AUTOMATED SHOPPING CHECKOUT SYSTEM – RFID READER CIRCUIT AND COMPUTER INTERFACE

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A progress project report submitted in partial fulfilment of the requirements for the award of the degree of Bachelor (Hons.) of Electrical and Electronic Engineering

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DECLARATION

I hereby declare that this project report is based on my original work except for citations and quotations which have been duly acknowledged. I also declare that it has not been previously and concurrently submitted for any other degree or award at UTAR or other institutions.

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APPROVAL FOR SUBMISSION

I certify that this project report entitled **"AUTOMATED SHOPPING CHECKOUT SYSTEM – RFID READER CIRCUIT AND COMPUTER INTERFACE"** was prepared by **LEE HONG CHUN** has met the required standard for submission in partial fulfilment of the requirements for the award of Bachelor of Engineering (Hons.) Electrical and Electronic at Universiti Tunku Abdul Rahman.

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ABSTRACT

Nowadays, the demand for low cost and effectiveness is increase for most services. This had motivate us to carry out automated shopping checkout system project which is believe can significantly meet the demand. In this project, an automated shopping checkout system designed based on the use of RFID technology are proposed to improve the effectiveness and flexibility for current shopping checkout system. The design of this automated shopping checkout system is using a 13.56 MHz operating frequency RFID reader module which believe to be the suitable specification for the system from the aspect of scanning speed, scanning accuracy and also overall cost of the system This report will also present some literature research of some related technology for the designed system and also task and components that had been carried out to carried out and implemented in this project to achieve the objective. Several test also been carried out in analyse the performance of the designed system such as effective UART transmission delay experiment, system RF switching delay time testing, system read time experiment, tag attachment material experiment and system GUI program testing. The outcome of all the testing experiment is interpreted in discussion and result section of this report. Finally, this report also includes the discussion on several limitation and possible future enhancement for the current system design.

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LIST OF SYMBOLS / ABBREVIATIONS

f_c	carrier frequency, Hz
ϕ	phase angle, degree
E	signal energy, J
RFID	radio frequency identification
RTF	reader talk first
TTF	tag talk first
LF	low frequency
HF	high frequency
UHF	ultra high frequency
EM	electro magnetic
UART	universal asynchronous receiver/transmitter
VB	Microsoft Visual Basic 2008
PIR	passive infra-red
RF	radio frequency wave

CHAPTER 1

INTRODUCTION

1.1 Background and Motivation

Spending 5 to 15 minute queues up and waiting for the items to be scanned is commonly involved in shopping of present day. This phenomenon not only result time wasting for the customers but also a sign of ineffectiveness performance of current barcodes checkouts technology. Besides that, high setup cost for conventional shopping checkout system also pert of the motivation for this project. In the effort to solve this problem, introduce and implementation of other technologies that believe can improve the overall cost and performance of shopping checkout process is a must. One of the technologies that hold great potential for the automated shopping checkout is the 13.56 MHz operating frequency RFID technology.

Even though the implementation if RFID technologies as an automated checkout system is long been introduced, yet it is not widely employ in the retail sector. Most retailers did not realize the RFID automated checkout systems hold a great promise in the retailer world for both the customer and also the retailer itself. These motivate us to come out with a low cost and high accuracy automated checkout system based on RFID technology.

1.2 Aims and Objectives

The main aim and objective of this project is to design an automated shopping checkout system using RFID technology that increase the effectiveness of shopping checkout system through enable indirect tag scanning feature. The designed RFID automated shopping checkout system is aim to be more energy saving than conventional shopping checkout system by using 5 V supply to power up. Lastly, the designed system should come with lower cost than most of the shopping checkout system available in the market through the usage of 13.56 MHz operating frequency RFID technology.

1.3 Scope and Progression Schedule

This automated shopping checkout system is divided into two sections as following

Part 1 (RFID reader circuit and computer interface)

i. Microcontroller program writing
ii. Sensor circuitry implementation
iii. RFID reader hardware implementation
iv. System GUI program design

Part 2 (RFID system antenna design)

i. Antenna Analysis
ii. Antenna design and testing

1.4 Summary of Chapter

Basically this section will briefly go through summarize contain of each chapter that included in this report.

Chapter 1 is the introduction of the report. The detail will mostly touch on some of the background, motivation, aim and objective of this project. Summary of each chapter will also be included.

Chapter 2 is the section that contains the literature review and research of this project. Most of the research and literature review from external source that relate to the development of this project is placed in this section.

Chapter 3 is the methodology part of the project. This section will focus on the work scope is justify, verification of main task of this project, explanation of tool usage, experiment technique and FYP part two millstone.

Chapter 4 is the result and discussion section of the report. This section will be the place that most of the experiment data and project result will be present. The interpretation of outcome will also carry out in this section.

Chapter 5 is the last chapter of this report which is the conclusion and recommendation section. Essentially this chapter will cover up the conclusion obtained from the project. Limitation of our outcome and also future enhancement for it will also be included.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction of RFID Technology

Radio frequency identification (RFID) is a technology that tracking down and identified the special design tag incorporated into certain product, animal and people in the effective area through radio wave. The basic working principle of the RFID system is illustrated in Figure 2.1,

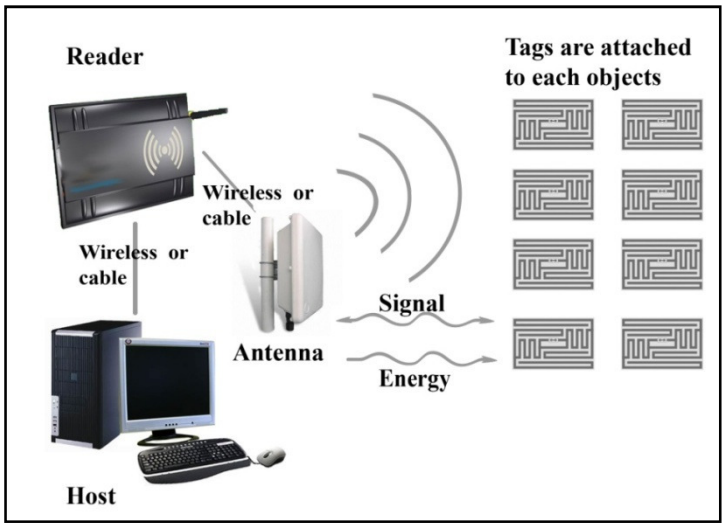


Figure 2.1: Basic RFID Working Principle

First, the reader sending RF wave at certain frequency to awaken the RFID tags place on things in the specific effective area. Then, the awaken RFID tags will in response with the RFID reader by sending back the information in it through near field inductive coupling or far field back scattering method. After the information is

retrieve at the reader, it will be send to microprocessor or computer database for data processing and update. The RFID technology is widely apply at various applications such as animal tracking, human identification, ware housing stock management, and traffic toll collection.

2.1.1 Type of RFID Tag

Basically, the special design tag use in RFID system is normally known as RFID tag or transponder. It is an electronic component that consist some integrated circuit, memory and an antenna to detect and transmit radio wave. The RFID tag can be read- only and read-write depend on the memory setting during manufacturing. Generally, there are three categories of RFID tag can be found commonly in the market, which are passive tag, active tag and semi-passive tag. Table 2.1 briefly descript the different and characteristic of these three categories of RFID tag,

Table 2.1: Type of RFID Tag and Their Characteristic

Tag Type	Passive	Semi-passive	Active
Communication Model	Reader talk first(RTF)	RTF	Tag talk first (TTF)
Communication principle	Inductive coupling/ Backscatter	Backscatter	Self generate EM wave
Operating Frequency	LF/HF/UHF/Microwave	UHF	UHF/Microwave
Tag characteristic	Thin and flexible	Thin and flexible	Large and bulky
Common read range	0.1m~7m	60m~80m	>100m

2.1.2 RFID Tag Signal Transmission

There are two kind of response signal transmission method for the RFID tag, which is inductive coupling and backscattering propagation. Induction coupling signal transmission method is near field communication mechanism that work base on the

Faraday’s principle of magnetic induction. It commonly use for RFID system with frequency range less than 100MHz that held in the HF and LF frequency range. In this transmission method, small coil antenna incorporate in the tag induce alternating voltage when pass through the alternating magnetic field around the RFID reader. The small magnetic field induce at the tag will oppose the reader localize magnetic field and produce a small increase in current flowing through the reader antenna coil that was proportional to the load applied to the tag coil. Figure 2.2 illustrate the concept of induction coupling transmission of RFID tag.

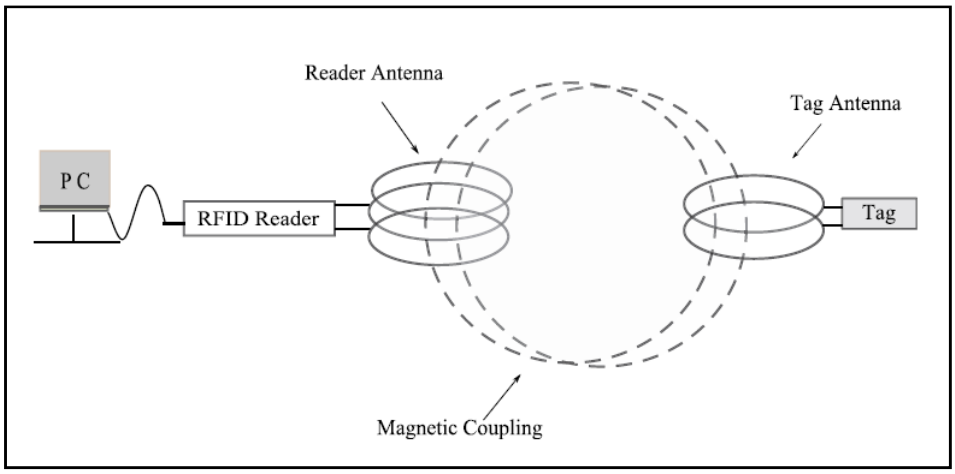


Figure 2.2: Induction Coupling Transmission (Klair, D. K., K.-W. Chin)

However, it works on near field because the range for which the magnetic induction approximates to $c/2\pi f$, where c is light speed and f is the operating frequency. Thus, as the frequency of operation increases, the distance over which near-field coupling can operate decrease as well. The induction energy of the antenna coil also limited by distance because magnetic field drops off at a factor of $1/r3$, where r is the separation of the tag and reader, along a centred line perpendicular to the coil antenna (Want, R. (2006)).

Next, back scattering and EM wave propagation signal transmission method for the RFID tag is far field communication mechanism that work well for RFID system with UHF and microwave frequency range. Instead of using coil antenna, dipole antenna is used at the reader and tag to receive and transmit signal. The back scattering signal transmission method is work by changing the impedance of the tag antenna overtime that create impedance mismatch between the reader and tag

antenna to reflect back certain incoming signal in a pattern that encodes the tag response. Figure 2.3 illustrate the concept of back scattering and EM wave propagation transmission of RFID tag.

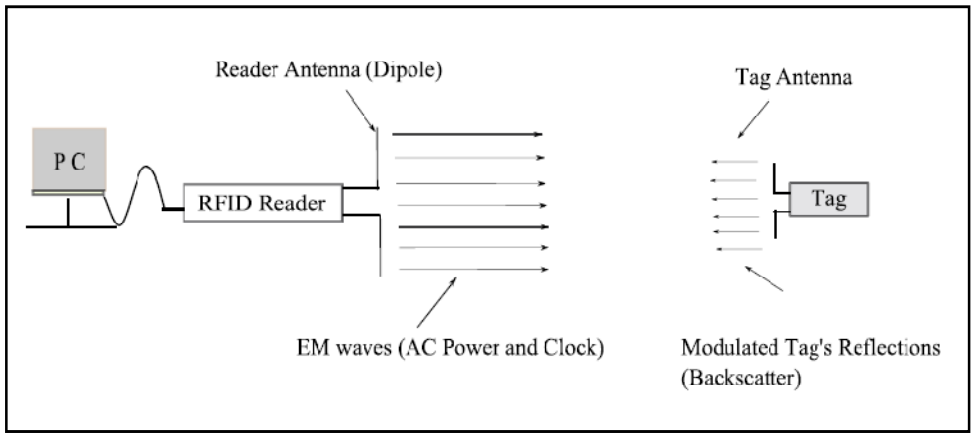


Figure 2.3: Backscatter Transmission (Klair, D. K., K.-W. Chin)

Hence, it can achieve further transmission distance than induction coupling method However, it also limited by the amount of energy that reaches the tag from the reader and sensitivity of reader to the reflected signal. The backscatter transmission introduce to two attenuations that based on the inverse square law. The first attenuation when signal transmit from reader to tag and second attenuation is occurs when the reflected signal is travel back to the reader. The return energy of the RFID tag is approximately $1/r^4$, where r is the distance between the reader and tag (Want, R. (2006)).

2.1.3 Standard RFID Operating Frequency

Various type of radio wave frequency range are utilize in RFID system for different application field based on their characteristic. Low frequency (LF), high frequency (HF), ultra high frequency (UHF) and microwave are the four common frequency range categories for RFID system. All four kind of operating frequency range of RFID system is summarized in Table 2.2.

Table 2.2: Summary of RFID Operating Frequency

Frequency Type	LF	HF	UHF	Microwave
Frequency range	<135kHz	13.56MHz	860 - 930 MHz	2.45 GHz
Physical coupling	Inductively-coupled systems		Backscatter systems	
Tag use	Passive	Passive	Passive/Semi-passive/Active	Passive /Active
Communication Boundary	Near Field	Near Field	Far-Field	Far-Field
Approximate read range	< 0.5m	< 1m	< 7m (passive) < 80m (semi) > 100m (active)	> 100m (active) < 3m (passive)
Antenna	Coil	Coil	Dipole	Dipole
Effect of liquid	None	Low attenuation	High attenuation	High attenuation
Effect of metal	Disturbance	Disturbance	Attenuation and reflection	Attenuation and reflection
Data rate	< 10 kbit/s	< 100 kbit/s	< 100 kbit/s	< 200 kbit/s

2.2 Improvement of RFID System against Metallic and Liquid Object

In RFID scanning system, the effect for the present of metallic and high humidity object must take into serious consideration because it will highly affect the overall performance of the system (Zhang, Y., K. Yemelyanov, et al. (2009)).

When metallic platform is placed too near to the RFID tag, it can appear as a antenna for the RFID tag and it also will act as an reflector that reflect most of the incoming electromagnetic wave signal. Therefore, the present of metallic platform near the RFID tag will decrease the signal receiption of the RFID tag in some case and dramatically varied the parameters of the RFID tag build in antenna (Yu, B., F. J. Harackiewicz, et al. (2007)). Some common parameters of the RFID tag antenna that will affect by nearby metal platform including the impedance properties, resonant frequency, and antenna gain and radiation pattern. The variation of RFID tag property due to present of metal object can be positive or negative, but most of the time it give negative effect if proper adjustment to the placement and design of the RFID tag is not apply.

Besides that, present of high liquid contain object around the RFID tag will also cause degradation of performance for the RFID system (Dobkin, D.M.; Weigand, S.M. (2005)). The degradation level of the RFID system due to the present of liquid is highly depending on the properties of the liquid. Normally oil based liquid will tend to give less impact to the RFID system compare to water base liquid due to the electromagnetic wave absorption properties of it (Sweeney, P. J. (2005)). The absorption of signal from nearby liquid contain cause the RFID tag unable to receive sufficient signal from RFID reader to power up and transmit feedback signal. The liquid may also absorb part of the transmitting signal from the RFID tag that cause the reader having difficulty in detect the weak signal from RFID tag.

In current technology, there are many ways to increase the reliability of RFID system against the present of metal and liquid object through modification of RFID tag design, but most of the method will increase the production price of the RFID tag which is not desirable. According to (Dobkin, D.M.; Weigand, S.M. (2005)), the influence of the nearby metal platform against the RFID tag can be reduced with proper separation between them with Styrofoam and the distance is around 0.5 cm from the research outcome. Figure 2.4 from the research article will briefly descript the concept behind the design. Next, it is also suggested that multiple RFID tag placement on the items can increase the scanning outcome of RFID system in metallic and liquid contain object (Bolotnyy, L., S. Krize, et al. (2007)). Lastly, increase the coverage scanning direction can also increase line of sign scanning of the RFID tag on both metal and liquid contain object which lead to higher detection rate.

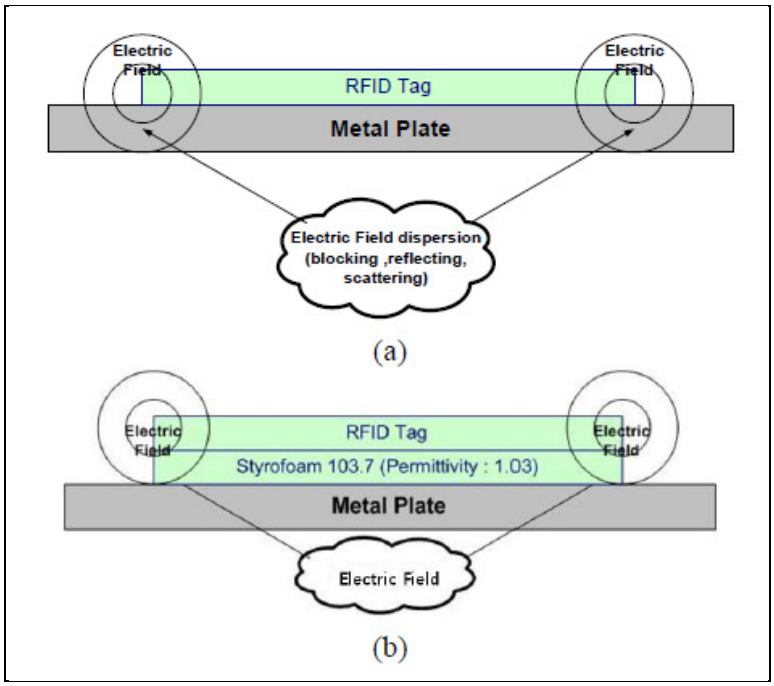


Figure 2.4: Simple RFID Tag Improvement against Metal platform (Dobkin, D.M.; Weigand, S.M. (2005))

2.3 Introduction on UART Serial Communication

The main key communication of the automated shopping checkout system will utilize the UART serial communication. UART serial communication is normally configure as full duplex asynchronous system which mean communication between devices at both end at the same time is possible for it.

