

ELECTRONICS TRAVEL AID (ETA) WITH COMPASS AND QIBLA FINDER
USING HMC6352

NORLIZA BINTI MORBAN

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

Faculty of Electrical & Electronics Engineering
Universiti Malaysia Pahang

MAY, 2009

“All the trademark and copyrights use herein are property of their respective owner. References of information from other sources are quoted accordingly; otherwise the information presented in this report is solely work of the author.”

Signature : _____

Author : NORLIZA BINTI MORBAN

Date : 12 MAY 2009

To my beloved parents, brothers and sister
who understand and guided me through the journey of my study
And for YOU who believe in me and keep whispering
“You can do it!”

ACKNOWLEDGEMENT

I would like to express profound gratitude to my supervisor, Mr. Mohd. Zamri bin Ibrahim, for his invaluable support, encouragement, supervision and stimulating suggestions throughout this project. Above all and the most needed, his moral support and continuous guidance enabled me to complete this project successfully.

I am as ever, deeply indebted to my parents, Mr. Morban bin Samingon and Mrs. Jamilah binti Mohamad for their love, support and understanding during my study. I also wish to thank my brothers and sister for being supportive and caring siblings.

Collective and individual acknowledgements are also owed to my Faculty of Electrical & Electronics Engineering (FKEE) for providing needed facilities during my research and my colleagues from BEE 05/06 program whose help, support, interest and valuable hints in difficult times are somehow perpetually.

Finally, I would like to thank everybody who was important to the successful realization of this project, as well as expressing my apology that I could not mention personally one by one. Once again, thank you very much.

ABSTRACT

People nowadays love to travel but they have to bring a lot of stuff during the travel including compass and maps. For Muslim travelers, they even have to bring Qibla pointer as they must be faced to Qibla while performing their five times prayer throughout the day and the night regardless of the location. Thus, there is a need for a simple and cost effective device to facilitate these travelers. This compass-based device finds the direction of Magnetic North through built-in compass (HMC6352). HMC6352 gives output heading which then be sent to PIC18F452. As the brain of the device, PIC18F452 processes the output heading to be displayed as digital numeric readout on a 16×2 LCD. With database of longitude and latitude for 14 locations in Malaysia installed in this device, Qibla direction is determined using the solution of spherical triangle. The solution involves longitude and latitude of user's current location and Makkah. C language is used to develop the algorithm for the solution in CCS C Compiler. The calculated direction of Qibla is indicated in degree as well as Magnetic North direction which are pointed out by an arrow on the device. This device is reliable as there is only 2.147% of Qibla angle difference between this device and JAKIM database. In short, this device is successfully developed to be used anywhere in Malaysia.

ABSTRAK

Manusia pada hari ini gemar mengembara tetapi mereka perlu membawa pelbagai kelengkapan semasa pengembaraan termasuk kompas dan peta. Bagi pengembara Muslim, mereka perlu membawa bersama penunjuk arah Kiblat kerana mereka mesti menghadap ke arah Kiblat ketika menunaikan sembahyang lima waktu sehari semalam walau di mana pun mereka berada. Oleh itu, alat yang mudah dan efektif dari segi kos adalah menjadi satu keperluan bagi memudahkan para pengembara. Alat yang berasaskan kompas ini mengesan arah Utara Magnet menggunakan kompas terbina dalam (HMC6352). HMC6352 memberikan keluaran arah yang kemudian dihantar ke PIC18F452. Sebagai otak kepada alat ini, PIC18F452 memproses keluaran arah tersebut untuk dipaparkan dalam bentuk bacaan angka digital di atas 16×2 Paparan Kristal Cecair. Berdasarkan pangkalan data longitud dan latitud untuk 14 lokasi di Malaysia yang ditempatkan di dalam alat ini, arah Kiblat ditentukan menggunakan penyelesaian segitiga sfera. Penyelesaian ini melibatkan longitud dan latitud lokasi semasa pengguna dan Makkah. Pengaturcaraan C digunakan untuk membangunkan prosedur pengiraan bagi penyelesaian tersebut di dalam Penyusun C CCS. Arah Kiblat yang telah dikira dalam darjah dan arah Utara Magnet ditunjukkan oleh anak panah di atas alat ini. Alat ini boleh dipercayai kerana hanya terdapat 2.147% perbezaan sudut Kiblat antara alat ini dan pangkalan data JAKIM. Secara keseluruhannya, alat ini telah dibangunkan dengan jayanya untuk digunakan di mana sahaja di dalam Malaysia.

TABLE OF CONTENTS

CHAPTER	TITLE	PAGE
	TITLE	i
	DECLARATION	ii
	DEDICATION	iii
	ACKNOWLEDGEMENT	iv
	ABSTRACT	v
	ABSTRAK	vi
	TABLE OF CONTENTS	vii
	LIST OF FIGURES	x
	LIST OF TABLES	xii
	LIST OF ABBREVIATIONS	xiii
	LIST OF SYMBOLS	xiv
	LIST OF APPENDICES	xv
1	INTRODUCTION	1
	1.1 Overview	1
	1.2 Project Objectives	2
	1.3 Project Scopes	2
	1.4 Thesis Outline	3
2	LITERATURE REVIEW	4
	2.1 Background	4
	2.2 Compass System	4

2.3	Qibla Direction	8
2.2.1	Methods to Locate Qibla Direction	9
2.3.2	Spherical Triangle Solution	11
2.4	Qibla Compass	12
2.5	Relationship of Compass and Qibla Direction in ETA Design	14
3	METHODOLOGY	15
3.1	Introduction	15
3.2	System Framework	16
3.3	Hardware Implementation	17
3.3.1	ISIS 7 Professional	18
3.3.2	PIC18F452	19
3.3.3	HMC6352	21
3.3.4	Programmer	23
3.4	Software Implementation	26
3.4.1	CCS C Compiler	26
3.4.2	Algorithm of ETA	27
3.4.3	Interfacing with HMC6352	29
3.4.4	Building the Qibla direction algorithm	30
4	RESULT AND DISCUSSION	33
4.1	Introduction	33
4.2	The Features of ETA	35
4.3	Performance of ETA	36
4.4	Costing	40

5	CONCLUSION AND RECOMMENDATION	42
	5.1 Conclusion	42
	5.2 Recommendation for ETA Project	43
	5.3 Commercialization	43
	REFERENCES	45
	APPENDIX A	46
	APPENDIX B	48

LIST OF FIGURES

FIGURE NO.	TITLE	PAGE
2.1	Illustration from " <i>De Magnete</i> "	5
2.2	Declination Angles of Earth Magnetic Field from True North in 2000	7
2.3	Difference of True North and Magnetic North	8
2.4	Qibla Direction (Q)	11
2.5	D9032 and D9033, Qibla indicator, lid at National Maritime Museum, Greenwich, London	13
2.6	Qibla Indicator, Iran, 1938-1939 at The Bakken Library and Museum	13
3.1	Flowchart for ETA development	16
3.2	Block Diagram of ETA	17
3.3	ISIS 7 Professional Interface	18
3.4	Pin Diagram of PIC18F452 / PIC18F442	19
3.5	PIC18F452 Block Diagram	20
3.6	HMC6352 Compass Module	22
3.7	HMC6352 Pin Diagram	22
3.8	Reference Design for Basic HMC6352 Application Circuit	23
3.9	UP00A Cytron Programmer	25
3.10	ICSP Connection of UP00A	25

3.11	Schematic Diagram for ICSP Connection	26
3.12	WinPic800 Interface	26
3.13	CCS C Compiler Interface	28
3.14	Flowchart of ETA	28
3.15	Function for heading output reading of HMC6352	30
3.16	Flowchart of heading output reading	31
3.17	Function for Qibla direction algorithm	32
3.18	Flowchart for Qibla direction algorithm	32
4.1	Top view	33
4.2	Side view	34
4.3	Main board of ETA	34
4.4	AC/DC Adapter with 9V DC output	35
4.5	Rechargeable Battery 6V	35
4.6	Welcome screen	35
4.7	Menu view	36
4.8	Buttons for User Interfacing	36
4.9	Compass menu	37
4.10	Arrow to appoint North and Qibla direction	37
4.11 (a)	Some of database installed in ETA : Malacca	37
4.11 (b)	Some of database installed in ETA : Shah Alam	37
4.11 (c)	Some of database installed in ETA : Kuching	37
4.11 (d)	Some of database installed in ETA : Kuantan	37
4.12	Example of finding the Qibla direction in Kuantan	38

LIST OF TABLES

TABLE NO.	TITLE	PAGE
3.1	PIC18F452 Features	21
3.2	HMC6352 Specifications	24
4.1	Differences of data from ETA and e-Solat JAKIM	39
4.2	Basic Component Price List	40
4.3	Main Component Price List	41

LIST OF ABBREVIATIONS

ETA	-	Electronics Travel Aid
LCD	-	Liquid Crystal Display
B.C.	-	Before Christ
A.D.	-	<i>anno domini</i>
DC	-	Direct Current
AC	-	Alternate Current
PIC	-	Peripheral Interface Controller
TTL	-	Transistor-Transistor Logic
CMOS	-	Complementary Metal Oxide Semiconductor
ECL	-	Emitter-Coupled Logic
IC	-	Integrated Circuit
FET	-	Field Effect Transistor
PCB	-	Printed Circuit Board
I/O	-	Input / Output
I ² C	-	Inter-Integrated Circuit
ICSP	-	In-Circuit Serial Programming
USB	-	Universal Serial Bus
V	-	Volts
RAM	-	Random Access Memory
EEPROM	-	Electrically Erasable Programmable Read-Only Memory
A/D	-	Analog-to-Digital Converter
ROM	-	Read Only Memory
OLED	-	Organic Light-Emitting Diode

LIST OF SYMBOLS

D	-	Declination
MD	-	Magnetic Declination
MB	-	Magnetic Bearing
TB	-	True Bearing
Q	-	Qibla Direction
N	-	Geographical North Pole
E	-	East
λ_M	-	Longitude of Makkah
Φ_M	-	Latitude of Makkah
L	-	Current Location
λ_L	-	Longitude of Current Location
Φ_L	-	Latitude of Current Location
F _m	-	Latitude of Makkah (radian)
L _m	-	Longitude of Makkah (radian)
F _d	-	Latitude of Current Location (radian)
L _d	-	Longitude of Current Location (radian)

LIST OF APPENDICES

APPENDIX	TITLE	PAGE
A	Hardware Schematic Diagram	46
B	Programming in CCS C Compiler	48

CHAPTER I

INTRODUCTION

This chapter explains the overview of ETA's project, objectives of project, project scopes and thesis outline.

1.1 Overview

People nowadays love to travel around the world. During traveling, they have to bring maps, compass and for Muslims, they even have to bring a Qibla pointer as they still have to perform the five times prayer wherever they are. In today's market, technology is becoming more prevalent each day and it offers variety of devices to facilitate humans' daily life. The goal of this project is to come out with a simple and portable device for travellers in order to disburden them from bringing all those equipments into a small device instead.

Electronics travel device in this project is designed combining compass and Qibla finder. It displays the digital numeric readout of a compass and Qibla direction. This project uses an electronic compass, HMC6352 which measures the orthogonal axes X and Y of the earth magnetic field. Thus, the output of HMC6352 is in the form of heading (Mag X, Mag Y).

