DIGITAL RAIN GAUGE

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DIGITAL RAIN GAUGE

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This thesis is submitted as partial fulfillment of the requirements for the award of the Bachelor of Electrical Engineering (Hons.) (Power System)

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Dedicated to my beloved
Father, Mother and my Family,
My Supervisor, staff &
My Friends

Million of thanks for all the Assist,
Supporting and Encouragement

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ABSTRACT

Rain fall is nature phenomena that occur that give humidity on the ground. Too much humidity cause flood on the ground and if the humidity is small, the ground is dry. The rain gauge is the equipment that used by people in weather station to measure cumulative rain fall at a given location and given time. Rain gauge also known as udometer or pluviometer consist main part can to collect water fall from funnel above it, and outer case to protect the inner can. The new design of rain gauge give more accurate reading now day and have many other advantage such as observer can observe the rain fall from far, the measure of rain fall is according tip drop not only looking at the water level anymore where is sometimes cause error, the digital reading can be taken and many more. Tipping Bucket Rain Gauge is the new device that has all the advantage of the criteria above. This rain gauge is using two small bucket acting like see-saw, when one of the buckets is fill with water it will spill because of the unbalance see-saw. Then the other bucket will fill the water and repeat the same action like the first bucket and keep repeating until the rain stop. With the combination of the Microcontroller, sensor and LCD, digital rain gauge is build.

ABSTRAK

Hujan adalah fenomena semulajadi cuaca yang memberikan kelembapan pada tanah. Jika kelembapan tanah tinggi ia boleh menyebabkan banjir dan jika kelembapan tanah kurang atau sedikit maka kawasan itu adalah kering. Tolok hujan adalah alat yang digunakan di stesen pengkaji cuaca untuk mengukur timbunan hujan di sesetengah kawasan pada sesuatu masa. Tolok hujan juga dikenali sebagai Udometer atau Pluviometer mengandungi 3 bahagian iaitu bekas luar, yang melindungi bekas dalam berbentuk silinder dan corong yang mengumpul air hujan di bahagian teratas tolok hujan. Reka bentuk tolok hujan yang baru memberikan bacaan yang lebih tepat dan mempunyai banyak kelebihan antaranya pemerhati boleh mengambil bacaan jauh dari tolok hujan ketika hujan, bacaan air hujan di kira melalui titisan air yang melalui corong bukan lagi dengan membaca di selinder penyukat yang boleh menyebabkan ralat, bacaan digital boleh dilihat dan lain-lain lagi. Tolok hujan titisan timba adalah alat sukatan hujan yang terbaru dan memenuhi setiap kelebihan tersebut. Tolok hujan ini mempunyai 2 timba yang bertindak seperti jongkang-jongkit, apabila satu daripada timba dipenuhi air maka ia menjadi tidak stabil dan mengalirkan air keluar dan satu lagi timba akan dipenuhi air menyebabkan proses tersebut berulang sehingga hujan berhenti. Dengan kombinasi Pengawal-mikro, alat pengesan dan LCD maka terhasillah tolok hujan digital.

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PIC	-	Peripheral interface controller
LCD	-	Liquid Crystal Display
mL	-	mililitre
mm	-	millimeter

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Malaysia is the one of the country on the equator and have tropical climate in this world. This country having heavy rain fall in every year even when in dry season there still cloud at the sky. For the state on east cost of Malaysia, November until January constitute the month for maximum rain fall and for June till July is the most dry season among all the state in Malaysia. To measure the rain fall, one device is used that is digital rain gauge where the measurement is accurate and readable.

Common rain gauge only consist three main part funnel, inner can and outer can. Rain fall is collected by the funnel and flow the water into inner can, after rain stop meteorologist will take the reading by looking at the inner can scale. Then other version of rain gauge came up where each drop of rain is counted and recorded. The tipping bucket rain gauge solve the problem but the design is used many mechanical part to record the data. The recorder consists of a pen mounted on an arm attached to a geared wheel that moves once with each signal sent from the collector. At the top of the cylinder is a funnel that collects and channels the precipitation. The precipitation falls onto one of two small buckets or levers which are balanced in same manner as a scale or seesaw. After an amount of precipitation equal to 0.5 mm falls the lever tips and an electrical signal is sent to the recorder.

1.2 Objective of Project

i) To built Tipping Bucket Rain Gauge with digital display
   (a) Tipping bucket rain gauge is constructed with several can, funnel and two bucket that balance each other. The material to build the tipping bucket rain gauge mostly is plastic.

ii) Measure the water level of rainfall with precise reading
   (a) The tipping bucket is design and setting to measure the rain fall in more accurate way. Every tip drop of the water must be measure small enough to make sure the counter in small percentage.

iii) To understand and study about Microcontroller (PIC)
   (a) The project is involving the microcontroller and basically this will indirectly introduce the function and the programming of Peripheral Interface Controller (PIC). In this project the involve PIC16F84A.

1.3 Scope of Project

Work scope in this project can be dividing by 2:

1.3.1 Hardware:

i. Designing the circuit using Microprocessor (PIC 16F84A) and sensor reed switch. The circuit designs also provide display using Liquid Crystal Display (LCD).

ii. Produce the model of tipping bucket rain gauge with standard measurement stand with outer can, inner can, funnel and tipping bucket.

1.3.2 Software:

i. The program for the PIC is constructed by using BASIC language that can be done in Microcode Studio Software. The instruction basically assign input from the sensor as 1 input and each input trigger as 0.2ml then it will display in the LCD.

1.4 Problem Statement

The tipping bucket rain gauge with digital display is one good alternative way to measure rain fall rather than conventional rain gauge where Meteorologists need to wait until rain to stop then take the reading. While waiting rain to stop some of the rain precipitation will vaporise and make the reading not accurate. The advantage of the tipping bucket rain gauge is that the character of the rain (light, medium or heavy) may be easily obtained. Rainfall character is decided by the total amount of rain that has fallen in a set period (usually 1 hour) and by counting the number of 'clicks' in a 10 minute period the observer can decide the character of the rain. [1]

Although the tipping bucket rain gauge has many advantages, tipping bucket rain gauge is not as accurate as the standard rain gauge because the rainfall may stop before the lever has tipped. The ground must be level and must be mounted on a vibration-free level surface to make sure the lever didn’t tip before it should be.

The accuracy to take the measurement of rain fall is the most important part in building rain gauge model. So, the design and the details of the bucket and all the part of the rain gauge is the main priority. But this project is only considered in building the model, not to really measure rain fall because when measuring the rain fall we need to plot the average rain in month.

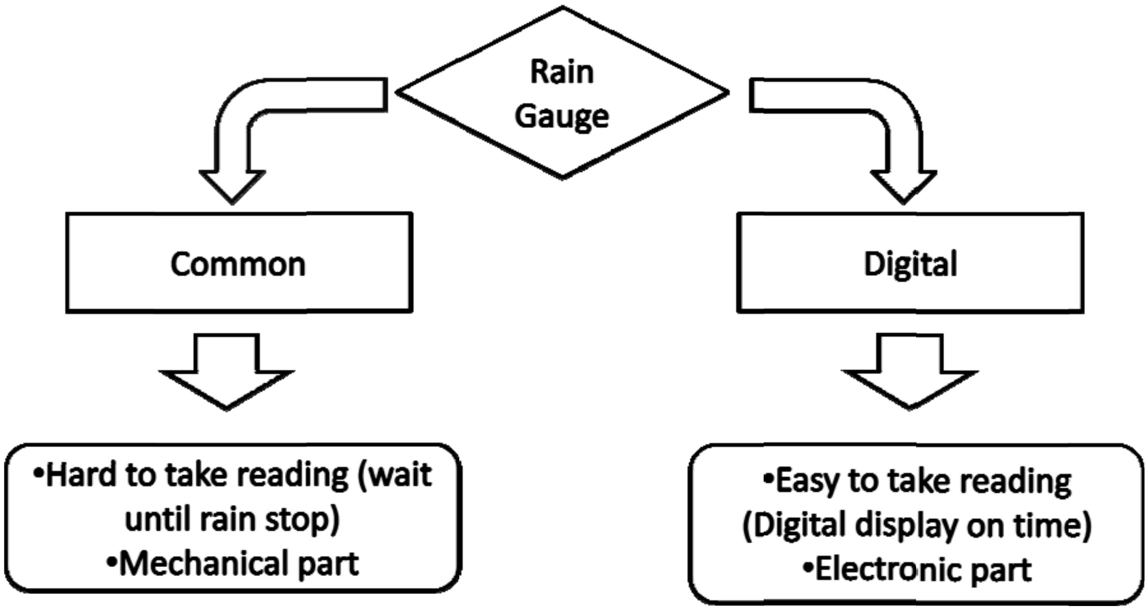


Figure 1.1: Problem Statement Summary

CHAPTER 2

THEORY AND LITERATURE REVIEW

2.1 Introduction

There is many version and design of rain gauge use to measure rain fall. Most of the design of the rain gauge is particularly about the same. In designing tipping bucket rain gauge there is a lot of part and component involve. In this chapter the theory of every mechanical part of the model and the circuit will be discuss.

2.2 Rain gauge

There is many type of rain gauge use nowadays. The different in design and function is optional but still the main purpose to build rain gauge is to measure the cumulative rain fall over certain area in certain time.

2.2.1 Standard Rain Gauge

The standard rain gauge consists of a funnel attached to a graduated cylinder that fits into a larger container. It consists of a 5" diameter funnel with a sharp rim, the spout of the funnel being inserted into a glass collecting jar. The jar is in an inner copper can and the two are contained in the main body of the gauge, the lower part of which is sunk into the ground. The diagram shows the whole gauge arrangement. [2]

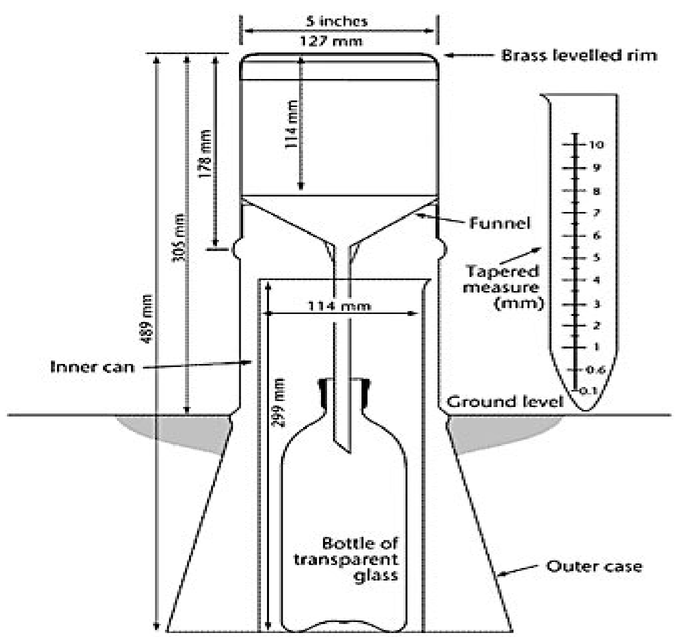


Figure 2.1: Standard Rain Gauge

2.2.2 Weighing Precipitation Gauge

A weighing-type precipitation gauge consists of a storage bin, which is weighed to record the mass. Certain models measure the mass using a pen on a rotating drum, or by using a vibrating wire attached to a data logger. The advantages of this type of gauge to tipping buckets is that it does not underestimate intense rain, and it can measure other forms of precipitation, including rain, hail and snow. However, these gauges are more expensive and require more maintenance than tipping bucket gauges. The weighing-type recording gauge also contains a device to measure the quantity of chemicals contained in the locations atmosphere. This is extremely helpful for scientists studying the effects of greenhouse gases released into the atmosphere and their effects on the levels of the acid rain. [1]

2.2.3 Optical Rain Gauge

These have a row of collection funnels. In an enclosed space below each is a laser diode and a phototransistor detector. When enough water is collected to make a single drop, it drips from the bottom, falling into the laser beam path. The sensor is set at right angles to the laser so that enough light is scattered to be detected as a sudden flash of light. The flashes from these photodetectors are then read and transmitted or recorded. Digital rain gauge is most expensive among of all the rain gauge because it provide with new technology equipment. [1]

Figure 2.2: Optical Rain Gauge

2.2.4 Self-syphoning Capacitance Gauge

This precipitation gauge collects water into a measuring chamber, which contains a capacitance probe. The water surrounds the probe and acts as the dielectric in the system. Therefore as the water level rises, the capacitance of the system also changes, allowing rainfall accumulation to be determined. The system automatically empties and resets when the accumulation reaches a certain level. The disadvantage of this sort of gauge is that it cannot record accumulation accurately enough for light rainfall, such as stratiform rain. The changes in capacitance are so small they lie within the "noise" level of the system, making it impossible to determine rainfall rate.

Figure 2.3: Self-syphoning Capacitance Gauge

2.2.5 Tipping bucket Rain Gauge

The tipping bucket rain gauge is the rain gauge use as the reference for this project model. This rain gauge has simple mechanical part and it is the main part of the rain gauge that makes it is different from other rain gauge. A tipping bucket rain gauge has several components that allow it to accurately measure of rainfall. As rain falls it lands in the funnel of the tipping bucket rain gauge. The rain travels down the funnel and drips into one of two very carefully calibrated ‘buckets’ balanced on a pivot (like a see-saw).

The top bucket is held in place by a magnet until it has filled to the calibrated amount (usually approximately 0.001 inches of rain). When the bucket has filled to this amount, the magnet will release its hold, causing the bucket to tip. The water then empties down a drainage hole and raises the other to sit underneath the funnel. When the bucket tips, it triggers a reed switch (or sensor), sending a message to the display or weather station. The display counts the number of times the switch is triggered. Because it knows how much rain is needed to fill the bucket, the display can calculate the rainfall [7]. Rainfall is measured in inches; 1 inch of rain would fill a container with straight edges to a level of 1 inch.

