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JUDUL: **PORTABLE WATER ALARM DETECTOR**

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Date : 19 NOVEMBER 2007

PORTABLE WATER ALARM DETECTOR

LINN WEN TECK

A report submitted in partial fulfillment of the requirements for the award of the degree of Bachelor of Electrical Engineering (Power Systems)

FACULTY OF ELECTRICAL & ELECTRONICS ENGINEERING
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NOVEMBER 2007

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To my beloved family and friends,

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Thank you.

ABSTRACT

One of the most common natural disasters that hit our country is flood. Many lives have perished in this hazardous natural disaster. Early precaution and safety measures can be taken if in anyway the people can be warn about the incoming flood. Most of those who died in these floods are not aware about the water accumulating outside their house and when they finally realize about the situation, it is too late for them to do anything. The purpose of this study is to develop a portable water alarm detector that can be used at home to detect the level of water outside the house. Extensive simulations using software were performed and the solution to the flood problem is proposed. Evaluation is based on the needs of the user, the cost of production, the portability of the alarm and the types of output that can be used to warn the user about the flood. Researches done on the water alarm shows that a portable type is more convenient for the users rather than a permanent placed water alarm because the users can know about the status of the level of water from anywhere inside the house. It was found that basic features for a water alarm such as sensors, buzzer alarm and LCD to display the water level with the usage of batteries is the best method. This method showed significant improvement in safety, reliability and user friendliness of the alarm compared to the other alternative methods. The findings suggest that the water alarm should be easy to maintain, easy to use and the most importantly can warn the users.

ABSTRAK

Salah satu bencana alam yang sering kali melanda negara kita ialah banjir. Banyak nyawa dan harta benda yang terkorban dalam bencana alam yang dahsyat ini. Langkah-langkah keselamatan dan berjaga-jaga boleh diambil agar para penduduk dapat mengetahui keadaan semasa ketika berlakunya banjir. Kebanyakkan daripada mereka yang terkorban dalam musibah ini adalah disebabkan oleh ketidaksedaran mereka mengenai bencana yang akan melanda ini dan apabila mereka menyedari keadaan ini, ianya sudah terlambat. Tujuan kajian ini adalah untuk menghasilkan sebuah penggera air mudah alih yang boleh digunakan untuk mengukur ketinggian air di luar kawasan rumah semasa berlakunya bamjir. Kajian mendalam menggunakan perisian computer telah dilakukan and langkah penyelesaian untuk masalah banjir ini telah dicadangkan. Kajian yang dilakukan adalah berdasarkan keperluan pengguna, kos penghasilan projek, kemudahalihan projek dan jenis penggera yang digunakan untuk memberi amaran kepada pengguna. Kajian yang telah dijalankan menunjukkan penggera air mudah alih adalah lebih sesuai untuk kegunaan orang ramai berbanding dengan penggera air yang tetap. Keperluan asas sebuah penggera air seperti LCD, buzzer dan pengesan air dengan penggunaan bateri adalah langkah terbaik dalam penghasilan projek ini. Kaedah ini menunjukkan penambahbaikkan dari segi keselamatan and mudah digunakan berbanding dengan kaedah lain.

TABLE OF CONTENTS

CHAPTER	TITLE		PAGE

CHAPTER	TITLE	PAGE

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 LITERATURE REVIEW

One of the most frequent natural disasters that hit our country is flood. In the most recent flood incident that hit this country, millions worth of properties and hundreds of lives are sacrificed. This scenario is a norm when flood happens because the people are not aware of the incoming disaster.

Some kind of safety measure must be taken to warn the people once the water starts to accumulate outside the house. A water alarm can be used to notify the people about the danger that's coming. The water alarm detector is a self-contained electronic device that sounds an alarm when its sensor is in contact with water. There are two types of water alarm detectors—passive and active. The passive detector uses a 9-volt battery

The moisture sensor is placed on the floor and activates the alarm when it becomes wet. Damp locations or high temperatures may reduce the life of the battery, so the detector should be checked regularly to see if it is working properly. These detectors can be purchased at most home improvement stores.

However, these alarms are permanently placed at the place where water accumulates and the alarm also sounds at the designated place. This type of alarm is not so practical because the sound of the alarm may not be heard by the user. Hence, a portable type water alarm is more suitable for this purpose.

1.2 DESIGN OBJECTIVE

The objective of this project is to develop a portable water alarm detector with LCD display output, buzzer alarm and LED indicators for water level.

The aim of the portable water alarm is to sense the accumulating water outside the house. At the same time, the alarm will alert the user about the water level by using LCD display and LED indicators. A buzzer alarm will sound when the water level reaches a critical level determined by the user.

The height of water that will be displayed by the LCD can be change accordingly to the user's need by programming. The LED indicators will light up one by one according to the level of the water that is accumulating outside the house.

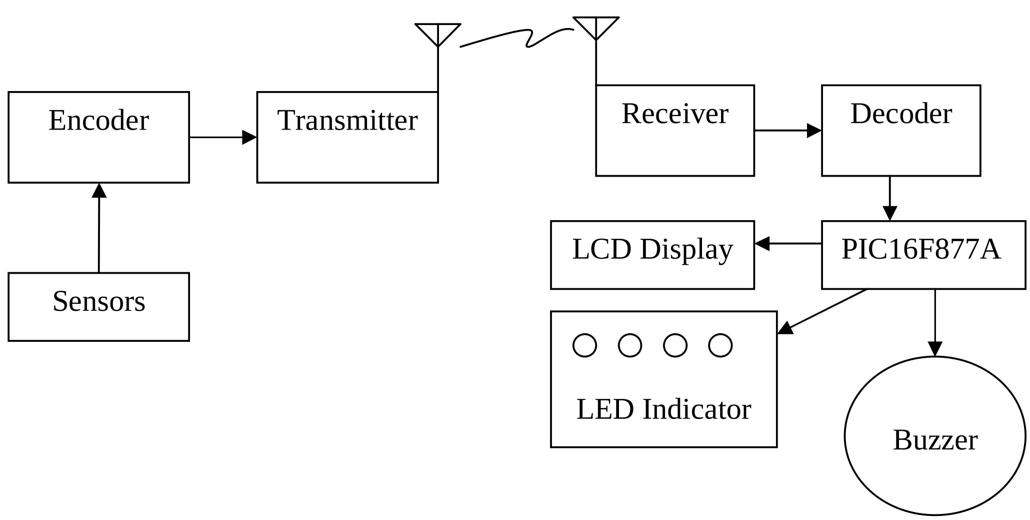

Figure 1.1: Block Diagram for Wireless Communication on Portable Water Alarm

1.3 SCOPE OF PROJECT

The scope of this project is to:

I. Produce a hardware for signal transmission and signal receiving
II. To program a microcontroller to control different outputs
III. To encode and decode data to be send
IV. To use only a 9V battery as power supply

This project consists of a few modules with sub modules. The following are the modules and sub modules throughout the execution of the whole project:

I. Project Research
   a. Types of water alarm in the market
   b. Type of wireless communications (Radio frequency(RF), Infrared etc)
   c. Microcontrollers (PIC16F877A)
   d. Encoders and Decoders

II. Circuit Design, Testing & Assembly
   a. Wireless (Radio Frequency (RF)) communication modules
   b. LCD Display using microcontroller PIC16F877A
   c. Water Level Detector Circuit
   d. Alarm Circuit
   e. LED display

III. Software Development
   a. LCD display to indicate water level
   b. Control the time the alarm sound
   c. Controlling the time of the LED emission

IV. Testing and Analysis

1.4 THESIS OVERVIEW

This thesis is primarily concerned with the understanding and modeling of electronic components and programming. All the work done in this project is presented in 7 chapters:

Chapter 2 outlines the architecture used to implement the system. This includes the water alarm's water sensing methods and the communication protocol. This is important because it provides the basis for the implementation of the project. The architecture of each subcomponent in the system is described as it is implemented in the system.

Chapter 3 outlines the methodology used in the implementation of the project. This chapter includes the flow of the project development and the flow of the programming used in the project. This is one of the most essential part of the project as it determines the whether the flow of the project is smooth or otherwise.

Chapter 4 provides a description of the water alarm hardware and output system used for this project. It briefly describes the physical structure of the water alarm.

Chapter 5 describes the software that controls for the output of the water alarm developed for the project. It describes the software functionality as an integrated system. The detailed subroutines program is also included.

Chapter 6 covers various testing of each module used and also the integration of the whole system. This is important to demonstrate modular development of a complex system.

Chapter 7 summarizes the overall project design and it's future development.

CHAPTER 2

PROJECT THEORY OF OPERATION

2.1 INTRODUCTION

Design and building a portable water alarm requires high knowledge of a portable water sensor taking into account water sensing ability, communication protocols, alarm output and others. This chapter discusses elaborately the system designs as they have been implemented in the final system design.

2.2 SENSING OF WATER

The sensors used in this project are made of conductors with high conductivity. Conductivity is the measure of the ease at which an electric charge or heat can pass through a material. A conductor is a material which gives very little resistance to the flow of an electric current or thermal energy. Materials are classified as metals, semiconductors, and insulators. Metals are the most conductive conductors and insulators (ceramics, wood, plastics) the least conductive.

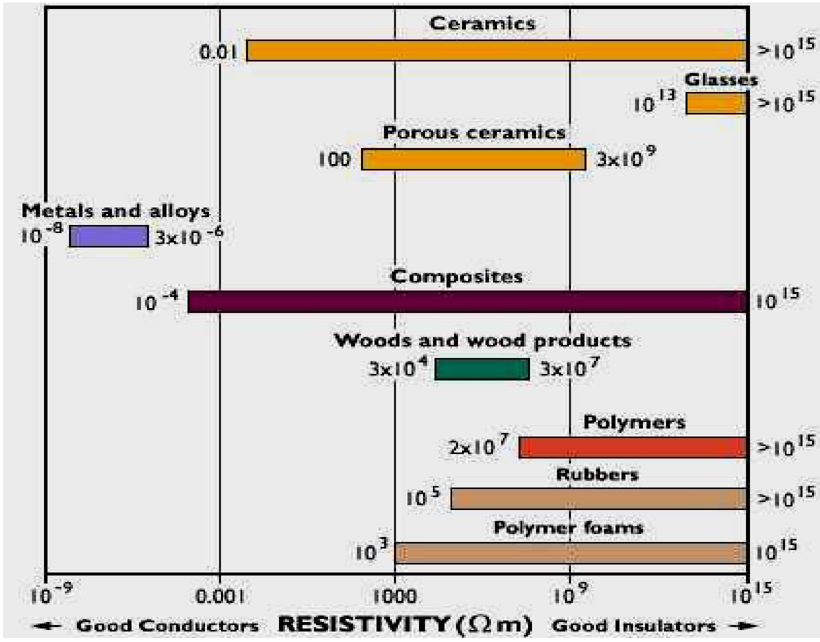

Figure 2.1: Conductors and Insulators

The sensor proposed to be used in this project is of the metals and alloys type. The sensors are to be made from aluminum or copper. One of the aluminum plates will be connected to the power supply at one end and the other aluminum plate will be connected to the encoder. When water comes in contact with the aluminum plates, electricity will flow through the water and activate the encoder.

2.3 TRANSMISSION & RECEPTION

Short for Radio Frequency, RF refers to the frequencies that fall within the electromagnetic spectrum associated with radio wave propagation. When applied to an antenna, RF current creates electromagnetic fields that propagate the applied signal through space. Any RF field has a wavelength that is inversely proportional to the frequency. This means that the frequency of an RF signal is inversely proportional to the wavelength of the field.

The RF signal is widely use in wireless telecommunication. The wide bandwidth of the radio frequency (300kHz-3GHz) makes it easier to detect and the frequency range can be easily adjusted without having to worry that the frequency tuned is out of range. Comparing to infrared signals, RF can penetrates obstacles unlike infrared. The infrared will interrupted when any obstacle comes between the transmitter and receiver. Bluetooth is another choice to replace RF for this project since Bluetooth, like RF, does not get interrupted by any obstacle that comes between the transmitter and receiver. However, the range cover by Bluetooth signal is very limited (around 10m- 15m).

Hence, RF is the most ideal for the wireless signal transmission of this project. The range that can be covered by the RF is around 100m for AM and 150m for FM. Besides that, the RF transmitter and receiver are much cheaper than the other device like Bluetooth.

2.4 ALARM OUTPUT

The outputs of this project consist of:

a. LCD Display
b. Buzzer
c. LED Indicators

Short for Liquid Crystal Display, LCD has the ability to display not just numbers but also letters, words and all manner of symbols, making them a good deal more versatile than the familiar 7-segment, light emitting diode (LED) display. The following table shows the standard LCD character table:

Table 1.1: Standard LCD Character Table

A buzzer is a device that emits sound when it is connected to the supply. In this project, the buzzer is only used when the water level reaches the critical level. At the other water level, the buzzer does not emit any sound.

The LED indicators consist of 4 LEDs, each representing a water level. Each of the LED will light up indicating the water level represented by the LED. For example, LED1 lights up to represent water level 1 and LED1 and 2 light up to represent water level 2 and so on.

2.5 OVERALL OPERATION

This project as a whole demonstrates the importance of keeping track of the water level when the water starts to accumulates. The transmission and reception of data from the water alarm to the output alarm requires careful construction so that data can be transmitted and received accordingly.

On theory, the water alarm should only operate when water is sensed by the water sensors. Then the data is transmitted to the alarm output where it will alert the user about the condition.

In detail, the circuit operation begins with the sensing of water by the sensors. The sensors are arranged so that they from 4 levels. One side of the sensor is connected to the input supply and the other side is connected to the input of the encoder. The encoder will in turn encode the 4 bits of data and then transmit it to the output alarm.

The received data is then decoded back into 4 bits data again. The decode data are inputted into the microcontroller. The microcontroller will scan each of the input pins of the microcontroller and when the conditions are fulfilled, the commands inside the microcontroller will be executed.

For example, when the input of the microcontroller is 0001, the LCD will display the word “The Water Level is 0.1m” and LED 1 will light up and so on. When the input reaches 1111, the LCD will display “Danger! Critical Water Level”, all 4 LEDs will light up and the buzzer will sound. These different inputs will produce different output to the alarm and LCD display.

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

This chapter will cover the process involved in the development of the portable water alarm detector. The process involved in the development of the project is very important so that the process is smooth without any difficulties. The processes involved are under constant changes due to unexpected changes or complications. Flow of the development of the project is divided into 2 that are the hardware and software. The hardware part is divided into 2 parts that are the water sensor part and the output alarm part.

3.2 FLOW CHART FOR PROJECT DEVELOPMENT

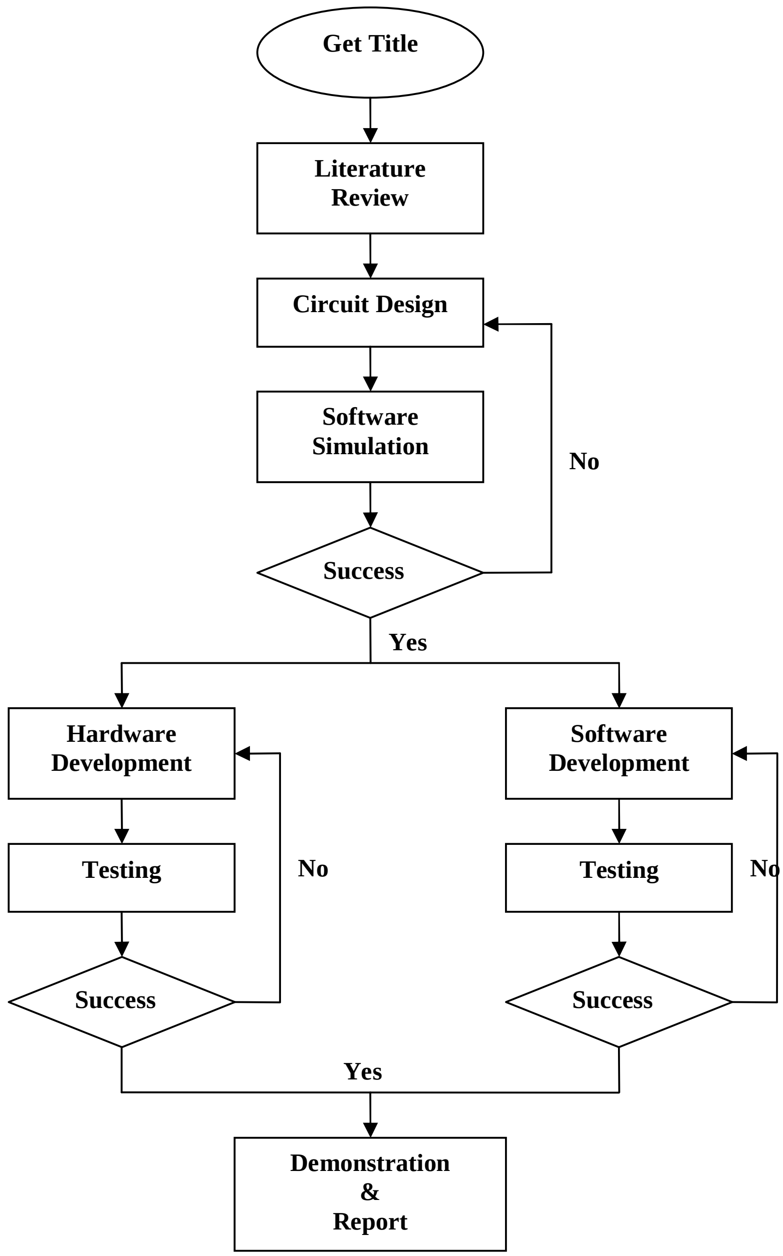

Figure 3.1: Flow Chart for Project Development

The project begins with literature reviews of the project. The literature reviews will investigate and comment about the current water alarm detector in the market. The literature reviews will help to produce a project that is not yet available in the market. After the literature review, the project will continue with the circuit design of the water alarm. With the information gotten from the literature review, the circuit can be design from various parts of projects done. The combinations of all these circuitry from the literature review, a new circuit can be produced.

