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DESIGN OF FUNGI CULTURE ENVIRONMENTAL CHARACTERIZATION SYSTEM

MOHD SYAFIQ AFIFI BIN BUSTAM

A thesis submitted in fulfillment of the
requirements for the award of the degree of
Bachelor of Engineering (Electrical-Electronic)

Faculty of Electrical Engineering
Universiti Teknologi Malaysia

DECEMBER 2010

I declare that this thesis entitled "Design of Fungi Culture Environmental Characterization System" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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To my beloved mother, father and brothers…

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In preparing this thesis, I was in contact with many people, academicians and practitioners. They have contributed towards my understanding and thoughts. In particular, I wish to express my sincere appreciation to my main thesis supervisor, Associate Professor Dr. Muhammad Nasir Ibrahim, for encouragement guidance, critics, motivation and advices. Without his continued support and interest, this thesis would not have been the same as presented here.

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ABSTRACT

Agriculture industry is expected to grow rapidly to become an important contributor to the economy. Indoor cultivation of mushroom is among the agro industry that flourishes recently. The weather and condition of Malaysian tropical environment enable the growth of this sector. Meanwhile, at this cutting edge of technology era, the usage of embedded system in conventional farming has become widely accepted. The use of technologies could possibly enhance the quality of products in food industry. Hence the purpose of this project is to develop an embedded application via microcontroller as a monitoring system in cultivation of mushroom. The embedded system will have PIC18F452 as the heart of the system and the brain of this system written in C language. The fruiting body or mushroom depends on the growth of fungi called mycelium. This fungi demands a highly control of environment to growth. Hence the embedded system is included with the sensors of temperature, humidity and light. Besides, a GUI was developed so farmer could monitor the condition from computer. Finally, with the usage of technology shall boosting the food production market and stay competitive so as the human population growth.

ABSTRAK

Industri agrikultur dijangka berkembang dengan pesat nya dan menjadi penyumbang penting kepada ekonomi negara. Antara industri agro yang kian berkembang dengan pantas adalah penanaman cendawan secara tertutup. Faktor cuaca dan keadaan iklim tropika Malaysia juga membolehkan sektor ini berkembang dengan baik. Sementara itu, dalam ledakan era teknologi ini penggunaan sistem tertanam dalam pertanian secara tradisional telah menjadi perkara biasa dan diterima umum. Penggunaan teknologi boleh menambah baik kualiti hasil dalam sektor industri pemakanan. Oleh yang demikian, projek ini bertujuan untuk membangunkan aplikasi sistem tertanam melalui penggunaan mikropengawal sebagai sistem pengawal dalam penanam cendawan. Sistem ini akan menggunakan PIC18F452 sebagai jantung operasi manakala pengaturcaraan untuk sistem terbenam ini menggunakan bahasa C. Tumbesaran cendawan adalah bergantung kepada sejenis kulat dipanggil mycelium. Kulat ini memerlukan pemerhatian yang teliti terhadap kawasan tumbesarannya. Oleh itu, sistem tertanam yang dibangunkan akan mempunyai beberapa pengesan seperti pengesan suhu, kelembapan dan kehadiran cahaya. Selain itu, paparan tetingkap juga dibangunkan agar petani dapat mengawal selia keaadaan tempat penanaman melalui komputer. Melalui penggunaan teknologi ini, pengeluaran makanan dapat ditingkat kan seiring dengan pertambahan penduduk.

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CHAPTER 1

INTRODUCTION

1.1 Background of Study

Malaysia's agro sector is expected to grow from year to year and remain an important contributor to the economy. Rapid developments in the agro-food industry will further boost the output of this sector. The agriculture industry can be divided into several types, one of those part is fungi culture or mushroom industry.

Commercial and indoor cultivation of mushroom has a high potential to be developed since Malaysia is a tropical environment. The weather and condition will enhance the capability of growing the fungi. Besides, Malaysia also has the unwanted waste from others agro industry like oil palm, wood and husk from rice field. Those unwanted waste could be used as the seed to favor the fruiting of fungi. Hence the growth of mushroom could possibly take an advantage and fully utilize this unwanted waste.

Meanwhile, embedded system is some combination of computer hardware and software, either fixed in capability or programmable that is specifically designed for a particular function. Embedded system can be found in various industry and product from simple to complex embedded. The versatility of embedded system makes it able to utilize and fulfill any purpose of project.

Thus, the fungi culture industry might benefit from this advancement of technology. Developing a monitoring system through this embedded application may expand the qualities of mushroom for business purpose. Besides, through this monitoring system, fungi products may be produced in mega scale production to support the food and medical need in industry. Controlling the condition of several processes ensure the growth of mushroom much faster and competence to be in mega scale production.

1.2 Problem Statement

There are many important aspects need to be controlled in cultivation of mushroom and the most important three aspects are temperature, humidity and light.

Problems:

1. Indoor mushroom production demand continuous monitoring and timely manipulation of environment condition.
2. Maintaining optimal temperature, moisture and other condition for fungi growth to favor fruiting.
3. Since there is no hardware for collecting fungi environment, farmer could not able to monitor and control the parameters.

1.3 Objective of Project

The objective of this project are listed as follows

i) To develop a model of fungi culture monitoring system via sensors and PIC microcontroller.

ii) To implement GUI that able to interface with PIC microcontroller.

1.4 Scope of Project

The scopes of this project are:

1. The environment analyses considered via sensors are limited to temperature, humidity and light.
2. Hardware implemented involving circuit for microcontroller PIC18F452 and circuit for temperature sensor, humidity sensor, light sensor, LCD and serial communication circuit.
3. This project is using C language for PIC programming and Microsoft Visual Basic 6.0 to implement the GUI for monitoring system.

1.5 Outline of Thesis

CHAPTER 1.0 : This chapter commence with an introduction of the project fungi culture monitoring system and automated control system.

CHAPTER 2.0 : This chapter focused on lit review presenting up to data findings and useful theoretical definition. Besides, research related to project is reviewed.

CHAPTER 3.0 : This chapter focused on the exact steps to be undertaken to complete the project. The development of operating system and hardware will be examined.

CHAPTER 4.0 : Full system and results from the preferred project will be discuss in details.

CHAPTER 5.0 : Review and summary of project's finding will be concluded in the thesis. Recommendation for future development will be included.

1.6 Methodology

This project consists of two parts which can be divided into hardware and software. The hardware part includes a circuit for microcontroller, 3 sensors circuit, temperature, humidity and light. Temperature sensor will sense the temperature of the growth field and humidity to sense the presence of moisture. Besides, the light sensor will sense the presence of light either on or off.

The control system consists of PIC18F452 as microcontroller, crystal 20MHz as oscillator and voltage regulator used to regulate high voltage to 5V. The control system functions to process analog data received from sensor system and send digital data to display system. The system block diagram as shown in Figure 1.1

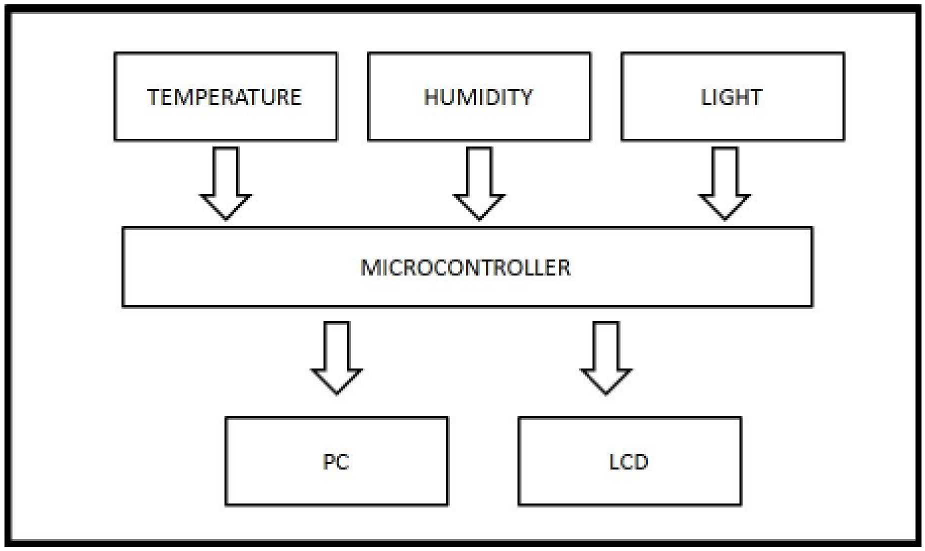

Figure 1.1 : The block diagram of the system

The software part will be divided into two. First is software for controlling system on microcontroller and second software purposely for monitoring system on PC.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter presents the theories and fact related to the fungi culture monitoring system topic. A whole concept and further details regarding the monitoring control system will be explained for example the fungi culture, sensors, microcontroller and software.

2.2 Mushroom

Mushroom production is completely different from growing green plants. Mushroom does not contain chlorophyll and therefore depend on other plant material (substrate) for their food. The part of the organism that we see and call a mushroom is really just the fruiting body. The unseen is the mycelium, tiny threads that grow throughout the substrate and collect nutrients by breaking down the organic material. This is the main body of mushroom [2].

The market for mushroom continues to grow due to interest in their culinary, nutritional and health benefits. Besides this mushroom also show the potential for use in waste management since they grow and fruiting from this organic waste. However as fungi, mushrooms have life cycles very different from those of green plants. Different species require different type of growth media and environment consideration. The biggest challenge is maintaining the optimal temperature and moisture and other condition so that mycelium could favor fruiting and we obtain a mushroom.

