor nodes due to their complex functionality. In many applications the number of nodes is much higher than the number of sinks or gateways, thus their cost and size must be kept low.

2.4.1 Node Architecture

Architecture of node focuses to reduce cost, increase flexibility, provide fault-tolerance, improve development process and conserve energy. The sensor node consists of sensing unit, processing unit (MCU- microcontroller unit), communication unit, and power supply as shown in Figure 2.2.

- Sensing unit: Composed of collection of sensor which produces the signal then relay to microcontroller for further processing. The type of sensor being used in a sensor node will depend on the application.
- Processing Unit: Microcontroller is general purpose processor, it forms the core part of the sensor node to tackle many aspects including the operating system, networking and power management. It is responsible for collecting data from various sources then processes it and stores it. The microcontroller is not only consists of memory and processor but

also non-volatile memory and interfaces. It helps to reduce the requirement of wiring, extra hardware, circuit board space and energy. For saving of power, microcontroller should have three states-active, sleeps, idle.

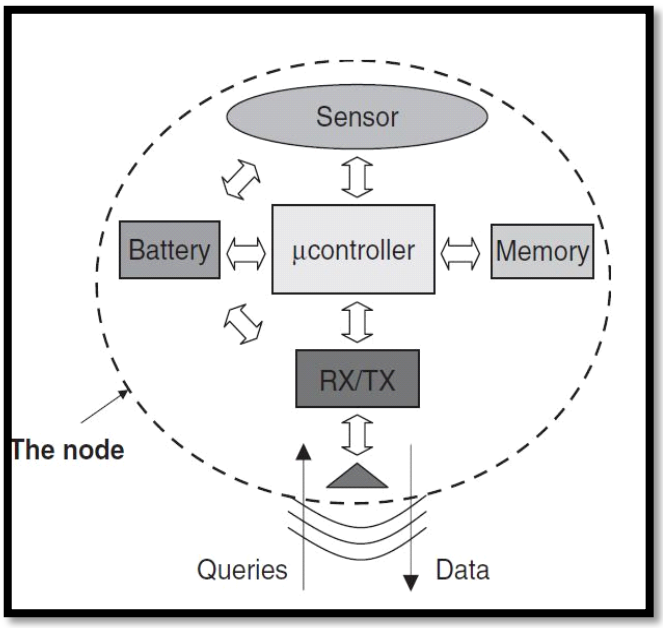


Figure 2.2: Architecture of a sensor node

- Power Supply Unit: Which responsible for providing energy to the sensor node for monitoring the environment at low-cost and time. It takes energy from power generator and pass to other component of node. Life of sensor node depends upon battery so battery is the important component that must be distribute properly. Power unit are required due to the following reasons provide long life, provide stability of voltage, has capacity under load, has ability to recharge under low current, has low self-discharge.
- Communication or Transceiver Unit: A transceiver is a unit in which transmitter as well as receiver is sharing same circuitry on single board. It receives command from processing unit and passes it to the other node of the network. Communication is performed through communication channels. This phase provide some network protocol in

order to perform communication. Using communication channel such as radio, laser, optical and infrared or ZigBee.

2.4.2 Sink or gateway architecture

It provides four services such as sensor manager which provide access to sensors and manage the delivery of sensor data, it is responsible for providing the persistent storage for data streams, query manager performs query processing and manages active queries, integrity services is used for access control [9].

2.5 Light-Emitting Diodes

Many parking slot and parking garages in commercial and institutional facilities are currently illuminated with HID lighting sources. Because this type of lighting is not suitable to dimming or frequent switching, this lighting is typically operated the entire evening, even when the parking lot or garage is mostly or completely empty. HID were replaced with new LED luminaires. Light-emitting diodes are semiconductor devices that convert electricity to light. LED lighting is also called “solid state lighting” because the light is emitted from a solid object—a block of semiconductor material—rather than from a vacuum or gas tube, as in traditional incandescent or fluorescent lights. LED technology has existed in specialized applications since the 1960s. Unlike incandescent or fluorescent lights, LEDs are not inherently white. White light is actually a mix of wavelengths in the visible spectrum, whereas LEDs emit light in a very narrow range of wavelengths, and so are ideal for producing colored light.

Today LEDs have been used widely to create the highly efficient red, green, and blue lights in devices including digital clocks, watches, televisions, dashboards, and traffic lights. In 1993 Japan’s Nichia Corporation devised a way to create white light from a single diode. This discovery initiated the ongoing quest to develop an LED-based technology that can produce a high-quality, warm white light suitable for general illumination. LED lighting technology has its own

terminology distinct from traditional lighting. The light emitting part of an LED lighting product, the chip is a very small square of semiconductor material, (also called a die). This chip is packaged with several components within an epoxy dome. Unlike traditional lighting products, LED lighting does not involve a bulb. Instead, a number of LED packages are clustered in a housing to form an LED lamp. An LED lamp cannot simply be screwed into a traditional lighting fixture like an incandescent or fluorescent bulb, instead, it must be integrated into a specially designed lighting fixture, or luminaire—although the installation skills needed to install an LED luminaries are the same as for traditional lighting fixtures [10-11].

2.6 Intelligent Lighting Control system based on ZigBee Communication

Traditional lighting systems are out dated and have lost lot of energy. These systems must be replaced with intelligent systems. Several communication media and protocols are used to transfer control function and status data between lamp node and local node. Usually, WSN and power line are common ways. Recently papers and reports illustrate the systems which are made by centralized architecture with control terminal, some local nodes and lots of lamp nodes. The system are defined a monitoring section for adaptive street light made up of subsystems; road equipment, power segment, local control system, central control system and communications network. A typical overview is shown in Figure 2.3.

The lamp nodes are composed of lamp driver, and sensors. For example, in [12-14] the relay and the dimmer are used to switch ON/OFF the lamp and control light intensity respectively. In [15] power consumption of the line is measured by line's voltage and current, which is led to find the place of short or amputations of power line. Or in [16] they were used photocell for detecting

faulty lamps. Moisture and temperature sensors are used in [12] to sense environment of the nodes *e.g.* foggy or cloudy weather. In these systems there are a short distance and a long distance transmission. Radio Frequency (RF), ZigBee and Power Line Career (PLC) protocol are three common ways to communicate between local and lamp node. For example, in [13, 15], the PLC and ZigBee modules are used to transfer data between local node and lamps respectively. In [17], they have used general packet radio service for communication between control terminal and the local nodes, which are connected to the lamp nodes by radio frequency. Another product uses Short Message Service (SMS) protocol to control On/Off mechanism of lights [16]. The duty of local node is gathering lamp node's status and manages this information with its functions and sends them back. The priority of node, the on/off time, synchronizes the date. In case [18] smart server Lon works network controller were used to support the PLC combination in local node and it can manage a hundred lamp nodes. An Liquid Crystal Display (LCD) module can added to local node for easy maintenance which operators can find easily what is problem to fix [15] it also uses Code Division Multiple Access (CDMA) modem to transfer data between centralized control center and local nodes.

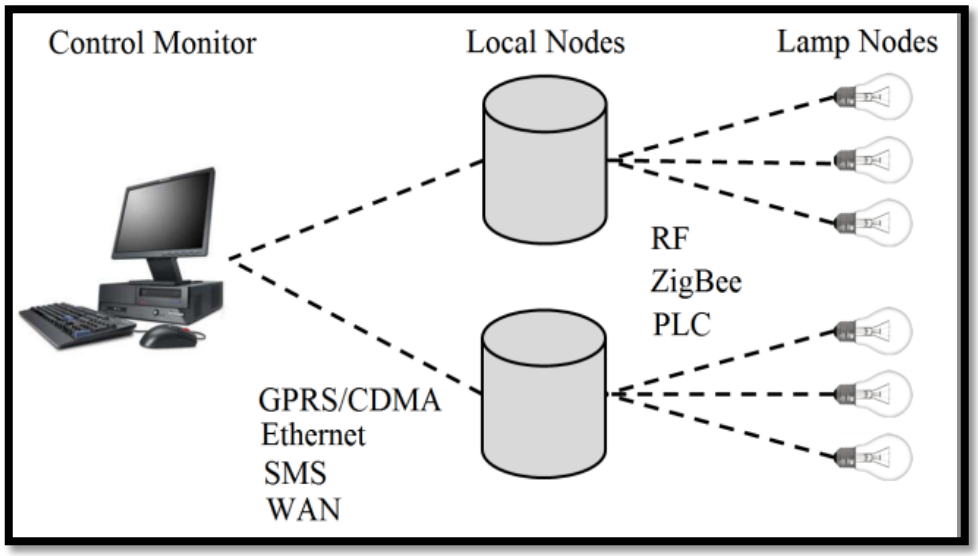


Figure 2.3: Typical overview of street lights system

Control terminal are designed to gather all information of local node and it can shows information about faulty lamps, on/off the lamps, traffic data and so on. A graphical interface was designed to display information in operator's monitor [15]. An intelligent system is designing for general application of lightings based on the ZigBee communication technique .The system utilizes wireless communication techniques and offers real time surveillance of individual group of lamps. The system can represent the faulty lamps in the control monitor and exhibit energy consumption of each lamp node. Any number of new lights can be added to the existing network with simple and easy modifications. The local node monitors the sensors data and controls the duration of on/off lamp nodes based on the feedback information from lamp nodes. This information transmits in data frames from ZigBee protocol to a lamp node to control the light, which is connected. Control equipment are achieved power energy saving ranging from 10% to 50%. This system must drive high power LEDs and must be capable to handle common demand in the network, e.g. dimming, on/off, measuring voltage, current and phase angle and also the necessary network functions (join to system, form the system, permit joining others to the system, enable data transmission mode, update security key and so on [19].

2.7 Energy Savings from the Occupancy Sensor

Table 2.1 presents the cumulative effect of the different time settings for all nineteen LED luminaries. Energy savings relative to the original HPS baseline amounted to 74% at the ten minute setting and 88% at the 2.5 minute setting. If the initial ten minute LED setting is instead used as the baseline rather than the HPS (i.e., yielding a projected 134 KWh/yr per fixture at 2.5 minutes versus 293 kWh/yr per fixture at ten minutes), the gain in savings from simply adjusting the occupancy sensor delay is an impressive 54 %. No complaints about the shorter

delay setting have been received from the parking structure users to date, quite possibly because few have even noticed [20].

Table 2.1: Summary results of annual energy use and savings

Luminaries and Delay Setting	Annual Energy Use (KWh/yr per luminaries)	Annual Energy Savings (KWh/yr per luminaries)
Baseline HID	1,134	(NA)
Phase 1: LED (10-minute delay)	293	841 (74%)
Phase 2: LED (2.5-minute delay)	134	1,000 (88%)

2.8 Embedded System- Based Smart Park System

Embedded system are the electronic system that contain a microprocessor or a microcontroller, but is not itself intended to be a computer, the computer is hidden or embedded in the system to organizing, working, performing one or many tasks according to a fixed set of rule, program or plan. Real time embedded controlled parking system can provide full or partial solution for building or multi-storey based parking, can provide quality efficient, cost effective solution to manage multi-storey parking requirements. Also, it can provide solution to manage multi-storey car parking system. Multi-storey parking system requires boom barrier, direction indicator, webcam, devices connected in control manner. These devices are controlled by microcontroller based embedded systems which work on different electrical signal levels, plus they also require communication link without electrical connection [21]. Many approaches were suggested and implemented under the concept of smart parking throughout last few years. Among them, Image Processing and Infrared Sensor Signal Processing are outperforming in research.

Reve and Choudhri [6] have proposed management of car parking system using WSN, infrared (IR) sensor to sense the status of the parking lots, microcontroller (MCU) for processing, LED screen to display the processed data and entry buttons which mounted at the entrance of parking space to detect the status of parking lots. The sensor node detects that the parking space is occupied or not and it sends a report message to the MCU. The MCU turn on/off the respective LED in the Parking PSDU to indicate that the respective lot is free or not. It side by side it also shows the nearest parking lot for incoming vehicle by continuously glowing the LED of that respective lot. Unfortunately, the number of indicated LEDs at the PSDU will increase as the size of the parking, which may cause visual noise to the user at entrance to determine the suitable available lot. They proposed the architecture which satisfies the car parking management system requirement [6].