A circuit simulation using software is done after the circuit design to ensure that the circuit can work according to the required specifications. It is also to ensure that the current and voltage in the circuit is not to large so that it will not spoil the circuit. If the simulation is successful, the project continues with hardware and software development. If not the circuit simulation is continued until it is successful.

After the hardware is built and the program is written, the hardware and program undergoes testing. If the testing is successful, the project is demonstrated to the panel. However, if the testing fails, the hardware built and the program written will be re-tested again until it is successful.

3.3 FLOW CHART FOR HARDWARE DEVELOPMENT

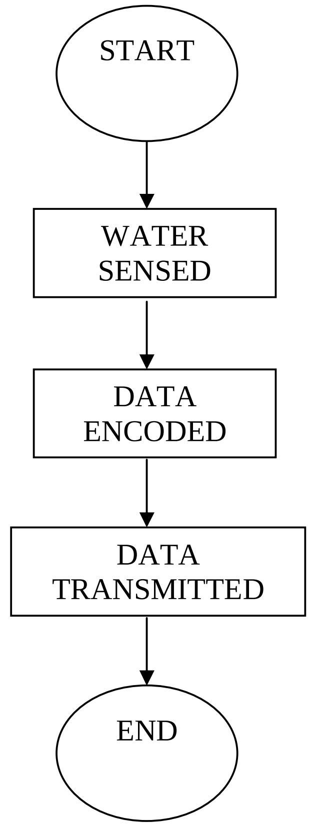

Figure 3.2: Flow Chart for Water Sensor Operation

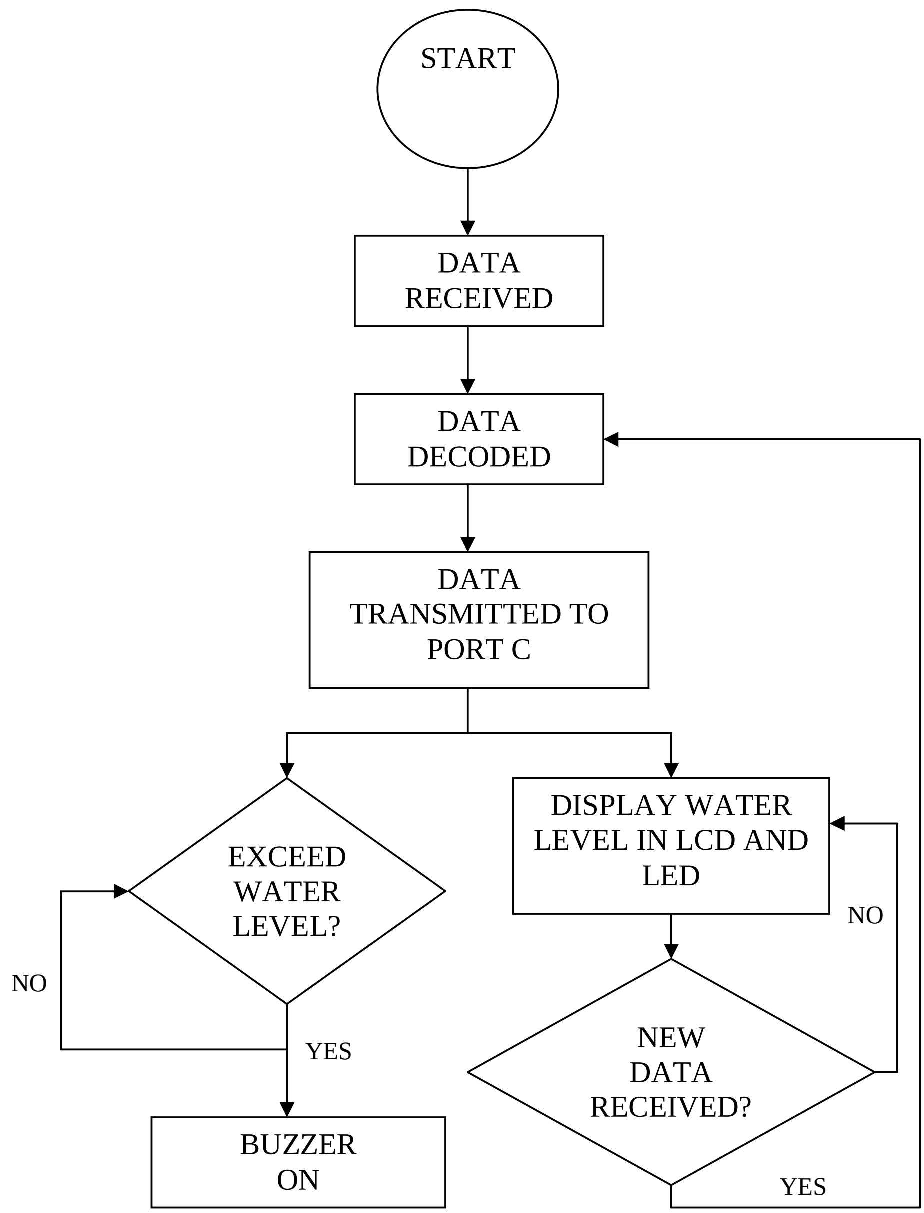

Figure 3.3: Flow Chart for Output Alarm Development

The hardware development starts with the development of the water sensor part. Once water is sensed, the data is encoded and then transmitted to the output alarm circuit. The received data in turn is decoded and transmitted into the PORT C of the microcontroller.

The decoded data will then run the command in the microcontroller. Then the command will activate the LCD, LED and the buzzer if necessary. The process continues until the system is reset by the user.

3.4 FLOW CHART FOR SOFTWARE DEVELOPMENT

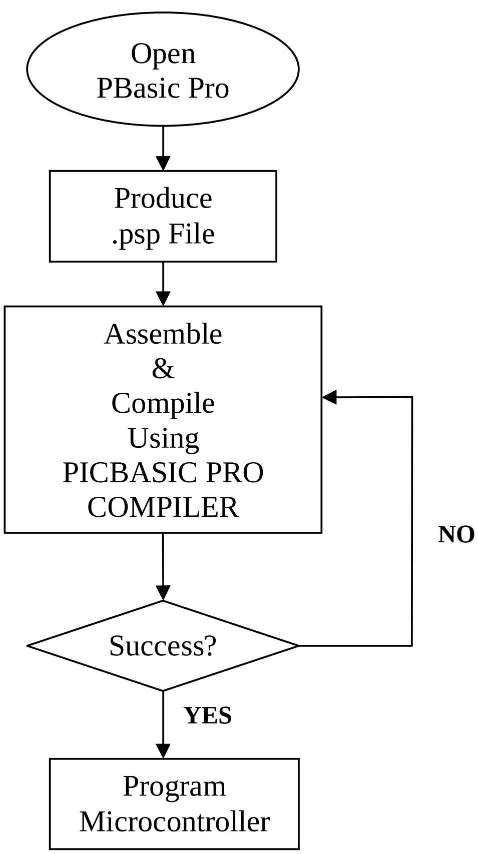

Figure 3.4: Programming Flowchart

The projects programming can be written using 2 methods that are using assembly language or high level language. However, for this project, high level language is used. The high level language will be written using a software called PBasic Pro which is used to program PIC. The first step to using the software is to write a program using PBasic Pro. Then save the written program to produce a .psp file. Assemble and compile the .psp file to make sure that there is no error in the file. If there is no error in the program, then the program can be transferred into the microcontroller. However, if there are errors, the program is to be re-written again.

3.5 SUMMARY

The methodologies used in this process are essential so that no important steps are skipped. Skipping any of these processes may cause failure to the outcome of the project. The steps are done is to helped us troubleshoot the hardware and software if any complications should arise.

CHAPTER 4

SYSTEM HARDWARE DESIGN

4.1 INTRODUCTION

This chapter will cover the main component of the thesis that is the hardware of the portable water alarm detector. This includes the system's hardware development and explanations on the sub-modules involved in producing the project. Each sub-module will discuss how the sub-modules operate and the integration of these sub-modules to complete the whole project. It briefly describes the physical structure of the water alarm. The portable water alarm detector is a complex device to produce but with proper understanding of the internal structure of the hardware, we can make the task easier to accomplish. Each of these sub-modules is essential to the project and the success of each sub-modules are vital to the completion of the project.

4.2 PIC16F877A

A PIC16F877A would be able to do various task. The PIC16F877A has 5 ports that can be configured to either an input or output port. Some of the pins have more than 1 function and these functions can be activated with special commands. The PIC16F877A microcontroller features include:

- 10-bit, up to 8-channel Analog-to-Digital Converter (A/D)
- Brown-out Reset (BOR)
- Analog Comparator module with:
  - Two analog comparators
  - Programmable on-chip voltage reference (V_{REF}) module
  - Programmable input multiplexing from device inputs and internal voltage references
  - Comparator outputs are externally accessible
- Programmable code protection
- Power saving Sleep mode
- Selectable oscillator options
- In-Circuit Debug (ICD) via two pins
- 100,000 erase/write cycle Enhanced Flash program memory typical
- 1,000,000 erase/write cycle Data EEPROM memory typical
- Data EEPROM Retention > 40 years
- Self-reprogrammable under software control
- In-Circuit Serial Programming™ (ICSP™) via two pins
- Single-supply 5V In-Circuit Serial Programming
- Watchdog Timer (WDT) with its own on-chip RC oscillator for reliable operation
- Programmable code protection

Figure 4.1 illustrate the architecture of the PIC16F877A port functionality.

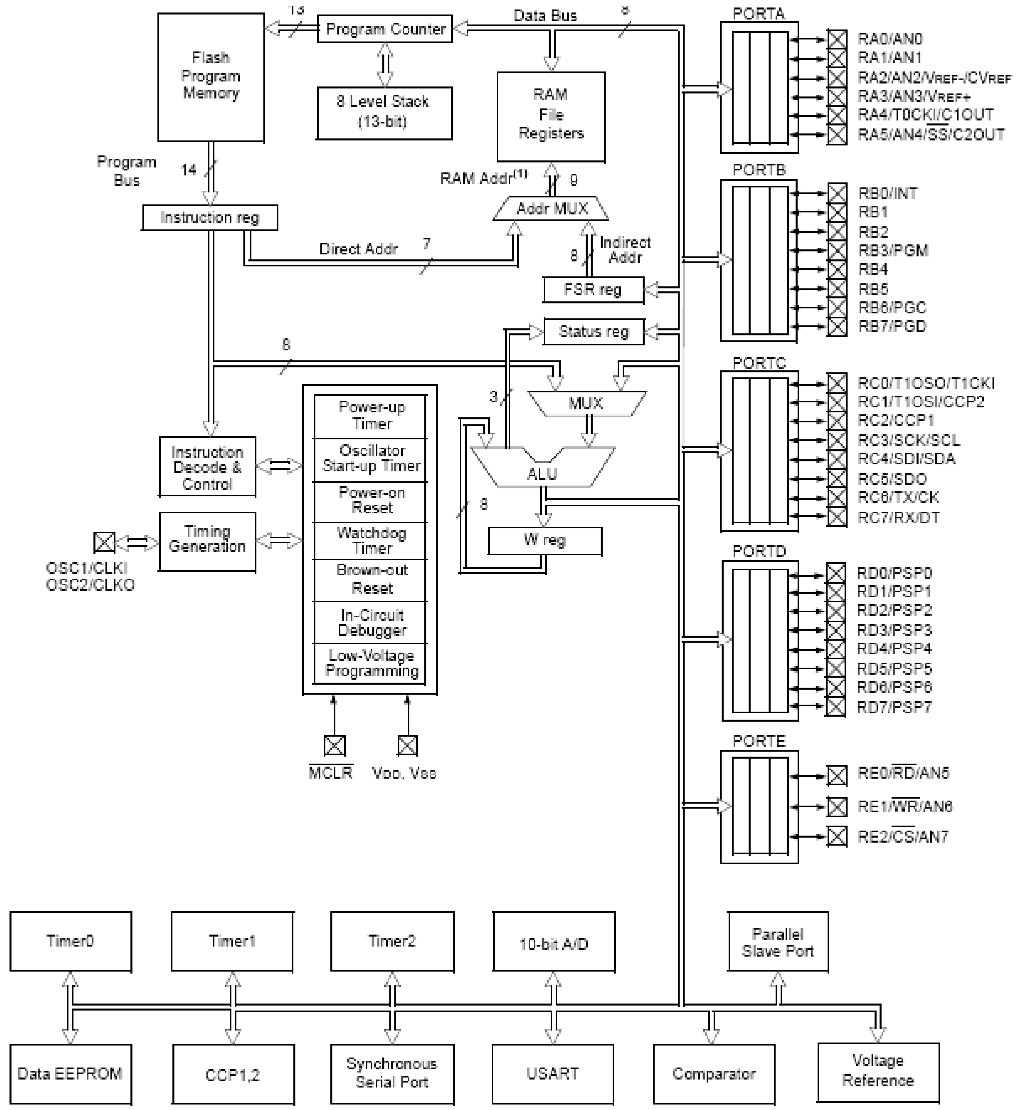

Figure 4.1: Block Diagram of PIC16F877A

4.2.1 OPERATION

There are three memory blocks in each of the PIC16F87XA devices. The program memory and data memory have separate buses so that concurrent access can occur The PIC16F87XA devices have a 13-bit program counter capable of addressing an 8K word x 14 bit program memory space. The PIC16F876A/877A devices have 8K words x 14 bits of Flash program memory, while PIC16F873A/874A devices have 4K words x 14 bits. Accessing a location above the physically implemented address will cause a wraparound. The Reset vector is at 0000h and the interrupt vector is at 0004h.

The data memory is partitioned into multiple banks which contain the General Purpose Registers and the Special Function Registers. Bits RP1 (Status<6>) and RP0 (Status<5>) are the bank select bits. Each bank extends up to 7Fh (128 bytes). The lower locations of each bank are reserved for the Special Function Registers. Above the Special Function Registers are General Purpose Registers, implemented as static RAM. All implemented banks contain Special Function Registers. Some frequently used Special Function Registers from one bank may be mirrored in another bank for code reduction and quicker access.

The Special Function Registers are registers used by the CPU and peripheral modules for controlling the desired operation of the device. These registers are implemented as static RAM. The Special Function Registers can be classified into two sets: core (CPU) and peripheral.

4.2.2 PIC16F877A PIN ASSIGNMENTS

The water portable water alarm detector has three main functions. One of these functions is to display the water level that starts to accumulate outside the house. The other functions are the LED indicators and buzzer alarm. For each of the specific function, specific ports are assigned to suit the requirements. Table 4.1(a) & 4.1(b) describes in detail the PIC16F877A pin assignments for every function of the water alarm.

	Function	**Pin Assignment**	**I/O**
LED INDICATOR	Water Level 1	PORTA.1	Output
	Water Level 2	PORTB.1	Output
	Water Level 3	PORTB.3	Output
	Water Level 4	PORTB.4	Output
DATA INPUT FROM DECODER	Input Data 1	PORTC.0	Input
	Input Data 2	PORTC.1	Input
	Input Data 3	PORTC.2	Input
	Input Data 4	PORTC.3	Input
BUZZER	Buzzer Output	PORTB.4	Output

Table 4.1(a): PIC16F877A Pin Assignments

LCD	R/S Select	PORTB.7	Output
	Enable	PORTB.5	Output
	R/$\overline{W}$	PORTB.6	Output
	Data 1 In	PORTD.0	Output
	Data 2 In	PORTD.1	Output
	Data 3 In	PORTD.2	Output
	Data 4 In	PORTD.3	Output
	Data 5 In	PORTD.4	Output
	Data 6 In	PORTD.5	Output
	Data 7 In	PORTD.6	Output
	Data 8 In	PORTD.7	Output

Table 4.1(b): PIC16F877A Pin Assignments (Continuation)

As can be seen from the table, all the I/O ports of the PIC16F877A are utilized. This shows that the PIC16F877A has served well the requirements to build a portable water alarm detector with the ability to sense water, display the level of water, warned the user and the wireless communication. The schematics and hardware design for each function of the portable water alarm will be depicted in the following sub-topics.

4.3 FM WIRELESS SYSTEM MODULES

This module consists of four different components. They are the encoder, decoder, transmitter and receiver modules. Each one is placed on the water sensor and the output alarm as shown in Figure 4.2.

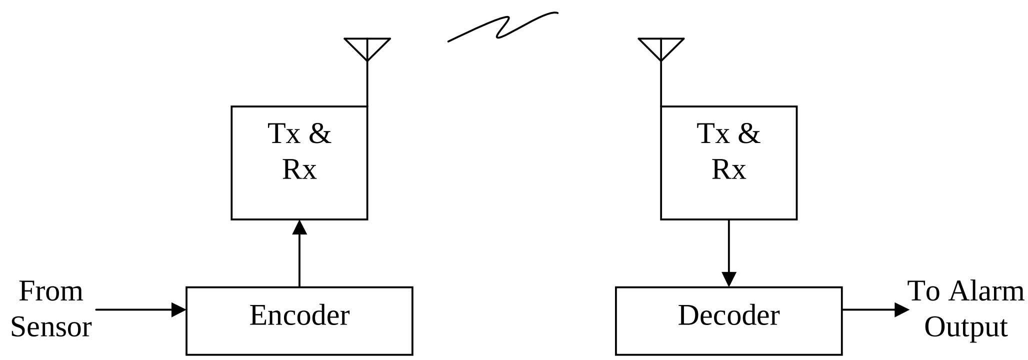

Figure 4.2: FM Wireless as Communication Medium

In order to transmit data to a specific receiver, both the encoder and decoder must have the same address. Both the transmitter and receiver must also be of the same frequency in order to transmit the data. This is done by implementing a half-duplex transmission since carrier of both sets is operating at the frequency of 433MHz. Following are the description of each component for this project.

4.3.1 ENCODER

The encoder implemented in this project is the HT12E from HOLTEK. This encoder has 8-bit address and 4-bit data pins. The encoder is used to send 4-bit data along with address bits appended to it in order to define which receiver would receive the data.

This encoder is chosen due to its ability to encode 12-bit data. The preset address and current data will be encoded and sent together once the transmit enable pin is triggered low.

