BUS MONITORING SYSTEM (HARDWARE PART)

NASRUNG BIN NURBA

This thesis is submitted as partial fulfillment of the requirements for the award of the
Bachelor of Electrical Engineering (Control & Instrumentation)

Faculty of Electrical & Electronics Engineering
Universiti Malaysia Pahang

MAY, 2008

UNIVERSITI MALAYSIA PAHANG

BORANG PENGESAHAN STATUS TESIS♦

JUDUL: **BUS MONITORING SYSTEM (HARDWARE PART)**

SESI PENGAJIAN: 2007/2008

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ABSTRACT

Vehicle monitoring system has become very famous method in engineering field these days to monitor any types of break down, vehicle behavior, fuel consumption including safety and health and many more. Bus Monitoring System was the other types of vehicle monitoring system and categorized in public transport monitoring system. The purpose of this project is to monitor the movement of public bus in the road using RF communication system. Along the way of the destination of the bus, it will arrive at few bus stops. Each time the buses reach the bus stop the driver will send the bus ID to the bus stop using RF Transmitter. Then it will help the officer to record the bus ID from the bus stop and ensure that the bus follow the right destination. In order to make this process succeed, each bus stop must have its own RF receiver to collect the bus ID that was sends from the bus. Hence, the circuit design must consist of RF module, PIC microchip, matrix keypad and also LCD to display the output. There will be two hardware constructed for this project which called transmitter board and receiver board. Transmitter board will be plugged in inside the bus and receiver board is placed at the bus stop in a safe area. Both hardware must have main control panel such as microcontroller or other microprocessors to ensure all the process in both side run smoothly.

ABSTRAK

Sistem pemantauan kenderaan telah menjadi sangat popular dan merupakan antara kaedah utama yang di gunakan dalam bidang kejuruteraan untuk memantau sebarang masalah ataupun kerosakan yg berlaku pada kenderaan, kehabisan bahan api dan juga di gunakan untuk keselamatan seperti pemantauan kondisi kenderaan sama ada berstatus baik ataupun tidak. Selain itu banyak lagi aplikasi lain yang menggunakan kaedah ini. Pemantaun pergerakan bas awam adalah salah satu kaedah yang di gunakan oleh syarikat-syarikat bas pada masa kini untuk memantau pergerakan bus mereka di dalam perjalanan. Caranya adalah semua pemandu bas perlu menghantar ID bas mereka ke setiap perhentian bus yang mereka lalui sepanjang perjalanan menuju ke destinasi terakhir . Cara ini dilaksanakan menggunakan sistem perhubungan frekuensi radio. Oleh itu setiap bas perlu mempunyai litar lengkap mengandungi 'RF Transmitter' untuk menghantar data ke bus stop. Pegawai di perhentian bas pula akan menerima data tersebut menggunakan 'RF receiver' dan ini sekaligus membolehkan mereka memastikan perjalanan bus tidak meghadapi masalah dan menuju ke destinasi yang tepat. Oleh itu, dalam menjayakan projek ini, dua jenis papan yg mempunyai litar lengkap akan di hasilkan yang juga boleh dikenali sebagai litar penghantar data dan juga litar penerimaan data. Litar penghantar data akan di letakkan berdekatan dengan pemandu bas di dalam setiap bas awam. Ini disebabkan litar tersebut khas untuk penggunaan pemandu bas sahaja dengan tujuan menghanr ID basnya ke perhentian bas yang berdekatan. Setiap perhentian bas pula dilengkapi dengan litar penerimaan data untuk tujuan menerima ID bas yg dihantar tadi. Kedua-dua litar akan di lengkapi dengan skrin paparan digital atau pun lebih dekenali sebagai LCD untuk mempamerkan ID bas.

ACKNOWLEDGEMENT

There are several people who contribute in preparing this thesis together with me. There are academicians, non-academicians and students. First of all, I wish to express my sincere gratitude to my supervisor, Mr. Raja Taufika Bin Raja Ismail for all his advices, guidance, motivation and supports throughout the whole project. As supervisor, he had done great job in ensuring the project reached its objectives.

Also not forgetting all the non-academicians in the FKEE laboratory who continuously giving the supports and concerns for this project. I will never forget the experience and the skills I have gathered from all of you from the very beginning of this project until it is completed. To University Malaysia Pahang (UMP), I am grateful that this institution really wanted to see its students to be skillful and knowledgeable. The funding supplied for this project is very much appreciated. I cannot return the money, but I return the victory I have achieved with this project.

Last but not least, I want to thank all my colleagues for their supports especially Kim Chin Seong and Steve. Without their warmth concern and kindness, it will be difficult for me in the programming stage at the beginning of this project. For those I did not mention here, it is not that I forgot, but the space is limited. Thank you for everything.

STUDENT DECLARATION

I declare that this thesis entitled "*Bus Monitoring System (Hardware Part)*" is the result of my own research except as cited in the reference. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature	: ....
Name	: Nasrung Bin Nurba
Date	: 06 May 2008

Dedicated to my beloved

Mother,

Father,

Sister, and

Brother

For their continues supports, great loves, confidence and

motivation for me throughout the whole project

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LIST OF ABBREVIATIONS

ASK	-	Amplitude Shift Keying
AF	-	Audio Frequency
BER	-	Bit-Error Rate
CPU	-	Central Processing Unit
CPCA	-	Carrier Present, Carrier Absent
DIP	-	Dual In line Package
EPROM	-	Erasable Read Only Memory
FSK	-	Frequency shift keying
FCC	-	Federal Communications Comission
GND	-	Ground
IR	-	infra red
LCD	-	Liquid-Crystal Displays
LED	-	Light Emitting Diode
OSC	-	Oscillator
OST	-	Oscillator Start-up Timer
OOK	-	On-Off Keying
RF	-	Radio Frequency
ROM	-	Read Only Memory
RAM	-	Random Access Memory
RxD	-	Receiver data pin
SAW	-	Surface Acoustic Wave
TxD	-	Transmitter data pin

LIST OF SYMBOLS

Dc	-	Direct Current
Hz	-	Hertz
Kbit/s	-	kilobit per Second
MHz	-	Mega Hertz
ms	-	Millisecond
V	-	Volts
Ω	-	Ohm
μ	-	Micro
ρ	-	Pico

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CHAPTER 1

INTRODUCTION

1.1 Introduction

As time goes by, the improvement in technology growth larger, advance and more sophisticated. Long time ago, we never heard about bus monitoring system or vehicle monitoring system where the vehicle can be detected by using wireless technologies application, GSM or using radio frequency technologies and people also can't imagine how the process work. But in this millennium era, it's become reality when one of the largest public transport company in London using all of this technologies to provide the best possible service to their passengers. At the other place, a group of expert people make a research to implement the use of radio frequency in monitoring the bus movement. The idea was tested and developed at the University of Virginia bus route using student volunteers and the outcome result is very good where each bus stop can detect the movement of the bus by using RFID. It was another type of radio frequency technologies in the world.

As we know, radio frequencies refer to the frequencies that fall within the electromagnetic spectrum associated with radio wave propagation. When applied to an antenna, RF current creates electromagnetic fields that propagate the applied signal through space. Any RF field has a wavelength that is inversely proportional to the frequency and this means that the frequency of an RF signal is inversely proportional to the wavelength of the field.

It goes the same with this project that used the application of radio frequencies by using RF transmitter and RF receiver to monitor the movement of the bus from the bus stop. The whole process that was described here is focus only on hardware part. It was known that when the buses start moving, it will reach many bus stops along the route. So, in order to ensure that the bus already arrived at the bus stop is the RF receiver at the bus stop must be able to receive the data that was transmitted from the bus which is the ID of the bus. Thus, the system that can fulfill the requirement of this project is the circuit installed at bus must consist of four main component which is keypad to insert the bus ID, PIC16F877A that can use to analyze the data and of course RF transmitter which is the function is to transmit the data to the bus stop and finally the LCD use to display the bus ID that was insert by a bus driver. At the other side, the circuit at the bus stop must have RF receiver to receive the data and PIC to analyzing the data which received and then communicate with LCD to display the data.

1.2 Problem statement

Public bus often moves in the wrong direction and it’s difficult for officer from bus company to detect this problem without implementing monitoring system. Hence, this project will contribute by providing few alternatives to the bus officer to find the solution. It also known that there must be a data transfer from buses to the bus stop for this project.

Due to the process of sending and receiving data there must be a transmitter and receiver to complete the task. Beside that, a PIC needs to be used to store and process the data then ordered LCD to display the data at the bus stop.

1.3 Objectives

There are several objectives of this project which are:-

I. To make sure the bus ID that was insert using keypad displayed correctly on LCD at transmitter board inside the bus.
II. To ensure the process of sending and receiving bus ID success using RF transmitter and RF receiver.

1.4 Project scope

I. Transmitter board will be installed inside the bus and receiver board will be plugged in at bus stop.
II. Each time bus arriving at the bus stop, bus driver will send the bus ID using RF transmitter to the bus Stop.

III. Receiver board will receive the ID using RF receiver .Then LCD will display the bus ID after get command from PIC16F877A.

1.5 Thesis Outline

Hardware part of bus monitoring system final thesis consist of 6 chapters that explain different part of the project. Each chapter elaborates all part of hardware and software about this chapter. Actually the content also consist of information about the project and the component used as illustrate in literature review.

Chapter 1 explains the introduction about this research where all the objectives and problems that lead to the implementation of this research are stated. The chapter starts with general information of radio frequency communication and the project background.

Chapter 2 explains the literature study regarding bus monitoring system project based on recent journals and papers. The information also comes from few resources in internet that can be trusted. Generally, most of the literature discuss about project module from the basic concept to its application to this project and engineering fields.

Chapter 3 will be more focus on hardware used in bus monitoring system project. Each module has its own connection and condition which need to put in consideration during the hardware constructing. This chapter also explains all the main circuit for each component in more detail.

Chapter 4 discuss about the software development hardware. All issues regarding the project such as the transmission and receiving data process will be discussed. Flow chart is used to show the whole process of transmitting and receiving data in this chapter.

Chapter 5 provides an outline of the results obtained from the transmitter board and receiver board. Detail explanation of the result starting from the input until the LCD display the output will be further discuss in this chapter.

Chapter 6 is the last chapter and it contains the brief summary for the whole research from the beginning until it is completed. Conclusion is included as well as some recommendations for future research on bus monitoring system.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Inside this chapter, brief description on each project module that was used in this project will be stated. Besides that, some elaboration on fundamental of radio frequency and data transmission can be fined in this chapter.

2.2 How RF wireless connectivity work

RF is commonly used in the wireless communications industry to describe certain types of equipment which use radio frequency waves to transmit sounds and data from one point to another. In computer networking, RF is used to describe network devices such as hubs or bridge that transmits data signals using radio waves instead of data cables or telephone lines. Even though the phrase "RF wireless networking" might seem mysterious, the underlying technology is very common. It uses radio waves, the same type of energy used to transmit radio and television broadcasting. Two-way radios and walkie-talkies also use this kind of technology.

In the middle of the radio transmission and receiving process sit two antennas in two different places which is one located at the point for transmitting the signal and the other point is for receiving the signal. In order to transmit the modulated radio signal, an electrical current will pass through the antenna inducing a magnetic field, which oscillates at the given frequency. The variations in the current create slight variations in the radio frequency [1].

Thus, we should remember that the range we get depends on terrain, obstructions, and height of antenna. Buildings can reflect RF energy making it difficult or impossible to receive the desired signal. Also, if a reflected signal is bounced off of a building or other object, it can be received along with the direct signal. If the reflected signal is out of phase with the direct signal, it is possible for the direct signal to be partially cancelled by the weaker, reflected signal. Hence, the ideal conditions for best transmission and reception signal are line of sight and outside with no obstructions.

An RF wireless communication system operating in the presence of a periodic noise environment, includes first and second wireless devices, each such device having a source of power, a transceiver coupled to the power source, for transmitting and receiving wireless information, a controller or CPU for controlling the operation of the transceiver; means for detecting and mapping the presence of the RF radiated periodic noise and means responsive to the mapped periodic noise for controlling the operation of the transceiver to communicate with the other wireless device during the quiescent periods of the radiated RF periodic noise[2].

Then the CPU will control the operation of the transceiver in response to the mapped radiated RF periodic noise to communicate with the other wireless device during the quiescent periods of the radiated RF periodic noise by enabling the transmitter to transmit when it predicts the periodic noise is in the quiescent state, thereby making the transmission process efficient.

2.3 Data transmission

Data transmission is the conveyance of any kind of information from one space to another. Historically this could be done by courier, a chain of bonfires or semaphores, and later by Morse code over copper wires.

In recent computer terms, it means sending a stream of bits or bytes from one location to another using any number of technologies, such as copper wire, optical fiber, laser, radio, or infra-red light. Practical examples include moving data from one storage device to another and accessing a website, which involves data transfer from web servers to a user's browser. A related concept to data transmission is the data transmission protocol used to make the data transfer legible. Current protocols favor packet based communication. There were two types of data transmission which is serial transmission and parallel transmission.

Serial transmission bits are sent over a single wire individually. Whilst only one bit is sent at a time, high transfer rates are possible. This can be used over longer distances as a check digit or parity bit can be sent along it easily. But for parallel transmission, multiple wires are used and transmit bits simultaneously [3]. It works much faster than serial transmission as one byte can be sent rather than one bit. This method is used internally within the computer, for example the internal buses, and sometimes externally for such things as printers, however this method of transmission is only available over short distances as the signal will degrade and become unreadable, as there is more interference between many wires than between one.

2.4 RF fundamental

The wireless link consists of a transmitter with antenna, a transmission path and the receiver with antenna. Parameters of interest are the output power of the transmitter and the sensitivity of the receiver. Figure 2.1 illustrates the link principle.

