Developement of Wireless Control Mechanism for Better EM Source and Receiver Positioning For Onshore Application

By

Rayzeme b Harun

Dissertation submitted in partial fulfillment of
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Universiti Teknologi PETRONAS
Bandar Seri Iskandar
31750 Tronoh
Perak Darul Ridzuan

CERTIFICATION OF APPROVAL

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Approved by,

(ASSOC. PROF DR NOORHANA BT YAHYA)
Project Supervisor

DR NOORHANA YAHYA
Associate Professor
Fundamental & Applied Sciences Department
Universiti Teknologi PETRONAS, PERAK

UNIVERSITI TEKNOLOGI PETRONAS
TRONOH, PERAK
JUNE 2009

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

RAYZEME B HARUN

ABSTRACT

This document describes the approach used by the writer in development of wireless control mechanism for better EM source and receiver positioning for onshore application. The implementation of EM wave to detect the possibility of hydrocarbon existence underground facing a few challenges which is the noise receive by the EM receiver and the miss position of EM receiver to receive the required signal. Thus, a mechanism has to be developed so as this mechanism can control the position of EM receiver to receive better signal from EM transmitter.

The project will make use of wireless communication technology as communication medium between the mechanism and the controller which is a computer. By using wireless communication, the computer can control the behavior of the mechanism for EM receiver repositioning and able to receive and record the data from the EM receiver. This will result in increased qualities of EM signal receive by the receiver and the data can be stored properly in the computer for better observation. Author has use Visual Basic and MPLab IDE for develop the interface of the controller and programming the microcontroller.

ACKNOWLEDGEMENT

This thesis arose in part out of years of research and development that has been done since I enter my final year in University of Technology PETRONAS. By that time, I have worked with a great number of people whose contribution in assorted ways to the research and the making of the thesis deserved special mention. It is a pleasure to convey my gratitude to them all in my humble acknowledgment.

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CHAPTER 1

INTRODUCTION

1.1 Problem Statement

The most critical part in using EM wave to detect the existence of reservoir underground is at the part where receiver receives the signal. The EM receiver will detect the EM signal form the transmitter in form of electric voltage. This current are in range of hundred milivolt and this signal are prone to be disturb by noise and experience attenuation. The noise and attenuation received by the receiver will cost lack of accuracy in determining the existence of hydrocarbon underground [1].

This problem occurs because of unwanted surrounding signal received by the receivers and miss-position between the EM receiver and transceiver [2]. Thus it is crucial to maintain the correct position between the EM transmitter and receiver so as it can be parallel to each other. To achieve this goal, a mechanism has to be developed so as this mechanism can reposition the EM receiver to be parallel with incoming signal form transmitter.

1.2 Objective

The objective of this project is to construct a wireless control mechanism for better EM source and receiver positioning for onshore application. The mechanism should be able to reposition the EM receiver so as its can get better EM wave detection via automatic control by the microcontroller and manual control by the user. To implement this function, a Zig-Bee type of wireless communication will be used as a communication medium for computer and the mechanism. By using this method, the computer can control the mechanism and at the same time, the computer can receive data from the mechanism and store the data in computer memory.

1.3 Scope of Study

This project will cover the development of mechanism for EM receiver repositioning and the mechanism can be control via wireless communication. A computer will act as a controller that located around 100 meters from the robot and responsible to control the position of EM receiver.

The development of wireless communication between a computer (controller) with the mechanism will also be covered in this project. Full duplex wireless communication will be used in this project to enable the computer to send instruction to the mechanism and at the same time receive the data from robot [2]. This data will then store in computer memory.

The objective of this work is as follow:

(1) To design and develop an EM detector robot
(2) To transmit EM waves to a ferrite based EM detector in the robot located approximately 100 meters apart

However, the construction of EM receiver and simulation of the data received by the computer form the robot will not be covered in this project.

CHAPTER 2

LITERATURE REVIEW AND THEORY

2.1 Literature Review

ZigBee is the name of a specification for a suite of high level communication protocols using small, low-power digital radios based on the IEEE 802.15.4-2006 standard for wireless personal area networks (WPANs), such as wireless headphones connecting with cell phones via short-range radio [5]. The technology is intended to be simpler and cheaper than other WPANs, such as Bluetooth. ZigBee is targeted at radio-frequency (RF) applications that require a low data rate, long battery life, and secure networking [1].

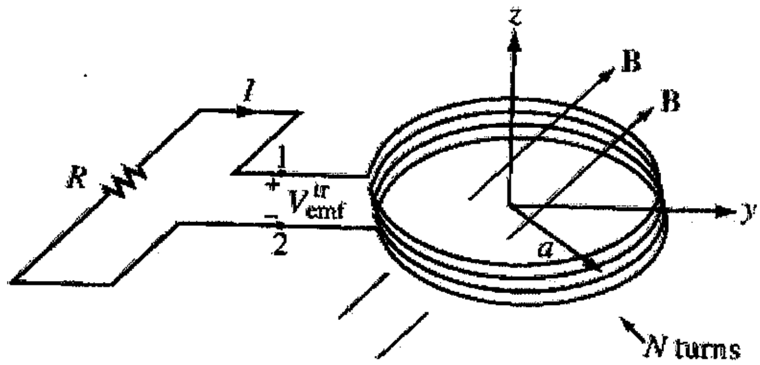
ZigBee protocols are intended for use in embedded applications requiring low data rates and low power consumption. ZigBee's current focus is to define a general-purpose, inexpensive, self-organizing mesh network that can be used for industrial control, embedded sensing, medical data collection, smoke and intruder warning, building automation, home automation, etc [3]. The resulting network will use very small amounts of power so individual devices might run for a year or two using the originally installed battery [4].

Table 1 Comparison of ZigBee, Bluetootoh and WiFi [5]

	ZigBee 802.15.4	Bluetooth 802.15.1	WiFi 802.11b
Applications:	Monitoring and control	Cable replacement	Web, video email
Data capacity (Kbps):	250	1,000	11,000+
Range (meters):	70	10	100
Battery life	years	days	hours
Nodes per network	255 - 65,000	8	30
Software size (Kbytes):	4 - 32	250	1,000+

2.2 Theory

Stationary loop in time- varying magnetic field



$$V_{emf} = -N\frac{d\Phi}{dt} = -N\frac{d}{dt}\int_S \mathbf{B} \cdot d\mathbf{s} \qquad (1)$$

When a surface is a plane and has total area A then

$$\phi = \vec{B} \,.\, \vec{A} = BA\cos\theta \quad (2)$$

Hence we find that the magnetic flux depends on

(i) The strength of the magnetic field.

(ii) The area of the surface.

(iii) The angle between the magnetic field vector and the area vector.

Increasing the magnetic flux through a surface can be done in 3 ways.

(i) Flux will increase if the magnitude of the area of the surface increases.

(ii) Flux increases if the magnetic field strength is more, i.e., when B is more.

(iii) It can also be increased by making the direction of magnetic field and the area of the surface to be parallel to each other, thus the flux will become maximum.

By implementing this theory, it is clear that, by maintaining the angle between magnetic field and surface (EM receiver) we can get maximum signal from the transmitter.

CHAPTER 3

METHODOLOGY

3.1 Designing overall system

In general, this project is held due to difficulty in manually position the receiver to get the receiver in parallel with the incoming signal form EM transmitter. Thus it is expected by doing this project, one mechanism can be produced as aid to the user so as the task of repositioning the EM receiver can be done efficiently to reduce error and increase the quality of collected data.

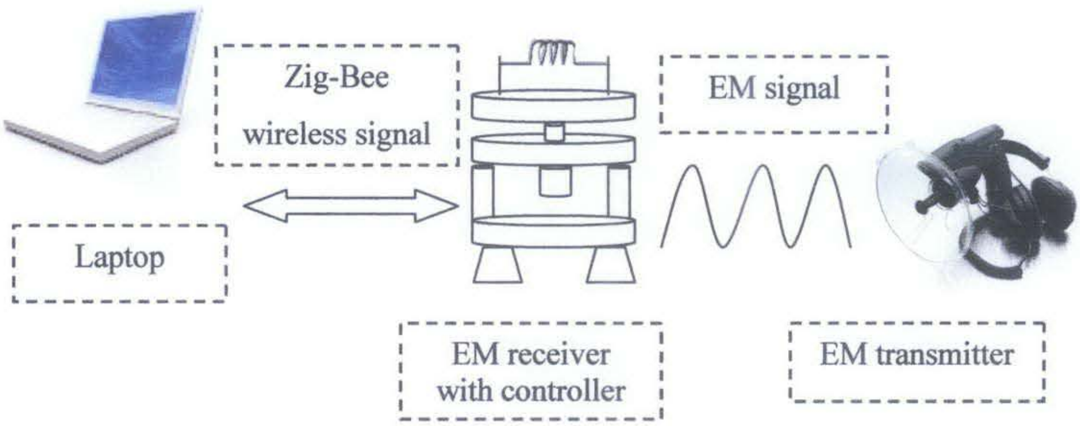


Figure 1 Overall System for the Project

The computer is used to transfer the instruction to the microcontroller on the robot, this instruction will be processed by the microcontroller and the microcontroller will control the behavior of the robot accordingly based on the instruction given by the computer. The computer and the robot has ability to communicate with each other via wireless communication and this enable the computer to store data sent by the robot and stored in computer memory for further analysis.

3.2 Physical Design of the Robot

The robot has been designed to be able to reposition the receiver to enhance quality of receiving EM signal. The structure of the robot must be strong enough to support the weight of various components that will be attached to the robot. Considering the receiver physical size, weight and various electrical components, author has decided to use perspex as main material to construct the body of the robot. This material is capable to handle strong force and suitable for outdoor environment.

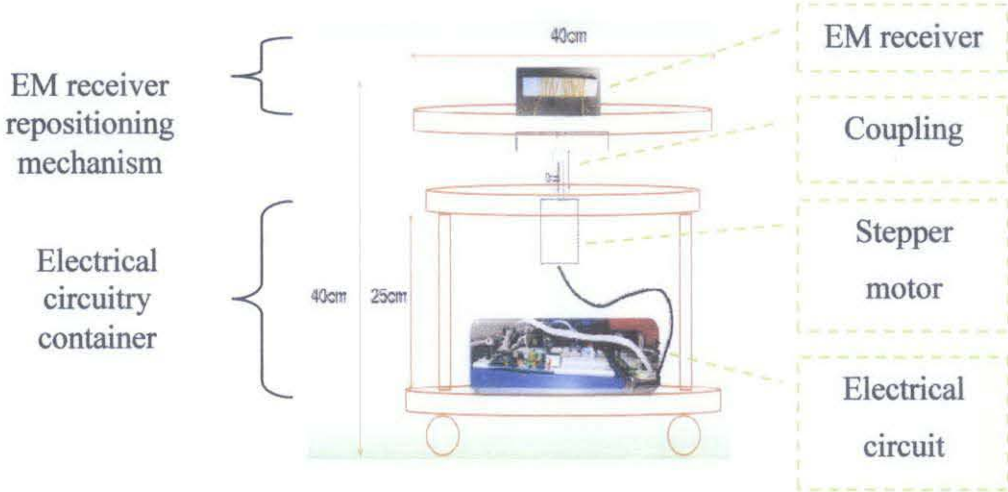


Figure 2 Complete mechanism design for the robot

As we can see from Figure 2, the robot consists of 2 parts which is EM receiver repositioning mechanism and electrical circuitry container. For EM receiver repositioning mechanism, it consists of EM receiver, a plate to attach the EM receiver and a coupling as a connector between the plate and stepper motor. All electrical circuit will be placed in electrical circuitry container.

3.3 Robot Construction

The body of the robot is made of perspex based on unique characteristic of perspex, the characteristic of perspex meet the requirement of our robot development since the robot will be used on challenging outdoor condition since the perspex is able to resist corrosion and it has low density to ensure ease of movement or repositioning.