Other features include:

- Operating voltage
- 2.4V~5V for the HT12A
- 2.4V~12V for the HT12E
- Low power and high noise immunity CMOS technology
- Low standby current: 0.1A (typical) at VDD=5V
- HT12A with a 38kHz carrier for infrared transmission medium

In addition, the input pins for addressing and data can be externally set to VSS (logic LOW) or left open (logic HIGH). Then encoder begins a 4-word transmission cycle upon receipt of a transmission enable. This cycle repeats as long as the transmission enable is held LOW. Once the $\overline{TE}$ returns high, the encoder output completes its final cycle and then stops as shown in Figure 4.3 below.

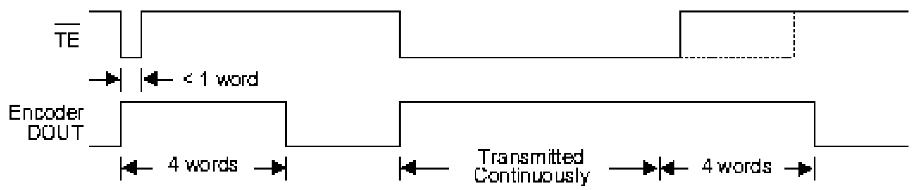

Figure 4.3: HT12E Timing Diagram

The status of each address/data pin can be individually pre-set to logic HIGH or LOW. If a transmission-enable signal is applied, the encoder scans and transmits the status of the 12-bits of address/data serially in the order A0 to AD11. During information transmission, these bits are transmitted with a preceding synchronization bit. If the trigger signal is not applied, the chip enters the standby mode and consumes a reduced current of less than 1µA for a supply voltage of 5V.

The operation of the HT12E encoder is summarized in Figure 4.4 below.

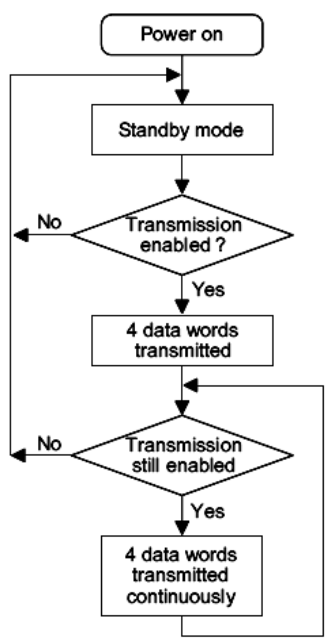

Figure 4.4: HT12E Flow of Operation

4.3.2 DECODER

The HT12D decoder is chosen as it has the same number of addresses and data format as that of HT12E encoder. It consists of 8 address bits and 4 data bits.

It features include that it operates on low power, CMOS technology that provides high noise immunity, low standby current, built in oscillator and which makes it requires a minimal set of external components. Received codes are checked 3 times, plus it has a valid transmission indicator. It is also easy to be interfaced with an RF transmission medium. The HT12D provides 4 latch type data pins whose data remain unchanged until new data are received.

The decoder received data that are transmitted by the encoder and interpret the first N bits of code period as addresses and the last 12-N bits as data, where N is the address code number. A signal in the D_{IN} pin activates the oscillator, which in turn decodes the incoming address and data. The decoder will then check the received address 3 times continuously. If the received address codes all match the contents of the decoder's local address, the 12-N bits of data are decoded to activate the output pins and the V_T is set HIGH to indicate a valid transmission. This will last unless the address code is incorrect or no signal is received.

The oscillator is disabled in the standby mode and activated when a logic HIGH signal applies to the D_{IN} pin. That is to say the D_{IN} should be kept LOW if there is no signal input. Figure 4.5 and Figure 4.6 are the decoding process flowchart and the decoder's timing diagram respectively.

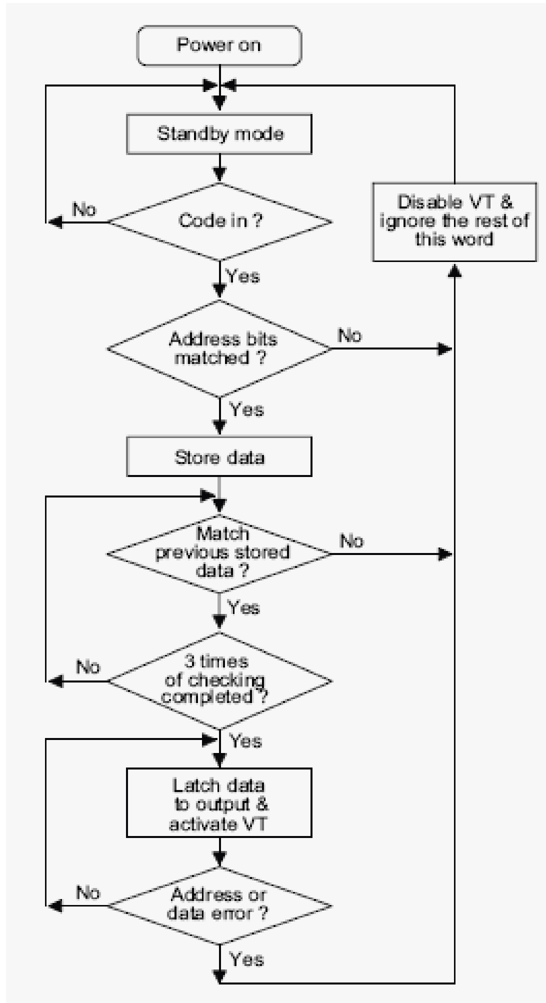

Figure 4.5: HT12D Flowchart

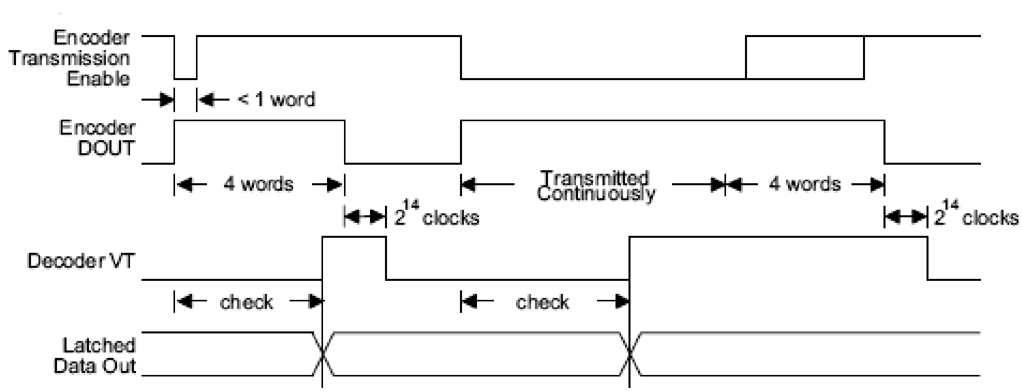

Figure 4.6: HT12D Decoder Timing Diagram

4.3.3 TRANSMITTER MODULE

Transmitter module used is the FMTX1-433a. It is a complete single in line board module capable of transmitting analogue or digital data up to 200m. the transmitter is suitable for general purpose telemetry applications where small size and high data rates are required.

D_{IN} can be in either digital or direct analogue form (AFSK). The input frequency bandwidth ranges from DC to 10kHz. However, it is not possible to pass data with a DC component because of frequency errors and drifts between the transmitter and receiver. The frequency difference between transmitter and receiver will produce a DC offset error which will result in the receiver module producing errors on long high or low pulses which exceed the maximum pulse width specification.

Data should be driven in from a CMOS logic output that and will be the HT12E encoder for this project. The power supply circuit for the CMOS circuit should be the same as that for the transmitter.

4.3.4 RECEIVER MODULE

The FMRX1-433a is a compact board SIL Modules that can be used to capture RF data from the FM transmitter such as the FMTX1-433a as described. When used in remote control system, a range of 200m can be achieved. It is designed to work with the matching FMTX1-433a. With the addition of a simple antenna, the pair may be used to transfer serial data up to 200m. The range of transmission system depends on several factors, primarily the type of antenna employed and the operating environment.

4.3.5 ANTENNA MODULE

Antennas are used in systems such as radio and television broadcasting, point-to-point radio communication, radar, and space exploration. Antennas usually work in air or outer space, but can also be operated under water or even through soil and rock at certain frequencies for short distances.

Physically, an antenna is an arrangement of conductors that generate a radiating electromagnetic field in response to an applied alternating voltage and the associated alternating electric current, or can be placed in an electromagnetic field so that the field will induce an alternating current in the antenna and a voltage between its terminals. Some antenna devices (parabola, horn antenna) just adapt the free space to another type of antenna. For this project, the most suitable antenna to be used is the whip antenna.

For an effective range of transmission, the length of the antenna must be $\frac{1}{4}$ of the wavelength. For this project, the length of the antenna is calculated as below:

$$\lambda = \frac{C}{f}$$

$$\lambda = \frac{3 \times 10^8}{433.92M}$$

$$\lambda = 0.6914m$$

$$\lambda = 69.14cm$$

$$\ell = \frac{1}{4}\lambda$$

$$\ell = 17.285cm$$

Where, λ = wavelength of signal used

ℓ = length of antenna used

f = frequency of signal/transmitter or receiver frequency

C = velocity of propagation

4.4 LCD DISPLAY

Several different liquid crystal technologies exist. “Supertwist” types, for example, offer improved contrast and viewing angle over the older “twistednematic” types. Some modules are available with back-lighting so that they can be viewed in dimly-lit conditions. The back-lighting may be either “electro-luminescent”, requiring a high voltage inverter circuit or simpler LED illumination.

4.4.1 OPERATION

LCDs have RAM onboard that is used for character memory. Most LCDs have more RAM available that is necessary for the displayable area. This RAM can be written using the LCDOUT instruction. The LCDIN instruction allows this RAM to be read. CG (character generator) RAM runs from address $40 to $7f. Display data RAM starts at address $80. See the data sheet for the specific LCD for these addresses and functions.

It is necessary to connect the LCD read/write line to a PICmicro MCU pin so that it may be controlled to select either a read (LCDIN) or write (LCDOUT) operation. Two DEFINEs control the pin address:

```
DEFINE LCD_RWREG PORTE      ‘ LCD read/write pin port
DEFINE LCD_RWBIT 2          ‘ LCD read/write pin bit
```

The LCD is initialized the first time any character or command is sent to it using LCDOUT. If it is powered down and then powered back up for some reason during operation, an internal flag can be reset to tell the program to reinitialize it the next time it uses LCDOUT.

Commands are sent to the LCD by sending a $FE followed by the command. Some useful commands are listed in Table 4.2 below:

Command	Operation
$FE, 1	Clear display
$FE, 2	Return home
$FE, $0C	Cursor off
$FE, $0E	Underline cursor on
$FE, $0F	Blinking cursor on
$FE, $10	Move cursor left one position
$FE, $14	Move cursor right one position
$FE, $80	Move cursor to beginning of first line
$FE, $C0	Move cursor to beginning of second line
$FE, $94	Move cursor to beginning of third line
$FE, $D4	Move cursor to beginning of fourth line

Table 4.2: Common LCD Command

Note that there are commands to move the cursor to the beginning of the different lines of a multi-line display. For most LCDs, the displayed characters and lines are not consecutive in display memory - there can be a break in between locations. For most 16x2 displays, the first line starts at $80 and the second line starts at $C0. The command:

LCDOUT *$FE, $80 + 4*

sets the display to start writing characters at the forth position of the first line. 16x1 displays are usually formatted as 8x2 displays with a break between the memory locations for the first and second 8 characters. 4-line displays also have a mixed up memory map, as shown in the table above.

4.4.2 PIN ASSIGNMENTS

Pin NO.	Symbol	Level	Description
1	VSS	0V	Ground
2	VDD	5.0V	Supply voltage for logic
3	VO	---	Input voltage for LCD
4	RS	H/L	H : Data, L : Instruction code
5	R/W	H/L	H : Read mode, L : Write mode
6	E	H, H → L	Chip enable signal
7	DB0	H/L	Data bit 0
8	DB1	H/L	Data bit 1
9	DB2	H/L	Data bit 2
10	DB3	H/L	Data bit 3
11	DB4	H/L	Data bit 4
12	DB5	H/L	Data bit 5
13	DB6	H/L	Data bit 6
14	DB7	H/L	Data bit 7
15	BLA	4.2V	Back light anode
16	BLK	0V	Back light cathode

Table 4.3: Pin Assignment of LCD

The table above shows the pin assignments of the LCD. The pin assignments are the same for most of the LCD. The 3 most important pin in the LCD are the RS pin, the R/W pin and the enable pin. These 3 pins can be called the control pin of the LCD. The enable pin should be constantly set to HIGH which allows the transmission of data into the LCD and then set to LOW when no data is transmitted into the LCD.

The RS pin is one of the most essential pin in operating the LCD. The RS pin must be in the LOW state to enable the instruction code to be programmed by the microcontroller into the LCD. When the RS pin is HIGH, the LCD will display the instruction code programmed earlier.

The R/W pin should be set to LOW when we want to write instruction code to the LCD and HIGH when we want to read the information in the LCD’s RAM. However, this is rarely done. Hence the R/W pin is usually set to LOW.

4.5 LED INDICATORS

The LED indicators consist of 4 LEDs where each represents a different water level. The LED indicators should light up one by one after the sensor detects water. The first LED will light up when the water reaches level 1 and then the second LED will light together with the first LED when the water level reaches level 2. This process continues until the fourth LED lights up indicating critical water level.

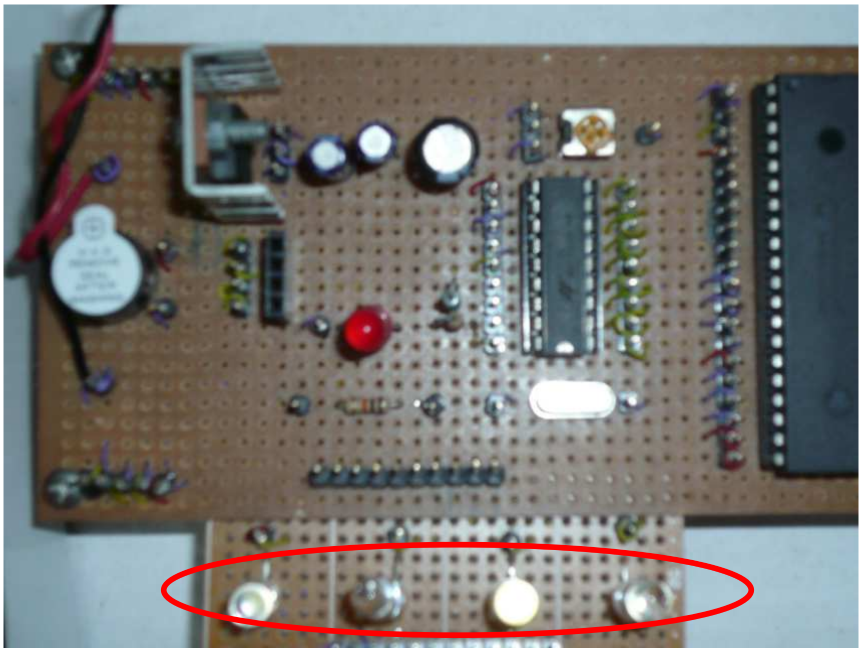

Figure 4.7: LED Indicators

4.6 BUZZER

The buzzer system used in this project is to warn the user about the critical water. The timing of the buzzer is controlled by PORTB.4 of the microcontroller. The buzzer will emit sound when PORTB.4 goes HIGH. The buzzer uses 5V supply and the tone of the buzzer can be varied using the microcontroller.

4.7 SUMMARY

The understanding of each sub-module is critical in order to achieve the desired output. Each of the sub-modules is then to be integrated together into a fully functional circuit. By reviewing each of the sub-modules, we can further explore the usage of the components and fully utilized all the features of these components so that the project can achieve its maximum potential.

CHAPTER 5

SOFTWARE IMPLEMENTATION

5.1 INTRODUCTION

Software development is one of the most important parts of this project. In this chapter, the software implemented in this project will be discussed and covered in detail. The main software of this project is done by using PICBASIC PRO. The programming done in this chapter is used as a controller that controls the output of the LCD, LED indicators and the buzzer. The function of each of the commands used in the program will also be explained in detail so that the functions are clearly understood.

5.2 PIC16F877A PROGRAMMING LANGUAGE

The PIC16F877A programming can be done using two methods which are the assembly language and high level language. Both languages can be used depending on the user. However, for this project, high level language is used because high level language is easier to troubleshoot and saves memory space. Hence, longer programming can be done using high level language.

5.2.1 ASSEMBLY LANGUAGE

Assembly language is one of the languages that can be used to program the PIC16F877A. However, using the assembly language can increase the memory size usage of the program due to the length of the program. For example, to initialize PORTA.0 and make it having a HIGH output:

ASSEMBLY:		HIGH LEVEL
BCF	*STATUS, 1*	*HIGH PORTA.0*
BSF	*STATUS, 0*	
MOVLW	*0XFE*	
MOVWF	*TRISA*	
BCF	*STATUS, 0*	
BCF	*STATUS, 1*	
CLRF	*PORTA*	
BSF	*PORTA, 0*	

Assembly language routines can be a useful adjunct to a PICBasic Pro Compiler program. While in general most tasks can be done completely in BASIC, there are times when it might be necessary to do a particular task faster, or using a smaller amount of code space, or just differently than the compiler does it. At those times it is useful to have the capabilities of an in-line assembler.

It can be beneficial to write most of a program quickly using the PICBasic Pro language and then sprinkle in a few lines of assembly code to increase the functionality. This additional code may be inserted directly into the PBP program or included as another file.

5.2.2 HIGH LEVEL LANGUAGE

High level language is an English-like programming language. The language is much easier to read and write than assembly language. The programming language used is shorter easier to troubleshoot in case of any programming error.

An example of a high level language programming to make a LED blinking for 3 seconds and then stops is shown below:

```
HIGH PORTA.0
PAUSE 3000
LOW PORTA.0
PAUSE 3000
```

From the example above, it is easy to analyze the function of the each line of the program. The "*HIGH PORTA.0*" command initializes PORTA.0 and gives it a HIGH output which makes it to act like a supply voltage that gives out a supply of 5V. Then the "*PAUSE 3000*" will hold the condition in PORTA.0 for 3 seconds and then "*LOW PORTA.0*" will set PORTA.0 to LOW condition which is similar to ground.