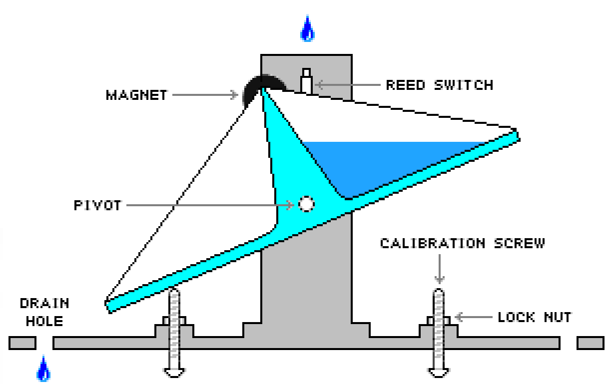


Figure 2.4: Tipping bucket rain gauge and mechanical part in rain gauge

2.3 Reed Switch

The key component in the Reed Sensor is the Reed Switch and the other major component is the magnet or electro-magnet used to open or close the Reed Switch. The

Reed Switches are used in Reed Relays, switching in the various test configurations for integrated circuits, ASICs, wafer testing and functional printed circuit board testing.

Several remarkably interesting advantages are observed when comparing the Reed Sensor technology to the Hall Effect technology:

i. Generally the cost of the Hall Effect device is low, but it requires power and circuitry to operate. Also, its signal output is so low it often times requires amplification circuitry as well. The net result, the Hall Effect sensor can be considerably more expensive than the Reed Sensor.
ii. The Reed Sensors are capable of withstanding much higher voltages (miniature sizes are rated up to 1000 Volts). Hall Effect devises need external circuitry for ratings as high as 100 Volts.
iii. The reed is hermetically sealed and can therefore operate in almost any environment.
iv. The reed has very low on resistance, typically as low as 50 milliohms, whereas the Hall Effect can be in the hundreds of ohms.
v. The reeds are capable of switching a variety of loads, where the Hall Effect sensor delivers only smaller voltages and currents.

2.4 Microcontroller

PIC stand for Programmable Interface Controller but shortly thereafter was renamed Programmable Intelligent Computer. PIC is used by developers and hobbyists due to their low cost, wide availability, large user base, extensive collection of application notes, availability of low cost or free development tools, and serial programming (and re-programming with flash memory) capability [3]. In this project PIC16F84A is used, where the PIC16F84A is an improved version of the PIC16C84, and almost completely compatible, with better program security and using flash memory instead of EEPROM memory for program memory. The PIC16F84A has 68 bytes of RAM feature a wide voltage range, low power consumption, internal timer, and PIC I/O controls.

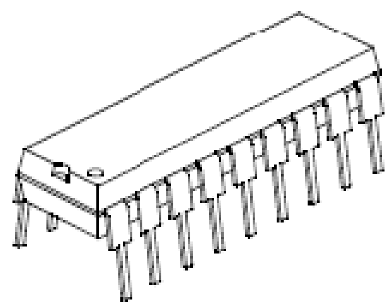


Figure 2.5: PIC16F84A with 18 pin

The F in a name generally indicates the PICmicro uses flash memory and can be erased electronically [3].

There are two memory blocks in the PIC16F84A. These are the program memory and the data memory. Each block has its own bus, so that access to each block can occur during the same oscillator cycle. The data memory can further be broken down into the general purpose RAM and the Special Function Registers (SFRs). The operations of the SFRs that control the “core” are described here. The SFRs used to control the peripheral modules are described in the section discussing each individual peripheral module. The data memory area also contains the data EEPROM memory. This memory is not directly mapped into the data memory, but is indirectly mapped. That is, an indirect address pointer specifies the address of the data EEPROM memory to read/write. The 64 bytes of data EEPROM memory have the address range 0h-3Fh (Figure 2.6).

The input and output ports are used for the PIC to do the operation which cooperates with the circuits outside. The PIC16F84A has the 13 input/output pins. Those are classified into five sets and eight sets and five sets are called A port and eight sets are called B port. The A port corresponds to the PORTA register and the B port corresponds to the PORTB register. Each register is composed of 8 bits and the input/output pin correspond every bit. As for PORTA, 5 bits from bit 0 to bit 4 are used. As for PORTB, all of the 8 bits correspond to the input/output pins respectively. The mode (the input or the output) of each pin is specified by the TRISA register (for PORTA) and the TRISB register (for PORTB). The setting "0" of TRISA or TRISB means for the output and "1" means for the input (Figure 2.7). This mode setting can be set every pin. The control of the A port and the B port is done with the PORTA register and the PORTB register. However, the actual output is done only by the pin which was set for the output and doesn't have an influence on the pin which was set for the input. The A port and the B port rather differently in the circuit and the function. Also, in the A port, the RA4 pin can be used as the clock input of the TMR0. In case of the B port, from RB4 to RB7 have the function to watch over the change of the input signal. Moreover, RB0 has an external interrupt function. These functions are a convenient function but are not an indispensable function.

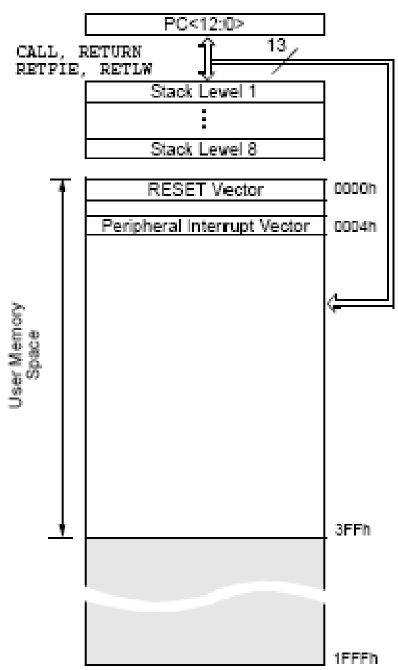


Figure 2.6: Program Memory Map and Stack PIC16F84A

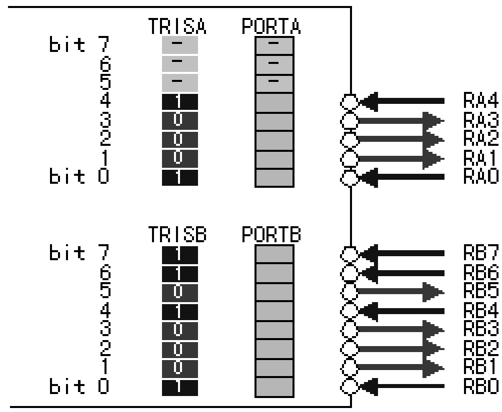


Figure 2.7: Define the port input or output

2.5 16 x 2 Characters LCD

The LCD (Liquid Crystal Display) Figure 2.8 is an electro-optical amplitude modulator realized as a thin, flat display device made up of any number of color or monochrome pixels arrayed in front of a light source or reflector. LCD powered by battery because it uses very small amounts of electric power. The LCD contains each row or column of the display has a single electrical circuit. The pixels are addressed one at a time by row and column addresses. This type of display is called *passive-matrix addressed* because the pixel must retain its state between refreshes without the benefit of a steady electrical charge [4].

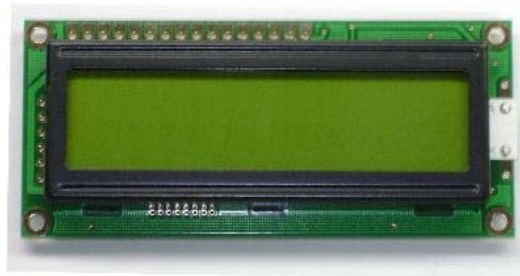


Figure 2.8: LCD 16 X 2 Characters

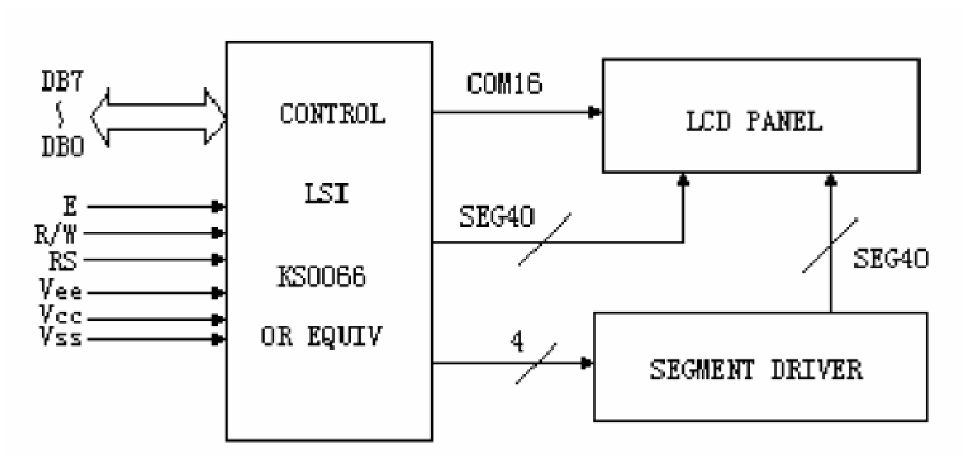


Figure 2.9: LCD Block Diagram

CHAPTER 3

METHODOLOGY

3.1 Introduction

This methodology chapter contains all aspect and method that been used to produce this project from the beginning to the end. The topic in this chapter is included flowchart of the project, the ways to build the model of the rain gauge, the circuit connection from microcontroller to the LCD, and the data collection method.

3.2 Project Research

To produce a good report, the researcher has to make a few systematic and successful steps (Figure 3.1). After the researcher gets title from the supervisor, the first step is to understand the characteristic of the project based on the basic knowledge. Collecting important data from the recognize source for the project is give a lot of idea and explanation about the project. Lot of the source is come from the internet, some book, journal, and also the last year thesis. To finding the references there is three different parts divided. The first part is about hardware implementation, the second part is software and lastly the rain gauge modeling.

The literature review is done from the data and the references. From the literature review, researcher finding more new knowledge and understand in detail about the project. By doing the literature review actually helping to limit the scope of the project, find a new way to solve the problem while working on the project, and to make sure the objective and the aim of the project is achieved.

After literature review process complete, researcher start to build the hardware, software and the model. The hardware involving power supply circuit, microcontroller circuit, LCD connection and Reed Switch sensor circuit. BASIC language implement in the microcontroller by using Microcode Studio. Using BASIC language give a lot of idea and it is easy to understand. Lot of the reference can get from the internet because the microcontroller is used by many people around the world. The model is build based on the standard measurement and the main part of the component is build using plastic.

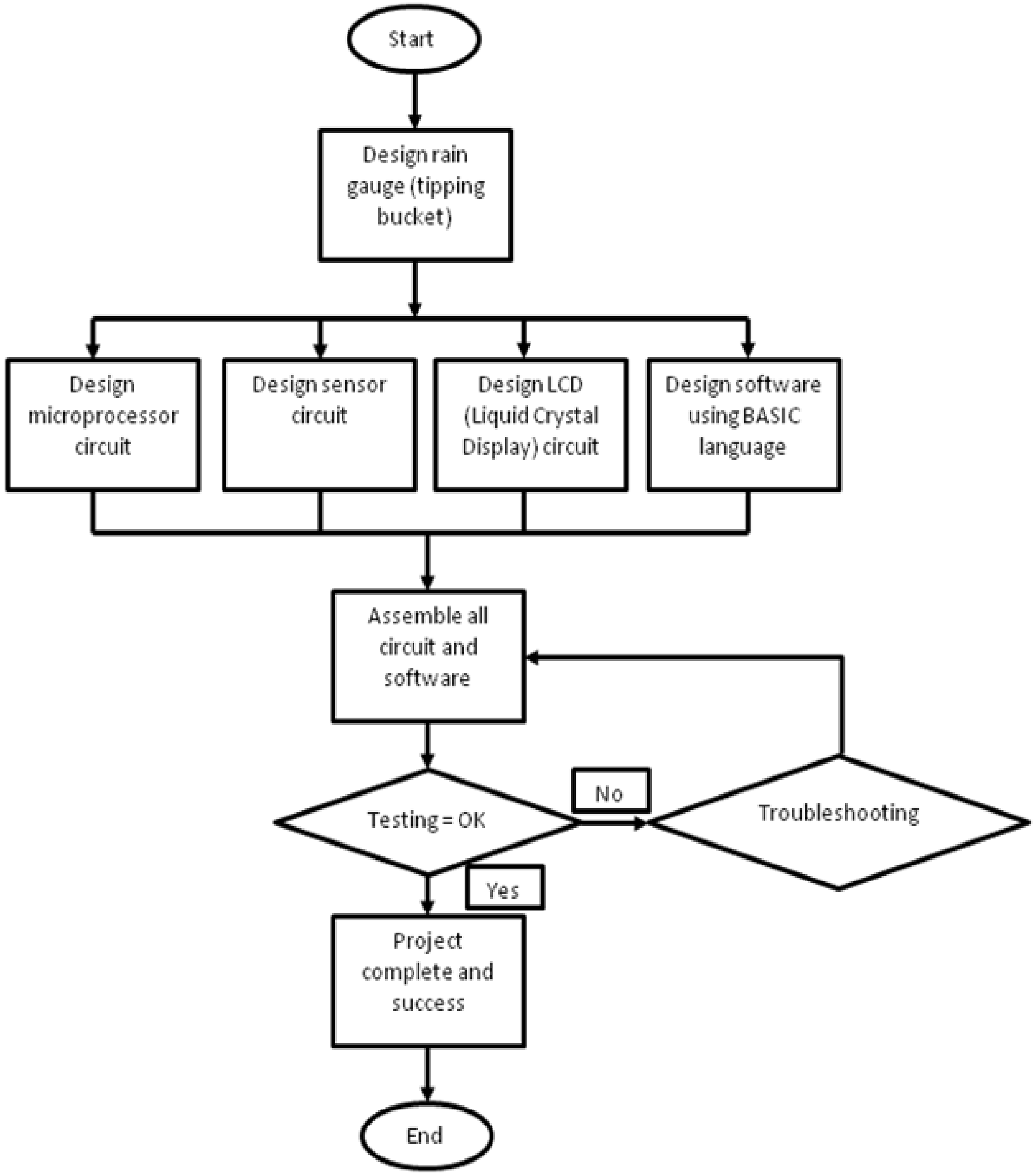
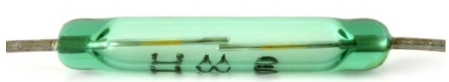


Figure 3.1: Project flowchart

3.3 Hardware Implementation

3.3.1 Reed Switch Sensor

Reed switch is design to operate when applied to magnetic field. The main part in the reed switch is two contactor and tube to protect the contactor. The contact is normally open and if it sense of magnetic field the contactor will close. The contact is made from ferrous metal reeds where it is sensitive with magnetic field. The connection between the sensor and the microcontroller is so simple, from the supply to either leg of the reed switch sensor and then into microcontroller, to stabilize the reading from the sensor to the microcontroller it needs third connection to the ground.