Chen and Chang [22] have proposed a Parking Guidance and Information System (PGIS) based on wireless sensor network. The PGIS composed of three nodes communicated with wireless channel, and self-organize into an ad-hoc network. The monitoring nodes detected the status of every parking space with ultrasonic and transmitted message by RF communication module through routing nodes hop by hop to the sink node which installed in the monitoring room. The sink node connected to the information and management center through RS-232 interface. After processed the data, the information and management center sent the message to all the nodes and update the information in LED screen at the entrance of the parking lot. They used ultrasonic sensors for detecting the status of parking spaces and proposed a non-standard network protocol. So this PGIS can help the drivers to park their cars quickly and safely [22].

Thakare and Chavan [2] have proposed performance evaluation of parking guidance and management system using wireless sensor network. They have

been developed Smart Parking Assistant System (SPAS) system architecture with sensor nodes for car parking system and MCU to guide and management of the parking area. IR sensors are the motion detectors which detected the motion of the vehicle and sent the information to the microcontroller which showed the status of parking at the PSDU. The MCU communicated with the IR sensors located at the parking lots so that no vehicle can be un-park during the arrival of the new vehicle at the Parking area and collision of two vehicles can be avoided [2].

Kaur and Singh [23] have proposed a design and implementation of car parking system on Field Programmable Gate Array (FPGA) using Hard word description Language (HDL). The parking system is implemented using Finite State Machine (FSM) modeling to increase productivity, reduces cost, and accelerates time to market. The system has two main modules: identification module and slot checking module for identifies the visitor and checks the slot status respectively. A prototype of parking system is designed and implemented with various interfaces like sensor interfacing such as RF sensor, stepper motor and LCD. At the entrance of parking area, LCD displays the status of parking system, if space is available or not. According to space status, door-motor rotates in clockwise direction and identifies the person. For new member temporary card is allotted [23].

Sarayu, Rajendra and Bongale [24] have proposed design and fabrication of prototype of automated smart car parking system using programmable logical controllers (PLC). An Inductive sensors, relays, DC motors were used to provide movements to transport the vehicle in the parking system. When the car comes and is placed on the tray, the inductive sensor senses the car after the tray is already sensed. When both the tray and the car are sensed, the counter is incremented by one. The user comes out of the car and presses the push button. The motor starts to run and the filled tray moves upward and the next empty tray

will be sensed and stops in the bottom position. The process continues and in the meanwhile when a user comes to retrieve the car and presses the push button, the car is retrieved and the decrement of one takes place in counter. When the counter reaches the maximum count, the motor stops and beeper will beep to indicate that all trays are filled. The researchers claimed that the main advantages of the proposed solution are space optimization, cost effectiveness and security [24].

Moon and Ha [8] have proposed a car parking monitoring system using wireless sensor networks. The system composed of a server, a gateway, a sink node, and multiple sensor nodes. Each of the sensor nodes equipped with a three axis AMR sensor at each parking space, to detect the availability of the parking space. To conserve the power consumption at the sensor node, these sensors only transmit measured data when meaningful (considerable) changes occur to the predetermined threshold. The sensor node sense the availability of the channel to transmit it measurement to the sink node. The sink node is connected to the gateway through Universal Asynchronous Receiver-Transmitter (UART) interface. Moreover, the sensor node does not need to perform computations for determining whether or not corresponding parking spaces are occupied. It is the server that determines the status of parking spaces based on the received data [8].

Tapas, Srikanth and Dileep [25] have proposed smart parking using wireless sensor networks. A sensor node has been deployed in each parking lot to detect its occupied status. Guiding nodes control the display on the turnoffs of the road to guide the drivers to found an idle parking space. Gateway transmitted the data to a management station, which is set in the monitoring room of the park. It displayed necessary information on the monitor and updated the display screen at the entrance of the parking lot in time. All of these nodes communicated through wireless channel, and self-organize into an ad hoc network. This system also enabled drivers to reserve for the car parking lot while at home through Global

System Mobile Communication (GSM) based Short Message Service (SMS) technologies or any computer with Internet facility can also be used as clientele device for reserved [25].

Kianpisheh *et al*. [26] have proposed a Smart Parking System (SPS) architecture using ultrasonic detector. The SPS detection system is based on ultrasonic sensors. For each individual car park, this would require one sensor fixed on the ceiling above each parking space. Drivers looked at an LED display board which showed how many and which types of vacant spaces are available at each level at that time. After that drivers looked at internal signs. Each internal sign showed two parts: the number of available spaces and the direction (left, right or forward) of the aisle which had a vacant space. Each individual parking space is equipped with LED lights which are located above the space and can show green, red, blue or yellow. The color indicates the status of that space: green means the space is vacant, red means the space is occupied, blue means the space is assigned for handicapped drivers and yellow means it has been booked or is a reserved space for specific reasons. When a driver entered a vacant space, the green light changed to red. The researcher have claimed that the proposed architecture for a parking detection system would decrease searching time for vacant spaces and reduce instances of single cars improperly parking across two spaces [26].

Vanessa *et al*. [7] have proposed an intelligent car park management system based on wireless sensor networks**.** The system typically adopted a three layer of framework for deployment. The first layer was the mote layer which was a wireless sensor mesh network. The moves are programmed as TinyOS firmware to perform some tasks, for example environment monitoring. The second layer was server layer which provided data logging and database services for sensory data transferred to the base station and stored on the server. Finally, the software at client layer provided visualizing, monitoring, and analyzing tools to display

and interpret sensory data. The sensor nodes can be deployed to a car parking field and collected the real-time occupation information and vehicle information. The collected information can be transmitted to a gateway via wireless communication among the sensor nodes. The gateway is connected to a database server via Internet. The collected information will be acquired and installed into a database by a database server. The car park management application operated on top of the database [7].

Karunarathne and Nanayakkara [1] have proposed a prototype to identify availability of a car in a smart car park with aid of programmable chip and infrared sensors. The system consisted of a set of infrared emitters and infrared receivers. The signal is generated when the car is inserted to particular slot and the signal is transmitted to the programmable chip through wires. The chip is programmed to generate a number based on availability of each slot. In the car park, LED bulbs were used to represent the availability of the car park on site. The auto generated number is fed to computer through serial port. This serial input is converted to Universal Serial Bus (USB) input through converter. The sensors should be powered by a five volts power supplier. The system is configured with a message server to ensure security of the vehicles. If a vehicle remains in the slot more than a defined time period, it will automatically send a short message stating abnormal staying of a vehicle to authority. Further if a car is removed from slot without updating the system; it also sends a short message to the authority. The smart car park provided the privilege to reserve a slot using mobile short messages [1].

Kumar and Siddarth [27] have proposed a prototype parking system using WSN. The system consists of WSN, communication subsystem, parking management, automated guidance, entrance display and client reservation subsystems. WSN detected the status of parking space with hybrid sensing techniques and transmitted status information through RF to Communication Subsystem which

delivered them to the parking management subsystem. Communication Subsystem act as a gateway between Parking Management Subsystem wireless sensor network and external networks. When the parking management subsystem received the data, processed and forwarded it to the database module, then the processed information will be sent to the parking entrance display which showed the availability of the parking lots in all the directions to helps vehicles to find idle parking spaces within less time. Whenever the client reserved a parking lot, the reservation message will be forwarded to parking reservation module running on the management subsystem. It retrieved data from the sensor database and based on the availability of parking lots will forward an acknowledgment to the client [27].

Wang and Hey [28] have proposed a reservation-based smart parking system. The design allowed drivers to found and reserved the vacant parking spaces. Every parking lot has access to the internet to communicate with the management system and users, and shared parking information with other parking lots. In each parking lot, the reservation authority is deployed for authenticating the individual user's identity and reservation request. In this case, the reservation authority in the parking lot communicated with the specific user individually. Once the reservation order is confirmed, the reservation authority updated reservation information to hold the related space for the user. The sensor system deployed in parking lot is responsible for monitoring the real-time condition of parking lots and delivered the live aggregated sensing information (the number of available spaces or occupancy rate) to the smart parking system. The sensing information is updated on demand. Upon retrieving the parking information, the system updated the state of the parking lot. Based on the state of parking lots, the system analyzed their occupancy status and congestion level, determined the parking prices according to their pricing scheme, broadcasted the prices to all users periodically, and stored the parking information and prices for

further analysis. The proposed reservation-based smart parking system can alleviated traffic congestion caused parking searching and reduced the amount of traffic volume searching for parking [28].

Alawi *et al*. [19] have proposed intelligent lighting control system based on ZigBee communication technique. The system consisted of lamp nodes, street controller (local node), and ZigBee protocol and control center. The node has Input/output channels to controlled the light and Analog to Digital Converter (ADC) to measured status data, also had the microcontroller which hold the time, created Phase Width Modulation (PWM) to derived high power LEDs and read/write data to memory. There is a serial interface between module and operator's computer. ZigBee module used to communicate between local and lamp nodes. For this case, we just updated the time registered of microcontroller and if link was broken the node would work with old data but still working. The local node gathered information of lamp nodes, Controller used as Control Unit (CU) for the local node. Flash memories are used to save the status information of nodes. The controller connected with sensors (photocell, moisture, and temperature). There is a serial interface for connection between user and microcontroller which can transfer node information and checked the lamps [19].

Based on the above classification of smart parking systems, a parking garage may employ one or a combination of above systems to best serve their customers. The system determines the occupancy of a given area and display space-availability information to customers via message located at the entrance of the garage. Today we can find several smart parking facilities in most of the major cities. Customer and the parking operator are benefited by the smart parking service in different ways:

i. Space availability can be determined before entering the garage or parking level.

ii. This type of system significantly reduces traffic and air pollution – by minimizing the time required to locate open spaces.

iii. Future parking patterns and trends can be predicted from the system data and this data can be used to minimize the vehicle thefts.

iv. Staff requirements are also reduced to control the traffic.

v. The parking operator can use the system data to develop or improve pricing strategies.

CHAPTER THREE

DESIGN OF WIRELESS SENSOR-BASED SMART PARKING SYSTEM

3.1 The System Overview

The current smart parkingor parking guidance systems only obtain the availability informationof parking spaces from deployed sensor networks,and simply publish the parking information to direct drivers.However, since these systems cannot guide the drivers totheir desired parking destinations, even sometimes make thesituation worse, they are not “smart” enough. For instance,when the number of vacant spaces in an area is limited, more drivers who obtain the parking information are heading forthese spaces. It will cause severer congestion. It is, therefore, strongly desired to provide an effective strategy to addressthese concerns. In this thesisa smart parking system was designed based on WSN and LED to provide convenient parking services to drivers in large parking lots. The proposed scheme is characterized by employing MCU to manage the whole parking lots through wireless communication. Uses IR sensors to detect car park occupancy which connected to the processing unit.System technology also contain a display unit control, lighting unit,wireless communication unit, power supply and driving unit as shown in Figure3.1.

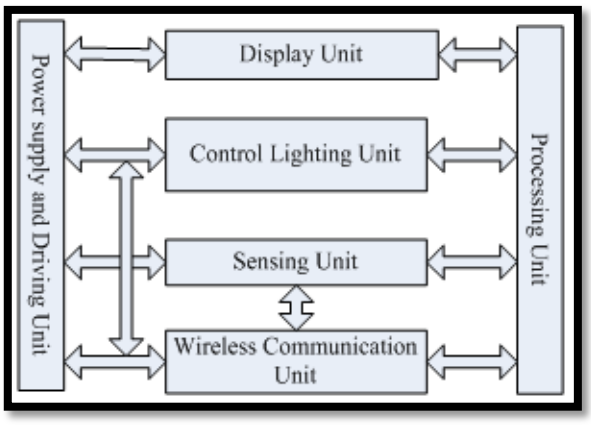


Figure 3.1: Smart parking system architecture

In the following, a detailed design and implementation for each system unit was provided.

3.2 Sensing Unit

The choice of appropriate detection technology for vehicles and parking status depends on different parameters such as cost, reliability and compatibility. There are two types of detection technology, vision-based and sensor-based. Vision-based methods use closed-circuit television (CCTV); usually one camera is responsible for more than one parking space, and image processing software to detect parking space status. Sensor-based methods use one sensor for each individual parking space.