From the example of the assembly language in section 5.2.1, it is hard for the user to interpret the command unless the user understands the internal structure of the microcontroller used because the addressing of each part in the microcontroller is different. However, by using high level language, the user does not need to understand the internal structure of the microcontroller.

5.3 PICBASIC PRO COMPILER

The PICBasic Pro Compiler (or PBP) makes it even quicker and easier to program Microchip Technology's powerful PICmicro microcontrollers (MCUs). The English-like BASIC language is much easier to read and write than the quirky Microchip assembly language.

First, start the included or one of the other available IDEs/editors. Select the PICmicro MCU you intend to use from the IDE's drop-down list. Next, create the BASIC source file for the program or open one of the BASIC source files included with PBP. The source file name usually (but isn't required to) ends with the extension .BAS.

The text file that is created must be pure ASCII text. It must not contain any special codes that might be inserted by word processors for their own purposes. You are usually given the option of saving the file as pure DOS or ASCII text by most word processors.

Once satisfied that the program that have been written will work flawlessly, execute the PICBasic Pro Compiler by clicking on the IDE's build or compile button. If DOS is used, enter PBP followed by the name of the text file at a DOS prompt.

Compiling large PICBasic Pro source code files can tax the memory of the PC running the compiler. If an Out of Memory error is issued and the FILES and BUFFERS are set as recommended, an alternate version of PBP can be used. PBPW .EXE has been compiled to make use of all of the memory available to Windows 95, 98, ME, NT, 2000 and XP.

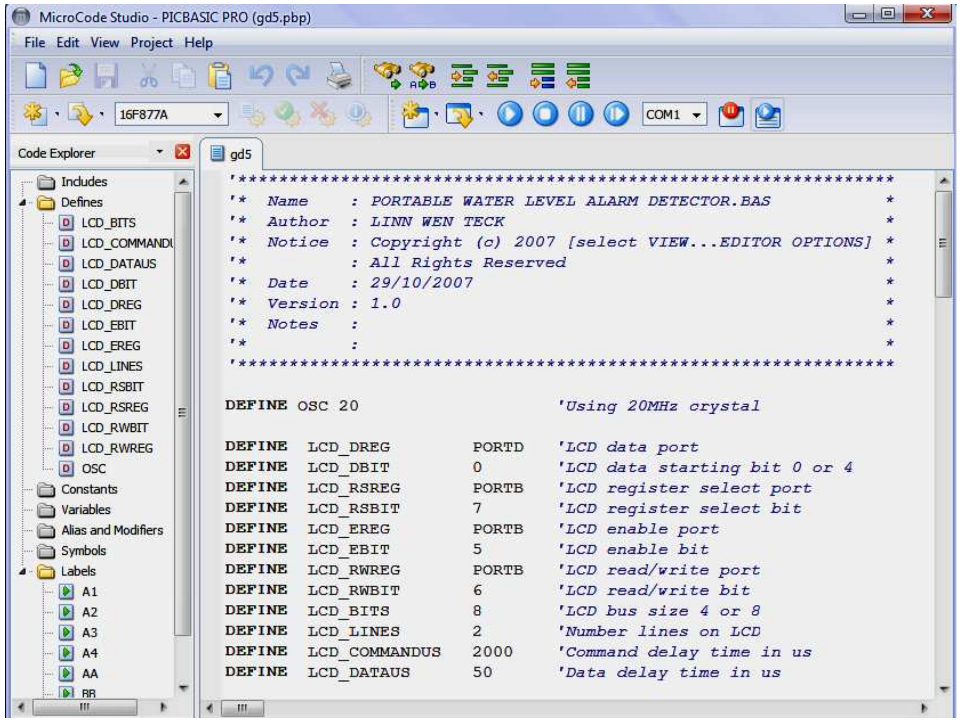

Figure 5.1: PICBASIC PRO Compiler

5.4 SUMMARY

The software implementation is a very integral part of the project. Without proper programming, the output of the water alarm could not be activated. The programming will determine when the buzzer will be turned on, which LED indicator will light up or what the LCD will display. Hence, it is important that this part of the project is understand clearly before continue executing the project

CHAPTER 6

EXPERIMENTAL RESULTS

6.1 INTRODUCTION

This chapter is the main part of the thesis. The results obtained, testing and analysis are done in this chapter. It covers various testing of each module used and also the integration of the whole system. This is important to demonstrate modular development of a complex system. Each module is tested thoroughly before they are integrated with one and another. The integrated output is the final output which is the water alarm detector. Hence, the analysis of each sub-module is done for easier troubleshooting in case of any complications happen. The experimental results that are covered in this chapter are the FM wireless module, the LCD output, the LED indicator output and the buzzer output.

6.2 FM WIRELESS MODULE TEST

The testing of the FM wireless module is divided into 2 major parts. They are:

a. Encoder & Decoder test
b. FM transmitter & Receiver test

The objective of testing of these 2 parts is to determine whether the encoder and decoder are in good conditions or not. It is also to test the stability and the distance of the FM transmitter and receiver.

6.2.1 ENCODER & DECODER TEST

The encoder decoder test is done to test the encoding and decoding of the encoder and decoder. Both HT12E encoder and HT12D decoder are tested in pairs as shown in Figure 6.1. From the figure, D_{OUT} of HT12E is connected directly to D_{IN} of the HT12D. The inputs of HT12E, AD8 through AD11, are connected to push buttons. The R_{OSC} is 1.2MΩ. As for the HT12D, the R_{OSC} is 5.6kΩ. This is to fulfill the requirement of the encoder and decoder to operate at 2.5 kHz and 145 kHz respectively. Outputs of HT12D, D8 to D11, are connected to a 220Ω resistor and LED. Addressing, TE, and the VT pins test are carried out.

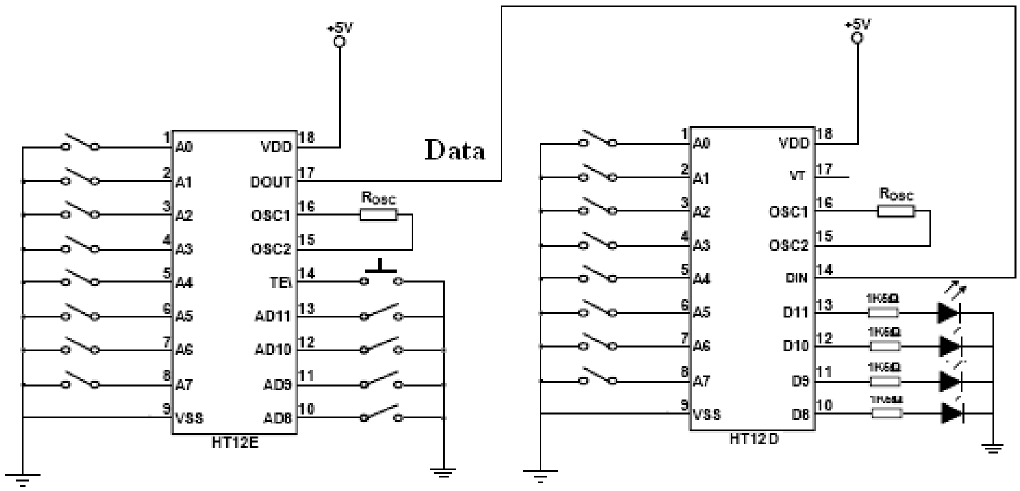

Figure 6.1: Encoder and Decoder Test Circuit

Several addresses have been tested. If the same address is tested, the LED at the decoder lights up accordingly to the button pressed at the encoder. The VT pin goes HIGH (LED light up) whenever TE is pressed. VT goes LOW when TE is HIGH. If different addresses are applied, the latch output of the decoder would not update the data as sent by the encoder. Instead, it holds the previous data latched.

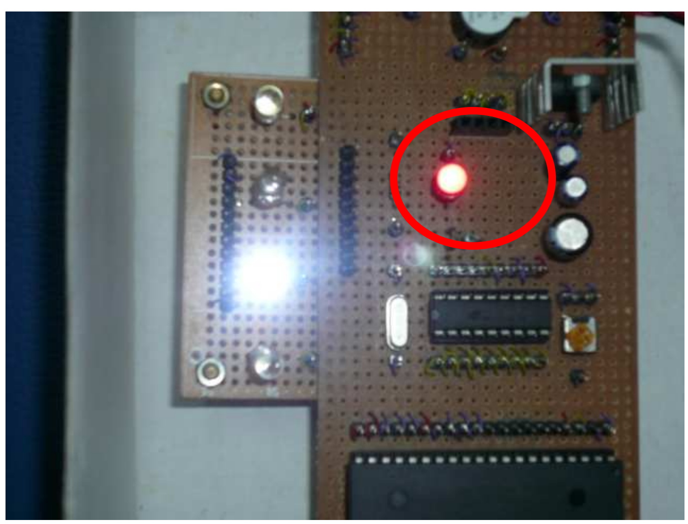

Figure 6.2: LED at VT Pin

6.2.2 FM TRANSMITTER & RECEIVER TEST

In Figure 6.3, the direct wire connection from D_{OUT} to D_{IN} is replaced with the FMTX1-433a and the FMRX1-433a modules.

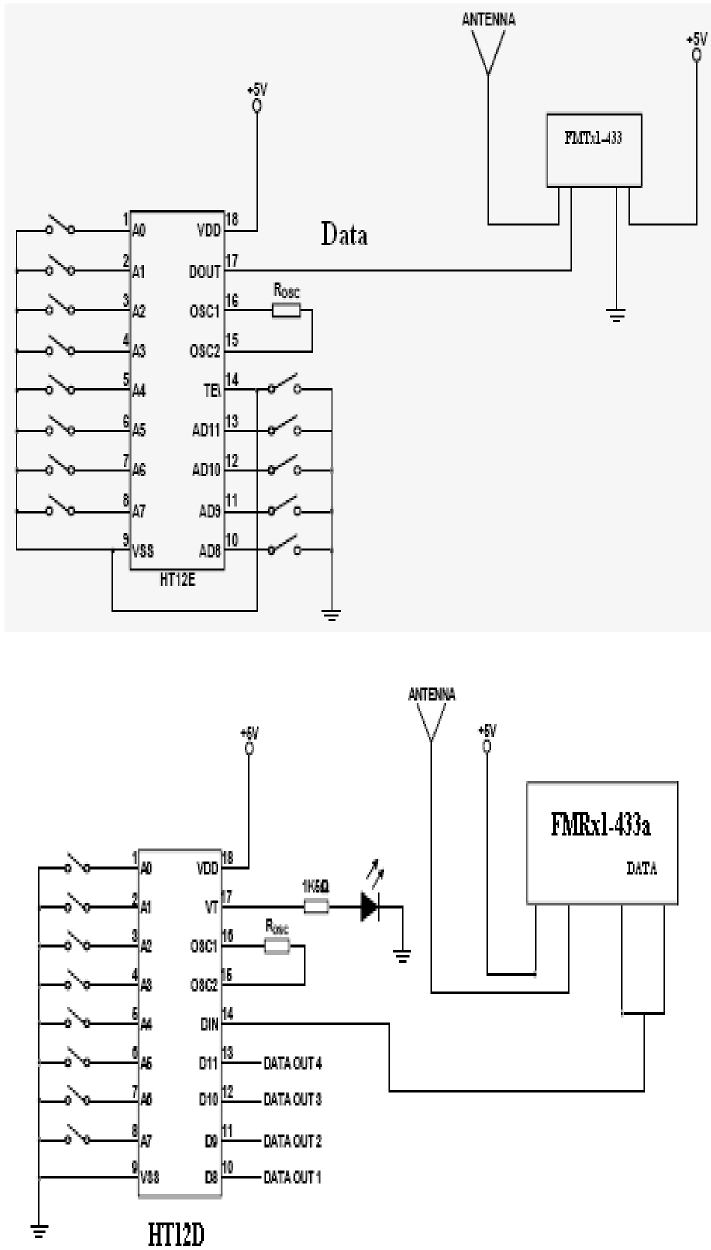

Figure 6.3: FM Wireless Module Testing

The antenna used is an extendable rod adjusted to a length of 17.3cm, as calculated in Chapter 4. For antenna length of 17.3cm and greater, the range achieved is approximately 200 meters. As for the length of 17.3cm and below, the range achieved is less than 40 meters. The distance of the transmitter and receiver also plays an important factor. Data will not be received if the distance is less than a quarter of the wavelength.

6.3 LCD DISPLAY

The figure below show the connection of the LCD display to the microcontroller:

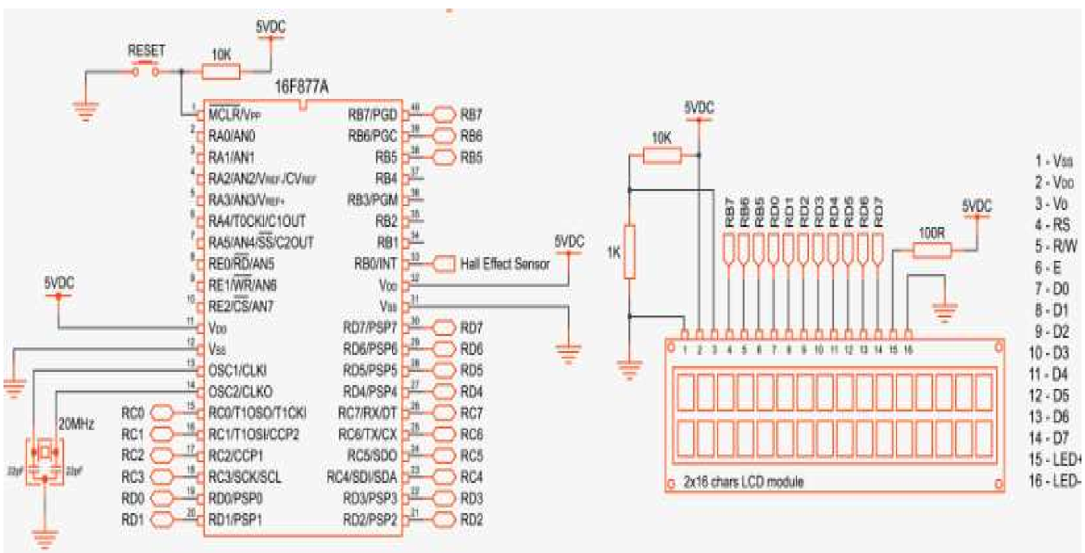

Figure 6.4: LCD Connection to PIC16F877A

When the enable pin is set to LOW, the LCD does not display anything and the current condition is held until the pin goes HIGH. The RS select pin is at HIGH when the LCD is displaying the data and LOW when the data is being transferred into the LCD. The contrast of the LCD can be changed by replacing the 1kΩ resistor.

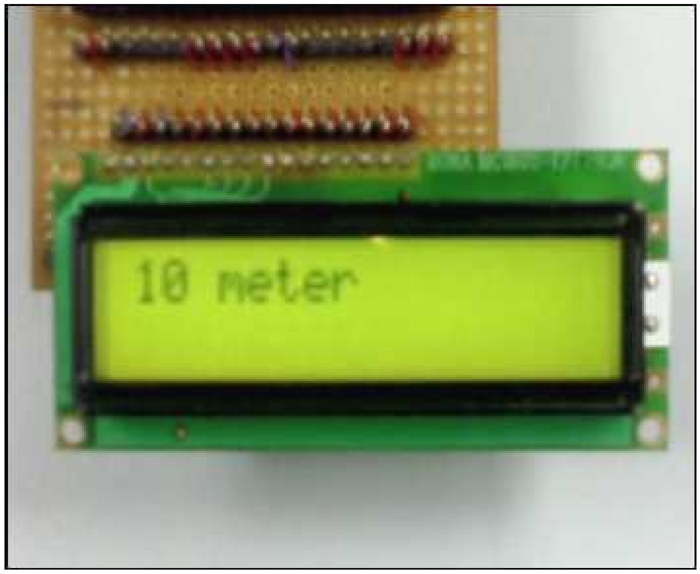

Figure 6.5: LCD Displaying Data

6.4 LED INDICATORS

LED indicator is tested by input voltage supply in PORTC.0 till PORTC.3 of the PIC16F877A. The PIC will scan each of the pins of PORTC and the respective LED will light up. Figure 6.6(a), (b), (c) and (d) shows the LED indicators lighting up.

Figure 6.6(a): LED 1 Lights Up

Figure 6.6(b): LED 1 & 2 Light UP

Figure 6.6(c): LED 1, 2 & 3 Light Up

Figure 6.6(d): LED 1, 2, 3 & 4 Light Up

6.5 SUMMARY

The result obtained from the testing of each sub-module is very interesting. The results are as expected it would be. However, the wireless module proved to be not very stable because of the design problem of the transmitter and receiver. However, this is a small problem and can be overcome. Hence, the results obtained can be said to achieve part of the main objective of the project.

CHAPTER 7

CONCLUSIONS

7.1 CONCLUSION

This project has successfully developed a portable water alarm detector. To implement the system, the water alarm is constructed from scratch using the PIC16F877A microcontroller along with sensors, LCD display, LED indicators and buzzer.

Communications is established between the water sensors and the output alarm using the FM wireless transmitter and receiver. Results show that the length of the antenna plays an important part in the transmission and reception. As for data transfer, it proves that acknowledged protocol communication provides the best data communication reliability.

In addition, sensors play an important role is the water alarm. Various type of sensors are applied to implement water sensing and data acquisition but finally only the copper sensors provides desirable results at the lowest cost

7.2 FUTURE IMPROVEMENTS

This project has successfully demonstrates a wireless communication for a portable water alarm detector. Future work on this project may include:

- A touch screen LCD and a motor can be added to the water alarm so that the water alarm can be implemented to the industry. The motor's function is to control the water pump. When the level of water increases or decreases, the motor can be start up to pump in or out water from the tank. The LCD touch screen can be used to start up the motor and also stops it.

- An alarm can be sent to the user no matter where the user is. An example is a warning message will be send to the user's mobile phone no matter where the user is. The message can be send using GPRS.