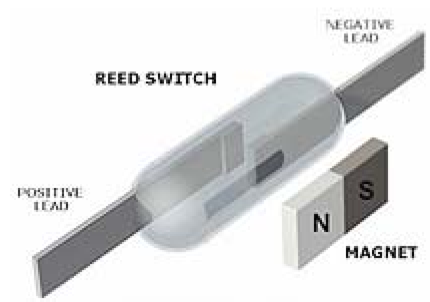


Figure 3.2: Reed Switch Sensor [5]

3.3.2 5 Volt Power Supply

In the circuit, the microcontroller and the LCD is using 5Vdc as supply. So the circuit is power by battery 9Vdc then flow through diode (1N4004) to allow an electric current to pass in one direction and to block the current in the opposite direction. Then the capacitor (100uF) is responsible to filter the voltage before it went through the voltage regulator. The LED indicates the supply is ON and resistor (220Ω) is to limit the current flow into the LED. Then voltage is regulated by Voltage Regulator (LM7805) to produce 5Vdc. After being regulated the voltage once more filtered by capacitor (100nF) to make sure the voltage ripple is lowest value possible.

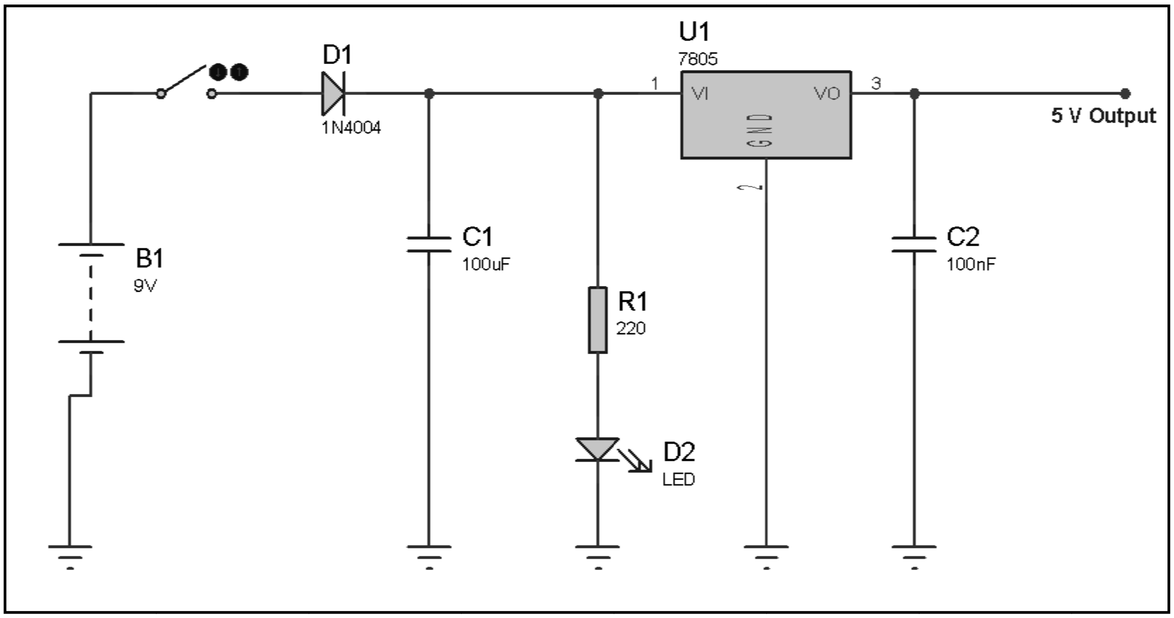


Figure 3.3: Power supply 5Vdc

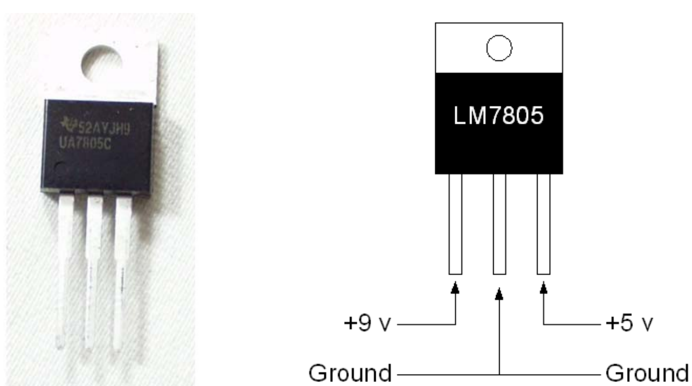


Figure 3.4: Voltage regulator LM7805 and leg descriptions

3.3.3 PIC 16F84A Microcontroller

The microcontroller PIC16F84A is like the heart of this circuit implementation in this project. The microcontroller is the device to process data from all the input and process the data so it can display as the output. The Figure 3.4 showed the circuit design in this project where the basic connection between reset switch to the supply, connection of the crystal is part of the microcontroller. This PIC16F84A doesn't have many special parts and function because this microcontroller is design to be simple, small and easy to use.

The connection from supply is go to pin 14 known as V_{DD} and ground connected to pin 5 known V_{SS} (not shown in the figure). The Master Clear or reset button is connected to the 5Vdc and then to the ground. The diode (1N4004) and resistance used to stabilize the current from the supply. The crystal is used to provide stable clock signal for the microcontroller and it is connected to pin 15 and 16 at the PIC16F84A. The crystal then connected to the ground point and before that it is paralleled with capacitor. From the figure the other connection is involving the other part of instrument.

First the connection is from the sensor where the connection happens at pin number 7 PORT B1. The PORT B1 is been assign as the input where it will be explain in the software implementation part.

Second, the connections of the LCD take almost all the pin of the microcontroller. All the PORT A is assign as the output because all five pin of PORT A is been used for the LCD. The connection for the LCD part is a bit mess but the connection doesn't matter if the port is defined in the programming.

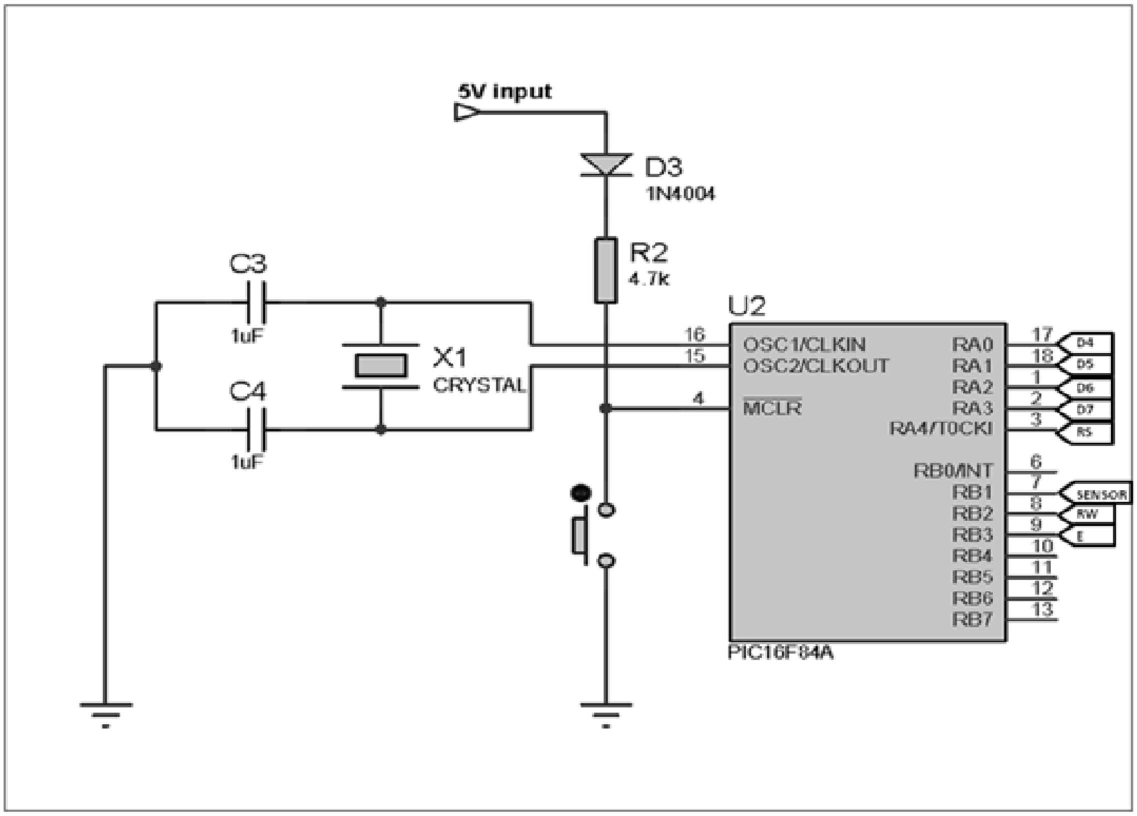


Figure 3.5: Microcontroller PIC16F84A circuit

The function and detail for each leg is shown in Table 3.1. There is some special function in this microcontroller is not used in this project but this is the list of the features in the PIC16F84A:

1. External interrupt
2. Change on PORTB interrupt
3. Timer0 clock input

Table 3.1: Connection of each pin microcontroller PIC16F84A

Pin Number	Pin Name	Descriptions	Circuit Implementations
15 and 16	OSC1 and OSC2	Connected at the crystal	Using 4Mhz crystal and parallel with capacitor
4	MCRL	Master Reset for the programming	The pin is in active low, only operate when no supply
17, 18, 1, 2 and 3	RA0, RA1, RA2, RA3 and RA4/TOCK1	Port A can be input or output	The LCD connection used all these port
6,7, 8…& 13	RB0/INT, RB1, RB2…& RB7	Port B can assign to be input or output	Only 3 pin is used, some pin is define as input and other as output
5	V_{SS}	Ground	Ground reference (0V)
14	VDD	Supply	+5Vdc (positive supply)

3.3.4 LCD 16x2 Character

The last part of the hardware implementation is the display for the output. To show the result LCD is used. The LCD like the main part of the project because of the title is digital rain gauge, so with the display result of the output seems more appropriate and compatible. The LCD connection in the circuit is fixed. There no need to design the circuit but have to be compatible with the microcontroller.

The LCD support 4 bit and 8 bit data input. For this project, the LCD use 4 bit data input because the microcontroller have a little number of pin so, to reduce the usage of the pin, LCD only use 4 pin instead of 8 pin. The data is transmitted using port A from RA0 to RA3. The RS pin at the LCD connected to the RA4 where RS pin is used for register. The R/W pin connect to the RB2 but the pin was set to low in the programming because it not used. The E pin is enable the LCD and connected to the microcontroller at pin RB3.

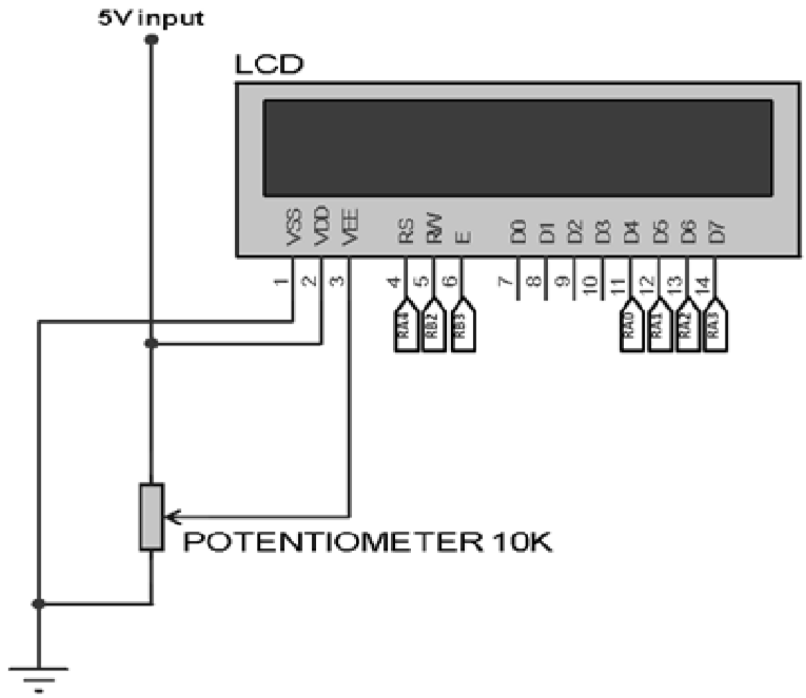


Figure 3.6: LCD connection

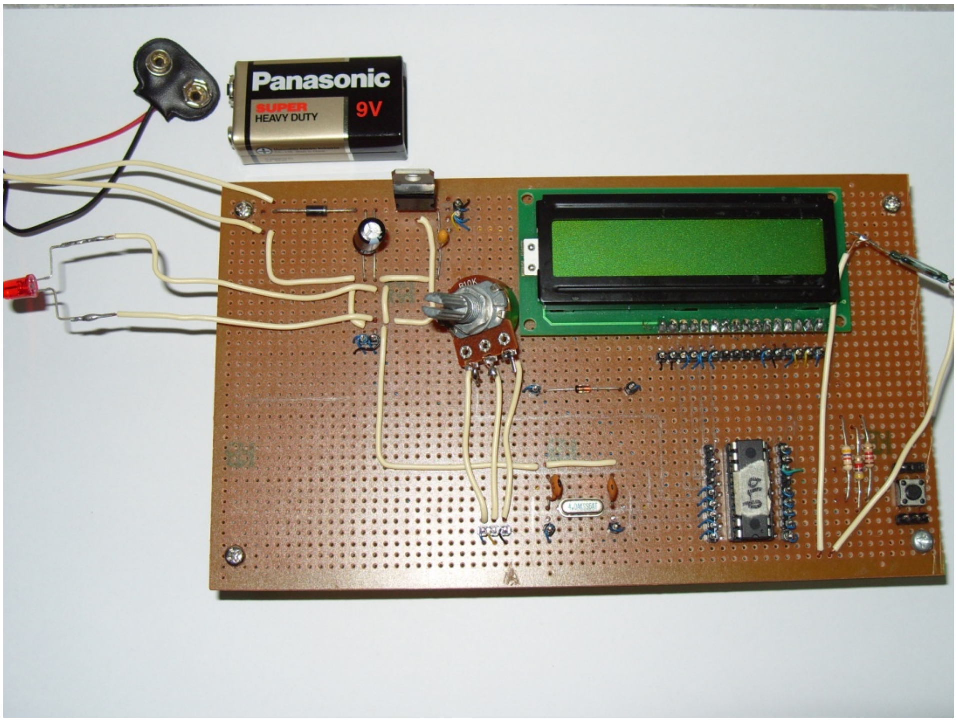


Figure 3.7: The circuits consist of PIC16F84A, Reed Switch Sensor, LCD and supply

3.4 Software Implementation

In this sub chapter, the software implementation, explain about the programming that used in the microcontroller PIC16F84A. To write the program, the MicroCode Studio Software is used where the program is written in BASIC language. A lot of reference and example to write the program using BASIC language so, it give advantage to understand more about the programming and the software.