The Qibla direction is appointed on the LCD after being calculated using the algorithm developed. The algorithm is developed using C Language programming as written C Language can be compiled for a very wide variety of computer platforms and operating systems with minimal change to its source code.

1.3 Project Objectives

The overall aim of the project is to facilitate travellers and navigators to find the direction of North and Qibla using a single device. The more specific objectives are described in the following:

- i. To design a mini portable travel device for travellers especially Muslim travellers.
- ii. To design a device with digital numeric readout.

1.4 Project Scopes

To achieve all the project's objectives, the following scopes are listed and must be focused throughout the development of ETA.

The first scope of this project is to develop a device for travellers based on electronics compass (HMC6352). This electronics compass will give the output heading that later can be implemented in finding the North and Qibla direction.

Another scope of this project is to implement C Language programming to display on LCD. The software created with this implementation will send the data from input to the microcontroller and LCD.

1.5 Thesis Outline

Chapter 1 explains the overview of ETA's project, objectives of project, project scopes and thesis outline.

Chapter 2 reviews the background of compass system, Qibla direction and the relationship of each part with ETA design. Each part in ETA is discussed based on the literature review made from various sources.

Chapter 3 focuses on the methodologies for the development and implementation of ETA. It discusses the hardware and software implementation of ETA, how ETA works and the algorithm of ETA.

Chapter 4 discusses all the results obtained and the limitation of the project. All discussions are concentrated on the result and performance of ETA.

Chapter 5 discusses the conclusion of development of the project. This chapter also discusses the problems and the recommendations for this project for the future development or modification.

CHAPTER II

LITERATURE REVIEW

2.1 Background

This chapter provides a concise and comprehensive description of compass, Qibla direction and the relationship of each part with ETA design. The compass and Qibla finder are two essential parts of ETA design.

2.2 Compass System

A compass is a navigational instrument for finding directions on the Earth. It consists of a magnetized pointer free to align itself accurately with Earth's magnetic field, which displays the direction of the horizontal component of the Earth's magnetic field at the point of observation.

The magnetic compass is an old Chinese invention, first made in China during the Qin dynasty (221-206 B.C.). Chinese fortune tellers used lodestones (a mineral composed of an iron oxide which aligns itself in a north-south direction) to construct their fortune telling boards. Eventually someone noticed that the lodestones were better at pointing out real directions, leading to the first compass. They designed the compass

on a square slab which had markings for the cardinal points and the constellations. The pointing needle was a lodestone spoon-shaped device, with a handle that would always point south. Magnetized needles used as direction pointers instead of the spoon-shaped lodestones appeared in the 8th century AD, again in China, and between 850 and 1050 they seem to have become common as navigational devices on ships. The first person recorded to have used the compass as a navigational aid was Zheng He (1371-1435), from the Yunnan province in China, who made seven ocean voyages between 1405 and 1433.

William Gilbert published *De Magnete*, a paper on magnetism in 1600, about the use and properties of Magnetite. An illustration from the paper is shown in Figure 2.1 below. Magnetite was nicknamed lodestone which made of ferrites or magnetic oxide. These are natural magnets and are not inventions that attract iron and other metals. Ferrites were first discovered thousands of years ago. Large deposits were found in the district of Magnesia in Asia Minor, giving the mineral's name of magnetite (Fe_3O_4). In 1819, Hans Christian Oersted reported that when an electric current in a wire was applied to a magnetic compass needle, the magnet was affected and this is called electromagnetism. [2]

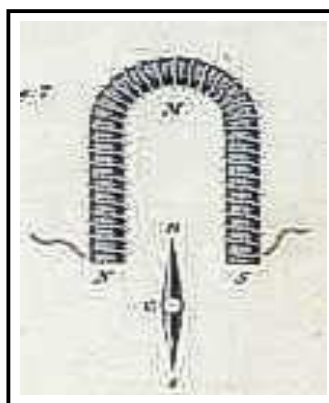


Figure 2.1: Illustration from "*De Magnete*"

The Earth's magnetic field intensity is about 0.5 to 0.6 Gauss. The performance of a compass will greatly depend on its installation location. A compass depends on the earth's magnetic field to provide heading. Any distortions of this magnetic field by other sources should be compensated for in order to determine an accurate heading. Sources of magnetic fields include permanent magnets, motors, electric currents either DC or AC, and magnetic metals such as steel or iron. The influence of these sources on compass accuracy can be greatly reduced by placing the compass far from them. Some of the field effects can be compensated by calibration.

Calibration is always used in electronics compass as the sensitivity is much higher than a usual magnetic compass. Calibration is done to diminish hard-iron effects of the end-user's (customer's) location of the compass. Hard-iron effects from nearby ferrous materials with residual magnetism will buck or boost the intensity of the earth's magnetic field, leading to heading errors. During calibration, the compass is rotated on a flat surface at least one full circular rotation. It collects several readings at various heading with the emphasis on rotation smoothness to gather uniformly spaced readings and corrects the hard-iron distortions of the earth's magnetic field. After being calibrated, the resulting offsets and scaling factors are updated.

The compass accuracy should be considered because of the variation or declination angle too. It is well known that the earth's magnetic poles and its axis of rotation are not at the same geographical location. They are about 11.5° rotation from each other. [4] This means that the north and south geographic poles and the north and south magnetic poles are not located in the same place. Declination Angles of Earth Magnetic Field from True North in 2000 can be seen in Figure 2.2.

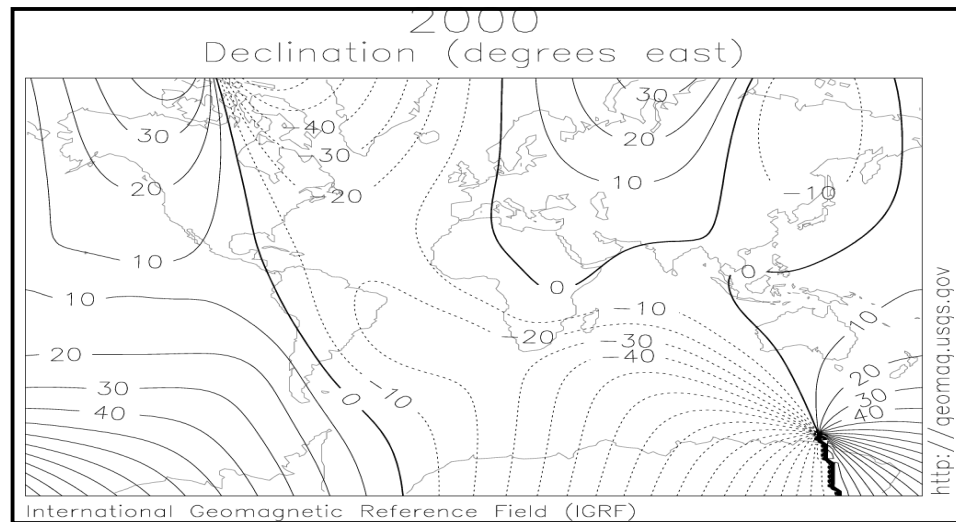


Figure 2.2: Declination Angles of Earth Magnetic Field from True North in 2000

The magnetic declination in a given area will change slowly over time, possibly as much as 2-2.5 degrees every hundred years or so, depending upon how far from the magnetic poles it is. This creates a difference between the true north, or grid north, and the magnetic north, or direction a magnetic compass will point. Simply it is the angular difference between the magnetic and true north expressed as an Easterly or Westerly variation. This difference is defined as the variation angle and is dependent on the compass location—sometimes being as large as 25° . To account for the variation simply add, if Westerly, or subtract, if Easterly, the variation angle from the corrected heading computation. [4] After heading is determined, the variation correction can be applied to find true north according to the geographic region of operation. An example on how to account the variation is shown in Figure 2.3.

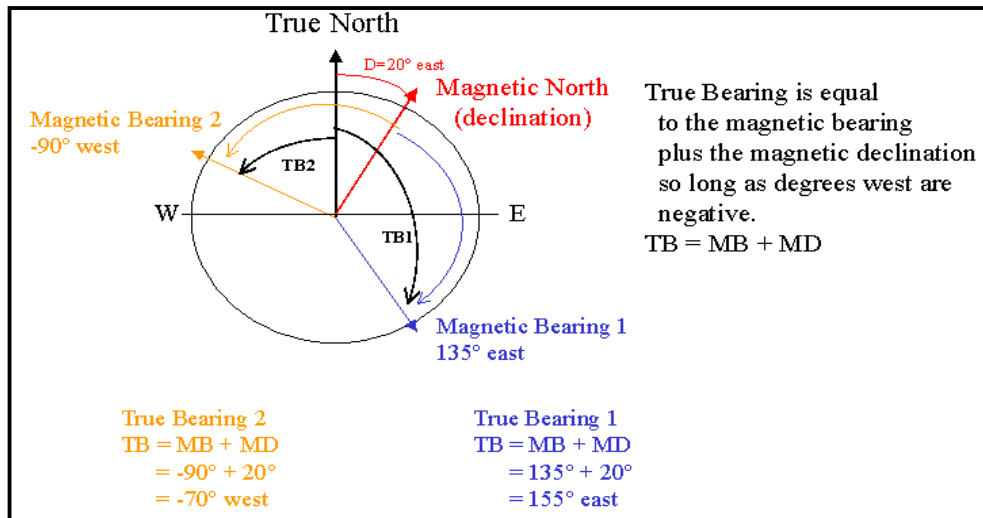


Figure 2.3: Difference of True North and Magnetic North

2.3 Qibla Direction

For Muslims it is obligatory to perform five times solah throughout the day and the night. Muslims need to know the Qibla direction wherever they are in order to direct themselves towards it at the time of prayers. This step comes in obedience of God's saying:

“From whencesoever Thou startest forth, turn Thy face in the direction of the sacred Mosque that is indeed the truth from the Lord. And Allah is not unmindful of what ye do.”

(Surah al-Baqarah: Verse 149)

The Qibla has importance to more than just the solah, and plays an important part in everyday ceremonies. The head of an animal that is slaughtered using Halal methods is aligned with the Qibla. After death, Muslims are buried with their faces in the

direction of the Qibla. Thus, archeology can indicate a Muslim necropolis if no other sign is present.

The Qibla, for any point of reference on the Earth, is the direction of the Kaabah in Makkah City of Saudi Arabia. Muslims do not worship the Kaabah or its contents; the Kaabah is simply a focal point for prayer. There are methods in determining the direction of Kiblah; in the last 1000 years, several Muslim mathematicians and astronomers, such as Biruni, have discussed the correct way of determining the Kiblah direction from any point on the Earth's surface.

2.3.1 Methods to Locate Qibla Direction

Grand Sheikh of Al-Azhar has formed a committee to give a final fatwa (religious opinion) on the correctness of the nine scientific methods used to locate the Qibla direction. As regards the nine methods of locating the Qibla direction, the first is arithmetic. It applies the laws of spherical triangle solution and "half sinus." It proves, for instance, that the Qibla direction for an observer in Alexandria, Egypt is 135.5 degrees to the direction of true north clockwise, in Seattle, Washington 17.5 degrees to the direction of true north clockwise, and in Hong Kong 285.1 degrees to the direction of true north clockwise.

Trigonometry and its tables are applied under the second and third methods. These two methods proved the above-mentioned degrees of Qibla direction in Alexandria, Seattle and Hong Kong.