- The water alarm can be used to determine the content or type of liquid that is measuring. For example, the content of a tank in a chemical plant can be determined by measuring the output voltage that is produced. This is because different type of liquid produces different voltage level due to the content of the liquids

- More precise sensing methods can be employed. For example, using the change of resistivity of a metal to detect the level of water.

- Addition of a battery charging system that can charge the battery when is low in supply.

7.2.1 COSTING AND COMMERCIALIZTION

The total cost used to produce this project is RM348.00. The costs of the project consist of the cost electronic components. The most expensive component used in the project is the pair of transmitter and receiver which cost RM75.00. The production cost of this project can be reduced if the components are bought in bulk.

This project can be commercialized after several features recommended are added to improve the functionality of the project. The project was originally produced to be used at homes to warn users about the water level outside the house but after the recommended features are added the project can be used in the water tanks in the industries.

With the additional features, the water alarm can be used to control the level of water in the water tanks. The water alarm can give an output command to the motor pump connected to it and it can pump in or pump out water into the tanks.

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APPENDIX A

HT12E ENCODER DATA SHEETS

HOLTEK

HT12A/HT12E
2^{12} Series of Encoders

Features

- Operating voltage
  - 2.4V~5V for the HT12A
  - 2.4V~12V for the HT12E
- Low power and high noise immunity CMOS technology
- Low standby current: 0.1μA (typ.) at V_{DD}=5V
- HT12A with a 38kHz carrier for infrared transmission medium
- Minimum transmission word
  - Four words for the HT12E
  - One word for the HT12A
- Built-in oscillator needs only 5% resistor
- Data code has positive polarity
- Minimal external components
- HT12A/E: 18-pin DIP/20-pin SOP package

Applications

- Burglar alarm system
- Smoke and fire alarm system
- Garage door controllers
- Car door controllers
- Car alarm system
- Security system
- Cordless telephones
- Other remote control systems

General Description

The 2^{12} encoders are a series of CMOS LSIs for remote control system applications. They are capable of encoding information which consists of N address bits and 12–N data bits. Each address/data input can be set to one of the two logic states. The programmed addresses/data are transmitted together with the header bits via an RF or an infrared transmission medium upon receipt of a trigger signal. The capability to select a $\overline{TE}$ trigger on the HT12E or a DATA trigger on the HT12A further enhances the application flexibility of the 2^{12} series of encoders. The HT12A additionally provides a 38kHz carrier for infrared systems.

Selection Table

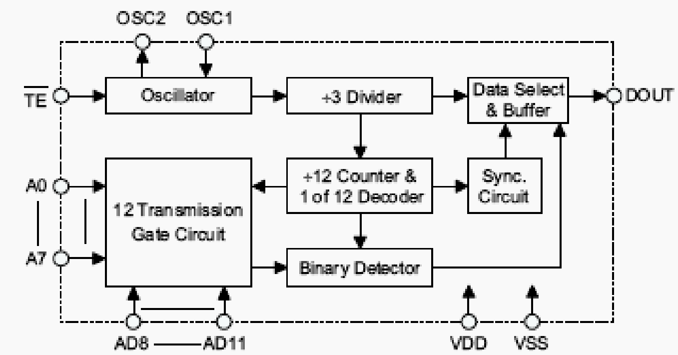
Function / Part No.	Address No.	Address/ Data No.	Data No.	Oscillator	Trigger	Package	Carrier Output	Negative Polarity
HT12A	8	0	4	455kHz resonator	D8~D11	18 DIP 20 SOP	38kHz	No
HT12E	8	4	0	RC oscillator	$\overline{TE}$	18 DIP 20 SOP	No	No

Note: Address/Data represents pins that can be address or data according to the decoder requirement.

Block Diagram

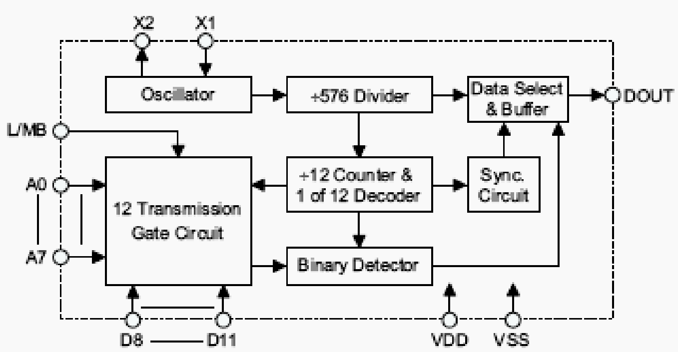
$\overline{TE}$ trigger

HT12E



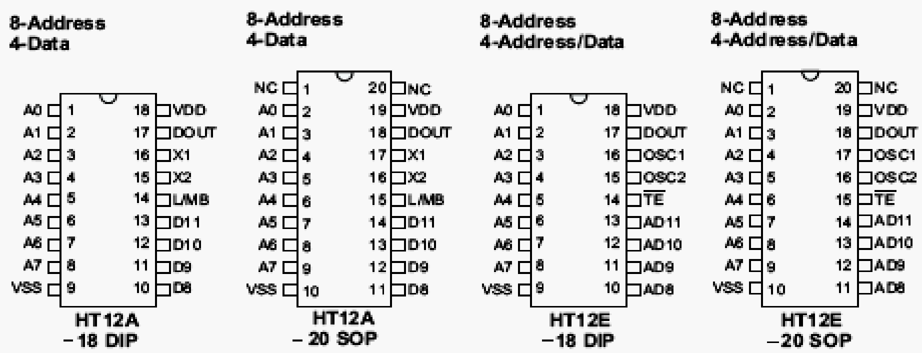
DATA trigger

HT12A



Note: The address data pins are available in various combinations (refer to the address/data table).

Pin Assignment



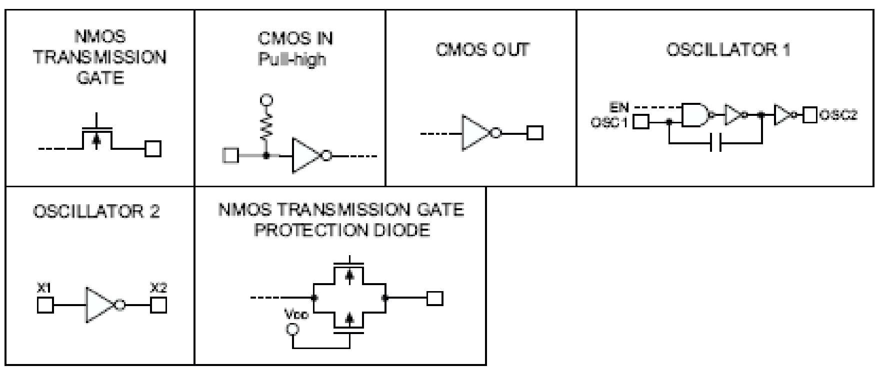
Pin Description

Pin Name	I/O	Internal Connection	Description
A0~A7	I	CMOS IN Pull-high (HT12A) NMOS TRANSMISSION GATE PROTECTION DIODE (HT12E)	Input pins for address A0~A7 setting These pins can be externally set to VSS or left open
AD8~AD11	I	NMOS TRANSMISSION GATE PROTECTION DIODE (HT12E)	Input pins for address/data AD8~AD11 setting These pins can be externally set to VSS or left open
D8~D11	I	CMOS IN Pull-high	Input pins for data D8~D11 setting and transmission enable, active low These pins should be externally set to VSS or left open (see Note)
DOUT	O	CMOS OUT	Encoder data serial transmission output
L/MB	I	CMOS IN Pull-high	Latch/Momentary transmission format selection pin: Latch: Floating or VDD Momentary: VSS

Pin Name	I/O	Internal Connection	Description
$\overline{TE}$	I	CMOS IN Pull-high	Transmission enable, active low (see Note)
OSC1	I	OSCILLATOR 1	Oscillator input pin
OSC2	O	OSCILLATOR 1	Oscillator output pin
X1	I	OSCILLATOR 2	455kHz resonator oscillator input
X2	O	OSCILLATOR 2	455kHz resonator oscillator output
VSS	I	—	Negative power supply, grounds
VDD	I	—	Positive power supply

Note: D8~D11 are all data input and transmission enable pins of the HT12A.
$\overline{TE}$ is a transmission enable pin of the HT12E.

Approximate internal connections



Absolute Maximum Ratings

Supply Voltage (HT12A) ....–0.3V to 5.5V

Input Voltage....................V_{SS}–0.3 to V_{DD}+0.3V

Operating Temperature..............–20°C to 75°C

Supply Voltage (HT12E) ....–0.3V to 13V

Storage Temperature................–50°C to 125°C

Note: These are stress ratings only. Stresses exceeding the range specified under "Absolute Maximum Ratings" may cause substantial damage to the device. Functional operation of this device at other conditions beyond those listed in the specification is not implied and prolonged exposure to extreme conditions may affect device reliability.

Electrical Characteristics

HT12A Ta=25°C

Symbol	Parameter	Test Conditions		Min.	Typ.	Max.	Unit
		V_{DD}	Conditions				
V_{DD}	Operating Voltage	—	—	2.4	3	5	V
I_{STB}	Standby Current	3V	Oscillator stops	—	0.1	1	μA
		5V		—	0.1	1	μA
I_{DD}	Operating Current	3V	No load f_{OSC}=455kHz	—	200	400	μA
		5V		—	400	800	μA
I_{DOUT}	Output Drive Current	5V	$V_{OH}=0.9V_{DD}$ (Source)	–1	–1.6	—	mA
			$V_{OL}=0.1V_{DD}$ (Sink)	2	3.2	—	mA
V_{IH}	"H" Input Voltage	—	—	$0.8V_{DD}$	—	V_{DD}	V
V_{IL}	"L" Input Voltage	—	—	0	—	$0.2V_{DD}$	V
R_{DATA}	D8~D11 Pull-high Resistance	5V	V_{DATA}=0V	—	150	300	kΩ

HT12E Ta=25°C

Symbol	Parameter	Test Conditions		Min.	Typ.	Max.	Unit
		V_{DD}	Conditions				
V_{DD}	Operating Voltage	—	—	2.4	5	12	V
I_{STB}	Standby Current	3V	Oscillator stops	—	0.1	1	μA
		12V		—	2	4	μA
I_{DD}	Operating Current	3V	No load f_{OSC}=3kHz	—	40	80	μA
		12V		—	150	300	μA
I_{DOUT}	Output Drive Current	5V	$V_{OH}=0.9V_{DD}$ (Source)	–1	–1.6	—	mA
			$V_{OL}=0.1V_{DD}$ (Sink)	1	1.6	—	mA
V_{IH}	"H" Input Voltage	—	—	$0.8V_{DD}$	—	V_{DD}	V
V_{IL}	"L" Input Voltage	—	—	0	—	$0.2V_{DD}$	V
f_{OSC}	Oscillator Frequency	5V	R_{OSC}=1.1MΩ	—	3	—	kHz
$R_{\overline{TE}}$	$\overline{TE}$ Pull-high Resistance	5V	$V_{\overline{TE}}$=0V	—	1.5	3	MΩ

APPENDIX B

HT12D DECODERS DATA SHEETS

HOLTEK

2^{12} Series of Decoders

Features

- Operating voltage: 2.4V~12V
- Low power and high noise immunity CMOS technology
- Low standby current
- Capable of decoding 12 bits of information
- Pair with Holtek's 2^{12} series of encoders
- Binary address setting
- Received codes are checked 3 times
- Address/Data number combination
  - HT12D: 8 address bits and 4 data bits
  - HT12F: 12 address bits only
- Built-in oscillator needs only 5% resistor
- Valid transmission indicator
- Easy interface with an RF or an infrared transmission medium
- Minimal external components

Applications

- Burglar alarm system
- Smoke and fire alarm system
- Garage door controllers
- Car door controllers
- Car alarm system
- Security system
- Cordless telephones
- Other remote control systems

General Description

The 2^{12} decoders are a series of CMOS LSIs for remote control system applications. They are paired with Holtek's 2^{12} series of encoders (refer to the encoder/decoder cross reference table). For proper operation, a pair of encoder/decoder with the same number of addresses and data format should be chosen.

The decoders receive serial addresses and data from a programmed 2^{12} series of encoders that are transmitted by a carrier using an RF or an IR transmission medium. They compare the serial input data three times continuously with their local addresses. If no error or unmatched codes are found, the input data codes are decoded and then transferred to the output pins. The VT pin also goes high to indicate a valid transmission.

The 2^{12} series of decoders are capable of decoding informations that consist of N bits of address and 12–N bits of data. Of this series, the HT12D is arranged to provide 8 address bits and 4 data bits, and HT12F is used to decode 12 bits of address information.

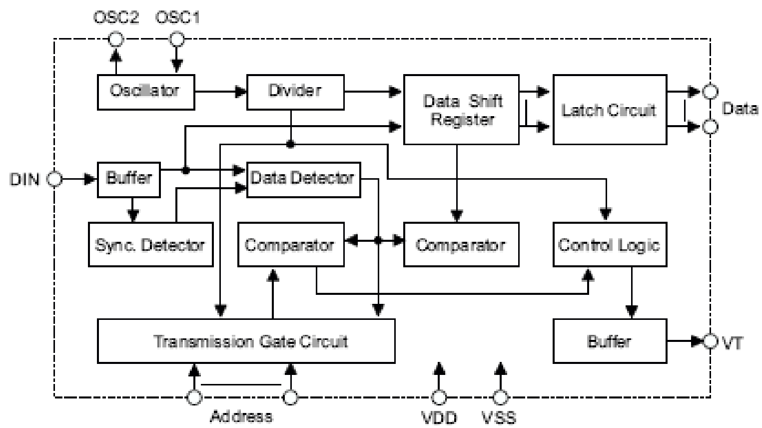
Selection Table

Function / Part No.	Address No.	Data		VT	Oscillator	Trigger	Package
		No.	Type				
HT12D	8	4	L	√	RC oscillator	DIN active "Hi"	18 DIP/20 SOP
HT12F	12	0	—	√	RC oscillator	DIN active "Hi"	18 DIP/20 SOP

Notes: Data type: L stands for latch type data output.

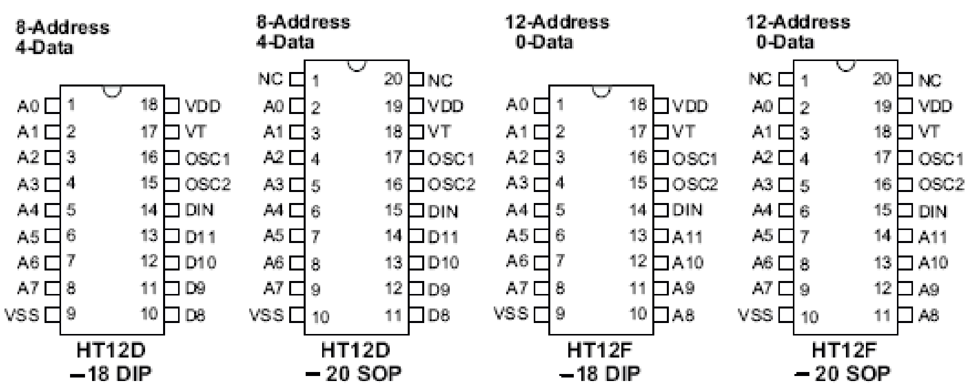
VT can be used as a momentary data output.

Block Diagram



Note: The address/data pins are available in various combinations (see the address/data table).

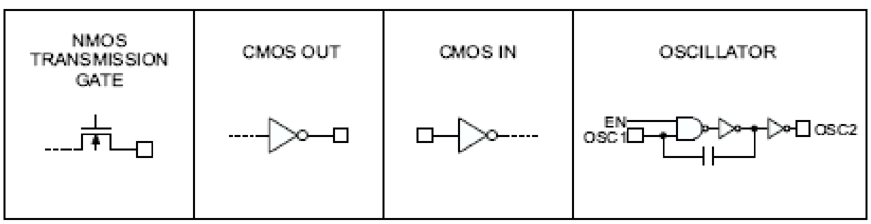
Pin Assignment



Pin Description

Pin Name	I/O	Internal Connection	Description
A0~A11	I	NMOS TRANSMISSION GATE	Input pins for address A0~A11 setting They can be externally set to VDD or VSS.
D8~D11	O	CMOS OUT	Output data pins
DIN	I	CMOS IN	Serial data input pin
VT	O	CMOS OUT	Valid transmission, active high
OSC1	I	OSCILLATOR	Oscillator input pin
OSC2	O	OSCILLATOR	Oscillator output pin
VSS	I	—	Negative power supply (GND)
VDD	I	—	Positive power supply

Approximate internal connection circuits



Absolute Maximum Ratings

Supply Voltage..............................–0.3V to 13V

Input Voltage..................V_{SS}–0.3 to V_{DD}+0.3V

Storage Temperature................–50°C to 125°C

Operating Temperature ....–20°C to 75°C

Note: These are stress ratings only. Stresses exceeding the range specified under "Absolute Maximum Ratings" may cause substantial damage to the device. Functional operation of this device at other conditions beyond those listed in the specification is not implied and prolonged exposure to extreme conditions may affect device reliability.