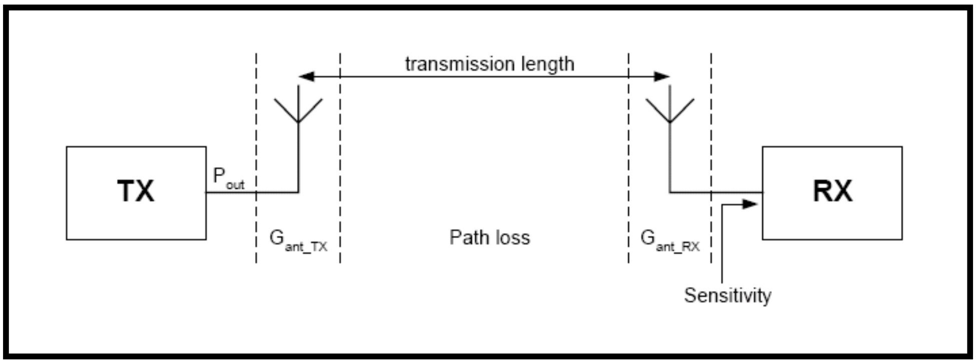

Figure 2.1 Wireless link

Sensitivity is the minimum received power that results in a satisfactory Bit Error Rate (BER, usually 1×10-3) at the received data output (i.e. correct demodulation). The difference between received signal power and sensitivity is the transmission link margin also known as ‘headroom’. Headroom is reduced by a number of factors such as transmission path length, antenna efficiency, carrier frequency and physical characteristics of obstructions in the transmission path. Sensitivity and output power given in the RF-circuit datasheets are given for the load impedance which is optimal for the input LNA and the output power amplifier. This means that the impedance of the antenna used must be equal to the load stated in the datasheet, otherwise mismatch and loss of headroom occur. A typical matching network introduces in the order of 1-3 dB of attenuation.

Radio Frequency (RF) waves are lower in frequency and longer in wavelength than Infrared. At 300 MHz the wavelength is 1 m (39.37") while Consumer IR wavelengths are just under 1 millionth of a meter. Most RF remotes use a carrier in the 300-1000 MHz range.

RF receiver only needs to be tuned to the carrier frequency used by the remote. RF remotes and their receivers are tuned to a fixed frequency. The FCC allows unlicensed, low power use of 300MHz-1000MHz as well as some higher frequency bands.

As a general rule, the codes are comprised of pulses and spaces with durations of 0.3-1.5 ms which is an audible signal in the 500-2000 Hz range as shown in Figure 2.2. The IR and RF receivers output the demodulated code waveform. The only difference is that IR receivers output an active low or inverted signal while RF receivers output an active high signal as shown on Figure 2.3.

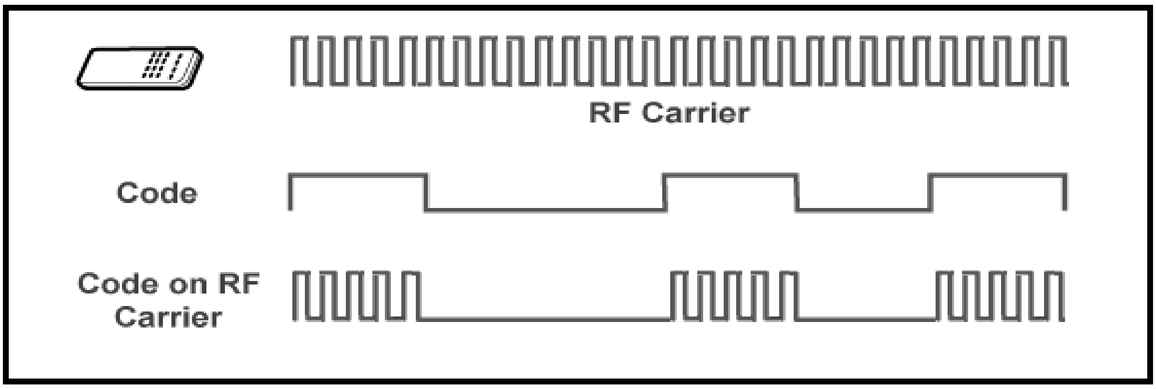

Figure 2.2 RF Carrier

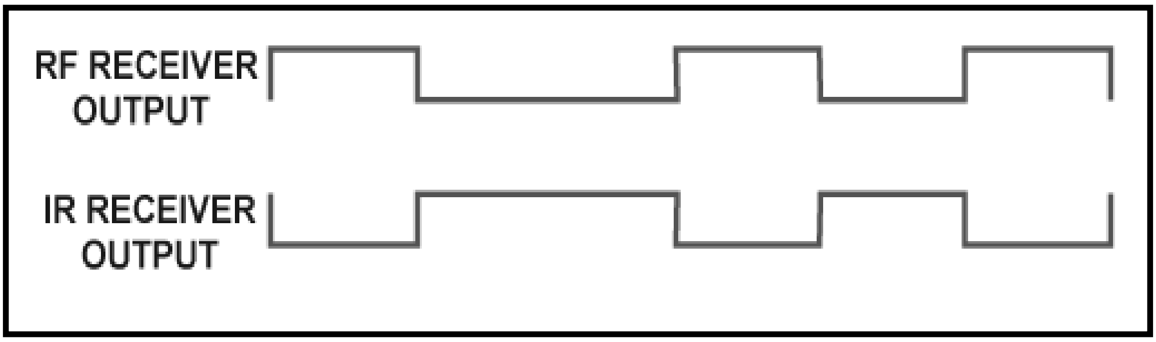

Figure 2.3 RF Receiver output & IF Receiver output

Other than range, it really makes no difference whether the data signal is used to modulate an RF carrier, an IR carrier, an ultrasonic carrier, a laser beam, or smoke. At the receiving end, the demodulated signal carries the same information. For RF control, both the transmitter and receiver need to be tuned to the same carrier frequency and need to use the same type of modulation.

Most RF remotes use ASK (Amplitude Shift Keying) or OOK (On-Off Keying). OOK is really just a special case of ASK. OOK is also called CPCA (Carrier Present, Carrier Absent). All of the illustrations above represent ASK. FSK (Frequency Shift Keying) uses two different carrier frequencies to denote two different states.

2.5 Voltage regulator

Voltage regulator ICs are available with fixed (typically 5 V, 12 V and 15 V) or variable output voltages. They are also rated by the maximum current they can pass. Negative voltage regulators are available, mainly for use in dual supplies. Most regulators include some automatic protection from excessive current (overload protection) and overheating (thermal protection).

Plenty of fixed voltage regulator ICs has three leads and looks like power transistors, such as the 7805 +5 V with 1 A regulator as shown in Figure 2.4. They include a hole for attaching a heat sink if necessary.

Voltage regulator will not stable if it work alone. Some capacitor in range 0.1 μF – 100 μF must be placed at pin 1 and pin 3. Voltage regulator will operate happily if there is a diode placed in pin 1 but it's not a compulsory. Diode can help to reduce the high voltage but it depends on the types of diode either it silicon, germanium or other models.

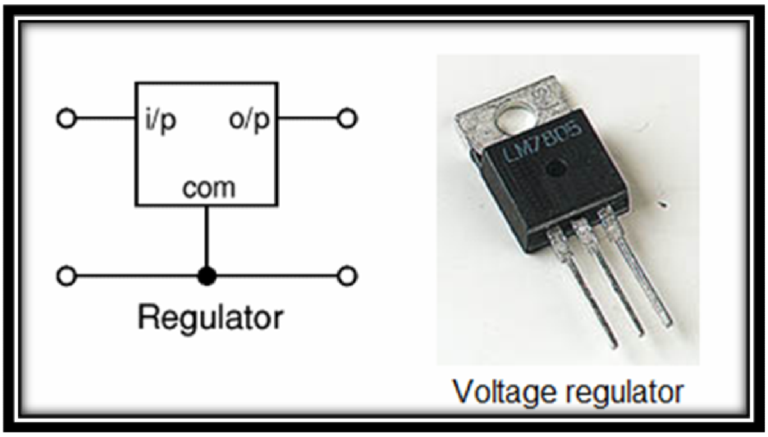

Figure 2.4 Voltage regulator

2.6 PIC16F877A

Many things should be considered before choosing a microcontroller as the controller. There is plenty of microcontrollers that was easy to find at electronics store such as ATMEL, Motorola's family and microchip product which is PIC. Basically this entire microcontroller capable to act as a controller but it's depends on the types of project that we build. It is because some of these microcontrollers have limited abilities in terms of lacking data memories and less of Input/output pins.

Amongst these microcontrollers, PIC6F877A have extra advancement. This device was build with special features such as 100,000 erase/write cycle enhanced flash program memory typical, self-reprogrammable under software control, In-Circuit Serial Programming via two pins, programmable code protection and power saving sleep mode. PIC16F87XA devices have a Watchdog Timer which can be shut-off only through configuration bits. It runs off its own RC oscillator for added reliability. There are two timers that offer necessary delays on power-up. One is the Oscillator Start-up Timer (OST), intended to keep the chip in Reset until the crystal oscillator is stable.

The other is the Power-up Timer (PWRT), which provides a fixed delay of 72 ms (nominal) on power-up only. It is designed to keep the part in reset while the power supply stabilizes. With these two timers on-chip, most applications need no external reset circuitry. Fully description of PIC16F877A can be seen at the Table 2.1 below.

Table 2.1: PIC16F877A key features

Features	PIC16F877A
Operating frequency	DC – 20MHZ
Reset and Delays	POR, BOR, (PWRT,OST)

Flash program memory (14-bit words)	8K
Data memory in bytes	368
EEPROM data memory in bytes	256
Interrupts	15
I/O ports	Ports A, B, C, D, E
Timers	3
PWM modules	2
Serial communication	MSSP, USART
Parallel communication	PSP
10-bit Analog-to-Digital module	8 input channels
Analog comparators	2
Instruction set	35 instruction
Packages	40 pin DIP

The data EEPROM and Flash program memory is readable and writable during normal operation. This memory is not directly mapped in the register file space. Instead, it is indirectly addressed through the Special Function Registers. When interfacing to the data memory block, EEDATA holds eight bits of data for read/write and EEADR holds the address of the EEPROM location being accessed.

These devices have 128 or 256 bytes of data EEPROM with an address range from 00h to FFh. On devices with 128 bytes, addresses from 80h to FFh are unimplemented and will wraparound to the beginning of data EEPROM memory. When writing to unimplemented locations, the on-chip charge pump will be turned off.

When interfacing the program memory block, the EEDATA and EEDATH registers form a two-byte word that holds the 14-bit data for read/write and the EEADR and EEADRH registers form a two-byte word that holds the 13-bit address of the program memory location being accessed. For PIC16F876A/877A, addresses above the range of the respective device will wraparound to the beginning of program memory. The EEPROM data memory allows single-byte read and writes. The Flash program memory allows single-word reads and four-word block writes. Program memory write operations automatically perform an erase-before write on blocks of four words. A byte write in data EEPROM memory automatically erases the location and writes the new data (erase-before-write). The write time is controlled by an on-chip timer. The write/erase voltages are generated by an on-chip charge pump, rated to operate over the voltage range of the device for byte or word operations.

When the device is code-protected, the CPU may continue to read and write the data EEPROM memory. Depending on the settings of the write-protect bits, the device may or may not be able to write certain blocks of the program memory; however, reads of the program memory are allowed. When code-protected, the device programmer can no longer access data or program memory, this does NOT inhibit internal reads or writes.

2.7 Transmitter module

A transmitter is an electronic device which with the aid of an antenna propagates an electromagnetic signal such as radio, television, or other telecommunications. A transmitter usually has a power supply, an oscillator, a modulator, and amplifiers for audio frequency (AF) and radio frequency (RF). The modulator is the device modulates the signal information onto the carrier frequency, which is then broadcast.

Sometimes a device like cell phone contains both a transmitter and a radio receiver, with the combined unit referred to as a transceiver. More generally and in communications and information processing, a "transmitter" is any object or source which able to sends information to an observer or receiver. When used in this more general sense, vocal cords may also be considered an example of a "transmitter"[4].

The transmitter module in Figure 2.5 was a RF transmitter which used in this project. The RF transmitter is placed at transmitter board inside the bus. The frequency range for this types of transmitter is 433 MHz and the modulation mode is ASK or amplitude shift keying mode. The temperature maximum rating is 230° C. The actual range for data transmitting is from 100 m to 150 m but it's depends on the stability of power supply.

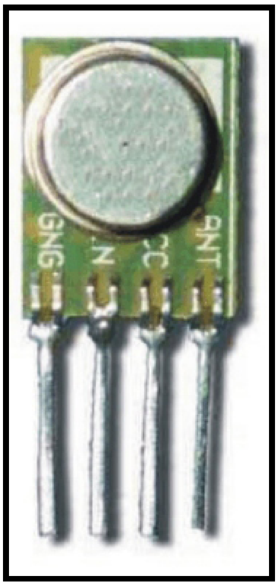

Figure 2.5 RF transmitter

Whenever possible avoid using bread-board or vary-board with RF transmitter. The long tracks inside these types of prototyping board introduce large capacitances or inductances to the circuit which can badly distort radio frequency signals. Ideally prototype or evaluation PCB should be used. Tracks connected to the antenna pin of transmitter modules should be as short as possible. Any conductor connected to this track will act as an antenna, so it will lengthen and detune the actual antenna. The suitable length of antenna for 433 MHz RF transmitter is 16 cm and above.

2.8 Receiver module

The receiver in information theory is the receiving end of a communication channel. It receives decoded messages or information from the sender, who first encoded them. Sometimes the receiver is modeled so as to include the decoder. Real world receivers like radio receivers or telephones can not be expected to receive as much information as predicted by the theorem. The receiver is designed to work with the matching transmitter. With the addition of simple antenna the pair may be used to transfer serial data up to 200 m. The range of the system depends upon several factors, principally the type of antenna employed and the operating environment. The 200 m quoted range is a reliable operating distance over open ground using 1/4 whip antenna at both ends of the link at 1.5 meters above ground.

Smaller antenna, interference or obstacles such as building will reduce the reliable working range (down to 30 meters in extreme cases). Increased antenna height, slow data or a larger receive antenna will increase the range. The RF module frequency is from 300 MHz to 434 MHz. Its high sensitivity passive design is simple to use with a low external parts count. An ASK data shaping comparator is included [5]. RF receiver in Figure 2.6 was the other types of superheterodyne receiver. This type of receiver supports the working frequency from 315 MHz to 433 MHz.

