

AMATEUR RADIO BASED WEATHER STATION

LIM CHIA CHEEN

This project is submitted in partial fulfillment of
the requirements for the degree of Bachelor of Engineering with Honours
(Electronics and Telecommunication Engineering)

Faculty of Engineering

UNIVERSITI MALAYSIA SARAWAK

2006

The following Final Year Report:

Title: Amateur Radio Based Weather Station

Name of author: Lim Chia Cheen

Matrix number: 8507

was read and certified by:

Cik Nordiana bt Rajeee

Supervisor

Date

Dedicated to my parents, family and loved one.

ACKNOWLEDGEMENTS

I would like to express my deepest appreciation to my final year project supervisors, Cik Nordiana bt Rajeee and Mr. Martin Anyi, for their invaluable assistance in guiding me to complete this project. They gave me the help that I needed most to make this project a success.

My special thanks also go to all the staffs of Electronics and Telecommunication Engineering, UNIMAS for their assistance, advice and support during this project was carried out.

I would like to show gratitude my family members and loved one for their support and understanding. Also, many thanks to my course mates for their help, especially Thye Hun Shen, Kenny Chew Liang Chung and Lim Tze Chiat.

Last but not least, I would like to dedicate this project to my close friends who have been providing me with their encouragement and moral support. Thank you for your undivided attention, for without it I may not have come this far.

ABSTRACT

Weather is an important factor in daily activities and economic sectors, such as tourism and agriculture. As easy as it may seem to be to get a weather report from mass media, it is difficult to get local weather status at a specific area, which may be different from other places at a few kilometers away. In rural areas, where telecommunication and transportation are hard to establish, local weather report is even harder to come by. This project presents an alternative using weather station that based on amateur radio as its communication tool. In this final year project report, a detailed description about project concept and technical aspect is given. Based on the methodology as mentioned in the report, the outcome of the project is described. At the end of this report, recommendations are made to further improve the project.

ABSTRAK

Cuaca merupakan faktor yang penting dalam aktiviti seharian dan sektor ekonomi, seperti pelancongan dan pertanian. Walaupun laporan cuaca senang diperoleh dari media massa, namun cuaca tempatan di suatu kawasan tertentu susah ditentukan, lebih-lebih lagi terdapat perbezaan cuaca tempatan berbanding dengan kawasan lain dalam jarak beberapa kilometer sahaja. Di kawasan pedalaman, cuaca tempatan lebih susah diperoleh kerana kekurangan telekomunikasi dan pengangkutan. Projek ini memberi satu alternatif dengan menggunakan stesen cuaca berdasarkan radio amatour sebagai alat komunikasi. Penjelasan secara terperinci mengenai konsep projek dan aspek teknikal telah diberi dalam laporan projek tahun akhir ini. Berdasarkan kaedah-kaedah yang tersenarai dalam laporan, keputusan yang diperoleh melalui projek ini telah dipersembahkan. Akhir sekali, beberapa cadangan telah dikemukakan untuk menjadikan projek ini lebih baik.

TABLE OF CONTENTS

CONTENTS	Page
DEDICATION	ii
ACKNOWLEDGEMENTS	iii
ABSTRACT	iv
ABSTRAK	v
TABLE OF CONTENTS	vi
LIST OF TABLES	xi
LIST OF FIGURES	xii
LIST OF ACRONYMS	xvi
Chapter 1 INTRODUCTION	
1.1 Microclimate	1
1.2 Problems Identification	2
1.3 Project Introduction	3
1.4 Application and Recent Advancement	
1.4.1 The Torrey Pines Gliderport, San Diego, California	4
1.4.2 APRS-Internet Service (APRS-IS)	4
1.5 Objectives	5

1.6	Expected Outcomes	5
Chapter 2	LITERATURE REVIEW	
2.1	Amateur Radio	8
2.2	Packet Radio	9
2.2.1	Introduction	9
2.2.2	Advantages of Packet Radio over Digital Modes	11
2.2.3	AX.25 Protocol	12
2.3	Automatic Positioning Reporting System (APRS)	13
2.3.1	Introduction	13
2.3.2	Equipment	14
2.3.3	Format of APRS Weather Report	17
2.4	PIC Microcontroller	19
2.4.1	PIC16F84A	20
2.4.1.1	Pin Diagram	20
2.4.1.2	PIC16F84A Architecture	22
2.5	RS232 Serial Communication	26
2.6	PicBasic Pro Compiler	29
2.7	IC-Prog	30
2.8	Liquid Crystal Display (LCD)	32
2.9	Sound Card Modem: AGWPE	35
2.10	Sensirion SHT11 Temperature and Humidity Sensor	36
2.10.1	Introduction	36

