MULTIPURPOSE MOISTURE CONTENT DETECTOR

By

HASLINDA BT MEOR MUHAMAD

FINAL PROJECT REPORT

Submitted to the Electrical & Electronics Engineering Programme
in Partial Fulfilment of the Requirements
for the Degree
Bachelor of Engineering (Hons)
(Electrical & Electronics Engineering)

Universiti Teknologi Petronas
Bandar Seri Iskandar
31750 Tronoh
Perak Darul Ridzuan

CERTIFICATION OF APPROVAL

MULTIPURPOSE MOISTURE CONTENT DETECTOR

by

HaslindaBt Meor Muhamad

A project dissertation submitted to the
Electrical & Electronics Engineering Programme
Universiti Teknologi PETRONAS
in partial fulfilment of the requirement for the
Bachelor of Engineering (Hons)
(Electrical & Electronics Engineering)

Approved:

Assoc. Prof. Dr. Josefina Barnachea Janier
Project Supervisor

UNIVERSITI TEKNOLOGI PETRONAS
TRONOH, PERAK

December 2006

CERTIFICATION OF ORIGINALITY

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

____

Haslinda Bt Meor Muhamad

ABSTRACT

This report explains on the designation of multipurpose moisture content detector. The objective of this project and research is to design and implement a device that can determine moisture content of substances. The detector is designed to measure a minimum range of 5 to 30 percent of moisture content in substances by utilizing a correlation with the electric resistivity of the sample. A pair of probes is used to measure the voltage difference in the sample and then the value is converted into percentage of moisture content by a microcontroller, PIC16F877. The output of the conversion circuit is indicated by a LCD display. The detector was able to measure the moisture content of two substances; soil and paddy. However the value measured by the detector is unstable and inconsistent. The main reasons are because the effect of electrolysis, distribution of moisture and physical and electrical properties of samples. As the recommendations, the direct current (DC) supply of the detector should be replaced with alternate current (AC) supply and the properties parameters should be held as constant values.

ACKNOWLEDGEMENTS

First and foremost, the Author would like to thank God, for giving His precious time to the Author to work on Final Year Project. Not forgotten to Electrical and Electronics Engineering Department of Universiti Teknologi Petronas (UTP) for the chance given to her to carry out this project.

A special thank is dedicated to her supervisor, Assoc. Prof. Dr. Josefina Barnachea Janier for supervising in project completion. Also an appreciation to Ms Nasreen Badrudin (FYP Coordinator) and Pn. Siti Hawa Tahir (EE FYP Technician) for helping the Author throughout the project process.

Not forgotten to Electrical and Electronics lecturers, Dr. John Ojour Dennis and Mr. Patrick Sebastian for helping the Author with the circuit design from the beginning. Besides, the Author would like to thank Mr. Zaini (Geotechnical, Civil Engineering Lab Technician) who allowed the Author to do lab experiments.

Last but not least, the Author would like to thank her family who support her continuously, all lecturers, technicians and colleagues who involve directly or indirectly throughout the completion of the project. All ideas, advices and compassions to the Author are completely appreciated.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

FYP	Final Year Project
PCB	Printed Circuit Board
LCD	Liquid Crystal Display
ADC	Analogue-to-Digital Converter
MC	Moisture Content
LED	Light Emitting Diode

CHAPTER 1
INTRODUCTION

1.1 Background of Study

Presently, there are numerous types of moisture detector available in market. The detectors differ in terms of cost, type of sample measured, method and purpose in determining the moisture content.

Determining of moisture level in substances has variety of purposes especially in industry. For example, in agriculture, moisture level in grain such as paddy or bean is measured to control the quality of products and facilitate in research and development for new product development. Besides that, agriculture researchers perform assessment of soil quality and organic resource quality by monitoring the moisture level. By determining the moisture content, not only quality is improved but also quantity of agriculture product is increased.

Some of the detector measures moisture content based on electrical properties of the substances. The most simple, lowest cost and did not require considerable skill in manipulation detector is by measuring conductance or capacitance of substance. Electrical conductivity or resistance type instruments measure the ability of a sample to conduct a current relative to its moisture content. Conductivity of the substrate increases as the moisture content increases. Capacitance type instruments measure the ability of a set volume of air and substance to store an electric charge relative to its moisture content [1].

Some devices use sophisticated methods for instance infrared, radio frequency, or microwave techniques to evaporate water from a sample. This latest technology determined the high production cost of the detector.

1.2 Problem Statement

1.2.1 Problem identification

At present, there are various types of detecting the moisture content in substances. However, one device is subjected to measure only one type of material, for example, soils or grains, wood and wood-base materials. Apparently, these groups of substances have different range of moisture content and physical properties. Current available devices are incapable of measuring several types of substance. Some sophisticated types of detector are very expensive in the market.

1.2.2 Significance of Project

The significant of this project is to enhance the technology used currently. This project improves the similar devices present in the market. This design will reduce the cost of fabrication a moisture detector. Beside, the detector is also cheaper compared to buying several devices of detecting moisture since only one detector is able to measure various types of substances. The project design will provide benefits to farmers in increasing product quality and maximize profit.

1.3 Objectives and Scope of Study

1.3.1 The Relevancy of the Project

The objectives of the project are as follow:

1. To design a device that can measure moisture content in various types of substances.
2. To design a detector that determines the range of moisture content percentage in samples.
3. To provide a low cost, portable, pocketsize and easy-to-use moisture detector.

1.3.2 Feasibility of the Project within the Scope and Time Frame

This project design is capable of measuring a range of moisture content in various types of substances. Taking the examples of substance to be measured; grain (paddy) and soil (peat soil) determined the minimum range of measurement display by the indicator. Based on literature reviews done, grains has a range of 9 to 30 percent, soil is between 5 to almost 100 percent of moisture content. Due to time constrain and limited equipment, the detector is expected to have a range of measurement from 5 up to 30 percent of moisture content.

The Multipurpose Moisture Content Detector circuit uses a pair of metal probes to measure the voltage difference as regards to moisture presence in sample. Voltage difference measured between the probes is connected to a microcontroller, PIC16F877 that will determine the range of moisture content percentage in the substance. Then, the output of the conversion circuit is connected to Liquid Crystal Display (LCD) circuit that will indicate the range of moisture content in the sample.

The limitation of the output which will be represented in range of moisture content is because of the difference in resistance for different substances. The differences in resistance of substance affect the amount of current flowing between the probes. In other words, even though the amount of current flowing between the probes is the same in paddy and peat soil, it may represent different values of moisture content.

As for the time scope, the first semester was focused on research relates to theory and specification of the design. The second semester was concentrated on construction of circuit and analysis which are useful to improve the design. Then, the PCB fabrication and implementation process was the final phase of the project.