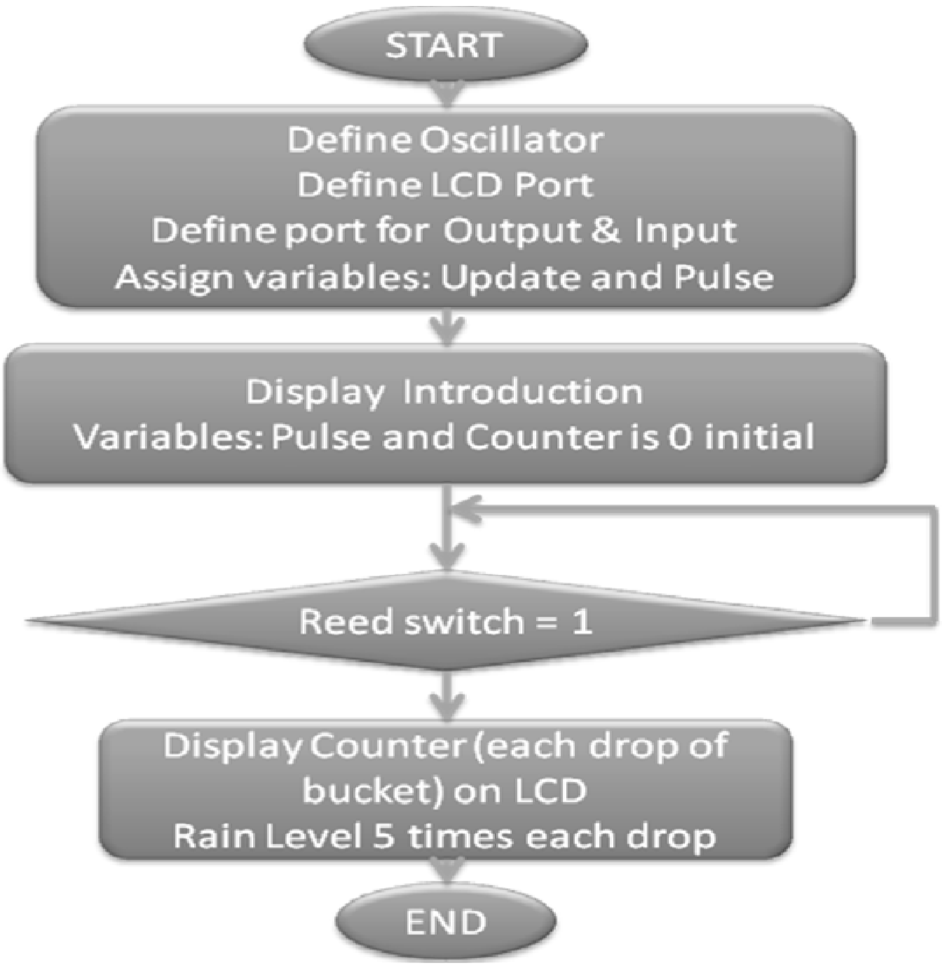


Figure 3.8: Flowchart of the program

The main idea for the programming is shown in Figure 3.8. It involved defining the oscillator value, LCD port, input, output and each other. The programming is simple because only use loop and display the result at the LCD. From the beginning the microcontroller will not interact with outside world like input or output if it don't know what is the connection has been made to it pin. The DEFINE in program tell the PIC16F84A the port involve and the function that will be used.

First define the value of the crystal to tell the microcontroller the real timing to the real world. In this case the crystal is 4MHz. Even in the programming don't define the value of the crystal it have default value that is also 4MHz.

Second is defining the LCD port. The connection between the LCD and the microcontroller is assign with proper pin. So in the programming the same things happen where the pins need to be assign or in other word define. The list defines in the table below:

Table 3.2: The Programming define for LCD port

LCD Register	**Define Program**
Data port	LCD DATA port starting at RA bit 0 to 3
Register port	LCD REGISTER port at RA at bit 4
Bus size	LCD BITS port RB at bit 3
Enable port	LCD ENABLE port at RB at bit 3
Read/write port	LCD READ/WRITE port at RB at bit 2
Number of lines	LCD LINES have 2 lines

Port RB2 as assign in the program to be read/write port will be put to LOW condition because it is not use. So it is the same if this port connects to the ground.

The sensor port or the inputs of the microcontroller also need to be defined. Reed switch sensor is connected to the pin RB1, meaning the port is input receiver and need to be assign as one. The explanation in chapter before (Chapter 2: Theory and Literature Reviews) show the input must be assign with "1" and output "0".

In the program we use some variables to be refers as the equation or statement. The variable in PIC16F84A is assign maximum data 14-bit wide instruction words and 8-bit wide data bytes. Some of the variable is using byte and some other using word for larger data range. Back to the programming in the PIC16F84A for the project, there are 2 variables, PULSE using bytes data and LEVEL using words data.

```
'*******************************************************************
DEFINE OSC 4        'Using 4MHz crystal

DEFINE  LCD_DREG        PORTA   'LCD data port
DEFINE  LCD_DBIT        0       'LCD data starting bit 0
DEFINE  LCD_RSREG       PORTA   'LCD register select port
DEFINE  LCD_RSBIT       4       'LCD register select bit
DEFINE  LCD_EREG        PORTB   'LCD enable port
DEFINE  LCD_EBIT        3       'LCD enable bit
DEFINE  LCD_RWREG       PORTB   'LCD read/write port
DEFINE  LCD_RWBIT       2       'LCD read/write bit
DEFINE  LCD_BITS        4       'LCD bus size 8
DEFINE  LCD_LINES       2       'Number lines on LCD
DEFINE  LCD_COMMANDUS   2000    'Command delay time in us
DEFINE  LCD_DATAUS      50      'Data delay time in us

TRISA = %00000000   'Set PORTA to all input
```

Figure 3.9: Crystal value and LCD define port

3.4.1 Register Configuration

As been discussing earlier, in this chapter the register part is where the input and output of the microcontroller been assign to. The connection need to be configured and define. A TRIS register controls the flow on a port, weather it is input or output. Setting the TRIS bit to “1” make the corresponding port pin an input and setting the TRIS bit “0” make the corresponding port pin an output.

```
DEFINE  LCD_DATAUS      50      'Data delay time in us

TRISA = %00000000   'Set PORTA to all input
TRISB = %00000010   'Set port B as output except bit.1

PULSE   VAR BYTE    'Pulse count
```

Figure 3.10: Register the port

3.4.2 Introduction Program

Introduction program is initial display on the LCD. The introduction is more about the project name and other necessary information. At first, the LCD is been pause 100 to hold about 1 microsecond (the calculation for the timing instruction is $\frac{1}{\frac{1MHZ}{4}} = 1 microsecond$) [8]. Then the first intro massage shown in the LCD. After all the introduction massage is done, the programs enter the looping part.

```
INTRO:  PAUSE    100                          'Wait until the LCD initializes
        LCDOUT   $FE, 1                        'Clear LCD screen
        LCDOUT   $FE,$80,"    Digital  " '1st line-display title
        LCDOUT   $FE,$C0,"   Rain Gauge" '2nd line-display version
        PAUSE    1500
        LCDOUT   $FE, 1                        'Clear LCD screen
        LCDOUT   $FE,$C0,"      V 1.00"        '2nd line-display version
        PAUSE    1500
        LCDOUT   $FE,$C0,"    PSM 2008"        '2nd line-display title
        PAUSE    1000
        LCDOUT   $FE,$C0,"      U M P   "      '2nd line-display UMP
        PAUSE    1000
        LCDOUT   $FE, 1                        'Clear LCD screen
```

Figure 3.11: The spacing before the intro will shown in LCD as blank

3.4.3 Loop Program

In this part, the programming will do looping. The part to do the looping is mark with LOOP. The programs start to do looping when it reaches part GOTO LOOP, the program doo the looping because there is a part to update. Every time variable PULSE is receive signal "1" from the sensor the reading in the LCD will be update for each part that is necessary. If no (the value is "0") there will be no update on the LCD then the program looping forever until the program is restart or off the supply it will stop.

```
PULSE = 0
LEVEL = 0

LOOP:
IF PORTB.1 = 1 THEN
    PULSE = PULSE + 1

ENDIF

IF PORTB.1 = 0 THEN
    PULSE = PULSE
ENDIF

display:
LEVEL = (PULSE+ PULSE+ PULSE+ PULSE+ PULSE)

LCDOUT $FE,1
LCDOUT $FE,$80,"Counter=", DEC PULSE ,"Drop" 'Display Rain Level value on 1st line

LCDOUT $FE,$c0,"Rain Lvl=", DEC LEVEL ,"mL"
PAUSE 100

GOTO LOOP

END
```

Figure 3.12: Before looping the variables need to be define as "0" for initial value

3.5 Rain Gauge model implementation

The model was build from the tipping bucket rain gauge design and standard rain gauge design. The combination of digital rain gauge model from the two rain gauges is to ensure the model is build with proper measurement according with the standard and to make sure the model have good accuracy measurement and able to be used for real usage.

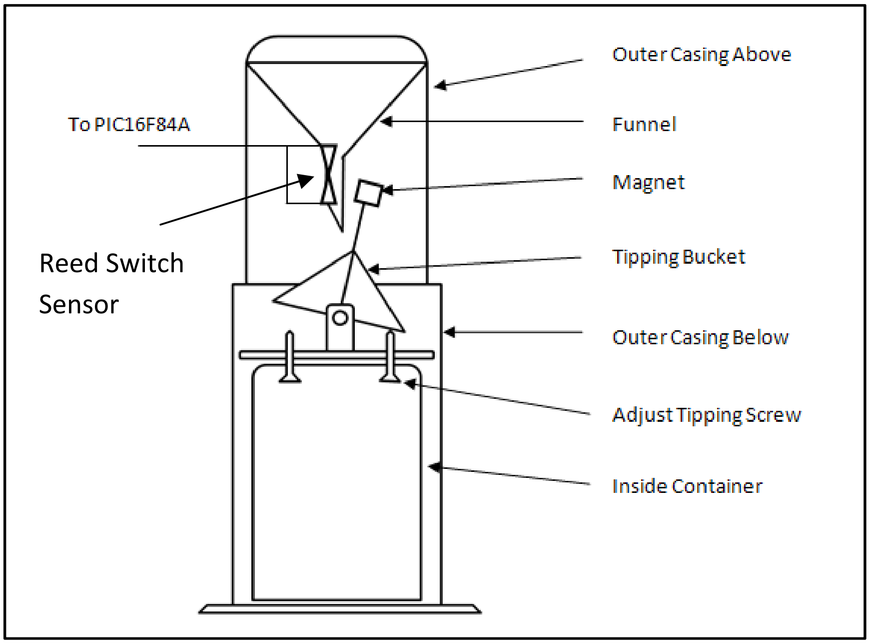


Figure 3.13: Digital Rain Gauge Model

Referring the Figure 3.12 above, the digital rain gauge consist many part. The main part of the digital rain gauge can be divided into two sections, the container (casing) and the tipping bucket.

The outer casing was build to protect the inner part of the rain gauge. The tipping bucket can't be disturbed by any disturbance from out of the casing such as wind. The outer case is built by plastic (and also a lot of part was build using plastics) with double layer of plastic to make sure the model can endure any kind of disturbance. But the outer casing below is using bright color hard paper and then covered with plastic both side to make sure the precipitation that have been collected not evaporate easily. The inside container just a container use to collect the precipitations fall from the tipping bucket.

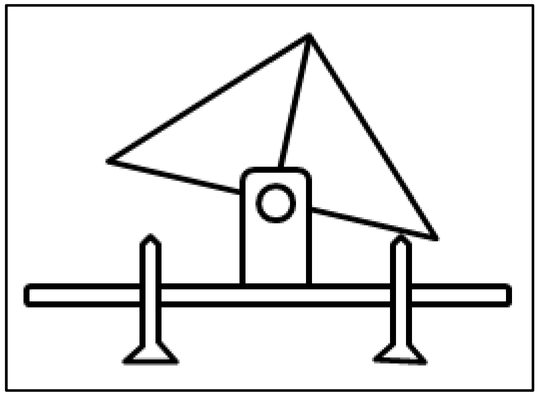


Figure 3.14: The tipping bucket

The tipping bucket also was build using plastic and some other substance such as stick and screws. The stick was use to hold up the magnet, so that it can contact with the reed switch place at the funnel. The screws was use to adjust the level of the tip will fall after certain amount of precipitations full the bucket.

The model was built using plastic, tape, stick and wire. The actual model shown in figure below is built based on the actual standard rain gauge.

Figure 3.15: The real model of Digital Rain Gauge

Figure 3.16: The model built consist inner container, outer casing above and below, funnel, and tipping bucket.

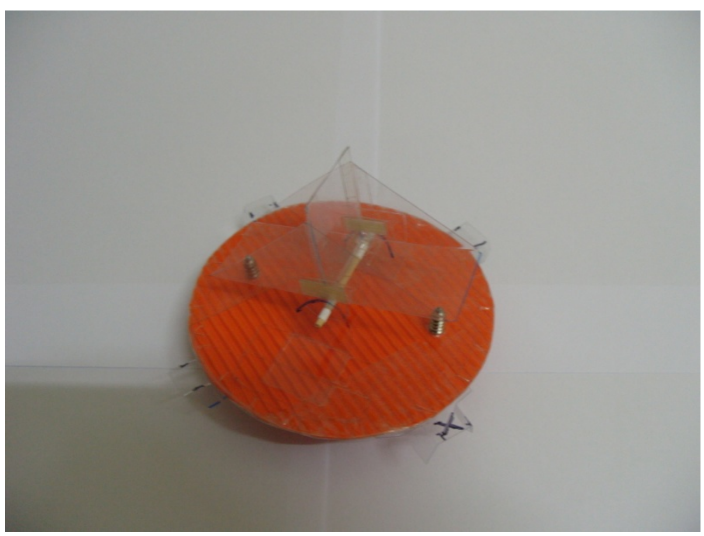


Figure 3.17: The tipping bucket

CHAPTER 4

RESULT AND ANALYSIS

4.1 Introduction

The Digital Rain Gauge successfully finished and achieved all the scope perfectly. The level of the precipitation in the case is been measured by using tipping bucket and display using LCD on time. In order to ensure every tips o the precipitation is true some of the test have been conducted.