The perspex was cut using electrical saw based on the specific size design by the author. To construct the electrical circuitry container, it's requiring 2 Perspex plates of 40cm x 40cm for the floor and top of the container. Four Perspex bar in the size of 25cm x 4cm x 4cm are required as a connector between floor and the top of the electrical circuitry container. On the top of the electrical circuitry container, one stepper motor is attached to it and the function of this motor is to turn the EM receiver accordingly based on input from microcontroller.

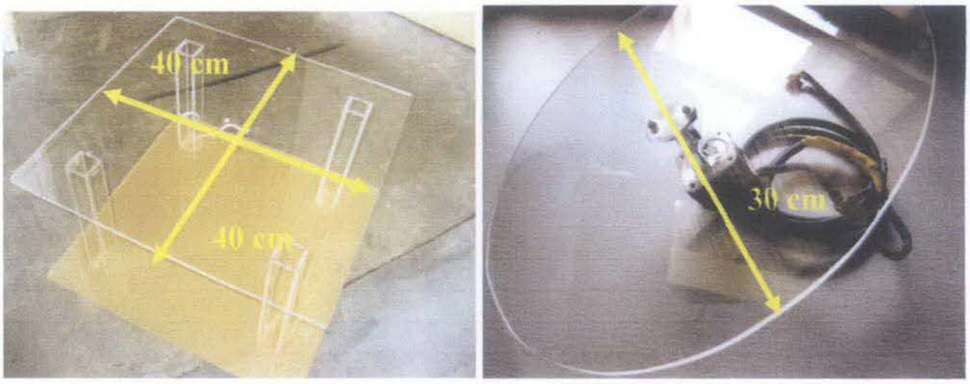


Figure 3 Picture of EM receiver repositioning mechanism and electrical circuitry container

To complete EM receiver positioning mechanism, one circular plate in radius of 10cm is required as platform to hold the EM receiver. The plate was connected to a stepper motor using coupling method, this coupling are made of aluminum solid and fabricated using Lathe Machine available in Manufacturing Technology Lab in UTP. After two main parts which is EM receiver repositioning mechanism and electrical circuitry container is done these two parts were combine as a final step to complete the physical design of the robot.

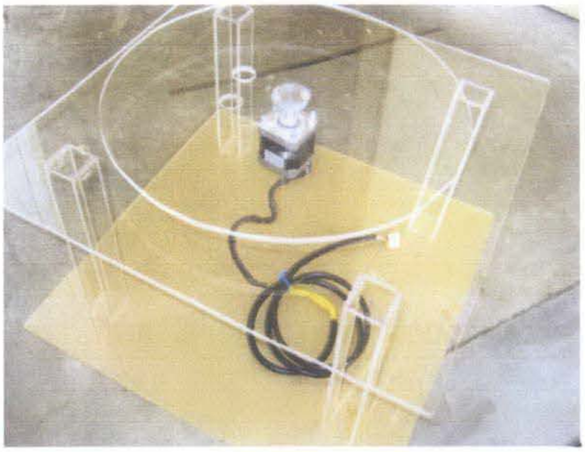


Figure 4 Complete physical structure of EM receiver robot

3.4 Electrical Circuit Design

3.4.1 System Overview

Figure 5 shows an overall system in detail where each of critical electrical components is clearly shown. As we can see, the computer will combine with one Zig-Bee transceiver to produce one controller system. The electrical component equipped to the robot will be another one Zig-Bee transceiver, a microcontroller, one stepper motor and EM receiver.

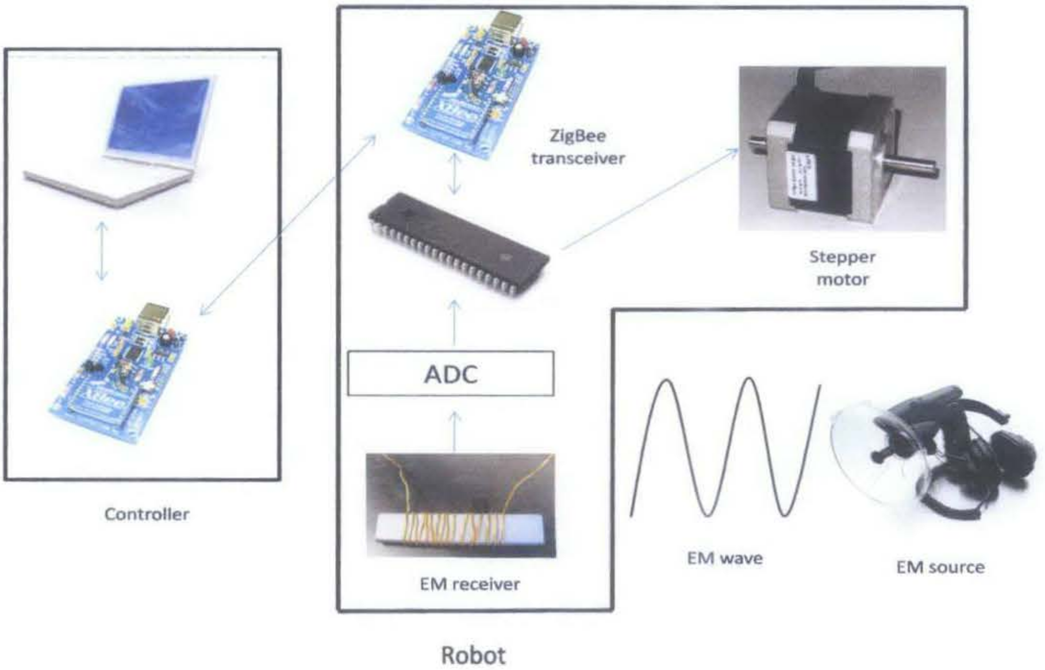


Figure 5 Overall system and electrical component used for the project

The interconnection between each components are also shown in Figure 5, as discussed before, two Zig-Bee transceiver has offer full duplex wireless communication used between the controller and the robot to enable instruction to be send by the controller to the microprocessor and at the same time received the data from the robot and this data will be stored in computer memory. The data stored in computer memory is a reading of voltage value received by EM receiver. Instruction sent by the computer then will be processed by the microcontroller and the microcontroller will produce an output to control the stepper motor for EM receiver repositioning.

There is lot of wireless technology available on market, thus author has to consider the available technology which is suitable to the application. Figure 6 shows information for various type of wireless communication.

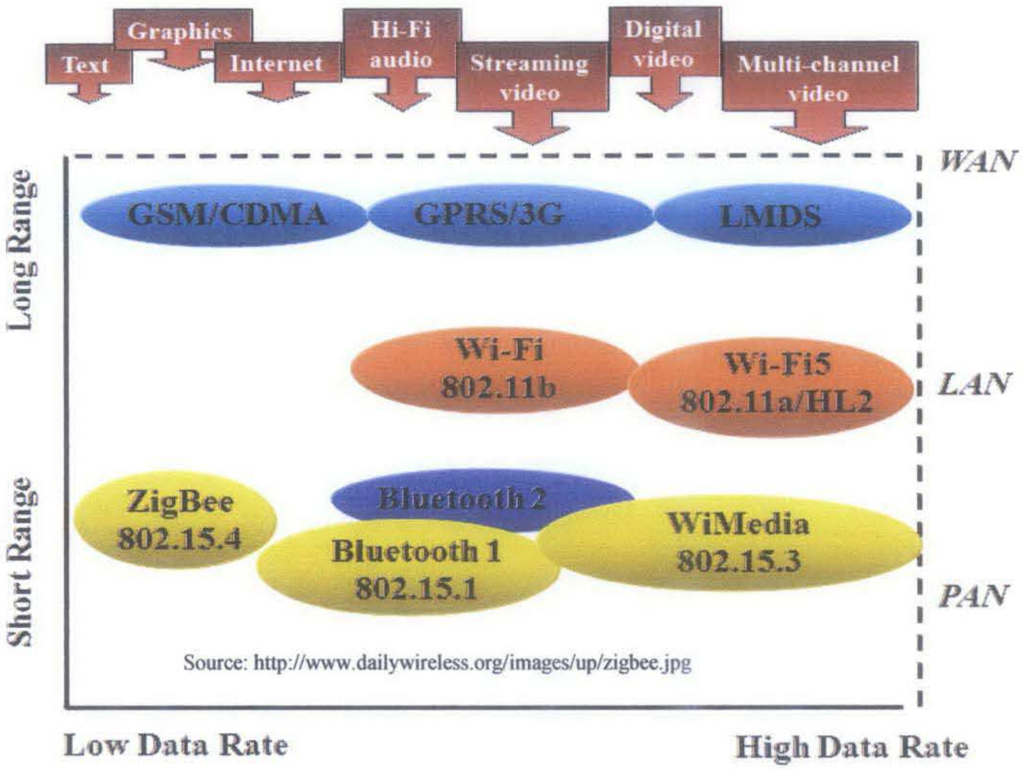


Figure 6 Info of various type of wireless technology

The author has chosen to use Zig-Bee technology based on reason as follow [8]:

- Standard in a fragmented market
- Low Power consumption
- Low Cost
- High density of nodes per network
- Simple protocol, global implementation

As mention before, the controller which is computer will control the robot via wireless communication and the robot will send the data received from the transmitter back to the computer. The network topology for this system will be explained in Figure 7 on the next page.

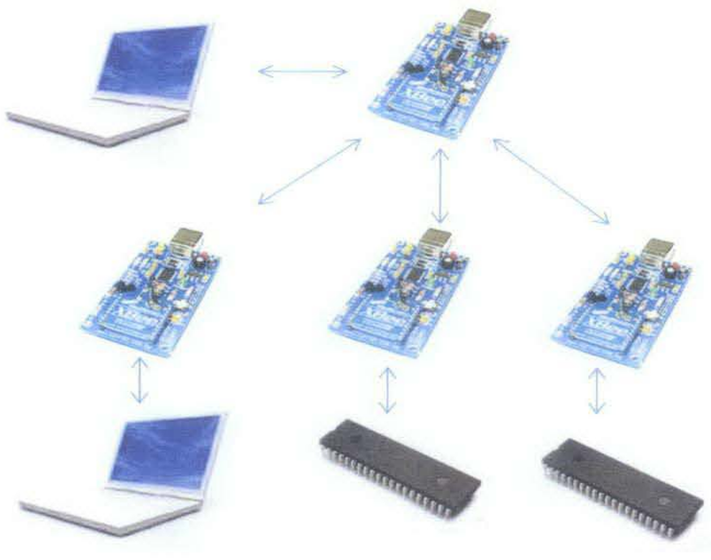


Figure 7 Wireless communication topology implemented to the project

By using this method, the computer can control more than one robot at one time, thus it is possible to control multiple receivers and at the same time the data from the entire receiver can be stored in computer memory.