CHAPTER 2
LITERATURE REVIEW

2.1 Moisture Content Measurement

In line with the new emphasis to revitalise the agriculture sector as the third engine of growth, the Government will be allocating a total of RM11.4 billion in Ninth Malaysia Plan (9MP) to implement various agricultural programs and projects. To develop and modernize the agriculture industry, government is focusing on automation, precision farming and implementing various mechanisms.

One of the agriculture sectors in Malaysia that play important role is rice production. Malaysia will be able to achieve self-sufficiency in rice production by 2007 provided farmers incorporate the latest farming technologies in paddy cultivation [2]. In order to achieve the target, farmers not only need to increase the quantity of rice production but also maximize the capability in the process.

One of the vital factors that affect the production is moisture content of the rice. Previously, farmer's method of determining the moisture content of rice is only by estimating based on their experience. This situation always leads to problems especially when their estimation is incorrect and cause huge loss in rice production.

Researches have proved that moisture content in soil also affect the agricultural process as water is essential in plant growth [3]. Fruits and vegetable plants in horticultural sector such as greenhouse farming usually affected by level of minerals and moisture content of the soil. Without enough water, normal plant functions are disturbed, and the plant gradually wilts, stops growing, and dies. However, excessive soil moisture may lead to the destruction of the roots by root rot and the yellowing of plant leaves.

The design of this detector is extremely useful to farmers to determine moisture content in substance. Thus, the success of this project will be in lined with the efforts of achieving the Malaysia plan and target.

2.2 Moisture Detector for Paddy

This project design is an improvement to Final Year Project done by previous semester student: Maliki Bin Maidin on Moisture Detector for Paddy [4]. The project is dedicated to design a device to help farmers in monitoring the dryness of paddy. The device detects the level of moisture content in paddy in the range of wet (20% MC), medium (18% MC) and dry (14% MC). The design is based on resistivity and conductivity principle. The outputs of the device are represented by three LEDs which are red (wet sample), yellow (medium sample) and green (dry sample).

Thus, this project improved the function of the previous project design by varying the substances that can be measure by the device. The output of Multipurpose Moisture Content Detector is displayed in digits and in terms of percentage which improved the previous device's output; three LEDs indicator.

2.3 Existing Methods for Moisture Content Determination

Table 1 Methods for Moisture Content Determination [5]

Electrical Resistivity Applying Ohm's Law, wet sample has higher moisture content thus has lower resistance than dry sample.	**Measured Parameter -** Moisture content and voltage relationship. **Disadvantages** – Factors that influence measurement: temperature of ambient condition, sample and detector, moisture distribution in sample, sample size and density. **Advantages** - Simple, lowest cost and it does not require considerable skill in manipulation.
Gravimetric Techniques (Oven-drying techniques) Involves preparing a sample and determining the mass of water content in relation to the mass of dry sample.	**Measured Parameter** - Mass water content (percentage of dry vs. wet sample weight). **Disadvantages** - Destructive test, time consuming, inapplicable to automatic control, must know dry bulk density and transform data to volume moisture content **Advantages** - Ensures accurate measurements, easy to calculate
Time-domain Reflectometer (TDR) Determinations involve measuring the propagation of electromagnetic (EM) waves or signals.	**Measured Parameter** - Volumetric water content aided by propagation of electromagnetic wave measurements. **Disadvantages** – Costly **Advantages** - Independent of sample texture, temperature, and salt content. Possible to perform long-term measurements
Neutron scattering Estimating volumetric water content, fast neutrons emitted from a radioactive source are thermalized or slowed down by hydrogen atoms in the sample.	**Measured Parameter** - Volumetric water content aided by propagation of electromagnetic wave measurements. **Disadvantages** – Costly, dependent on dry bulk density and salinity, radiation hazard, must calibrate for different types of samples, access tubes must be installed and removed, depth resolution questionable, measurement partially dependent on physical and chemical sample properties, depth probe cannot measure sample water near sample surface, subject to electrical drift and failure **Advantages** – Nondestructive, possible to obtain profile of water content in sample, water can be measured in any phase, measurement directly related to sample water content

2.3.1 Electrical Resistivity

This design project is based on electrical resistivity. The rationale why this method is chosen is related to the objectives of this project itself; to design a low cost, portable, pocketsize and easy-to-use moisture detector. Comparison is made based on literature reviews done and concluded in previous table. Theoretically, when minerals or impurities from materials or substances are added, water becomes a good conductor. Most of material easily dissolved in water thus produces ionized atoms that carry the current. Wet sample has higher moisture content which has more ions and be able to conduct electricity well (lower resistance, by applying Ohm's Law) compared to dry sample which has less ions and higher resistance. This method is simple, lowest cost and it does not require considerable skill in manipulation.

Some factors that influence the performance of the detector are [6];

1. Temperature of ambient condition, sample and detector.
2. Moisture distribution in sample.
3. Sample size and density.
4. Soil mineral and pH value.

To reduce the influences to the design, the temperature and sample size are held constant through the lab experiment. In addition, a fixed time of delay is before any measurement during the experiment is taken to ensure that the moisture is fully distributed in sample. Mineral in soil and pH value are considered insignificant to the result of the detector.

CHAPTER 3
METHODOLOGY

3.1 Project Process Flow

The project was based on the flow chart for project management and development. This is to ensure that the objectives of this project will be achieved within the time frame given.

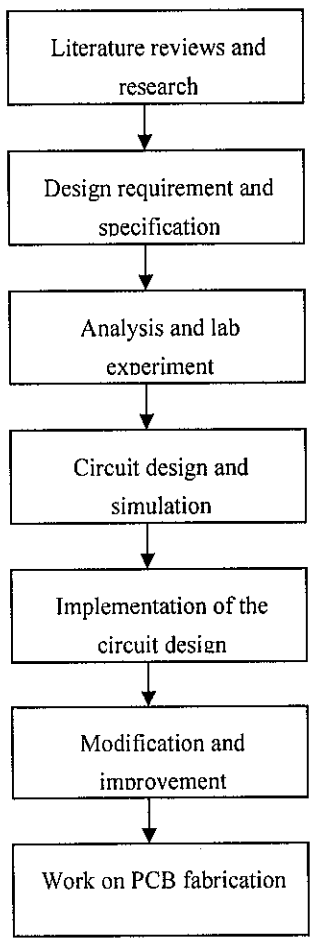


Figure 1 Process Flow Chart for FYP

The project started with literature reviews and research regarding the basic principle and existing devices. The various principles used to operate moisture detector and features available were studied. Based on the findings, a method of operation is selected after analyzing the data. Next, requirements and specification of the detector are determined which were focused through time frame of two semester.

Analysis and lab experiments were conducted to determine required data and parameter in circuit design and in writing programming code for the microcontroller. At this stage, the circuit was constructed separately by parts; detector, converter and display circuit. Simulation of the design is necessary to test that the design functions correctly.