2.10.2	Interface Specifications	37
2.12	Brushless DC (BLDC) Motor	38
2.12.1	Introduction	38
2.12.2	Application of BLDC Motor in Building Anemometer	39
Chapter 3	METHODOLOGY	
3.1	Research and analysis	40
3.2	Build PIC Programmer	41
3.3	Breadboard Prototyping	41
3.4	Programming weather station plus interface (data converter)	42
3.4.1	Using PicBasic Pro Compiler	42
3.4.2	Using IC-Prog Software	44
3.5	Setup and Testing of RS232 Serial Communication	47
3.6	Setup and Testing of Transmitting Station	49
3.6.1	Setup of Terminal Node Controller (TNC)	49
3.6.2	TNC-to-Radio Cable Interface	52
3.7	Setup and Testing of Receiving Station	54
3.7.1	Radio-to-Soundcard Cable Interface	54
3.7.2	AGWPE Setup	55
3.7.3	UI-View Setup	60
3.8	Making Printed Circuit Board (PCB)	63

Chapter 4 RESULTS AND DISCUSSIONS

4.1	Hardware	68
4.1.1	PIC Programmer	68
4.1.2	Breadboard prototype	70
4.1.3	Final Amateur Radio Based Weather Station prototype	70
4.1.3.1	Weather station	70
4.1.3.2	Data converter	74
4.1.4	LCD display and LEDs indication	75
4.2	Software	77
4.2.1	Program flow of Amateur Radio Based Weather Station	77
4.2.2	Program flow of Data Converter	82
4.2.3	HyperTerminal output	84
4.3	System	85
4.3.1	Transmitting radio and TNC output	85
4.3.2	Received Packet Sound	86
4.3.3	AGWPE and UI-View output	87
4.4	Problems faced and their solutions	90

Chapter 5 CONCLUSION AND RECOMMENDATION

5.1	Conclusion	91
5.2	Recommendation	92

REFERENCES

94

APPENDICES

A	Netlist of JDM PIC Programmer	99
B	Netlist of Weather Station	100
C	Netlist of Data Converter	102
D	Program of Weather Station Using PicBasic Pro	104
E	Program of Data Converter Using PicBasic Pro	108

LIST OF TABLES

Table		Page
1	Explanation of APRS weather data string	18
2	Pin Identifiers for PIC16F84A	21
3	Commonly used RS232 signals	28
4	Pin layout and function for HD44780 LCD Display	33
5	Pin-out and function for SHT11	37
6	Component list of JDM PIC Programmer	42
7	Setting of TNC's baud rate switches for 1200 baud	49
8	TNC instructions for the weather station	51
9	Pin out of TNC radio port connector	52
10	Component list of JDM PIC Programmer	68
11	I/O ports of PIC16F84A used for the weather station	80
12	I/O ports of PIC16F84A used for the data converter	83
13	Problems faced during project implementation and their solutions	90

LIST OF FIGURES

Figures	Page
1.01 Block diagram of amateur radio based weather station	7
2.01 Packet Radio System	10
2.02 AMSAT (Amateur Satellite) Live Nationwide APRS Traffic page in USA	13
2.03 Some examples of VHF-FM radios	15
2.04 Terminal Node Controller (TNC)	15
2.05 Screenshot of UI-View	16
2.06 Examples of Complete APRS Weather Report Format	17
2.07 PIC16F84A microcontroller	19
2.08 PIC16F84A Pin Diagram	20
2.09 PIC16F84A Block Diagram	22
2.10 Usage of Program Memory Address	24
2.11 Serial communications bit stream	27
2.12 DB25 and DB9 Pin Layout (view into male connector)	28
2.13 Main Areas of IC-Prog	31
2.14 HD44780 LCD Display	32
2.15 Sensirion SHT11 Sensors	36
2.16 Brushless DC motor	38
3.01 Metal strips of a breadboard	41

