RFID Based Automated Toll Plaza System

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Abstract- This research paper describes the automated toll collection system for toll gate based on RFID technology. Most of the toll collection systems commonly used in Myanmar is manual transaction. Nowadays, streams of traffic are increased and toll gate on highways are congested. It will cause the traffic jam and waste time. The objective of this journal paper is to transform manual transaction to automated toll collection with the help of RFID technology. There are three portions in toll collection system. They are RFID system, balance deduction system in host computer and toll gate control system. For the RFID system, 13.56 MHz passive RFID reader and tag pairs are used. The balance deduction system is implemented by Microsoft Visual Studio and Microsoft SQL Server as IDE. C# language is used to implement this system. The PIC microcontroller is also used to control the stepper motor and display the deposit on the LCD. The authorized person at the toll gate can check the ID numbers, vehicle numbers and the amount of balance with the database on PC. The new user can register and update the amount of balance via Graphical User Interface (GUI) easily. The amount of deposits will also update simultaneously at the two database of the toll gate because of LAN network. By using this system, it will save time, i.e. by avoiding long queue as no need to stop the vehicle and no need of manual transaction at the toll gate.

Index Terms- RFID, Microsoft Visual Studio, Stepper Motor, Database

I. Introduction

Nowadays, increasing traffic volume causes congestions commonly around the toll gate of highway. Therefore, the new technique is urgently required to reform the problem of congestions. Automated toll collection system is one of the methods to solve the above conditions. The automated system is composed of several subsystems. The RFID technology, computer database, power supply, microcontroller, motor and inferred device are included. Automated system can bring the several sectors for toll gates as saving time and reducing the human workers. Develop the prototype model, which reproduces the operation states of various toll gate systems: passing time and waiting time.

The RFID tag and RFID reader are contained in RFID technology. RFID means Radio Frequency Identification that consists of the tags which can be either active or passive tag. Passive tag do not have own power supply, much cheaper to manufacture and small coil antenna is used. On the other hand, active tag must have own power supply. It has longer range and larger memories. It can store additional information sent the RFID reader.RFID reader is an interrogator. It is placed at the toll gate on every single row where vehicles are passed. The reader contains an RF module, which acts as both transmitter and receiver of radio frequency signals. The reader generates the signal to receive the data from tag. The received signals send to the computer system which contains Graphical User Interface (GUI) and the database of all users. The ID number from the tag checks with the recorded database and deduces the toll tax. The computer and microcontroller are connected with USB cable. So, the PIC 18F4550 microcontroller is very compatible for system. The microcontroller will display the amount of deposits on LCD and the gate will open. The IR sensor senses the vehicle motion for closing gate automatically.

II. Related Work

In [3], the author mentioned that the micro simulation model for the automated toll plaza system using RFID technology. The 8051 microcontroller is used for the control system. The signal is sent to the PC via RS-232 cable from PIC. In this system, the microcontroller is the main part of the system because of the signal is sent to PC and the output results showed on the LCD display. And then, the microcontroller sent the signal to the motor driver for opening the traffic gate. The author also described the GSM modem to update the information about the database of user account.

In [5], the author explained that the RFID based automatic toll gated system. The frequency 928 MHz is used for the communication between RFID system and the control system. The microcontroller was programmed using the C programming language and Visual Basic was used in the serial communication between the computer and the RFID as well as with the PIC. The database was developed using Microsoft Access because it can contain up to 32768 records of objects. The RS-232 cable is also used for the connection between PIC and PC.

III. Design and Implementation for the System

In order to design and implement the automated toll collection system, it should be divided into two main systems. They are hardware design for the system and software implementation for the system.

A. Hardware Design for the system

The automated system using RFID technology can be classified into two modules. They are vehicle module and base module. The vehicle module consists of passive RFID tag. The RFID reader, host computer system and gate control system are composed as the base module. The general RFID based toll tax image in figure1 and the block diagram of automated toll collection system is described in figure2.