Fundamentally, UART serial communication allows the signal data transmit to the receiver without the utility of clock signal in little-endian mode. Instead of using a clock signal to synchronize the transmitter and receiver of UART serial communication, the timing parameters for both side is agreed at advance and special bits are added to each word to synchronize the sending and receiving units. When a word is given to the UART asynchronous transmissions, a start bit is added to the beginning of each word that is to be transmitted that alert the receiver when a word of data is about to be sent and eventually force the clock in the receiver into synchronization with the clock in the transmitter. In addition, stop bit also added at

the end of the word data to inform the receiver it is the end of data and prepare for incoming of next start bit (Durda, F. (1996)). Figure 2.5 shows the concept of simple UART signal transmission.

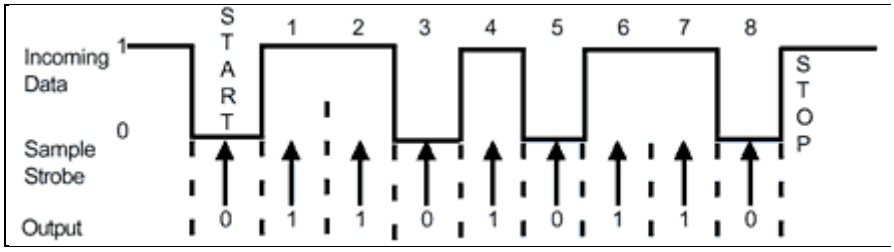


Figure 2.5: Simple UART Signal Transmission [Source: Inch, Q. (2011)]

Since the data transmission in UART serial communication is “self synchronization”, the transmission line will go into idle state when no data is transmit.

Slightly mismatch in the sender and receiver speed will cause several problems to the UART serial communication such as overrun error and framing error. Overrun error occur when there is a lag in receiver to handle the receive data which cause next package of data arrive before the current data is process. For framing error is cause by the missing of the start bit or stop bit in the UART transmission data word. An optional of parity bit function can be added into the transmission if the hardware is supported and also both receiver and transmitter agree. The extra parity bits can use to check the present of overrun error and framing error in the UART serial communication and let the user to determine what action to be taken.

CHAPTER 3

METHODOLOGY

3.1 System Logical Structure

The project start with come out a logical structure for the RFID automated shopping checkout system that suits the requirement.

Firstly, the system should equip with an high performance antenna that capable to effectively detect and capture the response signal transmit from the RFID tags attach on each item that pass through the scanning zone. Next, tag response will be passing into the reader module to identify the tag unique and pass through the microcontroller for further data processing. Furthermore, motion sensor is added into to control the on and off of the RFID reader module by sense the present of moving object pass through it detection region. This function is added in objective to minimize system power consumption and also reduce the EM wave pollution to the surrounding.

The main data processor in this system is the microcontroller. All instruction signal and logic signal from the host computer and motion sensor will pass into the microcontroller for action determination. Moreover, four LED will be use to indicate the status of system power up indicator, system on/off indicator, RF on/off indicator and motion present indicator. This will simplified the process of troubleshooting by observe the status of LED and also easier for user to determine the current state of system.

Computer graphical user interface (GUI) is the main control of the system that enables interaction between the user and the system. It will be software that set up in the desktop or laptop that can sends the instruction given by the user to the device. The GUI should also be able to perform simple data processing with information retrieve from device and display it to the user. A prototype of the RFID automated shopping checkout system will be made base on interaction flow diagram shown in Figure 3.1

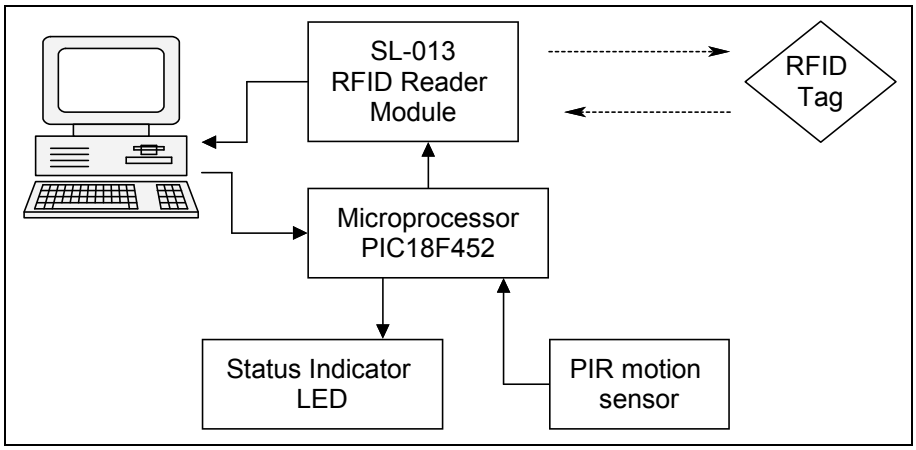


Figure 3.1: System Interaction Flow Diagram

3.2 Scope Specification

Mainly, the work scope in this project is focussing more on the setting up the hardware of the system and also workout the control logic for both the microprocessor unit and the host computer GUI program. Some and criteria of the task can be specified as below,

1. The setting of the RFID reader module must enable it to successfully detect and accurately interpret the correct information emit from the RFID tag.

2. The hardware unit of the automated shopping checkout system must able to communicate with the host computer GUI program through serial communication

3. The microcontroller in hardware unit must able to process the information and instructions from computer and delicate precise task to the RFID reader module.

4. The PIR motion sensor circuit must operate correctly by turn on the reader RF transmission if sense the present of motion and turn off the reader RF after certain period without the present of motion in the scanning zone.

5. The GUI program should be worked well in 32 bits Microsoft XP, Microsoft Vista and Microsoft 7 operating system host computer with all requirement software installed.

6. The GUI program has to accurately interpret the information and instruction from the system hardware unit and execute correct operation based on them.

7. SQL database must successfully accessed by the GUI program to retrieve and update the information in the database.

3.3 Difficulty and Problem

While carry out this project, there are several difficulty and problem faced to carry out portion of the task in this project.

The main problem in this project is facing choosing a suitable RFID reader module for our system needed in this project. It is difficult to obtain a suitable specification 13.56 MHz RFID reader module from the local market due to low demand for the product. Next, the price of RFID reader module that meet the specification of this project also come with expensive price which cost more than the budget provided for this project due to the low production unit.

Besides that, the RFID reader communication protocol for most of the unit also comes out to be different. Therefore, it cost some time for me to find a module with user friendly communication protocol that I can operate with it.

3.4 Hardware Components and Circuit Design

The overall circuit layout for the RFID automated shopping checkout system designed in this project can presented as given in Figure 3.4. The circuit will contain the main hardware components such as PIC18F452 microcontroller, PIR motion sensor, an IRFZ44N n-channel MOSFET, UC00A UART to USB converter and SL-013 13.56 MHz RFID reader module.

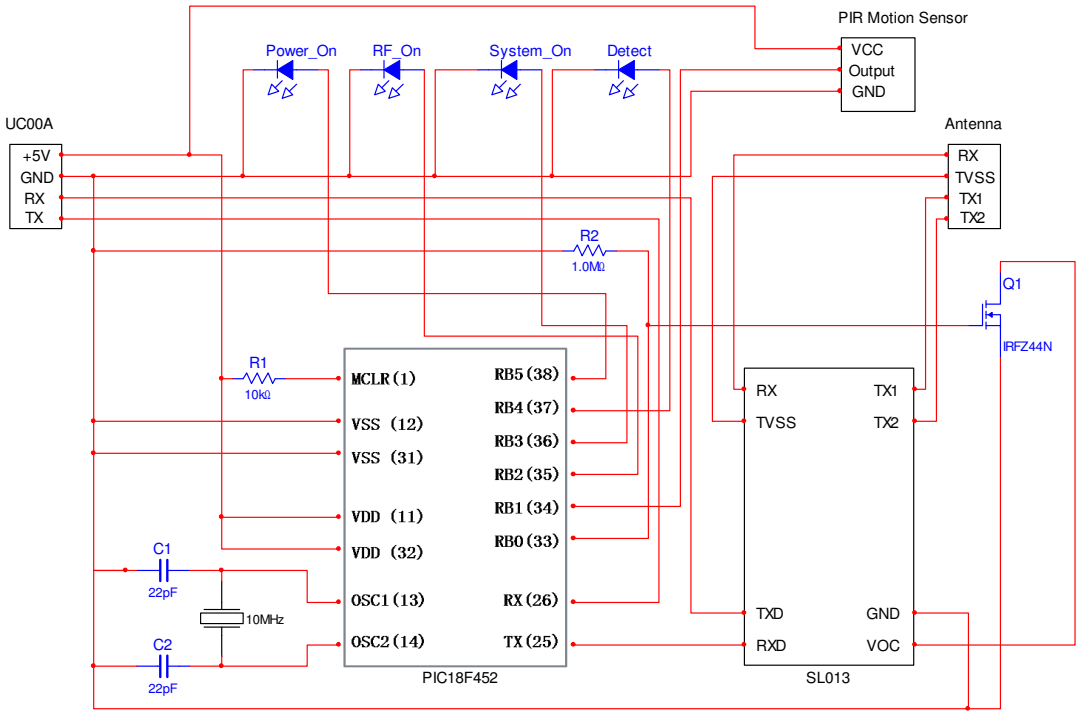


Figure 3.2: Overall Hardware Circuit Design

3.4.1 SL013 RFID Reader Module

SL013 is the model of RFID reader module use in this project. The reason I choose this model of RFID reader is because it is operate at 13.56 MHz frequency that satisfied the specification needed for the system. Besides that, it also designs with simple communication protocol that can easily understand and work it out.

The communication protocol of this module is design in byte oriented and hexadecimal format is used for both receive and transmit data. This RFID module using 8 bits UART serial communication to communicate with external unit at baud rate of 19200 bps. Basically the communication format for both receive signal and transmit signal are almost the same which include the header, length, command and checksum fields, but transmit signal will include an extra field which is the status field. The header field is the header of the instruction for the module which is "AABB" in this case. Length is filling with the length of the instruction start counting from command to checksum. Command field is the important field that indicate the module operation and it also affect the usage of data field. Status field is only available for the feedback signal from the module that indicates the status of operation. If status field return as 0×FF then it indicate the operation is fail and 0×00 indicate the operation is success. Last field is checksum which is value for exclusive OR from the length field to data. Figure 3.4 shows the field format arrangement for both receive and transmit signal for the module.

Host to SL013:

Header	Len	Command	Data	Checksum

Header:	Communication header, 2 byte. From host to module: 0xAABB.
Len:	Byte length counting from Command to Checksum inclusively, 1 byte.
Command:	Command, 1 byte.
Data:	Data, variable length depends on the command type.
Checksum:	Exclusive ORed result from Len to Data inclusively, 1 byte.

SL013 to Host:

Header	Len	Command	Status	Data	Checksum

Header:	Communication header, 2 byte. From module to host: 0xAABB
Len:	Byte length counting from Command to Checksum inclusively, 1 byte.
Command:	Command, 1 byte.
Status:	Command status, 1 byte 0x00 = succeed, 0xFF = fault
Data:	Data, variable length depends on the command type.
Checksum:	Exclusive ORed result from Len to Data inclusively, 1 byte.

Figure 3.3: SL013 Communication Format(StringLink (2008))

The reader module only comes with 8 pins. The name and functions of each pin is clearly listed in Table 3.1.

Table 3.1: Pins Function for SL013 (StringLink (2008))

PIN	SYMBOL	TYPE	DESCRIPTION
1	RX	Input	Receiver Input: Pin for the received RF signal
2	TVSS	PWR	Transmitter Ground: supplies the output stage of TX1 and TX2
15	TXD	Output	Serial output port
16	RXD	Input	Serial input port
17	VCC	PWR	Power Supply
18	GND	PWR	Ground
31	TX2	Output	Transmitter 2: delivers the modulated 13.56 MHz energy carrier
32	TX1	Output	Transmitter 1: delivers the modulated 13.56 MHz energy carrier

The RX, TX1, TX2 and TVSS pins will be connected to the antenna circuit part of the system. RXD and TXD are the universal asynchronous receiver/transmitter (UART) input and output port of the module that uses to interact with the microcontroller and host computer. VCC and GND pins are the power supply pin that power using and grounding pin of the module.

3.4.2 UC00A USB to UART converter

Next, UC00A is a model USB to UART converter module that chosen in this project. The main reason to choose this module is to enable the UART communication of SL013 RFID reader module can operate in USB port that support by most computer. This module comes with 4 pins and the name and also function of those pins are listed in Table 3.2. This module will receive the information transmit from the SL013 module through its Rx pin and transmit the instruction from the computer through its Tx pin to the microcontroller. 5 V supply will also provided from UC00A module to power up the system hardware.

Table 3.2: Pins Function for UC00A (Joliza (2009))

Pin	Label	Definition	Function
1	+	5V Power output from UC00A	5V supply from USB, optional for user to power external device, maximum current 200mA.
2	–	Ground or negative	Ground of power and signal. This pin should be connected to device's GND pin.
3	**TX**	UC00A UART Transmit pin	This is UC00A's transmitter pin (5V TTL). It should be connected to device's receiver pin.
4	**RX**	UC00A UART Receive pin	This is UC00A's receiver pin (5V TTL). It should be connected to device's transmitter pin.

3.4.3 PIR Motion Sensor

PIR (Passive Infra-Red) is the model motion sensor that use in this project to control the on and off of the system RF transmission. This motion comes with three pin option, two jumper setting option and a variable resistor delay time setting as shown in Figure 3.5. The three pin option are the 5 V power up pin, grounding pin and the last pin is the output pin that give 5 V logic high output whenever motion is detected.

Next, the two jumpers setting give the retrigger function and normal function. If retrigger function is choose, the output remains HIGH when sensor is retriggered repeatedly and normal function give output goes HIGH then LOW when triggered. The jumper setting will be set to retrigger function in this project to avoid unstable signal due to present of crowd motion that will affect the RF on/off setting. Lastly, the delay time setting variable resistor is use to control the 'ON' delay time for the sensor.

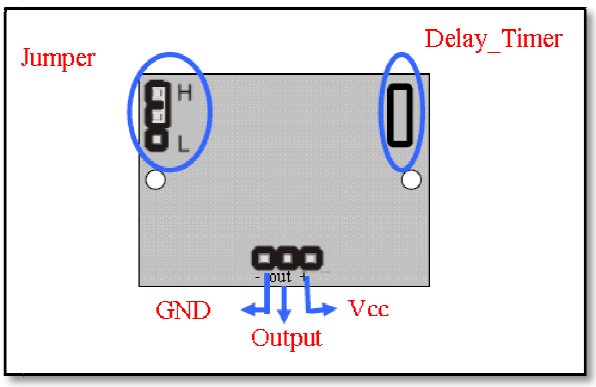


Figure 3.4: PIR Sensor Connection Pin and Setting (Cytron, T. (2007))

3.4.4 PIC18F452 Microcontroller

PIC18F452 is the model of microcontroller use in this project. The reason PIC18F452 microcontroller is used in this system is because it is supported by PICKit 2 software. Besides that, it also comes with large program memory which is around 32kB. Besides that it also support up to maximum five I/O port. These two features are an advantage for future upgrading the program control of the system.

In this microcontroller, Port B registers of this microcontroller is use as the main input and output (I/O) port that connect to most control and indication components of this project. Next, pins 25 and 26 of this microcontroller are the UART transmission and reception port that connect to SL013 RFID reader module and UC00A module. The I/O list of the microcontroller is summarized in Table 3.3.

Table 3.3: Summary of Microcontroller I/O

I/O Name	Pin number	I/O type	Description
RB0	33	Output	Switch on the MOSFET
RB1	34	Input	PIR motion sensor signal input
RB2	35	Output	RF on LED
RB3	36	Output	System on LED
RB4	37	Output	Motion present LED
RB5	38	Output	Power on LED
RX	26	Output	Connect to UC00A transmit pin
TX	25	Input	Connect to SL013 RXD pin

3.5 GUI Program Design

In this project, the GUI program work as a medium to display the processed information for the user and also allow the user to delegate certain operation to the system.

The basic design concept of the GUI program should possibly include the following function in the main menu,

1. Display the individual name of item checkout
2. Display the individual price of item checkout
3. Display Item Quantity
4. Total price of checkout item
5. Pay Bill button
6. System on/off button
7. Remove item button
8. Add/remove access user button
9. Login button
10. Stock view button
11. Show hardware connection status
12. Exit button

The computer interface software should be constructed with all criterion listed above and well organized in a systematic method and design.

3.6 Use of Software

In this project, some of the software is used to carry out this project such as Microsoft Visual Basic 2008, DipTrace, PICKit2 and MPlab.

3.6.1 Microsoft Visual Basic 2008

The GUI program for the automated RFID shopping checkout system in this project will be designed Visual Basic 2008 software (VB). VB is chosen as the development software that use to write the GUI program for this system because it is an object oriented based software that is easy to learn and apply in short period of time.

Besides that, the application created through VB can implement on Microsoft .NET Framework that available in most Microsoft operating system computer. VB also provide simple solution to connecting and interact to the external

source such as SQL database and also computer serial port communication through special build in class library such as SerialPort Class and SQL data provider Class.

3.6.2 DipTrace

DipTrace is a schematic and PCB design software that use in this project to design PCB board of the hardware circuit. It is a free software that available download from their homepage at www.diptrace.com.

Even though it is free software, it is still very useful in designing simple PCB board for beginner. The software supports a lot of libraries for many common components use in the circuit. The software provide the function to enable user convert the schematic diagram of their circuit draw in DipTrace Scematic to PCB layout which is very convenient. Another advantage of this software is include the function to auto arrange the components and wiring of PCB layout to the size of PCB board provided, which can save up a lot of time from it.

3.6.3 PICKit 2 and MPLab

Generally, PICKit 2 is free software that come together with the PIC programming when purchase. It is important software to enable the user to burn the Hex file program to the microcontroller through the programmer. It supports wide range of PIC microcontroller that is commonly used.

Next MPlab is the main program used in this project to write the program of PIC microcontroller. The software itself support the machine language code writing and extra free Mplab C18 compiler can be installed to the software to enable it compile the C programming program to hex file. Stimulation function also provided in MPlab to troubleshooting the microcontroller program written with it.

3.7 Planning For FYP Part 2

In FYP part 2, the main aim is to carrying out all the preparation work that already well planned and decided during the FYP part 1. In preparation for FYP part 2, activity planning and schedule also had been built to estimate and coordinate the FYP part 2 progressions.

Some of the estimated activity that will be involve in FYP part 2 are determined and listed as given below.

