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Automated Multi-storied Car Parking System Using RFID

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Abstract

Radio Frequency Identification (RFID) technology is very useful technology in automation of vehicle parking system in mall/building. One of the challenging problems for many vehicle owners in big cities is where to park their vehicles. If the parking slot is known in advance one can save precious time and fuel wastage. In this research, the user is informed about the parking slot availability at a particular parking location. The slot availability details are collected using an RFID system and are updated periodically into the database. Entry-point and exit-point of the parking-lots will be under control with RFID readers, labels and barriers. Since there won't be any waiting during entry-point and exit-point the pollution problem will be avoided. There are three portions in automated multi-storied car parking system. They are RFID system, car lift control system and Bluetooth serial system. For the RFID system, 13.56 MHz passive reader and tag pairs are used. For car lift system, DC motor drivers (L298) and IR obstacle sensor are used. DC motor drivers are used to accurate the feedback operation of barrier for car lift and IR obstacle sensors are used to sense a room which was passed through the barrier after showing RFID tag. DC motor drivers and IR obstacle sensors were controlled by Basic-Pro program.

Keywords: RFID module; PIC microcontroller; IR obstacle sensor; Basic Pro program.

1. Introduction

Today, RFID is the popular wireless induction system. Each RFID tag in RFID system is given a Unique ID (UID). When an independent RFID tag approaches the RFID reader, the induction between tag and reader happens. The information and content recorded in the tag is transmitted to the RFID reader and translated into the computational data.

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Following up the data translation, the tag recognition can be completed and related applications are provided. The RFID card is used to identify that a user is legal or not.

According to the short distance wireless signal, the RFID tag users can be monitored within the specific area. However, most of these applications are based on the indoor environments or be a tiny area service and independent of the existed system. In opposition to creating new execution or service environment, there were many existed systems or applications deployed [1].

This project aims at implementing an automated vehicle management system using radio frequency identification (RFID) technology. This automated multi-storied car parking system will enhance stage of embedding the code into a tag and assigning the same to car.

The second stage is reading the data from the RFID tag to the RFID reader. In the third stage, the data is updated from RFID reader to the Database. The final stage is to keep a track of vacancies of the parking spaces [2]. Main sections in this system are -:

1. PIC microcontroller
2. RFID
3. Display section (LCD)
4. Bluetooth Serial Module
5. Lift & motor section.
6. IR Obstacle Sensor
7. Pneumatic system

Figure 1 shows overall block diagrams for car parking system. System is composed of a lift to carrying car and three floors building. There are three cars can be kept in one floor as maximum. So, maximum capacity can be nine for three floors. First floor, second floor and third floor are used. So, a RFID card protected security is enhanced in floors access. Idea is to use car lift without go outside from car. Operator or user of parking system needs to stop access area of lift.

If lift is free, car is carried to first floor. If first floor is full, second floor is automatically chosen by system. If lift is busy, an alarm indicated that access is stopped.

For accessing the floors, user must enter valid predefined security card number with RFID. If number is granted, green LED will light on and car will be carried to floor.

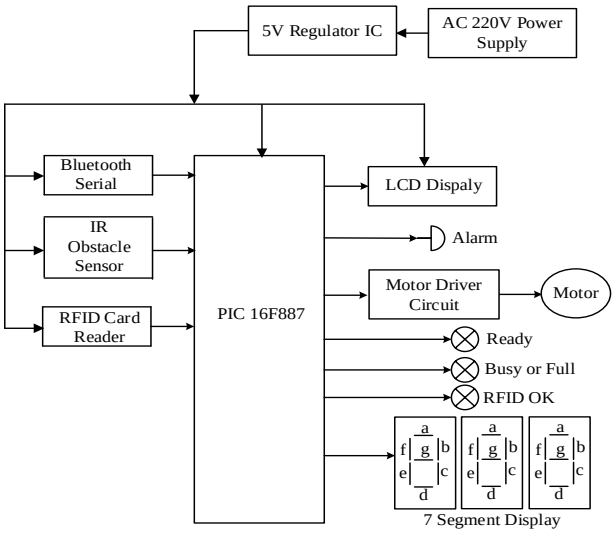

Figure 1: System Block Diagram of Automatic Multi-storied Car Parking System

2. Hardware configurations

In this car parking system, PIC microcontroller is used to control the overall system. In this system there are two types of classification, which mean a RFID system and car lift control system. For controlling this situation determining RFID discrimination is composed by RFID reader and RFID tag. For authorization process, matching with the user information already stored in database system. SD card adaptor is used as database and data storage device. For the first identification and classification, radio frequency produced by RFID reader and RFID tag are used to identified whether register person or not. For second, Android mobile phone is used to check the room by the users. 16×2 line LCD display is used to alert notification message depend on identification process.