Figure1.General RFID based toll tax image

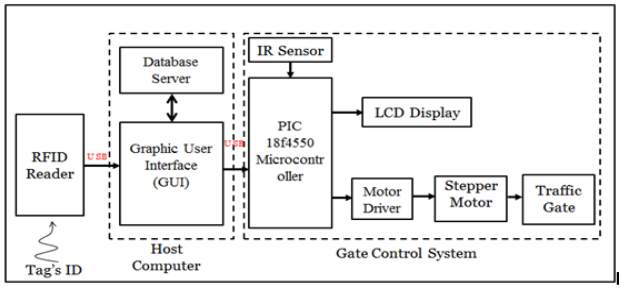

Figure2.Block diagram of the Toll gate System (Base module)

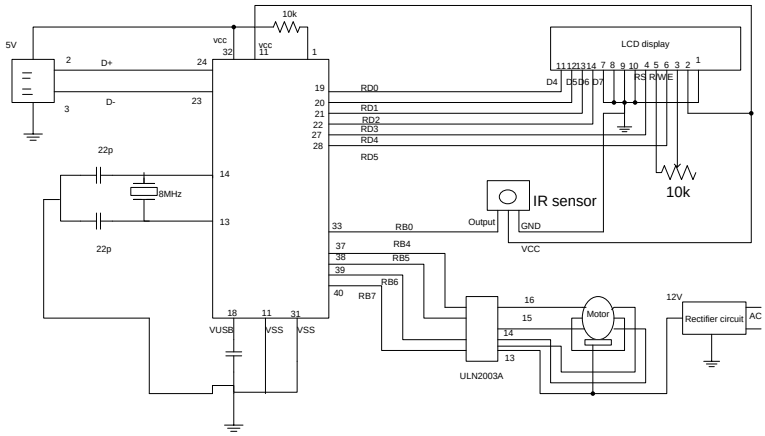

Figure3. Circuit Diagram of Gate Control System

The major components of the gate control system are as follow:

- PIC 18F4550 microcontroller
- Motor driver
- Stepper motor
- LCD display
- 555 timer
- IR sensor
- Power supply unit

1. PIC 18F4550 microcontroller

The PIC 18F4550 a is 16 bit microcontroller which contains a program memory of 32-kbytes, data memory of 256 byte, version 2.0 USB compliant, DC operating frequency of 48MHz, 10bit A/D module (13 channels) and wide operating voltage range (2.2V to 5.2V). The main reasons of using PIC 18f4550 are compliant of USB connection, many I/O ports and having interrupt pin for IR sensor (RB0).

2. Motor Driver

The ULN2003A driver IC is used for this system. An ULN2003A is a high-voltage, high-current Darlington transistor array features continuous load current rating to 500mA for each of the seven driver. High output voltage is 50V. Its input is compatible with various types of logic.

3. Stepper Motor

The stepper motor is an electronic device that converts digital pulses into mechanical shaft rotation. The most significant advantage of stepper motor is its ability to be accurately controlled in an open loop system. The advantages of stepper motor are –

- Low cost and high reliability
- High torque at low speeds and a simple
- Rugged construction that operates in almost any environment

There are two types of stepper motor. They are unipolar stepper motor and bipolar stepper motor.The unipolar stepper motor is used for this system because its winding is made relatively simple with the communication circuit than bipolar stepper motor in open loop system. The supply voltage for motor is 12V. This motor is used to open the traffic gate at the toll gate station.

4. Liquid Crystal Display (LCD)

This module used for display the present status of the system. This is interface to 4 bit mode with LM016L

microcontroller LCD screen consists of two lines with sixteen characters each.

5. 555 Timer

The 555 timer IC is an integrated circuit (chip) used in a variety of timer, pulse generation, and oscillator applications. The 555 can be used to provide time delays, as an oscillator, and as a flip-flop element. The supply voltage is usually between 3 and 15V depending on the variation. The 555 timer has three operation modes :

(a) Monostable operation mode

In this mode, the 555 functions as a "one-shot" pulse generator.Applications include timers, missing pulse detectionfrequency divider, capacitance measurement, pulse-width modulation (PWM) and so on.