1. Components experimental testing
2. PCB circuit board design
3. Components assemble and soldering
4. Circuitry board testing and troubleshooting
5. Tag and Microcontroller program writing
6. Computer Interface Software Programming
7. Overall Prototype Assemble
8. Prototype Testing and Troubleshooting

The prediction main activity progression flow for FYP part 2 will be approximately shown in the flow chart prepared as Figure 4.1. In overall, most of the tasks that will be engage in the FYP part 2 will lead to the outcome and result we had been plan in during FYP part 1.

The milestone planning for FYP 2 had been prepared to well plan the time management for all the prediction activities that will be carry out. The schedule is roughly stated in the Grant chart Table 4.1.

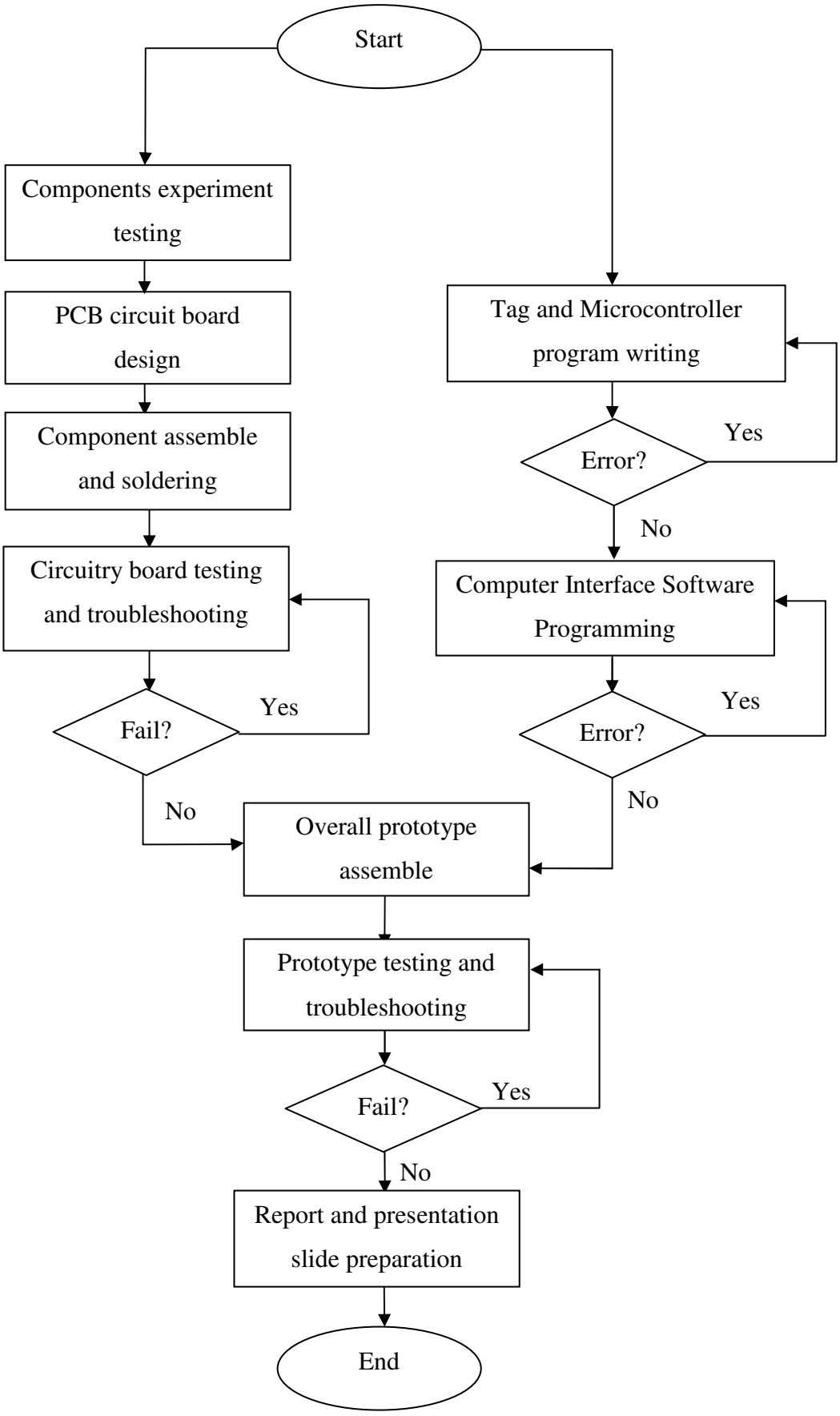


Figure 3.5: FYP part 2 progression flow

Table 3.4: Milestone for FYP Part 2

Week / Task	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Components experimental testing															
PCB circuit board design															
Components assemble and soldering															
Circuitry board testing and troubleshooting															
Tag and Microcontroller program writing															
Computer Interface Software Programming															
Overall Prototype Assemble															
Prototype Testing and Troubleshooting															
Thesis Report writing															
First summition checking															
Second summition checking															
Thesis Report Summition															
Thesis Report Presentation Slide Preparation															
Thesis Report Presentation															

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 Result and Discussion Overview

In this chapter, all the result of experiments carries out in this project and interpretation experiments data are presented. Effective UART transmission delay experiment, system RF switching delay time testing, system read time experiment, tag attachment material experiment and system GUI testing are some of the core experiment that contributing the result and discussion in this chapter.

4.2 Effective UART Transmission Delay Experiment

The effective UART transmission delay experiment is carried out in this project to obtain the optimize transmission delay setting for the microcontroller.

The experiment is starting by setting the delay of microcontroller 0.050 s. After that, the system is run to enable the microcontroller to send the instruction to the reader module with the new delay. As reader module receives certain instruction from the microcontroller, it will transmit a feedback to host computer. This experiment is run until twenty instructions is executed and a count program in the host computer will count number error feedback signal transmit to the host computer. The previous step is run for thirty times to obtain thirty observation of

outcome. After that, the experiment is repeated with microcontroller instruction transmit delay set to 0.075 s, 0.1 s, 0.3 s, 0.5 s and 0.7 s.

4.2.1 Result of Effective UART Transmission Delay Experiment

The detail results for effective UART transmission delay experiment are tabulated in six sets of table according to the transmission delay with three field of information which are case (number of error occur), case frequency within 30 observations and contribution percentage as shown in Table 4.1, Table 4.2, Table 4.3, Table 4.4, Table 4.5 and Table 4.6.

Table 4.1: Result for 0.050 s transmission delay

Case (number of error occur)	Case Frequency (30 observations)	Contribution Percentage (%)
2	6	20.00
3	11	36.67
4	10	33.33
5	3	10.00
6	0	0.00

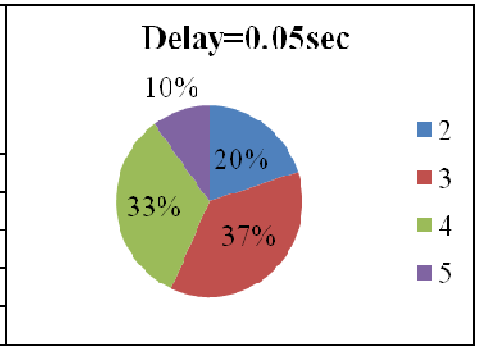


Table 4.2: Result for 0.075 s transmission delay

Case (number of error occur)	Case Frequency (30 observations)	Contribution Percentage (%)
2	7	23.33
3	10	33.33
4	8	26.67
5	4	13.33
6	1	3.33

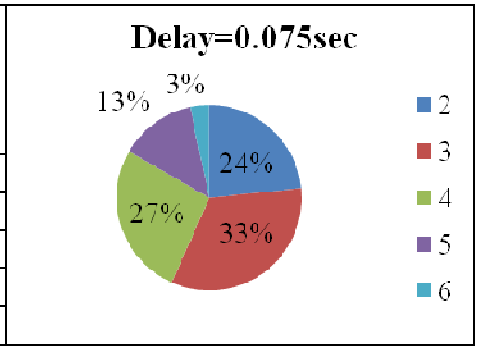


Table 4.3: Result for 0.1 s transmission delay

Case (number of error occur)	Case Frequency (30 observations)	Contribution Percentage (%)
2	15	50.00
3	5	16.67
4	8	26.67
5	1	3.33
6	1	3.33

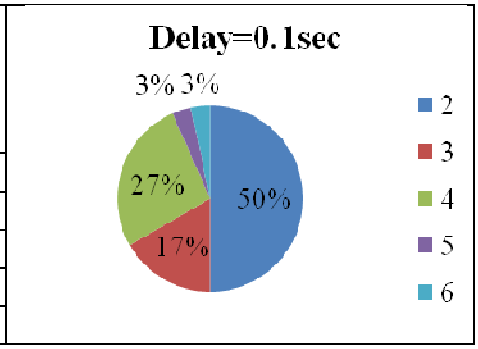


Table 4.4: Result for 0.3 s transmission delay

Case (number of error occur)	Case Frequency (30 observations)	Contribution Percentage (%)
2	19	63.33
3	8	26.67
4	3	10.00
5	0	0.00
6	0	0.00

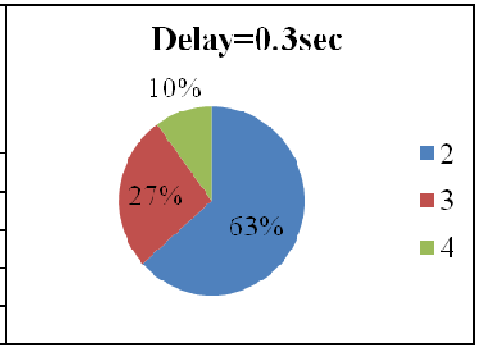


Table 4.5: Result for 0.5 s transmission delay

Case (number of error occur)	Case Frequency (30 observations)	Contribution Percentage (%)
2	3	10.00
3	14	46.67
4	8	26.67
5	3	10.00
6	2	6.67

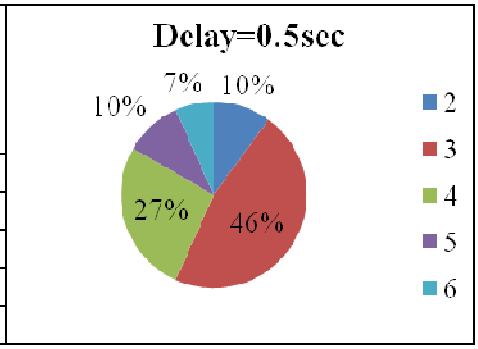
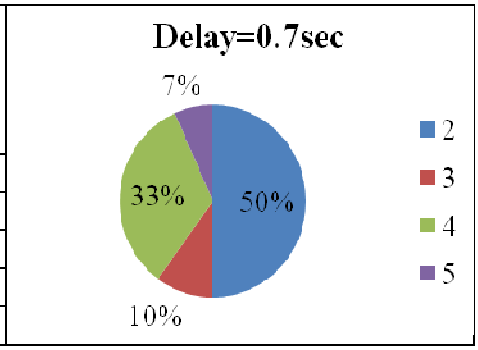


Table 4.6: Result for 0.7 s transmission delay

Case (number of error occur)	Case Frequency (30 observations)	Contribution Percentage (%)
2	15	50.00
3	3	10.00
4	10	33.33
5	2	6.67
6	0	0.00



4.2.2 Effect of UART Transmit Delay for Continuous Transmission

In this project, some time some error will occurs when signal sent from the reader module to host computer. The number of error occurrence is considerate high when the signal is sending continuously from the reader module without any delay is introduced. This may cause by the slightly mismatch of synchronization between transmit and receive unit.

In order to reduce the occasion of error during signal transmission form the RFID reader module to the host computer, certain amount of delay which is less than one second is added to the instruction sending of microcontroller. The delay will slightly slow the instruction send to the RFID module and also lead to slowing down of reader module feedback. This will provide some extra interval time for the each feedback signal to transmit in continuous process.

The delay time show improvement for the signal reception accuracy at the host computer side, but yet small amount of error is still present. In order to further improve the accuracy of system, few sets of delay time is chosen between 0.05 s to 0.7 s and tested to obtain the optimize choice among them. From the experiment, we can conclude 0.3 s delay give the best performance with less error introduces in average compare to others. Delay time which less than 0.1 s is show less improvement for the system with average of 2 errors occur every 20 feedback signal receive. When the delay time is too large, the feed signal error tend to be less consistence which can fluctuate up to 4 errors sometimes for each 20 feedback signal received.

4.3 RF Switching Delay Time Testing

To test the RF switching delay time of the system, a simple test can be taken by recording the time consume for the RF to turn on each time the motion sensor is triggered to logic high state. The state of RF can be easily determined through the RF on LED implement to the system and an assumption of no delay introduce to switch on the LED is made. For accuracy purpose, the testing is carried out in ten observations

4.3.1 Result of System RF Switching Delay Time Testing

Following section will include all the information data obtained from system RF switching delay testing. All the data collected from RF switching delay testing is tabulated in Table 4.8 and also presented in graphical line graph in Figure 4.5.

The table is come with two field which are RF switching delay time that indicate the delay time of the RF turn on after motion sensor is triggered and number of observations in the experiment. Through the line graph presented in Figure 4.4, the RF switching delay time is observed that scattered between 1 s to 1.5 s.

Table 4.7: System Read Time Experiment Result

Number of observation	RF turn on delay time (s)
1	1.30
2	1.20
3	1.10
4	1.20
5	1.10
6	1.20
7	1.20
8	1.40
9	1.30
10	1.50

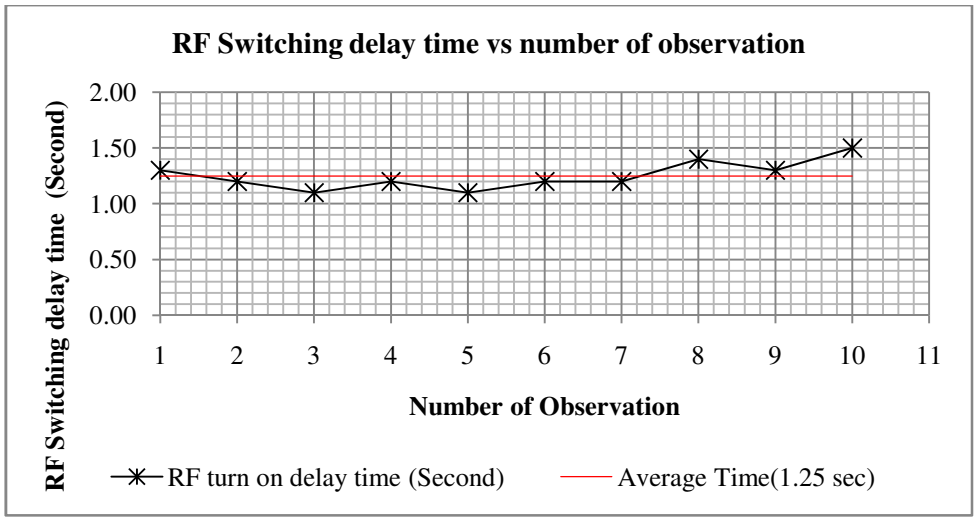


Figure 4.1: Line graph of Table 4.7 data

4.3.2 Analysis Cause of RF Switching Delay

The average of RF switching delay is found to be 1.25 s. Through statistical analysis calculation, the standard deviation of the experiment data is 0.12 s. This mean the average RF switch in delay time will deviate around 0.12 s from average of RF switching delay, which give a average range of around 1.13 second to 1.37 s. The results obtained from the experiment come out to be different from the expected hypothesis. In the hypothesis made, the RF switching of the system is assume to be executed instantly but in real case, some delay which range within couple of second is introduce in the process.

Through analyse the working principle of the system process, the delay time that introduced to the RF switching process is more likely cause by looping process of the system program. In this system design, the microprocessor is programmed that once motion sensor is triggered, it will start looping RF on instruction sent to RFID module until a feedback signal that confirm the switching of RF was sent to the microprocessor. Therefore, the process consumes certain time for the instruction or feedback signal to send among process unit such as from microcontroller to RFID module, from RFID module to host computer and from host computer to the microcontroller.

Next, the RF switching delay can also influence by the switching speed of the MOSFET that implement in the system to switch on and off the RFID module. When the PIR motion sensor signal was delivered to microcontroller, microcontroller will first turn on the RFID module by switching the MOSFET to on state. However, switching of MOSFET is not instantaneous and it cause some delay to fully turn on the MOSFET. The delay time for this case is highly effect by the switching characteristic of the MOSFET itself and but normally is very small.

4.3.3 Consequential and Solutions for RF Switching Delay

The RF switching delay of the system is very important for the system overall performance and important factor to be considered. High RF switching delay will prolong the time taken for the system to complete the task in each work cycle and

directly decrease the performance of the system. Some RFID also may miss out from scan process due to the delay in RF turn on which lower the accuracy of the system. RF switching delay problem will always exist and cannot be fully terminated but it can be reduced to a considerable value.

Some common way to minimize the time delay problem is decrease the signal transmission path from each processing unit and also using MOSFET with good switching characteristic. Another way to compromise the RF switching problem is properly adjust the sensor location from the scan zone of the system. This can make sure the item take some time to reach the scanning zone once the sensor is triggered to make sure the RF of the system is fully turn on. For the system design in this project take average of 1.5 s to turn on the RF once the sensor I triggered and it is tested around 10 cm separation distance between the sensor and the scan zone can be sufficient to compromise the delay issues of system.

4.4 System Average Read Time Testing

In order to obtain the average read time of the system, a simple test is carry out in this project. First of all the RFID tag is placed at the scanning zone of the system and use the GUI program to turn on the system and measure the time taken for the GUI show the information of tag. After that, repeat the process by removing the scanned tag information from the GUI program and determine how long it takes for the tag to redetect by the system. Repeat the experiments for thirty times to collect thirty observations to increase the accuracy of outcome.

4.4.1 System Average Read Time Analysis

From the system average read time analysis experiment, the data is plotted in line graph of Figure 4.5. The data elements from the experiment are number of observation and read time of RFID tag for the system. There are total of thirty observations taken in the experiment, so it will give thirty sets of read time for analysis.