3.4.2 Critical electrical component

Table 2 Detail of critical electrical components

XBEE Starter Kit	Price: RM 195
	Quantity: 2
	Features:
	• 5V UART interface, ready for microcontroller interface • Default baud rate of 9600bps • Long Range Data Integrity (100m) • Low power consumption • Compact yet easy and reliable platform • As serial port replacement (wireless) • Point-to-point, point-to-multipoint and peer-to-peer topologies supported

<table>
<tr>
<td>USB programmer

</td>
<td>Price: RM 180.00
Quantity: 1
Features:
• Designed for Intel based PC, DO NOT support AMD based system.
• Fast, reliable and low-cost.
• Do not support Window Vista
• Require USB port only.
• 12F, 16F and 18F PIC MCU are supported.</td>
</tr>
<tr>
<td>Stepper Motor
</td>
<td>Price: RM 154.00
Quantity: 1
Features:
• 4 phase's stepper motor.
• 6 lead wire.
• Size: 42mm x 42mm x 44mm
• 1.8 Degree per step
• Resistance: 26 Ohm
• Current: 0.5A
• Holding Torque: 3.5Kg.cm</td>
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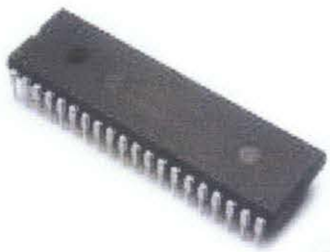
<tr>
<td>PIC-16F877A
Microcontroller
</td>
<td>Price: RM 30.00
Quantity: 1
Features :
• Flash 40-pin 4MHz 8kB Microcontroller with A/D converter
• Controlling the mechanism for the robot
• Convert analogue signal to digital signal to be transmitted to the computer</td>
</tr>
<tr>
<td>SD02A 2A Stepper Motor Driver
</td>
<td>Price: RM 120
Quantity: 1
Features:
• Support up to 2A per phase
• 10 micro stepping
• 5V logic level compatible inputs
• 6V to 12V compatible for V
• Maximum speed up to 1000 micro steps per second or 1KHz pulses
• Fan heat sink for fast thermal release</td>
</tr>
</table>

3.4.3 Controller Circuitry

As shown on Figure 8, the computer is directly connected to Zig-Bee wireless device. The computer and the wireless device will connect via USB cable

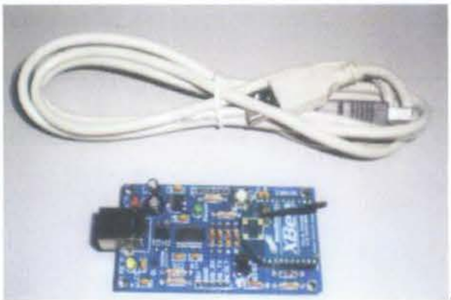


Figure 8 Zig-Bee wireless device with USB cable

For this device to work properly, the manufacturer has provided driver and software for this device so as it easier for the user to make use of all the function offered by SK-Xbee [4]. Zig-Bee wireless device that connect to the computer will be set as master and Zig-Bee wireless device that connect to the microcontroller will be configure as slave. User computer will act as a host, where it will host the network.

3.4.4 Robot Circuitry

For circuitry for the robot, there are 3 major critical sections that have to be done which is analog to digital converter (ADC), stepper motor and Zig-Bee wireless device. Those entire three devices will be control by 16f877 microcontroller. Figure below illustrate the function of each device and how this device controlled by the micro controller

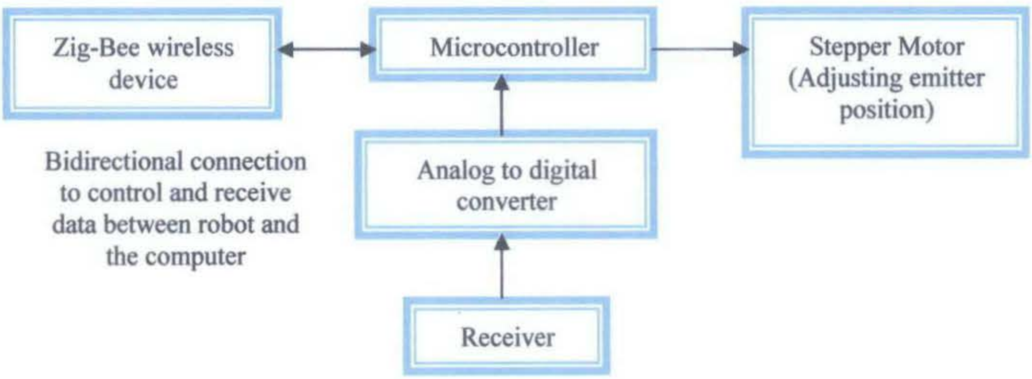


Figure 9 High level block diagram for electrical circuitry on the robot.

3.4.4.1 Zig-Bee wireless module interconnection

The robot has been design to operate via two methods which are, automatically control the position of receiver by the microcontroller and manual control by the user that monitor the robot from the computer. As show in Figure 10, the receiver will receive analog input from the transmitter; this signal then will be converting to digital signal by ADC. After the signal has been converted to digital form, the microcontroller will analyze the digital input signal for receiver repositioning as well as sending voltage reading of the receiver to the computer that monitored by the user.

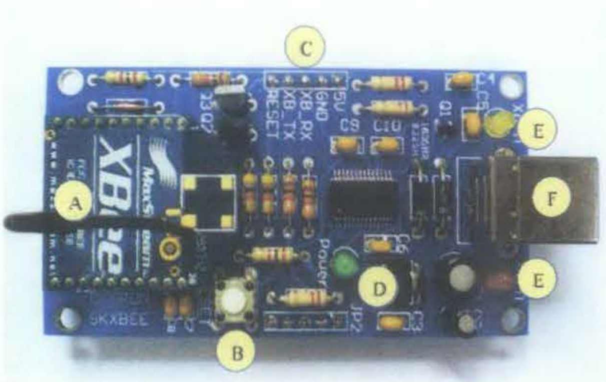


Figure 10 Zig-Bee wireless device

Table 3 Function of main component on Zig-Bee wireless module

Label	Function
A	Xbee module
B	On board reset button
C	5 ways header pin for external power and interface to microcontroller
D	On board 3.3V power indicator LED
E	Two LED indicator for USB receiver and transmitter status
F	USB B type socket

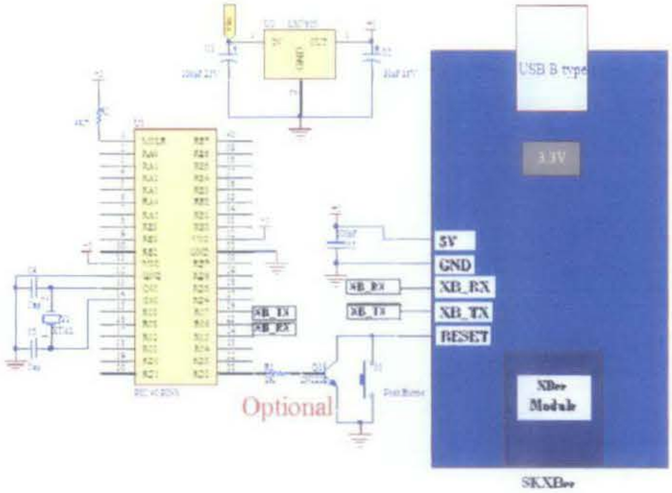


Figure 11 Circuitry connection between Zig-Bee wireless modules with microcontroller

Zig-Bee wireless module can only be control by the microcontroller or the computer at one time [8]. Figure 12 illustrated a circuitry to enable microcontroller to control wireless module. During in this configuration, USB cables are prohibited to be plug with the wireless module to avoid any risk of potential damage on the module [9].

3.4.4.2 SD02A 2A Stepper Motor interconnection

SD02A is designed to drive unipolar or bipolar stepper motor. The board incorporates most of the components of the typical applications. With minimum interface, the board is ready to use. Simply add in power and a few push buttons, this driver is ready to drive unipolar or bipolar stepper motor. SD02A will actually drive stepper motor in bipolar method. However, since unipolar stepper motor can also be used as bi-polar stepper motor, thus this driver can be used to drive both unipolar and bipolar stepper motor [4].

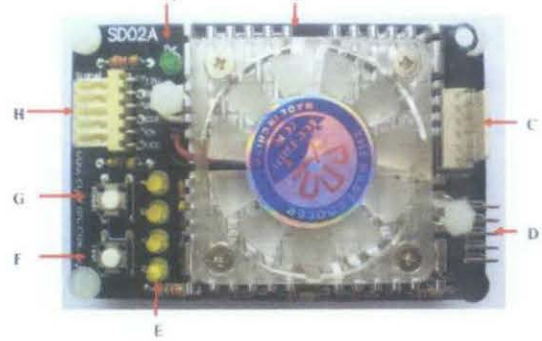


Figure 12 SD02A Motor Driver Board Layout

Table 4 Component in SD02A board

Label	Function	Label	Function
A	Small green LED as VCC indicator	E	Stepper motor coil power indicator (4 LEDs)
B	Heat sink with fan	F	Push button to test SD02A
C	Connector to stepper motor	G	Push button to reset SD02A
D	Manufacturing test point	H	Connector to Host (Signal)

Typical application would require a microcontroller to generate pulses and control the direction. Following figure shows an example of SD02A connected to microcontroller.

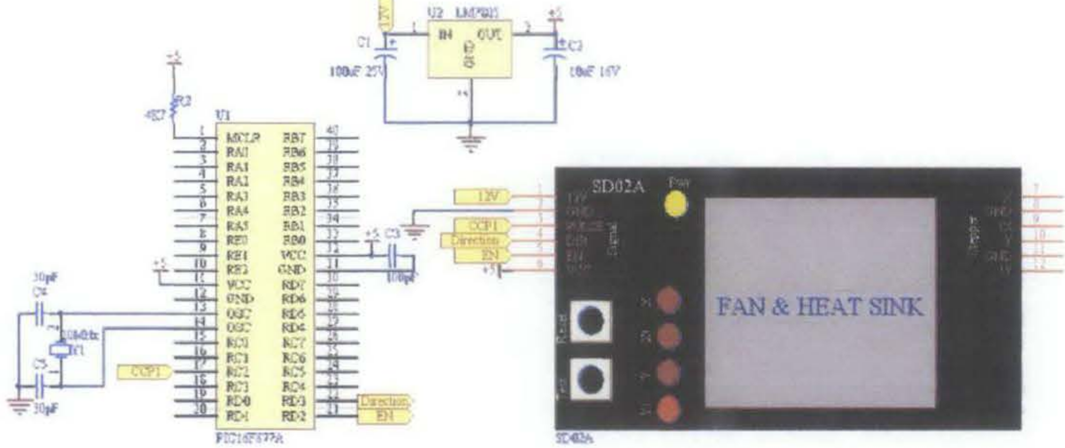


Figure 13 SD02A connection with microcontroller

3.4 Controlling Stepper motor using SD02A

Driving stepper motor is common necessity in most robotic project. A stepper motor is a brushless, synchronous electric motor that can drive a full rotation into a large number of steps. Stepper motor is ideally suited for precision control.

Figure 14 System overview for controlling stepper motor

This motor can operate in forward/reverse with controllable speed from a microcontroller through a transistor driver circuit. There are various kinds of stepper motor. Some example are variable reluctant stepper motor, permanent magnet stepper motor, bipolar/unipolar stepper motor, bifilar stepper motor and hybrid stepper motor [5]. For this project, author has chosen unipolar stepper motor to control the rotation for EM receiver.

SD02A is designed to drive stepper in 10 micro steps. This will offer smoother rotation for mechanism [4]. Of course, the step angle will depend on the specification of stepper motor being drive. As an example, if the stepper motor being drive is 1.8° per step, with SD02A, the smallest step (1 pulse) is 0.18°. This will offer much better rotation.

<u>Calculation:</u>

The resolution of stepper motor = 1.8 degree/step.

By using SD02A (1/10 micro-stepping), every pulse given to SD02 will rotate the motor for

$\frac{1.8}{10}$ = 0.18 degree.

$$\text{Number of pulse needed} = \frac{Desired\ rotation\ degree}{0.18\ degree} \quad (3)$$

<u>Example:</u>

If we want the motor to rotate 180 degrees from the current position, the number pulse to be provided to SD02A is:

$$\text{No of pulses needed} = \frac{180}{0.18} = 1000 \text{ pulses.}$$

3.6 Analog to Digital Converter

In this project, analog to digital converter will be done by the microcontroller, there is several factor has to be consider when to perform ADC using microcontroller. The consideration factors are:

- The range of voltage
- Polarity of the voltage
- ADC sensitivity

A microcontroller that used in the project which is 16f877-A has limitation of voltage that can convert to digital. This microprocessor only capable to convert analog voltage in range of 0-5v, and the microcontroller has ability to measure single polarity voltage at one time, which mean the negative magnitude of sine wave signal can't be convert to digital. The most importing consideration factor by using this microcontroller is ADC sensitivity; the receiver will sense the voltage in range hundred mill volts. Thus it's important to tune microcontroller so as it can detect small voltage changes during analog to digital conversion. The calculation of determining the sensitivity of the microcontroller is shown below.