2.1. RFID reader and RFID tag

RFID is known as Radio Frequency Identification System. RFID technologies are efficient and secure compare to other network security system. The primary goal of RFID technology is to automatically identify data that are contained in electromagnetic fields. That can be implemented for several applications such as security, tracking, inventory detection and access control applications. RFID technology consists of a combination of tags and readers which is shown in Figure 2. A typical RFID system includes three basic elements:

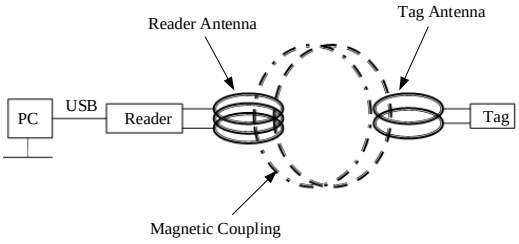

Figure 2: Block diagram of the RFID Tag and RFID reader

2.1.1. RFID Tag

It is responds to queries from reader by wirelessly transmitting a serial number or similar identifier. It comprises of a chip and the antenna. There are two types of RFID tags namely Active and passive. Both tags use radio frequency energy to communicate with RFID reader but the method of powering the tags is different. Active RFID tag uses a battery as an internal power source within the tag to continuously power up the tag and its RF communication circuitry, whereas passive RFID tag depends on RF energy transferred from the reader to the tag to power up the tag. Thus, passive RFID tags require very strong signal from the reader to operate. So, these factors limit passive RFID tags to operate in 3 meters or less. Depending on the frequency of operation, the communication range may be as short as a few centimeters. Active RFID tag can provide communication range of 100 meters or more. RFID transponder used in this project is a passive transponder where it doesn't use any internal power supply to activate it.

The four common tags that are categorized by radio frequencies are:

- Low frequency tags (125 or 134.2 kHz),
- High frequency tags (13.56 MHz),
- UHF tags (868 to 956MHz), and
- Microwave tags (2.45 GHz).

Since the car parking system only needs to read tag from short distance, passive RFID tag is choose for this application.

2.1.2. Reader (transceiver)

It is responsible for the transmission of information between the reader and tag using radio waves. The RF energy used to activate and power the passive RFID tags.

2.1.3. Back-end application system

It demands the support of the computer network. And Software is used for management, controlling, transaction, operation and maintaining record of the various users.

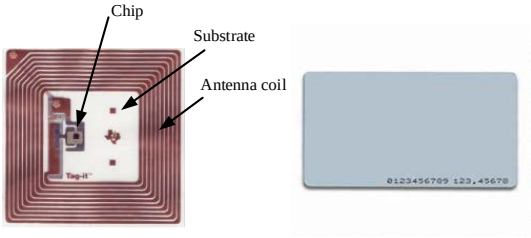

Figure 3: Sample passive RFID Tags [2]

Figure 2 illustrate a general working system and components of RFID. When a RFID transponder is placed near

a RFID reader, the reader reads information contained in the transponder without any physical contact. RFID reader transmit radio frequency and RFID tag receive radio frequency to power up the chip and then transmit its own serial number by frequency. This power is sufficiently enough to send back information on that transponder to the RFID reader to be processed. The tags store and transmit data to readers using radio waves. The readers gather data from the different tags and relay them back to the server for further analysis and processing. The system serves the purposes of identification, monitoring, authentication and alerting through this exchange of data between the tag and the reader. This application use passive RFID tags because they are lighter, small in size, less expensive and more lifespan than any other tags. Passive RFID tag present substrate, IC chip and coil are described in Figure 3. The RFID reader used in this application will operate with 5V DC power supply and have a RS232 serial interface with 9600 baud rate. The operating frequency of the RFID reader is 13.56 MHz with 1.5 cm reading range and 0.1s response time.

2.2. Infra-red (IR) Obstacle Avoidance Sensor

This system consists of IR obstacle avoidance sensor. This IR obstacle avoidance sensor connects to the each slot of the system. IR obstacle avoidance sensor consist transmitter and receiver module. Transmitter sends the pulse and receiver receives the signal. The main workings of sensor are to sense the car and to send the signal to the microcontroller. After that microcontroller take proper action.

Figure 4: Infra-red (IR) Obstacle Avoidance Sensor Module

2.2.1. Transmitter section

The transmitter section sends out a wave at a certain frequency such as 38kHz or other frequencies [3]. The frequency choosing depends on the receiver IR sensor. In this system, the transmitter is designed for 38kHz frequency. The 555 timer is used as an astable state. The variable resistor can adjust upto a certain frequency. The transmitter circuit diagram is designed as shown in Figure 4.