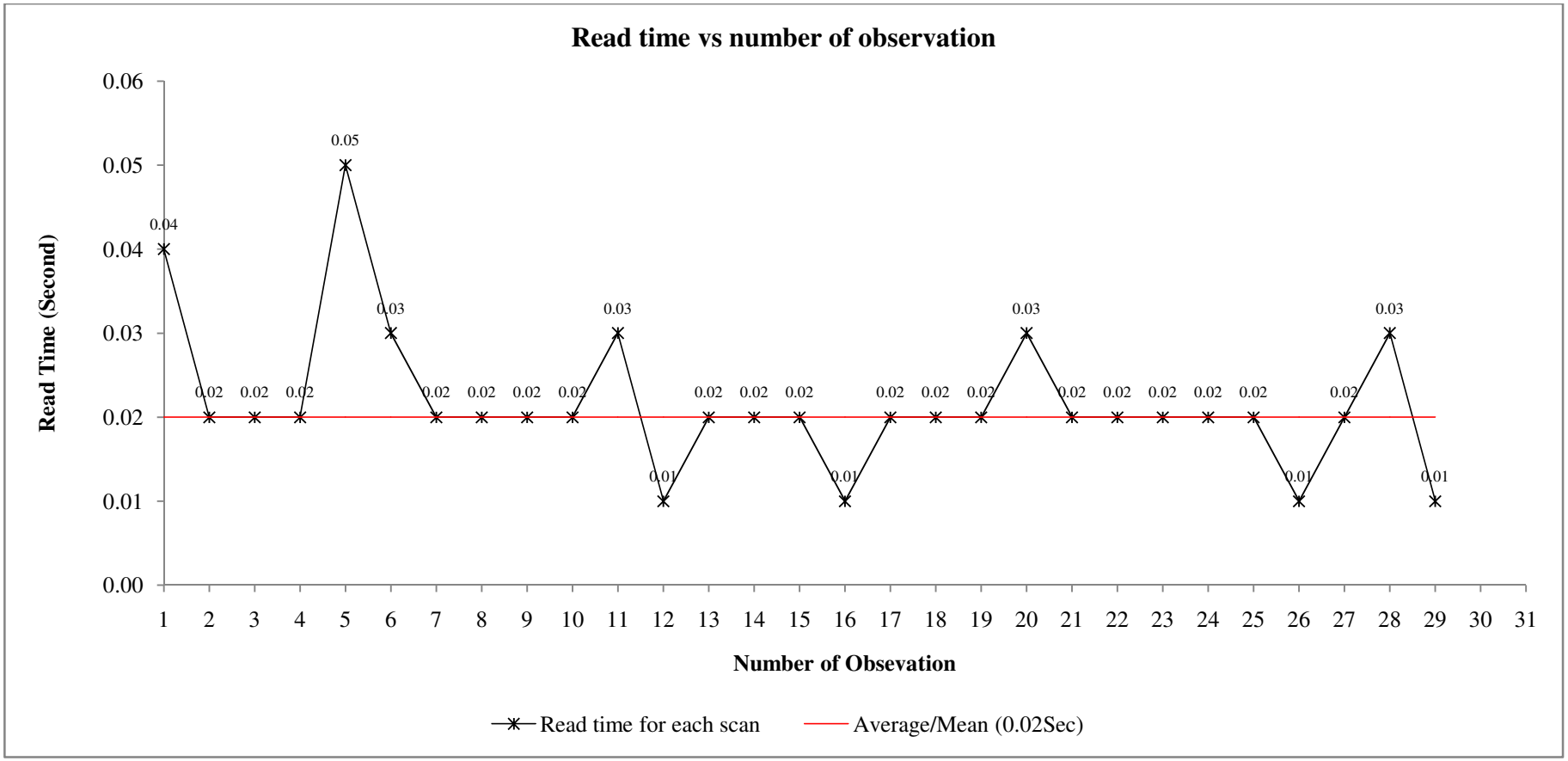


Figure 4.2: Line Graph of System Read Time Data

4.4.2 Interpretation System Read Time Data

Basically, the scan time of the system is found to be very fast and close to instantaneous with very small delay which is around average of 20 ms. The fluctuation of the collected read time data may cause by the instability of the system or human error when conducting the experiments.

Through statistical analysis, the mean of the system read time is found to be 20 ms and the standard deviation of the data is 8ms. With both the mean and standard deviation obtained, I can conclude the average read time of the system is fall within 12 ms to 28 ms. Since the deviation range of the read time is very small, it provides the information about the system have a very fast and accurate scan performance. The read time of the system is very crucial in determine that work cycle time consumption of the system. However, this experiment result is obtained from RFID tag without attaching any item, so it is the original read time that requires reading an unattached RFID tag.

4.5 RFID Tag Attach Material Experiment and Result

In this experiment, the system is tested on scanning the RFID tag attached on different material platform such as metal, glass, cardboard paper and plastic. All the platform is chose to have around thickness of 0.2 mm to obtain a clearer result. When this experiment is carrying out, criteria such as read times change, maximum detection range and readability of the system is observed. Same method previously used in determines the average read time of system is use again in this experiment to obtain the read time and readability of system. The maximum read range of the system is obtained through slowly moving the RFID tag away from scanning antenna in horizontal distance until the tag is not detected by the system.

The outcome result of the experiment is clearly presented in Table 4.8 in detail. Simplification of result is also presented in the form of column chart as shown in Figures 4.3 and 4.4.

Table 4.8: RFID Tag Attach Material Experiment Result

Material	Attachment Method	Observation		
		Readability	Read Time (s)	Maximum Read Distance (cm)
Plastic	Surface attach	Yes	0.02	2.8
	Internal attach	Yes	0.02	3.2
Glass	Surface attach	Yes	0.03	3.0
	Internal attach	Yes	0.05	2.8
Metal	Surface attach	No	No Reading	No Reading
	Internal attach	No	No Reading	No Reading
Metal with paper cardboard separation	Surface attach	Yes	0.20	0.5
	Internal attach	No	-	-
Paper Cardboard	Surface attach	Yes	0.02	3.3
	Internal attach	Yes	0.03	2.9
Glass container with liquid	Surface attach	Yes	0.04	2.8
	Internal attach	Yes	0.13	2.2

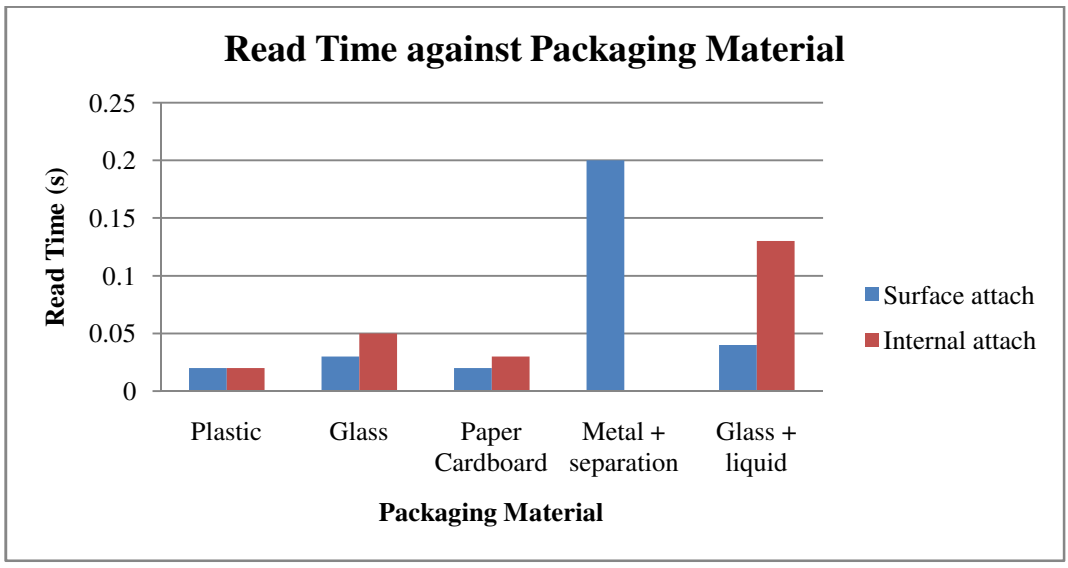


Figure 4.3: Read Time against Packaging Material

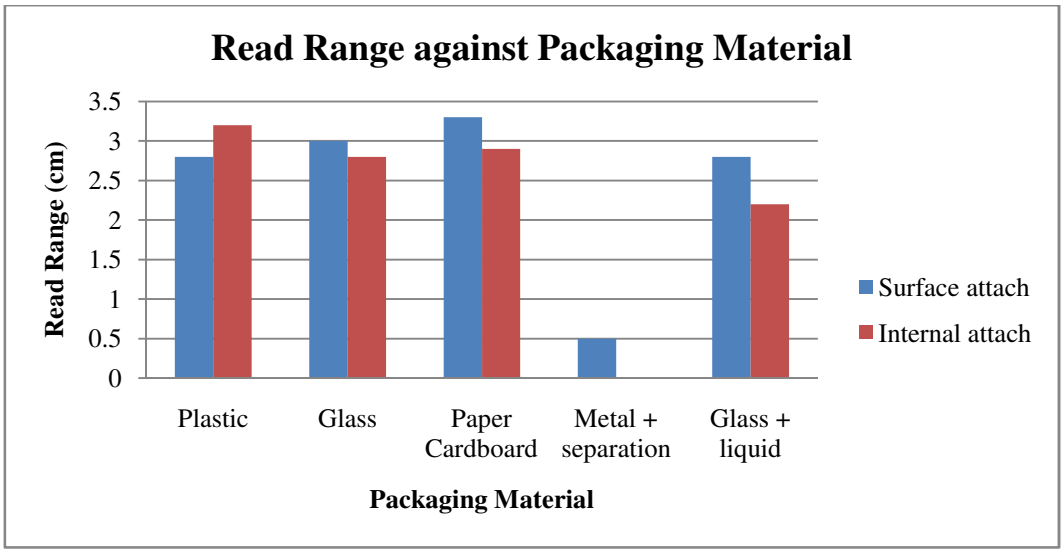


Figure 4.4: Read Range against Packaging Material

4.5.1 Effect of Platform Material to System Performance

From the tabulated result show in Table 4.9, the result clearly show the system had no difficulty when dealing with RFID tag attached on the plastic, glass and paper cardboard packaging materials. The read time and read range of the system is still fall within average where the read time is around 0.02 s and read range is around 3 to 3.5 cm maximum.

Next, base on the result, metal material packaging causing the system fail to read the RFID tag attach on it. The reason that system acting poor on metal packaging item is because the metal platform will change the parameters such as input impedance, resonant frequency, gain, radiation pattern of RFID tag antenna attach to it (Yu, B., F. J. Harackiewicz, et al. (2007)). This effect is known as de-tuning that will lead to impedance matching problem between tag antenna and tag microchip and cause the tag cannot receive sufficient energy from reader to reflect back a signal (Hunt, V. D., A. Puglia, et al. (2007)). Metal platform also can act as an efficient radio frequency signal reflector that will reflect any electromagnetic wave that incident on it. This make the electromagnetic wave signal from the system hard to reach the RFID tag attach to the other side of metal platform.

In order to improve the reception of RFID tag signal attached to metal platform, some separation space between the metal platform and the RFID can implement (Park, C. R. and K. H. Eom (2011)). With paper cardboard thick around 0.5cm as separation between the tag and the metal platform, system become capable to read the RFID tag from direct scan but outcome is highly degraded from the aspect of reading speed and range as presented in the result. Besides that, the increase separation between the RFID tag and metal platform just can solve direct scanning problem and can solve indirectly scanning problem of the system. The indirect scanning problem of RFID tag mount on metal platform can only solve by increase the scanning direction of reader which will lead to increase the chance of direct scan of RFID tag.

Beside metal platform, from the result shown in previous section, it is also noticeable that liquid give slightly influence to the performance of the system. Even though the effect is not significant but the result shows the read range and speed of the system slightly fall when scanning a RFID tag place next to a glass containing water. This can be cause by the electromagnetic wave absorption characteristic of liquid which causing the RFID tag to have insufficient energy to power up and backscatter information to the reader. Different liquid react differently to electromagnetic wave and normally water base liquid will have higher absorption characteristic than oil based liquid.

Some simplest method to reduce the effect of liquid absorption for the RFID tag is increase the separation distance between liquid and the tag like implemented to metal platform. This can reduce the amount of receive and transmit signal from RFID tag absorbed by the liquid contain (Technology, A. (2007)). Increase the system read direction will also work in reduces the affect of liquid absorption problem.

4.6 System GUI Program Testing

This section will cover all the description and testing of the graphical user interface (GUI) for the automated shopping checkout system.

4.6.1 Program Communication

In the GUI program designed for the automated shopping checkout system, serial port communication plays an important role in enable the communication between the host computer with the other processing unit such as microcontroller and RFID module. An UART to USB converter hardware is used to enable the UART transmission access through the USB port of computer, but it still present as a serial port in the host computer where can be link up with the GUI program using serial port class in VB.

When the program start, it will trigger a timer that repeat to count up to two second and trigger a sub function to check for the present of COM port connection for the system (In this project COM10 is used) in the COM port list of host computer. If COM10 present in the list, program will create and open a serial port that link directly with COM10. Update the connection status in GUI main menu to “connected” and unlock system on/off button will also be executed. If COM10 is not present the program will update the connectivity status to “Disconnected” and lock system on/off button. Even with present of administrator user login, the system on/off button will be disabled when the system is in disconnected state. This is to prevent the user from access system on/off button while the hardware is not connected which will lead to error in program flow. The program flow of the system hardware connection checking can be illustrated as given in Figure 4.5.

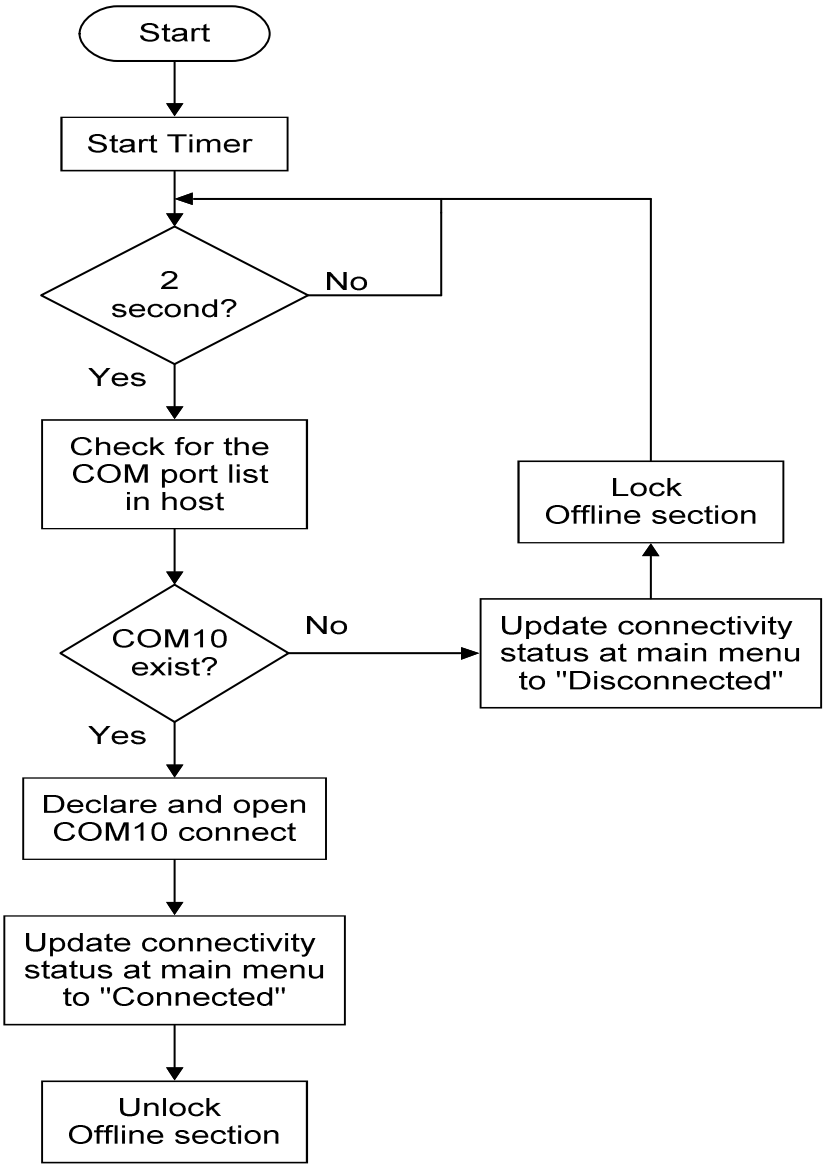


Figure 4.5: Read Range against Packaging Material

4.6.2 GUI Main Menu

The GUI Main Menu is the place where the administrator can access most of the function of the GUI and place for normal user confirm their checkout goods information.

Basically the layout of GUI main menu can be separate up to two sections which is information display section and the user function access section. The

information display sections are such as the connectivity indicator, user indicator, checkout product information displayer and total price displayer. Connectivity indicator will indicate the connectivity status of the system hardware to the host computer and user indicator shows the user of the current login administrator account. Checkout product information displayer is place to provide the information such as product name, product ID and product price of the checkout item scanned by the system. Lastly, total price displayer shows the total price of the checkout item scanned by the system. For functions access section, there are log in/out button, add/remove access user button, system on/off button, remove item button, view stock button and pay bill button. Figure 4.6 shows the layout of the GUI main menu.