3.2.1Vision-based method

Monitoring parking lot vacancy is a significant technology which can be used for guiding cars to vacant spaces and for efficient use of parking spaces. Monitoring detection technology can be divided into two categories. The first estimates the number of remaining vacant spaces for the entire parking lot by counting incoming and outgoing vehicles. The second monitors the status of each individual space and can be used to guide a car to a vacant space. To help drivers find a vacant parking space without much effort, intelligent parking systems should provide the specific location of vacant spaces and not just the total number of spaces. To detect the status of an individual parking space different methods have been utilized, such as ultrasonic sensors placed at each space (thus it requires many sensors), or surveillance cameras placed at a high position (allowing supervision of a wide area by a few cameras, which is more useful in outdoor parking lot).

Detection methods based on cameras and image processing suffer from a lack of accuracy and can be affected by environmental or weather circumstances. Major problems of vision-based parking detection systems include shadow effects, occlusion effects, vacillation of lighting conditions and perspective distortion.

Light-colored cars in strong sunlight might mislead detector software into detecting a full space as vacant; in the same way, a shadowed area may be mistakenly identified as a dark-colored vehicle, leading an empty space to be mistakenly seen as occupied. When the sun is blocked by a cloud, the change in lighting may also affect detection performance. Variable light intensity is one of the major challenges in a camera-based detection system.

3.2.2 Sensor-based method

Another detection technology uses sensors to detect vacant spaces in a parking lot. With the availability of various types of sensors, selecting a suitable detection system is an important part of implementing a smart parking system. Different technologies are used for detecting motion, generally depending on the application. And different factors play a role in choosing the proper sensor, including size, reliability, adaptation to environmental changes; robustness and cost [26].There are different types of sensors that used for motion detectionin car parking as shown in Table3.1.

Table 3.1: Different sensors used for car parking system

Sensor Used	Detection of parking spaces	Circuit	Cost	Disadvantages	Advantage
IR Sensor	Accurate	Simple	Very low	Reflection can be affected by color of thecar.	1.Range canbe changeddepending on ambient light intensity 2. Ease to design low range as well as high range sensor.
Magnetic Sensor	False Detection may occur	Highly Sensitive	Low	Continuous operation would drain more than 1.5mA at3V.	Sensors based on magneto-resistors are suitable for vehicle detection.

Light Sensor	Accurate	Simple	Expensive	1. TwonearbySensors can cause interference. 2. More light tooperate.	Able to distinguish module at delight from ambient light.
Optical Sensor	Accurate	Complex	Expensive	It cannot detect pedestrians or object from vehicles of interest, therefore acknowledge false detection.	Easy installation and maintenance.
Image Sensors	More Accurate	Complex	More Expensive	1.More Expensive 2.complex Circuit	More accurate to detect the object.

From Table 3.1 we decide to use IR Sensor because of its simple operation and relatively low power requirement.

3.2.3IR sensor

An infrared sensor is an electronic device that emits and/or detects infrared radiation in order to sense some aspect of its surroundings. Infrared sensors can measure the heat of an object, as well as detect motion. Many of these types of sensors only measure infraredradiation, rather than emitting it, and thus are known as passive infrared (PIR) sensors(for more information about IR Sensors please refers to Appendix A). IR sensors are the motion detectors which detects the motion of the vehicle and also the presence of the vehicle at the parking lot as shown in Figure 3.2. Whenever any vehicle comes at the entrance of the parking area that vehicle is detected by the IR sensor and sends the information to the AVR controller. This sensor can be also used for most indoor applications

where no important ambient light is present. This sensor doesn't provide ambient light immunity. However, this sensor can be used to measure the speed of object moving at a very high speed, like in industry or in tachometers. In such applications, ambient light ignoring sensor, which rely on sending 40 KHz pulsed signals cannot be used because there are time gaps between the pulses where the sensor is 'blind'[6].

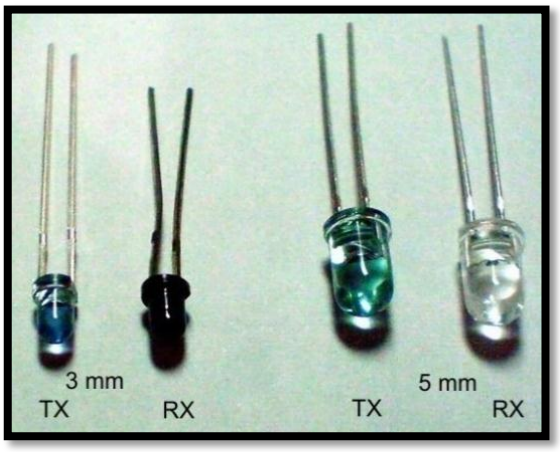


Figure3.2: Actual photograph of IR sensors

3.3 Processing and Storing Unit

The microcontroller performs a task, controls the functionality of other componentsand processes data.Advanced virtual RISC controller is the main control unit of the smart parking assists system. It Controls all the IR Sensor nodes, PSDU and the whole system. It receives the signal from the IR sensors and also sends the information to them in order to manage the parking System.

The selected microcontroller is ATmega32 as shown in Figure3.3, It is 8 bit MCU working with low power supply voltage range 2.7V to 5.5V. It consists of advanced RISC architecture with 32 KB self-programming flash program memory, 2KB Static Random Memory (SRAM), 1KB Electrically Erasable Programmable Read Only Memory (EEPROM)and 32bit.Programmable I/O lines, with 16MHz max operating frequency. The power consumption at1MHzis 3VA.Activemode: 1.1mA, Idle mode: 0.35mA, and power down mode :< 1µA

(see Appendix B).Microcontroller was programmed by code vision AVR compiler (for more information about programming code please refers to Appendix E), and tested in Proteus program with virtual program.

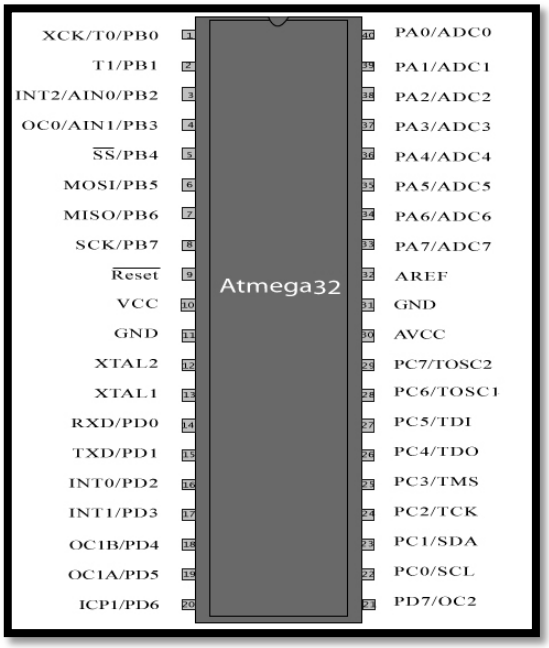


Figure3.3:AVR controller pin diagram of ATmega32

3.4 Wireless Communication Unit (Based on ZigBee)

ZigBee is a typical wireless communication technology, which is widely used in wireless sensing networks, anditis a specification for a suite of high level communication protocols**.** ZigBee uses low rate, low-power digital radios based on an Institute of Electrical and Electronic Engineering (IEEE) 802 standard for personal area networks. The technology defined by the ZigBee specification is intended to be simpler and less expensive than other Wireless Personal Area Networks (WPANs), such as Bluetooth. ZigBee is targeted at RF applications that require a low data rate, long battery life, and secure networking. ZigBee has a defined rate of 250 Kbps best suited for periodic or intermittent data or a single signal transmission from a sensor or input device. It is open standard protocol with no or negligible licensing fees, chipsets available from multiple sources, remotely upgraded firmware, fully wireless and low power, mesh networking to

operate on batteries, low maintenance and larger network size with standard based high security.

3.4.1IEEE 802.15.4/ZigBee standard overview

The ZigBee Alliance selected the IEEE 802.15.4 standard, released in May 2003, as the wheels and chassis upon which ZigBee networking and applications have to be constructed.IEEE 802.15.4/ZigBee is a standard protocol for Low-Rate Wireless Personal Area Networks (LR-WPAN). Its main features are network flexibility, low data rate, low cost and very low power consumption, which make it suitable for an ad-hoc network between inexpensive fixed, portable and moving devices.

3.4.2 ZigBee specifications

The basic specifications of the ZigBee802.15.4 standard are present in Table 3.2.

Table3.2: Basic ZigBee specifications

Parameters	ZigBee Value
Transmission range(meters)	1 – 100
Battery life (days)	100 – 1.000
Network size(# of nodes)	> 64.000
Throughput (kb/s)	20 – 250

3.4.3Network components

IEEE 802.15.4 protocol generally defines three types of nodes or three kinds of devices that incorporate ZigBee radios, with all three found in a typical ZigBee network as in Figure 3.4.

- Coordinator (ZC): Organizes the network and maintains routing Tables.
- Routers (ZR): Can talk to the coordinator, to other routers and to reduced-function end devices.

- End devices (ZED):Can talk to routers and the coordinator, but not to each other.

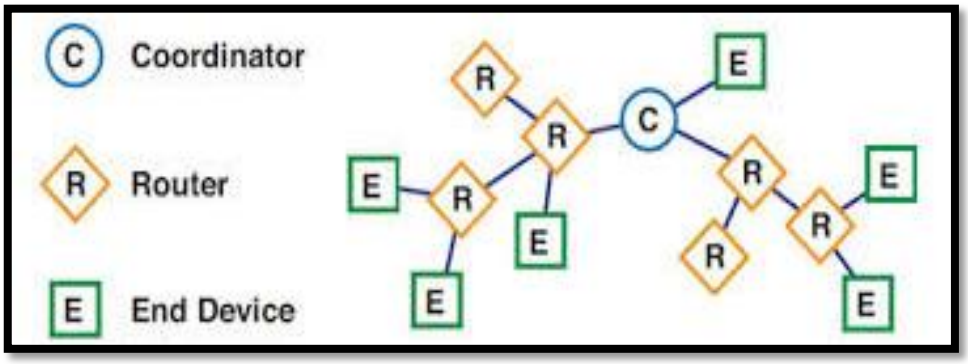


Figure 3.4:ZigBeenetwork components

3.4.4 ZigBee topologies

IEEE 802.15.4 supports three types of topologies: Star, Mesh and Tree that can be considered as a special case of Mesh topology as shown in Figure 3.5.

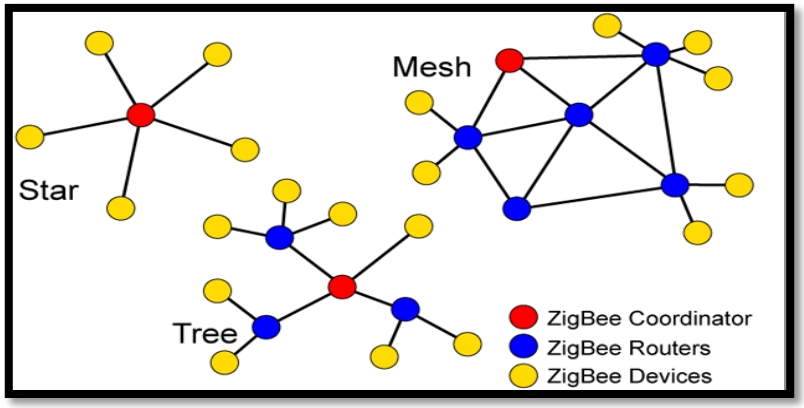


Figure 3.5:ZigBee network topologies

- Star Topology: In this simple topology, a coordinator is surrounded by a group of either end devices or routers. This type of topology is attractive because of its simplicity, but at the same time presents some key disadvantages. In the moment when the coordinator stops functioning, the entire network is functionless because all traffic must travel through the center of the star. For the same reason, the coordinator could easily be a bottleneck to traffic within the network, especially since a ZigBee network can have more than 60000 nodes.

- Tree Topology:In a tree network, a coordinator initializes the network, and is the top (root) of the tree. The coordinator can now have either routers or end devices connected to it. For every router connected, there is a possibility for connection of more child nodes to each router. Child nodes cannot connect to end devices because it does not have the ability to relay messages. This type of topology is not the most reliable topology. If a router fails, then all of that router's children are cut off from communicating with the rest of the network.
- Mesh Topology: Mesh topology is the most flexible topology of the three. Flexibility is present because a message can take multiple paths from source to destination. If a particular router fails, then ZigBee's self-healing mechanism will allow the network to search for an alternate path for the message to be passed[29].