As for the fourth method, the star sphere is used. During sailing, a navigator needs a quick method to locate the Qibla accurately. This method locates the Kaabah by adjusting its latitude to the inclination parallels on the star sphere and the Kaabah longitude.

The fifth method uses the star disc. The direction of Kaabah is located on the star disc with the same method used on the star sphere. The latitude of the Kaabah is matched with the inclination parallels of the celestial body and longitude of the Kaabah from the observer's site.

The sixth method uses Weris' cone. The longitude of the Kaabah is matched with the base line of gradation on the celestial body inclination.

The seventh method considers the site of the Kaabah a point of reference on some navigational devices. Some of these devices, like the one that locates sites via satellites, can store points of reference and indicate the direction and distance of these points at any moment. Thus, the site of Kaabah is stored in the device memory as a point of reference. If the direction of the Kaabah is needed at any time, the point of reference can be recalled.

Regarding the eighth method, it benefits from the perpendicularity of the sun on the Kaabah. When the sun is perpendicular to Mecca, its direction at this very moment is the direction of the Qibla. The sun is perpendicular to the Kaabah twice a year when the sun inclination equals the Kaabah latitude and during the sun time. The sun height will be 90 degrees at this very moment for observers in Mecca. This phenomenon happens on May 28 at seventeen minutes and 52.8 seconds past 12 p.m. local time of Saudi Arabia and Egypt (summer time) and on July 16 at twenty-six minutes and 40.8 seconds past 12 p.m. local time of Saudi Arabia and Egypt (summer time). On these two days, the sun can be watched by all inhabitants of Africa, Europe, East Asia up to the Philippines and the northwest part of Australia. Those who see the sun at the above-mentioned moment will be facing the Qibla, God willing. A streetlight, for instance, can be observed at this very moment to locate the direction of Qibla. Thus, each Muslim can be assured of his direction and stick to it the whole year round.

The ninth method is the prayer map drawn by the Islamic Center in the United States of America. It locates the Qibla direction by angles worldwide. [3]

2.3.2 Spherical Triangle Solution

Spherical Triangle Solution is mostly used in today's device to locate the Qibla direction. Figure 2.4 shows geometrical situation for determination of direction between two geographical places and Equation (1) is Qibla direction (Q) counts from north to west. When N is Geographical North Pole, M is Makkah city [4]

λ_M = Longitude of Makkah = 39.8230°E

Φ_M = Latitude of Makkah = 21.42330°N

L = Current Location

λ_L = Longitude of Current Location

Φ_L = Latitude of Current Location

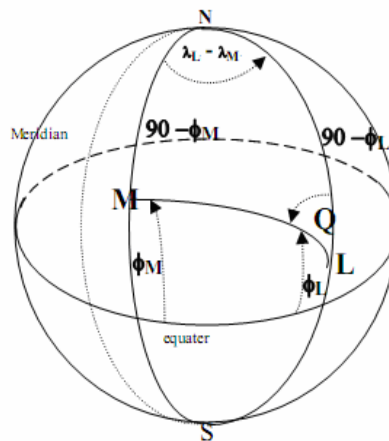


Figure 2.4: Qibla Direction (Q)

$$Q = \tan \left[\frac{\sin(\lambda_L - \lambda_M)}{\cos(\phi_L) \times \tan(\phi_M) - [\sin(\phi_L) \times \cos(\lambda_L - \lambda_M)]} \right] \quad (1)$$

By computer aided and algorithm of Equation (1) of Qibla direction, we can use any programming language such as Visual Basic, C, Pascal and etc. to compute where the Qibla direction is with most accuracy.

2.4 Qibla Compass

Qibla can be determined using compass, but there are errors involved in compass. Firstly, the compass is affected by metallic objects in the vicinity, in furniture, in building materials, or even buried in the ground, so the compass placed at different locations in the same room gives different directions. Secondly, the angle of Qibla can only be calculated from True North, and True North cannot be determined by compass. Compass points to magnetic North, (based on earth's magnetic field, which is changing continuously, and sometimes has erratic behavior) that may be many degrees away from True North.

Qibla indicators were made after al-Kindi (an Arab polymath, an Islamic philosopher, scientist, astrologer, astronomer, cosmologist, chemist, logician, mathematician, musician, physician, physicist, psychologist, and meteorologist). The indicator comprises a round brass box with a hinged lid and an inset magnetic compass. A list of important Islamic places with their longitudes, latitudes, is inscribed in Arabic on all sides of the box. The compass has a blued steel needle with an open circle to indicate North. It is surmounted by a brass pyramidal pivot and a glass plate covers all. A brass ring over the rim of the compass carries a degree circle numbered in '*abjad*'

numerals and the cardinal points are marked. The folding triangular gnomon is supported by a decorative open-work motif. The lid of the box is secured by a hook fastener (refer Figure 2.5). [5]



Figure 2.5: D9032 and D9033, Qibla indicator, lid at National Maritime Museum, Greenwich, London



Figure 2.6: Qibla Indicator, Iran, 1938-1939 at The Bakken Library and Museum

The above device is signed by Faraj Allâh Isfahânî. It is made of brass plates over a wood core, 2" x 3" overall. It is engraved in Arabic, and equipped with an inset glazed compass and a suspension ring for carrying. One face has a calibrated degree circle and pointer, to show the azimuth of the Qibla. There are additional calibrated semicircles for the direction of Makkah. The dates (1317 Persian solar and 1357 Hegira) correspond to 1938/1939 AD. The reverse has a gazetteer of 60 cities and their

directions. Travelers would estimate their position among the cities, adjust the pointer accordingly, and then use the compass to find North. Modern version of Qibla compass uses digital readout instead of magnetic pointer.

2.5 Relationship of Compass and Qibla Direction in ETA Design

Qibla direction in ETA design is determined using the solution of spherical triangle in Equation (1). This method is used since it has the most accuracy for a device such as ETA. Compass is used to locate the Qibla direction once the direction is obtained in form of degree from the calculation. These two elements are combined in developing ETA's system.

CHAPTER III

METHODOLOGY

3.1 Introduction

Chapter 3 focuses on the methodologies for the development and implementations of ETA. It gives a brief review of all parts in ETA. It explains and discusses the process of hardware and software implementation of ETA and how ETA works.

Figure 3.1 shows the process flow of developing ETA. Literature review gives comprehensive background on parts consisted in ETA. Findings from the literature review are availed through the methodology development of ETA. Material selection is very important as different material will give different results to the output. Suitable materials are selected based on their specification of both mechanical and electrical specification.

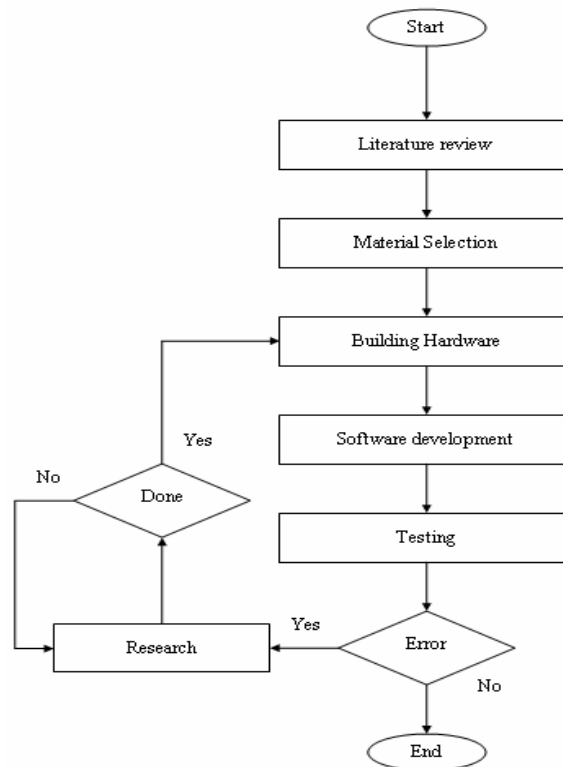


Figure 3.1: Flowchart for ETA development

3.2 System Framework

Figure 3.2 is the Block Diagram of ETA that develops the three parts of ETA. ETA's system consists of the measuring part which requires electronics compass (HMC6352) to measure the orthogonal axes X and Y of the earth magnetic field and gives the output of heading. The output acquired is sent to microcontroller. For user interface, ETA has four buttons which used to select to display user mode (compass or Qibla direction) and select current location of the user.

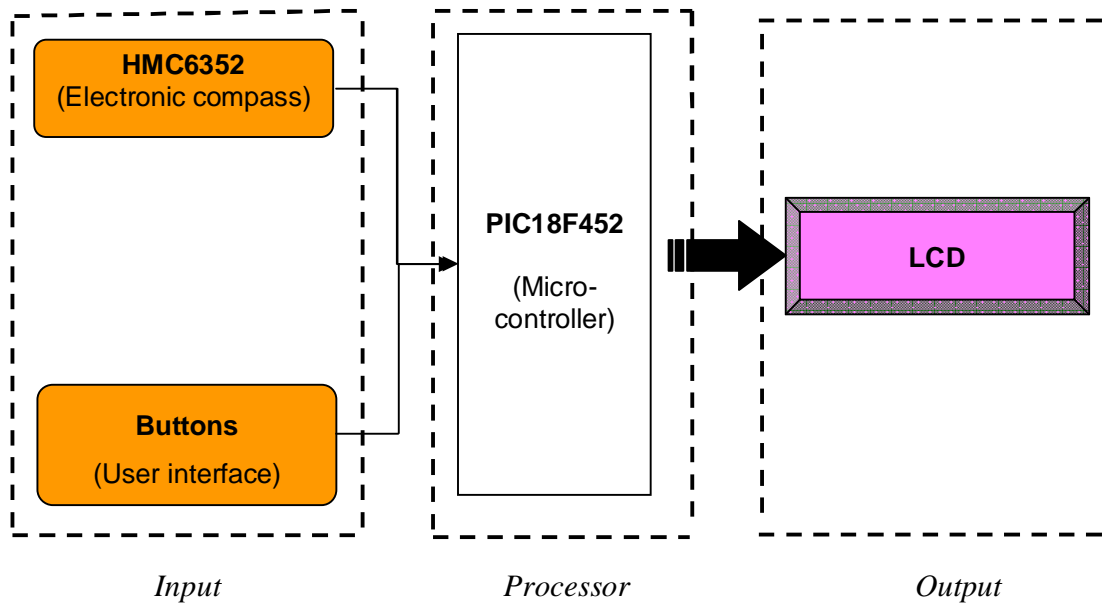


Figure 3.2: Block Diagram of ETA

Microcontroller (PIC18F452) receives information from HMC6352 and user input (buttons). The output heading is displayed on LCD for compass reading. If user chooses to display Qibla direction, ETA then calculates the direction of Qibla based on the location the user has chose. The algorithm for calculating the Qibla direction is developed using C Language programming.

3.3 Hardware Implementation

Circuit of ETA is designed using ISIS 7 Professional from Labcenter Electronics. Basic circuits in ETA consist of power supply module, clock circuit and reset circuit. PIC18F452 is chose to be the microcontroller in this project and HMC6352 as the compass module.