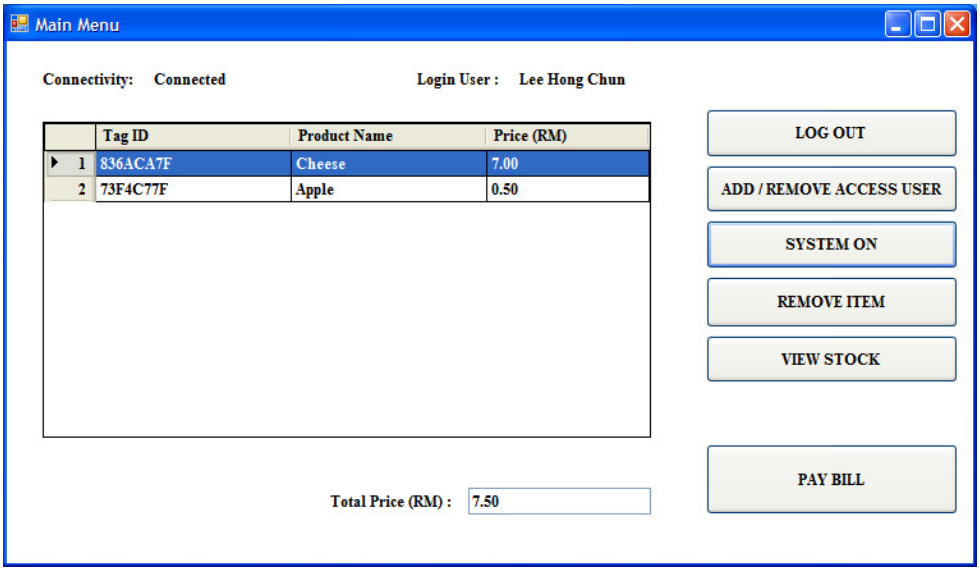


Figure 4.6: GUI Main Menu Layout

While the system is in on state, the GUI program will automatically update the checkout list if any checkout item is detected scanning zone of the system. Besides that, the accumulation of the checkout item total price at the bottom of the GUI maim menu will also be updated each time an item is added to the checkout list. The program flow from signal receive to updating the checkout item list in GUI main menu can be illustrated as given in Figure 4.7

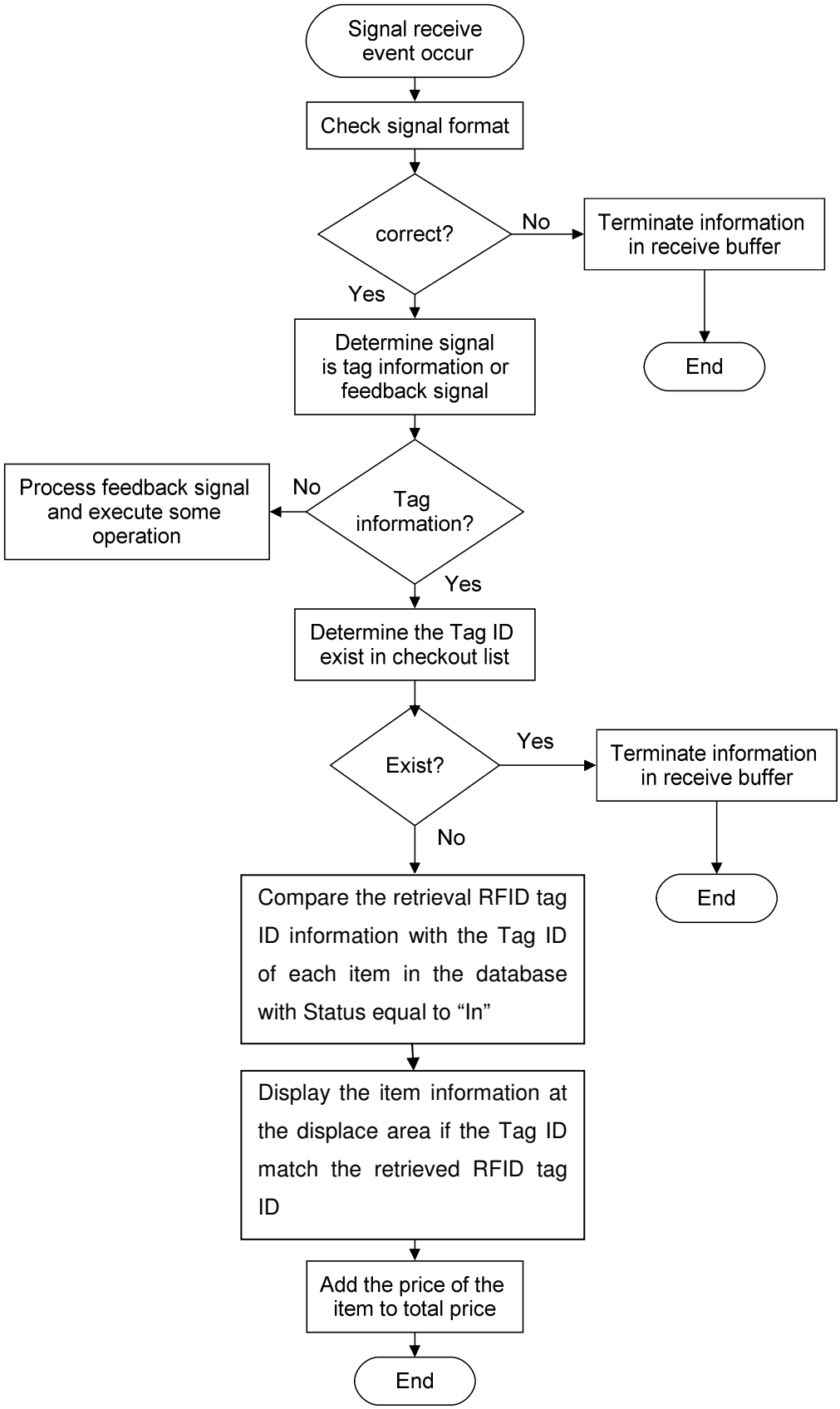


Figure 4.7: Checkout List Updating Program Flow Chart

4.6.3 Administrator Lock Function

The administrator lock function is implemented to the GUI program to lock certain function of the program that is not accessible by normal user and also prevent normal user to change the GUI setting.

When the program is first launch, a login form will pop up to request the user to login as administrator user. If user did not login, the program will proceed to the GUI with certain functions locked. If user is not log in when the program is first launce, a log in button is available in the GUI form to enable the user to log in anytime. Functions that only accessible by administrator user are such as add /remove access user, system on/off, remove item and view stock. If the program is not log in, the user only can access log in and pay bill function. The program flow chart of the log in form is presented in Figure 4.8.

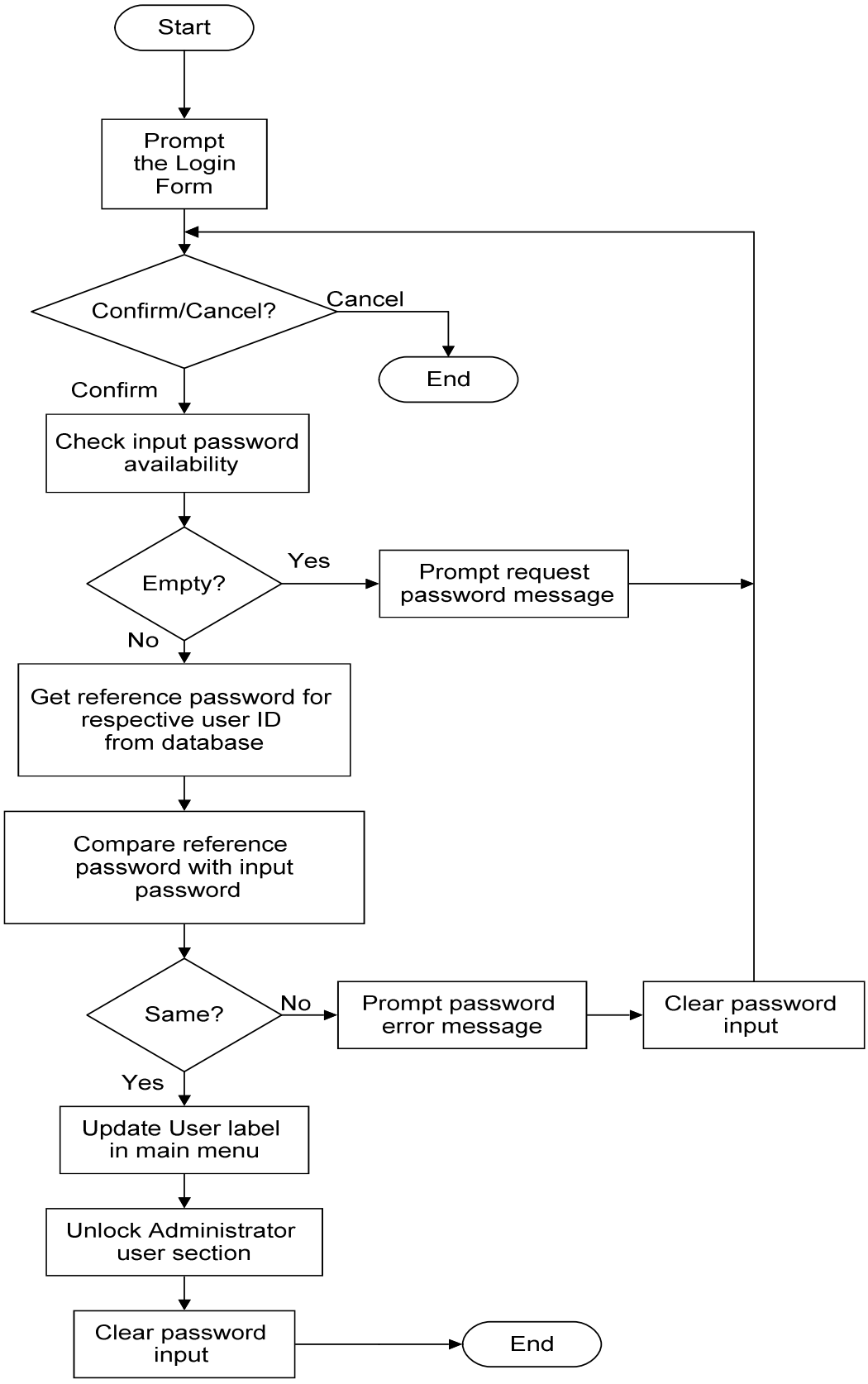


Figure 4.8: Login Form Program Flow Chart

4.6.4 Pay Bill Function and Remove Item Function

In this system, the pay bill function is included to allow the user to checkout their items. When the pay bill button is press, the GUI program will pop up a message box that shows the total amount of purchase for all the checkout goods and let user to decide whether want to proceed or not as shown in Figure 4.9.

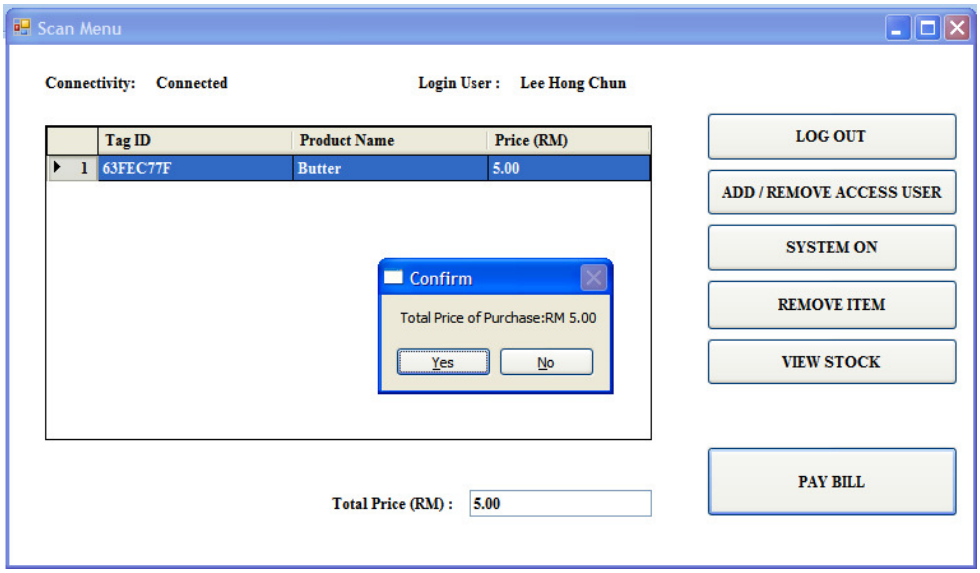


Figure 4.9: Pay Bill Button Demonstrate

If users confirm to checkout their items, the program will search through the database for all the in stock items with the same tag ID with the items displayed in GUI main menu and update their status to checkout. After that, the program will clear the checkout items display and total price display section of the GUI main menu. Figure 4.10 will demonstrate the program flow of the pay bill function.

Next, the remove item function is provided to enable the scanned checkout items to be removed from the checkout list when unwanted item is accidently add into the checkout item. This function is restricted to administrator user to ensure the scanned checkout item is not purposely removed from the checkout list.

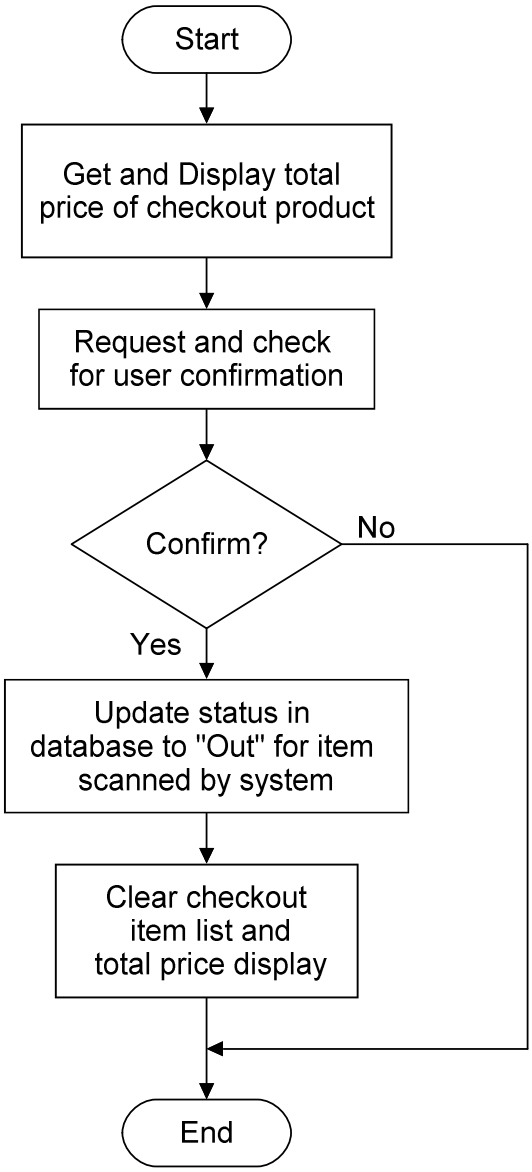


Figure 4.10: Pay Bill Function Program Flow Chart

4.6.5 Add/ Remove Access User Function

This function is implemented in the system in order to insert or withdraw any access user to the system data base. However, this function also restricted to administrator to administrator user with master password. This is to restrict the action to avoid violation the usage of the add/remove access user function of the system. Basically, when this function is access, user will jump into an add/remove access user form

which give user the option to add a new administrator user, remove an existing administrator user and also the exit the function.

The add/remove access user is initially load with add new user ID function when initiated as shown in Figure 4.11. From Figure 4.11, we can see that in order to add a new user, user need to fill up the new user ID, new password, confirmation of new password and also the master password. The new admin ID should only include characters or numbers that no longer than 15 words. Once the new user is added, it can be use for the next log in.

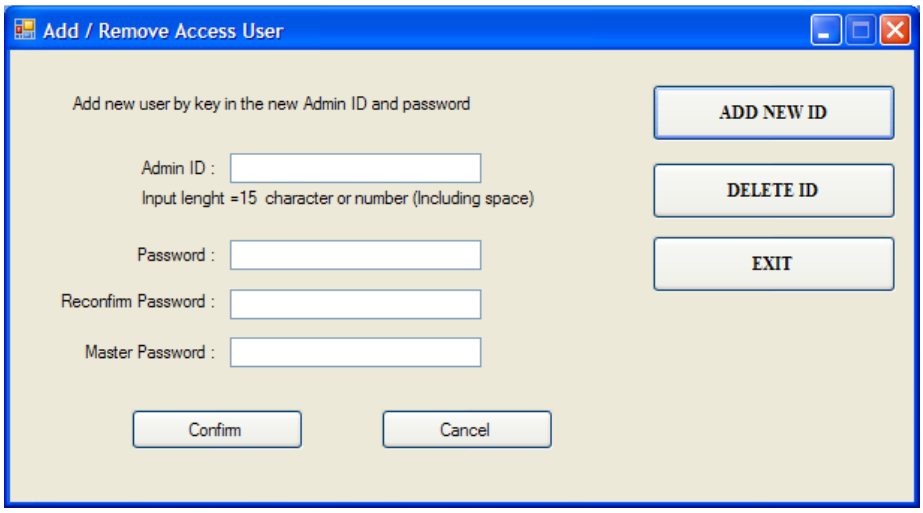


Figure 4.11: Add User Program Interface

When the delete ID button on the add/remove access user form is pressed, add new ID section will swap with the Delete ID section as shown in Figure 4.12. From the delete ID section, a combo box will be provided to user to choose which existing ID that will be deleted. After user choose the admin ID to be delete and master password is fill, user can proceed to confirm the action. When the action is taking, the program will check whether the master password filled and after that the program makes sure the deleting admin ID is not the one currently in use. If the admin ID is successfully removed, a message box will pop up to confirm with user.

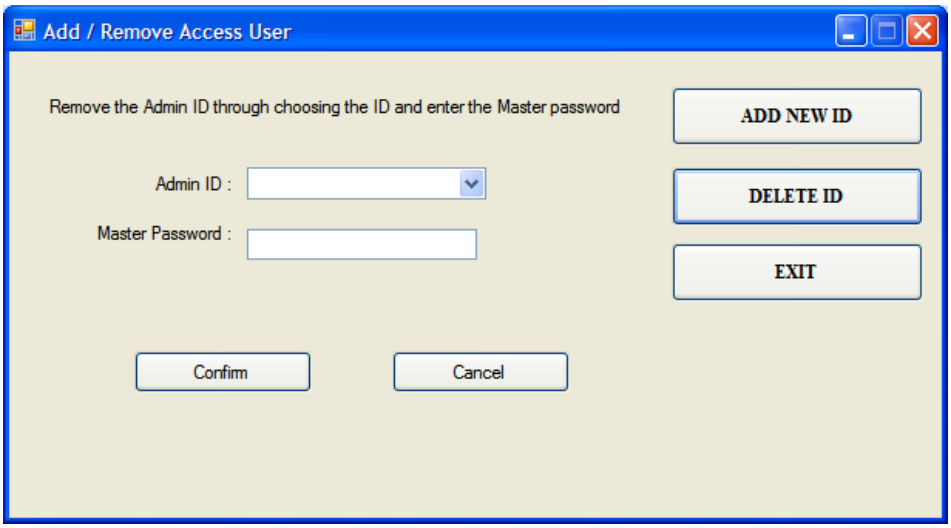


Figure 4.12: Delete User Program Interface

4.6.6 View Stock Function

The view stock function is added into program to enable the admin user can easily access to the database and check for the quantity of available stock and also the status of the stock.

Whenever the product is register into the system, it status in the database will be labelled with "In" which stand for the meaning of stock available. When the items is checkout from the system, the system will update the status of the checkout item in the database to "Out" which mean the item is check out form the store. Figure 4.13 shows the layout of the view stock form access to holding stock of the store and Figure 4.14 shows the layout when access to checkout stock.