As related works studied, different technology has been explored to implement intelligent lighting systems. A comparison between these kinds of communication approaches are shown in Table 3.3.

Table 3.3:Comparison available communications technologies

	Power Line Communication	Z-Wave	ZigBee
Data rate(kbps)	0.625-50	40	250
Power consumptions	Very Good	Good	Very Good
Implementation	Good	Good	Best
Installation cost	Good	VeryGood	Very Good
Maintenance cost	Good	Good	Very Good
Max number of nodes	-	232	2^16
Frequency	-	900MHz	900 and 2.4GHz
Range	-	30m	10m-1.6km

The available PLC modules in Iran's market suffer from some disadvantages such high cost and no networking capabilities. Opposed of ZigBee technology, Z-wave technology has lower data rates and supporting limited nods. The reason of why ZigBee media are used mainly is its easiness of installation and maintenance. There are no needs to install additional transmission line and it is more economical than other media's case [19].

3.5 Lighting Unit

- LED and luminaire technology: Parking lots, parking structures, and exterior areas are presently illuminated by a host of different light source technologies. Each technology has relative advantages and disadvantages, and may be individually favored or avoided for a variety of reasons.
- High Intensity Discharge (HID):Including both metal halide (MH) and high-pressure sodium (HPS), is the most prevalent technology used to illuminate surface lots. HID lamps are efficacious, operate effectively in a wide range of ambient temperatures, and easily produce enough lumen output for mounting on widely spaced poles. MH lamps typically offer better color rendering and have a cooler color temperature than HPS lamps; this improves visibility through increased color contrast and contributes to the general perception that MH lamps are more visually pleasing, but sacrifices luminous efficacy and lamp life slightly, relative to HPSlamps. In the past, almost all HID systems used magnetic ballasts; newer electronic ballasts may allow for bi-level operation or a minimal range of dimming. However, dimming tends to degrade lamp lifetime, to the point that manufacturers void the warranty if dimmed below a certain threshold.In addition, because HID ballasts become less efficient as their electric loads are reduced, dimming causes light output to decrease more rapidly than power use. Combined, these factors significantly limit dimming's potential benefit relative to other technologies with more

compatible characteristics, as suggested by the relatively low penetration of dimming HID systems in the market to date.

- Fluorescent:lighting is the most prominent technology used (in terms of numbers of installed lamps) in parking garagesbecause of its relatively low cost, high efficiency, and long life. However, unlike HID point sources, the broad area of emission from fluorescent lamps makes precise optical control difficult, limiting fluorescent use in applications where large areas must be illuminated from regularly spaced locations. Additionally, fluorescent lamps can have difficulty starting in extreme cold temperatures. Fluorescent lamps offer desirable color characteristics and can be dimmed with appropriate ballasts, although lamp life can be reduced when switched off rather than dimmed due to cumulative degradation of the electrodes.
- Induction:lighting technology has many characteristics similar to fluorescent, but has no electrodes, eliminating the risk of reducing lamp life with increased on-off cycles. Induction products are long-life and can be an attractive option in many situations, although at present claim only a small portion of the exterior and parking structure lighting markets.
- LED:luminaries are now a viable alternative to conventional technologies in the applications under discussion, and in many cases offer improved efficacy, color quality, and luminous intensity distributions as shown in Figure 3.6. Notably, LEDs can be dimmed much more easily and to lower levels than (HID) (~10% versus ~50%) without sacrificing lifetime. In fact, operating LEDs at lower drive currents tends to reduce lumen depreciation while simultaneously increasing efficacy. The favorable dimming capabilities of LEDs can substantially improve the cost-effectiveness of sensing technology, and in fact are strongly correlated with the emerging development of advanced control systems for exterior

lighting applications. However, there are still technical issues, such as visible flicker, with the use of dimming equipment in many situations that require resolution before these systems can achieve widespread implementation[20].Table 3.4 summarizes the characteristics of each of these lighting sources and LED light compared to the other types of lighting.

Figure 3.6:LEDi (LED retrofit lamp) and control must be compatible

Table3.4:LED light compared to traditional lamps

ENERGY EFFICIENCY & ENERGY COSTS	Light Emitting Diodes (LED)	Incandescent Light Bulbs	Compact Fluorescents (CFL)
Life Span (average)	50,000 hours	1,200 hours	8,000 hours
Watts of Electricity Used (Equivalent to 60 watt bulb)	6-8 watts	60 watts	13-15 watts
Kilowatts of Electricity used	329 KWh/y	3285 KWh/y	767 KWh/y
ENVIRONMENTAL IMPACT	Light Emitting Diodes (LED)	Incandescent Light Bulbs	Compact Fluorescents (CFL)
Contains toxic mercury	No	No	Yes
RoHS Compliant	Yes	Yes	No
Carbon Dioxide Emissions	451 pounds/year	4500 pounds/year	1051 pounds/year
LIGHT OUTPUT	Light	Incandescent	Compact Fluorescents

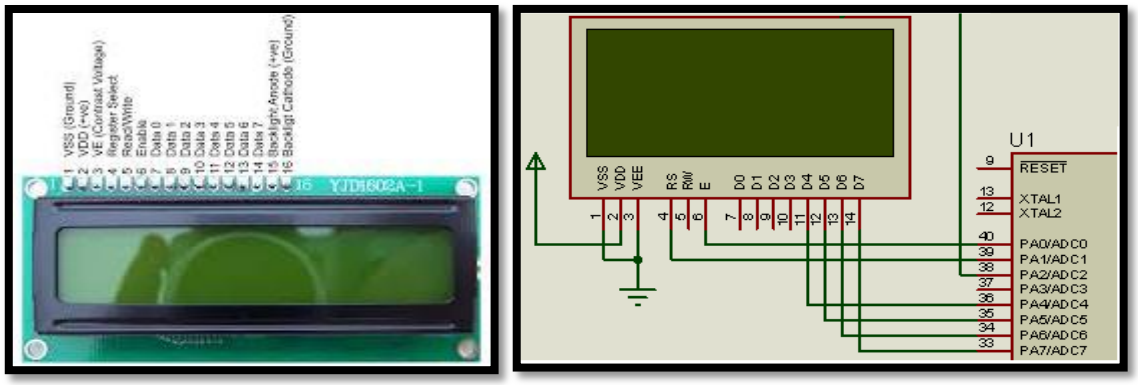
	Emitting Diodes (LED)	Light Bulbs	(CFL)
Lumens	Watts	Watts	Watts
450	4-5	40	9-13
800	6-8	60	13-15
1,100	9-13	75	18-25
1,600	16-20	100	23-30
2,600	25-28	150	30-55
IMPORTANT FACTS	Light Emitting Diodes (LED)	Incandescent Light Bulbs	Compact Fluorescents (CFL)
Sensitivity to Low Temperatures	None	Some	Yes may not work below -10 degrees F or over 120 degrees F
Sensitivity to humidity	None	Some	Yes
Turns on instantly	Yes	Yes	No takes time to warm up
On/Off cycling effect	None	Some	Yes CFLs warm slowly and reach full brightness gradually; turning a CFL bulb on & off quickly can drastically reduce its life span
Fragility	Very Durable LEDs can handle jarring & bumping	Not Durable glass or filament breaks easily	Not Durable glass breaks easily
Heat Emitted	3.4 btu's/hour	85 btu's/hour	30 btu's/hour
Failure Modes	Not typical	Some	Yes may catch on fire, smoke or emit odor

Financial consideration -namely, purchase price and operating costs -always figure in the selection of lighting products, but many other aspects also come

into play, varying in importance depending on the application. LEDs have several unique attributes, and it is critical to understand how they can be used advantageously. Some considerations are dependent on product design, but others amount to using LEDs in appropriate situations. Some of the potentially favorable characteristics of LED sources compared to traditional lamps include: directional light emission, Size and form factor, Resistance to mechanical failure such as breaking, instant on at full output, Rapid on-off cycling capability without detrimental effects, improved performance at cold temperatures, dimming and control capability, opportunity for color tuning, minimal nonvisible radiation [such as Ultra Violet (UV), infrared (IR)], and extended lifetime.

3.6 Parking Status Display Unit (PSDU)

The data can collect at any time and the collected data may need to be displayed, for this purposeLCDat the entrance of the parking lots used for simplicity and cost efficientas shown in Figure 3.7, to tell the new-coming car the available parking spaces in this parking lot and show the path to the optimal parking space according to the results.



(a) (b)

Figure3.7: The LCD (a) Pin out (b) Schematic Diagram

3.7 Design of Power Supply

Electrical power is the rate of movement of electrons that create energy. As a result of the electronic age many products need electrical power to perform

certain activities. To create a cheap, reliable, and effective Direct Current (DC) power supply, transformer was used to step down the120VAC to a lower voltage. Then, the low voltage Alternative Current(AC) was sent through a rectifier to make it DC and use a capacitor to smooth out the ripples in the DC. Finally, voltage regulator added to regulate the output voltage. A regulator (LM317T) does exactlywhat the name says; it regulates the voltageas shown in Figure 3.8 (for more information about regulator (LM317T) please refers to Appendix D). Using the voltage input a regulator generates an internal voltage for the regulator to compare the output to be able to hold the outputconstant. A voltage regulator can be used to guarantee the required voltage supply to the microcontroller and most of the other peripherals and components is +5V. The voltage needed for the components of the system as shown in Table 3.5.

Table 3.5:Power consumption for component

NAME	NUMBER OF ELEMENTS	POWER CONSMPTION
Microcontroller (Atmega32)	2	5 Volt DC, 1.1 mA
IR Sensor	10	5 Volt DC, 11uA
LCD	1	5 Volt DC, 100 mA
Stepper Motor	1	5 Volt DC, 0.5 W
An 8- channel analog multiplexer	1	5 Volt DC, 10 mA
ZigBee Module	2	3.3Volt DC, 45 mA
LED	6	220 Volt AC, 70 mA

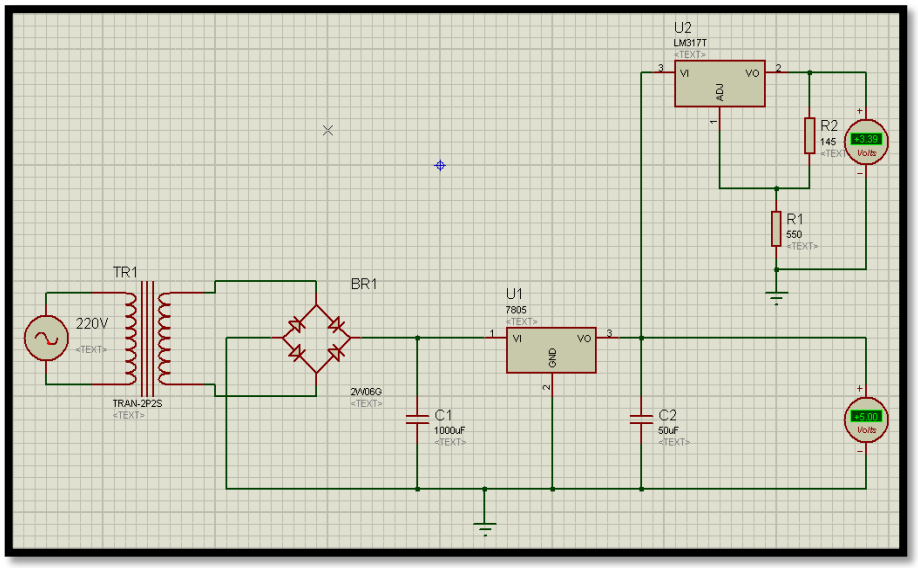


Figure3.8:Design of the power supply

3.8 Design of Parking Lights Using LED

Energy efficiency of light sources is typically measured in lumens per watt (lm/W), meaning the amount of light produced for each watt of electricity consumed. In Table 3.5, an analysis comparing the Luminous System Application Efficiency (LSAE) values for single pole configurations and a complete parking lot application for three nominally 150W with high pressure sodium, LED and metal halide.From Table 3.6, a selection was made for a single parking unit to be 10m×4m with minimum 8lm/W for LED with single pole, where this area occupied four saloon cars (four lots).