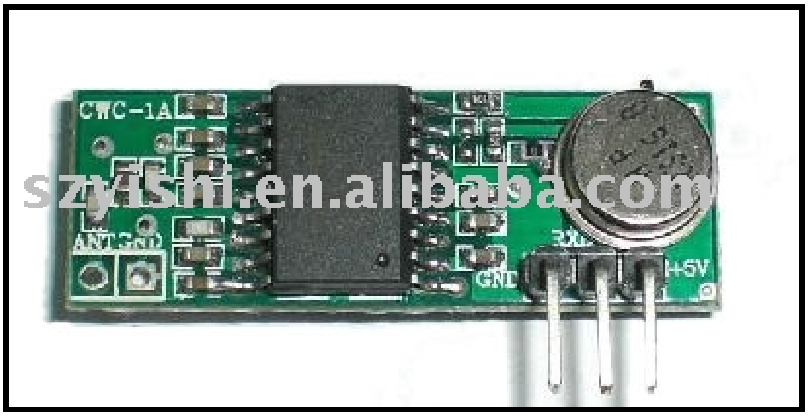

Figure 2.6 RF Receiver

The receiving sensitivity for this RF receiver is -101 dBm and the operating voltage supply is from 3 V to 6 V. Applying SAW crystal oscillation overcomes easy frequency excursion of LC circuit was the advantages of this RF receiver. Most parts of module are integrated into the chip 3310A, less external components, stable and reliable performance, and excellent anti-jamming ability.

The output data signal is TTL and can be directly connected to decoder. The antenna must be set to 16 cm length if the operating frequency is 433 MHz. These types of receiver are quite popular around few countries in Asia because it's easy to get and the market is very wide compare to the European model of RF receiver.

The only problem of this type of receiver is the output of receiver module come with noise and also can create noise in case of special requirement, but the receiving sensitivity will be reduced. The output or RxD pin which receives a lot of noise will cause a trouble because the data that was received will not accurate. It is because noise will interfere with the data signal at receiving point. The way to troubleshoot this problem was explain in next chapter inside the designation of receiver circuit article.

2.9 Keypad module

A keypad is a convenient way of entering data into the PIC without tying up one I/O line for each switch. A four row by four column keypad consists of 16 individual push buttons, but only needs eight input/output lines to determine which of the sixteen keys has been pressed.

A 4×4 keypad consists of 16 individual push buttons and eight wires. Each switch will connect two of the eight wires together when pressed. The eight wires are arranged in a 4 ×4 wire grid patterns and when any one of the 16 push buttons is pressed, a contact is made between the wire that is associated with the switches column and the wire that is associated with the switches row. By scanning the eight wires for these connections, the button that is pressed, if any, can be determined. The types of keypad which used in this project are 4×4 matrix keypad as shown on Figure 2.7.

Figure 2.7 4×4 matrix keypad

2.10 Liquid Crystal Display (LCD)

LCD is short for liquid crystal display, a type of display used in digital watches and many portable computers. LCD displays utilize two sheets of polarizing material with a liquid crystal solution between them. An electric current passed through the liquid causes the crystals to align so that light cannot pass through them. Each crystal, therefore, is like a shutter, either allowing light to pass through or blocking the light.

The Serial 2×16 LCD as shown on Figure 2.8 is the low cost compare to other types of LCD such as color LCD. The serial 2×16 LCD was used in this project to display the bus ID that was transferred from bus to bus stop. This type of LCD has a high quality 2×16 backlit super twist LCD display. It's also capable to operate in variable types of baud rate such as 2400 and 9600. Even limited to character based module, there is still a wide variety of shapes and sizes available. Line lengths of 8, 16, 20, 24, 32 and 40 characters are all standard in one, two or four line version. Several LCD have advanced technologies called super twist types for example offer improved contrast and viewing angle over the older twisted nematic types.

Some are available with back lightning so they can be viewed in dimly-lit condition or dark condition. The back lighting can be simpler types of LED or electro illumination types which require high voltage inverter circuit. Most LCD modules conform to a standard specification. A 14-pin access provided which have eight data lines, three control lines, three power lines. The connections are laid out in one of two configurations either two rows of seven pins or a single row of 14 pins. On most displays, the pins are numbered on LCD's printed circuit board but if not, it is quite easy to locate pin 1. Since this pin is connected to ground, it often has a thicker PCB track connected to it and it is generally connected to metal work at some point.

For an LCD module to be used effectively in any piece of equipment, a microprocessor or a microcontroller is required to drive it. However, before attempting to wire the two together, some initial experiments can be performed by connecting up a series of switches to the pins of the module. This can be a quite a beneficial steps even if we are thoroughly conversant with the working of microprocessors.

Figure 2.8 2×16 LCD

CHAPTER 3

HARDWARE IMPLEMENTATION

3.1 Introduction

Hardware implementation can be considered 80 % from the whole project of bus monitoring system. Hence this chapter explains and elaborates how the hardware was constructed from the very beginning. Also listed in this chapter is the precaution during the hardware construction to avoid any error from occurring.

3.2 Installing PIC16F877A

From the previous chapter we have been introducing to PIC16F877A which have few extra capabilities in handling various types of project. PIC16F877A is a small piece of semiconductor integrated circuits. The package type of these integrated circuits is DIP package. DIP stand for Dual Inline Package for semiconductor IC.

This package is very easy to be soldered onto the strip board. However using a DIP socket is much easier so that this chip can be plugged and removed from the development board. Beside that, PIC16F877A is also very popular because PIC16F877A is very cheap. Apart from that it is also very easy to be assembled.

Additional components that we need to make this IC work are just a 5 V power supply adapter, a 20 MHz crystal oscillator and two units of 22 ρF capacitors. Hence, this project has fully utilized the used of PIC16F877A and makes it work as main control panel for both hardware.

There is two hardware constructed for this project which called transmitter board and receiver board. PIC16F877A have 40 bidirectional input and output pins which is port A, port E, port B, Port C and port D. At transmitter board and receiver board, four ports will act as input and output pin which is port A, Port B, port C and port D meanwhile port E will remain unused. Further explanation about the input/output pins application in both hardware will be described clearly in this chapter.

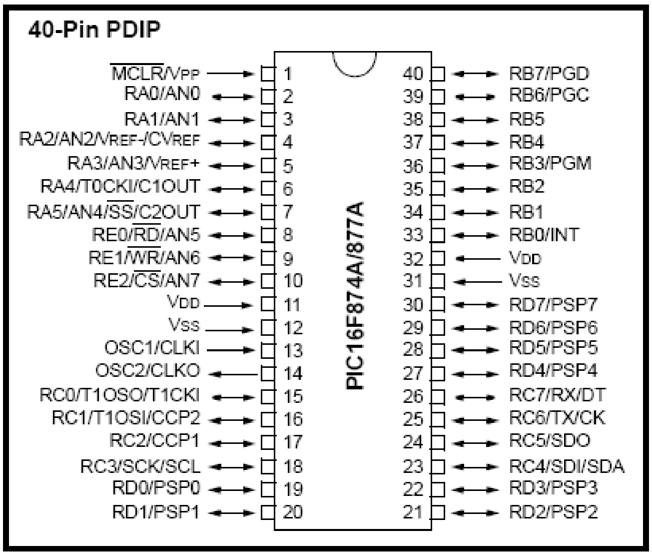

Figure 3.1 PIC16F877A

PIC16F877A is so much easier to program using C language. PicBasic Pro compiler was use to create and edit the code for PIC16F877A. Then it will compile the program using MPASMWIN.exe then check if there is error in the program. PicBasic pro compiler compatible with microcode studio. Microcode Studio is a powerful, visual Integrated Development Environment (IDE) with In Circuit Debugging (ICD) capability designed specifically for microEngineering Labs PICBasic PRO compiler.

The code explorer allows us to automatically jump to include files, defines, constants, variables, aliases and modifiers, symbols and labels that are contained within the source code. It's easy to set up the compiler, assembler and programmer options or we just can let Microcode Studio do it itself with its built in auto search feature. Compilation and assembler errors can easily be identified and corrected using the error results window. Full cut, copy, paste and undo are provided, together with search and replace features. The view of Microcode studio is shown in Figure 3.2.

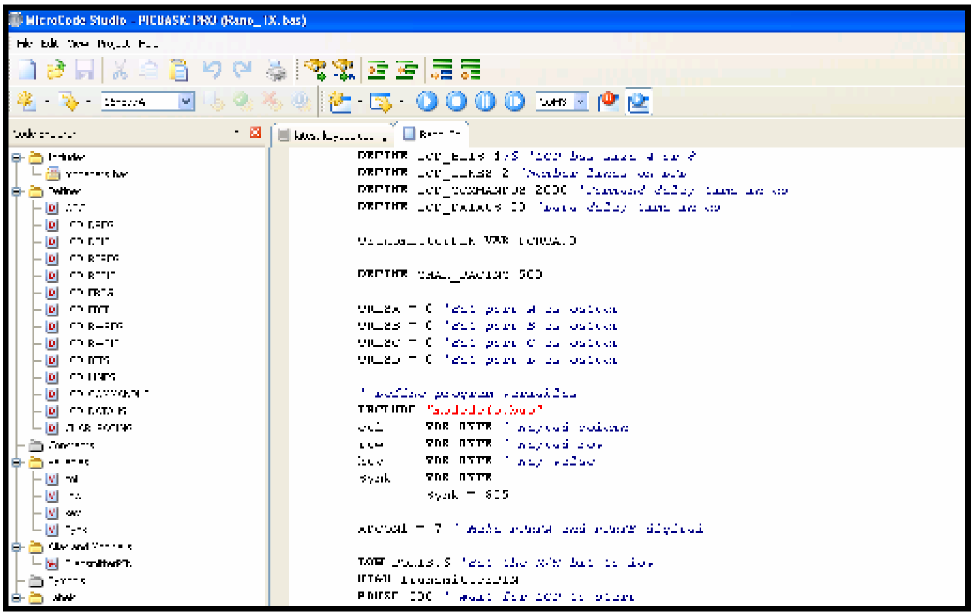

Figure 3.2 Microcode studio

UP00A is a hardware programmer that is used to burn hex file into PIC16F877A and it was shown on Figure 3.3. This type of programmer need a driver installation to make it work and it's made for Intel processor only. Other processor such as AMD athlon will make the programmer damage or not function properly. After driver installation, USB programmer is ready to be used with WinPic800 software. To use it, just plug the PIC16F877A in the socket that was indicated on the board then click "load program" at WinPic800 software to download the hex file to PIC16F877A.

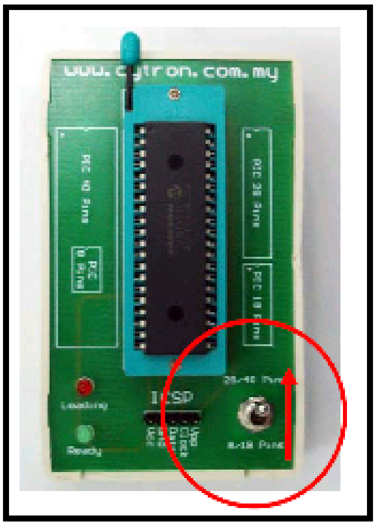

Figure 3.3 UP00A PIC USB Programmer.

3.3 Power circuit

Power circuit was a compulsory for both hardware to function properly. It will provide supply in a range of 5 V to all the components inside transmitter board and receiver board especially PIC16F877A. As mention in the previous chapter, PIC16F877A was design to operate in low power consumption.

Thus, a suitable voltage rating must be produce for this device to make it work in a good condition. By referring the datasheet, a good operating voltage range for PIC16F877A is from 2 V to 5.5 V. That's why LM7805 was installed in a power circuit to produce 5 V supply to PIC16F877A and the other devices. The circuit shown on Figure 3.4 below.

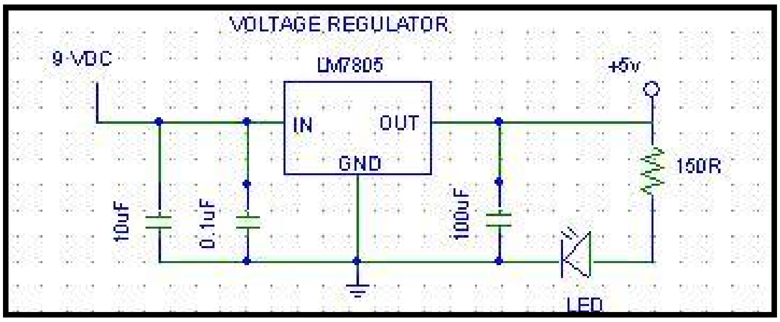

Figure 3.4 Power Circuit

The fundamental of creating a power supply circuit must be implementing in this project in order to make both transmitter and receiver boards run smoothly. We need to make sure the voltage supply is nice and clean. Moreover, building a project which consist Radio frequency communication will cause us to play with low and high frequency.

Bad voltage supply will produce a high frequency or noise in Vcc line where it could interfere with signals that about to transmit or receive. The consequences is, the data that we transmit or receive will loss or corrupted by this high frequency. That's why tantalum and ceramic capacitor was placed at input and output pin of LM7805. The tantalum is 100 µF and 10 µF while the ceramic one is 0.1 µF. Tantalum and ceramic capacitor was used because these types of capacitor have a good characteristic in handling high frequency.

The supply from main power should be from 8 V to 10 V DC voltage to produce the suitable amount of voltage and current. Low voltage and current will cause most of the component unused. Input pin at LM7805 will connected to the main supply and the output pin will go directly to pin 11 at PIC16F877A because this pin stand for Vdd that will give supply to this device. The other devices including RF transmitter and RF receiver will also get 5 V supply from the power circuit.

3.4 Oscillator circuit

Figure 3.5 show the oscillator circuit for both PIC16F877A at transmitter and receiver board. The crystal used for oscillator is 20 MHZ and it was connected at pin 13 and pin 14 at PIC16F877A. Oscillator circuit will work as a provider for an accurate and stable periodic clock signal to PIC16F877A. The internal clock frequency is one-fourth of that supplied to the crystal pins. A typical system designed for maximum clock frequency uses a 20 MHz crystal. Hence the clock speed or frequency is 5 MHz. The value of capacitor at crystal pin must be the same in order to produce high frequency clock input.