4.2 Calibration Method 1

To measure the water level of each tip drop there is several methods has been used. First, to make sure every tip drop contain 5mL, the bucket is filled with water using ink injection that has measurement level. The every 5mL water injected into the bucket it should tip. To confirm it accuracy the process was repeated with 3 different measurements and each measurement it is repeated 5 times.

Table 4.1: 5mL precipitation level

Amount Injected (mL):	**Measured (mL):**
5	5
6	5
5	5
5	5
6	5

Table 4.2: 10mL precipitation level

Amount Injected (mL):	**Measured (mL):**
12	10
11	10
10	10
10	10
11	10

Table 4.3: 15mL precipitation level

Amount Injected (mL):	**Measured (mL):**
17	15
16	15
16	15
16	15
15	15

Then the measurement of every measurement is plotted into the graph:

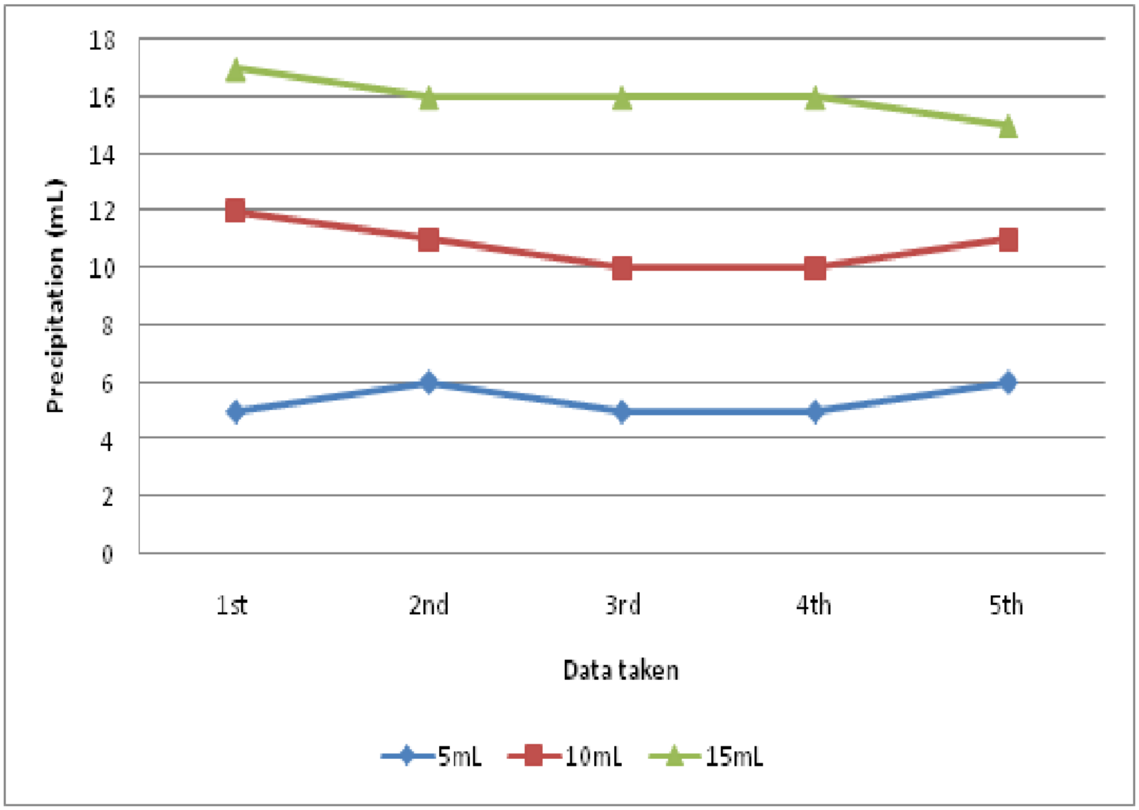


Figure 4.1: Combination of calibration method 1

From the graph, the first calibration method shows the different reading from the actual and the injected precipitation. The slight different show the bucket actually have good measurement and accurate but not too perfect. For each tip drop is measure 5mL but the tipping bucket may have some slightest error such as the bucket is have glutinous surface. To solve the problem the surface of the bucket are wiped with candle to make sure every times it drop all the water is fall and not remain in the bucket.

4.3 Calibration Method 2

In the second calibration method, the measurement to find if the bucket is accurate every tip drop or not have the same principle such as first calibration method. The different is the amount of the precipitation is raised to certain value.

Table 4.4: 240mL amount of precipitation

Amount Pour (mL):	**Measured (mL):**
240	235
240	220
240	230
240	235
240	240

Table 4.5: 500mL amount of precipitation

Amount Pour (mL):	**Measured (mL):**
500	450
500	455
500	465
500	475
500	470

From the table it is change to graph:

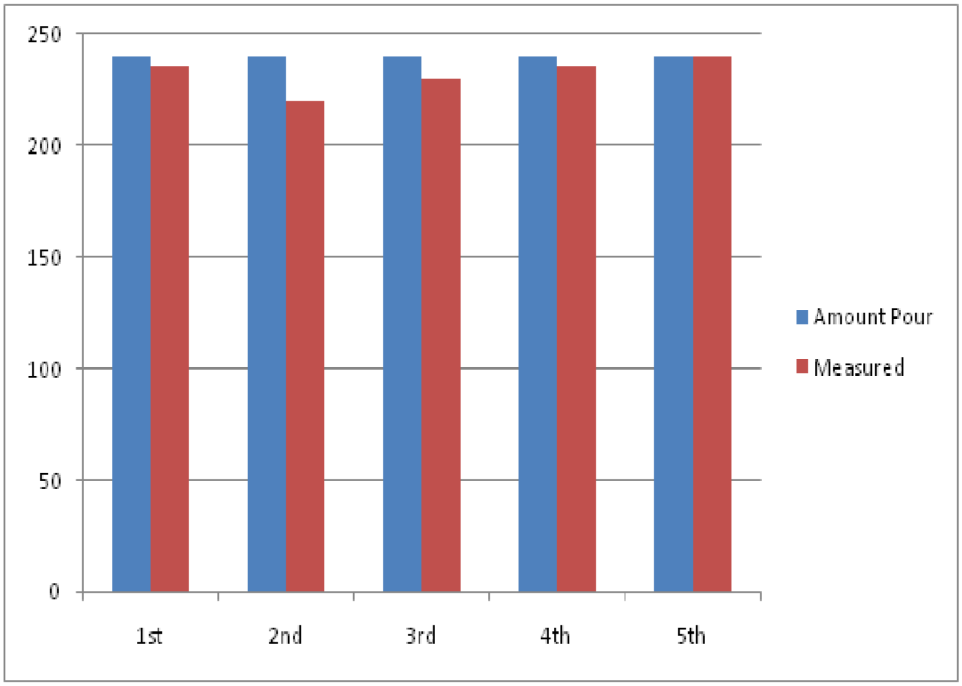


Figure 4.2: The amount of precipitation poured and measured Table 4.4

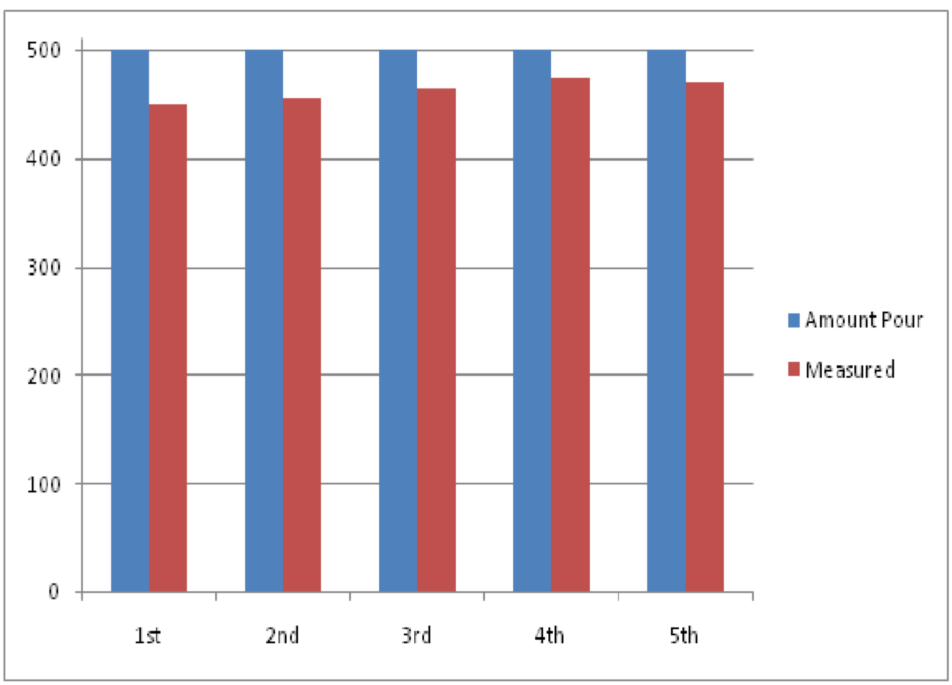


Figure 4.3: The amount of precipitation poured and measured Table 4.5

The different from measured and the poured water due to error and also the disturbance while doing the calibration. Some of the error has been mention in the earlier part of this project such as the ground is not level, wind disturbance and many more. The tipping bucket rain gauge is actually little sensitive equipment, so it must build to overcome the problem. The future recommendation will be discuss in the next chapter.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

Every part of the project, the design, the method, the calibration, the idea and everything involved have to come to the conclusion. The project was successfully developed and the model was build with proper method. The project is about build the rain gauge that has display too easy for the weather man to take reading and record it. By using microcontroller PIC16F84A from Microchip and the LCD 16x2 character the digital rain gauge was built. The Reed Switch Sensor is also the main part to contribute an accurate and reliable rain gauge.

Now days, the rain gauge is more complex and function. The special part of each new model now days are to overcome the problem happened to the oldest rain gauge. The type and sizes of the rain gauge has so many to fill the desire of the hobbyists around the world. The weather forecast has to make sure every equipment to measure the environment is in top condition because sometimes it can save human life.

For the conclusion, the digital rain gauge work well. The combination of the microcontroller and reed switch sensor shown perfectly in the LCD.

5.2 Problems

The beginnings of the project there are some problems occur. The microcontroller use in the project initially was PIC16F877A because this microcontroller has many special parts and also has many pin. The design of the circuit in the reference show many examples for this microcontroller. But there is no specific connection of the circuit to combine with the reed switch. The PIC16F877A has so many pin yet it is not use, so it such a waste. To solve the problem PIC16F84A was used instead PIC16F877A because the pin has smaller scale eventually reduce the size of the microcontroller. So the basic connection and programming was figured by doing some experiment and comparison because of lack reference. Even PIC16F84A has lack of special function and leg but the pin is more than enough even the programming is easy to understand.

The most critical part is building the tipping bucket. The tipping bucket needs to be balance and have precise to every drop. So to solve the problem, screw is place under each bucket. The screw was use to adjust the level of every tip precipitation, to be precise calibration method is conducted. Until every drop is approximately 5mL the screw was adjusted up and down. The failure to get every tip drop 5mL can cause the whole reading is not accurate.

5.3 Future Recommendation

Overall of the project, the digital rain gauge can be considered as useful and good. However the demand from the people and rough environment, the rain gauge must be built with high level of accuracy, contain proper additional function and many more.

The future recommendation to developing of the new model must be taking into consideration:

a. Model of the rain gauge was built from better material for precise measurement and robust

For better instrument in the weather station the rain gauge must be robust so less maintenance. The model must be built using proper material such as copper case anti corrosion or hard plastic. The design of the tipping bucket must be done carefully and precisely, so that every drop can be measure until 0.01mL (the smaller the better).

b. Record data automatically each hour of the rain fall.

This project is the experiment and has lot parts that still need to do improvement. The program need to be improved by making each hour of the rain fall the data was recorded automatically. So after each hour of raining day the weather man from weather station doesn’t need to bother taking reading repeatedly. Even there is raining non-stop for 2 days if the data recorded weather station just take the reading after the rain fall stop.

c. Transmitted data wireless

Nowadays, everything is wireless because it is easy. The data from the rain gauge transmit to the controller inside the weather station without using wire. This method more convenience because there no need to do wiring maintenance. The data send from the rain gauge so, there will be other circuit need to be install in the rain gauge for transmitting and also controller for receiving. So the costing is about to increase but in the long run it is more reliable.

d. Structure to support the model

Rain gauge model was built only to measure the rain fall but the design must be good because some disturbance can make the rain gauge not precise. The structure to support the model need to be built in order the model to stay put. Mostly the model is place above the house or high structure (not to high) so it can't be disturb by any disoperation such as vibration from the earth or wind blowing that can moved the rain gauge. So the support structure is so important to make sure the rain gauge is stay on it position for the whole time when raining.

e. Add more feature such as temperature sensing or raining detector

More features put in one device means more advantages. The rain gauge can be more complex if more option is use. The new feature such as temperature sensing can give reading of the temperature environment before rain, while raining and after rainfall stop. The more data can be collected the more chance finding some pattern to be discovered. If rain detector sensing device is place it also gives advantage to the weather station because before it is raining weather man can prepare or alert when the rain will fall.