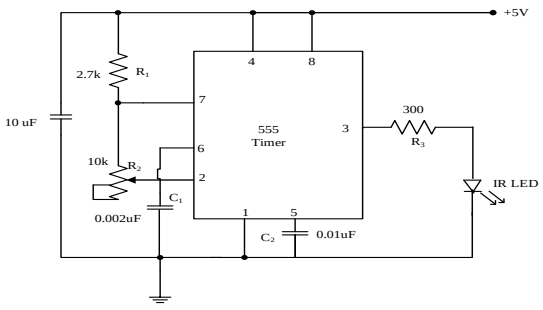

Figure 4: 38kHz IR Transmitter Circuit [3]

The frequency oscillation of the astable operation for 555 timer is

$$f = \frac{1.44}{(R_1 + 2R_2)C_1} \qquad (1)$$

f = frequency (Hz), R2 = variable resistor (8.123k ohms), C1 = capacitor (0.002 µF).

2.2.2. Receiver section

The receiver section is designed to pick up the tramsmitted frequency. The 555 timer is also used in the receiver circuit as the monostable state [3]. The output condition of the 555 timer IC is need to be stable and send these signal to the PORTA0~A5 and PORTB1~B3 of the PIC 16F887 microcontroller as shown in Figure 11. TSOP 1738 IR sensor is used for the system because of the transmitted frequency is 38 kHz. The TSOP 1738 is a standard IR remote control receiver. The circuit diagram of the IR receiver section is shown in Figure 5.

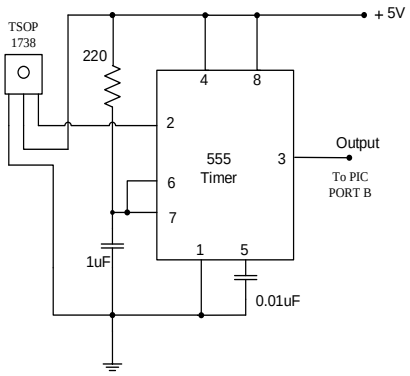

Figure 5: 38 kHz IR Receiver Circuit [3]

3. System design

The RFID System consists of a reader, and RFID tags. Each RFID tag records a unique ID and finite information [4]. The tag is triggered when it approaches the RFID reader. The information recorded in the tag is transmitted to the RFID reader. A RFID reader will pass the signal into the digital and computing content. In the proposed RFID Parking system the RFID reader is deployed at the gate. In addition, the RFID tags are placed in the car. Considering the practicability, the RFID system should overcome the accuracy affection of weather and sunshade - paster of car, and the RFID tag type. When an RFID Parking Management System user's car approaches the gate, the induction and communication between RFID tag inside the car and antenna of RFID system is automatically established. Then the reader of RFID system translates the signal information to the digital content. Figure 6 presents the work flowchart of the RFID system. The same procedure will be followed whenever the vehicle leaves from a parking slot. The user again has to swipe the card while coming out of the parking .

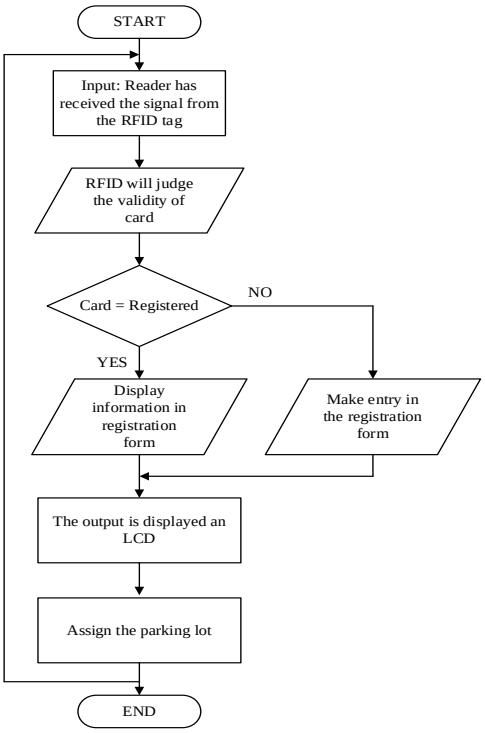

Figure 6: The Work Flowchart of RFID System

3.1. Input/output Pin Assignment of Microcontroller

As shown in Figure 1, the construction of Automated Car Parking System consists of two parts: the hardware and software implementations. Both software and hardware will be accomplished using PIC 16F887 microcontroller. The PIC microcontroller was chosen for reasons of speed memory storage, number of I/O ports and digital ports ability. This program is written by Basic-pro language because it is easy to understand than other programming languages. PIC 16F887 is used to control all I/O and processing. There are nine inputs for IR sensor circuit. Car detection circuit, floor arrived signal circuit and RFID signal from three inputs are connected to RA0~ RA5, RB1~RB3, RB0 and RB6. PORTB6 is used for GSM mobile.