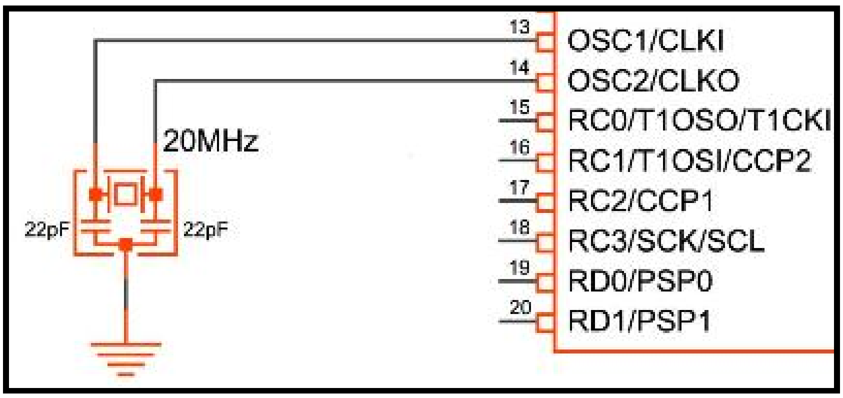

Figure 3.5 Clock Circuit

3.5 Reset circuit

Reset circuit is use to reset the program inside PIC16F877A. As we can see at Figure 3.6, MCLR pin or master clear pin is connected in series with resistor 10 kΩ before goes to 5 V supply voltage. Then the switch will be connected between the 5 V supply voltage and ground. At initial condition MCLR pin will be tied high which is logic '1' and it is permanently inactive. When the reset button is pushed, MCLR pin will be grounded and it will become logic '0'. This situation will activate the reset program inside PIC16F877A through MCLR pin and then reset the program inside PIC16F877A.

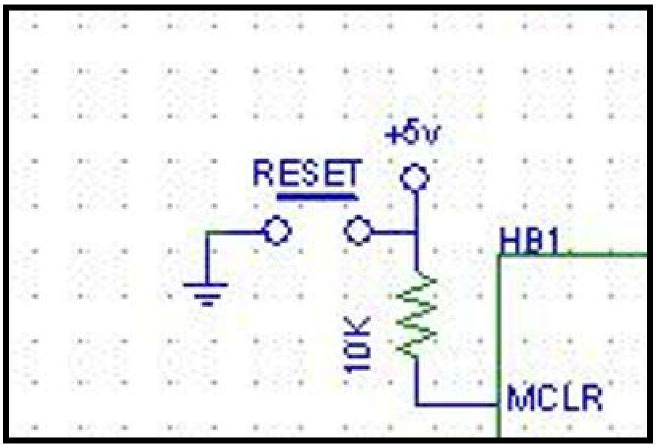

Figure 3.6 Reset Circuit

3.6 Keypad circuit

Keypad is a compulsory device in this project. The purpose of using keypad is for inserting the bus ID that supposes to be done by a bus driver. The types of keypad that used in this project are matrix keypad 4×4. This type of keypad was consisting of 16 keys which arranged in four columns and four rows. Each switch pad has their on decimal and ASCII code number. Matrix keypad 4×4 will be placed in transmitter board inside the bus. Figure 3.7 show 4×4 keypad connection with PIC16F877A. The entire row and columns in keypad was connected to Port D at PIC16F877A. As the switches are all interconnected, we need a way to differentiate between the different ones. The four 10 kΩ resistors on the interface board pull-up lines COL1 to COL4 high. These four lines are the ones which are read in the program. So, in the absence of any switch been pressed these lines will all read high. The four ROW connections are connected to output pins, and if these are set high the switches will effectively do nothing. Connecting a high level to a high level, results in a high level.

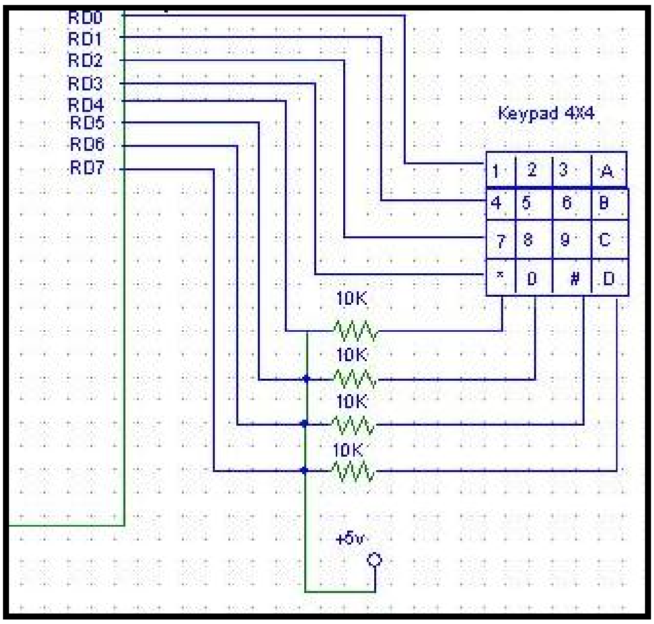

Figure 3.7 Keypad Circuit

In order to detect a switch, we need to take the ROW lines low. Assuming we press button 1, this joins COL1 with ROW1, as ROW1 is now at a low level, this will pull COL1 down resulting in a low reading on COL1. Unfortunately if we press button

‘4’, this joins COL1 with ROW2, as ROW2 is at a low level this also results in a low reading at COL1. This would only give us four possible choices, where each four buttons in a COL do exactly the same. The way round this is to only switch one ROW at a time low, so assuming we set ROW1 low we can then read just the top row of buttons, button 1 will take COL1 low, button2 will take COL2 low, and the same for buttons ‘3’ and ‘A’ in COL3 and COL4. The twelve lower buttons won't have any effect as their respective ROW lines are still high.

Hence to read the other buttons we need to take their respective ROW lines low, taking ROW2 low will allow us to read the second row of buttons (4, 5, 6, and B), again as the other three ROW lines are now high the other 12 buttons have no effect. We can then repeat this for the last two rows using ROW3 and ROW4, so we read four buttons at a time, taking a total of four readings to read the entire keypad. This is what we call keypad scanning. By defining all keys to a decimal number 1-16, PIC16F877A will ensure each key that was pressed will show its value on LCD. The explanation on how the interfacing process between keypad, PIC16F877A, and LCD will be describing more detail in next chapter.

3.7 Transmitter circuit

Designing a transmitter circuit is quite a challenge. As we all know there are so many periodic noises in environmental. Noise factor is a first priority that we need to avoid when construct transmitter circuit. The transmitter circuit was installed at transmitter board inside the bus.

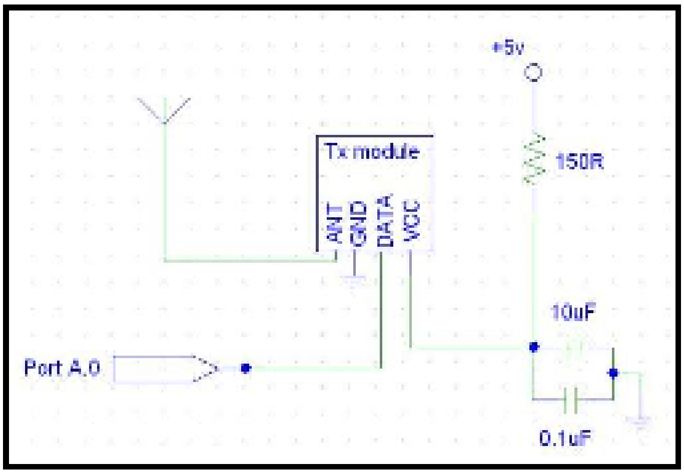

Figure 3.8 Transmitter Circuit

As seen on Figure 3.8, TxD pin or data pin at RF transmitter was connected through port A.0 at PIC16F877A. It is because port A at initial condition use TTL input or transistor-transistor logic input. TTL input pin become a first choice when choosing a transmitter pin because only 2 V need at Vdd to make the data pin get logic High. TxD pin must get logic high to make it function properly.

Avoiding noise is not a big deal when applying a correct way to transmitter circuit. Low pass filter circuit become a best solution to minimized noise. Low pass filter circuit will be installed at Vcc line. The supply from power circuit will flow through two piece of decoupling capacitor which is 10 µf and 0.1 µf which placed in series with 150 Ω resistor before go to Vcc pin at RF transmitter. Both capacitors were tantalum types because the capacitance value can change according to temperature as well as frequency. By using low pass filter circuit, low frequency signals input to the filter will be transferred unchanged to the output meanwhile higher frequencies filtered out [6]. Since the RF transmitter operates in 433 MHz LPRD bands, the antenna lengths suppose to be around 16 cm lengths. This could help the RF transmitter achieve its actual range when transmitting the data.

3.8 Receiver circuit

Compare to the other circuit, receiver circuit cause a lot of problem to this project. Need to put in caution when using low power RF receiver is connecting all the pins to its application directly without any extra circuit will cause instability to the receiver and create a lot of noise. The main problem is this type of RF receiver is a superheterodyne receiver and the output was open-collector. The meaning of open-collector types is the output of this receiver was easily affected by noise and probably receives a corrupted data signal from RF transmitter.

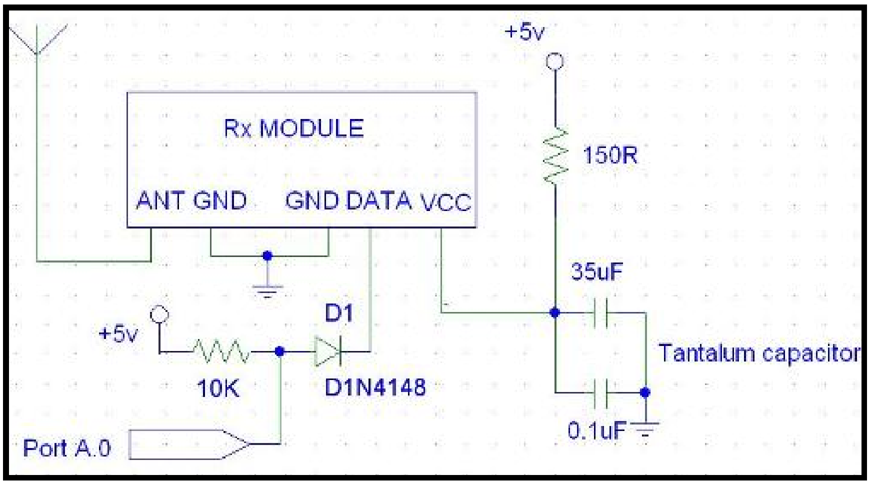

Figure 3.9 Receiver circuit

Hence, the first step of trouble shooting this problem is makes the power supply stable and clean. The way to filter out high frequency at Vcc lines is just the same with transmitter part which is applying low pass filter circuit at Vcc lines. Figure 3.9 show two piece of tantalum capacitor placed in series with 150 Ω resistor and act as low pass filter to Vcc line. Filter out noise in Vcc line is a must because it will give effect to the data that was received. For Example, the correct data BUS01 will transform to BUS55 after noise interfering.

Filtering out the noise is not enough to make the receiver done its job properly. By referring to single chip receiver datasheet, there was no internal pull up inside the receiver chip. That's why external pull up is used where 10 kΩ resistor sit between RxD pin and 5 V supply voltage. Adding a diode give extra advantages to the external pull up because it will help to drop down the voltage and noise at data pin. So, if the transistor inside receiver chip is not conducting (transistor base a 0 V), the voltage come from the +5 V rail, goes through the resistor, then go to port A.0 at PIC16F877A as shown in receiver circuit.

3.5 LCD schematics

LCD is one of the modules that were very important in this project. LCD must be placed at both sides where the first one is at transmitter board and the second one sit at receiver board. LCD connection at transmitter board is same with the connection in receiver board. The entire data bit was connected to port C at PIC16F877A. The total pins of LCD are 16 pins. Each pin has their own function and the most important one is R/W, RS and E pins. These pins if not connected will cause a chaos to LCD and this maybe harm the LCD.

The schematic in Figure 3.10 show these three pins were connected to port B and the data bits pin was connected through port C. Instead of connecting R/W pin to port B, it can be directly connected to the ground.

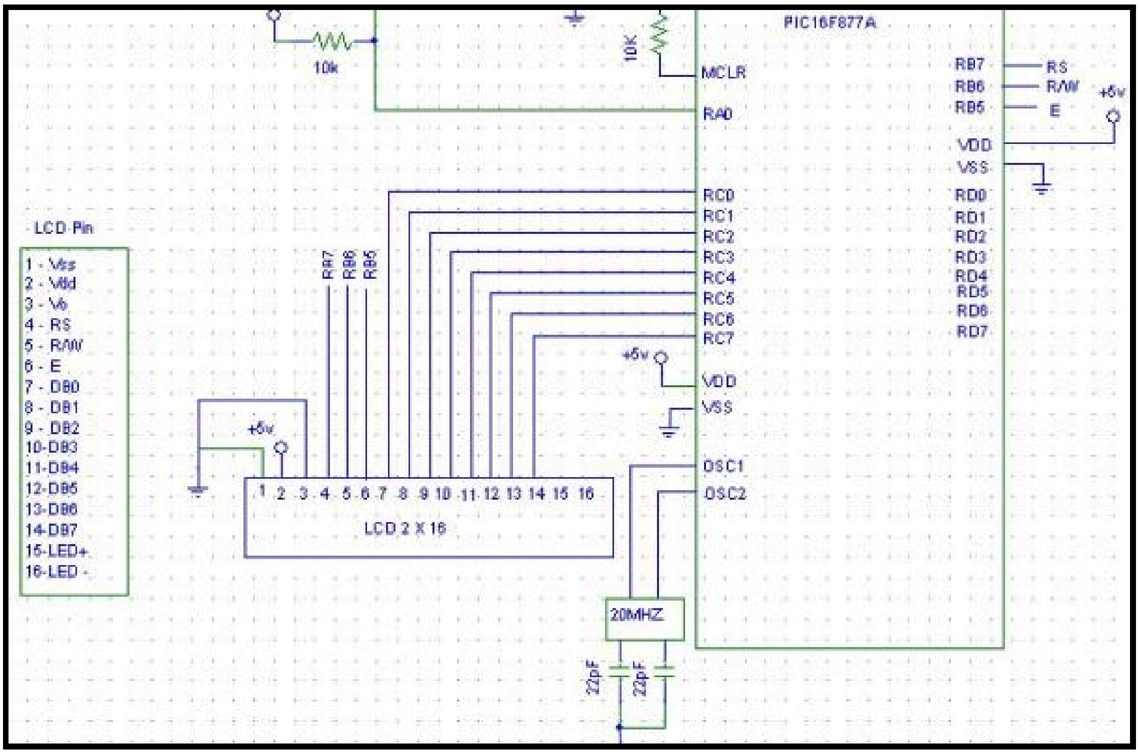

Figure 3.10 LCD schematic

But must bear in mind forgetting R/W pin connection will make the LCD unable to display character. Only bunch of black box can be seen on the screen. Pin 15 and pin 16 not connected because it's not causing any effect to display setting. It's not necessary to connect this pin unless we want to use the LCD back light.