3.02	DOS display for correct code compilation (blink.bas)	43
3.03	Hardware Settings of IC-Prog	44
3.04	Choosing devices and fuses	45
3.05	Hex data loaded into the IC-Prog	46
3.06	Connection description for HyperTerminal	47
3.07	Connection settings for HyperTerminal	48
3.08	Serial port properties for HyperTerminal	48
3.09	Display on HyperTerminal after turning on the TNC	50
3.10	TNC radio port connector and 5-pin male DIN cable	52
3.11	Schematic of TNC-to-radio cable interface	53
3.12	Simplified dynamic microphone circuit in TNC	54
3.13	Radio-to-Soundcard Cable Interface	54
3.14	AGWPE's pop-up menu	55
3.15	Properties of Port1 in AGWPE	56
3.16	Soundcard Modem/TNC Setup in AGWPE	56
3.17	AGWPE Soundcard Volume Settings	58
3.18	The SineWave scope display on AGWPE Soundcard Tuning Aid	58
3.19	Recording Control Window	59
3.20	Advanced Controls for Mic	60
3.21	Comms Setup for UI-View	60
3.22	Station Setup for UI-View	61
3.23	APRS Compatibility Setup of UI-View	61
3.24	Miscellaneous Setup of UI-View	62

3.25	Station Information Setup of UI-View	62
3.26	Example of home-made printed circuit board	63
4.01	Schematic Diagram for JDM PIC Programmer	68
4.02	Schematic diagram of PIC Programmer using Protel 98	69
4.03	PCB layout of PIC Programmer using Protel 98	69
4.04	Completed breadboard prototype of weather station	70
4.05	Schematic diagram of weather station using Protel 98	71
4.06	Schematic diagram of wind sensor circuit (anemometer)	72
4.07	Temperature and Humidity Sensing Circuit	73
4.08	PCB layout of weather station using Protel 98	74
4.09	Schematic diagram of data converter using Protel 98	74
4.10	PCB layout of data converter using Protel 98	75
4.11	LCD display of weather data	76
4.12	Program flow for weather station (Program 1)	77
4.13	Program flow for weather station (Program 2)	78
4.14	Program flow for data converter	82
4.15	The correct output from the weather station via serial communication	84
4.16	PWR LED is initially turned on, and then PTT LED lit up for every packet modulation process	85
4.17	VHF radio keyed by TNC to transmit packets, with transmit indicator	86
4.18	Location of potentiometer R76 inside TNC	87
4.19	Received signal display on the AGWPE Soundcard Tuning Aid	87
4.20	Received APRS weather data display on the UI-View Terminal	88

4.21	List of APRS weather station detected by the receiving side	89
4.22	The UI-View weather station window display	89

LIST OF ABBREVIATIONS

A/D	-	Analog/Digital
AC	-	Alternate current
AMSAT	-	Amateur Satellite
APRS	-	Automatic Positioning Reporting System
APRS-IS	-	Automatic Positioning Reporting System – Internet Service
ASCII	-	American Standard Code for Information Interchange
AX.25	-	Amateur X.25
BBS	-	Bulletin Board Systems
BLDC	-	Brushless Direct Current
CPU	-	Central Processing Unit
CRC	-	Cyclic Redundancy Check
CSMA	-	Carrier Sense Multiple Access
DC	-	Direct Current
DCE	-	Data Circuit-Terminating Equipment
EEPROM	-	Electrically Erasable Programmable Read Only Memory
FM	-	Frequency Modulation
GPR	-	General Purpose Registers
GPS	-	Global Positioning System
HF	-	High Frequency
HMS	-	Hour, Minute, Second

I/O	-	Input/Output
IC	-	Integrated Circuit
LCD	-	Liquid crystal display
LED	-	Light Emitting Diode
mph	-	miles per hour
PBP	-	PicBasic Pro Compiler
PC	-	Personal computer
PCB	-	Printed Circuit Board
PIC	-	Peripheral Interface Controller
PTT	-	Push to talk
RAM	-	Random Access Memory
RF	-	Radio frequency
RISC	-	Reduced Instruction Set Computer
SFR	-	Special Function Registers
SHF	-	Super High Frequency
SMT	-	Surface-mountable
TNC	-	Terminal Node Controller
TTL	-	Transistor-transistor Logic
UHF	-	Ultra High Frequency
VHF	-	Very High Frequency
WDT	-	Watchdog Timer

Chapter 1

Introduction

1.1 Microclimate

A microclimate or local weather is a weather pattern that is localized in a small area. It is different in some significant way from weather of nearby areas. The weather variables in a microclimate can consist of temperature, humidity, rainfall, wind, or any combination of these [1]. In short, it is the amalgam of many, slightly different microclimates that makes up the climate for a larger area [2].