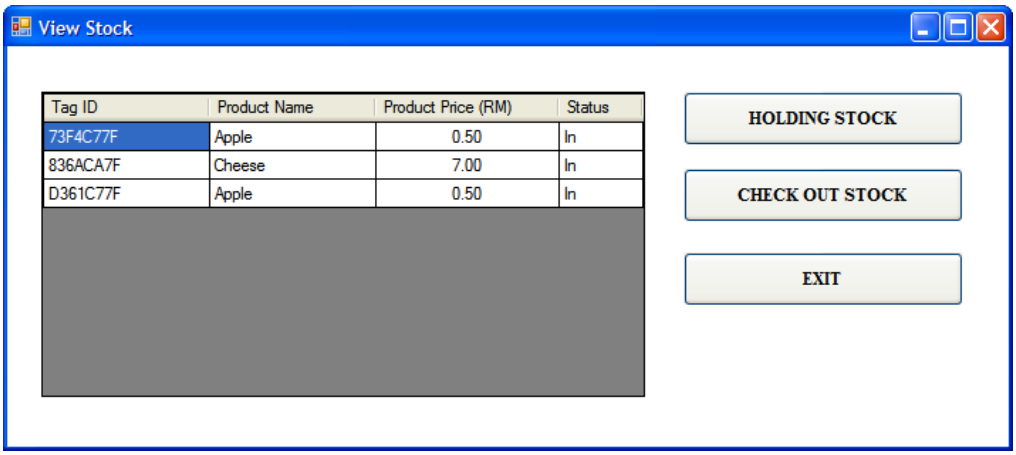


Figure 4.13: View Stock Form (Holding Stock)

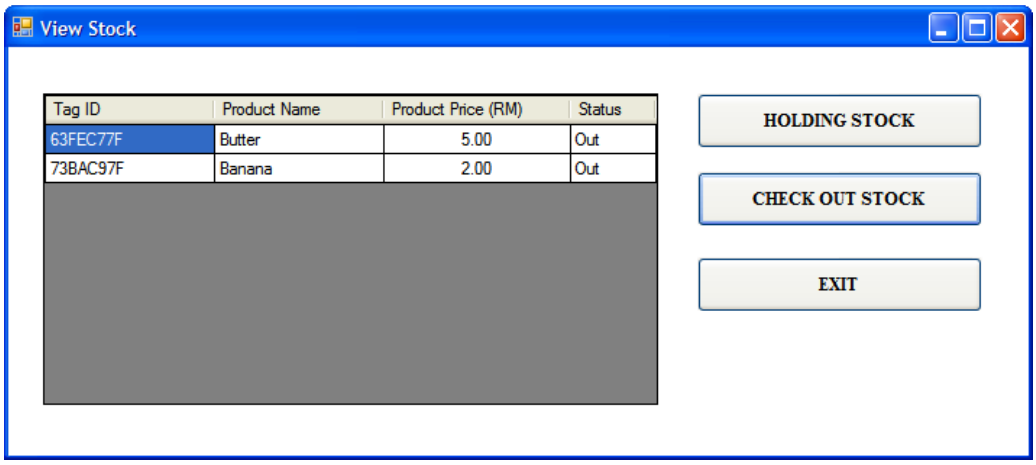


Figure 4.14: View Stock Form (Check Out Stock)

4.7 Hardware Microcontroller Program

Besides host computer as the data processing unit, some operation is executed through the microcontroller included in the hardware section of the system.

Mainly, the microcontroller is involving more at the sensor controlling part. The microcontroller will receive simple instruction from the host computer and decide which action will take base on the state of the PIR motion sensor. When the system on/off button is press, the host computer sends a “01” or “02” instruction to the microcontroller. The “01” instruction tell the microcontroller go into standby on state where once the PIR motion sensor is triggered, it will start power up the module, on the module RF and scan for RFID tag. In the other hand, the “02”instruction request the microcontroller go into off state where the system will not execute any scanning even sensor is triggered. Furthermore, as the microcontroller is switching the RF of the reader module, feedback signal will send from the module to host computer as a prove of RF turning on, then host computer will send “03”instruction to tell the microcontroller the RF of the module is successfully turn on and next operation can be carry out. Next, most of the LED lighting is controlled by the microcontroller as certain operation is carried out in it. This is to make the user easy to determine the condition of the system and also make the trouble shooting work easier.

The whole program flow of the microcontroller can be simplified into flow chart shown in Figure 4.15 and Figure 4.16.

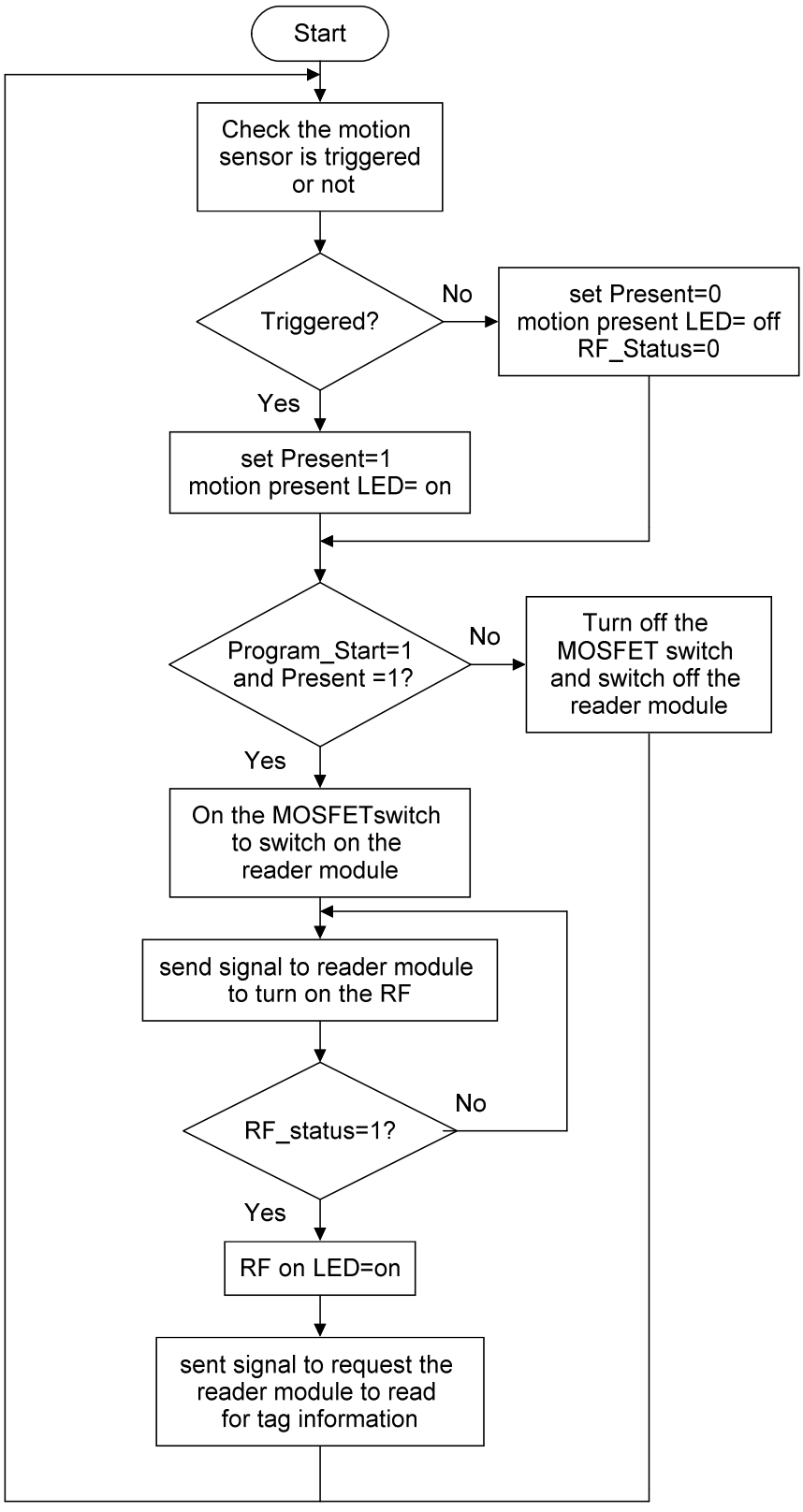


Figure 4.15: Microcontroller Main Program Flow Chart

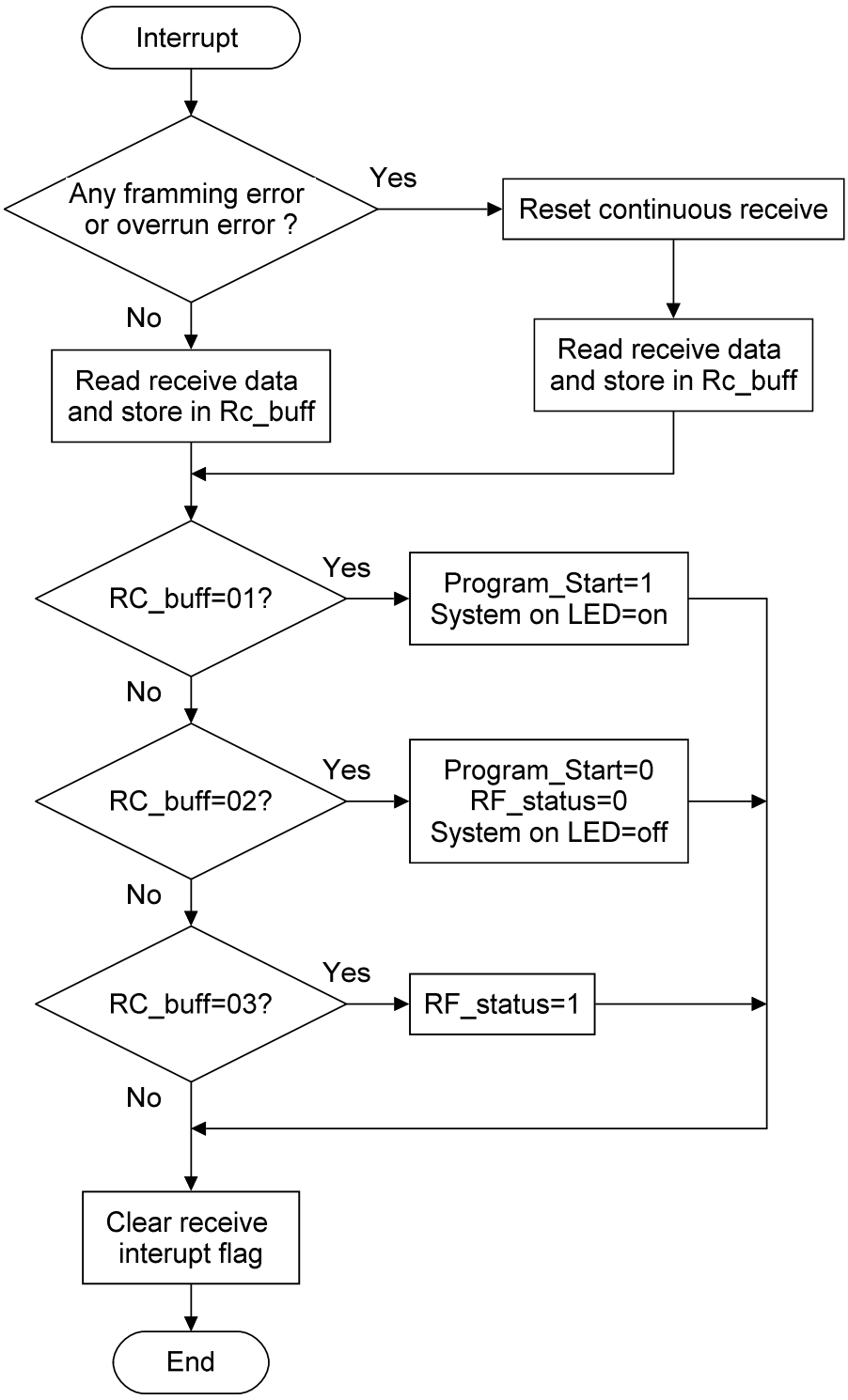


Figure 4.16: Microcontroller Signal Interrupt Section Flow Chart

As can see from the program flow chart, the microcontroller program can separate up to two sections. The First section is the main program which will loop through the process all the time. Another section is the interrupt service section which will be

execute once the receive interrupt flag of the microcontroller is triggered. In brief, the main program section is function to check through each status bit declare in the program and carry out certain operation accordingly, while interrupt program are mainly function to update the status bit in the microcontroller program once instruction is receive from host computer.

4.8 Overall Cost of System

In overall, the automated shopping checkout system designed in this project cost around RM411. The cost of the system considers low compare to other shopping checkout system available in current market which normally cost up to thousand of ringgit. Most of the cost of the system is spend on the RFID reader and converter module of this system. Some other electronic components such as resistors, capacitors, oscillator and many others are cost around RM50.00. The cost of some main components can be listed as following.

SL013 RFID Reader Module	RM250.00
PIC18F452 Microcontroller	RM 20.00
UC00A USB to UART converter	RM 58.00
PIR Motion Sensor	RM 33.00
Other electronic components	RM50.00

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Overview for Conclusion and Recommendation

The final section of this report will outline the final outcome obtained from this project. The limitation of the final product of this project and recommendation for possible future enhancements of current final product will also included in this section.

5.2 Conclusion

In conclusion, the aim and objective of this project which is design a low cost automated shopping checkout system using RFID technology that suitable for most shopping checkout application and compatible with conventional bar code system had been achieved.

Next, all the criteria's set up to meet up the standard of this project is also accomplished. Firstly, the automated shopping checkout system designed in this project is capable to read and interpret the correct information transmit from the RFID tag attach to checkout items. Secondly, the hardware unit of the automated shopping checkout system can successfully communicate with the host computer GUI program through serial communication. The microcontroller which is the core processing and control unit in the system hardware also manages to process the information and instructions from computer and delicate precise task to the RFID

reader module. The PIR motion sensor of the system hardware unit can also operate well as expected without much problem.

Moreover, the GUI program also work according to the expected performance which operate in 32 bits Microsoft XP, Microsoft Vista and Microsoft 7 operating system host computer with all requirement software installed. The program also able to accurately interpret the information and instruction from the system hardware unit and execute correct operation based on them. Lastly, retrieving and updating the information to the local host computer SQL database is also not a problem for the GUI program.

5.3 Limitation of Final Product

Even though the prototype final product of this project had been successfully carried, but there are still some limitations exist in it.

First of all, the automated shopping checkout system design in this project is still cannot support multiple RFID tag scanning which is a crucial criteria for efficient shopping checkout system. Subsequently, the automated shopping checkout system designed is still in sensitive in scanning RFID tag that mount on metal and high humidity material platform.

In addition, the UART serial communication that use as the primary signal communication method of this automated shopping checkout system is still lack of reliability. Lastly, the GUI program is districted to host computer with keyboard and mouse which consume quite some spacing.

All these limitations are the drawback for the final product designed in this project that makes this system far away from the standard of become a real time useful system in the market.

5.4 Recommendation for Future Enhancements

There are bunch of possible idea to enhance the current final product of this project to the next level which is more close to practical usage of the system.

At first, the current automated shopping checkout system can using a higher performance RFID reader module that support real time multiple RFID tag scanning. Through including this feature in the system, it enable the system to detect and scanning information of multiple tag at once which can be a huge improve in performance and also increase the practically usage of the system.

Instead of using asynchronous serial communication as primary communication method in this automated shopping checkout system, synchronous serial communication can provide higher data transfer reliability to the system in medium rage. Other than using hard wire, wireless communication can be the optional secondary transmission medium for longer range transmission between the hardware unit and host computer. This can probability removes the troublesome wiring problem of the system.

Finally, touch screen technology which is gaining popularity can be implementing at the host computer site to exclude the usage of mouse and keyboard. User can directly interact with the GUI program through touch screen for all the functions they want and on screen keyboard program can be implemented for section where input is text is needed. These not only save up a lot of space and also reduce the complexity of using the GUI program.