The schematics also show that pin 3 and pin 1 was jumped together and tied to ground. The purpose of doing this is to get the full contrast of LCD without using potentiometer. This setting is important for LCD part in this project because full contrast was needed to display the bus ID clearly on both sides.

CHAPTER 4

SOFTWARE DEVELOPMENT

4.1 Introduction

A flow chart is a graphical or symbolic representation of a process. Each step in the process flow is represented by a different symbol and contains a short text description of the process step in the flow chart symbol. The flow chart symbols are linked together with arrow connectors where it's also known as flow lines. A flowchart also described as "cross-functional" when the page is divided into different "lanes" describing the control of different organizational units. A symbol appearing in a particular "lane" is within the control of that organizational unit. This technique allows the analyst to locate the responsibility for performing an action or making a decision correctly, allowing the relationship between different organizational units with responsibility over a single process.

Inside this chapter, block diagram is also used instead of flow chart but it's only for explanation on the process of transmission and receiving data in general. Flow chart still becomes a main method to represent the whole process from starting line until the end. This chapter will more focus on software implementation and how the system will be developing according to the software. Each module has its own flow of system and with this flow software will be develop according to the flow. All the software comes up with its own hardware, so to test whether each software work as plan, hardware must play its role. If both software and hardware able to work with each other, it means that the project run successfully.

4.2 Block diagram of transmission and receiving bus ID

The whole process of this project was explained in Figure 4.1. The transmitter board was placed inside a bus very close to bus driver. Hence, when the bus arriving at the bus stop, bus driver will insert bus ID by pressing a keypad. PIC16F877A will execute keypad scanning and then order LCD to display the bus ID. After that RF transmitter will send the ID and receive by RF receiver at the bus stop. PIC16F877A will receive the input through receiver pin at port A.0.

Then, PIC16F877A will command LCD to display the bus ID on LCD and make the LED blinking. The entire LED will blink depends on signal received. Valid or invalid bus ID will cause to different types of blinking by LED. LED only placed on receiver board at bus stop. Detail explanation for the whole process for transmitter and receiver board will be explained in flow chart.

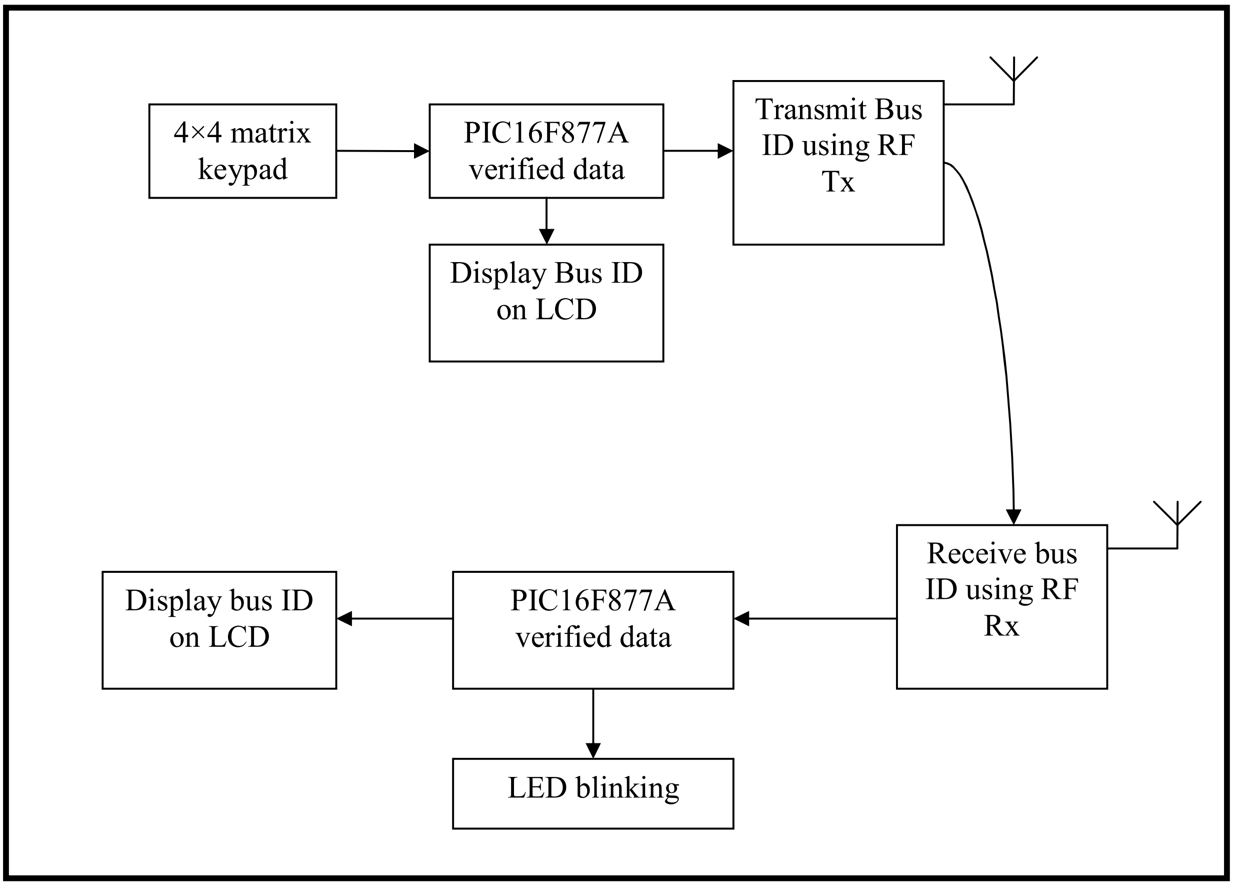

Figure 4.1 Transmitter board and receiver board block diagram

4.3 Transmitter Board flow chart

Transmitter board was the first hardware built in this project. Transmitter board contains a keypad, PIC16F877A, RF transmitter 433 MHZ and LCD. Figure 4.2 show the whole processes that occur in transmitter board in flow chart. Keypad will act as an input at transmitter board. Bus driver will use the keypad to insert bus ID. All entire row and column at keypad was defined in 16 decimal numbers where each pad has their own decimal number. Each time keypad was pressed, PIC16F877A will execute keypad scanning program to determine which column and row is tied low.

Then PIC16F877A will store every byte of data from the pressing keypad into memory block. Inside bus ID transmission program there was a phrase that defined the LCD to display only the data byte less than five after the word BUS at the second line. If the data byte is bigger than four, PIC16F877A will command LCD to display word “invalid BUS ID” in four seconds before back to initial condition.

After display the data on LCD either bus ID or character “Invalid BUS ID”, PIC16F877A will send 1 byte of data to RF transmitter pin through at port A.0 using SEROUT command. SEROUT is a basic command use in PicBasic Pro which used for sending data through serial port. Inside the programming of transmitter board, port A.0 which is pin two at PIC16F877A was already define as transmitter pin and the transmitter pin will send out any byte or bit of data in serial form. RF transmitter at the outside will receive the byte of data through data pin or TxD pin in binary form only which is ‘0’ or ‘1’.

One byte of data is equal to eight bits. Hence the binary form for 01 in data byte is 00000001. This type of data will be send by RF transmitter in a standard frequency 433 MHz through antenna. The data byte that was transmitted from transmitter board depends on the key which pressed by a bus driver. Some careless mistake by a bus driver will cause the RF transmitter to send invalid bus ID. But the precautions already make inside the program to display only valid bus ID on LCD at transmitter board. If invalid bus ID appears on screen, bus driver will alert and reinsert the bus ID.

The entire data will be converted to acoustic wave form by SAW filter or any other types of piezoelectric inside the RF transmitter. But for this project, the RF module use SAW filter to convert electrical signal to sound wave and vice versa.

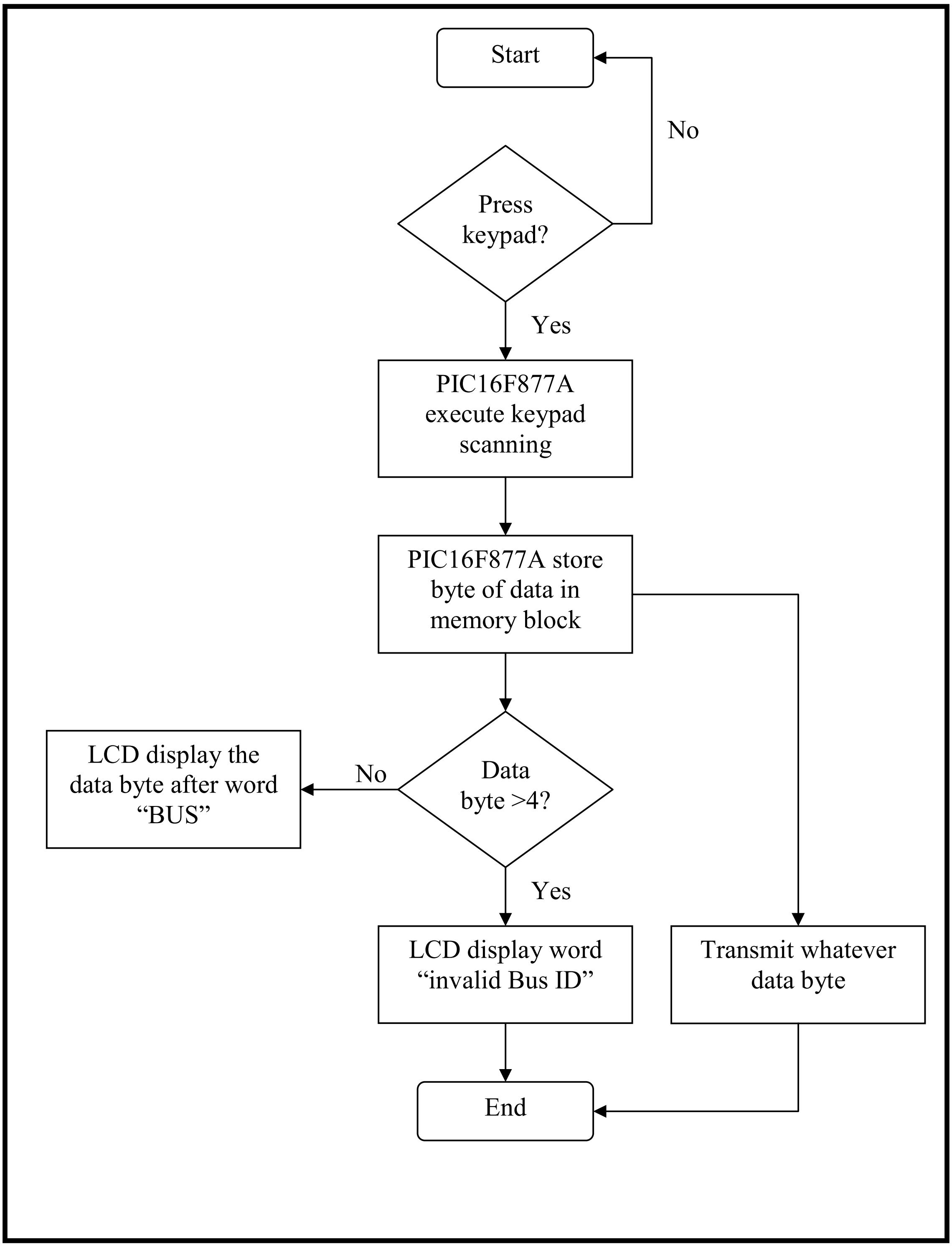

Figure 4.2 Transmitter board flow chart

4.4 Receiver board flow chart

Receiver board was done after the transmitter board installed completely. Receiver board must be setup properly as mention in previous chapter to make it work with programming software. Figure 4.3 shows the whole process which occurs at receiver board. RF receiver will receive every byte that was transmitted by RF transmitter.

After receive one byte of data, RF receiver will send it through data pin or RxD pin to port A.0 at PIC16F877A in receiver board. Port A.0 work as receiving pin and it will receive any bytes or bits from RF receiver. This process accomplishes using SERIN command at receiver programming software. PIC16F877A will automatically define port A.0 or pin 2 at port A as an input pin and store all the data from this pin to a memory block.

Then, PIC16F877A will check if the byte of data that was received is bigger than four or not. If the byte value is bigger than four, PIC16F877A will command LCD to display word "Invalid BUS ID" five times in blinking. The duration for each blinking is half a seconds. At the same moment, eight piece of LED will also get order from PIC16F877A to blink five times following the blinking word on LCD. But this is not the outputs that suppose to appear on LCD screen. This situation occur only for invalid bus ID which means the data byte receive is noise or maybe wrong inserted bus ID cause by a bus driver. The most important thing that should appear on LCD screen at bus stop is the valid bus ID which is BUS01, BUS02, BUS03 or BUS04. These situations only occur if the value of receiving byte is lower than five. LCD at receiver board will display the valid bus ID after get command from PIC16F877A. PIC16F877A will send 8 bits of data through port C to make the LCD display the data.