3.3.1 ISIS 7 Professional

ISIS 7 Professional is a commercial software product developed by Labcenter Electronics which allows simulation of many PICmicro devices along with a wide array of peripheral devices. This method can help bridge the gap between the limited peripheral support offered by the MPLAB simulator and traditional in-circuit debugging / emulating. The product interfaces directly with MPLAB to offer a schematic display of signals and peripheral devices. A screenshot showing a typical ISIS design in ISIS 7 Professional is shown in Figure 3.3 below.

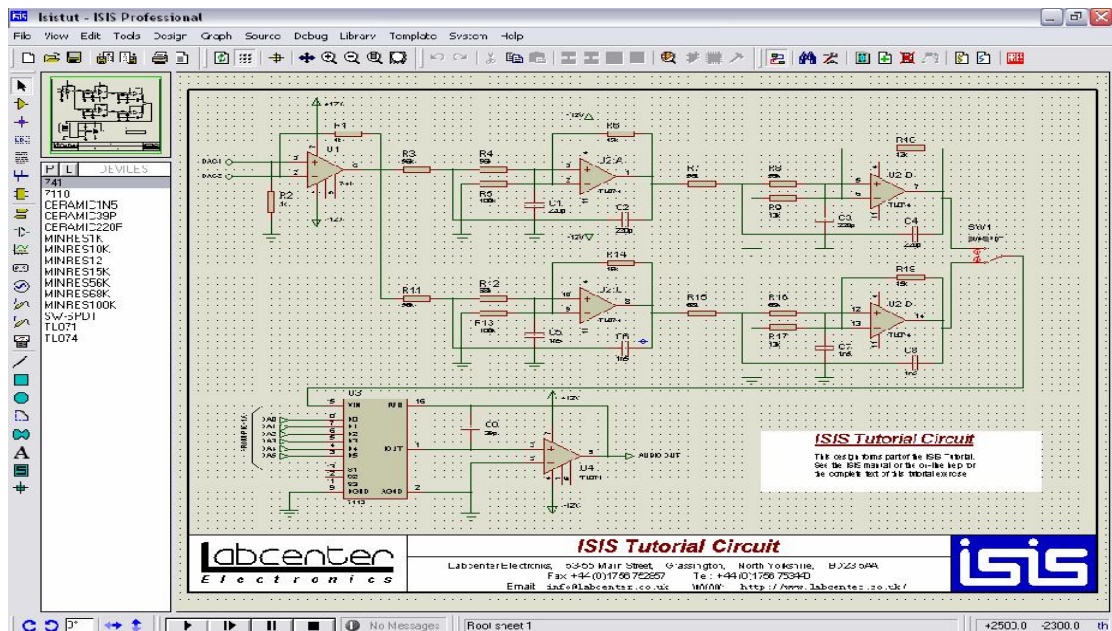


Figure 3.3: ISIS 7 Professional Interface

ISIS comes with libraries for TTL, CMOS, ECL, Microprocessor, Memory and Analogue ICs plus libraries with hundreds of named Bipolar, FET and Diode discrete semiconductors. Also included are manufacturer specific libraries from National Semiconductor, Philips, Motorola, Teccor, Texas Instruments, Dallas and Zetex amongst others - an expanding total, currently over 10,000 parts. These libraries also contain default properties for PCB packaging and simulator models.

3.3.2 PIC18F452

PIC18F452 is popular with developers due to its low cost, wide availability, large user base, extensive collection of application notes, availability of low cost or free development tools, and serial programming (and re-programming with flash memory) capability.

Among the PIC microcontroller families, PIC18F452 is chosen for its 16-bit wide instructions with 8-bit wide data path, allowing more new instructions. Five I/O ports in PIC18F452 are available for future expansion of this project. In contrast to other devices, which were more often programmed in assembly, C has become the predominant development language for this device.

Figure 3.4 shows the Pin Diagram of PIC18F452 used in this project. Port B is used for input devices (buttons) and Port D is used for output device (LCD).

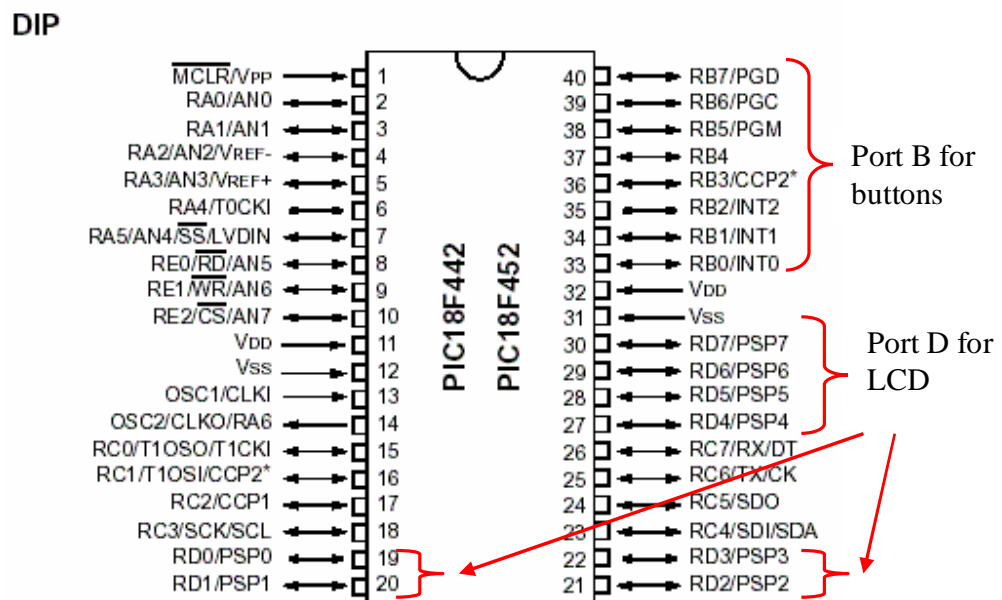


Figure 3.4: Pin Diagram of PIC18F452 / PIC18F442

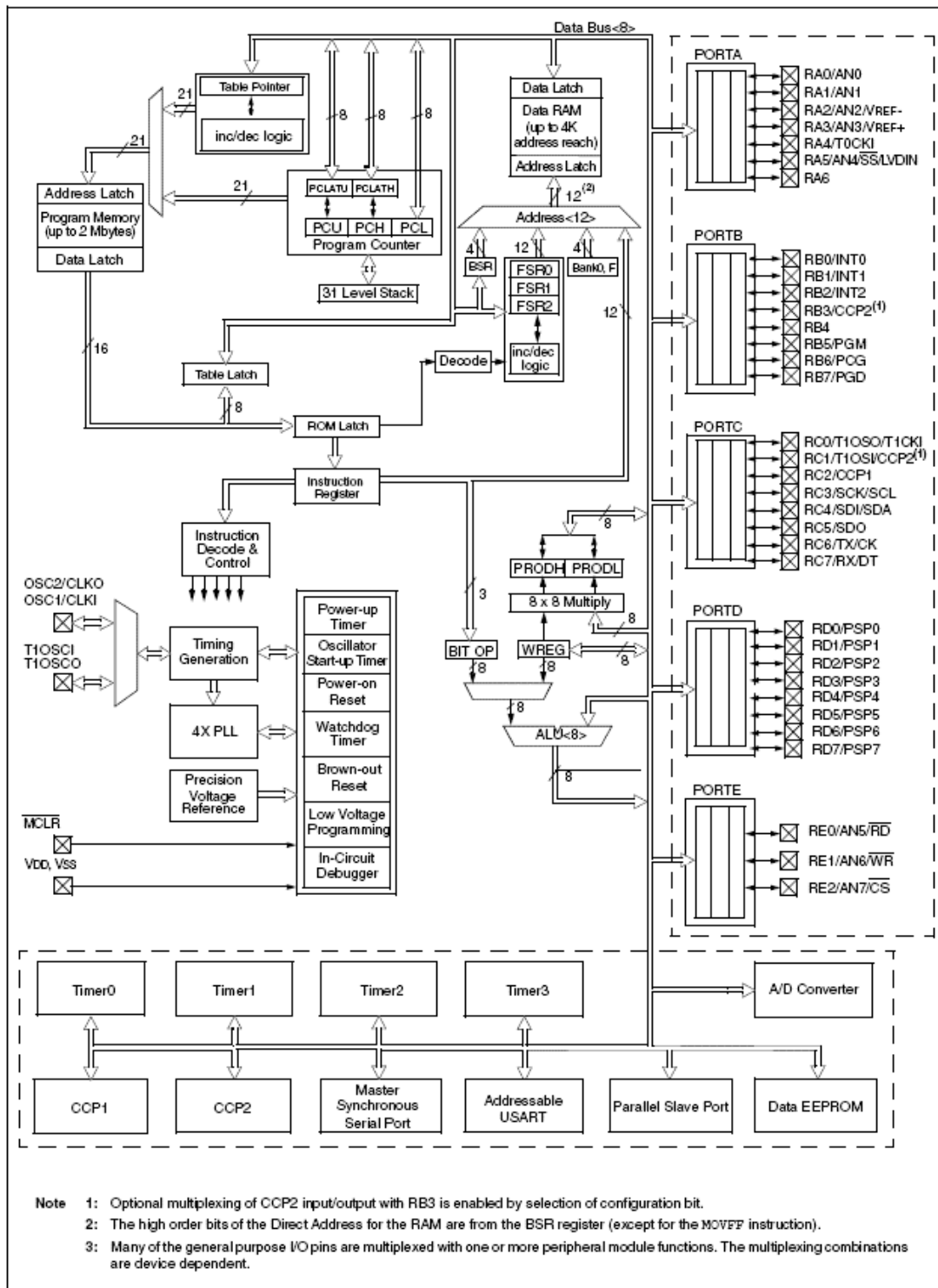


Figure 3.5: PIC18F452 Block Diagram

Table 3.1: PIC18F452 Features

Features	PIC18F452
Operating Frequency	DC - 40 MHz
Program Memory (Bytes)	32K
Program Memory (Instructions)	16384
Data Memory (Bytes)	1536
Data EEPROM Memory (Bytes)	256
Interrupt Sources	18
I/O Ports	Ports A, B, C, D, E
Timers	4
Capture/Compare/PWM Modules	2
Serial Communications	MSSP, Addressable USART
Parallel Communications	PSP
10-bit Analog-to-Digital Module	8 input channels
RESETS (and Delays)	POR, BOR, RESET Instruction, Stack Full, Stack Underflow (PWRT, OST)
Programmable Low Voltage Detect	Yes
Programmable Brown-out Reset	Yes
Instruction Set	75 Instructions
Packages	40-pin DIP 44-pin PLCC 44-pin TQFP

3.3.3 HMC6352

The HMC6352 integrates two-axis magnetic sensor with the required analog and digital support circuits for heading computation. The HMC6352 Integrated Compass Sensor circuit is composed of two magneto-resistive (MR) sensors with orthogonal orientation for sensing the horizontal components of the earth's magnetic field (0 to 630 milli-gauss), plus two amplifiers, a set/reset drive circuit, and a microprocessor (μ P). Best accuracy is obtained in clean magnetic environments (free air) and held

level, or perpendicular to the gravitational direction. HMC6352 has 4 pins to be connected to Ground, Vcc, SDA and SCL (refers Figure 3.7).