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APPENDICES

APPENDIX A: Coding For Microcontroller

```
#include <p18F452.h>
#include <usart.h>
#include <delays.h>

#pragma config WDT = OFF        //watchdog timer off
#pragma config LVP = OFF        // disable LVP
#pragma config PWRT = ON        // power up timer on
#pragma config OSC = HS

void InterruptHandlerHigh (void);
void InterruptHandlerLow (void);
void proc_rec(void);
void open_RF(void);
void open_Scan(void);

unsigned char rc_buff;
unsigned char discard;
unsigned char prog_start=0;
unsigned char RF_status=0;
unsigned char Present=0;

unsigned char RF_On[]={0xAA,0xBB,0x03,0x01,0x01,0x03};//command = AABB03010103
unsigned char Scan[]={0xAA,0xBB,0x02,0x10,0x12};    //command = AABB03010002

#pragma code InterruptVectorHigh = 0x08
void InterruptVectorHigh (void)
{
        _asm goto
        InterruptHandlerHigh //jump to interrupt routine
        _endasm
}
#pragma code

#pragma interrupt InterruptHandlerHigh
void InterruptHandlerHigh ()
{
        if (PIR1bits.RCIF)//if RCIF flag is triggered
        {
                if(RCSTAbits.OERR || RCSTAbits.FERR) //if framing error or overrun error
        {
```

```
            RCSTAbits.CREN = 0;                 //reset continuouse receive to fix overrun
error
                        rc_buff=ReadUSART();            //read RCREG to fix framing error
                        RCSTAbits.CREN = 1;
        }

       else     //if no error then read and store the data normally
                {
                        rc_buff=ReadUSART();
                }

                proc_rec();//process rec_buff data
                PIR1bits.RCIF=0;//reset the RCIF flag after read
        }
}

void main(void)
{
        unsigned char data[];
        int i;

        //initialize the microcontroller input and output setting
        TRISB = 0x02;
        PORTBbits.RB0=0;
        PORTBbits.RB2=0;
        PORTBbits.RB3=0;
        PORTBbits.RB4=0;

        INTCONbits.RBIF = 0; //make sure the RBIF is reset at start

        // Configure USART
        OpenUSART( USART_TX_INT_OFF &
        USART_RX_INT_ON &
        USART_ASYNCH_MODE &
        USART_EIGHT_BIT &
        USART_CONT_RX &
        USART_BRGH_LOW,7 );


        RCONbits.IPEN = 1;      //Enable interrupt priority
        INTCONbits.GIEH = 1; //Enable all high priority interrupts

        //Setting up the UART receive interrupt flag
        IPR1bits.RCIP = 1; //Make receive interrupt high priority
        INTCONbits.PEIE = 1; //Enables all peripheral interrupts

        PORTBbits.RB5=1;        //on PORTB RB5 to indicate system is power up

        while(1)
        {
                switch (PORTBbits.RB1) //check for sensor signal input
                        {
                                case 1: Present=1;//if sensor triggered, set present=1
                                                PORTBbits.RB4=1;//light up the motion
present LED
                                                break;
                                case 0: Present=0;//if sensor is not triggered,set
present=0
```

```
                                        PORTBbits.RB4=0; //turn off motion present
LED
                                        RF_status=0;//set RF_Status=0
                                        break;
                        }

                if (prog_start==1 && Present==1)//Detemine is program_Start and Present is
equal 1
                {
                        PORTBbits.RB0=1; //on supply to the module

                        while(!RF_status) //do while RF_status=0
                        {
                                open_RF();      //call sub function open_RF()
                        }

                        open_Scan();//call sub function open_Scan()
                }

                else
                {
                        PORTBbits.RB0=0;//off suppply to module
                }

                switch (RF_status) //check RF_status
                        {
                                case 1: PORTBbits.RB2=1; //light up RF on LED if equal 1
                                        break;
                                case 0: PORTBbits.RB2=0; //turn off RF on LED if equal 0
                                        break;
                        }


        }

        //CloseUSART();

}


void proc_rec(void)//check the rec_data range and content
{
        if (rc_buff>0x00 && rc_buff <=0x09)//check received data in range?
                {
                        switch (rc_buff) //check rc_buff content
                        {
                                case 0x01: prog_start=1; //if rc_buff=0x01 then set
prog_start=1
                                           PORTBbits.RB3=1;
                                           break;
                                case 0x02: prog_start=0; //if rc_buff=0x02 then set
prog_start=0
                                           PORTBbits.RB3=0;
                                           RF_status=0; //reset the RF_status
memory
                                           break;
                                case 0x03: RF_status=1; //set RF_status=1
                        }
                }
```

```
}

void open_RF(void)//send the RF on command to module
{
        int i;

        for (i=0; i<= ((sizeof RF_On)-1); i++)
        {
                while( BusyUSART() );
                WriteUSART( RF_On[i]);
        }
        Delay10KTCYx( 300 );

}

void open_Scan(void)//send the scan command to module
{
        int i;

        for (i=0; i<= ((sizeof Scan)-1); i++)
        {
                while( BusyUSART() );
                WriteUSART( Scan[i]);
        }
        Delay10KTCYx( 300 );

}
```

APPENDIX B: Coding For GUI Program

Main Menu Form of GUI

```
Private SQL_DA As SqlDataAdapter
    Private Dataset As New DataSet
    Private SQL_select As String

    Public Shared Login_User As String

    Delegate Sub SetTextCallback(ByVal [text] As String)


'#############################################################################################
    ' Form Control Section
'#############################################################################################

    'Form_1 load
    Public Sub Form1_Load(ByVal sender As Object, ByVal e As System.EventArgs) Handles
Me.Load

        '-------------------------------------------------------------------------------
        'Request log in when form load
        '-------------------------------------------------------------------------------
        Call Show_Form2()

        '-------------------------------------------------------------------------------
        'setup the tooltip parameter
        '-------------------------------------------------------------------------------
        explain_text.AutoPopDelay = 5000
        explain_text.InitialDelay = 1000
        explain_text.ReshowDelay = 500

        explain_text.ShowAlways = True

        explain_text.SetToolTip(Btn_SysOn, "Press to On/Off the System")
        explain_text.SetToolTip(BtnRemove_Item, "Press to remove the selected item from
list")

        '-------------------------------------------------------------------------------
        'setup the Datagridview parameter
        '-------------------------------------------------------------------------------
        With DataGridView1
            .Name = "Purchase List"
            .AutoSizeRowsMode = DataGridViewAutoSizeRowsMode.DisplayedCellsExceptHeaders
            .ColumnHeadersBorderStyle = DataGridViewHeaderBorderStyle.Single
            .CellBorderStyle = DataGridViewCellBorderStyle.Single
            .GridColor = Color.Black
```

```
            .RowHeadersVisible = True
            .SelectionMode = DataGridViewSelectionMode.FullRowSelect
            .MultiSelect = False
        End With

        '-------------------------------------------------------------------------------
        'Set database connection and parameter
        '-------------------------------------------------------------------------------
        SQL_connector.ConnectionString = "Data Source=.\SQLEXPRESS;AttachDbFilename=C:\My
Stock.mdf;Integrated Security=True;Connect Timeout=30;User Instance=True"


        '-------------------------------------------------------------------------------
        'Set timer parameter
        '-------------------------------------------------------------------------------
        Timer1.Enabled = True
        Timer1.Interval = 500
        AddHandler Timer1.Tick, AddressOf TimerEventHandler

    End Sub

    'Show login form
    Private Sub Show_Form2()

        If Login_form.ShowDialog() = DialogResult.OK Then
            Call Admin_Unlock()
        Else
            Call Admin_lock()
        End If
    End Sub

    'Prompt exit confirmation msg
    Private Sub Form_FormClosing(ByVal sender As Object, ByVal e As
System.Windows.Forms.FormClosingEventArgs) Handles Me.FormClosing

        Dim response As MsgBoxResult

        'Make confirmation about the
        response = MsgBox("Do you confirm want to close?", MsgBoxStyle.Question +
MsgBoxStyle.YesNo, "Confirm")

        'if choose "Yes" then exit"
        If response = MsgBoxResult.Yes Then

            'if the system still on then switch it off before exit
            If Btn_SysOn.Text = "SYSTEM ON" Then
                Call Send_command("SYS_OFF")
            End If

            'pause for 0.5 second before close COM port
            System.Threading.Thread.Sleep(500)

            'close the port before exit
            Serial_Port_1.Close()
            'close the database connection before exit

            'exit form
            Me.Dispose()
```

```
            'if choose "No" then cancel"
        ElseIf response = MsgBoxResult.No Then
            e.Cancel = True
            Exit Sub
        End If

    End Sub

    '<System on/off> button
    Private Sub Btn_SysOn_Click_1(ByVal sender As System.Object, ByVal e As
System.EventArgs) Handles Btn_SysOn.Click

        'call to control the RF on/off sub function
        If Btn_SysOn.Text = "SYSTEM ON" Then

            'clear the seriel port input and output buffer before close the system
            If detect Then
                Serial_Port_1.DiscardInBuffer()
                Serial_Port_1.DiscardOutBuffer()
            End If

            Call Send_command("SYS_OFF")
            Btn_SysOn.Text = "SYSTEM OFF"
        Else
            Call Send_command("SYS_ON")
            Btn_SysOn.Text = "SYSTEM ON"
        End If

    End Sub

    '<Delete Item> button
    Private Sub BtnRemove_Item_Click_1(ByVal sender As System.Object, ByVal e As
System.EventArgs) Handles BtnRemove_Item.Click

        If DataGridView1.Rows.Count <> 0 Then
            Dim RowToDelete As Integer =
DataGridView1.Rows.GetFirstRow(DataGridViewElementStates.Selected)

            Total_Price = Total_Price -
CDbl(Val(DataGridView1.Rows(RowToDelete).Cells(2).Value))
            Update_textbox3(Format(Total_Price, "0.00"))

            If RowToDelete > -1 Then
                DataGridView1.Rows.RemoveAt(RowToDelete)
            End If
        Else
            Exit Sub
        End If

    End Sub

    '<Show stock status> button
    Private Sub Btn_ViewStock_Click_1(ByVal sender As System.Object, ByVal e As
System.EventArgs) Handles Btn_ViewStock.Click
        ViewStock_form.ShowDialog()
    End Sub
```

```
    '<Paybill> button
    Private Sub btn_paybill_Click_1(ByVal sender As System.Object, ByVal e As
System.EventArgs) Handles btn_paybill.Click

        Dim Tag As String
        Dim Pay_response As MsgBoxResult

        Pay_response = MsgBox("Total Price of Purchase:RM " & TextBox3.Text,
MsgBoxStyle.SystemModal + MsgBoxStyle.YesNo, "Confirm")

        If Pay_response = MsgBoxResult.Yes Then

            'open the database connection to load the database info to dataset
            Call Open_SQLcon()

            Dataset = New DataSet
            SQL_select = "SELECT * FROM tbl_Stock WHERE tbl_Stock.[Product Status]='In'"
            SQL_command = New SqlCommand(SQL_select, SQL_connector)
            SQL_DA = New SqlDataAdapter(SQL_command)
            SQL_DA.Fill(Dataset, "Stock")

            For Row_inc As Integer = 0 To (DataGridView1.RowCount - 1)
                For i As Integer = 0 To (Dataset.Tables("Stock").Rows.Count - 1)
                    If (Dataset.Tables("Stock").Rows(i).Item("Tag ID")) =
DataGridView1.Rows(Row_inc).Cells(0).Value Then
                        Tag = (Dataset.Tables("Stock").Rows(i).Item("Tag ID"))
                        SQL_command = New SqlCommand("UPDATE tbl_Stock SET
tbl_Stock.[Product Status]='Out' WHERE tbl_Stock.[Tag ID]='" & Tag & "'", SQL_connector)
                        SQL_command.ExecuteNonQuery()
                    End If
                Next
            Next

            Call Close_SQLcon()

            Me.DataGridView1.Rows.Clear()
            Total_Price = Nothing
            TextBox3.Text = Nothing

        ElseIf Pay_response = MsgBoxResult.No Then
            Exit Sub
        End If



    End Sub

    '<Login> button
    Private Sub Btn_Login_Click_1(ByVal sender As System.Object, ByVal e As
System.EventArgs) Handles Btn_Login.Click

        If Btn_Login.Text = "LOG IN" Then
            Call Show_Form2()
        Else
            Login_User = Nothing
            Label5.Text = Login_User
            Call Admin_lock()
        End If
    End Sub
```

```
    '<Add login> button
    Private Sub btn_Adduser_Click(ByVal sender As System.Object, ByVal e As
System.EventArgs) Handles btn_Adduser.Click
        AddLogin_form.ShowDialog()
    End Sub

    '#UPDATE#  textbox 1
    Private Sub Update_textbox1(ByVal [text] As String)
        If TextBox1.InvokeRequired Then
            Dim Temp As New SetTextCallback(AddressOf Update_textbox1)
            Invoke(Temp, New Object() {[text]})
        Else
            TextBox1.Text = [text]
        End If
    End Sub

    '#UPDATE# textbox 2
    Private Sub Update_textbox2(ByVal [text] As String)
        If TextBox2.InvokeRequired Then
            Dim Temp As New SetTextCallback(AddressOf Update_textbox2)
            Invoke(Temp, New Object() {[text]})
        Else
            TextBox2.Text = [text]
        End If
    End Sub

    '#UPDATE# textbox 3
    Private Sub Update_textbox3(ByVal [text] As String)
        If TextBox3.InvokeRequired Then
            Dim Temp As New SetTextCallback(AddressOf Update_textbox2)
            Invoke(Temp, New Object() {[text]})
        Else
            TextBox3.Text = [text]
        End If
    End Sub

    '#UPDATE#  Datagrid row num
    Private Sub Auto_Row_Numbering(ByVal sender As System.Object, ByVal e As
System.EventArgs) Handles DataGridView1.RowsAdded, DataGridView1.RowsRemoved

        Dim RowNumber As Integer = 1

        For Each Row As DataGridViewRow In DataGridView1.Rows
            If Row.IsNewRow Then Continue For
            Row.HeaderCell.Value = RowNumber.ToString
            RowNumber = RowNumber + 1
        Next

    End Sub

    'Match the detected tag id with database and display datagridview
    Private Sub Match_Display(ByVal Receive_ID As String)

        Call Open_SQLcon()

        'open the database connection to load the database info to dataset
        Dataset = New DataSet
        SQL_select = "SELECT * FROM tbl_Stock WHERE tbl_Stock.[Product Status]='In'"
        SQL_command = New SqlCommand(SQL_select, SQL_connector)
```

```
        SQL_DA = New SqlDataAdapter(SQL_command)
        SQL_DA.Fill(Dataset, "Stock")

        Call Close_SQLcon()

        'scan through the ID colunm to check the match ID
        For Row_Inc = 0 To ((Dataset.Tables("Stock").Rows.Count) - 1)
            If Receive_ID = (Dataset.Tables("Stock").Rows(Row_Inc).Item("Tag ID")) Then

                'if the item already in the list then exit sub without add the item in list
                For i As Integer = 0 To (DataGridView1.RowCount - 1)
                    If Receive_ID = DataGridView1.Rows(i).Cells(0).Value Then
                        Exit Sub
                    End If
                Next

                If DataGridView1.InvokeRequired Then
                    Dim Temp As New SetTextCallback(AddressOf Match_Display)
                    Invoke(Temp, New Object() {Receive_ID})
                Else
                    DataGridView1.Rows.Add(Dataset.Tables("Stock").Rows(Row_Inc).Item("Tag
ID"), _

Dataset.Tables("Stock").Rows(Row_Inc).Item("Product Name"), _

Dataset.Tables("Stock").Rows(Row_Inc).Item("Product Price"))
                    Total_Price = Total_Price +
CDbl(Val(Dataset.Tables("Stock").Rows(Row_Inc).Item("Product Price")))
                    Call Beep()
                    Update_textbox3(Format(Total_Price, "0.00"))
                End If
            End If
        Next Row_Inc


    End Sub

    'lock control if no device connected
    Private Sub Offline_Lock()
        'lock all other button other than those in initialize setting, except <Check
Connectivity>
        Btn_SysOn.Text = "SYSTEM OFF"
        Btn_SysOn.Enabled = False
    End Sub

    'unlock control if device connected
    Private Sub Offline_Unlock()
        If Login_status = True Then
            Btn_SysOn.Enabled = True
        End If
    End Sub

    'lock certain control if no admind login
    Private Sub Admin_Unlock()

        Btn_Login.Text = "LOG OUT"
        Login_status = True
        Label5.Text = Login_User
```

```
    If detect = True Then
        Btn_SysOn.Enabled = True
    End If

    BtnRemove_Item.Enabled = True
    Btn_ViewStock.Enabled = True
    btn_Adduser.Enabled = True

End Sub

'unlock control if admind login
Private Sub Admin_lock()

    Btn_Login.Text = "LOG IN"
    Login_status = False
    Btn_SysOn.Enabled = False
    BtnRemove_Item.Enabled = False
    Btn_ViewStock.Enabled = False
    btn_Adduser.Enabled = False

End Sub

'check for device connectivity
Private Sub Connectivity_Checker()

    Dim ports_detect As String() = SerialPort.GetPortNames()
    Dim port As String

    'Check the available port detected for "COM10"
    For Each port In ports_detect
        If port = "COM10" Then
            detect = True
            Exit For
        Else
            detect = False
        End If
    Next port

    'selection case for detect variable
    Select Case detect
        Case True
            'make sure the port is really close
            If Serial_Port_1.IsOpen = False Then
                Try
                    With Serial_Port_1
                        .PortName = "COM10"         'Portname call "COM10"
                        .BaudRate = 19200           'Baudrate is 19200
                        .DataBits = 8               'Databit is 8bits
                        .StopBits = StopBits.One    'Stopbit is one
                        .Parity = Parity.None       'No parity
                        .ReadTimeout = 300          'Data read timeout is 300ms
                    End With
                    Serial_Port_1.Open()

                Catch ex As Exception
                    MsgBox(ex.Message)
                End Try
            End If
```

```
            Label2.Text = "Connected"
            Call Offline_Unlock()

        Case False
            Label2.Text = "Disconnected"
            Call Offline_Lock()
        Case Else
            MsgBox("Error in detect variable")
    End Select

End Sub

'Translate the string commnad to hex string command array
Public Function command_translate(ByVal command As String)

    Dim hex_command As String

    Select Case command
        Case "SYS_ON"    'if command is "SYS_ON", set the hex_command to 01
            hex_command = "01"
        Case "SYS_OFF"    'if command is "SYS_OFF", set the hex_command to 02
            hex_command = "02"
        Case "RF_SUCCESS"    'if command is "RF_SUCCESS" , set the hex_command to 03
            hex_command = "03"
        Case Else
            hex_command = Nothing
    End Select

    Return hex_command

End Function

'Decode feedback signal and take feedback action
Public Sub Decode_feedback(ByVal Feedback As String)

    Select Case Feedback

        Case "AABB03010002"
            Call Send_command("RF_SUCCESS")

        Case "AABB0301FF02"
            MsgBox("Fail to control RF")

        Case Else
            Exit Sub

    End Select

End Sub

'Check for feedback signal format
Public Function Format_Checker(ByVal return_code As String)

    Dim Char_Counter As Integer
    Dim Char_Array() As Char
    Dim Feeback_Header As String = Nothing

    Char_Array = return_code.ToCharArray
```

```
        'Iterate through the string.
        If return_code.Length >= 4 Then
            For Char_Counter = 0 To 3
                Feeback_Header = Feeback_Header + Char_Array(Char_Counter)
            Next
        End If

        If Feeback_Header = "AABB" Then
            Return True
        Else
            Return False
        End If

    End Function


'###########################################################################################
    'Serial port control section
'###########################################################################################

    'Send command signal through COM10
    Public Sub Send_command(ByVal command As String)

        Dim transmit_buffer() As Byte

        Hex_command = command_translate(command)

        'if command corrupt then ignore the command
        If Hex_command = Nothing Then
            Exit Sub
        Else
            transmit_buffer = convert_byte(Hex_command)
        End If

        If Serial_Port_1.IsOpen Then
            Try
                'Write this data to port
                Serial_Port_1.Write(transmit_buffer, 0, transmit_buffer.Length)

            Catch ex As Exception
                MsgBox(ex.Message)
            End Try
        Else
            MsgBox("The system connection is lose")
        End If

    End Sub

    'Convert the Hex command to byte
    Private Function convert_byte(ByVal Hex_char As String)

        'remove any spaces from the string
        Hex_char = Hex_char.Replace(" ", "")

        If Hex_char.Length Mod 2 <> 0 Then
            Hex_char = "0" + Hex_char
        End If

        'create a byte array the length of the divided by 2 (Hex is 2 characters in length)
```

```
    Dim combuffer As Byte() = New Byte(Hex_char.Length / 2 - 1) {}

    For i As Integer = 0 To Hex_char.Length - 1 Step 2
        Try
            'convert the hex character to byte and store in combuffer
            combuffer(i / 2) = CByte(Convert.ToByte(Hex_char.Substring(i, 2), 16))
        Catch ex As Exception
            MsgBox(ex.Message)
        End Try
    Next

    Convert_status = True

    '-------------------------------------------------------------------------
    'check for the convertion accuracy
    '-------------------------------------------------------------------------
    Dim x As String = ""

    For i = 0 To (combuffer.Length - 1)
        x = x + combuffer(i).ToString
        If i <> (combuffer.Length - 1) And x <> "" Then
            x = x + ", "
        End If
    Next

    Try
        Update_textbox1(x)
    Catch ex As Exception
        MsgBox("display fail")
    End Try


    '-------------------------------------------------------------------------

    'return the combuffer array
    Return combuffer

End Function

'Convert the byte array back to Hex string
Private Function convert_hex(ByVal Hex_byte As Byte())

    Dim hex_char As String = ""

    For Each byte_data As Byte In Hex_byte

        Dim Temp_store As String = Convert.ToString(byte_data, 16)

        If Temp_store.Length = 1 Then
            Temp_store = "0" + Temp_store
        End If

        hex_char = hex_char + Temp_store

    Next

    Return hex_char.ToUpper

End Function
```

```
    'Trigger this function when the COM10 seriel port receive any data
    Public Sub Receiver(ByVal sender As Object, ByVal e As SerialDataReceivedEventArgs)
Handles Serial_Port_1.DataReceived


        Dim read_byte As Integer = 11
        Dim receive_buffer As Byte() = New Byte(read_byte - 1) {}
        Dim return_hex_code As String = ""
        Dim Format_Identify As Boolean = Nothing
        Dim Tag_ID As String = Nothing
        Dim Return_Comm As String

        Try
            Serial_Port_1.Read(receive_buffer, 0, read_byte)
            System.Threading.Thread.Sleep(100)

        Catch ex As Exception
            MsgBox(ex.Message)
        End Try

        'convert the receive data from byte to ASCII hex
        return_hex_code = convert_hex(receive_buffer)

        'check for the return_hex_code header
        Format_Identify = Format_Checker(return_hex_code)

        If Format_Identify = True Then
            Return_Comm = return_hex_code.Substring(6, 2)

            Select Case (Return_Comm)

                Case "01"
                    return_hex_code = return_hex_code.Substring(0, 12)
                    Try
                        Call Decode_feedback(return_hex_code)
                    Catch ex As Exception
                        MsgBox(ex.Message)
                    End Try

                Case "10"
                    Tag_ID = return_hex_code.Substring(10, 8)
                    Call Match_Display(Tag_ID)

            End Select
        End If

    End Sub

    'Trigger this function to check connection status every time the timer1 is tick
    Private Sub TimerEventHandler(ByVal obj As Object, ByVal ergs As EventArgs)
        Call Connectivity_Checker()
    End Sub

    Private Sub Open_SQLcon()

        If SQL_connector.State = ConnectionState.Closed Then
            SQL_connector.Open()
        End If
```

```
    End Sub

    Private Sub Close_SQLcon()

        If SQL_connector.State = ConnectionState.Open Then
            SQL_connector.Close()
        End If

    End Sub


    Private Sub Panel1_Paint(ByVal sender As System.Object, ByVal e As
System.Windows.Forms.PaintEventArgs) Handles Panel1.Paint

    End Sub
End Class
```