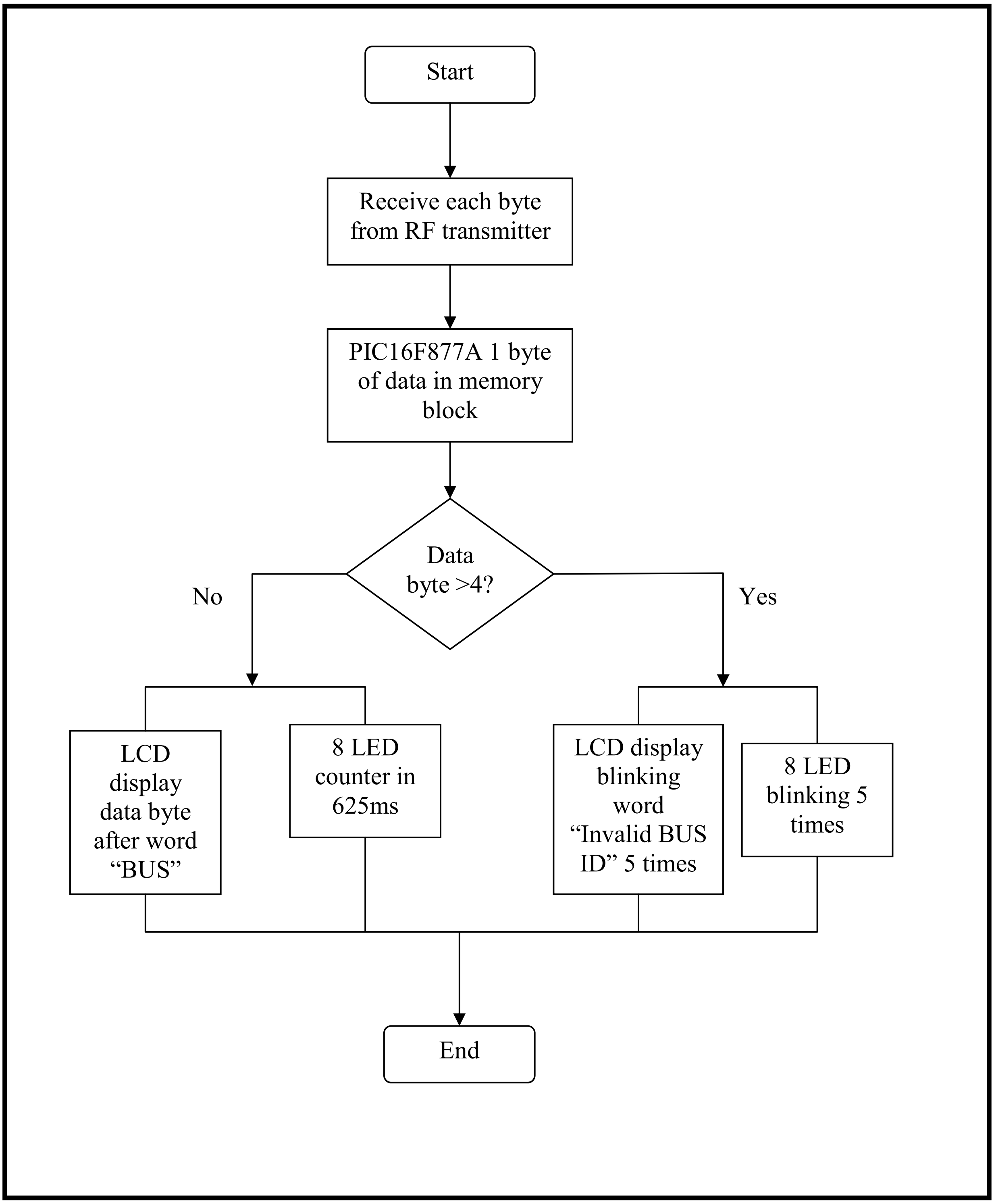

Figure 4.3 Receiver board Flow chart

CHAPTER 5

RESULT & ANALYSIS

5.1 Introduction

This chapter will discuss in detail the result of the project. There are two major parts in this project that will communicate with each other to get the output. The fist part is transmitter board and the second part is receiver board.

5.2 Transmitter board result

Table 5.1 show the table which content of transmitter board result. At transmitter board keypad work as an input to insert bus ID. PIC16F877A will act as a main control panel for the whole component inside the board. The programming for PIC16F877A includes all the commands which can make the components to play their role. Keypad programming already define the entire keypad switch or button to 16 decimal number. When pad 1 is pressed at keypad, it means a decimal value 01 detected by PIC16F877A. Pad 4 will produce decimal value 02, pad 3 will produce decimal value 03 and pad * will produce decimal value 04. These for push button or pad represent valid bus ID which is BUS01, BUS02, BUS03 and BUS04. The other pad will represent invalid bus ID following the keypad subroutine.

Table 5.1: Table content for transmitter board result

Inserting bus ID using keypad	PIC16F877A action	LCD display	RF transmitter action
Press pad 1	Scan keypad row & column then store data to memory	BUS01	Send 1 byte of data which is 01
Press pad 4	Scan keypad row & column then store data to memory	BUS02	Send 1 byte of data which is 02
Press pad 7	Scan keypad row & column then store data to memory	BUS03	Send 1 byte of data which is 03
Press pad *	Scan keypad row & column then store data to memory	BUS04	Send 1 byte of data which is 04
Press other pad	Scan keypad row & column then store data to memory	Invalid BUS ID	Send 1 byte of data in decimal value

.

Keypad subroutine is the programming part inside PIC16F877A to scan which keypad is pressed and automatically define their decimal number according to pressing pad. PIC16F877A will wait until all the column gets high to execute the keypad scanning. If there is no column get high PIC unable to scan it and that's mean keypad is not function at all. The keypad programming in Figure 5.1 shows this step. LCD will play its role every time the keypad is pressed. LCD part will determine either the pressing keypad is valid bus ID or invalid bus ID. Serial communication between PIC16F877A and LCD take place at port C. PIC16F877A will send 8 bits of data through port C each time LCD command was execute. Eight bits of data was equal to one byte. If a byte of data that was transmitted through port C is 01, it's equal to 00000001 in data bits. LCD will read this form of data and then display it on screen after the word BUS.

```
Subroutine to get a key from keypad,
getkey:
PORTD = 0                ' All output pins low
TRISD = $f0              ' Bottom 4 pins out, top 4 pins in
WHILE PORTD != $F0 : wEND   ' Wait 'till all key=up
PAUSE 50                 ' Debounce

ScanKeypad:
For col = 0 to 3              '
TRISD=~(DCD COL)           ' Set one I/O to output
PAUSEUS 5                 ' wait a little bit to avoid
'   erratic results
'
ROW=ncd((~(PORTD>>4)) & $f) ' read row
'
IF ROW THEN                ' Any key pressed?
key = ((row-1)*4)+ col+1' --- YES convert key value
return               '    and getout of here
ENDIF                '
NEXT                  '
Goto ScanKeypad               ' No keys down, go look again
```

Figure 5.1 Keypad subroutine

Figure 5.2 show the LCD command. This is the part where LCD able to differentiate between valid and invalid bus ID that suppose to display on screen. Actually LCD will works depends on the pressing keypad. PIC16F877A will play as a controller for LCD by determining the size of data byte from pressing keypad. At initial condition, LCD will display on screen “Insert Bus ID”.

Each time the keypad is press, PIC16F877A will check the pressing keypad either it produce the valid bus ID or not. If the byte is bigger than 4, PIC will order LCD to display “invalid Bus ID” and if the byte is lower than 5, LCD will display the byte in decimal value on second line at LCD. The decimal value can be seen after word “BUS” at second line on LCD

```
ADCON1 = 7 ' Make PORTA and PORTE digital

      low PORTB.6 'Set the R/W bit to low
      High TransmitterPin
      Pause 500 ' Wait for LCD to start
      Lcdout $fe, 1, "Insert Bus ID" ' Display sign on message

loop:
      Gosub getkey ' Get a key from the keypad
      Lcdout $FE, $C0, "BUS",DEC2 key
      IF key>4 then
         LCDOUT $FE,$C0,"Invalid BUS ID"
         Pause  4000
         lcdout $fe,1, "Insert Bus ID"
      ENDIF
      SEROUT
TransmitterPIN,T1200,[Synk,Synk,Synk,Synk,Synk,Synk,Synk,Synk,Synk,"~",
KEY]
      Goto loop ' Do it forever
```

Figure 5.2 LCD command

Figure 5.3 show the initial condition of LCD. LCD will display “insert Bus ID” at the first line just about 2 second after it get the 5V supply. Thus, if pad 1 is pressed, LCD will show the bus ID on second line as shown in figure 5.4 and this is the view for a valid bus ID. The LCD at this time show “BUS01” which appear when the keypad pressed is pad 1. This view goes the same with the other valid bus ID as listed on the table of transmitter board result.

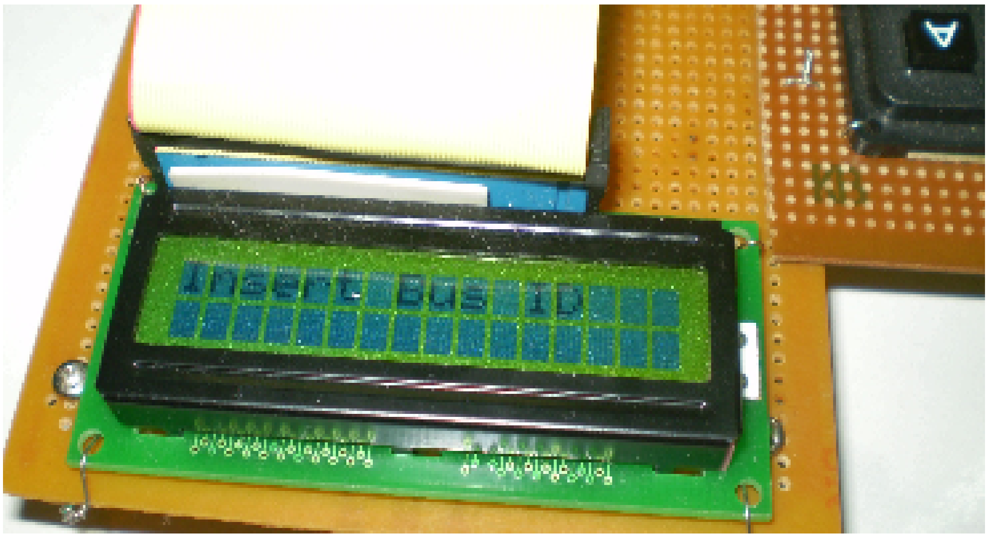

Figure 5.3 LCD at initial condition

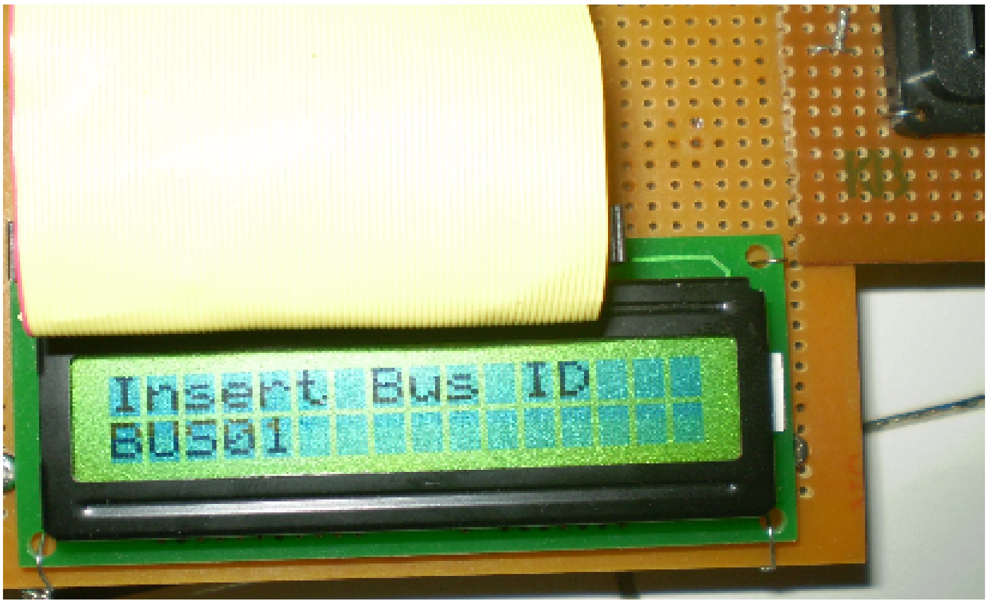

Figure 5.4 LCD display valid bus ID

The situation is different if wrong pad is pressed by a bus driver. If the pad pressed is 5 or other numbers, it will produce invalid bus ID. LCD will not display the decimal value unless the bus driver pressed the pad that will produce valid bus ID.

Under this circumstance, LCD will only displays the word “Invalid Bus ID” on second line as shown in Figure 5.5.