<u>ADC Configuration</u>:

- $F_{ull\ scale} = 5v$
- Number of register's bit for conversion = 10 bit

$$v_{resolution} = \frac{v_{full\ scale}}{2^n - 1} \qquad (4)$$

$$= \frac{5v}{2^{10} - 1} = 4.88mV$$

Thus with this configuration, the microcontroller can detect every 4.88mV changes during analog to digital conversion for ADC configuration as specify above.

3.7 Programming

3.7.1 Programming for Zig-Bee wireless device

To ease the testing and configuration of Zig-Bee wireless device, the author has used X-CTU software from Digi-International. First, setup X-CTU which is a computer based software to communicate with XBee, to change configuration or transmit data. Then, install X-CTU Software to PC by double-clicking on the "setup_x-ctu.exe" file. This file can be downloaded from SKXBee page. X-CTU has to be configured to correct baud rate (UART data speed) to enable the communication and display data from Zig-Bee wireless module. The figures below illustrate the instruction to setup the Zig-Bee wireless device.

Setup for wireless device 1

Setup for wireless device 2

Figure 15 XCT-U software command mode to setup the wireless device

Figure above shown command lines that has been send to Zig-Bee wireless device 1 and 2 respectively. For wireless device 1 which will be connected to the computer, it has been setup to act as a network coordinator (master) where wireless device 2 will act as a network node (slave).

Wireless device 1 Wireless device 2

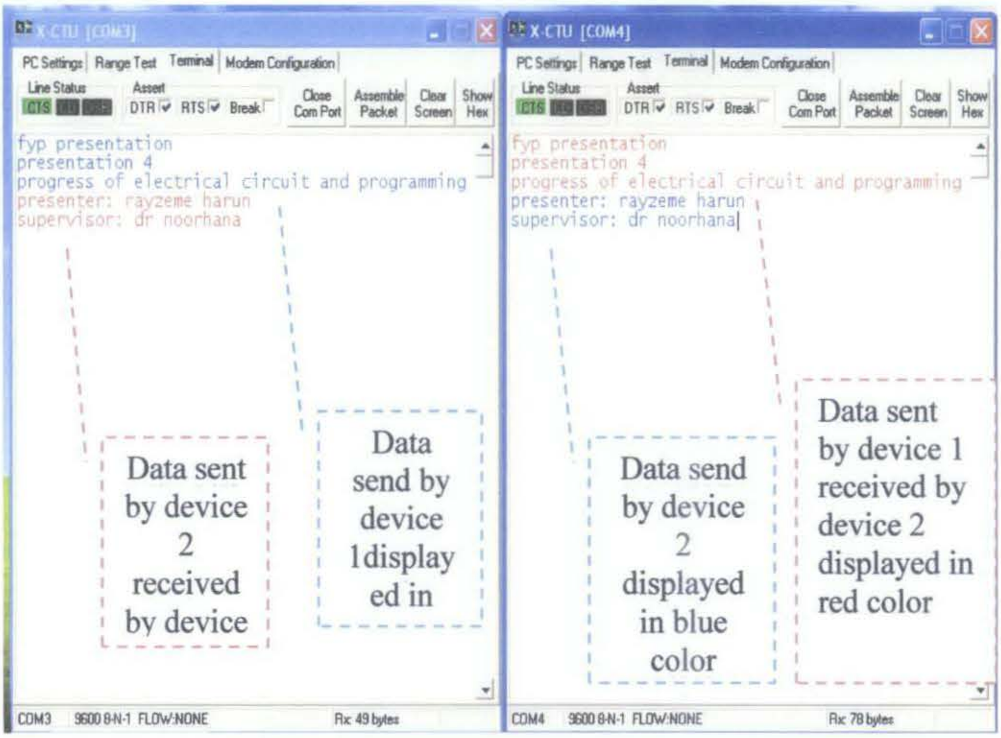


Figure 16 Sending and receiving data between 2 wireless devices

Wireless device 1 will act as a coordinator of the network to enable another wireless device connects to it. When this connection established, the host and the node can exchange the data between them. Referring to above figure, the data wish to be send (blue in color) will then received by device 2 (red in color). This connection is fully duplex connection where both device can send and receive the signal [1].

3.7.2 Programming for microcontroller

To program the microcontroller, the author has use MPlab IDE software which utilizes C programming to program the microcontroller. Below is the flow diagram to enable microcontroller to perform ADC and repositioning the position of receiver.

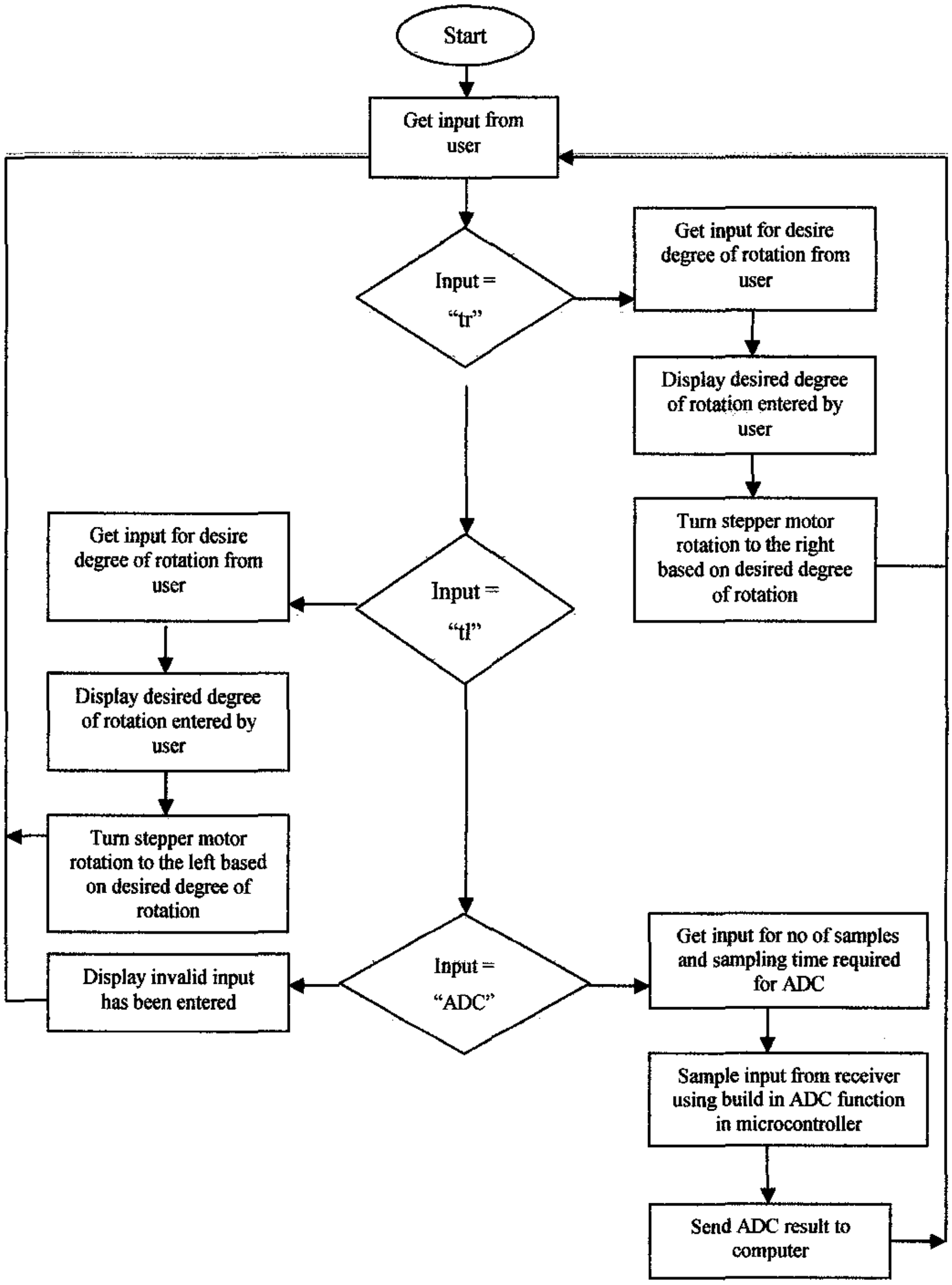


Figure 17 Flow diagram of ADC conversion and receiver positioning by the microcontroller

To apply all functionality described in flow diagram shown in Figure 18. The circuit shown below has been design and also have several additional features that help operator during handling this mechanism such as LCD display and also LED indicator.

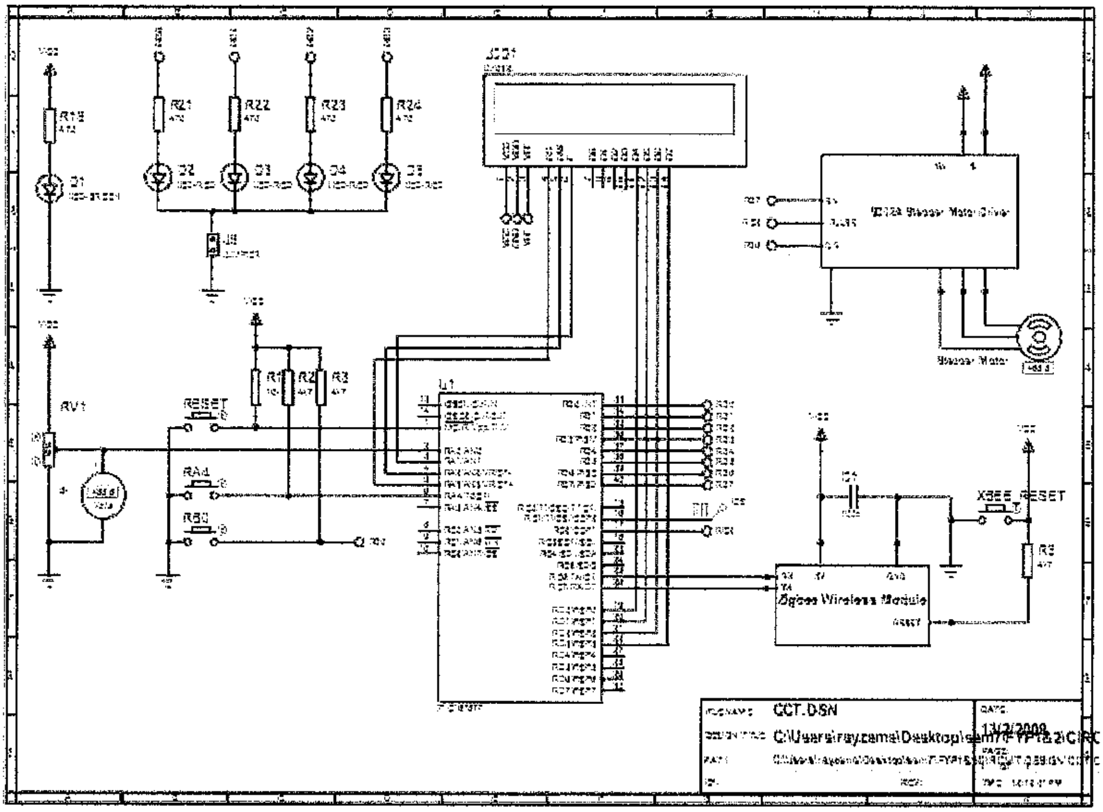


Figure 18 Electrical circuit configuration for the robot

The use of LCD was to enable the operator to monitor current signal receive by the receiver on the robot itself as an alternative from the data send by the robot to the computer. Meanwhile LED indicator will assist the operator should any error occur during the operation. This additional hardware is also very helpful to author for programming purpose since this hardware can be used to know how the program executed by the microcontroller.

```
}

void main()
{
char ch;
while(1)
{
ch= getchar();  //get the output
output_D (~ch); //
printf ("\n\r You Pressed %c", ch);
}
}
```

3.7.3.4 Data Logging and Stepper motor controller

```
#include <16F877a.h>
#use delay (clock = 10000000)
#fuses HS,NOWDT
#include <stdio.h>
#include <string.h>
#include <stdlib.h>
#use rs232(baud=9600, parity=N, xmit=PIN_C6, rcv=PIN_C7, stream=stream1,
bits=8)

char k[20];
char l[30]="Hardware Ready";
char a[3]="tl";
char b[3]="tr";
char deg[3];
int Volage;
short pulse;
unsigned char g;
unsigned char h;
unsigned char i;
unsigned char j;

setup_adc(ADC_CLOCK_INTERNAL);
setup_adc_ports(AN0_AN1_AN3);

void main(void)
{
while(1)
{
gets(k);
puts(k);
output_high(pin_B3);                                //testing LED

        Voltage = read_adc();                       // Perform ADC
        putc(Voltage);                              // Send the ADC result to the
computer

if (strcmp(k,a)==0)
{
strcpy(l, "About to turn left");
puts(l);
strcpy(l, "insert degree of rotation");
puts(l);

h=0;
while(h==0)
{gets(deg); h=atol(deg);putc(h);}      // convert character into intiger
format
g=h*2;
putc(g);
```

3.7.3 Source Code

To increase effectiveness and reduce complexity during programming, author has decided to develop the source code by dividing the whole function of microcontroller into smaller task so as it easier to develop and require less time to debug the program if error occur while develop the source code. The task has been divided as follow;

- Analog to digital converter
- Stepper motor controller
- Serial communication between microcontroller and Zig-Bee wireless device
- Data presentation thru LCD

Some of the code still under development and few changes need to be done to ensure the code can run smoothly. For the final stage, this entire sub task will be combining into single source code file to be downloaded into the microcontroller.