Table 3.6: Comparison values for single pole for HPS, LED, and MH

Lamp Type	Optimum Pole Height (ft)	LSAE at optimum pole height (lm/W)	Estimated Area Dimension (ft)
HPS	25	30.2	165×90
LED	20	25.6	140×70
MH	25	19.0	165×100

3.9 Design of IR Sensor Module

All objects emit some form of thermal radiation, usually in the infrared spectrum. This radiation is invisible to our eyes, but can be detected by an

infrared sensor that accepts and interprets it. In a typical infrared sensor like a motion detector, radiation enters the front and reaches the sensor itself at the center of the device. This part may be composed of more than one individual sensor, each of them being made from pyroelectric materials, whether natural or artificial. These are materials that generate an electrical voltage when heated or cooled. These pyroelectric materials are integrated into a small circuit board. They are wired in such a way so that when the sensor detects an increase in the heat of a small part of its field of view, it will trigger the motion detector's alarm. It is very common for an infrared sensor to be integratedinto motion detectors like those used as part of a residential or commercial security system. An infrared sensor can be thought of as a camera that briefly remembers how an area's infrared radiation appears. A sudden change in one area of the field of view, especially one that moves, will change the way electricity goes from the pyroelectric materials through the rest of the circuit. This will trigger the motion detector to activate an alarm. If the whole field of view changes temperature, this will not trigger the device. This makes it so that sudden flashes of light and natural changes in temperature do not activate the sensor and cause false alarms.

3.10 Object Detection Using IR Sensor

The object detection of IR sensor that shown in Figure 3.8. It is the same principle in all Infra-Red proximity sensors. The basic idea is to send infra red light through IR-LEDs, which is then reflected by any object in front of the sensor.From the electronic circuit of IR sensor that shown in Figure 3.9.As the name implies, the sensor is always ON, meaning that the IR led is constantly emitting light. This design of the circuit is suitable for counting objects, or counting revolutionsof a rotating object, thatmay be of the order of 15,000 rpm or much more. However this design is more power consuming and isnot optimized for high ranges.In this design, range can be from 1to 10 cm, depending on the ambient light conditions.

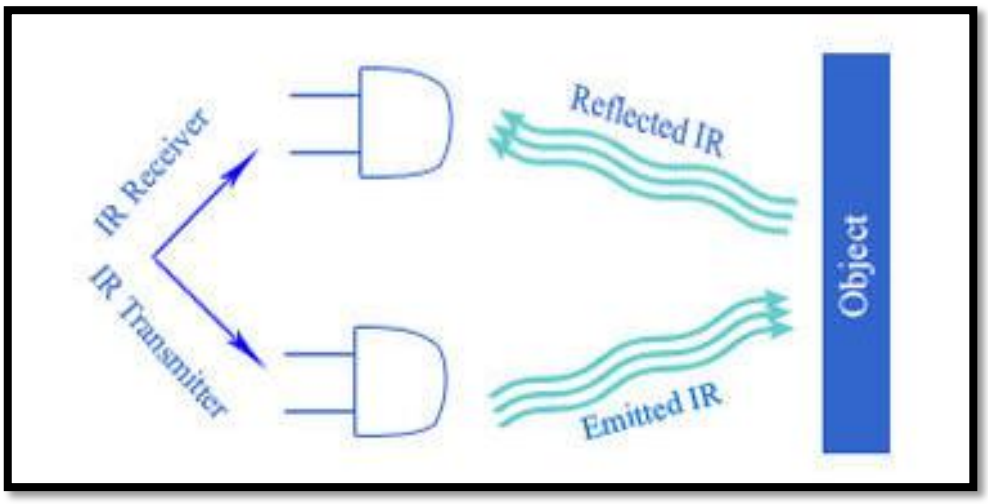


Figure 3.9:Object detection using IR sensor

The senderis composed of an IR LED (D2) in series with a 470 Ohm resistor, yielding a forward current of 7.5 MA The receiverpart is more complicated, the 2 resistors R2 and R3 form a voltage divider which provides 2.5V at the anode of the IR LED (here, this led will be used as a sensor). When IR light falls on the LED (D1), the voltage drop increases, the cathode's voltage of D1 may go as low as 1.7V or more, depending on the light intensity. This voltage drop can be detected using an Operational Amplifier(Op-Amp). The voltage after operational amplifier must be 5V *i.e.* logic 1.

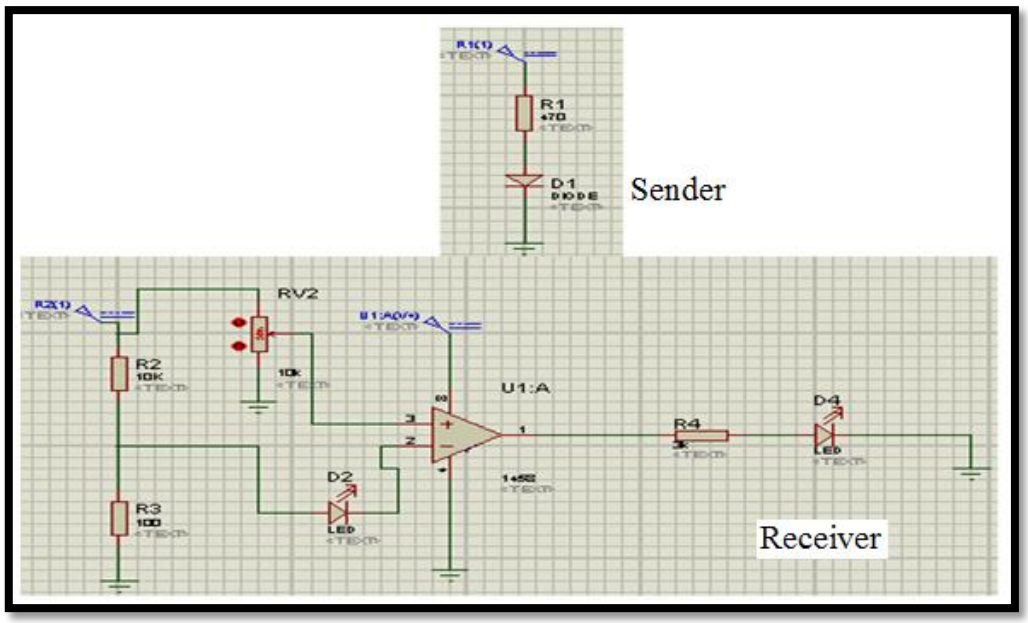


Figure3.10:Design of sender and receiverIR sensor

3.11Parking System Design

We design our system as shown in Figure 3.11.The parking system contains three sections, every section contains four units and every unit had four spaces for parking(fourlots).Every unit had four IR Sensors in every lots and one LED lamp. Also there are four LED lampsfor lighting the track of car between the three sections.

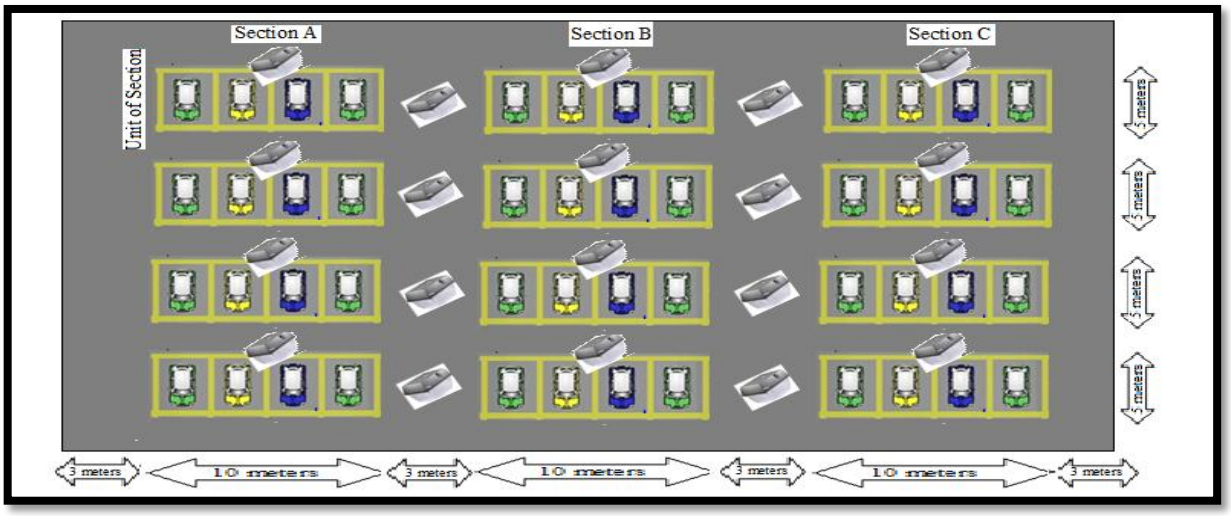


Figure 3.11:System design

Two units of the proposed design were implemented of one sectionas a sample for the system to show how it works.This system contains transmitting unit and receiving unit as shown in Figure 3.12.The components of the transmittingunit and receiving unit which used in this thesis that two microcontroller Atmega32, ten IR sensors, an 8-channel analog multiplexer, stepper motor, two ZigBee modules for communication between the transmitting unit and receiving unit, six relays, six LED lamps, keypads and LCD for displaying information.

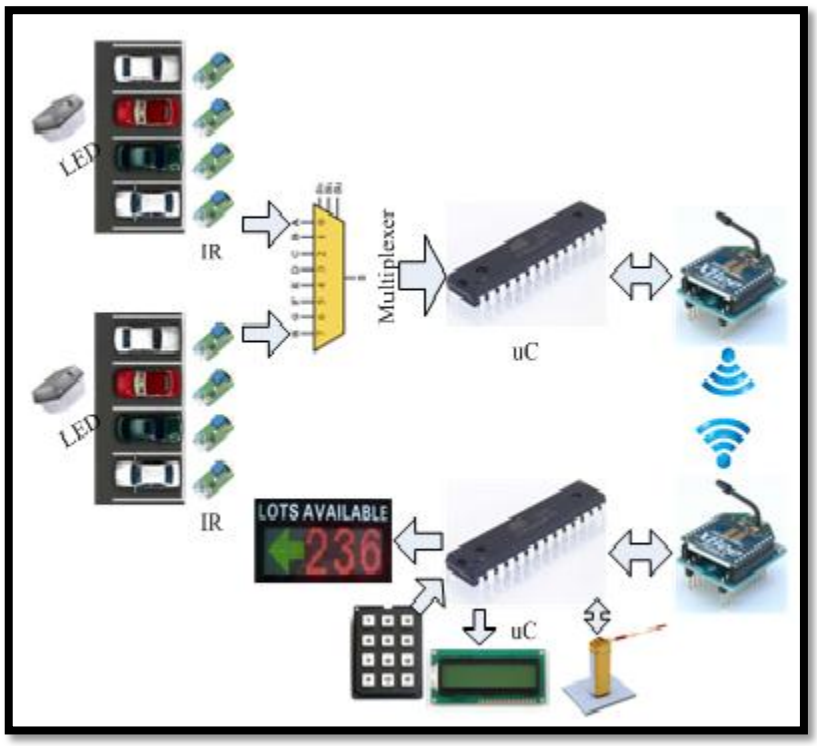


Figure 3.12: Design of transmitting and receiving units

3.12The Transmission Unit

The transmission unit connected as shown in Figure 3.12. It contains several electronic elements as flow:

- Microcontroller (Atmega 32) which replaced by microcontroller Atmega 16 for proteus simulation and ZigBee module for transmitting data and receiving it which replaced by serial communication for simulation (serial com1).
- Multiplexer: The 74HC4051; 74HCT4051 is an 8-channel analog multiplexer with three digital select inputs (S0 to S2), an active-LOW enable input (E), eight independent inputs/outputs (Y0 to Y7) and a common input/output (Z). The VCC to GND ranges are 2.0V to 10.0V for 74HC4051 and 4.5V to 5.5V for 74HCT4051. The analog inputs/outputs (Y0 to Y7, and Z) can swing between VCC as a positive limit and VEE as a negative limit (for more information about 74HC4051 or 74HCT4051 please refers to Appendix C).