Improvement and modification of the circuit was done based on the performance of the design. After finalizing the circuit design, the project continued with PCB fabrication. Then the designed circuit was implemented on the PCB and final evaluation was made to ensure that this project is successful.

3.2 Lab Experiment for Parameter Determination

Lab experiments were done to determine the relationship between voltage and resistance measured with respect to moisture content in sample. The objective of this experiment was to prepare sample with desired moisture content to determine desired data; moisture content and resistance and voltage relationships. The experiment was done based on gravimetric technique; removing water from sample to determine moisture content. The procedure of the experiment is as shown in next flow chart. The formula used to calculate moisture content in the sample is [2]

$$\text{Moisture Content (\%)} = \frac{\text{Wet sample weigh} - \text{Dry sample weigh}}{\text{Dry sample weigh}}$$

The weigh of sample with required amount of moisture content in the sample is first determined. This is done by manipulating the equation above by selecting a value for initial weigh of dry sample and the desired percentage of moisture content. Thus, the sample was prepared based on the value calculated using the equation.

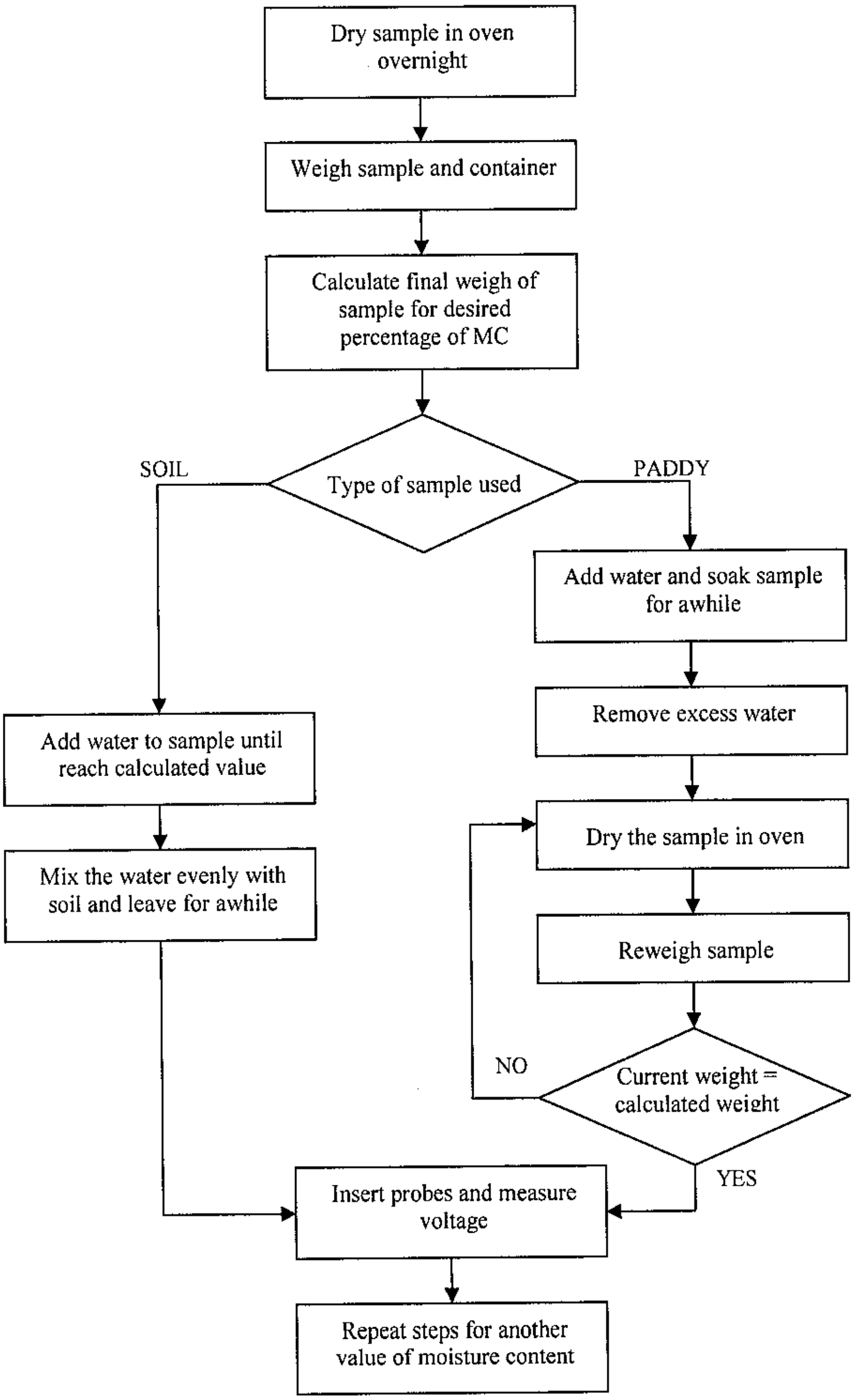


Figure 2 Lab Experiment Flow Chart

The method of preparing sample for soil is slightly differ from paddy sample. This is because soil absorbs moisture faster than paddy. Thus, paddy is soak with water for awhile to ensure that it will absorb the water uniformly. With soil sample, water is added directly until the sample calculated value reaches the calculated final weight.

3.3 Tool Required for Data Analysis

PSPICE was used for the design and simulation process. This software is an analogue circuit simulator which helps the user simulates the circuit design graphically on the computer before building a physical circuit. Hence, any necessary changes on the prototype without modifying any hardware. PSpice allows checking the operability of the circuit model in real life simulations to validate its viability.

CCS PIC C software is used to write C programming code for this project which aims to convert measured voltage difference into moisture content percentage by using the microcontroller PIC16F877. After the program is compiled successfully, the generate .hex code is written into the microcontroller by Warp13 software.

For PCB fabrication process, Multisim and UltiBoard software were used. Multisim was use to verify schematics prior to PCB layout and correct errors before they become costly mistakes. UltiBoard provided component placement and rapid trace editing that ensured quickly complete error-free boards [7].

CHAPTER 4
RESULT AND DISCUSSION

4.1 Multipurpose Moisture Content Detector Circuit

As mentioned earlier, this project is considered as an improvement to previous FYP. The designed circuit which used LM3914; LED Dot/Bar Display Driver senses voltage level and drives 10 LEDs as the equivalent output of the voltage measured. This circuit operates as a voltmeter with 10 values of output [3]. Multipurpose Moisture Content Detector circuit was designed based on some information and guidelines from the project.

Basically, the operation for Multipurpose Moisture Content Detector can be shown in the flow chart below.