For output, PORTD4~D6 are used as LED monitor for Ready, Busy or Full and RFID OK status. PORTC0~C3, PORTD0, D1 and PORTB5, B7 are used for H-Bridge motor driver control signal.

RE0, RE1 and RE2 are used as 7-segment displays with 74HC595 eight-bit registers. PORTD2, D3 and PORTC4~C7 are used as data inputs for LCD displays.

System design is based on digital control techniques, all I/O ports are used as only digital ports. Clock source for PIC is 4 MHz crystal which connected to OSC1 and OSC2 pins. Two 22 pF capacitor (C6 and C7) are used to stable crystal frequency and to avoid harmonic noises.

To accomplish the system, the choosing of software is very important. The Basic-Pro Program is used to implement the system. Figure 6 shows the flow chart for RFID card control system.

RFID reader reads the ID number from the RFID tag. Then, the reader sends the ID number to the PIC for checking with the database. If the ID number is valid, the user will be selected the room number with the mobile phone. And then, the car is presented that the room number will be showed at LCD and 7-segments. If the ID number is invalid, the alarm will be opened. PIC 16F887 microcontroller is used as control unit. 16F887 microcontroller consists of 40 pins. It contains a Central Processing Unit (CPU), Random-Access Memory (RAM), Read-Only Memory (ROM), Input/output (I/O) lines, serial and parallel ports, timers and sometimes other built-in peripherals such as Analog-to-Digital (A/D) and Digital-to-Analog (D/A) converters.

By using the sophisticated PIC 16F887, the automated car parking system uses fewer components that would have been required in the system. This microcontroller can be reprogrammed because it uses flash-read only memory for program storage.

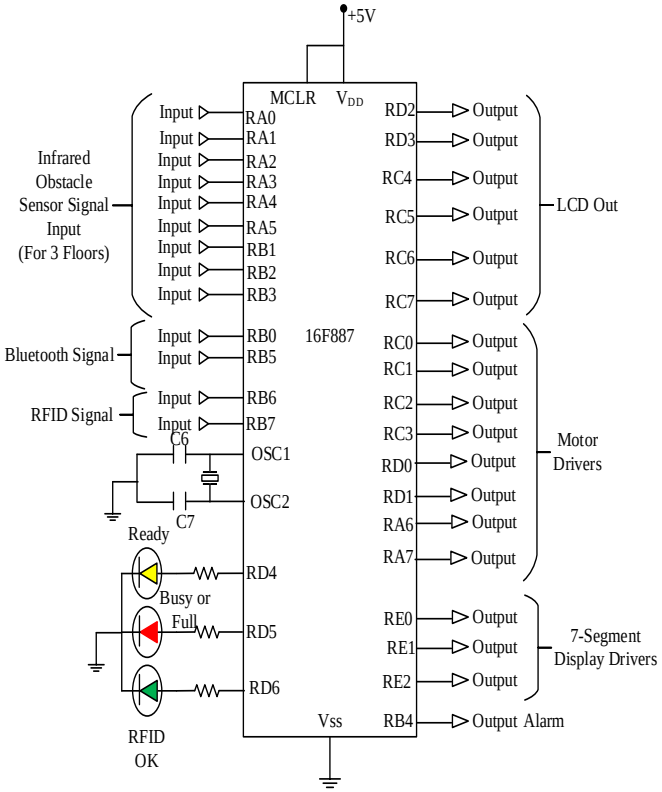

Figure 7: PIC 16F887 I/O Pin Assignment Diagram

The automated multi-storied car parking system contains power supply unit, PIC 16F887 and other components. The power supply unit is a combination of a 4 MHz crystal, two 22pf capacitors. 220V AC input voltage is supplied to the power supply unit and the output is DC 5V. Pin 11 and 32 of the PIC 16F887 are connected to the VDD while pin 12 and 31 are connected to the ground (VSS). Pin 13 and 14 are connected to 20MHz oscillating crystal. In this system, pins Port D, C and E are used for output pins and Port A and B are used for input. Pins Port B6 and B7 are connected to the RFID module. Pins Port B0 and B5 are connected to the Bluetooth Serial module. Port C pin 0 to 3 and Port D 0,1 and Port A pin 6, 7 are connected to the L298 motor drivers. Port E pin 0 to 2 are connected to the 74HC595 while Port D pin 2 and 3, Port C pin 4 to 7 are

connected to the LCD as shown in Figure 12. The 5V power supply is connected to VDD and MCLR of the PIC 16F887.