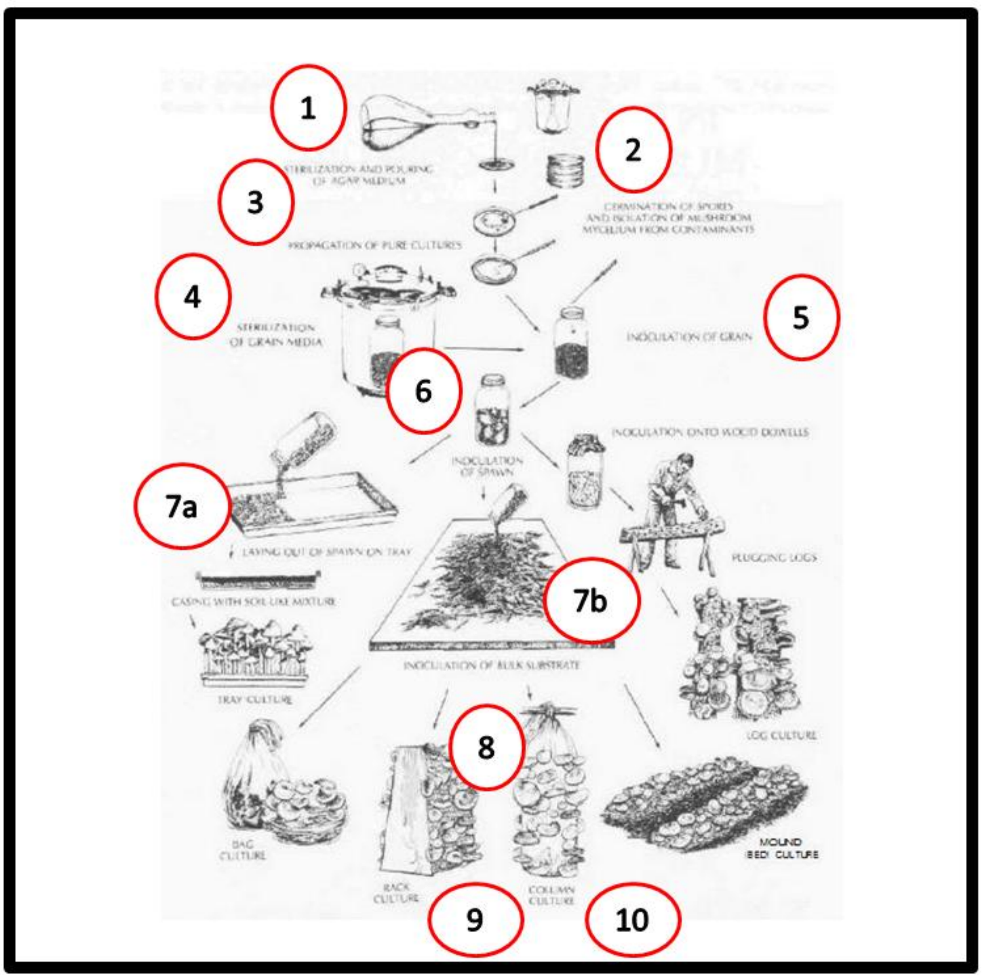

Figure 2.1 : Cultivation of mushroom[8]

Based on Figure 2.1 it is an overview of technique for mushroom Cultivation. Here are the description of each process and the requirement:

1. Preparation and pouring of agar media into petri dishes
2. Germination of spores and isolation pure mushroom mycelium
3. Expansion of mycelium mass on agar media
4. Preparation of grain media
5. Inoculation of grain media with pure mycelium grown on agar media
6. Incubation of inoculated grain media (spawn)
7. a) lying out grain spawn onto trays

   b) Inoculation of grain spawns into bulk substrate
8. Casing-covering of substrate with a moist mixture of peat and other materials
9. Initiation
10. Cropping

According to the step above the most important part to monitor and control the environment is during Initiation and Cropping, Table 2.1 shows the requirement.

Table 2.1 : The condition of fungi culture monitoring system

Process	Requirement
Expansion of mycelium in agar media	Temperature should be in 24°C-26°C Humidity 75%-80% Increase air circulation Presence of light is not important
Initiation	Lower the temperature around 18°C Increase humidity to 95% Increase air circulation Decreasing carbon dioxide Introducing light
Cropping	Maintaining temperature Lowering humidity to 85%-92% Maintaining air circulation Maintaining carbon dioxide Maintaining light level

During the growth of mycelium in agar media (e.g soil) the compost temperature has to be around 24°C to 26°C. The temperature shall not less than 20°C if not it will slower the growth of mycelium and if temperature higher than 30°C mycelium may die. Besides the presence of moisture should be around 75%-80%.

Meanwhile, during the initiation of fruiting, the temperature should be around 18°C**.** If mushroom is dry, skin will crack and caps open prematurely. The humidity should be maintaining at 95% or above 90%.. Finally, during the cropping humidity should be lowered to 85%-92% and others maintained.

2.2 Sensors

A sensor is a type of transducer and most of the sensors generate an analog signal. There are a few sensors can be used in this project and each has its own function. The device function can be extracted from the datasheet.

2.2.1 Light

Light sensor is developed through voltage divider and Light Dependent Resistor (LDR). LDR is a resistive light that change its electrical resistance from several thousand Ohm in the dark to only a few Ohm in bright condition. The net effect is a decrease in resistance for an increase in illumination. Material used as the semiconductor substrate include Lead Sulphide (PbS), Lead Selenide, (PbSe) Indium Antimonide (InSb) which detect light in the infrared range and the most commonly used of all is Cadmium Sulphide (Cds) as its spectral response curve closely match that of human eye and can even controlled using a simple torch as a light source.

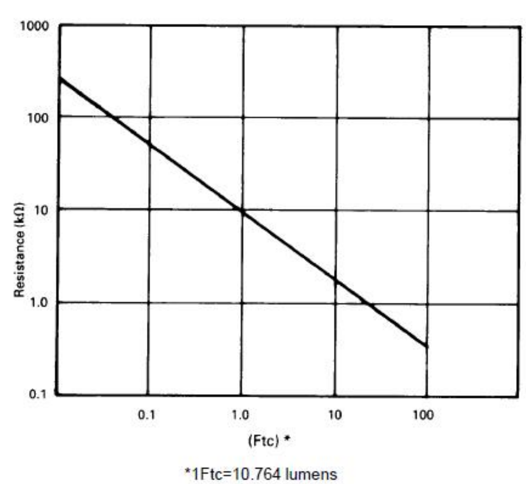

Figure 2.2 : Resistance vs illumination[17].

2.2.1 Temperature

Based on the LM35 Precision Centigrade Temperature Sensors manual by National Semiconductor Corporation, the LM35 series are precision integrated-circuit temperature sensors, whose output voltage is linearly proportional to the Celsius.

The LM35 does not require any external calibration or trimming to provide typical accuracies of ±1/4°C at room temperature and ±3/4°C over a full -55 to +150°C temperature range. The LM35's low output impedance, linear output and precise inherent calibration make interface to control circuit easy. It can be used with single power supply or with plus and minus supply. It has very low self heating, less than 0.1°C in still air. The LM35 is rated to operate over a -55°C to +150°C temperature range.

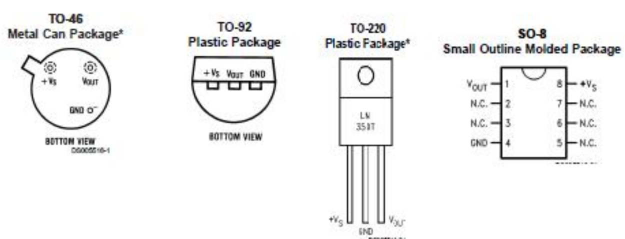

Figure 2.3 : The LM35 package[15].

This project used plastic package TO92 with LM35DZ type as a temperature sensor. The storage temperature for TO-92 is between -60°C to +150°C but the specified operating temperature range for this project is only for 0°C to 100°C

2.2.2 Humidity

Humidity sensor is a device consisting of special plastic material whose electrical characteristics change according to amount of humidity in the air. Basically it is a sensor that senses the amount of water vapor in air. The module of HSM-20G is essential for those applications where the relative humidity can be converted to standard voltage output. The applications of this sensor include air conditioner, humidifier and dehumidifier, automotive climate control and humidity data logger.

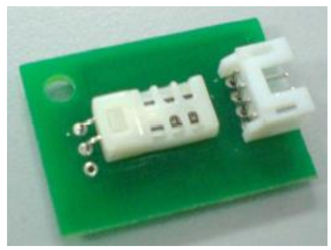

Figure 2.4 : Humidity sensor[16].

The product features for model HSM-20G include voltage analog output for humidity, small size and easy to conceal. Besides, this model of humidity sensor is compatible with all type of microcontrollers and high sensitivity to humidity in the air.

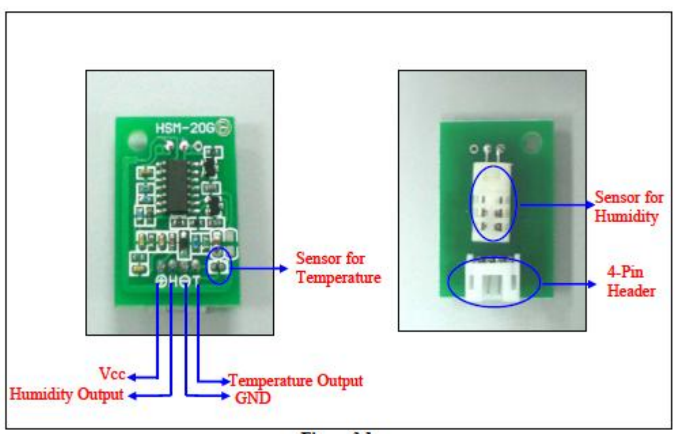

Figure 2.5 : Humidity configuration

2.4 Embedded System

The basic idea of an embedded system is very simple. Take any engineering product that needs control and if computer is incorporated within that product to undertake the control then we have an embedded system. A system whose principal function is not computational, but which is controlled by a computer embedded within it[1]. These days embedded systems are everywhere, appearing in the home, factory, car or hospital.

The microcontroller is the heart of the embedded system. A microcontroller is a microprocessor system which contains data and program memory, serial and parallel I/O, timers, external and internal interrupts. All integrated into a single chip. About 40 percent of all microcontroller applications are found in office equipment such as laser printers, fax machine and intelligent telephones [3]. About one third of all microcontrollers are founding in consumer electronic goods.

The microcontroller has all the support chips inside its single chip compared to microprocessor which requires several other components for it operation. Basically, the microcontroller executes a user program which is leaded in its memory. Base on program that had been loaded into the memory chip, data will receive from external devices (input), manipulated and then send to external devices (output).