(b) Astable operation mode

The 555 can operate as an oscillator.Uses include LED and lamp flashers, pulse generation, logic clocks, security alarms, pulse position modulation and so on.The 555 can be used as a simple ADC, converting an analog value to a pulse length.

(c) Bistable operation mode

The 555 can operate as a flip-flop, if the DIS pin (pin7) is not connected and no capacitor is used. Uses include bounce-free latched switches.

6. Infrared Sensor (IR Sensor)

The IR sensor is a detection device for motion and other devices. There are two portions for object detection. They are –

(i) Transmitter section

The transmitter section sends out a wave at a certain frequency such as 38kHz or other frequencies. 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 figure4.

The frequency oscillation of the astable operation for 555 timer is

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

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

(ii) 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. The output condition of the 555 timer IC is need to stable and send these signal to the PORTB (RB0) of the PIC 18F4550 microcontroller. TSOP 1738 IR sensor is used for the system because of the transmitted frequency is 38kHz. The TSOP 1738 is a standard IR remote control receiver.

The features of TSOP 1738 IR sensor are as follows.

- Photo detector and preamplifier in one package
- Internal filter for PCM frequency
- Improved shielding against electrical field disturbance
- TTL and CMOS compatibility
- Output active low
- Low power consumption
- High immunity against ambient light
- Continuous data transmission possible (1200 bit/s)
- Suitable burst length is 10 cycles/burst

The receiver circuit diagram using TSOP 1738 IR sensor is shown in figure4.

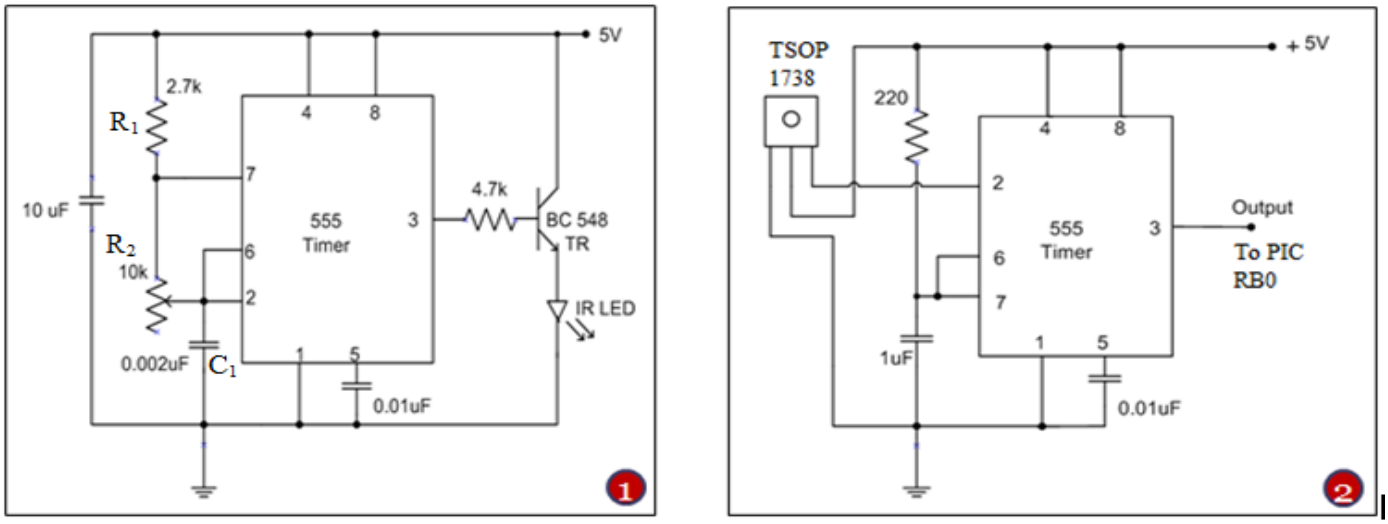

Figure4.(1) Transmitter circuit for 38 kHz frequency using IR LED, (2) Receiver circuit using TSOP 1738 IR sensor

7. Power Supply Unit

The DC power supply unit is vital component in modern electronic devices as they need a wide range of DC voltages for their operations. The purpose of a power supply is to provide the required amount of power specified voltage from primary source.