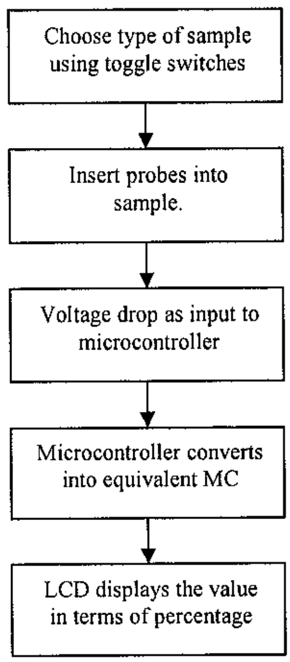


Figure 3 Multipurpose Moisture Content Detector operation flow chart

4.1.1 *The Sensor*

Multipurpose Moisture Content Detector circuit uses a pair of probes to measure the moisture content in substances. For this design, a pair of 7cm long and 4mm diameter steel nails which have a good electric conductivity. The distance between the probes has effect to the measurement result. Thus, a distance of 1 inch is held as constant for the probes.

The function of the probes depends on the nature properties of water. The probes are inserted into the substances to read the moisture content through the electrical conductance detected between probes. The larger the probes' exposed area to the sample; it becomes more sensitive to the moisture content. Higher moisture levels facilitate better electrical conductance, thus higher moisture readings.

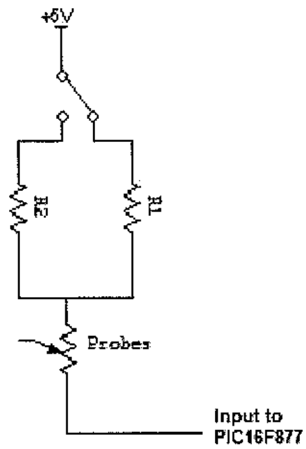


Figure 4 Sensor Circuit

A sample of substance with low percentage of moisture content has high value of resistance. Based on Ohm's Law (V=IR), the voltage drop is increased when the value of resistance increases. Thus, the probes will measure a high value of voltage drop if a low moisture content sample is measured. A constant value of resistor with combination of the probes is simply follows Voltage Divider Law which generate voltage input to the microcontroller.

4.1.2 *PIC16F877 Microcontroller*

The conversion circuit in the design uses a PIC16F877 microcontroller. The microcontroller has a built-in 10-bit analogue-to-digital converter (A/DC) with 8 channels for analogue input. The reference voltage is 5V and 255 is the number of iterations required for the conversion of one analogue input into digital form. The equations derived from the result of the experiment are used in order to program PIC16F877 microcontroller. The microcontroller converts the voltage measure which in analogue form into moisture content expressed in percentage which is in digital form by manipulating the A/D converter.

A C programming code is build in order to calculate the equivalent moisture content by the microcontroller and to display the value by using LCD. After the program is compiled successfully, the generated .hex code is written into the microcontroller. Refer to Appendix C for the programming code.

4.1.3 Lab Experiment for Calibrating the Detector

The result of the lab experiment in determining the relationship between voltage drop of the probes and moisture content of sample is shown in Table 2 and 3 and Figure 5 and 6.

Table 2 Result of Soil Sample Experiment

Moisture content (%)	Voltage(probes)	Average
5	4.677 4.666 4.547	4.630
7	4.463 4.331 4.475	4.423
10	4.094 4.034 4.026	4.051
12	3.564 3.654 3.458	3.559
15	3.148 3.059 2.991	3.066
17	2.312 2.198 2.138	2.216
20	2.122 2.094 1.937	2.051
22	1.744 1.735 1.547	1.675
25	1.174 1.279 1.158	1.204
27	0.898 0.874 0.883	0.885

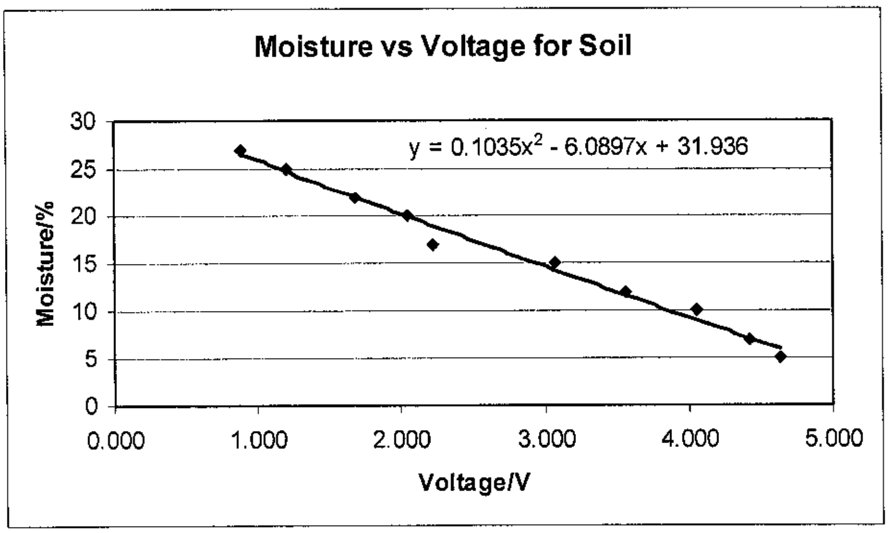


Figure 5 Graph of Moisture Content versus Voltage for Soil

Table 3 Result for Paddy Sample Experiment

Moisture content (%)	Voltage(probes)	Average
5	3.030 3.026 3.028	3.028
7	3.029 3.027 3.028	3.028
10	3.000 2.995 2.957	2.984
12	2.808 2.826 2.725	2.786
15	2.461 2.469 2.477	2.469
17	1.864 1.695 1.558	1.706
20	1.785 1.689 1.953	1.809
22	0.816 0.918 0.886	0.873
25	0.552 0.620 0.419	0.530

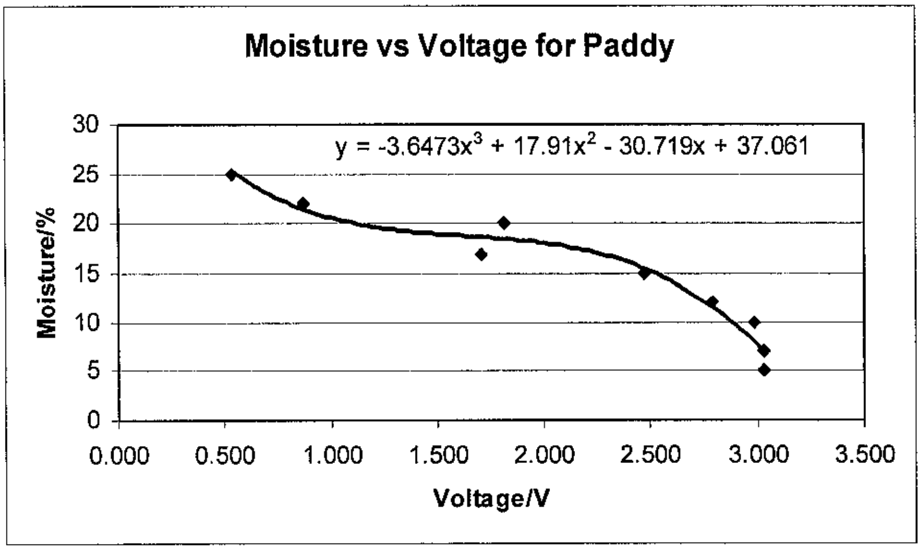


Figure 6 Graph of Moisture Content versus Voltage for Paddy

The graphs and equations are generated using Microsoft Excel. The table refer to the values measured during the experiment. The voltage drop of the probes is measured by using a known value of moisture content sample. From the result, the relationship between moisture content and voltage drop was determined. The graph represents the measured voltage drop versus moisture content values.