User Login Form

```
Imports System.Data.SqlClient

Public Class Form2


    Private SQL_connector As New SqlConnection
    Private SQL_command As New SqlCommand
    Private SQL_DA As SqlDataAdapter
    Private Dataset As New DataSet
    Private SQL_select As String

    Private Ref_pass As String = Nothing
    Private Max_row As Integer

    'Form_2 load
    Private Sub Form2_Load(ByVal sender As System.Object, ByVal e As System.EventArgs)
Handles MyBase.Load
        'TODO: This line of code loads data into the 'My_StockDataSet.tbl_Admin' table. You
can move, or remove it, as needed.
        Me.Tbl_AdminTableAdapter.Fill(Me.My_StockDataSet.tbl_Admin)
        '------------------------------------------------------------------------------
        'Bind the database admin ID to combo box
        '------------------------------------------------------------------------------
        'TODO: This line of code loads data into the 'My_StockDataSet.tbl_Admin' table. You
can move, or remove it, as needed.
        Me.Tbl_AdminTableAdapter.Fill(Me.My_StockDataSet.tbl_Admin)

        '------------------------------------------------------------------------------
        'Set database connection and parameter
        '------------------------------------------------------------------------------
        SQL_connector.ConnectionString = "Data Source=.\SQLEXPRESS;AttachDbFilename=C:\My
Stock.mdf;Integrated Security=True;Connect Timeout=30;User Instance=True"

        SQL_connector.Open()
```

```
        'open the database connection to load the database info to dataset
        Dataset = New DataSet
        SQL_select = "SELECT * FROM tbl_Admin"
        SQL_command = New SqlCommand(SQL_select, SQL_connector)
        SQL_DA = New SqlDataAdapter(SQL_command)
        SQL_DA.Fill(Dataset, "ID")

        SQL_connector.Close()

        '-------------------------------------------------------------------------------
        'Initialize set up
        '-------------------------------------------------------------------------------
        Call Clear_txb()
        Ref_pass = Nothing
        cbx_ID.Text = Nothing
        Max_row = Dataset.Tables("ID").Rows.Count

    End Sub

    '<ok> button click
    Private Sub btn_ok_Click(ByVal sender As System.Object, ByVal e As System.EventArgs)
Handles btn_ok.Click

        If tbx_pass.Text = Nothing Or cbx_ID.Text = Nothing Then
            MsgBox("Please key in the password to log in!!!")
            Exit Sub
        Else

            If tbx_pass.Text = Ref_pass Then
                Form1.Login_User = cbx_ID.Text
                Call Clear_txb()
                Me.DialogResult = DialogResult.OK
            Else
                MsgBox("Incorrect password!!!")
                Call Clear_txb()
                Exit Sub
            End If
        End If

    End Sub

    '<Cancel> button click
    Private Sub btn_Cancel_Click(ByVal sender As System.Object, ByVal e As
System.EventArgs) Handles btn_Cancel.Click
        Me.DialogResult = DialogResult.Cancel
    End Sub

    'clear text box
    Private Sub Clear_txb()
        Me.tbx_pass.Text = Nothing
    End Sub

    'Trigger when item is selected from combo box
    Private Sub cbx_ID_SelectedIndexChanged(ByVal sender As System.Object, ByVal e As
System.EventArgs) Handles cbx_ID.SelectedIndexChanged

        Dim Row_count As Integer
```

```
        If Max_row = 1 Then
            Ref_pass = (Dataset.Tables("ID").Rows(0).Item("Password")).ToString
        Else
            For Row_count = 0 To (Max_row - 1)
                If cbx_ID.Text = (Dataset.Tables("ID").Rows(Row_count).Item("Admin_ID"))
Then
                    Ref_pass =
(Dataset.Tables("ID").Rows(Row_count).Item("Password")).ToString
                End If
            Next
        End If


    End Sub

End Class
```

View Stock Form

```
Imports System.Data.SqlClient
Public Class Form3

    Private SQL_connector As New SqlConnection
    Private SQL_command As New SqlCommand
    Private SQL_DA As SqlDataAdapter
    Private Dataset As New DataSet
    Private SQL_select As String

    'Form_3 load
    Private Sub Form3_Load(ByVal sender As System.Object, ByVal e As System.EventArgs)
Handles MyBase.Load


        '-------------------------------------------------------------------------------
        'setup the Datagridview parameter
        '-------------------------------------------------------------------------------
        With Me.DataGridView1
            .Name = "Stock List"
            .AutoSizeRowsMode = DataGridViewAutoSizeRowsMode.DisplayedCellsExceptHeaders
            .ColumnHeadersBorderStyle = DataGridViewHeaderBorderStyle.Single
            .CellBorderStyle = DataGridViewCellBorderStyle.Single
            .GridColor = Color.Black
            .SelectionMode = False
            .MultiSelect = False
            .Rows.Clear()
        End With

        '-------------------------------------------------------------------------------
        'Set database connection and parameter
        '-------------------------------------------------------------------------------
        SQL_connector.ConnectionString = "Data Source=.\SQLEXPRESS;AttachDbFilename=C:\My
Stock.mdf;Integrated Security=True;Connect Timeout=30;User Instance=True"
```

```
        '-------------------------------------------------------------------------------
        'Load the in stock item list when first load the form
        '-------------------------------------------------------------------------------
        Call Show_Stock()

    End Sub

    '<Keep Stock> button click
    Private Sub btn_Keepstock_Click_1(ByVal sender As System.Object, ByVal e As
System.EventArgs) Handles btn_Keepstock.Click
        Me.DataGridView1.Rows.Clear()
        Call Show_Stock()
    End Sub

    '<Check Out> button click
    Private Sub btn_COStock_Click_1(ByVal sender As System.Object, ByVal e As
System.EventArgs) Handles btn_COStock.Click
        Me.DataGridView1.Rows.Clear()
        Call Check_Out()
    End Sub

    '<Exit>button click
    Private Sub btn_exit_Click_1(ByVal sender As System.Object, ByVal e As
System.EventArgs) Handles btn_exit.Click
        Me.DialogResult = DialogResult.Cancel
    End Sub

    'Show keep_stock to datagrid
    Private Sub Show_Stock()

        SQL_connector.Open()
        'open the database connection to load the database info to dataset
        Dataset = New DataSet
        SQL_select = "SELECT * FROM tbl_Stock WHERE tbl_Stock.[Product Status]='In'"
        SQL_command = New SqlCommand(SQL_select, SQL_connector)
        SQL_DA = New SqlDataAdapter(SQL_command)
        SQL_DA.Fill(Dataset, "Stock")

        For Row_count = 0 To ((Dataset.Tables("Stock").Rows.Count) - 1)
            Me.DataGridView1.Rows.Add(Dataset.Tables("Stock").Rows(Row_count).Item("Tag
ID"), _

Dataset.Tables("Stock").Rows(Row_count).Item("Product Name"), _

Dataset.Tables("Stock").Rows(Row_count).Item("Product Price"), _

Dataset.Tables("Stock").Rows(Row_count).Item("Product Status"))
        Next
        SQL_connector.Close()
    End Sub

    ''Show Checkout_stock to datagrid
    Private Sub Check_Out()
        SQL_connector.Open()
        'open the database connection to load the database info to dataset
        Dataset = New DataSet
        SQL_select = "SELECT * FROM tbl_Stock WHERE tbl_Stock.[Product Status]='Out'"
        SQL_command = New SqlCommand(SQL_select, SQL_connector)
        SQL_DA = New SqlDataAdapter(SQL_command)
```

```
        SQL_DA.Fill(Dataset, "Stock")

        For Row_count = 0 To ((Dataset.Tables("Stock").Rows.Count) - 1)
            Me.DataGridView1.Rows.Add(Dataset.Tables("Stock").Rows(Row_count).Item("Tag
ID"), _

Dataset.Tables("Stock").Rows(Row_count).Item("Product Name"), _

Dataset.Tables("Stock").Rows(Row_count).Item("Product Price"), _

Dataset.Tables("Stock").Rows(Row_count).Item("Product Status"))
        Next
        SQL_connector.Close()

    End Sub

End Class
```

Add/Remove Access User Form

```
Imports System.Data.SqlClient

Public Class Form4

    Private SQL_connector As New SqlConnection
    Private SQL_command As New SqlCommand
    Private SQL_DA As SqlDataAdapter
    Private Dataset As New DataSet
    Private SQL_select As String

    Private Selected_ID As String
    Private Master_pass As String = "1234"

    Private Sub Form4_Load(ByVal sender As System.Object, ByVal e As System.EventArgs)
Handles MyBase.Load
        'TODO: This line of code loads data into the 'My_StockDataSet.tbl_Admin' table. You
can move, or remove it, as needed.
        Me.Tbl_AdminTableAdapter.Fill(Me.My_StockDataSet.tbl_Admin)

        pnl_addID.Visible = True
        pnl_RomoveID.Visible = False

        SQL_connector.ConnectionString = "Data Source=.\SQLEXPRESS;AttachDbFilename=C:\My
Stock.mdf;Integrated Security=True;Connect Timeout=30;User Instance=True"
        cbx_f4_adminID.Text = Nothing

    End Sub

    '<ADD NEW ID> button click
    Private Sub btn_addID_Click_1(ByVal sender As System.Object, ByVal e As
System.EventArgs) Handles btn_addID.Click
        If pnl_addID.Visible = False Then
            pnl_RomoveID.Visible = False
            pnl_addID.Visible = True
        End If
```

```
    End Sub

    '<DELETE ID> button click
    Private Sub btn_delID_Click_1(ByVal sender As System.Object, ByVal e As
System.EventArgs) Handles btn_delID.Click
        If pnl_RomoveID.Visible = False Then
            pnl_addID.Visible = False
            pnl_RomoveID.Visible = True
        End If
    End Sub

    '<EXIT> button click
    Private Sub btn_f4_exit_Click(ByVal sender As System.Object, ByVal e As
System.EventArgs) Handles btn_f4_exit.Click
        Me.DialogResult = DialogResult.Cancel
    End Sub

    '<REMOVE-CONFIRM> button click
    Private Sub btn_f4_rom_ok_Click(ByVal sender As System.Object, ByVal e As
System.EventArgs) Handles btn_f4_rom_ok.Click

        If Selected_ID = Form1.Login_User Then
            MsgBox("The Admin user is currently in use, please log in with other user to
proceed!!")
            Exit Sub
        End If

        If Selected_ID = Nothing Then
            MsgBox("ERROR!!")
            Exit Sub
        End If

        If tbx_masterID.Text = Master_pass Then

            Dim Confirmation_msg As MsgBoxResult
            Confirmation_msg = MsgBox("Do you confirm want delete the user?",
MsgBoxStyle.Question + MsgBoxStyle.YesNo, "Confirm")

            If Confirmation_msg = MsgBoxResult.Yes Then

                SQL_connector.Open()

                Dataset = New DataSet
                SQL_select = "SELECT * FROM tbl_Admin"
                SQL_command = New SqlCommand(SQL_select, SQL_connector)
                SQL_DA = New SqlDataAdapter(SQL_command)
                SQL_DA.Fill(Dataset, "ID")

                If (Dataset.Tables("ID").Rows.Count) = 1 Then
                    MsgBox("This is the last user ID, cannot be romoved")
                    Exit Sub
                Else

                    For i As Integer = 0 To ((Dataset.Tables("ID").Rows.Count) - 1)
                        If (Dataset.Tables("ID").Rows(i).Item("Admin_ID")) = Selected_ID
Then
                            SQL_command = New SqlCommand("DELETE FROM tbl_Admin WHERE
tbl_Admin.[Admin_ID]='" & Selected_ID & "'", SQL_connector)
                            SQL_command.ExecuteNonQuery()
```

```
                        MsgBox("The user is succesfully removed")
                    End If
                Next

                SQL_connector.Close()
                Call Clear_MP()
            End If

        ElseIf Confirmation_msg = MsgBoxResult.No Then
            Call Clear_MP()
            Exit Sub
        End If
        Else
            MsgBox("Please input the correct Master password!!")
            Call Clear_MP()
            Exit Sub

        End If


    End Sub

    '<REMOVE-CANCEL> button click
    Private Sub Button3_Click(ByVal sender As System.Object, ByVal e As System.EventArgs)
Handles Button3.Click
        Call Clear_MP()
    End Sub

    '<ADD-CONFIRM> button click
    Private Sub btn_f4_add_ok_Click(ByVal sender As System.Object, ByVal e As
System.EventArgs) Handles btn_f4_add_ok.Click

        Dim Admin_ID As String = tbx_AdminID.Text
        Dim password As String = tbx_pass.Text

        If Check_Fill Then

            SQL_connector.Open()

            SQL_command = New SqlCommand("INSERT INTO tbl_Admin (Admin_ID,Password) VALUES
('" & Admin_ID & "', '" & password & "')", SQL_connector)
            SQL_command.ExecuteNonQuery()

            SQL_connector.Close()
            MsgBox("New user is succesfully inserted into the record")
            Call Clear_Add_ALL()

        Else
            Call Clear_Add_ALL()
            Exit Sub
        End If

    End Sub

    '<ADD-CANCEL> button click
    Private Sub btn_f4_add_cancel_Click(ByVal sender As System.Object, ByVal e As
System.EventArgs) Handles btn_f4_add_cancel.Click
        Call Clear_MP()
    End Sub
```

```
    '@Triger@ whenever the admin id combobox selection change, the ID is load to the
Selected_ID
    Private Sub cbx_f4_adminID_SelectedIndexChanged(ByVal sender As System.Object, ByVal e
As System.EventArgs) Handles cbx_f4_adminID.SelectedIndexChanged
        Selected_ID = cbx_f4_adminID.Text
    End Sub

    '!CALL! to clear tbx_masterID text box
    Private Sub Clear_MP()
        tbx_masterID.Text = Nothing
    End Sub

    Private Sub Clear_Add_ALL()
        tbx_AdminID.Text = Nothing
        tbx_pass.Text = Nothing
        tbx_re_pass.Text = Nothing
        tbx_masterID_2.Text = Nothing
    End Sub


    Private Function Check_Fill()

        If tbx_AdminID.Text <> Nothing And tbx_pass.Text <> Nothing And tbx_re_pass.Text <>
Nothing And tbx_masterID_2.Text = Master_pass <> Nothing Then

            If tbx_masterID_2.Text = Master_pass Then

                For Each Character As Char In tbx_AdminID.Text
                    If Char.IsSymbol(Character) Then
                        MsgBox("Incorrect Input!!!")
                        Return False
                    End If
                Next

                For Each Character As Char In tbx_pass.Text
                    If Char.IsSymbol(Character) Or Char.IsWhiteSpace(Character) Then
                        MsgBox("Incorrect Input!!!")
                        Return False
                    End If
                Next

                If tbx_pass.Text = tbx_re_pass.Text Then
                    Return True
                Else
                    MsgBox("Incorrect password confirm!!!")
                    Return False
                End If

            Else
                MsgBox("Please fill in the Admin ID and Password!!!")
                Return False
            End If

        Else
            MsgBox("Please Key in the Master password!!!")
            Return False
        End If
```

```
    End Function

    Private Sub Panel2_Paint(ByVal sender As System.Object, ByVal e As
System.Windows.Forms.PaintEventArgs) Handles Panel2.Paint

    End Sub
End Class
```