3.7.3.1 Analog to digital converter

```
#include <16F877.h>
#include <stdio.h>
#use delay(clock=10000000)

void blink_led() {
output_high( PIN_B2 );
delay_ms(100);
output_low( PIN_B2 );
delay_ms(100);
}


void main()
{
int threshold = 128;
int value;

setup_adc(ADC_CLOCK_INTERNAL);
setup_adc_ports(AN0_AN1_AN3);

while(TRUE)                          {
set_adc_channel(1);
delay_us(10);

value = read_adc();

if (value>=threshold)
{
blink_led();
}

delay_ms(3);
}
}
```

3.7.3.2 Serial communication between microcontroller and ZigBee wireless device

```
#include <16f877a.h>
#fuses HS,NOWDT,NOPROTECT
#use delay(clock=10000000)
#use RS232 (baud=9600,parity=N,xmit=PIN_C6,rcv=PIN_C7,stream=stream1,bits=8)


void main()
{
char ch;

set_tris_d(0x00);
while(TRUE)
{
ch=gets(stream1);     //get the data from the computer
puts(ch);            // mirror the data back to the computer
}
}
```

3.7.3.3 Data presentation thru LCD

```
#include <16F877.h>
#use delay (clock = 10000000)
#fuses HS,NOWDT
#include <stdio.h>
#use rs232(baud=9600, parity=N, xmit=PIN_C6, rcv=PIN_C7, stream=stream1,
bits=8)

void blink_led()
{
output_high( PIN_B2 );
delay_ms(100);
output_low( PIN_B2 );
delay_ms(100);
}

void ADC()
{
int threshold = 128;          //128 corresponds to 2.5v
int value;                    //The converted value returned from ADC will be
stored here

setup_adc(ADC_CLOCK_INTERNAL);
setup_adc_ports(AN0_AN1_AN3);

while(TRUE)             {
set_adc_channel(1);
delay_us(10);
value = read_adc();

if (value>=threshold)
{
blink_led();
}

delay_ms(3);
}
```

```
output_high(Pin_B1);                          // cw direction


for(i=0;i<=g;i++)                             //generate pulse for motor
{ for(j=0; j < 10; j++)
{pulse=!pulse;delay_ms(0);output_bit(Pin_B0,pulse);putc(pulse);}
}
}

else if (strcmp(k,b)==0)
{
strcpy(l, "About to turn right");
puts(l);
strcpy(l, "insert degree of rotation");
puts(l);

h=0;
while(h==0)
{gets(deg);h=atol(deg);putc(h);}        // convert character into intiger
format

g=(h*2);
putc(g);

output_low(Pin_B1);                           // ccw direction

for(i=0;i<=g;i++)                             //generate pulse for motor
{ for(j=0; j < 10; j++)
{pulse=!pulse;delay_ms(0);output_bit(Pin_B0,pulse);putc(pulse);}
}
}

else
{  strcpy(l, "invalid input");
puts(l);
}
}
}
```

3.7.3.5 Complete source code

```
#include <16F877a.h>
#use delay (clock = 10000000)
#fuses HS,NOWDT
#include <stdio.h>
#include <string.h>
#include <stdlib.h>
#use rs232(baud=9600, parity=N, xmit=PIN_C6, rcv=PIN_C7, stream=stream1,
bits=8)

char k[20];
char l[30]="Hardware Ready";
char a[3]="tl";
char b[3]="tr";
char c[4]="adc";
char deg[4];
short pulse;
unsigned int g;
unsigned int h;
unsigned char i;
unsigned char j;
unsigned char value;
unsigned long int x;      //variable in ADC loop
unsigned long int y;      //variable in ADC loop
unsigned long int z;      //variable in ADC loop
```

```
void main(void)
{
output_high(pin_B3);        //testing LED

setup_adc(ADC_CLOCK_INTERNAL);
setup_adc_ports(AN0_AN1_AN3);


while(1)
{

gets(k);                    // get comand for direction of rotation
//puts(k);                   //mirror gets(k);

/////////////////////////turn left section/////////////////////

if (strcmp(k,a)==0)
{
strcpy(l, "About to turn left");
puts(l);
strcpy(l, "Insert degree of rotation");
puts(l);

h=0;
while(h==0)
{gets(deg); h=atol(deg); fprintf(stream1, "The degree of rotation is %u
\n",h);}      // convert character into intiger format

g=h*2; // fprintf(stream1, "calculation for degree %u \n",g);

output_high(Pin_B1); // cw direction

for(i=0;i<=g;i++)      //generate pulse for motor
{ for(j=0; j < 10; j++)
{pulse=!pulse;delay_ms(1);output_bit(Pin_B0,pulse); }
}
}
//////////////////////////////////end///////////////////////////

///////////////////////////Turn right section//////////////////////

else if (strcmp(k,b)==0)
{
strcpy(l, "About to turn right");
puts(l);
strcpy(l, "insert degree of rotation");
puts(l);

h=0;
while(h==0)
{gets(deg);h=atol(deg);fprintf(stream1, "The degree of rotation is %u
\n",h);}       // convert character into intiger format

g=h*2; //
fprintf(stream1, "calculation for degree %u \n",g);

output_low(Pin_B1); // ccw direction


for(i=0;i<=g;i++)      //generate pulse for motor
{ for(j=0; j < 10; j++)
{pulse=!pulse;delay_ms(1);output_bit(Pin_B0,pulse);}
}
}
////////////////////////////////////end////////////////////////////////////
```

```
//////////////////////////ADC conversion and sampling////////////////

else if (strcmp(k,c)==0)
{
fprintf(stream1, "Insert no of samples \n");

x=0;
while(x==0)
{gets(deg); x=atol(deg);}

y=x;

for(z=0;z<=y;z++)
{  set_adc_channel(2);
delay_ms(100);
value = read_adc();
fprintf(stream1, " %u \n",value);
}
}
/////////////////////////////////end///////////////////////////////

/////////////////////////invalid input message//////////////////////
else
{  strcpy(l, "invalid input");
puts(l);
}
/////////////////////////////////end///////////////////////////////
}
 }
```

3.7.3.6 MATLAB codes for generating output graph from data logger

```
function plotGraph

load C:\Users\rayzeme\Desktop\datalogger.txt
z = datalogger();
y = z/255*5;
%y= datalogger(:,1); --> store data (column 1)
plot(y)
xlabel('No of sample')
ylabel('ADC value (V)')
title('Data from receiver robot')
```

3.8 Controlling the robot and data logging

After completing robot construction and programming. The robot should be able to reposition the EM receiver and able to perform data logging. To implement this, we should complete several step as described below:

Step1: Connecting the computer with ZigBee (modem)

To connect the computer with ZigBee transceiver, we must run X-CTU software. Select Com-Port respective to Zig-Bee transceiver connection with the computer. For this project the author had using setting as list below as standard setting for wireless module communication:

- Baud rate: 9600
- Flow control: NONE
- Data bits: 8
- Parity: NONE
- Stop bits: 1

After all the parameter has been set, the X-CTU software will acknowledge user that the connection has been establish.

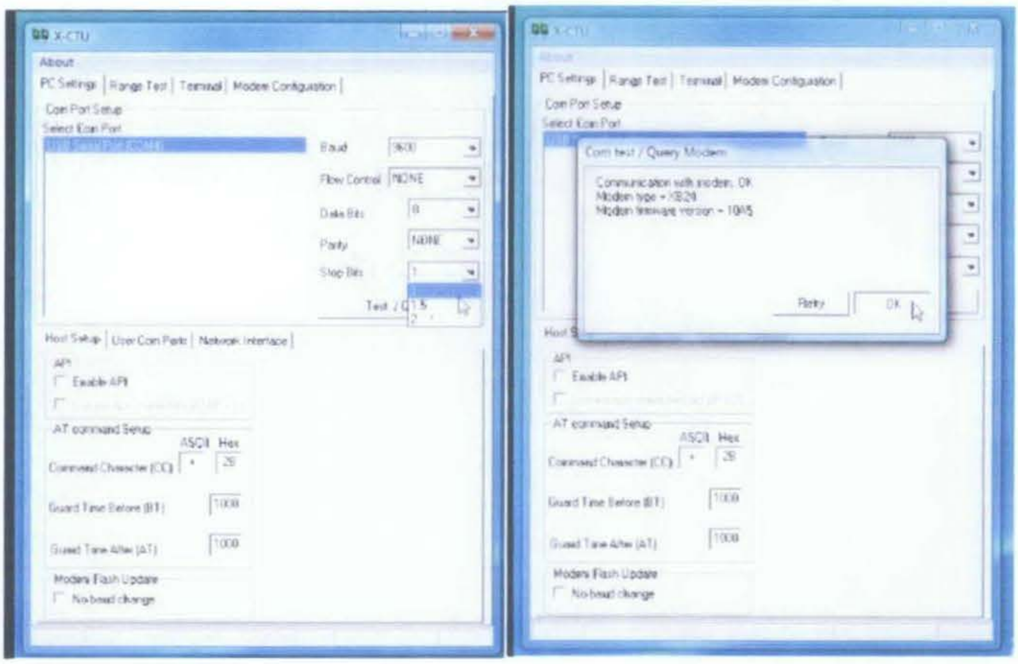


Figure 19 Parameters setting for X-CTU software

Step2: Sending command to receiver robot

There are several default commands that had been program into the robot. This command can be adjust according the needs of the operator who handle the robot. Currently there are 3 commands that can be recognized by the robot which are:

- TR – Turn EM receiver to the right
- TL – Turn EM receiver position to the left
- ADC – Perform ADC

Once the robot had receive the command either TR and TL, it will sent an conformation to user that either TR or TL command has been enter and informing which direction the robot is going to rotate. After this the user will be ask to insert the degree of rotation required to adjust the EM receiver. The robot will expect an input in range of 0-180(decimal) which correspond 0 to 180 degree of rotation.