- IR Sensors:for simulation purposesall the designed IR Sensors were replacedby push button switches with pull up resistors which have the same output.
- LED lamps:Two LED lamps were used for the two unit of the section, and four LED lamps for the track of car. LED lamp needed 220VAC when connected with microcontroller which needs5VDC, so we use relays between the microcontroller and LED lamps.
- Relays: A relay is an electrical switch that uses an electromagnet to move the switch from the off to on position instead of a person moving the switch. It takes a relatively small amount of power to turn on a relay but the relay can control something that draws much more power. For example a relay is used to control the air conditioner at home. The AC unit probably runs off of 220VAC at around 30A. That's 6600 watts! The coil that controls the relay may only need a few watts to pull the contacts together. When current is passed through the coil it creates a magnetic field that pulls the switch closed. Usually a spring will pull the switch open again once the power is removed from the coil. Select a relay with contacts that can handle the voltage and current requirements of the load, also with a coil voltage and current that you can control easily.

Eight push button switches were connected with eight pull up resistors(470 ohm)to an 8-channel analog multiplexer with three digital select inputs (S0 to S2) and one output, the three digital select inputs and the output of multiplexer were connected at pin (0, 1, 2, 3, and 4) in PORTA respectively. The output from pin (2, 3, 4, 5, 6, and 7) at PORTC is six relays which are connected to six LED lamps.For serial communication we connected pin 1 in PORTD (TXD) with pin TXD for serial (com 1).Vgg in microcontroller was connected with ground.

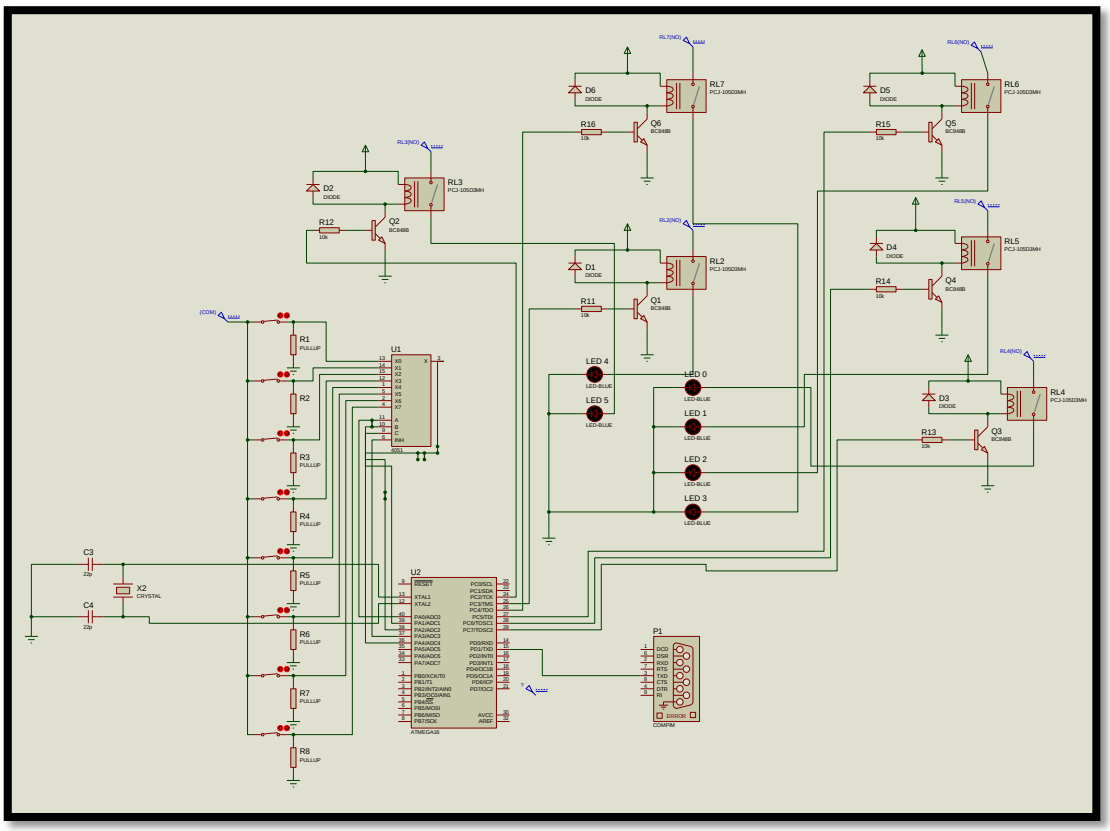


Figure 3.13: Transmit unit

3.13 The Receiving Unit

The receiving unit connected as shown in Figure 3.13. It contains several electronic elements as flow:

- Microcontroller (Atmega16) was used for proteus simulation, LCD for display, keypad for entering the numbers, and ZigBee module for receive or transmit if we needed which replaced by serial communication (serial com2).
- IR Sensors:Two IR sensors needed for entering and exit at entrance of the parking, which replaced by push button switches with pull up resistors because have the same output.
- Stepper Motor:An electromagnetic actuator, it is an incremental drive (digital) actuator and is driven in fixed angular steps. This means that a digital signal is used to drive the motor and every time

it receives a digital pulse it rotates a specific number of degrees in rotation. Each step of rotation is the response of the motor to an input pulse (or digital command). Step-wise rotation of the rotor can be synchronized with pulses in a command-pulse train, assuming that no steps are missed, thereby making the motor respond faithfully to the pulse signal in an open-loop manner. Stepper motors have emerged as cost-effective alternatives for DC servomotors in high-speed, motion-control applications (except the high torque-speed range) with the improvements in permanent magnets and the incorporation of solid-state circuitry and logic devices in their drive systems. Stepper motors are easily controlled with microprocessors; however logic and drive electronics are more complex. Stepper motors are operated open loop, while most DC motors are operated closed loop. Stepper motors can slip if overloaded and the error can go undetected. (A few stepper motors use closed-loop control.). Feedback control with DC motors gives a much faster response time compared to stepper motors.

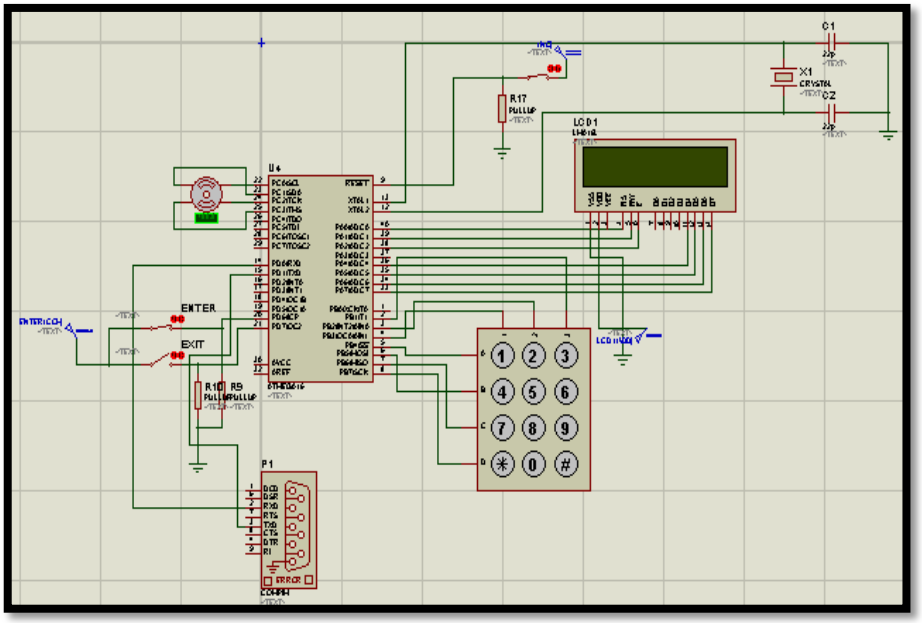


Figure 3.14: Receivingunit

The stepper motor was connected with microcontroller at pin (0. 1, 2, and 3) in PORTC, also two push button switches (for Enter and Exit) were connected at pins (6,7) in PORTD.The first output from pins (0, 1, 2, 4, 5, 6, and 7) at PORTA is LCD; the second output from pins (1, 2, 3, 4, 5, 6, and 7) at PORTB is key bad. For serial communication we connected pin TXD of the microcontroller with TXD of serial (com2).**Vgg** in the microcontroller was connected with ground.

3.14 Integration of the Proposed Parking System

The system proposed was connected as shown in Figure 3.15. Which represented the all system and its components and how connected together.

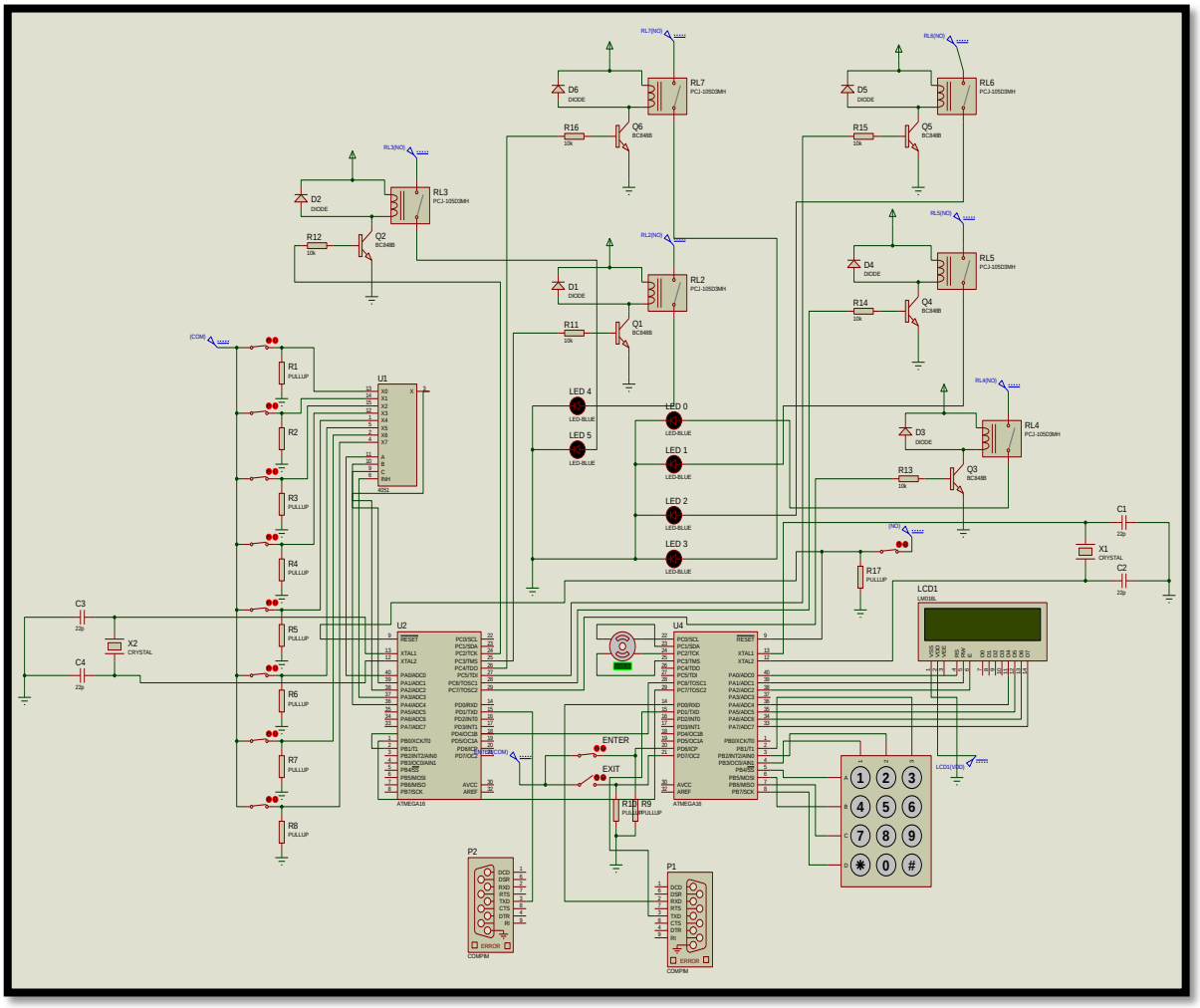


Figure 3.15: The Schematic of the system design

3.15 The Flow Chart

The system is clarified using the flowchart; it is illustrate the entering operation and the exit operation as shown in Figure 3.16.