B. Software Implementation for the system

To accomplish the system, the choosing of software is very important. The Microsoft SQL Server 2008 and Microsoft Visual Studio 2010 are used as Integrated Development Environment (IDE). The C# language and mikroC language are also used to implement the system. The C# language is familiar with many users and suitable for GUI design. The PIC microcontroller is programmed with the PIC kit2 programmer device.

❖ Microsoft SQL Server

Microsoft SQL Server is a relational database management system developed by Microsoft. As a database, it is a software product whose primary function is to store and retrieve data as requested by other software applications, be it those on the same computer or those running on another computer across a network (including the Internet).

❖ Microsoft Visual Studio

Microsoft Visual Studio is an integrated development environment (IDE) from Microsoft. It is used to develop computer programs for Microsoft Windows superfamily of operating systems, as well as web sites, web applications and web services. Visual Studio uses Microsoft software development platforms such as Windows API, Windows Forms applications, Windows Presentation Foundation and Windows Store. This IDE can connect with database by using query language. The C# language is used to write the program.

❖ C# language

C sharp is a programming language that is designed for building a variety of applications that run on the .NET Framework. C# is simple, powerful, type-safe, and object-oriented. The many innovations in C# enable rapid application development while retaining the expressiveness and elegance of C-style languages.

❖ Flow Chart of the System

The system can be seen clearly by showing the flow chart of each program. The overall flow chart of the toll collection system is illustrated as follow. The RFID reader reads the ID number from the RFID tag and then will check with the recorded database in host computer system. If the users are not register, they need to create register and the authorized person at the toll gate get user information from them. The user can update the balance at the user updating form. Moreover, if the user quit from using this system, the recorded information can be deleted on the database. The flow chart of user deletion form and IR section are as follow.

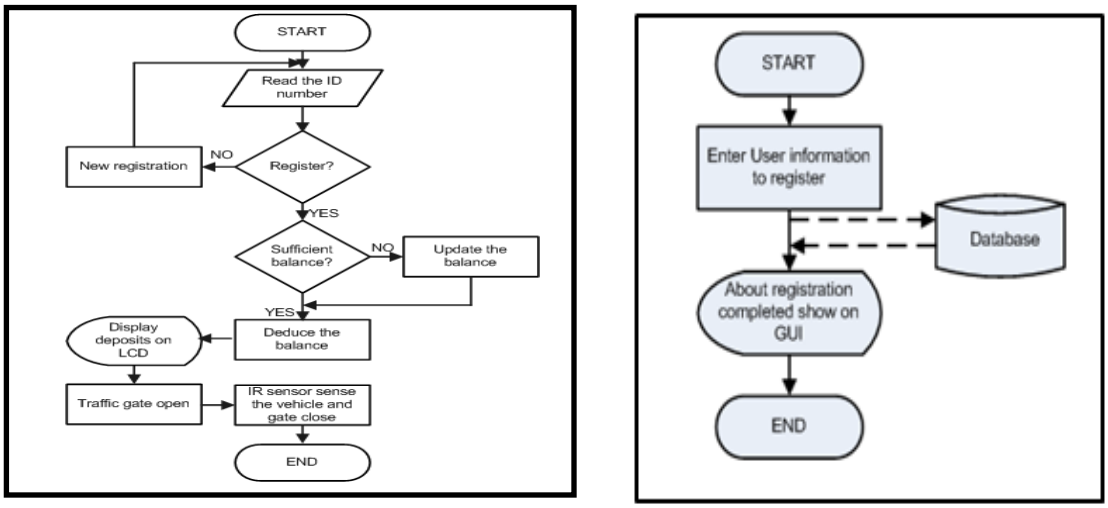

Figure5. Overall flow chart for toll collection system and User registration flow chart