Electrical Characteristics

Ta=25°C

Symbol	Parameter	Test Conditions		Min.	Typ.	Max.	Unit
		V_{DD}	Conditions				
V_{DD}	Operating Voltage	—	—	2.4	5	12	V
I_{STB}	Standby Current	5V	Oscillator stops	—	0.1	1	µA
		12V		—	2	4	µA
I_{DD}	Operating Current	5V	No load f_{OSC}=150kHz	—	200	400	µA
I_O	Data Output Source Current (D8~D11)	5V	V_{OH}=4.5V	–1	–1.6	—	mA
	Data Output Sink Current (D8~D11)	5V	V_{OL}=0.5V	1	1.6	—	mA
I_{VT}	VT Output Source Current	5V	V_{OH}=4.5V	–1	–1.6	—	mA
	VT Output Sink Current		V_{OL}=0.5V	1	1.6	—	mA
V_{IH}	"H" Input Voltage	5V	—	3.5	—	5	V
V_{IL}	"L" Input Voltage	5V	—	0	—	1	V
f_{OSC}	Oscillator Frequency	5V	R_{OSC}=51kΩ	—	150	—	kHz

APPENDIX C

PIC16F877A DATA SHEETS

1.0 DEVICE OVERVIEW

This document contains device specific information about the following devices:

- PIC16F873A
- PIC16F874A
- PIC16F876A
- PIC16F877A

PIC16F873A/876A devices are available only in 28-pin packages, while PIC16F874A/877A devices are available in 40-pin and 44-pin packages. All devices in the PIC16F87XA family share common architecture with the following differences:

- The PIC16F873A and PIC16F874A have one-half of the total on-chip memory of the PIC16F876A and PIC16F877A
- The 28-pin devices have three I/O ports, while the 40/44-pin devices have five
- The 28-pin devices have fourteen interrupts, while the 40/44-pin devices have fifteen
- The 28-pin devices have five A/D input channels, while the 40/44-pin devices have eight
- The Parallel Slave Port is implemented only on the 40/44-pin devices

The available features are summarized in Table 1-1. Block diagrams of the PIC16F873A/876A and PIC16F874A/877A devices are provided in Figure 1-1 and Figure 1-2, respectively. The pinouts for these device families are listed in Table 1-2 and Table 1-3.

Additional information may be found in the PICmicro® Mid-Range Reference Manual (DS33023), which may be obtained from your local Microchip Sales Representative or downloaded from the Microchip web site. 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.

TABLE 1-1: PIC16F87XA DEVICE FEATURES

Key Features	PIC16F873A	PIC16F874A	PIC16F876A	PIC16F877A
Operating Frequency	DC – 20 MHz	DC – 20 MHz	DC – 20 MHz	DC – 20 MHz
Resets (and Delays)	POR, BOR (PWRT, OST)	POR, BOR (PWRT, OST)	POR, BOR (PWRT, OST)	POR, BOR (PWRT, OST)
Flash Program Memory (14-bit words)	4K	4K	8K	8K
Data Memory (bytes)	192	192	368	368
EEPROM Data Memory (bytes)	128	128	256	256
Interrupts	14	15	14	15
I/O Ports	Ports A, B, C	Ports A, B, C, D, E	Ports A, B, C	Ports A, B, C, D, E
Timers	3	3	3	3
Capture/Compare/PWM modules	2	2	2	2
Serial Communications	MSSP, USART	MSSP, USART	MSSP, USART	MSSP, USART
Parallel Communications	—	PSP	—	PSP
10-bit Analog-to-Digital Module	5 input channels	8 input channels	5 input channels	8 input channels
Analog Comparators	2	2	2	2
Instruction Set	35 Instructions	35 Instructions	35 Instructions	35 Instructions
Packages	28-pin PDIP 28-pin SOIC 28-pin SSOP 28-pin QFN	40-pin PDIP 44-pin PLCC 44-pin TQFP 44-pin QFN	28-pin PDIP 28-pin SOIC 28-pin SSOP 28-pin QFN	40-pin PDIP 44-pin PLCC 44-pin TQFP 44-pin QFN

TABLE 1-2: PIC16F873A/876A PINOUT DESCRIPTION

Pin Name	PDIP, SOIC, SSOP Pin#	QFN Pin#	I/O/P Type	Buffer Type	Description
OSC1/CLKI	9	6		ST/CMOS(3)	Oscillator crystal or external clock input.
OSC1			I		Oscillator crystal input or external clock source input. ST buffer when configured in RC mode; otherwise CMOS.
CLKI			I		External clock source input. Always associated with pin function OSC1 (see OSC1/CLKI, OSC2/CLKO pins).
OSC2/CLKO	10	7		—	Oscillator crystal or clock output.
OSC2			O		Oscillator crystal output. Connects to crystal or resonator in Crystal Oscillator mode.
CLKO			O		In RC mode, OSC2 pin outputs CLKO, which has 1/4 the frequency of OSC1 and denotes the instruction cycle rate.
$\overline{MCLR}$/VPP	1	26		ST	Master Clear (input) or programming voltage (output).
$\overline{MCLR}$			I		Master Clear (Reset) input. This pin is an active low Reset to the device.
VPP			P		Programming voltage input.
					PORTA is a bidirectional I/O port.
RA0/AN0	2	27		TTL	
RA0			I/O		Digital I/O.
AN0			I		Analog input 0.
RA1/AN1	3	28		TTL	
RA1			I/O		Digital I/O.
AN1			I		Analog input 1.
RA2/AN2/VREF-/CVREF	4	1		TTL	
RA2			I/O		Digital I/O.
AN2			I		Analog input 2.
VREF-			I		A/D reference voltage (Low) input.
CVREF			O		Comparator VREF output.
RA3/AN3/VREF+	5	2		TTL	
RA3			I/O		Digital I/O.
AN3			I		Analog input 3.
VREF+			I		A/D reference voltage (High) input.
RA4/T0CKI/C1OUT	6	3		ST	
RA4			I/O		Digital I/O – Open-drain when configured as output.
T0CKI			I		Timer0 external clock input.
C1OUT			O		Comparator 1 output.
RA5/AN4/$\overline{SS}$/C2OUT	7	4		TTL	
RA5			I/O		Digital I/O.
AN4			I		Analog input 4.
$\overline{SS}$			I		SPI slave select input.
C2OUT			O		Comparator 2 output.

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.

TABLE 1-2: PIC16F873A/876A PINOUT DESCRIPTION (CONTINUED)

Pin Name	PDIP, SOIC, SSOP Pin#	QFN Pin#	I/O/P Type	Buffer Type	Description
					PORTB is a bidirectional I/O port. PORTB can be software programmed for internal weak pull-ups on all inputs.
RB0/INT	21	18		TTL/ST(1)	
RB0			I/O		Digital I/O.
INT			I		External interrupt.
RB1	22	19	I/O	TTL	Digital I/O.
RB2	23	20	I/O	TTL	Digital I/O.
RB3/PGM	24	21		TTL	
RB3			I/O		Digital I/O.
PGM			I		Low-voltage (single-supply) ICSP programming enable pin.
RB4	25	22	I/O	TTL	Digital I/O.
RB5	26	23	I/O	TTL	Digital I/O.
RB6/PGC	27	24		TTL/ST(2)	
RB6			I/O		Digital I/O.
PGC			I		In-circuit debugger and ICSP programming clock.
RB7/PGD	28	25		TTL/ST(2)	
RB7			I/O		Digital I/O.
PGD			I/O		In-circuit debugger and ICSP programming data.
					PORTC is a bidirectional I/O port.
RC0/T1OSO/T1CKI	11	8		ST	
RC0			I/O		Digital I/O.
T1OSO			O		Timer1 oscillator output.
T1CKI			I		Timer1 external clock input.
RC1/T1OSI/CCP2	12	9		ST	
RC1			I/O		Digital I/O.
T1OSI			I		Timer1 oscillator input.
CCP2			I/O		Capture2 input, Compare2 output, PWM2 output.
RC2/CCP1	13	10		ST	
RC2			I/O		Digital I/O.
CCP1			I/O		Capture1 input, Compare1 output, PWM1 output.
RC3/SCK/SCL	14	11		ST	
RC3			I/O		Digital I/O.
SCK			I/O		Synchronous serial clock input/output for SPI mode.
SCL			I/O		Synchronous serial clock input/output for I^2C mode.
RC4/SDI/SDA	15	12		ST	
RC4			I/O		Digital I/O.
SDI			I		SPI data in.
SDA			I/O		I^2C data I/O.
RC5/SDO	16	13		ST	
RC5			I/O		Digital I/O.
SDO			O		SPI data out.
RC6/TX/CK	17	14		ST	
RC6			I/O		Digital I/O.
TX			O		USART asynchronous transmit.
CK			I/O		USART1 synchronous clock.
RC7/RX/DT	18	15		ST	
RC7			I/O		Digital I/O.
RX			I		USART asynchronous receive.
DT			I/O		USART synchronous data.
V_{SS}	8, 19	5, 6	P	—	Ground reference for logic and I/O pins.
V_{DD}	20	17	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.

TABLE 1-3: PIC16F874A/877A PINOUT DESCRIPTION (CONTINUED)

Pin Name	PDIP Pin#	PLCC Pin#	TQFP Pin#	QFN Pin#	I/O/P Type	Buffer Type	Description
							PORTB is a bidirectional I/O port. PORTB can be software programmed for internal weak pull-up on all inputs.
RB0/INT	33	36	8	9		TTL/ST(1)	
RB0					I/O		Digital I/O.
INT					I		External interrupt.
RB1	34	37	9	10	I/O	TTL	Digital I/O.
RB2	35	38	10	11	I/O	TTL	Digital I/O.
RB3/PGM	36	39	11	12		TTL	
RB3					I/O		Digital I/O.
PGM					I		Low-voltage ICSP programming enable pin.
RB4	37	41	14	14	I/O	TTL	Digital I/O.
RB5	38	42	15	15	I/O	TTL	Digital I/O.
RB6/PGC	39	43	16	16		TTL/ST(2)	
RB6					I/O		Digital I/O.
PGC					I		In-circuit debugger and ICSP programming clock.
RB7/PGD	40	44	17	17		TTL/ST(2)	
RB7					I/O		Digital I/O.
PGD					I/O		In-circuit debugger and ICSP 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 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.

PIC16F87XA

TABLE 1-3: PIC16F874A/877A PINOUT DESCRIPTION (CONTINUED)

Pin Name	PDIP Pin#	PLCC Pin#	TQFP Pin#	QFN Pin#	I/O/P Type	Buffer Type	Description
							PORTC is a bidirectional I/O port.
RC0/T1OSO/T1CKI	15	16	32	34		ST	
RC0					I/O		Digital I/O.
T1OSO					O		Timer1 oscillator output.
T1CKI					I		Timer1 external clock input.
RC1/T1OSI/CCP2	16	18	35	35		ST	
RC1					I/O		Digital I/O.
T1OSI					I		Timer1 oscillator input.
CCP2					I/O		Capture2 input, Compare2 output, PWM2 output.
RC2/CCP1	17	19	36	36		ST	
RC2					I/O		Digital I/O.
CCP1					I/O		Capture1 input, Compare1 output, PWM1 output.
RC3/SCK/SCL	18	20	37	37		ST	
RC3					I/O		Digital I/O.
SCK					I/O		Synchronous serial clock input/output for SPI mode.
SCL					I/O		Synchronous serial clock input/output for I^2C mode.
RC4/SDI/SDA	23	25	42	42		ST	
RC4					I/O		Digital I/O.
SDI					I		SPI data in.
SDA					I/O		I^2C data I/O.
RC5/SDO	24	26	43	43		ST	
RC5					I/O		Digital I/O.
SDO					O		SPI data out.
RC6/TX/CK	25	27	44	44		ST	
RC6					I/O		Digital I/O.
TX					O		USART asynchronous transmit.
CK					I/O		USART1 synchronous clock.
RC7/RX/DT	26	29	1	1		ST	
RC7					I/O		Digital I/O.
RX					I		USART asynchronous receive.
DT					I/O		USART synchronous 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 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.

TABLE 1-3: PIC16F874A/877A PINOUT DESCRIPTION (CONTINUED)

Pin Name	PDIP Pin#	PLCC Pin#	TQFP Pin#	QFN Pin#	I/O/P Type	Buffer Type	Description
							PORTD is a bidirectional I/O port or Parallel Slave Port when interfacing to a microprocessor bus.
RD0/PSP0	19	21	38	38		ST/TTL(3)	
RD0					I/O		Digital I/O.
PSP0					I/O		Parallel Slave Port data.
RD1/PSP1	20	22	39	39		ST/TTL(3)	
RD1					I/O		Digital I/O.
PSP1					I/O		Parallel Slave Port data.
RD2/PSP2	21	23	40	40		ST/TTL(3)	
RD2					I/O		Digital I/O.
PSP2					I/O		Parallel Slave Port data.
RD3/PSP3	22	24	41	41		ST/TTL(3)	
RD3					I/O		Digital I/O.
PSP3					I/O		Parallel Slave Port data.
RD4/PSP4	27	30	2	2		ST/TTL(3)	
RD4					I/O		Digital I/O.
PSP4					I/O		Parallel Slave Port data.
RD5/PSP5	28	31	3	3		ST/TTL(3)	
RD5					I/O		Digital I/O.
PSP5					I/O		Parallel Slave Port data.
RD6/PSP6	29	32	4	4		ST/TTL(3)	
RD6					I/O		Digital I/O.
PSP6					I/O		Parallel Slave Port data.
RD7/PSP7	30	33	5	5		ST/TTL(3)	
RD7					I/O		Digital I/O.
PSP7					I/O		Parallel Slave Port data.
							PORTE is a bidirectional I/O port.
RE0/$\overline{\text{RD}}$/AN5	8	9	25	25		ST/TTL(3)	
RE0					I/O		Digital I/O.
$\overline{\text{RD}}$					I		Read control for Parallel Slave Port.
AN5					I		Analog input 5.
RE1/$\overline{\text{WR}}$/AN6	9	10	26	26		ST/TTL(3)	
RE1					I/O		Digital I/O.
$\overline{\text{WR}}$					I		Write control for Parallel Slave Port.
AN6					I		Analog input 6.
RE2/$\overline{\text{CS}}$/AN7	10	11	27	27		ST/TTL(3)	
RE2					I/O		Digital I/O.
$\overline{\text{CS}}$					I		Chip select control for Parallel Slave Port.
AN7					I		Analog input 7.
V_{SS}	12, 31	13, 34	6, 29	6, 30, 31	P	—	Ground reference for logic and I/O pins.
V_{DD}	11, 32	12, 35	7, 28	7, 8, 28, 29	P	—	Positive supply for logic and I/O pins.
NC	—	1, 17, 28, 40	12,13, 33, 34	13	—	—	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 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.

14.2 Oscillator Configurations

14.2.1 OSCILLATOR TYPES

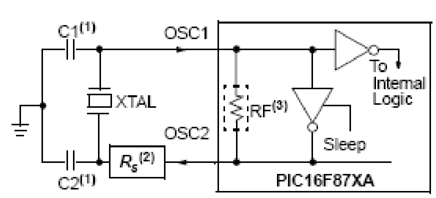
The PIC16F87XA can be operated in four different oscillator modes. The user can program two configuration bits (Fosc1 and Fosc0) to select one of these four modes:

- LP Low-Power Crystal
- XT Crystal/Resonator
- HS High-Speed Crystal/Resonator
- RC Resistor/Capacitor

14.2.2 CRYSTAL OSCILLATOR/CERAMIC RESONATORS

In XT, LP or HS modes, a crystal or ceramic resonator is connected to the OSC1/CLKI and OSC2/CLKO pins to establish oscillation (Figure 14-1). The PIC16F87XA oscillator design requires the use of a parallel cut crystal. Use of a series cut crystal may give a frequency out of the crystal manufacturer's specifications. When in XT, LP or HS modes, the device can have an external clock source to drive the OSC1/CLKI pin (Figure 14-2).

FIGURE 14-1: CRYSTAL/CERAMIC RESONATOR OPERATION (HS, XT OR LP OSC CONFIGURATION)



Note 1: See Table 14-1 and Table 14-2 for recommended values of C1 and C2.

2: A series resistor (R_s) may be required for AT strip cut crystals.

3: RF varies with the crystal chosen.

FIGURE 14-2: EXTERNAL CLOCK INPUT OPERATION (HS, XT OR LP OSC CONFIGURATION)

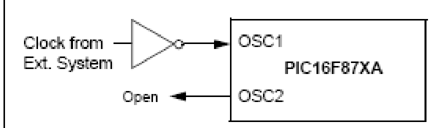


TABLE 14-1: CERAMIC RESONATORS

Ranges Tested:			
Mode	**Freq.**	**OSC1**	**OSC2**
XT	455 kHz 2.0 MHz 4.0 MHz	68-100 pF 15-68 pF 15-68 pF	68-100 pF 15-68 pF 15-68 pF
HS	8.0 MHz 16.0 MHz	10-68 pF 10-22 pF	10-68 pF 10-22 pF
These values are for design guidance only. See notes following Table 14-2.			
Resonators Used:			
2.0 MHz	Murata Erie CSA2.00MG	± 0.5%	
4.0 MHz	Murata Erie CSA4.00MG	± 0.5%	
8.0 MHz	Murata Erie CSA8.00MT	± 0.5%	
16.0 MHz	Murata Erie CSA16.00MX	± 0.5%	
All resonators used did not have built-in capacitors.			