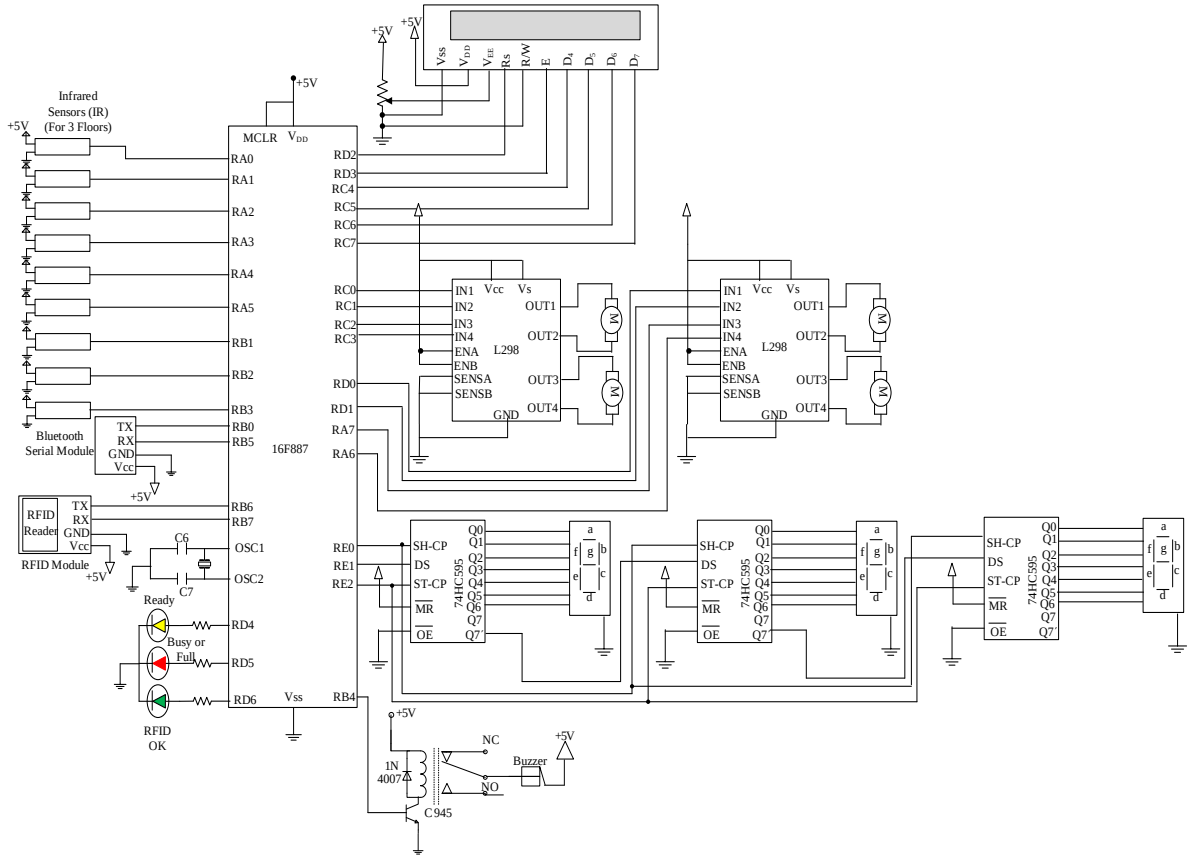

Figure 8: Overall Circuit Diagram of Automated Multi-storied Car Parking System

4. Simulation results

Before constructing the automated car parking system, the database construction and simulations are needed. Therefore the simulation results and experimental results of the system which is implemented are described.

For the database, the user ID and owner name are constructed in PIC16F887 with Basic-Pro Program. In this experiment, passive RFID tag and reader pairs are used. For the simulation results, PROTEUS 7.7 PROFESSIONAL is used. In PROTEUS, RFID reader, RFID tag and IR sensor do not have. So, virtual terminal is used for RFID reader and tag and the bush button are also used for IR sensors. In order to control the DC motor which is used for the lift, it is achieved by the combination of microcontroller and virtual port communication between Basic-Pro Program and Proteus software.

In the Proteus software, the user enters the input signals into the RFID edit virtual box and microcontroller receives this signal according to the card number and user name are shown on LCD. And then the user enters again the input room number into the Bluetooth Serial edit virtual box and microcontroller receives this signal and the motors will be rotated according to the room number is shown on LCD and 7 segments. The database table is as shown in Table I.

Table 1: RFID database table

ID Number	Name
048	Su Su
049	Mya Mya
050	Thida
051	Aung Aung
052	Tun Tun

And then, the simulation results of automated car parking system are shown when RFID card is running as shown in Figure 9 and when Bluetooth serial is running as shown in Figure10.