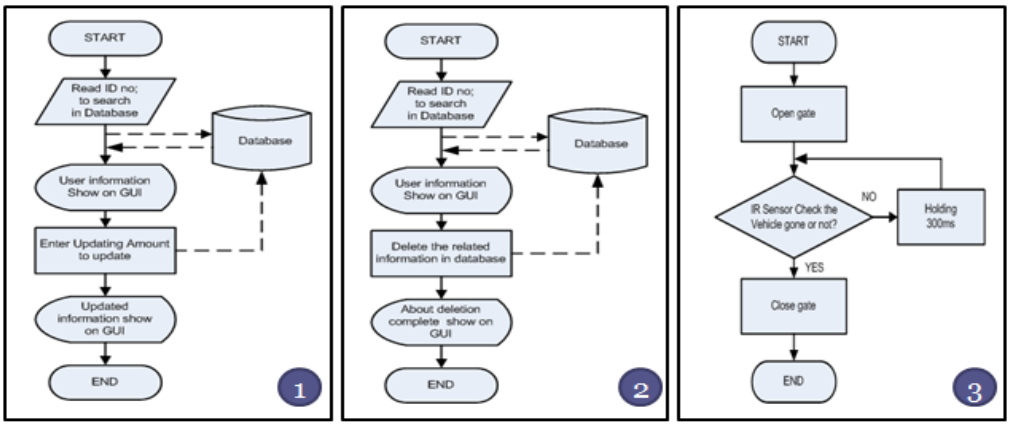

Figure6. flow chart for (1) User updating form, (2) User deleting form and (3) IR section for gate control

IV. SIMULATION AND EXPERIMENTAL RESULTS OF THE SYSTEM

Before constructing the automated toll collection system, the database construction and simulations are needed. Therefore the simulation results and experimental results of the system which is implemented are described. In the database, the userID, owner name, car number, driver licence, car model and deposits are constructed as the table. The database table is shown in figure7.

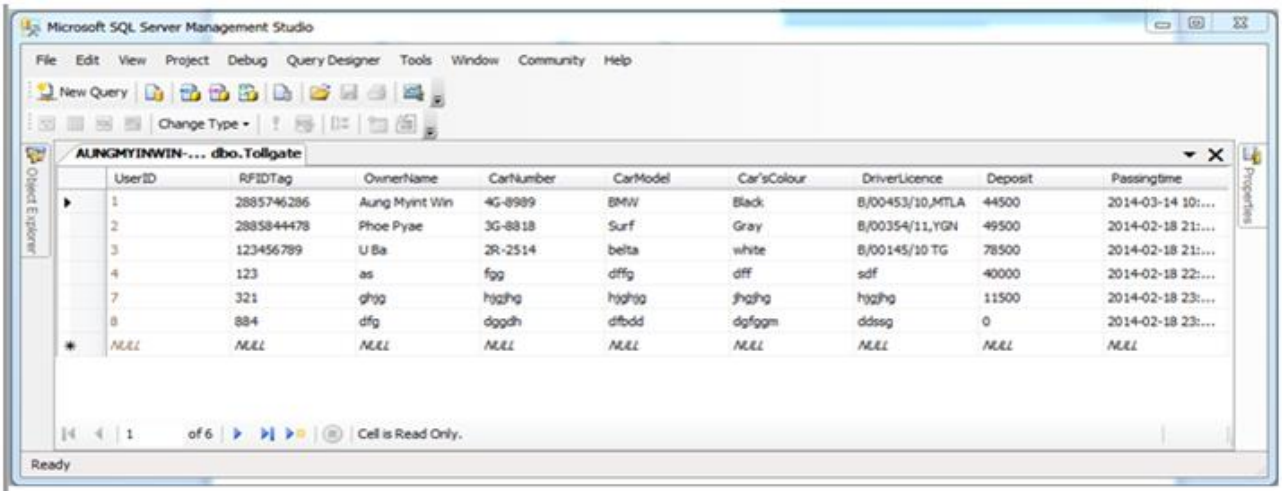

Figure7.Recorded database in SQL Server

The main window form of the toll collection, user registration, user updating and user deletion window forms are as follow.