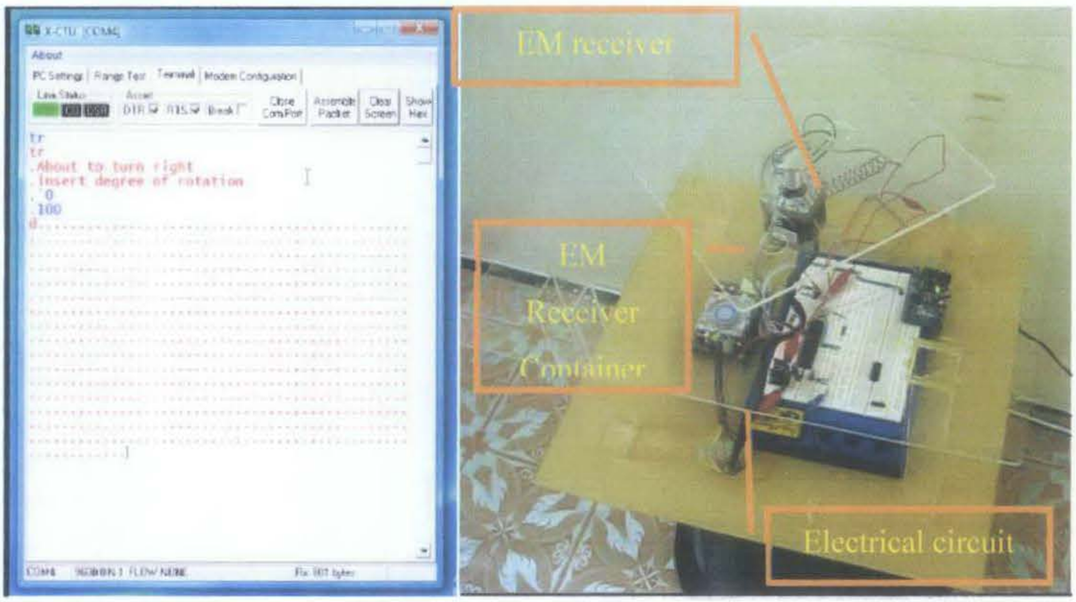


Figure 20 Command window for sending command to the robot and response of the robot to the command

As mention above, the task of controlling the robot will be handle by an operator. Currently the process of repositioning the reciver will be based on trial and error approach were the operator will try to adjust the position of EM receiver based on EM transmitter location. However, the automaic repositioning system is under development, where the repositioning task will be handle completely by the microcontroller inside the robot.

Step3: Data logging

After the process of tunnig the receiver completed. The EM receiver will start to collect the data, the data collected has to be stored in the computer for further analysis. To make this possible, the author has used freeware called RS232 DATA LOGGER to perform data logging. The data will be stored in Microsoft Excel format which can be further analysis by using available tools offered by Microsoft Exvel

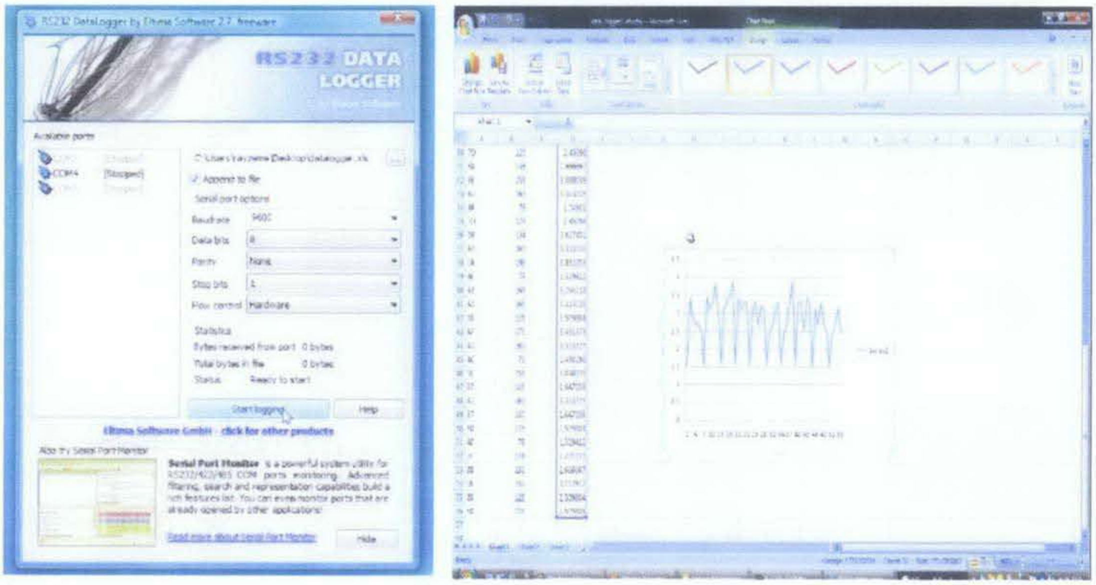


Figure 21 Interface of RS232 Data Logger software and Data stored in Microsoft Excel

The data logging process will continue until the computer has run out of memory. The data stored in Microsoft Excel will be in format of hexadecimal number. To analayze the data, we must convert the data into decimal format, this can be done by using "hex2dec" function available in Microsoft Excel. By doing this, the data has been convert into more understandable format and Microsoft Excel can be able to interprete this set of data into graphical aproach for further data analysis.

CHAPTER 4

RESULT AND DISCUSSION

4.1 Completed Prototype

For the circuit shown in Figure 22, all major electrical components required to control a stepper motor has been complete. This circuit has some unique features such as on board microcontroller programming and extra I/O pins for future use.

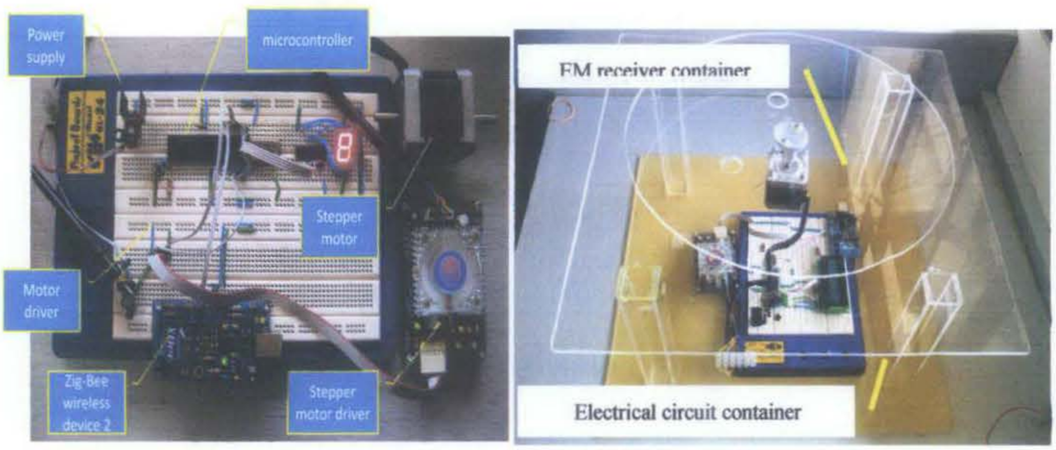


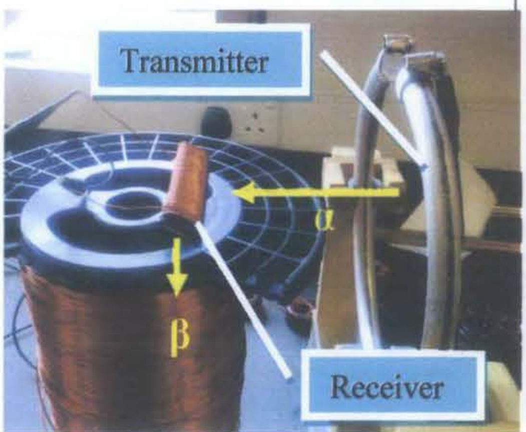
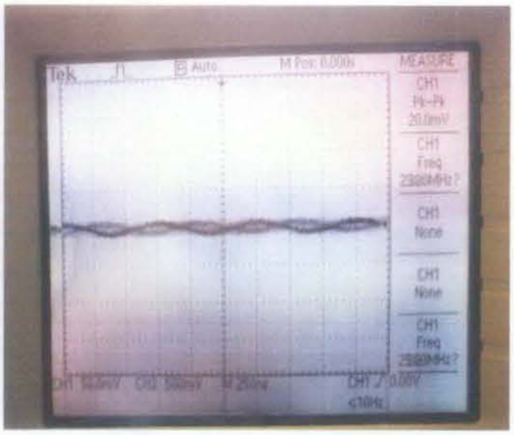
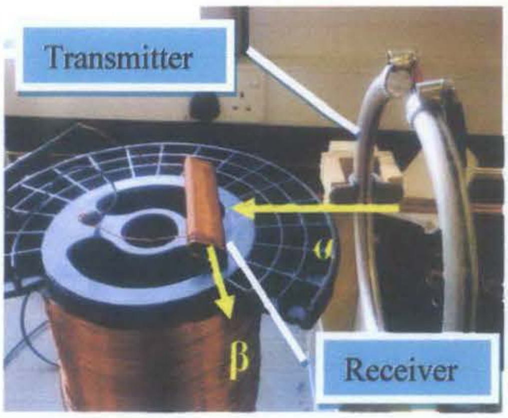
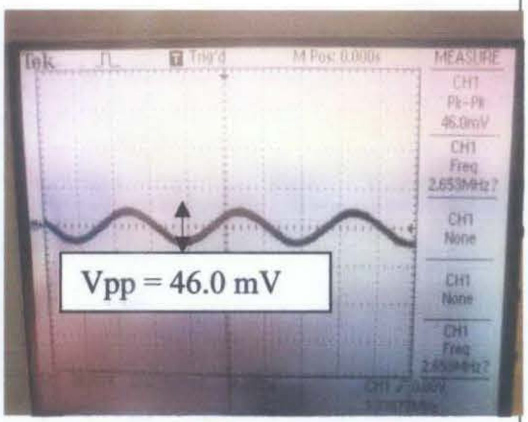
Figure 22 Actual circuit developed by the author

This circuit capable to receive instruction from the computer via wireless communication and the instruction will be process by the microcontroller to perform EM receiver positioning and sending back the data receive by the EM receiver to the computer. The sensitivity of stepper motor used on the robot was 1.8 degree of turning rotation, thus EM repositioning process has higher accuracy and precision.

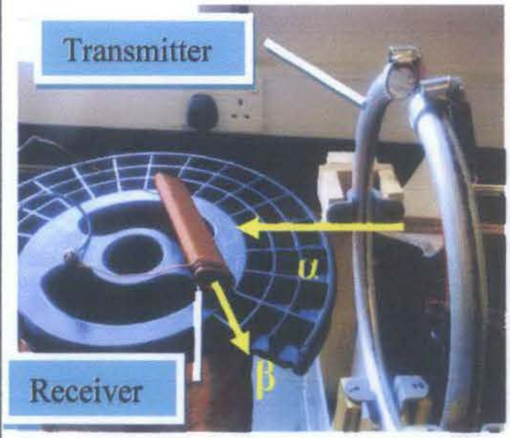
4.2 EM receiver repositioning experiment

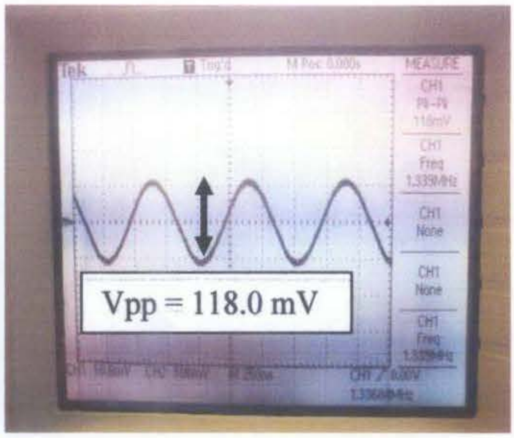
Table 5 is results of experiment conducted to prove that angle between receiver and transmitter play vital role in giving best output from the receiver. The transmitter will be connected to function generator as a source of sine wave and receiver will be connected to oscilloscope to measure generated induce voltage. Offset angle will be measured between normal angle to surface area of transmitter (α) and normal angle to surface area of receiver (β). Various offset angle has been test and the result of the experiment shown in Table 5.