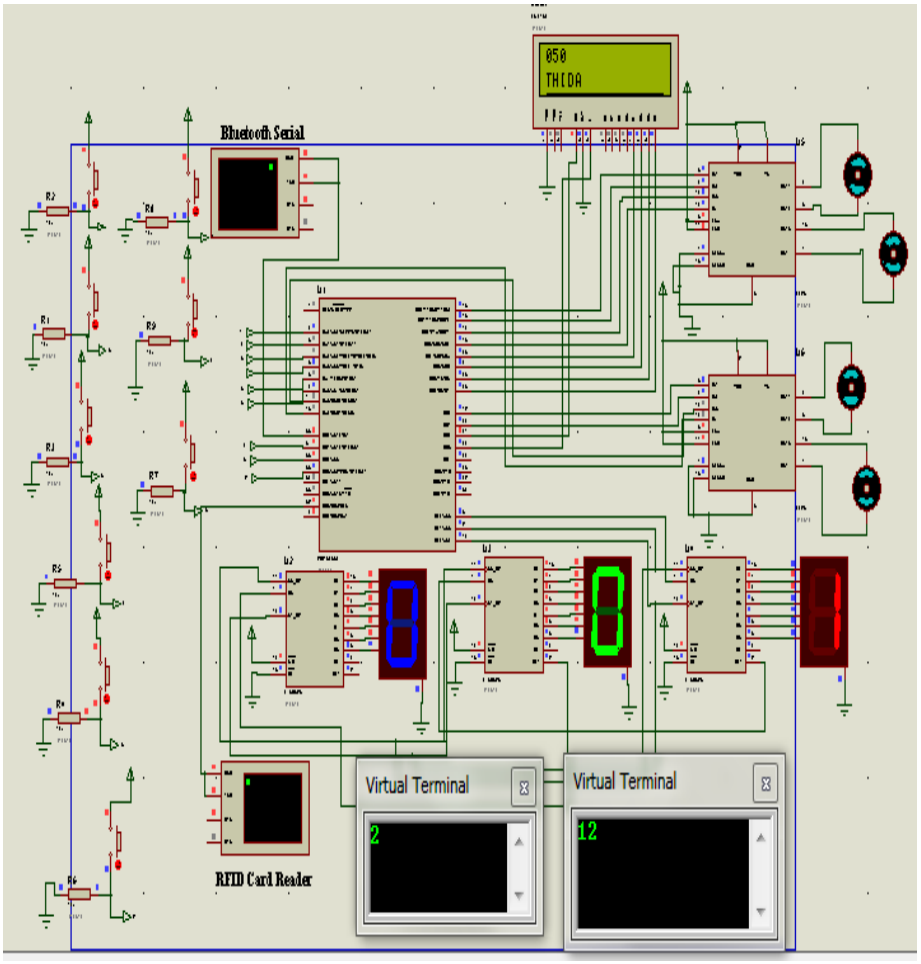

Figure 9: Simulation Result for Automated Car Parking System when RFID Card is running

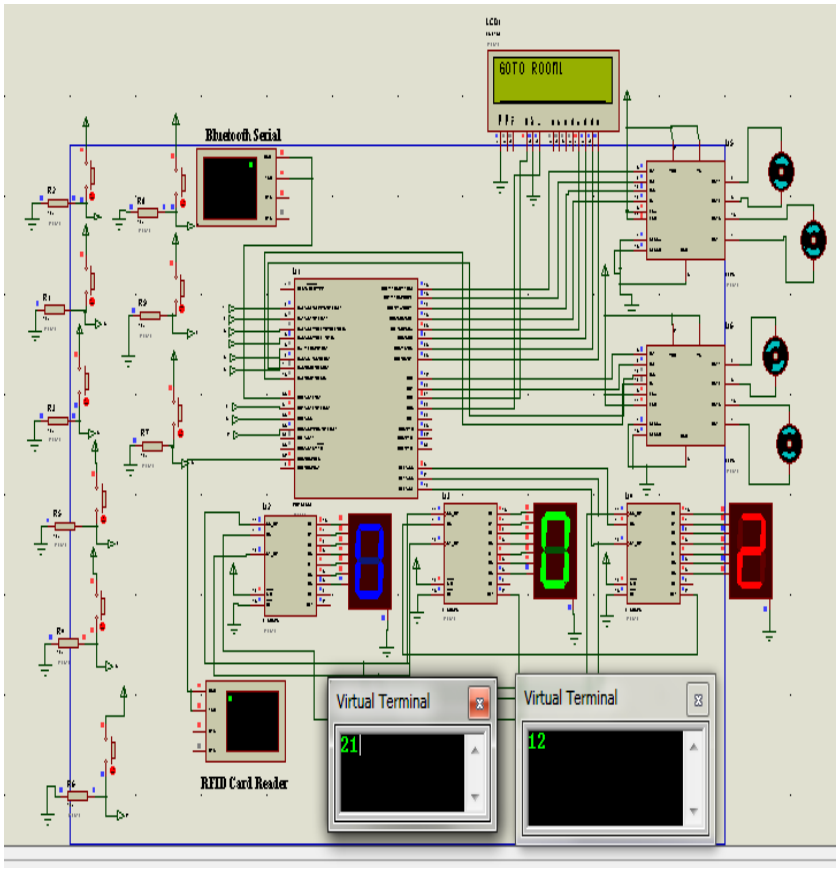

Figure 10: Simulation Result for Automated Car Parking System when Bluetooth Serial Module is running