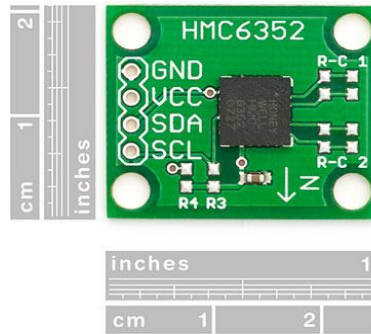


Figure 3.6: HMC6352 Compass Module

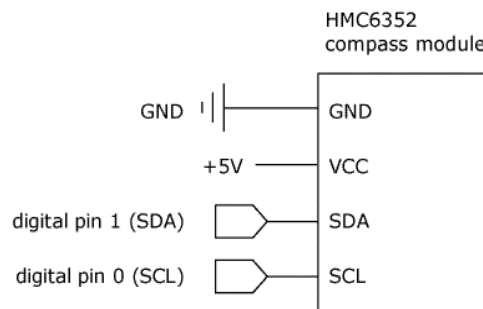


Figure 3.7: HMC6352 Pin Diagram

The HMC6352 communicates via a two-wire I²C bus system as a slave device. The HMC6352 Serial Clock (SCL) and Serial Data (SDA) lines do not have internal pull-up resistors, and require resistive pull-ups (R_p) between the master device (usually a host microprocessor) and the HMC6352. Pull-up resistance values of about 10k ohms are recommended with a nominal 3.0 to 5.0-V supply voltage. Figure 3.8 can be referred to connect HMC6352 for basic application circuit.

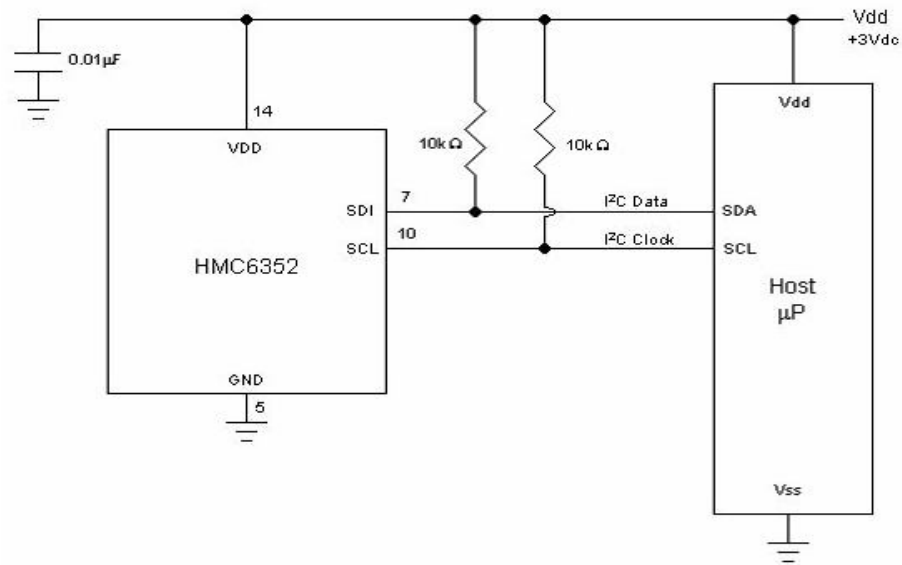


Figure 3.8: Reference Design for Basic HMC6352 Application Circuit

Two external 10k Ω pull-up resistors to the nominal +3V DC supply create normally high logic states when the interface lines are not in use. The 0.01mF supply decoupling capacitor in this reference can be omitted if another supply filter capacitor is already included in the overall circuit design. Table 3.2 shows the specifications of HMC6352.

Table 3.2: HMC6352 Specifications

Characteristics	Conditions ⁽¹⁾	Min	Typ	Max	Units
Supply Voltage	Vsupply to GND	2.7	3.0	5.2	Volts
Supply Current	Vsupply to GND				
	Sleep Mode (Vsupply = 3.0V)		1		μA
	Steady State (Vsupply = 3.0V)		1		mA
	Steady State (Vsupply = 5.0V)		2	10	mA
	Dynamic Peaks				mA
Field Range ⁽²⁾	Total applied field	0.10	-	0.75	gauss
Heading Accuracy	HMC6352		2.5		degRMS
Heading Resolution			0.5		deg
Heading Repeatability			1.0		deg
Disturbing Field	Sensitivity starts to degrade. Enable set/reset function to restore sensitivity.	20			gauss
Max. Exposed Field	No permanent damage and set/reset function restores performance.			10000	gauss
Operating Temperature	Ambient	-20		70	°C
Storage Temperature	Ambient	-55		125	°C
Peak Reflow Temperature	For Lead-Free SMT Reflow	230	-	240	°C
Moisture Sensivity	Max 240°C		MSL3		-
Output	Heading, Mag X, Mag Y				
Size	6.5 x 6.5 x 1.5				mm
Weight			0.14		grams

(1) Tested at 25°C except stated otherwise.

(2) Field upper limit can be extended by using external resistors across CA1/CA2 and CB1/CB2.

3.3.4 Programmer

There are several of programmers in the market for programming the PIC microcontroller. PIC18F452 used in this project is programmed using UP00A Cytron Programmer as this programmer can support up to 30 families of PIC microcontroller, less sensitivity to high current and reliable. This can be done by connecting one side of the cable to the programmer and the other side to the USB port of the computer.



Figure 3.9: UP00A Cytron Programmer

The UP00A USB Programmer is capable of supporting In-Circuit Serial Programming (ICSP) which means that the PIC microcontroller can be programmed directly on board (refers Figure 3.10 and Figure 3.11).

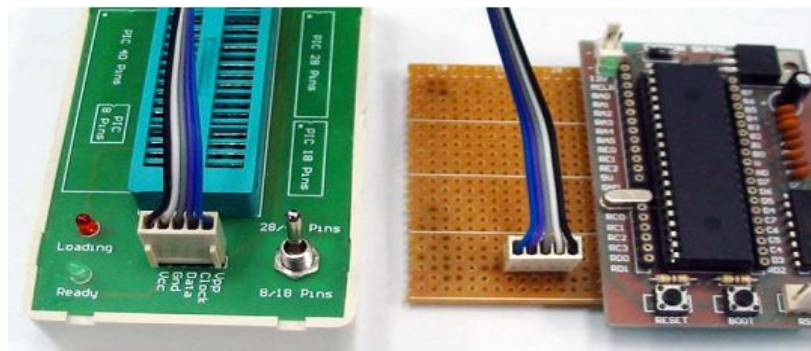


Figure 3.10: ICSP Connection of UP00A

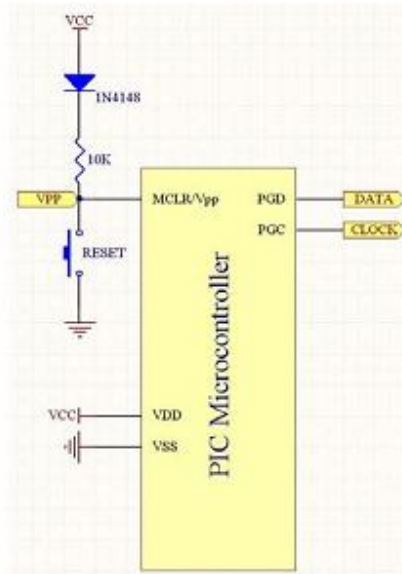


Figure 3.11: Schematic Diagram for ICSP Connection

Software used to program the PIC is WinPic800. It is compatible with Windows 95 / 98 / NT / 2000 / ME / XP. This software programs the PIC with the generated .hex file from CCS C Compiler.

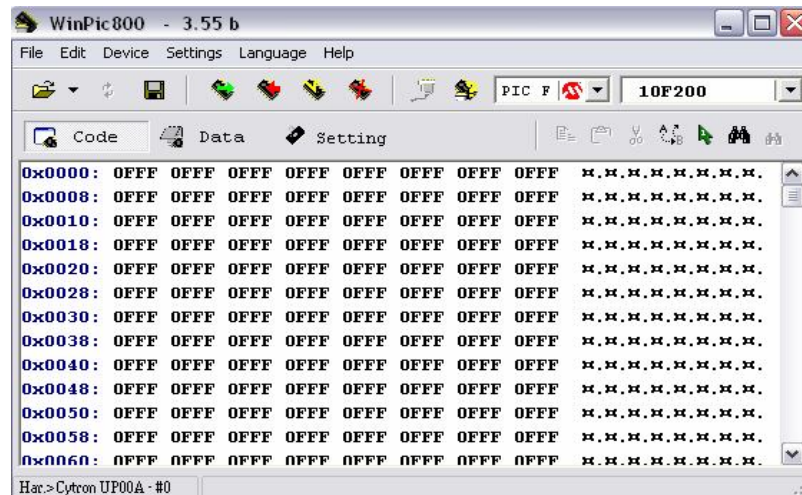


Figure 3.12: WinPic800 Interface

3.4 Software Implementation

ETA is developed using C Language and the source code is compiled using CCS C Compiler. C is a general-purpose programming language with features economy of expression, modern flow control and data structures, and a rich set of operators. Its absence of restrictions and its generality make it more convenient and effective for many tasks than supposedly more powerful languages. C Language is chose because C is a portable language intended to have minimal modification when transferring programs from one computer to another. The use of C in microcontroller applications has been brought about by manufacturers providing larger program and RAM memory areas in addition to faster operating speeds.

3.4.1 CCS C Compiler

The CCS C Compiler is available for PIC10, PIC12, PIC14, PIC16, and PIC18 microcontrollers. It has over 180 Built-in Functions to access PIC microcontroller easily and produces efficient and highly optimized code. Functions such as timers, A/D, EEPROM, SSP, PSP, USB, I²C and more built-in libraries that work with all chips for RS-232 serial I/O, I²C, discrete I/O and precision delays, source code drivers and over 100 ready-to-run programs is included.

The compiler can handle inline or separate functions, as well as parameter passing in re-usable registers. Transparent to the user, the compiler handles calls across pages automatically and analyzes program structure and call tree processes to optimize RAM and ROM Usage. It outputs hex and debug files that are selectable and compatible with popular emulators and programmers including the MPLAB® IDE for source level debugging.