For soil sample result, the graph is added with a second order polynomial trendline and generates an equation;

$$y = 0.1035x^2 - 6.0897x + 31.936 \quad (1)$$

For paddy sample result, the graph is added with third order polynomial trendline and generates an equation;

$$y = -3.6473x^3 + 17.91x^2 - 30.719x + 37.061 \quad (2)$$

where y = moisture content in percentage

x = voltage input to the microcontroller

Although the pattern of the graph for soil sample looks almost like a straight line, the polynomial equation was chose instead of a linear equation. This is to increase the accuracy of the conversion of the voltage input. Calibration test were done by calculated the result manually to get the corresponding moisture content value. Equation (1) and (2) are parts of programming code for the microcontroller as to calculate the equivalent moisture content measure by the probes.

4.1.4 Cost Estimation

Table 4 Cost Estimation for Detector Circuit

Component	Description	Quantity	Price(RM)	Total (RM)
Microcontroller	PIC16F877	1	25.00	25.00
Liquid Crystal Display	Single line	1	90.00	90.00
Crystal Oscillator	4 MHz	1	1.50	1.50
Voltage Regulator	L7805	1	1.20	1.20
Toggle Switch	Spdt	2	0.60	0.60
	Dpdt	1	0.60	0.60
LED		1	0.50	0.50
Resistor		4	0.05	0.20
Battery AA	1.5V	4	2.50	10.00
Probe	Nail	2	0.30	0.60
Printed Circuit Board	PCB	1	10.00	10.00
Total Cost				RM 140.80

Table above shows the list of components and price of the Multipurpose Moisture Content Detector. The total cost is around RM 140 and it is really a low-priced product compare to existing detectors available in the market which cost more than RM1000.

CHAPTER 5
CONCLUSION AND RECOMMENDATION

5.1 Conclusion

As a conclusion, the circuit design for Multipurpose Moisture Content Detector is well functioning. The detector is able to measure moisture in two types of substances; soil and paddy. A pair of probes is used to measure the voltage difference in the sample and then the value is converted into percentage of moisture content by a microcontroller, PIC16F877. The output of the conversion circuit is indicated by a LCD display.. The measurement range is from 5 to 30 percent of moisture content. It is also a low cost, portable, pocketsize and easy-to-use moisture detector.

The PCB of the design was put in a plastic casing. However, the prototype of the device was not working properly. The problem was caused by the microcontroller failure which was detected during troubleshooting.

5.2 Recommendation

After doing lab experiments to calibrate the detector, it showed that the measurement uncertainty of the detector is 2 percent of moisture content. The accuracy may be affected by the distribution of moisture and physical and electrical properties of the sample. As the recommendation, the accuracy of the detector should be improved by taking into consideration the factors affecting the measurement.

The value measured by the detector is unstable in such a way that the longer time the probes are inserted in sample, the value may increase. One of the reasons is because when a voltage difference is applied to the probes inside the sample, electrons will build up at the positive side of the probes. When this is happened, higher value of voltage difference between the probes will be measured. Thus, the effect of electrolysis can be eliminated by replacing direct current (DC) supply to alternate current (AC) supply.

To market the device, the design needs to be placed in a suitable and durable casing. This is to ensure the reliability and long-lasting of the device especially if the device is handled in a harsh environment. Some extra functions such as memory space to save the readings and indicator to alert the battery power will make the device more user-friendly.

REFERENCES

1. Building Envelope Research, "Moisture Detection Equipment-Manufacturer", March 2005, http://alcor.concordia.ca/~raojw/crd/essay/essay000141.html

2. T.F. Scherer, B. Seelig, D. Franzen, "Soil, Water and Plant Characteristics Important to Irrigation", February 1996, http://www.ag.ndsu.edu/pubs/ageng/irrigate/eb66w.html

3. Oryza, "Oryza Malaysia Market Rice Report", June 2004, http://www.oryza.com/asia/malaysia/index.shtml

4. M. Maidin, J.B. Janier, "Moisture Detector for Paddy", Final Year Project Thesis, Universiti Teknologi PETRONAS, December 2005.

5. Alberta Government, "Soil Moisture Meter", March 19, 2004, http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/eng8291

6. Stored Grain Research Laboratory, " What factors affects their accuracy and can they be calibrated", 2001, http://sgrl.csiro.au/faq/portable_moisture_meters.html

7. Electronics Workbench, "Product and Services", May 2006, http://www.electronicsworkbench.com/products/

APPENDICES

APPENDIX A

GANTT CHART FOR FYP SEMESTER 1

No.	Detail/ Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Selection of Project Topic														
	-Propose Topic														
	-Topic assigned to students														
2	Preliminary Research Work														
	-Introduction and objective														
	-Scope and specification														
3	Submission of Preliminary Report														
4	Project Work														
	-Design detector circuit														
	-Design measurement indicator														
	-Implementation of design														
5	Submission of Progress Report														
6	Project work continue														
	-Practical/Laboratory Work														
7	Submission of Interim Report Final Draft														
8	Submission of Interim Report														
9	Oral Presentation														

APPENDIX B

GANTT CHART FOR FYP SEMESTER 2

No.	Detail/ Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Project Work Continue														
	- Circuit Design Expansion														
	- Practical/Laboratory Work														
2	Submission of Progress Report 1														
3	Project Work Continue														
	- Modification and improvement														
4	Submission of Progress Report 2														
5	Project work continue														
	- Modification and improvement														
6	Submission of Dissertation Final Draft														
7	Oral Presentation														
8	Submission of Project Dissertation														