5.4 Costing and Commercialization

The cost needed to develop the digital rain gauge is in Table 5.1:

Table 5.1: Project estimation cost

Bil	Component and Stuff	Estimated price per unit	Quantity	Estimate Price
1	PCB board	RM 5.00	1	RM 5.00
2	Wire connector	RM 2.00	1	RM 2.00
3	Capacitor	RM 1.00	1	RM 1.00
8	Diode IN4007	RM 1.00	1	RM 4.00
9	Voltage regulator	RM 4.00	1	RM 4.00
10	Resistor 4.7kΩ	RM 0.50	1	RM 0.50
11	Resistor 10kΩ	RM 0.50	1	RM 0.50
12	Resistor 1kΩ	RM 0.50	1	RM 0.50
13	Header	RM 1.00	4	RM 4.00
14	Heat sink	RM 1.50	1	RM 1.50
15	IC base	RM 1.00	2	RM 2.00
16	PIC-16F84	RM 30.00	1	RM 30.00
17	Switch	RM 2.00	2	RM 4.00
18	LCD	RM 26.00	1	RM 26.00
19	LED	RM 0.50	1	RM 0.50
20	Potentiometer	RM 1.20	1	RM 1.20
21	Ceramic Resonator	RM 2.00	1	RM 2.00
22	Plastic casing	RM 2.50	3	RM 7.50
23	Others	RM10.00	1	RM 10.00
Total				**RM 106.20**

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APPENDIX A

PIC Programming for the Digital Rain Gauge:

```
'*************************************************************
'*  Name    : Digital Rain Gauge                             *
'*  Author  : Mohd Firdhaus Bin Samah                        *
'*  Notice  : Copyright (c) 2008                             *
'*          : All Rights Reserved                            *
'*  Date    : 10/8/2008                                      *
'*  Version : 1.0                                            *
'*                                                           *
'*                                                           *
'*************************************************************
define OSC 4     'Using 4MHz crystal

DEFINE  LCD_DREG       PORTA   'LCD data port
DEFINE  LCD_DBIT       0       'LCD data starting bit 0

DEFINE  LCD_RSREG      PORTA   'LCD register select port
DEFINE  LCD_RSBIT      4       'LCD register select bit

DEFINE  LCD_EREG       PORTB   'LCD enable port
DEFINE  LCD_EBIT       3       'LCD enable bit

DEFINE  LCD_RWREG      PORTB   'LCD read/write port
DEFINE  LCD_RWBIT      2       'LCD read/write bit

DEFINE  LCD_BITS       4       'LCD bus size 8

DEFINE  LCD_LINES      2       'Number lines on LCD

DEFINE  LCD_COMMANDUS   2000    'Command delay time in us

DEFINE  LCD_DATAUS     50      'Data delay time in us

TRISA = %00000000 'Set PORTA to all input
TRISB = %00000010   'Set port B as output except bit.1

PULSE   var byte    'Pulse count
counter var byte
pulse2  var word

INTRO:  pause   100                 'Wait until the LCD initializes
        Lcdout  $FE, 1              'Clear LCD screen
        LCDOUT  $FE,$80,"    Digital " '1st line-display title
        LCDOUT  $FE,$C0,"   Rain Gauge" '2nd line-display version
```

```
        pause   1500
        Lcdout  $FE, 1                  'Clear LCD screen
        LCDOUT  $FE,$C0,"     V 1.00"      '2nd line-display version
        pause   1500
        LCDOUT  $FE,$C0,"    PSM 2008"     '2nd line-display title
        pause   1000
        LCDOUT  $FE,$C0,"     U M P  "     '2nd line-display UMP
        pause   1000
        Lcdout  $FE, 1                  'Clear LCD screen

pulse = 0
counter = 0

LOOP:
IF PORTB.1 = 1 THEN
   PULSE = PULSE + 1

ENDIF

IF  PORTB.1 = 0 THEN
   PULSE = PULSE
ENDIF

display:
pulse2 = (pulse + pulse + pulse + pulse + pulse)

LCDOUT $FE,1
LCDOUT $FE,$80,"Counter=",dec pulse,"Drop" 'Display Rain Level value on 1st line

LCDOUT $FE,$c0,"Rain Lvl=",dec pulse2,"mL"
pause 100

GOTO LOOP

End
```

APPENDIX B

Calculation on size of the rain gauge:

The ratio (the funnel cross-sectional area divided by the cylinder cross-sectional area) is

- 10:1

Every 1 inch of rain that falls from the sky, 10 inch is collected in the cylinder

0.01 inches of rain (10 X 0.01 = 0.1 inches that actually collect in the cylinder)

Depth of rainfall = volume of rain water / area of funnel opening

APPENDIX C1

Data sheet PIC16F84A:

MICROCHIP

PIC16F84A

18-pin *Enhanced* FLASH/EEPROM 8-Bit Microcontroller

High Performance RISC CPU Features:

- Only 35 single word instructions to learn
- All instructions single-cycle except for program branches which are two-cycle
- Operating speed: DC - 20 MHz clock input
  DC - 200 ns instruction cycle
- 1024 words of program memory
- 68 bytes of Data RAM
- 64 bytes of Data EEPROM
- 14-bit wide instruction words
- 8-bit wide data bytes
- 15 Special Function Hardware registers
- Eight-level deep hardware stack
- Direct, indirect and relative addressing modes
- Four interrupt sources:
  - External RB0/INT pin
  - TMR0 timer overflow
  - PORTB<7:4> interrupt-on-change
  - Data EEPROM write complete

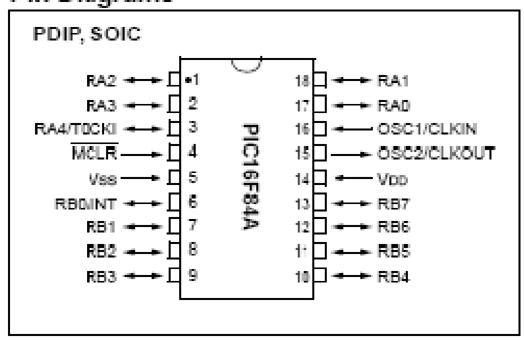
Peripheral Features:

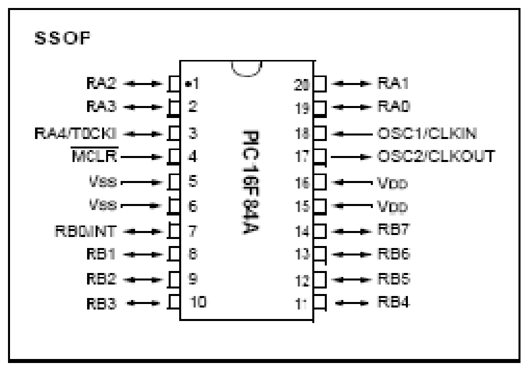
- 13 I/O pins with individual direction control
- High current sink/source for direct LED drive
  - 25 mA sink max. per pin
  - 25 mA source max. per pin
- TMR0: 8-bit timer/counter with 8-bit programmable prescaler

Special Microcontroller Features:

- 10,000 erase/write cycles *Enhanced* FLASH Program memory typical
- 10,000,000 typical erase/write cycles EEPROM Data memory typical
- EEPROM Data Retention > 40 years
- In-Circuit Serial Programming™ (ICSP™) - via two pins
- Power-on Reset (POR), Power-up Timer (PWRT), Oscillator Start-up Timer (OST)
- Watchdog Timer (WDT) with its own On-Chip RC Oscillator for reliable operation
- Code protection
- Power saving SLEEP mode
- Selectable oscillator options

Pin Diagrams





CMOS Enhanced FLASH/EEPROM Technology:

- Low power, high speed technology
- Fully static design
- Wide operating voltage range:
  - Commercial: 2.0V to 5.5V
  - Industrial: 2.0V to 5.5V
- Low power consumption:
  - < 2 mA typical @ 5V, 4 MHz
  - 15 μA typical @ 2V, 32 kHz
  - < 0.5 μA typical standby current @ 2V

1.0 DEVICE OVERVIEW

This document contains device specific information for the operation of the PIC16F84A device. Additional information may be found in the PICmicro™ Mid-Range Reference Manual, (DS33023), which may be downloaded from the Microchip website. The Reference Manual should be considered a complementary document to this data sheet, and is highly recommended reading for a better understanding of the device architecture and operation of the peripheral modules.

The PIC16F84A belongs to the mid-range family of the PICmicro® microcontroller devices. A block diagram of the device is shown in Figure 1-1.

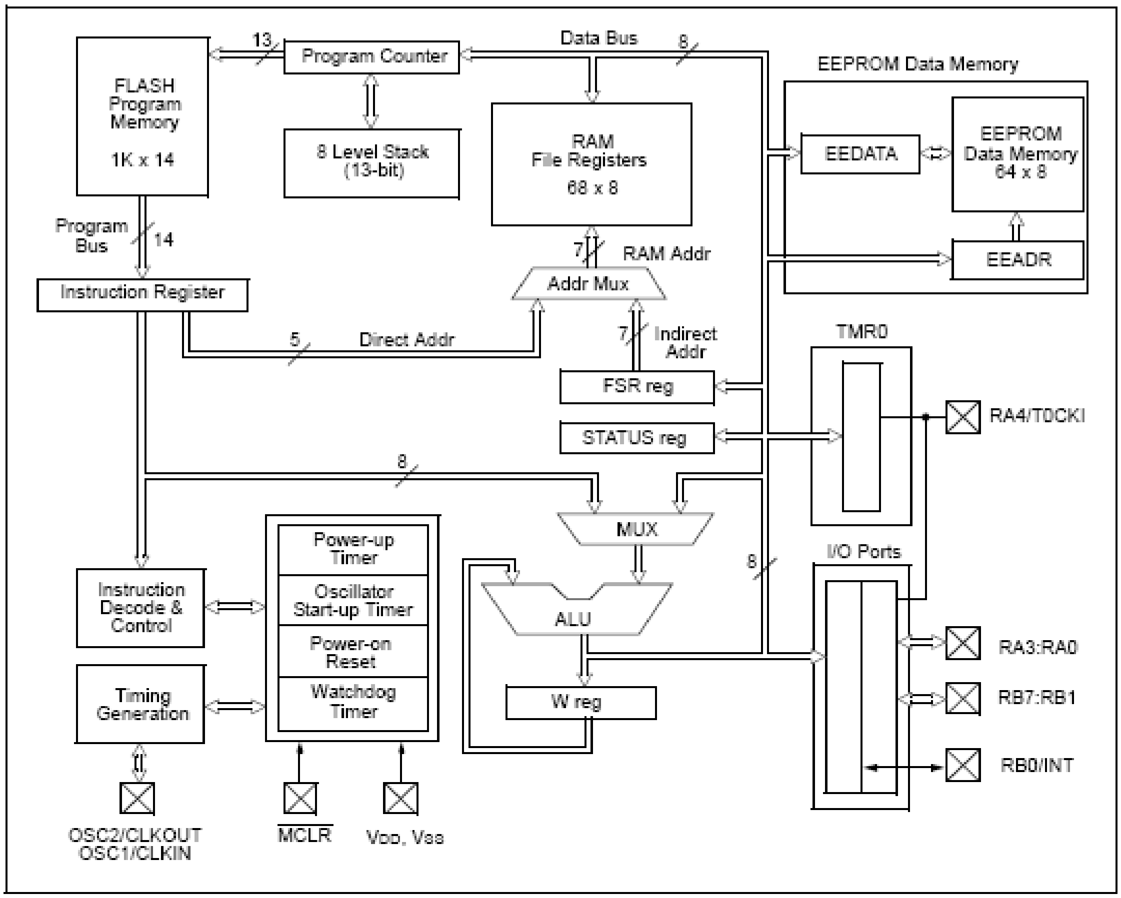
The program memory contains 1K words, which translates to 1024 instructions, since each 14-bit program memory word is the same width as each device instruction. The data memory (RAM) contains 68 bytes. Data EEPROM is 64 bytes.

There are also 13 I/O pins that are user-configured on a pin-to-pin basis. Some pins are multiplexed with other device functions. These functions include:

- External interrupt
- Change on PORTB interrupt
- Timer0 clock input

Table 1-1 details the pinout of the device with descriptions and details for each pin.

FIGURE 1-1: PIC16F84A BLOCK DIAGRAM



PIC16F84A

TABLE 1-1: PIC16F84A PINOUT DESCRIPTION

Pin Name	PDIP No.	SOIC No.	SSOP No.	I/O/P Type	Buffer Type	Description
OSC1/CLKIN	16	16	18	I	ST/CMOS[(3)]	Oscillator crystal input/external clock source input.
OSC2/CLKOUT	15	15	19	O	—	Oscillator crystal output. Connects to crystal or resonator in Crystal Oscillator mode. In RC mode, OSC2 pin outputs CLKOUT, which has 1/4 the frequency of OSC1 and denotes the instruction cycle rate.
$\overline{MCLR}$	4	4	4	I/P	ST	Master Clear (Reset) input/programming voltage input. This pin is an active low RESET to the device.
						PORTA is a bi-directional I/O port.
RA0	17	17	19	I/O	TTL	
RA1	18	18	20	I/O	TTL	
RA2	1	1	1	I/O	TTL	
RA3	2	2	2	I/O	TTL	
RA4/T0CKI	3	3	3	I/O	ST	Can also be selected to be the clock input to the TMR0 timer/counter. Output is open drain type.
						PORTB is a bi-directional I/O port. PORTB can be software programmed for internal weak pull-up on all inputs.
RB0/INT	6	6	7	I/O	TTL/ST[(1)]	RB0/INT can also be selected as an external interrupt pin.
RB1	7	7	8	I/O	TTL	
RB2	8	8	9	I/O	TTL	
RB3	9	9	10	I/O	TTL	
RB4	10	10	11	I/O	TTL	Interrupt-on-change pin.
RB5	11	11	12	I/O	TTL	Interrupt-on-change pin.
RB6	12	12	13	I/O	TTL/ST[(2)]	Interrupt-on-change pin. Serial programming clock.
RB7	13	13	14	I/O	TTL/ST[(2)]	Interrupt-on-change pin. Serial programming data.
V_{SS}	5	5	5,6	P	—	Ground reference for logic and I/O pins.
V_{DD}	14	14	15,16	P	—	Positive supply for logic and I/O pins.

Legend: I= input O = Output I/O = Input/Output P = Power
— = Not used TTL = TTL input ST = Schmitt Trigger input

Note 1: This buffer is a Schmitt Trigger input when configured as the external interrupt.
2: This buffer is a Schmitt Trigger input when used in Serial Programming mode.
3: This buffer is a Schmitt Trigger input when configured in RC oscillator mode and a CMOS input otherwise.

2.0 MEMORY ORGANIZATION

There are two memory blocks in the PIC16F84A. These are the program memory and the data memory. Each block has its own bus, so that access to each block can occur during the same oscillator cycle.

The data memory can further be broken down into the general purpose RAM and the Special Function Registers (SFRs). The operation of the SFRs that control the "core" are described here. The SFRs used to control the peripheral modules are described in the section discussing each individual peripheral module.