2.4.1 Microcontroller PIC18F452

The specific type of microcontroller that used in this project is a microcontroller from the Microchip Technology Incorporated which is PIC18F452. The PIC18F4452 is used as controller system that will process data from monitoring system and also to control output to display and output system. PIC18F452 is chose because of it characteristic is suitable to this project application. Besides, it has the high performance and multifunction. Furthermore the learning process for beginner on this can be discovered in many reliable sources.

According to the data sheet the specification of PIC18F452 is shown in Table 2. . The pin configuration of this PIC can be seen in Figure 2. Below

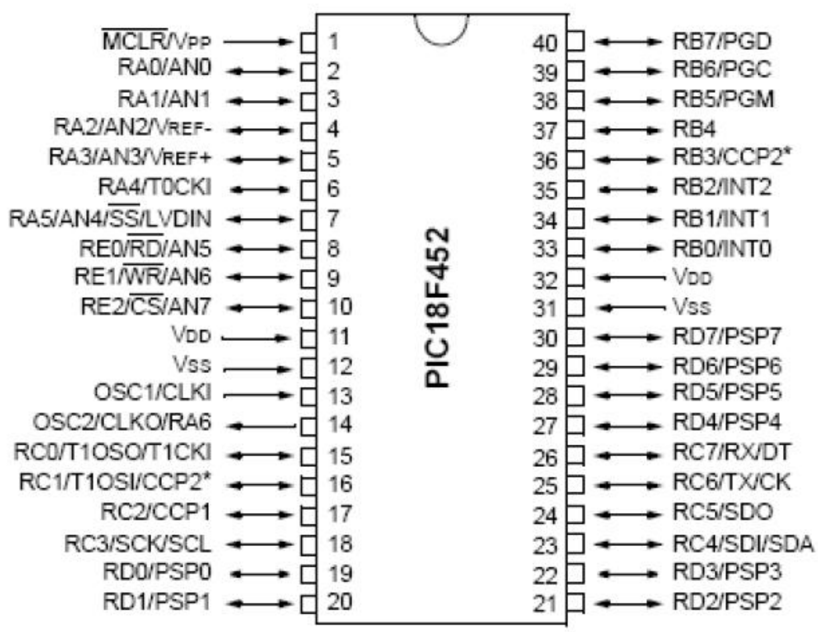

Figure 2.6 :Pin configuration of PIC18F452[14].

Table 2.2 : PIC18F452 Specification

On-Chip Program Memory		On-Chip RAM (bytes)	Data EEPROM (bytes)
FLASH (bytes)	# Single Word Instructions		
32K	16384	1536	256

Meanwhile the peripheral features as follows:

1. Three external interrupt pins
2. Timer0 module: 8-bit/16-bit timer/counter with
3. 8-bit programmable prescaler
4. Timer1 module:16-bit timer/counter
5. Timer2 module: 8-bit timer/counter with 8-bitprogrammable prescaler
6. Timer3 module: 16-bit timer/counter
7. Secondary oscillator clock option – Timer1/Timer3
8. Two Capture/Compare/PWM(CCP) modules
9. CCP pins that can be configured
10. Capture input: capture is 16-bit, max. resolution 6.25 ns (TCY/16)
11. Compare is 16-bit, max. resolution 100ns (TCY)
12. PWM output: PWM resolution is 1-bit to 10-bit. Max. PWM freq : 8-bit
13. 10-bit resolution = 39 kHz
14. High current sink/source 25mA

Analog feature:

1. Compatible 10-bit Analog to Digital Converter module (A/D) with:
   - Fast sampling rate
   - Conversion available during sleep
2. Programmable Low Voltage Detection(PLVD) Support interrupt on-Low Voltage Detection
3. Programmable Brown-Out Reset(BOR)

Special microcontroller feature:

1. 100,000 erase/write cycle Enhanced FLASH program memory typical
2. 1000000 erase/write cycle Data EEPROM memory
3. Flash/Data EEPRROM Retention: >40 years
4. Self-reprogrammable under software control
5. Watchdog Timer (WDT) with its own On-Chip RC Oscillator for reliable operation
6. Programmable code protection
7. Power saving SLEEP mode
8. Selectable oscillator options

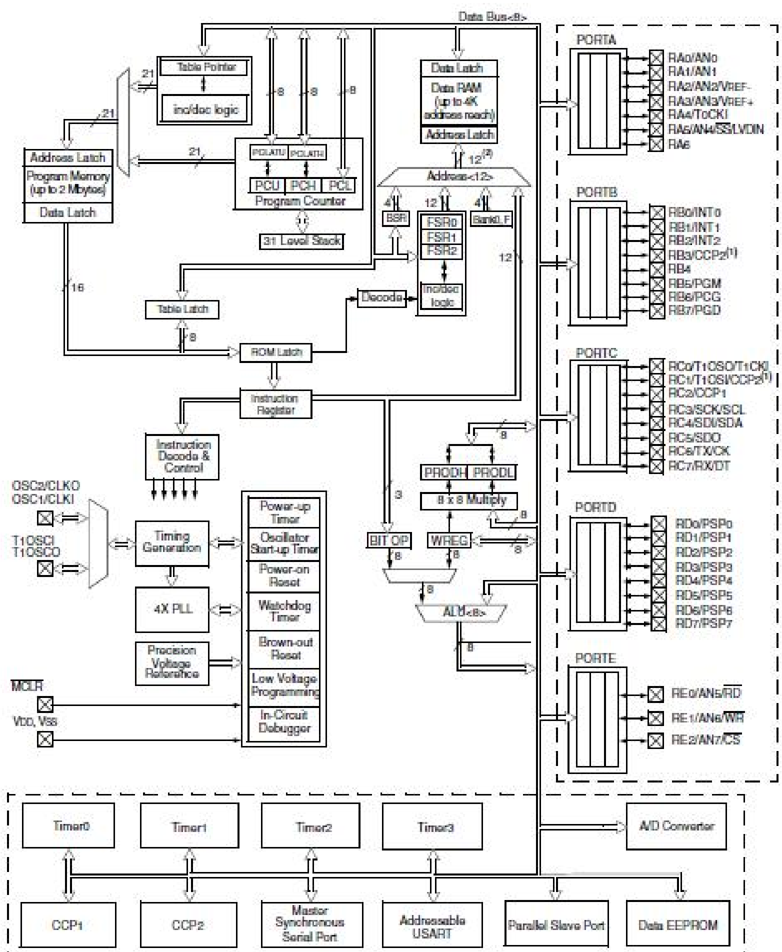

Figure 2.7 : PIC18F452 block diagram[14]

2.5 Programming Tools

2.5.1 MikroC IDE

MikroC is powerful and user friendly C compiler for PIC microcontroller from MikroElektronika. This software program runs on a PC to build up applications for PIC microcontroller families. It is called an Integrated Development Environment (IDE) because it provides a single integrated environment to develop code for embedded microcontroller [4].

Furthermore, highly sophisticated IDE provides the power we need with the simplicity of window based point and click environment. MikroC is a powerful, feature rich development tool for PIC. It is designed to provide the user with the easiest possible solution for developing applications for embedded systems without compromising performance control.

PIC and C fit together well because PICs are used widely over the world with wide variety of applications while C, credited for its efficiency, is a natural choice for developing microcontroller applications.

2.5.2 PIC Kit Programmer

In order to load the program in the microcontroller, this software is used. This software will load all program made into internal memory of PIC18F452. Once HEX file was created in MikroC, this file will then be loaded into PIC18F452 through PIC Kit2.

2.5.3 Microsoft Visual Basic 6.0

Visual Basic(VB) is powerful and useful programming tools for development of applications for the Microsoft Window operating system [5]**.**Microsoft Visual Basic 6.0 is designed to allow programmer to develop applications that run under windows without the complexity generally associated with window programming. The programmer can design a screen that holds standard window element such a command buttons, text boxes and list boxes. Each of these window objects operate as expected, producing a standard window user interface.

Visual basic enables the user to created a forms using drag and drop techniques. A tool is used to place control example like text box or button on the form (window). Programmer can literally draw out the graphical user interface (GUI). This makes developing a GUI relatively easy instead of writing long code.

CHAPTER 3

DESIGN AND IMPLEMENTATION

3.1 Introduction

This project was done according to carefully planned methodology in designing the system as to achieve the objectives. Hence this chapter will provide sufficient details of the necessary steps to complete project. This project divided into two parts which are hardware and software implementation.

Hardware part consists of microcontroller PIC18F452, 16x2 LCD, RS232 for data communication and three types of sensors which temperature, humidity and light. Meanwhile software part was implemented using MikroC to create a program of reading data from sensors and also a part of software that used Visual Basic 6.0 to implement the GUI for data display on computer.

Furthermore, serial communication had been used to communicate between hardware and GUI. Figure 3.1 is a few steps to follow in order to finish this project and Figure 3.2 is the block diagram for this project.