APPENDIX C

MULTIPURPOSE MOISTURE CONTENT DETECTOR CIRCUIT

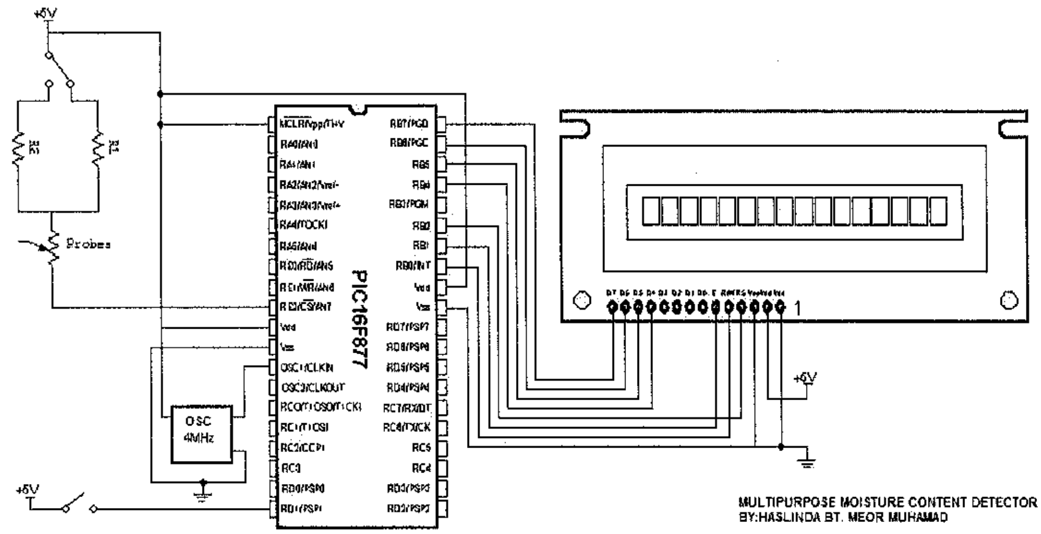


Figure 7 Multipurpose Moisture Content Detector Circuit

APPENDIX D

PROGRAMMING CODE FOR PIC16F877

```
/*
Author : Haslinda Meor Muhamad
Title  : Multipurpose Moisture Content Detector
Operation : Microcontroller 16F877 is used to calculate the percentage of moisture
content and display the value with LCD.
*/

#include <16F877.h>
#device ADC=8
#include <stdio.h>
#include <math.h>

#fuses XT,NOWDT,NOPROTECT,NOPUT,NOBROWNOUT,NOLVP
#use delay(clock=4000000)

#include <LCD.C>
#include <string.h>

//This function show the value on the screen digit by digit
//e.g:If value is 45, 1st for loop display 5, 2nd for loop display4

void adc(int value)
{
  int value1,value2,x;
  if (value!=0)
  {
    value1=value;
    if(value1!=0)
    {
      for (x=3;x>=1;x--)
```

```
      {
      lcd_gotoxy(x,2);
      value2=value1%10;
      value2=value2+48;
      lcd_putc(value2);
      value1=value1/10;
      }
    }
  }

  else
  {
    lcd_gotoxy(1,1);
    lcd_putc("0");
  }
}

main()
{
    //declare variable
    int adcValue;
    int portDValue;
    //float voltage;
    int moisture;

    //led
    output_high(pin_A0);

    //adc
    setup_adc_ports( ALL_ANALOG );
    setup_adc(ADC_CLOCK_INTERNAL);          //use internal clock
    set_adc_channel(7);
```

```
//lcd
lcd_init();

//sample
set_tris_d(0xff);                    //set portD as input

//Display Moisture Content
lcd_gotoxy(1,1);
lcd_putc('\f');
lcd_putc("Moisture");
delay_ms(700);
lcd_putc('\n');
lcd_putc("Detector");
delay_ms(700);

while(1)
{

    //adc//
    delay_us(50);                    //delay for sampling cap to charge
    adcValue = read_adc();               //get adc reading
    delay_us(50);                    //preser delay,repeat every 10ms
    portDValue = input(PIN_D1);

    //voltage = 5.000 * adcValue / 255.000;

    if (portDValue==1){
      moisture = (0.1035*adcValue*adcValue)-(adcValue*6.0897)+31.936 ;
    }
    else if (portDValue==0){
    moisture = (17.91*adcValue*adcValue)-
    (adcValue*adcValue*adcValue*3.6473)-(adcValue*30.719)+37.061 ;
    }
```

```
    lcd_gotoxy(1,1);
    lcd_putc('\f');
    lcd_putc("Moisture  ");
    delay_ms(10);
    lcd_putc('\n');
    adc(moisture);
}
```

APPENDIX E

PIN COFIGURATION FOR LIQUID CRYSTAL DISPLAY

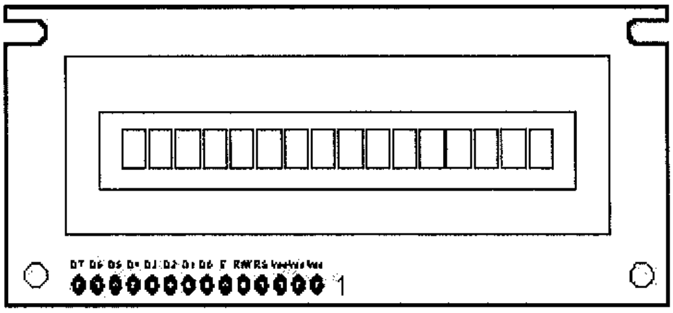


Figure 8 Liquid Crystal Display Diagram

Table 5 Pin Configuration for LCD

Pin	Description
1	Ground
2	Vcc
3	Contrast Voltage
4	"R/S" Instruction/Register Select
5	"R/W" Read/Write LCD Register
6	"E" Enable pin
7-14	Data I/O pins

APPENDIX F

PIC16F877 DATASHEET

MICROCHIP

PIC16F87X

28/40-Pin 8-Bit CMOS FLASH Microcontrollers

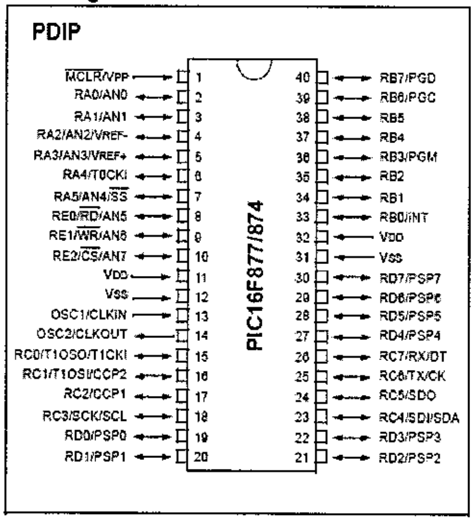
Devices Included in this Data Sheet:

- PIC16F873
- PIC16F874
- PIC16F876
- PIC16F877

Microcontroller Core Features:

- High performance RISC CPU
- Only 35 single word instructions to learn
- All single cycle instructions except for program branches which are two cycle
- Operating speed: DC - 20 MHz clock input
DC - 200 ns instruction cycle
- Up to 8K x 14 words of FLASH Program Memory,
Up to 368 x 8 bytes of Data Memory (RAM)
Up to 256 x 8 bytes of EEPROM Data Memory
- Pinout compatible to the PIC16C73B/74B/76/77
- Interrupt capability (up to 14 sources)
- Eight level deep hardware stack
- Direct, indirect and relative addressing modes
- Power-on Reset (POR)
- Power-up Timer (PWRT) and Oscillator Start-up Timer (OST)
- Watchdog Timer (WDT) with its own on-chip RC oscillator for reliable operation
- Programmable code protection
- Power saving SLEEP mode
- Selectable oscillator options
- Low power, high speed CMOS FLASH/EEPROM technology
- Fully static design
- In-Circuit Serial Programming™ (ICSP) via two pins
- Single 5V In-Circuit Serial Programming capability
- In-Circuit Debugging via two pins
- Processor read/write access to program memory
- Wide operating voltage range: 2.0V to 5.5V
- High Sink/Source Current: 25 mA
- Commercial, Industrial and Extended temperature ranges
- Low-power consumption:
  - < 0.6 mA typical @ 3V, 4 MHz
  - 20 μA typical @ 3V, 32 kHz
  - < 1 μA typical standby current

Pin Diagram

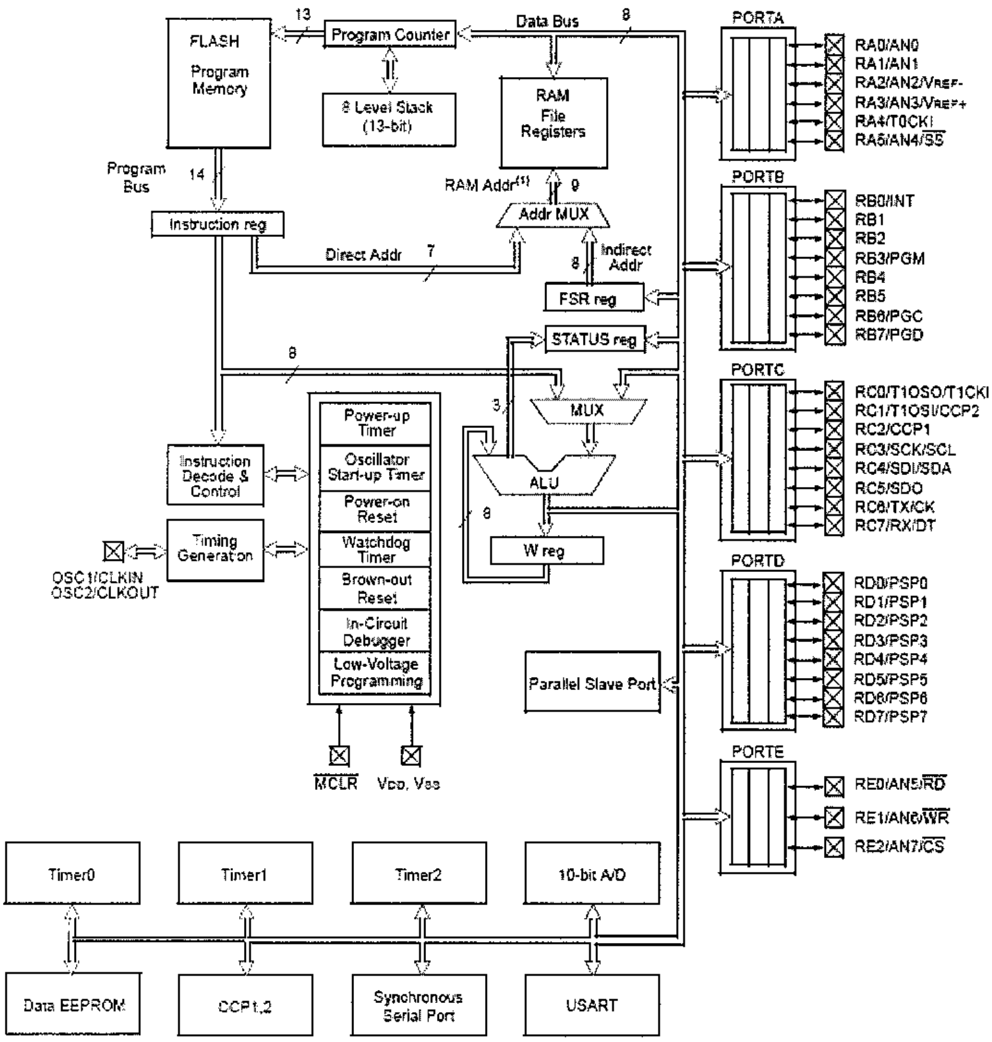


Peripheral Features:

- Timer0: 8-bit timer/counter with 8-bit prescaler
- Timer1: 16-bit timer/counter with prescaler, can be incremented during SLEEP via external crystal/clock
- Timer2: 8-bit timer/counter with 8-bit period register, prescaler and postscaler
- Two Capture, Compare, PWM modules
  - Capture is 16-bit, max. resolution is 12.5 ns
  - Compare is 16-bit, max. resolution is 200 ns
  - PWM max. resolution is 10-bit
- 10-bit multi-channel Analog-to-Digital converter
- Synchronous Serial Port (SSP) with SPI™ (Master mode) and I^{2}C™ (Master/Slave)
- Universal Synchronous Asynchronous Receiver Transmitter (USART/SCI) with 9-bit address detection
- Parallel Slave Port (PSP) 8-bits wide, with external RD, WR and CS controls (40/44-pin only)
- Brown-out detection circuitry for Brown-out Reset (BOR)

FIGURE 1-2: PIC16F874 AND PIC16F877 BLOCK DIAGRAM

Device	Program FLASH	Data Memory	Data EEPROM
PIC16F874	4K	192 Bytes	128 Bytes
PIC16F877	8K	368 Bytes	256 Bytes



Note 1: Higher order bits are from the STATUS register.

TABLE 1-2: PIC16F874 AND PIC16F877 PINOUT DESCRIPTION

Pin Name	DIP Pin#	PLCC Pin#	QFP Pin#	I/O/P Type	Buffer Type	Description
OSC1/CLKIN	13	14	30	I	ST/CMOS(4)	Oscillator crystal input/external clock source input.
OSC2/CLKOUT	14	15	31	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.
$\overline{MCLR}$/VPP	1	2	18	I/P	ST	Master Clear (Reset) input or programming voltage input. This pin is an active low RESET to the device.
						PORTA is a bi-directional I/O port.
RA0/AN0	2	3	19	I/O	TTL	RA0 can also be analog input0.
RA1/AN1	3	4	20	I/O	TTL	RA1 can also be analog input1.
RA2/AN2/VREF-	4	5	21	I/O	TTL	RA2 can also be analog input2 or negative analog reference voltage.
RA3/AN3/VREF+	5	6	22	I/O	TTL	RA3 can also be analog input3 or positive analog reference voltage.
RA4/T0CKI	6	7	23	I/O	ST	RA4 can also be the clock input to the Timer0 timer/counter. Output is open drain type.
RA5/$\overline{SS}$/AN4	7	8	24	I/O	TTL	RA5 can also be analog input4 or the slave select for the synchronous serial port.
						PORTB is a bi-directional I/O port. PORTB can be software programmed for internal weak pull-up on all inputs.
RB0/INT	33	36	8	I/O	TTL/ST(1)	RB0 can also be the external interrupt pin.
RB1	34	37	9	I/O	TTL	
RB2	35	38	10	I/O	TTL	
RB3/PGM	36	39	11	I/O	TTL	RB3 can also be the low voltage programming input.
RB4	37	41	14	I/O	TTL	Interrupt-on-change pin.
RB5	38	42	15	I/O	TTL	Interrupt-on-change pin.
RB6/PGC	39	43	16	I/O	TTL/ST(2)	Interrupt-on-change pin or In-Circuit Debugger pin. Serial programming clock.
RB7/PGD	40	44	17	I/O	TTL/ST(2)	Interrupt-on-change pin or In-Circuit Debugger pin. Serial programming data.