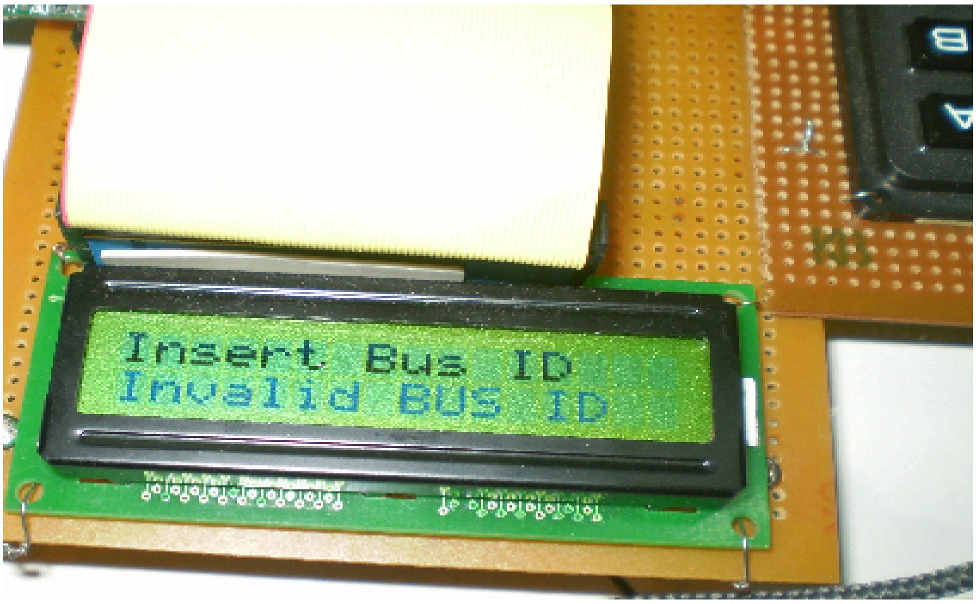

Figure 5.5 LCD display for invalid bus ID

RF transmitter is not very picky in doing its job. It will always transmit every byte from data pin through the antenna as an acoustic signal. Thus, if the keypad is pressed, RF transmitter will always send the data byte from port A.0 using antenna to the receiver part at the other side. Then the LCD at the receiver side will choose either to display the byte as a valid bus ID or invalid bus ID. The programming of transmission part can be seen on Figure 5.6.

```
SEROUT
TransmitterPIN,T1200,[Synk,Synk,Synk,Synk,Synk,Synk,Synk,Synk,Synk,"~",KEY]
```

Figure 5.6 Transmitter program

PIC16F877A defined port A.0 as a transmitter pin that supplies a data byte to RF transmitter for a signal transmission. Sending few preamble characters before our data to RF receiver is a must for all types of data transmission. The purpose of doing this is to train the receiver to receive bits '0' or '1' before receives the data. The suitable preamble character is hexadecimal $55. Hexadecimal $55 in binary from is 01010101 and a byte data will sit after these preamble characters. Hence, RF receiver will receive the preamble character first before receive the data byte. "Synk" symbol in Figure 5.6 means hexadecimal $55 where it's already defines at the early stage of the programming. A good starter for sending preamble characters is sending 2, 4, 6, or 9 characters before the data to the RF receiver.

5.3 Receiver board result

Receiver board was plugged at the bus stop. The main control panel for receiver board is just the same with transmitter board which is PIC16F877A. RF Receiver will receive one byte of data either it is 01, 02, 03, 04 or other byte of data. If there is no data received by RF receiver, LCD will show sign "wait for BUD ID" on screen as shown in Figure 5.7. This is the initial condition at receiver board in a bus stop. Table 5.2 show the full result in receiver board at bus stop.

Table 5.2: Table content for receiver board result

RF receiver receive data byte	**PIC16F877A action**	**LCD display**	**LED action**
Receive 1 byte of data which is 01	Store data to memory then order LCD to display it	BUS01	8 LED counter or dancing 1 times.
Receive 1 byte of data which is 02	Store data to memory then order LCD to display it	BUS02	8 LED counter or dancing 1 times.

Receive 1 byte of data which is 03	Store data to memory then order LCD to display it	BUS03	8 LED counter or dancing 1 times.
Receive 1 byte of data which is 04	Store data to memory then order LCD to display it	BUS04	8 LED counter or dancing 1 times.
Receive any other bytes of data	Store data to memory then order LCD to display it	Invalid Bus ID in 5 times blinking	8 LED blink 5 times with delay 0.5 second for each blink

Figure 5.7 LCD display at initial condition

Since RF receiver cannot differentiate the data byte either it's a valid bus ID or not, LCD will play it roles to display the valid bus ID or invalid bus ID. If the data byte receive was lower than 5, LCD will display the decimal value on second line after word "BUS". The first line of LCD will appear "Received Bus ID" at the same time with bus ID on second line as shown on Figure 5.8. If the RF receiver receives at bus stop one byte of data such as 08, LCD will not display it in the same way of displaying valid bus ID because the data was bigger than 04. LCD will display "Invalid Bus ID" instead on second line together with the word “Received Bus ID” at first line as shown in Figure 5.9.

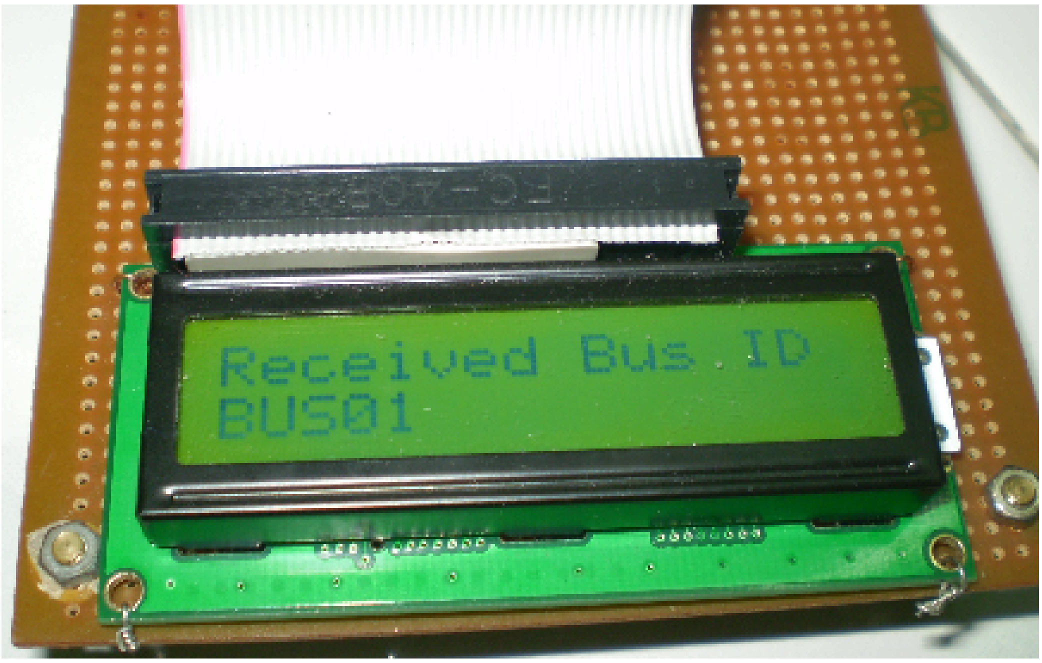

Figure 5.8 LCD display valid bus ID

Compare to the transmitter board, the word “Invalid Bus ID” will unmoved on second line. It just reset after four second and the view appear on LCD will be back to initial condition. The situation on receiver board is different, the word “Invalid Bus ID” will blink five times with duration 0.5 seconds for each blinked. Since the receiver board has a signal indicator which is LED, it will also blink five times with the same duration of LCD blinking. With the same duration here means each LED blink is equal 0.5 second for each blinking. Stable LED blinking requires high current to perform successfully. Low current supply will make it blinking one times or maybe not blink at all. That’s why we need a stable power supply to produce good voltage and current. Creating a stable power supply already been discussed in hardware implementation chapter.

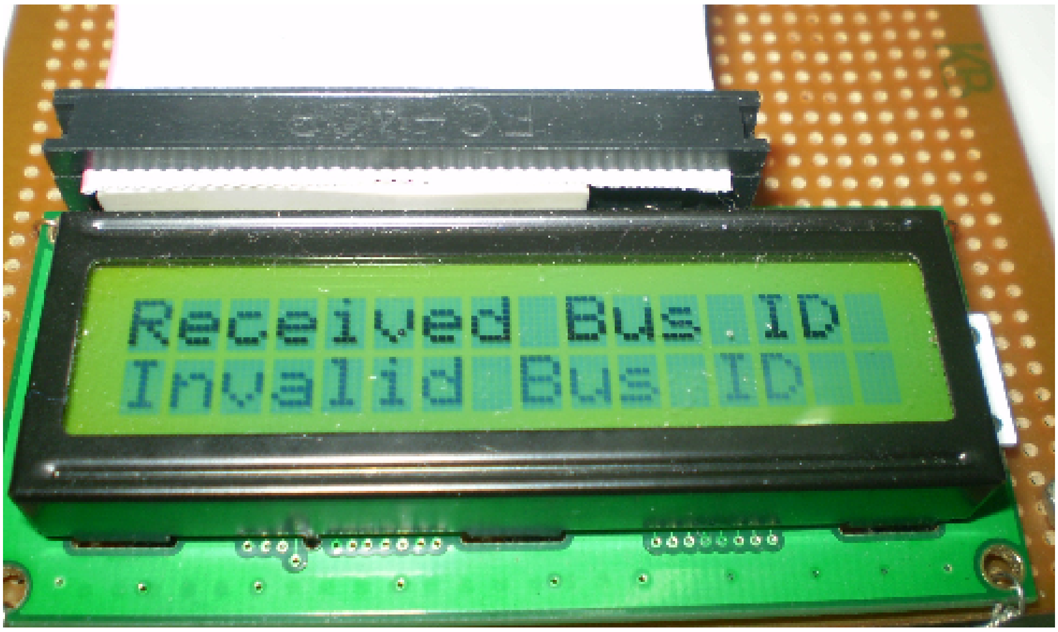

Figure 5.9 LCD display for invalid bus ID

Actually, LED act depends on the receiving signal together with LCD. Thus, each time the signal received at receiver board, the entire LED will function either blinking five times or make one counter from the first LED to the last one. All LED was connected to port D at PIC16F877A as shown in receiver board full schematic at appendices. If the data byte received by receiver is bigger than 4, the entire LED will blinking five times and this situation indicate invalid bus ID was receive at the bus stop. But if the data byte is lower than five, LED will make a counter only one time from the first LED to the last one to show that the valid bus ID is received at the bus stop. All LED was put very close to LCD at receiver board as shown in Figure 5.10. The blinking of LED perhaps alert the officer by any chance go to the bus stop for observation process of the sending and receiving bus ID at the bus stop or maybe doing some maintenance over there. This situation will also give advantage to the passengers at the bus stop by alerting them that the bus ID received is wrong. This will absolutely avoid them from taking a wrong bus.

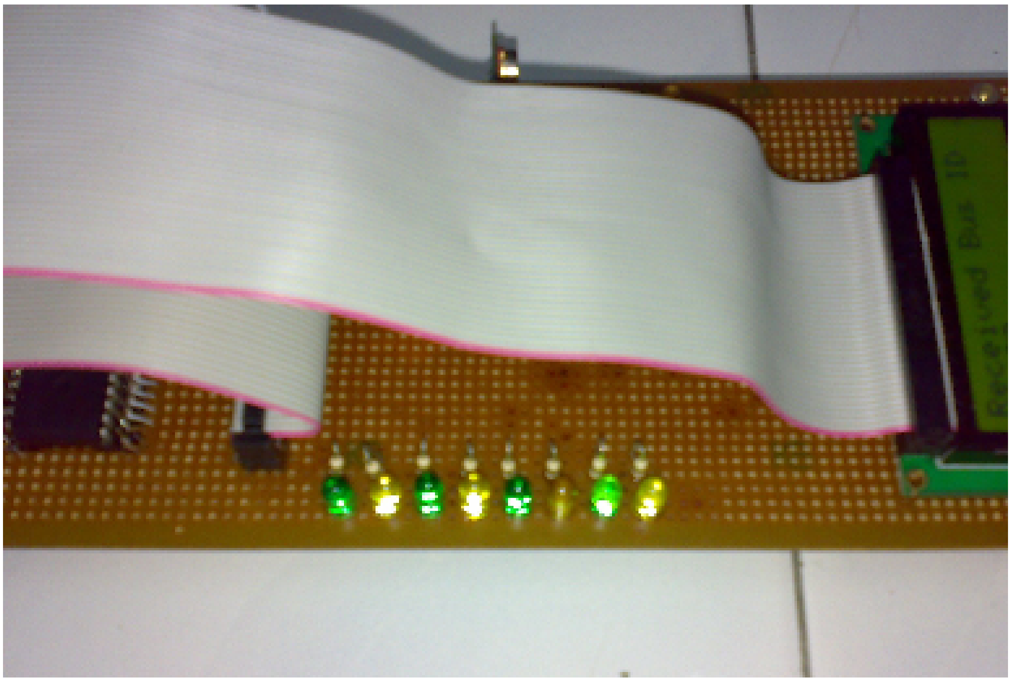

Figure 5.10 LED spot at receiver board

The fact is all the progress in receiver board handles by PIC16F877A with the receiver programming. Figure 5.11 show the receiver board program that control LCD, LED and RF receiver. Symbol “T1200” at receiver part inside the program represent a signal baud rate. T1200 is the value of baud rate that make the RF receiver feel comfort to receive the data. If the baud rate is changed, RF receiver will receive too much data in a short time and this means plenty of unused signal will also received by the RF receiver. Baud rate is a measure of how fast data is moving between instruments that use serial communication such as RF module. Data bits are transmitted upside down and backwards. That is, inverted logic is used and the order of transmission is from least significant bit (LSB) to most significant bit (MSB).

Knowing the structure of a character frame and the meaning of baud rate as it apply to RF module will help in calculating the maximum transmission rate in characters per second for a given communication setting. This rate is just the baud rate divided by the bits per frame. If the transmission rate is set at 1200 baud, then we get 1200 divided with 8 bits will equal to 150 characters per second. It means the RF transmitter capable to transmit 150 characters per second to the receiver. So, high baud will cause the RF receiver to receive too much character and perhaps noise is included between the characters.

```
      PORTD=0     'Clear ALL LEDs
      low PORTB.6 'Set the R/W bit to low
      pause 500   'wait until the LCD initializes
Main:
      LCDOUT $FE,1,"Wait for Bus ID"
      SERIN ReciverPIN,T1200,["~"],YourByteVar
      LCDOUT $FE,1,"Received Bus ID"
      IF YourByteVar>4 then
                gosub InvalidBus
            ELSE
                gosub ValidBus
            ENDIF
      GOTO Main
InvalidBus:
      for CounterA=1 to 5
         LCDOUT $FE,$C0,"Invalid Bus ID"
         portD=255              ' Enable all LEDs
         Pause 500              ' Delay for .5 seconds
         portD = 0              ' Clear All LEDs
         lcdout $FE,$C0, rep " "\16  ' Clear LCD 2nd line
         Pause 500              ' Delay for .5 seconds
         next
         return
 ValidBus:
      Lcdout $FE,$C0,"BUS", DEC2 YourByteVar
      for CounterA=0 to 7
         PORTD=DCD COUNTERA
         PAUSE 625 ' 5sec/8leds = 625 mSec
         NEXT
      PORTD=0 ' Clear ALL LEDs
      return
```

Figure 5.11 Receiver board program

5.4 Costing and commercialization

The overall cost of the whole project is based on the hardware development. As discussed in previous chapter, the hardware development consist of two hardware and for that, costing of the whole project is surely depends of the electronic devices used for the development process. Table 5.3 shows the overall cost for the hardware development of this project.