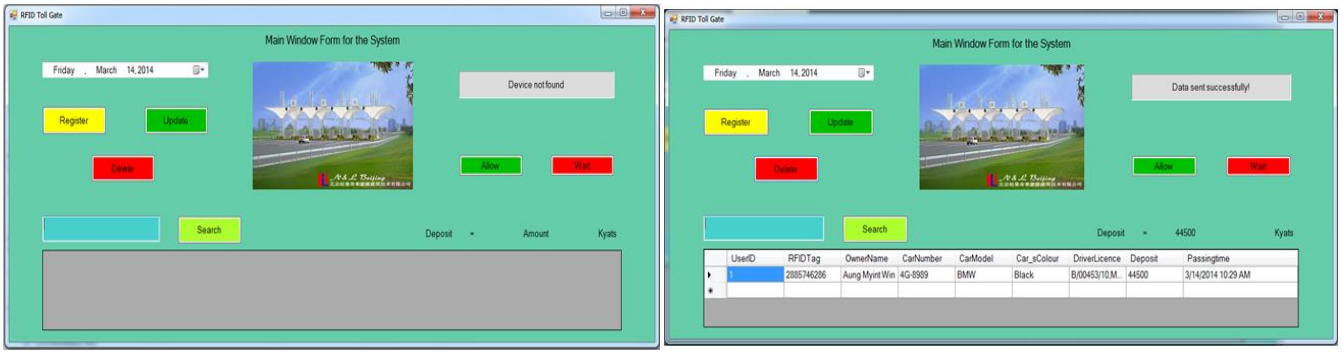

Figure8. Main window form of the toll collection system and Balance deducing from the user amount

The user's RFID number read from the RFID tag, send these number to the textbox of the GUI for checking with the recorded database. Then, if the balance enough, the amount of deposit will show on the LCD and allow the vehicle. If not, the message will show on the LCD as "Wait". For the new user, the user need to create register on the GUI easily. If the balance is not enough, the balance can update in the user updating form. The unwanted user for the system can delete from the database on the user deletion form.

The simulation of the USB connection between host computer system and PIC microcontroller using Proteus software is shown in figure9.

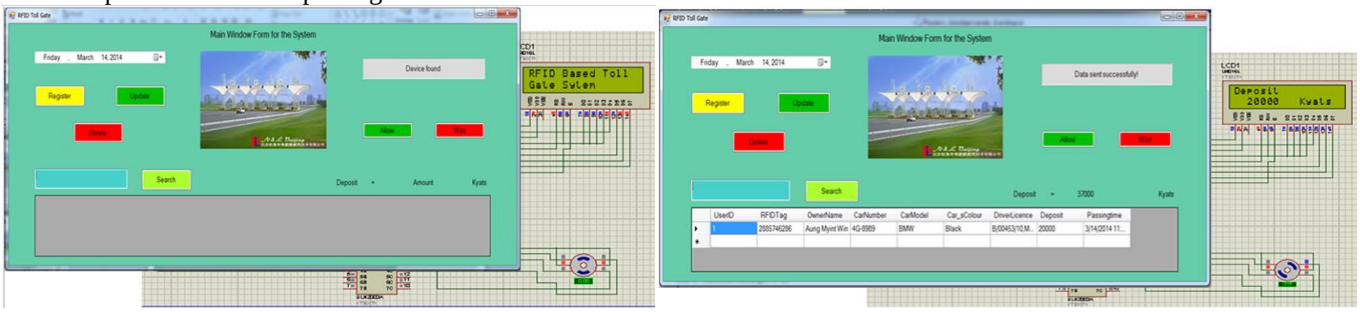

Figure9. User registring on the registration form, Updating amount on the user updating form and User deletion form

The output frequency of the IR transmitter circuit is measured with the oscilloscope. This experimental result of the IR transmitter output is shown in figure10(a). The output of the IR receiver circuit is input to the PIC 18F4550 microcontroller. The output results of the IR receiver is also mesaured with the oscilloscope. The output of the TSOP 1738 IR sensor is also input to the 555 timer. The condition between IR transmitter and receiver circuit without motion is shown in firuge10(b) and the object detection condition is shown in figure6(c).