Table 5 Result of various receiver positions from transmitter

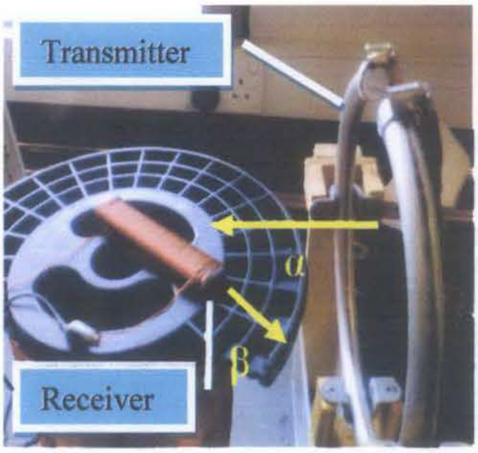
Angle offset (deg)	Result
Angle offset = 90 deg 	
Angle offset = 80 deg 	

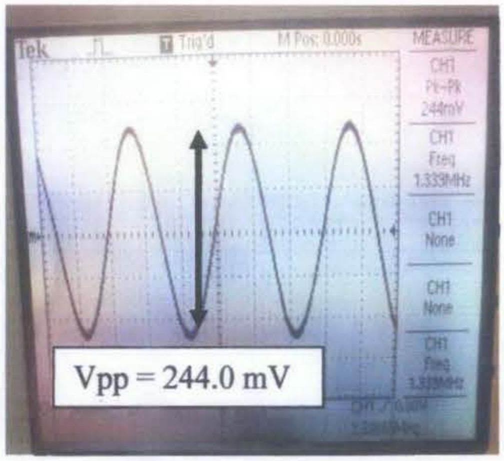
Angle offset = 75 deg



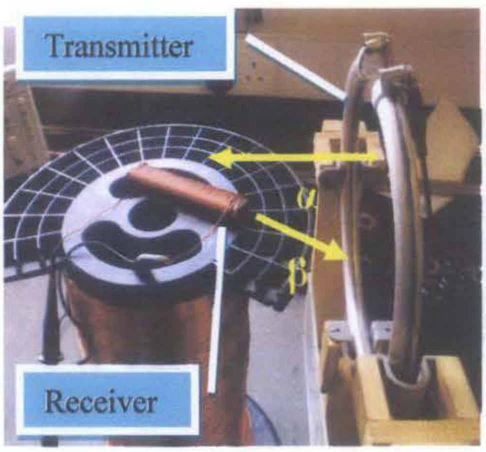


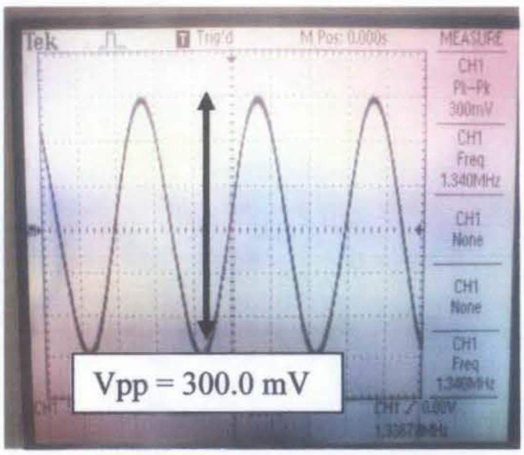
Angle offset = 45 deg

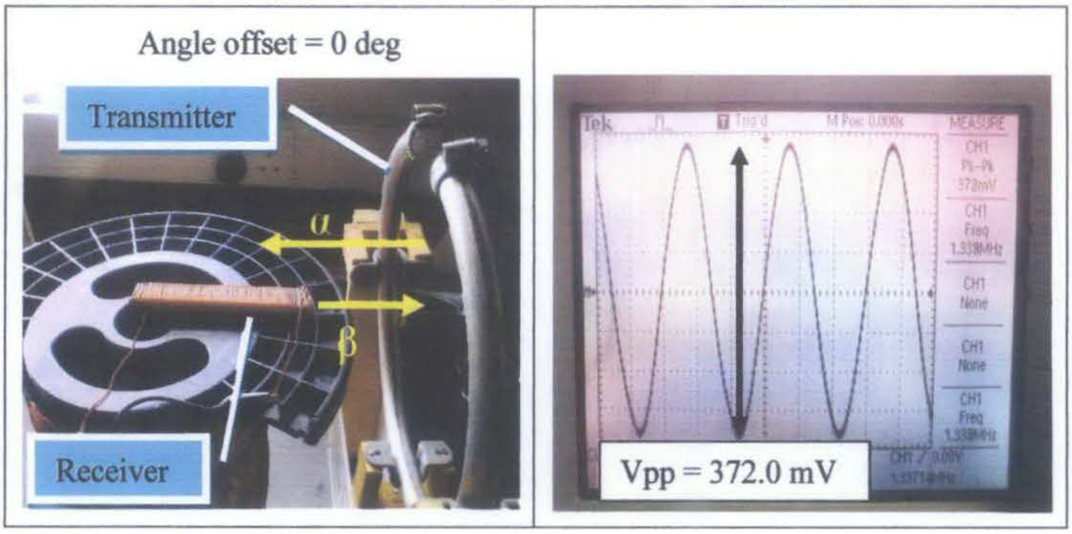




Angle offset = 15 deg







This experiment has been conduct using various degree offsets to show that the maximum reading will occur when surface of EM receiver is in series with surface of EM transmitter. In the other hand, EM receiver will give the lowest output reading when its surface area is in parallel with transmitter surface area.

4.3 EM receiver container repositioning

Figure 23 below shown process of repositioning the EM receiver container. To begin the repositioning process, user required to give input "tr" or "tl" which is a standard command to make the container turn left or right. After the command received by microcontroller, it will send back an instruction to user which is to insert degree of rotation. Once user insert the required degree of rotation, microcontroller will give suitable number of pulse to stepper motor that give angle of rotation as required by user.

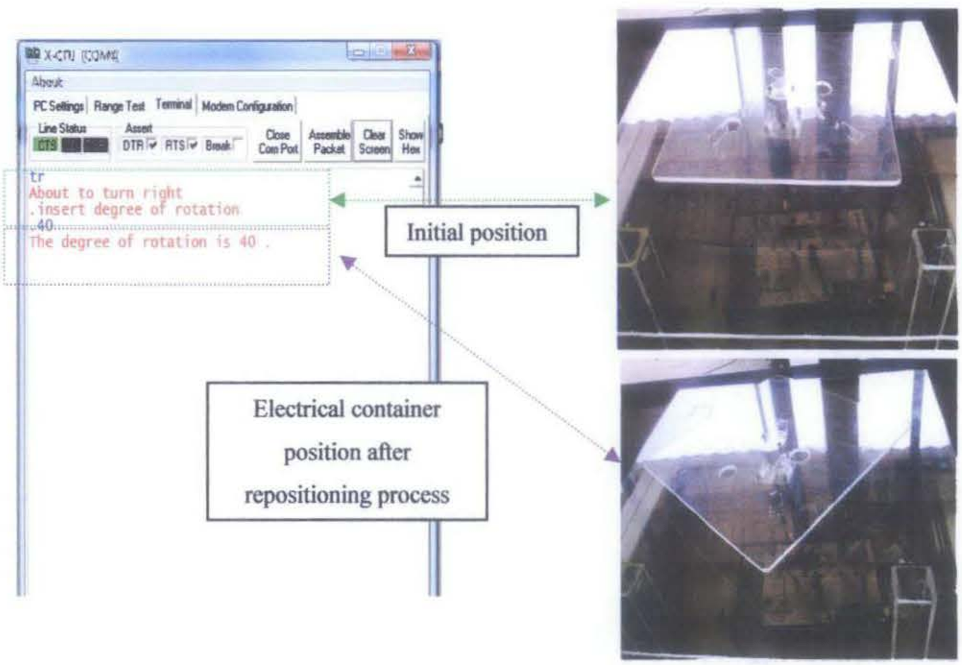


Figure 23 Interaction between computer and microcontroller to reposition the container of EM receiver

The use of stepper motor has given as better repositioning system where the ability of stepper motor to make a turn in sensitivity of 1.8 degree can increase the accuracy to achieve zero degree offset angle between receiver and transmitter. To make full use of this function, we must then perform ADC sampling to get the output of receiver for current receiver position. This process then will repeat until maximum theoretical voltage amplitude can be achieved.

4.4 Analog to Digital Conversion

The result obtain for Analog Digital Conversion as shown in Figure 27 is from the experiment where AC voltage are feed to the microcontroller by using function generator. This voltage then converted from analog signal to digital signal using build in ADC function available from the microcontroller, users are asked to enter number of sample and sampling time before microcontroller start to perform ADC as shown in Figure 24.

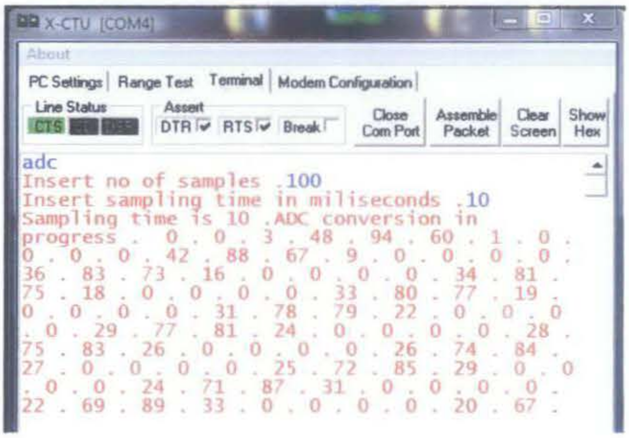


Figure 24 Sending command to microcontroller to perform ADC

The sampled data then will be sent to the computer and stored in .txt format as shown in Figure 25. All command, instruction from microcontroller and ADC result will be stored in this file. The advantage of using .txt file to store the data is mainly because this format requires very minimum memory size and possibility for computer to run out of memory is very slim.

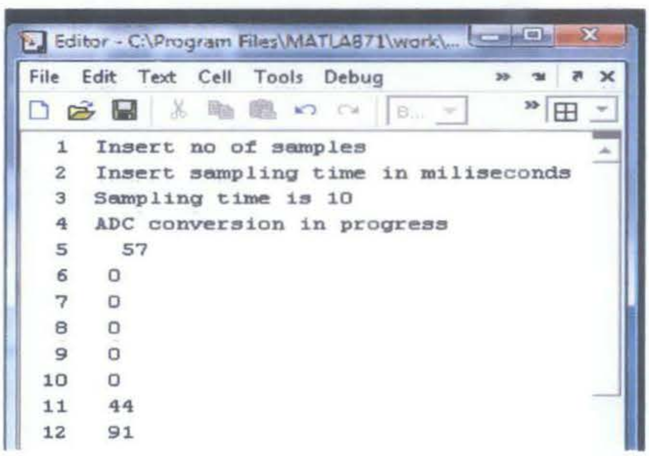


Figure 25 Data collected form RS232 data logger stored in .txt format

To generate graph as shown in Figure 27, author has write MATLAB code as shown in Figure 26, this code enable data from .txt file to be plot using MATLAB's plot function. This code can be convert to .exe file which mean it can act as standalone program where we can run this program without having MATLAB software running on our computer.