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 an 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 as general purpose I/O and a TTL input when used in the Parallel Slave Port mode (for interfacing to a microprocessor bus).
4: This buffer is a Schmitt Trigger input when configured in RC oscillator mode and a CMOS input otherwise.

TABLE 1-2: PIC16F874 AND PIC16F877 PINOUT DESCRIPTION (CONTINUED)

Pin Name	DIP Pin#	PLCC Pin#	QFP Pin#	I/O/P Type	Buffer Type	Description
						PORTC is a bi-directional I/O port.
RC0/T1OSO/T1CKI	15	16	32	I/O	ST	RC0 can also be the Timer1 oscillator output or a Timer1 clock input.
RC1/T1OSI/CCP2	16	18	35	I/O	ST	RC1 can also be the Timer1 oscillator input or Capture2 input/Compare2 output/PWM2 output.
RC2/CCP1	17	19	36	I/O	ST	RC2 can also be the Capture1 input/Compare1 output/PWM1 output.
RC3/SCK/SCL	18	20	37	I/O	ST	RC3 can also be the synchronous serial clock input/ output for both SPI and I^2C modes.
RC4/SDI/SDA	23	25	42	I/O	ST	RC4 can also be the SPI Data In (SPI mode) or data I/O (I^2C mode).
RC5/SDO	24	26	43	I/O	ST	RC5 can also be the SPI Data Out (SPI mode).
RC6/TX/CK	25	27	44	I/O	ST	RC6 can also be the USART Asynchronous Transmit or Synchronous Clock.
RC7/RX/DT	26	29	1	I/O	ST	RC7 can also be the USART Asynchronous Receive or Synchronous Data.
						PORTD is a bi-directional I/O port or parallel slave port when interfacing to a microprocessor bus.
RD0/PSP0	19	21	38	I/O	ST/TTL(3)	
RD1/PSP1	20	22	39	I/O	ST/TTL(3)	
RD2/PSP2	21	23	40	I/O	ST/TTL(3)	
RD3/PSP3	22	24	41	I/O	ST/TTL(3)	
RD4/PSP4	27	30	2	I/O	ST/TTL(3)	
RD5/PSP5	28	31	3	I/O	ST/TTL(3)	
RD6/PSP6	29	32	4	I/O	ST/TTL(3)	
RD7/PSP7	30	33	5	I/O	ST/TTL(3)	
						PORTE is a bi-directional I/O port.
RE0/$\overline{RD}$/AN5	8	9	25	I/O	ST/TTL(3)	RE0 can also be read control for the parallel slave port, or analog input5.
RE1/$\overline{WR}$/AN6	9	10	26	I/O	ST/TTL(3)	RE1 can also be write control for the parallel slave port, or analog input6.
RE2/$\overline{CS}$/AN7	10	11	27	I/O	ST/TTL(3)	RE2 can also be select control for the parallel slave port, or analog input7.
V_{SS}	12,31	13,34	6,29	P	—	Ground reference for logic and I/O pins.
V_{DD}	11,32	12,35	7,28	P	—	Positive supply for logic and I/O pins.
NC	—	1,17,28, 40	12,13, 33,34		—	These pins are not internally connected. These pins should be left unconnected.

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 an 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 as general purpose I/O and a TTL input when used in the Parallel Slave Port mode (for interfacing to a microprocessor bus).
4: This buffer is a Schmitt Trigger input when configured in RC oscillator mode and a CMOS input otherwise.

15.0 ELECTRICAL CHARACTERISTICS

Absolute Maximum Ratings †

Ambient temperature under bias .... -55 to +125°C

Storage temperature .... -65°C to +150°C

Voltage on any pin with respect to V_{SS} (except V_{DD}, $\overline{MCLR}$, and RA4) .... -0.3 V to (V_{DD} + 0.3 V)

Voltage on V_{DD} with respect to V_{SS} .... -0.3 to +7.5 V

Voltage on $\overline{MCLR}$ with respect to V_{SS} **(Note 2)** .... 0 to +14 V

Voltage on RA4 with respect to V_{SS} .... 0 to +8.5 V

Total power dissipation **(Note 1)** .... 1.0 W

Maximum current out of V_{SS} pin .... 300 mA

Maximum current into V_{DD} pin .... 250 mA

Input clamp current, I_{IK} (V_I < 0 or V_I > V_{DD}) .... ± 20 mA

Output clamp current, I_{OK} (V_O < 0 or V_O > V_{DD}) .... ± 20 mA

Maximum output current sunk by any I/O pin .... 25 mA

Maximum output current sourced by any I/O pin .... 25 mA

Maximum current sunk by PORTA, PORTB, and PORTE (combined) **(Note 3)** .... 200 mA

Maximum current sourced by PORTA, PORTB, and PORTE (combined) **(Note 3)** .... 200 mA

Maximum current sunk by PORTC and PORTD (combined) **(Note 3)** .... 200 mA

Maximum current sourced by PORTC and PORTD (combined) **(Note 3)** .... 200 mA

Note 1: Power dissipation is calculated as follows: $P_{dis} = V_{DD} \times \{I_{DD} - \sum I_{OH}\} + \sum \{(V_{DD} - V_{OH}) \times I_{OH}\} + \sum(V_{OL} \times I_{OL})$

2: Voltage spikes below V_{SS} at the $\overline{MCLR}$ pin, inducing currents greater than 80 mA, may cause latch-up. Thus, a series resistor of 50-100Ω should be used when applying a "low" level to the $\overline{MCLR}$ pin, rather than pulling this pin directly to V_{SS}.

3: PORTD and PORTE are not implemented on PIC16F873/876 devices.

† NOTICE: Stresses above those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress rating only and functional operation of the device at those or any other conditions above those indicated in the operation listings of this specification is not implied. Exposure to maximum rating conditions for extended periods may affect device reliability.