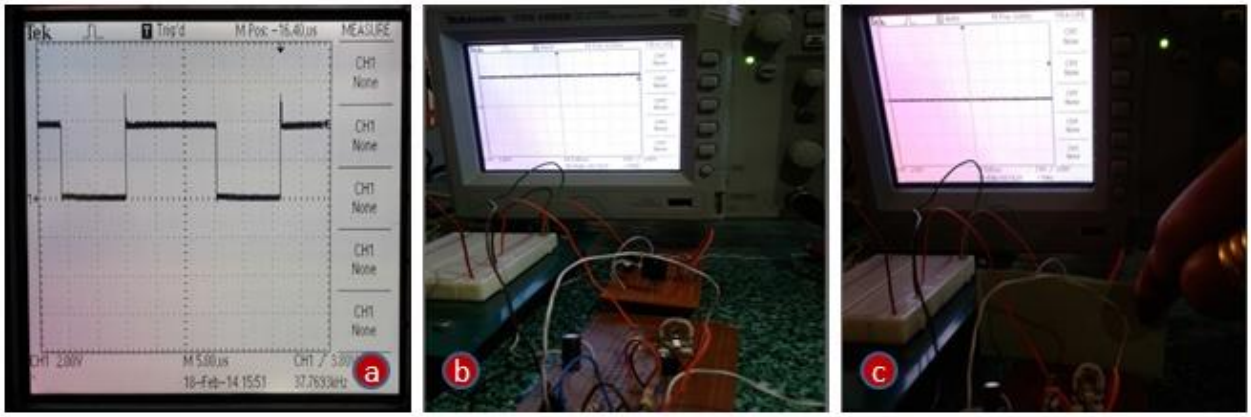

Figure6. (a) The output frequency (38kHz) mesaurement of the IR transmitter circuit and the outputcondition of the IR receiver circuit (b) no object detected (c) object detected

The prototype construction of the automated toll collection system is shown in figure13.

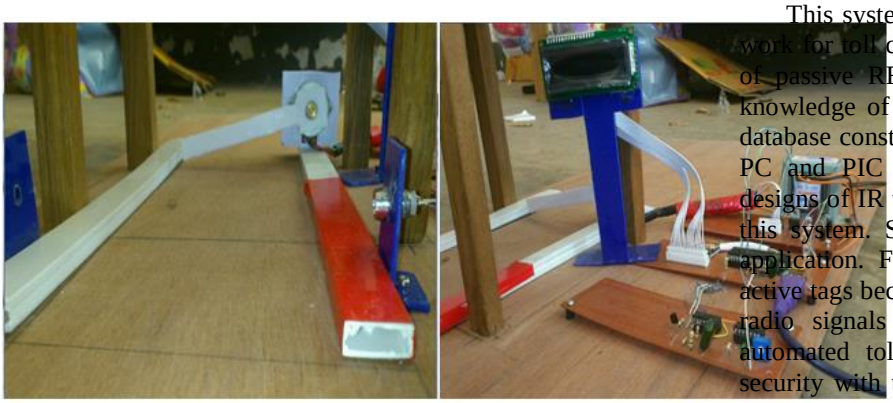

Figure6. Prototype design and circuit construction diagram

V. CONCLUSION

This system mainly reviewed the research and development work for toll collection at the toll gate on highway with the help of passive RFID technology. By developing this system, the knowledge of RFID system, PIC 18F4550 microcontroller, the database construction, GUI design and USB connection between PC and PIC using c# language are realized. Moreover, the designs of IR transmitter and receiver circuits are convenient for this system. So, these results can use for another IR sensing application. For this system, passive tags are better than the active tags because of low cost, low power consumption and also radio signals environmental factors. By using RFID based automated toll collection system, the vehicle can check for security with the passing time, save the time for toll collection and reduce traffic congestion at the toll plaza. Therefore, the

RFID based toll collection system is the best way for toll collection at the toll plaza.

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