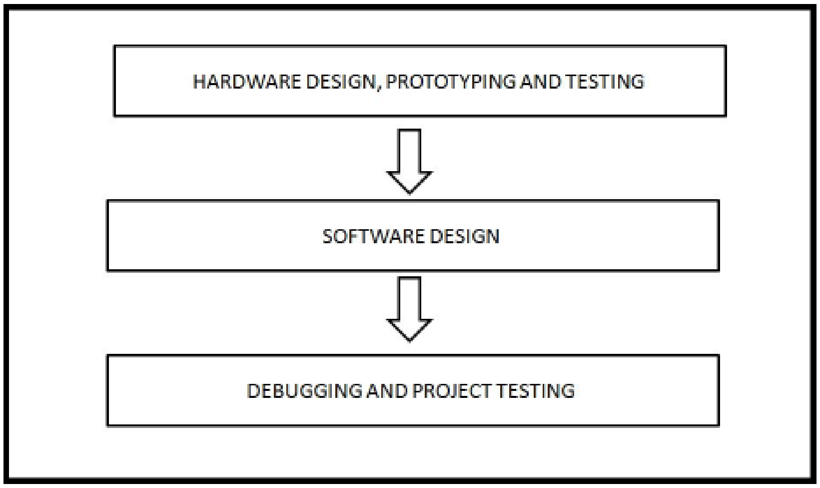

Figure 3.1 : Method to complete the project

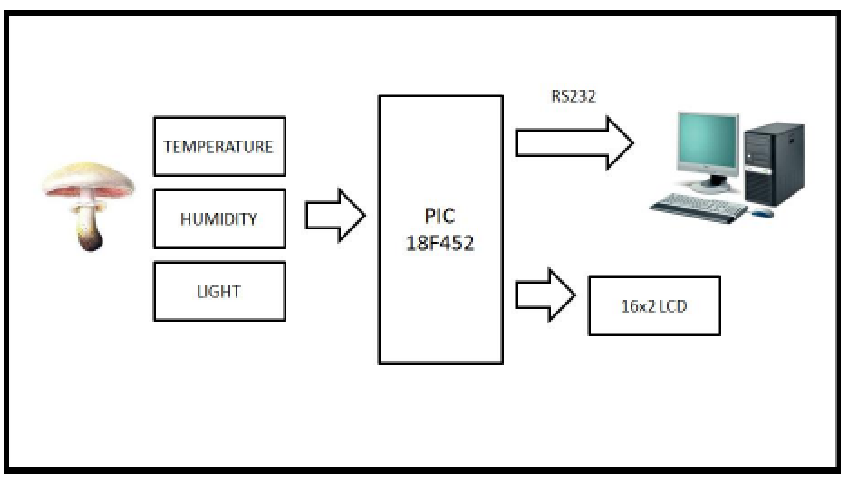

Figure 3.2 : Block diagram of the project

3.2 Hardware Design, Prototyping and Testing

Hardware design and prototyping works parallel with circuit testing to ensure the circuit is working. The most important and complicated part of designing a monitoring system is to design the sensors part. Working with an analog signal requires a highly knowledge and understand on how the sensors and microcontroller operate. The information of the hardware mostly can be read from data sheet, then important specification need to be extracted from data sheet and reliable source.

3.2.1 Microcontroller PIC18F452

Microcontroller is the controlling system that will control the whole operation. It was used to handling communication with sensors, LCD and the PC for display. The data received from field is in analog form, then microcontroller convert the data to digital and process those raw data into readable data to be displayed on LCD or PC. The basic circuits for the microcontroller are crystal oscillator and power supply. This project used 20Mhz crystal oscillator to produce high frequency and give the best performance. Figure 3.3 shows the connection of microcontroller.

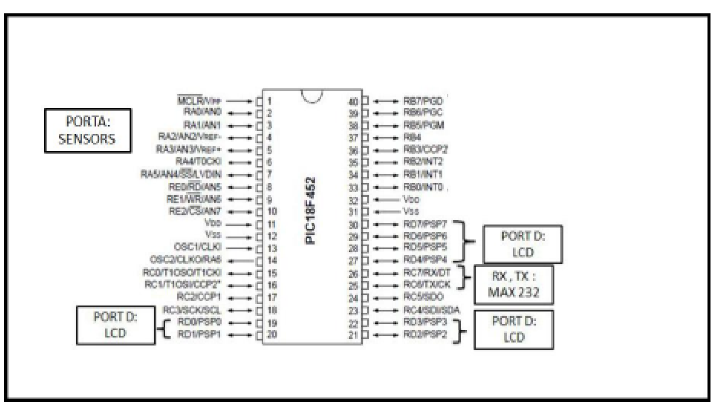

Figure 3.3 : The connection of microcontroller

3.2.2 Temperature Sensor

The LM35 series are precision integrated circuit temperature sensor, which output voltage is linearly proportional to the temperature. Thus, LM35 has an advantage over linear temperature sensor calibrated in degree Celsius. The scale factor is 10mV/°C. Besides, the LM35 temperature sensor does not require any external calibration or trimming and it does maintaining its accuracy of ±0.25°C at room temperature and ±0.75°C over range to 150°C. Figure 3.4 shows a typical electrical connection for the LM35 temperature sensor. Meanwhile Figure 3.5 shows the plastic package of the temperature sensor, LM35DZ.

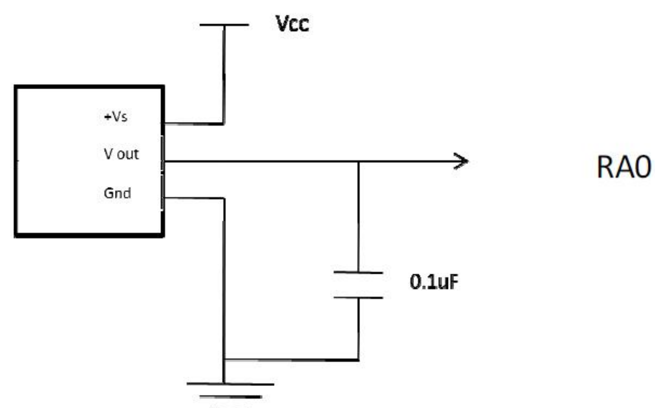

Figure 3.4 : Typical connection for LM35 temperature sensor

Figure 3.5 : LM35DZ temperature sensor

Based on Figure 3.5, simply connect the left pin to 5V and the right pin to the ground. The middle pin will have an analog voltage that is directly proportional to the temperature. LM35 will send data to the PIC microcontroller in voltage then the PIC will convert to degree Celsius base on below formula.

$$\text{Temp in } ^\circ\text{C} = (\text{Vout in mV}) / 10$$

Testing the temperature sensor require the Vcc connected to power supply 5V, ground to 0V and multimeter in DC voltage mode, connected to middle pin and ground. If room temperature is 25°C, the output voltage should be about 0.25V. If the plastic case of sensor pressed, then the voltage will or place on in such colder environment the voltage will drop.

3.2.3 Light Sensor

Light sensor is based on LDR (Light Dependent Resistor). Light dependent resistor is a resistive light sensor that changes its electrical resistance from several thousand Ohms in the dark to only a few hundred Ohms when light fall upon it.

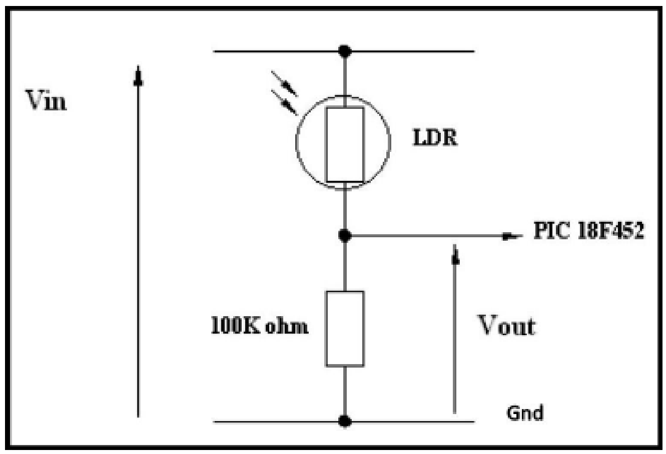

Figure 3.6 : Light sensor schematic

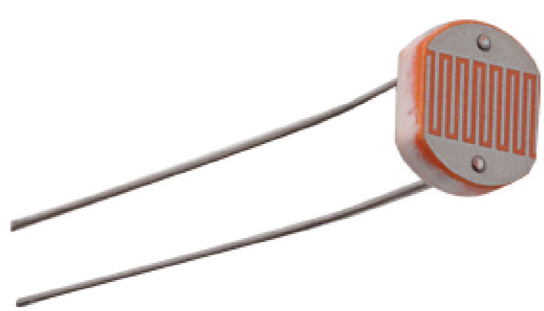

Figure 3.7 : Light Dependent Resistor

Based on Figure 3.6 the light sensor schematic diagram which consist of LDR and 100K Ohm resistor, Vout can be calculated using below formula

$$Vout = \frac{R\ bottom}{R\ bottom + R\ top}\ x\ Vin$$

According to this formula R bottom is equal to 100K ohm and Rtop is base on LDR resistance and Vin is equal to 5V. Figure 3.7 shows the Light Dependent Resistor that will be placed at Rtop. The resistance of LDR becomes higher when the illumination is low or the environment become dark. The value of Vout becomes 0V.

3.2.4 Humidity Sensor

Humidity sensor is used to read the moisture or water vapor in air. Few things need to be considered such as the external circuit. The purpose of external circuit is to make sure the relationship of humidity and voltage is linear. Components required to build the humidity sensor circuit is shown in Figure 3.8

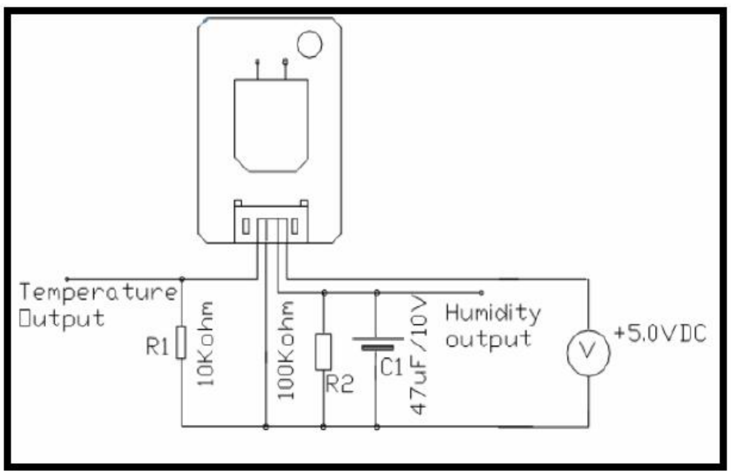

Figure 3.8 : Circuit for humidity sensor

In order to use this sensor, 4 pins was connected to the circuit required such that

I. (-) pin connects to GND.
II. (+) pin connects to Vcc.
III. H (humidity sensor) pin which included 47µF capacitor and 100kΩ resistor connects to microcontroller I/O pin.

To ensure the sensor works in the specified range, detailed programming must be considered.