The data memory area also contains the data EEPROM memory. This memory is not directly mapped into the data memory, but is indirectly mapped. That is, an indirect address pointer specifies the address of the data EEPROM memory to read/write. The 64 bytes of data EEPROM memory have the address range 0h-3Fh. More details on the EEPROM memory can be found in Section 3.0.

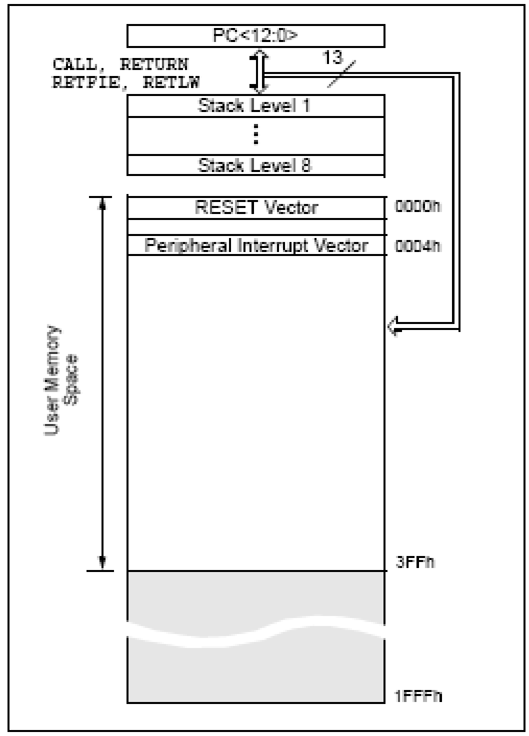
Additional information on device memory may be found in the PICmicro™ Mid-Range Reference Manual, (DS33023).

2.1 Program Memory Organization

The PIC16FXX has a 13-bit program counter capable of addressing an 8K x 14 program memory space. For the PIC16F84A, the first 1K x 14 (0000h-03FFh) are physically implemented (Figure 2-1). Accessing a location above the physically implemented address will cause a wraparound. For example, for locations 20h, 420h, 820h, C20h, 1020h, 1420h, 1820h, and 1C20h, the instruction will be the same.

The RESET vector is at 0000h and the interrupt vector is at 0004h.

FIGURE 2-1: PROGRAM MEMORY MAP AND STACK - PIC16F84A



PIC16F84A

2.2 Data Memory Organization

The data memory is partitioned into two areas. The first is the Special Function Registers (SFR) area, while the second is the General Purpose Registers (GPR) area. The SFRs control the operation of the device.

Portions of data memory are banked. This is for both the SFR area and the GPR area. The GPR area is banked to allow greater than 116 bytes of general purpose RAM. The banked areas of the SFR are for the registers that control the peripheral functions. Banking requires the use of control bits for bank selection. These control bits are located in the STATUS Register. Figure 2-2 shows the data memory map organization.

Instructions `MOVWF` and `MOVF` can move values from the W register to any location in the register file ("F"), and vice-versa.

The entire data memory can be accessed either directly using the absolute address of each register file or indirectly through the File Select Register (FSR) (Section 2.5). Indirect addressing uses the present value of the RP0 bit for access into the banked areas of data memory.

Data memory is partitioned into two banks which contain the general purpose registers and the special function registers. Bank 0 is selected by clearing the RP0 bit (STATUS<5>). Setting the RP0 bit selects Bank 1. Each Bank extends up to 7Fh (128 bytes). The first twelve locations of each Bank are reserved for the Special Function Registers. The remainder are General Purpose Registers, implemented as static RAM.

2.2.1 GENERAL PURPOSE REGISTER FILE

Each General Purpose Register (GPR) is 8-bits wide and is accessed either directly or indirectly through the FSR (Section 2.5).

The GPR addresses in Bank 1 are mapped to addresses in Bank 0. As an example, addressing location 0Ch or 8Ch will access the same GPR.

FIGURE 2-2: REGISTER FILE MAP - PIC16F84A

File Address	Bank 0	Bank 1	File Address
00h	Indirect addr.(1)	Indirect addr.(1)	80h
01h	TMR0	OPTION_REG	81h
02h	PCL	PCL	82h
03h	STATUS	STATUS	83h
04h	FSR	FSR	84h
05h	PORTA	TRISA	85h
06h	PORTB	TRISB	86h
07h	—	—	87h
08h	EEDATA	EECON1	88h
09h	EEADR	EECON2(1)	89h
0Ah	PCLATH	PCLATH	8Ah
0Bh	INTCON	INTCON	8Bh
0Ch – 4Fh	68 General Purpose Registers (SRAM)	Mapped (accesses) in Bank 0	8Ch – CFh
50h – 7Fh			D0h – FFh

☐ Unimplemented data memory location, read as '0'.

Note 1: Not a physical register.

2.3 Special Function Registers

The Special Function Registers (Figure 2-2 and Table 2-1) are used by the CPU and Peripheral functions to control the device operation. These registers are static RAM.

The special function registers can be classified into two sets, core and peripheral. Those associated with the core functions are described in this section. Those related to the operation of the peripheral features are described in the section for that specific feature.

TABLE 2-1: SPECIAL FUNCTION REGISTER FILE SUMMARY

Addr	Name	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	Value on Power-on RESET	Details on page
Bank 0											
00h	INDF	Uses contents of FSR to address Data Memory (not a physical register)								---- ----	11
01h	TMR0	8-bit Real-Time Clock/Counter								xxxx xxxx	20
02h	PCL	Low Order 8 bits of the Program Counter (PC)								0000 0000	11
03h	STATUS(2)	IRP	RP1	RP0	$\overline{TO}$	$\overline{PD}$	Z	DC	C	0001 1xxx	8
04h	FSR	Indirect Data Memory Address Pointer 0								xxxx xxxx	11
05h	PORTA(4)	—	—	—	RA4/T0CKI	RA3	RA2	RA1	RA0	---x xxxx	16
06h	PORTB(5)	RB7	RB6	RB5	RB4	RB3	RB2	RB1	RB0/INT	xxxx xxxx	18
07h	—	Unimplemented location, read as '0'								—	—
08h	EEDATA	EEPROM Data Register								xxxx xxxx	13,14
09h	EEADR	EEPROM Address Register								xxxx xxxx	13,14
0Ah	PCLATH	—	—	—	Write Buffer for upper 5 bits of the PC(1)					---0 0000	11
0Bh	INTCON	GIE	EEIE	T0IE	INTE	RBIE	T0IF	INTF	RBIF	0000 000x	10
Bank 1											
80h	INDF	Uses Contents of FSR to address Data Memory (not a physical register)								---- ----	11
81h	OPTION_REG	RBPU	INTEDG	T0CS	T0SE	PSA	PS2	PS1	PS0	1111 1111	9
82h	PCL	Low order 8 bits of Program Counter (PC)								0000 0000	11
83h	STATUS (2)	IRP	RP1	RP0	$\overline{TO}$	$\overline{PD}$	Z	DC	C	0001 1xxx	8
84h	FSR	Indirect data memory address pointer 0								xxxx xxxx	11
85h	TRISA	—	—	—	PORTA Data Direction Register					---1 1111	16
86h	TRISB	PORTB Data Direction Register								1111 1111	18
87h	—	Unimplemented location, read as '0'								—	—
88h	EECON1	—	—	—	EEIF	WRERR	WREN	WR	RD	---0 x000	13
89h	EECON2	EEPROM Control Register 2 (not a physical register)								---- ----	14
0Ah	PCLATH	—	—	—	Write buffer for upper 5 bits of the PC(1)					---0 0000	11
0Bh	INTCON	GIE	EEIE	T0IE	INTE	RBIE	T0IF	INTF	RBIF	0000 000x	10

Legend: x = unknown, u = unchanged. - = unimplemented, read as '0', q = value depends on condition

Note 1: The upper byte of the program counter is not directly accessible. PCLATH is a slave register for PC<12:8>. The contents of PCLATH can be transferred to the upper byte of the program counter, but the contents of PC<12:8> are never transferred to PCLATH.

2: The $\overline{TO}$ and $\overline{PD}$ status bits in the STATUS register are not affected by a $\overline{MCLR}$ Reset.

3: Other (non power-up) RESETS include: external RESET through $\overline{MCLR}$ and the Watchdog Timer Reset.

4: On any device RESET, these pins are configured as inputs.

5: This is the value that will be in the port output latch.

3.0 DATA EEPROM MEMORY

The EEPROM data memory is readable and writable during normal operation (full VDD range). This memory is not directly mapped in the register file space. Instead it is indirectly addressed through the Special Function Registers. There are four SFRs used to read and write this memory. These registers are:

- EECON1
- EECON2 (not a physically implemented register)
- EEDATA
- EEADR

EEDATA holds the 8-bit data for read/write, and EEADR holds the address of the EEPROM location being accessed. PIC16F84A devices have 64 bytes of data EEPROM with an address range from 0h to 3Fh.

The EEPROM data memory allows byte read and write. A byte write automatically erases the location and writes the new data (erase before write). The EEPROM data memory is rated for high erase/write cycles. The write time is controlled by an on-chip timer. The write-time will vary with voltage and temperature as well as from chip to chip. Please refer to AC specifications for exact limits.

When the device is code protected, the CPU may continue to read and write the data EEPROM memory. The device programmer can no longer access this memory.

Additional information on the Data EEPROM is available in the PICmicro™ Mid-Range Reference Manual (DS33023).

REGISTER 3-1: EECON1 REGISTER (ADDRESS 88h)

U-0	U-0	U-0	R/W-0	R/W-x	R/W-0	R/S-0	R/S-0
—	—	—	EEIF	WRERR	WREN	WR	RD
bit 7							bit 0

bit 7-5 **Unimplemented:** Read as '0'

bit 4 **EEIF:** EEPROM Write Operation Interrupt Flag bit
1 = The write operation completed (must be cleared in software)
0 = The write operation is not complete or has not been started

bit 3 **WRERR:** EEPROM Error Flag bit
1 = A write operation is prematurely terminated (any $\overline{MCLR}$ Reset or any WDT Reset during normal operation)
0 = The write operation completed

bit 2 **WREN:** EEPROM Write Enable bit
1 = Allows write cycles
0 = Inhibits write to the EEPROM

bit 1 **WR:** Write Control bit
1 = Initiates a write cycle. The bit is cleared by hardware once write is complete. The WR bit can only be set (not cleared) in software.
0 = Write cycle to the EEPROM is complete

bit 0 **RD:** Read Control bit
1 = Initiates an EEPROM read RD is cleared in hardware. The RD bit can only be set (not cleared) in software.
0 = Does not initiate an EEPROM read

Legend:			
R = Readable bit	W = Writable bit	U = Unimplemented bit, read as '0'	
- n = Value at POR	'1' = Bit is set	'0' = Bit is cleared	x = Bit is unknown

4.0 I/O PORTS

Some pins for these I/O ports are multiplexed with an alternate function for the peripheral features on the device. In general, when a peripheral is enabled, that pin may not be used as a general purpose I/O pin.

Additional information on I/O ports may be found in the PICmicro™ Mid-Range Reference Manual (DS33023).

4.1 PORTA and TRISA Registers

PORTA is a 5-bit wide, bi-directional port. The corresponding data direction register is TRISA. Setting a TRISA bit (= 1) will make the corresponding PORTA pin an input (i.e., put the corresponding output driver in a Hi-Impedance mode). Clearing a TRISA bit (= 0) will make the corresponding PORTA pin an output (i.e., put the contents of the output latch on the selected pin).

Note:	On a Power-on Reset, these pins are configured as inputs and read as '0'.

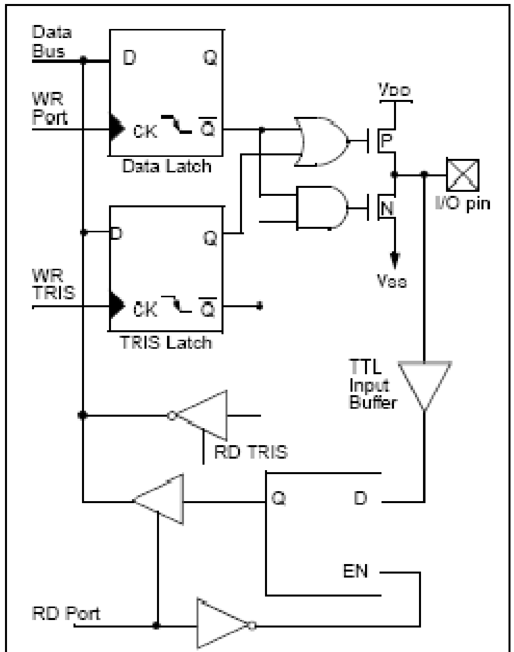
Reading the PORTA register reads the status of the pins, whereas writing to it will write to the port latch. All write operations are read-modify-write operations. Therefore, a write to a port implies that the port pins are read. This value is modified and then written to the port data latch.

Pin RA4 is multiplexed with the Timer0 module clock input to become the RA4/T0CKI pin. The RA4/T0CKI pin is a Schmitt Trigger input and an open drain output. All other RA port pins have TTL input levels and full CMOS output drivers.

EXAMPLE 4-1: INITIALIZING PORTA

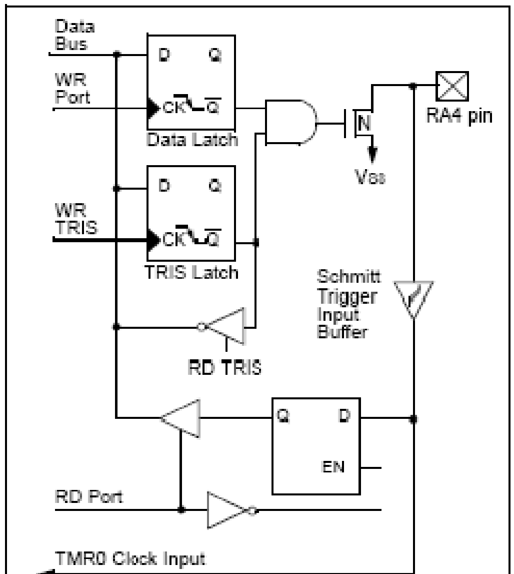
```
BCF     STATUS, RP0 ;
CLRF    PORTA       ; Initialize PORTA by
                    ; clearing output
                    ; data latches
BSF     STATUS, RP0 ; Select Bank 1
MOVLW   0x0F        ; Value used to
                    ; initialize data
                    ; direction
MOVWF   TRISA       ; Set RA<3:0> as inputs
                    ; RA4 as output
                    ; TRISA<7:5> are always
                    ; read as '0'.
```

FIGURE 4-1: BLOCK DIAGRAM OF PINS RA3:RA0



Note: I/O pins have protection diodes to VDD and VSS.