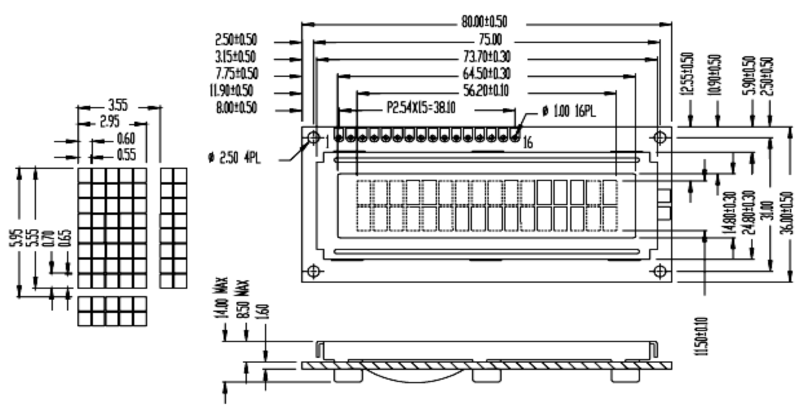
APPENDIX D

LCD DATA SHEETS

■ PHYSICAL DATA

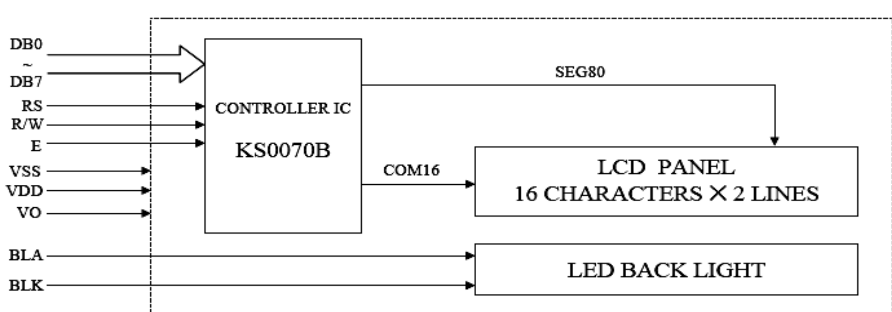
Item	Contents	Unit
LCD type	STN	---
LCD duty	1/16	---
LCD bias	1/5	---
Viewing direction	6	o'clock
Module size (W×H×T)	80 × 36 × 14MAX (3.15″ × 1.42″ × 0.55″MAX)	mm
Viewing area (W×H)	64.5 × 14.8 (2.54″ × 0.58″)	mm
Number of characters (characters×lines)	16 × 2	---
Character matrix (W×H)	5 × 8	dots
Character size (W×H)	2.95 × 5.55 (0.116″ × 0.219″)	mm
Dot size (W×H)	0.55 × 0.65 (0.022″ × 0.026″)	mm
Dot pitch (W×H)	0.60 × 0.70 (0.024″ × 0.028″)	mm

■ EXTERNAL DIMENSIONS



■ BLOCK DIAGRAM

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
VSS	VDD	VO	RS	R/W	E	DB0	DB1	DB2	DB3	DB4	DB5	DB6	DB7	BLA	BLK



■ ABSOLUTE MAXIMUM RATINGS (Ta = 25°C)

Parameter	Symbol	Min	Max	Unit
Supply voltage for logic	VDD	-0.3	7.0	V
Supply voltage for LCD	VDD - VO	-0.3	VDD+0.3	V
Input voltage	VI	-0.3	VDD+0.3	V
Operating temperature	TOP	0	50	°C
Storage temperature	TST	-10	60	°C

■ ELECTRICAL CHARACTERISTICS (VDD = +5V±10% , VSS = 0V, Ta = 25°C)

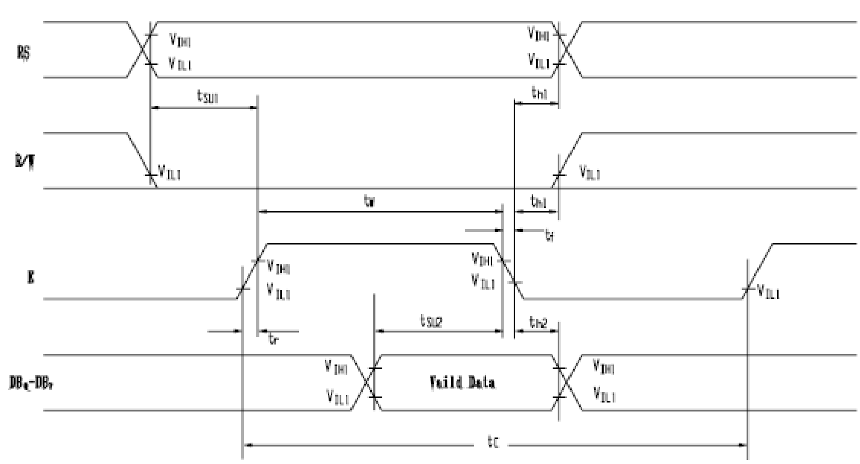
◆ DC Characteristics

Parameter	Symbol	Condition	Min	Typ	Max	Unit
Supply voltage for logic	VDD	---	4.5	5.0	5.5	V
Supply current for logic	IDD	---	---	1.38	3	mA
Operating voltage for LCD	VDD - VO	0°C	4.7	5.0	5.3	V
		25°C	4.5	4.8	5.1	V
		50°C	4.4	4.7	5.0	V
Supply voltage for back light	VF	---	---	4.2	4.6	V
Supply current for back light	IF	VF=4.2V	---	130	220	mA
Input voltage ' H ' level	VIH	---	2.2	---	VDD	V
Input voltage ' L ' level	VIL	---	-0.3	---	0.6	V

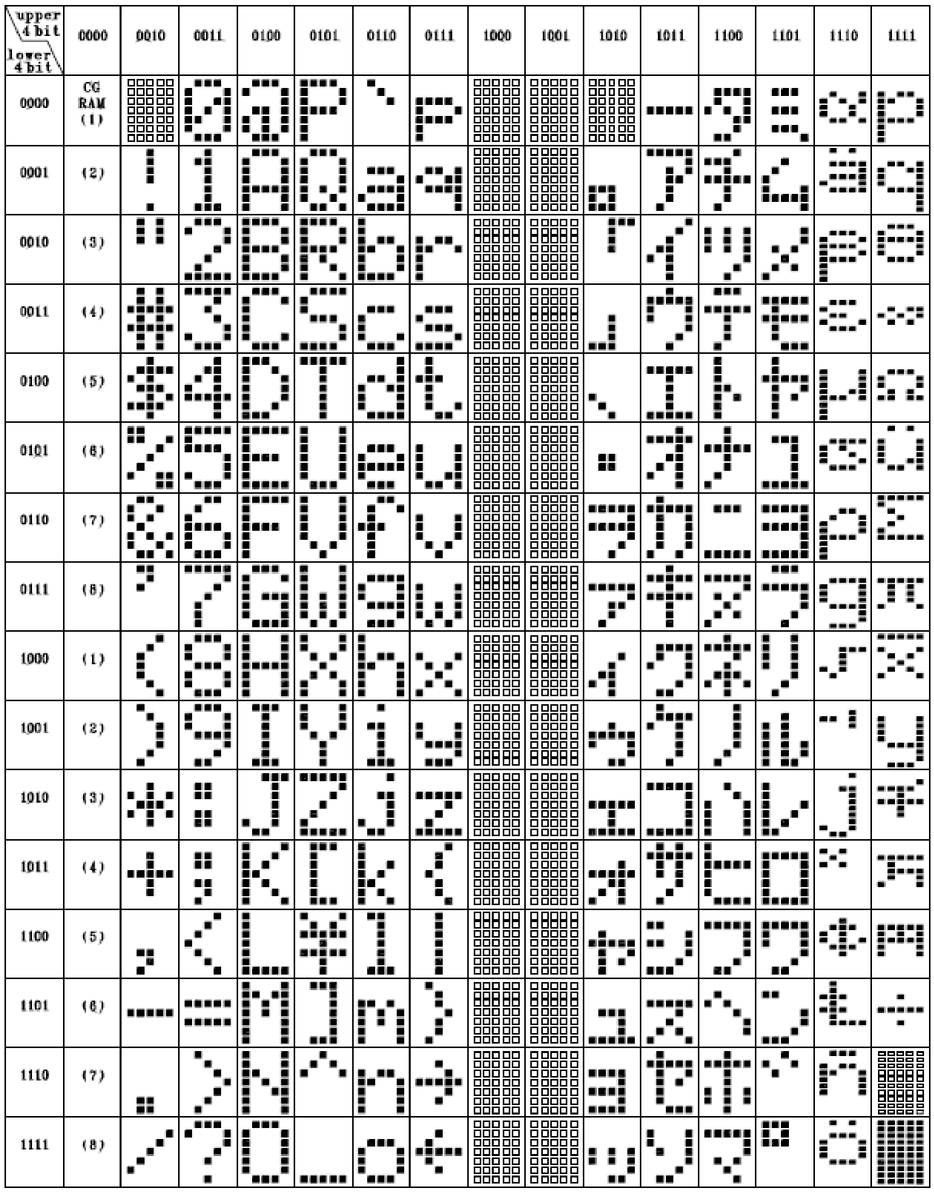
◆ AC Characteristics

● Write mode

Characteristic	Symbol	Min.	Typ.	Max.	Unit	Test pin
E cycle time	t_C	500	---	---	ns	E
E rise time	t_r	---	---	25	ns	E
E fall time	t_f	---	---	25	ns	E
E pulse width (High, Low)	t_W	220	---	---	ns	E
R/W and RS set-up time	t_{SU1}	40	---	---	ns	R/W, RS
R/W and RS hold time	t_{h1}	10	---	---	ns	R/W, RS
Data set-up time	t_{SU2}	60	---	---	ns	$DB_0 \sim DB_7$
Data hold time	t_{h2}	10	---	---	ns	$DB_0 \sim DB_7$



◆ **Standard Character Pattern**



■ DISPLAY DATA RAM ADDRESS MAP

Characters	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
First line	00H	01H	02H	03H	04H	05H	06H	07H	08H	09H	0AH	0BH	0CH	0DH	0EH	0FH
Second line	40H	41H	42H	43H	44H	45H	46H	47H	48H	49H	4AH	4BH	4CH	4DH	4EH	4FH

■ INTERFACE PIN CONNECTIONS

Pin NO.	Symbol	Level	Description
1	VSS	0V	Ground
2	VDD	5.0V	Supply voltage for logic
3	VO	---	Input voltage for LCD
4	RS	H/L	H : Data, L : Instruction code
5	R/W	H/L	H : Read mode, L : Write mode
6	E	H, H → L	Chip enable signal
7	DB0	H/L	Data bit 0
8	DB1	H/L	Data bit 1
9	DB2	H/L	Data bit 2
10	DB3	H/L	Data bit 3
11	DB4	H/L	Data bit 4
12	DB5	H/L	Data bit 5
13	DB6	H/L	Data bit 6
14	DB7	H/L	Data bit 7
15	BLA	4.2V	Back light anode
16	BLK	0V	Back light cathode

■ PART LIST

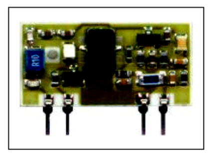
Part Name	Description	Quantity
IC	KS0070B.PCC	1
LCD	162C	1
PCB	162C	1
Frame	162C	1
Rubber connector	70.5x6.9x2.2mm YS	2
Resistor	2.2KΩ	5
Resistor	91KΩ	1
LED box	LB162-1	1
LED PCB	LB162A1-3	1
LED light	ED-011YGU	22

APPENDIX E

TRANSMITTER DATA SHEETS

FM SIL TRANSMITTER MODULE FM-RTF3-XXX

- FM Radio Transmitter
- Transmit Range Up To 250m
- CMOS/TTL Input
- SIL Package
- No Adjustable Components
- Very Stable Operating Frequency
- Low Current Consumption (Typ 8mA)
- Wide Operating Voltage (2.7-14V)
- Available As 315, 418 Or 433MHz
- Compatible With RF Solutions FM Receivers



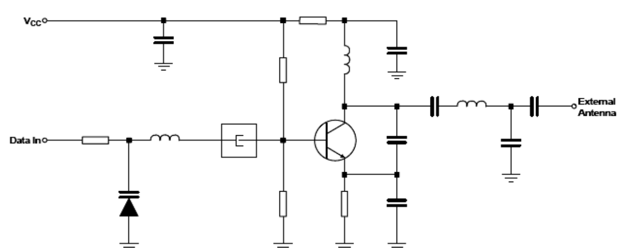
Applications

- Wireless Security Systems
- Car Alarms
- Remote Gate Controls
- Remote Sensing
- Data Capture
- Sensor Reporting

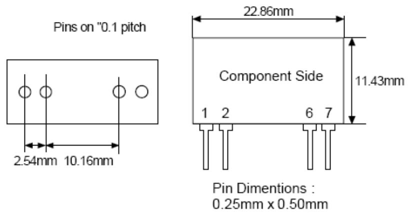
Description

The R F Solutions Ltd. FM hybrid transmitter module provides a complete RF transmitter which can be used to transmit data at up to 9.6KHz from any standard CMOS/TTL source.
The module is very simple to operate and offers low current consumption (typ. 8mA). Data can be supplied directly from a microprocessor or encoding device, thus keeping the component count down and ensuring a low hardware cost.
The module exhibits extremely stable electronic characteristics due to the use of 'Thick-Film' hybrid technology, which uses no adjustable components and ensures very reliable operation.
The modules are compatible with R F solutions Ltd. range of FM receivers to provide a complete solution.

Circuit Schematic



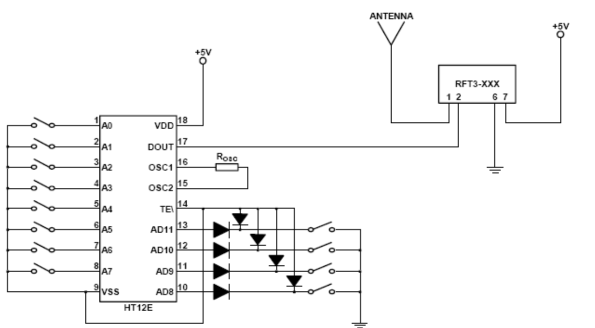
Mechanical Dimensions



Pin Description

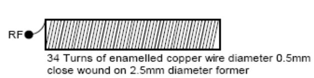
Pin Number	Name	Description
1	EA	External Antenna
2	IN	Data input
6	GND	Ground, Connect to RF earth return path
7	Vcc	Supply Voltage

Typical Application

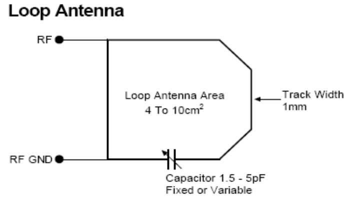


Antenna Configuration

Helical Coil Antenna



Loop Antenna



Whip Antenna

FM SIL TRANSMITTER MODULE   FM-RTF3-XXX

Technical Specifications

ELECTRICAL CHARACTERISTICS	MIN	TYPICAL	MAX	DIMENSION
Supply Voltage	2.7		14	VDC
Supply Current (Vcc = 5V, IN=1KHz Square Wave)		8		mA
Frequency Deviation		50		KHz
RF Output into 50Ω (Vcc=5V)		7		dBm
Harmonic Spurious Emissions		-50		dBc
Input High Voltage	2.5		Vcc	V
Time from Power on to data valid			200	µS
Max Data Rate			9.6	KHz
Operating Temperature	-25		+80	°C

Part Numbering

Part Number	Description
FM-RFT3-315	SIL FM Transmitter Module 315 MHz (Future Product)
FM-RFT3-433	SIL FM Transmitter Module 433 MHz

For more information or general enquiries, please contact our official UK distributor;

RF Solutions Ltd.,
Unit 21, Cliffe Industrial Estate,
South Street,
Lewes,
E Sussex, BN8 6JL. England

Tel +44 (0)1273 898 000 ***Fax +44 (0)1273 480 661***

Email sales@rfsolutions.co.uk ***http://www.rfsolutions.co.uk***

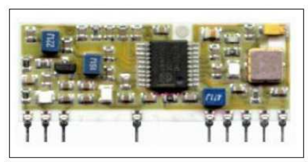
RF Solutions is a member of the Low Power Radio Association

APPENDIX F

RECEIVER DATA SHEETS

FM SIL RECEIVER MODULE FM-RRF1

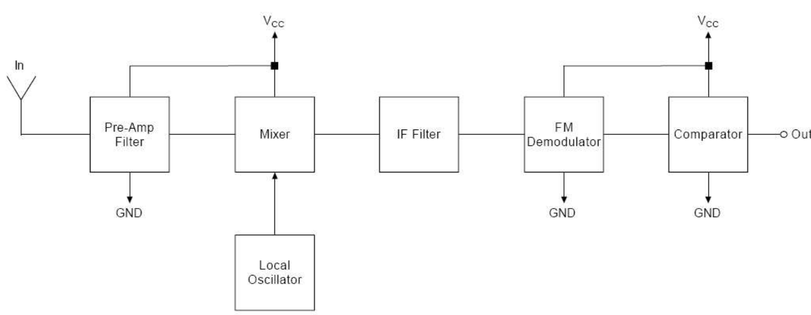
- Compact Hybrid Module
- Very High Frequency Stability (With No Adjustable Components).
- Receiving Range up to 250 Metres.
- CMOS/TTL Compatible Output.
- Low Current Consumption (Typ 5.5mA)
- Single Supply Voltage 5V.
- Compatible with R.F. Solutions FM Transmitters.
- Available as 315, or 433MHz
- Compliant To ETSI 300-220.
- Requires No Radio Licence to Operate.



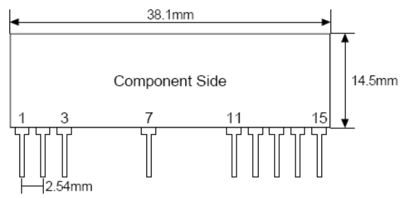
Description

The R F Solutions Ltd. FM hybrid receiver module provides a complete RF receiver which can be used to receive data at up to 9.6Kbps.
The module is very simple to operate and offers low current consumption (typ. 5.5 mA). The TTL/CMOS data output can be interfaced directly to a microprocessor or decoding device, thus keeping the component count down and ensuring a low hardware cost.
The module exhibits extremely stable electronic characteristics due to the use of 'Thick-Film' hybrid technology, which uses no adjustable components and ensures very reliable operation.
The module is compatible with R F solutions Ltd. range of FM transmitters to provide a complete solution.

Block Diagram



Mechanical Dimensions

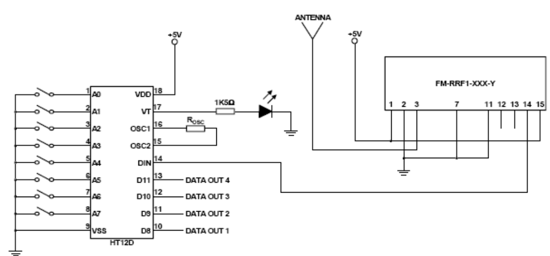


Pin Dimentions :
0.25mm x 0.50mm

Pin Description

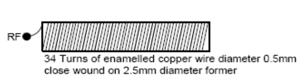
Pin Number	Name	Description
1	Vcc	Supply Voltage
2	GND	Ground, Connect to RF earth return path
3	IN	External Antenna
7	GND	Ground, Connect to RF earth return path
11	GND	Ground, Connect to RF earth return path
12	NC	No Connection
13	NC	No Connection
14	OUT	Data output
15	Vcc	Supply Voltage

Typical Application

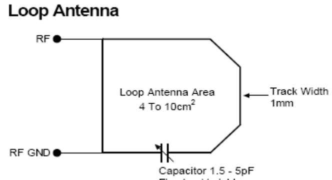


Antenna Configuration

Helical Coil Antenna



Loop Antenna



Whip Antenna

Technical Specifications

Electrical Characteristics		Min	Typical	Max	Dimension	Note
Supply Voltage		3.5	5	5.5	Vdc	
Supply Current			5.5		mA	
RF Sensitivity	A version: 2.4 Kbps B version: 4.8 Kbps C version: 9.6 Kbps		-94 -90 -87		dBm	
Frequency Deviation			±25		KHz	
-3dB Bandwidth			±400		KHz	
Level of Emitted Spectrum			-70	-65	dBm	
Low-Level Output Voltage				0.6	V	
High-Level Output Voltage		Vcc-0.5			V	
Output Current (Source)				10	uA	1
Time from Power on to data output valid				50	MSecs	
Digital Data output Rise time				10	USecs	1
Operating Temperature		-25		+80	°C	

Notes
1. If excess current is drawn from the output pin this will increase the max rise time.