3.2.5 16x2 LCD

This project also uses 16x2 LCD as a display for temperature, humidity and light sensor. The LCD has two rows and each row can display 16 characters. First row display temperature value and word LIGHT. Meanwhile the second row display humidity value.

Figure 3.9 : 16x2 LCD

Referring to the Figure 3.10 for pin configuration of LCD display, these pins were connected to PORTD at PIC18F452.

Figure 3.10 : 16x2 LCD configuration

3.2.6 RS232 Serial Communication

This project used the RS232, serial communication protocol to communicate between microcontroller and computer. Hardware connection can simply made between the microcontroller and PC via ic named MAX 232. The MAX 232 as shown in Figure 3.11 is an integrated circuit that converts signal from RS232 serial port to signals suitable for use in TTL compatible digital logic circuits. Since microcontroller operate in 5V and 0V signals, then the MAX232 needed to convert the Rx and Tx signals from PC to microcontroller or microcontroller to PC.

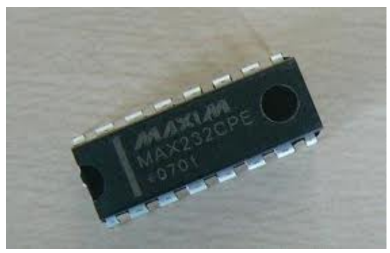

Figure 3.11 : MAX232 IC

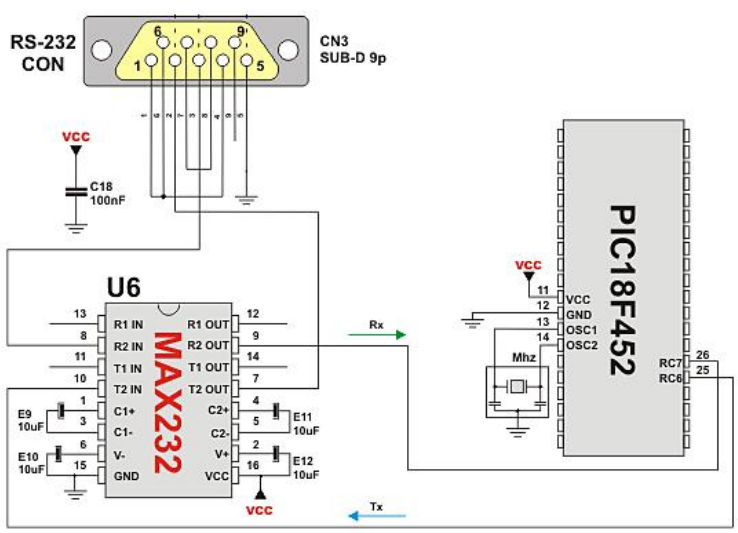

Figure 3.12 : Hardware connection for RS232 communication

3.3 Software Design

Software implementation is the most important part of developing this project and required sophisticated knowledge to achieve desire objective. There were 2 types software developed in this project. The first part was codes that programmed into the microcontroller's memory. Developing the codes will be the vital part of the project since it is the brain for the controller to think and process data correctly. This part develop using C language through IDE MikroC provided by MikroElektronika.

Figure 3.13 shows the flowchart of microcontroller's system. From the figure, system starts when power is turned on. Then the system will initiate the LCD, Analog to Digital Converter and USART. Next the system will start by reading the analog signal from temperature sensor convert to digital value and displayed on LCD as readable data in degree Celsius. Then the processed temperature data send to PC using USART via RS232 communication port. Next, the same process repeated for humidity and light. System terminate when power turned off.

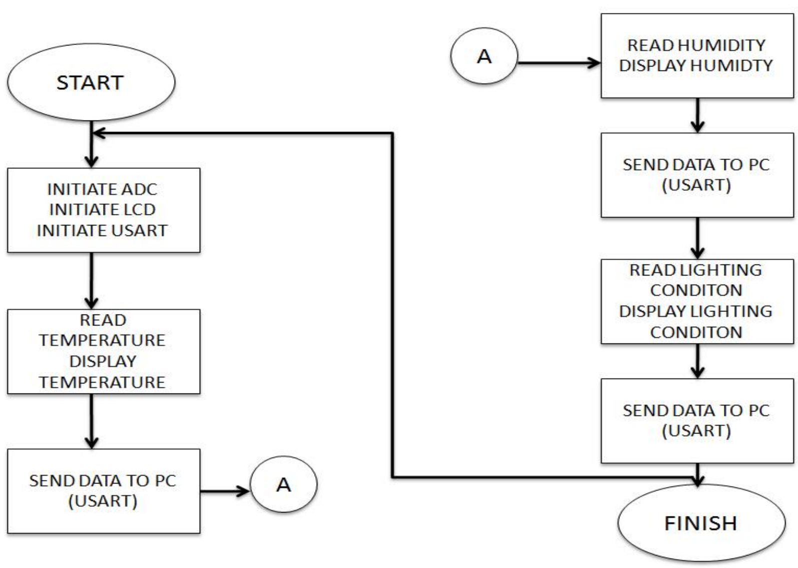

Figure 3.13 : Flowchart of microcontroller system

The second part involved developing software for Graphic User Interface (GUI) purpose. Microsoft Visual Basic 6.0 (VB6) was used as the platform to generate interface. The interface was provided with the display of processed data and monitoring system including the date and time. Flowchart of the monitoring system is given by Figure 3.14.

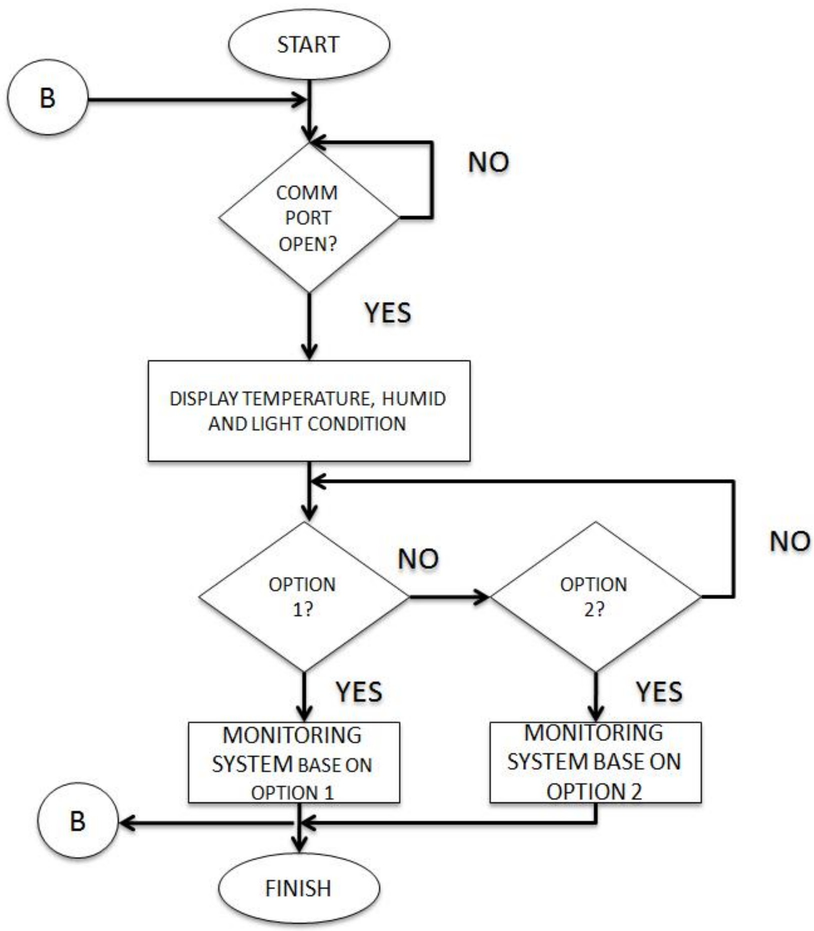

Figure 3.14 : Flowchart of GUI for monitoring system

3.3.1 Temperature Sensor Programming

Correct technique required to interface the sensor and hardware module. It can be done with the Analog to Digital Converter (ADC) provided in PIC18F452. Thus, the analog signal sense by sensor can be represented in a digital data, so that microcontroller could understand and process the raw data.

The PIC18F452 is a 10 bit analog to digital converter microcontroller. The maximum input voltage for microcontroller is 5V. Since the binary is 10bits, it is equal to $2^{10} - 1 = 1023$ steps or level of resolution, hence 5V then divided into 1023

$$\frac{5V}{1023} = 4.88mV\ per\ resolution$$

The scale factor for LM35DZ is given by 10mV/°C, Figure 3.15 shows a set of instruction that perform a subroutine for reading analog signal and calculation made to convert into degree Celsius.

```
void display_temp()
{
unsigned double val;
lcd_out(1,1,"T:");
adc_rd=ADC_read(0);
tempbuffer=adc_rd>>2;
val=(unsigned double)(adc_rd);
rs=4.88*val;
rs=(rs/10);

lcd_out(1,9,"C");
displayNum(rs,1,3);
}
```

Figure 3.15 : A subroutine to perform temperature reading

3.3.2 Light Sensor Programming

Based on equation below R bottom is fixed at 100K ohm and the voltage output value is taken from this equation. The value of Vout increases when the LDR resistive value decreases. The minimum value for LDR is about 15K-20K ohm. Meanwhile the value for LDR without presence of light is above 400K ohm.

$$Vout = \frac{R\ bottom}{R\ bottom + R\ top} x\ Vin$$

Table 3.1 : Calculation for the Min and Max of the voltage divider

Condition	Description
In Dark Condition	In dark condition, the value of LDR is high (around 400KΩ). Therefore it will output the minimal voltage value Vout = (100K/(100K+400K)*5 = 1.0V = 215 in digital (hex)
In Bright Condition	In bright condition, the value of LDR is low (15K-20KΩ). Therefore it will output the maximal voltage value Vout = (100K/(100K+15K)*5 = 4.34V

According to Table 3.1 , the dark condition is when the analog voltage is less than 1.0V and the bright condition is when the analog voltage is higher than. Thus the subroutine for light sensor can be written as Figure 3.16.

```
void display_light()
{
adc_rd=ADC_read(2);
lightbuffer=adc_rd>>2;
 lcd_out(1,11,"LIGHT:");

  if(adc_rd<=215) {
  lcd_out(2,12,"OFF");
  txt3[0]=0x46;
  for(i=0;i<=6;i++)
  usart_write(txt3[i]);
    }
  if(adc_rd>215) {
  lcd_out(2,12," ON");
  txt3[0]=0x4E;
  for(i=0;i<=6;i++)
  usart_write(txt3[i]);
    }
}
```

Figure 3.16 : A subroutine to sense light condition

3.3.3 Humidity Sensor Programming

For humidity sensor, the relation was extracted from the datasheet and focused on some specification. The following calculations will clarity the process to construct an equation for this sensor.