For interning case if there is any incoming car at the entrance of the parking garage, the MCU which install in the receiving unit send signal to the transmit unit by ZigBee module, in the transmit unit the multiplexer scanning and reading the IR Sensor status and deliver it to the MCU, then the MCU detect location of the available parking slot if there is one, if not the MCU send a message to the receive unit, then the receiving unit display there is no available parking in the parking status display unit. But if there is any available parking slot the MCU of transmitting unit detect the nearest available parking slot and transmit the number of available slot to the receive unit, so in receiving unit the MCU send a message to the PSDU to display the location of the available parking slot, then motor will open and theMCU send signal to control unit to light the LED lamps which install in the track of car, after the car retch its location the LED lamp of the unit turn on.

For exit case, the MCU of the receiving unit send a message to the PSDU to inform the user or the driver to enter his parking location number, if it wrong number a message in the PSDU will show to inform the driver that the entering number was wrong, but if was right the door will open for the driver and message “goodbye thank you for your visit” will show in the parking status display unit.

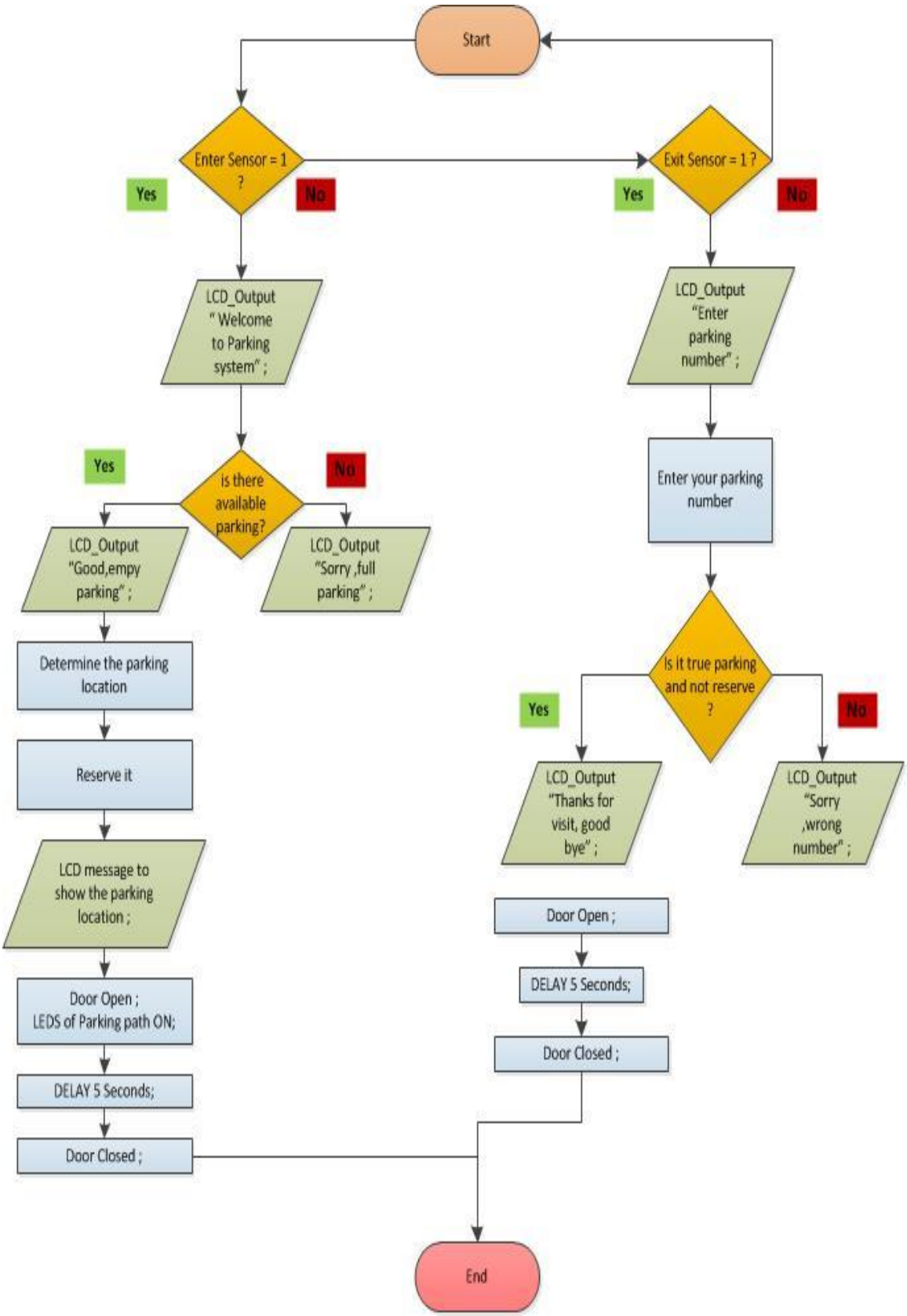


Figure3.16: The flow chart

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Introduction

A Smart parking system based onWSN and LED is designed for real time application to provide efficient parking guidance andmanagement. The performance of Smart Parking System can be identified by studies various parametersrelated with various sensors used in parking system as well asvarious parking methods implemented up till now for parking guidance and management.

The performance evaluation of system that test as simulation, we find that the MCU get sensor signals properly and monitors and updates the position of vehicle according to actual parking, every parking spaces are detected by IR sensors effectively, and IR Sensors properly detect the vehicle, so when the system starts functioning, all the IR sensors that install in the parking slot form a network. These IR sensors check the status of parking spaces and send the report to the MCU which install in the transmission unit through the multiplexer. MCU detects the status of the parking and transmits the status information to the receiving unit through ZigBee module, then the MCU which install in the receiving unit send the information to the Parking Status Display Unit (PSDU), Then the system calculates of the vehicle direction and lights the track lamps for it and trace the moving vehicle, if it parked on the lot to light the lot lamp.

4.2The IR Sensor Simulation Result

The circuit of IR Sensor was designed and testing successfully. It has developed by integrating of the software, as shown in Figure 4.1.

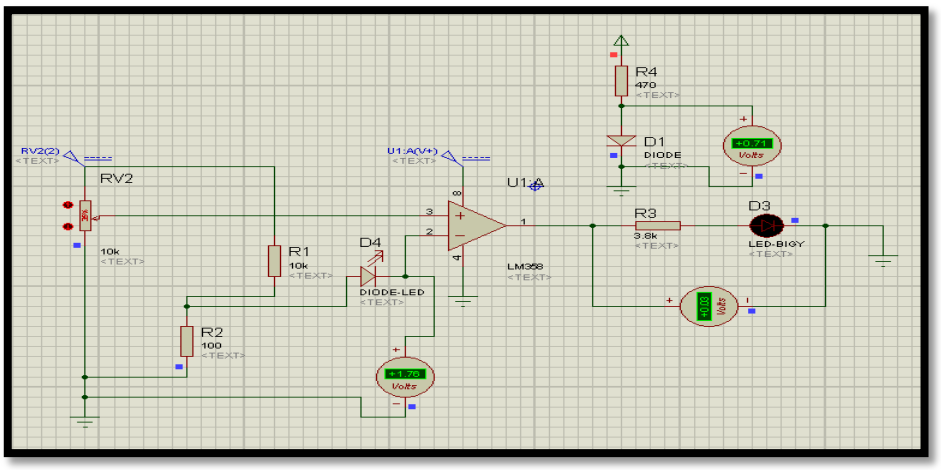


Figure 4.1: IR Sensor testing result

4.3The Entering Operation

When a vehicle arrival at entrance of the parking and there is no parking lot free, the IR sensors detects that the parking space is occupied and it sends areport message to the MCU of the transmission unit through the multiplexer. The MCU send this message to the receiving unitthrough the ZigBee module which display "SORRY FULL PARKINGS" message in the (PSDU) for the new incoming as shown in Figure 4.2.

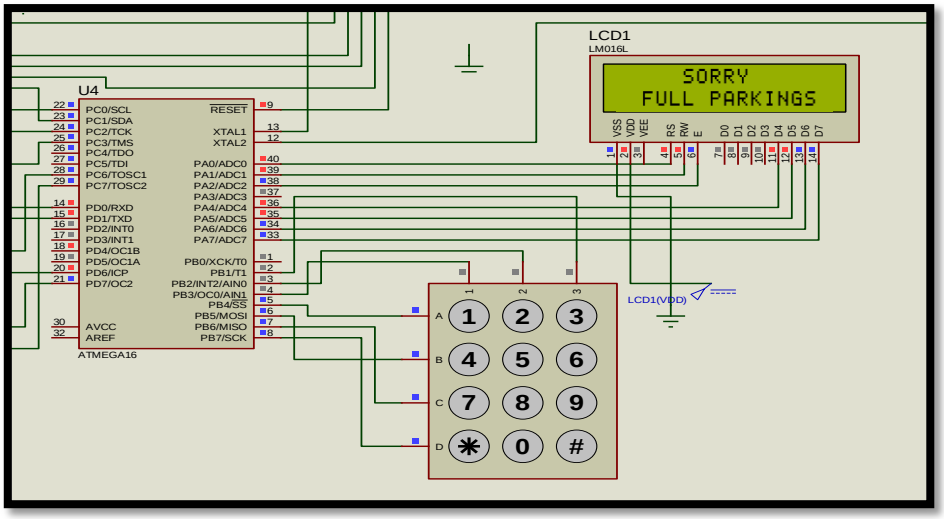


Figure 4.2: The parking space is occupied

Wheneverthere is a some parking slots are free, after the IR sensor placed in the entrance of the parking (Entering IR sensor) sense the new incoming car, the MCU which install in the receiving unit send signal to the transmission unit

through ZigBee module to detect the nearest parking space, so the MCU which install in the transmission unit detect and reserve the section and the slot witch the car must park in it, then send a messageto the receiving unit which display in the Parking Status Display Unit (PSDU) the path of the parking slot (show the No of section, no of slot or parking), then it open the door for the incoming car as shown in Figure 4.3.

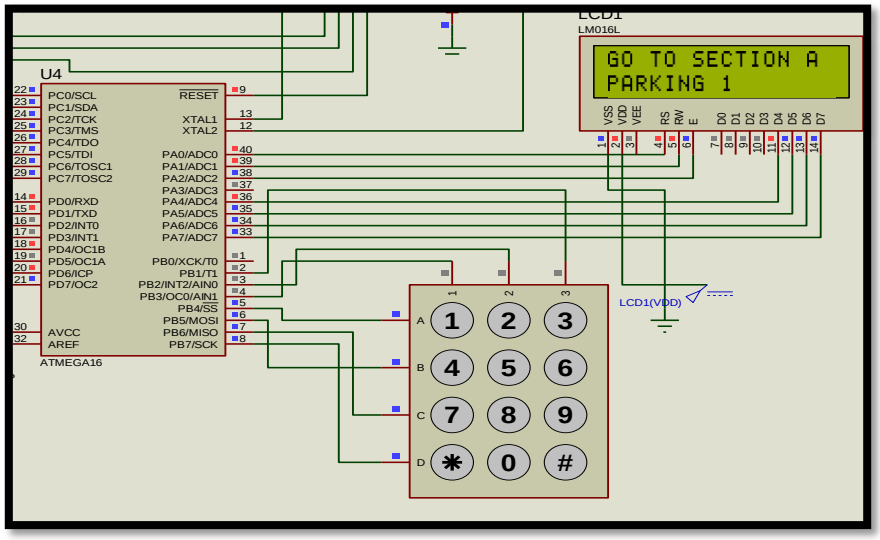


Figure 4.3: The path of the new incoming car

Then the MCU which install in the transmit unit send signal to the control lightingunit to light the path of the car (track LED lamps)and light also the LED lamp of unit of the section as shown in Figure 4.4. If the car park in his location and the IR sensor witch install in the slot read the car, the MCU in the transmit unit change status of slot from reserve to full slot.