5. Experimental results

5.1. Calculation of Power Control Circuit

For bridge rectifier circuit,

Input voltage = 220 V, 50 Hz AC source

The secondary voltage of transformer, V_s (rms) = 12 V

The desired output current, I_{DC} = 0.5 A

The diode cut-in voltage is assumed to be V_r = 0.7 V (0.7V for Si and 0.3 for Ge)

$$Vs(max) = \sqrt{2}\ Vs(rms) \qquad (2)$$

$$= \sqrt{2} \times 12\ V$$

$$= 16.97\ V$$

$$Vs\ (max) = V_0(max) + 2V_r \qquad (3)$$

V0 (max) $= V_s(max) - 2V_r$

$= 16.97 - (2 \times 0.7)$

$= 15.57$ V

Average value of DC voltage is,

$$V_0(avg) = \frac{2V_{0(max)}}{\pi} \qquad (4)$$

$$= \frac{2 \times 15.57}{\pi}$$

$= 9.912$ V

Where, V_S (rms) = the secondary voltage of the step-down transformer, V

V_S (max) = the peak value of VS, V

V_0(avg) = the average voltage of the DC voltage, V

For Figure 11, 220 V to 12 V AC step-down transformers can be used because the calculated secondary voltage is 9.912 V.

For Figure 11, the drop out voltage of LM7805 is 5V; the value of C for the desired 5V, 3A DC output can be calculated;

$$V_{dc} = 12\,V \ , \ I_{dc} = 1\,A$$

$$\text{Capacitor}, C_1 = \frac{10000 \times I_{dc}}{0.48 \times V_{dc}}$$

$$\text{Capacitor}, C_1 = \frac{10000 \times 1}{0.48 \times 12}$$

$$= 1736 \mu F$$

$$\approx 2200 \mu F$$

In this circuit, capacitor C1 = 2200µF is used and selected to give suitable value for regulated power supply. Since the operational DC current for control circuit can be less than the desired output current, the standard 2200F capacitor is chosen for C. It is also used to be more good the storage capacity. The circuit diagram of

power supply for automated multi-storied car parking system as shown in Figure 11.

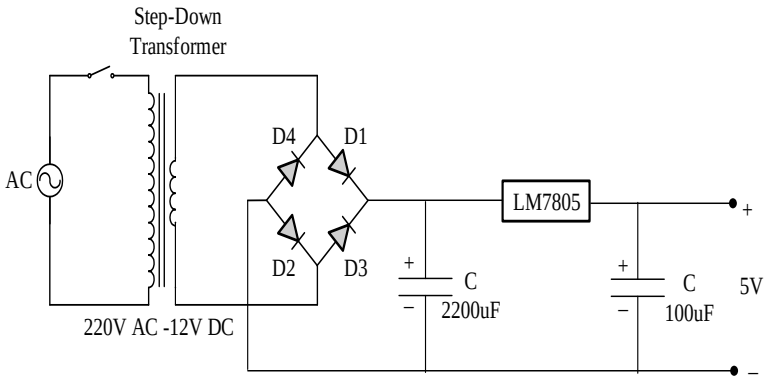

Figure 11: Circuit Diagram of Power Supply for Automated Multi-Storied Car Parking System

5.2. Practical Results

Based on a simple basic idea, this IR obstacle sensor is easy to build, easy to calibrate and still, it provides a detection range of 10- 30 cm. This sensor can be used for most indoor applications where no important ambient light is present. 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.

Figure 12: Signal Received by IR Obstacle Sensor with frequency 38.78kHz

By using these electrical components, hardware experimental testing result of automated multi-storied car parking system is shown in Figures 13 and 14. The system is constructed with a small demonstration model as shown in Figure 15. Model is composed of three floors, a lift and a motor mechanism assembly. Motor assembly is constructed by using small pulley, rotor and spring rope.

When motor is driven forward or backward, a lift from model is moved upward or downward by means of pulley.