Table 3.2 : Humidity sensor specification

Number	Specification	Value
1	Input voltage range	DC 5.0 V ± 0.2V
2	Output voltage range	DC1.0V ± 3.0V
3	Storage RH range	0 – 99%
4	Operating RH range	20%-95 %

As mentioned before PIC18F452 is 10 bits analog to digital converter microcontroller with 5V input, mean 4.88mV per resolution. Since the output voltage range of humidity sensor is 1V – 3V, hence microcontroller only read digital values from

$$\frac{1023}{5}x1 = 205 \leq adc_{read} \leq \frac{1023}{5}x3 = 614$$

The differences of this step will be 409 steps.

The operating range of humidity sensor is 20%-95% with 75% differences. It shows that at 20% RH the analog value is 1V while binary is 205 and at 95% RH the analog will be 3V while binary is 614. Hence the humidity relation was then obtained as:

$$\%RH = \frac{75\%}{409}\ x\ (adc_{read} - 205) +\ 20\%$$

The source code for humidity sensor can be written as Figure 3.17:

```
void display_humid(int row)
{
 lcd_out(row,1,"H:");
 adc_rd=ADC_read(1);
 humidbuffer=adc_rd>>2;

 if(adc_rd<205 || adc_rd>614){
      Lcd_Out(row,3,"ERROR");
      return;
   }
 humid=adc_rd-205;
 humid *= 0.18;
 humid += 20;
 lcd_out(row,9,"%");
 displayNum(humid,row,3);

 delay_ms(100);
 }
```

Figure 3.17 : A subroutine to perform humidity read

3.4 Debugging and Project Testing

Every programmer will not escape producing bugs in his or her codes. Thus, debugging and project testing process is necessary to ensure no fatal mistakes were done when the controller system is finish. The test could be done by run the programming in simulation environment, next test with actual environment. If mistakes occur, such wrong display value or pattern on LCD, then it is known that codes in such subroutine contains bug. Debugging process usually takes the most time because the problems are uncertain and the most time requires trial and error.

CHAPTER 4

RESULT AND DISCUSSION

4.1 Introduction

Through this chapter, this project hardware and software of monitoring system will be tested whether it is able to meet the desire objectives. This chapter explains about the result achieved and a few discussions regarding a problem solving during the process. Final project overview such as block and flow diagram are included.

4.2 Project Description

This project was based on the objectives stated before which is designing a model of monitoring system for fungi culture environment via few sensors such as temperature, humidity and light. Besides this project also include the implementation of GUI that able to interface with PIC microcontroller. Those sensors will sense analog signal from indoor fungi farm, convert and displayed into digital.

Furthermore, this project also fully utilizes the function of USART communication provided in PIC18F452, the communication between PC and microcontroller were connected via RS232 serial communication. After all the phases were completed, the whole project can be summarized as Figure 4.1

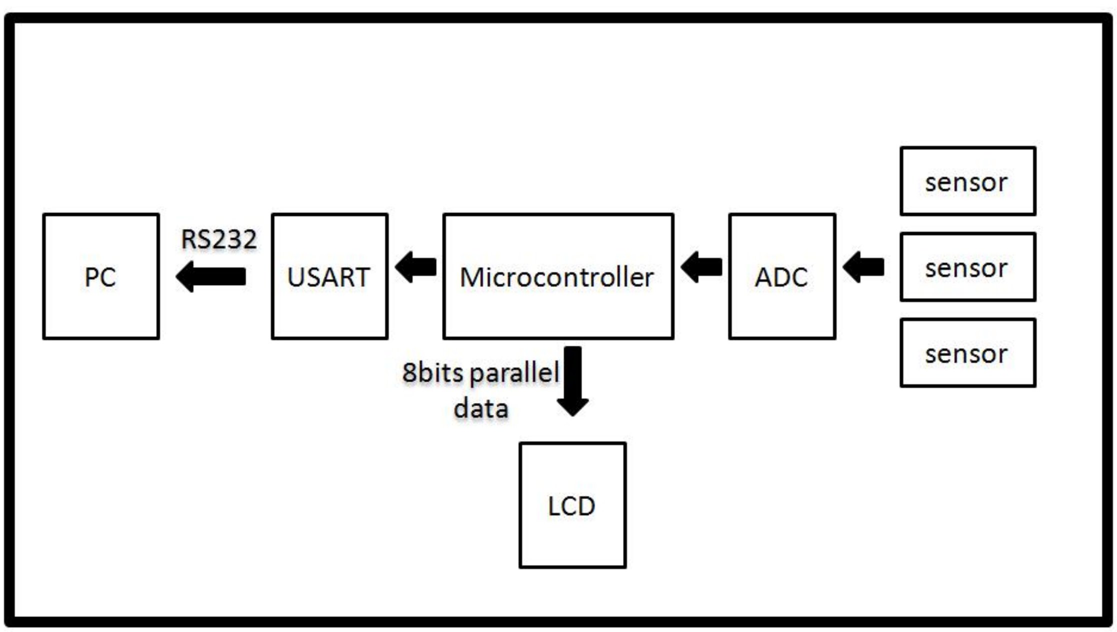

Figure 4.1 : Block diagram of whole project

4.3 Project Result

This project involves implementation of hardware and software. These two parts were highly dependent. The success of the whole project is on the functionally work between hardware and software. Microcontroller played a major role as a brain to the system where it capture signals, process into desire data, display and send to PC.

The most critical element in designing hardware is built up the component connection. For the first attempt, circuit is set up at proto board based on theory gathered from literature reviews done. This temporary circuit was used to make sure the connection working well and to avoid errors. Then the real connection was done and directly soldered at strip board as shown in Figure 4.2. Rainbow cable had been used to connect between the circuit of sensor, LCD circuit, serial communication circuit and main circuit of microcontroller.

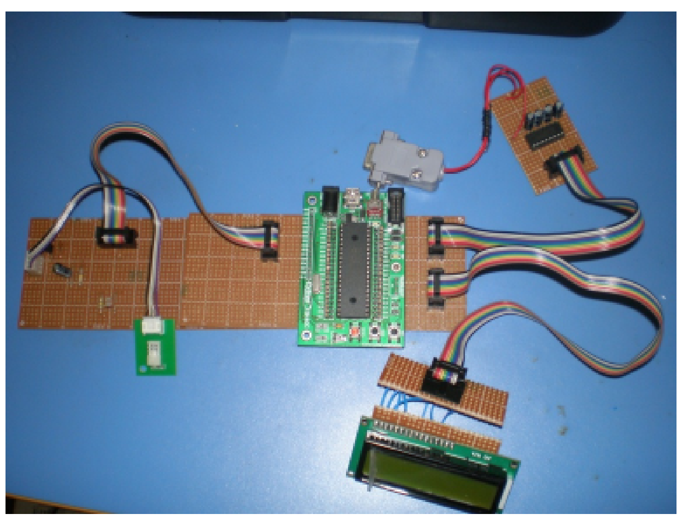

Figure 4.2 : Major connection of component

After soldering process finished, troubleshoot process take place. Checking for continuity between the connection and make sure the path is in the right pin. Finally, when the testing process completed, means the circuit system is done and model of the monitoring system is shown as in Figure 4.3 and Figure 4.4 below.

Figure 4.3 : Project prototype

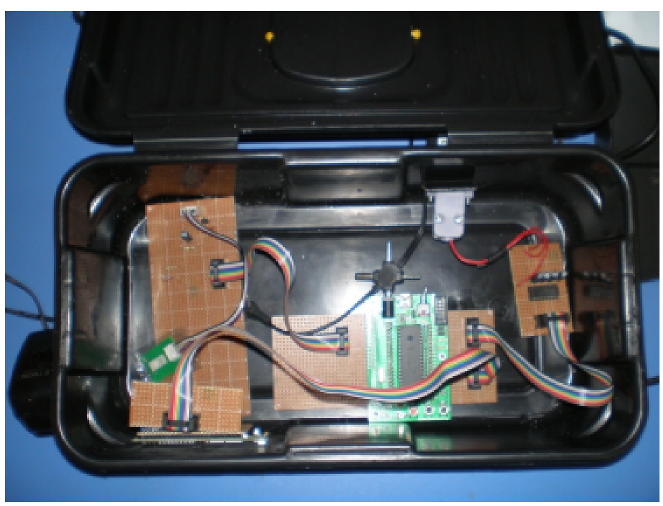

Figure 4.4 : Component inside the project prototype

Then, project proceeds with the software part, where it is the most important part, since the working of this part will ensure the successful of this project. The brain or the software of this system will ensure the hardware could control and monitor data as the programmer want. Software that was used in this project is MikroC and Visual Basic 6.0 where MIkroC is used to program the hardware meanwhile, VB6 is used to program the display and interface on PC.

4.4 Project Discussion

4.4.1 Programming in MikroC

MikroC is an IDE provided by MikroElektronika and it is a powerful, feature rich development tool for PIC microcontrollers. Programming was done in C language. Since C language used, it able the programmer to develop the possible solution for embedded system in the easiest way compare to assembly language.