Microclimates may be subtly different from one another due to the conditions prevailing over the area as a whole, such as atmospheric pressure or cloud cover. The most important factor that affects microclimates is the location of the area. Weather at upland areas is different from weather in urban areas or coastal areas. Therefore, microclimate can only be determined by a weather station at the site.

Better information about microclimates allows people to make better decisions:

- 1) When dangerous weather threatens life and property
- 2) In everyday planning (e.g. outdoor activities)
- 3) In normal economic activities that have some degrees of weather dependence, such as agriculture and tourism

1.2 Problems Identification

Telecommunication is a major problem in rural areas such as Belaga, due to limited infrastructure and resources. In these areas, Internet and telephone systems are hard to setup due to lack of transportation availability, geographical problems (e.g. at upland and forest areas) and limited population. These factors increase the installation and maintenance fees to establish communication with these areas, thus reducing the feasibility of the task [3].

Similar to other places, it is necessary to obtain local weather report in rural areas. Apart from determining weather condition in a particular area, the report is useful when it comes to natural disasters, such as heavy storm, flood and forest fire. Authorities concerned can alert nearby residents to evacuate to safer areas as soon as possible when emergency arises. Therefore, local weather needs to be monitored constantly [4].

However, as mentioned earlier, setting up effective telecommunication in rural areas is proven to be an arduous task. Weather data must be sent to a receiving station located further away, with easier access to infrastructure and facilities. Until now, weather officers have to travel to rural areas periodically to retrieve weather data from the weather station there, which is time-consuming and inefficient. Even if telephone lines are available, they are still limited and Internet connection is not fast enough to convey local weather data efficiently [4].

Furthermore, natural tourism venues, such as national parks and beaches depend on weather condition. For example, a trip to Bako National Park or Damai beach will be severely affected if rain occurred. Without knowing the particular weather condition, visitors may waste time if they find the weather unsuitable for trip along the way.

1.3 Project introduction

This project uses amateur radio in local weather reporting. It is achieved via *Automatic Positioning Reporting System (APRS)*, which allows one to transmit digital data in packet form using amateur radio. Local weather data that consists of temperature, humidity and wind speed, is collected and transmitted to a receiving station at a distance apart. It does not need telephone lines or Internet access to operate.

1.4 Application and Recent Advancement

1.4.1 The Torrey Pines Gliderport, San Diego, California

Paragliding is an extreme “foot-launched” sport, which allows ones to enjoy a short flight along a ridge or a lengthy cross-country flight by using sailplane [5]

Paragliding is at the mercy of the weather. To make things worse, installing a weather station at the remote Torrey Pines Gliderport is difficult, since there is no commercial AC power source and the number of phone lines is also limited [5]

Richard Parry, W9IF set up an APRS weather station to provide communication from the gliderport to a local APRS network and ultimately to the Internet, where anyone in the world can monitor the weather conditions [5].

1.4.2 APRS-Internet Service (APRS-IS)

APRS-IS is a high speed backbone interconnection of local RF (radio frequency) APRS networks worldwide, using Internet as communication link. It provides a method for strategic communication through a tactical protocol, allowing messaging to occur between two stations on opposite sides of the world, without requiring the knowledge of specific paths. APRS-IS allows Internet-connected HAMS (amateur radio operators) to combine APRS data with other Internet services [6].

1.5 Objectives

1. To develop an APRS weather station that can capture weather data, such as temperature, humidity and wind speed
2. To develop an interface to connect the weather station to a TNC (Terminal Node Controller). The interface will convert the weather data into APRS format
3. To establish connection between the weather station and the receiving side via radio communication
4. To display weather data on the computer at the receiving side

1.6 Expected Outcomes

Figure 1.01 shows the block diagram of the amateur radio based weather station. The weather station must be able to measure weather conditions at a location, which are then broadcasted periodically through APRS transmitting station. In particular, the weather station measures temperature, relative humidity and wind speed. It also provides information about the time when the weather data is captured. All these data are displayed on the 1-line liquid crystal display (LCD).

Any calibration and data conversion is done at the data converter, so that the weather station itself only needs to return raw data. This allows the sensor calibrations to be fine-tuned, without having to modify the weather station firmware. The weather station periodically sends weather data to the data converter. When it gets the data, it processes it to turn raw measurements like voltages into the desired values. The data is

then converted to APRS format before it is periodically broadcasted using terminal node controller (TNC) and transceiver.

The packets are sent to the receiving station via radio link. Upon received, the receiving station decodes, checks for errors, and sends the received messages to a computer for display.