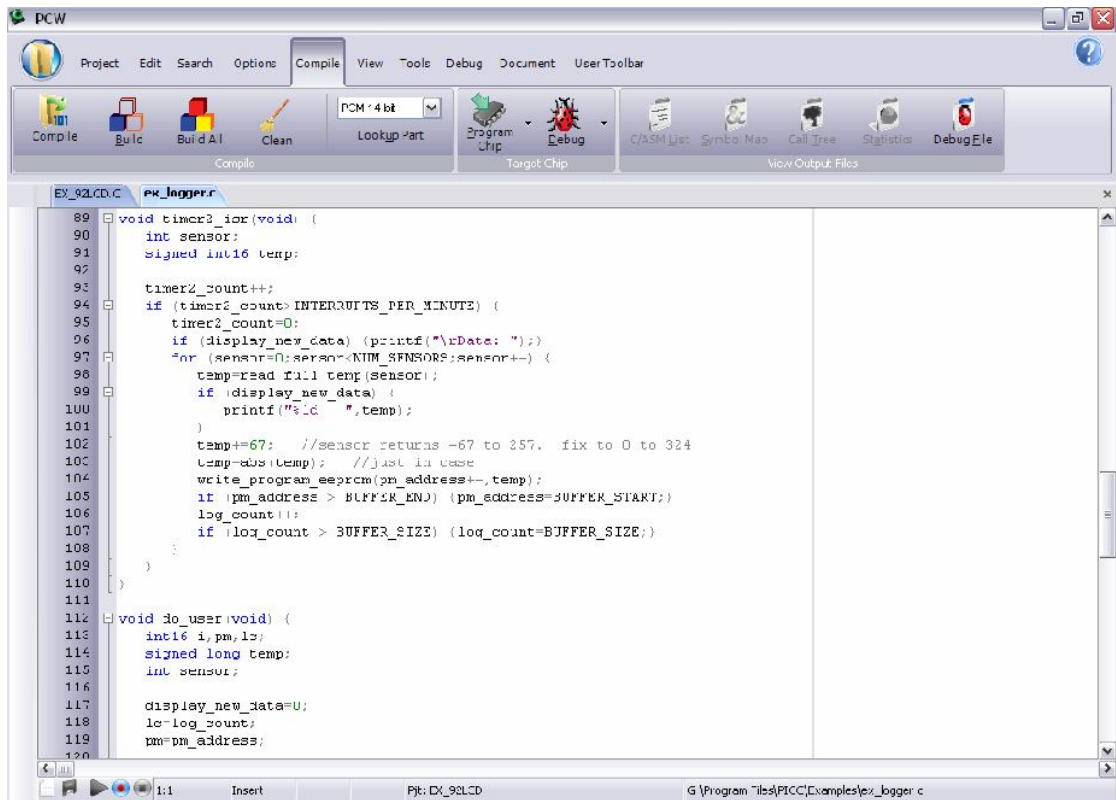


Figure 3.13: CCS C Compiler Interface

3.4.2 Algorithm of ETA

Figure 3.14 shows the overall flowchart of ETA. The flowchart guides throughout the development of ETA and briefly explains ETA's system.

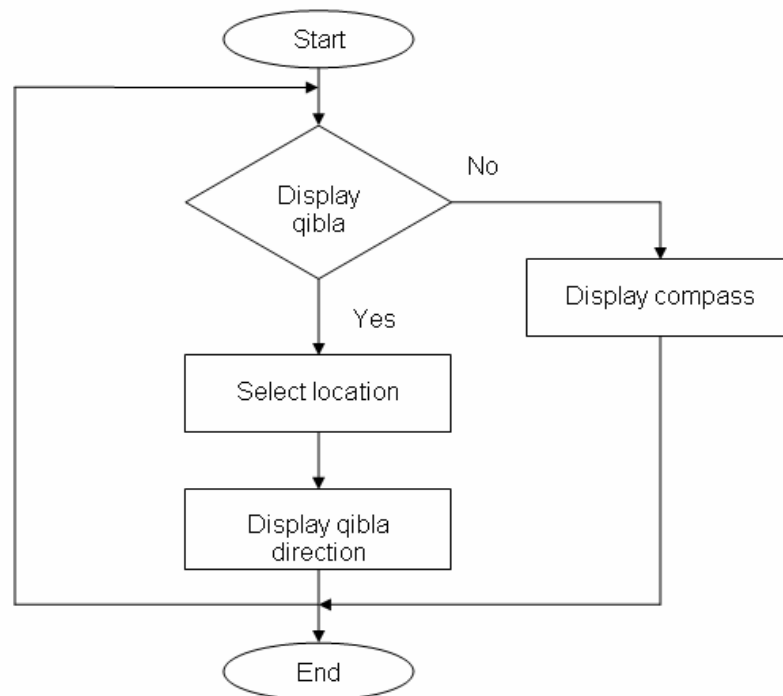


Figure 3.14: Flowchart of ETA

The algorithm of ETA is developed based on the flowchart. First, user has to choose to display Qibla direction or compass. If compass is chose then, ETA displays a range of degree from 0° to 360° . ETA must be rotated around to locate the North direction as North direction is indicated as 0° or 360° .

If user chooses to display Qibla direction, selection of location has to be made due to different location will gives different direction of Qibla. Right until now, there are 14 locations all over Malaysia in the database installed in ETA. Once location is selected, ETA displays the direction of Qibla also in degree.

3.4.3 Interfacing with HMC6352

Figure 3.15 below shows how the heading output reading of HMC6352 is done in CCS C Compiler.

```

int16 HMC_read_heading(void)
{
    int8 lsb;
    int8 msb;

    i2c_start();
    i2c_write(0x42); //slave address of HMC6352
    i2c_write(0x41); //also tried i2c_write(0x41);
    i2c_stop();

    delay_ms(7); //requires 6mS before data is ready to be read

    i2c_start();
    i2c_write(0x43);
    msb = i2c_read();
    lsb = i2c_read(0);
    i2c_stop();

    return (((int16)lsb | ((int16)msb << 8)) / 10);
}

```

Figure 3.15: Function for heading output reading of HMC6352

I²C functions let the user configure the hardware to communicate with other devices over the I²C interface. Functions used for communicating HMC6352 with PIC18F452 are defined for:

- Issues a start command when in the I²C master mode - **i2c_start()**
- Sends a single byte over the I²C interface - **i2c_write(data)**
- Reads a byte over the I²C interface - **i2c_read()**
- Issues a stop command when in the I²C master mode - **i2c_stop()**

The flowchart in Figure 3.16 summarizes the process flow for reading the heading output.

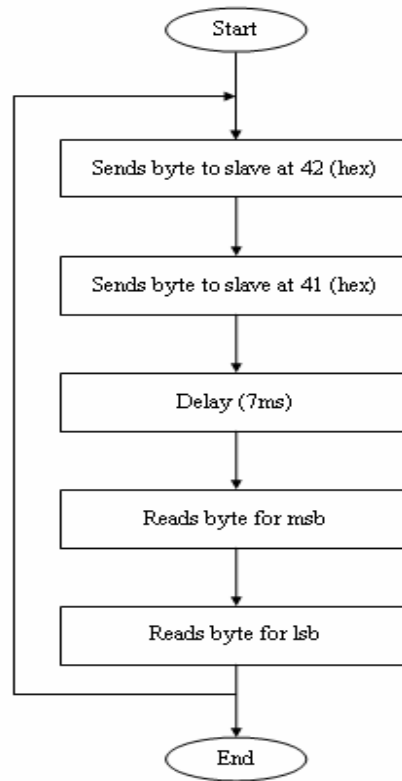


Figure 3.16: Flowchart of heading output reading

3.4.4 Building the Qibla direction algorithm

From Figure 3.17, it shows that the Qibla direction is calculated using the `<math.h>` library in CCS C Compiler. As this library requires the calculation to be done in radian, the longitude and latitude of each location has to be converted from degree to radian before calculation is performed.

```

float qibla_cal (void)
{
    float Fd,Ld;
    float Fm = 0.37437;
    float Lm = -0.69377;
    float qibla1;

    Fd = (pi/180)*latitude[location];
    Ld = (pi/180)*-(longitude[location]);

    qibla1 = (180/pi)* (atan ((sin (Ld-Lm))/((cos (Fd))*tan (Fm))-((sin (Fd))*cos((Ld)-(Lm)))));

    return qibla1;
}

```

Figure 3.17: Function for Qibla direction algorithm

Fm indicates the latitude of Makkah while Lm indicates the longitude of Makkah which are already in radian values. Latitude and longitude of desired location (which are represented by Fd and Ld) are grabbed from database installed in ETA and being converted into radian values. Then, the values converted are applied into the Qibla direction calculation from Equation (1). Flowchart in Figure 3.18 summarizes the flow of calculating the Qibla direction.

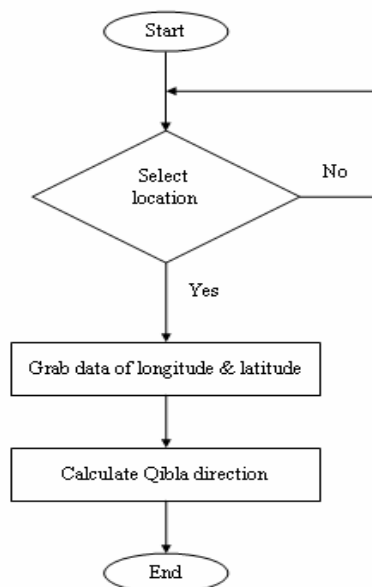


Figure 3.18: Flowchart for Qibla direction algorithm

CHAPTER IV

RESULT AND DISCUSSION

4.1 Introduction

This chapter discusses all the results obtained and the limitation of the project. All discussions concentrate on the features and performance of ETA.

Figure 4.1 and 4.2 above shows the exterior design of ETA while Figure 4.3 shows the interior design of ETA.

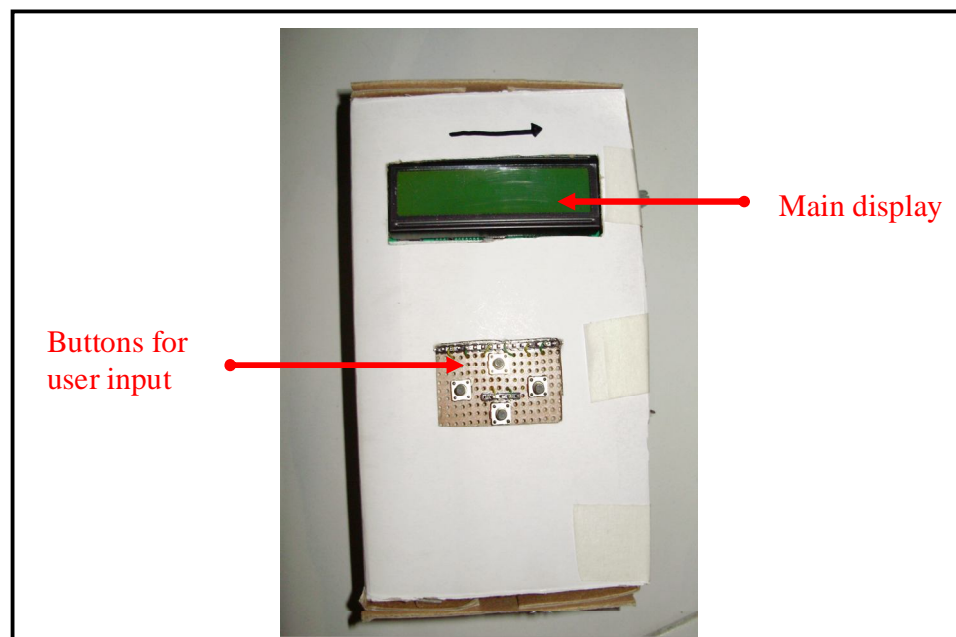


Figure 4.1: Top view

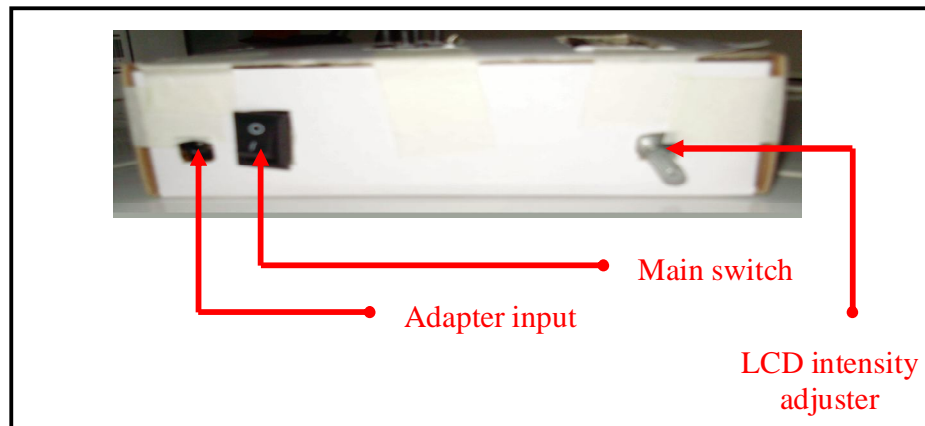


Figure 4.2: Side view

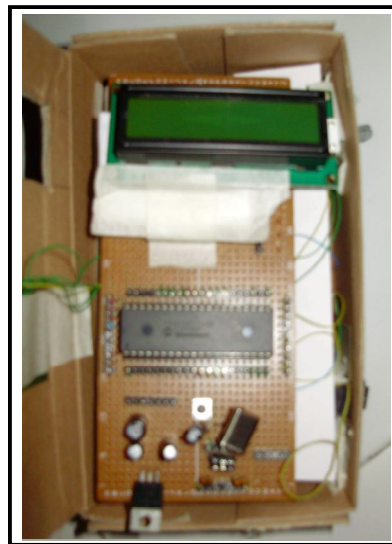


Figure 4.3: Main board of ETA

ETA uses 16x2 LCD for display and has 4 buttons for user interface. Main switch is used for switching on or off ETA while LCD intensity adjuster adjusts intensity of LCD display. ETA is operated using rechargeable battery 6V that can be charged using the adapter as in Figure 4.4. The adapter is connected to the adapter input whenever the battery needs to be charged.