Table 5.3: Table of project costing

Electronic devices	Specification	Quantity	Cost (RM)
PIC16F877A	40 DIP	2	44.00
RF Transmitter	FM Tx 433 MHz	1	50.00
RF Receiver	FM Rx 433MHz	1	50.00
Keypad	4×4 matrix keypad	1	21.00
LCD	2×16 LCD	2	32.00
IC base	40 pin	2	0.20
Crystal	20 MHz	2	6.00
Board	Independent types	2	5.00
Capacitor	Tantalum 0.1µF	2	0.60
Capacitor	Tantalum 10µF	1	0.30
Capacitor	Tantalum 35µF	1	0.30
Capacitor	Ceramic 0.1µF	4	0.80
Capacitor	Ceramic 22ρF	4	0.80
Capacitor	Tantalum 100µF	2	0.60
Capacitor	Tantalum 10µF	2	0.60
LED	-	10	1.50
Switch	Reset Switch	2	0.40
Voltage regulator	LM7805	2	3.00
Resistor	10kΩ	6	0.36

Resistor	150Ω	2	0.12
Resistor	100Ω	8	0.48
LCD cable	20 stripe	2	10.00
Ribbon wire	8 stripe	1	0.20
Diode	1N4148	1	0.20
Wire Wrapping	30 meter	1	8.00
Total cost			**RM 236.46**

The total cost for the development of the Bus monitoring system is RM 236.46. These values is quite cheap compared to the other types of monitoring system which RFID or GSM system and for that reason it can be commercialize in the market. Actually these types of bus monitoring system looks simple by using only keypad as an input but it works very well and easy maintenance.

CHAPTER 6

CONCLUSION & RECOMMENDATION

6.1 Introduction

There will be a brief project summary and conclusion will be describe in this chapter. Furthermore few recommendations and the total cost of project will also explained inside this chapter.

6.2 Conclusion

The major goal of this project is assure the bus ID can be received at the bus stop without any error occurs from the transmitting point. A lot of work has been done to make the project success and the hardest part is filtered out the noise which often interfered at receiver part. Hence, the bus ID that was showed on LCD screen sometimes wrong. But the troubleshooting process for this problem was done successfully using a filter circuit that was placed on transmitter and receiver side. As a result, both hardware able to communicate with each other using RF module without any other interference from unused frequency.

As a conclusion, the scope and the objective of this project was achieved successfully. Both hardware which is transmitter board and receiver board capable to work without any problem occur. The bus ID also display correctly on both side as mention in detail on hardware and software part.

Overall, all modules in this project function properly and able to work in a small voltage supply which is 5 V. However, some improvement on RF transmitter and RF receiver especially need to be done. Using the open-collector a type of receiver seems to create a lot of problem in terms of noise and unused frequency. Hence, high technology of RF module can be used to increase the efficiency of transmit and receiving data. There is many types of good RF module that can be used such as FSK types where the RF module have their own carrier detector to detect the data signal and receive only data signal and reject unused data. The programming for this system also needs to be improved. It is because the programming itself will determine the system stability as the microcontroller will response under difference condition and environment.

6.3 Future recommendation

For the future plan of this project, it is recommended other candidate to do more studies on the related information in order to develop a new design of bus monitoring system. There are two matters recommended into the design of bus monitoring system which is application of RFID and GSM to the project.

6.3.1 Radio Frequency Identification Device (RFID)

Radio Frequency Identification Device is not a new technology used in electronics devices. These technologies are widely used in a real time today in various applications and gadgets. RFID can replace the keypad as an input for this project.

It is because these devices make the system easier to be operated and controlled. The scanning antenna puts out radio-frequency signals in a relatively short range where it provides a means of communicating with the transponder provide RFID tag with energy to communicate. When an RFID tag passes through the field of the scanning antenna, it detects the activation signal from the antenna. That "wakes up" the RFID chip, and it transmits the information on its microchip such as bus ID to be picked up by the scanning antenna.

6.3.2 Global System for Mobile communication (GSM)

GSM system also can be implemented in designing bus monitoring system if we can afford the budget because as we all know the cost of using GSM system is too high. GSM (Global System for Mobile communications) is an open, digital cellular technology used for transmitting mobile voice and data services. GSM differs from first generation wireless systems in that it uses digital technology and time division multiple access transmission methods. GSM supports data transfer speeds up to 9.6 kbit/s, allowing the transmission of basic data services such as Short Message Service. It means the bus ID can travel very far using GSM system. That means bus ID can directly transmit to a bus company even the range is very far.

This will help the officer to finish their job easily without collecting the bus ID from the bus stop or using multiple RF modules to transmit the bus ID to the bus company. Another major benefit is its international roaming capability, allowing users to access the same services when traveling abroad as at home. GSM satellite roaming has also extended service access to areas where terrestrial coverage is not available.

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APPENDIX A

Program for transmitter board

```
@ device HS_OSC, LVP_OFF
define OSC 20

DEFINE LCD_DREG PORTC 'LCD data port
DEFINE LCD_DBIT 0 'LCD data starting bit 0 or 4
DEFINE LCD_RSREG PORTB 'LCD register select port
DEFINE LCD_RSBIT 7 'LCD register select bit
DEFINE LCD_EREG PORTB 'LCD enable port
DEFINE LCD_EBIT 5 'LCD enable bit
DEFINE LCD_RWREG PORTB 'LCD read/write port
DEFINE LCD_RWBIT 6 'LCD read/write bit
DEFINE LCD_BITS 8;4 'LCD bus size 4 or 8
DEFINE LCD_LINES 2 'Number lines on LCD
DEFINE LCD_COMMANDUS 2000 'Command delay time in us
DEFINE LCD_DATAUS 50 'Data delay time in us

TransmitterPIN VAR PORTA.0

DEFINE CHAR_PACING 500

TRISA = 0 'Set port A as output
TRISB = 0 'Set port B as output
TRISC = 0 'Set port C as output
TRISD = 0 'Set port D as output
```

```
' Define program variables
INCLUDE "modedefs.bas"
col     var byte ' Keypad column
row     var byte ' Keypad row
key     var byte ' Key value
Synk    VAR BYTE
    Synk = $55


ADCON1 = 7 ' Make PORTA and PORTE digital

low PORTB.6 'Set the R/W bit to low
High TransmitterPin
Pause 500 ' Wait for LCD to start
Lcdout $fe, 1, "Insert Bus ID" ' Display sign on message

loop:
    Gosub getkey ' Get a key from the keypad
    Lcdout $FE, $C0, "BUS",DEC2 key
    IF key>4 then
      LCDOUT $FE,$C0,"Invalid BUS ID"
      Pause  4000
      lcdout $fe,1, "Insert Bus ID"
    ENDIF
    SEROUT
TransmitterPIN,T1200,[Synk,Synk,Synk,Synk,Synk,Synk,Synk,Synk,Synk,"~",KEY]
    Goto loop ' Do it forever

    ' Subroutine to get a key from keypad
getkey:
    PORTD = 0               ' All output pins low
```

```
    TRISD = $f0               ' Bottom 4 pins out, top 4 pins in
    WHILE PORTD != $F0 : wEND   ' Wait 'till all key=up
    PAUSE 50                  ' Debounce

ScanKeypad:
    For col = 0 to 3                 '
      TRISD=~(DCD COL)            ' Set one I/O to output
      PAUSEUS 5                  ' wait a little bit to avoid
                              '   erratic results
                              '
      ROW=ncd((~(PORTD>>4)) & $f) ' read row
                              '
      IF ROW THEN                ' Any key pressed?
        key = ((row-1)*4)+ col+1' --- YES convert key value
        return                 '    and getout of here
        ENDIF                  '
      NEXT                     '
    Goto ScanKeypad              ' No keys down, go look again
```

APPENDIX B

Program for receiver board

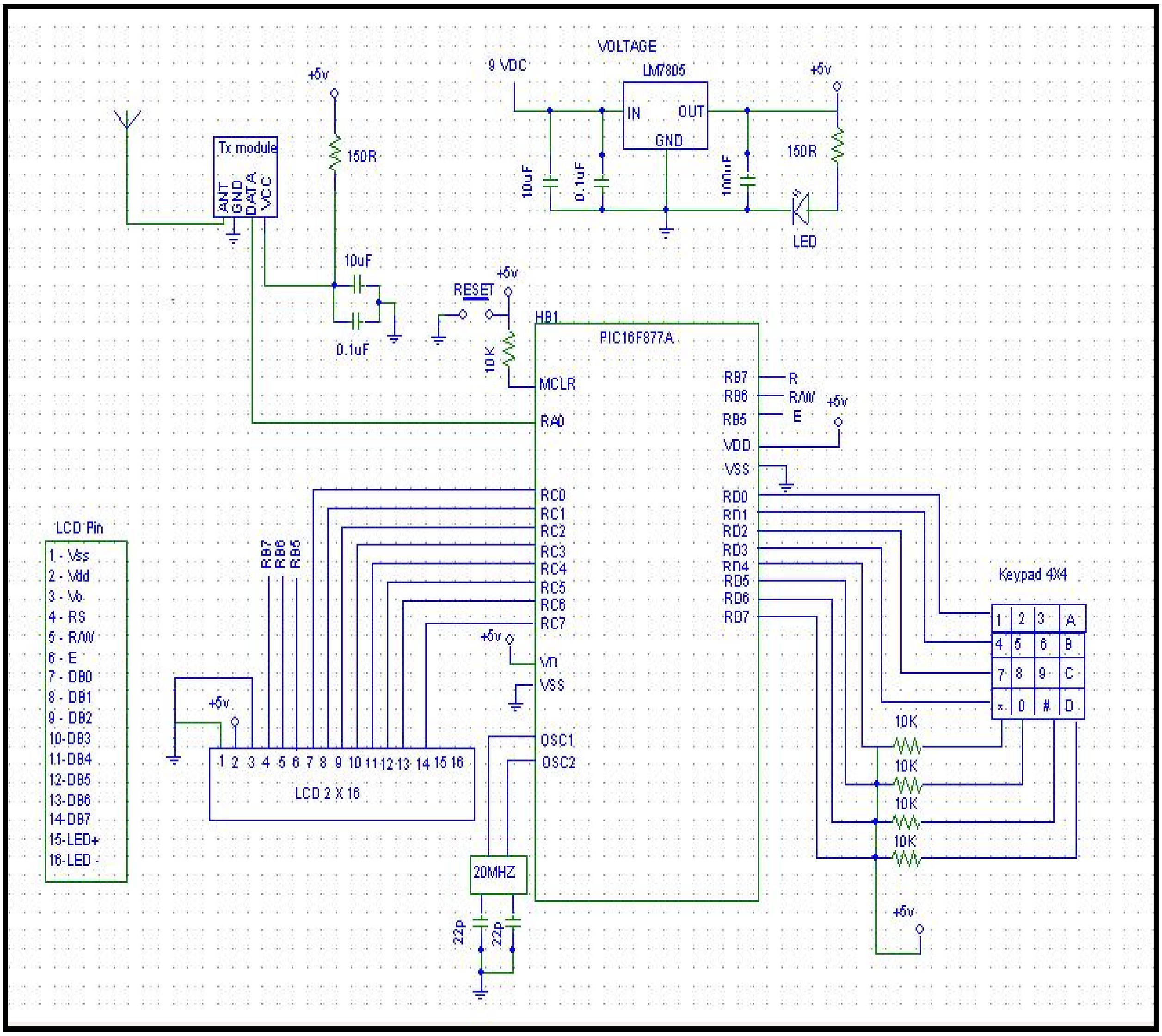
```
@ device HS_OSC, LVP_OFF
define OSC 20

DEFINE LCD_DREG PORTC 'LCD data port
DEFINE LCD_DBIT 0 'LCD data starting bit 0 or 4
DEFINE LCD_RSREG PORTB 'LCD register select port
DEFINE LCD_RSBIT 7 'LCD register select bit
DEFINE LCD_EREG PORTB 'LCD enable port
DEFINE LCD_EBIT 5 'LCD enable bit
DEFINE LCD_RWREG PORTB 'LCD read/write port
DEFINE LCD_RWBIT 6 'LCD read/write bit
DEFINE LCD_BITS 8;4 'LCD bus size 4 or 8
DEFINE LCD_LINES 2 'Number lines on LCD
DEFINE LCD_COMMANDUS 2000 'Command delay time in us
DEFINE LCD_DATAUS 50 'Data delay time in us

TRISA = 1 ' PORTA.0 input, other as output
TRISB = 0 ' Set port B as output
TRISC = 0 ' Set port C as output
TRISD = 0 ' Set port D as output

ReciverPIN VAR PORTA.0

ADCON1 = 7 ' Alla digitala
```

```
    INCLUDE "modedefs.bas"
    YourByteVar var byte
    CounterA    var byte
    PORTD=0     'Clear ALL LEDs
    low PORTB.6 'Set the R/W bit to low
    pause 500   'wait until the LCD initializes

Main:
    LCDOUT $FE,1,"Wait for Bus ID"
    SERIN ReciverPIN,T1200,["~"],YourByteVar
    LCDOUT $FE,1,"Received Bus ID"
    IF YourByteVar>4 then
            gosub InvalidBus
         ELSE
            gosub ValidBus
         ENDIF
    GOTO Main

InvalidBus:
    for CounterA=1 to 5
      LCDOUT $FE,$C0,"Invalid Bus ID"
      portD=255              ' Enable all LEDs
      Pause 500              ' Delay for .5 seconds
      portD = 0              ' Clear All LEDs
      lcdout $FE,$C0, rep " "\16  ' Clear LCD 2nd line
      Pause 500              ' Delay for .5 seconds
      next
    return

ValidBus:
    Lcdout $FE,$C0,"BUS", DEC2 YourByteVar
```

```
for CounterA=0 to 7
   PORTD=DCD COUNTERA
   PAUSE 625 ' 5sec/8leds = 625 mSec
   NEXT
PORTD=0 ' Clear ALL LEDs
return
```

APPENDIX C

Transmitter board full schematic



APPENDIX D

Receiver board Full Schematic