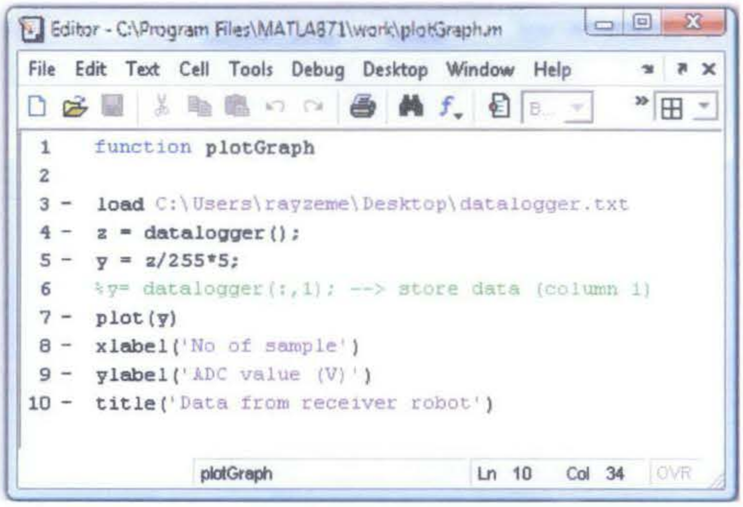


Figure 26 MATLAB codes to generate graph from datalogger.txt file

As we can see in Figure 26, the digital data can be covert to more understandable form which is a line graph by using MATLAB. Y-axis represent voltage reading from the receiver and X-axis is no of sample taken during ADC process.

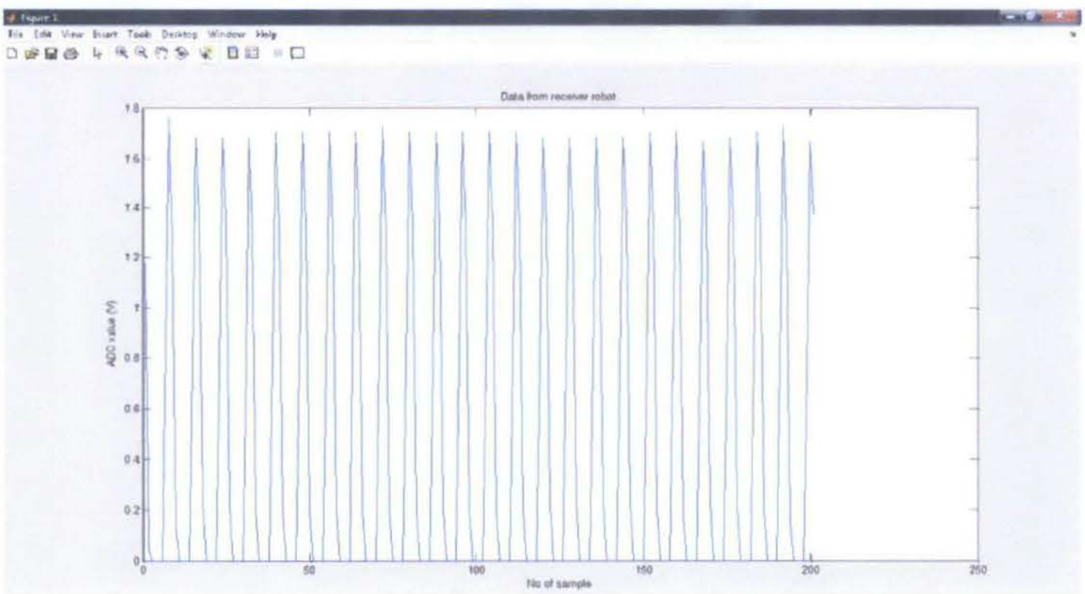


Figure 27 Graph generated based on ADC sampling input

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

From the progress of this project, it can conclude that both objective which is EM receiver reposition for better EM detection and data logger using computer has been closed to completion during one year specified to final year project. It can be said that the progress of this project is currently at 95% where there is some functionality of repositioning system still under development.

From the studies, we can see that microcontroller has play important role in this project. The ability of the microcontroller to make decision and perform analog to digital conversion has made this project possible with very effective cost. Introduction of Zig-Bee wireless module called SK-Xbee by local manufacturer has give students wider selection of wireless communication module. Thus enable author to complete this project within constraint budget provide by UTP.

5.2 Recommendation

5.2.1 Printed Circuit Board

From author point of view, there are various improvements that can be done for this project. The electrical circuitries are currently done using bread board which is prone to disturbance such dust and water. By upgrading this board to printed circuit board, the electrical circuitry of this project can become more reliable and have more ability to work on outdoor condition.

5.2.2 Fully automatic EM repositioning

Currently, repositioning system is completed by using trial and error approach where we have to set initial position of EM receiver then send the sampled ADC signal to the computer to read the output readings of the receiver and adjust accordingly based on output received from the robot. However we can make this whole process automatic by improving the programming in the microcontroller. By referring flow diagram on page 20, we know that the microcontroller can only acknowledge "tr", "tl", and "adc" command. This flow diagram can be expanding to achieve fully automatic repositioning system.

By understanding behavior of receiver, we can achieve this objective. Referring to result of experiment for EM receiver repositioning done as shown in Table 5, we know that when the offset degree between receiver and transmitter is equal to 90 degree, the output from the receiver become almost 0V peak to peak. We can use this position as a reference point to make an adjustment. To identify this point, EM receiver container has to make a test for one complete loop by moving motor by 2 degree for each test. The output of EM receiver will be sample for each position and this value will be sum up. The position that give reading closed to zero means that position has 90 degree offset with the transmitter.

$$Position\ of\ 90\ degree\ offsets = \sum_i^n ADC_{sampling} \approx 0 \quad (4)$$

The final step is to send information to stepper motor so as it can make 90 degree turn from current position. This will made the offset angle become 0 degree thus will give us maximum output from receiver. Accurate number of pulse sent to stepper motor is critical to ensure the accuracy of turning angle. Based on calculation shown in page 16, its require 500 pulse to be sent to stepper motor to make 90 degree turn. By doing this we can develop fully automatic repositioning system.

5.2.3 Real time EM receiver output graph display

The other improvement that can be applied to this project is the way data presented on the computer after receiving the data from EM receiver robot. Currently, the data is stored in computer memory once the data received by the computer then the graph will be generated using MATLAB. It is more efficient if a real time data display on the computer inform of line graph to be developed. The graph should be able to display the reading of voltage at EM receiver on real time. This will improve EM repositioning process since the data can be observed continuously by the operator.

5.2.4 Develop signal filter

In real situation, there is various EM wave instead of EM wave that sent by our transmitter. This EM wave will become a noise/disturbance to our system. Thus we have to develop electrical filter to avoid unwanted signal to disturb our system.

5.2.5 Replace full-wave rectifier circuit with summation amplifier

The limitation of ADC converter in microcontroller where it can only convert positive voltage will make negative side of the sine wave ignored by the microcontroller during ADC process. Currently author use full wave rectifier circuit to invert negative amplitude of sine wave to become positive. However, there other method to overcome this problem while maintaining original form of sine wave which is using summation amplifier. The concept of using this amplifier is shown in Figure 28. From the figure, we can see that output of full wave rectifier invert all negative side of sine wave to become positive amplitude where summing amplifier "shift" the original signal into positive side where the sine wave oscillate in positive amplitude margin.

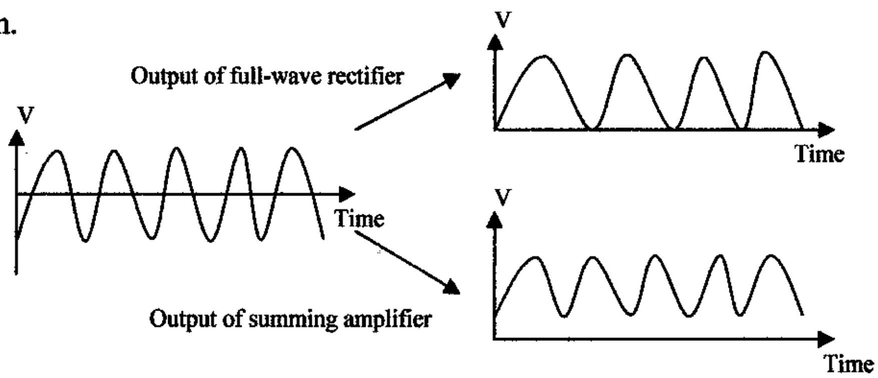


Figure 28 Methods of converting negative amplitude of sine wave to positive amplitude

CHAPTER 6

REFERENCES

1. Chave, A.D., Constable, S. and Edwards, R.N. (1991) "Electrical exploration methods for the seafloor". *Journal of Electromagnetic Methods in Applied Geophysics Vol. 2*, Pg 25-50

2. Das Aditya N., Lewis Frank L. and Popa Dan O. (2004). "Data-logging and Supervisory Control in Wireless Sensor Networks", *Journal of Wireless and Mobile Computing*, Vol. 00, Nos. 0/0/0, Pg.3–12.

3. TutorVista. July 2008. Stationary Loop in Time-Varying Magnetic Field. Citing Internet sources URL http://www.tutorvista.com/content/physics/physics-iv/electromagnetic-induction/magnetic-flux.php

4. Cytron Technologies. February 2009. XBEE Starter Kit. Citing Internet sources URL http://www.cytron.com.my/listProductCategory.asp?cid=132#244

5. Joanie Wexler. March 2005. Citing Internet sources URL http://www.stevenswater.com/telemetry_com/bluetooth_zigbee_info.aspx

6. Wikipedia. February 2008. Zig-Bee. Citing Internet sources URL http://en.wikipedia.org/wiki/ZigBee

7. Das, A. N., Popa, D. O., Ballal, P., & Lewis, F. L. (2006). "Data-Logging and Supervisory Control in Wireless Sensor Network" *Journal of Wireless and Mobile Computing* , Pg 25-40.

8. M., B., M., F., & K, R., 1999. "An overview of controller area network". *Journal of Computing & Control Engineering, Volume: 10, Issue: 3* , Pg 113-120.

9. Pan, M.-S., & Tseng, Y.-C. (2007). "Quick Convergecast in Zig-Bee beacon-enable tree-based wireless sensor network". *Journal of Computer Comunication* , Pg 25-34.

10. E.S. Nadimi, H.T. Søgaard, F.W. Oudshoorn. (2007). "ZigBee-based wireless sensor networks for monitoring animal presence and pasture time in a strip of new grass" *Journal Of Computers And Electronics In Agriculture*: Pg 1-5

11. NetworkTutorials. Zig-Bee Network Topology. Citing Internet sources URL http://www.networktutorials.info/topology.html

APPENDICES

APPENDIX A

BILL OF MATERIAL

Cytron Technologies Sdn. Bhd (755563-V)

No. 19, Jalan Kebudayaan 1A,
Taman Universiti,
81300 Skudai,
Johor, Malaysia.

ONLINE ORDER

Email : sales@cytron.com.my
Tel : 07-5213178
Fax : 07-5211861

Organization/Institution Name	UTPstudent
Name	Rayzema b Harun
Contact Num	(H) 0174687313
	(F)
E-mail	epstar7@yahoo.com
Delivery Address	V5A-L5-2-6 Universiti Teknologi PETRONAS Bandar Seri Iskandar 31750 Tronoh, Perak, West Malaysia

No.	Category	Item Code	Item Name	Qty	Unit Price (RM)	Amount (RM)
1	Product	SD02A	2A Stepper Motor Driver	1	120.00	120.00
2	Product	42BYGHD-444	LINIX Stepping Motor	1	154.00	154.00
3	Product	SKXBEE	XBEE Starter Kit	2	195.00	390.00
4	Product	UIC00A	USB ICSP PIC Programmer	1	49.90	49.90
					Sub Total	**RM 713.90**
					Shipping	**RM 0.00**
					Grand Total	**RM 713.90**

<< Back to Modify   Confirm Payment >>

Figure 29 Total cost on electrical component

APPENDIX B

GANTT CHART FOR FYP1

ACTIVITIES	WEEK NO/DATE													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Topic selection														
Confirmation of topic selection														
Problem study														
Electrical circuit and programming														
Physical mechanism construction														
Controller Interface														
Assemble														

Figure 30 Project Gantt chart for FYP1

APPENDIX C

GANTT CHART FOR FYP2

ACTIVITIES	WEEK NO/DATE													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Program ADC block function														
Program stepper motor controller block function														
Program serial communication between microcontroller and Zig-Bee device block function														
Program data presentation thru LCD block function														
Merge all block function														
Design and fabricate PCB														
Test Run														

Figure 31 Project Gantt chart for FYP2