Figure 4.4: AC/DC Adapter with 9V DC output



Figure 4.5: Rechargeable Battery 6V

4.2 The Features of ETA

ETA comes with two menus which are compass and Qibla. Figure 4.6 shows the welcome screen of ETA once ETA is switch on.



Figure 4.6: Welcome screen

The menus of ETA are displayed as in Figure 4.7 for user choices. To choose 'Compass' menu, user has to push LEFT button and RIGHT button is pushed for 'Qibla' menu.

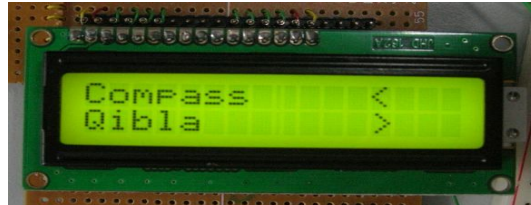


Figure 4.7: Menu view

Compass menu displays the direction of Magnetic North and Qibla menu displays the direction of Qibla for 14 locations in Malaysia. Buttons used to select these menus and location of the user is shown in Figure 4.8.

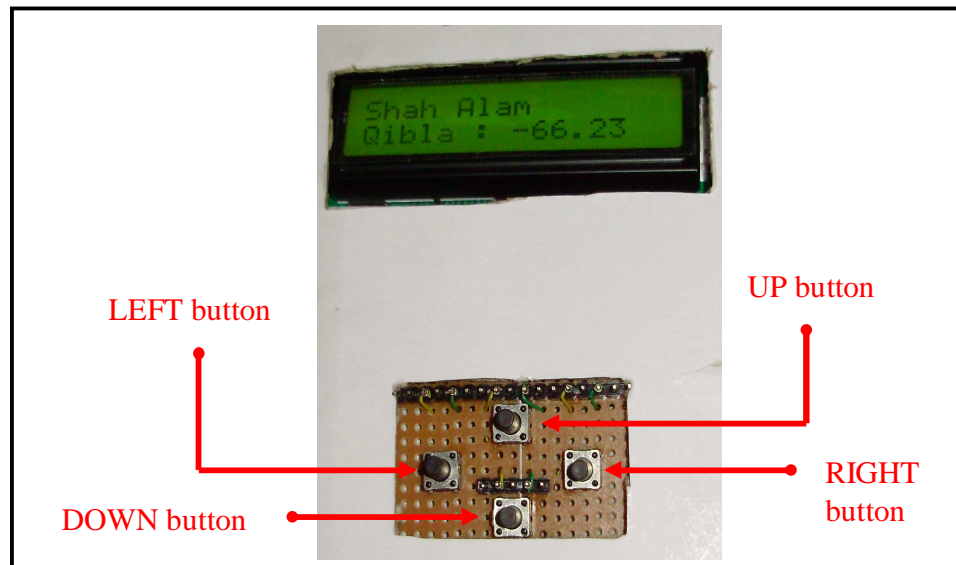


Figure 4.8: Buttons for User Interfacing

If the user chooses to display compass, ETA displays a range of 0° to 360° . User has to keep rotating ETA until it displays 0 or 360 (refer Figure 4.9) which means it has pointed out the North direction. North direction is pointed out by an arrow on ETA and HMC6352 as shown in Figure 4.10.

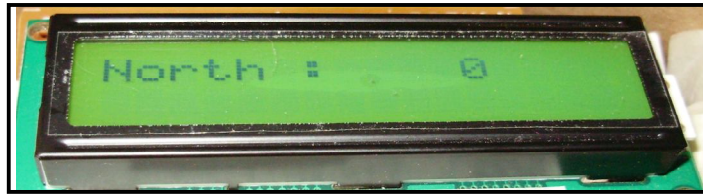


Figure 4.9: Compass menu

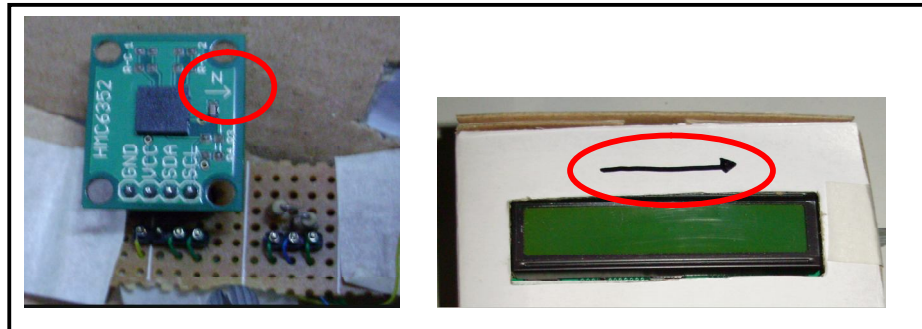
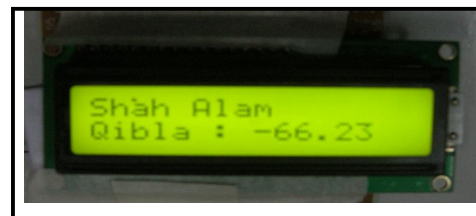


Figure 4.10: Arrow to appoint North and Qibla direction

There are 14 locations in the database installed in ETA. The locations are the capital city of each state in Malaysia. Below are some of the locations in ETA database.



(a)



(b)



(c)



(d)

Figure 4.11: Some of database installed in ETA (a) Malacca, (b) Shah Alam, (c) Kuching, (d) Kuantan

To locate the Qibla direction, ETA must be rotated to find the exact direction of Qibla from North direction. Example of finding the Qibla direction is shown in Figure 4.12 below ($360^{\circ} - 66.62^{\circ} \approx 294^{\circ}$).



Figure 4.12: Example of finding the Qibla direction in Kuantan

4.3 Performance of ETA

Data from ETA is compared to the data acquired from e-Solat JAKIM.[6] There are slightly differences of Qibla direction from e-Solat JAKIM and ETA because of the processor used in both systems is different. e-Solat JAKIM is a software that uses 32/64 bits processor (computer architecture) while PIC18F452 used in this project uses only 8 bits processor. 32/64 bits processor provides longer decimal point than 8 bits processor. Longer decimal point gives more accurate calculation and this is why the differences as shown in Table 4.1 exist.

Table 4.1: Differences of data from ETA and e-Solat JAKIM

Capital city	ETA (°)	e-Solat JAKIM (°)	Difference (°)	Difference (%)
Malacca	-66.29	-67.15	0.86	1.28
Seremban	-66.28	-67.19	0.91	1.35
Shah Alam	-66.23	-67.48	1.25	1.85
KL	-66.27	-67.48	1.21	1.79
Ipoh	-66.30	-68.16	1.86	2.72
Alor Setar	-66.34	-68.88	2.54	3.69
Arau	-66.36	-68.95	2.59	3.76
Georgetown	-66.25	-68.42	2.17	3.17
Kota Bharu	-66.67	-68.90	2.23	3.24
K. Terengganu	-66.74	-68.62	1.88	2.74
Kuantan	-66.62	-67.59	0.97	1.44
JB	-66.50	-67.09	0.59	0.88
K. Kinabalu	-68.28	-69.32	1.04	1.50
Kuching	-67.47	-67.91	0.44	0.65

From Table 4.1 above, it can be sum up that the average difference in percentage (%) between data from ETA and e-Solat JAKIM is 2.147% as calculated using Equation (2) below.

$$\left[\frac{\sum \text{Difference}(\%)}{14} \right] \times 100\% = \text{Average}(\%) \quad (2)$$

The percentage of average difference between ETA and e-Solat JAKIM is small enough to convince that ETA is reliable in locating Qibla direction.

4.4 Costing

Table 4.2 below shows the price listing of basic components used in ETA.

Table 4.2: Basic Component Price List

Component	Specification	Price/unit	Quantity	Total Price
Voltage Regulator	LM7805	RM 1.00	1	RM 1.00
Capacitor	22pF	RM 0.12	2	RM 0.24
Capacitor	4.7uF	RM 0.12	1	RM 0.12
Capacitor	1uF	RM 0.01	2	RM 0.02
Capacitor	100uF	RM 0.12	1	RM 0.12
Resistor	10k Ω	RM 0.10	3	RM 0.30
Header		RM 0.50	5	RM 2.50
Push button		RM 0.60	5	RM 3.00
Oscillator (Crystal)	20Mhz	RM 0.60	1	RM 0.60
Potentiometer	10k Ω	RM 0.60	1	RM 0.60
Dependent Board		RM 3.00	1	RM 3.00
IC Base	40 pins	RM 0.60	2	RM 1.20
Heat sink		RM 0.20	1	RM 0.20
Switch	Rocker	RM 0.80	1	RM 0.80
Wire wrap		RM 15.00	1	RM 15.00
TOTAL				RM 28.70

Table 4.3 lists the price of main components in ETA. The price is referred to the Sparkfun Electronics as the components are bought from there.

Table 4.3: Main Component Price List

Component	Specification	Price/unit	Quantity	Total Price
LCD	16x2	RM 20.00	1	RM 20.00
Compass Module	HMC6352	RM 217.44	1	RM 217.44
Adapter	Input AC 230V Output DC 12V	RM 25.00	1	RM 25.00
Microcontroller	PIC18F452	RM 10.00	1	RM 10.00
TOTAL				RM 272.44

From both tables, the total cost for developing ETA is RM 301.14.

CHAPTER V

CONCLUSION AND RECOMMENDATION

This chapter discusses the conclusion of development of the project. It also discusses the problems and the recommendations for this project for the future development or modification. Commercialization of ETA is briefly explained in this chapter.

5.1 Conclusion

In today's market, technology is becoming more prevalent in portable devices. ETA is one of the portable devices designed for travellers and navigators which combine compass system and Qibla finder.