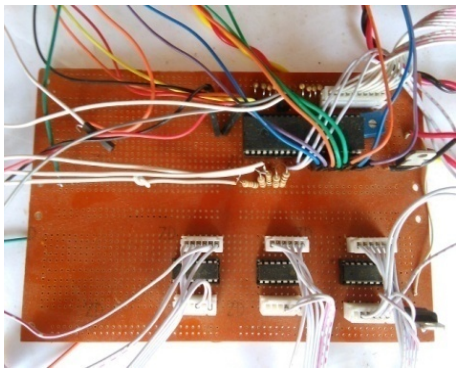

Figure 13: Control Circuit of the Automated Multi-storied Car Parking System

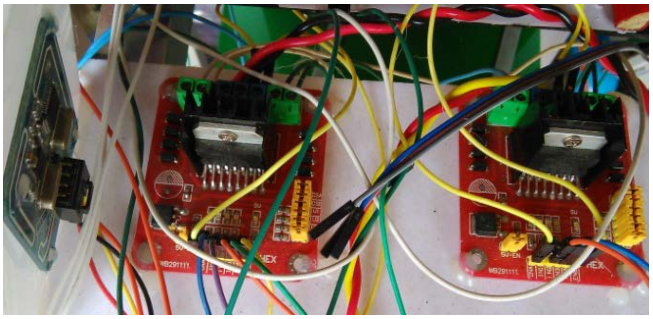

Figure 14: Control Driver Circuits of the DC Motors and RFID Card

After all sensors and motor supply are connected properly, system is power up. The lift is kept on the ground floor of the system. When a small object (car) is placed on the lift, the lift is moving upward until room 1 at floor 1 IR sensor is detected as shown in Figure 13. After sensor is detected light from floor-1, the lift motor is stopped. After object is removed from the lift (this mean that car is go down to the floor), the lift goes down to the ground floor and stay standby until the next car is arrived over the lift.

Figure 15: Test Result for Automated Car Parking System when Bluetooth Serial Module is running

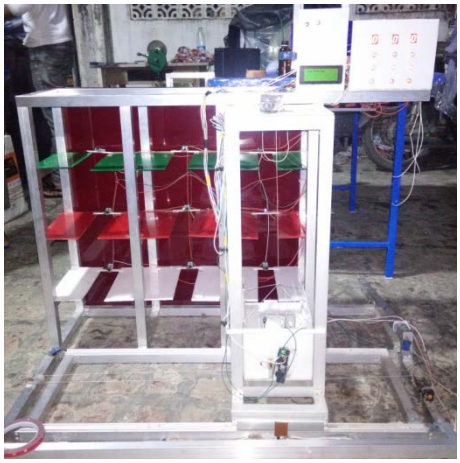

Figure 16: Prototype of Automated Car Parking System

To achieve the construction of automated multi-storied car parking control system using RFID and IR sensor, electrical components must be selected. The hardware components list for automated multi-storied car parking system is as shown in Table II.

Table 2: Components list for automated multi-storied car parking system

Sr. No	Device	Rating	Nos:
1	Microcontroller	PIC16F887(40 pins)	1
2	A pair of RFID	Module V1.2	1
3	DC motor	9V DC	4
4	Sensor	Infrared (IR) (5V)	9
5	Bluetooth	Bluetooth Serial	1
6	LCD	4×16 Line	1
7	Diode	1N4007	4
8	Capacitor	2200µF,25V	2
		100µF,16V	2
9	LM7805	5V Regulator IC	2
10	Preset	Adjustable Resistor (10kΩ)	1
11	Transformer	220VAC-12V DC	1

6. Discussion and conclusions

Automatic multi-storied car parks provides lower building cost per parking slot, as they typically require less building volume and less ground area than a conventional facility with the same capacity. However, the cost of the mechanical equipment within the building that is needed to transport cars internally needs to be added to the

lower building cost to determine the total costs. Other costs are usually lower too, for example there is no need for an energy intensive ventilating system, since cars are not driven inside and human cashiers or security personnel may not be needed. A multi-storied car parks offer greatest possible flexibility for the realization of optimum parking solution. A fast parking applications process in which the driver does not have to maneuver his car or drive backwards, guarantees highest comfort and security. A single lift serves 6 to 12 parking spaces per level taking up a minimum of space. Time-saving vertical and horizontal movements take place simultaneously ensuring fast parking and retrieval times.

Advantages of Multi-storied car parking system:-

- Provide enough parking spaces.
- Provide lower building cost per parking slots.
- Required less building volume and ground.
- Provides highest comfort and securities.
- Human error is less.
- Fast and time saving parking with greatest flexibility.

Limitations of a multistoried car parking system:- There are some limitations of the system are occurs such as

- Slots are pollutant due to the motor oil.
- Challenge for authority to realize need and quickly.
- Estimate cost is high.
- Periodic maintenance is required.
- Provide backup systems during electricity failure.

So, we can reduce the traffic problem by using multistoried car parking system. We can park more cars in small space. We also reduce time and cost required for conventional parking system with high degree of security.

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