The data sent and received between hardware and computer via comm. Port also can be checked with the USART communication terminal in MikroC. Collected data from field to computer shown as Figure 4.5

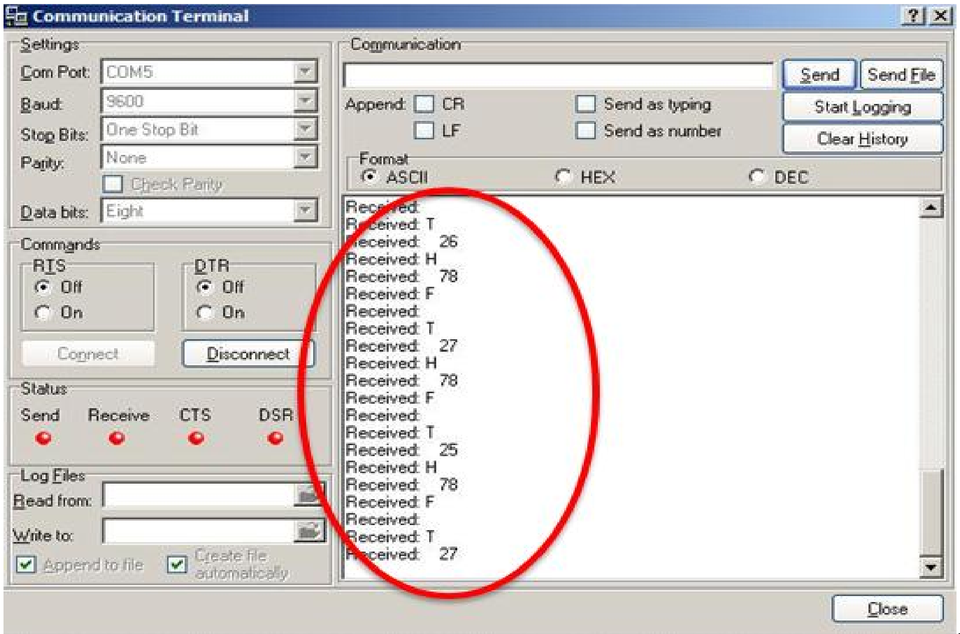

Figure 4.5 : Usart communication terminal receive data

Meanwhile, the process of read data from environment can be tested wia display on LCD. If the programming is success, hence there will be no problems with data displayed on LCD. If there is a bug in programming, mean the output on LCD will be not as desired. Figure 4.6 below shows the LCD display with free error and bug, mean system working well.

Figure 4.6 : Parameters show on LCD

The parameters included into the display of LCD were T for temperature in degree Celsius, H for humidity in %RH and LIGHT for light condition, either ON or OFF. If the condition changes the parameter should change too. For example the light condition in Figure 4.7, the light is ON meanwhile in Figure 4.8, the light condition is OFF.

Figure 4.7 : Light condition is ON

Figure 4.8 : Light condition is OFF

4.4.2 Graphic User Interface

Display of the monitoring system was implemented on window PC using Visual Basic. The window consists of three boxes in data column to display the data received from hardware in real time. These three boxes were temperature, humidity and light. The example of window display is shown in Figure 4.9 below.

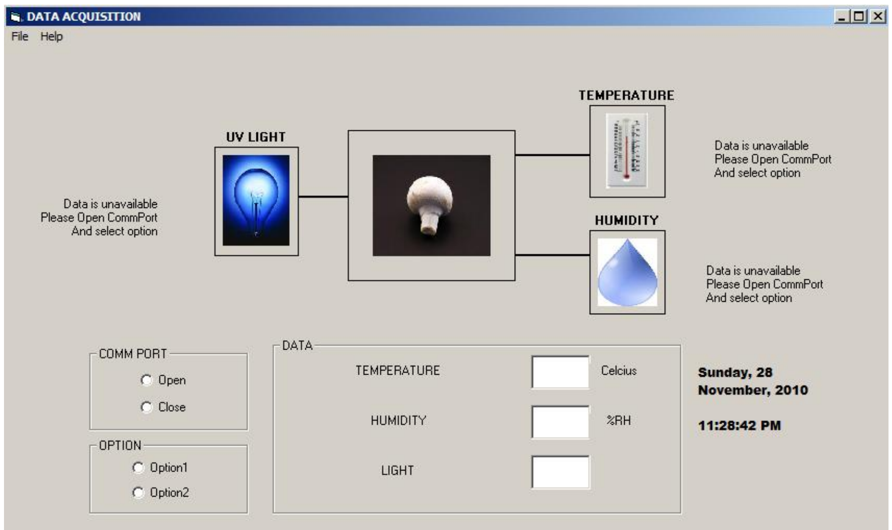

Figure 4.9 : GUI for fungi culture monitoring system

The Comm Port is used to open or closed serial communication, so data could enter or stop from coming into the monitoring system. If the button open clicked without communication port connected to hardware, this message box will come out as Figure 4.10

Figure 4.10 : Message box

After the communication port was opened and option column was selected, then data will be displayed on the window. Monitoring system also works completely according to desire environment selected by user. Figure 4.11 below shows the operating of fungi culture monitoring system.

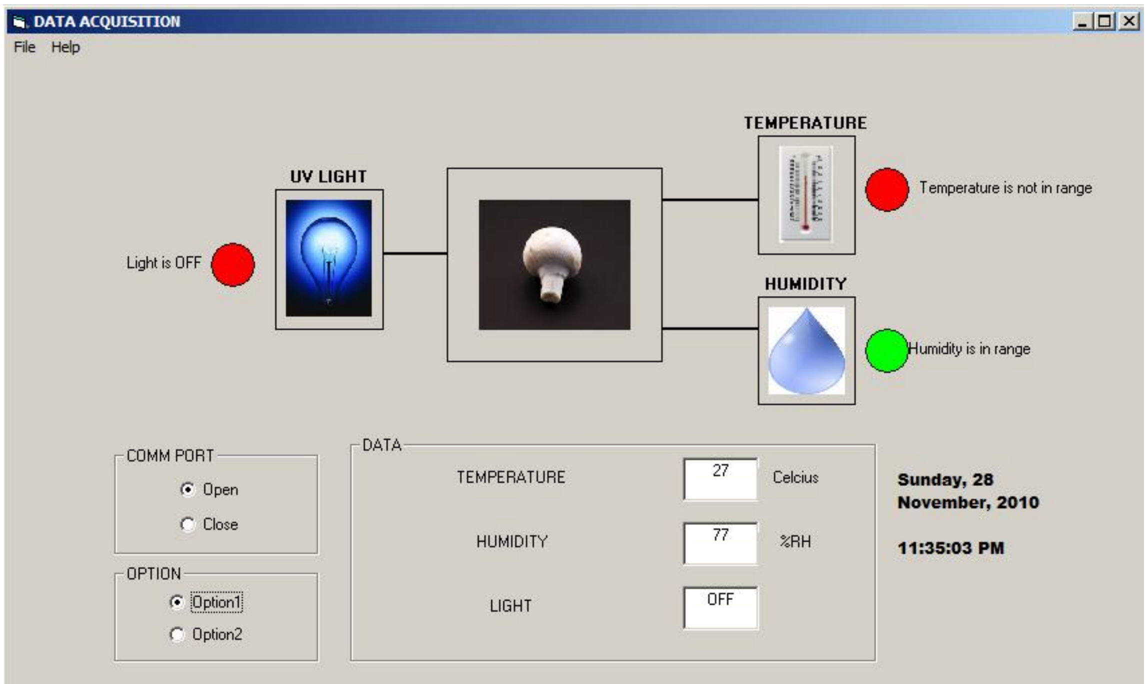

Figure 4.11 : A fungi culture monitoring system

where

Red = parameter is not in range

Green = parameter is in range

The condition for option 1 and option 2 is given by Table 4.1 below. Option1 is the medium for growing mycelium in composes meanwhile Option2 is the condition during initiation of mushroom cultivation. Finally is the harvesting of mushroom. During this time, Option2 condition still can be used as the medium of environment besides lowering the humidity to certain range between 85%-92% of moisture.

Table 4.1 : Condition for monitoring system in GUI

Process	Requirement
Option1 Expansion of mycelium in agar media	Temperature 24°C-26°C Humidity 75%-80% Presence of light is not important
Option2 Initiation	Temperature below 18°C Increase humidity to 95% Introducing light

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Introduction

This section will conclude the whole project and future recommendations for students or individual who is interested in continuing this project as their research.

5.2 Conclusion

In this project, cultivation of mushroom had been merging with the advancement of embedded application. Compared to traditional system this project greatly improves the production efficiency. In future and since Malaysia becoming the developing country, necessary of sustaining the foods stock in market will demand the usage of technology in agro industry.

The project of fungi culture environmental characterization has a great impact in leading the agro industry to the next level. This prototype of embedded application in monitoring system could be the basic in building more practical application in real world. The usage of technology might be able to enhance several possibilities in managing the farm precisely. Furthermore, all implementation in this project were designed to be highly expandable in future

Via this project, an understanding of embedded usage shall be a learning platform in order to perform more complex and advance embedded system developed in future. Complex system with more parameters and automated control perform farming duties and minimize human involvement. Thus, the product of agro industry will have such a better qualities and yield more corps.

The objective of the project had been state clearly before. The expected outcome of this project is able to model an embedded system via sensors and microcontroller and also able to perform monitoring task for cultivation of mushroom. The system met the expected outcome, therefore the objectives were fulfilled.

5.3 Recommendation

Further research is recommended to improve the reliability of this project especially in embedded system. This project uses few sensors and wired communication medium to communicate. To improve it, a wireless communication between microcontroller and computer could be used instead of serial communication. Thus, this project will become more efficient since the data transmitted from field to monitoring room (control station) without require the person to be at the field. Those sensors can be read from several meters away and beyond the sight of person in charge.

As improvement, the researcher could add some features like database into the GUI of monitoring system. Those data collected shall be kept and analyzed. The purpose of this feature is to guarantee there is a reliable source of data for further research in fungi growth in future.

In addition, with some alteration to the system, this project could monitor and control other type of monitoring system such as aquaculture and livestock industry. Those industries also have bigger potential to be developed with embedded application.