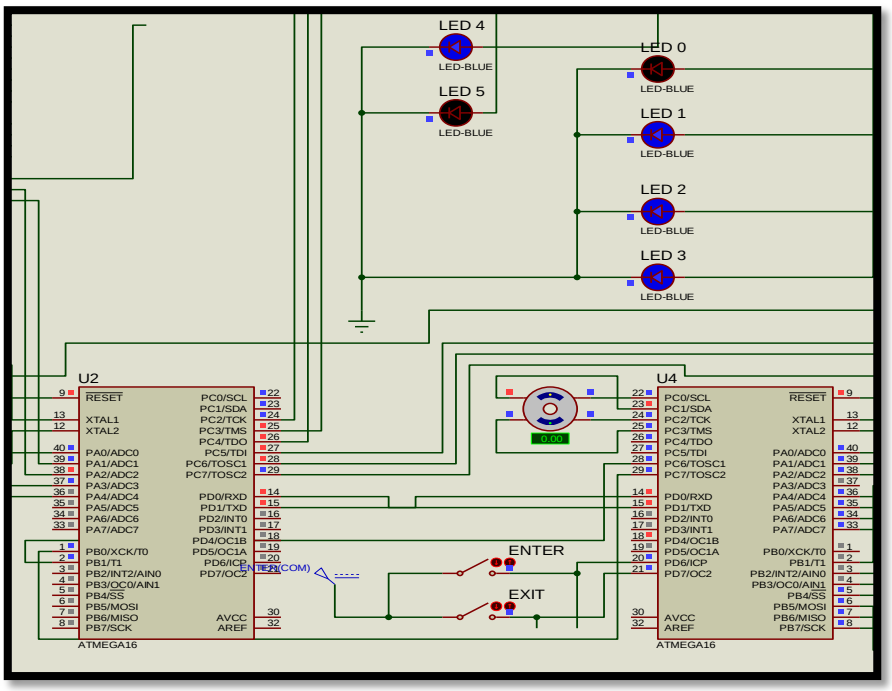


Figure 4.4:Lighting the path of the new incoming car

4.4 The Exit Operation

Whenever there is a car want to leave the parking the MCU of the transmission unit received signal from the parking slot witch the car left from it, so the MCU reserve this space until the exit IR sensor read this car, after that the MCU of the receiving unit send a message to the parking status display unit (PSDU) to inform the driver entering his location (no of section, No of parking or slot) by the keypad, as shown in Figure 4.5.

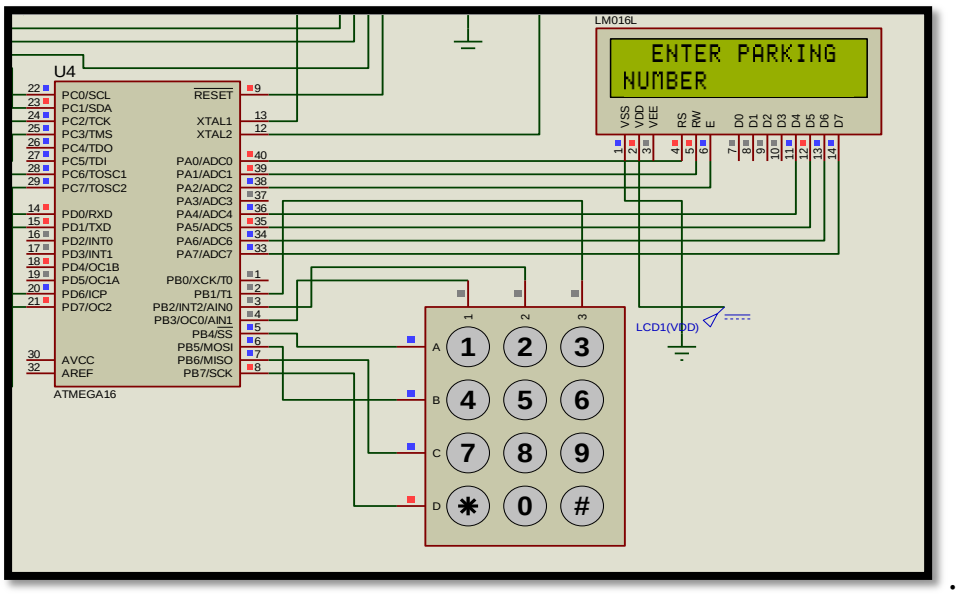


Figure 4.5: Entering location

If the location which enter was wrong, a message will shown in the parking status display unit that location which entering was wrong as shown in Figure 4.6.

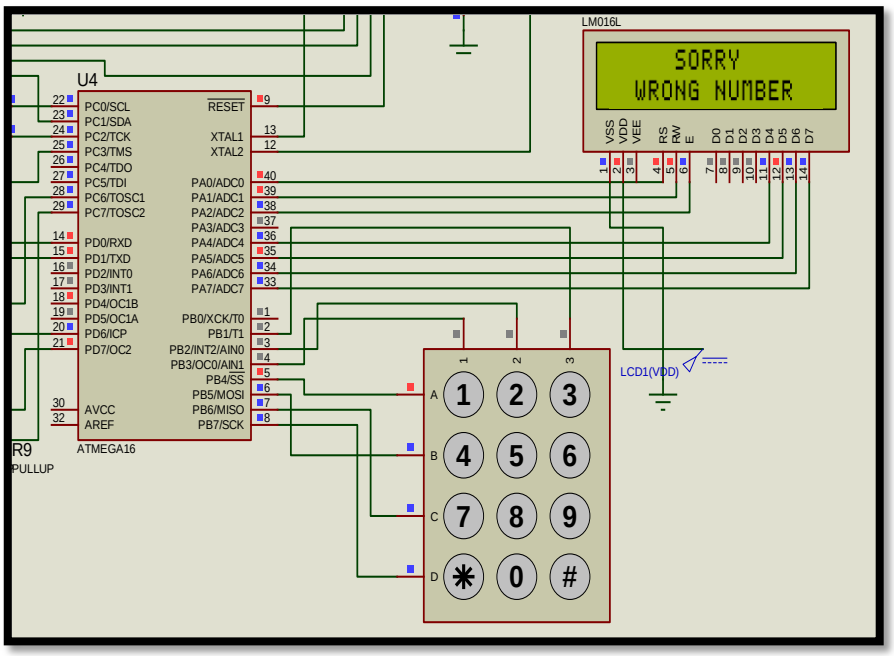


Figure 4.6: Entering wrong number

After the entering the write location the door will open and the car go out as shown in Figure 4.7, then the MCU change the status of the slot from reserveto empty space.

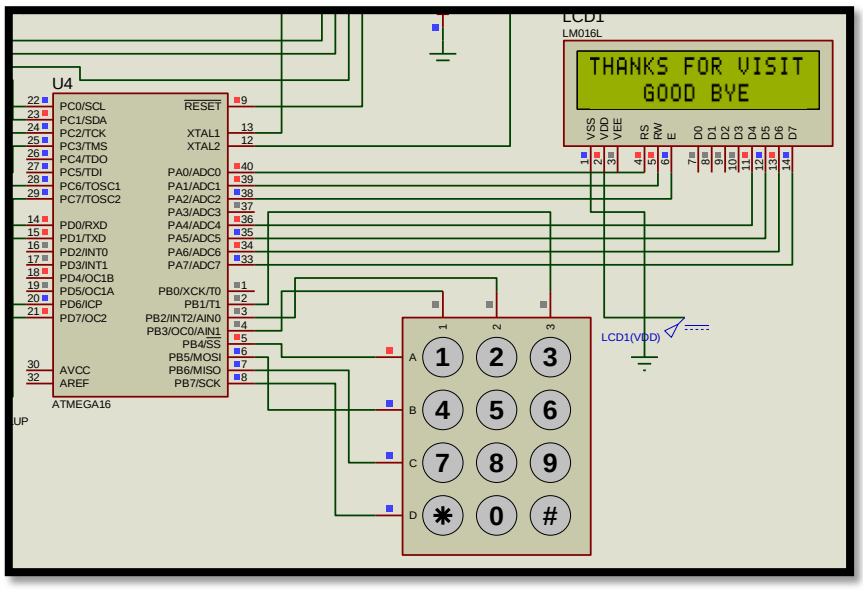


Figure 4.7:The car leaving

If this car was the last one in the unit of the section the MCU in the transmission unit send signal to the lighting control unit to turn off the lamps of the track as shown in Figure 4.8.

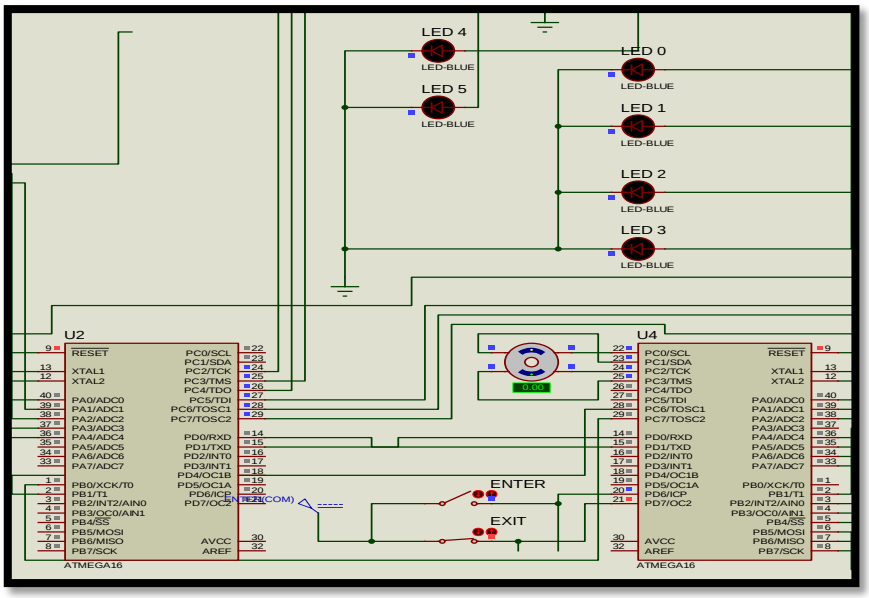


Figure 4.8:Lighting off the lamps

CHAPTER FIVE

CONCLUSION AND FUTURE WORK

5.1 Conclusion

A simple smart parking system based on wireless sensor network and light emitting diode has been successfully designed and tested. It has developed by integrating entire features of the hardware and software used in this thesis. The presence of any information has been reasoned and placed carefully thus contribute to the best work of the units. Besides that, the software and hardware architecture of a parking system has successfully developed for driver guidance. The graphical user interface is friendly user and can be monitor the parking system easily. In addition, to enhance motion sensor will be used and specifications of the sensor is very important. By using this system, visitors or users simply follow the direction of the system to the occupy parking lots easily. This system also helps the visitor or users to searching vacant parking lot in shorten time, the performance evaluation of the system can be categories into:

5.1.1 Parking Guidance

The system is developed to provide efficient solution for searching the free space in the parking area for the incoming vehicle.

5.1.2 Parking Management

- Reduces Parking Time: The SPS model guides the driver to find an empty parking lot to the incoming vehicle, so it reduces most of the time of the drivers for searching the parking lot as well as the gasoline wastage.
- Avoid Collision: There are no unpacking possibilities in the proposed system. Whenever there is a car parking in the slot during the arrival of the new vehicle at the Parking area the MCU of the transmission unit reserve the parking slot of the first car even that

the IR sensor witch install in that slot does not read and it give anew parking for the new incoming (new section, new slot). This can considerably avoid the collision.

- Saving Energy: Using WSN installing wired connection for sensors and replace high intensity discharge HID and metal halide MH with LED luminaries can provide energy savings up to 50% without compromising light characteristics required for parking lot applications.

Finally, it is clear that Smart Parking System based on wireless sensor network and light emitting diode model using IR Sensors are reliable, low cost, and easy to detect any type of vehicle and having simple circuit. Also it satisfies the requirement of the current parking systems. Therefore it is suitable for the current parking monitoring, guidance and management systems. LEDs may be a viable option in a new construction application. Performance of LEDs combined with growing market acceptance of their higher performance versus traditional outdoor area light sources may provide early adopters the impetus to invest in the emerging technology. The wireless sensor networks WSN can be a very promising technology to be used in future intelligent car parking systems.

5.2 Recommendation and Future Work

Although the developed system is at satisfactory level and can be used confidently, the project can be enhanced further in order to improve the quality of the product by increasing reliability, usability and functionality of the system. The sensor processing algorithm can be further optimized when the number of parking slot is increased, to detect the object and guide the driver or users fastest. In future works also, this system can be improved by adding other applications such as reservation parking system by using (GSM) or online booking. The driver or user can book their parking lot at home or on the way to the shopping mall. This can reduce the time of the user to searching the vacant parking lot.

The guidance for driver or user to searching or reserving the parking lot must be display clearly, for example at the entrance of the building or parking level must have a parking layout and display the empty parking lot and the reserve one clearly.

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