This project is successfully developed through hardware; PIC18F452 and HMC6532. Software is implemented in this project using C Language programming that later being compiled by CCS C Compiler. The output of ETA is displayed on the LCD with digital numeric readout in degree form. It may look quite simple but the methods and the process to develop this project are more important and valuable. Starting from a simple function, it has the possibility to be further improved with complex functions.

In general, the whole of ETA's project were successfully developed and anyone could use this device anywhere and anytime to locate the North and Qibla direction.

5.2 Recommendation for ETA Project

ETA can be more attractive if it uses OLED as its display because OLED has greater range of colours and brightness. OLED can directly emits light instead of LCD which uses backlight which will make the display brighter. In addition to that, OLED has low power consumption compared to LCD.

Each device designed must be user friendly. In order to fulfill this requirement, ETA needs to have interactive user interface such as hand phone's keypad. For being user friendly also requires ETA to be use easily. The display of ETA must be as easy as to read the analogue compass and Qibla pointer which has a pointer to point the direction instead of digital numeric readout.

User of ETA may travel overseas and the limitation of ETA being used in Malaysia only can be improved by installing the database of longitude and latitude of more countries around the world. As add-on for Muslim travellers, database of prayer time can also be included in ETA.

5.3 Commercialization

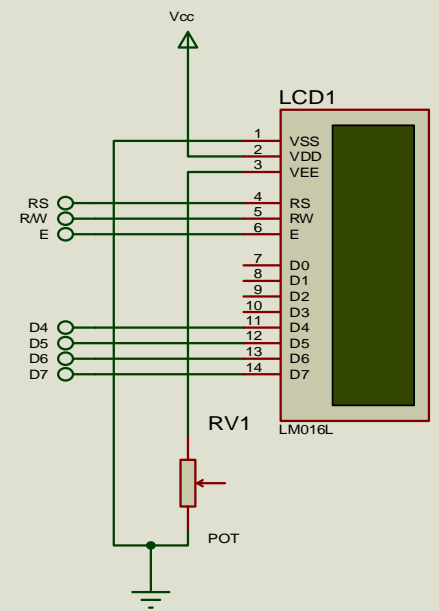
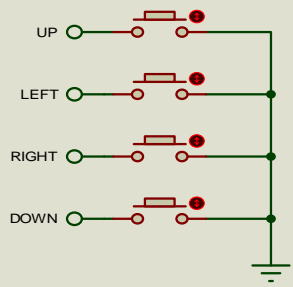
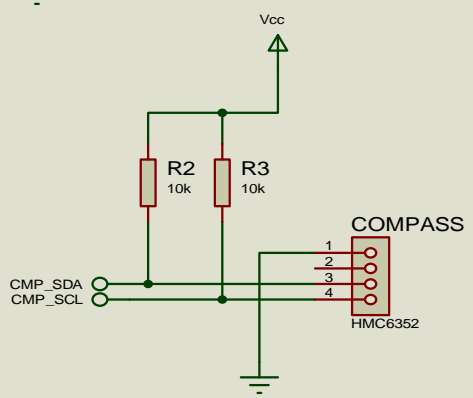
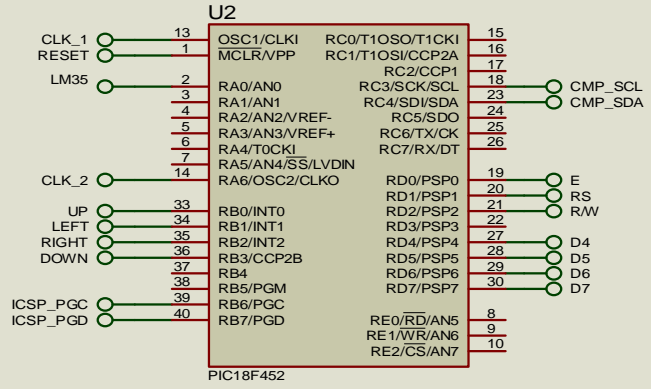
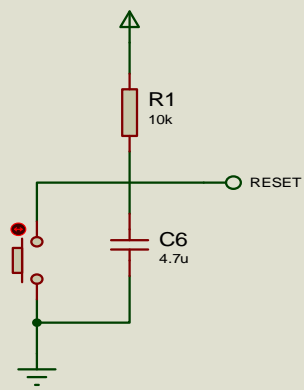
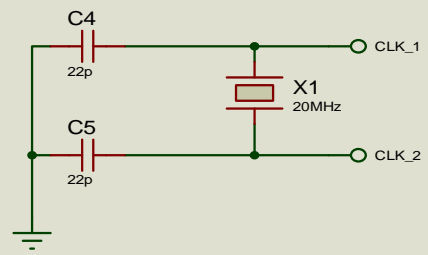
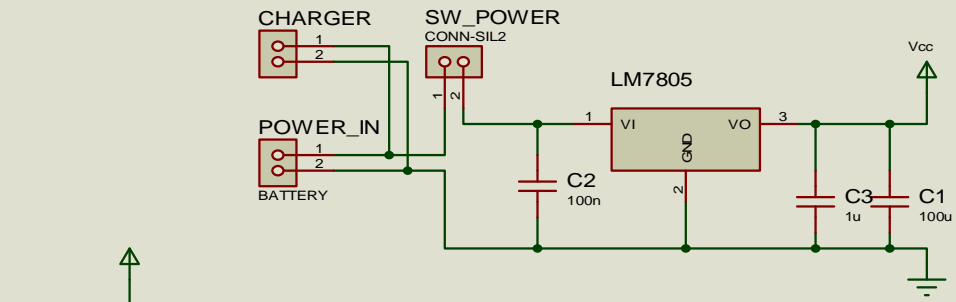
With some modification to the prototype of ETA, it has high market potential as ETA can be sum up as a device needed by everyone and everywhere especially Muslims nowadays. The most potential markets of ETA are travellers and military because of its portable features.

In commercializing ETA, some potential collaborators are highlighted such as Jabatan Kemajuan Islam Malaysia (JAKIM), Majlis Agama Islam Negeri, Government and Non-Governmental Organizations (NGO). From this collaboration, ETA can be further improved to be marketed in or out of Malaysia.

REFERENCES

1. Michael J. Caruso, *Applications of Magnetic Sensors for Low Cost Compass Systems*, Honeywell, SSEC, February 1997.
2. Mary Bellis, *The Compass and other Magnetic Innovations, Lodestones, Magnets, Electromagnetism*, 2000.
3. Hossam Abdel-Qader, *9 Scientific Methods to Locate Qibla Direction*, August 9, 2000.
4. Niweateh Hajewaming, *Astronomical Calculation of Islamic and Qiblat Direction*, 2002.
5. 20th April 2009, Internet Source, *Astronomical and Navigational Instruments*
URL: <http://www.nmm.ac.uk/collections/explore/object.cfm?ID=AST0443>
6. 20th April 2009, Internet Source, *JAKIM eSolat*
URL: www.e-solat.gov.my/
7. Nigel Gardner, *PICmicro MCU C®, An introduction to programming, The Microchip PIC in CCS C*, 2002.
8. Microchip, *PIC18FXX2 Datasheet*, 2006.

APPENDIX A
HARDWARE SCHEMATIC DIAGRAM



APPENDIX B
PROGRAMMING IN CCS C COMPILER

```

/* ELECTRONICS TRAVEL AID */

#include <18F452.h>
#fuses HS,NOWDT,NOPROTECT,NOLVP
#use delay(clock=20000000)

#include <lcd.c>
#include <math.h>

int menu_1 ();
int menu_2 ();
void array ();

int choice=0;
int location=0;

char a[14][12]={ "Malacca", "Seremban", "Shah Alam", "KL", "Ipoh", "Alor Setar",
" Arau", "Georgetown", "KB", "KT", "Kuantan", "JB", "KK", "Kuching"};
float longitude[14] =
{ 102.25,101.95,101.53,101.68,101.08,100.37,100.27,100.33,102.23,103.13,103.33,103.
77,116.07,110.42};
float latitude[14] =
{ 2.25,2.72,3.08,3.15,4.58,6.12,6.43,5.42,6.12,5.33,3.82,1.47,6.00,1.55};

#int_rtcc
void ext_isr()
{
    if(input(PIN_B0)== 0)
    {
        while(input(PIN_B0)== 0);
        location--; //up
    }

    if(input(PIN_B1)== 0)
    {
        while(input(PIN_B1)== 0);
        choice--; //left
    }

    if(input(PIN_B2)== 0)
    {
        while(input(PIN_B2)== 0);
        choice++; //right
    }
}

```



```
if(input(PIN_B3)== 0)
{
    while(input(PIN_B3)== 0);
    location++; //down
}

if(choice == 2)
choice = 0;

if(choice == -1)
choice = 1;

if(location == 14)
location = 0;

if(location == -1)
location = 13;

}

int16 HMC_read_heading(void)
{

    int8 lsb;
    int8 msb;

    i2c_start();
    i2c_write(0x42);
    i2c_write(0x41);
    i2c_stop();

    delay_ms(7);

    i2c_start();
    i2c_write(0x43);
    msb = i2c_read();
    lsb = i2c_read(0);
    i2c_stop();

    return (((int16)lsb | ((int16)msb << 8)) / 10);

}
```

```
float qibla_cal (void)
{
    float Fd,Ld;
    float Fm = 0.37437;
    float Lm = -0.69377;
    float qibla1;

    Fd = (pi/180)*latitude[location];
    Ld = (pi/180)*-(longitude[location]);

    qibla1 = (180/pi)* (atan ((sin (Ld-Lm))/((cos (Fd))*(tan (Fm)))-((sin (Fd))*(cos((Ld)-
(Lm))))));

    return qibla1;
}

int menu_1 ()
{
    int16 arah;

    while(TRUE)
    {
        lcd_gotoxy(1,1);
        printf(lcd_putc, "\fNorth : %4ld", arah);

        if(choice != 0)
            return 0;

    }

    return 0;
}
```

```
int menu_2 ()
{
    float qibla;

    while(TRUE)
    {

        lcd_gotoxy(1,1);
        printf(lcd_putc, "\f%s", a[location]);
        qibla = qibla_cal();
        lcd_gotoxy(1,2);
        printf(lcd_putc, "Qibla : %f", qibla);

        if(choice != 1)
            return 0;

        delay_ms(200);

    }

    return 0;
}

void main()
{

    setup_timer_0(RTCC_INTERNAL|RTCC_DIV_1);
    setup_timer_1(T1_DISABLED);
    setup_timer_2(T2_DISABLED,0,1);

    setup_ccp2(CCP_OFF);
    set_pwm2_duty(0);

    enable_interrupts(INT_RTCC);
    enable_interrupts(GLOBAL);

    port_b_pullups(TRUE);

    lcd_init();
    delay_ms(60);
    lcd_gotoxy(1,1);
    lcd_putc("\f ELECTRONICS \n");
```

```
lcd_gotoxy(1,2);
lcd_putc(" TRAVEL AID \n");
delay_ms(3000);
lcd_send_byte(0,0x01);

lcd_gotoxy(1,1);
lcd_putc("\fCompass <\n");
lcd_gotoxy(1,2);
lcd_putc("Qibla >\n");
delay_ms(4000);
lcd_putc("\f");

while(TRUE)
{
    if(choice==0)
        menu_1();

    if(choice==1)
        menu_2();
}
}
```