Part Numbering

Part Number	Description
FM-RRF1-315A**	FM Receiver Module 2.4Kbps 315MHz
FM-RRF1-315B**	FM Receiver Module 4.8Kbps 315MHz
FM-RRF1-315C**	FM Receiver Module 9.6Kbps 315MHz
FM-RRF1-433A	FM Receiver Module 2.4Kbps 433MHz
FM-RRF1-433B	FM Receiver Module 4.8Kbps 433MHz
FM-RRF1-433C	FM Receiver Module 9.6Kbps 433MHz

** Future Part

For more information or general enquiries, please contact our official UK distributor;

RF Solutions Ltd.,

Unit 21, Cliffe Industrial Estate,
South Street,
Lewes,
E Sussex, BN8 6JL. England

Tel +44 (0)1273 898 000 ***Fax +44 (0)1273 480 661***

Email sales@rfsolutions.co.uk ***http://www.rfsolutions.co.uk***

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APPENDIX G

CIRCUITS

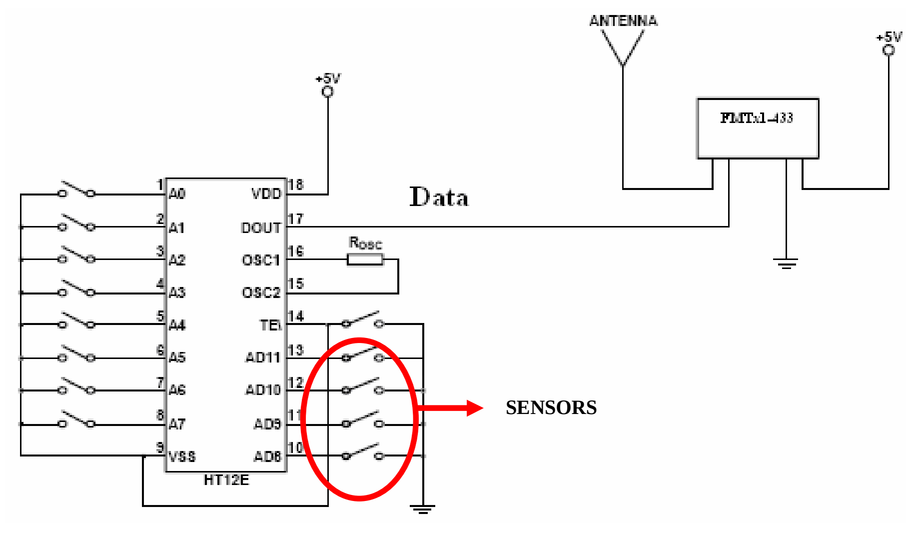


Figure G1: Circuit of Encoder and Transmitter

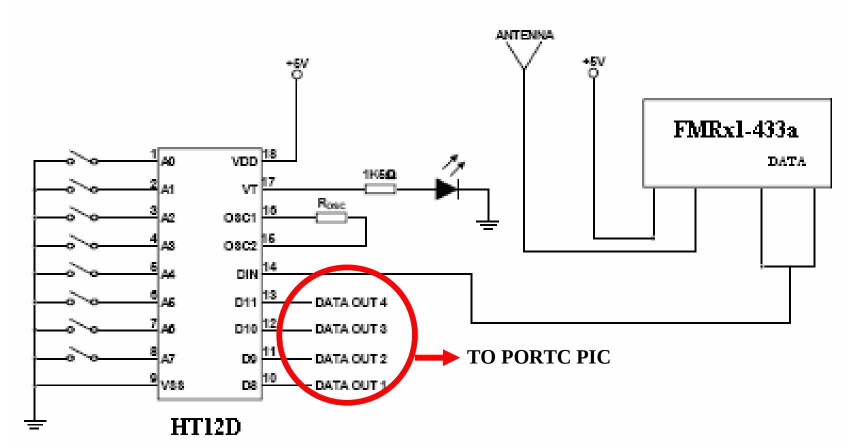


Figure G2: Circuit of Decoder and Receiver

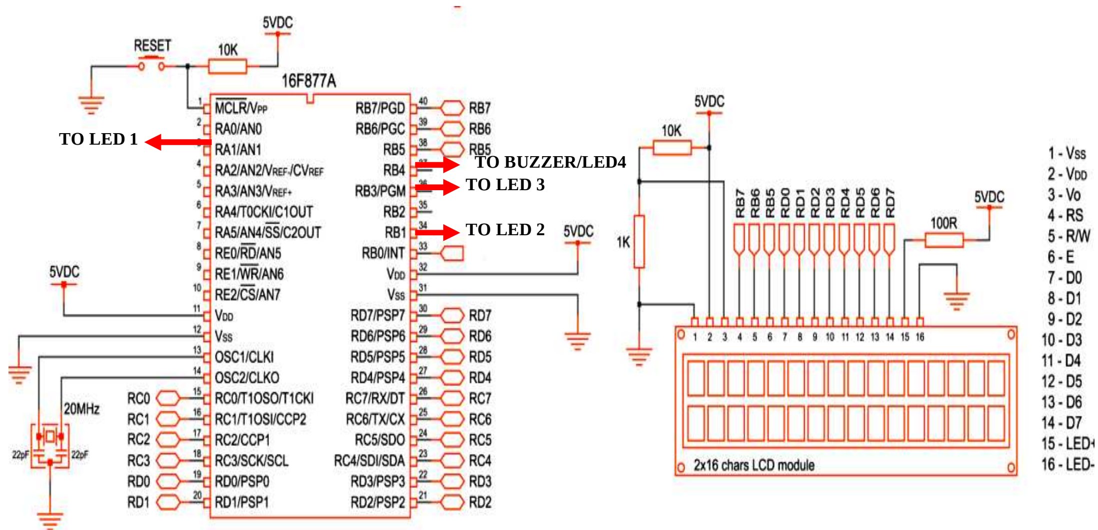


Figure G3: PIC16F877A, LCD and Buzzer Connection

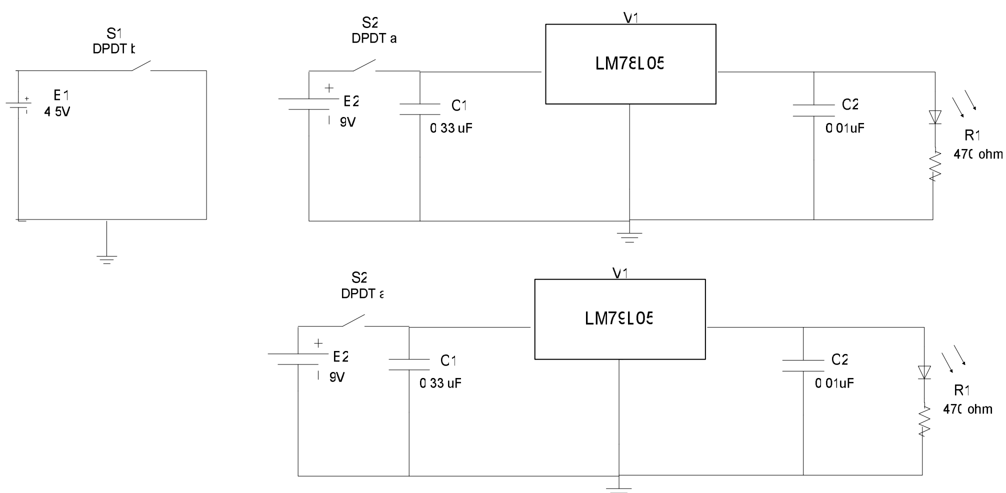


Figure G4: Power Supply Circuit

APPENDIX H

PROGRAM

```
'**************************************************************
Name       : PORTABLE WATER LEVEL ALARM DETECTOR.BAS
Author     : LINN WEN TECK
Notice     : Copyright (c) 2007 [select VIEW...EDITOR OPTIONS]
             All Rights Reserved
Date       : 29/10/2007
Version    : 1.0
Notes      :

'**************************************************************

DEFINE OSC 20                              'Using 20MHz crystal

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

TRISC = %11111111         'Set port B as input
TRISB = %00000000         'Set port B as output
TRISD = %00000000         'Set port D as output
low PORTB.6             'Set the R/W bit to low
LOW PORTB
LOW PORTA
pause  500            'Wait until the LCD initializes
```

```
START:      Lcdout $fe, 1
            Lcdout "portable water"
            Pause 1000
            Lcdout $fe, 1
            Lcdout "alarm detector"
            PAUSE 2000

IF PORTC.0 and PORTC.1 and PORTC.2 AND PORTC.3 THEN A1

BB: IF PORTC.0 and PORTC.1 and PORTC.2 THEN A2

AA: IF PORTC.0 and PORTC.1 THEN A3

IF PORTC.0 THEN A4

GOTO START

A1:  high PORTA.1
     high PORTB.1
     high PORTB.3
     high PORTB.4
     PAUSE 500
loop: Lcdout $fe, 1
      Lcdout "danger critical"
      Pause 2000
      Lcdout $fe, 1
      Lcdout "water level"
      Pause 2000
      GOTO loop

A2:  LOW PORTB.4
     high PORTA.1
     high PORTB.1
     high PORTB.3
     PAUSE 500
     Lcdout $fe, 1
     Lcdout "the water level"
     Pause 1000
     Lcdout $fe, 1
     Lcdout "is three meter"
     Pause 2000
     GOTO BB
```

```
A3:  LOW PORTB.3
     LOW PORTB.4
     high PORTA.1
     high PORTB.1
     PAUSE 500
     Lcdout $fe, 1
     Lcdout "the water level"
     Pause 1000
     Lcdout $fe, 1
     Lcdout "is two meter"
     Pause 2000
     GOTO AA

A4:  LOW PORTB.1
     LOW PORTB.3
     LOW PORTB.4
     high PORTA.1
     PAUSE 500
     Lcdout $fe, 1
     Lcdout "the water level"
     Pause 1000
     Lcdout $fe, 1
     Lcdout "is one meter"
     PAUSE 2000
```

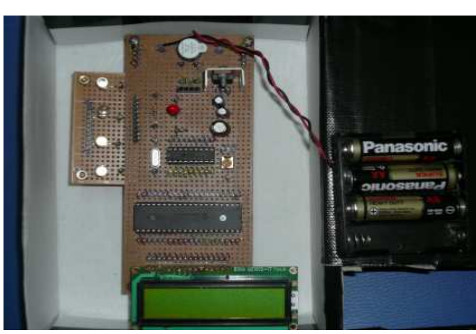
APPENDIX I

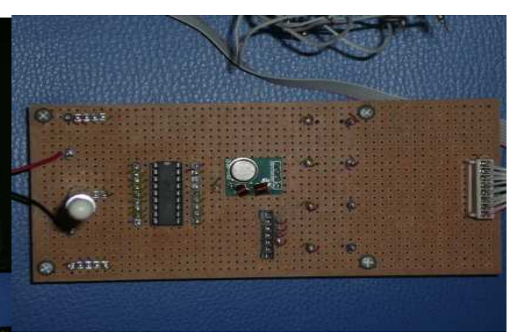
USER MANUAL

PORTABLE WATER ALARM DETECTOR

REFERENCE GUIDE

DETECTS WATER AND SOUNDS ALARM UP TO 150M AWAY





FEATURES:

- Battery powered
- Typical transmitter range up to 150m
- Transmission enabled indicators
- LED indicators for level indications

THIS PACKAGE INCLUDES:

- Water alarm receiver with LCD display
- Water alarm transmitter with holder and remote sensors
- LED water level indicators

REQUIREMENTS:

- 4 AA 1.5V battery (Rechargeable alkaline recommended) for transmitter
- 4 AA 1.5V battery (Rechargeable alkaline recommended) for alarm

APPLICATIONS:

This wireless alarm detector is suitable for use outside the house, the basement, bathroom, kitchens, toilets, water tanks… etc., anywhere you want to detect the water or monitor the level of water.

TRANSMITTER INSTALLATION

*IMPORTANT: The transmitter is not water resistant. Do not expose to water.

INSTALLING THE BATTERY

Attached 4 AA 1.5V alkaline batteries to the battery holder. Make sure to press hard so that the batteries are firmly in place.

INSTALLING THE TRANSMITTER

Place the remote sensors (the copper wires) at the desired heights and make sure the transmitter is at the highest level so that the transmitter is not directly exposed to water. The buzzer will sound when the 2 of the sensors that are at the same height comes in contact with water.

RECEIVER INSTALLATION

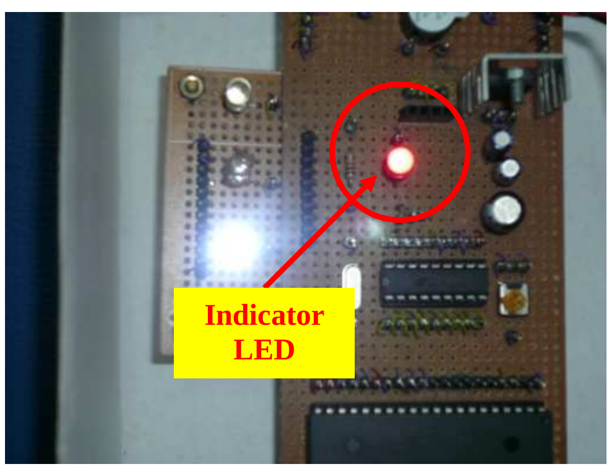
*IMPORTANT: The receiver is not water resistant. Do not expose to water.

INSTALLING THE BATTERY

Attached 4 AA 1.5V alkaline batteries to the battery holder. Make sure to press hard so that the batteries are firmly in place.

INSTALLING THE RECEIVER

Place the receiver at any place that is convenient for you to hear or you can bring the receiver along with you wherever you go (up to 150m away, but make sure the receiver is located within) the effective range. To check for the whether the transmission is enabled, check the indicator LED.



SPECIFICATION

TRANSMITTER

Transmitter Range	:	Up to 150m
Operating Voltage	:	5V ~ 6V
Transmit Frequency	:	433 MHz
Code Setting	:	00000000

RECEIVER

Receiver Range	:	Up to 150m
Operating Range	:	5V ~ 6V
Receiver Frequency	:	433 MHz
Code Setting	:	00000000

LCD DISPLAY

Item	Contents	Unit
LCD type	STN	---
LCD duty	1/16	---
LCD bias	1/5	---
Viewing direction	6	o'clock
Module size (W×H×T)	80 × 36 × 14MAX (3.15″ × 1.42″ × 0.55″MAX)	mm
Viewing area (W×H)	64.5 × 14.8 (2.54″ × 0.58″)	mm
Number of characters (characters×lines)	16 × 2	---
Character matrix (W×H)	5 × 8	dots
Character size (W×H)	2.95 × 5.55 (0.116″ × 0.219″)	mm
Dot size (W×H)	0.55 × 0.65 (0.022″ × 0.026″)	mm
Dot pitch (W×H)	0.60 × 0.70 (0.024″ × 0.028″)	mm

APPENDIX J

PROJECT PHOTOS

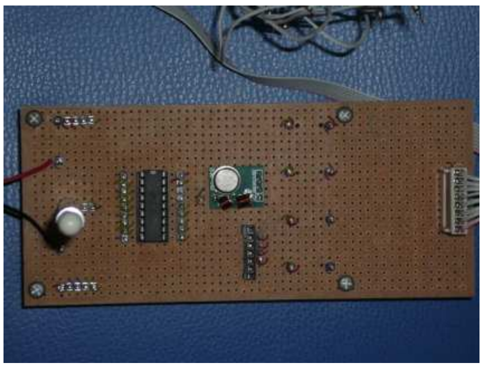


Figure J1: The Transmitter Board

Figure J2: The Custom Made Water Tank

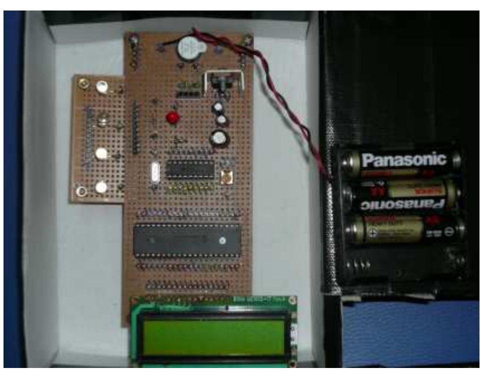


Figure J3: The Receiver Board

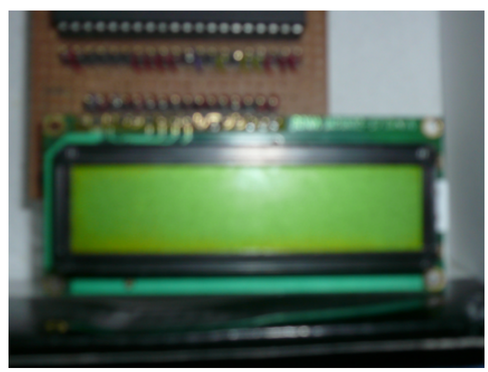


Figure J4: The LCD

UNIVERSITI MALAYSIA PAHANG

BORANG PENGESAHAN STATUS TESIS♦

JUDUL: **PORTABLE WATER ALARM DETECTOR**

SESI PENGAJIAN: 2004/2005

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