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APPENDIX A

PROGRAMMING FOR FIRMWARE

```
-----------------------------------------------------------------------------------------------------------
//DATA ACQUISITION FOR FUNGICULTURE MONITORING SYSTEM---USART
-----------------------------------------------------------------------------------------------------------
char *text="SYAFIQ AFIFI";
int i,j;
unsigned int adc_rd;
unsigned double rs,val;
unsigned double humid;
unsigned short tempbuffer, humidbuffer, lightbuffer;
unsigned char txt[7],txt2[7],txt3[7];
void app_init();
void display_temp();
void display_light();
void display_humid(int row);
void displayNum(unsigned double num,int row,int column);
void move();
void move2();

void main()
{
 app_init();
 while(1)
 {
  display_temp();                    //TEMPERATURE
  IntToStr(rs,txt);
  txt[0]=0x54;
  for(i=0;i<=6;i++)
  usart_write(txt[i]);
  delay_ms(2000);
    display_humid(2);                //HUMIDITY
    IntToStr(humid,txt2);
      txt2[0]=0x48;
      for(i=0;i<=6;i++)
```

```
     usart_write(txt2[i]);
    delay_ms(2000);
  display_light();                          //LIGHT
  }
}


void app_init()
{
 delay_ms(100);
 TRISD=0;
 TRISA=0xFF;
 ADCON1=0x80;
 usart_init(9600);
 lcd_init(&PORTD);
 lcd_cmd(LCD_CLEAR);
 lcd_cmd(LCD_CURSOR_OFF);
 lcd_out(1,3,text);
 text="FKE UTM";
 lcd_out(2,6,text);
 delay_ms(4000);
 lcd_cmd(LCD_CLEAR);
 text="FUNGICULTURE";
 lcd_out(1,3,text);
 text="DATA ACQUISITION";
 lcd_out(2,1,text);
 delay_ms(4000);

 j=0;
 do {                              // loop moving display
       move();
       move2();
       j++;
       }while(j<2);
 delay_ms(2000);
 lcd_cmd(LCD_CLEAR);
 lcd_out(1,1,"DATA ACQUISITION");
 lcd_out(2,1,"TEMP&HUMID&LIGHT");
 delay_ms(4000);
 lcd_cmd(LCD_CLEAR);
 }

//temperature display --AN0

void display_temp()
{
unsigned double val;
```

```
lcd_out(1,1,"T:");
adc_rd=ADC_read(0);
tempbuffer=adc_rd>>2;
val=(unsigned double)(adc_rd);
rs=4.88*val;
rs=(rs/10);

lcd_out(1,9,"C");
displayNum(rs,1,3);
}

//humidity display---AN1

void display_humid(int row)
{
 lcd_out(row,1,"H:");
 adc_rd=ADC_read(1);
 humidbuffer=adc_rd>>2;

 if(adc_rd<205 || adc_rd>614){
        Lcd_Out(row,3,"ERROR");
        return;
    }
 humid=adc_rd-215;
 humid *= 0.18;
 humid += 20;
 lcd_out(row,9,"%");
 displayNum(humid,row,3);
 delay_ms(100);
 }

void display_light()
{
adc_rd=ADC_read(2);
lightbuffer=adc_rd>>2;

 lcd_out(1,11,"LIGHT:");

 if(adc_rd<=215) {
 lcd_out(2,12,"OFF");
 txt3[0]=0x46;
 for(i=0;i<=6;i++)
 usart_write(txt3[i]);

    }
 if(adc_rd>215) {
```

```
  lcd_out(2,12," ON");
  txt3[0]=0x4E;
  for(i=0;i<=6;i++)
  usart_write(txt3[i]);
                }
}

void displayNum(unsigned double num,int row, int column){

    char ratus,puluh,sa,dec1,dec2;

    unsigned long ch = (unsigned long)(num*100);

    if(num>999){
       Lcd_Out(row,column,"ERROR");
       return;
    }

    ratus = (char)(ch/10000);
    ratus += 0x30;
    ch = ch%10000;
    if(ratus=='0'){
       ratus = ' ';
    }

    puluh = (char)(ch/1000);
    puluh += 0x30;
    ch = ch%1000;
    if(ratus==' ' && puluh=='0'){
      puluh = ' ';
    }

    sa = (char)(ch/100);
    sa += 0x30;
    ch = ch%100;

    dec1 = (char)(ch/10);
    dec1 += 0x30;
    ch = ch%10;

    dec2 = ch + 0x30;

    Lcd_Chr(row,column   ,ratus);
    Lcd_Chr(row,column+1 ,puluh);
    Lcd_Chr(row,column+2 ,sa);
    Lcd_Chr(row,column+3 ,'.');
    Lcd_Chr(row,column+4 ,dec1);
```

```
     Lcd_Chr(row,column+5 ,dec2);

}

void move()
{for(i=0; i<2; i++) {            // Move text to the Right
      Lcd_Cmd(LCD_SHIFT_RIGHT);
      delay_ms(500);
    }

    for(i=0; i<2; i++) {            // Move text to the Left
      Lcd_Cmd(LCD_SHIFT_LEFT);
      delay_ms(500);
       }
       }
void move2()
{ for(i=0; i<2; i++) {            // Move text to the Left
      Lcd_Cmd(LCD_SHIFT_LEFT);
      delay_ms(500);
       }
  for(i=0; i<2; i++) {            // Move text to the Right
      Lcd_Cmd(LCD_SHIFT_RIGHT);
      delay_ms(500);
    }
    }
```

APPENDIX B

PROGRAMMING FOR GUI

*****************************FORM LOAD*****************************

```
Private Sub Form_Load()
Label1.Caption = "Data is unavailable" & vbCrLf & "Please Open CommPort" &
vbCrLf & "And select option"
Label2.Caption = "Data is unavailable" & vbCrLf & "Please Open CommPort" &
vbCrLf & "And select option"
Label3.Caption = "Data is unavailable" & vbCrLf & "Please Open CommPort" &
vbCrLf & "And select option"
Shape5.Visible = False
Shape6.Visible = False
Shape7.Visible = False
Shape8.Visible = False
Shape9.Visible = False
Shape10.Visible = False
End Sub

Private Sub mnuAbout_Click()
MsgBox "Menu Demo" & vbCrLf & "Copyright " & Chr$(169) & " Syafiq Afifi", ,
"About"
Exit Sub

End Sub
```

************************** MSCOMM PORT**************************

```
Private Sub MSComm1_OnComm()
Dim tdata As String
Dim hdata As String
Dim rdata As String
Dim ldata As String
Dim TEMP As Integer
'Dim HUM As Integer
'Dim Tarikh As Integer
If MSComm1.CommEvent = comEvReceive Then
rdata = MSComm1.Input
   If (Left(rdata, 1) = "T") Then
   tdata = CInt(Trim(Mid(rdata, 2, 5)))
   txtTemperature.Text = tdata
   tdata = ""
   ElseIf (Left(rdata, 1) = "H") Then
   hdata = CInt(Trim(Mid(rdata, 2, 5)))
   txtHumidity.Text = hdata
   tdata = ""
   ElseIf (Left(rdata, 1) = "F") Then
   ldata = "OFF"
   txtLight.Text = ldata
   ldata = ""
   ElseIf (Left(rdata, 1) = "N") Then
   ldata = "ON"
   txtLight.Text = ldata
   ldata = ""
   End If
End If
If (Option1.Value = True) Then
   If (txtTemperature.Text < 26 And txtTemperature.Text > 24) Then
   Label1.Caption = "Temperature is in range"
   Shape6.Visible = False
   Shape5.Visible = True
   Else
   Label1.Caption = "Temperature is not in range"
   Shape5.Visible = False
   Shape6.Visible = True
   End If
   If (txtHumidity.Text > 75 And txtHumidity.Text < 80) Then
   Label2.Caption = "Humidity is in range"
   Shape8.Visible = False
   Shape7.Visible = True
```

```
    Else
    Label2.Caption = "Humidity is not in range"
    Shape7.Visible = False
    Shape8.Visible = True
    End If
    If (txtLight = "ON") Then
    Label3.Caption = "Light is ON"
    Shape10.Visible = False
    Shape9.Visible = True
    Else
    Label3.Caption = "Light is OFF"
    Shape9.Visible = False
    Shape10.Visible = True
    End If
End If
If (Option2.Value = True) Then
    If (txtTemperature.Text < 18) Then
    Label1.Caption = "Temperature is in range"
    Shape6.Visible = False
    Shape5.Visible = True
    Else
    Label1.Caption = "Temperature is not in range"
    Shape5.Visible = False
    Shape6.Visible = True
    End If
    If (txtHumidity.Text > 90) Then
    Label2.Caption = "Humidity is in range"
    Shape8.Visible = False
    Shape7.Visible = True
    Else
    Label2.Caption = "Humidity is not in range"
    Shape7.Visible = False
    Shape8.Visible = True
    End If
    If (txtLight = "ON") Then
    Label3.Caption = "Light is ON"
    Shape10.Visible = False
    Shape9.Visible = True
    Else
    Label3.Caption = "Light is OFF"
    Shape9.Visible = False
    Shape10.Visible = True
    End If
End If
'End With
End Sub
```

```
Private Sub Optionclose_Click()
'disable comm port
On Error GoTo HandleErrors
MSComm1.PortOpen = False
Option1.Value = False
Option2.Value = False
Exit Sub

HandleErrors:
Dim strMessage As String
strMessage = "Port already disconnected" & vbCrLf & vbCrLf _
            & Err.Description
MsgBox strMessage, vbExclamation, "Error"
Option1.Value = False
Option2.Value = False
On Error GoTo 0
End Sub

Private Sub Optionopen_Click()
On Error GoTo HandleErrors
With MSComm1
   .CommPort = 5
   .PortOpen = True
   .InputMode = comInputModeText
   .Handshaking = comNone
   .Settings = "9600,n,8,1"
   .RThreshold = 7
   .InputLen = 0
  End With
  Exit Sub

HandleErrors:
Dim strMessage As String
strMessage = "Please connect the Device" & vbCrLf & vbCrLf _
            & Err.Description
MsgBox strMessage, vbExclamation, "Error"
Option1.Value = False
Option2.Value = False
On Error GoTo 0
End Sub
Private Sub Timer1_Timer()
lblDisplay.Caption = Format$(Now, "Long Date") & vbCrLf & vbCrLf &
Format$(Now, "Long Time")
End Sub
```