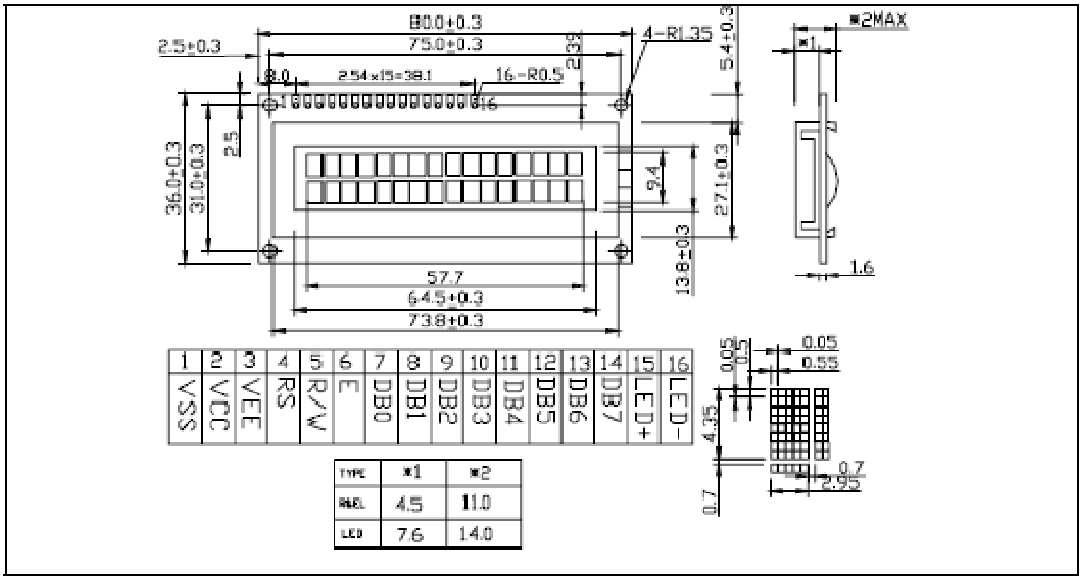
FIGURE 4-2: BLOCK DIAGRAM OF PIN RA4



Note: I/O pins have protection diodes to VDD and VSS.

APPENDIX C2

LCD data sheet:



■ PIN CONFIGURATION

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
VSS	Vcc	VEE	RS	R/W	E	DB0	DB1	DB2	DB3	DB4	DB5	DB6	DB7	LED+	LED-

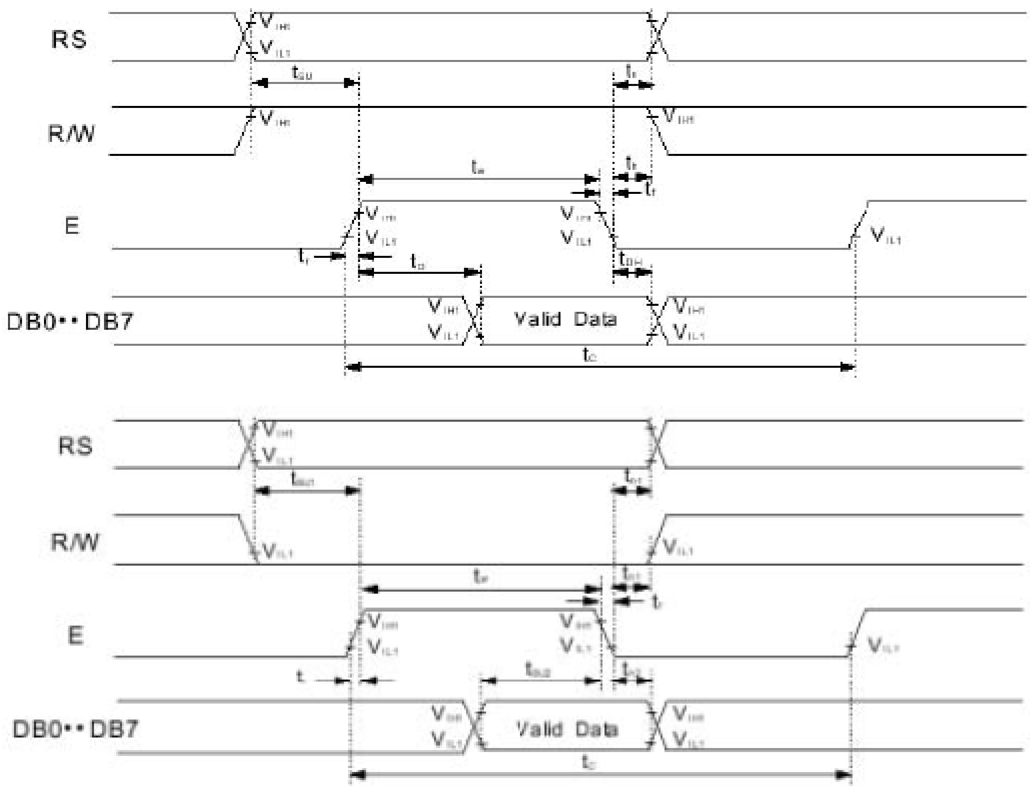
■ AC Characteristics Read Mode Timing Diagram

Table 12. AC Characteristics (V_{DD} = 4.5V ~ 5.5V, Ta = -30 ~ +85°C)

Mode	Characteristic	Symbol	Min.	Typ.	Max.	Unit
Write Mode (Refer to Fig-6)	E Cycle Time	tc	500	-	-	ns
	E Rise / Fall Time	t_R, t_F	-	-	20	
	E Pulse Width (High, Low)	tw	230	-	-	
	R/W and RS Setup Time	tsu1	40	-	-	
	R/W and RS Hold Time	t_{H1}	10	-	-	
	Data Setup Time	tsu2	80	-	-	
	Data Hold Time	t_{H2}	10	-	-	
Read Mode (Refer to Fig-7)	E Cycle Time	tc	500	-	-	ns
	E Rise / Fall Time	t_R, t_F	-	-	20	
	E Pulse Width (High, Low)	tw	230	-	-	
	R/W and RS Setup Time	tsu	40	-	-	
	R/W and RS Hold Time	t_H	10	-	-	
	Data Output Delay Time	t_D	-	-	120	
	Data Hold Time	t_{DH}	5	-	-	

Table 13. AC Characteristics (V_{DD} =2.7V ~ 4.5V, Ta = -30 ~ +85°C)

Mode	Characteristic	Symbol	Min.	Typ.	Max.	Unit
Write Mode (Refer to Fig-6)	E Cycle Time	tc	1000	-	-	ns
	E Rise / Fall Time	$t_R t_F$	-	-	25	
	E Pulse Width (High, Low)	tw	450	-	-	
	R/W and RS Setup Time	tsu1	60	-	-	
	R/W and RS Hold Time	t_{H1}	20	-	-	
	Data Setup Time	tsu2	195	-	-	
	Data Hold Time	t_{H2}	10	-	-	
Read Mode (Refer to Fig-7)	E Cycle Time	tc	1000	-	-	ns
	E Rise / Fall Time	t_R, t_F	-	-	25	
	E Pulse Width (High, Low)	tw	450	-	-	
	R/W and RS Setup Time	tsu	60	-	-	
	R/W and RS Hold Time	t_H	20	-	-	
	Data Output Delay Time	t_D	-	-	360	
	Data Hold Time	t_{DH}	5	-	-	

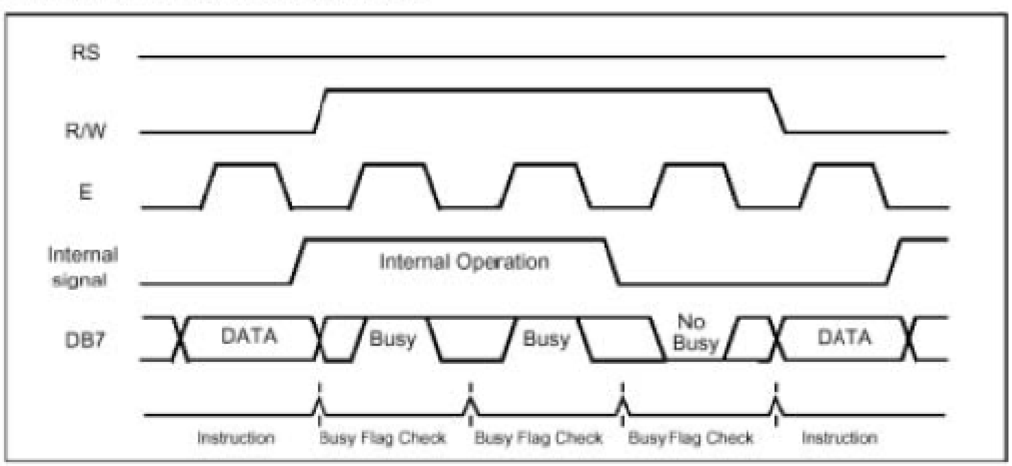


Write Mode Timing Diagram

Timing

1) Interface with 8-bit MPU

When interfacing data length are 8-bit, transfer is performed at a time through 8 ports, from DB0 to DB7. Example of timing sequence is shown below.



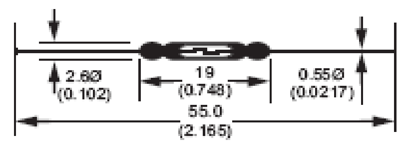
APPENDIX C3

Reed switch sensor data sheet:

COMUS Group — COMUS International

Reed Switch - Miniature - Normally Open Contacts
Part Number : GC2722
Product Data Sheet

PICTURE	DIMENSIONS



File Number E103299 ✔RoHS Compliant

Drawings not to scale
All dimensions in mm (Inches) nominal.

SPECIFICATION

Contact Form		Normally Open
Contact Material		Rhodium
Switching Capacity	Max.	12 VA
Switching Voltage	Max.	230 VAC/DC
Switching Current	Max.	1.0 A
Carrying Current	Max.	2.0 A
Dielectric Strength	Min.	400 VDC
Contact Resistance	Max.	100 mOhms
Insulation Resistance	Min.	10^{11}
Pull - In - Sensitivity		30 - 50 AT
Drop - Out - Sensitivity	Min.	5
Bounce Time	Max.	0.5 ms
Release Time	Max.	0.10 ms
Resonant Frequency	Typ.	2900 Hz
Operating Frequency	Max.	200 Hz
Vibration (10-1000Hz)		35 g
Shock (11 ms)		50
Capacitance	Typ.	0.5 pF
Operating Temperature Range		-40°C + 125°C
Test Coil	Type	1700

NOTE

- When cutting or bending switch leads it is important that the glass seal is not damaged. The cutting or bending point should be no closer than 3mm (.118in.) to the glass to metal seal and the lead should be supported between the cutting or bending point and the glass to metal seal.
- We offer a crop and form service for Reed Switches to be customized to your specification.

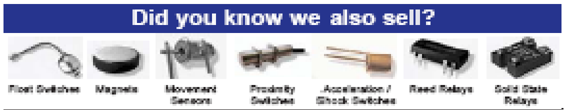
Ordering Information

PART NUMBER 2722 30 50

- Type — 2722
- Minimum (AT) Sensitivity — 30
- Maximum (AT) Sensitivity — 50

Example:
Type 2722 Standard Sensitivity. Pull-in sensitivity between 30-50 AT is PART NO: 2722 30 50
Available in ranges of 5 AT e.g: 30-35, 35-40 etc.

Did you know we also sell?



Rev. No.	Revision Note	Date	Signature
2	Datasheet Redesign	26-05-06	NG

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Data sheet comparing Reed Switch Sensor and Hall Effect Sensor:

SENSOR APPLICATIONS **MEDER electronic**

Table Comparing Hall Effect Sensors with Reed Sensors

Specifications	Hall Effect	Reed Sensor
Input requirements	External Magnetic Field > 15 Gauss Min.	External Magnetic Field > 5 Gauss Min.
Sensing Distance	Up to 20 mm Effectively	Up to 40 mm Effectively
Output required	Continuous Current > 10 ma dependent on sensitivity	None
Power Required all the Time	Yes	No
Requirements beyond sensing device	Voltage regular, constant current source, hall voltage generator, small signal amplifier, chopper stabilization, schmitt trigger, short circuit protection, external filter, external switch	None
Hysteresis	Fixed usually around 75%	Ability to adjust, to meet design requirement
Detection Circuit required	Yes, and generally needs amplification	None
Ability to switch loads directly	No, requires external switching	Yes, up to 2 amps and 1000 V depending upon the reed selection
Output switching power	Low mW	Up to 100 Watts depending upon switch selection
Voltage switching range	Requires external switch	O V to 200 V (1000 V available)
Current switching range	Requires external switch	O A to 2 Amps
Output sensitivity to polarity	Yes, critical for proper operation	No
Output offset voltage sensitivity	Yes, exacerbated by sensitivity to overmolding, temp. dependencies, and thermal stress	None
Chopper circuit requirement	Yes, helps reduce output offset voltage. Requires additional external output capacitance.	None required
Frequency range	Requires external switch	DC to 6 GHz
Closed output on resistance	> 200 ohms	0.050 ohms
Expected life switching < 5V @ 10 ma	> 1 billion operations	> 1 billion operations
Capacitance across output	100 pf typical	0.2 pf typical
Input / Output isolation	> 10^{+12} ohm min.	> 10^{+12} ohm min
Isolation across output	> 10^{+6} ohm min	> 10^{+12} ohm min
Output dielectric strength	< 10 volts typ.	> 250 volts typical (2500 volts available)
EDI (ESD) susceptibility	Yes, requires external protection	No, requires no external protection
Hermeticity	No	Yes
Shock	> 150 G's	150 G's (new ones up to 5000 G's)
Vibration	> 50 G's	10 G's
Operating temperature	$0^{\circ}C$ to $70^{\circ}C$ Typ. above or below range will degrade specifications	-55 $^{\circ}C$ to 150 $^{\circ}C$ no spec. degradation
Storage temperature	-55 $^{\circ}C$ to 125 $^{\circ}C$	-55 $^{\circ}C$ to 150 $^{\circ}C$

APPENDIX D

Amount of the rain fall in Malaysia (ml):